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ECOLOGY
State of Washington

Quality Assurance Project Plan

Sumas-Blaine Aquifer
Nitrate Contamination
Summary

October 2011

Publication No. 11-03-111

Publication Information

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 completing the study, Ecology will post the final report of the study to the Internet.

The plan for this study is available on Ecology's website at
www.ecy.wa.gov/biblio/1103111.html.
Ecology's Activity Tracker Code for this study is 11-032.

Waterbody Number: WA-01-1010

Author and Contact Information

Barb Carey, LHG
P.O. Box 47600
Environmental Assessment Program
Washington State Department of Ecology
Olympia, WA 98504-7710

This plan was prepared by a licensed hydrogeologist. A signed and stamped copy of the report is available upon request.

For more information contact: Communications Consultant, phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Quality Assurance Project Plan

Sumas-Blaine Aquifer Nitrate Contamination Summary

October 2011

Approved by:

Signature:	Date: October 2011
Ron Cummings, Client, Water Quality Program, Headquarters	
Signature:	Date: September 2011
Helen Bresler, Client's Unit Supervisor, Water Quality Program, Headquarters	
Signature:	Date: October 2011
Melissa Gildersleeve, Client's Section Manager, Water Quality Program, Headquarters	
Signature:	Date: September 2011
Barb Carey, Author / Project Manager/Principal Investigator, EAP	
Signature:	Date: September 2011
Martha Maggi, Author's Unit Supervisor, EAP	
Signature:	Date: September 2011
Will Kendra, Author's Section Manager, EAP	
Signature:	Date: September 2011
Robert F. Cusimano, Section Manager for Project Study Area, EAP	
Signature:	Date: October 2011
Bill Kammin, Ecology Quality Assurance Officer	

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
EIM: Environmental Information Management database

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Abstract

Nitrate concentrations exceeding the drinking water standard of 10 mg/L-N have been reported in the Sumas-Blaine Aquifer (SBA) for nearly 40 years. The SBA is the only usable source of drinking water for over 25,000 rural residents of northwest Whatcom County. The purpose of this study is to summarize available information on the current status of nitrate in the SBA, the characteristics of the aquifer that contribute to its vulnerability, and the estimated contributions of nitrate from overlying land uses. No field sampling will be conducted.

Each study conducted by Ecology must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to meet those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

Background

The Sumas-Blaine Aquifer (SBA) in northwest Whatcom County, Washington covers 150 square miles and is the exclusive source of drinking water for about 25,000 residents. The SBA is part of the larger Abbotsford-Sumas Aquifer that straddles the U.S.-Canada border.

Groundwater flows generally from north to south (Canada to the U.S.) but also diverges toward eastern and western stream boundaries (Figure 1). The depth to water is less than 10 feet in most of the SBA and is more variable on the British Columbia side (Tooley and Erickson, 1996). Heavy precipitation from October through March leads to a water table near the ground surface in much of the SBA. In many places artificial drainage is needed to prevent flooding. The average thickness of the SBA is about 50 feet. The underlying Everson-Vashon Semiconfining Layer is generally not usable as a drinking water source due to its low yield and poor water quality.

