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Quality Assurance Project Plan

Sumas-Blaine Surficial Aquifer Long-Term Ambient Groundwater Monitoring

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Signatures are not available on the Internet version.
EAP - Environmental Assessment Program
EIM - Environmental Information Management system
SCS – Statewide Coordination Section
WOS – Western Operations Section

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Abstract

The purpose of this project is to implement a long-term ambient groundwater monitoring program in the Sumas-Blaine surficial aquifer. This aquifer has been identified as one of the most severely contaminated aquifers in Washington State (Erickson, 2000).

The aquifer is contaminated with elevated concentrations of nitrate. A previous study examining trends and seasonal variations determined that nitrate is increasing in the aquifer at a rate of approximately 0.5 mg/l per year. Seventy-one percent of the wells sampled had at least one concentration higher than the groundwater quality nitrate standard of 10 mg N/l, and 31% of the wells displayed a statistically increasing nitrate tend over the 2003-2005 sampling period (Redding, 2008).

This study is designed to build on the previous monitoring efforts in order to provide an annual assessment of the status of the groundwater quality. Additionally, this monitoring program can assist in identifying new groundwater problems which may arise. Thirty-five wells will be sampled annually for nitrate, chloride, and bromide in March beginning in 2009. This project will continue as long as funding is available.

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completion of the study, a final report describing the study results will be posted to the Internet.

Background

The Sumas Blaine surficial aquifer is the principal aquifer in the Nooksack watershed in northwestern Whatcom County. The aquifer extends over 150 square miles and is the primary drinking water source for area residents. The aquifer is comprised mainly of permeable sand and gravel glacial outwash deposits, as well as alluvial deposits from the Nooksack and Sumas Rivers. The aquifer is largely unconfined and shallow, with depths to water commonly less than 10 feet below land surface. These hydrogeologic characteristics create an aquifer which is highly susceptible to contamination from surface activities.

The Sumas Blaine surficial aquifer was identified as one of the most severely contaminated aquifers in Washington State (Erickson, 2000). This aquifer is vulnerable to contamination due to permeable soils, a shallow water table, and historic and continued agricultural land use.

Agriculture is the predominant land use overlying the aquifer, and the density of dairies is among the highest in the state (Erickson, 2000). Whatcom County is also one of the nation's leading producers of raspberries.

There are numerous studies documenting groundwater contamination with elevated nitrate and pesticide concentrations: Erickson and Norton, 1990; Garland and Erickson, 1994; Erickson, 1998; Cox and Kahle, 1999; Cox and Liebscher, 1999; Erickson, 2000; Mitchell et al., 2000; Mitchell et al., 2005; O'Herron, 1999; and Redding, 2008.

Nitrate concentrations have steadily increased in the Sumas-Blaine aquifer over the past 20 years and are increasing at a rate of approximately 0.5 mg/l per year. Seventy-one percent of the wells, sampled during a two-year nitrate trend study, had at least one concentration higher than the groundwater quality standard of 10 mg/l. Nitrate concentrations ranged from 0.01 to 43.1 mg/l in the aquifer. (Redding, 2008.)

The study area is located northeast of Bellingham, Washington. It encompasses an area of approximately 80 square miles with the town of Lynden situated at the center of the study area.

Project Description

An ambient monitoring program refers to a long-term regional monitoring at fixed stations. An ambient monitoring network can be used to characterize the groundwater quality or quantity, identify new problems, and evaluate the effectiveness of activities over a large area. (Carey, 1987).

The United States Geological Survey uses ambient groundwater monitoring programs to identify risks to groundwater resources, characterize parameters of concern, and identify trends. The parameters monitored are specific to the area of concern and the activities which have a potential to impact groundwater quality. (Kulongoski and Belitz, 2006.)

The goal of this project is to implement a long-term ambient groundwater monitoring program in the Sumas Blaine surficial aquifer. This will provide an ongoing assessment of groundwater quality over time. The primary focus is nitrates; however, the parameters monitored could evolve as needed in the future.

This monitoring program will use the network developed during an earlier nitrate trends study (Redding, 2008) to continue monitoring nitrate concentrations in the aquifer. The same 35 monitoring wells and private domestic wells will be sampled on an annual basis beginning in 2009 for nitrate, chloride, bromide, and field parameters. The goal is to assess the current status of the condition of the aquifer and to determine long-term nitrate trends into the future.

