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Snohomish River Estuary Dry Season TMDL Study - Phase I

Water Quality Model Calibration

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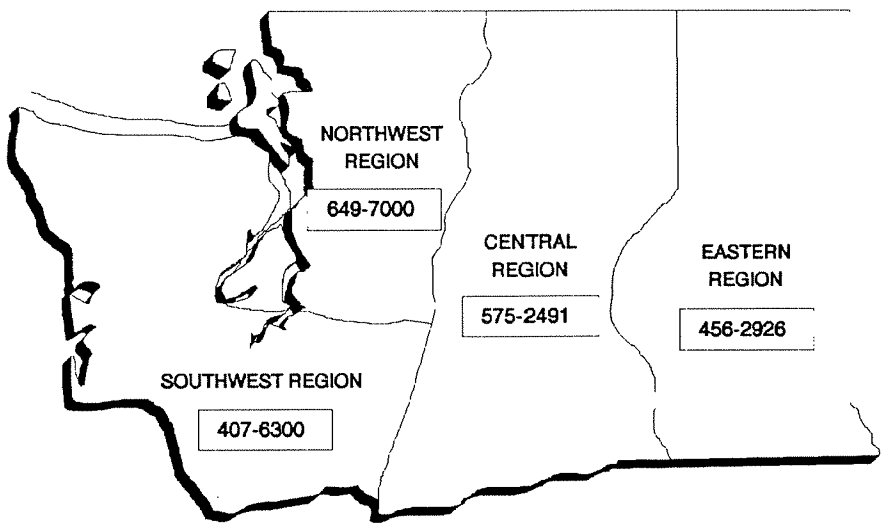

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Snohomish River Estuary Dry Season TMDL Study - Phase I

Water Quality Model Calibration

by
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Abstract

A psuedodynamic model of dissolved oxygen in the Snohomish River Estuary system from Possession Sound to river mile 20 was developed using the model WASP5 to simulate hydrodynamics and water quality. The model was calibrated using data collected in August and September 1993. The model predicted that natural conditions in a large portion of the estuary would be below dissolved oxygen standards under critical conditions. In addition, part of the lower mainstem is projected to display oxygen deficits in exceedance of the 0.2 mg/L allowed by the standards when natural conditions are below the standard. Eighty-nine percent of this deficit is predicted to be caused by discharges from the two City of Everett wastewater treatment plants. Analysis of the Monroe and Sultan wastewater treatment plant effluents indicate they would have a minimal effect on dissolved oxygen in the Skykomish and Snohomish Rivers.

Pending verification of the water quality model, a total maximum daily load (TMDL) will likely be needed to control the discharge of oxygen-depleting substances to the lower river and estuary. Survey and historical data show that the water quality of tributaries in the study area is poor due to high fecal coliform, high nutrients, and low dissolved oxygen concentrations. It is recommended that TMDLs be developed to address these problems. Class II inspection results suggest that point source loading of copper also may need to be controlled through the development of a TMDL.

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Introduction

Population growth and development in the Snohomish River Estuary may be causing adverse effects on water quality. In order to protect water quality, Ecology's Northwest Regional Office (NWRO) requested that the Watershed Assessments Section (WAS) assess current water quality, and recommend a total maximum daily load (TMDL) of problem pollutants in the estuary system.

In 1993, WAS distributed a proposal and quality assurance project plan (QAPP) for conducting a Snohomish River Estuary dry season TMDL study (Cusimano 1993). The study was initiated in the spring of 1993. First year sampling (model calibration sampling) was conducted on August 16 and 17, 1993. The second year of sampling has been rescheduled, in order to coincide with the Basin Approach time frame, from the QAPP schedule of summer 1994 to summer 1996. The final TMDL report is now scheduled to be completed in June 1997. The final report will be used to help set permit limits for dischargers to the river and estuary system beginning in 1999. Because permits are currently being issued through 1999, and because possible future increases in pollutant loading are now being discussed, WAS is publishing this interim report to supply permit managers with current information and suggestions based on first year sampling, data interpretation, and water quality model calibration results. The major activities from the first year of the project summarized in this report are listed below:

1. Collected ambient water quality data from the Skykomish, Snohomish (including sloughs and tributaries), and Possession Sound.

2. Conducted Class II inspections on significant point sources of pollution that are regulated under NPDES permits.

3. Developed a hydrodynamic model which includes channel discharge and velocity based on river flow and changing tidal elevations.

4. Calibrated a water quality model that can be used to assess the potential for dissolved oxygen depletion from carbonaceous and nitrogenous BOD from known sources.

5. Analyzed existing hydrology and long-term water quality data to establish critical conditions (e.g., 7-day , 20 year low flow events (7Q20) flows for the Snohomish and Skykomish Rivers).

6. Delineated saltwater/freshwater zones in the Snohomish River Estuary for applying appropriate water quality criteria.

7. Estimated potential effects of point and nonpoint sources of carbonaceous and nitrogenous biochemical oxygen demand (BOD) based on the calibrated water quality model.

8. Made recommendations for further assessment of water quality and pollutant loading to the Snohomish River Estuary system.

Background Information

The study area is the lower part of the Skykomish River and all of the Snohomish River, Port Gardner, and the adjacent portion of Possession Sound (Figure 1). The Snohomish River drains 1,780 square miles, not including Quilceda Creek drainage area, and accounts for about 30 percent of the freshwater discharge to Whidbey Basin of the Puget Sound (Pacific Northwest River Basins Commission 1969; U.S. Army Corps of Engineers 1979). The Snohomish River is formed by the junction of two major rivers--the Skykomish and Snoqualmie. The Snoqualmie drains 693 square miles and the Skykomish drains 844 square miles. Other sub-basins in the study area include the Pilchuck River, Woods Creek, and the Sultan River--plus Allen and Quilceda Creeks which enter Ebey Slough near Marysville (Figure 2). Within the study area there are also four drainage systems which are controlled by pumping stations: French Creek, the Marshland, Deadwater Slough, and Swan Trail Slough (Figure 2 and 3).

The Snohomish River enters inner Everett Harbor and then Possession Sound through several channels in the delta (Figure 3). These channels are known as Ebey Slough, which is cut along the north side of the delta; Steamboat Slough and Union Slough, through the center of the delta; and the main Snohomish River channel, which follows along the south side of the delta and the Everett Peninsula. Tang (1981) modeled the sloughs and determined the proportion of river water each channel would carry under 7Q10 flow as follows: 70.3 percent in the main channel, 19.2 percent in Ebey Slough, 7.3 percent in Steamboat Slough, and 3.2 percent in Union Slough. Tang also predicted Steamboat Slough would increase in flow to about 28 percent at the point where Ebey Slough joins Steamboat. After transferring most of its flow to Steamboat Slough, Ebey Slough again separates and then carries only about 2% of the overall river flow before entering Possession Sound. Cheyne and Foster (1942) reported that the U.S. Army Engineers estimated that 7 percent of the river flow travels through Ebey Slough into the Sound, about 61 percent out Steamboat Slough, and about 32 percent through the main channel. The difference between the 1942 and 1981 proportions may reflect some error in the respective estimates, but more likely demonstrates dynamic changes in channel morphology over time due to sediment movement/deposition and channel dredging/scouring.

By the deposition of alluvial material at its mouth, the Snohomish River has formed a tidal flat of about ten square miles in area. During extreme low tides much of this area is exposed, and the river moves westward to Possession Sound through channels cut by the sloughs, and south to Port Gardner Bay through the dredged main channel. High flooding tides cause a strong upstream current that can push salt water more than six miles up the main river channel from its mouth at Preston Point (U.S. Army Corps of Engineers 1979; Stevens 1992). It has been reported that river elevations are affected by the tides as far upstream as the City of Snohomish, at river mile (RM) 12, and sometimes may be affected as far as 18 miles upstream (Townsend *et al.* 1941; U.S. Army Corps of Engineers 1979).

The elevation of the Snohomish River at the confluence of the Snoqualmie and Skykomish Rivers (RM 20.5) is only 20 feet, which gives the lower river a slope of only about one foot per mile to the mouth. At Monroe (RM 25.0) and Sultan (RM 34.4) the Skykomish River elevations are 40 ft. and 90 ft., which provide river segment slopes of 4.4 and 5.3 ft per mile, respectively. From RM 20.5 to the mouth the river channel is well defined, consisting mainly of long, deep, slow-moving glides with a bottom substrate of sand or sand-mud (Williams *et al.* 1975). Along most of this segment the river is diked. From RM 34.4 to the Snoqualmie River, the Skykomish River channel is a mix of pools and riffles, with a number of channel braids. The bottom composition of this segment is mostly gravel-rubble (Williams *et al.* 1975).

Soils along the flood plain of the river from the City of Snohomish to the mouth are mostly deep clay, sand, and silt loam with some very poorly drained areas--*i.e.*, soils such as Mukilteo Muck and Terric Medisaprists (Alfonso and Klungland 1983). From the City of Snohomish to Monroe the soils are moderately well drained silt loam to excessively well drained alluvium composed of sand, gravel, cobble, and stone (*i.e.*, river rock). From Monroe to Sultan the flood plain soils are mostly well drained river rock. The alluvium along the floodplain has been reported to be deep and yields large quantities of ground water that are high in iron (Newcomb 1952). The ground water along the river, downstream of the Marshland, is brackish due to saltwater intrusion (Newcomb 1952).

The lower Snohomish River and its sloughs are an important habitat for acclimating adult and juvenile salmon to salt/fresh water before they migrate from one environment to the other. In addition to these waters providing a migration route to and from spawning grounds, the lower part of the river, sloughs, and near shore estuary are important juvenile rearing areas (Williams *et al.* 1975; Beauchamp *et al.* 1987). Portions of the Skykomish and Snoqualmie river systems provide excellent spawning habitat for chinook, coho, pink, and chum salmon both in the main channels and tributaries (Williams *et al.* 1975).

Historically, land-use in the area has mostly been agriculture and forest, but it is rapidly becoming more urban. In the 1980's Snohomish County was the fastest growing county in the state. Population increased by 38% from 1980 to 1990, and much of the growth took place in municipalities in the Snohomish River drainage (Fox and Hodgkin 1994). Increased urbanization is likely having a direct human impact on water quality through alteration of stream banks, riparian vegetation, and near stream forest. The growing urbanization also translates to increased loading from wastewater treatment plants (WWTPs), with potential adverse effects on water quality.

Project Objectives

The major goal of the Snohomish TMDL study is to develop waste load allocations (WLAs) and load allocations (LAs) for point and nonpoint sources of pollutants based on summer low river flow conditions. The specific objectives based on the project goal are as follows:

- assess the potential for dissolved oxygen depletion from carbonaceous and nitrogenous BOD from known point sources;
- identify other water quality variables which may need to be controlled (e.g., metals such as cadmium, copper, and mercury);
- determine pollutant loading from point and nonpoint sources and background levels;
- determine loading capacity and recommend WLAs, and LAs based on water quality modeling.

Sample Collection and Field Measurement Methods

An intensive survey was conducted on August 16 and 17, 1993, to collect water quality samples on two separate days at all major tributaries, and selected mainstem and slough sites (Figure 2). Ecology's Ambient Monitoring Section collected data from one station in Possession Sound on August 24, 1993, located at the mouth of the bay (48°01'00"N 122°16'30"W). Vertical profiles of light extinction were measured at sites 14, 16, 20, 23, 24, and 31 on August 24 and September 14, 1993. Hourly measurements of temperature, dissolved oxygen, pH, and specific conductance were made at sites 14, 16, 23, 24, and 31 at a depth of one meter, using *in situ* sensors, from August 24-26, 1993.

During the August 16 and 17 survey, grab samples were collected just below the surface from all sites at mid-channel; during high tide an additional sample was collected one meter from the bottom of the channel using a Van Dorn sampler at tidally influenced sites in the lower river and sloughs. Replicate samples were collected at specified sites by repeating the sampling effort immediately after the first sample was collected.

The 1992 section 303(d) list identified two segments of the Snohomish River as exceeding standards for copper, cadmium, and mercury, and Port Gardner/Inner Everett Harbor as exceeding standards for "metals." In response to these listings, total recoverable and dissolved cadmium and copper data, and total mercury data, were collected in the lower Snohomish River, Ebey Slough, and Steamboat Slough from sites 14, 16, 20, 23, and 31 during surveys conducted on September 14, 1993, and May 24, 1994. Metals samples were collected during each survey from just below the surface at low and high tide.

All samples for laboratory analysis were preserved as specified in Huntamer and Hyre (1991). Laboratory analyses were performed in accordance with Huntamer and Hyre (1991). Field sampling and measurement protocols followed those specified in WAS (1993) for temperature (mercury thermometer), pH (Orion Model 250A meter and Triode™ pH electrode), conductivity (Beckman Model RB-5 and YSI 33), dissolved oxygen (Winkler titration), light extinction (Kahl Irradiameter Model 268WA310), streamflow (Marsh-McBirney 201 & 2000), and *in situ* temperature, dissolved oxygen, pH and specific conductance (Hydrolab® Datasonde®). Sampling water quality variables and frequency are listed in Appendix A.

Quality Assurance/Quality Control

All analyses were performed within the specified holding times for general chemistry and metals using standard methods (Huntamer and Hyre 1991). These data were reported by Ecology's Manchester Laboratory as usable with data qualifiers noted. Data quality objectives (DQOs) listed in the QAPP for this study were met except for the BOD_5 target detection limit of 2 mg/L. The reported detection limit for BOD_5 was 3 mg/L.

Replicate precision for general chemistry variables, calculated as the root mean square error of the coefficients of variation, are listed in Table 1. With the exception of chlorophyll and phaeopigment *a*, replicate precision was acceptable for most variables given the analytical ranges measured. Replicates for metals samples were all at reporting limit values, so no estimate of replicate precision can be provided. Field blank samples for all variables indicate no sample contamination at reporting limits. The laboratory's performance on one standard reference metal sample (Riverine Water Reference Material prepared by the National Research Council Canada) demonstrated an accurate measurement of copper, but the reporting limit for cadmium was above the reference value, and no mercury concentration was listed for the standard (see Appendix B.2).

Results and Discussion

Survey Data

The August survey and metals survey results are listed in Appendix B. The major purpose of the August 1993 survey was to collect data to use in calibrating a water quality model (see WASP5 Model Calibration). Overall, the survey results are consistent with the historical data reviewed in the QAPP. The survey data indicate that most of the tributaries in the study area have poor water quality. The water quality variables in the tributaries that may need to be controlled are fecal coliform, nutrients, and oxygen-demanding substances. The following is a brief summary of the data results with respect to the water quality variables measured:

Port Gardner, Snohomish River, Steamboat Slough, and Ebey Slough

Dissolved oxygen concentrations at sampling sites in these areas were found to be less than saturated and, as expected, inversely related to salinity (*i.e.*, lower oxygen marine water mixing with higher oxygen fresh water). Oxygen levels in lower Ebey Slough by Marysville were found to be as low as 6.6 mg/L. Ebey and Steamboat Sloughs had relatively high chlorophyll *a* concentrations (up to 7.4 μg/L in lower Ebey Slough). Ammonia was found in measurable amounts in Port Gardner, lower Snohomish River (downriver from where Ebey Slough branches off the mainstem), and the sloughs, but not in the upper river or Possession Sound, indicating that significant ammonia sources are confined to these areas or that uptake is higher in the upper river and Possession Sound. Fecal coliform concentrations were found to be below the state water quality criterion for all sampling sites in the lower part of the river and sloughs.

Appendix B.2 contains the results of the metal surveys. All of the samples for dissolved cadmium were below the reporting limit of 0.10 μg/L. Two dissolved copper samples, one from the mainstem of the Snohomish and one from Ebey Slough, were above the reporting limit of 1.0 μg/L, but below the criteria. Only one mercury sample was above the reporting limit of 0.0010 μg/L, but it also was below the criteria. Copper loading to the estuary may need to be controlled because it was also identified as a pollutant of concern in the Class II inspections for WWTPs discharging to the lower river and sloughs (see section on Class II inspections).

Marshland, Deadwater Slough, and Swan Trail Slough

These tributaries to the Snohomish were found to have the poorest water quality in the Snohomish River drainage. The data suggest that diel changes in dissolved oxygen may be high due to productivity (between sampling days, dissolved oxygen was 1.7 and 7.1 mg/L for the Marshland, and 8.9 and 15.0 mg/L for Deadwater Slough).

Levels of chlorophyll *a* indicate the waters are hypereutrophic (e.g., chlorophyll *a* concentrations in Deadwater Slough exceed 100 μg/L). Dissolved oxygen levels of less than 2.5 mg/L were measured in the Marshland and Swan Trail Slough. High levels of nutrients, turbidity, and fecal coliform bacteria were also found. Normally, surface waters have 5-day biochemical oxygen demand (BOD_5) of below 2 mg/L and total organic carbon (TOC) below 1 mg/L; values found in these waters ranged between 3-10 and 5-14 mg/L, respectively. It should be noted that discharges to the Snohomish River from the Marshland and Deadwater Slough are controlled by pumping stations. The pumps were not operating during the survey, and no measurable flow was observed in Swan Trail Slough.

Quilceda and Allen Creeks

Quilceda and Allen Creeks have poor water quality. Dissolved oxygen levels were below the Class A criterion, with one Allen Creek value measured at 1.0 mg/L. TOC concentrations of 4-5 mg/L were found, which implies loading of organic material to these systems. Fecal coliform levels exceeded the Class A criterion. There was no measurable flow in Allen Creek during the survey.

Pilchuck River

Generally, the water quality of the Pilchuck River was found to be good, however, some loading of organic material is suggested by the measured 2-3 mg/L of TOC.

French Creek

The water quality in French Creek is poor and similar to that of the Marshland, Deadwater Slough, and Swan Trail Slough. Low dissolved oxygen (<5 mg/L), high TOC (8-10 mg/L), and moderate BOD5 (3 mg/L) were found. Turbidity and nutrient levels were also high. It should be noted that, like the Marshland and Deadwater Slough, French Creek's discharge to the Snohomish River is controlled by a pumping station which was not operating during the survey.

Skykomish River, Sultan River, and Woods Creek

The water quality of the Skykomish River is good, but fecal coliform samples exceeded the Class A criterion downstream of the City of Sultan. The Sultan River has good water quality and does not appear to be loading atypical amounts of nutrients or suspended material to the river system.

Woods Creek appears to be the most anthropogenically affected tributary to the Skykomish River. Nutrients, TOC, and chlorophyll *a* were high, suggesting the creek may be eutrophic.

Class II Inspections

Class II inspections were conducted during the weeks of August 16 and 23 at the following municipal wastewater treatment plants: Everett, Marysville, Lake Stevens (Sewer District), Snohomish, Monroe, and Sultan. These inspections were conducted by Norm Glenn of WAS using standard operating procedures. The inspections assessed plant performance and effluent quality with respect to NPDES permit limits, determined loadings and WWTP removal efficiencies, and evaluated the permittee's self-monitoring efforts. Technical memoranda, including tables of inspection data results, summarizing the significant findings have been distributed and are in Appendix C. The results of the effluent monitoring portion of the inspections were used in establishing effluent pollutant loads for calibrating the water quality model.

WASP5 Model Calibration

An EPA-supported model, WASP5, was used to simulate the hydrodynamics and water quality of the estuary system (EPA 1993). The WASP5 system is composed of two independent computer programs, DYNHYD5 and WASP5. DYNHYD5 simulates water movement or hydrodynamics while the water quality program, WASP5, simulates the movement and interactions of chemical constituents within the water. WASP5 is composed of two sub-programs, EUTRO5 and TOXI5 which simulate conventional pollutants (involving dissolved oxygen, biochemical oxygen demand, nutrients and eutrophication), and toxic pollutants (involving organic chemicals and metals), respectively. The Snohomish River Estuary WASP5 model networks extends from an upstream boundary just below the confluence of the Skykomish and Snoqualmie Rivers, to six seaward boundaries in Possession Sound (Figures 4 and 5).

An existing calibrated and verified WASP4 (EPA 1988), sub-program DYNHYD4, hydrodynamic model of Everett Harbor and the lower Snohomish River, developed by Stein *et al.* (1991), was updated to DYNHYD5. The DYNHYD5 program was used to simulate segment hydrodynamics (e.g., velocities, volumes, depths, etc.) under changing tidal conditions and steady state river flow. In addition, the WASP5 kinetic sub-program EUTRO5 was linked to DYNHYD5 to simulate water quality variables such as dissolved oxygen and ammonia under steady state loading conditions. The resulting combined model portrays psuedodynamic conditions in the estuary (*i.e.*, steady state pollutant loading and river flow with changing tides, resulting in changing velocities, volumes, and depths).

Although the lower Skykomish River was also in the study area, it was not included in the WASP5 model network. Extending the model upstream to include the City of Monroe and Sultan WWTPs was not considered necessary because water quality in the Skykomish River is good and the dischargers are very small relative to river flow. The oxygen demand of these discharges is discussed in more detail later.

Hydrodynamic Model Input Data

The hydrodynamic model link-node (channel-junction) network is presented in Figure 4. The DYNHYD5 input data set used to calibrate the Snohomish River Estuary System water quality model can be found in Appendix D.1. The input data set includes model junction and channel geometry, Manning's roughness coefficient, inflow, and seaward boundary tide data. The following is a description of the contents of the model "Data Groups" as defined in the input data set:

- **Data Group A--Simulation Control:**
  Consists of data such as number of junctions (83), number of channels (115), and simulation time step (60 seconds).

- **Data Group B--Printout Control:**
  Specifies printing options such as time for printout to begin and time interval between printouts.

- **Data Group C--Hydraulic Summary:**
  Specifies the type of file that will contain storage of flows and volumes. (This is where the stored file for linking DYNHYD to EUTRO5 is specified to be created.)

- **Data Group D--Junction Data:**
  Describes the model network and initial conditions at each junction, such as junction number, initial head (m), surface area at junction (m^2), bottom elevation (m), and channel number entering a junction. MLLW was used as the horizontal reference datum for geometry data.

  The original Stein *et al.* model input junction geometry data were modified as follows: maximum bottom elevations for junctions in Possession Sound were set at -5 meters MLLW; bottom elevations and surface areas for junctions in the river mainstem and sloughs were corrected, relative to MLLW, based on data collected from 63 cross-sections by Snohomish County Public Works (Snohomish County 1989).

  Bottom elevations in Possession Sound were set at -5 meters MLLW based on the likelihood that estuary freshwater and saltwater mixing will be confined to the upper layer of water. This modification has the effect of minimizing dilution of water from the Snohomish River and sloughs, thereby increasing the potential for water quality changes in Possession Sound due to river discharge.

- **Data Group E--Channel Data:**
  Describes the model network and initial conditions at each channel, such as channel number, length of channel (m), width of channel (m), depth of channel (m), Manning roughness coefficient, and the initial channel velocity (m/sec).

  The original Stein *et al.* model input channel geometry data were modified as follows: cross channel widths in Possession Sound were reduced to one meter, and main channel widths were increased such that the sum of the seaward boundary main channels were approximately equal to the width of the bay; channel widths in the river mainstem and sloughs were corrected, relative to MLLW, based on data collected from 63 cross-sections by Snohomish County Public Works (Snohomish County 1989).

  Channel widths in Possession Sound were modified to correct numeric instability encountered when trying to calibrate the water quality model to salinity (*i.e.*, multiple channels intersecting at junctions in Possession Sound caused mass balance instability, apparently due to the large tidal exchange and short time steps; reducing the cross channel widths corrected the mass balance instability).

- **Data Group F--Inflows:**
  Lists all inflows (m^3/sec) into the model system (to introduce a flow across a boundary into the network it must be negative). Table 2 lists the flow values used in the hydrodynamic model for calibrating the water quality model. The Snohomish River headwater inflow was set at the average flow for the two day survey reported from the USGS Snohomish River station (12150800) located near the City of Monroe at about RM 20. Inflows for other tributaries were set at the two day average flow measured by the survey team. WWTP discharges measured during the Class II inspections were also included as inflows.

  Ground water inflow estimates were provided by Denis Erickson, a Toxics Investigations Section Hydrogeologist, from the headwaters at RM 20 to junction 49 at RM 8 (where Ebey Slough branches off the mainstem of the river). The estimates were made as the highest probable ground water contribution in the area during low river flow conditions. Erickson estimated ground water flows from RM 12.5 to RM 20 to be as high as 1.1 cfs per mile based on hydraulic gradients (from surface water elevations on a 7-½ minute topographic map) and hydraulic conductivity (from grain size material descriptions for Fryland-French Creek aquifer, Pilchuck Creek aquifer, and the Marshland aquifer). In the area downstream of the City of Snohomish, Erickson estimated ground water input to be 0.5 cfs per mile primarily due to local infiltration of precipitation on the floodplain. Erickson suggested that no significant ground water contributions would be made downstream of RM 8.

- **Data Group G--Seaward Boundaries:**
  Establishes the number and type of seaward boundaries. WASP5 tide option 3 was used to simulate variable tides at the seaward boundary. This option requires entries of day, time, and tide elevation or head (m). The seaward boundaries were set to a series of daily tides estimated to occur at Mukilteo starting on August 2, 1993, using TideMaster™ (Zephyr Services 1988). The water quality survey period corresponds to tide days 14 and 15 in the input file. The tides for the six boundary junctions were offset by 6 minutes to account for the time difference across the bay (Mukilteo to Tulalip).

- **Data Groups H-K:**
  Not used.

- **Data Group L:**
  Provides junction to segment map to link DYNHYD5 to EUTRO5.

Water Quality Model-Calibration Input Data

The WASP5 sub-program EUTRO5 was used to simulate simple eutrophication kinetics in the river and estuary system that include the interactions and effects of the following: ammonia nitrogen, nitrate nitrogen, inorganic phosphorus, phytoplankton carbon, carbonaceous BOD, dissolved oxygen, organic nitrogen, and organic phosphorus.

Figure 5 shows the EUTRO5 spacial network that corresponds to the DYNHYD5 network. Each EUTRO5 segment corresponds exactly to a hydrodynamic volume element, or junction, and each segment interface corresponds exactly to a hydrodynamic link, or channel. It is important to note that the hydrodynamic model has additional junctions outside the EUTRO5 model network. These DYNHYD5 junctions correspond to EUTRO5 boundaries and are denoted in Figure 5 with a segment number "0." These extra junctions are necessary because EUTRO5 requires boundary flows from outside its network.

Data from the 1993 surveys and scientific literature were used to calibrate the EUTRO5 model to the Snohomish River estuary system. The EUTRO5 calibration input file is in Appendix D.2. The following is a description of the contents of the calibration model "Data Groups" as defined in the input data set:

- **Data Group A--Model Options:**
  Provides descriptive model identification and contains simulation control options. Some of the important model options specified are the number of segments in the network (80), number of systems or state variables modeled (9), advection factor (0.15), and day (1) and time (01.00) of simulation.

Tetra Tech, Inc. version 5.11s of EUTRO5 was used because it includes the additional system variable "salinity," which allows segment salinity to change as the tides change, thereby accounting for the effect of varying salinity on dissolved oxygen saturation calculations.

- **Data Group B--Exchanges:**
  Introduces dispersive exchange information. Dispersion coefficients are a key model parameter in establishing the EUTRO5 model, because they affect the distribution of a given pollutant. The coefficients were determined by matching model-predicted salinity values to the August 1993 survey data (see WASP5 Model Calibration Results).

  It should be noted that development of dispersion coefficients is not usually considered a calibration step, because dispersion characteristics of an estuary are likely to change under different hydrodynamic circumstances. However, since the purpose of this modeling was to predict water quality under similar hydrodynamic conditions (i.e. low river flow and similar tide range), defining dispersion characteristics using salinity could be considered the first step in model calibration.

- **Data Group C--Volumes:**
  Lists segment type and numbers, and initial segment volumes for calculating reaeration and volatilization rates. The rate of reaeration is calculated in the EUTRO5 model using the average segment depth provided in this data group, and the velocities and flows provided by DYNHYD5 for each time step.

- **Data Group D--Flows:**
  Enables EUTRO5 to be linked to DYNHYD5 through an external hydrodynamic file (*.HYD) containing segment volumes at the beginning of each time step, and average segment interfacial flows during each time step. EUTRO5 uses flows to calculate mass transport and volumes to calculate constituent concentrations. Segment depths and velocities are used only to calculate reaeration and volatilization rates.

- **Data Group E--Boundary Concentrations:**
  Specifies upstream (headwater) and downstream (seaward) boundary concentrations for the state variables: ammonia, nitrate, inorganic phosphorus, chlorophyll *a*, CBOD, dissolved oxygen, organic nitrogen, organic phosphorus, and salinity. Model boundaries are segments that import, export, or exchange water with locations outside the network. Upstream (freshwater) boundary concentrations were set at the average concentration measured during the two day August 1993 survey. Downstream (marine) boundary concentrations, except for dissolved oxygen and salinity, were set at the average value of survey samples collected on August 24 at 0.5 and 10 meter depths at a site

near the model downstream boundary. Downstream boundary concentrations for salinity and dissolved oxygen represent the average of 0-10 meter profile data collected with an *in situ* monitor. The boundary concentrations used to calibrate the EUTRO5 model are presented in Table 2.

- **Data Group F--Waste Loads:**
Lists loads for WWTPs and tributaries. A summary of the concentrations and flows used to calculate loading are listed in Table 2. WWTP effluent water quality variable concentrations were derived by Norm Glenn from the Class II inspection results summarized in Appendix C. The ratio of ultimate CBOD to BOD_5 was set to the EPA (1987) recommended value of 1.46, because ultimate CBOD laboratory test conducted during the Class II inspections were not successful (personal communication, Norm Glenn).

- **Data Group G--Parameters:**
Introduces spatially-variable environmental characteristics of the waterbody, such as segment temperature in °C (TMPSG), light extinction coefficient in m^{-1} (KESG), and sediment oxygen demand in g/m^2-day (SOD1D). These system characteristics vary with each model segment. Segment temperatures were set at values corresponding to or interpolated from the average survey data collected at sampling locations associated with the model network. Segment light extinction coefficients were estimated from *in situ* data collected at five sampling sites, then interpolated to all segments. Segment sediment oxygen demand was the main system characteristic used to adjust oxygen levels to calibrate to surface water data, and values were set between 0 and 9.5 g/m^2-day. Sediment oxygen demand measured on July 9-10, 1976 at 5 locations in the lower part of the river were found to range between 0.3 and 2.7 g/m^2-day (URS Company 1977).

  Although measured values of sediment oxygen demand in estuaries have been reported as high as 10.7 g/m^2-day, EPA cited an average value of sediment oxygen demand for estuarine mud to be 1.5 g/m^2-day (EPA 1985).

- **Data Group H--Constants:**
Designates constants used in the EUTRO5 model to simulate simple eutrophication kinetics. These constants, listed in Table 3, control the interaction of dissolved oxygen and associated variables. In order to simulate simple eutrophication, five EUTRO5 state variables are modeled: ammonia, nitrate, phytoplankton carbon, carbonaceous biochemical oxygen demand, and dissolved oxygen. The constants defined for these state variables are treated as global (*i.e.*, the constants for each state variable apply to all segments in the system).

  Except for the following, all of the constants were selected from within ranges recommended by USEPA (1985 1991): the value for the saturated growth rate of phytoplankton (K1C) was set to a value that would best fit the chlorophyll *a* data, and the CBOD deoxygenation rate (KDC) was set to the average rate determined from the ultimate CBOD river/estuary samples collected during the survey.

The EUTRO5 model allows for correction of reaction rates, from the rate at 20°C (which rates are usually reported at), to the ambient temperature set for the system during model simulations. The temperature correction coefficients recommended by EPA (EPA 1985, 1991) are also listed in Table 3.

- **Data Group I--Time Functions:**
  Enters time functions for total daily solar radiation (392 Langleys), fraction of day with sufficient light for phytoplankton growth (0.58), and percentage of water surface available for reaeration (100%). Total daily solar radiation was set to the average of values measured at the water's surface during the light extinction surveys; the daily phytoplankton growth period was estimated as the percentage of daylight for August; and reaeration was assumed to occur over the entire surface area of each segment.

- **Data Group J--Initial Conditions:**
  An original set of initial conditions for the state variables were set for all segments based on survey data. The initial conditions presented in the input file in Appendix D.2 are model output (predicted) values calculated after running the model to a point in time equal to the model starting tide conditions (*i.e.*, tide with the head at junction 1 of the hydrodynamic model equal to 1.6943 m above MLLW).

WASP5 Model Calibration Results

The model calibration was confirmed by comparing observed and simulated results for the survey period. Table 4 lists the overall root mean square error (RMSE) between the predictions and observations for salinity, dissolved oxygen, chlorophyll *a*, ammonia, and phosphorus. The estimate of model variation represented by the RMSE demonstrates a good model fit, relative to the ambient data range measured in the modeled system, for all these water quality variables with the possible exception of chlorophyll *a*. A "good model fit" was defined with respect to three qualitative criteria: (1) did the variable concentration increase or decrease as expected, e.g., dissolved oxygen increases during low tide and decreases during high tide; (2) how did the RMSE compare to other reported model and observed deviations, e.g., Pelletier (1993, 1994) reported dissolved oxygen RMSEs for models representing the Puyallup and Spokane Rivers of 0.20 and 0.38 mg/L, respectively, and an ammonia RMSE for the Spokane of 0.01 mg/L; and (3) how does the RMSE compare to temporal variability and measurement variability, e.g., *in situ* data suggest that diurnal dissolved oxygen changes upstream of tidal effects were at least 0.2 mg/L, and the RMSEs for ammonia and phosphorus were close to detection limits.

The estimator of model fit for chlorophyll *a* is strongly influenced by the poor fit of the model at two sites in Ebey Slough. In addition, the model fit reflects poor replicate precision for both chlorophyll *a* and phaeopigment *a* (chlorophyll *a* values are adjusted for the presence of degradation products during laboratory analysis).

Figures 6-12 are representations of salinity and dissolved oxygen at selected segments which compare survey data against model predictions over the two-day August sampling period. Changing tide heights are also shown on the graphs. In general, the model appears to be a reliable predictor of salinity and dissolved oxygen. While not shown, model predictions of ammonia appear to account for most of the ammonia measured during the survey, which suggests WWTP discharge is the major source of ammonia in the river and sloughs.

Water Quality Criteria and Classifications

The Snohomish River from the mouth upstream to the confluence with the Skykomish and Snoqualmie Rivers is currently classified as Freshwater Class A. From the river mouth upstream to the southern tip of Ebey Island a special condition has been established for fecal coliform: fecal coliform organism levels shall neither exceed a geometric mean value of 200 cfu/100 mL nor have more than 10 percent of the samples obtained for calculating the mean value exceeding 400 cfu/100 mL. Inner Everett Harbor northeast of a line bearing 121 degrees true from approximately 47°59'5"N and 122°13'44"W (approximately southwest corner of pier--Figure 3) is Marine Class B. Possession Sound (North of Mukilteo) is Marine Class A.

Estuarine systems are transitional environments between saltwater and freshwater habitats. In recognizing this, WAC 173-201A-060(2) states:

> In brackish waters of estuaries, where the fresh and marine water quality criteria differ within the same classification, the criteria shall be interpolated on the basis of salinity; except that the marine water quality criteria shall apply for dissolved oxygen when salinity is one part per thousand or greater and for fecal coliform organisms when salinity is ten parts per thousand (o/oo) or greater.

In the QAPP for the Snohomish River Estuary TMDL, WAS proposed using the vertically-weighted mean salinity of 1 ‰ at Mean Higher High Water (MHHW ≈ 11.1 feet) during low river flow to define the estuary's upstream boundary. WAS also proposed applying the Class A marine dissolved oxygen criterion in the area between the proposed upstream boundary and the mouth of the river and sloughs. Both of these proposed interpretations of the WAC are supported by Ecology's Shorelands Program classification of aquatic habitats (personal communication, Tom Hruby).

The classification scheme used by U.S. Fish and Wildlife Services (FWS), and supported by Shorelands, for wetlands and deepwater habitats identifies the limits of an estuarine system to extend upstream and landward to where ocean-derived salts measure less than 0.5 $^o/_{oo}$ during the period of average annual low flow and at MHHW (FWS 1979). WAC 173-22-030(6ii), designation of wetlands regulations, states:

> In low energy environments where the action of waves and currents is not sufficient to prevent vegetation establishment below mean higher high tide, the ordinary high water mark is coincident with the landward limit of salt tolerant vegetation. "Salt tolerant vegetation" means vegetation which is tolerant of interstitial soil salinities greater than or equal to 0.5 $^o/_{oo}$;

The intent of the FWS and WAC language for delineation of the ordinary high water mark is to define and protect estuary habitat based on salt-tolerant biota. The Shorelands estuary boundary definition suggests that using 1 $^o/_{oo}$ at MHHW to define the upstream boundary of an estuary is a conservative estimate of the zone of salt tolerant biota.

In addition to being dependent on tide height, the extent of saltwater movement up river is also a function of river flow. Conductivity measurements collected during the August 1993 survey, when the river flow was 2,990 cfs, were used to calibrate the water quality model. Again, in order to be consistent in defining the extent of an estuarine system, the average annual low flow (*i.e.*, 6,577 cfs) combined with the other conditions described above were used to define the saltwater-tolerant biotic zone. Model-predicted salinities for the mainstem of the river (RM 0 to 20) at MHHW using river flows equal to 1,051 (low flow 7Q20), 2,990, and 6,577 cfs, are shown in Figure 13. The resultant model-predicted estuary boundary (1 $^o/_{oo}$) using a river flow of 6,577 cfs is annotated in Figure 3.

WAS is also proposing that for toxic substances, Ecology apply the Environmental Protection Agency's National Rule for Toxics language that in summary recommends: freshwater toxics criteria be applied to waters with salinity less than 1 $^o/_{oo}$; saltwater criteria be applied in waters with salinity greater than 10 $^o/_{oo}$; and, the more stringent criteria be applied in waters between 1 and 10 $^o/_{oo}$. Applying the National Toxics Rule language for defining areas to apply criteria for toxics is supported by the Water Quality Program (Ecology 1994). Therefore, the Toxics Rule language will be used as the method for interpolating between salinities of 1 and 10 $^o/_{oo}$.

In summary, the following were used and recommended in this report to define the Snohomish estuary boundary and for applying appropriate water quality criteria:

1. Tide height corresponding to MHHW (*i.e.*, 11.1 feet).

2. Average annual low river flow (*i.e.*, 6,577 cfs).

3. Model-predicted salinities of 1 ‰ to apply marine Class A criteria for dissolved oxygen.

4. National Toxics Rule language to apply marine or freshwater criteria for toxic substances.

5. Continue to use special condition criterion for fecal coliform in the lower river and sloughs.

Dissolved Oxygen Standard and Targets for WASP5 Modeling

Following the recommendations discussed in the previous subsection, it is necessary to apply appropriate marine criteria to the estuary upstream of the mouth of the river and sloughs. WAS is proposing to apply the Marine Class A dissolved oxygen criterion of 6.0 mg/L in this area. The criteria for the modeled area would then be as follows: 6.0 mg/L for Possession Sound, 5.0 mg/L for Inner Everett Harbor, 6.0 mg/L for the river/slough estuary, and 8.0 mg/L for the rest of the Snohomish River, Ebey Slough and tributaries (annotated on Figure 3).

In addition to these criteria, the marine classifications in WAC 173-201A allow dissolved oxygen levels to be degraded up to 0.2 mg/L by human-caused activities when natural conditions are below the criterion. WAS recommends a 0.2 mg/L degradation in dissolved oxygen also be allowed in the freshwater portion of the Snohomish River where natural conditions are projected to be at or below the freshwater criterion (see Dissolved Oxygen Predictions Under Critical Conditions).

Modeling Critical Conditions

After verification of the calibrated WASP5 model using data collected in 1996, the model will be used to determine WLAs and LAs for the estuary system under critical design conditions. However, for this report, critical conditions were evaluated in the pre-verified model to estimate the potential effects of current and future waste loading to the estuary.

Critical conditions are those possible physical, chemical, and biological characteristics of the receiving water and pollutant loading sources that can increase the adverse effects of a pollutant of concern (e.g., lower river flow and increased temperature would increase the effect of a given BOD load). For the Snohomish River Estuary, the critical period was set to July through October (summer) based on a review of ambient data for the Snohomish River drainage by Ehinger (1993) presented in the QAPP. The ambient data showed that the probable combined occurrence of high temperature, low dissolved oxygen, and low river flow would be restricted to these months.

Table 5 lists estimated critical conditions for the modeled system. The following section is a summary of how the critical condition values for river flow (and tides), boundary and tributary concentrations, effluent discharge characteristics, and model segment characteristics were established.

River Flow and Tides

Critical river flows for the period were estimated as the 7-day average low flow with a recurrence interval of once every 20 years (7Q20) (Ecology 1991). Flow distribution estimates and flow statistic calculations for the Snohomish River were made using WQHYDRO (Aroner, 1992). Table 6 displays estimated critical flows for the mainstem of the Snohomish and Skykomish Rivers and their tributaries, including the annual 7Q10 and winter 7Q20 (November through June) statistics for comparison to the summer 7Q20.

USGS stations on the Snohomish River near Monroe (12150800), Sultan River near Sultan (1213800), and the Skykomish River near Goldbar (12134500) were used to determine flow statistics at these points in the basin. Critical flows for the Skykomish River near Monroe and the Pilchuck River near Snohomish were derived from regression relationships using Snohomish River station data and miscellaneous USGS flow data collected for these areas (Williams and Riis 1989). Critical flows on the Skykomish near Sultan were estimated by taking the difference between the Monroe and Goldbar Skykomish values, then interpolating based on river mile. The flow for the Snoqualmie River at its mouth was calculated as the difference between the Snohomish and Skykomish near Monroe values. (Note: Joy 1994, estimated the annual 7Q10 at the Snoqualmie's mouth using Snoqualmie River flow data to be 443 cfs.) The critical low flow for Quilceda Creek was set to the lowest flow measured for the summer period at the USGS gage on Quilceda near Marysville (1711011) from 1974-77 (Williams and Riis 1989). Flow for Allen Creek for the summer period was assumed to be "0" since no flow was observed during the survey.

Although no discharge was observed during the August 1993 survey from the "pumped" tributaries, an estimated discharge was included for the critical condition scenario. The average daily (July-October) pumping rate for French Creek was estimated by Rod Denherder of the U.S. Department of Agriculture, Renton, Washington, from pumping records for 1993. Since no records are available for the Marshland and Deadwater sloughs, an average daily value was estimated from the relative size of these drainages to French Creek.

Since no guidance exists for establishing critical tides, the August 1993 tides used in model calibration were also used as critical condition tides. For critical condition predictions, the model was run for 24 days corresponding to tides that occurred from August 2 through August 25, 1993. The 24-day period allows the model to simulate two typical spring and neap tide sequences.

Boundary and Tributary Concentrations

For most water quality variables, critical conditions for the upstream and downstream boundary, July-October period, were based on the 90th percentile of data from Ecology's ambient stations near the City of Snohomish and near Gedney Island (07A090) and PSS019, respectively). The seaward boundary conditions for temperature and dissolved oxygen were based on the most extreme (*i.e.*, high temperature and low dissolved oxygen) 10-meter vertically averaged profile data collected at PSS019 from 1990-94. Upstream and downstream boundary temperatures were set at 19.4 and 16.3°C. Tributary critical conditions were set to the same values as those measured during the August 1993 survey except for the Pilchuck River, which were based on the 90th percentile of data from Ecology's ambient station near the City of Snohomish (07B055). In addition, temperatures for all other tributaries were set at the upstream boundary value of 19.4°C.

Effluent Discharge Characteristics

Effluent critical condition characteristics for flow, ammonia, and $CBOD_5$ were provided by NWRO permit writers responsible for managing NPDES permits. All other effluent characteristics were set to those measured during the August 1993 Class II inspections.

Model Segment Characteristics

All model segment characteristics, except temperature, were those established during model calibration. Segment temperatures were based on interpolating the 90th percentile temperatures measured at the following Ecology historical ambient stations located within the model network: PSS005, PSS008, PSS009, PSS015, PSS016, PSS018, and PSS020.

Dissolved Oxygen Predictions Under Critical Conditions

The WASP5 pre-verification model results are presented in Figures 14-16 for dissolved oxygen. The graphs represent the predicted minimum and maximum dissolved oxygen concentrations, with and without loading sources, for the mainstem of the Snohomish River, Steamboat Slough, and Ebey Slough. The insert graph in Figure 14 shows how predicted values from the 24-day model run were used to construct the dissolved oxygen profiles for the series of segments corresponding to river miles shown on the X-axis. The profile presented in Figure 14 corresponds to the most direct line of segments from the seaward boundary at segment 2 to the headwaters at segment 76 (Figure 5). The profiles in Figures 15 and 16 both start at segment 6 and extend to the upper-most segment in each slough (*i.e.*, segment 58 for Steamboat Slough and 70 for Ebey Slough).

The dissolved oxygen profiles for the mainstem and sloughs show that the predicted minimum dissolved oxygen values without loading are below both the freshwater and marine criteria for most of the system. When the loading sources are added, the minimum dissolved oxygen values are only slightly lower in Steamboat (up to 0.06 mg/L deficit) and Ebey Sloughs (up to 0.05 mg/L deficit). However, the projected deficit caused by loading on the Snohomish River is as great as 0.27 mg/L at segments 35 and 36, which exceeds the 0.2 mg/L deficit allowed by the standards when natural conditions are below the criterion. Eighty-nine percent of the deficit at these segments is predicted to be caused by BOD loading from the Everett mechanical and lagoon WWTP discharges (58% due to ammonia and 31% due to CBOD). These estimates are preliminary, and any actions should wait until the model is verified and final WLAs and LAs are recommended.

The dissolved oxygen profile in the freshwater portion of the modeled area shows a rapid decline in dissolved oxygen starting at the furthest upstream tidally influenced point around RM 18 (Figure 14). The freshwater zone of Ebey Slough and the lower mainstem are projected to have natural conditions below the freshwater criterion (Figure 14 and 16).

Diel changes in dissolved oxygen were not incorporated in the modeling effort because *in situ* hourly monitoring data collected August 24-26, 1993 at sites 14, 16, 20, 23, 24, and 31 suggest that: (1) changes in dissolved oxygen in the lower part of the river were dominated by tidal effects (*i.e.*, changes in dissolved oxygen were associated with changes in conductivity); and (2) upstream of saltwater influences (site 4), diel variation in dissolved oxygen concentrations were estimated to be only between 0.2 to 0.4 mg/L. Also, model predictions suggest that most of the system loading will be determined by an allowable 0.2 mg/L deficit below natural conditions, thus making absolute dissolved oxygen values (including diel effects) less important as a standard.

Oxygen Demand of WWTPs on the Skykomish River

The oxygen demand of discharges from the City of Monroe and Sultan WWTPs were estimated using critical conditions, listed in Table 6, in a spreadsheet model (DOSAG.WK1) based on Streeter-Phelps equations (Ecology 1994). Critical WWTP flows and $CBOD_5$ concentrations were provided by Ecology permit managers. In order to assess the contribution of each WWTP to the dissolved oxygen deficit, upstream CBOD and NBOD were set to zero.

