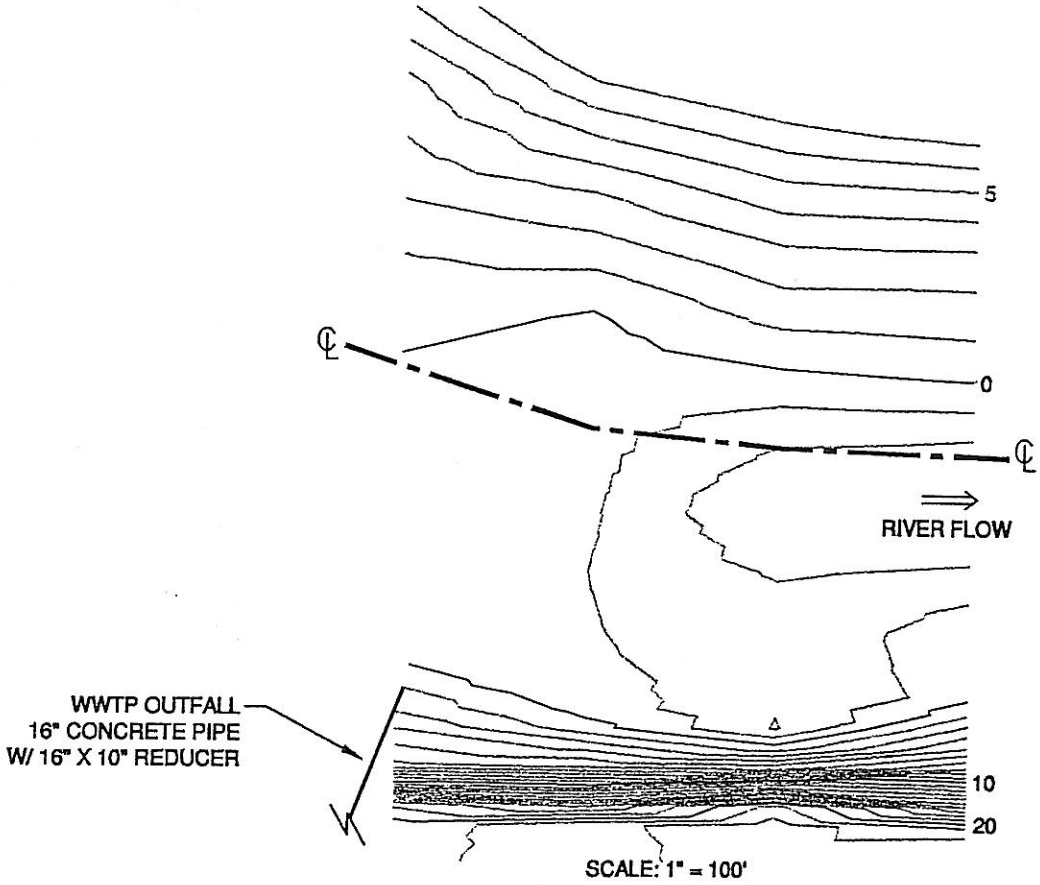
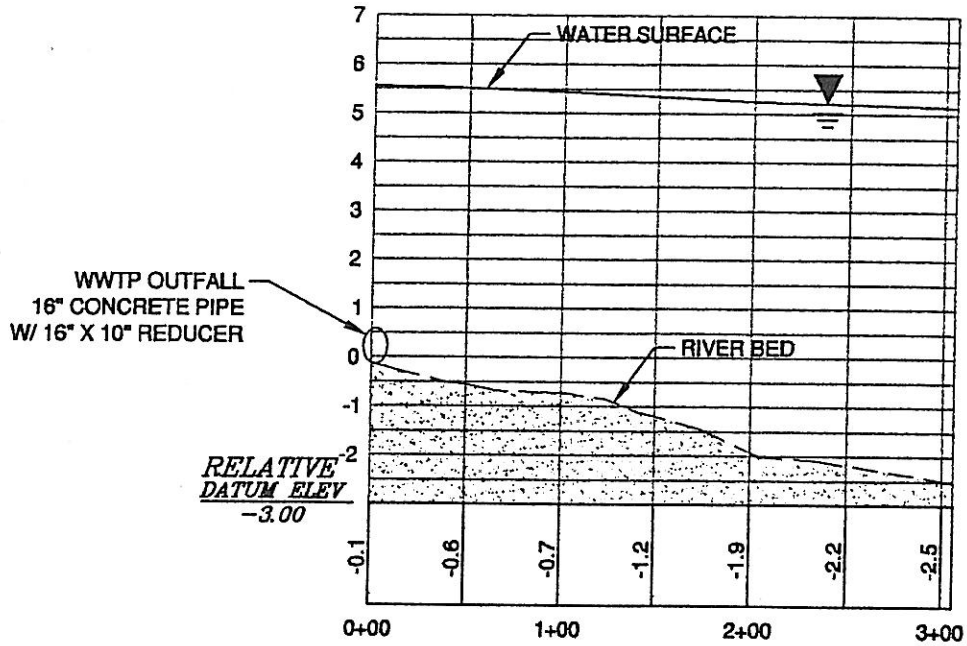



