USGS
science for a changing world

Prepared in cooperation with the Washington State Department of Transportation

Evaluation of the Washington State Department of Transportation Stormwater Monitoring and Effectiveness Program for 2014–19

Open-File Report 2020–1079

U.S. Department of the Interior
U.S. Geological Survey

Evaluation of the Washington State Department of Transportation Stormwater Monitoring and Effectiveness Program for 2014–19

By Craig A. Senter and Richard W. Sheibley

Prepared in cooperation with the Washington State Department of Transportation

Open-File Report 2020–1079

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

Suggested citation:
Senter, C.A., and Sheibley, R.W., 2020, Evaluation of the Washington State Department of Transportation stormwater monitoring and effectiveness program for 2014–19: U.S. Geological Survey Open-File Report 2020–1079, 11 p., https://doi.org/10.3133/ofr20201079.

ISSN 2331-1258 (online)

Contents

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)

Abbreviations

AADT	annual average daily traffic
BMP	best management practice
CAVFS	compost-amended vegetated filter strip
Ecology	Washington State Department of Ecology
EMC	event mean concentration
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbon
QAPP	quality-assurance project plan
RSMP	Regional Stormwater Monitoring Program
SAM	Stormwater Action Monitoring
TPH	total petroleum hydrocarbon
TSS	total-suspended solids
VFS	vegetated filter strip
WSDOT	Washington State Department of Transportation

Evaluation of the Washington State Department of Transportation Stormwater Monitoring and Effectiveness Program for 2014–19

By Craig A. Senter and Richard W. Sheibley

Abstract

The U.S. Geological Survey was asked by the Washington State Department of Transportation to provide technical assistance as a third-party reviewer of their stormwater effectiveness monitoring program during the transition between the completion of the 2014 Washington State Department of Ecology permit requirements and start of the new 2019 Washington State Department of Ecology permit requirements. For the purposes of this evaluation, the U.S. Geological Survey reviewed Washington State Department of Transportation's 2014 National Pollution Discharge Elimination System permit. This review focuses on sections S7, S8, G9, and appendix 4 of the permit that are specific to monitoring. These sections cover the methods of monitoring, the constituents that were monitored, laboratory requirements, reporting requirements, and data archival. Next, all quality-assurance project plans for the 2014 general permit and annual reports required for the permit were reviewed. The quality-assurance project plans and annual reports were reviewed to ensure that monitoring was executed and reported as required by the 2014 general permit. The monitoring requirements put forth from the permits were fully addressed in quality-assurance project plans and were completed and presented in the annual monitoring reports. Overall, the Washington State Department of Transportation monitoring program does not change much under its new 2019 permit. The Washington State Department of Transportation has followed through with the plan set out in each of its approved quality-assurance project plans and therefore, is in a good position to meet or exceed the new permit requirements in the upcoming 5-year permit cycle.

Introduction

The Washington State Department of Transportation (WSDOT) has developed a monitoring program in compliance with the Washington State Department of Ecology (Ecology) National Pollutant Discharge Elimination System (NPDES) and state discharge municipal stormwater general permits (Ecology, 2014). For the 2014 to 2019 permit cycle, the primary focus of the WSDOT monitoring program was to document the effectiveness of stormwater best management practices (BMPs) at five locations. The U.S. Geological Survey was asked to provide technical assistance as a third-party reviewer of WSDOT's stormwater BMP effectiveness monitoring program during the transition between the completion of the 2014 permit requirements and start of the new 2019 permit requirements. This report summarizes the evaluation of how adequately WSDOT's monitoring program fulfilled Ecology's permit requirements, as well as the scientific validity of the monitoring approach.

