WASHINGTON STATE'S STORMWATER MANAGEMENT PROGRAM

TRB Paper Number 960370

Presented January 7, 1996

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Word count: 5,375

ABSTRACT

To comply with state and federal laws, the Washington State Department of Transportation (WSDOT) developed a Stormwater Management Program. The program included an outfall inventory and retrofit program, a Highway Runoff Manual (HRM), and stormwater research.

Field crew inventoried sites where highway stormwater runoff is collected and discharged to surface water, ground water, and municipal storm sewers. Pipes, ditches, and stormwater structures that provide quantity and quality control were inventoried. The screening assessment for potential water pollution problems was made via observation and sampling kit. The sampling kit was found to be ineffective at identifying illicit connections. Inventoried sites were mapped using global positioning and geographic information system technology. Research was conducted on sites to determine watershed characteristics, potential environmental impacts, and Best Management Practice (BMP) retrofit options. A computer database of information is maintained to facilitate stormwater management activities.

A Prioritization Scheme was developed to identify priority sites for retrofit, based on the following factors: Receiving Water Body, Beneficial Uses, Pollution Loading, Percent Highway Drainage, Cost/Pollution Benefit, and Values Trade Off.

The HRM was developed to direct stormwater management for existing and new state highways, rest areas, park and ride lots, and ferry terminals. Water quality and quantity issues for construction and maintenance are addressed by meeting the minimum requirements of the manual.

Thirteen research projects have been funded to evaluate experimental BMPs, determine BMP pollutant removal efficiencies, and assess the cost/benefit of retrofitting outfalls. Research included bench scale work, field projects, and a department survey.

Key Words:

stormwater
highway
water quality
outfalls
sampling
prioritization
watershed

INTRODUCTION

This paper describes the progress in developing a stormwater management program at the Washington State Department of Transportation (WSDOT). Topics highlighted include: the inventory and field screening of outfalls in urbanized counties, the effort to prioritize outfalls for retrofitting, implementation of the Highway Runoff Manual, and WSDOT-funded water quality research. Development of the National Pollution Discharge Elimination System (NPDES) municipal stormwater application is also addressed.

The key regulatory framework under which the program is being developed includes Chapter 173-270 Washington Administrative Code (Puget Sound Highway Runoff Rule) and NPDES municipal stormwater regulations under the Federal Clean Water Act. The Runoff Rule states that WSDOT shall complete all practicable Best Management Practice (BMP) projects for stormwater treatment for highways with an Average Daily Traffic (ADT) of 50,000 or greater by December 31, 2005, and for other highways by December 31, 2015. The NPDES requires operators of a storm sewer system serving areas with a population greater than 100,000 to acquire a permit for stormwater discharges. WSDOT highways located in the following areas are subject to permit requirements: unincorporated Snohomish, King, Pierce, Clark, and Spokane Counties and the cities of Seattle and Tacoma. The permit application process requires that:

1) An inventory be conducted to identify stormwater sources and impacts.

2) A discharge characterization and monitoring program be developed.

3) Illicit connections be identified and a prevention plan be developed.

4) A comprehensive stormwater management program be developed.

The proposed stormwater management program is subject to public review and approval by the Department of Ecology (Ecology) (1). Each program element consists of a task description, implementation schedule, evaluation, and budget. Program elements include: Illicit Connections, Construction Site Runoff, New Construction and Retrofit BMPs, Maintenance, Sampling, and Public/Employee Education. WSDOT, other permitted municipalities, and Ecology have produced a guidance document to clarify permit conditions and program expectations (2).

The stormwater management program will build on the stormwater guidance manuals that have been in place since 1991. Prior to development of the Highway Runoff Manual, WSDOT designed facilities to be consistent with local requirements or the Puget Sound Manual (3, 4). The manuals have primarily been used as guidance for treating stormwater from new impervious surfaces. The data collected from the outfall inventory and field screening effort will aid in determining the percentage of resources that should be dedicated to addressing illicit connections and

retrofit efforts. The BMP research effort that is underway will serve as a feedback loop on the cost effectiveness of program activities.

