Adapting Watershed Tools to Protect Wetlands

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Wetlands & Watersheds Article #3

Prepared by:

Karen Cappiella, Tom Schueler, Julie Tasillo, and Tiffany Wright
Center for Watershed Protection
8390 Main Street, 2nd Floor
Ellicott City, MD 21043
www.cwp.org
www.stormwatercenter.net

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www.cwp.org

Executive Summary

Wetlands are impacted by land use activities that occur in or near wetlands, and within the watersheds that drain to them. Historically, wetland impacts have been regulated on a site-by-site basis by federal and state authorities. However, local governments have a very important role to play in wetland protection because they are responsible for the land use decisions that can impact wetlands, and can take a proactive approach that extends beyond individual sites to include the larger watershed. In addition, local governments can protect small or isolated wetlands or other natural resources that might not be regulated under the federal and state permitting programs.

Impacts to wetlands can greatly affect watershed health because wetlands are such an integral part of watershed hydrology, and provide many watershed benefits, such as pollutant removal, flood storage, erosion control, wildlife habitat, and groundwater recharge. Despite the strong connection between wetlands and watersheds, few communities comprehensively manage their wetland inventory in the context of local watershed plans. A watershed approach to local wetland management is needed so that wetlands are no longer managed separately from other water resources or on a site-by-site basis. Article 2 provides guidance on implementing such an approach. The purpose of this article is to provide guidance on one component of the watershed approach: adapting watershed tools to protect wetlands.

This article presents 37 specific techniques for protecting wetlands through local programs and ordinances related to development and other land use activities. The audience for this article includes local natural resource managers and land use planners who would benefit from guidance on tools to protect wetlands. The techniques presented in this article are organized by the Eight Tools of Watershed Protection, which are implemented as part of local watershed plans to provide comprehensive watershed protection. This article describes each watershed protection tool, and provides specific guidance on how to adapt each tool to protect wetlands and the watersheds of which they are a part.

The eight tools of watershed protection represent a comprehensive approach to protect aquatic resources in watersheds facing land development. The eight tools roughly correspond to the stages of the development cycle including initial land use planning, site design and construction, and ultimate occupancy and long-term maintenance. As a result,

local watershed managers will generally need to apply some form of all eight tools in every watershed to provide comprehensive protection. A local watershed plan is often used to define how and where the eight tools are specifically applied to meet their unique water resource objectives. Each of the eight tools should be specifically applied to protect unique wetland resources in watersheds that may be vulnerable to impacts from future development. Table E-1 presents wetland protection strategies for each of the eight tools that can be applied in or near wetlands.

Table E-1. Wetland Protection Strategies Applied In or Near Wetlands

Watershed Protection Tool	Strategies Applied In or Near Wetlands
1. Land Use Planning	• Incorporate wetland management into local watershed plans • Adopt a local wetland protection ordinance • Adopt floodplain, stream buffer, or hydric soil ordinance to indirectly protect wetlands
2. Land Conservation	• Identify priority wetlands to be conserved • Select techniques for conserving wetlands
3. Aquatic Buffers	• Require vegetated buffers around all wetlands • Expand wetland buffers to connect wetlands with critical habitats
4. Better Site Design	• Encourage designs that minimize the number of wetland crossings
5. Erosion and Sediment Control	• Require perimeter control practices along wetland buffer boundaries • Encourage more rapid stabilization near wetlands
6. Storm Water Treatment	• Prohibit use of natural wetlands for storm water treatment • Discourage constrictions at wetland outlets • Restrict discharges of untreated storm water to natural wetlands • Encourage fingerprinting of STPs around natural wetlands • Discourage installation of STPs within wetland buffers
7. Non-Storm Water Discharges	• Conduct illicit discharge surveys for all outfalls to wetlands • Actively enforce restrictions on dumping in wetlands and their buffers • Promote alternative mosquito control methods to reduce insecticide inputs to wetlands
8. Watershed Stewardship	• Incorporate wetlands into watershed education programs • Post signs to identify wetlands, buffers, and wetland CDA boundaries • Manage invasive wetland plants • Establish volunteer wetland monitoring and adoption programs • Encourage wetland landowner stewardship • Establish partnerships for funding and implementing wetland projects

While wetlands may be protected from direct impacts, such as dredging, filling, and draining, through federal and state permitting programs, their contributing drainage areas (CDAs) are seldom protected. Wetlands often occupy the low point of a development site, and can receive uncontrolled storm water discharges from upland areas. Storm water discharges cause indirect impacts to wetlands, such as altered hydroperiods, increased pollutant loads, and sediment deposition, which can sharply degrade their function and quality. Certain wetland types, collectively known as sensitive wetlands, have a very low tolerance for indirect impacts of storm water. The eight tools need to be specially adapted within the CDAs of sensitive wetlands to provide an additional level of protection. Table E-2 presents wetland protection strategies for each of the eight tools that can be applied within wetland CDAs.

Table E-2. Wetland Protection Strategies Applied Within Wetland CDAs	
Watershed Protection Tool	**Strategies Applied Within Wetland CDAs**
1. Land Use Planning	• Incorporate wetland management into local watershed plans • Adopt a local wetland protection ordinance
2. Land Conservation	• Prioritize other conservation areas in wetland CDAs
3. Aquatic Buffers	• Increase stream buffer widths to protect downstream wetlands
4. Better Site Design	• Encourage or require the use of open space design to protect wetlands • Encourage designs that utilize the natural drainage system
5. Erosion and Sediment Control	• Reduce disturbance thresholds that trigger ESC plans • Increase ESC requirements during rainy season • Encourage use of site fingerprinting or construction phasing • Increase frequency of site inspections
6. Storm Water Treatment	• Develop special sizing criteria for STPs • Promote effective STPs to protect downstream wetlands • Encourage the incorporation of wetland features into STPs and landscaping
7. Non-Storm Water Discharges	• Conduct illicit discharge surveys for all outfalls to wetlands • Require enhanced nutrient removal from on-site waste water treatment systems • Require regular septic system inspections
8. Watershed Stewardship	• Incorporate wetlands into watershed education programs • Post signs to identify wetlands, buffers, and wetland CDA boundaries

Communities can choose from the options outlined in tables E-1 and E-2 when adapting the eight tools of watershed protection to protect wetlands and their CDAs. Watershed planners and wetland managers should examine the numerous techniques within each category to determine the most appropriate combination for their community. Some techniques are more restrictive than others, and the choice of techniques depends on the future wetland protection needs in the community, as well as the capacity of the community to implement the techniques.

Communities should not feel limited to the 37 techniques described in this article, and should strive to be innovative where possible and develop new tools for protecting wetlands in their watersheds. In particular, there is a need for more innovative Better Site Design, erosion and sediment control, and storm water management techniques that are specifically designed with wetland protection in mind. In order to facilitate the development of better techniques to protect wetlands, additional research is needed to quantify the indirect impacts of storm water runoff and urban pollutants on wetlands and their functions.

About the Wetlands & Watersheds Article Series

The Wetlands & Watersheds article series was developed by the Center for Watershed Protection (CWP) in cooperation with the United States Environmental Protection Agency (USEPA). Funding for this project was provided by USEPA under cooperative agreements number CD-83192901-0 and WD-83264101-0.

Collectively, wetlands provide many watershed benefits, including pollutant removal, flood storage, wildlife habitat, groundwater recharge, and erosion control. While watersheds and wetlands are interconnected systems, their management is often segregated along regulatory and jurisdictional lines. Recent initiatives, such as the National Wetlands Mitigation Action Plan, provide a potential framework to integrate wetland protection in the context of larger local and state watershed planning efforts. However, no specific guidance exists for managing wetlands in the context of local watershed plans, and local governments often lack the tools and knowledge to effectively protect critical wetlands. This project was designed to fill this gap by expanding CWP's current watershed protection guidance, tools, and resources to integrate wetlands into larger watershed protection efforts. A key message conveyed in this new guidance is that wetlands should not be managed separately from other water resources because they are integral to water resource management.

This project included *research* on urban wetlands and local protection tools, *synthesis* of the research into a series of articles, and *transfer* of wetland protection tools and resources to wetland and watershed professionals across the country. The audience for the articles includes local natural resources managers and land planners who would benefit from guidance on local tools for protecting wetlands. The Wetlands & Watersheds article series currently includes three articles:

Article 1: Wetland Impacts, Watershed Woes?
This article reviews the direct and indirect impacts of urbanization on wetlands, and describes how impacts to wetlands affect watershed health.

Article 2: Protecting Wetlands Locally Through Watershed Planning
This article presents detailed methods for integrating wetland management into the local watershed planning process.

Article 3: Adapting Watershed Tools to Protect Wetlands
This article describes 37 techniques for protecting wetlands through local programs and ordinances.

Other wetland-related products of this project include wetland slideshows, an annotated bibliography of wetland research, a listing of key wetland web resources, and more products available on the newly expanded CWP wetlands website at www.cwp.org/wetlands/index.htm. The article series will be continued in 2006 with the production of three additional articles on the following topics:

- Model Ordinance for Local Wetland Protection
- Urban Wetland Restoration Techniques
- Local Tools for Protecting Vulnerable Wetlands and Aquatic Resources

The CWP project team included:

- Karen Cappiella
- Tom Schueler
- Tiffany Wright
- Anne Kitchell
- Neely Law
- Julie Tasillo
- Jennifer Tomlinson
- Lauren Lasher
- Hye Yeong Kwon
- David Hirschman

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Table of Contents

List of Tables

List of Figures

List of Case Studies

List of Boxes

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Introduction

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The Eight Tools of Watershed Protection

The eight tools of watershed protection represent a comprehensive approach to protect aquatic resources in watersheds facing land development. The eight tools roughly correspond to the stages of the development cycle including initial land use planning, site design and construction, and ultimate occupancy and long-term maintenance. As a result, local watershed managers will generally need to apply some form of all eight tools in every watershed to provide comprehensive protection. A local watershed plan is often used to define how and where the eight tools are specifically applied to meet their unique water resource objectives. For a more detailed discussion of the eight tools of watershed protection, see CWP (1998). The eight tools are presented in Figure 1 and described below.

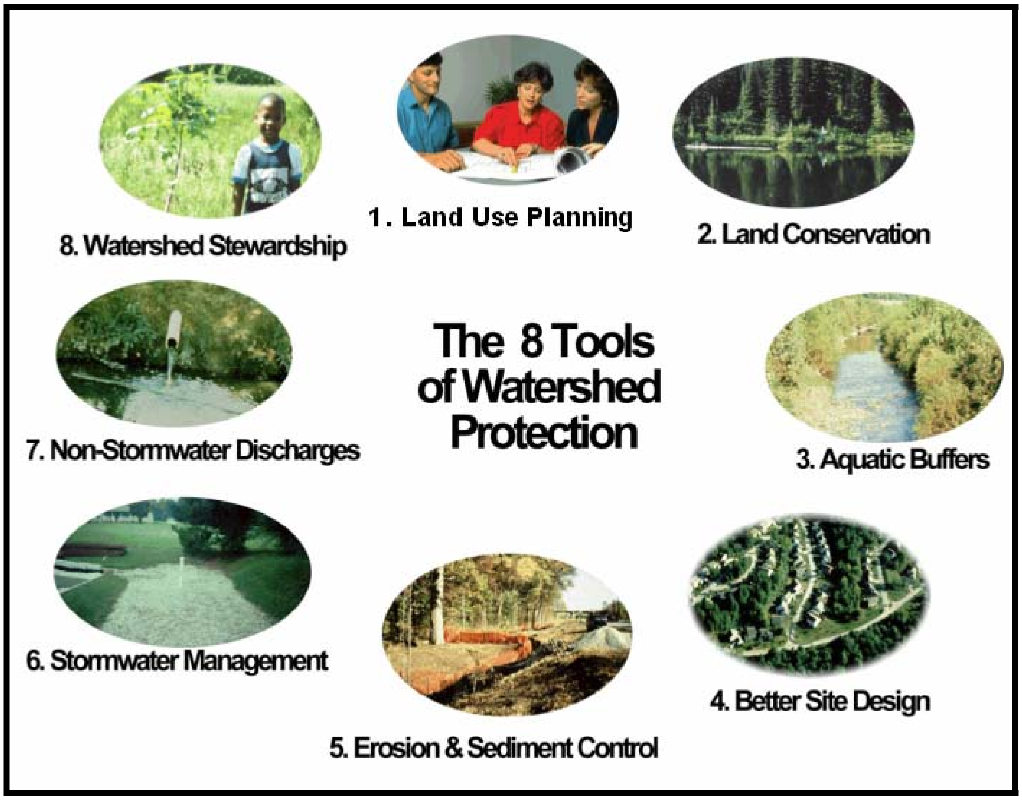


Figure 1. The Eight Tools of Watershed Protection

The first tool, **Land Use Planning**, is perhaps the most important because it involves making decisions about the amount and location of development (and new impervious cover) that occurs in a watershed. Land use planning techniques, such as watershed planning, watershed-based zoning, overlay zoning, and urban growth boundaries, are used to redirect development, preserve sensitive areas, or reduce impervious cover in a given portion of the watershed.

The second tool, **Land Conservation,** involves choosing the most critical areas in a watershed to conserve in order to sustain the integrity of aquatic and terrestrial ecosystems. Critical habitats for endangered species, aquatic corridors, hydrologic reserve areas, contiguous forests and wetlands may be important conservation areas, and can be protected via land acquisition and conservation easements, to provide permanent protection from development.

Aquatic Buffers are the third tool, and involves making choices on how to maintain the integrity of streams, shorelines, and wetlands, and protect them from encroachment. Buffers are recommended along aquatic corridors to physically protect and separate water resources from disturbance and pollution from adjacent land.

The fourth tool is **Better Site Design**, which seeks to design development sites to create less impervious cover, conserve more natural areas, and use pervious areas to more effectively treat storm water runoff. Better Site Design affords greater protection to water resources by reducing both storm water runoff volume and pollutant loads to downstream waters.

Erosion and Sediment Control deals with the clearing and grading stage in the development cycle, when storm water runoff can deliver high sediment loads to downstream waters. This tool reduces the impact of sediment by requiring specific temporary practices to be installed at construction sites that reduce erosion and prevent sediment from entering downstream waters.

The sixth tool, **Storm Water Management**, identifies how, when, and where to provide storm water management within a watershed, and which combination of storm water treatment practices will best meet watershed objectives. Storm water treatment practices compensate for the hydrological changes caused by new and existing development by reducing runoff volume and improving water quality.

The seventh tool, **Non-Storm Water Discharges**, involves making decisions on how to control discharges from waste water disposal systems, illicit connections to storm water systems, pollution from household and industrial products, and other point sources of water pollution.

The final tool, **Watershed Stewardship**, involves creating programs to promote private and public stewardship to sustain watershed quality. The goal of watershed stewardship is to increase public understanding and awareness about watersheds, promote better stewardship on private lands, and develop funding to sustain watershed management efforts.

Each of the eight tools should be specifically applied to protect unique wetland resources in watersheds that may be vulnerable to impacts from future development.

Protecting Wetlands and Their Contributing Drainage Areas

Wetlands are sustained by a variety of water sources, including surface runoff, precipitation, seasonal or periodic flooding, and groundwater. A wetland's water budget is the sum of water contributions from all these sources minus any water losses or discharges. Specific landscape features that transmit water to wetlands are known as **contributing drainage areas (CDAs)**. While wetlands may be protected from **direct impacts**, such as dredging, filling, and draining, through federal and state permitting programs, their CDAs are seldom protected. Wetlands often occupy the low point of a development site, and can receive uncontrolled storm water discharges from upland areas. In addition, many wetlands lack a buffer and development (and storm water outfalls) is shoehorned to just outside their boundaries. Storm water discharges cause **indirect** impacts to wetlands that can sharply degrade their function and quality. The many ways that storm water runoff can cause indirect impacts on wetlands within urban watersheds are reviewed in detail in Article 1.

Certain wetland types, collectively known as **sensitive wetlands**, have a very low tolerance for indirect impacts of storm water. The eight tools need to be specially adapted within the CDAs of sensitive wetlands to provide an additional level of protection. The boundaries of a wetland CDA have both surface runoff and groundwater components. The CDA from surface runoff is relatively simple to estimate, where the boundaries of groundwater recharge areas are more difficult to define since this requires a more detailed analysis of hydrogeologic conditions. Since most wetlands receive surface runoff to some extent, delineating the surface drainage area may be sufficient to delineate the CDA. Unless otherwise stated, all references to delineation of a wetland CDA made in this article are based on this assumption.

This section briefly summarizes the impacts of storm water runoff on wetlands, and provides general guidance on identifying sensitive wetlands, delineating sensitive wetland CDAs, and applying the eight tools to protect wetlands and their CDAs.

The Impacts of Storm Water Runoff on Wetlands

Wetlands are often significantly impacted by uncontrolled storm water runoff from upstream development because they typically occupy topographic low points, and therefore act as discharge points for this runoff (Figure 2). When land is developed within a wetland's CDA, forest or agricultural land is replaced by impervious surface, greatly increasing the volume of runoff produced during storms. The construction of storm sewers to efficiently deliver runoff to its end point also contributes to increased runoff. These changes in storm water inputs to a wetland alter wetland hydrology, and also affect water quality and biological functions.

Figure 2. A natural wetland highly degraded by urban storm water inputs

Indirect impacts include altered hydroperiods, increased pollutant loads, and sediment deposition that can alter vegetative communities and encourage invasive species. Schueler (2000) reviewed several Puget Sound studies that indicate that invasive or aggressive plant species are favored when storm water runoff increases wetland water level fluctuations (e.g., cattails, reed canary grass, *phragmites*). Storm water runoff also has the potential to impact the soils, flora and fauna, and water quality of wetlands (U.S. EPA, 1993). This is a particular concern for wetlands with a narrow pH range such as acidic sphagnum bogs and alkaline calcareous fens. Increased runoff also causes stream incision, which lowers water tables affecting nearby wetlands, particularly those fed by groundwater. Article 1 provides a detailed review of the indirect impacts of storm water runoff on wetlands.

Identifying Sensitive Wetlands

Some wetlands are sensitive to any disturbance, and will show signs of degradation with even low-level inputs of urban storm water. This degradation is typically expressed as reduced diversity and abundance of plant or animal species (see Article 1 for a review of studies). The primary indicators of sensitivity are the type and condition of the wetland community (MNSWAG, 1997). Local governments should clearly designate what types of sensitive wetlands will be addressed as part of the local watershed planning process; methods for doing so are presented in Article 2. Sensitive wetlands are afforded extra protection by requiring more stringent development controls within their CDA.

Some states, such as Minnesota and New Hampshire, have designated wetland community types they consider sensitive to land disturbance (MNSWAG, 1997; Mitchell, 1996). Classifying wetlands as sensitive or non-sensitive to storm water runoff inputs provides a useful framework for managing storm water inputs to different types of wetlands. Since wetland sensitivity varies regionally, communities should always consult with local wetland experts to develop their own locally adapted list of sensitive and non-sensitive wetlands. Table 1 presents some general examples of sensitive and non-sensitive wetland communities.

Table 1. Examples of Sensitive and Non-Sensitive Wetland Types

Normally Sensitive	Not Very Sensitive
• Sedge meadows	• Cattail marshes
• Open bogs	• Phragmites marshes
• Coniferous bogs	• Reed canary grass meadows
• Calcareous fens	• Deep marshes dominated by purple loosestrife
• Coniferous swamps	• Floodplain forests
• Lowland hardwood swamps	• Riverine wetlands
• Low prairies	• Fringe wetlands along lakes
• Seasonally flooded basins	• Fringe wetlands along estuaries
• Basin marshes and sandy pondshore marshes	• Treatment wetlands
• Vernal pools	• Highly degraded wetlands
• Emergent wetlands with thin-stemmed species	• Gravel pits
• Wetlands containing rare, threatened or endangered (RTE) species	• Cultivated hydric soils
• Wetlands whose water budget is dominated by groundwater or precipitation	• Dredge or fill material disposal sites
Sources: Brinson (1993b), MNSWAG (1997), Chase et al. (1997); Phillips (1996); Kusler (2003); Azous and Horner (1997), Ehrenfeld and Schneider (1991). Note: this table provides general examples only. Communities should consult with local and state wetland experts to identify their own sensitive and non-sensitive wetland types	

Communities generally protect sensitive wetlands by using an overlay zone that protects all wetlands and delineates sensitive wetland CDAs. Stricter development criteria are implemented within the sensitive wetland CDAs to reduce storm water impacts by minimizing impervious cover, conserving natural areas, reducing pollution, and infiltrating runoff. Examples of performance criteria that might be triggered by development within a sensitive wetland CDA include: special storm water management criteria to protect sensitive wetlands, more frequent erosion and sediment control inspections, and use of open space design.

Delineating Wetland CDAs

Wetland CDAs are delineated using topographic maps. Results are limited by the resolution of the map. For wetlands smaller than 10 acres, or very flat landscapes, U.S. Geological Survey (USGS) topographic quadrangles are not sufficient (USEPA, 2002). Finer-scale topographic data is recommended for more accurate delineations, and may be available from local agencies, such as public works or planning. Because alterations to natural surface drainage may not be reflected on topographic maps, storm drainage maps, and maps of agricultural ditch drainage systems should be consulted when available, to develop a more accurate delineation. The wetland CDA boundary should be modified to include the area drained by storm sewers or drainage networks that discharge into the wetland or its tributaries. Where it is not possible to delineate the CDA for a wetland due to lack of data, USEPA (2002) recommends substituting an arbitrary zone of influence around the wetland. The width of the zone should account for known surface and subsurface flow patterns into the wetlands.

To delineate a wetland CDA using topographic data, start by identifying the outlet of the **wetland of interest** (Figure 3). This point is the starting point, or **origin**, for delineating the CDA boundary. Next, identify ‘**breakpoints,**’ which are high points, as measured from the wetland boundary or the watercourse draining into the wetland, working upstream. Connect the breakpoints, beginning with the origin, to form a polygon of the **wetland CDA boundary**.

