

## Chapter 5



*Above: Bioswale along a public road  
(photo: Chagrin River Watershed Partners)*



*Above Right: Repairing damage to infrastructure due to excessive storm water from increased impervious surface upstream can be a significant community expense.  
(photo: Cuyahoga Valley National Park)*

# STORMWATER MANAGEMENT, EROSION & SEDIMENT CONTROL

## Background

### *What is Stormwater Management?*

Stormwater Management is the long-term, post-construction control of the increased volume, flow rates, and quality of stormwater runoff that are caused by manmade disturbances to land. Such controls consist of a system of structural and non-structural measures, referred to as Best Management Practices (BMPs). The goal of implementing stormwater management BMPs for disturbed lands is to achieve approximately the same stormwater runoff and infiltration characteristics that existed prior to development, and to minimize stormwater pollution.

*Structural BMPs* refer to engineered physical structures designed to collect, retain and/or treat runoff before it is discharged. Structural BMPs typically require engineering design and engineered construction. Examples include detention basins, retention basins, infiltration basins, porous concrete/pavement, bioretention cells, and vegetated swales, among others.

**BMPs reduce downstream flooding, benefiting floodplain property values.**

(Beggs & Perrin, n.d.)

*Non-structural BMPs* are integrated site planning, soil preservation and pollution-prevention practices implemented to prevent or minimize pollutants from entering stormwater runoff and/or reduce the volume and flow rates of stormwater runoff. These BMPs are focused more on the layout and management of sites, generally do not involve specific storm water facilities, and usually work by changing how a site functions through various land use practices or regulations. Examples include improving water infiltration (e.g. disconnecting downspouts), planting vegetation (e.g. trees), Conservation Subdivisions, Stream & Wetland Protection, and Woodland Protection.

Stormwater management is generally most effective when a combination of structural and non-structural BMPs is utilized. More information on structural and non-structural BMPs is available in the resources.

### ***What is Erosion & Sediment Control?***

Erosion and Sediment Control is a term that deals specifically with the controls utilized during soil disturbing activities, such as those found on construction sites, that minimize the impact these activities have on other properties and receiving waters.

*Erosion control* involves minimizing the detachment of soil particles during the rainfall-runoff process. Detachment of soil particles can occur during rainfall impact onto bare soil and by runoff eroding and transporting soil particles as the runoff flows across the disturbed area. Erosion control is achieved through the use of practices such as minimizing land disturbances to the site, maintaining natural vegetative cover, seeding and mulching where no vegetation exists, and applying compost blankets or erosion control mats.

*Sediment control* involves capturing runoff that flows across the disturbed area in a structural or non-structural BMP and settling out a significant fraction of the transported soil particles (i.e. sedimentation) before the runoff leaves the construction site so that impact to other properties and receiving waters is minimized. This can be achieved through practices such as silt fence installation, compost berms or filter socks, swales, slope drains, and sediment control basins. The degree to which the sediment control BMP promotes sedimentation of soil particles from the runoff is referred to as its trapping efficiency. The trapping efficiency of various sediment control BMPs can vary significantly and they must be strategically utilized and located based upon expected conditions. For more information on ESC practices, refer to the Resources and Additional Resources.



*Flooding caused by increased storm flows due to expanding impervious surfaces in a watershed can have a significant impact on daily life and business.*

*(photo: C. Riddle)*

### ***Why Stormwater Management and Erosion/Sediment Control?***

The benefits of stormwater management and erosion and sediment control are well documented in Ohio and nationwide. The quantity of stormwater runoff to streams and other water resources has increased as communities grow and expand parking lots, roads, rooftops, and other impervious surfaces, while impacting stream corridors and wetlands that naturally control flooding, limit erosion, and protect water quality. The results of this increase in impervious cover and loss of natural landscape and stream corridor services are increases in storm water runoff volume and flow rates, which include increased velocities, and decreases in water quality.

These impacts are evident in the increased magnitude and frequency of flash flooding, increases in stream bank erosion, and decreases in urban water quality. Flooding, erosion, and water quality problems result in property and infrastructure loss and the degradation of water resources. In areas where groundwater is critical for drinking water and commercial purposes, controlling stormwater quality and quantity is central to ensuring that groundwater is recharged and will retain the quality necessary for its use.

