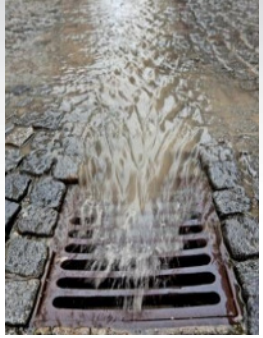
EPA

Office of Research and Development

SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM

Research Area 10: Stormwater Management



Background

- Stormwater management issues continue to be a challenge for many communities in the US.
- Many combined sewer systems in the northeast, midwest, and pacific northwest need innovative methods for addressing discharge issues.
- Municipal Separate Storm Sewer Systems (MS4) need new approaches for managing water quality and quantity.

Stormwater research will integrate green and gray infrastructure to minimize stormwater effects on human health and the environment and will explore ways to capture stormwater for beneficial uses.

Topic Lead: Chris Impellitteri – Cincinnati, OH

Water Treatment and Infrastructure

Research Area 7

Drinking Water/Distribution Systems

Provide essential results and tools to our customers for managing existing and future drinking water needs. Specifically, it focuses on areas of recent concern that require novel solutions.

Research Area 8

Per- and Polyfluoroalkyl Substances (PFAS)

Robust analytical methods for analyzing PFAS in water, solids, and tissue samples, and a centralized website for treatment and pretreatment recommendations for wastewater and reuse.

Research Area 9

Wastewater/Water Reuse

Guidance on new and existing treatment technologies and analytical methods for emerging contaminants and contaminant risks.

Research Area 10

Integrated Stormwater Management

Integrated aspects of green/gray infrastructure and stormwater flow control to help states, municipalities, and utilities reduce the number of combined sewer overflows.

Research Area 11

Technical Support

Provide a means for rapid response to specific, unplanned program office, state, tribe, and community research needs concerning high-priority issues.

Stormwater Management

This research area will provide essential results and tools to the program offices, primarily the Office of Water; states; tribes; and communities to better manage stormwater.

Agency Drivers

Regulatory determinations under the CWA and SDWA (current and future), National Pollution Discharge Elimination System requirements, state regulations.

Focus

Areas of recent concern that require novel solutions:

- Combined sewer overflows
- Monitoring stormwater infrastructure effectiveness and costs
- Enhanced aquifer recharge

Research Outputs Overview

Output 10.1

Planning, Implementing, and Monitoring Stormwater Management Practices

Output 10.2

Stormwater Management as a Resource for Enhanced Recharge, Capture, and Use

Research Products Overview

Products from this work will help provide stakeholders with resources to monitor and manage stormwater, provide planners with tools for stormwater management strategies, and evaluate best practices for enhanced aquifer recharge.

- Optimization of the Stormwater Management Model (SWMM) for green/gray infrastructure planning.
- Monitoring strategies for evaluating water quantity and quality management.
- Report on best practices for stormwater capture and use through enhanced aquifer recharge and decentralized reuse.

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Planning, Implementing, and Monitoring Stormwater Management Practices

Research Output 10.1

Lead: Matt Hopton

SSWR 10.1.1: Recommendations for planning, monitoring, and managing stormwater

Problem: EPA Regional and Program Office (PO) partners, states, tribes, and municipalities need better approaches for evaluating stormwater management options prior to installation.

Action: Develop modeling and cost/benefit tools for comparing and evaluating management options for managing stormwater quality and quantity. Provide monitoring solutions for evaluating management strategies.

Results (Anticipated):

- Cost/benefit tool (CLASIC) developed by WRF through STAR Grant.
- Report on the application of SWMM to simulate green/gray infrastructure.
- Tools to design stormwater control approaches (e.g., size and cost-effectiveness).
- Integration of sensing technologies, communications, digital data tools, and machine learning for planning.
- Monitoring and tracking pollutants (e.g., road salt, pathogens).

Expected Outcome: Improved stormwater management in CSO and MS4 systems by providing management options and monitoring solutions to Regional/Program Office, state and tribal partners.

Product POC:

Paul Mayer (CPHEA)

Internal Partners:

Jamie Piziali, Sharon Nappier, Robert Goo, Rachael Urban, Jenny Molloy (OW); Newton Tedder (R1); Elizabeth Ottinger (R3); Regina Poeske (R3); Matt Small (R9); Angela Adams (R10); Lewis Linker (CBPO)

External Collaborators:

Department of Energy & Environment; WRF; Seattle; U of W Center for Urban Waters; Riverside County Flood Control and Water Conservation District; Southern CA Coastal Water Research Project; USGS; DOE; U of MN; NEORSD; City of Fairfield, Ohio; Urbanalta, Inc.; OKI Water Science Center; University of MD; Joseph Cotruvo and Associates; Essential Environmental and Engineering Systems

SSWR 10.1.2: Recommendations for stormwater management implementation and performance

Problem: Stakeholders lack information on existing green infrastructure (GI) including efficacy, costs/benefits, and fate/transport of contaminants through GI.

