

CHAPTER 8:

BEST MANAGEMENT PRACTICES

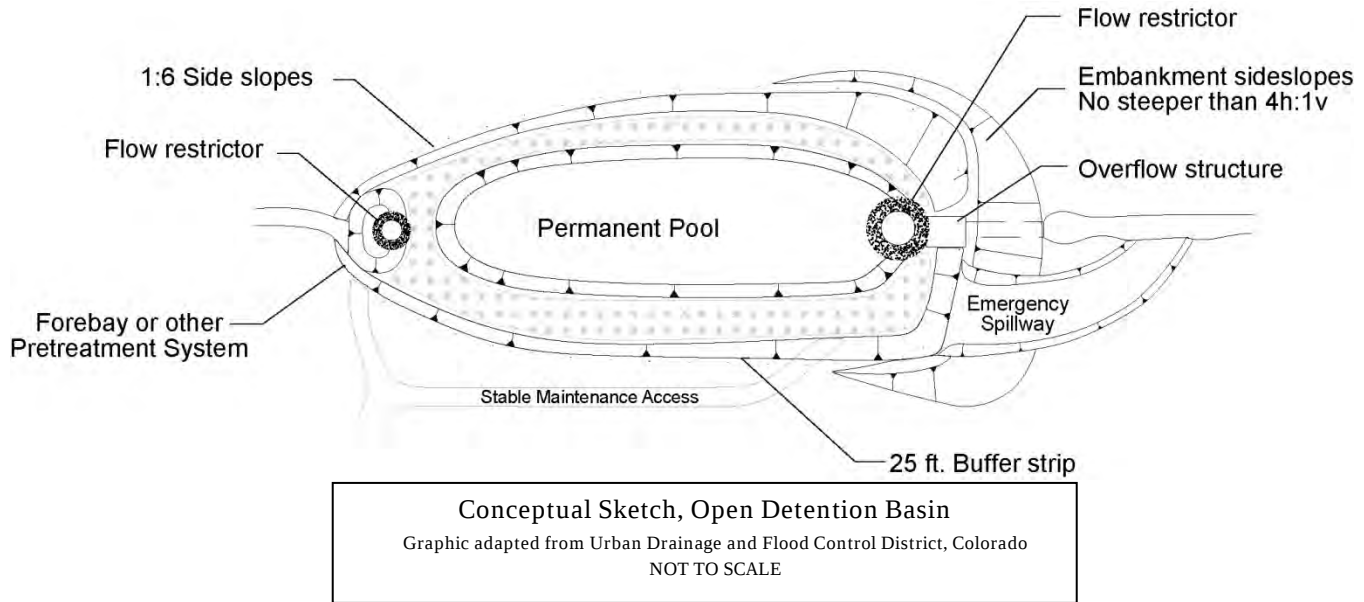
This chapter describes some of the most common Best Management Practices (BMPs) which may be used in designing a storm water management system. The information provided for each BMP includes a description

of the BMP and its purpose along with design criteria and guidelines, specifications and maintenance requirements. The type of applications for the BMPs in this section are summarized in the table below.

Best Management Practice	Use For					To Control									
	Paved Areas	Vegetated Areas	Unstable Soils	Waterways	Development Projects	Increased Flow Variability	Floatable Materials	Particulate Matter	Organic Matter	Dissolved Nutrients	Water-soluble Materials	Toxic Materials	Oil/Petroleum Products	Soil Erosion	Riparian Corridor and Habitat Loss
Detention and Retention (Section 8.1)															
Open Detention Basins	X	X			X	X	X	X	X	X	X	X	X	X	X
Retention Basins	X	X			X	X	X	X	X	X	X	X	X	X	X
Underground Detention Systems	X	X			X	X	X	X							
Outlets for Forebays and Detention Systems															
Pretreatment Systems (Section 8.2)															
Forebays	X	X			X		X	X	X						
Bioretention Areas	X	X					X	X					X		
Manufactured Treatment Systems	X	X		X	X	X		X							
Conveyance (Section 8.3)															
Closed Conduit Inlet/Outlet Design															
Vegetated Swales		X	X		X	X	X		X						
Streambank Stabilization (Section 8.4)															
Live Stakes		X	X	X	X			X						X	X
Live Fascines		X	X	X	X			X						X	X
Vegetated Geogrids		X	X	X	X			X						X	X
Live Cribwall		X	X	X	X			X						X	X
Brushmattress		X	X	X	X			X						X	X
Log Placements		X	X	X	X			X						X	X
Vegetation and Riparian Corridor Management (Section 8.5)															
Vegetation		X	X	X	X	X		X						X	X
Riparian Buffers		X	X	X	X	X		X						X	X
No-Mow Zones		X	X	X	X	X		X						X	X
Woody Debris Management		X	X	X	X	X		X						X	X

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8.1.1 Open Detention Basins



Open detention basins are man-made surface waters designed to temporarily detain storm water runoff to control peak flow rates and provide for pollutant removal through settling and plant uptake. There are two types of open detention basins traditionally used in Wayne County:

- Traditional detention basins, which detain storm water runoff for an extended period of time in a permanent pool and remove sediment and other pollutants via settling.
- Constructed wetlands, where over 50% of the surface area typically is covered by wetland vegetation. Permanent wetland pool depths may vary between 0.5 and 3.0 feet, depending on vegetation type.

Design Standards

Open detention basins must be sized to detain the required storage volumes (both the bank full and flood control volumes). Design standards specific to open detention basins include the following:

- A forebay or other pretreatment system is required at each inlet to the detention basin. Pretreatment systems trap sediment before entering the detention basin, reduce the incoming runoff velocities, and spread runoff evenly over the detention basin to create sheet flow conditions. Section 8.2 of this manual

provides detailed information and design criteria for pretreatment systems.

- All closed conduits entering or exiting an open detention system should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- Open detention basins must have a restricted outlet that limits outflow for the bank full flood and for the maximum allowable release rate from the development site.
- Flow restrictors, overflow structures, and emergency spillways are required for all open detention basins. Section 8.1.4 provides design criteria for outlet structures associated with forebays and open detention basins. Flow restrictors must be placed near or within the embankment of the detention basin to provide ready maintenance access.
- Open detention basins must include a minimum four (4) foot deep permanent pool that allows for removal of urban pollutants through settling and biological uptake. The volume of the permanent pool does not satisfy any portion of the required flood control storage volume.

- The design water level of an open detention basin must not exceed five (5) feet above the permanent pool water level.
- A minimum of one (1) foot of freeboard is required above the design water level of an open detention basin.
- Providing a safe design is a primary consideration for all storm water management systems. Side slopes for open detention basins must not be steeper than 1:6. Further safety measures (e.g., aquatic benches or safety shelves, vegetative and barrier plantings) may be warranted depending on the type of development.
- Although use of terraced side slopes generally is discouraged when other alternatives exist, terraced side slopes may be approved for open detention basins in certain, limited circumstances at the discretion of Wayne County. The overall slope of a terraced side of an open detention basin should not be steeper than 1:3. An example detail for terraced side slopes is provided in Appendix E-3.



Photo courtesy Environmental Consulting & Technology (ECT)

- Open detention basins may not be located within pre-existing surface waters.
- Plant vegetation is required for all types of open detention basins to control erosion and enhance sediment entrapment. A landscaping plan is required for open detention basins, due to the importance of the vegetation to the function of the entire system. Use of a registered landscape architect with experience in storm water management system design and native landscaping is encouraged.
- In constructed wetlands, a diversity of depth zones throughout the basin should be used to meet the unique growing requirements of divergent wetland plants. Use of a qualified

professional with specific expertise in hydrology and wetland plant ecology is recommended for design and construction of these systems.

- A buffer strip must be provided around all surface waters such as open detention basins. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the surface water or basin. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the pond perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room along the top of the basin to provide access to the basin for maintenance. The right side of the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” provided in Attachment C to this section illustrates a typical buffer strip associated with an open detention basin.
- In the following situations, the minimum width of the buffer strip around open detention basins is 15 feet measured from the minimum freeboard elevation of the basin:
 - When an open detention basin has a drainage area 5 acres or less; or
 - When an open detention basin has a drainage area greater than 5 acres and no storm water from areas outside of or within the buffer strip enters the basin via direct sheet flow (See the right side of the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” provided in Attachment C to this section).

Preferred Design Elements

- Open detention basins should be designed to maximize sheet flow across the open water portion of the facility.
- The shape and configuration of open detention basins will vary considerably based on detention type and storage requirements, local topography, land availability, hydraulic considerations, and other site-specific constraints. Generally, a rectangular configuration is preferable, with an approximate length to width ratio of 3:1. Inlet and outlet pipes should be placed at opposite ends.

- If a terraced side slope is approved by Wayne County for use in a detention basin, the materials proposed for use in its construction should be approved by the local community.
- Baffles may be used to increase the flow path and maintain the topography.
- If aerating devices are used as part of a storm water management system, they should be designed to minimize disturbance of bottom sediments. For example, open detention basins may need to have a deeper permanent pool if an aerating device is used. Bubbler systems are the preferred type of aerating device as they have been found to be more efficient at providing aeration. The manufacturer's recommendations should be followed in regards to design and maintenance.
- The locations of any mechanical structures/devices necessary for pond operation should be identified on the plans. The location should include a description of whether the structure/device is above ground or below ground.
- When discharge is within a watershed where thermal impacts are a primary concern, deep wet ponds with bottom draw may be required.

Vegetation Specifications

- A landscaping plan is required for open detention basins due to the importance of the vegetation to the function of the entire system. Vegetation should be specified for each zone within the detention basin as follows:
- Pond zone (permanent water depths from 0 to 3 ft deep): Vegetation in the pond zone is entirely or partially submerged and should consist of a combination of native plant plugs and bare-root stock.
- Edge zone (permanent water elevation to bank full elevation): Vegetation in the edge zone must withstand periods of inundation and drought. This vegetation also stabilizes the side slopes of the facility.
- Upland zone (bank full elevation to 100-year flood elevation and beyond): Vegetation in the upland



Bulrush
(Photo courtesy ECT)

zone may have little or no inundation by storm water, and must withstand periods of drought. This vegetation also stabilizes the side slopes of the system. Note that the buffer strip lies within the upland zone.

The landscaping plan for open detention basins should identify the following items:

- Existing site conditions and vegetation (e.g., trees 6-in caliper and larger) that may be affected by the project;
- Plan view of the open detention basin, including one foot grading contours;
- Elevations in the open detention basin, including detention basin bottom elevation, permanent water elevation, bank full storm elevation, 100-year storm elevation, and freeboard elevation;
- Area in square feet of each of the three planting zones (pond zone, edge zone, and upland zone);
- Seed mixes and wetland plugs/bare root stock in each of the three planting zones;
- Plant spacing and applicable depths, based on industry standards; and
- If the construction plans include any mechanical structures/equipment necessary for pond operation, use of evergreen trees (or other trees/shrubs recommended for the appropriate pond zone) around the mechanical structure should be considered if visual screening of the equipment is appropriate for the location.

All plant material and planting applications should meet all guidelines set by the American Standard of Nursery Stock. All plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association (see "References and Additional Resources" on page 8-6).

The type of vegetation used for open detention basins is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation for open detention basins should be composed of a mixture of species that will provide temporary cover (e.g., quick growing species such as annual rye grass (*Lolium multiflorum*)) and species which will provide the permanent cover (e.g., seed oats).

Use of native plants and “no mow zones” is encouraged. Native plants are adapted to the local climate and conditions, and have numerous short-term and long-term advantages.