The approach to this technical review was done in three parts. First, specific requirements of WSDOT's stormwater monitoring program were identified by reviewing the 2014 NPDES general permit (Ecology, 2014). Second, all WSDOT quality-assurance project plans (QAPPs) associated with the NPDES general permit were reviewed to ensure that permit requirements were addressed, including documentation of any changes that were needed as the program progressed (Ecology and WSDOT, 2018, 2019; WSDOT, 2014a, 2016a, 2017a, 2018a). Lastly, the U.S. Geological Survey reviewed the WSDOT annual reports that were submitted to Ecology to ensure the monitoring required by the permit and proposed in the QAPPs was completed (WSDOT, 2014b,c,d, 2015b, 2016b, 2017b, 2018b,c,d). In addition, the WSDOT annual reports were examined to ensure reporting requirements outlined in section S8 of the 2014 NPDES general permit (Ecology, 2014) were completed.

Description of Permits

Monitoring objectives for WSDOT are outlined in sections S7, G9, and appendix 4 of the 2014 NPDES general permit (Ecology, 2014). These objectives included (1) continuing their monitoring program extended from the 2009 permit to establish baseline stormwater discharge information from highway conveyances for the remainder of the 2014 water year, (2) implementing a monitoring program to evaluate BMP effectiveness at facility monitoring sites, (3) continuing a monitoring program to evaluate BMP effectiveness at highway monitoring sites, and (4) participating in the Puget Sound status and trends monitoring component of the Regional Stormwater Monitoring Program (RSMP), now called Stormwater Action Monitoring (SAM). Participation in the RSMP program was new to the 2014 permits and allowed permitees to pay into a collective fund that would be used to conduct a regional monitoring program to study impacts from stormwater runoff rather than perform this monitoring individually. The RSMP/SAM program is administered by Ecology.

The 2014 general permit stated these monitoring programs should be implemented to produce scientifically credible and representative data, to provide information WSDOT can use to manage stormwater at its facilities, and to provide information WSDOT can use to refine Stormwater Pollution Prevention Plans and the Highway Runoff Model (Ecology, 2014).

Baseline Monitoring of Washington State Department of Transportation Highways

At the time of issuing the 2014 general permit, the WSDOT had not completed the requirement established by the 2009 general permit to characterize baseline stormwater discharges from its highways. Therefore, WSDOT was required to continue this work through September 2014 (WSDOT, 2014c) so that 2 years of data were collected as required under the previous (2009) permit. Baseline monitoring of highways from the 2009 general permit continued with the following range of locations and levels of annual average daily traffic (AADT):

- Two highly urbanized western Washington sites (≥100,000 AADT)
- One urbanized western Washington site (≤100,000 and ≥30,000 AADT)
- One rural western Washington site (≤30,000 AADT)
- One urbanized eastern Washington site (≤100,000 and ≥30,000 AADT)

The designated sampling method was a flow-weighted composite sample for qualifying storm events, except where the permit specifies grab samples (see below), to determine event mean concentrations (EMCs) of measured parameters. To accomplish the flow-weighted composite sampling, an automated sampler was programmed to begin sampling as early in the runoff event as practical and consist of at least 10 aliquots; however, samples with 7 to 9 aliquots were acceptable if they met the

other sampling criteria and helped characterize the range of storm events and storm sizes. Samples were obtained from the edge of the pavement or from a location within a pipe if the stormwater had not passed through a treatment BMP, a vegetated area, or the soil column. Parameters to be analyzed in the composite samples were listed in order of importance if an insufficient volume of sample was collected and included the following:

- Total and dissolved metals: copper, zinc, cadmium, and lead;
- Hardness;
- Polycyclic aromatic hydrocarbons (PAHs);
- Total-suspended solids (TSS);
- Chlorides (for indication of road salt application);
- Phthalates;
- Herbicides: Triclopyr (Ester formula only), 2, 4-Dichlorophenoxyacetic acid, Clopyralid, Diuron, Dichlobenil, Picloram, and Glyphosate (only if nonaquatic formula is used); and
- Nutrients: total phosphorus and orthophosphate.

In addition to the composite samples, grab samples for total petroleum hydrocarbons (TPHs): semivolatile petroleum products method NWTPH-Dx and volatile petroleum products method NWTPH-Gx, fecal coliform, temperature, and visible sheen observation should be collected as early in the runoff event as possible. Chemicals below the method detection limit after 2 years for both grab and composite samples may be dropped from this list. Lastly, herbicides are to be sampled and analyzed only if applied near the monitoring site vicinity; it was not a routine parameter for analysis.

