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Spokane River/Aquifer Interaction Project

Quality Assurance Project Plan

by
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Environmental Assessment Program
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Project Background

The following points summarize what is known about aquifer/river interaction between the Spokane River and the Spokane Valley aquifer.

- The Spokane/Rathdrum-Prairie Aquifer is an extremely transmissive aquifer system.
- Based on historic information, we know that a great deal of water is exchanged between the Spokane River and the Spokane-Rathdrum Prairie Aquifer.
- Unpublished comparisons of river-stage and ground-water-level hydrographs by John Covert, (personal communication, February 1998) indicate a strong hydraulic connection between the river and the aquifer.
- The water quality of the upper Spokane River has been impaired by historic mining practices within the Coeur d' Alene River system.
- Cursory investigations by Spokane County indicate that water quality in the aquifer changes significantly with river stage changes. Water-quality changes may be particularly significant in the upper 50 feet of the aquifer (Stan Miller, Spokane County, 1998, personal communication).

However, significant data gaps exist which prevent an adequate understanding of the effect of aquifer recharge from the Spokane River on hydraulic heads in the Spokane Valley Aquifer and on ground-water quality. These data gaps include:

- The magnitude of river leakage and the resulting rate of flux in the aquifer are not adequately understood.
- Water-quality data and water-level data related to interaction between the river and the aquifer are scattered and not comprehensive enough to define the river/aquifer interaction with confidence, particularly in the Spokane Valley.

Project Description

Project Goal

The goal of the Spokane River/Aquifer Interaction Study is to conduct an initial assessment of the effect of aquifer recharge from the Spokane River on hydraulic heads and ground-water quality in the Spokane Valley Aquifer. Data gathered will be evaluated in the context of recharge patterns to the aquifer, comparisons of chemical properties in the river and aquifer, and on the mass transfer of trace metals from surface water to ground water. The project goal will be achieved using the following objectives.

Project Objectives

Water quality and ground water potentiometric patterns will be monitored to achieve baseline data for physical and chemical influences by the river on the aquifer. The upper aquifer response to river flow patterns from the spring runoff period through the fall low-flow season will be recorded and analyzed. This will be complemented by a preliminary monitoring of temporal and spatial influences by the river on upper-aquifer water quality. These results will aid in determining the influence of river seepage on aquifer water quality in the eastern portion of the Spokane Valley.

Spokane County installed six monitoring wells at two locations adjacent to the Spokane River in the fall of 1998. Two networks of 3 wells each were completed near the Sullivan Road and Barker Road bridges, on the east side of Spokane (Figure 1). These six monitoring wells were specifically placed to provide data for addressing river/aquifer interaction questions. Transducers and data loggers have been placed in all six wells - providing water level and temperature readings every two hours.

Six other monitoring wells, which have been installed in the project area for various monitoring purposes, have also been identified. These wells will suit the sampling and water-level needs of this project very well. Transducers and data loggers have been placed in all six of these wells and will provide water level and temperature readings once every hour.

Spokane County contracted with the Eastern Washington University graduate program (EWU) to have two graduate students sample the wells and the Spokane River as part of their Masters Thesis work. The graduate students will conduct their last sampling in June of 1999. The Spokane River/Aquifer Interaction Project expands on the thesis projects, emphasizing ground-water quality and potentiometric trends along the losing reach of the river, east of Sullivan Road to the Washington/Idaho State Line.

Continuing monthly sampling into the dry, low-flow season (July and August) will provide ground-water quality and potentiometric data related to the low-flow stages of the river. This data collection will also provide continuity with the County/EWU studies, resulting in a full year of ground-water data. This should provide the data needed for a look at seasonal water quality changes in the aquifer.

Ground-water monitoring along the river during the high-flow season is critically important data for analysis of river/aquifer interaction. However, it is sometimes difficult to determine whether water-level changes in the aquifer are caused by increases in river stage or by other seasonal recharge factors such as precipitation events and inflow from the Rathdrum Prairie Aquifer.

The Avista (Post Falls) Dam, near the headwaters of the Spokane River in Idaho, provides a unique opportunity for a controlled "hydrologic event" on the Spokane River. During the fall -- the low-flow season -- the Avista Dam conducts a controlled release of impounded water to lower the water level in Coeur d'Alene Lake in preparation for the coming winter and increased inflows. This release from the dam produces a surge, down stream, of between 1000 and 1400 cubic-feet per second (cfs). At low-flow season, a surge of this magnitude will increase the river flow by 125 to 175 percent (up from a low-flow average of about 800 cfs). The surge should be observable in the aquifer adjacent to the river -- certainly in ground-water levels, and possibly in ground-water quality. The fact that this controlled hydrologic event occurs in the fall should minimize troublesome influences from precipitation events and seasonal ground-water recharge.

