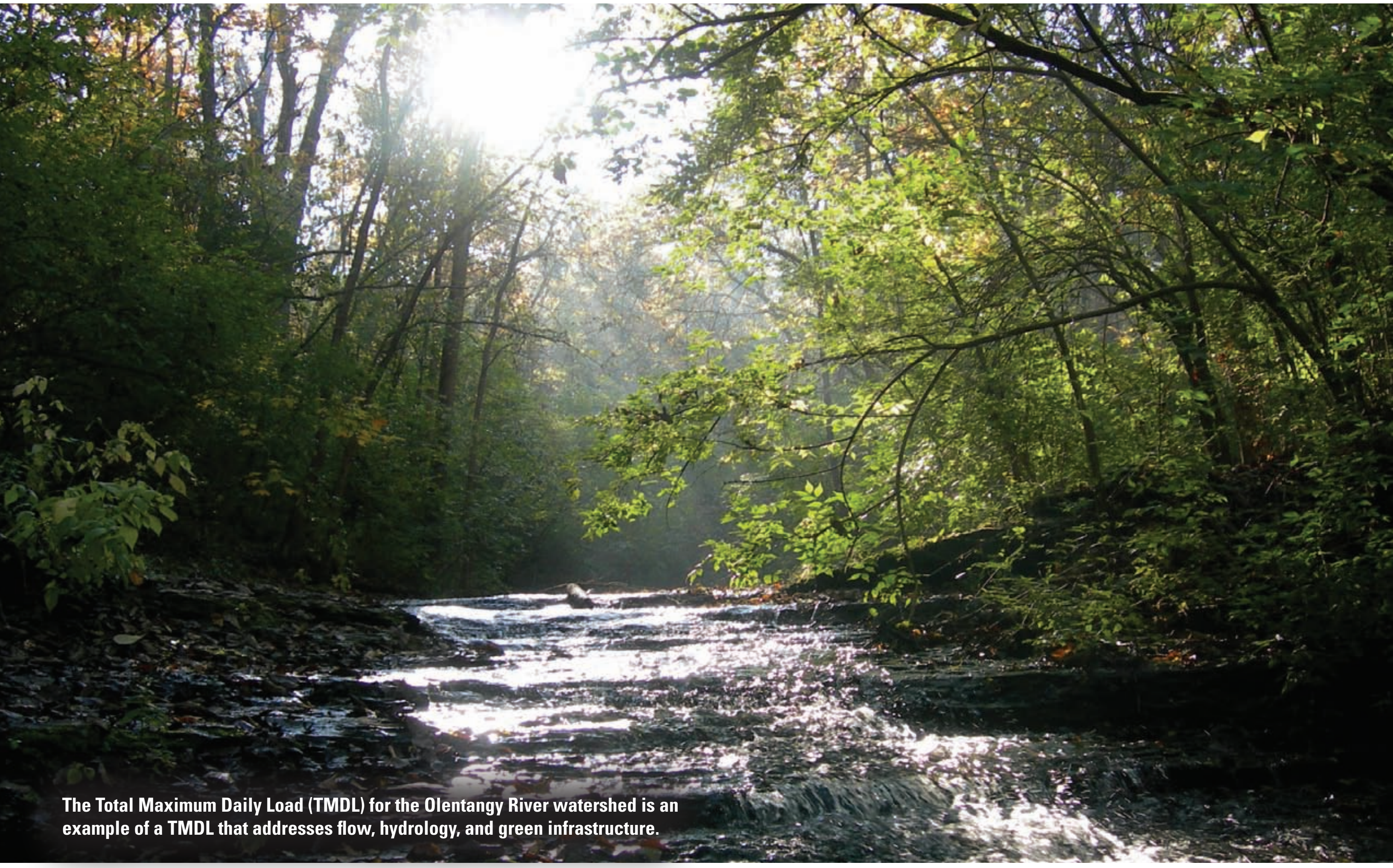
EPA United States Environmental Protection Agency



The Total Maximum Daily Load (TMDL) for the Olentangy River watershed is an example of a TMDL that addresses flow, hydrology, and green infrastructure.