Vegetation for open detention basins should be specified in the following categories:

- Seed mixes – Many species can be successfully established from seed mixes, including grasses, sedges and rushes; and forbs (herbaceous plants, other than grasses, that commonly grow in fields or meadows). Forbs are used for re-vegetation, wild flower gardens, prairie and detention basin planting and roadside plantings.
- Bare-root stock – Plants received with very little, if any, soil around the roots. Bare-root stock generally is wrapped in Hessian cloth or plastic to prevent the roots from drying out.
- Plugs – Plants raised as individual plants, each in a small container about the size of an ice cube. The cube of greenhouse soil (“plug”) can be pried from the tray, containing an individual plant up to 6 inches tall. Using a digging stick, the plants are plugged into the soil.

Additional specifications for designing the planting areas in each zone of an open detention basin are appended to the end of this section as Attachment A. The specifications recommend native plant species for each zone of open detention systems built in Wayne County.

Local community requirements for vegetation should also be consulted.



Photo courtesy Environmental Consulting & Technology (ECT)

Construction

Proper construction techniques, particularly installation of vegetation, are important to the successful functioning of open detention basins, especially for constructed wetland-type open detention basins in order to establish a dense and diverse emergent wetland plant community.

General guidelines for vegetation installation include:

- If emergent plant stock is proposed in the pond zone, the supplied plug material must have sufficient vegetative growth extending out of the water once planted.
- Seed must be planted above the permanent water elevation.
- All seeded areas should be properly stabilized with a mulch blanket pegged in place.
- Depending on the type of vegetation, barriers may be required for one year to protect the plantings (e.g., snow fence or netting to deter wildlife, prevent mowing).
- Additional guidance on seed and sod specifications and installation is provided in Section 8.5.1 of this manual.

For constructed wetland-type open detention basins, preparation of the wetland bed prior to planting is crucial to success. Good results can be achieved through the five-step process shown in Attachment B to this section.

Maintenance

Maintenance activities for open detention basins are listed below. These activities must be identified in the maintenance plan that the applicant must submit with an application for storm water construction approval. Additionally, provision for maintenance access should be shown on the plan; it is recommended that the maintenance access to the storm water management system be a minimum of 15-feet wide. The landscape plan should be designed to prevent obstruction of the access by trees and shrubs.

- Inspect and clean the storm sewer system and catch basins upstream from the detention basin (every five years or as needed).
- Inspect for sediment accumulation at the inlet pipes and remove sediment which may be

impeding flow (semiannually and after rain events).

- Inspect inlets, outlets, and appurtenances (e.g., grates) annually for structural integrity.
- Check the outlets regularly for clogging and clean when necessary, especially after large storm events.
- Inspect the stone around riser-type outlet structures semiannually and after rain events. If stone has accumulated sediment, vegetation and/or debris to an extent that water is not flowing through the stone and out of the pond as originally designed, then the stone should be replaced.
- Check for floatables and debris and remove as necessary.
- Remove dead vegetation that obstructs flow (early spring).
- Check banks and bottom for erosion, and regrade or reshape as necessary (annually).
- Remove sediment when accumulation reaches 6 – 12 inches or if resuspension is observed.
- Reseed banks near inlet/outlet and stabilize eroded banks as necessary.
- Inspect detention basin and buffer strip zone for invasive species such as purple loosestrife, phragmites, buckthorn (common & glossy), honeysuckle and autumn olive that out-compete native vegetation (annually - July).
- Have a professional selectively remove invasive species (annually, July-August). Purple loosestrife flower heads can be clipped off to reduce seed production until plant removal may be achieved. If woody debris is cut, the cut should be four inches above the ground surface and the stumps should be treated with herbicide immediately after cutting, and monitor for sucker growth. Use of chemicals within the pond (e.g., for control of algae or invasive species) requires a permit from the MDEQ.
- Plantings must be monitored for two years after establishment. Replacement will be necessary as determined by the agency having jurisdiction over the system.
- During the first two growing seasons, all areas planted with native prairie seed mix should be mowed three times at a height of 6-8 inches in order to control weeds. Beginning in the third year, a burning or mowing regimen should be

instituted, either burning or mowing once in spring, or once in the fall.

- Except as described herein, ensure that no mowing, chemical application, or construction has occurred in the buffer strip (annually). If it has, take corrective action to ensure these activities do not occur in the future.
- Except as described herein, ensure that chemicals are not applied to any aspect of the open detention basin, including the bottom, side slopes or buffer strip.
- If the outlet is pumped, then only a licensed electrician or company that provided the pump system should conduct maintenance.

References and Additional Resources

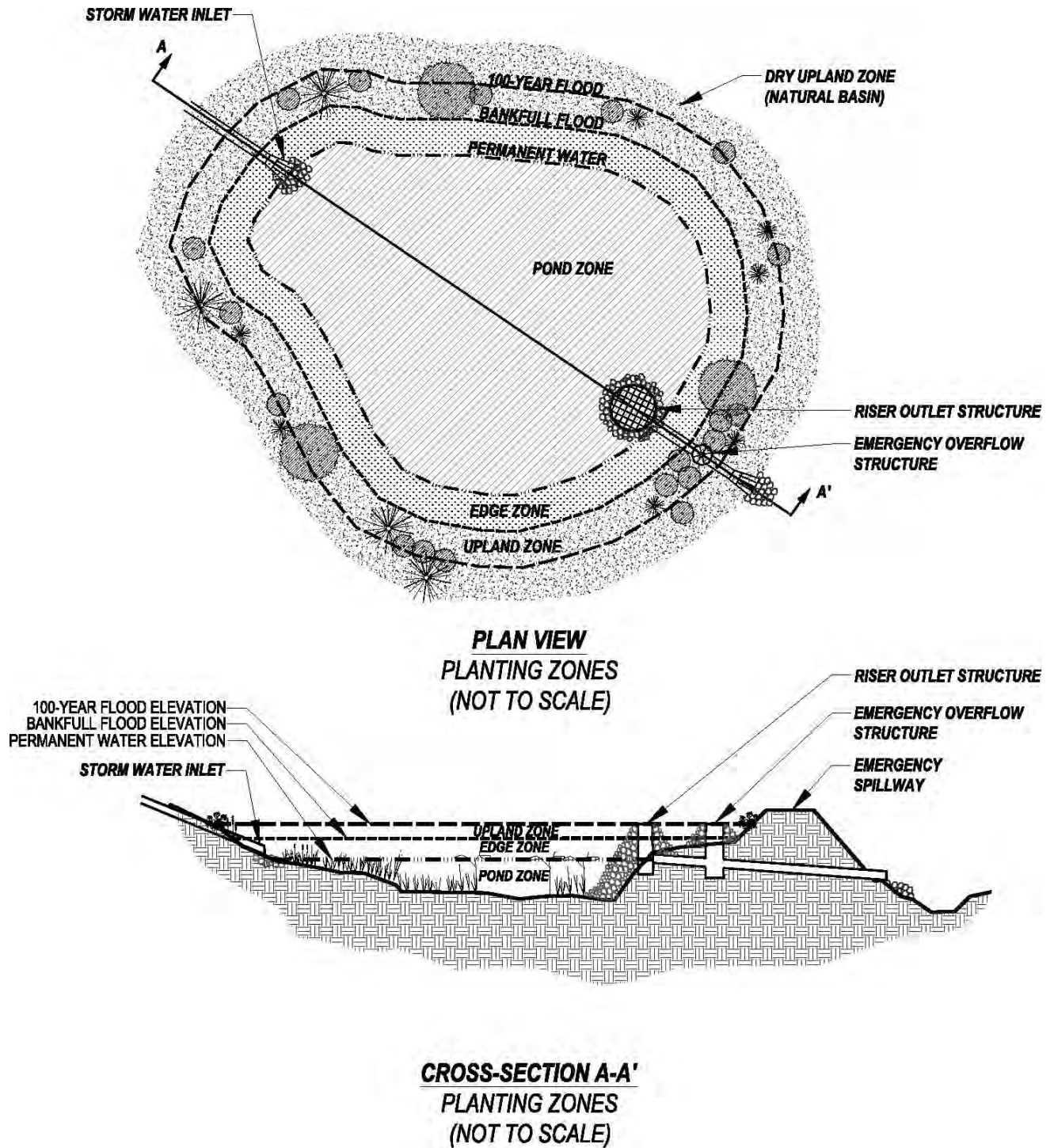
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Wild Ones Organization,
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ATTACHMENT A: SPECIFICATIONS FOR PLANTING ZONES FOR OPEN DETENTION BASINS

All material in this appendix is adapted from "General Landscaping Requirement, Storm Water Detention Basins", Zoning of the Code of Laws and Ordinances, Charter Township of Canton, July 11, 2006 and used courtesy of Canton Township, Municipal Services Division.



SCHEMATIC OF PLANTING ZONES FOR OPEN DETENTION BASINS

OPEN DETENTION BASINS: POND ZONE VEGETATION

A combination of native plant plugs and bare-root stock should be planted in the pond zone (0 to 3 feet deep). The tables below identify native plants recommended for the pond zone of an open detention basin. Alternate species or genus from those recommended in the following tables may be specified if they meet the criteria for successful establishment in each pond zone.

Additional factors for design of vegetation within the pond zone of an open detention basin include:

- Plants should be selected based on whether they will be submerged, emergent, or wetland edge.
- A minimum of four plant species is recommended for the pond zone, planted in equal numbers of species, scattered in groupings of similar species throughout the entire zone.
- Initial plantings should cover a minimum of 25% of the outer 15 foot perimeter of the pond zone.
- For constructed wetlands, rooted wetland species, such as cattails, bulrush and sedges, are placed throughout the majority of the wetland area.
 - A mixture of wetland plants should be used in the shallow pool that extends laterally across the basin.
 - A diversity of depth zones should be used throughout the system to meet the unique growing requirements of divergent wetland plants.
- Planting of purple loosestrife is not permitted as this invasive plant forms dense colonies which out-compete the native environment.

Alternately, the pond zone may be seeded with a suitable mix if it is demonstrated that the pond hydrology will be controlled for the establishment of the proposed mix.

Native Plants for Pond Zone (minimum 4 species)

Scientific Name	Common Name	Spacing (inches on center)	Scientific Name	Common Name	Spacing (inches on center)
<i>Acorus calamus</i>	Sweet flag	24	<i>Polygonum amphibium</i>	Water knotweed	36
<i>Carex lacustris</i>	Common lake sedge	24	<i>Pontederia cordata</i>	Pickerel weed	24
<i>Cephalanthus occidentalis</i>	Buttonbush	5 feet	<i>Potamogeton natans</i>	Common pondweed	36
<i>Decodon verticillatus</i>	Swamp Loosestrife	24	<i>Potamogeton pectinatus</i>	Sago pondweed	36
<i>Elodea canadensis</i>	Common waterweed	36	<i>Sagittaria latifolia</i>	Common arrowhead	24
<i>Hibiscus laevis</i>	Halberd-leaved rose mallow	24	<i>Scirpus acutus</i>	Hard-stemmed bulrush	18
<i>Hibiscus palustris</i>	Swamp rose mallow	24	<i>Scirpus atrovirens</i>	Dark green rush	18
<i>Iris virginica shrevei</i>	Blue flag iris	18	<i>Scirpus cyperinus</i>	Wool grass	24
<i>Justicia americana</i>	Water willow	5 feet	<i>Scirpus fluviatilis</i>	River bulrush	18
<i>Nelumbo lutea</i>	Lotus	48	<i>Scirpus validus creber</i>	Great bulrush	18
<i>Nuphar advena</i>	Yellow pond lily	36	<i>Sparganium americanum</i>	American bur reed	18
<i>Nymphaea tuberosa</i>	White water lily	36	<i>Sparganium eurycarpum</i>	Common bur reed	18
<i>Peltandra virginica</i>	Arrow arum	18	<i>Vallisneria Americana</i>	Tape grass	36

Note: Plant species selected should cover 25% of the pond zone and should also cover the range of water depths within the pond zone (0 ft to 3 ft). (For example, 4 plant species may not all be placed at an 18-inch water depth covering 25% of the pond zone.)