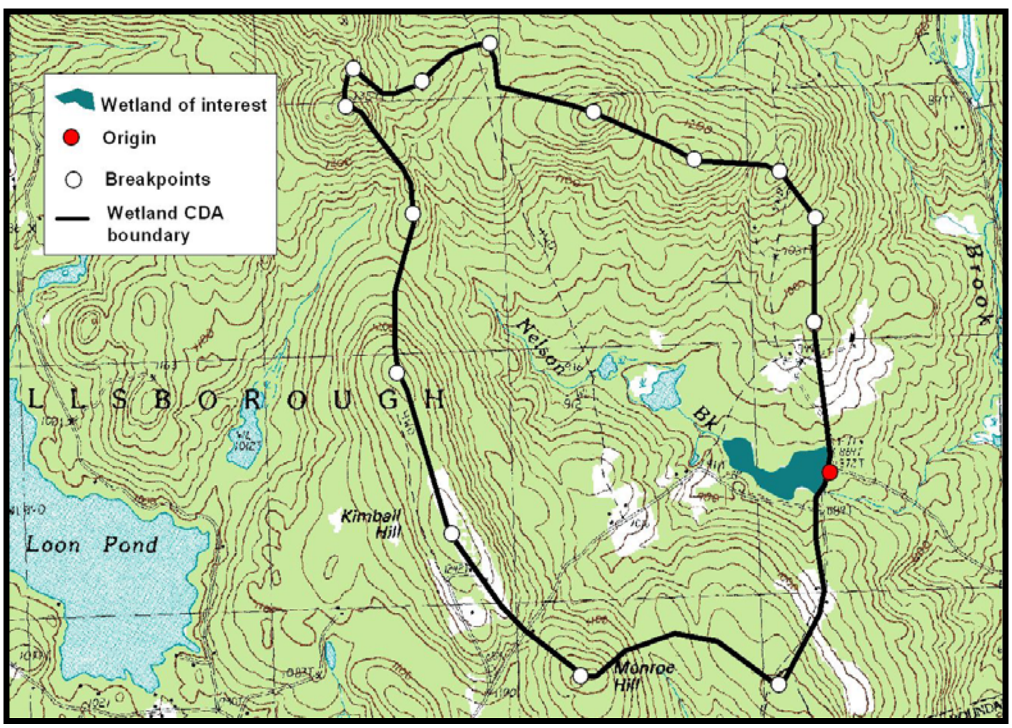


Figure 3. Example of delineation of wetland CDA from surface runoff (Adapted from Ammann and Lindley Stone, 1991)

Since the location of a wetland in the landscape plays a major role in wetland hydrology, pollutant retention, and the effects of increased storm water inputs (USEPA, 1993), the delineation method described above works best for wetlands in certain topographic positions. Brinson (1993a) defined six major types of wetlands, based on their landscape position, as part of the hydrogeomorphic (HGM) method for classifying and evaluating wetlands. These HGM wetland types are presented in Table 2.

Table 2. HGM Wetland Types

HGM Wetland Type	Description	Dominant Water Sources
Depressional	Topographic depression with closed contours that may have inlets or outlets, or lack them	Precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands
Slope	Surface discharge of groundwater on sloping land that does not accumulate	Groundwater or interflow discharging at the land surface
Flat	Low topographic gradients, such as old glacial lake beds, with moderate to abundant rainfall	Precipitation
Riverine	Occur in the floodplain and riparian corridor of larger streams and rivers (e.g., 2nd order and higher)	Overbank flow from channel, subsurface hydraulic connections between stream channel and wetlands
Headwater Stream Channel	Occur in the channel and floodplain of headwater streams (e.g., 1st order)	Precipitation, interflow and overland flow from surrounding uplands
Fringe	Adjacent to lakes or estuaries	Water elevations are controlled by the nearby lake or tides
Adapted from Brinson (1993a), Brinson (1993b), and Gwin et al. (1999), and Spivey and Ainslie (no date)		

In general, depressional, slope, headwater stream channel, and flat wetlands are more heavily influenced by storm runoff than are riverine and fringe wetlands. Riverine and fringe wetlands are largely dependant on water levels in adjacent waterbodies (e.g., rivers, lakes, estuaries), which in turn depend on much broader water regimes (Kusler, 2003; Phillips, 1996). Delineating the boundaries of sensitive wetland CDAs is most important for depressional, slope, headwater stream channel, and flat wetlands. For riverine and fringe wetlands that are identified as sensitive, communities should adjust the CDA delineation method, or investigate alternative methods of protection, such as an expanded wetland buffer. The key adjustment in delineation involves identifying the origin of the wetland CDA. For example, it is often difficult to identify the outlet for some wetlands that have diffuse outflows. In other cases, only one portion of a large wetland complex may be of interest. Some guidance on delineation methods for different HGM wetland classes is illustrated in Figure 4.

Surface delineation methods cannot fully protect wetlands where groundwater influence is significant (e.g., many slope wetlands, or very flat, poorly drained landscapes). In these situations, communities may wish to define the groundwater recharge areas for the wetland. This option requires significant detailed analysis and expense, but has been successful in communities such as Kane County, Illinois. In Kane County, government officials realized the unique fens located in the county were dependent upon groundwater and required more protection than just preserving the wetland itself. The groundwater recharge area for the fens was estimated using surface watershed boundaries, soil and geologic data, and well log data. The information will be used by the County and the Corps of Engineers to protect the 30 fens and their corresponding groundwater recharge zones (Burke Engineering West, Inc, 2004).

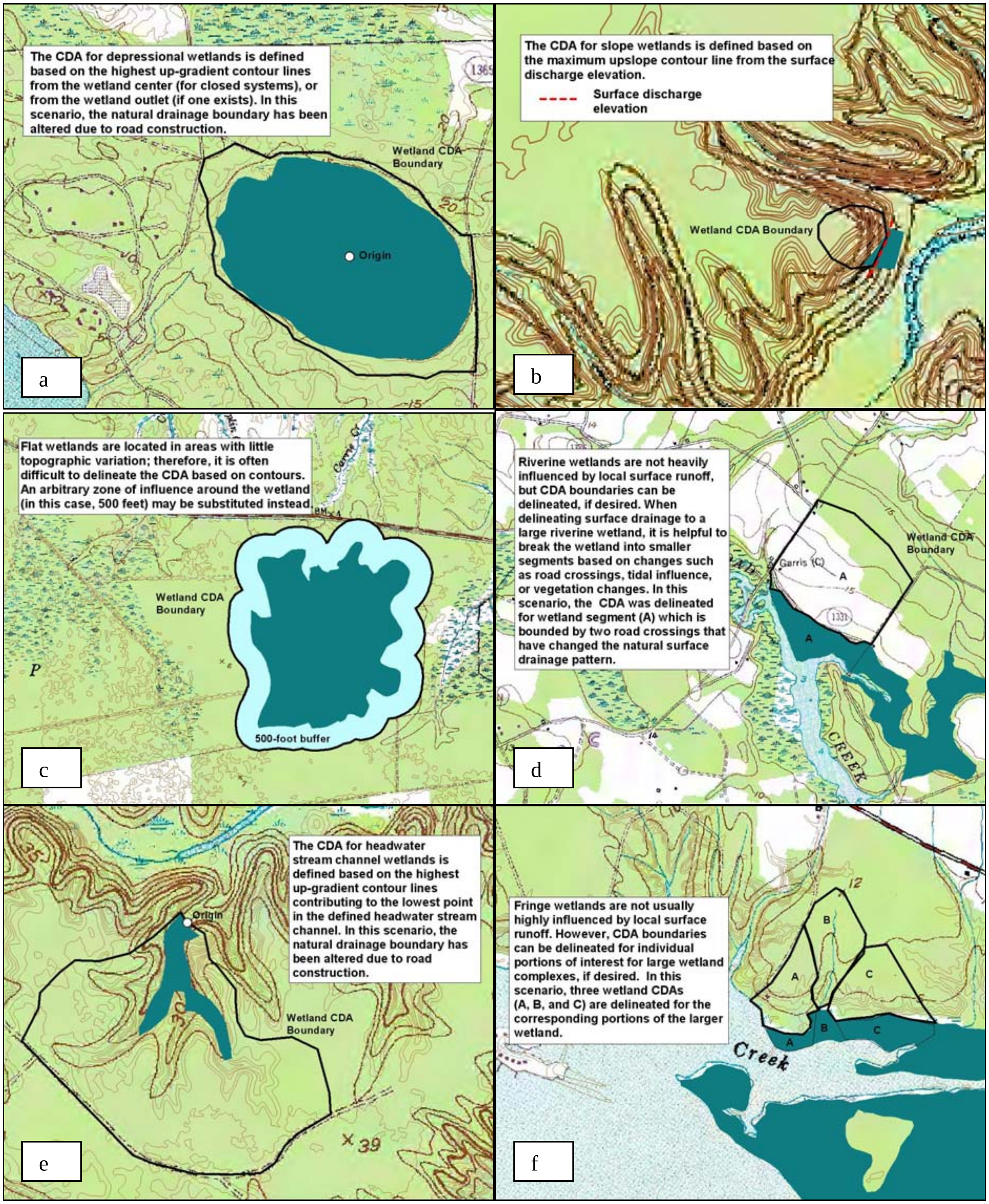


Figure 4. CDA delineation methods for (a) depressional wetlands, (b) slope wetlands, (c) flat wetlands, (d) riverine wetlands, (e) headwater stream channel wetlands, and (f) fringe wetlands

Applying the Eight Tools to Protect Wetlands and Their CDAs

Communities vary greatly in their size, technical and financial resources, development review process, and prior experience in wetland management and watershed planning. A menu of different wetland protection techniques are provided in Table 3 that communities can choose when adapting the eight tools of watershed protection to protect wetlands and their CDAs. Watershed planners and wetland managers should examine the numerous techniques within each category to determine the most appropriate combination for their community. Some techniques are more restrictive than others, and the choice of techniques depends on the future wetland protection needs in the community, as well as the capacity of the community to implement the techniques. Methods to evaluate community wetland protection needs and capabilities are described in Article 2.

Table 3. Adapting the 8 Tools of Watershed Protection for Wetlands

Watershed Protection Tool	How to Apply the Tool to Protect Wetlands and Their CDAs
1. Land Use Planning	• Incorporate wetland management into local watershed plans • Adopt a local wetland protection ordinance
	• Adopt floodplain, stream buffer, or hydric soil ordinance to indirectly protect wetlands
2. Land Conservation	• Identify priority wetlands to be conserved • Select techniques for conserving wetlands
	• Prioritize other conservation areas in wetland CDAs
3. Aquatic Buffers	• Require vegetated buffers around all wetlands • Expand wetland buffers to connect wetlands with critical habitats
	• Increase stream buffer widths to protect downstream wetlands
4. Better Site Design	• Encourage designs that minimize the number of wetland crossings
	• Encourage or require the use of open space design to protect wetlands • Encourage designs that utilize the natural drainage system
5. Erosion and Sediment Control	• Require perimeter control practices along wetland buffer boundaries • Encourage more rapid stabilization near wetlands
	• Reduce disturbance thresholds that trigger ESC plans • Increase ESC requirements during rainy season • Encourage use of site fingerprinting or construction phasing • Increase frequency of site inspections
6. Storm Water Treatment	• Prohibit use of natural wetlands for storm water treatment • Discourage constrictions at wetland outlets • Restrict discharges of untreated storm water to natural wetlands • Encourage fingerprinting of STPs around natural wetlands • Discourage installation of STPs within wetland buffers
	• Develop special sizing criteria for STPs • Promote effective STPs to protect downstream wetlands • Encourage the incorporation of wetland features into STPs and landscaping
7. Non-Storm Water Discharges	• Conduct illicit discharge surveys for all outfalls to wetlands
	• Actively enforce restrictions on dumping in wetlands and their buffers • Promote alternative mosquito control methods to reduce insecticide inputs to wetlands
	• Require enhanced nutrient removal from on-site waste water treatment systems • Require regular septic system inspections
8. Watershed Stewardship	• Incorporate wetlands into watershed education programs • Post signs to identify wetlands, buffers, and wetland CDA boundaries
	• Manage invasive wetland plants • Establish volunteer wetland monitoring and adoption programs • Encourage wetland landowner stewardship • Establish partnerships for funding and implementing wetland projects

Key:

(blue)	Strategies that are applied in or near wetlands
(green)	Strategies that are applied within wetland CDAs
(yellow)	Strategies that are applied to both wetlands and their CDAs

Tool 1: Land Use Planning

The goal of comprehensive land use planning is to identify areas that are suitable or unsuitable for different types of development and choose the appropriate planning tools to manage those areas accordingly. When done at the watershed scale, land use planning preserves sensitive areas by directing development to other portions of the watershed that can accommodate it. Some key decisions that must be made as part of this process include: identifying priority areas to protect in the watershed, and deciding on the range of regulatory and non-regulatory tools that can be used to protect these areas, such as overlay zones and performance standards. For the watershed plan to be effective it must be incorporated into the local comprehensive plan. Land use planning protects wetlands by directing growth away from sensitive wetland areas, and by regulating land use activities in wetlands, using the strategies listed in Table 4.

Table 4. Land Use Planning Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
Wetlands and their CDAs	• Incorporate wetland management into local watershed plans • Adopt a local wetland protection ordinance
In or near wetlands	• Adopt floodplain, stream buffer, or hydric soil ordinance to indirectly protect wetlands

Incorporate Wetland Management into Local Watershed Plans

Land use practices that impact wetlands are managed at the local level through zoning codes, subdivision ordinances, storm water criteria, and other development regulations. An effective local watershed plan makes recommendations for improving land use decisions to better protect watershed resources. This makes local watershed plans an ideal land use planning tool for protecting wetlands since they are an important component of watershed health. Unfortunately, communities are often inspired to take wetland management seriously at the watershed level only after serious impacts to their existing wetlands have taken place. Therefore, this approach is likely to be more common in urban and urbanizing watersheds, and is often driven by local advocacy groups such as watershed organizations, who play an important role in rallying support for protecting wetlands at the watershed level.

Incorporating wetland protection into the local watershed planning process can help minimize both direct and indirect impacts to wetlands. Practically, this means that local wetlands must be inventoried, assessed, and managed in the context of the entire watershed rather than on a site-by-site basis—requiring a broader understanding of how wetlands function within the watershed and the benefits they provide. Watershed planning allows communities to make better choices to preserve the highest quality wetlands, protect the most vulnerable wetlands, and find the best sites for wetland restoration. A watershed plan can also be used to inform wetland permit decisions made by state and federal agencies, to affect compensatory mitigation decisions regarding impacted wetland resources, or to identify opportunities for voluntary wetland conservation and restoration programs. Article 2 reviews detailed methods to incorporate wetland management into local watershed plans, including conducting an inventory, assessment, and prioritization of wetlands for protection, restoration and conservation.

Adopt a Local Wetland Protection Ordinance

Communities may choose to adopt a local wetland protection ordinance to ensure protection of all wetland types and functions. Kusler (2003) estimates that more than 5,000 communities have adopted local wetland ordinances. Some communities have adopted ordinances in response to state wetland mandates, while others have adopted wetland ordinances of their own accord, in the absence of state-level protection. By adopting a local wetland protection ordinance, communities can provide more stringent protection for a greater range of wetland types than is currently being regulated by state and/or federal agencies. Case Study 1 summarizes Wisconsin's approach to protecting wetlands at the local level using shoreland/wetland zoning ordinances.

Case Study 1: Shoreland/Wetland Zoning Ordinances in Wisconsin

Wetland protection in Wisconsin is implemented at the local level through shoreland/wetland zoning ordinances. These ordinances are regulatory tools to restrict development in wetlands near streams and lakes where their ecological value is significant. Every city, village and county in the state is required by state legislation to adopt this ordinance and meet or exceed the requirements prescribed.

Wetlands subject to shoreland/wetland zoning include all wetlands of at least 5 acres that are located inside the shoreland zone. Communities can also decide to zone wetlands less than 5 acres or outside the shoreland zone, if desired. The standard ordinance identifies all allowable wetland uses and states that all other uses are prohibited. Permitted uses are generally related to recreation, farming, forestry, or public infrastructure. For a property owner to conduct prohibited activities, such as filling or draining a wetland in this zone, a rezone must be granted by the local jurisdiction in order to take the impacted area out of the zoning district. For a rezone to occur, the applicant must demonstrate there will be no significant adverse impacts to the full range of wetland values, including:

- Storm and flood water storage
- Maintenance of dry season stream flow
- Filtering of sediments, nutrients, or contaminants
- Shoreline protection against erosion
- Fish and wildlife habitat
- Areas of scientific or recreational interest

Only wetlands that are so degraded they lack all the functional values described above should be eligible for a rezone, so oversight of the ordinance is essential to ensure this is enforced. In addition to protecting wetlands, the shoreland/wetland zoning ordinance typically outlines criteria for development that occurs on other lands within this zone. Criteria include: minimum lot sizes, limitations on removal of shoreline vegetation, and building restrictions that minimize impervious cover. These criteria help to reduce indirect impacts on wetlands from nearby development.

Source: WIDNR (2000) and WIDNR (no date)

Local wetland protection ordinances protect wetlands by restricting or requiring a special permit for certain activities, such as dredging, filling, clearing, and paving, within wetland boundaries or buffers. When developing a local wetland protection ordinance, communities must decide whether to allow compensatory mitigation as an option for replacing lost wetland functions due to permitted activities in wetlands. **Compensatory mitigation** is a process in which wetlands that are impacted through permitted activities are replaced through wetland restoration at a site near or within the same watershed as the impact site. Communities should consider the significant administrative and organizational capacity needed to support local wetland permitting, as well as coordination with existing state or federal regulatory programs in order to streamline the process (see Article 2 for more detail on coordinating with regulatory agencies). If allowed, the wetland protection ordinance should also outline what constitutes appropriate mitigation. Most communities allow compensatory mitigation, but some, such as the state of Wisconsin, have resisted the impulse to allow mitigation, arguing that it may encourage the development of land that would not normally be acceptable.

Local wetland protection ordinances frequently establish special zoning districts that incorporate the wetlands and other areas to be protected. Zoning districts can be identified as static zones, or can be applied as an overlay. An overlay zone is imposed over traditional zoning to protect specially recognized values, while still allowing the underlying use (Figure 5). Zoning districts established as part of a local wetland protection ordinance may include wetlands, their buffers, and CDAs. Specific criteria for development and other activities within wetland buffers and CDAs can be outlined in the ordinance to provide additional protection for sensitive wetlands.

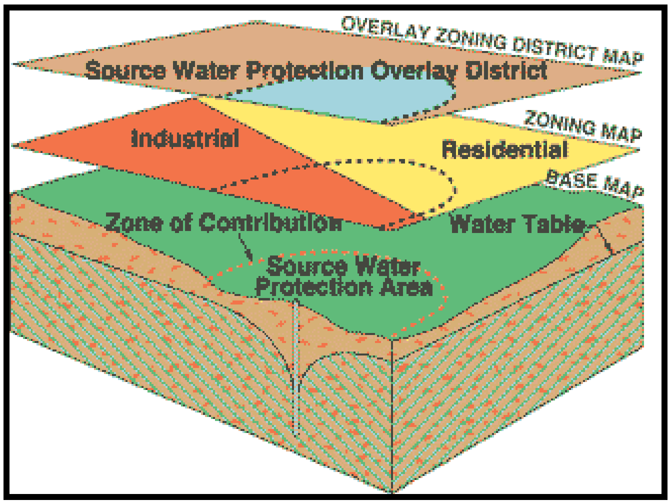


Figure 5. Overlay zoning (Graphic by Jon Witten)

Communities can either adopt a new wetland protection ordinance that protects wetlands and their CDAs, or can choose to revise existing ordinances, such as zoning, erosion and sediment control, and storm water management ordinances. Many municipal separate storm sewer system (MS4) communities regulated under the National Pollutant Discharge Removal System (NPDES) program may choose the latter option since they have to do this as part of their permit requirements anyway. Box 1 presents a checklist of elements to include in a wetland protection ordinance if the former option is selected.

Box 1. Elements of a Wetland Protection Ordinance

- ☐ *Statement of intent* – should specifically identify wetland protection and management of the CDA as the goal of the ordinance.
- ☐ *Applicability* – clearly identify where the ordinance applies, including protected wetlands, as well as their buffers and CDAs. Criteria for defining protected wetlands, buffers, and CDAs should be clearly defined and include reference to a map where appropriate (e.g. a local wetland inventory). Definitions of protected wetlands should include the minimum wetland size subject to the ordinance, and distinguish among wetland types that are subject to more restrictive management (e.g., sensitive wetlands).
- ☐ *Allowable and prohibited uses* – include a list of allowable and prohibited uses in the area of interest. Certain uses may require a permit.
- ☐ *Permitting process* – outline the procedure for obtaining a permit for a prohibited use (if applicable), including the permit application and development review process.
- ☐ *Performance standards* – identify specific criteria for determining whether to approve or deny a permit application. If applicable, identify compensatory mitigation requirements (e.g., for each acre of wetlands impacted by permitted activities, replacement must occur at a ratio of 2:1). Identify performance criteria for development within protected wetland CDAs. Example criteria include:
    1. Require undisturbed 100-foot wetland buffer to be placed in a permanent easement or deed restriction
    2. Require use of open space design and other techniques that reduce impervious cover
    3. Conserve 50% of forest on-site
    4. Restrict discharges of untreated storm water to wetlands
    5. Enforce more frequent ESC inspections
- ☐ *Penalties and enforcement measures* – outline a procedure for inspection and enforcement of regulations, along with penalties for violation, and the authority for the community to enforce the ordinance.

