Stormwater

THE CHALLENGE

Precipitation is a basic part of the water cycle, filling our streams and lakes and soaking into the ground to replenish our aquifers. Most moderate rainfall is readily absorbed by soil, which acts as a natural filter as water moves through the cycle. But, in heavy storms, too much of a good thing can be problematic—causing excess moisture to run off over-saturated ground and impervious surfaces. And because we've engineered so much of our land with resistant surfaces, that runoff can be excessive. Without the benefit of natural filtration, stormwater flows directly to waterbodies, storm drains, and sewer systems, taking with it any debris, chemicals, bacteria, eroded soil, and other pollutants it picks up along the way.

While new technologies and green infrastructure help reduce pollutant levels, many solutions are best equipped to handle frequent, low-intensity storms, rather than the sporadic, powerful storms experienced more recently. To compound the problem, population growth and rising water demand have increased dependence on local water sources, including groundwater recharge—raising more concern over potential contaminants.

THE RESEARCH

WRF has a comprehensive body of research to help utilities and municipalities manage stormwater and green infrastructure to meet new and existing regulations, improve water quality, reduce flooding, enhance climate resiliency, and diversify their water supply. With more than 130 stormwater-related projects, this science significantly increases the understanding of stormwater characteristics and maximizes its role as a beneficial resource. WRF research focuses on the bigger picture—stormwater as part of an integrated approach to water management, helping to promote more adaptable, resilient water infrastructure and sources.

Working collaboratively, WRF conducts technical, economic, and social research that results in innovative technologies and optimized practices. Key partners include the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the Federal Highway Administration (FHWA), the National Academies, the Environmental and Water Resources Institute (EWRI) of the American Society of Civil Engineers (ASCE), the American Public Works Association (APWA), and the National Fish and Wildlife Foundation (NFWF).

Water Quality

Exploring the impact of runoff on water quality was among the first stormwater research WRF undertook, and it is an area that WRF remains committed to today. Studying the effects of bacteria, nutrients, cyanotoxins, and invasive species, this research creates a better understanding of contaminants and provides innovative solutions to help stormwater managers monitor and treat them in order to meet regulations.

WRF research has led the way in identifying microorganisms in stormwater and accurately measuring their true risk. The 2008 guidebook *Development of a Protocol for Risk Assessment of Microorganisms in Separate Stormwater Systems* (03SW2) identifies the waterborne pathogens that

pose the greatest risk to human health and measures their concentrations in stormwater. It also outlines a program for collecting data to assess the risk from exposure.

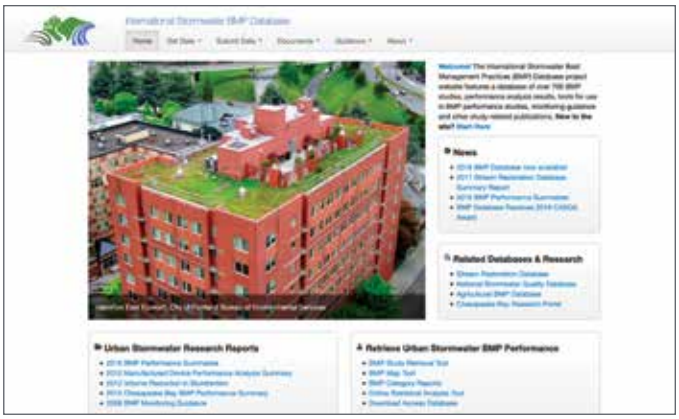
WRF has also been a pioneer in helping meet water quality standards, which are often impacted by stormwater. In the early 2000s, WRF published some of the water sector's first guidance on developing total maximum daily loads (TMDLs), the required plans for restoring waterbodies to meet standards for various uses. *Navigating the TMDL Process* (00WSM1, 00WSM2, 01WSM1, 02WSM2), a four-volume series, helps remove the uncertainty involved with these plans, laying the groundwork for a process that is practical, reasonable, and scientifically defensible. The reports offer useful tools and information on topics such as the science behind listing and delisting water on impairment lists, as well as approaches for quantifying and allocating pollutant loads. This was followed up by the 2010 release of *Drinking Water Source Protection Through Effective Use of TMDL Processes* (4007), a guide that helps drinking water utilities understand and get involved in the TMDL process—a big step in protecting source water.