The objectives are to:

- Collect annual water quality data in March.
- Compare concentrations to historical data.
- Compare concentrations to the Washington State groundwater quality standards.
- Determine if there are statistically significant trends using the non-parametric Mann-Kendall test for trends.

This information can be used to make informed water-resource management decisions and pollution-prevention strategies.

An annual report will be prepared describing the results, conclusions, and further recommendations.

Homeowners will be sent a copy of the well sampling results for their individual well along with an explanation of the water quality results after every sampling.

The data suitable for archiving will be entered into Ecology's EIM database every year, beginning in 2009.

Organization and Schedule

The following people are involved in this project. All are employees of the Washington State Department of Ecology.

Table 1. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Richard Grout Water Quality Program Bellingham Field Office Phone: (360) 715-5203	EAP Client	Clarifies scopes of the project, provides internal review of the QAPP, and approves the final QAPP.
Melanie Redding Groundwater/Forests and Fish Unit Statewide Coordination Section Phone: (360) 407-6524	Project Manager/ Principal Investigator	Writes the QAPP, oversees field sampling and transportation of samples to the laboratory, conducts QA review of data, analyzes and interprets data, and writes the draft report and final report.
Tanya Roberts Groundwater/Forests Fish Unit Statewide Coordination Section Phone: (360) 407-7392	EIM Data Engineer	Enters data into EIM.
Martha Maggi Groundwater / Forests and Fish Unit Statewide Coordination Section Phone: (360) 407-6453	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Will Kendra Statewide Coordination Section Phone: (360) 4076698	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Bob Cusimano Western Operations Section Phone: (360) 407-6596	Section Manager for the Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory Phone: (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: (360) 407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP – Environmental Assessment Program
EIM – Environmental Information Management system
QAPP – Quality Assurance Project Plan

Table 2. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	
Field work completed	March 2009
Laboratory analyses completed	June 2009
Environmental Information System (EIM) system	
EIM data engineer	Tanya Roberts
EIM Study User ID	mred 0001
EIM Study Name	Sumas-Blaine Surficial Aquifer Long Term Ambient Groundwater Monitoring
Data due in EIM	January 2010
Groundwater report	
Project Tracker code	09-223
Author lead	Melanie Redding
Schedule	
Draft due to supervisor	October 2009
Draft due to client/peer reviewer	November 2009
Draft due to external reviewer(s)	December 2009
Final report due on web	January 2010

Quality Objectives

The primary objective of this localized ambient monitoring program is to characterize the nitrate trends in groundwater into the future. This study will continue the nitrate trend assessment in the Sumas-Blaine surficial aquifer which was conducted between 2003 and 2005 (Redding, 2008). Data from this monitoring program will provide a basis for judging if current efforts for protecting groundwater are adequate, and if additional protection measures are necessary.

Data will be collected beginning in 2009 from a set of wells where seasonal variability has been previously defined by two years of bi-monthly monitoring. This determination of seasonal variability will allow trends to be more readily determined in the future with minimal monitoring.

The measurement quality objectives (MQOs) for this project are presented in Table 3. All water quality data referenced in the annual and final reports will be evaluated against the project MQOs. Providing pre-established criteria for data quality in the MQOs allows the determination of potential sources of error when evaluating precision and bias for the analytical method. Laboratory standards are listed in Table 4.

Field replicates will be collected at 10% of the wells sampled.

Table 3. Measurement quality objectives.

Parameter	Accuracy	Precision	Bias	Field Replicate Precision
	((Precision X 2) + Bias)	(% RSD)	(%)	(% RPD)
Field Measurements				
pH	+/- 0.15 SU	NA	NA	10
Conductivity	+/- 10 µmhos/cm	NA	NA	10
Temperature	+/- 0.1 ºC	NA	NA	
Dissolved Oxygen	+/- 0.2 mg/l	NA	NA	20
Laboratory Analyses				
Nitrate+Nitrite-N	20%	7	5	15
Chloride	25%	5	15	15
Bromide	25%	5	15	15

Table 4. Laboratory standards.