The use of stormwater management/erosion and sediment control tools provide a direct return on investment to communities and landowners by reducing future costs from flooding and erosion, and improved water quality. For example, erosion costs might come in the form of streambank stabilization projects to protect property and infrastructure (e.g. pipelines, bridges, or homes); flooding costs might come in the form more frequent and higher floods, which can adversely impact property and infrastructure. Improved water quality might limit the need for waste water treatment plant upgrades.

Non-structural BMPs, such as natural vegetation and landforms, slow, store, infiltrate and filter stormwater runoff and floodwaters, reducing flooding and erosion, reducing sedimentation, and improving water quality. The preservation and restoration of these natural features as land is developed provides for a lower-cost, lower-maintenance alternative to higher-cost, increased-maintenance, man-made structural BMPs. However, a combination of structural and non-structural BMPs through good site design and construction site management along with local, county and/or regional land use planning (e.g. floodplain management) will be most effective at reducing on-site and off-site flooding, erosion and sedimentation, and water pollution impacts.

In addition to lowering the burden on traditional water infrastructure, incorporating BMPs into new developments can reduce development costs (due to smaller costs for piping and detention facilities, grading, paving, etc.) and increase property values (due to proximity to open space and similar amenities).

(US EPA 2007)

### ***How do stormwater management and erosion and sediment control relate to Balanced Growth?***

Stormwater management and erosion and sediment control are our primary tools for reducing impacts to water quality as a result of development of the watershed. Every BMP implemented will result in better quality of our water resources – by slowing, storing, filtering and infiltrating stormwater runoff. Erosion and sediment control measures add to stormwater management measures by reducing soil and sedimentation, which are significant pollutants in our streams, lakes and rivers. In keeping with the economic goals of Balanced Growth, stormwater management and erosion and sediment control also provide economic benefit – by reducing water quantity and quality impacts, our properties are better protected from flooding and sedimentation; our communities save tax money through reduced infrastructure needs; and our quality of life is ensured for prosperity in the future.

### ***How do communities manage their stormwater?***

Typically, a community or county adopts a storm water management and erosion/sediment control ordinance or resolution, which can be part of the zoning code or subdivision regulations, or a stand-alone regulation. These regulations usually require the application of stormwater BMPs to new construction or redevelopment projects as well as erosion and sediment controls during soil disturbing activities.

Urban, limited home rule townships can adopt either type of these regulations; other townships can only adopt stormwater management, and typically fall under county authority for erosion and sediment control. Many townships provide zoning inspection or other collaborative services under an overarching county storm water regulation; some provide for the extension of the county regulation to smaller site disturbances than would otherwise be allowed. Township authority in the storm water area is complex, and it is recommended that communities consult with their law director regarding adoption or implementation of stormwater regulations.

In many cases it is most convenient and cost-effective for both municipalities and townships to contract with a county agency or department to provide both erosion-sediment control and stormwater program management services.

In Ohio and most other states, communities that are operators of Municipal Separate Storm Sewer Systems (MS4s) are required by the USEPA's National Pollution Discharge Elimination System (NPDES) program to implement stormwater management and erosion and





*Pervious pavement and rain garden with a curb cut (photo: Chagrin River Watershed Partners)*

sediment control plans. Communities that are not operators of MS4s can also benefit from stormwater management and erosion and sediment control regulations, particularly if there are development pressures near water resources. A county-wide stormwater management and erosion and sediment control program can encompass all communities which elect to participate.

A variety of additional zoning and land management tools are available to local governments to manage storm water and protect stream (riparian) and wetland functions, including stream and wetland setbacks, source water protection, and floodplain management, explored more thoroughly in other chapters.

Typically, stormwater management happens at the county level. Some municipalities and townships have their own programs; others work with their county agency. The overall approach differs from county to county: often it is the county's Soil & Water Conservation District or County Engineer's office that administers the stormwater management program; other times it is a stormwater management District. In cities, the Service Department, Building Department, or Zoning and Planning Department may be involved. There also are regional sewer districts that encompass multiple counties. Stormwater districts operate under Ohio Revised Code 6119 provisions for management of stormwater, sewer and water infrastructure.

