NOVEMBER/DECEMBER 2024 / WWW.STORMWATER.COM

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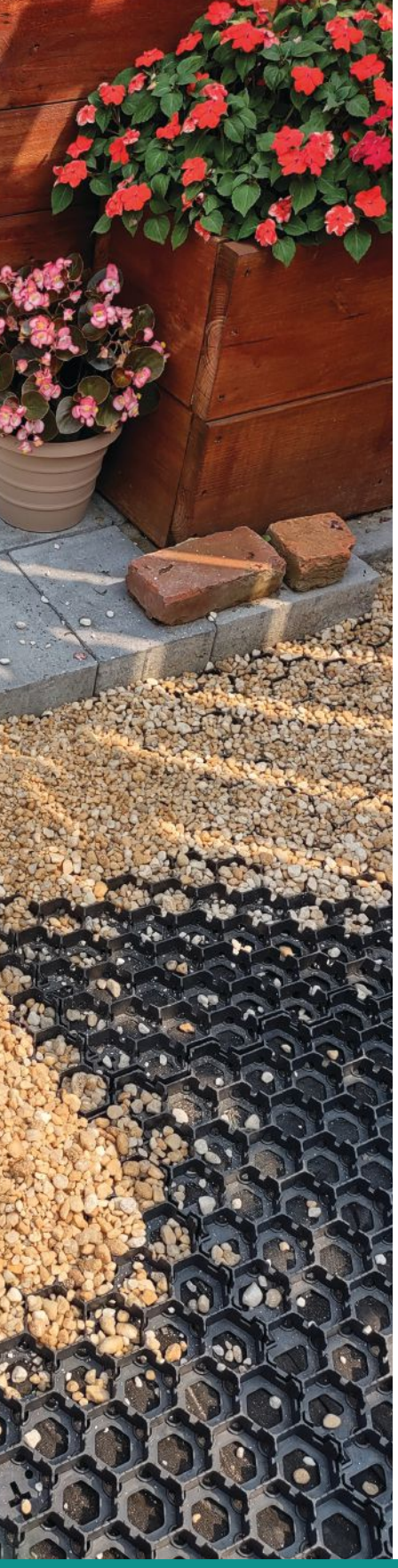
Regenerative Stormwater Conveyance

p. 8



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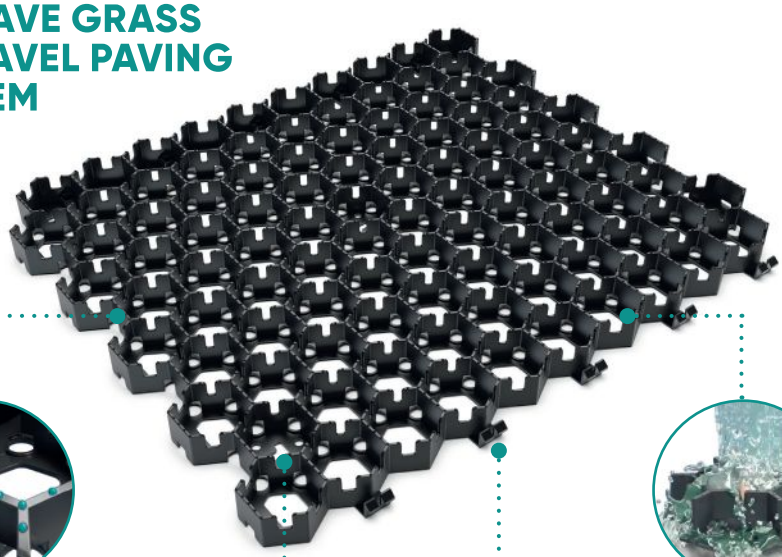

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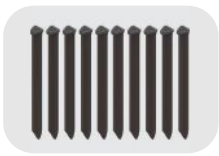

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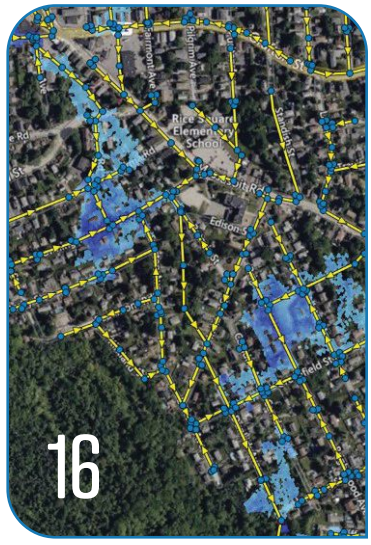

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EDITORIAL LETTER

How Do We Prepare for the Next Major Hurricane?

AS I WRITE THIS, IT IS ABOUT TWO DAYS AFTER HURRICANE MILTON MADE LANDFALL ON Siesta Key, Florida, as a Category 3 storm. The hurricane, which left millions without power, spurred numerous tornadoes, and left numerous other impacts, came on the heels of Hurricane Helene, which had hit just about two weeks earlier.

KATIE JOHNS | EDITOR-IN-CHIEF
kjohns@endeavorb2b.com

Many of you may not know, but my first job out of college was as a newspaper reporter in Sarasota. Specifically, I covered Longboat Key, a barrier island off the coast of Sarasota, and just slightly north of Siesta Key. This hurricane, literally and figuratively, hit close to home for me. While I was tracking it for work and reading about the impacts it would have on stormwater and flood control infrastructure, I was also texting the friends I still have down in Sarasota. Were they safe? Were they staying or evacuating? Is it really as bad as its being made out?

Some evacuated, and some, those who were not in mandatory evacuation zones, stayed. All have fared safely and OK, thankfully. It is disheartening to see the images of Siesta Key, a place I and millions of others have spent many a beach day, tore to pieces in many ways. A bit north, in St. Petersburg, many of you have likely seen the images of the ripped roof of Tropicana Field, home of the Tampa Bay Rays.

While these places that bring joy – beach days and baseball games – are hurting now, I have seen many resilient calls from Floridians that they will build back stronger.

Which begs me to ask – how will stronger, more sustainable stormwater infrastructure play into that? With hurricanes, and storms in general, increasing in both intensity and frequency, what can we as an industry do to be better prepared for the next major weather event?

Funding is always a challenge, of course, but there have to be other ways to broaden the conversation on the importance of sustainable and resilient stormwater management. I know it is a conversation many of you have in your day-to-day, and continuing with those discussions will hopefully help reach the ears of those in charge, who can determine budgets, funding and much more. Until then, we will have to keep fighting the good fight.

In other news, I wanted to update you all on our print schedule for next year. In 2025, *SWS* will be printed five times and will mail with our sister publication, *WaterWorld*. To continue receiving a print copy of *Stormwater Solutions*, make sure to subscribe to *WaterWorld* for 2025. Alternatively, you can receive this magazine digitally by signing up for our newsletter at www.stormwater.com/subscribe.

STORMWATER SOLUTIONS

VOL. 25, NO. 6

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Stormwater Solutions © USPS Permit #20363 (ISSN 1531-0574 print, ISSN 2641-659X online) is published six times (Jan, Mar, May, Jul, Sept, Nov) per year by Endeavor Business Media, LLC., 201 N Main St 5th Floor, Fort Atkinson, WI 53538. Periodicals postage paid at Fort Atkinson, WI, and additional mailing offices. POSTMASTER: Send address changes to Stormwater Solutions, PO Box 3257, Northbrook, IL 60065-3257. SUBSCRIPTIONS: Publisher reserves the right to reject non-qualified subscriptions. Subscription prices: U.S. $95.00 per year; Canada/Mexico $118.75 per year; All other countries $200.00 per year. All subscriptions are payable in U.S. funds. Send subscription inquiries to Stormwater Solutions PO Box 3257, Northbrook, IL 60065-3257. Customer service can be reached toll-free at 877-382-9187 or at stormwater@omeda.com for magazine subscription assistance or questions.

