Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

Water Quality Studies

Final Report

Ecology issued publication

To request ADA accommodation or materials in a format for the visually impaired, call Ecology at 360-407-7472, Relay Service 711, or TTY 877-833-6341.

Publication No. 17-10-025

September 2014

Prepared by
Anchor QEA, LLC

Prepared for
Washington State Office of Financial Management

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

^{o}C	degrees Centigrade
µg/L	micrograms per liter
7-DADMax	7-day average of daily maximum temperature
BOD	biochemical oxygen demand
BOD-5	5-year biochemical oxygen demand
Project	Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species
CHL-US-NWK	Chehalis River Upstream of Newwakus
COC	Chain-of-Custody
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
GPS	global positioning system
kg/d	kilograms per day
LCS/LCSD	laboratory control sample/ laboratory control sample duplicate
mg/L	milligrams per liter
MS/MSD	matrix spike/matrix spike duplicate
NIST	National Institute of Standards and Technology
NOx	nitrate plus nitrite
NTU	Nephelometric Turbidity Unit
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RM	River Mile
RPD	relative percent difference
TDP	total dissolved phosphorus
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
Work Group	Chehalis Basin Work Group

1 Introduction

1.1 Background

The Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project (Project) evaluated the benefits and impacts of alternatives for flood hazard mitigation and enhancement of aquatic species within the Chehalis Basin. The goal of this analysis is to provide to the Chehalis Basin Work Group (Work Group) and stakeholders information that they need to decide on a recommended path forward, including whether to advance to the permitting phase for a water retention structure.

The water quality studies described in this report are part of several scientifically based technical studies that were conducted to assess the environmental impacts that could result from the flood control structure and help support an informed decision on whether to move forward with the Project. The data collected during the water quality studies will be used to support the assessment of environmental impacts of the Project should the project move on to the next phase. A draft version of this report was reviewed by the environmental technical committee of the Work Group. The comments received and Anchor QEA's responses to those comments are provided in Appendix A.

1.2 Objective of Water Quality Studies

The purpose of the water quality studies is to collect data to further characterize water temperatures, dissolved oxygen (DO), and water quality throughout the mainstem Chehalis River. The water quality monitoring program was also designed to characterize the nutrient (nitrogen and phosphorus), and biochemical oxygen demand (BOD) inputs from the major tributaries of the Chehalis River, including South Fork Chehalis River, Newaukum River, Skookumchuck River, Lincoln Creek, and Black River.

The data collected during the water quality studies will be used to support the characterization of baseline conditions in the Chehalis River, and the evaluation of without- and with-project conditions in the Chehalis River under different operational scenarios in subsequent phases of the project. The with-project conditions will be determined through mechanistic modeling. If the flood retention only alternative is selected, water storage and release during low-flow conditions in summer and fall will not need to be evaluated, whereas under the multi-purpose dam alternative, a permanent reservoir will be constructed and water releases would occur during low-flow conditions in summer and fall. The data collected will be used to re-calibrate the existing CE-QUAL-W2 and HEC-RAS water quality models (or help support development of alternative water quality models) for the proposed reservoir and for the Chehalis River downstream of the reservoir, respectively. Water quality data collected during this study may be used to support evaluations of fish habitat suitability and aquatic species enhancement.

2 Water Quality Studies Program Design

2.1 Overview of Water Quality Program

The water quality monitoring program was designed to address the data gaps identified in the earlier phases of the fish impact study (Anchor QEA 2012) and to achieve the objectives described in Section 1.2. The water quality monitoring program comprised the following:

- Automated water temperature data collection
- Synoptic flow and water quality surveys
- Automated diel surveys and depth profiling of DO, pH, temperature, chlorophyll-a, and turbidity
- Boat survey on the Chehalis River between Newaukum and Skookumchuck River confluences (hereafter referred as the Centralia Reach)
- Winter water quality sampling at Pe Ell
- Groundwater temperature measurements
- Collection of meteorological data

In the original program, in addition to low-flow surveys, quarterly surveys were proposed to characterize the non-critical season loads. However, based on discussions with the Washington State Department of Ecology (Ecology), it was determined that a detailed water quality characterization of the Centralia Reach under summer low-flow conditions was more critical than the quarterly water quality surveys. Therefore, the quarterly surveys were dropped from the original program and replaced with the water quality profiling of Centralia Reach. Recognizing the importance of characterizing the upstream loads entering the reservoir during winter, a single water quality sampling event was conducted in January 2014 at Pe Ell.

A Quality Assurance Project Plan (QAPP) was prepared for the water quality monitoring program, and reviewed and approved by Ecology (Anchor QEA 2013).

The work elements are described in greater detail in the following subsections.

2.2 Monitoring Locations

The locations at which automated temperature monitoring, water quality sampling, and flow measurements were conducted are shown in Figure 1. The station identification and a brief description of the locations are shown in Table 1. Global Positioning System (GPS) coordinates for the locations were obtained during the time of Tidbit deployment (for temperature Tidbits) and during the first water quality survey (for water quality sampling locations), and are provided with the project database. Additional details specific to each work element are described below.

2.2.1 TEMPERATURE PROBES

The locations for automated temperature data collection were determined based on previous experience of the system, data availability in the river and its watershed, and discussions with Ecology. At 10 of the 12 locations, temperature tidbits were installed in July 2013. At the Skookumchuck and Black rivers, temperature tidbits were subsequently added in September 2013 following recommendations from Ecology. In addition to the aquatic temperature tidbits, a few tidbits were installed on the banks to record air temperature. The water temperature tidbit locations that included an adjacent air temperature tidbit are identified in Table 1.

2.2.2 LOW-FLOW SYNOPTIC WATER QUALITY SURVEYS

Three low-flow synoptic surveys were conducted in August 2013, September 2013, and July 2014. The water quality sampling and flow monitoring locations were selected to characterize the nutrient and BOD loads in the river. Paired flow and water quality data were collected at locations along the mainstem immediately upstream of the major tributaries (such as South Fork Chehalis River, Newaukum River, Skookumchuck River, Lincoln Creek, and Black River) and at the mouth of the major tributaries. Overall water quality data collection was completed at 15 locations, as shown in Figure 1.

2.2.2.1 FLOW MEASUREMENTS

Flow monitoring was conducted only at a subset of the water quality monitoring locations, because existing U.S. Geological Survey (USGS) flow gages provide information on river and tributary flow at some locations (see Figure 1). In addition to the synoptic flow locations, flows were recorded at an additional location on the mainstem between Adna and Newaukum River confluence. The location was added by the field crew as an alternative to the mainstem location upstream of Newaukum River. Due to relatively higher water levels during the September 2013 survey, it was not possible to wade across the Newaukum River mouth location. So, flows were measured at a location that is about 100 feet farther upstream of the August and July survey location.

2.2.2.2 DEPTH PROFILING OF FIELD PARAMETERS

Depth profiles of temperature, pH, DO, turbidity and chlorophyll-a were collected using a multi-parameter sonde (data sonde) at two locations in the Centralia Reach: the Route 6 bridge in Chehalis, and the Mellen Street bridge. Bridge locations are listed in Table 1 and shown in Figure 1.

2.2.2.3 DIURNAL MEASUREMENTS

During each low-flow survey, a Hydrolab data sonde was deployed at three locations over a 24- to 48-hour period to record diurnal variations in DO, pH, and temperature. The locations are identified as “HLab” in Figure 1.

2.2.3 DETAILED WATER QUALITY PROFILING ON THE CENTRALIA REACH

On July 31, 2014, a detailed characterization of the Centralia Reach was conducted by floating a boat with a depth finder to identify slow moving/stagnant pools where profiles of temperature, turbidity, pH, and DO were measured using a Hydrolab MS5 data sonde. The survey was timed over a dry period of approximately 7 days, so that conditions over the Centralia Reach were stable and suitable for thermal stratification. In a previous water quality study undertaken by Ecology, a similar survey was conducted at this reach at approximately one-half- to one-mile intervals based on river morphology and location of point sources (Ecology 1994). A similar approach was adopted for the survey in July to locate the stations. Overall depth profiles of field parameters were measured at 14 stations (Table 2 and Figure 2). At four of the depth profile locations, water quality samples were collected, one at the surface and the second near the sediment-water interface. The samples were analyzed for the same suite of parameters analyzed during the summer low-flow surveys described above.

2.2.4 GROUNDWATER TEMPERATURE MONITORING LOCATIONS

Groundwater temperature was measured at existing domestic wells, which were previously used by the USGS to monitor groundwater levels (Fasser and Julich 2010). These locations are shown on Figure 3. These wells are located in reaches that were identified by a USGS investigation to have the greatest contribution to the surface water flow (Ely et al. 2008). A larger suite of wells were originally targeted, but the wells at which temperature measurements could ultimately be conducted were limited to those where property owner permissions could be obtained. Temperature measurements conducted in September 2013 and July 2014 were closer to the summer low-flow synoptic surveys, and one additional survey was conducted in October 2013.

2.2.5 METEOROLOGICAL MONITORING LOCATION

Meteorological data is an essential input for any mechanistic modeling of temperature in the proposed flood control structure. In the Chehalis River Fish Study (Anchor QEA 2012), the lack of meteorological data was identified as a data gap. To address this gap, meteorological sensors that provide wind speed and direction, relative humidity, air temperature, and incident solar radiation were installed to an existing Chehalis River Early Warning System rain gage located on the mainstem Chehalis River at Thrash Creek. The location of the rain gage is shown on Figure 1. Installation was performed in February 2014 by WEST Consultants through a sub-contract. The installation of meteorological sensors was not originally scoped, but was added following modifications to the water quality program.

3 Field Program Implementation

3.1 Temperature Tidbit Deployment

3.1.1 PRE-DEPLOYMENT CALIBRATION

Prior to deployment, the tidbits were calibrated following procedures recommended by Ecology (Ecology 2003). Each tidbit was pre-set for a delayed start so that each would start recording at the same pre-set time prior to calibration and continue to log temperature every 5 minutes. A separate watch was synchronized with the computer specified start time so that calibration readings would be simultaneous with the watch.

Tidbits were placed into two separate water baths with a high and low temperature of approximately 20.5 and 1.8 degrees Celsius (°C), respectively. The temperature reading in both bath temperatures was allowed to equilibrate prior to recording temperatures. Calibration was performed using a National Institute of Standards and Technology (NIST)-certified HB Instruments thermometer with serial number 1114593. The calibration data are provided in Tables B-1 and B-2 of Appendix B for the new and 2012 tidbits, respectively, and the results are discussed further in Section 4.1.

3.1.2 FIELD DEPLOYMENT

The initial temperature tidbits were deployed in the river at low water on July 30 and 31, 2013. Additional tidbits were deployed in the mouth of the Black and Skookumchuck Rivers on September 5, 2013. The tidbits were deployed in a 1.5-inch black polyvinyl chloride (PVC) housing attached to the top of a 20-pound lead anchor ball with quick links. The PVC housings were drilled with multiple holes to allow water circulation around the tidbits. Arrays were generally anchored to the shore using a cable attached to a shoreline tree or other fixed anchoring point along the bank. In most locations, in-water tidbits were attached to a double set of cables for stability in the current, with one cable upstream of the deployment location. Each array was deployed at each location such that the PVC housing was off the bottom at the time of deployment. An example deployment is shown in Figure 4.

At select locations, tidbits were installed on the bank in locations adjacent to the water temperature tidbits to provide the corresponding air temperature. The air temperature tidbits were similarly housed in PVC pipe, but were affixed to trees or other structures in the bank away from the river such that they would be less susceptible to vandalism or theft.

3.2 Low-flow Synoptic Surveys

3.2.1 FLOW-MEASUREMENT METHODS

Flow measurements were taken at locations where the discharge was the same as the site where water samples were collected. The best available sites were selected for discharge measurements. Site selection was based on a number of criteria related to channel characteristics and velocity distribution. Flow measurements were conducted using equipment and procedures described by the USGS (Turnipseed and Sauer 2010).

All discharge measurements were taken by wading the stream and using the current-meter midsection method. This method assumes that the mean velocity and depth in each measured location (vertical) represents the mean velocity and depth in a partial rectangular area (segment). Water velocities and depths were measured at approximately 20 to 25 verticals across the channel. Water discharge for each segment was computed from width, depth, and velocity data collected at a single vertical in each segment. For each discharge measurement, an attempt was made to space verticals across the channel such that no more than 5 percent of the total flow was measured in any single segment, but this was not always possible.

The specific equipment used for all discharge measurements was a 4-foot top-setting wading rod for measuring stream depths, a Pygmy Current Meter or Price AA current meter for measuring water velocities, a measuring tape for measuring channel widths, and an AquaCalc streamflow computer for computing the total flow. Stream velocities were measured using the two-point method when depths were 1.5 feet or greater using the Pygmy Current Meter and 2.5 feet or greater using the Price AA Current Meter. With this method, velocity observations were taken in each vertical at 20 and 80% of the depth below the water surface. The average of the two observations was considered the mean velocity in each segment. At verticals in the stream where depths were less than 1.5 feet (Pygmy) and 2.5 feet (Price AA) a single velocity observation was taken at 60% of the depth below the water surface, and this is considered to be the mean velocity.

When using the midsection method, a long measuring tape is stretched tight across the channel and anchored at each end. The tape is positioned such that it is perpendicular to most flow lines in the river (an example is shown in Figure 5). At individual verticals where the flow line was not perpendicular to the measuring tape, a horizontal angle correction was applied to correct the measured velocity. At each vertical the depth and distance referenced to the tape measure was entered into a small field computer. The computer was connected to the current-meter to measure velocities and compute discharge.

When using a vertical-axis mechanical type current-meter it is standard procedure to perform a meter spin test before each discharge measurement and to again check the meter following the measurement. This ensures that the meter cups spin freely. A standard USGS Discharge Measurement Note Form 9-275 is filled out at the field site immediately after the discharge measurement is made. Items listed on this form include results of the discharge measurement, physical characteristics of the measurement site, equipment used, and a subjective rating of hydrologic/hydraulic conditions in which the measurement was made. Raw data from the AquaCalc computer was input into a streamflow software package (Kisters/Biber) for review.

3.2.2 WATER QUALITY SAMPLE COLLECTION METHODS

Water samples were collected from the shore at each water sample collection location using an extension pole to collect water from as close to the center of the river as possible or as far away from the shore as possible to avoid areas where back eddies occurred. A laboratory supplied sample bottle was attached at the end of the extension pole for the collection of water. Samples were collected by dipping the bottle into the river inverted and facing upstream. Once under water, the bottle was turned up to allow water to fill the container. Water was transferred into the other containers for the sample from the initial water bottle until all sample bottles were filled. Once collected, all bottles from each station were placed into sealed plastic bags and then placed into a sample cooler with ice and held for transport to the laboratory. Sample transport and Chain-of-Custody (COC) procedures followed those described in the QAPP (Anchor QEA 2013). The COC forms are provided in Appendix C.

3.3 Field Measurements of Water Quality Parameters

3.3.1 PRE-DEPLOYMENT CALIBRATION OF HYDROLAB SONDES

The water quality meters were calibrated prior to use for the monitoring program according to manufacturers' procedures presented in the user's manuals. Calibration of field parameters, including DO, turbidity, and pH, were performed prior to each sampling event. In addition, a field check was performed during each deployment. The pre-deployment and field calibration results are provided in Appendix D.

Prior to deployment of water quality meters, each of the deployed meters was programmed in advance to begin automatic logging in the morning of the logging period using the HYDRAS3 LT software provided by the manufacture. For the first diurnal sampling event in August 2013, the meters were set up to record water quality information throughout the survey period in 30 minute intervals. For the following two sampling events in September 2013 and July 2014, the logging period was reduced to 15 minute intervals, as the internal power supply was determined to be sufficient for the increased logging capabilities of the meters.

3.3.2 FIELD DEPLOYMENT

Water quality meters were deployed on day one of each synoptic water quality sampling events at the same three locations, at the downstream Pe Ell tidbit temperature monitoring location just upstream of the Wastewater Treatment Plant, below the Route 6 Bridge in Chehalis, and below the Mellen Street Bridge in Centralia (see Table 1 and Figure 2). For deployment, the water quality meters were housed in black 3-inch-diameter PVC pipes to avoid direct contact with sunlight and to protect the probes from floating debris. Each tube was perforated with holes around the meter probes to allow sufficient water flow into the PVC housings around the probes.

The Hydrolabs placed at the Route 6 and Mellen Street bridges were held in place using cables attached to shore, and the meter probes were suspended in the water off the bottom in approximately 2 feet of water as far away from the shore as possible. At the downstream Pe Ell location, it was not possible to suspend the Hydrolab as at the other two locations. Therefore, it was placed along the bank in a higher flow condition directly on the gravel bottom and secured to the bottom with a weight and cable attached to a shore structure.

3.3.3 DATA DOWNLOAD AND POST-DEPLOYMENT CHECKS

Following retrieval of the water quality meters from the sampling locations, data was downloaded using the HYDRAS3 LT software. Post-deployment checks were performed for each event using the procedures described in Section 3.3.1. The post-deployment data are provided with the pre-calibration data in Appendix D.

3.4 Detailed Depth Profiling of Centralia Reach

For measurement of field parameters during the boat survey, the same pre-and post-deployment protocols as used in the summer low-flow surveys described previously were followed. The calibration data for the boat survey are provided in Appendix E.

Water samples were collected using a Van Dorn water sampler deployed from the vessel. Water was transferred from the sampling device into laboratory supplied sample bottles. Samples were immediately placed into coolers with ice and held for transport to the laboratory. Samples were delivered to the lab under COC procedures as described in the QAPP (Anchor QEA 2013). The COC forms are provided in Appendix E.

3.5 Groundwater Temperature Measurements

Groundwater from the locations shown on Figure 3 was sampled through an available spigot associated with each well location. A hose manifold system was developed with a hose splitter to simultaneously measure the purge rate from the well during sampling and to allow water to flow directly through a flow cell for water parameter measurements. The purge rate was determined by directing the flow directly into a 5-gallon bucket marked with 1-gallon increments and recording the time to fill successive buckets. From the sampling manifold, a separate tube was used to direct water into a flow cell attached to a YSI data sonde capable of measuring temperature, DO, and pH. Water parameter measurements were recorded on field data forms at approximately 5-gallon intervals until the field parameters stabilized, indicating that well recharge water parameters were being recorded. Groundwater monitoring field data forms are presented in Appendix F.

3.6 Meteorological Data Collection

Meteorological sensors were added to the existing rain gage on the Chehalis River at Thrash Creek. The sensors added include wind speed and direction, pyranometer for recording incident solar radiation, air temperature, and relative humidity and barometric pressure. The accuracy and range of the sensors are provided in Table 4. Field photographs depicting the sensors installed are shown in Figure 6, along with the telemetry system that is used to transmit data to a remote server in real-time. Data are hosted on a public domain website[1] funded by the Chehalis River Flood Authority.

---

[1] Available at https://chehalis.onerain.com/site.php?site_id=17410&view_id=249.

3.7 Laboratory Analytical Methods

Some analytical methods deviated from the QAPP (Anchor QEA 2013) due to the necessity to obtain lower reporting limits. All methods used are appropriate and acceptable. Table 5 lists the methods used and reporting limits obtained by each laboratory.

4 Field and Laboratory Data Quality Assurance and Quality Control

4.1 Field Data Quality Assurance/Quality Control

4.1.1 TEMPERATURE TIDBITS

Pre-deployment calibration of the temperature tidbits were discussed in Section 3.1. The calibration data are provided in Tables B-1 and B-2 in Appendix B for the new and 2012 tidbits, respectively. It is evident from these tables that both the new and the 2012 tidbits were consistently higher than the NIST reference thermometer by approximately 0.4 to 0.6°C, which is higher than Ecology's recommendation of 0.2°C for continuous water temperature measurement instruments (Ecology 2003). To determine whether there is a bias in the tidbits, or whether there was some other source of error, the NIST-certified reference thermometer used in this study was compared against King County's NIST certified thermometer (Serial No. 1074, CAT No. 1003-3FC) by simultaneously recording temperature of the same water bath over a range of temperatures. The results of this check are provided in Table B-3. It was determined from this test that the reference thermometer used in this study consistently under-predicted the temperature by an average of 0.4°C. Based on this, a correction factor of -0.4°C was applied to the pre-calibration data, upon which the temperature differences between the tidbits and reference thermometer reduced to a range of 0.0 to 0.2°C, which meets Ecology's recommendation for continuous water temperature measurement.

The post-deployment calibration check (to be conducted in early fall when the tidbits will be decommissioned) will be conducted with two standard thermometers. In addition to the same standard thermometer that was used in the pre-deployment calibrations, a second standard thermometer will be used to determine the warm and cold bath temperatures. Relative Percent Difference (RPD) calculations will be performed for both sets of standard measurements. If a consistent bias is noted, then a bias correction will be calculated for each tidbit and applied to the final results.

Temperature tidbit data were also compared to air temperature to identify potential issues with temperature measurements. Appendix G shows a comparison of the raw outputs from the tidbit shown plotted with the nearest air temperature measurement (either from an air temperature tidbit [for tidbits above Newaukum River Confluence] or from the NOAA Station at Chehalis/Centralia [for tidbits downstream of Newaukum River confluence]). Based on these comparisons, about 2 days of data (taken between October 10 and 12, 2013) were removed from the Pe Ell upstream tidbit, as it became apparent that it was exposed to air. This was also confirmed by the field crew during the October data download, when it was noticed that the tidbit was stuck on the bank above the water surface. The tidbit was repositioned to be in the water. Furthermore, the Pe Ell downstream tidbit was found buried in the sediments during the July 2014 download. Based on the raw temperature outputs reported by this tidbit, it appears that this was buried in the sediments during high flows over winter. These data are presented in the subsequent sections, but a note has been added that this tidbit was potentially buried under the sediments through the winter and the following spring and summer.

Field water quality measurements conducted during the summer low-flow surveys using a Hydrolab were compared to the nearest temperature tidbit. A cross-plot of the closest (in time) temperature recorded by the tidbits is shown compared to the corresponding paired Hydrolab data sonde temperature measurement in Figure 7. One data point (recorded at Pe Ell downstream) was flagged as an outlier and removed from the comparison because the tidbit was found buried in the sediments during the July 2014 download. Figure 7 shows that the two datasets are very close. The average RPD between the two datasets is 0.5%, with a range of 0 to 1.6%.

4.1.2 HYDROLAB MEASUREMENTS

The accuracy of DO, turbidity, and pH were assessed through pre-deployment calibration and post-deployment checks according to manufacturers' procedures presented in the user's manuals for each sampling event as described in Section 3.2. The RPDs for DO and pH met the accuracy target of 10% in the QAPP (Anchor QEA 2013), with the exception of the post-deployment check for pH after the boat survey in July 2014 (see Appendix E, Table E-1). The pH sensor reported an upward drift of 1.4 standard units (for both the 4 and 7 pH solutions). The cause for this could not be determined, but it appears to have originated during the survey at around river mile (RM) 71.5. The field measurements suspected to be affected were flagged and shown with a different symbol in the data presentations. Laboratory samples from HL-12 and HL-14 (see Figure 2) analyzed for pH will be compared to the field pH measurements to determine a correction factor, if appropriate (the lab data are not available at the time that this draft report was prepared). RPDs for turbidity and chlorophyll-a were often much larger than the target accuracy of 10%, primarily because they were both very low throughout the river, and small values resulted in inflated RPDs. Based on visual observations of field conditions, and evidence from other parameters (such as total suspended solids [TSS] and laboratory derived chlorophyll-a levels) the values reported were deemed acceptable to meet the objectives of this study.

Field parameter measurements were also checked in the field through measurements from a second mobile Hydrolab made alongside each in situ Hydrolab deployed for the diurnal measurements. These checks were conducted both at the time of placement and at the time of retrieval of the in situ Hydrolabs. The field data comparisons are presented in Appendix D. In general, for all three events, the RPD in temperature, DO, and pH between the two measurements were less than the precisions limit of ±20% targeted in the QAPP (Anchor QEA 2013). DO calibrations for the Hydrolab used during the September 2013 survey were affected due a mis-specification of the barometric pressure (which continued to use a previously set value). Once this error was discovered on the field unit, the barometric pressure was reset. The measurements affected by the mis-specification (diurnal DO and field measurements at locations upstream of Adna) were adjusted by a correction factor, which was determined from the correct barometric pressure and temperature. Chlorophyll-a and turbidity measurements were generally variable between the field and mobile units, and were often close to the instrument detection and precision limits in both (often reported 0 nephelometric turbidity units [NTU] and less than 1 microgram per liter [µg/L] for chlorophyll-a). Therefore, the RPDs calculated were larger than the targeted range. The low levels of turbidity and chlorophyll-a recorded by the in situ and field Hydrolabs were consistent with visual observation of field conditions and laboratory analysis of water quality samples collected during low-flow surveys. Therefore, the data quality was deemed to be an acceptable representation of local conditions.

Duplicate water quality measurement was obtained at Oakville by waiting several minutes between sample collections. Table 6 summarizes the RPD in water quality parameter measurements for each sampling event.

In addition to the field check described above, field quality control was performed by collecting field duplicate water samples. The field duplicate was analyzed for water quality parameters for each event, as specified in the QAPP (Anchor QEA 2013). The duplicate water sample was collected by filling a separate set of sample bottle containers at one location (Chehalis River at Oakville).

4.2 Laboratory Data

All data submitted in this report were validated as per U.S. Environmental Protection Agency (USEPA) guidelines, as described in the QAPP (Anchor QEA, 2013) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (USEPA 2004). Data validation reports are provided in Appendix H.

Data validation verified the accuracy and precision of chemical determinations performed during this investigation. Accuracy was acceptable as demonstrated by the laboratory control sample/laboratory control sample duplicate (LCS/LCSD), and matrix spike/matrix spike duplicate (MS/MSD) recovery values. Precision was also acceptable, as demonstrated by the laboratory duplicates, MS/MSD RPD values. Most data were acceptable as reported, and all other data are acceptable as qualified. Two results for chlorophyll-a were rejected.

Data qualifiers assigned as a result of the data validation and their definitions are shown in the data validation report. Data may have been qualified as biased or estimated for a particular analysis based on method or technical criteria. Data qualified with a “J” indicates that the associated numerical value is the approximate concentration of the analyte. Data qualified with a “UJ” indicates the approximate reporting limit below which the analyte was not detected. Consequently, these data qualifications are not expected to impact the data quality objectives, and all data were determined to be useable as reported from the laboratory or as qualified in the Data Report. The data completeness goals provided in the QAPP has been met.

5 Discussion of Results

5.1 Designated Uses for Chehalis River

The baseline conditions in the Chehalis River were evaluated in terms of the designated uses, particularly the aquatic life uses. Table 7 summarizes the designated uses for the Chehalis River and its tributaries. Table 7 also shows the applicable water quality criteria for temperature, DO, pH and turbidity. Supplemental spawning and rearing temperature criteria applies to different sections of the river. These have also been identified in Table 7. Other criteria that apply to the river are discussed in the state water quality legislation (Chapter 173-201A of the Washington Administrative Code).

5.2 Flow

The stream flows measured during the low-flow synoptic surveys are shown in Table 8. A spatial comparison of the mainstem and tributary stream flows, along with USGS data, where available, are shown in Figure 8. The Centralia Sewage Treatment Plant (STP) discharges to mainstem downstream of Skookumchuck River confluence at approximately RM 61.25. Average flows obtained from the discharge monitoring reports (DMRs) are also shown on Figure 8 as a reference. Flows reported for Chehalis River upstream of Newaukum River confluence (CHL-US-NWK) were obtained by subtracting flows recorded at the Newaukum River mouth from the flows recorded immediately downstream of the confluence. This approach was adopted because a wadeable reach was not found on mainstem section immediately upstream of the confluence. Flows were measured at another wadeable reach about 1.5 river miles upstream of the Newaukum River confluence (CHL-RT603) to check the flows estimated at CHL-US-NWK.

The long-term average flows reported at the USGS gage at Doty for the months of July, August, and September are 70, 46, and 80 cubic feet per second, respectively. It is evident from Table 8 that summer synoptic surveys were conducted under conditions consistent with the long-term average low-flow conditions during these months. Newaukum, Skookumchuck, and Black Rivers add the largest flows to the mainstem, but both South Fork Chehalis River and Elk Creek contribute significantly to the overall stream flow in the upper reaches. A simple flow routing calculation indicated that the mainstem:

- Did not gain appreciably between the USGS gage at Doty and upstream of South Fork confluence
- Lost flows from the confluence with South Fork through Adna
- Did not appreciably gain flows between Adna and RT603 bridge
- Gained flows between RT603 bridge and upstream of Newaukum River confluence

These observations are generally consistent with the groundwater study conducted by the USGS, with the exception of the upstream reach between Doty and South Fork, which was classified as a losing reach (Ely et al. 2008). Gaining and losing reaches were not evaluated past Newaukum River confluence because a flow station on the main stem was not available until the USGS gage at Grand Mound. However, a cumulative flow routing calculation showed that the flows calculated by summing the mainstem and tributary contributions from Doty through Grand Mound were generally consistent with the flows reported for the USGS gage at Grand Mound (see footnote under Table 8 and Figure 8).

5.3 Temperature

5.3.1 STREAM TEMPERATURE

5.3.1.1 TEMPORAL TRENDS

The 7-day average of the daily maximum temperature (7-DADMax) was calculated for all the tidbit locations (Figure 9). The applicable water quality criteria at each location are also shown. The number of days when applicable temperature criteria were exceeded is summarized in Table 9. In general, over the 1-year period (August 2013 to July 2014) that data were collected, all tidbits located in reaches designated as core summer salmonid habitat showed 7-DADmax exceedances for all of the 2013 period that the criteria apply, and for most of the 2014 summer period that the criteria apply. Furthermore, Figure 9 shows that the exceedances got progressively worse from Pe Ell[2] through the confluence with Newaukum River and the extent of thermal refugia available in the tributaries were likely limited (both Elk Creek and South Fork Chehalis River mouths showed exceedances similar to the mainstem). The supplemental spawning/incubation criterion which applies over fall through the next spring and early summer was exceeded in early fall and early summer.

In reaches and tributaries designated as salmon spawning, rearing and migration habitat, the criterion applies over fall through spring. Over most of this period, the 7-DADMax temperature remained below the applicable criterion. Some minor exceedances were noted in early fall and late spring, when the river water began to cool in fall 2013, and began to warm in spring 2014, respectively. In these reaches, the supplemental spawning/incubation criterion was exceeded for a few days either at the beginning or at the end of the period over which the criterion was applicable.

5.3.1.2 SPATIAL PATTERNS

The spatial patterns in temperature during the three low-flow synoptic surveys are shown on Figure 10. The temperatures plotted on this figure are instantaneous field measurement collected at the time of water quality sampling. Therefore, diurnal variations and time of measurement could result in the general trend being greater or lesser (see Section 5.4.1.1 and Figure 12) at any particular location. Nonetheless, the field measurements, along with the temporal trends in Figure 9, provided a basis for identifying problematic reaches. The figure shows that temperature progressively warms from upstream to downstream, but can be variable depending on local stream flow, inflows, and meteorological conditions. For example, the temperatures recorded downstream of the South Fork Chehalis River (between RM 90 and RM 80), were considerably warmer than temperatures recorded at Pe Ell and Elk Creek on July 30 compared to July 22.

---

[2] The downstream Pe Ell tidbit was found buried under sediments in July 2014 survey, which probably resulted in the slightly cooler temperatures relative to the upstream Pe Ell tidbit in 2014.

5.3.1.3 IMPACT OF TRIBUTARY INFLOWS

Table 10 shows a comparison of the thermal loads from the tributaries relative the corresponding upstream location on the mainstem, where paired flow and temperature measurements were made. A simple mixing calculation was applied to determine the temperature downstream of the confluence. It is clear from Table 9 that at the upper reaches, Elk Creek and South Fork were about the same temperature as the mainstem, and therefore had only a small impact on the downstream temperature even though their flows were generally a substantial portion of the mainstem flows. Skookumchuck River and Black River temperatures were generally substantially lower than the corresponding paired location on the mainstem (by 2 to 7°C; see also Figures 9 and 10). Based on these observations and the tidbit and field measurements, the greatest temperature problems appear to be limited to the upper reaches of the river. Inflows from Newaukum and Skookumchuck Rivers result in higher flows in the lower reaches, with generally deeper pools that are less affected by the diurnal heating and cooling cycles (see also Figure 12).

5.3.2 GROUNDWATER TEMPERATURE PATTERNS

The spatial patterns in groundwater temperature recorded during the three low-flow surveys are shown in Figure 11. The corresponding surface water temperature ranges recorded in the mainstem tidbits are also shown. For the July 2014 survey, the surface water temperatures were downloaded a few days before the groundwater survey. Therefore, the surface water data shown reflects the last date with a complete dataset. In September 2013 and July 2014, groundwater temperatures were significantly cooler than surface water (by up to 6°C), whereas in October 2013, the groundwater temperatures were slightly warmer. In summer, the groundwater temperature in the upper reaches (above Elk Creek at RM 104) and immediately downstream of the South Fork Chehalis River confluence (RM 87) were warmer than at other locations, but still cooler in summer and warmer in October than surface water at both locations. Most of these wells are located in reaches identified to be gaining in the USGS groundwater study (Ely et al. 2008). The findings from this study generally support the conclusion from the USGS study, as there is no strong evidence to suggest that any of these wells, with the exception of the one at Pe Ell (RM 104) during the September 2013 survey, is directly influenced by surface water. The USGS study did not provide an interpretation near Pe Ell at RM 104, but the data collected in this study suggests that this could be a losing reach. At each of two locations (near RM 98 and near RM 87), two wells were sampled, one at a shallower depth and one at a deeper depth (see description column on Table 3). The differences between the shallow and deeper wells were generally not appreciable (within 2°C).

5.4 Water Quality Parameters

5.4.1 FIELD PARAMETERS

5.4.1.1 DIURNAL TRENDS

Diurnal trends in temperature, DO, pH, turbidity, and chlorophyll-a recorded during the three low-flow surveys are shown in Figures 12 through 16, respectively. In general, diurnal variations in temperature, DO, and pH were greater at Pe Ell compared to the two locations in the Centralia Reach. In the August 2013 and July 2014 surveys, temperature consistently exceeded the 7-DADMax criterion at Pe Ell on both days when the Hydrolab data sondes were deployed (Figure 12). During all three surveys, DO levels showed modest swings at Pe Ell, with the highest levels during the day and the lowest levels from midnight through dawn, on all six days when data were collected (Figure 13). The daily minimum DO did not meet the aquatic life use criterion in both August 2013 and July 2014 surveys. Similarly, pH levels at Pe Ell (Figure 14) were the lowest at night (possibly due to addition of carbon dioxide from respiration), and highest during the day (carbon removal during photosynthesis). This suggests that photosynthesis and respiration cycles were moderately influencing the local DO and pH levels at Pe Ell. Considering that turbidity and chlorophyll-a levels were near zero[3] at Pe Ell during all three surveys (Figures 15 and 16), these data indicate that the diurnal variations are most likely a result of attached (bottom) algae rather than phytoplankton.

At the Centralia Reach locations (Route 6 and Mellen St. Bridge), modest swings in DO were observed particularly in August (Figure 13), with similar diurnal trends as those at Pe Ell. However, corresponding swings in pH were not observed at either location (Figure 14). Moderate levels of chlorophyll-a were recorded at Mellen Street Bridge in both August and July (Figure 16). The July 2014 chlorophyll-a levels were corroborated by field depth profiles (see Figures 21 and 38 [from RM 67 through 70]) and field observations from both months were confirmed by lab data (see Figure 26). Despite these moderately higher levels in chlorophyll-a, evidence of super saturation in DO from photosynthesis was absent (Figure 13; see also DO depth profile and boat survey discussions below).

5.4.1.2 DEPTH PROFILES

Depth profiling of temperature, DO, pH, turbidity, and chlorophyll-a was conducted at the two Centralia Reach locations where diurnal measurements were made (Figures 17 through 21). The temperature depth profiles indicate that the Mellen Street Bridge location is generally deeper, with some evidence of stratification during the August and September 2013 surveys (Figure 17). The effect of stratification on the DO levels is apparent in August at Mellen Street Bridge, where the DO levels started to decline from about 9 milligrams per liter (mg/L) at 5 feet to about 5 mg/L near the sediment-water interface (Figure 18). The decline in DO is probably a result of limited mixing due to stratification, and oxygen demand exerted by the sediments, which typically reaches a peak in summer due to warmer conditions in sediments. Even under well mixed conditions, in September the DO levels at Mellen Street Bridge were notably lower than at the Route 6 Bridge, probably due to the additional oxygen demand exerted by reduced species such as methane, hydrogen sulfide, and ammonia that accumulated below the thermocline over the stratified period. Similarly, in August, pH declined in the deeper portions at Mellen Street Bridge, potentially due to redox activity in the sediments (Figure 19). Turbidity levels were generally low at both locations, suggesting that the water column was relatively clear (Figure 20), and could support photosynthesis in shallow areas. This is supported by the relatively moderate photosynthetic activity recorded at Mellen Street (see Figures 21[4] and 26, and also see discussion above). However, the DO and pH levels were not significantly influenced by photosynthesis and respiration cycles, except in August at Mellen Street Bridge (see Figures 18 and 19).

5.4.1.3 SPATIAL PATTERNS

Spatial patterns in DO, pH, turbidity, TSS, and chlorophyll-a are shown in Figures 22 through 26, respectively. The figures show both field and laboratory[5] measurements. Because the hold times could not be met for laboratory analysis of DO and pH, the field measurements are generally considered to be more reliable.

---

[3] The spike in turbidity towards the end of the July 2014 survey is probably an artifact of sediments getting stirred up during retrieval.

[4] The chlorophyll-a sensor was not installed during the August 2013 deployment.

[5] For all three low-flow surveys, it was not practical to meet the 15-minute hold time requirement for DO and pH. See data validation report in Appendix H.

The upper reaches of the river generally exhibited higher DO levels, which declined progressively downstream of South Fork River confluence through the Centralia Reach and improved downstream of Lincoln Creek (Figure 22). The core summer salmonid criterion (in the upper reaches for August 2013 and July 2014) and the salmonid spawning, rearing, and migration criterion (downstream of South Fork Chehalis River confluence in fall) were generally satisfied at the time of measurement, although it is noted that the criteria applies for the daily minimum DO. In the Centralia Reach, with the exception of one field measurement near the mouth of Skookumchuck River, DO stayed above 5 mg/L (the special water quality criterion applicable for this reach during summer) at the time and location of measurement (see discussion on depth profiles and boat survey in Section 5.6, where data indicated that DO did go below 5 mg/L at deeper, stratified locations).

Field pH measurements were within applicable criteria during all three surveys (Figure 23). pH levels generally showed a slight decline in the Centralia Reach, but remained well above the applicable criteria. Turbidity levels (Figure 24) were low throughout the system and met the water quality criteria, with the exception of Lincoln Creek, where somewhat larger turbidity levels were measured (up to 12 NTU). The TSS levels reported for the lab samples were largely below the reporting limit (Figure 25) consistent with the low turbidity levels. The chlorophyll-a levels in the system were low overall and seldom exceeded 5 µg/L. However, as discussed in Section 5.4.1.1, the low turbidity conditions were likely conducive to growth of attached algae (which were not surveyed in this study), particularly in the upper reaches where water levels are shallow.

5.5 Nutrient and Biochemical Oxygen Demand Loads

5.5.1.1 SPATIAL PATTERNS

Nutrients and BOD levels in the system were sampled during all three low-flow surveys. The laboratory reporting limits for the August 2013 survey were higher (see Appendix H) and affected some of the interpretations presented in the following paragraphs.

Figure 27 shows the 5-day biochemical oxygen demand (BOD-5) in the system. BOD-5 levels were low throughout the system, with the exception of the September 2013 survey, when higher levels were observed downstream of Lincoln Creek. However, the higher levels did not appear to influence DO, which remained close to saturation in this section of the river (see Figure 22).

Ammonia, nitrite plus nitrate (NOx) and total Kjeldahl nitrogen (TKN) are shown in Figures 28, 29, and 30, respectively. In the August 2013 survey, most values were below the reporting limit, but it is noted that the reporting limit was high. Samples from the July 2014 survey that were analyzed at a different lab, which was certified for a much lower reporting limit (see Table 5), showed that ammonia, NOx, and TKN levels were even lower. In the section below Lincoln Creek, significantly higher levels of NOx were recorded during all three surveys. Black River also contributed substantially higher levels of NOx to this reach.

Most of the orthophosphate, total dissolved phosphorus (TDP), and total phosphorus (TP) samples collected in the August and September 2013 surveys were also below the detection limits, but as with nitrogen, the reporting limits for the lab were too high (see Figures 31, 32, and 33, respectively). Subsequently, TP samples collected in September 2014 were reanalyzed, and most of the values were significantly lower (the largest value, with the exception of Lincoln Creek, was 48 µg/L). In July 2014 the range of orthophosphate, and TP were comparable to the previous surveys. The laboratory analyzed the July 2014 orthophosphate samples past the 48-hour hold time (even though all samples were delivered on time). Subsequently, on July 30, at a subset of locations on the mainstem, additional samples were collected and analyzed for orthophosphate. These have been identified with the date printed in Figure 31. There were no appreciable differences in the spatial patterns, and the values collected on the later date were similar to those observed in the earlier samples. Lincoln Creek generally exhibited substantially high phosphorus levels (both inorganic and total) during all three surveys. Considering that flows from Lincoln Creek are more than two orders of magnitude lower than the mainstem flows (see Table 8), the higher levels in TP are unlikely to have a significant effect on the mainstem water quality.

The nutrient levels in the mainstem are interpreted for the propensity to stimulate algal growth in Section 5.8.2.

5.5.1.2 IMPACT OF TRIBUTARY INFLOWS

Table 11 provides a comparison of the nutrient loads brought in by the major tributaries and the corresponding mainstem nutrient loads above the mouth of the tributary. Similar comparisons for BOD-5 and TSS loads are shown in Table 12. In addition, Table 12 also includes the BOD-5 and TSS loads in the STP effluent based on DMRs submitted to Ecology.

Nutrient, BOD, and TSS loads in the Chehalis River and its tributaries were generally higher in September particularly in the downstream sections below Skookumchuck River confluence. September flows were higher (see Table 8) which probably is a consequence of precipitation events in the week prior to the survey (almost 2 inches of rain was reported in the first two weeks of September). The average travel time in the river is thought to be 2 weeks (see review comments in Appendix A), which could explain the relatively higher flows in the lower reaches on the date of the survey which was conducted approximately 1 week after the precipitation event.

In the upper watershed, tributary nutrient loads were variable between the September 2013 and July 2014 surveys, and varied from approximately 25 to 100% of the loads carried by the mainstem upstream of the Newaukum River confluence. The net nitrogen loads (TKN + NOx) on the mainstem downstream of the Black River were 907 and 639 kilograms per day (kg/d) in September and July, respectively, whereas the cumulative (major) tributary contributions were 462 and 456 kg/d, respectively. This suggests that the mainstem gained approximately 49% of the nitrogen loads from other sources (point sources, groundwater inflows, direct runoff, etc.) in September, whereas the gain was only 29% in July. However, the corresponding gains in TP were 44 and 48%, respectively. This is probably due to the differences in the point sources and the in-stream processes that affect the fate and transport of nitrogen and phosphorus. The Centralia STP discharges into the Chehalis River downstream of Skookumchuck River confluence at approximately RM 61.25. The DMRs indicated that the average ammonia loads were 1.03, 0.29, and 0.61 kg/d in August 2013, September 2013, and July 2014 respectively, which represents a small fraction of the ammonia loads in the river. However, it is possible that during aeration ammonia oxidation is likely and nitrate loads in the effluent, which were not reported in the DMR, could be higher.

It is evident that tributaries contribute substantial amounts of TKN or NOx but not ammonia. A significant proportion of the TKN loads brought in by the tributaries undergo hydrolysis to ammonia on the mainstem, and can either be taken up biologically or undergo oxidation to nitrate. The latter appears to be a more dominant process, considering that the mainstem carried more NOx than TKN on a cumulative basis downstream of Black River. Moreover, in the reach between Lincoln Creek and Black River, substantial gains of all nutrients were observed. This is likely a result of increased groundwater inflow or inflows brought in by Scatter Creek (which was not surveyed in this Study). Historically, high nitrate concentrations have been observed in domestic wells developed in the Scatter Creek aquifer due to former dairy farm operations (Romero and Zulewski, 2010). In summary, while tributary sources of nutrients were significant, the simple mass balance calculation discussed herein suggests that other point and non-point sources could also be significant.

5.5.1.3 WINTER NUTRIENT AND BOD LOADS

In January 2014, water quality samples were collected from Pe Ell upstream station to determine the nutrient, solids, and BOD loads to the system over winter. The water quality data are summarized in Table 13. These data will provide a basis for developing the boundary conditions for the reservoir model in subsequent phases of this project.

5.6 Centralia Reach

5.6.1 FIELD PARAMETER DEPTH PROFILES

Depth profiles of temperature, DO, pH, turbidity, and chlorophyll-a recorded during the Centralia Reach boat survey are shown in Figures 34 through 38, respectively. The sampling locations are shown on Figure 2. Thermal stratification was primarily observed between RM 67 to RM 70. Upstream of RM 70 (Figure 34), even though there were deeper reaches (for example, RM 72.5), thermal stratification was not observed, either because local conditions do not promote stratification or because stratification has not set in yet this summer. At the deepest reach (RM 69.25) where the strongest stratification was present, the surface and bottom temperatures differed by about 7 °C.

The DO depth profiles followed the temperature patterns (Figure 35). In the upstream areas where thermal stratification was not present, DO levels were substantially higher, at about 8 mg/L. In the downstream reaches, the DO levels below the thermocline were often below 5 mg/L, which is the water quality criterion that applies to the Centralia Reach in the summer. At the sediment-water interface of the deepest sampling location (RM 69.25), near anoxic conditions existed. Furthermore, the downstream reaches above the thermocline did not exhibit any evidence of super saturation in DO from photosynthetic activity, even though somewhat elevated chlorophyll-a levels were observed in the top 10 feet of this section (see Figure 38). DO levels were largely in the vicinity of 9 mg/L. Strong algal activity would typically show levels well above 10 mg/L.

pH levels in upstream reaches and in the upper portion of the stratified downstream reaches were generally above 6.5 and below 8.5, the range for aquatic use criteria applicable to this reach (Figure 36). In the deepest portions of the downstream stretches, pH was at or below 6.5 at some reaches, probably due to elevated sediment redox activity.

At nearly all locations, turbidity levels were low near the surface, and showed modest increases with depth (Figure 37). At all locations, the turbidity criterion of 5 NTU was not exceeded. This suggests that light is unlikely to be a limiting factor, particularly in the top several feet. This is evident in the chlorophyll-a depth profiles (Figure 38), which were moderately higher above the thermocline in stratified reaches. The absence of chlorophyll-a in the upstream reaches likely indicates faster currents, which does not provide conditions conducive for phytoplankton growth (or thermal stratification).

5.6.2 NUTRIENT AND BOD LEVELS

The surface and bottom concentrations of nutrient and BOD are presented in Figures 39 through 46. Water quality samples were obtained at the four locations shown. The corresponding temperature depth profiles at these locations are also plotted for reference. The figures show that in the locations where thermal stratification was present (HL-05 and HL-01), there was evidence of greater oxygen demand (Figure 39), and nutrient accumulation (Figures 40 through 45). BOD-5, ammonia, and phosphorus accumulation were not notable at HL-01 even though there was evidence of stratification (Figures 39, 40, and 43 through 45). However, there was significant accumulation of NOx below the thermocline at this location (Figure 41). Upon comparing these to the DO levels shown on Figure 35, it is evident that there was enough oxygen at HL-05 to support BOD as well as nitrification. The lack of phosphorus accumulation is also consistent with this result because orthophosphate release from sediments typically occurs under anoxic conditions. Figure 35 indicates that bottom waters are completely anoxic at HL-05, but not at HL-01 through HL-04 where conditions are hypoxic, but yet to become anoxic. As dry conditions has persisted through the summer it is likely that these locations became fully anoxic, and likely released phosphorus from the sediments as at HL-05.

5.7 Meteorological Data Summary

Meteorological data collected on the mainstem near Thrash Creek are summarized in Figure 47. These data are available in real-time from the Chehalis River Basin Flood Authority's early warning website (see Section 3.6). The meteorological data will be used to develop boundary conditions for the reservoir model in subsequent phases of this project.

5.8 Discussion of Overall Water Quality

5.8.1 BASELINE CONDITIONS SUMMARY

The data collected during this study provided a basis for defining the baseline conditions in the Chehalis River. Baseline conditions refer to existing conditions in the river, prior to any activities, including construction of a dam that may occur as a result of the Chehalis Basin Strategy. In the Upper Chehalis River above Newaukum River confluence temperature is a major concern, particularly in summer. During both summers, when applicable in the upper reaches, the core summer salmonid habitat criterion was exceeded. While the river gets warmer in summer in the downstream reaches, the salmonid spawning, rearing, and migration criterion that applies to these reaches does not apply in summer. Considering that the tributaries in the upper reaches also exceeded the applicable core summer salmonid habitat criterion, the extent to which thermal refuge is available in the upper watershed in summer may be limited to the uppermost reaches. The water quality study did not attempt to investigate the causes for these exceedances in the upper reaches. However, some potential causes are discussed herein. Solar heating is the predominant factor controlling water temperature. The extent to which solar radiation reaches the water is controlled by the riparian cover, topography and channel geomorphology.