Parameter	Check Standard (LCS) (% Recovery Limits)	Duplicate Samples (% RPD)	Matrix Spikes (% Recovery Limits)	Matrix Spike Duplicates (% RPD)	Lowest Concentration of Interest (mg/l)
Nitrate+Nitrite-N	80 – 120%	+/- 15%	75 – 125%	+/- 20%	0.01
Chloride	80 – 120%	+/- 15%	75 – 125%	+/- 20%	0.02
Bromide	80 – 120%	+/- 15%	75 – 125%	+/- 20%	0.02

LCS – laboratory control samples
RPD – relative percent difference

Sampling Process Design (Experimental Design)

The primary focus of this study is to implement a long-term ambient groundwater monitoring program in the Sumas Blaine surficial aquifer. The monitoring network will consist of 35 wells, which were previously sampled bi-monthly for two years in the nitrate trends study. The network of wells will be sampled annually in March as recommended (Redding, 2008). Wells will be sampled for field parameters (temperature, pH, dissolved oxygen, and conductivity) and nitrate+nitrite-N, chloride and bromide, which will be sent to Manchester Environmental Laboratory for laboratory analysis.

Owners of these wells will be contacted by letters and telephone to discuss the goals of this project and to determine their willingness to participate in the project.

All wells which do not have a unique Ecology well tag will be tagged during this project.

Sampling Considerations

To minimize the effects of altering the water chemistry of groundwater samples, the following procedures will be used:

- Samples will be obtained from as close to the wellhead as possible.
- Samples will be obtained prior to any water treatment device.
- Wells will not be sampled that do not have adequate surface seals or may be contaminated by surface runoff.
- Wells will be purged until the field parameters have stabilized.
- Samples will be obtained when the pump is running to minimize the contribution from storage tanks.

Well Selection Criteria

The wells proposed for monitoring during this study were selected according to the following criteria (Erickson, 2002):

- The well must be completed only in the Sumas-Blaine surficial aquifer.
- The well owner must give permission to participate in the study.
- The well construction must meet the well construction standards specified in Chapter 173-160 WAC.
- The well log should be available and the completed well depth known.
- The well has a sampling history of elevated nitrate concentrations.
- The well must be accessible to sample.
- The water must be untreated prior to the sampling point.

These wells have the added advantage that the seasonal variations were previously defined in the nitrate trends study (Redding, 2008). Other wells may be added, as necessary to fill in data gaps.

Private Domestic Wells

This ambient monitoring network is comprised predominantly of private domestic wells. Groundwater monitoring wells are the ideal type of well for monitoring conditions in the aquifer. Unfortunately, due to limited resources, it is not possible to economically install a sufficient number of wells which would provide adequate areal coverage. Previous studies in the Sumas-Blaine surficial aquifer have used private domestic wells with much success. The wells proposed for monitoring in this study are all shallow wells, completed in the uppermost aquifer, and meet the well construction standards.

The wells proposed for this network were monitored every other month for two years, 2003-05. This intense monitoring provided an assessment of seasonal variations for each well. This is beneficial for understanding groundwater concentrations at specific times of the year.

Additionally, by following the elements listed under sampling considerations, the samples obtained should be representative of aquifer conditions.

Sampling Procedures

Groundwater wells will be purged prior to sampling. Samples will be obtained from taps as close to the wellhead as possible. Samples should be obtained only when the pump is operating, to minimize the effects of sampling water from storage tanks. Sampling water from a storage tank would not be representative of aquifer conditions because the water would be sitting stagnant in a storage tank, which may cause chemical alteration of the water. A storage tank is not comparable to aquifer conditions, and therefore, should be avoided.

Representative samples are obtained by using a “Y” fitting at a tap, whenever possible. Samples will be obtained from one side of the “Y” outlet, by use of a hose-bib adapter. The other side will direct the purge water to the other side of the “Y” outlet through a garden hose, discharging to a vegetated area.

Field parameters—temperature, pH, electrical conductivity, and dissolved oxygen—will be measured at intervals of five minutes during purging. A flow-through cell will be used to determine field measurements prior to the water being exposed to the atmosphere. Purging will continue until these parameters have stabilized. Stability criteria are listed in Table 5.

Table 5. Stability criteria for sampling groundwater.