Best Management Practices

With limited available funding, stormwater managers can't settle for ineffective solutions. Beginning in the 1980s, WRF was among the first organizations to provide research on identifying, designing, and implementing best management practices (BMPs) to counteract the negative effects of runoff—and ultimately reduce the demand on wastewater treatment systems. WRF research looks at everything from more effective practices to structural solutions and provides tools to calculate the true cost of projects so realistic numbers can be weighed against potential results.

In 1996, WRF partnered with EPA and ASCE to launch the International Stormwater BMP Database. Starting as a hub for sharing stormwater practices, it has grown to include over 700 BMP studies. The open-access site now houses the world's largest collection of field data on stormwater BMP performance, tools, and monitoring guidance—making it easy to see what is working for others and which practices would be the most effective at specific sites. Over the past two decades, the website has continued to evolve, adding areas for topics such as agriculture and stormwater quality—and pulling in other relevant partners, including EWRI, APWA, NFWF, and FHWA.

Despite best efforts to keep runoff from entering our waterways, contaminant levels can still run high, driving some stormwater managers to look toward stream restoration as a new type of BMP. As a result, WRF once again expanded the BMP Database, adding a module that covers stream restoration practice selection and design, water quality crediting, and performance evaluations. This was followed up by the releases of *Stream Restoration as a BMP: Crediting Guidance* (WERF1T13) and *Crediting Water Quality Benefits from Stream Restoration* (4844). The two reports lay out a framework for measuring benefits of the top restoration practices, highlighting those suitable for water quality crediting, and help utilities and municipalities learn how to apply crediting guidance to implement stream restoration.



WWW.BMPDATABASE.ORG

- **Interactive BMP Site Mapping**
- **Monitoring Guidance**
- **Performance and Cost Data**
- **Statistical Analysis Tools**
- **BMP Data Collection Software**

Now Featuring the National Stormwater Quality Database
www.bmpdatabase.org/nsqd.html

Green Infrastructure

As the challenge of treating stormwater continues to grow, more communities are turning toward natural processes to clean and filter runoff—moving beyond traditional infrastructure and incorporating green, sustainable solutions. The benefits of green infrastructure go well beyond just meeting stormwater goals, offering community perks like ponds, parks, and rain gardens. WRF research helps lead the way in this area, providing science to improve practices, lower costs, and boost environmental and social benefits by using rainwater to cultivate livable communities.

Because green infrastructure has become a successful piece of many stormwater programs, more utilities and municipalities are looking for ways to broaden the impact. WRF is working to expand the use and open the door for specifically targeted options like green infrastructure on privately owned land. *Incentives for Green Infrastructure Implementation on Private Property* (4684) provides the most

comprehensive look at incentive programs to date, helping home in on exercises that offer the most motivation for land owners to adopt practices based on particular circumstances—covering everything from rebates to credit trading to redevelopment incentives.

WRF is also tackling what is often the first and most complex step in getting a green infrastructure project off the ground: calculating the full cost. Through a $1.95M grant from EPA, WRF is collaborating with several universities and organizations to develop a publicly accessible tool to compare life-cycle costs and benefits of green and gray infrastructure, as well as hybrid solutions. The tool, known as the Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs Tool, or CLASIC, will help tally the expenses associated with designing, operating, maintaining, and replacing stormwater infrastructure, based on life-cycle costs, the value of co-benefits, and performance. This information will help decision makers more accurately weigh the costs and benefits of alternative stormwater practices, including green infrastructure.

Water Supply Diversity

As the demand for water continues to rise, many drinking water facilities are exploring alternative water sources to meet this demand, and WRF research is helping to carve out stormwater's role. Until now, large-scale direct potable reuse of stormwater has been largely nonexistent in the United States. WRF intends to change that through projects like *Alternative Water Source Requirements for Conventional Drinking Water Treatment* (4665), which found that stormwater blended with surface water can potentially be treated with conventional drinking water processes under the right water quality conditions and with additional disinfection.

In conjunction with this study, WRF released A•SWAT, the Alternative Source Water Assessment Tool, a program that allows users to look at potential water sources and estimate the quality of water that can be produced through treatment. It then ranks the suitability of those sources for drinking. The tool also offers strategies to improve water that falls short of being ready for conventional treatment.

SOLUTIONS IN THE FIELD: Urban Drainage and Flood Control District

The Urban Drainage and Flood Control District (UDFCD) in Denver has a long history of working with metropolitan areas to prevent flooding and the adverse effects. Since 1969, UDFCD has published the *Urban Storm Drainage Criteria Manual*, a handbook that provides guidance to minimize the impacts of runoff. The manual, now a three-volume series, is regarded as the industry-standard reference for BMP selection, and is revised regularly to keep up with the latest advances.

