

CONCEPTUAL FRAMEWORK FOR TOTAL MAXIMUM DAILY LOADS EFFECTIVENESS MONITORING IN WASHINGTON STATE

George C. Onwumere, Senior Environmental Specialist, Freshwater Monitoring Unit, Environmental Assessment Program, Washington State Department of Ecology, 300 Desmond Drive SE, PO Box 47710, Olympia, WA 98504, (360) 407-6730, OGE0461@ecy.wa.gov; Robert W. Plotnikoff, Unit Supervisor, Washington State Department of Ecology

INTRODUCTION

Currently, over 40 percent of the Nation's and most states' assessed waters still do not meet the water quality standards. Washington State has identified 1,317 impaired water bodies through the 1998 303(d) listing process and 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 Washington State Department of Ecology (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:

- Periodically assemble the list of water bodies that are out of compliance with the state water quality standards.
- Develop and implement Total Maximum Daily Loads (TMDLs) for these watersheds.
- Evaluate the effectiveness of the clean-up plan to achieve the needed improvement in water quality.

The TMDL is a tool used for achieving compliance with 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. 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
- technical feedback to refine the initial TMDL model, best management practices (BMPs), nonpoint source (NPS) plans, and permits.

The proposed strategy is exemplified by the fecal coliform TMDL effectiveness monitoring study in Pipers Creek, located within the City of Seattle. This report includes the following: TMDL summary and strategy; the Pipers Creek TMDL Effectiveness Study; and conclusion.

TMDL SUMMARY AND STRATEGY

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.

So far, use of TMDL effectiveness monitoring to evaluate the efficiency of the clean-up plans has been minimal. Consequently, Ecology is developing a strategy that would involve the TMDL modelers, agency planners, and local partnerships in developing and guiding implementation plans prior to the advent of effectiveness monitoring.

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) (Onwumere and Plotnikoff, 2003). 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 (Onwumere and Plotnikoff, 2003).

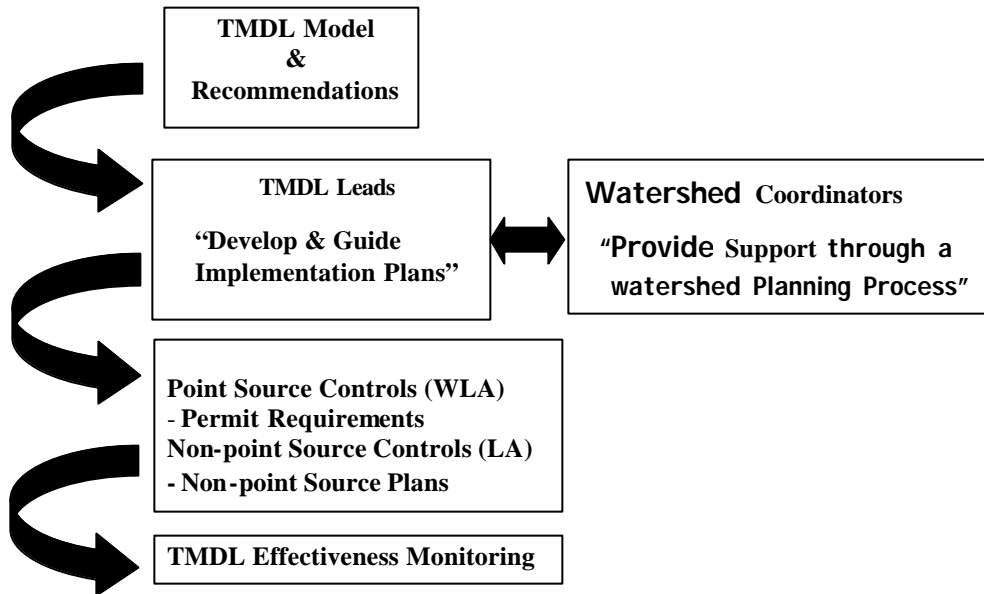


Figure 1. TMDL Effectiveness Monitoring Conceptual Framework for Washington State (Phase 1).