Ecology currently has a temperature Total Maximum Daily Load (TMDL) in place for the Upper Chehalis River and its tributaries (Ecology 2001), and the reaches discussed above are listed in the State's 2012 303(d) list. The temperature TMDL study estimated that the reach of Chehalis River from Elk Creek to Newaukum River required a 30% improvement in riparian cover from the existing 18% (Ecology 2001). As part of the water quality studies, riparian shading evaluation was completed using LiDAR data and field validation with hemi-view photography (Stillwater Sciences 2014). This study concluded that the average vegetative shading density ranged from 20% in areas classified as riparian forests to 50% in developed areas. This was a rather surprising finding because it was anticipated that riparian forests, which comprise much of the land use type in the upper watershed, would actually provide more shading cover. Nonetheless, the findings from this study are consistent with Ecology's TMDL allocation study, which called for significant increases in vegetative shading. In summary, the baseline conditions indicate that temperature in the Chehalis River is high, particularly in areas classified as core summer salmonid habitat, probably due to a lack of adequate vegetative shading, and could affect the habitat available for salmonids and other aquatic species.

DO levels in the Chehalis River and at the mouths of its tributaries were generally high. In the upper reaches, diurnal data suggested that DO could be lower than the criterion (but generally above 8 mg/L) and is apparently influenced by temperature and algal photosynthesis and respiration. In the Centralia Reach, thermal stratification results in near anoxic conditions in the bottom waters, particularly from RM 68 to RM 70. Levels of pH and turbidity met the aquatic life use criteria throughout the river on all three low-flow synoptic surveys.

5.8.2 NUTRIENT LIMITATION EVALUATION

Nutrient loading to the system primarily affects DO and pH by triggering algal growth, and in the case of ammonia, also directly exerting an oxygen demand during bacterially mediated nitrification. As discussed in the previous sections, chlorophyll-a levels were generally low throughout the river, suggesting that phytoplankton production is limited. The nutrient data collected throughout were generally low, with the exception of higher NOx levels downstream of Lincoln Creek confluence. Considering that turbidity levels are low throughout the river, even if conditions (currents) are not conducive for phytoplankton growth, it is possible that nutrient addition could trigger growth of attached algae, particularly in the upper reaches where water depth is shallow. In the upper river, diurnal patterns in DO and pH data showed evidence of attached algae activity, resulting in excursion of DO criterion.

In order to better evaluate whether sufficient nutrients are available in the system to trigger (attached or floating) algal production, should conditions change in the future under with reservoir condition, a nutrient limitation calculation was undertaken. In order to calculate nutrient limitation factors, a Monod equation[6] was used with half-saturation constants of 10 and 3 µg/L for nitrogen and phosphorus respectively (per the range provided in Chapra [1997]). A nutrient limitation factor of 1 indicates no nutrient limitation, and a limitation factor of 0 indicates severe nutrient limitation. The ratio of total nitrogen (TN) to TP is another way of assessing which of the two nutrients is more limiting. A value greater than seven[7] would typically indicate phosphorus limitation, and value less than seven would indicate nitrogen limitation.

Figure 48 shows the spatial distributions of nitrogen and phosphorus nutrient limitation factors (top two panels) and the ratio of TN to TP (bottom panel), all calculated using data collected during the July 2014 low-flow

---

[6] Nutrient limitation factor = $\frac{C}{C+K_s}$, where C is the concentration of the nutrient, and K_s is the half-saturation constant.

[7] Based on a typical C:N:P stoichiometry of 40:7:1 for an algal cell.

survey. The July data was used because the laboratory used for analysis was certified for lower reporting limits. The figure shows that the Chehalis River is generally moderately phosphorus limited, with relatively abundant nitrogen throughout the system. The assessment of environmental impacts of the reservoir, which would be constructed if the multi-purpose dam alternative is selected, should reconcile these baseline conditions in terms of developing an operational strategy. For instance, under the multi-purpose dam alternative, if the reservoir is operated to mitigate low-flow conditions in summer, then flow releases that target cooler waters in the lower portion of the reservoir should consider the nutrient pool present from sediment exchanges in terms of triggering algal production.

6 Conclusions

The water quality studies completed as part of the Project has addressed several data gaps identified in previous studies. The flow and water quality data collected during this study can be used to develop detailed water quality models of the reservoir and the Chehalis River downstream of the reservoir if the multi-purpose alternative is selected. The riparian shading assessment conducted during this phase provides information on developing inputs relating to vegetative shading that was previously not available. Furthermore, meteorological sensors installed in the upper river provide important weather-related inputs for the reservoir model that were previously based on meteorological stations farther away.

The data collected in this study also enabled an assessment of the baseline conditions in the Chehalis River. This will provide a basis for comparing the project-related impacts in subsequent phases. The baseline conditions indicated that temperature and DO are problematic in the upper reaches, and that moderate algal activity could be affecting diurnal patterns in DO and pH. If this project moves to subsequent phases, then reservoir operational scenarios that have been developed should reconcile these conditions.

If the project is funded for subsequent phases, then additional water quality evaluations through mechanistic modeling would be needed. The existing dataset provides a basis for calibrating and validating the previously (or newly) developed water quality models of the reservoir and the Chehalis River downstream of the reservoir. To improve the robustness of the dataset (considering that these data were collected over only two summers) continued water quality monitoring of the Chehalis River is recommended. Furthermore, it is recommended that other facets of the study, such as remote infra-red flight surveys, be integrated with the water quality data collection such that system wide data sets are consistent and robust. Modeling should consider the effect of climate change, how it can potentially affect both reservoir operations and downstream water quality, and its effects on enhancing or degrading aquatic species habitat.

7 References

Anchor QEA, 2012. Water Quality Evaluations, Appendix C of Chehalis River Flood Storage Dam Fish Population Impact Study. April, 2012.

Anchor QEA, 2013. Final Quality Assurance Project Plan, Chehalis Basin Flood Hazard Mitigation Alternatives Analysis Project. October, 2013.

Chapra, S.C., 1997. Surface Water Quality Modeling. McGraw-Hill, New York.

Ecology (Washington State Department of Ecology), 1994. Upper Chehalis River Dry Season Total Maximum Daily Load Study, Ecology Publication No. 94-126. July, 1994.

Ecology, 2001. Upper Chehalis River Basin Temperature Total Maximum Daily Load, Ecology Publication No. 99-52. Revised July 2001.

Ecology, 2003. Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section. Environmental assessment Program. Olympia, Washington, Publication No. 03-03-052. December, 2003

Ely, D.M., Frasl, K.E., Marshall, C.A., and Reed, F., 2008. Seepage investigation for selected river reaches in the Chehalis River basin, Washington: U.S. Geological Survey Scientific Investigations Report 2008-5180, 12 p.

Fasser, E.T., and Julich, R.H., 2010. Groundwater levels for selected wells in the Chehalis River basin, Washington: U.S. Geological Survey Data Series 512.

Romero, N., and Zulewski, B., 2010. Scatter Creek Groundwater Well Model: Grand Mound Municipal Well Field, Thurston County, Final Provisional Report. December 29, 2010.

Stillwater Sciences, 2014. Riparian Shade Parameters, Chehalis River, Technical memorandum from Amy Merrill (Stillwater Sciences) to Pradeep Mugunthan (Anchor QEA, LLC). July 31, 2014.

Turnipseed, D.P., and Sauer, V.B., 2010. Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods, book 3, chap. A8, 87 p. Available from http://pubs.usgs.gov/tm/tm3-a8/

USEPA (U.S. Environmental Protection Agency), 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation (OSRTI). EPA 540-R-04-004. October, 2004.

Tables

Table 1
Flow, Water Quality, and Temperature Measurement Stations

STATION ID[1]	DESCRIPTION	FLOW	WATER QUALITY	HYDROLAB SONDES	TEMPERATURE TIDBIT
CHL-PEL-US	Chehalis River Upstream of Pe Ell		X		X[3]
CHL-PEL-DS	Chehalis River Downstream of Pe Ell near the Pe Ell WWTP			X	X
ELK-CRK	Elk Creek at Elk Creek Road Bridge	X[2]	X		X
CHL-US-SF	Chehalis River Upstream of South Fork River Confluence	X	X		
SF-CHL-MOUTH	South Fork Chehalis River at Boistfort Road Bridge	X	X		X[3]
CHL-ADNA	Chehalis River near Adna	X	X		X[3]
CHL-RT603	Chehalis River at Route 603 Bridge[5]	X			
CHL-US-NWK	Chehalis River Upstream of Newaukum River Confluence	X	X		X
NWK-MOUTH	Newaukum River at Shorey Road Bridge	X	X		X
CHL-RT6-BR	Chehalis River at Route 6 Bridge		X	X	
CHL-US-SKM	Chehalis River at Mellen Road Bridge		X	X	
SKM-MOUTH	Skookumchuck River at Harrison Avenue Bridge	X	X		X[4]
CHL-GLV	Chehalis River at Galvin Road Bridge		X		X
LNC-CRK	Lincoln Creek at Lincoln Creek Road Bridge	X[2]	X		
CHL-US-BLK	Chehalis River at Independence Road Bridge near Rochester		X		X
BLK-RT12	Black River at Route 12 Bridge	X	X		X[4]
CHL-OAK	Chehalis River near Oakville		X		X

Notes:

"X" indicates the corresponding parameter was measured at that location

WWTP = Wastewater Treatment Plant

1 GPS coordinates for the flow, water quality and temperature tidbit locations are included with the water quality database (to be provided to Ecology at completion of project)

2 Flow measurements completed by Anchor QEA; At the other locations flow measurements were completed by WEST Consultants

3 At these locations a tidbit was installed adjacent to the river to record air temperature for quality control

4 Temperature tidbits were added in September 2013 at these locations.

5 This location was added as a backup for checking flow estimates at CHL-US-NWK

Table 2
Water Quality and Depth Profiling Stations During Boat Survey

STATION ID	NORTHING	EASTING	RIVER MILE	DEPTH PROFILING	WATER QUALITY SAMPLES
HL-01	513594.71	1019112.567	RM 67.25	X	X
HL-02	511274.47	1019311.153	RM 67.75	X	X
HL-03	508754.32	1018467.913	RM 68.25	X	
HL-04	507299.35	1019266.001	RM 68.75	X	
HL-05	505614.62	1019374.535	RM 69.25	X	
HL-06	505077.33	1017481.63	RM 70.0	X	
HL-07	504739.18	1017541.013	RM 70.5	X	
HL-08	504095.35	1015052.498	RM 71.0	X	
HL-09	501684.75	1014110.108	RM 71.5	X	
HL-10	499896.6	1014235.457	RM 72.25	X	
HL-11	498660.21	1015193.66	RM 72.5	X	
HL-12	496604.05	1014419.932	RM 73.0	X	X
HL-13	495869.25	1015612.966	RM 73.75	X	
HL-14	493931.73	1016773.19	RM 74.5	X	X

Notes:

“X” indicates the corresponding parameter was measured at that location

RM = river mile

Table 3
Locations of Groundwater Wells

STATION ID	NORTHING	EASTING	COMPLETED WELL DEPTH (ft bgs)	ECOLOGY WELL LOG NUMBER	DESCRIPTION
13N/05W-26D01	470212.8	941320	143	256805	Pe Ell, Al Johnston
13N/05W-26E02	469662.7	941398.5	20	528167	Pe Ell, Tim Speck
13N/05W-02L01	489227.3	943652.3	160	20338	Doty, Tom Toepelt
13N/05W-12C01*	486489	948611	NR	NR	Dryad, Brenda Boardman, 50 feet
13N/05W-12C01*	486489	948611	143	375988	Dryad, Brenda Boardman
13N/03W-18R01*	475453.1	987672.8	NR	NR	Curtis Hill, Don Rippee, 60 feet
13N/03W-18R01*	475453.1	987672.8	220	500152	Curtis Hill, Don Rippee
13N/03W-20E01	472379.7	988668.4	360	439348	Curtis Hill, Jose Ramirez
13N/03W-11C02	484304.2	1005670.1	63	552359	Adna, Edward Kasproswski

Notes:
ft bgs = feet below ground surface
NR = Not Recorded
None = Screen interval listed as no

Table 4
Accuracy and Range for Meteorological Sensors

SENSOR	RANGE	ACCURACY	RECALIBRATION PERIOD
Wind Speed (H-375)	0-100 m/s (224 mph)	+/- 0.6 mph	12 months
Wind Direction (H-375)	360° mechanical, 355° electrical	+/- 3°	12 months
Air Temperature (H-380)	-40° to 60°C	+/-0.1°C / 0.5° standard calibration	Field checks[2]
Relative Humidity (H-380)	0-100 % RH	+/- 0.8% RH at 23°C	Field checks[2]
Solar Radiation (H-3791)	0 to 1000 W/m²	± 3%	Every 2 years
Barometric Pressure (H-378)	600-1100 mB	± 1.0 mB	1.5 to 2 years[1]

Notes:

1 Recalibration should be performed by the manufacturer

2 These sensors come factory calibrated, and are checked against a NIST calibrated device. Any deviations in calibration will require replacement of the sensors.

mB - millibars

m/s = meters per second

mph - miles per hour

NIST = National Institute of Standards and Technology

RH = relative humidity

W/m^2 = Watts per square meter

Table 5
Analytical Methods and Reporting Limits

Parameter	Method	Reporting Limit	Laboratory
Total suspended solids (TSS)	SM2540D	2.5 (mg/L)	DAL
		1.1(mg/L)	ARI
Biochemical oxygen demand (BOD-5)	SM 5210B	2.0 (mg/L)	DAL
		1.0 (mg/L)	ARI
Total Kjeldahl nitrogen (TKN)	SM 4500N$_{org}$ B	2.0 (mg/L)	DAL
	SM 4500N$_{org}$ C	0.10 (mg/L)	IEH – Aquatic Research
	EPA 351.2	0.10 (mg/L)	Edge Analytical
Ammonia	SM 4500NH$_3$ D	0.40 (mg/L)	DAL
	EPA 350.1	0.010 (mg/L)	ARI
Nitrite/Nitrate	EPA 300.0	0.20 (mg/L)	DAL
	EPA 353.2	0.010 (mg/L)	ARI
Total phosphorus (TP)	SM 4500P E	0.100 (mg/L)	DAL
		0.008 (mg/L)	ARI
Dissolved phosphorous (DP)	SM 4500P E	0.200 (mg/L)	DAL
		0.008 (mg/L)	ARI
Orthophosphate (OP)	SM 4500P E	0.20 (mg/L)	DAL
		0.004 (mg/L)	ARI
Chlorophyll-a	SM 10200 H	--	DAL
		0.3 mg/m^3	AMTEST LABORATORIES
Dissolved oxygen (DO)	SM 4500-OG	0.01	DAL
	SM 4500-OC	0.1	ARI
pH	SM 4500 H$^+$	--	DAL
		0.01 SU	ARI

Notes:

ARI = Analytical Resources, Inc. (Used for September 2013 and July 2014 surveys)

DAL = Dragon Analytical Laboratory (Used for August 2013 and some water quality parameters from September 2013 surveys)

EA = Edge Analytical

EPA = Environmental Protection Agency

mg/L = milligrams per liter

mg/m^3 = milligram per cubic meter

SM = Standard Methods

SU = Standard units

Table 6
Field Parameter Relative Percent Differences Calculated for Field Duplicates During Water Quality Surveys

LOCATION	DATE	TIME	TEMPERATURE (°C)	DO (mg/L)	pH	TURBIDITY (NTU)	CHLOROPHYLL-A (µg/L)
CHL-OAK	8/6/2013	1745	22.7	9.6	7.8	0.9	0.5
CHL-OAK	8/6/2013	1750	22.7	9.6	7.8	1.1	0.5
RPD			0.0	0.2	0.4	20	7.7
CHL-OAK	9/17/2013	1550	18.8	9.7	7.6	2.3	1.2
CHL-OAK	9/17/2013	1555	18.8	9.7	7.6	2.5	1.2
RPD			0.1	0.1	0	8.3	3.4
CHL-OAK	7/22/2014	1907	20.4	9.4	7.6	0.3	2.2
CHL-OAK	7/22/2014	1920	20.4	9.4	7.6	1.2	1.8
RPD			0.1	0.1	0	8.3	3.4

Notes:

°C = degrees Centigrade

µg/L = micrograms per liter

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Unit

RPD = relative percent difference

Table 7
Summary of Designated Uses in the Chehalis River and in the Reaches Covering the Mouths of Major Tributaries

STREAM	DESIGNATED AQUATIC LIFE USES[1]	APPLICABLE WATER CRITERIA FOR SELECT PARAMETERS			
		7-DAY AVERAGE OF THE DAILY MAXIMUM TEMPERATURE (°C)	DISSOLVED OXYGEN (mg/L)	pH[3]	TURBIDITY (NTU)
Chehalis River: Upstream of RM 90.2	CSSH; SSIC	16; 13	9.5	6.5 to 8.5	5
Chehalis River: Downstream of RM 90.2[2]	SRM; SSIC	17.5; 13	8	6.5 to 8.5	5
Elk Creek	CSSH; SSIC	16; 13	9.5	6.5 to 8.5	5
South Fork Chehalis River: mouth to 0.4 mile upstream	SRM; SSIC	17.5; 13	8	6.5 to 8.5	5
Newaukum River	CSSH; SSIC	16; 13	9.5	6.5 to 8.5	5
Skookumchuck River: mouth to Hanaford Creek	CSSH; SSIC	16; 13	9.5	6.5 to 8.5	5
Lincoln Creek	SRM; SSIC	17.5; 13	8	6.5 to 8.5	5
Black River	SRM	17.5	8	6.5 to 8.5	5

Notes:

1 Recreational use designations are extraordinary primary contact (typically upper reaches of the watershed) or primary contact (lower reaches). The mainstem Chehalis River and all major tributaries are also designated for domestic, industrial, agricultural and stock water supply, and other miscellaneous uses reported in Table 602 of the Washington State Water Quality Standards

2 From RM 65.8 to RM 75.2, dissolved oxygen shall exceed 5.0 mg/L from June 1 to September 15
3 pH criteria apply year round
°C = degrees Centigrade
CSSH = Core Summer Salmonid Habitat
mg/L = milligrams per liter
NTU = Nephelometric Turbidity Units
RM - River Mile
RMO = Rearing and Migration Only
SRM = Spawning Rearing and Migration
SSIC = Supplemental Spawning/Incubation Criterion (for temperature only)

Table 8
Flows Measured During the Summer Low-Flow Synoptic Surveys

STATION ID	FLOW (cfs)		
	AUGUST 2013	SEPTEMBER 2013	JULY 2014
USGS Gage at Doty	45.0	56.0	49.0
ELK-CRK[1]	21.5	24.8	17.5
CHL-US-SF	68.0	82.8	72.4
SF-CHL-MOUTH	21.4	32.9	25.0
CHL-ADNA	94.7	122.0	107.0
CHL-RT603[2]	94.5	132.0	115.0
CHL-US-NWK[2]	102.5	N/A	115.0
LNC-CRK	0.4	0.7	0.3
NWK-MOUTH	53.5	121.0	63.8
SKM-MOUTH	78.8	111.0	130.0
USGS Gage at Grand Mound[3]	255.5	365.5	300
BLK-RT12	70.8	78.0	82.2

Notes:

1 July survey was conducted on July 30, 2014, whereas water quality sampling was conducted on July 22, 2014. Based on daily flows recorded at the USGS gage at Doty (48 cfs and 50 cfs on July, 22nd and July, 30th respectively), the magnitude of flows on these two dates at Elk Creek should be comparable.

2. Measurements in August and July were made downstream of confluence with Newaukum and the Newaukum River flows were subtracted out to estimate U/S, as there were no wadeable sections immediately upstream of the confluence. As a check flows were measured at a wadeable section 1.5 miles upstream of the confluence at Route 603 bridge for all three surveys. No wadeable section was found downstream of confluence in September.

3. The cumulative flows obtained by summing the flows measured during this study and the flow reported at the Doty Gage are 235, 365 and 309 cfs respectively, which is comparable to the USGS gage flows reported at Grand Mound.

cfs = cubic feet per second

U/S/ = upstream

USGS = U.S. Geological Survey

Table 9
Number of Days When 7-DADMax Temperature Exceeds Applicable Water Quality Criteria

STATION ID	RIVER MILE	NUMBER OF DAYS (8/1/2013 to 7/29/2014)			APPLICABLE CRITERIA
		WHEN CRITERIA APPLIES	DATA AVAILABLE OVER CRITERIA PERIOD[4]	TEMPERATURE > CRITERIA	
CHL-PEL-US_TB	107	91; 290	80; 283	79; 62	Core summer salmonid habitat[1]; Supplemental spawning[3]
CHL-PEL-DS	105.5	91; 290	86; 290	65; 41	Core summer salmonid habitat[1]; Supplemental spawning[3]
ELK-CRK	100.2	91; 290	80; 290	70; 58	Core summer salmonid habitat[1]; Supplemental spawning[3]
SF-CHL-MOUTH_TB	88	91; 290	78; 290	78; 66	Core summer salmonid habitat[1]; Supplemental spawning[3]
CHL-ADNA	81	272; 227	272; 227	18; 2	Salmonid spawning, rearing, and migration[2]; Supplemental spawning[3]
CHL-US-NWK	75.4	272; 227	272; 227	18; 2	Salmonid spawning, rearing, and migration[2]; Supplemental spawning[3]
NWK-MOUTH_TB	75.2	91; 290	37; 281	37; 59	Core summer salmonid habitat[1]; Supplemental spawning[3]
SKM-MOUTH	66.8	91; 290	5; 31	5; 19	Core summer salmonid habitat[1]; Supplemental spawning[3]
CHL-GLV_TB	64.1	272; 227	272; 227	17; 2	Salmonid spawning, rearing, and migration[2]; Supplemental spawning[3]
CHL-US-BLK	54.2	272; 227	272; 227	19; 10	Salmonid spawning, rearing, and migration[2]; Supplemental spawning[3]
BLK-RT12	47	272; 227	262; 217	6; 19	Salmonid spawning, rearing, and migration[2]; Supplemental spawning[3]
CHL-OAK	42.3	272; 227	262; 217	18; 12	Salmonid spawning, rearing, and migration[2]; Supplemental spawning[3]

Notes:

1 Core summer salmonid habitat = 7-DADMax temperature shall not exceed 16 degree Celsius from June 15th to September 15th. If listed, supplemental spawning/incubation criterion applies from September 15th to July 1st.

2 Salmonid spawning, rearing, and migration = 7-DADMax temperature shall not exceed 17.5 degree Celsius from September 16th to June 14th. If listed, supplemental spawning/incubation criterion applies from October 1st to May 15th.

3 Supplemental spawning/incubation criterion = 7-DADMax temperature shall not exceed 13 degrees Celsius.

4 Count includes only days for which it is possible to calculate the 7-DADMax (i.e. days with six preceding days with data available).

7-DADMax = 7-day average of daily maximum temperature

Table 10
Comparison of Thermal Loads Carried by Mainstem Chehalis River Relative to the Nearest Tributary

LOCATION	SURVEY	TEMPERATURE (°C)		THERMAL LOADS (MJ/sec)		TEMPERATURE D/S OF CONFLUENCE (°C)
		MAINSTEM	TRIBUTARY	MAINSTEM	TRIBUTARY	
Chehalis River and Elk Creek	2013 August	16.9	15.8	1.53	0.74	16.6
	2013 September	14.8	14.7	1.84	0.85	14.8
	2014 July	19.8	18.8	1.71	0.60	19.5
Chehalis River and South Fork Chehalis River	2013 August	19.5	20.1	2.36	0.74	19.6
	2013 September	16.7	16.7	2.84	1.13	16.7
	2014 July	18.3	18.4	2.50	0.86	18.3
Chehalis River and Newaukum River	2013 August	22.0	21.4	3.58	1.87	21.8
	2013 September[4]	18.0	17.1	4.55	4.16	17.5
	2014 July	20.2	19.3	3.99	2.21	19.9
Chehalis River and Skookumchuck River[1]	2013 August	23.2	19.0	6.18	2.72	21.9
	2013 September	19.6	16.3	8.80	3.80	18.6
	2014 July	22.3	15.3	5.94	4.44	19.3
Chehalis River and Lincoln Creek[2]	2013 August	21.8	20.5	8.91	0.01	21.8
	2013 September	18.7	17.7	12.60	0.02	18.7
	2014 July	19.8	17.9	10.40	0.01	19.8
Chehalis River and Black River[3]	2013 August	22.7	19.5	9.57	2.45	22.0
	2013 September	19.1	17.3	13.52	2.68	18.8
	2014 July	21.0	18.7	11.18	2.84	20.5

Notes:

1 Flow U/S of Skookumchuck River (RM 66.8) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) - Flow at Skookumchuck River Mouth - Flow at Lincoln Creek

2 Flow U/S of Lincoln Creek (RM 61.9) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) - Flow at Lincoln Creek

3 Flow U/S of Black River (RM 47) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) / Drainage area at Grand Mound * Drainage Area at USGS station at Chehalis near Rochester (RM 54.2, #12028060)

4 Used CHL-RT603 flows for Chehalis River

°C = degrees Centigrade

D/S = downstream

MJ/sec = megajoules per second

RM = river mile

U/S = upstream

USGS = U.S. Geologic Survey

Table 11

Comparison of Nutrient Loads Carried by Mainstem Chehalis River Relative to the Nearest Tributary

		AMMONIA (kg/d)		NO2 + NO3 (kg/d)		TKN (kg/d)		ORTHOPHOSPHATE[5] (kg/d)		TP (kg/d)	
LOCATION	SURVEY	MAINSTEM	TRIBUTARY	MAINSTEM	TRIBUTARY	MAINSTEM	TRIBUTARY	MAINSTEM	TRIBUTARY	MAINSTEM	TRIBUTARY
Chehalis River and Elk Creek	2013 September	1.3	1.2	6.5	3.2	15.9	17.0	--	--	2.1	1.9
	2014 July	2.9	1.1	14.0	3.2	36.9	12.1	0.6	0.3	1.0	0.3
Chehalis River and South Fork Chehalis River	2013 September	3.4	1.6	3.0	1.0	34.4	16.9	--	--	5.5	1.9
	2014 July	4.4	1.4	6.2	3.1	45.5	21.6	0.7	0.2	1.4	0.5
Chehalis River and Newaukum River	2013 September[4]	7.4	5.9	11.6	45.6	71.0	59.2	--	--	9.4	10.1
	2014 July	6.8	1.9	19.1	2.0	68.7	58.5	1.7	0.8	2.3	1.2
Chehalis River and Skookumchuck River[1]	2013 September	28.6	4.3	73.3	54.6	173.9	65.2	--	--	26.1	11.4
	2014 July	4.2	3.2	4.2	74.4	104.8	64.2	1.7	2.2	3.3	7.0
Chehalis River and Lincoln Creek[2]	2013 September	40.2	0.1	138.4	0.1	223.2	0.8	--	--	39.3	0.3
	2014 July	11.7	0.1	49.2	0.1	162.2	0.2	2.9	0.0	19.8	0.1
Chehalis River and Black River[3]	2013 September	33.5	3.6	402.5	112.8	306.0	85.9	--	--	52.6	9.2
	2014 July	11.0	2.0	225.4	132.5	196.3	84.5	3.9	1.4	21.2	3.8
Cumulative Mainstem and Tributary Loads Downstream of Black River[5]	2013 September	37.1	16.8	515.3	217.2	391.9	244.9			61.7	34.6
	2014 July	13.0	9.6	357.9	215.3	280.8	241.2	5.3	5.0	25.0	13.0

Notes:

1 Flow U/S of Skookumchuck River (RM 66.8) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) - Flow at Skookumchuck River Mouth - Flow at Lincoln Creek

2 Flow U/S of Lincoln Creek (RM 61.9) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) - Flow at Lincoln Creek

3 Flow U/S of Black River (RM 47) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) / Drainage area at Grand Mound * Drainage Area at USGS station at Chehalis near Rochester (RM 54.2, #12028060)

4 Chehalis river upstream of Newaukum river flow in 2013 September is from Chehalis at Route 603

5 Orthophosphate measurements from September had a higher reporting limit and were therefore not included for this analysis

contribution of all the major tributaries.

kg/d = kilograms per day

RM = river mile

U/S = upstream

USGS = U.S. Geological Survey

Table 12

Comparison of 5-Day Biochemical Oxygen Demand and Total Suspended Solid Loads Carried by Mainstem Chehalis River Relative to the Nearest Tributary

LOCATION	SURVEY	BOD-5 (kg/d)		TSS (kg/d)	
		MAINSTEM	TRIBUTARY	MAINSTEM	TRIBUTARY
Chehalis River and Elk Creek	2013 August	108.87	52.60	136.09	65.75
	2013 September	132.12	1474.41	52.85	91.01
	2014 July	120.55	42.70	132.60	46.97
Chehalis River and South Fork Chehalis River	2013 August	166.37	52.36	532.38	219.90
	2013 September	202.58	80.49	445.67	144.89
	2014 July	177.13	61.16	637.68	97.86
Chehalis River and Newaukum River	2013 August	250.78	130.89	313.47	575.93
	2013 September[5]	322.95	296.04	516.72	1598.60
	2014 July	281.36	156.09	675.26	249.75
Chehalis River and Skookumchuck River[1]	2013 August	431.43	192.79	539.29	655.49
	2013 September	621.04	271.57	1366.29	678.93
	2014 July	457.33	318.06	1164.10	413.47
Centralia Sewage Treatment Plant[2,3]	2013 August	624.22	34.47	780.28	43.54
	2013 September	5444.94	44.00	1695.97	78.47
	2014 July	733.81	24.49	1247.47	37.19
Chehalis River and Lincoln Creek[3]	2013 August	624.22	0.88	780.28	10.75
	2013 September	5444.94	4.04	1695.97	10.01
	2014 July	733.81	0.63	1247.47	3.96
Chehalis River and Black River[4]	2013 August	668.41	173.22	1737.86	216.52
	2013 September	13195.21	190.83	2677.29	57.25
	2014 July	785.31	201.11	5026.00	221.22

Notes:

1 Flow U/S of Skookumchuck River (RM 66.8) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) - Flow at Skookumchuck River Mouth - Flow at Lincoln Creek

2 Average Loads in Discharge Monitoring Reports

3 Flow U/S of Lincoln Creek (RM 61.9) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) - Flow at Lincoln Creek

4 Flow U/S of Black River (RM 47) = Flow at USGS station at Grand Mound (RM 59.9, #12027500) / Drainage area at Grand Mound * Drainage Area at USGS station at Chehalis near Rochester (RM 54.2, #12028060)

5 Chehalis river upstream of Newaukum river flow in 2013 September is from Chehalis at RT603

BOD-5 = 5-year biochemical oxygen demand

kg/d = kilograms per day

RM - river mile

TSS = total suspended solids

U/S = upstream

USGS = U.S. Geological Survey

Table 13

Nutrient, Suspended Solids, and BOD-5 Concentrations at the Upstream Pe Ell Station in Winter

ANALYTE	RESULT[1]	QUALIFIER
5-Day Biochemical Oxygen Demand (mg/L)	0.500	U
Total Suspended Solids (mg/L)	0.550	U
Ammonia (mgN/L)	0.018	
NO2+NO3 (mgN/L)	0.565	
Total Kjeldahl Nitrogen (mgN/L)	0.383	
Orthophosphate (mgP/L)	0.009	
Total Dissolved Phosphorus (mgP/L)	0.004	U
Total Phosphorus (mgP/L)	0.004	U

Notes:

1 Duplicates were averaged.

mg/L = milligrams per liter

mgN/L = milligrams of nitrogen per liter

mgP/L = milligrams of phosphorous per liter

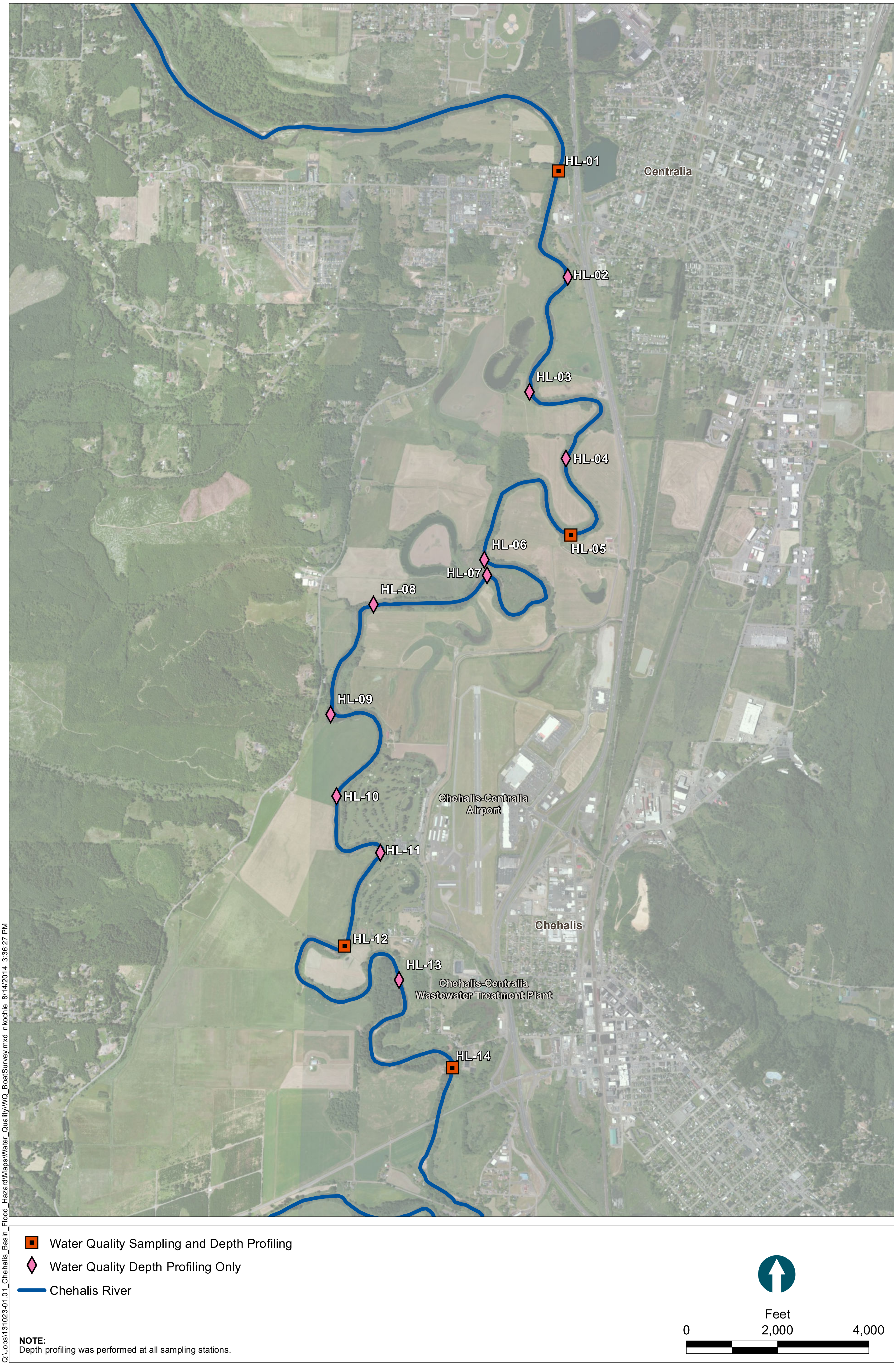
U = non-detect

Figures

NOTES:
HLab = Hydrolab Sonde
WQ = Water Quality
WTemp = Temperature Tidbit
USGS = U.S. Geological Survey
* This is an additional station where flow measurements were made to provide a backup for estimates at CHL-NWK station

Q:\Jobs\131023-01.01_Chehalis_Basin_Flood_Hazard\Maps\Water_Quality\WQ_Sampling_Locations.mxd nkochie 9/11/2014 11:32:44 AM

Figure 1
Proposed Flow Measurement, Water Quality Sampling, and Temperature Probe Locations
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



NOTE:
Depth profiling was performed at all sampling stations.

Q:\Jobs\131023-01.01_Chehalis_Basin_Flood_Hazard\Maps\Water_Quality\WQ_BoatSurvey.mxd nkochie 8/14/2014 3:36:27 PM

ANCHOR QEA

Figure 2
Water Quality Depth Profiling and Sampling Locations in the Centralia Reach Boat Survey
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

Q:\Jobs\131023-01.01_Chehalis_Basin_Flood_Hazard\Maps\Water_Quality\WQ_Groundwater_Wells.mxd nkochie 8/14/2014 3:55:09 PM

Figure 3
Groundwater Monitoring Locations
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

ANCHOR QEA

Figure 4
Field Deployment Example
Water Quality Studies
Chehalis Basin Strategy : Reducing Flood Damage and Enhancing Aquatic Species

Figure 5

A Typical Setup for Flow Measurement: September 2013 Synoptic Low-flow Survey on the Chehalis River at Adna

Water Quality Studies

Chehalis Basin Strategy : Reducing Flood Damage and Enhancing Aquatic Species

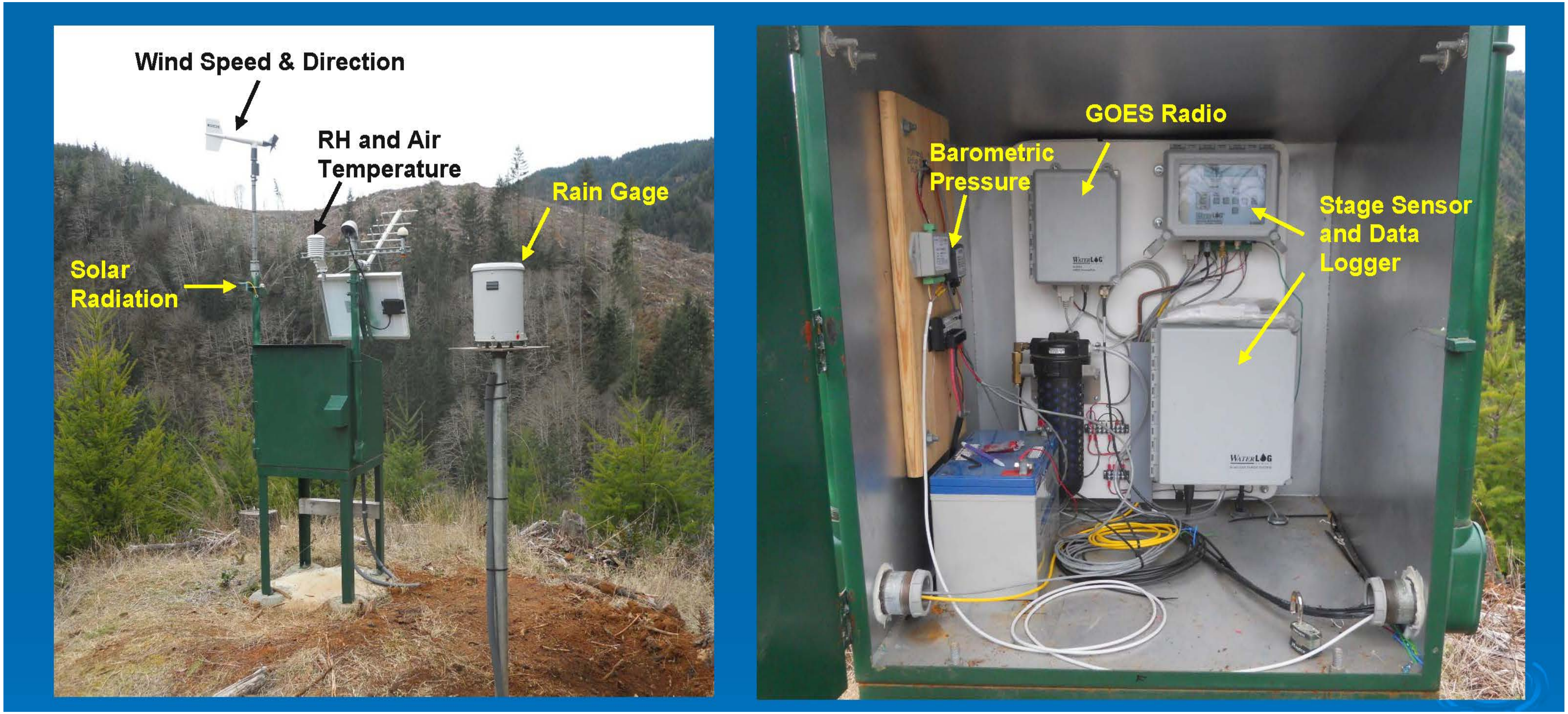
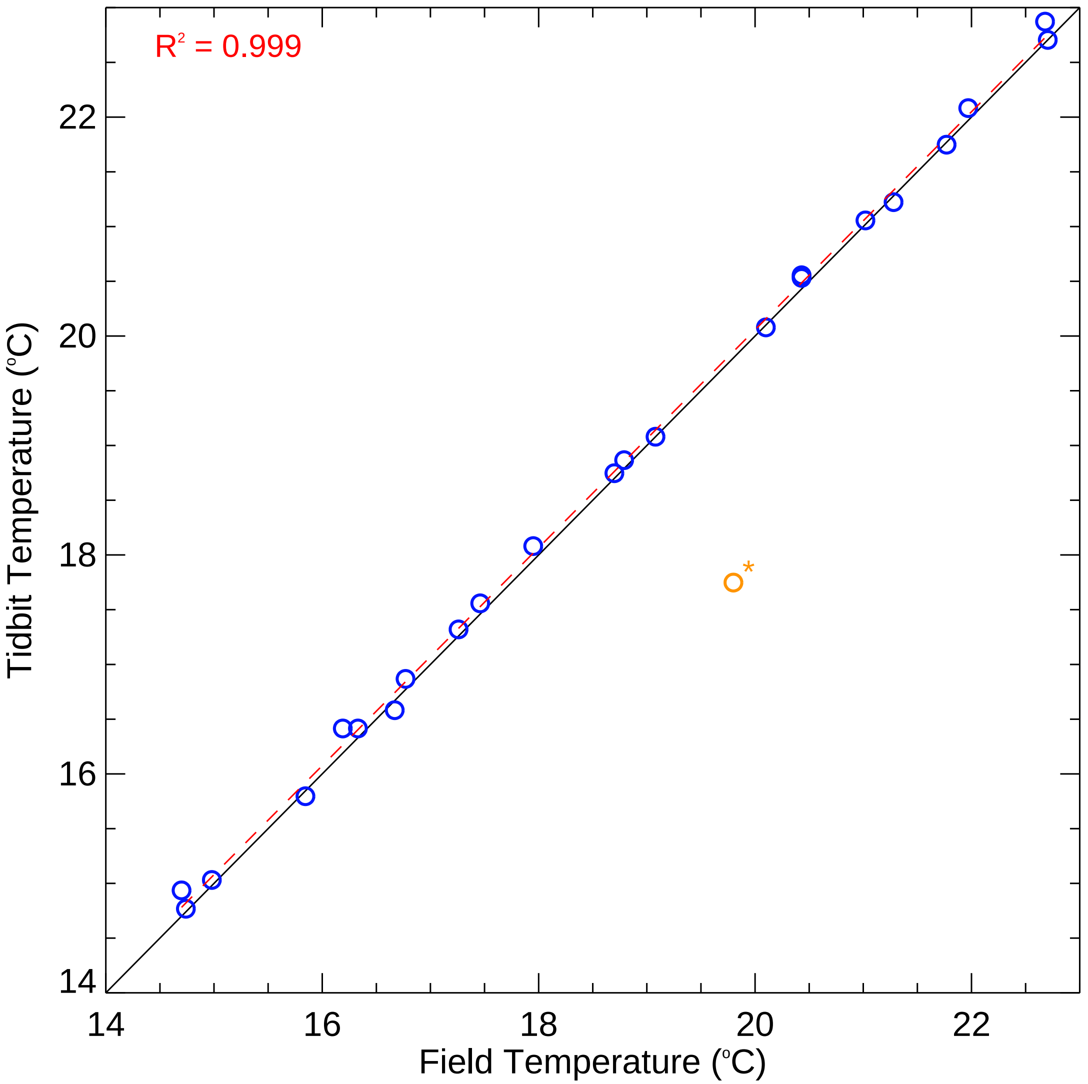


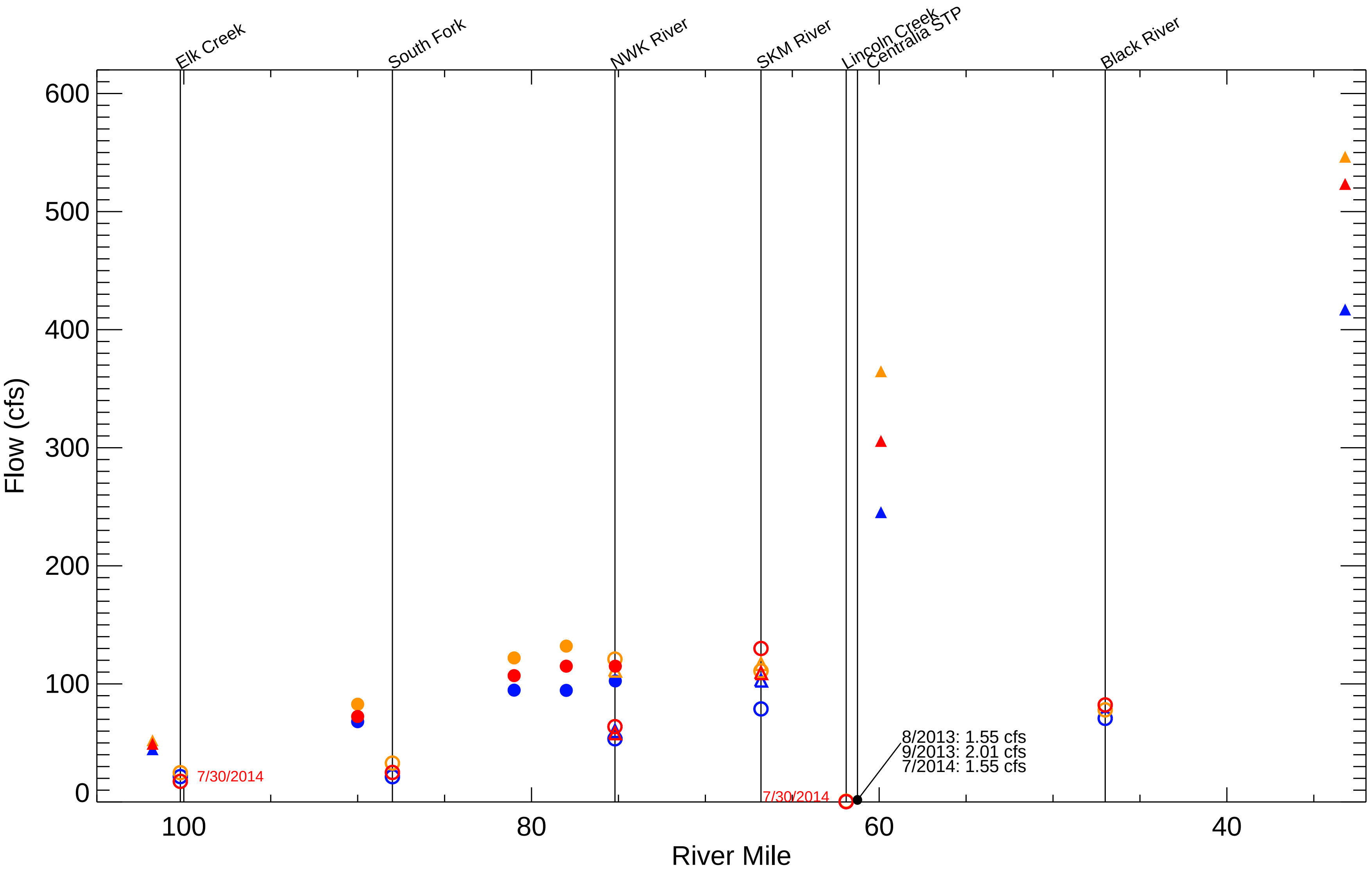
Figure 6
Deployment of Meteorological Sensors to the Existing Early Warning System Rain Gage on the Chehalis River at Thrash Creek
Water Quality Studies
Chehalis Basin Strategy : Reducing Flood Damage and Enhancing Aquatic Species



Note:
Measurements paired by station, date, and time
The measurement flagged with a * sign was from a tidbit that was buried under sediments and was excluded from regression

Figure 7

Cross-plot of Paired Field Versus Tidbit Temperature Measurements
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

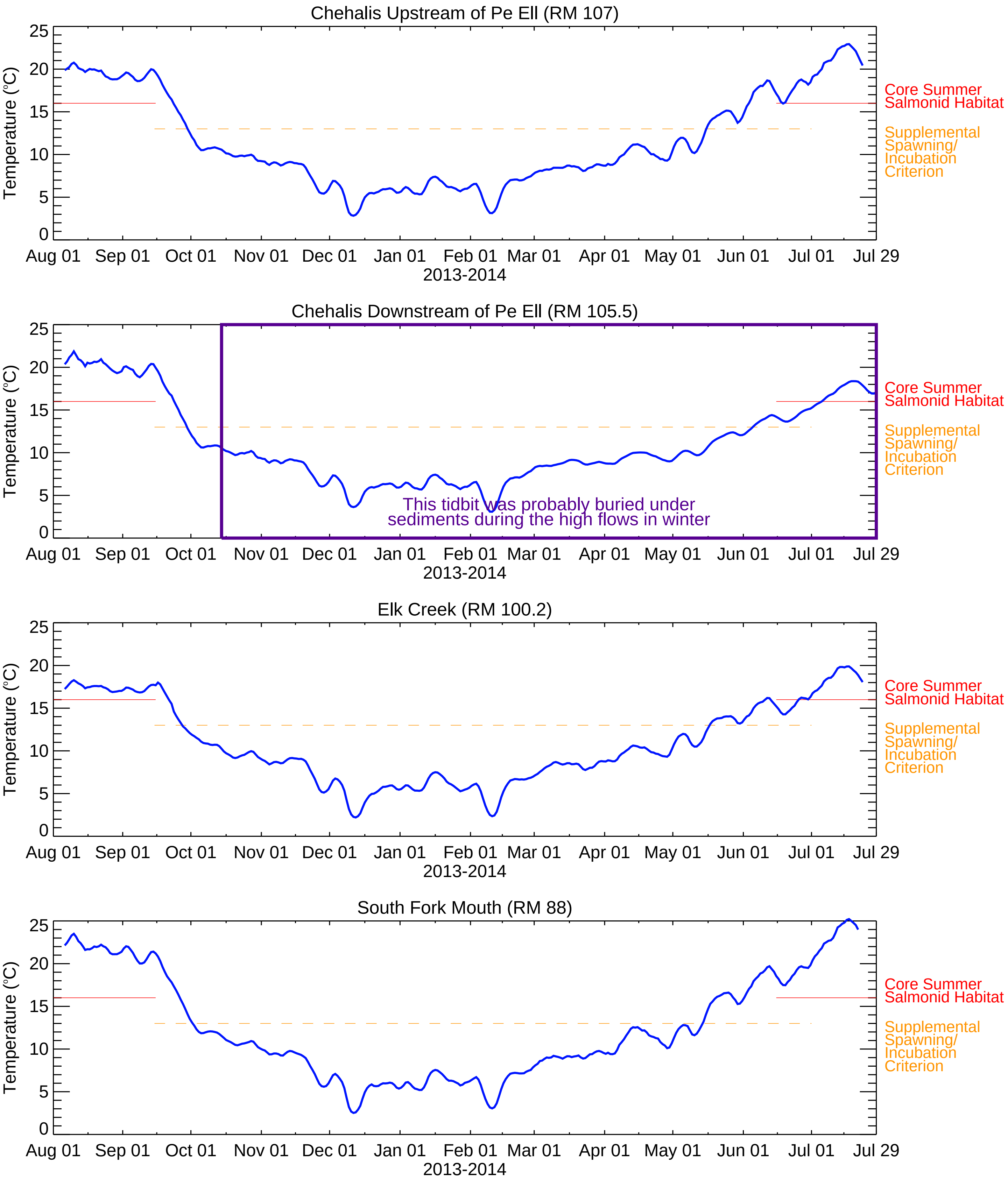


Note: Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. Flows shown for Centralia STP are averages reported in the discharge monitoring report. USGS flows shown are daily averages of 15−minute data.