Field Parameter	Criteria	Typical Change
Temperature	0.2 ºC	2%
pH	0.2 SU	3%
Electrical Conductivity	10 µmhos/cm	7%
Dissolved Oxygen	0.3 mg/l	10%

Purging will be considered complete when two consecutive sets of parameter readings show changes less than the criteria listed above.

All samples will be field filtered using a 0.45 micron filter, and samples will be placed in bottles obtained from Manchester Environmental Laboratory (MEL).

Table 6. Sample containers, preservation, and holding times for laboratory parameters.

Lab Parameter	Bottle	Preservative	Holding Time
Nitrate-nitrite-N	125 ml, wide mouth polyethylene	Sulfuric acid to pH<2, refrigerated at 6 ºC	28 days
Chloride	500 ml, wide mouth polyethylene	refrigerated at 6 ºC	28 days
Bromide	125 ml, polyethylene	refrigerated at 6 ºC	28 days

All samples will be placed in coolers with ice while in transit. At the completion of the sampling event, the coolers will be transported to the Ecology Operations Center walk-in cooler, where a MEL courier will pick up the coolers and transport the samples to MEL in Manchester, Washington.

Measurement Procedures

This study will employ both field and laboratory based measurements. The method, reporting limit, and expected concentration ranges are listed in Table 7.

Table 7. Summary of field and laboratory measurements, methods, reporting limits, and expected ranges for groundwater samples.

Parameter	Method	Reporting Limit	Expected Range
Field Measurements			
pH	EPA 150.1	+/- 0.1 SU	5.5 – 7.5 SU
Conductivity	EPA 120.1	+/- 1 µS/cm	100 – 1000 µS/cm
Temperature		+/- 0.2 ºC	7 -15 ºC
Dissolved Oxygen	EPA 360.1	+/- 0.2 mg/L	0.1 – 10 mg/L
Laboratory Parameters			
Nitrate+Nitrite-N	4500 NO3I	0.01 mg/L	0.01 – 50 mg/L
Chloride	EPA 300.0	0.1 mg/L	0.5 – 100 mg/L
Bromide	EPA 300.0	0.2 mg/L	0.2 – 2 mg/L

Quality Control Procedures

Field

Field meters will be calibrated in accordance with the manufacturer's instructions at the start of each day and midway through the day. Duplicate results will be obtained at a minimum of 10% of the wells to determine the overall precision of field parameters.

A field duplicate water quality sample will be collected for 10% of the wells sampled, and will be submitted to the laboratory as a blind sample. Duplicates provide estimates of combined field and analytical variability. A field duplicate is a second sample from the same well using identical sampling procedures. After the initial sample is collected, the pump will be shut off for approximately five minutes to allow the aquifer to equilibrate. For the duplicate sample, the entire purging and sampling procedure will be repeated. Duplicate sample results will provide an estimate of overall sampling and analytical precision.

Laboratory

Nitrate+nitrite-N concentrations will be determined using the cadmium reduction flow injection method, Standard Methods (20^{th} Edition) 4500 NO3I (MEL, 2006). The laboratory costs include a 50% discount for MEL.

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 (MEL, 2006).

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.

Data Management Procedures

All field observations and monitoring results will be recorded on individual well sampling sheets that will be maintained throughout the length of the project and eventually archived in project files. Field observations and data will be checked for legibility and completeness before leaving the site locations. Field data will be entered in spreadsheets and may be entered in the Ecology EIM database.

Analytical data from MEL will be stored in electronic format in the data management system (LIMS). After the data are verified, they will be summarized in case narratives and provided to the project manager.

At the completion of the sampling event, all field and laboratory analytical data will be compiled and evaluated against the project MQOs listed in Table 3. Data reduction, review, and reporting will follow the procedures outlined in MEL's Laboratory Users Manual (MEL, 2008).

All laboratory data will be entered into the EIM database. Data will also be entered into spreadsheets for evaluation and presentation in graphical formats.

Audits and Reports

MEL participates in performance and system audits of their routine procedures. Reported results of these audits are available upon request. Ecology's Accreditation Program establishes whether the laboratory has the capability to provide accurate and defensible data. The accreditation involves an evaluation of the laboratory's quality system, staff, facilities, equipment, test methods, records, and reports.