The estimated critical dissolved oxygen deficits caused by the Monroe and Sultan WWTPs were 0.03 and 0.02 mg/L, respectively (Appendix E). Even though the analysis estimates are based on only one set of flow and channel characteristics that occur near each plant, the results indicate that these plants will not likely impact dissolved oxygen in the river system under critical conditions.

Recommended Data Needed to Improve Model Accuracy

The water quality modeling presented in this report is the first phase of the Snohomish River Estuary dry season TMDL study. The second phase will involve collecting effluent and ambient data to verify the model's accuracy, and collecting additional data to confirm model geometry and calibration assumptions. The following is a list of tasks that should be completed before final WLAs and LAs for ammonia and BOD are recommended by WAS.

1. Conduct 2-3 CTD profile surveys of the lower Snohomish River, extending into Port Gardner, to ascertain the mixing characteristics of the estuary with respect to dissolved oxygen during July - October. In addition, collect data on the potential influences of primary productivity on dissolved oxygen (*i.e.*, algal biomass contributions to CBOD). This data will be used to better define the relationship between downstream boundary conditions and dissolved oxygen concentrations in the lower river and sloughs.

   Note: The high values of sediment oxygen demand needed to calibrate the water quality model possibly reflect inaccurate assumptions with respect to mixing characteristics and dissolved oxygen concentrations, and algal biomass contributions to CBOD.

2. Re-evaluate model geometry characteristics such as widths and depths in channels where, under critical conditions, the minimum dissolved oxygen concentration is predicted to be more than 0.2 mg/L below natural conditions. As discussed in the background section, channel morphology can be expected to significantly change over time in the lower river and sloughs. Changes or errors in channel widths and depths could significantly modify model predictions due to differences in hydrodynamic characteristics.

3. Verify with permit managers the discharge characteristics of the point source loads used as critical conditions. For example, in the Puyallup River BOD TMDL, permit managers recommended using the following critical conditions for far-field dissolved oxygen modeling: (1) seasonal daily maximum flows as the critical WWTP flows; (2) loading limits to establish critical concentrations for BOD_5; and (3) water quality-based daily maximum ammonia permit limits as the critical concentrations for ammonia (determined by mixing zone evaluations). In addition, permit managers need to resolve inconsistencies in critical conditions and NPDES permit limits. For example, City of Everett WWTP BOD_5 weekly average permit limits in lbs/day are higher than the model loading that was calculated from the

product of critical flow and weekly average concentration of 45 mg/L. In the final modeling effort to establish BOD and ammonia WLAs, critical conditions need to be consistent with future permit limits.

4. Incorporate the results of mixing zone studies for Everett, Marysville, and Lake Stevens WWTPs, with respect to any water quality-based ammonia limits, into final dissolved oxygen model predictions.

5. Collect ambient and effluent data, in the modeled area, during the summer of 1996 to verify the accuracy of model predictions. Emphasis should be placed on verifying effluent ultimate BOD/BOD_5 ratio.

Summary and Conclusions

- A psuedodynamic model of dissolved oxygen in the Snohomish River Estuary was developed using WASP5. The model was calibrated using data collected in August and September 1993. A measure of error analysis of the differences between predicted and observed values of salinity and dissolved oxygen indicate the model is an acceptable predictor for these variables. However, verification of the model still needs to be completed to determine whether the model is an accurate representation of the river and estuary.

- An interpretation of the current freshwater and marine water quality classification standards for the Snohomish River Estuary is proposed based on salinity influences in the lower river and sloughs. The proposed adjustment suggest extending the Marine Class A dissolved oxygen criterion upstream to a boundary where salinity would equal 1 $^{o}/_{oo}$ when the tide is at MHHW and river flow is equal to the annual average low flow.

- The calibrated model estimate of dissolved oxygen under critical conditions indicates that natural conditions in a large portion of the lower river and estuary would be below the dissolved oxygen criteria, even after adjusting the marine classification boundary upstream based on salinity. Comparing the predicted anthropogenically-caused dissolved oxygen deficit to an allowable 0.2 mg/L deficit suggests that only a few segments in the modeled system would not meet dissolved oxygen criteria. The affected segments appear to be mostly impacted by BOD loading from the Everett mechanical and lagoon WWTP discharges, though model verification will need to be completed before final WLAs decisions can be made for any of the discharges to the estuary.

- Streeter-Phelps analyses of the City of Monroe and Sultan WWTPs, under critical conditions, suggest that these plants would have only a small effect on dissolved oxygen concentrations. Permit limits for these discharges to the Skykomish River should be based on technology and mixing zone evaluations only.

- In the freshwater portion of the Snohomish River system estimated to have natural conditions below the freshwater Class A oxygen criterion, it is recommended that a 0.2 mg/L anthropogenically-caused dissolved oxygen deficit be allowed.

- A model verification study should be conducted that includes collecting additional information on the major causes of low dissolved oxygen in the river and sloughs. In addition, better information should be collected on the discharge characteristics of the WWTPs (including mixing zones) and pumping stations located on French Creek, Marshland, and Deadwater Slough.

- Survey and historical data identify high fecal coliform, high nutrients, and low dissolved oxygen concentrations as water quality problems common to most of the tributaries in the study area. It is recommended that TMDL studies be conducted to document water quality violations and establish target reductions for fecal coliform concentrations in Quilceda Creek, Allen Creek, French Creek, Woods Creek, and the Pilchuck River. A study should also be conducted to identify causes of low dissolved oxygen in Quilceda Creek, Allen Creek, French Creek, Marshland, Deadwater Slough, and Swain Trail Slough.

- Copper was identified as a possible problem pollutant in the Class II inspections and measurable dissolved copper was found in the lower river and sloughs. These findings suggest that copper loading may need to be controlled through the development of a TMDL.

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Figures

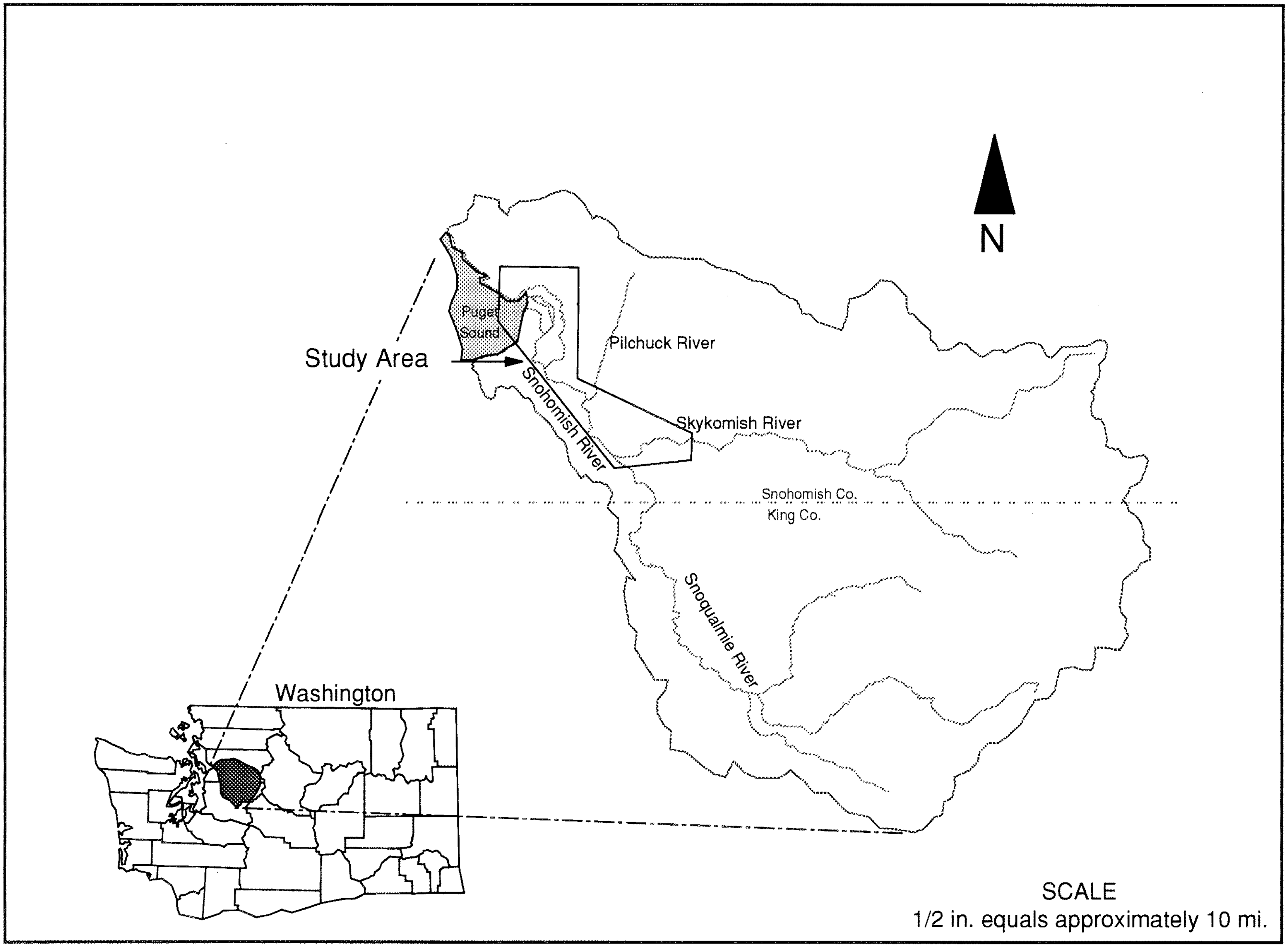

Figure 1. Snohomish River Basin and TMDL study area location map.

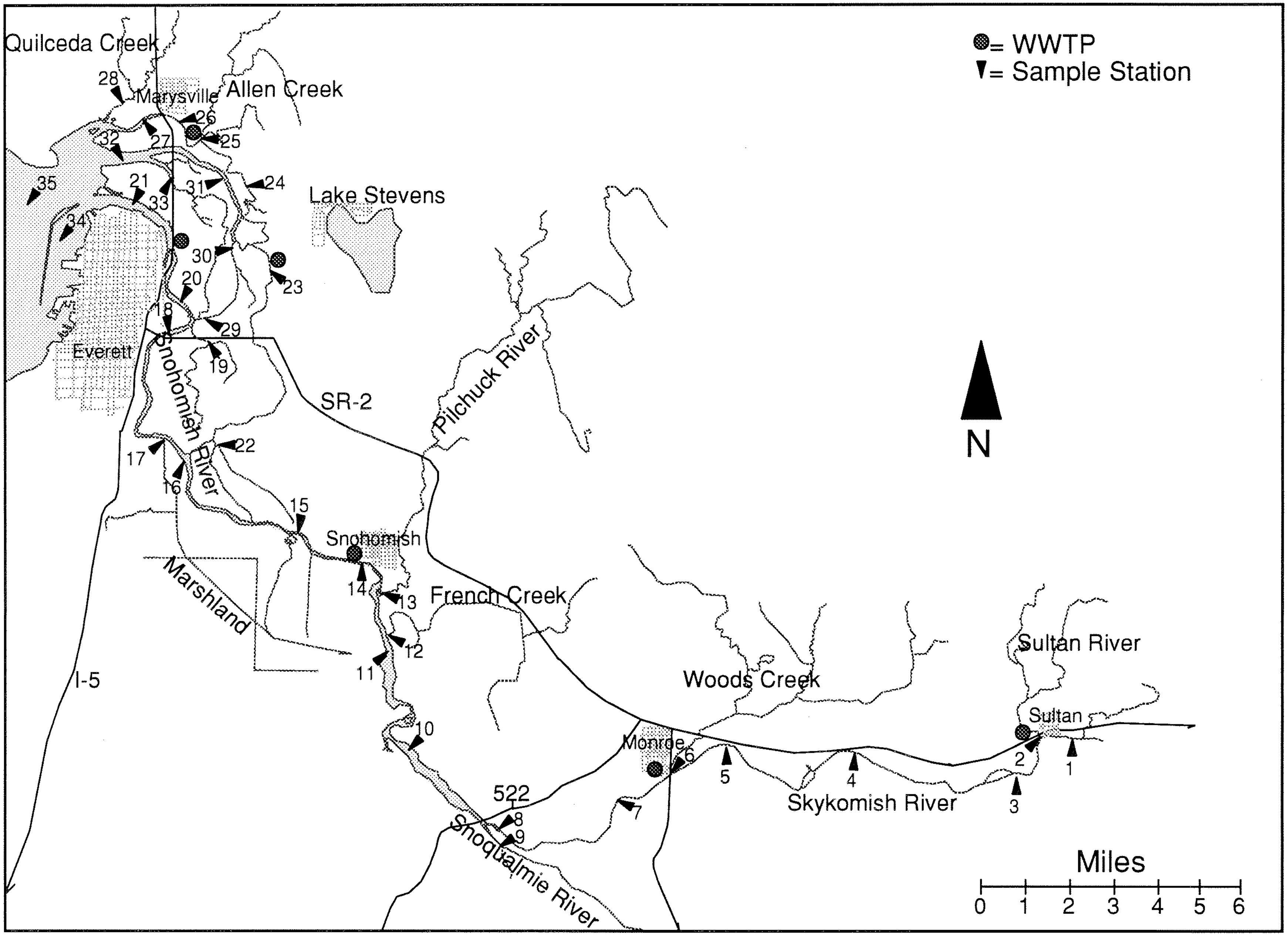

Figure 2. Study area map with sampling stations and wastewater treatment plants (WWTPs) annotated.

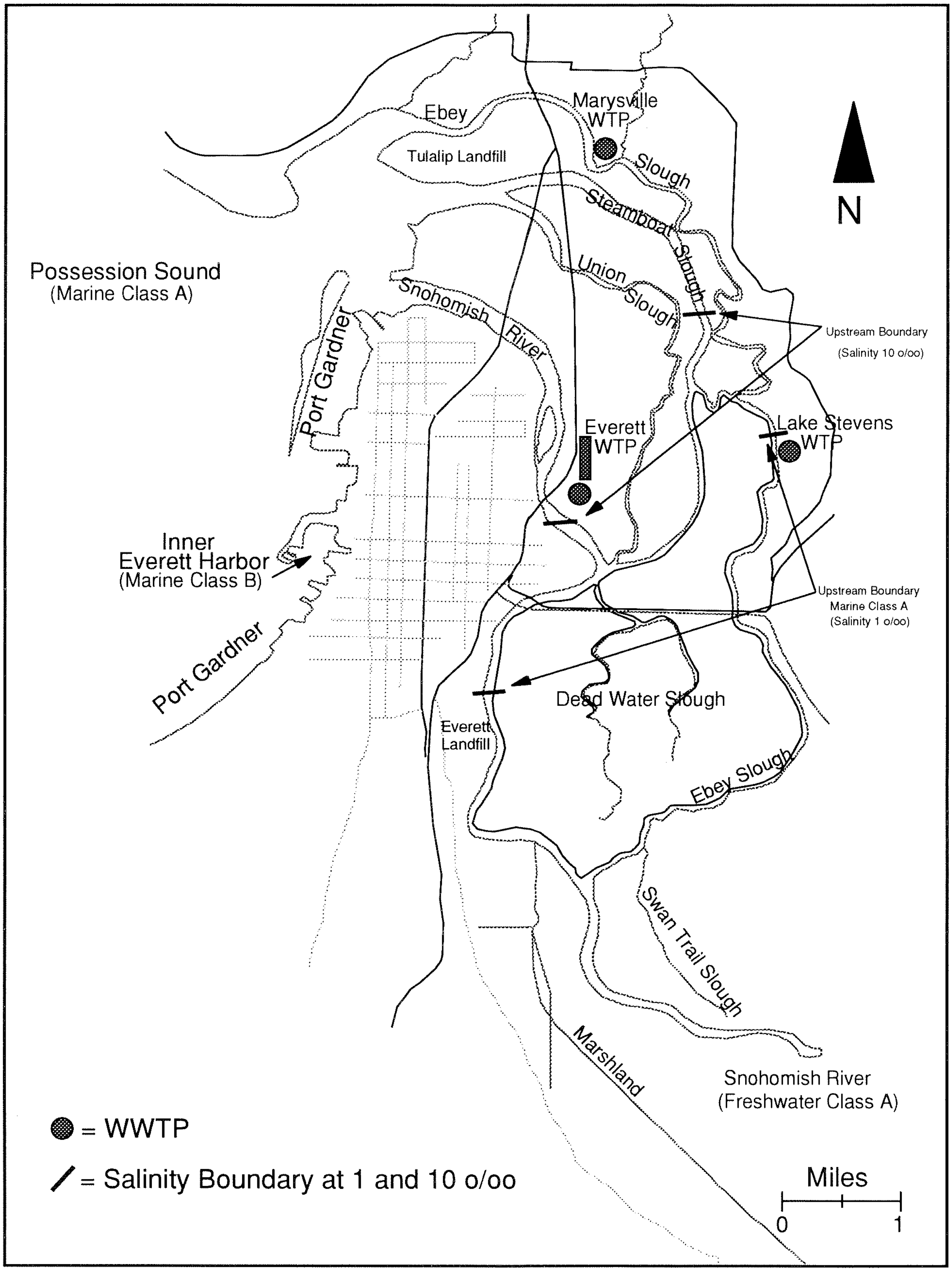

Figure 3. Map of sloughs and near shore estuary within study area.

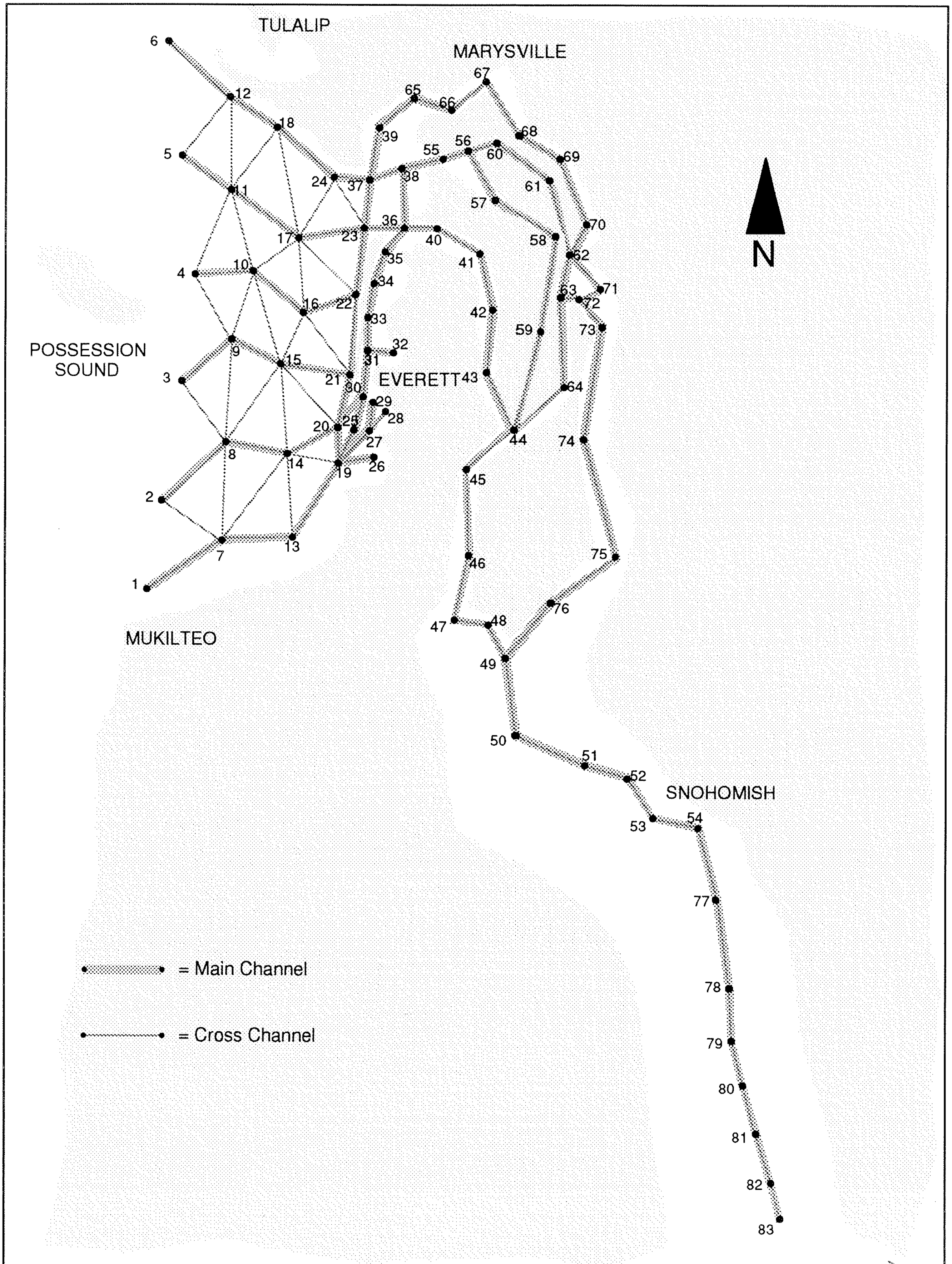

Figure 4. Link-Node network for the Snohomish River Estuary hydrodynamic model.

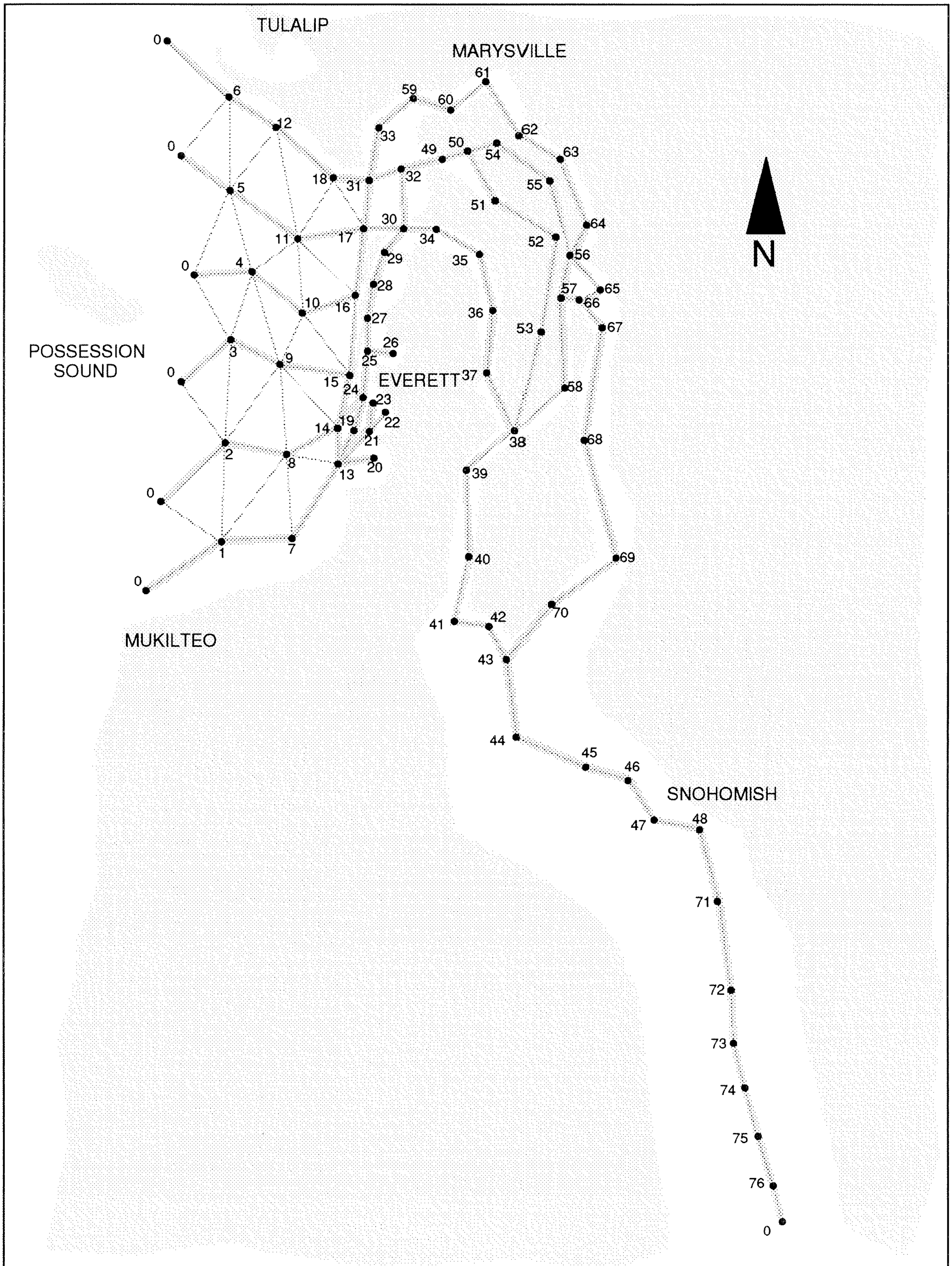

Figure 5. Segment network for the Snohomish River Estuary water quality model.

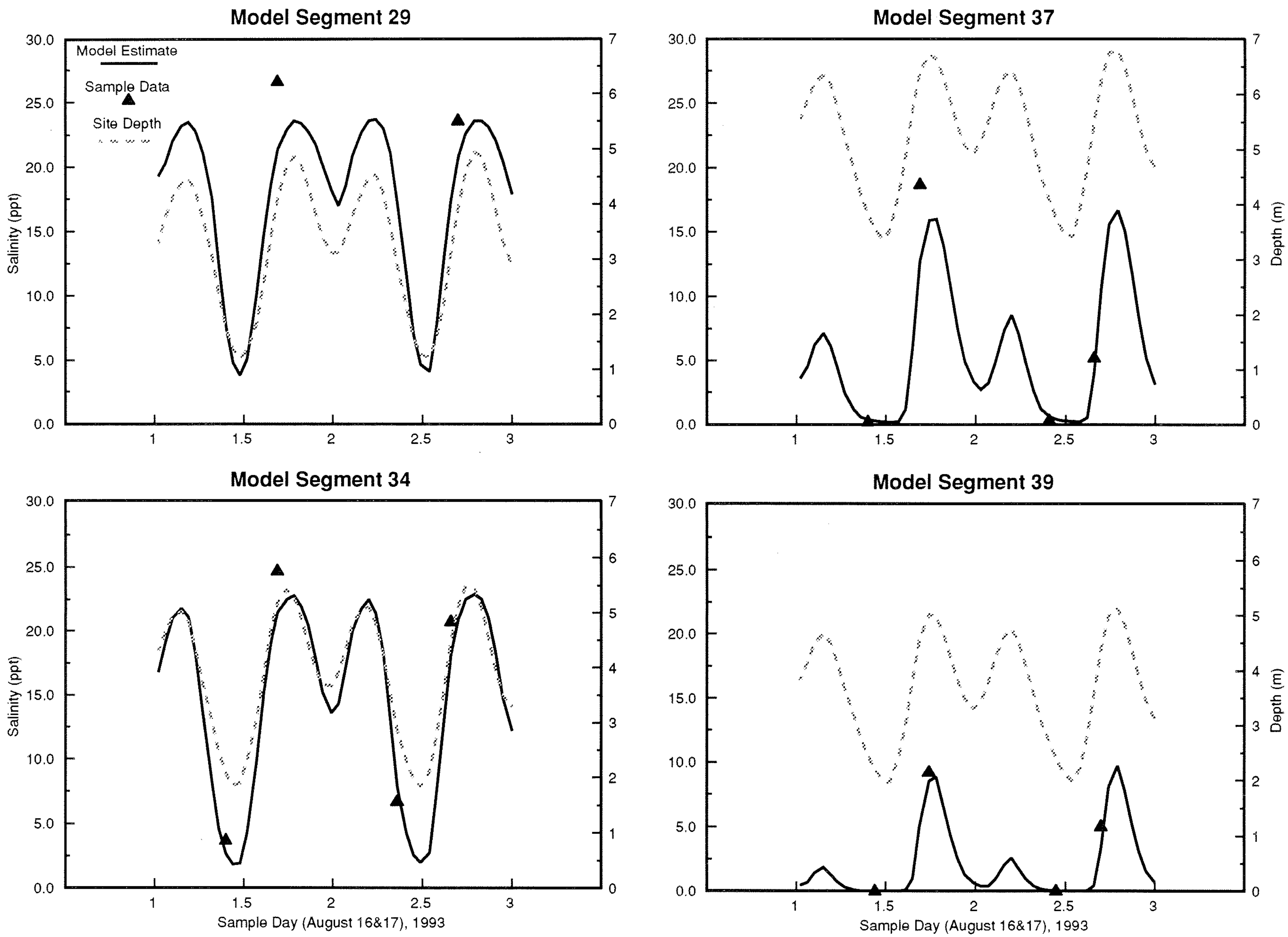

Figure 6. Calibration of EUTRO5 to predict salinity in the Snohomish River Estuary.

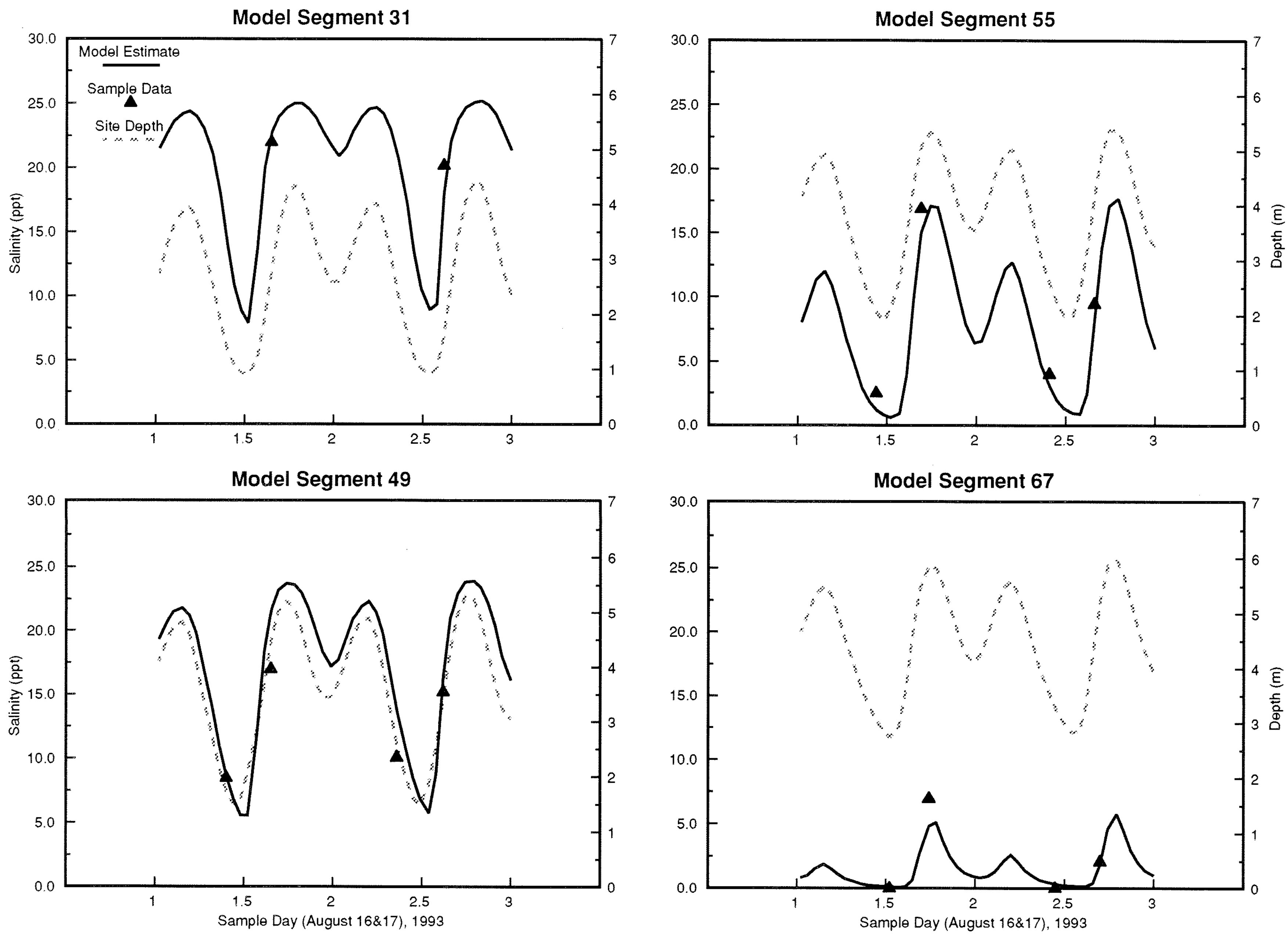

Figure 7. Calibration of EUTRO5 to predict salinity in the Snohomish River Estuary.

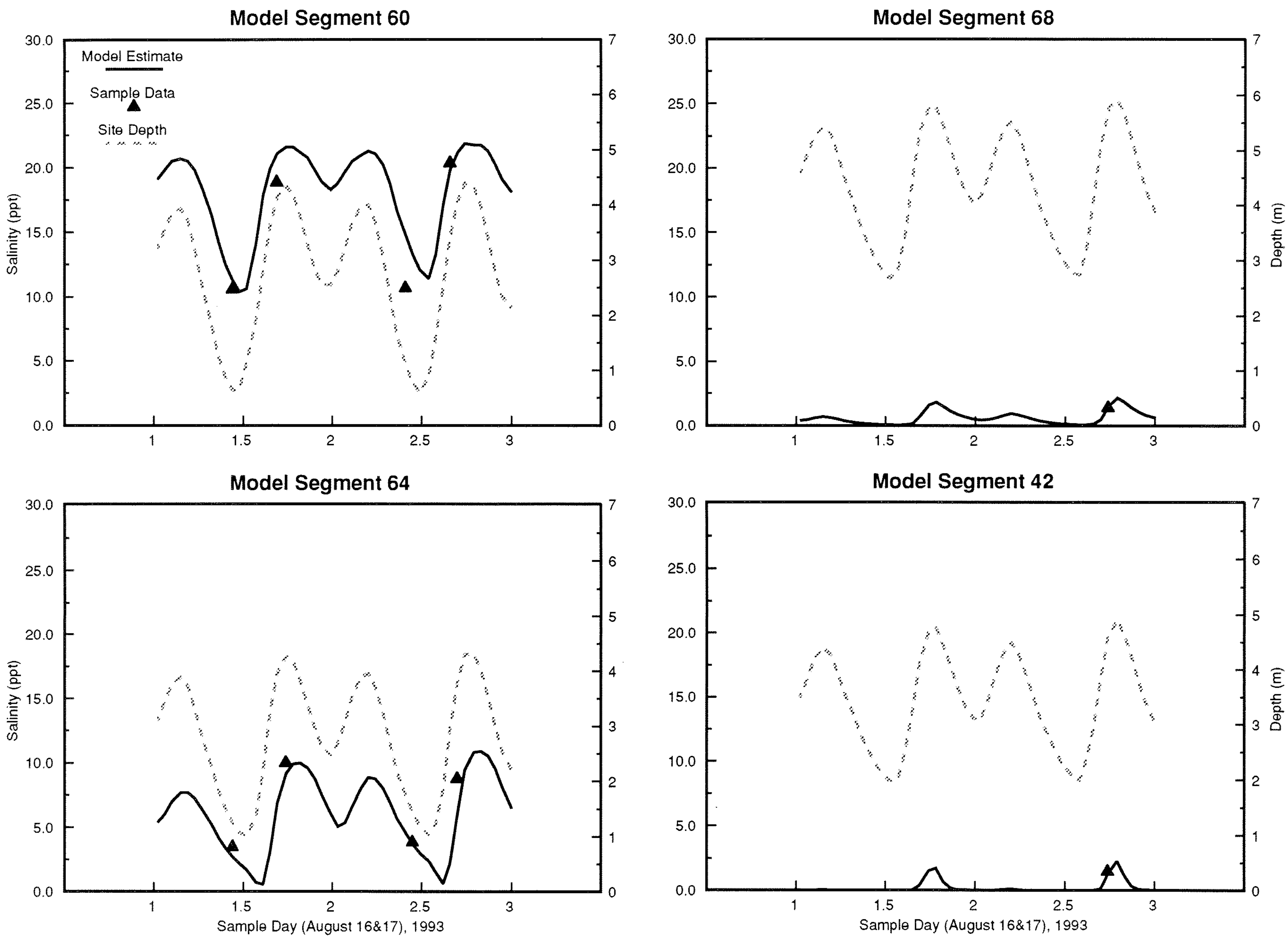

Figure 8. Calibration of EUTRO5 to predict salinity in the Snohomish River Estuary.

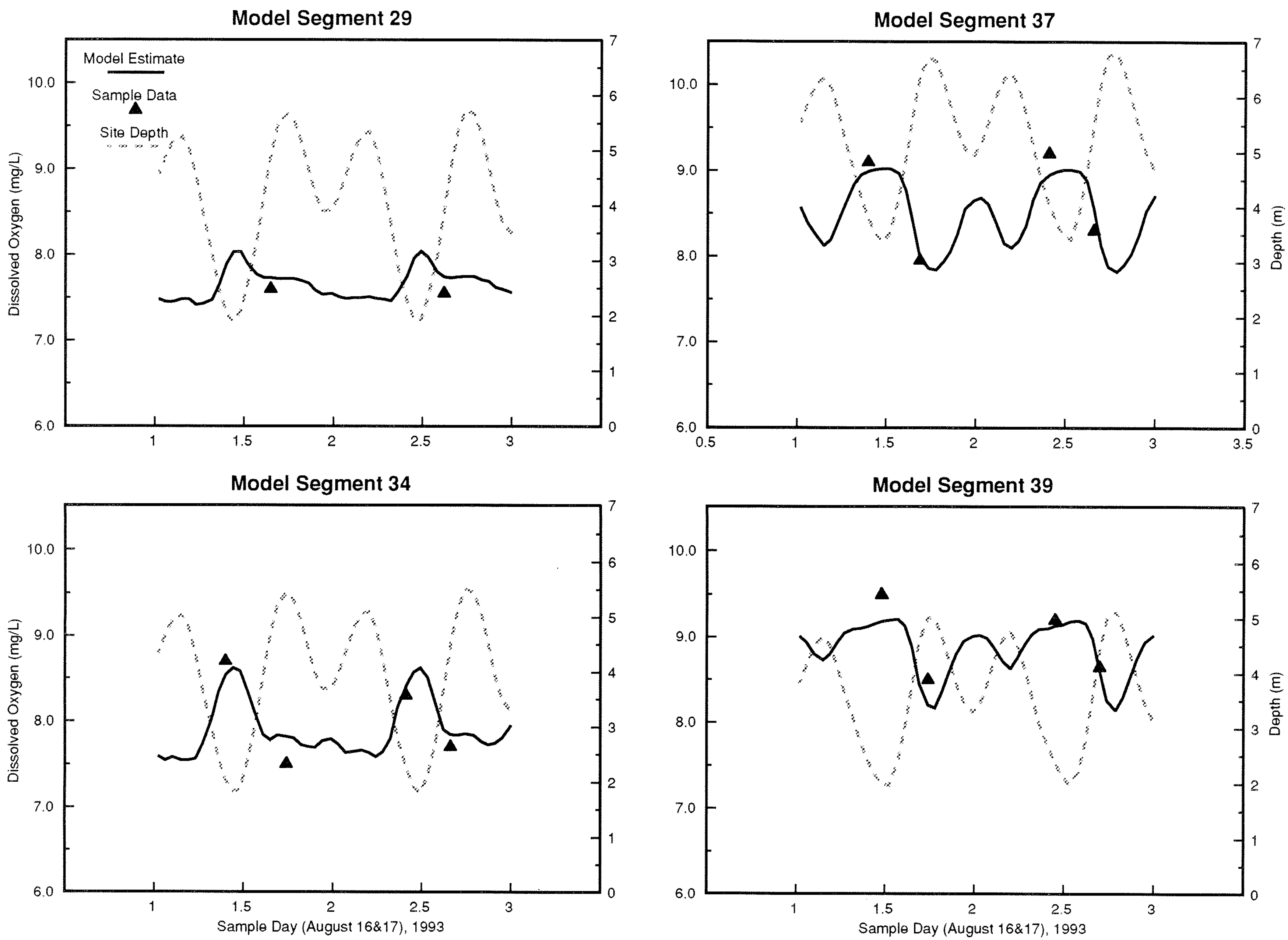

Figure 9. Calibration of EUTRO5 to predict dissolved oxygen in the Snohomish River Estuary.

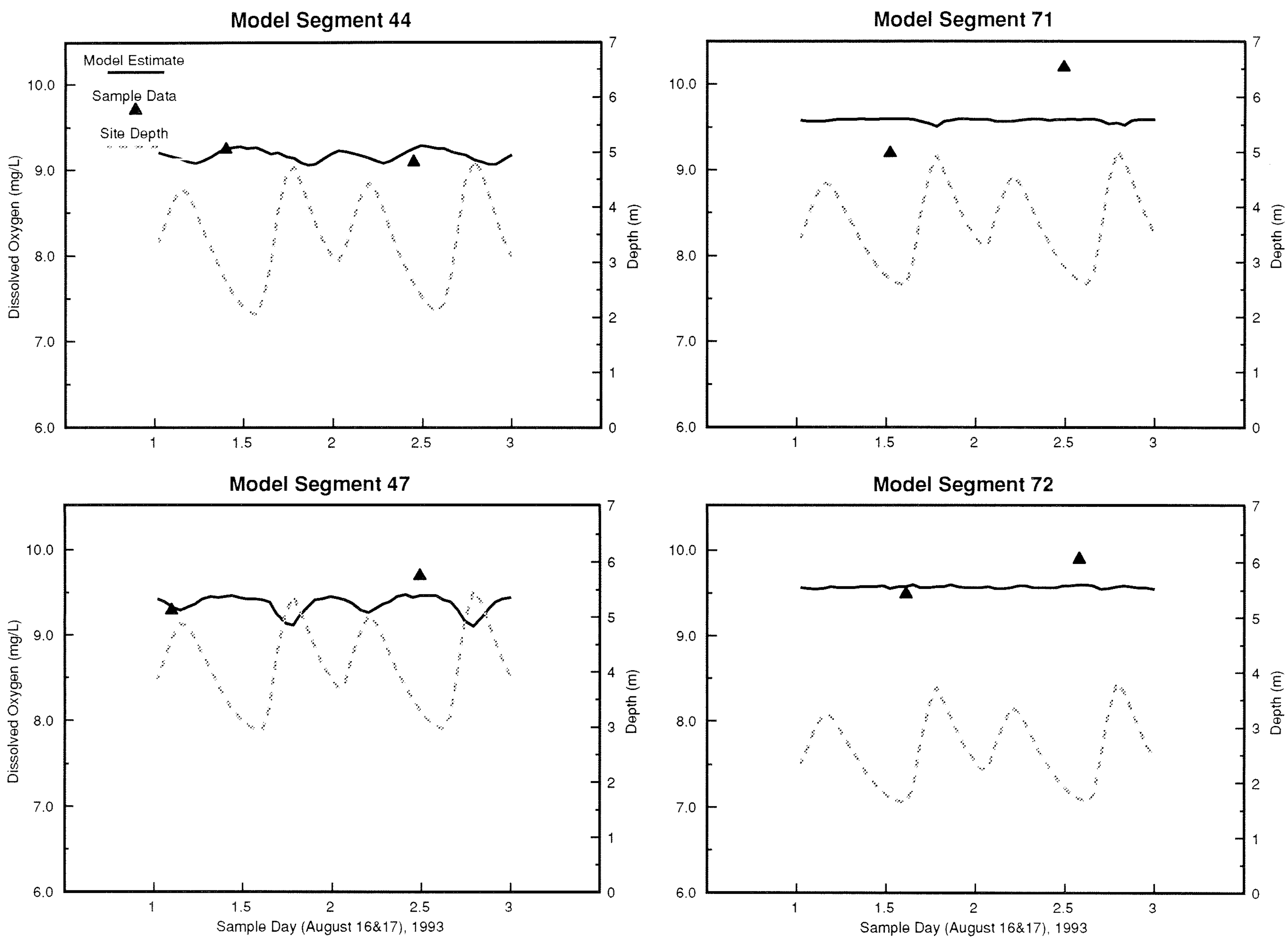

Figure 10. Calibration of EUTRO5 to predict dissolved oxygen in the Snohomish River Estuary.

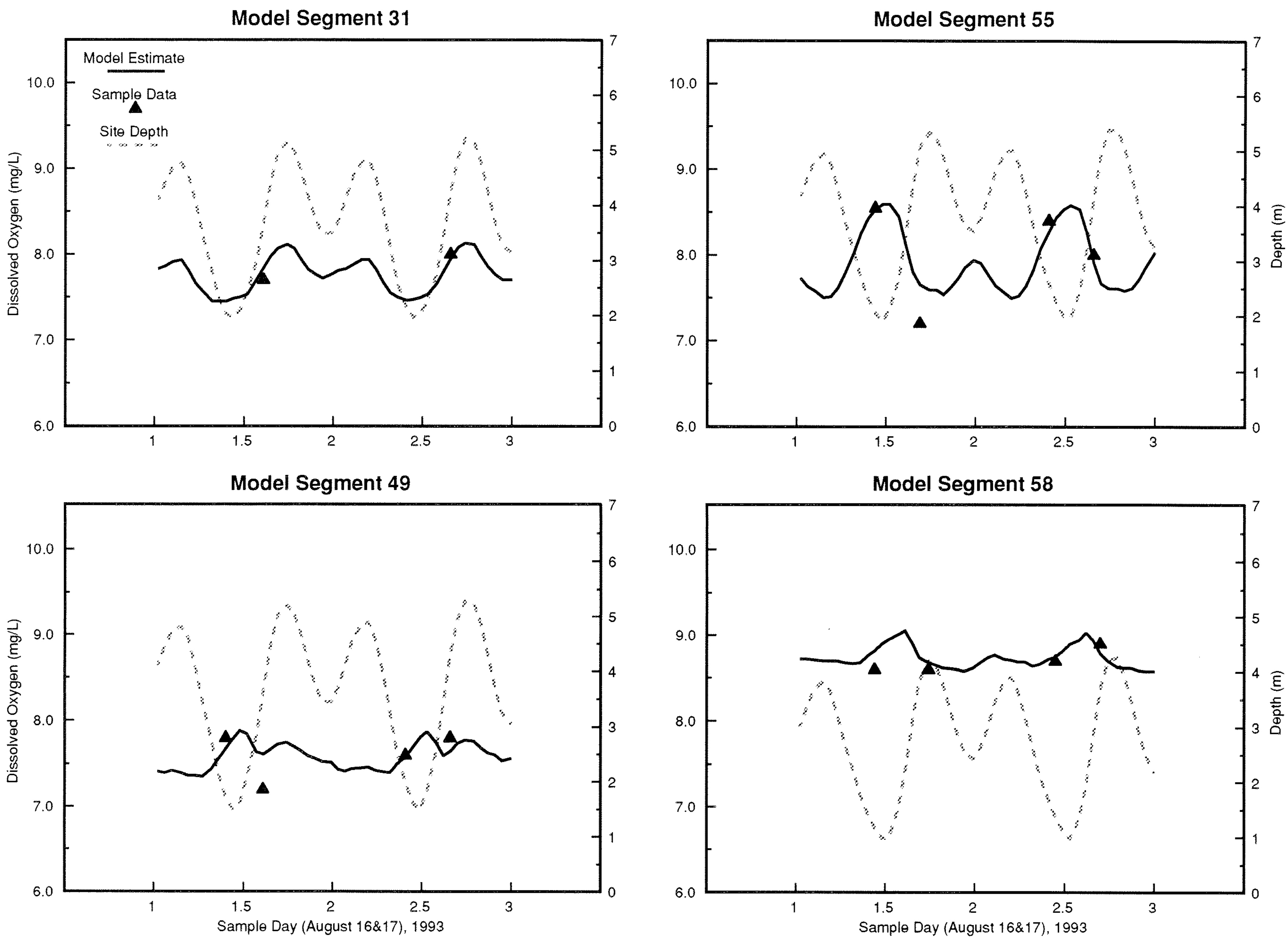

Figure 11. Calibration of EUTRO5 to predict dissolved oxygen in the Snohomish River Estuary.