STORMWATER SOLUTIONS ONLINE

ARTICLES

What is a Retrofit?

In the latest What Is series article, we explore all things retrofit related. From the purpose of a retrofit to examples, this article explores the basics of a fundamental stormwater element.
www.stormwater.com/55236338

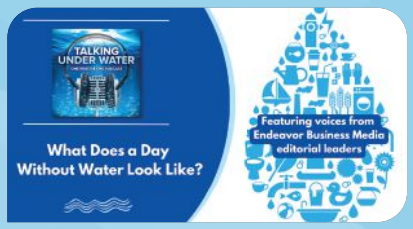
Stormwater Capture Drain Reimagines Flood Management and Sustainability

This article explores a capture project in Southern California that collects 150 to 500 acre-feet of stormwater annually — enough water to supply as many as 900 local families for a year.
www.stormwater.com/55234637

PODCASTS

WEFTEC 2024 Wrap-up

In this episode of Talking Under Water, hosts Mandy Crispin, Alex Cossin and Bob Crossen discuss their experience at WEFTEC and their main takeaways from the show. From PFAS to Lead and Copper Rule compliance, the co-hosts share points from discussions they had with utilities, engineers and many other attendees. The hosts also answer questions submitted by listeners at the show.
www.wwdmag.com/55234743



What Does a Day Without Water Look Like in 2024?

In this episode of Talking Under Water, we are continuing our annual tradition started last year of asking our colleagues within Endeavor Business Media about the importance of water for their industries and what a day without water would look like in their market. Each editor recorded a small featurette, and hosts Bob Crossen, Mandy Crispin and Alex Cossin share their takeaways and thoughts about those submissions throughout the episode.
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VIDEOS

How to Prepare Your Stormwater Systems for Hurricane Season

In the wake of hurricanes Helene and Milton, Jack Moran, CEO of Ecological Improvements, and Tucker Clarkson, CEO of The Lake Doctors, drop by to discuss stormwater management preparedness in the wake of extreme weather.
www.stormwater.com/55234952

OU to lead Stormwater Center of Excellence

Jason Vogel, professor at University of Oklahoma in civil engineering and environmental science, and director of the Oklahoma Water Survey, discusses the upcoming Stormwater Center of Excellence housed at The University of Oklahoma. The center, called the Great Plains Center for Green Advanced Stormwater Solutions, will aim to improve stormwater management in the area and will focus on innovation and community collaboration.
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WEBINARS

Nature Ignores Design That Ignores Nature

This presentation reviews various site planning and design techniques, approaches, principles, successes, pitfalls and roadblocks to designing, establishing and maintaining green infrastructure systems and how these landscapes can integrate with well designed environments.
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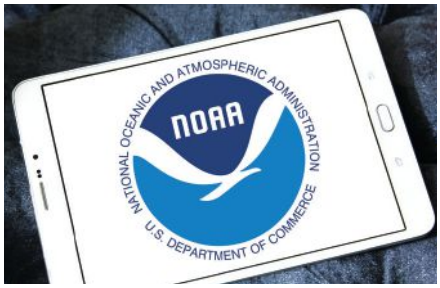
NEWSBRIEFS



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U.S. Department of Commerce, NOAA Announce $22.78 Million in Funding for Climate Research

The U.S. Department of Commerce and the National Oceanic and Atmospheric Administration (NOAA) announced on October 2, 2024, $22.78 million in funding to NOAA labs, programs, cooperative institutes, and other research partners to advance research on a wide range of water-driven climate impacts.

Research topics include coastal and inland flood and inundation mapping and forecasting, and next-generation water modeling activities, including modernized precipitation frequency studies.

The funding, which comes from the Bipartisan Infrastructure Law (BIL), will help communities prepare for a range of climate change impacts and will directly benefit policymakers, emergency responders, researchers and the general public.

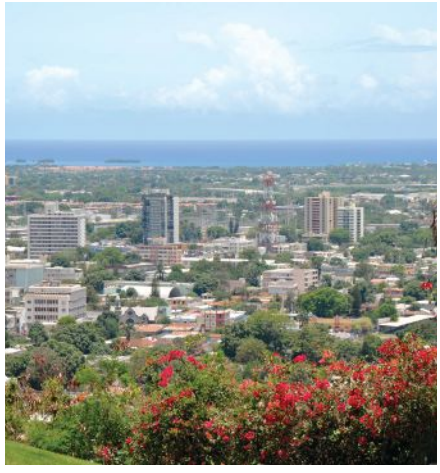
The announcement is part of more than $6 billion being invested by NOAA in habitat restoration, weather forecasting, and community resilience to weather and climate events through the BIL and Inflation Reduction Act.

U.S. EPA Orders Puerto Rico DTPW to Comply With Clean Water Act

The U.S. Environmental Protection Agency (EPA) has issued an administrative order to the Puerto Rico Department of Transportation and Public Works (DTPW) requiring it to resolve Clean Water Act violations associated with the municipality's separate storm sewer systems (MS4) and stormwater management program.

The EPA has received complaints from the local community about flooding events at PR-123 Road and PR-585 in Ponce Playa. EPA has been inspecting the system since 2022. EPA found that DTPW had not implemented a stormwater management plan that would detect illegal discharges into their storm sewer systems at Ponce Playa.

The most recent EPA investigation was conducted in August 2024. The inspection revealed that DTPW's storm sewer systems lack required operation and maintenance, and unpermitted pollutants are being discharged into the system, to the detriment of the community.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The administrative order requires DTPW to:

- Develop and submit to EPA a storm sewer map depicting DTPW's MS4s at specified segments in Ponce Playa.
- Investigate its storm sewer systems for any connection to PRASA's sanitary sewer systems that may cause sanitary sewer overflows and notify PRASA of the results of such investigations.
- Develop an inventory of DTPW's storm sewer systems discharge outfalls and interconnections in Ponce Playa.
- Prepare a work plan to perform assessments and make improvements. This plan will focus on identifying illegal discharges into the system; inspecting and cleaning storm sewer systems; and replacing or constructing infrastructure, if needed.


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U.S. EPA Administrator Joins North Carolina Leaders to Support Hurricane Helene Recovery Efforts

U.S. Environmental Protection Agency (EPA) Administrator Michael S. Regan joined North Carolina Governor Roy Cooper, Senator Thom Tillis, Congressman Chuck Edwards, Asheville Mayor Esther E. Manheimer and local officials in Asheville, North Carolina, to assess federal and state recovery efforts in response to Hurricane Helene.

The administrator's visit on October 10, 2024, reinforced the current administration's ongoing support for communities affected by Hurricane Helene, with a focus on the work to restore access to safe, clean drinking water in impacted communities.

"Together with our federal and state partners here in North Carolina, the Biden-Harris Administration is committed to restoring essential services for the communities affected by Hurricane Helene as soon as possible," said EPA Administrator Michael S. Regan in a press release. "EPA is on the ground in full force to ensure that everyone has access to safe, reliable drinking water, while supporting other state-led efforts to pick up the pieces and rebuild. As President Biden has made clear, we will continue to be here for as long as it takes."

The tour included key operational sites, beginning at the EPA Mobile Command Center in Lake Junaluska.

Administrator Regan also visited the EPA Mobile Drinking Water Lab in Asheville. Capable of testing 100 samples per day, the lab supports swift recovery by confirming water safety for communities impacted by the storm.

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Regenerative Stormwater Conveyance Mitigates Flooding in Georgia Cemetery

MIKE DEVUONO, ARCADIS

The City of Dalton Public Works Department and Arcadis collaborated to develop a stormwater infrastructure strategy to mitigate flooding.

by Michael DeVuono, Richard Greuel & Alexander Carlson

The outlet control structure of the RSC, which discharges to an extended detention basin within the cemetery.