### ***What is the NPDES Phase II Stormwater Program and who does it pertain to?***

The NPDES Stormwater Program regulates stormwater discharges from three potential sources: municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. Most stormwater discharges are considered point sources, and operators of these sources may be required to receive an NPDES permit before they can discharge. While Phase I of the program addressed stormwater runoff from large and medium municipalities (MS4s with population over 100,000), Phase II addresses runoff from communities with populations of less than 100,000. The program applies to all owners or operators of Municipal Separate Storm Sewers (MS4s) in urbanized areas including townships, villages, cities, counties, and non-traditional MS4s such as park districts. To comply with this program, these MS4 operators are required to do the following:

1. Implement a Storm Water Management Program (SWMP) detailing how the community will complete:
  - Public Education and Outreach
  - Public Involvement & Participation

- Illicit Discharge Detection & Elimination
- Construction Site Runoff Control
- Post Construction Runoff Control
- Pollution Prevention/Good Housekeeping

2. Require that all owners or operators of construction activities disturbing one (1) acre or more, or less than one (1) acre if it is part of a larger common plan of development, prepare a Storm Water Pollution Prevention Plan (SWP3) detailing how applicant will:

- Treat stormwater quality
- Minimize erosion
- Control sediment
- Control nonpoint pollution

Per the Ohio Construction General Permit, the SWP3 must be prepared in accordance with sound engineering and/or conservation practices by a professional experienced in the design and implementation of standard erosion and sediment controls and storm water management practices addressing all phases of construction and post-construction controls.

For more information regarding the Phase I and Phase II Stormwater Programs, refer to the Resources.

### ***The Role of Low Impact Development and Green Infrastructure***

In many cases, storm water management can be completely or partially achieved through Low Impact Development (LID). LID is a site design approach to storm water management that seeks to integrate hydrologically functional design with pollution prevention measures to compensate for land development impacts on hydrology and water quality. LID's goal is to mimic natural hydrology and processes by using site design and small-scale, decentralized practices that infiltrate, evaporate, detain, and transpire storm water. LID practices are uniformly and strategically located throughout the site.

Green infrastructure practices support LID principles with natural storm water management design features utilizing trees, plants, soil and water. "Green" infrastructure practices such as bioswales, vegetated swales, amended soil, and tree plantings can manage stormwater just as effectively as "gray" infrastructure, and often cost less to install and maintain.

**Keeping water clean through stormwater management practices is always cheaper than water treatment.**

(US EPA 2007)

LID is achieved by:

- Minimizing storm water runoff impacts to the extent practicable through preservation of existing landscape features, such as soil profiles, streams and wetlands, and their hydrologic functions.
- Maintaining or increasing predevelopment time of concentration through strategic routing of surface flows using a variety of site-design techniques.
- Dispersing runoff storage measures through a site's landscape with the use of a variety of detention, retention, infiltration and runoff and other management practices.

LID is a design approach that must be implemented early in the site-design process. LID measures provide post-construction water quality benefits. The LID principles differ from other Best Management Practices (BMPs) in that they are designed to minimize disturbance and manage storm water as close to its source as possible, as opposed to more centralized BMPs such as detention basins. Some examples of LID practices include:

- Pervious pavements
- Parking lot filter strips
- Impervious surface reduction through alternative site layouts
- Soil Preservation
- Stream (riparian) and wetland setbacks
- Bioretention cells
- Vegetated swales
- Cistern & rain barrels
- Infiltration trenches
- Green roofs
- Soil amendments to increase permeability

The Ohio Development Services Agency offers a below-market-rate loan program for the development of low-impact development practices and other BMPs. For more information, refer to the Resources.



*Woods at Jefferson Subdivision  
Raingarden, Columbus, Ohio  
(photo: Central Ohio Rain Garden Initiative)*

## Issues

- **Regulations:** Ohio EPA Has Set the Minimum Standard: Ohio EPA's NPDES Construction Stormwater General Permits apply to all owners and operators of construction sites disturbing 1 acre or more, or less than 1 acre if part of a larger common plan of development or sale and includes erosion and sediment control requirements and storm water quality requirements. Communities should ensure their erosion and sediment control regulation and storm water management regulation meets these standards at a minimum. Some communities may choose to exceed the minimum regulations. They should work with their community engineer and local district Ohio EPA representative to ensure consistency with surrounding communities and avoid conflicts with regulations.

**Meeting Ohio EPA's Requirements for Stormwater Quality Control:** Ohio EPA's requirements for storm water quality necessitate that new storm water infrastructure be designed to effectively detain storm water runoff for a period sufficient to protect stream channels and water quality. This will result in increased maintenance and related funding requirements as storm water infrastructure, such as detention basins, will be intentionally designed to promote sedimentation.

**Operation and Maintenance:** In light of these requirements, it is important that communities ensure the long-term operation and maintenance of storm water management infrastructure by establishing procedures for inspection and funding when these facilities are constructed.