OPEN DETENTION BASINS: EDGE ZONE VEGETATION

A variety of trees, shrubs, wildflowers, and grasses may be planted in the edge zone along the banks of detention basins. A native wetland edge or native sedge meadow seed mix is recommended.

Edge Zone: Native Seed Mixes

Grasses/Sedges/Rushes (Minimum 5 species)

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Carex `lurida</i>	Bottlebrush sedge	<i>Juncus effuses</i>	Common rush
<i>Carex vulpinoidea</i>	Brown fox sedge	<i>Leersia oryzoides</i>	Rice cut grass
<i>Echinochloa crusgalli</i>	Barnyard grass	<i>Scirpus acutus</i>	Hard-stemmed bulrush
<i>Elymus Canadensis</i>	Canada wild rye	<i>Scirpus atrovirens</i>	Dark green rush
<i>Glyceria striata</i>	Fowl manna grass	<i>Scirpus pungens</i>	Chairmaker's rush
		<i>Scirpus validus creber</i>	Great bulrush (softstem)

Native Forbs (Minimum 9 species)

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Acorus calamus</i>	Sweet flag		
<i>Actinomeris alternifolia</i>	Wingstem	<i>Mimulus ringens</i>	Monkey flower
<i>Alisma subcordatum</i>	Common water plantain	<i>Peltandra virginica</i>	Arrow arrum
<i>Asclepias incarnate</i>	Swamp milkweed	<i>Polygonum pensylvanicum</i>	Pinkweed
<i>Aster simplex</i>	Panicked aster	<i>Pontederia cordata</i>	Pickernel weed
<i>Bidens spp.</i>	Bidens, various	<i>Rosa palustris</i>	Swamp rose
<i>Cassia hebecarpa</i>	Wild senna	<i>Rudbeckia laciniata</i>	Wild golden glow
<i>Eupatorium perfoliatum</i>	Common boneset	<i>Sagittaria latifolia</i>	Common arrowhead
<i>Helenium autumnale</i>	Sneezeweed	<i>Spiraea alba</i>	Meadowsweet
<i>Iris virginica shrevei</i>	Blue flag iris	<i>Verbena hastata</i>	Blue vervain
<i>Ludwigia alternifolia</i>	Seedbox	<i>Vernonia fasciculata</i>	Common ironweed

Note: A quick growing species such as annual rye grass (*lillium multiflorum*)) and species which will provide the permanent cover (e.g., seed oats) should also be included in all Edge Zone seed mixes.

Edge Zone: Native Shrubs

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Alnus rugosa</i>	Speckled alder	<i>Ilex verticillata</i>	Winterberry (MI Holly)
<i>Aronia melanocarpa</i>	Black chokeberry	<i>Potentilla fruticosa</i>	Shrubby cinquefoil
<i>Betula pumila</i>	Bog birch	<i>Sambucus Canadensis</i>	Elderberry
<i>Cephalanthus occidentalis</i>	Buttonbush (plant in min. 6" water)	<i>Spiraea alba</i>	Meadowsweet
<i>Cornus amomum</i>	Silky dogwood	<i>Viburnum lentago</i>	Nannyberry
<i>Cornus stolonifera</i>	Red-oiser dogwood	<i>Viburnum trilobum</i>	American highbush cranberry

Edge Zone: Native Trees

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Acer saccharinum</i>	Silver maple	<i>Quercus bicolor</i>	Swamp white oak
<i>Betula nigra</i>	River birch	<i>Liquidambar styraciflua</i>	Sweetgum
<i>Carpinus caroliniana</i>	American hornbeam	<i>Liriodendron tulipifera</i>	Tuliptree
<i>Nyssa sylvatica</i>	Black gum	<i>Quercus palustris</i>	Pin oak
<i>Platanus occidentalis</i>	Sycamore	<i>Salix nigra</i>	Black willow

OPEN DETENTION BASINS: UPLAND ZONE VEGETATION

A variety of trees, shrubs, wildflowers, and grasses may be planted in the edge zone in the upland zone of open detention basins. Depending on the location and function of a detention basin within a development, vegetation within the Upland Zone may vary. Native plants recommended for the upland zone of an open detention basin are shown in the following tables.

For detention basins located at development entrances, adjacent to primary or secondary roads, adjacent to or directly behind proposed homes or are located within more formally landscaped areas in the proposed development: It is recommended that the seed mix for the Upland Zone extend from the upper boundary of the Edge Zone to the top of bank or slope. The area beyond the top of bank or slope of the basin should be sodded with an approved sod material. Section 8.5.1 provides additional specifications for sod installed as part of storm water management systems.

For detention basins adjacent to natural areas (forested areas, creeks/streams, wetlands), in remote areas, within interior areas of the development, adjacent to or directly behind proposed homes and terraced basins: seed mix appropriate for the areas extending beyond the 100-year flood elevation and top of bank or slope and functioning as a buffer for the pond should be a mesic-to-dry prairie mix, consisting of a broad-spectrum of prairie grasses and wildflowers with species that vary in height profile and also offer a variety of cover and food options for wildlife. The natural area seeded with prairie mix should be a minimum of fifteen (15) feet wide.

Upland Zone: Seed Mixes **Grasses/Sedges/Rushes (Minimum 5 species)**

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Calamagrostis canadensis</i>	Blue joint grass	<i>Glyceria striata</i>	Fowl manna grass
<i>Carex comosa</i>	Bristly sedge	<i>Juncus effusus</i>	Common rush
<i>Carex hystericina</i>	Porcupine sedge	<i>Leersia oryzoides</i>	Rice cut grass
<i>Carex stricta</i>	Common tussock sedge	<i>Panicum virgatum</i>	Switch grass
<i>Carex vulpinoidea</i>	Brown fox sedge	<i>Scirpus atrovirens</i>	Dark green rush
<i>Echinochloa crusgalli</i>	Barnyard grass	<i>Scirpus validus creber</i>	Great bulrush
<i>Elymus canadensis</i>	Canada wild rye	<i>Spartina pectinata</i>	Prairie cord grass

Upland Zone: Native Forbs (Minimum 9 species)

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Agalinis tenuifolia</i>	Slender false foxglove	<i>Juncus effusus</i>	Common rush
<i>Alisma subcordatum</i>	Common water plantain	<i>Liatris spicata</i>	Marsh blazing star
<i>Angelica atropurpurea</i>	Great angelica	<i>Lobelia cardinalis</i>	Cardinal flower
<i>Asclepias incarnata</i>	Swamp milkweed	<i>Lobelia siphilitica</i>	Great blue lobelia
<i>Aster novae-angliae</i>	New England aster	<i>Ludwigia alternifolia</i>	Seedbox
<i>Aster puniceus</i>	Bristly aster	<i>Peltandra virginica</i>	Arrow arum
<i>Aster simplex</i>	Panicked aster	<i>Physostegia virginiana</i>	Obedient plant
<i>Aster umbellatus</i>	Flat-top aster	<i>Pycnanthemum virginianum</i>	Common mountain mint
<i>Bidens cernua</i>	Nodding Burr marigold	<i>Sagittaria latifolia</i>	Common arrowhead
<i>Cassia hebecarpa</i>	Wild senna	<i>Silphium perfoliatum</i>	Cup plant
<i>Coreopsis tripteris</i>	Tall coreopsis	<i>Solidago rugosa</i>	Rough goldenrod
<i>Eupatorium maculatum</i>	Spotted joe-pye weed	<i>Sparganium eurycarpum</i>	Common bur reed
<i>Eupatorium perfoliatum</i>	Common boneset	<i>Spiraea alba</i>	Meadowsweet
<i>Gentiana andrewsii</i>	Bottle gentian	<i>Verbena hastata</i>	Blue vervain
<i>Helenium autumnale</i>	Sneezeweed	<i>Vernonia fasciculata</i>	Common ironweed
<i>Iris virginica shrevei</i>	Blue flag iris	<i>Zizia aurea</i>	Golden alexanders

Notes:

- An quick growing species such as annual rye grass (*lillium multiflorum*)) and species which will provide the permanent cover (e.g., seed oats) should also be included in all Upland Zone seed mixes.
- These native plants are appropriate for the Upland Zone; from the bank full elevation to the 100-year flood elevation and beyond. This seed selection consists of sedge meadow, wet-to-mesic prairie, and dry-to-mesic prairie plant species.

Upland Zone: Native Shrubs

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Ceanothus americanus</i>	New Jersey tea (dry-mesic)	<i>Lindera benzoin</i>	Spicebush (mesic)
<i>Cornus foemina</i>	Gray dogwood	<i>Physocarpus opulifolius</i>	Ninebark (dry or mesic)
<i>(C. racemosa)</i>	(dry to wet-mesic)	<i>Rhus aromatica</i>	Fragrant sumac (dry)
<i>Corylus americana</i>	American filbert (dry or mesic)	<i>Sambucus canadensis</i>	Elderberry (wet-mesic)
<i>Hamamelis virginiana</i>	Witch-hazel (dry-mesic)	<i>Viburnum dentatum</i>	Arrowwood (dry-mesic)

Upland Zone: Native Trees

<i>Scientific Name</i>	<i>Common Name</i>	<i>Scientific Name</i>	<i>Common Name</i>
<i>Acer rubrum</i>	Red maple (mesic)	<i>Cercis Canadensis</i>	Redbud (mesic)
<i>Acer saccharum</i>	Sugar maple (mesic)	<i>Crataegus crusgalli</i>	Cockspur hawthorn (dry)
<i>Amelanchier arborea</i>	Serviceberry (Juneberry)(dry or mesic)	<i>Gymnocladis dioicus</i>	Kentucky coffeetree (mesic)
<i>Betula alleghaniensis</i>	Yellow birch (mesic)	<i>Ostrya virginiana</i>	Hip-hornbeam Ironwood (dry-mesic)
<i>Carya cordiformis</i>	Bitternut hickory (mesic)	<i>Quercus alba</i>	White oak (mesic)
<i>Carya glabra</i>	Pignut hickory (dry)	<i>Quercus imbricaria</i>	Shingle oak (mesic)
<i>Carya lacinosa</i>	Shellbark hickory (mesic)	<i>Quercus macrocarpa</i>	Bur oak (dry or mesic)
<i>Carya ovata</i>	Shagbark hickory (dry-mesic)	<i>Quercus muehlenbergii</i>	Chinkapin oak (dry or mesic)
<i>Celtis occidentalis</i>	Hackberry (mesic)	<i>Quercus prinoides</i>	Dwarf chinkapin oak (dry)
<i>Celtis tenuifolia</i>	Dwarf hackberry (dry-mesic)	<i>Quercus rubra</i>	Red Oak (mesic)
		<i>Tilia americana</i>	American basswood (mesic)

Note: These plants range from dry to mesic according to the moisture conditions in the Upland Zone. Small sizes of native trees and shrubs may be proposed to increase plant diversity. The total tree caliper inches must equal the calculated caliper inches of required trees.

