Spokane River TMDL Collaboration

Monitoring Workgroup Draft Report

November 22, 2005

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Introduction

The Spokane River TMDL Collaboration aims to develop an Implementation Plan to significantly improve water quality in the Spokane River. Discussions point toward a strategy that will employ not only major improvement in point source discharge treatment technology, but also efforts to reduce non-point source pollution, reduce point source influent through water conservation, divert treated water discharge to re-use applications, and possibly employ river aeration. Such a strategy could take 10 to 20 years to implement. Measurement of results and documentation of the impact of various water quality improvement actions is critical to assuring the success of a TMDL Implementation Plan since success will likely be the sum of many small pollutant reductions that achieve the goal of improved water quality.

The Collaboration's Full Group formed a special purpose task force called the Monitoring Workgroup; this is the preliminary draft report of that Workgroup meant to provide a basis for discussion. The Monitoring Work Group is charged with devising an outline of a multi-year, on-going Spokane River monitoring effort that provides a continuous flow of good-quality data and analysis that guides the TMDL Implementation Plan. This document should be considered the first edition of this outline so that the Full Group can have a basis for discussion about whatever monitoring program it decides to include in the Implementation Plan.

The Workgroup focused on several areas and divided their information-gathering and report into four sections: Monitoring Principles and Management, Current Monitoring Programs, Core TMDL Implementation Monitoring Program, and Special Studies. In addition the past monitoring and sampling activities undertaken in the Hangman Creek and Little Spokane River watersheds are detailed in Appendix C.

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I. Monitoring Principles and Management

Continuity and consistency are two important and fundamental "principles" to appropriately construct and operate a long-term Spokane River Collaboration Monitoring Program. The Program, built on existing river monitoring efforts, is expected to be continuous throughout the estimated 20-year term of the Spokane River Collaboration's implementation of strategies to meet the TMDL regulation.

Data

Monitoring activities should include both "effectiveness" monitoring of specific actions (such as site-specific non-point efforts) and "trend analysis" to answer the global question "What is the Health of the River?" Different standards for data might be applied in different circumstances. The Monitoring Workgroup recommends generally uniform standards for data quality with the full understanding that this may likely cost more. The utility of being able to use the same good data for a variety of purposes, including modeling, outweighs the extra cost and serves to enhance the credibility of the overall monitoring effort which will guide or influence many significant, high value decisions. Similarly, uniform quality assurance/quality control methods are recommended whenever practical.

Management

The Monitoring Workgroup recommends that one well-qualified and experienced manager be hired by the Spokane River Collaboration Full Group to manage the on-going Spokane River Collaboration Monitoring Program. Administratively, the Monitoring Workgroup recommends the manager be housed in the Department of Ecology Spokane Regional Office. Ecology would be responsible for using standard government methods to pay the manager, handle monitoring funds and provide an administrative structure for the selection of contractors and management of contracts. Alternatively, the manager could be attached to the City of Spokane or Spokane County.

The manager should receive program guidance, including the prioritization of study efforts, the selection and scaling of effectiveness monitoring activities, budget development and approval, and the periodic reporting of all monitoring data and modeling information, from a designated sub-group of the existing Full Group or its long-term successor. The manager would be available to present information to all Spokane River Collaboration participants and the public and would be responsible for assuring the monitoring, study and modeling aims and interests of the collective Full Group are timely met within budget limits.

Further, the manager would establish and enforce the Spokane River Collaboration Monitoring Program's standards, QA/QC methods, and monitoring protocols. The manager would also coordinate the running of the Spokane River model to assure its currency and efficient use. The manager, as advised by his/her Collaboration sub-group advisory group, would coordinate with both Washington and Idaho State environmental officials and the Environmental Protection Administration.

Budget

Based on very preliminary assessment, the Monitoring Workgroup suggests that this manager would need an annual budget of about $250,000 to support the Collaboration Monitoring Program basic trend analysis effort. Larger effectiveness monitoring actions, specific biological, hydrological or other types of studies, and model upgrades are not included in this estimate.

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II. Current Monitoring Programs

One of the needs for a TMDL monitoring program is to avoid duplication of effort. In order to facilitate development of an ongoing program of monitoring for TMDL implementation, the Monitoring Workgroup investigated existing monitoring efforts on the Spokane River. These existing monitoring programs are summarized in Table 1.

Table 1. Summary of Current Monitoring Programs

	Parameters	Sites	Frequency	Notes
Spokane County Groundwater	Drinking water inorganics – metals, VOC's	45 – 50 25 monitoring wells, 2 nested sites	Quarterly	
C d'A Basin Environmental Monitoring	Nutrients, general inorganics, metals	Coeur d'Alene Lake outlet	8 times per year	Sampling targets outlet conditions rather then exact dates
Coeur d'Alene Lake Monitoring	Nutrients, general inorganics, metals	Spokane River at Outlet, near Post Falls, at Stateline	Quarterly	Part of USGS C d'A lake monitoring: ends fall 2006
Ecology Freshwater Monitoring	Nutrients[a], general inorganics[b], fecal coliform	Spokane River at State Line, Bowl and Pitcher, Hangman and Little Spokane	Monthly	
Avista FERC License	To be determined	To be determined	To be determined	Avista is willing to coordinate with the TMDL Implementation effort to avoid duplication of effort.
Discharger Compliance Monitoring	See attached for selected dischargers	Coeur d'Alene City of Spokane		

[a] = ammonia, nitrate plus nitrite, total phosphorus, soluble reactive phosphorus, total nitrogen
[b] = conductivity, oxygen, pH, suspended solids, temperature, turbidity

Spokane County Groundwater Monitoring

Spokane County Monitors quarterly 45 – 55 wells that draw water from the Spokane Valley Aquifer as part of a Coordinated Monitoring Program. Under this Program, Spokane County collects and has samples analyzed for drinking water compliance for cooperating water purveyors. This cooperation provides support for collecting samples for the County's monitoring of 25 specially installed Wellhead Protection "early warning" wells. In addition to the 25 dedicated monitoring well sites, samples are collected from 20 to 30 water supply wells. Except for about 10 water supply wells with an extensive monitoring history, the water supply wells sampled vary depending on the cooperating purveyors compliance needs. Locations for the "permanent" sampling sites are shown on the map in Appendix A. Several of the dedicated monitoring wells are located near the river in losing (Barker Road) and gaining (Sullivan Road) reaches. The variable sample locations are selected from the more than 100 public water supply well fields drawing water from the Spokane Valley Aquifer.

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Appendix B includes a list of parameters analyzed. Due to cost considerations field duplicates are collected infrequently. However, extensive laboratory QA/QC measures are followed. These include laboratory duplicates and blanks and spiked sample analysis.

Laboratory costs for this program range from $40,000 to $50,000 per year depending on the number and type of drinking water compliance samples collected. Sample collection requires 2 people for 3 days each quarter for a total of 24 worker days per year. An additional worker day per quarter is needed for preparation of equipment obtaining sample bottles and labeling. This brings the total staff time to 28 worker days per year. Data management is not included in the above estimates.

This program is funded by a combination of Water Purveyor contributions and Aquifer Protection Area funding. The shrinking APA funding due to changes in the District boundaries last year put the APA portion of this package on shaky ground. The program is needed to document water quality changes brought about by septic tank elimination so it will remain in some form through the duration of the STEP program, but maintaining the current level of effort may require lobbying.

Coeur d'Alene Basin Environmental Monitoring Program

The BEMP program only runs the lake outlet station at Coeur d'Alene. Other funding gives the discharge record just below Post Falls Dam (Spokane River near Post Falls gage at McGuire Park). EPA has just approved funding to install an Acoustic Doppler Velocity Meter station with optical backscatter (for computation of sediment transport) and real-time data transmission at the lake outlet station. That should be fully operational by this summer (2006).

BEMP sampling at the lake outlet occurs eight times per year. The sampling frequency is not fixed; the program is after description of the important features of the hydrograph in relation to lake elevation changes, i.e., stable pool in winter and summer, filling and drawdown transient conditions, and (if lucky) migration of extreme event inflow plumes through the lake.

Samples are collected for analysis of dissolved and total Cd, Pb, Zn, Fe, and Mn along with hardness. Nutrients include dissolved ammonia, nitrite+nitrate, ortho-P, and P as well as total P and N. Suspended-sediment concentration is also determined.

Coeur d'Alene Lake Monitoring Program

The Coeur d'Alene Lake monitoring program was established as part of the "outside the box" clean up effort. The primary goal of this monitoring effort is to identify recent trends in Lake quality to help craft an updated Lake Management Plan. An update of the Lake Management Plan approved by both the U.S. Geological Survey and the Coeur d'Alene Tribe is one of the prerequisites for "delisting" the Lake from Superfund designation. The Lake Monitoring Program expands the Basin Environmental Monitoring Program by adding several lake sampling sites and a Stateline site on the Spokane River. The sampling frequency and parameters covered are the same as for the Basin Environmental Monitoring program. Only the Stateline station would be of value to a river-monitoring network.