- ● This Study − 2013 Aug (8/6 or 8/7)
- ▲ USGS − 2013 Aug (Mean of 8/6 and 8/7)
- ● This Study − 2013 Sep (9/17 or 9/18)
- ▲ USGS − 2013 Sep (Mean of 9/17 and 9/18)
- ● This Study − 2014 Jul (7/22 or 7/30)
- ▲ USGS − 2014 Jul (Mean of 7/22 and 7/30)

Figure 8

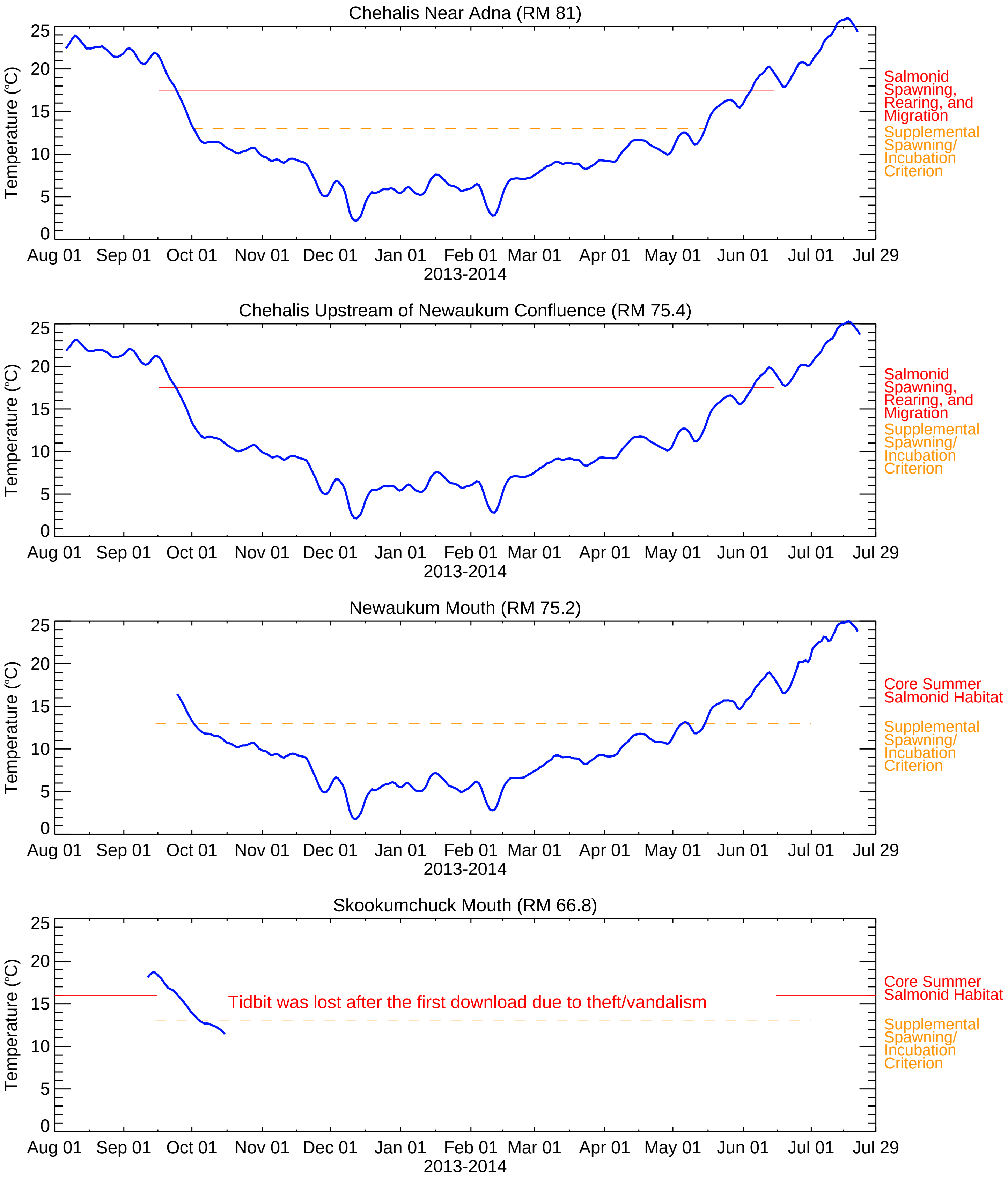
Flows Measured During the Summer Low−Flow Synoptic Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood
Damage and Enhancing Aquatic Species



Note:
Tidbit data measured every 30 minutes and shown as 7-DADmax.
7-DADmax - 7-day average of daily maximum temperature
RM - river mile

Figure 9

Temporal Trends in Temperature in the Chehalis River and Its Major Tributaries
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

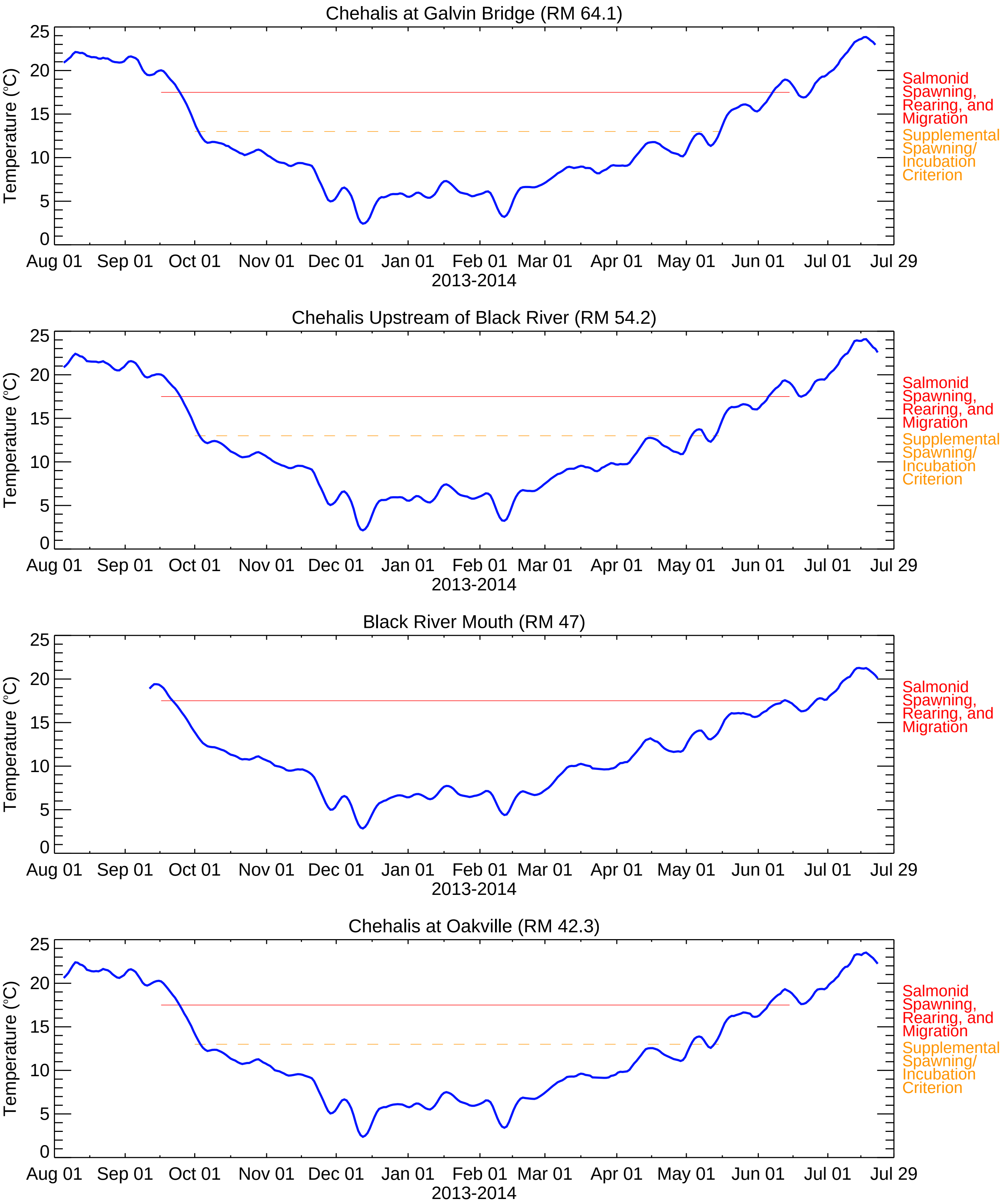


Note:
Tidbit data measured every 30 minutes and shown as 7-DADmax.
7-DADmax - 7-day average of daily maximum temperature
RM - river mile

ANCHOR QEA

Figure 9 (continued)

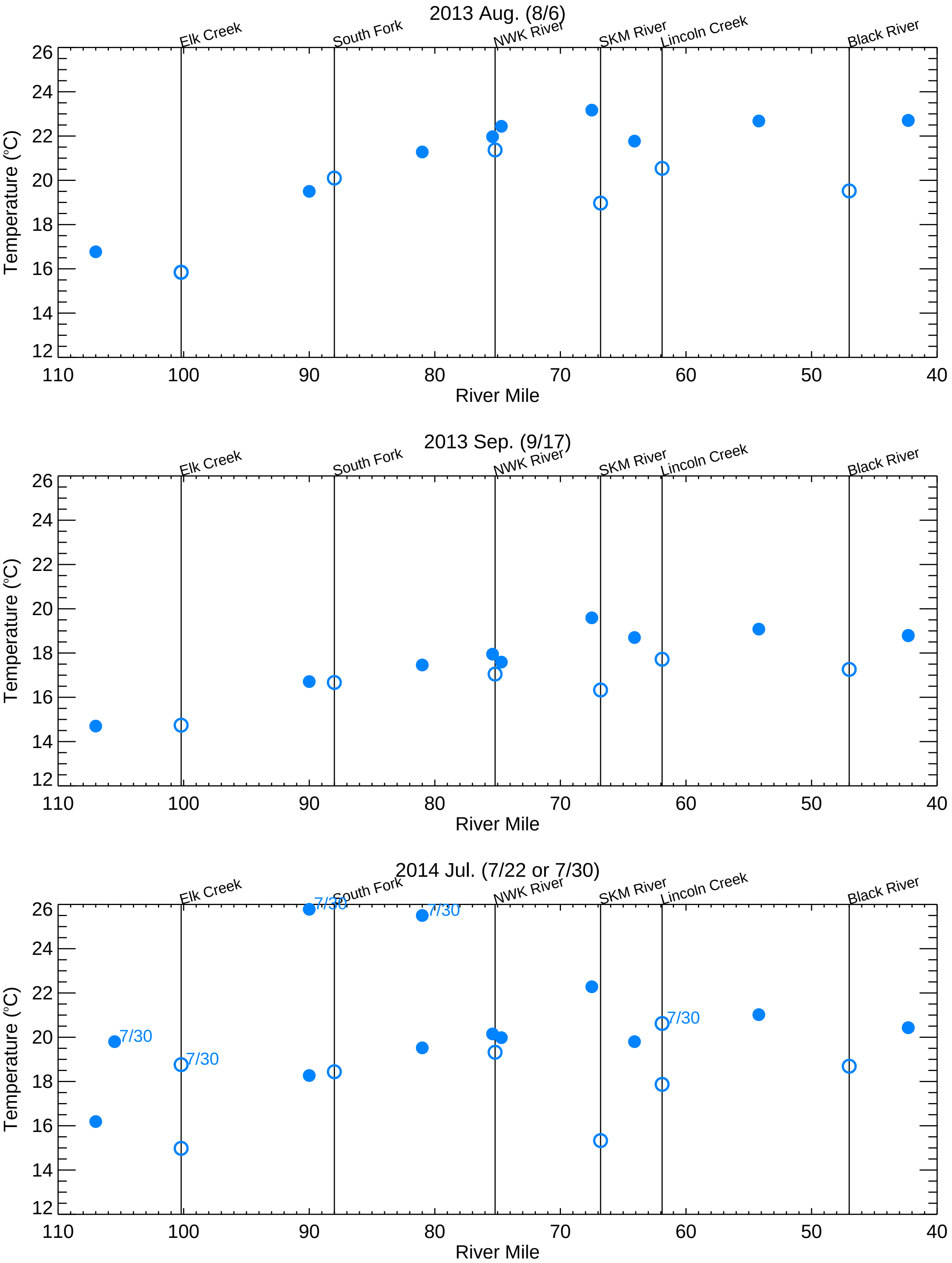
Temporal Trends in Temperature in the Chehalis River and Its Major Tributaries
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Tidbit data measured every 30 minutes and shown as 7-DADmax.
7-DADmax - 7-day average of daily maximum temperature
RM - river mile

Figure 9 (continued)

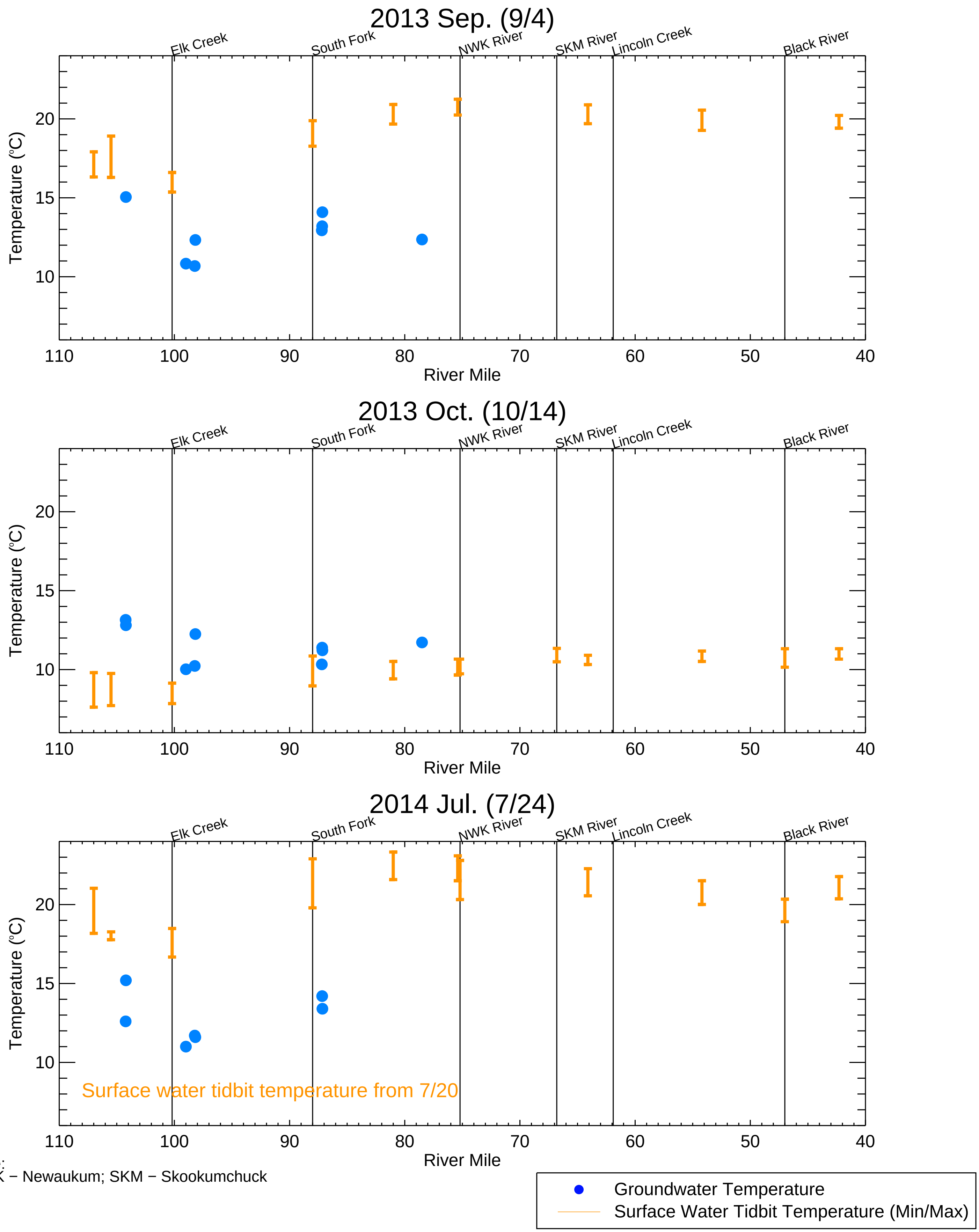
Temporal Trends in Temperature in the Chehalis River and Its Major Tributaries



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.

ANCHOR QEA

Figure 10
Spatial Patterns in Temperature in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
NWK – Newaukum; SKM – Skookumchuck

Figure 11
Groundwater Temperature in the Chehalis River and Its Tributaries
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

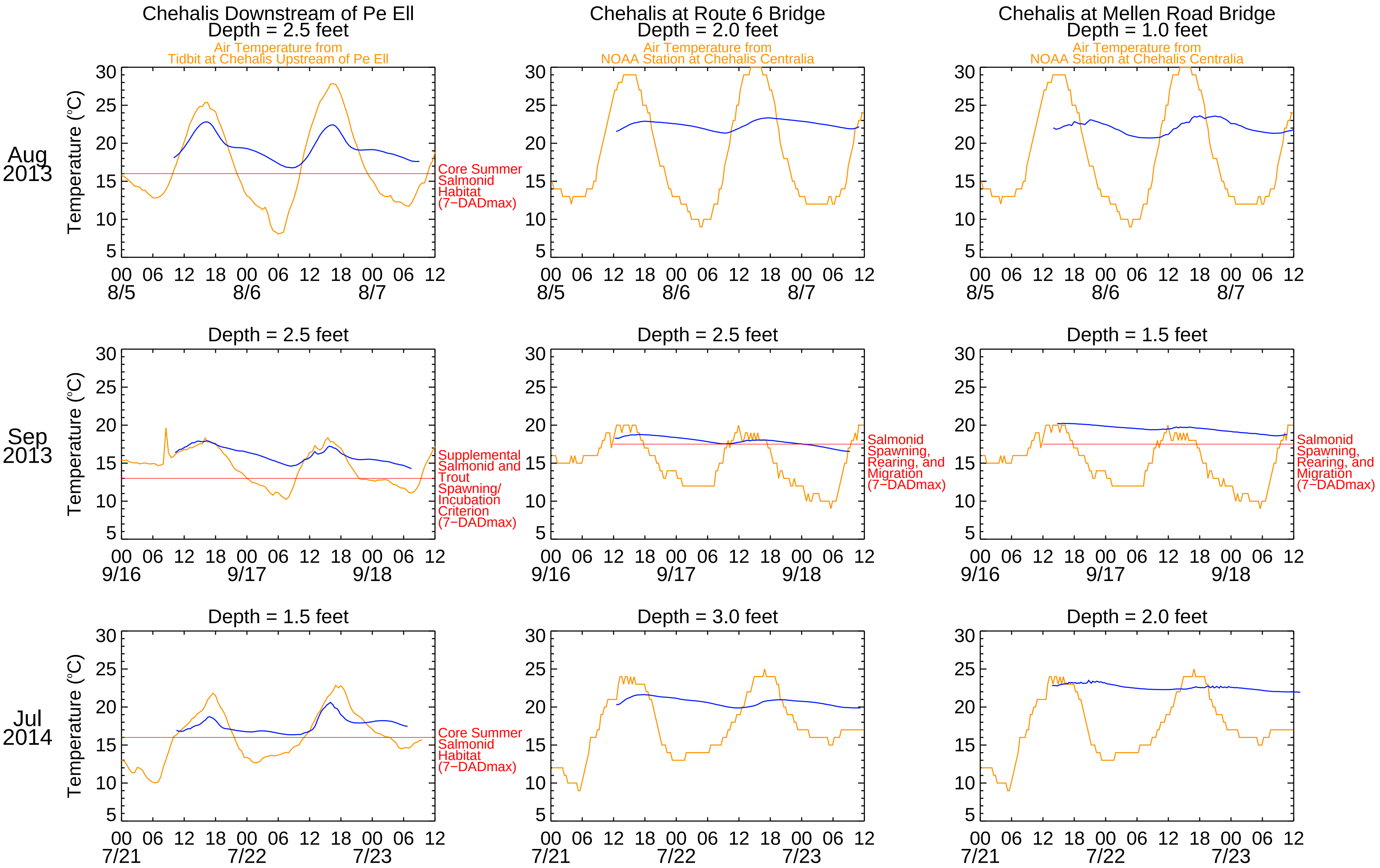
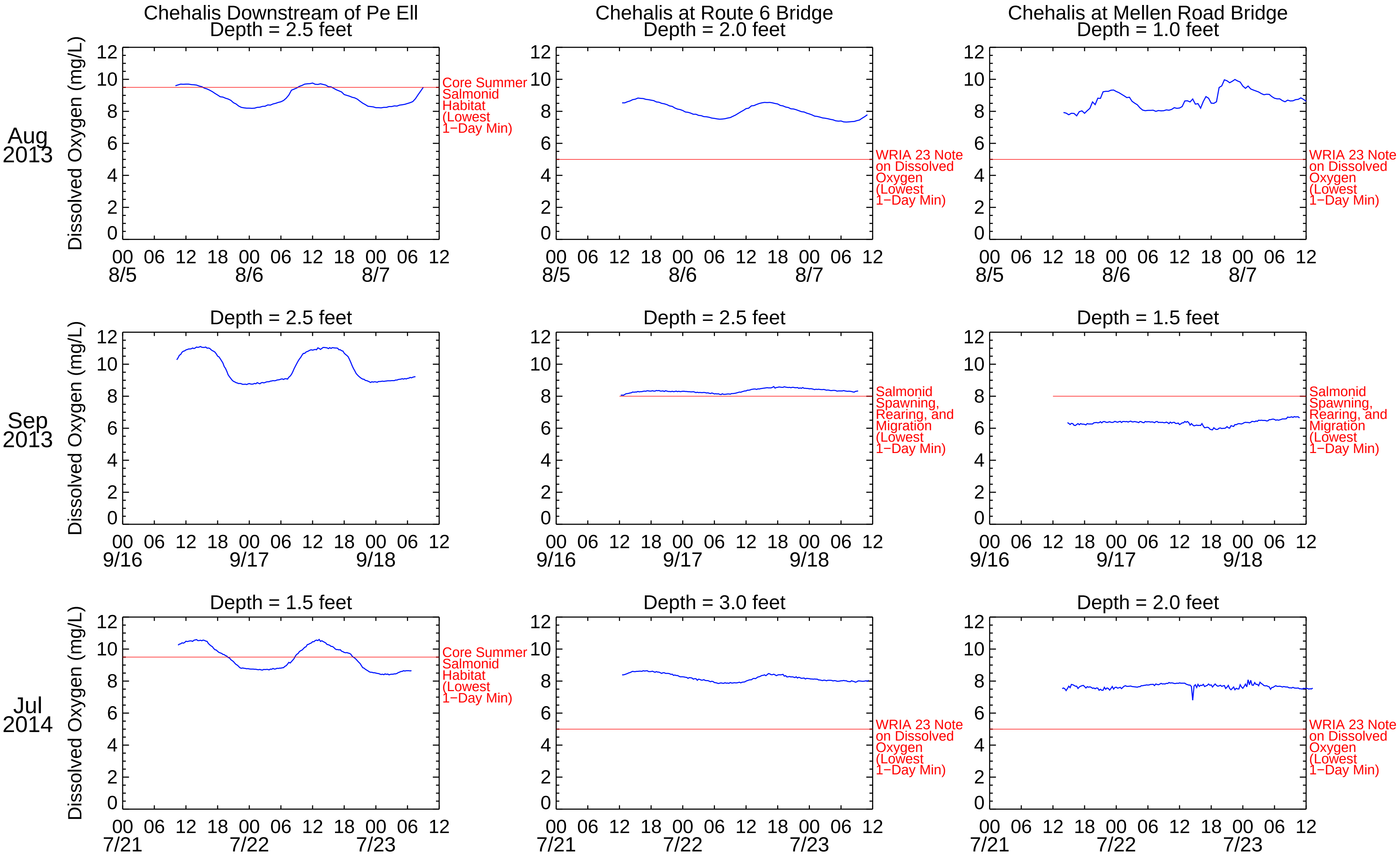


Figure 12

Diurnal Trends in Temperature Recorded at Three Locations on the Mainstem Chehalis River

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Sept. data calibrated from raw measurements at 637 mmHg to values shown at 750 mmHg.

Figure 13
Diurnal Trends in Dissolved Oxygen Recorded at Three Locations on the Mainstem Chehalis River
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

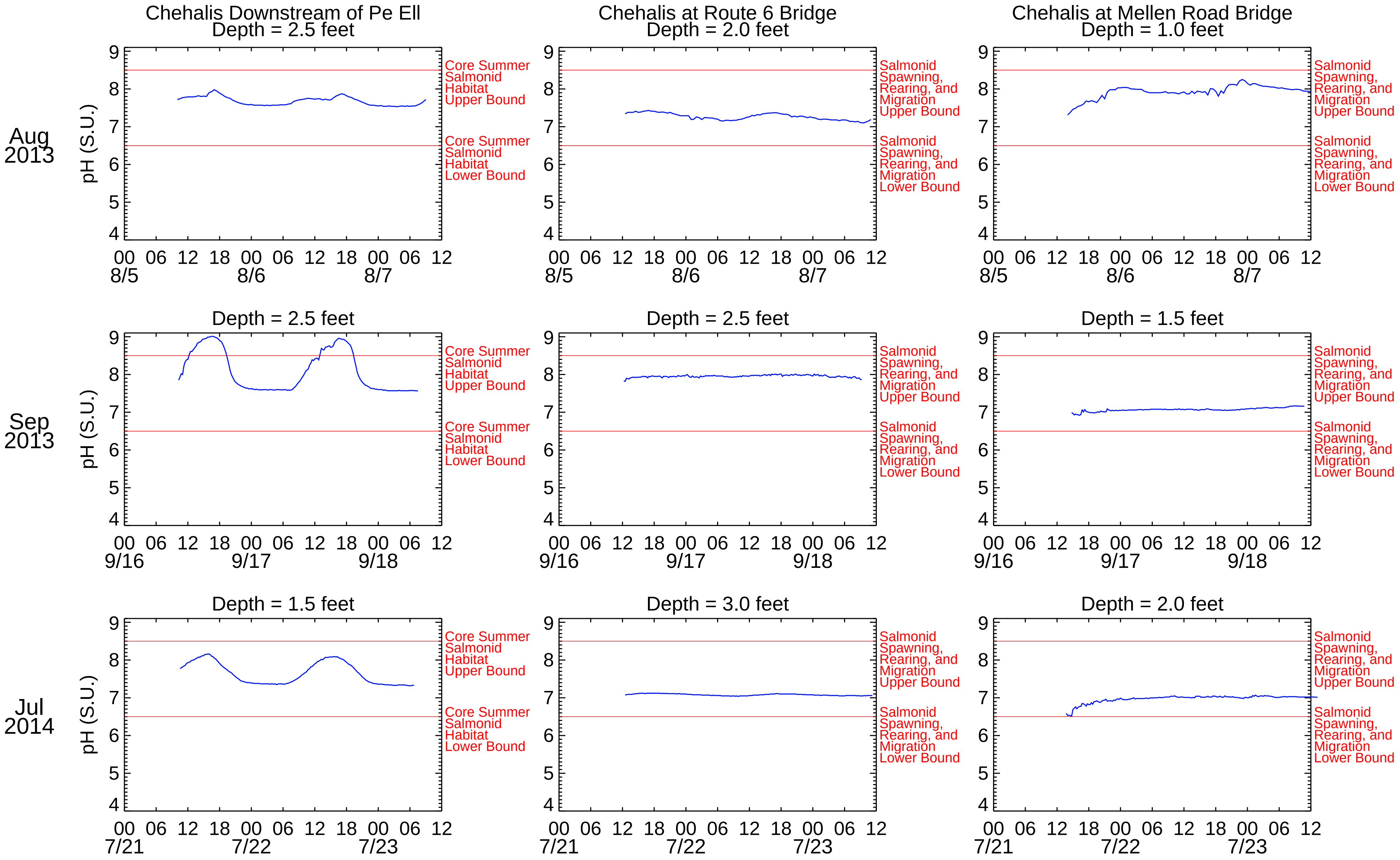


Figure 14

Diurnal Trends in pH Recorded at Three Locations on the Mainstem Chehalis River

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

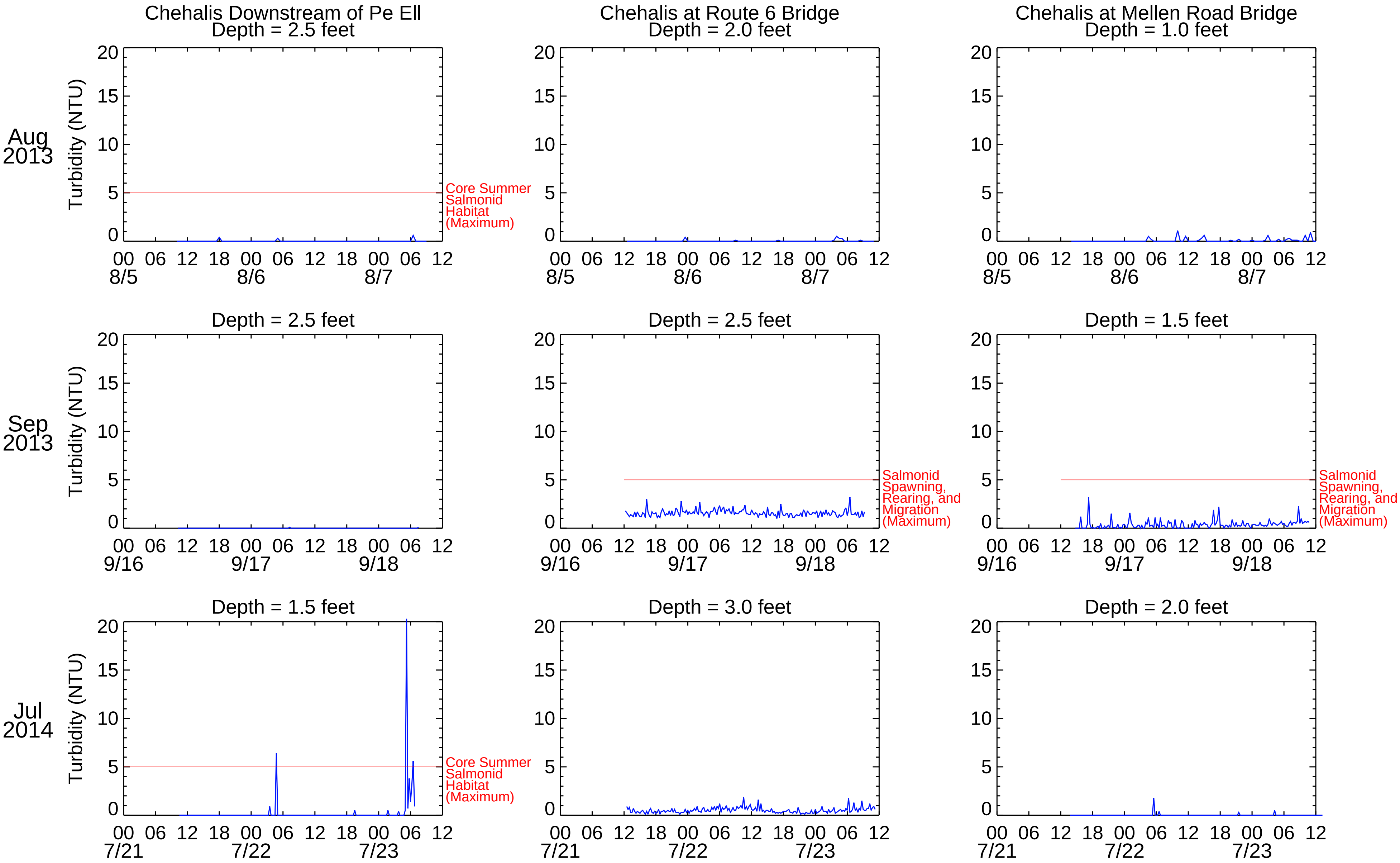


Figure 15

Diurnal Trends in Turbidity Recorded at Three Locations on the Mainstem Chehalis River

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

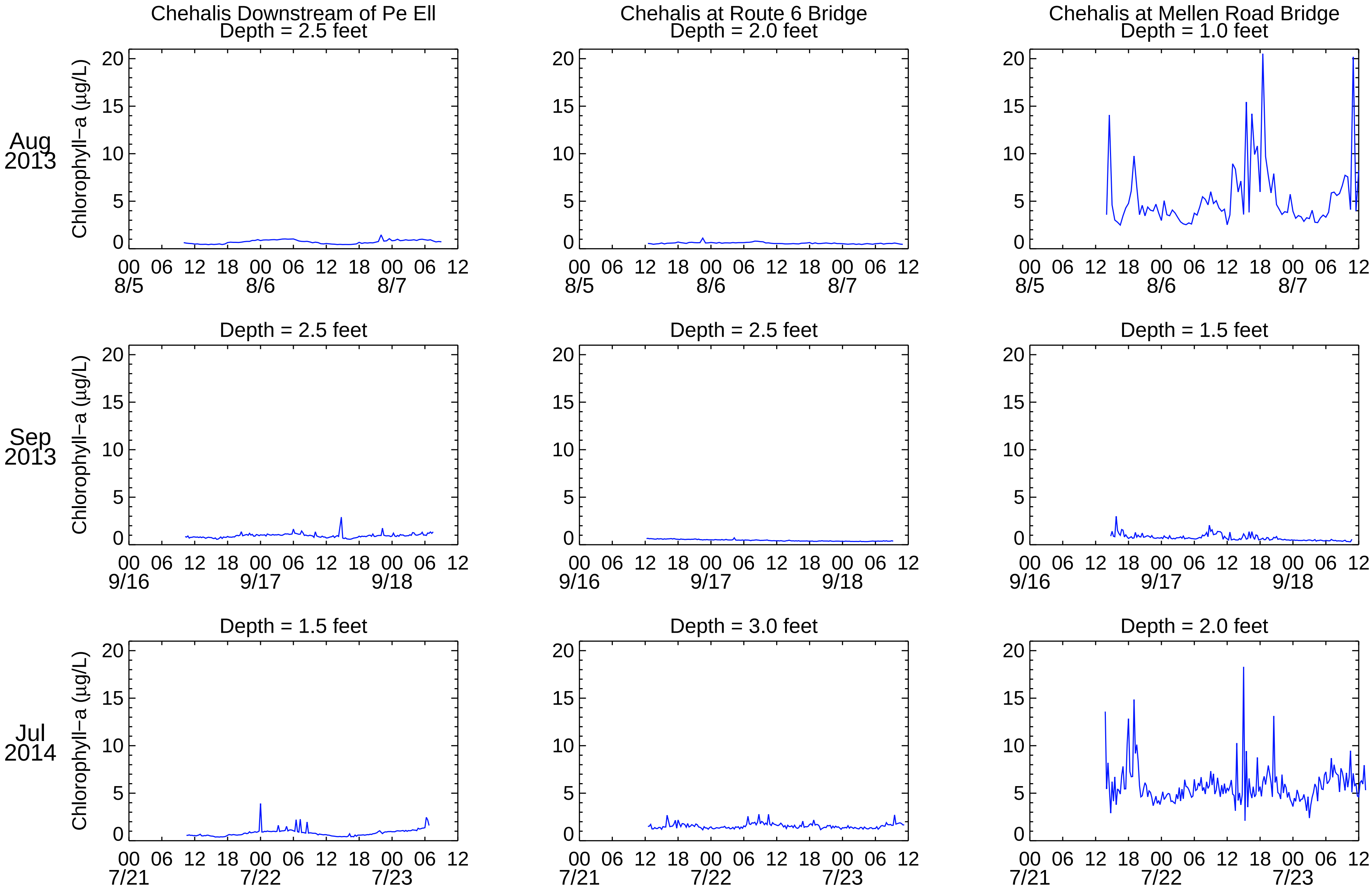


Figure 16

Diurnal Trends in Chlorophyll−a Recorded at Three Locations on the Mainstem Chehalis River

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

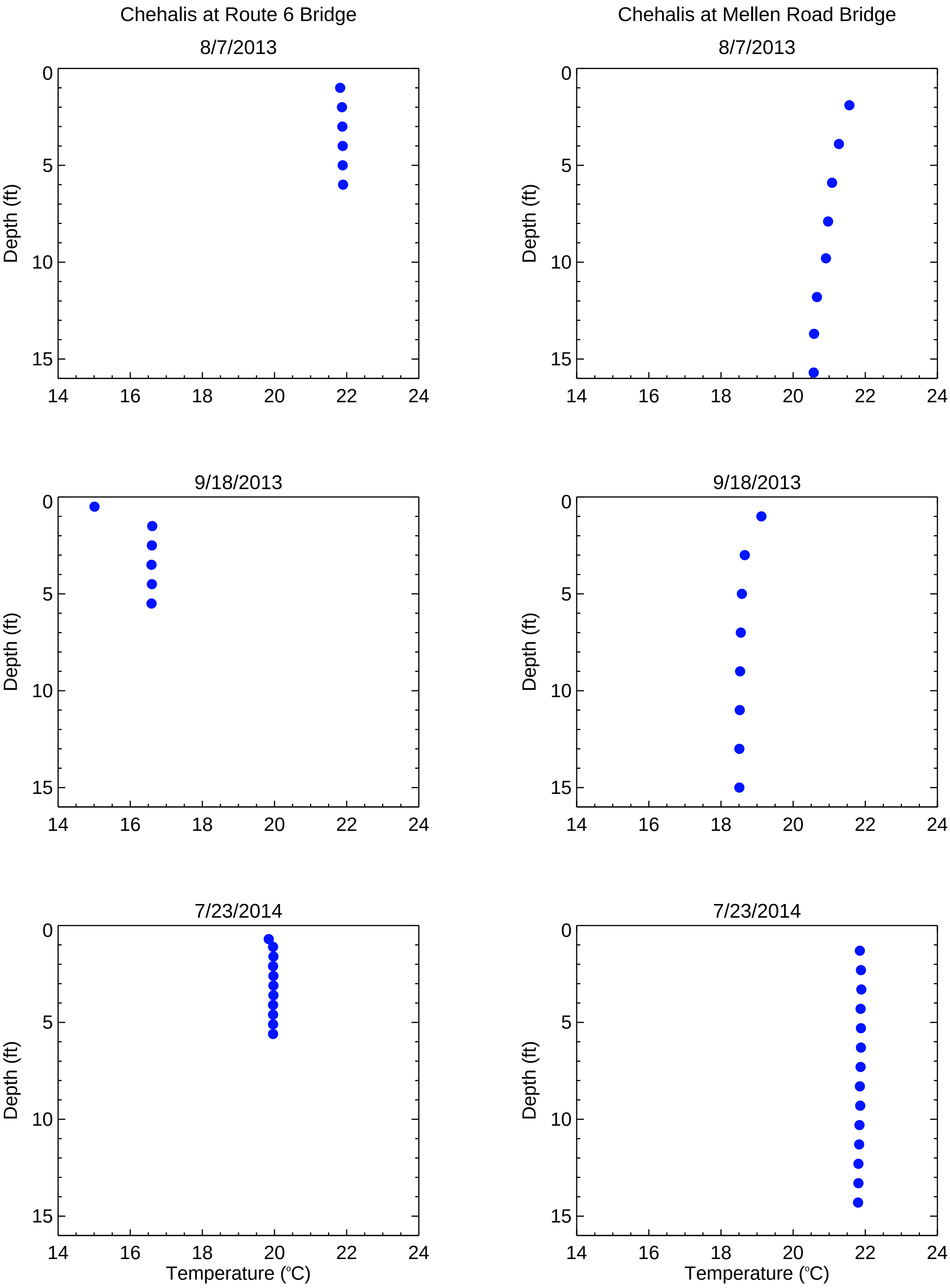


Figure 17
Temperature Depth Profiles at Two Locations on the Mainstem Chehalis River
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

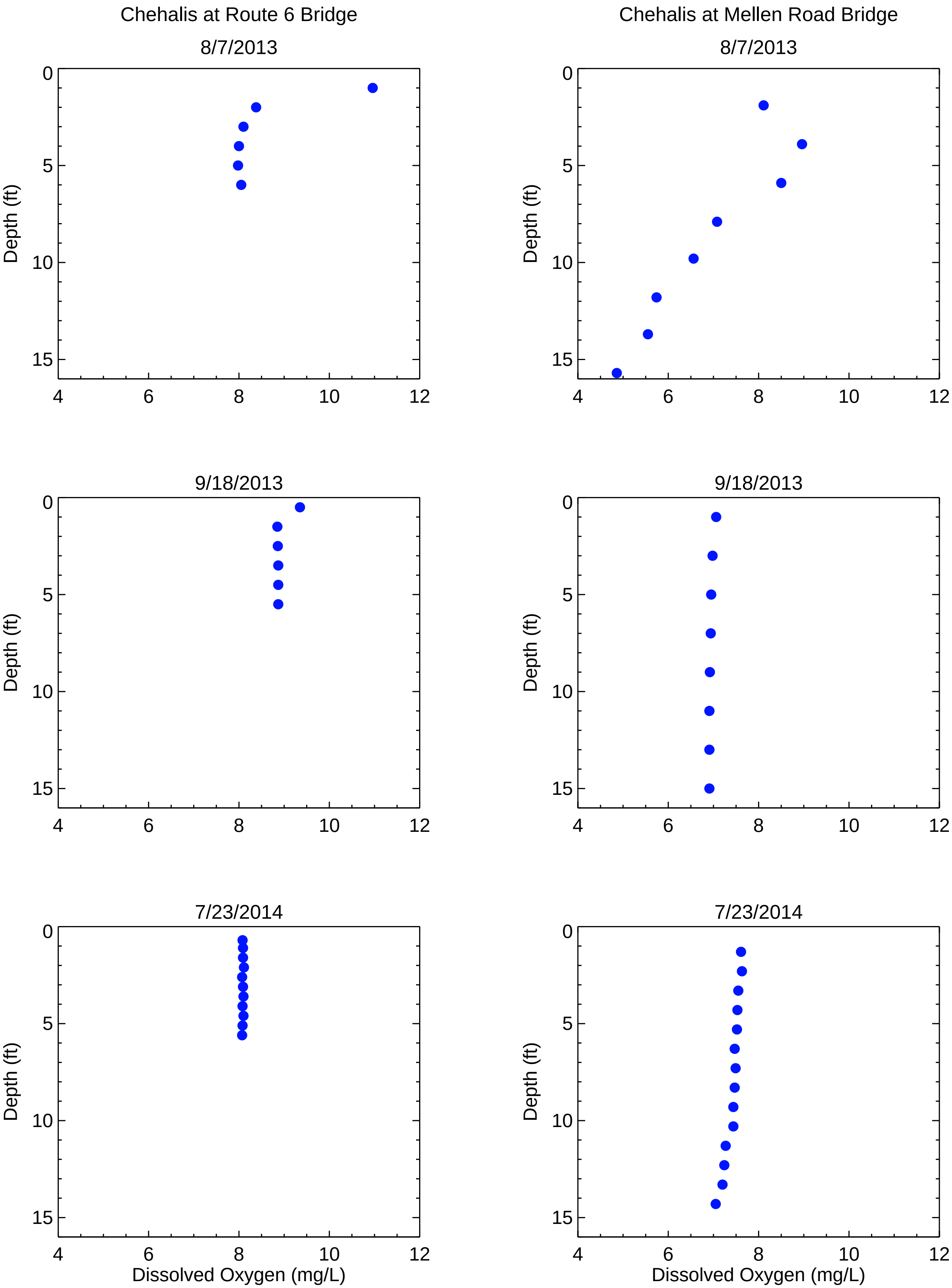


Figure 18

Dissolved Oxygen Depth Profiles at Two Locations on the Mainstem Chehalis River

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

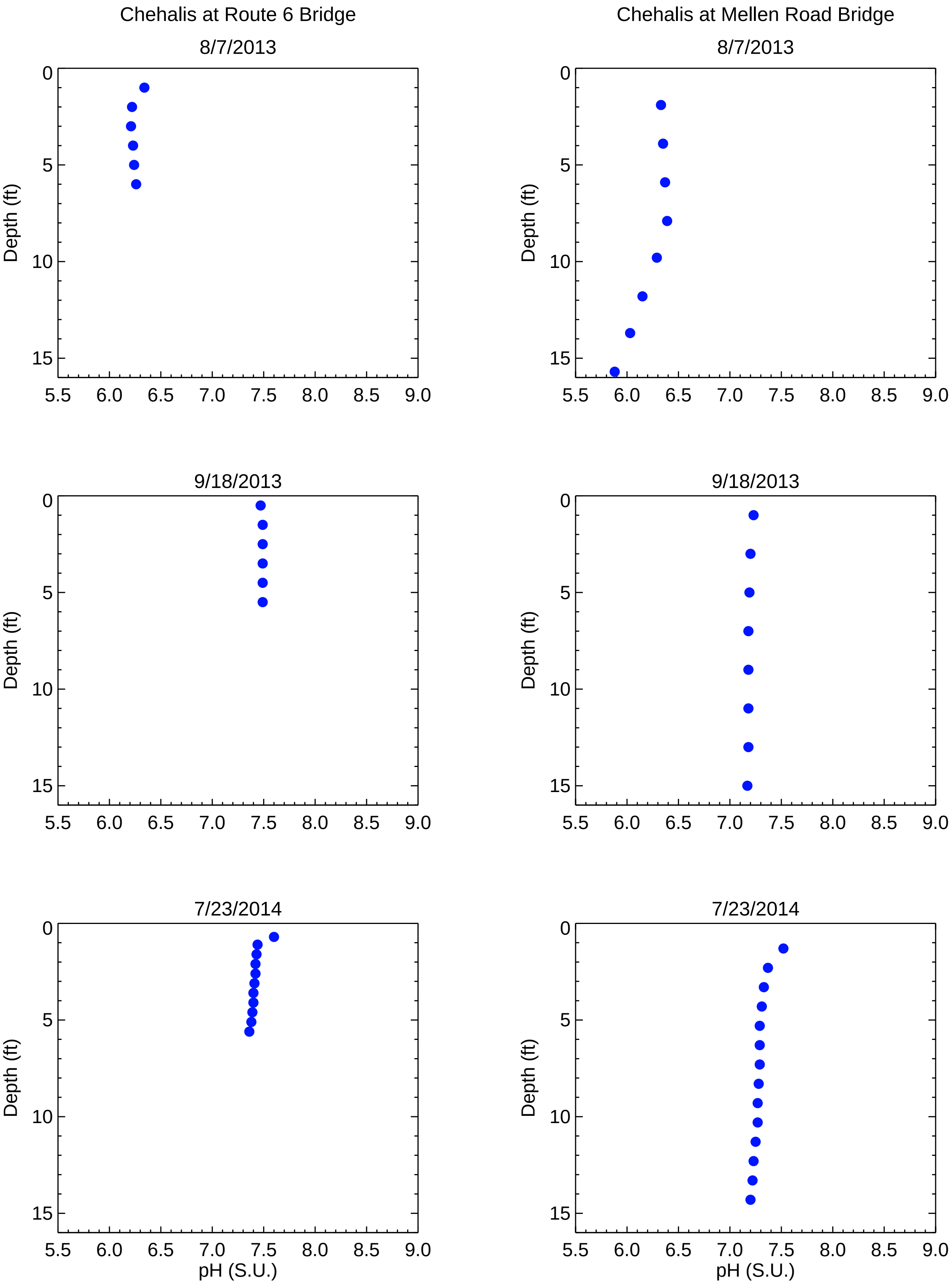
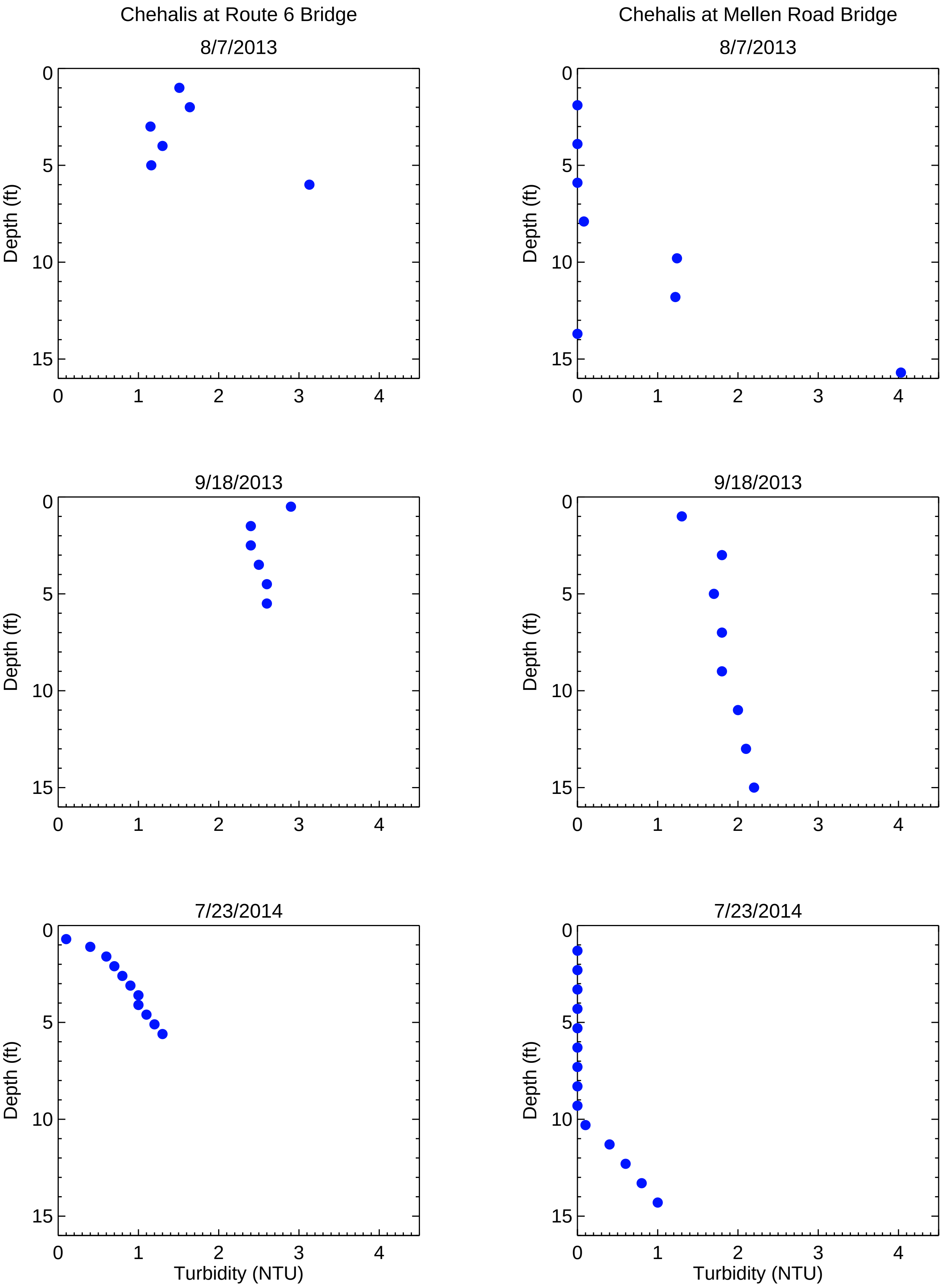


