Washington Stormwater Center Research

Updates May 2023

Overall Research Goals

The Washington Stormwater Center's research aims to improve understanding of stormwater runoff impacts on biota, the efficacy of best management practices in reducing or eliminating those impacts and improve water quality and animal/human health. These findings help communities use the most efficacious technologies, tools, and approaches and collaborate to address stormwater. The research also focuses on sources of stormwater and potential pollution prevention strategies.

Research Questions Answered

The Washington Stormwater Center's research is focused on why stormwater runoff is toxic, how we can provide solutions to protect aquatic ecosystems from polluted runoff, and how we can engineer stormwater measures that are more efficient, cheaper, and self-sustaining. In addition, we look at individual substances routinely found in stormwater mixtures to evaluate the effects on aquatic invertebrates and vertebrates, including salmonid species. This testing allows us to explore the characteristics of runoff and identify the problems and the effectiveness of solutions such as Green Stormwater Infrastructure.

This work encompasses ecotoxicology experiments, ecological engineering, extension/outreach, training, and evaluating the effectiveness of best management practices and continued experimentation at Washington State University's Research and Extension Center at Puyallup, WA.

Research Collaboration

We collaborate with scores of scientists and subject matter experts, including those at other universities, state and federal agencies, tribes, and non-profits, to fund and conduct this critical

work. We provide training and education for our graduate students and post-doctoral researchers who are integral to our shared research and discoveries.

2021-2023 Biennial Research

1. Longevity of Bioretention Depths for Preventing Acute Toxicity from Urban Stormwater Runoff
Jen McIntyre
Partner Entities: WA Department of Ecology

Duration: 2+ years (expected completion Autumn 2023)

Description: This project explores the life expectancy of various depths of bioretention soil media in experimental columns. The chemical and biological effectiveness in treating urban stormwater runoff is being assessed using analytical chemistry and the health of two fish species: juvenile coho salmon and zebrafish embryos. 6PPD-quinone concentrations are being measured for a subset of storms through 13 accelerated water years of collected roadway runoff.

Funding Source: ***Stormwater Action Monitoring (SAM) Program & 6PPD Proviso***

2. Investigation of Sediment Contaminant Impacts on the Growth and Survival of Juvenile Puget Sound Chinook Salmon
(John Stark, Melissa Driessnack, Jen McIntyre)
Funding: Puget Sound Partnership

3. Puget Sound Starts Here: making habitat from stormwater pond infrastructure in developed and developing landscapes.
Ani Jayakaran
Partner Entities: Washington Department of Fish and Wildlife, WA Department of Ecology

Duration: 2 years (expected completion in Fall 2025)

Stormwater ponds are common green infrastructure around Puget Sound, but habitat is seldom incorporated into pond design and management. Ponds around Puget Sound will be surveyed for amphibians and birds and assess habitat and land cover. The project aims to determine which stormwater pond conditions promote species diversity and abundance and whether stormwater ponds are equitably distributed and managed across socioeconomic strata. This work will inform how infrastructure can be used as habitat.

Funding: National Estuary Program

4. The effectiveness of trees in mitigating stormwater runoff in Western Washington

Ani Jayakaran
Partner Entities: DNR, Evergreen State College, Clemson University, and the Department of Ecology (as part of the SAM program)

Duration: 4 years (Phase 1 completed in 2021). Phase 2 began in the Spring of 2022 and will be completed in the Spring of 2025.

Description: The project aims to quantify individual tree water use by four species of evergreen and deciduous trees in the region. By quantifying individual tree water use of existing trees, information from this work will help incentivize tree retention when a landscape is developed. Phase 1 investigated tree water use in large mature trees growing in large stands. Phase 2 will focus on younger isolated trees growing close to pavements. We have developed a discrete mobile data logger to enable sap flux data collection. This work supports one Ph.D. student and one master's student. For updates, see https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Stormwater-monitoring/Stormwater-Action-Monitoring/SAM-effectiveness-studies/Water-budgets-of-individual-local-trees

Funding Source: ***SAM***

5. The effect of cured carbon fiber in permeable pavements in removing pollutants from stormwater
Ani Jayakaran
Partner Entities: Boeing, IDEA School – Tacoma, City of Tacoma

Duration: 4 years (Fall 2023)

The project aimed to determine how cured carbon fibers incorporated in permeable pavements manage stormwater volumes and remove pollutants from stormwater. An experiment to characterize the movement of tire wear particles and 6PPD-q was completed in 2022. Water quality and data analyses are underway. This work supported the education of one Ph.D. student.