The exact details of each element of a local wetland protection ordinance may vary in each community, but, in general, should be more stringent than existing federal, state, or tribal regulations. King County, Washington’s Wetland Management Areas (Case Study 2) are a great example of a local wetland protection ordinance that protects both wetlands and their CDAs in the form of an overlay zone. Article 4 provides model ordinance language for local wetland protection. Other good resources for developing local wetland protection ordinances include:

- Clinton River Watershed Council
  http://www.crwc.org/programs/watershedmgmt/scwetlands/wetlandord.html

- Croton-on-Hudson, NY Wetlands and Watercourses Ordinance
  http://www.stormwatercenter.net/Model%20Ordinances/misc__wetlands.htm

Case Study 2: King County, Washington Wetland Management Areas

King County, Washington has developed an overlay zone, known as Wetland Management Areas (WMAs) that focuses on watershed-based controls to protect the most high quality or rare wetland types in the county. WMAs were developed because King County realized that simply providing buffers around these wetlands was inadequate to protect functions influenced by the broader watershed and surrounding landscape. The intent of WMAs was to minimize the storm water-related impacts on wetlands by minimizing impervious surfaces, retaining forest, clustering, and providing constructed infiltration systems, where feasible. Examples of controls implemented within WMAs include:

- Limitation of impervious cover in the wetland CDA to eight percent
- Required retention of 50 percent of existing forest
- Clustering of development away from landscape features that directly transmit water to wetlands
- Use of constructed infiltration systems to reduce increases in storm water volumes due to new development
- Seasonal clearing limits imposed on construction activities

Source: Azous et al. (1997)

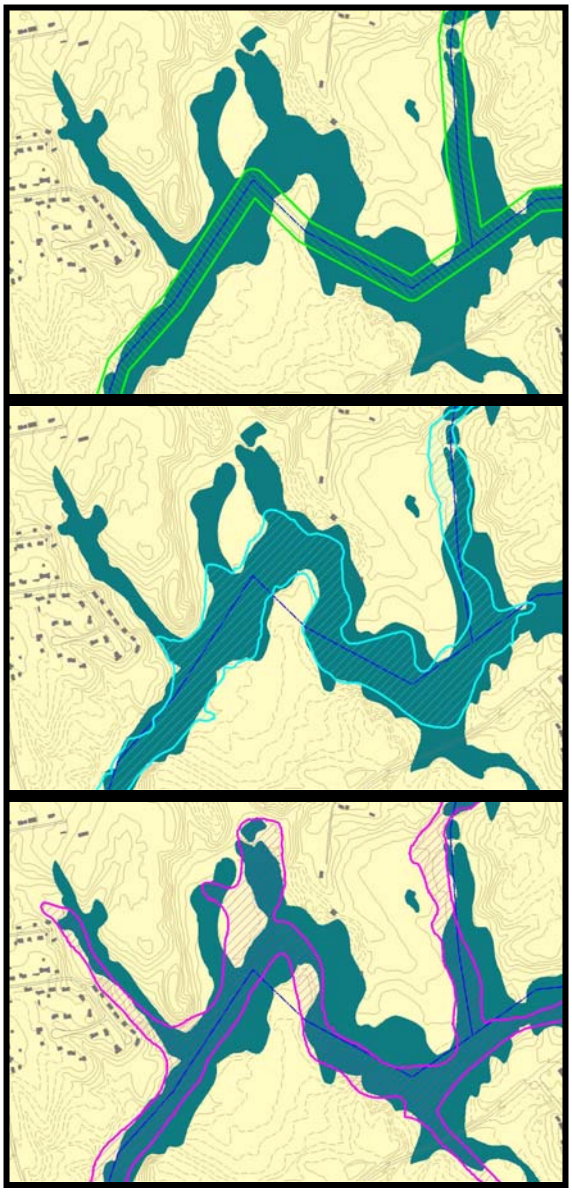
Adopt Floodplain, Stream Buffer, or Hydric Soil Ordinance to Indirectly Protect Wetlands

Many communities lack a detailed inventory of their wetlands. The National Wetlands Inventory (NWI) may be their only source of wetland data—but this inventory does not cover the entire nation, much of the data is over 20 years old, and tends to miss wetlands one to three acres or smaller. Lack of detailed wetland data can weaken the effectiveness of local wetland protection ordinances and overlay zones that rely on advance identification of protected wetlands. Reference to outdated or inaccurate NWI wetland maps in wetland protection ordinances means that many smaller wetlands may not be fully protected. In these cases, communities may choose to protect wetlands by mapping other natural resource features for which data is readily available, such as floodplains, stream buffers, and hydric soil features. Table 5 describes the significance of these features in protecting wetlands and provides sources of mapping data.

Table 5. Significance of Floodplains, Stream Buffers, and Hydric Soils to Wetland Protection

Natural Resource Feature	Significance to Wetland Protection	Source of Mapping Data*
Floodplains	Protecting floodplains can indirectly protect floodplain wetlands that are not included in the wetland inventory.	Download flood hazard maps from www.fema.gov
Stream buffers	Protecting stream buffers can indirectly protect riparian wetlands that are not included in the wetland inventory. The number of wetlands protected is directly related to the width of the stream buffer, which varies in each community.	Delineate buffer based on specified distance from stream
Hydric soils	Wetlands are defined by three criteria: hydrology, vegetation and hydric soils, which are soils that formed under saturated conditions. Protecting hydric soils may protect some wetlands, and has the added benefit of providing built-in protection for future restoration sites, since drained hydric soils (e.g., former wetlands) are often ideal restoration sites.	Download state or county soil maps from www.nrcs.usda.gov County soils data not available for all counties.
*If more accurate or detailed mapping data is available locally, these should be used instead		

Figure 6 shows how each layer overlaps with wetlands to provide significant wetland protection. By combining these three layers together, a community can produce a natural resources overlay zone that effectively protects wetlands without the need of a detailed wetland inventory. It is important to note that the composite map created by this approach is only as accurate as the least accurate mapping layer, and should not be relied on to delineate protected boundaries in the field. If wetlands are found at the site during the preliminary or concept plan stage, the boundaries of the protected area will change based on this more detailed delineation.



These maps illustrate the proportion of riverine wetlands that may be indirectly protected by protecting stream buffers, floodplains and hydric soils, where local wetland protection regulations are not adequate to protect all wetlands.

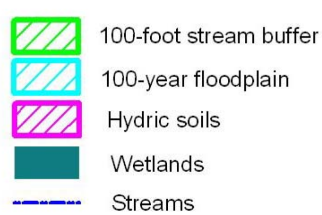


Figure 6. Wetland maps showing overlap with the 100-foot stream buffer (top), 100-year floodplain (center), and hydric soils (bottom).

Tool 2: Land Conservation

Land conservation involves the application of a variety of techniques to permanently protect sensitive natural resources, such as wetlands, from development. Communities protect these resources using two steps. The first is to identify the most critical conservation areas in their watersheds. The second is to outline the best techniques to permanently protect them. In the context of wetlands, a community will want to use the strategies outlined in Table 6.

Table 6. Land Conservation Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
In or near wetlands	• Identify priority wetlands to be conserved • Select techniques for conserving wetlands
Within wetland CDAs	• Prioritize other conservation areas in wetland CDAs

Identify Priority Wetlands to be Conserved

Communities should identify priority wetlands for conservation in their watersheds as part of the watershed planning process. This can be accomplished through an inventory of wetlands in the watershed. An initial desktop inventory of wetlands can be done based on mapping data, although detailed field assessments of wetland function may be needed to verify and update it. A community needs to make difficult decisions on what kind of wetlands merit conservation---should they provide certain functions, be minimally impacted, be sensitive to storm water runoff, or be locally rare? Other factors to consider when choosing wetland conservation sites include: their location in the watershed, size, connection to landscape features, ownership, and vulnerability to future development. Systematic methods to inventory the most critical wetland resources in a watershed are described in detail in Article 2.

A local watershed plan is a good mechanism to prioritize wetland conservation sites in relation to other conservation areas, and choose the tools to implement them. A watershed plan is a proactive approach to conservation since it identifies the best sites in the watershed well in advance of wetland permit or site plan applications, thereby increasing the chances of their permanent protection.

Select Techniques for Conserving Wetlands

A good watershed plan outlines a conservation plan for individual wetlands that includes what land conservation tools will be used, who will apply then, and when they will be applied. Communities should pursue priority sites for implementation as soon as the plan is complete. In some cases, the local government may be able to purchase the land. More often, they must work with a local land trust or other organization to acquire the land (Case Study 3) or restrict development, using tools such as conservation easements. Land acquisition and conservation easements are described below.

Case Study 3: Eightmile River Watershed, Connecticut

The lower Connecticut River is home to internationally recognized tidal marsh communities, exceptionally intact forest blocks and tributaries, and a multitude of creatures, including six kinds of plants and animals that are rare or endangered worldwide. The Nature Conservancy (TNC) has protected more than 4,000 acres in the Lower Connecticut River region since 1960. A key component of TNC's Lower Connecticut River Program is community partnerships, particularly in East Haddam, Lyme and Salem, the three towns through which the Eightmile River flows. This tributary of the Connecticut has remarkably high water quality, and is surrounded by large blocks of undeveloped forest; despite more than 350 years of settlement, the area today is more than 80 percent forested. It comprises a variety of habitats, from its cold, fast-flowing headwaters to the freshwater tidal marshes where it meets the Connecticut.

Local government partners have been working with TNC to protect the Eightmile River watershed by acquiring key parcels of land and conservation easements. In October of 2004, the town of Lyme and TNC protected the town's highest conservation priority, the 480-acre Jewett property. 434 acres were purchased, while conservation easements protected the remaining 46 acres for a total of $3,270,500. It was one of the three largest unprotected parcels in the Eightmile River watershed, and includes more than a mile of high quality tributaries of the Connecticut River. The land links a 1,000-acre block of protected open space to the south with a 3,000-acre block to the northeast, forming more than 10 miles of open space predominantly along the Eightmile River. The cost of the acquisition was split by TNC and the town of Lyme. A portion of the town's funding came from the state Department of Environmental Protection Open Space and Watershed Protection grant program.

Source: TNC (no date)

Acquisition

Land acquisition is outright acquisition of title to conservation areas by a municipality, land trust, or other nonprofit organization that provides full control of the land. The landowner is paid full market value of their land and may also enjoy tax benefits. This is an expensive way to protect wetlands, but provides long term protection from development. Once the land is purchased, it is managed and protected by the title holders.

Sources of funding for land acquisition are numerous and include both public and private sources. Local sources include: property taxes, special assessment districts, real estate transfer taxes, impact fees, and mitigation fees. Corporations, foundations, and other individuals may also contribute funds for land acquisition.

Easements

Conservation easements are conveyances of development rights necessary to protect specific conservation values from a property's landowner to a municipality, land trust, or other nonprofit organization. The easement may be purchased or donated and may grant the landowner a reduction in property taxes. If a donated easement benefits public interest and meets other federal tax code requirements, it can also qualify as a tax-deductible charitable donation valued at the difference between the land value with and without the easement (LTA, no date). The landowner still retains use, occupancy, and ownership of the land itself, but agrees to give up certain rights of the land for the term of the easement. In addition, easements can relieve property owners of the burden of managing these areas by shifting responsibility to a private organization or government agency better equipped to handle maintenance and monitoring. Communities can encourage the use of easements to conserve wetlands.

Each easement is unique in that it protects conservation values specific to the parcel and is developed to meet the needs of the landowner by defining what types of activities are allowed on the land, such as continuation of farming on a portion of the land. The agency that holds the easement, such as a land trust, is responsible for enforcing the easement. Ideally, easements are permanent, but some may expire after a specified number of years. Easements are transferable with the land if sold or passed onto heirs. National land trusts that can assist in protecting conservation areas through easements include:

Land Trust Alliance:	www.lta.org
The Nature Conservancy:	www.tnc.org
Trust for Public Land:	www.tpl.org

Transfer or Purchase of Development Rights Programs
Transfer of development rights (TDR) is a land use planning technique that transfers development potential from environmentally sensitive areas, called sending zones, to specific areas designated for growth, called receiving zones. Sending zones typically include land that has significant development restrictions placed on it, such as wetlands. A TDR is economically attractive because the landowner is allowed to sell the previously existing development rights, based on the development density that would have been possible prior to implementation of development restrictions. Communities may choose to establish or modify TDR programs to protect high quality wetlands designated for conservation by identifying these areas as priority sending zones. Case Study 4 describes a TDR program used to conserve wetlands.

Case Study 4: New Jersey Pinelands Density Transfer Program

The Pinelands National Reserve consists of approximately 1.1 million acres in southern New Jersey. Low, dense forests of pine and oak, ribbons of cedar and hardwood swamps bordering drainage courses, pitch pine lowlands, and bogs and marshes combine to produce an expansive vegetative mosaic unsurpassed in the Northeast. In 1983, the Pinelands was designated a Biosphere Reserve by the U.S. Man and the Biosphere Program and the United Nations Educational, Scientific and Cultural Organization. Today, the Pinelands is protected, and its future development guided by the Pinelands Comprehensive Management Plan. The plan is administered by the New Jersey Pinelands Commission in cooperation with units of local, state, and federal governments.

The Pinelands Comprehensive Management Plan Land Capability Map establishes nine land use management areas with goals, objectives, development intensities, and permitted uses for each. These are implemented through local zoning, which must conform with Pinelands land use standards. Since the plan was adopted, a TDR program has been in place, which permits density transfers from conservation areas to growth areas using "Pinelands Development Credits" (PDCs). Within the framework of the Comprehensive Management Plan, the Pinelands Commission awards PDCs in certain critical areas that can be used to permit bonus densities when developing in less critical areas. Conservation or agricultural easements are placed on the sending property when PDCs are transferred to permanently protect it. To date, this TDR program has protected more than 13,000 acres in the conservation areas.

Source: Liggett (no date), Kinsey (1997)

Under a purchase of development rights (PDR) program, a willing landowner can sell the development rights of a property to a qualified conservation entity, such as a non-profit land trust, public agency, or historic preservation organization. The development rights are held by the conservation entity, and a conservation easement is placed on the parcel. The landowner retains full ownership and use of the property for purposes other than real-estate development.

PDRs are a cost-effective method of conserving key wetland parcels, since the development rights generally cost 25% to 50% less than outright acquisition of the property. However, PDRs are not as attractive in situations where the development value of the land is low because it is subject to significant development restrictions. Therefore, communities should work with land trusts to target wetland landowners whose property contains a relatively small proportion of wetlands. This is not the most effective way to conserve a large acreage of wetlands, but is useful for conserving smaller unique and isolated wetlands. Both PDRs and TDRs are generally only applicable in communities with significant financial resources and sophisticated technology, such as an excellent GIS-based wetland inventory.

Other Tools

Communities can require compensatory mitigation for impacts to wetlands from activities permitted under local zoning and wetland protection ordinances. Mitigation requirements generally focus on restoring wetlands elsewhere at a specified ratio based on the acres of wetland impacted. Communities can structure their mitigation requirements to include conservation of existing high quality wetlands adjacent to proposed restoration sites in addition to the usual restoration projects. This approach could be taken not only to discourage development in sensitive wetlands, but also as a tool to conserve key wetland resources in the watershed. Recognizing the benefits of this approach, the U.S. Army Corps of Engineers (USACE) now gives compensatory mitigation credit for preserving wetlands or other aquatic resources when they are preserved in conjunction with, and augment the functions of, newly established, restored, or enhanced aquatic resources (MAP Interagency Workgroup, 2004a).

Prioritize Other Conservation Areas in Wetland CDAs

Wetland managers should clearly recognize that wetlands are only one of many conservation areas considered in the context of a watershed plan. Other conservation areas include: contiguous forest, meadow, hydric soils, steep slopes, critical habitat, recharge areas, active karst features, stream buffers, and other natural features (Figure 7). Permanent protection of these conservation areas can help preserve hydrology and reduce pollutant inputs to downstream wetlands. All conservation areas should also be ranked as part of the watershed planning process. To provide additional protection for sensitive wetlands, key conservation areas within sensitive wetland CDAs may be assigned a higher ranking as part of this process.

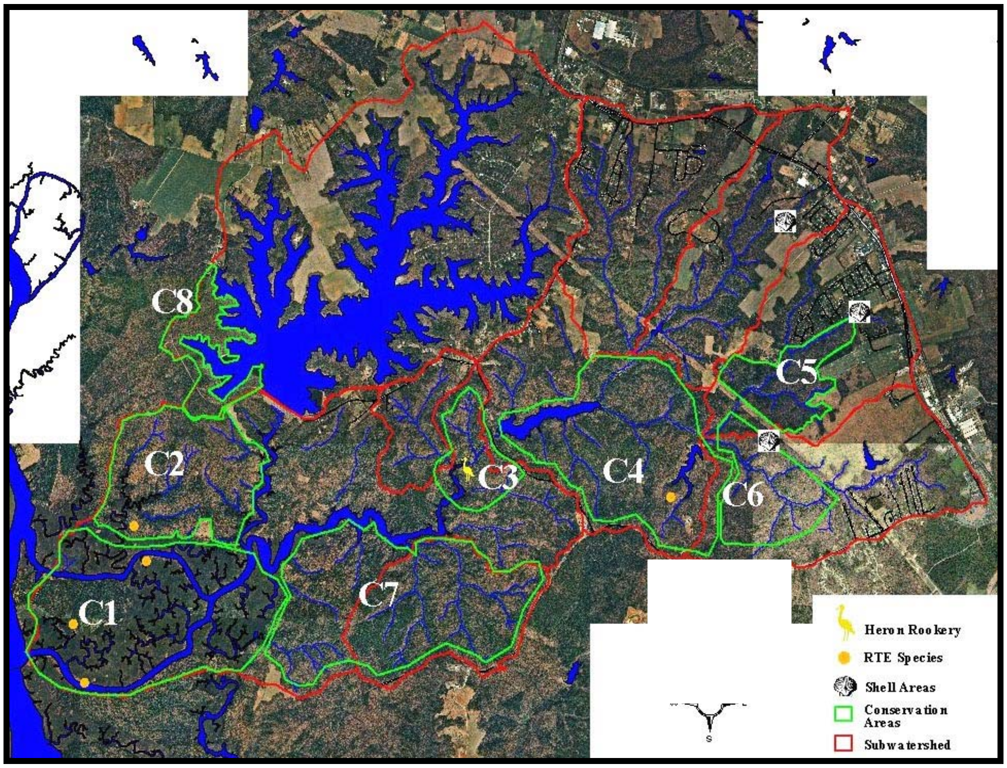


Figure 7. Priority conservation areas (in green) identified for the Yarmouth Creek Watershed, Virginia

Tool 3: Aquatic Buffers

Aquatic buffers physically separate water resources from adjacent land, providing protection from disturbance. Since these buffers are generally vegetated, they provide numerous other functions including water quality, fish and wildlife habitat, and wildlife travel corridors. Many communities have recognized the importance of providing buffers along streams, but fewer have used this tool to protect wetlands. Specific ways to apply buffers for wetland protection are listed in Table 7.

Table 7. Aquatic Buffer Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
In or near wetlands	• Require vegetated buffers around all wetlands • Expand wetland buffers to connect wetlands with critical habitats
Within wetland CDAs	• Increase stream buffer widths to protect downstream wetlands

Require Vegetated Buffers Around All Wetlands

Communities may choose to require vegetated buffers to protect wetlands (Figure 8). Wetland buffers provide habitat for wildlife, remove pollutants from runoff, reduce erosion, regulate temperature, store floodwaters, and increase aesthetic and recreational value (Castelle et al., 1992). They also provide a visual separation between wetlands and developed areas that discourages dumping, reduces human access to the site, and creates a greater distance between the wetland and surrounding human development. (Castelle et al., 1992). The benefits provided by a buffer vary depending on the buffer width. Buffer widths of 50 to 100 feet are typically recommended to protect wetland water quality, while buffer widths of 100 to 300 feet or more are recommended for wetlands with important wildlife functions (EOR, 2001, Chase et al., 1997; Castelle et al., 1992). This width should be expanded to include nearby sensitive resources, such as steep slopes or erodible soils, and to account for factors such as adjacent land use, buffer vegetation, and the size of the wetland. Buffers are measured horizontally from the edge of the delineated wetland.

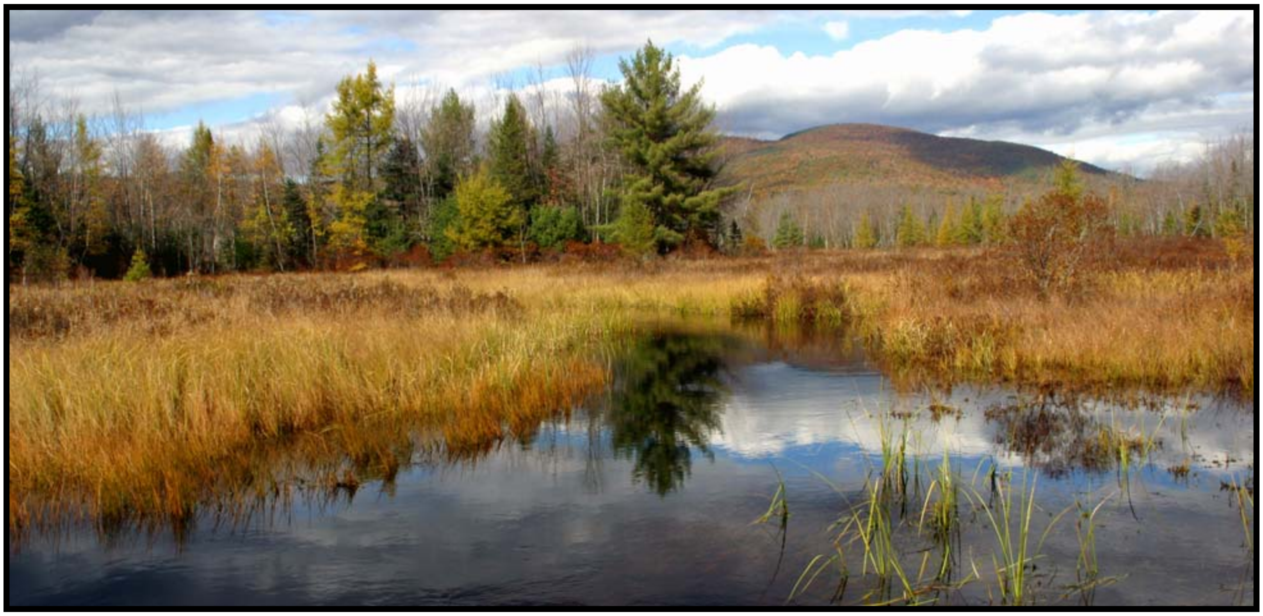


Figure 8. This Nature Conservancy preserve in Effingham holds some of New Hampshire's most remarkable wetlands and upland buffers. (Photo Source: Eric Aldrich, The Nature Conservancy)

If a community does not wish to require buffers for all wetlands, they may set buffer widths based on wetland type (Case Study 5). For example, the state of New Hampshire requires buffers greater than 100 feet around sensitive wetlands, with narrower buffers for altered wetlands with limited wetland functions (Mitchell, 1996). Semlitsch and Jensen (2001) suggest a multi-zone buffer approach that uses wetland functional boundaries to define buffer zone widths. Wetland functional boundaries are defined as areas in which land use changes may negatively affect the functions of a specific wetland (Pearsell and Mulamootil, 1996). The zones suggested by Semlitsch and Jensen (2001) include an aquatic buffer zone to protect the core wetland, a core habitat zone that protects habitat for species that depend on both wetland and upland habitats for survival (e.g., turtles), and finally, a terrestrial buffer zone to provide a buffer between the core habitat and the adjacent land use. The wetland CDA is the ideal functional boundary to protect, especially for sensitive wetlands, although it may not be feasible for communities to incorporate the entire CDA into a protected buffer zone.

