Selection of Stormwater Action Monitoring Studies 2015-2024

These BMP effectiveness studies and source control projects have information relevant to stormwater management in Eastern Washington:

- **Bioretention reduction of toxicity to Coho salmon from urban stormwater**
- **Illicit discharge detection and elimination (IDDE) data evaluation for Western Washington**
- **Business Inspection Stormwater Source Control Effectiveness Study**
- **Bioretention Media Blends to Improve Stormwater Treatment: Final Phase of Study to Develop New Specifications**
- **Bioretention Capture Efficacy of PCBs from Stormwater**
- **2020 Update to the Illicit Connection and Illicit Discharge (IC-ID) Field Screening and Source Tracing Guidance Manual**
- **Regional Spill Hotline Feasibility Study**
- **The Effects of Mulch on Stormwater Treatment and Maintenance Effort in Bioretention Systems**
- **Designing and Evaluating Behavior Change Marketing Campaigns**
- **Stormwater Particle Size Distribution (PSD) & Implications for BMP Effectiveness**
- **Business Source Control & Inspection Program Guidance**

For more information about SAM visit our website: www.ecology.wa.gov/SAM

Stormwater Action Monitoring

Bioretention reduction of toxicity to Coho salmon from urban stormwater

Effectiveness Study

Lead Entity

Puget Sound Stormwater Science Team

Partners

U.S. Fish and Wildlife Service

NOAA-Fisheries

Washington State University

Suquamish Tribe

Collectively improving stormwater management

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation. SAM's goal is to improve stormwater management to reduce pollution, improve water quality, and reduce flooding. We do this by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Questions about SAM? Send an email to SAMinfo@ecy.wa.gov

Study questions

Bioretention is a common choice for stormwater treatment (filtration through an engineered soil mix) and infiltration in Washington State.

- Is the standard 60% sand 40% compost (60:40 mix) bioretention soil media (BSM) specified by Ecology's stormwater management manual effective enough to prevent toxic impacts of urban runoff from multiple storms to Coho salmon adult spawners and embryos?
- Do contaminants leached from the BSM contribute to water quality problems?

Stormwater management problem

Bioretention is shown to be a highly effective means of reducing many pollutants in stormwater runoff, especially contaminants associated with particulate matter. Bioretention treatment prevented toxicity from road runoff in a single test with juvenile Coho, mayfly nymphs, and daphnia. Pilot work filtering stormwater runoff through bioretention soil media columns showed reductions in metals and PAHs. Recent work has shown that toxicity of road runoff to developing fish is associated with dissolved contaminants rather than particulates.

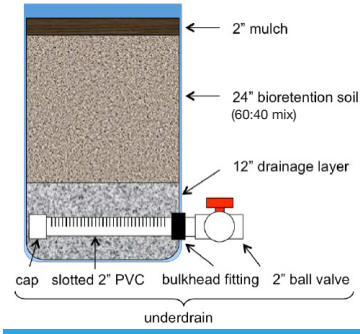


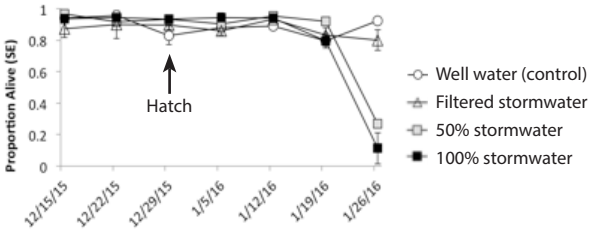
Diagram of bioretention unit using 55-gallon drum.

The 60:40 mix commonly used contains bacteria, nutrients, and metals that are sometimes leached out during stormwater treatment. There is concern that bioretention may be exacerbating water quality problems in some settings, particularly in salmon spawning streams and in lakes and other phosphorus-sensitive water bodies.

Project findings

Installing green infrastructure with bioretention treatment cleans urban stormwater runoff sufficiently to help protect sensitive life history stages of salmon species. Results showed the standard BSM provides adequate treatment across numerous storms. Bacteria, nutrients, metals, and polycyclic aromatic hydrocarbons (PAHs) were measured before and after filtration. Concentrations of all of these contaminants except arsenic, nickel, and nutrients were lower in filtered stormwater than in untreated stormwater for the same storm event.

Filtering stormwater through BSM prevents lethal stormwater impacts to adult Coho spawners. Unfiltered stormwater killed 100% of Coho exposed in these experiments, while 100% of Coho exposed to filtered stormwater survived. Bioretention filtration also prevented mortality in Coho embryos episodically exposed to urban stormwater runoff. However, some sublethal effects were observed. Untreated stormwater induced a gene responsible for PAH detoxification (*cyp1a*) on all sampling dates, with the highest induction during exposure and somewhat lower levels on days with clean water. Filtered stormwater rarely induced *cyp1a*. Evidence of cardiac stress (induction of the gene *nppb*) was only present during exposure to runoff, not days with clean water; however filtration through bioretention did not prevent *nppb* induction. The same chemicals may not be triggering the PAH detox and the cardiac stress.



Survival of Coho embryos in unfiltered stormwater runoff was high from fertilization until after hatching, when most coho died. Mortality in hatched coho was high in both diluted and undiluted unfiltered stormwater. By contrast, there was very little mortality among embryos in well water (the control) and in the filtered stormwater.

There was a net export of arsenic, nickel, nitrogen, and phosphorus from the BSM, with low concentrations that were higher in the effluent than influent water across the ten treatment events. Although the BSM also contained measurable amounts of other metals, there was a net removal of zinc, copper, chromium, lead, and cadmium from runoff. Most importantly, the study found that sufficient dissolved organic carbon is released from BSM to bind dissolved copper and make it biologically unavailable. More than half of the untreated stormwater samples were predicted to be neurotoxic, whereas none of the BSM filtered stormwater samples were predicted to be neurotoxic. BSM filtration also reduced bacteria. PAHs were always reduced by bioretention treatment, showing an overall 91% reduction. There was no apparent loss of chemical performance after repeated treatment of highway runoff through bioretention.

Recommendations

Bioretention filtration of urban stormwater runoff can prevent pre-spawn mortality in adult Coho salmon during 24 hour exposures and eliminate toxic impacts to Coho embryos developing in episodic exposure to runoff. Assessing the biological benefits of bioretention to receiving waters is mentioned only at the basin scale in the recent review. In contrast, biological impacts should be incorporated at smaller scales in order to increase the likelihood of ecological success as we move towards larger and more comprehensive installations.

Why does this study matter?

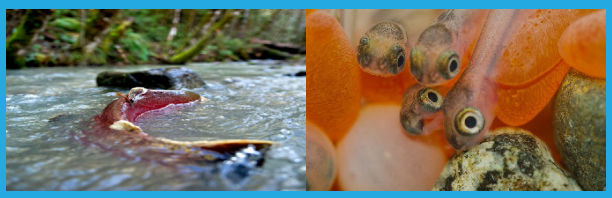
Untreated stormwater has been found responsible for Coho salmon pre-spawn mortality in streams in our region; stormwater also causes numerous sublethal effects. Bioretention is a promising solution to this problem. Knowing that the required treatment practices are protective of embryos and adult spawners provides confidence in widespread application of bioretention. These results confirm that treating stormwater using bioretention with the standard 60:40 mix prevents toxic and lethal effects to Coho salmon.

