Groundwater/Surface Water Interactions In the Sammamish River: a Preliminary Analysis

Quality Assurance Project Plan

by
Barbara M. Carey

Waterbody Numbers: WA-08-1100 and WA-08-1090

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Environmental Assessment Program
Olympia, WA 98504-7710

Approvals:

Approved by:	October 30, 2001
Vishaka Smith, NWRO Ecology TMDL Cedar/Green Coordinator	Date
Approved by:	October 30, 2001
Kevin Fitzpatrick, Water Quality Program Section Manager, Northwest Regional Office	Date
Approved by:	October 30, 2001
Ken Johnson, King County Dept. of Natural Resources, Groundwater Program Lead	Date
Approved by:	October 30, 2001
Barbara Carey, EAP Project Manager, Watershed Ecology Section	Date
Approved by:	November 1, 2001
Dale Norton, EAP Unit Supervisor, Contaminant Studies Unit	Date
Approved by:	October 31, 2001
Will Kendra, EAP Section Manager, Watershed Ecology Section	Date
Approved by:	October 30, 2001
Cliff Kirchmer, Ecology Quality Assurance Officer	Date

Background/Problem Statement

The Sammamish River is on the 303-d list at three locations for excessive temperature during low flow months. The listed segments are WA-08-1050, WA-08-1070, and WA-08-1100. An understanding of the interaction of groundwater and surface water is needed to develop methods for improving temperature conditions. The King County Department of Natural Resources (KC DNR) Water and Land Resources Division is developing a comprehensive, phased study of the hydrogeology of the river valley to evaluate the influence of groundwater on flow and temperature in the Sammamish River. This study is designed to provide support for the King County study as requested by the Ecology Northwest Regional Office. The results of the EAP study will be used by KC DNR to identify areas for further investigation of groundwater inflow and outflow along the Sammamish River. Groundwater temperature and flow direction information obtained during this study, as well as the more detailed KC DNR study, will also be useful for future temperature TMDL analyses on the Sammamish River.

The Sammamish River flows from the outlet of Lake Sammamish to Lake Washington at Kenmore, a distance of about 13 miles (Figure 1). The river corridor has been used mostly for agriculture and recreation (Marymoor Park, a bike trail, and a golf course). The watershed has changed from forested to urban and residential uses over the past 30-50 years with especially rapid development in the past 20 years in and around the city of Redmond.

The once densely forested valley was cleared for agriculture early in the century and contained extensive meanders and ox-bows. When settlers first came to the Sammamish Valley in the mid to late 1800's, the river is estimated to have been 30 miles long (Martz, et al., 1999). The level of Lake Washington was lowered almost nine feet with construction of the Ship Canal and Ballard Locks. The level of Lake Sammamish likewise decreased by six feet causing the adjoining Sammamish River to become more entrenched in its mainly artificial channel to convey nearly the same flows.

Dredging, at least once to enhance navigation in the early 1900's, is believed to have destroyed most salmon spawning habitat in the river (Martz, et al., 1999). All fisheries, except resident trout, were depleted in the basin by the early 1950's. The river was already nearly as straight as it is today when the most recent U.S. Army Corps of Engineers (COE)/King County flood control project began in the 1950's. Most of the remaining abandoned river channels and wetlands were removed and riparian (willow) vegetation was replaced with grass (Martz, 1999).

There are three USGS gages along the river and seven gages at tributaries to the river as shown in Figure 1 (KC DNR, 2001). Average annual river flow at Woodinville from 1965 to 2000 is 311 cfs (USGS Gage No. 12125200). The lowest flow in the river is about 70 cfs and typically occurs in August.

Most of the flow in the river is from surface water: Lake Sammamish, Bear Creek, and other tributaries. However, a modeling analysis of the historical streamflow records for the watershed indicates that 65-85% of summer flow in the tributaries has been from baseflow derived from groundwater (Sinclair and Pitz, 1999). It is not known if recent changes in land use have altered