The results of this project will be applicable to at least four other studies currently planned or underway for the Spokane River and Spokane Valley Aquifer. They are:

1. An evaluation of water resources under the Washington State Watershed Planning Act, initiated by Spokane County. Aquifer and river interaction is a fundamental consideration of their watershed planning process.

2. The US Environmental Protection Agency (EPA) is sponsoring an expanded remedial investigation (RI) and feasibility study (FS). The study includes an evaluation of the extent and magnitude of trace metals distributed into the environment along the Spokane/Coeur d' Alene River system. The RI work along the Spokane River will include enhanced flow gaging, river sediment analysis, and the evaluation of suspended and dissolved trace metal transport from Coeur d' Alene Lake to the mouth of the Spokane River.

3. The U.S. Geological Survey National Ambient Water Quality Assessment (NAWQA) program also is studying the aquifer and river. Part of their assessment will include the evaluation of river water exchange with the aquifer.

4. Bob Cusimano of EAP's Watershed Ecology Section is conducting a Total Maximum Daily Load (TMDL) study for dissolved oxygen in the Spokane River. Part of the TMDL objectives are to quantify the loading of phosphates to the river from ground water. To support the TMDL project, samples will be collected and analyzed for low-level total phosphorous and orthophosphate. Dissolved oxygen in the ground water will also be measured.

Study Design

The project objectives will be met through a combination of field sampling, ground-water-level measurements, and analyses of ground-water and surface-water quality data.

Water Quality Sampling Surveys

Ground-Water Sampling

Seven sampling events are scheduled for May, June, July, August, September, and October 1999. There will be one sampling event per month except in September or early October, during which two events are planned in response to the Avista Dam water release. Sampling will occur according to the schedule shown in the table below. The twelve ground-water-sampling stations and their locations are presented on Table 1. Sampling site areal distribution is shown on Figure 1.

Surface-Water (Spokane River) Sampling

Ongoing monthly sampling of the Spokane River by the U.S. Geological Survey (USGS), under contract with the Environmental Protection Agency (EPA), will provide the surface-water quality data needed for comparison with the ground-water data collected for this project. The USGS analyses include an extensive list of water-quality constituents that is more than adequate for comparison to the ground-water constituents targeted in this study.

Water-Level Surveys

Ground Water

Water levels will be monitored using pressure transducers and data loggers in all 12 observation/sampling wells (Table 1). The transducers and data loggers have been supplied jointly by Spokane County, USGS, and the Washington Department of Ecology. Water-level measurements via pressure transducers will be made at 1-hour intervals throughout the project. If, for some reason a well cannot be measured with transducers, that well will be measured with an electric sounding tape at the time of sampling. In addition to the transducer water-level readings, depth-to-water will be measured by electric sounder in all observation/sampling wells prior to purging the well for sampling.

Surface Water

River-stage and flow data are being provided by USGS through an on-going river-monitoring project. USGS maintains the Spokane gage, a continuous river-stage recorder, in Spokane at the Maple Street Bridge. This is the primary source of flow data for the river in the Spokane area, and daily "real-time" flow data can be accessed through USGS's Internet Web site. USGS, in cooperation with Spokane Community College (SCC) has recently re-established a continuous gage at the Harvard Street Bridge. SCC also maintains a gage at the Green Street Bridge. Additionally, there is a gage downstream of the Avista (Post Falls) dam, in Idaho, for flow data near the headwaters of the river.

Project Schedule and Lab Budget

The schedule for the Spokane River/Aquifer Interaction Project is as follows:

Organization meeting with John Roland, John Covert, Stan Miller, and Jim Blake, the principle project planners	February 25, 1999
Draft QAPP to Contaminant Studies Unit Supervisor (Dale Norton), Clients (Doug Allen, John Roland, John Covert, Stan Miller, and Jim Blake), QAQC Section, and Manchester Lab for review (See "Project Organization" section)	April 9, 1999
QAPP Revised, as per review comments	May 1999
Sampling Events	May 17 - 20, 1999 June 14 - 20 July 12 - 16 August 16 - 20 September/Early October (2 sampling events, dates are flexible) October 18 - 21 (?)
Interim Project Assessment -- to look at project results to date and determine if the sampling regime should be changed for the controlled hydrologic event (dam release) in the fall.	August 1999
Last Field Sampling Survey	October 1999
Data Report (lab results) Sent to Clients	December 1999
Draft Report to Designated Unit Reviewer and Unit Supervisor	December 1999
Draft Report to Client	January 2000
Final Report	February 2000

The lab budget for the project is presented in Table 2. Total laboratory expenses for the six-month project are projected to be approximately $26,500.