What should we do with this information?

Stormwater managers should continue to install bioretention systems as opportunities arise. Permittees should implement Ecology's guidance for applying bioretention to projects in Western Washington. Bioretention treatment with BSM can be incorporated at any scale, even very small scales, when planning stormwater retrofit projects. Permittees should encourage developers to include bioretention in all site plans for new development, redevelopment, and retrofit projects where bioretention is feasible.

What will Ecology do with this information?

Ecology's stormwater management manual will continue to specify the 60:40 mix as the standard BSM for bioretention. Ecology will continue to discourage underdrains below bioretention facilities due to the lack of flow control and likelihood of transporting nutrients to receiving waters. Meanwhile, stormwater management continues to evolve and Ecology will continue to support studies to improve BSM to reduce nutrient export and not increase toxicity.



For more information

See the project website at www.ecology.wa.gov/SAM for the full report and other SAM effectiveness studies.

Stormwater Action Monitoring

Illicit discharge detection and elimination (IDDE) data evaluation for Western Washington

Source Identification

Lead Entity

City of Lakewood

Partners

Aspect Consulting, Cardno, Inc.

WA Dept. of Ecology Water Quality Program

Collectively improving stormwater management

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Study goals

The goals of the project were to:

1. Compile a regional dataset of illicit discharge detection and elimination (IDDE) activities by municipal stormwater permittees; and
2. Analyze the data to: provide information about the most common problems; compile the source identification and elimination methods in use; and find opportunities for regional solutions to common problems and support permittees' IDDE programs.

Photo credit: Diana Halar, City of Lakewood

Stormwater management problem

Municipal stormwater staff invest a substantial amount of time investigating and addressing potential illicit discharges to their storm sewer systems. They encounter many different types of problems that require unique approaches. Over the past decade of implementing IDDE programs, stormwater staff have gained a general sense of the most common problems in their jurisdictions. A collective summary of permittees' IDDE activities helps the region to set overall priorities and secure funding to enhance efforts to address sources of stormwater pollution.

Project findings

Permittees throughout Western Washington reported 2,913 illicit discharge detection and elimination (IDDE) incidents for the 2014 calendar year. Fifteen permittees reported zero illicit discharges or illicit connections during this time period. The evaluation compared counts of record types and incident characteristics. About two-thirds of the Phase I records and about one-fifth of the Phase II records came from just two cities. Much of the data summary and analysis was weighted toward these cities' programs. Statistical analysis was done to quantitatively compare all permittees' records.

The most common stormwater pollution problems were petroleum hydrocarbons and other vehicle fluids from spills and accidents, sediment from construction sites and flooding, chemicals from industrial activities, and sewage from illicit connections.

Most of the incidents were reported directly by the public via pollution hotline calls and other citizen complaints. Municipal staff observations during inspections resulted in the second highest number of reports. A significant number of the incidents permittees responded to were not illicit discharges to the stormwater system; these included allowable discharges, solid waste dumping, and unconfirmed complaints. Permittees will continue to spend time and effort responding to such calls.

Permittees most commonly traced sources using visual indicators and empirical methods, which included visual reconnaissance, field observations, and mapping analysis. Problems were most commonly corrected and eliminated using best management practices (BMPs) such as adding or improving source control, cleaning up spills, education, technical assistance, and behavior or operational modification.

Enforcement was used in relatively higher proportion for Phase I jurisdictions than for Phase IIs. Incident response times were mostly within one to three days on average and resolution times were mostly under eight days for Phase I permittees and up to 53 days for Phase II permittees. Almost all of the 59 illicit connections reported were resolved within six months.

Recommendations

A regional dataset provides objectivity to understand and therefore address the most common IDDE problems encountered by municipal stormwater permittees. The entry of data for this evaluation from permittee submittals was a time-consuming process that would be more efficient with standardization of information that permittees report. An expanded and improved list of standard data fields and entry options was developed through this project to provide consistent and richer data while not increasing the time needed for data entry by permittees.

Knowing the relatively large number of incidents related to vehicle spills and accidents, we should consider enhanced efforts to educate transportation accident responders such as tow truck drivers and police on the use of spill kits and the importance of timely reporting. We should place more spill kits in emergency response vehicles and in businesses. Ecology and local jurisdictions should consider more frequent and proactive construction inspections to reduce the incidents of sediment leaving those sites.

Why does this study matter?

The goal of stormwater management is to protect receiving waters and biota. These results confirm that collectively, the large number of small spills from vehicles and incidents of sediment runoff from construction sites are likely posing a threat to these public resources. Local jurisdictions may need assistance from a regional effort to make meaningful headway to reduce these types of pollution. This type of objective data – rather than a collection of anecdotes – is needed to set priorities for regional activities. Standardized data from permittees will provide even more basis for regional action.

What should we do with this information?

Stormwater managers should consider prioritizing education and outreach campaigns and staff training programs around the most common stormwater pollution problems in their jurisdictions. Permittees should keep good records to support enforcement actions and to explain the value of their IDDE programs to their councils and commissions.

What will Ecology do with this information?

Ecology will use these findings to drive priorities for funding requests that support permittees' IDDE programs and address common IDDE problems. Ecology will continue to invest in developing tools and technologies to identify, prevent, and reduce illicit discharges from various sources and support permittees' efforts to keep pollution from entering stormwater systems. Ecology has already assisted many permittees in making needed improvements to their record keeping and reporting, and has proposed a detailed municipal stormwater permit requirement to improve and standardize future reporting. Ecology is committed to supporting the regional effort to collect and maintain a consistent dataset to inform regional funding priorities.

For more information

Visit the SAM website at www.ecology.wa.gov/SAM and search for "IDDE data analysis report."

Stormwater Action Monitoring

Business Inspection Stormwater Source Control Effectiveness Study

Effectiveness Study

Lead Entity

City of Lakewood

Partner

Aspect Consulting LLC, Cardno Inc.

Collectively improving stormwater management

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Study goals

This study's goals were to compile and analyze data from permittees' business inspections to identify:

- Which types of businesses are inspected;
- What best management practices (BMPs) are implemented well;
- What BMPs need improvement;
- Which business types need follow-up inspections to achieve proper and consistent BMP use; and
- Other factors that make stormwater source control inspections effective.

Stormwater management problem

Businesses with activities that can potentially cause stormwater pollution need to understand the value and effective use of stormwater source control and treatment BMPs. Some business sectors with high potential to pollute also have substantial employee turnover and untrained staff. This can lead to a lapse in implementation and maintenance of BMPs, resulting in polluted runoff entering the stormwater system. Stormwater managers can more effectively use staff time for these pollution prevention efforts if they know types of businesses to inspect, inspection frequency, which BMPs are most likely to be issues, and the most needed technical assistance.

Project findings

The study gathered survey responses from municipal stormwater permittees in western Washington. More than 47,300 inspection records were analyzed from 40 jurisdictions, Ecology's Local Source Control Partnership (LSCP), and the Urban Waters Initiative. The 27 types of businesses in the records were grouped into six business categories. The three most frequently inspected categories where:

- **Auto/boat**: vehicle sales, repair, maintenance, transportation, and fueling;
- **Food/retail**: food stores, restaurants, food production, and hotels; and
- **Land usage**: construction, recreation, and landscaping.

