FINAL QAPP

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QUALITY ASSURANCE PROJECT PLAN
CHEHALIS BASIN FLOOD HAZARD MITIGATION ALTERNATIVES ANALYSIS PROJECT

Prepared for

Washington Office of Financial Management

Prepared by

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Ecology issued publication

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Publication No. 17-10-026

October 2013

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QUALITY ASSURANCE PROJECT PLAN
Chehalis Basin Flood Hazards Mitigation Alternatives and Analysis
October 10, 2013

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Where signatures are missing, an electronic approval is appended to the end of the document in Appendix C.

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
%R	percent recovery
°C	degrees Celsius
BOD-5	biochemical oxygen demand
CBFHMAA Project	Chehalis Basin Flood Hazard Mitigation Alternatives Analysis Project
COC	chain of custody
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
GPS	Global Position System
ICV	Initial Calibration Verification
LCS	laboratory control sample
MDL	method detection limits
MS	matrix spike
MSD	matrix duplicate spike
NIST	National Institute of Standards and Technology
OFM	Washington State Office of Financial Management
OP	orthophosphate
PARCC	precision, accuracy, representativeness, comparability, and completeness
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RFD	relative percent difference
SOP	standard operating procedure
TDP	total dissolved phosphorus
TP	total phosphorus
TSS	Total suspended solids

USGS	U.S. Geological Survey
Work Group	Chehalis Basin Work Group

1 INTRODUCTION

On behalf of the Office of Financial Management, State of Washington (OFM), Anchor QEA is proposing a water quality monitoring program in the Chehalis River.

This Quality Assurance Project Plan (QAPP) describes the water quality monitoring program objectives and the procedures to be followed to achieve the project objectives. This QAPP was developed using the *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology 2004).

1.1 Background

The proposed Chehalis Basin Flood Hazard Mitigation Alternatives Analysis Project (CBFHMAA Project) will evaluate 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 they need to decide on a recommended path forward, including whether to advance to the permitting phase for a water retention structure, by September 2014.

Several scientifically based technical studies are being 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. This QAPP describes the water quality data collection objectives, methods, and quality control procedures. The data collected during the water quality monitoring program is intended to support the assessment of environmental impacts of the Project.

1.2 Water Quality Data Collection Objectives

The purpose of the water quality monitoring program is to further characterize water temperatures, dissolved oxygen (DO), and water quality throughout the mainstem Chehalis River. The water quality monitoring program is also designed to characterize the nutrient (nitrogen and phosphorus), and biochemical oxygen demand (BOD-5) inputs from the major tributaries of the Chehalis River (such as South Fork Chehalis River, Newaukum River, Skookumchuck River, Lincoln Creek, and Black River).

The data collected 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. The with-project conditions will be determined through mechanistic modeling. Thus, the data collected will also 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 here (temperature, turbidity, and DO) may be used to support evaluations of fish habitat suitability.

2 WATER QUALITY PROGRAM DESIGN

The water quality monitoring program was designed by using the data gaps identified in the earlier phases of the fish impact study (Anchor QEA 2012) and the objectives described in Section 1.2 of this QAPP. The following elements are proposed for the water quality monitoring program:

- 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
- Groundwater temperature measurements

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

2.1 Monitoring Locations

The locations at which automated temperature monitoring, water quality sampling, and flow measurements will be conducted are shown in Figure 1. The descriptions of the locations are shown in Table 1. Global Positioning System (GPS) coordinates for the locations will be obtained during the time of Tidbit deployment (for temperature Tidbits) and during the first water quality survey (for water quality sampling locations).

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 Washington State Department of Ecology (Ecology). The water quality sampling and flow monitoring locations were selected to characterize the nutrient and BOD loads brought in from the major tributaries (such as South Fork Chehalis River, Newaukum River, Skookumchuck River, Lincoln Creek, and Black River) and sections upstream of the major tributaries. Flow monitoring is proposed only at a subset of the water quality monitoring locations, because existing U.S. Geological Survey (USGS) and Ecology flow/stage gages provide information on river and tributary flow at some locations (see Figure 1).

2.2 Deployment of Temperature Probes

Automated water temperature monitoring will be accomplished by deploying Onset® Tidbit v2® temperature probes (Tidbit probes). The Tidbit probes will be deployed at ten locations covering the mainstem Chehalis River and its tributaries (Figure 1). Based on feedback received from Ecology, up to three Tidbit probes will be deployed to record air temperature in the reaches of river where water levels are likely to be low. The Tidbit probes deployed for recording air temperature will be used to assess the quality of data collected by Tidbit probes deployed water temperature by providing a corresponding estimate of the air temperature at the time of water temperature measurement.

The Tidbit probes will be deployed in the first week of August 2013, and allowed to remain in place for at least 1 year. Data will be downloaded from the Tidbit probes during low-flow and quarterly water quality surveys described below.

2.3 Summer Low-flow Synoptic Surveys

Water quality data will be collected through synoptic surveys from upstream to downstream to characterize nutrient and BOD loads. The surveys will include flow measurements and water quality data collection along the mainstem Chehalis River and at the mouths of major tributaries (such as South Fork Chehalis River, Newaukum River, Skookumchuck River, Lincoln Creek, and Black River). Overall water quality data collection is proposed at 15 locations as shown in Figure 1. The exact locations may be modified based on input from Ecology, other stakeholders, and field conditions encountered.

The water quality parameters analyzed will include DO, pH, total suspended solids (TSS), biochemical oxygen demand (BOD-5), total Kjeldahl nitrogen (TKN), ammonia, nitrite plus nitrate, total phosphorus (TP), orthophosphate, (OP), total dissolved phosphorus (TDP), and chlorophyll-a.

Three low-flow synoptic surveys are proposed to be conducted in August 2013, September 2013, and July 2014. Water samples and water quality environmental parameters (DO, temperature, pH and chlorophyll-a) will be collected from the bank at each sampling location.

Water samples at each location will be analyzed at the Analytical Resources, Inc. (ARI)[1] in Tukwila, Washington. ARI is accredited by Ecology (LAB ID: C558-13). Chlorophyll-a and TKN samples will be sent to and analyzed by ARI's support laboratories, AMTest Laboratories, in Kirkland, Washington and Aquatic Research Inc. in Seattle, Washington. The Ecology accreditation numbers for these labs are C554-13 and C550-13, respectively.

During each water quality sampling period, flow measurements will be conducted at nine locations that includes locations on the mainstem Chehalis River upstream of Newaukum River and at the mouths of major tributaries (South Fork Chehalis River, Newaukum River, Skookumchuck River, Lincoln Creek, and Black River). The proposed locations for flow measurements are shown in Figure 1 and Table 1.

In addition to the water quality samples, three Hydrolab DS5 multi-parameter sondes (Sondes) will be deployed to collect temperature, DO, pH, turbidity and chlorophyll-a data over a 24-hour period coincident with each synoptic survey. This data will help characterize the diurnal changes in these parameters and will help calibrate a water quality model developed with sub-daily time steps. The locations proposed for deployment of the Sondes are shown in Figure 1 and Table 1, and may be modified based on discussions with Ecology and other stakeholders and conditions encountered in the field.

2.4 Boat Survey on the Centralia Reach of the Chehalis River

Upon reviewing the draft version of this QAPP, Ecology noted that to better characterize the temperature variations with depth in the Centralia Reach of the Chehalis River (i.e. between Newaukum River and Skookumchuck River confluences), it may be necessary to traverse this reach in a boat to identify deeper areas for thermal and water quality characterization in addition to the two stationary locations for Sonde deployment proposed in Figure 1. After reviewing the draft program design Ecology recommended that the quarterly water quality

[1] Water quality samples from the first two rounds of summer low-flow synoptic surveys were analyzed at Dragon Analytical Laboratory (LAB ID: C890-11A). Because of a need for lower reporting limits, samples from subsequent rounds were analyzed at ARI. TKN samples from the first two rounds of low-flow sampling were sub-contracted out by Dragon Analytical Lab to Spectra Laboratories (LAB ID: C575-13A).

surveys, which were originally proposed as part of the water quality monitoring program to characterize year round nutrient loading, be substituted with a boat survey in summer 2014.

