APPENDIX E

IMPLEMENTATION ACTIONS AND REASONABLE ASSURANCES

Agricultural Best Management Practices

The following information is adapted from the Wisconsin Natural Resource Conservation Service web site: http://www.wi.nrcs.usda.gov/programs/solutions/.

Crop Rotation

Definition: Changing the crops grown in a field, usually in a planned sequence.

How it works: Crop rotations in Ohio typically include corn, legumes, and small grains. Rotations that include small grains and alfalfa can significantly reduce soil erosion. Alfalfa and other legumes in the rotation can save fertilizer costs because they replace the nitrogen that corn and other grains remove from the soil. Rotations reduce pesticide use by naturally breaking the cycle of weeds, insects and diseases.

Crop Residue Management

Definition: Any tillage method that leaves crop residue on the surface to reduce erosion.

How it works: Crop residue left on the surface shields the soil from rain and wind until emerging plants provide a protective canopy. Crop residue also improves soil tilth, adds organic matter to the soil, and may even result in a little grain being left for wildlife. Less tillage reduces soil compaction and saves the farmer time and fuel.

Contour Buffer Strips

Definition: Strips of grass or other permanent vegetation in a contoured field that help trap sediment or nutrients; similar to contour stripcropping except that the grass strips are narrower.

How it works: Because the buffer strips are established on the contour, runoff flows slowly and evenly across the grass strip, reducing sheet and rill erosion. The vegetation can also provide habitat for small birds and animals. In some cases buffer strips might be an inexpensive substitute for terraces.

Contour Farming and Stripcropping

Definition: Tilling and planting across the slope following the contours of the land, and breaking the field into alternating bands of row crops and hay or small grains.

How it works: Farming on the contour creates small ridges that slow runoff water. In stripcropping, the small grain or hay strips slow runoff water, allowing infiltration and filtering sediment. Farming on the contour rather than up and down reduces fuel consumption and is easier on equipment.

Cover Crop

Definition: A close-growing crop that temporarily protects the soil during the period before the next crop is established.

How it works: Cover crops such as cereal rye, oats and winter wheat are planted as soon as possible after harvest on fields where residue will not adequately protect the soil from wind and water erosion during winter and spring. Cover crops can also be used on sandy soils to reduce nitrate leaching. In some situations a cover crop can be planted after the last cultivation to provide a longer growing period.

Field Border

Definition: A strip of grass or legumes at the edge of a field used in place of end rows.

How it works: Perennial vegetation is established at the outside edges of a field where the edges are eroding. The grass or legume strips replace crop end rows, which would be planted up and down hill. The vegetation prevents erosion, helps filter runoff from the field, and provides habitat for birds and small animals. The border provides equipment turning and travel lanes.

Rotation Grazing

Definition: Planting forage and using grazing rotations among different fields to maximize production and reduce sediment and nutrient runoff.

How it works: A landowner develops a management plan for grazed land to improve forage quality, livestock health and water quality. In a managed grazing system, livestock are moved frequently among pasture divisions or paddocks based on forage quality and livestock nutrition needs. Portable fencing allows each paddock to rest and regrow until the next grazing rotation. Compared to traditional continuous grazing, managed grazing can provide a healthier plant community, decreased erosion and runoff, better livestock health and performance, and reduced costs to the landowner.

Pasture Planting

Definition: Planting grasses or legumes in low-producing pasture or as a replacement for a cropped field.

How it works: Establishing heavy sod cover provides quality forage for livestock, stabilizes eroding areas, filters runoff water, and can provide wildlife habitat and cover.

Grass Waterways

Definition: Shaping a natural drainageway and establishing grass to prevent gullies from forming in fields.

How it works: A natural drainageway is graded and shaped to form a smooth, shallow channel and then planted to sod- forming grasses. The drainageway carries runoff water from the field and the grass prevents the water from forming a gulley. The vegetation may also trap some sediment washed from cropland, absorb some chemicals and nutrients in the runoff water, and provide cover for small birds and animals.

Grade Stabilization Structures

Definition: An earthen, concrete or other structure built across a drainageway to prevent gully erosion.

How it works: A dam or embankment built across a gully or grass waterway drops water to a lower elevation while protecting the soil from gully erosion or scouring. Structures are typically either a drop spillway or a small dam and basin with a pipe outlet.

Water and Sediment Control Basin

Definition: A small earthen embankment built across the bottom of a drainageway to temporarily store runoff.

How it works: An earthen embankment acts similar to a terrace. It traps water and sediment running off cropland upslope from the structure, and reduces gully erosion by controlling flow within the drainage area. The basin releases water slowly, usually through infiltration or a pipe outlet and tile line. Basins can be effective in reducing sedimentation of nearby waters, especially in areas where residue management or other practices are impractical.

Critical Area Planting

Definition: Planting grass, legumes or other vegetation to protect small, badly eroding areas.

How it works: Permanent vegetation stabilizes areas such as gullies, over-grazed hillsides or terrace backslopes. While the primary goal is erosion control, the vegetation can also serve as nesting cover for birds and small animals.

Diversion

Definition: An earthen embankment and channel, similar to a terrace, constructed across a slope to collect water, divert it to a stable outlet, and protect an area downslope.

How it works: A diversion keeps excess runoff away from areas with concentrated pollutants such as barnyards or feedlots and fields with easily eroded soils. A diversion at the base of a slope can help keep bottom lands drier and more productive. Similar to terraces, the permanent vegetation on a diversion provides habitat for birds and small animals.

Terrace

Definition: An earthen embankment that follows the contour of a hillside, breaking a long slope into shorter segments and intercepting the flow of water.

How it works: Terraces serve as small dams on a hillside, intercepting runoff water and guiding it to a safe outlet. Some terraces are designed to collect water and temporarily store it until it can filter into the ground or be released through a stable outlet. Other terraces are designed as a channel to slow runoff and carry it to a stable outlet such as a grass waterway. Terraces can greatly reduce erosion on steep slopes, and the permanent grass on front or back slopes serves as nesting habitat.

Manure Storage and Runoff Control

Definition: Structural practices that can help protect water quality and make manure management more convenient for the farmer.

How it works: Along with a nutrient management plan, many farmers use manure storage structures and barnyard runoff controls to improve manure management and protect water quality. Storage allows manure to be safely stockpiled until conditions are environmentally safe for spreading. Runoff controls such as diversions, rain gutters, settling basins and filter strips keep clean water from flowing over manure-covered areas and clean up runoff water before it reaches a waterway.

Nutrient Management

Definition: Careful management of all aspects of soil fertility to meet crop needs and minimize impacts on water quality.

How it works: A landowner develops a farm nutrient management plan. The plan is based on realistic crop yield goals, soil tests to determine the nutrients available in fields, and taking credit for nutrients from legumes and manure applications. The plan may also identify areas of special concern such as flood plains and steep slopes. Nutrients are applied at the proper time using the appropriate application method. Sound nutrient management reduces fertilizer costs and protects water quality.

Pest Management

Definition: Using a pest management strategy that identifies specific treatments for specific pests on specific areas of a field to economically protect the crop and minimize environmental damage.

How it works: Crops are scouted to determine the types of pests (insects, weeds, diseases) and their stage of development. The potential damage from the pest is weighed against the cost of control. If pest control is economical, alternatives are evaluated to select the best treatment in terms of cost, effectiveness and environmental impact. Specific treatment only when needed saves money, prevents over-treatment and protects water quality.

Well Abandonment

Definition: Unused wells that are filled and sealed to prevent surface runoff from contaminating drinking water aquifers.

How it works: Many farms have unused wells. Pollutants that enter these wells move quickly and without filtration to groundwater. Large open wells themselves can pose a safety hazard to children and animals. Abandoned wells are sealed by removing pumps, piping and debris, and filling the hole with a slurry of cement or bentonite chips.

Riparian Buffer

Definition: Strips or small areas of land in permanent vegetation that help control pollutants and promote other environmental benefits.

How it works: Riparian vegetative buffers are strips of grass, trees or shrubs established along streams, ditches, wetlands or other water bodies. Riparian buffers trap sediment, filter nutrients, and provide habitat and corridors for fish and wildlife.

Streambank and Shoreline Stabilization

Definition: Protecting a stream or other body of water by re-shaping and stabilizing the bank and excluding livestock.

How it works: Where stream banks are eroded, they are re-shaped and seeded, and sometimes protected with rock rip-rap or seeded with bio-engineering materials. In some cases a special wood structure (lunker) is fitted into the bank to stabilize it and provide fish habitat. Stabilizing the streambank or shoreline protects water quality, improves fish habitat, and the vegetation provides habitat for birds and small animals. Fencing restricts livestock access to the bank or shore, with the exception of controlled areas for drinking or crossing.

Wetland Restoration

Definition: Restoring a previously drained wetland by filling ditches or removing or breaking tile drains.

How it works: Where wetlands have been drained and farmed, subsurface and surface drains are plugged or removed so water can refill the area. In other cases, low-lying areas are scraped to form a shallow basin, and small dikes or embankments are installed to establish and maintain water levels. Native wetland vegetation can be planted to enhance existing plants. The wetland temporarily holds runoff (reducing flooding downstream), and filters sediment, nutrients and chemicals before the water recharges groundwater. America's ducks and geese rely on wetlands, as do hundreds of species of plants, amphibians and native birds.

Windbreak

Definition: Rows of trees and shrubs that protect areas from wind and act as a snow fence.

How it works: Multiple rows of trees are planted to protect a farmstead, feedlot or open fields from wind and snow. Coniferous trees or a mix of coniferous and deciduous trees can be used, along with one or two rows of shrubs. The established trees and shrubs slow wind on the downwind side of the windbreak for a distance of 10 times the height of the trees. The windbreak reduces wind erosion, conserves energy used for heating and cooling, serves as a sound barrier, and provides wildlife food and cover.

Woodlot Management

Definition: Improving the quality and quantity of existing woodland trees and ground cover to conserve soil and water, enhance wildlife and produce valuable timber.

How it works: Land devoted to timber production is managed to provide income, protect soil and water, improve wildlife habitat, and create opportunities for recreation. Twigs, limbs, leaves and other debris filter nutrients and chemicals from surface runoff and reduce erosion.

Tree Planting

Definition: Establishing and maintaining trees in fields or understocked woodlands.

How it works: Tree species are matched to existing soil types, site conditions and the landowner's objectives. Planting trees on marginal cropland prevents soil erosion, protects water quality, improves wildlife habitat and may provide a break against wind and drifting snow. Increasing the number of trees on a poorly stocked, thin woodlot can increase the woodlot's productivity and farm income.

Wildlife Food Plot

Definition: Establishing a variety of plants that provide food for wildlife.

How it works: Food plots can be established within an existing crop field or in a separate location. A few rows of corn left standing after harvest or a small plot planted elsewhere will help wildlife through the winter when food is in short supply.