Sample timing and frequency is detailed in the permits as well (WSDOT, 2014b,c,d). Storm events should be sampled early in the event and extend past time of concentration for the contributing area. For short storms (less than 24 hours), at least 67 percent of the storm should be sampled; and for storms greater than 24 hours, at least 75 percent of the first 24 hours of the storm event should be sampled. A qualifying storm event must meet the following conditions: rainfall depth of 0.15 inch minimum with no maximum; rainfall duration of more than 1 hour; storm start (antecedent dry condition) is a minimum of 6 hours with less than 0.04 inch of rain; storm end is the time when a minimum of 6 hours with less than 0.04 inch of rain began. In addition, details on the required number of samples and span of wet and dry season sampling include:

- 67 percent of forecasted storms are sampled, ranging from 11 to 14 events per year;
- Up to 20 percent of forecasted storms that did not meet the qualifying storm criteria can be reported and counted towards the event total; and
- Storm samples from the wet season (October 1 to June 30) should be collected during 60 to 80 percent of events in western Washington and 80 to 90 percent of events in eastern Washington.

The final monitoring requirement for the highway baseline monitoring is to conduct chemical testing of sediments in runoff. WSDOT is required to trap and analyze sediment during a single event in spring or summer of 2014 at each highway site. Parameters to be analyzed, in order of priority, if sufficient volume exists include the following:

- Particle size (grain size);
- Total organic carbon;
- Total metals: copper, zinc, cadmium, and lead;
- PAHs;
- TPH, NWTPH-Dx method;
- Phenolics;
- Herbicides: Triclopyr, Picloram, and Clopyralid, only if applied in the monitoring site drainage area;
- Phthalates;
- Total solids; and
- Polychlorinated biphenyls.

The 2014 permit (Ecology, 2014)required that reporting the results from baseline highway monitoring be included in the annual stormwater report due by October 31 and should include all storm event information, water-quality data, information on establishing rainfall/runoff relations at each site, calculation of EMCs and seasonal and annual pollutant loads, and any proposed changes to the monitoring program.

Monitoring the Effectiveness of Stormwater Treatment and Hydrologic Management Best Management Practices at Rest Areas, Maintenance Facilities, or Ferry Terminals

WSDOT was required to implement a monitoring program to evaluate BMP effectiveness at rest areas, maintenance facilities, or ferry terminals at 3 sites; 2 in western Washington and 1 in eastern Washington. This monitoring was to begin no later than October 1, 2016, with site approval done by March 6, 2016, and follow guidance from Ecology (2011) or International Stormwater Best Management Practices (2009) for preparing the BMP evaluation (WSDOT, 2014b, 2015b, 2016b, 2017b, 2018b).

This monitoring program was to continue until a minimum of 12 and maximum of 35 sample events from each site were collected. Samples were to be analyzed for TSS, TPH, metals (total and dissolved copper, zinc, cadmium, and lead), and nutrients at each maintenance facility and rest area. The permit required that reporting for this program be included in the annual stormwater report. It requires status updates for 2014–17, and full reporting in 2018 and annually thereafter until final reports for each BMP are submitted. Required report contents are the same as those for the highway monitoring program with the inclusion of information on BMP effectiveness calculations through the comparison of inlet and outlet samples.

Monitoring the Effectiveness of Stormwater Treatment and Hydrologic Best Management Practices at Highway Monitoring Sites

WSDOT was required by Ecology to continue from the previous permitting cycle (Ecology, 2014) to evaluate the effectiveness of its vegetated filter strip (VFS) and modified-VFS stormwater treatment and hydrologic BMPs for highway applications. The VFS effectiveness monitoring shall

continue until statistical goals of determining mean effluent concentration with 95-percent confidence and mean percent removal with 80-percent confidence are met. This could be achieved from a minimum of 12 and maximum of 35 sampling events as outlined in Ecology's TAPE guidance (Ecology, 2011).