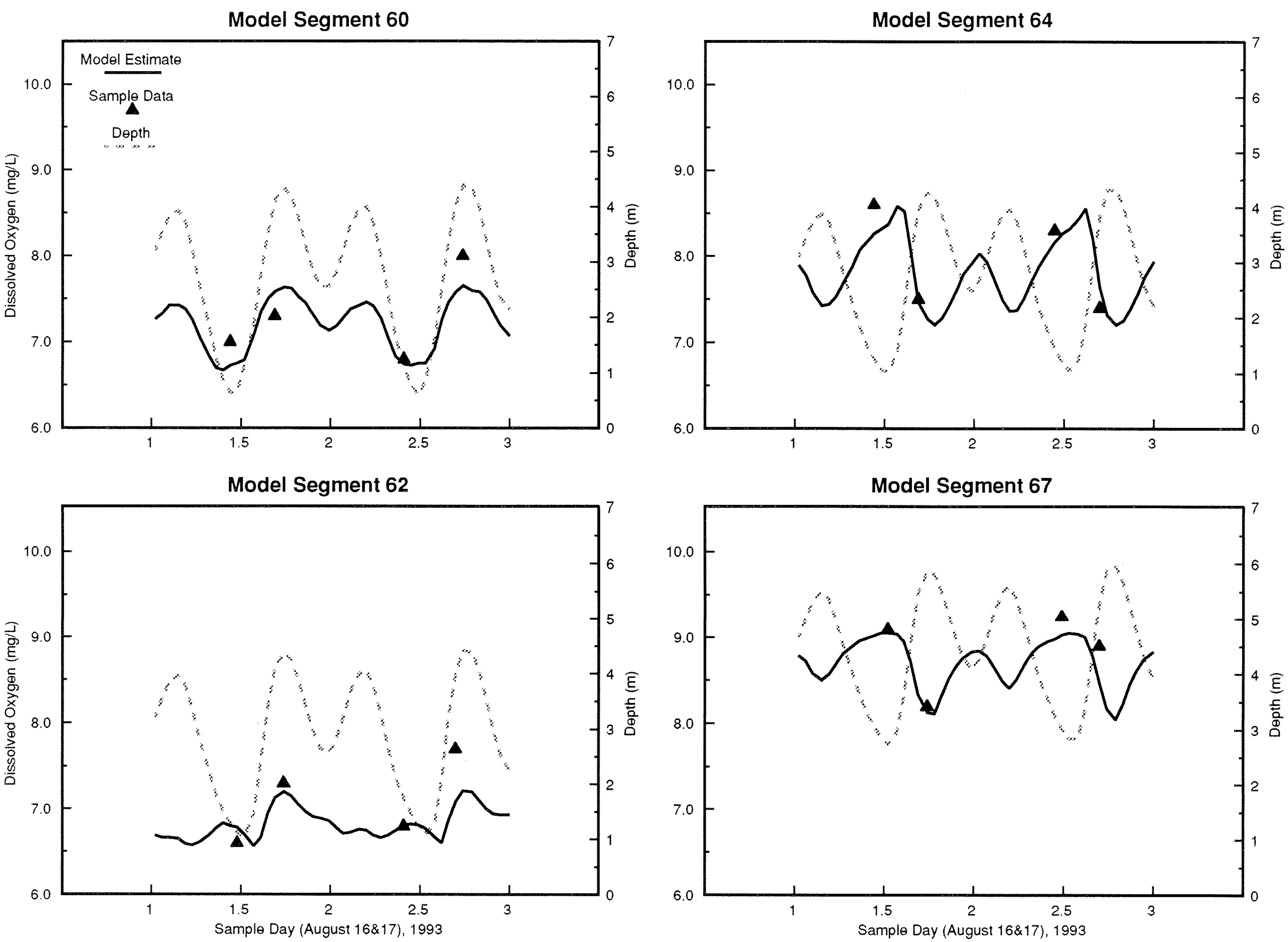

Figure 12. Calibration of EUTRO5 to predict dissolved oxygen in the Snohomish River Estuary.

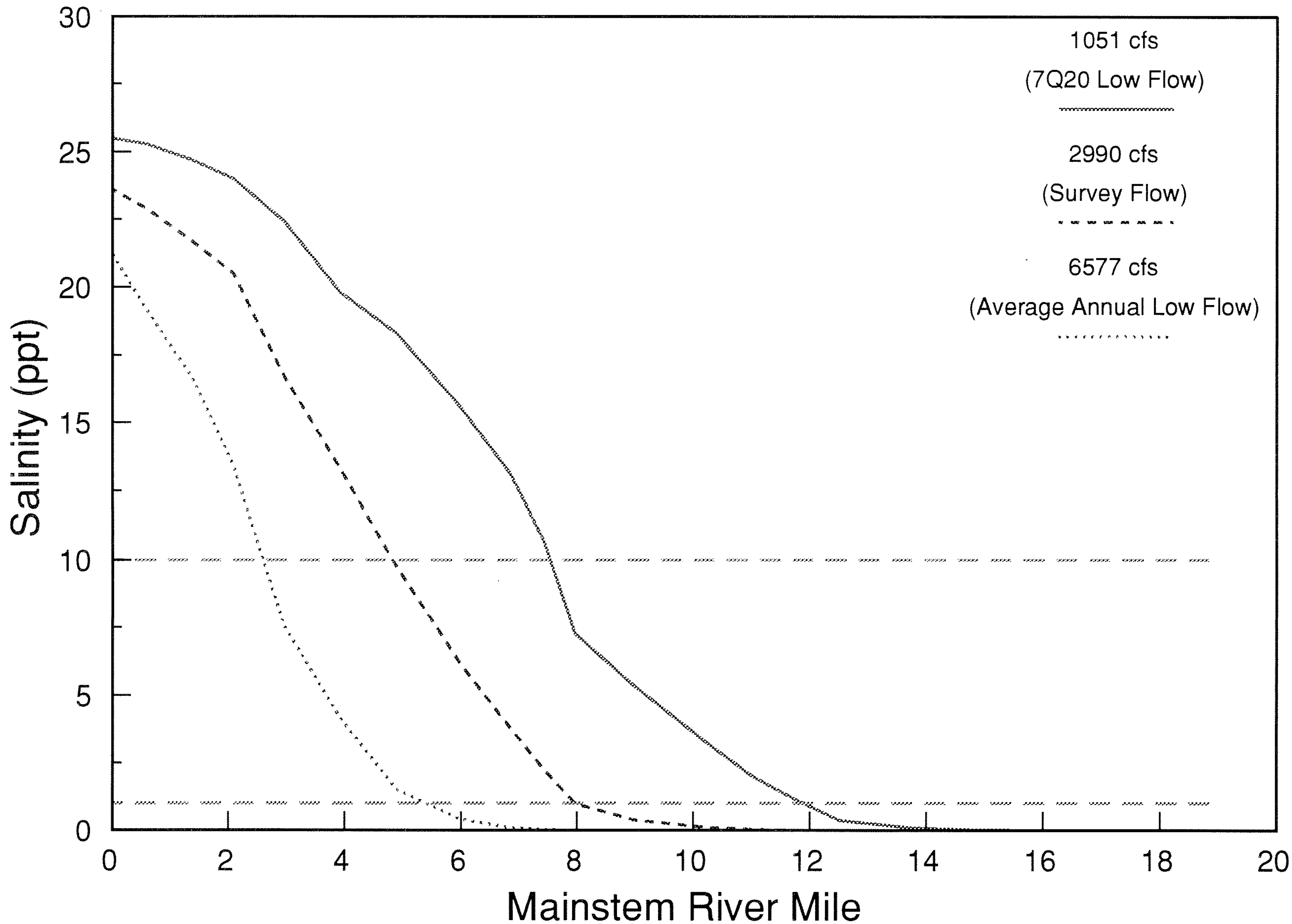

Figure 13. EUTRO5 model predicted salinities for different river flows on the mainstem Snohomish River from the mouth to RM20.

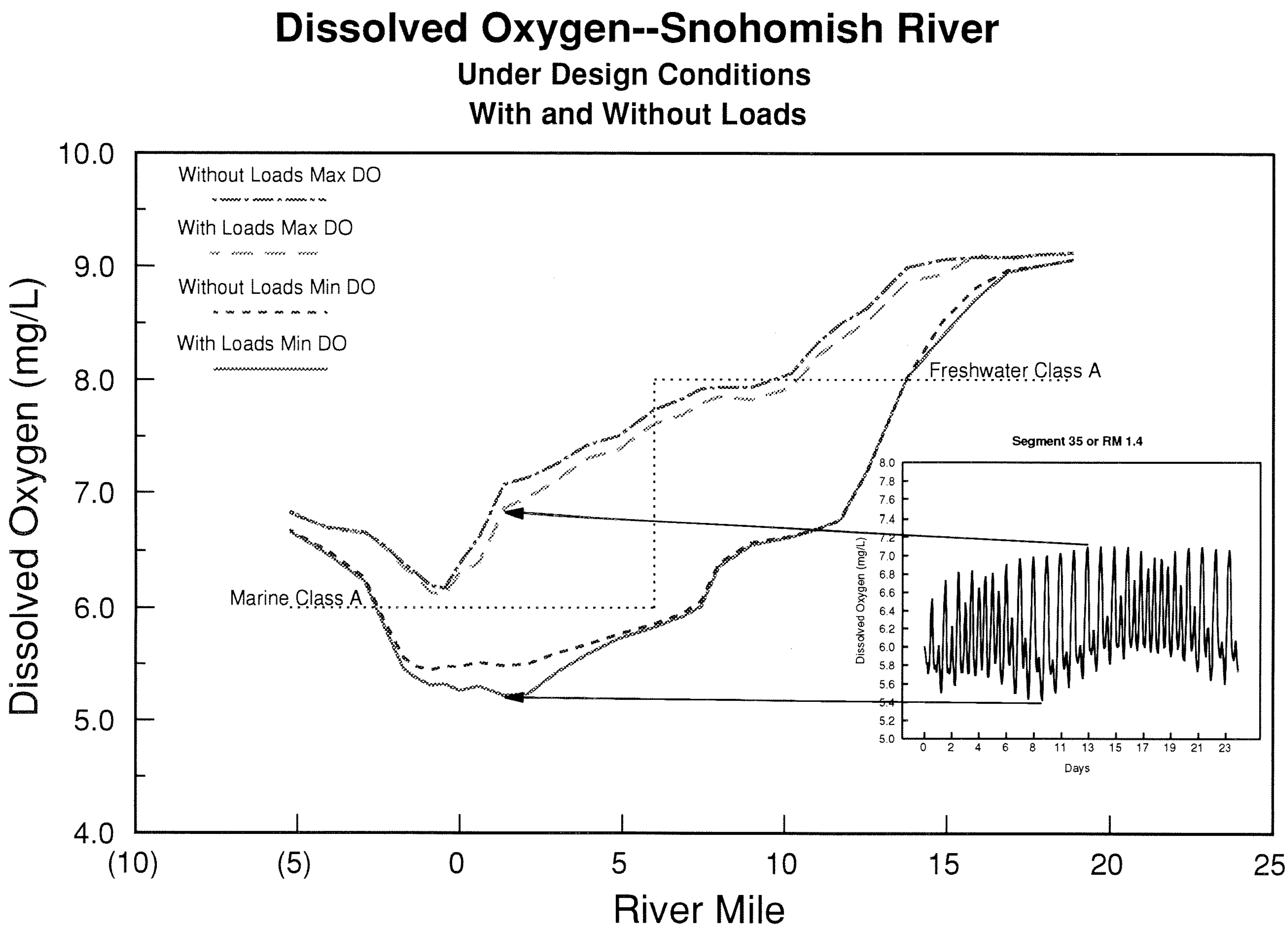

Figure 14. EUTRO5 preverification model results for dissolved oxygen.

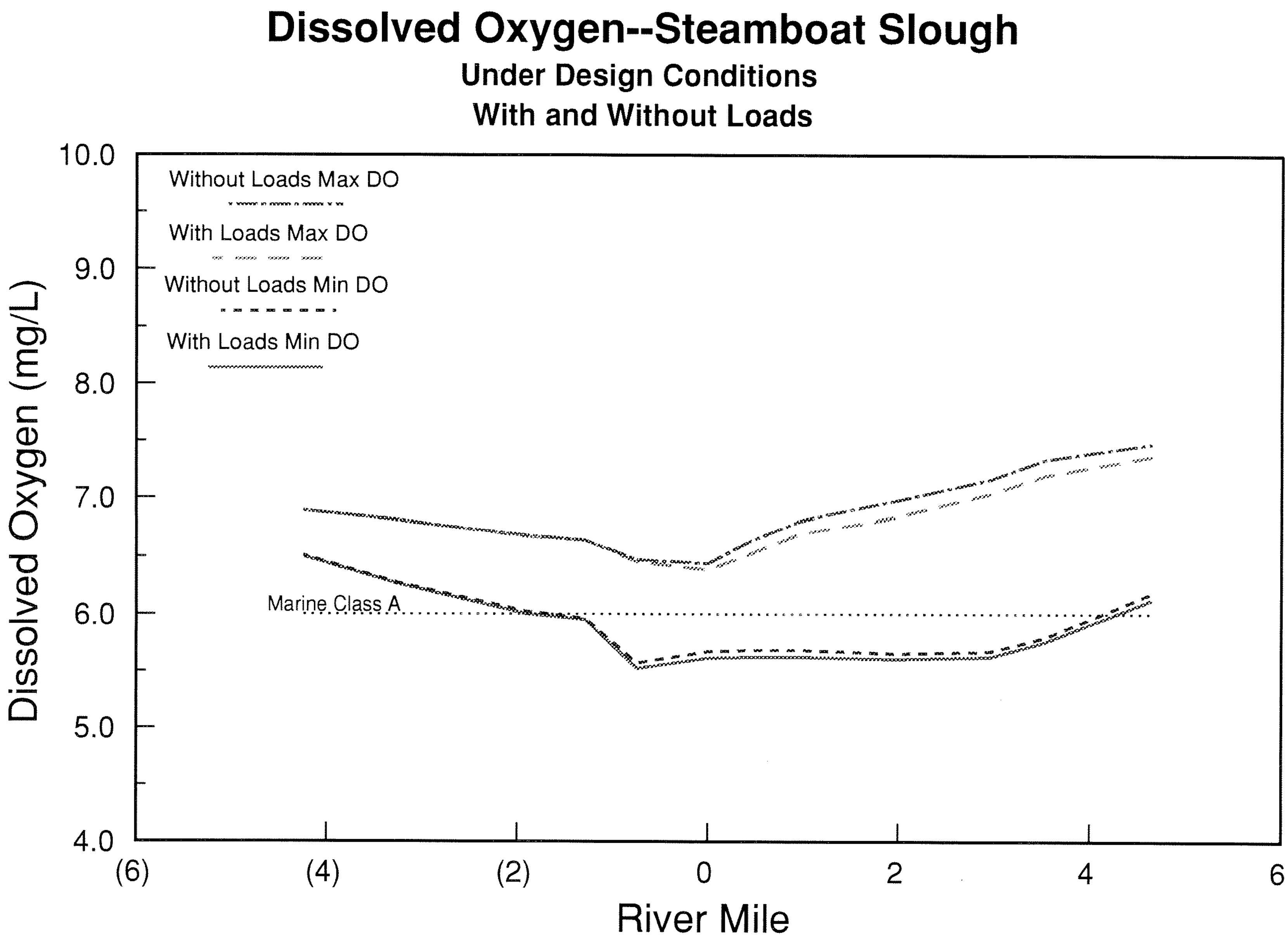

Figure 15. EUTRO5 preverification model results for dissolved oxygen.

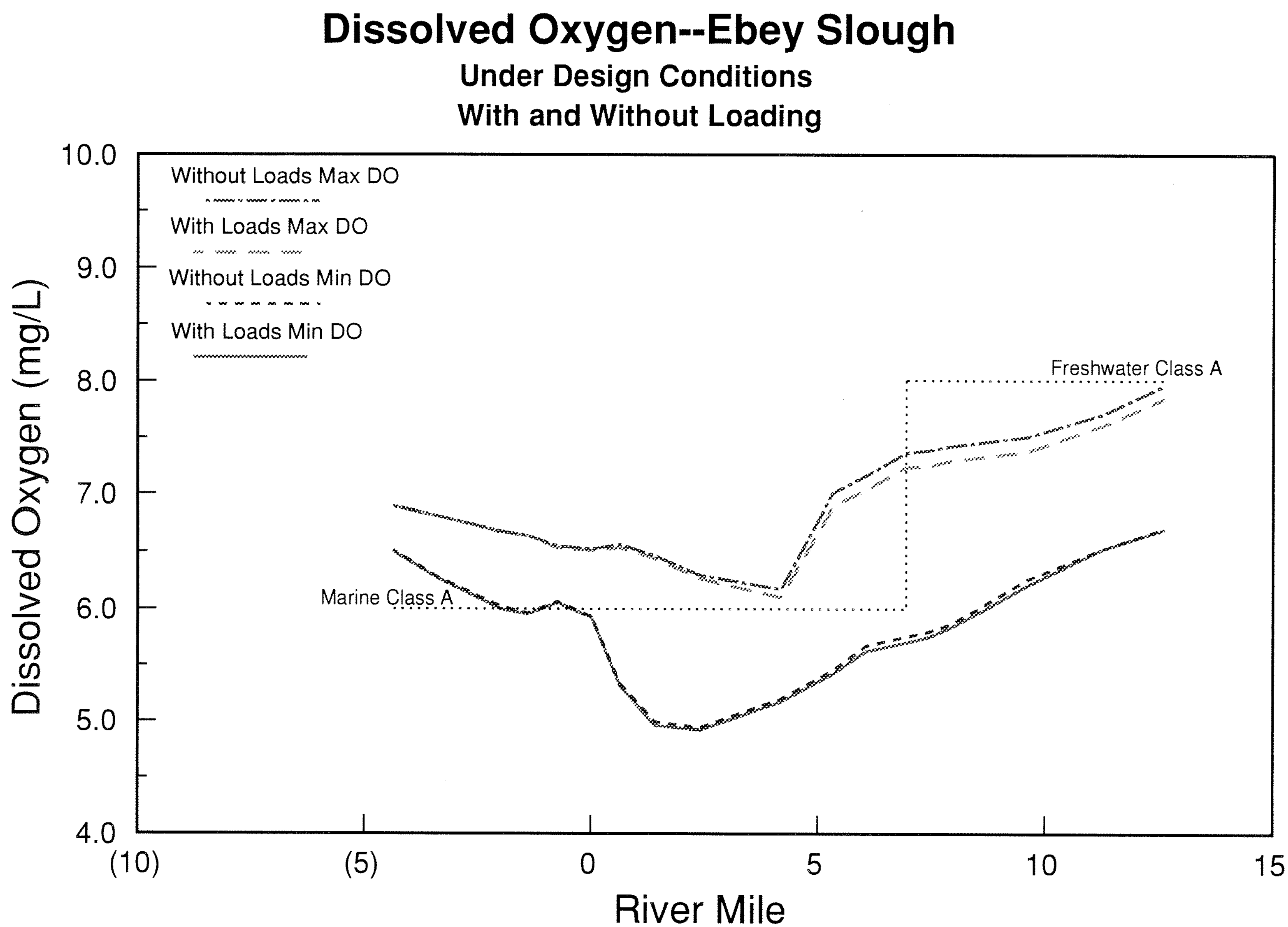

Figure 16. EUTRO5 preverification model results for dissolved oxygen.

Tables

Table 1. Field Replicate Precision.

Parameter	Root Mean Square of the Coefficient of Variation (%) of Replicates
Conductivity	1.4
Temperature	0.9
Dissolved Oxygen	3.7
pH	1.3
Total Persulfate Nitrogen	5.4
Ammonia	14.2
Nitrate-Nitrite	1.9
Total Phosphorus	15.5
Ortho-Phosphorus	3.9
Turbidity	61.4
Total Suspended Solids	2.0
Total Organic Carbon	9.3
Chlorophyll *a*	29.7
Phaeophytin *a*	44.4
Total Hardness	4.3
Fecal Coliform	45.1

Table 2. Calibration conditions for water quality of upstream and downstream boundaries and pointloads (tributaries and WWTPs).

	Flow (cfs)[a]	Ammonia (mg/L)	Nitrate (mg/L)	Ortho P (mg/L)	Chlorophyll *a* (μg/L)	Non-algal CBODU (mg/L)	Dissolved Oxygen (mg/L)	Organic N (mg/L)	Organic P (mg/L)	Salinity (ppt)
Upstream Boundary	2990	0.005	0.179	0.005	1.6	1.1	9.5	0.067	0.005	0.0
French Creek	0.0[b]	0.219	1.08	0.023	1.9	4.0	3.5	0.806	0.059	0.0
Pilchuch River	133	0.005	0.262	0.005	1.9	2.7	10.1	0.083	0.004	0.0
Snohomish WWTP	0.706	0.19	0.03	1.59	0.0	39.4	6.0[d]	12.8	1.11	0.0
Marshland	0.0[b]	0.231	1.03	0.052	14.7	6.6	4.4	0.519	0.135	0.0
Deadwater Slough	0.0[b]	0.752	0.209	0.008	104.5	14.2	12.0	1.28	0.136	0.5
Everett WWTP (Mechanical)	10.1	24.0	0.08	3.49	0.0	22.0	6.0[d]	4.0	0.41	0.0
Everett WWTP (Lagoon)	5.90	16.0	0.95	3.99	0.0	84.6	6.0[d]	25.0	0.31	0.0
Swan Trail Slough	0.0[b]	3.46	0.005	0.008	11.7	16.8	2.7	0.470	0.099	0.1
Lake Stevens WWTP	1.87	14.0	0.17	2.17	0.0	10.2	6.0[d]	4.0	0.23	0.0
Marysville WWTP	2.97	0.07	3.94	4.73	0.0	45.3	6.0[d]	5.0	0.27	0.0
Allen Creek	0.0[c]	0.025	0.893	0.090	1.3	2.7	1.0	0.282	0.025	0.0
Quilceda Creek	54.7	0.023	0.943	0.064	1.6	2.7	7.2	0.219	0.039	0.5
Downstream Boundary	NA	0.005	0.196	0.45	2.6	2.4	8.5	0.126	0.005	27.3

[a] Flows in model input as m^3/s
[b] Tributaries controlled by pumping stations; were not pumping during survey.
[c] No flow measured during survey.
[d] Assumed dissolved oxygen concentration of WWTP effluent.

Table 3. Summary of EUTRO5 model constants for eutrophication kinetics.

Model Constant	Description	Units	Value Used	Temperature Correction Coefficient
K12C	Nitrification rate	day^{-1}	0.2	1.085
KNIT	Half-saturation constant for nitrification-oxygen limitation	mg O_2/L	2.0	
K20C	Denitrification rate	day^{-1}	0.09	1.045
KNO3	Half-saturation constant for denitrification oxygen limitation	mg O_2/L	0.1	
K1C	Saturated growth rate of phytoplankton	day^{-1}	1.40	1.066
LGTHTS	Light formulation switch: LGHTS = 1 use Di Toro et al. (1971) formulation.		1	
CCHL	Carbon-to-chlorophyll ratio	mg C/mg chl *a*	75	
IS1	Saturation light intensity for phytoplankton growth.	Ly/day	100	
KMNG1	Nitrogen half-saturation constant for phytoplankton growth, which also affects ammonia preference.	mg N/L	0.03	
KMPG1	Phosphorous half-saturation constant for phytoplankton growth.	mg PO_4-P/L	0.002	
NCRB	Nitrogen-to-carbon ratio in phytoplankton	mg N/L	0.25	
PCRB	Phosphorus-to-carbon ratio in phytoplankton	mg P/L	0.025	
K1RC	Endogenous respiration rate of phytoplankton	day^{-1}	0.092	1.045
K1D	Non-predatory phytoplankton death rate	day^{-1}	0.02	
KDC	CBOD deoxygenation rate	day^{-1}	0.152	1.047
OCRB	Oxygen to carbon ratio in phytoplankton	mg O_2/mg C	2.67	
K71C	Mineralization rate of dissolved organic nitrogen	day^{-1}	0.10	1.047
FON	Fraction of dead and respired phytoplankton nitrogen recycled to organic nitrogen		1.0	
K83C	Mineralization rate of dissolved organic phosphorus	day^{-1}	0.10	1.047
FOP	Fraction of dead and respired phytoplankton phosphorus recycled to organic phosphorus		1.0	

Table 4. Root mean square error (RMSE) between model predicted (P) and observed (O) values for salinity, dissolved oxygen, chlorophyll *a*, ammonia, and phosphorus.

Parameter	n (number of pairs)	RMSE $[\sqrt{\Sigma(P_i - O_i)^2/n}]$	Range Observed
Salinity (°/₀₀)	38	2.18[a]	0.0 - 27.3
Dissolved Oxygen (mg/L)	52	0.23	6.6 - 10.2
Chlorophyll *a* (µg/L)	26	1.55[b]	1.4 - 7.4
Ammonia (mg/L)	52	0.0167	0.005[c] - 0.140
Phosphorus (mg/L)	52	0.0050	0.005[c] - 0.049

[a] For salinity values ≤ 3 ppt RMSE is 0.53.

[b] RMSE is 0.76 µg/L excluding two sites in Ebey Slough associated with water quality model segments 60 and 67.

[c] Minimum value is one-half the detection limit.

Table 5. Critical conditions for water quality of upstream and downstream boundaries and pointloads (tributaries and WWTPs).

	Flow (cfs)[b]	Ammonia (mg/L)	Nitrate (mg/L)	Ortho P (mg/L)	Chlorophyll *a* (μg/L)	Non-algal CBODU (mg/L)	Dissolved Oxygen (mg/L)	Organic N (mg/L)	Organic P (mg/L)	Salinity (ppt)
Upstream Boundary	1051	0.050	0.340	0.005	1.6	1.1	9.1	0.117	0.020	0.0
French Creek	16.2	0.219	1.08	0.023	1.9	4.0	3.5	0.806	0.059	0.0
Pilchuck River	55.8	0.030	0.400	0.005	1.9	2.7	9.2	0.134	0.020	0.0
Snohomish WWTP	1.27	21.0	0.030	1.59	0.0	65.7	6.0[d]	12.8	1.11	0.0
Marshland	16.2	0.231	1.03	0.520	14.7	6.6	4.4	0.519	0.135	0.0
Deadwater Slough	5.51	0.752	0.209	0.008	104.5	14.2	12.0	1.28	0.136	0.0
Everett WWTP (Mechanical)	12.4	26.0	0.080	3.49	0.0	65.7	6.0[d]	4.0	0.410	0.0
Everett WWTP (Lagoon)	16.3	24.0	0.950	3.99	0.0	73.0	6.0[d]	25.0	0.310	0.0
Swan Trail Slough	1.62	3.46	0.005	0.008	11.7	16.8	2.7	0.470	0.099	0.0
Lake Stevens WWTP	1.20	12.7	0.170	2.17	0.0	65.7	6.0[d]	4.0	0.230	0.0
Marysville WWTP	3.32	21.0	3.94	4.73	0.0	65.7	6.0[d]	5.0	0.270	0.0
Allen Creek	0.0[c]	0.025	0.893	0.900	1.3	2.7	1.0	0.282	0.025	0.0
Quilceda Creek	4.5	0.023	0.943	0.064	1.6	2.7	7.2	0.219	0.039	0.0
Downstream Boundary	NA	0.095	0.300	0.060	3.0	2.4	6.9	0.126	0.040	27.3
Monroe WWTP[a]	1.19	25.0	0.180	4.66	0.0	65.7	6.0[d]	8.0	0.140	0.0
Sultan WWTP[a]	0.47	25.0	0.060	0.850	0.0	65.7	6.0[d]	1.90	0.150	0.0

[a] Used in spreadsheet model based on Streeter-Phelps equations.
[b] Flows in model input as m^3/s.
[c] No flow measured during survey; assumed no flow during critical conditions.
[d] WWTP effluent assumed dissolved oxygen concentration.

Table 6. Critical 7-day average low flows in cfs.

Location	$7Q10_{Annual}$	$7Q20_{Jul-Oct}$	$7Q20_{Nov-Jun}$
Skykomish @ Goldbar	442	401	563
Sultan @ Sultan	40	29	120
Skykomish @ Sultan	580	530	822
Woods Creek @ Monroe	14	13	20
Skykomish @ Monroe	701	653	993
Snoqualmie @ Mouth	436	398	675
Snohomish @ RM 20.4	1137	1051	1668
Pilchuck @ Snohomish	58	56	73
Allen Creek @ Ebey S.	-	0	-
Quilceda Creek	-	4.5	-

Appendix A
Sampling Schedules

Appendix A.1. Snohomish River TMDL Site Sampling Schedule.

TEAM 1 8/16/93

Site	Location	Station ID	LAB ID	Tide(a)	Sample Depth	Secchi Disc	pH Cond Temp	DO	FC	Total Hard	TSS	Turb	TOC	BOD5	BOD35	NH3	NO3-NO2	TPN	Ortho-P	TP	Chloro a	Phyto
11	Upriver of French Creek	SNO11	34-8450	Low	Surface	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
14	Upriver of Snohomish WTP	SNO14	34-8451	Low	Surface	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	
15	1 mi. below Snohomish WTP	SNO15	34-8452	Low	Surface	X	X	X	X		X	X	X			X	X	X	X	X	X	
16	Upriver of Ebey Slough	SNO16	34-8453	Low	Surface	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
		REP16	34-8454	Low	Surface	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
18	By Hwy 2 bridge	SNO18	34-8455	Low	Surface	X	X	X	X	X	X	X	X			X	X	X	X	X		X
			34-8456	High	Surface	X	X	X		X	X	X	X			X	X	X	X	X		
			34-8457	High	Bottom	X	X	X			X	X	X			X	X	X	X	X		
20	Upriver of Everett WTP	SNO20	34-8458	Low	Surface	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
			34-8459	High	Surface	X	X	X			X	X	X			X	X	X	X	X	X	
			34-8460	High	Bottom	X	X	X			X	X	X	X		X	X	X	X	X		
21	1 mi. downriver Everett WTP	SNO21	34-8461	Low	Surface	X	X	X	X		X	X	X		X	X	X	X	X	X		X
			34-8462	High	Surface	X	X	X			X	X	X			X	X	X	X	X		
			34-8463	High	Bottom	X	X	X			X	X	X			X	X	X	X	X		
30	Steamboat S. upriver Ebey S. junction	STM30	34-8464	Low	Surface	X	X	X	X		X	X	X			X	X	X	X	X		
			34-8465	High	Surface	X	X	X			X	X	X			X	X	X	X	X		X
			34-8466	High	Bottom	X	X	X			X	X	X			X	X	X	X	X		
34	Port Gardner	POG34	34-8467	High	Surface	X	X	X	X		X	X	X			X	X	X	X	X	X	
			34-8468	High	10 m	X	X	X			X	X	X			X	X	X	X	X		

(a) Sampled both high and low tide and surface and bottom if stratified.
Blank samples collected for TOC and O-P, LAB ID 34-8469 and 34-8470, respectively.

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Site	Location	Station ID	LAB ID	Tide(a)	Sample Depth	Secchi Disc	pH Cond Temp	DO	FC	Hard	TSS	Turb	TOC	BOD5	BOD35	NH3	NO3-NO2	TPN	Ortho-P	TP	Chloro a	Phyto
11	Upriver of French Creek	SNO11	34-8550	Low	Surface	X	X	X	X	X		X	X			X	X	X	X	X	X	X
14	Upriver of Snohomish WTP	SNO14	34-8551	Low	Surface	X	X	X	X	X		X	X			X	X	X	X	X	X	
15	1 mi. below Snohomish WTP	SNO15	34-8552	Low	Surface	X	X	X	X			X	X			X	X	X	X	X	X	
16	Upriver of Ebey Slough	SNO16	34-8553	Low	Surface	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
18	By Hwy 2 bridge	SNO18	34-8554	Low	Surface	X	X	X	X	X		X	X			X	X	X	X	X		X
			34-8555	High	Surface	X	X	X		X		X	X			X	X	X	X	X		
			34-8556	High	Bottom	X	X	X				X	X			X	X	X	X	X		
20	Upriver of Everett WTP	SNO20	34-8557	Low	Surface	X	X	X	X			X	X			X	X	X	X	X	X	
			34-8558	High	Surface	X	X	X				X	X			X	X	X	X	X	X	
			34-8559	High	Bottom	X	X	X				X	X			X	X	X	X	X		
21	1 mi. downriver Everett WTP	SNO21	34-8560	Low	Surface	X	X	X	X			X	X			X	X	X	X	X		X
		REP21	34-8561	Low	Surface	X	X	X	X			X	X			X	X	X	X	X		X
			34-8562	High	Surface	X	X	X				X	X			X	X	X	X	X		
			34-8563	High	Bottom	X	X	X				X	X			X	X	X	X	X		
30	Steamboat S. upriver Ebey S. junction	STM30	34-8564	Low	Surface	X	X	X	X			X	X			X	X	X	X	X		
			34-8565	High	Surface	X	X	X				X	X			X	X	X	X	X		
			34-8566	High	Bottom	X	X	X				X	X			X	X	X	X	X		
34	Port Gardner	POG34	34-8567	High	Surface	X	X	X	X			X	X			X	X	X	X	X	X	
			34-8568	High	10 m	X	X	X				X	X			X	X	X	X	X		

(a) Sampled both high and low tide and surface and bottom if stratified.
Blank samples collected for TOC and O-P, LAB ID 34-8560 and 34-8570, respectively.

Appendix A.1. Snohomish River TMDL Site Sampling Schedule.

TEAM 2 8/16/93

Site	Location	Station ID	LAB ID	Tide(a)	Sample Depth	Site Depth	Secchi Disc	pH Cond Temp	DO	FC	Hard	TSS	Turb	TOC	BOD5	BOD35	NH3	NO3-NO2	TPN	Ortho-P	TP	Chloro a	Phyto
23	Upriver of Lake Stevens WTP	EBE23	34-8420	Low	Surface	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
			34-8421	High	Surface	X	X	X	X		X	X	X	X			X	X	X	X	X	X	
			34-8422	High	Bottom	X		X	X			X	X	X	X		X	X	X	X	X		
24	Ebey S. downriver Lake Stevens WTP	EBE24	34-8423	Low	Surface	X	X	X	X	X		X	X	X		X	X	X	X	X	X		
			34-8424	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X		
			34-8425	High	Bottom	X		X	X			X	X	X			X	X	X	X	X		
26	Downriver Allen Creek	EBE26	34-8426	Low	Surface	X	X	X	X	X		X	X	X			X	X	X	X	X		
			34-8427	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X		
			34-8428	High	Bottom	X		X	X			X	X	X			X	X	X	X	X		
27	Mouth of Ebey Slough	EBE27	34-8429	Low	Surface	X	X	X	X	X		X	X	X			X	X	X	X	X	X	X
			34-8430	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X	X	
			34-8431	High	Bottom	X		X	X			X	X	X			X	X	X	X	X		
31	Steamboat S. Upriver Marysville WTP	STM31	34-8432	Low	Surface	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
		REP	34-8433	Low	Surface	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	
			34-8434	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X	X	
			34-8435	High	Bottom	X		X	X			X	X	X	X		X	X	X	X	X		
32	Mouth of Steamboat Slough	STM32	34-8436	Low	Surface	X	X	X	X	X		X	X	X		X	X	X	X	X	X		
			34-8437	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X		
			34-8438	High	Bottom	X		X	X			X	X	X			X	X	X	X	X		
33	Union Slough at I-5	UNS33	34-8439	Low	Surface	X	X	X	X	X		X	X	X	X		X	X	X	X	X		
			34-8440	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X		
			34-8441	High	Bottom	X		X	X			X	X	X			X	X	X	X	X		
35	Inner Everett Harbor	IEH35	34-8442	High	Surface	X	X	X	X			X	X	X			X	X	X	X	X	X	
			34-8443	High	10 m	X	X	X	X			X	X	X			X	X	X	X	X		

(a) Sampled both high and low tide and surface and bottom if stratified.
Blank samples collected for TOC and Ortho-P, LAB ID 34-8444 and 34-8445, respectively.

TEAM 2 8/17/93

Site	Location	Station ID	LAB ID	Tide(a)	Sample Depth	Site Depth	Secchi Disc	pH Cond Temp	DO	FC	Hard	TSS	Turb	TOC	BOD5	BOD35	NH3	NO3-NO2	TPN	Ortho-P	TP	Chloro a	Phyto
23	Upriver of Lake Stevens WTP	EBE23	34-8520	Low	Surface	X	X	X	X	X	X		X	X			X	X	X	X	X	X	X
	Replicate sample for 8/17/93	REP23	34-8521	Low	Surface	X	X	X	X	X	X		X	X			X	X	X	X	X	X	
			34-8522	High	Surface	X	X	X	X		X		X	X			X	X	X	X	X	X	
			34-8523	High	Bottom	X		X	X				X	X			X	X	X	X	X		
24	Ebey S. downriver Lake Stevens WTP	EBE24	34-8524	Low	Surface	X	X	X	X	X			X	X			X	X	X	X	X		
			34-8525	High	Surface	X	X	X	X				X	X			X	X	X	X	X		
			34-8526	High	Bottom	X		X	X				X	X			X	X	X	X	X		
26	Downriver Allen Creek	EBE26	34-8527	Low	Surface	X	X	X	X	X			X	X			X	X	X	X	X		
			34-8528	High	Surface	X	X	X	X				X	X			X	X	X	X	X		
			34-8529	High	Bottom	X		X	X				X	X			X	X	X	X	X		
27	Mouth of Ebey Slough	EBE27	34-8530	Low	Surface	X	X	X	X	X			X	X			X	X	X	X	X	X	X
			34-8531	High	Surface	X	X	X	X				X	X			X	X	X	X	X	X	
			34-8532	High	Bottom	X		X	X				X	X			X	X	X	X	X		
31	Steamboat S. Upriver Marysville WTP	STM31	34-8533	Low	Surface	X	X	X	X	X			X	X			X	X	X	X	X	X	
			34-8534	High	Surface	X	X	X	X				X	X			X	X	X	X	X	X	
			34-8535	High	Bottom	X		X	X				X	X			X	X	X	X	X		
32	Mouth of Steamboat Slough	STM32	34-8536	Low	Surface	X	X	X	X	X			X	X			X	X	X	X	X		
			34-8537	High	Surface	X	X	X	X				X	X			X	X	X	X	X		
			34-8538	High	Bottom	X		X	X				X	X			X	X	X	X	X		
33	Union Slough at I-5	UNS33	34-8539	Low	Surface	X	X	X	X	X			X	X			X	X	X	X	X		
			34-8540	High	Surface	X	X	X	X				X	X			X	X	X	X	X		
			34-8541	High	Bottom	X		X	X				X	X			X	X	X	X	X		
35	Inner Everett Harbor	IEH35	34-8542	High	Surface	X	X	X	X				X	X			X	X	X	X	X	X	
			34-8543	High	10 m	X	X	X	X				X	X			X	X	X	X	X		

(a) Sampled both high and low tide and surface and bottom if stratified.
Blank samples collected for TOC and Ortho-P, LAB ID 34-8544 and 34-8545, respectively.

Appendix A.1. Snohomish River TMDL Site Sampling Schedule.

TEAM 3 8/16/93

Site	Location	Station ID	LAB ID	Flow	Secchi Disc	pH Cond Temp	DO	FC	Hard	TSS	Turb	TOC	BOD5	BOD35	NH3	NO3-NO2	TPN	Ortho-P	TP	Chloro a	Phyto
1	Upriver of Sultan WTP	SKY01	34-8401			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
2	Sultan River	SUL02	34-8402	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	
3	1 mi. downriver of Sultan	SKY03	34-8403			X	X	X													
5	Upriver of Woods Creek (and WTP)	SKY05	34-8404			X	X	X	X	X	X	X			X	X	X	X	X	X	
6	Woods Creek	WOD06	34-8405	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	
7	1 mi. downriver of Monroe	SKY07	34-8406			X	X	X													
9	Snoqualmie at confluence	SNQ09	34-8407			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
	Replicate sample for 8/16/93	REP09	34-8408			X	X	X	X	X	X	X	X		X	X	X	X	X	X	
12	French Creek	FRN12	34-8409	a		X	X	X		X	X	X	X		X	X	X	X	X	X	
13	Pilchuck River	PIL13	34-8410	X		X	X	X		X	X	X	X		X	X	X	X	X	X	
17	Marshland	MAR17	34-8411	a		X	X	X		X	X	X	X		X	X	X	X	X	X	
19	Deadwater Slough	DED19	34-8412	a		X	X	X		X	X	X	X		X	X	X	X	X	X	
22	Swan Trail Slough	STS22	34-8413	a		X	X	X		X	X	X	X		X	X	X	X	X	X	
25	Allen Creek	ALL25	34-8414	X		X	X	X		X	X	X	X		X	X	X	X	X	X	
28	Quilceda Creek	QIL28	34-8415	X		X	X	X		X	X	X	X		X	X	X	X	X	X	

(a) note if water was being pumped.
Blank samples collected for Ortho-P, LAB ID 34-8416.

TEAM 3 8/17/93

Site	Location	Station ID	LAB ID	Flow(b)	Secchi Disc	pH Cond Temp	DO	FC	Hard	TSS	Turb	TOC	BOD5	BOD35	NH3	NO3-NO2	TPN	Ortho-P	TP	Chloro a	Phyto
1	Upriver of Sultan WTP	SKY01	34-8501			X	X	X	X		X	X	X		X	X	X	X	X	X	X
2	Sultan River	SUL02	34-8502	X		X	X	X	X		X	X	X		X	X	X	X	X	X	
3	1 mi. downriver of Sultan	SKY03	34-8503			X	X	X													
5	Upriver of Woods Creek (and WTP)	SKY05	34-8504			X	X	X	X		X	X			X	X	X	X	X	X	
6	Woods Creek	WOD06	34-8505	X		X	X	X	X		X	X	X		X	X	X	X	X	X	
7	1 mi. downriver of Monroe	SKY07	34-8506			X	X	X													
9	Snoqualmie at confluence	SNQ09	34-8507			X	X	X	X		X	X	X		X	X	X	X	X	X	X
12	French Creek	FRN12	34-8508	b		X	X	X			X	X	X		X	X	X	X	X	X	
13	Pilchuck River	PIL13	34-8509	X		X	X	X			X	X	X		X	X	X	X	X	X	
17	Marshland	MAR17	34-8510	b		X	X	X			X	X	X		X	X	X	X	X	X	
	Replicate sample for 8/17/93	REP17	34-8511			X	X	X			X	X	X		X	X	X	X	X	X	
19	Deadwater Slough	DED19	34-8512	b		X	X	X			X	X	X		X	X	X	X	X	X	
22	Swan Trail Slough	STS22	34-8513	b		X	X	X			X	X	X		X	X	X	X	X	X	
28	Quilceda Creek	QIL28	34-8515	X		X	X	X			X	X	X		X	X	X	X	X	X	

(a) Flow measurements will be made at selected locations in the sloughs at low tide.
(b) note if water was being pumped.
Blank samples collected for Ortho-P, LAB ID 34-8516.

Appendix A.2. Snohomish River TMDL Site Sampling Schedule.

Metals Sampling 9/14/93

Site Location	Station ID	LAB ID	Type	Sample Depth	Tide (a)	pH Cond Temp	Total Hard	TSS	TOC	TR-Metal	Dissolved Metal
20 Upstream of Everett WTP	SNO20	38-8080	routine	Surface	Low	X		X	X	X	X
	SNO20	38-8081	routine	Surface	High	X		X	X	X	X
	REP20	38-8082	replicate	Surface	High	X		X	X	X	X
31 Uptstream of Marysville WTP	STM31	38-8083	routine	Surface	Low	X		X	X	X	X
	STM31	38-8084	routine	Surface	High	X		X	X	X	X
23 Upstream of L. Stevens WTP	EBE23	38-8085	routine	Surface	Low	X		X	X	X	X
	REP23	38-8086	replicate	Surface	Low	X		X	X	X	X
	EBE23	38-8089	routine	Surface	High	X		X	X	X	X
	EBE23	38-8087	blank					X	X		X
	EBE23	38-8088	standard							X	X
16 Upstream of Ebey Slough	SNO16	38-8090	routine	Surface	Low	X	X	X	X	X	X
	SNO16	38-8091	routine	Surface	High	X	X	X	X	X	X
14 Upstream of Snohomish WTP	SNO14	38-8092	routine	Surface	Low	X	X	X	X	X	X
	SNO14	38-8093	routine	Surface	High	X	X	X	X	X	X
	SNO14	38-8094	blank			X	X	X	X	X	X

(a) Sampled both high and low tide at surface.
TR-Metal for cadmium, copper, and mercury; Dissolved Metal for cadmium and copper.

