Quality Assurance Project Plan

Groundwater Assessment Program Pilot Study Phase 1

by
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October 2003

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Approvals

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Will Kendra, Section Manager, Watershed Ecology Section	Date
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Stuart Magoon, Director, Manchester Environmental Laboratory	Date
Approved by:	October 9, 2003
Stewart Lombard, EAP Quality Assurance Coordinator	Date

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Abstract

In October 2002, the Environmental Assessment Program (EA Program) received a Clean Water Act 104(b)(3) grant from the Region 10 office of the U.S. Environmental Protection Agency (USEPA). A primary purpose of the grant is to support the early stages of an EA Program pilot groundwater assessment study in a high priority basin. Conducting a pilot study will allow the EA Program to evaluate and refine the technical methods and schedule, staff, and budget requirements of a proposed groundwater assessment approach. The lessons learned during the pilot study will be instrumental in the agency's decision whether to pursue and dedicate resources to a longer-term state program.

This Quality Assurance Project Plan (QA Project Plan) was prepared to specifically describe the field activities of the pilot study that the EA Program is obligated to complete under the terms of the USEPA grant. A summary of the complete scope and schedule of work for the pilot study is presented below, but the detailed technical description of field tasks taking place beyond the terms of the grant will be documented separately (Phase 2).

Background

The Washington State Department of Ecology's EA Program recently completed an in-depth review of the program's groundwater assessment efforts. The goals of the review were two-fold: 1) evaluate the current state of affairs for the assessment and measurement of state ambient groundwater conditions and 2) outline recommendations for how the EA Program can best help the agency and the state meet current and future information needs for the groundwater resource. A final report summarizing the findings and recommendations of this review was published in May 2003 (Pitz, 2003a).

In response to concerns regarding the absence of a systematic, state-level approach to measuring and describing ambient groundwater conditions, a key suggestion of the recommendations report was to pilot test an EA Program-based state groundwater assessment program. The program design proposed for trial is intended to provide systematic, comparable procedures for the collection of *baseline* information about groundwater and hydrogeologic conditions at a basin or subbasin scale. If successful, the approach could be progressively applied to study areas in various portions of the state where baseline groundwater data is missing and is in high demand.

In October 2002, the EA Program received a Clean Water Act 104(b)(3) grant from the Region 10 office of the USEPA. A primary purpose of the grant is to support the early stages of an EA Program pilot assessment study in a high priority groundwater basin. Conducting a pilot study will allow the EA Program to evaluate and refine the technical methods and schedule, staff, and budget requirements of the proposed assessment approach. The lessons learned during a pilot study will be instrumental in the agency's decision whether or not to pursue and dedicate resources to a longer-term state program.

This QA Project Plan was prepared to specifically describe the field activities of the pilot study that the EA Program is obligated to complete under the terms of the USEPA grant. A summary of the complete scope and schedule of work for the pilot study is presented below, but the detailed technical description of field tasks taking place beyond the terms of the grant will be documented separately.

Project Goals and Objectives

The ultimate goal of the pilot study is to test the design of the groundwater assessment approach that was outlined in the recommendations report. To help accomplish this goal, the EA Program has identified a high priority study area that would benefit from baseline characterization and monitoring (Pitz, 2003b). The area selected is focused on the unconsolidated valley-fill deposits located between Napavine and Grand Mound, Washington, along the Newaukum and Chehalis Rivers in Lewis County (Figure 1).

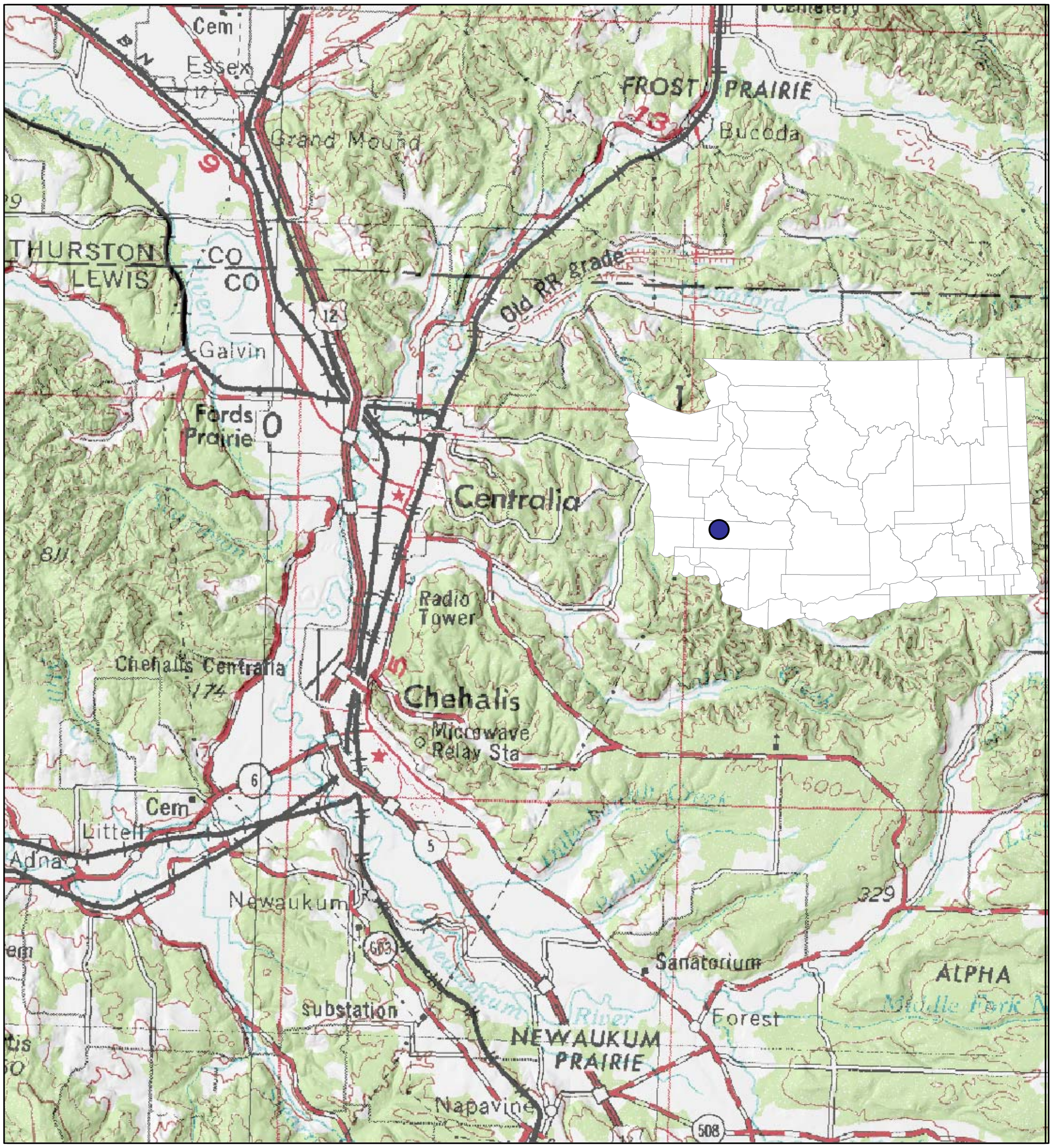
The main objectives for the pilot study will include:

