Multnomah County NPDES MS4 Phase I Permit
Stormwater Management Program

Annual Report 2019
Permit year 24

Submitted to:
Oregon Department of Environmental Quality
November 2019

Submitted in Accordance with the Requirements of the National Pollutant Discharge Elimination System (NPDES) Permit Number 103004, File Number 120542

Submitted by:
Water Quality Program
Department of Community Services
Multnomah County

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1. Introduction

Multnomah County implements a comprehensive stormwater management program with the goal of reducing pollutants into the municipal stormwater system to the maximum extent practicable. This program is maintained and prioritized in response to the federal Clean Water Act and the County's responsibility to protect the health and welfare of its citizens and natural environment. The Stormwater Management Plan is the main component of the stormwater management program. This plan is submitted to and approved by the Oregon Department of Environmental Quality (DEQ) under the National Pollutant Discharge and Elimination System Municipal Separate Storm Sewer Phase I (NPDES MS4 Phase I) permit. The County's roles and responsibilities for complying with the permit term falls under seven categories of Best Management Practices (BMPs) with a focus on operating and maintaining the County bridges and roads.

This Annual Report summarizes the implementation activities of Multnomah County's Stormwater Management Plan in the County's permit area for the Permit Year 24 (Fiscal year 2019: July 1, 2018 – June 30, 2019).

2. Program Overview

History

From 1995 to 2010, the Oregon Department of Environmental Quality (DEQ) regulated stormwater from Multnomah County through two separate NPDES MS4 Phase I Discharge permits: Permit #101314 for the areas within the City of Portland permit boundary and Permit #108013 for the areas within the Gresham permit boundary. Multnomah County was a co-permittee on both Portland and Gresham's MS4 Permit.

The County had a limited amount of regulatory area under each permit under the two separate MS4 permits. To reduce the administrative burdens for program management and reporting, Multnomah County requested to DEQ that the permit areas be combined under a single individual permit for the 2010 permit renewal. DEQ granted this request and issued the new individual Phase I permit on December 30, 2010.

Permit area description

Multnomah County is a unique jurisdiction with NPDES permit areas composed of several discrete urban pockets, and approximately twenty-eight miles of road and bridge right-of-ways. The terms "Portland Area" and "Gresham Area" are used in this report to provide clarity in the area descriptions, and to provide continuity from the previous reporting areas.

Within the Portland Area, Multnomah County is responsible for five Willamette River bridges (see Figure 2-1). A few small unincorporated pocket areas within the Portland Urban Services boundary are under Portland's stormwater management through an Intergovernmental Agreement with the City of Portland. These areas are also under the City of Portland's land use authority.

Within the Gresham Area, Multnomah County is responsible for approximately twenty-eight miles of arterial roadways in the Cities of Fairview, Troutdale, and Wood Village, and the unincorporated residential area known as "Interlachen" that is located between Fairview Lake and Blue Lake (see Figure 2-2). In 2007, Troutdale and Wood Village came under NPDES Phase II coverage, and the County roads in those communities also came into permit coverage. Some road segments shown in the following maps are served by Underground Injection Controls or lack curb/gutter systems and do not discharge to surface waters.

More specific details regarding the County's jurisdiction are provided in the Stormwater Management Plan (updated April 2011).

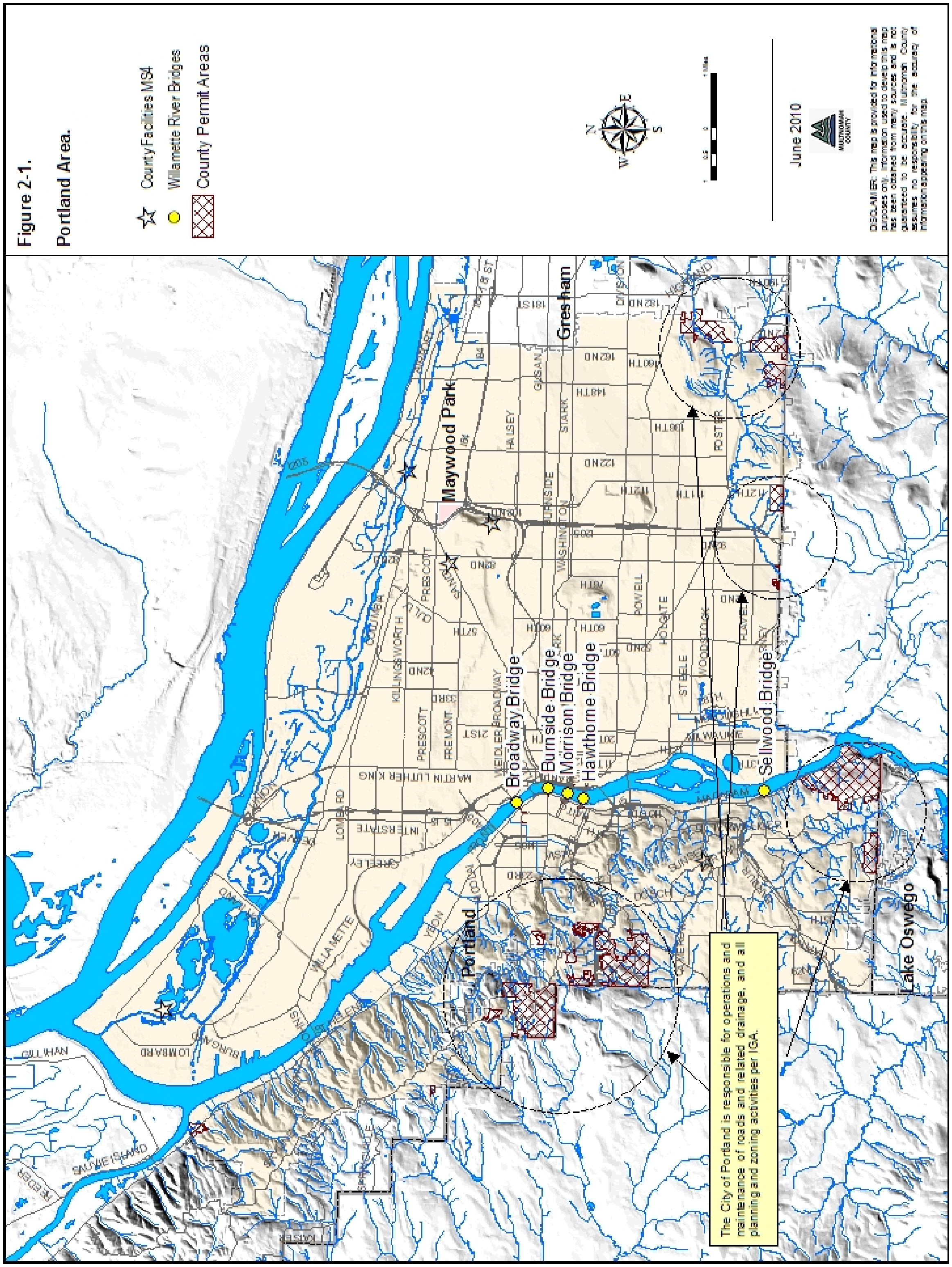


Figure 2-1.
Portland Area.
County Facilities MS4
Willamette River Bridges
County Permit Areas
June 2010
Broadway Bridge
Burnside Bridge
Morrison Bridge
Hawthorne Bridge
Sellwood Bridge
Maywood Park
Gresham
Portland
Lake Oswego
The City of Portland is responsible for operations and maintenance of roads and related drainage, and all planning and zoning activities per IGA.

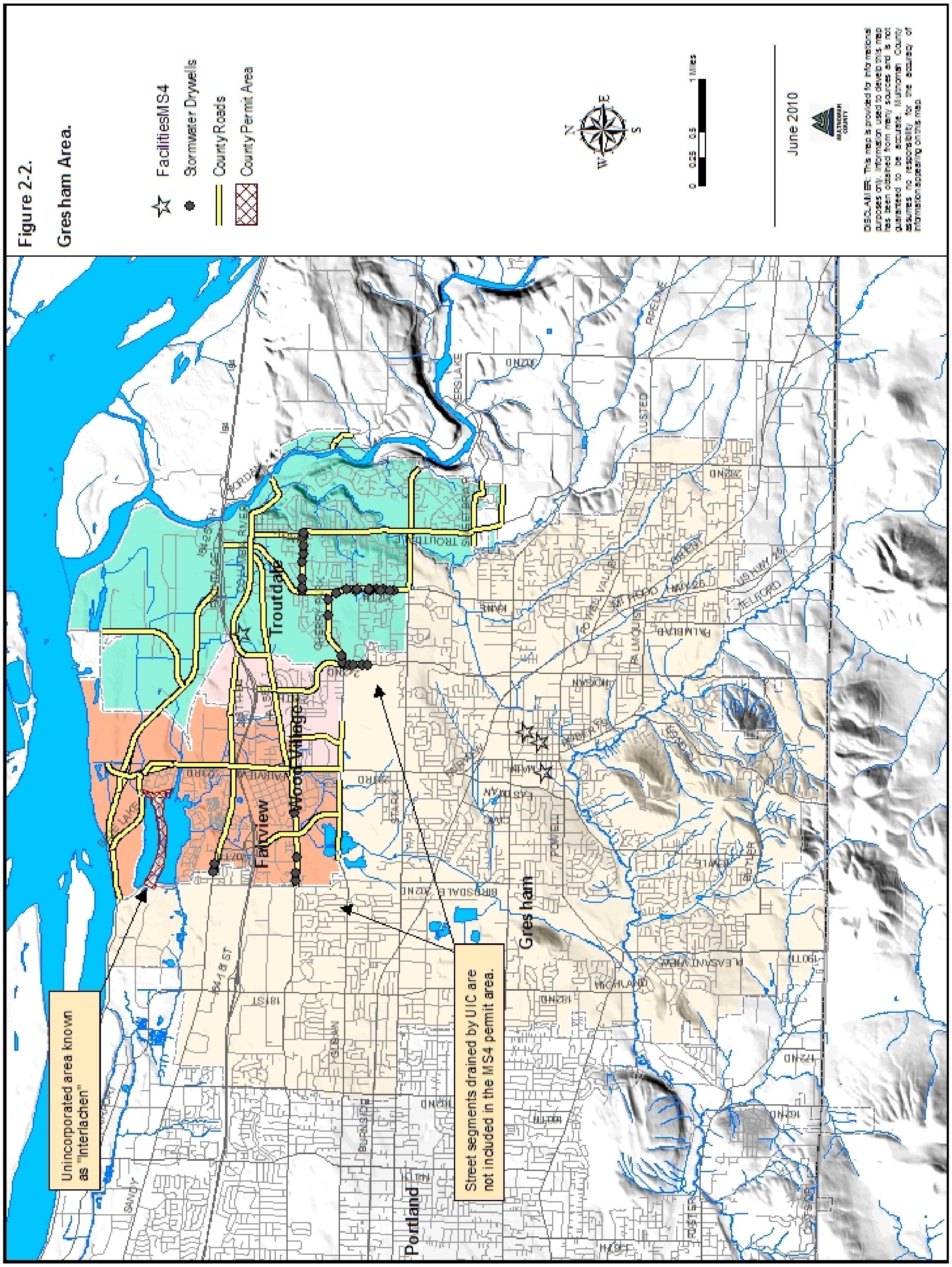


Figure 2-2.
Gresham Area.
FacilitiesMS4
Stormwater Drywells
County Roads
County Permit Area
June 2010
DISCLAIMER: This map is provided for informational purposes only. Information used to develop this map has been obtained from many sources and is not guaranteed to be accurate. Multnomah County assumes no responsibility for the accuracy of information appearing on this map.
Unincorporated area known as "Interlachen"
Street segments drained by UIC are not included in the MS4 permit area.
Troutdale
Wood Village
Fairview
Gresham
Portland

Reporting requirements

The following table summarizes the requirements for the annual report as described in Schedule B.5 of the permit:

Permit reporting requirement	*Annual report section*
a. Status of each SWMP program element and progress in meeting measurable goals	BMP summary - status
b. Status or results of any public education program effectiveness evaluation conducted during the reporting year and summary of how the results were or will be used for adaptive management	BMP summary PI-1
c. Summary of the adaptive management process implementation during reporting year, including proposed changes or additions to BMPs	BMP summary – adaptive management
d. Proposed changes to SWMP elements designed to reduce TMDL pollutants	BMP summary
e. Summary of total stormwater program expenditures and funding sources over the reporting year and those anticipated in the next reporting year	Stormwater program budget
f. Summary of monitoring program results, including monitoring data and analyses	Environmental monitoring; also see Gresham and Portland permit annual reports
g. Proposed modifications to the monitoring plan	Environmental monitoring
h. Summary of the enforcement actions, inspections, public education programs, and illicit discharge screening and investigations	BMP summary
i. Overview of land use changes, concept planning and new development activities in the reporting year, including number of new post-construction permits issued and an estimate of the total new or replaced impervious surface area related to new development and redevelopment projects	Permit area description; BMP summary (ND, STR)
j. Results of ongoing field screening and follow up related to illicit discharges.	BMP summary (ILL-5)

Environmental monitoring

The City of Gresham and City of Portland have historically collected, managed, and analyzed stormwater and instream data on behalf of the County as the lead Permittee for the respective NPDES permits when the County was a co-permittee on both permits. Because the County's jurisdiction is part of the fabric of both permit areas, the data for each permit represented the overall quality of stormwater and instream health. This environmental monitoring was a component of the Intergovernmental Agreements (IGA) with both the City of Portland and City of Gresham.

Beginning December 2010, the County managed its stormwater program under a single individual permit. The monitoring requirements are met through a new IGA with the City of Gresham, and the monitoring plan is available online through the City of Gresham website.

The environmental data and analysis presented in the Annual Reports for City of Gresham independent of this report fulfill the monitoring requirement for the County's Annual Report, per the respective IGA. A monitoring summary is provided at the end of this report.

The data includes monitoring requirements from the County permit: two instream monitoring sites, two macroinvertebrate monitoring sites.

<u>Mercury monitoring</u>

The mercury monitoring requirement is part of a special study to further the development of the Mercury TMDL. Two full years of mercury monitoring were completed during 2011-2013, which fulfilled the mercury monitoring requirement as described in Table B-1 of the NPDES permit. The mercury monitoring data has contributed to the characterization of urban stormwater runoff, a stormwater monitoring program objective. DEQ is expected to review the monitoring data once all of the results from the MS4 permittees have been submitted.
The County submitted a permit modification request to eliminate the mercury monitoring after two years of data collection. The request was submitted to DEQ on November 1, 2013. Permit modification was granted on January 8, 2014.

The mercury monitoring data analysis by the City of Gresham was included as an appendix to the 2013 Annual Report.

Adaptive management process

The assessment of BMPs occurs annually during preparation of the County NDPES annual report, to be submitted to DEQ by November 1 of each permit year. Among other reporting requirements, the MS4 annual report must contain (Schedule B.5) the following:

> *The status of implementing the stormwater management program and each SWMP program element, including progress in meeting the measurable goals identified in the SWMP.*

By providing a summary in the NPDES annual report of progress toward attaining BMP measurable goals (through data collection and tracking measures), the County both: 1) meets the aforementioned reporting requirement, and 2) facilitates a critical step in adaptively managing its stormwater program by assessing each BMP.

While preparing this MS4 annual report, the County collected data and feedback from staff responsible for implementing/reporting on each BMP to facilitate the BMP assessment process. Key factors considered in the annual evaluation include but are not limited to:

- *Was the BMP measurable goal attained? If not, describe circumstances why, and how progress will be made toward future attainment.*
- *For multi-year BMPs, were milestones or timelines met?*
- *Can we feasibly refine or improve the BMP to gain efficiency or effectiveness in removing stormwater pollutants?*
- *Are staffing/financial resources available to support such a BMP improvement or refinement?*

3. BMP Summary

The Multnomah County Stormwater Management Plan is a set of Best Management Practices (BMPs) designed to reduce stormwater pollutants to the maximum extent practicable. The County's stormwater management plan is made up of thirty-two BMPs grouped into seven categories as shown below. The following table summarizes the task, measurable goals, status, and changes for each BMP.

PI	Public Involvement and Education
OM	Operations and Maintenance
ILL	Illicit Discharges Control
ND	New Development Standards
STR	Structural Controls
NS	Natural Systems
PM	Program Management

Managers and staff in several Multnomah County workgroups implement the Stormwater Management Program. The functional groups are:

Public Affairs	Public Affairs Office
Bridge Engineering	Department of Community Services
Bridge Maintenance	Department of Community Services
Land Use Planning	Department of Community Services
Transportation Planning	Department of Community Services
Code Compliance	Department of Community Services
Facilities	Department of County Assets
Emergency Response	Department of Community Services
Right-of Way Permits	Department of Community Services
Road Maintenance	Department of Community Services
Road Engineering	Department of Community Services
Asset Management	Department of Community Services
Nuisance Code	Health Department, Community Health Services
Program Management	Department of Community Services

PI – Public Involvement and Education

Overall goal: *To inform and educate the public about the causes of stormwater pollution, the effects on local streams and rivers, and the need for stormwater management, and to encourage active participation in pollution reduction efforts.*

BMP	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
PI-1 Participate in Regional Public Education Efforts	Provide County representative to attend the *Regional Coalition for Clean Rivers and Streams* (RCCRS) meetings. Plan and Implement public education campaign promoting behaviors that improve water quality.	Help develop and implement RCCRS annual strategy to promote behavior change through the RCCRS website, television, radio and social media. Evaluate education campaign effectiveness by November 1, 2014.	RCCRS continued to manage the River Starts Here outreach campaign for 2017-2018. The River Starts Here annual report is attached as an appendix to this report. County staff led the formation of the Clean Rivers Coalition (CRC), a new statewide outreach collaboration. The CRC was awarded a $100,000 grant from Meyer Memorial Trust to develop a strategic communications plan in November 2017. A contractor was selected in October 2018, and project has been underway since January 2019.	The Clean Rivers Coalition continues preparing for a strategic plan to develop a statewide clean water outreach platform and campaign. DEQ is participating in this effort along with many partners across the state.
PI-2 Participate in Public Meetings	Attend public meetings related to water quality.	Track participation in watershed council and ad hoc committee meetings.	Water Quality (WQ) staff shared monitoring and project updates at regular monthly meetings of the Johnson Creek Watershed Council and Sandy River Watershed Council. WQ Staff participates in the Interjurisdictional Committee for Johnson Creek, a technical workgroup that coordinates stream monitoring and analysis for Johnson Creek watershed. WQ staff facilitates the Beaver Creek Conservation Partnership. All meetings are held approximately once a month.	No change
PI-3 Distribute Public Education Information Regarding Stormwater	Make brochures and other educational materials from Soil & Water Conservation Districts and Watershed Councils available at the planning office. Ensure that public education materials are current and cover relevant topics.	Track the number of materials distributed at meetings, front counters and online.	Although the landowners who visit the planning office are largely rural property owners not included in the NPDES permit area, this public education outlet is maintained for the TMDL pollutant reduction. 140 brochures on various topics from septic maintenance, riparian management and livestock care were taken from the office.	Because there are not stormwater specific brochures available, this BMP will likely be modified at permit renewal

PI-4 Conduct Training and Education for County Personnel	Send a representative(s) to water quality conferences when feasible. Share information learned in training with other staff. Train volunteers, maintenance and operations crews, as well as inspectors on impacts of activities on water quality and MS4 in addition to new approaches to water quality protection and proper reporting procedures.	Conduct a minimum of one staff training session a year.	WQ staff attended the regional Urban Ecology symposium (2/2019), and ACWA Annual Conference (7/2018) Vegetation staff continued to participate in regular meetings of the Cooperative Weed Management Areas group and applicator training. Staff also attended the Oregon Vegetation Management Association conference in October 2018. Road Engineering and Road Maintenance managers and staff attended a stormwater presentation by Water Quality staff (June 2019) Al	No change
PI-5 Implement the Adopt-a-Road Program	Develop a strategy to promote the adopt-a-road program. Track road segments where volunteer roadside litter removal and clean-up is performed through participation in County Adopt-A-Road programs.	Continue to advertise and support the adopt-a-road program as interest exists.	Adopt-a-road program is promoted though a County webpage. Twenty one groups are active in Multnomah County. Clean ups range from once a month to once a year depending on the group. Adopt a Road is a trash pickup, but additional eyes on the road for illegal dumping is a benefit to the Roads program, as well as increasing the stewardship ethic in the community.	No change
PI-6 Maintain Signage to Protect Water Quality	Determine whether any areas need to be marked or re-marked and provide staff and materials to carry this out. Maintain signs in right-of-way promoting watershed awareness, as requested by watershed councils.	Inspect drain markers and signage once per permit term at all catch basins and stream crossings in the permit area.	Drain marker inspection was completed during the catch basin cleaning in Fall 2012	No change
PI-7 Provide Opportunities for Public Involvement During the CIP Process	Involve the public in the process of updating the Capital Improvement Plan and Program (every two years) and in evaluating the stormwater quality impacts and issues associated with the program.	Ensure opportunities for public participation in the CIP update process through public meetings. Ensure that public comment period is established for permit renewal.	The Capital Improvement Plan and Program (CIPP) is reviewed annually and updated biennially to ensure that limited resources for projects are efficiently and equitably allocated to the most critical capital needs, including where equity can be improved, as well as to leverage County funds. The CIPP is readily available for review online where feedback can be submitted to the County. The County is currently updating the Plan (long range list) and the Program (5 year list) of needs.	No change

			Multnomah County conducted a round of public outreach between December, 2018, and March, 2019. This consisted of three public open houses and an online open house. In total, 192 community members were reached through these events, and were asked to provide input on the County's trial list of projects for the next 20 years and the criteria to be used for ranking them. Along with public open houses, Multnomah County staff gave stakeholder briefings to the Northeast Multnomah County Community Association in Corbett; the Multnomah County Bicycle/Pedestrian Citizens Advisory Committee; and the Southwest Hills Residential League at Ainsworth Elementary School. These included a brief presentation and question-and-answer session by staff. Approximately 60 people in total attended the stakeholder briefings.	
PI-8 Facilitate Public Reporting of Illicit Discharges	Determine where signs need to be posted regarding illegal dumping and place them.	Install and maintain signage in all known areas that are problematic in terms of dumping.	No activity in permit area.	No change

OM – Operations and Maintenance

Overall goal: *To implement operations and maintenance practices for public streets, bridges, storm sewers, and other facilities to reduce pollutants in discharges from the municipal separate storm sewer system.*

BMP	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
OM-1 Review the RMOM for Potential Updates to Address Water Quality	Review the Road Maintenance Operations Manual annually. When manual revisions are made, conduct refresher staff training as provided for under BMP PI-4.	Annually review of the RMOM to ensure current practices are incorporated respect to water quality.	Discussions with Asset management staff to add RMOM into Cartegraph asset management and work order system. Work is on hold to allow for new Road Maintenance Manager to get up to date on all tasks related to RMOM.	No change
OM-2 Inspect and Maintain the Storm Drainage System	Inspect the entire stormwater conveyance system on an annual basis. Utilize the record keeping system and database to record findings and follow-up work completed by field crews.	Establish criteria used to determine catch basin (CB) cleaning frequency to maintain effective pollutant removal by July 1, 2011. Clean all roadway catch basins (CB) a minimum of 2 times per year, unless catch basin cleaning records indicates less frequent or more frequent cleaning is appropriate.	Criteria for roadway CB and sweeping frequency were submitted to DEQ on June 22, 2011. The program uses Cartegraph software and iPads in the field. Catch basin cleaning was completed according to existing cleaning frequency regimen. New analysis of cleaning data is forthcoming. Parking lot CBs maintained by County Facilities were inspected and cleaned on annual basis by Road Maintenance.	Catch basin cleaning timing was off slightly in previous year and made data analysis difficult. Analysis will occur at the end of the two year cycle
OM-3 Conduct Street Sweeping	Track street sweeping efforts to record the sweeping frequency.	Use catch basin cleaning records or inspections to inform the necessary sweeping frequency. Establish criteria used to determine street sweeping frequencies to maintain effective pollutant removal, and identify high priority street sweeping areas by July 1, 2011	(See OM-2 and PM-3) Sweeping routes are included in the Cartegraph work order system. Regular sweeping occurred until June, when the sweeper taken in for repairs. Sweeping was not conducted while the equipment was served. A single sweeper serves our jurisdiction due to the size of the County program.	See OM-2
OM-4 Properly Dispose of Road Waste Material	Identify alternatives for a new decant facility to be used for the dewatering of road wastes, or upgrades to the existing facility.	Annually review disposal options that protect water quality.	Vactor waste and sweepings are disposed at a private transfer facility (PPV Inc). Vactor liquid is field decanted into public sewer trunk with approval from Fairview. Ditching spoils from the urban area will continue to be disposed at a waste facility.	No change

OM-5 Minimize Impacts from Anti-icing Operations	Continue to follow the County RMOM procedures for the application, collection, and washing of sanding materials applied to roadways. Continue to research alternative anti-icing methods.	Conduct street sweeping to recover sanding materials within two weeks after the Road Maintenance Manager determines that the roads are free from the threat of an ice or snow event.	Sanding materials were used very sparingly on steep hills and freeway ramps during freezing events in FY18 and were removed within two weeks after the threat of ice was gone. Total of 20 days applications of sanding material occurred, and 180 gal of MgCl was applied during the winter. The effectiveness of MgCl has come into question with the storms from 2015-2016	No new updates on conventional road salt use from ODOT.
OM-6 Minimize Impacts from County Truck Hauling Practices	Follow the RMOM procedures for conducting equipment checks when hauling materials.	See OM-1	No activity in permit area.	See OM-1
OM-7 Minimize Impacts From Right-of-Way and Road Shoulder Maintenance	Conduct maintenance according to RMOM	See OM-1	No activity in permit area.	See OM-1
OM-8 Minimize Impacts from Ditch Maintenance	Conduct maintenance according to RMOM	See OM-1	No activity in permit area.	See OM-1
OM-9 Maintain County-owned stormwater facilities	Inventory facilities by January 1, 2013	Annual inspection of treatment facility	Two stormfilter vaults exist in the permit area. Annual inspection did not occur in the permit year due to Road Maintenance staffing changes. A new contractor has been selected and inspections are scheduled. Stormfilters on County bridges were inspected and replaced in FY18. Vegetated facilities were maintained by Road Maintenance staff and the inmate work crew labor. County Facilities maintains several Vortex units which were cleaned.	No change

ILL – Illicit Discharge

Overall goal: *To prevent, identify, investigate, and if appropriate, control/eliminate any non-stormwater discharges into the municipal separate storm sewer system.*

BMP	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
ILL-1 Implement the Spill Response Program	Continue to follow and implement the Multnomah County Spill Response Plan. Track and record spills and information regarding spills as they occur.	Conduct spill response procedures when spills are reported.	County crews inspect the Spill Response Truck monthly to ensure proper spill control materials are stocked. No spills of significance during permit term.	No change
ILL-2 Address Spills from Private Truck Haulers	Report to the appropriate agency of the private truck hauling practices impacting the County right-of-way and the stormwater conveyance system.	Contact all private haulers when spills are observed to ensure proper clean up	See incident response from spills above.	No change
ILL-3 Require Erosion and Pollution Controls for Public Projects (formerly ILL-4 and ILL-5)	Execute formal contracting practices including pre-construction meetings, bonding, construction permit review, and erosion control inspections.	Inspect 100% of County project sites	FY 19 projects were all inspected for proper erosion control: • Sandy Blvd, Ararta Rd, Cochran Rd, and Discovery Block projects all had erosion control inspection during construction.	No change
ILL-4 Investigate Illegal Dumping	Continue to implement the existing field inspection program during routine maintenance activities. Record and report any noticeable illegal discharge and dumping in the right-of-way.	Clean up all reported discharge or debris dumped in the right-of-way	No threats to water quality were reported from illegal dumping activity in the permit area.	No change
ILL-5 Detect and Eliminate Illicit Discharges to the Storm Sewer	Continue to maintain the bridge restroom facility holding tanks quarterly. Document enforcement response plan for illicit discharges by November 1, 2011 Develop pollutant parameter actions levels and identify priority outfall locations by July 1, 2012.	Conduct quarterly maintenance of bridge facilities. Conduct tasks by date above, and annual inspection of dry weather flows at major outfalls.	Bridge facilities maintained quarterly without incident. Dry weather outfall inspection of four outfalls occurred in August 2018. No visible signs or other indications of illicit discharge were observed.	No change

ND – New Development

Overall goal: *New Development Standards (ND) BMPs are designed to mitigate pollutant discharges and other water quality impacts associated with new development and redevelopment during and after construction.*

BMP Description	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
ND-1 Require Erosion Control for Private Development	Review and provide comments on applications for grading permits and hillside development permits. Perform Erosion and Sediment Control Inspections for all approved construction projects.	Inspect 100% of sites once during the permit review, and a second time during active construction.	One permit for a sanitary sewer upgrade. Transportation Planning coordinated the grading work.	No change
ND-2 Regulate Stormwater Discharge	Continue to review new development permit applications to ensure proper connection to the storm sewer system and application of design standards. Inspect stormwater facilities during and after construction to ensure that the site is compliant with design standards.	Conduct plan reviews and inspections for 100% of permitted projects.		