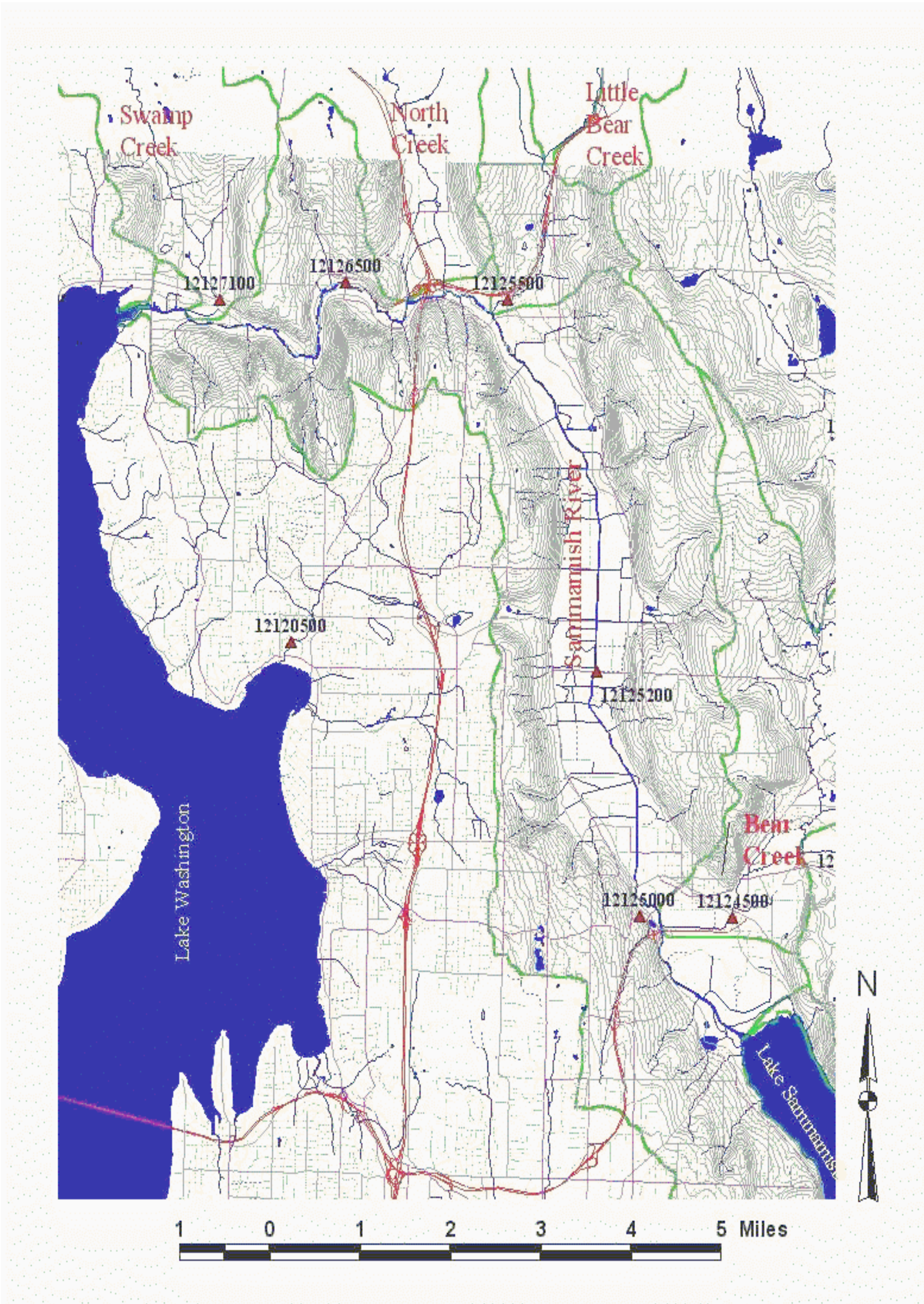


Figure 1. The Sammamish River Valley area and local USGS gaging stations (from KC DNR, 2001).