- Characterizing and describing the basic hydrogeologic setting through assembly of existing and new information.
- Monitoring and describing baseline water table conditions.
- Monitoring and describing ambient water-quality conditions.
- Monitoring and describing baseline conditions for groundwater/surface water interactions, focused on the interactions between the uppermost portions of the study area aquifer system and the mainstem drainage.

Since many of the most pressing groundwater-related environmental or public drinking-water health issues occur or begin near-surface, pilot study monitoring and characterization efforts will focus primarily on the surficial aquifer system of the study area. Sampling and measurement of groundwater and hydrogeologic conditions will be accomplished through the use of surface water seepage evaluations, installation, and monitoring of in-stream piezometers, monitoring of existing water-supply wells (*Tier 1* wells), and installation and monitoring of new dedicated monitoring wells (*Tier 2* wells).

The pilot study will focus on *description* (vs. explanation) of current ambient conditions. The assessment study will not attempt to assign cause or origin to problems observed and will not attempt to provide solutions for specific water-supply or water-quality concerns present in the study area. Sampling and measurement is intended to provide a description of basin-scale conditions and will not be biased towards specific, known point sources or facilities. Standard tools such as geologic or hydrogeologic maps and cross-sections, geochemical diagrams, and descriptive statistics will be employed to summarize the data collected during the project.

If the conceptual approach and technical methods used during this study are shown to provide reliable information on hydrogeologic conditions in a cost effective manner, the procedures will be recommended for use in a longer term state groundwater assessment program. If these procedures are not adequate for this purpose, modifications or alternatives to the approach will be recommended.



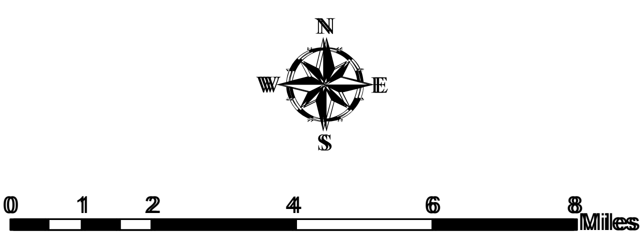


Figure 1
Pilot Study
Location Map

Responsibilities

The following individuals will be involved in this project:

Alison Clanton, Washington Operations Office, USEPA Region 10. As the USEPA grant project officer, Alison is the primary client for this QAPP (360-753-8185).

Jennifer Parker, Ground Water Protection Unit, USEPA Region 10. As the USEPA grant technical officer, Jennifer will advise Ms. Clanton and will provide technical input to the project (206-553-1900).

Kahle Jennings, SEA Program, SWRO. As the WRIA 23 watershed lead, Kahle will be instrumental in serving as a point of contact with the local stakeholders, agencies, and public. Kahle will assist in arranging access for measurement and sampling efforts conducted during the project (360-407-6310).

Melanie Kimsey, WQ Program, SWRO. As a regional hydrogeologist for the Water Quality Program, Melanie will serve as a point of contact for technical issues that arise during the study (360-407-6368).

Brad Hopkins, Ambient Monitoring Section. As the unit supervisor for the Stream Hydrology Unit, Brad will be the primary point of contact for project services received from the unit in support of stream or river discharge measurement.

Charles Pitz, Watershed Ecology Section. He is the EA Program project manager for this study. Charles will also serve as a project hydrogeologist for the study (360-407-6775).

Denis Erickson, Watershed Ecology Section. He will serve as a project hydrogeologist for the study (360-407-6524).

Adam Oestriech, Watershed Ecology Section. He will serve as a project intern for the study.

Will Kendra, Section Manager, Watershed Ecology Section. He is responsible for approving the QA Project Plan, project budget, and project reports (360-407-6698).

Darrel Anderson, Unit Supervisor, Watershed Ecology Section. He is responsible for internal review of the QA Project Plan and project reports (360-407-6453).

Stewart Lombard, EA Program Quality Assurance Coordinator. He will assist in providing technical guidance for QA/QC issues or problems that arise during the project and will review and approve the QA Project Plan (360-895-6148).

Manchester Environmental Laboratory (MEL). The lab will conduct the analysis of all field samples collected during this study, other than field-measured parameters. Pam Covey is responsible for coordinating requests for analysis and providing access to project data. Karin Feddersen is the primary contact for lab coordination on sample management and data quality issues. Phone numbers are MEL (360-871-8800), Pam (360-871-8827), and Karin (360-871-8829).

Study Area Description

The study area, which in total encompasses approximately 80 square miles, is focused on the surficial aquifer system lying between the USGS gauging station on the Newaukum River near Chehalis (12025000 – RM 4.1), and the USGS gauging station on the Chehalis River near Grand Mound (12027500 – RM 59.9) (Figure 2). The lateral boundaries of the surficial aquifer system that will be used for this study were defined by Garrigues et al., (1998).

The physiography of the study area consists of a broad, north-south trending, flat-lying valley surrounded by mature hills and uplands. Topographic relief ranges between 250 to 450 feet with uplands achieving elevations of 500 to 600 feet above sea level and floodplain elevations at 250 to 150 feet. The surface hydrology is dominated by the north-flowing Chehalis River and its major tributaries the Newaukum and Skookumchuck Rivers.