Figure 19

pH Depth Profiles at Two Locations on the Mainstem Chehalis River

Water Quality Studies

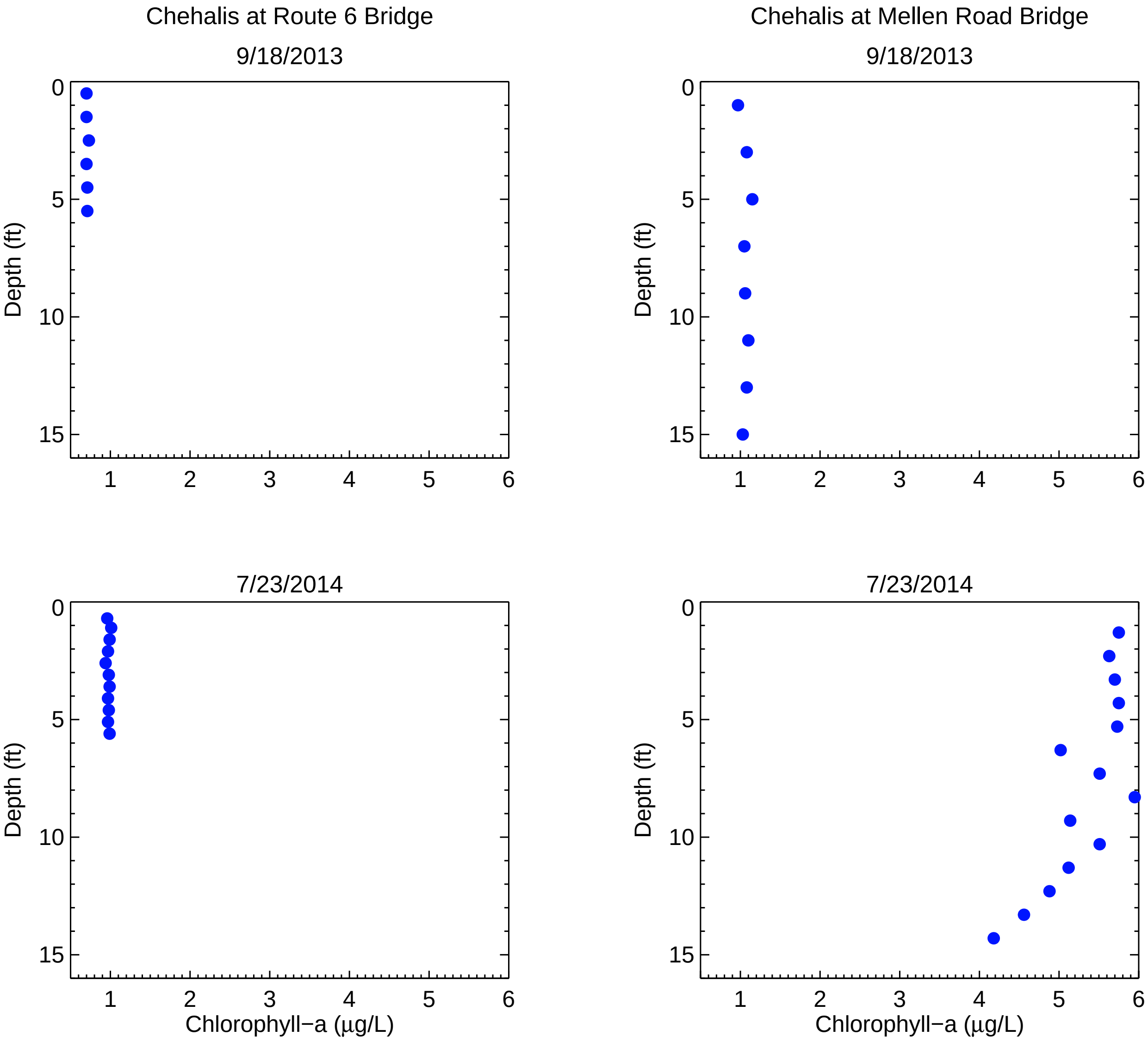
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



ANCHOR QEA

Figure 20

Turbidity Depth Profiles at Two Locations on the Mainstem Chehalis River
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species


Chehalis at Route 6 Bridge

Chehalis at Mellen Road Bridge

9/18/2013

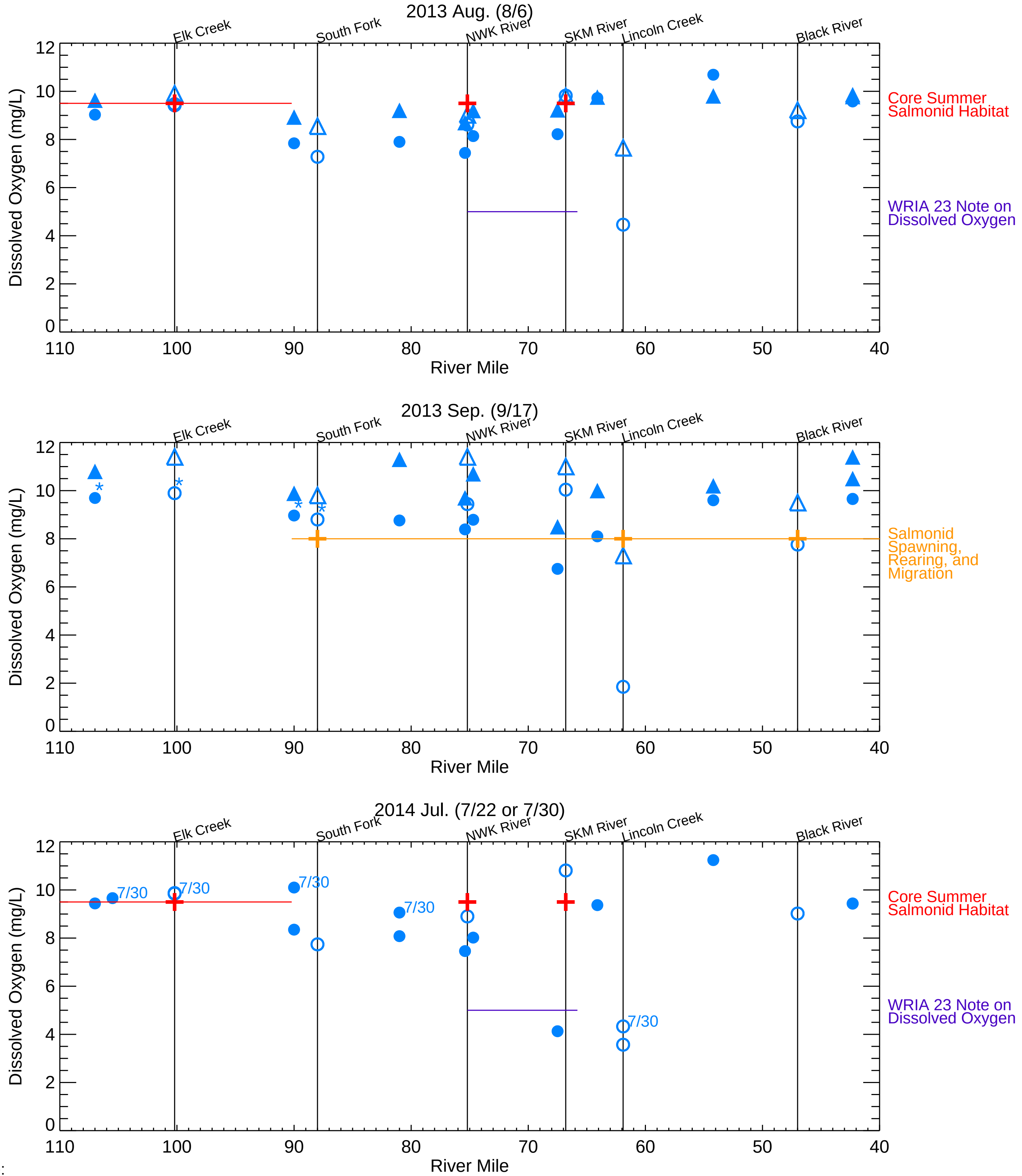
7/23/2014

Figure 21

Chlorophyll−a Depth Profiles at Two Locations on the Mainstem Chehalis River

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

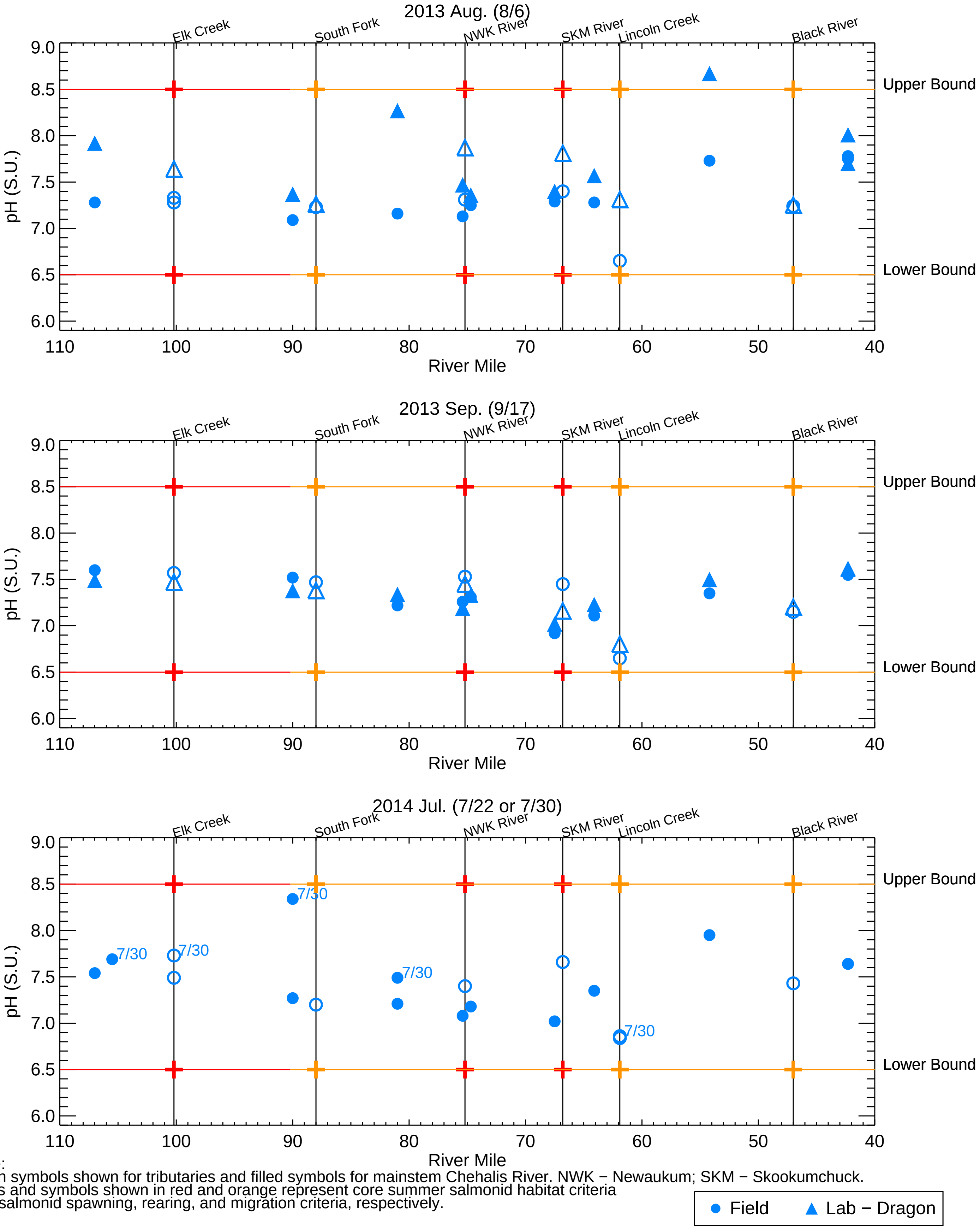


Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries. September measurements flagged with * signs were calibrated from raw measurements at 637 mmHg to values shown at 750 mmHg.

ANCHOR QEA

Figure 22

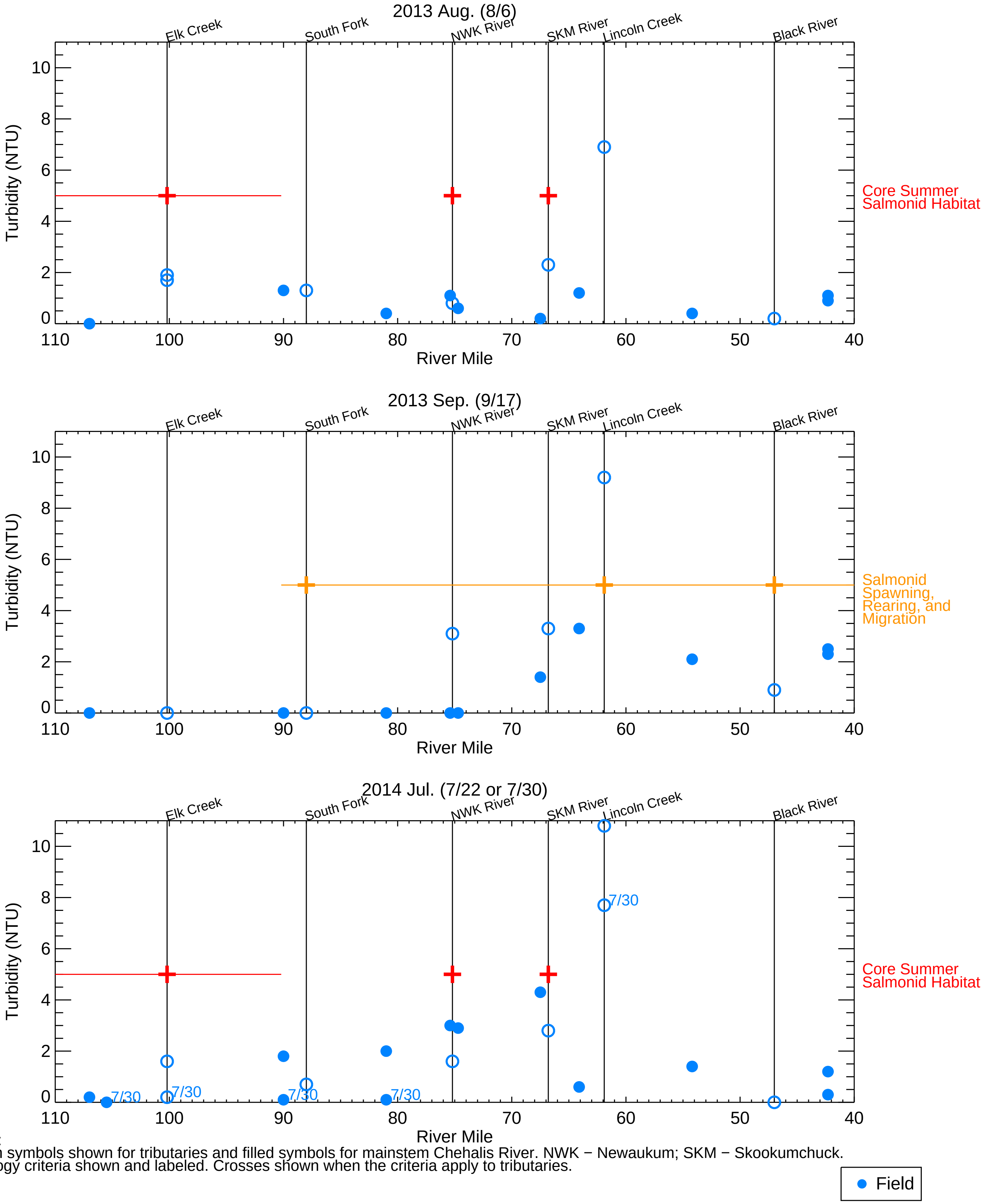
Spatial Patterns in Dissolved Oxygen in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Lines and symbols shown in red and orange represent core summer salmonid habitat criteria
and salmonid spawning, rearing, and migration criteria, respectively.

Figure 23

Spatial Patterns in pH in the Mainstem Chehalis River
and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



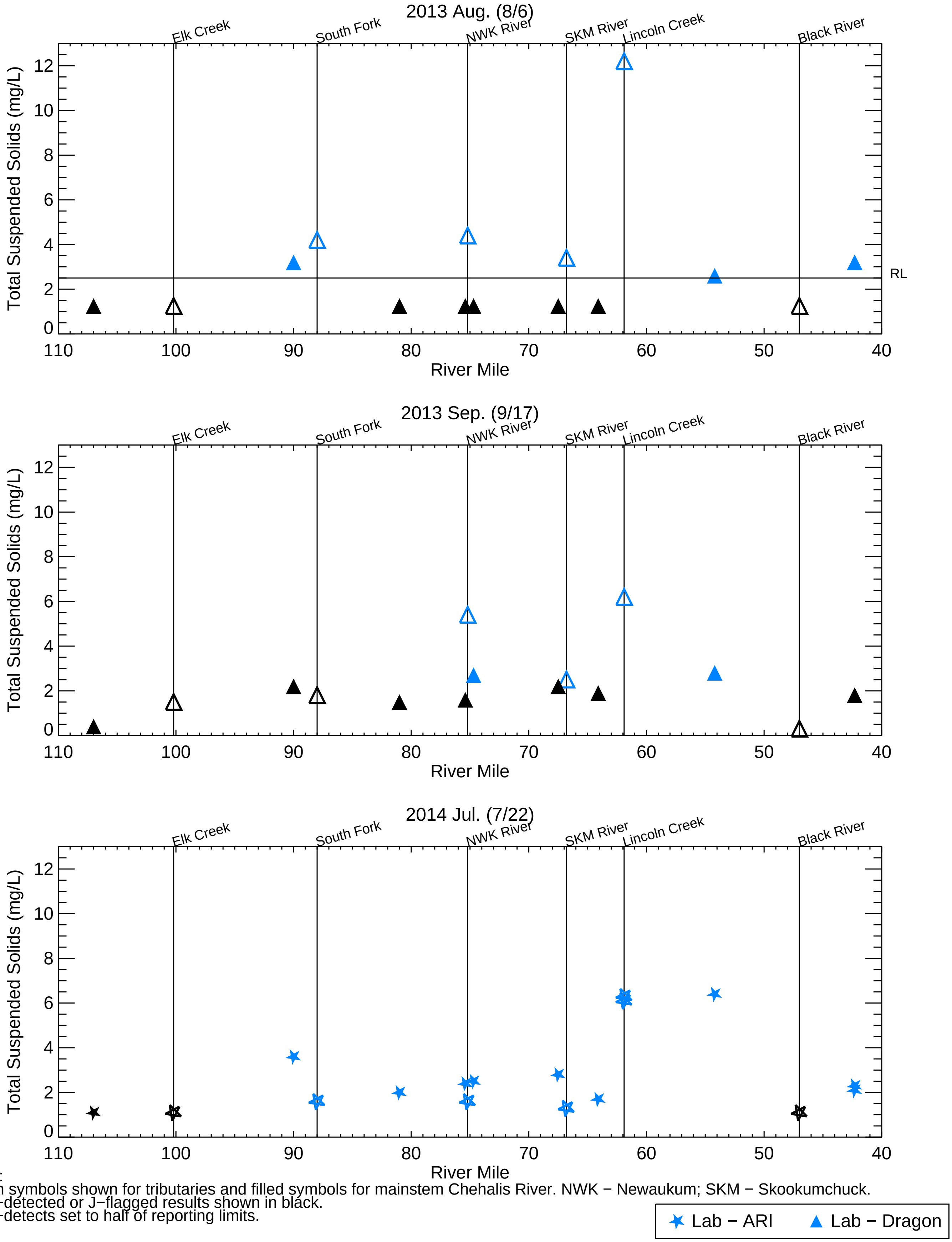
Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries.

Figure 24

Spatial Patterns in Turbidity in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys

Water Quality Studies

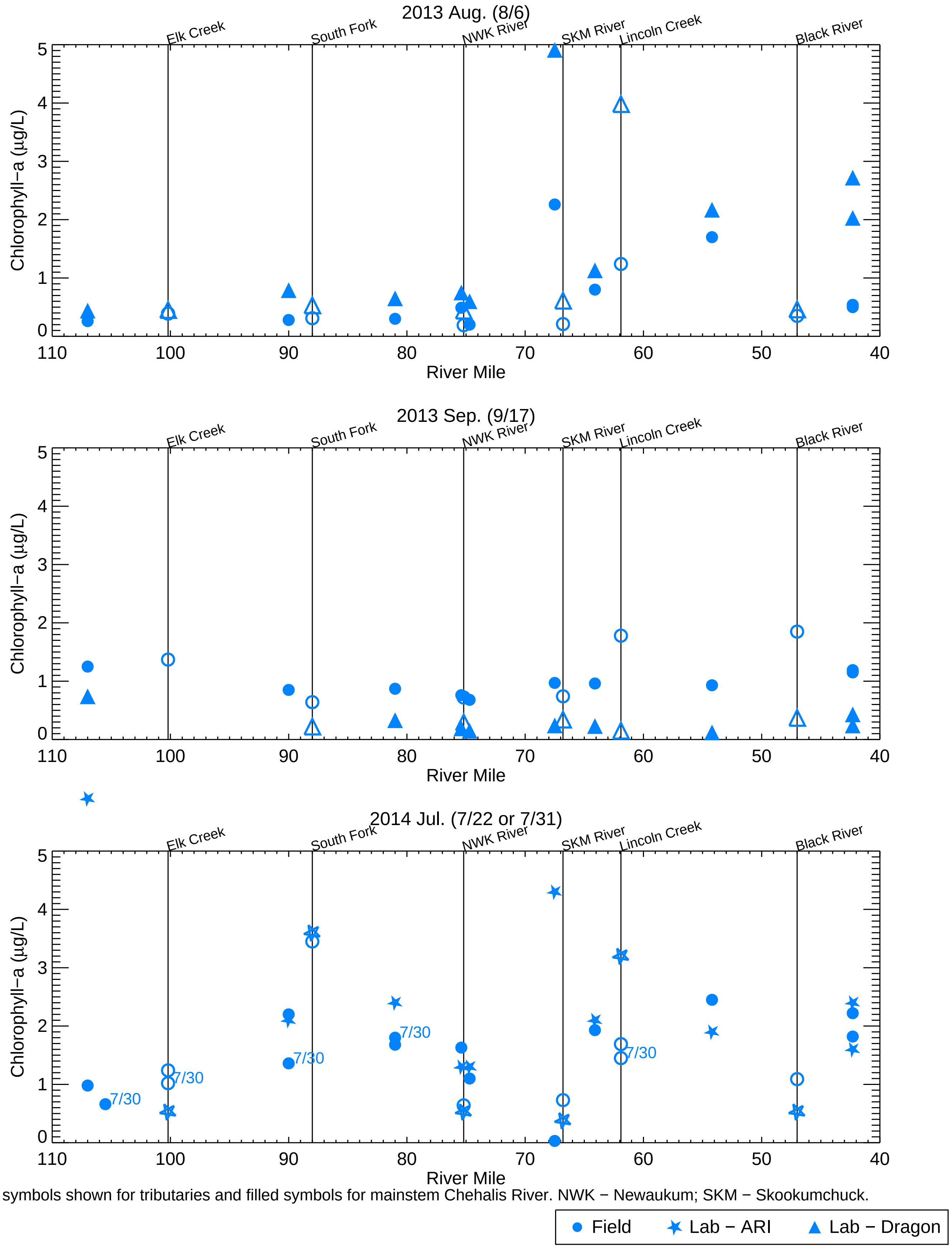
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

Figure 25

Spatial Patterns in Total Suspended Solids in the Mainstem Chehalis River
and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

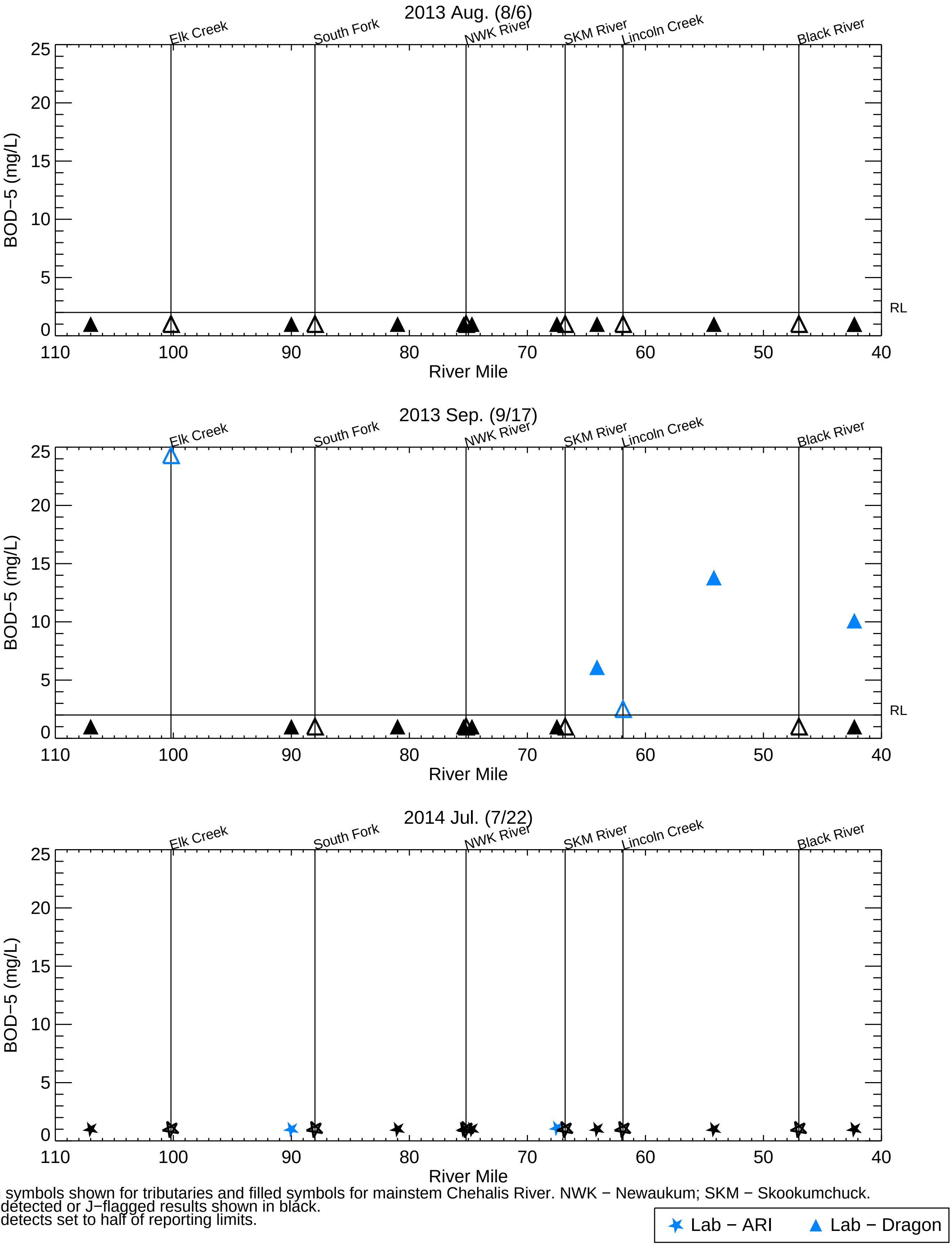


Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.

ANCHOR QEA

Figure 26

Spatial Patterns in Chlorophyll−a in the Mainstem Chehalis River
and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



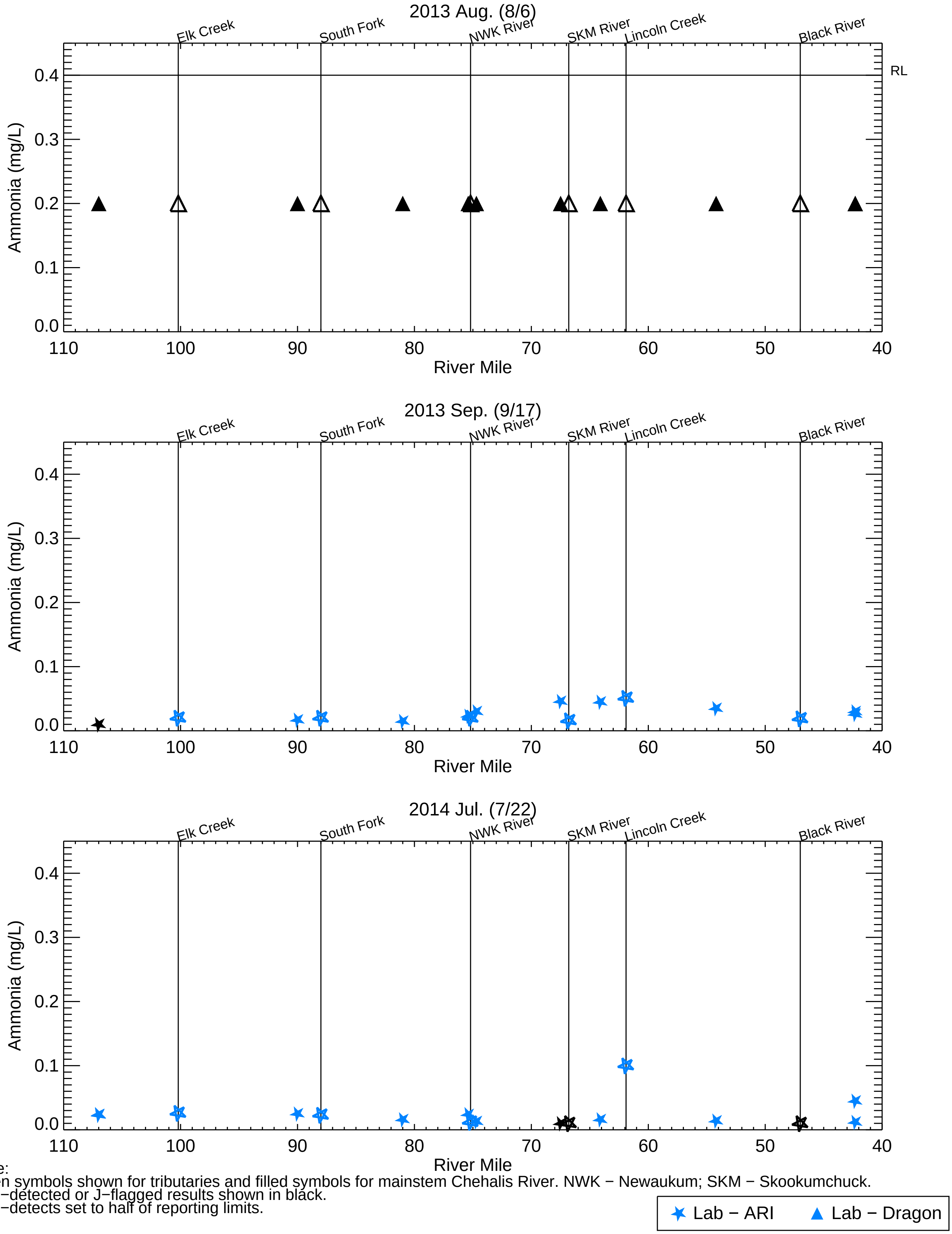
Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

Figure 27

Spatial Patterns in 5−Day Biochemical Oxygen Demand in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys

Water Quality Studies

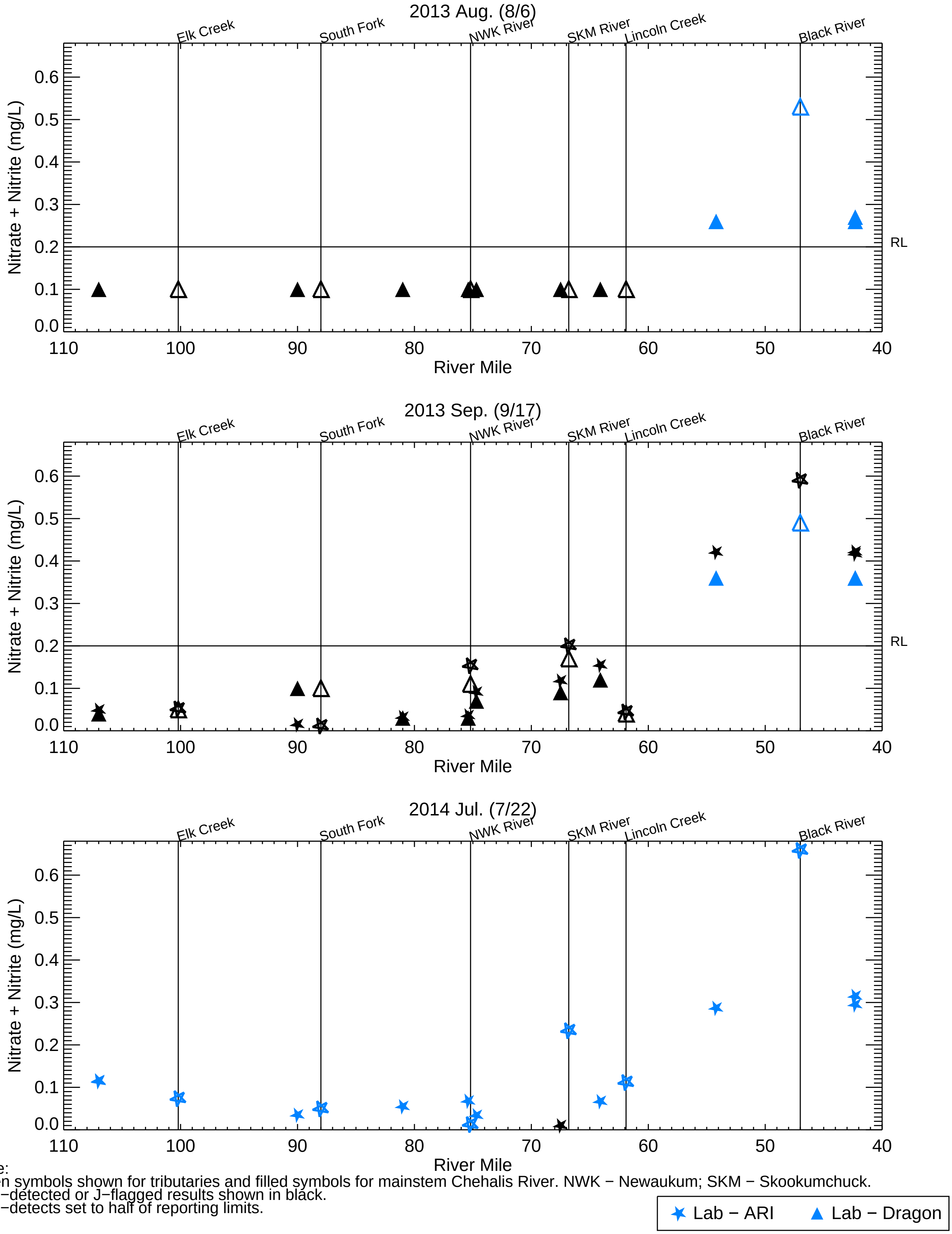
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

Figure 28

Spatial Patterns in Ammonia in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

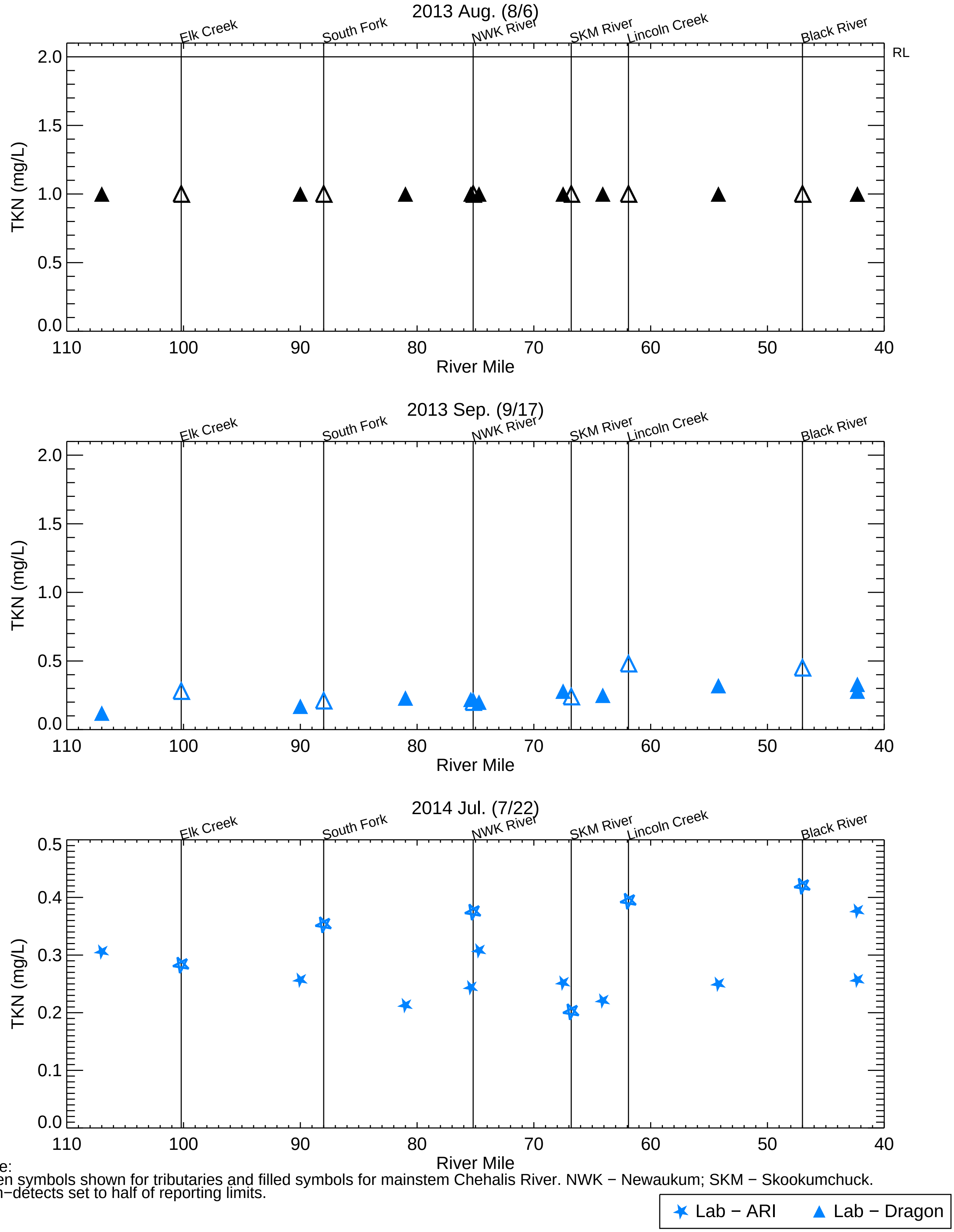


Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

ANCHOR QEA

Figure 29

Spatial Patterns in Nitrite plus Nitrate in the Mainstem Chehalis River
and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



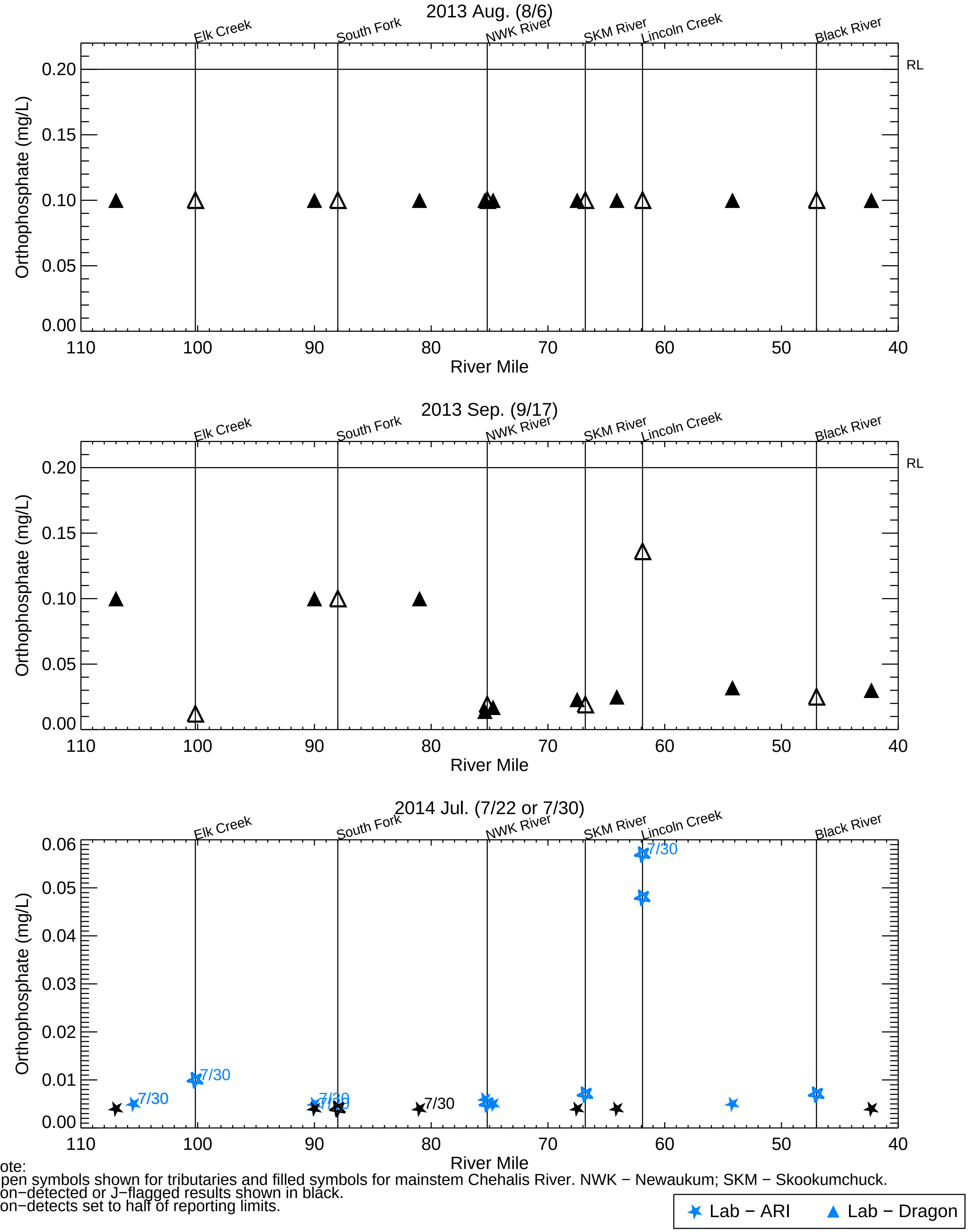
Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detects set to half of reporting limits.