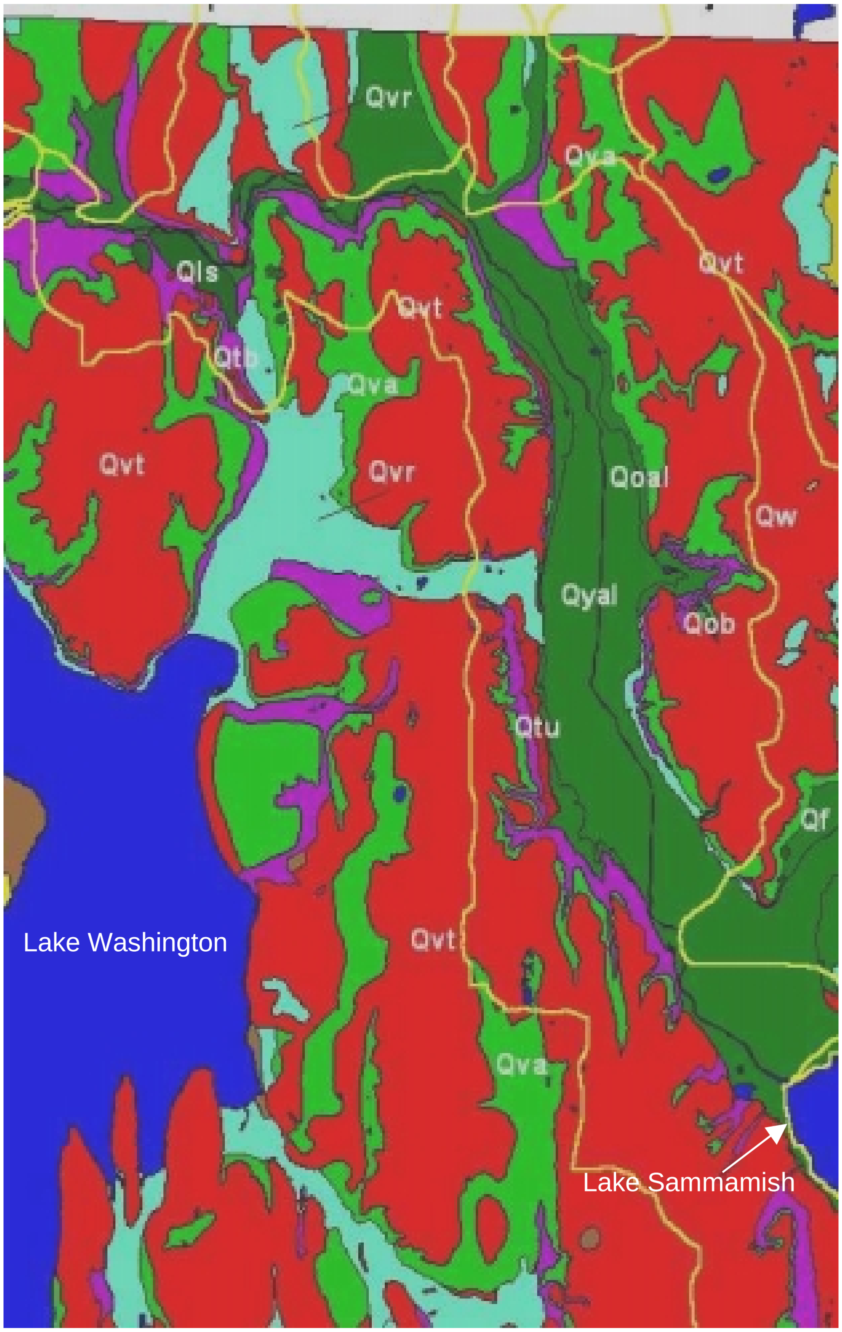
these patterns, because the records used in the analysis are mainly from earlier dates. Runoff estimates for the largest tributary to the river, Bear Creek, indicate that it contributes about 25% of the flow to the river. Numerical estimates indicate that groundwater flow beneath the creek channel may also account for about 10 cfs, a significant amount during the summer (KC DNR, 2001).

Information on the location of areas of subsurface inflow and outflow along the river itself has not been analyzed and can be useful in developing design modifications for high temperature.

The main aquifers interacting with the river are the alluvial aquifers beneath the river and tributary valleys (Figure 2). Much of the watershed is covered with Vashon till which allows only marginal infiltration of precipitation. Local upland aquifers cover some of the topographic ridges surrounding the valley watershed and are comprised of Vashon advance outwash and in some places more permeable till. These local aquifers may recharge the alluvial aquifers along the valley walls (Redmond-Bear Creek Valley Ground Water Advisory Committee, 1999). The deeper aquifers, referred to as the sea level aquifers and the regional aquifer, are separated for the most part from the alluvial aquifers by low permeability layers and, therefore, do not interact significantly with the alluvial aquifers.