In addition to the VFS program, WSDOT was required to begin implementing the next round of highway BMP effectiveness studies at two other sites by October 1, 2017. Evaluation of these additional sites should follow guidance from Ecology's TAPE program (Ecology, 2011) and International Stormwater Best Management Practices (2009) guidance. This highway BMP monitoring was required to follow the same statistical goals as VFS effectiveness monitoring. Reporting for this program is included in the annual stormwater report and includes status updates for 2014–17 and full reporting in 2018 and annually thereafter until final reports for each BMP are submitted. Required report contents are the same as those for the WSDOT facilities outlined previously (WSDOT, 2014c, 2015a, 2018a).

Status and Trends Monitoring

The 2014 general permit (Ecology, 2014) requires WSDOT to participate in the Puget Sound status and trends monitoring component of the RSMP/SAM program. The RSMP/SAM program is a permitee funded program to determine if stormwater BMPs are protecting receiving waters across Puget Sound. This was a new permit element in 2014 intended to replace traditional "end-of-pipe" monitoring that was previously required under the NPDES permits (WSDOT, 2015-2018b). WSDOT could satisfy this new permit requirement through one of three options: (1) pay into the collective SAM program monitoring fund, (2) coordinate and pay for adding dissolved organic carbon to monthly water-quality sampling and analysis of sediment pesticides (2,4-Dichlorophenoxyacetic acid, Dichlobenil, Diuron, and Triclopyr) in summer 2015 to the SAM program's small stream status and trends program, or (3) conduct monitoring of caged mussels nearby its 8 ferry terminals in the winter of 2015–16 and again in 2017–18. For this part of their permit, WSDOT chose option 2.

The 2014 general permit (Ecology, 2014) required all relevant data collected pursuant to S7 be stored in the Environmental Information Management Database, as well as the International Stormwater BMP Database in accordance with the Ecology-approved QAPPs. This includes information relating to outfalls, discharge points, and stormwater treatment/control facilities (including Underground Injection Control – UIC - facilities).

Review of Quality-Assurance Project Plans

All subsets of the general permit (Ecology, 2014) required the writing of QAPPs, which were completed for all sections of WSDOT's monitoring program. A QAPP is an agreed upon, approved document that explicitly identifies how a project will accomplish its objectives. In this case, the objectives are to meet the permit requirements in a scientifically defensible way. Two QAPPs were included in this review, one for the baseline monitoring of WSDOT highways (WSDOT, 2014a) and one for the facility BMP effectiveness monitoring program (WSDOT, 2016a). The QAPPs did not deviate from permit requirements for monitoring, field sampling, data collection, and equipment maintenance and cleaning. The QAPPs clearly state the methods and procedures for identifying, organizing, collecting, maintaining, and processing samples, equipment, and data in the field. There was a laboratory verification report in each QAPP, and it used the correct methods and reporting limits as specified in the permit (Ecology and WSDOT, 2019). Specific sections of each QAPP review are summarized below.

Baseline Monitoring of the Washington State Department of Transportation Highways

Completion of baseline monitoring laid out by the 2009–14 QAPP did not occur within that timeframe. Therefore, revisions to the original 2009 QAPP for baseline monitoring of WSDOT highways was revised to extend monitoring through the end of the 2014 water year. This aspect of the WSDOT program was an extension of the 2009–14 plan and did not apply to the full 5 years of the 2014 to 2019 permit cycle (Ecology, 2014).

Five sites were identified to satisfy permit requirements (WSDOT, 2014c, fig. 1). Two sites in Everett, Washington, fulfilled the highly urbanized western Washington criteria (≥100,000 AADT), 1 site in Pilchuck, Wash., fulfilled the urbanized western Washington criteria (≤100,000 AADT and ≥30,000 AADT), 1 site in Marysville, Wash., fulfilled the rural western Washington criteria (≤30,000 AADT), and 1 site near Spokane, Wash., fulfilled the urbanized eastern Washington criteria (≤100,000 AADT and ≥30,000 AADT).