As per Ecology's recommendation we are proposing to conduct this survey[2] in July 2014 by floating a boat with a depth finder to identify slow moving/stagnant pools where profiles of temperature, turbidity, pH and DO will be measured using a Hydrolab Sonde. The survey will be timed over an extended dry period of approximately seven days so that conditions over the Centralia Reach are 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-mile to one-mile intervals based on river morphology and location of point sources (Ecology 1994). A similar approach will be adopted here to locate the stations. At a subset (up to 4) of these locations water quality samples will be collected, one at surface and the second at depth near the sediment-water interface. The samples will be analyzed for the same suite of parameters analyzed during the summer low-flow surveys described above.

The quarterly water quality surveys that were proposed originally will not be conducted. Recognizing the importance of characterizing the loads of nutrients and suspended solids to the flood control structure over the high-flow season, when the dam can be a net accumulator of the loads in the systems, water quality samples will be collected at the downstream Pe Ell station (CHL-PEL-DS; see Figure 1), to the extent that logistics, schedule and budget can support such an effort. The samples, if collected, will be analyzed for the same suite of water quality parameters as the summer low-flow surveys.

2.5 Groundwater Temperature Measurements

Groundwater temperature will be measured at existing wells used by the USGS to monitor groundwater levels (Fasser and Julich 2010). Efforts will focus on wells located in reaches identified to have the greatest contribution to the surface water flow based on groundwater investigations conducted by the USGS (Gendaszek 2011; Ely et al. 2008). See Figure 2 for a map of targeted groundwater well locations. Temperature measurements will occur close to the time of summer low-flow synoptic surveys.

[2] Subject to client's approval of proposed changes to the scope

2.6 Logistical and Practical Constraints in Completing the Water Quality Monitoring Program

The primary logistical issues anticipated are getting permissions for accessing the river and getting sampling equipment to the river at locations where access is difficult. Other potential difficulties during field monitoring include:

- Siting temperature probes at locations relatively remote such that they can be protected from vandalism, theft, etc., while still being accessible for data retrieval
- Lowering sampling equipment in the Newaukum/Skookumchuck Reach of the Chehalis River to measure depth profiles of field parameters
- Weather and stream flow conditions during sampling
- Accessing the thalweg from the shore during water quality sampling

The following steps will be taken to overcome logistical issues identified above:

- Locations for siting temperature probes and collecting water quality samples will be planned in public areas and will minimize requirement for accessing private properties. Where needed, permissions to access private properties will be procured in advance before the field sampling locations are finalized.
- The locations will be identified based on the team's prior experience with the watershed and discussions with Ecology. The locations will be away from commonly used public areas to help minimize vandalism and theft, but still provide access to field crews.
- Weather and streamflow conditions will be reviewed closely during the sampling period, and the actual field visit will be planned during periods of supportive weather and streamflow.
- Lowering of Hydrolab to measure depth profiles of field parameters in the Newaukum/Skookumchuck Reach of the Chehalis River will be achieved by locating publicly accessible bridges from where the sampling equipment will be lowered through cables running through a pulley.

As described in Section 4.1.2.2, water quality samples will be collected by attaching sampling jars to extension poles that can access the thalweg.

3 DATA QUALITY OBJECTIVES AND CRITERIA

The data quality objective for this project is to ensure that the data collected are of known and acceptable quality sufficient to meet the sampling program goal, as described in Section 1.2.

3.1 Laboratory Data

The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the PARCC parameters). Definitions of these parameters and the applicable quality control procedures are given below. Laboratory analysis will be done for DO, pH, TSS, BOD-5, TKN, ammonia, nitrite plus nitrate, TP, OP, TDP, and chlorophyll-a.

The target method reporting limits (MRL) are shown in Table 2. The MRLs shown are within the range normally expected for this method and should be sufficient for understanding water quality in the River. Applicable holding time requirements are listed in Table 3, while the frequency of quality control procedures used to evaluate the PARCC parameters are noted in Table 4. Applicable quality assurance/quality control (QA/QC) goals for the laboratory water quality parameters are listed in Table 5.

3.1.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical precision is measured with analytical replicates. As shown in Table 4, analytical replicates will be carried out on project-specific samples at an approximate frequency of one per laboratory analysis group or one in 20 samples, whichever is more frequent, as practical. Field duplicate samples will be collected at a frequency of one per sampling event, with a maximum of 15 water quality samples collected per event. Laboratory and field duplicate precision will be evaluated against quantitative relative percent difference (RPD) performance criteria in Table 5.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit, where the percent error (expressed as RPD) increases. The equation used to express precision is as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

Where:

RPD	=	relative percent difference
C_1	=	larger of the two observed values
C_2	=	smaller of the two observed values

The acceptable precision based on laboratory replicates for the analytes in this study is less than ±20 percent RPD according to Table 5.

3.1.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, standard solutions, and adherence to initial and continuing calibration procedures. Analytical accuracy may also be assessed by analyzing “spiked” samples with known standards such as matrix spikes and laboratory control samples. Laboratory-fortified field samples (i.e., matrix spikes) are measured to determine the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (%R) of the measured value, relative to the true or expected value. If a measurement process produces results for which the mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in an analytical method (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination). Analytical laboratories utilize several quality control measures to eliminate analytical bias, including systematic analysis of method blanks and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

As shown in Table 4, laboratory accuracy measurements on matrix spikes/matrix spike duplicates (MS/MSDs) will be carried out at an approximate frequency of one in 20 samples. Given that a maximum of 15 samples will be collected per event, MS/MSDs will be conducted once per sampling event. Because MS/MSDs measure the effects of potential matrix interferences of a specific matrix, the laboratory will perform MS/MSDs only on samples from this investigation and not from other projects. An additional measure of accuracy will be evaluated using an Initial Calibration Verification (ICV) spike, which is an independent standard used to verify the calibration and will be analyzed prior to the sample analysis and every 20 samples thereafter. This standard may be reported in place of the laboratory control sample (LCS), which is also an independent standard spiked into laboratory reagent grade water. According to Table 4, this will be conducted per batch for batches of less than 20 samples or every 20 samples, whichever is applicable.

The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa}$$

Where:

%R	=	percent recovery
S	=	measured concentration in the spiked aliquot
U	=	measured concentration in the unspiked aliquot
C_{sa}	=	actual concentration of spike added

The target accuracy and bias goals for laboratory LCSs, MS/MSDs, and ICV spikes in this study are listed in Table 5.

3.1.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent the environmental condition being monitored. For this monitoring program, the list of analytes and sampling frequency has been identified to provide a representative characterization of nutrient and BOD loads along the mainstem Chehalis River as well as the major tributaries. In addition, at a few locations the Hydrolab Sondes will provide field measurements of DO and chlorophyll-a, which can be used to verify the accuracy of the laboratory estimates for these analytes.

3.1.4 Comparability

Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this program, comparability of data will be established through the use of standard analytical methodologies and reporting formats as well as common traceable calibration standards used to perform the analytical determination. There are several factors that contribute to, or detract from, data comparability. These are usually grouped into two general categories: factors related to sample collection and handling, and factors related to the analytical methods used. Sample collection issues include sample support (i.e., exactly what was sampled) and acquisition techniques, environmental conditions at the time of sampling, and sample handling and preservation methods. Field comparability will be evaluated through the use of standardized sampling techniques and the use of blind field duplicates, while laboratory comparability will be evaluated through laboratory duplicates and the use of standardized analytical methods throughout the sampling event. Comparison between the field duplicates and between laboratories duplicates will be determined through the precision data collected for RPDs.

3.1.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{\text{Number of acceptable data points x 100}}{\text{(Total number of data points)}}$$

The data quality objective for completeness for all components of this project is 95 percent. Data contributing to completeness (i.e., representing valid analytical results) will be assessed through comparison to the above parameters as well as other quality control checks consistent with data validation as described in Sections 5 and 6 of this QAPP. Data that have been qualified during the data validation as estimated, because the quality control criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

3.2 Field Data

3.2.1 Precision

Precision of field measurements will be assessed by collection of field replicate measurements for approximately 1 in 20 measurements. Given that water quality samples will be collected at 15 locations during each event, field parameter replicate measurements will be made at a frequency of one per sampling event, according to Table 4. For the field parameters in this study, the acceptable precision for field replicates will be an RPD of ±20 percent according to Table 5. Field instrument manufacturer's stated precision targets are listed in Table 6.