OUTFALL INVENTORY

Methodology

From July 1993 through December 1995, field crews have been conducting a stormwater drainage inventory on state highways in the urbanized counties of Clark and Spokane, as well as the Puget Sound counties of Whatcom, Skagit, Snohomish, King, Pierce, Island, and Thurston. Unlimited access highways within incorporated communities were not surveyed, because these roads are maintained by the local road department.

A budget of approximately $680,000 supported the temporary labor, field equipment, and travel. Two permanent staff provided administrative support for a total of 12 months and $52,000. The inventory was initiated by a project manager and 12 temporary employees (two supervisors and five pairs of crew) working out of four regional offices (Seattle, Olympia, Spokane, Vancouver). All of the crew members had environmental or engineering educational backgrounds and job experience. Over the course of the project, 17 people have worked 186 months, with a task breakdown as follows: field work - 127 months, research - 35 months, data processing - 17 months, and administration - 7 months (5).

The inventory consists of: outfalls (sites where highway runoff is collected and discharged to surface water, ground water, and municipal storm sewers); existing stormwater structures providing quantity and quality control (BMPs); and potentially illicit off-site connections to the WSDOT drainage system. Information on each drainage structure was collected during a visual inspection in the field, and recorded on a field data sheet (6). Characteristics recorded for the drainage structures include:

1) Outfalls - inventoried as belonging to one of the following four categories:

   - Culverts 30 cm (12 in) or larger - shape, size, material, condition, blockage. Culverts below this size were also inventoried if they drained directly into surface water (e.g., from a bridge surface).

   - Open channels discharging to surface water or leaving WSDOT right of way - lining (vegetation, soil, or an impermeable material such as asphalt or concrete), dimensions, amount of vegetation, and degree of obstruction.

   - Interconnections between municipal storm drain systems and the WSDOT drainage system.

   - Dry wells - inventoried as both outfalls and water quantity BMPs, as they remove runoff from the road surface but also discharge it, untreated, to aquifers.

2) Existing Best Management Practices (BMPs) - Water quality and quantity BMPs were categorized into one of the following types: infiltration trenches, dry ponds, dry wells, wet vaults, wet ponds, oil/water separators, biofiltration swales, or spill control structures. Ecology ditches and catch basin filters were inventoried as experimental BMPs. Erosion control BMPs associated with permanent BMPs (hay bales, rock check dams, silt fences, etc.) were also noted. Field notes were made on the apparent effectiveness of the BMP, based on observation only.

3) Connections to WSDOT right of way from off site - These are pipes or open channels that are connected, or that convey stormwater, to the WSDOT drainage system from off the right of way. The Utility Permit database was reviewed to determine if approval to make the connection had been applied for and recorded. In addition, engineering and maintenance personnel were contacted to locate areas where off-site drainage was permitted. Non-permitted or unknown connections were documented as illicit.

The inventory was accomplished by: reviewing construction plans; consulting both regional WSDOT personnel and local public works departments; and locating structures in the field. The screening assessment for potential water pollution problems was made from observations and, if necessary, sampling (7). Global Positioning System (GPS) equipment is being used to obtain accurate locations for the outfalls (8). Data sheets are entered on a computer database using Filemaker™ software. Key attributes for each outfall are being loaded into a stormwater outfall layer in a Geographic Information System (GIS), using ArcInfo™ format.

Due to time constraints, a faster field screening protocol known as "windshield survey" was established for certain low ADT highways. Using this protocol, the field crews were able to characterize long sections of homogeneous rural highways. Field notes were taken on general drainage characteristics, and outfalls that discharged directly to surface water were inventoried.