Project Organization

The following individuals and organizations will be involved in the project.

- Department of Ecology, Environmental Assessments Program, Olympia, Washington: **Robert Garrigues** (360) 407-6638, **Denis Erickson** (360) 407-6767, and **Pam Marti** (360) 407-6768, *Hydrogeologists, Contaminant Studies Unit;* **Dale Norton** (360) 407-6765, *Contaminant Studies Unit Supervisor;* **Will Kendra** (360) 407-6698, *Watershed Ecology Section Supervisor*; **Shirley Rollins** (360) 407-6696, *Secretary Senior, Watershed Ecology Section;* **Stuart Magoon** (360) 871-8813, *Manchester Laboratory Director;* **Pam Covey** (360) 871-8827, *Manchester Environmental Laboratory;* and **Cliff Kirchmer** (360) 407-6455 and **Stew Lombard** (360) 895-4649, *Quality Assurance.*

- Department of Ecology, Eastern Regional Office, Spokane Washington: **John Roland** (509) 625-5182, *Hydrogeologist, Toxics Cleanup Program;* **John Covert** (509) 456-6328, *Hydrogeologist, Water Resources Program;* **Kenneth Merrill** (509) 456-6148, *Water Quality Program;* **Doug Allen** (509) 625-5344, *Shoreline and Environmental Assistance Program.*

- Spokane County Utilities Department, Water Quality Management Program, 1026 W. Broadway, Spokane, Washington: **Stan Miller** (509) 456-6024, **Jim Blake** (509) 324-3260, and **Reanette Boese** (509) 324-7678.

- Eastern Washington University Graduate Program, Cheney, Washington: Jeff **Walkley**.

Responsibilities will be divided generally as follows:

Project Lead - **Robert Garrigues.**
May through October Sampling - **Robert Garrigues, Jim Blake, Pam Marti** (as needed), **Reanette Boese** (as needed), **John Roland** (as needed), and **Jeff Walkley** (May & June).
Transducer/data logger maintenance and data downloads - **John Covert, Jim Blake**, and **Reanette Boese.**
Client Contacts - **Kenneth Merrill, Doug Allen, John Covert**, and **John Roland.**
Reviewers of Draft QAPP - **Will Kendra, Dale Norton, Cliff Kirchmer, Stew Lombard, Stuart Magoon, Jim Blake**, and **John Roland.**
Reviewers of Final Report - **Will Kendra, Dale Norton, Denis Erickson, Kenneth Merrill, John Roland, John Covert, Jim Blake**, and **Stan Miller**
Project Coordination - Robert Garrigues and John Roland
Coordination at Manchester Laboratory - **Pam Covey**
Proof reading, editing, and formatting of QAPP and final report - **Shirley Rollins**

Data Quality Objectives

Precision/Bias

The precision and bias routinely achieved by Manchester Lab using the methods described in this QAPP will be satisfactory for purposes of this study. Sources of bias from sampling procedures and sample handling will be minimized by adherence to EPA Method 1669.

Representativeness

In order to obtain representative data, each sampling station will be sampled on seven separate occasions. The sampling events will provide water-quality and water-level data covering river-flow levels and ground-water levels from seasonal highs to lows - including a "high flow" event caused by a controlled release of water from the Avista dam.

Completeness

The amount of usable data obtained will be maximized by careful planning of field work and by following EPA Method 1669 sampling guidance. The laboratory will be asked to save excess sample until the data can be reviewed by the project lead.

Comparability

Sampling, quality assurance, and analytical methods are consistent with other low-level metals work done by EAP.

USGS surface-water quality data is being collected under contract to EPA and the sampling will be consistent with EPA Method 1669 sample guidance. The USGS analyses include an extensive list of water-quality constituents that is more than adequate for comparison to the ground-water constituents targeted in this study.