Inspection frequencies ranged from eight to 16 months. The auto/boat category had the most frequent inspections and it also had the most follow-up inspections focused on BMPs for cleaning and washing and for storing and covering materials to prevent leakage, spills, or contact with precipitation.

Other issues repeatedly identified across many business types included BMPs for housekeeping, spill planning, and transfer of materials. Regular attention to proper BMP use and BMP maintenance during inspections will likely help reduce the potential for lapses in proper BMP implementation and increase overall environmental compliance.

Recordkeeping by the permittees doing inspections is inconsistent due to the non-prescriptive approach in the municipal stormwater permits. The data from the LSCP were of consistent quality and completeness per the program requirements and easily evaluated.

Recommendations

Inspect businesses with outdoor activities and all those in the auto/boat, food/retail, industrial, and land usage categories. Assess the risk of pollution potential at each business and inspect high-risk businesses annually or every other year. Where issues are identified, revisit those businesses more often (monthly or quarterly) until the problem is resolved.

Standardize record-keeping. Collect these basic data during business source control inspections:

- Date and type of inspection (full inspection, screening, or follow-up);
- Specific types of operational, structural, and treatment BMPs in use;
- BMP maintenance records;
- Type of technical assistance provided during the inspection; and
- Reasons for lack of BMP implementation, *e.g.*, financial burden, need technical assistance, or maintenance issues.

Consider developing a system for inspectors to evaluate businesses' overall compliance. This could be done by scoring each specific BMP type as to its effective and proper use at the site on a numeric scale from 1 to 5.

Evaluate data collected under source control programs to learn from past efforts and advance stormwater source control efforts.

Do a follow-up study to determine the most optimum inspection frequencies for specific business types. This will also answer questions about barriers to BMP compliance, the most effective technical assistance in the LSCP program, and the optimum inspection frequencies for existing business inspection programs.

Why does this study matter?

Many types of businesses have the potential for illicit discharges and spills into municipal stormwater systems. This study informs stormwater managers about past inspection efforts and makes recommendations for ways to create or improve permittees' business inspection programs. The results help permittees and permit writers focus their efforts for the greatest potential impact: preventing stormwater pollution at its source.

What should we do with this information?

Stormwater managers should use the outcomes of this study to inform, refine, and improve the effectiveness of their source control efforts. This study can help permittees determine their staffing needs and priorities for where to inspect, how often to conduct inspections, and what to look for. Being prepared for possible spills is important, but so is proper materials storage and BMP maintenance. Municipal stormwater permittees who do not already have business inspection programs should consider prioritizing screening level inspections of the auto/boat, food/retail, industrial, and land usage types of businesses that exist in their jurisdictions. Permittees with existing inspection programs should consider optimizing inspection frequencies based on the findings of this study and their own records. The information can also be used to develop tailored education and outreach materials.

What will Ecology do with this information?

Based on the success of the Phase I permittees' business inspection programs and the LSCP technical assistance program, Ecology has proposed adding business source control inspections to Phase II permits. The recommendations from this study will help inform both a source control program requirement for the Phase II permit and future SAM studies to continue to improve the programs. Ecology encourages standardization of recordkeeping protocols for inspections. Future analyses will support data-driven adaptive management of permittees' Stormwater Management Programs. Ecology will continue to support the LSCP statewide and encourage coordination of LSCP technical assistance and any necessary follow-up or enforcement actions.

For more information

Go to ecology.wa.gov/SAM and search for SAM Business Source Control Survey.

Stormwater Action Monitoring

Bioretention Media Blends to Improve Stormwater Treatment: Final Phase of Study to Develop New Specifications

Effectiveness Study

Lead Entity

King County

Partners

Herrera Environmental Consultants

Washington State University

Western Washington University (Institute for Watershed Studies and Environmental Toxicology)

Collectively improving stormwater management

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Study goals

This project developed a new bioretention soil media (BSM) specification that achieves the following treatment objectives, in order of priority:

1) Meets basic treatment objectives (80% removal for total suspended solids)
2) Meets enhanced treatment objectives (30% removal for dissolved copper and 60% for zinc)
3) Meets the phosphorus treatment objectives (50% phosphorus removal)
4) Is affordable and available
5) Reduces stormwater toxicity for aquatic organisms

Healthy plant growth was also important so that bioretention installations, which are often placed in urban street settings, are an attractive landscape amenity.

Stormwater management problem

Bioretention is a widely applicable and flexible best management practice (BMP) in the suite of stormwater treatment practices. The current Stormwater Management Manual for Western Washington specification for BSM is a mixture of 60% sand and 40% compost (60:40). Nitrogen, phosphorus, and copper are often exported from the current 60:40 BSM mixture. This can increase concentrations of these pollutants in the BMP outflow, which is a concern for sensitive surface waters.

Project findings

This column-scale study tested eight experimental BSM treatments using stormwater from a regional highway. Influent stormwater was compared to effluent from each BSM blend for total suspended solids (TSS), total and dissolved copper (Cu), lead (Pb), and zinc (Zn), total phosphorus (TP), orthophosphorus (ortho-P), nitrate + nitrite, fecal coliform bacteria, polycyclic aromatic hydrocarbons (PAHs), and total petroleum hydrocarbons (TPH).

Only one experimental blend, an 18-inch layer of sand, coir, and biochar placed on top of a 12-inch polishing layer of sand, activated alumina, and iron aggregate (Treatment 4 in the study), provided adequate pollutant capture to meet the study objectives. This blend provides the basis of the study's final recommendation. The other experimental blends had the following results:

- **Treatment 1:** An 18-inch layer of 60:40 placed on top of a 12-inch drainage layer of pure sand exported TP, ortho-P, nitrate + nitrite, and total and dissolved Cu.
- **Treatment 2:** An 18-inch layer of 60:40 placed on top of a 12-inch polishing layer of sand, activated alumina, and iron aggregate performed better than 60:40 on pure sand due to the polishing layer capturing contaminants flushing from the compost-based media. However, the polishing layer could not fully mitigate the TP, ortho-P, and nitrate + nitrite from the 18 inches of 60:40.
- **Treatments 5 and 6:** Both sand, coir, and biochar placed on top of a pure sand drainage layer met basic treatment (80% TSS reduction) and enhanced treatment (30% reduction of dissolved Cu and 60% dissolved Zn reductions objectives). They did not meet study objectives for ortho-P or TP removal.
- The other four treatments did not achieve study objectives.

In the toxicological evaluations, most of the treatments prevented the anticipated toxic impacts to *C. dubia* and *D. rerio* to a similar degree in four dosing experiments. However, for yet unknown reasons, the treatments lost some of the preventative benefit during the final dosing event.

Recommendations

An alternative BSM specification is recommended which includes a cost-effective combination of media blends or layers to meet water quality treatment objectives. Combined, the primary and polishing layers meet Ecology's basic, enhanced, and phosphorus treatment objectives. The primary layer alone (sand–coir–biochar) meets basic and enhanced treatment objectives. The polishing layer should be used if reducing phosphorus by 50% is required or desired. The compost mulch overlay ensures robust plant growth. Specifications for the components of the recommended blend layers are provided in the final report.