**Lewis River Plan View Bathymetric Map**
**(River Bed Elevations in Feet)**
**Figure III-5a**




NOTE:
SURVEYED 10/24/91 BY GIBBS & OLSON.
RIVER FLOW WAS 2,880 CUBIC FEET PER SECOND.

**Lewis River Bed Elevation (ft.) & Water Surface Elevation (ft.)**
**at River Centerline**
**Figure III-5b**

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**CITY OF WOODLAND GENERAL SEWER PLAN**
**LEWIS RIVER ELEVATIONS PLAN & PROFILE**
**FIGURES III-5a & III-5b**

Many factors, in addition to stream flow, impact the potential to meet Water Quality Standards in a river. These factors include, but are not limited to, temperature, pH, hardness, ambient stream conditions, and the presence or absence of salmonids. DOE has collected limited ambient Lewis River data during the years 1991, and 1992 (see Appendix B). A summary of effluent and critical river flow conditions that will be used in this report to evaluate the reasonable potential to exceed Water Quality Standards is shown in Table III-1. DOE mixing zone analysis guidelines recommend the use of peak daily concentrations for priority pollutants (such as ammonia, and chlorine), and 90$^{th}$ percentile (or monthly average) for all other pollutants/water quality parameters. For existing WWTP flow DOE recommends using the average dry weather flow for plants operating below 85% of its dry weather design flow. The Woodland WWTP currently operates at about 75% of it's design flow of 0.48 MGD. The future WWTP flows are determined in Section V.

**Table III-1. Lewis River and WWTP Critical Conditions Evaluation Data.**

| Parameter | Lewis River | Water Quality Analysis Case Scenarios | | | |
|---|---|---|---|---|---|
| | | Existing | Future Phase I SBC (2009) | Future Phase II SBC (2023) | Future Max. SBR Decant Rate |
| Flow | 789 cfs | 0.460 MGD (0.712 cfs) | 0.79 MGD (1.22 cfs) | 1.57 MGD (2.43 cfs) | 4.8 MGD (7.43 cfs) |
| River Velocity | 1.01 fps | -- | -- | -- | -- |
| River Width | 281 ft | -- | -- | -- | -- |
| Depth (at Diffuser) | 2.9 ft | -- | -- | -- | -- |
| Slope (at Diffuser) | 0.0005 ft/ft | -- | -- | -- | -- |
| Chlorine Residual | 0 mg/L* | 1.2 mg/L | 1.2 mg/L | 1.2 mg/L | 1.2 mg/L |
| Ammonia-N | 0.02 mg/L | 10 mg/L | 10 mg/L | 10 mg/L | 10 mg/L |
| Temperature | 14.2 °C | 22.8 °C | -- | -- | -- |
| pH | 7.5 | 7.0 | 7.0 | 7.0 | 7.0 |
| Alkalinity | 22 mg/L | 150 mg/L* | 150 mg/L* | 150 mg/L* | 150 mg/L* |
| Dissolved Oxygen | 9.9 mg/L | 4.2 mg/L | 4.2 mg/L | 4.2 mg/L | 4.2 mg/L |
| BOD | 1.5 mg/L* | 19 mg/L | 19 mg/L | 19 mg/L | 19 mg/L |
| NBOD | 0.06 mg/L** | 38.7 mg/L** | 38.7 mg/L** | 38.7 mg/L** | 38.7 mg/L** |

Notes: * Values are estimated, no data for the parameter exists.
** NBOD is calculated by 4.57*$NH_3$ ($NO_2$and $NO_3$ assumed negligible).