Natural Basin: Dry Upland Zone: Permanent Grasses (Minimum 5 species)

Scientific Name	Common Name	Scientific Name	Common Name
<i>Andropogon gerardii</i>	Big bluestem grass	<i>Koeleria cristata</i>	June grass
<i>Andropogon scoparius</i>	Little bluestem grass	<i>Panicum virgatum</i>	Switch grass
<i>Bouteloua curtipendula</i>	Side-oats gramma	<i>Sorghastrum nutans</i>	Indian grass
<i>Elymus canadensis</i>	Canada wild rye	<i>Sporobolus heterolepis</i>	Prairie dropseed

Natural Basin: Dry Upland Zone: Native Forbs (Minimum 9 species)

Scientific Name	Common Name	Scientific Name	Common Name
<i>Amorpha canescens</i>	Lead plant	<i>Lupinus perennis</i>	Wild lupine
<i>Anemone cylindrica</i>	Thimbleweed	<i>Monarda fistulosa</i>	Wild bergamot
<i>Aquilegia canadensis</i>	Wild columbine	<i>Parthenium integrifolium</i>	Wild quinine
<i>Asclepias tuberosa</i>	Butterfly weed	<i>Petalostemum purpureum</i>	Purple prairie clover
<i>Aster ericoides</i>	Heath aster	<i>Physostegia virginiana arenaria</i>	Prairie obedient plant
<i>Aster laevis</i>	Smooth blue aster	<i>Pycnanthemum virginianum</i>	Common mountain mint
<i>Aster novae-angliae</i>	New England aster	<i>Ratibida pinnata</i>	Yellow coneflower
<i>Baptista leucantha</i>	White wild indigo	<i>Rudbeckia hirta</i>	Black-eyed susan
<i>Cassia fasciculata</i>	Partridge pea	<i>Rudbeckia subtomentosa</i>	Sweet black-eyed susan
<i>Coreopsis lanceolata</i>	Sand coreopsis	<i>Silphium laciniatum</i>	Compass plant
<i>Coreopsis tripteris</i>	Tall coreopsis	<i>Solidago juncea</i>	Early goldenrod
<i>Echinacea purpurea</i>	Broad-leaved purple coneflower	<i>Solidago nemoralis</i>	Old-field goldenrod
<i>Eryngium yuccifolium</i>	Rattlesnake master	<i>Solidago rigida</i>	Stiff goldenrod
<i>Helianthus mollis</i>	Downy sunflower	<i>Tradescantia ohiensis</i>	Common spiderwort
<i>Heliopsis helianthoides</i>	False sunflower	<i>Vernonia altissima taeniotricha</i>	Hairy tall ironweed
<i>Lespedeza capitata</i>	Round-headed bush clover	<i>Veronicastrum virginicum</i>	Culver's root
<i>Liatis aspera</i>	Rough blazing star		

Note: These native plants are appropriate for areas surrounding basins categorized as natural basins and recommended within areas that have elevations higher than the 100-year flood elevation. This seed selection consists of dry-to-mesic prairie, basic prairie, and low-profile prairie plant species.

ATTACHMENT B: WETLANDS CONSTRUCTION TECHNIQUES



Photo courtesy ECT

- *Step 1 - Prepare the Final Pondscaping and Grading Plans for the Wetland:* At this stage the engineer, landscape architect, and wetland expert work jointly to prepare a pondscaping and grading plan for the wetland. It is also an appropriate time to order the wetland plant stock from aquatic nurseries, since up to six to nine months lead time may be needed to fill orders.
- *Step 2 - Grade the Wetland to Interim Elevations:* Once the basic excavation of the storm water wetland has been completed, it is time to create the major topographic features within the wetland, such as wedges, benches, and deep water channels. A skid loader or other excavator can be used to form the internal complexity within the wetland. These topographic features can only be added while working in the “dry.” Spot surveys should be made to ensure that the interim elevations are 3 to 6 inches below the final elevations for the wetland.
- *Step 3 - Add Topsoil/Wetland Mulch Amendments:* Since most storm water wetlands are excavated to deep subsoils, they often lack the nutrients and organic matter needed to support vigorous growth of wetland plants. It is therefore essential to add 3 to 6 inches of topsoil or wetland mulch to all depth zones in the wetland from 1 foot below the normal pool to 6 inches above. Topsoil can be stockpiled during

construction of the wetland or can be scavenged from elsewhere at the development site. Wetland mulch is preferable to topsoil if it is available.

- The importance of soil amendments in excavated wetlands cannot be overstressed; poor survival and future wetland coverage are likely if these soils are not added (Bowers, 1992). Fertilizers and other soil amendments are not needed if topsoil or wetland mulch are used.
- *Step 4 - Grade the Wetland to Final Elevations:* After topsoil or wetland mulch has been added to the storm water wetland, the wetland can be graded to its final elevations. This is normally done by “roughing up” the interim elevations with a skid loader or other equipment to achieve the desired micro topography across the wetland. All wetland features above the normal pool should be temporarily stabilized by hydroseeding or seeding over straw.
- *Step 5 - Measure and Stake Planting Depths:* The storm water wetland is surveyed and staked at the onset of the planting season. Depths in the wetland should be measured to the nearest inch to confirm the original planting depths of the planting zone. At this time, it may be necessary to modify the pondscape plan to reflect altered depths or the availability of wetland plant stock. Surveyed planting zones should be marked on the as-built or design plan, and also located in the field using stakes or flags.

For constructed wetlands, plant plugs or container-grown wetland plant stock should be planted. The transplanting window extends from early April to mid-June. Planting after these dates is quite chancy, as emergent wetland plants need a full growing season to build the root reserves needed to get through the winter. If at all possible, plants should be ordered at least six months in advance to ensure the availability of desired species.

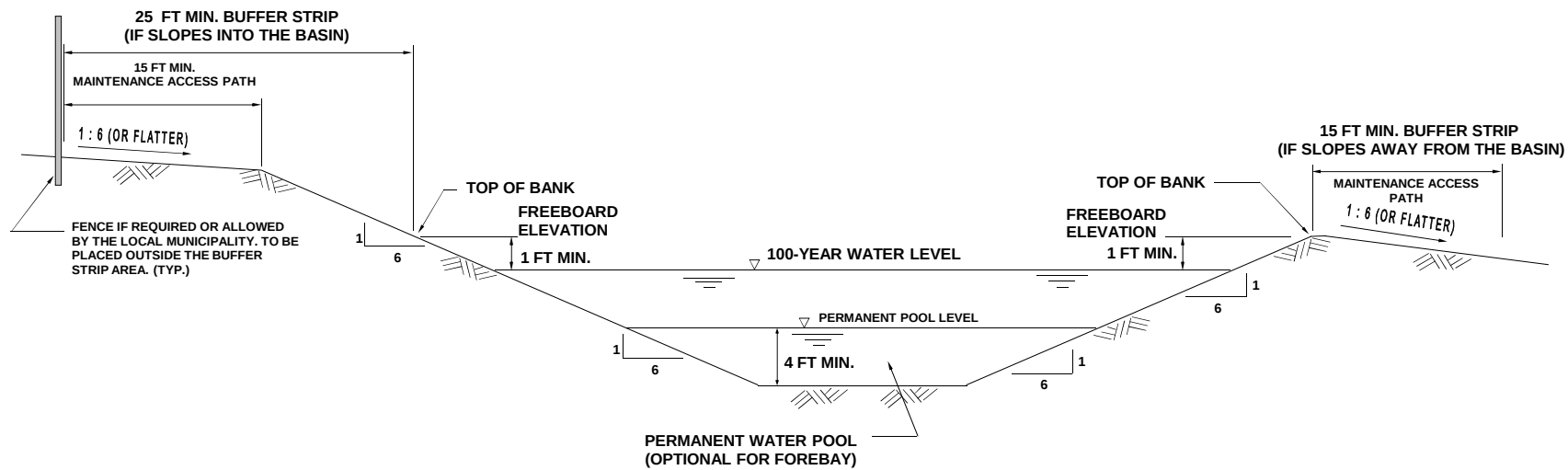
It is not necessary to plant more than half the wetland surface area. If the appropriate planting depths are achieved, the entire wetland should be colonized within three years. The wetland area should be subdivided into separate planting zones of more or less constant depth. One plant species should be planted within each flagged planting zone based on its approximate depth requirements. Individual plants should be planted 18 inches on center within each single species "clump."

Post-nursery care of wetland plants is very important during the interval between delivery of the plants and subsequent planting, as they are prone to desiccation. Stock should be frequently watered and shaded while on-site.

After the second growing season, reinforcement plantings may be needed to expand the spatial coverage of the wetland.

ATTACHMENT C:

**DETAIL FOR REQUIRED BUFFER STRIPS FOR FOREBAYS, OPEN DETENTION
BASINS, AND RETENTION BASINS
WITH DRAINAGE AREA GREATER THAN 5 ACRES**



REQUIRED BUFFER STRIP FOR FOREBAYS, OPEN DETENTION BASINS, AND
RETENTION BASINS
(DRAINAGE AREA GREATER THAN 5 ACRES)
 NOT TO SCALE

8.1.2 Retention Basins

Description

Retention basins are man-made surface waters designed to provide gravity settling of pollutants and to promote infiltration into the soil rather than discharging the storm water runoff to a surface water or closed conduit. The soils beneath a proposed retention basin must be sufficiently permeable to allow the infiltration of storm water.

Design Standards

Design standards for retention basins include the following:

- A registered Professional Engineer must certify that the soils beneath a proposed retention basin are sufficiently permeable to allow the infiltration of storm water and storm water runoff. Calculations showing the percolation rate of soils below the proposed retention basin must be provided.
- A forebay or other pretreatment system is required at each inlet to the retention basin. Pretreatment systems trap sediment before entering the retention basin, reduce the incoming runoff velocities, and spread runoff evenly over the retention basin to create sheet flow conditions. Section 8.2 of this manual provides detailed information and design criteria for pretreatment systems.
- All closed conduits entering retention basins should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- Retention basins must be designed to retain the volume of storm water equal to the runoff from two consecutive 100-year storm events as described in Section 6.2.2. The design storage volume in a retention basin must be provided above the existing ground water elevation.
- A minimum of one (1) foot of freeboard is required above the design water level of a retention basin.
- Providing a safe design is a primary consideration for all storm water management basins. Side slopes for retention basins may not be steeper than 1:6. Further safety measures (e.g., safety shelves, vegetative and barrier plantings) may be warranted depending on the type of development.
- Although use of terraced side slopes generally is discouraged when other alternatives exist, terraced side slopes may be approved for retention basins in certain, limited circumstances at the discretion of Wayne County. The overall slope of a terraced side of a retention basin should not be steeper than 1:3. An example detail for terraced side slopes is provided in Appendix E-3.
- An emergency spillway is required for all retention basins. The applicant must demonstrate that there exists a defined drainage path downstream from the emergency spillway to allow discharge when flows exceed the design water level. Design criteria for emergency spillways are the same as those for open detention basins as described in Section 8.1.4.
- Retention basins may not be located within pre-existing surface waters.
- A buffer strip must be provided around all surface waters such as retention basins.. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the basin or surface water. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the pond perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room along the top of the basin to provide access to the basin for maintenance. The buffer strip requirements illustrated in the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” in Attachment C of Section 8.1.1 for open detention basins are applicable to retention basins.
- In the following situations, the minimum width of the buffer strip around retention basins is 15 feet measured from the minimum freeboard elevation of the basin:

- o When a retention basin has a drainage area 5 acres or less; or
- o When a retention basin has a drainage area greater than 5 acres and no storm water from areas outside of or within the buffer strip enters the basin via direct sheet flow (see the right side of the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” in Attachment C of Section 8.1.1).
- Plant vegetation, such as along the side slopes of retention basins, is necessary to control erosion and enhance sediment entrapment. A landscaping plan is required for retention basins, due to the importance of the vegetation to the function of the entire system. Use of a professional landscape architect with experience in storm water management system design and native landscaping is encouraged.