Communities may also set buffer widths based on the specific functions performed. Table 8 presents recommended buffer widths for various wetland functions based on the specific functions performed. These recommended widths come from a review of more than 40 reports on wetland buffers across a wide variety of geographic settings (EOR, 2001).

Case Study 5: Washington State Wetlands Rating System

Washington State Department of Ecology developed a rating system for wetlands based on functions, values, sensitivity to disturbance, rarity, and replacement difficulty. Local management decisions that are based on this rating include: the level of impact avoidance required, width of buffers necessary to protect from adjacent development, mitigation acreage and replacement ratios, and permitted uses in wetlands. The wetlands rating system includes four categories, ranging from the highest quality, rare wetland types (Category I) to the smallest, and least diverse wetlands (Category IV). Category I wetlands include Natural Heritage wetlands and bogs, and require a buffer width of 215 feet, while only a 50 foot buffer is required for Category IV wetlands.

Source: WADOE (1993)

Table 8. Recommended Buffer Widths for Various Wetland Functions

Function	Special Features	Recommended Minimum Width (feet)
Sediment reduction	Steep slopes (5-15%) and/or sensitive wetland	100
	Shallow slopes (<5%) or low quality wetland	50
	Slopes over 15%	Consider buffer width additions with each 1% increase in slope (e.g., 10 feet for each 1% of slope greater than 15%)
Phosphorus reduction	Steep slope	100
	Shallow slope	50
Nitrogen (nitrate) reduction	Focus on shallow groundwater flow	100
Biological contaminant and pesticide reduction	N/A	50
Wildlife habitat and corridor protection	Unthreatened species	100
	Rare, threatened or endangered species	200-300
	Maintenance of species diversity	50 in rural area 100 in urban area
Flood control	N/A	Variable, depending upon elevation of flood waters and potential damages
Source: EOR (2001)		

Four options for communities to implement wetland buffers include:

1. Adopt a wetland buffer ordinance
2. Add wetland buffers to existing or new wetland protection ordinance
3. Add wetland buffers to existing stream buffer ordinance
4. Include wetland buffers in post-construction storm water management ordinance

Communities should select the option that is most efficient and appropriate for them. For example, NPDES MS4 communities are likely to choose option #4, since they already have to develop a storm water management ordinance as part of their permit requirements. In addition to these four local options for implementing wetland buffers, the USACE may give credit for wetland buffers within a compensatory mitigation project if the protection and management of these buffers enhances aquatic functions and increases the overall ecological functioning of the mitigation site (MAP Interagency Workgroup, 2004b). More information on wetland buffers can be found in Chase et al. (1997) and Castelle et al. (1992), and a model ordinance for buffers is provided at: http://www.stormwatercenter.net/Model%20Ordinances/buffer_model_ordinance.htm.

Expand Wetland Buffers to Connect Wetlands with Critical Habitats

Several communities have departed from fixed widths for wetland buffers and take a more flexible approach to connect and protect larger terrestrial habitat zones adjacent to wetlands. Linking adjacent wetlands together and then linking them to high-value upland habitats can potentially offset habitat fragmentation due to urbanization. Large, unbroken habitat areas have been shown to be much more valuable for habitat than several smaller pieces of similar cumulative size. Therefore, connections between nearby wetlands significantly affect the habitat value and function of the wetland. The zones of upland habitat surrounding wetlands provide critical habitat for many semi-aquatic and terrestrial "ecotone" species (Semlitsch and Jensen, 2001). Communities should consider developing wetland buffer ordinances that maximize wetland habitat value by encouraging the creation of large, contiguous habitat patches and linkages between these patches.

To encourage use of expanded wetland buffers, communities must be flexible in their ordinance requirements – techniques such as buffer averaging allow for expansions to connect to nearby habitats. Ordinance language should encourage or require expansion of the wetland buffer when it is near defined critical habitats to provide a corridor between wetland and upland habitats. The corridor should be designed to support wildlife species that use wetlands during a critical life cycle stage, such as breeding, rearing, or feeding. For example, King County, Washington's Critical Areas Ordinance states that an increase in buffer width of 50 feet may be required for certain wetland types if located within 300 feet of priority habitat areas, as defined by the State. Alternatively, the developer may provide a relatively undisturbed vegetated corridor at least 100 feet wide between wetlands and all priority habitat areas located within 300 feet of the wetland, provided this corridor is protected by easement (King County, Washington, 2005).

Figure 9 illustrates a comparison between a traditional fixed width buffer and an expanded buffer that connects wetlands with surrounding habitat. By simply establishing a standard 100-foot wetland buffer, wetlands A and B are connected by the buffer into one larger habitat complex. However, wetlands C and D are isolated from adjacent wetland habitats. By expanding the 100-foot buffer around wetland C by approximately 40 feet on one side, a connection is provided to wetland E without losing much buildable land. In addition, a 100-foot wide corridor was established between wetlands C and D to allow wildlife passage. In this scenario, as an incentive to protect wetland habitat value, the developer received storm water credits for the 300-foot long wildlife corridor connecting wetlands C and D.

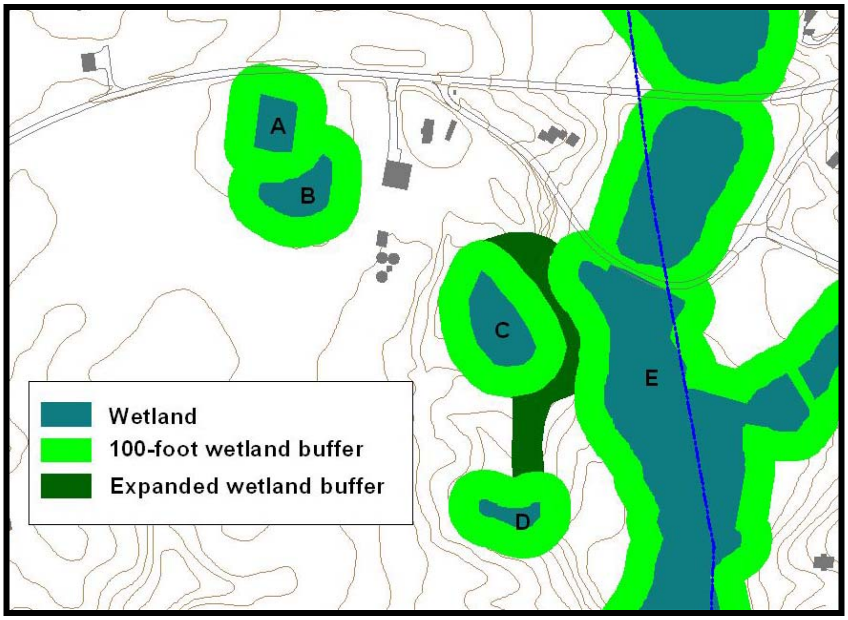


Figure 9. Expanded wetland buffers

Increase Stream Buffer Widths to Protect Downstream Wetlands

While wetland buffers provide some protection from adjacent land use disturbance, they cannot fully protect wetlands from the effects of activities within their CDAs. Establishing stream buffers within wetland CDAs can provide some protection from these impacts. Where sensitive wetlands are present, stream buffer widths may be increased for direct tributaries to the wetland, or for all streams within the wetland CDA. Communities can then revise their stream buffer ordinances to reflect increased buffer widths for streams that drain to sensitive wetlands. For more information on urban stream buffer design and ordinances, see Wenger and Fowler (2000) and Schueler (1995).

Tool 4: Better Site Design

One of the best ways to mitigate the impacts of storm water runoff on downstream waters and wetlands is to control the way that development sites are designed. Better Site Design, also referred to as environmentally sensitive design, refers to a collection of site design techniques that reduce storm water runoff by minimizing impervious cover, conserving natural areas, and providing more distributed storm water management. Not only does Better Site Design reduce storm water impacts, it also is attractive economically, because Better Site Design developments can be cheaper to build, bring higher premiums, and sell faster than conventional developments, depending on the site design and local costs and market conditions. CWP (1998) summarizes the 22 Better Site Design techniques that communities should review. Three Better Site Design strategies that are particularly applicable to wetland protection are presented in Table 9.

Table 9. Better Site Design Strategies to Protect Wetlands and their CDAs	
Where the Strategy is Applied	**Strategy**
In or near wetlands	• Encourage designs that minimize the number of wetland crossings
Within wetland CDAs	• Encourage or require the use of open space design to protect wetlands • Encourage designs that utilize the natural drainage system

Encourage Designs that Minimize the Number of Wetland Crossings
Designs that limit the number of wetland crossings by roads or utilities can reduce impacts to wetlands at a development site. Road and utility crossings often result in outlet constrictions and cause hydrologic impacts to wetlands. The effect of wetland crossings and outlet constriction on wetland condition is described in Article 1. The number of wetland crossings in a new development can be limited by:

- Using efficient road layouts that limit the number of crossings
- Using lot layouts, such as open space design, that focus development away from the wetlands
- Utilizing existing crossings and upgrading as necessary
- Locating all utilities and roads at a single crossing

When crossings are unavoidable, they should be located at the narrowest point of the wetland using the least restrictive culvert design possible. Construction techniques, such as horizontal directional drilling, can minimize impacts when utilities cross underneath a wetland. Communities should consider requiring developers to conduct an environmental inventory of a site before it is subdivided into smaller lots for development, or before a conceptual design is made. This allows for the identification of sensitive areas, such as wetlands, and the design of the site to avoid these areas at the early planning stages of site design.

The local site plan review process should coordinate with the federal and state regulatory process to make sure that every proposed wetland crossing is carefully scrutinized to determine whether it can be minimized or avoided altogether. Wetland crossings require a Clean Water Act Section 404 permit, although some may be covered under general or nationwide permits, depending on the size of the area impacted and the discretion of the local USACE District. The local site plan review process can also influence the design of crossings such that impacts are minimized.

Encourage or Require the Use of Open Space Design to Protect Wetlands
Open space design (also known as conservation design or cluster design) is a Better Site Design technique that clusters residential lots on a portion of the development site in order to provide open space elsewhere on the site that can be used for wetland conservation and other uses. In many residential subdivisions, open space design can preserve as much as half the site in open space, without reducing the *number* of lots (Case Study 6). Reduced lot sizes, yard setbacks, and frontage distances help to achieve this clustering of lots (Figure 10). Open space design creates less impervious cover than conventional subdivisions, and preserving forest and wetlands also reduces storm water runoff and therefore downstream impacts.

Case Study 6: The Villages of Thomas Run

When originally proposed, the Village of Thomas Run in Harford County, Maryland consisted of 450 single-family homes on individual lots. The plan required extensive filling of wetlands and five stream crossings. When the county rejected the proposal, citing adverse impacts on wetlands, the developer hired a local planning and engineering consultant to redesign the site. The revised plan called for townhomes to be clustered on upland portions of the site. Careful designing of the site allowed nearly half of the site to be preserved as open space, reduced the number of stream crossings, and greatly minimized the impact to wetlands.

Source: ULI (1994)

Figure 10. Open space design clusters lots and preserves natural drainageways as open space (Graphic source: MNSWAG, 1997)

Communities may choose to encourage or even require the use of open space design for residential subdivisions as a creative way to conserve wetlands and other conservation areas without sacrificing lot or revenue yields. Open space design may be a community-wide requirement, or may only be required as a development practice within a wetland protection overlay zone, within sensitive wetland CDAs, or on sites with wetlands. In order to mandate use of open space design, an open space design ordinance must be adopted, and development review requirements should be the same as for conventional developments (e.g., no special review process for open space design). In order to encourage the use of open space design, NJPC (2004) suggests that communities impose a strict 300-foot buffer around wetlands when conventional site design is used. This buffer would decrease the amount of developable land on the site and thereby serve as a disincentive for using conventional development.

The local open space design ordinance should specify a percentage of the existing open space that must be conserved for each residential zoning category, and define allowable and restricted

uses for the open space. For example, pavement and structures should be prohibited, native vegetation should be specified, and limits should be placed on how much of the open space (if any) can be golf courses, ballfields or other "park-like" uses. Specific targets for wetland or native vegetation can also be included in the ordinance. Because residents tend to expand their lawns into adjacent open space, it is also useful to include requirements for fencing or other barriers or to limit access points into the conservation area. Open space should be protected by a legally enforceable deed restriction, conservation easement, and maintenance agreement, and typically a homeowner or community association has responsibility of maintenance. A model open space design ordinance is provided at:
www.stormwatercenter.net/Model%20Ordinances/open_space_model_ordinance.htm

Encourage Designs that Utilize the Natural Drainage System

The volume of storm water runoff produced by a development is directly related to the amount of impervious cover, as well as how it is configured in relation to the drainage network and pervious areas. Too often, the natural drainage network is altered due to extensive grading of the site to create site topography that fits the site plan. Mass grading is costly and requires stripping, stockpiling, and replacing topsoil, resulting in soil compaction and destruction of natural drainageways. Communities may wish to promote site designs that preserve or utilize the natural drainage pathways and swales to disconnect and infiltrate runoff before it is conveyed to downstream wetlands. The following Better Site Design techniques can help maintain natural hydrology:

- *Avoid development-related construction activity in the most sensitive areas.* This means avoiding clearing in or along shorelines, stream valleys, natural drainageways, and groundwater recharge areas, and keeping pavement and other impervious surfaces out of these areas.

- *Fit development to the terrain.* In rolling or dissected terrain, use strict street hierarchies with local streets branching from collectors along ridge lines. This approach results in a road pattern that resembles the branched patterns of ridgelines and drainageways in the natural landscape (Figure 11). This minimizes disruption of existing grades and natural drainage (MNSWAG, 1997).

- *Utilize natural topography and vegetated waterways to convey acceptable levels of runoff.* Utilize vegetated open channels to convey and treat runoff from roads, rather than the traditional curb and gutter systems (Figure 12). This provides water quality treatment and reduces runoff by providing some infiltration (CWP, 1998).

- *Direct runoff to pervious areas for infiltration.* Avoid connecting impervious areas with pipes or other structures. Where possible, direct runoff from pavement and rooftops to pervious areas, where it can infiltrate and recharge groundwater. For example, downspouts can be directed to lawn areas, or rain gardens, where site and soil conditions permit (Figure 12). This is especially important for wetlands that require groundwater support.

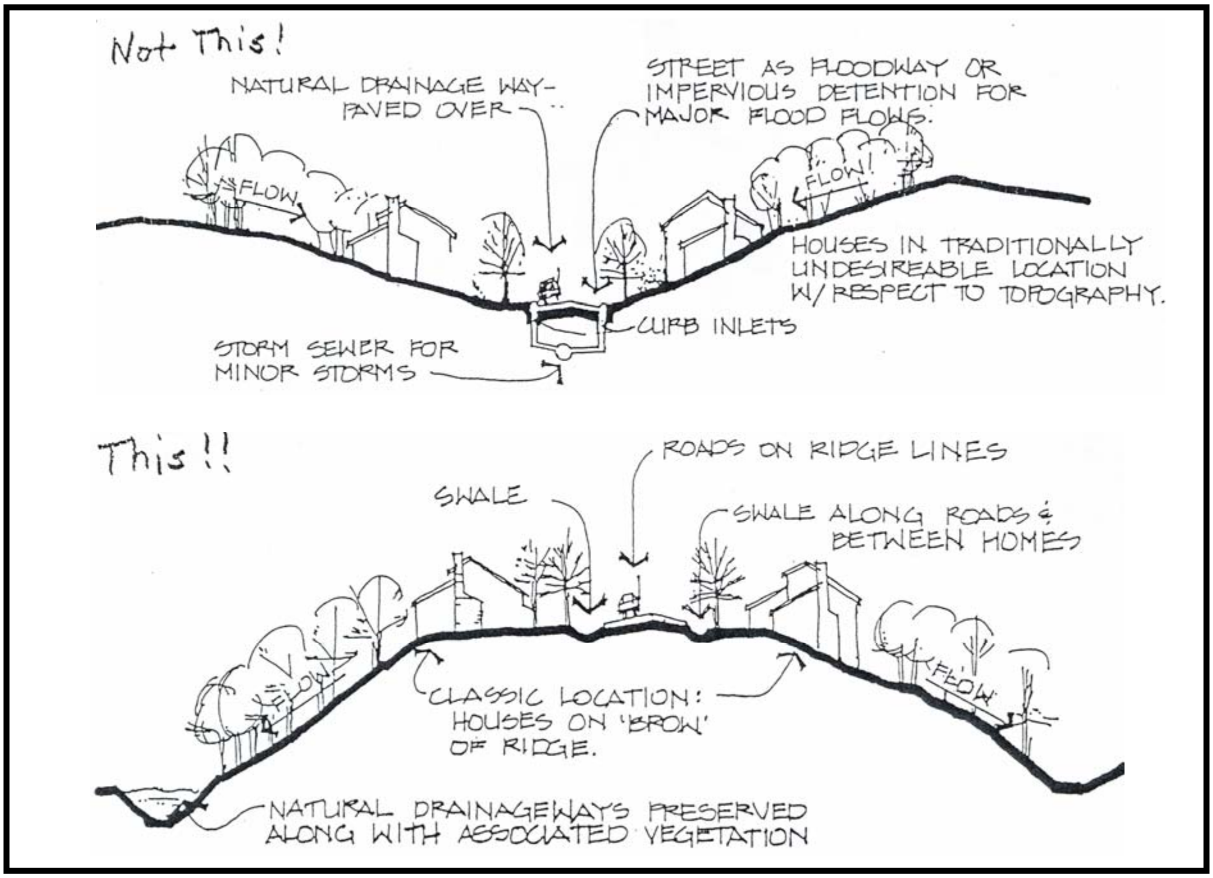


Figure 11. Conventional development (top) versus development that works with the existing topography (bottom) (Graphic source: MNSWAG, 1997)

Figure 12. Roadside swales (left), and rain gardens (right) are used to infiltrate runoff (Rain garden photo source: Roger Bannerman)

Communities should give preference to designs that meet these goals during site plan review. If desired, the above goals can be written into site development regulations as required criteria.

Tool 5: Erosion and Sediment Control

Uncontrolled urban construction sites can lose between 20 and 200 tons/acre of sediment per year (Dreher and Mertz-Erwin, 1991). This sediment can smother habitat, clog pipes, and deliver pollutants, such as nutrients and metals, to downstream receiving waters. Sediment deposition from uncontrolled construction can exert serious impacts on natural wetlands as described in Article 1. A survey of local erosion and sediment control (ESC) programs by Ohrel (1996) found only 35% of local programs explicitly considered wetland protection in their plan approval process. Communities may choose to tailor their ESC programs to protect wetlands by requiring special ESC practices. Erosion control practices prevent soil erosion from occurring at a site, while sediment control practices prevent sediment from leaving the site and discharging to wetlands. This section provides some guidance on specific ESC strategies to protect wetlands, which are listed in Table 10.

Table 10. Erosion and Sediment Control Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
In or near wetlands	• Require perimeter control practices along wetland buffer boundaries • Encourage more rapid stabilization near wetlands
Within wetland CDAs	• Reduce disturbance thresholds that trigger ESC plans • Increase ESC requirements during rainy season • Encourage use of site fingerprinting or construction phasing • Increase frequency of site inspections

Require Perimeter Control Practices Along Wetland Buffer Boundaries

Perimeter control practices are typically installed along the upland boundary of streams and wetlands as a last line of defense to prevent sediment discharges. Perimeter controls include sediment traps and basins, diversions/dikes, earthen berms, and silt fences. To provide additional protection, perimeter controls should be installed along the boundary of any required wetland buffer, rather than at the wetland boundary (Figure 13). This approach uses the buffer to provide additional sediment filtering, which is especially important in case perimeter controls fail. Communities may need to revise existing ESC manuals to ensure sediment control practices are installed along the wetland buffer perimeter. As a general rule, ESC practices should never be installed inside the wetland buffer; therefore, limits of disturbance should be located outside the wetland buffer. For more information on proper installation and maintenance of perimeter controls such as silt fences, see Caraco (1997).