THE CITY OF DALTON, GEORGIA, LOCATED approximately 30 miles southeast of Chattanooga, Tennessee, is a community of approximately 35,000 residents. Dalton is famously known as the "carpet capitol of the world" and is home to many of the carpet and flooring manufacturers that outfit indoor spaces worldwide. Located in the ridge and valley section of Georgia, in the foothills of the Blue Ridge Mountains, the terrain is known for its steep ridges draining to wide relatively flat valleys. The unique topographic conditions have resulted in structural flooding, and more frequent nuisance flooding.

Under the leadership of the mayor, who challenged city staff to address the issues, the city set out on a journey to address flooding in a careful and systematic approach. In 2020, the City of Dalton Public Works Department began working directly with Arcadis to develop an actionable and defensible stormwater infrastructure strategy. The city worked with Arcadis to develop a stormwater capital improvement program (CIP). The CIP features an off-right-of-way catalog, which features 31 potential areas of concern, outside of the public right-of-way, identified by the city.

Policy dictated that all corrective action measures to address flooding be performed entirely within the city's extent of service areas consisting primarily of dedicated easements, public property, and public rights-of-way. However, the city formally adopted an extent of service expansion policy outlining where new easements should be adopted. With this policy in place, the city began exploration of options to address these concerns.

Understanding these constraints, the project team explored solutions for new stormwater infrastructure and best management practices (BMPs) that would capture and convey runoff in the public

right-of-way to alleviate these off-right-of-way flooding conditions.

The Walnut North Drainage Basin, located immediately west of the downtown district of Dalton, is comprised of rolling terrain leading to a relatively flat valley. Several projects within the basin were identified in the above-referenced off-right-of-way area of concern catalog, including the flooding challenges located around the vicinity of Ridge Street and Emery Street in the City.

MIKE DEVUONO, ARCADIS

Rock selection is a critical component of RSC construction.

Implementing Modeling

To quantify the extent of flooding in "The Ridge Street Drainage Study," an existing conditions model was developed as a baseline of comparison. The existing drainage system and culverts within the study area were analyzed for their level of service (LOS), with the LOS for the model node junction being defined as the maximum design storm event. This can pass through the model junction while maintaining a maximum computed water surface elevation that is below the surface or structure rim elevation.

A total of 55 analysis points or junctions representing inlets, manholes and culvert headwall locations were analyzed were using PCSWMM to develop the existing conditions and proposed scenarios models.

Challenging conditions like narrow roads and streets, resident access to their homes, and underground utilities made a simple gray infrastructure bypass design difficult to achieve any meaningful improvements in level of service in the area. It was acknowledged that simply increasing the size of the culverts and other pipe

systems would likely exacerbate flooding in downstream areas that were already experiencing flooding or would experience flooding as a result. During the preliminary planning phase, several alternatives to alleviate flooding in the area were explored including several bypass iterations with and without storage.

While options that explored conveyance only may have alleviated flooding in some of the identified areas of concern within Dalton, these options tended to move the flooding downstream into areas that either were already experiencing flooding or could be expected to experience flooding as a result.

As such, the design team opted for some form of detention to be included in the project. However, with limited open space for traditional detention ponds and an unwillingness to utilize imminent domain to acquire property, more unconventional approaches would be needed. This was achieved using a step pool conveyance system, alternatively known as a regenerative stormwater conveyance (RSC), to reduce flows enough to facilitate the other elements of program. An RSC is a BMP that can be used to restore incised or eroded ditches and channels, ephemeral streams and outfalls. The RSC is constructed with a series of step pools, riffles and shallow pools that help to dissipate energy, promote infiltration, and water quality. If done correctly, these can also be an added visual benefit to the space.

Accounting for Location

The West Hill Cemetery is located upstream of the area of concern along Ridge Street and presented an excellent opportunity for the RSC with supplemental storage. An existing rip rap-lined channel that drains the upper reaches of the watershed leads to a depressed area to be converted to additional stormwater storage. Ground penetrating radar (GPR) was used in the construction of the RSC, as the conveyance channel and step pools were to meander through a cemetery with headstones that date back to the civil war.

MIKE DEVUONO, ARCADIS

A rip rap channel within the West Hill Cemetery in Dalton was converted into a regenerative stormwater conveyance for flood control.

Originally, the design was completed specifying rip rap stone so that a portion of the existing material in the existing channel could be reused; however, with the practice being in a cemetery, an increased emphasis on the character and appearance of the feature was a focus of the design. To accomplish this, Tennessee field stone sourced in the vicinity was used for the riffles instead of rip rap stone due to its attractive natural appearance in the landscape.

During the design of the RSC, the design was optimized using PCSWMM stormwater modeling software to determine system hydraulics through the practice and downstream within the watershed. The existing depression area immediately downstream of the RSC was also improved for supplemental storage. An outlet control structure was designed and installed, and storage volume was optimized through minor regrading and excavation in the area.

The discharge from the RSC and detention pond are then directed to a newly installed storm sewer line which incorporated a bypass line to bring runoff flows though the right of way and bypass existing channels and culverts located within several backyards which experienced significant flooding.

Since Construction Completion

With construction completed on the RSC in 2023, the area of concern downstream of the RSC has already seen significant improvements in levels of service, with some stakeholders commenting "do we really need to complete the remainder of the project?" The second phase of the project was completed in 2024, which consisted of construction of a by-pass drainage system that transferred stormwater around the homes. Because of the investments in the RSC, the city was able to build this system without flooding downstream areas along W. Franklin Avenue. Future improvements along W. Franklin Avenue will also be facilitated by the reductions realized by the RSC in 2025.

Also, planned for 2025, the final detention component of this effort is planned on an adjacent tributary of the same drainage basin. A local synagogue and its campus were recently donated to the city. The city intends to construct a small regional detention pond on the site to help reduce flows in the watershed that will also double as a greenspace for the public. As part of the design, a heritage park will be built into the plans to illustrate the contributions of the Jewish community to Dalton and the carpet and flooring industry that they helped build.

Michael DeVuono, PE, is national practice lead of Stormwater Design and Engineering at Arcadis.

Richard Greuel is principal water engineer at Arcadis.

Alexander Carlson is a project water engineer at Arcadis.

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Improving Stormwater Infrastructure O&M: BMP Design, Monitoring and Workforce Development

SEAN PORTER, BLACK & VEATCH

Why designing with O&M in mind is crucial to maintaining stormwater treatment assets

by Sean Porter

THE GROWING NEED FOR BETTER OPERATIONS

and maintenance (O&M) practices for stormwater assets, best management practices (BMPs), green infrastructure improvements, and innovative approaches to stormwater management are being developed around the country.

After years of stormwater characterization studies, feasibility assessments, and municipal planning document development, stormwater treatment controls are cropping up in communities not commonly seen as centers for stormwater progress. In Los Angeles County alone there are hundreds of stormwater capture and treatment projects in the design and construction phase, and completed ones are being operated and maintained. Each stormwater BMP has a unique O&M Plan — the document that identifies the inspection, operation and maintenance frequency and cleaning methods. The resounding report from most municipalities is that compliance with these plans and the O&M of these assets is an ongoing challenge and requires more frequent cleanings than originally planned. Private landowners, industrial facilities and commercial developments (think big box stores) are also challenged with maintaining their stormwater infrastructure. Most commercial developments constructed after 2010 have stormwater treatment infrastructure in accordance with NPDES MS4 compliance, and there is a growing need for trained and qualified staff to maintain this infrastructure. Three ways to begin overcoming these challenges are to design with O&M in mind, to monitor the BMPs' condition and performance and to develop a qualified workforce.

Types of BMPs

Beginning with design, a typical stormwater treatment project will consider operations and maintenance as a cost consideration. Controls on system configuration for above ground and below ground BMPs are usually governed by hydraulics, existing utilities and available land area, such as medians, parks and open spaces. Long term O&M efforts are more difficult to predict.

ABOVE GROUND TREATMENT CONTROLS

The forward-facing BMPs are generally composed of bioswales, biofiltration or vegetated infiltration systems, and formally known as green infrastructure (GI). With GI maintenance, most maintenance activity includes trash removal, vegetation management, identification and removal of invasive species, and cleaning of stormwater conveyance and underdrains.