For water quality analysis, the potential impacts of constructing WWTP improvements need to be considered. The main alternatives which will be evaluated in Section VII consist of providing additional capacity to the WWTP by installing additional Submerged Biological Contactors (SBCs), or constructing a Sequenching Batch Reactor (SBR) treatment system. In order to provide wastewater treatment services through the year 2023, the City desires to implement improvements in two phases. The first phase will be planned through the year 2009, and the second phase through 2023. Since the alternative for adding additional SBCs can be accomplished modularly, there are two different WWTP flowrates to consider. WWTP flows were taken to be the 99$^{th}$ percentile dry season flows from WWTP data from July 1996 through June 1998. The SBR option would entail constructing two SBR basins sized to handle, at the least, Phase I flows and loadings. A third basin will be constructed to meet the flow and loading capacity requirements for Phase II. This means that, for the SBR alternative, the maximum decant rate of the system proposed would have to be analyzed since the SBR system does not decant on a continual basis. The results of the analysis for the SBR alternative would enable us to determine whether or not an effluent equalization storage tank would be required to lower the discharge impacts of the high decant rate of the SBR alternative.

## DILUTION MODEL

Several DOE and EPA models and spreadsheets have been developed to help evaluate the water quality dilution effects of a wastewater discharge into a receiving stream. The computer model 3PLUMESa (developed by Center of Exposure Assessment Modeling (CEAM), documented in EPA no. 600/R-93/139) has a provision for use with outfall discharge conditions which meet the definition for Very Shallow Waters (VSW). VSW is defined by EPA as a river depth, at the point of discharge, that is "less than three plume diameters deep." The 3PLUMESa model calculates the near-field and far-field plume characteristics, under VSW conditions, by using the reflection method described in the Workbook of Atmospheric Dispersion Estimates (USEPA No. AP-26, 1970). Results from the model output were interpolated to obtain plume characteristics under critical river flow for existing and future conditions. The model results are provided in Appendix B. Although EPA has not officially accepted the VSW method of modeling plume characteristics, DOE recommends the use of

VSW in Appendix 6.2 of the Permit Writer's Manual by Washington State Department of Ecology (DOE pub. no. 92-109).

The outfall from the WWTP is a single port 16" x 10" pipe reducer embedded in a concrete footing. The invert of the outfall is flush with the river bottom. For the SBR alternative, the removal of the existing outfall reducer was studied in order to maximize effluent conveyance efficiency and to ensure that the mixing zones will be maximized in accordance with the Water Quality Standards.

## ESTIMATING THE CHRONIC MIXING ZONE SIZE

Dilution factors based on allowable flows that can be used for establishing a chronic mixing zone are calculated for the WWTP flow and the river during critical low flow conditions. WAC 173-201A-100(7) requires that the chronic mixing zone be based on the most limiting of:

- A plume volume of no more than 25% of the critical river flow.
- A plume length of no more than 300 ft plus the depth of the outfall.
- A plume width of no more than 25% of the river width.

The chronic dilution factors, using 25% of the stream flow as allowed in WAC 173-201A-100(7), are calculated below:

Chronic Dilution Factor = $(Q_{WWTP} + 0.25*Q_{7Q10})/Q_{WWTP}$

Existing Conditions: (0.712 cfs + 0.25*789 cfs)/0.712 cfs = 278.0

Future Conditions Phase I SBC (2009): (1.21 cfs + 0.25*789 cfs)/1.21 cfs = 164.0

Future Conditions Phase II SBC (2023): (2.43 cfs + 0.25*789 cfs)/2.43 cfs = 82.2

Future Conditions Max. SBR Decant Rate: (7.43 cfs + 0.25*789 cfs)/7.43 cfs = 27.5

The dilution factors based on plume modeling, by using the maximum plume length (300 ft) or maximum allowable stream width during the $7Q_{10}$ river flow (25% of the stream width), are

determined through the use of the 3PLUMESa model (as mentioned above). The chronic dilution factors, calculated using the 3PLUMESa model, is 157.1 during existing conditions with a plume diameter of 39.4 feet, 300 feet downstream of the outfall; 117.0 for future Phase I SBC conditions with a plume width of 49.5 feet, 300 feet downstream of the outfall; 73.5 for future Phase II SBC conditions with a plume width of 66.3 feet, 300 feet downstream of the outfall; and 30.9 for future maximum SBR decant rate conditions with a plume width of 70.3 feet, 237.3 feet downstream of the outfall.

The chronic mixing zone dilution factors that are most stringent which will be used for water quality analysis will be: **157.1 for existing conditions (plume length restricted), 117.0 for future Phase I SBC conditions (plume length restricted), 73.5 for future Phase II SBC conditions (plume length restricted), and 27.5 for the future maximum SBR decant rate (plume volume restricted).**

## ESTIMATING THE ACUTE MIXING ZONE SIZE

The determination of the acute mixing zone follows a similar exercise as above except that the allowable plume volume is limited to 2.5% of the critical river flow, and the allowable plume length is limited to 10% of the chronic plume length.