Survey Results

There are approximately 2696 km (1,675 mi) of state highways in the Puget Sound Basin, all of which lie within the boundaries of WSDOT's Northwest and Olympic regional offices. Of these, 1114 km (692 mi) are covered under the NPDES Stormwater Permits. As of December 1995, the inventory work has been completed on 1537 km (955 mi), which break down by county as follows (total km/km inventoried): Island (82/13 km) (51/8 mi); King (534/480 km) (332/298 mi); Kitsap (142/100 km) (89/62 mi); Mason (192/19 km) (119/12 mi); Pierce (433/417 km) (269/259 mi); Skagit (269/161 km) (167/100 mi); Snohomish (348/142 km) (216/88 mi); Thurston (90/62 km) (56/38 mi); Whatcom (282/145 km) (175/90 mi). Highways in Kitsap, Mason, Pierce, Thurston, and southern King Counties with an ADT below a threshold of 10,000 were inventoried using the windshield survey protocol. In Skagit and Whatcom Counties, the ADT threshold was 20,000.

Only the low ADT roads remain to be surveyed in Puget Sound. One hundred thirty five kilometers (84 miles) were inventoried in Clark County, and 135 kilometers (84 miles) were inventoried in Spokane County. A limited inventory effort will continue in order to incorporate new construction in inventoried areas. Also, Regions may request an inventory for corridors proposed for construction or to accommodate watershed management planning efforts.

Inventory Results

Of 3,068 outfalls characterized, 1,013 were open channels; 1,624 were culverts with a diameter ranging from 10 to 213 cm (4 to 84 inches); 257 were dry wells; 174 were pipes connecting to stormwater drainage systems belonging to jurisdictions other than WSDOT.

BMPs were found on 1,128 outfalls, as follows:

87 catch basins	15 wet vaults
46 wet ponds	85 dry ponds
16 infiltration ponds	63 biofiltration swales
6 constructed wetlands	19 oil/water separators
4 "other"	2 dry vaults

Most of the BMPs were designed and constructed prior to the development of design standards. Many of the biofiltration swales and constructed wetlands were designed and constructed according to 1992 or later design standards.

Recommendations for other transportation departments considering a large scale inventory include:

1. Develop standardized protocols for inventory, prioritization, data collection, and data processing before collecting the data. Verify your procedures through the collection process.

2. Design data management and tracking systems with consideration of how the data will be used and what type of reports will be needed.

3. Determine acceptable levels of Global Position System precision before data are collected. Periodically verify accuracy of equipment.

4. Keep batteries fully charged and have spare batteries and parts readily available.

5. Collect and process data concurrently. People move on. Vegetation overgrows the outfall, making it difficult to locate previously identified outfalls.

6. Consider using portable computers to collect and enter data in the field.

FIELD SCREENING AND WATER QUALITY SAMPLING RESULTS

A protocol based on federal regulations was established to sample the outfalls for possible illicit connections (4). Sampling was conducted at outfalls where illicit connections or discharges were suspected, the main cause for suspicion being discharge after a period of dry weather. Each flowing site was sampled twice within a 24-hour period and was analyzed according to EPA-approved methods for the following physical and chemical parameters: color, odor, scum, floatables, turbidity, temperature, pH, chlorine, copper, phenols, and detergents.

The field screening process extended into fall and winter wet weather, and flows were observed at 380 outfalls and 11 suspected illicit connections. Of these flows, 76 outfalls and 11 suspected illicit connections were sampled. Elevated levels were detected at 19 outfalls and seven illicit connections. The rest of the flows were determined to be from natural sources, such as springs or a ground water table near the surface, with no visible signs of contamination, so sampling was not conducted. Physical observations and chemical analyses are as follows (note: elevated levels are concentrations at 0.2 mg/l or greater):

- Color - All samples appeared close to transparent in color.

- Odor - Odors were detected at six sites. These were either musty and rancid, strong petroleum, muddy, or sewage.

- Scum - Scum was recorded at seven sites, one of which was an illicit connection from a commercial area.

- Floatables - Eight sites had a petroleum sheen and one had algae associated with sewage. The source was believed to be a faulty septic system.