Forward-facing BMPs are commonly bioswales, biofiltration or vegetated infiltration systems.

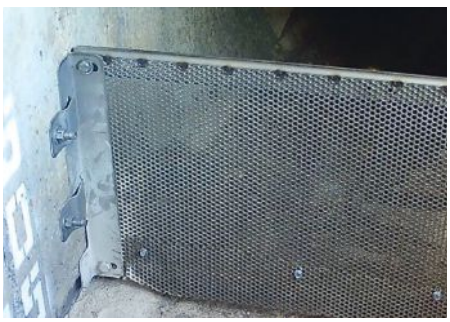
BELOW GROUND TREATMENT INFRASTRUCTURE

Most large scale BMPs use a stormwater diversion located in the storm drainpipe or channel to direct flows into the treatment system. Flows can be controlled with a slide gate and a subsequent trash rack collects larger debris. There are many different types of pretreatment and screening devices such as hydrodynamic separators, debris separating baffle boxes, and pretreatment chambers to remove most trash and some sediment. From there, flows are directed into cisterns to infiltrate or reuse the stormwater or are directed into drywells designed to recharge groundwater. Each one of these components requires regular inspections and maintenance.

Designing with O&M in Mind

To ensure BMPs function as designed, frequent maintenance is necessary, and access to perform this maintenance makes the process much simpler. Too often, the manhole for inspections and cleanings are located in the intersection, requiring lane closures and traffic controls for every maintenance event. Some examples are underground pretreatment devices with access doors located in parking spots, limited space to park a vacuum truck and access manholes that are too small for a person to enter. These are all potential challenges for maintenance crews. At the predesign stage, it is important for engineers to seek input from the maintenance staff within the agency department. Simple changes to design, like placing the most frequently maintained assets, such as the diversion and pretreatment devices, outside the public roadway.

If the system is fitted with flowmeters or monitoring equipment, placing those devices in dedicated conduits prevents damage during maintenance. Many pretreatment devices require a confined

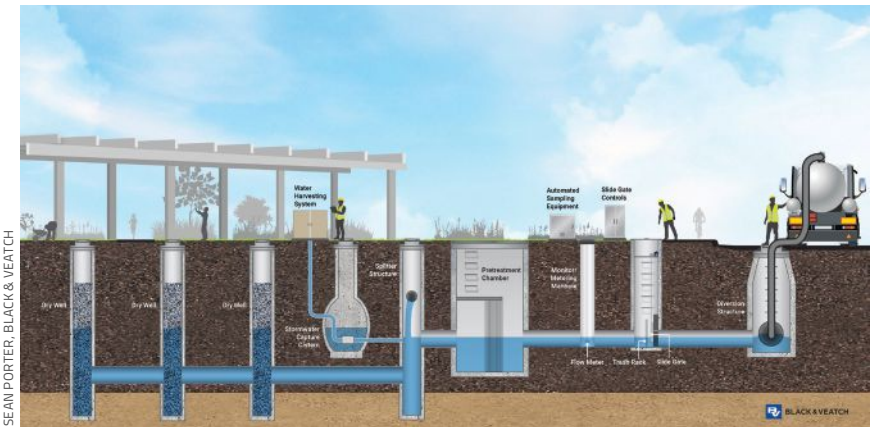


SEAN PORTER, BLACK & VEATCH

There are many different types of pretreatment and screening devices such as hydrodynamic separators, debris separating baffle boxes, and pretreatment chambers to remove most trash and some sediment.

SEAN PORTER, BLACK & VEATCH

Some trash capture requires confined space entry for maintenance.



SEAN PORTER, BLACK & VEATCH

A snapshot of the variety of operations and maintenance tasks necessary for maintaining a stormwater system.

space entry. Special attention should be considered when designing and locating these devices to either minimize confined space entry or eliminate it altogether. The level of effort to perform a confined space entry and cleaning in a busy intersection can cost much more. Another example of designing with O&M in mind is to locate the access in a parking lane with a "No Parking" sign on designated days. This way the truck and crews can set up, clean the device, and leave without costly lane closures and traffic disruptions. By designing with future O&M in mind, the result is to increase safety, minimize O&M burden and reduce hours spent.

Optimizing BMP Performance

Many of the newer stormwater treatment systems as described above are fitted with water level loggers, flow meters and rain gauges telemetry for data acquisition. The concept is that continued monitoring of these parameters can help assess the BMP effectiveness over time.

When coupled with maintenance data, monitoring the system can inform when maintenance is needed. This is known as predictive maintenance or "just in time" maintenance, which means the inspection reports should include quantity removed, material type, liquids and organics amounts. Storm predictive data and historical rainfall amounts can help correlate slide gate opening to anticipated rainfall and/or dry well water levels. This helps to optimize drywell performance.

In addition, when influent and post BMP effluent water quality samples are collected, the performance of the BMP can be directly measured. Future designs can be better constructed when based on actual data, which ultimately reduces O&M effort.

Developing a Qualified Workforce

As more BMPs are constructed, cities will need to continue hiring staff to maintain these assets. Municipalities will need to establish a framework for training staff on O&M of stormwater infrastructure, particularly treatment control measures including GI.

A common challenge is maintenance crews being able to recognize invasive species from the vegetation originally designed and planted. Invasive weeds are undesirable plants from other regions that grow and spread quickly. Removing the wrong vegetation can significantly reduce the BMP's effectiveness. The best way to avoid improper maintenance is to implement a training program consisting of classroom, field and on-the-job training.

Maintaining underground stormwater assets requires OSHA certified technicians with confined space training and equipment operation experience. The staff may be required to operate hoists and lifts, vactor trucks, hydrojetting equipment and slide gate controls. It is essential that a robust training program is in place and that safe working practices are implemented. With GI maintenance, some important detailed learning points include vegetation management, identification of invasive species, understanding of stormwater conveyance and underdrains.

Several national GI training programs currently exist, including the National Green Infrastructure Certification Program (NGICP) through Envirocert International Inc., and the Green Infrastructure Training Program (GRIT) and more local to Southern California, such as the Los Angeles Conservation Corps (LACC).

Effective training consists of classroom or virtual training content, field training and regular assessments of said training. The most effective training programs work in conjunction with municipal stormwater programs already in place: community outreach, educational signage, storm drain markings and public-facing information related to green infrastructure and stormwater treatment projects.

Summary

Most municipalities are reporting that full compliance with the O&M plans for their stormwater treatment assets are an ongoing challenge, as well as maintaining a qualified workforce. It is clear the way to begin overcoming these challenges is to design with O&M in mind, monitor BMP condition and performance, and develop a qualified workforce.

Sean Porter is a senior technical advisor and stormwater manager with SCS Engineers.

Philadelphia Gear® Rebuild Helps Modernize Water Facility

The water station's maintenance team applied Chockfast to support the mounting bars, and all repaired and new gearboxes.

The Primary Challenge

Water and wastewater utilities are crucial to providing clean, easily accessible water for people globally. One utility commission in Maryland delivers clean water and responsibly manages wastewater for nearly 2 million residents in a major suburban area. This is accomplished through a network of five water stations and 11,600 miles of pipeline spanning nearly 1,000 square miles.

One of the utility commission's water stations used a set of seven Archimedes screw pumps, with each screw operating intermittently. The screws were driven by five Philadelphia Gear® gearboxes and two non-Philadelphia Gear brand gearboxes installed in 1994 by the engineering firm that designed the station. After over 25 years of service, several gearboxes experienced repeat failure despite multiple repairs and rebuilds by a competitor's facility.