Table 1: Application of New Bioretention Soil Media (BSM) Layers

	Basic Treatment	Enhanced Treatment	Phosphorus Treatment	Expanded Plant Palette & Growth
Primary layer of 70% sand/20% coir/ 10% high-carbon wood ash (biochar)	X	X		
Primary layer plus polishing layer of 90% sand/7.5% activated alumina/ 2.5% iron aggregate	X	X	X	
Primary plus polishing layer plus compost mulch[1]	X	X	X	X

[1]For surface-draining bioretention facilities, do not use the primary layer alone with compost mulch, without the polishing layer, because the BSM will export phosphorus and nitrogen. For compost specifications, see SWMMWW BMP T7.13 Bioretention which refines the Washington State compost specifications (WAC 173-350-220)

Why does this study matter?

The export of nutrients and copper from bioretention with the current BSM specification is an increasing concern for facilities with underdrains or those in proximity to sensitive receiving waters. A new BSM specification that meets Ecology's basic, enhanced, and phosphorus treatment objectives greatly expands the settings where designers and jurisdictions can confidently apply bioretention systems to manage stormwater runoff. In addition, the study provides treatment information for copper, zinc, nitrate + nitrite, fecal coliform, PAHs, and TPH.

What should we do with this information?

Stormwater managers should share this information with their project engineers and review staff as well as with local designers. The 60:40 BSM is still appropriate for use in most areas when surface discharges from bioretention are not needed. The new BSM specification is intended for projects in areas that are sensitive to phosphorus or nitrogen, or where bioretention facilities with underdrains are likely to be installed.

What will Ecology do with this information?

Given this new information, Ecology will update the Focus Sheet on BSM specifications (Ecology Publication #13-10-017, last revised in May 2016) to include final specifications for this new BSM in addition to the current 60:40 BSM.

Want more information?

Visit the SAM website at ecology.wa.gov/SAM and search for "Bioretention Alternative Blend"

Stormwater Action Monitoring

Bioretention Capture Efficacy of PCBs from Stormwater

Effectiveness Study

Lead Entity

King County Department of Natural Resources and Parks

Partners

Washington State University

United States Fish and Wildlife Service

Collectively improving stormwater management

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Study goals

Bioretention is a widely applicable and flexible best management practice (BMP) in western Washington and the fate of organic pollutants such as polychlorinated biphenyls (PCBs) in bioretention facilities has not been studied much historically. The goal of this study was to improve our understanding of the fate and transport of PCBs in the most commonly used bioretention BMP soil mixture (60% sand and 40% compost; the 60:40 mix). The study examined:

1) Does the bioretention soil mix effectively sequester PCBs from stormwater?
2) Are PCBs lost from the bioretention soil mix in the dry season?
3) Do PCBs accumulate in the bioretention soil mix?

Stormwater management problem

PCBs have caused impairments and fish consumption advisories in Washington State's freshwaters and in Puget Sound. Many PCB sources contribute to widespread distribution through urban air deposition and wash off of impervious surfaces. Despite their intentional manufacture being banned decades ago, PCBs continue to be created as byproducts of other manufacturing processes and are inadvertently used in the urban landscape. Reducing ongoing loads of PCBs is important to reduce and prevent adverse impacts on waterbodies. The potential for successful treatment and removal of PCBs from stormwater runoff by bioretention was largely unknown prior to this study.

Project findings

This two-year monitoring project installed six experimental bioretention soil mesocosms in 55-gallon drums in a Seattle neighborhood and applied stormwater gathered from 30 acres of the Interstate-5 highway and associated grassy medians and rights-of-way. Influent, effluent, and the bioretention soil mix were sampled quarterly.

We found over the course of the study that:

1) On average, effluent concentrations of PCBs were approximately 90% lower than the stormwater influents when filtered through the 60:40 bioretention soil mix. Including plantings in the mesocosms did not significantly change capture effectiveness compared to those with no plantings.
2) There was no seasonal pattern detected in PCB concentrations in bioretention soils.
3) PCBs did not accumulate in bioretention soils. No special soil management practices need be considered in the short term (years) with regard to accumulated PCBs. Overall, PCB concentrations in the bioretention soil went down slightly over the two-year period.

4) Loadings from stormwater to soil were modest in this study and bioretention soils are biologically active. Thus, PCBs are probably degrading at a rate comparable to their input, but this requires confirmation.

Recommendations

The long-term efficacy of bioretention for removing PCBs remains unknown. Establishing an annual or semi-annual bioretention monitoring program which includes persistent organic compounds including PCBs would be a valuable contribution. Conducting bench-scale studies of labelled PCBs in bioretention soil mix would help conclusively determine their fate.

Why does this study matter?

Bioretention soils are highly effective at removing PCBs from stormwater. Widespread application of BMPs incorporating bioretention could make significant progress towards reducing the impacts of PCBs on receiving waters and related fish consumption advisories.

There were no direct or known sources of PCBs to the study site and the concentrations were relatively low, presumably typical to stormwater from atmospheric deposition and low-level dispersed sources. The lack of buildup in the bioretention soils provides some assurances for stormwater managers that bioretention facilities in typical residential and roadway settings will not accumulate PCBs in the 60:40 soil mix.

What should we do with this information?

Stormwater managers should continue to utilize bioretention based BMPs with the 60:40 soil mix wherever practicable. Typical urban watersheds with high concentrations of PCBs in stormwater will benefit the most from bioretention retrofits to reduce PCB discharges to receiving waters. However, more study is needed to understand the fate and transport of PCBs in bioretention facilities in areas with the highest concentrations of PCBs.

What will Ecology do with this information?

Ecology will continue to encourage, support, and fund installation of bioretention facilities using the 60:40 mix to treat stormwater across the state. This study provides much needed information about the successful treatment and removal of PCBs in stormwater. Finding no buildup of PCBs in the soil matrix is promising. Ecology would welcome continued study to determine an upper treatment threshold of organic contaminants by established bioretention facilities and alternative bioretention soil mixes.

Want more information?

Visit the SAM website at ecology.wa.gov/SAM, search for "Bioretention PCB Capture"

Stormwater Action Monitoring

2020 Update to the Illicit Connection and Illicit Discharge (IC-ID) Field Screening and Source Tracing Guidance Manual

Source Identification

Lead Entity

King County
Stormwater Services

Partners

Aspect Consulting, LLC

Herrera Environmental Consultants, Inc.

Collectively improving stormwater management

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Questions about SAM?
See ecology.wa.gov/SAM

Study goals

The project:

1. Updated the Illicit Connection and Illicit Discharge (IC-ID) Field Screening and Source Tracing Guidance Manual (IC-ID Manual), originally published in 2013, with new and improved information on field methodologies and indicators for screening, identifying, and tracing the sources of stormwater pollution.
2. Provided eight trainings on the updated 2020 IC-ID Manual for municipal stormwater staff throughout Washington.
3. Updated and enhanced the training resources to support the updated IC-ID Manual.

Stormwater management problem

Municipal stormwater staff invest a substantial amount of time investigating and addressing potential illicit discharges to the municipal separate storm sewer system (MS4) for permit compliance. They encounter many different types of pollution that require quick, accurate, and inexpensive approaches to identify and find the source. This is especially challenging for diffuse sources of pollution.