The Lake Monitoring Program was funded as part of the EPA grant to the state of Idaho dedicated to funding planning and clean up efforts outside the 21 square mile Bunker Hill site Superfund site. Funding was limited to three years and monitoring will be finalized in 2006.

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Ecology Freshwater Monitoring Program

The Washington State Department of Ecology (Ecology) has conducted monthly water quality monitoring at hundreds of stream stations throughout the state for nearly 50 years. The Freshwater Monitoring Unit (FMU) has active ambient monitoring stations on the Spokane River at the Stateline with Idaho (station number 57A150), at Riverside State Park (54A120), near the mouth of Hangman Creek (56A070), and near the mouth of the Little Spokane River (55B070). All of these stations have been sampled regularly for greater than 10 years. FMU collects samples monthly by water year (October through September).

Measured indicators of water quality include the following:

- ammonia
- conductivity
- fecal coliform bacteria
- flow (at most stations)
- nitrate plus nitrite
- nitrogen, total
- oxygen
- pH
- phosphorus, soluble reactive
- phosphorus, total
- suspended solids
- temperature
- turbidity

FMU occasionally samples other constituents, as well, to meet special needs.

A detailed explanation of our stream monitoring program along with specific methods and quality control procedures may be found in our annual reports (e.g., Hallock 2003a) and Quality Assurance Monitoring Plan (Hallock 2003b), as well as on the World Wide Web (http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

Hallock, D. 2003a. *River and Stream Ambient Monitoring Report for Water Year 2002*. Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 03-03-032, 17 pp. + appendices.

Hallock, D. 2003b. *Quality Assurance Monitoring Plan*. Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 03-03-200, 28 pp.

Avista

Currently Avista is undergoing relicensing for its Spokane River Hydroelectric Project. Currently defined water quality problems associated directly with the project are limited to Total Dissolved Gas below the spillways at Post Falls and the Long Lake installations. Additional parameters for study may be identified as the 401 certification by the States of Washington and Idaho progresses. Avista is willing to participate as cooperator in any monitoring effort that evolves out of the TMDL work that will help them satisfy their license requirements.

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Little Spokane River

The Pend Orielle Conservation District conducted monitoring of five sites on the Little Spokane River and one site on the West Branch of the Little Spokane River from October 1998 through September 1999. Samples were collected monthly and were scheduled to correspond with monthly sampling performed by Ecology Environmental Assessment Program staff at four additional Little Spokane River sites.

The primary water quality component of this project was intended to evaluate possible nitrate/nitrite inputs from recent housing developments on Deadman and Little Deep Creeks. Monthly sampling began in January of 2001 above and below the developments. Deadman Creek was sampled at Bruce Road and Shady Slope Road. Little Deep Creek was sampled at Colbert Road and Little Spokane Drive. The monthly downstream water quality samples were inconclusive because springs immediately upstream of the Shady Slope Road sample site were found to have significantly high nitrate levels

The site near the confluence with the Spokane River (Rutter Parkway Bridge) is part of the Department of Ecology Freshwater Monitoring Program.

Latah (Hangman) Creek

Beginning in 1968 the USGS periodically sampled Latah Creek at State Line and Spokane River confluence stations.

The Spokane County Conservation District began extensive water quality sampling in the Hangman Creek watershed in 1994. In 1994, the SCCD completed a watershed management plan for Hangman Creek that has guided SCCD water quality sampling programs. Recently the SCCD expanded the program to include water quality sampling to evaluate the ground water/surface water interactions along the main stem.

The site near the confluence with the Spokane River (Marne Bridge) is part of the monthly Department of Ecology Freshwater Monitoring Program. Additional Details of this effort are included in Attachment C.

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Discharger Monitoring Summary

The following summarizes the discharge monitoring requirements of some of the current discharges in comparison with the proposed "core" monitoring parameters.

Discharger: City of Coeur d'Alene			
Core Parameter	Sampled	Frequency	Sample Type
Ammonia	Yes	1 - 2 / week	24 hr Composite
BOD5	Yes	3 / week	24 hr Composite
CBODU**	No		
Conductivity			
Dissolved Oxygen			
flow	Yes	Continuous	Recorder
nitrogen, total			
nitrate plus nitrite			
pH	Yes	Daily	Grab
phosphorus, total	Yes	3 / week	24 hr Composite
phosphorus, soluble reactive,			
suspended solids	Yes	3 / week	24 hr Composite
temperature	Yes	7 / week	Grab

Discharger: City of Spokane			
Parameter	Sampled	Frequency	Sample Method
Ammonia	Yes	7 / week	24 hr Composite
BOD5	Yes	7 / week	24 hr Composite
CBODU**	No		
Conductivity	No		
Dissolved Oxygen	Yes	7 / week	Grab
flow	Yes	Continuous	Recorder
nitrogen, total	No		
nitrate plus nitrite	Yes	1 / week	24 hr Composite
pH	Yes	Continuous	Recorder
phosphorus, total	Yes	7 / week	24 hr Composite
phosphorus, soluble reactive,	Yes	7 / week	24 hr Composite
suspended solids	Yes	7 / week	24 hr Composite
temperature	Yes	7 / week	Grab

Discharger: Liberty Lake Wastewater Treatment Facility			
Core Parameter	Sampled	Frequency	Sample Type
Ammonia	yes	1 every 2 weeks	Composite
BOD5	yes	1 / week	Composite
CBODU**	no		
Conductivity	no		
Dissolved Oxygen	yes	daily	Grab
flow	yes	continuous	
nitrogen, total	no		
nitrate plus nitrite	no		
pH	yes	2/day	Grab
phosphorus, total	yes	1/week	Composite
phosphorus, soluble reactive,	no		
suspended solids	yes	4/week	Composite
temperature	yes	daily	Grab

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III. Core TMDL Implementation Monitoring Program

Introduction

The Spokane River TMDL Collaboration Monitoring Workgroup is proposing that the Spokane River TMDL implementation plan include a "core" water quality monitoring program. The goal of the core monitoring program is to assess current conditions and trends in water quality as improvements in wastewater treatment and mitigation of nonpoint sources occur over time. The following is a brief description of the monitoring plan.

Core Monitoring Program

The monitoring program will be composed of existing point source permit required effluent monitoring and both existing and new river and tributary sampling station monitoring.

Currently, Ecology's Freshwater Monitoring Unit (FMU) has active ambient monitoring stations on the Spokane River (see Figure 1) at the Stateline with Idaho (station number 57A150 at river mile - RM 96.0), at Riverside State Park (54A120 at RM 66.0), near the mouth of Hangman Creek (56A070 at RM 72.4), and near the mouth of the Little Spokane River (55B070 at RM 56.4). All of these stations have been sampled regularly for greater than 10 years and will continue to be included in the "core" monitoring plan for TMDL implementation. In addition, we are proposing to add monitoring stations in ID at the outlet of Lake Coeur d'Alene (RM 111.7) and just downstream of Post Falls Dam (RM 100.1) and in WA at Barker Road Bridge (90.4), Monroe Street Bridge (RM 73.1), Ninemile Bridge RM 58.1), and just downstream of the Lake Spokane Dam (RM 32.2). [Note: River Miles are approximate.]

All permitted point sources are currently required to monitor some water quality parameters. In order to better assess the water quality conditions and trends in the river, we recommend that their permits included daily or at a minimum weekly monitoring of the following parameters during March through October:

- ammonia
- CBODU*
- BOD5
- conductivity
- flow
- nitrate plus nitrite
- nitrogen, total
- oxygen
- pH
- phosphorus, soluble reactive
- phosphorus, total
- suspended solids
- temperature

* CBODU collected every other month April through October (i.e., 4 times per season)

River and tributary samples will be collected monthly by water year (October through September).

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Measured indicators of water quality will include the following:

- ammonia
- CBODU*
- conductivity
- carbon (total and dissolved)
- flow
- nitrate plus nitrite
- nitrogen, total
- oxygen
- pH
- phosphorus, soluble reactive
- phosphorus, total
- suspended solids
- temperature

*CBODU collected every other month April through October (i.e., 4 times per season)

Ecology's sampling methods and quality control procedures will be followed (Hallock 2003b). A detailed explanation of Ecology's stream monitoring program along with specific methods and quality control procedures can be found on the World Wide Web at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html.

Hallock, D. 2003b. *Quality Assurance Monitoring Plan*. Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 03-03-200, 28 pp.