While onsite at the request of the water station's reliability engineer, Philadelphia Gear experts listened to the customer's problem and discovered that the root cause was not gearbox-related after all. It turned out that each gear drive rested on mounting bars that were affixed to a concrete baseplate that was missing Chockfast®, a synthetic quick-set concrete that helps stabilize the equipment and support its weight. This led to settling, called soft foot, that resulted in twisted gear housings, misalignment, and uneven wear on all of the gearing.

"Chockfast should have been used during the initial installation and reinforced every time a gearbox was removed for repairs and reinstalled. But that wasn't what happened," said Steve Dyal, territory account representative at Philadelphia Gear, a part of Timken Power Systems. "The customer was impressed with our field service engineering and appreciated that we identified the root cause so quickly. They immediately asked us to help solve the problem for good."

The Solution

In addition to pinpointing the root cause of the damage, Philadelphia Gear provided repairs to all five Philadelphia Gear gearboxes and completely replaced the two competitor gearboxes. All work was performed at Philadelphia Gear's Delaware Service Center in New Castle, Del.

Each repaired gearbox was thoroughly inspected to determine specific damage and repair needs, which ranged from bearing and seal replacement to more complex rebuilds requiring new pinions, gears and shafts. All repaired units underwent a two-hour spin test to measure vibration and bearing temperatures before being returned to the customer for reinstallation.

To replace the non-Philadelphia brand gearboxes, Philadelphia Gear's technical experts reverse-engineered the units and then enhanced the designs to improve equipment performance, reliability, and life. These enhancements included an improved gear mesh that helps reduce noise and premature wear, all of which extend the lifecycle of the gears.

Key Results

The water station's maintenance team applied Chockfast to support the mounting bars and all repaired and new gearboxes, preventing future damage due to soft foot settling. Over a period of seven years, the customer affordably upgraded its entire series of Archimedes screw pump gearboxes. The repairs generated significant savings over purchasing all new units.

Philadelphia Gear and the customer have also formed a strong relationship, leading to projects at one of the utility commission's other wastewater treatment facilities. Philadelphia Gear is providing gearbox repair, line shaft repair, equipment removal, and installation of a new agitator-mixer gearbox at that location.

"As a technical solution provider, we want to solve customer challenges completely the first time," said Dyal. "The quicker we get to the root cause, the faster we can deliver products and services that will reduce maintenance, improve uptime, and save money over the long run. It's all about what's best for the customer."

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Implementing Green & Gray Stormwater Solutions in The Broad Meadow Brook Watershed

Hydrologic model of a New England watershed helps the City of Worcester understand runoff patterns and identify design flows.

by Kylie Tardif, Doris Jenkins and Alex Simpson

Figure 1: The Broad Meadow Brook Wildlife Sanctuary with its isolated eastern floodplain (right), looking north towards its urbanized watershed (top). CITY OF WORCESTER

THE 435-ACRE BROAD MEADOW BROOK Wildlife Sanctuary (Figure 1), the largest urban wildlife sanctuary in the southeast corner of Worcester, Massachusetts, is in an urbanized landscape. The sanctuary is a partnership between the City of Worcester, National Grid, and the Massachusetts Audubon Society (Mass Audubon).

The sanctuary has its challenges, including flooding in nearby low-lying neighborhoods and invasive plant species. The brook is isolated from part of its floodplain by an earthen embankment that contained a sewer force main. When the city decommissioned that force main to improve its wastewater treatment system, Mass Audubon, along with the city and the Massachusetts Division of Ecological Restoration (MA DER), initiated a restoration program.

Weston & Sampson developed a hydrologic model of the brook's watershed to understand runoff patterns and identify design flows. The effort included a hydraulic model of the brook and its floodplain to support stream restoration design alternatives, green and gray infrastructure solutions, and watershed-wide strategies to reduce urban runoff under various climate scenarios, while also improving water quality.

Watershed Model Development

The team updated the hydrologic model, which had been initially developed to identify design flows for the planned stream restoration project. The watershed model was developed using PCSWMM, a software package that combines the EPA's SWMM methodology for estimating runoff rates from pervious and impervious surfaces containing piped stormwater systems with a 2D mesh for evaluating surface flooding and flow paths. This model was developed with a combination of publicly available datasets like soil type and LiDAR, with GIS of existing stormwater infrastructure provided by the city, along with field investigations to fill in remaining data gaps.

The model was calibrated with water level data collected using automated monitoring equipment in a city manhole adjacent to the sanctuary. This data was supplemented with continuous water level and streamflow data recorded by MA DER in the downstream Broad Meadow Brook channel. Multiple model input parameters were iteratively modified until the simulated model flow depths and runoff rates reasonably matched historical observations.

Existing Conditions Results

The model was used to simulate flooding conditions under present and future climate scenarios and identify a baseline to compare the effectiveness of mitigation strategies and individual green and/or gray solutions. Then, it was used to evaluate flooding in terms of peak discharge and total runoff volume arriving in the sanctuary, as well as in terms of the depths, and volume of flooding within the watershed's neighborhoods and streets (FIGURE 2). Flooding ranged from half an acre to over 12 acres during simulated 24-hour design storms ranging from the 2- to the 100-year events. Shorter (i.e., 6-hour) duration events with greater peak rainfall intensity produced simulated flooding from 15 to 20 acres. That pattern is expected to continue under a 2070 climate scenario, with flooding extents ranging from two acres to about 25 acres during 24-hour events and more than 30 acres during the shorter, higher intensity events.

Watershed-Related Benefits

Based on these findings, the project team evaluated anticipated flood reduction benefits of three different watershed-wide mitigation strategies. Those strategies are to:

- Implement the equivalent of 1 inch of storage for all impervious surfaces within the watershed, consistent with Massachusetts Stormwater Water Quality Standards.

GREEN INFRASTRUCTURE PRIORITIZATION MATRIX METHODOLOGY				
INDICATOR		**SCORING**		
		3	**2**	**1**
Flood Reduction Benefit	H&H Performance	Flood Reduction Benefits: Significant	Flood Reduction Benefits: Moderate	Flood Reduction Benefits: Minimal
	Water Quality Performance	Bioretention	Subsurface Infiltration and Porous Pave	Depave
Feasibility	Permitting Level of Effort / Presence of Resource Area	No Permitting / NOI Necessary	AE Flood Zone / Ch. 97 – reasonable permitting required	Resource Area – extensive permitting required
	Ease of Implementation: Land Ownership	City-owned land or right-of-way	City-affiliated ownership such as Worcester Housing Authority	Private Property Owner
	Operations and Maintenance (labor, equipment, cost)	Bioretention and Depaving	-	Subsurface Infiltration and Porous Pave
	Cost of Implementation	Depaving	Bioretention Basin	Subsurface Infiltration and Porous Pave
	Feasibility of Implementation (W&S Best Professional Judgment)	Highly Implementable	Moderately Implementable	Barriers to Implementation Identified
Co-Benefit	Environmental Justice Neighborhood	Two Criteria	One Criteria	No Criteria
	Reduction of Urban Heat / Pedestrian Improvements	Bioretention and Depaving	-	Subsurface Infiltration and Porous Pave
	Biodiversity / Habitat	Bioretention	Depaving	Subsurface Infiltration and Porous Pave

Table 1: Green infrastructure prioritization matrix indicating the scoring methodology to sort various opportunities within the watershed

- Reduce impervious surface cover throughout the watershed by 10%. The current average percent impervious within the sub-catchments draining to the project area is on the order of 50 to 55%.
- A combination of 1 and 2.

As expected, the combination of increasing impervious runoff storage using techniques such as subsurface chambers, along with reducing the impervious surface cover, provided the largest benefits. However, model results indicate that due to soil conditions that may limit infiltration, increased storage was significantly more effective than impervious cover reductions. The largest reduction in peak and total runoff for all three strategies is experienced during the short-duration, high-intensity events to which this watershed appears vulnerable.

WESTON & SAMPSON

Figure 3: Map of the 42 green infrastructure opportunities identified within the watershed, with the three highest priority clusters (see Prioritization in Table 1) circled in red.