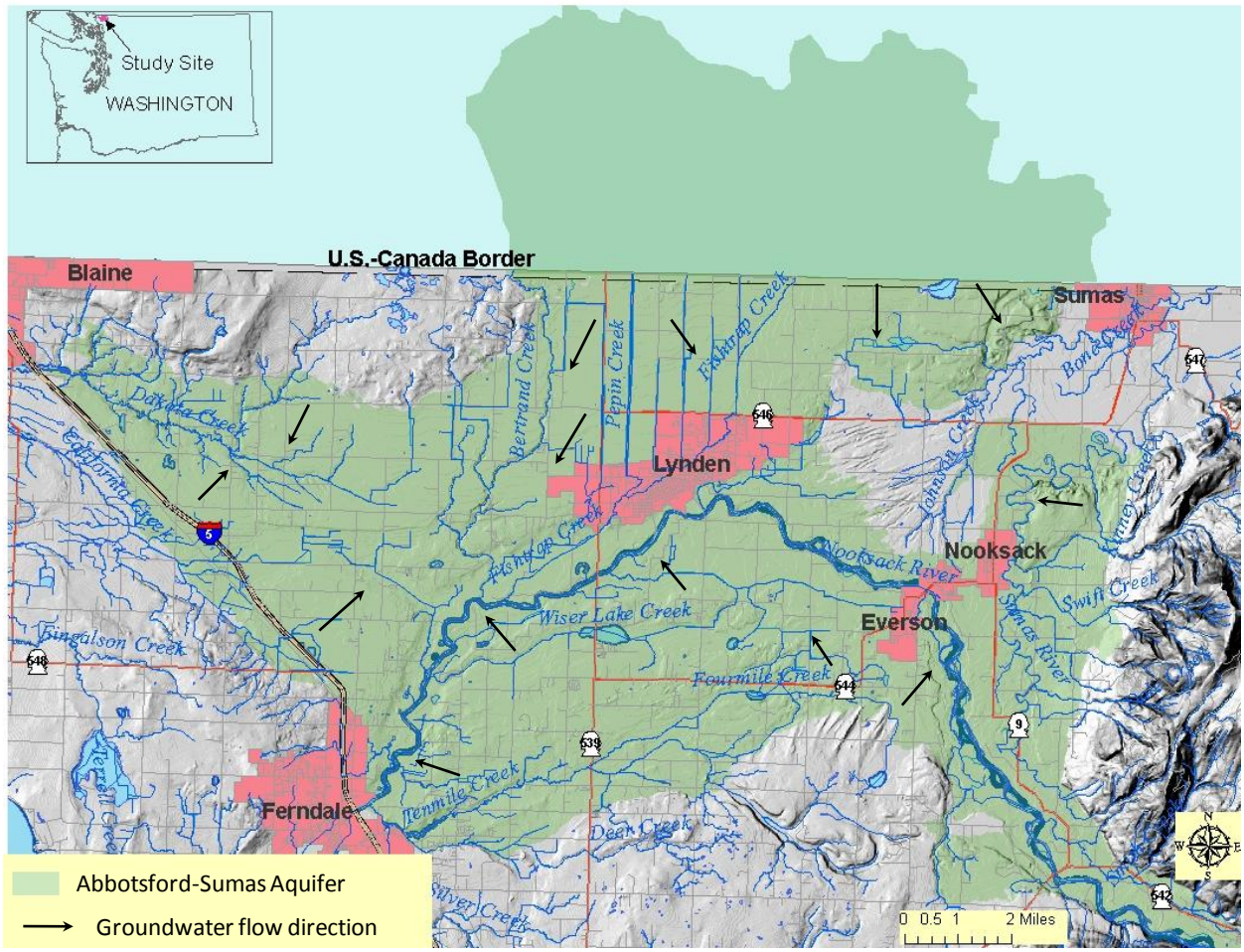

Figure 1. Map of the Abbotsford-Sumas Aquifer with generalized groundwater flow directions in the U.S. portion (Sumas-Blaine Aquifer). Aquifer map is from Tooley and Erickson (1996) and Graham (2006). Groundwater flow directions are from Erickson (1998) and Graham (2006).

Agriculture has been the predominant land use over the shallow SBA for the past 50 years. Nitrate concentrations exceeding the maximum contaminant level of 10 mg/L N for drinking water have been documented in the SBA for the past 40 years (Obert, 1973; Erickson and Norton, 1990; Garland and Erickson, 1994; Cox and Kahle, 1999; Erickson, 2000 and 1998; Carey, 2002; Carey et al., 2011; Almasri and Kaluarachchi, 2004; Mitchell et al., 2005; Redding, 2008, 2011*a* and 2011*b*; Redding et al., 2011).

In 1997, 21% of 250 private wells in the SBA exceeded the nitrate limits for drinking water (Erickson, 1998). Six to eight years later, 71% of private wells in a 35-well subset of the 250 wells previously sampled, contained nitrate-N at concentrations greater than 10 mg/L (Redding, 2008).