The geology, listed youngest to oldest, consists of floodplain alluvium, glaciofluvial deposits, and Tertiary sedimentary bedrock (Walsh et al., 1987). A simplified map of the study area surficial geology is shown in Figure 3. The bedrock consists of marine and near-shore sediments and underlies most of the study area and crops out in the uplands most frequently in the northern portion of the study area. The glaciofluvial deposits consist of outwash of both the Pre-Fraser glaciation and the Vashon Stade of the Fraser glaciation. The Pre-Fraser outwash deposits dominate the southern portion of the study area and the Vashon outwash deposits crop out mostly in the northern half of the study area. Floodplain alluvium associated with the major rivers and tributaries blankets the flat-lying valley floors.

Water is transmitted through the bedrock along fractures and typically the bulk hydraulic conductivity of the bedrock is low. The glaciofluvial deposits consist of sand and gravel and represent the most significant water-supply aquifers (Weigel and Foxworthy, 1962). The alluvium consists of heterogeneous mixtures of gravel, sand, silt, and clay and, as a result, the hydraulic conductivity of the alluvium shows wide ranges of spatial variability. In general, the saturated glaciofluvial deposits and hydraulically connected alluvial deposits combine to form the major surficial aquifers in the study area.

Precipitation across the study area ranges from 35 to 40 inches per year (WDNR, 1995). Surficial aquifers are recharged primarily by infiltrated precipitation.

Groundwater/surface water interaction with the Chehalis River was estimated to be significant especially in the area near where the Skookumchuck River flows into the Chehalis River and northward (Sinclair and Hirschey, 1992; Erickson, 1993).

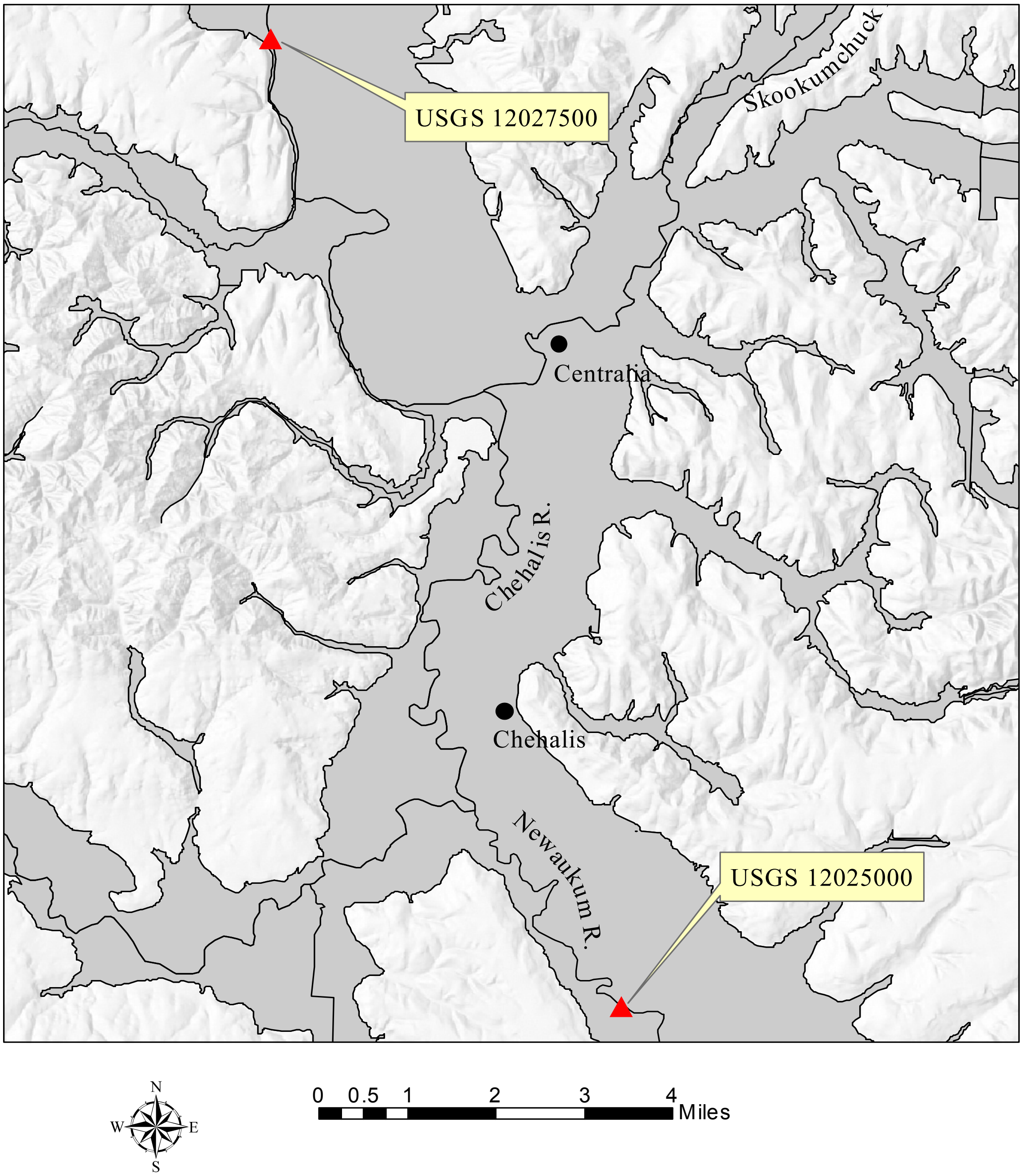
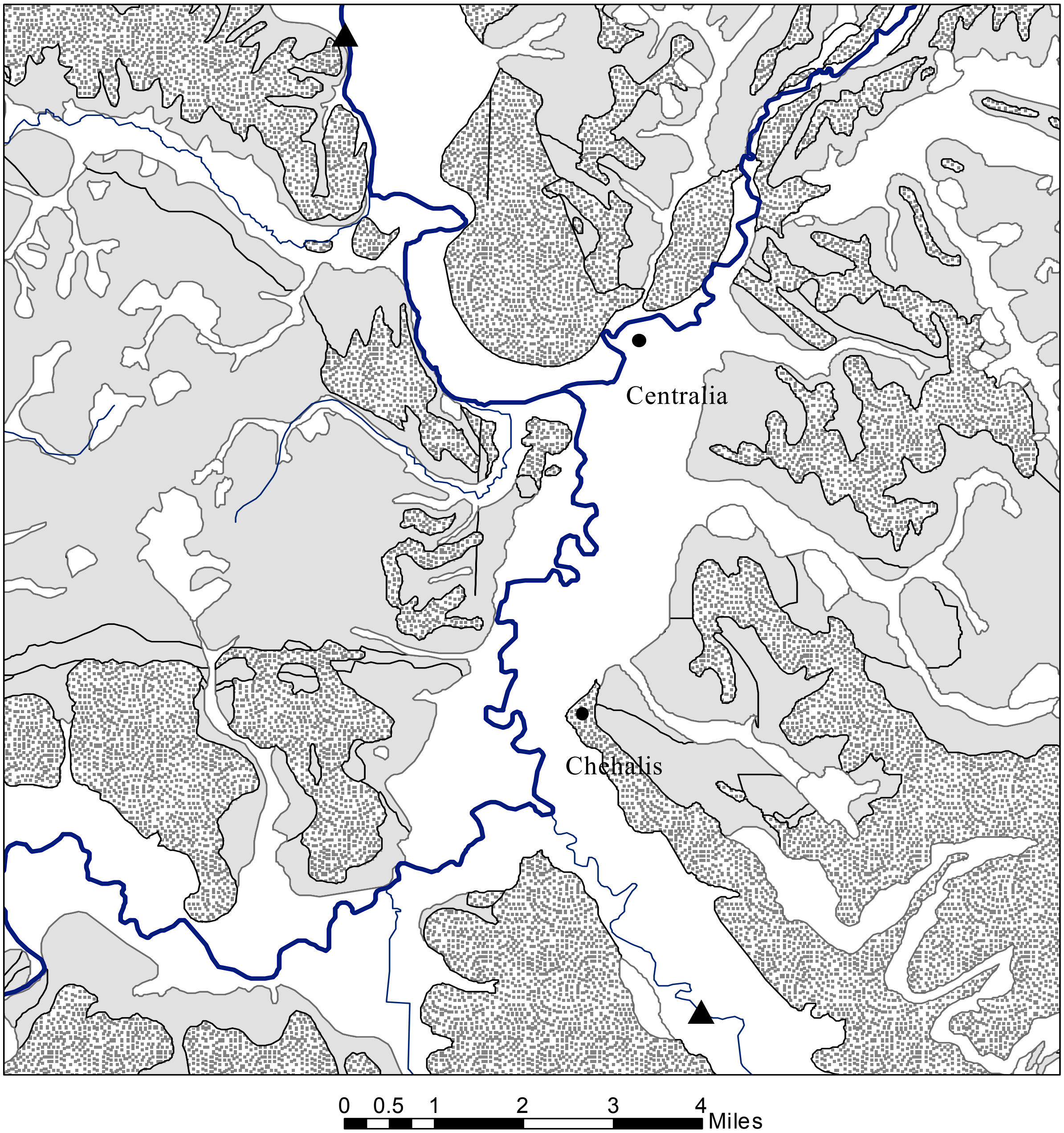