The percent of critical stream flow at the edge of the acute mixing zone boundary is 2.5%. The acute dilution factors, using 2.5% of the critical stream flow, are:

Acute Dilution Factor = $(Q_{WWTP} + 0.025*Q_{7Q10})/Q_{WWTP}$

Existing Conditions: (0.712 cfs + 0.025*789 cfs)/0.712 cfs = 28.7

Future Conditions Phase I SBC (2009): (1.21 cfs + 0.025*789 cfs)/1.21 cfs = 17.3

Future Conditions Phase II SBC (2023): (2.43 cfs + 0.025*789 cfs)/2.43 cfs = 9.1

Future Conditions Max. SBR Decant Rate: (7.43 cfs + 0.025*789 cfs)/7.43 cfs = 3.7

The dilution factors based on the 3PLUMESa model output are as follows: 13.1 (existing) with a plume width of 4.9 feet, 30 feet downstream of the outfall; 10.4 (future Phase I SBC) with a

plume width of 5.2 feet, 30 feet downstream of the outfall; 9.4 (future Phase II SBC) with a plume width of 7.2 feet, 30 feet downstream of the outfall; and 5.2 (future max. SBR decant rate) with a plume width of 8.3 feet, 23.7 feet downstream of the outfall.

The most conservative dilution factors in the acute mixing zone that will be used in this report for water quality analysis will be: **13.1 (plume length restricted) for existing conditions; 10.4 (plume length restricted) for future Phase I SBC conditions; 9.1 (plume volume restricted) for future Phase II SBC conditions; and 3.7 (plume volume restricted) for future max. SBR decant rate conditions**.

The maximum allowable stream width at $7Q_{10}$ river-flow conditions is 70.3 feet based on existing river morphology and characteristics. The maximum modeled chronic zone plume width at existing conditions is 39.4 feet, 66.3 feet at future Phase II SBC conditions, and 70.3 feet at future maximum SBR decant rate conditions based on output from the 3PLUMESa model. Based on these analyses of future WWTP flows, the chronic mixing zone becomes restricted by plume volume once the discharge rate exceeds about 3.8 MGD, and the acute mixing zone becomes restricted by plume volume once the discharge exceeds about 1.5 MGD. Should the City find the need for higher dilution factors before the WWTP is plume volume restricted, a larger outfall and/or a diffuser may be installed to maximize dilution. Once the plume is volume restricted, an enhanced/optimized outfall is of no advantage due to compliance with Chapter 173-201A WAC.

## REASONABLE POTENTIAL TO EXCEED WATER QUALITY CRITERIA

After determining the dilution factors, the next step is to determine the Water Quality Criteria for those pollutants of interest. For municipal WWTP's like Woodland's, DOE is focusing their interest on chlorine and ammonia. WAC 173-201A-040 lists the methodology to determine Water Quality Criteria. Formulas listed in the WAC were revised, by DOE, on November 18, 1997. Table III-2 provides the revised Water Quality Criteria provided in the WAC, the calculated Water Quality Criteria at the edge of the mixing zones, and shows if

there is a "reasonable potential to exceed" those criteria based upon the information from Table III-1.

**Table III-2. Water Quality Criteria and Reasonable Potential to Exceed in Lewis River for Selected Parameters.**

| | Water Quality Criteria (ppb) | | Modeled Concentration at Edge of Mixing Zone (ppb) | | Reasonable Potential to Exceed? |
|---|---|---|---|---|---|
| | Acute | Chronic | Acute | Chronic | |
| Ammonia | | | | | |
| Existing | 10818 | 2130 | 1992 | 184 | N |
| Future (Phase I SBC 2009) | 10818 | 2130 | 2504 | 241 | N |
| Future (Phase II SBC 2023) | 10818 | 2130 | 2859 | 371 | N |
| Future (Max. SBR Decant Rate) | 10818 | 2130 | 7002 | 959 | N |
| Chlorine | | | | | |
| Existing | 19 | 11 | 53 | 4 | Y |
| Future (Phase I SBC 2009) | 19 | 11 | 66 | 6 | Y |
| Future (Phase II SBC 2023) | 19 | 11 | 76 | 9 | Y |
| Future (Max. SBR Decant Rate) | 19 | 11 | 186 | 25 | Y |

To determine if the discharge has a reasonable potential to exceed the acute and chronic criteria, the method specified in the document titled *Technical Support Document for Water Quality-Based Toxics Control* (EPA/505/2-90-001, PB91-127415, March 1991) is used. The Technical Support Document specifies a statistical procedure to determine if a discharge has the potential to exceed Water Quality Standards. The procedure is based on the dilution factors previously calculated above, the maximum concentration of a pollutant, the number of samples represented by the maximum concentration, and the ambient concentration of the pollutant in the stream. A multiplier and coefficient of variability, which are essentially "safety factors" dependent upon the variability of the data and number of samples, are then used to calculate the "reasonable potential to exceed" Water Quality Criteria. If a "reasonable potential to exceed" exists, the delegating agency (DOE) must issue limitations upon the discharger to ensure criteria are met.