3.2.2 Accuracy

Field accuracy is controlled by adherence to sample collection and equipment maintenance and calibration procedures outlined in Section 4.6.1 of this QAPP. Frequency of field calibration is once per day prior to each sampling event and field calibration checks are conducted throughout the day as shown in Table 4. Field measurements of temperature using the Hydrolab Sondes and handheld thermometers will provide alternative verification of the temperature measurement by the Tidbits. Similarly, pH, DO, and chlorophyll-a will be analyzed in the laboratory to provide a verification of the Hydrolab Sondes measurements of these parameters.

3.2.3 Representativeness

Field representativeness expresses the degree to which data accurately and precisely represent the environmental condition being monitored. For this monitoring program, the list of field parameters has been identified to provide supporting information to further characterize water temperatures, DO, and water quality throughout the mainstem Chehalis River.

3.2.4 Comparability

Field measurement comparability is determined by the use of standard calibration checks and standard calibration procedures following recommended manufacturer's methods and as described in Section 4. DO, pH, and turbidity calibration will be performed prior to each sampling event. Ongoing calibration checks against standard solutions will be made periodically throughout the day as deemed necessary by the lead field sampler based on equipment observations and any potentially anomalous readings. If the meter registers outside user-manual-specified accuracy upon calibration check, the instrument will be recalibrated prior to continuing with the monitoring event.

3.2.5 Completeness

Field completeness is determined in the same manner as described in Section 3.1.5 above for laboratory parameters.

4 DATA GENERATION AND ACQUISITION

4.1 Monitoring Methods and Equipment

4.1.1 Temperature Probe Design and Deployment

The Tidbits will be deployed in a polyvinyl chloride (PVC) housing attached atop a 20-pound lead anchor ball with quick links. Based on feedback received from Ecology, at some locations concrete weights may be used to prevent the Tidbits from getting buried in the sediments. PVC housings will be drilled with multiple holes to allow water circulation around the Tidbits. Arrays will be anchored to the shore using a cable attached to a shoreline tree or anchored in the bank using a screw anchor. Each array will be deployed at each location such that the PVC housing is off the bottom.

At select locations, Tidbits will be installed on the bank in locations adjacent to the water temperature Tidbits to provide an estimate of the corresponding air temperature. The air temperature Tidbits will be similarly housed in PVC pipe, but will be affixed to trees or other structures in the bank away from the river such that they are relatively difficult for public access.

Prior to deployment, the Tidbits will be calibrated following procedures recommended by Ecology (Ecology 2003). Each Tidbit will be 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 will be synchronized with the computer start time so that calibration readings would be simultaneous with the watch.

Tidbits will be placed into two separate water baths with a high and low temperature of 22.5 and 2.0 degrees Celsius (°C), respectively, and allowed to equilibrate prior to recording temperatures. Calibration will be performed using a National Institute of Standards and Technology- (NIST-) certified HB Instruments thermometer with serial number 1114593. Mean differences calculated from the Tidbit calibration procedures are added or subtracted as appropriate from field data prior to use.

4.1.2 Water Quality Sampling

In situ water quality parameters will be measured in the field using a water-column-deployed multiprobe water quality meter. Water grab samples will be collected directly into sample containers using sample jars attached to an extension pole.

4.1.2.1 Field Water Quality Measurements

At each measurement location, the water quality meter probe will be lowered to the target depth and allowed to equilibrate for 30 seconds. When readings have stabilized, they will be recorded on a field-measurement log sheet. A water quality log form is presented in Appendix A.

4.1.2.2 Collection and Handling of Water Grab Samples

At each sample location, a grab sample will be collected directly into sample containers attached to an extension pole, or collected in a single jar on the extension pole and collected water will be decanted into separate laboratory-supplied water bottles. A clean, unused sample collection bottle will be used at each location. The laboratory will supply sample bottles with sample preservatives prior to each event. Water samples will then immediately be placed in a cooler with ice and delivered on ice to the laboratory within 24 hours of collection.

4.1.2.3 Field Documentation

Water quality field measurement data, sample collection information, and ancillary information from each collection site and event will be recorded on field data forms (Appendix A). Ancillary information will include:

- Date and time of each sample or measurement collection
- Weather conditions, river flow conditions, and general observations (e.g., debris present)
- Visual observations of water and samples at each sampling location
- Field calibration check and calibration information
- Names of personnel present collecting samples and recording data
- General observations about collection procedures and any deviations from this QAPP

- Condition of equipment or meters that might impact water quality data

Generally, all information that might be pertinent to water quality will be recorded on the field data forms. Each water grab sample will be treated as a discrete sample and will be labeled with a unique sample number. The sample numbering scheme for each sample is provided in Table 1. Each sample collected will be clearly labeled using a waterproof label with an indelible pen. Each sample label will contain the project name and project number, the unique sample identification number, date and time of sample collection, analysis to be performed, preservative (as applicable), and the initials of the person collecting the sample.

4.1.2.4 Sample Transport and Chain-of-Custody Procedures

Once all samples for the day or project have been collected, a chain-of custody (COC) form is generated to document the sample collection and address the sample analytical requirements.

Samples are considered to be in one's custody if they are: 1) in the custodian's possession or view; 2) in a secured location (under lock) with restricted access; or 3) in a container that is secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). COC procedures will be followed for all samples throughout the collection, handling, and analysis process. The principal document used to track possession and transfer of samples is the COC form. Each sample will be represented on a COC form the day it is collected. All data entries will be made using indelible ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, then dating and initialing the change. An example COC form is provided in Appendix A.

A COC form will accompany each cooler of samples to the analytical laboratories. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secure. Copies of all COC forms will be retained in the project file.

The COC will contain the project name and project number, all applicable sample identification (sample ID), and date and time of collection) as well as the required analyses, and signature of relinquished field personnel with date and time. Samples will be retained in a cooler on ice at 4°C until shipment to the laboratory. Sample holding times will be strictly adhered to by the field personnel and the analytical laboratories. All samples will be shipped to the laboratory with sufficient holding time remaining for analysis to be completed. All containerized samples will be transported to the analytical laboratory after the collection of samples for each event is completed. Specific sample shipping procedures will be as follows:

1. Each cooler or container containing the water samples to be analyzed will be delivered to the laboratory within 24 hours of being sealed.
2. The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
3. A sufficient amount of ice will be double-bagged in sealable plastic bags and placed within the cooler.
4. A sealed envelope containing COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
5. Signed and dated COC seals will be placed on all coolers prior to shipping.

The persons transferring custody of the sample containers will sign the COC form upon transfer of sample possession to the analytical laboratory or shipping agent. The shipping container seal will be broken upon receipt of samples at the laboratory and the receiver will record the condition of the samples. COC forms will be used internally by the laboratory to track sample handling and final disposition.

4.1.3 Flow Measurements

In situ river flow measurements will be performed at representative locations from within the main stem of the Chehalis River and the mouths of the major tributaries. River flow measurement will be completed across river transects using hand-held flow meters by wading across the river. Flow measurements will be performed by WEST Consultants using standard procedures.

4.1.4 Groundwater Temperature Measurements

Groundwater temperature measurements will be performed at selected groundwater well locations within the Chehalis River Basin using the USGS Field Manual (Wilde 2013).

Specific wells monitored are dependent on location, well type, and owner permission. Groundwater temperature measurements will be completed using field (liquid-in-glass/thermistor) thermometers calibrated and office-laboratory certified against a certified calibration thermometer. Temperature measurements will follow USGS standard procedures for measuring temperature in a supply well setting (flowthrough-chamber system).

4.1.5 Equipment Cleaning and Decontamination Procedures

Decontamination procedures will be used to reduce the chance of cross-contaminating samples. All sampling equipment and reusable materials that come into contact with sample media will be decontaminated prior to sampling and between sample locations. Decontamination will follow this sequence:

1. Tap water rinse
2. Non-phosphate detergent wash, consisting of a dilute mixture of Liquinox and tap water (visible soil or plant material to be removed by scrubbing with a soft brush)
3. Distilled water rinse

To avoid the risk of spreading invasive species, all equipment that will be used for the collection of water quality measurements and sample collection, including waders, footwear, personal protective equipment, and all equipment hardware that is installed in the river, will be inspected for cleanliness prior to field work to insure that material from outside the Chehalis River system is not introduced. Installed field equipment will be decontaminated following procedures described above prior to installation and following use to avoid the spread of invasive species to other systems. Only approved footwear, (i.e., felt less boots), will be used.