Figure 2
Study Area Map



Legend

- Alluvium and Landslide Deposits
- Glacial Deposits
- Bedrock
- USGS Gaging Station

Figure 3
General Surficial Geology

Study Design

To accomplish the objectives presented above, the following field tasks will be undertaken for this project:

1. A low-flow-season seepage evaluation along the main-stem study area drainage.
2. Installation of a network of in-stream piezometers for periodic water-quality and water-level monitoring for a one-year period.
3. Single-event sampling and analysis for a set list of common water-quality constituents for all Tier 1 and 2 wells.
4. Single-event sampling and analysis for a customized list of water-quality constituents of unique concern to the study basin for all Tier 2 wells.
5. Bimonthly water-quality monitoring for a one-year period for a short-list of indicator parameters for all Tier 1 and 2 wells.
6. Where feasible, bimonthly water-level monitoring of Tier 1 wells for a one-year period.
7. Continuous water-level monitoring of Tier 2 wells for a one-year period.
8. Hydraulic parameter testing of Tier 2 wells.

The seepage evaluation and the installation of the piezometer network are the field efforts specifically required under the terms of the grant and are described in detail in this project plan.

The primary purpose of the seepage evaluation is to: 1) identify the major areas of seepage loss and gain along the sections of interest of the Chehalis and Newaukum Rivers and 2) if feasible, estimate the net water-volume flux between the groundwater system and these drainages during the low-flow season. The preliminary findings of the seepage evaluation will be used to guide the design of the in-stream piezometer network. The piezometer network will be used as an additional tool to characterize the primary areas of groundwater discharge to the mainstem sections of interest and to provide a basic description of the influence of groundwater inflow on surface water conditions. Early information collected from the seepage evaluation and piezometer network will be used to guide the design of the well network subsequently developed for this study.

Schedule

The anticipated schedule for the complete project is presented below. The preliminary schedules for the field tasks described in detail in this project plan are bolded.

Task	2003						2004												2005											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1 - Desktop Study																														
Collect and review existing information	•	•	•	•																										
Develop and refine conceptual model			•	•																										
2 - QAPP	•	•	•	•	•																									
3 - Seepage Evaluation																														
Field reconnaissance	•	•																												
Coordinate with SHU	•	•																												
Compile and evaluate existing streamflow data	•	•	•																											
Conduct field seepage run			•																											
4 - Piezometer Network																														
Field reconnaissance	•	•	•																											
Permit arrangements	•	•	•	•																										
Piezometer installation				•																										
Piezometer sampling				•		•		•		•		•		•																
5 - Domestic Well Network																														
Well inventory	•	•	•	•																										
Develop database	•	•	•	•																										
Well selection/network design		•	•	•																										
Field verification			•	•	•																									
Access arrangements			•	•	•	•																								
Monitoring							•		•		•		•		•		•													
Well owner notification										•		•		•		•		•		•										
6 - Monitoring Well Network																														
Network design			•	•	•	•	•																							
Permitting			•	•	•	•	•																							
Access arrangements			•	•	•	•	•																							
Contract development					•	•	•																							
Well installation								•	•																					
Well development								•	•																					
Transducer installation									•																					
Monitoring									•		•		•		•		•		•											
Hydraulic testing													•		•															
7 - EIM																														
Project development	•	•																												

Task	2003						2004												2005											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
LIMS data migration to EIM						•		•	•	•	•	•	•	•	•	•	•		•		•									
EIM project quality assurance and closeout																									•					
8 - Analysis and Reporting																														
Compile, evaluate, and summarize project data		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•								
Data quality assurance review						•		•		•		•		•		•		•		•										
Cross section and map development			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•								
Prepare draft report																•	•	•	•	•	•	•								
Draft report review																						•	•							
Finalize report																							•	•	•					

Data Quality Objectives and Decision Criteria

One objective of this project is to measure the baseline water quality of the groundwater discharging to the mainstem surface drainages of the study area. To minimize bias (systematic error), standard sample collection procedures will be used that minimize potential changes to water chemistry during sampling. EA Program Watershed Assessment Section protocols will be followed when measuring water quality field parameters and samples will be preserved, handled, and stored in a consistent manner using accepted procedures for maintaining sample integrity prior to analysis (Ecology, 1993).