Figure 30

Spatial Patterns in Total Kjeldahl Nitrogen in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys

Water Quality Studies

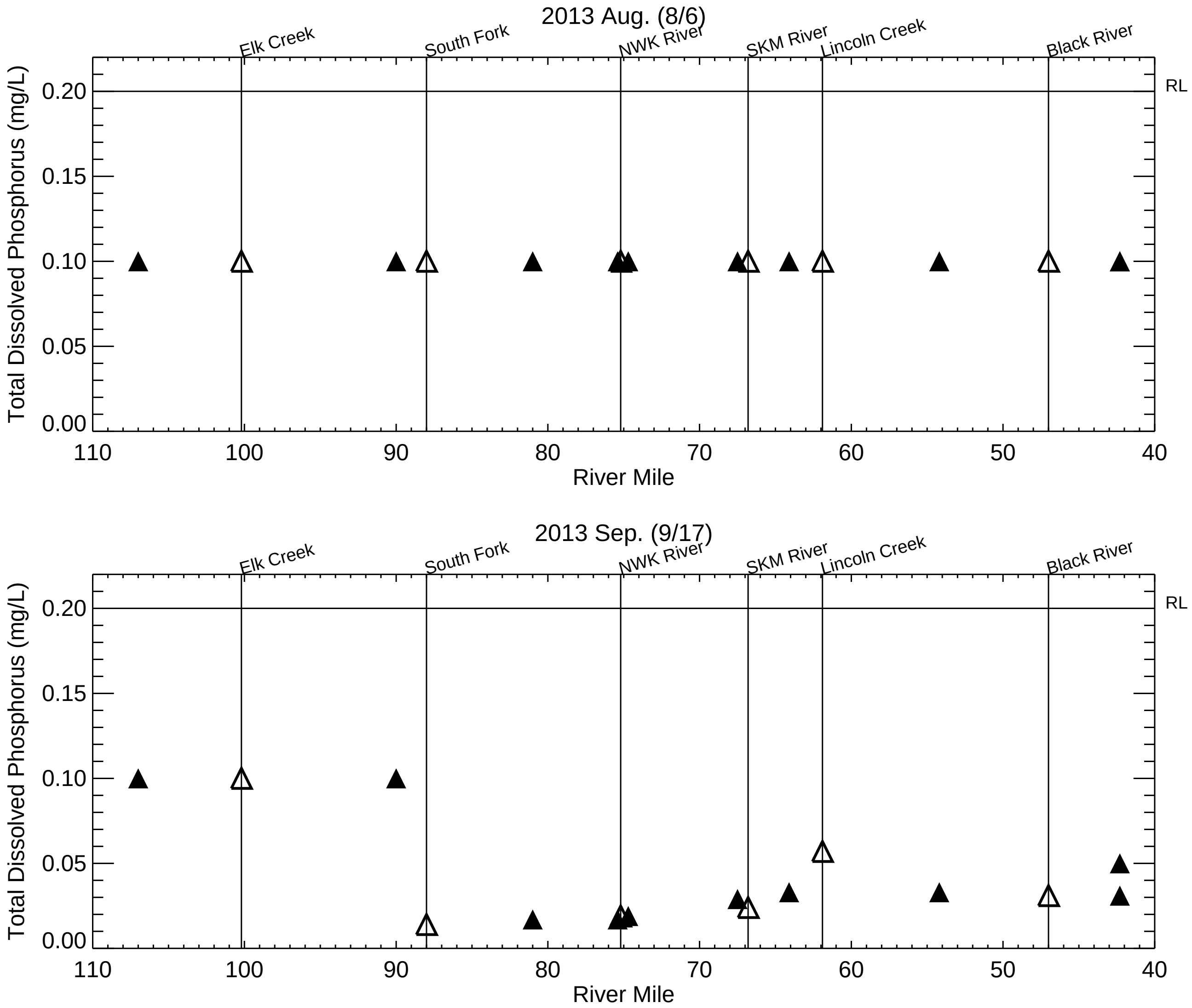
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

Figure 31

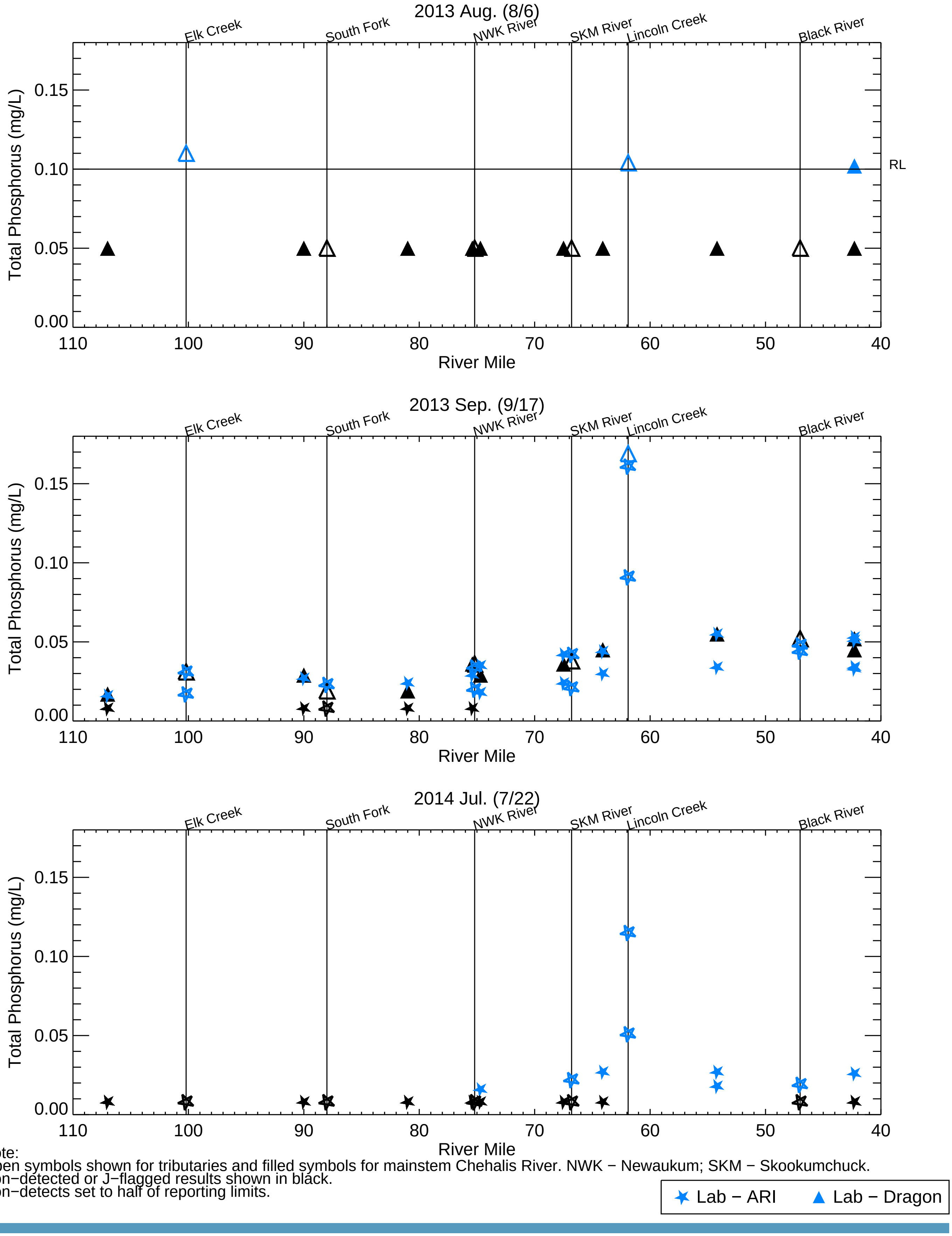
Spatial Patterns in Orthophosphate in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

Figure 32

Spatial Patterns in Total Dissolved Phosphorus in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys



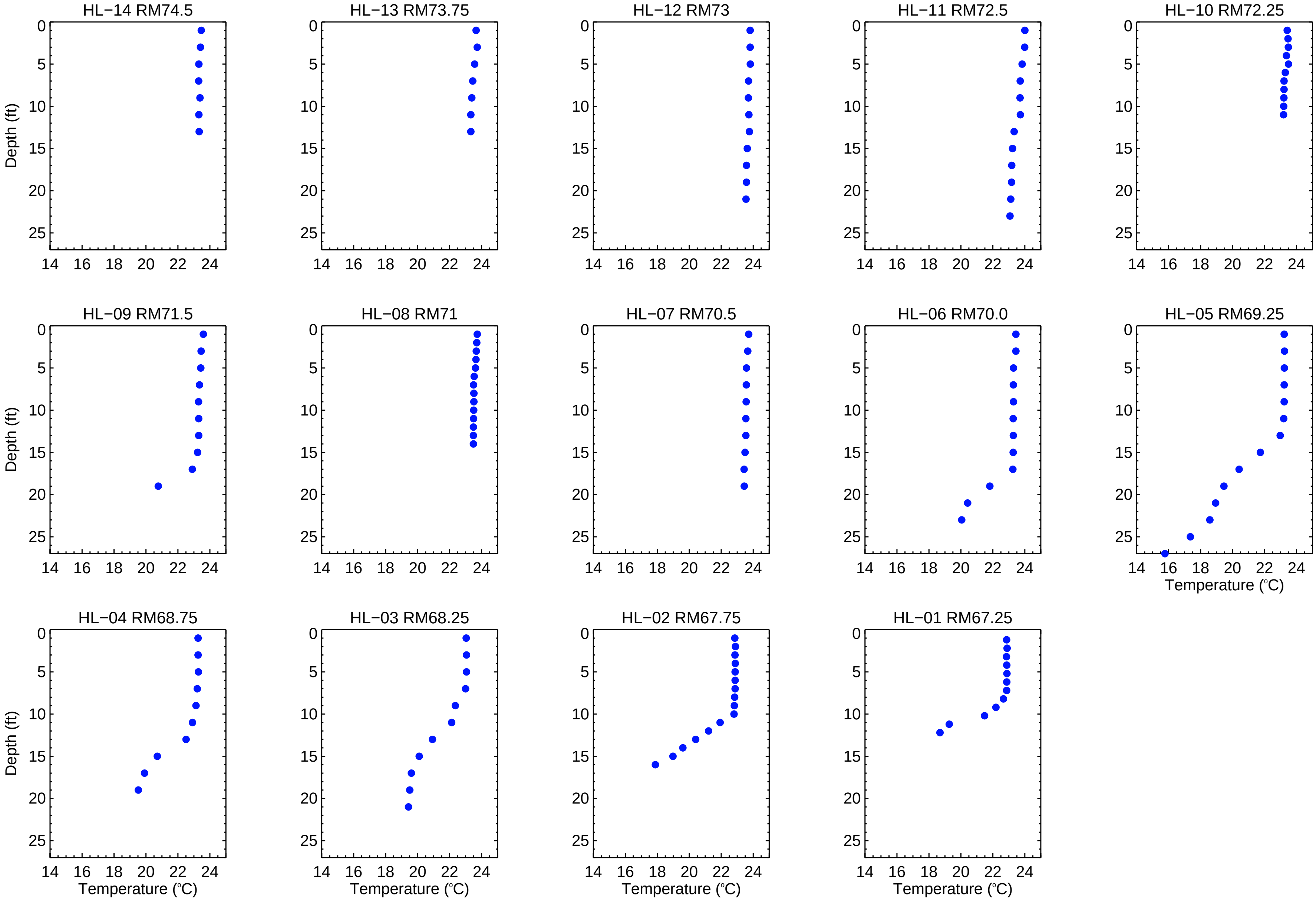
Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Non−detected or J−flagged results shown in black.
Non−detects set to half of reporting limits.

Figure 33

Spatial Patterns in Total Phosphorus in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys

Water Quality Studies

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

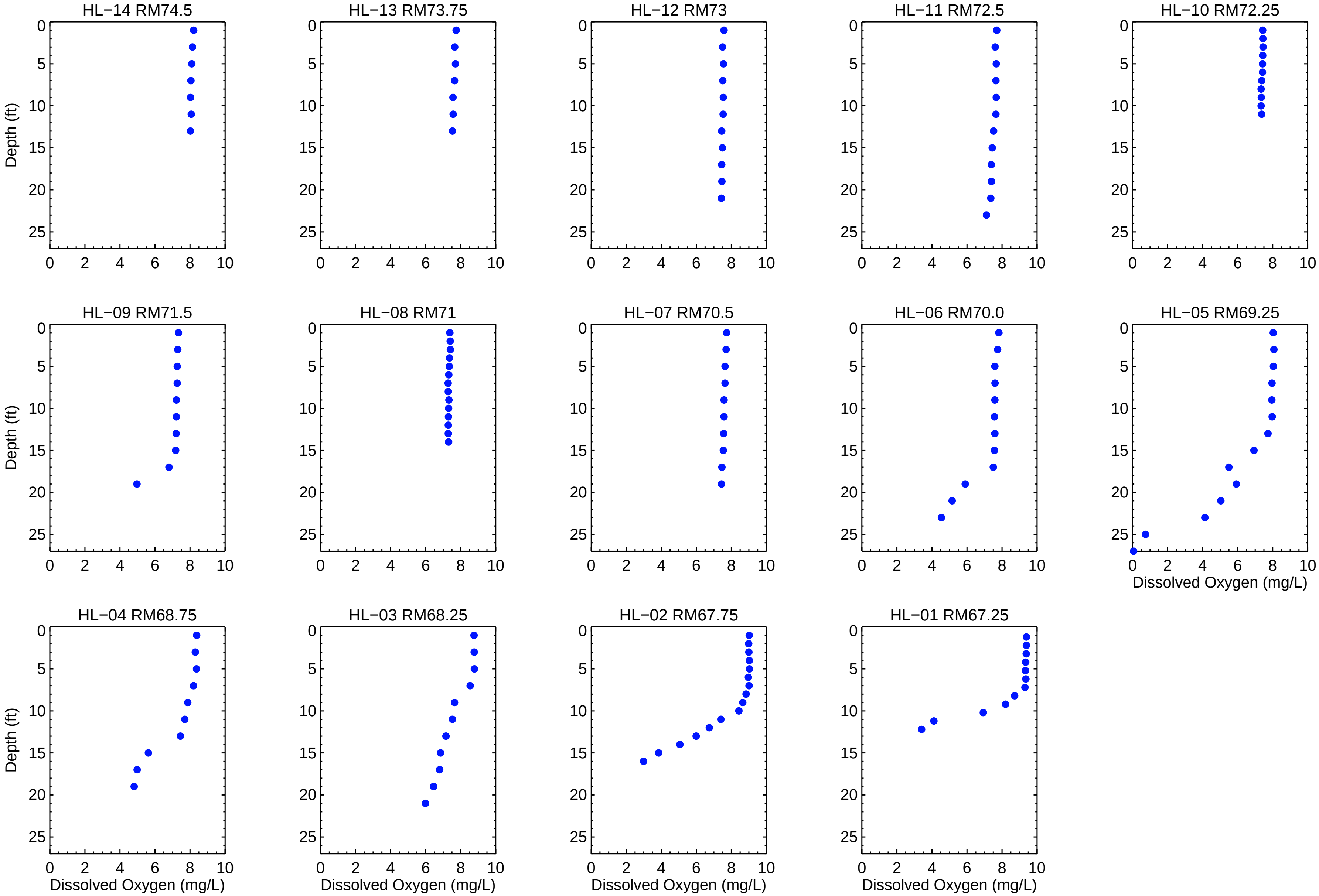


Note:
RM – river mile
Depth profiles were collected on 7/31/2014.

ANCHOR QEA

Figure 34

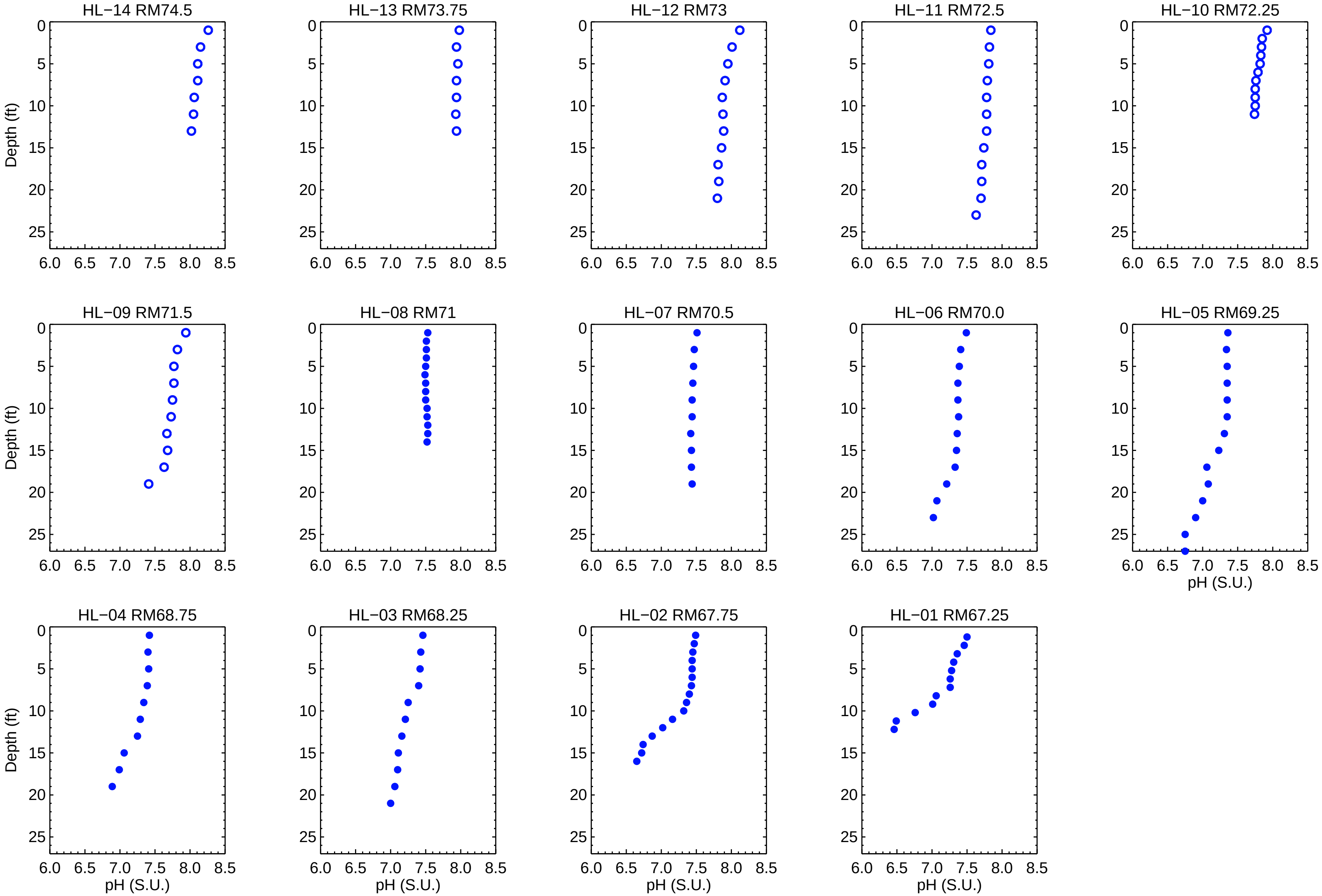
Depth Profiles of Temperature in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM – river mile
Depth profiles were collected on 7/31/2014.

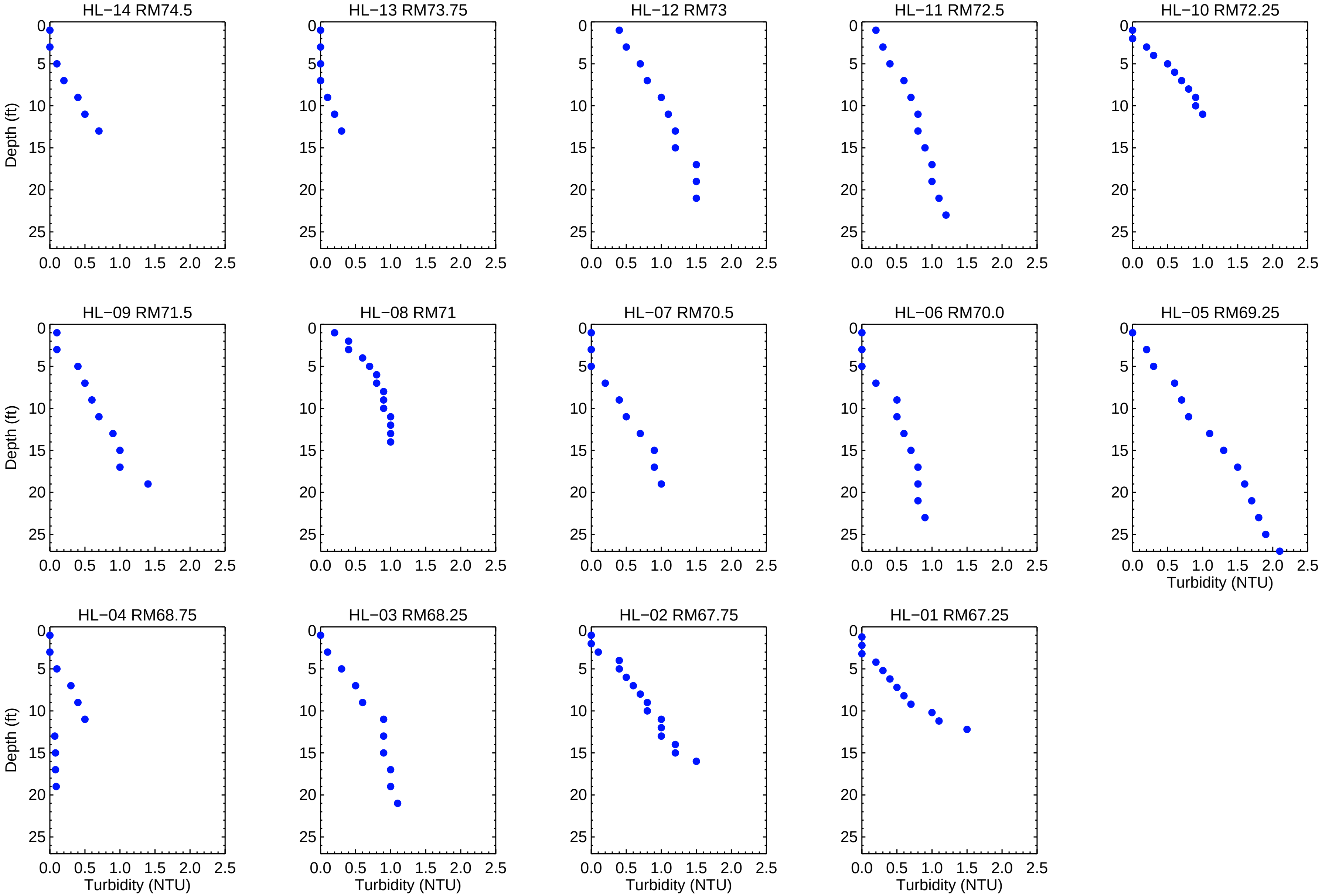
Figure 35

Depth Profiles of Dissolved Oxygen in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



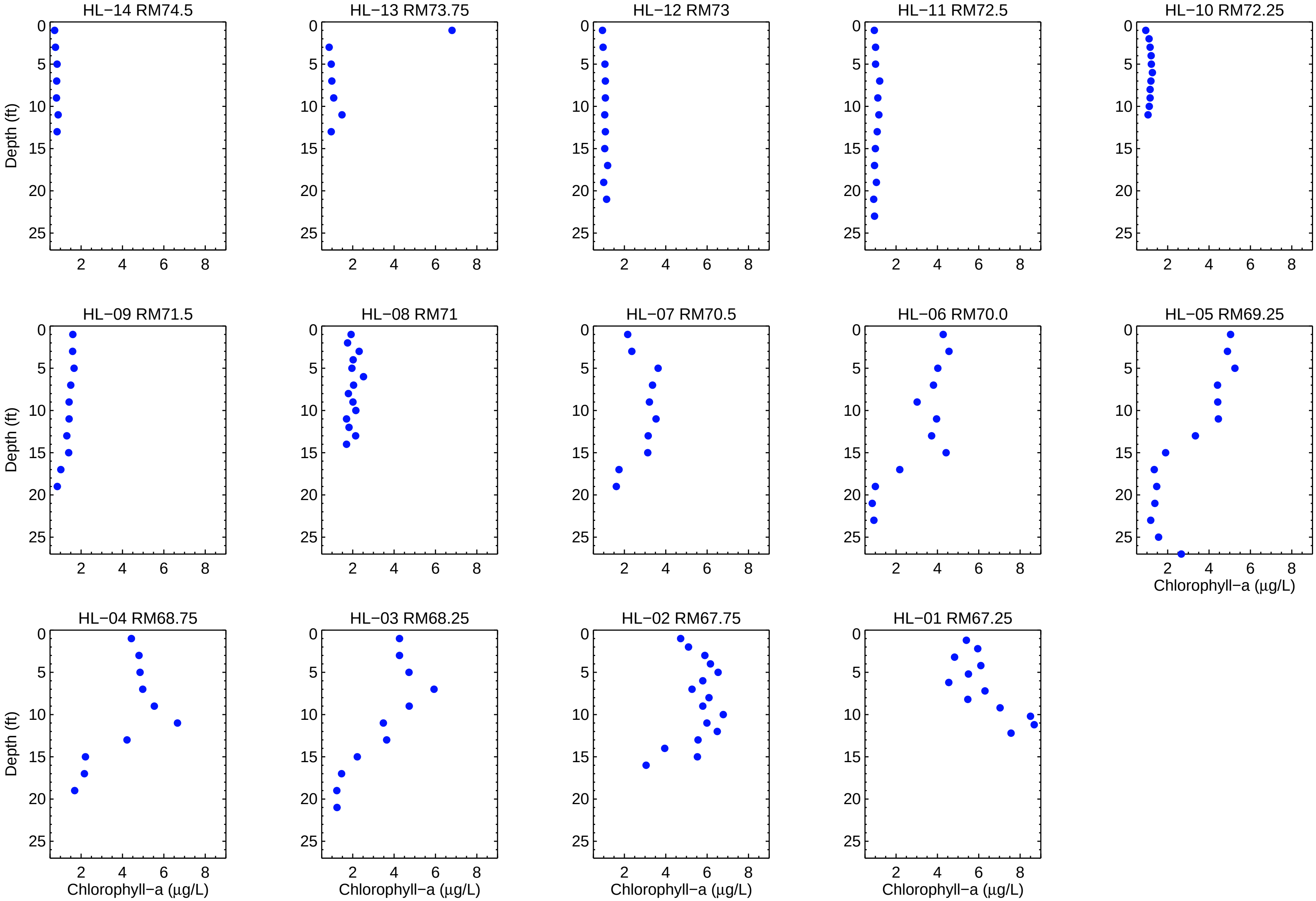
Note:
RM − river mile
Measurements suspected to be affected due to a malfunctioning pH sensor are shown with an open symbol. Depth profiles were collected on 7/31/2014.

Figure 36
Depth Profiles of pH in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Depth profiles were collected on 7/31/2014.

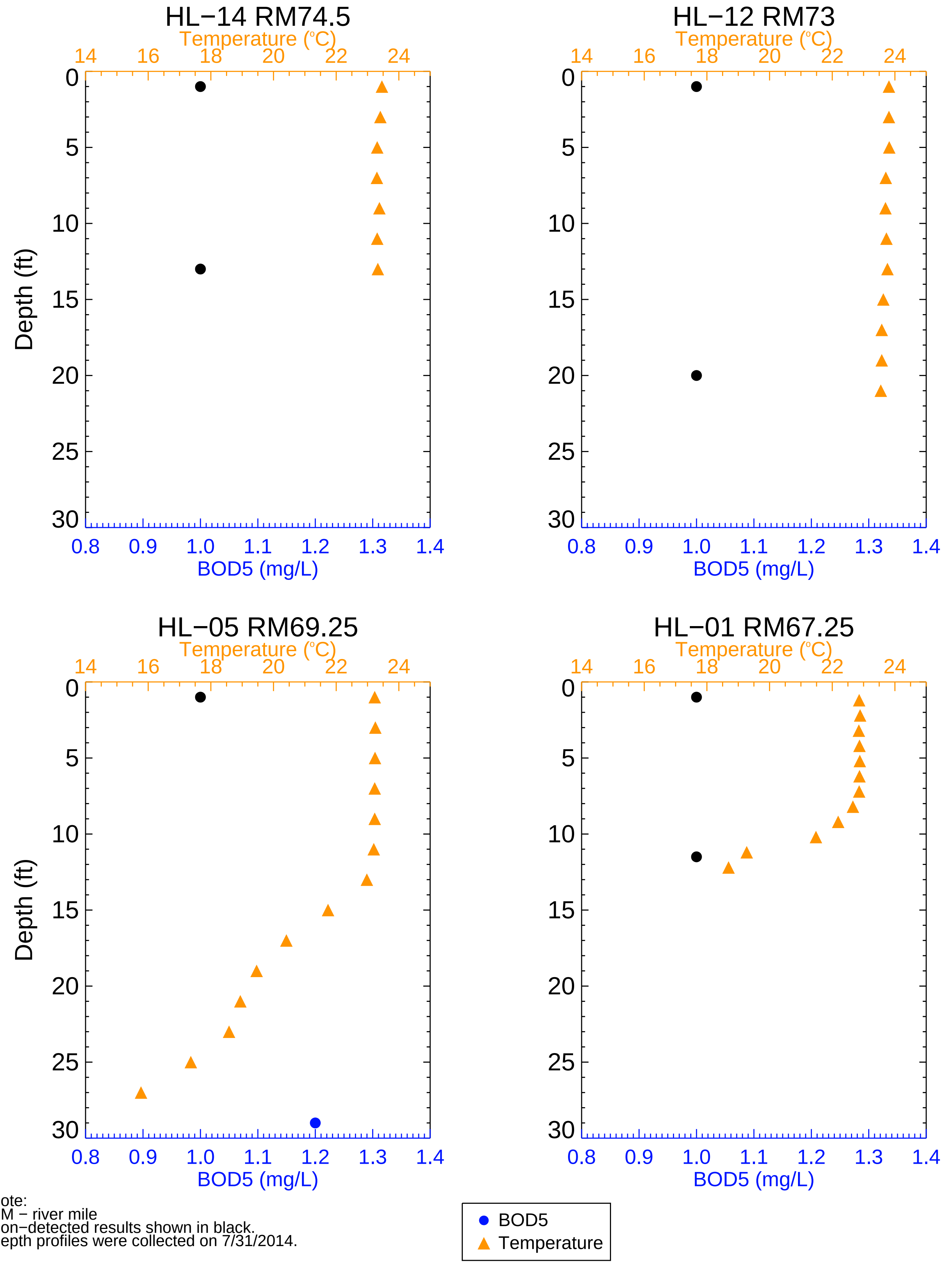
Figure 37
Depth Profiles of Turbidity in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM – river mile
Depth profiles were collected on 7/31/2014.

Figure 38

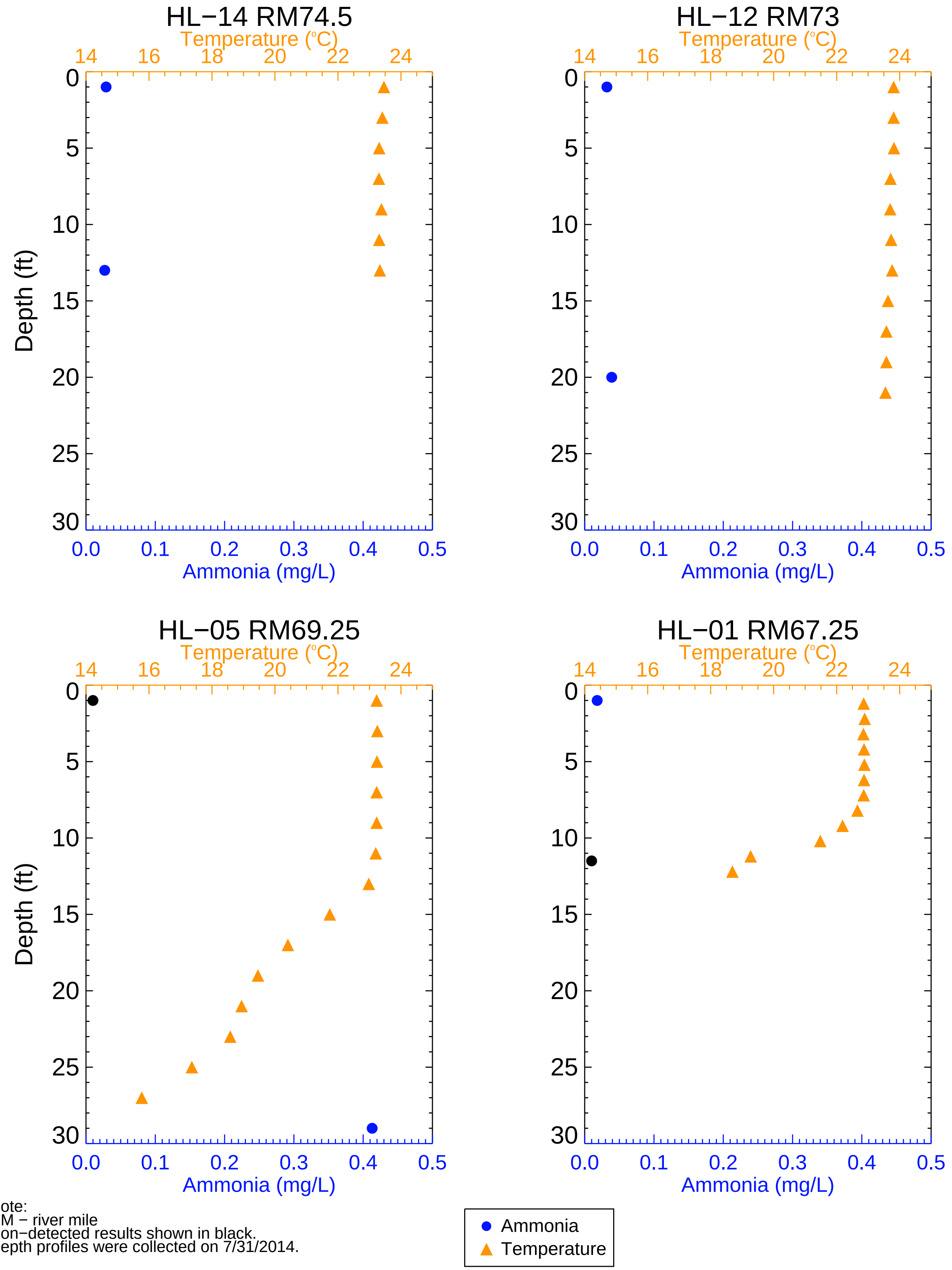
Depth Profiles of Chlorophyll−a in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Non−detected results shown in black.
Depth profiles were collected on 7/31/2014.

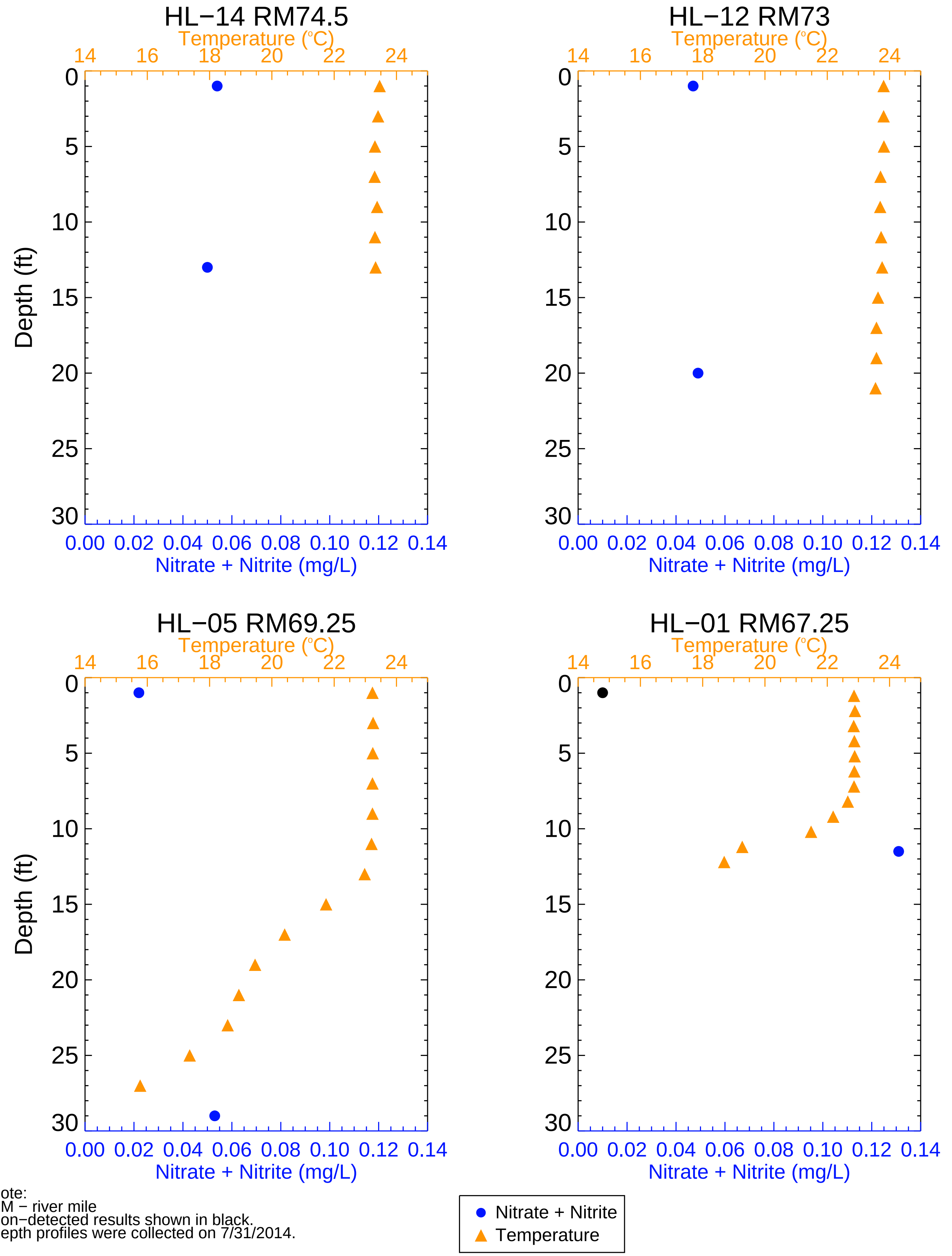
Figure 39

Depth Profiles of 5−Day Biochemical Oxygen Demand in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Non−detected results shown in black.
Depth profiles were collected on 7/31/2014.

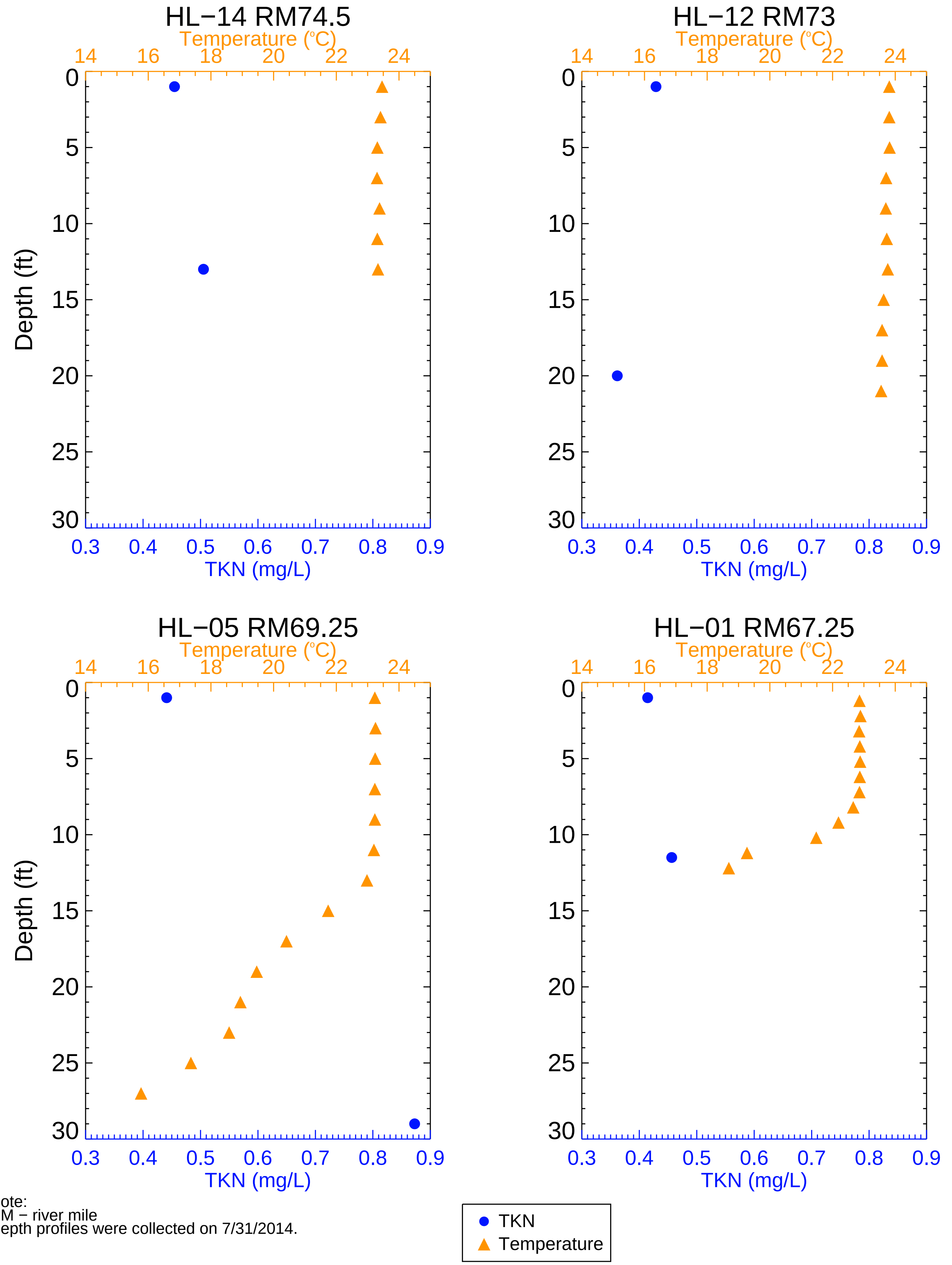
Figure 40
Depth Profiles of Ammonia in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Non−detected results shown in black.
Depth profiles were collected on 7/31/2014.

Figure 41

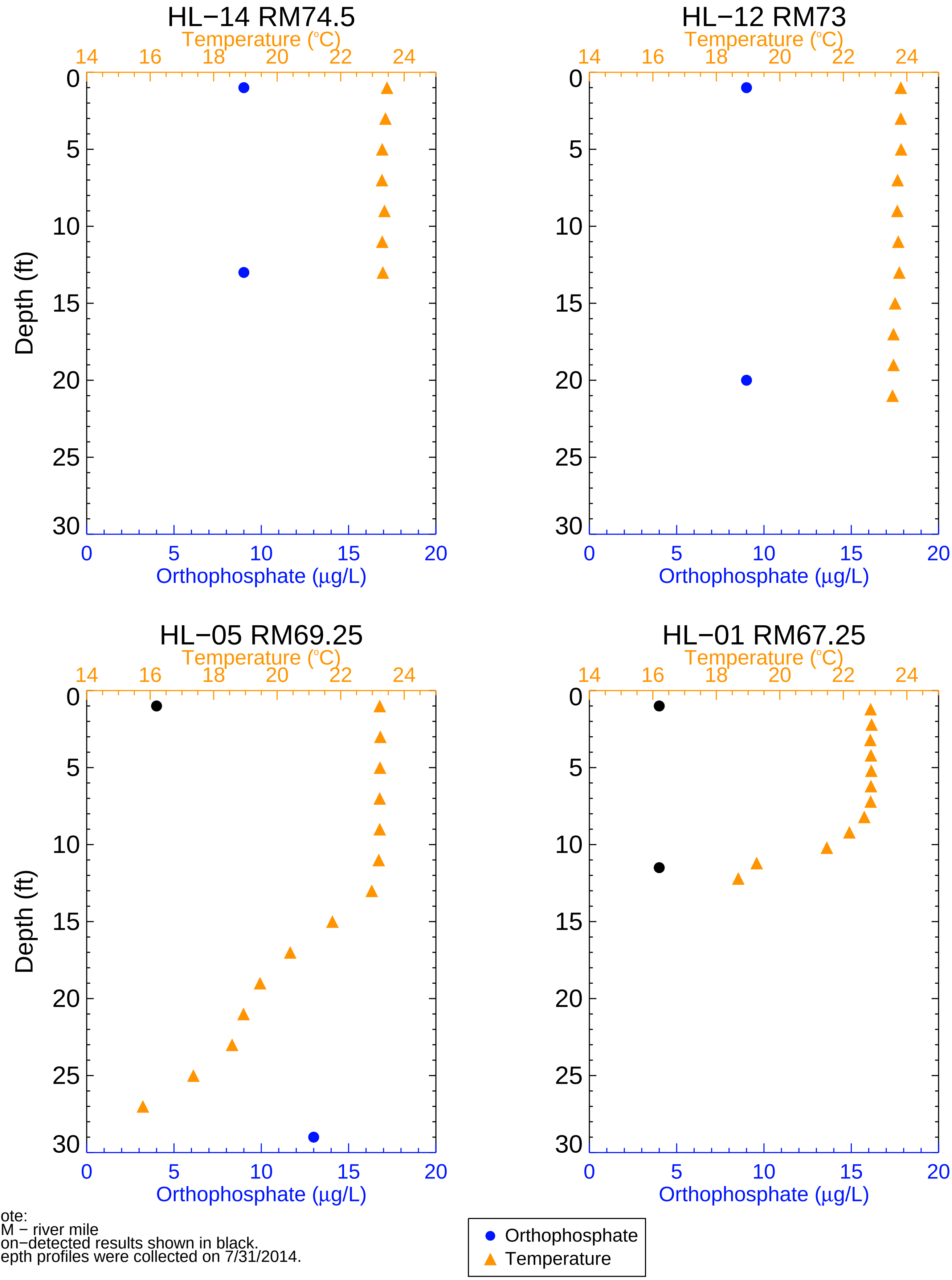
Depth Profiles of Nitrite plus Nitrate in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Depth profiles were collected on 7/31/2014.

Figure 42

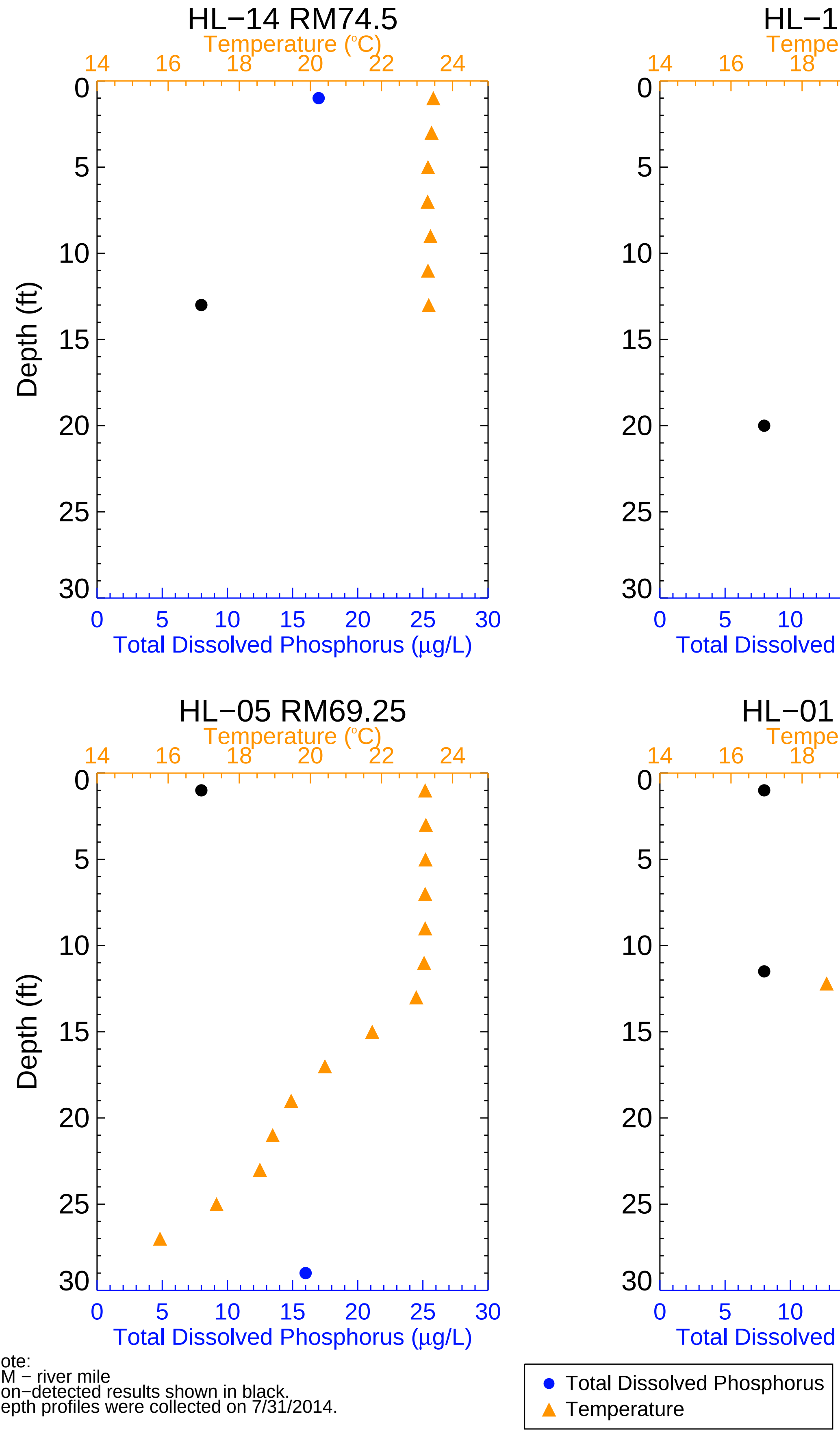
Depth Profiles of Total Kjeldahl Nitrogen in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Non−detected results shown in black.
Depth profiles were collected on 7/31/2014.

Figure 43

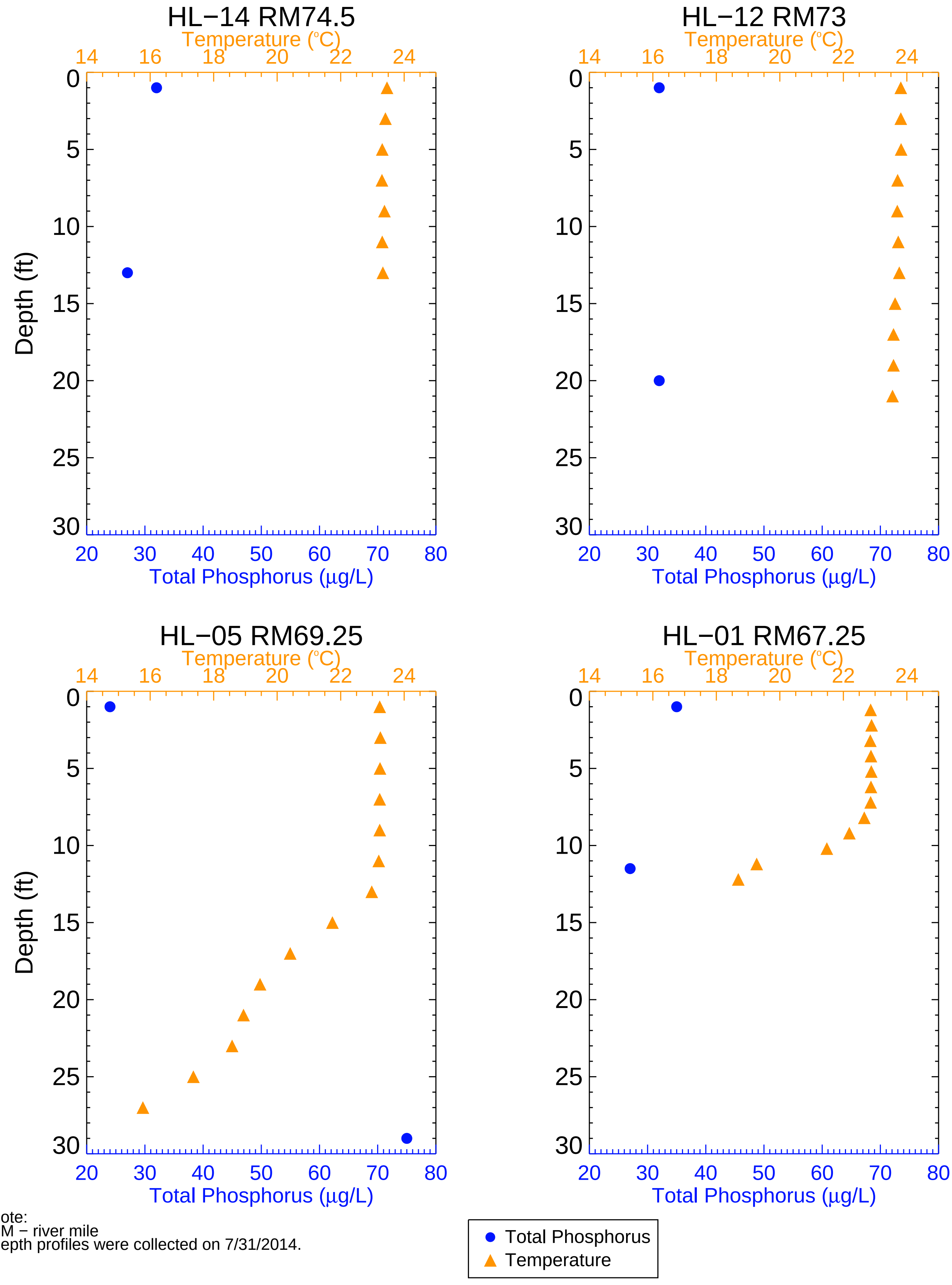
Depth Profiles of Orthophosphate in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Non−detected results shown in black.
Depth profiles were collected on 7/31/2014.