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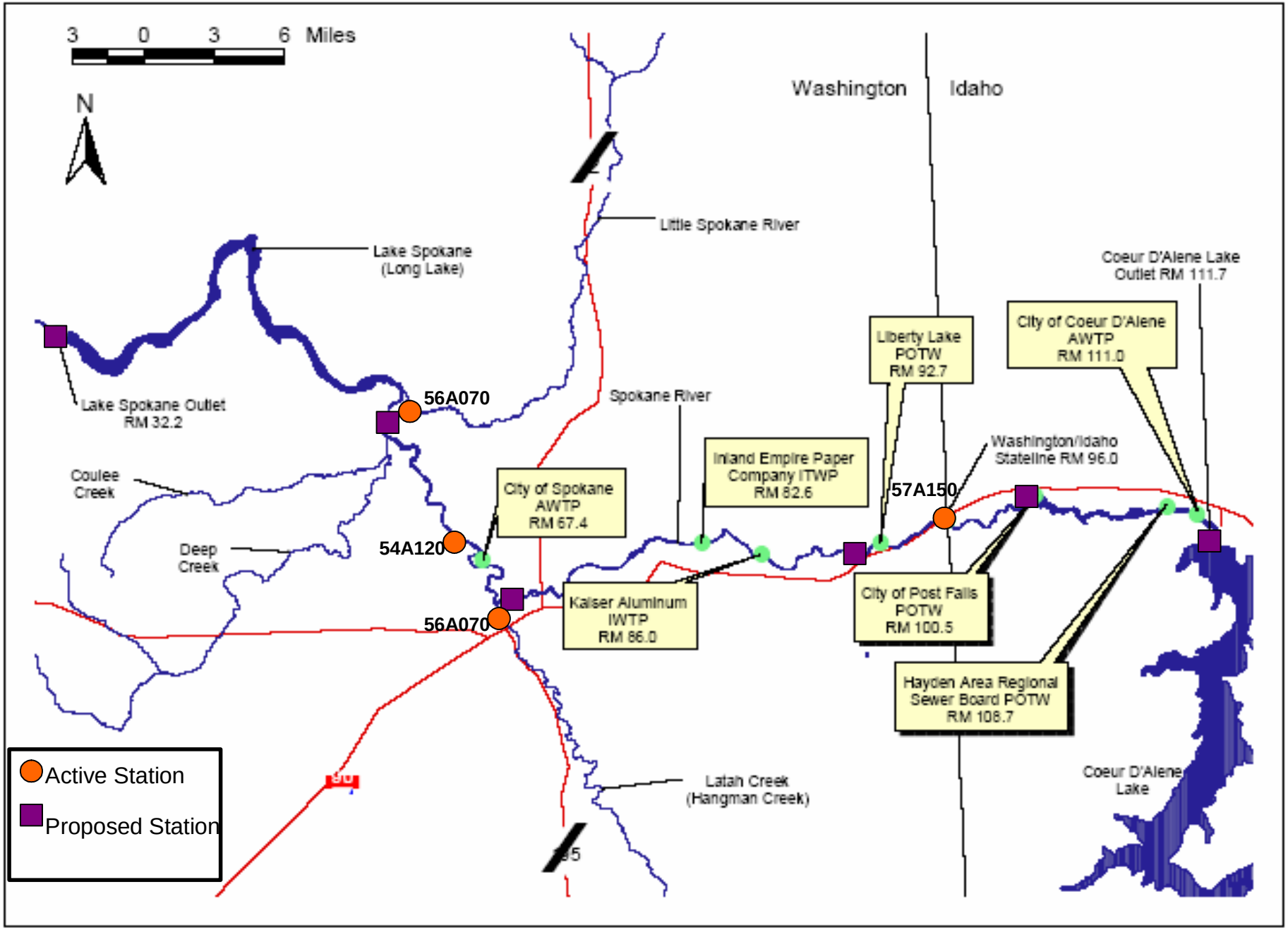

Figure 1. Ecology's active Spokane River ambient monitoring stations and proposed new station locations.

IV. Summary of Special Studies

At its first meeting the Monitoring Workgroup identified several areas that may need additional data and thus fit into the category of "special study." The results of the various modeling scenarios will be a key factor in determining whether additional data is needed. Potential areas of study include:

- Determining the impact of aerobic phosphorus release from sediment on algal productivity,
- Refining the estimates of sediment oxygen demand (SOD) of Lake Spokane,
- Evaluating the phosphorus load from stormwater runoff and combined sewer overflows,
- Refining estimates of parameters used to predict dissolved oxygen concentrations within the Spokane River,
- Developing an improved understanding of ground water contribution of phosphorus and,
- Conducting an evaluation of meteorological conditions on Lake Spokane.

Recent discussions have raised concerns about the potential causes of high algal productivity in the upstream end of Lake Spokane and how the CE QUAL W2 model is representing them.. One potential source of phosphorus not included in the model could be the aerobic release of phosphorus from lake bottom sediment. An evaluation of the aerobic release rate of phosphorus from the sediment would help determine the importance of this mechanism as a source of phosphorus for algal growth and subsequently a source of BOD.

Sediment oxygen demand is a required input of the CE QUAL W2 model. The current calibration was accomplished by back calculating SOD and did not use site-specific SOD data. This is viewed by many as a short-fall of the model. However, the model developers believe it is the most accurate way of setting SOD values for a within year or season calibration in order to use the model to predict the impacts of pollutants for the critical period. Site-specific evaluation of SOD in Lake Spokane may provide some insight into the assumed SOD values and the potential for recovery as pollutants are reduced.

As point source loads of phosphorus are better controlled non-point sources become a more significant fraction of the remaining phosphorus load. Given the limited data for phosphorus concentrations in forms of concern in direct storm water and combined sewer overflow discharges, an effort to increase the knowledge of the loading accounted for by storm water and CSO sources.

The current model over-predicts the dissolved oxygen concentrations between river miles 60 and 75 in the vicinity of the City of Spokane. Data from downstream of the Spokane advanced wastewater treatment plant (AWTP) show that the period when the model over-predicts oxygen concentrations correlates with a period when the nitrate and ammonium loads from the AWTP had increased. This suggests that the model predictions for dissolved oxygen in the river may not be as sensitive to nitrate and ammonium loads as the true system. One explanation for this lack of sensitivity is that the parameters used to simulate the sensitivity of algal growth to nutrients need adjustments. Additional data and studies would be required to further refine these parameters.

Recent work by the USGS indicates that during summer low flow periods over half of the Spokane River stream flow entering Lake Spokane originated in from the Spokane Valley Aquifer. Consequently, groundwater phosphorus comprises a significant fraction of the summer time phosphorus load into Lake Spokane. The importance of ground water phosphorus not withstanding the model does not rely on specific phosphorus data for ground water; it uses an "average" value

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based on aquifer wide historic data. A study of ground water phosphorus would provide more precise phosphorus input for the model. However, because of the chemical equilibrium changes as groundwater moves to the river it also will be important to conduct surface water surveys upstream and downstream of the major groundwater input zones.

Wind velocity over the surface of Lake Spokane is a factor in the CE QUAL W2 that may impact model results. Calibration runs of the model rely on limited meteorological data. While long term weather data collected at stations around Lake Spokane would provide the best resolution of this data shortage, short-term studies of wind velocity and direction performed over one or two seasons would greatly improve the data base.

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Appendix A: Physical and Inorganic Analytical Parameters—Spokane County Coordinated Monitoring Program

Analyte	EPA Method	Reporting Limit
Arsenic	200.8	0.00100 mg/L
Cadmium	200.8	0.00100 mg/L
Calcium	200.7	0.250 mg/L
Chloride	300.0	0.400 mg/L
Chromium	200.8	0.00100 mg/L
Copper	200.8	0.00100 mg/L
Fluoride	340.2	0.100 mg/L
Iron	200.7	0.150 mg/L
Lead	200.8	0.00100 mg/L
Magnesium	200.7	0.500 mg/L
Manganese	200.8	0.00100 mg/L
Mercury	245.1	0.00100 mg/L
Ortho-phosphate phosphorous	365.2	0.00200 mg/L
Potassium	200.7	2.00 mg/L
Sodium	200.7	0.250 mg/L
Sulfate	300.0	0.800 mg/L
Total Dissolved Solids	160.1	10 mg/L
Total Nitrate+Nitrite	353.2	0.010 mg/L as N
Total Phosphorus	365.2	0.00500 mg/L
Zinc	200.8	0.0100 mg/L
Temperature		
Specific Conductance		
pH		