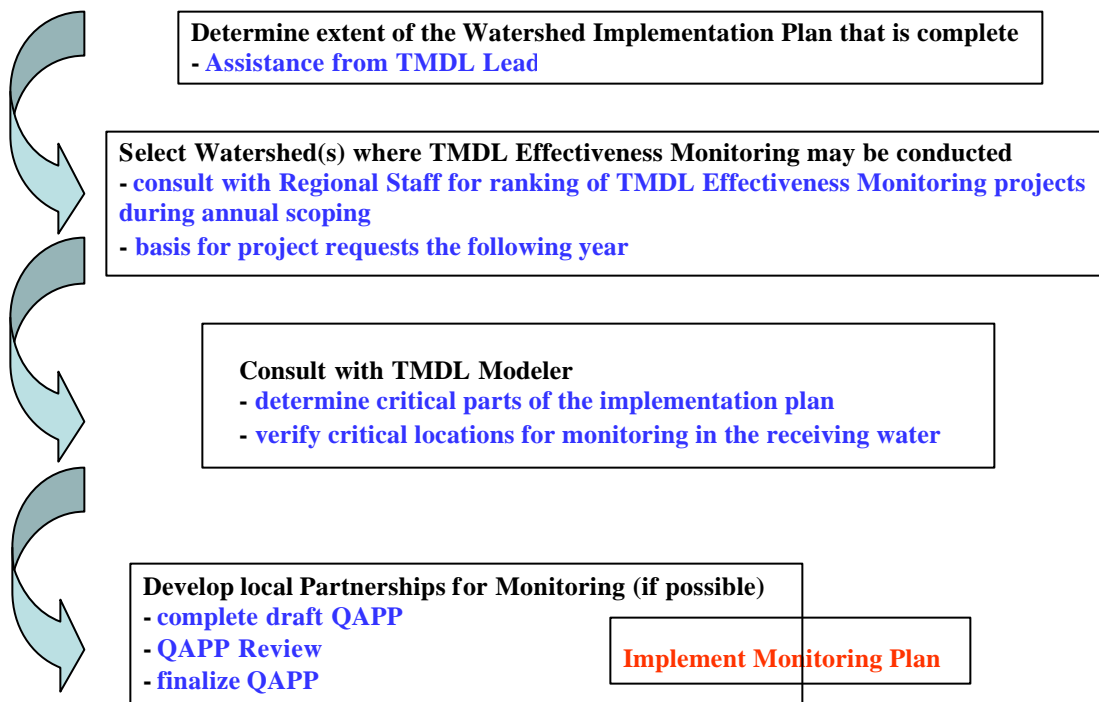


Figure 2. Conceptual TMDL Effectiveness Monitoring Protocols for Washington State (Phase 2).

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).

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 (Onwumere and Plotnikoff, 2003).

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

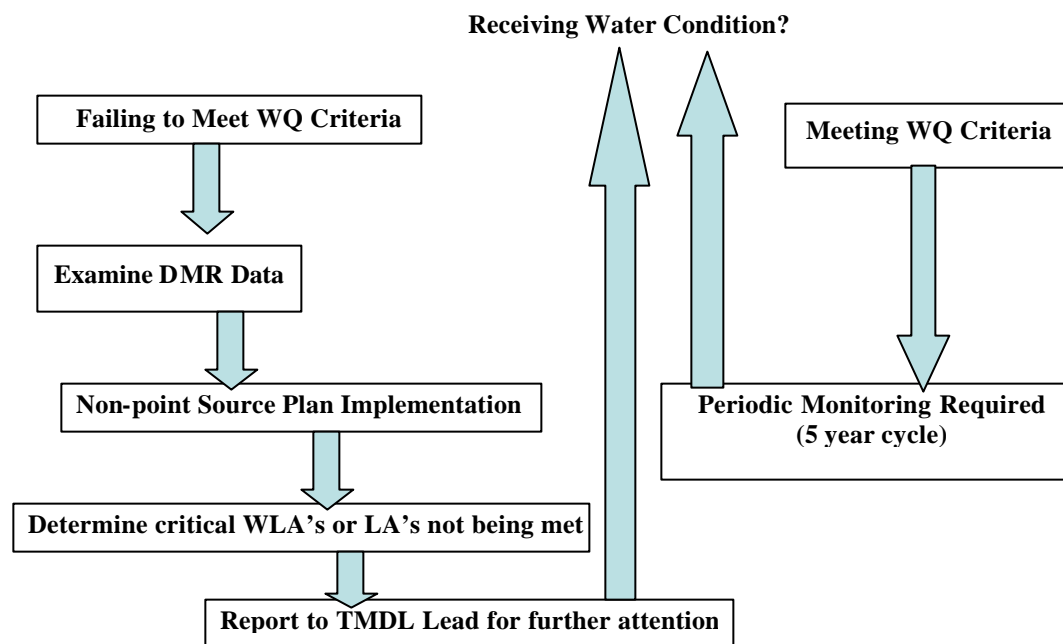


Figure 3. Procedure for Evaluating TMDL Effectiveness Monitoring in Washington State (Phase 3).