4.2 Quality Control

4.2.1 Field Quality Control Procedures

Field quality control procedures will consist of following standard instrument operation procedures for making in situ water quality measurements and consistent, acceptable practices for collecting and handling of water grab samples. Adherence to these procedures will be complemented by periodic and routine equipment inspection and calibration.

Field quality control samples will consist of the collection of additional volume for MS/MSD analysis, and collection of field duplicate water samples. MS/MSD volumes and duplicate samples will be collected at a frequency of one per sampling event. Sufficient volume will be collected in one grab to fill all water samples and duplicate sample bottles. Field duplicate water samples and MS/MSD volume locations and sample numbers will be noted on the field logs and included on laboratory COC forms.

The water quality meters will be calibrated prior to use for the monitoring program according to manufacturers' procedures presented in the user's manuals. DO, turbidity, and pH calibration will be performed prior to each sampling event. Ongoing calibration checks against standard solutions, for meters used for the synoptic water quality measurements, will be made periodically throughout the day as deemed necessary by the lead field sampler based on equipment observations and any potentially anomalous readings. If the meter registers outside user-manual-specified accuracy upon calibration check, the instrument will be recalibrated prior to continuing with the monitoring event. Calibration information will be recorded on the field data forms. Water quality measurements using independent monitoring equipment will be made side by side instruments placed into the Chehalis River over a two-day period to characterize the diurnal changes in the water quality parameters during both at the time of placement and at the time of retrieval. Data will be compared to determine if raw data adjustments are warranted due to sensor drift during the deployment period. Monitoring equipment will be handled according to manufacturer's recommendations. Unusual or questionable readings will be noted and duplicate readings made.

As described in Section 4.1.1 of this QAPP, the Tidbits will undergo calibration checks prior to deployment following standard procedures. It is anticipated that control of the Tidbits will be handed over to Ecology at the completion of the project contract period, and the Tidbits will continue to be in service. It is recommended that a post-deployment calibration of the Tidbits be done to help verify the accuracy of the temperature loggers by comparing those temperatures to the pre-deployment calibration. If the results indicate a consistent bias of more than 0.2°C, then the raw data may need to be adjusted or flagged with the appropriate data qualifier.

4.2.2 Laboratory Quality Control Procedures

Laboratory Quality Control Criteria. Results of the quality control samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The quality control sample results will then be evaluated to determine if control limits have been exceeded from those shown in Table 5. If control limits are exceeded in the sample group, the QA/QC Coordinator will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

Laboratory Duplicates/Replicates. Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates and replicates are subsamples of the original sample that are prepared and analyzed as a separate sample. Duplicate/replicate frequency and quality control limits are shown in Tables 4 and 5, respectively.

Matrix Spikes and Matrix Spike Duplicates. Analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate MS analyses, information on the precision of the method is also provided. MS/MSD frequency and control limits are shown in Tables 4 and 5, respectively.

Method Blanks. Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. Method blank frequency is shown in Table 4. The quality control limit for method blanks is no detection of the analyte in the blank sample.

Laboratory Control Samples. LCSs are analyzed to assess laboratory performance at all stages of sample preparation and analysis. LCSs are matrix-dependent spiked samples prepared at the time of sample analysis along with the method blank, sample, and MS preparation. The LCSs will provide information on the precision of the analytical process and, when analyzed in duplicate, will provide accuracy information as well. The frequency of and control limits for LCSs are shown in Tables 4 and 5, respectively.

Instrument/Equipment Calibration Verification Samples and Blanks. Initial and ongoing calibration verification samples are analyzed to assess instrument performance. If the ongoing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to meet control specifications. All project samples analyzed while instrument calibration was out of control will be reanalyzed. Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately prior to continuing calibration verification at a frequency shown in Table 4.

Anticipated Range of Field and Analytical Water Quality Parameters. Given that the study covers large sections of the river, a wide range of values are likely for both field (pH, temperature, DO, turbidity and chlorophyll-a) and analytical (BOD, TKN, ammonia, nitrite, nitrate, TP, and orthophosphate) parameters. However, historical studies (for example, Anchor QEA 2012) and other water quality information on the system from publicly available information sources, such as Ecology's River and Stream Water Quality Monitoring Program, will be consulted to identify anomalous measurements of field and analytical parameters during quality control review.

4.3 Analytical Methods

In completing chemical analyses for this project, the contract laboratories are expected to meet the following minimum requirements:

- Adhere to the methods outlined in this QAPP, including methods referenced for each analytical procedure
- Deliver hard copy and electronic data as specified in Section 4.5
- Meet reporting requirements for deliverables as specified in Section 4.5
- Meet turnaround times for deliverables as specified in Section 7.2
- Implement QA/QC procedures, including the QAPP data quality requirements and laboratory QA requirements as specified in Tables 4 and 5
- Allow laboratory and data audits to be performed as specified in Section 5.1

Table 2 presents the method of analysis and MRLs for water samples. Prior to the analysis of the samples, the laboratory will calculate Method Detection Limits (MDLs) and MRLs for each analyte of interest, where applicable. MRLs will be at or below the limits specified in Table 2, if technically feasible. If not technically feasible, the Laboratory Project Manager will contact the Project Manager prior to completing any sample analyses.

4.4 Data Management

Field data forms will be checked for completeness and accuracy by the Field Coordinator (FC) prior to delivery to the Data Manager. All data generated in the field will be documented on hard copy and provided to the Data Manager. All manually entered data will be checked by a second party. Field documentation will be filed in the main project file after data entry and checking are complete.

Laboratory data will be provided to the Data Manager in electronic and paper formats. Laboratory data, which are electronically provided and loaded into the database, will undergo a 10 percent check against the laboratory hard copy data. Data will be reviewed manually and qualifiers, if assigned, will be entered manually. The accuracy of all manually entered data will be verified by a second party. The database will be developed in MS Access and exported to other formats for report preparation.

4.5 Project Documentation and Records

Revisions to this QAPP are contingent on review comments. In the event that revisions should be necessary, the entire document will be reissued and distributed to the same individuals that received this document. Sample documentation is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analysis, to the time sample results are reported. Custody procedures (for example as discussed for field transport procedures in Section 4.5) will be used for all samples at all stages in the analytical or transfer process and for all data and data documentation whether in hard copy or electronic format.

4.5.1 Field Documentation

Sample data forms entries will be completed for each location occupied and each sample collected as described in Section 4.4.3. (A sample data form is shown in Appendix A). Sample labeling and custody documentation will be performed as described in Section 4.4.3.

4.5.2 Laboratory Documentation

The analytical laboratory will be required, where applicable, to report the information in this subsection.

Project Narrative. This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, quality control, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived, and their resolutions will be documented in as much detail as appropriate.

Chain of Custody Records. Legible copies of the custody forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additionally, a cooler receipt forms will be completed for each set of coolers received. This form should document the cooler temperature and any sample discrepancies noted at the time of sample log-in. Additional internal tracking of sample custody by the laboratory will also be documented.

Sample Results. The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:

- Field sample identification code and the corresponding laboratory identification code
- Sample matrix
- Date and time of analysis
- Weight and/or volume used for analysis
- Final dilution volumes or concentration factor for the sample
- Identification of the instrument used for analysis
- Method reporting and quantitation limits
- Analytical results with reporting units identified
- Data qualifiers and their definitions

Quality Assurance/Quality Control Summaries. This section will contain the results of the laboratory QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below:

Method Blank Analysis. Report the method blank analyses associated with each sample and the concentration of all compounds of interest identified in these blanks.

Matrix Spike Recovery. Report all MS recovery data for the TOC analysis. List the name and concentration of all compounds added, percent recoveries, and range of recoveries. Report the RPD for all duplicate analyses.

Matrix Duplicate/Replicate. Report the RPD for all matrix duplicate/replicate analyses.

Original Data. All original raw data collected from this project will be kept by the laboratory for 10 years after the project is completed.

Additional information, if any, may be requested as needed.