Upland Wildlife Habitat

Definition: Creating, maintaining or improving food and cover for upland wildlife.

How it works: Planting trees, shrubs, warm season grasses and other vegetation that provide food and cover will attract wildlife to an area. The perennial ground cover reduces soil erosion, filters runoff and increases infiltration. Carefully planned wildlife habitat can add value and beauty to a farm.

BMP Effectiveness

Potential effectiveness of various best management practices applicable

BMP	Description and Removal Mechanism	Estimated Removal Rate			
		Sediment/ TSS	TN	TP	Fecal
Nutrient management plan	Site specific guidance on appropriate fertilization rates, methods of application, and timing. Appropriate application rates for optimized crop yield reduce loading from excessive nutrient application.	Minimal	Minimal based on SWAT modeling	Approximately 20 percent based on SWAT modeling	Minimal
Conservation tillage	Reduced tillage practice with a minimum of 30 percent cover of crop residuals. Reduces erosion rates and phosphorus losses. Increases soil quality by providing organic material and nutrient supplementation.	75 to 88 percent reduction in soil loss rates [1; 2, respectively]	Minimal based on SWAT modeling	30 to 40 percent based on SWAT modeling	Minimal

BMP	Description and Removal Mechanism	Estimated Removal Rate			
		Sediment/ TSS	TN	TP	Fecal
Manure composting	Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land.	Application of composted manure improves soil infiltration and reduces sediment loss by 68 percent [3]	30 to 75 percent due to volatization that occurs during storage	Minimal	Reductions of up to 99% in fecal coliform concentrations have resulted from composted manure [4]
Providing alternative sources of water for cattle	Providing water sources for cattle away from streams. Reduces streambank trampling and deposition of fecal matter in the stream.	90 percent reduction in direct deposition of fecal matter [1]	90 percent reduction in direct deposition of fecal matter [1]	90 percent reduction in direct deposition of fecal matter [1]	90 percent reduction in direct deposition of fecal matter [1]
Cattle exclusion from streams	Placement of fencing between the cattle grazing area and stream channel. Reduces streambank trampling and deposition of fecal matter in the stream.	Theoretically, 100 percent reduction in direct deposition of fecal matter	15 percent reduction in nitrogen loading [1]	15 percent reduction in phosphorus loading [1]	Theoretically, 100 percent reduction in direct deposition of fecal matter
Grazing land protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [5]	60 percent reduction in nitrogen loading [1]	49 to 60 percent reduction in phosphorus loading [1]	29 to 46 percent reduction in fecal coliform loading [1]
Precision feeding	Feeding strategies designed to reduce nitrogen (N) and phosphorus (P) losses include more precise diet formulation, enhancing the digestibility of feed ingredients, genetic enhancement of cereal grains and other ingredients resulting in increased feed digestibility, and improved quality control.	Minimal	20 to 30 percent reduction in nitrogen loading [6]	20 to 30 percent reduction in phosphorus loading [6]	Not Available
Controlled drainage	This practice involves placing simple water control structures at various locations in the tiling system to raise the water elevation. Decreases in nitrate losses have been attributed primarily to reductions in the volume of water drained and, to a somewhat lesser extent, by increased denitrification in the soil. If managed properly, controlled drainage has the potential to improve crop yields by making more water available to plants.	Minimal	40 to 50 percent reduction in nitrogen loading compared to conventionally drained fields	Minimal	Minimal

BMP	Description and Removal Mechanism	Estimated Removal Rate			
		Sediment/ TSS	TN	TP	Fecal
Cover crop	Use of ground cover plants on fallow fields. Reduces erosion, provides organic materials and nutrients to soil matrix, reduces nutrient losses, suppresses weeds, and controls insects.	88 percent reduction in soil erosion [3]	30 percent reduction in nitrogen loading rates [5]	70 to 85 percent removal of total phosphorus [3]	Variable
Filter strips	Placement of vegetated strips in the path of field drainage to treat sediment and nutrients.	60 to 65 percent reduction in sediment [1]	70 percent reduction in total nitrogen [1]	~ 65 percent removal of total phosphorus [7; 8]	55 percent reduction in fecal coliform [1]
Grass swales	A runoff conveyance that provides storage for approximately 24 hours. Removes pollutants by sedimentation and plant uptake. Reduces peak flow velocities and subsequent erosion.	93 percent reduction of TSS [7]	92 percent removal of total nitrogen [7]	83 percent removal of total phosphorus [7]	Minimal
Conservation Easements	Conversion of highly erodible land or land near nutrient sensitive waterbodies to grass or forest cover. Reduces loading rates to natural conditions.	98 percent reduction in sediment loading rates [5]	92 percent reduction in nitrogen loading rates [5]	90 percent reduction in phosphorus loading rates [5]	Variable impacts depending on presence of cattle and wildlife in the area
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97 percent removal of sediment from treated area, assuming a 90 ft buffer width [9]	80 percent removal of total nitrogen from treated area, assuming a 90 ft buffer width [9]	78 percent removal of total phosphorus from treated area, assuming a 90 ft buffer width [9]	Variable impacts depending on presence of cattle and wildlife in the area
Proper use of onsite wastewater disposal systems.	Includes periodic maintenance (e.g., pumping every 3 to 5 years) and inspection of all onsite wastewater disposal systems in the watershed. Requires immediate repairs (or replacement) of malfunctioning systems as well as disconnection of direct discharges to tile drainage systems.	Variable depending on the degree and type of failure as well as type of onsite system used	Variable depending on the degree and type of failure as well as type of onsite system used	Variable depending on the degree and type of failure as well as type of onsite system used	Variable depending on the degree and type of failure as well as type of onsite system used

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Urban

The following information regarding storm water BMPs was adapted from the U.S. EPA Storm water Program web site: http://cfpub1.epa.gov/npdes/storm water/menuofbmps/index.cfm. Further details regarding applicability of these BMPs (where and when to use them) is available on that web site in the fact sheet for each BMP.

Construction BMPs

Erosion Control

Chemical Stabilization
Chemical stabilizers, also known as soil binders or soil palliatives, provide temporary soil stabilization. Vinyl, asphalt, or rubber are sprayed onto the surface of exposed soils to hold the soil in place and minimize erosion from runoff and wind. These materials are easily applied to the surface of the soil, can stabilize areas where vegetation cannot be established, and provide immediate protection.

Compost Blankets
A compost blanket is a layer of loosely applied compost or composted material that is placed on the soil in disturbed areas to control erosion and retain sediment resulting from sheet-flow runoff. It can be used in place of traditional sediment and erosion control tools such as mulch, netting, or chemical stabilization. When properly applied, the erosion control compost forms a blanket that completely covers the ground surface. This blanket prevents storm water erosion by (1) presenting a more permeable surface to the oncoming sheet flow, thus facilitating infiltration; (2) filling in small rills and voids to limit channelized flow; and (3) promoting establishment of vegetation on the surface. Composts used in compost blankets are made from a variety of feedstocks, including municipal yard trimmings, food residuals, separated municipal solid waste, biosolids, and manure.

Compost blankets can be placed on any soil surface: rocky, frozen, flat, or steep. The method of application and the depth of the compost applied will vary depending upon slope and site conditions. The compost blanket can be vegetated by incorporating seeds into the compost before it is placed on the disturbed area (recommended method) or the seed can be broadcast onto the surface after installation (Faucette and Risse, 2001).

In general, compost-based erosion and sediment control systems have several advantages over more traditional storm water best management practices (BMPs) such as geotextile blankets.

Advantages provided by compost blankets include the following (Alexander, 2003; Faucette, 2004):

- The compost retains a large volume of water, which helps reduce runoff, prevents or reduces sheet and rill erosion, and aids in establishing vegetation in the blanket.
- The compost blanket acts as a buffer to absorb rainfall energy, which prevents soil compaction and crusting and facilitates rainfall infiltration.
- Compost blankets facilitate plant growth by capturing and retaining moisture and providing a suitable microclimate and nutrients for seed germination.
- The compost stimulates microbial activity, which increases decomposition of organic matter, increases nutrient availability for plants, and improves the soil structure.
- Compost can remove pollutants, such as heavy metals; nitrogen; phosphorus; oil and grease; and fuel, from storm water, thus improving downstream water quality (W&H Pacific, 1993; U.S. EPA, 1998).

Dust Control

Dust control BMPs reduce surface activities and air movement that causes dust to be generated from disturbed soil surfaces. Construction sites can generate large areas of soil disturbance and open space for wind to pick up dust particles. Limited research at construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction (WA Dept. of Ecology, 1992). Airborne particles pose a dual threat to the environment and human health. First, dust can be carried offsite, thereby increasing soil loss from the construction area and increasing the likelihood of sedimentation and water pollution. Second, blowing dust particles can contribute to respiratory health problems and create an inhospitable working environment.

Geotextiles

Geotextiles are porous fabrics also known as filter fabrics, road rugs, synthetic fabrics, construction fabrics, or simply fabrics. Geotextiles are manufactured by weaving or bonding fibers that are often made of synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass, and various mixtures of these materials. As a synthetic construction material, geotextiles are used for a variety of purposes such as separators, reinforcement, filtration and drainage, and erosion control (U.S. EPA, 1992a). Some geotextiles are made of biodegradable materials such as mulch matting and netting. Mulch mattings are jute or other wood fibers that have been formed into sheets and are more stable than normal mulch. Netting is typically made from jute, wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well. Mulch binders (either asphalt or synthetic) are sometimes used instead of netting to hold loose mulches together. Geotextiles can aid in plant growth by holding seeds, fertilizers, and topsoil in place. Fabrics come in a wide variety to match the specific needs of the site and are relatively inexpensive for certain applications.

Gradient Terraces

Gradient terraces are earthen embankments or ridge and channel systems that reduce erosion by slowing, collecting and redistributing surface runoff to stable outlets that increase the distance of overland runoff flow. Terraces hold moisture and help trap sediments, minimizing sediment-laden runoff.

Mulching

Mulching is an erosion control practice that uses materials such as grass, hay, wood chips, wood fibers, straw, or gravel to stabilize exposed or recently planted soil surfaces. Mulching is

highly recommended and is most effective when used in conjunction with vegetation. In addition to stabilizing soils, mulching can reduce storm water velocity and improve the infiltration of runoff. Mulching can also aid plant growth by holding seeds, fertilizers, and topsoil in place, preventing birds from eating seeds, retaining moisture, and insulating plant roots against extreme temperatures.

Mulch matting is made from materials such as jute or other wood fibers that are formed into sheets and are more stable than loose mulch. Use jute and other wood fibers, plastic, paper, or cotton individually or combine them into mats to hold mulch to the ground. Use netting to stabilize soils while plants are growing; although, netting does not retain moisture or insulate against extreme temperatures. Mulch tackifiers made of asphalt or synthetic materials are sometimes used instead of netting to bind loose mulches.