When it came time for the most recent revision, UDFCD turned to the International Stormwater BMP Database. As the leading website on stormwater BMP performance, UDFCD tapped into the extensive data to support its storm drainage criteria recommendations, compare local BMP performance with national data, and estimate achievable effluent concentrations.

This sparked UDFCD's involvement in a follow-up effort—a new cost tracking protocol and companion report,

***Recommended Operation and Maintenance Activity and Cost Reporting Parameters for Stormwater Best Management Practices Database* (SIWM22T17), which are helping to create a better picture of the full cost of operating and maintaining BMPs. UDFCD provided co-funding and peer review, assisting in the development of industry-wide protocols for tracking stormwater BMPs costs and standard maintenance requirements. This information is being incorporated into the BMP Database to create a common ground for budget estimation and maintenance planning.**

Because getting started is often the hardest part of integrating stormwater into a balanced water portfolio, WRF research is making it easier for utilities to take the first step. A recently released tool that stemmed from the project *Drivers, Hindrances, Planning, and Benefits Quantification: Economic Pathways and Partners for Water Reuse and Stormwater Harvesting* (SIWM8R14), helps utilities weigh the benefits from reuse, like stormwater, and provides resources to jump start projects.

Extreme Weather

In recent decades many parts of the world have seen an increase in extreme weather, and often the water sector is at the forefront of the impacts. As wet weather becomes more severe and flooding more widespread, WRF is helping facilities successfully adapt and protect infrastructure and services.

In 2013, WRF teamed up with EPA and NOAA, on *Water/ Wastewater Utilities and Extreme Climate and Weather Events* (CC7C11). This concerted effort consolidated experiences from watersheds and river basins across the United States and looked at how the water sector, including stormwater utilities, made decisions in response to extreme weather. The report highlights successful, and often concurrent, strategies—underscoring the need for long-term preparedness and emergency response planning that considers multiple risks.

Because understanding the impacts of extreme weather can help facilities respond more effectively, WRF is taking steps to identify and characterize these effects. In 2010, WRF released *Implications of Climate Change for Adaptation by Wastewater and Stormwater Agencies* (CC2R08), offering one of the first overarching views of what climate change can mean for stormwater facilities, connecting global warming signs with operations and infrastructure impacts. This was followed up in 2014 by *Water Quality Impacts of Extreme Weather-Related Events* (CC4C10). Based on case studies from across the United States and Australia, the research highlights the stress severe events can put on water treatment and conveyance, from source to tap, and includes a tool to search studies based on water quality impact, type of weather, location, and water source.

LIFT

The Leaders Innovation Forum for Technology (LIFT) helps move water technology to the field quickly and efficiently. Recognizing the potential for technology to considerably change the way stormwater is treated and used, LIFT launched the

As the challenge of treating stormwater continues to grow, WRF research is leading the way in helping integrate green solutions to clean and filter runoff.

Stormwater and Green Infrastructure Focus Area. This serves as a hub for facilities and communities interested in sharing information on practices and technologies that improve the design, cost, performance, maintenance, and communication aspects of green infrastructure and stormwater BMPs.

WHAT'S NEXT?

Because lack of funding and aging infrastructure continue to be a challenge for many stormwater programs, WRF is expanding efforts to measure costs and manage assets. The ongoing project *Framework and Tools for Quantifying Green Infrastructure Co-Benefits and Linking with Triple Bottom Line Analysis* (SIWM4T17) is helping to quantify the benefits of implementing green infrastructure and to evaluate the economic, environmental, and social values. This will supplement other available tools, such as the CLASIC tool and BMP Database, to support a more integrated stormwater management approach.

WRF research will also help stormwater managers understand mounting regulations, providing resources and tools to develop effective TMDLs as well as advancing innovative technologies to meet water quality goals. Green and gray infrastructure will play an important role in how stormwater is treated, and WRF will provide the science to identify the best practices and how to successfully integrate both approaches. A large portion of this will be centered around a watershed-based planning approach—integrating stream restoration, flood mitigation, and stormwater retrofits to cost effectively meet water quality goals.

1199 North Fairfax Street, Suite 900
Alexandria, VA 22314-1445

6666 West Quincy Avenue
Denver, CO 80235-3098

info@waterrf.org
www.waterrf.org