- Turbidity - The majority of the samples had low turbidity ratings; however, elevated levels of turbidity were recorded at nine sites.

- pH - The normal pH results ranged from 6.5 to 8.0. There were 10 outfalls and three illicit connections where the pH levels were outside this range.

- Chlorine - Elevated levels of chlorine, from 0.3 to 3.0 mg/l, were detected at three outfalls and one illicit connection from a commercial area.

- Copper - Elevated levels of copper, ranging from 0.25 to 2.0 mg/l, were detected at six outfalls and three illicit connections. Elevated levels from three of the outfalls and two of the illicit connections were located in King County. These may be from high concentrations of copper that occur naturally in the ground water in many parts of the county. Another possible source is leaching from copper in pipes.

- Phenols - Elevated levels of phenols were recorded, at 0.5 mg/l, at two outfalls and one illicit connection.

- Detergents - Elevated levels of detergents, from 0.2 to 0.9 mg/l, were detected at 12 outfalls and five illicit connections. At one of the illicit connections, detergents were also visible in the flow. The highest level (0.9 mg/l) was recorded at an illicit connection from a commercial area.

It was concluded that the field sampling process was not an effective method for discovering illicit connections. The most effective method is simple visual identification of connections to the WSDOT drainage system, and tracing these back to their sources off the right of way. No illicit connections were discovered by sampling alone. Sampling does not help in discovering illicit connections unless there are flows at the time of sampling. Instead, it may be more useful in providing additional confirmation of an already suspect site.

Illicit Connections

Illicit connections are unauthorized drainage structures that potentially convey non-stormwater discharges to, or through, the WSDOT drainage system from locations off the right of way. There are 99 connections so far that appear to be suspect and could potentially lead to water quality and quantity problems. Of these connections, 29 were discharges to open channels. These were considered to be illicit connections as a result of visual evidence of the nature of the discharges in the channels; e.g., heavy sediment loading from dredging or construction upstream. Fifty-six were discharges from culverts, ranging in diameter from 3 to 122 cm (1 to 48 inches). Seven were discharges into storm sewers.

Flows were observed at 27 of the illicit connections, and 11 of these were sampled. Elevated levels of either turbidity, pH, chlorine, copper, phenols, or detergents were found in the flows from seven illicit connections. All of these connections were located on highways in commercial/residential areas. The flows from the other 16 connections were considered to be from natural sources, with no visible evidence of contamination, and therefore were not sampled. The illicit connections were primarily located in urbanized areas. The 16 discharges were primarily located in rural areas. Additional investigation and/or periodic monitoring of these sites is recommended. For confirmed illicit connections, it is recommended that property owners be notified and either the connection be removed, or the flow be diverted to prevent it from entering the WSDOT drainage system. The other 66 suspected illicit discharges did not have flows at the time. In general, these appeared to be pipes or culverts that were directly connected to a commercial area or business.

The database of illicit connections produced by this inventory does not represent a comprehensive survey. Only those connections in close proximity to outfalls were observed. A complete inventory would entail walking the entire length of the state highway. Since this is not practical, it is recommended that when maintenance crews observe contamination or flooding problems, the area tributary to the problem site be surveyed. Given the minimal complaints received in the past, and the low number of illicit discharges discovered to date, it is concluded that contaminated illicit discharges are a minor problem.

RETROFIT PROGRAM

One of the primary goals of the Outfall Inventory and Field Screening project was to determine which areas of the drainage system have the greatest impact on receiving water bodies. Beginning with the 1995-97 biennium, WSDOT developed a new project category for constructing BMPs for existing highways where a need for stormwater management improvement has been identified. The stormwater retrofit category will provide funds for projects to construct BMPs at locations where no future improvements to the highway are anticipated. The WSDOT Agency Funding Request for the biennium was $4.6 million; however, no funds were appropriated. It has been estimated that the capital cost for stormwater retrofit projects in Puget Sound alone will require upward of $200 million over the course of twenty years (9).