- **Program Rules:** The Ohio Revised Code requires construction erosion and sediment control, post-construction stormwater management and stormwater management plans that address new development and redevelopment which disturbs land of one (1) acre or more. Communities may choose to address smaller plots of land through local zoning resolutions that require erosion and sediment control and storm water management, on sites less than one (1) acre. However, not all communities may have the legal authority to impose more stringent construction stormwater requirements because of home rule authority or lack thereof. Moreover, other state law may prohibit laws or rules that are more stringent than U.S. EPA regulations. As noted above it is recommended that communities consult with their law director or designated legal counsel regarding their authority to implement storm water programs.



Stream and floodplain preservation is the most cost-effective means of minimizing flood damage and controlling erosion.

(Chagrin River Watershed  
Partners, Inc. 2006)

- **Low Impact Development:** Site Considerations: High clay content soil, high water tables and other site-specific considerations may reduce the cost-effectiveness of LID practices and should be considered during project review.

Deed Restrictions: Maintaining distributed storage and treatment measures within residential subdivisions will require deed restrictions on individual parcels as well as homeowner education to ensure measures are maintained.

Developers may consider locating stormwater infrastructure in right of way and common areas.

Zoning Variances: Variances from zoning, subdivision, building, storm water management, and drainage regulations may be required unless LID is permitted under the storm water management regulations.

- **Runoff Velocity:** One of the chief problems with storm water runoff is velocity. Historically, the approach to managing storm water was to remove it as quickly as possible from the site where it fell, usually through underground systems that directly collected both surface water and roof water. As a result, the increased runoff reached the natural drainage systems (stream and waterways) sooner and with much greater volume and velocity than before development. The cumulative effects of such an approach have been a major cause of accelerated downstream channel erosion and increased frequency and magnitude of flooding downstream from urban development. This issue of velocity is addressed in new construction via the enforcement of release rates from a site into receiving waters that mimic predevelopment rates. The Ohio Department of Natural Resources offers a release rate model that communities may use for guidance. For more information, see the Resources.

- **Stormwater Utilities:** Many communities and/or counties have created storm water utilities and departments that manage storm water programs with funds generated by resident and business fees. Often the fee is based on the amount of impervious surface on a typical or actual site, and the level of service is based on the need within the community, as well as the amount of revenue the community is able to generate through the stormwater program. Many of these programs allow for credits or reduced fees for on-site stormwater management practices, and reduction of impervious surface area.

The choice of fee basis method is of critical importance to the long term success of the utility; options should be carefully evaluated in light of community needs and typical conditions.

- **Complete Streets:** Complete Streets is a planning concept that characterizes a street as a thoroughfare not only for automobiles, but also for multiple purposes to meet the needs of all community members. A Complete Street is designed for use of the young, the old, the motorcyclist, the bicyclist, and the walker or wheelchair user.. In addition, streets can be seen as key locations for enhancing the green infrastructure of a community, with stormwater management structural practices in place to help improve infiltration and reduce runoff from the street itself. Many standards and practices in use by road designers, including the AASHTO Green Book, the TRB Highway Capacity Manual, and the FHWA Manual on Uniform Traffic Control Devices, are in the process of being revised to incorporate Complete Street practices. For more information, see the Resources.

## 6 Structural Post-Construction BMPs Recommended by the Ohio EPA



*Bioretention area in a parking lot  
(photo: Chagrin River Watershed Partners)*



*Fleet Avenue, a "complete, green street" in Cleveland's Slavic Village neighborhood that utilizes bike lanes, bioretention bump-outs and other green infrastructure. Construction to commence in late 2013.  
(photo: Human Nature)*

1. Grass Filter Strips
2. Enhanced (Water Quality) Swales
3. Bioretention Cells
4. Sand Filters
5. Infiltration Trenches
6. Water Quality Ponds
  - Dry Extended Detention Basin
  - Wet Extended Detention Basin
  - Constructed Wetland



(Photo: Beatrice Murch)

## Recommendations

### 1. Provide a combination of structural and non-structural BMPs:

An essential part of the comprehensive planning process should begin with the careful strategizing of non-structural BMPs, such as the placement of Priority Development Areas (PDAs) and Priority Conservation Areas (PCAs), the implementation of Stream and Wetland Setbacks, and Conservation Development Subdivisions. (see the Introduction chapter, and the chapters on stream protection, and conservation development.)