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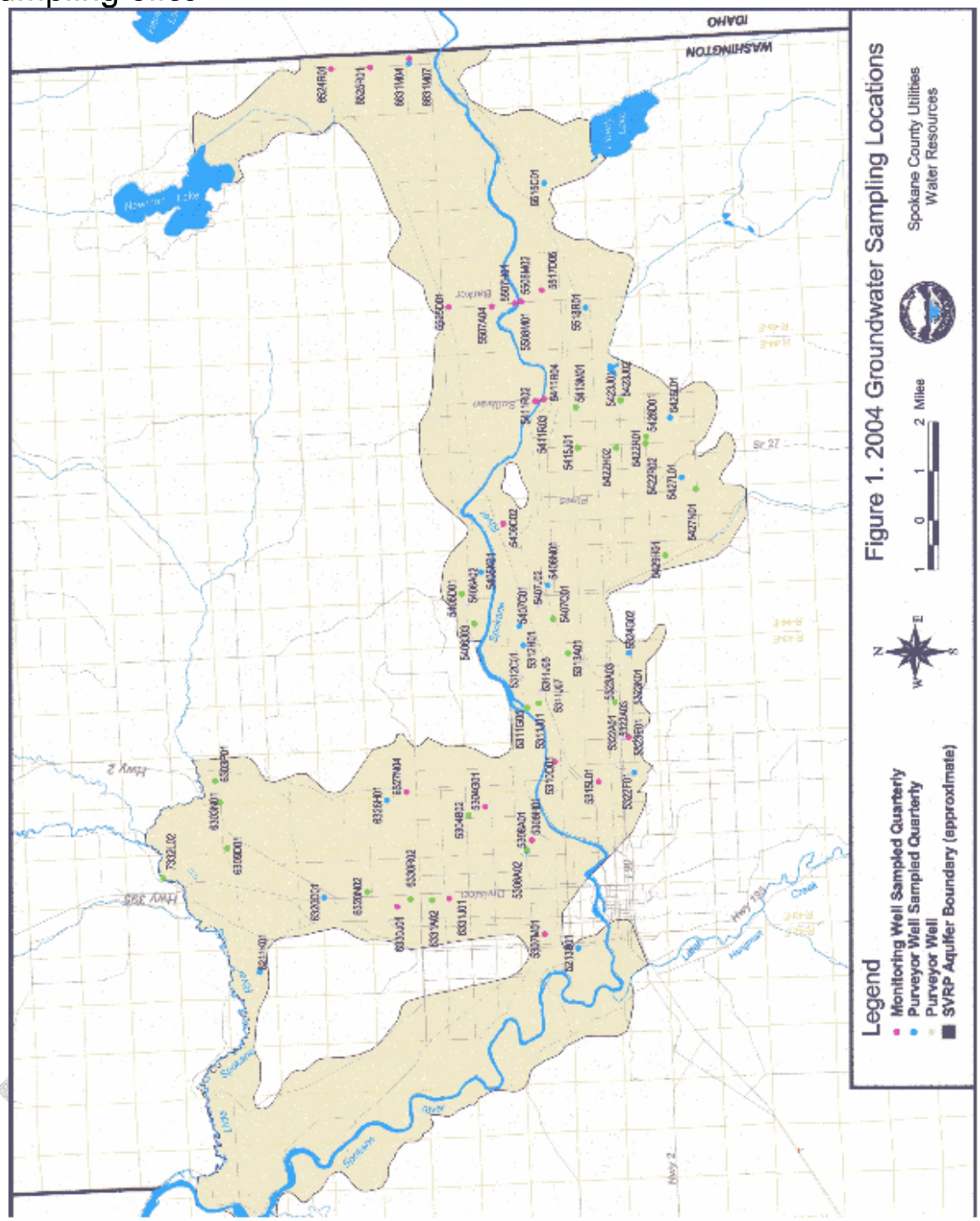
Appendix B: Spokane County Coordinated Monitoring Program Sampling Sites



Appendix C: Summary of Hangman and Little Spokane Watershed Water Quality Sampling

Summary of Hangman Watershed Water Quality Sampling

Water quality sampling has been conducted by several agencies to evaluate Hangman Creek.

United States Geological Survey

The USGS has collected miscellaneous surface water quality samples at two areas, one near the mouth of Hangman Creek and the second at a station near the Stateline. Along with the miscellaneous surface water samples, the USGS has collected sediment samples, ground water samples, and suspended sediments at the gage near the mouth (Station 12424000). The suspended sediment results are published in the USGS annual Water Resources Data for Washington reports. The other miscellaneous sampling results are available from the USGS web site: http://waterdata.usgs.gov/wa/nwis/qwdata.

The Hangman Creek water samples from near Tensed, Idaho, were collected from September 1976 through May 1989. The samples were field data that consisted of air and water temperature and conductivity. Of the 35 samples collected, eight exceeded the Ecology standard of 18 °C, with the maximum value at 27.0 °C on August 10, 1981.

Hangman Creek near Station 12424000 was sampled at three different locations, Hangman Creek near Spokane, WA; Hangman Creek at Spokane, WA; and Hangman Creek at mouth at Spokane, WA. Hangman Creek near Spokane had two samples collected from February 1968 through June 1968. Hangman Creek at Spokane had 18 samples collected from April 1977 through August 2000. Hangman Creek at mouth at Spokane had 108 samples collected from October 1972 through October 1980. Not all parameters were analyzed for every sample.

The USGS grouped their samples into the following categories (1968 through 2000):

- Information – agency and laboratory codes
- Biological – bacteria and other biological samples
- Nutrients – ammonia, phosphate, etc.
- Organic – generally pesticides and fertilizers
- Major inorganics – Ca^{2+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, K^{+}, Na^{+}, HCO_3^{-}
- Minor and trace inorganics – mostly trace metals, etc.
- Physical property – temperature, conductivity, DO, etc.
- Radiochemicals - radioruthenium
- Sediment - turbidity

The number of samples for each of the parameter groups varies along with the number of parameters analyzed (Table 1). For all surface water samples, four parameters exceeded Washington State water quality standards; temperature (27 exceedances), pH (14 exceedances), turbidity (14 exceedances), and dissolved oxygen (two exceedances).

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Table 1: Parameter Group Summary of USGS Data near the Mouth

Parameter Group	First Date	Last Date	Number of Samples			Number of Values		
			HCA	HCN	HCM	HCA	HCN	HCM
Information	10-10-78	8-30-00	17	NR	32	117	NR	63
Biological	10-10-72	4-3-00	NR	NR	33	NR	NR	64
Nutrients	2-20-68	4-3-00	11	2	91	55	2	695
Organic	10-10-72	4-3-00	NR	NR	22	NR	NR	22
Major inorganics	2-20-68	4-3-00	10	2	36	62	24	215
Trace inorganics	2-20-68	4-3-00	10	2	5	95	4	176
Physical Property	2-20-68	8-30-00	18	2	108	123	19	782
Radiochemicals	9-23-80	9-23-80	NR	NR	1	NR	NR	1
Sediment	5-19-80	9-23-80	NR	NR	10	NR	NR	46

Notes:
1. HCA is USGS sample site 12424000, Hangman Creek at Spokane, WA.
2. HCN is USGS sample site 12423980, Hangman Creek near Spokane, WA.
3. HCM is USGS sample site 12434003, Hangman Creek at Mouth at Spokane, WA.
4. NR is not reported.

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Spokane County Conservation District

The SCCD has conducted extensive water quality sampling in the Hangman Creek watershed since 1994. In 1994, the SCCD completed a watershed management plan for Hangman Creek that has guided SCCD water quality sampling programs.

The SCCD has recently included water quality sampling to evaluate the ground water/surface water interactions along the main stem. The details of the water quality projects are provided below.

Hangman Creek Management Plan (SCCD, 1994)

In 1994, the SCCD completed a watershed management plan for Hangman Creek. The plan provides information on the watershed characteristics, soils, general land uses in the watershed, land ownership, flow data, fauna and flora, water quality problems, and best management practices. In order to address water quality problems associated with Hangman Creek, the management plan included a Water Quality Monitoring Plan to:

1. document existing levels of suspended sediment, selected nutrients, bacterial contamination, and other water quality parameters in the Hangman Creek watershed,
2. quantify the effectiveness of erosion-reducing BMPs on water quality, and
3. compare water quality samples collected during different seasons to help quantify the contribution of bank erosion versus agricultural runoff to water quality impairment.

Hangman (Latah) Creek Water Quality Monitoring Report (SCCD, 1999)

The water quality report completed in 1999 summarizes water quality monitoring at six stations over a three-year period from October 1, 1994 through September 30, 1997. The stations monitored were:

1. Hangman Creek at the Idaho State Line
2. Little Hangman Creek
3. Rattler Run Creek at the mouth
4. Hangman Creek at Bradshaw Road
5. Rock Creek at Jackson Road
6. Hangman Creek at Keevy Road

Routine water quality samples were taken at five sites, along with selected samples during high flow events to characterize the water quality of the Hangman Creek watershed (Tables 2 and 3). A sixth site, Hangman Creek at Keevy Road, was moved to Bradshaw Road, and only had a minimal number of samples taken. Discharge measurements, or discharge values estimated from stage measurements, were routinely taken along with the water quality sample. All monitored stations exceeded one or more of either the Washington State Class A Water Quality standards or EPA recommended standards (Table 4).

Routine water quality samples were taken at the two subwatersheds, along with selected samples during high flow events to characterize the water quality of the two small tributaries to Hangman Creek (Tables 5 and 6). The data were evaluated using the U.S. EPA paired watershed study design, as outlined in EPA circular 841-F-93-009. The data from the study suggest that the BMPs used did reduce the total suspended sediment concentration by more than 10 percent. Even with the improvement in total suspended sediment data, all monitored stations exceeded one or more of either the Washington State Class A Water Quality standards or EPA standards (Table 7).

Hangman Creek Sediment Discharge Reports (SCCD, 2000b, 2002)
To evaluate sediment sources and loads from the Hangman Creek watershed to the Spokane River, a suspended sediment and bedload measurement project was completed. The SCCD, in conjunction with the USGS, monitored both suspended sediment and bedload at the mouth of Hangman Creek from water year 1998 through 2001.