Metals Sampling 5/24/94

Site Location	Station ID	LAB ID	Type	Sample Depth	Tide (a)	pH Cond Temp	Total Hard	TSS	TOC	TR-Metal	Dissolved Metal
20 Upstream of Everett WTP	SNO20	21-8105	routine	Surface	Low	X		X	X	X	X
	SNO20	21-8106	routine	Surface	High	X		X	X	X	X
	REP20	21-8107	replicate	Surface	High	X		X	X	X	X
31 Uptstream of Marysville WTP	STM31	21-8108	routine	Surface	Low	X		X	X	X	X
	STM31	21-8109	routine	Surface	High	X		X	X	X	X
23 Upstream of L. Stevens WTP	EBE23	21-8110	routine	Surface	Low	X		X	X	X	X
	REP23	21-8111	replicate	Surface	Low	X		X	X	X	X
	EBE23	21-8113	routine	Surface	High	X		X	X	X	X
	EBE23	21-8112	blank			X		X	X	X	X
16 Upstream of Ebey Slough	SNO16	21-8114	routine	Surface	Low	X	X	X	X	X	X
	SNO16	21-8115	routine	Surface	High	X	X	X	X	X	X
14 Upstream of Snohomish WTP	SNO14	21-8116	routine	Surface	Low	X	X	X	X	X	X
	SNO14	21-8117	routine	Surface	High	X	X	X	X	X	X
	SNO14	21-8118	blank			X	X	X	X	X	X

(a) Sampled both high and low tide at surface.
TR-Metal for cadmium, copper, and mercury; Dissolved Metal for cadmium and copper.

Appendix B
Ecology Survey Data

Appendix B.1 Laboratory data and field measurements for samples collected August 16 and 17, 1993.

Date 1993	LAB ID	Station ID	Time (hour)	Tide	Sample Depth (m)	Cond (umhos/cm)	Sal (o/oo)	Temp (C°)	DO Sat (mg/L)	DO (mg/L)	DO Sat (%)	pH (S.U.)	TPN (mg/L)	NH3 (mg/L)	NO2-NO3 (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Turb (NTU)	TSS (mg/L)	TOC (mg/L)	BOD5 (mg/L)	BOD35 (mg/L)	Chloro a (ug/L)	Pheo a (ug/L)	Total Hard (mg/L)	FC (#/100mL)
16-Aug	348401	SKY01	2015	-	0.2	46	0.0	14.7	10.1	9.8	97	7.6	0.194	0.010 U	0.129	0.010 U	0.010 U	0.5	2	1 U	3 U	-	4.8	1.5	19	78
16-Aug	348402	SUL02	1945	-	0.2	35	0.0	12.1	10.8	11.0	102	7.8	0.118	0.010 U	0.076	0.010 U	0.010 U	1.0	4	1.1	3 U	-	3.1	1.2	12 J	52
16-Aug	348404	SKY05	1830	-	0.2	42	0.0	13.5	10.4	10.6	102	7.7	0.129	0.010 U	0.085	0.010 U	0.010 U	1.6	4	1 U	-	-	3.1	2.0	14	190
16-Aug	348405	WOD06	1800	-	0.2	92	0.0	14.2	10.3	9.6	94	7.8	0.671	0.010 U	0.551	0.021	0.011	1.4	3	3.2	3 U	-	6.8	3.1	39	750
16-Aug	348406	SKY07	1440	-	0.2	48	0.0	14.0	10.3	10.0	97	7.8	-	-	-	-	-	-	-	-	-	-	-	-	-	160
16-Aug	348407	SNQ09	1700	-	0.2	66	0.0	15.2	10.0	9.7	97	7.5	0.297	0.010 U	0.225	0.011	0.010 U	1.5	2	1.2	3 U	-	0.7 J	0.6	27	140
16-Aug	348408	SNQ09	1705	-	0.2	66	0.0	15.2	10.0	9.4	94	7.5	0.297	0.010 U	0.228	0.011	0.010 U	1.6	2	1.0	3 U	-	1.2	0.5	28	100
16-Aug	348409	FRN12	1515	-	0.2	217	0.0	15.5	10.0	2.4	24	6.8	2.10	0.211	1.13	0.090	0.024	16	3	8.1	3 U	-	2.4	1.1	-	51
16-Aug	348410	PIL13	1430	-	0.2	88	0.0	14.8	10.1	10.0	99	7.7	0.344	0.010 U	0.249	0.010 U	0.010 U	0.6	1	2.0	3 U	-	2.0	1.3	-	210
16-Aug	348411	MAR17	1330	-	0.2	205	0.0	15.2	10.0	1.7	17	6.9	1.86	0.311	1.13	0.131	0.055	9.9	3	4.5	3	-	17.4	4.0	-	72
16-Aug	348412	DED19	1140	-	0.2	1100	0.6	17.7	9.5	8.9	94	7.0	1.90	0.619	0.214	0.129	0.011	24	11	10.2	6	-	104.0	10.9	-	57
16-Aug	348413	STS22	1225	-	0.2	352	0.1	14.3	10.2	2.4	23	6.7	4.33	3.95	0.010 U	0.056	0.010	80	26	8.8	9	-	11.0	4.6	-	190
16-Aug	348414	ALL25	1007	-	0.2	191	0.0	14.6	10.2	1.0	10	7.0	1.20	0.025	0.893	0.115	0.090	1.7	1	5.2	3 U	-	1.3	1.0	-	200
16-Aug	348415	QIL28	905	-	0.2	740	0.4	14.2	10.2	7.0	68	7.5	1.19	0.022	0.958	0.113	0.069	6.6	9	4.9	3 U	-	0.8	0.8	-	810 S
16-Aug	348416	SNQ19	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	0.010 U	-	-	-	-	-	-	-	-	-
16-Aug	348420	EBE23	1235	LOW	0.2	141	0.0	16.1	9.8	9.1	92	7.7	0.253	0.053	0.186	0.012	0.010 U	2.2	5	1.2	3 U	-	6.8	1.3	21	51 S
16-Aug	348421	EBE23	1745	HIGH	0.2	10300	6.8	18.2	9.1	8.3	92	7.4	0.367	0.046	0.170	0.033	0.021	2.3	4	1.2	-	-	3.3	2.0	730	-
16-Aug	348422	EBE23	1750	HIGH	5.5	11000	7.3	18.0	9.1	8.1	89	7.4	0.376	0.05	0.164	0.035	0.015	3.4	8	1.0 U	3 U	-	-	-	-	-
16-Aug	348423	EBE24	1040	LOW	0.2	5400	3.5	17.0	9.5	8.6	91	7.4	0.294	0.025	0.163	0.033	0.010 U	4.0	14	1.0 U	-	2.0	-	-	-	57
16-Aug	348424	EBE24	1730	HIGH	0.2	12100	7.9	18.7	8.9	8.2	92	7.4	0.290	0.032	0.158	0.024	0.010 U	2.6	4	1.0 U	-	-	-	-	-	-
16-Aug	348425	EBE24	1735	HIGH	4	18000	12.2	19.0	8.6	6.8	79	7.4	0.402	0.050	0.135	0.047	0.022	6.8	18	1.0 U	-	-	-	-	-	-
16-Aug	348426	EBE26	1110	LOW	0.2	16800	11.7	17.5	8.9	6.6	74	7.4	0.346	0.047	0.138	0.041	0.020	4.9	12	1.0 U	-	-	-	-	-	110
16-Aug	348427	EBE26	1710	HIGH	0.2	18000	12.3	18.6	8.7	7.4	85	7.7	0.367	0.032	0.128	0.037	0.034	3.7	7	1.0 U	-	-	-	-	-	-
16-Aug	348428	EBE26	1715	HIGH	5.2	22200	15.4	18.6	8.5	7.2	84	7.8	0.272	0.025	0.108	0.046	0.035	4.0	14	1.0 U	-	-	-	-	-	-
16-Aug	348429	EBE27	1125	LOW	0.2	15400	10.6	17.6	9.0	7.0	78	7.4	0.340	0.052	0.138	0.044	0.023	4.2	11	1.0 U	-	-	4.2	2.5	-	290
16-Aug	348430	EBE27	1650	HIGH	0.2	24800	17.7	18.0	8.5	7.3	86	7.8	0.262	0.011	0.101	0.043	0.035	2.7	6	1.0 U	-	-	7.4	1.7	-	-
16-Aug	348431	EBE27	1655	HIGH	4.3	27800	20.1	18.0	8.4	7.3	87	7.9	0.262	0.013	0.096	0.046	0.038	2.4	11	1.0 U	-	-	-	-	-	-
16-Aug	348432	STM31	1005	LOW	0.2	4030	2.6	16.2	9.7	8.3	86	7.4	0.305	0.037	0.171	0.033	0.014	1.8	26	1.0 U	3 U	-	3.6	2.1	-	51 S
16-Aug	348433	STM31	1010	LOW	0.2	3950	2.5	16.2	9.7	8.8	91	7.4	0.335	0.040	0.170	0.039	0.014	6.9	25	1.0 U	3 U	-	4.2	4.1	-	73
16-Aug	348434	STM31	1615	HIGH	0.2	23200	16.5	18.0	8.6	7.3	85	7.8	0.295	0.021	0.107	0.049	0.038	2.0	9	1.0 U	-	-	4.4	1.6	-	-
16-Aug	348435	STM31	1620	HIGH	4	24000	17.4	18.4	8.5	6.9	82	7.8	0.276	0.020	0.106	0.048	0.040	2.5	10	1.0 U	3 U	-	-	-	-	-
16-Aug	348436	STM32	910	LOW	0.2	12200	8.5	16.5	9.3	7.8	84	7.5	0.317	0.038	0.145	0.041	0.030	4.2	14	1.0 U	-	2.9	-	-	-	49
16-Aug	348437	STM32	1535	HIGH	0.2	19500	13.6	18.2	8.7	7.3	84	7.7	0.363	0.03	0.117	0.043	0.036	3.1	9	1.0 U	-	-	-	-	-	-
16-Aug	348438	STM32	1540	HIGH	4	28000	20.2	18.1	8.4	7.1	85	7.9	0.255	0.021	0.099	0.044	0.034	1.7	8	1.0 U	-	-	-	-	-	-
16-Aug	348439	UNS33	940	LOW	0.2	11000	7.6	16.5	9.3	7.4	79	7.3	0.336	0.048	0.137	0.033	0.013	2.5	10	1.0 U	3 U	-	-	-	-	100
16-Aug	348440	UNS33	1600	HIGH	0.2	23000	16.3	18.0	8.6	7.4	86	7.8	0.306	0.025	0.110	0.043	0.031	3.0	12	1.0 U	-	-	-	-	-	-
16-Aug	348441	UNS33	1605	HIGH	2	24200	17.2	18.0	8.5	7.2	84	7.8	0.291	0.024	0.108	0.041	0.034	3.5	8	1.0 U	-	-	-	-	-	-
16-Aug	348442	IEH35	1510	HIGH	0.2	28700	21.8	16.0	8.6	7.8	90	7.9	0.238	0.013	0.095	0.040	0.035	1.0	4	1.0 U	-	-	3.5	0.9	-	-
16-Aug	348443	IEH35	1515	HIGH	4.6	29100	22.2	16.0	8.6	7.6	88	8.0	0.234	0.012	0.100	0.040	0.036	0.8	4	1.0 U	-	-	-	-	-	-
16-Aug	348445	STM31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.010 U	-	-	-	-	-	-	-	-	-
16-Aug	348450	SNO11	1430	LOW	0.2	45	0.0	14.5	10.2	9.5	93	7.4	0.251	0.010 U	0.179	0.010 U	0.010 U	1.0	3	1.4	3 U	-	1.6	1.4	21	-
16-Aug	348451	SNO14	1220	LOW	0.2	45	0.0	14.5	10.2	9.2	90	7.5	0.267	0.010 U	0.185	0.010 U	0.010 U	1.5	5	1.1	3 U	-	1.4	1.6	24	58
16-Aug	348452	SNO15	1205	LOW	0.2	45	0.0	14.5	10.2	9.3	91	7.5	0.266	0.010 U	0.185	0.010 U	0.010 U	1.0	3	1.0 U	-	-	1.5	1.3	-	150
16-Aug	348453	SNO16	1120	LOW	0.2	48	0.0	15.0	10.1	9.2	91	7.5	0.276	0.010 U	0.192	0.010 U	0.010 U	2.0	2	1.1	-	0.7	1.3	1.2	23	57
16-Aug	348454	SNO16	1125	LOW	0.2	48	0.0	15.0	10.1	9.3	92	7.5	0.280	0.010 U	0.193	0.010 U	0.010 U	1.5	2	1.1	-	1.5	1.4	1.2	23	100 S
16-Aug	348455	SNO18	1103	LOW	0.2	60	0.0	15.0	10.1	9.5	94	7.5	0.273	0.010 U	0.181	0.013	0.010 U	1.6	4	1.0 U	-	-	-	-	23	65
16-Aug	348456	SNO18	1750	HIGH	0.2	5000	3.4	15.0	9.9	8.8	89	7.6	0.415	0.087	0.193	0.033	0.041	2.5	2	1.0 U	-	-	-	-	598	-
16-Aug	348457	SNO18	1755	HIGH	5	20000	14.9	15.0	9.2	8.2	89	7.7	0.442	0.095	0.182	0.053	0.039	3.6	7	1.0 U	-	-	-	-	-	-
16-Aug	348458	SNO20	1005	LOW	0.2	450	0.2	15.0	10.1	9.1	90	7.5	0.282	0.010 U	0.186	0.018	0.010 U	3.3	7	1.1	3 U	-	2.2	1.8	-	88
16-Aug	348459	SNO20	1705	HIGH	0.2	19000	14.2	15.0	9.2	8.4	91	7.6	0.424	0.090	0.187	0.041	0.029	2.5	3	1.0 U	-	-	2.2	1.4	-	-
16-Aug	348460	SNO20	1710	HIGH	10	29000	23.2	14.0	8.9	7.5	84	7.9	0.379	0.055	0.170	0.062	0.050	3.2	13	1.0 U	3 U	-	-	-	-	-
16-Aug	348461	SNO21	930	LOW	0.2	5500	3.7	15.0	9.9	8.7	88	7.4	0.420	0.090	0.192	0.047	0.023	7.8	22	1.0 U	-	0.9	-	-	-	92
16-Aug	348462	SNO21	1630	HIGH	0.2	29500	23.7	14.0	8.9	7.5	84	7.9	0.350	0.035	0.162	0.053	0.048	2.2	4	1.0 U	-	-	-	-	-	-
16-Aug	348463	SNO21	1645	HIGH	4	31500	25.8	13.5	8.9	7.5	84	8.0	0.301	0.015	0.174	0.055	0.049	1.9	9	1.0 U	-	-	-	-	-	-
16-Aug	348464	STM30	1035	LOW	0.2	4200	2.8	15.5	9.8	8.6	88	7.3	0.344	0.049	0.190	0.019	0.012	2.7	3	1.0 U	-	-	-	-	-	160
16-Aug	348465	STM30	1730	HIGH	0.2	4300	2.8	16.0	9.7	9.1	94	7.5	0.294	0.032	0.176	0.021	0.012	2.4	3	1.0 U	-	-	-	-	-	-
16-Aug	348466	STM30	1735	HIGH	4	11500	8.2	15.0	9.6	8.0	83	7.5	0.301	0.030	0.174	0.019	0.012	2.5	3	1.0 U	-	-	-	-	-	-
16-Aug	348467	POG34	1555	HIGH	0.2	32500	27.1	13.0	8.9	7.9	89	7.9	0.367	0.029	0.188	0.054	0.046	1.5	3	1.0 U	-	-	3.9	1.1		67
16-Aug	348468	POG34	1600	HIGH	4.5	32000	26.6	13.0	8.9	7.2	81	8.0	0.343	0.012	0.184	0.057	0.050	2.0	7	1.0 U	-	-	-	-	-	-
16-Aug	348469	SNO16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0 U	-	-	-	-	-	-
16-Aug	348470	SNO16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.010 U	-	-		-	-	-	-	-	-

U The analyte was not detected at or above the reported limit.
S Data Qualifier for Microbiology.
J The analyte was positively identified, but the associated numerical result is an estimate.

Appendix B.1 Laboratory data and field measurements for samples collected August 16 and 17, 1993

Date 1993	LAB ID	Station ID	Time (hour)	Tide	Sample Depth	Cond (umhos/cm)	Sal (o/oo)	Temp (C°)	DO Sat (mg/L)	DO (mg/L)	DO Sat (%)	pH (S.U.)	TPN (mg/L)	NH3 (mg/L)	NO2-NO3 (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Turb (NTU)	TSS (mg/L)	TOC (mg/L)	BOD5 (mg/L)	BOD35 (mg/L)	Chloro a (ug/L)	Pheo a (ug/L)	Total Hard (mg/L)	FC (#/100mL)
17-Aug	348501	SKY01	1015	-	0.2	55	0.0	13.7	10.4	10.6	102	7.7	0.209	0.010 U	0.148	0.012	0.010 U	0.8		1.1	3 U	-	3.5	1.5	19	41
17-Aug	348502	SUL02	1100	-	0.2	38	0.0	12.2	10.7	11.3	105	7.9	0.128	0.010 U	0.08	0.010 U	0.010 U	0.6		1.3	3 U	-	1.7	0.6	11 J	25
17-Aug	348503	SKY03	1040	-	0.2	52	0.0	14.2	10.3	10.5	102	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	15
17-Aug	348504	SKY05	1135	-	0.2	45	0.0	14.0	10.3	10.7	104	7.8	0.140	0.010 U	0.091	0.010 U	0.010 U	0.6		1.0	-	-	1.5	1.1	14	20
17-Aug	348504	SKY07	1440	-	0.2	40	0.0	15.3	10.0	10.5	105	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-	46
17-Aug	348505	WOD06	1225	-	0.2	90	0.0	14.5	10.2	11.4	112	8.0	0.698	0.010 U	0.537	0.028	0.012	1.5	-	3.6	3 U	-	14.3	3.3	38	870
17-Aug	348507	SNQ09	1400	-	0.2	72	0.0	15.3	10.0	9.6	96	7.6	0.294	0.010 U	0.239	0.014	0.010 U	1.1	-	1.2	3 U	-	1.0	0.6	26	88
17-Aug	348508	FRN12	1505	-	0.2	225	0.0	17.5	9.6	4.5	47	6.8	2.11	0.226	1.03	0.074	0.022	12	-	10.3	3 U	-	1.4	1.7	-	63
17-Aug	348509	PIL13	1545	-	0.2	89	0.0	17.7	9.5	10.2	107	7.8	0.355	0.010 U	0.274	0.013	0.010 U	0.7	-	3.0	3 U	-	1.8	1.1	-	92
17-Aug	348510	MAR17	1810	-	0.2	232	0.0	17.0	9.7	7.1	73	7.1	1.69	0.137	0.912	0.133	0.050	9.0	-	5.8	4	-	11.9	7.1	-	29
17-Aug	348511	MAR17	1815	-	0.2	232	0.0	17.0	9.7	7.0	72	7.1	1.71	0.165	0.931	0.144	0.048	7.6	-	5.6	5	-	9.6	3.9	-	32
17-Aug	348512	DED19	1720	-	0.2	1100	0.5	23.0	8.6	15.0	175	7.0	2.59	0.884	0.203	0.159	0.010 U	33	-	13.9	10	-	105.0	54.6	-	81
17-Aug	348513	STS22	1630	-	0.2	375	0.1	19.5	9.2	2.9	32	6.9	3.54	2.96	0.01 U	0.157	0.010 U	54	-	9.0	10	-	12.3	2.7	-	96
17-Aug	348515	QIL28	0830	-	0.2	1000	0.6	14.6	10.1	7.3	72	7.3	1.18	0.024	0.928	0.092	0.058	4.5	-	3.9	3 U	-	2.4	2.7	-	930
17-Aug	348516	MAR17	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	0.010 U	-	-	-	-	-	-	-	-	-
17-Aug	348520	EBE23	1100	LOW	0.2	105	0.0	16.5	9.8	9.2	94	7.6	0.291	0.010	0.192	0.020	0.010 U	2.6	-	1.3	-	-	5.3	1.7	25	49 S
17-Aug	348521	EBE23	1105	LOW	0.2	107	0.0	16.8	9.7	9.3	96	7.4	0.283	0.012	0.191	0.016	0.010 U	3.0	-	1.3	-	-	5.2	1.7	27	70 S
17-Aug	348522	EBE23	1705	HIGH	0.2	3420	2.1	17.7	9.4	8.9	95	7.7	0.311	0.034	0.188	0.028	0.013	4.0	-	1.0 U	-	-	4.2	1.9	420	-
17-Aug	348523	EBE23	1710	HIGH	5.5	3550	2.2	18.0	9.3	8.9	95	7.7	0.336	0.035	0.189	0.033	0.012	6.8	-	1.0 U	-	-	-	-	-	-
17-Aug	348524	EBE24	1040	LOW	0.2	6100	3.9	17.3	9.4	8.3	88	7.3	0.324	0.046	0.178	0.023	0.013	5.9	-	1.0 U	-	-	-	-	-	88
17-Aug	348525	EBE24	1650	HIGH	0.2	13400	8.8	19.2	8.8	7.7	88	7.4	0.495	0.058	0.157	0.077	0.022	6.1	-	1.0 U	-	-	-	-	-	-
17-Aug	348526	EBE24	1655	HIGH	3.7	13600	8.8	19.8	8.7	7.1	82	7.4	0.413	0.056	0.158	0.043	0.023	13	-	1.0 U	-	-	-	-	-	-
17-Aug	348527	EBE26	1020	LOW	0.2	15900	10.9	17.8	8.9	6.8	76	7.3	0.388	0.053	0.162	0.030	0.020	5.2	-	1.0 U	-	-	-	-	-	160
17-Aug	348528	EBE26	1630	HIGH	0.2	14100	9.3	19.2	8.7	7.6	87	7.5	0.389	0.038	0.156	0.035	0.026	6.9	-	1.0 U	-	-	-	-	-	-
17-Aug	348529	EBE26	1635	HIGH	4.3	14700	9.6	19.5	8.7	7.8	90	7.5	0.360	0.038	0.157	0.042	0.026	9.2	-	1.0 U	-	-	-	-	-	-
17-Aug	348530	EBE27	1000	LOW	0.2	15500	10.7	17.5	9.0	6.8	76	7.4	0.357	0.047	0.136	0.030	0.024	4.2	-	1.0 U	-	-	3.0	2.5	-	160
17-Aug	348531	EBE27	1615	HIGH	0.2	1900	12.7	19.5	8.5	8.3	97	7.7	0.328	0.032	0.140	0.022	0.030	4.3	-	1.0 U	-	-	3.6	1.9	-	-
17-Aug	348532	EBE27	1620	HIGH	4.3	22600	14.8	21.2	8.1	7.7	95	7.7	0.346	0.028	0.127	0.041	0.034	6.9	-	1.0 U	-	-	-	-	-	-
17-Aug	348533	STM31	935	LOW	0.2	6200	4.0	17.0	9.4	8.4	89	7.4	0.354	0.050	0.174	0.032	0.015	5.3	-	1.0 U	-	-	2.8	2.7	-	89
17-Aug	348534	STM31	1540	HIGH	0.2	14500	9.6	18.9	8.8	8.1	92	7.5	0.363	0.041	0.160	0.031	0.029	4.2	-	1.0 U	-	-	4.2	2.7	-	-
17-Aug	348535	STM31	1545	HIGH	3.7	14900	9.3	21.8	8.3	7.9	95	7.5	0.372	0.040	0.157	0.039	0.028	5.8	-	1.0 U	-	-	-	-	-	-
17-Aug	348536	STM32	850	LOW	0.2	14600	10.1	17.1	9.1	7.6	84	7.5	0.326	0.040	0.150	0.032	0.029	3.1	-	1.0 U	-	-	-	-	-	59
17-Aug	348537	STM32	1500	HIGH	0.2	20000	13.5	19.5	8.5	7.6	90	7.6	0.338	0.037	0.140	0.033	0.029	4.7	-	1.0 U	-	-	-	-	-	-
17-Aug	348538	STM32	1505	HIGH	4.6	24600	16.9	19.6	8.3	8.0	96	7.8	0.293	0.023	0.121	0.038	0.037	3.2	-	1.0 U	-	-	-	-	-	-
17-Aug	348539	UNS33	910	LOW	0.2	15500	10.8	18.2	8.8	7.3	83	7.3	0.350	0.048	0.145	0.030	0.020	4.0	-	1.0 U	-	-	-	-	-	60
17-Aug	348540	UNS33	1520	HIGH	0.2	15500	10.1	19.9	8.6	8.2	96	7.6	0.344	0.041	0.158	0.030	0.026	5.5	-	1.0 U	-	-	-	-	-	-
17-Aug	348541	UNS33	1525	HIGH	0.9	15200	9.6	21.0	8.4	8.0	95	7.5	0.351	0.038	0.147	0.033	0.026	5.8	-	1.0 U	-	-	-	-	-	-
17-Aug	348542	IEH35	1430	HIGH	0.2	27900	20.1	18.0	8.4	7.9	94	7.9	0.258	0.019	0.111	0.039	0.038	2.2	-	1.0 U	-	-	2.5	1.0	-	-
17-Aug	348543	IEH35	1435	HIGH	4.8	29500	20.4	20.0	8.1	8.1	100	8.0	0.252	0.014	0.105	0.033	0.039	1.5	-	1.0 U	-	-	-	-	-	-
17-Aug	348544	STM31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-	-	-	-	-	-
17-Aug	348545	EBE23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.010 U	-	-	-	-	-	-	-	-	-
17-Aug	348546	SNO11	1230	LOW	0.2	40	0.0	14.5	10.2	9.9	96	7.4	0.262	0.010 U	0.180	0.010 U	0.010 U	1.0	-	1.4	3 U	-	2.0	1.4	21	-
17-Aug	348551	SNO14	1155	LOW	0.2	40	-	14.5	10.2	10.2	100	7.4	0.261	0.010 U	0.179	0.017	0.010 U	1.2	-	1.1	-	-	2.3	1.8	21	71
17-Aug	348552	SNO15	1140	LOW	0.2	40	-	14.5	10.2	9.7	95	7.4	0.271	0.013	0.182	0.012	0.010 U	1.3	-	1.4	-	-	1.6	1.6		150
17-Aug	348553	SNO16	1115	LOW	0.2	45	-	15.0	10.1	9.1	90	7.4	0.317	0.010 U	0.186	0.013	0.010 U	1.4	-	1.2	3 U	-	1.6	1.5	22	140 S
17-Aug	348554	SNO18	1050	LOW	0.2	52	-	15.0	10.1	9.8	97	7.4	0.255	0.010 U	0.188	0.016	0.010 U	2.3	-	1.3	-	-	-	-	23	130 S
17-Aug	348555	SNO18	1700	HIGH	0.2	5000	3.2	17.0	9.5	8.9	94	7.5	0.465	0.078	0.201	0.035	0.021	3.3	-	1.0 U	-	-	-	-	620	-
17-Aug	348556	SNO18	1705	HIGH	4.6	10000	6.8	16.5	9.4	8.4	90	7.6	0.380	0.090	0.197	0.039	0.028	4.6	-	1.0 U	-	-	-	-	-	-
17-Aug	348557	SNO20	1000	LOW	0.2	550	0.3	15.0	10.1	9.2	91	7.3	0.272	0.018	0.194	0.018	0.010 U	3.4	-	1.3	-	-	2.3	2.1	-	100 S
17-Aug	348558	SNO20	1615	HIGH	0.2	4100	2.6	17.5	9.4	8.8	93	7.6	0.343	0.079	0.189	0.033	0.019	3.8	-	1.0 U	-	-	2.4	1.8	-	60
17-Aug	348559	SNO20	1630	HIGH	9.5	11000	7.8	17.0	9.2	7.8	85	7.7	0.437	0.111	0.190	0.054	0.042	6.5	-	1.0 U	-	-	-	-	-	-
17-Aug	348560	SNO21	915	LOW	0.2	9500	6.7	15.0	9.7	8.4	87	7.6	0.430	0.134	0.189	0.045	0.031	3.8	-	1.0 U	-	-	-	-	-	110
17-Aug	348561	SNO21	920	LOW	0.2	9550	6.7	15.0	9.7	8.2	85	7.6	0.449	0.146	0.194	0.040	0.029	3.8	-	1.0 U	-	-	-	-	-	75 S
17-Aug	348562	SNO21	1515	HIGH	0.2	25500	19.7	15.0	8.9	7.7	86	7.9	0.392	0.053	0.191	0.043	0.049	2.0	-	1.0 U	-	-	-	-	-	20
17-Aug	348563	SNO21	1535	HIGH	2.8	28000	21.8	15.0	8.8	7.6	86	8.0	0.372	0.036	0.188	0.044	0.050	2.8	-	1.0 U	-	-	-	-	-	-
17-Aug	348564	STM30	1030	LOW	0.2	4200	2.8	15.5	9.8	8.7	89	7.3	0.306	0.055	0.193	0.019	0.010	2.4	-	1.0 U	-	-	-	-	-	69
17-Aug	348565	STM30	1640	HIGH	0.2	3450	2.1	17.5	9.4	9.2	97	7.4	0.264	0.031	0.184	0.018	0.012	3.4	-	1.0 U	-	-	-	-	-	-
17-Aug	348566	STM30	1645	HIGH	2.8	7500	4.9	17.0	9.4	8.6	92	7.4	0.322	0.051	0.188	0.024	0.014	4.1	-	1.0 U	-	-	-	-	-	-
17-Aug	348567	POG34	1445	HIGH	0.2	29500	23.4	14.5	8.8	7.7	87	7.8	0.373	0.067	0.194	0.037	0.045	2.2	-	1.0 U	-	-	-	-	-	12
17-Aug	348568	POG34	1500	HIGH	5.2	30000	23.8	14.5	8.8	7.4	84	8.0	0.502	0.030	0.192	0.050	0.053	3.0	-	1.0 U	-	-	2.8	1.0	-	-
17-Aug	348570	SNO21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.013	-	-	1.0 U	-	-	-	-	-	-

U The analyte was not detected at or above the reported limit.
S Data Qualifier for Microbiology.
J The analyte was positively identified, but the associated numerical result is an estimate.

Appendix B.2. Results of metal sampling surveys with acute and chronic freshwater and marine criteria noted.

Date 1993	Lab ID	Station ID	Type	Tide	Cd rec (ug/L)	Cd dis (ug/L)	Cu rec (ug/L)	Cu dis (ug/L)	Hg rec (ug/L)	Hard (mg/L)	TOC (mg/L)	TSS (mg/L)
14-Sep	388080	SNO20	routine	Low	0.11 U	0.10 U	1.1 U	1.0 U	0.010 U		1.5	13
14-Sep	388081	SNO20	routine	High	0.11 U	0.10 U	1.2 P	1.0 U	0.010 U		1.4	17
14-Sep	388082	SNO20	replicate	High	0.11 U	0.10 U	1.2 P	1.0 U	0.010 U		1.5	15
14-Sep	388083	STM31	routine	Low	0.11 U	0.10 U	1.5 P	1.0 U	0.010 U		1.1	21
14-Sep	388084	STM31	routine	High	0.11 U	0.10 U	1.1 U	1.0 U	0.010 U		1 U	11
14-Sep	388085	EBE23	routine	Low	0.11 U	0.10 U	1.1 U	1.0 U	0.010 U		1.6	13
14-Sep	388086	EBE23	replicate	Low	0.11 U	0.10 U	1.1 U	1.0 U	0.010 U		1.3	9
14-Sep	388087	EBE23	blank		0.11 U	0.10 U	1.1 U	1.0 U	0.010 U			
14-Sep	388088	EBE23	standard (a)		0.11 U	0.10 U	2.9 P	2.7 P	0.139 U			
14-Sep	388089	EBE23	routine	High	0.11 U	0.10 U	2.1 P	1.0 U	0.010 U		1.3	29
14-Sep	388090	SNO16	routine	Low	0.11 U	0.10 U	1.1 U	1.0 U	0.010 U	23	1.3	2
14-Sep	388091	SNO16	routine	High	0.11 U	0.10 U	8.5 P	1.4 P	0.010 U	27	1.3	7
14-Sep	388092	SNO14	routine	Low	0.21 P	0.10 U	1.1 U	1.0 U	0.010 U	23	1.2	4
14-Sep	388093	SNO14	routine	High	0.11 U	0.10 U	1.1 U	1.0 U	0.010 U	23	1.1	2
14-Sep	388094	SNO14	blank		0.11 U	0.10 U	1.1 U	1.0 U	0.010 U			
24-May	218105	SNO20	routine	Low	0.10 U	0.10 U	1.5 P	1.0 U	0.0010 U		1.2	9
24-May	218106	SNO20	routine	High	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U		1.3	8
24-May	218107	SNO20	replicate	High	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U		1.3	8
24-May	218108	STM31	routine	Low	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U		1.2	12
24-May	218109	STM31	routine	High	0.10 U	0.10 U	1.1 P	1.0 U	0.0010 U		1.3	7
24-May	218110	EBE23	routine	Low	0.10 U	0.10 U	1.0 U	1.9 P	0.0010 U		1.3	5
24-May	218111	EBE23	replicate	Low	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U		1.3	6
24-May	218113	EBE23	routine	High	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U		1.3	6
24-May	218112	EBE23	blank		0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U			
24-May	218114	SNO16	routine	Low	0.10 U	0.10 U	1.0 U	1.0 U	0.0026 P	12.6	1.2	5
24-May	218115	SNO16	routine	High	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U	13.1	1.1	4
24-May	218116	SNO14	routine	Low	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U	13.1	1.1	4
24-May	218117	SNO14	routine	High	0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U	12.1	1.1	4
24-May	218118	SNO14	blank		0.10 U	0.10 U	1.0 U	1.0 U	0.0010 U			

(a) Standard reference material: Cd = 0.028 +/- 0.004; Cu = 2.76 +/- 0.17 ug/L; Hg = NA.
U The analyte was not detected at or above the reported result.
P The analyte was detected above the instrument detection limit but below the quantification limit.

	Criteria (ug/L)			
	Freshwater		Marine	
	Acute	Chronic	Acute	Chronic
Hardness	27	27		
Cadmium	0.8	0.4	37.2	8.0
Copper	4	3	2.5	-
Mercury	2.4	0.012	2.100	0.025

Appendix C
Memorandum Summarizing Class II Inspection Results

DEPARTMENT OF ECOLOGY

November 15, 1994

TO: John Glynn and Dave Wright
Water Quality Program, NWRO

THROUGH: Will Kendra
EILS Program, Watershed Assessments Section

FROM: Norm Glenn
Watershed Assessments Section

SUBJECT: City of Everett Basin Class II Inspection Summary

An announced Basin Class II inspection was conducted at the above facility during the week of August 16, 1993. My original intent was to provide the usual inspection report. However, due to the recent reprogramming of Class II activities in EILS, it became necessary to abbreviate the reporting effort on my remaining projects. This transmittal memo summarizes the significant findings from my review of the inspection data (attached):

- No conclusions could be reached regarding the accuracy of the plant's three flow measuring devices because they weren't accessible; instantaneous flows could not be checked. Plant personnel acknowledged that for flows below 7 MGD, the propeller meter (outfall 015) precision is suspect. Periodic verification of all three by an independent contractor must be done on a regular basis.

- Reduction of ammonia concentrations throughout the WWTP was minimal, resulting in relatively high concentrations in effluent.

- Copper and silver are pollutants of concern in effluent from the TF/SC system. Metals limits contained in the NPDES permit have been temporarily stayed by the Pollution Control Hearings Board; nevertheless copper concentrations are well above limits. Silver matched the "instantaneous concentration not to be exceeded at any time" contained in the water quality standards.

- BOD_5 of effluent from the lagoon system exceeded permit limits at times, but the pattern appeared to be highly variable. Fecal coliform counts in effluent to outfall 015a were well above the allowable limit. Total residual chlorine concentrations were high, but installation of dechlorination equipment is imminent.

- The plant manager chose to replicate each of our sampling efforts, with the single exception of the grab samples on August 18. The split sample data appear to indicate that plant composite samples are not thoroughly mixed before dispensing to lab split samples (part of the sampling procedure) and before dispensing to aliquots within the lab (part of the analytical procedure). Since this is likely a common problem that has a direct bearing on whether the "85 percent removal" permit limit is met, it is recommended that Ecology's Quality Assurance Section assess the plant's sample handling and preparation procedures.

If you have any questions concerning this memo, please contact me at 407-6683.

NLG:blt
Attachments

References:

APHA-AWWA-WEF, 1992. Standard Methods for the Examination of Water and Wastewater, 18 edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.

Ecology, 1992. Administrative Order No. DE 92WQ-N305, Department of Ecology, Northwest Regional Office, Bellevue WA.

EPA, 1983. Methods for Chemical Analyses of Water and Waste. EPA-600/4-79-020 (Rev. March, 1983). Washington D.C.

PCHB, 1993. City of Everett, Department of Public Works vs. Department of Ecology. Pollution Control Hearings Board, Lacey WA. PCHB No. 92-214.

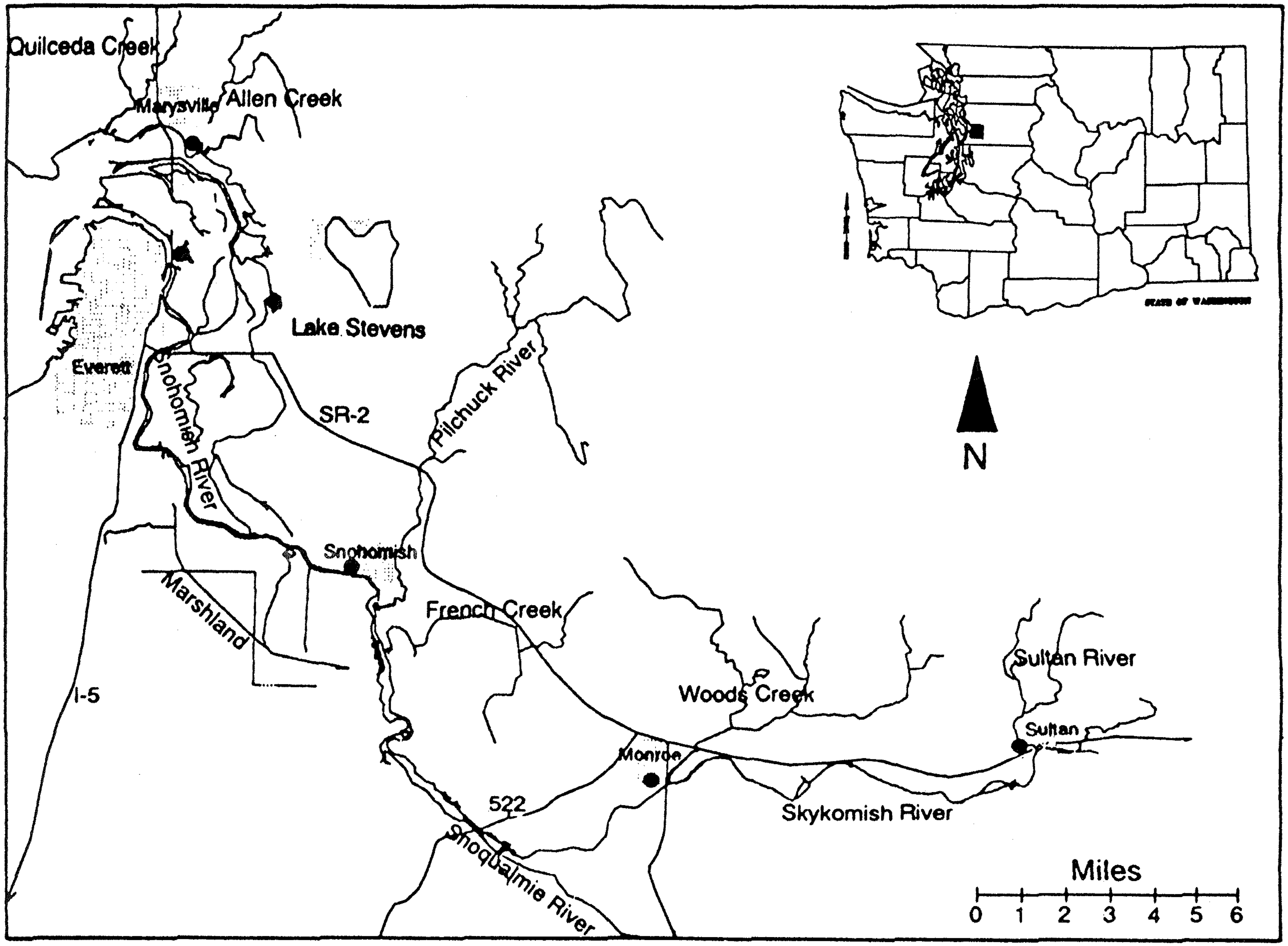

Figure 1. Location Map for WWTPs in Lower Snohomish TMDL Study Area, 8/93.

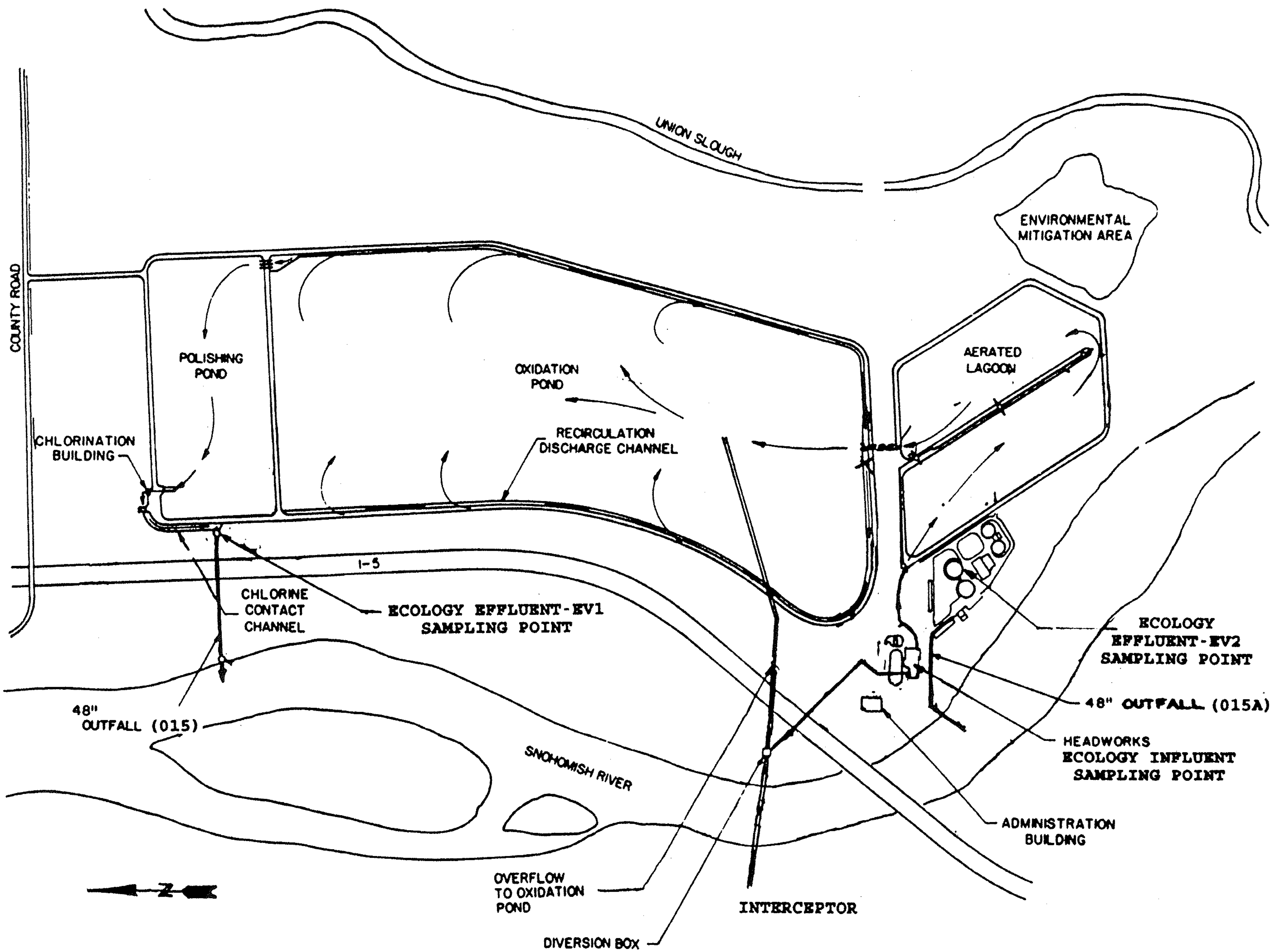

Figure 2. Plant Schematic - City of Everett WWTPs, 8/93.

Table 1. Chemical Analytical Methods and Laboratories – City of Everett – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Method	Lab used
Alkalinity	EPA, 1983: 310.1	Ecology; Manchester WA
Chloride	EPA, 1983: 330.0	Ecology; Manchester WA
SOLIDS		
Total solids (TS)	EPA, 1983: 160.3	Ecology; Manchester WA
Total non-volatile solids (TNVS)	EPA, 1983: 160.4	Ecology; Manchester WA
Total suspended solids (TSS)	EPA, 1983: 160.2	Ecology; Manchester WA
Total non-volatile suspended solids (TNVSS)	EPA, 1983: 160.4	Ecology; Manchester WA
Five-day biochemical oxygen demand (BOD5)	APHA, 1992; 5210	Sound Analytical Svcs.; Tacoma WA
NUTRIENTS		
Total ammonia, as nitrogen (NH3-N)	EPA, 1983: 350.1	Sound Analytical Svcs.; Tacoma WA
Nitrate-nitrite, as nitrogen (NO2+NO3-N)	EPA, 1983: 353.2	Sound Analytical Svcs.; Tacoma WA
Total Kjeldahl nitrogen	EPA, 1983: 351.2	Sound Analytical Svcs.; Tacoma WA
O-phosphate	EPA, 1983: 365.3	Ecology; Manchester WA
T-phosphorus	EPA, 1983: 365.3	Sound Analytical Svcs.; Tacoma WA
Fecal Coliform MF	APHA, 1992:9222D	Ecology, Manchester WA
METALS		
Cadmium	EPA, 1983;213.2	Ecology; Manchester WA
Copper	EPA, 1983;220.2	Ecology; Manchester WA
Lead	EPA, 1983;239.2	Ecology; Manchester WA
Mercury	EPA, 1983;245.1	Ecology; Manchester WA
Silver	EPA, 1983;272.2	Ecology; Manchester WA
Zinc	EPA, 1983;200.7	Ecology; Manchester WA

Table 2. General Chemistry and Metals Results, City of Everett – L. Snohomish River Basin Class II Inspections, 8/93

Parameter	Location:	Blank1-E	Blank2-E	InfEV-E	InfEV-EV	EffEV1-E	EffEV1-EV
	Type:	Equip	Equip	Comp	Comp	Comp	Comp
	Date:	8/17	8/17	8/18-19	8/18-19	8/18-19	8/18-19
	Time:	1245	1210	24 hour	24 hour	24 hour	24 hour
	Lab Log #: 3482	-40	-49	-41	-42	-43	-44
GENERAL CHEMISTRY							
Alkalinity (mg/L)				162		151	
Chloride (mg/L)				37		41	
SOLIDS 4 (mg/L)							
TS				543	591	311	320
TNVS				217	212	182	191
TSS				178	235	50	31
TNVSS				48	55	5	8
BOD5 (mg/L)				160	220	71	92
NH3-N (mg/L)				18		16	
NO2+NO3-N (mg/L)				0.09J		0.95	
Total Kjeldahl N (mg/L)				52		41	
Phosphate - Ortho (mg/L)						3.99	
Phosphate - Total (mg/L)				5.5		4.3	
F-Coliform MF (#/100mL)							
METALS (µg/L)*							
Cadmium		0.12P	0.21P			0.20P	
Copper		1.3P	1.0U			6.5P	
Lead		1.0U	1.0U			2.8P	
Mercury		0.05U	0.05U			0.05U	
Silver		0.50U	0.50U			0.50U	
Zinc		4UB	4UB			14PB	
FIELD OBSERVATIONS							
Flow (MGD)							
Temperature (°C.)				9.6**		14.3**	
pH (s.u.)				7.8**		8.1**	
Conductivity (µmho/cm)				534		534	
Chlorine, free (mg/L)						0.03	
total (mg/L)						0.03	

InfEV - Influent; EffEV1 - Effluent to outfall 015; EffEV2 - Effluent to outfall 015a; -E - Ecology sampler; -EV - Everett sampler.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
U means the analyte was not detected at or above the reported result.
J means the analyte was positively identified. The associated numerical result is an estimate.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.
* - All metals data are total recoverable metals. ** - Iced composite sample.