Several public water supply wells near the City of Lynden have been taken off line in recent years due to nitrate exceedances, leaving over 1,000 people without a potable water supply. High nitrate concentrations can cause methemoglobinemia, or blue-baby syndrome, in infants. This potentially life-threatening condition is caused by nitrate converting to nitrite in the digestive system. The nitrite then reacts with iron in hemoglobin restricting transport of oxygen to the cells. Cancer risks have been associated with elevated nitrate in water and food (Chiu and Tsai, 2007; Ward et al., 2005; Weyer et al., 2001).

Besides affecting human health, groundwater nitrate can also affect surface water by increasing primary productivity in streams, rivers, and lakes. When algal and plant material that depend on nitrogen decompose, oxygen depletion can affect fish and other aquatic life.

Dairy farming has been the predominant agricultural activity over the SBA for the past 40 to 50 years with raspberry and other berry production becoming more prominent in the past 15 years. Similar agricultural activities occur on the Canadian side of the aquifer, although berry and poultry production have replaced more of the former dairy land in the Abbotsford area than in Whatcom County.

On the Washington side of the aquifer, the number of dairy farms has dropped by one-half in the past decade. However, the number of milk cows has only decreased by 30% (Embertson, 2010). In 2010, the Department of Agriculture reported 46,000 adult cows in Whatcom County dairies (Prest, 2011). The total amount of nitrogen produced by adult and juvenile cows and applied to land overlying the SBA is 11 to 14 million pounds per year. This amount is comparable to the amount of nitrogen produced by a city of one million people.

Numerous studies have been conducted to evaluate and describe aspects of the hydrogeology and water quality of the SBA. A brief summary is needed to synthesize the available information in a format that is understandable by all.

Project Description

The purpose of the study is to summarize historical groundwater quality data, describe aquifer characteristics and vulnerability to contamination, and discuss regional land uses and their relationship to groundwater conditions. The Department of Ecology (Ecology) Water Quality Program will use this information to understand the current status of groundwater quality, inform the public, and make decisions to improve the situation.

The goals of the study are to:

1. Describe the characteristics of the SBA and explain why the aquifer is vulnerable.
2. Describe the soil and climate characteristics and their effect on the aquifer's vulnerability.
3. Summarize groundwater quality data for the aquifer, particularly nitrate.
4. Estimate annual nitrogen loading from land uses over the aquifer and likely effects on groundwater quality.

Ecology will complete a final report with maps and relatively non-technical explanations. The project manager will also coordinate with the public information officer for the Water Quality Program and EAP to prepare a public information release.

The tasks to be accomplished to meet the above goals are to:

- Gather and evaluate data from various sources.
- Screen data for quality, comparable sampling and analytical methods and usability.
- Map water quality and water level data using GIS or existing maps.
- Update analyses integrating data from various sources.
- Summarize results including any uncertainty or bias.

Organization and Schedule

Table 1 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 2 presents the proposed schedule for this project.

Table 1. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Ron Cummings Water Quality Program Headquarters Phone: 360-407-6795	EAP Client	Clarifies scopes of the project. Provides internal review of the QAPP and approves the final QAPP.
Barb Carey GFFU-SCS- EAP Phone: 360-407-6769	Project Manager/Principal Investigator	Writes the QAPP. Analyzes existing data. Writes the draft report and final report.
Martha Maggi GFFU-SCS-EAP 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: 360-407-6696	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Robert F. Cusimano WOS Phone: 360-407-6596	Section Manager for the Project Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
William R. Kammin EAP Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP: Environmental Assessment Program.
GFFU: Groundwater Forest & Fish Unit.
WOS: Western Operations SectionQAPP: Quality Assurance Project Plan.

Table 2. Proposed schedule for completing the report.

Final Report	
Author lead	Barb Carey
Schedule	
Draft due to supervisor	October 14, 2011
Draft due to client/peer reviewer	October 28, 2011
Draft due to external reviewer(s)	November 30, 2011
Final (all reviews done) due to publications coordinator	January 2012
Final report due on web	February 2012

Analysis Methods

Data analysis

Groundwater quality, water level, and soils data will be displayed graphically on maps of the SBA, showing groundwater flow directions, water quality data, and changes over time. Previous data analyses will be used and updated.

