# TOTAL MAXIMUM DAILY LOAD EFFECTIVENESS MONITORING STRATEGY FOR WASHINGTON STATE

George C. Onwumere and Robert W. Plotnikoff [1]

ABSTRACT: Washington State, located in the Pacific Northwest, is bounded on the north by the Canadian province of British Columbia, on the east by Idaho, on the south by Oregon, and on the west by the Pacific Ocean. The state has identified 1,317 impaired water bodies through the 1998 303(d) listing process. Washington State Department of Ecology is required, under Section 303(d) of the federal Clean Water Act (CWA) and U.S. Environmental Protection Agency's (EPA) implementing regulations, to develop and implement total maximum daily loads (TMDLs) for impaired waters, and to evaluate the effectiveness of the clean up plan to achieve the needed improvement in water quality. Currently, the State of Washington has approximately 398 EPA-approved TMDLs with impairments caused by pathogens, metals, conventional pollutants, priority pollutants, and exotic biological species. To date, TMDL effectiveness monitoring that evaluates the efficiency of the clean-up plans has been ignored. Consequently, Department of Ecology is developing a strategy that would involve the TMDL modelers, agency planners, and local partnerships in developing and guiding implementation plans prior to initiation of effectiveness monitoring. Preliminary success for the proposed effectiveness monitoring strategy is exemplified by the Puyallup River study located in Western Washington.
KEY TERMS: Clean Water Act; total maximum daily load; effectiveness; impaired waters; improvement; water quality.

## INTRODUCTION

Washington State Department of Ecology is required, under Section 303(d) of the federal Clean Water Act (CWA) and U.S. Environmental Protection Agency's (EPA) implementing regulations, to develop and implement Total Maximum Daily Loads (TMDLs) for water quality impaired surface waters and to evaluate the effectiveness of the clean-up plans following implementation of water quality restoration projects. Currently, the state has approximately 398 EPA-approved TMDLs addressing water quality impairments that include pathogens, metals, conventional pollutants, priority pollutants, and exotic biological species (U.S. Environmental Protection Agency, 2002). The TMDL is a tool for implementing water quality standards under the CWA and is based on the relationship between pollution sources and in-stream or lake water quality conditions. It is a summation of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, including natural background conditions.

This paper presents a strategy Department of Ecology is formulating for developing a TMDL effectiveness monitoring plan. Washington State, located in the Pacific Northwest, is bounded on the north by the Canadian province of British Columbia, on the east by Idaho, on the south by Oregon, and on the west by the Pacific Ocean. The state has identified 1,317 impaired water bodies through the 1998 303(d) listing process that are out of compliance with the state water quality standards (U.S. Environmental Protection Agency, 2002).

The TMDL clean-up process begins with the development of a scientific study, which culminates in a technical report by the Department of Ecology analyzing the pollution parameters identified in the Section 303(d) list of impaired water bodies. This scientific study takes between one and two years to identify the pollution sources and the load allocations needed to bring the water body into compliance with state water quality standards. The technical report provides a single source of data and analysis for the community and Department of Ecology staff (i.e. agency planners and TMDL leads) to join together to determine pollution control strategies (McBride, 2000). Community involvement is encouraged during this period as pollution control strategies are reviewed and converted into solutions and activities. These are technology-based solutions that are economically feasible and capable of early implementation by the partnership. These implementation activities are on-going until periodic follow-up monitoring indicates compliance with state water quality standards.

TMDL effectiveness monitoring is a fundamental, but often neglected, component of any TMDL implementation activity. It measures to what extent the work performed has attained the needed improvement recommended in the TMDL in order to comply with the state water quality standards. The benefits of TMDL effectiveness evaluation include:

- a measure of progress toward water quality improvements (i.e. how much watershed restoration has been achieved, how much more effort is required);
- more efficient allocation of funding and optimization in planning/decision-making; and

[1] Respectively, Ph.D. Senior Environmental Specialist, Unit Supervisor, Freshwater Monitoring Unit, Washington State Department of Ecology, 300 Desmond Drive SE, PO Box 47710, Olympia, WA 98504, Phone: (360) 407-6677, Fax: (360) 407-6884

- technical feedback to refine the initial TMDL model, best management practices (BMPs), nonpoint source (NPS) plans, and permits.

To date, TMDL effectiveness monitoring, a required component of the CWA, which evaluates the efficiency of the clean-up plans has been ignored. Consequently, Department of Ecology is presently formulating a strategy that involves the TMDL modelers, agency planners, and local partnerships in developing and guiding implementation plans prior to the need for effectiveness monitoring.

