THE NATIONAL ACADEMIES
REPORT IN BRIEF

Urban Stormwater Management in the United States

The rapid conversion of land to urban and suburban areas has profoundly altered how water flows during and following storm events, putting higher volumes of water and more pollutants into the nation's rivers, lakes, and estuaries. These changes have degraded water quality and habitat in virtually every urban stream system. The Clean Water Act regulatory framework for addressing sewage and industrial wastes is not well suited to the more difficult problem of stormwater discharges. This report calls for an entirely new permitting structure that would put authority and accountability for stormwater discharges at the municipal level. A number of additional actions, such as conserving natural areas, reducing hard surface cover (e.g., roads and parking lots), and retrofitting urban areas with features that hold and treat stormwater, are recommended.

Stormwater has long been regarded as a major culprit in urban flooding, but only in the past 30 years have policymakers appreciated its significant role in degrading the streams, rivers, lakes, and other waterbodies in urban and suburban areas. Large volumes of rapidly moving stormwater can harm species habitat and pollute sensitive drinking water sources, among other impacts. Urban stormwater is estimated to be the primary source of impairment for 13 percent of assessed rivers, 18 percent of lakes, and 32 percent of estuaries—significant numbers given that urban areas cover only 3 percent of the land mass of the United States.

Photo by Roger Bannerman

Urbanization—the conversion of forests and agricultural land to suburban and urban areas—is proceeding at an unprecedented pace in the United States. Stormwater discharges have emerged as a problem because the flow of water is dramatically altered as land is urbanized. Typically, vegetation and topsoil are removed to make way for buildings, roads, and other infrastructure, and drainage networks are installed. The loss of the water-retaining functions of soil and vegetation causes stormwater to reach streams in short concentrated bursts. In addition, roads, parking lots, and other "impervious surfaces" channel and speed the flow of water to streams. When combined with pollutants from lawns, motor vehicles, domesticated animals, industries, and other urban sources that are picked up by the stormwater, these changes have led to water quality degradation in virtually all urban streams.

In 1987 Congress wrote a new section into the Clean Water Act's National Pollutant Discharge Elimination System to help address the role of stormwater in impairing water quality. This system, which is enforced by the U.S. Environmental Protection Agency (EPA), has focused on reducing pollutants from industrial process wastewater and municipal sewage discharges—"point sources" of pollution that are relatively straightforward to regulate. Under the new "stormwater program,"

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the number of permittees in the National Pollutant Discharge Elimination System has ballooned from about 100,000 to more than 500,000, to include stormwater permittees from municipal areas, industry, and construction sites one acre or larger. Not only do stormwater permittees vastly out number wastewater permittees, it is much more difficult to collect and treat stormwater than wastewater.

In light of these challenges, EPA asked the National Research Council to review its stormwater program, considering all entities regulated under the program (i.e., municipal, industrial, and construction). The report finds that the stormwater program will require significant changes if it is to improve the quality of the nation's waters. Fortunately, there are a number of actions that can be taken. The report concludes that the course of action most likely to halt and reverse degradation of the nation's waterways would be to base all stormwater and other wastewater discharge permits on watershed boundaries instead of political boundaries, which is a radical shift from the current structure.

The Challenges of Regulating Stormwater

One of the problems in managing stormwater discharge is that it is being addressed so late in the development of urban areas. Historically, stormwater management has meant flood control—by moving water away from structures and cities as fast as possible. Ideally, stormwater discharges would be regulated through direct controls on land use, strict limits on both the quantity and quality of stormwater runoff into surface waters, and rigorous monitoring of adjacent waterbodies to ensure that they are not degraded by stormwater discharges. Future land use development would be controlled to minimize stormwater discharges. Products or sources that contribute pollutants through stormwater—like de-icing materials, fertilizers, and vehicular exhaust—would be regulated by EPA at a national level to ensure that the most environmentally benign materials are used.

The current regulatory scheme lacks many of these attributes. EPA's program has monitoring requirements that are so benign as to be of little use for the purposes of program compliance. Most dischargers have no measurable, enforceable requirements. Instead, the stormwater permits leave a great deal of discretion to the regulated community to set their own standards, develop their own pollution control schemes, and to self-monitor. Current statistics on the states' implementation of the stormwater program, compliance with stormwater requirements, and the ability of states and EPA to incorporate stormwater permits with pollution limits are uniformly discouraging.

High volumes of stormwater discharge have badly damaged this stream near Philadelphia, which is suffering from Urban Stream Syndrome. Photo by Chris Crockett, City of Philadelphia Water Department.

Significant changes to the current regulatory program are necessary to provide meaningful regulation of stormwater dischargers in the future. One idea is to focus the stormwater program less on chemical pollutants in stormwater and more on problems associated with increased volumes of water. Some states have used flow volumes as a metric for controlling and reducing stormwater discharge; other regulators have used the extent of hard surfaces (impervious cover) as a proxy for stormwater pollutants. These substitutes for the traditional focus on the "discharge" of "pollutants" have great potential as stormwater management tools because they provide specific and measurable targets. At the same time, they focus regulators on the problems of increased water volume, which include a condition known as Urban Stream Syndrome (see image above).

In addition, the federal government should provide more financial support to state and local efforts to regulate stormwater. Today, the stormwater program still receives much less funding than the wastewater program despite having many more permittees.

The Case For Watershed Permitting

The report concludes that the most likely way to halt and reverse damage to waterbodies is through a substantial departure from the status quo—namely a watershed permitting structure that bases all stormwater and other wastewater discharge permits on watershed boundaries instead of political boundaries. Watershed-based permitting is not a new concept, but it has been attempted in only a few communities.