STR – Structural Controls

Overall goal: *To implement structural modifications (constructed facilities) to existing systems/development to reduce pollutants in discharges from the municipal separate storm sewer system.*

BMP	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
STR-1 Address Water Quality with New Capital or Roadway Improvement Projects	Develop criteria and strategy for when stormwater treatment will be incorporated into public projects. Conduct plan checks of stormwater quality treatment facilities that are included in capital improvement or roadway improvement projects to assure they follow standard design criteria that include stormwater quality considerations, and that the appropriate facility is selected for the intended purpose.	Identify strategy or criteria used to determine when stormwater quality treatment will be incorporated into Capital Improvement Projects by November 1, 2013.	The County submitted criteria for when stormwater treatment is incorporated into public projects to DEQ in 2013. SE 238th Drive project incorporates stormwater swales and a bioretention pond in the design. Stark St road widening project includes bioretention features for stormwater treatment. Sandy Blvd project features off site UICs.	No change
STR-2 Retrofit Existing Facilities for Water Quality Benefit	Include consideration of stormwater treatment for water quality purposes in capital projects to reduce pollutants to the maximum extent practicable. Conduct a hydromodification assessment and develop a strategy to identify and prioritize potential retrofit projects by November 1, 2014.	Identify one retrofit project by November 1, 2013. Develop hydromodification and retrofit strategy by November 1, 2014.	Halsey St project was completed in 2016. Hydromodification Assessment and Stormwater Retrofit Strategy was submitted to DEQ on November 1, 2014.	No change
STR-3 Inventory and Map the County Storm Sewer System	Continue to update the County GIS storm sewer system map.	Complete GIS drainage system maps of the NPDES permit area by 2014, including catch basins, culverts, manholes, ditches and pipes systems.	Since 2015, the County has coordinated and maintained an online stormwater map with the cities of Troutdale, Gresham, Wood Village and Fairview. In 2018, data from the City of Portland, Port of Portland, and Multnomah County Drainage District were added to the map.	No change

NS – Natural Systems

Overall goal: *to help preserve and restore the natural environment/functions to reduce pollutants in discharges from the municipal separate storm sewer system.*

BMP	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
NS-1 Conduct Vegetation Management Activities	Follow RMOM and IVM procedures. Maintain current Oregon Department of Agriculture (ODA) certifications for chemical applicators. Review and update integrated vegetation management practices (IVM) annually.	Review RMOM vegetation activities and the Integrated Vegetation Management Program (IVM) annually.	The County has partnered with the Portland Water Bureau (PWB) to test a new BMP to use grass seed mix and broadleaf herbicide in the area adjacent to the road edge on roads adjacent to the Bull Run watershed. This study will ultimately reduce the spread of shiny geranium and help reduce herbicide use. Grass seed germination was not as successful as anticipated, however, shifting the timing of broadleaf herbicide to later winter helped to control the geranium.	The grass seeding study will take a couple years to see full results. The County will mow, and the PWB will monitor. Full report will be drafted next year.
NS-2 Specify Native Vegetation in ROW and Permitted Projects	Review the current contract specifications for landscaping in the right-of-way, and update as needed. Promote the use of native vegetation and develop contract specifications for landscaping. Condition plan approvals with invasive plants removal, if needed. Ensure contract specifications are followed which require certain landscaping materials and placement.	Inspect 100% of project sites for landscaping specifications.	No activity in the permit area	No change

PM – Program Management

Overall goal: *Program Management BMPs ensure effective program management, coordination, and reporting.*

BMP	*Tasks*	*Measurable Goal*	*Status*	*Adaptive Management*
PM-1 Stormwater Program Management	Continue to participate in the NPDES MS4 coordination meetings and any DEQ meetings. Continue to work with other NPDES MS4 permittees and DEQ to implement the stormwater management program. Review each BMP file annually. Prepare an annual report to demonstrate the County's compliance with requirements. Submit to DEQ.	Annually review BMP implementation data and submit annual report by November 1 each year.	Annual report submitted to DEQ.	No change
PM-2 Assess and Evaluate the Stormwater BMP Program	Evaluate progress of BMPs for annual report using adaptive management approach.	Develop an adaptive management approach by November 1, 2011.	The adaptive management approach was discussed mainly in the context of our catch basin and sweeping efficiency program.	No change
PM-3 Maintain Environmental Management Database	Pilot new GPS and onboard computer technology by July 2011. Develop GIS or other mapping technology to sync with GPS system by July 2012. Develop SAP work orders and tracking to integrate with GIS by July 2013.	Ensure tasks are completed by dates shown.	Work orders for Road Maintenance are captured in Cartegraph operations management system. Cartegraph uses GIS to capture catch basin cleaning and sweeping data.	No change

4. Stormwater Management Program Budget

Program activity within the County's NPDES permit area is divided between areas that were previously managed under the Portland area and Gresham area NDPES permits. The Water Quality program, consisting of one staff manages the County stormwater program, and portions of two Asset Management staff provide mapping and database services across the entire permit area. Services specific to the two areas are described below.

<u>Gresham area stormwater related services:</u>

- Road Maintenance expenditures and anticipated budget allocations within the Fairview and Interlachen incorporate items including drainage maintenance, right-of-way, surface management, vegetation management, general administration, emergency road hazard response and training.
- Road Engineering expenditures and anticipated budget allocations within Fairview and Interlachen incorporate drainage studies and reviews, environmental compliance review, as-built plan drafting and inventory, GIS database entry, and training.
- Land Use and Transportation Planning expenditures and anticipated budget for design review of capital improvements and right-of-way impacts to the County roads in Fairview, Troutdale, and Wood Village, and for design review and permits for development within the Interlachen Area.

<u>Portland area stormwater related services:</u>

- Bridge Maintenance expenditures and anticipated budget allocations within the Portland Permit area incorporate items including, drainage maintenance, right-of-way, surface management, vegetation management, general administration, emergency road hazard response and training.
- Bridge Engineering expenditures and anticipated budget allocations within the Portland Permit area incorporate drainage studies and reviews, environmental compliance review, as-built plan drafting and inventory, GIS database entry, and training.
- Multnomah County Road Maintenance, contracts the City of Portland and Clean Water Services to maintain and operate County owned roads to their respective standards in the urban unincorporated pocket areas through Intergovernmental Agreements.
- Road Engineering continues to retain authority to review access and impacts to the right-of-way including stormwater discharge when such discharges cannot be retained on site.
- Transportation Planning within the Portland Permit area includes development review in the unincorporated pockets where such development has the potential to access or impact the county right-of-way.

Funding for stormwater program expenditures are derived from two sources. The Land Use Planning receives funding from County's General Fund. The Transportation Division (Road and Bridge Services and

Transportation Planning) receive funding from the State Highway Trust Fund, which includes the State gasoline tax, weight/mile tax on trucks, and vehicle registration fees. Highway Trust Funds are constitutionally dedicated to road related issues. The County has no revenue from dedicated stormwater fees. This is a result of the County roads and unincorporated pockets being nested within other city jurisdiction's service areas.

The table below outlines program expenditures for Fiscal Year 2018 and provides the anticipated budget for Fiscal Year 2019.

Program Area	*FY 2019 actual*	*FY 2020 budget*
Water Quality Program[1]	$20,000	$276,936
Asset Management[2]	$8,391	$8,642
Gresham area		
• Road Maintenance[3]	$55,520	$56,000
• Road Engineering[3]	$17,847	$3,000
Portland Area		
• Bridge Maintenance/Operations	$19,339	$20,763
• Bridge Engineering[4]	$4,297,623	$7,368,094
• Road Maintenance IGA	$0[5]	$100,000
• Road Engineering[6]	$16,607	$17,105

[1]*Figure includes entire Water Quality program includes one staff, monitoring budget for UIC, TMDL and NPDES programs, and additional program costs. Decrease from previous year is the result of the hire of a limited duration GIS technician for stormwater mapping.*
[2]*Estimate is based on a portion of time from two Asset Management staff.*
[3]*Budget estimate is based on actual spending from the previous year for time spent on water quality work plus a budget for training.*
[4] *The amount shown represents the entire Bridge Engineering program. The entire program is included because Bridge Services do not budget or collect charges for water quality tasks. Water quality best practices are integral in all aspects of design and construction and hence we are not able to be segregated from the other work. Increase in budget reflects Sellwood Bridge funding.*
[5]*Portland Road Maintenance IGA funds were used for non-water quality related maintenance, thus not reported here.*
[6]*Estimate of the amount of time spent on water quality issues in Portland area right-of-way.*

5. Monitoring Summary

Environmental monitoring for the NPDES MS4 Phase I permit includes instream monitoring, macroinvertebrate monitoring, stormwater sampling for mercury, and pesticide monitoring. This summary describes the instream and macroinvertebrate monitoring. In previous permit terms, the mercury monitoring was completed. Pesticide monitoring is slated to be done in conjunction with the County's underground injection control (UIC) Water Pollution Control Facility (WPCF) permit requirements. The County received the UIC WPCF permit in March 2014, and stormwater sampling began in fall of 2014.

<u>Instream Data</u>

Instream monitoring is required at two sites in the permit area for a range of pollutant parameters shown in the table below. Monitoring is coordinated with the City of Gresham; the County maintains an intergovernmental agreement with Gresham to contract monitoring services, including monitoring scope, and sampling methods. Fairview Creek and Beaver Creek are the two priority watersheds in the Gresham area. Fairview Creek results are summarized in the Gresham NPDES Annual Report.

Monitoring location	*Sampling frequency*	*Parameters*
Lower Beaver Creek (BCI1) Upper Beaver Creek (BCI2)	4 events/year	Biological Oxygen Demand (BOD5) Total suspended sediment (TSS) Hardness Temperature Dissolved Oxygen (DO) Conductivity pH Nitrate (NO3) Ammonia nitrogen (NH3-N) Total phosphorus (TP) Ortho-phosphorus (O-PO4) Copper, total and dissolved Lead, total and dissolved Zinc, total and dissolved E.coli bacteria
Lower Beaver Creek (BCI1) Upper Beaver Creek (BCI2)	1 event/year	Macroinvertebrate

Two sites in Beaver Creek are monitored by the County, one site at the boundary of the urban and agricultural land uses, and one near the mouth of the stream, where the stream joins the Sandy River. Instream monitoring results are generally within expected ranges, with exceedances in temperature and E.coli. Macroinvertebrate scores are low, which is consistent with previous sampling results.

Sample ID	Site ID	Date	Time	24-hr Rainfall	Field DO	Field pH	Field Temp	Conductivity	Turbidity	BOD5	DOC	TSS	NH3-N	Chloro- phyll-a	NO3-N
				(in)	(mg/L)		(deg C)	(µS/cm)	(NTUs)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(mg/M3)	(µg/L)
W18G213-10	BCI1	7/31/2018	13:25	0.00	4.24	7.63	22.3	215.8	3.24	**2**	1.67	**3**	24	**2**	1200
W18J260-10	BCI1	10/30/2018	13:44	0.03	7.57	6.93	12.1	99.6	7.39	**2**	4.09	**3**	**20**	**2**	960
W19B041-10	BCI1	2/6/2019	13:23	0.18	13.48	6.67	3.4	49.1	7.42	**2**	1.94	**3**	**20**		2900
W19D274-10	BCI1	4/30/2019	12:59	0.00	7.51	7.61	13.4	132.8	3.69	**2**	2.47	**3**	**20**		2000
W18G213-11	BCI2	7/31/2018	12:12	0.00	5.29	7.34	20.8	169.3	15.1	7	5.86	21	26	94.5	220
W18J260-11	BCI2	10/30/2018	12:36	0.03	9.87	6.69	11	9.85	9.74	**2**	5	**3**	24	2.4	1800
W19B041-11	BCI2	2/6/2019	12:28	0.18	14.49	7.07	4	72.2	7.59	**2**	1.71	**3**	**20**		3800
W19D274-11	BCI2	4/30/2019	11:15	0.00	8.23	7.4	11.3	84.9	9.72	**2**	3.06	4	34		3160

Sample ID	Site ID	Date	Time	24-hr Rainfall	O-PO4	TKN	Total-P	Hardness	Hg-Total	Cu-Total	Pb-Total	Zn-Total	Cu-Diss	Pb-Diss	Zn-Diss	E. coli
				(in)	(µg/L)	(µg/L)	(µg/L)	(mg CaCO3/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(MPN/100ml)
W18G213-10	BCI1	7/31/2018	13:25	0.00	74	200	74	88.5	**0.00100**	0.764	0.1	3.0	0.616	**0.105**	1.51	86
W18J260-10	BCI1	10/30/2018	13:44	0.03	54	510	64	44.7	0.00167	1.74	0.104	8.2	1.48	**0.105**	6.19	41
W19B041-10	BCI1	2/6/2019	13:23	0.18	23	310	34	46.1	**0.00167**	1.73	0.134	8.9	1.36	**0.105**	6.44	31
W19D274-10	BCI1	4/30/2019	12:59	0.00	25	200	29	56.9	**0.00150**	1.23	**0.1**	4.1	1.01	**0.105**	2.17	10
W18G213-11	BCI2	7/31/2018	12:12	0.00	49	940	208	66	0.00385	1.83	0.131	2.2	1.6	**0.105**	1.1	30
W18J260-11	BCI2	10/30/2018	12:36	0.03	88	640	114	40.9	0.00223	2.67	0.113	3.5	2.33	**0.105**	1.8	160
W19B041-11	BCI2	2/6/2019	12:28	0.18	**20**	360	33	34.2	**0.00167**	1.23	**0.111**	3.0	1	**0.105**	2.12	130
W19D274-11	BCI2	4/30/2019	11:15	0.00	67	380	109	38.9	0.00222	2.47	0.142	4.8	1.86	**0.105**	2.09	52

Macroinvertebrate Site	B-IBI score
BCI1	20
BCI2	18

*Bold indicates values below detection limits
*Shaded cells indicate values above water quality standards

Pesticide monitoring data

Pesticide data was collected through the County's Underground Injection Control (UIC) Program, as described in the letter to DEQ, April 25, 2011. Details of the pesticide selection process are found in the County's UIC Monitoring Plan (2014), which can be downloaded from the County's Water Quality Program website (https://multco.us/water-quality-program/reports-and-plans).

The objective of this pesticide sampling was to fill data gaps about pesticides that may be commonly found along County's urban roadways. The County contributed this pesticide data to a regional pesticide characterization of emerging pollutants for the UIC program. 179 different pesticides were screened using two methods to provide a baseline of pesticide information: Multi-residue Pesticide Screen (EPA 8141, 8270D, 8081B, 8321B) and the Chlorinated Acid Herbicide Profile (EPA 8151). Data were collected from two UICs and three facilities during two storms each year.

GSI Water Solutions, Inc, published an analysis of pesticides in stormwater from major urban areas in Oregon in September, 2017, as part of the UIC permit program requirements. The Technical Memorandum – *Analysis of Urban Stormwater Quality Data and Pollutant Fate and Transport Simulations In Support of Emerging Pollutant Evaluations* – summarizes pesticides and herbicide data collected by Multnomah County (Appendix B).

APPENDIX A. Regional Coalition for Clean Rivers and Streams Annual Report 2019

APPENDIX B. Technical Memorandum - *Analysis of urban stormwater quality data and pollutant fate and transport simulations in support of emerging pollutant evaluations*.

Regional Coalition for Clean Rivers and Streams

Fiscal Year 2018-2019 Annual Report

October 11, 2019

Prepared by:

enviroissues

FY 2018-19 Overview

The Regional Coalition for Clean Rivers and Streams (Coalition) continued its work – initiated in the mid-1990s – of providing coordinated messaging to target behaviors linked to stormwater pollution from residential sources across the Portland metropolitan region. The Coalition continues its brand recognition efforts by consistently using the previously developed *The River Starts Here* creative concept in its various materials. Other Coalition activities in the 2018-19 fiscal year included sponsoring The Big Float 2018 and promoting the Coalition and its messages at community events.

Coalition participants include:

- Clackamas County
- City of Gladstone
- City of Lake Oswego
- City of Milwaukie
- City of Oregon City
- City of West Linn
- City of Wilsonville
- Oak Lodge Water Services
- Washington County
- Multnomah County
- City of Gresham/Fairview
- City of Troutdale

The Coalition continues active discussions with additional future members. Multnomah County transferred its role as Coalition fiscal agent to The City of Gresham for this fiscal year.

This report covers the time frame of July 1, 2018 - June 30, 2019. Supporting materials are included in an appendix.

Background

As identified in the 2013 Strategic Plan, the mission of the Coalition is to collaborate across the Portland metropolitan region to improve watershed health by changing household behaviors, reducing polluted runoff and connecting people with their local waterways. Coalition members leverage their collective resources to conduct outreach to communities across the region with common stormwater information and messages. Coalition activities complement individual agency efforts to raise awareness of stormwater runoff and affect behavior change to prevent pollution and protect regional surface water quality. Coalition activities support commitments relative to state permits under the federal Clean Water Act (administered by the Oregon Department of Environmental Quality), including Total Maximum Daily Load and Municipal Separate Storm Sewer System (MS4) programs, as well as compliance with the federal Endangered Species Act.

Participants in the Coalition represent agencies that serve diverse population sizes from very small (Troutdale) to very large (Clean Water Services). As such the ability to run programs specific to their community is limited by funding and staffing and the Coalition represents an efficient, effective method to combine stormwater outreach funds. Coalition members continue to provide funding for the collaborative work each fiscal year based on the size of the respective community. The group's funds are shared through Multnomah county acting as the fiscal agent to purchase associated consulting services, advertising, materials, and event sponsorships. By sharing resources, the group is able to reach many thousands of people in the region compared to what entities can typically achieve on their own.

The Coalition targets behaviors from residential sources linked to stormwater pollution prevention. Information and messages used by the Coalition are intended to reach those making purchasing and management decisions about yard care, pets and auto maintenance activities – some of the most likely sources of stormwater pollution from residents. Coalition activities address a range of surface water contaminants, including nutrients and toxics from fast-releasing synthetic fertilizers and pesticides applied to yards and lawns, pollutant loads from car washing soaps, metals and other toxics from vehicle maintenance (and unmaintained vehicles), *E. coli* from pet waste, turbidity from eroded soils and other contaminants from illicit discharges.

Key messages

The Coalition's key messages focus on raising awareness about pollution from stormwater runoff and motivating actions to protect surface water quality through action at the household level. The key messages are:

- Stormwater runoff is now our number one source of water pollution. When it rains, pollutants from your home, car, and garden wash into our rivers and streams.
- Bacteria from uncollected dog waste washes into our rivers and streams. You can protect our water by picking up after your pets.
- Yard and garden products wash into our rivers and streams. You can protect our water by eliminating these products or using compost and slow-release fertilizer.
- Motor oil, solvents, and soaps wash into our rivers and streams. You can protect our water by keeping car-care chemicals out of storm drains, diverting wash water onto your landscaping, and going to a car wash.

FY 2018-19 Activities and Results

Activities during the reporting period focused on continuing to implement the Coalition's strategic plan with messaging and outreach using *The River Starts Here* creative concept, developed in FY 2014-15. This concept was informed by the research summary about stormwater behavior (DHM Research, Feb. 2014) used by Coalition members in partial fulfillment of the FY 2014-2015 MS4 permit requirement to evaluate the effectiveness of permittee's education and outreach program.

Strategic Plan Implementation

A strategic plan, adopted in 2013, continued to guide Coalition efforts during the fiscal year. The Coalition acted on strategic plan goals as summarized below:

Goal 1: Maintain a functioning Coalition

Each year, Coalition members prepare an updated cost sharing approach and budget, which was implemented in 2018-19. Members of the Coalition share their knowledge with the broader regulated communities in Oregon via the Association of Clean Water Agencies (ACWA). Members have presented on prioritizing public behaviors to maximize pollutant reduction success and on a water pollutant risk assessment database at the past two spring ACWA conferences.

Goal 2: Develop and adapt creative products to fulfill the Coalition's mission

The Coalition continued to use collateral materials developed with *The River Starts Here* creative concept through event promotion and digital advertising, including materials such as temporary tattoos, T-shirts for staffing, message banners for booths, and a large durable watershed map. Coalition members use collateral materials through individual outreach events held throughout the year.

Goal 3: Practice adaptive management

The Coalition is committed to leveraging available resources to maximize impact while setting the stage for a future collaboration among agencies. Total member representation in the Coalition has increased in the past few years, bringing in more regional partners.

The River Starts Here Messaging and Outreach

Community Events and Agency Collaboration

Representatives of member agencies promoted Coalition messages throughout the fiscal year. The Coalition produced collateral materials emphasizing *The River Starts Here* brand and messages to support community events.

The Big Float 2018 – Event Sponsorship and Promotion

The Coalition sponsored and promoted The Big Float 2018 both in-print and online:

- The Coalition advertised The Big Float in English and Spanish on Facebook in collaboration with KOIN TV. This effort achieved over 45,000 impressions and over 400 clicks. Facebook followers increased by less than 100 from July 2017 to 2018.
- The Coalition placed quarter-page print ads in the Portland Tribune twice on behalf of the event. The Portland Tribune reports about 70,000 papers distributed throughout the metro area.

Overall, the event was a major success, attended by about 5,000 people from across the region! See map of attendee ZIP codes in the appendix.

The Big Float 2018 – 'Watershed Village' Tabling

In 2018, the Coalition coordinated with regional watershed councils to conduct outreach together at The Big Float. The 'Watershed Village' was composed of six 10'x10' tents with six partner watershed councils.

Figure 1: The Big Float 2018 'Watershed Village' Crew

The Coalition brought its Raindrop costume that members where to be a mascot, a large aerial map of the watersheds in the area and a mobile photo booth. Additionally, Gresham staff conducted intercept surveys of participants at the event (n=35) testing people's level of concern for local river health (20/35 somewhat to very concerned); awareness that household chemicals cause impacts to rivers (33/35 agreed), whether they believed individuals play a role in water protection (33/35 agreed, two young people were not sure), and their rating of self awareness of things they can do to protect water (13/35 somewhat to very aware, most were middle of the road or less confident about their knowledge).

This was the first year the watershed councils coordinated tabling at The Big Float. Most councils had not been to The Big Float before. In addition to internal uncertainty, event leaders were not sure where to put the Watershed Village. As a result, the councils chose a traditional tabling set-up.

There were some lessons learned with the first Watershed Village. Traditional tabling set-ups are not suited for a beach party atmosphere and the photobooth location turned out to be in an area not heavily trafficked by event goers. The watershed village did not attract much attention as a result, but had approximately 50 visits over the day. The roaming photo booth did not work as well as having a stationary photo booth located with the tables, but took ~115 photos shared more than 1,500 times. The stationary photobooth attracts more visitors. Next year, the group will work with the event organizers for better booth visibility and switch back to a stationary photo booth.

The following groups were represented in the village:

- The Regional Coalition for Clean Rivers and Streams
- Clackamas River Basin Council
- North Clackamas Urban Watersheds Council
- Columbia Slough Watershed Council
- Oswego Lake Watershed Council
- Johnson Creek Watershed Council

- Sandy Watershed Council

In addition, the following groups expressed interest in attending future tabling opportunities:

- Greater Oregon City Watershed Council
- SW Watershed Resource Center

The Clackamas Down the River Cleanup & Lower Sandy River Floating Cleanup – Event Promotion

The Coalition promoted The Clackamas Down the River Cleanup through quarter-page print ads in the Portland Tribune, Clackamas Review, and Sandy Post in late August. Both events were considered a success, engaging several hundred people, in part thanks to the Coalition's promotional partnership.

Additional community events

Oregon City promoted *The River Starts Here* as part of their *Stormwater Starts Here* booth at the Clackamas County Water Education Team event for middle school-aged children. Four hundred and fifty fourth and fifth graders participated in the event, along with 90 chaperones and 32 teachers.

Oak Lodge Water Services shared *The River Starts Here* resources at the Oak Grove Trolley Trail Festival on August 24, 2018. Brochures were distributed to many of the event's ~500 attendees.

WEBSITE: THERIVERSTARTSHERE.ORG

TheRiverStartsHere.org launched in June 2015. The website uses a modern design featuring *The River Starts Here* creative assets (Figure 4). It features an image slider highlighting Coalition messages and includes links to member websites and additional web resources. The website URL was promoted through newspaper and web advertisements.

Summary website analytics for the fiscal year are shown below. Statistics in parenthesis are the difference between last year's and this year's data. Positive changes are shown in green, negative changes are shown in red, and inconsequential changes are shown in lavender. New data points are presented in black.

Total sessions: 1,144 (▼50)

- **Traffic type**
  - Direct: 34% (▼2)
  - Organic (search engine): 17% (▼2%)
  - Referral: 45% (-)
- **Bounce rate:** 85% (▼4%)
- **Time on site:** 36 seconds (▲:01)

Of note, the web traffic is down, due in part to the Coalition's focus on the use of social media to directly engage with the public. In other words, the website URL is not being heavily marketed. The Coalition understands that given its limited budget, it's not realistic to drive people to its website, but rather a more effective approach is to advertise and educate them directly with social media followers and also paid social media advertising in addition to some other digital ad placement with Google AdWords' Display Network. The website primarily acts as a foundation to hold and describe the structure of the organization and basic stormwater tips with links to the social media posts in a blog format. Maintaining the website also lends credibility to its social media presence.

Social Media

The Coalition continued posting to its social media channels. As in past years, the Coalition concentrated social media activity in the spring and summer time period when households in the region have an increased interest in yard and garden activities relevant to surface water quality. Social media messages build on existing conversations and connect with organizations around the region. The Coalition delivers its messages on social media following its seasonal messaging calendar and heavily promotes summer river restoration and cleanup events.

Statistics in parenthesis are the difference between last year's and this year's data. Positive changes are shown in green, negative changes are shown in red, and inconsequential changes are shown in lavender.