The purpose of this report is to evaluate the development of a TMDL effectiveness monitoring strategy in achieving TMDL target limits. These target limits are often based on water quality models that are the basis of TMDLs. The model serves as a tool to prevent further deterioration of water quality, improve the quality of polluted waters, and ensure compliance with state water quality standards.

This report includes the following: Washington State background information; TMDL summary and strategy; the Puyallup River TMDL Effectiveness Study; conclusion

## Washington State

Washington State, with a population of 5.9 million people at the end of 2000, has a land area of 66,582 $mi^2$ (176,600 $km^2$). The elevations range from sea level to 14,411 ft (4,392 m) atop Mount Rainier. The climate varies from mild and humid weather in the west to a cooler dry weather east of the Cascade Range. The average annual temperature ranges from 10.6° C (51° F) on the Pacific coast to 4.4° C (40° F) in the northeast. The western side of the Olympic Peninsula receives as much as 160 in (4,064 mm) of precipitation annually. The western slopes of the Cascade Range receive the heaviest annual snowfall, with more than 200 in (5,080 mm) in some places. However, some of the rain shadow areas east of the Cascades have annual precipitation as low as 6 in (152 mm) (Washington State Department of Information Services, 2002).

There are many rivers and lakes in the state. These major rivers: the Nooksack, Skagit, Stillaguamish, Snohomish-Snoqualmie, Nisqually, Chehalis, and Cowlitz drain the western part of the state. The Columbia River, the largest river in the western U.S., drains the eastern part of Washington. These rivers historically supported a healthy population of salmon prior to human-induced influences and associated water quality degradation.

The state economy is dominated by forestry, manufacturing, and agriculture with fishing, mining, tourism, transportation, and energy representing the remainder (Washington State Department of Information Services, 2002). The growth of these economic activities and associated increase in the state population has contributed to the deterioration in water quality in some geographic areas.

## TMDL SUMMARY AND STRATEGY

Based on the 1998 303(d) listing process, most of the 1,317 impairments occurred in the stream/creek/river category (1,110 stream segments), followed by estuaries (141 waterbodies), lake/reservoir/pond (65 waterbodies), and 1 unknown (U.S. Environmental Protection Agency, 2002). Table 1 shows the parameter impairments reported in the 1998 303(d) list and number of EPA-approved TMDLs, by pollutant, since 1992. According to this table, Washington State has approximately 2,188 parameter listings with 398 EPA-approved TMDLs (U.S. Environmental Protection Agency, 2002). The top five impairment listings, by parameter, are pathogens (565), thermal modifications (455), organic enrichment/low DO (227), priority organics (219), and metals (165).

So far, TMDL monitoring has been ignored to evaluate the effectiveness of the clean-up plans in the state. Department of Ecology is presently formulating a strategy involving the TMDL modelers, agency planners, and local partnerships in developing and guiding implementation plans prior to the need for effectiveness monitoring. Figure 1 shows the conceptual framework of the monitoring plan.

This initial phase requires that the TMDL modelers provide recommendations for water quality improvement and construct implementation plans. TMDL leads (staff that coordinate TMDL activities in a watershed) and watershed coordinators then assess the waste load allocations (WLA) for point source and load allocations (LA) for nonpoint source controls in order to make improvements in the watershed (Figure 1). The technical report provides a single source of data and analysis for the community and Department of Ecology staff (i.e. agency planners and TMDL leads) to join together when determining pollution control strategies. Community involvement is strongly encouraged during this period as pollution control strategies are reviewed and then implemented. Water quality improvements following implementation of these pollution control strategies and activities form the basis for prioritizing effectiveness monitoring in a watershed.

The TMDL leads (staff that coordinate TMDL activities in a watershed) consult with the regional staff during the ranking and selection of effectiveness monitoring projects (Figure 2). Ranking is dependent on the extent of the watershed implementation plan that is complete. The ranked projects are forwarded to the TMDL effectiveness staff each year for final consultation with the TMDL modelers. This final consultation verifies critical locations and time periods for receiving water monitoring projects.

After this final consultation, local partnerships are developed, where possible, in order to expedite completion of quality assurance project plans (QAPP) before the receiving water monitoring projects are initiated (as illustrated in Figure 2).