The stream stations monitored by the SCCD were:

1. Hangman Creek at the mouth near the Marne Bridge
2. Hangman Creek at Bradshaw Road
3. Rock Creek at Jackson Road

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Table 2: Summary Laboratory Statistics for the 1999 Water Quality Report

Parameter		Hangman Creek at the Idaho State Line	Little Hangman Creek	Rattler Run Creek	Hangman Creek at Bradshaw Road	Rock Creek at Jackson Road
Total Suspended Solids (mg/l)	Minimum	2	2	<2	2	<2
	Maximum	810	4,640	10,540	3,170	7,565
	Mean	124	833	626	378	632
	Median	24.0	208	29.0	42.5	84.8
Turbidity (NTU)	Minimum	1.1	1.5	0.4	0.6	0.3
	Maximum	195	900	850	750	885
	Low Median	12.5	5.6	3.6	3.6	4.0
	High Median	50.0	129	92.0	90.0	116
Fecal Coliform (colonies/ 100 ml)	Minimum	3	3	<1	6	<1
	Maximum	2,400	1,400	14,300	3,800	1,700
	Geometric Mean	53	58	87	69	63
	% > 200	16	24	30	15	27
Nitrate NO_3 (mg/l as N)	Minimum	0.05	0.09	0.27	0.14	0.08
	Maximum	5.68	13.4	15.5	5.76	12.0
	Mean	1.71	2.70	5.88	1.91	3.22
	Median	1.32	0.95	4.65	1.22	1.70
Nitrite NO_2 (mg/l as N)	Minimum	0.001	<0.001	<0.001	0.001	<0.001
	Maximum	0.015	0.098	0.083	0.020	0.028
	Mean	0.004	0.010	0.016	0.005	0.009
	Median	0.003	0.006	0.011	0.005	0.008
Ammonia (mg/l as N)	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01
	Maximum	0.10	0.10	3.24	0.18	0.46
	Mean	0.03	0.04	0.32	0.03	0.06
	Median	0.01	0.01	0.09	0.01	0.01
Total Phosphorus (mg/l)	Minimum	0.04	0.04	0.15	0.04	0.04
	Maximum	0.80	0.96	10.5	4.27	5.70
	Mean	0.15	0.17	0.72	0.48	0.42
	Median	0.10	0.13	0.42	0.10	0.12

Notes:
1. Mean and median values include samples from high flow events, which may skew the results. The number of high flow events sampled was not uniform for all stations.
2. For turbidity, the low median is for flows less than 100 (10 for Rattler Run Creek) cfs and the high median is for flows greater than 100 (10 for Rattler Run Creek) cfs. Only turbidity values that were paired with discharge measurements were used in the low/high flow evaluation. At some sites, turbidity measurements were taken without any discharge estimation.
3. NTU is Nephelometric Turbidity Units.

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Table 3: Summary Field Statistics for the 1999 Water Quality Report

Parameter		Hangman Creek at the Idaho State Line	Little Hangman Creek	Rattler Run Creek	Hangman Creek at Bradshaw Road	Rock Creek at Jackson Road
pH (units)	Minimum	6.63	6.50	6.49	7.53	6.52
	Maximum	7.86	8.15	8.84	9.52	8.70
	Mean	7.34	7.41	7.96	8.25	7.79
	Median	7.39	7.38	8.05	7.16	7.79
Conductivity (μ S)	Minimum	45.1	97.0	120	82.9	94.6
	Maximum	247	316	532	339	357
	Mean	104	212	352	198	219
	Median	120	199	374	173	202
Dissolved Oxygen (mg/l)	Minimum	4.9	3.5	7.6	6.0	6.7
	Maximum	11.7	13.2	13.7	14.0	18.5
	Mean	8.6	8.4	10.7	9.6	10.5
	Median	8.7	9.0	10.5	9.5	10.5
Temperature (°C)	Minimum	-0.5	0.4	-0.6	0.3	-0.7
	Maximum	22.8	21.9	19.3	23.8	24.7
	Mean	10.6	9.1	7.9	12.0	8.1
	Median	8.0	7.1	6.5	12.8	5.2

Notes:
1. Values include samples from high flow events, and may skew the results. The number of high flow events sampled was not uniform for all stations.
2. Temperature data are for grab samples only. Continuous temperature recorders were installed at some sites, but the data recorded by the continuous temperature recorders are not included here.

The USGS determined the average daily suspended-sediment load at the Marne Bridge site near the confluence of Hangman Creek and the Spokane River. The SCCD estimated the average daily bedload discharge at the Marne Bridge site. The annual total bedload and suspended sediment discharged for water years 1998 through 2001 ranged from 4,740 to 189,000 tons per year (Table 8). Along with the sediment sampling, a low flow water quality sampling run was completed at 18 sites within the watershed to characterize the base flow water type along the Hangman Creek main stem.

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Table 4: Summary of Exceedances for the 1999 Water Quality Report

Parameter		Hangman Creek at the Idaho State Line	Little Hangman Creek	Rattler Run Creek	Hangman Creek at Bradshaw Road	Rock Creek at Jackson Road
Turbidity Low Flows	Exceedances	NA	7	7	1	6
	Number of Samples	NA	19	41	16	44
Turbidity High Flows	Exceedances	NA	6	6	14	46
	Number of Samples	NA	10	10	23	63
Fecal Coliform	Percent > 200 col/100 ml	16	24	30	15	27
Nitrate NO_3	Exceeds EPA Limit	0	1	14	0	3
	Number of Samples	25	25	57	27	59
Nitrite NO_2	Exceeds EPA Limit	0	1	2	0	0
	Number of Samples	25	25	57	27	59
Ammonia	Exceedances	0	0	4	0	0
	Number of Samples	24	24	47	19	50
Total Phosphorus	Exceeds EPA Limit	10	18	57	14	34
	Number of Samples	25	25	57	29	61
pH	Exceedances	0	0	8	5	3
	Number of Samples	25	25	53	23	58
Dissolved Oxygen	Exceedances	7	8	1	6	7
	Number of Samples	19	20	51	25	57
Temperature	Exceedances	7	5	1	11	14
	Number of Samples	25	30	76	33	88

Notes:
1. NA is not applicable. Turbidity values from Hangman Creek at the Idaho State Line were used as background values to establish the limits for the rest of the sample sites.
2. For turbidity, the low flows are less than 100 (10 for Rattler Run Creek) cfs and the high flows are greater than 100 (10 for Rattler Run Creek) cfs.
3. The number of temperature exceedances is for grab samples only. Continuous temperature recorders were installed at some sites, but the exceedances recorded by the continuous temperature recorders are not included here, see the original report Section 4.1.4.
4. For nitrate, nitrite, and total phosphorus, the EPA recommended limits are used. No Washington State Standards for these parameters are presently contained in the Water Quality Standards for Surface Waters of the State of Washington.

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Table 5: 2000 Subwatershed Improvement Report Laboratory Summary Statistics

Parameter		Southern Watershed	Northern Watershed Channel	Northern Watershed Ditch	Northern Watershed Composite
Total Suspended Solids (mg/l)	Minimum	<2	<2	<2	<2
	Maximum	3,568	2,923	5,105	3,408
	Mean	193	151	471	244
	Median	22	18	37	13
Turbidity (NTU)	Minimum	1.8	0.6	1.4	0.8
	Maximum	768	825	760	638
	Mean	81	88	112	58
	Median	18	45	50	7
Fecal Coliform (colonies/ 100 ml)	Minimum	5	0	0	<1
	Maximum	1,410	61	11	1,400
	Geometric Mean	37.4	5.4	7.7	11.6
	% > 200	15	0	0	14
Nitrate NO_3 (mg/l as N)	Minimum	0.45	0.74	1.00	0.60
	Maximum	16.2	8.74	8.74	8.72
	Mean	3.77	3.13	3.67	3.24
	Median	2.99	2.31	3.41	1.76
Nitrite NO_2 (mg/l as N)	Minimum	<0.001	<0.001	<0.001	0.001
	Maximum	0.026	0.015	0.015	0.024
	Mean	0.005	0.005	0.005	0.007
	Median	0.005	0.005	0.005	0.006
Ammonia (mg/l as N)	Minimum	<0.01	<0.01	<0.01	<0.01
	Maximum	0.41	0.08	0.08	1.03
	Mean	0.04	0.02	0.02	0.09
	Median	0.02	0.01	0.02	0.02
Total Phosphorus (mg/l)	Minimum	0.09	0.06	0.08	0.04
	Maximum	1.50	0.54	0.54	2.44
	Mean	0.35	0.18	0.21	0.25
	Median	0.27	0.14	0.17	0.16

Notes:
1. Mean and median values include samples from high flow events, which may skew the results. The number of high flow events sampled was not uniform for all sites.
2. NTU is Nephelometric Turbidity Units.