Temperature measurements have been collected for the Sammamish River by the COE to model temperature changes along the river (KC DNR, 2001). The COE has also conducted a Forward Looking Infrared (FLIR) remote sensing study on the river (McIntosh, et al., 2000). Information from these studies may be useful in detecting areas of groundwater inflow.

The purpose of this study is to provide data to the larger King County Sammamish Basin hydrogeologic study. Data collected in this study will help evaluate groundwater flow direction in selected areas of the river and seasonal variation in direction. Access to the river is available at Marymoor Park, along the Sammamish River trail, other local parks, and via bridges over the river.



Qva: Vashon advance outwash
Qvr: Vashon recessional outwash
Qvt: Vashon till
Qtb: Transitional beds
Qyal: Younger alluvium

Qoal: Older alluvium
Qob: Olympia beds
Qtu: Till, undifferentiated
Qf: Alluvial fan deposits
Qw: Wetland deposits

Figure 2. Surficial geology of the study area (from Johnson, 2001).

Project Description

Goal/Decision Statement

Determine whether groundwater is flowing into or out of the river at selected locations during the summer/fall low flow period. The study will focus on the upstream (southern) part of the river above the narrow canyon valley, because this is the area where groundwater/surface water exchange is expected to be most significant.

Objectives

The objective of the study is to determine whether groundwater is flowing into or out of the river at selected sites under summer/fall low flow conditions.

Information needed includes:

- Measurements of hydraulic heads in the streambed below the stream bottom and in the river (to be collected),

- Simultaneous measurements of temperature and conductivity in the streambed sediment pore-water and the river (to be collected), and

- Locations where there are indications of groundwater inflow based on temperature (from McIntosh, et. al., 2000).

Responsibilities

Clients

Vishaka Smith, Ecology King County TMDL Project Manager, (206) 649-7036.
Responsible for coordinating with other agency and King County staff, reviewing drafts of the Quality Assurance Project Plan (QAPP) and project report, and coordinating Ecology's implementation of the report recommendations.

Ken Johnson, King County Department of Natural Resources, Water and Land Resources Division, Groundwater Program Lead, (206) 296-8323.
Responsible for reviewing the draft QAPP and project report. Lead role in King County Sammamish River hydrogeologic study.

Environmental Assessment Program (EAP) Project Manager

Barbara Carey, Ecology, (360) 407-6769.
Responsible for managing the project, preparing the project QAPP, coordinating with King County Sammamish River hydrogeologic study lead, coordinating and completing field activities, project data, and preparing the draft and final report. Serves as the principal public contact for the technical aspects of the study components described in this QAPP.

Schedule

June 2001 to May 2002 as Shown Below:

Scoping: June-July 01
QAPP: August 01
Install mini-piezometers: August 01
Sampling: August-November 01
Draft report: March 02
Final report: May 02
Water quality and water level data entered into EIM: July 02

Data Quality Objectives and Decision Criteria

Standard procedures will be used for all field measurements to limit sources of bias (US Geological Survey, 1980). Duplicate water level and field conductivity measurements will be taken in the streambed piezometers to evaluate precision. If the difference between successive measurements is more than 0.01 foot for water level and 5% for specific conductivity, repeated measurements will be taken until consistent readings are obtained. A back-up meter will be available for water level, temperature, and conductivity.

River temperature and conductivity will be measured by lowering the temperature/conductivity probe into the river near the mini-piezometer. Measurements will be recorded when the output has stablized.

The Measurement Quality Objectives for the study are shown in Table 1. Further details are also provided in *Quality Control Procedures* below.

Table 1. Measurement Quality Objectives

Parameter	Accuracy	Precision	Bias
	Deviation from True Value		*% of True Value*
Conductivity	10 umhos/cm	5% (RPD)	10%
Temperature	0.5^0C	+/- 0.2^0 C	NA

*RPD: Relative percent difference.

Field equipment will be calibrated daily and maintained according to the manufacturer's recommendations to ensure maximum accuracy. This includes the Geoprobe temperature/ conductivity meter used for both surface and groundwater measurements and calibrated electronic tapes (e-tapes). Water temperature will be recordeded to the nearest 0.1^0 C. The temperature will be calibrated against a thermometer certified by National Institute of Standards and Technology prior to sampling.