The Legislative Transportation Committee (LTC) is currently reconsidering whether to continue funding stormwater utility fees charged by 20 municipalities. While this fee is only 30 percent of the actual fee charged to other like landowners, the LTC is concerned that the total of these fees, one million dollars, is not dedicated to priority WSDOT retrofit sites. Potential funding strategies will be presented to the Legislature by the Washington Chapter of the American Public Works Association-Stormwater Managers Section and WSDOT (10).

Prioritization Scheme

A prioritization scheme was developed to compare outfall impacts and rank sites for retrofit funding (9,11). The equation and factors used in making prioritization and BMP planning decisions were:

$(A + B) + (C \times D) + (E + F) =$ Rating Score

A = Water Body Type (ground water, small stream, small lake, sensitive wetland, large lake, river, wetlands and tidelands) and size of the receiving water body. A small stream is assigned a higher impact value than a large stream.

B = Beneficial Uses of the water body (in descending priority: drinking, public health, fisheries, aesthetics, and flood protection).

C = Pollutant Loading, which is in direct proportion to ADT.

D = Percentage contribution of highway runoff to the watershed.

E = Cost/Pollution Benefit, which weighs the overall cost of the BMP retrofit against its benefit to the receiving water body. This factor also incorporates a coefficient to consider the size of the water body as a measure of its sensitivity to pollution.

F = Values Trade-off, which assesses how local environmental and societal factors, such as legal obligations or local watershed action plans, influence the construction or maintenance of the BMP retrofit.

The initial step in the prioritization process was to make a "first cut" of all the outfalls inventoried. The outfalls were divided into high, medium, or low priority categories, based on the best professional judgment of the inventory crews. Outfalls in the high category were further evaluated according to factors A, B, C, and D in order to determine the highest priority group for further research (12).

To date, the 2,932 inventoried outfalls have been prioritized as follows: 498 high, 593 medium, and 1,841 low. Extensive research and evaluation of all six factors were conducted on the highest priority outfalls from within the high category, in order to rank these sites. Recommended BMP retrofits were developed for each of these outfalls, or groups of outfalls. A retrofit could include either constructing a new BMP (e.g., a biofiltration swale and wet pond) or modifying an existing structure (e.g., changing an asphalt-lined open channel to a biofiltration swale). The complete prioritization scheme was then applied to these sites to obtain a score and final rank.

Findings

So far, 498 high priority outfalls within the state have been researched and prioritized. One hundred sixty seven high priority outfalls are located in three NPDES permit areas; 35 of these are larger than 91 centimeters (36 inches). Of these, 35 outfalls are located within one of the three NPDES Puget Sound permit areas. The four highest ranked outfalls scored 72 points out of a maximum of 91, and were grouped together into one BMP retrofit site. This site is located on SR 5 in Whatcom County, and is tributary to Lake Samish, a public drinking water supply.

Prioritization of the outfalls is an ongoing process and rankings will change as more sites are prioritized and conditions such as funding and regulations change. However, from the results of the initial prioritization conducted for the 1995-97 budget process, the highest ranked sites typically:

- Are on the highways with the highest ADT, particularly SR 5.
- Threaten drinking water supplies.
- Drain tight-line storm trunk systems and discharge to headwater streams, contributing to erosion, sedimentation, and flooding downstream.

- Are dry wells discharging to a sole source aquifer, or
- Present a significant risk of hazardous spills entering a water supply.