The first IC-ID Manual in 2013 provided municipal illicit discharge detection and elimination (IDDE) programs with a comprehensive and useful resource for investigating stormwater pollution. The updated IC-ID Manual provides municipal stormwater professionals across the region with widely used information in an accessible format for screening, identifying, and tracing the sources of stormwater pollution. Trainings on the updated IC-ID Manual provided a refresher for existing personnel, and new additional training resources will help to train future personnel.

Project findings

The updated IC-ID Manual was published in May 2020 and is available via the SAM Source Identification webpage and the Washington Stormwater Center's IC-ID webpage. Updates were informed by feedback from municipal staff in two workshops, a literature review on updated and new methodologies and indicators, and a review of data from IDDE programs. The updates include:

- New *Index* and revised *Flow Charts* to quickly determine appropriate methods and tests to use
- Updated *Screening* and *Source Tracing* descriptions
- More *Indicator* tests
- Expanded *Bacteria* section to include four bacterial types and easy culturing test instructions
- Updated *Equipment Costs* and *Field Sheet* templates
- Reorganized and streamlined information

Eight training sessions in 2020 drew more than 200 attendees, mostly municipal staff from Western Washington. While the trainings were originally planned to be in-person, the COVID-19 pandemic provided an opportunity to reformat and present the trainings on a virtual platform more easily accessible to professionals across the region. The trainings included a small group exercise to find the sources of pollution in a hypothetical scenario, along with live demonstrations and prerecorded videos of field equipment usage, indicator tests, and sampling techniques.

The original 2013 IC-ID Manual included 14 videos giving an overview of the manual and demonstrating specific indicator tests. The 2020 update created five short videos on indicator tests and a new, longer video presenting an overview of the updated IC-ID Manual, all posted on the Washington Stormwater Center's YouTube channel.

Recommendations

A comprehensive and up-to-date guidance manual and training materials are essential resources for conducting IDDE investigations. This 2020 IC-ID Manual and training resources should be used by municipal stormwater staff to support training and implementation of their programs on MS4 screening, source identification, and control. These materials are available online at no cost, providing access to all stormwater professionals and others working on pollutant source identification and control.

As stormwater pollution regulations adaptively improve in Washington, the knowledge and data available to evaluate best practices also improve. Ecology and permittees will benefit from more up-to-date efforts with National Pollutant Discharge Elimination System (NPDES) permit implementation in this updated IC-ID Manual. This will improve consistency, accuracy, and efficiency in how stormwater pollution is screened, identified, traced, and reported.

The project trainings on the updated IC-ID Manual were described as a valuable resource for ongoing stormwater management, helping train and refresh over 200 municipal stormwater staff on IC-ID field methodologies and indicators. Stormwater managers are encouraged to use these materials to train staff every two to five years on the updated IC-ID Manual.

Ecology and permittees are encouraged to consider supporting a future update to the IC-ID Manual and trainings in five to ten years.

Why does this study matter?

Stormwater carries numerous potential sources of pollution. Proven, accurate, and efficient methods to screen, identify, and trace the sources (which are often intermittent) are essential tools of stormwater management. Keeping municipal staff up to date and trained on how to spot and respond to illicit discharges is an essential requirement of the Municipal Stormwater Permits and a critical component of a local government's stormwater management program.

This project expanded educational and training materials for identifying and tracing stormwater pollution, which will help stormwater managers ensure their staff are efficient and knowledgeable on implementation of IDDE, source control, and MS4 screening.

What will Ecology do with this information?

Recognizing the need for and benefit of coordinated IC-ID practices and training materials, Ecology will continue to support regional efforts to develop consistent methods for pollution screening, identification, and tracing.

Ecology will share the updated IC-ID Manual with the Pollution Prevention Assistance program (formerly the Local Source Control program) and update websites to reference the updated manual and training materials.

What should we do with this information?

Permittees and stormwater managers should use the 2020 IC-ID Manual for IDDE investigations and the training resources and videos for ongoing staff training needs.

The Washington Stormwater Center should continue to host the material in an easy-to-find location on its Municipal Resources webpage, which provides a central source of permit tools.

For more information

Visit the Washington Stormwater Center's IC-ID webpage https://www.wastormwatercenter.org/permit-assistance/municipal/permit-assistance-2/ic-id/

Stormwater Action Monitoring

Regional Spill Hotline Feasibility Study

Source Identification

Lead Entity

King County Department of Natural Resources and Parks

Partners

Herrera Environmental Consultants, Inc.

Hardwick Research

Other participants:

Washington State Department of Ecology

Stormwater Work Group (SWG)

Source ID Subgroup

Technical Advisory Committee

Survey participants

Interview participants

Cooperating vendors

Collectively improving stormwater management

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation. SAM's goal is to improve stormwater management to reduce pollution, improve water quality, and reduce flooding. We do this by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Questions about SAM?
See ecology.wa.gov/SAM

Study goals

The goal of this study was to assess the feasibility of a regional or statewide "hotline" (reporting system) for citizens and municipal staff in Washington state to report spills and environmental incidents.

Key study questions included:

1. Is a regional spill reporting system technically feasible?
2. Is a regional spill reporting system preferred?

Stormwater management problem

The municipal stormwater permit requires jurisdictions to publicize a hotline or other telephone number for public reporting of spills and other illicit discharges. Permittees have expressed doubt about public awareness, confusion around numbers that vary widely by location, and concerns about potential delays and inefficiencies in spill response leading to lost opportunities to prevent environmental damages. Stormwater managers want to know what options are available to improve spill reporting and interjurisdictional cooperation, whether the options are recommended for regional-scale implementation, and what considerations individual jurisdictions should take into account.

Project findings

This project documented industry knowledge, experience, and preferences and interviewed municipalities, Ecology, hotline owners, and vendors. The final report contains a brief overview of findings as well as two appendices containing interview summaries and an options matrix.

1. Based on the survey and interviews, the idea of implementing a regional spill reporting system is not broadly supported by most jurisdictions or state agencies.
2. Currently, municipalities interpret and use Ecology's Environmental Report Tracking System (ERTS) for regional spill reporting. Although Ecology did not initially intend for ERTS to function as a regional spill reporting system, it is used for that purpose to some extent.
3. Implementation of a multi-jurisdiction regional spill reporting system is technically feasible. Multiple vendors can provide accessible, cloud-based products with desired features including geodynamic routing, data standardization, and two-way communication with the public.
4. Implementation of a regional spill reporting system could streamline Municipal NPDES Permit annual reporting activities and promote regional analysis while allowing local spill response procedures to remain in place.

Recommendations

This study determined that implementing a regional spill reporting system is feasible and identified key benefits of a regional system that are not addressed by the current system of disparate local hotlines. The study identified overall low support from jurisdictions to implement a new regional system. However, these recommendations can apply at smaller scales for individual jurisdictions or several jurisdictions working together. The study recommends further discussions on this topic. See next page for specific recommendations.