Ground-water levels are comparable between wells since all wells are being measured by the same method (transducers) and at the same time intervals. River stage is being measured by continuous recorders established by USGS at two essential locations on the Spokane River. These continuous stage measurements, combined with other flow and stage measurement work during the project period, will meet the water level comparability needs of the project.

Sampling Procedures

Each sampling-well site will be described in the field notes and will be photographed, if possible. Sampling methods described in EPA Method 1669 sampling guidance (EPA, 1995) will be used as appropriate for ground-water sampling. Chain of custody will be maintained.

All wells except SVA-1 (Green Acres Landfill) will be purged and sampled using a Grundfos Redi-Flo2 portable submersible pump. Well SVA-1 has a dedicated bladder pump which will be used for sampling at that site. The Grundfos pump will be rinsed between wells with de-ionized water.

Before sampling, we will purge all wells at 2 to 3 gpm until at least three well-volumes have been purged from the casing and until specific conductance, dissolved oxygen (DO), and water temperature stabilize (changes of 10% or less of the mean value of three consecutive measurements). Field measurements of water temperature, pH, specific conductance, and DO will be made and recorded at the place and time of each collected sample. Initially, temperature, conductivity, and DO will be measured by placing the measurement probes in the bottom of a five-gallon plastic bucket along with the outlet of the purge hose. The purge water flows around the probes, without introducing entrained air to the system. This method works well for temperature and conductivity measurements, but is probably less than ideal for DO measurements. Hopefully, EAP will be able to buy a flow-through cell for conducting field measurements by the July or August sampling event to use through the remainder of the project.

Samples will be collected from a sampling "T" at the pump outlet. Dissolved samples will be filtered in the field through a pre-cleaned 0.45 µm Nalgene filter unit (#450-0045, type S). Teflon sample bottles and Nalgene filters will be obtained from Manchester Lab. They are cleaned as described in Kammin et al (1995), and individually sealed in plastic bags. Sample bottles, preservatives, and holding times for each parameter are listed in Table 4. Samples will be preserved as shown on Table 4 and will be kept on ice until analyzed by Manchester Lab. Analytes will be tested using standard methods listed in Table 3.

Nitrile gloves will be worn by all personnel collecting and filtering the samples. Samples will be filtered, transferred to sample bottles, and preserved in the back of the sampling vehicle to minimize chances of contamination from wind-blown contaminants. Sample bottles from each well will be packed in a plastic bag and held on ice for shipping to Manchester Lab. Additionally, each low-level metals sample bottle will be sealed in the original, zip-lock-type, plastic bag in which the cleaned bottle was packed. The double-sealed sample will then be packaged in the plastic bag with the other samples from the well and held on ice. All metals samples will be preserved in the field by adding nitric acid to ≤pH 2. The low-level (ICP/MS) metals (Table 3) will be preserved using high-purity nitric acid supplied by Manchester Lab in specially cleaned Teflon vials. The ICP-scan metals (Table 3) samples will be preserved using commercially available 1 mL nitric acid (70% HNO_3) ampules.

Analytical Methods

Analytical methods and detection or precision limits for field measurements and lab analyses of conventional parameters are listed in Table 3. These standard analytical methods will meet the analytical needs of this project.

Quality Control Procedures

Data quality control for this study is limited to determining the accuracy and precision (bias) of the sampling and laboratory results.

Field QC

Field QC samples will include field duplicates, filter blanks, and field transfer blanks. One field-duplicate ground-water sample will be collected during each sampling event (one field duplicate for 12 sampling sites). Since repeats of "non-detects" do no good from a QC perspective, all field duplicates will be collected from wells where detectable concentrations of the target trace metals are expected. At least one filter blank will be used in the field to test whether there is detectable trace metal contamination of the samples from the filtering process. An attempt will be made to collect one "transfer blank". The blank will be run through the sampling pump, the sample tubing, and the filter in order to simulate the exact process used to collect each sample and test for sample contamination. This process is problematic though, due to the difficulty in obtaining and transporting the large volume (at least 10 gallons) of extra-pure, de-ionized (DI) water necessary to purge the sampling pump and tubing.

Laboratory QC

Manchester laboratory will conduct their routine analytical quality control procedures, which will be sufficient for the needs of this project. These procedures may include, but are not limited to, check standards, duplicates, spikes, and blanks (MEL, 1994, p. 111).

Data Reduction, Review, and Reporting

Manchester Laboratory's standard operating procedures for data reduction, review, and reporting will meet the needs of this project.