Gray Infrastructure Opportunities

The team evaluated five gray infrastructure options that fell into two categories. The first category consisted of capturing runoff from sub-catchments within the watershed and redirecting small to moderate

event runoff with in-manhole diversion weirs away from neighborhoods that are prone to nuisance flooding, discharging to other existing outfalls. The second type of gray infrastructure option consisted of the construction of additional relief drains in those neighborhoods. While model simulations confirmed modest reductions in flooding in those neighborhoods, some of the gray infrastructure options increased the peak discharge rate to the sanctuary. No options addressed increased upland flooding under climate change scenarios or provided a meaningful benefit to water quality or other co-benefits.

IMAGES BY WESTON & SAMPSON

Figure 2: Example of model output comparing present and future flooding during a 10-year, 24-hour storm event.

Green Infrastructure Benefits

The watershed was assessed for implementing green infrastructure. Sixteen sites were identified as being good opportunities due to available space, land ownership and proximity to flooding. Within those sites, the team outlined 42 green infrastructure opportunities (FIGURE 3) of four main types: subsurface infiltration chambers, bioretention basins, porous pavement and de-paving. For each concept, estimates for reductions in impervious cover and increases in stormwater runoff capture and storage were made based on the type of green infrastructure incorporated and its approximate footprint. The model reflected these proposed conditions across a range of design storms to understand their capacity to reduce total runoff from the watershed and potential to reduce flooding impacts.

The model showed the green infrastructure opportunities have varied capacity to reduce runoff from their drainage areas, ranging from less than 1% to more than 75%. When all opportunities are simulated together, their ability to reduce peak runoff rates to Broad Meadow Brook are modest, approximately 2.7% and 2.0% during the 2- and 10-year storm events respectively. Reductions in total runoff are more significant, approximately 7.4% and 4.3%, respectively, during the same events.

Both flood reduction benefits and environmental/societal co-benefits were factored in to develop a prioritized list of solutions. The green infrastructure opportunities were ranked by their individual percent runoff reduction within their immediate drainage area. Each location and opportunity for the presence of priority environmental justice populations was assessed, as well as the ability of the proposed green infrastructure to reduce urban heat island effect, improve walkability, and provide ecological benefits to the surrounding area.

Summary

The strength of green infrastructure lies in its co-benefits and ability to reduce nuisance flooding on a local scale. A combination of gray and green solutions will be required to comprehensively address flooding. The prioritization process resulted in a list of the top 10 green infrastructure concepts across the watershed the city can refer to as it moves forward in its work to reduce flooding and increase climate resilience.

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MICHAEL DRENNAN

Extreme Weather Strains Stormwater Infrastructure, Prompts Proposed Solutions

In San Diego, officials are tackling flooding issues from multiple angles, including a proposed new sales tax.

by Michael Drennan & Lisa Kay

The proposed sales tax initiative offers a pathway to address issues by investing in stormwater infrastructure and promoting green solutions.

SAN DIEGO IS A PRIME EXAMPLE OF A CITY THAT IS FACING AN URGENT NEED TO ADDRESS THE challenges posed by stormwater runoff and aging infrastructure, particularly as extreme weather events become more frequent and severe. The rains of the winter of 2023-2024 served as a stark reminder of San Diego's vulnerabilities, highlighting the need for a comprehensive strategy to manage stormwater and protect urban infrastructure. In response, a new sales tax initiative has emerged as a potential solution to fund various infrastructure improvements including repair and replacement of failing underground storm drains, maintenance of creeks and flood control conveyance facilities, and installation of green infrastructure. This article will explore how this initiative could help address San Diego's stormwater problems and serve as an example for other cities.

Stormwater Problems and Damage in San Diego

Stormwater management has been a long-standing issue in San Diego, as aging infrastructure and increasing urbanization have combined to exacerbate problems with runoff and flooding. In a city that sees relatively dry weather most of the year, heavy rainfall events, such as those during the winter of 2023-2024, often catch communities off-guard. These rains led to widespread flooding, infrastructure damage and environmental degradation, severely impacting both residents and ecosystems.

The winter of 2023-2024 brought unusually heavy storms, causing significant stormwater damage in neighborhoods across San Diego. Streets were flooded, homes were damaged, and businesses were temporarily forced to close due to unsafe conditions. Flooded roadways led to traffic accidents and transportation delays, while some residential areas experienced prolonged flooding, leading to water damage and mold growth in homes. Local infrastructure, particularly the storm drains and sewage systems, were overwhelmed, further contributing to the severity of the flooding.

Environmental damage was also significant. Stormwater runoff carries pollutants like oil, chemicals and debris from urban areas into local rivers, creeks, and ultimately, the ocean. This runoff can devastate aquatic ecosystems, harm wildlife, and degrade water quality, affecting both marine life and human health. As the climate continues to shift toward more extreme weather patterns, these problems are expected to worsen unless comprehensive measures are taken to address stormwater management.

MICHAEL DRENNAN

The city prepared a comprehensive Watershed Asset Management Plan (WAMP) in 2013.

The Watershed Asset Management Plan

The city prepared a comprehensive Watershed Asset Management Plan (WAMP) in 2013 and updated in 2021 in response to increasing regulatory pressures, aging infrastructure, and the need for effective budget management. The plan summarized the challenges posed by the city's aging stormwater infrastructure, as well as the regulatory requirements of the Clean Water Act, which mandates the reduction of pollutants in water bodies that fail to meet water quality standards. The WAMP detailed the costs, the need for upgrades, replacements of existing infrastructure, and the need for new infrastructure to comply with regulatory requirements. This summary was crucial for justifying the necessary budget allocations and prioritizing projects to address the most critical needs. This plan provides a portion of the rationale for the need for additional revenues in the city and helps to explain why the sales tax initiative is needed.

The Role of San Diego's Sales Tax Initiative

San Diego's current response to these stormwater issues involves a proposed sales tax initiative that will be on the November 2024 ballot. The measure will provide a funding stream that can be used for critical upgrades to infrastructure including stormwater and roads. With much of the city's stormwater systems aging and underfunded, this tax would provide a vital resource to ensure that future flooding events can be better managed, and long-term investments can be made in green infrastructure.

Sales tax revenue would be used to:

- **Upgrade stormwater systems**: Replacing outdated pipes, drains and water channels with more robust and modern systems capable of handling increased volumes of stormwater.
- **Improve flood management**: Expanding and upgrading flood control systems, such as retention basins, flood channels, and pump stations to prevent urban flooding during extreme weather events.
- **Improve water quality:** Water Quality Improvement Plan (WQIPs) are watershed scale plans developed to meet regulatory requirements for water quality. Each watershed within the city has a unique WQIP, which identifies the highest priority water quality condition(s), or problems, and the corresponding numeric goals, strategies and schedules to address those problems.
- **Support green infrastructure**: Promoting the implementation of environmentally sustainable solutions, such as stormwater capture and detention, rain gardens, bioswales, permeable pavements, and urban green spaces, to reduce runoff and naturally manage stormwater.

By investing in green infrastructure, San Diego can address both the immediate challenges of stormwater and the long-term impacts of climate change.

Green Infrastructure and Stormwater Management

Green infrastructure refers to a range of practices that mimic natural processes to manage stormwater and create healthier urban environments. Unlike traditional "gray" infrastructure (such as storm drains and pipes), green infrastructure emphasizes sustainability and environmental benefits, while also addressing urban challenges like flooding and pollution.

In the context of stormwater management, green infrastructure can:

- **Reduce runoff**: By absorbing and filtering rainwater where it falls, green infrastructure reduces the volume of stormwater that enters the city's drainage system, alleviating pressure on pipes and reducing the risk of flooding.
- **Filter pollutants**: Vegetation and soil in green infrastructure systems can capture and break down pollutants found in stormwater, such as oil, heavy metals and chemicals. This helps improve water quality and protects ecosystems.
- **Increase resilience**: Green infrastructure helps cities adapt to changing weather patterns and extreme weather events by providing natural stormwater buffers. Solutions like permeable pavement and rain gardens help urban areas cope with intense rainfall.