Recommendations for implementing a regional spill reporting system:

- Incorporate the following core components for a centralized system:
  - Primary coordinating entity
  - Central call center (supplemental service)
  - Central web form
  - Central cloud-based data storage
  - Mobile application is not necessary
- To promote equity and accessibility:
  - Provide a central hotline number
  - Offer multiple language options for phone and web formats
  - Allow anonymous reporting when necessary
- For multi-jurisdiction regional spill reporting systems, establish a primary coordinating entity to:
  - House centralized data
  - Manage contracting and system maintenance
  - Lead a cohesive communication network
- Use vendors that prioritize features which support efficient response, streamlined reporting, regional analysis, and community engagement:
  - Map integration
  - Geodynamic routing
  - Workflow customization
  - Data standardization
  - Follow-up (two-way communication) with community members
- While possible, a hybrid system (integrating the local hotline with a regional hotline) is not the primary recommendation of this study due to added costs and workflow complexity.
- Further cost evaluation for regional implementation would require a preliminary structure (e.g., system components, participants, and hybrid features).

Recommendations for Ecology:

- Post clarifying language on the purpose, function, and limitations of ERTS on Ecology's website.
- Configure a regional spill reporting system, if implemented, for compatibility with ERTS and WQWebIDDE. Participate directly in the system to receive reports in a preferred format.

Recommendations for future study:

- Resurvey jurisdictions to determine whether opinions have changed based on vendor capabilities.
- Form a preliminary structure with centralized entity to begin interjurisdictional coordination and define cost variables.
- If broad regional implementation is still not desired, consider local or subregional strategies and options identified in this study (Appendix 1 and 2 of final report).
- Gather community input on what would make spill reporting easier. Consider jurisdictions' needs for more public outreach support.

Why does this study matter?

There are over 90 municipal stormwater permittee hotlines for the public to report spills to the environment and stormwater system in Western Washington alone. Complex coordination among state and local programs can delay spill reporting and response. This study was funded to examine feasibility of a single regional hotline to complement local numbers. Interestingly, despite enough support to fund this feasibility study, surveys and interviews of stormwater permittees indicate a reluctance to support a modern regional hotline; many believe the role is filled by Ecology's ERTS.

What will Ecology do with this information?

The ERTS reporting system continues to rely on an imperfect process, and some delays in reporting are likely when ERTS reports are submitted outside of work hours. Though the Water Quality Program at Ecology has a limited role in the maintenance and enhancement of ERTS, we aim to improve reporting timeframes for jurisdictions. We will aim to streamline reporting requirements for the municipal stormwater permit where feasible and appropriate.

What should we do with this information?

Stormwater managers may consider subregional approaches working in cooperation with other jurisdictions. The concept is technically feasible, and potential advantages include improved response times to reported spills, mobilization efficiencies, data standardization, and better interjurisdictional communication.

For more information

Visit the SAM website at www.ecology.wa.gov/SAM and search for "regional spill hotline feasibility."

The Effects of Mulch on Stormwater Treatment and Maintenance Effort in Bioretention Systems

Stormwater Action Monitoring

Effectiveness Study

Lead Entities

Partners

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation.

SAM's goal is to improve stormwater management by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Highlights:

- Mulches preserve bioretention soil moisture to aid plant survival in the summer. Arborist chips and nugget mulches help retain the most water.
- Mulches cut weeding time by half and limit nitrogen export from soil.

Stormwater issues related to the study

Weeding, summer watering, and replacement of plants in bioretention systems can be costly. By design, stormwater that flows into bioretention facilities will contact a mulch layer first, before other biological components. Stormwater managers want to understand the role that mulch plays in reducing operation and maintenance (O&M) costs and limiting pollutant export, and how benefits differ among common mulch choices.

Study Objectives

The study used 16 experimental bioretention cells located at Washington State University's Puyallup Extension campus. The cells were refurbished and four replicates each were topped with: three different types of mulch (arborist chips, medium bark mulch, and nugget mulch, see Figure 1) and no-mulch, for study control. The study objectives were to quantify, by mulch presence and type:

- difference in the necessary weeding time and effort;
- water retention in the bioretention cells;
- soil moisture content in the bioretention cells; and
- pollutant reduction across the mulch types.

Project findings

All three mulches suppressed weed growth significantly over controls, and no single mulch type was significantly better over the two years of this study.

All bioretention cells reduced by half the water outflow *rates*. The cells topped with nugget mulch had significantly lower outflow *volumes* than the other mulches and no-mulch controls.

Figure 1: Three types of mulch were tested in bioretention systems

All three mulches preserved more soil moisture than the no-mulch controls. The cells with arborist chips maintained the highest soil moisture readings during the study, experiencing dry conditions (defined for this study as having soil moisture less than 25% water content by volume) only 22% of the study period, while no-mulch control cells

experienced dry conditions nearly 83% of the time. Bioretention cells with medium bark and nugget mulch experienced dry conditions 38% and 33% of the time, respectively.

The arborist chips - but not the other mulches - were depleted, presumably due to soil microbe consumption, and were replenished during the study.

While all of the bioretention cells exported nitrogen and phosphorus, the nitrogen concentrations in bioretention effluent were significantly lower in the presence of mulch compared to the no-mulch controls.

While not an intentional component of the study design, sun exposure and shade had a significant impact in plant stress and survival. The plants in the cells that were partially shaded by a nearby building were more robust than the plants in full sun.

Figure 2: Mulch plays a critical role in maintaining soil moisture, and limiting weeds

Recommendations

Add and maintain mulch at the recommended depth of 2 to 3 inches to help retain water and suppress weeds. The nugget mulch and medium bark mulch lasted for the duration of the study, and may need to be replenished after 2 or 3 years. Arborist chips needed annual replenishment in this study, increasing costs.

Use the plant “ninebark” sparingly in Washington bioretention cells and rain gardens because it spreads rapidly by putting out runners under the mulch, likely requiring added maintenance to prevent it from taking over the bioretention facility.

Why does this study matter?

This study quantifies the benefits provided by a 2-3 inch layer of mulch in a bioretention facility for weed suppression, water retention, plant survival, and pollutant reduction.

What should stormwater managers do with this information?

Add and maintain a mulch layer to help retain water and reduce plant loss in bioretention cells, particularly in full sun, and to limit the establishment of weeds. Stormwater maintenance programs utilizing mulches may see reduced O&M costs overall due to reducing watering needs in the summer, improved plant survival, and reduced weeding or the need for herbicides. Bioretention designers, landscape designers, horticulturists and others should limit use of water loving and easily spreading plants such as ‘ninebark’ to minimize maintenance needs in bioretention facilities and rain gardens.

What will Ecology do with this information?

Ecology will update the guidance for bioretention facility best management practices (BMPs) in the stormwater management manuals to recommend covering bioretention soil mix with a mulch covering. Ecology continues to support bioretention BMP projects and to prioritize these approaches and other low impact development (LID) or ‘green infrastructure’ treatment options for stormwater runoff management.

For more information see the completed project at ecology.wa.gov/SAM Effectiveness Studies or contact Dr. Jayakaran anand.jayakaran@wsu.edu, the lead of this study.

Designing and Evaluating Behavior Change Marketing Campaigns

Stormwater Action Monitoring

Effectiveness Study

Lead Entities

Partner

Stormwater Action Monitoring

(SAM) is a collaborative, regional stormwater monitoring program funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation. SAM's goal is to improve stormwater management by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Questions about SAM?

See ecology.wa.gov/SAM

Study Goals

The overall goal of this study was to provide jurisdictions with tools to identify and select which stormwater problems and behaviors to focus on as well as guidance for conducting and reporting effectiveness evaluations. These evaluations can then inform and improve future education and outreach (E&O) efforts in a positive feedback loop of doing and learning.