Action: Conduct research on monitoring gray/green infrastructure and identifying best management practices that combine GI and gray infrastructure to minimize CSO events.

Results (Anticipated):

- Summary document/website on models, tools, and best-management practices using green/gray infrastructure to eliminate urban CSOs.
- Development and validation of integrated infrastructure models with temperature/precipitation models.
- Evaluation of nitrogen fate and transport in urban stormwater.
- Report on practical methods for watershed management and community involvement for practical stormwater management implementation.

Expected Outcome: Reduced CSO events by providing stakeholders with tools for monitoring and optimizing stormwater management approaches.

Product POC:
Ariamalar Selvakumar (CESER)

Internal Partners:
Matt King, Stephanie Santell, Smiti Nepal (OW); Micah Bennett, Sydney Wiess, Danielle Green (R5); Veronica Fasselt (R4)

External Collaborators:
USGS; DOE; WI Department of Natural Resources; FL State University; FL Escambia County, Environmental Management Division; Northeast OH Regional Sewer District; University of MN; Great Plains Institute; Monroe and Vernon County Conservationist; Village of Viola

SSWR 10.1.3: Decision-support tools for cost-effective community and watershed-scale integrated planning, including stormwater, wastewater, drinking water management, and land-use conservation

Problem: Stormwater, wastewater, drinking water resource, and land use management are often stove-piped and not coordinated at the watershed scale, leading to higher costs and unintended consequences. Tools were not previously available to support EPA's integrated water management program.

Action: Develop tools for cost-effective integrated water management, including not only wastewater + stormwater, but also drinking water and land conservation.

Results:

- EPA ORD has released multiple versions of the Watershed Management Optimization Support Tool (WMOST) with user guides, theoretical documentation, case studies, and training material.
- Optimization is now provided for both water quantity (water supply, flooding) and water quality (water quality standards, TMDL loads) goals.
- Dollar value of associated benefits and cobenefits of green infrastructure can be quantified with the new Benefits Module.

Outcome: Stakeholders have tools to find cost-effective solutions involving integrated water management at the small watershed scale (HUC12-HUC10). MDE has been trained in use of WMOST.

Product POC:

Naomi Detenbeck (CEMM)

Internal Partners:

Chau Vu (R1), Regina Poeske (R3), Christopher Taylor (R7)

External Collaborators:

MD Department of the Environment, Southeastern Regional Planning & Economic Development District, Resilient Taunton Watershed Network, KS Department of Health and Environment

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Stormwater Management as a Resource for Enhanced Recharge, Capture, and Use

Research Output 10.2

Lead: John Johnston

SSWR 10.2.1: Recommendations for water system recharge to aquifers

Problem: Stormwater is often seen as a nuisance rather than a resource.

Action: Conduct research to explore the possible use of stormwater for enhanced aquifer recharge (EAR).

Results (Anticipated):

- Report on the state-of-the-science for EAR best practices.
- Costs/benefits of enhanced stormwater recharge.
- Comparisons of design, performance and maintenance issues for sink holes infiltration ponds, serial dams, spreading basins and drywells.
- Application of methods to evaluate impacts of EAR on groundwater quality.
- Treatment options for stormwater for EAR.

Expected Outcome: Recharged aquifers by providing stakeholders with stormwater best management practices.

Product POC:
Doug Beak (CESER)

Internal Partners:
Robert Goo, Sharon Nappier, Justin Mattingly (OW), Newton Tedder (R1), Elizabeth Ottinger (R3)

External Collaborators:
Kris Patton, Kara Berst (Chickasaw Nation); Saba Tahessebi (Oklahoma DEQ); Julie Cunningham (Oklahoma Water Resources Board); Guy Sewell (City of Ada Oklahoma/ East Central U.); Todd Halihan (Oklahoma State U.); Shana Mashburn (USGS); Scott Bradford, Salini Sasidharan (USDA ARS); Jirka Simunk (UC Riverside); Helen Dahlke (UC Davis)

SSWR 10.2.2: Recommendations for stormwater capture and on-site use

Problem: Communities lack data on stormwater quality including chemical and microbial pollutants and how these pollutants vary by location.