Facebook page, Clean Rivers and Streams

A summary of Coalition Facebook account use during the fiscal and as of July 1, 2019 is as follows:

- **Total followers ("likes"):** 1,574 (▲403)
- **Weekly organic reach:** 164 (▼50)
- **Posts:** 75 (▲68)

Facebook follower demographics breakdown:

Age	Female	Male	Total by Age
18-24	3%	2%	4%
25-34	12%	7%	19%
35-44	19%	8%	27%
45-54	16%	8%	24%
55-64	9%	4%	13%
65+	8%	4%	12%
Total by Gender	67%	33%	-

Table 1: Facebook followers by age range and gender

Twitter, @riverstartshere

A summary of use during the fiscal year is as follows:

- **Followers:** 1,470 (▲127)
- **Tweets during the period:** 49 (▲38)

Female	Male
67%	33%

Table 2: Twitter followers by gender

Instagram, @theriverstartshere

A summary of Coalition Instagram account use during the fiscal and as of July 1, 2019 is as follows:

- **Total followers:** 4
- **Posts:** 12

Instagram, @riverstartshere

A summary of Coalition Instagram account use during the fiscal and as of July 1, 2019 is as follows:

- **Total followers:** 114
- **Posts:** 4

FY 2018-19 BUDGET

	Services	Investment
Event sponsorship and promotion		
The Big Float 2018	Event Sponsorship	$3,000
	KOIN Facebook Ads – English and Spanish	$800
	Portland Tribune, ¼ page ads x 2	$992
	Photo Booth Rental	$750
Clackamas Down The River & Lower Sandy Floating Cleanup	Portland Tribune, Sandy Post, Clackamas Review, ¼ page ads x 3	$1,905
Johnson Creek, Sandy, Tualatin, and Clackamas River Events	KOIN Facebook Ads	$5,000
Materials		
Print Materials	PDX Printing Services - Vinyl banner of aerial watershed map	$541
Coordination support		
EnviroIssues	Meeting facilitation and member coordination, website maintenance, social media authoring	$3,245
	TOTAL	**$16,233**

Table 3: FY 2018-19 expenditures

Observations

The following observations are based on the results of FY 2018-19 activities and suggest future direction the Coalition may take in its mission of educating the public about the impact of stormwater runoff pollution on the health of our rivers and streams.

The Big Float Watershed Village group reconvened in Spring 2019 to re-imagine the village. The group drafted new plans for The Big Float 2019. Plans included a single 20'x20' tent where watersheds planned fun interactive activities for youth. The Watershed Village would be set up in a central location near other children's activities (e.g. water bounce house) and would provide shade for parents.

The Coalition's website online events calendar continues to attract traffic, but is outdated and will be updated in 2019-2020 to match the social media calendar or be replaced with the Facebook events calendar. The group has limited funding, so streamlining the administration needs is important for efficiency. The latter could include embedding the Facebook events calendar on the website so both information outlets are always synced.

Both the Coalition's **Facebook and Twitter** followings are dominated by women, particularly those 35-54. Engaging this audience may be a priority for the Coalition for the upcoming fiscal year. In contrast, attracting and engaging more men could be the Coalition's focus. A clear goal for 2019-2020 is to consolidate the Coalition's **Instagram** handles and create more original content for all social media platforms. Instagram is particularly important in reaching young people; Most of Instagram's users are 29 and younger.

The Coalition continued to use **low cost web advertising** as part of its campaign in FY 2018-19. Continuing to focus on defined target audiences for messages (male v. female, age level for behavior, etc.) as well as targeting by ZIP code is a primary strategy.

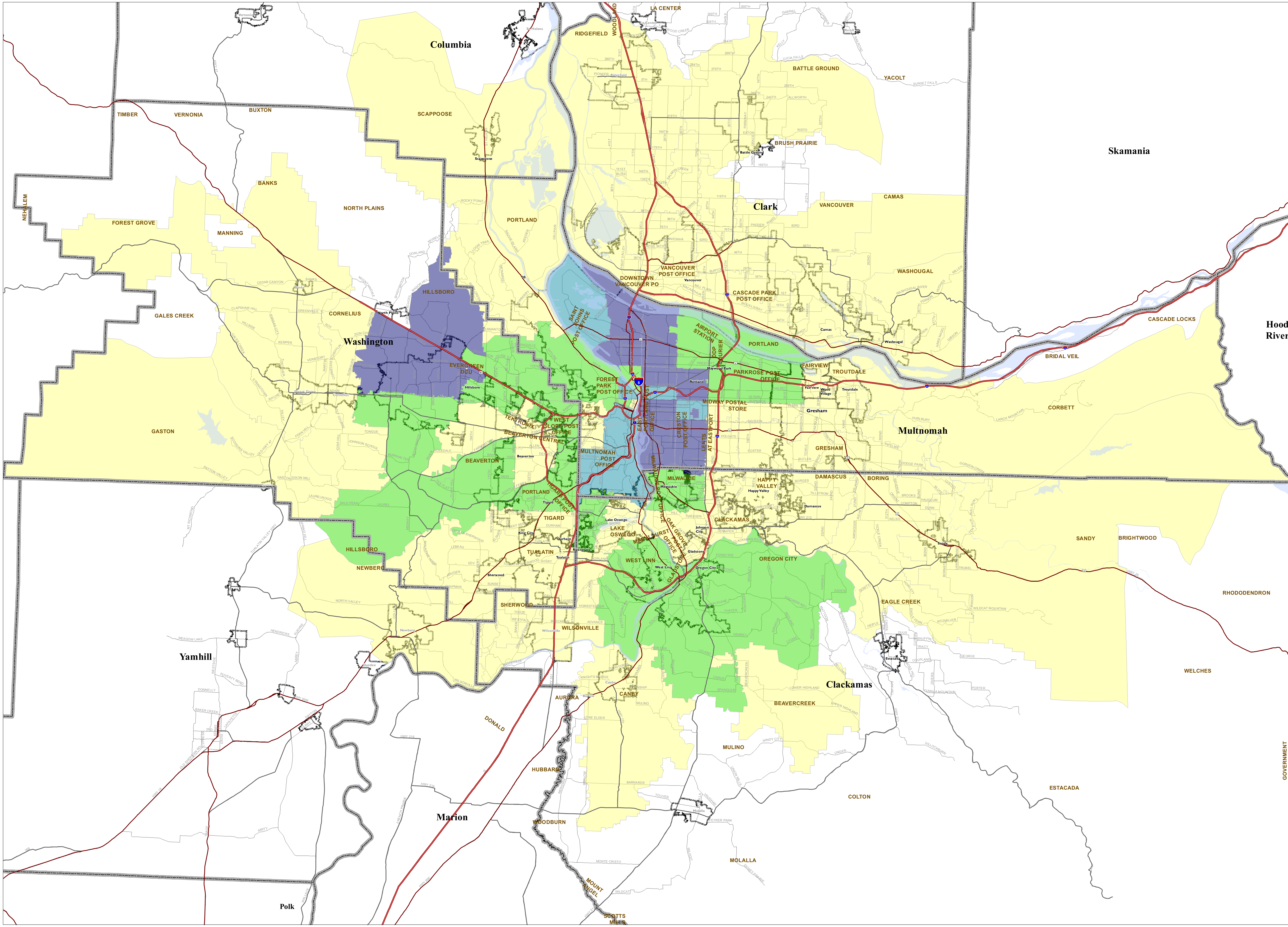
Direct, person-to-person outreach is a powerful way to share information, allows immediate feedback and compliments advertising. However, not all of the agencies have staffing to support event attendance and of the events they attend, they generally have to promote their own agency specific branding and programs (although still stormwater pollution reduction focused). As such, the Coalition is satisfied with its strategy to do the one large festival together and combine efforts with local watershed councils.

Outreach to local youth is conducted in a variety of ways by members of the Coalition. Connecting students to local rivers and developing an appreciation of natural resources and the protection of our water is one of the Coalition's goals in addition to focusing on their parents' home maintenance and yard care potential impacts. The Coalition will explore ways to engage youth in 2019-2020.

APPENDICES

A. The Big Float 2018 – Attendee ZIP Code Map
B. The Big Float 2018 – KOIN Ads Tearsheets
C. The Big Float 2018 – WES Advertisement
D. TheRiverStartsHere.org Analytics
E. Facebook Analytics
F. Twitter Profile
G. Instagram Profile - @theriverstartshere
H. Instagram Profile - @riverstartshere
I. Budget Detailed Breakdown
J. American Social Media Use by Demographic, Pew Research Center

Big Float Attendance (2012-2018)



Limited Access

Highway

Major Road

Local Road

Portland Metropolitan Area Counties

Major rivers and water bodies

Zip Code

AverageYear

0-10 Persons

11-30 Persons

31-60 Persons

61-101 Persons

Portland Area Cities

Other Locations Not Included in Map	Average/Year
CA	28
WA	23
All Other States/ International	39

CITY OF GRESHAM

0 10,000 20,000 Feet

Path: Y:\Inter-Departmental\MapsAndData\Projects\2018\09\35641\BigFloat2018.mxd

Date: 9/6/2018

Big Float 18 –how’d we do?

Face book

KOIN TV Ad Placements $600 Eng, $200 Sp

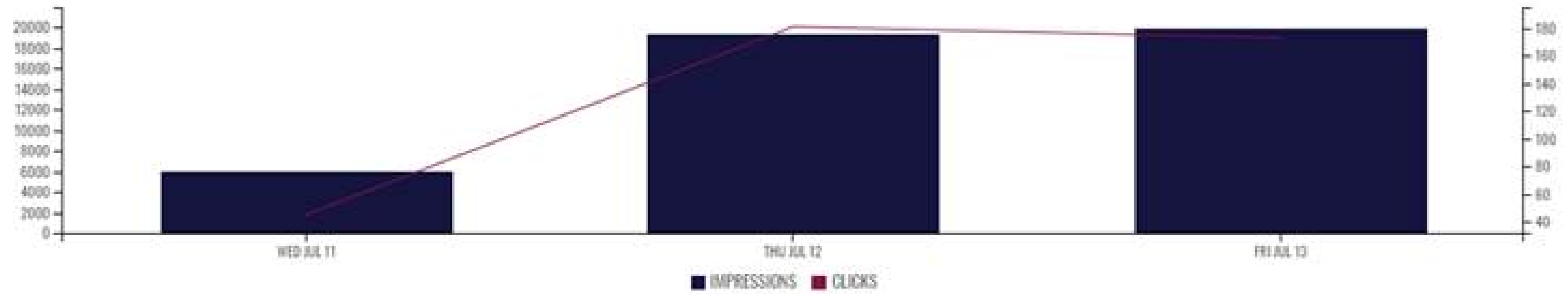
45,147 IMPRESSIONS -2.49% LAST 24 HOURS

399 CLICKS 4.62% LAST 24 HOURS

0.884 % CTR

$ 2.005 AVERAGE CPC

$ 800.00 TOTAL COST

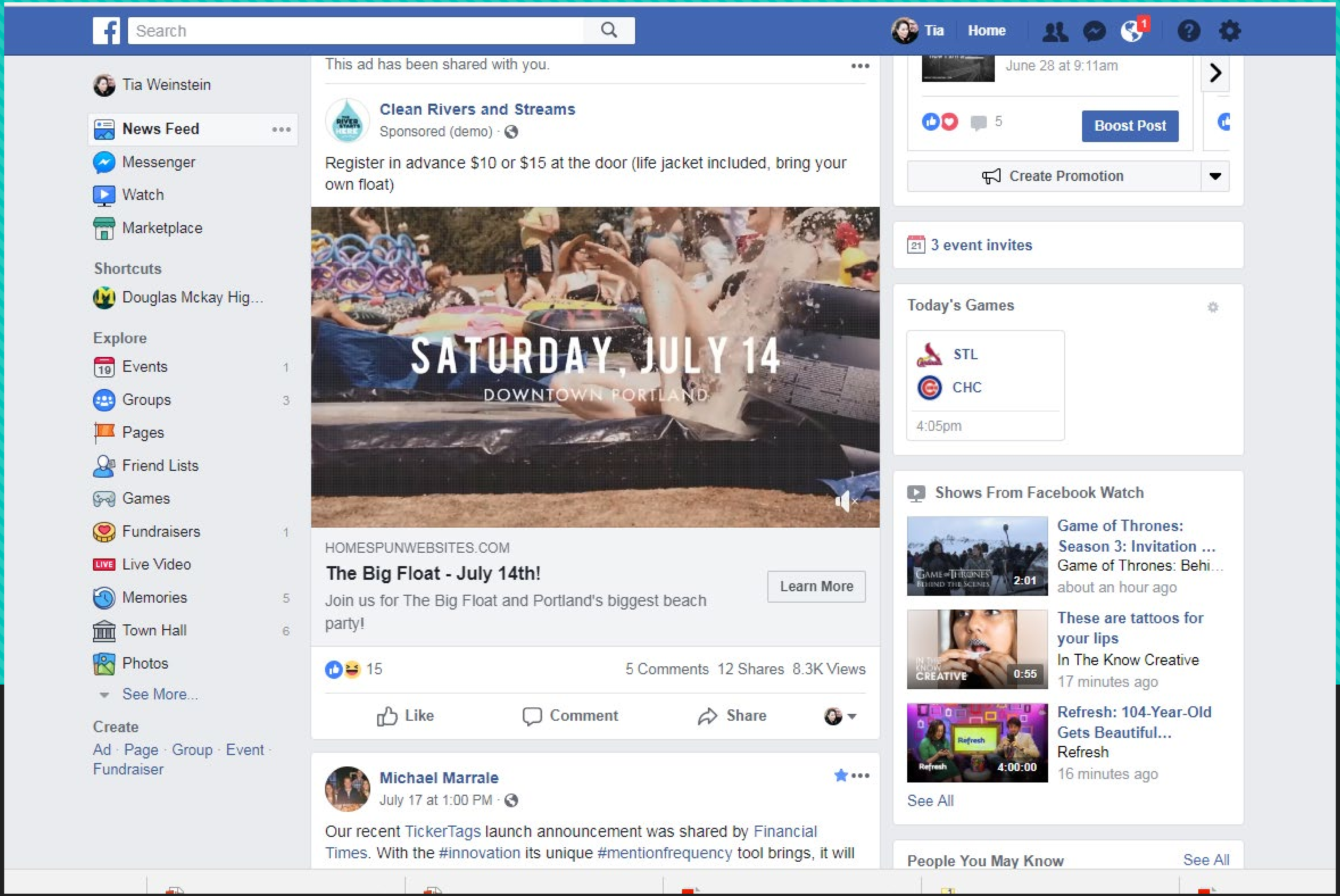


PERFORMANCE BY CAMPAIGN

Campaign	Impressions	Clicks	Page Likes	Post Likes	Video Views	CTR	Reach	Average CPC	CPV	Total Cost
(cid:136354) Social - Facebook Video Views Spanish - Facebook Video Views (687232)	11814	133	0	12	2327	1.126%	9635	$1.50	$0.09	$200.00
(cid:136354) Social - Facebook Video Views English - Facebook Video Views (687231)	33333	266	0	15	8124	0.798%	28890	$2.26	$0.07	$600.00

PERFORMANCE BY CREATIVE

Title	Image	Body	Impressions	Clicks	Page Likes	Post Likes	Video Views	CTR	Reach	Average CPC	CPV	Total Cost
The Big Float - July 14th!		Register in advance $10 or $15 at the door (life jacket included, bring your own float)	33333	266	0	15	8124	0.798%	28890	$2.26	$0.07	$600.00
Todos a Flotar - 14 de Julio!		Favor de registrarse con tiempo $10 preventa, $15 el dia del evento (el chaleco salvavida incluido) , trae tu propio flotador.	11814	133	0	12	2327	1.126%	9635	$1.50	$0.09	$200.00

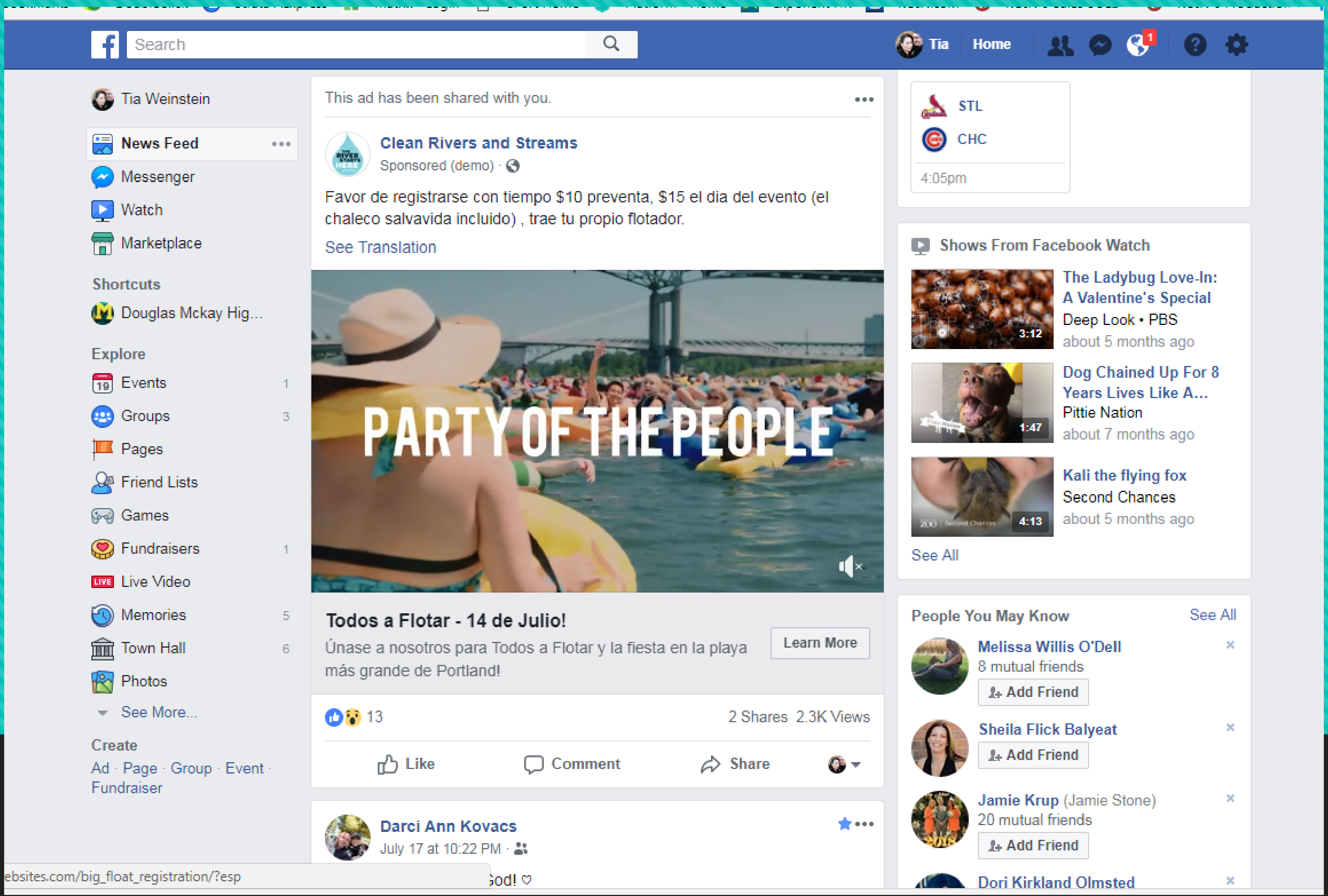


hyfn LOCAL

Clean Rivers and Streams

The Big Float – English ad

7/12/18



hyfn LOCAL

Clean Rivers and Streams

The Big Float – Spanish ad
7/12/18

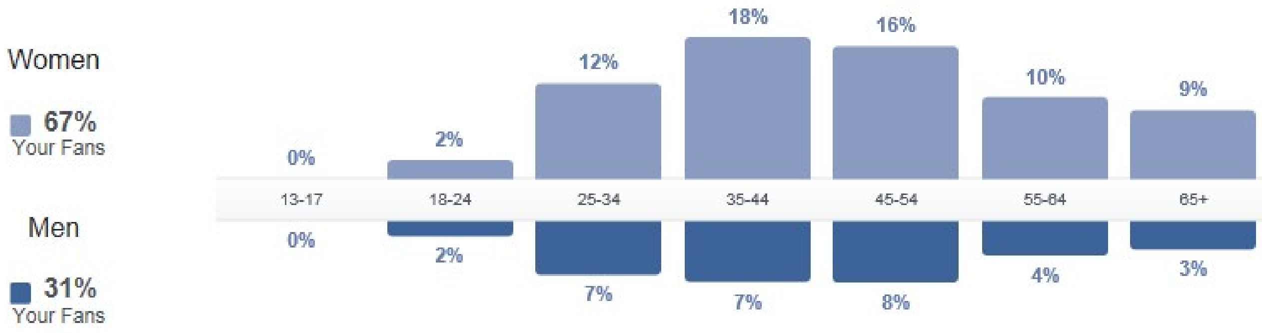
Big Float

- 311 Page Views
- 30,000 People Reached in July
- 11,000 Video Views
- 500 Engagements
- But no increase to our followers this year
- *We need to start doing ads to increase our followers

Clean Rivers Fan Summary

Your Fans | **Your Followers** | **People Reached** | **People Engaged**

Aggregated demographic data about the people who like your Page based on the age and gender information they provide in their user profiles.



Country	Your Fans
United States of America	1,121
India	5
Mexico	5
Australia	4
Canada	4
United Kingdom	4
Indonesia	4
Jordan	4
Brazil	3
Germany	2

City	Your Fans
Portland, OR	406
Vancouver, WA	62
Beaverton, OR	54
Gresham, OR	35
Hillsboro, OR	24
Clackamas, OR	22
Oregon City, OR	21
Tigard, OR	21
Milwaukie, OR	16
Lake Oswego, OR	15

Language	Your Fans
English (US)	1,103
English (UK)	34
Spanish	18
Arabic	3
Indonesian	3
Spanish (Spain)	2
French (France)	2
Japanese	2
Portuguese (Brazil)	2
Turkish	2

See More

Salem, OR	12
Wilsonville, OR	12
Canby, OR	11
Eugene, OR	11
Sandy, OR	10
New York, NY	7
Aloha, OR	7
Sherwood, OR	7
Longview, WA	7
Tulatin, OR	7
Bend, OR	6
Forest Grove, OR	6
Keizer, OR	6
Molalla, OR	6
West Linn, OR	6
Kelso, WA	6
Washougal, WA	6
Estacada, OR	5

People Reached with our page

- Women are more likely to be fans (67%), but we are reaching more men with content (58%)

City	People Reached
Portland, OR	18,488
Beaverton, OR	2,081
Gresham, OR	2,049
Clackamas, OR	1,014
Oregon City, OR	962
Salem, OR	914
Tigard, OR	790
Milwaukie, OR	403
Wilsonville, OR	393
Hillsboro, OR	380
Sherwood, OR	349
Tulatin, OR	335
Troutdale, OR	301
Lake Oswego, OR	237
Aloha, OR	224
Vancouver, WA	213
Fairview, OR	150
Forest Grove, OR	119
Seattle, WA	68
Happy Valley, OR	65
Canby, OR	62
Cornelius, OR	62
Wood Village, OR	59
West Linn, OR	57
Honolulu, HI	55
Damascus, OR	52
Redland, OR	45
Cedar Mill, OR	42
Battle Ground, WA	40
Newberg, OR	39
Lake Shore, WA	34
King City, OR	32
Stafford, OR	32
Corvallis, OR	31
Indianapolis, IN	30
Eugene, OR	30
Keizer, OR	30
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Summer River Events

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Saturday, July 14

Clackamas Down the River Cleanup
Sunday, Sept. 9

Lower Sandy River Floating Cleanup
Saturday, Sept. 22

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theriverstarshere.org

Traffic Type	Users	New Users	Sessions	Sessions	Bounce Rate	Avg. Session Duration
Referral	504	502	510	45%	83%	37.84
Direct	350	349	390	34%	92%	30.55
Organic Search	158	153	194	17%	81%	35.76
Social	29	27	31	3%	87%	75.45
Display	19	19	19	2%	79%	80.58
TOTALS	1060	1050	1144	-	86%	36.73

Date of Data Export	**Lifetime Total Likes**	**Daily Page Engaged Users**	**Weekly Page Engaged Users**
43,647	1,574	23	279
28 Days Page Engaged Users	**Daily Total Reach**	**Weekly Total Reach**	**28 Days Total Reach**
1,480	764	27,377	118,516
Daily Organic Reach	**Weekly Organic Reach**	**28 Days Organic Reach**	**Daily Paid Reach**
32	543	2,892	737
28 Days Paid Reach	**Weekly Paid Reach**	**Daily Viral Reach**	**Weekly Viral Reach**
116,844	27,031	21	245
28 Days Viral Reach	**Daily Total Impressions**	**Weekly Total Impressions**	**28 Days Total Impressions**
2,392	819	32,519	238,047
Daily Organic impressions	**Weekly Organic impressions**	**28 Days Organic impressions**	**Daily Paid Impressions**
40	1,089	5,843	776
Weekly Paid Impressions	**28 Days Paid Impressions**	**Daily Viral impressions**	**Weekly Viral impressions**
31,411	232,122	26	334
28 Days Viral impressions	**Daily Logged-in Page Views**	**Weekly Logged-in Page Views**	**Daily Logged-in Page Views**
3,195	3	19	2
Weekly Logged-in Page Views	**Daily Reach Of Page Posts**	**Weekly Reach Of Page Posts**	**28 Days Reach Of Page Posts**
10	764	27,377	118,516
Daily Organic Reach of Page posts	**Weekly Organic Reach of Page posts**	**28 Days Organic Reach of Page posts**	**Daily Paid Reach of Page posts**
32	543	2,892	737
Weekly Paid Reach of Page posts	**28 Days Paid Reach of Page posts**	**Daily Viral Reach Of Page Posts**	**Weekly Viral Reach Of Page Posts**
27,031	116,844	21	245
28 Days Viral Reach Of Page Posts	**Daily Total Impressions of your posts**	**Weekly Total Impressions of your pos**	**28 Days Total Impressions of your posts**
2,392	816	32,500	237,965
Daily Organic impressions of your posts	**Weekly Organic impressions of your post**	**28 Days Organic impressions of your**	**Weekly Total get direction click count pe**
40	1,089	5,843	
Weekly Paid impressions of your posts	**28 Days Paid impressions of your posts**	**Daily Viral Impressions Of Your Posts**	**Weekly Viral Impressions Of Your Posts**
31,411	232,122	26	334
28 Days Viral Impressions Of Your Posts	**Daily Total Consumers**	**Weekly Total Consumers**	**28 Days Total Consumers**
3,195	13	217	1,256
Daily Page Consumptions	**Weekly Page Consumptions**	**28 Days Page Consumptions**	**Daily Negative Feedback**
15	270	1,508	
Weekly Negative Feedback	**28 Days Negative Feedback**	**Daily Negative Feedback From Users**	**Weekly Negative Feedback From Users**
	1		

28 Days Negative Feedback From Users	**Daily Total Organic Views**	**Weekly Total Organic Views**	**28 Days Total Organic Views**
1	9	88	719
Daily Total Promoted Views	**Weekly Total Promoted Views**	**28 Days Total Promoted Views**	**Daily Total Organic 30-Second Views**
128	11,479	96,407	1
Weekly Total Organic 30-Second Views	**28 Days Total Organic 30-Second Views**	**Daily Paid 30-Second Views**	**Weekly Paid 30-Second Views**
14	138	19	2,016
28 Days Paid 30-Second Views	**Daily Total Video Views**	**Weekly Total Video Views**	**28 Days Total Video Views**
14,211	137	11,567	97,126
Daily Total Auto-Played Views	**Weekly Total Auto-Played Views**	**28 Days Total Auto-Played Views**	**Daily Total Clicked Views**
135	11,538	97,049	2
Weekly Total Clicked Views	**28 Days Total Clicked Views**	**Daily Video Repeats**	**Weekly Video Repeats**
29	77	2	835
28 Days Video Repeats	**Daily Total Unique Video Views**	**Weekly Total Unique Video Views**	**28 Days Total Unique Video Views**
31,294	135	10,732	65,832
Daily Total 30-Second Views	**Weekly Total 30-Second Views**	**28 Days Total 30-Second Views**	**Daily Auto-Played 30-Second Views**
20	2,030	14,349	19
Weekly Auto-Played 30-Second Views	**28 Days Auto-Played 30-Second Views**	**Daily Total Clicked 30-Second View**	**Weekly Total Clicked 30-Second Views**
2,022	14,312	1	8
28 Days Total Clicked 30-Second Views	**Daily Total 30-Second Repeats**	**Weekly Total 30-Second Repeats**	**28 Days Total 30-Second Repeats**
37		97	1,523
Daily Total Unique 30-Second Views	**Weekly Total Unique 30-Second Views**	**28 Days Total Unique 30-Second V**	**Daily Total: total action count per Page**
20	1,933	12,826	
Weekly Total: total action count per Page	**Daily Total website click count per Page**	**Weekly Total website click count p**	**Daily Total website click count per Page**
Weekly Total website click count per Page			

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Clean Rivers and Streams

We are a coalition of public agencies working to enhance appreciation of Oregon's rivers, and protect our water for people, pets, and wildlife.

