Section 729
Muskingum River Basin
Final Watershed Assessment and Watershed Management Plan

Appendices

August 2018

MUSKINGUM WATERSHED CONSERVANCY DISTRICT

Appendix A

Acronyms

AMD - Acid Mine Drainage

APAP - Agricultural Abatement Program

ARC - Appalachian Regional Commission

BFE - Base Flood Elevation

BMP - Best Management Practices

CREP - Conservation Reserve Enhancement Program

CRP - Conservation Reserve Program

CSO - Combined Sewer Overflows

CWA – Clean Water Act

DHS - Department of Homeland Security

EC - Engineering Circular

EOP - Emergency Operations Plans

ER – Engineering Regulation

EWP – Emergency Watershed Protection

FEMA - Federal Emergency Management Agency

FRM – Flood Risk Management

FWA – Final Watershed Assessment

FWP - Farmable Wetlands Program

FWS - Flood Warning System

FWEEP - Flood Warning Emergency Evacuation Plan

HMGP - Hazard Mitigation Grant Program

HSTS - Home Sewage Treatment Systems

HUC - Hydrologic Unit Code

H&H - Hydraulic and Hydrology

ILF - In-lieu Fee

IWA - Initial Watershed Assessment

LOI – Letter of Intent

LPP - Local Protection Project

LRW – Limited Resource Water

MWH - Modified Warmwater Habitat

NACD - National Association of Conservation Districts

NFIP - National Flood Insurance Program

NOAA - National Oceanic and Atmospheric Administration's

NPDES - National Pollutant Discharge Elimination System

NRCS - Natural Resources Conservation Service

NWS - National Weather Service

OAC - Ohio Administrative Code

OEPA - Ohio Environmental Protection Agency

ODNR – Ohio Department of Natural Resource

ODOD - Ohio Department of Development

PAS – Planning Assistance to States

PB – Planning Bulletin

PWA - Public Works Administration

SWCD - Soil and Water Conservation District

SWMM - Stormwater Management Model

SWPPP - Stormwater Pollution Prevention Plan

TMDL - Total Maximum Daily Loads

TNC - The Nature Conservancy

USACE - U.S. Army Corps of Engineers

USEPA - U.S. Environmental Protection Agency

USDA - U.S. Department of Agriculture

USFWS - U.S. Fish and Wildlife Service

USGS - United States Geological Survey

WFPO - Watershed and Flood Prevention Operations

WMP – Watershed Management Plan

WRDA - Water Resources Development Act

WRP - Wetlands Reserve Program

WWTP – Wastewater Treatment Plant

Appendix B
Study Authority

Section 729 of the Water Resources Development Action of 1986
Study of Water Resources Needs of River Basins and Regions

(a) The Secretary, in coordination with the Secretary of the Interior and in consultation with appropriate Federal, State, and local agencies, is authorized to study the water resources needs of river basins and regions of the United States. The Secretaries shall report the results of such study to Congress not later than October 1, 1988.

(b) In carrying out the studies authorized under subsection (a) of this section, the Secretaries shall consult with State, interstate, and local governmental entities.

(c) There is authorized to be appropriated $5,000,000 for fiscal years beginning after September 30, 1986, to carry out this section.

Section 202 of the Water Resources Development Act of 2000
Watershed and River Basin Assessments

Section 729 of the Water Resources Development Act of 1986 (100 Stat. 7164) is amended to read as follows:

"Sec. 729, Watershed and River Basin Assessments.

(a) In General. – The Secretary may assess the water resources needs of river basins and watersheds of the United States, including needs relating to –

(1) ecosystem protection and restoration;
(2) flood damage reduction;
(3) navigation and ports;
(4) watershed protection;
(5) water supply; and
(6) drought preparedness

(b) Cooperation. – An assessment under subsection (a) shall be carried out in cooperation with –

(1) the Secretary of the Interior
(2) The Secretary of Agriculture
(3) The Secretary of Commerce

(4) The Administrator of the Environmental Protection Agency; and
(5) the heads of other appropriate agencies

(c) Consultation. – In carrying out an assessment under sub-section (a), the Secretary shall consult with Federal, tribal, State, interstate, and local government entities.
(d) Priority River Basins and Watersheds. – In selecting river basins and watersheds under this section, the Secretary shall give priority to –

(1) the Delaware River basin;
(2) the Kentucky River basin;
(3) the Potomac River basin;
(4) the Susquehanna River basin; and
(5) the Willamette River basin.

(e) Acceptance of Contributions. – In carrying out an assessment under subsection (a), the Secretary may accept contributions, in cash or in kind, from Federal, tribal, State, interstate and local governmental entities to the extent that the Secretary determines that the contributions will facilitate completion of the assessment.

(f) Cost-Sharing Requirements. –

(1) Non-Federal Share. – The non-Federal share of the costs of an assessment carried out under this assessment shall be 50 percent.
(2) credit. –
(A) In General. – Subject to subparagraph (B), the Secretary may credit toward the non-Federal share of an assessment under this section the cost of services, materials, supplies, or other in-kind contributions provided by the non-Federal interests for the assessment.
(B) Maximum Amount of Credit. – The credit under subparagraph (A) may not exceed an amount equal to 25 percent of the costs of the assessment.

(g) Authorization of Appropriations – There is authorized to be appropriated to carry out this section $15,000,000."

Section 2010 of the Water Resources Development Act 2007
Watershed and River Basin Assessments

Section 729 of the Water Resources Development Act of 1986 (33 U.S.C. 2267a; 114 Stat. 2587-2588; 100 Stat. 4164) is amended –

(1) in subsection (d) –
(A) by striking "and" at the end of the paragraph (4);
(B) by striking the period at the end of the paragraph (5) and inserting a semicolon; and
(C) by adding at the end the following:

"(6) Tuscarawas River Basin, Ohio;
(7) Sauk River Basin, Snohomish and Skagit Counties, Washington
(8) Niagara River Basin, New York;
(9) Genesse River Basin New York; and
(10) White River Basin, Arkansas and Missouri.";

(2) by striking paragraph (1) of subsection (f) and inserting the following:

(1) Non-Federal Share.- The non-Federal share of the costs of an assessment carried out under this section on or after December 11, 2000, shall be 25 percent."; and

(3) [sic] by striking subsection (g).

Appendix C

Stakeholder Meeting Notes

Muskingum River Basin

Final Watershed Assessment

Kickoff Stakeholder Meetings

13 June – 15 June, 2016

General/Overarching

- The interagency coordination and requirements present a significant issue when it comes to residents and local officials addressing water resource issues.
    - Education of floodplain mangers would be good so they can pass along the message of what can be done and can't be done.
    - Guide to all local, state, and Federal help for issues and solutions is needed for the entire Basin.
        - Who can do what
        - Who's responsible for what (residents, municipalities, state or Fed government?)
        - Regulatory permits information
        - Grant programs available
        - Clarification on 'ditching' laws
- Meetings between Soil and Water Conservation Districts and USACE Regulatory would be helpful to build relationships.
- ACTION ITEM: Place power points, Initial Watershed Assessment and Nimishillen FWA on District website
- Need for water resources education
    - There is a significant need for general water resources education in the Basin. Most residents/officials do not understand watersheds and how they work as a system.
        - McKinley Museum has educational classes for the younger generation
        - Several Soil & Water Conservation Districts have useful education tools, but lack funding to travel with them
        - Enviro Science has a good watershed 101
        - Need for clear, understandable educational material on best management practices

- Opportunities for adult education about watersheds and best practices along with how these recommendations help and benefit everyone
    - Ohio township Associations
    - County Commissioner Associations
    - County Engineers Association

Flooding

General/Overarching

- More frequent intense rains have been occurring and causing flooding events more often
- Ohio and Erie Canal structures could potentially hold back floodwaters if upgrades were made. This would require dredging as many portions are full of sediment.
- USGS's main focus with regards to gaging is on reservoirs and outfalls
    - Lack of funding for gauges, they are installed but in many cases there is no O&M funding
    - MWCD installed more steam/rain gauges at 6 reservoirs and 8 on the down streams

Mount Vernon

- Old levees (non Corps) need repairs and have vegetation issues

Big and Little Stillwater Creeks

- Flooding homes and roads in the area

Bellville

- study needed to determine issues and solutions
    - part of the problem is urban development and the placement of impervious surfaces
- railroad tracks were removed in order to construct a bike path, now approximately 40 more houses flood
- Route 97 East and West in Bellville floods – emergency personnel ingress and egress issues
- 20 miles of route 71 in Bellville will flood
- ODOT cleaned under a bridge which has elevated flow and help a lot with flooding issues

Knox County

- more river gauges would be welcomed, they have floods during less frequent events and can't be read
- flood preparedness and warning is an issue overall within Knox County
- Lots of seasonal residences which are subject to flooding
- North end of Waterford does not drain quickly enough, many roads are closed around Knox Lake and south affecting traffic and access

- Mt. Vernon has some flood levees (not Corps) that have not been maintained and with water pressure on levees starting to erode and wash away the edge of the levee, potential for levee failure

Richland County

- Adams Street to Bowman Street to Route 30 floods and cuts off access to the area for emergency vehicles and for the public to get to safety.
- Route 96 and Route 13 on the Black fork Mohican River near Shelby floods
- Franklin County township floods
- Route 42 floods
- Stream flooding backup from storm sewers
- Richland, Bellville and Mansfield all have flooding issues
- Fatalities associated with floods – rooftop rescues

Killbuck Creek

- Killbuck Creek in Holmes County is unregulated and undeveloped
    - Address flooding, or utilize ecosystem restoration opportunities? (encourage naturalization)

Massillon

- Sediment in river increasing and causing more frequent flooding
- Several ponding areas associated with pump stations are holding water year round

Wadsworth

- Localized flooding – believe low head dam removal could benefit

Norton and Barberton

- Flooding continues to be an issue
    - Additional rain and stream gages would be beneficial
    - Need for H&H studies and updated mapping

Wills Creek, Cambridge, Byesville

- Debris from flooding impacts recreation
- Inundated roads and restricts access to emergency vehicles

Dresden

- Agricultural flooding

Zanesville

- Predominantly agricultural flooding

Water Quality

General/Overarching

- Soil Quality
    - Ashland, Coshocton, Holmes, Wayne, and Knox counties are building a Soil Quality group to look overall at soil quality in the region. Encourage the use of cover crops, not tilling, etc.
    - Cover crop programs are growing - improving soil conditions, less erosion, better water quality (particularly in Morgan County)
        - Field testing of soils and levels of nutrients left behind
        - The downside to the farmers is planting something that won't yield much money but has many benefits in the long term
        - German Rye is the most common cover crop and it can grow through the winter
    - High levels of nitrate during certain times of the year most below drinking level standards
    - Looking at updating fertilizer recommendation based on current nutrients in soil and what is needed vs not needed because of the use of cover crops
    - NRCS Fed Conservation Program is a potential area for funding but Lake Erie gets the majority of funds available each year
        - Could help build nutrient management plans
- Failing Home Septic Treatment Systems
    - Cuyahoga is studying household septic systems, how much phosphorous and other chemicals comes out
    - Smaller town and municipalities have no treatment plants
    - High concentrations with old septic systems
    - Municipalities struggling to update systems and comply with regulations since they have very limited budgets
    - Funding is an issue with just maintaining what municipalities have
    - Tuscarawas county got $300,000 to address failing septic systems
        - Funding coming from OEPA - some counties applied and received the money but not sure how to most effectively use the funding
        - Tuscarawas County using it to help low income families with septic issues
        - (USACE Section 594 potential)
    - Around Leesville and Clendening houses may have never had septic put in; lots of straight pipes; however no huge red flags with water quality within the lakes
- Harmful Algal Blooms (HABS)
    - issue in the basin last year. More education is needed about causes and possible solutions
    - Agricultural land areas seeing more HABS

    - ACTION ITEM: Reach out to USACE Water Quality Lab for HABS data (ORSANCO helped with data collection and study)
- Land Use
    - Agricultural land use is the main issue for water quality and water issues in the region.
        - More land is being converted to crop land – especially in the Walhonding River Watershed
        - Wayne and Holmes Counties are big dairy counties "Dairy Belt of Ohio"
- Invasive species issues
    - (re: Asian Carp). Potential passageways between the Muskingum River Basin and the Great Lakes.
        - There are four hotspots in Ohio where this is happening. People are 'linking watersheds' rivers to lakes.
- Riparian Corridor through the Basin
    - Need for riparian corridors and filter strips between ag land and streams
    - Lack of setback ordinances throughout the Basin
- Baseline Sampling
    - MWCD did baseline in 30 locations in 6 eastern counties, sampled 6 times over a year and a half; sampling completed in May 2016 and they are compiling data now
- Acid Mine Drainage
    - High acidity low pH
    - ODNR just released acid mine drainage summary for counties or watersheds
    - Worsens as you move south in the watershed
        - Moxahalia Creek and tributaries
        - White eyes sub watershed
    - Wolf Creek, Middle Run, Little Middle Run
- Recognize the need to protect the WQ of headwater streams
- Need to break "water quality" out into all of the things that impact it – nutrient loading, sedimentation, etc.
- Sedimentation
    - Soil erosion due to intense crop rotations

<u>Knox County</u>

- Nutrient management
    - Growing poultry and swine operations, some dairy
    - TMDLs need either developed or updated
- Fracking issues
- Erosion issue on Kokosing near State Highway 229 East; ODOT installed a project but it did not address the problem (Potential for USACE Section 14)

Morrow County

- Gravel Quarry dewatering discharging into Kokosing River; with no known environmental regulations in place, this action will greatly increase sediment levels and affect aquatic life in the stream

Walhonding Watershed

- The area has issues with nutrient management, sedimentation, and storm water runoff

Sugar Creek

- Issues associated with ag runoff

North Fork

- Initiated nutrient loading study completed; however no follow up monitoring due to lack of resources
- Need for baseline data

Mount Vernon

- Opportunities for stream restoration
- Green Alley Program

Wills Creek

- agriculture run off
- Sedimentation in the streams
- Small streams
- Restore buffer zones

Environmental Infrastructure Needs

General/Overarching

- It was noted the State of Ohio has updated private sewer inspection to every 10 years. The health department is doing 10% of private homes wastewater treatment every year and it is a rolling 10 years.
- Storm water phase 2 is mandated but unfunded and hurts small municipalities
- Issues with Twin City Water Treatment
- Aging infrastructure – local municipalities with no resources to maintain or upgrade

Bellville

- Bellville spent $1.5 million on system specifically designed for the growing swine industry in the area
- Ontario and Mansfield cooperate on public sewer which is piped to Mansfield for treatment and if they decide to build their own there could be potential issues

Knox County

- The Village of Martinsburg has sewer issues that the health department notes every year.
- Seven villages trying to get wastewater treatment systems installed (Section 594)
- ACTION ITEM: Email out Section 594 info to Knox County attendees

Morrow County

- No storm water regulations in place
    - Currently rural but expected to grow
- ACTION ITEM: Planning Assistance to States or Corps Floodplain Management Services to help set up storm water regulations for the county / region.
- ACTION ITEMS: Provide examples from other municipalities with similar criteria.

Massillon

- Issues with Massillon levee gate closure. Local government wants to update the stop logs from railroad ties to aluminum beams which are easier and faster to install
    - ACTION ITEM: Rebecca Albert has been working with City engineer and will follow up

Stormwater

General/Overarching

- Questions about whether flooding on the Tuscarawas is due to climate change or increased urban runoff
- There needs to be more regulations and oversite for developers so that stormwater management issues are not just pushed downstream. Need to rethink ordinances.
- Need to include green solutions in updated stormwater management ordinances

Tuscarawas, Morrow and Carrol Counties

- No stormwater management regulations

Dennison

- Has stormwater issues, some urban growth – placement of impermeable surface causing both flooding and runoff issues
- Subdivision storm water plans need updated; last done in 1990

Recreation Opportunities

- Tuscarawas River as a water trail
    - two main low head dams to portage around
        - low head dam in Stillwater Creek, one in Dover
    - Dover has the largest river canoe run in the state
    - Need a portage around Dover Dam
    - Most recreation is on the main stem of the Tuscarawas River
- City of Dover working on a park along the river
- Need for stream access on Wills Creek
- Debris in the streams impacts recreation opportunities

Floodplain Management

General/Overarching

- There is a need to establish who is in charge of floodplain management in a given municipality and to educate that individual on effective administration.
- Need for floodplain mapping to be updated Basin wide (impacts to/from Flood Insurance Rate Maps)
- Many communities have repetitive damage structures in the floodplain
- Need to convert floodplain to greenspace

Uhrichsville, Yorkville, Dennison, Harrison, Sharonville and Malvern

- No floodplain management
- Building in floodplains with no oversite
- Political buy in not happening because counties do not want to take floodplain land out of the tax base

Tuscarawas County

- Need floodplain mapping update
    - Potential for Corps Floodplain Management Services assistance
    - Silver Jackets could potentially help
        - Potentially use Corps Inflow Design Flood update as a starting point

Mt. Vernon

- Several structures in floodplain

Appendix D

Additional Information

stormwater management for clean rivers

Green Streets

Urban stormwater runoff that isn't properly managed can pollute rivers and streams and contribute to combined sewer overflows (CSOs) to the Willamette River. Green Streets reduce the negative impacts of stormwater runoff. They mimic natural conditions by using soil and vegetation to manage runoff on the surface, at the source.

Green Streets transform impervious street surfaces into landscaped green spaces that capture stormwater runoff and let water soak into the ground as plants and soil filter pollutants. Green Streets convert stormwater from a waste directed into a pipe, to a resource that replenishes groundwater supplies. They also create attractive streetscapes and urban green spaces, provide natural habitat, and help connect neighborhoods, schools, parks, and business districts.

The City of Portland is committed to green development practices and sustainable stormwater management. Green Streets are an innovative, effective way to restore watershed health. They protect water quality in rivers and streams, manage stormwater from impervious surfaces, and can be more cost efficient than new sewer pipes. Green Streets offer many benefits that sewer pipes can't. Green Streets:

- Clean and cool air and water
- Enhance neighborhood livability
- Increase community and property values
- Enhance pedestrian and bicycle access and safety
- Protect valuable surface and groundwater resources
- Add urban green space and wildlife habitat
- Help meet regulatory requirements for pollutant reduction and watershed resource management
- Reduce stormwater in the sewer system
- Save money on wastewater pumping and treatment costs

The plants absorb water and their roots help water soak into the ground. Green Streets can be attractive neighborhood amenities, and a variety of plants can provide a range of looks.

Portland has been designing and building Green Streets for years. On-going monitoring proves they effectively reduce peak stormwater flows and runoff volume. Keeping stormwater runoff out of sewer pipes reduces sewer backups in basements, street flooding and combined sewer overflows (CSOs) to the Willamette River.

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers
Sam Adams, Commissioner
Dean Marriott, Director

Types of Green Streets

Green Streets have different shapes and sizes, but they all have stormwater management benefits and help protect watershed health. Here are some examples:

SE 42nd and Belmont

SE 12th and Clay

Stormwater Curb Extension

Extending into the street, stormwater curb extensions transform the curb lane into a landscape area. Curb extensions can conveniently integrate a ramp for safe pedestrian crossing.

SW 12th and Montgomery

SE 92nd street

Stormwater Street Planter

Stormwater Street Planters between the sidewalk and the curb work well in areas with limited space, and they allow for adjacent street parking or travel.

NE 21st and Sandy

SE 55th and Belmont

Rain Gardens

Where there is plenty of space, rain gardens are ideal. They can also transform awkward street intersections into safe pedestrian and bicycle crossings.

N Willamette and Denver

NE 23rd and Irving

Simple Green Street

Excavating an existing planting area behind a reinforced curb, making curb cuts for inflow and outflow, and landscaping with appropriate vegetation is a simple approach to capture and treat street runoff.

Rain Garden Demonstration Site

This site demonstrates and allows EPA to document the capabilities of rain gardens to allow stormwater to seep, or infiltrate, into underlying soil where it will eventually recharge groundwater and nearby streams. Infiltration of stormwater in rain gardens serves to reduce stormwater runoff volumes, improve water quality through removal of stormwater contaminants, and enhance the physical and biological integrity of streams.

Research

Stormwater runoff from Building 205 and the adjacent parking lot is directed through a pipe and curb cuts into the rain garden. The rain garden has six cells of different sizes separated by walls, allowing researchers to study how size affects the ability of rain gardens to infiltrate stormwater runoff created by a wide range of storm sizes. Instruments buried in the media and underlying soil measure how quickly runoff infiltrates through the rain garden profile into the underlying soil.