**2. Adopt zoning and other appropriate land-use and management provisions:** This allows a community to address storm water management and erosion and sediment control, and allows for the use of low impact development techniques by interested landowners. This may be done through a comprehensive regulation related to site development or a set of related regulations, and should be done in concert with county and regional storm water regulations and programs.

**3. Enforce Site Runoff Release Rates:** Adopt site release rates that mitigate runoff velocity. The Ohio Department of Natural Resources recommends that development sites control the post-development peak rate of runoff up to the critical storm (e.g. 5-year, 24-hour) so that the peak discharge from more frequent storm events including the critical storm does not exceed the pre-development peak discharge from the 1-year, 24-hour duration storm event for the same area. (Determination of the critical storm is based on the percentage of increase in volume of runoff as a result of development.) Subsequently, the less frequent post-development storm events than the critical storm (e.g. 25-year, 24-hour) should not exceed the pre-development peak discharge for the same storm event for the same area. This stormwater management strategy combined with the Ohio EPA's water quality volume requirement will control release rates that slow runoff velocities and thereby minimize or prevent downstream impacts from development sites. Refer to ODNR's "Ohio Stormwater Control Guidebook", and the Ohio EPA Stormwater Program under Resources for more detailed information.

**4. Review Parking and Street Standards:** Conduct a detailed review of the community's parking standards and road/street design. It is not uncommon after such a review, to determine that substantial reductions can be made, and street redesign may yield new opportunities for state-of-the-art project design, as well as green infrastructure practices.

For more information on parking and innovative solutions to minimize parking requirements while meeting parking needs, see CRWP's "Review of National Trends in Parking Requirements" in the Resources.



**5. Integrate your SWM Plan:** Ensure your community's SWM Plan is integrated into daily activities including site plan review, zoning requirements, public involvement, municipal operations, floodplain management, education and outreach.

**6. Incorporate ongoing monitoring into community activities:** Evaluate the SWM Plan annually; ensure site practices are inspected and maintained, and the provisions for monitoring and maintenance are in place at the project level.

**7. Apply SWM Plans even if not legally required to do so:** Communities without regulatory obligations should consider incorporating aspects of SWM Plans that apply to them, to ensure protection of valuable water resources and property.

**8. Design and Review Process:** Create a project design and review process in the storm water management code that enforces the integration of storm water management concerns early in the project design process, instead of adding BMPs at the end of project design. This can be done by requiring attention to storm water management approaches at the pre-application and concept plan review stages, prior to submittal of the preliminary plan.

## **Erosion and Sediment Control & Storm Water Management Checklist**

**1. Meet Ohio EPA Standards:** Regulations should meet or exceed Ohio EPA minimum standards for erosion and sediment control and storm water management best management practices, as detailed in the most recent version of the NPDES General Permit for Construction Sites.

**2. Erosion and Sediment Control and Storm Water Management Plan Review, Inspection, and Enforcement:** Regulations should have provisions for plan review prior to construction, regular inspections during construction, and provide the community with the authority to stop work, where allowable by local laws, for activities not in compliance with an approved plan.

**3. Allow for the Implementation of Low Impact Development Techniques:** A community's storm water management regulation should allow for the implementation of low impact development techniques and provide community staff with the resources necessary to review such proposals and ensure on-going operation and maintenance.



**4. On-going Operation and Maintenance:** Under both erosion and sediment control regulations and storm water regulations, communities must ensure that contractors provide sufficient funds to stabilize sites if the contractor is unable to complete erosion and sediment control requirements. Similarly for storm water management, communities must ensure that landowners make provisions for on-going operation and maintenance of any structural or non-structural storm water best management practices. It is important that communities clarify long-term costs and have funds available for on-going operation and maintenance before problems develop. Where BMPs are located on private property, communities may want to consider access and maintenance easements to facilitate longterm maintenance. In general, delegating these responsibilities to homeowner associations is not an effective long-term solution.