5 DATA VERIFICATION

5.1 Assessments and Response Actions for Analytical Chemistry Results

Once data are received from the laboratory, a number of quality control procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness. Should the need arise due to data integrity issues, the QA/QC Coordinator may request laboratory and data audits be performed.

5.1.1 Laboratory and Field Performance Assessment

Laboratory and field performance audits consist of on-site reviews of quality assurance systems and equipment for sampling, calibration, and measurement.

Response Action for Field Sampling. The FC will be responsible for correcting equipment malfunctions during the field sampling effort. The QA/QC Coordinator will be responsible for resolving situations via communication with field personnel that may result in noncompliance with this QAPP. All corrective measures will be immediately documented in the field data forms.

Responsive Action for Laboratory Analyses. The laboratory is required to comply with their Standard Operating Procedures (SOPs). The Laboratory Project Manager will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

5.2 QA/QC Reports to Management

The final project report will include a QA/QC summary to identify any quality control issues associated with the data.

6 DATA QUALITY ASSESSMENT, VALIDATION, AND REPORTING

6.1 Data Review, and Verification Requirements

Data files will be reviewed by the Data Manager to identify outliers, spurious results, or omissions. Any problems will be reported to the Project Manager. Quality assurance personnel will review data for compliance with data quality objectives. Any problems with data quality will be included in the final report.

6.2 Reconciliation with User Requirements

Laboratory data packages will be generated for each chemistry data set collected. The quality assurance personnel will perform a preliminary review of data after each survey to verify that all components of the analytical report are present as documented in Section 4.5.2 and briefly identified here:

- Analytical laboratory summary reports including quality control summary data for method blanks, laboratory duplicates, LCSs, and MS/MSD samples (as applicable)
- Field duplicate results
- Field data such as sample identifications and sample dates in laboratory report will be checked against the field data forms

Raw data files from the laboratory may not be reviewed unless there is a significant problem noted with the summary information.

Once the preliminary review is completed and all discrepancies reconciled with the analytical laboratory, the data will undergo a final data validation. The QA/QC Coordinator or their designee will be responsible for the data validation review. This validation process identifies the validity of the data as it pertains to the data quality objectives specified in this document. Under this process, the data is reviewed against the COC forms and QAPP to ensure all samples were analyzed appropriately, that the method reporting limits match those in the QAPP, and that any discrepancies or out-of-control events are documented in the case narrative. The actual data validation will follow the procedures outlined below:

- Review the data to check field and laboratory quality control data, to verify that holding times acceptance and performance criteria were met, and to note any anomalous values

- For data completeness, review that the results are reported for each sample and analyte requested and that reporting limits in Table 2 are met
- Review that holding times from Table 3 are met
- Confirm data report format (e.g., significant figures and units)
- Review that QA sample summaries (blanks, MS, MSD, and/or laboratory replicates/duplicates) and ICV are reported for each analyte at the frequencies addressed in Table 4 and that they meet the data quality objectives listed in Table 5
- Ensure all analytical problems and corrections are reported in the case narrative and that appropriate laboratory qualifiers are added
- For any problems identified, review concerns with the laboratory, obtain additional information as necessary, and verify all related data to determine the extent of the error
- Apply data qualifiers to the analytical results to indicate potential limitations on data usability

Field generated data will also be reviewed for completeness and compliance with the QAPP including:

- Field calibration information
- Field measurement duplicate results
- Sample times and dates
- Any other field data to be included in the final report

Depending on the data quality, a more in-depth review may be initiated.

Deviations or findings are documented in the data validation report. The analytical results are qualified based on the data review according to the validation findings and compliance to method requirements. The validation report is then used to determine what effects the deviations have on the quality and potential usability of the data. A copy of the data packages and the data review will be included in the results report appendix.

6.3 Summary of Data Reduction and Reporting

A final report documenting all activities with field sample collection, field monitoring data collection, sample transportation, and sample analysis will be prepared by Anchor QEA. Reports received from the analytical laboratory and the data validation reports will be included as appendices. At a minimum, the following will be included in the final report:

- Summary of all field activities, including a description of any deviations from the approved QAPP
- Project map with sample locations identified
- Final QA/QC report
- Data results
  - At the request of the client, hard copy of main report and summary results tables
  - CD copies of field data, laboratory analysis results, and associated QA/QC data
  - All electronic data files will be stored in Microsoft Access and all documents will be stored in Microsoft Word format
- Summary comparison of chemical results with interpretive criteria
- An interpretation of the spatial patterns and temporal trends in field parameters and water quality

7 PROJECT MANAGEMENT

7.1 Project/Task Organization

The overall project organization and the individuals responsible for the various tasks required for the implementation of the water quality monitoring program are described in the following subsections.

Mr. Paul Pickett, Ecology Technical Lead, will be involved in all aspects of this project, including discussion, review, and approval of this QAPP, and interpretation of the results of the investigation. In this role, he will be responsible for coordination between Ecology and the contractor performing the environmental monitoring. He will also review the monitoring to help ensure that it is performed according to specifications and that the environmental data collected are of sufficient quality to meet the project objectives.

Mr. Robert Montgomery, Anchor QEA, will serve as Project Manager for the water quality monitoring program. He will be responsible for overall project coordination, planning, and implementation; project deliverables; and performing the administrative tasks needed to ensure timely and successful completion of the project.

Mr. David Gillingham will serve as the FC for the monitoring efforts. The FC is responsible for day-to-day technical oversight, and for QA/QC oversight of field activities, ensuring that appropriate protocols are followed for collection of environmental data and any associated field samples. The FC will also be responsible for ensuring that daily reporting of monitoring results is performed.

Ms. Cindy Fields, Anchor QEA, will serve as the QA/QC Coordinator. The QA/QC Coordinator will provide QA oversight for both the field sampling and laboratory programs. The QA/QC Coordinator will ensure that samples are collected and documented appropriately, coordinate with the analytical laboratory, ensure data quality, oversee data review, and supervise project QA coordination.

Dr. Pradeep Mugunthan, Anchor QEA, will serve as water quality lead providing oversight and review for the project. In this role, he will be responsible for reviewing all planning and reporting documents to ensure project objectives are met. He will also review field and laboratory data as it becomes available to ensure compliance with this QAPP and identify any technical issues that may arise.

Ms. Binglei Gong, Anchor QEA, will serve as Data Manager and will be responsible for data entry and maintenance in the project database, including the results of data validation and any data qualifiers. The Data Manager will also be responsible for conducting data quality control checks to ensure the database is accurate and she (or her designee) will run database queries for reporting purposes.

Ms. Cheronne Oreiro, ARI, will serve as the Laboratory Project Manager[2] and will oversee all laboratory operations associated with the receipt of environmental samples, chemical analyses, and laboratory report preparation for this project. The Laboratory Manager will review all laboratory reports and prepare case narratives describing any anomalies and exceptions that occurred during analysis.

Dragon Analytical Laboratory, will:

- Perform the methods outlined in this QAPP, including those methods referenced for each analytical procedure
- Follow documentation, custody, and sample logbook procedures
- Implement QA/QC procedures
- Meet all reporting requirements
- Deliver electronic data files as specified in this QAPP
- Meet turnaround times for deliverables as described in this QAPP
- Allow Ecology and the QA/QC Coordinator to perform laboratory and data audits

[2] Mr. Robert Lewis, Dragon Analytical Laboratory, served as the Laboratory Project Manager for the first two summer low flow surveys.

7.2 Project Schedule

Water quality monitoring will be conducted to characterize water temperature, DO, and water quality throughout the mainstem Chehalis River during the August 2013 to July 2014 time frame. Activities are as follows:

- Tidbits will be installed in August 2013. Data will be downloaded at frequent intervals coinciding with water quality surveys and to the extent that other project activities can support having personnel in the field that are able to download data from the tidbits.
- Low-flow synoptic surveys are to be conducted in August 2013, September 2013, and July 2014.
- The boat-survey will be conducted in July 2014 close to the last summer low-flow synoptic survey.

Data will be reported after all sampling events are complete and laboratory data are obtained from the last sampling event. Laboratory data turnaround time is expected to be two weeks from the sample delivery to the laboratory. The last sample event is expected to occur in July 2014. The preparation of the final report is anticipated to be completed by September 2014.