Study Design

This study is a small component of a larger effort being coordinated and conducted by the King County Department of Natural Resources. The purpose of the larger study is to characterize the hydrogeology of the Sammamish Valley with emphasis on interactions with surface water. The results of the study will be used to make decisions to help reduce summer and fall temperature conditions for salmonids (KC DNR, 2001). The results of the mini-piezometer study described in this document will supplement the information collected for the larger King County study by indicating whether groundwater is entering or leaving the river at selected locations.

As part of the King County study (separate from the Ecology EAP study), 17 monitoring wells will be installed near the Sammamish River as shown in Figure 3. These wells are scheduled for installation in fall 2001. Thereafter water levels in the monitoring wells and nearby existing wells will be measured monthly, and in some cases continuously, for at least one year. Slug tests will be conducted to estimate hydraulic conductivity in each location.

Current EAP Study

Nine seven-foot long, 1/2-inch diameter steel pipes will be installed and serve as mini-piezometers. These samplers will help identify areas of groundwater discharge to the river and recharge to the aquifer (Sinclair, 2000 and Simonds, et al., 1999).

Small holes (3/16") will be drilled in the bottom of the steel mini-piezometers. The bottom end will be crimped, while the other end will be open for sampling. The samplers will be hand-driven into the streambed to a depth of five feet.

Water levels inside and outside the mini-piezometer will be measured four times in the late summer-fall from August to November 2001. If the water level inside the mini-piezometer is higher than that outside, then groundwater is flowing into the river at that point. If the level outside the mini-piezometer exceeds that inside, then river water is discharging into the aquifer.

Temperature and conductivity measurements inside and outside the mini-piezometers will also be compared. Generally in western Washington, surface water conductivity is lower than that in groundwater. Likewise, temperature is generally lower in groundwater during the summer and fall than in surface water. A peristaltic pump will be used to sample pore water from the mini-piezometers.

Some of the mini-piezometers will be located in areas where previous studies indicate a potential for groundwater discharge, i.e., where temperature studies have shown an abrupt drop in temperature relative to nearby areas and there is no tributary nearby (Figure 4). Other samplers will be placed near the mouth of Bear Creek, the largest tributary to the river, and which Johnson (2001) has estimated contributes a relatively large amount of groundwater below the surface of the river. Most of the mini-piezometers will be located near enough to one or two of the King County proposed monitoring wells that a flow direction can be estimated using water level measurements collected by King County personnel after the wells are drilled.

Potential mini-piezometer locations will be evaluated during a reconnaisance survey before final site selection. Factors such as bottom sediment composition and accessibility will also be taken into account.