CASE STUDY - THE PIPERS CREEK TMDL EFFECTIVENESS MONITORING

Pipers Creek watershed, located within the City of Seattle, is an urban drainage basin of approximately 3.5 mi². The watershed is highly developed in the upper plateau with residential homes, shopping malls, and commercial buildings. The lower watershed has contrasting land

uses that include a park, cemetery, and other open spaces (Shapiro and Associates, Inc., 1989). Typical of the urban stream setting, Pipers Creek has a drainage network that includes a tributary stream, storm drain pipes, and drainage ditches. These drainage network systems convey stormwater runoff events and their associated pollutants, including fecal coliform, into the creek and eventually into the Puget Sound. The deterioration in water quality and pollutant loading, especially fecal coliform, into Puget Sound were the motivation for constructing a Pipers' Creek TMDL.

Pipers Creek is a Class AA (extraordinary) waterbody and has a fecal coliform bacteria limit not to exceed a geometric mean value of 50 colonies/100 ml (freshwater) and 14 colonies/100 ml (marine water) – part 1 of the water quality standard, and not to have more than 10% of all samples used for calculating the geometric mean exceeding 100 colonies/100 ml (freshwater); and 43 colonies/100 ml (marine water) – part 2 of the water quality standard (Washington State Department of Ecology, 1997).

Effects to humans of bacteriological contamination include: gastrointestinal distress, respiratory, and infection symptoms such as skin irritations (from contact recreation). Environmental impacts include commercial and recreational shellfish beach closures. In fact, high levels of fecal coliform bacteria have been measured in the Pipers Creek watershed by the City of Seattle and King County Department of Natural Resources that have prompted the following actions:

- King County beach closures to avoid contact recreation.
- Recommendations to limit harvest and consumption of seaweed, crab, shellfish, and bottomfish from King County beaches (Pipers Creek Watershed Management Committee, 1990).

PIPERS CREEK TMDL SUMMARY

Potential sources of bacterial contamination to the creek were identified as pet wastes, combined sewer overflows at the treatment facility and North Beach Pump Station, leaking sewer pipes, failing septic tank systems, and a local duck pond (Pipers Creek Watershed Management Committee, 1990). Difficulties in dealing with nonpoint source pollution encouraged public education as an early implementation element from the Watershed Action Plan.

The Watershed Action Plan supposition stressed that storm event-driven nonpoint sources are primary causes of pollution problems and that limiting stormwater impacts would curtail fecal coliform loading.

The overall goal of the Watershed Action Plan is attainment of the fecal coliform water quality standard in receiving water for the protection of human and aquatic life. The TMDL required that adequate monitoring be conducted to assess progress in achieving both the TMDL and Watershed Action Plan's goals. Water quality sampling was conducted bi-weekly or monthly by both City of Seattle and King County in the Pipers Creek watershed from 1993 to the present. However, only the data from 1993 to 2002 was used in the evaluation, as indicated in Figure 1 and Table 1. The Pipers Creek TMDL was limited to freshwater issues. Freshwater monitoring

results from the four sites (KTHA01, KTHA02, KTHA03, and KSHZ06) are used in this analysis (Table 1).

Table 1. Pipers Creek Watershed Sampling Locations

Site	Latitude & Longitude	Site description	Monitoring Period
ITCarkeekP	47 42 45 122 22 45	Marine water beach station at Carkeek Park that is north of Pipers' Creek mouth, away from the creek's influence.	2000 - 2001
KSHZ03	47 42 45 122 22 46	Marine water beach station at Carkeek Park that is at the mouth of Pipers Creek.	1993 - 2002
KTHA01	47 42 41 122 22 27	Freshwater Pipers Creek station upstream from the Treatment Facility.	1993 - 2002
KTHA02	47 42 39 122 22 18	Freshwater Pipers Creek station, main channel.	1993 - 2002
KTHA03	47 42 39.8 122 22 18	Freshwater station at the mouth of Venema Creek.	1993 - 2002
KSHZ06	47 42 42 122 22 46	Freshwater Pipers Creek station, main channel	1993 - 2002