Seeding

Seeding is used to control runoff and erosion on disturbed areas by establishing perennial vegetative cover from seed. It reduces erosion and sediment loss and provides permanent stabilization. This practice is economical, adaptable to different site conditions, and allows selection of a variety of plant materials.

Sodding

Sodding is a permanent erosion control practice and involves laying a continuous cover of grass sod on exposed soils. Sodding can stabilize disturbed areas and reduce the velocity of storm water runoff. Sodding can provide immediate vegetative cover for critical areas and stabilize areas that cannot be readily vegetated by seed. It also can stabilize channels or swales that convey concentrated flows and reduce flow velocities.

Soil Retention

Soil retention measures are structures or practices that hold soil in place or keep it contained within a site boundary. They include grading or reshaping the ground to lessen steep slopes or shoring excavated areas with wood, concrete, or steel structures. Some soil-retaining measures are used only for erosion control, while others are also used to protect workers during excavation projects.

Soil Roughening

Soil roughening is a temporary erosion control practice often used in conjunction with grading. Soil roughening involves increasing the relief of a bare soil surface with horizontal grooves by either stair-stepping (running parallel to the contour of the land) or using construction equipment to track the surface. Slopes that are not fine graded and left in a roughened condition can also reduce erosion. Soil roughening reduces runoff velocity, increases infiltration, reduces erosion, traps sediment, and prepares the soil for seeding and planting by giving seed an opportunity to take hold and grow.

Temporary Slope Drain

A temporary slope drain is a flexible conduit for storm water that extends the length of a disturbed slope to divert the flow and serve as a temporary outlet. Temporary slope drains, also called pipe slope drains, convey runoff without causing erosion on or at the bottom of the slope. This practice is a temporary measure, typically used for less than 2 years. It is used during grading operations until permanent drainage structures are installed and until slopes are permanently stabilized.

Temporary Stream Crossings
A temporary steam crossing is used to provide a safe, stable way for construction vehicle traffic to cross a watercourse. Temporary stream crossings provide streambank stabilization, reduce the risk of damage to the streambed or channel, and minimize sediment loading from construction traffic. The crossing might be a bridge, a culvert, or a ford.

Wind Fences or Sand Fences
Sand fences are barriers made of small, evenly spaced wooden slats or fabric. They are erected to reduce wind velocity and to trap blowing sand. Sand fences can be used as perimeter controls around open construction sites to keep sediments from being blown offsite by the wind. They also prevent offsite damage to roads, streams, and adjacent properties. The spaces between the fence slats allow wind and sediment to pass through but reduce the wind's speed, causing sediment to deposit along the fence.

Runoff Control

Check Dams
Check dams are relatively small, temporary structures constructed across a swale or channel. They are used to slow the velocity of concentrated water flows, a practice that helps reduce erosion. As storm water runoff flows through the structure, the check dam catches sediment from the channel itself or from the contributing drainage area. However, check dams should not be used as a substitute for other sediment-trapping and erosion-control measures. Check dams are typically constructed out of gravel, rock, sandbags, logs or treated lumber, or straw bales. They are most effective when used with other storm water, erosion, and sediment-control measures.

Grass-Lined Channels
A grass-lined channel conveys storm water runoff through a stable conduit. Vegetation lining the channel slows down concentrated runoff. Because grassed channels are not usually designed to control peak runoff loads by themselves, they are often used with other BMPs, such as subsurface drains and riprap stabilization.

Where moderately steep slopes require drainage, grassed channels can include excavated depressions or check dams to enhance runoff storage, decrease flow rates, and improve pollutant removal. Peak discharges can be reduced by temporarily holding them in the channel. Pollutants can be removed from storm water by filtration through vegetation, by deposition, or in some cases by infiltration of soluble nutrients into the soil. The degree of pollutant removal in a channel depends on how long the water stays in the channel and the amount of contact with vegetation and the soil surface. Local conditions affect the removal efficiency.

Permanent Slope Diversions
Permanent slope diversions are designed to transport runoff down a slope in a manner that minimizes the potential for erosion. Diversions can be constructed by creating channels laterally across slopes to intercept the down-slope flow of runoff. The channels have a supporting earthen ridge on the bottom sides to reduce slope length, collect storm water runoff, and deflect the runoff to outlets that convey it without causing erosion.

Temporary Diversion Dikes
An earthen perimeter control usually consists of a dike or a combination dike and channel constructed along the perimeter of and within the disturbed part of a site. An earthen perimeter control is a ridge of compacted soil, often accompanied by a ditch or swale with a vegetated

lining, at the top or base of a sloping disturbed area. Depending on its location and the topography of the landscape, an earthen perimeter control can achieve one of two goals.

When on the upslope side of a site, earthen perimeter controls help to prevent surface runoff from entering a disturbed construction site. An earthen structure located upslope can improve working conditions on a construction site. It can prevent an increase in the total amount of sheet flow runoff traveling across the disturbed area and thereby lessen erosion on the site.

Earthen perimeter control structures also can be located on the downslope side of a site. They divert sediment-laden runoff created onsite to onsite sediment-trapping devices, preventing soil loss from the disturbed area.

These control practices are called temporary diversion dikes, earth dikes, and interceptor dikes. No matter what they are called,, all earthen perimeter controls are constructed in a similar way with a similar objective—to control the velocity or route (or both) of sediment-laden storm water runoff.

Sediment Control

Brush Barrier
Brush barriers are perimeter sediment control structures constructed of material such as small tree branches, root mats, stone, or other debris left over from site clearing and grubbing. Brush barriers can be covered with a filter cloth to stabilize the structure and improve barrier efficiency.

Compost Filter Berms
A compost filter berm is a dike of compost or a compost product that is placed perpendicular to sheet flow runoff to control erosion in disturbed areas and retain sediment. It can be used in place of a traditional sediment and erosion control tool such as a silt fence. The compost filter berm, which is trapezoidal in cross section, provides a three-dimensional filter that retains sediment and other pollutants (e.g., suspended solids, metals, oil and grease) while allowing the cleaned water to flow through the berm. Composts used in filter berms are made from a variety of feedstocks, including municipal yard trimmings, food residuals, separated municipal solid waste, biosolids, and manure.

Compost filter berms are generally placed along the perimeter of a site, or at intervals along a slope, to capture and treat storm water that runs off as sheet flow. A filter berm also can be used as a check dam in small drainage ditches. The berms can be vegetated or unvegetated. Vegetated filter berms are normally left in place and provide long-term filtration of storm water as a post-construction BMP. Unvegetated berms are often broken down once construction is complete and the compost is spread around the site as a soil amendment or mulch.

Filter berms, in general, provide an effective physical barrier in sheet flow conditions; however, the use of compost in the filter berm provides additional benefits. These benefits include the following:

- The compost retains a large volume of water, which helps prevent or reduce rill erosion and aids in establishing vegetation on the berm.
- The mix of particle sizes in the compost filter material retains as much or more sediment than traditional perimeter controls, such as silt fences or hay bale barriers, while allowing a larger volume of clear water to pass through the berm. Silt fences often become clogged with sediment and form a dam that retains storm water, rather than letting the filtered storm water pass through.

- In addition to retaining sediment, compost can retain pollutants, such as heavy metals, nitrogen, phosphorus, oil and grease, fuel, herbicides, pesticides, and other potentially hazardous substances, from storm water.improving water quality downstream of the berm (U.S. EPA, 1998).
- Nutrients and hydrocarbons adsorbed and/or trapped by the compost filter can be naturally cycled and decomposed through bioremediation by microorganisms commonly found in the compost matrix (U.S. EPA, 1998).

Compost Filter Socks

A compost filter sock is a type of contained compost filter berm. It is a mesh tube filled with composted material that is placed perpendicular to sheet-flow runoff to control erosion and retain sediment in disturbed areas. The compost filter sock, which is oval to round in cross section, provides a three-dimensional filter that retains sediment and other pollutants (e.g., suspended solids, nutrients, and motor oil) while allowing the cleaned water to flow through (Tyler and Faucette, 2005). The filter sock can be used in place of a traditional sediment and erosion control tool such as a silt fence or straw bale barrier. Composts used in filter socks are made from a variety of feedstocks, including municipal yard trimmings, food residuals, separated municipal solid waste, biosolids, and manure.

Compost filter socks are generally placed along the perimeter of a site, or at intervals along a slope, to capture and treat storm water that runs off as sheet flow. Filter socks are flexible and can be filled in place or filled and moved into position, making them especially useful on steep or rocky slopes where installation of other erosion control tools is not feasible. There is greater surface area contact with soil than typical sediment control devices, thereby reducing the potential for runoff to create rills under the device and/or create channels carrying unfiltered sediment.

Additionally, they can be laid adjacent to each other, perpendicular to storm water flow, to reduce flow velocity and soil erosion. Filter socks can also be used on pavement as inlet protection for storm drains and to slow water flow in small ditches. Filter socks used for erosion control are usually 12 inches in diameter, although 8 inch, 18 inch, and 24 inch– diameter socks are used in some applications. The smaller, 8 inch–diameter filter socks are commonly used as storm water inlet protection.

Compost filter socks can be vegetated or unvegetated. Vegetated filter socks can be left in place to provide long-term filtration of storm water as a post-construction BMP. The vegetation grows into the slope, further anchoring the filter sock. Unvegetated filter socks are often cut open when the project is completed, and the compost is spread around the site as soil amendment or mulch. The mesh sock is then disposed of unless it is biodegradable. Three advantages the filter sock has over traditional sediment control tools, such as a silt fence, are:

- Installation does not require disturbing the soil surface, which reduces erosion
- It is easily removed
- The operator must dispose of only a relatively small volume of material (the mesh)
- These advantages lead to cost savings, either through reduced labor or disposal costs. The use of compost in this BMP provides additional benefits, include the following:
    - The compost retains a large volume of water, which helps prevent or reduce rill erosion and aids in establishing vegetation on the filter sock.
    - The mix of particle sizes in the compost filter material retains as much or more sediment than traditional perimeter controls, such as silt fences or hay bale barriers, while allowing a larger volume of clear water to pass through. Silt

fences often become clogged with sediment and form a dam that retains storm water, rather than letting the filtered storm water pass through.

- In addition to retaining sediment, compost can retain pollutants such as heavy metals, nitrogen, phosphorus, oil and grease, fuels, herbicides, pesticides, and other potentially hazardous substances—improving the downstream water quality (U.S. EPA, 1998).
- Nutrients and hydrocarbons adsorbed and/or trapped by the compost filter can be naturally cycled and decomposed through bioremediation by microorganisms commonly found in the compost matrix (U.S. EPA, 1998).