POSTS IGTV SAVED TAGGED

Budget Breakdown

Accounting Date	Amount	Supplier Name	Header Memo	Line Memo
6/1/2019	909.06	ENVIROISSUES INC	Prjct#130-005-001 Task 001 04/01/19-05/31/19	4400004102Prjct#130-005-001 Task 001 04/01/19-05/31/19
6/19/2019	750.00	FLASH PHOTOBOOTH LLC	Multco Big Float 7/13/19	Photo Booth Rental - The Big Float 7/13/19
	1,659.06			

Date	Amount	Offset. acct name	Doc.Header Text	Name
11/1/2018	541.00	Professional Svcs	Correcting Amounts	PDX Printing Services 0701-073118P+D SR# 786710
9/1/2018	800.00	NEXSTAR DIGITAL LLC	CLEAN RVRS & STREAMS	REGIONAL COALITION FOR CLEAN RVRS & STREAMS 0718
10/9/2018	991.80	NEXSTAR DIGITAL LLC	CLEAN RVRS & STREAMS	REGIONAL COALITION FOR CLEAN RVRS & STREAMS 0918
9/5/2018	3,931.70	NEXSTAR DIGITAL LLC	CLEAN RVRS & STREAMS 0818	REGIONAL COALITION FOR CLEAN RVRS & STREAMS 0818
7/14/2018	3,000.00	HUMAN ACCESS PROJECT	BIG FLOAT 8	BIG FLOAT 8 TAKE PLACE 7/14/18
	9,264.50			

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NEWS IN THE NUMBERS

APRIL 10, 2019

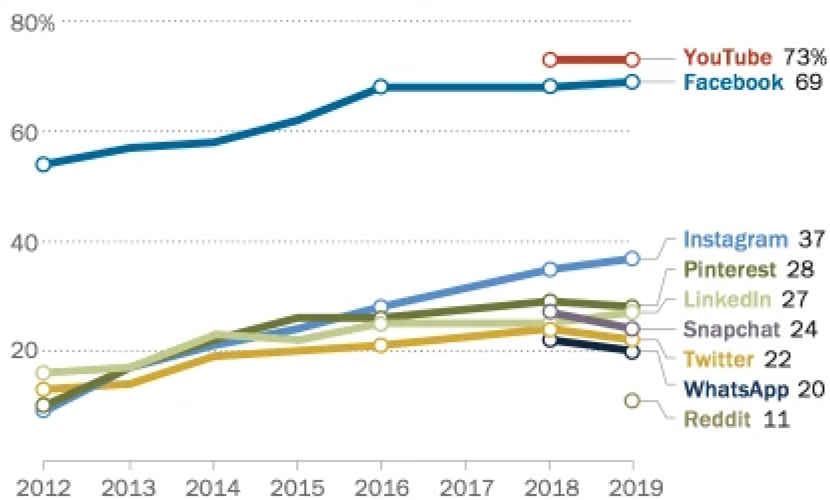
Share of U.S. adults using social media, including Facebook, is mostly unchanged since 2018

BY ANDREW PERRIN AND MONICA ANDERSON

The share of U.S. adults who say they use certain online platforms or apps is statistically unchanged from where it stood in early 2018 despite a long stretch of controversies over privacy, fake news and censorship on social media, according to a new Pew Research Center survey conducted Jan. 8 to Feb. 7, 2019.

Facebook, YouTube continue to be the most widely used online platforms among U.S. adults

% of U.S. adults who say they ever use the following online platforms or messaging apps online or on their cellphone



Note: Pre-2018 telephone poll data is not available for YouTube, Snapchat and WhatsApp. Comparable trend data is not available for Reddit.
Source: Survey conducted Jan. 8-Feb. 7, 2019.
PEW RESEARCH CENTER

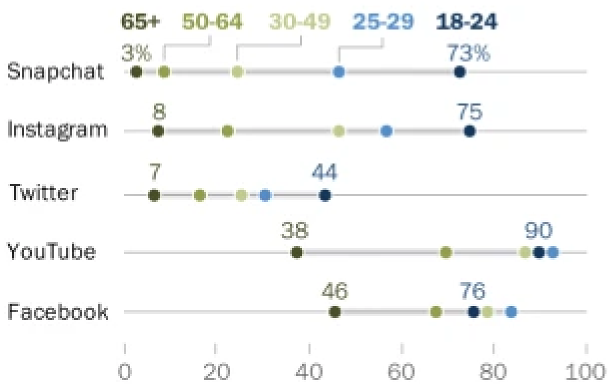
More broadly, the steady growth in adoption that social platforms have experienced in the United States over the past decade also appears to be slowing. The shares of adults who say they use Facebook, Pinterest, LinkedIn and Twitter are each largely the same as in 2016, with only Instagram showing an uptick in use during this time period. (There are no comparable 2016 phone survey data for YouTube, Snapchat, WhatsApp or Reddit.)

Facebook – which recently celebrated its 15th anniversary – remains one of the most widely used social media sites among adults in the U.S. Roughly seven-in-ten adults (69%) say they ever use the platform. (A separate 2018 Center survey showed Facebook use among U.S. teens had dropped in recent years.) YouTube is the only other online platform measured that matches Facebook's reach: 73% of adults report using the video sharing site. But certain online platforms, most notably Instagram and Snapchat, have an especially strong following among young adults.

Instagram, Snapchat remain especially popular among those ages 18 to 24

Snapchat and Instagram are especially popular among 18- to 24-year-olds

% of U.S. adults in each age group who say they ever use ...



Note: Respondents who did not give an answer are not shown.
Source: Survey conducted Jan. 8-Feb. 7, 2019.

PEW RESEARCH CENTER

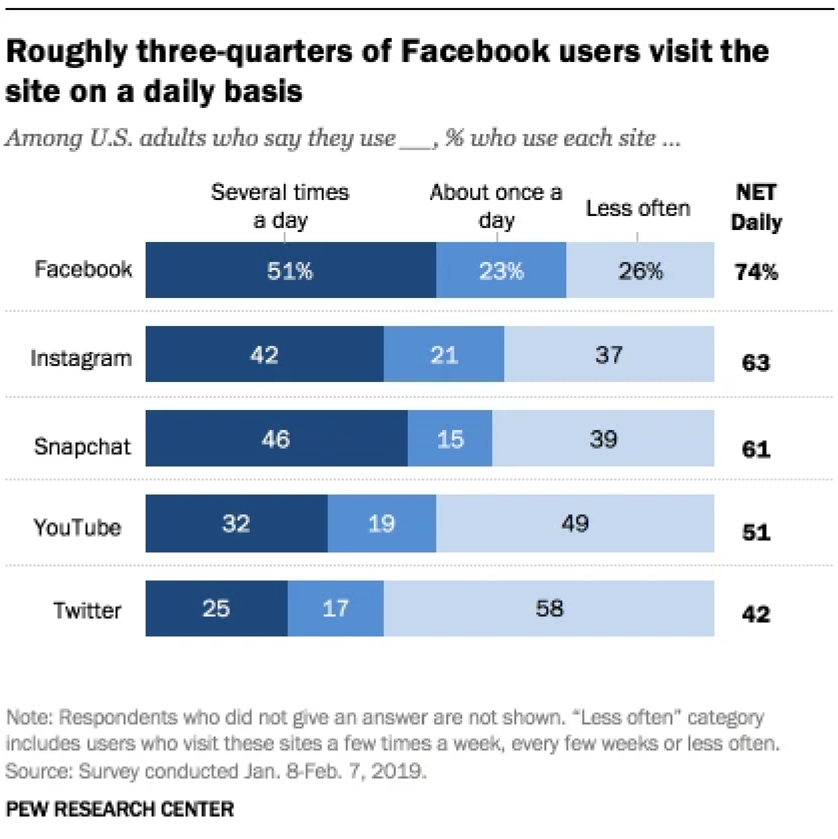
As was true in previous surveys of social media use by the Center, there are substantial age-related differences in platform use. This is especially true of Instagram and Snapchat, which are used by 67% and 62% of 18- to 29-year-olds, respectively.

Particularly for these two platforms, there are also pronounced differences in use *within* the young adult population. Those ages 18 to 24 are substantially more likely than those ages 25 to 29 to say they use Snapchat (73% vs. 47%) and Instagram (75% vs. 57%).

By comparison, age differences are less pronounced for Facebook. Facebook use is relatively common across a range of age groups, with 68% of those ages 50 to 64 and nearly half of those 65 and older saying they use the site.

Other demographic patterns related to social media and messaging app use are relatively unchanged from last year. Women are nearly three times as likely as men to use Pinterest (42% vs. 15%). Around half of college graduates and those who live in high-income households use LinkedIn, compared with 10% or fewer of those who have not attended at least some college or those in lower-income households. And WhatsApp continues to be popular among Hispanics: 42% use the messaging app, compared with 24% of blacks and 13% of whites. (For more details on social media and messaging app use by different demographic groups, see the bottom of the post.)

Majority of Facebook, Snapchat and Instagram users visit these sites daily



A 2018 Center survey found that some Facebook users had recently taken steps to moderate their use of the site – such as deleting the Facebook app from their phone or taking a break from the platform for some time. But despite these findings and amid some high profile controversies, Facebook users as a whole are just as active on the site today as they were a year ago. Roughly three-quarters of Facebook users (74%) visit the site daily, including about half who do so several times a day. These shares are identical to those reported by Facebook users in the Center's 2018 social media use survey.

Majorities of Snapchat and Instagram users also say they visit these sites daily, though they are slightly less likely than Facebook users to do so. The shares of young adults using these platforms daily are especially large. Roughly eight-in-ten Snapchat users ages 18 to 29 (77%) say they use the app every day, including 68% who say they do so multiple times day. Similarly, 76% of Instagram users in this age group visit the site on a daily basis, with 60% reporting that they do so several times per day. These patterns are largely similar to what the Center found in 2018.

Other platforms are visited somewhat less frequently. Some 51% of YouTube users say they visit the site daily – a slight increase from the 45% who said this in 2018.

Use of different online platforms by demographic groups

% of U.S. adults who say they ever use the following online platforms or messaging apps

	YouTube	Facebook	Instagram	Pinterest	LinkedIn	Snapchat	Twitter	WhatsApp	Reddit
U.S. adults	73%	69%	37%	28%	27%	24%	22%	20%	11%
Men	78	63	31	15	29	24	24	21	15
Women	68	75	43	42	24	24	21	19	8
White	71	70	33	33	28	22	21	13	12
Black	77	70	40	27	24	28	24	24	4
Hispanic	78	69	51	22	16	29	25	42	14
Ages 18-29	91	79	67	34	28	62	38	23	22
18-24	90	76	75	38	17	73	44	20	21
25-29	93	84	57	28	44	47	31	28	23
30-49	87	79	47	35	37	25	26	31	14
50-64	70	68	23	27	24	9	17	16	6
65+	38	46	8	15	11	3	7	3	1
<$30,000	68	69	35	18	10	27	20	19	9
$30,000-$74,999	75	72	39	27	26	26	20	16	10
$75,000+	83	74	42	41	49	22	31	25	15
High school or less	64	61	33	19	9	22	13	18	6
Some college	79	75	37	32	26	29	24	14	14
College+	80	74	43	38	51	20	32	28	15
Urban	77	73	46	30	33	29	26	24	11
Suburban	74	69	35	30	30	20	22	19	13
Rural	64	66	21	26	10	20	13	10	8

Note: Respondents who did not give an answer are not shown. Whites and blacks include only non-Hispanics. Hispanics are of any race.
Source: Survey conducted Jan. 8-Feb. 7, 2019.

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Note: See full topline results and methodology here.

Topics Social Media, Technology Adoption

Andrew Perrin *is a research analyst focusing on internet and technology at Pew Research Center.*

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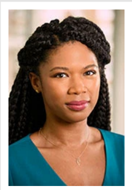
Research Center.



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GSI Water Solutions, Inc.

TECHNICAL MEMORANDUM

Analysis of Urban Stormwater Quality Data and Pollutant Fate and Transport Simulations in Support of Emerging Pollutant Evaluations

PREPARED FOR: Joel Bowker—City of Portland
Torrey Lindbo and Katie Holzer—City of Gresham
Therese Walch and Tom Mendez—City of Eugene
Larry Morse—City of Redmond
Wendy Edde—City of Bend
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Kyle Carpenter—City of La Grande
Andrew Swanson—Clackamas County WES
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Roy Iwai—Multnomah County
Rob Livingston—City of Milwaukie
Shashi Bajracharya—Lane County

PREPARED BY: Mary Hingst, RG – GSI Water Solutions, Inc.
Matt Kohlbecker, RG – GSI Water Solutions, Inc.

DATE: September 21, 2017

Executive Summary

This memorandum is a technical background document in support of Emerging Pollutant Evaluations that are required by Individual Underground Injection Control (UIC) Permits in Oregon. The memorandum presents an evaluation of the types and concentrations pesticides in urban stormwater, and model simulations of pesticide fate and transport after the stormwater infiltrates into subsurface soils from UICs. The objectives of the memorandum are to:

(1) Statistically summarize the types and concentrations of pesticides in urban stormwater that discharges to UICs based on data collected by Phase I Municipal Separate Storm Sewer System (MS4) permit holders, the United States Geological Survey (USGS), Pesticide Stewardship Partnerships (PSPs), and UIC permit holders.

(2) Identify pesticides that have a relatively high potential to violate the Safe Drinking Water Act (SDWA) based on frequency of occurrence and concentration, and

(3) Using a modeling approach, evaluate the environmental fate of these pesticides that have a relatively higher potential to violate the SDWA, with the objective of determining whether the pesticides are predicted by the model to violate the SDWA's prohibition of fluid movement standard or prohibition of endangerment.

The findings of this memorandum are:

- The urban stormwater dataset analyzed in this memorandum is a robust, comprehensive screen of pesticides in urban stormwater that includes analysis of 248 unique pesticides. Of these 248 pesticides, 169 pesticides have a regulatory standard [i.e., an Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), Department of Environmental Quality (DEQ) Risk Based Concentration (RBC), USGS Health-Based Screening Level (HBSL), or an EPA Human Health Benchmark for Pesticides (HHBP)].

- These 169 pesticides with regulatory standards were evaluated to determine if pesticide concentrations potentially violated the SDWA. The remaining 79 pesticides do not have an MCL or human health standard, and were not evaluated in this memorandum (the SDWA only regulates stormwater pollutants that have the potential to violate an MCL or adversely affect human health; therefore, MCLs and human health standards are required to determine if a pesticide violates the SDWA).

    - Only one of the 169 pesticides—pentachlorophenol (PCP)—exceeded its respective regulatory standard in one or more samples. PCP is a wood preservative that was detected in both stormwater and urban stream samples.

    - Because concentrations of the remaining 168 pesticides are below their respective regulatory standards when stormwater discharges into the UIC, EPA does not consider these pesticides to violate the SDWA (EPA, 2001). However, two of these 168 pesticides—diuron and fipronil—are more commonly detected in stormwater (detected in more than 15% of samples) and are detected at concentrations closer to their respective regulatory standard (detected at concentrations of over 10% of their respective regulatory standard). These pesticides pose a higher risk of endangering groundwater, and, along with PCP, were evaluated further in this memorandum.

    - A generic Groundwater Protectiveness Demonstration (GWPD) model was used to simulate fate and transport of PCP, diuron and fipronil after discharge from a UIC, with the objective of determining if the pesticides were predicted to violate the SDWA. Existing GWPD models have simulated the fate and transport of PCP, and have used the results to determine vertical setbacks (between UICs and groundwater) and horizontal setbacks (between UICs and water wells) that ensure compliance with the SDWA. Based on the generic GWPD model, diuron attenuates to a concentration of zero (i.e., nondetect) more rapidly than PCP, and fipronil attenuates to a concentration of zero as rapidly as PCP. Therefore, the protective vertical and horizontal setbacks that have been established for UICs based on PCP are also protective for diuron and fipronil.

- The information in this memorandum provides UIC permittees with several options for adaptively managing their UIC systems, including but not limited to:

    - Some pesticides in stormwater do not have MCLs or human health-based regulatory standards (see Table 2). Permittees may want to review whether MCLs or human health-based regulatory standards are developed for these pesticides, and evaluate whether the pesticides violate the SDWA as a part of the 10-year Emerging Pollutant Evaluation that is due with each permittee's permit renewal application.

    - Several pesticides—simazine, mcpp-p, MCPA, ethoprop, Aldrin, alpha-hch, diazinon, heptachlor, p,p'-ddd—were detected at concentrations of over 10 percent of their respective regulatory standards, but were not evaluated further as a part of this memorandum because the frequency of detection was less than 15 percent. Permittees may want to collect additional stormwater samples to increase the size of the datasets for these pesticides and determine whether further evaluation of these pesticides is necessary as a part of the 10-year Emerging Pollutant Evaluation that is due with each permittee's permit renewal application.

    - Regulatory agencies and jurisdictions should continue to promote pesticide source controls through education and other best management practices, and may want to continue encouraging stormwater infiltration using UICs because human and ecological receptors are not exposed to the pesticides in stormwater, as long as the UICs are operated in accordance with permit-required setbacks (to ensure the soil thickness is sufficient to attenuate the pollutants). Specifically, many of the pesticides in urban stormwater pose acute and/or chronic toxicological impacts to fish and other environmental receptors when they are discharged directly to surface water; when discharged into the ground, the pesticides are naturally attenuated in the subsurface.

The memorandum is organized as follows:

- **Background.** Provides information about the UIC permit condition that requires an Emerging Pollutant Evaluation, the scope of the evaluation, and the urban stormwater data used in the evaluation.

- **Regulatory Framework.** Discusses SDWA regulations that are relevant to the evaluation, including the prohibition of fluid movement standard and endangerment in the federal and/or state UIC rules, and regulatory standards used in the evaluation.

- **Methods.** Discusses the methods used to evaluate the types and concentrations of pesticides in urban stormwater, and to model the fate of pesticides after discharge from a UIC.

- **Results.** Presents results of the analysis, including a statistical summary of the urban stormwater data and fate and transport evaluations for pollutants that are considered to have a relatively higher potential to violate the SDWA.

- **Conclusions and Recommendations.**

Background

In 2005, the Oregon Department of Environmental Quality (DEQ) issued the first Individual Underground Injection Control (UIC) Water Pollution Control Facilties (WPCF) permit to the City of Portland. Based on the implementation of Portland's 2005 permit, DEQ developed a UIC permit template to streamline and facilitate the issuing of subsequent UIC permits. In 2012, DEQ began issuing Individual UIC WPCF permits to cities, service districts, and counties in Oregon using this template[1]. A table of the active Individual UIC permits in Oregon is provided in Appendix A.

Requirement for an "Emerging Pollutant Evaluation"

The Individual UIC permits issued between 2012 and June 2016 were developed using the same template and, therefore, contain similar conditions. One of these similar conditions is that permittees adaptively manage their UIC system. Adaptive management is a structured, iterative process designed to refine and improve stormwater programs over time by evaluating results and adjusting actions on the basis of what has been learned. An element of the adaptive management strategy required by Individual UIC permits is that permittees develop an Emerging Pollutant Evaluation that:

> *". . . evaluate(s) trends in emerging pollutant types and concentrations . . . and address(es) the implications of any significant findings for protection of beneficial uses and for the application of best management practices."*[2]

Defining Emerging Pollutants

Because "Emerging Pollutant(s)" are not defined in the permit, permittees have worked closely over the years with DEQ to clarify which pollutants should be included in the Emerging Pollutant Evaluation. In 2015, the City of Portland requested clarification on DEQ's definition of "Emerging Pollutants" as a part of its UIC permit renewal and, as a result, the following language was added to Schedule D, condition 6 of all subsequent permit evaluation reports:

> *"Consideration must be given for emerging pollutant types and concentrations. 'Emerging Pollutant Types' refers to pesticides, herbicides, or other pollutants identified as being most prevalent in Oregon urban stormwater on the basis of studies currently being conducted by MS4 communities (as a part of their Phase I MS4 permits) . . ."*

For the remainder of this memorandum, "pesticides" refer to pesticides, herbicides, and other pollutants that were analyzed in samples collected by Municipal Separate Storm Sewer System (MS4) communities as a requirement of their Phase I MS4 permits.

Defining "Emerging Pollutant(s)" to be pesticides is consistent with DEQ's five year review plan for UIC Permits. Specifically, the permit evaluation reports that accompany each permit state that:

> *"We (DEQ) currently are requiring communities with a MS4 National Pollutant Discharge Elimination System (NPDES) permit to sample and evaluate which pesticide and herbicide are most prevalent in urban stormwater . . . We intend to use the results of this screening as a part of the five-year review of each UIC municipal permit."* [3]

UIC permittees continued to solicit input from DEQ on the scope of the Emerging Pollutant Evaluation by discussing the evaluation with DEQ during Association of Clean Water Agency (ACWA) Groundwater

[1] The City of Portland's 2005 permit expired in 2015, and was renewed in 2015 using the UIC permit template.

[2] Schedule D, condition 6

[3] See Schedule A, condition 2 of permit evaluation reports

Committee Meetings. During the September 21, 2015, meeting, DEQ staff confirmed that pesticides should be the focus of the Emerging Pollutant Evaluations and, on November 30, 2016, ACWA held a Special Meeting with DEQ, the United States Geological Survey (USGS), Oregon Department of Agriculture, and Portland Water Bureau to learn more about pesticides that are detected in stormwater. In an April 2017 email, UIC permit holders verified with DEQ that the focus of the Emerging Pollutant Evaluation should be pesticides (Edde, 2017).

Consistent with the permit requirement for an Emerging Pollutant Evaluation, and clarifications in the administrative record, this memorandum presents a statistical analysis of pesticides in stormwater, and evaluates whether the pesticides are predicted by pollutant fate and transport modeling to violate the Safe Drinking Water Act (SDWA) after discharge from a UIC. The results of this memorandum will be used by UIC permittees to adaptively manage their UIC systems, and to inform the Emerging Pollutant Evaluations required by their UIC Permits.

Urban Stormwater Quality Data

The evaluation in this memorandum is based on stormwater and urban stream samples collected within the jurisdictions of MS4 communities. As required by the permits, most of the samples were collected by Phase I MS4 permittees as a requirement of their Phase I MS4 permits that were renewed between 2010 and 2012. Permittees included the Portland Group[4], the City of Salem, the Gresham Group[5], the Clackamas County Group[6], Multnomah County, and the City of Eugene. These permits contained a condition in Table B-1 requiring the permittee to characterize pesticides in stormwater. The resulting dataset is comprised of pesticides explicitly required by Table B-1, as well as a list of pesticides that the interagency Water Quality Pesticide Management Team (WQPMT) provided to Phase I MS4 permittees during a meeting on February 25, 2011. The WQPMT list contained pesticides based on non-agricultural uses (for example, pesticides used on golf courses, lawns, rights of way, etc., that would be expected to be present in the urban environment), toxicity [based on Environmental Protection Agency (EPA) benchmarks], and lists that indicate the pesticide is a high priority for DEQ (for example, the POC list, which identifies “Pesticides of Concern”).

The samples collected as a requirement of Phase I MS4 Permits were supplemented by samples from the following three sources:

- **Pesticide Stewardship Partnership (PSP) data.** Includes urban stream samples that were collected as a part of the Clackamas River Watershed’s PSP (Sieben Creek) and Long Tom Watershed Council PSP (Amazon Creek). A PSP is a collaborative effort by several groups, including DEQ, to enhance water quality in local watershed.
- **USGS Data.** Includes urban stream data published in the USGS report *Pesticide Occurrence and Distribution in the Lower Clackamas River Basin, Oregon, 2000-2005* (USGS, 2008).
- **City of Redmond.** Includes stormwater samples collected from five City UICs.

The pesticides that were analyzed in urban stormwater are shown in Table 1 (pesticides with a regulatory standard) and Table 2 (pesticides without a regulatory standard). Table 1 and Table 2 also show which pesticides were analyzed by each jurisdiction. The following bullets provide additional information about the urban stormwater dataset, including sampling dates and sampling locations:

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[4] Portland and the Port of Portland

[5] Gresham and Fairview

[6] Clackamas County DTD, Gladstone, Johnson City, Lake Oswego, Milwaukie, Oregon City, West Linn, Wilsonville, Oak Lodge Sanitary District, CCSD#1 Happy Valley, SWMACC Rivergrove

- **Portland Group.** Samples collected from 2005 through 2015 from UICs.
- **City of Salem.** Samples collected from 2012 through 2014 from the City's MS4 system.
- **Gresham Group.** Samples collected from 2009 through 2015, primarily from UICs with additional samples from stormwater outfalls and urban stream Fairview Creek. Samples collected from Johnson Creek were excluded from the analysis in this memorandum because Johnson Creek has a significant amount of agricultural inputs and, therefore, is not representative of urban stormwater quality.
- **Clackamas County Group.** Samples collected in 2013, primarily from stormwater outfalls and urban streams Kellogg Creek, Lost Dog Creek, Sieben Creek, and Tanner Creek.
- **Multnomah County.** Samples collected in 2014 and 2015 from UICs.
- **City of Eugene.** Samples collected from 2012 through 2014 from Spring Creek and the A3 Channel.
- **Pesticide Stewardship Partnership Data.** Samples collected from Sieben Creek at Highway 212 (2008 to 2016) and Amazon Creek (2011 to 2017).
- **USGS Data.** Samples collected in 2005 from the Cow Creek at Mouth, Carli Creek near mouth, and Sieben Creek at Sunnyside Road.
- **City of Redmond.** Samples collected from the City's UICs in 2015 and 2016.

Samples from urban streams and outfalls were collected during storm events so that samples would be representative of urban stormwater runoff.

Regulatory Framework

UICs are regulated under the federal SDWA[7] and State of Oregon UIC Rules[8]. The analysis of pesticides in this memorandum is based on the requirements that these regulations establish for UICs, including the prohibition of fluid movement standard, prohibition of endangerment, the point of compliance, and applicable regulatory standards.

Prohibition of Fluid Movement Standard and Prohibition of Endangerment

The two central provisions of the SDWA for stormwater UICs are the prohibition of fluid movement standard and prohibition of endangerment. The prohibition of fluid movement standard is defined in 40 Code of Federal Regulations (CFR) 140.12(a), and states that:

> *"No (UIC) owner or operator shall . . . conduct any . . . injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR part 142 or may otherwise adversely affect the health of persons."*

The prohibition of fluid movement standard is also incorporated in the Oregon Administrative Rules (OAR) 340-044-0014(1). Endangerment is defined in 42 United States Code (USC) 300h(d)(2):

> *"Underground injection endangers drinking water sources if such injection may result in the presence in underground water which supplies or can reasonably be expected to supply any public water system of any contaminant, and if the presence of such contaminant may result in such system's not complying with any national primary drinking water regulation or may otherwise affect the health of persons."*

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[7] 40 Code of Federal Regulations (CFR) Parts 144, 145 and 146
[8] Oregon Administrative Rules (OAR) 340-044

Endangerment is prohibited by 40 CFR 144.82.