HIGHWAY RUNOFF MANUAL

The Department of Ecology granted a two-year interim approval of the Highway Runoff Manual (HRM) in January 1995. The HRM establishes minimum requirements and provides technical, uniform guidance on how to avoid and reduce impacts to water resources (3). It contains the comprehensive listing, design standards, maintenance requirements, and other related information on stormwater BMPs. The HRM is a primary tool in planning for highway runoff management, because it assists with determination of cost-effectiveness, practicability, and applicability of the various stormwater BMPs available to treat highway runoff. The minimum requirements described in HRM address:

Erosion and Sediment Control	Wetland Protection
Preservation of the Natural Drainage System	Downstream Analysis
Source Control	Sensitive Areas and Basin Plans
Water Quality Treatment	Stormwater Site Plan
Water Quantity Treatment	

All new impervious surface will be treated to standard. Where existing pavement occurs within a project boundary, a practicality analysis will be done to determine if stormwater quality treatment will be provided. The analysis will be provided in the Stormwater Site Plan.

The manual is mandatory within the Puget Sound Basin and is used as guidance elsewhere in the state. Ecology is updating its Stormwater Management Manual for the Puget Sound Basin for statewide use in early 1997. In turn, WSDOT will incorporate new research findings and revise its HRM. If sampling results from experimental BMPs are positive, WSDOT can propose the BMP for inclusion in the manual.

WSDOT FUNDED RESEARCH PROJECTS

The amount and technical complexity of stormwater research at WSDOT have increased significantly. Most of the research projects are being led by principal researchers at Washington State University (WSU); however, WSDOT staff, consultants, and local units of government are also involved in several projects. Approximately 0.7 full time equivalent Water Quality Unit staff time per month is spent on work plan development and review, project planning, technical monitoring, equipment acquisition, data analysis, implementation plan

development, project coordination with principal investigators, and budgeting tasks. Project descriptions, budget, and the lead research organization are as follows:

1. *Assessment and Application of Highway Slopes for Highway Stormwater Contaminant Removal* - An examination of the mechanisms and effectiveness of vegetative strips occupying roadway cut and fill banks for the removal of highway runoff contaminants. $100,000 - WSU (13).

2. *Enhancing Contaminant Removal in Stormwater Detention Basins by Coagulation* - Scale model study of coagulant effectiveness in facilitating removal of suspended solids and associated heavy metals from highway stormwater detention basins. Implementation options are currently being examined. $72,000 - WSU (14).

3. *Development of Detention Basin Design Criteria by Scale Model Testing* - As a second phase to the coagulant study (above), solids settling rate effects facilitated by the addition of baffles to scale model stormwater detention basins were evaluated. WSU (14).

4. *Assessment of Groundwater Pollution Potential Resulting from Stormwater Infiltration BMPs* - Examination of three common soil types in Washington for competitive sorption interactions among four metals (zinc, copper, lead, and cadmium) typical of highway runoff and implications to ground water supplies. $122,600 - WSU (15).

5. *Treatment of Nonpoint Runoff Using Catalytic Pavement Borders* - Measuring the effectiveness of titanium dioxide, a powerful phototcatalytic oxidizer, as a pavement border in reducing the concentration of hydrocarbons in highway stormwater runoff. $75,000 - WSU (16).

6. *BMP Effectiveness Monitoring on the Ecology Ditch* - This experimental BMP is designed to remove pollutants through a combination of biofiltration and infiltration in roadside borrow and drainage ditches. $25,000 - David Evans & Associates (17).

7. *Construction Site Sampling at SR 18* - A King County grading permit condition requires daily sampling for turbidity and settleable solids. $32,000 (as of 12/95).

8. *Stormwater Retrofit Cost/Benefit Estimating Project* - Development of a weighted decision matrix that evaluates the cost/benefit relationship of BMP retrofit projects. $60,000 - WSU (18).

9. *Assessment of Relative Storm Runoff Control Advantages of Alternate Roadway Shoulder Pavements* - A King County, Washington project, partially funded by WSDOT, examined the relative water quality and roadway safety aspects of porous pavements for roadway shoulders. $90,000 - University of Washington (19).

10.

Filter Strip Field Evaluation - A project to obtain field data on the pollutant removal effectiveness of roadside vegetative filter strips constructed on WSDOT right of ways in King and Thurston Counties. $73,500 - WSU (20).

11.