Table 2. General Chemistry and Metals Results, City of Everett – L. Snohomish River Basin Class II Inspection, 8/93 (P. 2)

Parameter	Location:	EffEV1-1	EffEV1-2	EffEV2-E	EffEV2-EV	EffEV2-1	EffEV2-2
	Type:	Grab	Grab	Comp	Comp	Grab	Grab
	Date:	8/18	8/19	8/18-19	8/18-19	8/18	8/19
	Time:	1230	1200	24 hour	24 hour	1200	1050
	Lab Log #: 3482	-45	-46	-50	-51	-52	-53
GENERAL CHEMISTRY							
Alkalinity (mg/L)		149	146	186		187	188
Chloride (mg/L)		39	41	53		56	48
SOLIDS 4 (mg/l)							
TS		321	336	358	329	348	332
TNVS		163	173	210	222	159	182
TSS		40	29	11	10	8	4
TNVSS		3	1U	2	1U	3	1U
BOD5 (mg/L)		86	36	15	27	29	24U
NH3-N (mg/L)		15	15	24		21	24
NO2+NO3-N (mg/L)		0.97	1.26	0.08J		0.14	0.12
Total Kjeldahl N (mg/L)		21	48	28		29	28
Phosphate - Ortho (mg/L)		3.87	3.88	3.49		3.37	3.56
Phosphate - Total (mg/L)		4.3	4.4	3.9		3.8	3.8
F-Coliform MF (#/100 mL)		160	170			1600	1600
METALS (µg/L)*							
Cadmium			0.11P	0.31P			0.26P
Copper			6.5P	13.3			12.4
Lead			1.8P	4.4P			4.5P
Mercury			0.05U	0.06P			0.05P
Silver			0.50U	1.1P			1.2P
Zinc			11PB	30PB			29PB
FIELD OBSERVATIONS							
Flow (MGD)				6.5			
Temperature (°C.)		22.1	22.5	12.4**		20.5	20.1
pH (s.u.)		8.4	8.5	7.5**		7.5	6.9
Conductivity (µmho/cm)		494	484	634		604	634
Chlorine free (mg/L)		0.15	0.03	0.04		0.07	0.03
total (mg/L)		0.10	0.03	0.04		0.08	0.03

EffEV1 - Effluent to outfall 015; EffEV2 - Effluent to outfall 015a; -E - Ecology sampler;
-EV - Everett sampler; -1 - grab sample on 8/18; -2 - grab sample on 8/19.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
U means the analyte was not detected at or above the reported result.
J means the analyte was positively identified. The associated numerical result is an estimate.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.
* - All metals data are total recoverable metals. ** - Iced composite sample.

Table 3a. Comparison of Inspection Results to NPDES Permit Limits for Outfall 015, City of Everett – L. Snohomish River Basin Class II Inspections, 8/93.

	NPDES Permit Limits (Outfall 015)*		Inspection Data		Loading and Performance			
Parameter	Monthly Average	Weekly Average	Ecology Composite	Grab Samples	Design Criteria (DC)	Derived Results	Plant Loading (% of DC)	Planning to begin (% of DC)
Influent BOD5 (mg/L)			160					
(lbs/d)					29,400	17,600**	60	85
Effluent BOD5 (mg/L)	33	50	71					
(lbs/d)	2890	4380				2,250		
(% removal)	78.5					56		
Influent TSS (mg/L)			178					
(lbs/d)					45,530	19,600**	43	85
Effluent TSS (mg/L)	63	95	50					
(lbs/d)	5520	8320				1,580		
(% removal)	72					72		
Fecal Coliform (#/100mL)	200	400		160;170				
pH (s.u.)	$6.0 \le pH \le 9.0$			8.4;8.5				
Flow (MGD)	10.5					3.8		
		Daily Maximum						
Chlorine, total (µg/L)	(23)200^	(59)500^		100;30				
(lbs/d)	2.01					2.06		
Heavy Metals^^								
Cadmium (µg/L)	1.1	2.2	0.20P	0.11P				
(lbs/d)	0.1					0.006		
Copper (µg/L)	4.7	9.5	6.5P	6.5P				
(lbs/d)	0.41					0.206		
Lead (µg/L)	12	24	2.8P	1.8P				
(lbs/d)	1.05					0.089		
Mercury (µg/L)	0.46	0.93	0.05U	0.05U				
(lbs/d)	0.04					0.000		
Silver (µg/L)	1.5	3.0	0.50U	0.50U				
(lbs/d)	0.13					0.000		
Zinc (µg/L)	51	103	14PB	11PB				
(lbs/d)	4.46					- - -		

U means the analyte was not detected at or above the reported result.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.
* - Seasonal limits for August and September.
** - Based on an influent flow of 13.2 MGD on 8/18.
^ - Concentrations have been modified by Order (Ecology, 1992); number in ( ) is original limit.
^^ - Metals limits have been stayed (PCHB, 1993); metals limits and data are total recoverable metals.

Table 3b. Comparison of Inspection Results to NPDES Permit Limits for Outfall 015a, City of Everett – L. Snohomish River Basin Class II Inspections, 8/93.

	NPDES Permit Limits (Outfall 015a)*		Inspection Data		Loading and Performance			
Parameter	Monthly Average	Weekly Average	Ecology Composite	Grab Samples	Design Criteria (DC)	Derived Results	Plant Loading (% of DC)	Planning to begin (% of DC)
Influent BOD5 (mg/L)			160					
(lbs/d)					29,400	17,600**	60	85
Effluent BOD5 (mg/L)	30	45	15					
(lbs/d)	1615	3000				810		
(% removal)	85					91		
Influent TSS (mg/L)			178					
(lbs/d)					45,530	19,600**	43	85
Effluent TSS (mg/L)	30	45	11					
(lbs/d)	2000	3000				600		
(% removal)	85					94		
Fecal Coliform (#/100mL)	200	400		1600;1600				
pH (s.u.)	6.0 ≤ pH ≤ 9.0			7.5;6.9				
Flow (MGD)	8.0					6.5		
		Daily Maximum						
Chlorine (µg/L)	(28)200^	(72)500^		80;30				
(lbs/d)	1.87					2.98		
Heavy Metals^^								
Cadmium (µg/L)	1.4	2.7	0.31P	0.26P				
(lbs/d)	0.09					0.017		
Copper (µg/L)	4.7	9.5	13.3	12.4				
(lbs/d)	0.31					0.721		
Lead (µg/L)	12	24	4.4P	4.5P				
(lbs/d)	0.80					0.239		
Mercury (µg/L)	0.6	1.2	0.06P	0.05P				
(lbs/d)	0.04					0.003		
Silver (µg/L)	1.5	3.0	1.1P	1.2P				
(lbs/d)	0.10					0.060		
Zinc (µg/L)	62	125	30PB	29PB				
(lbs/d)	4.13					- - -		

P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.
* - Seasonal limits for August and September.
** - Based on an influent flow of 13.2 MGD on 8/18.
^ - Concentrations have been modified by Order (Ecology, 1992); number in ( ) is original limit.
^^ - Metals limits have been stayed (PCHB, 1993); metals limits and data are total recoverable.

Table 4. Comparison of Sampling and Laboratory Procedures, City of Everett - L. Snohomish River Basin Class II Inspections, 8/93

Location:	Blank1-E		Blank2-E		InfEV-E		InfEV-EV		EffEV1-E	
Lab Log #~:	348240		348249		348241		348242		348243	
Date:	8/17		8/17		8/18-19		8/18-19		8/18-19	
Sampler:	Ecology		Ecology		Ecology		Everett		Ecology	
Laboratory:	Ecology	Everett*	Ecology	Everett*	Ecology	Everett**	Ecology	Everett***	Ecology	Everett****
GENERAL CHEMISTRY										
Alkalinity (mg/L)					162	157		157	151	144
Chloride (mg/L)					37				41	
SOLIDS 4 (mg/L)										
TS					543	434	591	300	311	295
TNVS					217	195	212	108	182	173
TSS					178	263	235	300	50	47
TNVSS					48	16	55	0	5	1
BOD5 (mg/L)					160	200	220	220	71	>67
NH3-N (mg/L)					18	21.2		20.7	16	15.9
NO2+NO3-N (mg/L)					0.09J	0.00		0.003	0.95	1.11
Total Kjeldahl N (mg/L)					52	33.2		33.7	41	22.6
Phosphate - Ortho (mg/L)									3.99	3.95
Phosphate - Total (mg/L)					5.5	5.80		6.17	4.3	4.63
F-Coliform MF (#/100mL)										
METALS (µg/L)										
Cadmium	0.12P	0.2U	0.21P	0.2U					0.20P	0.2U
Copper	1.3P	14	1.0U	14					6.5P	10
Lead	1.0U	3P	1.0U	3P					2.8P	2J
Mercury	0.05U	0.2U	0.05U	0.2U					0.05U	0.2U
Silver	0.50U	1	0.50U	1					0.50U	0.5P
Zinc	4UB	19	4UB	20					14PB	7P
FIELD OBSERVATIONS										
Temperature (°C.)										
pH (s.u.)									8.1	
Conductivity (µmho/cm)					534	447		446	534	428
Chlorine, free (mg/L)									0.03	
total (mg/L)									0.03	

Blank1-E means equipment blank run through Ecology compositor used for sampling effluent to outfall 015.
Blank2-E means equipment blank run through Ecology compositor used for sampling effluent to outfall 015a.
InfEV - Influent; EffEV1 - Effluent to outfall 015; -E - Ecology composite sampler; -EV - Everett composite sampler.
~ - Lab Log # is assigned at Manchester Environmental Lab (MEL) and therefore, applicable only to those samples submitted to MEL for analysis.
* - City of Everett Environmental Lab ID is Project #2593, QC File #: QC-M2592, Sample ID: 2593B.
** - City of Everett Environmental Lab ID is Project #2593, Plant Influent (PI)19C.
*** - City of Everett Environmental Lab ID is Project #2592, Plant Influent (PI)19C.
**** - City of Everett Environmental Lab ID is Project #2593, Final Effluent North (FEN)19C.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit. J means analyte was positively identified. Result is an estimate.
U means the analyte was not detected at or above the reported result. B means analyte was also found in the analytical method blank indicating the sample may have been contaminated.

Table 4. Comparison of Sampling and Laboratory Procedures, City of Everett - L. Snohomish River Basin Class II Inspections, 8/93 (P. 2)

Location:	EffEV1-EV		EffEV2-E		EffEV2-EV		EffEV1-2	FEN19G	EffEV2-2	FES19G
Lab Log #~:	348244		348250		348251		348246		348253	
Date:	8/18-19		8/18-19		8/18-19		8/19		8/19	
Sampler:	Everett		Ecology		Everett		Ecology	Everett	Ecology	Everett
Laboratory:	Ecology	Everett^	Ecology	Everett^^	Ecology	Everett^^^	Ecology	Everett	Ecology	Everett
GENERAL CHEMISTRY										
Alkalinity (mg/L)		144	186	176		178	146	140	188	185
Chloride (mg/L)			53				41'		48	
SOLIDS 4 (mg/L)										
TS	320	288	358	288	329	288	336	297	332	278
TNVS	191	172	210	200	222	200	173	179	182	182
TSS	31	52	11	14	10	18	29	52	4	12
TNVSS	8	3	2	0	1U	0	1U	0	1U	0
BOD5 (mg/L)	92	>67	15	24	27	29	36	56	24U	23
NH3-N (mg/L)		16.6	24	26.7		25.0	15	15.9	24	26.8
NO2+NO3-N (mg/L)		1.38	0.08J	0.098		0.12	1.26	1.55	0.12	0.167
Total Kjeldahl N (mg/L)		21.9	28	29.7		29.3	48	21.5	28	29.8
Phosphate - Ortho (mg/L)		3.86	3.49	3.50		3.39	3.88	3.88	3.56	3.47
Phosphate - Total (mg/L)		4.65	3.9	4.02		3.97	4.40	4.63	3.8	4.11
F-Coliform MF (#/100mL)							170	42	1,600	72
METALS (μg/L)										
Cadmium			0.31P	0.2U			0.11P	0.2U	0.26P	0.2U
Copper			13.3	14			6.5P	6	12.4	14
Lead			4.4P	3P			1.8P	2J	4.5P	3P
Mercury			0.06P	0.2U			0.05U	0.2U	0.05P	0.2U
Silver			1.1P	1.3			0.50U	0.4P	1.2P	1.3
Zinc			30PB	19			11PB	4J	29PB	18
FIELD OBSERVATIONS										
Temperature (°C.)							22.5	23.1	20.1	21.0
pH (s.u.)							8.5	8.5	6.9	7.4
Conductivity (μmho/cm)		431	634	538		536	484	412	634	527
Chlorine, free (mg/L)			0.04				0.03	0.08	0.03	0.1
total (mg/L)			0.04				0.03	0.10	0.03	0.1

EffEV1 - Effluent to outfall 015; EffEV2 - Effluent to outfall 015a; -E - Ecology composite sampler; -EV - Everett composite sampler; -2 - Grab sample on 8/19.
FEN19G - Grab sample taken by Everett at same time and place as Ecology's EffEV1-2. City of Everett Environmental Lab ID is Project # 2592.
FES19G - Grab sample taken by Everett at same time and place as Ecology's EffEV2-2. City of Everett Environmental Lab ID is Project # 2592.
~ - Lab Log # is assigned at Manchester Environmental Lab (MEL) and therefore, applicable only to those samples submitted to MEL for analysis.
^ - City of Everett Environmental Lab ID is Project #2592, Final Effluent North (FEN)19C.
^^ - City of Everett Environmental Lab ID is Project #2593, Final Effluent South (FES)19C.
^^^ - City of Everett Environmental Lab ID is Project #2592, Final Effluent South (FES)19C.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
U means the analyte was not detected at or above the reported result.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.

DEPARTMENT OF ECOLOGY

November 15, 1994

TO: John Glynn and Dave Wright
Water Quality Program, NWRO

THROUGH: Will Kendra
EILS Program, Watershed Assessments Section

FROM: Norm Glenn
Watershed Assessments Section

SUBJECT: City of Marysville Basin Class II Inspection Summary

An announced Basin Class II inspection was conducted at the above facility during the week of August 16, 1993. My original intent was to provide the usual inspection report. However, due to the recent reprogramming of Class II activities in EILS, it became necessary to abbreviate the reporting effort on my remaining projects. This transmittal memo summarizes the significant findings from my review of the inspection data (attached):

- Short-circuiting of flow in the system, which was documented in the 1992 inspection report as contributing to the minimal nitrification, appears to have been corrected with recent system modifications. The system was nitrifying; nitrite-nitrate concentrations in effluent were elevated.

- Cadmium, copper, lead and zinc detected in effluent will likely pose no threat if the receiving water dilution factor at the zone of acute criteria exceedance is at least 4:1 under critical design conditions. [Note: A higher dilution factor may be required if background concentrations in the river of one or more of these pollutants of concern is elevated or if other effluent or receiving water conditions are more critical than those which were assumed]. The completed mixing zone study can provide this information.

- Several monthly average limits contained in the Order (Ecology, 1989) were exceeded during the inspection: five-day biochemical oxygen demand (BOD_5) and fecal coliform. While these results (from this 3-day inspection) are not enforceable violations, they reflect a recurring pattern. It is recommended that the facility be reinspected when the upgrade is completed.

- A number of "split" sample comparisons showed significant differences in results (Table 4). The 1992 inspection report (Glenn, 1992) pointed out a number of concerns with their sampling and preservation procedures, and it does not appear that these problems have been addressed:

- frequent cleaning of the compositor tubing. Flushing at least once a month with a chlorine solution avoids biomass build-up and nitrite problems that can affect sample representativeness;

- thoroughly mixing composited samples before dispensing to "split" samples (part of the sampling procedure) and before dispensing to aliquots in the lab (part of the analytical procedure). The procedures within Ecology call for samples to be "well-mixed" in order to entrain all solids from the compositor bottle (Glenn, in prep; Thomson, 1993).

- Results from two of four standards left by Ecology for analysis by the Marysville Lab were unacceptable: chlorine and TSS.

If you have any questions concerning this memo, please contact me at 407-6683.

NLG:blt
Attachments

References:

APHA-AWWA-WEF, 1992. Standard Methods for the Examination of Water and Wastewater, 18 edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.

Ecology, 1989. Administrative Order no. DE 89-N259, Washington State Department of Ecology, Northwest Regional Office.

EPA, 1983. Methods for Chemical Analyses of Water and Waste. EPA-600/4-79-020 (Rev. March, 1983). Washington D.C.

Glenn, N., 1992. City of Marysville Class II Inspection, July 16-17, 1990. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia WA.

------, in prep. Generic Quality Assurance Project Plan for Basin Class II Inspections. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia WA.

Thomson, D., 1993. Personal communication, December 29. Ecology Manchester Laboratory, Manchester WA.

Table 1. Chemical Analytical Methods and Laboratories – City of Marysville – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Method	Lab used
Alkalinity	EPA, 1983: 310.1	Ecology; Manchester WA
Chloride	EPA, 1983: 330.0	Ecology; Manchester WA
SOLID		
Total solids (TS)	EPA, 1983: 160.3	Ecology; Manchester WA
Total non-volatile solids (TNVS)	EPA, 1983: 160.4	Ecology; Manchester WA
Total suspended solids (TSS)	EPA, 1983: 160.2	Ecology; Manchester WA
Total non-volatile suspended solids (TNVSS)	EPA, 1983: 160.4	Ecology; Manchester WA
Five-day biochemical oxygen demand (BOD5)	APHA, 1992; 5210	Sound Analytical Svcs.; Tacoma WA
NUTRIENTS		
Total ammonia, as nitrogen (NH3-N)	EPA, 1983: 350.1	Sound Analytical Svcs.; Tacoma WA
Nitrate-nitrite, as nitrogen (NO2+NO3-N)	EPA, 1983: 353.2	Sound Analytical Svcs.; Tacoma WA
Total Kjeldahl nitrogen	EPA, 1983: 351.2	Sound Analytical Svcs.; Tacoma WA
Ortho phosphate	EPA, 1983: 365.3	Ecology; Manchester WA
Total phosphorus	EPA, 1983: 365.3	Sound Analytical Svcs.; Tacoma WA
Fecal Coliform, by membrane filter technique	APHA, 1992:9222D	Ecology; Manchester WA
METALS		
Cadmium	EPA, 1983;213.2	Ecology; Manchester WA
Copper	EPA, 1983;220.2	Ecology; Manchester WA
Lead	EPA, 1983;239.2	Ecology; Manchester WA
Mercury	EPA, 1983;245.1	Ecology; Manchester WA
Silver	EPA, 1983;272.2	Ecology; Manchester WA
Zinc	EPA, 1983;200.7	Ecology; Manchester WA

Table 2. General Chemistry and Metals Results – City of Marysville – L. Snohomish River Basin Class II Inspections, 8/93.

	Location:	Blank-E	InfMA1-E	InfMA1-MA	InfMA2-E	InfMA2-MA	EffMA-E	EffMA-MA	EffMA-1	EffMA-2
	Type:	Equip	Comp	Comp	Comp	Comp	Comp	Comp	Grab	Grab
	Date:	8/17	8/18-19	8/18-19	8/18-19	8/18-19	8/18-19	8/18-19	8/18	8/19
	Time:	1440	24 hour	24 hour	24 hour	24 hour	24 hour	24 hour	1330	1430
Parameter	Lab Log #: 3482	-30	-31	-32	-37	-38	-33	-34	-35	-36
GENERAL CHEMISTRY										
Alkalinity (mg/L)			149		189		94		94	95
Chloride (mg/L)			89		34		57		56	57
SOLIDS 4 (mg/L)										
TS			607	620	596	499	361	364	367	474
TNVS			265	270	199	203	221	191	215	210
TSS			165	205	167	129	37	35	35	85
TNVSS			21	28	33	24	15	7	5	30
BOD5 (mg/L)			200	260	270	170	31	20	39	45
NH3-N (mg/L)			24		21		0.07		0.02J	0.54
NO2+NO3-N (mg/L)			0.06J		0.08J		3.94		3.59	3.99
Total Kjeldahl N (mg/L)			33		40		5.1		4.9	7.4
Phosphate - Ortho (mg/L)							4.73		4.55	4.54
Phosphate - Total (mg/L)			5.6		6.3		5.0		5.0	5.0
F-Coliform MF (#/100mL)									190	260
METALS (µg/L)										
Cadmium		0.20P					0.10U			0.19P
Copper		1.5P					4.3P			9.7P
Lead		3.1P					2.1P			8.9P
Mercury		0.05U					0.05U			0.05U
Silver		0.50U					0.50U			0.50U
Zinc		6.6PB					8.7PB			21PB
FIELD OBSERVATIONS										
Flow (MGD)			0.76		1.69		1.91			
Temperature (°C.)			8.7*		5.8*		7.4*		24	24.5
pH (s.u.)			7.3*		7.8*		7.9*		8.9	8.6
Conductivity (µmho/cm)			734		559		494		484	484
Chlorine, free (mg/L)									0.07	0.03
total (mg/L)									0.09	0.04

InfMA1 - Westside Influent; InfMA2 - Eastside Influent; EffMA - Effluent.
-E - Ecology sampler; -MA - Marysville sampler; -1 - Grab sample taken on 8/18; -2 - Grab sample taken on 8/19.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
U means the analyte was not detected at or above the reported result.
J means the analyte was positively identified. The associated numerical result is an estimate.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.
* - Iced composite sample.

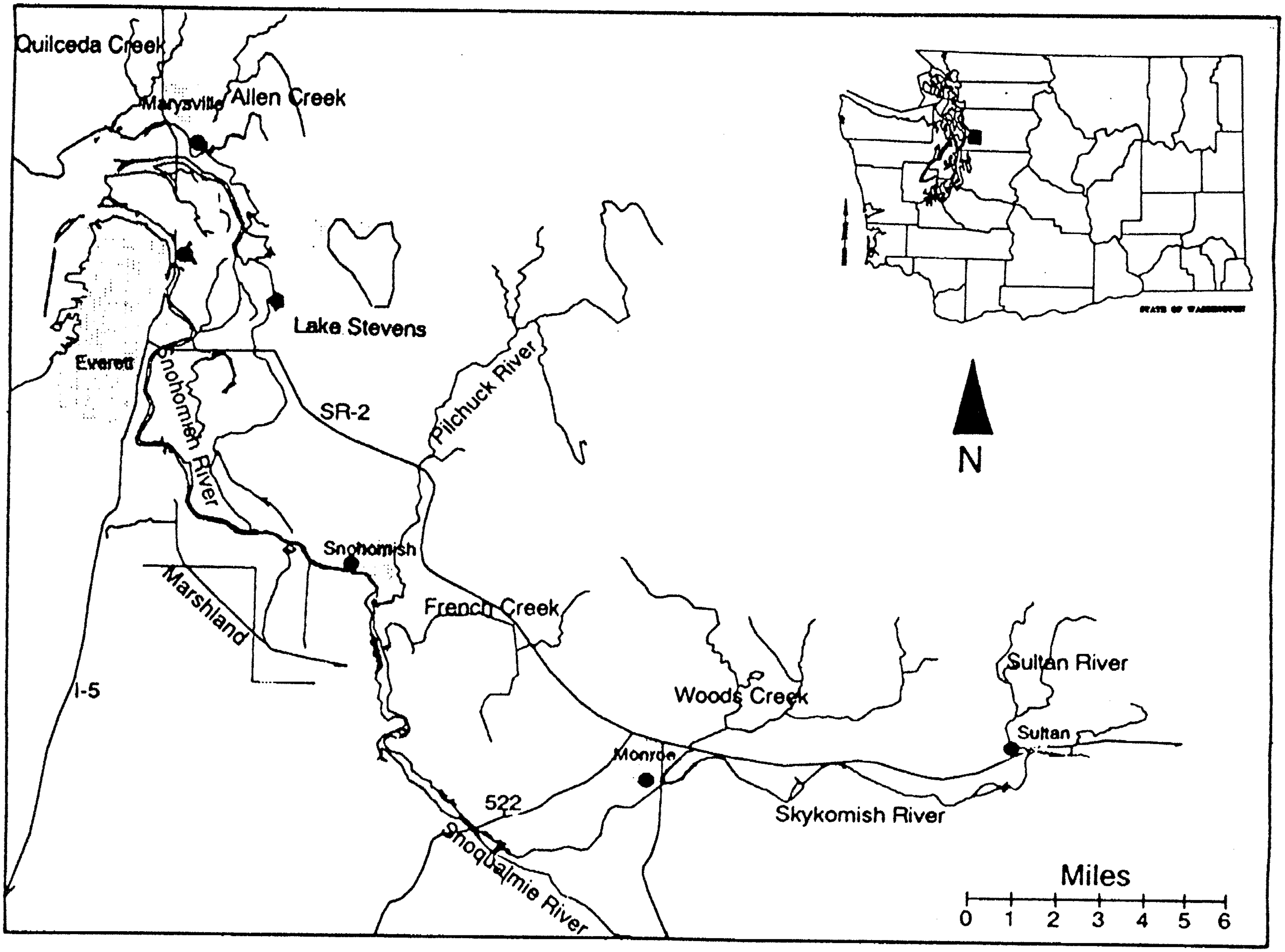

Figure 1. Location Map for WWTPs in Lower Snohomish TMDL Study Area, 8/93.

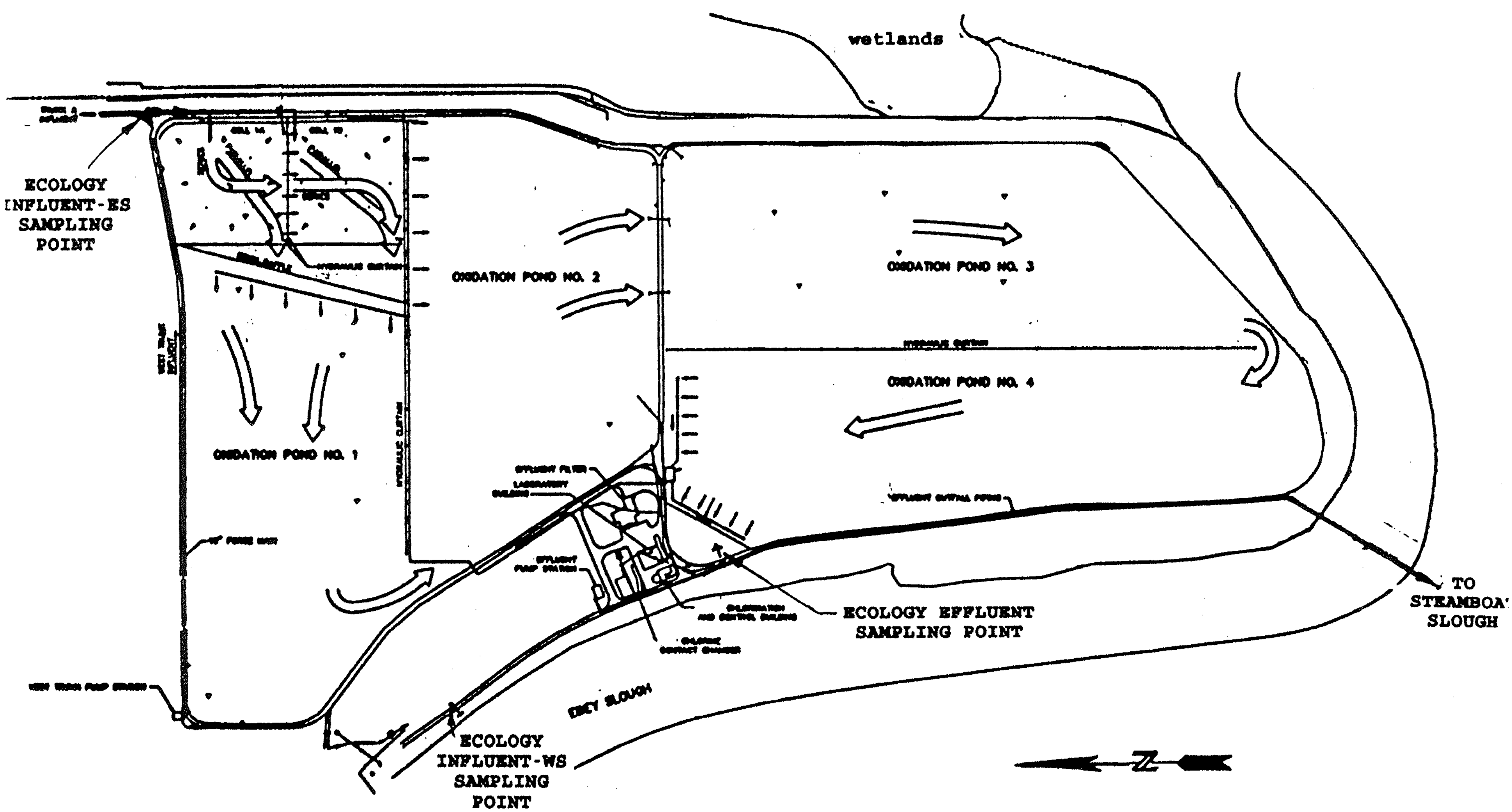

Figure 2. Plant Schematic - City of Marysville WWTP, 8/93.

Table 3. Comparison of Inspection Results to NPDES Permit Limits, City of Marysville – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	NPDES Permit Limits* Monthly Average	NPDES Permit Limits* Weekly Average	Inspection Data Ecology Composite	Inspection Data Grab Samples	Loading and Performance Design Criteria (DC)**	Loading and Performance Derived Results	Loading and Performance Plant Loading (% of DC)	Loading and Performance Planning to begin (% of DC)
Influent BOD5								
(mg/L)			248***					
(lbs/d)					---			
Effluent BOD5								
(mg/L)	30		31					
(lbs/d)	700				700	490	70	85
(% removal)	85****					88		
Influent TSS								
(mg/L)			166***					
(lbs/d)					---			
Effluent TSS								
(mg/L)	75		37					
(lbs/d)	1,750				1,750	590	34	85
Fecal Coliform								
(#/100 mL)	200			230(190;260)				
pH (s.u.)	6.0 ≤ pH ≤ 9.0			8.9;8.6				
Flow (MGD)					---	1.91		

* – Contained in Order on Consent no. DE 89–N259 (Ecology, 1989), Second Amendment.
** – Criteria contained in 1983 permit are no longer considered appropriate due to recent upgrades. Monthly average values for effluent contained in Second Amendment to Order will be used instead.
*** – Weighted average based on prorated flows from westside and eastside influent lines.
**** – During the months April through September only.

Table 4. Comparison of Laboratory Results of Sample Splits, City of Marysville – L. Snohomish River Basin Class II Inspections, 8/93.

Location:	InfMA1-E		InfMA1-MA		InfMA2-E		InfMA2-MA		EffMA-E		EffMA-MA	
Lab Log #:	348231		348232		348237		348238		348233		348234	
Date:	8/18-19		8/18-19		8/18-19		8/18-19		8/18-19		8/18-19	
Sampler:	Ecology		Marysville		Ecology		Marysville		Ecology		Marysville	
Laboratory:	Ecology	Marysville	Ecology	Marysville	Ecology	Marysville	Ecology	Marysville	Ecology	Marysville	Ecology	Marysville
BOD5 (mg/L)	200	*	260	398	270	*	170	304	31	*	20	52
TSS (mg/L)	165	*	205	341	167	*	129	162	37	*	35	42

* – Not analyzed for.

DEPARTMENT OF ECOLOGY

November 15, 1994

TO: John Glynn and Ed Abbasi
Water Quality Program, NWRO

THROUGH: Will Kendra
EILS Program, Watershed Assessments Section

FROM: Norm Glenn
Watershed Assessments Section

SUBJECT: Lake Stevens Sewer District Basin Class II Inspection Summary

An announced Basin Class II inspection was conducted at the above facility during the week of August 23, 1993. My original intent was to provide the usual inspection report. However, due to the recent reprogramming of Class II activities in EILS, it became necessary to abbreviate the reporting effort on my remaining projects. This transmittal memo summarizes the significant findings from my review of the inspection data (attached):

- The plant was performing well, achieving high removal efficiencies for BOD_5 and TSS. An aeration basin and clarifier were out of service. Solids loading was less than 40 percent of design capacity. The site appeared to be well maintained.

- One total residual chlorine reading was unusually high. Undoubtedly there would be toxicity to aquatic life if this level were sustained for a one-hour duration.

- The ammonification and nitrification/denitrification portion of the nitrogen cycle was occurring (decrease in alkalinity, ammonia and total Kjeldahl N; some increase in nitrate/nitrite). Total ammonia in effluent was sufficiently elevated to cause some concern about chronic toxicity, especially if reversing tides and the commensurate background concentrations in the river are considered. A mixing zone study would provide the necessary information about toxicity to aquatic life.

- The permit issued to Lake Stevens Sewer District contains a $CBOD_5$ limitation - in lieu of BOD_5. The appropriateness of this limitation should be reviewed carefully when the permit is reissued (Albertson, 1993).

- No explanation can be given for significant differences found in "split" sample results. A closer examination of sampling procedure being used is warranted. Acceptable results were achieved on three standards left for their analysis; the chlorine result was unacceptable.

If you have any questions concerning this memo, please contact me at 407-6683.

NLG:blt
Attachments

References:

Albertson, O., 1993. The $CBOD_5$ Test: More Trouble Than It's Worth?, Water Environment & Technology. Water Environment Federation, Alexandria, VA.

APHA-AWWA-WEF, 1992. Standard Methods for the Examination of Water and Wastewater, 18 edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.

EPA, 1983. Methods for Chemical Analyses of Water and Waste. EPA-600/4-79-020 (Rev. March, 1983). Washington D.C.

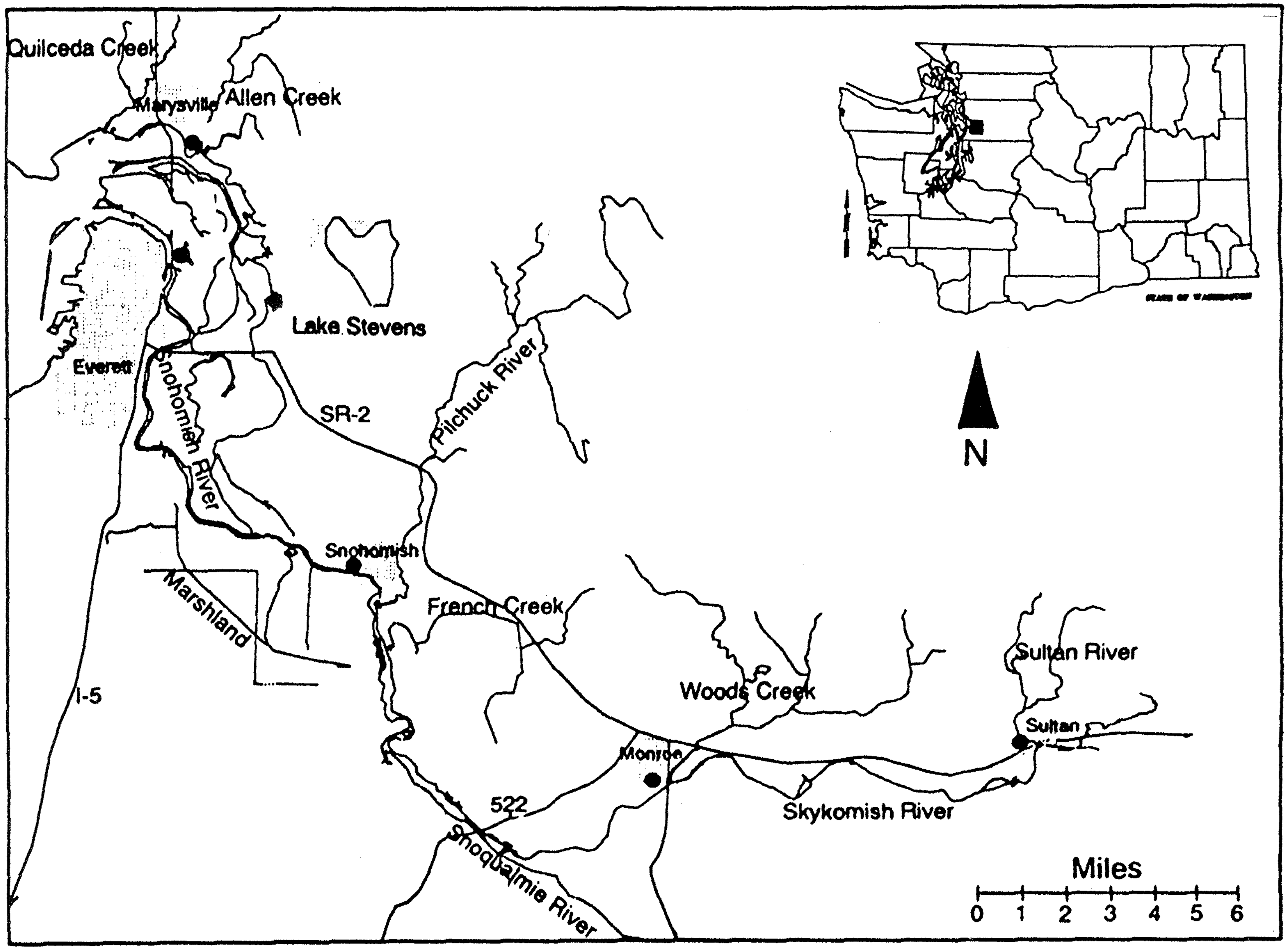

Figure 1. Location Map for WWTPs in Lower Snohomish TMDL Study Area, 8/93.

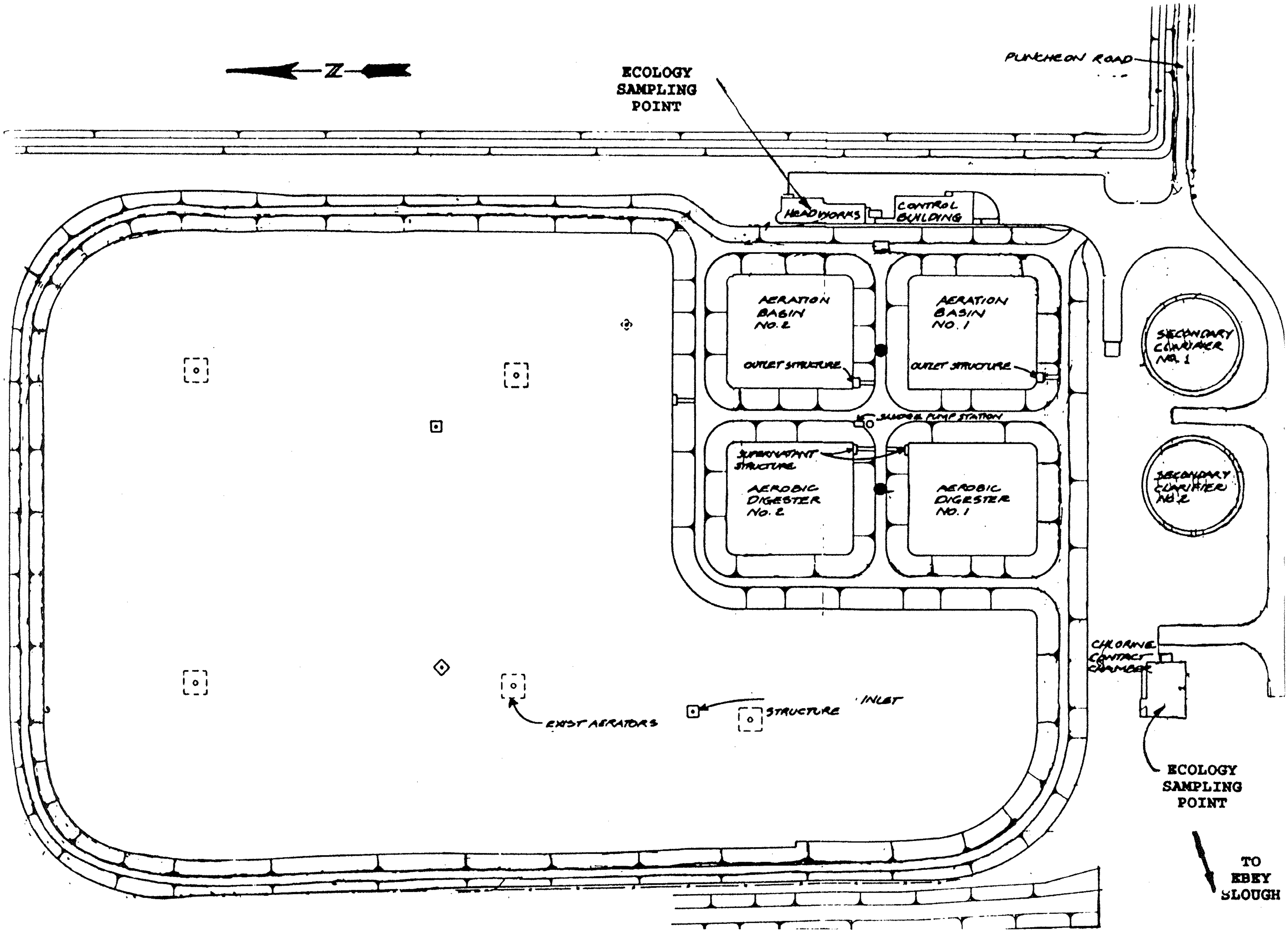

Figure 2. Plant Schematic - Lake Stevens Sewer District WWTP, 8/93.

Table 1. Chemical Analytical Methods and Laboratories – Lake Stevens S. D. – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Method	Lab used
Alkalinity	EPA, 1983: 310.1	Ecology; Manchester WA
Chloride	EPA, 1983: 330.0	Ecology; Manchester WA
SOLIDS		
Total solids (TS)	EPA, 1983: 160.3	Ecology; Manchester WA
Total non-volatile solids (TNVS)	EPA, 1983: 160.4	Ecology; Manchester WA
Total suspended solids (TSS)	EPA, 1983: 160.2	Ecology; Manchester WA
Total non-volatile suspended solids (TNVSS)	EPA, 1983: 160.4	Ecology; Manchester WA
Five-day biochemical oxygen demand (BOD5)	APHA, 1992; 5210	Sound Analytical Svcs.; Tacoma WA
NUTRIENTS		
Total ammonia, as nitrogen (NH3-N)	EPA, 1983: 350.1	Sound Analytical Svcs.; Tacoma WA
Nitrate-nitrite, as nitrogen (NO2+NO3-N)	EPA, 1983: 353.2	Sound Analytical Svcs.; Tacoma WA
Total Kjeldahl nitrogen	EPA, 1983: 351.2	Sound Analytical Svcs.; Tacoma WA
Ortho phosphate	EPA, 1983: 365.3	Ecology; Manchester WA
Total phosphorus	EPA, 1983: 365.3	Sound Analytical Svcs.; Tacoma WA
Fecal Coliform, by membrane filter technique	APHA, 1992:9222D	Ecology; Manchester WA
METALS		
Cadmium	EPA, 1983;213.2	Ecology; Manchester WA
Copper	EPA, 1983;220.2	Ecology; Manchester WA
Lead	EPA, 1983;239.2	Ecology; Manchester WA
Mercury	EPA, 1983;245.1	Ecology; Manchester WA
Silver	EPA, 1983;272.2	Ecology; Manchester WA
Zinc	EPA, 1983;200.7	Ecology; Manchester WA

Table 2. General Chemistry and Metals Results, Lake Stevens Sewer District – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Location:	Blank-E	InfLS-E	InfLS-LS	EffLS-E	EffLS-LS	EffLS-1	EffLS-2
	Type:	Equip	Comp	Comp	Comp	Comp	Grab	Grab
	Date:	8/24	8/25-26	8/25-26	8/25-26	8/25-26	8/25	8/26
	Time:	1445	0800-0800	0800-0800	0900-0900	0800-0800	1400	1445
	Lab Log #: 3582	-50	-51	-52	-53	-54	-55	-56
GENERAL CHEMISTRY								
Alkalinity (mg/L)			153		137		135	137
Chloride (mg/L)			26		30		30	28
SOLIDS 4 (mg/L)								
TS			429	520	238	244	235	232
TNVS			177	186	146	158	158	147
TSS			143	318	6	6	5	7
TNVSS			23	50	1	1U	3	1
BOD5 (mg/L)			160	220	12	20	8	7
NH3-N (mg/L)			18		14		14	14
NO2+NO3-N (mg/L)			0.06J		0.17		0.14	0.26
Total Kjeldahl N (mg/L)			34		18		15	18
Phosphate - Ortho (mg/L)					2.17		1.16	1.79
Phosphate - Total (mg/L)			4.6		2.4		1.3	2.1
F-Coliform MF (#/100mL)								1
METALS (µg/L)								
Cadmium		0.17P			0.10U			0.10U
Copper		2.7P			4.3P			4.0P
Lead		1.0U			1.0U			1.0U
Mercury		0.05U			0.05U			0.05U
Silver		0.50U			0.50U			0.50U
Zinc		4U			25.P			19P
FIELD OBSERVATIONS								
Flow (MGD)			1.21					
Temperature (°C.)			8.0*		2.8*		17.6	17.5
pH (s.u.)			7.2*		7.6*		7.4	7.4
Conductivity (µmho/cm)			480		445		430	415
Chlorine, free (mg/L)							0.02	0.40
total residual (mg/L)							0.02	2.00

InfLS - Influent; EffLS - Effluent; -E - Ecology sampler; -LS - Lake Stevens' sampler; -1 - Grab sample taken on 8/25; -2 - Grab sample taken on 8/26.
U means the analyte was not detected at or above the reported result.
J means the analyte was positively identified. The associated numerical result is an estimate.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
* - Iced composite sample.

Table 3. Comparison of Inspection Results to NPDES Permit Limits, Lake Stevens S. D. – L. Snohomish River Basin Class II Inspections, 8/93.