## Example Regulations

The following example codes are outlined in the Example Regulations Matrix (link):

### Stormwater:

Chagrin River Watershed Partners, *Comprehensive Stormwater Management Model Ordinance* (2010)

<http://www.crowp.org/index.php/member-services/model-regulations/storm-water-management>

Geauga County, *Geauga County Water Management and Sediment Control Regulations, Post-Construction Storm Water Control Methods* (Section 4.04) [http://www.geaugaswcd.com/construction\\_sites](http://www.geaugaswcd.com/construction_sites)

Hamilton County, *Post Construction Storm Water Quality Regulations (Article V)* [http://www.hamilton-co.org/stormwater/HCSWD\\_Rules\\_And\\_Regulations.htm](http://www.hamilton-co.org/stormwater/HCSWD_Rules_And_Regulations.htm)

NOACA, *Ordinance Controlling Post-Construction Water Quality* <http://www.noaca.org/index.aspx?page=99>

TMACOG, *Stormwater Management Standards Manual, Sediment and Erosion Control Ordinance* [http://www.tmacog.org/Environment/TMACOG\\_Stormwater\\_Standards\\_Manual\\_.pdf](http://www.tmacog.org/Environment/TMACOG_Stormwater_Standards_Manual_.pdf)

### Erosion and Sediment Control:

Chagrin River Watershed Partners, *Model Ordinance for Erosion and Sediment Control* <http://www.crowp.org/index.php/member-services/model-regulations/erosion-sediment-control>

Geauga County, Geauga County Water Management and Sediment Control Regulations [http://www.geaugaswcd.com/construction\\_sites](http://www.geaugaswcd.com/construction_sites)

Hamilton County, *Earthwork (Erosion and Sediment Control Rules and Regulation) (Article III)* <http://www.hamilton-co.org/>

Lake County, *Erosion & Sediment Control Rules* <http://www.lake-countyohio.gov/RulesandPermits/ErosionandSedimentControlRules/tabid/633/Default.aspx>

NOACA, *Ordinance Controlling Construction Site Soil Erosion, Sediment, and Other Wastes and Storm Water Runoff* <http://www.noaca.org/reglmodord.html>

### Impervious Surface Coverage Percentages:

Multi-Resolution Land Characteristics Consortium (MRLC), National Land Cover Database  
<http://www.csc.noaa.gov/digitalcoast/data/nlcd-impervious/>

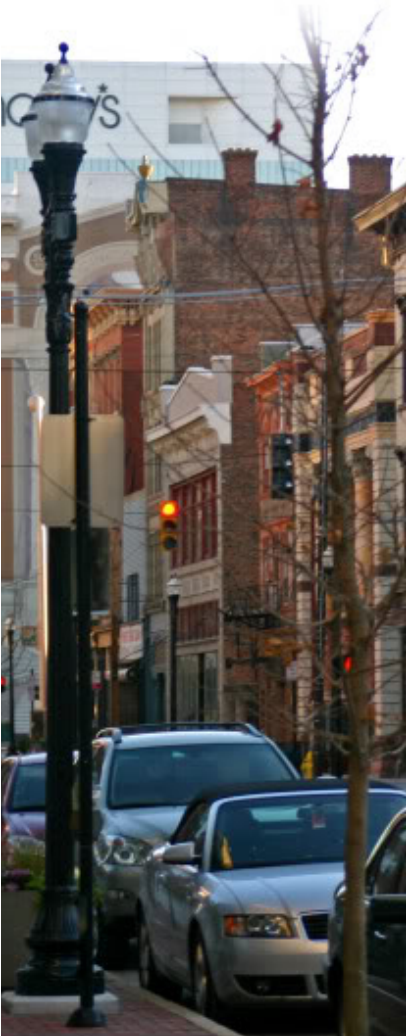
### Updated Parking Standards:

City of Columbus, Ohio; Department of Development, Planning Division: Title 33 (Zoning Code), Chapter 3372 (Planning Overlay), Section 521 (Supplemental Parking Requirements) (2010)  
[https://www.municode.com/library/oh/columbus/codes/code\\_of\\_ordinances](https://www.municode.com/library/oh/columbus/codes/code_of_ordinances)

Chagrin River Watershed Partners, *Review of Nation Trends in Parking Requirements* (2005) <http://www.crwpp.org/index.php/member-services/model-regulations/off-street-parking>

## Use of the Guidance and Example Regulations

This example guidance and/or regulations **should never be adopted without careful legal review** to assure that they are adapted to fit the authority and needs of the specific governmental body. They may need to be adapted for use by the specific type of local government and must be independently evaluated against potentially applicable federal or state law. **The law director/ solicitor, county prosecutor or other appropriate qualified legal counsel should always be consulted prior to adoption of any enforceable measures** based upon this guidance document to insure compliance and consistency with any applicable state and federal law, and to consider potential legal ramifications and liability in the implementation of the laws or rules to be adopted. Questions about the models and guidance can be directed to the Ohio Balanced Growth Program.