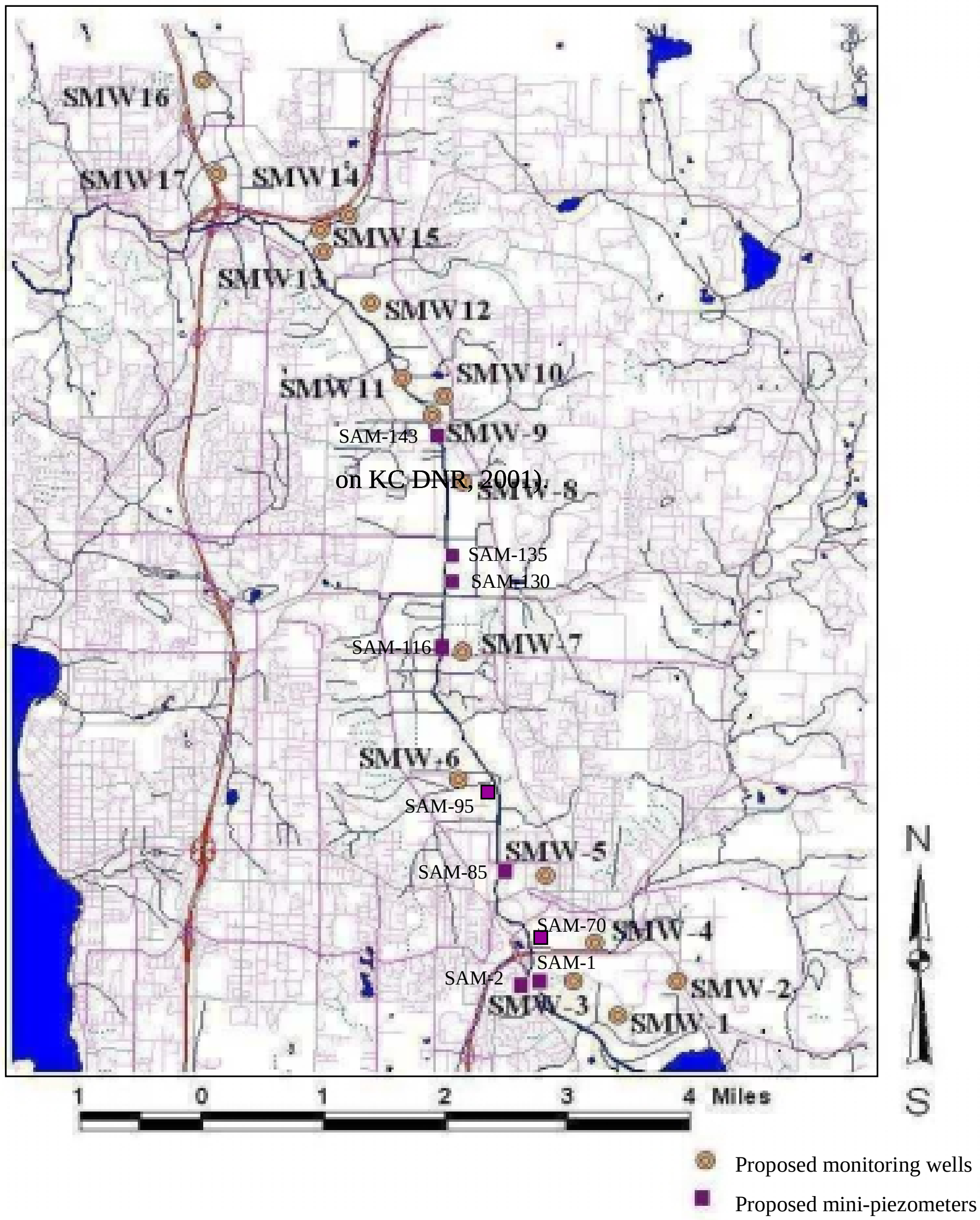


Figure 3. Proposed locations for monitoring wells and mini-piezometers (based on KC DNR, 2001).

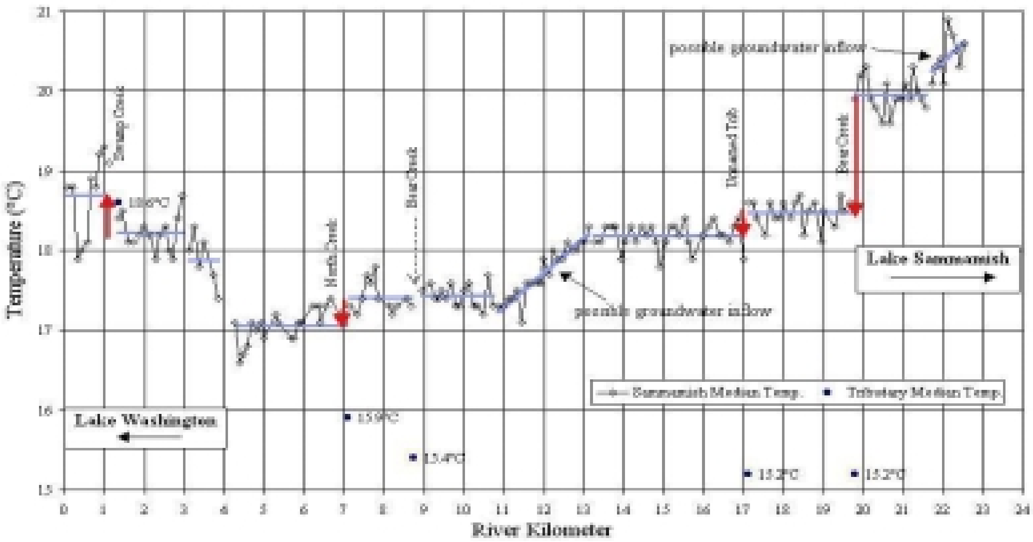


Figure 4. Temperature profile in Sammamish River from FLIR data (from KC DNR, 2001 and McIntosh, et al, 2000).