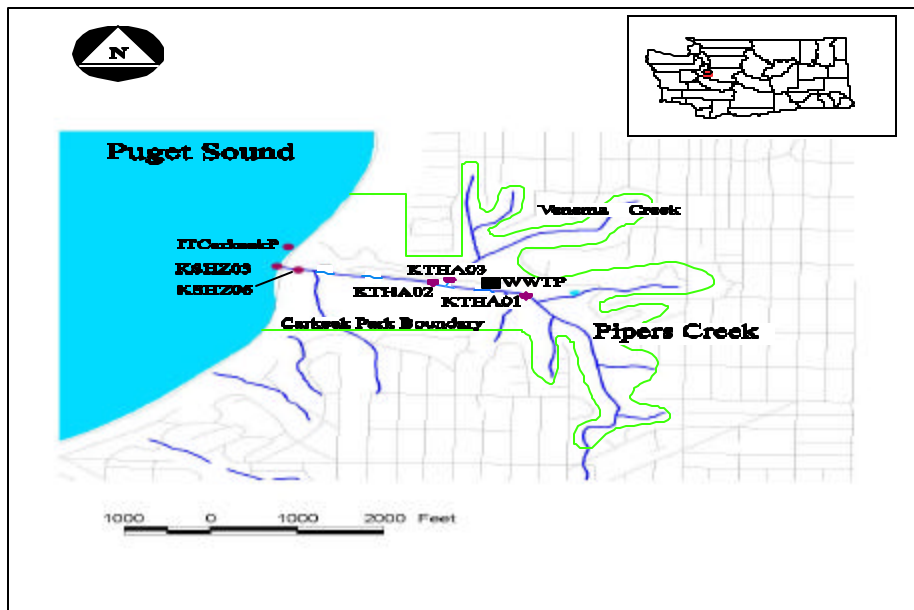


Figure 1. Pipers Creek Water Quality Sampling Locations.

RESULTS AND DISCUSSION

Table 2 reports the annual geometric mean calculated from fecal coliform results for all sites beginning 1993 to 2002. Fecal coliform data from January to June was used in the 2002 geometric mean calculation. The data indicate a variation in annual fecal coliform concentration ranging from 50 colonies/100 ml in 1997 (KTHA03 site) to 533 colonies/100 ml in 1999 (KTHA02 site). These results indicate that fecal coliform concentrations exceeded the criterion each year (Figure 2), except for 1997 at the KTHA03 (mouth of Venema Creek) site. Table 2 also presents the 90th percentile values and percent of samples exceeding part 2 of the water quality standard in brackets.

Table 2. Upstream to Downstream Annual Geometric Mean for Fecal Coliform Data for Pipers Creek sites (#/100 mL).

Year	KTHA01		KTHA02		KTHA03		KSHZ06	
	Geo-mean	90 th Percentile	Geo-mean	90 th Percentile	Geo-mean	90 th Percentile	Geo-mean	90 th Percentile
1993	122	559 (67)	138	892 (60)	68	270 (46)	126	389 (50)
1994	151	558 (67)	197	1,520 (69)	51	148 (42)	93	382 (50)
1995	179	600 (67)	297	1,750 (77)	105	332 (58)	303	1,630 (83)
1996	261	587 (92)	300	806 (83)	145	569 (50)	280	654 (77)
1997	255	645 (83)	425	5,540 (77)	50	140 (23)	218	852 (67)
1998	197	899 (67)	263	860 (73)	124	879 (40)	259	1,241 (60)
1999	175	600 (67)	553	11,270 (83)	214	1,310 (57)	297	1,730 (92)
2000	208	529 (83)	294	760 (82)	122	590 (46)	248	420 (83)
2001	100	312 (50)	255	5,528 (62)	56	87 (8)	231	1,690 (70)
2002	87	430 (20)	228	354 (100)	67	147 (20)	117	268 (40)

Note:

1. Bold numbers in brackets are percent of samples exceeding water quality standard part 2.
2. Part 1 - geometric mean value (GMV) shall not exceed 50 colonies/100mL. Part 2 - not more than 10% of the samples used for calculating the GMV shall exceed 100 colonies/100mL.
3. For geometric mean calculation, the minimum sample number/year/site = 11, except for year 2002 with the minimum sample number/year/site = 5.