Table 1. Parameter Impairments for 1998 Section 303(d) list and EPA-Approved TMDLs by Pollutants.

| Impairment name | Parameter Number Reported | TMDL Pollutants | Number of EPA-Approved TMDLs |
|---|---|---|---|
| Pathogens | 565 | Fecal Coliform<br>Bacteria | 80<br>1 |
| Thermal Modifications | 455 | Temperature | 64 |
| Organic Enrichment/Low DO | 227 | BOD<br>DO | 40<br>4 |
| Priority Organics | 219 | PCB's<br>4-Methylphenol<br>Phenol | 1<br>1<br>1 |
| Metals | 165 | Copper<br>Zinc<br>Lead<br>Arsenic<br>Mercury<br>Cadmium | 2<br>2<br>2<br>1<br>1<br>1 |
| pH | 127 | | -- |
| Pesticides | 99 | DDT<br>4,4'-DDE<br>Dieldrin | 13<br>2<br>4 |
| PCB's | 73 | | |
| Other Habitat Alterations | 56 | Large Woody Debris | 1 |
| Flow Alteration | 50 | | -- |
| Other Cause | 35 | | -- |
| Biological Criteria | 28 | | -- |
| Nutrients | 24 | Phosphorus | 5 |
| Sediments/Siltation | 22 | Sediment<br>Sediment Bioassay<br>Turbidity | 28<br>1<br>13 |
| Other Inorganics | 15 | | -- |
| Unionized Ammonia | 13 | Ammonia-N<br>Ammonia | 39<br>1 |
| Dioxin | 12 | Dioxin | 8 |
| Chlorine | 2 | Chlorine | 2 |
| Exotic Species | 1 | | -- |
| Others (1992-1995) | | | 88 |
| **Total** | **2,188** | **Total** | **398** |

The final phase involves actual monitoring of receiving water quality conditions to determine compliance with state water quality standards (Figure 3). Waterbodies that meet criteria would undergo periodic monitoring on a 5-year cycle to ensure improvement and sustained water quality conditions. Listed segments that continue to fail meeting water quality expectations would be subjected to:

- Re-examination of discharge monitoring reports (DMRs) for point sources to ensure compliance with permit requirements,
- Re-evaluation of nonpoint source plan implementation projects, and
- Re-evaluation of critical WLAs and LAs to validate the initial TMDL model, re-calibrate the model or recommend new modeling.

All findings are reported to TMDL leads for further action. The Puyallup River TMDL effectiveness monitoring study served as a model approach for this strategy.

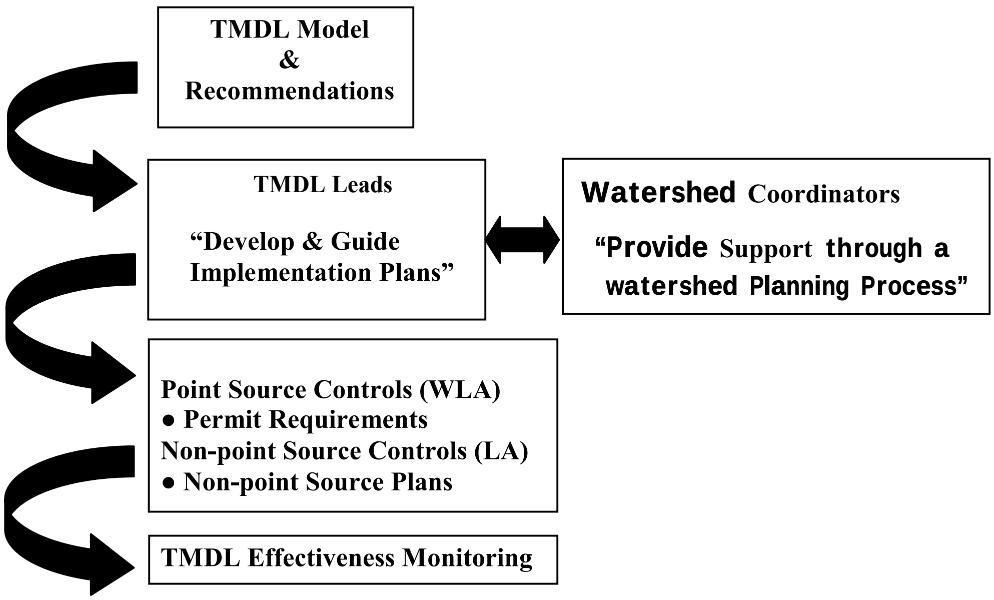


Figure 1. TMDL Effectiveness Monitoring Conceptual Framework for Washington State (Phase 1).