The precision and bias routinely obtained by the analysis methods for all target parameters will be adequate for this project. The measurement quality objectives (maximum acceptable values) for this project are listed in Table 1. For this project, measurement quality objectives are identical to project data quality objectives.

Table 1. Measurement Quality Objectives for Project Measurements

Parameter	Accuracy (Precision * 2) + Bias)	Precision (%RSD)	Bias (%)	Required Reporting Limit (concentration units)
Field				
Water Velocity[a]	±0.5 ft/sec			
pH[a]	±0.15 s.u.			
Temperature[a]	±0.2°C			
Specific Conductance[a]	±10 µhmo/cm			
Dissolved Oxygen[a,b]	± 0.2 mg/L >2 mg/L ±0.05 mg/L < 2 mg/L			
Laboratory				
Orthophosphate (OP)	27	12	3	0.003 mg/L
Nitrate+Nitrite-N, dissolved	20	9	2	0.01 mg/L
Ammonia, dissolved	20	9	2	0.01 mg/L
Dissolved Organic Carbon	20	9	2	1 mg/L
Iron, dissolved (ICP/AES)	26	12	2	50 µg/L
Total Dissolved Solids (TDS)	20	9	2	1 mg/L
Chloride	20	9	2	0.1 mg/L

[a] Accuracy as units of measure.
[b] Field photometric test kit for confirmation of field meter values below 2 mg/L.

Field Procedures

Seepage Evaluation

To conduct a seepage evaluation, synoptic flow measurements will be collected at selected points along the Newaukum and Chehalis Rivers during a low-flow period. The discharge measurement for the upstream and downstream ends of the mainstem seepage evaluation will be based on data from active flow gaging stations operated by the U.S. Geological Survey (USGS)(Stations 12025000 and 12027500); no EA Program field measurement of flow will occur at these locations.

Figure 4 shows the proposed locations for field measurements of flow that will be collected between the two USGS gages, including key tributaries entering the mainstem. Past studies and recent field reconnaissance have shown that the low dry-season water velocities typical of the segment of the Chehalis River between the Newaukum and Skookumchuck Rivers will prevent the collection of accurate flow measurements in this area (Pickett, 1994; Hopkins, 2003). Additional piezometers may be installed in this area during a later stage of the study to assist in identifying gaining reaches. Secondary tributaries that may contribute significantly to flow are also identified on Figure 4; measurement of these locations is dependent on the relative flow condition at time of measurement.

All points shown on Figure 4 are preliminary; actual measurement locations will be dictated by access considerations, measurement method, field conditions of flow, and quality of the measurement section. Final measurement locations will be recorded in the field using handheld global positioning system units, and field photographs of each location will be taken at the time of measurement.

Measurements of discharge will be collected at all sites over as short a time period as practical during stable, dry weather conditions with no observable storm runoff entering streams. The relative increase or decrease in discharge between mainstem stations that is not accounted for through point diversion or discharge, tributary input, or measurement error is interpreted as the volume of water exchanged between the stream and the groundwater system.

Discharge measurements from wadeable portions of streams will be collected according to standard USGS operating procedures for mid-section method wading measurements, slightly modified to accommodate EA Program equipment (SHU, 2003; Hopkins, 1999; Rantz, et al., 1982). Wading measurements will be collected using a standard USGS-type top set wading rod fitted for a Swoffer Model 2100 optical sensor. In general, cross sections will be divided into approximately 20 to 25 sections in an effort to ensure that no more than 5% to 10% of the total discharge passes through any single cell, meaning the width of the individual cells can vary. Velocity measurements will be collected at 60% of the stream depth when the total stream depth is less than 1.5 feet, and at 20% and 80% of the stream depth when the depth is greater than 1.5 feet.