Long-term water quality data, especially nitrate-N, will be analyzed in wells located in the SBA. Statistical changes over time will be evaluated using Student's t-test or non-parametric methods depending on whether the data (or transformed data) are normally distributed.

Relationships between groundwater quality, soil type, and land use will be evaluated.

Data Sources

Existing data from various sources collected through 2010 will be integrated and summarized. Sources of data will include:

- USGS (NWIS database)
- Natural Resources Conservation Service (SSURGO soils maps)
- Ecology (EIM database and QA-validated data not yet in EIM)
- Washington State Department of Agriculture (estimated N production from dairies)
- Washington Department of Health public water supply data
- Western Washington University
- Utah State University study
- Environment Canada studies
- Simon Fraser University studies
- University of Calgary studies

Nitrate-N will be the main constituent analyzed. Other parameters that will be evaluated as they relate to nitrate include:

- Chloride
- EDB, 1,2-DCP, DBCP, 1,2,3-TCP
- Conductivity
- Dissolved oxygen
- Organic carbon
- Phosphorus

Data analysis

Several methods of data analysis will be used. Groundwater quality, water level, and soils data will be displayed graphically on maps of the aquifer showing groundwater flow direction, water quality data, changes over time and, if possible, nitrate hot spots.

Water quality data, especially nitrate-N from Ecology and USGS studies will be analyzed over the period of record in wells located in the SBA. Statistical changes over time will be evaluated using Student's t-test or non-parametric methods depending on whether the data (or transformed data) are normally distributed.

Data Acceptance Criteria

No new data will be collected for this project and specific quality objectives are not specified for existing data. However, the following acceptance criteria will be applied for data included in the report.

- Data reasonableness—Quality of existing data will be evaluated where available. Formal testing will be used to identify erroneous or outlier data (U.S. EPA, 2009), and these values will be removed from the data set.
- Data representativeness—Data that are reasonably complete and representative of the location and time period will be used. Incomplete data sets will be used if they are considered representative of conditions during the period of interest.
- Data comparability—Procedures for sample collection, handling, preserving, and analysis evolve over time. Best professional judgment will be used to decide if data sets can be compared. The final report will explain any caveats or assumptions made if data are used that derive from differing sampling or analysis methods.
- The following general data screening procedures will be used:
    - Water quality results will be converted to common units, e.g., mg/L for nitrate-N.
    - Results qualified as estimates (e.g., "J" qualification) will be included without change.
    - Data from private wells and monitoring wells will be combined.
    - Data for filtered and unfiltered samples will be combined. If both are available, then the filtered result will be used.
    - Non-detects will be treated at 0.5 x the reporting limit (U.S. EPA, 2009)
    -
- Because USGS and Ecology data are pre-screened for quality, most data should be usable.

Data Set Bias

Because groundwater sampling locations are restricted to existing wells for sampling, there is a bias toward locations and depths that are fairly removed from the more contaminated areas. Private wells also usually obtain water from tens of feet below the top of the aquifer, which is below the zone where contaminants are at the highest concentration. Therefore the existing data probably represent the low range for contaminants of interest. In addition to the relatively uncontaminated locations with existing data, the number of wells with usable data is small relative to the size of the aquifer.

Project Deliverables

A summary report that includes a relatively non-technical explanation of data analysis, maps, and graphs will be produced.

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Appendix A. Glossary, Acronyms, and Abbreviations

Glossary

1,2-DCP: 1,2-dichloropropane, a soil fumigant.

1,2,3,-TCP: 1,2,3-trichloropropane, a soil fumigant.

EDB: Ethylene dibromide, a soil fumigant.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
et al.	And others
GIS	Geographic Information System software
MEL	Manchester Environmental Laboratory
QA	Quality assurance
SOP	Standard operating procedures
USGS	U.S. Geological Survey

Units of Measurement

mg/L	milligrams per liter (parts per million)