	NPDES Permit Limits		Inspection Data		Loading and Performance			
Parameter	Monthly Average	Weekly Average	Ecology Composite	Grab Samples	Design Criteria (DC)	Derived Results	Plant Loading (% of DC)	Planning to begin (% of DC)
Influent CBOD5								
(mg/L)			147*					
(lbs/d)**					4,096	1,610	39	85
Effluent CBOD5								
(mg/L)	25	40	7***					
(lbs/d)	500	801						
(% removal)	85					95		
Influent TSS								
(mg/L)			143					
(lbs/d)					4,324	1,440	33	85
Effluent TSS								
(mg/L)	30	45	6					
(lbs/d)	600	901						
(% removal)						96		
Fecal Coliform (#/100 mL)	200	400		1				
pH (s.u.)	$6.0 \leq pH \leq 9.0$			7.4;7.4				
Flow (MGD)					2.4	1.21	50	85

* - This number is the result of adjusting the BOD5 result from Table 1 by the ratio of influent CBOD5:BOD5 (245:267) for 8/26 as provided by plant personnel.

** - Lbs/d BOD5 (not CBOD5). Refer to "Comprehensive Plan and Engineering Report for Lake Stevens S.D.", 1983, for design criteria.

*** - This number is the result of adjusting the BOD5 result from Table 1 by the ratio of effluent CBOD5:BOD5 (10.3:17.3) for 8/26 as provided by plant personnel.

Table 4. Comparison of Laboratory Results of Sample Splits, Lake Stevens Sewer District – L. Snohomish River Basin Class II Inspections, 8/93.

Location:	InfLS-E		InfLS-LS		EffLS-E		EffLS-LS	
Lab Log #:	358251		358252		358253		358254	
Date:	8/25-26		8/25-26		8/25-26		8/25-26	
Sampler:	Ecology		Lake Stevens		Ecology		Lake Stevens	
Laboratory:	Ecology	Lake Stevens	Ecology	Lake Stevens	Ecology	Lake Stevens	Ecology	Lake Stevens
BOD5 (mg/L)	160	188	220	267	12	14	20	17
TSS (mg/L)	143	176	318	309	6	6	6	6

U – Not detected at or above the reported result.

DEPARTMENT OF ECOLOGY

November 15, 1994

TO: John Glynn and Ed Abassi
Water Quality Program, NWRO

THROUGH: Will Kendra
EILS Program, Watershed Assessments Section

FROM: Norm Glenn
Watershed Assessments Section

SUBJECT: City of Snohomish Basin Class II Inspection Summary

An announced Basin Class II inspection was conducted at the above facility during the week of August 16, 1993. My original intent was to provide the usual inspection report. However, due to the recent reprogramming of Class II activities in EILS, it became necessary to abbreviate the reporting effort on my remaining projects. This transmittal memo summarizes the significant findings from my review of the inspection data (attached):

- Metals were found in sufficient concentrations in effluent to be a cause for concern. All six metals analyzed for were detected; but only silver, mercury, and copper showed the potential to exceed water quality standards in the receiving water. A mixing zone study would be necessary to generate accurate information about background concentrations in the river, the dilution capacity of the river under critical design conditions, and thus the potential for toxicity to aquatic life.

- NPDES permit limits on TSS in effluent and TSS percent removal were not being met during the several days of the inspection - probably because of algal growth. Organic loading to the WWTP approached the design criterion for BOD_5, so planning should be considered for an upgrade to the plant.

- BOD_5 removal was good. Nitrification was effectively reducing ammonia concentrations, while denitrification was keeping nitrate-nitrite levels low.

If you have any questions concerning this memo, please contact me at 407-6683.

NLG:WK:blt
Attachments

References:

APHA-AWWA-WEF, 1992. Standard Methods for the Examination of Water and Wastewater, 18 edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.

EPA, 1983. Methods for Chemical Analyses of Water and Waste. EPA-600/4-79-020 (Rev. March, 1983). Washington D.C.

Table 1. Chemical Analytical Methods and Laboratories – City of Snohomish – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Method	Lab used
Alkalinity	EPA, 1983: 310.1	Ecology; Manchester WA
Chloride	EPA, 1983: 330.0	Ecology; Manchester WA
SOLIDS		
Total solids (TS)	EPA, 1983: 160.3	Ecology; Manchester WA
Total non-volatile solids (TNVS)	EPA, 1983: 160.4	Ecology; Manchester WA
Total suspended solids (TSS)	EPA, 1983: 160.2	Ecology; Manchester WA
Total non-volatile suspended solids (TNVSS)	EPA, 1983: 160.4	Ecology; Manchester WA
Five-day biochemical oxygen demand (BOD5)	APHA, 1992; 5210	Sound Analytical Svcs.; Tacoma WA
NUTRIENTS		
Total ammonia, as nitrogen (NH3-N)	EPA, 1983: 350.1	Sound Analytical Svcs.; Tacoma WA
Nitrate-nitrite, as nitrogen (NO2+NO3-N)	EPA, 1983: 353.2	Sound Analytical Svcs.; Tacoma WA
Total Kjeldahl nitrogen	EPA, 1983: 351.2	Sound Analytical Svcs.; Tacoma WA
Ortho phosphate	EPA, 1983: 365.3	Ecology; Manchester WA
Total phosphorus	EPA, 1983: 365.3	Sound Analytical Svcs.; Tacoma WA
Fecal Coliform, by membrane filter technique	APHA, 1992:9222D	Ecology; Manchester WA
METALS		
Cadmium	EPA, 1983;213.2	Ecology; Manchester WA
Copper	EPA, 1983;220.2	Ecology; Manchester WA
Lead	EPA, 1983;239.2	Ecology; Manchester WA
Mercury	EPA, 1983;245.1	Ecology; Manchester WA
Silver	EPA, 1983;272.2	Ecology; Manchester WA
Zinc	EPA, 1983;200.7	Ecology; Manchester WA

Table 2. General Chemistry and Metals Results, City of Snohomish – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Location:	Blank-E	InfSN-E	InfSN-SN	EffSN-E	EffSN-SN	EffSN-1	EffSN-2	EffSN-T
	Type:	Equip	Comp	Comp	Comp	Comp	Grab	Grab	Grab
	Date:	8/17	8/17-18	8/17-18	8/18-19	8/18-19	8/18	8/19	8/19
	Time:	1015	0800-0800	0800-0800	0800-0800	0800-0800	1045	1750	1800
	Lab Log #: 3482	-60	-61	-62	-63	-64	-65	-66	-67
GENERAL CHEMISTRY									
Alkalinity (mg/L)			151		67		69	66	66
Chloride (mg/L)			32		29		30	30	30
SOLIDS 4 (mg/L)									
TS			468	*	330	*	269	368	319
TNVS			170	*	122	*	124J	137	147
TSS			144	*	83	*	47	96	83
TNVSS			19	*	13	*	3	27	13
BOD5 (mg/L)			200	*	27	*	16	19	22
NH3-N (mg/L)			21		0.19		0.86	0.02J	0.02J
NO2+NO3-N (mg/L)			0.09J		0.03J		0.03J	0.03J	0.02J
Total Kjeldahl N (mg/L)			31		13		8.7	11	13
Phosphate - Ortho (mg/L)					1.59		1.66	1.41	1.42
Phosphate - Total (mg/L)			5.6		2.7		2.5	2.7	2.2
F-Coliform MF (#/100mL)							3U	49	40
METALS (μg/L)									
Cadmium		0.36P			0.20P			0.10U	
Copper		1.0U			13.6			13.8	
Lead		2.1P			3.2P			1.2P	
Mercury		0.05U			0.6P			0.07P	
Silver		0.50U			1.0P			1.1P	
Zinc		6.1PB			17PB			16PB	
FIELD OBSERVATIONS									
Flow (MGD)					0.45				
Temperature (°C.)			3.5**		7.5**		19.7	24.3	
pH (s.u.)			7.5**		7.8**		6.9	9.0	
Conductivity (μmho/cm)			480		290		320	285	
Chlorine, free (mg/L)							0.45	0.1	
total (mg/L)							0.7	0.4	

InfSN - Influent; EffSN - Effluent.
-E - Ecology sampler; -SN - Snohomish sampler; -1 - Grab sample taken on 8/18; -2 - Grab sample taken on 8/19; -T - Duplicate of EFFSN-2.
J means the analyte was positively identified. The associated numerical result is an estimate.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
U means the analyte was not detected at or above the reported result.
B means the analyte was also found in the analytical method blank indicating the sample may have been contaminated.
* - Samples not collected.
** - Iced composite sample.

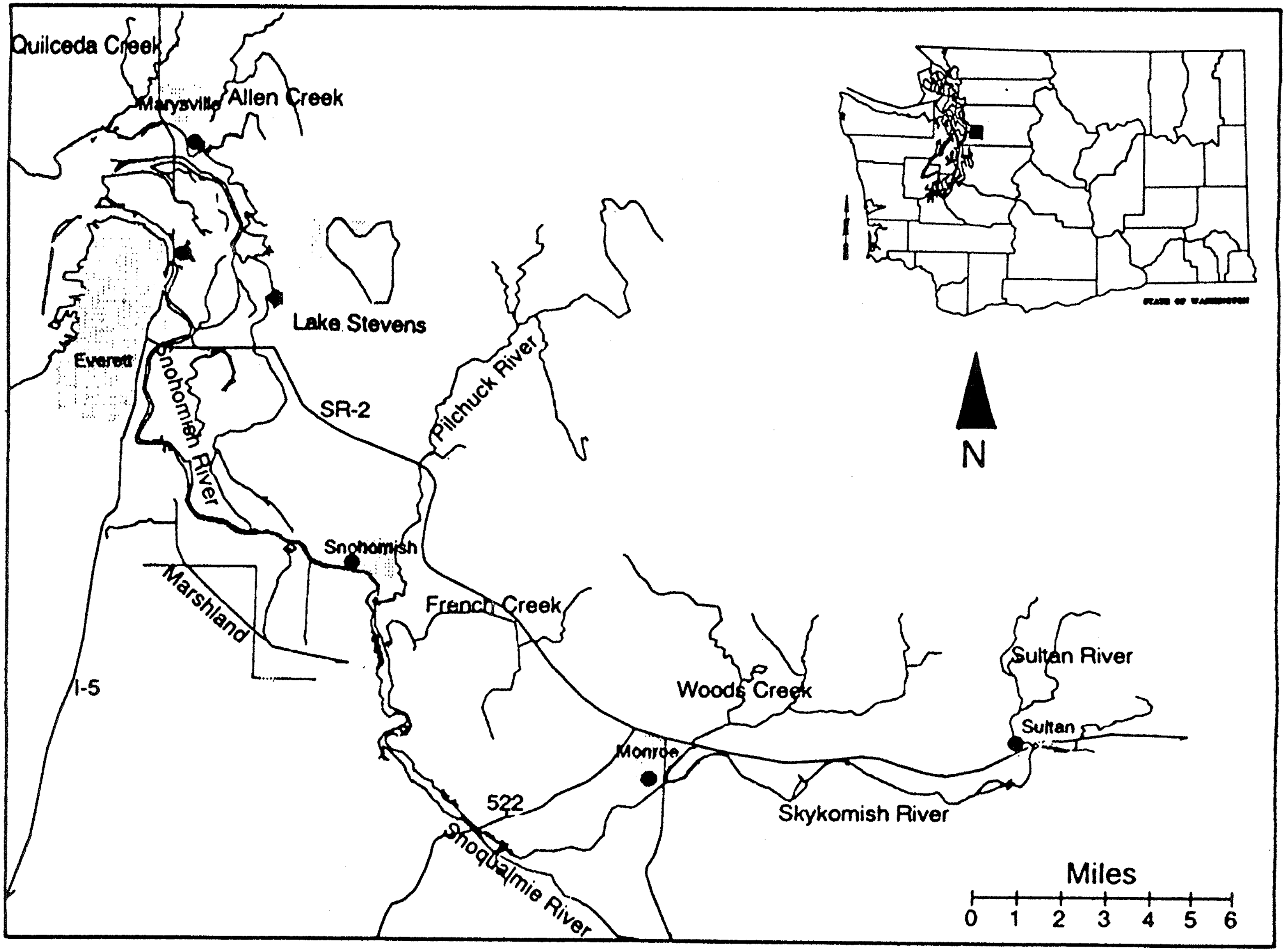

Figure 1. Location Map for WWTPs in Lower Snohomish TMDL Study Area, 8/93.

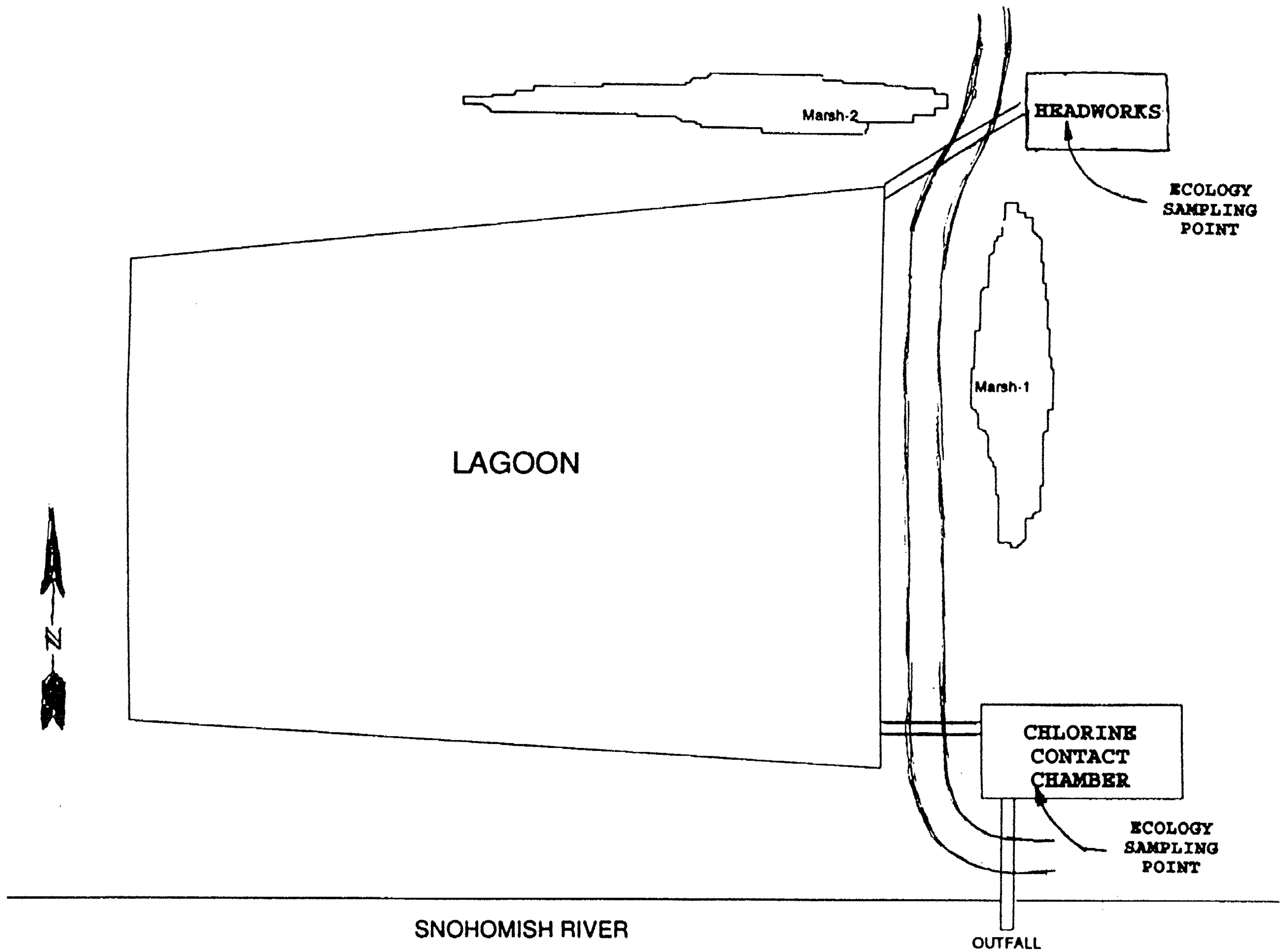

Figure 2. Plant Schematic - City of Snohomish WWTP, 8/93.

Table 3. Comparison of Inspection Results to NPDES Permit Limits, City of Snohomish – L. Snohomish River Basin Class II Inspections, 8/93

Parameter	NPDES Permit Limits		Inspection Data		Loading and Performance			
	Monthly Average	Weekly Average	Ecology Composite	Grab Samples	Design Criteria (DC)	Derived Results	Plant Loading (% of DC)	Planning to begin (% of DC)
Influent BOD5								
(mg/L)			200					
(lbs/d)					800	750	94	85
Effluent BOD5								
(mg/L)	30	45	27					
(lbs/d)	250	375				100		
(% removal)	85					86		
Influent TSS								
(mg/L)			144					
(lbs/d)								
Effluent TSS								
(mg/L)	75	110	83					
(lbs/d)	625	917				310		
(% removal)	85					42		
Fecal Coliform								
(#/100 mL)	200	400		3U;49;40				
pH (s.u.)	$6.0 \leq pH \leq 9.0$			6.9;9.0				
Flow (MGD)					1.0	0.45	45	85

U – Not detected at or above the reported result.

DEPARTMENT OF ECOLOGY

November 15, 1994

TO: John Glynn and Ed Abassi
Water Quality Program, NWRO

THROUGH: Will Kendra
EILS Program, Watershed Assessments Section

FROM: Norm Glenn
Watershed Assessments Section

SUBJECT: City of Monroe Basin Class II Inspection Summary

An announced Basin Class II inspection was conducted at the above facility during the week of August 23, 1993. My original intent was to provide the usual inspection report. However, due to the recent reprogramming of Class II activities in EILS, it became necessary to abbreviate the reporting effort on my remaining projects. This transmittal memo summarizes the significant findings from my review of the inspection data (attached):

- The calculated flow rate was determined by measuring depth of flow over the two effluent weirs. This flow rate was significantly different from the instantaneous flow rate read in the control room. All flow measuring equipment and instrumentation should be calibrated by an independent specialist.

- Of the general chemistry parameters, ammonia and total residual chlorine exceeded water quality standards at "end-of-pipe."

- Metals in effluent are a cause for concern. The criteria for silver is an instantaneous concentration which was exceeded by 10-fold. Exceedances of acute and chronic criteria for cadmium, copper, lead and zinc were less pronounced.

- A mixing zone study, which includes receiving water characterization as well as ammonia, chlorine, and metals sampling, would establish whether exceedances occur at acute and chronic boundaries.

- A comparison of inspection results to National Pollutant Discharge Elimination System (NPDES) limits revealed several problems. The plant was not achieving 85 percent removal of five-day biochemical oxygen demand (BOD_5), and the monthly average for BOD_5 was exceeded somewhat. Both the monthly and weekly averages for fecal coliform were not met during the three days of this inspection, suggesting a potential problem with the disinfection process. Although these weren't enforceable violations, they point to emerging patterns which may have resulted in violations of the permit limits for weekly and monthly averages.

- Comparison of results from sample "splits" produced some signifi^ant differences attributable to lab procedures. However, they analyzed all standards accurately, and no further light can be shed on the disparity.

If you have any questions concerning this memo, please contact me at 407-6683.

NLG/WK:blt
Attachments

References:

APHA-AWWA-WEF, 1992. Standard Methods for the Examination of Water and Wastewater, 18 edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.

Cusimano, R., in prep. Snohomish River Basin Dry Season TMDL Study. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

Ecology, 1992. Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington. Washington State Department of Ecology, Water Quality Program, Olympia, WA.

EPA, 1983. Methods for Chemical Analyses of Water and Waste. EPA-600/4-79-020 (Rev. March, 1983). Washington D.C.

------, 1986. Quality Criteria for Water. EPA 440/5-86-001.

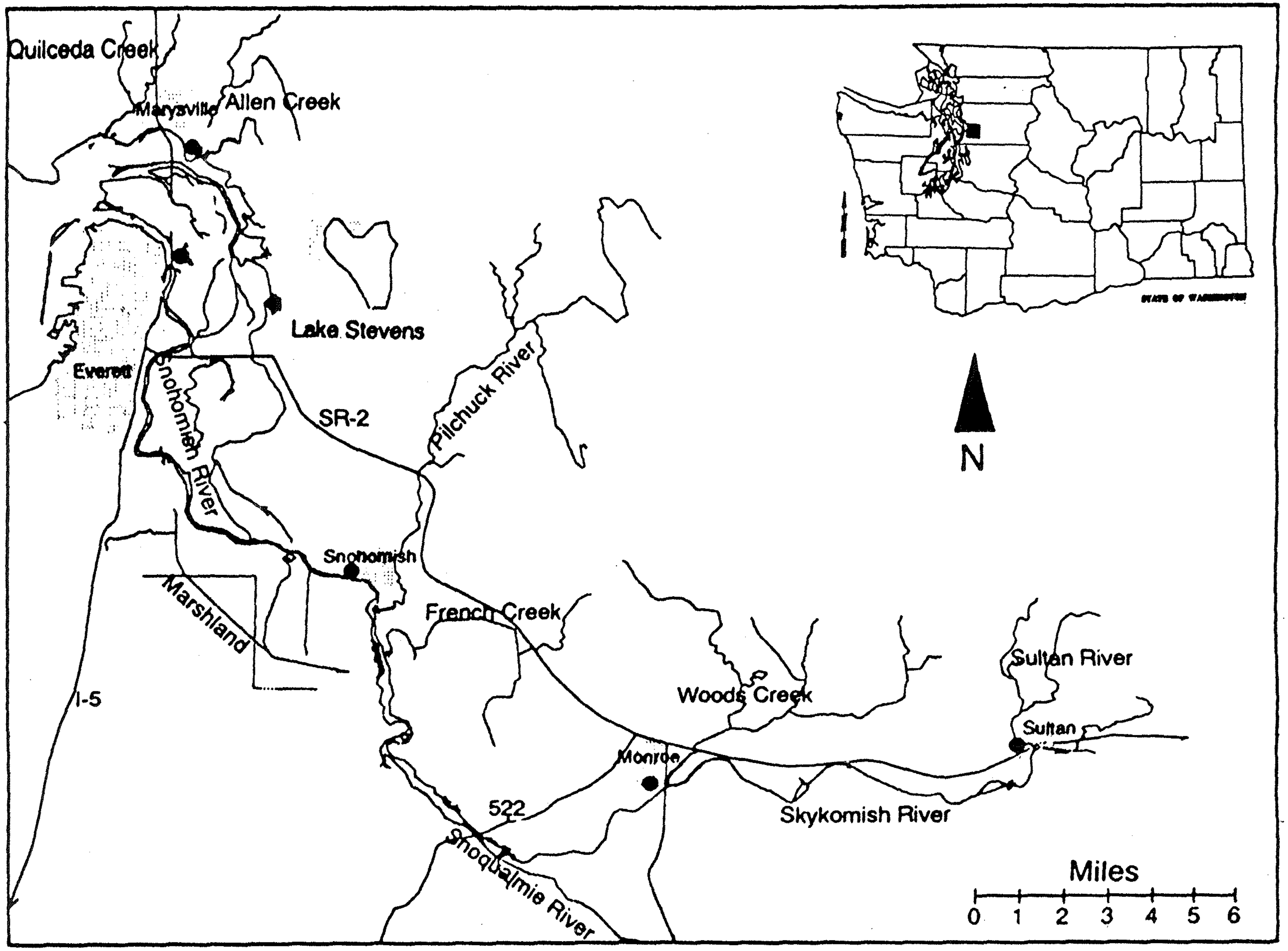

Figure 1. Location Map for WWTPs in Lower Snohomish TMDL Study Area, 8/93.

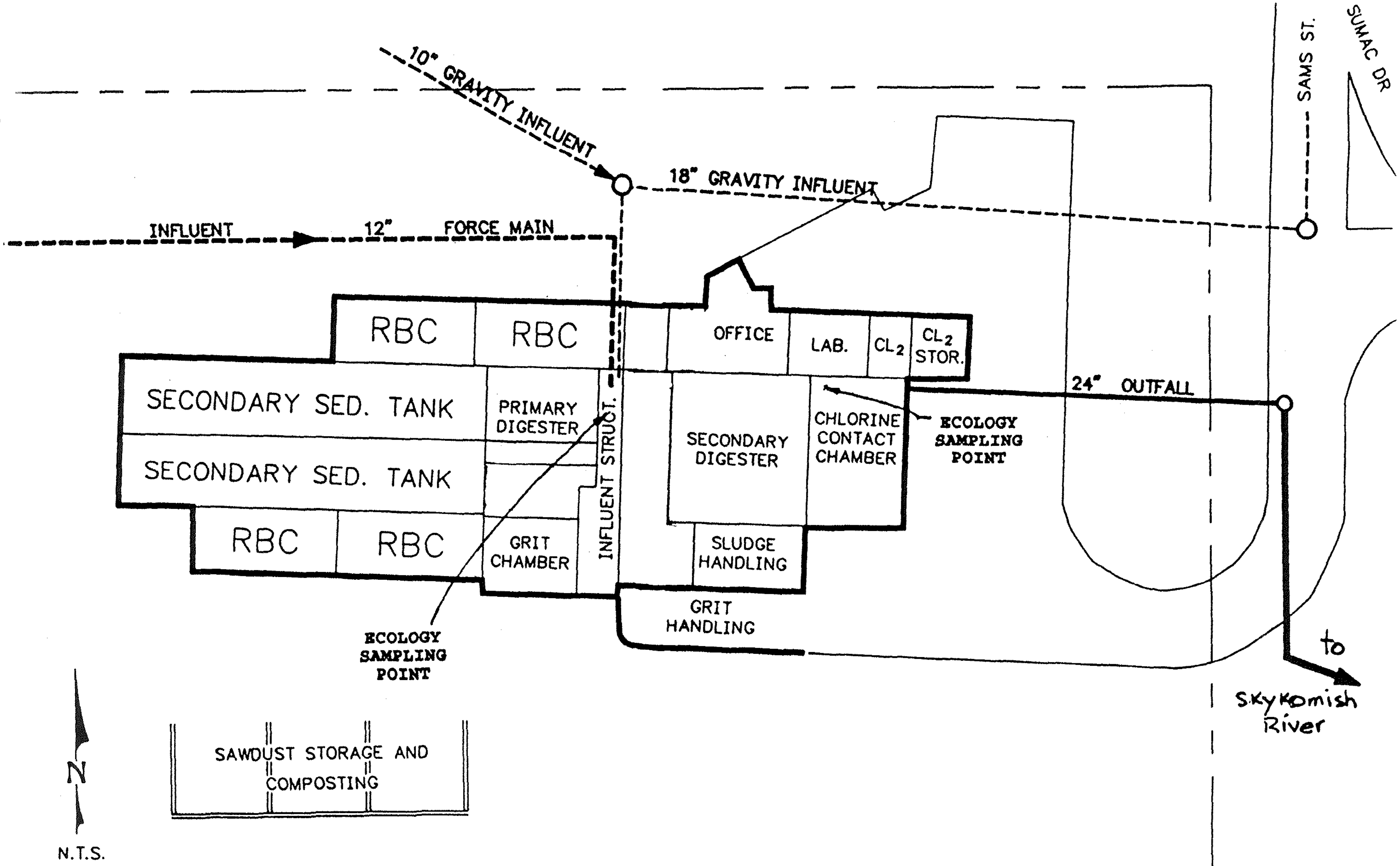

Figure 2. Plant Schematic - City of Monroe WWTP, 8/93.

Table 2. General Chemistry and Metals Results, City of Monroe – L. Snohomish River Basin Class II Inspections, 8/93

Location:	Blank-E	InfMO-E	InfMO-MO	EffMO-E	EffMO-MO	EffMO-1	EffMO-2
Type:	Equip	Comp	Comp	Comp	Comp	Grab	Grab
Date:	8/24	8/25-26	8/25-26	8/25-26	8/25-26	8/25	8/26
Time:	am	0700-0700	0800-0800	1100-1100	0800-0800	1045	1100
Parameter / Lab Log #: 3582	-40	-41	-42	-43	-44	-45	-46
GENERAL CHEMISTRY							
Alkalinity (mg/L)		154		155		162	150
Chloride (mg/l)		54		65		80	65
SOLIDS 4 (mg/l)							
TS		601	743	392	403	402	382
TNVS		287	337	244	272	280	245
TSS		275	411	26	25	16	23
TNVSS		65	67	9	6	1	7
BOD5 (mg/l)		220	220	37	37	28	36
NH3-N (mg/L)		14		14		13	13
NO2+NO3-N (mg/L)		0.78		0.18		0.11	0.46
Total Kjeldahl N (mg/L)		33		22		18	20
Phosphate - Ortho (mg/L)				4.66		5.07	4.74
Phosphate - Total (mg/L)		6.3		4.8		1.7	4.3
F-Coliform MF (#/100mL)						LAC	660
METALS (µg/L)							
Cadmium	0.10U			*			0.36P
Copper	2.2P			*			16.2
Lead	1.0U			*			2.1P
Mercury	0.05U			*			0.05U
Silver	0.50U			*			2.5P
Zinc	4U			*			66.1
FIELD OBSERVATIONS							
Flow (MGD)							
Temperature (°C.)		5.5**		4.2**		19.9	20.0
pH (s.u.)		7.4**		7.3**		7.1	7.1
Conductivity (µmho/cm)		585		625		650	700
Chlorine free (mg/L)						0.6	0.1
total (mg/L)						0.9	0.7

InfMO - Influent; EffMO - Effluent; -E - Ecology sampler; -MO - Monroe sampler.
-1 - Grab sample taken on 8/25; -2 - Grab sample taken on 8/26.
U means the analyte was not detected at or above the reported result.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
LAC means Laboratory Accident.
* - Samples not collected.
** - Iced composite sample.

Table 1. Chemical Analytical Methods and Laboratories – City of Monroe – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Method	Lab used
Alkalinity	EPA, 1983: 310.1	Ecology; Manchester WA
Chloride	EPA, 1983: 330.0	Ecology; Manchester WA
SOLIDS		
Total solids (TS)	EPA, 1983: 160.3	Ecology; Manchester WA
Total non-volatile solids (TNVS)	EPA, 1983: 160.4	Ecology; Manchester WA
Total suspended solids (TSS)	EPA, 1983: 160.2	Ecology; Manchester WA
Total non-volatile suspended solids (TNVSS)	EPA, 1983: 160.4	Ecology; Manchester WA
Five-day biochemical oxygen demand (BOD5)	APHA, 1992; 5210	Sound Analytical Svcs.; Tacoma WA
NUTRIENTS		
Total ammonia, as nitrogen (NH3-N)	EPA, 1983: 350.1	Sound Analytical Svcs.; Tacoma WA
Nitrate-nitrite, as nitrogen (NO2+NO3-N)	EPA, 1983: 353.2	Sound Analytical Svcs.; Tacoma WA
Total Kjeldahl nitrogen	EPA, 1983: 351.2	Sound Analytical Svcs.; Tacoma WA
Ortho phosphate	EPA, 1983: 365.3	Ecology; Manchester WA
Total phosphorus	EPA, 1983: 365.3	Sound Analytical Svcs.; Tacoma WA
Fecal Coliform, by membrane filter technique	APHA, 1992:9222D	Ecology; Manchester WA
METALS		
Cadmium	EPA, 1983;213.2	Ecology; Manchester WA
Copper	EPA, 1983;220.2	Ecology; Manchester WA
Lead	EPA, 1983;239.2	Ecology; Manchester WA
Mercury	EPA, 1983;245.1	Ecology; Manchester WA
Silver	EPA, 1983;272.2	Ecology; Manchester WA
Zinc	EPA, 1983;200.7	Ecology; Manchester WA

Table 3. Comparison of Effluent Pollutants to Water Quality Criteria, City of Monroe – L. Snohomish River Basin Class II Inspections, 8/93.

	Station:	Blank-E	EffMO-E	EffMO-1	EffMO-2	Water Quality Criteria*	
	Type:	Equip	comp	grab	grab		
Parameter	Lab Log # 3582:	-40	-43	-45	-46	Acute	Chronic
General Chemistry (mg/L)							
Total Ammonia (as N)		---	14	13	13	8.6	1.7
Total Residual Chlorine		---	---	0.9	0.7	0.019	0.011
Total Recoverable Metals (µg/L)							
Cadmium		0.10U	---	---	0.36P	0.60	0.31
Copper		2.2P	---	---	16.2	3.71	2.86
Lead		1.0U	---	---	2.1P	9.85	0.38
Silver		0.50U	---	---	2.5P	0.23**	---
Zinc		4U	---	---	66.1	28.65	25.95

EffMO - Effluent; -E - Ecology sampler; -1 - Grab sample on 8/25; -2 - Grab sample on 8/26.

* - Refer to EPA's Gold Book (EPA, 1986) or WA State Water Quality Standards (Ecology, 1992).
Based on receiving water temperature of 15°C., pH of 7.75, and hardness of 19 (Cusimano, in prep).

** - An instantaneous concentration not to be exceeded at any time.

P - The analyte was detected above the instrument detection limit but below the established minimum quantitation limit.

U - The analyte was not detected at or above the reported result.

Table 4. Comparison of Inspection Results to NPDES Permit Limits, City of Monroe – L. Snohomish River Basin Class II Inspections, 8/93.

	NPDES Permit Limits		Inspection Data		Loading and Performance			
Parameter	Monthly Average	Weekly Average	Ecology Composite	Grab Samples	Design Criteria (DC)	Derived Results	Plant Loading (% of DC)	Planning to begin (% of DC)
Influent BOD5								
(mg/L)			220					
(lbs/d)					----	1,376	----	85
Effluent BOD5								
(mg/L)	30	45	37					
(lbs/d)	250	350				200		
(% removal)	85					83		
Influent TSS								
(mg/L)			275					
(lbs/d)					---	1,720	---	85
Effluent TSS								
(mg/L)	30	45	26					
(lbs/d)	250	350				120		
(% removal)	85					90		
Fecal Coliform								
(#/100 mL)	200	400		660				
pH (s.u.)	$6.5 \le pH \le 8.5$			7.1;7.1				
Flow (MGD)	1.4				---	0.75	---	85

Table 5. Comparison of Laboratory Results of Sample Splits, City of Monroe – L. Snohomish River Basin Class II Inspections, 8/93.

Location:	InfMO-E		InfMO-MO		EffMO-E		EffMO-MO	
Lab Log #:	358241		358242		358243		358244	
Date:	8/25-26		8/25-26		8/25-26		8/25-26	
Sampler:	Ecology		Monroe		Ecology		Monroe	
Laboratory:	Ecology	Monroe	Ecology	Monroe	Ecology	Monroe	Ecology	Monroe
BOD5 (mg/L)	220	442	220	301	37	49	37	41
TSS (mg/L)	275	270	411	290	26	26	25	32

DEPARTMENT OF ECOLOGY

November 15, 1994

TO: John Glynn and Ed Abassi
Water Quality Program, NWRO

THROUGH: Will Kendra
EILS Program, Watershed Assessments Section

FROM: Norm Glenn
Watershed Assessments Section

SUBJECT: Town of Sultan Basin Class II Inspection Summary

An announced Basin Class II inspection was conducted at the above facility during the week of August 23, 1993. My original intent was to provide the usual inspection report. However, due to the recent reprogramming of Class II activities in EILS, it became necessary to abbreviate the reporting effort on my remaining projects. This transmittal memo summarizes the significant findings from my review of the inspection data (attached):

- The different locations used by Sultan and Ecology for their effluent composite samplers (pre-chlorination vs. post-chlorination) did not produce significant differences in BOD_5 and TSS results. Nevertheless, it is recommended that their location be changed to post-chlorination.

- Flow through the WWTP was above normal because it rained for several days prior to the inspection. The flow rate recorded by the plant's instrumentation was dramatically different from the flow rate calculated during the inspection. An authorized technician should be retained to calibrate their instrumentation.

- Total residual chlorine readings were extraordinarily high. It is very doubtful that the river provides adequate dilution to protect aquatic life when readings are this high, especially if the levels are sustained for any period of time. Despite these high chlorine readings, fecal coliform counts were also elevated. A licensed engineer should examine the entire chlorination system and make recommendations for design changes.

- Copper from this plant would exceed aquatic life toxicity criteria unless one part effluent can be diluted with 5 parts receiving water within the zone of acute criteria exceedance.

- Ammonia in effluent exceeded the chronic water quality criterion. A dilution ratio of more than 6:1 at the mixing zone boundary would be required to meet water quality standards. [Note: A higher dilution factor may be required if background concentrations in the river of one or more of these pollutants of concern is elevated or if other effluent or receiving water conditions are more critical than those which were assumed]. It is recommended that more monitoring and receiving water studies be done in order to generate this information.

- The plant was very efficient at removing BOD_5 and TSS.

If you have any questions concerning this memo, please contact me at 407-6683.

NLG:blt
Attachments

References:

APHA-AWWA-WEF, 1992. Standard Methods for the Examination of Water and Wastewater, 18 edition. American Public Health Association, American Water Works Association, Water Environment Federation, Washington D.C.

EPA, 1983. Methods for Chemical Analyses of Water and Waste. EPA-600/4-79-020 (Rev. March, 1983). Washington D.C.

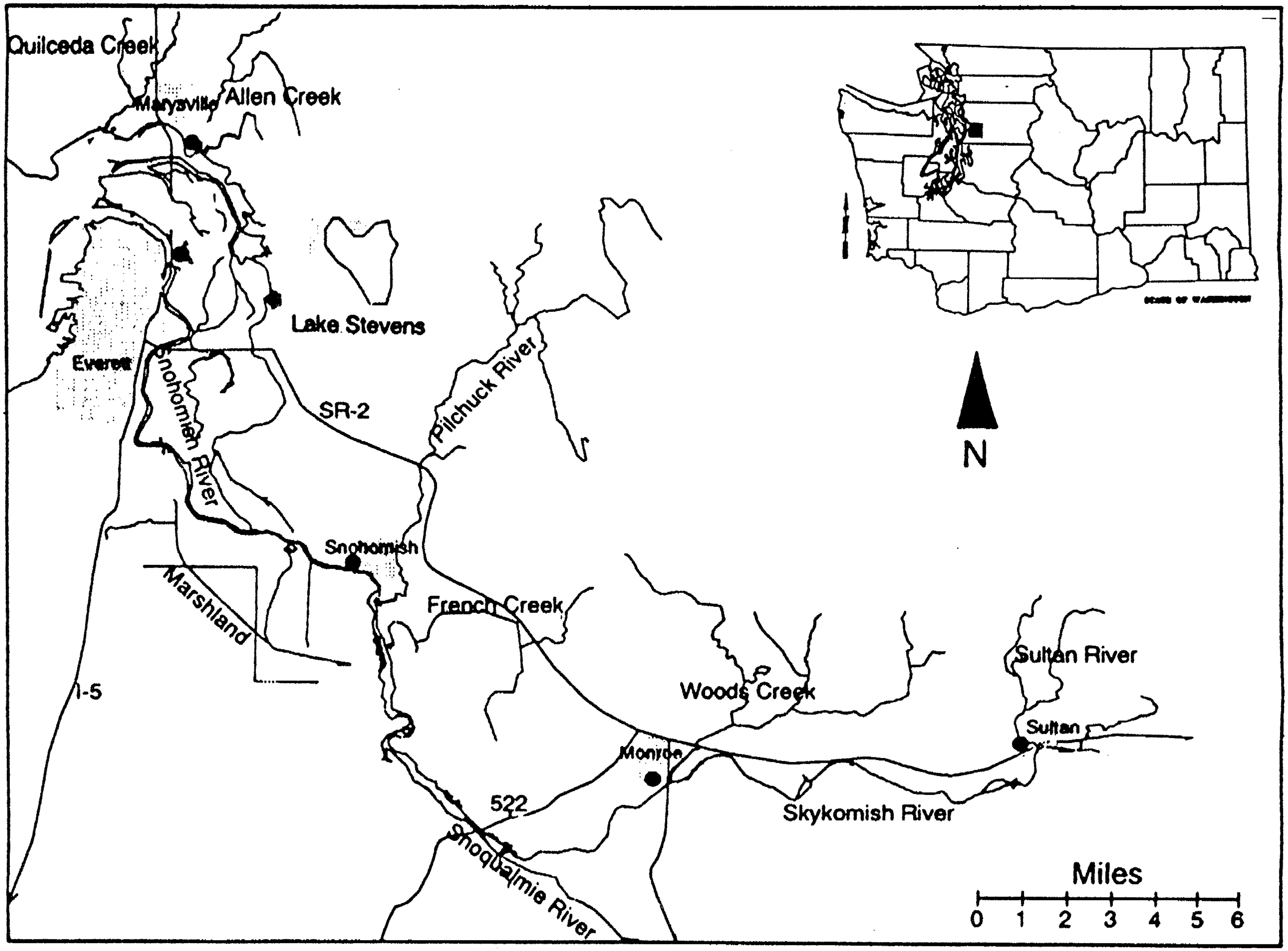

Figure 1. Location Map for WWTPs in Lower Snohomish TMDL Study Area, 8/93.

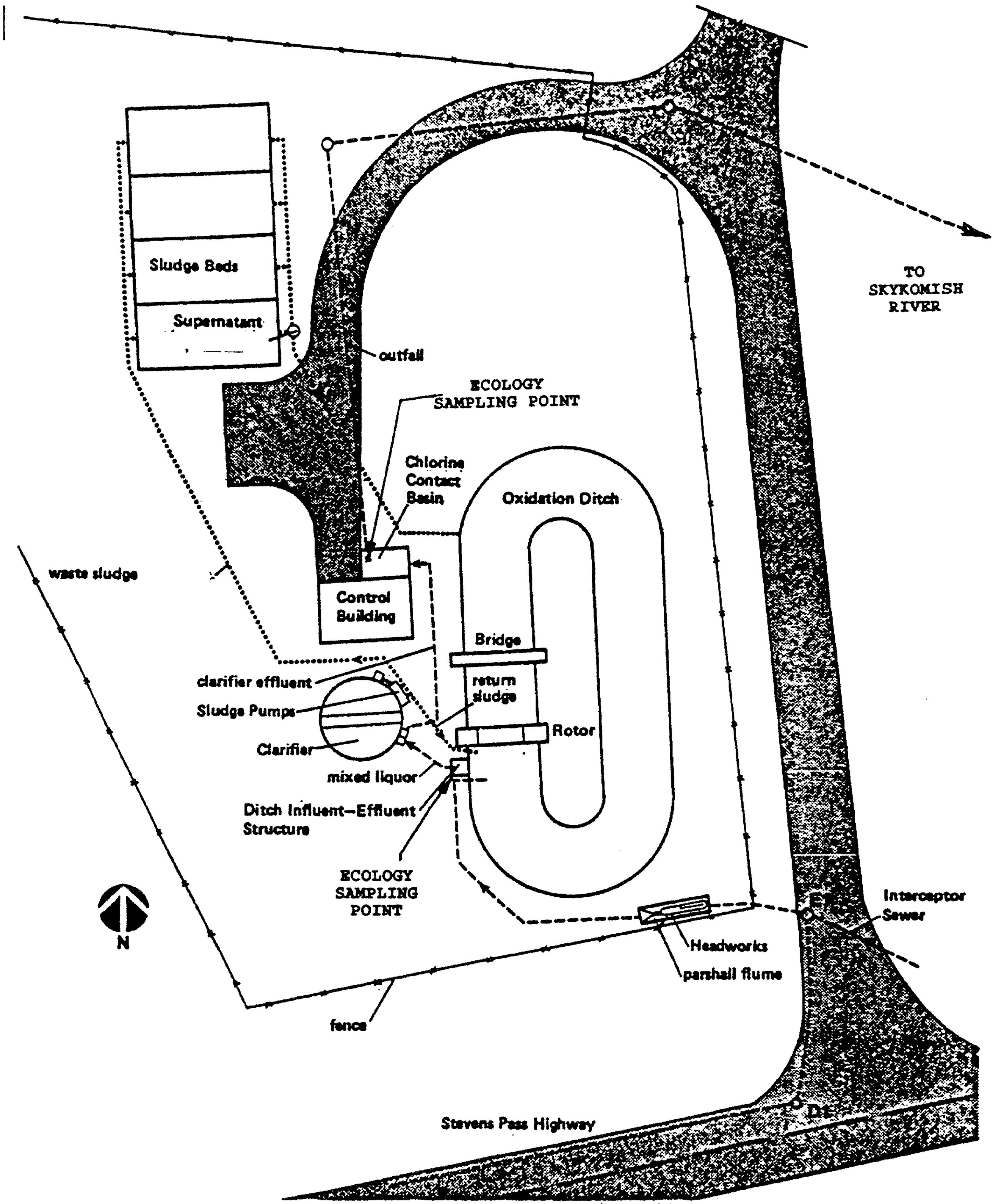

Figure 2. Plant Schematic - Town of Sultan WWTP, 8/93.

Table 1. Chemical Analytical Methods and Laboratories – Town of Sultan – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	Method	Lab used
Alkalinity	EPA, 1983: 310.1	Ecology; Manchester WA
Chloride	EPA, 1983: 330.0	Ecology; Manchester WA
SOLIDS		
Total solids (TS)	EPA, 1983: 160.3	Ecology; Manchester WA
Total non-volatile solids (TNVS)	EPA, 1983: 160.4	Ecology; Manchester WA
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Total non-volatile suspended solids (TNVSS)	EPA, 1983: 160.4	Ecology; Manchester WA
Five-day biochemical oxygen demand (BOD5)	APHA, 1992; 5210	Sound Analytical Svcs.; Tacoma WA
NUTRIENTS		
Total ammonia, as nitrogen (NH3-N)	EPA, 1983: 350.1	Sound Analytical Svcs.; Tacoma WA
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Lead	EPA, 1983;239.2	Ecology; Manchester WA
Mercury	EPA, 1983;245.1	Ecology; Manchester WA
Silver	EPA, 1983;272.2	Ecology; Manchester WA
Zinc	EPA, 1983;200.7	Ecology; Manchester WA

Table 2. General Chemistry and Metals Results, Town of Sultan - L. Snohomish River Basin Class II Inspections, 8/93.