Bedload discharge samples from the upper reaches of the watershed were insignificant. At the Rock Creek Jackson Road site, the bedload sediment discharge was 24 grams at a discharge of 540 cfs. Sampling at Rock Creek and Hangman Creek at Bradshaw Road suggest that there is little bedload discharge from the upper watershed at low and moderate flows. In the lower reach (Hangman Creek at Marne Bridge), both moderate and high flows had significant bedload sediment discharges. The data suggest there is little bedload movement for flows less than approximately 216 cfs at the mouth of Hangman Creek. The highest bedload sediment discharge was 15,212 grams at a discharge of 5,300 cfs.

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Table 6: 2000 Subwatershed Improvement Report Field Summary Statistics

Parameter		Southern Watershed	Northern Watershed Channel	Northern Watershed Ditch	Northern Watershed Composite
pH (units)	Minimum	6.80	6.90	6.89	7.50
	Maximum	8.29	8.46	8.55	8.25
	Mean	7.78	7.80	7.98	7.76
	Median	7.85	7.81	8.07	7.75
Conductivity (μS)	Minimum	64	69	66	130
	Maximum	422	417	381	419
	Mean	305	284	269	314
	Median	326	324	304	334
Dissolved Oxygen (mg/l)	Minimum	4.5	6.1	9.3	4.5
	Maximum	12.2	13.6	12.8	12.7
	Mean	9.4	10.3	11.2	9.8
	Median	10.0	11.1	11.3	10.1
Temperature (°C)	Minimum	0.1	0.0	0.0	0.0
	Maximum	15.8	14.1	14.1	13.7
	Mean	6.3	5.5	5.4	5.1
	Median	5.5	4.3	4.2	3.9

Notes:
1. Values include samples from high flow events, and may skew the results. The number of high flow events sampled was not uniform for all sites.

The suspended sediment accounted for the majority of the total sediment discharged from the watershed. Generally, the higher the average annual flow rate, the higher the suspended sediment percentage. The suspended sediment is derived from both stream bank and agricultural field erosion. However, it is suspected to be primarily from field, road, and ditch erosion. The suspended sediment concentrations, as opposed to the bedload samples, were significant in the upper reaches of the watershed.

Water quality samples were taken at 18 sites on a single day along the main stem of Hangman Creek. The water samples were taken to evaluate low flow water quality (Table 9) and to characterize the ground water input to the creek.

Trilinear diagrams were used to evaluate trends in the composition of the streamflow at the sampling points along Hangman Creek (Figure 1). The trends evaluate changes in the major dissolved cations (calcium, magnesium, and sodium plus potassium) and the major anions (chloride, sulfate, and bicarbonate). The diagrams illustrate the major dissolved ionic constituents in milliequivalents expressed as the percentages of the total cation or anion milliequivalents.

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Table 7: Summary of Exceedances for the 2000 Subwatershed Improvement Report

Parameter		Southern Watershed	Northern Watershed Channel	Northern Watershed Ditch	Northern Watershed Composite
Turbidity > 50 NTU	Exceedances	21	19	19	11
	Number of Samples	56	40	38	33
Fecal Coliform	Percent > 200 col/100 ml	15	0	0	14
Nitrate NO_3	Exceeds EPA Limit	1	0	0	0
	Number of Samples	31	13	12	23
Nitrite NO_2	Exceeds EPA Limit	0	0	0	0
	Number of Samples	31	13	12	23
Ammonia	Exceedances	0	0	0	0
	Number of Samples	26	7	6	23
Total Phosphorus	Exceeds EPA Limit	34	13	14	18
	Number of Samples	35	17	16	23
pH	Exceedances	0	0	1	0
	Number of Samples	35	19	17	20
Dissolved Oxygen	Exceedances	6	3	0	2
	Number of Samples	32	17	15	19
Temperature	Exceedances	0	0	0	0
	Number of Samples	53	27	24	35

Notes:
1. Turbidity values were considered an exceedance if greater than 50 NTU. Background turbidity values are not known for the project watersheds. The 50 NTU limit value was assumed for exceedances and is not based on any regulatory limit.
2. The temperature values are for site visits only. Continuous temperature recorders were not installed at any site.
3. For nitrate, nitrite, and total phosphorus, the EPA recommended limits are used. No Washington State Standards for these parameters are presently contained in the Water Quality Standards for Surface Waters of the State of Washington.

Table 8: Bedload and Suspended Sediment Annual Summary

Year	Annual Bedload (tons)	Annual Suspended Sediment Load (tons)	Total Annual Sediment Load (tons)	Average Annual Discharge (cfs)
1998	5,100	35,200	40,300	166
1999	14,000	175,000	189,000	315
2000	12,300	83,000	95,300	273
2001	1,310	3,430	4,740	83.7

Notes:
1. Suspended sediments were estimated by the USGS from automated samples.
2. Bedload estimations were by the SCCD using regression equations developed from sample results and USGS flow data. The regression equation uses USGS daily average flow as the predictive input.

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Table 9: Summary of Exceedances for the 2001 Low Flow Sampling

	Total Phosphorus (μg/l)	Fecal Coliform (colonies /100ml)	pH (units)	Dissolved Oxygen (mg/l)	Temperature (°C)
Stateline	63	59	7.21	7.14[e]	12.6
HC at Tekoa	79	28	7.94	11.49	16.3
HC at Marsh Rd	64	46	7.70	10.05	16.0
Cove Creek	100	190	7.65	10.32	13.1
HC at Roberts Rd	77	16	7.86	9.41	17.6
Rattler Run Creek	256[e]	310[e]	7.81	9.24	13.8
HC at Bradshaw Rd	97	16	8.00	7.61[e]	18.4[e]
HC at Keevy Rd	58	2	8.64[e]	11.55	19.2[e]
HC u/s Rock Ck	72	7	9.23[e]	16.64	20.4[e]
Rock Creek	35	790[e]	9.15[e]	8.37	19.9[e]
HC u/s California Ck	74	4	8.93[e]	10.21	18.8[e]
California Ck	95	290[e]	8.34	10.23	16.0
HC at HV Golf Course	32	19	8.52[e]	13.90	20.7[e]
HC at Grunte Home	41	17	8.18	10.86	20.3[e]
HC at Yellowstone	29	3	8.29	10.75	21.2[e]
HC u/s Marshall Ck	32	2	7.83	10.58	20.5[e]
Marshall Ck	65	1600[e]	7.56	7.56[e]	17.5
USGS Gage site	22	65	8.17	12.56	18.2[e]

Notes:
1. Total Phosphorus is not listed on the 1998 Ecology 303(d) list, but exceedances of EPA recommended levels have been documented in previous SCCD sampling within the Hangman Creek watershed.
2. Fecal coliform was considered an exceedance if greater than 200 colonies per 100 ml sample. Not enough samples were obtained to adequately characterize the geometric mean for exceedances.
3. HC is Hangman Creek.
4. u/s is upstream.
5. HV is hangman Valley.
6. e indicates an exceedance of Ecology water quality standards, except for total phosphorus which is an EPA recommended limit.
7. There were no exceedances for nitrate, nitrite, or ammonia.
8. Two ammonia samples had corresponding pH values greater than 9.00. The exceedances criteria are dependent on pH, and the pH limit used in the calculation of exceedances is 9.00. For the samples with pH values greater than 9.00, extrapolations were used to estimate the limits.

The trilinear plot uses two equilateral triangles, one for cations and the other for anions. Each vertex represents 100 percent of a particular ion or group of ions. The composition of the water with respect to cations is indicated by a point plotted in the cation triangle, and the composition with respect to anions by a point plotted in the anion triangle. The coordinates at each point add to 100 percent.

The trilinear diagram constitutes a useful tool in water-analysis interpretation. Applications of the diagram are used to evaluate whether a particular water may be a mixture of others, or if two solutions of different concentrations are mixed. The results of this sample set indicate that the water in Hangman Creek is predominantly a calcium-bicarbonate water type. Sodium plus potassium quantities were estimated based on the other major ion concentrations and the field conductivity by the EWU Limnology Laboratory. No significant mixing trends were apparent using the major ions (Figure 8).