Endangerment occurs, and the prohibition of fluid movement is violated, when UIC discharges violate a Maximum Contaminant Level (MCL) or adversely affect human health, which occurs when pollutants from a UIC reach a water well[9]. For the purpose of this memorandum, pesticides are considered to violate the SDWA if the prohibition of fluid movement standard or prohibition of endangerment is violated.

Point of Compliance and Groundwater Protectiveness Demonstrations

It is not sufficiently proactive to detect endangerment or the violation of the prohibition of movement standard at a water well. Therefore, EPA recommends in the *Technical Program Overview of Underground Injection Control Regulations* that the end-of-pipe, where stormwater discharges into the UIC, be used ". . . to assess whether endangerment is a potential problem" (EPA, pg. 74, 2001). According to EPA, endangerment is a "potential" problem if pollutant concentrations at the end-of-pipe exceed a regulatory standard.

UIC Individual Permits provide a framework for evaluating whether exceedance of a regulatory standard at the end-of-pipe constitutes a violation of the SDWA. Permitteees can conduct a Groundwater Protectiveness Demonstration (GWPD) to determine if the pollutant reaches a water well, in which case the SDWA is violated. GWPDs are pollutant fate and transport models that simulate reductions in pollutant concentrations after discharge from a UIC. Specifically, pollutant concentrations are reduced due to volatilization as stormwater cascades into the bottom of the UIC, settlement of stormwater solids in the UIC sump, filtration of stormwater solids by subsurface soils, sorption of dissolved pollutants onto soil surfaces, degradation of pollutants by microbes, and dispersion of the pollutants. The GWPDs prepared to date only simulate three of these processes (sorption, degradation and dispersion) when calculating reductions in pollutant concentrations. Several jurisdictions have conducted GWPDs and found that the pollutant pentachlorophenol (PCP) is the most mobile and persistent of the common stormwater pollutants[10]. These jurisdictions have established horizontal setbacks between UICs and water wells and/or vertical setbacks between UICs and groundwater based on PCP, to ensure that stormwater discharges do not violate the SDWA (i.e., by endangering groundwater or violating the prohibition of fluid movement standard).

Regulatory Standards

Both the prohibition of fluid movement standard and prohibition of endangerment in the SDWA clearly prohibit injection that violates an MCL or adversely affects the health of persons. Therefore, the regulatory standards used to evaluate pesticide concentrations are MCLs and human health-based standards. The following human health-based standards were used in this analysis:

- **U.S. Geological Survey Health-Based Screening Levels (HBSLs).** HBSLs are standards that are used to determine whether contaminants in water have the potential to adversely impact human health (Toccolino et al., 2003; Toccalino, 2007). A contaminant may have up to three HBSLs based on: (1) chronic exposure to the contaminant (noncarcinogens), (2) a cancer risk of 1

[9] Because the pollutant must be ingested from groundwater in order to adversely affect human health, and the violation of an MCL occurs at a specified location. Specifically, by 40 CFR 142.2, an MCL ". . . means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system." In practice, DEQ considers endangerment to occur or the prohibition of fluid movement standard to be violated if a UIC discharge causes *or contributes to* violation of an MCL or an adversely affecting human health. See, for example, the definitions section in the City of Hermiston's Individual UIC Permit (Permit No. 103126).

[10] See DEQ (2017)

in 10,000 persons (carcinogens), and (3) a cancer risk of 1 in 1,000,000 persons (carcinogens). GSI conservatively used the lowest of these HBSLs to evaluate whether pesticides in stormwater have the potential to adversely affect human health. The HBSLs used in this study were published by the USGS on June 30, 2014; no updates to the HBSLs have been published since that date.

- **Environmental Protection Agency (EPA) Human Health Benchmark for Pesticides (HHBPs).** HHBPs are "levels of certain food-use pesticides in water at or below which adverse health effects are not anticipated" (EPA, 2017). A contaminant may have up to four HHBPs based on: (1) acute exposure to the contaminant (noncarcinogens), (2) chronic exposure to the contaminant (noncarcinogens), (3) a cancer risk of 1 in 10,000 persons (carcinogens), and (4) a cancer risk of 1 in 1,000,000 persons (carcinogens). GSI conservatively used the lowest of these HHBPs to evaluate whether pesticides in stormwater have the potential to adversely affect human health. The HHBPs used in this study were published by the EPA in January 2017; no updates to the HHBPs have been published since that date.

- **DEQ Risk Based Concentrations (RBCs).** DEQ RBCs are screening levels used to assess the risk that a pollutant poses to environmental receptors (DEQ, 2003). RBCs are calculated for different exposure pathways (for example, exposure to a pollutant from soil ingestion, contact or inhalation; inhalation from air; ingestion from tap water, etc.) and exposure scenarios (for example, urban residential scenario, occupational scenario, etc.). GSI evaluated pesticide concentrations using the ingestion from tap water exposure pathway (because ingestion from groundwater is the likely way that humans would be exposed to pesticides from a UIC source) under the residential receptor scenario (the most conservative scenario). For carcinogens, DEQ RBCs are based on a cancer risk of 1 in 1,000,000 persons. GSI used RBCs published by DEQ on November 1, 2015; no updates to the RBCs have been published since that date.

In summary, HHBPs, HBSLs and DEQ RBCs for tapwater are calculated based on human exposure to a contaminant through ingestion of groundwater (Toccolino et al., 2003; EPA, 2017; DEQ, 2003). These regulatory standards are appropriate for evaluating pesticides in stormwater that discharges to UICs because the ingestion from groundwater pathway is the reasonably likely way that people would come into contact with the pesticides from a UIC source (in other words, the pathway is complete). This memorandum does not compare pesticide concentrations to other human health-based standards because the exposure pathways are incomplete. For example, humans are unlikely to come into contact with stormwater solids that accumulate in the bottom of a UIC (because UICs are typically over ten feet deep and covered by a manhole lid), so regulatory standards based on exposure to soil in the bottom of a UIC are not used in this evaluation. In addition, the pollutants from UICs are unlikely to reach a surface water body (UICs are not located close to surface water bodies), so regulatory standards based on fish consumption by humans are not used in this evaluation.

Methods

The objectives of the Emerging Pollutant Evaluation were accomplished with the following tasks:

- **Selection of Emerging Pollutants for Analysis.** The urban stormwater dataset contained 248 unique pesticides, some of which have no regulatory standard. A pesticide was included in the analysis of Emerging Pollutants if it had regulatory standard (i.e., an MCL or a health-based standard like a HHBP, HBSL or DEQ RBC). The remaining 79 pesticides do not have an MCL or human health standard, and were not evaluated in this memorandum (the SDWA only regulates stormwater pollutants that have the potential to violate an MCL or adversely affect human health; therefore, MCLs and human health standards are required to determine if a pesticide violates the SDWA). Pesticides that were not detected in any of the stormwater samples were included in the analysis only if the practical quantification limit (PQL) or Method Reporting Limit (MRL) was less than the regulatory standard.

- **Statistical Analysis.** The Emerging Pollutants were statistically analyzed by calculating percent detection and concentration statistics (minimum, maximum and mean). In addition, the 95% UCL on the mean was calculated using the EPA's ProUCL Software. Following EPA guidance, 95% UCLs were not calculated for pesticides with fewer than 8 detections (in those cases, the maximum value was used instead) (Singh and Singh, 2007).

- **Comparison of Pesticide Statistics to Regulatory Standards.** Pesticide concentrations were compared to MCLs, HHBPs, HBSLs or DEQ RBCs for the purpose of identifying pesticides that potentially violate the SDWA. The lowest regulatory standard was used in the comparison. If both the following statements were true, the pesticide was considered to pose a relatively higher potential to violate the SDWA and was selected for further evaluation with a GWPD model:

    - The pesticide was detected in more than 15 percent of stormwater samples, and
    - The 95% UCL on the mean (or maximum) concentration of the pesticide is more than 10 percent of the regulatory standard.

- **Pesticide Fate and Transport Modeling (GWPD).** An unsaturated zone GWPD was conducted to determine if the pesticides with a relatively higher potential to violate the SDWA are predicted by the model to violate the SDWA. Technical background about the GWPD is provided in Appendix B, and includes the governing equation, model assumptions, and input parameters.

    The GWPD presented in this memorandum is a worst-case generalization of 11 existing unsaturated zone GWPD models[11]. Specifically, the worst-case input parameters from the 11 existing GWPDs were used as input parameters for the GWPD; for example, the worst case (lowest) fraction organic carbon (0.0057 $grams_{carbon}/grams_{soil}$ from the City of Keizer's GWPD) was used along with the worst case (highest) pore water velocity (1.051 meters per day from the City of Portland's GWPD) in the pesticide transport simulations. The result is a generic GWPD that cannot be applied to a specific jurisdiction, but that can be used to evaluate relative mobilities of pesticides in the subsurface under worst case conditions.

Results

This section summarizes the analysis of the urban stormwater quality data and GWPD results.

Selection of Pesticides for Analysis

In total, the urban stormwater dataset included analysis of 248 unique pesticides. Of those pesticides, 169 had a regulatory standard (i.e. MCL, DEQ RBC, HBSL or HHBP), and were evaluated as a part of this memorandum (see Table 1). The pesticides in the urban stormwater dataset that did not have a regulatory standard are shown in Table 2.

[11] See models in DEQ (2017)

Of the 169 pesticides with a regulatory standard, 11 were not detected in any samples and had a PQL or MRL that was greater than the corresponding regulatory limit; these 11 pesticides were excluded from the evaluation. Therefore, the evaluation was performed on the remaining 158 pesticides.

Statistical Analysis

Table 3 summarizes the statistical analyses for all regulated pesticides, including the percent detection, minimum, maximum, mean, number of exceedances of the regulatory standard, and 95% UCL on the mean. Table 3 also indicates which method was used to calculate the 95% UCL (which is based on the statistical model used to fit the observed data). Nine pesticides—PCP; diuron; fipronil; 2,4-D; 2,6-dichlorobenzamide; sulfometuron-methy; atrazine; metsulfuron methyl; and propiconazole—were detected in more than 15% of samples[12]. Table 4 shows pesticides that were not detected in any of the urban stormwater samples.

Comparison to Regulatory Standards

Table 3 shows the MCL, HBSL, HHBP or DEQ RBC that corresponds to each pesticide, as well as whether the standard is based on cancer, noncancer, acute, or chronic conditions. Only one pesticide—PCP—exceeded its regulatory limit. Twelve pesticides—PCP; diuron; fipronil; simazine; MCPA; mcpp-p; ethoprop; Aldrin; alpha-hch; diazinon; heptachlor; and p,p'-ddd—had 95% UCLs or maximum concentrations that were more than 10% of their respective regulatory standards.

Pesticides Identified for Further Evaluation

The following three pesticides were detected in more than 15% of stormwater samples and have 95% UCL on the mean concentrations (or maximum concentrations) that are more than 10% of the regulatory standard:

- **PCP**, detected in about 83% of samples, is a common wood preservative from utility poles. PCP has an MCL and a DEQ RBC. The DEQ RBC (ingestion of tap water, residential exposure scenario) of 0.044 ug/L is lower than the MCL of 1 ug/L, and was used to assess the potential for PCP to violate the SDWA. PCP was detected in all three of the jurisdictions where it was analyzed (Gresham, Multnomah County, and Portland).

- **Diuron**, detected in about 23% of samples, is an herbicide that was introduced by Bayer Crop Science in 1954. Diuron was detected in three of the four jurisdictions where it was analyzed (detected in Eugene, Portland and Salem, not detected by Multnomah County).

- **Fipronil**, detected in about 19% of samples, is an insecticide that was synthesized by the Rhone Poulenc Agricultural Company in 1987 and registered in the United States in 1996 (Uniyal et al., 2016). Fipronil was detected in two of the four jurisdictions where it was analyzed (detected in Eugene and Clackamas, not detected in Salem or Multnomah County).

Groundwater Protectiveness Demonstration (GWPD)

An unsaturated zone GWPD pollutant fate and transport model was used to predict whether the pesticides that have a relatively higher potential to violate the SDWA would violate the prohibition of fluid movement standard or prohibition of endangerment (i.e., travel far enough to reach a water well). Technical background for the GWPD model is provided in Appendix B. Model calculations and simulated concentration profiles simulated by the model are provided in Appendix C.

[12] Excluding pesticides only analyzed in three samples (kresoxim-methyl and zoxamide) or one sample (flusilazole, desulfinylfipronil, and piperonyl butoxide)

Table 5 summarizes the GWPD results. Diuron attenuates to a concentration of nondetect (i.e., zero) more rapidly than PCP, and fipronil attenuates to a concentration of nondetect (i.e., zero) at as rapidly as PCP. The detection limit was used for "zero" because models calculate pollutant concentrations that are infinitely small (for example, 1.0×10^{-40} ug/L), thereby requiring that a value be chosen for zero. The detection limit is two orders of magnitude below the regulatory standard for fipronil and diuron, represents the concentrations that a laboratory can detect, and has been used in previous GWPDs.

Table 5. GWPD Results

Pesticide	**Regulatory Standard**	**Initial Concentration** (ug/L)	**Distance to Reduce Concentrations Below Regulatory Standard** (feet)	**Distance to Reduce Concentrations Below Detection Limit** (feet)
Fipronil	HHBP (1 ug/L)	0.117	0.0	4.5
Diuron	HBSL (2 ug/L)	0.466	0.0	3.3
PCP	DEQ RBC (0.044 ug/L)	0.720	4.5	4.6

NOTE:
ug/L = micrograms per liter
HBSL = Health Based Screening Level
HHBP = Human Health Based Benchmark for Pesticides
DEQ RBC = Department of Environmental Quality Risk Based Concentration
PCP = Pentachlorophenol

The following sections provide additional discussion about the fate and transport of fipronil, diuron and PCP in subsurface soils, and whether fipronil, diuron and PCP violate the SDWA.

Fipronil

Based on the calculated 95% UCL on the mean, fipronil concentrations are below regulatory standards (HHBPs) at the end-of-pipe where stormwater discharges into the UIC. Concentrations decline to below the detection limit (about 0.012 ug/L) within about 4.5 feet of vertical transport from the UIC.

Diuron

Based on the calculated 95% UCL on the mean, diuron concentrations are below regulatory standards (HBSLs) at the end-of-pipe where stormwater discharges into the UIC. Concentrations decline to below the detection limit (about 0.03 ug/L) within about 3.3 feet of vertical transport from the UIC.

PCP

Based on the calculated 95% UCL on the mean, PCP concentrations exceed regulatory standards (DEQ RBCs) at the end-of-pipe where stormwater discharges into the UIC. Concentrations decline to below the detection limit (about 0.03 ug/L) within about 4.6 feet of vertical transport from the UIC.

Several UIC permit holders (see DEQ, 2017) have established vertical setbacks between UICs and groundwater and horizontal setbacks between UICs and water wells based on the fate and transport of PCP. The setbacks based on PCP were selected to prevent violation of the SDWA (i.e., violation of the prohibition of fluid movement standard and violation of the prohibition of endangerment). Because fipronil and diuron do not travel as far as PCP, the analysis in this memorandum indicates that the horizontal and vertical setbacks for PCP are also compliant with the SDWA for fipronil and diuron.

Conclusions and Recommendations

GSI makes the following conclusions and recommendations based on the analysis presented in this memorandum:

- The urban stormwater dataset analyzed in this memorandum is a robust, comprehensive screen of pesticides in urban stormwater that includes analysis of 248 unique pesticides. Of these 248 pesticides, 169 pesticides have a regulatory standard [i.e., an Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), Department of Environmental Quality (DEQ) Risk Based Concentration (RBC), USGS Health-Based Screening Level (HBSL), or an EPA Human Health Benchmark for Pesticides (HHBP)].

- These 169 pesticides with regulatory standards were evaluated to determine if pesticide concentrations potentially violated the SDWA. The remaining 79 pesticides do not have an MCL or human health standard, and were not evaluated in this memorandum (the SDWA only regulates stormwater pollutants that have the potential to violate an MCL or adversely affect human health; therefore, MCLs and human health standards are required to determine if a pesticide violates the SDWA).

    - Only one of the 169 pesticides—pentachlorophenol (PCP)—exceeded its respective regulatory standard in one or more samples. PCP is a wood preservative that was detected in both stormwater and urban stream samples.

    - Because concentrations of the remaining 168 pesticides are below their respective regulatory standards when stormwater discharges into the UIC, EPA does not consider these pesticides to violate the SDWA (EPA, 2001). However, two of these 168 pesticides—diuron and fipronil—are more commonly detected in stormwater (detected in more than 15% of samples) and are detected at concentrations closer to their respective regulatory standard (detected at concentrations of over 10% of their respective regulatory standard). These pesticides pose a higher risk of endangering groundwater, and, along with PCP, were evaluated further in this memorandum.

    - A generic Groundwater Protectiveness Demonstration (GWPD) model was used to simulate fate and transport of PCP, diuron and fipronil after discharge from a UIC, with the objective of determining if the pesticides were predicted to violate the SDWA. Existing GWPD models have simulated the fate and transport of PCP, and have used the results to determine vertical setbacks (between UICs and groundwater) and horizontal setbacks (between UICs and water wells) that ensure compliance with the SDWA. Based on the generic GWPD model, diuron attenuates to a concentration of zero (i.e., nondetect) more rapidly than PCP, and fipronil attenuates to a concentration of zero as rapidly as PCP. Therefore, the protective vertical and horizontal setbacks that have been established for UICs based on PCP are also protective for diuron and fipronil.

- The information in this memorandum provides UIC permittees with several options for adaptively managing their UIC systems, including but not limited to:

- Some pesticides in stormwater do not have MCLs or human health-based regulatory standards (see Table 2). Permittees may want to review whether MCLs or human health-based regulatory standards are developed for these pesticides, and evaluate whether the pesticides violate the SDWA as a part of the 10-year Emerging Pollutant Evaluation that is due with each permittee's permit renewal application.

- Several pesticides—simazine, mcpp-p, MCPA, ethoprop, Aldrin, alpha-hch, diazinon, heptachlor, p,p'-ddd—were detected at concentrations of over 10 percent of their respective regulatory standards, but were not evaluated further as a part of this memorandum because the frequency of detection was less than 15 percent. Permittees may want to collect additional stormwater samples to increase the size of the datasets for these pesticides and determine whether further evaluation of these pesticides is necessary as a part of the 10-year Emerging Pollutant Evaluation that is due with each permittee's permit renewal application.

- Regulatory agencies and jurisdictions should continue to promote pesticide source controls through education and other best management practices, and may want to continue encouraging stormwater infiltration using UICs because human and ecological receptors are not exposed to the pesticides in stormwater, as long as the UICs are operated in accordance with permit-required setbacks (to ensure the soil thickness is sufficient to attenuate the pollutants). Specifically, many of the pesticides in urban stormwater pose acute and/or chronic toxicological impacts to fish and other environmental receptors when they are discharged directly to surface water; when discharged into the ground, the pesticides are naturally attenuated in the subsurface.

References

DEQ, 2003. Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites, including Table of Generic Risk-Based Concentrations for Petroleum Constituents and Total Petroleum Hydrocarbons, and Generic Remedy for Simple Risk-Based Sites. September 22.

DEQ, 2017. Fact Sheet: Groundwater Protectiveness Demonstrations for UIC Permits. Available online at: http://www.oregon.gov/deq/FilterDocs/UICpermits.pdf. January 10.

Edde, W, 2017. Re: WPCF UIC Permit Emerging Pollutant Evaluations. Message to: Derek Sandoz and Bill Mason. April 13.

EPA, 2001. Technical Program Overview: Underground Injection Control Regulations.

EPA, 2017. Fact Sheet: Human Health Benchmarks for Pesticides—2017 Update. January, 2 pp.

Singh, A. and A. K. Singh, 2007. ProUCL Version 4.0 Technical Guide. April, 232 pp.

Toccalino, P., Nowell, L., Wilber, W., Zogorski, J., Donohue, J., Eiden, C., Krietzman, S., and G. Post, 2003. Development of Health-Based Screening Levels for Use in State- or Local-Scale Water-Quality Assessments. U.S. Geological Survey Water Resources Investigation Reports 03-4054, 22 pp.

Toccalino, P., 2007. Development and Application of Health-Based Screening Levels for Use in Water-Quality Assessments. U.S. Geological Survey Scientific Investigations Report 2007-5106, 18 pp.

Uniyal, S., Paliwal, R., Sharma, R. K., and J. P. N. Raj, 2016. Degradation of fipronil by *Stenotrophomonasacidaminiphila* isolated from rhizospheric soil of *Zea mays*. Biotech, 6(1): 48.

USGS, 2008. Pesticide Occurrence and Distribution in the Lower Clackamas River Basin, Oregon, 2000-2005. U.S. Geological Survey Scientific Investigations Report 2008-5027.