The main channel sites (KTHA02 and KSHZ06) below the Waste Treatment Facility have consistently higher fecal coliform concentrations than the upstream (KTHA01) site (Figure 3). Fecal coliform concentrations are lowest at the KTHA03 site (Freshwater station at the mouth of Venema Creek), except in 1999 (Figure 2). The lower Venema Creek (KTHA03) site still does not meet the fecal coliform water criterion. It appears there are sources of fecal coliform contribution to Pipers Creek from the Venema Creek tributary to the downstream (KSHZ06) site (Figure 3). The nonpoint source control programs implemented over the past years appear ineffective in bringing Pipers Creek water quality into compliance with state standards.

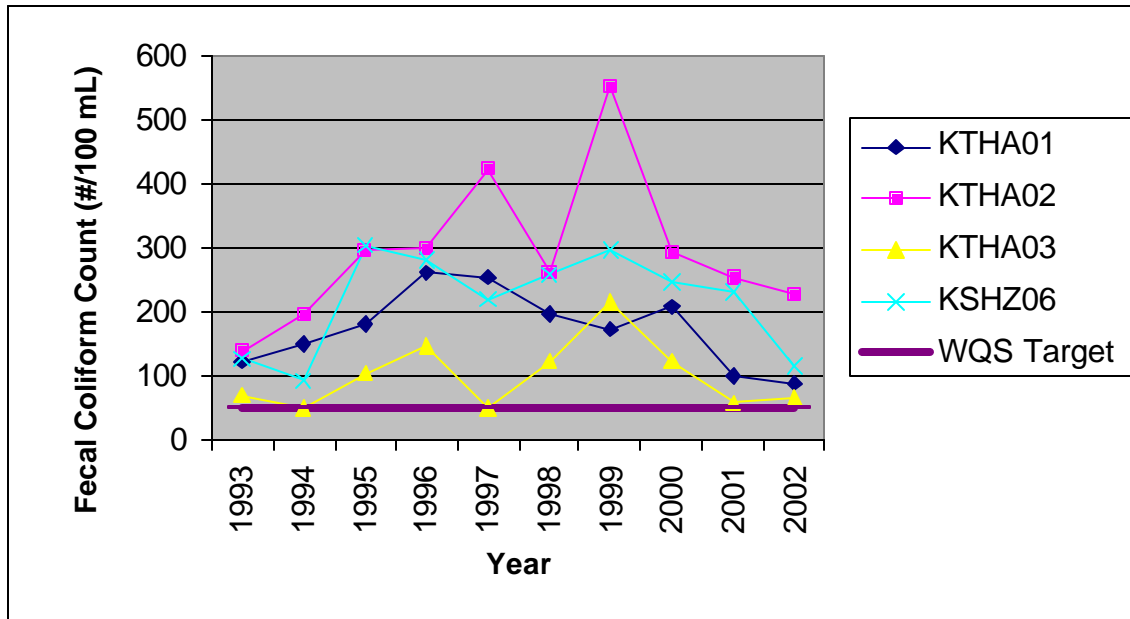


Figure 2. Annual Geometric Mean Fecal Coliform Comparison to Water Quality Standard Target for Pipers Creek Freshwater sites from 1993 to 2002.