Figure 13. Silt fence used as perimeter control to protect wetland (Photo source: MDE, no date)

Encourage More Rapid Stabilization Near Wetlands

Immediate stabilization is important to reduce sediment inputs to wetlands on exposed slopes near wetlands at construction sites. Communities should encourage developers to permanently stabilize upland areas near wetlands as soon as possible after completion of ground disturbing work (seed and straw or matting should be applied to disturbed areas within 10 days), and to use temporary seeding and stabilization if disturbed areas will be left exposed for longer than 14 days. For sites where stabilization will be difficult due to slope, aspect, soils, time of year, or other factors, additional methods are recommended, including topsoiling, surface roughening, and/or application of erosion control matting (Figure 14).

Figure 14. Exposed slope stabilized with erosion control matting

The ultimate objective, and the most effective means of stabilization, is to establish a vigorous grass cover, which will prevent erosion from occurring. Lee and Skogerboe (1985) found that suspended solids decreased by 99% when stabilized with vegetative cover.

In cases where actual wetlands, or their immediate buffers, are disturbed due to unintended or planned encroachments, it is important that the areas be revegetated with native wetland seed mixes (or a more aggressive mitigation planting plan). Most seed mixes used for site stabilization contain various aggressive non-native seeds, most notably fescues. Invasive plants that become established at the development site can quickly migrate to nearby wetlands, and the seeds can be washed down into or blown into nearby wetlands (especially when hydroseeders are used).

To reduce invasive species in wetlands, local ESC regulations should specify the use of native seed mixes for areas immediately adjacent to wetlands or within a designated wetland buffer. This can be verified when ordering seed and may require checking species lists against local native plant lists. Depending on how close to the wetland the exposed site is, wetland seed mixes may be specified.

Hydroseeding, a technique in which seed is sprayed on the surface with a slurry of water, tackifiers, fertilizers, and fiber mulch, cannot be used for wetland species because the seeds are very fine and will not get enough sun once mixed with the slurry. Instead, wetland mixes should be applied by hand or with a spreader. Wetland seeds generally must be cold stratified, meaning they should be refrigerated for a period of time before planting, or planted in the fall. Also, many native species can take longer to establish than conventional fescue or rye-based mixes, so extra inspections or use of biodegradable erosion control matting may be necessary to ensure that erosion does not occur.

Reduce Disturbance Thresholds that Trigger ESC Plans

In response to the NPDES Program Storm Water Phase I and II permit regulations, many communities have established ESC programs. ESC program regulations typically apply to sites disturbing some minimum area of land (e.g., NPDES disturbance threshold is one acre). Communities can reduce sediment inputs to wetlands by increasing the number of construction sites that are regulated under the ESC programs. This can be accomplished by reducing or eliminating minimum disturbance thresholds that trigger ESC requirements. Cumulatively, the sediment lost from sites that do not meet these minimum thresholds (e.g., all construction sites disturbing less than one acre) can be significant at a watershed scale.

Reducing minimum disturbance thresholds increases the number of sites subject to ESC requirements, but also greatly increases the plan review and inspection burden on local ESC staff. If communities lack the resources to handle greater staff review, they may elect to require them only within sensitive wetland CDAs. This approach protects the most sensitive wetlands, but also reduces the burden on local staff.

Communities may also want to carefully review their ESC regulations to identify specific projects that are exempted or waived. Common exemptions include single-family lots, maintenance practices, road projects and utility repair. Cumulatively, these exemptions can have a significant impact on wetland quality if uncontrolled, and should be carefully reviewed to determine if the exemptions are justified.

Increase ESC Requirements During Rainy Season

Construction site erosion is directly linked to rainfall events, meaning that sediment deposition into wetlands can increase significantly during the rainy season if these sites are not controlled. Despite this, most communities have not linked their ESC requirements to seasonal variations in rainfall. Some communities in the western U.S., however, have taken steps to minimize the threat to wetlands and other sensitive waters during the rainy season, as shown in Case Study 7.

Case Study 7: King County, Washington Erosion Control Guidance

The King County Department of Development and Environmental Services (DDES) has written guidance for contractors regarding construction site controls needed during the "wet" season of October 1 through April 30. In certain designated areas of the county, no clearing and grading work can occur during the wet season unless the site infiltrates 100% of its runoff or the applicant submits and obtains approval for a "Winterization Plan" from DDES. This plan must identify the areas where work is to be performed, describe the techniques that will be used to mitigate erosion, and include the name and number of a 24-hour contact who has demonstrated ability in erosion control.

Source: King County, Washington, 2002

To reduce sediment inputs to wetlands, communities may require more stringent controls during the rainy season, including: restrict major grading operations, require faster vegetative stabilization, and increase the frequency of inspections. Communities may also choose to work with contractors to inspect the site before the start of the rainy season to ensure that soils are stabilized and existing ESC practices are adequate to prevent erosion. Erosion control practices should be inspected after every storm event. Inspections should focus on the area where runoff leaves the site and particularly perimeter controls that can fail during heavy rains.

Encourage the Use of Site Fingerprinting or Construction Phasing

The best way to reduce sediment inputs to wetlands is to prevent erosion from occurring at the construction site in the first place. Communities can prevent erosion by limiting the amount of clearing conducted at a given site by encouraging site fingerprinting and construction phasing. These preventative techniques can significantly reduce the amount of erosion that occurs on a site, and can either be required community-wide, or within sensitive wetland CDAs. Each is described below.

Site fingerprinting (also known as site footprinting) minimizes clearing at a site by limiting disturbance to the absolute minimum needed to construct buildings and roadways (Figure 15). For site fingerprinting to be effective, the limits of disturbance around non-cleared areas must be clearly marked. Signs, flags, and fencing can be used for this purpose. A suggested limit of disturbance around structures is five to ten feet outward from the building pad (Greenfeld, et. al, 1991). In arid regions where fire is a concern, a larger setback may be required to provide a firebreak (e.g., 100 feet). Where possible, construction access points should correspond with planned roads to further reduce clearing. Inspectors should work with contractors during a preconstruction meeting in the field to clearly delineate the limits of disturbance. More guidance on site fingerprinting can be found in Brown and Caraco (2000).

Figure 15. Site fingerprinting
(Photo source: ARC, 2001)

Construction site phasing minimizes the amount of land disturbed at any one time at a construction site by clearing in distinct phases (Case Study 8). This practice departs from traditional construction sequencing, where the entire site is cleared and graded at one time. Under construction site phasing, a portion of the site is cleared and graded, infrastructure is installed, and the disturbed soil is stabilized before work begins on the next phase. Instead of relying on ESC techniques that detain eroded soil, the phasing techniques rely on erosion prevention. Construction phasing works best at large construction sites of at least 25 acres (Claytor, 1997). Practical tips on construction phasing can be found in Claytor (1997).

Case Study 8: Mecklenburg County, North Carolina ESC Ordinance

Mecklenburg County, North Carolina has incorporated construction site phasing into its erosion and sediment control ordinance. The County encourages contractors not to disturb more than 20 acres at any one time. When an area larger than 20 acres is disturbed, the corresponding ESC plan must contain five additional measures to ensure that soils are exposed for the shortest amount of time possible. Included among these measures is construction sequencing and construction phasing to "justify the time and amount of exposure."

Source: Mecklenburg County, North Carolina, 2002

Increase Frequency of Site Inspections

Even the most well-designed ESC plans cannot be effective without frequent inspections and enforcement. Surveys of local ESC experts have revealed that 16% to 50% of ESC practices specified in plans are never installed or are installed improperly (Paterson, 1994; Mitchell, 1993). These findings highlight the importance of bi-weekly inspections and/or inspections after certain sized storm events. Communities can require more frequent ESC inspections within the CDAs of sensitive wetlands. Inspections should be triggered after a certain storm threshold is passed (e.g., a one-inch rain that occurs during a 24-hour period).

Increasing the inspection frequency increases the burden on already overloaded local ESC staff. Communities that lack staff resources may wish to require contractors to hire an independent, certified erosion and sediment inspector to ensure that approved plans are closely followed, to inspect the site on a regular basis, and who can approve in-field plan modification that do not increase impacts to wetlands.

Tool 6: Storm Water Management

Storm water management attempts to compensate for the hydrological changes caused by new and existing development. Effective storm water management programs should identify the primary watershed objectives that govern the selection, design, and location of storm water treatment practices (STPs) at individual development sites. In watersheds with a lot of development pressures and/or sensitive wetland communities, a major objective should be to protect wetlands from upstream storm water impacts. Because sensitive wetlands are affected by even small changes in inundation and water quality, they may need special storm water criteria when working near a wetland or within its CDA. The range of storm water management strategies that can be used to protect wetlands are outlined in Table 11 and described below.

Table 11. Storm Water Treatment Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
In or near wetlands	• Prohibit use of natural wetlands for storm water treatment • Discourage constrictions at wetland outlets • Restrict discharges of untreated storm water to natural wetlands • Encourage fingerprinting of STPs around natural wetlands • Discourage installation of STPs within wetland buffers
Within wetland CDAs	• Develop special sizing criteria for STPs • Promote effective STPs to protect downstream wetlands • Encourage the incorporation of wetland features into STPs and landscaping

Prohibit Use of Natural Wetlands for Storm Water Treatment

Natural wetlands and optimal sites for storm water treatment practices are often located very close together at many development sites. As a result, some communities still utilize natural wetlands for storm water treatment. This occurs when a natural wetland is used to detain or retain storm water, which increases the depth of temporary or permanent ponding in the wetland. Over time, the altered hydrology transforms a natural wetland into a storm water wetland, with the attendant loss of wetland biological diversity and functional value. Communities should review their existing storm water ordinances to make sure they prohibit the use of natural wetlands for storm water treatment, unless they are severely impaired and construction would enhance or restore lost wetland functions. Communities should ensure that both their local storm water and wetland management programs provide consistent guidance on how to balance the need for storm water treatment versus wetland protection.

Discourage Constrictions at Wetland Outlets

Increases in storm water runoff to natural wetlands are compounded if constrictions are built below wetland outlets. Constrictions may be caused by downstream culverts, bridges, dikes, roadway embankments, storm water embankments, and other water control structures. Each type of constriction has the potential to back water up into the wetland – increasing ponding or the frequency of inundation. As noted in Article 1, these hydrological alterations can strongly influence the wetland plant community, and can cause dieback for some woody species, and may impact other wetland dependant species.

In urban watersheds, under-sized culverts can disrupt wetland ecosystems by interfering with the natural flow of water. For example, a Duke University study found that box culverts associated with highway crossings through wetlands acted as bottlenecks for stream flows, impounding water in upstream wetlands (Richardson and Nunnery, 1997). The change in the inundation regime caused existing woody vegetation to die and shifted the wetlands into a more emergent condition, thus changing the wetland function. Communities should carefully evaluate the effect of any proposed constriction in or near a wetland, either as part of the preliminary site plan review process or as part of the local wetland permit review. The local review process can also influence the type of constriction and the design in order to minimize any potential impacts (e.g., require a span or arched culvert instead of a box culvert).

Restrict Discharges of Untreated Storm Water to Natural Wetlands

Storm water runoff may unintentionally be discharged to natural wetlands when storm water pipes daylight above a wetland. Many wetlands exist at a topographic low point and can be expected to receive storm water flows from up-gradient areas. Given the detrimental effects of untreated storm water runoff, communities may choose to restrict these discharges from new and existing storm water pipe outfalls to wetlands.

Local storm water ordinances should require full treatment of runoff prior to discharging to wetlands. This allows removal of pollutants, such as sediment and nutrients, and dissipates the velocity of runoff into the wetland. Communities may also want to explore the feasibility of retrofitting existing storm water outfalls that discharge to wetlands with some form of storm water treatment.

Encourage Fingerprinting of STPs Around Natural Wetlands

In situations where larger STPs are located near wetlands, communities should make sure that the practices are carefully fingerprinted around the wetland to prevent a direct discharge into the wetland. In many cases, storm water can be routed around sensitive wetlands using a diversion or bypass system as described below.

Several structural alternatives for fingerprinting STPs around wetlands to maintain their natural hydrology have been proposed by Schueler (1992). The preferred course of action is to locate the STP in an upstream or off-stream location. An alternative is to install a parallel pipe system that diverts storm flows around the existing wetland to a downstream STP (Figure 16). A flow splitter is installed above the wetland that diverts the storm flows from the development away from the wetland, and sends dry weather base flow to the wetland. The design should attempt to mimic the original water balance to the wetland.

A second technique involves employing a series of smaller storm water pools and wetland areas above and below the natural wetland (Figure 16). Runoff is pre-treated before it enters the wetland, where temporary extended detention is provided. A downstream storm water wetland is created to compensate for impacts to the existing wetland. This scenario will still result in significant storm water influence to the existing wetland, but by lowering peak flows, it can reduce the overall degradation that might occur.

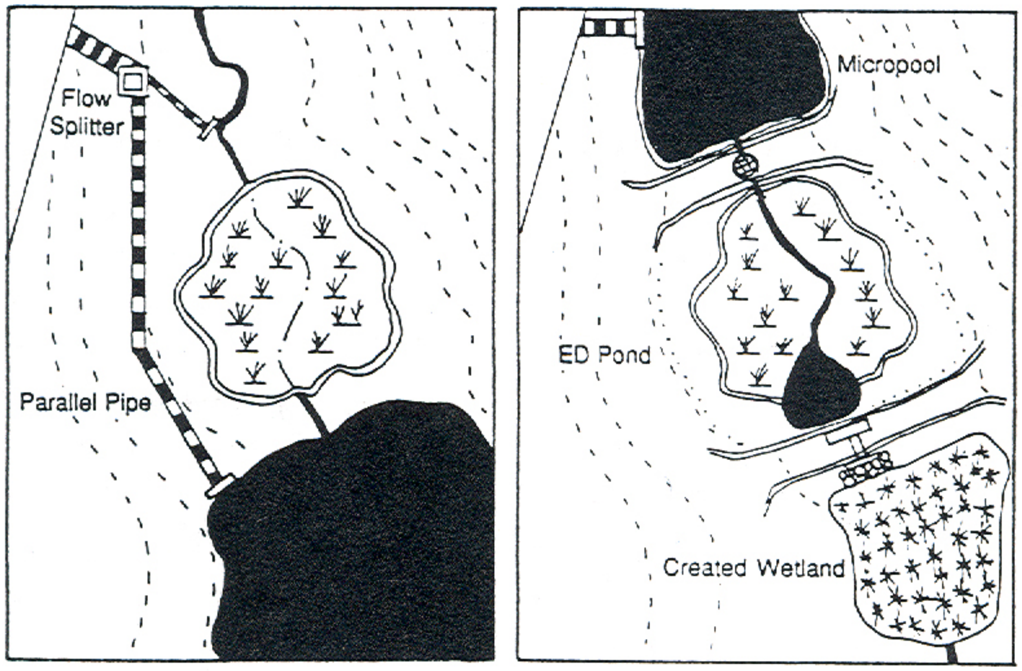


Figure 16. Techniques for fingerprinting STPs around a natural wetland (Graphic source: Schueler, 1992)

Discourage Installation of STPs Within Wetland Buffers

Wetland buffers are intended to connect the wetland with upland habitat areas and provide a transitional area of native vegetation that protects it from future disturbance or encroachment. As a general rule, communities should strongly discourage the location of large STPs, such as storm water ponds or created wetlands, inside the wetland buffer.

In some cases, it may be desirable to transition STPs into the boundary of a wetland buffer. A good example is the forested filter strip shown in Figures 17 and 18, which is explicitly designed to spread storm water runoff over the buffer, where it is filtered and/or infiltrated. Figure 19 shows an alternative outlet for the forested filter strip. The filter strip approach works well when the storm water occurs as sheet flow or shallow concentrated flow. When runoff becomes more concentrated, a storm water depression or bioretention area (Figure 20) may need to be employed at the buffer boundary to store and release the increased runoff volumes.

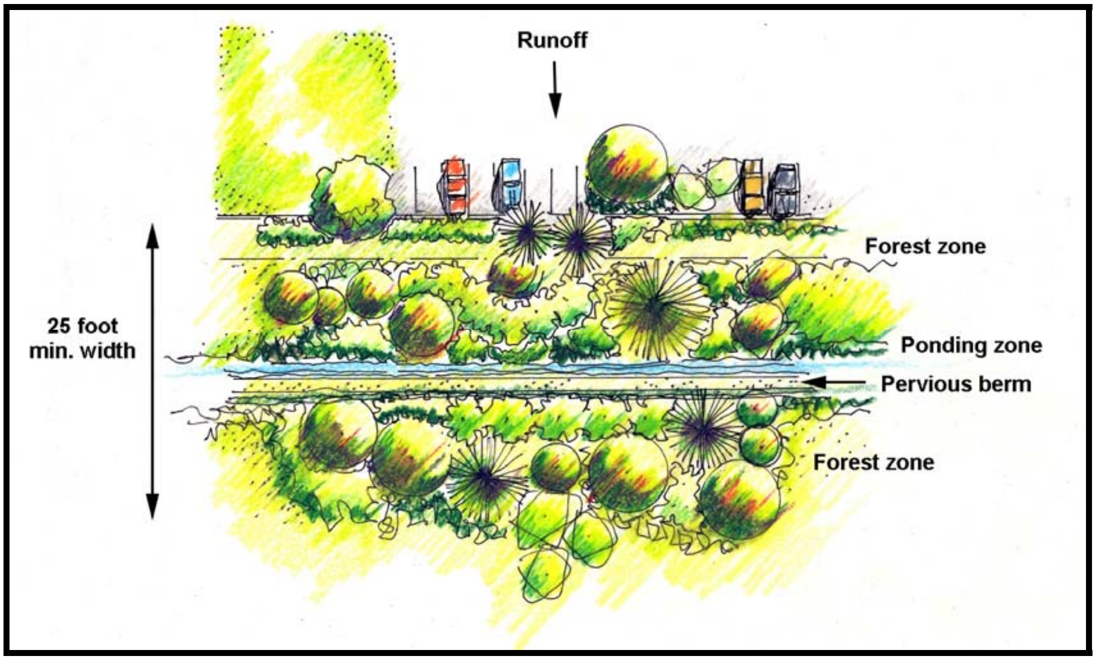


Figure 17. Forested filter strip plan view (Graphic source: Cappiella et al., 2005)

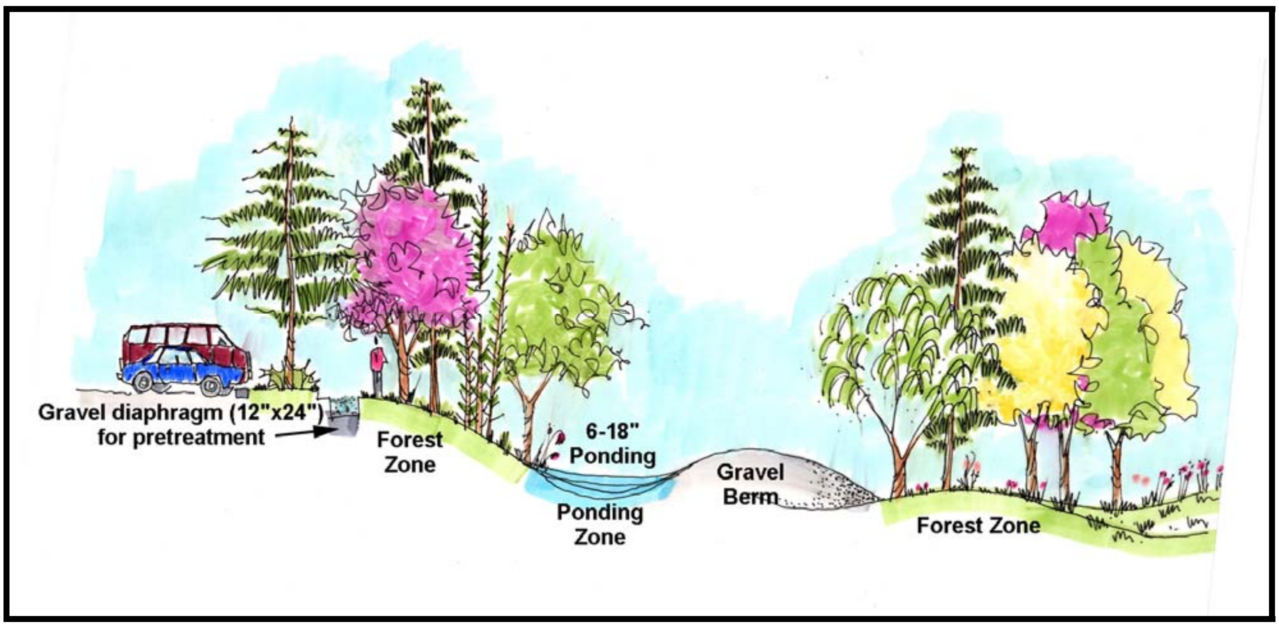


Figure 18. Forested filter strip profile (Graphic source: Cappiella et al., 2005)

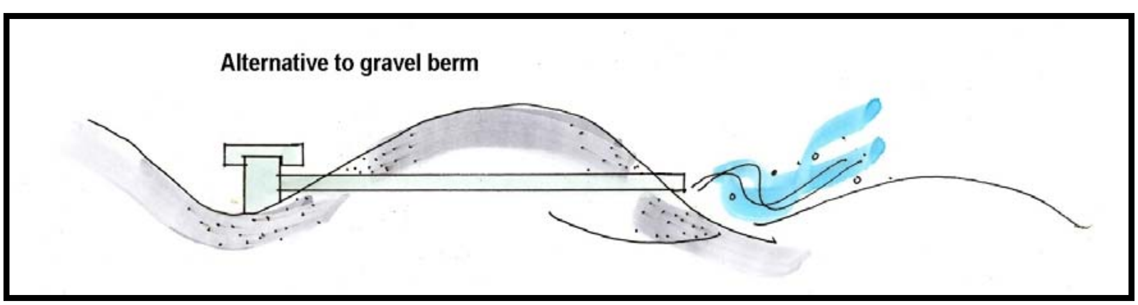


Figure 19. Alternative outlet for forested filter strip (Graphic source: Cappiella et al., 2005)