Table 1. Regulated Pesticides in the Urban Stormwater Dataset

			Phase I MS4 Permit Data and UIC Permit Data							USGS (2008) Data	PSP Data	
			Clackamas	Eugene	Gresham	Multnomah County	Portland	Redmond	Salem		Sieben Creek	Amazon Creek
Total Number of Pesticides Analyzed			**16**	**172**	**41**	**188**	**143**	**20**	**190**	**33**	**123**	**123**
Regulated Pesticides Analyzed:			**17**	**125**	**28**	**139**	**94**	**14**	**139**	**33**	**104**	**104**
Unregulated Pesticides Analyzed:			**1**	**47**	**13**	**41**	**44**	**5**	**43**	**0**	**19**	**19**
Pesticide	**Lowest Concentration Regulation**	**Concentration (ppb)**	**X = analyzed for**									
2,4,5-tp (silvex)	MCL	50	--	--	X	X	X	--	X	--	X	X
2,4-DBA	Chronic or Lifetime (HHBP)	200	--	--	X	X	X	--	X	--	X	X
2,4,5-T	Noncancer HBSL	70	--	--	X	X	X	--	X	--	X	X
2,4-D	MCL	70	--	--	X	X	X	--	X	X	X	X
2,6-dichlorobenzamide	Chronic or Lifetime (HHBPs)	29	--	--	--	--	--	--	--	--	X	X
Acetamiprid	Chronic or Lifetime (HHBPs)	450	--	--	--	--	--	--	--	--	X	X
Acetochlor	Chronic or Lifetime (HHBP)	100	--	X	--	X	X	--	X	--	X	X
Acifluorfen	Noncancer HBSL	90	--	--	X	X	X	--	X	--	--	--
Acifluorfen (sodium)	Noncancer HBSL	90	--	--	--	--	--	--	--	--	X	X
Alachlor	MCL	2	--	X	--	X	X	--	X	--	X	X
Aldicarb	Noncancer HBSL	7	--	X	--	X	X	--	X	--	--	--
Aldicarb sulfone	Noncancer HBSL	7	--	X	--	X	X	--	X	--	--	--
Aldicarb sulfoxide	Noncancer HBSL	7	--	X	--	X	X	--	X	--	--	--
Aldrin	Residential RBC	0.00092	--	X	X	X	X	X	X	--	X	X
alpha-HCH	Cancer HBSL (10-6 to 10-4)	0.006	--	X	X	X	X	X	X	--	X	X
Ametryn	Noncancer HBSL	500	--	X	--	X	--	--	X	--	X	X
Amitraz	Acute or One Day HHBP	8.33	--	X	--	X	--	--	X	--	--	--
Atrazine	MCL	3	--	X	--	X	--	--	X	X	X	X
Azinphos-methyl	Chronic or Lifetime (HHBP)	9.6	--	X	--	X	X	--	X	X	X*	X*
Azoxystrobin	Chronic or Lifetime (HHBP)	1200	--	X	--	X	--	--	X	--	--	--
Bendiocarb	Noncancer HBSL	9	--	X	--	X	--	--	X	--	--	--
Benfluralin	Chronic or Lifetime (HHBP)	30	--	X	--	X	X	--	X	--	--	--
Bensulide	Chronic or Lifetime (HHBP)	30	--	X	--	X	--	--	X	--	--	--
Bentazon	Noncancer HBSL	200	--	--	X	X	X	--	X	X	--	--
beta-HCH	Cancer HBSL (10-6 to 10-4)	0.02	--	X	X	X	X	X	X	--	X	X
Bifenthrin	Acute or One Day HHBP	70	X	X	--	X	X	--	X	--	X	X
Boscalid	Chronic or Lifetime (HHBP)	1400	X	X	--	X	--	--	X	--	--	--
Bromacil	Noncancer HBSL	700	--	X	--	X	--	--	X	X	X	X
Butylate	Noncancer HBSL	400	--	--	--	--	--	--	--	--	X	X
Captan	Chronic or Lifetime (HHBP)	830	--	X	--	X	X	--	X	--	--	--
Carbaryl	Cancer HBSL (10-6 to 10-4)	40	X	X	--	X	X	--	X	X	X	X
Carbofuran	MCL	40	--	X	--	X	X	--	X	--	X	X
Carfentrazone-ethyl	Chronic or Lifetime (HHBP)	200	--	X	--	X	--	--	X	--	--	--
Chlordane	MCL	2	--	X	X	X	X	X	X	--	--	--
Chlordane, technical	MCL	2	--	--	--	--	X	--	--	--	--	--
Chloroneb	Chronic or Lifetime (HHBP)	83	--	X	--	X	X	--	X	--	X	X
Chlorothalonil	Noncancer HBSL	100	--	X	--	X	X	--	X	X	X	X
Chlorpropham	Chronic or Lifetime (HHBPs)	300	--	--	--	--	--	--	--	--	X	X
Chlorpyrifos	Noncancer HBSL	2	--	X	--	X	X	--	X	X	X	X
cis-Chlordane	MCL	2	--	--	--	--	--	--	--	--	X	X
Clopyralid	Chronic or Lifetime (HHBP)	960	--	--	X	X	X	--	X	--	--	--
Clothianidin	Chronic or Lifetime (HHBP)	630	--	X	--	X	--	--	X	--	--	--
Coumaphos	Chronic or Lifetime (HHBP)	2	--	X	--	X	X	--	X	--	--	--
Cyanazine	Cancer HBSL (10-6 to 10-4)	0.03	--	X	--	X	--	--	X	--	X	X
Cycloate	Chronic or Lifetime (HHBPs)	30	--	--	--	--	--	--	--	--	X	X
Cyfluthrin	Acute or One Day HHBP	100	--	X	--	X	X	--	X	--	--	--
Cyhalothrin	Chronic or Lifetime (HHBP)	6	--	X	--	X	X	--	X	--	--	--
Cypermethrin	Acute or One Day HHBP	150	--	X	--	X	X	--	X	--	--	--
Dacthal	Cancer HBSL (10-6 to 10-4)	20	--	X	--	X	X	--	X	X	X	X
Deltamethrin	Acute or One Day HHBP	30	--	X	--	X	X	--	X	--	--	--
Desulfinylfipronil	Noncancer HBSL	1	X	--	--	--	--	--	--	--	--	--
Diazinon	Noncancer HBSL	1	--	X	--	X	X	--	X	X	X	X
Dicamba	Noncancer HBSL	3000	--	--	X	X	X	--	X	--	X	X
Dichlobenil	Chronic or Lifetime (HHBP)	60	--	X	--	X	X	--	X	--	X	X
Dichlorprop	Noncancer HBSL	300	--	--	X	X	X	--	X	X	X	X
Dichlorvos	Chronic or Lifetime (HHBP)	3	--	X	--	X	X	--	X	--	X	X
Diclofop-methyl	Carcinogenic HHBP (E-6 to E-4)	0.435	--	X	--	X	--	--	X	--	--	--
Dicofol	Chronic or Lifetime (HHBP)	3	--	X	--	X	X	--	X	--	--	--
Dicrotophos	Chronic or Lifetime (HHBP)	0.2	--	X	--	X	X	--	X	--	--	--
Dieldrin	Residential RBC	0.0017	--	X	X	X	X	X	X	X	X	X
Dimethenamid	Chronic or Lifetime (HHBP)	300	--	X	--	X	--	--	X	X	X	X
Dimethoate	Chronic or Lifetime (HHBP)	14	--	X	--	X	X	--	X	--	X	X
Dinoseb	MCL	7	--	--	X	X	X	--	X	X	X	X
Diphenamid	Noncancer HBSL	200	--	--	--	--	--	--	--	--	X	X
Diphenylamine	Chronic or Lifetime (HHBP)	600	--	X	--	X	--	--	X	--	--	--
Disulfoton	Noncancer HBSL	0.9	--	X	--	X	X	--	X	--	--	--
Diuron	Cancer HBSL (10-6 to 10-4)	2	--	X	--	X	X	--	X	X	X	X
Endrin	Residential RBC	1.9	--	X	X	X	X	X	X	--	X	X
EPTC	Chronic or Lifetime (HHBPs)	300	--	--	--	--	--	--	--	--	X	X
Esfenvalerate	Acute or One Day & Chronic or Lifetime HHBP	12	X	X	--	X	X	--	X	--	X^	X^
Ethalfluralin	Carcinogenic HHBP (E-6 to E-4)	0.36	--	X	--	X	X	--	X	--	--	--
Ethion	Noncancer HBSL	4	--	X	--	X	X	--	X	--	--	--
Ethofumesate	Chronic or Lifetime (HHBP)	2000	--	X	--	X	--	--	X	--	--	--
Ethoprop	Carcinogenic HHBP (E-6 to E-4)	1.14	--	X	--	X	--	--	X	X	X	X
Fenamiphos	Noncancer HBSL	0.7	--	X	--	X	X	--	X	--	X	X
Fenarimol	Chronic or Lifetime (HHBP)	40	--	X	--	X	X	--	X	--	X	X
Fenbuconazole	Carcinogenic HHBP (E-6 to E-4)	8.91	X	X	--	X	--	--	X	--	--	--
Fenitrothion	Chronic or Lifetime (HHBP)	0.8	--	X	--	X	X	--	X	--	--	--
Fenoxaprop-ethyl	Chronic or Lifetime (HHBP)	16	--	X	--	X	--	--	X	--	--	--
Fenthion	Chronic or Lifetime (HHBP)	0.4	--	X	--	X	X	--	X	--	--	--
Fipronil	Chronic or Lifetime (HHBP)	1	X	X	--	X	--	--	X	--	--	--
Fluazifop-P-Butyl	Chronic or Lifetime (HHBP)	47	--	X	--	X	--	--	X	--	--	--
Fludioxonil	Chronic or Lifetime (HHBP)	200	--	X	--	X	--	--	X	--	--	--
Flumioxazin	Chronic or Lifetime (HHBP)	100	--	X	--	X	--	--	X	--	--	--
Fluometuron	Cancer HBSL (10-6 to 10-4)	2	--	X	--	X	--	--	X	--	X	X
Fluridone	Chronic or Lifetime (HHBPs)	960	--	--	--	--	--	--	--	--	X	X
Flusilazole	Chronic or Lifetime (HHBP)	10	X	--	--	--	--	--	--	--	--	--
Flutolanil	Chronic or Lifetime (HHBP)	3000	--	X	--	X	X	--	X	--	--	--
Folpet	Chronic or Lifetime (HHBP)	600	--	X	--	X	X	--	X	--	--	--
g-bhc (lindane)	Residential RBC	0.043	--	X	X	X	X	X	X	--	X	X
Glyphosate	MCL	700	--	--	--	--	X	--	--	X	X	X
Heptachlor	Residential RBC	0.0014	--	X	X	X	X	X	X	--	X	X
Heptachlor epoxide	Residential RBC	0.0014	--	X	X	X	X	X	X	--	X	X
Hexazinone	Noncancer HBSL	400	--	X	--	X	--	--	X	--	X	X
Imazapyr	Chronic or Lifetime (HHBPs)	16000	--	--	--	--	--	--	--	--	X	X
Imidacloprid	Chronic or Lifetime (HHBP)	360	--	X	--	X	--	--	X	X	X	X
Iprodione	Carcinogenic HHBP (E-6 to E-4)	0.729	X	X	--	X	X	--	X	X	--	--
Isoxaben	Chronic or Lifetime (HHBP)	300	--	X	--	X	--	--	X	--	--	--
Kresoxim-methyl	Carcinogenic HHBP (E-6 to E-4)	11	X	--	--	--	--	--	--	--	--	--
Linuron	Chronic or Lifetime (HHBP)	49	--	X	--	X	--	--	X	--	X	X
Malathion	Noncancer HBSL	500	--	X	--	X	X	--	X	X	X	X
MCPA	Residential RBC	7.4	--	--	X	X	X	--	X	X	X	X
MCPP-p	Chronic or Lifetime (HHBP)	300	--	--	X	X	X	--	X	--	X	X
Mefenoxam	Chronic or Lifetime (HHBP)	474	--	X	--	X	--	--	X	--	--	--
Methidathion	Chronic or Lifetime (HHBP)	9.6	--	X	--	X	X	--	X	--	--	--
Methiocarb	Noncancer HBSL	40	--	X	--	X	X	--	X	X	X	X
Methomyl	Noncancer HBSL	200	--	X	--	X	X	--	X	--	X	X
Methoxychlor	MCL	40	--	X	X	X	X	X	X	--	X	X
Metolachlor	Noncancer HBSL	700	X	X	--	X	X	--	X	X	X	X
Metribuzin	Noncancer HBSL	90	--	X	--	X	--	--	X	--	X	X
Metsulfuron methyl	Chronic or Lifetime (HHBPs)	1600	--	--	--	--	--	--	--	--	X	X
Mevinphos	Chronic or Lifetime (HHBP)	0.16	--	X	--	X	X	--	X	--	X	X
MGK 264	Chronic or Lifetime (HHBPs)	390	--	--	--	--	--	--	--	--	X	X
Mirex	Noncancer HBSL	1	--	X	--	X	X	--	X	--	X	X
Molinate	Noncancer HBSL	7	--	--	--	--	--	--	--	--	X	X
Myclobutanil	Chronic or Lifetime (HHBP)	160	--	X	--	X	--	--	X	--	--	--
Napropamide	Chronic or Lifetime (HHBP)	770	--	X	--	X	--	--	X	X	X	X
Norflurazon	Chronic or Lifetime (HHBP)	96	--	X	--	X	X	--	X	X	X	X
Oxamyl	MCL	200	--	X	--	X	--	--	X	--	X	X
Oxyfluorfen	Carcinogenic HHBP (E-6 to E-4)	0.437	--	X	--	X	X	--	X	X	X	X
p,p'-DDD	Residential RBC	0.031	X	X	X	X	X	X	X	--	X	X
p,p'-DDE	Residential RBC	0.046	X	X	X	X	X	X	X	--	X	X
p,p'-DDT	Residential RBC	0.023	--	X	X	X	X	X	X	--	X	X
Parathion-methyl	Noncancer HBSL	1	--	X	--	--	X	--	--	--	X	X

Table 1. Regulated Pesticides in the Urban Stormwater Dataset

			Phase I MS4 Permit Data and UIC Permit Data							USGS (2008) Data	PSP Data	
			Clackamas	Eugene	Gresham	Multnomah County	Portland	Redmond	Salem		Sieben Creek	Amazon Creek
Total Number of Pesticides Analyzed			**16**	**172**	**41**	**188**	**143**	**20**	**190**	**33**	**123**	**123**
Regulated Pesticides Analyzed:			**17**	**125**	**28**	**139**	**94**	**14**	**139**	**33**	**104**	**104**
Unregulated Pesticides Analyzed:			**1**	**47**	**13**	**41**	**44**	**5**	**43**	**0**	**19**	**19**
Pesticide	**Lowest Concentration Regulation**	**Concentration (ppb)**	**X = analyzed for**									
Pebulate	Chronic or Lifetime (HHBPs)	4	--	--	--	--	--	--	--	--	X	X
Pendimethalin	Chronic or Lifetime (HHBP)	2000	X	X	--	X	X	--	X	X	X	X
Pentachlorophenol	Residential RBC	0.044	--	--	X	X	X	--	--	--	X	X
Permethrin	Carcinogenic HHBP (E-6 to E-4)	3.344	--	X	--	X	X	--	X	--	X	X
Phorate	Chronic or Lifetime (HHBP)	1.1	--	X	--	X	X	--	X	--	--	--
Phosmet	Chronic or Lifetime (HHBP)	3	--	X	--	X	X	--	X	--	X*	X*
Picloram	MCL	500	--	--	X	X	X	--	X	--	X	X
Piperonyl butoxide	Chronic or Lifetime (HHBP)	992	X	--	--	--	--	--	--	--	--	--
Pirimiphos-methyl	Chronic or Lifetime (HHBP)	0.4	--	X	--	X	X	--	X	--	--	--
Prometon	Noncancer HBSL	400	--	X	--	X	--	--	X	X	X	X
Prometryn	Chronic or Lifetime (HHBP)	300	--	X	--	X	--	--	X	--	X	X
Pronamide	Chronic or Lifetime (HHBPs)	300	--	--	--	X	X	--	X	--	X	X
Propachlor	Cancer HBSL (10-6 to 10-4)	1	--	X	--	X	X	--	X	--	X	X
Propanil	Chronic or Lifetime (HHBP)	60	--	X	--	X	X	--	X	--	--	--
Propargite	Carcinogenic HHBP (E-6 to E-4)	0.167	--	X	--	X	--	--	X	--	--	--
Propazine	Noncancer HBSL	100	--	X	--	X	--	--	X	--	X	X
Propiconazole	Chronic or Lifetime (HHBP)	600	X	X	--	X	X	--	X	X	X	X
Pyraclostrobin	Chronic or Lifetime (HHBP)	220	--	X	--	X	--	--	X	--	X	X
Pyridaben	Chronic or Lifetime (HHBP)	30	--	X	--	X	--	--	X	--	--	--
Pyrimethanil	Chronic or Lifetime (HHBP)	1100	--	X	--	X	--	--	X	--	--	--
Pyriproxyfen	Chronic or Lifetime (HHBPs)	2200	--	--	--	--	--	--	--	--	X	X
Sethoxydim	Chronic or Lifetime (HHBP)	900	--	X	--	X	--	--	X	--	--	--
Siduron	Chronic or Lifetime (HHBP)	960	--	X	--	X	--	--	X	--	X	X
Simazine	MCL	4	--	X	--	X	--	--	X	X	X	X
Sulfentrazone	Chronic or Lifetime (HHBP)	900	--	X	--	X	--	--	X	--	--	--
Sulfometuron-methyl	Chronic or Lifetime (HHBPs)	1760	--	--	--	--	--	--	--	--	X	X
Sulprofos	Noncancer HBSL	20	--	X	--	X	X	--	X	--	--	--
Tebuconazole	Acute or One Day & Chronic or Lifetime HHBP	190	--	X	--	X	--	--	X	--	--	--
Tebuthiuron	Noncancer HBSL	1000	--	X	--	X	--	--	X	X	X	X
Terbacil	Noncancer HBSL	100	--	X	--	X	X	--	X	--	X	X
Terbufos	Noncancer HBSL	0.4	--	X	--	X	X	--	X	--	X	X
Terbutryn	Noncancer HBSL	7	--	--	--	--	--	--	--	--	X	X
Tetrachlorvinphos	Carcinogenic HHBP (E-6 to E-4)	17.5	--	X	--	X	X	--	X	--	X	X
Thiabendazole	Chronic or Lifetime (HHBP)	210	--	X	--	X	--	--	X	--	--	--
Thiobencarb	Chronic or Lifetime (HHBP)	60	--	X	--	X	--	--	X	--	--	--
Toxaphene	MCL	3	--	X	X	X	X	X	X	--	--	--
trans-Chlordane	MCL	2	--	--	--	--	--	--	--	--	X	X
Triadimefon	Chronic or Lifetime (HHBP)	220	--	X	--	X	--	--	X	--	X	X
Triclopyr	Chronic or Lifetime (HHBP)	300	--	--	X	X	X	--	X	X	X	X
Tricyclazole	Chronic or Lifetime (HHBPs)	430	--	--	--	--	--	--	--	--	X	X
Trifloxystrobin	Chronic or Lifetime (HHBP)	240	--	X	--	X	X	--	X	--	--	--
Triflumizole	Chronic or Lifetime (HHBP)	74.9	--	X	--	X	X	--	X	--	--	--
Trifluralin	Cancer HBSL (10-6 to 10-4)	10	--	X	--	X	X	--	X	X	X	X
Vernolate	Noncancer HBSL	7	--	--	--	--	--	--	--	--	X	X
Zoxamide	Chronic or Lifetime (HHBP)	3100	X	--	--	--	--	--	--	--	--	--

Regulations:

MCL - (Maximum Contaminat Level) Established by the EPA and legally enforceable

HHBP - (Human Health Benchmark for Pesticides) Established by the EPA for food-use pesticides. Non-enforceable levels represent concentrations below which adverse health are not anticipated. Updated January 2017.

HBSL - (Health-Based Screening Levels) Non-enforceable water-quality benchmarks developed by the USGS. The HBSL range represents a one-in-one million (10-6) to one-in-ten thousand (10-4) cancer risk range. HBSLs are current as of June 30, 2014.

Residential RBC - (Risk-Based Concentrations) Oregeon Department of Environmental Quality guidance levels for site remediation

* : Laboratory included metabolites of pesticide, which are not accounted for by the regulatory limit. Data was included to be conservative.

^ : Laboratory analysis included fenvalerate which is not regulated. Data was included to be conservative.

Table 2. Unregulated Pesticides in the Urban Stormwater Dataset

Phase I MS4 Permit Data and UIC Permit Data							USGS (2008) Data	PSP Data	
Clackamas	**Eugene**	**Gresham**	**Multnomah County**	**Portland**	**Redmond**	**Salem**		**Sieben Creek**	**Amazon Creek**
1	**47**	**13**	**41**	**44**	**5**	**43**	**0**	**19**	**19**
Fipronil sulfide	3-Hydroxycarbofuran	3,5-Dichlorobenzoic acid	3-Hydroxycarbofuran	3-hydroxycarbofuran	Endosulfan I	3-hydroxycarbofuran		3,5-dichlorobenzoic acid	**3,5-dichlorobenzoic acid**
	Aspon	alpha-Chlordane	Aspon	**3,5-dichlorobenzoic acid**	Endosulfan II	aspon		aminocarb	aminocarb
	Bromopropylate	Dalapon	Bromopropylate	AMPA	Endosulfan sulfate	benot detectediocarb		aminomethylphosphonic acid	aminomethylphosphonic acid
	Captafol	delta-BHC	Captafol	aspon	Endrin aldehyde	bromopropylate		baygon	baygon
	Carbofenothion	**Endosulfan I**	Carbofenothion	baygon	Endrin ketone	captafol		chlorobenzilate	chlorobenzilate
	Chlorfenvinphos	Endosulfan II	Chlorfenvinphos	captafol		carbofenothion		dcpa acid metabolites	dcpa acid metabolites
	Chlorobenzilate	Endosulfan Sulfate	Chlorobenzilate	chlordane, alpha		chlorfenvinphos		**deet**	**deet**
	Chlorpyrifos-methyl	**Endrin Aldehyde**	Chlorpyrifos-methyl	chlordane, gamma		chlorobenzilate		**deisopropylatrazine**	**deisopropylatrazine**
	delta-BHC	Endrin Ketone	delta-BHC	chlorfenvinphos		chlorpyrifos-methyl		desethylatrazine	**desethylatrazine**
	DCPMU	gamma-Chlordanet	DCPMU	chlorobenzilate		dcbp		endosulfan i	endosulfan i
	Demeton	Quinclorac	Demeton	chlorpyrifos-methyl		dcpaa		endosulfan ii	endosulfan ii
	Dichlofenthion		Dichlorofenthion	dacthal acid metabolites		dcpmu		endosulfan sulfate	endosulfan sulfate
	Dicloran		Dicloran	dalapon		demeton		etridiazole	etridiazole
	Dithiopyr		Dithiopyr	**DCPMU**		dichlorofenthion		methyl paraoxon	methyl paraoxon
	Endosulfan I		Endosulfan I	demeton		dicloran		mexacarbate	mexacarbate
	Endosulfan II		Endosulfan II	dichlorofenthion		dithiopyr		parathion-ethyl	neburon
	Endosulfan sulfate		Endosulfan sulfate	dicloran		endosulfan i		prophos	parathion-ethyl
	Endrin aldehyde		Endrin aldehyde	diquat		endosulfan ii		terbutylazine	terbutylazine
	Endrin ketone		Endrin ketone	dithiopyr		endosulfan sulfate		trans-nonachlor	trans-nonachlor
	EPN		EPN	endosulfan I		endrin aldehyde			
	Etridiazole		Etridiazole	endosulfan II		endrin ketone			
	Famphur		Famphur	endosulfan sulfate		epn			
	Fenobucarb		Fenobucarb	endothall		etridiazole			
	Fensulfothion		Fensulfothion	endrin aldehyde		famphur			
	Fenuron		Fenvalerate	endrin ketone		fenobucarb			
	Fenvalerate		Fluroxypyr-meptyl	epn		fensulfothion			
	Fluroxypyr-meptyl		Hexachlorobenzene	ethoprop (mocap)		fenvalerate			
	Hexachlorobenzene		Merphos	etridiazole		fluroxypyr-meptyl			
	Merphos		Monocrotophos	famphur		hexachlorobenzene			
	Metalaxyl		Monuron	fensulfothion		merphos			
	Monocrotophos		Ovex	fenvalerate		monocrotophos			
	Monuron		Oxadiazon	hexachlorobenzene		monuron			
	Neburon		PCNB	merphos		ovex			
	Ovex		Phosphamidon	monocrotophos		oxadiazon			
	Oxadiazon		Pirimicarb	ovex		pcnb			
	Parathion		Prodiamine	oxadiazon		phosphamidon			
	PCNB		Quinclorac	oxamyl (vydate)		pirimicarb			
	Phosphamidon		Ronnel	PCNB		prodiamine			
	Pirimicarb		Tokuthion	phosphamidon		quinclorac			
	Prodiamine		Trichloronate	prodiamine		ronnel			
	Propoxur		Vinclozalin	**quinclorac**		tokuthion			
	Ronnel			ronnel		trichloronate			
	Simetryn			tokuthion (prothiofos)		vinclozalin			
	Tokuthion			trichloronate					
	Trichloronate			vinclozalin					
	Vinclozalin								

Bold: pesticide was detected

Table 3. Upper Confidence Limits (UCL) for Detected Pesticides

Pesticide	Regulatory Standard	Regulatory Limit (ug/L)	Type of UCL	UCL	UCL:RL (%)	Total Number of Samples	Percent Detected	Detections	Non-Detections	Minimum	Maximum	Mean	Number of Exceedances
pentachlorophenol	Residential RBC	0.044	95% Chebyshev (Mean, Sd) UCL	0.72	1636%	1883	83%	1566	317	0.011	9.1	0.625	1504
2,4-d	MCL	70	95% Chebyshev (Mean, Sd) UCL	1.2	2%	1956	19%	369	1587	0.0275	32.3	0.742	0
diuron	Cancer HBSL (10-6 to 10-4)	2	95% H-UCL	0.466	23%	187	59%	111	76	0.0043	4.5	0.297	0
propiconazole	Chronic or Lifetime (HHBP)	600	95% Chebyshev (Mean, Sd) UCL	2.646	0.44%	208	30%	62	146	0.0218	20.4	1.098	0
dicamba	Noncancer HBSL	3000	95% H-UCL	0.788	0.03%	1931	3%	55	1876	0.03	3.72	0.473	0
2,6-dichlorobenzamide	Chronic or Lifetime (HHBPs)	29	95% Student's-t UCL	0.213	0.73%	53	81%	43	10	0.0688	0.428	0.19	0
sulfometuron-methyl	Chronic or Lifetime (HHBPs)	1760	95% Chebyshev (Mean, Sd) UCL	0.398	0.02%	89	43%	38	51	0.00421	1.16	0.183	0
triclopyr	Chronic or Lifetime (HHBP)	300	95% Adjusted Gamma UCL	1.329	0.44%	262	15%	38	224	0.08	8.2	0.925	0
atrazine	MCL	3	95% Adjusted Gamma UCL	0.0123	0.41%	162	18%	29	133	0.00447	0.023	0.0105	0
carbaryl	Cancer HBSL (10-6 to 10-4)	40	95% H-UCL	0.0525	0.13%	201	14%	29	172	0.00566	0.197	0.0354	0
simazine	MCL	4	97.5% Chebyshev (Mean, Sd) UCL	0.857	21%	162	12%	20	142	0.00448	1.3	0.277	0
dichlobenil	Chronic or Lifetime (HHBP)	60	95% Chebyshev (Mean, Sd) UCL	0.421	0.70%	150	13%	19	131	0.0214	1.1	0.16	0
metribuzin	Noncancer HBSL	90	95% Adjusted Gamma UCL	0.0677	0.08%	156	10%	16	140	0.00452	0.119	0.0385	0
2,4-dba	Chronic or Lifetime (HHBP)	200	95% Adjusted Gamma UCL	3.193	2%	1931	1%	15	1916	0.57	8.8	1.995	0
mcpp-p	Chronic or Lifetime (HHBP)	300	95% Chebyshev (Mean, Sd) UCL	45.57	15%	236	6%	15	221	0.092	62.3	4.44	0
metolachlor	Noncancer HBSL	700	95% H-UCL	0.052	0.01%	233	6%	15	218	0.006	0.072	0.0276	0
glyphosate	MCL	700	95% Chebyshev (Mean, Sd) UCL	13.78	2.0%	109	10%	11	98	0.211	27	3.41	0
2,4,5-tp (silvex)	MCL	50	95% Student's-t UCL	0.171	0.3%	1931	1%	10	1921	0.063	0.24	0.139	0
metsulfuron methyl	Chronic or Lifetime (HHBPs)	1600	95% Adjusted Gamma UCL	0.307	0.02%	42	24%	10	32	0.00949	0.378	0.108	0
prometon	Noncancer HBSL	400	95% Adjusted Gamma UCL	0.0878	0.02%	141	7%	10	131	0.00379	0.11	0.033	0
bifenthrin	Acute or One Day HHBP	70	95% Adjusted Gamma UCL	0.0928	0.13%	201	4%	9	192	0.0047	0.121	0.0449	0
dichlorprop	Noncancer HBSL	300	95% Student's-t UCL	1.225	0.41%	1936	0%	9	1927	0.13	2.3	0.819	0
picloram	MCL	500	95% Student's-t UCL	0.539	0.11%	1931	0%	9	1922	0.051	0.797	0.358	0
bentazon	Noncancer HBSL	200	95% Student's-t UCL	1.699	0.85%	1880	0%	8	1872	0.164	2.5	1.13	0
fipronil	Chronic or Lifetime (HHBP)	1	95% Student's-t UCL	0.117	12%	43	19%	8	35	0.0061	0.24	0.0622	0
imazapyr	Chronic or Lifetime (HHBPs)	16000	95% Adjusted Gamma UCL	0.602	0.00%	98	8%	8	90	0.0468	0.542	0.21	0
MCPA	Residential RBC	7.4	Maximum	3.1	42%	287	2%	6	281	0.2	3.1	1.073	0
bromacil	Noncancer HBSL	700	Maximum	0.277	0.04%	133	4%	5	128	0.101	0.277	0.2	0
2,4,5-t	Noncancer HBSL	70	Maximum	0.31	0.44%	1921	0.21%	4	1917	0.11	0.31	0.231	0
ethoprop	Carcinogenic HHBP (E-6 to E-4)	1.14	Maximum	0.13	11%	155	2.6%	4	151	0.055	0.13	0.0868	0
imidacloprid	Chronic or Lifetime (HHBP)	360	Maximum	0.128	0.04%	141	2.8%	4	137	0.023	0.128	0.0495	0
pendimethalin	Chronic or Lifetime (HHBP)	2000	Maximum	0.37	0.02%	207	1.9%	4	203	0.0251	0.37	0.127	0
tebuthiuron	Noncancer HBSL	1000	Maximum	1.26	0.13%	133	3.0%	4	129	0.024	1.26	0.654	0
aldrin	Residential RBC	0.00092	Maximum	0.00064	70%	273	1.1%	3	270	0.0002	0.0006	0.0004	0
dacthal	Cancer HBSL (10-6 to 10-4)	20	Maximum	0.008	0.04%	206	1.5%	3	203	0.003	0.008	0.005	0
dinoseb	MCL	7	Maximum	0.235	3.4%	1926	0.16%	3	1923	0.081	0.235	0.162	0
hexazinone	Noncancer HBSL	400	Maximum	0.106	0.03%	135	2.2%	3	132	0.056	0.106	0.0763	0
iprodione	Carcinogenic HHBP (E-6 to E-4)	0.729	Maximum	0.0402	5.5%	110	2.7%	3	107	0.0148	0.0402	0.0253	0
kresoxim-methyl	Carcinogenic HHBP (E-6 to E-4)	11	Maximum	0.0115	0.10%	3	100%	3	0	0.00587	0.0115	0.00845	0
zoxamide	Chronic or Lifetime (HHBP)	3100	Maximum	0.0285	0.001%	3	100%	3	0	0.00924	0.0285	0.0171	0
alpha-hch	Cancer HBSL (10-6 to 10-4)	0.006	Maximum	0.00066	11%	275	0.7%	2	273	0.0006	0.0007	0.0006	0
diazinon	Noncancer HBSL	1	Maximum	0.25	25%	156	1.3%	2	154	0.032	0.25	0.141	0
heptachlor	Residential RBC	0.0014	Maximum	0.0012	86%	275	0.7%	2	273	0.0007	0.0012	0.0009	0
methoxychlor	MCL	40	Maximum	0.596	1.5%	275	0.7%	2	273	0.14	0.596	0.368	0
p,p'-dde	Residential RBC	0.046	Maximum	0.00404	8.8%	277	0.7%	2	275	0.00107	0.00404	0.00255	0
acifluorfen	Noncancer HBSL	90	Maximum	0.988	1.1%	1875	0.05%	1	1874	0.988	0.988	0.988	0
boscalid	Chronic or Lifetime (HHBP)	1400	Maximum	0.0086	0.001%	37	2.7%	1	36	0.0086	0.0086	0.0086	0
chlorothalonil	Noncancer HBSL	100	Maximum	0.718	0.72%	190	0.5%	1	189	0.718	0.718	0.718	0
desulfinylfipronil	Noncancer HBSL	1	Maximum	0.0105	1.1%	1	100%	1	0	0.0105	0.0105	0.0105	0
dimethoate	Chronic or Lifetime (HHBP)	14	Maximum	0.0765	0.55%	151	0.7%	1	150	0.0765	0.0765	0.0765	0
esfenvalerate	Acute or One Day & Chronic or Lifetime HHBP	12	Maximum	0.0062	0.05%	203	0.49%	1	202	0.0062	0.0062	0.0062	0
ethofumesate	Chronic or Lifetime (HHBP)	2000	Maximum	0.35	0.02%	36	2.8%	1	35	0.35	0.35	0.35	0
fenbuconazole	Carcinogenic HHBP (E-6 to E-4)	8.91	Maximum	0.0072	0.08%	37	2.7%	1	36	0.0072	0.0072	0.0072	0
flusilazole	Chronic or Lifetime (HHBP)	10	Maximum	0.0063	0.06%	1	100%	1	0	0.0063	0.0063	0.0063	0
g-bhc (lindane)	Residential RBC	0.043	Maximum	0.0016	3.72%	275	0.36%	1	274	0.0016	0.0016	0.0016	0
napropamide	Chronic or Lifetime (HHBP)	770	Maximum	0.016	0.002%	140	0.71%	1	139	0.016	0.016	0.016	0
p,p'-ddd	Residential RBC	0.031	Maximum	0.00513	16.5%	276	0.36%	1	275	0.00513	0.00513	0.00513	0
piperonyl butoxide	Chronic or Lifetime (HHBP)	992	Maximum	0.0179	0.002%	1	100%	1	0	0.0179	0.0179	0.0179	0
pyrimethanil	Chronic or Lifetime (HHBP)	1100	Maximum	0.15	0.014%	36	2.8%	1	35	0.15	0.15	0.15	0
siduron	Chronic or Lifetime (HHBP)	960	Maximum	0.00442	0.0005%	136	0.74%	1	135	0.00442	0.00442	0.00442	0
terbacil	Noncancer HBSL	100	Maximum	0.025	0.025%	201	0.50%	1	200	0.025	0.025	0.025	0
trifluralin	Cancer HBSL (10-6 to 10-4)	10	Maximum	0.004	0.040%	206	0.49%	1	205	0.004	0.004	0.004	0