Green Infrastructure in Total Maximum Daily Loads (TMDLs)

This supplement supports Factsheet 5 in the Green Infrastructure Permitting and Enforcement Series: Total Maximum Daily Loads

Integrating Green Infrastructure Concepts into Permitting, Enforcement, and Water Quality Standards Actions

*This supplement is a companion to the U.S. EPA Green Infrastructure Permitting and Enforcement Series (*http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries*). This series describes how EPA and state permitting and enforcement professionals can incorporate green infrastructure practices and approaches into National Pollutant Discharge Elimination System (NPDES) wet weather programs, including stormwater permits, Total Maximum Daily Loads (TMDLs), combined sewer overflow (CSO) long-term control plans (LTCPs), and enforcement actions. This series builds upon EPA's continued investment in green infrastructure and low impact development. Existing EPA authority, guidance, and agreements enable EPA Regions and state agencies to work with permittees to include green infrastructure measures as part of control programs.*

For additional resources on green infrastructure, go to the EPA Green Infrastructure Web page: http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm.

Key green infrastructure guidance issued to date can be found at: http://water.epa.gov/infrastructure/greeninfrastructure/gi_policy.cfm.

Stormwater discharges can degrade riparian and aquatic habitat and the fish, shellfish, and wildlife that depend on that habitat. *Photo courtesy of USDA NRCS*

Introduction

Where regulated or unregulated stormwater discharges are a major source of impairment, green infrastructure can play an important role in the development of Total Maximum Daily Loads (TMDLs) and associated implementation plans. This supplement highlights two TMDLs that address flow, hydrology, and green infrastructure: the TMDL for the Olentangy River Watershed in Ohio, and the TMDL for the Barberry Creek Watershed in Maine. A summary of the two TMDLs is presented in Table 1, followed by excerpts of the language relating to green infrastructure.

ADDITIONAL INFORMATION ABOUT TMDLS AND STORMWATER DISCHARGES CAN BE FOUND AT EPA WEBPAGE:

http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/stormwater_index.cfm.

Table 1: Summary of Olentangy River and Barberry Creek TMDLs

	Olentangy River, OH TMDL	**Barberry Creek, ME TMDL**
Pollutants/Pollution of Concern	• Impaired for aquatic life use and recreational uses • Causes of impairment: siltation, nutrient enrichment, habitat and flow alteration, pathogens • In-stream targets: Total Suspended Solids, Total Phosphorous, and Fecal Coliform • Stream geomorphology and floodplain targets also established in the TMDL	• Impaired for aquatic life uses • Percent impervious cover used as surrogate for complex aquatic life stressors • Lead (Pb) and zinc (Zn) used as surrogate measures for an array of metals in stormwater runoff
Major Sources Associated with Impairment	**Point Sources:** Phase II MS4s, 32 minor, and 14 miscellaneous sources **Nonpoint Sources:** • Unregulated stormwater • Channelization for drainage improvement	**Point Sources:** City of South Portland regulated under MS4 stormwater general permit **Nonpoint Source:** • Unregulated stormwater
Impacts	• Runoff from agriculture resulting in high nutrient and pathogen loadings • Channelization leading to habitat degradation and sedimentation • Changing land cover resulting in altered hydrology and poor habitat	• Impaired stream habitat and low baseflow were identified as aquatic life stressors • Runoff leading to loadings of an array of metals to the water body
Green Infrastructure Practices Proposed	• Reduction of impervious cover • Various stormwater abatement techniques for individuals and businesses to reduce flow	• Implementation of techniques to minimize the effects of urbanization • Disconnection of impervious surfaces • Conversion of impervious surfaces to pervious surfaces
Method of Implementation	• Revisions to construction permit and future general stormwater permit • Implement incentives and market-based programs to encourage onsite stormwater management	• Abatement measures implemented under an adaptive management approach • Controls implemented through a phased program focusing on sensitive areas first
Sections of TMDL containing Green Infrastructure Discussion	Section 9: Water Quality Improvement Strategy (Implementation Plan)	Section 7: Implementation Plan

Case Study 1: The Olentangy River Watershed TMDL, Ohio (2007)

TMDL Background

The Olentangy River, located in central Ohio, is approximately 93 miles long with a drainage area of 536 square miles. The river was listed on the Ohio 303(d) list (list of impaired waters) based on impairments to aquatic life use and recreation. Land use primarily includes agricultural land interspersed with suburban areas that are being developed rapidly. The Olentangy River watershed flows across Ohio's first and sixth most rapidly growing counties, and includes Exceptional Warmwater Habitat reaches and the State Scenic River portion of the mainstem. Key future threats to the river are conversion of farmland to suburban and commercial land uses, especially in Delaware County.