Funding Source: ***Boeing***

6. The effects of mulch on stormwater treatment and maintenance effort in bioretention systems

Ani Jayakaran
Duration: 2 years (Completed in April 2022)

The project aimed to determine the role of mulch in managing soil moisture, removing stormwater pollutants, and mitigating weeds in bioretention systems. This work showed that

mulch increased soil moisture retention in bioretention soils, mitigated weeding effort significantly, and limited nitrogen export from the soils. For updates, please see https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Stormwater-monitoring/Stormwater-Action-Monitoring/SAM-effectiveness-studies/Mulch-choices-for-bioretention.

Funding Source: ***SAM***

7. Orifice Control of Bioretention
(John Stark, Ani Jayakaran)
Partner – Geosyntec)
Duration: 2 years (expected completion in June 2023)

The project will evaluate the effect of outflow rate-controlling orifices in under-drained bioretention systems. Three bioretention blends are also being compared – a mature 60:40 mix, a new 60:40 mix, and the recently approved "high-performance blend" that contains no compost. In addition, the project compares the impacts of altered hydraulic retention times and bioretention performance in terms of water quantity and quality. This project supported the education of one master's student.

Funding Source: ***SAM***

8. Evaluation of Biofiltration Swale Media Mixes for Maximizing Phosphorus Removal
Jen McIntyre, Ed Kolodziej)
Current compost-based media mixes for bioretention and bioswale systems have a negative removal of phosphorus from stormwater because the compost degrades over time and leaches phosphorus. Using batch adsorption isotherms, column studies, and small-scale swale experiments, this project will investigate various media and identify low-cost materials that that readily adsorb phosphorus. The goal of the project is to develop a more effective biotreatment media mix with either a lower compost ratio, by adding a new material, or by creating a layered system. (Nigel Pickering, Ani Jayakaran)

Duration: 2 years

Partners: WSDOT

Funding Source: ***WSDOT***

9. Clean Cars Toxicity of Tire Derived Chemicals to Aquatic Organisms

Jen McIntyre

Test the bioavailability of 6PPD-quinone under varying water quality (e.g., variations in temperature, pH, ionic strength, organic carbon content) and flow conditions. Test toxicity at

various life history stages of our target organism (coho salmon) to determine whether there is a sensitive life history stage for which risk assessments should be focused.

Assess the toxicity of select antiozonants as possible alternatives to 6PPD.

Partner: UWT Ed Kolodziej at UWT

Funding Source: ***WA Ecology***

10. Blood-brain barrier disruption in juvenile Chinook exposed to roadway runoff (Jen McIntyre, Stephanie Blair)

Investigates blood-brain barrier disruption in juvenile Chinook as a sublethal mechanism of toxicity for contaminants in roadway runoff.

Funding Source: King County Flood Control District

Duration: 1 year

16. Effects of a neonicotinoid mixture on the aquatic invertebrate community

(John Stark, Melissa Driessnack)

Neonicotinoid insecticides are the most commonly used insecticides in the world today. These insecticides are routinely found in Washington State surface waters, often as mixtures and at low concentrations. In this study, we are investigating the potential effects of the three most commonly detected neonicotinoids in our surface water, imidacloprid, thiamethoxam and clothianidin, on aquatic invertebrate communities. The team will establish replicated aquatic invertebrate communities,

- Exposure these communities to each neonicotinoid separately and as a mixture.
- Evaluate the effects of these insecticides on these communities.

We are conducting a research study at WSU Puyallup where we are exposing aquatic invertebrate communities to these insecticides.

These insecticides are routinely found in Washington State surface waters, but we don't know whether they cause damage to aquatic organisms. It is therefore important to determine whether neonicotinoids are a threat to our aquatic ecosystems.

Funding Source: EPA's National Estuary Program

Duration: July 2020-June 2022

17. Effects of an anti-coagulant rodenticide on salmonids

(Jen McIntyre, Melissa Driessnack)

Nothing is known about the impacts of rodenticides on salmonids. The most-used chemicals in this category are brodifacoum and diphacenone, which are lethal via interference with blood coagulation. The goal of this project is to gain information about the hazard of brodifacoum use in salmon-bearing watersheds.

Funding Source: USDA

Duration: expected completion Sep 2024

Green Infrastructure and Other Research

The following research projects are underway at the Washington Stormwater Center and reflect research topics that include, but also fall outside, ecotoxicology.