Bold: the UCL is ≥10% the regulatory limit and ≥15% of samples were detected

>10%

>15%

Exceeds UCL

Table 4. Non-detected Pesticides

Pesticide	Regulatory Standard	Regulatory Limit (ug/L)	Number of Samples
acetamiprid	Chronic or Lifetime (HHBPs)	450	97
acetochlor	Chronic or Lifetime (HHBP)	100	202
acifluorfen (sodium)	Noncancer HBSL	90	46
alachlor	MCL	2	222
aldicarb	Noncancer HBSL	7	91
aldicarb sulfone	Noncancer HBSL	7	91
aldicarb sulfoxide	Noncancer HBSL	7	91
ametryn	Noncancer HBSL	500	136
amitraz	Acute or One Day HHBP	8.33	36
azinphos-methyl	Chronic or Lifetime (HHBP)	9.6	182
azoxystrobin	Chronic or Lifetime (HHBP)	1200	36
bendiocarb	Noncancer HBSL	9	36
benfluralin	Chronic or Lifetime (HHBP)	30	102
bensulide	Chronic or Lifetime (HHBP)	30	21
beta-hch	Cancer HBSL (10-6 to 10-4)	0.02	275
butylate	Noncancer HBSL	400	99
captan	Chronic or Lifetime (HHBP)	830	102
carbofuran	MCL	40	191
carfentrazone-ethyl	Chronic or Lifetime (HHBP)	200	36
chlordane	MCL	2	161
chlordane, technical	MCL	2	55
chloroneb	Chronic or Lifetime (HHBP)	83	201
chlorpropham	Chronic or Lifetime (HHBPs)	300	99
chlorpyrifos	Noncancer HBSL	2	207
cis-chlordane	MCL	2	99
clopyralid	Chronic or Lifetime (HHBP)	960	180
clothianidin	Chronic or Lifetime (HHBP)	630	36
coumaphos	Chronic or Lifetime (HHBP)	2	51
cyanazine	Cancer HBSL (10-6 to 10-4)	0.03	129
cycloate	Chronic or Lifetime (HHBPs)	30	99
cyfluthrin	Acute or One Day HHBP	100	102
cyhalothrin	Chronic or Lifetime (HHBP)	6	102
cypermethrin	Acute or One Day HHBP	150	102
deltamethrin	Acute or One Day HHBP	30	102
dichlorvos	Chronic or Lifetime (HHBP)	3	135
diclofop-methyl	Carcinogenic HHBP (E-6 to E-4)	0.435	36
dicofol	Chronic or Lifetime (HHBP)	3	102
dicrotophos	Chronic or Lifetime (HHBP)	0.2	51
dieldrin	Residential RBC	0.0017	280
dimethenamid	Chronic or Lifetime (HHBP)	300	83
diphenamid	Noncancer HBSL	200	79
diphenylamine	Chronic or Lifetime (HHBP)	600	36
disulfoton	Noncancer HBSL	0.9	51
endrin	Residential RBC	1.9	362
eptc	Chronic or Lifetime (HHBPs)	300	99
ethalfluralin	Carcinogenic HHBP (E-6 to E-4)	0.36	102
ethion	Noncancer HBSL	4	51
fenamiphos	Noncancer HBSL	0.7	150
fenarimol	Chronic or Lifetime (HHBP)	40	201
fenitrothion	Chronic or Lifetime (HHBP)	0.8	51
fenoxaprop-ethyl	Chronic or Lifetime (HHBP)	16	36
fenthion	Chronic or Lifetime (HHBP)	0.4	51
fluazifop-p-butyl	Chronic or Lifetime (HHBP)	47	36
fludioxonil	Chronic or Lifetime (HHBP)	200	36
flumioxazin	Chronic or Lifetime (HHBP)	100	36
fluometuron	Cancer HBSL (10-6 to 10-4)	2	136
fluridone	Chronic or Lifetime (HHBPs)	960	99
flutolanil	Chronic or Lifetime (HHBP)	3000	102
folpet	Chronic or Lifetime (HHBP)	600	102
heptachlor epoxide	Residential RBC	0.0014	275
isoxaben	Chronic or Lifetime (HHBP)	300	36
linuron	Chronic or Lifetime (HHBP)	49	136
malathion	Noncancer HBSL	500	155
mefenoxam	Chronic or Lifetime (HHBP)	474	36
methidathion	Chronic or Lifetime (HHBP)	9.6	51
methiocarb	Noncancer HBSL	40	196
methomyl	Noncancer HBSL	200	191
mevinphos	Chronic or Lifetime (HHBP)	0.16	150
mgk 264	Chronic or Lifetime (HHBPs)	390	99
mirex	Noncancer HBSL	1	166
molinate	Noncancer HBSL	7	99
myclobutanil	Chronic or Lifetime (HHBP)	160	36
norflurazon	Chronic or Lifetime (HHBP)	96	206
oxamyl	MCL	200	191
oxyfluorfen	Carcinogenic HHBP (E-6 to E-4)	0.437	149
p,p'-ddt	Residential RBC	0.023	276
parathion-methyl	Noncancer HBSL	1	151
pebulate	Chronic or Lifetime (HHBPs)	4	99
permethrin	Carcinogenic HHBP (E-6 to E-4)	3.344	201
phorate	Chronic or Lifetime (HHBP)	1.1	51
phosmet	Chronic or Lifetime (HHBP)	3	95
pirimiphos-methyl	Chronic or Lifetime (HHBP)	0.4	51
prometryn	Chronic or Lifetime (HHBP)	300	136
pronamide	Chronic or Lifetime (HHBPs)	300	201
propachlor	Cancer HBSL (10-6 to 10-4)	1	201
propanil	Chronic or Lifetime (HHBP)	60	102
propargite	Carcinogenic HHBP (E-6 to E-4)	0.167	36
propazine	Noncancer HBSL	100	156

Table 4. Non-detected Pesticides

Pesticide	Regulatory Standard	Regulatory Limit (ug/L)	Number of Samples
pyraclostrobin	Chronic or Lifetime (HHBP)	220	136
pyridaben	Chronic or Lifetime (HHBP)	30	36
pyriproxyfen	Chronic or Lifetime (HHBPs)	2200	100
sethoxydim	Chronic or Lifetime (HHBP)	900	36
sulfentrazone	Chronic or Lifetime (HHBP)	900	36
sulprofos	Noncancer HBSL	20	51
tebuconazole	Acute or One Day & Chronic or Lifetime HHBP	190	36
terbufos	Noncancer HBSL	0.4	150
terbutryn	Noncancer HBSL	7	100
tetrachlorvinphos	Carcinogenic HHBP (E-6 to E-4)	17.5	144
thiabendazole	Chronic or Lifetime (HHBP)	210	36
thiobencarb	Chronic or Lifetime (HHBP)	60	36
toxaphene	MCL	3	176
trans-chlordane	MCL	2	99
triadimefon	Chronic or Lifetime (HHBP)	220	135
tricyclazole	Chronic or Lifetime (HHBPs)	430	92
trifloxystrobin	Chronic or Lifetime (HHBP)	240	102
triflumizole	Chronic or Lifetime (HHBP)	74.9	102
vernolate	Noncancer HBSL	7	99

Appendix A

UIC Permits Issued by DEQ

State of Oregon Department of Environmental Quality

Active Individual UIC Permits

No.	Permittee Name	Permit Number	Permit Issuance Date	Permit Expiration Date
1	City of Portland	102830	6/1/2005	5/31/2015
2	City of Gresham	103043	12/10/2012	11/30/2022
3	City of Eugene	103047	1/22/2013	12/31/2022
4	City of Redmond	103050	2/14/2013	1/31/2023
5	City of Bend	103052	5/14/2013	4/30/2023
6	Clackamas County	103059	7/1/2013	6/30/2023
7	City of Keizer	103068	11/24/2013	9/30/2023
8	Multnomah County	103076	4/21/2014	3/31/2024
9	City of Canby	103077	4/30/2014	3/31/2024
10	Tri-Met	103083	6/10/2014	5/31/2024
11	Parkrose School District	103084	6/30/2014	5/31/2024
12	City of Milwaukie	103089	8/11/2014	7/31/2024
13	City of La Grande	103093	10/8/2014	9/30/2024
14	Eastport Plaza	103097	11/6/2014	10/31/2024
15	Lane County	103100	12/16/2014	11/30/2024
16	Wal-Mart	103101	1/22/2015	12/31/2024
17	RiverRim Public Utility District	103103	2/24/2015	1/31/2025
18	City of Umatilla	103110	5/8/2015	4/30/2025
19	City of Portland	102830	5/19/2015	4/30/2025
20	Canby School District	103112	6/11/2015	5/31/2025
21	Portland Community College	103115	7/13/2015	6/30/2025
22	City of Hermiston	103126	2/18/2016	1/31/2026
23	Reynolds School District	103133	5/25/2016	4/30/2026
24	Home Depot Bend Area	103136	6/7/2016	5/31/2026
25	Home Depot Portland Area	103137	6/7/2016	5/31/2026
26	Cascade Village Shopping Center	103142	7/14/2016	6/30/2026
27	North Rim Public Utility District	103143	7/21/2016	6/30/2026
28	City of Troutdale	103145	8/1/2016	7/31/2026
29	City of Sisters	103146	8/3/2016	7/31/2026
30	Pacific Realty Associates	103148	9/13/2016	8/31/2026
31	Forum Holdings	103149	9/20/2016	8/31/2026
32	Overbay Development	103153	10/31/2016	9/30/2026
33	Deschutes County	103155	11/17/2016	10/31/2026
34	Bend River Promenade (RPP Bend)	103157	12/13/2016	11/30/2026
35	Adventist Medical Center	103158	12/14/2016	11/30/2026
36	St. Charles Health System	103159	12/29/2016	11/30/2026
37	Fred Meyer Portland Area	103160	1/3/2017	12/31/2026
38	Albertsons Portland Area	103161	1/23/2017	12/31/2026

Note:
Gray shading indicates a permit is inactive

Appendix B

Half-Life and Soil Organic Carbon-Water Partitioning Coefficients for Fipronil and Diuron

Appendix B. Technical Background on GWPD

This appendix presents the technical background documentation for the Groundwater Protectiveness Demonstration (GWPD) model, including pollutant-specific fate and transport parameters.

Governing Equation for Unsaturated Zone GWPD

A one-dimensional pollutant fate and transport equation was used to estimate the magnitude of pollutant attenuation during transport through the unsaturated zone. This constant source Advection-Dispersion Equation (ADE) incorporates adsorption, degradation (biotic and abiotic), and dispersion to estimate pollutant concentration at the water table (e.g., Watts, 1998). The equation is provided below:

$$\frac{C(y,t)}{C_0} = \frac{1}{2}\left[\left(e^{A_1}\right)erfc\left(A_2\right) + \left(e^{B_1}\right)erfc\left(B_2\right)\right] \qquad \text{(B.1)}$$

where:

$$A_1 = \left(\frac{y}{2D'}\right)\left(v' - \sqrt{(v')^2 + 4D'k'}\right)$$

$$A_2 = \frac{y - t\sqrt{(v')^2 + 4D'k'}}{2\sqrt{D't}}$$

$$B_1 = \left(\frac{y}{2D'}\right)\left(v' + \sqrt{(v')^2 + 4D'k'}\right)$$

$$B_2 = \frac{y + t\sqrt{(v')^2 + 4D'k'}}{2\sqrt{D't}}$$

$$v' = \frac{v}{R}$$

$$D' = \frac{D}{R}$$

$$k' = \frac{k}{R}$$

and:

y is distance in the vertical direction (L),
v is average linear pore water velocity (L/T),
D is the dispersion coefficient (L^2/T),
R is the retardation factor (dimensionless),

k is the first-order degradation constant (T^{-1}),
t is average infiltration time (T),
C_0 is initial pollutant concentration (M/L^3),
C(y, t) is pollutant concentration at depth *y* and time *t* (M/L^3), and
erfc is complementary error function used in partial differential equations

Equation (B.1) is an exact solution to the one-dimensional ADE. The exact solution can be used for both short (i.e., less than 3.5 meters) and long transport distances (greater than 35 meters; Neville and Vlassopoulos, 2008). An approximate solution to the 1-dimensional ADE has also been developed, and can only be used for long transport distances. The unsaturated zone GWPD uses the exact solution to the ADE.

The key assumptions in applying this equation include:

- Transport is one-dimensional vertically downward from the bottom of the Underground Injection Control (UIC) to the water table (Note: in reality, water also exfiltrates from holes in the side of the UIC, as well as from the bottom).
- The stormwater infiltration rate into the UIC is constant and maintains a constant head within the UIC to drive the water into the unsaturated soil. (Note: in reality, stormwater flows are highly variable, short duration, and result in varying water levels within the UIC dependent on the infiltration capacity of the formation).
- Pollutant concentrations in water discharging into the UIC are uniform and constant throughout the period of infiltration (Note: in reality, concentrations are variable seasonally and throughout storm events).
- The pollutant undergoes equilibrium sorption (instantaneous and reversible) following a linear sorption isotherm.
- The pollutant is assumed to undergo a first-order transformation reaction involving biotic degradation.
- The pollutant does not undergo transformation reactions in the sorbed phase (i.e., no abiotic or biotic degradation).
- There is no portioning of the pollutant to the gas phase in the unsaturated zone.
- The soil is initially devoid of the pollutant.

Soil Properties

The soil properties used in this GWPD are documented in Appendix C, and have been discussed in detail by several previous GWPD reports [see for example, GSI (2013)]. This appendix discusses K_{oc} and half-lives for fipronil and diuron, which have not previously been documented as a part of a GWPD. See, for example, GSI (2013) for documentation of the chemical fate and transport parameters for pentachlorophenol (PCP).

Chemical Fate and Transport Parameters

Chemical fate and transport parameters include degradation rates (i.e., half-lives) and the soil organic carbon-water partitioning coefficient (K_{oc}). Half-life is the amount of time required for the quantity of a pollutant to be reduced to half of its initial value (units of days). The K_{oc} is a measure of a tendency of a chemical to bind to soil that is normalized to the organic carbon content of soil (units of Liters per Kilogram or L/kg).

Fipronil

Fipronil is an insecticide that was synthesized by the Rhone Poulenc Agricultural Company in 1987 and registered in the United States in 1996 (Uniyal et al., 2016).

Half-life

Under aerobic conditions (which are the conditions that occur in shallow unsaturated zone soils around UICs), fipronil degrades by photolysis, hydrolysis, and microbial action following first order kinetics (Chopra et al., 2010; Humphries et al., 1993; Ying and Kookana, 2002) or pseudo first order kinetics (Uniyal et al., 2016). The photolysis degradation pathway is not applicable to UICs, and the hydrolysis pathway is not significant at pH levels typical of stormwater (fipronil degradation by hydrolysis has been found to occur at pH levels above 9) (Bobe et al., 1998; Ngim and Crosby, 2001). The microbial degradation pathway under aerobic conditions is significant, and applicable to UICs.

The following variables affect the degradation of fipronil by microbes under aerobic conditions:

- **Temperature.** Fipronil degradation becomes more rapid as temperature increases (Fitzmaurice and Mackenzie, 2002; Mohapatra et al., 2010).

- **Moisture Content.** Fipronil degradation becomes more rapid as moisture content increases (Ying and Kookana, 2002).

GSI's estimate of the fipronil degradation rate is based on laboratory studies conducted in the dark, which removes the photolysis pathway. In addition, GSI only included degradation rates from studies that were conducted between 4 C (39.2 degrees F) and 20 C (68 degrees F) so that fipronil degradation rates would be representative of conditions encountered at UICs[1]. Soil moisture contents in the studies ranged from 15 percent to saturated, which is representative of the variable saturation that occurs at UICs. Data from both sterile and non-sterile soils were included in the analysis. The half-lives of fipronil are summarized in Table 1 below. Based on a total of 14 values, the half-life of fipronil under conditions in a UIC ranges from 31 days to 686 days, and averages 199.8 days.

[1] Most Fipronil degradation rates reviewed in this study were measured at 25 C (77 degrees F) and above.

Table 1. Half-lives for Microbial Degradation of Fipronil

Author	Half-life (days)	Notes
Ying and Kookana (2002)	217	Sandy loam soil, sterile, 15% "water holding capacity", 20 C
Ying and Kookana (2002)	210	Sandy loam soil, sterile, 60% WHC, 20 C
Ying and Kookana (2002)	198	Sandy loam soil, non-sterile, 15% WHC, 20 C
Ying and Kookana (2002)	161	Sandy loam soil, non-sterile, 30% WHC, 20 C
Ying and Kookana (2002)	68	Sandy loam soil, non-sterile, 60% WHC, 20 C
Fitzmaurice and Mackenzie (2002)	304	Chazay Clay Loam, pH=8.2, WHC=45.3, 20 C
Fitzmaurice and Mackenzie (2002)	102	Ongar Clay Loam, pH=7.3, WHC=60.1, 20 C
Fitzmaurice and Mackenzie (2002)	31	Royston Clay Loam, pH=8.3, WHC=104.6, 20 C
Fitzmaurice and Mackenzie (2002)	221	Levington Sandy Loam, pH=6.6, WHC=39.3, 20 C
Fitzmaurice and Mackenzie (2002)	686	Chazay Clay Loam, pH=8.2, WHC=45.3, 10 C
Fitzmaurice and Mackenzie (2002)	358	Ongar Clay Loam, pH=7.3, WHC=60.1, 10 C
Mohapatra et al., (2012)	90	4 degrees C, 20 % Field capacity moisture
Mohapatra et al. (2012)	61.5	4 degrees C, saturated
Mohapatra et al. (2012)	90.13	4 degrees C, saturated

Soil Organic Carbon-Water Partitioning Coefficient

Fipronil sorbs to organic matter (Bobe et al., 1997) and follows a Freundlich Isotherm (Godward et al., 1996). GSI compiled 30 values of the soil organic carbon-water partitioning coefficient for fipronil. Results are summarized in Table 2 below. Based on a total of 30 values, the K_{oc} of fipronil ranges from 58 L/kg to 2,023 L/kg and averages 551.4 L/kg.

Table 2. Fipronil Retardation—K_{oc} values

Author	K_{oc} (L/kg)
Godward et al. (1996)	427
Godward et al. (1996)	1248
Godward et al. (1996)	486
Godward et al. (1996)	800
Godward et al. (1996)	673
Ying and Kookana (2001)	278
Ying and Kookana (2001)	290
Ying and Kookana (2001)	546
Ying and Kookana (2001)	268
Ying and Kookana (2001)	410
Ying and Kookana (2001)	380
Ying and Kookana (2001)	254
Ying and Kookana (2001)	369
Doran et al. (2006)	320
Doran et al. (2006)	292
Mukerjee and Kalpana (2006)	116
Mukerjee and Kalpana (2006)	58
Mukerjee and Kalpana (2006)	70
Mukerjee and Kalpana (2006)	65

Mukerjee and Kalpana (2006)	72
Mukerjee and Kalpana (2006)	2023
Mukerjee and Kalpana (2006)	1452
Mukerjee and Kalpana (2006)	1642
Mukerjee and Kalpana (2006)	1500
Mukerjee and Kalpana (2006)	1428
Mukerjee and Kalpana (2006)	351
Mukerjee and Kalpana (2006)	234
Mukerjee and Kalpana (2006)	192
Mukerjee and Kalpana (2006)	149
Mukerjee and Kalpana (2006)	150

Diuron

Diuron is an herbicide that was introduced by Bayer Crop Science in 1954.

Half-life

Diuron degrades by hydrolysis, photolysis, and microbial degradation; however, the hydrolysis pathway is not significant over the pH range and temperature range of typical stormwater (pH of 7 to 9, below 25 degrees Celsius), and photolysis is not an applicable pathway for UICs, although diuron does degrade by photolysis with half-lives on the order of several hours (Williams, 1995). In soil, diuron degrades by biodegradation under both aerobic and anaerobic conditions. Because shallow unsaturated zone soils are aerobic, only degradation rates measured under aerobic conditions were used to estimate the half-life of diuron for the GWPD model. The rate of diuron degradation appears to be affected by temperature above 25 degrees C, with biodegradation rate increasing with increasing temperature (see Madhun and Freed, 1987 and Madhun, 1984). Therefore, laboratory experiments that measured diuron biodegradation at temperatures exceeding 25 degrees Celsius were not used to calculate the diuron half-life because temperature during infiltration from a UIC are not expected to exceed 25 degrees Celsius.

The half-lives of diuron are summarized in Table 3. Based on a total of 10 studies, the half-life of diuron under conditions in a UIC range from 20 days to 1,378 days, and averages 358 days.

Table 3. Half-lives for Microbial Degradation of Diuron

Author	Half-life (days)	Notes
AG (2011)	372	Aerobic soil, 25 C
AG (2011)	20	Aerobic soil, 25 C
AG (2011)	119	Aerobic soil, 20 C
AG (2011)	51	Aerobic soil, 20 C
AG (2011)	143	Aerobic soil, 10 C
AG (2011)	27	Aerobic soil, 20 C
AG (2011)	112	Aerobic soil, 20 C
Madhun and Freed (1987)	705	Aerobic soil, 20 C
Madhun (1984)	653	Aerobic soil, 25 C
Madhun (1984)	1,378	Aerobic soil, 25 C

Soil Organic Carbon-Water Partitioning Coefficient

Diuron sorbs to organic matter (Priester, 1990) and follows a Linear Isotherm (Kasozi et al., 2010). Based on a total of 37 values (Table 4), the K_{oc} of diuron ranges from 145 to 5,240 L/kg and averages 893 L/kg.

Table 4. Diuron Retardation—K_{oc} values

Author	K_{oc} (L/kg)
Kasozi et al. (2010)	259
Kasozi et al. (2010)	558
Kasozi et al. (2010)	973
Kasozi et al. (2010)	2,090
Bramble et al. (1998)	1,666
Bramble et al. (1998)	468
Bramble et al. (1998)	626
Priester (1990)	452
Priester (1990)	418
Priester (1990)	574
Priester (1990)	487
Simpson and Hargreaves (2001)	1,326
Simpson and Hargreaves (2001)	3,738
Simpson and Hargreaves (2001)	2,244
Simpson and Hargreaves (2001)	5,240
Ahangar et al. (2008)	507
Ahangar et al. (2008)	884
Ahangar et al. (2008)	598
Ahangar et al. (2008)	918
Ahangar et al. (2008)	556
Ahangar et al. (2008)	762
Ahangar et al. (2008)	459
Ahangar et al. (2008)	583
Ahangar et al. (2008)	473
Ahangar et al. (2008)	679
GAhangar et al. (2008)	477
Ahangar et al. (2008)	678
Ahangar et al. (2008)	428
Ahangar et al. (2008)	707
Ahangar et al. (2008)	452
Ahangar et al. (2008)	479
Ahangar et al. (2008)	405
Ahangar et al. (2008)	547
Ahangar et al. (2008)	538
Ahangar et al. (2008)	975
Dores et al. (2009)	145
Dores et al. (2009)	917
Nkedi-Kizza et al., (1983)	636
Nkedi-Kizza et al., (1983)	570
Nkedi-Kizza et al., (1983)	884
Nkedi-Kizza et al., (1983)	619
Nkedi-Kizza et al., (1983)	706
Nkedi-Kizza et al., (1983)	733

References

AG, 2011. Diuron Environment Assessment. Australian Government Australian Pesticides and Veterinary Medicines Authority, 247 pp., July.

Ahangar, A. G., Smernik, R. J., and R. S. Kookana, 2008. Role of the chemistry of soil organic matter on the sorption of diuron. In: Environmental Toxicology II, Kungolos, A. G., Brebbia, C. A., and Zamorano, M., Eds. WIT Press, Southampton, Boston, 327 – 336.

Bramble, F. Q., Behmke F. D., and G. I. Norwood, 1998. Batch equilibrium (adsorption/desorption) of 14C-Diuron, fenuron, and N'-(3-chlorophenyl)-N,N-Dimethylurea on Soil.

Callahan, M. A., 1979. Water-Related Environmental Fate of 129 Priority Pollutants: Volume 1. U.S. Environmental Protection Agency, Office of Water Planning and Standards, 520 pp.

Castro, T. F. and T. Yoshida, 1971. Degradation of Organotin Insecticides in Flooded Soils in the Phillipines. Journal of Agricultural Food Chemistry, Volume 19, pp. 1168-1170.

Ding, J. Y. and S. C. Wu, 1995. Partition coefficients of organochlorine pesticides on soil and on the dissolved organic matter in water, Chemosphere, Volume 30, Issue 12, pp. 2259—2266.

Doran, G., Eberbach, P., and S. Helliwell, 2006. The sorption and Degradation of the rice pesticides fipronil and thiobencarb on two Australian rice soils, Australian journal of soil research, vol. 44, pp. 599-610.

Dores, E. F. G. C., Spadotto, C. A., Weber, O. L. S., Carbo, L., Vecchiato, A. B., and A. A. Pinto, 2007. Environmental Behavior of Metolachlor and Diuron in a Tropical Soil in the Central Region of Brazil. Water Air Soil Pollution, Vol 197, pp. 175—183.

GSI, 2013. Groundwater Protectiveness Demonstration and Risk Prioritization for Underground Injection Control (UIC) Devices, City of Keizer, Oregon.

Howard, P. H., Boethling, R. S., Jarvis, W. F., Meylan, W. M. and E. M. Michalenko. 1991. Handbook of Environmental Degradation Rates, Lewis Publishers, Boca Raton, FL.

Humphries, S. P., Lowden, P., and R. G. Oliver, 1993. Fipronil: Rate of Degradation in Four Soils under Aerobic Conditions at 22 C, Study No. O91/087, Rhone Poulence Agriculture Ltd, Essex, Unpublished.

Fitzmaurice, M. and E. MacKenzie, 2002. 14C Fipronil: Degradation in Four soils at 20 C and two soils at 10 C (AE F124964), Document No. C018800, Aventis CropScience UK Limited, 17 January 2002.

Godward, P. J., D. L. Quarmby, and D. J. Austin, 1992. M&B 46030-14C: Adsorption/Desorption on five soils: amendment to final report. Report No. 548, Rhone-Poulenc Agricultural Ltd., Essex, unpublished.

Kasozi, G. N., Nkedi-Kizza, P., Agyin-Birikorang, S., and A. R. Zimmerman, 2010. Characterization of adsorption and degradation of diuron in carbonatic and noncarbonatic soils. Journal of Agricultural and Food Chemistry, Volume 58 (2), pp. 1055-1061.