Action: Characterize stormwater constituents as it flows through different environments (e.g., urban, rural) to apply risk-based assessments for reuse.

Results (Anticipated):

- Evaluation of stormwater pathogen concentrations in urban and rural settings.
- Data on chemical pollutants in stormwater and potential impacts for reuse and EAR.
- Develop risk-based frameworks for decentralized stormwater use.

Expected Outcome: Provide communities with results and best practices for implementing stormwater capture and use.

Product POC:

John Johnston (CEMM)

Internal Partners:

Robert Goo, John Ravenscroft, Rachel Urban, Sharon Nappier, Amina Pollard (OW); Newton Tedder (R1); Elizabeth Ottinger (R3)

SSWR 10.2.3: Modeling and monitoring the influence of stormwater on groundwater quality and aquifer recharge

Problem: Data is lacking on potential stormwater effects on groundwater resources.

Action: Conduct research on subsurface interactions with stormwater. Evaluate the fate and transport of contaminants in stormwater and those present in the subsurface.

Expected Outcome: Provide communities with information on contaminant movement and potential threats, or lack thereof, to groundwater resources.

External Collaborators:

Chris Otto, Marc Kodack, Katherine Hammack, Muhammad Bari, Christopher Woodruff (DoD); Army Corp of Enginneers; Erin Wagnor, Dwight Mitchell, Jason Dempster, (Louisville and Jefferson County MSD); Michael Price (City of Yakima); Joel Freudenthal (County of Yakima); Jirka Simunek, Salini Sadidharan (UC Riverside), David Goodrich, Lainie Levick, Mark Kautz (USDA ARS); Ben Olimpio (U. Arizona); Jill Densmore, Krishangi Groover (USGS, California Water Science Center)

Product POC:

Doug Beak (CESER)

Internal Partners:

Dawn Taylor (R4); Christopher Taylor (R7); David Albright, Matthew Small, Leslie Greenberg (R9); Robert Elleman (R10)

SSWR 10.2.3: Modeling and monitoring the influence of stormwater on groundwater quality and aquifer recharge (cont.)

Results:

- Data from monitoring networks in different geological and climatological settings for evaluating contaminant behavior.
  - Mixing infiltrate water with groundwater can cause groundwater changes.
  - The concentration of traditional stormwater contaminants did not pose a concern.
  - One of the greatest risks to groundwater quality is the dilution effect. Dilution of the groundwater could change the drinking water source chemistry and impact water treatment.
  - Reverse ion exchange. Increased sodium loading on the fine-grained particles in the vadose zone could lead to clogging diminish infiltration and water movement.
  - The solubility and mobility of barium was affected by the concentrations of chloride. This relationship with chloride can also happen with other metals. The enhanced mobility of some metals could be potentially problematic when chloride salts are applied as de-icing agents.
- Development of models to evaluate stormwater best management practices for aquifer recharge.

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Questions?

Publications

SSWR.10.1.1

- Nissen, K. A., Borst, M., & Fassman-Beck, E. 2020. Bioretention Planter Performance Measured by Lag and Capture. Hydrologic Processes, 5176-5184. doi:https://doi.org/10.1002/hyp.13927
- Hoover, F.A., J.I. Price, and M.E. Hopton. 2020. Examining the Effects of Green Infrastructure on Residential Sales Prices in Omaha, Nebraska. Urban Forestry & Urban Greening 54:126778. doi.org/10.1016/j.ufug.2020.126778
- Brumfield et al. 2021. Metagenomic sequencing and quantitative real-time PCR for fecal pollution assessment in an urban watershed. Frontiers in Water, 3:626849. https://doi.org/10.3389/frwa.2021.626849
- Fu, X., M.E. Hopton, X. Wang. 2021. Assessment of green infrastructure performance through the lens of urban resilience using fuzzy comprehensive evaluation. Journal of Cleaner Production 289(2):125146. https://doi.org/10.1016/j.jclepro.2020.125146
- Galella JG, S Kaushal, KL Wood, J Reimer, PM Mayer. 2021. Sensors track 'chemical cocktails' in streams impacted by road salts in the Chesapeake Bay watershed. Invited paper, Environmental Research Letters 16:035017. https://iopscience.iop.org/article/10.1088/1748-9326/abe48f
- Kaushal SS, G Likens, PM Mayer, M Pace, JE Reimer, CM Maas, JG Galella et al. Freshwater Salinization Syndrome: Past, Present, and Future Perspectives on a Global Issue. Invited paper, Biogeochemistry, in prep
- Hoover, F.A., P.C. Jordan, and M.E. Hopton. (in review). Leveraging ancillary benefits from urban greenspace—a case study of St. Louis, Missouri. Ecosystem Services.