Construction Entrances

The purpose of stabilizing entrances to a construction site is to minimize the amount of sediment leaving the area as mud and sediment attached to vehicles. Installing a pad of gravel over filter cloth where construction traffic leaves a site can help stabilize a construction entrance. As a vehicle drives over the pad, the pad removes mud and sediment from the wheels and reduces soil transport off the site. The filter cloth separates the gravel from the soil below, keeping the gravel from being ground into the soil. The fabric also reduces the amount of rutting caused by vehicle tires. It spreads the vehicle's weight over a soil area larger than the tire width.

In addition to using a gravel pad, a vehicle washing station can be established at the site entrance. Using wash stations routinely can remove a lot of sediment from vehicles before they leave the site. Diverting runoff from vehicle washing stations into a sediment trap helps to make sure the sediment from vehicles stays onsite and is handled properly.

Fiber Rolls

Fiber rolls (also called fiber logs or straw wattles) are tube-shaped erosion-control devices filled with straw, flax, rice, coconut fiber material, or composted material. Each roll is wrapped with UV-degradable polypropylene netting for longevity or with 100 percent biodegradable materials like burlap, jute, or coir. Fiber rolls complement permanent best management practices used for source control and revegetation. When installed in combination with straw mulch, erosion control blankets, hydraulic mulches, or bounded fiber matrices for slope stabilization, these devices reduce the effects of long or steep slopes (Earth Saver Erosion Control Products, 2005). Fiber rolls also help to slow, filter, and spread overland flows. This helps to prevent erosion and minimizes rill and gully development. Fiber rolls also help reduce sediment loads to receiving waters by filtering runoff and capturing sediments.

Filter Berms

A gravel or stone filter berm is a temporary ridge made up of loose gravel, stone, or crushed rock. It slows and filters flow and diverts it from an open traffic area. It acts as an efficient form of sediment control. One type of filter berm is the continuous berm, a geosynthetic fabric berm that captures sand, rock, and soil.

Sediment Basins and Rock Dams

Sediment basins and rock dams can be used to capture sediment from storm water runoff before it leaves a construction site. Both structures allow a pool to form in an excavated or natural depression, where sediment can settle. The pool is dewatered through a single riser and drainage hole leading to a suitable outlet on the downstream side of the embankment or through the gravel of the rock dam. The water is released more slowly than it would be without the control structure.

A sediment basin is constructed by excavation or by erecting an earthen embankment across a low area or drainage swale. The basin can be temporary (up to 3 years) or permanent. Some sediment basins are designed to drain completely during dry periods. Others are constructed so that a shallow pool of water remains between storm events.

Rock dams are similar to sediment basins with earthen embankments. These damming structures are constructed of rock and gravel. They release water from the settling pool gradually through the spaces between the rocks.

Sediment Filters and Sediment Chambers

Sediment filters are sediment-trapping devices typically used to remove pollutants (mainly particulates) from storm water runoff. Sediment filters have four components: (1) inflow regulation, (2) pretreatment, (3) filter bed, and (4) outflow mechanism. Sediment chambers are one component of a sediment filter system.

Inflow regulation is diverting storm water runoff into the sediment-trapping device. After runoff enters the filter system, it enters a pretreatment sedimentation chamber. This chamber is used as a preliminary settling area for large debris and sediments. It is usually no more than a wet detention basin. As water reaches a predetermined level, it flows over a weir into a bed of some filter medium. The medium is typically sand, but it can consist of sand, soil, gravel, peat, compost, or a combination. The filter bed removes small sediments and other pollutants from the storm water as it percolates through the filter medium. Finally, treated flow exits the sediment filter system via an outflow mechanism. It returns to the storm water conveyance system.

Sediment filter systems can be confined or unconfined, on-line or off-line, and aboveground or belowground. Confined sediment filters are constructed with the filter medium contained in a structure, often a concrete vault. Unconfined sediment filters are made without a confining structure. For example, sand might be placed on the banks of a permanent wet pond detention system to create an unconfined filter. On-line systems retain storm water in its original stream channel or storm drain system. Off-line systems divert storm water.

Sediment Traps

Sediment traps are small impoundments that allow sediment to settle out of construction runoff. They are usually installed in a drainageway or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap (U.S. EPA, 1993). Sediment traps detain sediments in storm water runoff to protect receiving streams, lakes, drainage systems, and the surrounding area. The traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff (U.S. EPA, 1992b).

Silt Fences

Silt fences are used as temporary perimeter controls around sites where construction activities will disturb the soil. They can also be used around the interior of the site. A silt fence consists of a length of filter fabric stretched between anchoring posts spaced at regular intervals along the site at low/downslope areas. The filter fabric should be entrenched in the ground between the support posts. When installed correctly and inspected frequently, silt fences can be an effective barrier to sediment leaving the site in storm water runoff.

Storm Drain Inlet Protection
Storm drain inlet protection measures prevent soil and debris from entering storm drain drop inlets. These measures are usually temporary and are implemented before a site is disturbed.

There are several types of inlet protection:

- *Excavation around the perimeter of the drop inlet*: Excavating a small area around an inlet creates a settling pool that removes sediments as water is released slowly into the inlet through small holes protected by gravel and filter fabric.
- *Fabric barriers around inlet entrances*: Erecting a barrier made of porous fabric around an inlet creates a shield against sediment while allowing water to flow into the drain. This barrier slows runoff while catching soil and other debris at the drain inlet.
- *Block and gravel protection*: Standard concrete blocks and gravel can be used to form a barrier to sediments that permits water runoff to flow through select blocks laid sideways.

Sandbags can also be used to create temporary sediment barriers at inlets. For permanent inlet protection after the surrounding area has been stabilized, sod can be installed. This permanent measure is an aesthetically pleasing way to slow storm water near drop inlet entrances and to remove sediments and other pollutants from runoff.

Vegetated Buffers
Vegetated buffers are areas of natural or established vegetation maintained to protect the water quality of neighboring areas. Buffer zones slow storm water runoff, provide an area where runoff can permeate the soil, contribute to ground water recharge, and filter sediment. Slowing runoff also helps to prevent soil erosion and streambank collapse.

Post-Construction BMPs

Innovative BMPs

Alternative Pavers
Alternative pavers are permeable surfaces that can replace asphalt and concrete and can be used for driveways, parking lots, and walkways. From a storm water perspective, this is important because alternative pavers can replace impervious surfaces, creating less storm-water runoff. The two broad categories of alternative pavers are paving blocks and other surfaces, including gravel, cobbles, wood, mulch, brick, and natural stone. While porous pavement is an alternative paver, as an engineered storm water management practice it is discussed in more detail below.

Alternative Turnarounds
Alternative turnarounds are end-of-street vehicle turnarounds that reduce impervious cover in neighborhoods by replacing cul-de-sacs. Cul-de-sacs are local access streets with closed circular ends that allow for vehicle turnarounds. Many cul-de-sacs have radiuses of more than 40-feet. From a storm water perspective, cul-de-sacs create a huge bulb of impervious cover that increases the amount of storm water runoff. Reducing the size of cul-de-sacs, either though the use of alternative turnarounds or by eliminating them altogether, can reduce the amount of impervious cover created at the site.

There are numerous alternatives to the traditional 40-foot cul-de-sac, all of which reduce impervious cover. One alternative reduces cul-de-sacs to a 30-foot radius. Others create hammerheads, loop roads, and pervious islands in the cul-de-sac's center.

Conservation Easements

Conservation easements are voluntary agreements that allow individuals or groups to limit the type or amount of development on their property. A conservation easement can cover all or just a portion of a property, and it can either be permanent or temporary. Easements typically describe the resource they are designed to protect (e.g., agricultural, forest, historic, or open space easements), and they explain and mandate the restrictions on the uses of the particular property. Easements can relieve property owners of the burden of managing these areas. They do so by shifting responsibility to a private organization (land trust) or government agency better equipped to handle maintenance and monitoring issues. Furthermore, in some cases, tax benefits might be realized by property owners who place conservation easements on some or all of their property.

Conservation easements may indirectly contribute to water quality protection. Land set aside in a permanent conservation easement has a prescribed set of uses or activities that generally restrict future development.

The location of the land held in a conservation easement may be evaluated to determine its ability to provide water quality benefits. Property along stream corridors and shorelines can act as a vegetated buffer that filters-out pollutants from storm water runoff. The ability of a conservation easement to function as a stream buffer depends on the width of the easement and in what vegetated state the easement is maintained.

Development Districts

Development districts (or in some cases special zoning districts) are zoning districts created for the purpose of permitting property development. Development districts are characterized by larger site areas (typically 5 or more acres), and their construction requires complex and coordinated rezoning, transportation, and planning efforts. Examples of special zoning districts include, but are not limited to:

- Transit Oriented Development districts (TOD),
- Business Improvement Districts (BIDs),
- Traditional Neighborhood Designs (TNDs),
- Brownfields redevelopment projects and
- Main Street Revitalization Districts.

A development district's storm water handling performance is typically assessed at the site, neighborhood, and regional (or watershed) levels. While the construction of a development district may involve a higher percentage of imperviousness than surrounding or conventional patterns, satisfying development needs on a smaller footprint brings benefits. In addition, the coordinated planning effort can help identify strategic opportunities for infiltration, storm water recapture, and treatment.

A city, county or township's Planning or Zoning Department usually develops plans for development districts. Storm water managers may need to meet with planning counterparts to coordinate plans, since common, stand-alone elements found in storm water management plans for individual site plans, such as site coverage limitations, infiltration requirements, and rules discouraging sidewalks can run counter to the urban design elements of successful development districts.

Eliminating Curbs and Gutters

This practice promotes grass swales as an alternative to curbs and gutters along residential streets. Curbs and gutters are designed to quickly convey runoff from the street to the stormdrain and, ultimately, to a local receiving water. Consequently, they provide little or no removal of storm water pollutants. Indeed, curbs often act as traps where deposited pollutants remain until the next storm washes them away. Many communities require curbs and gutters as standard elements of road sections. In fact, many communities discourage the use of grass swales. Revisions to current local road and drainage regulations are needed to promote greater use of grass swales along residential streets.

Green Parking

Green parking refers to several techniques that applied together reduce the contribution of parking lots to total impervious cover. From a storm water perspective, green parking techniques applied in the right combination can dramatically reduce impervious cover and, consequently, reduce the amount of storm water runoff. Green parking lot techniques include: setting maximums for the number of parking lots created; minimizing the dimensions of parking lot spaces; utilizing alternative pavers in overflow parking areas; using bioretention areas to treat storm water; encouraging shared parking; and providing economic incentives for structured parking.

Green Roofs

Green roofs can be effectively used to reduce storm water runoff from commercial, industrial, and residential buildings. In contrast to traditional asphalt or metal roofing, green roofs absorb, store, and later evapotranspire initial precipitation, thereby acting as a storm water management system and reducing overall peak flow discharge to a storm sewer system. Furthermore, conventional roofing can act as a source for numerous toxic pollutants including lead, zinc, pyrene, and chrysene (Van Metre and Mahler, 2003).