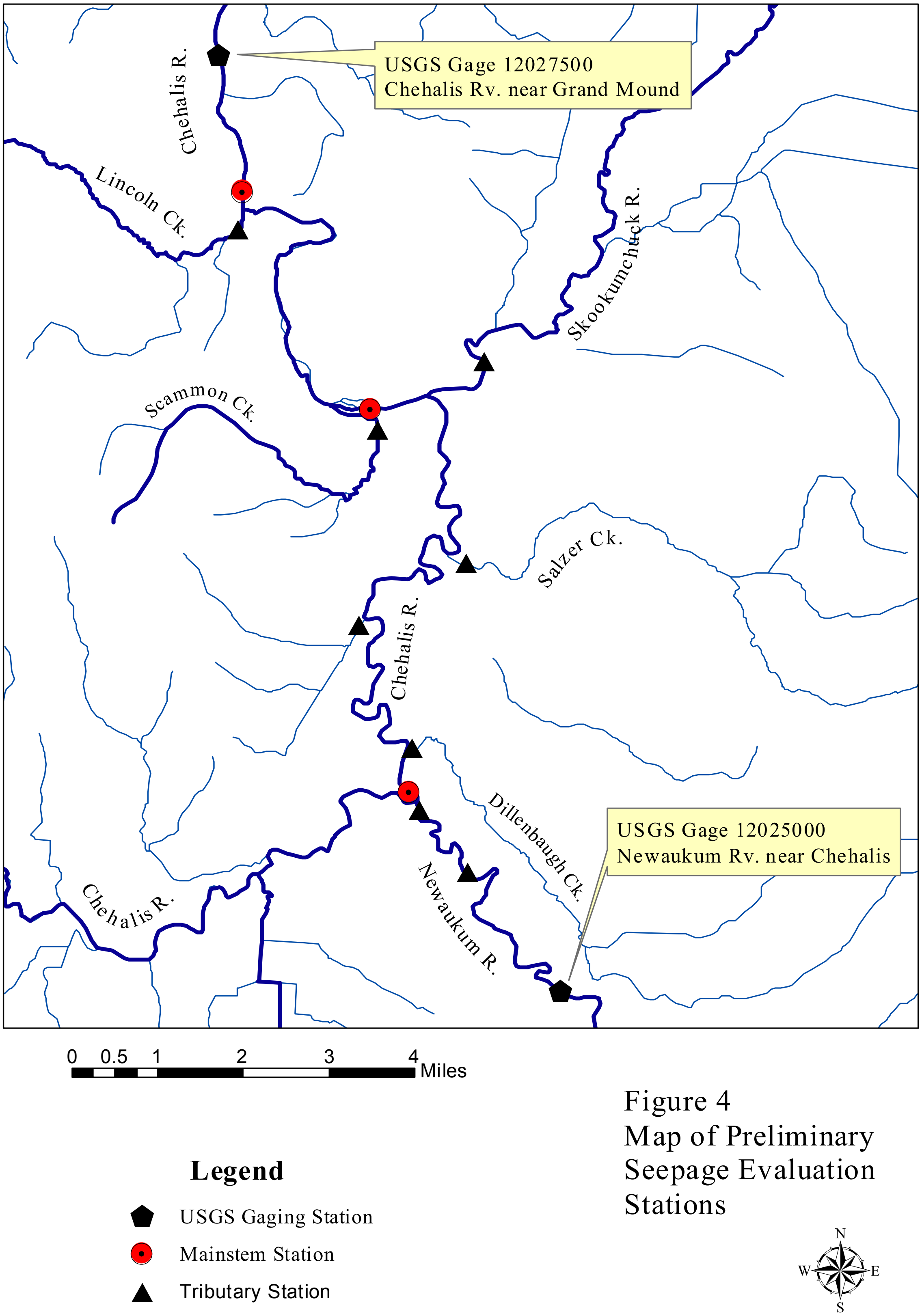


Figure 4
Map of Preliminary Seepage Evaluation Stations

In-stream Piezometer Network

After completion of the seepage evaluation, a network of approximately 10 to 15 in-stream piezometers will be installed along the study area mainstem. Location placement for the piezometers will be guided by the results of the seepage evaluation, the review of existing information about hydrogeologic conditions, and access considerations. Placement of piezometers will be biased towards locations identified as areas of likely groundwater inflow to the mainstem to support the objective of characterizing groundwater influence on surface water.

Piezometers will be constructed of an approximately 7 to 9 foot total length of small diameter pipe or tubing. Piezometer material will be either galvanized pipe crimped and perforated at the lowermost end for water entry, galvanized pipe attached to a stainless steel drive screen, or rigid polyethylene tubing perforated at the lowermost end and attached to a steel drive point. The upper end of each piezometer will be fitted with a secure cap when not in use. Piezometers will be hand driven into the stream bed in a near-bank position to a depth of approximately 4 to 5 feet below the sediment surface. All piezometers will be developed by surge pumping with a hand-held bilge pump or battery-operated peristaltic pump to ensure hydraulic connection with the surrounding sediments.

Historic data indicates that significant changes in river stage may prohibit access to piezometers for measurement and sampling during wet season (flood) conditions. Data collection emphasis during this project will be placed on completion of dry season monitoring of the piezometers. If applicable, an alternative piezometer design may also be used to allow access during high stage conditions (e.g. the use of tubing piezometers extending to the top of a bank).

Measurement and sampling of piezometers will occur no sooner than one week after installation and development to ensure equilibration of conditions adjacent to the device. Monitoring will occur, where feasible, on a bimonthly schedule for a one-year period (six events). Water quality sampling will only be conducted for piezometers that exhibit a positive (upward) vertical hydraulic gradient indicating a groundwater discharge condition. Piezometers will be removed from the streambed after the final sampling round is complete.

The steps followed during each measurement and sampling event include:

1. Measure and compare relative head between piezometer and river stage.
2. Measure field parameters for surface water quality (pH, temperature, specific conductance, dissolved oxygen) adjacent to piezometer.
3. Purge the piezometer through a closed-atmosphere flow cell until stabilization of field parameters.
4. Record final pore-water field parameters (pH, temperature, specific conductance, dissolved oxygen) at end of purge period.
5. Collect pore-water water quality samples, filter, and preserve as required.

Hydraulic Head Measurement

Measurement of relative head conditions between the piezometer and the river stage will be accomplished by direct comparison measurement using standard procedures for calibrated electric well probes, or by potentiomanometer methods outlined by Winter et al., (1988). A manometer board enables simultaneous relative head measurements of both the piezometer and the river water surface. Either method provides a quantitative measure of the relative vertical hydraulic gradient and direction of flow between the river and underlying pore water. When the piezometer head exceeds the river stage, groundwater discharge into the river can be inferred. Similarly, when the river water surface exceeds the head in the piezometer, seepage loss of water to groundwater storage is assumed.

Water Quality Measurement and Sampling

Measurement of surface water and porewater field water-quality parameters will be accomplished through the use of calibrated field meters. Porewater field parameters will be measured within a closed flow chamber that is connected directly to a peristaltic pump. Flow chamber measurements will be collected on average at five minute intervals until parameters stabilize. End-of-purge measurements of porewater dissolved oxygen will be confirmed using field photometric or colorimetric test kits when field meter concentrations show less than 2.0 mg/L. Table 2 presents a summary of the field methods that will be used for the measurement of field parameters.

Table 2. Summary of Project Field Measurement Methods

Parameter	Measurement Method	Expected Range of Results
pH	GeoTech Meter	5.5-8.0 SU
Temperature	GeoTech Meter	8-20 ºC
Specific Conductance	2510 GeoTech Meter	30-1000 µmhos/cm
Dissolved Oxygen	4500-O G. Membrane Electrode >2 mg/L Chemetrics Indigo Carmine Photometric <2 mg/L Chemetrics Rhodazine-D Photometric <0.8 mg/L	0.1-18 mg/L

Where feasible, piezometers will be sampled for selected water quality constituents on a bimonthly schedule for a one-year period. Water quality samples will be collected using a peristaltic pump through clean silastic tubing and analyzed for orthophosphate (OP), nitrate+nitrite as N (nitrate-N), ammonia as N (ammonia-N), dissolved organic carbon (DOC), dissolved iron, total dissolved solids (TDS), and chloride.