Publications

SSWR.10.1.3

- United States Environmental Protection Agency (U.S. EPA). 2020a. WMOST Scenario Comparison with Benefits Module. EPA/600/B-20/242. (https://www.epa.gov/ceam/wmost-scencompare-benefits-module).
- United States Environmental Protection Agency (U.S. EPA). 2020b. Watershed Management Optimization Support Tool Benefits Module: Theoretical Documentation. EPA/600/R-20/244. (Watershed Management Optimization Support Tool Benefits Module: Theoretical Documentation, Appendix A Illustrative calculations for cobenefits)
- US EPA. 2020. WMOST v3 Case Study: Cabin John Creek, Maryland. EPA/600/R-19/185.
- Piscopo, A., C. Weaver, and N. Detenbeck. (In external review) Using multi-objective optimization to inform green infrastructure decisions as part of robust integrated water resources management plans. Submitted to Journal of Water Resources Planning and Management. (partially supported by A_E)
- Piscopo, A. GreenOpt https://github.com/USEPA/Greenopt, associated with Piscopo et al, above
- Detenbeck, N., R. Sullivan, and A. Piscopo. 2019. Watershed Management Optimization Support Tool (WMOST) v3.01 Training Webinar Series
- Detenbeck, N. 2019. Watershed Management Optimization Support Tool (WMOST) Fact Sheet EPA/600/F-18/054
- Detenbeck, N., A. Lee, A. Piscopo, T. Stagnitta, J. White, A. Brown, and M. ten Brink, 2018. User-Friendly Decision Support for Integrated Water Management: EPA's Watershed Management Optimization Support Tool. Proceedings, International Environmental Modeling and Software Society Conference, Fort Collins, CO, June 24-28, 2018. (Available online at: https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=3909&context=iemssconference)

Publications

SSWR.10.1.3 cont.

- Stagnitta, T., N. Detenbeck, and A. Piscopo. 2018. Outlining the use of the U.S. EPA's Watershed Management Optimization Support Tool (WMOST): a case study in Taunton, Massachusetts. Proceedings, International Environmental Modeling and Software Society Conference, Fort Collins, CO, June 24-28, 2018. (Available online at: https://scholarsarchive.byu.edu/iemssconference/2018/Stream-C/129/)
- Piscopo, A., N. Detenbeck, and T. Stagnitta. 2018. Incorporating green infrastructure into water management plans using multi-objective optimization. Proceedings, International Environmental Modeling and Software Society Conference, Fort Collins, CO, June 24-28, 2018. (Available online at: https://scholarsarchive.byu.edu/iemssconference/2018/Stream-C/130/
- Detenbeck, N., A. Piscopo, M. Tenbrink, C. Weaver, A. Morrison, T. Stagnitta, R. Abele, J. Leclair, T. Garrigan, V. Zoltay, A. Brown, A. Le, J. Stein, AND I. Morin. Watershed Management Optimization Support Tool v3. U.S. Environmental Protection Agency, Washington, DC, EPA/600/C-18/001, 2018. (www.epa.gov/ceam/wmost)
- Detenbeck, N., A. Piscopo, M. Tenbrink, C. Weaver, A. Morrison, T. Stagnitta, R. Abele, J. Leclair, T. Garrigan, V. Zoltay, A. Brown, A. Le, J. Stein, AND I. Morin. Watershed Management Optimization Support Tool (WMOST) v3: User Guide. US EPA Office of Research and Development, Washington, DC, EPA/600/R-17/255, 2018. (www.epa.gov/ceam/wmost)
- Detenbeck, N., M. Tenbrink, A. Piscopo, A. Morrison, T. Stagnitta, R. Abele, J. Leclair, T. Garrigan, V. Zoltay, A. Brown, A. Le, J. Stein, AND I. Morin. Watershed Management Optimization Support Tool (WMOST) v3: Theoretical Documentation. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-17/220, 2018. (www.epa.gov/ceam/wmost)

SSWR.10.2.3

- Beak, D., M. Borst, Steve Acree, R. Ross, Ken Forshay, R. Ford, J. Huang, C. Su, J. Brumley, A. Chau, AND C. Richardson. The Influence of Stormwater Management Practices and Wastewater Infiltration on Groundwater Quality: Case Studies. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-20/143, 2020.