The baseline monitoring QAPP described how storms are targeted; rainfall was monitored; samples were collected; sample points were identified; monitoring stations were configured; results were verified and validated; and data were managed and reported. There was no discrepancy between the parameters required by the baseline WSDOT highway monitoring permit (Ecology, 2014) and those outlined in the associated QAPP (WSDOT, 2014a; Ecology and WSDOT, 2019).

The QAPP adequately described all sampling protocols outlined under the general permit. Site-specific characterization of each site was determined through continuous sampling of rainfall, temperature, and stormwater flow every 5 to 15 minutes, as well as the use of automatic samplers for water quality samples. Grab samples were used to capture early runoff from storms but also to fill gaps in nonqualifying events. Lastly, annual sediment grab-composite samples were included.

Monitoring the Effectiveness of Stormwater Treatment and Hydrologic Management Best Management Practices at Rest Areas, Maintenance Facilities, Ferry Terminals, or Highway Monitoring Sites

Three facility BMP effectiveness monitoring sites were chosen to satisfy permitting requirements. The two sites in western Washington were Mottman Maintenance Facility in the city of Tumwater, Wash., and Lakeview Maintenance Facility in the city of Lakewood, Wash. The eastern Washington site was Geiger Maintenance Facility in the city of Spokane, Wash. The QAPP stated that data collection was to begin October 2016 with a minimum of 12 and a maximum of 35 sampling events conducted, which meets the permitting requirement. The QAPP (WSDOT, 2016a) listed the parameters to be sampled in four categories: highway characterization, BMP effectiveness (rest areas, ferry terminals, maintenance facilities), BMP effectiveness (highway), and bioswale research. Many of these sites are collocated across different permits there is some overlap regarding sampling designation.

The BMP effectiveness QAPP addressed all permit requirements and included documentation of changes to the original QAPP resulting from the ongoing BMP effectiveness monitoring. Two separate addendum documents were completed relating to the facility BMP QAPP (WSDOT, 2014a; Ecology and WSDOT, 2019). The use of addendums here shows a commitment to achieving project goals and making the necessary adjustments and (or) improvements to the project after closer review of ongoing monitoring or when unforeseen issues are noticed.

The first addendum (WSDOT, 2014) addressed the contributing areas covered by each of the three facility BMPs. It was noticed that the originally listed contributing areas did not match the actual area of catchment at the Lakeview Maintenance Facility. After a thorough ground truthing by WSDOT personnel of the actual catchment area at the Lakeview site, the area was reduced by almost 50 percent

from 4.01 to 2.56 acres. It was then determined that a similar review or ground truthing should be conducted at the other two facilities. This provided a reduction at the Geiger Maintenance Facility from 1.18 to 0.98 acres and confirmed the original area used for the Mottman Maintenance Facility.

The second addendum (Ecology and WSDOT, 2019) addressed qualifying storm criteria and how statistical data review is conducted. The qualifying storm criteria, both minimum rainfall and antecedent dry time, were removed. This came after reviewing 1 year of hydrology site data for the number of 24-hour periods with sufficient flow for sampling at the influent and effluent separately by WSDOT. They determined that there were insufficient qualifying events to meet the number of required samples. Instead, a random amount of sampling days that meet the minimum number of samples required by TAPE (Ecology, 2011) was assigned to meet the required number of samples. In addition, WSDOT states in this addendum that it will collect first flush data by targeting two storms during the dry season.

Review of Annual Reports

The final part of this review seeks to confirm that the annual reporting requirements from the permit were completed. All annual reports submitted from WSDOT to Ecology during the 2014 to 2019 period were reviewed (WSDOT, 2014b,c,d, 2015b, 2016b, 2017b, 2018b,c,d). Verifying requirements from the QAPPs that weren't subject to inclusion in annual reports; such as archival of field notes, calibration notes, laboratory quality-assurance samples, and other data archival would have been difficult to physically check because it was done by WSDOT internally. However, it was discussed with WSDOT personnel as something that was indeed completed. The reporting requirements for the baseline monitoring of highways and BMP effectiveness were in general the same but did vary slightly based on the unique nature of each program. The specific variations are discussed in the next two sections.