	Location:	Blank-E	InfSU-E	InfSU-SU	EffSU-E	EffSU-SU	EffSU-1	EffSU-2	EffSU-T
	Type:	Equip	Comp	Comp	Comp	Comp	Grab	Grab	Grab
	Date:	8/24	8/25-26	8/25-26	8/25-26	8/25-26	8/25	8/26	8/26
	Time:	am	0001-2400	0800-0800	0800-0800	0800-0800	0900	0845	0900
Parameter	Lab Log #: 3582	-30	-31	-32	-33	-34	-35	-36	-37
GENERAL CHEMISTRY									
Alkalinity (mg/L)			175		110		98	113	113
Chloride (mg/L)			36		32		31	32	32
SOLIDS 4 (mg/L)									
TS			675	507	210	246	201	219	210
TNVS			240	217	146	151	136	145	142
TSS			286	150	19	27	13	9	15
TNVSS			50	28	2	2	1U	2	6
BOD5 (mg/L)			270	230	6U	20	8U	6U	6U
NH3-N (mg/L)			22		11		9.1	11	11
NO2+NO3-N (mg/L)			0.19		0.06J		0.04J	0.02J	0.02J
Total Kjeldahl N (mg/L)			15		12.9		10	15	14
Phosphate - Ortho (mg/L)					0.85		0.41	0.48	0.48
Phosphate - Total (mg/L)			4.7		1.0		0.65	0.69	0.68
F-Coliform MF (#/100mL)							LAC	1,300	440
METALS (µg/L)									
Cadmium		0.10U			*			0.10U	
Copper		3.1P			*			17.4	
Lead		1.0U			*			1.3P	
Mercury		0.05U			*			0.05U	
Silver		0.50U			*			0.50U	
Zinc		4U			*			26P	
FIELD OBSERVATIONS									
Flow (MGD)									
Temperature (°C.)			3.1**		2.4**		16.9	17.0	
pH (s.u.)			7.3**		7.2**		7.0	7.0	
Conductivity (µmho/cm)			535		375		275	380	
Chlorine, free (mg/L)							0.40	1.60	
total (mg/L)							3.80	3.50	

InfSU - Influent; EffSU - Effluent; -E - Ecology sampler; -SU - Sultan sampler.
-1 - Grab sample taken on 8/25; -2 - Grab sample taken on 8/26; -T - Duplicate taken on 8/26.
J means the analyte was positively identified. The associated numerical result is an estimate.
U means the analyte was not detected at or above the reported result.
P means the analyte was detected above the instrument detection limit but below the established minimum quantitation limit.
LAC means Laboratory Accident.
* - Samples not collected.
** - Iced composite sample.

Table 3. Comparison of Inspection Results to NPDES Permit Limits, Town of Sultan – L. Snohomish River Basin Class II Inspections, 8/93.

Parameter	NPDES Permit Limits		Inspection Data		Loading and Performance			
	Monthly Average	Weekly Average	Ecology Composite	Grab Samples	Design Criteria (DC)	Derived Results	Plant Loading (% of DC)	Planning to begin (% of DC)
Influent BOD5								
(mg/L)			270					
(lbs/d)					320	225	70	85
Effluent BOD5								
(mg/L)	30	45	6U					
(lbs/d)	48	75				<5		
(% removal)	85					>97		
Influent TSS								
(mg/L)			286					
(lbs/d)								
Effluent TSS								
(mg/L)	30	45	19					
(lbs/d)	50	75				16		
(% removal)	85					93		
Fecal Coliform								
(#/100 mL)	200	400		760(1,300;440)				
pH (s.u.)	$6.0 \le pH \le 9.0$			7.0;7.0				
Flow (MGD)	0.2				0.20	0.10	50	85

U - Not detected at or above the reported result.

Table 4. Comparison of Laboratory Results of Sample Splits, Town of Sultan – L. Snohomish River Basin Class II Inspections, 8/93.

Location:	InfSU-E		InfSU-SU		EffSU-E		EffSU-SU	
Lab Log #:	358231		358232		358233		358234	
Date:	8/25-26		8/25-26		8/25-26		8/25-26	
Sampler:	Ecology		Sultan		Ecology		Sultan	
Laboratory:	Ecology	Sultan	Ecology	Sultan	Ecology	Sultan	Ecology	Sultan
BOD5 (mg/L)	270	---	230	230	6U	---	20	15
TSS (mg/L)	286	---	150	173	19	---	27	26

Appendix D
WASP5 Input Files

```
SNOTIDE1.INP,TIME=0 IS AUG 16, 17 HR 0 1993 HYDRODYNAMIC FILE FOR EUTROWASP
ROBERT CUSIMANO, WA.DEPT.OF ECOLOGY, January 31, 1995
**********A: PROGRAM CONTROL DATA******************************************
   83 115 0000 60.0    5    1 0000 17.5 0000
**********B: PRINTOUT CONTROL DATA*****************************************
      1.0       1.0    0
   1    6    9   11   15   17
**********C: SUMMARY CONTROL DATA******************************************
   1    1 0100 25.0    6    2
**********D: JUNCTION DATA*************************************************
```

junction number	head (m)	surface area (m2)	depth MLLW (m)	channel number entering junction								
1	1.6943	2226443.	-5.0	1	0	0	0	0	0	0	0	0
2	1.6976	2101893.	-5.0	2	3	0	0	0	0	0	0	0
3	1.7010	1854725.	-5.0	4	5	0	0	0	0	0	0	0
4	1.7045	1731141.	-5.0	6	7	8	0	0	0	0	0	0
5	1.7080	1669349.	-5.0	9	10	0	0	0	0	0	0	0
6	1.7116	2226443.	-5.0	11	0	0	0	0	0	0	0	0
7	1.6929	2803443.	-5.0	1	2	12	13	14	0	0	0	0
8	1.6955	3025846.	-5.0	3	4	14	15	16	17	0	0	0
9	1.6990	2198943.	-5.0	5	6	16	18	19	0	0	0	0
10	1.7023	2045937.	-5.0	7	19	20	21	31	32	0	0	0
11	1.7052	2713145.	-5.0	8	9	21	22	33	34	0	0	0
12	1.7067	2208976.	-5.0	10	11	22	35	0	0	0	0	0
13	1.6925	1932227.	-5.0	12	23	25	0	0	0	0	0	0
14	1.6944	2374524.	-5.0	13	15	23	24	26	27	0	0	0
15	1.6977	2262487.	-5.0	17	18	20	24	28	29	30	0	0
16	1.7002	1886242.	-5.0	30	31	41	42	43	0	0	0	0
17	1.7017	2328539.	-5.0	32	33	37	38	39	40	41	0	0
18	1.7032	1826042.	-5.0	34	35	36	37	0	0	0	0	0
19	1.6931	1370368.	-5.0	25	26	44	45	48	49	0	0	0
20	1.6940	999976.	-5.0	27	28	49	50	54	0	0	0	0
21	1.6964	1320202.	-5.0	29	43	50	51	0	0	0	0	0
22	1.6984	1375385.	-5.0	40	42	51	52	0	0	0	0	0
23	1.6975	1367860.	-1.2	39	52	53	61	91	0	0	0	0
24	1.6976	1293447.	-5.0	36	38	91	92	0	0	0	0	0
25	1.6928	128676.	-5.0	48	0	0	0	0	0	0	0	0
26	1.6930	147822.	-5.0	44	0	0	0	0	0	0	0	0
27	1.6915	349195.	-5.0	45	46	47	0	0	0	0	0	0
28	1.6914	115298.	-5.0	46	0	0	0	0	0	0	0	0
29	1.6914	116719.	-5.0	47	0	0	0	0	0	0	0	0
30	1.6929	285110.	-4.6	54	55	0	0	0	0	0	0	0
31	1.6916	330761.	-4.6	55	56	57	0	0	0	0	0	0
32	1.6915	156769.	-2.4	56	0	0	0	0	0	0	0	0
33	1.6909	161451.	-2.7	57	58	0	0	0	0	0	0	0
34	1.6903	352166.	-2.4	58	59	0	0	0	0	0	0	0
35	1.6902	360108.	-2.4	59	60	0	0	0	0	0	0	0
36	1.6905	537696.	-1.2	60	61	64	108	0	0	0	0	0
37	1.6934	663111.	-1.2	53	62	63	92	0	0	0	0	0
38	1.6890	1067031.	-0.4	62	79	108	0	0	0	0	0	0
39	1.6893	1336282.	-0.4	63	93	0	0	0	0	0	0	0
40	1.6867	336079.	-2.4	64	65	0	0	0	0	0	0	0
41	1.6814	188683.	-2.4	65	66	0	0	0	0	0	0	0
42	1.6782	182003.	-2.2	66	67	0	0	0	0	0	0	0
43	1.6761	186832.	-3.7	67	68	0	0	0	0	0	0	0
44	1.6814	249220.	-0.1	68	69	84	90	0	0	0	0	0
45	1.7724	182976.	-1.6	69	70	0	0	0	0	0	0	0
46	1.8112	156024.	-1.6	70	71	0	0	0	0	0	0	0
47	1.8498	111288.	-1.6	71	72	0	0	0	0	0	0	0
48	1.8646	91403.	-1.2	72	73	0	0	0	0	0	0	0

49	1.8845	121938.	-0.1	73	74	107	0	0	0	0	0	0
50	2.0382	174131.	-1.2	74	75	0	0	0	0	0	0	0
51	2.1236	167059.	-1.2	75	76	0	0	0	0	0	0	0
52	2.1573	113393.	-1.4	76	77	0	0	0	0	0	0	0
53	2.2189	97025.	-1.0	77	78	0	0	0	0	0	0	0
54	2.2615	176054.	-2.0	78	109	0	0	0	0	0	0	0
55	1.6849	449458.	-1.8	79	80	0	0	0	0	0	0	0
56	1.6802	203386.	-2.0	80	81	85	0	0	0	0	0	0
57	1.6753	73188.	-0.5	81	82	0	0	0	0	0	0	0
58	1.6553	61591.	-0.5	82	83	0	0	0	0	0	0	0
59	1.6490	58953.	-0.5	83	84	0	0	0	0	0	0	0
60	1.6755	209072.	-2.1	85	86	0	0	0	0	0	0	0
61	1.6664	213638.	-1.9	86	87	0	0	0	0	0	0	0
62	1.6589	181067.	-1.7	87	88	99	100	0	0	0	0	0
63	1.6607	114302.	-0.7	88	89	102	0	0	0	0	0	0
64	1.6675	82867.	-0.4	89	90	0	0	0	0	0	0	0
65	1.6849	476240.	-1.2	93	94	0	0	0	0	0	0	0
66	1.6831	280913.	-0.7	94	95	0	0	0	0	0	0	0
67	1.6707	110083.	-0.7	95	96	0	0	0	0	0	0	0
68	1.6613	148623.	-1.1	96	97	0	0	0	0	0	0	0
69	1.6463	128584.	-0.9	97	98	0	0	0	0	0	0	0
70	1.6506	77249.	-0.5	98	99	0	0	0	0	0	0	0
71	1.6593	48980.	-0.5	100	101	0	0	0	0	0	0	0
72	1.6622	57857.	-2.0	101	102	103	0	0	0	0	0	0
73	1.6637	115385.	-2.1	103	104	0	0	0	0	0	0	0
74	1.6781	173080.	-3.1	104	105	0	0	0	0	0	0	0
75	1.7043	150098.	-1.1	105	106	0	0	0	0	0	0	0
76	1.8204	116614.	-0.5	106	107	0	0	0	0	0	0	0
77	2.3168	193875.	-1.7	109	110	0	0	0	0	0	0	0
78	2.3827	203587.	0.5	110	111	0	0	0	0	0	0	0
79	2.8786	204176.	1.5	111	112	0	0	0	0	0	0	0
80	3.3530	192477.	1.7	112	113	0	0	0	0	0	0	0
81	3.9414	180116.	2.4	113	114	0	0	0	0	0	0	0
82	5.1500	187842.	4.3	114	115	0	0	0	0	0	0	0
83	6.2099	92928.	4.5	115	0	0	0	0	0	0	0	0

**********E: CHANNEL DATA***

channel number	length (m)	width (m)	depth (m)	direction degrees	Mannings N	initial velocity	connecting junction	
1	2306.	1931.	6.69	64.	0.010	0.03860	1	7
2	2113.	1.	6.70	114.	0.010	0.05980	2	7
3	2177.	1931.	6.70	56.	0.010	0.05280	2	8
4	1985.	1.	6.70	134.	0.010	0.03420	3	8
5	1921.	1931.	6.70	59.	0.010	0.04430	3	9
6	1921.	1.	6.70	140.	0.010	-0.02310	4	9
7	1793.	1931.	6.70	88.	0.010	0.01080	4	10
8	2306.	1.	6.70	29.	0.010	0.02940	4	11
9	1729.	1931.	6.71	115.	0.010	0.02330	5	11
10	2049.	1.	6.71	47.	0.010	0.07410	5	12
11	2306.	1931.	6.71	122.	0.010	0.03530	6	12
12	2177.	1448.	6.69	88.	0.010	0.03050	7	13
13	2817.	1.	6.69	45.	0.010	0.03210	7	14
14	2049.	1.	6.69	3.	0.010	0.01110	7	8
15	1921.	1448.	6.69	97.	0.010	0.04610	8	14
16	2306.	1.	6.70	4.	0.010	-0.02410	8	9
17	2497.	1.	6.70	42.	0.010	-0.01340	8	15
18	1601.	1448.	6.70	111.	0.010	0.04030	9	15
19	1601.	1.	6.70	20.	0.010	0.04450	9	10
20	2177.	1.	6.70	155.	0.010	0.01220	10	15
21	1985.	1.	6.70	338.	0.010	0.05260	10	11
22	2049.	1.	6.71	358.	0.010	0.05370	11	12

23	1921.	1.	6.69	354.	0.010	-0.00316	13	14
24	2177.	1.	6.70	354.	0.010	-0.06020	14	15
25	2306.	1042.	6.69	40.	0.010	0.02700	13	19
26	1665.	1.	6.69	96.	0.010	0.07110	14	19
27	1793.	1042.	6.69	70.	0.010	0.04500	14	20
28	2306.	1.	6.70	128.	0.010	0.10900	15	20
29	2049.	1042.	6.70	96.	0.021	0.03740	15	21
30	1409.	1.	6.70	30.	0.024	0.14200	15	16
31	1857.	1448.	6.70	119.	0.028	0.00063	10	16
32	1665.	1.	6.70	59.	0.032	0.15300	10	17
33	2369.	1448.	6.70	116.	0.032	0.01140	11	17
34	2049.	1.	6.70	44.	0.037	0.13400	11	18
35	1601.	1448.	6.70	113.	0.037	0.02880	12	18
36	2177.	1042.	6.70	122.	0.035	0.02460	18	24
37	2562.	1.	6.70	344.	0.037	0.08770	17	18
38	1793.	1.	6.70	39.	0.034	0.15600	17	24
39	2049.	1042.	4.80	82.	0.037	-0.00512	17	23
40	2049.	1.	6.70	125.	0.037	-0.08040	17	22
41	1665.	1.	6.70	353.	0.032	0.12600	16	17
42	1729.	1042.	6.70	75.	0.032	-0.01460	16	22
43	2049.	1.	6.70	133.	0.028	-0.08840	16	21
44	1089.	362.	6.69	80.	0.010	0.00343	19	26
45	1217.	148.	6.69	53.	0.010	0.03330	19	27
46	768.	354.	6.69	43.	0.017	0.00276	27	28
47	768.	281.	6.69	8.	0.017	0.00353	27	29
48	896.	127.	6.69	32.	0.010	0.00851	19	25
49	768.	758.	6.69	360.	0.010	0.01250	19	20
50	1216.	758.	6.70	14.	0.021	0.06190	20	21
51	1857.	758.	6.70	4.	0.029	0.09840	21	22
52	1537.	758.	4.80	9.	0.037	0.08750	22	23
53	1089.	396.	2.90	8.	0.037	0.12600	23	37
54	1025.	447.	6.49	44.	0.022	0.00256	20	30
55	931.	310.	6.29	7.	0.022	-0.00442	30	31
56	643.	359.	5.19	97.	0.026	0.00474	31	32
57	637.	313.	5.34	360.	0.024	-0.02160	31	33
58	670.	363.	4.24	9.	0.026	-0.02940	33	34
59	714.	854.	4.09	25.	0.026	-0.01860	34	35
60	765.	242.	3.49	46.	0.024	-0.10100	35	36
61	1114.	384.	2.89	90.	0.037	0.06040	23	36
62	879.	737.	2.49	76.	0.042	0.04090	37	38
63	1062.	711.	2.49	11.	0.027	0.07150	37	39
64	925.	322.	3.49	90.	0.027	-0.05680	36	40
65	1271.	142.	4.08	112.	0.035	-0.15700	40	41
66	1165.	169.	3.98	161.	0.035	-0.14900	41	42
67	1403.	133.	4.63	186.	0.035	-0.15900	42	43
68	1546.	121.	3.63	147.	0.038	-0.23800	43	44
69	1551.	119.	2.63	240.	0.037	-0.39600	44	45
70	1761.	103.	3.39	176.	0.036	-0.31800	45	46
71	1405.	93.	3.43	194.	0.034	-0.37000	46	47
72	910.	101.	3.26	93.	0.031	-0.31600	47	48
73	874.	104.	2.52	140.	0.031	-0.32500	48	49
74	1622.	105.	2.61	169.	0.031	-0.56700	49	50
75	1995.	96.	3.28	107.	0.031	-0.46700	50	51
76	1308.	109.	3.44	101.	0.031	-0.37000	51	52
77	1144.	74.	3.39	136.	0.032	-0.52900	52	53
78	1253.	87.	3.74	98.	0.034	-0.39200	53	54
79	1201.	620.	2.79	82.	0.048	0.01630	38	55
80	708.	217.	3.58	75.	0.055	0.00254	55	56
81	1333.	68.	2.93	142.	0.052	0.02200	56	57
82	2005.	27.	2.17	114.	0.052	0.00355	57	58

83	2220.	31.	2.15	191.	0.052	-0.04270	58	59
84	2416.	21.	2.02	18.	0.052	0.11700	44	59
85	828.	195.	3.73	79.	0.055	-0.01970	56	60
86	1629.	158.	3.67	117.	0.055	-0.04520	60	61
87	1588.	107.						

```
3.46     159.     0.046  -0.10000   61   62
      88     922.       78.     2.86     195.      0.036  -0.19200   62   63
      89    1797.       49.     2.21     175.      0.036  -0.05930   63   64
      90    1597.       49.     1.97      55.      0.036   0.08520   64   44
      91    1284.        1.     4.80     319.      0.036   0.16100   23   24
      92     978.      763.     4.80      91.      0.033   0.02630   24   37
      93    1200.      392.     2.49      57.      0.034   0.04960   39   65
      94    1039.      464.     2.63     106.      0.034   0.01820   65   66
      95    1235.       65.     2.38      58.      0.034   0.03880   66   67
      96    1599.       87.     2.57     139.      0.036  -0.00240   67   68
      97    2868.       55.     2.65     113.      0.036  -0.06510   68   69
      98    1819.       55.     2.35     149.      0.036  -0.12300   69   70
      99    1201.       46.     2.75      34.      0.036   0.15000   70   62
     100    1425.       46.     2.76     129.      0.036  -0.15600   62   71
     101     726.       46.     2.91     248.      0.036  -0.15700   71   72
     102     831.       61.     3.01      94.      0.036  -0.15700   63   72
     103     819.       70.     3.71     126.      0.036  -0.18800   72   73
     104    2710.       64.     4.27     192.      0.036  -0.23200   73   74
     105    2683.       64.     3.79     157.      0.036  -0.25700   74   75
     106    2180.       59.     2.56     240.      0.036  -0.39200   75   76
     107    1773.       59.     2.55      45.      0.036   0.28100   76   49
     108    1195.      102.     2.49     353.      0.052   0.06100   36   38
     109    2012.       86.     4.14     158.      0.041  -0.33100   54   77
     110    1768.      121.     2.95     167.      0.045  -0.29000   77   78
     111    1609.      121.     1.63     167.      0.052  -0.47000   78   79
     112    1609.      133.     1.52     167.      0.052  -0.43300   79   80
     113    1609.      106.     1.60     240.      0.052  -0.50300   80   81
     114    1609.      118.     1.20     140.      0.052  -0.59900   81   82
     115    1609.      115.     1.28     140.      0.052  -0.57600   82   83
**********F: CONSTANT INFLOW DATA*******************************************
    18
     junction   inflow
      number     (m3)
         83     -84.7
         82     -0.03
         81     -0.03
         80     -0.03
         79     -0.03
         78     -0.03
         77     -3.80
         73     -0.05
         65     -1.55
         60     -0.08
         54     -0.01
         53     -0.01
         52     -0.01
         51     -0.01
         50     -0.01
         49     -0.01
         43     -0.29
         42     -0.17
           *variable inflow data*
    0
**********G: SEAWARD BOUNDARY DATA******************************************
    6
    3    1  100   20    0    0    0  1.0
junction tim    head junction time   head junction time    head junction time    head
    1   0000    1.6943    1   538    2.8651    1   1219   -0.1829    1   1930    3.4138
    2    103    1.4326    2   624    2.8042    2   1251    0.0000    2   1953    3.3833
    3    138    1.2497    3   710    2.7432    3   1326    0.2743    3   2016    3.3223
```

4	214	1.0668	4	758	2.6518	4	1402	0.5486	4	2041	3.2614
5	256	0.9144	5	852	2.5603	5	1440	0.8839	5	2108	3.1699
6	337	0.7620	6	951	2.4689	6	1519	1.2192	6	2138	3.1090
7	426	0.6096	7	1101	2.4079	7	1605	1.5850	7	2213	3.0175
8	519	0.4877	8	1227	2.4079	8	1703	1.8898	8	2254	2.9261
9	617	0.3658	9	1403	2.4994	9	1813	2.1336	9	2339	2.8651
10	715	0.1829	10	1519	2.7127	10	1932	2.2555	11	32	2.8346
11	810	0.0000	11	1607	2.8956	11	2047	2.2250	12	130	2.8346
12	901	-0.1829	12	1649	3.0785	12	2142	2.1031	13	233	2.8956
13	949	-0.3353	13	1718	3.2614	13	2231	1.8898	14	328	2.9870
14	1033	-0.3962	14	1746	3.3833	14	2313	1.6154	15	428	3.0785
15	1115	-0.3962	15	1815	3.4747	15	2355	1.2497	16	524	3.1394
16	1157	-0.2743	16	1844	3.5662	17	36	0.8839	17	622	3.1699
17	1239	0.0305	17	1914	3.6271	18	123	0.5486	18	722	3.1394
18	1325	0.3048	18	1950	3.6271	19	211	0.2438	19	825	3.0481
19	1410	0.7315	19	2025	3.5662	20	300	0.0611	20	931	2.9261
20	1500	1.1582	20	2107	3.4747	21	356	-0.0611	21	1050	2.8042
21	1554	1.5545	21	2152	3.3223	22	500	-0.0914	22	1217	2.7737
22	1701	1.8898	22	2244	3.1394	23	607	-0.0914	23	1349	2.8346
23	1827	2.0726	23	2349	2.9871	24	716	-0.0914	24	1502	2.9871
24	1958	2.0726	25	102	2.8346	25	821	-0.0914	25	1601	3.1091
25	2114	1.9507	26	214	2.8042	26	917	-0.0915	26	1644	3.2309
3	2 100	20	0	0 0	1.0						
1	0000	1.6976	1	537	2.8651	1	1218	-0.1829	1	1929	3.4138
2	102	1.4326	2	623	2.8042	2	1250	0.0000	2	1952	3.3833
3	137	1.2497	3	709	2.7432	3	1325	0.2743	3	2015	3.3223
4	213	1.0668	4	757	2.6518	4	1401	0.5486	4	2040	3.2614
5	255	0.9144	5	851	2.5603	5	1439	0.8839	5	2107	3.1699
6	336	0.7620	6	950	2.4689	6	1518	1.2192	6	2137	3.1090
7	425	0.6096	7	1100	2.4079	7	1604	1.5850	7	2212	3.0175
8	518	0.4877	8	1226	2.4079	8	1702	1.8898	8	2253	2.9261
9	616	0.3658	9	1402	2.4994	9	1812	2.1336	9	2338	2.8651
10	714	0.1829	10	1518	2.7127	10	1931	2.2555	11	31	2.8346
11	809	0.0000	11	1606	2.8956	11	2046	2.2250	12	129	2.8346
12	900	-0.1829	12	1648	3.0785	12	2141	2.1031	13	232	2.8956
13	948	-0.3353	13	1717	3.2614	13	2230	1.8898	14	327	2.9870
14	1032	-0.3962	14	1745	3.3833	14	2312	1.6154	15	427	3.0785
15	1114	-0.3962	15	1814	3.4747	15	2354	1.2497	16	523	3.1394
16	1156	-0.2743	16	1843	3.5662	17	35	0.8839	17	621	3.1699
17	1238	0.0305	17	1913	3.6271	18	122	0.5486	18	721	3.1394
18	1324	0.3048	18	1949	3.6271	19	210	0.2438	19	824	3.0481
19	1409	0.7315	19	2024	3.5662	20	259	0.0611	20	930	2.9261
20	1459	1.1582	20	2106	3.4747	21	355	-0.0611	21	1049	2.8042
21	1553	1.5545	21	2151	3.3223	22	459	-0.0914	22	1216	2.7737
22	1700	1.8898	22	2243	3.1394	23	606	-0.0914	23	1348	2.8346
23	1826	2.0726	23	2348	2.9871	24	715	-0.0914	24	1501	2.9871
24	1957	2.0726	25	101	2.8346	25	820	-0.0914	25	1600	3.1091
25	2113	1.9507	26	213	2.8042	26	916	-0.0915	26	1643	3.2309
3	3 100	20	0	0 0	1.0						
1	0000	1.7010	1	536	2.8651	1	1217	-0.1829	1	1928	3.4138
2	101	1.4326	2	622	2.8042	2	1249	0.0000	2	1951	3.3833
3	136	1.2497	3	708	2.7432	3	1324	0.2743	3	2014	3.3223
4	212	1.0668	4	756	2.6518	4	1400	0.5486	4	2039	3.2614
5	254	0.9144	5	850	2.5603	5	1438	0.8839	5	2106	3.1699
6	335	0.7620	6	949	2.4689	6	1517	1.2192	6	2136	3.1090
7	424	0.6096	7	1059	2.4079	7	1603	1.5850	7	2211	3.0175
8	517	0.4877	8	1225	2.4079	8	1701	1.8898	8	2252	2.9261
9	615	0.3658	9	1401	2.4994	9	1811	2.1336	9	2337	2.8651
10	713	0.1829	10	1517	2.7127	10	1930	2.2555	11	30	2.8346
11	808	0.0000	11	1605	2.8956	11	2045	2.2250	12	128	2.8346

12	859	-0.1829	12	1647	3.0785	12	2140	2.1031	13	231	2.8956
13	947	-0.3353	13	1716	3.2614	13	2229	1.8898	14	326	2.9870
14	1031	-0.3962	14	1744	3.3833	14	2311	1.6154	15	426	3.0785
15	1113	-0.3962	15	1813	3.4747	15	2353	1.2497	16	522	3.1394
16	1155	-0.2743	16	1842	3.5662	17	34	0.8839	17	620	3.1699
17	1237	0.0305	17	1912	3.6271	18	121	0.5486	18	720	3.1394
18	1323	0.3048	18	1948	3.6271	19	209	0.2438	19	823	3.0481
19	1408	0.7315	19	2023	3.5662	20	258	0.0611	20	929	2.9261
20	1458	1.1582	20	2105	3.4747	21	354	-0.0611	21	1048	2.8042
21	1552	1.5545	21	2150	3.3223	22	458	-0.0914	22	1215	2.7737
22	1659	1.8898	22	2242	3.1394	23	605	-0.0914	23	1347	2.8346
23	1825	2.0726	23	2347	2.9871	24	714	-0.0914	24	1500	2.9871
24	1956	2.0726	25	100	2.8346	25	819	-0.0914	25	1559	3.1091
25	2112	1.9507	26	212	2.8042	26	915	-0.0915	26	1642	3.2309
3	4 100	20	0	0	0 1.0						
1	0000	1.7045	1	535	2.8651	1	1216	-0.1829	1	1927	3.4138
2	100	1.4326	2	621	2.8042	2	1248	0.0000	2	1950	3.3833
3	135	1.2497	3	707	2.7432	3	1323	0.2743	3	2013	3.3223
4	211	1.0668	4	755	2.6518	4	1359	0.5486	4	2038	3.2614
5	253	0.9144	5	849	2.5603	5	1437	0.8839	5	2105	3.1699
6	334	0.7620	6	948	2.4689	6	1516	1.2192	6	2135	3.1090
7	423	0.6096	7	1058	2.4079	7	1602	1.5850	7	2210	3.0175
8	516	0.4877	8	1224	2.4079	8	1700	1.8898	8	2251	2.9261
9	614	0.3658	9	1400	2.4994	9	1810	2.1336	9	2336	2.8651
10	712	0.1829	10	1516	2.7127	10	1929	2.2555	11	29	2.8346
11	807	0.0000	11	1604	2.8956	11	2044	2.2250	12	127	2.8346
12	858	-0.1829	12	1646	3.0785	12	2139	2.1031	13	230	2.8956
13	946	-0.3353	13	1715	3.2614	13	2228	1.8898	14	325	2.9870
14	1030	-0.3962	14	1743	3.3833	14	2310	1.6154	15	425	3.0785
15	1112	-0.3962	15	1812	3.4747	15	2352	1.2497	16	521	3.1394
16	1154	-0.2743	16	1841	3.5662	17	33	0.8839	17	619	3.1699
17	1236	0.0305	17	1911	3.6271	18	120	0.5486	18	719	3.1394
18	1322	0.3048	18	1947	3.6271	19	208	0.2438	19	822	3.0481
19	1407	0.7315	19	2022	3.5662	20	257	0.0611	20	928	2.9261
20	1457	1.1582	20	2104	3.4747	21	353	-0.0611	21	1047	2.8042
21	1551	1.5545	21	2149	3.3223	22	457	-0.0914	22	1214	2.7737
22	1658	1.8898	22	2241	3.1394	23	604	-0.0914	23	1346	2.8346
23	1824	2.0726	23	2346	2.9871	24	713	-0.0914	24	1459	2.9871
24	1955	2.0726	25	59	2.8346	25	818	-0.0914	25	1558	3.1091
25	2111	1.9507	26	211	2.8042	26	914	-0.0915	26	1641	3.2309
3	5 100	20	0	0	0 1.0						
1	0000	1.7080	1	534	2.8651	1	1215	-0.1829	1	1926	3.4138
2	59	1.4326	2	620	2.8042	2	1247	0.0000	2	1949	3.3833
3	134	1.2497	3	706	2.7432	3	1322	0.2743	3	2012	3.3223
4	210	1.0668	4	754	2.6518	4	1358	0.5486	4	2037	3.2614
5	252	0.9144	5	848	2.5603	5	1436	0.8839	5	2104	3.1699
6	333	0.7620	6	947	2.4689	6	1515	1.2192	6	2134	3.1090
7	422	0.6096	7	1057	2.4079	7	1601	1.5850	7	2209	3.0175
8	515	0.4877	8	1223	2.4079	8	1659	1.8898	8	2250	2.9261
9	613	0.3658	9	1359	2.4994	9	1809	2.1336	9	2335	2.8651
10	711	0.1829	10	1515	2.7127	10	1928	2.2555	11	28	2.8346
11	806	0.0000	11	1603	2.8956	11	2043	2.2250	12	126	2.8346
12	857	-0.1829	12	1645	3.0785	12	2138	2.1031	13	229	2.8956
13	945	-0.3353	13	1714	3.2614	13	2227	1.8898	14	324	2.9870
14	1029	-0.3962	14	1742	3.3833	14	2309	1.6154	15	424	3.0785
15	1111	-0.3962	15	1811	3.4747	15	2351	1.2497	16	520	3.1394
16	1153	-0.2743	16	1840	3.5662	17	32	0.8839	17	618	3.1699
17	1235	0.0305	17	1910	3.6271	18	119	0.5486	18	718	3.1394
18	1321	0.3048	18	1946	3.6271	19	207	0.2438	19	821	3.0481
19	1406	0.7315	19	2021	3.5662	20	256	0.0611	20	927	2.9261

```
20   1456   1.1582  20  2103   3.4747  21   352  -0.0611  21  1046   2.8042
21   1550   1.5545  21  2148   3.3223  22   456  -0.0914  22  1213   2.7737
22   1657   1.8898  22  2240   3.1394  23   603  -0.0914  23  1345   2.8346
23   1823   2.0726  23  2345   2.9871  24   712  -0.0914  24  1458   2.9871
24   1954   2.0726  25    58   2.8346  25   817  -0.0914  25  1557   3.1091
25   2110   1.9507  26   210   2.8042  26   913  -0.0915  26  1640   3.2309
 3     6  100   20   0    0    0  1.0
 1   0000   1.7116   1   533   2.8651   1  1214  -0.1829   1  1925   3.4138
 2     58   1.4326   2   619   2.8042   2  1246   0.0000   2  1948   3.3833
 3    133   1.2497   3   705   2.7432   3  1321   0.2743   3  2011   3.3223
 4    209   1.0668   4   753   2.6518   4  1357   0.5486   4  2036   3.2614
 5    251   0.9144   5   847   2.5603   5  1435   0.8839   5  2103   3.1699
 6    332   0.7620   6   946   2.4689   6  1514   1.2192   6  2133   3.1090
 7    421   0.6096   7  1056   2.4079   7  1600   1.5850   7  2208   3.0175
 8    514   0.4877   8  1222   2.4079   8  1658   1.8898   8  2249   2.9261
 9    612   0.3658   9  1358   2.4994   9  1808   2.1336   9  2334   2.8651
10    710   0.1829  10  1514   2.7127  10  1927   2.2555  11    27   2.8346
11    805   0.0000  11  1602   2.8956  11  2042   2.2250  12   125   2.8346
12    856  -0.1829  12  1644   3.0785  12  2137   2.1031  13   228   2.8956
13    944  -0.3353  13  1713   3.2614  13  2226   1.8898  14   323   2.9870
14   1028  -0.3962  14  1741   3.3833  14  2308   1.6154  15   423   3.0785
15   1110  -0.3962  15  1810   3.4747  15  2350   1.2497  16   519   3.1394
16   1152  -0.2743  16  1839   3.5662  17    31   0.8839  17   617   3.1699
17   1234   0.0305  17  1909   3.6271  18   118   0.5486  18   717   3.1394
18   1320   0.3048  18  1945   3.6271  19   206   0.2438  19   820   3.0481
19   1405   0.7315  19  2020   3.5662  20   255   0.0611  20   926   2.9261
20   1455   1.1582  20  2102   3.4747  21   351  -0.0611  21  1045   2.8042
21   1549   1.5545  21  2147   3.3223  22   455  -0.0914  22  1212   2.7737
22   1656   1.8898  22  2239   3.1394  23   602  -0.0914  23  1344   2.8346
23   1822   2.0726  23  2344   2.9871  24   711  -0.0914  24  1457   2.9871
24   1953   2.0726  25    57   2.8346  25   816  -0.0914  25  1556   3.1091
25   2109   1.9507  26   209   2.8042  26   912  -0.0915  26  1639   3.2309
**********H: WIND DATA******************************
 0
**********I: EVAPORATION OR GEOMETRY DATA***********
 0
**********J: JUNCTION GEOMETRY DATA*****************
 0
**********K: CHANNEL GEOMETRY DATA******************
 0
**********L: MAP TO WASP5***************************
 0  83
junction segment
number   number
 1    0
 2    0
 3    0
 4    0
 5    0
 6    0
 7    1
 8    2
 9    3
10    4
11    5
12    6
13    7
14    8
15    9
16   10
```

17	11
18	12
19	13
20	14
21	15
22	16
23	17
24	18
25	19
26	20
27	21
28	22
29	23
30	24
31	25
32	26
33	27
34	28
35	29
36	30
37	31
38	32
39	33
40	34
41	35
42	36
43	37
44	38
45	39
46	40
47	41
48	42
49	43
50	44
51	45
52	46
53	47
54	48
55	49
56	50
57	51
58	52
59	53
60	54
61	55
62	56
63	57
64	58
65	59
66	60
67	61
68	62
69	63
70	64
71	65
72	66
73	67
74	68
75	69
76	70

77	71
78	72
79	73
80	74
81	75
82	76
83	0

```
SNOCAL1.INP: WATER QUALITY SALINITY CALIBRATION FILE (TETRA TECH VERSION)
******ROBERT CUSIMANO, WA. DEPT. OF ECOLOGY, February 2,1995**************
 NOSE NOSY ICFL MFLA JMAS NEGS INTY ADFA ZDAY HHMM TFLG ***A: MODEL OPTIONS***
   80    9    0    0    1    0    0 0.15  1.0 0100    0
   38   39   40   41   42   43
    1
    0.042      15.0
   2
   12.978    12.978     0.042      15.0
   0    0    0    0    0    0    0    0
   1    0                                                   *******B: EXCHANGES***
   6     1.000     1.000      (number of different exchanges = 6)
  50 (number of exchanges for field 1)
  exchange   length   segment
    area      (m)      pair
    10595     2306     0    1     <<<Possession Sound>>>
    10595     2177     0    2
    10595     1921     0    3
    10562     1793     0    4
    10595     1729     0    5
    10595     2306     0    6
        6     1970     1    2
     8011     1947     1    7
        6     2509     1    8
        6     2096     2    3
     8011     1682     2    8
        6     2194     2    9
        6     1450     3    4
     8011     1432     3    9
        6     1765     4    5
        6     2007     4    9
     8011     1647     4   10
        6     1437     4   11
        6     1869     5    6
     8011     2123     5   11
        6     1810     5   12
     8011     1434     6   12
        6     1715     7    8
     6806     1986     7   13
        6     1828     8    9
        6     1477     8   13
     6806     1548     8   14
        6     1230     9   10
        6     2092     9   14
     6806     1940     9   15
        6     1507    10   11
        6     1812    10   15
     6806     1474    10   16
        6     2320    11   12
        6     1969    11   16
     6806     1847    11   17
        6     1572    11   18
     6806     1971    12   18
     5456      708    13   14
      914      803    13   19
     2605     1014    13   20
     1063     1056    13   21
     5456     1115    14   15
     5456     1621    15   16
     5456     1391    16   17
```

```
     792       961   17   31
       6      1284   17   18
    5495       978   18   31
    2547       642   21   22
    2021       651   21   23
  2
  Dispersion
value (m2/sec)
  120.00       0.0    120.00      365.
  4
     769      1114   17   30
    1622       879   31   32
    1564      1062   31   33
     203      1195   30   32
  2
   20.00       0.0     20.00      365.
 17
    1427      1201   32   49
     863      1200   33   59
      56      2416   53   38    <<<Sloughs>>>
     231      1773   43   70
     779       750   49   50
     198      1333   50   51
     743       828   50   54
      68      2005   51   52
      77      2220   52   53
     599      1629   54   55
     375      1588   55   56
     227       922   56   57
     124      1201   64   56
     124      1425   56   65
     112      1797   57   58
     257       831   57   66
     107      1597   58   38
  2
   20.00       0.0     20.00      365.
  8
    3533       937   14   24     <<<Lower Snohomish River>>>
    1796       931   24   25
    1688       643   25   26
    1535       637   25   27
    1378       670   27   28
    3074       750   28   29
     726       765   29   30
     967       925   30   34
  2
  120.00       0.0    120.00      365.
 13
    1067      1039   59   60     <<<Ebey Slough>>>
     142      1235   60   61
     192      1599   61   62
     121      2868   62   63
     121      1819   63   64
     133       750   65   66
     335       819   66   67
     243      2710   67   68
     275      2683   68   69
     211      2180   69   70
     460      1271   34   35     <<<Middle Snohomish River>>>
     533      1165   35   36
```

```
    626       1403   36   37
 2
   0.00        0.0       0.00       365.
18
    591       1546   37   38
    452       1551   38   39
    419       1761   39   40
    297       1405   40   41     <<<Upper Snohomish River>>>
    288        910   41   42
    322        874   42   43
    358       1622   43   44
    424       1995   44   45
    545       1308   45   46
    436       1144   46   47
    541       1253   47   48
    398       2012   48   71
    350       1768   71   72
    181       1609   72   73
    200       1609   73   74
    159       1609   74   75
    130       1609   75   76
    139       1609    0   76
2
  0.00        0.0       0.00      365.
0    0    0    0    0    0    0    0
2    0       1.0                                  *********C: VOLUMES***
1.0000    1.0000
```

(Data group "C" only used to calculate reaeration and volatilization based on average segment characteristics. DYNHYD5 provides hydrodynamics.)

segment number	bottom segment		segment volume (m3)			average depth	
1	77	1	2.58E+07	0	0	7.2	0
2	77	1	2.37E+07	0	0	7.2	0
3	77	1	2.03E+07	0	0	7.2	0
4	77	1	2.09E+07	0	0	7.2	0
5	77	1	2.32E+07	0	0	7.2	0
6	77	1	2.28E+07	0	0	7.2	0
7	77	1	2.00E+07	0	0	7.2	0
8	77	1	1.67E+07	0	0	7.2	0
9	77	1	1.61E+07	0	0	7.2	0
10	77	1	1.62E+07	0	0	7.2	0
11	77	1	2.01E+07	0	0	7.2	0
12	77	1	1.66E+07	0	0	7.2	0
13	77	1	1.32E+07	0	0	7.2	0
14	77	1	1.38E+07	0	0	7.2	0
15	77	1	1.61E+07	0	0	7.2	0
16	77	1	1.58E+07	0	0	7.2	0
17	77	1	7.07E+06	0	0	3.4	0
18	77	1	1.09E+07	0	0	7.2	0
19	77	1	4.09E+05	0	0	7.2	0
20	77	1	1.42E+06	0	0	7.2	0
21	77	1	2.40E+06	0	0	7.2	0
22	77	1	9.81E+05	0	0	7.2	0
23	77	1	7.77E+05	0	0	7.2	0
24	77	1	2.54E+06	0	0	6.8	0
25	77	1	2.44E+06	0	0	6.8	0
26	77	1	5.31E+05	0	0	4.6	0
27	77	1	1.08E+06	0	0	4.9	0
28	77	1	1.96E+06	0	0	4.6	0