The proposed watershed permitting structure would put both the authority and accountability for stormwater discharges at the municipal level. A municipal lead permittee, such as a city, would work in partnership with other municipalities in the watershed as co-permittees. Permitting authorities (designated states or, otherwise, EPA) would adopt a minimum goal in every watershed to avoid any further loss or degradation of designated beneficial uses in the watershed's component waterbodies and additional goals in some cases aimed at recovering lost beneficial uses. Permittees, with support by the states or EPA, would then conduct comprehensive impact source analyses as a foundation for targeting solutions.

The approach gives municipal co-permittees more responsibility, with commensurately greater authority and funding, to manage all of the sources discharging to the waterbodies comprising the watershed. The report also outlines a new monitoring program structured to assess progress toward meeting objectives, diagnosing reasons for any lack of progress, and determining compliance by dischargers. The proposal further includes market-based trading of credits among dischargers to achieve overall compliance in the most efficient manner, and adaptive management to determine additional actions if monitoring demonstrates failure to achieve objectives.

As a first step to taking the proposed program nationwide, a pilot program is recommended that will allow EPA to work through some of the more predictable impediments to watershed-based permitting, such as the inevitable limits of an urban municipality's authority within a larger watershed.

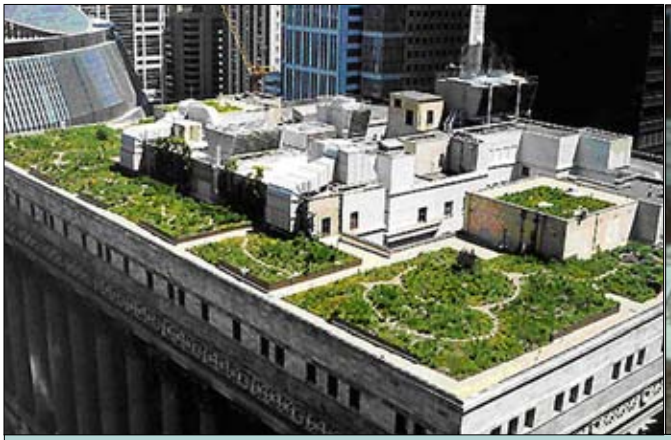
Short of adopting watershed-based permitting, other smaller-scale changes to the EPA stormwater program are possible. The report recommends that EPA integrate the three different permitting types so that construction and industrial sites come under the jurisdiction of their associated municipalities.

Stormwater Management Approaches

Even in the absence of regulatory changes, there are many stormwater management approaches that can be used to prevent, reduce, and treat stormwater flows. Central to the EPA Stormwater Program is the requirement for permittees to develop stormwater pollution prevention plans that include stormwater control measures. When designed, constructed, and maintained correctly, stormwater control measures have been demonstrated to reduce runoff volume and peak flows and to remove pollutants. A classic example is the removal of lead from gasoline, which has reduced lead concentrations in stormwater by at least a factor of four.

Stormwater control measures are grouped in two categories: nonstructural and structural. Nonstructural stormwater control measures include a wide range of actions that can reduce the volume of runoff and pollutants from a new development. Examples include the use of products that contain less pollutants; improved urban design, for example, of new developments that have fewer hard surfaces; the disconnection of downspouts from hard surfaces to instead connect with porous surfaces; the conservation of natural areas; and improved watershed and land use planning.

Structural stormwater control measures are designed to reduce the volume and pollutants of small storms by the capture and reuse of stormwater, the infiltration of stormwater into porous surfaces, and the evaporation of stormwater. Examples include rainwater harvesting systems that capture runoff



There are many innovative approaches to stormwater management that can be applied in urban and suburban areas. Chicago's City Hall (left) was retrofitted with a "green roof" to capture stormwater. Photo courtesy CDF Inc. The downspoutings on the house (right) drain onto a porous surface instead of onto a driveway. Photo by William Wenk.

from roofs in rain barrels, tanks, or cisterns; the use of permeable pavement; the creation of "infiltration trenches," into which stormwater can seep or is piped; the planting of rain gardens on both public and private lands, and the planting of "swales" along the roadside that capture and treat stormwater.

The report recommends that nonstructural stormwater control measures be considered first before structural practices, because their use reduces the reliance on and need for structural measures. The report discusses the characteristics, applicability, goals, effectiveness, and cost of nearly 20 different broad categories of stormwater control measures, organized as they might be applied from the roof top to the stream.

There is an opportunity to retrofit urban areas with stormwater control measures. Promoting growth in these areas is a good thing because it can take pressure off the suburban fringes, thereby preventing sprawl, and because it minimizes the creation of new impervious surfaces. However, it can be more expensive because there is existing infrastructure and limited availability and affordability of land. Both innovative zoning and development incentives, along with careful selection of stormwater control measures, are needed to achieve fair and effective stormwater management in these areas.

Data on Stormwater Discharges

Thanks to a 10-year effort to collect and analyze monitoring data from municipal separate storm sewer systems nationwide, a lot is known about the quality of stormwater from urbanized areas. Residential land use has been shown to be a relatively smaller source of many pollutants, but it is the largest fraction of land use in most communities, typically making it the largest stormwater source on a mass pollutant discharge basis. Freeway, industrial, and commercial areas can be very significant sources of heavy metals, and their discharge significance is usually much greater than their land area indicates. Construction sites are usually the overwhelming source of sediment in urban areas, even though they make up very small areas of most communities. These results come from many thousands of storm events, systematically compiled. These data make it possible to accurately estimate the concentration of many pollutants for any given storm.

This traffic island on the Villanova University campus has a "bioinfiltration" system to capture water. Photo by Robert Traver.

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This report brief was prepared by the National Research Council based on the committee's report. For more information or copies, contact the Water Science and Technology Board at (202) 334-3422 or visit http://nationalacademies.org/wstb. Copies of *Urban Stormwater Management in the United States* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.