Preferred Design Elements

- Calculations showing the percolation rate of soils should be based on soil borings. Wayne County generally requires soil borings to be taken as follows:
 - o Minimum four soil borings per retention basin.
 - o Borings should be taken every 200 feet within the perimeter of the basin.
 - o Borings should be at least 10 feet deep, measured from the bottom elevation of the proposed basin.
- Soil samples collected from borings should be collected every five vertical feet. Soil analysis should include:
 - o Sieve analysis
 - o Hydrometer reading
 - o Soil classification
 - o Standard penetration numbers
 - o The shape and configuration of retention basins may vary, depending on storage requirements, local topography, land availability, hydraulic considerations, and other site-specific constraints.
- Retention basins should be designed to maximize sheet flow across the open water portion of the facility.
- If aerating devices are used as part of a storm water management system, they should be

designed to minimize disturbance of bottom sediments. For example, retention basins may need to have a deeper permanent pool if an aerating device is used. Bubbler systems are the preferred type of aerating device as they have been found to be more efficient at providing aeration. The manufacturer’s recommendations should be followed in regards to design and maintenance.

- If a terraced side slope is approved for use in a retention basin, the materials proposed for use in its construction should be approved by the local community.

Vegetation Specifications

The type of vegetation used is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation specifications for retention basins are the same as those for open detention basins (see Section 8.1.1).

Maintenance

Required maintenance activities for retention basins are the same as those for open detention basins (see Section 8.1.1). These activities must be identified in the submitted maintenance plan. Additionally, provision for maintenance access should be shown on the plan; it is recommended that the maintenance access be a minimum of 15 feet wide.

References

See references in Section 8.1.1

8.1.3 Underground Detention Systems

Description

Underground detention systems consist of one or more underground pipes or structures designed to provide the required storage volumes (both the bankfull flood and flood control volumes) for a development project. Just as with any above ground means of storm water detention, underground detention systems must have a restricted outlet that limits outflow for the bankfull flood and for the maximum allowable release rate from the development site.

Underground detention systems are the least preferred method of detention and generally are allowable only when an open detention system is not feasible for a given site.

Preferred Design Elements and Materials

Before entering an underground detention system, storm water runoff must pass through a pretreatment system as described in Section 6.3.1. All construction components and materials used from the pre-treatment structure through the underground detention system out to the point of discharge must be tested, inspected and approved by Wayne County. The pretreatment system includes the last structure in the collection system leading into the treatment system.

For underground detention systems consisting of pipes, spacing of the pipes should conform to the manufacturer's recommendation except that a minimum clearance of 12 inches is required between pipes to provide for adequate backfill and support (as described in "Installation," below).

Underground detention systems must confine storm water runoff to the interior of the detention system, and may discharge storm water only through a restricted outlet. Examples of two types of restricted outlets are shown on the following pages. Example A, a restricted outlet with no overflow, is appropriate for underground detention systems that discharge to

a storm water management system within a Wayne County road right-of-way or other County-owned property, or to any other storm water management system with restrictions on the allowed inflow. Example B, a restricted outlet with overflow, is appropriate for underground detention systems that discharge to surface waters or other storm water management systems. Note that the designs for a restricted outlet for underground detention systems shown in Examples A and B illustrate acceptable designs; other designs also may be acceptable.

If a manufactured treatment system is installed upstream of the underground detention system, the underground detention system should be designed, to the extent possible, such that the flood control design water elevation within the underground detention system is equal to or below the controlling water surface elevation in the manufactured treatment system. This design consideration is necessary to maximize the performance of this type of pretreatment system and to minimize the resuspension of collected sediment.

Wayne County prefers gravity outlets to pumped outlets from underground detention systems. If an underground detention system is designed to include a pumped outlet:

- Pumps should be located downstream of the flow restrictor within the outlet
- Two pumps should be provided in any pumped outlet system:
 - If the system is designed to use one pump, with one pump as a backup, each pump should be sized to operate such that the maximum pumping capacity does not exceed the allowable release rate (Q_a)
 - If the system is designed to use two pumps alternately or at the same time, the maximum pumping capacity of the system should not exceed the allowable release rate (Q_a) at any time.

- A manhole structure should be provided downstream of the pump station.

Access

All underground detention systems should have a means to inspect and maintain the entire system. For underground detention systems made of pipes, access risers (minimum of 24-inch diameter) and clean outs (size as recommended by manufacturer) are required. For storm water collection chamber (SCC) underground detention systems, inspection ports (sized as recommended by manufacturer) are required.

It is the responsibility of the system manufacturer to detail the access to the system. For systems made of corrugated metal pipe and polymer-coated corrugated steel pipe, the gauge of the material used for the risers should follow the same requirements as listed for the detention system pipe materials.

Materials

Wayne County is authorized to restrict the types of materials that may be used to construct underground detention systems. Generally, underground detention systems should be constructed from pre-cast or cast-in-place concrete, corrugated metal pipe (CMP), polymer-coated corrugated steel pipe (PCCSP), reinforced concrete pipe (RCP), smooth-lined corrugated plastic pipe (CPE), or storm water collection chambers (SCC). Unless otherwise indicated in this section, materials used for underground detention systems should meet the requirements of the current MDOT Standard Specification for Construction.

Storm water detention systems made of pre-cast or cast-in-place reinforced concrete structures should conform to current Wayne County Specifications for Structural Concrete with the wall thickness not less than the minimum thickness necessary to sustain HS20 loading requirements, as determined by a registered Professional Engineer. Pipe openings should be sized to accept pipes of the specified size(s) and material(s) and should be sealed with hydraulic cement conforming to ASTM C595.

Underground detention systems made of reinforced concrete pipe should conform to ASTM C76.

Circular CMP should conform to AASHTO M36 (ASTM A760) and should be made from aluminum coated sheet conforming to AASHTO M274. The use of the continuous welded seam process in the fabricating of pipe is not permitted. Unless otherwise approved by the Wayne County Permit Engineer, CMP is limited to a maximum diameter of 60-inches. See Table 8.2.3-1 for additional information.

Polymer coated corrugated steel pipe (PCCSP) should conform to AASHTO M245 (ASTM A762) using AASHTO M246 (ASTM A742) Grade 250/250 polymer on zinc coated steel meeting AASHTO M218. The use of the continuous welded seam process in the fabricating of pipe is not permitted. Unless otherwise approved by the Wayne County Permit Engineer, PCCSP is limited to a maximum diameter of 60-inches. See Table 8.1.3-1 for additional information.

Smooth-lined corrugated plastic pipe should conform to AASHTO M294, Type S and should be limited to a maximum size of 60-inches. In areas where the CPE pipe will be under the influence of pavement, the cover should be a minimum of 24-inches measured from the top of pipe to the top of a concrete (rigid) pavement or 24-inches from the top of pipe to the bottom of asphalt (flexible) pavement.

Underground detention systems consisting of SCC should conform to ASTM F 2418. The structural design of the SCC, its structural backfill and requirements for its installation should ensure that the load factors specified in the AASHTO LRFD Bridge Design Specifications, Section 12.12 are met. It is required that the factors for both long-duration dead loads and short-duration live loads, based on the AASHTO Design Truck for HS-20 live loads and deep burial earth loads with consideration for impact and the presence of multiple vehicles. To date, the Stormtech™ SC-740, SC-310, MC-3500, and MC-4500 have been approved by Wayne County as meeting these criteria.

Testing

The manufacturer of underground detention system elements must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior

to fabrication to schedule inspection during fabrication. Wayne County inspects the material fabrication process to ensure that the manufacturer's testing of the product occurs at the applicable AASHTO or ASTM standards. Testing of pipe materials should occur at the following frequencies:

- RCP should be tested at a frequency of one test per 200 pieces per size per day.
- CMP and PCCSP should be tested at a frequency of one test per 2,500 lineal feet per heat number.
- CPE should be tested at a frequency of one test per 1,000 straight length of pipe per diameter per lot number.

Testing of SCC and end caps should occur at a frequency of one test per 200 pieces (chambers or end caps) or per shift, whichever is less.

Installation

Wayne County is authorized to restrict the methods used to construct underground detention systems. At a minimum, unless otherwise directed by the County, installation of underground detention systems constructed of pipes should conform to the current MDOT specification(s) for installation of the specific pipe material used. Based on soil conditions, Wayne County may require the entire underground detention system to be enveloped with geotextile fabric conforming to MDOT Section 910.

For underground detention systems consisting of pipes and SCC, a stable foundation is necessary to insure that the proper line and grade is maintained. Unstable foundations may be undercut and replaced with MDOT Class I granular bedding material placed in 6 inch lifts and compacted to 95% of its maximum unit weight. Other methods of stabilization can be used if approved by the Wayne County Permit Engineer.

For underground detention systems consisting of CPE, CMP, and PCCSP, embedment materials should be worked under the haunches by hand for pipes 30-inches and larger.

When installing underground pipe as part of a underground detention system, backfill should be as follows:

- RCP: backfill should conform to Wayne County Trench "A" backfill and Trench "B" backfill specifications.
- CPE, CMP, or PCCSP: the dimensions of the trench backfill are the same as Trench "A" and "B"; however, 2G, 34G, 6A or 21AA stone or gravel should be used as backfill to a minimum of 6-in above the pipe. In the event that a different backfill is used above the 2G, 34G, 6A or 21AA stone or gravel, a geotextile separation fabric shall be used between the two different materials. A minimum cover from the bottom of the pavement to the top of the pipe should be 12 inches except for CPE pipe under the influence of pavement, in which case the cover shall be a minimum of 24-inches measured from the top of pipe to the top of a concrete (rigid) pavement or 24-inches from the top of pipe to the bottom of asphalt (flexible) pavement.
- CMP and PCCSP: the minimum cover (including the 21AA or 22A backfill from the top of pipe) from the top of the pipe to the bottom of the pavement is 12-inches, plus the pavement thickness.

For underground detention systems consisting of SCC, foundations and embedment stone should be clean, angular stone meeting the requirements of MDOT 4AA, 6AA, 6A or the requirements of Wayne County Specifications for 3-in x 1-in maintenance aggregate (no crush concrete) with a maximum percentage of 5% passing the #200 sieve.

Backfill for all types of underground detention system should be installed as follows:

- All backfill materials should be placed in a balanced manner making sure that no more than a 2 lift differential is present from one side of the pipe/SCC/structure to the other. Balanced lifts should be advanced across the width of the system, evenly along the length of the system throughout the backfilling process.
- All backfill materials should be placed in lifts of maximum 10-inches.

- For each backfill lift, all materials should be compacted to a minimum of 95% (90% minimum required for 6A and 21AA) of the backfill material's maximum unit weight at moisture content not greater than optimum. The maximum unit weight of the backfill materials should be determined by the AASHTO T 180 or Michigan Cone Method. The frequency of the compaction testing should be one test per lift of backfill per 200 lineal feet or less of trench.