BMP Evaluation for Handling and Treating Stormwater in Confined Situations - Evaluation of media for stormwater filtration units to be installed wherever space to build conventional BMPs is not available, such as bridges, ferry docks, shorelines, and urbanized areas. Sand, compost, diatomaceous earth, activated wood products, and various mixtures will be measured for pollutant removal efficiency and maintenance requirements. $75,000 - WSU (21).

12.

BMP Effectiveness Monitoring per NPDES Municipal Permit Requirements - A multi-jurisdictional project to coordinate data compilation from the BMP effectiveness monitoring being conducted by NPDES permitted jurisdictions. $47,000 (22).

13.

Wet Detention Pond Design for Highway Runoff Pollutant Control - National Cooperative Highway Research Program Project 25-12, granted in 12/95, will develop a rational, optimized design and operational protocol for wet detention ponds in highway environments. A computerized "expert system" will be developed to enable engineers and scientists to select optimized design criteria based on site parameters. $450,000 - WSU (23).

CONCLUSION

Stormwater Management Program Development has been underway for four years. This has consisted of identifying and communicating needs, obtaining funds, and initiating program elements. Methods for reporting progress and answering questions (How is the program working? Is it effective? How can it be improved?) are currently being evaluated and will be publicly debated during the approval process for the NPDES Stormwater Management Programs in the summer of 1996.

The overall effectiveness of a transportation department's stormwater management program can be measured by several factors:

- Compliance with HRM minimum requirements: adequate stormwater site plans are developed and implemented, variances are sought due to reasonable non-practicality situations.

- Retrofit: priority outfalls are retrofitted either through stand-alone projects or in projects associated with new construction (addition of new impervious surface).

- Compliance with NPDES Municipal and Construction Stormwater Permits: third party lawsuits are minimized.

- Ability to comply with water quality standards: efforts are made to reduce discharges to water bodies identified as not meeting state water quality, ground water, or sediment standards.

- Recognition of investments in stormwater facilities: evidenced by a commensurate increase in the maintenance budget for BMPs.

- Balance: stormwater investments are balanced with all the needs identified through a watershed planning effort; trade-offs between stormwater controls and other mitigation options, such as fish barrier removal or wetlands enhancement, are considered.

- Public and resource agency perception of progress: progress in developing and implementing a stormwater management program is evidenced by flexibility in permitting, the aggressiveness with which enforcement actions are pursued, and the joint cooperative efforts initiated between WSDOT and local, state, and federal agencies and the private sector.

Based on peer comments, it is generally recognized that WSDOT has made substantial progress in the area of water quality management but also has a long way to go, particularly in the area of retrofitting. The Water Quality Unit staff (permanent and temporary staff) has increased from one in 1993 to ten in 1995. The foundations for program success are in place; e.g., staffing, guidance material, training opportunities, data management, research, and executive management support. The major limiting factor for program expansion is a dependable funding source for retrofit projects. This budget element is tied to a proposed gas tax increase that was rejected by the Legislature. In addition, there currently is a major disconnect between building new BMPs and maintaining BMPs to ensure continued pollutant removal efficiencies.

It remains to be seen how much the NPDES municipal permits will dominate department priorities. Every effort is being made to balance program elements between permitted jurisdictions and statewide needs. Substantial resources are dedicated to administration of the permits. With regard to improving the program there are three areas to which resources should be redirected: implementation of erosion control plans, applying research findings, and incorporating watershed management into the project development process. Pilot projects and initiatives are now underway to address these areas (25, 26, 27, 28). Updates on WSDOT's Stormwater Program can be accessed through the WSDOT Internet Home Page (http://www.wsdot.wa.gov).

ACKNOWLEDGMENTS

The author wishes to thank Bert Bowen and Ed Molash for collating the data presented in this paper.

REFERENCES

1. Washington Department of Ecology. *NPDES Municipal Stormwater Permit for Cedar - Green, Island - Snohomish, & South Puget Sound Water Quality Management Area*. WSDOT 1995.