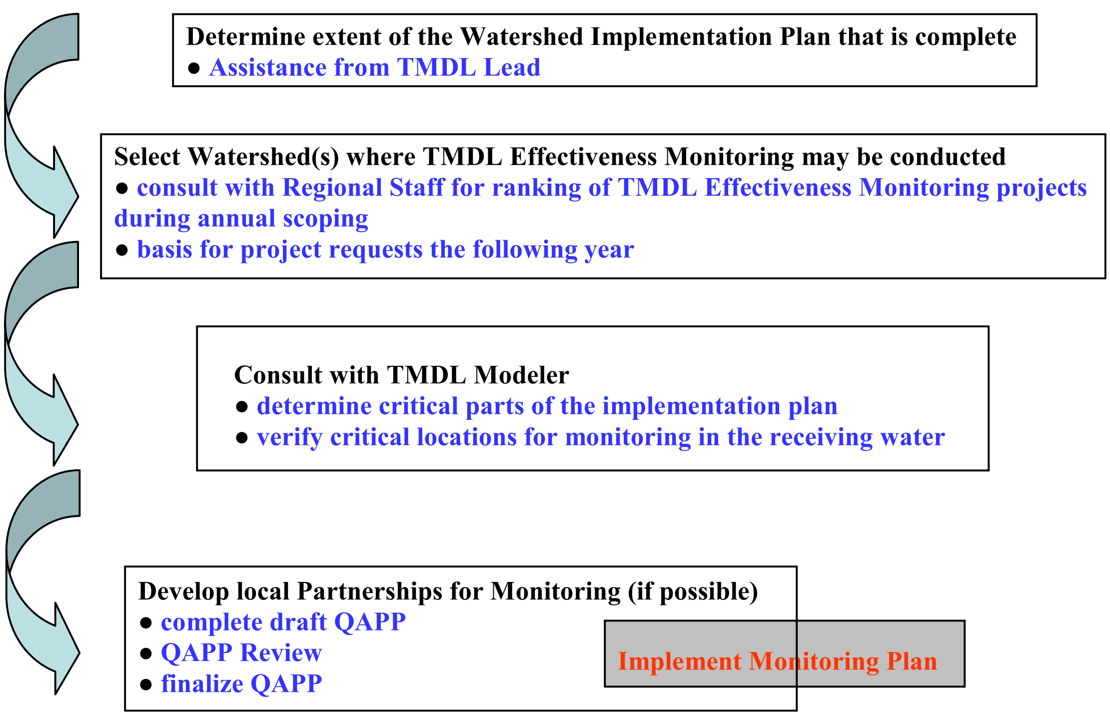


Figure 2. Conceptual TMDL Effectiveness Monitoring Protocols for Washington State (Phase 2).