8 REFERENCES

Anchor QEA, LLC (Anchor QEA), 2012. Chehalis River Flood Storage Dam Fish Population Impact Study. Prepared for the Chehalis River Basin Flood Authority. April, 2012.

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

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TABLES

Table 1

Proposed Flow, Water Quality, and Temperature Measurement Locations

Station ID	Description	Flow	Water Quality	Hydrolab Sondes	Temperature Tidbit
CHL-PEL-US	Chehalis River Upstream of Pe Ell		X		X
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	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
CHL-ADNA	Chehalis River near Adna	X	X		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 RT 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		
CHL-GLV	Chehalis River at Galvin Road Bridge		X		X
LNC-CRK	Lincoln Creek at Lincoln Creek Road Bridge	X	X		
CHL-US-BLK	Chehalis River at Independence Road Bridge near Rochester		X		X
BLK-RT12	Black River at Route 12 Bridge	X	X		
CHL-OAK	Chehalis River near Oakville		X		X

Notes:
"X" indicates the corresponding parameter will be measured at that location
WWTP = Wastewater Treatment Plant

Table 2

Recommended Analytical Methods and Target Method Reporting Limits

Parameter	Method	Method Reporting Limit	
Conventionals (mg/L)			
		First Two Summer Low-Flow Surveys[1]	All Other Water Quality Surveys[1]
Total suspended solids (TSS)	SM2540D	2.5	1.0
Biochemical oxygen demand (BOD-5)	SM 5210B	2.0	2.0
Total Kjeldahl nitrogen (TKN)	SM 4500N[2] or 351.4/SM4500-Norg[3]	0.1	0.1
Ammonia	SM 4500NH3D[2] or 350.1/SM4500-NH3[3]	0.40	0.01
Nitrite/Nitrate	EPA 300.0[2] or 353.2[3]	0.20	0.01
Total phosphorus (TP)	SM 4500P E	0.10	0.008
Dissolved phosphorous (DP)	SM 4500P E	0.20	0.008
Orthosphosphate (OP)	EPA 300.0[2] or SM4500-PE[3]	0.10	0.004
Chlorophyll-a	SM 20 10200 H3	--	--
Field Parameters			
Dissolved oxygen	N/A		
Temperature	N/A		
Turbidity	N/A		
pH	N/A		

Notes:
mg/L = milligrams per liter
SM = Standard Methods
EPA = Environmental Protection Agency
N/A = Not applicable

1. Samples from the first two low-flow surveys were collected and analyzed at Dragon Analytical Laboratory prior to finalizing this QAPP. Samples from subsequent surveys will be analyzed at Analytical Resources, Inc.
2. Method used by Dragon Analytical Labs for first two summer low-flow surveys
3. Method used by Analytical Resources, Inc. for the rest of the surveys

Table 3
Guidelines for Sample Handling and Storage

Parameter	Container Type and Size	Holding Time	Preservative
Total suspended solids (TSS)	1L HDPE	7 days	4° C ± 2°C
Biochemical oxygen demand (BOD-5)	1L HDPE	48 hours	4° C ± 2°C
Total Kjeldahl nitrogen (TKN)	1L HDPE	28 days	pH <2 with H2SO4; 4° C ± 2°C
Ammonia	1L HDPE	28 days	pH <2 with H2SO4; 4° C ± 2°C
Nitrite plus Nitrate	1L HDPE	48 hours	4° C ± 2°C
Total phosphorus (TP)	1L HDPE	28 days	pH <2 with H2SO4; 4° C ± 2°C
Orthosphosphate (OP)	1L HDPE	48 hours	4° C ± 2°C
Total dissolved phosphorus	1L HDPE	28 days	4° C ± 2°C
Chlorophyll-a	500L HDPE	As soon as possible	4° C ± 2°C

Notes:
ml = millimeter

Table 4
Laboratory Sample Analysis and Field Water Measurement Quality Control Summary

Analysis Type	Initial Calibration[a]	Ongoing Calibration	Laboratory Control Samples	Field Duplicate Samples	Duplicates	Matrix Spikes	Method Blanks
Total suspended solids (TSS)	Each batch[b]	N/A	N/A	1 per event	1 per 20 samples	N/A	N/A
Biochemical oxygen demand (BOD-5)	Daily or each batch	N/A	1 per 20 samples	1 per event	1 per 20 samples	N/A	N/A
Total Kjeldahl nitrogen (TKN)	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Ammonia	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Nitrite plus Nitrate	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Total phosphorus (TP)	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Orthosphosphate (OP)	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Total dissolved phosphorus	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Chlorophyll-a	Daily or each batch	1 per 10 samples	1 per 20 samples	1 per event	1 per 20 samples	1 per 20 samples	1 per 20 samples
Field Measurements: Dissolved Oxygen, Temperature, Turbidity, and pH	Daily[c]	Daily[c]	N/A	N/A	1 per 20 measurements	N/A	N/A

Notes:
a = Initial calibration verification and calibration blank must be analyzed at the beginning of each batch.
b = Initial calibrations are considered valid until the ongoing continuing calibration no longer meets method specifications; at that point, a new initial calibration is performed.
c = Field calibration of sampling equipment prior to sampling each day. Field calibration checks throughout the day.
N/A = not applicable
ICV = Initial Calibration Verification

Table 5
Analysis Data Quality Objectives

Parameter	Accuracy (%R)	Precision (RPD)	Bias	Completeness
Total suspended solids (TSS)	80-120%	< 15%	10%	95%
Biochemical oxygen demand (BOD-5)	80-120%	< 25%	N/A	95%
Total Kjeldahl nitrogen (TKN)	70-130%	< 10%	10%	95%
Ammonia	75-125%	< 10%	5%	95%
Nitrite plus Nitrate	75-125%	< 10%	5%	95%
Total phosphorus (TP)	75-125%	< 10%	5%	95%
Orthosphosphate (OP)	75-125%	< 10%	5%	95%
Total dissolved phosphorus	75-125%	< 10%	5%	95%
Chlorophyll-a	50-150%	< 20%	10%	95%
Field Measurements: Dissolved Oxygen, Temperature, Turbidity, pH	NA	< 10%	5%	95%

Notes:
Accuracy goals for TSS and BOD-5 apply to initial and continuing calibration verifications.
%R = Percent recovery
RPD = Relative percent difference

Table 6
Field Instrumentation Precision Targets

Sensors	Range	Accuracy	Resolution
Hach LDO	0 to 60 mg/L	± 0.1 mg/L @ ≤ 8 mg/L ± 0.1 mg/L @ > 8 mg/L	0.01 mg/L
pH	0 to 14 pH units	± 0.2 units	0.01 units
Turbidity, Self-Cleaning	0 to 3000 NTU	± 1% up to 100 NTU	0.1 NTU from 0 to 400 NTU
Chlorophyll-a	Low Sensitivity: 0.03 to 500 µg/L	± 3% using Rhodamine WT dye as a standard at ≥ 400 ppb	0.01 µg/L

Notes:
mg/L = milligrams per liter
NTU = Nephelometric Turbidity Unit
ppb = parts per billion
µg/L = micrograms per liter