2. Washington Department of Ecology. *NPDES Municipal Permit Clarification of Permit Conditions*. WSDOT, 1995.

3. WSDOT. *Highway Runoff Manual*, 1995.

4. Washington Department of Ecology. *Stormwater Management Manual for the Puget Sound Basin*. 1992.

5. WSDOT, Water Quality Unit. *Draft Final Report Outfall Inventory and Field Screening Project*. 1995.

6. WSDOT, Water Quality Unit. *Outfall Inventory/Field Screening Form*. 1995.

7. WSDOT, Water Quality Unit. *Manual for Outfall Inventory and Field Screening Project*. 1993.

8. Hobbins, Mike. *Global Positioning System Protocol (Draft)*. WSDOT, Water Quality Unit, June 1995.

9. Entranco. *WSDOT Stormwater Runoff Management Overview*. WSDOT 1992.

10. Ficklin Environmental Services, et al. *Environmental Cost Savings and Permit Coordination Study*. Washington State Legislative Transportation Committee. 1994.

11. WSDOT, Water Quality Unit. *Prioritization Scheme for Retrofitting Highways with Stormwater BMPs*. 1994.

12. WSDOT, Water Quality Unit. *Manual For Research - Outfall Inventory and Field Screening Project*. 1994.

13. Washington State Transportation Center (TRAC)/WSU, Yonge, D., and G. P. Newberry, *The Retardation of Heavy Metals in Stormwater Runoff by Highway Grass Strips*. 3/96

14. TRAC/WSU, Hathorne, W., and D. Yonge. *Enhancing Contaminant Removal in Stormwater Detention Basins by Coagulation*, Draft final report, 9/95.

15. TRAC/WSU, Hathorne, W., and D. Yonge. *Assessment of Groundwater Pollution Potential Resulting from Stormwater Infiltration BMPs*, Draft final report, 9/95.

16.TRAC/WSU, Jones, A., and R. Watts. *Catalytic Pavement Borders,* Draft final report, 10/95.

17.David Evans and Associates. *Ecology Ditch Water Quality Monitoring,* WSDOT, 11/94.

18.TRAC/WSU, Barber, M. *Cost/Benefit Analysis of Stormwater Retrofits,* Project work plan, 6/95.

19.TRAC/WSU, Horner, R., and B. Mar. *Assessment of Relative Storm Runoff Control Advantages of Alternative Roadway Shoulder Pavements,* Interim report, 5/95.

20.TRAC/WSU, Hathorne, W., and D. Yonge. *Filter Strips and Ecology Ditch Monitoring and Assessment,* Project work plan, 11/95.

21.TRAC/WSU, Barber, M. *BMP Evaluation For Handling and Treating Stormwater in Confined Situations,* Project work plan, 12/95.

22.WSDOT. *NPDES Part 1 Permit Applications for Cedar - Green, Island - Snohomish, & South Puget Sound Water Quality Management Area,* 1995.

23.Yonge, D., M. Barber, W. Hathorne, and S. Chen. *Wet Detention Pond Design for Highway Runoff Pollutant Control,* NCHRP Grant Project 25-12 proposal, 11/95.

24.WSDOT. Draft *NPDES Permit Application for Clark County,* 1995.

25.Lynch, Patty, WSDOT, Water Quality Unit. *Water Quality Protection Measures for Highway Construction in Washington State,* (Paper approved for presentation at International Erosion Control Association's 1996 conference), 1995.

26.WSDOT, Research Office. *WSDOT Research Implementation Strategy,* 1995.

27.WSDOT, Water Quality Unit. *WSDOT Watershed Demonstration Project - The Snohomish Basin,* (Wetland protection grant proposal submitted to Environmental Protection Agency - Region 10), 1995.

28.WSDOT, Water Quality Unit. *Environmental Performance Elements, Construction Phase of WSDOT Projects,* 10/5/95.