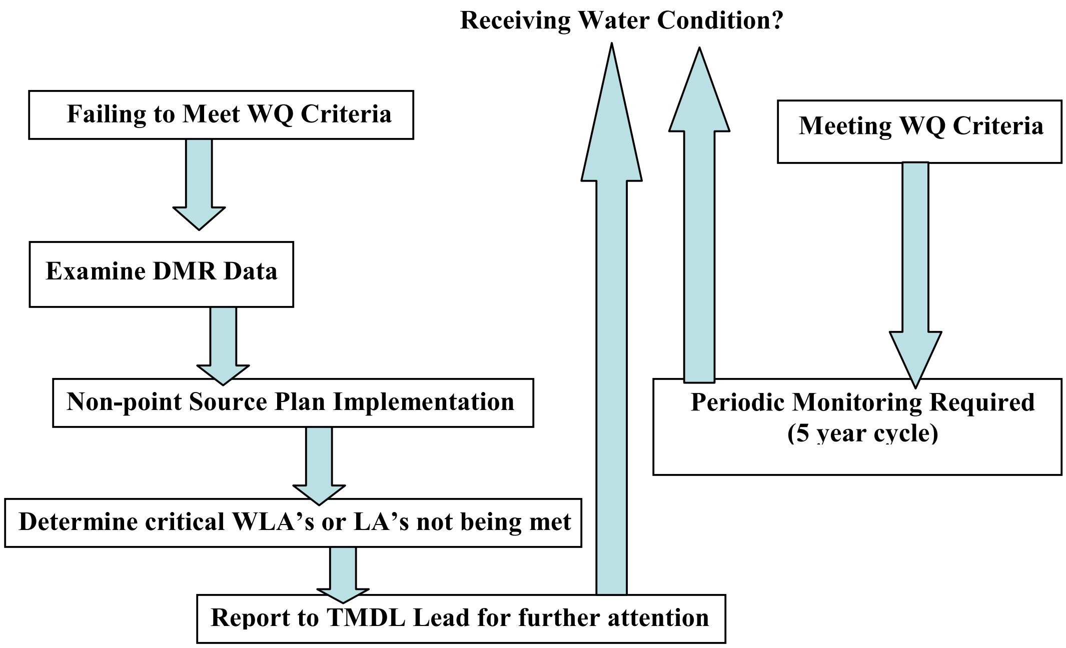


Figure 3. Procedure for Evaluating TMDL Effectiveness Monitoring in Washington State (Phase 3).

## THE PUYALLUP RIVER TMDL EFFECTIVENESS STUDY

The Lower Puyallup River flows through an alluvial floodplain east of Tacoma, Washington. The elevations of the streambed in the study area range from about 9 ft below sea level at river mile (RM) 2.9 on the Puyallup River to about 25 ft at RM 1.8 on the White River (Prych, 1988). The lower Puyallup River is a salt-wedge estuary with deeper marine water overlain by a layer of fresh water. The salt wedge generally extends less than 2.5 miles upstream from the river mouth (Ebbert et. al., 1987); and sometimes reaches RM 2.9 according to current monitoring data.

At the USGS gage (station 1210500 at RM 6.6), mean monthly flows in the Puyallup River during August and September for the period 1943 through 2000 were 2,069 and 1,665 cubic ft per second ($ft^3/s$), respectively. The record prior to 1943 does not reflect the present flow conditions because flood flow in the White River, a tributary to the Puyallup River, has been regulated since 1943 (Kresch and Prych, 1989).

Puget Sound Energy (PSE) operates Lake Tapps hydropower facility during the summer, which can have a substantial impact on flows in the lower White and Puyallup Rivers. Water is diverted from the White River at mile 24.3 into Lake Tapps, and released from the lake to a lower portion of the White River (RM 3.6) in order to produce power. During peak power usage, water is released from Lake Tapps which often causes discharge in the Puyallup River to increase by a factor of two and eventually falling back to base levels in a 12 hour period. The capacities of the diversion channel and the outlet from the hydropower facility are about 2,000 $ft^3/s$ each (Prych, 1988).

Surface water quality in the Puyallup and White Rivers is usually turbid during summer due to glacial melt water from Mount Rainier. Poor light penetration reduces productivity (Wetzel, 1983), which probably moderates 24-hour variations in concentration of dissolved oxygen (DO) in the lower Puyallup and White Rivers. This fluctuation is highly influenced by photosynthesis and respiration of algal and microbial communities.

Department of Ecology developed a TMDL for the basin, setting a maximum load for 5-day biochemical oxygen demand (BOD5) at 20,322 pounds per day (lbs/day) and a maximum load for ammonia at 3,350 lbs/day. The TMDL also included a reserve capacity of 3,670 lbs/day of BOD5 and 1,200 lbs/day of ammonia (Pelletier, 1993, 1994). In 1996, Department of Ecology initiated a mediation process which resulted in an agreement (Washington State Department of Ecology, 1998) that allocated the reserve capacity to such parties as municipalities, industry, and Indian Tribes. In addition, the agreement outlined a plan for additional monitoring to ensure that DO and ammonia concentrations remain compliant with applicable water quality standards.

In August 2000, Department of Ecology established more monitoring stations for water quality sampling between August and September to evaluate the status of the reserve capacity and TMDL effectiveness. In September 2000, unusually low DO concentrations (1-6 mg/L) were measured on several occasions which led to the issuance of a moratorium on allocation of the reserve capacity for BOD5 and ammonia (Washington State Department of Ecology, 2000).

In May 2001, Department of Ecology in partnership with the Puyallup Tribe, partnered with the U.S. Geological Survey (USGS) in an evaluation of the data collected from August to September 2000 and in gathering additional TMDL effectiveness monitoring data. A cooperative study was established, and results reported by the USGS found sediment fouling of the monitoring device sensors the most likely cause of low DO concentrations observed in September 2000 (Ebbert, 2002). Table 2 shows a summary of the data collected in the Lower White and Puyallup Rivers in August and September of 2001. According to Ebbert (2002), the low DO reading at Puyallup River (river mile 2.9) was due to movement of saline water upstream during high tide. The minimum concentration of DO (7.6 mg/L) observed at this site coincided with the maximum value of specific conductance. On the other hand, the low DO at White River (river mile 1.8) was inconclusive due to some uncertainty in the monitoring record for those days. Additionally, evaluation of the TMDL model with current monitoring data indicated that reserve capacity for BOD5 and ammonia had been depleted.