A TMDL was required because portions of the Olentangy River and its tributaries do not attain their beneficial use designations for aquatic life and recreation. TMDL allocations were developed for (1) fecal coliform to address the recreational use impairment; and (2) total phosphorus, total suspended solids (a surrogate for sedimentation), and habitat to address the aquatic life use impairment. Although no allocations were developed for parameters related to stream geomorphology, floodplain area, or hydrology, the TMDL report described how these factors related to attaining water quality standards. The Olentangy River TMDL identified managing stormwater quality and quantity in developing areas as an important step to preserving natural stream function through channel protection, and restoring stream habitat in agricultural areas. In the Olentangy River watershed, the City of Powell, Orange, and Liberty townships and Delaware County are designated Phase II municipal separate storm sewer system (MS4) communities and have initiated stormwater programs which include construction site permitting and inspections, good housekeeping training, and public outreach and education.

Following are excerpts from the TMDL that discuss the hydrology of the watershed and the need for green infrastructure practices. The full TMDL is available at:

http://www.epa.state.oh.us/portals/35/tmdl/OlentangyTMDL_final_aug07.pdf

Excerpt from Section 9: Water Quality Improvement Strategy

This section of the Olentangy TMDL describes the nature and causes of the water quality impairment. Large and increasing amounts of impervious surfaces in the watershed and the resulting stormwater discharges and altered flow conditions in the water bodies were found to contribute to impairments of biological communities.

Section 9.1.2. Habitat

Developing Areas

The most serious threat to channel stability, and possibly overall water quality and biological integrity, in the Olentangy River watershed is the rapid conversion of forest and/or agriculture land uses to residential, commercial, and industrial uses. Numerous scientific studies show that increasing impervious cover in a watershed (i.e., through development) is commensurate with the degradation of water quality and biological communities (Booth et al., 2005; Brabec et al.,2002; Roy et al., 2003; Roy et al., 2006; Morgan and Cushman, 2005).

This type of land use conversion substantially increases the volume of runoff, which is eventually routed to the stream system. Ultimately the sediment transport capacity of the system increases resulting in more channel erosion and instability (Booth, 2005). The resulting morphology provides poor habitat and may have a reduced capacity for nutrient assimilation (Walsh et al., 2005). Higher runoff volume increases pollutant loading (e.g., nutrients, metals, salts, pesticides, sediment). Additionally stream temperatures can be raised when runoff is heated by impervious surfaces such as asphalt and concrete or while residing in detention basins. Temperature increases reduce dissolved oxygen concentration and create stressful conditions for aquatic biota (Ward, 1992; Cossins and Bowler, 1987).

A hydrologic regime that approximates that of pre-development conditions is important for protecting water quality and aquatic biological communities (Roy et al., 2006). Approximating the pre-development hydrology is not likely to be achieved with centralized controls (i.e., end of pipe retention/detention basins). However, onsite retention and infiltration is a realistic and potentially effective way to accomplish this (Andoh and Declerck, 1997). With an onsite approach, stormwater is managed near the area generating the runoff and infiltration is maximized. Onsite stormwater management contrasts with centralized systems that collect runoff over a broad area, provide relatively little opportunity for infiltration and consequently must manage very large volumes. Individual onsite controls operate on a small scale but systems are distributed to act collectively in managing runoff across a large area. Incentives, utilities and/or market based programs should be explored as a means to achieve more effective and ecologically meaningful stormwater management. Parkyn et al. (2005) provide an analysis of options for addressing stormwater management in an environmentally and economically sustainable manner.

Onsite, or decentralized, stormwater management increases infiltration and reduces runoff generation by decreasing imperviousness. This is accomplished through appropriate planning, such as that used for Low Impact Development (LID). Low Impact Development is based on maximizing contiguous open space, protecting sensitive areas, namely floodplains and wetlands, and preserving existing vegetation (especially trees). Web-based resources for LID include: www.lowimpactdevelopment.org/. In a Low Impact Development, houses are located relatively closer to one another, roadways are narrower, and bio-retention and infiltration techniques are used. LID reduces runoff and can provide cost savings in stormwater infrastructure. Additional non-environmental benefits include a greater than average increase in property values.

Watersheds that retain relatively large areas of forest are able to better mitigate the impacts of increasing imperviousness than those with little forest cover (Brabec et al., 2006, Booth, 2005). The procurement of conservation easements and the establishment of parkland and nature preserves can help retain some of the existing forest cover as well as facilitate the conversion from open land to forest. Although land preservation alone is not likely to occur at a level necessary to mitigate development impacts, it will augment other measures that are taken (e.g., LID and/or discrete onsite stormwater management).