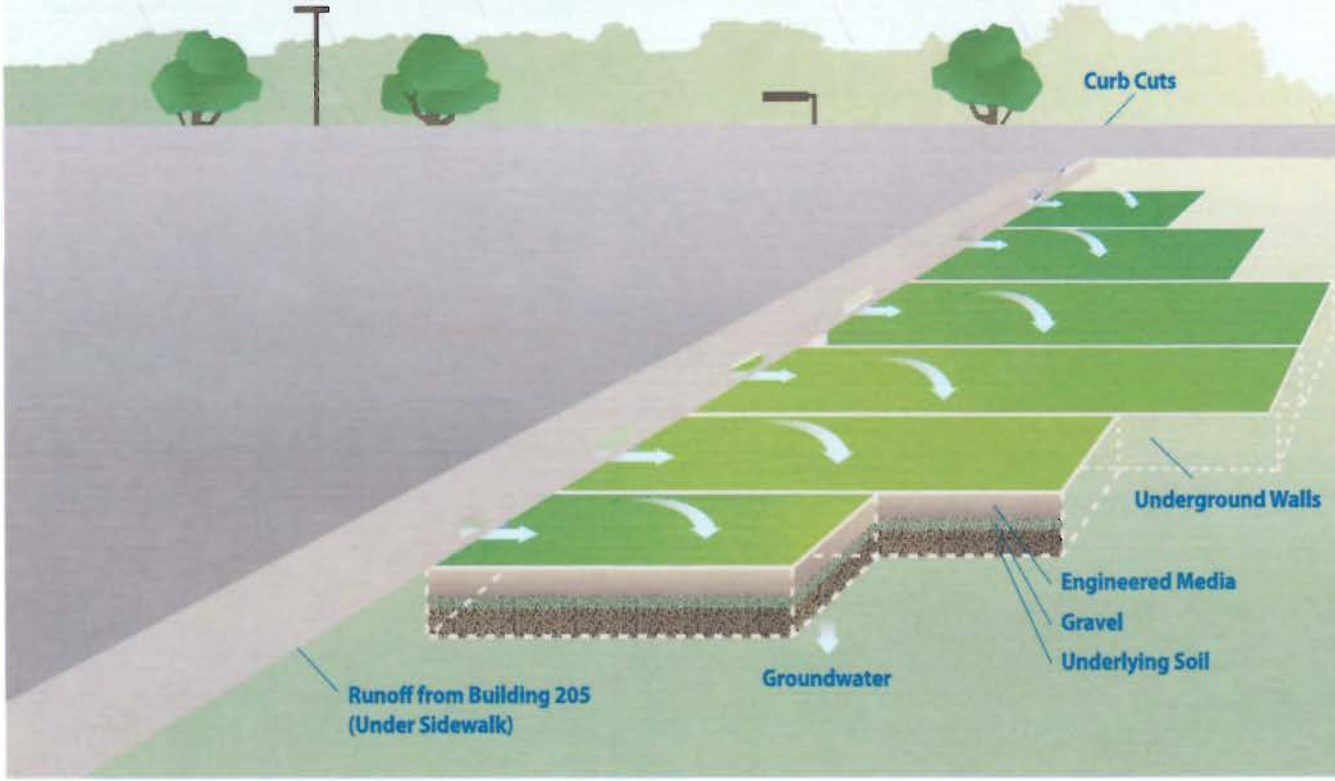
Results

The rain garden will help EPA study:

- How rain gardens mimic natural drainage processes and reduce stormwater runoff volume to the conventional storm sewer system.
- The effects of surface area on drainage properties of rain gardens.

Acknowledgements

This project is a joint research effort between EPA's Office of Administration and Resources Management, Region 2, and the Office of Research and Development.



Native Plants for Mid-Atlantic Rain Gardens

Trees
Red Maple
Redosier
Dogwood

Grasses/Rushes
Switchgrass
Indian Grass
Big Bluestem
Common Rush

Shrubs
Highbush Blueberry
Beach Plum
Winterberry
Black Chokeberry
Groundsel Tree

Herbs
Seaside Goldenrod
Blue Flag
Sunflower
Golden Zizia

United States Environmental Protection Agency | Office of Water Washington, D.C. | 832-F-99-006 September 1999

EPA

Storm Water Technology Fact Sheet
Vegetated Swales

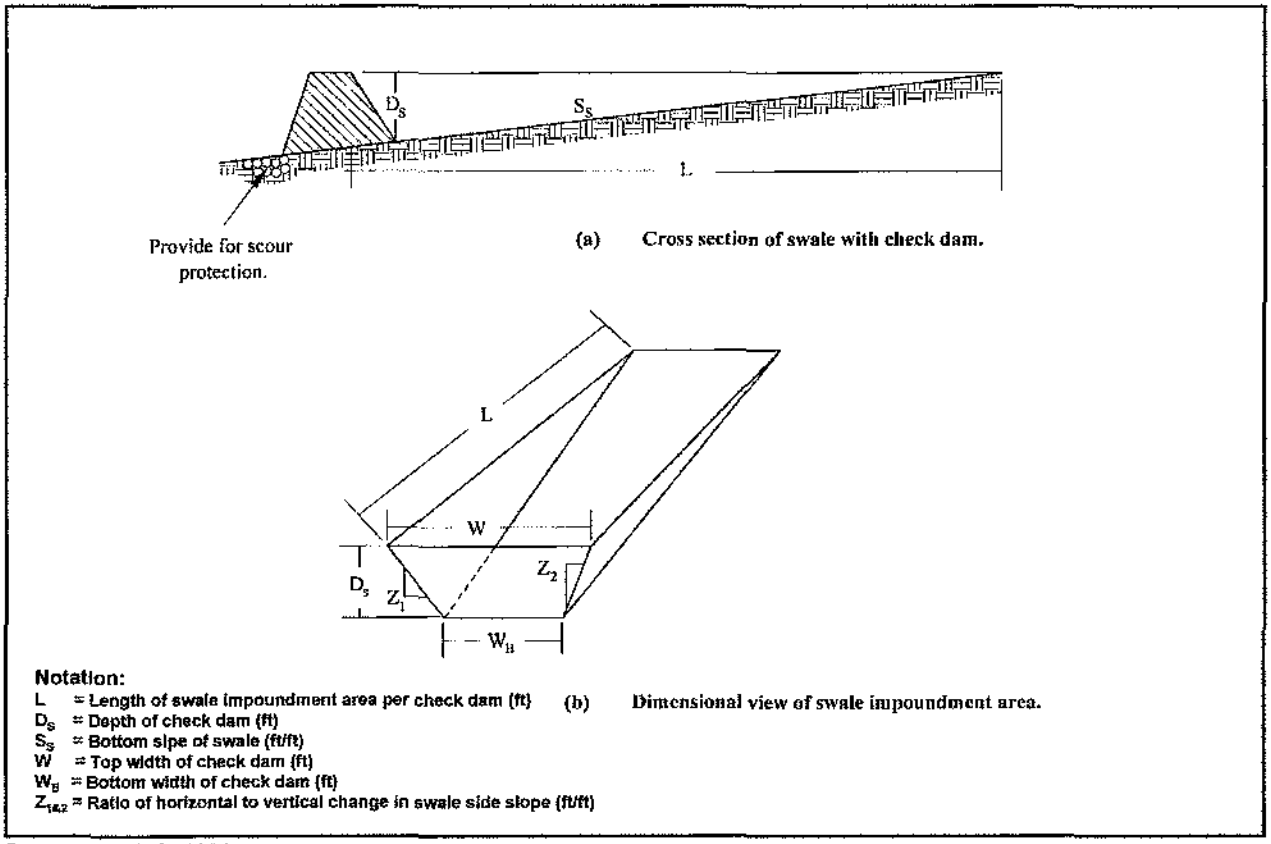
DESCRIPTION

A vegetated swale is a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom. Swales can be natural or manmade, and are designed to trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of storm water runoff. A typical design is shown in Figure1.

Vegetated swales can serve as part of a storm water drainage system and can replace curbs, gutters and storm sewer systems. Therefore, swales are best suited for residential, industrial, and commercial areas with low flow and smaller populations.

APPLICABILITY

Vegetated swales can be used wherever the local climate and soils permit the establishment and maintenance of a dense vegetative cover. The feasibility of installing a vegetated swale at a



Source: NVPDC, 1996.

FIGURE 1 EXAMPLE OF A VEGETATED SWALE

particular site depends on the area, slope, and perviousness of the contributing watershed, as well as the dimensions, slope, and vegetative covering employed in the swale system.

Vegetated swales are easy to design and can be incorporated into a site drainage plan. While swales are generally used as a stand-alone storm water Best Management Practice (BMP), they are most effective when used in conjunction with other BMPs, such as wet ponds, infiltration strips, wetlands, etc.

While vegetated swales have been widely used as storm water BMPs, there are also certain aspects of vegetated swales that have yet to be quantified. Some of the issues being investigated are whether their pollutant removal rates decline with age, what effect the slope has on the filtration capacity of vegetation, the benefits of check dams, and the degree to which design factors can enhance the effectiveness of pollutant removal.

ADVANTAGES AND DISADVANTAGES

Swales typically have several advantages over conventional storm water management practice, such as storm sewer systems, including the reduction of peak flows; the removal of pollutants, the promotion of runoff infiltration, and lower capital costs. However, vegetated swales are typically ineffective in, and vulnerable to, large storms, because high-velocity flows can erode the vegetated cover.

Limitations of vegetated swales include the following:

- They are impractical in areas with very flat grades, steep topography, or wet or poorly drained soils.
- They are not effective and may even erode when flow volumes and/or velocities are high.
- They can become drowning hazards, mosquito breeding areas, and may emit odors.
- Land may not be available for them.
- In some places, their use is restricted by law: many local municipalities prohibit vegetated swales if peak discharges exceed 140 liters per second (five cubic feet per second) or if flow velocities are greater than 1 meter per second (three feet per second).
- They are impractical in areas with erosive soils or where a dense vegetative cover is difficult to maintain.

Negative environmental impacts of vegetated swales may include:

- Leaching from swale vegetation may increase the presence of trace metals and nutrients in the runoff.
- Infiltration through the swale may carry pollutants into local groundwater.
- Standing water in vegetated swales can result in potential safety, odor, and mosquito problems.

DESIGN CRITERIA

Design criteria for implementation of the vegetated swales are as follows:

Location

Vegetated swales are typically located along property boundaries along a natural grade, although they can be used effectively wherever the site provides adequate space. Swales can be used in place of curbs and gutters along parking lots.

Soil Requirements

Vegetated swales should not be constructed in gravelly and coarse sandy soils that cannot easily support dense vegetation. If available, alkaline soils and subsoils should be used to promote the removal and retention of metals. Soil infiltration rates should be greater than 0.2 millimeters per second (one-half inch per hour); therefore, care

must be taken to avoid compacting the soil during construction.

Vegetation

A fine, close-growing, water-resistant grass should be selected for use in vegetated swales, because increasing the surface area of the vegetation exposed to the runoff improves the effectiveness of the swale system. Pollutant removal efficiencies vary greatly depending on the specific plants involved, so the vegetation should be selected with pollution control objectives in mind. In addition, care should be taken to choose plants that will be able to thrive at the site. Examples of vegetation appropriate for swales include reed canary grass, grass-legume mixtures, and red fescue.

General Channel Configuration

A parabolic or trapezoidal cross-section with side slopes no steeper than 1:3 is recommended to maximize the wetted channel perimeter of the swale. Recommendations for longitudinal channel slopes vary within the existing literature. For example, Schueler (1987) recommends a vegetated swale slope as close to zero as drainage permits. The Minnesota Pollution Control Agency (1991) recommends that the channel slope be less than 2 percent. The Storm Water Management Manual for the Puget Sound Basin (1992) specifies channel slopes between 2 and 4 percent. This manual indicates that slopes of less than 2 percent can be used if drain tile is incorporated into the design, while slopes greater than 4 percent can be used if check dams are placed in the channel to reduce flow velocity.

Flows

A typical design storm used for sizing swales is a six-month frequency, 24-hour storm event. The exact intensity of this storm must be determined for your location and is generally available from the U.S. Geological Survey. Swales are generally not used where the maximum flow rate exceeds 140 liters/second (5 cubic feet per second).

Sizing Procedures

The width of the swale can be calculated using various forms of the Manning equation. However, this methodology can be simplified to the following rule of thumb: the total surface area of the swale should be one percent of the area (500 square feet for each acre) that drains to the swale.

Unless a bypass is provided, the swale must be sized both to treat the design flows and to pass the peak hydraulic flows. However, for the swale to treat runoff most effectively, the depth of the storm water should not exceed the height of the grass.

Construction

The subsurface of the swale should be carefully constructed to avoid compaction of the soil. Compacted soil reduces infiltration and inhibits growth of the grass. Damaged areas should be restored immediately to ensure that the desired level of treatment is maintained and to prevent further damage from erosion of exposed soil.

Check Dams

Check dams can be installed in swales to promote additional infiltration, to increase storage, and to reduce flow velocities. Earthen check dams are not recommended because of their potential to erode. Check dams should be installed every 17 meters (50 feet) if the longitudinal slope exceeds 4 percent.

PERFORMANCE

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height. Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients. A conservative estimate would say that a properly designed vegetated swale may achieve a 25 to 50 percent reduction in particulate pollutants, including sediment and sediment-attached phosphorus, metals, and bacteria. Lower removal rates (less than 10 percent) can be expected for dissolved pollutants, such as soluble phosphorus, nitrate, and chloride. Table 1 summarizes some pollutant removal efficiencies for vegetated swales.

TABLE 1 EFFECTIVENESS OF DESIGN SWALES

Pollutant	Median % Removal
Total Suspended Solids	81
Oxygen Demanding Substances	67
Nitrate	38
Total Phosphorus	9
Hydrocarbons	62
Cadmium	42
Copper	51
Lead	67
Zinc	71

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Structures to skim off floating debris may also be added to the swales. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

OPERATION AND MAINTENANCE

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely.

The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover. Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid the transport of resuspended sediments in periods of low flow and to prevent a damming effect from sand bars. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary.

Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements.

COSTS

Vegetated swales typically cost less to construct than curbs and gutters or underground storm

sewers. Schueler (1987) reported that costs may vary from $16-$30 per linear meter ($4.90 to $9.00 per linear foot) for a 4.5 meter (15-foot) wide channel (top width).

The Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1991) reported that costs may vary from $28 to $164 per linear meter ($8.50 to $50.00 per linear foot) depending upon swale depth and bottom width. These cost estimates are higher than other published estimates because they include the cost of activities (such as clearing, grubbing, leveling, filling, and sodding) that may not be included in other published estimates. Construction costs depend on specific site considerations and local costs for labor and materials. Table 2 shows the estimated capital costs of a vegetated swale.

Annual costs for maintaining vegetated swales are approximately $1.90 per linear meter ($0.58 per linear foot) for a 0.5 meter (1.5-foot) deep channel, according to SEWRPC (1991). Average annual operating and maintenance costs of vegetated swales can be estimated using Table 3.

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ADDITIONAL INFORMATION

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TABLE 2 ESTIMATED CAPITAL COST OF A 1.5- FOOT DEEP, 10-FOOT-WIDE GRASSED SWALES[a]

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	–	–	–	–	–	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	–	–	–	–	–	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right) \times$ swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

TABLE 3 ESTIMATED OPERATION AND MAINTENANCE COSTS

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	\$0.85 / 1,000 ft^2/ mowing	\$0.14 / linear foot	\$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	\$9.00 / 1,000 ft^2/ year	\$0.18 / linear foot	\$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	\$0.10 / linear foot / year	\$0.10 / linear foot	\$0.10 / linear foot	--
Grass Reseeding with Mulch and Fertilizer	\$0.30 / yd^2	\$0.01 / linear foot	\$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	\$0.15 / linear foot / year, plus \$25 / inspection	\$0.15 / linear foot	\$0.15 / linear foot	Inspect four times per year
Total	--	**\$0.58 / linear foot**	**\$ 0.75 / linear foot**	--

Source: SEWPRC, 1991.

For more information contact:

Municipal Technology Branch
U.S. EPA
Mail Code 4204
401 M St., S.W.
Washington, DC, 20460

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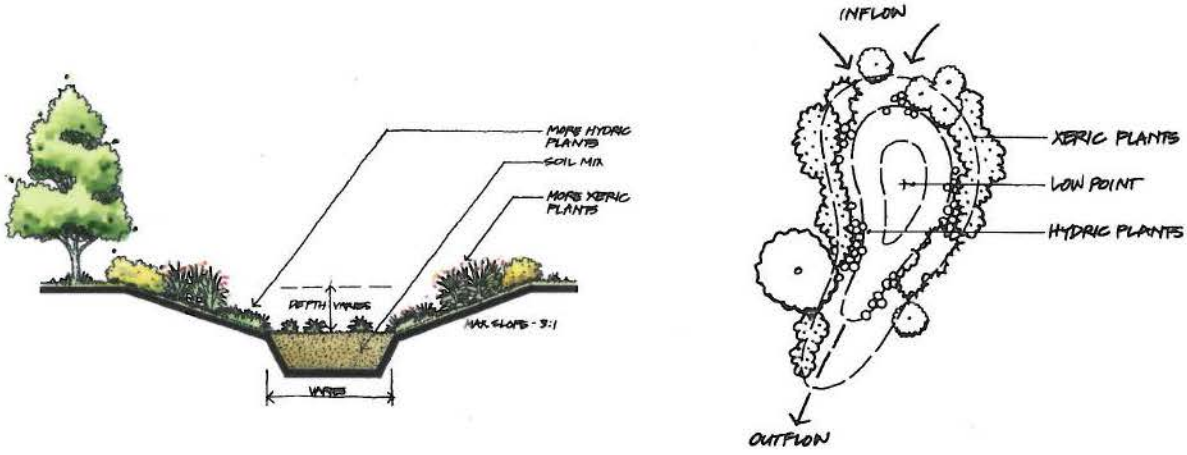
IFAS Extension

Bioretention Basins/Rain Gardens



Depiction of typical bioretention area design illustrating shallow slopes, well drained soil profile and location of plant material along hydrologic gradient. Basins with large catchments should include an over drain or provide a spillway in case of high flow event, and underdrains can be used in areas with low conductivity soils.

Definition:

A bioretention area or rain garden is a shallow planted depression designed to retain or detain stormwater before it is infiltrated or discharged downstream. While the terms "rain garden" and "bioretention basin" may be used interchangeably, they can be considered along a continuum of size, where the term "rain garden" is typically used to describe a planted depression on an individual homeowner's lot, where the lot comprises the extent of the catchment area. Bioretention basins serve the same purpose but that more technical term typically describes larger projects in community common areas as well as non-residential applications.

Applications

- **Residential yards (most common in smaller, urban sites)**
- **Commercial developments**
- **Parking lot islands**
- **Roadways (off-line cells adjacent to roadways accessed by curb cut)**

Objectives:

Bioretention basins/rain gardens retain, filter, and treat stormwater runoff using a shallow depression of conditioned soil topped with a layer of mulch or high carbon soil layer and vegetation tolerant of short-term flooding. Depending on the design, they can provide retention or detention of runoff water and will trap and remove suspended solids and filter or absorb pollutants to soils and plant material.

Overview:

Bioretention basins can be installed at various scales, for example, integrated with traffic calming measures in suburban parks and in retarding basins. In larger applications, it is considered good practice to have pretreatment measures (e.g. vegetated strips and swales) upstream of the basin to capture sediment and reduce the maintenance frequency of a bioretention basin.

The size of the rain garden or bioretention area will determine the volume of runoff that can be stored or reduced, as well as the treatment benefits. Where the volume of runoff exceeds that of the bioretention area, additional stormwater devices will be required in the treatment train to handle the design storm.

Benefits

- **Pollutant removal through infiltration and plant absorption**
- **Reduction of water runoff from site**
- **Reduced irrigation for planting beds**
- **Increased biodiversity in the landscape with wildlife and aesthetic values**

Water Protection Benefits:

Bioretention basins use vegetation in retention areas to reduce nutrient export through plant uptake, filtering and sorption. The vegetation also improves soil infiltration.

Water conservation implications – Biorention basins are designed to capture and retain stormwater in recessed gardens that typically do not need irrigation beyond plant establishment.