The data from the sample sets will be formally transmitted to the ERO client and Spokane County personnel twice during the project. The first transmittal will occur after the July sample results have been received and the second after the final sample-event results have been released by Manchester Laboratory.

All project data produced through Manchester Laboratory will be downloaded to Ecology's Environmental Information Management (EIM) database through Manchester's LIMS system. The project lead will ensure that all data is validated before preparing a final project database. One hundred percent of the data will be reviewed for possible transcription errors, missing data, and improbable values when importing data from Manchester Lab submittals. The precision of the sample results will be estimated by using field duplicate results to calculate the relative percent difference (RPD).

A draft report of the study results will be provided to ERO and Spokane County in December 1999. Principle components of the report will be:

- A map of the study area showing sampling sites.
- Latitude/longitude and other location information for each sampling site.
- Descriptions of field and laboratory methods.
- A discussion of data quality, estimates of precision and bias, and the significance of any problems found in the analyses.
- Summary tables of ground-water quality and water-level data.
- Summary tables of surface-water quality and river stage data.
- An evaluation of significant findings with respect to: comparisons of ground-water-quality data between stations; comparisons of ground-water and USGS surface-water quality data; comparisons of ground-water level data and USGS river-stage data; and additional data interpretation as appropriate.
- Recommendations for follow-up work, if warranted.
- The complete physical and chemical data as appendices.

A final report will be prepared after receiving review comments from ERO, and Spokane County, plus internal comments from EAP. The goal is to have the revised final report published in February 2000.

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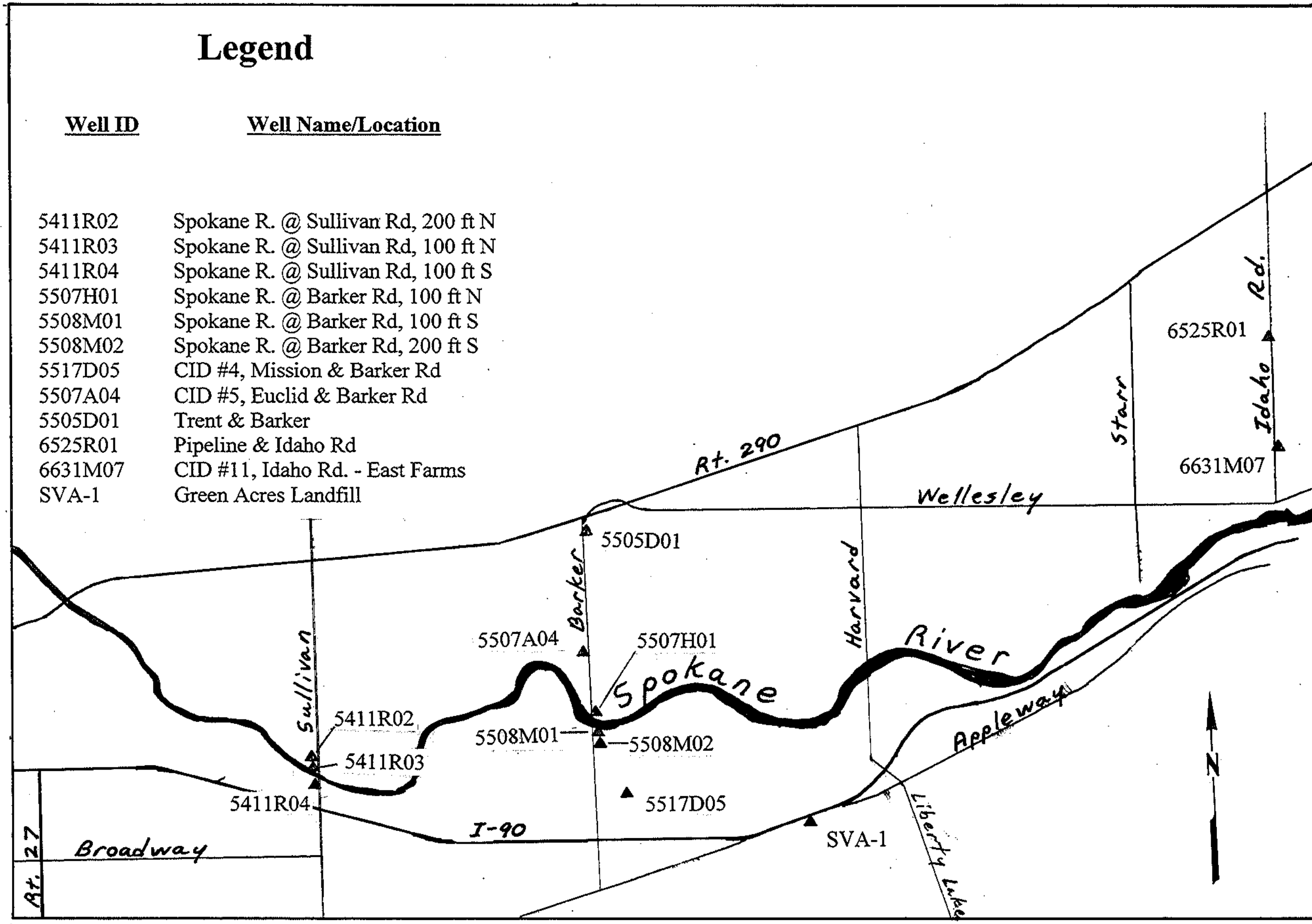