Study Objectives & Project Findings

1. What types of stormwater problems are amenable to, and best addressed, by behavior change efforts?

The annotated bibliography provides an overview of stormwater pollutant prioritization by summarizing several critical, peer-reviewed studies from the last 15 years. One of the summarized projects is the cumulative environmental factors study by the Washington Department of Health.

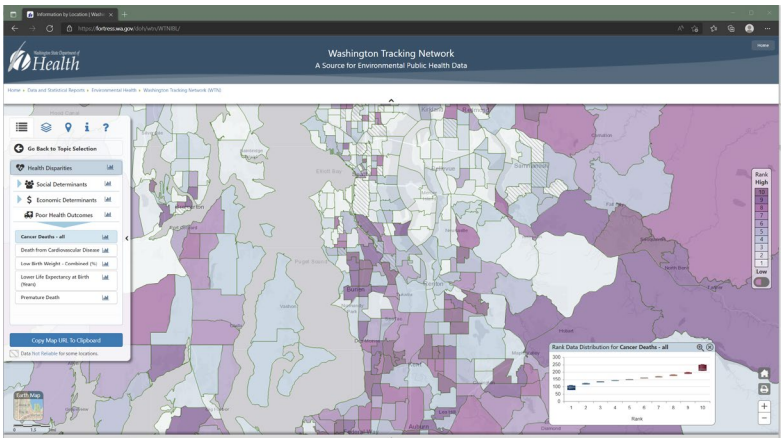

Figure 1: An interactive mapping tool that ranks the cumulative risk from environmental factors faced by Washington neighborhoods.

https://fortress.wa.gov/doh/wtn/WTNIBL/

Other key findings from literature, interviews and surveys are that a) most campaigns focus on pet waste and yard care; b) there is a desire for additional training on social marketing and program evaluation; c) staff feel that campaigns are often under-resourced; and d) additional high-quality evaluations of behavior change campaigns are needed.

2. Evaluate effective behavior changes tools in the literature and create a compilation tool organized by stormwater issue for jurisdictions to use.

A systematic review of behavior change campaigns was conducted which included evaluating the research quality on nine criteria. We rated 25% of studies as "fair", 66% of studies as "good", and 9% as "exemplary". Most studies identified well-targeted audiences and behaviors, and the majority collected pre-intervention data. However,

three-quarters relied on self-reported data, and only 13% measured behavior in a comparison group. We created **www.waterbehaviorchange.org** to help jurisdictions search for information on evaluations of existing campaigns around the country. It also provides jurisdictions with guidance on choosing their own campaigns (as a downloadable spreadsheet).

3. **Jurisdictions can now use the report template to report on behavior change evaluations.**

   Western Washington Permittees can use a template developed in this project to meet their stormwater Permit E&O requirements (Phase I S5.C.11.a.vi-vii and WWA Phase II S5.C.2.a.ii.(e)-(f)). The template streamlines report writing by identifying what information is required by the Permit, providing suggestions for content, and highlighting the basic information Ecology would like included in Permittees' final report.

4. **Guidance manual helps jurisdictions evaluate the effectiveness of their behavior change campaigns.**

   Permittees can use the Evaluation Guidance Manual developed as part of this project to assess understanding and adoption of targeted behaviors of their implemented behavior change campaign. The manual content includes information about social marketing and community-based social marketing resources, sample size selection, common evaluation instruments (e.g., surveys, observational data checklist), data types, and analysis methods.

Why does this study matter?

This study synthesizes and evaluates effective behavior change campaigns for local jurisdictions to use to improve stormwater management success. It provides behavior change professionals with information and guidance they can apply to their own permit-required programs.

What should stormwater managers do with this information?

Cities and counties cannot fully control all the stormwater draining from the urban environment. Aspects of their stormwater management programs which aim to change behaviors of households, businesses, and others are critical tools in improving stormwater quality and protecting our natural resources. Managers can use information from the website, literature review, and evaluation guidance manual to help select suitable behavior change campaigns and then evaluate those efforts using valid approaches. Those evaluations can inform their decisions on management needs and future campaigns. Permittees may also use the report template to meet their permit reporting requirements.

What will Ecology do with this information?

Ecology considers social marketing to be a Best Management Practice (BMP) used to achieve behavior change that will reduce impacts of stormwater discharges to the environment. The permit requirement on behavior change requires significant time and resources to create and implement behavior change campaigns for the target audiences. Ecology will reference this project's products in our guidance as resources for local programs implementing and reporting on the effectiveness of the education and outreach programs. The literature review of pollutants, online decision tool, the reporting templates, and evaluation guidance can be used to inform new campaigns or evaluation of existing efforts. The template and guidance are written for use on large and complex campaigns or small and simple ones.

For more information see the completed project at ecology.wa.gov/SAM Effectiveness Studies or contact the study leads: Dr. Joe Cook joe.cook@wsu.edu, Dr. Aimee Navickis-Brasch aimee@evergreenstormh2o.com, Dr. Ani Jayakaran anand.jayakaran@wsu.edu, and Laurie Larson-Pugh laurie.larson-pugh@wsu.edu.

Stormwater Particle Size Distribution (PSD) & Implications for BMP Effectiveness

Stormwater Action Monitoring

Effectiveness Study

Lead Entity

Partner

EVERGREEN STORMH2O

Collectively improving stormwater management

Stormwater Action Monitoring

(SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation.

SAM's goal is to improve stormwater management by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

ecology.wa.gov/SAM

Highlights

- Fine particle sizes carry more bound pollutants to stormwater systems, yet many existing BMPs target this and other size ranges.

Study Goals

The particle size distribution (PSD) of stormwater runoff can influence the types and amounts of pollutants that are present, as well as the way that pollutants are transported and interact with each other and the environment. BMP effectiveness in controlling the full range of particles in stormwater is typically not reported or even tested, which makes selecting a BMP more challenging. This literature review gathered the latest information on the size of particles in stormwater, the connection between particle size and stormwater chemistry, and the effectiveness of treatment approaches for particle sizes.

Findings

Methods for Measuring PSD

We identified common testing methods for PSD, and found that ASTM 3977-97 Method B with laser diffraction is most likely to have comparable results the TAPE method, The TAPE method ASTM D3977-97, is a modified version of ASTM 3977-97 Method B and Method C.

Sources of Particulates to Stormwater

Sources of particles to stormwater include automotive, local soil erosion products, and atmospheric deposition. The most transported sizes appear to be clay and silt sizes. There was not enough basin condition data in the literature to characterize particles and sources by land use or area.

BMP Effectiveness as a Function of PSD

To better understand pollutant transport, we identified what is known about the influence of PSD on stormwater chemistry. Literature reviewed focused on heavy metals, nutrients, and PAHs attached to particles, which suggests pollutant concentrations are generally higher for clay- and silt-sized particles. Targeting clay- and silt-sized particles may remove the highest amounts of metals, nutrients, and bacteria.

BMP studies with PSD influent and effluent data were located for 19 structural and 1 operational BMP. Most BMPs were highly effective at removing silt and fine sand sized particles (Table 1). These findings are based on only a few data points or a single study and there are many BMPs for which data were not located.

Recommendations for Future Research

- Encourage researchers to report more basin conditions and pollutant data that is portioned to particle size ranges. This information can inform BMP selection and pollutant load estimates.
- Conduct BMP effectiveness testing for PSD on more structural, operational, and source control BMPs.