Stormwater implications – Infiltration processes and adsorption to plant roots remove pollutants from the flow stream. This is a key practice in the LID suite for improving stormwater quality. This also reduces the quantity of water flowing off-site into the larger municipal stormwater system.

Design Considerations:

This is an infiltration dependent practice affected by soil type and groundwater table. Where soils are well drained and groundwater tables are well below the surface, an under drain is not required. Where soils have low conductivity, underdrains can be used to reduce ponding time and increase treated volume. There is no specific slope requirement for bioretention, although size of the basin will typically decrease or become narrower and follow the elevation contour as slopes increase above 5%.

Determination of ponding depth should consider inflow characteristics (inflow rate, total volume, etc.), soil infiltration rate, and total ponding volume available. The ponding depth should not be greater than 12 inches, with 6-8 inch depths preferred. The duration of ponding after a storm should also not exceed 24 hours to reduce the likelihood of mosquito breeding or safety hazards.

A bioretention area/rain garden is used to encourage infiltration, so place it in an area where infiltration is good, not where water normally pools. It should be at least 10 ft. from any building, to avoid moisture around the building's foundation. Don't place a rain garden over a septic system. Consider how it can be integrated into existing and future landscaping. When adding plant material, do not place woody plants in the inflow path. Use native plants to improve the site's biodiversity.

Operations and Maintenance:

When rain gardens are installed on individual lots, it is important to implement educational programming to homeowners on proper maintenance. It is also important that the storage capacity of the rain garden/bioretention area be maintained through regular maintenance of vegetation and removal of debris that may compromise any structures during a high flow event. Regular visual inspection of the basin, looking for signs of erosion, excessive sediment deposits or dead and diseased vegetation, should be conducted. Mulch in the bioretention area should also be monitored for bare spots and should be replaced every 2-3 years. Plant selection is critical to aid operation, and other considerations may include gravel or stone to limit volunteer growth that can reduce storage area.

Design Keys

- **The design of a bioretention area/rain garden is a balance of stormwater function with biological functions. That means there must be consideration of:**
- **Basin design (soil type, drainage, groundwater table, slope, outfall device)**
- **Location in the treatment train**
- **Plant material selection and placement**
- **On-going management**

HOA or Regulatory Considerations:

There is presently no regulatory "presumption of compliance" granted to rain gardens or bioretention basins in stormwater permits. Although not significantly different than a conventional dry retention basin except for size, spatial distribution and landscape integration of this practice requires them to be submitted as an "alternative" management practice during the permitting process. Water management districts are also cautious about giving credit toward volume storage for any structure installed on a homeowner's property without sufficient guarantee that the structure will be adequately maintained in the long-term.

Credits in Green Building Certification Programs:

- FGBC-Home Standard (S-15 onsite designated retention areas)
- Florida Yards & Neighborhoods (stormwater runoff: swales, terraces and/or rain gardens created to catch and filter stormwater)
- LEED for Homes (SS 4.3 management of runoff from roof)
- LEED for Neighborhood Development Pilot (GCT Credit 9: Stormwater Management)
- NAHB Model Green Home Building Guidelines (1.3.5 Manage storm water using low-impact development when possible)

Relative Costs:

While this practice may create additional site work costs as compared to conventional practices, it can be offset by reduced infrastructure such as stormwater pipes, storm drains and stormwater ponds. Costs per acre of development range from $5,000 to $10,000 for larger areas and costs per square foot range from $3 to $15. In some cases it has been found that bioretention can yield a 50% savings over conventional systems for overall site drainage. In most cases the area would have been landscaped, so the cost of installing and maintaining a bioretention area should be compared to the cost of otherwise landscaping the area.

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This fact sheet was produced with funding from The Elizabeth Ordway Dunn Foundation.

FEMA

Fact Sheet

Federal Insurance and Mitigation Administration

Community Rating System

March 2014

The National Flood Insurance Program (NFIP) Community Rating System (CRS) was implemented in 1990 as a voluntary program for recognizing and encouraging community floodplain management activities exceeding the minimum NFIP standards. Any community in full compliance with the minimum NFIP floodplain management requirements may apply to join the CRS.

1,296 Communities Participate in the CRS

Nearly 3.8 million policyholders in 1,296 communities participate in the CRS by implementing local mitigation, floodplain management, and outreach activities that exceed the minimum NFIP requirements.

Under the CRS, flood insurance premium rates are discounted to reward community actions that meet the three goals of the CRS, which are: (1) reduce flood damage to insurable property; (2) strengthen and support the insurance aspects of the NFIP; and (3) encourage a comprehensive approach to floodplain management.

Although CRS communities represent only 5 percent of the over 22,000 communities participating in the NFIP, more than 67 percent of all flood insurance policies are written in CRS communities.

CRS Classes

The CRS uses a Class rating system that is similar to fire insurance rating to determine flood insurance premium reductions for residents. CRS Classes* are rated from 9 to 1. Today, most communities enter the program at a CRS Class 9 or Class 8 rating, which entitles residents in Special Flood Hazard Areas (SFHAs) to a 5 percent discount on their flood insurance premiums for a Class 9 or a 10 percent discount for Class 8. As a community engages in additional mitigation activities, its residents become eligible for increased NFIP policy premium discounts. Each CRS Class improvement produces a 5 percent greater discount on flood insurance premiums for properties in the SFHA.

Best of the Best

Four communities occupy the highest levels of the CRS. Each has developed a floodplain management program tailored to its own particular hazards, character, and goals. Under these programs, each community carries out numerous and varied activities, many of which are credited by the CRS. The average discount in policyholder premiums varies according to a community's CRS Class and the average amount of insurance coverage in place. Some highlights:

Roseville, California was the first to reach the highest CRS rating (Class 1). Damaging floods in 1995 spurred Roseville to strengthen and broaden its floodplain management program. Today the City earns points for almost all CRS creditable activities. The average premium discount for policies in the Special Flood Hazard Area (SFHA) is $832.

Comprehensive planning for floodplain management has been a key contributor to **Tulsa, Oklahoma's** progress in reducing flood damage from the dozens of creeks within its jurisdiction. The City (Class 2) has cleared more than 900 buildings from its floodplains. The average premium discount for policies in the SFHA is $583.

King County, Washington (Class 2) has preserved more than 100,000 acres of floodplain open space and receives additional CRS credit for maintaining it in a natural state. The average premium discount for policies in the SFHA is $650.

Pierce County, Washington (Class 2) maintains over 80 miles of river levees. County officials annually mail informational brochures to all floodplain residents. The average premium discount for policies in the SFHA is $666.

* CRS Class changes occur on May 1 and October 1 of each year. The data contained in this fact sheet were current through May 2014.

CRS Credit

A community accrues points to improve its CRS Class rating and receive increasingly higher discounts. Points are awarded for engaging in any of 19 creditable activities, organized under four categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Warning and response.

Formulas and adjustment factors are used to calculate credit points for each activity.

The communities listed below are among those that have qualified for the greatest premium discounts:

Class 1: Roseville, California

Class 2: Tulsa, Oklahoma
King County, Washington
Pierce County, Washington

Class 3: Sacramento County, California

Class 4: Fort Collins, Colorado
Skagit County, Washington
Snohomish County, Washington
Charleston County, South Carolina
Maricopa County, Arizona
Louisville-Jefferson County, Kentucky
Thurston County, Washington

Benefits of the CRS

Lower cost flood insurance rates are only one of the rewards a community receives from participating in the CRS. Other benefits include:

- Citizens and property owners in CRS communities have increased opportunities to learn about risk, evaluate their individual vulnerabilities, and take action to protect themselves, as well as their homes and businesses.
- CRS floodplain management activities provide enhanced public safety, reduced damage to property and public infrastructure, and avoidance of economic disruption and loss.
- Communities can evaluate the effectiveness of their flood programs against a nationally recognized benchmark.
- Technical assistance in designing and implementing some activities is available to community officials at no charge.
- CRS communities have incentives to maintain and improve their flood programs over time.

How to Apply

To apply for CRS participation, a community must initially inform the Federal Emergency Management Agency (FEMA) Regional Office of its interest in applying to the CRS and will eventually submit a CRS application, along with documentation that shows it is implementing the activities for which credit is requested. The application is submitted to the Insurance Services Office, Inc. (ISO)/CRS Specialist. ISO works on behalf of FEMA and insurance companies to review CRS applications, verify communities' credit points, and perform program improvement tasks.

A community's activities and performance are reviewed during a verification visit. FEMA establishes the credit to be granted and notifies the community, the State, insurance companies, and other appropriate parties.

Each year, the community must verify that it is continuing to perform the activities that are being credited by the CRS by submitting an annual recertification. In addition, a community can continue to improve its Class rating by undertaking new mitigation and floodplain management activities that earn even more points.

CRS Training

CRS Specialists are available to assist community officials in applying to the program and in designing, implementing, and documenting the activities that earn even greater premium discounts. A week-long CRS course for local officials is offered free at FEMA's Emergency Management Institute (EMI) on the National Emergency Training Center campus in Emmitsburg, Maryland, and can be field deployed in interested states. A series of webinars is offered throughout the year.

For More Information

A list of resources is available at the CRS website: www.fema.gov/national-flood-insurance-program-2/community-rating-system For more information about the CRS or to obtain the CRS application, contact the Insurance Services Office by phone at (317) 848-2898 or by e-mail at nfipcrs@iso.com.

OHIO STREAM MANAGEMENT GUIDE

Trees for Ditches

Guide No. 08

Trees along ditches? What was once seldom recommended is now considered a responsible approach to drainage management and, when done properly, very compatible with drainage objectives. Trees planted or maintained along ditches can: 1) save money, 2) meet environmental regulations, 3) improve water quality and 4) provide wildlife habitat.

SAVE MONEY

When constructing a new ditch or maintaining an existing one, clearing and grubbing costs can be reduced substantially by leaving at least one side vegetated. Leaving woody vegetation minimizes wind and water erosion' which affects crop yields and reduces the accumulation of sediment in the channel. Where one or both sides remain vegetated, shading inhibits nuisance cattail growth, thereby reducing dip-out or spraying maintenance costs. Ditch berms can grow marketable trees or firewood if selected and managed properly and provide income in later years. If land adjacent to ditches is already out of crop production and taxed at a lower rate trees are a bonus.

MEET ENVIRONMENTAL REGULATIONS

When ditch construction must meet environmental protection standards or require a Section 401 or 404 permit under the Clean Water Act, preserving or planting trees will help mitigate water quality and wildlife damages, often making permit issuance easier.

IMPROVE WATER QUALITY

Tree cover, especially on the south or west side of a ditch, shades the water, keeping water temperatures cooler which increases oxygen levels needed for fish and other aquatic life. Shading also controls nuisance algae growth, which often results in fish kills and other water quality problems. Tree leaves and leaf litter help reduce soil erosion and resulting sedimentation. Tree roots also provide some erosion control by protecting ditch banks from high velocity water.

PROVIDE WILDLIFE HABITAT

Upland and aquatic wildlife benefit from trees. Upland wildlife benefits from cover, food, access to travel lanes and greater number of species which habitat diversity supports. In-stream, leaf litter is the base of the aquatic food chain. Leaves are eaten by aquatic insects which in turn feed minnows and fish. Fallen branches provide cover for fish and smaller aquatic life. Undisturbed vegetation, like that found on one-sided construction, provides better wildlife food and cover than leaving selected trees growing among planted grass.

TREE USE

Trees are suitable for all drainage projects constructed under Ohio Drainage Law (Sections 61 31, 6133, 6135 or 6137 of the Ohio Revised Code), Conservation Works of Improvement (Section 1515 of the Ohio Revised Code), mutual group process, by developers or by individual landowners. With proper tree selection and maintenance, both drainage and environmental benefits can often be achieved.

The recommended width of woody vegetation on "berms" of natural or unmodified channels is two and one-half times the width of the ditch or fifty feet, whichever is less. However, for ditches constructed under Ohio Drainage Law, a minimum of four feet or a maximum of 25 feet width may be "constructed and maintained" and not subject to typical property taxes.

TREE SELECTION

When preserving trees along a ditch, protect those with hardwood, minimal branching, deep rooting and non-brittle characteristics. Where possible, protect trees and their adjacent vegetation from root and soil compaction from heavy equipment for a 10 foot radius around the trunk. When spreading dredged material near trees, never spread more than one inch of soil per year over the roots to avoid feeder root suffocation. The feeder roots are mostly within the tree canopy drip line. When planting trees, choose those that are suitable to the soil drainage and pH conditions. Dredged sediment and compaction from construction access may drastically alter pH and drainage conditions; soil testing may be helpful. Native trees may be a first choice for planting or preserving as listed below, but many other species may be suitable as listed in most county soil survey reports or nursery catalogs.

If future income is desired, select trees with expected high market value. If wildlife management is a goal, select a species with food and cover characteristics. The following table lists recommended trees in Ohio for use along drainage ditches. These trees can withstand periodic flooding and are less likely to cause maintenance problems. High market value trees like Black Walnut (Juglans nigra), White Oak (Quercus alba), Red Oak (Quercus rubra borealis), Sugar Maple (Acer saccharum), White Ash (Fraxinus americana), and Basswood (Tilia americana) are not listed since they are typically found on better drained soils or upland sites. The table also illustrates their suitability to different soil/climate conditions and desirable characteristics. Short lived, brittle and shallow rooted species like Willow (Salix species) are not listed, with the exception of Box Elder (Acer negundo) and Silver Maple (Acer saccharinum) which are common and less problematic trees.

Planted shrubs are fast growing and provide more immediate erosion control and habitat than planted trees. Shrubs may complement tree planting well by establishing a dense vegetative planting. Shrubs and bank erosion control species like Bankers Willow (Salix X cotteti) or

Dogwoods (Cornus species) have beneficial uses in ditch management, but are not covered in this publication.

TREE MAINTENANCE

Wooded ditch berms require maintenance. Regular inspections are needed, especially after ice storms to locate and remove damaged trees which may become water flow obstructions. When dead, leaning or other trees susceptible to breakage are removed, future maintenance costs can be reduced. While the listed species are not likely to cause problems, certain weather damages are not preventable. Trees should be kept away from subsurface drainage outlets so that roots do not plug the drainage pipes and outlets can be located for inspection and maintenance. Trees affected by insects or disease should be treated or removed before problems spread to other trees or they die, fall in and become obstructions.

When trees are managed properly they can provide income, benefit water quality and wildlife, protect crops from wind erosion and beautify the landscape. For more information on tree selection or site suitability contact your local Soil and Water Conservation District (SWCD), ODNR Divisions of Forestry or Wildlife, Ohio State University Extension, or qualified private consultant. For more information on drainage laws and standards contact your County or City Engineer, City Manager, Township Trustee or SWCD.

TreeSource—Ohio's Greenprint for the Future— is a strong new partnership between state and local government, private businesses and citizen volunteers renewing Ohio's commitment to planting and nurturing trees across the state.

For more information on TreeSource, contact the Ohio Department of Natural Resources, Division of Forestry (614) 265-6694.

Common/Scientific Name	Average Mature Height	pH Preferance	Specific Characteristics
			Highly Flood Tolerant Tress
American Sycamore Platanus occidentalis	100+	6.6-8.0	Adaptable to many soils, streambanks, bottomlands, windfirm, long-lived, fast growth, urban tolerant.
Swamp White Oak Quercus bicolor	60-70	6.0-6.5	Lowlands, stream edges, swamps, long-lived, fast growth, wildlife food, sprouts, timber, firewood.
Bur Oak Quercus macrocarpa	70-80	4.6-8.0	Adaptable to many soils, very drought resistant, deep-rooted long-lived, sprouts, wildlife food, timber, firewood.
Pin Oak Quercus palustris	70-80	5.5-6.5	Bottomlands or moist uplands, tolerant of urban stresses, moderately long-lived (100-150 years), firewood, wildlife food,sprouts, fast growth.
Bald Cypress Taxodium distichum	60-80	6.1-6.5	Highly flood tolerant, grows on flooded, poorly drained to upland soils, extensive root system, very windfirm slow-growing. longlived, sensitive to drought and heat, loses leaves in winter, not native although widely planted in Ohio.
Red Maple Acer rubrum	50-70	4.5-6.5	Adaptable to many soil types, some susceptibility to ice and snow damage, moderately long-lived (100-150 years), sprouts, resistant to herbicides, wildlife food, firewood, brilliant fall color
Silver Maple Acer saccharinum	60-80	4.5-6.5	Bottomlands, streambanks, alluvial floodplains, moist sites, drought resistant, branches are somewhat brittle, susceptible to ice damage, can tolerate temporary flooding, sprouts.
Box Elder Acer negundo	30-40	6.5-7.5	Adaptable to many soils, tolerant to drought and cold, short-lived (60-80 years), fibrous root system provides good erosion control, susceptible to wind/ice damage
Honey Locust Gleditsia triacanthos	70-80	6.1-7.5	Alluvial floodplains, bottomlands, drought resistant, shelter-belt series, windfirm, used to pioneer strip-mine spoils, initially fast growing, thorns.
			Moderately Flood Tolerant Tress
Shellbark Hickory Carya laciniosa	80-100	6.1-6.5	Bottomlands & alluvial floodplains, sprouts, long-lived, slow growing, some susceptibility to frost damage, wildlife food, firewood.
Green Ash Fraxinus pennsylvanica	50-70	6.1-7.5	Bottomlands, strip-mine reclamation species, windfirm, alluvial soils along streams, wildlife food, firewood, sprouts, timber
Hackberry Celt/s occ/dentalis	30-50	6.6-8.0	Bottomland, limestone outcrops or soils, drought resistant, fast growing, long-lived (150-200 years), wildlife food.
Slippery Elm Ulmus rubra	60-70	6.6-8.0	Moist, rich soils of lower slopes, streambanks, terraces, and bottomlands, moderately fast growing, fairly long-lived, sprouts. Dutch Elm disease, urban tolerant.
Black Tupelo (Gum) Nyssa sylvatica	40-60	6.1-6.5	Adaptable to many soil types, alluvial stream bottoms, shade tolerant, wildlife food, wildlife den tree, moderateiy long-lived.
River Birch Betula nigra	60-80	<6.5	Alluvial soils, stream bottoms, highly tolerant of acid soils, sprouts, firewood, most common in South/Central Ohio.

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Creation of this guide was partially funded by Nonpoint Source Programs under Section 319 of the Clean Water Act.

Prepared by the Ohio Department of Natural Resources, Dave Bergman, Division of Real Estate and Land Management, principal author. Input from staff of several ODNR divisions, state and federal agencies are used in the development of the Ohio Stream Management Guides.

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OHIO STREAM MANAGEMENT GUIDE

Stream Debris and Obstruction Removal

A Proactive Landowner's Guide to Maintaining a Free-Flowing Stream

Guide No. 18

PREFACE

Over the years, Ohio citizens have frequently contacted the Department of Natural Resources seeking assistance in the resolution of problems they have encountered related to water resources. One of the most common concerns raised by private landowners involves the situation in which trees and other debris accumulate in stream channels and obstruct streamflow through their properties. These obstructions, sometimes referred to as logjams, may become large enough to disrupt existing drainage patterns and contribute to flooding. In-stream debris often gets lodged behind bridge and culvert openings, which can cause higher flood levels and result in additional land inundation and property damage. Some streams also serve as recreational boating resources, and logjams may interfere with canoeing or other small watercraft navigation. This fact sheet poses some of the frequently raised questions regarding logjams, and provides responses from the Ohio Department of Natural Resources.

WHAT IS A LOGJAM?

A logjam is any woody vegetation, with or without other debris, which obstructs a stream channel and creates a backwater condition. Logjams occur naturally, providing beneficial stream structure and cover for fish and wildlife and allowing nutrient-rich sediment to be deposited on adjacent floodplains. However, Ohio's streams are also expected to function as efficient drainage outlets, conveying water off the land in a timely manner. Logjams may inhibit this drainage function.

DO LOGJAMS CONTRIBUTE TO FLOODING?

Yes, especially during small-scale floods. Since a logjam and the backwater pool created behind it take up volume in the stream channel or floodplain, less natural storage is available when a flood event occurs. This can elevate the level of small-scale flood events, those that occur several times a year. Such impacts can be significant to farm fields and residences in the floodplain and to particularly low-lying, flood-prone areas. A logjam can also lengthen the duration of inundation during these floods, which can have a significant impact on crops planted in floodplain fields.