Madhun, Y. A. W., 1984. Interaction of Selected Herbicides with Soil Constituents. MS Thesis, Oregon State University, 171 pp.

Madhun, Y. A. and V. H. Freed, 1987. Degradation of the herbicides bromacil, diuron, and chlortoluron in soil. Chemosphere, Volume 16 (5): 1003—1011.

Mohapatra, S., Ajuja, AK, and M. Deepa, 2010. Effect of Temperature on the Degradation of Fipronil in Soil. Pesticide Research Journal. Vol. 22 (2): 120-124.

Montgomery, J. H., 1993. Agrochemicals Desk Reference: Environmental Data. Lewis Publishers, Ann Arbor, 625 pg.

Mukherjee, I and Kalpana, 2006. Sorption of Fipronil in tropical soils. Bulletin of Environmental Contaminant Toxicology. Volume 76(2): 334-40.

Muwamba, A, 2007. Determination of Aqueous Soil Sorption Coefficient (Koc) of Strongly Hydrophobic Organic Chemicals (SHOCs) Using Mixed Solvent Systems and the Solvophobic Model. MS Thesis, University of Florida, 113 pg.

Nash, R. G. and E. A. Woolson, 1967. Persistence of Chlorinated Hydrocarbon Insecticide in Soils, Science, Volume 157, pp. 924-927.

Nkedi-Kizza, P., Rao, P.S.C., and J. W. Johnson, 1983. Adsorption of diuron and 2,4,5-T on soil particle size separates. Journal of Environmental Quality, Volume 12, pp. 195-197.

Priester, T. M., 1990. Batch Equilibrium (Adsorption/desorption) and soil thin-layer chromatography studies with [carbonyl-14C] Diuron, E. I. du Pont Nemours & Co Inc., Wilmington, Delaware. Report No. AMR 452-85.

Sharom, M. S., J. R. W. Miles, C. R. Harris, and F. L. McEwen, 1980. Behavior of 12 insecticides in soil and aqueous suspensions of soil and sediment. Water Res, vol. 14, pp. 1095—1100.

Simpson, B. W. and P. A. Hargreaves, 2001. Pesticide transport in sugar production systems. Natural Resources and Mines, Queensland Government, Indooroopily Brisbane.

Travis, C.C. and A. D. Arms, 1988. Bioconcentration of organics in beef, milk and vegetation, Environmental Science and Technology, Volume 22, pp. 271—274.

Uniyal, S., Paliwal, R., Sharma, R. K., and J. P. N. Raj, 2016. Degradation of fipronil by *Stenotrophomonasacidaminiphila* isolated from rhizospheric soil of *Zea mays*. Biotech, 6(1): 48.

Williams, M. D., 1995. Determination of the aqueous photodegradation of 14C-Diuron, ABC Laboratories, Inc.; Columbia, Missouri. Sanachem Pty Ltd, Durban South Africa. Report No. 42581.

Ying, G. G. and R. S. Kookana, 2001. Sorption of fipronil and its metabolites on soils from south Australia. Journal of Environmental Science and Health B, Volume 36: pp. 545-558.

Ying, G. G. and R. Kookana, 2002. Laboratory and field studies on the degradation of fipronil in a soil. Aust. J. Soil Res. 40: 1095-1102.

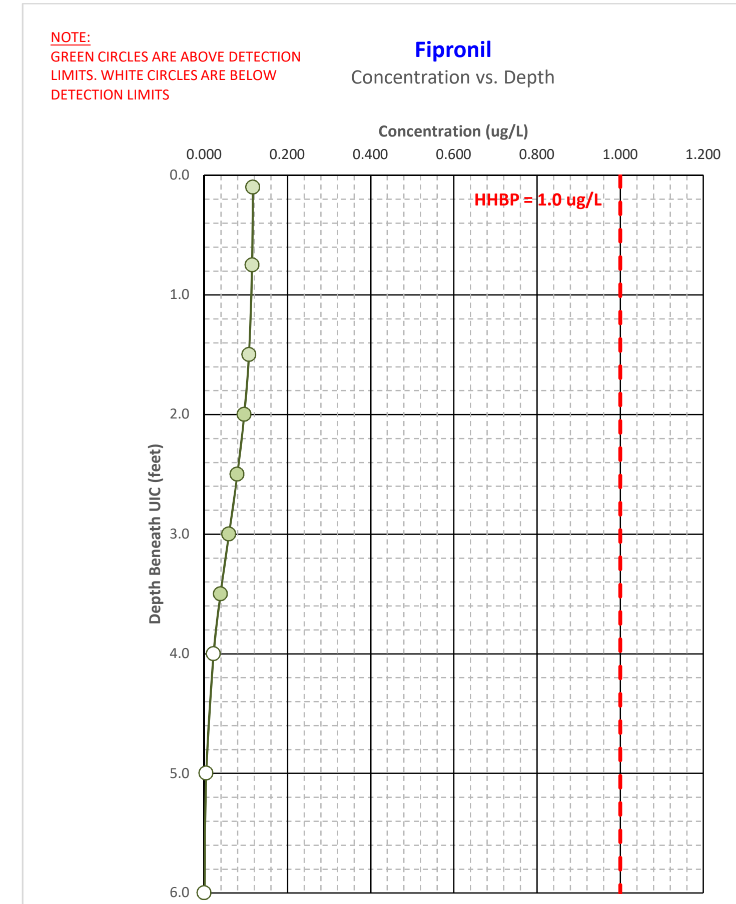
Appendix C

GWPD Calculations and Concentration Profiles

Table C-1. Pollutant Fate and Transport

Groundwater Protectiveness Demonstration

	Parameter	Symbol	Units	Fipronil									
				0.1 ft	0.75 ft	1.5 ft	2	2.5 ft	3.0 ft	3.5 ft	4.0 ft	5.0 ft	6 ft
UIC Properties	Distance	y	m	0.03048	0.22859	0.45718	0.60957	0.76196	0.91436	1.06675	1.21914	1.52393	1.82871
		y	ft	0.10	0.75	1.50	2.00	2.50	3.00	3.50	4.00	5.00	6.00
	Initial Concentration	C_0	mg/L	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]	0.000117 [1]
	Infiltration Time	t	d	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]
Pollutant Properties	First-Order Rate Constant	k	d^{-1}	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]	3.47E-03 [3]
	Half-Life	h	d	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]	199.8 [4]
Physical and Chemical Soil Properties	Soil Porosity	η	-	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]
	Soil Bulk density	ρ_b	g/cm^3	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]
	Fraction Organic Carbon	f_{oc}	-	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]
	Organic Carbon Partition Coefficient	K_{oc}	L/kg	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]	551.4 [8]
	Distribution Coefficient	K_d	L/kg	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]	3.1 [9]
	Pore Water Velocity	v	m/d	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]
Calculations	Retardation Factor	R	-	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3
	Dispersion Coefficient	D	m^2/d	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02
	Normalized Dispersion	D'	m^2/d	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03	4.38E-03
	Normalized Velocity	v'	m/d	5.74E-02	5.74E-02	5.74E-02	5.74E-02	5.74E-02	5.74E-02	5.74E-02	5.74E-02	5.74E-02	5.74E-02
	Normalized Degradation	k'	d^{-1}	1.90E-04	1.90E-04	1.90E-04	1.90E-04	1.90E-04	1.90E-04	1.90E-04	1.90E-04	1.90E-04	1.90E-04
	A_1	-	-	-1.01E-04	-7.54E-04	-1.51E-03	-2.01E-03	-2.51E-03	-3.02E-03	-3.52E-03	-4.02E-03	-5.03E-03	-6.03E-03
	A_2	-	-	-1.61E+00	-1.23E+00	-7.78E-01	-4.79E-01	-1.80E-01	1.18E-01	4.17E-01	7.16E-01	1.31E+00	1.91E+00
	e^{A1}	-	-	1.00E+00	9.99E-01	9.98E-01	9.98E-01	9.97E-01	9.97E-01	9.96E-01	9.96E-01	9.95E-01	9.94E-01
	$erfc(A_2)$	-	-	1.98E+00	1.92E+00	1.73E+00	1.50E+00	1.20E+00	8.67E-01	5.55E-01	3.11E-01	6.32E-02	6.88E-03
	B_1	-	-	4.00E-01	3.00E+00	6.00E+00	8.00E+00	1.00E+01	1.20E+01	1.40E+01	1.60E+01	2.00E+01	2.40E+01
	B_2	-	-	1.73E+00	2.12E+00	2.57E+00	2.87E+00	3.17E+00	3.47E+00	3.77E+00	4.06E+00	4.66E+00	5.26E+00
	e^{B1}	-	-	1.49E+00	2.01E+01	4.04E+02	2.99E+03	2.21E+04	1.63E+05	1.21E+06	8.92E+06	4.88E+08	2.66E+10
	$erfc(B_2)$	-	-	1.42E-02	2.69E-03	2.78E-04	4.95E-05	7.45E-06	9.43E-07	1.01E-07	9.02E-09	4.30E-11	1.02E-13
	Concentration at y	C	mg/L	1.17E-04	1.15E-04	1.08E-04	9.63E-05	7.97E-05	5.96E-05	3.95E-05	2.28E-05	4.91E-06	5.59E-07
	Concentration at y	C	ug/L	0.116916	0.115222	0.107537	0.096337	0.079718	0.059574	0.039464	0.022843	0.004906	0.000559
Detection Limit		C	ug/L	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]	0.012 [11]



NOTES *(SEE APPENDIX B FOR CITATIONS)*

[1] Equal to the 95% UCL on the mean (95% Student's-t UCL), based on 43 stormwater samples.

[2] Infiltration time is the number of hours (converted to days) during the year that stormwater infiltrates into the UIC. Stormwater infiltration is conservatively assumed to occur when the precipitation rate is $\geq$ 0.04 inches/hour. Precipitation data source is from the Clackamas County WES pollutant fate and transport model, which is conservative because the precipitation in the WES model was the highest of any of the pollutant fate and transport models (Portland, Gresham, Keizer, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County).

[3] Calculated from ln(1/2)/(Half Life)

[4] Average half life of fipronil from literature review (see Appendix B)

[5] Most UICs infiltrate stormwater into highly permeable gravels. The value used for porosity is the midrange porosity for a gravel from Table 2.4 of Freeze and Cherry (1979)

[6] Calculated by formula 8.26 in Freeze and Cherry (1979): $\rho_b = 2.65(1-\eta)$.

[7] Estimate of f_{oc} based on loading of TOC in stormwater. Foc is from the City of Keizer pollutant fate and transport model, which is conservative because the Foc in the Keizer model was the lowest of any of the pollutant fate and transport models (Portland, Gresham, Clackamas County, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County)

[8] Average K_{oc} from literature review (see Appendix B)

[9] K_d calculated from the following equation: Kd = $(f_{oc})(K_{oc})$ (e.g., Watts, pg. 279, 1998).

[10] Estimate of velocity based on infiltration tests and aquifer tests. The value used in this model is from the City of Portland BES pollutant fate and transport model, which is conservative because the velocity in the Portland model was the highest of any of the pollutant fate and transport models (Keizer, Gresham, Clackamas County, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County)

[11] Lowest quantitation limit from City of Salem, City of Eugene, and Multnomah County data.

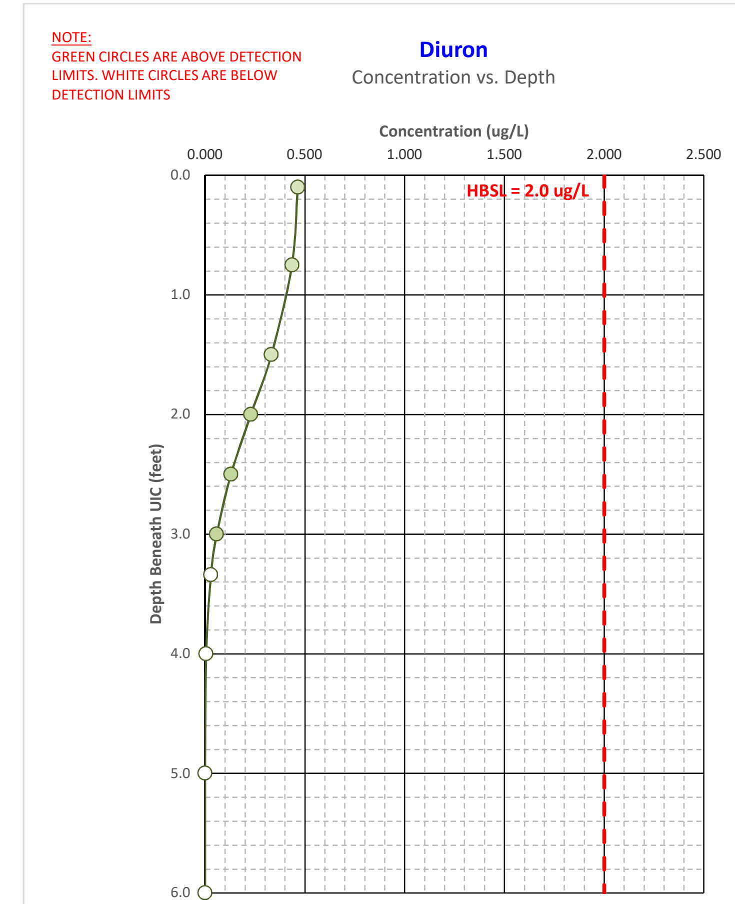
ABBREVIATIONS

ft = feet
m = meters
mg/L = milligrams per liter
ug/L = micrograms per liter
d = day
g/cm^3 = grams per cubic centimeter
L/kg = Liters per kilogram
m/d = meters per day
m^2/d = square meters per day

Table C-2. Pollutant Fate and Transport

Groundwater Protectiveness Demonstration

	Parameter	Symbol	Units	Diuron									
				0.1 ft	0.75 ft	1.5 ft	2	2.5 ft	3.0 ft	3.5 ft	4.0 ft	5.0 ft	6 ft
UIC Properties	Distance	y	m	0.03048	0.22859	0.45718	0.60957	0.76196	0.91436	1.01798	1.21914	1.52393	1.82871
		y	ft	0.10	0.75	1.50	2.00	2.50	3.00	3.34	4.00	5.00	6.00
	Initial Concentration	C_0	mg/L	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]	0.000466 [1]
	Infiltration Time	t	d	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]
Pollutant Properties	First-Order Rate Constant	k	d^{-1}	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]	1.94E-03 [3]
	Half-Life	h	d	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]	358.0 [4]
Physical and Chemical Soil Properties	Soil Porosity	η	-	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]
	Soil Bulk density	ρ_b	g/cm^3	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]
	Fraction Organic Carbon	f_{oc}	-	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]
	Organic Carbon Partition Coefficient	K_{oc}	L/kg	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]	893.0 [8]
	Distribution Coefficient	K_d	L/kg	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]	5.1 [9]
	Pore Water Velocity	v	m/d	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]
Calculations	Retardation Factor	R	-	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
	Dispersion Coefficient	D	m^2/d	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02
	Normalized Dispersion	D'	m^2/d	2.76E-03	2.76E-03	2.76E-03	2.76E-03	2.76E-03	2.76E-03	2.76E-03	2.76E-03	2.76E-03	2.76E-03
	Normalized Velocity	v'	m/d	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.62E-02	3.62E-02
	Normalized Degradation	k'	d^{-1}	6.67E-05	6.67E-05	6.67E-05	6.67E-05	6.67E-05	6.67E-05	6.67E-05	6.67E-05	6.67E-05	6.67E-05
	A_1	-	-	-5.61E-05	-4.21E-04	-8.42E-04	-1.12E-03	-1.40E-03	-1.68E-03	-1.88E-03	-2.25E-03	-2.81E-03	-3.37E-03
	A_2	-	-	-1.25E+00	-7.65E-01	-2.01E-01	1.76E-01	5.52E-01	9.28E-01	1.18E+00	1.68E+00	2.43E+00	3.19E+00
	e^{A1}	-	-	1.00E+00	1.00E+00	9.99E-01	9.99E-01	9.99E-01	9.98E-01	9.98E-01	9.98E-01	9.97E-01	9.97E-01
	erfc(A_2)	-	-	1.92E+00	1.72E+00	1.22E+00	8.04E-01	4.35E-01	1.89E-01	9.40E-02	1.75E-02	5.80E-04	6.63E-06
	B_1	-	-	4.00E-01	3.00E+00	6.00E+00	8.00E+00	1.00E+01	1.20E+01	1.34E+01	1.60E+01	2.00E+01	2.40E+01
	B_2	-	-	1.40E+00	1.89E+00	2.46E+00	2.83E+00	3.21E+00	3.59E+00	3.84E+00	4.34E+00	5.09E+00	5.84E+00
	e^{B1}	-	-	1.49E+00	2.01E+01	4.04E+02	2.98E+03	2.21E+04	1.63E+05	6.35E+05	8.91E+06	4.87E+08	2.66E+10
	erfc(B_2)	-	-	4.70E-02	7.41E-03	5.09E-04	6.12E-05	5.62E-06	3.93E-07	5.50E-08	8.43E-10	5.99E-13	1.40E-16
	Concentration at y	C	mg/L	4.65E-04	4.35E-04	3.33E-04	2.30E-04	1.30E-04	5.90E-05	3.00E-05	5.81E-06	2.03E-07	2.41E-09
	Concentration at y	C	ug/L	0.464569	0.435414	0.332644	0.229606	0.130095	0.058954	0.030017	0.005809	0.000203	0.000002
Detection Limit		C	ug/L	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]	0.030 [11]



<u>NOTES</u> *(SEE APPENDIX B FOR CITATIONS)*

[1] Equal to the 95% UCL on the mean (95% Student's-t UCL), based on 82 stormwater samples.

[2] Infiltration time is the number of hours (converted to days) during the year that stormwater infiltrates into the UIC. Stormwater infiltration is conservatively assumed to occur when the precipitation rate is $\geq$ 0.04 inches/hour. Precipitation data source is from the Clackamas County WES pollutant fate and transport model, which is conservative because the precipitation in the WES model was the highest of any of the pollutant fate and transport models (Portland, Gresham, Keizer, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County).

[3] Calculated from ln(1/2)/(Half Life)

[4] Average half life of diuron from literature review (see Appendix B)

[5] Most UICs infiltrate stormwater into highly permeable gravels. The value used for porosity is the midrange porosity for a gravel from Table 2.4 of Freeze and Cherry (1979)

[6] Calculated by formula 8.26 in Freeze and Cherry (1979): $\rho_b = 2.65(1-\eta)$.

[7] Estimate of f_{oc} based on loading of TOC in stormwater. Foc is from the City of Keizer pollutant fate and transport model, which is conservative because the Foc in the Keizer model was the lowest of any of the pollutant fate and transport models (Portland, Gresham, Clackamas County, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County)

[8] Average K_{oc} from literature review (see Appendix B)

[9] K_d calculated from the following equation: Kd = (f_{oc})(K_{oc}) (e.g., Watts, pg. 279, 1998).

[10] Estimate of velocity based on infiltration tests and aquifer tests. The value used in this model is from the City of Portland BES pollutant fate and transport model, which is conservative because the velocity in the Portland model was the highest of any of the pollutant fate and transport models (Keizer, Gresham, Clackamas County, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County)

[11] Lowest detection limit from Eugene, Multnomah County, City of Salem, and Portland Group data.

ABBREVIATIONS

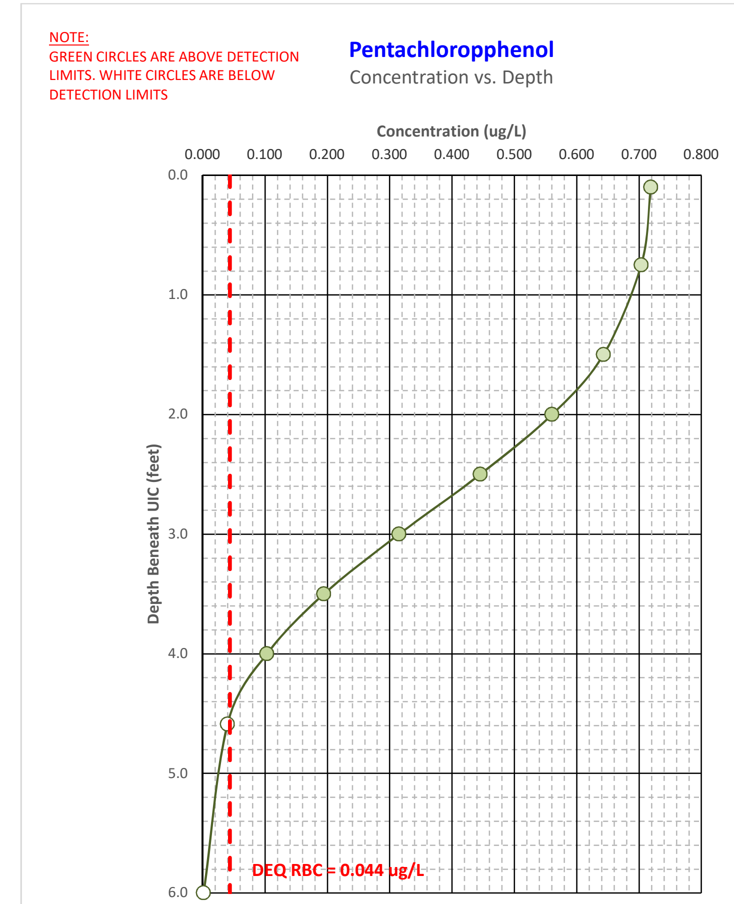
- ft = feet
- m = meters
- mg/L = milligrams per liter
- ug/L = micrograms per liter
- d = day
- g/cm^3 = grams per cubic centimeter
- L/kg = Liters per kilogram
- m/d = meters per day
- m^2/d = square meters per day

GSI Water Solutions, Inc.

Table C-3. Pollutant Fate and Transport

Groundwater Protectiveness Demonstration

	Parameter	Symbol	Units	Pentachlorophenol									
				0.1 ft	0.75 ft	1.5 ft	2	2.5 ft	3.0 ft	3.5 ft	4.0 ft	5.0 ft	6 ft
UIC Properties	Distance	y	m	0.03048	0.22859	0.45718	0.60957	0.76196	0.91436	1.06675	1.21914	1.39896	1.82871
		y	ft	0.10	0.75	1.50	2.00	2.50	3.00	3.50	4.00	4.59	6.00
	Initial Concentration	C_0	mg/L	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]	0.000720 [1]
	Infiltration Time	t	d	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]	14.86 [2]
Pollutant Properties	First-Order Rate Constant	k	d^{-1}	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]	2.21E-02 [3]
	Half-Life	h	d	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]	31.4 [4]
Physical and Chemical Soil Properties	Soil Porosity	η	-	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]	0.325 [5]
	Soil Bulk density	ρ_b	g/cm^3	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]	1.79 [6]
	Fraction Organic Carbon	f_{oc}	-	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]	0.0057 [7]
	Organic Carbon Partition Coefficient	K_{oc}	L/kg	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]	592.0 [8]
	Distribution Coefficient	K_d	L/kg	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]	3.4 [9]
	Pore Water Velocity	v	m/d	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]	1.051 [10]
Calculations	Retardation Factor	R	-	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
	Dispersion Coefficient	D	m^2/d	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02	8.01E-02
	Normalized Dispersion	D'	m^2/d	4.09E-03	4.09E-03	4.09E-03	4.09E-03	4.09E-03	4.09E-03	4.09E-03	4.09E-03	4.09E-03	4.09E-03
	Normalized Velocity	v'	m/d	5.37E-02	5.37E-02	5.37E-02	5.37E-02	5.37E-02	5.37E-02	5.37E-02	5.37E-02	5.37E-02	5.37E-02
	Normalized Degradation	k'	d^{-1}	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03
	A_1	-	-	-6.39E-04	-4.79E-03	-9.59E-03	-1.28E-02	-1.60E-02	-1.92E-02	-2.24E-02	-2.56E-02	-2.93E-02	-3.83E-02
	A_2	-	-	-1.56E+00	-1.16E+00	-6.96E-01	-3.87E-01	-7.82E-02	2.31E-01	5.40E-01	8.49E-01	1.21E+00	2.08E+00
	e^{A1}	-	-	9.99E-01	9.95E-01	9.90E-01	9.87E-01	9.84E-01	9.81E-01	9.78E-01	9.75E-01	9.71E-01	9.62E-01
	$erfc(A_2)$	-	-	1.97E+00	1.90E+00	1.68E+00	1.42E+00	1.09E+00	7.44E-01	4.45E-01	2.30E-01	8.61E-02	3.19E-03
	B_1	-	-	4.01E-01	3.00E+00	6.01E+00	8.01E+00	1.00E+01	1.20E+01	1.40E+01	1.60E+01	1.84E+01	2.40E+01
	B_2	-	-	1.69E+00	2.09E+00	2.55E+00	2.86E+00	3.17E+00	3.48E+00	3.79E+00	4.10E+00	4.46E+00	5.33E+00
	e^{B1}	-	-	1.49E+00	2.02E+01	4.07E+02	3.02E+03	2.24E+04	1.66E+05	1.23E+06	9.12E+06	9.69E+07	2.75E+10
	$erfc(B_2)$	-	-	1.72E-02	3.17E-03	3.10E-04	5.26E-05	7.44E-06	8.76E-07	8.57E-08	6.97E-09	2.84E-10	4.71E-14
	Concentration at y	C	mg/L	7.19E-04	7.03E-04	6.43E-04	5.60E-04	4.45E-04	3.15E-04	1.95E-04	1.04E-04	4.00E-05	1.57E-06
	Concentration at y	C	ug/L	0.718972	0.703380	0.642792	0.560492	0.445442	0.315093	0.194670	0.103565	0.040016	0.001573
Detection Limit		C	ug/L	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]	0.040 [11]



NOTES *(SEE APPENDIX B FOR CITATIONS)*

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[2] Infiltration time is the number of hours (converted to days) during the year that stormwater infiltrates into the UIC. Stormwater infiltration is conservatively assumed to occur when the precipitation rate is $\geq$ 0.04 inches/hour. Precipitation data source is from the Clackamas County WES pollutant fate and transport model, which is conservative because the precipitation in the WES model was the highest of any of the pollutant fate and transport models (Portland, Gresham, Keizer, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County).

[3] Calculated from ln(1/2)/(Half Life)

[4] 10 percent of the average biodegradation rate of PCP under aerobic conditions [see Table B-5 of BES(2008) for references].

[5] Most UICs infiltrate stormwater into highly permeable gravels. The value used for porosity is the midrange porosity for a gravel from Table 2.4 of Freeze and Cherry (1979)

[6] Calculated by formula 8.26 in Freeze and Cherry (1979): $\rho_b = 2.65(1-\eta)$.

[7] Estimate of f_{oc} based on loading of TOC in stormwater. Foc is from the City of Keizer pollutant fate and transport model, which is conservative because the Foc in the Keizer model was the lowest of any of the pollutant fate and transport models (Portland, Gresham, Clackamas County, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County)

[8] K_{oc} from the Lane County GWPD.

[9] K_d calculated from the following equation: Kd = $(f_{oc})(K_{oc})$ (e.g., Watts, pg. 279, 1998).

[10] Estimate of velocity based on infiltration tests and aquifer tests. The value used in this model is from the City of Portland BES pollutant fate and transport model, which is conservative because the velocity in the Portland model was the highest of any of the pollutant fate and transport models (Keizer, Gresham, Clackamas County, Canby, Milwaukie, Bend, Redmond, Eugene, Lane County)

[11] Method Reporting Limit of PCP (e.g., see GSI, 2013a).

ABBREVIATIONS

ft = feet
m = meters
mg/L = milligrams per liter
ug/L = micrograms per liter
d = day
g/cm^3 = grams per cubic centimeter
L/kg = Liters per kilogram
m/d = meters per day
m^2/d = square meters per day

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