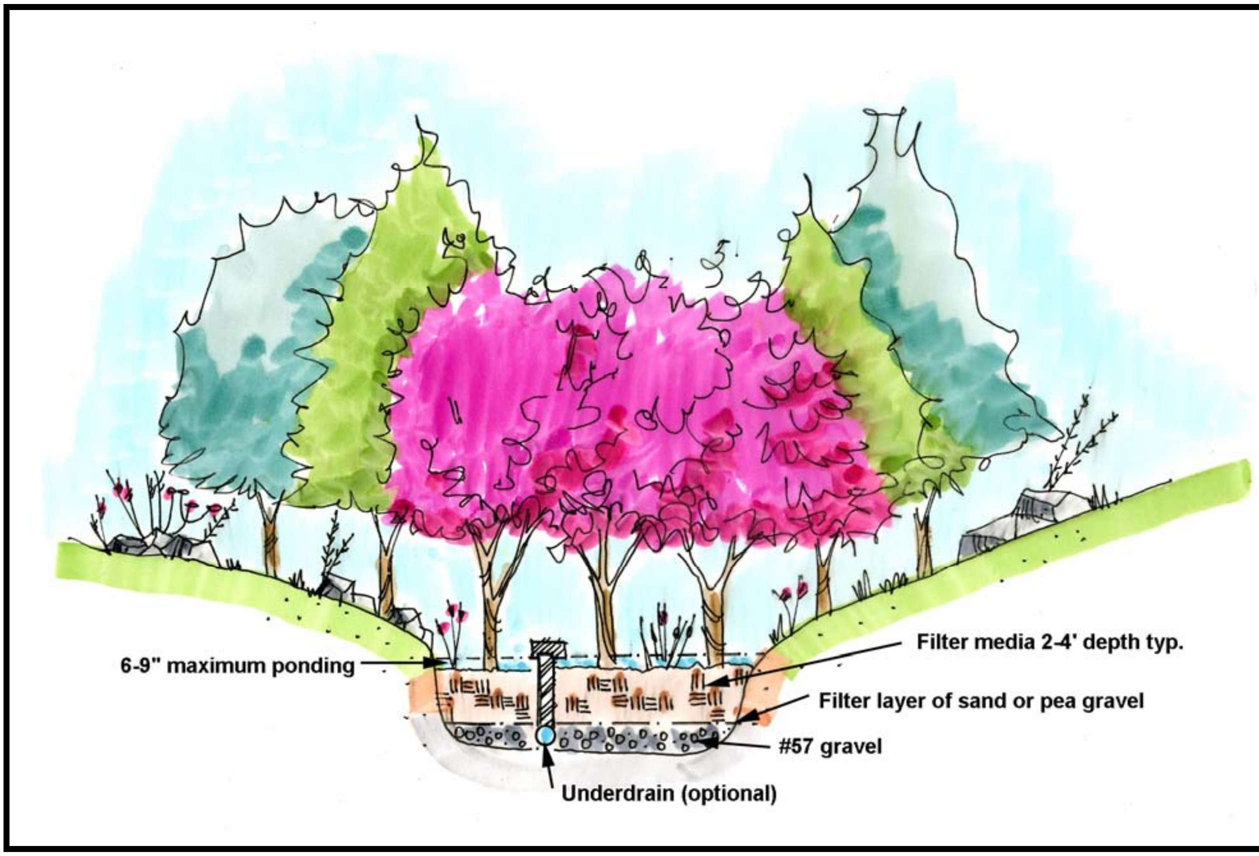


Figure 20. Bioretention facility with trees (Graphic source: Cappiella et al., 2005)

Develop Special Sizing Criteria for STPs

Most communities have already adopted a series of sizing criteria that dictate how much storm water runoff is managed for different-sized storm events. These sizing criteria are outlined in local or state storm water manuals or regulations, and may involve recharge, water quality, channel protection, overbank flooding, and extreme flood control (Figure 21). Communities may want to adjust their existing storm water sizing criteria to protect wetlands from the indirect impacts of storm water runoff. They may also want to require field investigation of any wetlands present at a development site to determine their sensitivity, delineate the CDA, and evaluate whether any additional runoff will be delivered to the wetland as a result of the proposed project. This will allow decisions to be easily made regarding the use of special sizing criteria to protect sensitive wetlands. A general description of basic storm water sizing criteria can be found in ARC (2001) and MDE (2000), and some guidance on how these criteria are expanded to protect wetlands is offered below.

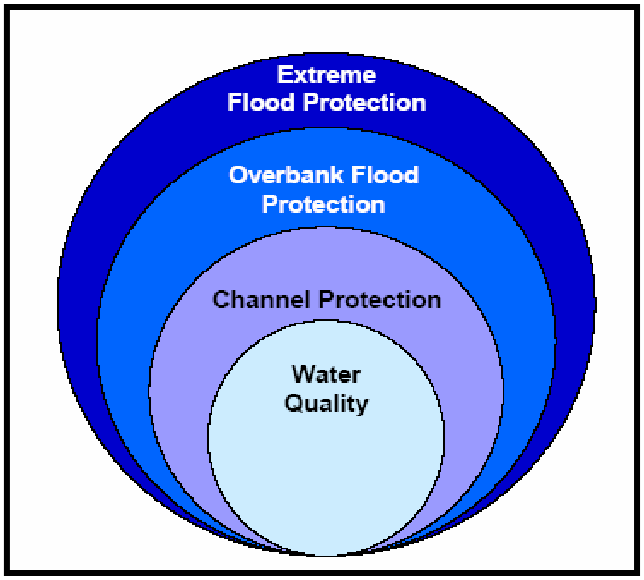


Figure 21. Representation of storm water sizing criteria (Graphic source: ARC, 2001)

Recharge

In recent years, several states and localities have adopted recharge criteria to maintain existing groundwater recharge rates at development sites in order to preserve existing water table elevations and maintain wetland hydrology. The actual recharge volume depends on slope, soil type, and vegetative cover present at the site. Sites with natural ground cover, such as forest and meadow, have higher recharge rates, less runoff, and greater transpiration losses under most conditions. This helps to preserve existing water table elevations thereby maintaining the hydrology of streams and wetlands during dry weather. Because development increases impervious surfaces, a new decrease in recharge rate is inevitable.

To meet the recharge criteria, designers must infiltrate or otherwise filter small volumes of runoff into pervious areas at the development site. In most cases, designers can comply with the recharge criteria by using Better Site Design techniques (see Tool 4) or by installing non-structural STPs. Some communities promote recharge by offering storm water credits that reduce the recharge and/or water quality volume needed for a site when Better Site Design techniques are used (see Case Study 9). Communities can also encourage designers to identify potential recharge soils on the site and design the development around those areas by locating pavement and structures elsewhere on the site, and directing runoff to these areas for infiltration.

Since many sensitive wetlands depend on groundwater to maintain their natural hydrology, communities may choose to require recharge to maintain predevelopment recharge rates within their CDAs. Recharge is also recommended for non-sensitive wetland types that are known to depend on groundwater for their water budget. Specific engineering guidance on the methods to compute and handle recharge requirements are provided in MDE (2000), ARC (2001), NJDEP (2004), WIDNR (2004) and MPCA (2005).

Case Study 9: James City County, Virginia Special Storm Water Criteria

Special Storm Water Criteria (SSC) were developed for James City County, Virginia, to achieve two primary goals. The first is to preserve pre-development hydrology to reduce impacts to high quality streams. The second primary goal of the SSC is to provide enhanced water quality treatment of storm water runoff. The recommended criteria for maintaining recharge are described below.

The recommended criteria for maintaining recharge is a simplified approach to mimic what is a complicated physical process, and is based on the average annual recharge rate of the hydrologic soil group (HSG) present at a site as determined from NRCS soil surveys or from detailed site investigations. To determine whether sufficient recharge is achieved at a site, a certain number of best management practice (BMP) points must be attained. The number of BMP points required is dependant on the site impervious cover and the soils types present. When applying these criteria to a site, designers must first determine the number of BMP points that must be achieved by the storm water plan for the site. The BMP points for recharge that must be provided at a site is calculated as follows:

BMP points required = $S * I_a * 10$

Where:
S = Soil specific recharge factor (varies based on hydrologic soil group: A = 0.4, B = 0.3, C = 0.2, D = 0.1)
I_a = Site impervious cover fraction
10 = Factor

The BMP points can be attained through a combination of structural practices, open space preservation, and site design credits. The recharge volume that must be provided is considered part of the total water quality volume that must be provided at a site. As such, structural BMPs, open space preservation, and site design credits used to achieve the BMP points for water quality may also be use to attain the BMP points for recharge. However, the points applied to storm water BMPs for recharge varies from the points applied to storm water BMPs for water quality. Recommended BMP points for recharge are provided for various infiltration systems, filtering systems, open channel systems, and open space conservation easements. Site design credits are given for disconnection of rooftop runoff or non-rooftop runoff, forestation, green rooftops and environmentally sensitive development.

Source: Zielinski, 2001

Water quality
Under the NPDES MS4 storm water permit system, most communities need to adopt ordinances that require developers to treat a specified volume of storm water runoff in order to remove pollutants. This volume is known as the water quality volume and captures and treats runoff from about 90% of the rain events each year in an acceptable STP. In most regions of the country, the water quality volume is defined as the runoff volume produced from a one-inch storm event. Research indicates that STPs sized in this manner can remove about 80% of the sediment load and 50% of the phosphorus load in urban storm water runoff annually (MPCA, 2005).

The water quality volume should be fully treated before any storm water is discharged to a down-gradient wetland (i.e., within its CDA). While this level of water quality treatment is sufficient for most wetlands, it is inadequate to protect nutrient-sensitive wetlands, such as bogs and calcareous fens. Communities may choose to require a higher level of storm water treatment for these sensitive wetlands by requiring no net increase in phosphorus loading for the portion of the development site within the wetland's CDA. Guidance on calculating site based phosphorus load reductions can be found in CWP (2003) and MPCA (2005).

Channel protection
The purpose of channel protection criteria is to prevent stream channel enlargement and stream habitat degradation due to the increased frequency of bankfull and sub-bankfull flows that follow urbanization (Schueler and Brown, 2004). The most common channel protection criterion requires 24 hours of extended detention storage for the 1-year, 24-hour design storm event. Stored runoff is released in such a gradual manner that critical erosive velocities during channel-forming events are seldom exceeded in downstream channels.

While channel protection criteria are primarily intended to protect the physical integrity of streams, they can also be applied to protect wetlands in two situations. The first is when a headwater stream is a direct tributary to a wetland where future increases in bed and bank erosion are expected to greatly increase sediment deposition in the wetland. The second is when a community has a large proportion of freshwater palustrine wetlands that are located in or near headwater stream channels that are expected to be adversely impacted by sedimentation.

Wetland hydroperiod
The term 'wetland hydroperiod' refers to the extent and duration of inundation and/or saturation of wetland systems. As discussed in Article 1, upland development can increase the frequency and duration of inundation within a wetland. Even small changes in wetland hydroperiod can have detrimental effects in sensitive wetlands. In recent years, a handful of communities have adopted hydroperiod standards into their existing storm water management regulations. The basic goal of such standards is to maintain the existing wetland hydroperiod in all sensitive wetlands, while allowing some minor hydroperiod changes in more tolerant wetland types. Table 12 presents some representative guidance on wetland hydroperiods that defines the allowable water level fluctuation (WLF), discharge rate, and duration of inundation for Minnesota wetlands of varying sensitivity to storm water inputs. WLF is the difference between the maximum and minimum water level elevation, and is commonly used to quantify wetland hydroperiod.

Table 12. Hydroperiod Standards for Wetlands

Hydroperiod Standard	Wetland Type			
	Highly Sensitive	Moderately Sensitive	Slightly Sensitive	Least Sensitive
WLF	Existing*	Existing + 0.5 feet	Existing + 1 foot	No limit
Discharge rate	Existing	Existing	Existing or less	Existing or less
Inundation period for 1- and 2-year storm event	Existing	Existing + 1 day	Existing + 2 days	Existing + 7 days
Inundation period for 10-year+ storm event	Existing	Existing + 7 days	Existing + 14 days	Existing + 21 days
Run-out control elevation (free flowing)	No change	No change	0 to 1 foot above existing run out	0 to 4 feet above existing run out
Run-out control elevation (landlocked)	Above delineated wetland	Above delineated wetland	Above delineated wetland	Above delineated wetland
*Existing refers to the existing hydrologic conditions, or the conditions that established the current wetland, if recent changes have occurred. Source: MNSWAG (1997)				

Designers must model the effect of runoff discharge from the CDA to the sensitive wetland to ensure they conform to the WLF and inundation duration guidelines set forth in Table 12 using infiltration, extended detention storage, diversion, or other methods. As might be imagined, the modeling needed to assess wetland hydroperiod can be complex, and requires very detailed field information for both the wetland and the CDA. In some cases, studies need to be performed to establish the naturally-occurring hydroperiod for each individual wetland so that a baseline can be developed. Factors such as the wetland bathymetry, outlet configuration, ratio of the wetland surface area to its CDA, and landscape position may also need to be determined.

To date, only a handful of communities have adopted hydroperiod standards for wetlands, probably due to difficulties in how to model, implement, review, and enforce them. Perhaps the best-developed local wetland hydroperiod regulations have been developed by King County, Washington, which are described in Case Study 10.

Case Study 10: Puget Sound Wetland Guidelines

Washington State Department of Ecology's Storm Water Management Manual specifies that discharges to wetlands must maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated beneficial uses. To provide guidance for developers on how to meet this requirement, the Puget Sound Wetlands and Stormwater Management Research Program developed criteria for determining the maximum allowed exceedances in alterations to wetland hydroperiods. The resulting Puget Sound Wetland Guidelines are summarized below.

In order to determine if the proposed development will impact the wetland hydroperiod, designers must first determine the existing hydroperiod of the wetland using simulation models or actual measurement over a period of time. Next, they must forecast the future hydroperiod of the wetland using simulation models or impervious cover (IC) estimates and relationships between IC and WLF (Chin, 1996; Horner et al., 1997). The future hydroperiod of the wetland must meet the following standards:

- Mean annual WLF shall not exceed 20 cm
- The frequency of stage excursions of 15 cm above or below pre-development stage shall not exceed an annual average of six
- The duration of such stage excursions shall not exceed 72 hours per excursion
- The total dry period shall not increase or decrease by more than two weeks in any year
- Alterations to watershed and wetland hydrology that may cause perennial wetlands to become vernal shall be avoided

For priority peat wetlands (e.g., bogs, fens), the duration of stage excursions above the pre-development stage shall not exceed 24 hours in any year. For wetlands inhabited by breeding native amphibians during breeding season, the magnitude of stage excursions above or below the pre-development stage shall not exceed 8 cm, and the total duration of such excursions shall not exceed 24 hours in any 30-day period.

If the analysis forecasts exceedance of any of the hydroperiod standards, then the designer must consider reducing the level of development, increasing the runoff storage capacity, using selective runoff bypass, or increasing runoff infiltration, where feasible. After development, wetland hydroperiod must be monitored continuously to determine if applicable limits are exceeded.

Source: Horner et al. (1997)

Promote Effective STPs to Protect Downstream Wetlands

The selection and design of STPs applied in the CDA is very important in protecting sensitive wetlands. Some STPs work better than others, and all can incorporate design features to enhance their effectiveness in protecting wetlands. The primary storm water management strategy within the CDA is to maximize the amount of infiltration and filtering across the site. Many of the Better Site Design techniques discussed earlier can be used for this purpose. In addition, designers should seek to:

- Disconnect rooftops and other impervious surfaces from the storm drain network
- Use any pervious areas to treat runoff close to the source through recharge and infiltration
- Use swales rather than curbs and gutters along streets wherever possible
- Conserve forests and other natural areas at the site to maintain predevelopment hydrology
- Replant open or turf areas to achieve greater site forest cover or other native vegetative cover
- Take care during clearing and construction to minimize the degree of soil compaction.

When combined with reductions in impervious cover as a result of Better Site Design, these storm water management practices can greatly reduce storm water inputs to downstream wetlands. Communities should realize that these runoff reduction opportunities can only be realized if they are considered very early in the site layout process. Communities may find it advisable to request a runoff reduction "concept plan" during the early stages of development plan review to make sure these opportunities are maximized.

Most local and state storm water design manuals contain dozens of different STP designs that can be used at a development site. Communities may choose to closely review their manuals to provide more guidance on STP design within the CDA. In general, infiltration and bioretention practices are recommended to protect sensitive wetlands. Wet ponds, sand filters, and storm water wetlands may also be used, although great care must be taken when siting and designing them because these STPs do not significantly reduce runoff volumes generated at the development site. Dry detention ponds are generally not recommended as a wetland protection practice since they only have a mediocre capability to remove pollutants or reduce runoff volumes. Indeed, the discharge from a detention pond directly to a wetland is likely to alter the wetland's hydroperiod. A combination of STPs is often needed to protect sensitive wetlands, and should be based on its current functions, water budget, and future changes in storm water inputs. Guidance on the use of specific STPs to protect wetlands is provided below.

Infiltration practices

Infiltration practices capture and temporarily store runoff and allow it to infiltrate into the ground over a period of days. Infiltration practices are the ideal STP since they are the only practices that maintain the predevelopment runoff volume at a development site. Infiltration practices, however, are often limited by soil conditions, such as permeability and depth to water table. Often, the presence of wetlands at a site signals that local conditions may not be suitable for infiltration. If soil testing indicates that infiltration is infeasible, bioretention should be considered the preferred practice to use in the CDA. For more information on designing infiltration practices, see MDE (2000) and NJDEP (2004).

Bioretention practices
Bioretention practices are shallow landscaped depressions that capture runoff and filter it though a prepared soil mix. Runoff is typically collected in an underdrain system and returned to the storm drain system. Bioretention practices are highly recommended if soils are unsuitable for infiltration. Recent research indicates that several bioretention designs have high pollutant removal rates and help reduce runoff volumes through evapotranspiration, and in some cases, partial or full infiltration into the subsoil. Bioretention practices treat runoff near its source and can also be an attractive landscape feature. For more information on the design of bioretention practices, see Claytor and Schueler (1996).

Wet ponds and sand filters
Wet ponds and sand filters may also be appropriate practices to consider within the CDA of a wetland. Both types of practices receive high marks for pollutant reduction, but only produce minor changes in runoff volumes. Designers should be extremely careful in fingerprinting these practices around wetlands, and keeping them outside of the wetland buffer. Most importantly, designers should ensure that storm water discharges from both practices do not alter the hydroperiod of any sensitive wetland located downstream. Additional guidance on the design of wet ponds and sand filters is provided in MDE (2000), NJDEP (2004), and Claytor and Schueler (1996).

Storm water wetlands
Storm water wetlands can be an effective practice to protect sensitive natural wetlands, but only if they are carefully fingerprinted so their discharge does not change the wetland hydroperiod. A storm water wetland is located away from natural wetlands and their buffers, and is designed to provide storage to mimic the wetland pollutant removal and flood control functions of a single wetland type — the freshwater emergent marsh. Storm water wetlands have a high pollutant removal capability, and help add to the inventory of "new" wetland cover within a watershed.

A typical example of a storm water wetland design is provided in Figure 22. The basic goal is to create an artificial wetland that evolves over time to achieve the same functions and benefits of a natural wetland. This can be an elusive goal—since a storm water wetland receives much greater runoff and pollutant inputs. The pair of photos shown in Figure 23 shows the range of outcomes that can be achieved in a storm water wetland. The first storm water wetland is complex, diverse and attractive, while the second is a monoculture of a single species (cattails). While both storm water wetlands may provide about the same pollutant removal, they clearly differ in the other wetland functions they provide. Indeed, the invaded storm water wetland may well serve as a source of unwanted colonization to other nearby natural wetlands. The difference in the two storm water wetland outcomes is primarily rooted in careful design and proper construction. Some real world tips to create storm water wetlands that most resemble natural wetlands are provided in Box 2.