Green roofs have the potential to reduce discharge of pollutants such as nitrogen and phosphorous due to soil microbial processes and plant uptake. However, initial studies conflict as to the removal efficiency of nutrients, particularly nitrogen, by green roofs. If implemented on a wide scale, green roofs will reduce the volume of storm water entering local waterways resulting in less in-stream scouring, lower water temperatures and better water quality. In urban areas with combined sewer systems, storm water and untreated human and industrial waste are collected in the same pipe. During periods of heavy rainfall and snow melt, these systems can become overwhelmed by the volume of water and overflow into nearby waterbodies resulting in combined sewer overflows (CSOs). Since green roofs can reduce the volume of storm water discharged, CSOs can also be reduced, thus preventing the discharge of millions of gallons of sewage into local waterways.

Green roofs offer additional benefits including reduction of urban heat island effects, increased thermal insulation and energy efficiency, increased acoustic insulation, and increased durability and lifespan compared to conventional roofs. Europeans, led by the Germans, have been using green roofs for decades and have found them to be a cost effective method to mitigate some environmental impacts of development.

Green roofs are classified as extensive, semi-intensive, or intensive. Generally, extensive green roofs have six inches or less of growing medium, whereas intensive green roofs have greater than 6 inches of substrate. Semi-intensive green roofs can be defined as a hybrid between intensive and extensive green roofs, where at least 25 percent of the roof square footage is above or below the 6 inch threshold. Extensive green roofs provide many of the

environmental benefits of intensive green roofs, but they are designed to be very low-maintenance and are not typically designed for public access. Semi-intensive and intensive green roofs are designed to be used by the public or building tenants as a park or relaxation area. However, they also require greater capital and maintenance investments than extensive green roofs. Intensive green roofs are particularly attractive for developers, property owners, and municipalities, in areas where land prices command a premium, but property owners want to provide some of the amenities associated with parks.

Infrastructure Planning

Infrastructure planning involves changes in the regional growth planning process to contain 'sprawl' development. Sprawl development is the expansion of low-density development into previously undeveloped land. The American Farmland Trust has estimated that the United States is losing about 50 acres an hour to suburban and exurban development (Longman, 1998). This sprawl development requires local governments to extend public services to new residential communities whose tax payments often do not cover the cost of providing those services. For example, in Prince William County, Virginia, officials have estimated that the costs of providing services to new residential homes exceeds what is brought in from taxes and other fees by $1,600 per home (Shear and Casey, 1996).

Infrastructure planning makes wise decisions to locate public services, water, sewer, roads, schools, and emergency services in the suburban fringe and direct new growth into previously developed areas, discouraging low-density development. Generally, this is done by drawing a boundary or envelope around a community, beyond which major public infrastructure investments are discouraged or not subsidized. Meanwhile, economic and other incentives are provided within the boundary to encourage growth in existing neighborhoods. By encouraging housing growth in areas that are already provided with public services, water, sewer, roads, schools, and emergency services communities not only save infrastructure development costs, but reduce the impacts of sprawl development on urban streams and water quality.

Sprawl development negatively impacts water quality in several ways. One of the most significant impacts comes from the increase in impervious cover that is associated with 'sprawl' growth. In addition to impervious area from rooftops, extension of road systems and additions of paved surface from driveways create an overall increase in imperviousness. This increase in the impervious cover level of an area directly influences local streams and water quality by increasing the volume of storm water runoff. These elevated runoff levels impact urban streams in several ways, including enlarging stream channels, increasing sediment and pollutant loads, degrading stream habitat, and reducing aquatic diversity (Schueler, 1995). Sprawl has been reported to generate 43 percent more runoff that contains three times greater sediment loads than traditional development (SCCCL, 1995).

Sprawl development influences water quality in other ways. This type of development typically occurs in areas not served by centralized sewer or water services. For example, over 80 percent of the land developed in the state of Maryland in the last decade has been outside the sewer and water "envelope." This requires new housing developments to use septic systems or another form of on-site wastewater disposal to treat household sewage. These on-site treatment systems can represent a significant source of nutrients and bacteria that affect both surface waters and ground water.

Low Impact Development (LID) and Other Green Design Strategies

Urban development significantly alters the natural features and hydrology of a landscape. Development and redevelopment usually creates impervious surfaces like concrete sidewalks

and asphalt roadways, commercial and residential buildings, and even earth compacted by construction activities. Prevented from soaking into the ground, rainwater runs across parking lots and streets, collecting used motor oil, pesticides, fertilizers, and other pollutants.

In most cities, a complex system of piping usually feeds contaminated storm water flows directly into streams and coastal waters. More recently, storm water control structures (sometimes BMPs) like dry extended detention ponds or wet retention ponds have been installed, most in new development, to intercept storm water on its way to surface waters.

Historically, the goal of storm water planning has been to prevent localized flooding by moving large amounts of water offsite as quickly as possible. However, experience has shown that traditional storm water management has many limitations.

Expensive, ever-expanding storm sewer systems strain municipal budgets. Fast moving storm water discharges cause downstream flooding, erode stream banks, and contribute to water quality violations. Bacteria and other pathogens carried in storm water contaminate coastal waters, often requiring beach closures. Rainwater diverted or otherwise unable to soak into the soil cannot recharge aquifers. This reduces stream base flows, which can cause streams to dry up for extended periods of time. Storm water that collects in detention basins or flows over impervious surfaces is often much warmer than the streams into which it flows. This is a problem because a temperature increase of just one or two degrees can stress fish and other aquatic organisms.

Mimicking Natural Hydrology

Efforts to address storm water problems resulting from traditional development methods have produced a number of innovative design alternatives. For example, researchers and developers are experimenting with minimizing the distance between land uses to decrease infrastructure requirements. Another method reduces storm water runoff by conserving forests and green spaces and protecting stream buffers. Yet another technique diminishes impervious surfaces, narrows road and sidewalk widths, reduces parking lot sizes, minimizes or removes cul-de-sacs, and replaces traditional paving materials with pervious concrete.

Such innovative site design grew out of concerns that rapid urban development was not only impairing water quality but eroding quality of life. Concerned by the development of sensitive agricultural and wetlands, and burdened by the rising costs of storm water damage, some communities are implementing Green Design strategies, such as LID, Conservation Development, Better Site Design, and Smart Growth. The complementary goals of these design schemes lessen the impact of storm water while still providing opportunities for development.

Low Impact Development (LID)

Like other alternative development strategies, LID seeks to control storm water at its source. Rather than moving storm water offsite though a conveyance system, the goal of LID is to restore the natural, pre-developed ability of an urban site to absorb storm water.

LID integrates small-scale measures scattered throughout the development site. Constructed green spaces, native landscaping, and a variety of innovative bioretention and infiltration techniques capture and manage storm water on-site. LID reduces peak runoff by allowing rainwater to soak into the ground, evaporate into the air, or collect in storage receptacles for irrigation and other beneficial uses. In areas with slow drainage or infiltration, LID captures the first flush before excess storm water is diverted into traditional storm conveyance systems. The

result is development that more closely maintains pre-development hydrology. Furthermore, LID has been shown to be cost effective, and in some cases, cheaper than using traditional storm water management techniques.

Conservation Development
Like LID, Conservation Development tries to mitigate the effects of urbanization, but it places additional emphasis on protecting aquatic habitat and other natural resources. Conservation Development subdivisions are characterized by compact clustered lots surrounding a common open space. Conservation Development's goal is to disturb as little land area as possible while simultaneously allowing for the maximum number of residences permitted under zoning laws.

Prior to new construction, conservation developers evaluate natural topography, natural drainage patterns, soils and vegetation. They deploy storm water best management practices to help prevent flooding and protect natural hydrology. By maintaining natural hydrological processes, Conservation Development creates conditions that slow, absorb, and filter storm water runoff onsite.

Because future development threatens valuable natural features, Conservation Development provides specific provisions for long-term and permanent resource protection. Conservation easements, transfer of development rights, and other "in perpetuity" mechanisms ensure that protective measures are more than just temporary.

Better Site Design
The goals of Better Site Design are to reduce impervious cover, preserve natural lands, and capture storm water onsite. To meet these goals, designers employ a variety of methods. To reduce impervious cover, they narrow streets and sidewalks, minimize cul-de-sacs, tighten parking spaces, and reduce the size of driveways and housing lots.

To reduce storm water runoff, designers preserve natural lands, using them as buffer zones along streams, wetlands and steep slopes. They employ landscaping techniques that flatten slopes and preserve native vegetation and clusters of trees. They create bioretention areas - open channels, filter strips and vegetated swales - to increase storm water infiltration, helping to protect steams, lakes, and wetlands.

Development Districts
Development districts are areas zoned specifically for the purpose of permitting property development. Development districts concentrate intense, mixed-use development in an area typically five-acres and larger. Although a development district's percentage of imperviousness may exceed those of surrounding areas, such focused, compact development creates a smaller "footprint" than traditional development patterns.

A well-designed development district can contribute to a number of water quality benefits. Compact development lends itself to more environmentally friendly transportation options, like biking or walking, and shorter and less frequent automobile trips. A development district that redevelops an urban area reuses existing infrastructure, which can reduce the demand for new construction elsewhere in a watershed. Many development districts incorporate tree-lined streets, rain gardens, green roofs and other best management practices into their designs, helping manage storm water onsite.

Smart Growth
Smart Growth is a set of development strategies that seek to balance economic growth, urban renewal, and conservation. In newly developing areas, Smart Growth advocates compact, town-centered communities composed of open green space, businesses, and affordable housing, interconnected by pedestrian walkways and bicycle lanes. Smart Growth's emphasis on walkable communities and alternative forms of transportation can help alleviate the environmental consequences of automobile use. Smart Growth also advocates the revitalization of inner cities and older suburbs. Reusing existing infrastructure often costs less than new construction, and it helps slow the spread of large-scale impervious surfaces.

Narrower Residential Streets
This better site design practice promotes the narrowing of streets to reduce the amount of impervious cover created by new residential development. By doing so, storm water runoff and associated pollutant loads may also be reduced. Currently, many communities require residential street widths of 32, 36, and even 40-feet. Wide streets provide two parking lanes and two moving lanes, but they provide more parking than is necessary. In many residential settings, street widths can be as narrow as 22 to 26-feet without sacrificing emergency access, on-street parking, or vehicular and pedestrian safety. Even narrower access streets or shared driveways can be used when only a handful of homes need to be served. However, developers often have little flexibility to design narrower streets because most communities require wide residential streets as a standard element of their local road and zoning standards. Revisions to current local road standards are often needed to promote a wider use of narrower residential streets.