Stormwater abatement techniques that are employed in commercial developments and on individual residences (i.e., that are not a part of a LID) will provide protections to water quality.

In particular, parking lots often account for a very high proportion of the impervious surfaces in urban watersheds. According to the University of Connecticut Extension, impervious cover associated with automobile traffic accounts for a significant proportion of the total impervious cover in a given watershed (http://nemo.uconn.edu/).

At the scale of individual residences or businesses, stormwater abatement techniques can be used that include diverting drainage from rooftops, driveways, and other impervious surfaces away from a centralized collection system (e.g., outlets to either curb-and-gutter drains or stormwater sewer lines) and to permeable areas that can provide infiltration and/or temporary storage. Minimizing the extent of impervious surfaces by limiting their size or substituting them with permeable surfaces will also increase infiltration and detention for a given property.

Outreach and education activities are likely to result in some increase in this type of voluntary action taken by watershed residents, however to what extent would be very difficult to predict. Outreach efforts that include landscape design and construction companies may also be beneficial as they can present options for enhanced stormwater management to their prospective clients.

Excerpt from Section 9.2 Implementation Recommendations by Sub-watersheds

This section of the Olentangy TMDL describes the types of requirements and practices that should be implemented as future development occurs in order to protect water quality and the biological communities in the watershed.

9.2.3. Lower Olentangy

Point Sources

Threat to Resource Quality from Development

To protect against the degradation of water quality in one of the nation's most rapidly developing areas, the Ohio EPA recommends that general stormwater permits for construction activities be revised for the Delaware County and the uppermost Franklin County portion of the watershed downstream of the Delaware Reservoir. It is recommended that the NPDES General Permit for Storm Water Associated with Construction Activity Located within Portions of the Olentangy River Watershed include additional requirements, beyond the current statewide construction storm water general permit requirements. The additional requirements should include requiring submittal of the storm water pollution prevention plan (SWP3), riparian setback requirements and more stringent sediment and erosion controls which include performance standards.

Regional planning and local zoning authorities should adhere to the principles of Low Impact Development and encourage land preservation. Additionally, onsite stormwater management should be encouraged and incentives, utilities, and/or market based programs should be explored as a means to achieve this.

Case Study 2: Barberry Creek TMDL, Maine (2007)

TMDL Background

Barberry Creek, located just south of Portland, Maine, was listed as impaired for non-attainment of Maine's Class C aquatic life standards. Maine concluded that impairments were due primarily to a combination of pollutant (metals) and non-pollutant (stream habitat and low baseflow) stressors related to stormwater runoff from developed areas. The major sources of impairment are stormwater from the City of South Portland (regulated by a MEPDES stormwater general permit), and overland runoff from a highly urbanized drainage area. The TMDL calculated the total extent of impervious cover (% IC) in the watershed as a surrogate for the complex mixture of pollutant and non-pollutant aquatic life stressors which are attributable to stormwater discharges from developed areas. The current extent of impervious cover in the Barberry Creek watershed is estimated at 23% IC. The TMDL set a target of 12% impervious cover to guide implementation efforts. The TMDL also identified pollutant-specific loadings of lead and zinc as surrogates for numerous metals found in stormwater runoff.

The full Barberry Creek TMDL document is available at:

http://www.maine.gov/dep/water/monitoring/tmdl/2007/barberry_ck_rep.pdf

Excerpts from Section 7: Implementation Recommendations:

This section of the Barberry Creek TMDL describes the types of practices that should be implemented to restore and protect water quality and the biological communities in the watershed. This section also describes how an adaptive management approach should be built into the plan for implementing restoration actions.

Stormwater effects can be lessened, water quality improved, and impairments curtailed by implementing management practices and remedial actions in a cost-effective manner using the following adaptive management approach:

- Implement management practices strategically through a phased program which focuses on getting the most reductions, for least cost in sensitive areas first (for example, begin with habitat restoration, flood plain recovery, and treatment of smaller, more frequent storms);
- Monitor ambient water quality to assess stream improvement;
- Compare monitoring results to water quality standards (aquatic life criteria);
- Continue Implementation in a phased manner until water quality standards are attained.