Samples for lab analysis will be collected upon completion of purging into the proper sample container, with filtration and preservation as appropriate. All samples will be collected in pre-cleaned bottles supplied by MEL and stored on ice pending their arrival at the laboratory. Samples requiring filtration will be filtered using a clean, dedicated in-line 0.45 micron filter, and collected after discarding the first 100 ml of filtrate. Table 3 summarizes the container type, sample volume, field handling, preservation requirements, and holding times for the project parameters.

Table 3. Container, Sample Volume, Handling, Preservation, and Holding Time Requirements

Analyte	Container Type	Container Volume (ml)	Sample Handling	Preservation	Holding Time
OP	Amber w/m poly	125	Filter @ 0.45 micron	Cool to <4°C	48 hrs
Nitrate-N	w/m clear Nalgene (pre-acidified)	125[a]	Filter @ 0.45 micron	Adjust pH to <2 w/ H_2SO_4 and cool to <4°C	28 days
Ammonia-N	w/m clear Nalgene (pre-acidified)	125[a]	Filter @ 0.45 micron	Adjust pH to <2 w/ H_2SO_4 and cool to <4°C	28 days
DOC	n/m poly (pre-acidified)	60	Filter @ 0.45 micron	Adjust pH to <2 w/ HCl and cool to <4°C	28 days
Iron (dissolved)	w/m clear Nalgene	125	Filter @ 0.45 micron	Adjust pH <2 w/ HNO_3 and cool to <4°C	6 months
TDS	w/m poly	500[b]		Cool to <4°C	7 days
Chloride	w/m poly	500[b]		Cool to <4°C	28 days

[a]Nitrate-N and ammonia-N sample collected in common 125 ml nutrients bottle.
[b]TDS and chloride sample collected in a common 500ml bottle.

Laboratory Procedures

Past studies have indicated that, relative to the natural heterogeneity, concentration ranges and temporal variations in groundwater quality, the precision and bias routinely obtained by the analytical methods selected are considered adequate for the purposes of this project. No special reporting limits, analytical testing, or handling requirements will be needed. The laboratory parameters, test methods, and expected ranges of results for the project are listed in Table 4.

Table 4. Summary of Project Laboratory Analysis Methods

Parameter	Matrix	Test Method Standard Methods (APHA, 1998)	Sample Preparation Method	Expected Range of Results
OP	Water	4500-P G. Colormetric flow injection.	Field filtered	<0.003-30 mg/L
Nitrate-N	Water	4500 NO3- I Colormetric flow injection.	Field filtered	<0.01-20 mg/L
Ammonia-N	Water	4500-NH3 G. Automated Phenate Method	Field filtered	<0.01-1 mg/L
DOC	Water	5310 B. Combustion Infrared Method	Field filtered	<1-20 mg/L
Iron (dissolved)	Water	EPA 200.7 Inductively Coupled Plasma	Field filtered	<0.050-5 mg/L
TDS	Water	2540 C. Gravimetric at 180ºC	None	30-1000 mg/L
Chloride	Water	4110 B. Ion Chromatography	None	2-250 mg/L

Estimated Laboratory Costs

Table 5 below summarizes the anticipated analytical costs for the water-quality sampling of the in-stream piezometers.

Table 5. Estimated Laboratory Cost by Parameter

Parameter	Predicted Number of Samples(1)	Cost per Sample(2)	Cost per Parameter
OP	78	$12	$936
Nitrate-N	78	$12	$936
Ammonia-N	72	$12	$864
DOC	72	$29	$2088
Iron (dissolved)	72	$26(3)	$1872
TDS	72	$10	$720
Chloride	78	$12	$936
Estimate Total Lab Cost			$8352

(1) Assumes 10 piezometers, 1 duplicate, 1 reference sample (OP, Nitrate-N, and Chloride), and 1 blank per round for 6 sampling rounds.
(2) Assumes MEL "planned" price (50% discount).
(3) $10 credit on MEL price due to field filtration (1 element).

Quality Control Procedures

Field Quality Control

Stream Discharge

Under ideal conditions, instantaneous discharge estimates are typically assumed to have a built-in error of at least ±5%. The largest potential source of measurement error for stream discharge estimation is the measurement of stream velocity. Proper site selection for measurement and equipment calibration are the key field quality controls used to ensure reasonably accurate estimates.

Site selection for velocity profiles will follow procedures outlined in SHU (2003) and Rantz et al., (1982) and will focus on identifying stream measurement locations that exhibit relatively straight, free-flowing conditions with minimal vegetative growth, single channel morphology, and regular stream-bed uniformity. Cross sections meeting ideal criteria can be difficult to find, so each cross section used will be rated by USGS and SHU standards for quality of section to assign an assumed potential error in the discharge estimate. A section judged to be good for measurement is assumed to have a potential error of 5%, a fair section up to 8% potential error, and a poor section >8% potential error.

Swoffer instruments used for stream velocity measurements will be pre- and post-calibrated. The ideal calibration value for a Swoffer propeller is 186. A calibration rating of 186 means that for every 186 revolutions of the propeller, 10 feet of water have passed the measurement point. Acceptable calibration values will range from 182-186, with a calibration value of 182 underestimating the discharge measurement by 2%.

Prior to conducting the synoptic survey, all measurement teams, including staff from the EA Program's Stream Hydrology unit, will measure and compare results for the same stream section. This information will be used to estimate variability introduced by the different teams and will provide confirmation that the correct measurement procedures are being used by all teams. To assist in determining the reproducibility of the data, a minimum of two duplicate cross section discharge estimates will be made during the synoptic flow evaluation. A temporary reference point will be established to monitor stage changes during the duplicate measurements.

The accuracy of the estimate of seepage occurring between measured stations can also be significantly influenced by unaccounted inputs or diversions of water to or from the stream (e.g. permitted or un-permitted outfalls or intakes). If the net volume of these inputs or diversions is similar to the natural loss or gain from the groundwater system, it can lead to an inaccurate estimate of seepage. While it is not practical to field survey the entire reach of interest for such flows, existing state water resource and water quality program databases will be reviewed to identify all permitted point flows and diversions. These inputs or diversions will be incorporated into the water balance calculations to assist in determining seepage loss or gain.

Collins (2003) estimates the precision for USGS discharge determinations at the Ground Mound station to be about 5-8% at the low-flow end of the rating curve. For the Newaukum station, he estimates the precision of discharge determinations to be on the order of 25% under low-flow conditions. The poorer precision at the Newaukum station is the result of no-flow measurements at the existing stage height. The USGS is planning to obtain a flow measurement during the current low-flow conditions in September 2003. This flow measurement will improve the accuracy at the low end of the rating curve to about 5-8%. Bias is minimized by using calibrated flow meters and standard flow measurement procedures.