The amount by which a logjam reduces the floodplain's natural storage capacity is inadequate to make a significant difference in flood elevation during large-scale flood events. Thus, removing logjams is generally not considered an effective measure to mitigate large-scale floods. Large-scale flood events can create, relocate, or enlarge logjams, though, by carrying debris from the floodplain into the stream channel and blocking bridge and culvert openings, resulting in localized impacts.

HOW DOES A LOGJAM FORM?

A logjam most commonly forms when a relatively large object, often a tree that has fallen into a stream channel, becomes wedged or blocked across the streambed. Sometimes human activities induce stream obstructions, like when trimmings from tree pruning or large appliances and other litter are dumped in a stream or left in a floodplain and subsequently are carried into the stream by high water. When an object obstructs the channel, it slows the flow and creates a pool of water behind it. As the water slows or stops behind the object, sediment suspended in the water settles out. The deposited sediment adds to the obstruction and causes additional debris to be trapped on and behind it. As more sediment and debris accumulate around and behind the obstruction, the logjam becomes larger and more tightly packed, forming a natural dam across the stream.

WHY SHOULD LOGJAMS BE REMOVED?

The formation of a logjam is a natural phenomenon and there are beneficial as well as detrimental impacts. A logjam provides structure and cover for fish and other aquatic organisms. The pool created behind the logjam provides critical aquatic habitat during low flow conditions, and the stirring and mixing oxygenates the water as it cascades over, around, and through the logjam.

A logjam may also negatively impact the stream. A tightly packed stream obstruction can act as a barrier to fish migration. Other problems caused by logjams are more insidious. A stream's energy is naturally channeled toward the route of least resistance, which is often around the obstruction. As the stream's flow is directed around an obstruction, it scours away the stream bank until a new channel is created. As the stream flows in its new channel around the logjam, it is re-directed toward the opposite bank. This begins a process, depicted in Figure 1, in which the stream's energy is directed subsequently from one bank to the other as the water flows downstream, eroding the stream banks and undercutting riparian vegetation as it creates a series of meanders. In an undeveloped watershed, where the streamside vegetation

on a newly cut channel is similar to the vegetation on the original channel, such meandering and channel relocation is not really a problem. In a developed watershed, where the streamside vegetation consists of a narrow corridor with adjacent farm fields and housing tracts, stream meandering and relocation can inflict considerable riparian property damage and also degrade the quality of the stream habitat as the limited riparian habitat is destroyed.

IS THERE A GOVERNMENT AGENCY RESPONSIBLE FOR REMOVING LOGJAMS IN ORDER TO KEEP OHIO STREAMS FREE FLOWING?

No. Governmental entities at the municipal, county, state, and federal levels have the statutory authority to undertake stream clearing and drainage improvement projects, but no governmental entity at any level has been assigned by statute the responsibility for such logjam removal activities. For more information on legal responsibilities regarding logjams see Guide 02, Who Owns Ohio Streams? The Ohio Department of Natural Resources recommends that, before an obstruction removal project is begun, there should be consultation with the applicable local, state, and federal regulatory agencies listed in Guide 06, Permit Checklist for Stream Modification Projects. The extent of permit requirements will depend on the location and design of the particular project.

Technical, educational, and other assistance may be available for obstruction removal projects. Township trustees, county engineers, soil & water conservation districts, conservancy districts, local emergency management agency and floodplain management coordinators, and staff with The Ohio State University Extension may all be possible sources of information or assistance to individuals. State agencies (e.g., the Ohio Department of Natural Resources, the Ohio Environmental Protection Agency) and federal agencies (e.g., the USDA Natural Resource Conservation Service) may also provide assistance to organized groups.

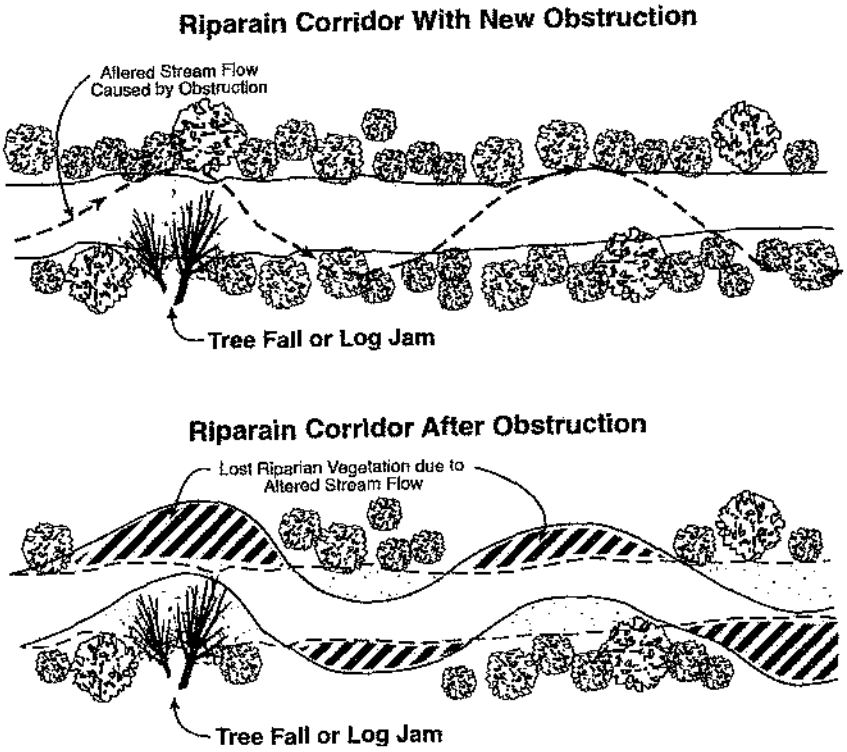

Figure 1. Effects of Obstruction on Riparian Corridor

Successful logjam removal projects have been undertaken in Ohio on many streams, some by volunteers and others using state and local appropriations and/or landowner assessments.

ARE RIPARIAN PROPERTY OWNERS REQUIRED TO REMOVE LOGJAMS FROM STREAMS ON THEIR PROPERTY?

Landowners generally are not required by statute to remove logjams from streams on their properties. Statutes do exist that grant county commissioners (Ohio Revised Code ß 6151.14) and township trustees (Ohio Revised Code ß 505.82) the authority to remove stream obstructions on private property and charge the costs of removal back to the property owner; however, these statutes are rarely used. The common law also does not specify that landowners must keep the streams flowing through their properties clear of natural obstructions. An obstruction to streamflow on one property can result in damages to upstream properties by reducing the stream's capacity for conveying runoff, contributing to flooding, or reducing the effectiveness of artificial drainage systems. Landowners have the right to pursue civil litigation for damages to their property caused by the unreasonable actions of others, but it is unclear whether a landowner's inaction in failing to remove natural stream obstructions could be successfully litigated. For more information on this subject, see Guide 02, Who Owns Ohio Streams?

While they are not required to remove logjams, landowners can contribute to the stability and overall health of their streams by proactively removing obstructions to flow. Such activities, especially on streams with limited riparian habitat, help maintain the multiple use nature of streams for fish and wildlife, drainage, recreation, and other purposes. A regular program for stream maintenance and obstruction removal may alleviate the need for a large, expensive channel restoration project later on.

HOW SHOULD IT BE DETERMINED WHAT ACTIVITIES ARE NEEDED ON A STREAM?

The easiest way to deal with log-

jams is to remove them before significant sediment and debris has been deposited. Riparian landowners should conduct routine stream inspections twice a year to identify fallen trees and other debris on their properties that need to be removed from the stream and floodplain. Special inspections should be made following large storm events, during which debris is commonly deposited. A volunteer organization could be formed to undertake annual stream walks or canoe trips of the entire stream (with landowner permission and support) to identify obstructions that need to be removed, develop a work plan of needed activities, and perhaps even assist landowners in the obstruction removal. Such a group can serve a valuable function to riparian landowners by building support throughout the watershed for a regular inspection and maintenance program.

HOW SHOULD STREAM OBSTRUCTIONS BE REMOVED AND WHAT TOOLS ARE NEED?

Fallen trees and other debris in the floodplain should be removed, buried, or secured as soon as possible. Fallen trees and other debris encountered in the stream should be removed at the earliest appropriate time. Standing trees should be left as they are. All debris should be buried, secured, or removed from the floodplain so that it won't be re-deposited during the next flood. Debris removal should be conducted only during low flow periods, which typically occur during late summer, autumn, and winter. Small debris can be removed from the channel without any tools or equipment. Larger logs and trees across the channel will need to be cut into manageable pieces and dragged out of the stream. Accumulated sediment can be raked and grubbed to remove vegetation. Large equipment should not be placed within the stream channel. Any disturbed areas along the stream channel should be seeded immediately to avoid unnecessary streambank erosion. If stream bank erosion has already occurred where a logjam has been removed, bank stabilization may be appropriate. For more information on bank stabilization methods, see Guide 07, Restoring Stream Banks With Vegetation, Guide 08, Trees for Ditches, Guide 11, Tree Kickers, Guide 12, Evergreen Revetments, Guide 13, Forested Buffer Strips, Guide 14, Live Fascines, Guide 15, Gabion Revetments, Guide 16, Rip Rap Revetments, and Guide 17, Live Cribwalls.

The following equipment is typically used for logjam removal projects: hand tools to facilitate removal of small debris; articulated log skidders with cable winches to remove larger logs; a chain saw or reciprocating saw to cut large logs and trees to manageable size; an adequate length of cable, chain, or rope to attach to the logs to facilitate their removal; a tractor, truck, or team of draft horses on the top of the stream bank to pull the logs out of the stream; and a wagon or truck on which to load the debris for subsequent removal from the floodplain.

Large logjams that are already well established need to be left for properly trained and equipped crews to remove. Specialized power equipment and explosives should never be used by anyone other then highly trained experts. The use of expensive and elaborate equipment is often not necessary when landowners take the time to perform routine maintenance and upkeep on their properties.

WHAT PRECAUTIONS SHOULD BE TAKEN BEFORE AND DURING AN OBSTRUCTION REMOVAL PROJECT?

The Ohio Department of Natural Resources recommends a consultation with the county engineer and local floodplain coordinator prior to initiation of an obstruction removal project. All tractors and other wheeled or tracked vehicles need to be kept out of the stream channel and well away from the top of the bank. Logjam removal activities should never be attempted alone, and a crew leader should be appointed to keep visual contact with everyone on the crew. The utmost caution should be taken to protect the personal safety of all workers. To avoid unnecessary damage to the streambank or riparian corridor, a single route to and from the project site should be utilized.

REFERENCES

Mecklenburg, Dan, Rainwater and Land Development—Ohio's Standards for Stormwater Management, Land Development, and Urban Stream Protection, 2nd edition, 1996, the Ohio Department of Natural Resources in cooperation with the USDA Natural Resources Conservation Service and the Ohio Environmental Protection Agency.

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OHIO STREAM MANAGEMENT GUIDE

Forested Buffer Strips

Guide No. 13

Trees along streams are so vital to the integrity of streams in climates like Ohio's, they are given the name "forested buffer strips." This Ohio Stream Management Guide is designed to give landowners, land managers and volunteer groups general guidance on the creation, protection and enhancement of forest areas along streams.

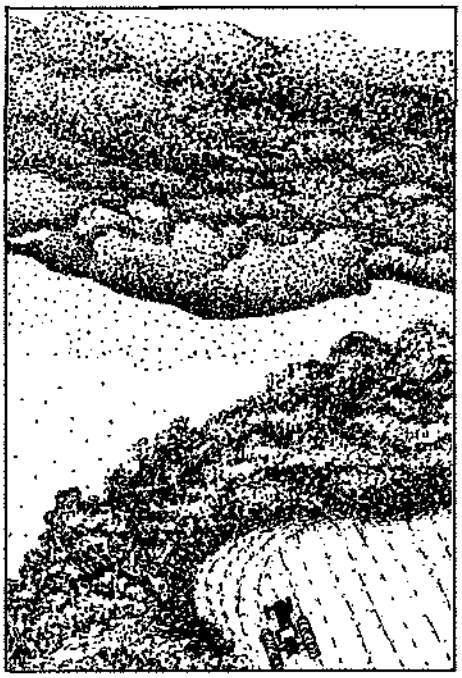

Figure 1. A forested buffer strip as seen from the air.

BENEFITS PROVIDED BY FORESTED BUFFER STRIPS

Streamside forests nurture Ohio's streams. The stream and it's adjacent land (riparian area) together form the most vital and diverse feature of Ohio's landscape. Without trees in this land-water transition zone, streams typically become wide and shallow, habitat is degraded and water quality drops.

Riparian ecosystems with forest vegetation:

- remove pollutants from stream flows during periods of over-bank flow;
- reduce water temperatures by sheltering and shading;
- provide wildlife habitat and protect and create aquatic habitat;
- provide detritus (leaves and woody debris), which is the basic source of energy for the stream ecosystem; and
- reduce streambank erosion through the high durability of tree root mass.

THREATS TO FORESTED STREAM BUFFERS

Encroachment — Meandering ribbons of trees often show up on aerial photos. Clearing trees has historically occurred last along streams and rivers leaving forested riparian strips winding through farm fields and suburbs. From a stream management perspective, we are fortunate that these areas are rough, steep and subject to flooding, making them generally less desirable for intensive land uses. However, most forested buffer strips only remain today because of decisions made independent of stream benefits. Until the importance of riparian areas is understood, forested buffer strips will be extremely vulnerable to encroachment as adjacent land uses become more intense. In fact, a major cause of buffer strip loss and stream degradation continues to be encroachment.

Overuse — Stream-side areas are often popular recreation areas, but overuse can reduce the integrity of the buffer through soil compaction and vegetation loss. High use can coexist with water quality objectives and damage limited by establishing trails and stabilized access points to the stream. Trails parallel to a stream should be set away from the banks. Provide viewing and lounging access to the stream through branches of trail which access the inside of meander bends.

Figure 2. A forested buffer between a stream and other land uses

This will minimize impacts and leave the critical vegetation on the outside banks undisturbed.

Grazing — Forested buffers are degraded by livestock. Not only is vegetation and soil damaged on the banks and uplands areas, but livestock trample and degrade the stream channel. Typical impacts include wide shallow channels with less cover, less shade, increased nitrates, increased turbidity, compacted soils and poor ground cover and understory. One Ohio study cited a 40% reduction in soil loss after livestock were fenced from a stream.

PROTECTING STEAMSIDE FORESTS

Define the Buffer Strip Width — Riparian areas are definitive land forms. They are transition zones between channels and uplands where the land influences the stream and the stream influences the land. It is in this zone that 'buffer strips' of forest vegetation have special importance for the quality of streams. Riparian areas correspond very well with the active flood plain. The active floodplain is the area that would become flooded if stream levels rose above the maximum bankfull depth (see Figure 3). Estimations of riparian area boundaries may also be based on floodplains identified on federal Flood Insurance Rate Maps. Lastly, county soil survey reports list soils 'subject to frequent flooding' which may help delineate some riparian areas.

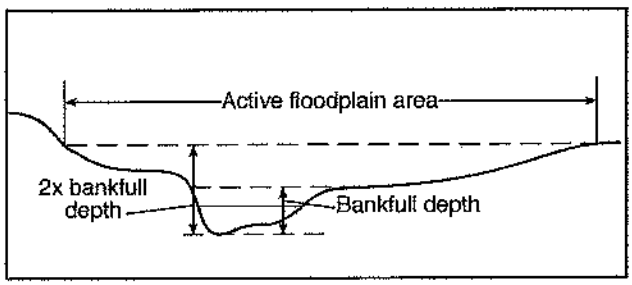

Figure 3. Buffer strip width defined by the active floodplain

It is not always feasible to base buffer strip width on the riparian area. For example, highly entrenched channels may have a riparian area hardly wider than the channel itself and in other places floodplains and riparian areas may be so extensive that encroachment is inevitable. For these conditions a generic minimum standard may be useful. One such standard is based on a dimension equal to two and one-half times the bankfull channel width or 50 feet, whichever is less (see Figure 4). This distance is then measured away from the bankfull channel to arrive at the standard buffer width.

Fence livestock from the stream — Stream

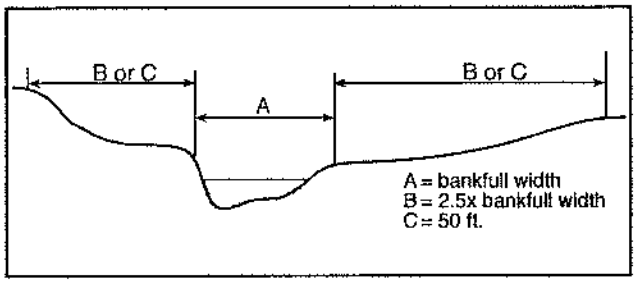

Figure 4. Buffer strip width defined by a minimum standard

fencing is a practice which keeps livestock away from the stream channel. Stream fencing projects often include stock tanks and water lines. Assistance for fencing livestock from streams may be sought through:

- Ohio State University Extension, Grazing Coordinator, 614/ 397-0401.
- USDA-Natural Resources Conservation Service (NRCS), Grazing Coordinator, 614/ 653-1559.
- County offices for the NRCS and local Soil & Water Conservation Districts, listed under County Government in local phone directories.

Establish a Legal Easement — One of the best ways to protect riparian areas is to establish legal easements, also known as conservation easements. Easements allow you to protect your streamside forests without giving up ownership. An easement is a legal agreement that protects a land's conservation value by restricting certain actions which can be taken, even by future owners. Among other things, riparian protection easements can prohibit or restrict timber harvesting, pesticide spraying and development in the buffer strip. The landowner may receive or waive compensation. The easement is held by a legally qualified conservation organization (such as a land trust) or a government agency. Conservation easements can be tailored for each landowner and situation, so may differ from property to property.

The following private organizations and public agencies are among those who can provide you information or assistance in creating a legal easement:

- The Trust for Public Land, 612/ 338-8494
- American Farmland Trust, 202/ 659-5170
- Land Trust Alliance, 202/ 638-4725
- The Nature Conservancy, 614/ 717-2770
- Ohio Department of Natural Resources, Division of Natural Areas and Preserves, 614/265-6460
- Ohio Department of Natural Resources, Division of Soil and Water Conservation, 614/265-6637
- Soil and Water Conservation Districts, listed under County Government in local phone directories

Erect Visual Barriers — Easements alone are only lines on paper which have proven to be ineffective against encroachment. One study found that 90% of easement protected forested buffers had been encroached upon to some extent, with 45% severely degraded. Visual barriers such as fences or signs appeared to be most effective at stopping encroachment.

REFORESTATION METHODS

Allow Natural Regeneration — Simply establishing a preservation area or "no-mow" zone may be enough to allow natural forest regeneration if there are some trees nearby to provide a seed source. This may not work in areas without trees which have been farmed or have managed turf. Areas with intrusive species or dense turf may require some site preparation to improve regeneration potential.

Transplant Woody Plants — A number of sources for trees exist including commercial nurseries, the ODNR Division of Forestry, and compatible sites where you obtain permission to harvest plants. A list of flood tolerant tree species is found in Guide No. 08,Trees for Ditches. Planting dormant cuttings such as willow posts and stakes is discussed in Guide No. 07, Restoring Streambanks with Vegetation.

A combination of tree planting and natural regeneration may be a good choice for certain areas. For example, natural regeneration may be adequate for the majority of a buffer strip but trees may need to be planted adjacent to the stream to expedite streambank stabilization or to restore a tree canopy over the stream.

Species Selection:

- It is best to use a diverse mix of tree and shrub species with an emphasis on native species.
- Species should be mixed randomly across the site.
- In areas of partial shade, use a large proportion of shade-tolerant species.
- Ideally a mix of dominant tree species, understory trees and shrubs, and herbaceous plants should be planted.
- In open areas, it may be useful to mix hardier pioneer species (two-thirds) with later successional species (one-third) in recognition of the difficult environment for new plants.

Pioneer Species	Later Successional Species
Cottonwood	Swamp white oak
Box elder	Pin oak
Red maple	Black walnut
Ash (green)	Silver maple
Red osier dogwood	Hawthorn
Gray dogwood	Black haw viburnum
Silkey dogwood	Maple leaf viburnum
Sycamore	

Stocking Rates — Common reforestation stocking rates are 600 -1,000 seedlings per acre or 500 containerized stock per acre. If planting in the fall or in high use areas, seedlings are generally not recommended. Seedlings are best planted after the ground thaws and before April 14.

Soil Preparation — Depending on soil conditions, the site may benefit from pre-planting preparation, including lime and/or fertilizer, and disking or plowing.