Solutions like green roofs, tree trenches and community gardens could be implemented across neighborhoods to not only manage stormwater but also enhance urban landscapes, reduce urban heat and promote biodiversity.

Learning from Los Angeles: Measure W and its Impact

San Diego's initiative can draw inspiration from the success of Measure W, a landmark program passed in Los Angeles in 2018 that provided dedicated funding for stormwater projects. Known as the Safe, Clean Water Program, Measure W established a parcel tax to raise approximately $300 million annually, funding multi-benefit projects that improve stormwater capture, water quality, and promote green infrastructure.

The initiative has had a transformative effect on Los Angeles' approach to stormwater management:

- **Green infrastructure projects**: Measure W has enabled Los Angeles to advance a variety of nature-based solutions, including permeable pavements, bioswales, and stormwater capture systems. These systems help slow and filter stormwater, reducing runoff, recharging groundwater supplies, and reducing potable water use through stormwater capture and use.
- **Community benefits**: In addition to addressing stormwater, Measure W is providing multiple benefits to communities, such as creating new green spaces, reducing urban heat and enhancing air quality. Parks with stormwater capture features and landscaped streetscapes will make neighborhoods more resilient and livable.
- **Water conservation**: One of the primary goals of Measure W is to improve water sustainability in a drought-prone region. By capturing and using stormwater, the Los Angeles region is predicted to conserve millions of gallons of water that would otherwise have flowed into the ocean. This is particularly crucial in Southern California, where water resources are often scarce.
- **Collaborative governance**: Measure W established a regional governance structure that brings together stakeholders from local governments, environmental organizations, and the public to oversee the distribution of funds and ensure that projects meet environmental and community goals. This collaborative approach helps advance projects that have broad support and are multi-benefit in nature.

Lessons Learned

Stormwater managers in urban areas can learn a great deal from the success of Measure W. By implementing a similar approach, stormwater programs in urban

CASE STUDY

Twin Stormwater Culvert Rehabilitation in Greenwood Place, Baltimore County, Maryland

Problem

Baltimore County, Maryland, needed to rehabilitate 96 linear feet of twin 72-inch corrugated metal pipes that passed under a county road that accesses an apartment community's main office, and beneath its swimming pool amenity. Extreme deterioration from prolonged exposure to constant running creek water and advanced deterioration created pipe failure concerns.

Single access point to the community ruled out traditional dig-and-replace as a viable option. Open cut and several potential trenchless methods were also ruled out because an existing playground adjacent to the site presented dangers to children.

Solution

Pleasants Construction, Inc., won the project bid as a cured-in-place-pipe (CIPP) lining job using the Alphaliner 1800H UV-cured liner system.

The creek ravine containing the pipes was located between a roadway and railway track. This required cut-in of a temporary work area for equipment, liner crates, crew access, sandbag weir and accommodate diversion for bypass pumping.

Pleasants pressure wash cleaned and televised the pipes in preparation for the lining process as well as cleared debris and prepped the pipes' interior surfaces.

The weight of the resin-impregnated liners required a 40-ton crane to lift the liner crates from the truck and position them in the crews' work area. Crews pulled the Alphaliner into place and introduced air for expansion into the failing host pipe. Using the Reline America REE4000 Curing Unit, the liner was successfully cured in place.

Quality control testing was performed followed by site remediation. Within 48 hours of crews arriving on-site, the pipes were rehabilitated and returned to service.

Result

Possible structural concerns, now and in the future, have been eliminated. Due to the success of the project with such limited disruption to the community, the local municipality has been utilizing UV GRP lining on other problematic stormwater assets and failing outflow lines throughout the county.

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areas can create a sustainable funding stream for stormwater projects and green infrastructure, ensuring that they are well-prepared for future storms and climate challenges.

Key lessons include:

- **Long-term investment**: Like Los Angeles, San Diego needs a long-term strategy that focuses on sustainable and resilient infrastructure solutions. Green infrastructure should be integrated into urban planning, zoning and public works projects to ensure a coordinated approach to stormwater management.
- **Community involvement**: Measure W has demonstrated the importance of engaging communities in stormwater projects, ensuring that new infrastructure provides multiple benefits beyond flood control. By involving local stakeholders and prioritizing community needs, San Diego can ensure that its stormwater initiatives not only reduce runoff but also improve quality of life for residents.
- **Water sustainability**: As climate change brings more intense rainfall and, conversely, longer droughts, San Diego will need to focus on water conservation and stormwater reuse. Stormwater capture systems can help San Diego build more sustainable water supplies by harvesting rainwater during storms and using it during dry periods.

A Vision for San Diego's future

San Diego's stormwater challenges, especially in light of the damage caused by the rains of 2023-2024, underscore the need for innovative solutions and dedicated funding. The proposed sales tax initiative offers a pathway to address these issues by investing in stormwater infrastructure and promoting green solutions that will not only manage runoff but also enhance the city's resilience to future storms and climate change.

San Diego can transform its approach to stormwater management, creating a more sustainable, livable and resilient city. With the right investments, San Diego can protect its residents, improve its environment, and ensure that future generations inherit a city that is well-equipped to handle the challenges of a changing climate.

San Diego is the latest example of municipalities recognizing the importance of stormwater management and green infrastructure in the face of extreme weather. We will undoubtedly see more cities embracing the benefits of investing in multi-benefit infrastructure solutions in the future.

Michael Drennan is Director of Water Resources and Green Infrastructure in the San Diego office of NV5, a global engineering and technology firm.

Lisa Kay is chief growth officer and national director of Water Resources for NV5.

Stormwater is a Resource … No, Really, It is!

Looking at the benefits of stormwater capture and use

by Seth Brown

A MISSION OF THE NATIONAL MUNICIPAL Stormwater Alliance (NMSA) is to promote stormwater as a resource and that investments in stormwater infrastructure should be valued as one would value investments in a precious non-renewable resource such as gold. To place a value on a resource requires some understanding of the amount available for use. The Pacific Institute, teamed with 2NDNature Software, recently released a report that outlined a GIS-based analysis that found a national estimate of the total annual stormwater capture and use (SCU) potential as being nearly 60 million acre-feet per year. This amount is greater than the estimated potential for wastewater reuse and more than the total urban water use in the country.

But what about water-rich areas? If SCU investments only make sense in water-scarce climates, the impact of SCU practices will have limited overall value in a national context. In water-rich regions of the country, the problem of runoff is often the excess of it, not the scarcity of it. This suggests that scarcity of water provides value to stormwater resources, even when relatively scarce, such as water in arid areas. Whereas, the value of those same resources could be more limited in water-rich areas where excess water means flooding. But we are seeing that there are frameworks and circumstances where captured rainfall and runoff can have enough value to drive sustainably funded programs centered around SCU.

Implementing SCU Practices

In Minnesota, there are examples of SCU practices being implemented in multiple jurisdictions. Why would this be the case in a state that receives between 18 and 32 inches of precipitation annually and has a surface water to land ratio of 6%, which is the highest of any state in the U.S.?

The abundance of water resources in Minnesota would suggest this would be one of the last states where SCU innovations would be developed, but there are several factors that have motivated some Minnesota communities to do exactly that. For instance, Minnesota sources groundwater supplies for use at a surprisingly high – and unsustainable – rate in both urban and agricultural areas. Other factors include challenging soils in urban areas and available land for stormwater management.

In response to these factors, two Minnesota communities — Hugo and Waconia — have developed innovative approaches to better manage their water resources. These communities have some similarities as they both have a populations between 10,000 and 20,000, are located in exurban areas experiencing a high degree of urbanization pressures, and both have areas within their communities with high clay content soils making the goal of meeting retention-based stormwater standards difficult.