Piezometers

Hydraulic Methods

Because it is not possible to install a standard surface seal for the piezometer beneath the water surface, there is a potential for direct hydraulic communication between surface water and the piezometer intake due to annular leakage along the ouside wall of the piezometer.
To minimize potential annular leakage the following steps will be taken:

- Piezometers will be allowed to equilibrate at least one week after installation before obtaining water levels and water quality samples. This will allow formation material to re-establish contact with the outside wall of the piezometer due to natural consolidation.
- The piezometer will be pumped at a low rate to minimize drawdown during purging and sampling.

To verify that annular leakage is not occurring, a sample of the surface water at each location will be initially tested for field parameters and compared to end-of-purge piezometer results. Substantial differences of piezometer and surface water results will be used as evidence that direct hydraulic communication is not occurring. Pitz (2003c) successfully used this approach in a lake study to verify that pore-water samplers were not in direct hydraulic connection with the lake. In addition, the local vertical hydraulic gradient will be determined using relative water level elevations of the piezometer and the surface water as described previously. The existence of a vertical hydraulic gradient (i.e. a difference in hydraulic head) will serve as another indicator of the absence of annular leakage. If field evidence indicates leakage through the annular space is occuring, additional steps will be used to eliminate the problem (e.g. tamping of the sediments surrounding the piezometer, additional development, or reinstallation of the piezometer).

Water Quality Sampling

A variety of field quality assurance tests will be conducted, including replicate testing, to assist in determining the error introduced by the sample acquisition methods.

Dissolved oxygen and pH meters will be calibrated in accordance with the manufacturers' instuctions at the start of each day and midway through the day. Duplicate results will be obtained at a minimum of 10% of the piezometers to determine overall precision of field parameters. For electrical conductivity, a one-point calibration on a known commercial standard will be run before each sampling event to verify that the meter is operating properly.

A field duplicate sample will be collected for every ten piezometer samples and submitted to the laboratory as a blind sample. A field duplicate is a second sample from the same well or piezometer using identical purging and sampling procedures. After the initial sample is collected, the water level will be allowed to stabilize before re-starting sampling procedures. The entire purging and sampling sequence will be repeated for the duplicate sample. Duplicate sample results provide an estimate of overall sampling and analytical precision.

For each sampling event one filter blank will be submitted to the laboratory for all field filtered parameters. A filter blank will be obtained by passing laboratory Milli-Q water through a clean 0.45 µm in-line filter and collected in the appropriate sample bottles. The filter blank will be used to determine whether the filter, sample containers, preservatives, or transport methods represent a source of bias. If bias is recognized in blank samples early in the project, additional steps will be taken to isolate the source of error, and field procedures or equipment will be modified to eliminate the problem.

For each sampling event, reference samples obtained from the Quality Assurance Section of the Department of Ecology will be submitted to the laboratory as blind samples for the following parameters: nitrate+nitrite-N, orthophosphate, and chloride. The measured concentrations when compared to the concentrations of the reference samples will provide an estimate of the overall accuracy of the analytical results for these parameters.

Laboratory Quality Control

In addition to the submittal of blind reference samples, routine laboratory quality control procedures will be adequate to estimate laboratory precision and accuracy for this project. Laboratory quality control samples consist of blanks, duplicates, matrix spikes, and check standards (laboratory control samples) (Manchester Environmental Laboratory, 2002).

Duplicates will be used to assess analytical precision. Matrix spikes will be used to indicate bias due to matrix interferences. Check standards will be used to estimate bias due to calibration. Laboratory blanks will be used to measure the response of the analytical system at a theoretical concentration of zero. Manchester Laboratory's quality control samples and procedures are discussed in detail in the Quality Assurance Manual, Manchester Environmental Laboratory (MEL, 2001).

Data Reduction and Management Procedures

Field data will be recorded at the time of measurement or sampling in a field notebook and, if appropriate, input into the Environmental Information Management (EIM) system. Data to be entered into field notebooks includes dates and times of measurement or sampling, names of field personnel, station identification, appropriate field measurement values and units of measure, laboratory sample numbers, and field comments on any deviations from described procedures.

To estimate stream discharge, stream velocity and profile measurements collected in the field will be evaluated using a specialized discharge calculation software program developed by the EA Program's Stream Hydrology Unit.

Data generated by MEL will be managed by the Laboratory Information Management System (LIMS) and sent to the project lead in both electronic and printed format. After evaluation of the analytical data against the project data quality objectives, the reported results will be input into the EIM system.

Data Review and Validation

Data Review

Prior to distribution to the project lead, all laboratory data will undergo a quality assurance review by Manchester Laboratory staff to verify that quality control samples met acceptance criteria as specified in the standard operating procedure for that method. Appropriate qualifiers will be attached to results that did not meet requirements. An explanation for the data qualification will be described in a quality assurance memorandum attached with the data package.

Data Validation

Upon receipt of the verified data from MEL, the project lead will verify that the results have met the measurement quality objectives for bias, precision, and accuracy for that sampling episode.

Precision will be estimated by calculating the relative percent standard deviation (%RSD) between results for duplicate pairs. These values provide an indication of the degree of random variability introduced by sampling and analytical procedures. These values will be compared to the mean duplicate concentration (over the entire concentration range reported during the project) to assess the ability of the data to meet the project measurement quality objectives. The %RSD for duplicate pairs at or near the reporting limit are typically higher than the allowed error described by the measurement quality objectives and will not automatically disqualify data from use.

Analytical bias is assumed to be within acceptable limits if laboratory quality control limits are met for blanks, matrix spikes, and check standards. Sampling bias will be assured by verifying that the correct sampling and handling procedures were used. Overall accuracy will be estimated by comparing the measured result with the true value of the blind reference sample. Goals for completeness will then be evaluated and, if needed, replacement samples would be obtained and adjustments in subsequent sampling events will be made.

Data Quality Assessment

The purpose of the water quality data is to determine baseline groundwater quality for the target aquifers; no specific decision will be forthcoming based on the results. If measurement quality objectives have been met for all sampling episodes, the data will be considered acceptable for use except as qualified during the data review and validation process, and no additional data quality assessment will be needed.

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