Field Procedures

Installation of Mini-Piezometers

Each mini-piezometer will be driven into the streambed using a fencepost driver so that the top of the sampler is above the water surface and the bottom is about five feet below the bottom of the riverbed. The top of the mini-piezometer will have a screw-on cap during installation. The sampler will remain capped except when it is being sampled. Each sampler will be developed initially using a peristaltic pump. Water will be pumped from the sampler until the discharge is clear.

The mini-piezometers will be left in place after the 2001 sampling. KC DNR will take over responsibility for the samplers.

Mini-Piezometer Sampling

The mini-piezometer will be allowed to equilibrate after which the depth to water inside the sampler will be measured using an e-tape. The outside depth to water level relative to the top of the piezometer will also be measured using a measuring tape. Both measurements will be made to the nearest 0.01 foot.

Temperature and conductivity will be measured in the streambed water by pumping from the open bottom end of the sampler to a ½-liter container, a flow cell containing the Geoprobe temperature and conductivity probe. Temperature and conductivity of the groundwater will be measured in a ½-liter container until measurements in the container receiving the pumped groundwater have stablized to within 5% for conductivity and +/- 0.2^{0}C. Measurements for surface water temperature and conductivity will be made at the same time and location in the river as the mini-piezometer using the Geoprobe sampler. Additional details of procedures for temperature and conductivity measurements are described in Appendix A.

Quality Control Procedures

Field Quality Control

Duplicate water level measurements will be made at each site both inside and outside the mini-piezometers. If there is a difference between the duplicates, additional measurements will be made until the same measurement is obtained in two consecutive measurements.

Accuracy of conductivity samples will be measured by an analyzing KCl check standards in the range of 70-300 umhos/cm which brackets the measurements found in the river and ground water. Check standards will be measured at the beginning of each sampling day.

Data Reduction and Management Procedures

Field data will be recorded in a standard format on moisture-resistant paper in a project notebook. Data will be entered into an Excel spreadsheet and analyzed in Excel. Sample site locations will be identified using GPS which will facilitate entry into the EIM database.

King County personnel will provide GPS positions for monitoring wells and existing wells from which water level and stratigraphic information will be obtained and used in this study.

Data Review and Validation

Data Review

Before leaving the site, mini-piezometer water level measurements and field water quality measurements will be reviewed for consistency, correctness, errors, and omissions.

Laboratory results for conductivity will be reviewed and verified by qualified and experienced lab staff and documented in the case narrative.

Data Validation

When the data package is complete, the EAP project manager will evaluate whether the prescribed methods, the Standard Operating Procedures (SOP's), and the QAPP were followed.

Data Quality Assessment

Precision and Bias

The data will be considered acceptable for use if they meet the required measurement Quality Objectives in *Data Quality Objectives and Decision Criteria* in Table 1.

Completeness

At least 90% of the planned data for each parameter is needed for a complete data package. The final report will include sampling results and indicate whether groundwater inflow or outflow was occurring on each date at each sampling location. Data will also be entered into the EIM system and will be available electronically.

References

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Appendix A

Standard Operating Procedures for Temperature and Conductivity Measurements

A Geotech (Orion) probe will be used for all temperature and specific conductivity measurements according to the following procedures:

- Calibrate the Geotech Sampler on the Day of Sampling:

  For temperature, at least one time during the two-month study, compare the Geotech readings to those of an NIST mercury thermometer through the range of 0-25^{0}C in 5^{0}C intervals.

  For specific conductivity, calibrate according to the User's Manual with 1,413 umhos/cm standard. Following calibration, test a sample of a known standard in the range of the water to be sampled.

- When sampling surface water near a mini-piezometer, allow the probe to equilibrate in the river for at least three minutes at about six inches depth. When temperature is not changing more than 0.2^{0}C and conductivity more than 5 umhos/cm, record the measurements.

- When sampling mini-piezometer discharge, monitor temperature and conductivity output of the discharge in a 500 ml polyethylene bottle with the probe submerged. When purging is complete (at least 10 minutes) and temperature and conductivity readings are stable, as described for surface water above, record the temperature and conductivity.