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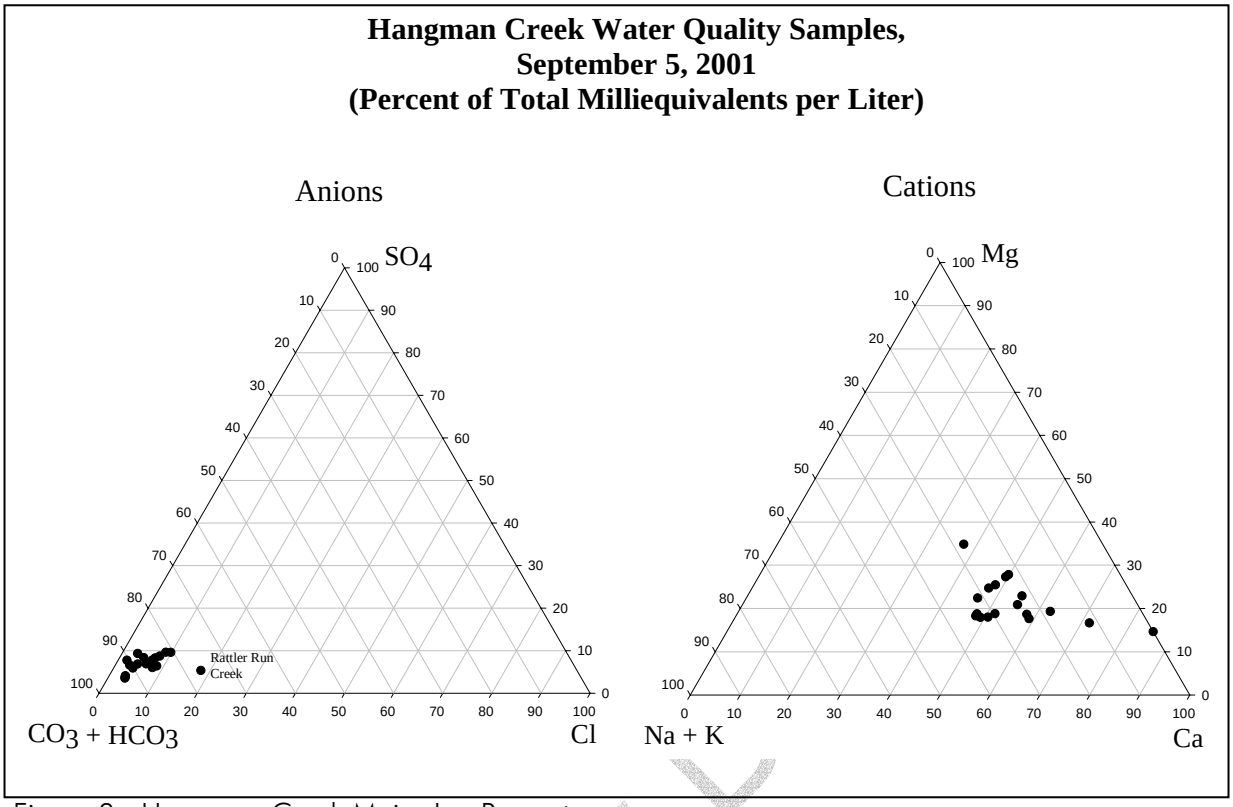

Figure 8: Hangman Creek Major Ion Percentages

<u>Washington State Department of Ecology</u>

Ecology samples two sites on Hangman Creek for their River and Stream Water Quality Monitoring network. The sites are sampled for fecal coliform bacteria, DO, pH, TSS, temperature, total persulfate nitrogen, total phosphorus, and turbidity. The two sites are located at the mouth (station 56A070) and near Bradshaw Road (station 56A200). The first sampling at the mouth was on 10-10-72 and is ongoing. The Bradshaw Road site was first sampled on 10-5-98 and was last sampled on 9-13-99. The data are available from the Ecology web site, www.ecy.wa.gov.

Preliminary

Summary of Little Spokane River Watershed Water Quality Sampling

Pend Oreille Conservation District Data

Little Spokane Water Quality Assessment (undated report, probably from 2000)

The POCD conducted monitoring of five sites on the Little Spokane River and one site on the West Branch of the Little Spokane River from October 1998 through September 1999. Samples were collected monthly and were scheduled to correspond with monthly sampling performed by Ecology EAP staff at four additional Little Spokane River sites.

No summary tables were provided in the report. The narrative section on phosphorus is copied below:

> *Though there is no State Criteria for total phosphorus concentrations, the US Environmental Protection Agency suggests surface waters should remain below 100 μg/L to limit excessive algae and aquatic macrophyte growth. There were four instances where Little Spokane water samples exceeded this amount: in February at sites LS5 (112 μg/L), LS6 (127 μg/L) and 55B82 (106 μg/L) and in March at site LS5 (103 μg/L). While these concentrations exceed the EPA's recommendation, they occurred during winter months and probably did little to accelerate eutrophication.*

Spokane County Conservation District

The Little Spokane River Watershed Plan Development, A Compilation of Project Results, (2001 – 2002)

The primary water quality component of this project was intended to evaluate possible nitrate/nitrite inputs from recent housing developments on Deadman and Little Deep Creeks. Monthly sampling began in January of 2001 above and below the developments. Deadman Creek was sampled at Bruce Road and Shady Slope Road. Little Deep Creek was sampled at Colbert Road and Little Spokane Drive. The monthly downstream water quality samples were inconclusive because springs immediately upstream of the Shady Slope Road sample site were found to have significantly high nitrate levels (Table 10 and 11).

Chemical Parameters Measured during the Macro Invertebrate Sampling

A summary of the physical and chemical parameters measured during the macro invertebrate sampling is provided in Table 13. The water temperatures ranged from a low of 0.0°C to a high of 23.5°C, the pH ranged from a low 5.7 to a high of 9.4, the conductivity ranged from a low of 32 μS to a high of 414 μS, and the dissolved oxygen ranged from a low of 5.9 mg/l to a high of 14.5 mg/l. The embededdness ranged from a low of 22 percent to a high of 63 percent. The water velocity ranged from a low of 0.5 feet per second to a high of 5.0 feet per second, and the water depth ranged from a low of 0.14 feet to a high of 2.10 feet.

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Table 10: Deadman Creek Monthly Sampling Results 2001-2002.

Parameter		Deadman at Bruce Road	Deadman upstream of outfall and springs	Spring upstream of Kaiser outfall	Kaiser outfall	Spring upstream of Hwy. 2	Deadman at Shady Slope Road
Nitrate (NO_3) (mg/l as N)	Maximum	0.23	0.98	1.74	1.54	3.61	1.03
	Minimum	0.08	0.20	1.65	1.43	1.52	0.44
	Mean	0.14	0.53	1.70	1.47	3.09	0.82
Nitrite (NO_2) (mg/l as N)	Maximum	0.001	0.001	0.006	0.003	0.001	0.006
	Minimum	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	0.001	0.001	0.006	0.002	0.001	0.002
Ammonia (mg/l)	Maximum	0.03	0.04	0.03	0.08	0.52	0.04
	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	0.015	0.025	NA	NA	0.14	0.025
Kjeldahl N (mg/l)	Maximum	0.52	0.31	0.06	0.12	2.40	0.39
	Minimum	0.19	0.10	0.04	0.05	0.01	0.12
	Mean	0.28	0.19	0.04	0.08	0.51	0.20
Temperature (°C)	Maximum	16.7	19.0	11.1	12.8	17.6	16.3
	Minimum	0.0	7.6	11.0	11.2	14.2	4.8
	Mean	9.1	12.6	11.1	12.0	15.8	10.4
pH (units)	Maximum	7.46	8.24	7.82	8.35	8.05	8.31
	Minimum	6.33	7.30	7.45	7.80	7.84	7.73
	Mean	NA	NA	NA	NA	NA	NA
Conductivity (µS)	Maximum	210	392	426	335	616	414
	Minimum	158	103	115	310	540	232
	Mean	84	245	361	323	597	339
Dissolved Oxygen (mg/l)	Maximum	12.96	10.40	3.88	11.59	9.63	12.76
	Minimum	4.53	7.73	3.49	9.69	8.23	9.53
	Mean	7.45	9.26	3.75	10.64	9.10	10.91

Notes:
1. Not all sample sites were sampled the same number of times. The Kaiser outfall was dry several times.
2. Sample results of less than detectable were not included in the averages.
3. mg/l as N is milligrams per liter as Nitrogen.

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Table 11: Little Deep Creek Monthly Sampling Results 2001-2002.

Parameter		Little Deep Creek at Colbert Road	Little Deep Creek at Little Spokane Drive
Nitrate (NO_3) (mg/l as N)	Maximum	0.50	0.96
	Minimum	0.11	0.22
	Mean	0.28	0.49
Nitrite (NO_2) (mg/l as N)	Maximum	0.001	0.006
	Minimum	<0.001	<0.001
	Mean	0.001	0.002
Ammonia (mg/l)	Maximum	0.05	0.02
	Minimum	<0.01	<0.01
	Mean	0.03	0.01
Kjeldahl N (mg/l)	Maximum	0.56	0.54
	Minimum	0.20	0.12
	Mean	0.32	0.22
Temperature (°C)	Maximum	16.4	16.0
	Minimum	0.0	2.6
	Mean	7.5	9.7
pH (units)	Maximum	7.87	8.34
	Minimum	6.06	7.60
	Mean	NA	NA
Conductivity (µS)	Maximum	151	440
	Minimum	88	132
	Mean	114	304
Dissolved Oxygen (mg/l)	Maximum	13.62	12.95
	Minimum	6.14	9.43
	Mean	10.96	11.04

Notes:
1. Sample results of less than detectable were not included in the averages.
2. mg/l as N is milligrams per liter as Nitrogen.