Parking on Vine Street, Cincinnati, Ohio  
(Photo: UrbanCincy)

## Resources

Always start by checking with your local resources. Local government agencies and non-government organizations might have the most up-to-date information on these issues and will have the most expertise for the unique characteristics of your region.

- **Your Local Metropolitan Planning Organization**
- **Your Local County or Municipality Planning Commission and Engineer's Office**
- **Your Local County Soil and Water Conservation District**
- **Your Local Watershed Group**
- **Your Ohio EPA District Office**

**Ohio Department of Natural Resources**, *Rainwater and Land Development Manual* (2010); [http://soilwater.ohiodnr.gov/portals/soilwater/pdf/stormwater/3-3-14RLD\\_All.pdf](http://soilwater.ohiodnr.gov/portals/soilwater/pdf/stormwater/3-3-14RLD_All.pdf)

**Ohio Department of Natural Resources**, *Ohio Stormwater Control Guidebook* (1980); <http://soilandwater.ohiodnr.gov/portals/soilwater/pdf/stormwater/OhioSWControlGuidebook1980.pdf>

**Ohio EPA**, Division of Surface Water, Stormwater Program (2011); <http://www.epa.state.oh.us/dsw/storm/index.aspx>

**Ohio EPA**, Division of Surface Water, Stormwater Program, *Ohio Administrative Code Chapter 3745-39* (2009); [http://www.epa.state.oh.us/dsw/rules/3745\\_39.aspx](http://www.epa.state.oh.us/dsw/rules/3745_39.aspx)

**Ohio Development Services Agency**, Alternative Stormwater Infrastructure Loan Program (2011); [http://development.ohio.gov/cs/cs\\_alt-stormwater.htm](http://development.ohio.gov/cs/cs_alt-stormwater.htm)

**Ohio Department of Natural Resources**, Division of Soil and Water Resources, Floodplain Management Program; <http://soilandwater.ohiodnr.gov/water-use-planning/floodplain-management>

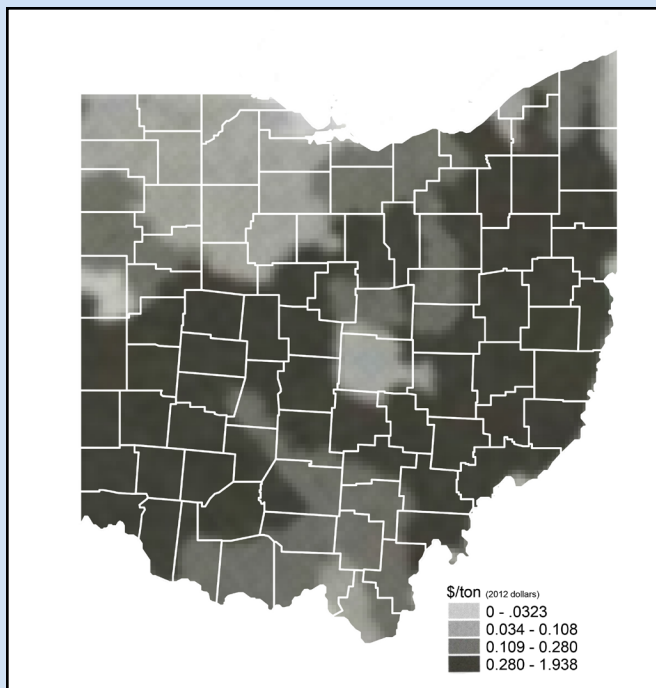
**The Chagrin River Watershed Partners**, *Review of National Trends in Parking Requirements* (2005). Prepared by FMSM Engineers for Chagrin River Watershed Partners; <http://www.crwpp.org/index.php/member-services/model-regulations/off-street-parking>