FIGURES

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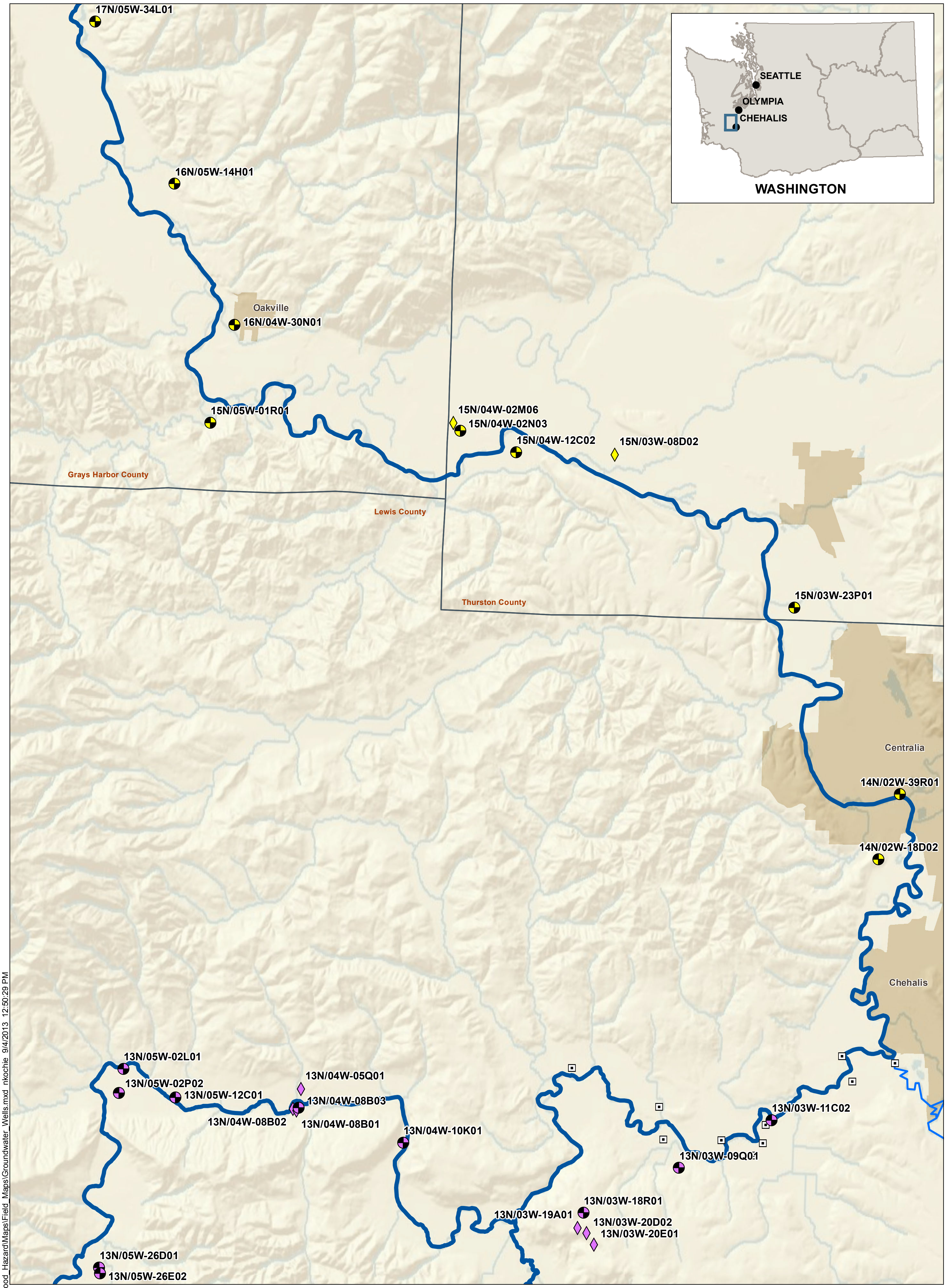
Figure 1
Proposed Flow Measurement, Water Quality Sampling, and Temperature Probe Locations
Quality Assurance Project Plan
Chehalis Basin Flood Hazard Mitigation Alternatives Analysis



Groundwater Well

- Primary
- Primary Backup
- Secondary
- Secondary Backup
- Ecology EIM Temperature Well
- Chehalis River

NOTES:
1. Primary wells were selected based on their proximity to gaining reaches in the critical sections of the Chehalis River, and will be targeted first.
2. Primary backup locations will be targeted if it is not possible to obtain permission to access the primary wells.
3. Secondary wells were also selected based on their proximity to gaining reaches but are in reaches where warming is not expected significantly. These will be targeted if there is sufficient time left for monitoring after the primary wells are completed.
4. Groundwater wells monitored in 2011 USGS study but not selected for temperature sampling are not shown.
5. Groundwater wells in Environmental Information Management (EIM) System with temperature information downstream of the Newaukum River confluence with the Chehalis River are not shown.

Feet
0 4,500 9,000 13,500 18,000

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Figure 2
Groundwater Well Locations
Chehalis Basin Flood Hazard Mitigation Alternatives Analysis

APPENDIX A
CHEHALIS RIVER WATER QUALITY MONITORING FIELD FORMS

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

Water Quality Monitoring Form

Project Name: Chehalis Basin Flood Hazard Mitigation Alternatives Analysis	Station ID:
Project Number: 131023-01.01	Sample ID:
Field Staff:	QC Sample ID:
Sampling Method:	Date:

Weather Observation:

Sample Depth:

Time	Temperature (°C)	Dissolved Oxygen (mg/L)	pH Units	Turbidity (NTU)	Chlorophyll-a (µg/L)

Evidence of floating or suspended materials:

Discoloration and Turbidity:

Color: Odor:

Comments:

Sample	Bottle Type	Preservative	# of Bottles	√ if collected
TSS	I-Liter HDPE	No		
BOD, Dissolved Phosphorus	I-Liter HDPE	No		
Chlorophyll-a	500 ml HDPE	No		
TP, NH3, TKN	I-Liter HDPE	Yes		
DO, pH, OP, Nitrogen	I-Liter HDPE	No		
Total # of bottles (include duplicate)				

Recorded by:

APPENDIX B
RESPONSE TO ECOLOGY’S REVIEW OF DRAFT QAPP

QAPP Peer Review Checklist

Title of QAPP:	Quality Assurance Project Plan - Chehalis Basin Flood Hazard Mitigation Alternatives Analysis Project
Author:	Anchor QEA, LLC
Peer reviewer	Paul J. Pickett, P.E., WA Dept. of Ecology

Element	Acceptable as written? Y/N/NA	Comments	Anchor QEA Response
1 Title Page with Approvals			
Title, author, organization	Y	Show personnel who wrote the QAPP	Included David Gillingham, Cindy Fields and Pradeep Mugunthan as authors of the QAPP
Date prepared or revised	Y		
Signature page includes key individuals per element 5 below	Y	Identify Paul Pickett as “Ecology Technical Lead” (global in doc)	Changed as suggested
2 Table of Contents and Distribution List			
3 Background			
Study area and surroundings	Y		
Logistical problems	N	Describe some of the challenges you expect and how you address them	A new subsection (Section 2.6) has been added discussing logistical issues
History of study area	Y		
Contaminants of concern	Y		
Results of previous studies	Y	Mentioned by reference	
Regulatory criteria or standards	NA		
4 Project Description			
Project goals	Y		
Project objectives	Y		
Information needed and sources	N	Ecology has a flow station on the Black River – not mentioned.	Revised text and Figure 1 to mention missing flow monitoring location

Element	Acceptable as written? Y/N/NA	Comments	Anchor QEA Response
Target population	NA		
Study boundaries	Y		
Tasks required	Y		
Practical constraints	N	Same as "Logistical problems" above.	Included as part of the discussion in Section 2.6
Systematic planning process used	NA		
5 Organization and Schedule			
Key individuals and their responsibilities (Project team, decision-makers, stakeholders, lab, etc.)	N	See my edits on my duties at the end of this document	Edits incorporated into the main document as suggested
Organization chart	NA		
Project schedule	Y		
Limitations on schedule	Y		
Budget and funding	NA	Done outside QAPP	
6 Quality Objectives			
Decision Quality Objectives			
Measurement Quality Objectives Table of targets for: Precision	N	Precision targets are unrealistic for chlorophyll-a and may be lax for other parameters. Cite sampling or past studies for expected RPD. Field meters should have individual precision targets, based on manufacturers' specifications. These are usually shown at +/- readings, such as +/- 0.2 mg/L DO.	Table 6 has been added to list the precision targets for the WQ meter. Precision targets have been updated to match measurement quality objectives as stated in Ecology's Publication No. 06-03-044 (Replicate Precision for 12 TMDL Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters). Table 6 is called out in Section 3.2.1. Instrument precision was obtained from the equipment manufacturer's web page.
Bias	N	Bias objectives should be stated	Bias objectives have been added to Table 5.
Sensitivity	NA		
Targets developed for: Comparability	Y		
Representativeness	Y		