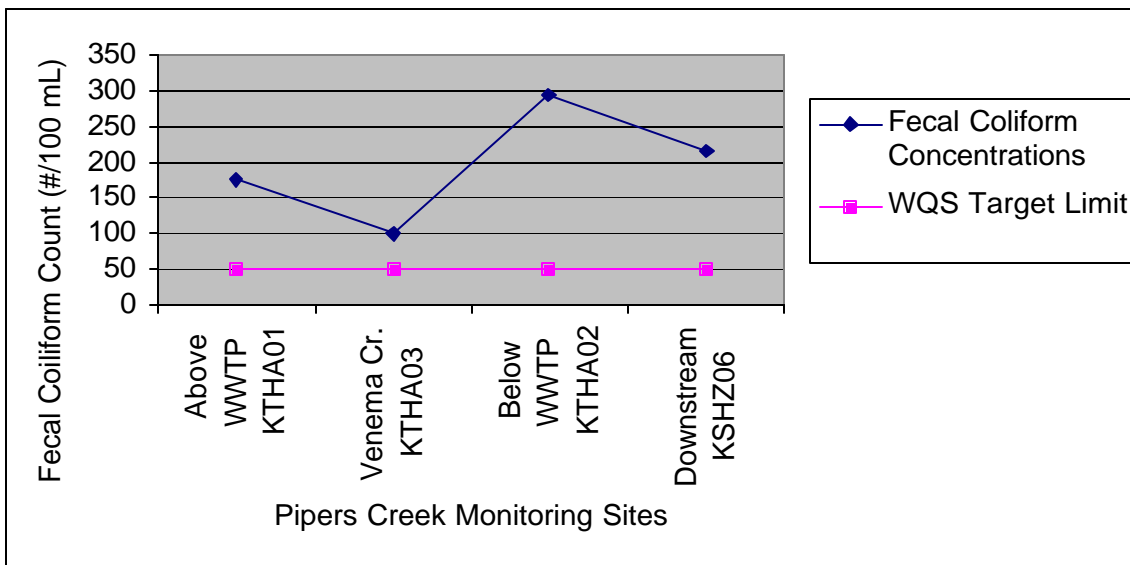


Figure 3. Upstream to Downstream Fecal Coliform Concentration Pattern at the Pipers Creek Watershed.

The data evaluation suggests that current implementation programs to reduce fecal coliform sources to Pipers Creek have not been effective despite management programs such as public education and outreach. Future programs should target nonpoint source identification and aggressively implement management guidelines to curtail these sources (Onwumere, 2003).

CONCLUSION

The proposed strategy for involving multiple interests in a monitoring partnership including: TMDL modelers, agency planners, tribes, and local agencies have worked in improving the quality of the receiving water. Preliminary success for the proposed effectiveness monitoring strategy is exemplified by the Pipers Creek study, although evaluation of available effectiveness monitoring data indicates that fecal coliform concentrations still exceed both parts of the water quality criterion at all Pipers Creek sites. Past programs such as flyer dissemination, public education and outreach to bring the creek into compliance with water quality standards have not been effective in curtailing nonpoint sources of fecal coliform bacteria. Reducing fecal coliform levels in this creek should consider:

1. Identifying and reducing potential sources during the dry (non-winter) period (April – October) and the wet (winter) stormwater runoff-related fecal coliform contributions.
2. Targeting specific areas with additional high resolution monitoring.
3. Checking for the presence of human sources, e.g., leaking septic systems and sewers (dye test).
4. Continuing the public education campaign.
5. Aggressive enforcement of local ordinances to deter violators.

ACKNOWLEDGEMENTS

The author would like to thank the following people and organizations for their contributions to this report.

- King County, for providing the Pipers Creek data sets. Sally Abella (King County) and Beth Schmoyer (Seattle Public Utilities) for reviewing the draft report.
- Tony Whiley, Steve Butkus (Department of Ecology), and Lisa Olson (NWRO) for providing the Unit-level review and comments on the report. Special thanks to Robert W. Plotnikoff for editing the final draft report.
- Karol Erickson, Department of Ecology, for providing timely Program-level review.
- Dr. Stephen Smith, Simon Fraser University, Burnaby, Canada, for providing timely external-level review of the draft report.

REFERENCES

- McBride, R., 2000. Responsiveness Summary: Fiscal Year 2000 TMDL Priority List. Washington State Department of Ecology, Olympia, WA. Pub. No. 0-10-055, 23p.
- Onwumere, G.C. 2003. Effectiveness Monitoring for Fecal Coliform Total Maximum Daily Loads in Pipers Creek. Washington State Department of Ecology, Olympia, WA. Pub. No. 03-03-027, 17p
- Onwumere, G.C., and Plotnikoff, R.W. 2003. Total Maximum Daily Loads Effectiveness Monitoring Strategy for Washington State. Paper Presentation at the American Water Resources Association's (AWRA) International Water Congress Conference in New York City, New York. June 29-July 2, 2003, 7p
- Pipers Creek Watershed Management Committee. 1990. Pipers Creek Watershed Action Plan For the Control of Nonpoint Source Pollution. Final Action Plan. Seattle, WA. pp. 92.
- Shapiro and Associates, Inc. 1989. Pipers Creek Watershed Action Plan for Nonpoint Source Pollution – Watershed Characterization and Water Quality Assessment. Prepared for City of Seattle Engineering Department, Seattle, WA. pp. 129.
- 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. 1997. Water Quality Standards for Surface Waters of the State of Washington. Washington State Department of Ecology, Olympia, WA. pp. 37.