Stabilization — A cover of annual grains such as wheat, rye or oats at 1 to 1 1/2 bushel per acre may need to be planted to temporarily stabilize soil during the establishment period. Perennial grasses are not recommended because of their competition with woody vegetation.

Maintenance — Within the first two years, monitor at least monthly during the spring and summer. Once per month in the fall and winter should be adequate. On these monitoring visits check the planted sites for soil moisture, competing vegetation, mulch and pruning needs; maintain as needed. Fertilizing is not recommended during the first two years of plant growth.

Competing Vegetation — Competing vegetation is a critical factor to monitor for during the first two years. Minimize competition from weeds and grasses through hand weeding where feasible, or mowing, mulching and use of selected herbicides.

References:

Mecklenburg, Dan, 1996, "Rainwater and Land Development, Ohio's Standards for Stormwater Management, Land Development and Urban Stream Protection," Ohio Department of Natural Resources.

Lewis, S., J. Kopec, D. Rice, 1991, "Ohio's Streamside Forests: The Vital, Beneficial Resource," The Ohio Department of Natural Resources, Division of Natural Areas and Preserves.

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National Risk Management Research Laboratory

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GREEN INFRASTRUCTURE RESEARCH PROGRAM

Providing Research Solutions to Manage Wet-Weather Flow

Rain Garden Hydrology

Introduction

Rain gardens are vegetated surface depressions, often located at low points in landscapes, designed to receive stormwater runoff from parking lots, roofs and roads. Typically constructed with sandy soils, the gardens allow stormwater to infiltrate quickly to underlying native soil and eventually contribute to groundwater recharge. Vegetation and soils within the rain garden remove stressors in stormwater runoff through biological and physical processes such as plant uptake and sorption to soil particles. Compared with stormwater release to receiving waters through conventional storm drains, infiltrating stormwater through rain gardens reduces peak flow rates and volumes with stressor loadings. This reduction improves the physical and biological integrity of receiving streams by reducing stream bank erosion and negative effects on aquatic communities.

Background

The National Risk Management Research Laboratory (NRMRL) is evaluating rain gardens as part of a larger collection of long-term research examining multiple stormwater management practices. The U.S. EPA recognizes the potential of rain gardens as a green infrastructure management tool to lessen the effects of peak flows on aquatic resources. While local governments and individual homeowners are building many of these systems, relatively few studies have quantified rain gardens' ability to infiltrate stormwater to groundwater, thereby reducing peak flows.

Objectives

The Green Infrastructure Research Program's long-term rain garden research addresses two objectives to meet these challenges:

- Quantify the hydrologic performance of rain gardens accepting parking lot and roof runoff and changes with season and rain garden age.
- Test multiple ratios of impervious surface area to rain garden area in terms of hydrologic performance.

Experimental Approach

Controlled-condition research enables NRMRL investigators to collect high-quality information. Collecting data and performing experiments at field sites away from the laboratory limits research due to uncertainties in weather forecasts, site access, utility locations, vandalism, and other logistical issues that collectively add greatly to the costs and timelines of research projects.

Using on-site, experimental rain gardens enables NRMRL to collect high-quality data necessary for evaluating engineered structures. The laboratory facilities and space available at the Edison Environmental Center also allow for construction and monitoring of functioning, full-scale rain gardens, producing data directly relevant to real world applications while avoiding unnecessary risks to people and equipment.

Research Background

Cities and towns across the nation are building or planning to install rain gardens to accept and infiltrate stormwater runoff from parking lots, roofs, and roads in high-density urban settings. Although hydrologic properties such as infiltration rates, surface ponding depths and duration, and overflow have been well-researched at the bench and pilot scale, few studies have been conducted in full-scale rain garden applications. As a result, current sizing criteria in federal and state rain garden manuals range between 5% and 50% of the impervious area draining to the rain garden (NC Coop. Ext. Serv., 2005; UW-Extension, 2003; U.S. EPA, 2009), leaving designers with little clear guidance when making decisions about rain garden sizing. This is a critical need given the importance of avoiding excessively long periods of flooding and overflow, particularly during the more common small- and moderately-sized storm events. The question of how large to make a rain garden in a

given location relative to the impervious area draining to it takes on added significance in urban settings where land is expensive and highly valued for a variety of uses.

An additional area of uncertainty in full-scale rain gardens involves the mechanics of acquiring high-quality monitoring data. Previous experiences of EPA researchers and the wider scientific community have shown that green stormwater management practices like rain gardens and pervious parking lots must be designed with the capacity for long-term monitoring, as retroactively equipping an existing structure to collect monitoring data is impractical. In this study replicated rain garden cells are outfitted with buried instrumentation to collect long-term hydrologic data. This data will be analyzed to evaluate the effectiveness of the monitoring plan in terms of the location, number, and types of instruments employed as well as the measurement frequency, storage and analyses techniques.

Current Research

The schematic on the following page details the design of the rain garden cells located south of a newly-constructed green parking lot. The rain garden consists of six separate cells that are hydrologically isolated from each other using 3/8 inch-thick plastic sheeting installed to a depth of 4 feet (see figure on next page). The six cells receive stormwater runoff from an impervious section of the parking lot and adjoining sidewalk through curb cuts at the south end of the parking lot. Stormwater runoff from the roof of the adjacent building is collected from multiple downspouts and conveyed beneath the sidewalk in a common 8 inch-diameter pipe. A dedicated 4 inch-diameter pipe distributes the roof runoff upward into each rain garden cell just south of the curb cuts. The drainage area to all six cells is roughly equal (12,500 m^2), but because the rain gardens are different sizes, they represent different percentages of their drainage areas. The two smallest cells are 2%, the two medium-sized cells 4%, and the two largest cells are 8% of their drainage areas, respectively. Each cell size is duplicated for statistical purposes. All cells are equipped with soil water content reflectometers and thermistors (to measure soil moisture and temperature, respectively) at multiple depths in the soil profile at the north and south ends of each cell. A cluster of piezometers and wells at various depths is located in the center of each cell. All instrumentation contributes to quantifying the timing and size of the wetting front in the rain garden during and following storm events.

In addition to the rain gardens and associated pervious pavement parking lot, NRMRL operates the 20-acre Urban Watershed Research Facility that includes stormwater mesocosms, laboratories, greenhouses, fabrication space, a pipeline testing facility, swale and pervious parking lot performance testing, and storage for equipment and supplies. This unique facility is part of the larger 200-acre Edison Environmental Center operated by the U.S. EPA Region 2. This land area allows NRMRL to undertake research on a scale that cannot be executed at any other U.S. EPA facility. Additional rain garden research at the pilot-scale is ongoing at the research facility (U.S. EPA, 2008). This work focuses on stressor removal in rain garden media and vegetation.

Impacts

The successful application of bioretention and pervious pavement systems at the Edison Environmental Center's pervious pavement parking lot demonstration site, as determined by the results of the research and monitoring effort, will allow for technology transfer to other federal facilities and to municipalities considering adopting green infrastructure to alleviate CSO problems. A more complete understanding of how rain gardens function will enable the U.S. EPA to provide national guidelines on rain garden design, construction, maintenance, and monitoring which local organizations can use to reduce peak flows to receiving waters. Reducing stormwater peak flows will help maintain the function and integrity of aquatic resources. Rain gardens and other management tools will help watershed managers assure that receiving waters meet the "fishable and swimmable" goals that Congress outlined in the Clean Water Act and better assure the continuing supply of high-quality, potable water needed for human life.

Contact

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http://www.epa.gov/ednnrmrl

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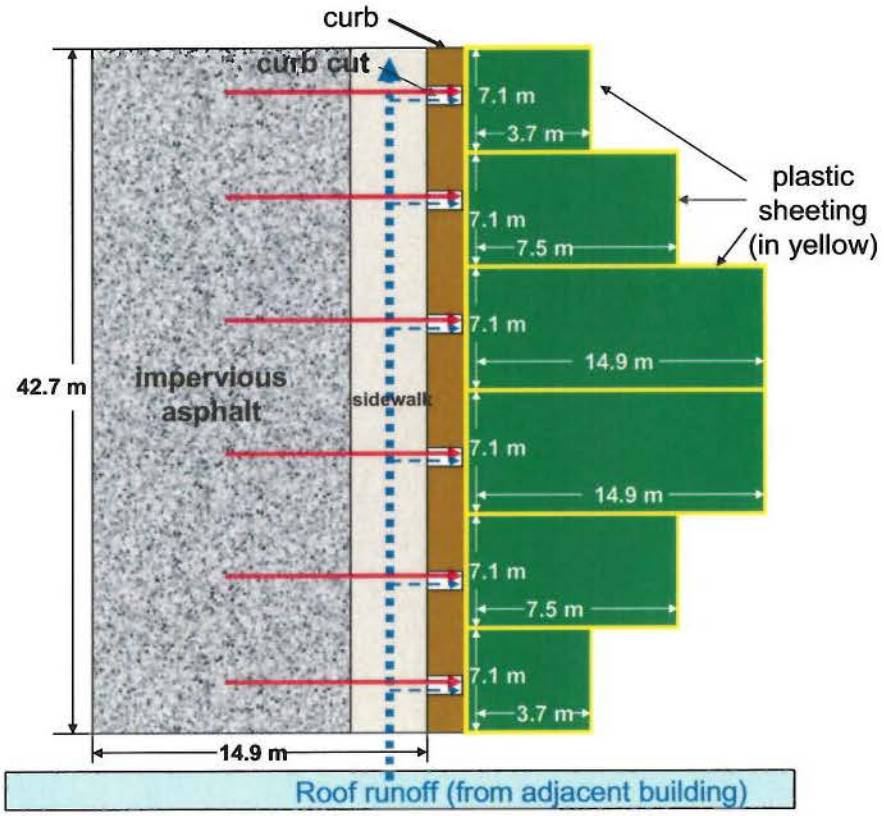


This schematic shows the rain garden cells (in green) located south of the impervious section and sidewalk associated with the newly-constructed parking lot. All rain garden cells are hydrologically isolated from each other; the yellow lines represent the plastic walls which separate the cells. All six cells receive stormwater runoff (represented by red arrows) from the impervious section of the parking lot through curb cuts. Stormwater runoff from the adjacent building is conveyed to the six rain garden cells through an underground pipe manifold system (represented by the dotted blue arrows).

OHIO STREAM MANAGEMENT GUIDE

An Introduction to Stream Management

Guide No. 01

STREAMS ARE CONNECTED TO THE LAND

The character of Ohio's rivers, streams and ground water has changed greatly over the last 200 years due to human activities. Forests and prairie lands once kept our streams narrow and deep by holding the banks intact. Stream water was cooler, cleaner and clearer, with a greater diversity of species than is found today.

Over the years agricultural production has increased through artificial land drainage. Crops are often planted up to streambanks, eliminating a crucial forested buffer zone for streams. Many of Ohio's streams were straightened to allow water to flow faster. Urbanization increases watertight surfaces (streets, roofs, and parking lots), and our streams receive greater amounts of runoff and the pollution it carries from crossing land surfaces. The increased runoff resulted in streambanks and beds being scoured and nearby cropland being lost. Downstream flood damage also increases as streams carry more water at a faster rate.

The changes we make to each watershed or drainage basin's land use, changes the character of our streams. The loss of trees and their streambank root structures allow streams to run wider and shallower, allowing sediment to fall out, silting-over important biological habitats within the stream. Sediments and pollutants must be filtered from raw water before it is used for industry and drinking. And millions of dollars are spent each year dredging sediment from channels, harbors and reservoirs.

Few people realize the overall importance of watershed-based land use practices, such as increasing the ability of surface areas to absorb water and retaining streamside forested buffer zones. Suitable streamside and in-stream habitat is the single most important factor determining the existence of diverse fish and wildlife populations. Healthy aquatic populations indicate good water quality which results in fewer external costs to society. The quality and productivity of our rivers and lakes can be improved if we retain and restore their natural characteristics.

During the 1960's and 1970's people started to see that our prosperous and productive life style was seriously impacting the quality of the environment around us, including the resource-base which supports that life style. As a society we have started to make choices to alter our land use practices in order to preserve and restore habitat that are critical for the survival of plants and animals whose continued existence we once took for granted.

Each year new information and practices help us stay productive and prosperous while protecting the natural environment. This series of Ohio Stream Management Guides is designed to make practical advice available to landowners and others responsible for land use decisions involving streams.

WHAT IS STREAM MANAGEMENT?

Stream management includes all land use activities which affect stream environments, particularly their physical structure. Streams and their watershed lands should be managed in ways that work toward finding and maintaining healthy balances between our various land uses and the needs of fish and wildlife. The Ohio Stream Management Guides will focus on the physical structure of streams and management practices which support the search for healthy balances.

More intensive land use and development tends to disrupt natural processes which protect and preserve water resources. Therefore, land uses and the design and maintenance of stream modifications and storm water structures must be managed responsibly. This means minimizing the disruption of those natural processes, and mitigating necessary disruptions as much as possible.

STREAMS ARE PART OF THE HYDROLOGIC CYCLE

Stream systems drain the land as a key part of nature's water cycle. The water cycle contains the following elements:

1. precipitation of all forms of water which falls from the atmosphere to the earth's surface;
2. infiltration and percolation of precipitation deep into the ground, replenishing the ground water supply;
3. overland flow or runoff of precipitation across land surfaces and through drainageways to streams, lakes and eventually, the ocean;
4. evaporation from surface water, soil and vegetation, returning water vapor to the atmosphere; and
5. transpiration by plants through their roots to their leaves, returning water vapor to the atmosphere.

The cycling of water from the earth's surface to the atmosphere and then returning to the earth, is called the hydrologic cycle. Hydrology is the study of the various waters of the earth, their occurrence, circulation, distribution, chemical and physical properties and reaction with the environment, including their relationships with living things.

STREAMS AND OTHER WATER RESOURCE FEATURES

Stream systems are related to other water resource features such as watersheds, lakes and reservoirs, wetlands, ground water, floodplains, riparian zones and fish and wildlife habitats.

Watersheds, or drainage basins, are areas of land which drain to a single outlet. The term watershed is also used for the outline of the drainage basin. Precipitation falling on one side of a

watershed line will drain to one outlet while precipitation falling on the other side of the line will drain to another outlet. The peak of a roof functions in the same way, dividing which direction runoff will flow off the roof. A watershed area may be as small as a farm field draining toward a gully, or as big as the Ohio River drainage basin, which is a combination of thousands of smaller watersheds across several states. Every river, stream and tributary is part of a watershed. The geography, geology and land uses in a watershed greatly influence a stream's character.

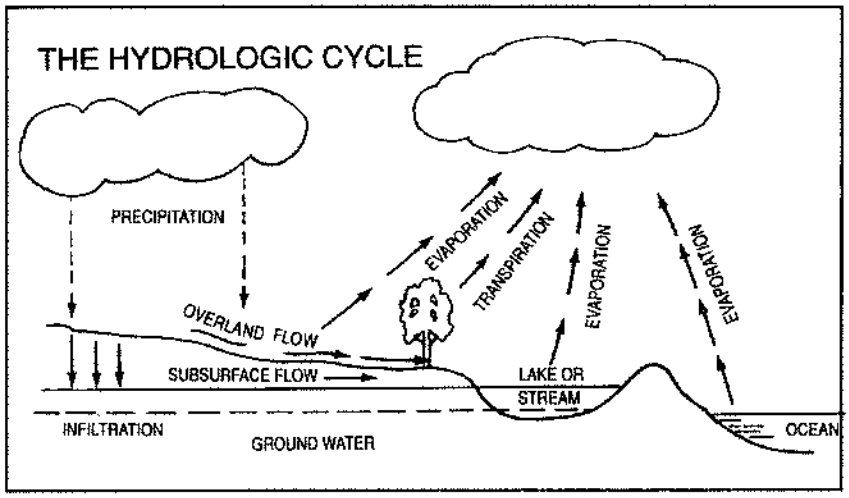
Lakes are naturally occurring impoundments of water, while reservoirs are made by humans. Lakes and reservoirs both serve as sinks where the sediment load that streams carry are deposited. These areas can provide water supply, flood control, fish and wildlife habitat, recreational opportunities and other benefits.

Wetlands are transitional areas between dry land and streams, ponds or lakes. Bogs, fens, marshes and swamps are examples of different types of wetlands. Wetlands are one of nature's ways of managing water quantity and quality. Wetlands provide a variety of no-cost, maintenance-free benefits such as, cleaning water, storing and slowing flood waters, providing ground water recharge and discharge, and providing wildlife habitat. Wetlands also have recreational, educational and aesthetic values which are enjoyed by more and more people.

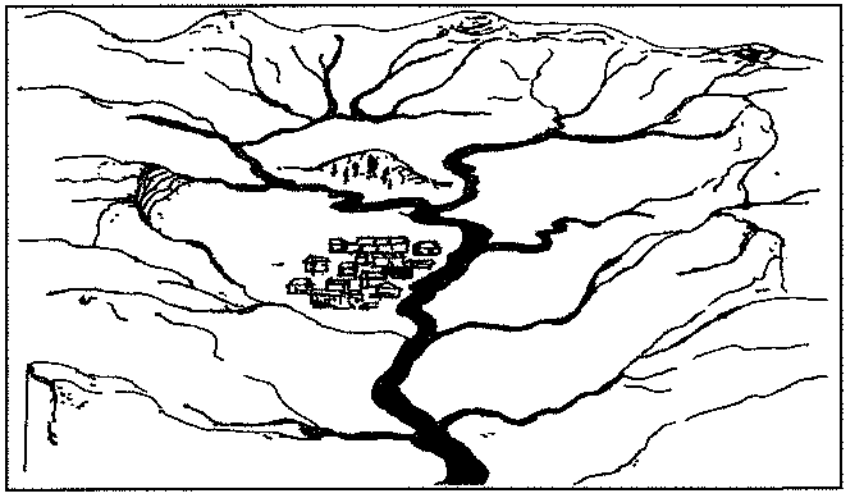
Ground water, a valuable source of drinking water, is water stored underground in porous, permeable layers of sedimentary rock or unconsolidated sand and gravel deposits, known as aquifers. Replenishment, or recharge, of the ground water supply occurs when precipitation penetrates deep into the subsurface and becomes part of the ground water system. Shallow ground water discharges into streams where water tables intersect stream channels, providing base flow to the stream. Streams may also exist as areas of discharge for deeper ground water aquifer systems.

Floodplains are the valley floors adjacent to stream channels which may be inundated during flood events. Flooding is a natural and unavoidable characteristic of all streams. Floodplains function as nature's safety valve by providing a place for floodwater to spread out, thus slowing the speed of floodwater discharge. Floodplains provide other valuable functions too, including wildlife habitat, ground water recharge, water quality maintenance and sediment control. They also have recreational, aesthetic and scientific values.

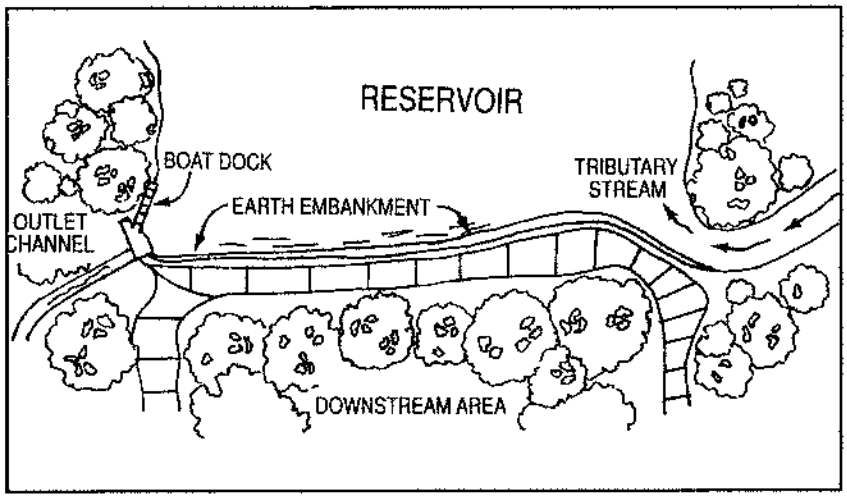
Riparian zones are lands immediately adjacent to streams, sometimes called stream corridors, usually within floodplains. The term riparian zone is often used to mean a streamside forested buffer area, particularly in water



Hydrologic Cycle



Watershed



Reservoir

quality programs and local ordinances. The width of the zone is then defined according to the program's purpose. Indeed, one of the best uses of stream side land is as a forested buffer area between the stream and other land uses. Retaining or restoring riparian land to forest provides many water quality and floodplain benefits. The riparian area provides a transition between aquatic habitat and upland habitat and may contain wetlands. The relative health of the riparian zone, or stream corridor, directly affects fish and wildlife survival.