The annual report and a final report (approximately every 5 years) will include a Quality Assurance section describing data quality. These reports will undergo scientific peer review by staff with appropriate expertise who are not directly connected with this project.

After the data are reviewed for each sampling event, the results will be sent to each homeowner for their individual well, along with an explanation of the water quality analyses.

Data Verification

Data verification is a quality assurance review process to determine the quality and the completeness of the field and analytical data. This is done by determining that all quality control samples meet the acceptance criteria as specified in the standard operating procedure for that method.

MEL staff will review all laboratory analysis for the project to verify that the methods and protocols specified in the Quality Assurance Project Plan were followed; that all instrument calibrations, quality control checks, and intermediate calculations were performed appropriately; and that the final reported data are consistent, correct and complete with no omissions or errors, (MEL, 2006). Evaluation criteria will include the acceptability of instrument calibrations, procedural blanks, spike sample analysis, precision data, laboratory control sample analysis, and the appropriateness of assigned data qualifiers. MEL staff will prepare a written case narrative describing the results of their data review.

Precision will be estimated by calculating the relative percent difference for field duplicate results. Analytical bias will be assumed to be within acceptable limits if laboratory quality control limits are achieved for blanks, matrix spikes and check standards. Sampling bias will be assessed by verifying that the correct sampling and handling procedures were used. Goals for completeness will be evaluated and, if needed, replacement samples will be obtained and adjustments in subsequent sampling events will be made.

Field quality control procedures include reviewing field notes for completeness, errors, and consistency. Duplicate measurements and documentation of conditions in field notes will support verification of analytical measurements and field measurements.

The project lead will review the data package and case narrative to determine if the results meet the MQOs for accuracy, precision, and bias for that sampling episode. Field duplicate results will be evaluated and compared to the quality objectives shown in Table 3. Based on these assessments, the data will either be accepted, accepted with appropriate qualifications, or rejected.

After the laboratory and field data have been reviewed and verified by the project manager, they will be transitioned to the EIM database for access by the project client and others. The EIM data sets will be independently reviewed for errors by another Environmental Assessment Program staff person before finalizing and completing the project in EIM.

Data Quality (Usability) Assessment

After the data have been reviewed and verified, the project lead will use best professional judgment to determine if the data can be used towards the project goals and objectives. Data will be compared to the project MQOs for accuracy, precision, and bias. Additionally, the laboratory case narratives and duplicate sample analyses will be evaluated. Depending upon the ability to meet these goals, the data will be deemed acceptable for use.

Data analysis will include analyzing past and present data by using summary statistics and the non-parametric Mann-Kendall test for trends. This test is a monotonic trend analysis that evaluates trends in data where seasonal variations exist (EPA, 1989; Fisher and Potter, 1989). A monotonic trend is one which is exclusively increasing or decreasing, but not both, (EPA, 2000). The null hypothesis (H_O) is that the samples are independent and identically distributed variables that are random with respect to time, and therefore no distinguishable trend is present. The alternate hypothesis (H_A) is that a trend is present, either increasing or decreasing. The type of trend is determined by whether the calculated Mann-Kendall statistic (S) is positive or negative (Aroner, 1994). This non-parametric test can accommodate missing values, values less than the detection limit, and a non-normally distributed data set (Gilbert, 1987).

Additionally, nitrate concentrations will be graphically displayed to show areal distribution.

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary terms

Accuracy: The closeness of a measured value to its true value.

Ambient: Long-term regional monitoring at fixed stations to assess large-scale or area-wide conditions (i.e., conditions not associated with a specific discrete source, facility, or property).

Bias: A systematic error inherent in a method or caused by some artifact or idiosyncrasy of the measurement system, which influences the result either positively or negatively.

Groundwater: Water in the subsurface that saturates the rocks and sediment in which it occurs. The upper surface of groundwater saturation is commonly called the water table.

Precision: Agreement among two or more results which have been collected in an identical fashion.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
MEL	Manchester Environmental Laboratory
mg/l	Milligrams per liter
mg/ N/l	Milligrams of nitrogen per liter
ml	Milliliter
MQO	Measurement quality objectives
RSD	Relative standard deviation
RPD	Relative percent difference
SU	Standard unit
µmhos/cm	Micromhos per centimeter
µS/cm	Microsiemens per centimeter, a unit of conductivity