Open Space Design
Open space design, also known as conservation development or cluster development, is a better site design technique that concentrates dwelling units in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed in order to create the open space at the site. Open space designs have many benefits in comparison to the conventional subdivisions that they replace: they can reduce impervious cover, storm water pollutants, construction costs, grading, and the loss of natural areas. However, many communities lack zoning ordinances to permit open space development, and even those that have enacted ordinances might need to revise them to achieve greater water quality and environmental benefits.

The benefits of open space design can be amplified when it is combined with other better site design techniques such as narrow streets, open channels, and alternative turnarounds.

Protection of Natural Features
Undeveloped sites can have numerous natural features that provide environmental, aesthetic, and recreational benefits if preserved and protected from the impacts of construction and development. These features include wetlands, riparian areas, floodplains, aquifer recharge areas, mature trees, woodlands, and other wildlife habitat. Restricted areas such as floodplains and steep slopes should also be protected from possible impacts from construction activities. Natural area protection is not limited to undeveloped land; properties that are being redeveloped might have attractive open space, well-drained soils, or riparian areas that should be identified and considered for preservation early in the planning process.

Natural features and open space can be protected both during the development process and after a site is occupied through a combination of (1) site planning techniques, (2) construction

site BMPs, and (3) measures employed after the site is in use. Each of these will be discussed in depth below.

Redevelopment

Redevelopment is typically defined as development that occurs on previously developed land. The definitions of development and redevelopment vary in storm water guidance documents and NPDES storm water permits. However, both types of development require storm water management.

In some states and localities, development and redevelopment are subject to the same requirements. For storm water management, however, redevelopment of already-impervious surfaces can be a key strategy for reducing net increases in impervious surfaces and associated degradation to receiving waters. In watersheds that are experiencing growth, the reuse of impervious surface mitigates developmental impacts that would be experienced elsewhere. Where development takes place on undeveloped land, runoff is still generated on both the previously developed site and the new site.

Redevelopment can also deliver related benefits. For example, in established development districts, infrastructure upgrades can be used to repair deteriorating pipes contributing to water quality impairments.

Redevelopment can be accomplished on a site-by-site basis, but it can also be part of a larger effort to spur investment and development activity in a larger district. Common programs include business improvement districts (BIDs), Main Street programs for older downtowns, brownfields programs, vacant property campaigns and efforts to revive older, underperforming shopping malls. The transfer of development rights (or TDRs) can help spur redevelopment by directing development demand to existing activity centers.

Riparian/Forested Buffer

A riparian or forested buffer is an area along a shoreline, wetland, or stream where development is restricted or prohibited. The primary function of aquatic buffers is to physically protect and separate a stream, lake, or wetland from future disturbance or encroachment. If properly designed, a buffer can provide storm water management, and can act as a right-of-way during floods, sustaining the integrity of stream ecosystems and habitats. As conservation areas, aquatic buffers are part aquatic ecosystem and part urban forest.

There are three types of buffers: water pollution hazard setbacks, vegetated buffers, and engineered buffers. Water pollution hazard setbacks are areas separating potential pollution hazards from waterways. Such buffer setbacks reduce the potential for pollution. Vegetated buffers are natural areas that divide land uses or provide landscape relief. Engineered buffers are specifically designed to treat storm water before it enters streams, lakes, or wetlands.

Street Design and Patterns

Two aspects of street design relate to storm water and its impacts. The first is the street itself. EPA, watershed researchers, and local governments have developed guidance on designing "green streets," that focuses on narrower widths, infiltration opportunities, and eliminating curbs and gutters. However, the underlying street patterns are just as influential, particularly as they relate to development patterns in a neighborhood and region.

Smart Growth Street Designs are based on a network of well-connected streets that support multiple transportation modes. Some smart growth approaches to street design include

decreasing street widths, adjusting the vehicular level of service (LOS), creating LOS for other modes of transportation, and designing connected street networks to support multiple uses.

Urban Forestry

Urban forestry is the study of trees and forests located in and around towns and cities. Since trees absorb water, patches of forest and the trees that line streets can help provide some of the storm water management required in an urban setting. Urban forests help break up a landscape of impervious cover, provide small but essential green spaces, and link walkways and trails.

Successful urban forestry requires a conservation plan for individual trees as well as forest areas larger than 10,000 square feet. A local forest or tree ordinance is one technique for achieving conservation, and when specific measures to protect and manage these areas are included, urban forests and trees can help reduce storm water management needs in urban areas.

Infiltration

Grassed Swales

In the context of BMPs to improve water quality, the term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to a vegetated, open-channel management practices designed specifically to treat and attenuate storm water runoff for a specified water quality volume. As storm water runoff flows along these channels, it is treated through vegetation slowing the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Infiltration Basin

An infiltration basin is a shallow impoundment which is designed to infiltrate storm water into the soil. This practice is believed to have a high pollutant removal efficiency and can also help recharge the ground water, thus increasing baseflow to stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

Infiltration Trench

An infiltration trench (a.k.a. infiltration galley) is a rock-filled trench with no outlet that receives storm water runoff. Storm water runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.

Porous Pavement

Porous pavement is a permeable pavement surface, often built with an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil. Porous pavement replaces traditional pavement, allowing parking lot storm water to infiltrate directly and receive water quality treatment. There are various types of porous surfaces, including porous asphalt, pervious concrete, and even grass or permeable pavers. From the surface,

porous asphalt and pervious concrete appear to be the same as traditional pavement. However, unlike traditional pavement, porous pavement contains little or no "fine" materials. Instead, it contains voids that encourage infiltration. Porous asphalt pavement consists of an open-graded coarse aggregate, bonded together by asphalt cement, with sufficient interconnected voids to make it highly permeable to water. Pervious concrete typically consists of specially formulated mixtures of Portland cement, uniform, open-graded coarse aggregate, and water. Pervious concrete has enough void space to allow rapid percolation of liquids through the pavement. Grass or permeable pavers are interlocking concrete blocks or synthetic fibrous grids with open areas that allow grass to grow within the voids. Some grid systems fill the voids with sand or gravel to allow infiltration. Other alternative paving surfaces can help reduce runoff from paved areas, but do not incorporate a stone trench for temporary storage below the pavement. While porous pavement can be a highly effective treatment practice, maintenance and proper installation are necessary to ensure its long-term effectiveness.

Like all BMPs, porous pavement should be combined with other practices to capitalize on each technology's benefits and to allow protection in case of BMP failure. However, construction using pervious materials may not require as much treatment as other BMP approaches. For instance, a small facility using porous pavement may only need several bioretention basins or a grass swale, rather than a full dry detention basin. This combined approach might prove less land intensive and more cost effective. It may increase the amount of open space for public or tenant use. It may also lead to an increase in environmental benefits.

Filtration

Bioretention (Rain Gardens)
Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of storm water runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system.

Catch Basin Inserts
Catch basins, also known as storm drain inlets and curb inlets, are inlets to the storm drain system. They typically include a grate or curb inlet and a sump to capture sediment, debris, and pollutants. Catch basins are used in combined sewer overflow (CSO) watersheds to capture floatables and settle some solids, and they act as pretreatment for other treatment practices by capturing large sediments. The effectiveness of catch basins, their ability to remove sediments and other pollutants, depends on its design (e.g., the size of the sump) and on maintenance procedures to regularly remove accumulated sediments from its sump.

Inserts designed to remove oil and grease, trash, debris, and sediment can improve the efficiency of catch basins. Some inserts are designed to drop directly into existing catch basins, while others may require retrofit construction.

Sand and Organic Filters
Sand filters are usually designed as two-chambered storm water practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As storm

water flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as storm water flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).

Vegetated Filter Strip

Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

Retention/Detention

Dry Detention Ponds

Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain storm water runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

In-Line Storage

In-line storage refers to a number of practices designed to use the storage within the storm drain system to detain flows. While these practices can reduce storm peak flows, they are unable to improve water quality and offer limited protection of downstream channels. Hence, EPA does not recommend using these practices in many circumstances. Storage is achieved by placing devices in the storm drain system to restrict the rate of flow. Devices can slow the rate of flow by backing up flow, as in the case of a dam or weir, or through the use of vortex valves, devices that reduce flow rates by creating a helical flow path in the structure. A description of various flow regulators is included in Urbonas and Stahre (1990).

On-Lot Treatment

The term "on-lot treatment" refers to a range of practices designed to treat runoff from individual residential lots. The primary purpose of most on-lot practices is to manage runoff from rooftops and, to a lesser extent, driveways and sidewalks. Rooftop runoff, particularly from residential roofs, generally has low pollutant concentrations compared to other urban sources (Schueler, 1994b). Managing runoff from rooftops effectively disconnects these impervious surfaces, reducing a watershed's overall imperviousness. This is important because many of the deleterious effects of urbanization on water quality can be traced to fundamental changes in the hydrologic cycle caused by increases in impervious materials, like roofs, covering the landscape (Schueler, 1994a).

Although a variety of on-lot treatment options exist, all can be placed in one of three categories: 1) practices that infiltrate rooftop runoff; 2) practices that divert runoff to a pervious area; and 3)

practices that store runoff for later use. The best option depends on the goals of a community, the feasibility at a specific site, and the preferences of the homeowner.
Schueler, T. 1994a. The importance of imperviousness. *Watershed Protection Techniques* 1(3):100-111.

Storm water Wetland
Storm water wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As storm water runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective storm water practices in terms of pollutant removal and they also offer aesthetic and habitat value. Although natural wetlands can sometimes be used to treat storm water runoff that has been properly pretreated, storm water wetlands are fundamentally different from natural wetland systems. Storm water wetlands are designed specifically for the purpose of treating storm water runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the storm water wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

A distinction should be made between using a constructed wetland for storm water management and diverting storm water into a natural wetland. The latter practice is not recommended because altering the hydrology of the existing wetland with additional storm water can degrade the resource and result in plant die-off and the destruction of wildlife habitat. In all circumstances, natural wetlands should be protected from the adverse effects of development, including impacts from increased storm water runoff. This is especially important because natural wetlands provide storm water and flood control benefits on a regional scale.

Wet Ponds
Wet ponds (a.k.a. storm water ponds, wet retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming storm water runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as storm water runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Traditionally, wet ponds have been widely used as storm water best management practices.

Reasonable Assurances

The recommendations made in this TMDL report will be carried out if the appropriate entities work to implement them. In particular, activities that do not fall under regulatory authority require that there be a committed effort by state and local agencies, governments, and private groups to carry out and/or facilitate such actions. The availability of adequate resources is also imperative for successful implementation.

The following discusses organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. This section establishes why it is reasonable to be assured of successful implementation.