The quality of fish and wildlife habitat is a function of the physical, chemical, and biological features of the entire watershed as well as the stream corridor. It indicates the capacity of the stream to support viable, diverse populations of both aquatic and terrestrial organisms.

HOW LAND USE AFFECTS WATER QUANTITY AND QUALITY

Land use changes affect the hydrology of an area in three ways:

1. Peak Flow Characteristics

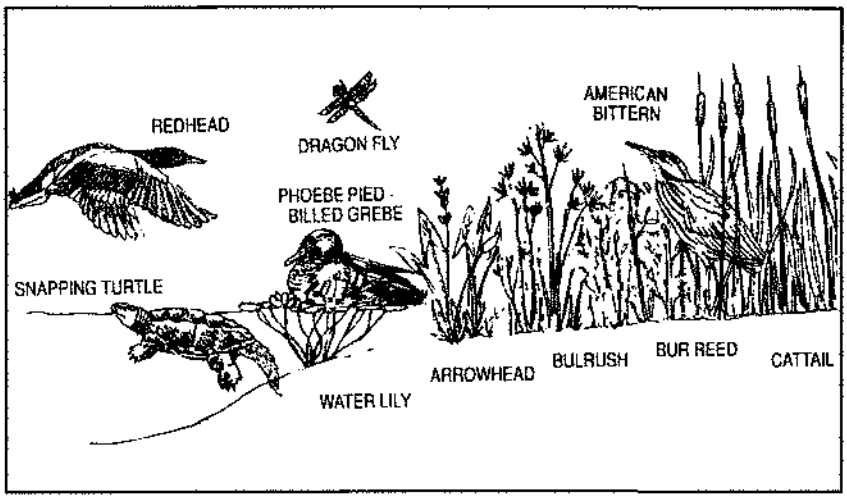
After rainfall events, runoff reaches streams and rises to reach a peak before subsiding. As land uses change from natural to agricultural or urban, the total amount of flow, peak flow height and stream flow speed increases. Streams rise higher, flow faster, and reach peak flows more quickly than under natural conditions. These effects are due to an increase in impervious area (streets, parking lots, roofs, etc.); a reduction in the opportunity for infiltration, evaporation, transpiration and depression storage; and the modification of surface drainage patterns.

2. Water Quality

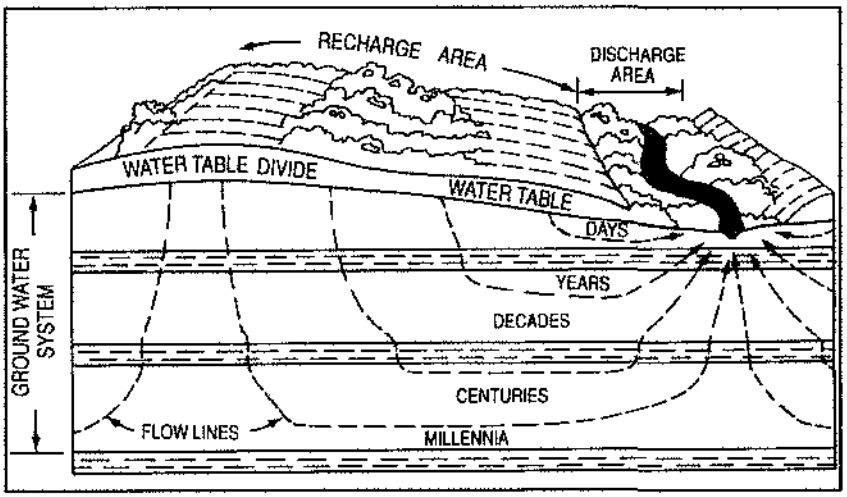
As the human use of land intensifies, the naturally occurring physical, chemical and biological activities which normally interact to recycle most of the materials found in runoff are disrupted. Human activities add pollutants such as pesticides, fertilizers, animal wastes, oil, grease and heavy metals to the land surface. Construction activities expose soil directly to precipitation. Soil and pollutant particles are washed downhill by rainfall and runoff, and increase the pollutant and sediment loads carried by receiving streams.

3. Stream Amenities

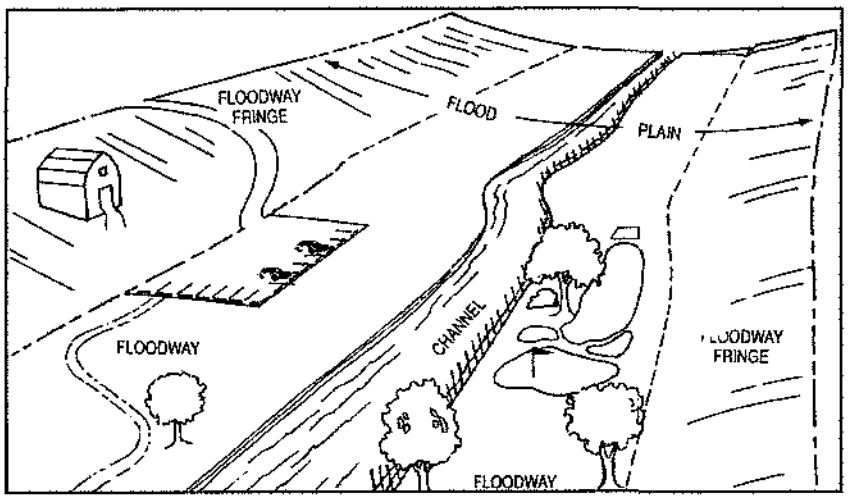
The value of natural stream corridors, as both a public and private good, reflects a higher land value near wooded stream corridors. A channel which has gradually enlarged due to increased flooding tends to possess unstable and un-vegetated banks, scoured or muddy channel beds, and accumulations of sediment and debris. In addition to being unsightly, these factors disrupt the natural balance in stream organisms. The addition of nutrients, organics and sediment caused by changes in hydrology tend to increase algae growth and turbidity (green- and brownish water),



Wetland



Ground Water



Floodplain

lower the oxygen content of the water and thereby reduce the variety of organisms supported by the stream. The beauty and value of the stream corridor is negatively affected when the stream channel is unstable, trash accumulates, and fish and wildlife communities are disrupted.

We are all land managers, so we are all stream managers. How we handle that responsibility — directly or indirectly — affects our neighbors in the watershed and along our stream. Our actions both reflect and change the society and environment around us. We should seek to improve the balance between aquatic organisms, water quality, water quantity, and land development in our Ohio watersheds and streams.

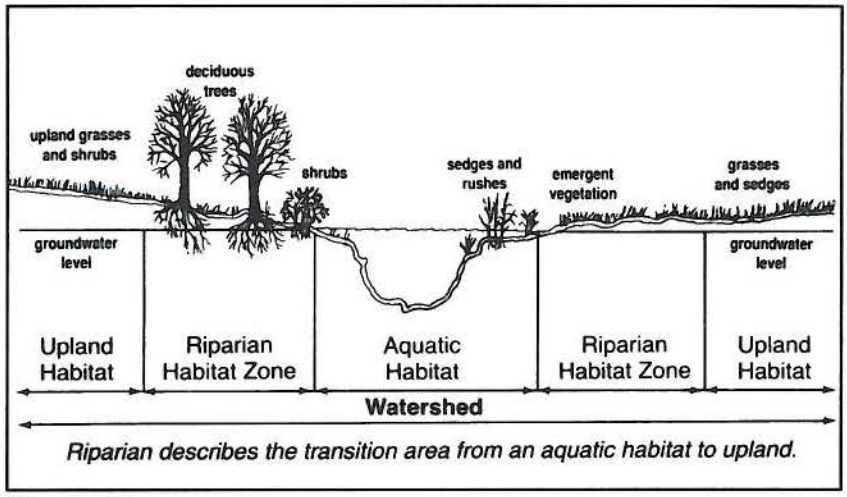
~

This Guide is one of a series of Ohio Stream Management Guides covering a variety of watershed and stream management issues and methods of addressing stream related problems. The first several guides in the series are overview guides intended to give the reader an understanding of the functions and values of streams. For more information about stream management programs, issues and methodologies, see Guide 05 Index of Titles or call the ODNR Division of Soil and Water Resources at 614/265-6739. All Guides are available from the Ohio Department of Natural Resources. Single copies are available free of charge and may be reproduced. Please contact:

ODNR
Division of Soil & Water Resources
2045 Morse Road, Bldg. B
Columbus, Ohio 43229-6693
614/265-6740

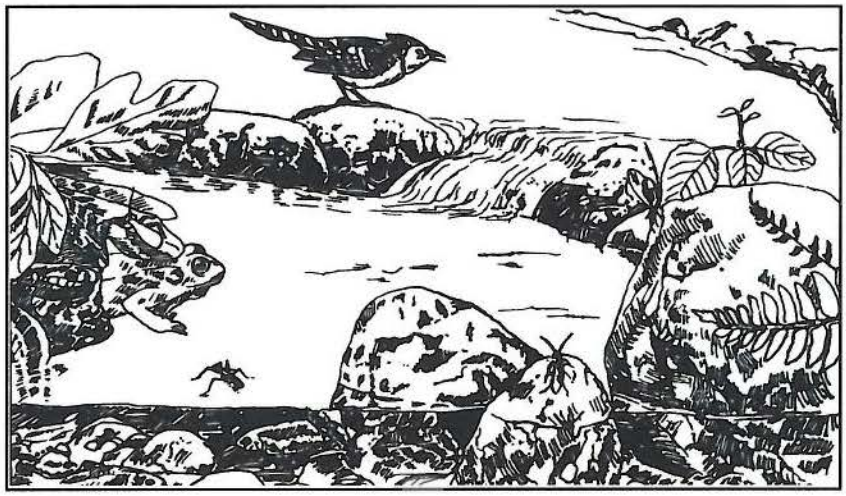
The guides are also available on-line as web pages and PDF files so you may print high quality originals at your location. You will find the guides on-line at:

http://www.ohiodnr.gov/soilandwater/



Riparian describes the transition area from an aquatic habitat to upland.

Riparian Zone



Wildlife Habitat

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Prepared by the Ohio Department of Natural Resources, Kim Baker, Division of Real Estate and Land Management, principal author. Input from staff of several ODNR divisions, state and federal agencies are used in the development of the Ohio Stream Management Guides.

Guides are available on-line at: http://www.ohiodnr.gov/soilandwater/

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Water Quality Watch

Homeowner's Guide to Flood Plain Management

What Are Flood Plains?

Flood plains are lands that border rivers and streams. They normally are dry but can be covered with water during or after storms.

Flood plains serve a critical function during severe storms — they provide storage capacity for excess water until downstream water courses can accept it.

Why Is Flood Plain Management So Important?

Floods can damage buildings or other structures that are placed in flood plains. Placing structures in a flood plain can increase flooding and flood damage on adjacent property. That's because structures in flood plains can change the pattern of water flow by blocking the flow of water and increasing the width, depth, or velocity of flood waters.

In addition to storing excess water during severe storms, flood plains (if they are properly managed) have the secondary benefit of protecting the water quality of our streams. Flood plains, in the form of vegetated land cover, act as buffer zones between streams and nearby development.

As stormwater flows over developed areas, it picks up pollutants such as motor oil from roads, soil from construction areas, and fertilizers and pesticides from lawns. A vegetated buffer can effectively remove these pollutants, through the filtering action of grasses, shrubs, and trees and by allowing stormwater to soak into the soil.

Flood Plain Ordinance

In March 1983, Chesterfield County adopted the *Flood Plain Management Ordinance*. The Ordinance prohibits certain uses, activities, and residential development from locating within areas that are subject to flooding. The purpose of the Ordinance is to prevent loss of life and damage to dwellings.

A copy of the complete *Flood Plain Management Ordinance* can be picked up from the Department of Environmental Engineering at 6806 West Krause Road.

Do's and Don'ts of Flood Plain Management

Please DO:

- ☺ Leave natural vegetation, including undergrowth, in flood plains.
- ☺ Remove significant blockages, such as fallen trees, from flood plains and water courses.
- ☺ Maximize the distance between lawns or vegetable gardens and flood plains.
- ☺ Contact the Department of Environmental Engineering at 748-1035 with questions about flood plains.

Please DON'T:

- ☹ Clear-cut or fill in flood plains.
- ☹ Deposit leaves, grass clippings, brush, or other debris in flood plains.
- ☹ Stockpile firewood in flood plains.

Frequently Asked Questions

Q. *Can I put a fence in the flood plain?*

A. The Ordinance doesn't prohibit fences. However, the practice is discouraged because fences located in flood plains are very often damaged by flooding, are prone to collect debris, and can alter flood plains.

Q. *Is filling in the Flood Plain recommended?*

A. **No!** Filling in the flood plain can permanently alter the flow of water, compromise the storage capacity and water quality benefits of the flood plain, and potentially affect adjacent properties.

Q. *Can I clear-cut trees in the flood plain?*

A. The Flood Plain Ordinance does not expressly prohibit clear-cutting trees in a flood plain. However, the Department of Environmental Engineering **strongly discourages** this practice because clear-cutting can permanently alter the flood plain and result in the release of excess sediment into a stream.

Q. *If a flood plain is located in the Chesapeake Bay Resource Protection Area, can I clear-cut trees?*

A. **No**. The *Chesapeake Bay Preservation Ordinance* **prohibits** clear-cutting trees in Resource Protection Areas. If trees are to be removed, it should be done selectively, removing only trees that are dead, dying, or diseased.

Q. *Can I build a swimming pool in the flood plain?*

A. The Flood Plain Ordinance does not expressly prohibit swimming pools. However, the County's *Chesapeake Bay Preservation Ordinance* **prohibits** the location of swimming pools in a flood plain that is part of a **Resource Protection Area**. The Department of Environmental Engineering strongly discourages swimming pools in flood plains, because they will be subject to periodic flooding and will collect debris.

Q. *Can I build structures such as sheds and detached garages in the flood plain?*

A. You can do so in some cases, as determined by the Department of Environmental Engineering. The entrance or "front" of the structure must be located along the landward edge of the flood plain (the edge farthest from the stream).

Q. *What kind of drainage improvements will the County make in a flood plain?*

A. **None**. Flood plains are natural areas that serve as a "storage area" for excess water in streams and other waters during severe storms. The County will assist in assessing any problems that may be occurring on a homeowner's property due to the existence of a flood plain.

Q. *How will the County help with erosion problems in the flood plain or watercourse?*

A. If a man-made channel is located in a County easement, the County will assess the problem and take any necessary corrective measures. If there is erosion in a stream or drainage-way that is not in a County easement, the County may provide rip-rap (large rock) to the homeowner or Homeowners' Association to help correct the problem.

Q. *What can I do about beavers in the flood plain?*

A. Call the Drainage Superintendent at 748-1035 with specific questions about beavers. Before trapping beavers, the State Department of Game & Inland Fisheries must be contacted, and a permit must be obtained.

What You Should Know if a Flood Plain Is Located on Your Property

Fact: A 100-year flood plain is defined as an area with a 1% chance of being flooded in any given 12-month period. This means that, during periods of wet weather such as spring or fall, or during severe summer storms, water might frequently flow over the stream banks and spread onto the land next to the stream.

When purchasing property, it is important to look for flood plains. Flood plains are most often delineated on final record plats for subdivisions recorded after 1979.

Fact: A 100-year "backwater" refers to a temporary, artificially created ponded area, caused by the backup of stormwater from a culvert or pipe. Such areas are designed to pond water during severe storms, because the culverts and pipes are designed to handle only average storms. To handle the most severe storms, those culverts and pipes would have to be designed as excessively large structures.

And More Facts:

- ✓ Houses that were built before 1983 (when the *Flood Plain Management Ordinance* was adopted) were not required to be set back from flood plains.
- ✓ Houses built between 1983 and 1989 were required to be set back 5 feet from flood plains.
- ✓ Houses built from 1989 to the present are required to be set back 20 feet from flood plains.

This is one of a series of fact sheets about surface water quality issues in Chesterfield County. Copies are available in the Department of Environmental Engineering offices at 6806 West Krause Road. The series includes:

- *Chesterfield County's Stormwater Management Program* (August 1997)
- *Household Guide to Chesterfield County's Illicit Discharge Ordinance* (October 1997)
- *Business and Industry Guide to Chesterfield County's Illicit Discharge Ordinance* (October 1997)
- *Chesapeake Bay Resource Protection Areas and Flood Plains* (December 1997)
- *The Streams of Chesterfield County* (September 1998)

These fact sheets are produced by the Water Quality Section of the Department of Environmental Engineering. Our mission is to protect, maintain, and restore the chemical, physical, and biological integrity of Chesterfield County's waters. This mission furthers one of the County's Strategic Goals: to maintain an extraordinary quality of life in the County by protecting and preserving our natural and historical resources. For more information, call 804-748-1035.

Guidance for Collecting High Water Marks

High water marks should be collected after a flooding event has occurred and as soon as the flood waters have receded as possible as clean-up efforts will quickly remove the traces needed to set the marks. After the event, officials should make a list of areas where flooding occurred and try to rank them in priority. Teams of at least two should be sent into the field equipped with survey books, cameras, levels and GPS units, if available. Flooded streams with historical high water marks should be looked at first and high water marks on those streams should be placed in similar locations so that events can be compared, tables from Appendix H can be used.

Once in the field, a high water mark team should look for areas of access to the stream where flooding occurred. High water marks should be placed on telephone poles, trees or any other structure that is more or less permanent. If possible, multiple points of reference should be collected when setting a high water mark. Multiple debris, mud or trash lines can be referenced to the same high water mark location using a level.

The best place to look for high water marks is on structures. High water marks can be set at these locations by measuring the height of the mud line from a fixed feature such as a step or window ledge or by using a level to transfer the high water mark onto a nearby tree or telephone pole.

Figure G - 1. Example picture of a mud line on the outside of a building.

Figure G - 2. Example picture of a mud line on the inside of a building.

Debris lines can also be found on fences. These debris lines are usually not as accurate as those on structures but can be used as a check or in areas where there are no structures in the vicinity.

Figure G - 3. Example of a debris line on a chain link fence.

Figure G - 4. Example of a debris line on farm fencing.

Figure G - 5. Example of a debris line on farm fencing.

Less accurate but still worth noting are debris lines or trash lines on the ground or in trees. These should be used as a check or in rural locations where no structures or fences can be found.

Figure G - 6. Example of a debris line on the ground.

Figure G - 7. Example of a debris line on the ground.

Figure G - 8. Example of a debris line in a single tree.

Figure G - 9. Example of a debris line in a group of trees.

Once the high water mark team has arrived at a location, they should look for any structures in the area with clear mud or seed lines on them. If multiple debris lines are found in the area they should all be looked at to determine which one is thought to be the most accurate. Shooting multiple debris line elevation back to the point where the high water mark will be placed helps to increase accuracy of the high water mark.

Once the location of the high water mark is identified, a means of marking the location such as a nail and cap with flagging should be placed, making the high water mark more easily found at a later date. If you are putting the high water mark on a structure and a nail cannot be placed, measure the height from the first floor elevation to the high water mark location and document this measurement. If the high water mark is being placed higher than is feasible to drive a nail, place a nail at a more reasonable height and include the measurement up to the high water mark in your description. Once the nail is set, write a detailed description in your field book about the location of the nail, debris lines that it was set from, accuracy of the high water mark, and any other details about the area as well as GPS coordinates. Pictures can also be taken or drawn in the field books to help illustrate locations. Examples to the right show the proper way to document a high water mark.

After a detailed description is written, take pictures or the location of the high water mark as well as the debris line if they are in different locations. If possible, collect a point using a GPS unit in the location so that an electronic location can be created of all of the high water mark points. The point should be named appropriately. A good way to name high water mark points is by a two or three letter abbreviated stream name and a number that identifies that high water mark on the stream. If an abbreviated stream name was used in previous events, default to that. (Example: Sunset Branch – SB023)

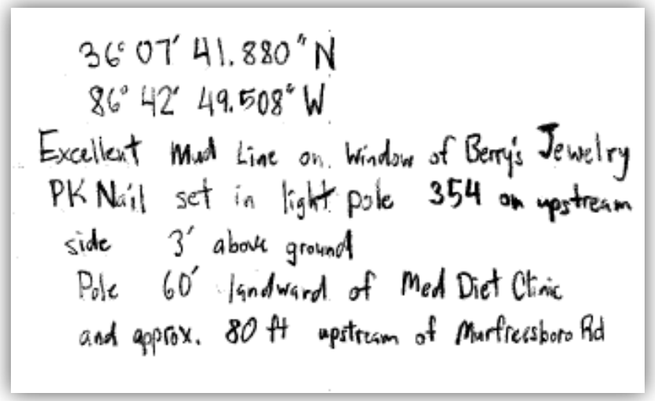


Figure G - 10. Example of a mud line high water mark description.