Reporting for Baseline Monitoring of Highways

Because baseline monitoring of highway runoff was only required to continue into late 2014, there were two annual reports submitted (WSDOT, 2014c, 2015a). Report year 2014 included all data from October 1, 2012, through September 30, 2013, and report year 2015 included cumulative data from October 1, 2012, through September 30, 2014. Both these reports had the same reporting requirements outlined in the 2014 general permit (Ecology, 2014):

- For each sampling event from each site:
  - Sample event identification (date, time, and location);
  - Tabular water-quality data and summary results for each monitored parameter including sediments;
  - Antecedent dry period, inter-event period, and total precipitation depth; and
  - A graphical representation of the storm's hyetograph and hydrograph, with aliquot collection points spatially located throughout the hydrograph; the sampled time period (percentage of hydrograph sampled), total runoff period and total runoff volume.
- Information establishing the rainfall/runoff relation using continuous flow records and precipitation data for each site.

- The following information for each parameter:
  - Mean and median EMCs only from sampled storm events;
  - Total annual pollutant load and seasonal pollutant load for the wet and dry seasons only from sampled storm events (expressed as total pounds and as pounds per acre);
  - rainfall/runoff relation established using continuous flow records and precipitation data (report year 2015 only);
  - The method used to estimate loads for unsampled events a (report year 2015 only).
- Proposed changes to the monitoring program that could affect future data results (report year 2014 only).
- An evaluation of each monitoring site's conditions related to sampling and monitoring strategies to collect representative data for each site.
- Stormwater management activities taken or planned to reduce pollutants.
- An estimated cost for the highway runoff monitoring.
- Review of the highway runoff annual reports confirmed that all these requirements were met.

Reporting for the Best Management Practice Effectiveness Monitoring

The reporting requirements for the BMP program were very similar to those for the highway runoff program. The following requirements were required in the annual reporting:

- For each sampling event from each site:
  - Sample event identification (date, time, and location);
  - Tabular water-quality data and summary results for each monitored parameter including sediments;
  - Antecedent dry period, inter-event period and total precipitation depth; and
  - A graphical representation of the storm's hyetograph and hydrograph, with aliquot collection points spatially located throughout the hydrograph; the sampled time period (percentage of hydrograph sampled), total runoff period and total runoff volume.
- The following information for each site:
  - Status of monitoring implementation and a description of the BMP monitoring programs still in progress at the end of the reporting year;
  - For treatment BMPs, cumulative (including previous years) performance data for each test site consistent with guidelines in appropriate sections of Ecology (2011) and International Stormwater Best Management Practices (2009) or the most recent version of these guidelines;
  - Status of cumulative (including previous years) performance data in terms of statistical goals for each test site;
  - If applicable, status of performance data concerning flow reduction performance for any hydrologic reduction BMP; and
  - Proposed changes to the monitoring that could affect future data results.
  - Specific recommendations or changes regarding BMP design or operations.
- Stormwater management actions taken or planned to reduce pollutants.
- For the final report (which is a compilation of each annual report for the 5-year cycle):
  - Analysis of all performance data, including pollutant removal calculations.
  - An estimated cost for the BMP effectiveness monitoring.

All the above reporting requirements were met for the BMP effectiveness program except for the following. One part of the study was abandoned due to repeated vandalism and theft. The compost-amended vegetated filter strip (CAVFS) site at Pilchuck, Wash., totaled about $18,000 before losses were cut and the site was discontinued. It is also stated that this CAVFS data were not reported due to the inability to compare influent data to the other vegetated filter strip sites, as well as the likely groundwater influence during rain events due to the nature of how the CAVFS effluent collectors were situated in the ground.