Two parameters of concern in most WWTP's are ammonia and chlorine. At Woodland, Water Quality Criteria for ammonia is not exceeded under either the alternative to expand WWTP capacity with additional SBC units nor with the SBR option. However, chlorine possesses the potential to exceed Water Quality Criteria in the acute mixing zone for both existing and future conditions under both alternatives being evaluated. The City should undertake a pilot study to test for the efficiency of Ultra-Violet (UV) disinfection if the alternative to expand the WWTP with additional SBC's is selected. This is due to concerns that the SBC treatment system is unable to provide the adequate solids removal required for effective UV disinfection. If the pilot test proves that UV disinfection is effective, then it is recommended that the City replace the existing chlorination disinfection system with UV disinfection units. This will eliminate the discharge of chlorine into the river and thereby allow the WWTP to meet Water Quality Standards for chlorine. If UV does not work, then a de-chlorination system will be required to remove the chlorine residual in the WWTP effluent. Under the SBR alternative, a UV disinfection system is recommended to be installed as part of the Phase I WWTP expansion.

Based on limited data, the existing concentration of ammonia entering the plant is about 30 mg/L and the existing concentration of ammonia leaving the plant is about 8.45 mg/L during the dry season. Design parameters for the SBR system requires that effluent ammonia concentration to be less than 10 mg/L. Due to the sensitivity of ammonia concentration with pH, a worst-case receiving water pH scenario was conducted. Table III-1 shows the maximum pH (7.4) during the critical season which is assumed to occur from July through October. Using DOE's ambient water quality data (Appendix B), the highest pH that was found throughout the entire year was 7.5.

There was no reasonable potential to exceed Water Quality Standards for ammonia using this pH; and the greatest ammonia concentration that could be discharged in the WWTP effluent using future flows are 38.0 mg/L for Phase II SBC flow conditions, and 15.5 mg/L under maximum SBR decant rate conditions before a reasonable potential to exceed exists. Although ammonia does not appear to cause a water quality problem, it can become a problem should a high ammonia discharger become a sewer customer, or in the future past the planning horizon

of this report. As a result of the water quality analysis for ammonia, it does not seem likely that nitrification will be required as part of the WWTP upgrade through year 2023 planning conditions.

## CLASS A WATER QUALITY STANDARDS

Pollutants in an effluent may affect the aquatic environment near the point of discharge (near-field) or at a considerable distance from the point of discharge (far-field). Toxic pollutants are, for the most part, near-field pollutants – their adverse effects diminish rapidly with mixing in the receiving water and thus a mixing zone is allowed. Conversely, a pollutant such as BOD is a far-field pollutant whose adverse affect occurs away from the discharge even after dilution has occurred. In addition to evaluating compliance with the toxic substances criteria, compliance with Class A Water Quality Standards specified in WAC173-201A-030 must also be evaluated.

Evaluations of pH, temperature, and a DO sag curve down the stretch of the river, show no violations of Class A surface water quality due to WWTP discharge (please refer to Appendix B for calculation spreadsheets).

## CONCLUSIONS

This water quality evaluation indicates there is a potential to exceed the Water Quality Standards for chlorine residual under existing and future conditions. It is recommended that a UV disinfection system be pilot-tested for its effectiveness to disinfect Submerged Biological Contactor effluent if the SBC alternative is selected to provide future WWTP capacity. Should the pilot study show that UV disinfection does not provide effective disinfection with the SBC alternative, then the City will need to install a de-chlorination system to remove residual chlorine from the WWTP effluent. If the Sequenching Batch Reactor wastewater treatment alternative is selected, a pilot study is not necessary and UV-disinfection is recommended to be installed as part of Phase I SBR improvements.

Ammonia currently has no potential to violate Water Quality Standards, nor does it have the potential to violate Water Quality Standards in future conditions. Therefore, nitrification within the expanded WWTP is not necessary.

Water quality analyses for the SBC, and SBR WWTP upgrade alternatives show the stretch of Lewis River receiving WWTP discharge currently meets Class A surface Water Quality Criteria and will meet Class A criteria in the future; this ensures that no further degradation will result in the river. The Class A water quality criterion analyzed included pH, temperature, and dissolved oxygen.