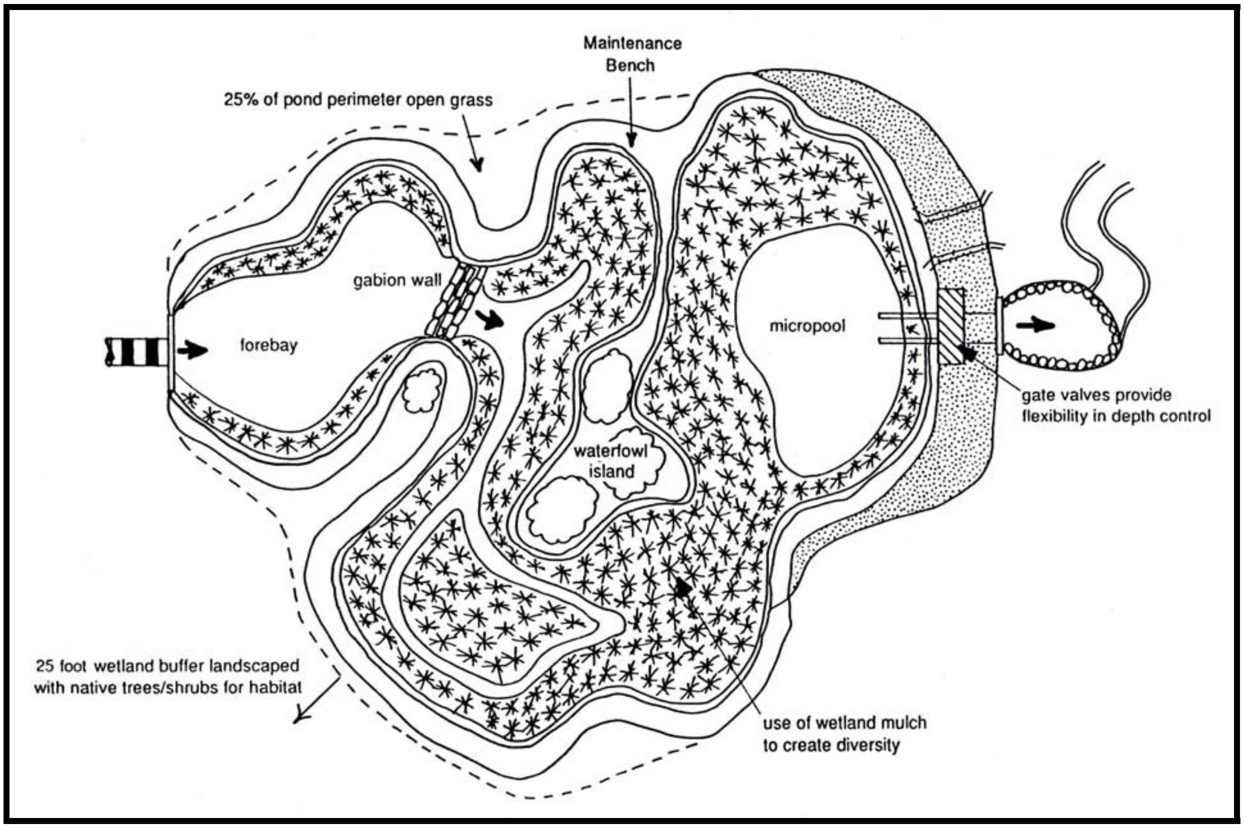


Figure 22. Shallow marsh schematic (Graphic source: Schueler, 1992)

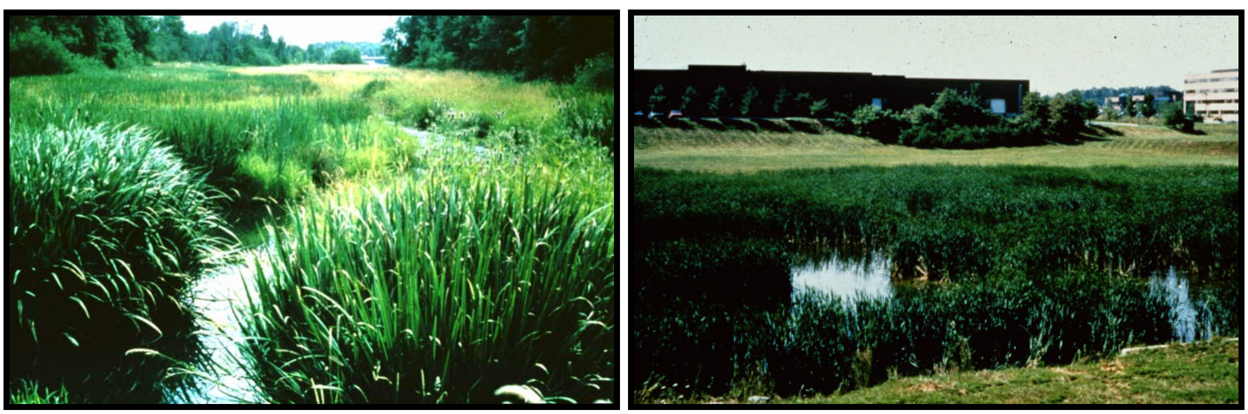


Figure 23. Comparison of a well designed (left) and a poorly designed (right) storm water wetland

Box 2. Real World Design Guidance for Storm Water Wetlands

- ☐ Clearly understand both the pre- and post development hydrology at the proposed wetland site
- ☐ Take some tests to determine the real groundwater interaction at the proposed wetland site
- ☐ The final wetland plant community seldom resembles the one that was originally planted—the initial planting should be viewed as a template within which new colonizers will appear.
- ☐ Plant diversity is created when variable microtopography creates a wide range of depths both above and below the pool
- ☐ A few deeper pools are needed for the forebay, micropool and to provide water quality storage
- ☐ The most vigorous wetland plant density occurs with a fairly narrow depth range (+ or - 6 inches from normal pool)
- ☐ Extended detention can be provided above the permanent pool to reduce the land consumption—but try to limit it to no more than 2 or 3 feet elevation
- ☐ A micropool is an essential design element to trap sediments before they reach the wetland
- ☐ Better landscaping of buffers can discourage geese and provide links to terrestrial habitat
- ☐ Chloride inputs are a problem in some northern climates
- ☐ Adapt a good regional plant list and look at the surviving plant community in older storm water wetlands when specifying species to establish in the new wetland
- ☐ Many communities may be concerned about the future regulatory status of wetlands designed for storm water treatment—the precedent appears to be that if a created storm water wetland is regularly maintained and was required under a storm water NPDES permit, it will be considered a treatment system and not a jurisdictional wetland.

Many natural wetlands are forested in nature. New storm water wetland designs proposed by Cappiella et al. (2005) seek to replicate wooded wetlands using tree mounds within the wetland to increase forest cover. These innovative approaches to storm water wetland design are illustrated in Figure 24 and 25. Figure 26 illustrates numerous ways to enhance wildlife habitat in storm water wetlands.

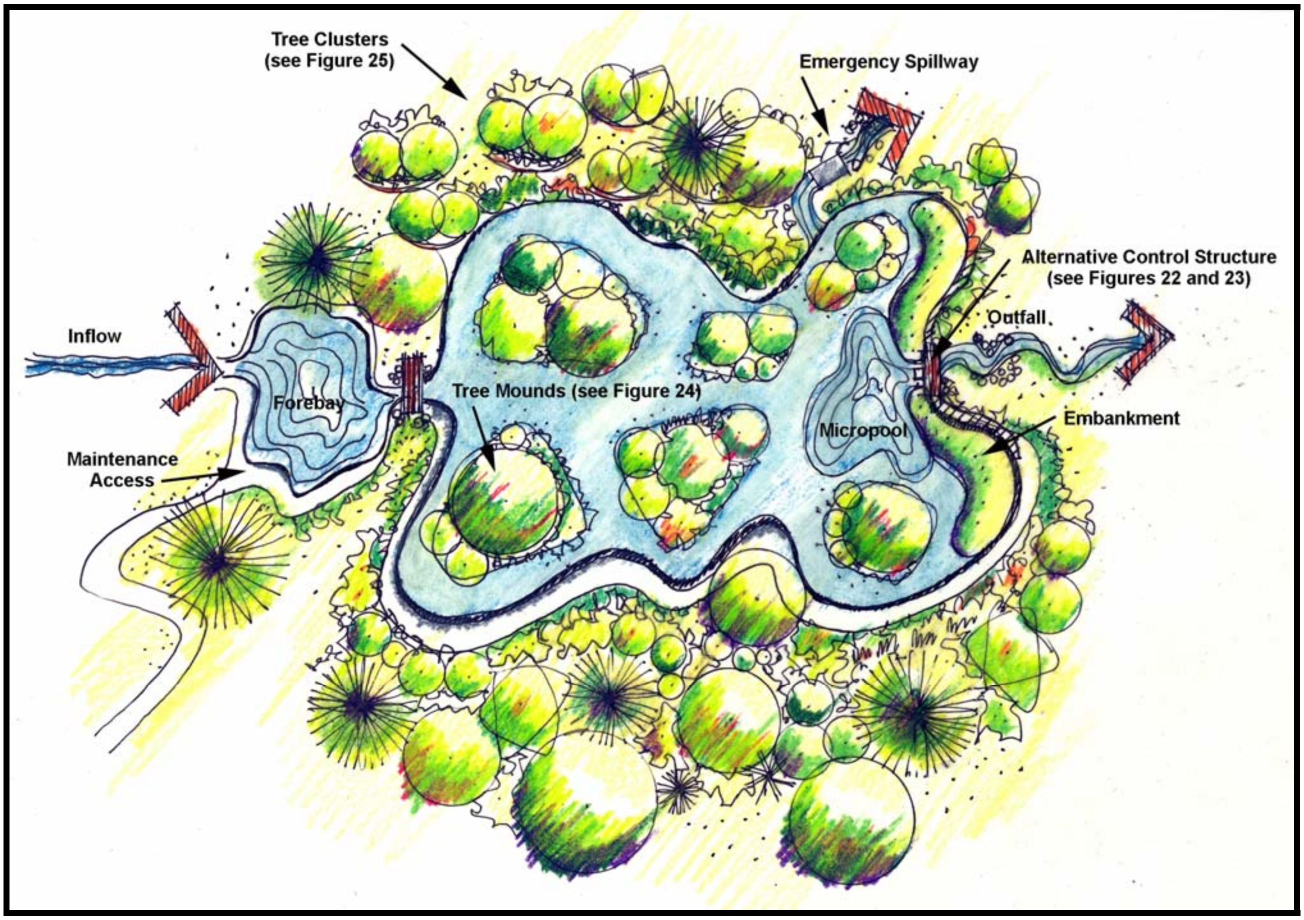


Figure 24 Wooded wetland (Graphic source: Cappiella et al., 2005)

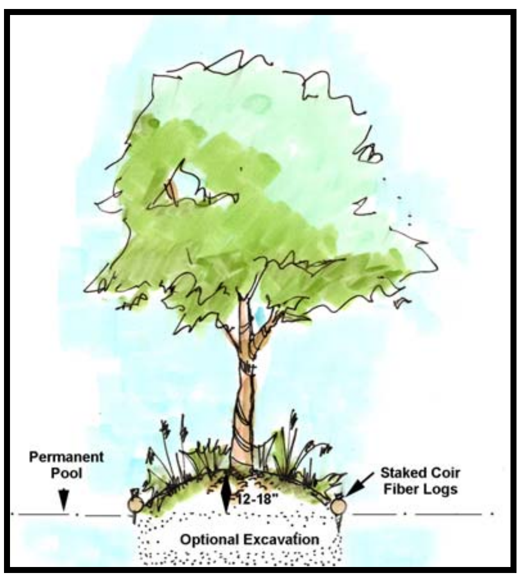


Figure 25. Tree mound (Graphic source: Cappiella et al., 2005)

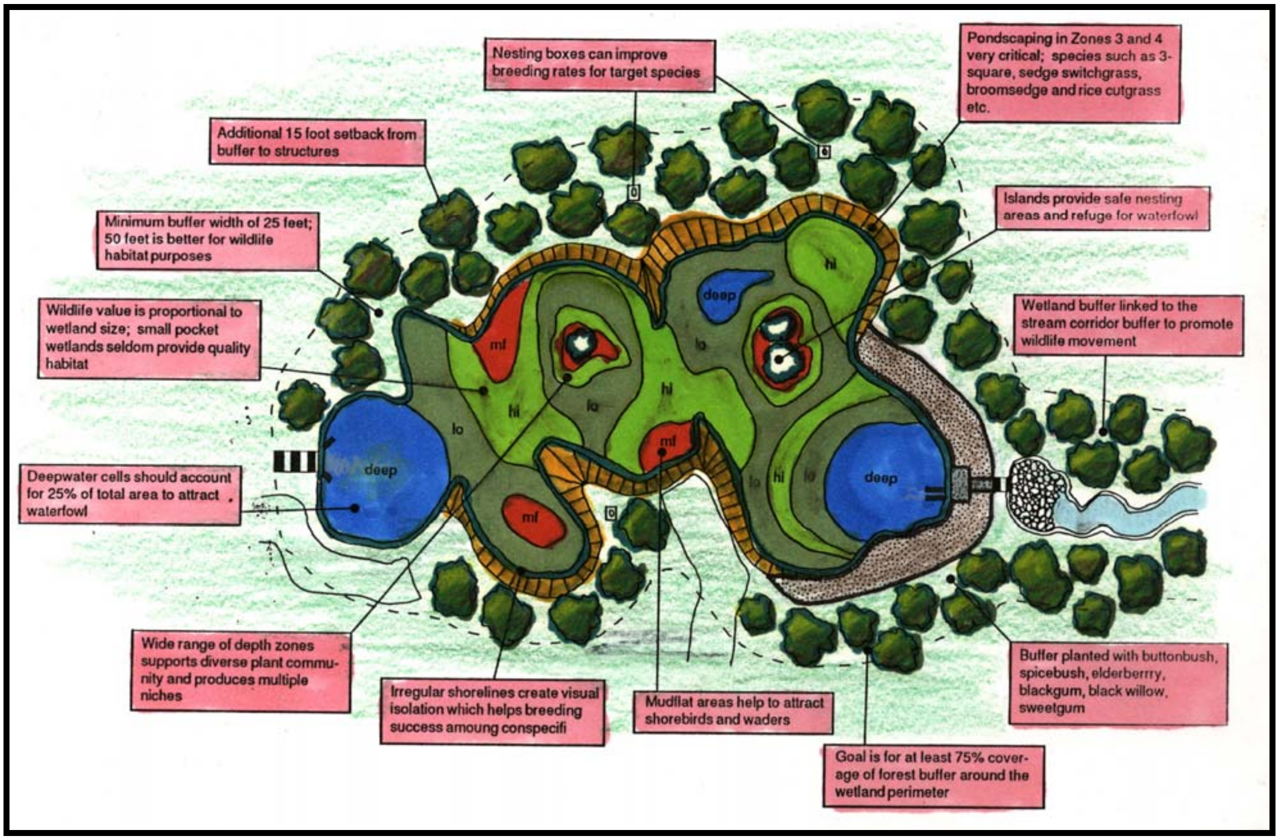


Figure 26. Techniques for enhancing wildlife habitat in storm water wetlands (Graphic source: Schueler, 1992)

Encourage Incorporation of Wetland Features into STPs and Landscaping

Wetland features can be incorporated into other STPs and site landscaping to increase the pollutant removal performance, habitat value, and appearance of these practices. Wetland features can be incorporated into areas of other STPs that are expected to receive regular inundation. Prominent examples include:

- The aquatic bench and safety benches of wet ponds
- The bottom of wet swales
- Around the fringes of basins
- The center of bioretention areas that lack underdrains

Wetland features can also be incorporated into landscaping features at a site. Traditionally, landscaping and storm water management have been treated separately in site planning. In recent years, engineers and landscape architects have discovered that integrating storm water into landscaping features can improve the function and quality of both. The basic concept is to adjust the planting area to accept storm water runoff from adjacent impervious areas and utilize wetland plant species adapted to the modified inundation regime (Table 13). Excellent guidance on how to match plant species to storm water conditions can be found in Shaw and Schmidt (2003) and in Cappiella et al. (2005).

Table 13. Environmental Factors to Consider When Integrating Storm Water and Landscaping	
Duration and depth of inundation	Invasive plants
Frequency of inundation	Pollutants and toxins
Available moisture during dry weather	Soil compaction
Sediment loading	Susceptibility to erosion
Salt exposure	Browsers (deer and beavers)
Nutrient loading	Slope
Adapted from Shaw and Schmidt (2003)	

Tool 7: Non-Storm Water Discharges

Non-storm water discharges, such as sewer overflows, septic system effluent, illicit connections, runoff from confined animal feedlots, and illegally dumped materials can contribute significant pollutant loads to downstream waters and wetlands. Communities have a range of techniques to control these discharges, and prevent pollutants from entering wetlands. Specific strategies to prevent non-storm water discharges to wetlands are listed in Table 14.

Table 14. Non-Storm Water Discharge Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
Wetlands and their CDAs	• Conduct illicit discharge surveys for all outfalls to wetlands
In or near wetlands	• Actively enforce restrictions on dumping in wetlands and their buffers • Reduce alternative mosquito control methods to reduce insecticide inputs to wetlands
Within wetland CDAs	• Require enhanced nutrient removal from on-site waste water treatment systems • Require regular septic system inspections

Conduct Illicit Discharge Surveys for all Outfalls to Wetlands

A storm drain that has measurable flow during dry weather containing pollutants is defined as an "illicit discharge." Sources of illicit discharges include cross-connections between the sewer system and the storm drain system, as well as land use activities that illegally discharge pollutants to the storm drain system. Storm drain outfalls can contribute a variety of pollutants to a wetland during both dry and wet weather. A discussion of the impact of urban storm water pollutants to wetlands is provided in Article 1. To help protect wetlands from illicit discharges, communities can conduct illicit discharge surveys for all outfalls that discharge directly to wetlands or are located within wetland CDAs.

Illicit discharge surveys involve finding and fixing the source of each illicit discharge. These surveys are not only useful for protecting wetlands, but they also meet a requirement of the NPDES program for Phase II communities. Illicit discharge surveys are conducted during dry weather, and involve locating and evaluating all storm water outfalls to determine if there is flow. If flow is detected at a storm drain outfall during dry weather, it is considered a potential illicit discharge. Survey teams take water quality samples at all flowing outfalls to identify the type of discharge and track the source of the discharge. Communities can conduct illicit discharge surveys for wetlands as part of their existing illicit discharge detection and elimination programs, or can survey outfalls to wetlands as part of ongoing wetland assessments, stream assessments, or other local watershed assessments. Brown et al. (2004) provides additional guidance on conducting illicit discharge surveys.

Actively Enforce Restrictions on Dumping in Wetlands and their Buffers

Urban stream valleys and wetlands are common locations for illegal dumping because they do not have obvious landowners, are not usually policed, and are often poorly lit (Figure 27). Most communities have ordinances that prohibit dumping, but they are often very difficult to enforce. To prevent wetlands and their buffers from becoming dumping grounds, restrictions must be imposed and enforced in these areas. This includes specifically identifying wetlands and buffers as restricted dumping areas, posting *No Dumping* signs, installing lighting, making use of community groups or adopt-a-wetland groups as monitors, and clearly outlining and enforcing penalties.

Figure 27. Illegal dumping in a wetland (Photo source: USFWS, no date)

Promote Alternative Mosquito Control Methods to Reduce Insecticide Inputs to Wetlands

A common public concern regarding wetlands is the presence of mosquitoes that carry and spread diseases, such as the West Nile Virus. In an attempt to reduce public exposure to mosquitoes, many communities have instituted mosquito control programs that consist of population surveillance, source reduction, insecticide application, and public education (USEPA and CDC, 2005). In the past, source reduction usually meant ditching and draining wetlands to control mosquito populations. Today, it typically includes less extreme habitat modification methods, with application of insecticides when mosquito populations are abundant. USEPA and CDC (2005) encourage the use of an integrated approach to mosquito control, where insecticides are used only as a last resort. To reduce insecticide inputs to wetlands, communities can review their current mosquito control programs, and investigate and promote effective alternative control methods.

Alternative mosquito control methods include biological control methods and Open Marsh Water Management (OMWM), which is used primarily in coastal areas. OMWM was first applied in New Jersey in the 1960's, and has since been implemented in coastal areas of the Northeast and Mid-Atlantic, and has been extensively studied in the scientific arena (Lesser, 2003). OMWM includes the management of impounded water or open marshes to reduce the production and survival of mosquitoes by eliminating breeding depressions and increasing natural enemies of mosquitoes. For the majority of mosquito species, production increases with duration of standing water. OMWM is used mainly in coastal areas, where the prevalent mosquito species are "temporary pool" species, ones that depend on dry periods for egg development (McClean, 1994). If this habitat modification method is used in areas where "permanent pool" species also exist, populations of these types of mosquitoes may actually increase. Therefore, it is important when using alternative control methods to be familiar with the prevalent species and their breeding requirements. Additional information on OMWM is provided in Lesser (2003).

Biological control of mosquitoes includes the use of natural predators, such as dragonflies, damselflies, bats, and fish that eat mosquito larvae and pupae. The most commonly used biological control species are mosquito fish, *Gambusia affinis* and *G. holbrooki,* because they are easily reared (Lesser, 2003). Naturally occurring killifish, *Fundulus* spp, also play an important role in mosquito control in OMWM, as the habitat modification associated with this method creates conditions that are ideal for the species (Lesser, 2003). Another biological control option is a bacterium, *bacillus thuringiensis israelensis (Bti,)* that can be applied to stagnant waters or storm sewers with little to no environmental impact (INDNR, no date). Since some of these biological control options involve the introduction of non-native species, consultation with state fish and wildlife departments is required before pursuing these methods. Because healthy wetlands sustain numerous species of mosquito-eating fish, amphibians, insects, and birds, all of which help limit mosquito populations, protecting and restoring wetlands may be the best way to control mosquito populations (USEPA, 2004). Case Study 11 illustrates this concept.

Case Study 11: Wetland Restoration and Mosquito Reduction in New Hampshire

Restoration of a two-acre wetland near Portsmouth, New Hampshire in 1999 had an unintended secondary benefit—reduction of the mosquito population. The Edmond Avenue wetland was in a degraded condition prior to restoration, as a result of residential development that had partially filled the wetland. Urban storm water runoff had contaminated the water, and excessive sediment inputs and invasive species were common. By 1996, the site had become a major breeding site for the *Culex* species of mosquito, which is primarily responsible for West Nile Virus transmission. As a result, application of mosquito larvicides increased four-fold during 1996 to1999 compared to the previous 15 years.

Restoration of the Edmond Avenue wetland in 1999 has changed the ecology of the site so much that mosquito control measures are no longer required. Stagnant depressions where mosquitoes can breed were eliminated, and the wetland now supports populations of fish that eat mosquitoes. The wetland restoration project resulted in a near 100% reduction in mosquito habitat, and the virtual elimination of the *Culex* species, in addition to improved water quality, bird habitat, and wetland function.

Source: USEPA (2004)

Require Enhanced Nutrient Removal from On-Site Waste Water Treatment Systems.
On-site waste water treatment systems provide a means of treating household waste for those areas that do not have access to public sewer, or where sewering is not feasible. Traditional on-site waste water treatment systems are not designed to remove nitrogen from the wastewater they discharge. Nitrogen from these systems leaches into groundwater, which can have major water quality implications for groundwater-dependant wetlands. As an example, an estimated 7.7 million pounds of nitrogen enter the Chesapeake Bay each year from on-site waste water treatment systems (OSSDTF, 1999). Phosphorus is less of a concern from these systems because this nutrient typically binds to soil particles before reaching water resources. The impacts of nutrient loadings on wetlands are discussed in detail in Article 1.