The report prioritized the parameters that were to be sampled. However, this is not identical to how the permit prioritized them. The annual report listed them in the following order: TSS, total copper/zinc, dissolved copper/zinc, particle size distribution, pH, total phosphorus, orthophosphate, and hardness; whereas the permit listed them total and dissolved copper, zinc, cadmium, and lead, hardness, PAHs, TSS, chlorides, phthalates, herbicides, and nutrients. There could be some confusion on the different programs, which protocols are being followed, or both. For example, if the TAPE protocol (Ecology 2011) supersedes the QAPP. Also, the general permit (Ecology, 2014) mentions that baseline monitoring will be completed in 2014, at which point there would be a re-prioritization of parameters of concern based on analysis of pollutant loads from collected data. There could be a clear statement explaining how each program prioritizes parameters. This is a suggestion to make a minor clarification, and not a failure to meet any permit requirement.

Each annual report has a section listing lessons learned. This allows for reflection and the improvement of data-collection efforts. In the final BMP annual report (Ecology and WSDOT, 2019), which includes all BMP annual reports from 2014 to 2019, seven lessons learned are listed:

1. Establishment of guidance documentation;
2. Reassessment of staff roles;
3. Changes to sampling deployment protocol;
4. Reassessment of the sampling infrastructure and maintenance;
5. Cross training of staff;
6. Include data analysis throughout the study; and
7. Conduct frequent site storm event observations.

There were four lessons learned listed for the final report for highway BMP monitoring program (WSDOT, 2015a):

1. More rigorous system cleaning routine and design;
2. Use of a decision matrix for storm forecasting;
3. Sampling staff (including alternates) should be clearly defined, and sample attempts should be tracked; and
4. Must have standard operating practices and use them.

Listing lessons learned also helps gain a better understanding of difficulties of achieving project requirements. One good example from the lessons learned section is taking specific, thorough field observations during storm events which is crucial to the understanding and success of any monitoring effort and is often overlooked.

Summary

The main purpose of this review was to verify that the permit requirements were addressed in the quality-assurance project plans, and that the annual reports match what was stated to be done in the quality-assurance project plans. The remainder of this review was ensuring the methods used were scientifically defensible. There were not very many discrepancies, which made the review straightforward. There seems to be a good framework to the way the monitoring effort addresses permit requirements. Important protocols of taking field notes, calibration notes, data archival, and laboratory quality-assurance samples, which were not required in the annual reporting, were confirmed through personal communication and were maintained and made available for review. Using standard procedures improves likelihood of achieving the goal of representative and repeatable data collection; and consistent use of these procedures should also limit the amount of lost, erroneous, or omissions of data. In the instance where permit required work was discontinued at the compost-amended vegetated filter strip site at Pilchuck, Washington, it was clearly stated why. In general, the lessons learned section is very useful for the progress of a scientifically defensible and adaptable monitoring program.

References Cited

International Stormwater Best Management Practices (BMP), 2009, Urban stormwater BMP performance monitoring: Report prepared by Geosyntec Consultants and Wright Water Engineers, Inc., 335 p., plus appendixes, accessed March 2019, at http://www.bmpdatabase.org/Docs/2009%20Stormwater%20BMP%20Monitoring%20Manual.pdf.

Washington State Department of Ecology [Ecology], 2011, Technical guidance manual for evaluating emerging stormwater treatment technologies—Technology assessment protocol – ecology (TAPE): Olympia, Wash., Washington State Department of Ecology, Water Quality Program, 73 p. accessed March 2019 at https://fortress.wa.gov/ecy/publications/SummaryPages/1110061.html.

Washington State Department of Ecology [Ecology], 2014, Washington State Department of Transportation National Pollutant Discharge Elimination System and state waste discharge municipal stormwater general permit: Olympia, Wash., Washington State Department of Ecology, permit number WAR043000A, 99 p. [Also available at https://fortress.wa.gov/ecy/ezshare/wq/permits/WSDOT2014FinalPermit.pdf.]

Washington State Department of Ecology [Ecology] and Washington State Department of Transportation [WSDOT], 2018, Quality assurance project plan for WSDOT facility stormwater treatment evaluation—Best management practices (January 2018 addendum to the March 2016 ver.): Olympia, Wash., Washington State Department of Transportation, 8 p.