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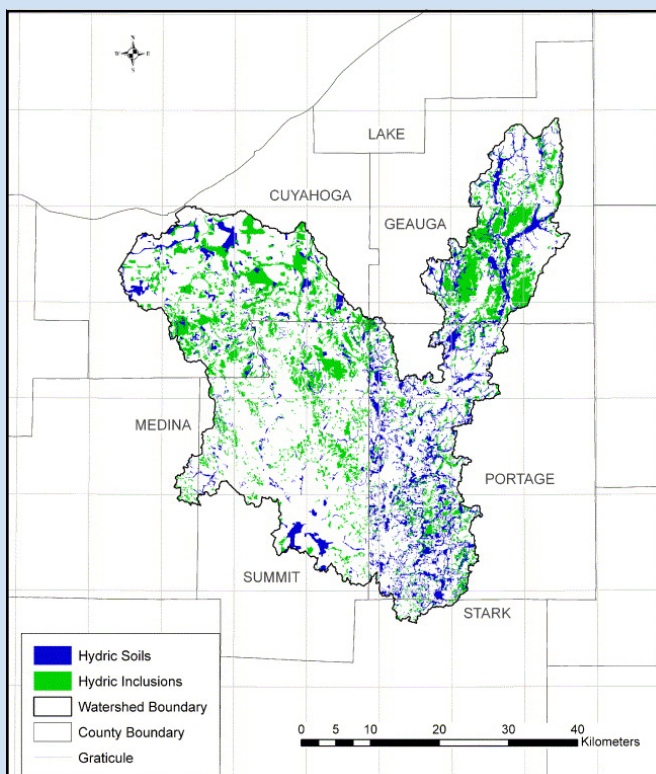
## Marginal Benefits of Reduced Erosion in Ohio



In a study that used replacement cost theory to evaluate the impact of soil conservation on reservoir services, results show that the marginal benefit of a one-ton reduction in soil erosion varies widely across watersheds. Results show that, across the 326 Ohio watersheds, a one-ton reduction in soil erosion provides benefits of up to \$1.94 per ton reduced. These benefits are realized through reductions in reservoir sediment which in turn reduce risks of flooding, increase storage capacity for power generation, increase the productivity of fish stocks, and maintain the depth of water around boat docks. (Hansen and Hellerstein, 2007)

*The Marginal Benefits of Reduced Erosion in Ohio*  
(map: Gregory SJ Soltis)

## Sediment in the Cuyahoga River



Runoff and sediment from residential development, construction sites and agricultural lands may enter the Cuyahoga River watershed's streams and lakes. Also, runoff may carry other pollutants, such as lawn and agricultural chemicals (pesticides and fertilizers), effluent from septic systems, oil and gas from spills, and industrial wastes. The U.S. Geological Survey (USGS) tabulated suspended solid loads on the Cuyahoga River at Independence, where the river flows from Summit County into Cuyahoga County, and calculated total sediment loading based on total drainage area and average annual flow. The average sediment load for the Cuyahoga River is 300,000 tons per year, which means that about 1159 pounds of soil per acre in the watershed enters surface waters through erosion each year. (USGS)

*Map of hydric soils and soils with hydric inclusions in the Cuyahoga River watershed.*  
(map: White & Fennessy, 2005)



## Other Resources

**Center for Watershed Protection** (2011) <http://www.cwp.org/>

**The Low Impact Development Center** (2011); <http://www.lowimpactdevelopment.org/>

**Maryland Department of the Environment, Maryland Storm Water Design Manual Volumes I and II** (2009); [http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater\\_design/index.aspx](http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx)

**National Association of Home Builders Research Center, Toolbase Resources**; <http://www.toolbase.org/>

Thomas R. Schueler, *Environmental Land Planning Series: Site Planning for Urban Stream Protection* (1995). [http://www.mwcog.org/store/item.asp?PUBLICATION\\_ID=56](http://www.mwcog.org/store/item.asp?PUBLICATION_ID=56)

**U.S. Environmental Protection Agency, Division of Water, Urban Run-off** (2011); <http://water.epa.gov/polwaste/nps/urban.cfm>

**FEMA Library, The Natural & Beneficial Functions of Floodplains, Reducing Flood Losses by Protecting and Restoring the Floodplain Environment**, FEMA Publication Number 409 (order free hardcopy) (Scroll down to the section entitled "Search by FEMA Publication Number" towards the bottom of the page, then type "409" under "Search Criteria" where it says "FEMA Publication Number"); <https://www.fema.gov/media-library/assets/documents/2128>

**Association of State Floodplain Management (ASFPM), Natural and Beneficial Floodplain Functions: Floodplain Management – More than Flood Loss Reduction**; [http://www.floods.org/PDF/WhitePaper/ASFPM\\_NBF%20White\\_Paper\\_%200908.pdf](http://www.floods.org/PDF/WhitePaper/ASFPM_NBF%20White_Paper_%200908.pdf) (Copy and paste this address into your web browser)

See the Comprehensive Planning Chapter for resources on complete streets.

For additional references cited, see the Bibliography in the Appendix, <http://balancedgrowth.ohio.gov/BestLocalLandUsePractices/BestLocalLandUsePractices2012.aspx>