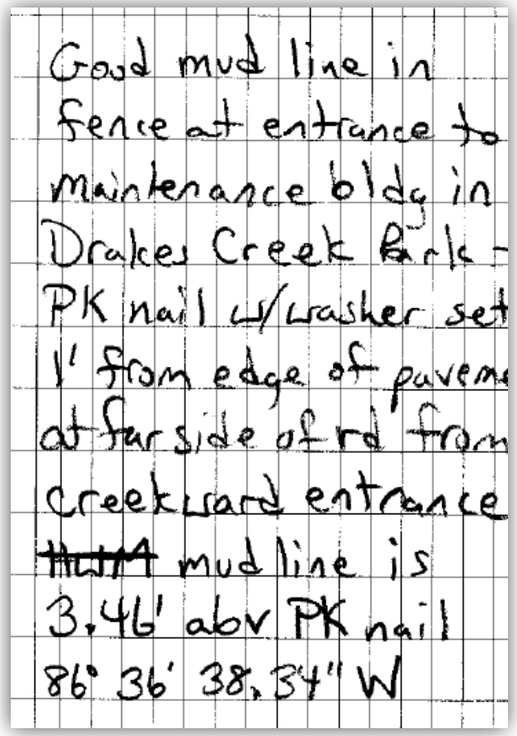


Figure G - 11. Example of a debris line on a fence high water mark description.

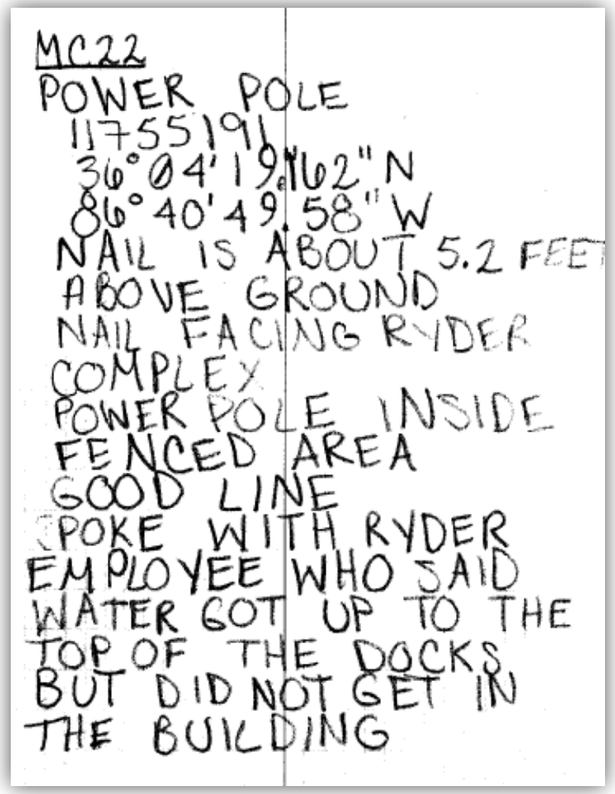


Figure G - 12. Example of high water mark that was transferred from a building to a power pole.

Once high water marks have been set, a survey crew can go back out and assign elevations to the high water marks. The survey crew will need to take the GPS points as well as copies of the high water mark books to help locate all placed high water marks. Place these elevations into an electronic format (such as and ESRI shapefile or CADD) for later use.

High water marks can be used to calibrate hydraulic computer models, determine the variance in current and historical events and help to determine inundated areas after an event occurs.

Appendix E

USACE Fact Sheets

CONTINUING AUTHORITIES PROGRAM
SECTION 14
EMERGENCY STREAMBANK AND SHORELINE PROTECTION

WHAT CAN THE CORPS DO?

Section 14 of the Flood Control Act of 1946, as amended, provides authority for the Corps of Engineers to plan and construct emergency streambank and shoreline protection projects to protect endangered highways, highway bridge approaches, public facilities such as water and sewer lines, churches, public and private nonprofit schools and hospitals, and other nonprofit public facilities.

The unstable conditions caused by flood induced streambank and shoreline erosion call for prompt action to eliminate the threat to public safety and to prevent interruption of vital services. This is recognized in the streamlined study and shortened time frame of the Section 14 Program. Federal costs are limited to not more than $1,500,000 in one locality during any fiscal year.

A Section 14 project may include new streambank or shoreline protection works, or it may repair, restore, or modify existing works. Each project must constitute a complete solution to the problem and not commit the Federal government to additional improvements to ensure effective protection. A project is accepted for construction only after an investigation shows its engineering feasibility, environmental acceptability, and economic justification.

After a state or local agency requests Federal assistance, the Corps will conduct a feasibility study pending potential Federal interest and available funding. The feasibility study begins at Federal expense. Study costs in excess of $100,000 are shared 50/50 with the non-Federal sponsor according to a Feasibility Cost Sharing Agreement (FCSA). In the feasibility study, the problem is defined, project viability is determined, potential solutions are identified, and the most feasible plan is selected for implementation. The costs, benefits, and environmental impacts of the potential project are analyzed. A draft project partnership agreement (PPA) is drawn up by which the Federal government and the sponsor agree to share project construction costs. No more than 12 months should pass between the start of the feasibility study and the time the project is ready for construction.

WHAT ARE THE LOCAL RESPONSIBILITIES?

Costs for emergency streambank and shore protection projects are shared between the Federal government and a non-Federal sponsor in accordance with the Water Resources Development Act of 1986, as amended. During construction the local sponsor must contribute a minimum of 35% of the total cost of a project, with credit granted toward the amount for providing lands, easements and rights-of-way, and pay a minimum cash requirement of 5% of the total project cost. The local sponsor (a state or local government) must have the legal and financial capability to fulfill the requirements of cost sharing and local cooperation.

Formal assurances of cooperation must be furnished by the local sponsor. The sponsor generally must agree to the following:

- Contribute a minimum of 5%of the total project cost in cash;
- Provide all lands, easements, rights-of-way, and relocations;
- Provide any additional cash contributions needed to make the local sponsor's share of the project costs 35%;
- Assume the full responsibility for all project cost above the Federal cost limit of $1,500,000;
- Hold and save the United States free from claims for damages due to the construction and maintenance of the project, except damages due to fault or negligence of the United States or its contractors;
- Provide all access routes and relocations of utilities necessary for project construction and subsequent operation and maintenance;
- Operate, maintain, repair, replace, and rehabilitate the project as long as the project is authorized; and
- Comply with provisions of pertinent Federal acts in carrying out the specified non Federal responsibilities of the project

HOW CAN HELP BE REQUESTED?

An investigation under Section 14 may be initiated after receipt of a formal request from the prospective sponsoring agency. A sample letter is offered below. This letter is generally referred to as a Letter of Intent (LOI) and must be received by the Corps from a prospective non-Federal sponsor prior to initiating the feasibility phase.

District Engineer
U.S. Army Corps of Engineers, Huntington District
502 8th Street
Huntington, West Virginia 25701

Dear Sir:

In accordance with the provisions of Section 14 of the Flood Control Act of 1946, the (name of local sponsor, i.e. Town of Newberry) requests Corps of Engineers assistance in addressing a streambank erosion problem (briefly state problem) on (name of site, i.e. street or park name) along (name of stream).

We are aware of the following cost sharing requirements associated with projects undertaken under this authority and are able to meet these obligations within 12 months.

a) Feasibility Phase is Federally funded up to $100,000. Costs in excess of$100,000 are shared on a 50/50 basis with the local sponsor. The sponsor's 50% share of any costs over $100,000 may be provided by in-kind services.
b) Sponsor's Share of Construction consists of provision of land, easements, rights-of-way, relocations and disposal areas, plus a cash contribution of at least 5% of the total project cost. If this amount is less than 35% of the total project cost, the sponsor will provide any additional cash contribution required to equal 35%. The Federal limit is $1,500,000.
c) The sponsor is responsible for removal of all Hazardous, Toxic, and Radioactive Wastes prior to any construction and for the operation and maintenance of the project after it is completed.

We are aware that this letter serves as an expression of intent and is not a contractual obligation and that either party may discontinue the study process at any stage prior to construction.

Sincerely,

(Name and title of public official authorized to request study)

CONTINUING AUTHORITIES PROGRAM
SECTION 205
Flood Damage Reduction

WHAT CAN THE CORPS DO?

Section 205 of the Flood Control Act of 1948, as amended, provides authority to the Corps of Engineers to plan and construct small flood damage reduction projects not specifically authorized by Congress. A project is accepted for construction only after detailed investigation clearly shows its engineering feasibility, environmental acceptability, and economic justification. Each project must be complete within itself, not a part of a larger project. The maximum Federal expenditure per project is $7,000,000, which includes both planning and construction costs. Costs of lands, easements, and operation and maintenance must be non-Federal.

There are two types of projects: structural and nonstructural. Structural projects may include levees, flood walls, diversion channels, pumping plants, and bridge modifications. Nonstructural alternatives, which have little or no effect on water surface elevations, might include measures such as floodproofing, relocation of structures, and flood warning systems.

After a state or local agency requests Federal assistance, the Corps will conduct a feasibility study pending potential Federal interest and available funding. The feasibility study begins at Federal expense. Study costs in excess of $100,000 are shared 50/ 50 with the non-Federal sponsor according to a Feasibility Cost Sharing Agreement (FCSA).

In the feasibility study, the problem is defined, project viability is determined, potential solutions are identified, and the most feasible plan is selected for implementation. The costs, benefits, and environmental impacts of the potential project are analyzed. If there is a feasible solution to the flooding problem recommended by the study, a draft project partnership agreement (PPA) is drawn up by which the Federal government and the sponsor agree to share project construction costs. No more than 3 years should pass between the start of the feasibility study and the time the project is ready for construction.

WHAT ARE THE LOCAL RESPONSIBILITIES?

Costs for Section 205 flood damage reduction projects are shared between the Federal government and a non-Federal sponsor in accordance with the Water Resources Development Act of 1986, as amended. During construction the local sponsor must contribute a minimum of 35% of the total cost of a project, with credit granted toward the amount for providing lands, easements and rights-of-way, and for structural projects, pay a minimum cash requirement of 5% of the total project cost. The local sponsor (a state or local government) must have the legal and financial capability to fulfill the requirements of cost sharing and local cooperation. The sponsor generally must agree to the following:

- Contribute the local share of project planning and construction costs;
- Provide all lands, easements, rights-of-way, relocations, and dredged material disposal area;
- Provide any additional cash contributions needed to make the local sponsor's share of the flood damage reduction cost at least 35%;

- Hold and save the United States free from damages due to the construction and maintenance of the project, except damages due to fault or negligence of the United States or its contractors;
- Prepare a floodplain management plan designed to reduce the impact of future flood events in the project area;
- Comply with provisions of pertinent Federal acts in carrying out specified non- Federal responsibilities of the project; and
- Operate, maintain, repair, replace, and rehabilitate the project.

HOW CAN A STUDY BE REQUESTED?

An investigation under Section 205 may be initiated after receipt of a formal request from the prospective sponsoring agency. A sample letter is offered below. This letter is generally referred to as a Letter of Intent (LOI) and must be received by the Corps from a prospective non-Federal sponsor prior to initiating the feasibility phase.

District Engineer
U.S. Army Corps of Engineers, Huntington District
502 8th Street
Huntington, West Virginia 25701

Dear Sir:

In accordance with the provisions of Section 205 of the Flood Control Act of 1948, as amended, the (name of local sponsor) requests the Corps of Engineers to undertake a flood control study for (name of site) along (name of stream).

We are aware of the following cost sharing requirements associated with projects undertaken under this authority.

a) Feasibility Phase is Federally funded up to $100,000. Costs in excess of $100,000 are cost shared on a 50/ 50 basis with the local sponsor. The sponsor's 50% share of any costs over $100,000 may be provided by in-kind services.
b) Preparation of Plans and Specifications is cost-shared in the same proportion as construction and is collected with the construction cost share.
c) Sponsor's Share of Construction for structural measures consists of provision of land, easements, rights-of-way, relocations and disposal areas, plus a cash contribution of at least 5% of the total project cost. If this amount is less than 35% of the total project cost, the sponsor is required to provide additional cash contribution to equal 35%. The sponsor's cost share is limited to a maximum of 50% of the total cost when the project is under the Federal limit of $7,000,000. The sponsor's share for nonstructural measures such as flood proofing is 35%.
d) The sponsor is responsible for the operation and maintenance of the project after it is completed.

We are aware that this letter serves as an expression of intent and not a contractual obligation and either party may discontinue the study process at any stage prior to construction.

Sincerely,

(Name and title of public official authorized to request study)

CONTINUING AUTHORITIES PROGRAM
SECTION 206
Aquatic Ecosystem Restoration

WHAT CAN THE CORPS DO?

Section 206 of the Water Resources Development Act of 1996, provides authority for the Corps to restore aquatic ecosystems. A project is accepted for construction after a detailed investigation shows it is technically feasible, environmentally acceptable, and provides cost effective environmental benefits. Each project must be complete within itself, not a part of a larger project. The maximum Federal expenditure per project is $5,000,000, which includes both planning and construction costs.

The Corps does restoration projects in areas that affect water, such as rivers, lakes, and wetlands. We evaluate projects that benefit the environment through restoring, improving, or protecting aquatic habitat for plants, fish and wildlife.

After a state or local agency requests Federal assistance, the Corps will conduct a feasibility study pending potential Federal interest and available funding. The feasibility study begins at Federal expense. Study costs in excess of $100,000 are shared 50/50 with the non-Federal sponsor according to a Feasibility Cost Sharing Agreement (FCSA). In the feasibility study, the problem is defined, project viability is determined, potential solutions are identified, and the most feasible plan is selected for implementation. The costs, benefits, and environmental impacts of the potential project are analyzed. A draft project partnership agreement (PPA) is drawn up by which the Federal government and the sponsor agree to share project construction costs. No more than two years should pass between the start of the feasibility study and the time the project is ready for construction.

WHAT ARE THE LOCAL RESPONSIBILITIES?

Costs for Section 206 projects are shared between the Federal government and a non- Federal sponsor in accordance with the Water Resources Development Act of 1986, as amended. During construction the non-Federal sponsor must contribute a minimum of 35% of the total cost of a project, with credit granted toward the amount for providing lands, easements and rights-of-way, and pay a minimum cash requirement of 5% of the total project cost. Section 206 also allows credit for certain works in-kind, including design work, provision of materials, and construction activities. Contributions, such as volunteer labor, can also be accepted to reduce the overall project cost. The local sponsor (a state or local government) must have the legal and financial capability to fulfill the requirements of cost sharing and local cooperation. The sponsor generally must agree to the following:

- Provide all lands, easements, rights-of-way, relocations, and dredged material disposal areas;
- Provide any additional cash contributions needed to make the local sponsor's share
- of the cost 35%;

- Hold and save the United States free from damages due to the construction and maintenance of the project, except damages due to fault or negligence of the United States or its contractors;
- Provide all access routes and relocations of utilities necessary for project construction and subsequent operation and maintenance;
- Comply with provisions of pertinent Federal acts in carrying out the specified non- Federal responsibilities of the project;
- Contribute in cash the local share of project planning and construction cost; and
- Maintain and operate all the non-Federal works after completion in accordance with regulations prescribed by the Secretary of the Army.

HOW CAN A STUDY BE REQUESTED?

An investigation under Section 206 may be initiated after receipt of a formal request from the prospective sponsoring agency. A sample letter is offered below. This letter is generally referred to as a Letter of Intent (LOI) and must be received by the Corps from a prospective non-Federal sponsor prior to initiating the feasibility phase.

District Engineer
U.S. Army Corps of Engineers, Huntington District
502 8th Street
Huntington, West Virginia 25701

Dear Sir:

In accordance with the provisions of Section 206 of the Water Resources Development Act of 1996, as amended, the (name of local sponsor) requests the Corps of Engineers to undertake a study of aquatic ecosystem restoration at (name of site) along (name of stream(s)).

(Briefly describe the nature of the aquatic ecosystem restoration and any issues that might affect the acceptability of any recommended solutions, from the perspective of local government and/or the public.)

We are aware of the following cost sharing requirements associated with projects undertaken under this authority.

a) Feasibility Phase is Federally funded up to $100,000. Costs in excess of $100,000 are cost shared on a 50/50 basis with the local sponsor. The sponsor's 50% share of any costs over $100,000 may be provided by in-kind services.
b) Preparation of Plans and Specifications is cost-shared in the same proportion as construction and is collected with the construction cost share.
c) Non-federal interests shall provide 35% of the cost of construction including the provision of all lands, easements, rights-of-way, and necessary relocations.
d) The non-Federal share of construction costs shall be paid after the project is approved for implementation and before a construction contract is awarded.
e) The non-Federal Sponsor is responsible for all operation, maintenance, repair, rehabilitation and replacement of the project.

We are aware that this letter serves as an expression of intent and not a contractual obligation and either party may discontinue the study process at any stage prior to construction.

Sincerely,

(Name and title of public official authorized to request study)

Planning Assistance to States

Authority and Scope.

Section 22 of the Water Resources Development Act (WRDA) of 1974, as amended, provides authority for the Corps of Engineers to assist the States, local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land. Section 208 of the Water Resources Development Act of 1992 amended the WRDA of 1974 to include Native American Tribes as equivalent to a State.

Funding.

The Planning Assistance to States (PAS) Program is funded annually by Congress. Federal allotments for each State or Tribe from the nation-wide appropriation are limited to $500,000 annually, but typically are much less. Individual studies, of which there may be more than one per State or Tribe per year, generally cost $25,000 to $75,000. These studies are cost shared on a 50 percent Federal-50 percent non-Federal basis.

Program Development.

The needed planning assistance is determined by the individual States and Tribes. Every year, each State and Indian Tribe can provide the Corps of Engineers its request for studies under the program, and the Corps then accommodates as many studies as possible within the funding allotment. Typical studies are only planning level of detail; they do not include detailed design for project construction. The studies generally involve the analysis of existing data for planning purposes using standard engineering techniques although some data collection is often necessary. Most studies become the basis for State or Tribal and local planning decisions. To assist in expediting a request for Planning Assistance to States activities, a sample letter and Cost Sharing Agreement are included.

Typical Studies. The program can encompass many types of studies dealing with water resources issues. Types of studies conducted in recent years under the program include the following:

- Water Supply and Demand Studies
- Water Quality Studies
- Environmental Conservation/Restoration Studies
- Wetlands Evaluation Studies
- Dam Safety/Failure Studies
- Flood Damage Reduction Studies
- Flood Plain Management Studies
- Coastal Zone Management/Protection Studies

- Harbor/Port Studies

How to Request Assistance. State, local government, and Tribal officials who are interested in obtaining planning assistance under this Program can contact the appropriate Corps office for further details. Alternatively, interested parties can contact the appropriate State or Tribal Planning Assistance to States coordinator to request assistance. In either case, the Corps will coordinate all requests for assistance with the State or Tribal Planning Assistance to States coordinator to ensure that studies are initiated on State or Tribal prioritized needs.

SAMPLE COST SHARING AGREEMENT
FOR
PLANNING ASSISTANCE BETWEEN
THE U.S. ARMY CORPS OF ENGINEERS
AND
(SPONSOR'S NAME)

THIS AGREEMENT, entered into this _____ day of _____, by and between the United States of America (hereinafter called the "Government"), represented by the Contracting Officer executing this Agreement, and (Name of the Requesting State Entity or Tribe)(hereinafter called the "Sponsor").