A Wayne County Permit Engineer must observe the installation of all underground detention systems.

Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours prior to installation to schedule inspection during installation. Wayne County will not accept any underground detention systems installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

Documentation of the following items relative to the installation of underground detention systems is required to be submitted to the Wayne County Permit Engineer before permits and financial assurances are released:

- All backfill materials are from Wayne County tested stock.
- All backfill materials were placed in lifts of maximum 10-inches.
- For each backfill lift, all materials were compacted to a minimum of 95% of the backfill material's maximum unit weight at moisture content not greater than optimum. If 6A and 21AA backfill was used, materials were compacted to 90% of the backfill material's maximum unit weight at moisture content not greater than optimum.
- The maximum unit weight of the backfill material was determined by the AASHTO T 180 or Michigan Cone Method.
- The compaction was tested a minimum of one test per lift of backfill per 200 lineal feet or less of trench.

Maintenance

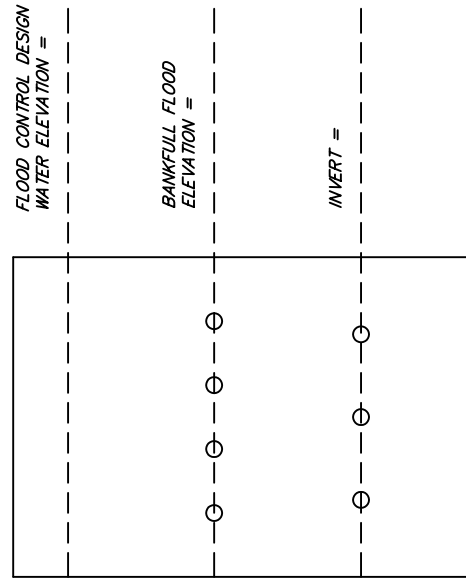
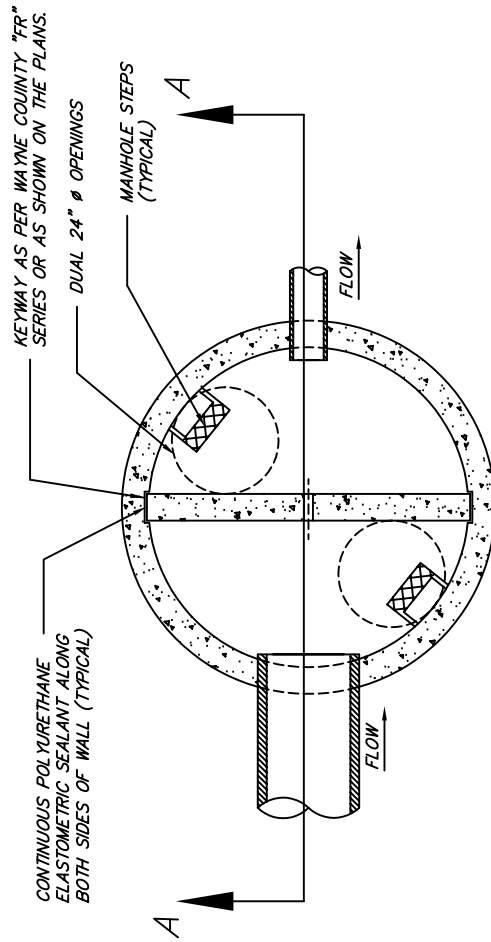
Underground detention systems should be inspected every 6 months to verify proper operation, and to identify and perform any necessary maintenance. As a general rule, the detention system requires cleaning if its volume is reduced by more than 10 percent due to the accumulation of silt and sediment.

Table 8.1.3-1

**WALL THICKNESS REQUIREMENTS FOR CORRUGATED METAL PIPE AND
POLYMER COATED CORRUGATED STEEL PIPE
(DIAMETER-GAUGE)**

DIAMETER (INCHES)	SIZE OF CORRUGATION		
	2 2/3-in x ½-in	3-in x 1-in	5-in x 1-in
UP TO 30	0.079-in - 14 ga.	---	---
36 - 54	0.079-in - 14 ga.	0.079-in - 14 ga.	0.079-in - 14 ga.
60	0.109-in - 12 ga.	0.079-in - 14 ga.	0.079-in - 14 ga.

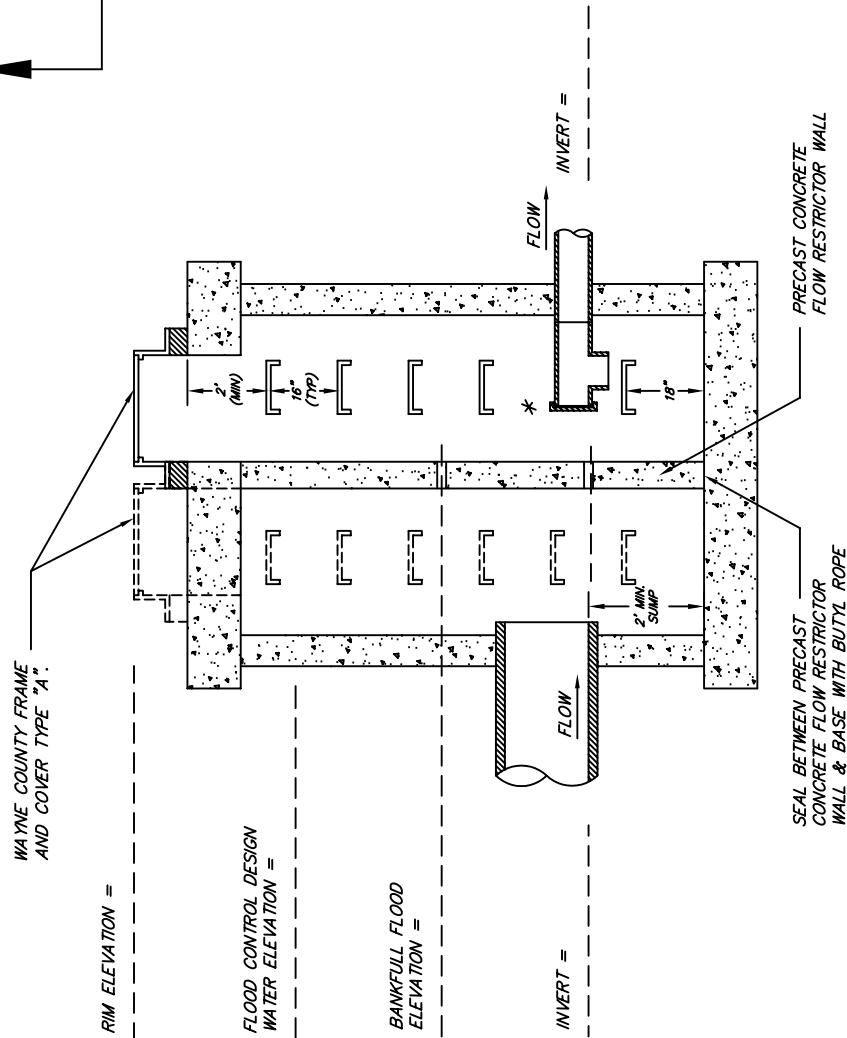
- All welds for aluminized pipe should be coated with a paint containing zinc dust as described in the Materials Section of ASTM A 780 and should be applied to a dry film thickness of at least 0.005 inch. Any repair to damaged aluminized coatings should be in accordance with ASTM A 760 Section 11.
- All welds for polymer pre-coated pipe (PCCSP) should first be coated with a zinc dust paint as described above followed by a polymer coating similar and compatible to the original polymer coating or a protective coating meeting ASTM A 849. Repairs to damaged PCCSP should be in accordance with ASTM A 762.
- Welding on site is not permitted unless approved by the Wayne County Permit Engineer.
- Elliptical CMP or PCCSP is not permitted.
- CMP and PCCSP connections should be per the manufacturer's recommendations.
- Larger size CMP or PCCSP will be as approved by the Wayne County Permit Engineer.



FLOW RESTRICTOR WALL
FRONT VIEW

NUMBER AND SIZE OF HOLES AS PER DESIGN, MINIMUM 1" DIA.
EQUALLY SPACED, MINIMUM 6" O/C.

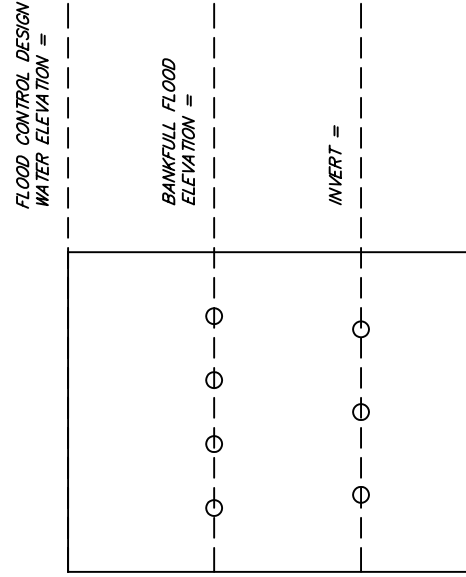
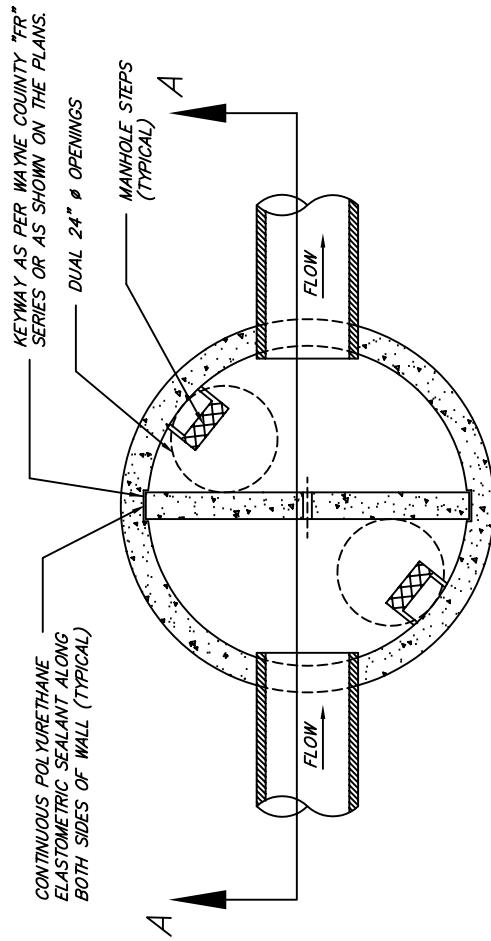
* OIL/WATER SEPARATOR IS REQUIRED FOR OUTFLOW PIPE LESS THAN 12" DIA.



SECTION "A-A"

1. THIS TYPE OF FLOW RESTRICTOR STRUCTURE TO BE USED ONLY WITH UNDERGROUND DETENTION SYSTEMS.
2. OVERFLOW IS NOT ALLOWED TO A WAYNE COUNTY ROAD STORM SYSTEM OR ENCLOSED DRAIN.
3. THE PRECAST REINFORCED FLOW RESTRICTOR STRUCTURE SHALL BE MANUFACTURED PER ASTM C-478 SPECIFICATIONS AND MEETING HS20 LOADING REQUIREMENTS.
4. THE STRUCTURE GEOMETRIC AND REINFORCEMENT DETAILS SHALL BE PER WAYNE COUNTY STANDARD DETAILS "FR" SERIES.