Table 2. Maximum and minimum concentrations of dissolved oxygen (DO) and values of specific conductance and temperature in the Lower White and Puyallup Rivers (Ebbert, 2002).

| **Site** | | **DO (mg/L)** | **Specific Conductance (µS/cm)** | **Temperature ($^{o}$ C)** |
|---|---|---|---|---|
| White River at river mile 1.8 | Maximum | 11.2 | 98 | 20.4 |
| | Minimum | 7.8 | 59 | 9.7 |
| Puyallup River at river mile 5.8 (upstream) | Maximum | 10.7 | 100 | 17.1 |
| | Minimum | 8.4 | 45 | 9.6 |
| Puyallup River at river mile 5.8 (downstream) | Maximum | 11.2 | 102 | 17.8 |
| | Minimum | 8.5 | 47 | 10.0 |
| Puyallup River at river mile 2.9 | Maximum | 10.5 | 36,500 | 17.4 |
| | Minimum | 7.6 | 57 | 10.1 |

## CONCLUSION

The proposed strategy for involving multiple interests in a monitoring partnership including: TMDL modelers, agency planners, tribes, and local agencies has worked in improving water quality in the river. Preliminary success for the proposed effectiveness monitoring strategy is exemplified by the Puyallup River study. The TMDL effectiveness monitoring efforts of the partnership found the causation for the low DO problems and provided guidance for the re-evaluation and recalibration of the initial TMDL model.


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## REFERENCES


Ebbert, J.C., 2002. Concentrations of dissolved oxygen in the lower White and Puyallup Rivers, Washington, August and September 2000 and 2001: U.S. Geological Survey Water-Resources Investigations Report 02-4146, 40 p.

Ebbert, J.C., Bortleson, G.C., Fuste', L.A., and Prych, E.A., 1987. Water quality in the lower Puyallup River Valley and adjacent uplands, Pierce County, Washington: U.S. Geological Survey Water-Resources Investigations Report 86-4154, 199 p.

Kresch, D.L., and Prych, E.A., 1989. Streamflow statistics for streams on the Puyallup Indian Reservation, Washington: U.S. Geological Survey Water-Resources Investigations Report 87-4228, 43 p.

McBride, R., 2000. Responsiveness Summary: Fiscal Year 2000 TMDL Priority List. Washington State Department of

Ecology, Olympia, WA. Pub. No. 0-10-055, 23p.

Pelletier, G.J., 1993. Puyallup River total maximum daily load for biochemical oxygen demand, ammonia, and residual chlorine: Washington State Department of Ecology Pub. No. 96-326, 105 p.

Pelletier, G.J., 1994. Addendum to the 1993 Puyallup River TMDL Report: Washington State Department of Ecology Memorandum dated July 22, 1994.

Prych, E.A., 1988. Flood-carrying capacities and changes in channels of the lower Puyallup, White, and Carbon Rivers in Western Washington: U.S. Geological Survey Water-Resources Investigations Report 87-4129, 69 p.

U.S. Environmental Protection Agency., 2002. 1998 Section 303(d) List Fact Sheet for Washington, accessed November 2002, at URL http://oaspub.epa.gov/waters/state_rept.control?p_state=WA

Washington State Department of Ecology., 1998. Agreement on the allocation of the Puyallup River TMDL reserve capacity of biochemical oxygen demand (BOD5) and ammonia, accessed October 2001, at URL http://www.ecy.wa.gov/programs/wq/tmdl/watershed/puyallup/index.html

_____ 2000. Letter dated December 1, 2000 to Citizens for a Healthy Bay describing the moratorium on allocating reserve capacity of BOD5 and ammonia, accessed October 2001, at URL http://www.ecy.wa.gov/programs/wq/tmdl/watershed/puyallup/index.html.

Washington State Department of Information Services., 2002. General Information about Washington State, accessed November 2002, at URL http://access.wa.gov/government/awgeneral.asp

Wetzel, R.G., 1983. Limnology. Saunders College Publishing – Harcourt Brace College Publishers, New York. 2nd Edition.