Table 1 BMP Effectiveness Summary by BMP and Particle Size

BMP	# of Studies	# of Data Points	% Removal				
			<4 µm	4-62 µm	62-250 µm	250-500 µm	>500 µm
Biofiltration Swale	1	1	-65%	74%	100%	-233%	-40%
Bioinfiltration Swale	1	27	51%	100%	97%	37%	41%
Bioinfiltration Pond	1	34	75%	96%	96%	37%	49%
Vegetated Filter Strip	0	0	-	-	-	-	-
Bioretention	1	1	74%	92%	-	15%	22%
Bioretention Plus Jellyfish	0	0	-	-	-	-	-
Dry Detention Basin	0	0	-	-	-	-	-
Extended Detention Basin	2	1	-	60%	-	34%	18%
Filterra	1	4	-17%	100%	95%	61%	-
High Rate Media Filtration	1	1	11%	83%	90%	-	100%
Media Filter Drain	1	48	-	-	-	-	-
Oil/Grit Separator	3	1	36%	46%	0%	51%	41%
Porous Pavement – Modular Blocks	1	1	-	-	-	-	-
Sand Filter	1	4	-	-22%	58%	72%	-
Wet Vault	1	30	52%	92%	0%	51%	56%
MWS-Linear Modular Wetland	1	27	23%	33%	25%	35%	-
The BioPod BioFilter	1	17	-72%	-8%	22%	-	62%
StormGarden Biofilter System	1	17	83%	89%	77%	83%	85%
The Kraken	1	14	86%	88%	88%	93%	97%
Mechanical Street Sweeper	2	-	-	56.5%	52.9%	44.4%	61%
Vacuum Street Sweeper	2	-	-	65.0%	69.9%	85.9%	87.7%
Regenerative Air Street Sweeper	3	-	-133%	-73.5%	41.8%	80.0%	79.0%

Why does this study matter?

This summary of recent literature on PSD (from clay to coarse sand sizes) in stormwater runoff and the effectiveness of BMPs is needed to understand pollutant transport and select suitable BMPs to protect downstream receiving waters.

What should stormwater managers do with this information?

Continue to target silt-sized and smaller particles (less than 62.5 µm) when selecting BMPs. While PSD effectiveness data for all size ranges is not typically reported, the BMPs in Ecology's Stormwater Manuals that meet 'basic' treatment goals capture much of finer particles benefitting downstream water bodies.

What will Ecology do with this information?

The relationship between particle size and pollutant transport is complex and not fully understood. However, the literature review confirms our assumption that finer particles (clay and silt-sized particles less than 62.5 µm) is of concern, as these particles can carry high concentrations of pollutants longer distances in stormwater runoff. Therefore, we will continue to recommend testing for clay and silt-sized particles when consulted on BMP effectiveness testing. Ecology will discuss with the TAPE program the added benefits of gathering more basin information for future TAPE studies.

For more information see the completed project at ecology.wa.gov/SAM or contact the study lead: Dr. Aimee Navickis-Brasch at aimee@evergreenstormh2o.com

Business Source Control & Inspection Program Guidance

Stormwater Action Monitoring

Source Identification

Lead Entity

Partners

Other participants

Ecology Pollution Prevention Assistance (PPA) program, Business Inspection Group (BIG), Technical Advisory Committee (TAC), interview participants, and case study volunteers.

Collectively improving stormwater management

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation.

SAM's goal is to improve stormwater management by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Highlights

- A new Source Control Inspection Program Guidance Manual was developed specifically to aid Phase II MS4 permittees implement new or revised programs.
- Free on-line training is available to help train municipal and business staff.

Stormwater Source Control Needed for Businesses

Figure 1: source control training at business

Ecology's 2019 Phase II Municipal Separate Storm Sewer (MS4) National Pollutant Discharge Elimination System permit (permit) required for the first time these permittees to develop and implement a source control business/site inspection program. A few Phase I and Phase II jurisdictions with existing business inspection programs offered to share lessons learned.

Study goals

1. Develop a Source Control Inspection Program Guidance Manual that provides resources, templates, and strategies that permittees can use to achieve compliance with the 2019-2024 NPDES Phase II permit requirements for the Source Control Program for Existing Development (S5.C.8).
2. Provide in-person trainings on Business/Site Source Control Inspection as well as program development for municipal stormwater staff throughout Washington.
3. Provide an online training for use after the in-person trainings were complete.
4. Provide education and outreach materials for business source control inspectors.

Project findings

The Washington Stormwater Center website hosts the completed Source Control Inspection Program Guidance Manual and online training that were developed for this SAM project. The **Source Control Inspection Program Guidance Manual** includes:

- Chapter 1: project background and regulatory requirements.
- Chapter 2: developing code/ordinances and enforcement policies.
- Chapter 3: source control inventory development, updates, and prioritization.
- Chapter 4: developing a business/site inspection program.
- Chapter 5: conducting business/site inspections.
- Chapter 6: data management and recordkeeping.
- Chapter 7: education and outreach materials.
- Chapter 8: training staff and online module.

Some of the novel and innovative content includes an example inspection form (Survey123 format) in Chapter 5, business letter templates (Word format) in Chapter 4, and flyers and half sheets for automotive businesses, restaurants, and secondary containment (PDF and InDesign format) in Chapter 7. Materials developed for this project for Chapters 4, 5, and 7 are also provided in Spanish, Traditional Chinese, and Vietnamese.

The resources, templates, and strategies included in the Source Control Inspection Program Guidance Manual and trainings were developed based on research, input, and experiences of jurisdictions that have developed and implemented similar inspection programs.

Figure 2: Business Inspection and Source Control Program Training 2023

More than 210 people, majority were municipal staff, were trained on developing and implementing a Source Control Inspection Program. The training included an overview of the Source Control Inspection Program Guidance Manual, detailed information on developing and implementing an inspection program, two interactive group activities, and recorded case studies provided by other permittees in the region.

Recommendations

Municipal stormwater staff and managers are encouraged to explore this new resource to support their NPDES programs. The Source Control Inspection Program Guidance Manual and associated training resources are available online at no cost, providing access to municipal stormwater staff and other stormwater professionals in the region.

Why does this study matter?

The Source Control Inspection Program Guidance Manual and the expanded education and outreach materials developed for this project will help to reduce stormwater pollution and support municipal staff responsible for NPDES program implementation.

What should stormwater managers do with this information?

Permittees and stormwater managers should consider this new resource and training for developing and implementing their source control inspection programs. The education and outreach materials can be provided to local businesses. Municipal business source control inspectors are encouraged to become familiar with the new manual and consider taking the free online training.

What will Ecology do with this information?

Ecology continues to support efforts to develop resources, templates, and strategies for source control inspection programs. This new resource will be added to the MS4 permit webpages to help spread the word and share the Source Control Inspection Program Guidance Manual and training materials. Ecology's Pollution Prevention Assistance (PPA) program will include these materials with their resources for specialists and partners and will incorporate applicable parts of this guide into their training materials.

For more information see the completed project at ecology.wa.gov/SAM Source Identification Projects or contact the study lead: Laurie Larson-Pugh laurie.larson-pugh@wsu.edu.