Element	Acceptable as written? Y/N/NA	Comments	Anchor QEA Response
Completeness	Y		
7 Sampling Process Design			
Study Design Sampling location and frequency	N	Need tidbits on Skook and Black Rivers.	Will plan on installing the two spare tidbits near the mouths of Skookumchuck and Black Rivers coincident with the water sampling locations during groundwater monitoring in early September (see updated Figure 1).
Parameters to be determined	N	YKN reporting limit is very high compared to NH_3 and $NO_{2/3}$. Have you considered using Total Persulfate Nitrogen?	Dragon Laboratory is not accredited for using the Standard Method 4500 NC which achieves a lower reporting limit. TKN samples will be sent to Dragon's supporting lab, Spectra Laboratories in Tacoma, Washington which is Ecology accredited for the method capable of achieving a 0.1 mg/L reporting limit. Spectra's Ecology accreditation ID number has been added to the text in Section 2.3. Table 2 has been updated to indicate the lower reporting limit for TKN.
Field measurements	N	Recommend you float the Newaukum-Skook reach and do hydrolab profiles during a synoptic survey.	Water column profiling will be conducted at two locations in that reach: from the R6 Bridge; and, the Mellen Street bridge during each summer low-flow synoptic survey. Floating the river was not scoped as part of the water quality monitoring program, but the above approach will provide depth profiles of water quality parameters. We have noted in the text (Section 2.4) that upon client approval we will conduct the survey in July 2014 as suggested.
Maps or diagrams	Y		
Assumptions underlying design	Y		
Relation to objectives and	Y		

Element	Acceptable as written? Y/N/NA	Comments	Anchor QEA Response
site characteristics			
Characteristics of existing data	Y	Not described, but ok	
8 Sampling Procedures			
Field measurement and sampling SOPs	Y		
Minimizing the spread of aquatic organisms (If working in an Area of Extreme Concern, did Jenifer Parsons review the QAPP?)	N	Describe procedures to address invasive species	Section 4.1.5 Equipment Cleaning and Decontamination was added to address the minimization of spreading invasive species.
Measurement and sample collection	Y		
Containers, preservation, holding times	Y		
Equipment decontamination	N	Address decontamination procedures	Section 4.1.5 Equipment Cleaning and Decontamination Procedures was added to describe decontamination procedures.
Sample ID	Y		
Chain-of-custody, if required	Y		
Field log requirements	Y		
Other activities	NA		
9 Measurement Methods			
Lab procedures table, including: Analyte	Y		
Matrix	Y		
Number of samples	Y		
Expected range of results	Y	It would be good to provide tables of the range of expected values from previous studies, but that mainly benefits the lab.	Given that a wide range of values are possible, and are also likely to be location specific, we have not provided tables of range of expected values, but have cited Ecology's EIM website and previous reports to provide guidance on the range of values. Text has been added to Section 4.2 to address this.
Analytical method	Y		
Sensitivity	Y		
Sample preparation	Y		

Element	Acceptable as written? Y/N/NA	Comments	Anchor QEA Response
method			
Special method requirements	Y		
Field procedures table	Y		
Lab(s) accredited for method(s)	N	Document that Dragon is accredited.	Dragon Laboratory is an Ecology accredited laboratory. The text “DAL is accredited by Washington State Department of Ecology (LAB ID: C890-11A)” has been added to the third paragraph in Section 2.3.
10 Quality Control			
Table of lab and field QC required	N	See #6 above	Table 6 has been added to list the precision targets for the water quality meter. Table 6 is called out in Section 3.2.1. Instrument precision was obtained from the equipment manufacturer's web page.
Corrective action	Y		
11 Data Management Procedures			
Data recording/reporting requirements	Y		
Lab data package requirements	Y		
Electronic transfer requirements	NA		
Acceptance criteria for existing data	Y		
EIM data upload procedures	NA		
12 Audits and Reports			
Number, frequency, type, and schedule of audits	Y		
Responsible personnel	Y		
Frequency and distribution of reports	Y		
Responsibility for reports	Y		
13 Data Verification			
Field data verification, requirements, and responsibilities	Y		

Element	Acceptable as written? Y/N/NA	Comments	Anchor QEA Response
Lab data verification	Y		
14 Data Quality (Usability) Assessment			
Process for determining whether project objectives have been met	Y		
Data analysis and presentation methods	Y		
Treatment of non-detects	Y		
Sampling design evaluation	Y		
Documentation of assessment	Y		
15 References	Y		
16 Figures	Y		
17 Tables	Y		

Additional comments or significant concerns that need to be addressed in a revised QAPP:
(Peer Reviewer: Both here and for specific comments marked within the reviewed QAPP, please strive to differentiate between comments/concerns that are significant and threaten study integrity, vs. those that are for the author's consideration and discretion. This will assist the author with addressing your comments.)

Peer reviewer determination (select either 1 or 2 below):

1. **<u>QAPP is acceptable</u> as is or with minor revisions as noted above in comments/section. No further review is required.**

Enter date when each step is completed:	**Date**
Peer reviewer emails router/review checklist (and a link to the marked-up draft QAPP if necessary) to author, with cc's to unit supervisors of the peer reviewer and author.	

2. **<u>QAPP needs to be revised</u> and reviewed again. The QAPP should be revised and returned to the peer reviewer along with a response to significant concerns identified above.**

Enter date when each step is completed:	**Date**
Peer reviewer emails router/review checklist (and link to the marked-up draft QAPP if necessary) to author.	
Author revises QAPP per the comments above, and prepares a brief response summary indicating how the reviewer's significant concerns were addressed.	
Author sends a revised draft QAPP and response summary to peer reviewer.	
Peer reviewer emails author when QAPP is technically adequate, with cc's to author.	

Mr. Paul Pickett, Ecology Technical Lead, will be involved in all aspects of this project, including discussion, review, and approval of this QAPP, and interpretation of the results of the investigation. In this role, he will be responsible for coordination between Ecology and the contractor performing the environmental monitoring. He will also review the monitoring to help ensure that it is performed according to specifications and that the environmental data collected are of sufficient quality to meet the project objectives.

APPENDIX C
ELECTRONIC APPROVAL FOR MISSING SIGNATURES ON TITLE AND APPROVAL PAGE

Amy Florence

From:	Cheronne Oreiro <cheronneo@arilabs.com>
Sent:	Friday, October 11, 2013 10:14 AM
To:	Cindy Fields
Cc:	Amy Florence
Subject:	Re: Chehalis - WQ Program QAPP

Hi Cindy,

I approve of this QAPP.
-Cheronne

Cheronne Oreiro
Project Manager
Analytical Resources, Inc.
4611 S. 134th Place, Suite 100
Tukwila, WA 98168-3240
cheronneo@arilabs.com
(206)-695-6214

On 10/10/2013 4:23 PM, Cindy Fields wrote:

> Hi Cheronne,
> Our Chehalis QAPP (updated) has been approved by Ecology. The methods in Table 2 were changed per your recommendations.
>
> Could you please look it over and send us your approval similar to what is stated below?
>
> We will append that to the QAPP as your electronic signature.
>
> Please let me know if you have any questions or concerns.
>
> Thank you,
>
> **Cindy Fields**
> Scientist

ANCHOR QEA, LLC
cfields@anchorqea.com
D 206.903.3394

From: Pickett, Paul (ECY) [mailto:Ppic461@ECY.WA.GOV]
Sent: Thursday, October 10, 2013 4:11 PM
To: Pradeep Mugunthan
Cc: Robert Montgomery; David Gillingham; Christine Hempleman; Cindy Fields; Greg Summers; Erickson, Karol (ECY); Kammin, William R. (ECY)
Subject: RE: Chehalis - WQ Program QAPP

This has my approval – consider this to be my electronic signature.

Thanks.

Paul J. Pickett
WA Dept. of Ecology
P.O. Box 47710
Olympia, WA 98504-7710
(360) 407-6882

Amy Florence

From: Pradeep Mugunthan
Sent: Thursday, October 10, 2013 4:32 PM
To: Amy Florence
Subject: RE: Chehalis - WQ Program QAPP
Attachments: Chehalis QAPP Final_October 2013.pdf

From: Pickett, Paul (ECY) [mailto:Ppic461@ECY.WA.GOV]
Sent: Thursday, October 10, 2013 4:11 PM
To: Pradeep Mugunthan
Cc: Robert Montgomery; David Gillingham; Christine Hempleman; Cindy Fields; Greg Summers; Erickson, Karol (ECY); Kammin, William R. (ECY)
Subject: RE: Chehalis - WQ Program QAPP

This has my approval – consider this to be my electronic signature.

Thanks.

Paul J. Pickett
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