To protect wetlands from potential water quality impacts from on-site waste water treatment systems, communities may require enhanced nutrient removal from these systems. It is up to the community to define the desired removal efficiencies, although in some cases this may be driven by state regulations. For example, in order for a septic system in Maryland to be labeled "nitrogen reducing," the state requires a 50% nitrogen removal rate (Maryland General Assembly, 2002). Alternative waste water treatment systems that provide enhanced nutrient removal typically do so through denitrification or vegetative uptake. There are many types of alternative systems, including:

- Peat bio-filters
- Intermittent sand filters
- Recirculating sand filters
- Constructed wetlands
- Aerobic treatment units

Communities can encourage the use of these alternative systems by establishing more stringent performance criteria for waste water treatment, including higher nutrient removal efficiencies, and writing this into their local septic system design guidance and/or ordinances. New systems would only be certified after a post-construction inspection verifies they have met the specific criteria. Several alternative waste water treatment systems that provide enhanced nutrient removal are described below.

Peat bio-filters
Peat bio-filters function similar to a conventional septic system in that waste water from the residence first flows through a septic tank to allow solids to settle. The effluent then flows to a peat filter, where it is filtered through two to three feet of peat for treatment before being discharged to the soil for final disposal. Nitrogen is removed through denitrification. The peat filter system nitrogen removal ranges from 30% to 65%, depending on the system (MADEP, 1997). This variation is probably due to the different types of peat used, different wastewater strengths, or different system designs and wastewater loading rates (MADEP, 1997).

Sand filters
Sand filters are an alternative that is commonly used to provide additional treatment for effluent before it is discharged. These filters can be located either above or below ground, depending on the site conditions, and can be used in conjunction with a septic tank or an aerobic treatment unit.

The filter acts to reduce the amount of suspended solids and dissolved organic material present in the water. Microorganisms attached to the sand particles are able to aerobically digest the organic material within the waste water. Underneath the sand bed is a layer of gravel and underdrain piping, which either carries the effluent away from the filter, or rechannels a portion of the effluent back to the sand filter to be treated again. This latter design is called a recirculating sand filter (RSF). RSFs remove an estimated 60% of total nitrogen (Swann, 2000). Another variation is an intermittent sand filter, where waste water is dosed onto a sand bed intermittently during the day.

Constructed wetlands
Constructed wetlands are designed to mimic the sediment and nutrient removal processes occurring in natural wetlands. Design is based on holding or slowing the passage of effluent through the wetland, where a range of physical, chemical, and biological processes can operate to store, transform, or remove various pollutants. A constructed wetland usually consists of a lined excavation filled with gravel and planted with deep-rooted emergent marsh vegetation (e.g., bulrushes, reeds, rushes, and sedges). There are two basic designs of constructed wetlands: surface flow systems, where the wastewater passes over the medium; and subsurface flow systems in which the wastewater passes directly through the medium (Swann, 2000).

Aerobic treatment units
Aerobic treatment units (ATUs) are designed to treat waste water in an oxygen rich environment and, therefore, tend to produce a cleaner effluent than septic tanks alone. ATUs may be used in addition to, or instead of, a septic tank although septic tank pretreatment is recommended. Most aerobic units are buried underground and effluent from the unit is conveyed to further treatment processes, or to final treatment and disposal in a soil disposal system. ATUs are efficient at reducing total suspended solids and biological oxygen demand levels, and can be designed with denitrifying equipment to enhance their nitrogen removal capability (Swann, 2000). ATUs remove an estimated 67% of total nitrogen (NAHB, 2004).

Require Regular Septic System Inspections
While properly operating septic systems can contribute nutrients to wetlands through groundwater inputs, failing systems can have an even greater impact on wetland water quality by releasing bacteria and other pollutants into groundwater. A Chesapeake Bay area survey by CWP (1999) found that 46% of septic system owners had not had the system cleaned in the last three years, which is the minimum recommended cleanout frequency. Lack of maintenance is a major contributor to septic system failure, with typical failure rates ranging from 5% to 30% in some regions of the country (Swann, 2001).

To reduce pollutant inputs to wetlands from septic systems, local health departments must regularly inspect septic systems and take actions to fix or replace failing systems. Innovative approaches to local septic system management include charging homeowners a monthly fee that is used for inspection, maintenance, and education. Others have developed a revolving loan program to provide low-cost repair to failed systems. For example, the Stinson Beach, California Water District monitors septic system operation to identify failures and detect water contamination, and charges homeowners $12.90 per month for this inspection service, plus the cost of any repairs (Ohrel, 1995). This type of requirement may apply community-wide, or within sensitive wetland CDAs.

Tool 8: Watershed Stewardship

Watershed stewardship increases public understanding and awareness about watersheds, promotes better stewardship of private lands, and develops funding to sustain watershed management efforts. Wetlands should be a key component of watershed stewardship, but are often not specifically addressed in watershed education and outreach efforts. To increase stewardship of wetlands, communities can use the strategies presented in Table 15.

Table 15. Watershed Stewardship Strategies to Protect Wetlands and their CDAs

Where the Strategy is Applied	Strategy
Wetlands and their CDAs	• Incorporate wetlands into watershed education programs • Post signs to identify wetlands, buffers, and wetland CDA boundaries
In or near wetlands	• Manage invasive wetland plants • Establish volunteer wetland monitoring and adoption programs • Encourage wetland landowner stewardship • Establish partnerships for funding and implementing wetland projects

Incorporate Wetlands into Watershed Education Programs
Two goals of watershed education are to increase community awareness and preserve local water resources; therefore, wetlands should be an important component of any watershed education initiative. However, many watershed education programs tend to focus only on rivers and/or streams. Communities should be sure to include wetlands in their watershed education programs, as many citizens look to their local governments to give them information on wetlands (Christie, 2000).

Educating the public about wetlands presents some unique challenges, since it was not so long ago that wetlands were viewed as wastelands that had little value to society. Many residents are still unaware of the benefits that wetlands provide and may still harbor misconceptions about wetlands, including the idea that wetlands function only as breeding grounds for mosquitoes that carry the West Nile Virus. To overcome these barriers, a wetland education program should always include some educational information on the benefits of wetlands, both individual and watershed-wide.

Other key ingredients of a wetland education program include providing information on how the average citizen can reduce inputs of nutrients and other pollutants to wetlands, enhance or restore wetlands on their property, and provide input on the federal wetland permitting process and state or local programs, where applicable. This last topic is particularly important because most residents are not aware that the general public can help protect their local wetlands from development impacts by participating in the public comment period for any wetland permit application submitted under the Clean Water Act Section 404 permitting program.

Tailoring wetland education to fit the specific audience is critical, as it may include representatives from agriculture, forestry, mining, development, utilities, conservation groups, and state, federal and local governments. Three key groups to target include the development community (e.g., contractors, developers, design consultants), wetland landowners, and the general public. Contractors are accountable for development that can impact wetlands and should be trained in how to responsibly develop sites with, or adjacent to, wetlands. They should also become aware of federal and state wetland permit requirements and the need to examine permits early in the development process at the concept stage. Wetland landowners are the first line of defense in wetland protection, since most wetlands are now in private ownership. They need to understand how to maintain and enhance wetlands, and they should also be aware of various funding opportunities or incentives in place for restoring their wetlands. The third group to target is the general public. This may be the most challenging group, as the awareness level can vary considerably from one person to another. Specific groups to target may include schools and scouting groups, garden clubs, and homeowner associations. Box 3 lists some key wetland education resources that communities can use as models for their own programs.

Box 3. Wetland Education Resources

- ☐ USEPA Wetland Fact Sheet Series
  http://www.epa.gov/owow/wetlands/facts/contents.html
- ☐ USACE – Recognizing Wetlands
  http://el.erdc.usace.army.mil/wetlands/pdfs/wetbroc.pdf
- ☐ Digital Frog International – The Digital Field Trip to Wetlands
  http://www.digitalfrog.com/products/wetlands.html
- ☐ Environmental Concern Wetland Information Website
  http://www.wetland.org/educ_wetlandinfo2.htm
- ☐ Ducks Unlimited
  http://www.ducks.org/conservation/wetland_functions.asp
- ☐ University of Florida Wetland Extension
  http://wetlandextension.ifas.ufl.edu/about.htm
- ☐ Environmental Concern, Inc - WOW! The Wonders of Wetlands
  http://www.wetland.org/wowteacher.html

Post Signs to Identify Wetlands, Buffers, and Wetland CDA Boundaries

An important companion to any new local ordinance is a means of notifying the public of the new requirements. Signs are most commonly used to notify the public about ordinances that protect natural resources, such as wetlands and their buffers. Signs are posted to identify the boundaries of the protected area, to inform residents of restricted uses and penalties, and to educate residents as to why these areas are protected (Figure 28). Signs should be posted around protected wetlands and their buffers, and may even be used to identify the boundaries of sensitive wetland CDAs.

Figure 28. Sign posted at conserved wetland (Photo source: www.landandfarm.com)

Manage Invasive Wetland Plants

Invasive or aggressive plant species that commonly impact wetlands include purple loosestrife (Figure 29), *phragmites*, reed canary grass, cattails, kudzu, multiflora rose, Asiatic tearthumb, water hyacinth, and Eurasian watermilfoil. Invasive plants may become dominant in disturbed wetland ecosystems because they are more tolerant of changes in hydrology and pollutant inputs. Therefore, most urban wetlands contain some invasive plants, and many of these wetlands are monocultures of a single species. A large volume of information exists on managing invasive plants, and communities should target wetland-specific resources to manage invasive wetland plants in their watersheds---some key resources are provided in Box 4.

Figure 29. Purple loosestrife, a common invasive wetland plant (Photo © John M. Randall, The Nature Conservancy)

Invasive plant control methods vary with each species and can range from simple measures, such as mowing, to methods that require heavy equipment, herbicides, or burning. Most methods require repeat application and constant monitoring, and will never fully eradicate the species from a site. Therefore, the most important management method is prevention. Communities should consider prioritizing invasive plant management in their sensitive wetlands and including control of invasive plants as an important step in any wetland restoration project.

Box 4. Wetland Invasive Plant Management Resources

- ☐ American Wetlands Campaign Kit 2001: Common Invasive Wetland Plants http://www.iwla.org/sos/awm/2001/kit_invplants.html
- ☐ Wetland Science Institute: Noxious, Invasive and Alien Plant Species http://www.pwrc.usgs.gov/WLI/wris1.htm
- ☐ Western Aquatic Plant Management Society: Invasive, Exotic, Aquatic and Wetland Plants in the Western U.S. http://www.wapms.org/plants/
- ☐ University of Florida: Center for Aquatic and Invasive Plants http://plants.ifas.ufl.edu/welcome.html
- ☐ USACE Jacksonville District: Biological Control of Exotic Aquatic and Wetland Plants http://www.saj.usace.army.mil/conops/apc/weed_bio.html
- ☐ USACE: Aquatic Plant Control Research Program http://el.erdc.usace.army.mil/aqua/
- ☐ Aquatic Ecosystem Restoration Foundation http://www.aquatics.org/

Establish Volunteer Wetland Monitoring and Adoption Programs

Communities can establish programs that engage citizen volunteers to monitor and ‘adopt’ wetlands in the watershed. Adopt-a-wetland programs are similar in concept to the successful adopt-a-highway program--volunteers adopt a specific wetland and perform general maintenance such as trash removal. Volunteers can also perform activities such as invasive species removal, buffer plantings, and water quality monitoring, where desired. These types of programs provide educational and research opportunities for residents and can lead to increased concern, understanding, and stewardship of wetlands. Several communities across the country have instituted adopt-a-wetland programs to encourage citizen involvement in wetland maintenance and monitoring. Case Study 12 describes an adopt-a-wetland program for the City of Oakdale, Minnesota.

Case Study 12: Oakdale, Minnesota Adopt-A-Wetland Program

The City of Oakdale, Minnesota established an adopt-a-wetland program for community groups, homeowner associations, businesses, or other interested parties who want to help with the improvement and upkeep of a particular Oakdale wetland, pond, lake or stream. Volunteers can select their own water body or have the City suggest one for them, and choose from the following list of activities:

- Trash removal
- Invasive plant removal (e.g., buckthorn, purple loosestrife)
- Native buffer planting
- Water quality monitoring
- Wetland data collection
- Wetland monitoring
- Community education

Volunteers can conduct the activity as frequently as they wish, and have officially 'adopted' the wetland after have completing one activity. Volunteers receive an Adopt-A-Wetland certificate, and a sign commemorating the volunteer group may be installed at the site. The City has created an Adopt-A-Wetland How-To Kit, which contains instructional materials and resources for adopting a wetland. This kit is available on the City's website.

Source: City of Oakdale, Minnesota (no date)

Other communities have established programs that focus solely on volunteer wetland monitoring. Volunteer wetland monitoring can consist of a simple, qualitative assessment performed by a wide range of watershed residents, such as school children, homeowner associations, scout groups, gardening clubs, and senior citizens groups. More advanced monitoring can be conducted by trained volunteers, including surveys of invasive species, water quality, amphibians, and benthic macroinvertebrates. Wetlands monitored through these programs typically include restoration sites or wetlands in protected open space. For more information on establishing a wetland monitoring program, see www.epa.gov/owow/wetlands/monitor/volmonitor.pdf.

Encourage Wetland Landowner Stewardship

Landowners have the responsibility of being good stewards of their wetlands. Agricultural landowners can take advantage of federal funding offered through several U.S. Department of Agriculture (USDA) programs to implement wetland conservation and restoration techniques on their property. Some of these programs provide cost-sharing assistance to landowners for developing habitat for threatened and endangered species, fish, and other types of wildlife. Others provide cost-share assistance for establishing and maintaining long-term conservation practices, such as buffer plantings, cover crops, and cattle fencing, on highly erodible and environmentally sensitive cropland. The USDA Natural Resources Conservation Service (NRCS) website provides more information on federal programs for wetland stewardship: www.nrcs.usda.gov/programs

While the federal programs mentioned above are excellent incentives to protect and restore wetlands, they are limited to agricultural lands and have limited funding. Local governments and other partners can greatly increase the effectiveness of landowner stewardship with additional funding. Communities should consider developing and actively promoting their own programs that encourage all wetland landowners to establish buffers, monitor wetlands, or conduct restoration activities. For example, communities may provide additional incentives to wetland landowners for fencing cattle out of wetlands and their buffers to reduce the impacts of grazing on wetlands, and reduce inputs of sediment and bacteria (Figure 30). Incentives can include financial assistance, such as estate or personal property tax credits, recognition by local government, and on-site technical assistance.

Figure 30. Before (left) and after (right) cattle fencing project (Photo source: USFWS, no date)

Establish Partnerships for Funding and Implementing Wetland Projects
Land conservation and other non-profit groups are often ideal partners to work with local governments to help implement wetland conservation and restoration projects recommended as part of a watershed plan. These groups can provide volunteers to monitor or maintain project sites or implement simple projects, such as wetland buffer plantings. Other groups, such as land trusts, can hold conservation easements or raise funds to acquire priority conservation lands. Well-established groups that have a membership base can even assist in fundraising for specific wetland restoration projects. Some of these groups may have a specific wetland focus, while other have broader purpose, but all may be good partners. These partnerships can have a major beneficial impact on a community's wetland resources, and in many cases result in a net gain of wetland acreage (Case Study 13). A few examples of potential partners include:

- *Coastal America*. A unique partnership of federal agencies, state and local governments, and private organizations working to protect, preserve, and restore our nation's coasts http://www.coastalamerica.gov/

- *Ducks Unlimited.* A non-profit dedicated to conserving, restoring, and managing wetlands and associated habitats for North America's waterfowl. http://www.ducks.org

- *Trust for Public Land*. A national non-profit that helps communities target lands for conservation, establish local land conservation goals, design and promote public funding programs that support conservation, and structure, negotiate and complete land transactions for conservation areas. www.tpl.org

- *Environmental Concern Inc*. A public non-profit corporation dedicated to wetland education, restoration, and research. http://www.wetland.org/
- *Land Trust Alliance***.** National representative for more than 1,500 land trust that promotes voluntary private land conservation. http://www.lta.org/
- *The Nature Conservancy*. A global organization dedicated to preserving plants, animals and natural communities by protecting the lands and waters they need to survive. http://nature.org/partners/
- *U.S. Fish and Wildlife Service*. Through its Partners for Fish and Wildlife Program, the U.S. Fish and Wildlife Service works with a wide variety of partners to restore wetlands and other fish and wildlife habitats on private lands. http://www.fws.gov/partners/index.htm

Case Study 13: Wetland Restoration in the San Francisco Bay Estuary

The San Francisco Bay Estuary is the nation's second largest and perhaps the most biologically significant estuary on the Pacific Coast. It has also suffered the most extensive degradation of any estuary in the nation. Many years of filling, pollution, and alien species invasions have taken a great toll on the ecosystem. Despite these losses, however, the San Francisco Bay Estuary is now a major center for a vibrant habitat restoration movement.

The Bay Estuary's ecological value lies mainly in the wetlands along its edge, and in the riparian habitats of streams and rivers feeding into it. These habitats are essential to the health of the myriad fish and wildlife populations of the region. Millions of shorebirds and waterfowl stop by during their annual migrations between Alaska and South America. The Western Hemisphere Shorebird Reserve Network has designated the San Francisco Bay Estuary as a site of "Hemispheric Importance" (its highest ranking), and the North American Waterfowl Management Plan has listed it as one of 34 waterfowl habitats of major concern in North America.

Over the past two decades, the San Francisco Bay Joint Venture (SFBJV) has made significant progress to protect what remains and to begin restoring as much as possible of what was lost. This partnership of public agencies, environmental organizations, the business community, local governments, the agricultural community, and landowners works cooperatively to protect, restore, increase, and enhance wetlands and riparian habitat in the San Francisco Bay watershed.

The SFBJV helps partners put habitat restoration, acquisition and enhancement projects on the ground by connecting partners with the funding opportunities, information and resources they need to make projects happen. Over the past few years, the San Francisco Bay Joint Venture (SFBJV) partners have completed 22 wetland protection, restoration, or enhancement projects involving over 11,100 acres, with another 31,400 acres in progress. Working with the SFBJV, Ducks Unlimited staff have created a comprehensive, yet user-friendly habitat project tracking system that will help the SFBJV with their facilitation role and help the partnership track regional progress towards their restoration goals.

Source: http://www.sfbayjv.org/

Summary

Each of the Eight Tools of Watershed Protection can be adapted to protect wetlands as part of the watershed planning process. Specific changes to local programs and ordinances are recommended in the watershed plan in order to better protect wetlands in the watershed. The techniques recommended in this article can be applied in or near wetlands and/or within wetland CDAs, as summarized in Tables 16 and 17. Article 2 provides detailed guidance on methods to incorporate wetlands into a watershed plan. Article 4 provides guidance for communities to develop a local wetland protection ordinance that protects both wetlands and their CDAs.

Table 16. Wetland Protection Strategies Applied In or Near Wetlands

Watershed Protection Tool	Strategies Applied In or Near Wetlands
1. Land Use Planning	• Incorporate wetland management into local watershed plans • Adopt a local wetland protection ordinance • Adopt floodplain, stream buffer, or hydric soil ordinance to indirectly protect wetlands
2. Land Conservation	• Identify priority wetlands to be conserved • Select techniques for conserving wetlands
3. Aquatic Buffers	• Require vegetated buffers around all wetlands • Expand wetland buffers to connect wetlands with critical habitats
4. Better Site Design	• Encourage designs that minimize the number of wetland crossings
5. Erosion and Sediment Control	• Require perimeter control practices along wetland buffer boundaries • Encourage more rapid stabilization near wetlands
6. Storm Water Treatment	• Prohibit use of natural wetlands for storm water treatment • Discourage constrictions at wetland outlets • Restrict discharges of untreated storm water to natural wetlands • Encourage fingerprinting of STPs around natural wetlands • Discourage installation of STPs within wetland buffers
7. Non-Storm Water Discharges	• Conduct illicit discharge surveys for all outfalls to wetlands • Actively enforce restrictions on dumping in wetlands and their buffers • Promote alternative mosquito control methods to reduce insecticide inputs to wetlands
8. Watershed Stewardship	• Incorporate wetlands into watershed education programs • Post signs to identify wetlands, buffers, and wetland CDA boundaries • Manage invasive wetland plants • Establish volunteer wetland monitoring and adoption programs • Encourage wetland landowner stewardship • Establish partnerships for funding and implementing wetland projects

Table 17. Wetland Protection Strategies Applied Within Wetland CDAs	
Watershed Protection Tool	**Strategies Applied Within Wetland CDAs**
1. Land Use Planning	• Incorporate wetland management into local watershed plans • Adopt a local wetland protection ordinance
2. Land Conservation	• Prioritize other conservation areas in wetland CDAs
3. Aquatic Buffers	• Increase stream buffer widths to protect downstream wetlands
4. Better Site Design	• Encourage or require the use of open space design to protect wetlands • Encourage designs that utilize the natural drainage system
5. Erosion and Sediment Control	• Reduce disturbance thresholds that trigger ESC plans • Increase ESC requirements during rainy season • Encourage use of site fingerprinting or construction phasing • Increase frequency of site inspections
6. Storm Water Treatment	• Develop special sizing criteria for STPs • Promote effective STPs to protect downstream wetlands • Encourage the incorporation of wetland features into STPs and landscaping
7. Non-Storm Water Discharges	• Conduct illicit discharge surveys for all outfalls to wetlands • Require enhanced nutrient removal from on-site waste water treatment systems • Require regular septic system inspections
8. Watershed Stewardship	• Incorporate wetlands into watershed education programs • Post signs to identify wetlands, buffers, and wetland CDA boundaries

Communities should not feel limited to the 37 techniques described in this article, and should strive to be innovative where possible and develop new tools for protecting wetlands in their watersheds. In particular, there is a need for more innovative Better Site Design, erosion and sediment control, and storm water management techniques that are specifically designed with wetland protection in mind. In order to facilitate the development of better techniques to protect wetlands, additional research is needed to quantify the indirect impacts of storm water runoff and urban pollutants on wetlands and their functions.

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