Figure 1
Spokane Aquifer Monitoring Well Locations

Table 1. Sample stations, Spokane Aquifer.

Site ID	Owner/Well Name	Location	Screened Interval (ft below LSD)	Depth to Water (avg)
5411R02	Spokane R. @ Sullivan Rd, 200 ft N	25N/44E-11R02	26.2-66.2	30
5411R03	Spokane R. @ Sullivan Rd, 100 ft N	25N/44E-11R03	?	29
5411R04	Spokane R. @ Sullivan Rd, 100 ft S	25N/44E-11R04	47.8-87.8	51
5507H01	Spokane R. @ Barker Rd, 100 ft N	25N/45E-07H01	39.5-79.5	47
5508M01	Spokane R. @ Barker Rd, 100 ft S	25N/45E-08M01	?	66
5508M02	Spokane R. @ Barker Rd, 200 ft S	25N/45E-08M02	63.3-98.5	66
5517D05	CID #4, Mission & Barker Rd	25N/45E-17D05	85.2-115.2	81
5507A04	CID #5, Euclid & Barker Rd	25N/45E-07A04	69.5-99.5	70
5505D01	Trent & Barker	25N/45E-05D01	87-127	91
6525R01	Pipeline & Idaho Rd	26N/45E-25R01	97-142	101
6631M07	CID #11, Idaho Rd. - East Farms	26N/45E-31M07	112-147	115
SVA-1	Green Acres Landfill	25N/45E-16??	114-124	86 - 104

Note: All wells listed will be used both as water level monitoring stations (using transducers and data loggers) and water quality sampling stations.

Table 2. Sampling schedule, lab use, and cost predictions: Spokane River – Spokane/Rathdrum Prairie Aquifer Project, May and June 1999

Sampling Dates	Parameter	Cost/sample	# of samples (incl. QA/QC)	# of Sampling Events	Subtotal
May 17-20 and June 14-17, 1999					
	alkalinity	$ 14.00	13	2	$ 364.00
	chloride	$ 12.00	13	2	$ 312.00
	nitrate + nitrite	$ 12.00	13	2	$ 312.00
	TDS	$ 10.00	13	2	$ 260.00
	sulfate	$ 12.00	13	2	$ 312.00
	calcium	$ 14.00	13	2	$ 364.00
	magnesium	$ 14.00	13	2	$ 364.00
	potassium	$ 14.00	13	2	$ 364.00
	sodium	$ 14.00	13	2	$ 364.00
	silica	$ 14.00	13	2	$ 364.00
	iron	$ 14.00	13	2	$ 364.00
	cadmium	$ 34.00	13	2	$ 884.00
	lead	$ 34.00	13	2	$ 884.00
	zinc	$ 34.00	13	2	$ 884.00
	Metals clean-room fee	$ 42.00	13	2	$ 1,092.00
					$ 7,488.00
	Subtotal Cost: May and June, 1999				**$ 7,488.00**

Table 2 (cont). Sampling schedule, lab use, and cost predictions: Spokane River – Spokane/Rathdrum Prairie Aquifer Project, July through October 1999.