Examples from the Field

The City of Hugo is home to White Bear Lake. Some have claimed that groundwater resources for potable water supply have been used to fill the lake. There is disagreement regarding the dynamics of White Bear Lake, which calls into question the link between these groundwater draws and the volume/level of the lake. To be good stewards and find ways to meet retention-based stormwater requirements, Hugo has embraced the mantra of "Reduce, Replenish, Reuse" by sourcing irrigation in many residential areas with runoff captured and detained in stormwater retention ponds. This approach, which is supported by user fees, reduces the amount of potable water supplies used in the city.

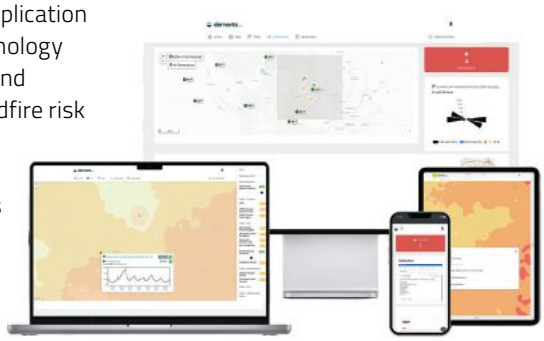
Waconia has taken a similar approach for mostly publicly owned and commercial areas with regional stormwater basins used for irrigation water, not only reducing potable water use but also providing stormwater treatment credits for existing and future land development activities. This community has also established a dedicated stormwater reuse utility that city residents opt in to by paying a setup and annual maintenance fees.

The examples of Hugo and Waconia illustrate that even small and midsized communities can apply SCU practices and programs. A common thread here is a commitment to common-sense solutions as well as to the protection of local water resources. Both also benefit from the Clean Water, Land and Legacy Trust Fund established through legislative action in the state of Minnesota. This state-driven program as well as the commitments at the local level by communities like Hugo and Waconia should be seen as models for others across the region and the country.

Seth Brown is executive director of NMSA and can be reached at seth.brown@nationalstormwateralliance.org.

Hazard Detection Technology

AEM has recently integrated its Multi-Source Hazard Detection technology within the AEM Elements 360 application. The multi-source detection enhances the identification and response to diverse environmental threats. The technology leverages data from multiple sources to deliver speed, accuracy and confidence in detecting potential hazards across geographically linked areas.



The initial application for this technology centralizes and analyzes wildfire risk data from different technologies like visual AI smoke detection, lightning detection networks, satellite hotspot monitoring, air quality sensors and fire weather forecasting. The AEM Elements model also includes flood forecast modeling, wildfire risk management data logger, meteorological data logger and lightning detection.

AEM
www.aem.eco

Sweeper Cameras

The Elgin Sweeper DualEyes camera system is for increased visibility on sweepers. The camera system increases visibility on the front right tire and front right corner of the sweeper in addition to the right-side broom. The enhanced visibility of the curbline shows any possible obstructions in the sweeper's path. The product will first be available on the Elgin RegenX, a mid-dump, regenerative air sweeper. The camera system is for use when there is no right-hand steering available, so operating the sweeper from the left-hand position is possible. The system can be used in bright sunlight or in darkness without any lighting, and a clear color picture is available at night. The camera integrates rear-view and pickup head cameras on RegenX sweepers utilizing a 10-inch dash-mounted screen. The system is dustproof and waterproof.

Elgin
www.elginsweeper.com

Flood-Tight Access Door

The BILCO Company Type FT-30 door is flood-tight against 30-foot head of water from the topside and a 5-foot head of water from the underside. It features corrosion-resistant aluminum construction with stainless steel hardware. Covers are reinforced for AASHTO H-20 wheel loading to withstand vehicular loading as a standard feature. The door includes a 25-year warranty and is available in a number of standard and special sizes to satisfy different requirements. The door will resist low-pressure gases and odors and will be beneficial in applications with wells and other job sites that are prone to flooding. The door features a latching system that securely seals the cover and allows the cover to be opened quickly and easily. The doors also feature engineered lift assistance. An optional Thermion Safetrax non-skid cover finish can also be included on the doors.

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The Lane Enterprises, LLC., DeepCorr is a steel structural plate that addresses the needs of small to medium-span bridges allowing longer spans, typically 40 to 80 feet, to better compete with traditional beam bridges. It features a 5-1/2-inch by 15-inch corrugation and is available with 3-ounce hot-dipped galvanized coating (ASTM A761) or with a polymer coating (ASTM A1113) with color options. The structural plate is available in seven thicknesses from 8 gage to 3/8-inch. Popular applications include rehabilitating highway and railway bridges, fish passage culverts and wildlife crossings.

Lane
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Statement of Ownership, Management, and Circulation **(Requester Publications Only)**

1. Publication Title: STORMWATER SOLUTIONS
2. Publication Number: 1531-0574
3. Filing Date: 09/30/2024
4. Issue of Frequency: January, March, May, July, September, November
5. Number of Issues Published Annually: 6
6. Annual Subscription Price: 95.00
7. Complete Mailing Address of Known Office of Publication (Not Printer): Endeavor Business Media, LLC, 201 N. Main Street Ste. 5 Fort Atkinson, WI 53538 — Contact Person: SHIRLEY PATINO, Telephone: 205-409-0690
8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not Printer): Endeavor Business Media, LLC,30 Burton Hills Blvd., Ste. 185., Nashville, TN 37215
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor - Publisher: RYAN HANSON, 201 N. Main Street Ste. 5 Fort Atkinson, WI 53538; Editor: KATIE JOHNS, 201 N. Main Street Ste. 5 Fort Atkinson, WI 53538; Managing Editor: KATIE JOHNS , 201 N. Main Street Ste. 5 Fort Atkinson, WI 53538
10. Owner - Full name and complete mailing address: Endeavor Media Holdings I, LLC, 905 Tower Place, Nashville, TN 37204; Endeavor Media Holdings II, LLC, 905 Tower Place, Nashville, TN 37204;Resolute Capital partners Fund IV, LP, 20 Burton Hills Blvd, Suite 430, Nashville, TN 37215;RCP Endeavor, Inc, 20 Burton Hills Blvd, Suite 430, ,Nashville, TN 37215;Northcreek Mezzanine Fund II, LP,312 Walnut Street, Suite 2310,Cincinnati, OH 45202;Invegarry Holdings, LP,44235 Hillsboro Pike,Nashville, TN 37215;Everside Fund II, LP,155 East 44th St, Suite 2101 - 10 Grand Central,New York, NY 10017Everside Endeavor F1 Blocker, LLC, 155 East 44th St, Suite 2101 - 10 Grand Central, New York, NY 10017;Everside Endeavor International Blocker, LLC, 155 East 44th St, Suite 2101 - 10 Grand Central, New York, NY 10017;Everside Founders Fund, LP, 155 East 44th St, Suite 2101 - 10 Grand Central, ,New York, NY 10017;Suncap Endeavor Blocker, LLC,155 East 44th St, Suite 2101 - 10 Grand Central,New York, NY 10017;
11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages or Other Securities: None
12. Tax Status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one) The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: N/A
13. Publication Title: STORMWATER SOLUTIONS
14. Issue Date for Circulation Data: September/October 2024

15. Extent and Nature of Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies (Net press run)	18,730	17,492
b. Legitimate Paid and/or Requested Distribution (By Mail and Outside the Mail)		
(1) Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	17,945	16,802
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h. Total (Sum of 15f and g)	18,730	17,492
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)	97.34%	98.03%
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b. Total Requested and Paid Print Copies (Line 15c)+ Requested/Paid Electronic Copies (Line 16a)	19,820	18,554
c. Total Requested Copy Distribution Distribution(Line 15f) + Requested/Paid Electronic Copies (Line 16a)	20,310	18,891
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17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the issue of this publication. Nov/Dec 2024

18 SHIRLEY PATINO, AUDIENCE DEVELOPMENT MANAGER Date 9/30/24

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