Figure 44

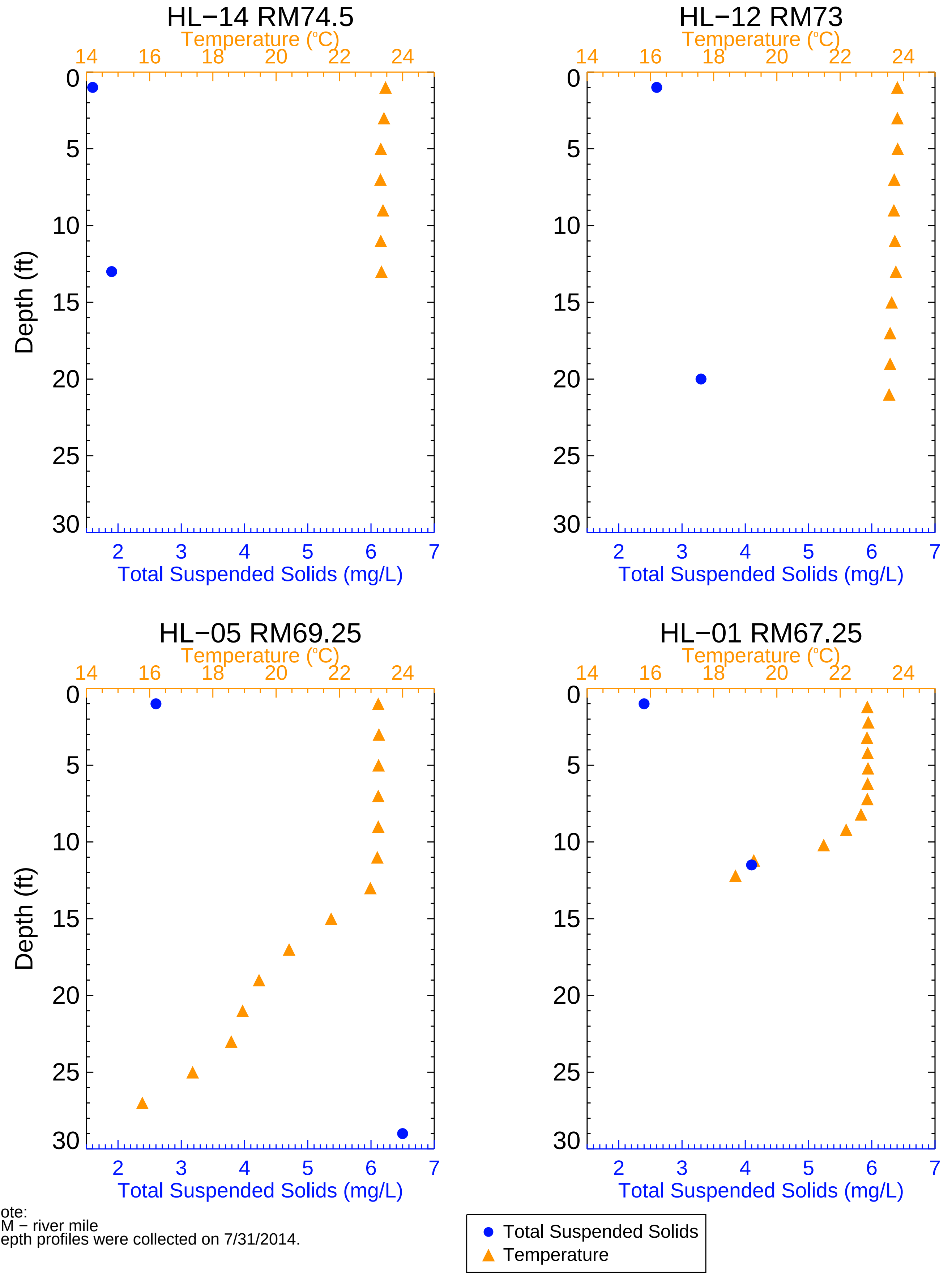
Depth Profiles of Total Dissolved Phosphorus in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Depth profiles were collected on 7/31/2014.

Figure 45

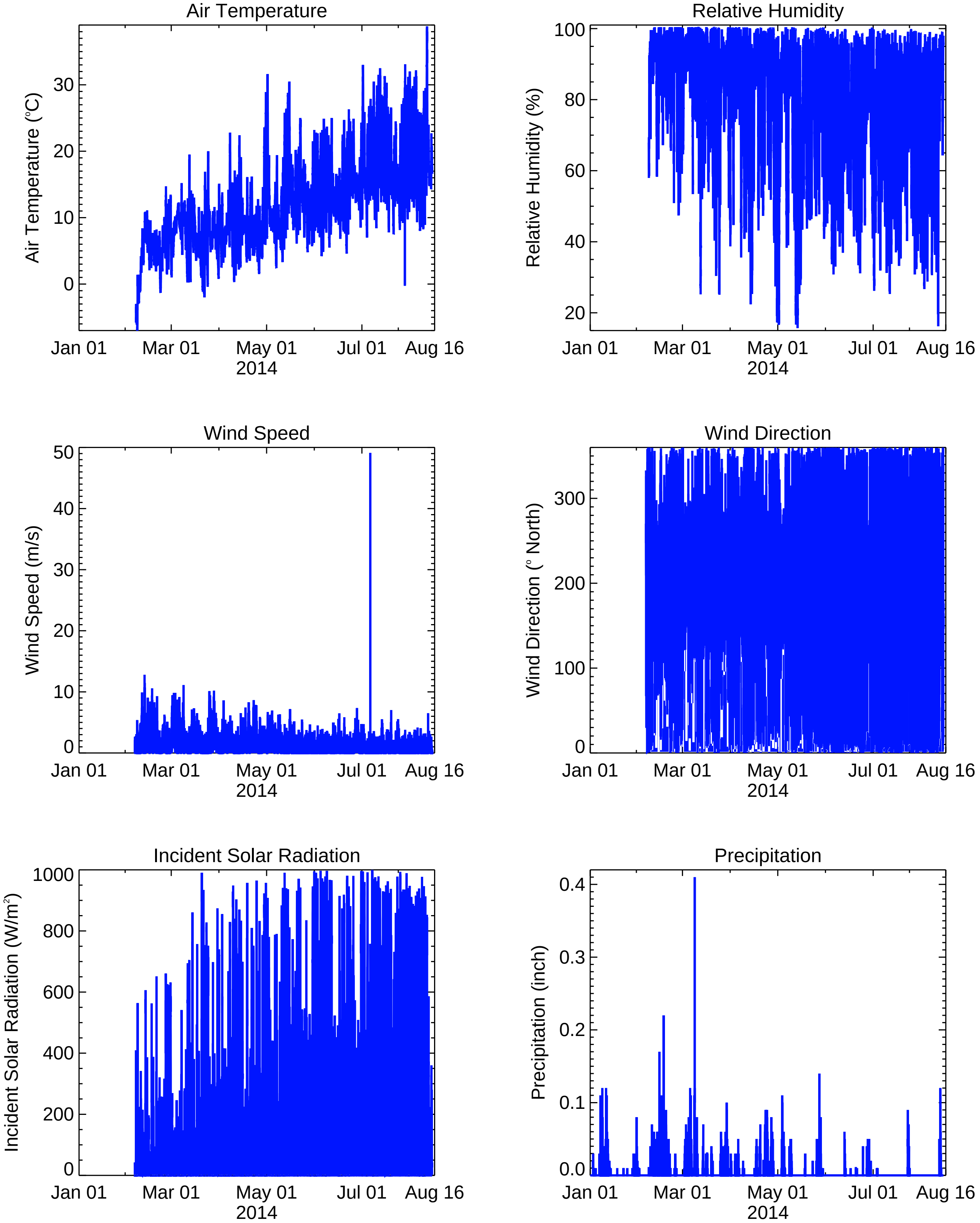
Depth Profiles of Total Phosphorus in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
RM − river mile
Depth profiles were collected on 7/31/2014.

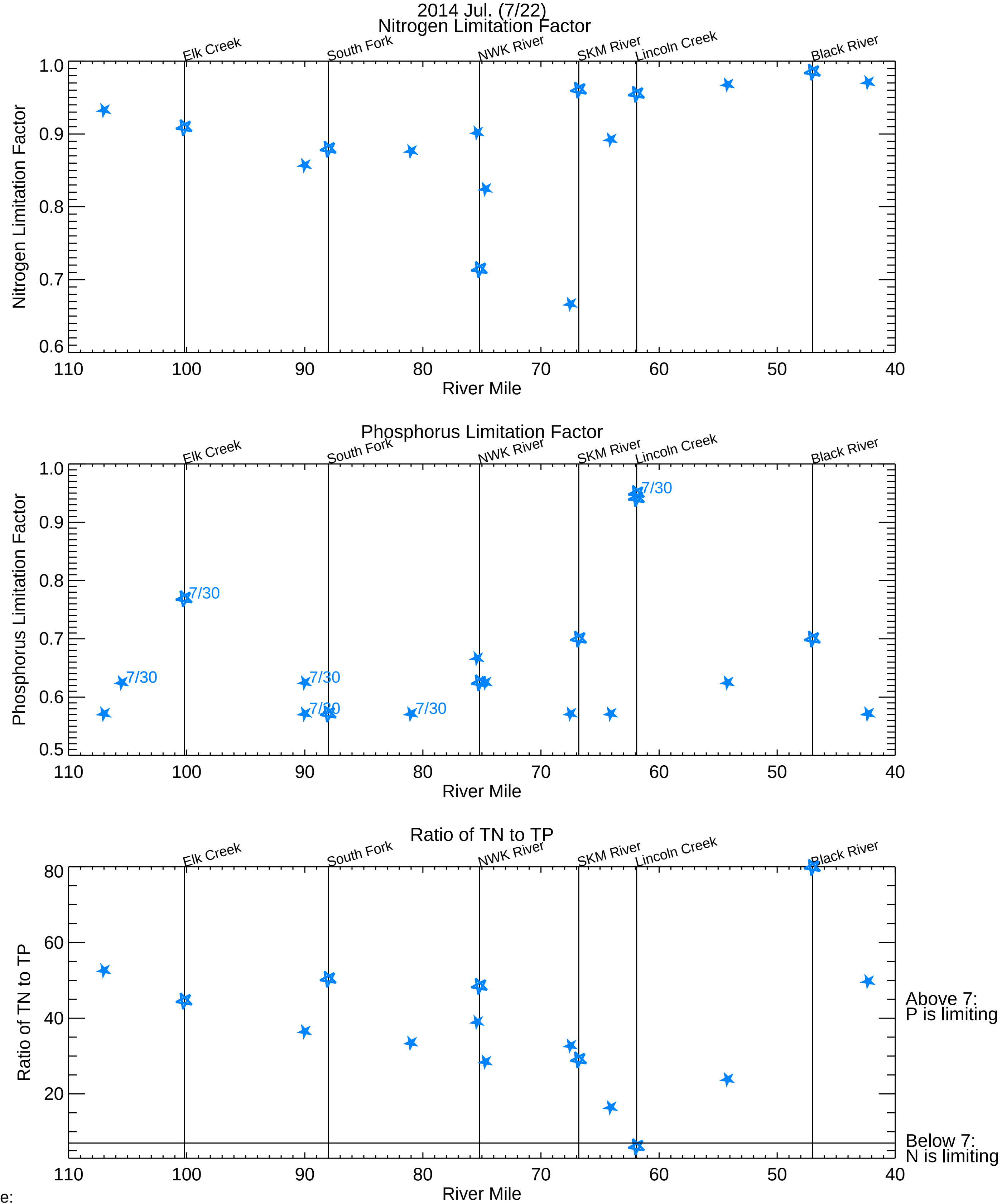
Figure 46

Depth Profiles of Total Suspended Solids in the Centralia Reach
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
W/m² - Watts per square meter

Figure 47
Meteorological Data Collected on the Chehalis River at Thrash Creek
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River. NWK − Newaukum; SKM − Skookumchuck.
Nitrogen limitation factors calculated based on ammonia plus nitrate plus nitrite using Ks of 10 µg/L
Phosphorus limitation factors calculated based on orthophosphate using Ks of 3 µg/L
Ratios of TN to TP calculated based on TN (TKN plus nitrate plus nitrite) and total phosphorus

Figure 48

Spatial Patterns in Nutrient Limitation in the Mainstem Chehalis River and Its TributariesDuring the Summer Low−Flow Surveys
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

Appendix A: Comments on Draft Water Quality Studies Report and Responses

Table A-1
Comments Received on Draft Report and Responses

Comment	Response
Application of Water Quality Standards	
1. The text of sections 5.1 and 5.3.1 should be updated to identify there are supplemental spawning criteria and identify time periods where that criteria is exceeded and include the number of days of exceeding that criteria in Table 9.	The text and table has been updated as suggested.
2. Table 7 should include the supplemental salmon spawning/incubation criteria (13°C) for time periods other than the summer critical period and locations where those apply (see attached spawning23F.pdf).	Table 7 has been updated as indicated.
3. Figure 9 should include the supplemental spawning criteria in addition to the summer temperature criteria already shown.	Figure 9 has been updated to show the supplemental spawning criteria.
4. Figure 14: pH criteria apply year-round, so all the graphs should show the pH upper and lower criteria.	Figure 14 has been updated as suggested.
Analysis of Results	
1. Section 5.5.1.2 discusses substantial gains of all nutrients in the mainstem reach between Lincoln Creek and Black River. A groundwater study of Scatter Creek by Thurston County (Nadine Romero's draft report) and well monitoring data I've seen indicate high concentrations of nitrates in the shallow aquifer underlying Scatter Creek which supports your assertion that groundwater nutrients are likely to be a big part of the increases observed in the mainstem.	A reference to this study has been included in the report.
2. Samples for pH and DO were reportedly not stabilized chemically. This adds variability to the laboratory pH values and makes the DO values unreliable. This should be evaluated and explained in the report.	A statement has been added in Section 5.4.1.3 to note that the field measurements are more reliable for DO and pH.
3. It would be helpful to describe the weather conditions during and for several days prior to the field survey dates. Comparing survey temperature to the range found the summer months of that year, and compared to long-term averages, would provide some context for study results. Also, any antecedent rainfall could have a significant effect on the results, given that the travel time of the river can be up to a week in the Centralia Reach and almost two weeks for the entire system.	Conditions prior to August 2013 and July 2014 low-flow surveys were largely dry. Mild precipitation occurred towards the end of the July low-flow survey. As a result the boat survey which was scheduled for the next day was postponed by a week. The September 2013 low-flow survey was conducted during a dry period, but in the first half of September there were precipitation events that resulted in higher flows in the river overall. We have included references to this precipitation event in relevant sections as noted in the responses below.
4. Where was the Hydrolab at Pe Ell relative to the City of Pe Ell wastewater treatment plant outfall? If the Hydrolab was downstream of the outfall, interpretation of results should take this into account.	The Hydrolab was placed upstream of the plant outfall.
5. The tributary loading in September is notably higher than other surveys. Provide some analysis of this pattern relative to instream flows and antecedent precipitation.	We have included additional discussion as requested.
6. The City of Centralia wastewater plant discharges to the Chehalis River between the Skookumchuck River and Lincoln Creek. This should be evaluated as part of the analysis of spatial patterns.	Figure 8 has been updated to include flows from the City of Centralia treatment plant, to the extent data were available in the discharge monitoring reports. The discussions in the text have been updated to include the effect of the plant's discharge.
Other Comments	
1. Interpreting Figure 8 would be easier if the daily average flow (for the same days shown in the graph) from the Chehalis and Centralia STPs were included at their appropriate RM locations to compare against the increased discharge at RM 60. That would help to visually estimate the contribution to flow from the STPs and from the increase due to groundwater discharge.	We have included flows reported in the DMRs for City of Centralia Sewage Treatment Plant (STP). Flow information was not available for Chehalis STP. In general flows from Centralia STP were a small fraction of the river flows at Grand Mound gage.
2. Will the GIS features and data associated with the points/lines be available in a geodatabase? The data will be very helpful for TMDL effectiveness studies in addition to the next phase water quality modeling.	A GIS shapefile of the locations was provided to Ecology. The database included as one of the project deliverables will contain GPS coordinates of all sampling locations.
3. Meteorological station described on page 11 is not shown in Figure 1.	Figure 1 has been revised to include the meteorological station location.
4. There's a "Figure 1-b" between Figures 11 and 12. It's not clear what these are measuring. If these were lab samples, than they may reflect the problem mentioned in an earlier comment.	This is an error. Figure 1-b was not intended for presentation. The page containing Figure 1-b has been removed.
5. Non-detect values show in Figures should be noted in some way. Are the detection values or half-detection values shown?	Non-detects were set to half of the reporting limits. This is indicated on the figures below the caption.

Table A-1
Comments Received on Draft Report and Responses

Comment	Response
6. Section 5.8.1, p 31: Explain what is meant by “baseline” in this section. Compared to what? This is a system that is currently understood to be impaired by human activities.	"Baseline" in this context refers to the conditions that exist in the river as of now prior to construction of the flood control structure. A clarification has been included in this section.
7. p 31: “The extent to which solar radiation reaches the water is controlled by the riparian cover.” Also by the topography and geomorphology of the channel.	We have edited the text to note the additional factors.
8. P 32: “In the upper reaches, diurnal data suggested that DO could be lower than the criterion (but generally above 8 mg/L) during what appeared to be algal respiration.” Better to say: “…8 mg/L) apparently influenced by temperature variation and algal productivity and respiration.”	Edited as suggested.

Appendix B: Temperature Tidbit Pre-Deployment Calibration

Table B-1
Pre-Deployment Calibration Data for New Tidbits

DATE AND TIME	NIST WATER BATH READING TEMP (°C)	LGR S/N: 10385394		LGR S/N: 10385395		LGR S/N: 10385396		LGR S/N: 10385397		LGR S/N: 10385398		LGR S/N: 10385399		LGR S/N: 10385400		LGR S/N: 10385401		LGR S/N: 10385402		LGR S/N: 10385403		LGR S/N: 10385404		LGR S/N: 10385405	
		READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)
Cold Water Bath																									
7/25/2013 17:20	1.7	2.5	0.8	2.4	0.7	2.5	0.8	2.4	0.7	2.4	0.7	2.3	0.6	2.5	0.8	2.4	0.7	2.4	0.7	2.5	0.8	2.4	0.7	2.3	0.6
7/25/2013 17:25	1.8	2.4	0.6	2.4	0.6	2.4	0.6	2.4	0.6	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.3	0.5
7/25/2013 17:30	1.8	2.5	0.7	2.4	0.6	2.5	0.7	2.4	0.6	2.3	0.5	2.3	0.5	2.5	0.7	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.4	0.6
7/25/2013 17:35	1.9	2.5	0.6	2.5	0.6	2.5	0.6	2.5	0.6	2.4	0.5	2.4	0.5	2.5	0.6	2.4	0.5	2.4	0.5	2.4	0.5	2.4	0.5	2.5	0.6
7/25/2013 17:40	1.8	2.5	0.7	2.4	0.6	2.5	0.7	2.4	0.6	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5
7/25/2013 17:45	1.8	2.5	0.7	2.4	0.6	2.5	0.7	2.4	0.6	2.3	0.5	2.3	0.5	2.5	0.7	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.4	0.6
7/25/2013 17:50	1.8	2.5	0.7	2.4	0.6	2.4	0.6	2.4	0.6	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5
7/25/2013 17:55	1.9	2.5	0.6	2.4	0.5	2.5	0.6	2.4	0.5	2.3	0.4	2.3	0.4	2.4	0.5	2.3	0.4	2.3	0.4	2.3	0.4	2.3	0.4	2.4	0.5
7/25/2013 18:00	1.8	2.5	0.7	2.4	0.6	2.4	0.6	2.4	0.6	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5
Warm Water Bath																									
7/25/2013 16:15	20.5	21.0	0.5	20.9	0.4	21.0	0.5	21.0	0.5	20.9	0.4	20.9	0.4	21.0	0.5	20.9	0.4	20.9	0.4	21.0	0.5	20.9	0.4	20.9	0.4
7/25/2013 16:20	20.5	21.0	0.5	20.9	0.4	20.9	0.4	20.9	0.4	20.9	0.4	20.8	0.3	20.9	0.4	20.8	0.3	20.9	0.4	20.9	0.4	20.9	0.4	20.9	0.4
7/25/2013 16:25	20.5	21.0	0.5	20.9	0.4	20.9	0.4	20.9	0.4	20.9	0.4	20.8	0.3	20.9	0.4	20.9	0.4	20.9	0.4	20.9	0.4	20.9	0.4	20.9	0.4
7/25/2013 16:30	20.6	21.0	0.5	20.9	0.4	21.0	0.4	20.9	0.4	20.9	0.4	20.9	0.3	21.0	0.4	20.9	0.3	20.9	0.4	21.0	0.4	20.9	0.4	20.9	0.4
7/25/2013 16:35	20.6	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4	20.9	0.3	21.0	0.4	20.9	0.3	20.9	0.3	21.0	0.4	20.9	0.3	21.0	0.4
7/25/2013 16:40	20.6	21.1	0.5	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4	20.9	0.3	21.0	0.4	20.9	0.3	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4
7/25/2013 16:45	20.6	21.1	0.5	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4	20.9	0.3	21.0	0.4	20.9	0.3	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4
7/25/2013 16:50	20.6	21.1	0.5	21.0	0.4	21.1	0.4	21.0	0.4	21.0	0.4	21.0	0.4	21.1	0.4	21.0	0.4	21.0	0.4	21.1	0.4	21.0	0.4	21.0	0.4
7/25/2013 16:55	20.6	21.1	0.5	21.1	0.4	21.1	0.4	21.1	0.4	21.0	0.4	21.0	0.3	21.1	0.4	21.0	0.3	21.0	0.4	21.1	0.4	21.0	0.4	21.1	0.4
7/25/2013 17:00	20.7	21.1	0.4	21.1	0.4	21.1	0.4	21.1	0.4	21.1	0.4	21.0	0.3	21.1	0.4	21.0	0.3	21.1	0.4	21.1	0.4	21.1	0.4	21.1	0.4
Average Difference			0.6		0.5		0.5		0.5		0.4		0.4		0.5		0.4		0.4		0.5		0.4		0.5
Correction Based on King County's Reference Thermometer			-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4
Corrected Average Difference			0.2		0.1		0.1		0.1		0.0		0.0		0.1		0.0		0.0		0.1		0.0		0.1

Notes:

°C = degrees Centigrade

NIST = National Institute of Standards and Technology

Table B-2

Pre-Deployment Calibration Data for 2012 Tidbits

DATE AND TIME	NIST WATER BATH READING TEMP (°C)	LGR S/N: 9800555		LGR S/N: 98005556		LGR S/N: 9800557		LGR S/N: 9800558		LGR S/N: 9800560		LGR S/N: 9800561		LGR S/N: 9800562		LGR S/N: 9800564		LGR S/N: 9800569		LGR S/N: 9800570Water	
		READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)	READING (°C)	DIFF. (°C)
Cold Water Bath																					
7/25/2013 17:20	1.7	2.3	0.6	2.4	0.7	2.3	0.6	2.3	0.6	2.3	0.6	2.4	0.7	2.3	0.6	2.4	0.7	2.4	0.7	2.4	0.7
7/25/2013 17:25	1.8	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.4	0.6	2.4	0.6	2.4	0.6
7/25/2013 17:30	1.8	2.4	0.6	2.4	0.6	2.4	0.6	2.3	0.5	2.3	0.5	2.5	0.7	2.3	0.5	2.5	0.7	2.4	0.6	2.4	0.6
7/25/2013 17:35	1.9	2.4	0.5	2.5	0.6	2.4	0.5	2.4	0.5	2.3	0.4	2.5	0.6	2.4	0.5	2.5	0.6	2.5	0.6	2.5	0.6
7/25/2013 17:40	1.8	2.4	0.6	2.4	0.6	2.3	0.5	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.4	0.6	2.4	0.6	2.4	0.6
7/25/2013 17:45	1.8	2.4	0.6	2.4	0.6	2.3	0.5	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.4	0.6	2.4	0.6	2.4	0.6
7/25/2013 17:50	1.8	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.4	0.6	2.4	0.6	2.4	0.6
7/25/2013 17:55	1.9	2.4	0.5	2.4	0.5	2.4	0.5	2.3	0.4	2.3	0.4	2.5	0.6	2.3	0.4	2.4	0.5	2.5	0.6	2.4	0.5
7/25/2013 18:00	1.8	2.3	0.5	2.3	0.5	2.3	0.5	2.3	0.5	2.2	0.4	2.3	0.5	2.3	0.5	2.4	0.6	2.3	0.5	2.3	0.5
Warm Water Bath																					
7/25/2013 16:15	20.5	20.9	0.4	20.8	0.3	20.9	0.4	20.8	0.3	20.8	0.3	20.9	0.4	20.8	0.3	20.9	0.4	20.9	0.4	20.9	0.4
7/25/2013 16:20	20.5	20.9	0.4	20.8	0.3	20.9	0.4	20.8	0.3	20.8	0.3	20.9	0.4	20.8	0.3	20.9	0.4	20.9	0.4	20.9	0.4
7/25/2013 16:25	20.5	20.9	0.4	20.9	0.4	20.9	0.4	20.8	0.3	20.8	0.3	20.9	0.4	20.8	0.3	20.9	0.4	21.0	0.5	20.9	0.4
7/25/2013 16:30	20.6	20.9	0.4	20.9	0.3	20.9	0.3	20.9	0.3	20.9	0.3	20.9	0.4	20.9	0.3	21.0	0.4	21.0	0.4	21.0	0.4
7/25/2013 16:35	20.6	20.9	0.3	20.9	0.3	20.9	0.3	20.9	0.3	20.9	0.3	21.0	0.4	20.9	0.3	21.0	0.4	21.0	0.4	21.0	0.4
7/25/2013 16:40	20.6	21.0	0.4	20.9	0.3	20.9	0.3	20.9	0.3	20.9	0.3	21.0	0.4	20.9	0.3	21.0	0.4	21.0	0.4	21.0	0.4
7/25/2013 16:45	20.6	21.0	0.4	21.0	0.4	21.0	0.4	20.9	0.3	20.9	0.3	21.0	0.4	20.9	0.3	21.0	0.4	21.1	0.5	21.0	0.4
7/25/2013 16:50	20.6	21.0	0.4	21.0	0.4	21.0	0.4	21.0	0.4	20.9	0.3	21.0	0.4	21.0	0.4	21.1	0.4	21.1	0.5	21.1	0.4
7/25/2013 16:55	20.6	21.0	0.4	21.0	0.3	21.0	0.4	21.0	0.3	21.0	0.3	21.0	0.4	21.0	0.3	21.1	0.4	21.1	0.5	21.1	0.4
7/25/2013 17:00	20.7	21.1	0.4	21.0	0.3	21.0	0.3	21.0	0.3	21.0	0.3	21.1	0.4	21.0	0.3	21.1	0.4	21.1	0.4	21.1	0.4
Average Difference			0.5		0.4		0.4		0.4		0.4		0.5		0.4		0.5		0.5		0.5
Correction Based on King County's Reference Thermometer			-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4		-0.4
Corrected Average Difference			0.1		0.0		0.0		0.0		0.0		0.1		0.0		0.1		0.1		0.1

Notes:

°C = degrees Centigrade

NIST = National Institute of Standards and Technology

Table B-3
Simulataneous Temperatures Recorded by the Reference Thermometer Used in This Study Against the King County Reference Thermometer

TEMPERATURE (°C)		
ANCHOR QEA's REFERENCE THERMOMETER	KING COUNTY STANDARD THERMOMETER	DIFFERENCE
2.7	3	-0.3
3.8	4.1	-0.3
4.7	5	-0.3
9.7	10.1	-0.4
10.4	10.8	-0.4
10.6	11.1	-0.5
10.8	11.2	-0.4
11	11.4	-0.4
11.1	11.6	-0.5
11.8	12.2	-0.4
12.2	12.6	-0.4
12.6	13	-0.4
13.2	13.6	-0.4
13.3	13.7	-0.4
14.7	15	-0.3
14.7	15.1	-0.4
15.7	16.1	-0.4
16.4	16.8	-0.4
17.2	17.4	-0.2
17.3	17.6	-0.3
18	18.3	-0.3
18.2	18.5	-0.3
22.3	22.6	-0.3
Average Difference		-0.4

Note:

°C = degrees Centigrade

Appendix C: Chain-of-Custody Forms for Low-Flow Synoptic Surveys

Chain of Custody Record & Laboratory Analysis Request DAL# B0807-01 COC# Page 1 of 2

ANCHOR QEA

Date: 8/7/13
Laboratory : **Dragon Laboratory**
Project Name: **Chehalis River**
Project Number: **1310023-01.01**
Project Manager: **David Gillingham**
Phone Number: **206-287-9130**
Shipment Method: Hand delivered

Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers	Total suspended solids (TSS)	Biochemical oxygen demand (BOD-5)	Total Kjeldahl nitrogen (TKN)	Ammonia	Nitrite plus nitrate	total Phosphorus (TP)	Orthophosphate	total dissolved phosphorus	Chlorophyll-a	Comments
1	PE-ELL-US-130806 1	2013-08-06 07:18	Water	5	X	X	X	X	X	X	X	X	X	
2	ELK-CRK-130806 2	2013-08-06 08:03	Water	5	X	X	X	X	X	X	X	X	X	
3	CHL-US-SF-130806 3	2013-08-06 08:55	Water	5	X	X	X	X	X	X	X	X	X	
4	SF-CHL-MOUTH-130806 4	2013-08-06 09:57	Water	5	X	X	X	X	X	X	X	X	X	Bottles say 10:57 for time
5	ADNA-130806 5	2013-08-06 10:37	Water	5	X	X	X	X	X	X	X	X	X	
6	CHL-US-NWK-130806 6	2013-08-06 11:27	Water	5	X	X	X	X	X	X	X	X	X	
7	NWK-MOUTH-130806 7	2013-08-06 12:19	Water	5	X	X	X	X	X	X	X	X	X	
8	CHL-RT6-BR-130806 8	2013-08-06 12:45	Water	5	X	X	X	X	X	X	X	X	X	
9	CHL-US-SKM-130806 9	2013-08-06 13:30	Water	5	X	X	X	X	X	X	X	X	X	
10	SKM-MOUTH-130806 10	2013-08-06 14:15	Water	5	X	X	X	X	X	X	X	X	X	
11	CHL-AT-GALVIN-130806 11	2013-08-06 14:55	Water	5	X	X	X	X	X	X	X	X	X	
12	LNC-CRK-130806 12	2013-08-06 15:40	Water	5	X	X	X	X	X	X	X	X	X	

1 See SAP Table 2 for analyte lists and test methods

Additional notes/comments:

Relinquished By: David Gillingham 8/7/13 0800
Company: Anchor QEA LLC.
Signature/Printed Name Date/Time

Received By: 8/7/13 8:00
Company:
Signature/Printed Name Date/Time

Relinquished By:
Company:
Signature/Printed Name Date/Time

Received By:
Company:
Signature/Printed Name Date/Time

Distribution: A copy will be made for the laboratory and client. The Project file will retain the original.

Page ______ of _____

Chain of Custody Record & Laboratory Analysis Request DAL # 130807-01 **COC#** Page 2 of 2

ANCHOR QEA

Date: 8/7/13
Laboratory : **Dragon Laboratory**
Project Name: **Chehalis River**
Project Number: **1310023-01.01**
Project Manager: **David Gillingham**
Phone Number: **206-287-9130**
Shipment Method: Hand delivered

Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers	Total suspended solids (TSS)	Biochemical oxygen demand (BOD-5)	Total Kjeldahl nitrogen (TKN)	Ammonia	Nitrite plus nitrate	total Phosphorus (TP)	Orthophosphate	total dissolved phosphorus	Chlorophyll-a	Comments
1	CHL-US-BLK-130806 13	2013-08-06 16:48	Water	5	X	X	X	X	X	X	X	X	X	
2	BLK-RT12-130806 14	2013-08-06 17:20	Water	5	X	X	X	X	X	X	X	X	X	
3	CHL-OAK-130806 15	2013-08-06 17:45	Water	5	X	X	X	X	X	X	X	X	X	
4	CHL-OAK-D-130806 16	2013-08-06 17:50	Water	5	X	X	X	X	X	X	X	X	X	
5														
6														
7														
8														
9														
10														
11														
12														

1 See SAP Table 2 for analyte lists and test methods

Additional notes/comments:

Relinquished By:	Company: Anchor QEA LLC.	Received By:	Company:
8/7/13 0800		8/7/13 8:00	
Signature/Printed Name	Date/Time	Signature/Printed Name	Date/Time
Relinquished By:	Company:	Received By:	Company:
Signature/Printed Name	Date/Time	Signature/Printed Name	Date/Time

Distribution: A copy will be made for the laboratory and client. The Project file will retain the original.

Page ______ of ______

Chain of Custody Record & Laboratory Analysis Request

COC#

Date: 9/18/2013
Laboratory : **Dragon Laboratory**
Project Name: **Chehalis River**
Project Number: **1310023-01.01**
Project Manager: **David Gillingham**
Phone Number: **206-287-9130**
Shipment Method: Hand delivered

Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers	Total suspended solids (TSS)	Biochemical oxygen demand (BOD-5)	Total Kjeldahl nitrogen (TKN)	Ammonia	Nitrite plus nitrate	Total Phosphorus (TP)	Orthophosphate	Total dissolved phosphorus	Chlorophyll-a	Dissolved Oxygen (DO)	pH								Comments
1	PE-ELL-US-130917	9/17/13 07:30	Water	5	X	X	X	X	X	X	X	X	X	X	X								
2	ELK-CRK-130917	9/17/13 08:05	Water	5	X	X	X	X	X	X	X	X	X	X	X								
3	CHL-US-SF-130917	9/17/13 08:40	Water	5	X	X	X	X	X	X	X	X	X	X	X								
4	SF-CHL-MOUTH-130917	9/17/13 09:15	Water	5	X	X	X	X	X	X	X	X	X	X	X								
5	ADNA-130917	9/17/13 10:05	Water	5	X	X	X	X	X	X	X	X	X	X	X								
6	CHL-US-NWK-130917	9/17/13 10:50	Water	5	X	X	X	X	X	X	X	X	X	X	X								
7	NWK-MOUTH-130917	9/17/13 11:45	Water	5	X	X	X	X	X	X	X	X	X	X	X								
8	CHL-RT6-BR-130917	9/17/13 11:15	Water	5	X	X	X	X	X	X	X	X	X	X	X								
9	CHL-US-SKM-130917	9/17/13 12:25	Water	5	X	X	X	X	X	X	X	X	X	X	X								
10	SKM-MOUTH-130917	9/17/13 13:00	Water	5	X	X	X	X	X	X	X	X	X	X	X								
11	CHL-AT-GALVIN-130917	9/17/13 13:25	Water	5	X	X	X	X	X	X	X	X	X	X	X								
12	LNC-CRK-130917	9/17/13 13:55	Water	5	X	X	X	X	X	X	X	X	X	X	X								

1 See SAP Table 2 for analyte lists and test methods

Additional notes/comments:

Relinquished By:
Company: Anchor QEA LLC.
Signature/Printed Name
Date/Time 9/18/13 0730

Received By:
Company:
Signature/Printed Name
Date/Time

Relinquished By:
Company:
Signature/Printed Name
Date/Time

Received By:
Company:
Signature/Printed Name
Date/Time

Distribution: A copy will be made for the laboratory and client. The Project file will retain the original.

Chain of Custody Record & Laboratory Analysis Request

COC#

ANCHOR QEA

Date: 9/18/2013
Laboratory : **Dragon Laboratory**
Project Name: **Chehalis River**
Project Number: **1310023-01.01**
Project Manager: **David Gillingham**
Phone Number: **206-287-9130**
Shipment Method: Hand delivered

Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers	Total suspended solids (TSS)	Biochemical oxygen demand (BOD-5)	Total Kjeldahl nitrogen (TKN)	Ammonia	Nitrite plus nitrate	total Phosphorus (TP)	Orthophosphate	total dissolved phosphorus	Chlorophyll-a	Dissolved Oxygen (DO)	pH								Comments
1	CHL-US-BLK-130917	9/17/13 15:10	Water	5	X	X	X	X	X	X	X	X	X	X	X								
2	BLK-RT12-130917	9/17/13 15:30	Water	5	X	X	X	X	X	X	X	X	X	X	X								
3	CHL-OAK-130917	9/17/13 15:50	Water	5	X	X	X	X	X	X	X	X	X	X	X								
4	CHL-OAK-D-130917	9/17/13 15:55	Water	5	X	X	X	X	X	X	X	X	X	X	X								
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							

1 See SAP Table 2 for analyte lists and test methods

Additional notes/comments:

Relinquished By:	Company: Anchor QEA LLC.	Received By:	Company:
Signature/Printed Name	Date/Time 9/18/13 0730	Signature/Printed Name	Date/Time
Relinquished By:	Company:	Received By:	Company:
Signature/Printed Name	Date/Time	Signature/Printed Name	Date/Time

Distribution: A copy will be made for the laboratory and client. The Project file will retain the original.

DRAGON
Analytical Laboratory, Inc.

X673

CWA CHAIN OF CUSTODY RECORD

530 A-1 Ronlee Lane NW, Olympia, WA 98502
Phone: (360) 866-0543 Fax: (360) 866-0556
Email: customerservice@dragonlaboratory.com
Website: dragonlaboratory.com

Page 1 of 2

Samples Collected By:
Contact Number:

Client: Dragon Labs
Address: See above
Phone:
Fax:
E-mail: mlewis@dragonlaboratory.com
Project Name:
Project Location:
Project Number:
Project PO:
Contact :
DAL Project #: 130918-02

Matrix Code:
WW = wastewater GW =ground water O =other
SL = sludge V = vapor S = soil or solid

Sample Identification	Sample Matrix	Date Sampled	Time Sampled	Container Type	Alkalinity	Chloride	Chemical Oxygen Demand (COD)	Fecal Coliform	Total Coliform	Hardness, Total	Metals	Nitrogen, Ammonia	Nitrogen, Nitrate	Nitrogen, Nitrite	Nitrogen, Nitrate, Nitrite	Nitrogen, Total Kjeldahl	Oil and Grease	pH	Phosphorus, Ortho	Phosphorus, Total	Specific Conductance	Solids, Total	Solids, Total Dissolved	Solids, Total Suspended	Solids, Total Volitile	Turbidity	PCBs	Pesticides	Semi-Volitile Compounds	Volitile Organic Compounds			
PE-ELL-US-130917 (1)												X								X													
Elk-CRK-130917 (2)																																	
CHL-US-SF 130917 (3)																																	
SF-CHL-Mouth-130917 (4)																																	
ADNA-130917 (5)																																	
CHL-US-NWK-130917 (6)																																	
NWK-Mouth-130917 (7)																																	
CHL-RT6-BR-130917 (8)																																	
CHL-US-SKM-130917 (9)																																	
SKM-Mouth-130917 (10)																																	
CHL-AT-Galvin-130917 (11)																																	
NWK-CKK-130917 (12)																																	
CHL-US-BLK-130917 (13)												↓								↓													

Relinquished By (Signature)	Date/Time	Received By (Signature)	Date/Time
	9/25/13 16:31		9/26/13 1045

Relinquished By (Signature)	Date/Time	Received By (Signature)	Date/Time

Sample Disposal Instructions : ☐ DAL Disposal @$2 50 per container ☐ Return ☐ Pick Up

Turn Around Time
☐ 1 Day
☐ 2 Day
☐ 5 day
☐ 10 day (approx)
☐ Other________

Metals: Please circle the desired analytes. Total or Dissolved

Ag Al As Ba Be Ca Cd Cr Cr-VI Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sn Tl Zn

Comments:
Records for this project will not be maintained beyond 7 years.

Sample Temp: ________ Cooler Temp: ________

DRAGON
Analytical Laboratory, Inc.

CWA CHAIN OF CUSTODY RECORD

530 A-1 Ronlee Lane NW, Olympia, WA 98502
Phone: (360) 866-0543 Fax: (360) 866-0556
Email: customerservice@dragonlaboratory.com
Website: dragonlaboratory.com

Page 2 of 3

Samples Collected By:
Contact Number:

Client: See Page 1
Address:
Phone:
Fax:
E-mail:
Project Name:
Project Location:
Project Number:
Project PO:
Contact :
DAL Project #:

Matrix Code:
WW = wastewater **GW** =ground water **O** =other
SL = sludge **V** = vapor **S** = soil or solid

Sample Identification	Sample Matrix	Date Sampled	Time Sampled	Container Type	Alkalinity	Chloride	Chenical Oxygen Demand (COD)	Fecal Coliform	Total Coliform	Hardness, Total	Metals	Nitrogen, Ammonia	Nitrogen, Nitrate	Nitrogen, Nitrite	Nitrogen, Nitrate, Nitrite	Nitrogen, Total Kjeldahl	Oil and Grease	pH	Phosphorus, Ortho	Phosphorus, Total	Specific Conductance	Solids, Total	Solids, Total Dissolved	Solids, Total Suspended	Solids, Total Voltile	Turbidity	PCBs	Pesticides	Semi-Volitile Compounds	Volitile Organic Compounds	TDP	BOD	
BLK-RT12-130917(14)												X								X													
CHL-OAK-130917(15)																																	
CHL-OAK-D-130917(16)												↓								↓													
See Sample ID's above @Page 1															X				X												X	X	
															↓				↓												↓	↓	

Relinquished By (Signature)	Date/Time	Received By (Signature)	Date/Time
	9/25/13 16:31		9/26/13 1045

Sample Disposal Instructions ☐ DAL Disposal @$2.50 per container ☐ Return ☐ Pick Up

Turn Around Time
☐ 1 Day
☐ 2 Day
☐ 5 day
☐ 10 day (approx)
☐ Other________

Metals: Please circle the desired analytes. Total or Dissolved

Ag Al As Ba Be Ca Cd Cr Cr-VI Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sn Tl Zn

Comments:
Records for this project will not be maintained beyond 7 years.

Sample Temp. ________ Cooler Temp. ________

Chain of Custody Record & Laboratory Analysis Request

COC#

ANCHOR QEA

Date: 1-27-2014
Laboratory : ARI
Project Name: Chehalis River
Project Number 1310023-01.01
Project Manager: David Gillingham
Phone Number 206-287-9130
Shipment Method: Hand delivered

Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers[1]	Total suspended solids (TSS)	Biochemical oxygen demand (BOD-5)	Total Kjeldahl nitrogen (TKN)	Ammonia	Nitrite plus nitrate	Total Phosphorus (TP)	Orthophosphate	Total dissolved phosphorus	Chlorophyll-a	Dissolved Oxygen (DO)	pH								Comments
1	PE-ELL-US-140127		Water	5	X	X	X	X	X	X	X	X	X	X	X								
2	PE-ELL-US-DUP-140127		Watetr	5	X	X	X	X	X	X	X	X	X	X	X								
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							
12																							

1 See SAP Table 2 for analyte lists and test methods

Additional notes/comments:

Relinquished By:	Company: Anchor QEA LLC.	Received By:	Company: ARI
John Geffney	1-27-14	Jennifer Millsap	1/28/14 700
Signature/Printed Name	Date/Time	Signature/Printed Name	Date/Time
Relinquished By:	Company:	Received By:	Company:
Signature/Printed Name	Date/Time	Signature/Printed Name	Date/Time

Distribution. A copy will be made for the laboratory and client. The Project file will retain the original.

Page ______ of _____

Chain of Custody Record & Laboratory Analysis Request

Analytical Resources, Incorporated
Analytical Chemists and Consultants
4611 South 134th Place, Suite 100
Tukwila, WA 98168
206-695-6200 206-695-6201 (fax)
www.arilabs.com

ARI Assigned Number: YU69
Turn-around Requested:
Page: of
ARI Client Company: Anchor QEA
Phone: 206-287-9130
Date:
Ice Present? Y
Client Contact: David Gillingham
No. of Coolers: 1
Cooler Temps: 1.0
Client Project Name: Chehalis River WQ
Client Project #: 131023-01.01
Samplers: AH

Sample ID	Date	Time	Matrix	No Containers	Analysis Requested: Orthophosphate								Notes/Comments
CHE-REL-DS-140730	7/30/14	12:00	Water	1	✓								
ELK-CRK-140730	7/30/14	12:50	Water	1	✓								
LCN-CRK-140730	7/30/14	14:50	Water	1	✓								
CHL-US-SF-140730	7/30/14	17:40	Water	1	✓								
CHL-US-SF-DUP-140730	7/30/14	17:45	Water	1	✓								Field Dup
CHL-ADNA-140730	7/30/14	18:05	Water	1	✓								

Comments/Special Instructions	Relinquished by	Received by:	Relinquished by	Received by
	(Signature) Adam Hill	(Signature)	(Signature)	(Signature)
	Printed Name Adam Hill	Printed Name A. Volgaardsen	Printed Name:	Printed Name:
	Company Anchor QEA	Company: ARI	Company:	Company:
	Date & Time: 7/31/14 16:20	Date & Time: 7/31/14 1620	Date & Time:	Date & Time

Limits of Liability: *ARI will perform all requested services in accordance with appropriate methodology following ARI Standard Operating Procedures and the ARI Quality Assurance Program. This program meets standards for the industry. The total liability of ARI, its officers, agents, employees, or successors, arising out of or in connection with the requested services, shall not exceed the Invoiced amount for said services. The acceptance by the client of a proposal for services by ARI release ARI from any liability in excess thereof, not withstanding any provision to the contrary in any contract, purchase order or co-signed agreement between ARI and the Client.*

Sample Retention Policy: All samples submitted to ARI will be appropriately discarded no sooner than 90 days after receipt or 60 days after submission of hardcopy data, whichever is longer, unless alternate retention schedules have been established by work-order or contract.