Ohio EPA

The several programs that Ohio EPA Division of Surface Water (DSW) administers are designed to control pollution from point sources and certain storm water discharges as well as provide assistance for abating nonpoint sources of pollution. Other divisions within the Ohio EPA provide assistance such as funding, technical assistance, and education for water resource related issues. Information regarding the specific programs within the Ohio EPA DSW can be found on the web at http://www.epa.ohio.gov/dsw/Home.aspx, and information about the Division of Environmental and Financial Assistance (DEFA) at http://www.epa.ohio.gov/defa/Home.aspx. What follows are programs within the agency that are especially important for the implementation of this TMDL.

NPDES Program
National Pollution Discharge Elimination System (NPDES) permits authorize the discharge of substances at levels that meet the more stringent of technology or water-quality-based effluent limits and establish requirements related to combined sewer overflows, pretreatment, and sludge disposal. All entities that wish to discharge to the waters of the state must obtain a NPDES permit and both general and individual permits are available for coverage. Through the NPDES program (http://www.epa.ohio.gov/dsw/permits/permits.aspx), the Ohio EPA will use its authority to ensure that recommended effluent limits are applied to the appropriate permit holders within the watershed. Ohio EPA staff in the NPDES Program can provide technical assistance for permitted entities when needed. Permits issued under the NPDES program must be consistent with the point source recommendations in a TMDL that has been approved by the U.S. EPA.

Combined Sewer Overflow Program
Ohio EPA implements CSO controls through provisions included in NPDES permits and by using orders and consent agreements when appropriate. The NPDES permits for CSO communities require the implementation of nine minimum control measures (http://cfpub.epa.gov/npdes/cso/ninecontrols.cfm?program_id=5). Requirements to develop and implement Long Term Control Plans are also included where appropriate. Through the CSO program, the Ohio EPA will use its authority to ensure that recommended control activities are conducted by the permit holders within the watershed.

Storm Water Program
Ohio EPA implements the federal regulations for storm water dischargers (http://cfpub1.epa.gov/npdes/home.cfm?program_id=6). The following fact sheet describes which discharges are regulated (http://www.epa.ohio.gov/portals/35/storm/phase2factsheet.pdf). Both general and individual permits can be used for coverage of storm water effluent. The following website provides a list of Ohio EPA permitted storm water discharges: http://www.epa.ohio.gov/dsw/permits/gplist.aspx.

Through the Storm Water Program, the Ohio EPA will ensure that the storm water permit related recommendations of this TMDL are applied. Staff within the Storm Water Program provides technical assistance to permitted entities when needed. District Office staff within the Storm Water Program respond to and investigate complaints received by individuals and organizations.

401 Water Quality Certification Program
In Ohio, anyone wishing to discharge dredged or fill material into the waters of the United States, regardless of whether on private or public property, must obtain a Section 404 permit

from the U.S. Army Corps of Engineers (Corps) and a Section 401 Water Quality Certification (WQC) from the state.

Stream and wetland mitigation is used as a condition for granting 401 certificates and is the means of ensuring that water resources do not experience a net decline in quality. When a wetland or stream segment is impacted, an appropriate mitigation is required such that there is no net loss of wetlands or unimpaired stream length. Restoration, creation, or other forms of enhancement is required at a level that depends upon the original quality of the resource.

Currently there are proposed rules changes to the 401 Program that are designed to provide a more scientific basis for determining appropriate criteria for 401 permit decisions (i.e., acceptance or denial) as well as mitigation stipulations for the respective projects (http://www.epa.ohio.gov/dsw/401/index.aspx). These rule changes are expected to be finalized in 2008. Ohio EPA staff will conduct reviews and issue permits to provide the most reasonable protections and improvements, where possible, of surface waters in the watershed.

Wetland Protection Program
House Bill 231 established a permanent permitting process for isolated wetlands. Reviewers in the 401 Water Quality Certification Section are responsible for the isolated wetland permits required by this state law. Ohio EPA staff will conduct reviews and issue permits to provide the most reasonable protections and improvements of surface waters in the watershed.

Enforcement Program
When Ohio EPA is unable to resolve continuing water quality problems because of violations of permitting rules or laws, the DSW may recommend that enforcement action be taken. The enforcement and compliance staffs work with Ohio EPA attorneys, as well as the Attorney General's Office to resolve these cases. Where possible, an added emphasis and priority is given to actions in sensitive watersheds. All completed enforcement actions are posted on the DSW web page.

208 Program (State Water Quality Management Plans)
Ohio EPA oversees the State Water Quality Management (WQM) Plan. The State WQM Plan is like an encyclopedia of information used to plot and direct actions that abate pollution and preserve clean water. A wide variety of issues is addressed and framed within the context of applicable law and regulations. The TMDL becomes a part of the State WQM Plan when it is approved by the U.S. EPA and the recommendations found herein align with and support the state's overall plan for clean waters. More importantly, the requirement and intention to review and update the State WQM Plan on an annual basis creates an avenue to apply adaptive management and make adjustments in these recommendations as necessary.

Nonpoint Source Program
The Ohio Nonpoint Source (NPS) program focuses on identifying and supporting implementation of management practices and measures that reduce pollutant loadings, control pollution from nonpoint sources and improve the overall quality of these waters. Ohio EPA receives federal Section 319(h) funding to implement a statewide nonpoint source program, including offering grants to address nonpoint sources of pollution. Staff from the NPS program work with state and local agencies, governments, watershed groups, and citizens.

In addressing sources of impairment related to agricultural activities, NPS staff will correspond with Ohio DNR to promote BMPs as well as cost-share and incentive based conservation programs. In particular, Ohio EPA will encourage the Ohio DNR to continue to work with Farm

Service Agency personnel and staff from local SWCD and NRCS offices. NPS staff will also provide assistance to agencies and groups actively promoting conservation as well as direction to other appropriate resources within the Ohio EPA.

NPS staff will continue to work with any watershed groups active in the basin. Local NPS implementation is critical to achieving state environmental targets. Additionally, there is a reliance on watershed management plans to identify and outline actions to correct water quality problems caused by NPS pollution.

Section 319(h) grants are expected to be directed to projects that eliminate or reduce water quality impairments caused by nonpoint sources of pollution. Applicants may apply for a maximum of $500,000 for a three year period. Each project funded must provide an additional 40% matching share and the total federally funded share of project costs may not exceed 60%. Because a TMDL exists, grant proposals for work within the watershed will receive special consideration for funding.

Division of Environmental and Financial Assistance
The Division of Environmental and Financial Assistance (DEFA) provides incentive financing, supports the development of effective projects, and encourages environmentally proactive behaviors through the Ohio Water Pollution Control Loan Fund (WPCLF). Municipal wastewater treatment improvements—sewage treatment facilities, interceptor sewers, sewage collection systems and storm sewer separation projects—are eligible for financing. Nonpoint pollution control projects that are eligible for financing include:

- Improvement or replacement of on-lot wastewater treatment systems
- Agricultural runoff control and best management practices
- Urban storm water runoff
- Septage receiving facilities
- Forestry best management practices

The Water Resource Restoration Sponsor Program (WRRSP) is a part of the WPCLF and directs funding toward stream protection and restoration projects. The primary focus of this program is to improve and protect stream habitat. Like Section 319 (h) grants, proposals for stream improvements within the watershed will receive special consideration.

Ohio Department of Natural Resources

The Ohio DNR works to protect land and water resources throughout Ohio. A specific objective in regards to water resources is to *"Lead in the development and implementation of stream and wetlands conservation initiatives, applying advanced science, technology and research to restore and protect stream and wetlands habitats."* This commitment attests that the Ohio DNR will be a reliable partner in addressing causes and sources of impairment in the watershed.

The following are programs and divisions within the Ohio DNR that are particularly instrumental in protecting and improving water resources within the watershed.

Pollution Abatement Program
Under Ohio's Pollution Abatement Rules (OAC 1501) the Ohio DNR is required to respond to written and non-written complaints regarding agricultural pollution. As defined by OAC 1501, agricultural pollution is the "failure to use management or conservation practices in farming or silvicultural operations to abate wind or water erosion of the soil or to abate the degradation of

waters of the state by animal waste or soil sediment including substances attached thereto." In cooperation with SWCDs, an investigation is begun within five days of receipt of the complaint and a Pollution Investigation Report (PIR) is generated within ten days. Resource management specialists from Ohio DNR within the Division of Soil and Water Conservation (DSWC) typically become involved with pollution abatement cases in their respective areas of the state.

If it is determined necessary, an operation and management plan will be generated to abate the pollution. This plan is to be approved by the SWCD or Ohio DNR and implemented by the landowner. Cost-share funding may be available to assist producers in implementing the appropriate management practices to abate the pollution problems and such practices may be phased in if necessary. If a landowner fails to take corrective action within the required timeframe, the Chief of the Division of Soil and Water Conservation (Ohio DNR) may issue an order such that failure to comply is a first degree misdemeanor. This program safeguards against chronic problems that lead to the degradation of water quality.

SWCD Program

Ohio DNR-DSWC has a cooperative working agreement with the Soil and Water Conservation Districts throughout Ohio and the NRCS. According to the agreement Ohio DNR-DSWC is responsible to "provide leadership to Districts in strategic planning, technical assistance, fiscal management, staffing, and administering District programs." The Division also provides "training and technical assistance to District supervisors and personnel in their duties, responsibilities, and authorities." Program Specialists from Ohio DNR work with the SWCDs to identify program needs and training opportunities. Ohio DNR also ensures that program standards and technical specifications are available to SWCDs and NRCS personnel.
State matching dollars from the Ohio DNR constitute roughly half of the annual operating budgets of SWCDs.

Through the partnership established by the working agreement and their history of collaboration, Ohio DNR can communicate the goals and recommendations highlighted in this TMDL to SWCDs and provide guidance to actively promote conservation efforts that are consistent with those goals.

Urban Storm Water Program

Ohio DNR staff provides technical expertise regarding storm water management and controls as well as administers urban storm water-related grants. The Urban Storm Water Program has been responsible for the development and maintenance of the Rainwater Manual for the State of Ohio which provides guidance regarding storm water management and sediment and erosion control measures.

Staff from the Urban Storm Water Program will be an important resource for communicating with the development community and promoting storm water management that is consistent with recommendations and goals of this TMDL report.

Scenic River Program

The Scenic River Program is administered within the Division of Natural areas and Preserves (DNAP) and functions according to the Scenic Rivers Act of 1968. By statute, Ohio DNR has the authority to approve or disapprove any publicly funded projects on streams with a Scenic River designation that lie outside of municipal boundaries. Decisions are based on the potential impact that such projects may have on stream quality. An appointed citizens' advisory council, representing local officials, landowners and conservation organizations, provides advice regarding local river preservation and protection concerns.

Staff within the Scenic River program communicates with private citizens, businesses, local governments, watershed groups, and other organizations in regards to streamside preservation and other actions that protect and/or improve water quality. Scenic River coordinators will be useful resources in communicating with the development community in this part of the watershed and advancing appropriate planning, setbacks, preservation, and management strategies.