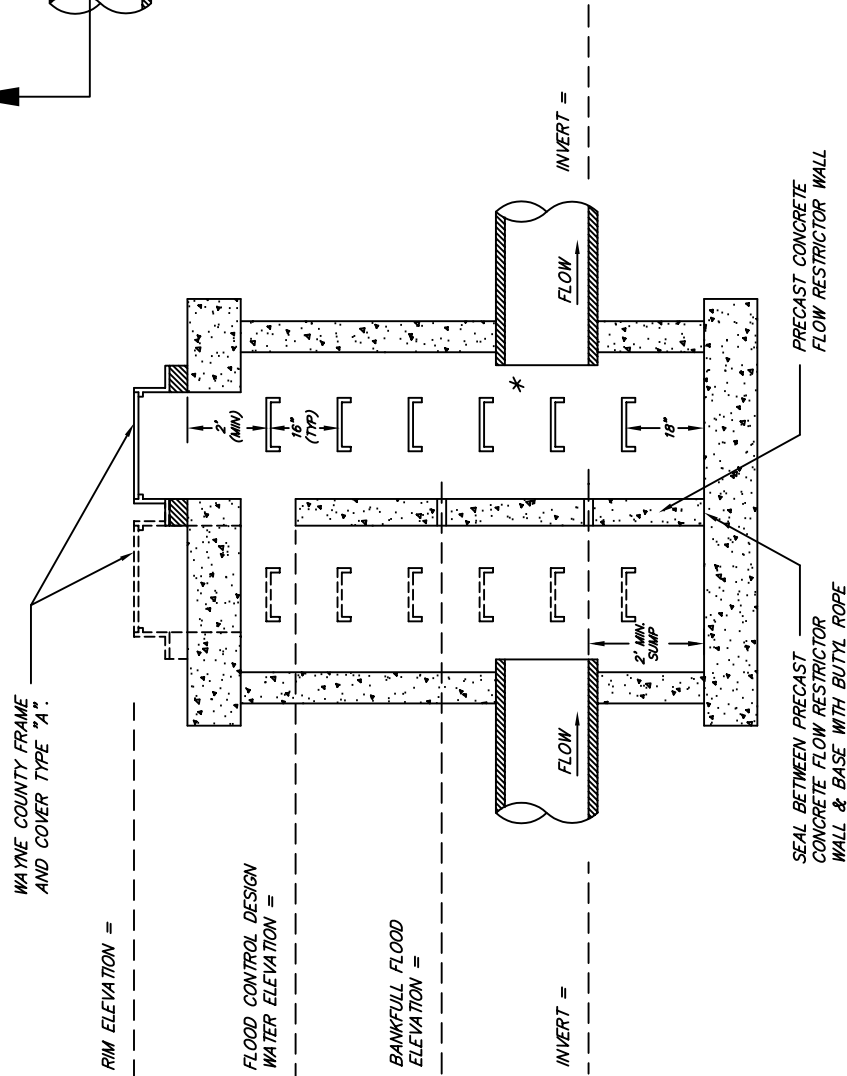
EXAMPLE A: FLOW RESTRICTOR WITHOUT OVERFLOW
NOT TO SCALE



FLOW RESTRICTOR WALL
FRONT VIEW

NUMBER AND SIZE OF HOLES AS PER DESIGN, MINIMUM 1" DIA. EQUALLY SPACED, MINIMUM 6" O/C.

* OIL/WATER SEPARATOR IS REQUIRED FOR OUTFLOW PIPE LESS THAN 12" DIA.



SECTION "A-A"

1. THIS TYPE OF FLOW RESTRICTOR STRUCTURE TO BE USED ONLY WITH UNDERGROUND DETENTION SYSTEMS.
2. OVERFLOW IS NOT ALLOWED TO A WAYNE COUNTY ROAD STORM SYSTEM OR ENCLOSED DRAIN.
3. THE PRECAST REINFORCED FLOW RESTRICTOR STRUCTURE SHALL BE MANUFACTURED PER ASTM C-478 SPECIFICATIONS AND MEETING HS20 LOADING REQUIREMENTS.
4. THE STRUCTURE GEOMETRIC AND REINFORCEMENT DETAILS SHALL BE PER WAYNE COUNTY STANDARD DETAILS "FR" SERIES.

EXAMPLE B: FLOW RESTRICTOR WITH OVERFLOW NOT TO SCALE

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8.1.4 Outlets for Forebays and Open Detention Basins

Description

Forebay outlets convey flow from a forebay into detention systems and retention basins. Forebay outlets must include a flow restrictor, which conveys restricted flow, and a weir, which conveys unrestricted flow.

Outlets from open detention basins convey flow from the detention basin into a surface water or off-site closed conduit. Required outlets from open detention basins include a flow restrictor to convey restricted flow, an overflow structure to discharge when the water level exceeds the design water level, and an emergency spillway to convey unrestricted flow. An example of a storm water management system with forebay and open detention basin outlets is shown in the detail at the end of this section.

Design Standards for Forebay Outlets

Outlets for forebays must be designed as follows:

- Flow restrictors in forebays must be placed near or within the embankment of the forebay to provide ready maintenance access and must be constructed of materials that minimize future maintenance requirements.
- Flow restrictors must be designed to gradually release the first flush storage volume over a period of twenty-four (24) hours, as described in Section 6.3.1.
- Forebays must include a weir to allow discharge from the forebay into the detention system or retention basin when the forebay water level exceeds the top of the forebay storage volume. The weir must be designed to convey the peak flow rate tributary to the forebay for the 10-year design storm.

Design Standards for Open Detention Basin Outlets

Outlets for open detention basins must be designed as follows:

- A flow restrictor is required in each detention basin. Depending on which performance standard(s) the system is being designed to meet, the flow restrictor may be designed to meet the flood control outflow requirements, the bank full flood outflow requirements, or both.
 - For flood control, the flow restrictor must be designed such that the maximum outflow rate at the design water level does not exceed the maximum allowable

outflow rate for flood control as determined by the equations described in Section 6.2.1.

- For water resources protection, the flow restrictor must be designed to gradually release the bank full flood storage volume over a period of forty (40) hours as described in Section 6.3.2.
- Flow restrictors in open detention basins must be placed near or within the embankment of the basin to provide ready maintenance access. Flow restrictors must be constructed of materials that minimize future maintenance requirements.
- An overflow structure must be provided to allow discharge when the basin water level exceeds the design water level. The overflow structure and its outlet pipe must be designed to convey the peak flow rate tributary to the basin for the 10-year design storm.
- An emergency spillway with a defined downstream drainage path must be provided to allow discharge from the basin when flows exceed the capacity of the overflow structure. The emergency spillway elevation must be 6 inches below the top of freeboard elevation. The spillway must be armored to prevent erosion of the berm.

Preferred Design Elements and Materials

- Wayne County prefers gravity outlets versus pumped outlets from open detention basins. If an open detention basin is designed to include a pumped outlet:
 - Pumps should be located downstream of the flow restrictor within the outlet
 - Two pumps should be provided in any pumped outlet system:
 - If the system is designed to use one pump, with one pump as a backup, each pump should be sized to operate such that the maximum pumping capacity does not exceed the allowable release rate (Q_a)
 - If the system is designed to use two pumps alternately or at the same time, the maximum pumping capacity of the system should not exceed the allowable release rate (Q_a) at any time.
 - A manhole structure should be provided downstream of the pump station.

- Risers and overflow structures should be constructed of 12-gage corrugated metal pipe (CMP) conforming to ASTM A760 and should be made from aluminum coated sheet conforming to AASHTO M274. The use of the continuous welded seam process in the fabricating of pipe is not permitted. Risers and overflow structures should have a minimum diameter of 36-inches.
- Riser holes should be 1 inch minimum diameter but no larger in size than the surrounding stone. The holes should be spaced a minimum of 4 inches apart, on center, both vertically and horizontally. The holes should be pre-drilled prior to galvanizing.
- Risers and overflow structures should have a 2-foot deep sump and a concrete base of 6-inch minimum thickness. The concrete base should be constructed of either pre-cast concrete meeting ASTM C478, or cast-in-place concrete with a 28-day strength requirement of 3,500 psi.
- Risers and overflow structures should be securely attached to the base. They may be embedded in concrete or affixed by an approved fastening method.
- The top of risers and overflow structures should be equipped with a steel grate. Openings should be a minimum of 3 inches square and a maximum of 4 inches square.
- Stone filter backfill around risers should consist of 3-inch diameter washed stone, with an outer blanket of MDOT 6A stone. The side slope of the stone blanket is typically 1:4.
- The berm on which an emergency spillway rests should be made of approved material free of debris, organic material and large rocks (over 4 inches in diameter).
- Suggested options for armoring spillways include riprap, tri-lock, geoweb with infill material, and reinforced turf.
- The outlet "Tee" should be equipped with a removable cap in the horizontal direction; the vertical leg should serve as an oil separator. The horizontal leg often is used as a clean out.
- The minimum preferred outlet pipe diameter is 4 inches.
- An anti-seepage collar should be provided on each outlet pipe. The anti-seepage collar consists of a watertight joint; the specifications for watertight joints vary depending on the type of material used for the outlet pipe.

Testing

The CMP riser must be inspected during fabrication. CMP manufacturers must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior to fabrication to schedule inspection during fabrication. Wayne County inspects the material fabrication process to ensure that the

manufacturer's testing of the product occurs at the applicable AASHTO or ASTM standards.



Installation

Wayne County is authorized to restrict the methods used to construct outlets from forebays and open detention systems. Specifications for construction of these types of outlets include:

- Any field modifications to risers, overflow structures, or other outlet pipes should be performed in accordance with ASTM A780.
- The berm on which an emergency spillway rests should be made of approved embankment material placed and compacted as roadway embankment per the current MDOT Standard Specifications for Construction.
- The concrete base for the risers and overflow structures should be constructed on a suitable subgrade material compacted to 95% of its maximum unit weight. Unsuitable subgrade materials will be removed at the direction of the Permit Engineer, backfilled with MDOT Class 2 granular material in no more than 10-in lifts, and compacted to 95% of its maximum unit weight.
- Onsite welding of the CMP riser is not permitted unless approved by the Wayne County Permit Engineer

A Wayne County Permit Engineer must observe the installation of outlets for forebays and open detention systems. Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours prior to installation to schedule inspection during installation. Wayne County will not accept any forebay or detention system outlet installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

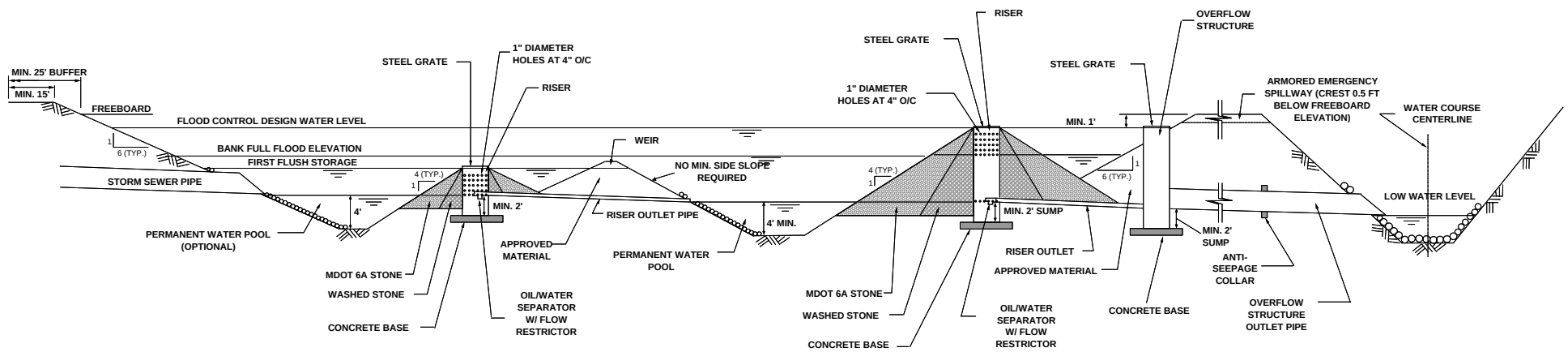
Documentation of the following items relative to the installation of outlets for forebays or open detention systems is required to

be submitted to the Wayne County Permit Engineer before permits and financial assurances are released:

- MDOT 6A stone, 3-inch washed stone, and Class 2 granular material were from Wayne County tested stock.
- Berm materials were compacted to the requirements of roadway embankment per the current edition of the MDOT Standard Specification for Construction.
- Test reports indicating the 28-day compressive strength of the cast-in-place concrete utilizing 6-in x 12-in cylinders. Concrete failing to meet the 28-day compressive strength of 3,500 psi must be removed and replaced with concrete meeting the 28-day strength requirement.
- All pre-case manhole bases were provided from Wayne County tested stock.
- In the event any unsuitable soils were removed to create a suitable subgrade for the base(s), test results for the compacted backfill must be provided.