29	77	1	1.83E+06	0	0	4.6	0
30	78	1	1.76E+06	0	0	3.4	0
31	79	1	4.38E+06	0	0	3.4	0
32	79	1	3.02E+06	0	0	4	0
33	79	1	1.47E+06	0	0	2.4	0
34	78	1	7.37E+05	0	0	3.2	0
35	78	1	7.81E+05	0	0	4.6	0
36	78	1	4.91E+05	0	0	2.7	0
37	78	1	1.10E+06	0	0	5.9	0
38	78	1	5.48E+05	0	0	2.2	0
39	78	1	6.95E+05	0	0	3.8	0
40	78	1	5.93E+05	0	0	3.8	0
41	78	1	4.23E+05	0	0	3.8	0
42	78	1	3.11E+05	0	0	3.4	0
43	80	1	2.80E+05	0	0	2.3	0
44	80	1	6.17E+05	0	0	3.4	0
45	80	1	5.69E+05	0	0	3.4	0
46	80	1	4.09E+05	0	0	3.6	0
47	80	1	3.11E+05	0	0	3.2	0
48	80	1	5.95E+05	0	0	4.2	0
49	79	1	1.80E+06	0	0	4	0
50	79	1	8.53E+05	0	0	4.2	0
51	79	1	1.96E+05	0	0	2.7	0
52	79	1	1.65E+05	0	0	2.7	0
53	79	1	1.59E+05	0	0	2.7	0
54	79	1	8.99E+05	0	0	4.3	0
55	79	1	8.75E+05	0	0	4.1	0
56	79	1	7.07E+05	0	0	3.9	0
57	79	1	3.31E+05	0	0	2.9	0
58	79	1	2.14E+05	0	0	2.6	0
59	79	1	1.62E+06	0	0	3.4	0
60	79	1	8.15E+05	0	0	2.9	0
61	79	1	3.19E+05	0	0	2.9	0
62	79	1	4.91E+05	0	0	3.3	0
63	79	1	3.99E+05	0	0	3.1	0
64	79	1	2.09E+05	0	0	2.7	0
65	79	1	1.33E+05	0	0	2.7	0
66	79	1	2.43E+05	0	0	4.2	0
67	79	1	5.01E+05	0	0	4.3	0
68	79	1	9.09E+05	0	0	5.3	0
69	79	1	4.93E+05	0	0	3.3	0
70	79	1	3.85E+05	0	0	2.7	0
71	80	1	7.55E+05	0	0	3.9	0
72	80	1	5.29E+05	0	0	2.6	0
73	80	1	3.47E+05	0	0	1.7	0
74	80	1	3.47E+05	0	0	1.8	0
75	80	1	3.07E+05	0	0	1.7	0
76	80	1	3.19E+05	0	0	1.7	0
77	0	3	1.00E+08	0	0	0.01	0
78	0	3	1.00E+08	0	0	0.01	0
79	0	3	1.00E+08	0	0	0.01	0
80	0	3	1.00E+08	0	0	0.01	0

```
3    1SNOTIDE1.HYD (hydrodynamic file)               ***********D: FLOWS***
0    0    0    0    0    0    0    0    0
     7    +    *    +    *    +                   ******E: BOUNDARIES***
   1.0       1.0                    (System 1--Ammonia)
1    2
ammonia    starting  ammonia  ending (same for other "system" variables)
(mg/L)       day     (mg/L)    day
  .005        0.      .005    365.0
```

```
  2    2
    .005       0.      .005     365.0
  3    2
    .005       0.      .005     365.0
  4    2
    .005       0.      .005     365.0
  5    2
    .005       0.      .005     365.0
  6    2
    .005       0.      .005     365.0
 76    2
    .005       0.      .005     365.0
       7    +    *    +    *    +                   ******E: BOUNDARIES***
     1.0      1.0                  (System 2--Nitrate)
  1    2
    .196       0.      .196     365.0
  2    2
    .196       0.      .196     365.0
  3    2
    .196       0.      .196     365.0
  4    2
    .196       0.      .196     365.0
  5    2
    .196       0.      .196     365.0
  6    2
    .196       0.      .196     365.0
 76    2
    .179       0.      .179     365.0
       7    +    *    +    *    +                   ******E: BOUNDARIES***
     1.0      1.0                  (System 3--Inorg Phos)
  1    2
    .045       0.      .045     365.0
  2    2
    .045       0.      .045     365.0
  3    2
    .045       0.      .045     365.0
  4    2
    .045       0.      .045     365.0
  5    2
    .045       0.      .045     365.0
  6    2
    .045       0.      .045     365.0
 76    2
    .005       0.      .005     365.0
       7    +    *    +    *    +                   ******E: BOUNDARIES***
     1.0      1.0                  (System 4--Chlorophyll-a)
  1    2
     2.6       0.       2.6     365.0  (chloropyll is in ug/L)
  2    2
     2.6       0.       2.6     365.0
  3    2
     2.6       0.       2.6     365.0
  4    2
     2.6       0.       2.6     365.0
  5    2
     2.6       0.       2.6     365.0
  6    2
     2.6       0.       2.6     365.0
 76    2
     1.6       0.       1.6     365.0
```

```
       7    +    *    +    *    +                ******E: BOUNDARIES***
     1.0      1.0                  (System 5--CBOD)
   1   2
     2.4       0.       2.4     365.0
   2   2
     2.4       0.       2.4     365.0
   3   2
     2.4       0.       2.4     365.0
   4   2
     2.4       0.       2.4     365.0
   5   2
     2.4       0.       2.4     365.0
   6   2
     2.4       0.       2.4     365.0
  76   2
     1.0       0.       1.0     365.0
       7    +    *    +    *    +                ******E: BOUNDARIES***
     1.0      1.0                  (System 6--DO)
   1   2
     8.5       0.       8.5     365.0
   2   2
     8.5       0.       8.5     365.0
   3   2
     8.5       0.       8.5     365.0
   4   2
     8.5       0.       8.5     365.0
   5   2
     8.5       0.       8.5     365.0
   6   2
     8.5       0.       8.5     365.0
  76   2
     9.5       0.       9.5     365.0
       7    +    *    +    *    +                ******E: BOUNDARIES***
     1.0      1.0                  (System 7--Org Nitrogen)
   1   2
    .126       0.      .126     365.0
   2   2
    .126       0.      .126     365.0
   3   2
    .126       0.      .126     365.0
   4   2
    .126       0.      .126     365.0
   5   2
    .126       0.      .126     365.0
   6   2
    .126       0.      .126     365.0
  76   2
    .067       0.      .067     365.0
       7    +    *    +    *    +                ******E: BOUNDARIES***
     1.0      1.0                  (System 8--Org Phos)
   1   2
    .005       0.      .005     365.0
   2   2
    .005       0.      .005     365.0
   3   2
    .005       0.      .005     365.0
   4   2
    .005       0.      .005     365.0
   5   2
    .005       0.      .005     365.0
```

```
 6    2
   .005        0.       .005     365.0
76    2
   .005        0.       .005     365.0
      7    +    *    +    *    +                  ******E: BOUNDARIES***
    1.0       1.0                     (System 9--Salinity)
 1    2
   27.3        0.       27.3     365.0
 2    2
   27.3        0.       27.3     365.0
 3    2
   27.3        0.       27.3     365.0
 4    2
   27.3        0.       27.3     365.0
 5    2
   27.3        0.       27.3     365.0
 6    2
   27.3        0.       27.3     365.0
76    2
    0.0        0.        0.0     365.0
      7    +    *    +             *****F: WASTE LOADS (System 1 - Ammonia)
   1.00    0.4535 (#lbs/day to kilograms/day conversion factor)
71    2                                (Pilchuck River)
 ammonia   starting   ammonia  ending
#lbs/day      day    #lbs/day    day
   3.59       0.0       3.59     365.0
48    2                                (Snohomsih WTP)
   0.72       0.0       0.72     365.0
67    2                                (Lake Stevens WTP)
  141.2       0.0      141.2     365.0
54    2                                (Marysville WTP)
   1.12       0.0       1.12     365.0
37    2                                (Everett Mech WTP)
 1301.8       0.0     1301.8     365.0
36    2                                (Everett Lagoon WTP)
  508.5       0.0      508.5     365.0
59    2                                (Quilceda Creek)
   6.78       0.0       6.78     365.0
      7    +    *    +             *****F: WASTE LOADS (System 2 - Nitrate)
   1.00    0.4535
71    2                                (Pilchuck River)
  172.4       0.0      172.4     365.0
48    2                                (Snohomsih WTP)
   0.11       0.0       0.11     365.0
67    2                                (Lake Stevens WTP)
   1.72       0.0       1.72     365.0
54    2                                (Marysville WTP)
   62.8       0.0       62.8     365.0
37    2                                (Everett Mech WTP)
   4.34       0.0       4.34     365.0
36    2                                (Everett Lagoon WTP)
   30.1       0.0       30.1     365.0
59    2                                (Quilceda Creek)
  279.0       0.0      279.0     365.0
      7    +    *    +             *****F: WASTE LOADS (System 3 - Inorg Phos)
   1.00    0.4535
71    2                                (Pilchuck River)
   3.47       0.0       3.47     365.0
48    2                                (Snohomsih WTP)
   5.97       0.0       5.97     365.0
```

```
67    2                             (Lake Stevens WTP)
  21.9      0.0      21.9   365.0
54    2                             (Marysville WTP)
  75.3      0.0      75.3   365.0
37    2                             (Everett Mech WTP)
 189.2      0.0     189.2   365.0
36    2                             (Everett Lagoon WTP)
 126.5      0.0     126.5   365.0
59    2                             (Quilceda Creek)
  18.8      0.0      18.8   365.0
      7   +   *   +            *****F: WASTE LOADS (System 4 - Chloropyl)
  1.00   0.4535
71    2                             (Pilchuck River)
  36.9      0.0      36.9   365.0
48    2                             (Snohomsih WTP)
   0.0      0.0       0.0   365.0
67    2                             (Lake Stevens WTP)
   0.0      0.0       0.0   365.0
54    2                             (Marysville WTP)
   0.0      0.0       0.0   365.0
37    2                             (Everett Mech WTP)
   0.0      0.0       0.0   365.0
36    2                             (Everett Lagoon WTP)
   0.0      0.0       0.0   365.0
59    2                             (Quilceda Creek)
   0.0      0.0       0.0   365.0
      7   +   *   +            *****F: WASTE LOADS (System 5 - CBOD)
  1.00   0.4535
71    2                             (Pilchuck River)
 486.7      0.0     486.7   365.0
48    2                             (Snohomsih WTP)
 147.9      0.0     147.9   365.0
67    2                             (Lake Stevens WTP)
  70.6      0.0      70.6   365.0
54    2                             (Marysville WTP)
 715.4      0.0     715.4   365.0
37    2                             (Everett Mech WTP)
1182.6      0.0    1182.6   365.0
36    2                             (Everett Lagoon WTP)
2628.0      0.0    2628.0   365.0
59    2                             (Quilceda Creek)
 207.1      0.0     207.1   365.0
      7   +   *   +            *****F: WASTE LOADS (System 6 - DO)
  1.00   0.4535
71    2                             (Pilchuck River)
7022.6      0.0    7022.6   365.0
48    2                             (Snohomsih WTP)
  22.6      0.0      22.6   365.0
67    2                             (Lake Stevens WTP)
  60.5      0.0      60.5   365.0
54    2                             (Marysville WTP)
  95.6      0.0      95.6   365.0
37    2                             (Everett Mech WTP)
 325.3      0.0     325.3   365.0
36    2                             (Everett Lagoon WTP)
 190.2      0.0     190.2   365.0
59    2                             (Quilceda Creek)
2130.6      0.0    2130.6   365.0
      7   +   *   +            *****F: WASTE LOADS (System 7 - Org N)
  1.00   0.4535
```

```
    71     2                                    (Pilchuck River)
      55.6       0.0      55.6     365.0
    48     2                                    (Snohomsih WTP)
      48.0       0.0      48.0     365.0
    67     2                                    (Lake Stevens WTP)
      40.4       0.0      40.4     365.0
    54     2                                    (Marysville WTP)
      80.1       0.0      80.1     365.0
    37     2                                    (Everett Mech WTP)
     217.0       0.0     217.0     365.0
    36     2                                    (Everett Lagoon WTP)
     792.0       0.0     792.0     365.0
    59     2                                    (Quilceda Creek)
      64.8       0.0      64.8     365.0
           7    +    *    +             *****F: WASTE LOADS (System 8 - Org P)
      1.00    0.4535
    71     2                                    (Pilchuck River)
      5.56       0.0      5.56     365.0
    48     2                                    (Snohomsih WTP)
      4.17       0.0      4.17     365.0
    67     2                                    (Lake Stevens WTP)
      2.32       0.0      2.32     365.0
    54     2                                    (Marysville WTP)
      4.30       0.0      4.30     365.0
    37     2                                    (Everett Mech WTP)
      22.2       0.0      22.2     365.0
    36     2                                    (Everett Lagoon WTP)
      9.82       0.0      9.82     365.0
    59     2                                    (Quilceda Creek)
      11.5       0.0      11.5     365.0
           7    +    *    +             *****F: WASTE LOADS (System 9 - Salinity)
      1.00    0.4535
    71     2                                    (Pilchuck River)
           0     0.0         0     365.0
    48     2                                    (Snohomsih WTP)
           0     0.0         0     365.0
    67     2                                    (Lake Stevens WTP)
           0     0.0         0     365.0
    54     2                                    (Marysville WTP)
           0     0.0         0     365.0
    37     2                                    (Everett Mech WTP)
           0     0.0         0     365.0
    36     2                                    (Everett Lagoon WTP)
           0     0.0         0     365.0
    59     2                                    (Quilceda Creek)
           0     0.0         0     365.0
           0    +    *    +    *    +    (System F.2 - NPS loads)
           5    +    *    +    *    +               ******G: PARAMETERS***
SAL        2       1.0 TMPSG    3       1.0 KESG    5      1.0 SOD1D    9      1.0
SODAT     12       1.0

        "1" segment number
             average          temperature     light extinction      sediment oxygen
.............salinity ...................  ........coefficient ...........demand
SAL        2      27.3 TMPSG    3      14.8 KESG    5     0.85 SOD1D    9      0.0
           segment specific
        temperature correction
.............coefficient
SODAT     12      1.08
    2
```

```
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    3
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    4
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    5
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    6
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    7
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    8
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
    9
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
   10
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       0.0
SODAT   12       1.08
   11
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       6.0
SODAT   12       1.08
   12
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       2.0
SODAT   12       1.08
   13
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       5.0
SODAT   12       1.08
   14
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       5.0
SODAT   12       1.08
   15
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       2.0
SODAT   12       1.08
   16
SAL      2      27.3 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       2.0
SODAT   12       1.08
   17
SAL      2      27.3 TMPSG    3      17.5 KESG     5      0.85 SOD1D     9       9.5
SODAT   12       1.08
   18
SAL      2      27.3 TMPSG    3      17.5 KESG     5      0.85 SOD1D     9       6.0
SODAT   12       1.08
   19
SAL      2      26.0 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       6.0
SODAT   12       1.08
   20
SAL      2      26.0 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       6.0
SODAT   12       1.08
   21
SAL      2      26.0 TMPSG    3      14.8 KESG     5      0.85 SOD1D     9       6.0
SODAT   12       1.08
   22
```

SAL	2	26.0	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	6.0
SODAT	12	1.08								
23										
SAL	2	26.0	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	6.0
SODAT	12	1.08								
24										
SAL	2	26.0	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
25										
SAL	2	26.0	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
26										
SAL	2	25.2	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
27										
SAL	2	25.2	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
28										
SAL	2	25.2	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
29										
SAL	2	25.2	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
30										
SAL	2	25.2	TMPSG	3	14.8	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
31										
SAL	2	23.0	TMPSG	3	17.5	KESG	5	0.85 SOD1D	9	8.0
SODAT	12	1.08								
32										
SAL	2	21.1	TMPSG	3	17.5	KESG	5	0.85 SOD1D	9	8.0
SODAT	12	1.08								
33										
SAL	2	21.1	TMPSG	3	17.5	KESG	5	0.85 SOD1D	9	2.0
SODAT	12	1.08								
34										
SAL	2	12.0	TMPSG	3	14.7	KESG	5	0.85 SOD1D	9	9.5
SODAT	12	1.08								
35										
SAL	2	10.2	TMPSG	3	14.7	KESG	5	0.85 SOD1D	9	8.0
SODAT	12	1.08								
36										
SAL	2	8.2	TMPSG	3	14.7	KESG	5	0.85 SOD1D	9	8.0
SODAT	12	1.08								
37										
SAL	2	6.5	TMPSG	3	15.5	KESG	5	0.85 SOD1D	9	5.0
SODAT	12	1.08								
38										
SAL	2	0.0	TMPSG	3	15.9	KESG	5	0.85 SOD1D	9	5.0
SODAT	12	1.08								
39										
SAL	2	0.0	TMPSG	3	15.9	KESG	5	0.85 SOD1D	9	4.0
SODAT	12	1.08								
40										
SAL	2	0.0	TMPSG	3	15.9	KESG	5	0.85 SOD1D	9	0.0
SODAT	12	1.08								
41										
SAL	2	0.0	TMPSG	3	15.9	KESG	5	0.85 SOD1D	9	1.0
SODAT	12	1.08								
42										

SAL	2	0.0	TMPSG	3	15.0	KESG	5	0.85	SOD1D	9	1.0
SODAT	12	1.08									
43											
SAL	2	0.0	TMPSG	3	15.0	KESG	5	0.85	SOD1D	9	1.0
SODAT	12	1.08									
44											
SAL	2	0.0	TMPSG	3	15.0	KESG	5	0.85	SOD1D	9	4.0
SODAT	12	1.08									
45											
SAL	2	0.0	TMPSG	3	15.0	KESG	5	1.51	SOD1D	9	9.0
SODAT	12	1.08									
46											
SAL	2	0.0	TMPSG	3	14.5	KESG	5	1.51	SOD1D	9	9.0
SODAT	12	1.08									
47											
SAL	2	0.0	TMPSG	3	14.5	KESG	5	1.51	SOD1D	9	9.0
SODAT	12	1.08									
48											
SAL	2	0.0	TMPSG	3	14.5	KESG	5	1.51	SOD1D	9	7.0
SODAT	12	1.08									
49											
SAL	2	14.0	TMPSG	3	17.9	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
50											
SAL	2	12.0	TMPSG	3	17.9	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
51											
SAL	2	10.0	TMPSG	3	17.9	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
52											
SAL	2	8.0	TMPSG	3	17.9	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
53											
SAL	2	6.0	TMPSG	3	17.9	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
54											
SAL	2	9.7	TMPSG	3	17.9	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
55											
SAL	2	9.0	TMPSG	3	18.0	KESG	5	0.69	SOD1D	9	6.0
SODAT	12	1.08									
56											
SAL	2	2.0	TMPSG	3	18.0	KESG	5	0.69	SOD1D	9	6.0
SODAT	12	1.08									
57											
SAL	2	1.0	TMPSG	3	16.0	KESG	5	0.69	SOD1D	9	4.0
SODAT	12	1.08									
58											
SAL	2	0.5	TMPSG	3	16.0	KESG	5	0.69	SOD1D	9	0.0
SODAT	12	1.08									
59											
SAL	2	16.0	TMPSG	3	18.4	KESG	5	1.20	SOD1D	9	1.0
SODAT	12	1.08									
60											
SAL	2	13.5	TMPSG	3	18.4	KESG	5	1.20	SOD1D	9	1.0
SODAT	12	1.08									
61											
SAL	2	11.8	TMPSG	3	18.4	KESG	5	1.20	SOD1D	9	7.0
SODAT	12	1.08									
62											

```
SAL       2      6.0 TMPSG    3      18.3 KESG    5     1.20 SOD1D    9     8.0
SODAT    12      1.08
   63
SAL       2      5.5 TMPSG    3      18.2 KESG    5     1.20 SOD1D    9     6.0
SODAT    12      1.08
   64
SAL       2      1.0 TMPSG    3      18.2 KESG    5     1.20 SOD1D    9     3.0
SODAT    12      1.08
   65
SAL       2      1.0 TMPSG    3      17.3 KESG    5     1.10 SOD1D    9     3.0
SODAT    12      1.08
   66
SAL       2      1.0 TMPSG    3      17.3 KESG    5     1.10 SOD1D    9     5.0
SODAT    12      1.08
   67
SAL       2      1.0 TMPSG    3      17.3 KESG    5     1.10 SOD1D    9     3.0
SODAT    12      1.08
   68
SAL       2      0.3 TMPSG    3      17.3 KESG    5     1.10 SOD1D    9     1.0
SODAT    12      1.08
   69
SAL       2      0.0 TMPSG    3      16.5 KESG    5     1.10 SOD1D    9     1.0
SODAT    12      1.08
   70
SAL       2      0.0 TMPSG    3      15.0 KESG    5     1.10 SOD1D    9     1.0
SODAT    12      1.08
   71
SAL       2      0.0 TMPSG    3      14.5 KESG    5     1.51 SOD1D    9     1.0
SODAT    12      1.08
   72
SAL       2      0.0 TMPSG    3      14.5 KESG    5     1.51 SOD1D    9     0.5
SODAT    12      1.08
   73
SAL       2      0.0 TMPSG    3      14.5 KESG    5     1.51 SOD1D    9     0.5
SODAT    12      1.08
   74
SAL       2      0.0 TMPSG    3      14.5 KESG    5     1.51 SOD1D    9     0.5
SODAT    12      1.08
   75
SAL       2      0.0 TMPSG    3      14.5 KESG    5     1.51 SOD1D    9     0.5
SODAT    12      1.08
   76
SAL       2      0.0 TMPSG    3      14.5 KESG    5     1.51 SOD1D    9     0.5
SODAT    12      1.08
   77
SAL       2      0.0 TMPSG    3      14.5 KESG    5     10.0 SOD1D    9     0.0
SODAT    12      1.08
   78
SAL       2      0.0 TMPSG    3      14.5 KESG    5     10.0 SOD1D    9     0.0
SODAT    12      1.08
   79
SAL       2      0.0 TMPSG    3      14.5 KESG    5     10.0 SOD1D    9     0.0
SODAT    12      1.08
   80
SAL       2      0.0 TMPSG    3      14.5 KESG    5     10.0 SOD1D    9     0.0
SODAT    12      1.08
    +    *    +    *    +    *    +                *******H: CONSTANTS***
   GLOBAL            0
AMMONIA-N            1
nitrif               3
```

```
        K12C        11      0.20      K12T        12      1.085
        KNIT        13      2.0
NITRATE-N            1
denitrif             3
        K20C        21      0.09      K20T        22      1.045
        KNO3        23      0.1
O-PO4                0
PHYTO-C              4
growth               2
         K1C        41      1.40       K1T        42      1.066
light                5
       LGHTS        43      1.0      PHIMX        44      720.0
         XKC        45    0.0170      CCHL        46       75.0
         IS1        47     100.
nutrients            4
       KMNG1        48     0.030    KMPG1         49      0.002
        NCRB        58     0.250     PCRB         57      0.025
death                3
        K1RC        50     0.092     K1RT         51      1.045
         K1D        52      0.02
CBOD                 1
deoxygen             2
         KDC        71     0.152       KDT        72      1.047
DO                   1
ratio                1
        OCRB        81      2.67
ORGANIC-N            1
mineralize           3
        K71C        91      0.10      K71T        92      1.047
         FON        95       1.0
ORGANIC-P            1
mineralize           3
        K83C       100      0.10      K83T       101      1.047
         FOP       104       1.0
SALINITY             0
           8         *    +    *    +                    **I: TIME FUNCTIONS***
 ITOT     2    5
      392.         0.0     392.      365.0
    F     2    6
       0.58        0.0     0.58      365.0
 WIND     2    7
        0.0        0.0      0.0      365.0
TFNH4     2   13
        0.0        0.0      0.0      365.0
TFPO4     2   14
        0.0        0.0      0.0      365.0
  ZOO     2   19
        0.0        0.0      0.0      365.0
AIRTM     2   21
       22.0        0.0     22.0      365.0
XICEV     2   22
        1.0        0.0      1.0      365.0
SYSTEM-1 (AMMONIA)                              3  0.0      50.0 ***J: INITIAL CONDS***
segment ammonia         segment ammonia         segment ammonia
number   (mg/L)         number   (mg/L)         number (mg/L)
    1 0.697E-02      1.0    2 0.660E-02      1.0    3 0.597E-02        1.0
    4 0.625E-02      1.0    5 0.676E-02      1.0    6 0.652E-02        1.0
    7 0.130E-01      1.0    8 0.115E-01      1.0    9 0.866E-02        1.0
   10 0.961E-02      1.0   11 0.125E-01      1.0   12 0.104E-01        1.0
   13 0.146E-01      1.0   14 0.145E-01      1.0   15 0.122E-01        1.0
```

16	0.121E-01	1.0	17	0.155E-01	1.0	18	0.140E-01	1.0
19	0.147E-01	1.0	20	0.147E-01	1.0	21	0.168E-01	1.0
22	0.169E-01	1.0	23	0.170E-01	1.0	24	0.187E-01	1.0
25	0.255E-01	1.0	26	0.253E-01	1.0	27	0.314E-01	1.0
28	0.387E-01	1.0	29	0.440E-01	1.0	30	0.679E-01	1.0
31	0.154E-01	1.0	32	0.212E-01	1.0	33	0.155E-01	1.0
34	0.922E-01	1.0	35	0.132E+00	1.0	36	0.107E+00	1.0
37	0.977E-01	1.0	38	0.209E-01	1.0	39	0.197E-01	1.0
40	0.206E-04	1.0	41	0.141E-01	1.0	42	0.659E-02	1.0
43	0.736E-02	1.0	44	0.763E-02	1.0	45	0.784E-02	1.0
46	0.672E-02	1.0	47	0.715E-02	1.0	48	0.669E-02	1.0
49	0.240E-01	1.0	50	0.279E-01	1.0	51	0.300E-01	1.0
52	0.383E-01	1.0	53	0.430E-01	1.0	54	0.306E-01	1.0
55	0.345E-01	1.0	56	0.362E-01	1.0	57	0.372E-01	1.0
58	0.564E-01	1.0	59	0.174E-01	1.0	60	0.181E-01	1.0
61	0.202E-01	1.0	62	0.220E-01	1.0	63	0.281E-01	1.0
64	0.345E-01	1.0	65	0.358E-01	1.0	66	0.365E-01	1.0
67	0.360E-01	1.0	68	0.327E-01	1.0	69	0.814E-02	1.0
70	0.112E-01	1.0	71	0.604E-02	1.0	72	0.576E-02	1.0
73	0.554E-02	1.0	74	0.542E-02	1.0	75	0.518E-02	1.0
76	0.505E-02	1.0	77	0.115E-02	1.0	78	0.115E-02	1.0
79	0.115E-02	1.0	80	0.115E-02	1.0			

SYSTEM-2 (NITRATE) 3 0.0 50.0 ***J: INITIAL CONDS***

1	0.196E+00	1.0	2	0.195E+00	1.0	3	0.195E+00	1.0
4	0.196E+00	1.0	5	0.195E+00	1.0	6	0.194E+00	1.0
7	0.193E+00	1.0	8	0.193E+00	1.0	9	0.195E+00	1.0
10	0.195E+00	1.0	11	0.194E+00	1.0	12	0.193E+00	1.0
13	0.192E+00	1.0	14	0.193E+00	1.0	15	0.193E+00	1.0
16	0.194E+00	1.0	17	0.193E+00	1.0	18	0.191E+00	1.0
19	0.192E+00	1.0	20	0.193E+00	1.0	21	0.191E+00	1.0
22	0.191E+00	1.0	23	0.191E+00	1.0	24	0.193E+00	1.0
25	0.192E+00	1.0	26	0.192E+00	1.0	27	0.192E+00	1.0
28	0.192E+00	1.0	29	0.191E+00	1.0	30	0.192E+00	1.0
31	0.191E+00	1.0	32	0.188E+00	1.0	33	0.191E+00	1.0
34	0.191E+00	1.0	35	0.189E+00	1.0	36	0.188E+00	1.0
37	0.186E+00	1.0	38	0.182E+00	1.0	39	0.180E+00	1.0
40	0.179E+00	1.0	41	0.180E+00	1.0	42	0.180E+00	1.0
43	0.180E+00	1.0	44	0.181E+00	1.0	45	0.181E+00	1.0
46	0.182E+00	1.0	47	0.181E+00	1.0	48	0.181E+00	1.0
49	0.187E+00	1.0	50	0.187E+00	1.0	51	0.185E+00	1.0
52	0.185E+00	1.0	53	0.185E+00	1.0	54	0.188E+00	1.0
55	0.185E+00	1.0	56	0.185E+00	1.0	57	0.184E+00	1.0
58	0.186E+00	1.0	59	0.199E+00	1.0	60	0.194E+00	1.0
61	0.188E+00	1.0	62	0.187E+00	1.0	63	0.184E+00	1.0
64	0.185E+00	1.0	65	0.183E+00	1.0	66	0.183E+00	1.0
67	0.183E+00	1.0	68	0.182E+00	1.0	69	0.180E+00	1.0
70	0.180E+00	1.0	71	0.180E+00	1.0	72	0.177E+00	1.0
73	0.180E+00	1.0	74	0.178E+00	1.0	75	0.180E+00	1.0
76	0.179E+00	1.0	77	0.181E+00	1.0	78	0.181E+00	1.0
79	0.181E+00	1.0	80	0.181E+00	1.0			

SYSTEM-3 (INORGANIC PHOSPHORUS) 3 0.0 50.0 ***J: INITIAL CONDS***

1	0.450E-01	1.0	2	0.449E-01	1.0	3	0.449E-01	1.0
4	0.450E-01	1.0	5	0.449E-01	1.0	6	0.446E-01	1.0
7	0.443E-01	1.0	8	0.444E-01	1.0	9	0.449E-01	1.0
10	0.448E-01	1.0	11	0.444E-01	1.0	12	0.438E-01	1.0
13	0.442E-01	1.0	14	0.441E-01	1.0	15	0.444E-01	1.0
16	0.446E-01	1.0	17	0.442E-01	1.0	18	0.425E-01	1.0
19	0.442E-01	1.0	20	0.442E-01	1.0	21	0.440E-01	1.0
22	0.441E-01	1.0	23	0.441E-01	1.0	24	0.436E-01	1.0
25	0.426E-01	1.0	26	0.424E-01	1.0	27	0.423E-01	1.0

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 28 0.421E-01     1.0   29 0.421E-01     1.0   30 0.427E-01     1.0
 31 0.423E-01     1.0   32 0.396E-01     1.0   33 0.409E-01     1.0
 34 0.419E-01     1.0   35 0.345E-01     1.0   36 0.306E-01     1.0
 37 0.225E-01     1.0   38 0.665E-02     1.0   39 0.667E-02     1.0
 40 0.381E-02     1.0   41 0.652E-02     1.0   42 0.524E-02     1.0
 43 0.542E-02     1.0   44 0.571E-02     1.0   45 0.565E-02     1.0
 46 0.532E-02     1.0   47 0.531E-02     1.0   48 0.529E-02     1.0
 49 0.354E-01     1.0   50 0.314E-01     1.0   51 0.269E-01     1.0
 52 0.206E-01     1.0   53 0.182E-01     1.0   54 0.289E-01     1.0
 55 0.195E-01     1.0   56 0.156E-01     1.0   57 0.138E-01     1.0
 58 0.201E-01     1.0   59 0.386E-01     1.0   60 0.371E-01     1.0
 61 0.319E-01     1.0   62 0.295E-01     1.0   63 0.224E-01     1.0
 64 0.188E-01     1.0   65 0.128E-01     1.0   66 0.125E-01     1.0
 67 0.116E-01     1.0   68 0.890E-02     1.0   69 0.549E-02     1.0
 70 0.584E-02     1.0   71 0.481E-02     1.0   72 0.525E-02     1.0
 73 0.487E-02     1.0   74 0.509E-02     1.0   75 0.499E-02     1.0
 76 0.502E-02     1.0   77 0.500E-02     1.0   78 0.500E-02     1.0
 79 0.500E-02     1.0   80 0.500E-02     1.0
SYSTEM 4 (CHLOROPHYL a)                    3  0.0     50.0 ***J: INITIAL CONDS***
  1        2.60   1.0   2        2.60      1.0   3       2.60     1.0
  4        2.60   1.0   5        2.60      1.0   6       2.60     1.0
  7        2.86   1.0   8        2.80      1.0   9       2.83     1.0
 10        2.77   1.0   11       2.85      1.0   12      2.95     1.0
 13        2.91   1.0   14       2.88      1.0   15      2.83     1.0
 16        2.84   1.0   17       2.88      1.0   18      3.22     1.0
 19        2.92   1.0   20       2.91      1.0   21      3.02     1.0
 22        3.03   1.0   23       3.03      1.0   24      2.94     1.0
 25        3.01   1.0   26       3.01      1.0   27      3.04     1.0
 28        3.06   1.0   29       3.05      1.0   30      2.99     1.0
 31        3.25   1.0   32       3.51      1.0   33      3.71     1.0
 34        2.88   1.0   35       2.45      1.0   36      2.35     1.0
 37        2.16   1.0   38       1.80      1.0   39      1.73     1.0
 40        1.69   1.0   41       1.67      1.0   42      1.63     1.0
 43        1.60   1.0   44       1.60      1.0   45      1.60     1.0
 46        1.60   1.0   47       1.60      1.0   48      1.60     1.0
 49        3.67   1.0   50       3.54      1.0   51      3.47     1.0
 52        3.05   1.0   53       2.61      1.0   54      3.37     1.0
 55        2.98   1.0   56       2.51      1.0   57      2.32     1.0
 58        2.40   1.0   59       4.04      1.0   60      4.24     1.0
 61        4.57   1.0   62       4.36      1.0   63      3.79     1.0
 64        2.89   1.0   65       2.25      1.0   66      2.19     1.0
 67        2.08   1.0   68       1.81      1.0   69      1.73     1.0
 70        1.67   1.0   71       1.60      1.0   72      1.60     1.0
 73        1.60   1.0   74       1.60      1.0   75      1.60     1.0
 76        1.60   1.0   77        1.6      1.0   78       1.6     1.0
 79         1.6   1.0   80        1.6      1.0
SYSTEM-5 (CBOD)                            3  0.0     50.0 ***J: INITIAL CONDS***
  1 2.381E+00     1.0    2 2.383E+00     1.0    3 2.386E+00     1.0
  4 2.387E+00     1.0    5 2.383E+00     1.0    6 2.376E+00     1.0
  7 2.318E+00     1.0    8 2.333E+00     1.0    9 2.359E+00     1.0
 10 2.253E+00     1.0   11 2.339E+00     1.0   12 2.327E+00     1.0
 13 2.208E+00     1.0   14 2.216E+00     1.0   15 2.230E+00     1.0
 16 2.237E+00     1.0   17 2.231E+00     1.0   18 2.288E+00     1.0
 19 2.105E+00     1.0   20 2.107E+00     1.0   21 2.176E+00     1.0
 22 2.176E+00     1.0   23 2.175E+00     1.0   24 2.107E+00     1.0
 25 2.195E+00     1.0   26 2.191E+00     1.0   27 2.195E+00     1.0
 28 2.100E+00     1.0   29 2.104E+00     1.0   30 2.140E+00     1.0
 31 2.186E+00     1.0   32 2.150E+00     1.0   33 2.134E+00     1.0
 34 2.163E+00     1.0   35 2.188E+00     1.0   36 2.185E+00     1.0
 37 1.905E+00     1.0   38 1.880E+00     1.0   39 1.854E+00     1.0
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40 1.878E+00	1.0	41 1.898E+00	1.0	42 1.903E+00	1.0
43 1.911E+00	1.0	44 1.926E+00	1.0	45 1.929E+00	1.0
46 1.935E+00	1.0	47 1.936E+00	1.0	48 1.945E+00	1.0
49 1.816E+00	1.0	50 1.802E+00	1.0	51 1.780E+00	1.0
52 1.787E+00	1.0	53 1.839E+00	1.0	54 1.803E+00	1.0
55 1.764E+00	1.0	56 1.779E+00	1.0	57 1.790E+00	1.0
58 1.861E+00	1.0	59 1.779E+00	1.0	60 1.760E+00	1.0
61 1.707E+00	1.0	62 1.711E+00	1.0	63 1.715E+00	1.0
64 1.768E+00	1.0	65 1.783E+00	1.0	66 1.795E+00	1.0
67 1.805E+00	1.0	68 1.839E+00	1.0	69 1.875E+00	1.0
70 1.891E+00	1.0	71 0.955E+00	1.0	72 0.994E+00	1.0
73 0.969E+00	1.0	74 0.996E+00	1.0	75 0.993E+00	1.0
76 0.100E+01	1.0	77 0.995E+00	1.0	78 0.995E+00	1.0
79 0.995E+00	1.0	80 0.995E+00	1.0		

SYSTEM-6 (DO) 3 0.0 50.0 ***J: INITIAL CONDS***

1 0.848E+01	1.0	2 0.848E+01	1.0	3 0.848E+01	1.0
4 0.850E+01	1.0	5 0.847E+01	1.0	6 0.840E+01	1.0
7 0.830E+01	1.0	8 0.836E+01	1.0	9 0.847E+01	1.0
10 0.843E+01	1.0	11 0.831E+01	1.0	12 0.815E+01	1.0
13 0.822E+01	1.0	14 0.824E+01	1.0	15 0.833E+01	1.0
16 0.835E+01	1.0	17 0.822E+01	1.0	18 0.783E+01	1.0
19 0.820E+01	1.0	20 0.821E+01	1.0	21 0.805E+01	1.0
22 0.805E+01	1.0	23 0.805E+01	1.0	24 0.813E+01	1.0
25 0.795E+01	1.0	26 0.792E+01	1.0	27 0.786E+01	1.0
28 0.781E+01	1.0	29 0.778E+01	1.0	30 0.782E+01	1.0
31 0.781E+01	1.0	32 0.747E+01	1.0	33 0.750E+01	1.0
34 0.789E+01	1.0	35 0.831E+01	1.0	36 0.847E+01	1.0
37 0.872E+01	1.0	38 0.910E+01	1.0	39 0.912E+01	1.0
40 0.916E+01	1.0	41 0.919E+01	1.0	42 0.921E+01	1.0
43 0.927E+01	1.0	44 0.935E+01	1.0	45 0.941E+01	1.0
46 0.947E+01	1.0	47 0.945E+01	1.0	48 0.948E+01	1.0
49 0.749E+01	1.0	50 0.755E+01	1.0	51 0.766E+01	1.0
52 0.797E+01	1.0	53 0.843E+01	1.0	54 0.764E+01	1.0
55 0.792E+01	1.0	56 0.826E+01	1.0	57 0.847E+01	1.0
58 0.861E+01	1.0	59 0.710E+01	1.0	60 0.700E+01	1.0
61 0.682E+01	1.0	62 0.696E+01	1.0	63 0.734E+01	1.0
64 0.801E+01	1.0	65 0.849E+01	1.0	66 0.857E+01	1.0
67 0.868E+01	1.0	68 0.900E+01	1.0	69 0.919E+01	1.0
70 0.923E+01	1.0	71 0.953E+01	1.0	72 0.950E+01	1.0
73 0.954E+01	1.0	74 0.952E+01	1.0	75 0.954E+01	1.0
76 0.950E+01	1.0	77 0.948E+01	1.0	78 0.948E+01	1.0
79 0.948E+01	1.0	80 0.948E+01	1.0		

SYSTEM-7 (ORGANIC NITROGEN) 3 0.0 50.0 ***J: INITIAL CONDS***

1 0.125E+00	1.0	2 0.125E+00	1.0	3 0.125E+00	1.0
4 0.125E+00	1.0	5 0.125E+00	1.0	6 0.124E+00	1.0
7 0.120E+00	1.0	8 0.121E+00	1.0	9 0.123E+00	1.0
10 0.123E+00	1.0	11 0.122E+00	1.0	12 0.120E+00	1.0
13 0.120E+00	1.0	14 0.120E+00	1.0	15 0.121E+00	1.0
16 0.122E+00	1.0	17 0.122E+00	1.0	18 0.117E+00	1.0
19 0.120E+00	1.0	20 0.120E+00	1.0	21 0.118E+00	1.0
22 0.118E+00	1.0	23 0.118E+00	1.0	24 0.120E+00	1.0
25 0.119E+00	1.0	26 0.118E+00	1.0	27 0.120E+00	1.0
28 0.122E+00	1.0	29 0.123E+00	1.0	30 0.130E+00	1.0
31 0.117E+00	1.0	32 0.112E+00	1.0	33 0.114E+00	1.0
34 0.133E+00	1.0	35 0.126E+00	1.0	36 0.121E+00	1.0
37 0.891E-01	1.0	38 0.737E-01	1.0	39 0.590E-01	1.0
40 0.653E-01	1.0	41 0.658E-01	1.0	42 0.666E-01	1.0
43 0.666E-01	1.0	44 0.687E-01	1.0	45 0.686E-01	1.0
46 0.673E-01	1.0	47 0.666E-01	1.0	48 0.671E-01	1.0
49 0.103E+00	1.0	50 0.960E-01	1.0	51 0.918E-01	1.0

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   52 0.857E-01       1.0   53 0.880E-01       1.0   54 0.918E-01       1.0
   55 0.796E-01       1.0   56 0.744E-01       1.0   57 0.729E-01       1.0
   58 0.896E-01       1.0   59 0.111E+00       1.0   60 0.108E+00       1.0
   61 0.995E-01       1.0   62 0.956E-01       1.0   63 0.839E-01       1.0
   64 0.785E-01       1.0   65 0.708E-01       1.0   66 0.712E-01       1.0
   67 0.705E-01       1.0   68 0.684E-01       1.0   69 0.642E-01       1.0
   70 0.659E-01       1.0   71 0.640E-01       1.0   72 0.675E-01       1.0
   73 0.654E-01       1.0   74 0.668E-01       1.0   75 0.668E-01       1.0
   76 0.670E-01       1.0   77 0.620E-01       1.0   78 0.620E-01       1.0
   79 0.620E-01       1.0   80 0.620E-01       1.0
SYSTEM-8 (ORGANIC PHOSPHORUS)                  3  0.0     50.0 ***J: INITIAL CONDS***
    1 0.498E-02       1.0    2 0.498E-02       1.0    3 0.497E-02       1.0
    4 0.499E-02       1.0    5 0.498E-02       1.0    6 0.497E-02       1.0
    7 0.491E-02       1.0    8 0.492E-02       1.0    9 0.495E-02       1.0
   10 0.495E-02       1.0   11 0.497E-02       1.0   12 0.498E-02       1.0
   13 0.491E-02       1.0   14 0.493E-02       1.0   15 0.493E-02       1.0
   16 0.495E-02       1.0   17 0.499E-02       1.0   18 0.503E-02       1.0
   19 0.491E-02       1.0   20 0.491E-02       1.0   21 0.487E-02       1.0
   22 0.488E-02       1.0   23 0.488E-02       1.0   24 0.497E-02       1.0
   25 0.504E-02       1.0   26 0.502E-02       1.0   27 0.512E-02       1.0
   28 0.522E-02       1.0   29 0.529E-02       1.0   30 0.568E-02       1.0
   31 0.506E-02       1.0   32 0.512E-02       1.0   33 0.531E-02       1.0
   34 0.605E-02       1.0   35 0.667E-02       1.0   36 0.634E-02       1.0
   37 0.618E-02       1.0   38 0.504E-02       1.0   39 0.505E-02       1.0
   40 0.475E-02       1.0   41 0.509E-02       1.0   42 0.501E-02       1.0
   43 0.512E-02       1.0   44 0.527E-02       1.0   45 0.527E-02       1.0
   46 0.516E-02       1.0   47 0.508E-02       1.0   48 0.511E-02       1.0
   49 0.524E-02       1.0   50 0.530E-02       1.0   51 0.513E-02       1.0
   52 0.516E-02       1.0   53 0.525E-02       1.0   54 0.536E-02       1.0
   55 0.514E-02       1.0   56 0.513E-02       1.0   57 0.514E-02       1.0
   58 0.549E-02       1.0   59 0.594E-02       1.0   60 0.583E-02       1.0
   61 0.583E-02       1.0   62 0.568E-02       1.0   63 0.536E-02       1.0
   64 0.516E-02       1.0   65 0.509E-02       1.0   66 0.513E-02       1.0
   67 0.514E-02       1.0   68 0.517E-02       1.0   69 0.492E-02       1.0
   70 0.502E-02       1.0   71 0.481E-02       1.0   72 0.500E-02       1.0
   73 0.492E-02       1.0   74 0.496E-02       1.0   75 0.500E-02       1.0
   76 0.499E-02       1.0   77 0.500E-02       1.0   78 0.500E-02       1.0
   79 0.500E-02       1.0   80 0.500E-02       1.0
SYSTEM-9 (SALINITY)                            3  0.0     50.0 ***J: INITIAL CONDS***
    1 0.273E+02       1.0    2 0.273E+02       1.0    3 0.273E+02       1.0
    4 0.273E+02       1.0    5 0.273E+02       1.0    6 0.273E+02       1.0
    7 0.273E+02       1.0    8 0.273E+02       1.0    9 0.273E+02       1.0
   10 0.235E+02       1.0   11 0.273E+02       1.0   12 0.273E+02       1.0
   13 0.264E+02       1.0   14 0.263E+02       1.0   15 0.265E+02       1.0
   16 0.265E+02       1.0   17 0.261E+02       1.0   18 0.251E+02       1.0
   19 0.265E+02       1.0   20 0.265E+02       1.0   21 0.263E+02       1.0
   22 0.264E+02       1.0   23 0.264E+02       1.0   24 0.256E+02       1.0
   25 0.242E+02       1.0   26 0.241E+02       1.0   27 0.233E+02       1.0
   28 0.224E+02       1.0   29 0.217E+02       1.0   30 0.193E+02       1.0
   31 0.247E+02       1.0   32 0.215E+02       1.0   33 0.238E+02       1.0
   34 0.161E+02       1.0   35 0.705E+01       1.0   36 0.669E+01       1.0
   37 0.316E+01       1.0   38 0.100E-24       1.0   39 0.366E+00       1.0
   40 0.100E-24       1.0   41 0.673E-01       1.0   42 0.188E-01       1.0
   43 0.100E-24       1.0   44 0.409E-05       1.0   45 0.640E-05       1.0
   46 0.426E-05       1.0   47 0.162E-05       1.0   48 0.169E-05       1.0
   49 0.168E+02       1.0   50 0.128E+02       1.0   51 0.114E+02       1.0
   52 0.637E+01       1.0   53 0.484E+01       1.0   54 0.992E+01       1.0
   55 0.555E+01       1.0   56 0.272E+01       1.0   57 0.197E+01       1.0
   58 0.481E+01       1.0   59 0.215E+02       1.0   60 0.206E+02       1.0
   61 0.167E+02       1.0   62 0.147E+02       1.0   63 0.860E+01       1.0
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64	0.481E+01	1.0	65	0.150E+01	1.0	66	0.132E+01	1.0
67	0.920E+00	1.0	68	0.100E-24	1.0	69	0.123E+00	1.0
70	0.132E-01	1.0	71	0.100E-24	1.0	72	0.100E-24	1.0
73	0.100E-24	1.0	74	0.100E-24	1.0	75	0.100E-24	1.0
76	0.100E-24	1.0	77	0.100E-23	1.0	78	0.100E-23	1.0
79	0.100E-23	1.0	80	0.100E-23	1.0			

Appendix E
Estimate of WWTP Discharge on Dissolved Oxygen

Appendix E.1. Oxygen demand caused by Monroe WWTP based on critical conditions.

Streeter-Phelps analysis of critical dissolved oxygen sag.

Lotus File DOSAG2.WK1 Revised 19-Oct-93

INPUT

1. EFFLUENT CHARACTERISTICS	
Discharge (cfs):	1.19
CBOD5 (mg/L):	45
NBOD (mg/L):	151
Dissolved Oxygen (mg/L):	6
Temperature (deg C):	18.4
2. RECEIVING WATER CHARACTERISTICS	
Upstream Discharge (cfs):	653
Upstream CBOD5 (mg/L):	0.0
Upstream NBOD (mg/L):	0
Upstream Dissolved Oxygen (mg/L):	9.377
Upstream Temperature (deg C):	18.4
Elevation (ft NGVD):	40
Downstream Average Channel Slope (ft/ft):	0.0008
Downstream Average Channel Depth (ft):	2.16
Downstream Average Channel Velocity (fps):	1.15
3. REAERATION RATE (Base e) AT 20 deg C (day^-1):	4.38

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Values
Churchill	1.5 - 6	2 - 50	3.66
O'Connor and Dobbins	.1 - 1.5	2 - 50	4.38
Owens	.1 - 6	1 - 2	5.71
Tsivoglou-Wallace	.1 - 6	.1 - 2	3.81

4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1): 0.43

Reference	Suggested Value
Wright and McDonnell, 1979	0.43

OUTPUT

1. INITIAL MIXED RIVER CONDITION	
CBOD5 (mg/L):	0.1
NBOD (mg/L):	0.3
Dissolved Oxygen (mg/L):	9.4
Temperature (deg C):	18.4
2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)	
Reaeration (day^-1):	4.22
BOD Decay (day^-1):	0.40
3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU	
Initial Mixed CBODU (mg/L):	0.1
Initial Mixed Total BODU (CBODU + NBOD, mg/L):	0.4
4. INITIAL DISSOLVED OXYGEN DEFICIT	
Saturation Dissolved Oxygen (mg/L):	9.377
Initial Deficit (mg/L):	0.01
5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days):	0.58
6. DISTANCE TO CRITICAL DO CONCENTRATION (miles):	10.89
7. CRITICAL DO DEFICIT (mg/L):	**0.03**
8. CRITICAL DO CONCENTRATION (mg/L):	9.35

Appendix E.2. Oxygen demand caused by Sultan WWTP based on critical conditions.

Streeter-Phelps analysis of critical dissolved oxygen sag.

Lotus File DOSAG2.WK1 Revised 19-Oct-93

INPUT

1. EFFLUENT CHARACTERISTICS

Discharge (cfs):	0.47
CBOD5 (mg/L):	45
NBOD (mg/L):	123
Dissolved Oxygen (mg/L):	6
Temperature (deg C):	18.4

2. RECEIVING WATER CHARACTERISTICS

Upstream Discharge (cfs):	530
Upstream CBOD5 (mg/L):	0.0
Upstream NBOD (mg/L):	0
Upstream Dissolved Oxygen (mg/L):	9.36
Upstream Temperature (deg C):	18.4
Elevation (ft NGVD):	90
Downstream Average Channel Slope (ft/ft):	0.001
Downstream Average Channel Depth (ft):	2.41
Downstream Average Channel Velocity (fps):	1.15

3. REAERATION RATE (Base e) AT 20 deg C (day^-1): 3.71

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Values
Churchill	1.5 - 6	2 - 50	3.05
O'Connor and Dobbins	.1 - 1.5	2 - 50	3.71
Owens	.1 - 6	1 - 2	4.66
Tsivoglou-Wallace	.1 - 6	.1 - 2	4.77

4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1): 0.46

Reference	Suggested Value
Wright and McDonnell, 1979	0.48

OUTPUT

1. INITIAL MIXED RIVER CONDITION

CBOD5 (mg/L):	0.0
NBOD (mg/L):	0.1
Dissolved Oxygen (mg/L):	9.4
Temperature (deg C):	18.4

2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)

Reaeration (day^-1):	3.57
BOD Decay (day^-1):	0.43

3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU

Initial Mixed CBODU (mg/L):	0.1
Initial Mixed Total BODU (CBODU + NBOD, mg/L):	0.2

4. INITIAL DISSOLVED OXYGEN DEFICIT

Saturation Dissolved Oxygen (mg/L):	9.360
Initial Deficit (mg/L):	0.00

5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days): 0.63

6. DISTANCE TO CRITICAL DO CONCENTRATION (miles): 11.91

7. CRITICAL DO DEFICIT (mg/L): 0.02

8. CRITICAL DO CONCENTRATION (mg/L): 9.34