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Receipt Form

ARI Client: Anchor

COC No(s): ______ [✓ NA]

Assigned ARI Job No: YU69

Project Name: Chehalis RiverWQ

Delivered by Fed-Ex UPS Courier [✓ Hand Delivered] Other: ______

Tracking No: ______ [✓ NA]

Preliminary Examination Phase:

Were intact, properly signed and dated custody seals attached to the outside of to cooler?	YES	[✓ NO]
Were custody papers included with the cooler?	[✓ YES]	NO
Were custody papers properly filled out (ink, signed, etc.)	[✓ YES]	NO

Temperature of Cooler(s) (°C) (recommended 2 0-6 0 °C for chemistry) 1.0

Time: 1620

If cooler temperature is out of compliance fill out form 00070F

Temp Gun ID#: 90877952

Cooler Accepted by: AV Date: 7/31/14 Time: 1620

Complete custody forms and attach all shipping documents

Log-In Phase:

Was a temperature blank included in the cooler?		YES	[✓ NO]
What kind of packing material was used? Bubble Wrap [✓ Wet Ice] Gel Packs [✓ Baggies] Foam Block Paper Other: ______			
Was sufficient ice used (if appropriate)?	NA	[✓ YES]	NO
Were all bottles sealed in individual plastic bags?		YES	[✓ NO]
Did all bottles arrive in good condition (unbroken)?		[✓ YES]	NO
Were all bottle labels complete and legible?		[✓ YES]	NO
Did the number of containers listed on COC match with the number of containers received?		[✓ YES]	NO
Did all bottle labels and tags agree with custody papers?		[✓ YES]	NO
Were all bottles used correct for the requested analyses?		[✓ YES]	NO
Do any of the analyses (bottles) require preservation? (attach preservation sheet, excluding VOCs)	[✓ NA]	YES	NO
Were all VOC vials free of air bubbles?	[✓ NA]	YES	NO
Was sufficient amount of sample sent in each bottle?		[✓ YES]	NO
Date VOC Trip Blank was made at ARI	[✓ NA]		

Was Sample Split by ARI: [✓ NA] YES Date/Time: ______ Equipment: ______ Split by: ______

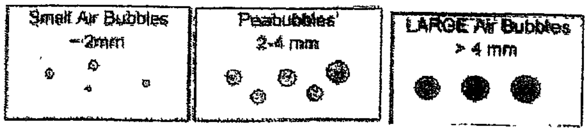
Samples Logged by: AV Date: 7/31/14 Time: 1653

***** Notify Project Manager of discrepancies or concerns *****

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Additional Notes, Discrepancies, & Resolutions:

By: Date:



Small → "sm" (< 2 mm)
Peabubbles → "pb" (2 to < 4 mm)
Large → "lg" (4 to < 6 mm)
Headspace → "hs" (> 6 mm)

ANALYTICAL
RESOURCES
INCORPORATED

Sample ID Cross Reference Report

ARI Job No: YU69
Client: Anchor QEA, LLC.
Project Event: 131023-01.01
Project Name: Chehalis River WQ

	Sample ID	ARI Lab ID	ARI LIMS ID	Matrix	Sample Date/Time	VTSR
1.	CHE-PEL-DS-140730	YU69A	14-15749	Water	07/30/14 12:00	07/31/14 16:20
2.	ELK-CRK-140730	YU69B	14-15750	Water	07/30/14 12:50	07/31/14 16:20
3.	LCN-CRK-140730	YU69C	14-15751	Water	07/30/14 14:50	07/31/14 16:20
4.	CHL-US-SF-140730	YU69D	14-15752	Water	07/30/14 17:40	07/31/14 16:20
5.	CHL-US-SF-DUP-140730	YU69E	14-15753	Water	07/30/14 17:45	07/31/14 16:20
6.	CHL-ADNA-140730	YU69F	14-15754	Water	07/30/14 18:05	07/31/14 16:20

INORGANICS ANALYSIS DATA SHEET
Ortho-Phosphorus by Method SM4500-PE

Data Release Authorized:
Reported: 08/05/14
Date Received: 07/31/14
Page 1 of 1

QC Report No: YU69-Anchor QEA, LLC.
Project: Chehalis River WQ
131023-01.01

Client/ ARI ID	**Date Sampled**	**Matrix**	**Analysis Date & Batch**	**RL**	**Result**
CHE-PEL-DS-140730 YU69A 14-15749	07/30/14	Water	08/01/14 080114#1	0.004	0.005
ELK-CRK-140730 YU69B 14-15750	07/30/14	Water	08/01/14 080114#1	0.004	0.010
LCN-CRK-140730 YU69C 14-15751	07/30/14	Water	08/01/14 080114#1	0.004	0.057
CHL-US-SF-140730 YU69D 14-15752	07/30/14	Water	08/01/14 080114#1	0.004	0.005
CHL-US-SF-DUP-140730 YU69E 14-15753	07/30/14	Water	08/01/14 080114#1	0.004	0.004
CHL-ADNA-140730 YU69F 14-15754	07/30/14	Water	08/01/14 080114#1	0.004	< 0.004 U

Reported in mg-P/L

RL-Analytical reporting limit
U-Undetected at reported detection limit

MS/MSD RESULTS-CONVENTIONALS
YU69-Anchor QEA, LLC.

Matrix: Water
Data Release Authorized:
Reported: 08/05/14

Project: Chehalis River WQ
Event: 131023-01.01
Date Sampled: 07/30/14
Date Received: 07/31/14

Analyte	**Date**	**Units**	**Sample**	**Spike**	**Spike Added**	**Recovery**
ARI ID: YU69A Client ID: CHE-PEL-DS-140730						
Ortho-Phosphorus	08/01/14	mg-P/L	0.005	0.093	0.100	88.0%

REPLICATE RESULTS-CONVENTIONALS
YU69-Anchor QEA, LLC.

Matrix: Water
Data Release Authorized:
Reported: 08/05/14

Project: Chehalis River WQ
Event: 131023-01.01
Date Sampled: 07/30/14
Date Received: 07/31/14

Analyte	**Date**	**Units**	**Sample**	**Replicate(s)**	**RPD/RSD**
ARI ID: YU69A Client ID: CHE-PEL-DS-140730					
Ortho-Phosphorus	08/01/14	mg-P/L	0.005	0.005	0.0%

METHOD BLANK RESULTS-CONVENTIONALS
YU69-Anchor QEA, LLC.

Matrix: Water
Data Release Authorized:
Reported: 08/05/14

Project: Chehalis River WQ
Event: 131023-01.01
Date Sampled: NA
Date Received: NA

Analyte	**Date/Time**	**Units**	**Blank**
Ortho-Phosphorus	08/01/14 11:53	mg-P/L	< 0.004 U

STANDARD REFERENCE RESULTS-CONVENTIONALS
YU69-Anchor QEA, LLC.

Matrix: Water
Data Release Authorized:
Reported: 08/05/14

Project: Chehalis River WQ
Event: 131023-01.01
Date Sampled: NA
Date Received: NA

Analyte/SRM ID	Date/Time	Units	SRM	True Value	Recovery
Ortho-Phosphorus ERA #030112	08/01/14 11:53	mg-P/L	0.153	0.150	102.0%

8/4/14

PHOSPHORUS BENCHSHEET, Aqueous		Digested:	Analyzed:
Soluble Reactive P (SRP) by EPA 365.2, SM 4500-P	Date	NA	8/1/14 11:53
Indicate "Total" or "SRP" **SRP**	Analyst	NA	RR

Total P by digestion (indicate procedure used) *SM 4500-P B5-99, Acid persulfate*
NOTE: *curve standards must be digested !* *SM 4500-P B4-99, Sulfuric-Nitric Acid*

Curve Standards *make no entries to shaded cells, they are calculated !!*

Stock Standard
Stock #: C000747 *Prep date:* 2/20/2014 Conc = 50.00 *mg/L P*

Intermediate Standard
5 *mL stk to* 50 *mL DI =* ***5.00*** *mg P/L*

Combined Color Reagent
Ant. Pot. Tart. ID: C000203
Amm. Molyb ID: C002142
Ascorbic Acid ID: C002146
Sulfuric Acid ID: C001197

Calibration Curvefor Digested Curve
std make-up volume (mL) = 25 Digest Final Vol (mL) = 50

mL intermediate Std		CONC	UNITS		AVG	
SRP	Total P	(mg/L)	(ABS 880 nm 5cm cell)			*mg/L*
0.00		0.000	0.000		0.000	*0.001*
0.04		0.004	0.009		0.009	*0.004*
0.25		0.025	0.073		0.073	*0.025*
0.50		0.050	0.150		0.150	*0.049*
1.00		0.100	0.305		0.305	*0.099*
5.00		0.500	1.550		1.550	*0.500*

REGRESSION DATA

CONC = (ABS-intercept)/ slope

intercept = -0.0037
Slope = 3.1062
r = 1.0000

Comment: Calibration OK!

maxabs = *1.550*

Verification Standards *Source:* ERA# 290613 / C000096 *Conc (mg/L)* 1000

Intermediate	0.50	*mL to*	50	*mL DI =*	***10.0***	*mg/L*	
SRP ICV *dilution =*	0.75	*mL Int to*	50	*mL DI =*	***0.150***	*mg/L*	CVS
Tot P LCS *dilution =*	0.75	*mL Int to*	25	*mL DI =*	***0.300***	*mg/L*	LCS

DQL Standard (low level) *Source:* ***Curve Int.*** *Conc (mg/L)* 5.0

SRP	0.080	*ml to*	50	*ml DI =*	***0.008***	*mg/L*
Total P	0.080	*ml to*	25	*ml DI =*	***0.016***	*mg/L*

Sample Data

1. *For SRP, leave digest data blank!!*
2. *Spike with 10 mg/L Intermediate Standard* *enter dilution as final vol / sample vol*

SAMPLE ID	Tot P Digest		Analysis Data			TOT P	SRP	
	mL sample	mL digest	Abs	Dilution	(mg/L)	(mg/L)	(mg/L)	*Notes*
Calib Blank			0.000	1.0	0.0012		**< 0.004**	*OK*
ICV			0.471	1.0	0.1528		**0.1528**	*101.88%*
DQL SRP			0.018	1.0	0.0070		**0.0070**	*87.25%*
Filter Blank			0.000	1.0	0.0012		**< 0.004**	*OK*
YU69 A1			0.011	1.0	0.0047		**0.0047**	
YU69 A1 dup			0.012	1.0	0.0050		**0.0050**	*RPD = 6.59*
YU69 A1 ms			0.285	1.0	0.0929		**0.0929**	*88.2% Rec*
Spike =	0.2	*ml of*	5	*mg/L to*	10	*ml sample =*	0.100	
YU69 B1			0.026	1.0	0.0096		**0.0096**	
YU69 C1			0.173	1.0	0.0569		**0.0569**	
YU69 D1			0.011	1.0	0.0047		**0.0047**	
YU69 E1			0.010	1.0	0.0044		**0.0044**	
YU69 F1			0.005	1.0	0.0028		**< 0.004**	
Calib Blank			-0.001	1.0	0.0009		**< 0.004**	*OK*
CCV			0.469	1.0	0.1522		**0.1522**	*101.45%*
Filter Blank 2			0.006	1.0	0.0031		**< 0.004**	*OK*
~~YU70 A1~~			~~0.011~~	~~1.0~~	~~0.0047~~	-	~~**0.0047**~~	-
~~YU70 A1 dup~~			~~0.008~~	~~1.0~~	~~0.0038~~	-	~~**< 0.004**~~	~~*RPD na*~~
YU70 A1 ms			0.286	1.0	0.0933		**0.0933**	*93.3% Rec*
Spike =	0.2	*ml of*	5	*mg/L to*	10	*ml sample =*	0.100	
YU70 B1			0.005	1.0	0.0028		**< 0.004**	
YU70 C1			0.007	1.0	0.0034		**< 0.004**	
YU70 D1			0.036	1.0	0.0128		**0.0128**	
YU70 E1			0.023	1.0	0.0086		**0.0086**	
YU70 F1			0.024	1.0	0.0089		**0.0089**	
YU70 G1			0.023	1.0	0.0086		**0.0086**	
Calib Blank			-0.001	1.0	0.0009		**< 0.004**	*OK*
CCV			0.468	1.0	0.1519		**0.1519**	*101.24%*

YU70 H1			0.023	1.0	0.0086		0.0086	
YU70 I1			0.024	1.0	0.0089		0.0089	
YU70 A1			0.005	1.0	0.0028		< 0.004	
YU70 A1 dup			0.005	1.0	0.0028		< 0.004	*RPD na*
Calib Blank			-0.001	1.0	0.0009		< 0.004	*OK*
CCV			0.466	1.0	0.1512		0.1512	*100.81%*

Chain of Custody Record & Laboratory Analysis Request

ANCHOR QEA

Laboratory Number:

Date: July 22, 2014
Project Name: Chehalis River WQ
Project Number: 131023-01.01
Project Manager: David Gillingham
Phone Number: 206-287-9130
Shipment Method:

					Test Parameters									
Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers	Total Suspended Solids (TSS)	Biochemical oxygen demand	Total Kjeldahl nitrogen	Ammonia	Nitrite plus nitrate	Total Phosphorus (TP)	Orthophosphate	Total dissolved phosphorus	Chlorophyll-a	Comments/Preservation
1	CHE-PEL-US-140722	7/22/14 - 07:44	Water	8	x	x	x	x	x	x	x	x	x	
2	ELK-CRK-140722	7/22/14 - 08:30	Water	8	x	x	x	x	x	x	x	x	x	
3	CHL-US-SF-140722	7/22/14 - 09:10	Water	8	x	x	x	x	x	x	x	x	x	
4	SF-CHL-MOUTH-140225	7/22/14 - 09:45	Water	8	x	x	x	x	x	x	x	x	x	
5	CHL-ADNA-140722	7/22/14 - 10:10	Water	8	x	x	x	x	x	x	x	x	x	
6	CHL-US-NWK-140722	7/22/14 - 11:40	Water	8	x	x	x	x	x	x	x	x	x	
7	NWK-MOUTH-140725	7/22/14 - 13:30	Water	8	x	x	x	x	x	x	x	x	x	
8	CHL-RT6-BR-140722	7/22/14 - 12:30	Water	8	x	x	x	x	x	x	x	x	x	
9	CHL-US-SKM-140722	7/22/14 - 14:07	Water	8	x	x	x	x	x	x	x	x	x	
10	SKM-MOUTH-140722	7/22/14 - 14 50	Water	8	x	x	x	x	x	x	x	x	x	
11	CHL-AT-GLV-140722	7/22/14 - 15:33	Water	8	x	x	x	x	x	x	x	x	x	
12	LCN-CRK-140722	7/22/14 - 16:05	Water	8	x	x	x	x	x	x	x	x	x	
13	CHL-US-BLK-140722	7/22/14 - 17:30	Water	8	x	x	x	x	x	x	x	x	x	
14	BLK-RT12-140722	7/22/14 - 18:40	Water	8	x	x	x	x	x	x	x	x	x	
15	CHL-OAK-140722	7/22/14 - 19:05	Water	8	x	x	x	x	x	x	x	x	x	
16	CHL-OAK-DUP-140722	7/22/14 - 19:12	Water	8	x	x	x	x	x	x	x	x	x	Field Rep

Notes:

Relinquished By: Adam Hill Adam Hill
Company: Anchor QEA, LLC
Signature/Printed Name
Date/Time: 7/23/14 6:10

Received By: YARED LISANEWORK
Company: YL # 328
Signature/Printed Name
Date/Time: 6:30 07/23/14

Relinquished By: YARED LISANEWORK
Company: YL #328
Signature/Printed Name
Date/Time: 8:25AM 07/23/14

Received By: A. Volgardsen
Company: ARI
Signature/Printed Name
Date/Time: 7/23/14 825

Distribution: A copy will be made for the laboratory and client. The Project file will retain the original.

Page____of_____

Appendix D: Hydrolab Calibrations for Low-Flow Synoptic Survey

Table D-1
Pre-deployment Calibration and Post-Deployment Check for Hydrolab Data Sondes for August 2013 Low-Flow Survey

AUGUST 2013 EVENT			DO					pH		TURBIDITY		
PRE/POST CALIBRATION	CALIBRATION DATE	DEPLOYMENT LOCATION	TEMP. (°C)	BP (mm Hg)	FINAL DO (mg/L)	EXP. DO[1] (mg/L)	RPD (%)	FINAL 7 pH	RPD (%)	FINAL 0 NTU	FINAL 40 NTU	RPD (for 40 NTU) (%)
Pre	8/2/2013	Pe Ell	23.3	764.5	8.6	8.5	0.9	7.00	0.0	0.0	39.7	0.8
Post	8/7/2013	Pe Ell	23.4	752.1	8.5	8.4	0.7	7.01	0.1		36.5	9.2
Pre	8/2/2013	Route 6 Bridge	23.3	764.3	8.6	8.4	1.8	7.00	0.0	0.0	40.2	0.5
Post	8/7/2013	Route 6 Bridge	23.4	751.9	8.5	8.4	0.6	7.02	0.3		35.1	**13.0**
Pre	8/2/2013	Mellen Street Bridge	23.7	764.6	8.6	8.4	2.1	6.99	0.1	0.0	40.0	0.0
Post	8/7/2013	Mellen Street Bridge	23.4	752.4	8.5	8.4	0.8	7.45	6.2		38.7	3.3
Pre	8/2/2013	Water Quality	24.9	757.2	8.3	8.2	0.6	7.00	0.0	0.0	40.1	0.2
Post	8/7/2013	Water Quality	26.5	756.8	8.0	8	0.4	7.10	1.4	0.2	39.9	0.3

Notes:

1. Expected value from USGS Table 6.2-6 Solubility of oxygen in water at various temperatures and pressures (from R.F. Weiss 1970)

Values in bold red indicate RPD exceeded 10% target in QAPP

°C = degrees Celsius

BP = barometric pressure

DO = dissolved oxygen

mg/L = milligrams per liter

mm Hg = millimeters of mercury

NTU = Nephelometric Turbidity Units

QAPP = Quality Assurance Project Plan

RPD = relative percent difference

USGS = U.S. Geological Survey

Table D-2
Pre-deployment Calibration and Post-Deployment Check for Hydrolab Data Sondes for September 2013 Low-Flow Survey

SEPTEMBER 2013 EVENT			DO					pH				TURBIDITY		
PRE/POST	CALIBRATION DATE	DEPLOYMENT LOCATION	TEMP. (°C)	BP (mm Hg)	FINAL DO (mg/L)	EXPECTED DO[1] (mg/L)	RPD (%)	FINAL 7 pH	RPD (for 7 pH) (%)	Final 4 pH	RPD (for 4 pH) (%)	FINAL 0 NTU	FINAL 40 NTU	(for 40 NTU) (%)
Pre[2]	9/13/2013	Pe Ell	21.5	637.0	7.2	7.3	0.8	7.0	0.0	4.0	0.2	0.1	39.9	0.3
Post	9/18/2013	Pe Ell	20.6	758.0	8.9	9.0	1.5	7.0	0.0			0.0	39.0	2.5
Pre[2]	9/13/2013	Route 6 Bridge	21.9	637.0	7.3	7.2	0.8	7.0	0.3	4.0	0.8	0.1	40.0	0.0
Post	9/18/2013	Route 6 Bridge	19.0	758.0	9.2	9.3	1.4	7.5	6.9			0.1	40.5	1.2
Pre[2]	9/13/2013	Mellen Street Bridge	22.1	637.0	7.2	7.2	0.1	7.0	0.0	4.0	0.0	0.0	40.0	0.0
Post	9/18/2013	Mellen Street Bridge	19.6	758.0	9.1	9.2	1.6	7.5	6.9			0.0	29.8	**29.2**
Pre[2]	9/13/2013	Water Quality	21.9	637.0	7.3	7.2	0.8	7.0	0.0	4.0	0.0	0.1	40.0	0.0
Intermediate[3]	9/18/2013	Water Quality	22.5	757.0	8.8	8.6	1.8	6.9		4.1	3.4	2.0	45.0	
Pre (final day)	9/18/2013	Water Quality	22.5	757.0	8.5	8.6	1.3	7.0	0.0	4.0	0.0	0.1	39.9	0.3
Post[4]	9/18/2013	Water Quality						7.1	1.3			0.3	38.6	3.6

Notes:

1. Expected value from USGS Table 6.2-6 Solubility of oxygen in water at various temperatures and pressures (from R.F. Weiss 1970)

2. During pre-calibration the pressure sensor value was not present, which was not noticed by the field crew. The value at calibration reflects setting from the previous calibration. The error was noticed when field measurements were being made with the "Water Qaulity" hydrolab, and it was recalibrated with the correct barometric pressure. The three in situ hydrolabs used an incorrect pressure setting and therefore are likely biased low.

3. An intermediate check on the morning of 9/18 indicated was performed, and the unit recalibrated for some parameters

4. A post-event check was not performed for DO because a check and calibration were performed on the morning 9/18

Values in bold red indicate RPD exceeded 10% target in QAPP

°C = degrees Celsius

BP = barometric pressure

DO = dissolved oxygen

mg/L = milligrams per liter

mm Hg = millimeters of mercury

NTU = Nephelometric Turbidity Units

QAPP = Quality Assurance Project Plan

RPD = relative percent difference

USGS = U.S. Geological Survey

Table D-3
Pre-deployment Calibration and Post-Deployment Check for Hydrolab Data Sondes for July 2014 Low-Flow Survey

JULY 2014 EVENT			DO					pH[1]		TURBIDITY		
PRE/POST CALIBRATION	CALIBRATION DATE	DEPLOYMENT LOCATION	TEMP. (°C)	BP (mm Hg)	FINAL DO (mg/L)	EXP. DO (mg/L)	RPD (%)	7 pH	RPD (%)	0 NTU	40 NTU	RPD (for 40 NTU) (%)
Pre	7/18/2014	Pe Ell	23.8	754.4	8.3	8.4	0.7	--		0.3	37.1	7.5
Post	7/25/2014	Pe Ell	23.1	757.0	9.0	8.5	5.9	6.9	1.3	0.0	39.2	2.0
Pre	7/18/2014	Route 6 Bridge	23.7	754.5	8.44	8.4	0.5	--		0.0	42.9	7.0
Post	7/25/2014	Route 6 Bridge	23.3	757.0	8.93	8.5	4.9	6.7	3.8	0.0	41.1	2.7
Pre	7/18/2014	Mellen Street Br.	23.3	754.6	8.43	8.4	0.4	--		0.0	43.2	7.7
Post	7/25/2014	Mellen Street Br.	23.4	757.0	8.9	8.5	4.6	6.9	1.9	0.0	40.5	1.2
Pre	7/18/2014	Water Quality	23.5	754.8	8.4	8.3	1.2	--		0.0	42.8	6.8
Post	7/29/2014	Water Quality	23.7	755.5	8.5	8.4	0.9	7.5	6.6	0.5	39.3	1.8

Notes:

1. Pre-calibration for pH was not done, but the values were checked prior to deployment and they were all within the manufacture's recommended calibration standards

°C = degrees Celsius

BP = barometric pressure

DO = dissolved oxygen

mg/L = milligrams per liter

mm Hg = millimeters of mercury

NTU = Nephelometric Turbidity Units

QAPP = Quality Assurance Project Plan

RPD = relative percent difference

Table D-4
Hydrolab Data Sonde Field Check during August 2013 Event

	LOCATION	DATE	TIME^1	TEMP. (°C)	DO (mg/L)	pH UNITS	TURB. (NTU)	CHLORO-A (µg/L)
Installation	Pe Ell Mobile	8/5/2013	855	17.5	9.6	6.6	0	--
	Pe Ell In Situ	8/5/2013	930	17.9	9.6	7.7	0	0.7
	RPD			2.4	0.2	15.0		
Retrieval	Pe Ell Mobile	8/7/2013	1035	18.3	9.9	7.7	0	0.6
	Pe Ell In Situ	8/7/2013	900	17.6	9.5	7.7	0	0.7
	RPD			3.9	4.1	0.0		26.4
Installation	Route 6 Mobile	8/5/2013	1116	20.8	7.8	6.5	0.6	--
	Route 6 In Situ	8/5/2013	1130	21.2	8.3	7.4	0	0.6
	RPD			2.1	6.0	12.1		
Retrieval	Route 6 Mobile	8/7/2013	1202	22.6	8.2	7.6	3.2	0.6
	Route 6 In Situ	8/7/2013	1100	22.2	7.8	7.2	0	0.5
	RPD			2.1	4.9	6.1		29.6
Installation	Mellen Street Mobile	8/5/2013	1303	22.3	8.9	6.4	0.3	--
	Mellen Street In Situ	8/5/2013	1330	22.0	8.2	7.2	0	3.8
	RPD			1.5	9.1	12.8		
Retrieval	Mellen Street Mobile	8/7/2013	1350	23.2	9.0	7.5	17.7	5.8
	Mellen Street In Situ	8/7/2013	1200	21.8	8.6	7.9	0	8.2
	RPD			6.4	4.2	5.0		34.6

Notes:

1. The in situ units recorded data every 30 minutes. The field unit provided instantaneous measurements

🟨 = The Chlorophyll-a sensor did not work on the mobile hydrolab during the deployment of Hydrolabs. A replacement Hydrolab was obtained prior to retrieval of hydrolabs.

🟥 = Potentially anamolous measurement due to local conditions

°C = degrees Celsius

µg/L = micrograms per liter

DO = dissolved oxygen

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Units

RPD = relative percent difference

Table D-5
Hydrolab Data Sonde Field Check during September 2013 Event

	LOCATION	DATE	TIME[1]	TEMP. (°C)	DO (mg/L)	pH UNITS	TURB. (NTU)	CHLORO-A (µg/L)
Installation	Pe Ell Mobile	9/16/2013	924	16.3	8.3	7.5	0	1.0
	Pe Ell In Situ	9/16/2013	930	16.3	8.4	7.6	0	1.0
RPD				0.1	0.4	1.1	-	5.0
Retrieval[2]	Pe Ell Mobile	9/18/2013	823	14.2	9.9	7.6	0	1.1
	Pe Ell In Situ	9/18/2013	830	14.0	10.1	7.7	0	0.1
RPD				1.3	2.8	1.3	-	157.7
Installation	Route 6 Mobile	9/16/2013	1154	18.1	7.1	7.3	1.2	0.7
	Route 6 In Situ	9/16/2013	1215	18.3	6.8	7.8	1.8	0.7
RPD				0.9	4.0	6.7	40.0	6.0
Retrieval2	Route 6 Mobile	9/18/2013	1010	16.5	9.0	7.6	0.0	0.7
	Route 6 In Situ	9/18/2013	1000	16.6	8.4	7.9	1.7	0.4
RPD				0.4	7.2	4.4	-	57.7
Installation	Mellen Street Mobile	9/16/2013	1350	20.1	5.6	6.9	1.4	1.1
	Mellen Street In Situ	9/16/2013	1400	20.2	5.4	7.0	0.0	0.8
RPD				0.5	3.3	1.6	-	27.7
Retrieval2	Mellen Street Mobile	9/18/2013	1148	18.6	6.8	7.2	3.2	1.0
	Mellen Street In Situ	9/18/2013	1130	18.8	6.4	7.1	0	0.3
RPD				0.6	5.4	0.8	-	107.9

Notes:

1. The in situ units recorded data every 15 minutes. The field unit provided instantaneous measurements
2. The field unit was recalibrated on the morning of 9/18 with the correct barometric pressure. The in situ units were not corrected from the incorrect barometric pressure of 637 mm Hg at the tiem of deployment. Therefore, the DO values reported from these units were adjusted to reflect the appropriate barometric pressure.

°C = degrees Celsius

µg/L = micrograms per liter

DO = dissolved oxygen

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Units

RPD = relative percent difference

Table D-6
Hydrolab Data Sonde Field Check during July 2014 Event

	LOCATION	DATE	TIME[1]	TEMP. (°C)	DO (mg/L)	pH UNITS	TURB. (NTU)	CHLORO-A (µg/L)
Installation	Pe Ell Mobile	7/21/2014	913	15.9	9.8	7.6	0.3	0.9
	Pe Ell In Situ	7/21/2014	930	16.2	10.0	7.6	0.0	0.6
	RPD			1.9	2.0	0.7	-	44.0
Retrieval	Pe Ell Mobile	7/23/2014	808	17.3	9.0	7.7	5.0	1.6
	Pe Ell In Situ	7/23/2014	800	17.4	9.0	7.4	3.0	1.2
	RPD			0.5	0.1	3.5	50.0	27.7
Installation	Route 6 Mobile	7/21/2014	1110	19.9	8.2	7.3	1.2	1.0
	Route 6 In Situ	7/21/2014	1145	20.1	8.3	7.1	0.6	1.3
	RPD			0.8	1.5	3.1	66.7	19.3
Retrieval	Route 6 Mobile	7/23/2014	1235	20.0	8.1	7.5	9.1	1.1
	Route 6 In Situ	7/23/2014	1230	19.9	8.2	7.1	0.5	1.7
	RPD			0.3	1.2	5.4	179.2	41.4
Installation	Mellen Street Mobile	7/21/2014	1231	22.9	7.7	7.1	6.7	5.4
	Mellen Street In Situ	7/21/2014	1300	22.8	7.5	6.5	1.0	5.0
	RPD			0.5	2.9	8.8	148.1	6.2
Retrieval	Mellen Street Mobile	7/23/2014	1432	21.7	7.5	7.4	1.8	6.7
	Mellen Street In Situ	7/23/2014	1400	21.9	7.5	7.0	0.0	6.7
	RPD			1.1	0.5	4.9	200.0	0.0

Notes:

1. The in situ units recorded data every 15 minutes. The field unit provided instantaneous measurements.

🟨 = Data suggests this is an outlier

°C = degrees Celsius

µg/L = micrograms per liter

DO = dissolved oxygen

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Units

RPD = relative percent difference

Appendix E: Boat Survey - Hydrolab Calibrations and Chain-of-Custody Forms

Table E-1

Hydrolab Pre-Event Calibration and Post-Event Check for July 2014 Boat Survey

		DO					pH				Turbidity		
Pre/Post	Calibration Date	Temp. (°C)	BP (mm Hg)	Final DO (mg/L)	Exp. DO (mg/L)	RPD (%)	Final 7 pH	RPD (for 7 pH) (%)	Final 4 pH	RPD (for 4 pH) (%)	Final 0 NTU	Final 40 NTU	RPD (for 40 NTU) (%)
Pre	7/29/2014	23.7	755.5	8.4	8.4	0.0	7.0	0.0	4.0	0.0	0.0	40.0	0.0
Post	8/1/2014	22.8	753.8	8.3	8.6	3.7	8.4	18	5.4	30.1	0.0	37.6	6.2

Notes:

°C = degrees Celsius

µg/L = micrograms per liter

DO = dissolved oxygen

mg/L = milligrams per liter

mm Hg = millimeters of mercury

NTU = Nephelometric Turbidity Units

RPD = relative percent difference

Chain of Custody Record & Laboratory Analysis Request

ANCHOR QEA

Laboratory Number:

Date: July 24, 2014
Project Name: Chehalis River Profile WQ
Project Number: 131023-01.01
Project Manager: David Gillingham
Phone Number: 206-287-9130
Shipment Method:

					Test Parameters																			
Line	Field Sample ID	Collection Date/Time	Matrix	No. of Containers	Total Suspended Solids (TSS)	Biochemical oxygen demand	Total Kjeldahl nitrogen	Ammonia	Nitrite plus nitrate	Total Phosphorus (TP)	Orthophosphate	Total dissolved phosphorus	Chlorophyll-a											Comments/Preservation
1	CHE-1A-1407~~24~~31-	7/~~24~~31/14 - 640	Water	8	x	x	x	x	x	x	x	x	x											
2	CHE-1C-1407~~24~~31-	7/~~24~~31/14 - 655	Water	8	x	x	x	x	x	x	x	x	x											
3																								
4	CHE-2A-1407~~24~~31-	7/~~24~~31/14 - 910	Water	8	x	x	x	x	x	x	x	x	x											
5	CHE-2C-1407~~24~~31-	7/~~24~~31/14 - 920	Water	8	x	x	x	x	x	x	x	x	x											
6																								
7	CHE-3A-1407~~24~~31-	7/~~24~~31/14 - 1210	Water	8	x	x	x	x	x	x	x	x	x											
8	CHE-3C-1407~~24~~31-	7/~~24~~31/14 - 1225	Water	8	x	x	x	x	x	x	x	x	x											
9																								
10	CHE-4A-1407~~24~~31-	7/~~24~~31/14 - 1310	Water	8	x	x	x	x	x	x	x	x	x											
11	CHE-4C-1407~~24~~31-	7/~~24~~31/14 - 1320	Water	8	x	x	x	x	x	x	x	x	x											
12																								
13	CHE-3A-DUP-140731	7/31/14 1215	Water	8	✓	✓	✓	✓	✓	✓	✓	✓	✓											Field dup
14																								
15																								
16																								

Notes:

Relinquished By: Adam Hill
Company: Anchor QEA, LLC
Signature/Printed Name
Date/Time: 7/31/14 1625

Received By: A.Volgardsen
Company: ARI
Signature/Printed Name
Date/Time: 7/31/14 1625

Relinquished By:
Company:
Signature/Printed Name
Date/Time

Received By:
Company:
Signature/Printed Name
Date/Time

Distribution: A copy will be made for the laboratory and client. The Project file will retain the original.

Appendix F: Groundwater Measurements – Field Forms

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Well Tag ID: 13N/03W-18R01

Project Number: 131023-01.01

Well Name:

Well Owner: Rippee 50' well

Well Address: 453 Curtis Hill Rd.

Field Staff: ELP/DG

Date: 10/15/13

Sampling Method: Flow well

Sample Start Time: 0819

Purge rate: 2 gall/min

Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
0821	11.73	1.40	7.12	5	
0823	11.78	0.90	7.09	10	
0825	11.68	0.44	7.13	15	
0827	11.60	0.30	7.13	20	
0829	11.55	0.25	7.11	25	
0832	11.32	0.24	7.06	30	
0835	11.25	0.21	7.12	35	
0837	11.22	0.20	7.21	40	

Evidence of floating or suspended materials: N/A

Discoloration and Turbidity: N/A

Color: N/A

Odor: N/A

Comments:

50' well near drive way

Recorded by: ELP

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/03W - 18R01
Project Number: 131023-01.01
Well Name:
Well Owner: Rippee 300' well
Well Address:
Field Staff: ELP/DC
Date: 10/15/13
Sampling Method: Flow cell
Sample Start Time: 0847
Purge rate: ~~0.5~~ 2 gal/min
Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
0844	11.01	1.09	7.25	5	
0846	11.60	0.73	7.22	10	
0848	11.46	0.36	7.24	15	
0850	11.55	0.28	7.27	20	
0852	11.45	0.29	7.29	25	
0854	11.39	0.29	7.34	30	
~~08~~ ELP					

Evidence of floating or suspended materials: N/A
Discoloration and Turbidity: N/A
Color: N/A
Odor: N/A
Comments:
300' well near woods

Recorded by: ELP

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/03W-20E01
Project Number: 131023-01.01
Well Name:
Well Owner: Ramirez
Well Address: 248 Sholes Dr.
Field Staff: ELP/DG
Date: 10/15/13
Sampling Method: Flow cell
Sample Start Time: 0909
Purge rate: 2 gal per min
Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
0909	10.40	11.68	6.93	5	
0911	10.38	9.38	6.91	10	
0913	10.28	7.35	6.94	15	
0915	10.31	0.33	6.83	20	
0917	10.33	0.26	6.82	25	
0919	10.33	0.24	6.89	30	

Evidence of floating or suspended materials: N/A
Discoloration and Turbidity: N/A
Color: N/A
Odor: N/A
Comments:
Spigot attached to house

Recorded by: ELP

ANCHOR
QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/03W-11C02
Project Number: 131023-01.01
Well Name:
Well Owner: edward Kasprowski
Well Address: 262 twin Oaks Rd
Field Staff: ELP/DG
Date: 10/14/13
Sampling Method: Flow cell
Sample Start Time: 1447
Purge rate: ~2 gal per min
Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
1449	11.98	0.62	7.24	5	
1451	11.81	0.38	7.06	10	
1453	11.77	0.29	6.96	15	
1455	11.72	0.24	7.06	20	
1457	11.72	0.23	7.09	25	

Evidence of floating or suspended materials: /
Discoloration and Turbidity: /
Color: /
Odor: /
Comments:
same spigot as before

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River

Field Crew: EP/DG

Project Number: 131023-01.01

Date/Time: 10/14/13 1026

Well ID: 13N/05W-26B02

Well Tag ID:

Well Owner name: Speck Timothy Speck

Facility Name: ~~103~~

Current Phone Number: 360-291-3773

Current Mailing Address: 103 Mauerman Rd

Renter: Name:

Permission granted to locate well? yes

Permission granted to collect Water Level? no

Permission granted to collect Water Quality? yes

Call ahead required before site visit? no call required but call to confirm intent

Recon GPS Well Coordinates

Northing:

Easting:

Comments:

Add Schetch map of well location and sample faucet location:

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/05W-26E02
Project Number: 131023-01.01
Well Name:
Well Owner: Speck Timothy Speck
Well Address: 103 Mauerman Rd
Field Staff: ELP/DG
Date: 10/14/13
Sampling Method: flow cell
Sample Start Time: 1026
Purge rate: 2 gal per min
Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
1028	12.21	7.02	6.04	5	
1030	13.22	6.88	6.05	10	
1032	12.79	6.81	6.04	15	
1034	12.77	6.82	6.01	20	
1036	12.98	6.78	6.00	25	
1038	13.10	6.77	5.99	30	
1040	13.08	6.77	5.97	35	
1042	13.15	6.76	5.97	40	

Evidence of floating or suspended materials: NA
Discoloration and Turbidity: NA
Color: NA
Odor: NA
Comments:

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Well Tag ID: 13N/05W-26D01

Project Number: 131023-01.01

Well Name:

Well Owner: Alice Johnston

Well Address: 127 Beam Rd

Field Staff: DG, EP

Date: 10/14/13

Sampling Method: flow cell

Sample Start Time: 1000

Purge rate: 2 gal per min

Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
1003	12.08	9.66	6.53	5	
1006	12.17	9.15	6.54	10	
1008	12.76	3.56	6.44	15	
1010	12.95	3.52	6.48	20	
1012	12.85	3.49	6.49	25	
1014	12.81	3.48	6.49	30	

Evidence of floating or suspended materials:

Discoloration and Turbidity:

Color: Odor:

Comments:

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/05w-02L01
Project Number: 131023-01.01
Well Name:
Well Owner: Tom Toepelt
Well Address: 166 Truman
Field Staff: ELP/DG
Date: 10/14/13
Sampling Method: flow cell
Sample Start Time: 1146
Purge rate: 2 gal per min
Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
1148	9.83	0.45	8.93	5	
1151	9.80	0.28	8.93	10	
1153	9.95	0.22	6.78	15	
1156	10.02	0.18	8.88	20	
1158	10.02	0.16	8.90	25	
1200	10.02	0.14	8.91	30	

Evidence of floating or suspended materials: NA
Discoloration and Turbidity: NA
Color: NA
Odor: NA
Comments:
spigot attached to house

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Well Tag ID: 13N/05W-12C01

Project Number: 131023-01.01

Well Name:

Well Owner: Brenda Boardman 50' well

Well Address: 829 Leudinghaus Rd

Field Staff: ELP/DG

Date: 10/14/13

Sampling Method: Flow cell

Sample Start Time: 1219

Purge rate: 2 gal per min

Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
1222	10.66	1.47	8.62	5	
1224	10.56	0.99	8.61	10	
1226	10.36	0.73	8.61	15	
1228	10.35	0.52	8.59	20	
1230	10.18	0.20	8.44	25	
1232	10.24	0.15	8.43	30	
1234	10.22	0.13	8.43	35	
1236	10.23	0.12	8.45	40	

Evidence of floating or suspended materials: N/A

Discoloration and Turbidity: N/A

Color: N/A

Odor: N/A

Comments:

Recorded by: ELP

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Project Number: 131023-01.01

Well Tag ID: 13N/05W-12C01

Well Name:

Well Owner: Brenda Boardman 150' well

Well Address:

Field Staff: ELP/DG

Date: 10/14/13

Sampling Method: Flow cell

Sample Start Time: 1239

Purge rate: 2 gal per min

Meter: YSI 556

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Purge (Gal)	
1241	12.21	1.20	5.78	5	
1243	12.27	1.12	5.76	10	
1245	12.25	1.09	5.77	15	
1247	12.27	1.11	5.73	20	
1249	12.25	1.08	5.74	25	
1250	12.25	1.07	5.75	30	

Evidence of floating or suspended materials: N/A

Discoloration and Turbidity: slightly turbid

Color: N/A

Odor: N/A

Comments:

Pump kickedon several times during sampling period, no change in readings.

Recorded by: ELP

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River	Field Crew: DG LS
Project Number: 131023-01.01	Date/Time: 9/4/13

Well ID: W60

Well ~~Tag~~ ID: ~~13N/03W-26D01~~ ~~463520123165220~~ 13N/03W-18R01

Well Owner name: Don & Loretta Rippee

Facility Name:

Current Phone Number: 360-740-7704

Current Mailing Address: 453 Curtis Hill Rd Adna

Renter:		Name:

Permission granted to locate well? yes

Permission granted to collect Water Level? no

Permission granted to collect Water Quality? yes

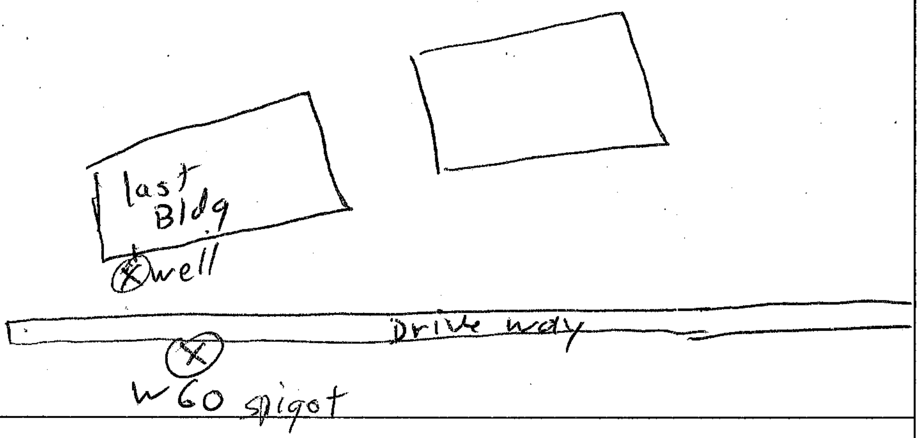
Call ahead required before site visit? no

Recon GPS Well Coordinates

Northing: 46 36.499	Easting: 123 05.848

Comments: ~~elev~~ ~~66~~

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River	Well Tag ID: 13N/05W-18R01 ~~13N/05W-26D01~~
Project Number: 131023-01.01	Well Name: W60
Well Owner: Don & Loretta Rippee	
Well Address: 453 Curtis Hill Rd. Adna	
Field Staff: DG, LS	Date: 9/4/13
Sampling Method: Flow cell	Sample Start Time: 1:27
Purge rate: 20 sec/gal	Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	gal ~~Turbidity (NTU)~~	Chlorophyll-a (µg/L)
1:28	17.53	4.97	7.38	5	—
1:30	16 33	2.85	7.38	10	—
1:33	14.8	2.27	7.31	15	
1:35	14.42	1.88	7.25	20	
1:37	14.27	1.57	7.22	25	
1:39	14.07	1.38	7.23	30	
1:41	13.97	1.23	7.24	35	
1:43	13.89	1.14	7.24	40	
1:45	14.06	1.07	7.25	45	
1:47	1409	1.05	7.25	50	

Evidence of floating or suspended materials: NA

Discoloration and Turbidity: NA

Color: NA Odor: NA

Comments:
25' to well from Spigot

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River

Field Crew: DG LS

Project Number: 131023-01.01

Date/Time: 9/4/13 / 1256

Well ID: 13 N / 03W - 18R01 W300

Well Tag ID:

Well Owner name: Don & Loretta Rippee

Facility Name:

Current Phone Number: 360-740-7704

Current Mailing Address: 453 Curtis Hill rd.

Renter:

Name:

Permission granted to locate well? Yes

Permission granted to collect Water Level? NO

Permission granted to collect Water Quality? Yes

Call ahead required before site visit? NO

Recon GPS Well Coordinates

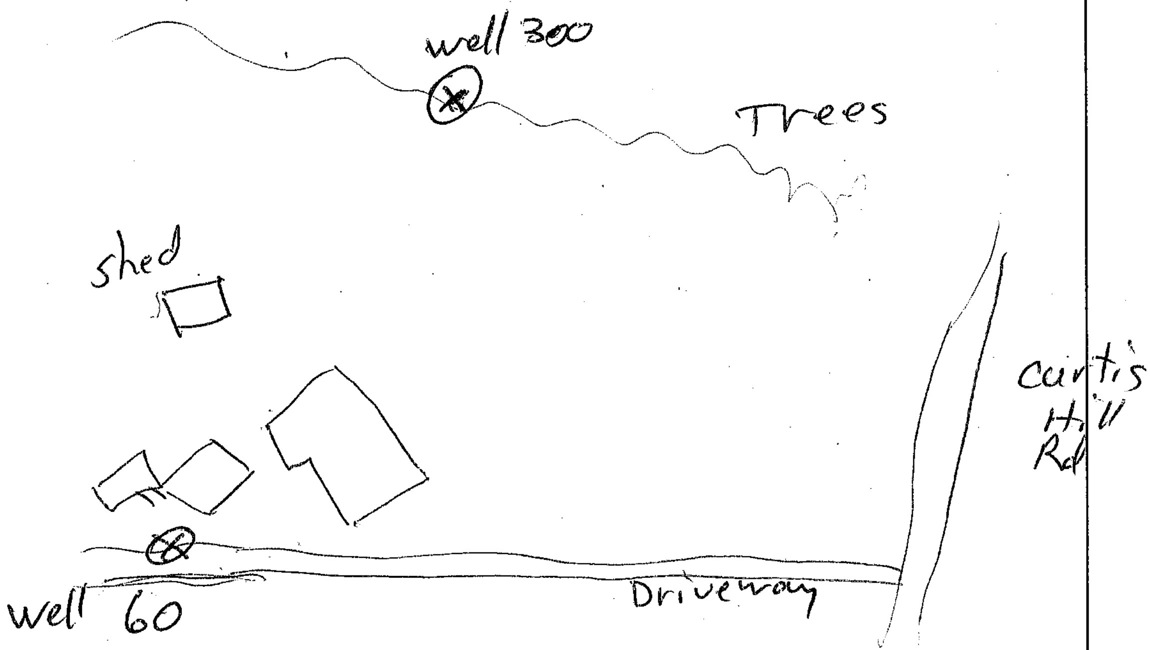
Northing: N46°36.462

Easting: W123°05.877

Comments: ~~W 123° 05.877~~

~~elev. 830~~' ~~well~~ ~~80~~ well≈300' deep

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form [redacted]

Project Name:	Chehalis River	Well ~~Tag~~ ID:	13N/03W-18R01
Project Number:	131023-01.01	Well Name:	W 300
Well Owner:	Don & Loretta Ripper		ALH791
Well Address:	453 Curtis Hill rd, Adna		
Field Staff:	DG LS	Date:	9/4/13
Sampling Method:	Flow through	Sample Start Time:	12:56 pm
Purge rate:	30 sec/gal	Meter:	YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	~~Turbidity (NTU)~~ Purge (gal)	Chlorophyll-a (µg/L)
12:59	14.52	3.28	7.25	5	
1:02	14.97	2.60	7.12	10	
1:05	13.65	1.59	7.20	15	
1:08	13.08	1.49	7.19	20	
1:11	12.95	1.43	7.20	25	
1:14	12.91	1.40	7.22	30	
1:17	13.06	1.37	7.24	35	
1:20	13.17	1.38	7.24	40	
1:23	13.20	1:40	7.24	45	

Evidence of floating or suspended materials: ~~no~~ NA

Discoloration and Turbidity: ~~na~~ NA

Color: / Odor: /

Comments: about 500' of pipe
well about 300' deep

~~V=46°~~

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River
Field Crew: DG LS
Project Number: 131023-01.01
Date/Time: 9/4/13
Well ID: 13N/03W-20E01
Well Tag ID:
Well Owner name: Jose & Augistina Ramirez
Facility Name:
Current Phone Number: 360-245-3412
Current Mailing Address: 248 Sholes Dr, Adna

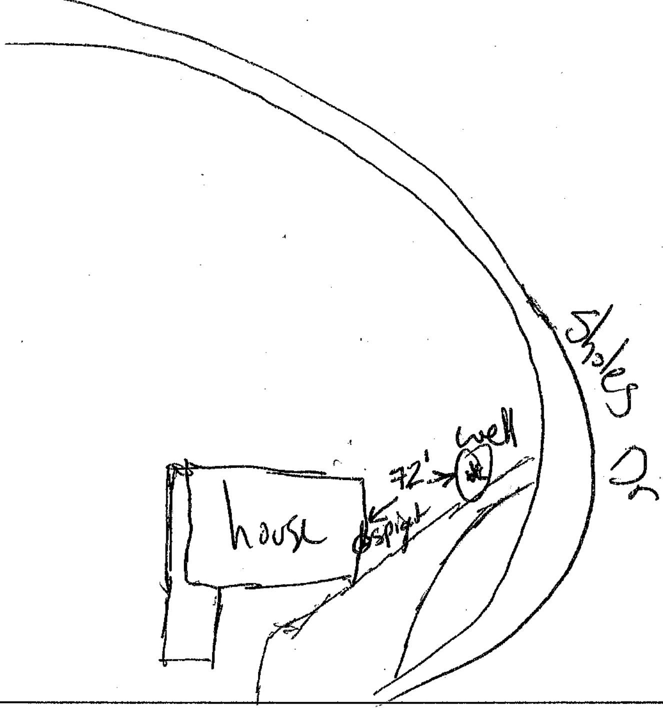
Renter: Name:
Permission granted to locate well? Yes
Permission granted to collect Water Level? ~~Yes~~ NO
Permission granted to collect Water Quality? Yes
Call ahead required before site visit? Yes

Recon GPS Well Coordinates

Northing: N 46°35.956'
Easting: W 123°05.608

Comments:

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River	Well Tag ID: 13N/03W-20E01
Project Number: 131023-01.01	Well Name:
Well Owner: Jose & Augistina Ramirez	
Well Address: 248 Sholes Dr.	
Field Staff: DG, LS	Date: 9/14/13
Sampling Method: Flow Cell	Sample Start Time: 2:08
Purge rate: 2gpm	Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	~~Turbidity~~ Purge ~~(NTU)~~ (gal)	Chlorophyll-a (µg/L)
2:10	15.06	4.67	7.09	5	
2:12:30	14.94	2.79	7.04	10	
2:15	15.03	1.81	7.01	15	
2:17:30	14.74	1.51	7.01	20	
2:19:30	14.42	1.59	7.00	25	
2:21:30	14.23	1.27	7.01	30	
2:24	14.13	1.03	7.01	35	
2:26	13.88	0.78	7.00	40	
2:28:30	13.64	0.77	7.00	45	

Evidence of floating or suspended materials: —

Discoloration and Turbidity: —

Color: — Odor: —

Comments:

Page 1

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Well ~~Tag~~ ID: 13N/03W-20E07

Project Number: 131023-01.01

Well Name:

Well Owner: Jose & Augistina Ramirez

Well Address: 248 Sholes Dr.