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Seepage Runs

The seepage run water quality results for Deadman Creek and Little Deep Creek are shown in Tables 14 and 15. Deadman Creek water temperatures ranged from a low of 11.1°C to a high of 14.1°C, the pH ranged from a low 6.82 to a high of 8.03, the conductivity ranged from a low of 40.9 µS to a high of 752 µS, and the dissolved oxygen ranged from a low of 3.39 mg/l to a high of 10.0 mg/l. Deadman nitrates ranged from a low of 0.05 mg/l to a high of 7.86 mg/l, the nitrite ranged from a low of less than 0.001 mg/l to a high of 0.001 mg/l, the total Kjeldahl nitrogen ranged from a low of 0.06mg/l to a high of 0.47 mg/l, and ammonia ranged from less than 0.01 mg/l to a high of 0.06 mg/l.

Table 13: Summary of Macro Invertebrate Sample Site Parameters

Parameter		Fall 2000		Spring 2001		Fall 2001		Spring 2002	
		Value	Site	Value	Site	Value	Site	Value	Site
pH (units)	Maximum	8.5	5	9.0	21	8.0	14,24	9.4	9
	Minimum	7.0	26	7.0	17	5.7	15	5.7	19
Conductivity (µS)	Maximum	366	14	311	15	414	16	296	24
	Minimum	52	15	55	23	48	15	32	15
DO (mg/l)	Maximum	14.5	26	10.0	13	13.05	24	12.8	2
	Minimum	9.4	27	5.9	24	7.14	22	8.0	16
Salinity (ppt)	Maximum	0.2	14	0.1	Note 2	0.2	16,14	0.1	Note 6
	Minimum	0.0	Note 1	0.0	Note 3	0.0	Note 4	0.0	Note 7
Temperature (°C)	Maximum	7.6	25,26	23.5	21	9.6	10	20.6	21
	Minimum	0.0	17	9.5	23	4.1	24	7.9	23
Embededdness (percent)	Maximum	62	19	63	24	62	13,22	55	7
	Minimum	28	21	22	17	24	2	22	21
Velocity (fps)	Maximum	3.0	5	3.0	2	3.0	8	5.0	23
	Minimum	0.5	22	0.5	22	0.5	Note 5	1.1	22
Depth (feet)	Maximum	1.94	22	2.10	5	1.94	13	1.91	13
	Minimum	0.26	27	0.27	20	0.14	17	0.32	23

Notes:
1. Sites 8, 15, 17, 19, 22, and 23.
2. Sites 2, 15, 17, 18, 22, 23, and 27.
3. Sites 1, 4, 5, 7, 8, 9, 10, 12, 13, 14, 16, 19, 20, 21, 24, 25, and 26.
4. Sites 15, 17, 21, 22, and 23.
5. Sites 14, 17, 21, and 22.
6. Sites 7, 15, 16, 17, 18, 19, 21, 22, and 23.
7. Sites 1, 2, 4, 5, 8, 9, 10, 12, 13, 14, 20, 24, 25, 26, and 27.
8. DO is dissolved oxygen.
9. mg/l is milligrams per liter.
10. ppt is parts per thousand.
11. fps is feet per second.
12. The depth is the average sampling depth for the sample site.
13. All sampling was conducted by EWU.

Little Deep Creek water temperatures ranged from a low of 8.4°C to a high of 11.4°C, the pH ranged from a low 6.57 to a high of 7.76, the conductivity ranged from a low of 50.9 µS to a high of 419 µS, and the dissolved oxygen ranged from a low of 7.45 mg/l to a high of 10.8 mg/l. Little Deep Creek nitrates ranged from a low of 0.08 mg/l to a high of 0.57 mg/l, the nitrite ranged from a low of less than 0.001 mg/l to a high of 0.011 mg/l, the total Kjeldahl nitrogen ranged from a low of 0.06mg/l to a high of 0.31 mg/l, and ammonia ranged from less than 0.01 mg/l to a high of 0.01 mg/l.

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Table 14: September 2002 Seepage Run Field Water Quality Results

River Mile	Site Name	Discharge (cfs)	Temperature (°C)		pH (units)	Conductivity (µS)
			Air	Water		
14.7	Deadman at Fire Station	2.18	16.1	12.5	6.82	40.9
11.1	Deadman at Mt. Spokane Rd.	2.04	16.4	14.1	7.15	78.0
5.8	Deadman at Bruce Rd.	1.41	17.4	13.4	7.50	125
3.6	Spring above RR	0.12	20.0	11.8	8.03	752
3.6	Deadman at RR crossing	1.24	14.8	12.9	7.68	201
2.1	Deadman u/s of Kaiser	2.10	14.9	13.0	7.67	265
2.1	Spring u/s of Kaiser outfall	NM	19.3	11.1	7.49	430
2.1	Spring u/s of Hwy 2	NM	17.2	12.1	7.58	601
0.4	Deadman at Shady Slope Rd.	10.1	20.1	11.6	7.80	386
11.5	Little Deep S-Fork at Big Meadow	0.41	15.1	8.4	6.57	50.9
10.4	Little Deep N-Fork at Big Meadow	0.11	14.0	9.9	6.82	126
8.3	Little Deep at Dunn Road	0.68	13.7	9.2	6.67	102
6.6	Little Deep at Woolard Road	0.31	21.8	9.7	6.85	103
5.4	Little Deep at Congleton Prop.	0.28	16.4	11.2	6.79	107
3.7	Little Deep in Colbert	0.15	20.7	11.4	6.96	108
0.0	Little Deep at Hargreaves Prop.	1.32	17.2	10.1	7.76	419

Notes:
1. The Kaiser outfall (DM-6B) was dry.
2. Deadman Creek seepage run was conducted on September 16, 2002
3. Little Deep Creek seepage run was conducted on September 30, 2002.

Washington State Department of Ecology Data

Ecology samples one long-term site in the Little Spokane River watershed for their River and Stream Water Quality Monitoring network. The sites are sampled for ammonia, conductivity, fecal coliform bacteria, DO, pH, TSS, temperature, nitrate plus nitrite, total nitrogen, soluble reactive phosphorus, total phosphorus, and turbidity. The long-term site is located at the mouth (station 55B070). Ecology has sampled at 13 other sites at various times (Table 16). The data are available from the Ecology web site, www.ecy.wa.gov.

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Table 15: September 2002 Seepage Run Laboratory and Field Water Quality Results

Site Name	DO (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	TKN (mg/l)	Ammonia (mg/l)
Deadman at Fire Station	7.04	0.05	0.001	0.08	<0.01
Deadman at Mt. Spokane Rd.	6.26	0.10	0.001	0.11	0.02
Deadman at Bruce Rd.	5.02	0.06	<0.001	0.17	0.04
Spring above RR	7.65	7.86	0.001	0.06	0.02
Deadman at RR crossing	6.26	0.81	0.001	0.36	0.03
Deadman u/s of Kaiser	8.76	0.63	0.001	0.21	0.03
Spring u/s of Kaiser outfall	3.39	1.80	0.001	0.28	0.04
Spring u/s of Hwy 2	8.29	3.41	0.001	0.47	0.06
Deadman at Shady Slope Rd.	10.10	1.01	0.001	0.13	0.01
Little Deep S-Fork at Big Meadow	10.72	0.08	<0.001	0.31	<0.01
Little Deep N-Fork at Big Meadow	10.83	0.08	<0.001	0.15	<0.01
Little Deep at Dunn Road	9.97	0.08	<0.001	0.09	0.01
Little Deep at Woolard Road	10.21	0.10	0.011	0.10	<0.01
Little Deep at River Mile 5.4	10.61	0.10	0.001	0.11	<0.01
Little Deep in Colbert	10.77	0.09	0.001	0.13	<0.01
Little Deep at Hargreaves Prop.	7.45	0.57	<0.001	0.06	0.01

Notes:
1. The Kaiser outfall (DM-6B) was dry.
2. Deadman Creek seepage run was conducted on September 16, 2002.
3. Little Deep Creek seepage run was conducted on September 30, 2002.

Table 16: Ecology Sampling Sites for the Little Spokane River Watershed

Station code	Station name *link to monitoring results*	Type	Class	Last year sampled
55B070	Little Spokane R nr Mouth	long-term	A	2005
55B075	Little Spokane @ Painted Rocks	basin	A	1999
55B080	Little Spokane R nr Griffith Spring	basin	A	1991
55B082	Little Spokane R abv Dartford Creek	basin	A	1999
55B085	Little Spokane nr Dartford	basin	A	1966
55B090	Little Spokane R abv Wandermere	basin	A	1973
55B100	Little Spokane R abv Deadman Creek	basin	A	1994
55B200	Little Spokane @ Chattaroy	basin	A	1999
55B300	Little Spokane River @ Scotia	basin	A	2004
55C065	Deadman Cr nr Mouth	basin	A	1994
55C070	Peone (Deadman) Creek abv L Deep Cr	basin	A	2004
55C200	Deadman Cr@Holcomb Rd	basin	A	2004
55D070	Deer Cr nr Chattaroy	basin	A	1994
55E070	Dragoon Cr nr Chattaroy	basin	A	1994

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