Division of Forestry
The mission of the Division of Forestry is to promote sustainable use and protection of forests on public and private lands. The division provides technical expertise and other forms of assistance regarding riparian forest establishment and protection.

Division of Wildlife
Through efforts to increase the amount of habitat for game birds and other forms of wildlife, private lands biologists actively promote the establishment of warm season grass in buffer strips and on cropland set-asides. Private lands biologists come into contact with private landowners and conservation groups to educate, and provide assistance regarding these types of habitat improvements.

Agricultural Services and Programs

Local SWCD, NRCS, and Farm Service Agency (FSA) offices often work to serve the county's agricultural community. Staffs from these offices establish working relationships with private landowners and operators within their county, which are often based on trust and cooperation.

SWCD and NRCS staffs are trained to provide sound conservation advice and technical assistance (based on standard practices) to landowners and operators as they manage and work the land. Sediment and erosion control and water quality protections make up a large component of the mission of their work. SWCD and NRCS activities also include outreach and education in order to promote stewardship and conservation of natural resources. SWCD and NRCS staffs also serve county residents not associated with agriculture and some districts have well developed urban conservation programs.

The close working relationships that SWCD and NRCS staffs typically maintain with local land owners and producers make them well suited for promoting both widely used conservation practices as well as some that are more innovative.

Federal Farm Bill programs are administered by the local NRCS and FSA offices. NRCS is responsible for the Environmental Quality Incentives Program (EQIP), while FSA is responsible for set-aside programs such as the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and the Wetland Reserve Program (WRP).

Environmental Quality Incentives Program
EQIP is an incentive-based, voluntary program designed to increase the use of agriculturally-related best management and conservation practices. EQIP is available to operators throughout the entire watershed irrespective of whether they own or rent the land that they farm. Through this program operators receive cost share and/or incentive payments for employing conservation management practices. Contracts are five years in length.

Eligible conservation practices cover broad categories such as nutrient and pesticide management, conservation tillage, conservation crop rotation, cover cropping, manure management and storage, pesticide and fertilizer handling facilities, livestock fencing, pastureland management, and drainage water management among others. However, funding for these practices is competitive and limited to the allocations made to any respective county in Ohio. Each county in receives a minimum of $100,000 per year and may receive more depending on state priorities for that year. More information on this program is available on the NRCS website at www.nrcs.usda.gov.

Conservation Reserve Program and Wetland Reserve Program
The Conservation Reserve and Wetland Reserve Programs (CRP and WRP respectively) are set aside programs much like the CREP (see below), which is the enhanced version of CRP. The goals of these programs are to protect environmentally sensitive lands (e.g., highly erodible soils) and improve water quality and wildlife habitat.

Set aside programs are voluntary and incentive-based and provide compensation to farmers for establishing and maintaining buffers, wetlands, grasslands or woodlands on land that would otherwise be used for agricultural production. Compensation is restricted to the timeframe established in the contract agreement. Incentive payments for these two programs are lower than the enhanced versions (CREP and WREP), which are limited to areas that have been approved by the USDA for the additional funding. These programs can assist in creating land use changes that improve water resource quality in the watershed.

Watershed Conservation Reserve Enhancement Program
The Conservation Reserve Enhancement Program (CREP) is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. The program is a partnership among producers; tribal, state, and federal governments; and, in some cases, private groups. CREP is an offshoot of the country's largest private-lands environmental improvement program, the Conservation Reserve Program (CRP; see above).

Like CRP, CREP is administered by USDA's Farm Service Agency (FSA). By combining CRP resources with state, tribal, and private programs, CREP provides farmers and ranchers with a sound financial package for conserving and enhancing the natural resources of farms.

CREP addresses high-priority conservation issues of both local and national significance, such as impacts to water supplies, loss of critical habitat for threatened and endangered wildlife species, soil erosion, and reduced habitat for fish populations such as salmon. CREP is a community-based, results-oriented effort centered around local participation and leadership.

A specific CREP project begins when a state, Indian tribe, local government, or local nongovernment entity identifies an agriculture-related environmental issue of state or national significance. These parties and FSA then develop a project proposal to address particular environmental issues and goals. In Ohio, there are three CREP programs: one in the Scioto River basin; one in the upper Big Walnut Creek basin; and one in the Western Lake Erie basin.

Like CRP, CREP contracts require a 10- to 15-year commitment to keep lands out of agricultural production. CREP provides payments to participants who offer eligible land. A federal annual rental rate, including an FSA state committee-determined maintenance incentive payment, is offered, plus cost-share of up to 50 percent of the eligible costs to install the practice. Further, the program generally offers a sign-up incentive for participants to install specific practices.

FSA uses CRP funding to pay a percentage of the program's cost, while state, tribal governments or other non-federal sources provide the balance of the funds. States and private groups involved in the effort may also provide technical support and other in-kind services.

Extension and Development Services

Each county in Ohio has an extension agent dedicated to agricultural and natural resource issues. The primary purpose of extension is to disseminate up-to-date science and technology so it can be applied for the betterment of the environment and society. Like SWCD and NRCS staff, extension agents provide technical advice to landowners and operators and often develop strong relationships with the local community. Local extension agents are particularly well-suited for promoting innovative conservation measures that have not yet been established in the standard practices developed by NRCS.

Agricultural Organizations and Programs

Agricultural organizations are working to address water quality problems associated with traditional farming practices. The Ohio Farm Bureau Federation (OFBF) seeks to improve water quality through the employment of economically sound conservation management practices (http://www.ofbf.org/). In order to pursue this mission, OFBF initiated programs aimed at engaging producers in voluntary water quality protection and improvement efforts. At the local level most county Farm Bureaus have a chairperson of an Agricultural Ecology committee that is responsible to administer OFBF programs related to environmental quality. The Agricultural Ecology chairperson often works with the county's Organizational Director, who is a staff member of the OFBF, to implement program initiatives.

The Agricultural Watershed Awareness and Resource Evaluation program within the OFBF promotes water quality monitoring and education so that producers have more information when making decisions regarding their operations. OFBF has collaborated with other organizations through the Ohio Agricultural Environmental Assurance Alliance (OAEAA) in developing a self assessment program aimed at identifying source of water pollution on farms and developing strategies to abate those problems. OFBF also offers assistance to producers who are having difficulties in complying with environmental regulations.

The Ohio Livestock Coalition (OLC) developed the Livestock Environmental Assurance Program (LEAP). This program provides training to producers in employing best management practices to their livestock operations. The On Farm Assessment and Environmental Review (OFAER) is a national program similar to LEAP but provides a more comprehensive analysis. Livestock producers can request an evaluation of their operation that is conducted by a two-person assessment team. Following the assessment, OFAER participants receive a confidential report that highlights the specific areas on their operation that can be improved in terms of environmental soundness and has recommendations for such improvements. Both of the programs are available to persons operating farms in the watershed.

Local Health Departments

Under OAC 3701-29, local health departments are responsible for code enforcement, operational inspections, and nuisance investigations of household sewage treatment systems

serving one, two, or three family dwellings. The Ohio Department of Health works with locals health departments and provides technical assistance and training.

Local Zoning and Regional Planning

Local zoning is typically controlled at the county or municipality level. Local zoning can be a useful tool for implementing some recommendations of the TMDL, such as streambank setbacks for developing land.

Local governments typically conduct planning to meet the sewage disposal needs of the community. Ohio EPA has established guidelines for planning that are useful in the context of Section 208 and the State Water Quality Management Plan. Local governments that follow these guidelines are more likely to have the results of their planning work incorporated into the State 208 plan prepared by Ohio EPA. The Areawide Planning Agencies have established their own operating protocols, committees and processes to involve local governments in shaping their 208 plans.

Planning should account for long range sewer and treatment needs by looking at projections for community growth and development. Comprehensive land use planning, where available, is an excellent tool that can help those assessing the sewage disposal needs of a community or group of communities. In highly populated areas regional solutions involving several communities have proven to be a cost-effective means to solve sewage disposal problems in urban and suburban areas.

Regulated Storm Water Communities

Regulated storm water communities must develop storm water management programs that include controls for the six minimum control measures outlined by the U.S. EPA (http://www.epa.ohio.gov/dsw/storm/ms4_index.aspx). Local areas that fall within the municipal separate storm sewer system (MS4) program are regulated under the general storm water permit for the State of Ohio.

Easements and Land Preservation

A conservation easement is a voluntary agreement that allows a landowner to limit the type or amount of development on their property while retaining private ownership of the land. The easement is signed by the landowner, who is the easement donor, and the party receiving the easement. The receiving party accepts the easement with understanding that it must enforce the terms of the easement in perpetuity. After the easement is signed, it is recorded with the County Register of Deeds and applies to all future owners of the land (landtrust.org/). Easements and preservation agreements can be excellent tools to preserve high quality or particularly diverse areas within a watershed. Frequently such agreements will include streams, riparian areas and/or wetlands.

Process for Evaluation and Revision

The effectiveness of actions implemented based on the TMDL recommendations should be validated through ongoing monitoring and evaluation. Information derived from water quality analyses can guide changes to the implementation strategy to more effectively reach the TMDL

goals. Additionally, monitoring is required to determine if and when formerly impaired segments meet applicable water quality standards (WQS).

This section of the report provides a general strategy for continued monitoring and evaluation and lists parties who can potentially carry out such work. It highlights past efforts and those planned to be carried out in the future by the Ohio EPA and others. It also outlines a process by which changes to the implementation strategy can be made if needed.

Evaluation and Analyses

Aquatic life and recreational uses are impaired in the watershed, so monitoring that evaluates the river system with respect to these uses is a priority to the Ohio EPA. The degree of impairment of aquatic life use is exclusively determined through the analysis of biological monitoring data. Recreational use impairment is determined through bacteria counts from water quality samples. Ambient conditions causing impairment are discussed in the main text of the report. This report sets targets values for these parameters, which should also be measured through ongoing monitoring.

A serious effort should be made to determine if and to what degree the recommended implementation actions have been carried out. This should occur within an appropriate timeframe following the completion of this TMDL report and occur prior to measuring the biological community, water quality or habitat.

Recommended Approach for Gathering and Using Available Data
Early communications should take place between the Ohio EPA and any potential collaborators to discuss research interests and objectives. Through this, areas of overlap should be identified and ways to make all parties research efforts more efficient should be discussed. Ultimately important questions can be addressed by working collectively and through pooling resources, knowledge, and data.

Revision to the Implementation Approach

An adaptive management approach will be taken in the watershed. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al., 1999) and this approach is applied on federally-owned lands. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the current strategy is inadequate or ineffective. The recommendations put forth for the watershed are discussed in the last chapter of the main report. If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the implementation plan has been carried out, then a TMDL revision would be initiated. The Ohio EPA would initiate the revision if no other parties wish to do so.

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