Generally speaking, these abatement measures can take one of three forms: they can consist of general stream restoration techniques (including flood plain and habitat restoration), they can disconnect impervious surfaces from the stream, or they can convert impervious surfaces to pervious surfaces. In general, practices that achieve multiple goals are preferred over those that achieve only one goal (ENSR 2005). For example, installing a detention basin along with runoff treatment systems provides more effective abatement of stormwater pollution than installing detention best management practices (BMPs) alone. Because of the effort and cost involved in implementing these BMPs, a long-term strategy can be used to achieve water quality standards. For example, lower cost general stream restoration techniques that lessen stormwater effects immediately can be implemented in the short-term to initiate stream recovery.

The following three sections list the options available for BMPs aimed at stream restoration techniques, and disconnection and conversion of impervious surfaces. Because many factors must be considered when choosing specific structural BMPs (e.g., target pollutants, watershed size, soil type, cost, runoff amount, space considerations, depth of water table, traffic patterns, etc.), the sections below only suggest categories of BMPs, not particular types for particular situations. Implementation of any BMPs will require site-specific assessments and coordination among local authorities, industry and businesses, and the public.

In summary, implementation of remedial measures will occur under an adaptive management approach in which certain measures are implemented, their outcome evaluated, and future measures, selected so as to achieve maximum benefit based on new insights gained. The order in which measures are implemented should be determined with input from all concerned parties (e.g., city, businesses, industry, residents, regulatory agencies, watershed protection groups). It is suggested that the City develop implementation recommendations by the end of 2006 and present them to the watershed stakeholders, the

Rain gardens disconnect impervious surfaces by intercepting runoff from roads, parking lots, or roofs and allowing it to soak into the ground.

Cumberland County Soil and Water Conservation District, and MDEP. In the annual report required each year by the MEPDES stormwater general permit (MS4), the City should highlight its efforts to meet the wasteload allocation of this TMDL.

General Stream Restoration Techniques

- Encouraging responsible development by promoting Smart Growth or Low-Impact Development guidelines and the use of pervious pavement techniques will minimize overall effects of urbanization.
- Reducing new impervious cover by promoting shared parking areas between homes or between facilities that require parking at different times will reduce impacts related to impervious surfaces. Lowering minimum parking requirements for businesses and critically assessing the need for new impervious surfaces will have the same effect.

Disconnection of Impervious Surfaces

- Channel runoff from large parking lots, roads or highways into
  - Detention/retention BMPs (e.g., dry/wet pond, extended detention pond, created wetland), preferably one equipped with a treatment system;
  - Vegetative BMPs (e.g., vegetated buffers or swales);
  - Infiltration BMPs (e.g., dry wells, infiltration trenches/basins, bio-island/cells);
  - Underdrained soil filters (e.g., bioretention cells, dry swales).
- Guide runoff from paved driveways and roofs towards pervious areas (e.g., grass, driveway drainage strip, decorative planters, and rain gardens).
- Remove curbs on roads or parking lots.
- Collect roof runoff in rain barrels and discharge into pervious areas.

Conversion of Impervious Surfaces

- Replace asphalt on little-used parking lots, driveways or other areas with light vehicular traffic with porous pavement blocks or grass/gravel pave.
- Replace small areas of asphalt on large parking lots with bioretention structures (bio-islands/cells).
- Replace existing parking lot expanses with more space-efficient multistory parking garages (i.e., go vertical).
- Replace conventional roofs with green roofs.

These options for conversion of impervious surfaces also provide for a virtual elimination of runoff during light rains (which account for the majority of runoff events), reduction in peak discharge rate and volume during heavy rains, filtration of some pollutants, and improvement in groundwater recharge.

By mimicking natural hydrology, green infrastructure can reduce channel erosion and the associated loss of habitat and species diversity.

Green Infrastructure Permitting and Enforcement Series

*This series on integrating green infrastructure concepts into permitting, enforcement, and water quality standards actions contains six factsheets plus four supplemental materials that can be found at **http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries**.*

Factsheets

1. Potential Challenges and Accountability Considerations
2. Combined Sewer Overflows
3. Sanitary Sewer Overflows
4. Stormwater
5. Total Maximum Daily Loads
6. Water Quality Standards

Supplemental Materials

1. Consent Decrees that Include Green Infrastructure Provisions
2. Consent Decree Language Addressing Green for Grey Substitutions
3. Green Infrastructure Models and Calculators
4. Green Infrastructure in Total Maximum Daily Loads (TMDLs)

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For additional resources on green infrastructure, go to the EPA Green Infrastructure Web page: http://www.epa.gov/greeninfrastructure/.