WITNESSETH, that

WHEREAS, the Congress has authorized the Corps of Engineers in Section 22 of the Water Resources Development Act of 1974 (Public Law 93-251) as amended to assist the States in the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources; and whereas, Section 319 of the Water Resources Development Act of 1990 (Public Law 101-640) authorized the Government to collect from non-Federal entities fees for the purpose of recovering fifty (50) percent of the cost of the program; and,

WHEREAS, the Sponsor has reviewed the State's comprehensive water plans and identified the need for the planning assistance as described in a Scope of Studies; (Name of the study which is described in Appendix A), incorporated into this agreement; and

WHEREAS, the Sponsor has the authority and capability to furnish the cooperation hereinafter set forth and is willing to participate in study cost-sharing and financing in accordance with the terms of this agreement;

NOW THEREFORE, the parties agree as follows:

1. The Government, using funds contributed by the Sponsor and appropriated by the Congress, shall expeditiously prosecute and complete the Study, estimated to be completed within twelve (12) months, substantially in compliance with the Scope of Studies attached as Appendix A and in conformity with applicable Federal laws and regulations and mutually acceptable standards of engineering practice.

2. The Government and the Sponsor shall contribute in cash, fifty (50) percent and fifty (50) percent, respectively, of all study costs, the total cost of which is currently estimated to be $_____, as specified in the cost estimate attached as Appendix B. The Sponsor agrees to provide a cashier or certified check in the amount of $_____ which shall be made payable to FAO, USAED, **(District Office)**, prior to any work being performed under this Agreement.

3. No Federal funds may be used to meet the local Sponsor share of study costs under this Agreement unless the expenditure of such funds is expressly authorized by statute as verified by the granting agency.

4. Before any Party to the Agreement may bring suit in any court concerning any issue relating to this Agreement, such Party must first seek in good faith to resolve the issue through negotiation or another form of nonbinding alternate dispute resolution mutually acceptable to the Parties.

5. In the event that any one or more of the provisions of this Agreement is found to be invalid, illegal, or unenforceable, by a court of competent jurisdiction, the validity of the remaining provisions shall not in any way be affected or impaired and shall continue in effect until the Agreement is completed.

6. This Agreement shall become effective upon the signature of both Parties.

For the Sponsor:
By:_____
Title:_____
Date:_____

For the Corps:
By:_____
Title:_____
Date:_____

District Engineer
U.S. Army Corps of Engineers, Huntington District
502 8th Street
Huntington, West Virginia 25701

Dear Sir:

This is in reference to the Corps of Engineers' Planning Assistance to States Program. We understand that the provisions of Section 22 of the Water Resources Development Act of 1974, as amended, provides authority for the Corps to assist in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. The **[name of State, Indian Tribe, local government, or other non-Federal entity]** requests planning assistance for **[briefly describe problem or need, including if appropriate, the name of the body of water or waterway, and City, Township, etc.]**, in **[County and State]**.

We would like to discuss the availability of information, required schedule, and level of effort required in order to negotiate the appropriate Letter of Agreement to initiate a Section 22 study. Please contact **[Name, title, phone number]** to arrange a further discussion of this inquiry.

Signature of Cooperating Agency or Individual

SAMPLE COST SHARING AGREEMENT
FOR
PLANNING ASSISTANCE BETWEEN
THE U.S. ARMY CORPS OF ENGINEERS
AND
(SPONSOR'S NAME)

THIS AGREEMENT, entered into this _____ day of _____, by and between the United States of America (hereinafter called the "Government"), represented by the Contracting Officer executing this Agreement, and (Name of the Requesting State Entity or Tribe)(hereinafter called the "Sponsor").

WITNESSETH, that

WHEREAS, the Congress has authorized the Corps of Engineers in Section 22 of the Water Resources Development Act of 1974 (Public Law 93-251) as amended to assist the States in the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources; and whereas, Section 319 of the Water Resources Development Act of 1990 (Public Law 101-640) authorized the Government to collect from non-Federal entities fees for the purpose of recovering fifty (50) percent of the cost of the program; and,

WHEREAS, the Sponsor has reviewed the State's comprehensive water plans and identified the need for the planning assistance as described in a Scope of Studies; (Name of the study which is described in Appendix A), incorporated into this agreement; and

WHEREAS, the Sponsor has the authority and capability to furnish the cooperation hereinafter set forth and is willing to participate in study cost-sharing and financing in accordance with the terms of this agreement;

NOW THEREFORE, the parties agree as follows:

1. The Government, using funds contributed by the Sponsor and appropriated by the Congress, shall expeditiously prosecute and complete the Study, estimated to be completed within twelve (12) months, substantially in compliance with the Scope of Studies attached as Appendix A and in conformity with applicable Federal laws and regulations and mutually acceptable standards of engineering practice.

2. The Government and the Sponsor shall contribute in cash, fifty (50) percent and fifty (50) percent, respectively, of all study costs, the total cost of which is currently estimated to be $_____, as specified in the cost estimate attached as Appendix B. The Sponsor agrees to provide a cashier or certified check in the amount of $_____ which shall be made payable to FAO, USAED, **(District Office)**, prior to any work being performed under this Agreement.

3. No Federal funds may be used to meet the local Sponsor share of study costs under this Agreement unless the expenditure of such funds is expressly authorized by statute as verified by the granting agency.

4. Before any Party to the Agreement may bring suit in any court concerning any issue relating to this Agreement, such Party must first seek in good faith to resolve the issue through negotiation or another form of nonbinding alternate dispute resolution mutually acceptable to the Parties.

5. In the event that any one or more of the provisions of this Agreement is found to be invalid, illegal, or unenforceable, by a court of competent jurisdiction, the validity of the remaining provisions shall not in any way be affected or impaired and shall continue in effect until the Agreement is completed.

6. This Agreement shall become effective upon the signature of both Parties.

For the Sponsor:
By:_____
Title:_____
Date:_____

For the Corps:
By:_____
Title:_____
Date:_____

District Engineer
U.S. Army Corps of Engineers, Huntington District
502 8th Street
Huntington, West Virginia 25701

Dear Sir:

This is in reference to the Corps of Engineers' Planning Assistance to States Program. We understand that the provisions of Section 22 of the Water Resources Development Act of 1974, as amended, provides authority for the Corps to assist in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. The **[name of State, Indian Tribe, local government, or other non-Federal entity]** requests planning assistance for **[briefly describe problem or need, including if appropriate, the name of the body of water or waterway, and City, Township, etc.]**, in **[County and State]**.

We would like to discuss the availability of information, required schedule, and level of effort required in order to negotiate the appropriate Letter of Agreement to initiate a Section 22 study. Please contact **[Name, title, phone number]** to arrange a further discussion of this inquiry.

Signature of Cooperating Agency or Individual

Planning Assistance to States

U.S. ARMY CORPS OF ENGINEERS **BUILDING STRONG®**

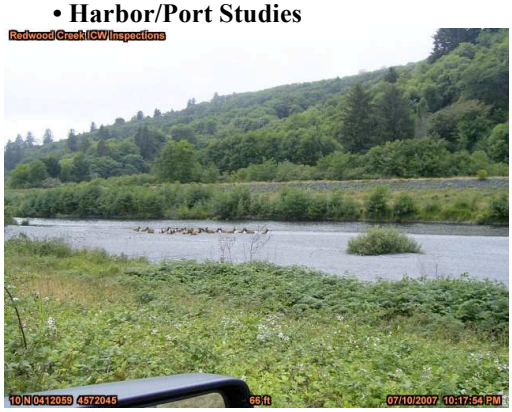
States, local governments and Native American Tribes often have needs in planning for water and related resources of a drainage basin or larger region of a state, for which the Corps of Engineers has expertise.

Authority and Scope. Section 22 of the Water Resources Development Act (WRDA) of 1974, as amended, provides authority for the Corps of Engineers to assist the States, local governments, Native American Tribes and other non-Federal entities, in the preparation of comprehensive plans for the development and conservation of water and related land resources.

Program Development. The needed planning assistance is determined by the individual States and Tribes. Typical studies are only undertaken at the planning level of detail; they do not include detailed design for project construction. The studies generally involve the analysis of existing data for planning purposes using standard engineering techniques although some data collection is often necessary. Most studies become the basis for State or Tribal and local planning decisions.

Typical Studies. The program can encompass many types of studies, dealing with water resources issues. Types of studies conducted in recent years under the program include the following:

- **Water Supply and Demand Studies**
- **Water Quality Studies**
- **Environmental Conservation/Restoration Studies**
- **Wetlands Evaluation Studies**
- **Dam Safety/Failure Studies**
- **Flood Risk Management Studies**
- **Flood Plain Management Studies**
- **Coastal Zone Management/Protection Studies**
- **Harbor/Port Studies**



Redwood Creek flow capacity study

Eau Galle River nutrient study for water quality

Funding. The Planning Assistance to States program is funded annually by Congress. Federal allotments for each State or Tribe from the nation-wide appropriation are limited to $2,000,000 annually, but typically are much less. Individual studies, of which there may be more than one per State or Tribe per year, are cost shared on a 50 percent Federal - 50 percent non-Federal basis (may include 100% work in kind).

How to Request Assistance. State, local government and Tribal officials who are interested in obtaining planning assistance under this Program can contact the appropriate USACE office for further details. Alternatively, interested parties can contact the appropriate State or Tribal Planning Assistance to States coordinator to request assistance. In either case, USACE will coordinate all requests for assistance with the State or Tribal Planning Assistance to States coordinator to ensure that studies are initiated on State or Tribal prioritized needs.

Point of Contact for Factsheet:

Maria Wegner-Johnson
USACE Headquarters
202-761-5541

Flood Plain Management Services Program

U.S. ARMY CORPS OF ENGINEERS BUILDING STRONG®

People that live and work in the flood plain need to know about the flood hazard and the actions that they can take to reduce property damage and to prevent the loss of life caused by flooding.

The Flood Plain Management Services (FPMS) Program was developed by the Corps of Engineers specifically to address this need.

Authority, Objective, and Scope. The program's authority stems from Section 206 of the 1960 Flood Control Act (PL 86-645), as amended. Its objective is to foster public understanding of the options for dealing with flood hazards and to promote prudent use and management of the Nation's flood plains.

Land use adjustments based on proper planning and the employment of techniques for controlling and reducing flood damages provide a rational way to balance the advantages and disadvantages of human settlement on flood plains. These adjustments are the key to sound flood plain management.

Types of Assistance. The FPMS Program provides the full range of technical services and planning guidance that is needed to support effective flood plain management.

a. General Technical Services. The program develops or interprets site-specific data on obstructions to flood flows, flood formation and timing; and the extent, duration, and frequency of flooding. It also provides information on natural and cultural flood plain resources of note, and flood loss potentials before and after the use of flood plain management measures.

b. General Planning Guidance. On a larger scale, the program provides assistance and guidance in the form of "Special Studies" on all aspects of flood plain management planning including the possible impacts of off-flood plain land use changes on the physical, socio-economic, and environmental conditions of the flood plain.

This can range from helping a community identify present or future flood plain areas and related problems, to a broad assessment of which of the various remedial measures may be effectively used.

Some of the most common types of Special Studies include:

- **Flood Plain Delineation/Flood Hazard Evaluation Studies**
- **Dam Break Analysis Studies**
- **Hurricane Evacuation Studies**
- **Flood Warning/Preparedness Studies**
- **Regulatory Floodway Studies**
- **Comprehensive Flood Plain Management Studies**
- **Flood Risk Management Studies**
- **Urbanization Impact Studies**
- **Stormwater Management Studies**
- **Flood Proofing Studies**
- **Inventory of Flood Prone Structures**
- **Evaluation of Levees for Potential FEMA Certification**

Flood Plain Management Services Program

U.S. ARMY CORPS OF ENGINEERS BUILDING STRONG®

Example of a typical flood proofed structure

The program also provides guidance and assistance for meeting standards of the National Flood Insurance Program, flood risk communication and for conducting workshops and seminars on non-structural flood plain management measures, such as Flood Proofing.

c. Guides, Pamphlets, and Supporting Studies. Studies are conducted under the program to improve the methods and procedures for mitigating flood damages. Guides and pamphlets are also prepared on flood proofing techniques, flood plain regulations, flood plain occupancy, natural flood plain resources, and other related aspects of flood plain management.

The study findings and the guides and pamphlets are provided free-of-charge to Federal agencies, Indian Tribes, State, regional and local governments and private citizens for their use in addressing the flood hazard.

Charges for Assistance. Upon request, program services are provided to State, regional, and local governments, Indian Tribes, and other non-Federal public agencies without charge.

State, regional, local government, non Federal pubic agencies and Tribes can request activities/assistance under this program and provide voluntary funding. For most of these requests, payment is required before services are provided. Letter requests or signed agreements are used.

All requestors are encouraged to furnish available field survey data, maps, historical flood information and the like, to help reduce the cost of services.

Meeting with local governmental officials

How to Request Assistance. Agencies, governments, organizations, and individuals interested in flood-related information or assistance should contact the appropriate Corps office. Information that is readily available will be provided in response to a telephone request. A letter request is required for assistance that involves developing new data, making a map, or preparing a report.

Point of Contact for Factsheet:

Maria Wegner-Johnson
USACE Headquarters
202-761-5541

Appendix F
Prior Studies

Several investigations concerning the study area have been made by various organizations since the 1930's. To gain a better understanding of problems, needs and opportunities within the watershed, the findings and results of prior studies and reports – along with implemented water resources projects – were considered as part of the FWA. Prior studies, reports and existing projects are summarized below:

Section 905(b) Reconnaissance Study, Muskingum River Basin, Ohio System Study (2000)

A Section 905(b) reconnaissance study for the Muskingum River Basin was conducted under USACE's General Investigations Program and was authorized by the US House of Representatives' Resolution Comprehensive Flood Control Plan for Ohio and Lower Mississippi Rivers, Committee on Flood Control, House of Representatives Committee Document No. 1, 75th Congress, 1st session. The purpose of the study was to evaluate potential federal interest in implementing solutions to flooding, ecosystem degradation, water supply, recreation and other related water resource problems and opportunities in the Muskingum River Basin, Ohio. In addition to infrastructure issues with existing Corps reservoirs, this study identified as significant issues in the Basin:

- residual flood damages;
- lack of floodplain management enforcement;
- ecosystem degradation; and
- recreation issues stemming from sedimentation resulting in loss of recreation pool acreage.

Some potential flood damage reduction measures recommended by the study included a limited nonstructural project and an early flood warnings system. The reconnaissance study went on to identify several Local Flood Protection Projects for further study. One was located on the East Branch of Nimishillen Creek upstream of the mouth of West Branch. All alternatives for this Local Protection Project consisted of varying levels of channel modifications; however the project was never constructed.

Muskingum River Basin System Operations Study (2006)

The goal of the study was to develop a comprehensive plan to revitalize the aging flood control system through infrastructure renewal, to ensure public safety and to improve water quality and

other environmental resources through ecosystem restoration. The report served as the initial phase of work in the Basin; its purpose was to develop a preliminary plan of action for proceeding with projects under existing Corps authorities, as well as supporting a legislative initiative for a comprehensive study with General Investigations funding.

The report identified a number of water-resources problems in the Basin, many associated with USACE dams and reservoirs. These issues currently are being addressed under the Dam Safety Modification Program, which is discussed in more detail in the IWA. Other watershed problems identified by the report include acid mine drainage, residual flood damages, floodplain development, and water and sewer infrastructure needs.

The study also identified a number of potential measures for improving water resources within the Basin, such as:

- improve stream channels that have extensive erosion problems through a comprehensive program of bank stabilization and environmental restoration;
- reduce flood damages at several identified locations in the Muskingum Basin by implementing feasible structural or non-structural measures;
- renovate water and sewage treatment plants where infrastructure problems exist, if facilities are inadequate;
- review the accuracy of ten river gages downstream of the Muskingum reservoirs and determine whether floods have higher stages now than originally established, because of changes in downstream channel capacity;
- determine the need for and the economic feasibility of installing a flood warning system in the Muskingum River Basin in cooperation with state and local officials; and
- conduct surveys of the Muskingum River Basin to identify environmental problems or needs that can be addressed as part of a comprehensive environmental restoration program.

The scope of the renewal and revitalization program was described as “robust and multi-faceted,” estimated to cost more than $2.4 billion (FY 06 price level) and to take several decades to complete. The report recommended that the Corps move on to a more detailed phase of study, to further define and quantify the potential scope of problems and opportunities. However, a more detailed study phase was never undertaken, and none of the projects are currently budgeted, with the exception of those related to dam safety. Dam safety issues are being pursued under the USACE Dam Safety authority, an effort led by the USACE Risk Management Center.

Nimishillen Creek Watershed Action Plan (2007)

The Nimishillen Creek Watershed Action Plan was developed by the Northeast Ohio Four County Regional Planning and Development Organization (NEFCO). The purpose of the report was to develop a plan to protect and restore the water quality the Creek and its tributaries to meet state water quality standards and ensure the health and safety of watershed residents. It also endeavored to raise public awareness of pollution sources and solutions, as well as to consolidate existing watershed information previous reports and studies into a single, stand-alone report. The report is available online at: www.nefcoplanning.org/nimi_creek_wap.

Zimber Ditch Study (1997)

This study was undertaken by Stark County, Ohio as well as the City of North Canton and Jackson Township in March of 1997. Growth had been rapid in the North Canton area at the time and there was concern the new growth may have increased the risk of flooding. An array of alternatives was evaluated with the final recommendation including:

- Removal of pockets of siltation at most structures and restoration of the original grade line of the Zimber Ditch;
- Development of detention basins for the upper part of the drainage basin;
- Replacement of the bridge at Strausser Street;
- Replacement/construction of several culverts; and
- Construction of some bank stabilization.

With the exception of the detention basins, none of these alternatives were ever implemented.

Zimber Ditch Section 205 Study (2006)

This recon-level study was undertaken by the Huntington District in 2006 and focused primarily on the West Nimishillen drainage basin, including Zimber Ditch. Flooding issues along Zimber Ditch seemed to stem from stormwater run-off, resulting from rapid development in the area. The final recommendation (referencing the 1997 Zimber Ditch Study previously mentioned) was the development of a series of detention basins in the upper portion of the Basin. The recommended plan included approximately 6,000 feet of channel work along the Ditch, as well as the replacement of several culverts with larger culverts and bridges. The study did not progress to implementation/construction.

Section 594 Zimber Ditch Flood Control Project (2005)

The Section 594 project was undertaken by the Huntington District in 2005, and also referenced the previously aforementioned 1997 Zimber Ditch Study and the flooding issues thought to be a

result of rapid growth in the area. As part of this effort, alternative locations for construction detention basins with the Zimber Ditch drainage basin were evaluated. The preferred alternative was the construction of two upstream detention basins (referred to as Basin A and Basin B) in areas which would not require the relocation of any businesses or residents. The construction of the detention basins was completed in 2010.

Flood Plain Study Main Report and Summary (1967)

This document was prepared by the USACE for the Ohio Department of Natural Resources (ODNR) and the Stark County Regional Planning Commission. The study provided planners and local governments with technical information on flooding along approximately 16 miles of the Nimishillen Creek and its West, East and Middle Branches.

Storm Drainage Facilities Plan Part II (1970)

This report was prepared by the Stark County Engineer for the Stark County Regional Planning Commission. The purpose of the report, together with the Storm Drainage Facilities Plan Part I, was to provide the foundation of a master drainage plan for future construction projects and to provide advance drainage information to land developers.

Flood Hazard Analysis Report (1975)

This report was prepared by the U.S. Department of Agriculture (USDA), Soil Conservation District in cooperation with the ODNR. The report was intended to serve as a technical base from which local floodplain management decision could be made along the East Branch of Nimishillen Creek.

Master Drainage Program Phase I (1975)

This report was prepared by Mosure & Syrakis, Ltd. for the Stark County Engineer. The report represented the first phase of the development of a two phase master flood control and drainage plan for Stark County, Ohio with the objective of Phase I describing the engineering scope of work, costs and priorities for each drainage basin within the County. Note: The Master Drainage Program Phase II was completed to outline the actual projects associated with the recommendations of the overall master drainage plan.

Flood Hazard Analysis Report (1977)

This report was prepared by the USDA, Soil Conservation District for the Stark County Commissioners, Stark County Regional Planning Commission and the ODNR. The report was intended to serve as a technical base from which local floodplain management decisions could be made along the Middle Branch of the Nimishillen Creek.

Flood Insurance Study (1983)

The report was prepared by Malcolm Pirnie, Inc. for the Federal Emergency Management Agency (FEMA). The report investigated the existence and severity of flood hazards in the unincorporated areas of Stark County including the Nimishillen Creek watershed. The study was to provide aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973, as well as to assist regional planners in their efforts to promote sound floodplain management.

Appendix G

Quality Control