- Quantifying the Impact of Real-World Rain Gardens and Bioretention across Puget Sound and Identifying Key Factors for Success/Failure (Robert Simmons, Ani Jayakaran, Aaron Clark – 12,000 Rain Gardens/Stewardship Partners)(***SAM*** funded)

- Increasing Adoption and Integration of Reclaimed Water for Irrigation within Cedar Sammamish Watershed (Doug Collins, Jordan Jobe, Joan Wu, Ani Jayakaran; Jason Hatch – Washington Water Trust)(King Conservation District)

- Fate and transport of micro- and nanoplastics in soils (Markus Flury, Andy Bary, Stephen Taylor, Zhan Wang)(Department of Energy, Pacific NW Laboratories, ***USDA/NIFA and China Scholarship Council***)
- Ohop Creek stormwater treatment pilot (Jen McIntyre with Long Live the Kings)

- Evaluation of neonicotinoid insecticide effects on aquatic invertebrate communities (Claire Duchet, John Stark, Jen McIntyre) (***EPA National Estuary Program***)(completed)

- Effects of neonicotinoid insecticides on Daphnia (Claire Duchet, John Stark, Jen McIntyre)(***EPA National Estuary Program***)(completed)

- Stormwater retrofit of the KTP Express gas station on the Sqaxin Island Tribe Reservation- Kamilche, WA (Anand Jayakaran, Erica Marbet)(EPA 319 Funds)

- Review of City of Spokane's regulations for stormwater, drinking water and wastewater. The project will review all City codes in the context of federal, state, and regional regulations and manuals. This project will identify conflicting messages, weak language that needs improvement, suggest additional language to promote green infrastructure (GI) or other water sustainability, and suggest where language might be needed as a separate ordinance. (Nigel Pickering)
  Duration: 1 year

  Partner: City of Spokane

  Funding Source: ***City of Spokane***

Completed Research

Determination of Organics and Bacterial Reductions by Treatment BMP

Department of Ecology
Duration: 1 year (expected completion date is March 2021)
Project aims to determine what BMPs are best suited to remove polycyclic aromatic hydrocarbons and fecal indicator bacteria from influent stormwater. COMPLETED

Wastewater effluent discharge impacts to marine organism assessment
Sample effluent from three wastewater treatment facilities in King County, assess for target and non-target chemical composition during one high flow and one low flow event. Marine waters near outfalls in Puget Sound will also be sampled during a low-flow period. Laboratory study will expose juvenile Chinook salmon to effluent from one facility for a period of 10 days to assess and model bioaccumulation and health impacts.
Duration: 2 years (completed Oct 2022)
Partners: UW, NOAA/NMFS
Funding Source: King County Council

Biological effectiveness of alternative bioretention blends (Jen McIntyre, Jenee Colton- King County, Curtis Hinman – Herrera)(SAM funded)(completed in 2020)

BURitos: Bioretention Urban Retrofits of Stormwater Retention Ponds
Testing the chemical and biological effectiveness of installing rolls of bioretention-like media to treat stormwater entering existing stormwater retention ponds.
Funding Source: City of Bellevue (completed in 2021)

Stormwater Threats and Clean Water Strategies to Conserve and Recover Puget Sound Salmon and their Habitats. Includes the following research themes at WSU:

- Determine physiological mechanisms underlying acute mortality in adult and juvenile coho exposed to roadway runoff

- Compare relative sensitivities of Puget Sound salmonids to untreated stormwater
- Characterize the chemical composition and toxicity of specific motor vehicle-derived sources of contamination
- Identify the chemical characteristics of compounds in urban stormwater that are toxic to coho using fractionation and dilutions
- Develop novel green stormwater infrastructure methods to improve water quality and protect fish health
- Assess impacts of urban runoff on Puget Sound forage fish, before and after bioretention treatment

Duration: Completion date is Sept 2022
Funding Source: EPA Region 10 (NEP)

Funding Source: ***EPA National Estuary Program***

- Effectiveness studies of permeable pavements – flow control, treatment, and maintenance (Ani Jayakaran, John Stark, T.J. Knappenberger - Auburn University)

- Field test of plants and fungi on bioretention performance over time (Jen McIntyre, John Stark, Claire Duchet, Jill Wetzel, Jay Davis – USFWS) 2020

- Evaluating the toxicity of runoff pollutants from roofing materials (John Stark, Jen McIntyre, Lisa Rozmyn, Nancy Winters, Taylor Haskins) 2018

- Identification and treatment of toxicants in road runoff using WSDOT compost-amended bioswales (Jen McIntyre, Benjamin Leonard, Ed Kolodziej – UW-Tacoma) 2017

- Optimizing Green Stormwater Infrastructure efficacy by integrating hydrologic, cultural and socioeconomic elements in a watershed spanning the urban agricultural continuum (Ani Jayakaran, Joan Wu, Michael Brady, John Stark, Jolie Kaytes, Michael Sánchez, John Harrison, Danna Moore, Stephanie Hampton)(WSU Grand Challenge Seed Grant)

- Monitoring temperature and water level in a restored agricultural ditch in the Puyallup River watershed (Ani Jayakaran)(PCC Farmland Trust)

- Carbon fiber pilot study to evaluate the possible strengthening, pollutant removal and flow rate effects of carbon composites in permeable pavements (John Stark, Lisa Rozmyn, Jen McIntyre, WSU Engineering, Boeing)(Boeing funded) 2020

Contact for this overview:

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