Washington State Department of Ecology [Ecology] and Washington State Department of Transportation [WSDOT], 2019, Quality assurance project plan for WSDOT facility stormwater treatment evaluation—Best management practices (January 2019 addendum to the March 2016 ver.): Olympia, Wash., Washington State Department of Transportation, 6 p.

Washington State Department of Transportation [WSDOT], 2014a, Quality assurance project plan for baseline monitoring of WSDOT highway runoff (July 2014 addendum to the March 2014 rev.): Olympia, Wash., Washington State Department of Transportation, 68 p. [Also available at https://www.wsdot.wa.gov/publications/fulltext/design/Final_QAPP_Hwy_Update.pdf.]

Washington State Department of Transportation [WSDOT], 2014b, WSDOT NPDES municipal stormwater permit BMP effectiveness monitoring report (S7, S8, G9, appendix 4) water year 2013: Olympia, Wash., Washington State Department of Transportation, 123 p.

Washington State Department of Transportation [WSDOT], 2014c, WSDOT NPDES municipal stormwater permit highway runoff characterization report (S7.B) water year 2013, Olympia, Wash., Washington State Department of Transportation, 198 p.
Washington State Department of Transportation [WSDOT], 2014d, WSDOT NPDES municipal stormwater permit rest areas, maintenance facilities, and ferry terminals stormwater monitoring report (S7.D) water years 2012 and 2013: Olympia, Wash., Washington State Department of Transportation, 198 p.
Washington State Department of Transportation [WSDOT], 2015a, WSDOT NPDES municipal stormwater permit final highway runoff characterization report (S7.B) water years 2012 to 2014: Olympia, Wash., Washington State Department of Transportation, 426 p.
Washington State Department of Transportation [WSDOT], 2015b, WSDOT NPDES municipal stormwater permit BMP effectiveness monitoring status report (S7.C and S7.D) water years 2012–2014: Olympia, Wash., Washington State Department of Transportation, 231 p.
Washington State Department of Transportation [WSDOT], 2016a, Quality assurance project plan for WSDOT facility stormwater treatment evaluation—Best management practices: Olympia, Wash., Washington State Department of Transportation, 244 p.
Washington State Department of Transportation [WSDOT], 2016b, WSDOT NPDES municipal stormwater permit BMP effectiveness monitoring status report (S7.C and S7.D) water years 2012–2015: Olympia, Wash., Washington State Department of Transportation, 205 p.
Washington State Department of Transportation [WSDOT], 2017a, Quality assurance project plan for WSDOT embankment hydrology monitoring: Olympia, Wash., Washington State Department of Transportation, 48 p.
Washington State Department of Transportation [WSDOT], 2017b, WSDOT NPDES municipal stormwater permit BMP effectiveness monitoring status report (S7.C and S7.D) water years 2012–2016: Olympia, Wash., Washington State Department of Transportation, 286 p.
Washington State Department of Transportation [WSDOT], 2018a, Quality assurance project plan for WSDOT roadway stormwater treatment evaluation—Modified vegetated filter strip: Olympia, Wash., Washington State Department of Transportation, 228 p.
Washington State Department of Transportation [WSDOT], 2018b, WSDOT NPDES municipal stormwater permit BMP effectiveness monitoring status report (S7.D) water years 2012–2018: Olympia, Wash., Washington State Department of Transportation, 93 p.
Washington State Department of Transportation [WSDOT], 2018c, WSDOT NPDES municipal stormwater permit compost-amended bioswale monitoring status report (S7.C) water years 2017–2018: Olympia, Wash., Washington State Department of Transportation, 33 p.
Washington State Department of Transportation [WSDOT], 2018d, WSDOT NPDES municipal stormwater permit embankment hydrology monitoring status report (S7.D) water years 2017–2018: Olympia, Wash., Washington State Department of Transportation, 25 p.

Publishing support provided by the U.S. Geological Survey
Science Publishing Network, Tacoma Publishing Service Center

For more information concerning the research in this report, contact the
Director, Washington Water Science Center
U.S. Geological Survey
934 Broadway, Suite 300
Tacoma, Washington 98402
https://wa.water.usgs.gov

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20201079