Field Staff: DG, LS

Date: 9/4/13

Sampling Method: Flow Cell

Sample Start Time: 2:08

Purge rate: 2gpm

Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Turbidity (NTU)	Chlorophyll-a (µg/L)
2:30:30	13.29	0.61	6.97	50	
2:32:30	13.17	0.56	6.98	55	
2:35	13.04	0.57	6.99	60	
2:37	12.94	0.51	6.99	65	

Evidence of floating or suspended materials: —

Discoloration and Turbidity: —

Color: —

Odor: —

Comments:

Page 2

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

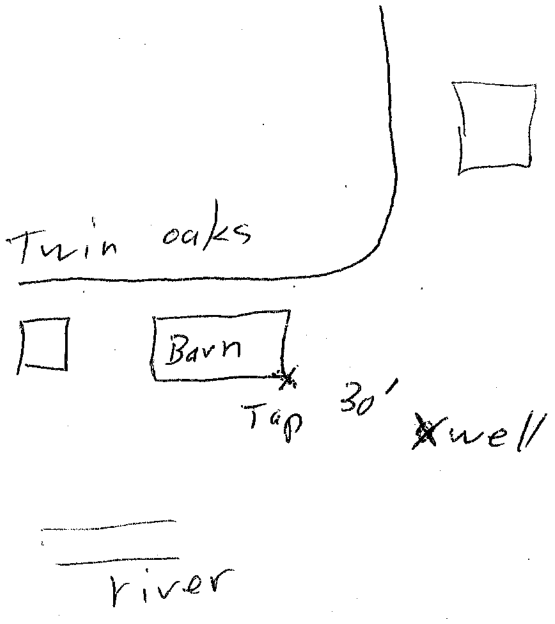
Project Name: Chehalis River
Field Crew: DG LS
Project Number: 131023-01.01
Date/Time: 9/5/13 / 9:5
Well ID: 13N/03W-11C02
Well Tag ID:
Well Owner name: Edward Kasprowski
Facility Name:
Current Phone Number: 360-740-1025
Current Mailing Address: 262 twin oaks Rd

Renter: Name:
Permission granted to locate well? yes
Permission granted to collect Water Level? ~~yes~~ NO
Permission granted to collect Water Quality? yes
Call ahead required before site visit? NO

Recon GPS Well Coordinates

Northing: 46 38.012
Easting: 123 01.706
Comments:

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Well ~~Tag~~ ID: 13N/03W-11C02

Project Number: 131023-01.01

Well Name:

Well Owner: Edward Kasprowski

Well Address: 262 twin oaks Rd

Field Staff: DG, LS

Date: 9/5/13

Sampling Method: flow cell

Sample Start Time: 1010

Purge rate: 25 sec/gal

Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	~~Turbidity (NTU)~~ Purge (gal)	Chlorophyll-a (µg/L)
1010	18,90	1,18	7,88	5	
1012	12,86	0,66	7,82	10	
1014	12.91	0.47	7,76	15	
Temp spike down → 1016	12:58	0,44	7,78	20	
1018	12,70	0,42	7,79	25	
1020	12,33	0,39	7,83	30	
1022	12,54	0,38	7,80	35	
1024	12,36	0,35	7,82	40	
1026	12,44	6,38	7,83	45	
10,28	12,42	0,34	7,83	50	
10,30	12,36	0.34	7,85	55	

Evidence of floating or suspended materials: N/A

Discoloration and Turbidity: N/A

Color: N/A

Odor: N/A

Comments: 65' dep well
Tap 30' from well

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River

Field Crew: DG LS

Project Number: 131023-01.01

Date/Time: 9/4/13

Well ID: 13N/05W-26E02

Well Tag ID:

Well Owner name: Timothy and Stacia Speck

Facility Name:

Current Phone Number: 360-291-3773

Current Mailing Address: 126 Beam Rd

wrong house

Renter:

Name:

Permission granted to locate well? yes

Permission granted to collect Water Level? ~~ye~~ no

Permission granted to collect Water Quality? yes - temp

Call ahead required before site visit? no

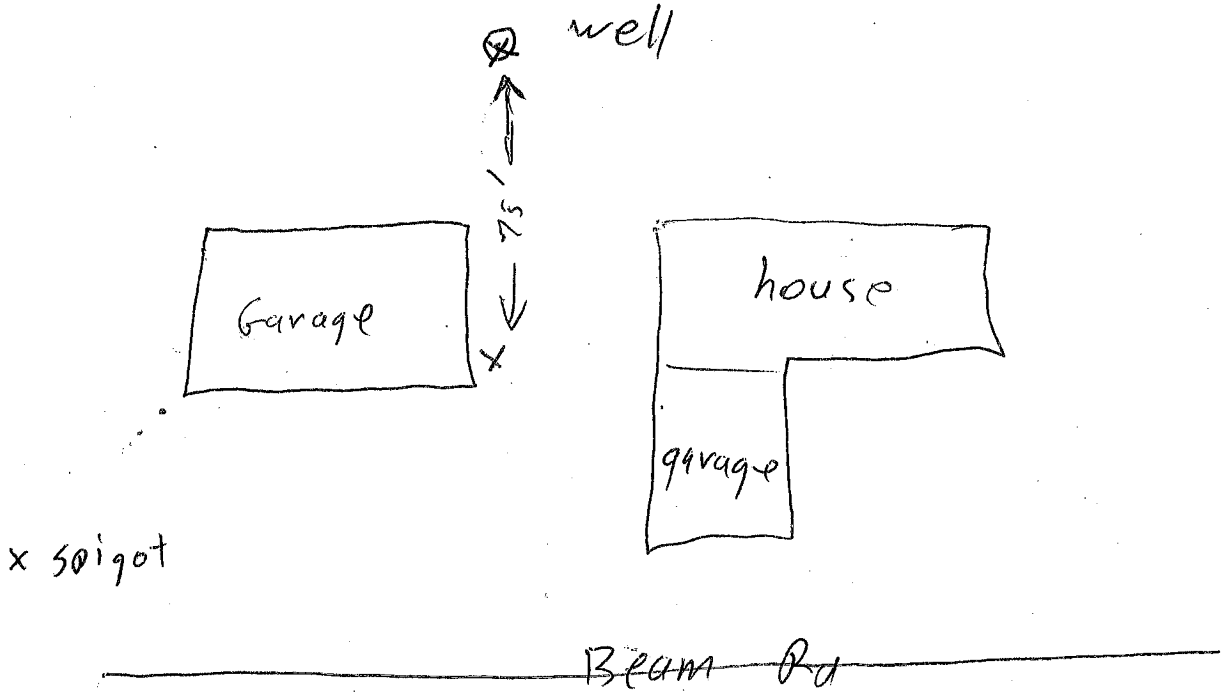
Recon GPS Well Coordinates

Northing: N 46° 35.260'

Easting: W 123° 16.858

Comments:

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River

Well ~~Tag~~ ID: 13N/05W-26E02

Project Number: 131023-01.01

Well Name:

Well Owner: Timothy and Stacia Speck

Well Address: 126 Beam Rd, Pe Ell

Field Staff: DG LS

Date: 9/4/13

Sampling Method: Flow Cell

Sample Start Time: 10:59 am

Purge rate: 2 gpm

Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Turbidity (NTU)	Chlorophyll-a (µg/L)
10:59	15.62	7.15	6.92		
11:04	15.46	6.74	6.73		
11:09	15.31	6.77	6.76		
11:11	15.19	6.75	6.76		
11:13	15.17	6.77	6.76		
11:15	15.15	6.77	6.76		

wrong house

Evidence of floating or suspended materials: /

Discoloration and Turbidity: /

Color: / Odor: /

Comments:

Purged 35 gal

Recorded by: Luke Smith

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River
Field Crew: PG-LS
Project Number: 131023-01.01
Date/Time: 9/4/13 1130
Well ID: 13N/05W-26D01
Well Tag ID:
Well Owner name: Alice Johnston
Facility Name:
Current Phone Number: 360-291-3466
Current Mailing Address: 127 Beam Rd

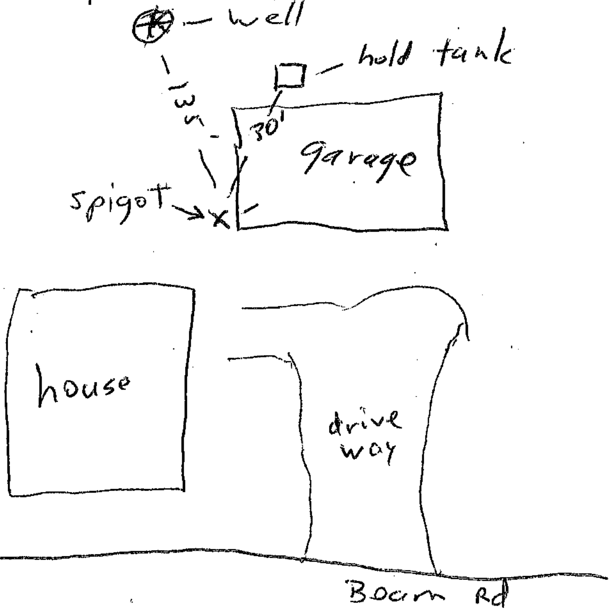
Renter:
Name:
Permission granted to locate well? yes
Permission granted to collect Water Level? no
Permission granted to collect Water Quality? yes
Call ahead required before site visit? no

Recon GPS Well Coordinates

Northing: 46 35.312
Easting: 123 16.874

Comments:

Add Schetch map of well location and sample faucet location:



Recorded by:

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/05W-26D01
Project Number: 131023-01.01
Well Name:
Well Owner: Alice Johnston
Well Address: 127 Beam Rd, Pe Ell
Field Staff: DG LS
Date: 9/4/13
Sampling Method: Flow Cell
Sample Start Time: 11:33
Purge rate: 2 gpm
Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	~~Turbidity~~ Purge ~~(NTU)~~ (gal)	Chlorophyll-a (µg/L)
11:36	15.45	2.23	6.32	5	
11:40	15.26	1.65	6.24	10	
11:43:30	15.20	1.39	6.25	15	
11:46	15.04	1.20	6.25	20	
11:49	15.05	1.15	6.25	25	

Evidence of floating or suspended materials: /
Discoloration and Turbidity: /
Color: / Odor: /
Comments:

Recorded by: Luke Smith

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

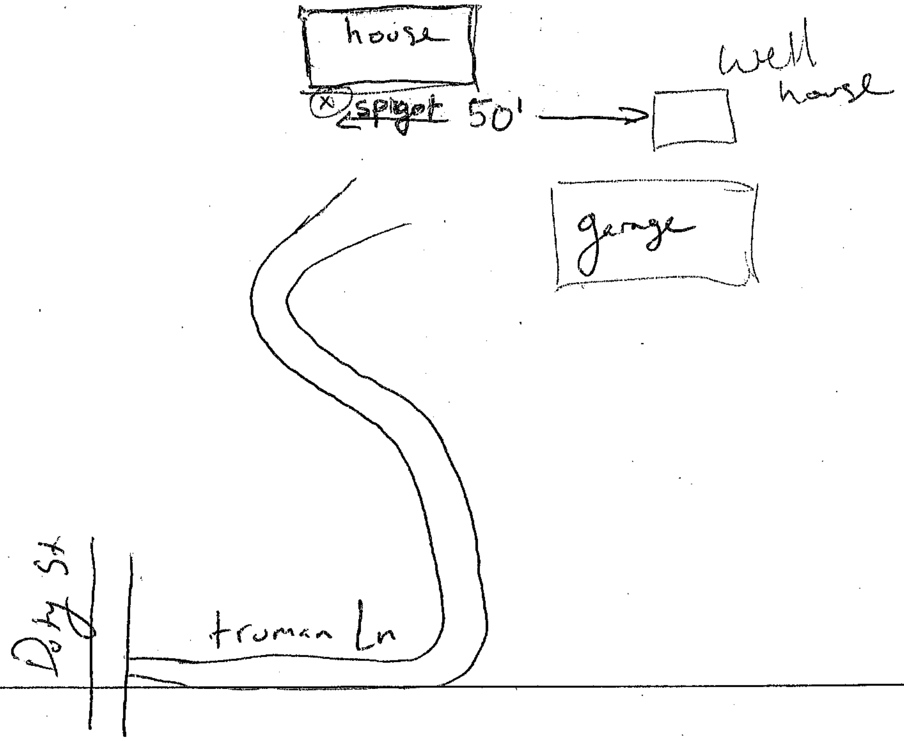
Well Reconnaissance Field Sheet

Project Name: Chehalis River
Field Crew: DG LS
Project Number: 131023-01.01
Date/Time: 9/5/2013 8:41
Well ID: 13N/05W-02L01
Well Tag ID:
Well Owner name: Tom Toepelt
Facility Name:
Current Phone Number: 360-291-3515
Current Mailing Address: 166 Truman Ln

Renter: Name:
Permission granted to locate well? yes
Permission granted to collect Water Level? ~~yes~~ NO
Permission granted to collect Water Quality? yes
Call ahead required before site visit? yes

Recon GPS Well Coordinates
Northing: ~~[illegible]~~ N46°38.286
Easting: ~~[illegible]~~ W123°16.293
Comments:

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well-~~Tag~~ ID: 13N/05W-02L01
Project Number: 131023-01.01
Well Name:
Well Owner: Tom Toepelt
Well Address: 166 Truman Ln
Field Staff: DG LS
Date: 9/5/13
Sampling Method: Flow Cell
Sample Start Time: 8:41
Purge rate: 30 sec/gal = 2gpm
Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	~~Turbidity~~ Purge (NTU) gal	Chlorophyll a (µg/L)
8:43	12:82	1.33	8.82	5	
8:45	12.52	0.81	8.61	10	
8:47.5	12.82	0.68	8.57	15	
8:49.5	10.98	0.57	8.71	20	
8:51.5	10.82	0.44	8.6	25	
8.54	10.83	0.41	8.6	30	
				35	
				40	
				45	

well kicked in

Evidence of floating or suspended materials: N/A
Discoloration and Turbidity: N/A
Color: —
Odor: —

Comments: 50' from well
shallow well ≈ 50'-60' deep

hand measure 10°C at final reading

Recorded by: Luke Smith

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River

Field Crew: PG, LS

Project Number: 131023-01.01

Date/Time: 9/4/13 3:19pm

Well ID: 13N/05W-12C01 W50

Well Tag ID:

Well Owner name: Brenda Boardman

Facility Name:

Current Phone Number: 360-291-3632

Current Mailing Address: 829 Leudinghaus Rd

Renter: Name:

Permission granted to locate well? Yes

Permission granted to collect Water Level? Yes

Permission granted to collect Water Quality? Yes

Call ahead required before site visit? ~~no~~ yes

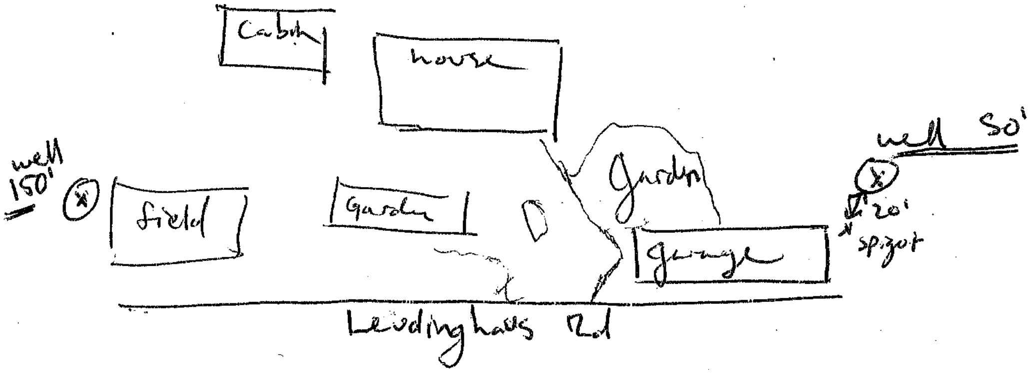
Recon GPS Well Coordinates

Northing: N 46° 38.047

Easting: W 123°15.351'

Comments: 50' deep well ~~[illegible]~~ ~~150' deep well~~
= W50 ~~W150~~

Add Schetch map of well location and sample faucet location:



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/05W-12C01
Project Number: 131023-01.01
Well Name: W50
Well Owner: Brenda Boardman
Well Address: 829 Leudinghaus Rd, Pe Ell
Field Staff: DG LS
Date: 9/4/13
Sampling Method: Flow cell
Sample Start Time: 3:19 pm
Purge rate: 25 sec/gal
Meter: YSI 650

Purge Parameters:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	~~Turbidity~~ (gal) ~~(NTU)~~	Chlorophyll-a (µg/L)
3:21.5	12.91	2.08	8.48	5	
3:23.5	10.78	1.19	8.59	10	
3:25	10.67	1.09	8.76	15	
3.27	11.53	1.53	8.81	20	
3:29	12.31	0.59	8.80	25	
3:31.5	12.3	0.7	8.80	30	
well kicked on → 3.33.5	10.68	0.77	8.90	35	

Evidence of floating or suspended materials: N/A
Discoloration and Turbidity: N/A
Color: N/A
Odor: N/A

Comments: 50' deep
20' from well
fluctuating between 10.7 & 12.3, ~~well~~
when well kicks on temp drops

Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Well Reconnaissance Field Sheet

Project Name: Chehalis River	Field Crew: DG, LS
Project Number: 131023-01.01	Date/Time: 9/4/13 3:40

Well ID: 13N/05W-12C01 W150

Well Tag ID:

Well Owner name: Brenda Boardmen

Facility Name:

Current Phone Number: 360-291-3632

Current Mailing Address: 829 Leudinghaus Rd

Renter:		Name:

Permission granted to locate well? Yes

Permission granted to collect Water Level? NO

Permission granted to collect Water Quality? Yes

Call ahead required before site visit? Yes

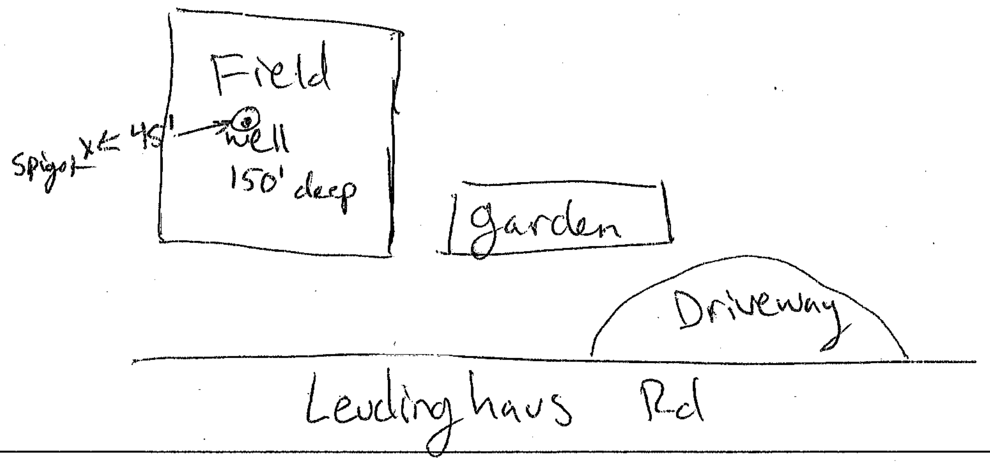
Recon GPS Well Coordinates

Northing: N 46° 38.098	Easting: W 123°15.363'

Comments: 150' deep well = W150

Add Schetch map of well location and sample faucet location:

See previous sketch



Recorded by:

ANCHOR QEA

Anchor QEA L.L.C.
720 Olive Way, Suite 1900
Seattle, WA 98101
Phone 206.287.9130 Fax 206.287.9131

Groundwater Monitoring Form

Project Name: Chehalis River
Well Tag ID: 13N/05W-12C01
Project Number: 131023-01.01
Well Name: W 150
Well Owner: Brenda Boardman
Well Address: 829 Leudinghaus Rd
Field Staff: DG LS
Date: 9/4/13
Sampling Method: Flow cell
Sample Start Time: 3:40pm
Purge rate: 25 sec/gal
Meter: YSI 650

Purge Parameters:

Pumps kicked on

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Turbidity (NTU) Purge (gal)	Chlorophyll-a (µg/L)
3:42.5	12.45	2.74	6.31	5	
3:44	12.32	2.01	6.13	10	
3:46	12.32	1.81	6.06	15	
3:50	12.29	1.68	5.99	20	
3:53	12.33	1.63	5.97	25	

Evidence of floating or suspended materials: N/A
Discoloration and Turbidity: N/A
Color: N/A
Odor: N/A

Comments: ~150' deep well
~45' from well
GPS - N 46° 38.058 W 123° 15.263

Recorded by:

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	
Well Owner:	Tim Speak		
Well Address:	103 Maverman Rd, Pe El, WA		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	YS1 - Flow Cell	Sampling Start:	7:52
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
7:52	17.7°c	4.26	6.45	5
7:56	13.8°c	4.42	6.16	10
8:00	13.4°c	4.59	5.85	15
8:03	13.1°c	4.49	5.66	20
8:06	13.0°c	4.45	5.68	25
8:08	12.6°c	4.59	5.84	30
8:11	12.6°c	4.53	5.79	35

Comments: Weather was overcast, slight breeze and cool

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	
Well Owner:	Alice Johnson		
Well Address:	127 Beam Rd		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	Flow Cell	Sampling Start:	8:29
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
8:32	15.3°c	1.05	6.26	5
8:35	15.3°c	0.84	6.31	10
8:39	15.2°c	0.71	6.35	15
8:43	15.2°c	0.66	6.37	20

Comments: Weather was overcast, light rain and cool

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	
Well Owner:	Tom Toepelt		
Well Address:	166 Truman Ln, Chehalis, WA		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	YS1 - Flow Cell	Sampling Start:	9:36
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
9:43	13.5°c	2.99	8.56	5
9:47	12.5°c	1.26	8.1	10
9:50	11.0°c	0.98	8.26	15
9:54	11.1°c	0.74	8.14	20
9:58	11.0°c	0.68	8.36	25

Comments: Weather- light rain, overcast and light breeze

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	
Well Owner:	Brenda Boardman		
Well Address:	829 Leudinghalt Rd., Chehalis, WA		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	Flow Cell	Sampling Start:	10:20
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
10:24	11.8°c	1.8	6.55	5
10:27	11.6°c	1.32	5.82	10
10:31	11.5°c	1.26	5.77	15
10:35	11.5°c	1.15	5.95	20
10:39	11.6°c	1.13	5.94	25

Comments: Weather- light rain, overcast and light breeze

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	W50
Well Owner:	Brenda Boardman		
Well Address:	829 Leudinghalt Rd., Chehalis, WA		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	Flow Cell	Sampling Start:	10:46
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
10:49	12.1°c	0.72	7.89	5
10:53	12.2°c	0.31	8.09	10
11:57	11.7°c	0.38	8.25	15
11:00	11.0°c	0.34	8.09	20
11:03	11.8°c	0.32	8.38	25
11:07	11.8°c	0.33	8.42	30

Comments: Weather- Partly sunny, cloudy, on and off rain, light wind

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	w300
Well Owner:	Don and Lorreta Rippee		
Well Address:	453 Curtis Hill Rd, Adna, WA		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	Flow Cell	Sampling Start:	11:31
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
11:35	17.6°c	7.45	7.09	5
11:39	16.5°c	8.21	6.73	10
11:43	15.4°c	1.78	7.01	15
11:45	15.0°c	1.46	7.1	20
11:48	14.5°c	1.34	7.14	25
11:51	14.1°c	1.28	7.15	30
11:55	14.1°c	1.28	7.16	35
11:58	14.2°c	1.3	7.18	40

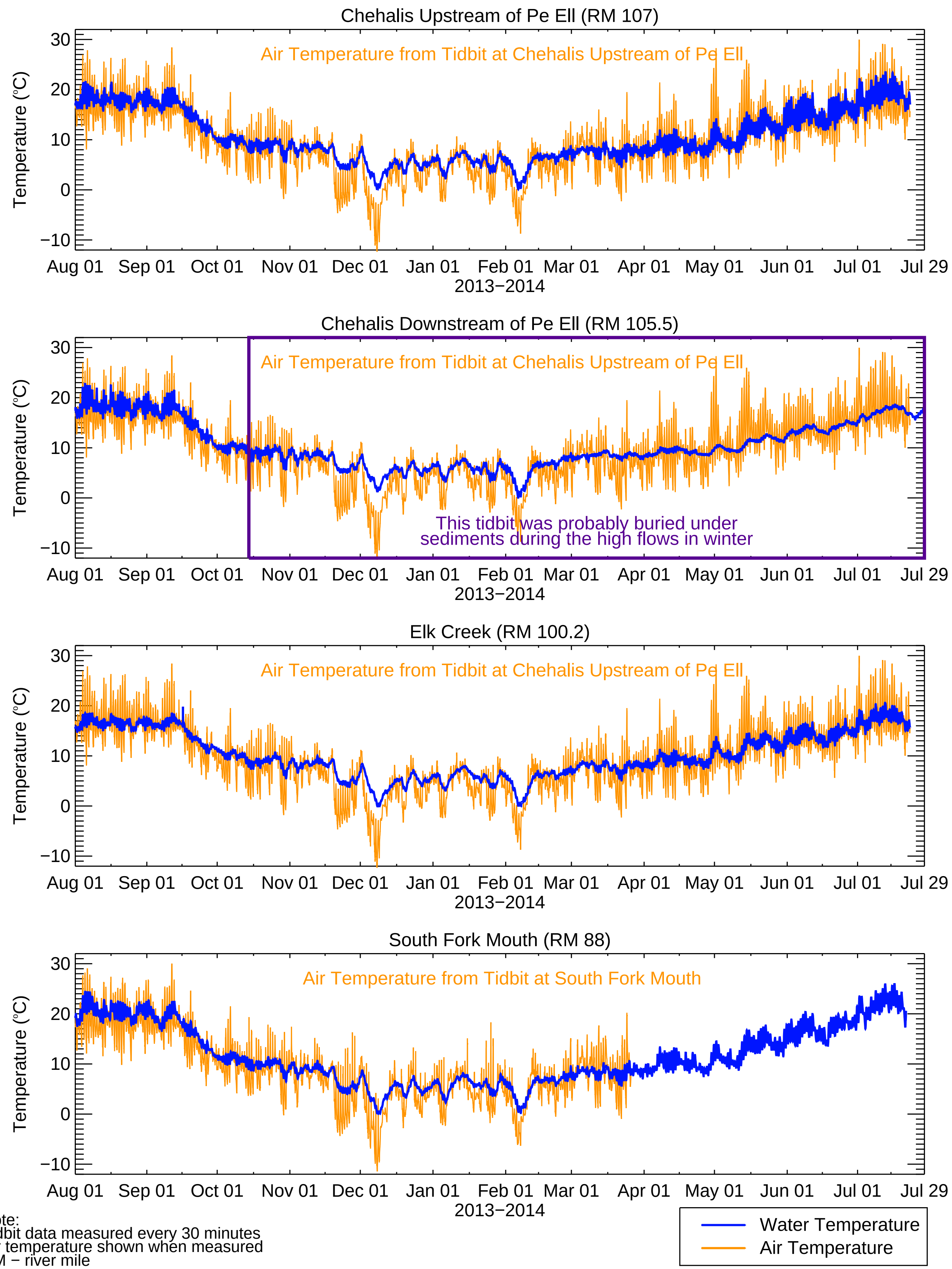
Comments: Overcast, light breeze

Project Name:	Chehalis River	Well Tag I.D.:	
Project Number:	131023-01.01	Well Name:	w60
Well Owner:	Don and Lorreta Rippee		
Well Address:	453 Curtis Hill Rd, Adna, WA		
Field Staff:	Emily and Grace	Date:	7/24/2014
Sampling Method:	Flow Cell	Sampling Start:	12:01
Purge Rate:	5 gallon/4 min	Meter:	YS1 650

Time	Temp	Dissolved Oxygen	pH Units	Purge
12:04	15.2°c	8.36	6.56	5
12:08	13.9°c	10.16	6.38	10
12:11	13.5°c	9.73	6.3	15
12:13	13.6°c	10.01	6.11	20
12:16	13.4°c	9.85	6.16	25
12:19	13.4°c	9.76	6.27	30

Comments: Overcast, light wind

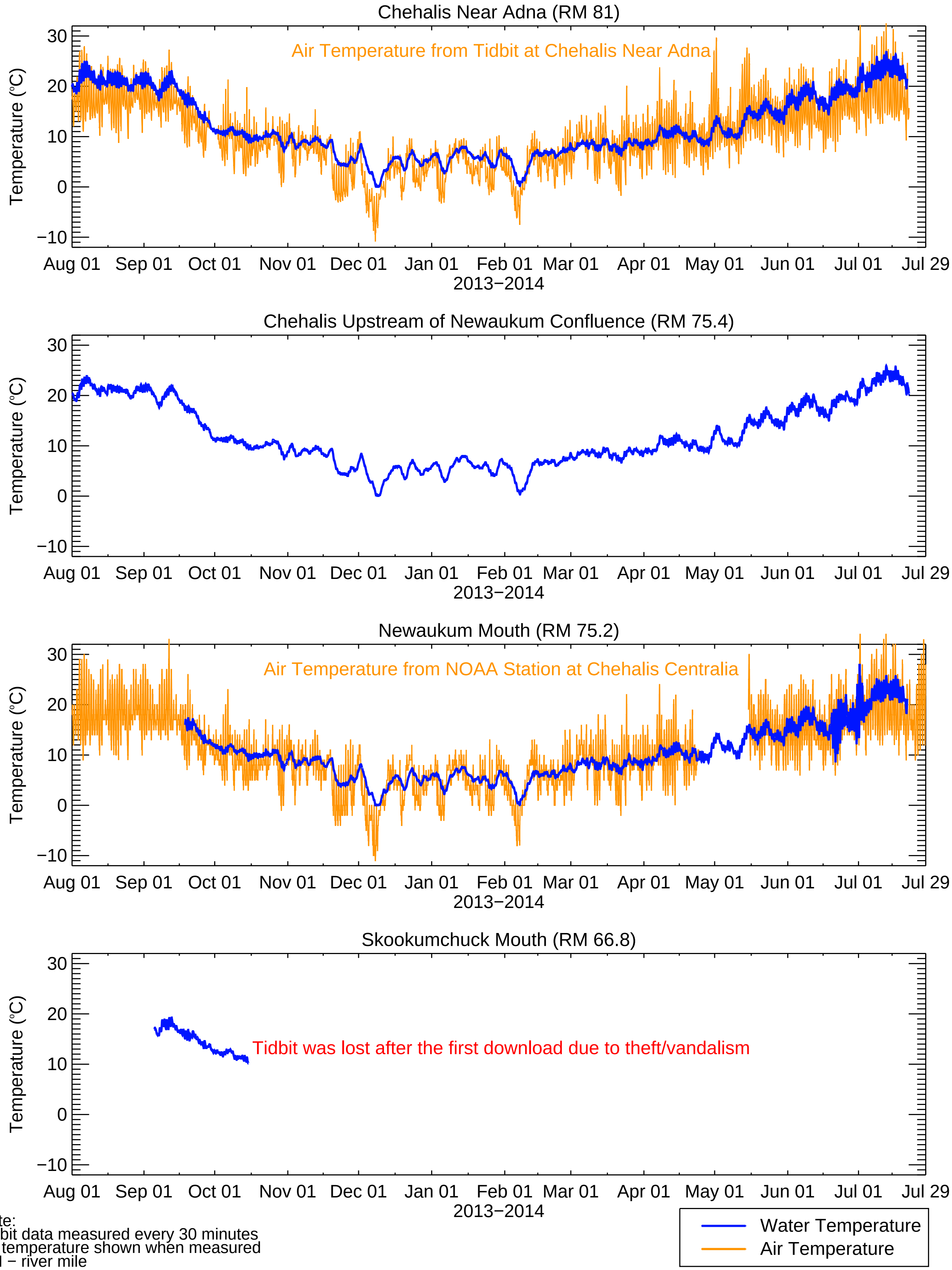
Appendix G: Water versus Air Temperature Comparisons for Temperature Tidbits



Note:
Tidbit data measured every 30 minutes
Air temperature shown when measured
RM − river mile

Figure G−1

Temporal Plots of Hourly Temperature in the Chehalis River and Tributaries



Chehalis Near Adna (RM 81)

Chehalis Upstream of Newaukum Confluence (RM 75.4)

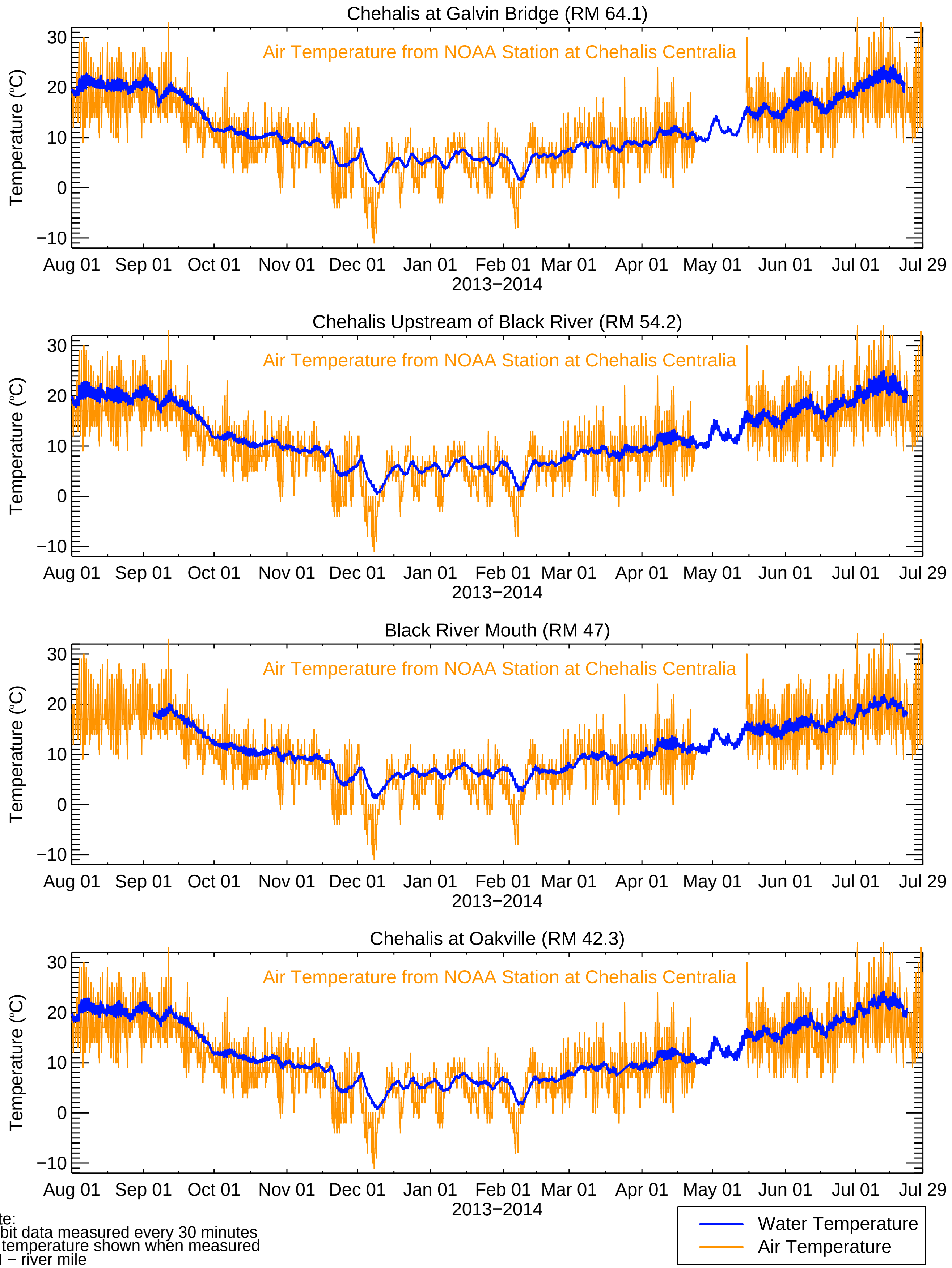
Newaukum Mouth (RM 75.2)

Skookumchuck Mouth (RM 66.8)

Note:
Tidbit data measured every 30 minutes
Air temperature shown when measured
RM − river mile

Figure G−1 (continued)

Temporal Plots of Hourly Temperature in the Chehalis River and Tributaries
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species



Note:
Tidbit data measured every 30 minutes
Air temperature shown when measured
RM − river mile

ANCHOR
QEA

Figure G−1 (continued)

Temporal Plots of Hourly Temperature in the Chehalis River and Tributaries
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

Appendix H: Analytical Data Validation Report

720 Olive Way, Suite 1900
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287.9131
www.anchorqea.com

DATA VALIDATION REVIEW REPORT – EPA STAGE 2A

Project:	Chehalis Basin Water Quality Monitoring
Project Number:	131023-01.01
Date:	August 8, 2014

This report summarizes the review of analytical results for 56 surface water samples collected on August 6 and September 17, 2013, January 27, and July 22 and July 30, 2014. The samples were collected by Anchor QEA, LLC, and submitted to Dragon Analytical Laboratory (DAL) in Olympia, Washington, and/or Analytical Resources, Inc. (ARI) in Tukwila, Washington. DAL subcontracted Total Kjeldahl Nitrogen (TKN) analyses to Edge Analytical in Burlington, Washington. ARI subcontracted TKN analyses to IEH-Aquatic Research in Seattle, Washington and Chlorophyll-a analyses to AmTest Laboratories in Kirkland, Washington. The samples were analyzed for the following parameters:

- Total suspended solids (TSS) by Standard Method (SM) 2540D
- Biochemical oxygen demand (BOD-5) by SM 5210B
- Total Kjeldahl nitrogen (TKN) by SM 4500$_{org}$ B and C, and United States Environmental Protection Agency (USEPA) method 351.2
- Ammonia (NH_3) by SM 4500 NH_3 and USEPA method 350.1
- Nitrate and nitrite (NO_3^-/NO_2^-) by USEPA method 300.0 and 353.2
- Total phosphorous (TP), dissolved phosphorous (DP), and orthophosphate (OP) by SM 4500P-E
- Chloropyll-a by SM 10200 H
- Dissolved oxygen (DO) by SM 4500O C and G
- pH by SM 4500 H^+

Dragon Labs sample data group (SDG) numbers 130807-01, 130918-02 and ARI SDGs XG73, XG74, XW08, XW09 and YU69 were reviewed in this report. IDs of samples reviewed in this report are presented in Table 1.

Table 1
Samples Reviewed

Sample ID	DAL ID	ARI ID	Matrix	Analyses Requested
PE-ELL-US-130806	#1	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
ELK-CRK-130806	#2	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-SF-130806	#3	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
SF-CHL-MOUTH-130806	#4	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
ADNA-130806	#5	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-NWK-130806	#6	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
NWK-MOUTH-130806	#7	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-RT6-BR-130806	#8	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-SKM-130806	#9	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
SKM-MOUTH-130806	#10	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-AT-GALVIN-130806	#11	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
LNC-CRK-130806	#12	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-BLK-130806	#13	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
BLK-RT12-130806	#14	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-OAK-130806	#15	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-OAK-D-130806	#16	--	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
PE-ELL-US-130917	#1	XG73/XG74A	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
ELK-CRK-130917	#2	XG73/XG74B	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-SF-130917	#3	XG73/XG74C	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
SF-CHL-MOUTH-130917	#4	XG73/XG74D	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
ADNA-130917	#5	XG73/XG74E	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-NWK-130917	#6	XG73/XG74F	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a

Sample ID	DAL ID	ARI ID	Matrix	Analyses Requested
NWK-MOUTH-130917	#7	XG73/XG74G	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-RT6-BR-130917	#8	XG73/XG74H	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-SKM-130917	#9	XG73/XG74I	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
SKM-MOUTH-130917	#10	XG73/XG74J	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-AT-GALVIN-130917	#11	XG73/XG74K	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
LNC-CRK-130917	#12	XG73/XG74L	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-BLK-130917	#13	XG73/XG74M	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
BLK-RT12-130917	#14	XG73/XG74N	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-OAK-130917	#15	XG73/XG74O	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-OAK-D-130917	#16	XG73/XG74P	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
PE-ELL-US-140127	--	XW08A/XW09A	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
PE-ELL-US-DUP-140127	--	XW08B/XW09B	Water	TSS, BOD, TKN, NH_3, NO_3^-/NO_2^-, TP, DP, OP, DO, pH, chlorphyll-a
CHE-PEL-US-140722	--	YS98/ YS99A	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
ELK-CRK-US-140722	--	YS98/YS99B	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-SF-140722	--	YS98/YS99C	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
SF-CHL-MOUTH-140722	--	YS98/YS99D	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-ADNA-140722	--	YS98/YS99E	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-NWK-140722	--	YS98/YS99F	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
NWK-MOUTH-140722	--	YS98/YS99G	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-RT6-BR-140722	--	YS98/YS99H	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-US-SKM-140722	--	YS98/YS99I	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
SKM-MOUTH-140722	--	YS98/YS99J	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-AT-GLV-140722	--	YS98/YS99K	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
LCN-CRK-140722	--	YS98/YS99L	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a

Sample ID	DAL ID	ARI ID	Matrix	Analyses Requested
CHL-US-BLK-140722	--	YS98/YS99M	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
BLK-RT12-140722	--	YS98/YS99N	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-OAK-140722	--	YS98/YS99O	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHL-OAK-DUP-140722	--	YS98/YS99P	Water	TSS, BOD, TKN, NH3, NO3-/NO2-, TP, DP, OP, DO, pH, chlorphyll-a
CHE-PEL-DS-140730	--	YU69A	Water	OP
ELK-CRK-140730	--	YU69B	Water	OP
LCN-CRK-140730	--	YU69C	Water	OP
CHL-US-SF-140730	--	YU69D	Water	OP
CHL-US-SF-DUP-140730	--	YU69E	Water	OP
CHL-ADNA-140730	--	YU69F	Water	OP

Data Validation and Qualifications

The following comments refer to the laboratory's performance in meeting the quality assurance/quality control (QA/QC) guidelines outlined in the analytical procedures and data quality objective sections of the Quality Assurance Project Plan (QAPP; Anchor QEA 2013). Laboratory results were reviewed using *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (USEPA 2004) guidelines.

Laboratory and method QC criteria were also used as stated in USEPA 1986 (SW-846, Third Edition), *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, update 1, August 1993; update II, January 1995; update IIA, February 1994; update IIB, August 1995; update III, June 1997; update IIIA, May 1999; update IIIB, June 2008; update IVA and IVB, January 2008. Unless noted in this report, laboratory results for the samples listed above were within QC criteria.

Field Documentation

Field documentation was checked for completeness and accuracy. The chain-of-custody (COC) forms were signed by Analytical Resources, Inc. (ARI) at the time of sample receipt; the samples were received cold and in good condition.

The cooler temperature was not recorded for samples delivered to Dragon Analytical Laboratory (DAL) on August 7, 2013. The field coordinator confirmed that samples were held on ice overnight until courier pick up at 7:00am, and samples were received at the lab within one hour of pick up, so data is not expected to be affected.

Holding Times and Sample Preservation and Analytical Methods

All samples were appropriately preserved and prepared and analyzed within recommended holding times, with the following exceptions:

- ARI SDG XG73 NO3-/NO2-: Sixteen samples were analyzed past the 48 hour hold time. These samples were previously analyzed at DAL and were reanalyzed at ARI to obtain a lower reporting limit. Results were qualified “J” to indicate a potentially low bias.
- DO and pH: All lab analyzed DO and pH analysis was performed outside of the recommended 15 minute hold time. All results have been qualified “J” to indicate that they are estimated.
- ARI SDG YS98 OP: Thirteen samples were analyzed slightly past the 48 hour hold time or OP. Results were qualified “J” or “UJ” to indicate a potentially low bias.
- ARI SDG YS98 NO3-/NO2-: Samples were analyzed past the 48 hour hold time noted in the QAPP for USEPA method 300.0. However, ARI confirmed that the hold time for samples that are pre-preserved and analyzed by 353.2 is 28 days, so data is not expected to be affected.

See Table 3 for qualified results.

Laboratory Method Blanks

Laboratory method blanks were analyzed at the required frequencies. All method blanks were free of target analytes.

Field Quality Control

Rinse Blanks

No rinse blanks were required in association with these sample sets.

Field Duplicates

Two field duplicates were collected in association with these sample sets. Detected results are summarized in Table 2.

Table 2
Field Duplicate Summary

Analyte	CHL-OAK-140722	CHL-OAK-DUP-140722	RPD
Nitrate + Nitrite	0.315 mg/L	0.295 mg/L	7%
Total Suspended Solids	2.1 mg/L	2.3 mg/L	9%
N-Ammonia	0.012 mg/L	0.045 mg/L	116%
Total Phosphorus	0.026 mg/L	0.008U mg/L	200%

Analyte	CHL-US-SF-140730	CHL-US-SF-DUP-140730	RPD
Ortho-Phosphorus	0.005 mg/L	0.004 U mg/L	200%

Results at or near the reporting limit (RL) may have exaggerated relative percent difference (RPD) values. No data were qualified based on field duplicate results.

Laboratory Control Sample and Laboratory Control Sample Duplicate

Laboratory control samples (LCS) and laboratory control sample duplicates (LCSD) were analyzed at the required frequencies. All LCS/LCSD analyses resulted in recoveries and/or RPD values within project-required control limits.

Matrix Spike and Matrix Spike Duplicate

Matrix spike (MS) and matrix spike duplicate (MSD) samples were analyzed at required frequencies and resulted in recoveries and/or RPD values within project-required control limits.

Laboratory Duplicates

Laboratory duplicates were analyzed at the required frequencies. If the sample or duplicate result is less than five times the method reporting limit (MRL), than the RPD control limit is no longer appropriate. Sample results within ± 1 time the MRL is the control limit in these situations. All duplicate results were within required limits.

Method Reporting Limits

Reporting limits were acceptable as reported. All values were reported using the laboratory reporting limits. Values were reported as undiluted, or when reported as diluted, the reporting limit accurately reflects the dilution factor.

Sample Analysis

Several samples were collected on July 30, 2014 for orthophosphate only, due to a hold time exceedance on samples collected July 22, 2014.

Two chlorophyll results have been rejected due to analytical errors associated with lab contamination.

See Table 3 for qualified results.

Overall Assessment

As was determined by this evaluation, the laboratories followed acceptable analytical methods and all requested sample analyses were completed. Accuracy was acceptable as demonstrated by the LCS/LCSD, and MS/MSD recovery values. Precision was also acceptable as demonstrated by the laboratory duplicates, MS/MSD RPD values. Most data were acceptable as reported; all other data are acceptable as qualified. Two results for chlorophyll-a were rejected. Table 3 summarizes the qualifiers applied to samples reviewed in this report.

Data Qualifier Definitions

U	Indicates the compound or analyte was analyzed for but not detected at or above the specified limit.
J	Indicates an estimated value.
R	Indicates data is rejected and unusable
UJ	Indicates the compound or analyte was analyzed for but not detected and the specified limit reported is estimated
DNR	Do not report

Table 3
Data Qualification Summary

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
All 16 samples in XG73	Conventionals	NO_3^-/NO_2^-	Varies	"J" all detects	Analyzed past hold time
All samples	Conventionals	DO	Varies	"J" all detects	Analyzed past hold time
All samples	Conventionals	pH	Varies	"J" all detects	Analyzed past hold time
PE-ELL-US-130917	Conventionals	Chlorophyll-a	-0.78 mg/m^3	R	Lab Contamination
ELK-CRK-130917	Conventionals	Chlorophyll-a	-0.69 mg/m^3	R	Lab Contamination
CHE-PEL-US-140722	Conventionals	NO3-/NO2-	0.116 mg/L	0.116J mg/L	Analyzed past hold time
ELK-CRK-US-140722	Conventionals	NO3-/NO2-	0.074 mg/L	0.074J mg/L	Analyzed past hold time
CHL-US-SF-140722	Conventionals	NO3-/NO2-	0.035 mg/L	0.035J mg/L	Analyzed past hold time
SF-CHL-MOUTH-140722	Conventionals	NO3-/NO2-	0.05 mg/L	0.05J mg/L	Analyzed past hold time
CHL-ADNA-140722	Conventionals	NO3-/NO2-	0.055 mg/L	0.055J mg/L	Analyzed past hold time
CHL-US-NWK-140722	Conventionals	NO3-/NO2-	0.068 mg/L	0.068J mg/L	Analyzed past hold time
NWK-MOUTH-140722	Conventionals	NO3-/NO2-	0.013 mg/L	0.013J mg/L	Analyzed past hold time
CHL-RT6-BR-140722	Conventionals	NO3-/NO2-	0.034 mg/L	0.034J mg/L	Analyzed past hold time
CHL-US-SKM-140722	Conventionals	NO3-/NO2-	0.01U mg/L	0.01UJ mg/L	Analyzed past hold time
SKM-MOUTH-140722	Conventionals	NO3-/NO2-	0.234 mg/L	0.234J mg/L	Analyzed past hold time
CHL-AT-GLV-	Conventionals	NO3-/NO2-	0.067 mg/L	0.067J mg/L	Analyzed past hold time

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
140722					
LCN-CRK-140722	Conventionals	NO3-/NO2-	0.112 mg/L	0.112J mg/L	Analyzed past hold time
CHL-US-BLK-140722	Conventionals	NO3-/NO2-	0.287 mg/L	0.287J mg/L	Analyzed past hold time

REFERENCES

Anchor QEA, 2013. Quality Assurance Project Plan. Chehalis Basin Flood Hazard Mitigition Alternatives Analysis. September 2013.

USEPA (U.S. Environmental Protection Agency), 1986. Test methods for Evaluating Solid Waste: Physical/Chemical Methods. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA 530/SW-846.

USEPA, 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation (OSRTI). EPA 540-R-04-004. October.