Month/Year	Parameter	Cost/sample	# of samples (incl. QA/QC)	# of Sampling Events	Subtotal
July 12-16, Aug 16-20, Sept ?, & Oct ? 1999					
	alkalinity	$ 14.00	13	5	$ 910.00
	chloride	$ 12.00	13	5	$ 780.00
	nitrate + nitrite	$ 12.00	13	5	$ 780.00
	TDS	$ 10.00	13	5	$ 650.00
	sulfate	$ 12.00	13	5	$ 780.00
	calcium	$ 14.00	13	5	$ 910.00
	magnesium	$ 14.00	13	5	$ 910.00
	potassium	$ 14.00	13	5	$ 910.00
	sodium	$ 14.00	13	5	$ 910.00
	silica	$ 14.00	13	5	$ 910.00
	iron	$ 14.00	13	5	$ 910.00
	cadmium	$ 34.00	13	5	$ 2,210.00
	lead	$ 34.00	13	5	$ 2,210.00
	zinc	$ 34.00	13	5	$ 2,210.00
	Metals clean-room fee	$ 42.00	13	5	$ 2,730.00
					$ 18,720.00
	Subtotal Cost: July - Oct., 1999				**$ 18,720.00**

Table 3. Summary of Field and Laboratory Measurements, Target Detection Limits, and Methods.

Parameter	Target Detection Limit	Method
Field Measurements		
Conductivity	± 2% of reading, in µmhos/cm	YSI T-L-C 3000 Meter[1]
pH	± 0.1 standard units	Orion 25A Field Meter[1]
Temperature	± 0.1°C	YSI T-L-C 3000 Meter[1]
Dissolved Oxygen (DO)	± 0.2 mg/L	YSI Model 57
Turbidity	± 0.1 NTU	HF Scientific DRT 15C
Laboratory Analyses		
Alkalinity	1 mg/L	EPA 310.1
Chloride	0.1 mg/L	EPA 300.0
Nitrate + Nitrite	0.01 mg/L	EPA 353.2
TDS	1 mg/L	EPA 160.1
Sulfate	0.5 mg/L	EPA 300.0
Calcium	25 µg/L	ICAP[2] (EPA 200.7)
Potassium	400 µg/L	ICAP[2] (EPA 200.7)
Magnesium	25 µg/L	ICAP[2] (EPA 200.7)
Sodium	25 µg/L	ICAP[2] (EPA 200.7)
Silica	20 µg/L	ICAP[2] (EPA 200.7)
Iron	20 µg/L	ICAP[2] (EPA 200.7)
Cadmium	0.02 µg/L	ICP/MS[3] (EPA 200.8)
Lead	0.02 µg/L	ICP/MS[3] (EPA 200.8)
Zinc	0.5 µg/L	ICP/MS[3] (EPA 200.8)
Total Phosphorous (low-level)	0.01 µg/L	EPA 365.3
Orthophosphate (low-level)	0.01 µg/L	EPA 365.3

[1] Operated in accordance with operators manual or WAS (1993).
[2] Inductively Coupled Argon Plasma method (MEL, 1994, p. 201).
[3] Inductively Coupled Plasma Mass Spectrometry method (MEL, 1994, p. 201).

Table 4. Sample containers, preservatives, and holding times.

Parameter	Holding Time	Bottle Index No.	Bottle type	Preservative
Alkalinity	14 days	22	500 ml w/m poly	
Chloride	28 days	22	500 ml w/m poly	On ice
Sulfate	28 days	22	500 ml w/m poly	
Nitrate + Nitrite	28 days	19	125 ml clear w/m poly, pre-preserved	H_2SO_4 to pH <2, On ice
TDS	7 days	23	1000 ml w/m poly	On ice
Calcium	6 months	16	1 L HDPE bottle	
Iron	6 months	16	1 L HDPE bottle	
Magnesium	6 months	16	1 L HDPE bottle	
Potassium	6 months	16	1 L HDPE bottle	Filter in field then HNO_3 to pH <2, store on ice
Silica	6 months	16	1 L HDPE bottle	
Sodium	6 months	16	1 L HDPE bottle	
Cadmium	6 months	S.O.[1]	500 ml teflon FEP bottle	
Lead	6 months	S.O.[1]	500 ml teflon FEP bottle	Filter in field then HNO_3 to pH <2, store on ice
Zinc	6 months	S.O.[1]	500 ml teflon FEP bottle	
Total Phosphorus (dissolved, low level)	28 days	22	New 500 ml w/m poly, pre-preserved	On ice @ 4° C
Orthophosphate, low-level	48 hours	20	125 ml amber w/m poly	Filter in field, store on ice, ship by air to lab

[1] Special order bottles