Maintenance

Inlets and outlets should be checked regularly for clogging and the system should be cleaned as necessary. Sediment should be removed if accumulation reaches 6 inches or if re-suspension is observed. Pipe inspections should be made to verify that the pipe is not crumbling or broken.



**EXAMPLE: FOREBAY AND OPEN DETENTION BASIN
DETAIL**

8.2.1 Forebays

Description

Forebays are man-made surface waters used as pretreatment systems. Forebays are designed to temporarily store the first flush of runoff from a storm event and provide for pollutant removal through settling. A forebay or other pretreatment system is required at each inlet to a detention system or retention basin.

Design Standards

Forebays must capture the first flush and release it gradually to the detention system and/or retention basin over a period of twenty-four (24) hours. Section 6.3.1 provides detailed information regarding how to calculate the storage volume required to capture the first flush for the area tributary to each forebay, and how to calculate the average allowable release rate from the forebay.

Design standards specific to forebays include the following:

- The volume of the forebay above any permanent pool may be used to satisfy a portion of the flood control storage volume (described in Section 6.2.1) and the bank full flood storage volume (described in Section 6.3.2). If a permanent pool is provided, the volume of the permanent pool may not be used to satisfy these other storage volume requirements.
- All closed conduits entering or exiting a forebay should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- A buffer strip must be provided around all surface waters such as forebays. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the surface water or forebay. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the forebay perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room to provide access to the forebay for maintenance.

The buffer strip requirements illustrated in the figure “Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins” in Attachment C of Section 8.1.1 for open detention basins are applicable to forebays.

- In the following situations, the minimum width of the buffer strip around a forebay is 15 feet measured from the minimum freeboard elevation of the forebay:
 - When the forebay has a drainage area 5 acres or less; or
 - When the forebay has a drainage area greater than 5 acres and no storm water from areas outside or within the buffer strip enters the forebay via direct sheet flow.
- Plant vegetation, such as along the side slopes of retention basins, is necessary to control erosion and enhance sediment entrapment. A landscaping plan is required for retention basins, due to the importance of the vegetation to the function of the entire system. Use of a professional landscape architect with experience in storm water management system design and native landscaping is encouraged.
- Forebays may not be located within pre-existing surface waters.
- Design standards for outlet structures associated with forebays are described in Section 8.1.4.

Wayne County generally requires forebays to have side slopes no steeper than 1:6. However, earthen berms used as a weir between the forebay and an open detention basin have no minimum side slope requirement.

Vegetation Specifications

The type of vegetation used is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation specifications for forebays are the same as those for open detention basins (see Section 8.1.1).

Maintenance

Maintenance activities for forebays are the same as those for open detention basins (see Section 8.1.1). These activities must be identified in the submitted maintenance plan.

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8.2.2 Bioretention Areas



Use of Bioretention within a Parking Lot: Wayne City Hall

(Photo courtesy Alicia Askwith, Ayres Lewis Norris & May)

Bioretention areas are designed to use soil and plant material to mimic natural processes and store, filter and infiltrate storm water into the ground.

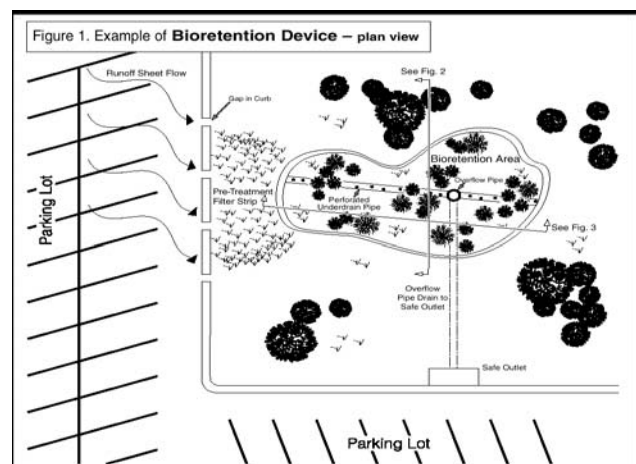
Bioretention areas may be used anywhere to achieve a degree of stormwater treatment; the location depends in part on the type of facility employed. Common applications include:

- Pretreatment system for detention systems and retention basins.
- Within parking lots: bioretention areas are recessed and the pavement is graded to these areas, where storm water is captured and treated (see figure above). Traditional parking lots typically have curbed, elevated islands of vegetation.



Use of Bioretention within a Residential Development

- On new residential subdivision lots or commercial lots, near the source of the runoff generated from impervious surfaces.
- Areas upland from inlets or outfalls that receive sheet flow from graded areas.
- Areas of the site that are planned to be excavated or cut.
- In stormwater management retrofit and redevelopment situations, the addition of bioretention facilities will provide some improvement in the amount of runoff and in water quality.



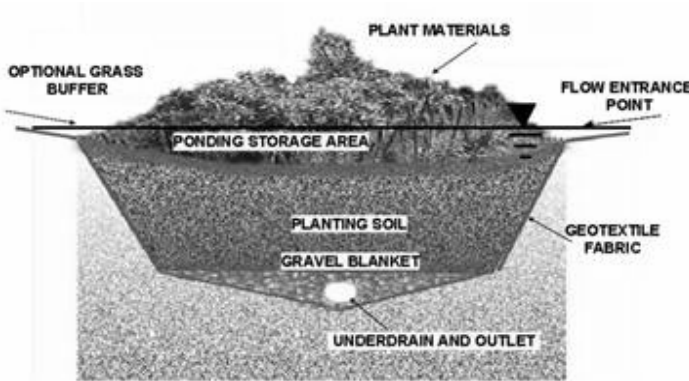
Schematic showing example Bioretention Area (Photo bottom left and Figure above from Wisconsin Department of Natural Resources, Post Construction Stormwater Management presentations)

Benefits of Use

Potential benefits for the incorporation of bioretention facilities as part of storm water management systems include:

- Assist with compliance with Wayne County Storm Water Standards
- Reduces impervious surfaces and increases the amount of disconnected impervious areas, which reduces the amount of storm water runoff that must be managed.
- Potential reductions in the need for and size of traditional storm sewers and storm water management systems.
- The above ground pooled water and some of the below ground storage volume can be counted toward meeting the water resources protection requirements described in Chapters 5 and 6.

- Greater lot yields.
- May count as both part of the required stormwater management system and toward local landscape and/or green space requirements.
- Increases natural habitats within a development.
- Construction and maintenance of bioretention facilities can be less costly than detention ponds.



Components of a Typical Bioretention Area (Figure from *Bioretention Manual*, Prince George's County, Maryland)

Features of Bioretention Areas

Bioretention areas typically have the following features:

- Grass buffer strips reduce runoff velocity and filter particulate matter.
- Sand bed provides aeration and drainage of the planting soil and assists in the flushing of pollutants from soil materials
- Ponding area provides storage of excess runoff and facilitates the settling of particulates and evaporation of excess water.
- Organic layer performs the function of decomposition of organic material by providing a medium for biological growth (such as microorganisms) to degrade petroleum-based pollutants. It also filters pollutants and prevents soil erosion.
- Planting soil provides the area for storm water storage and nutrient uptake by plants. The planting soils contain clays, which adsorb pollutants such as hydrocarbons, heavy metals and nutrients.
- Vegetation functions in the removal of water through evapotranspiration and pollutant removal through nutrient cycling.

Design Standards

Bioretention areas must be designed as follows:

- The drainage area to each bioretention area should be smaller than 5 acres and preferably less than 1 acre. Note that there can be multiple bioretention areas within a given development site.
- Sheet flow to bioretention areas should travel a maximum distance of 150 feet.
- A vegetated buffer strip with a minimum width of 2 feet must be provided around each bioretention area. The width of the buffer strip around bioretention areas is measured from the maximum water surface elevation of the ponding area associated with the bioretention area.
- The depth of the ponding area in a bioretention area cannot exceed 6 inches (see Typical Bioretention Cross-Section at end of this section). A maximum of 3 inches to 4 inches is preferred for areas that receive high hydraulic loading or have soils with low infiltration rates. This should be done in combination with a smaller drainage area.
- Soil borings and field infiltration/laboratory tests must be performed to determine characteristics of the in-situ soils at the proposed bioretention areas.
- Bioretention areas must include an underdrain and overflow structure (see Typical Bioretention Overflow Structure detail at end of this section), unless the applicant demonstrates that the infiltration rate of soil within the bioretention area is sufficient to prevent excess ponding. Underdrains must satisfy the following requirements:
 - Underdrains must have a hydraulic capacity greater than the infiltration rate of the soil in the bioretention area.
 - The underdrain must be perforated along its entire length. The location of the perforations (invert of pipe or elsewhere) depends upon the design of the facility. Typically, the perforations are placed closest to the invert of the pipe to achieve maximum potential for draining the facility. The perforations can be placed near the top of the pipe if an anaerobic zone is intended. Water below the perforated portion of the underdrain will have a tendency to

accumulate during periods of saturation. Otherwise, water will have a tendency to infiltrate into the surrounding in-situ soils.

- Underdrains cannot be perforated within 5 feet of where the underdrain system connects to a storm sewer structure.
- Underdrains must include an adequate outlet into a detention system, retention basin, storm sewer or watercourse to achieve positive flow.
- A 6-inch gravel bed is required to protect underdrain pipes and to reduce clogging. A gravel blanket around the underdrain helps keep it free of possible soil transport.
- The underdrain system must include a cleanout well to provide access for cleaning the system.
- The bottom of bioretention areas should be 3 feet or more above the seasonal high ground water table.
- A maximum of 20% void spaces in the planting soils and underdrain gravel blankets can be considered storage volume within the bioretention area.
- Bioretention areas may not be located within pre-existing surface waters.

Grading and Landscape Plans

Applicants that propose to include one or more bioretention areas as components of a storm water management system must submit a grading plan for the development project. The grading plan must clearly identify bioretention areas in relation to the topography and physical location. In addition, the grading plan must clearly identify routes for construction traffic that direct traffic around the bioretention areas. Allowing construction traffic to traverse a bioretention area may compact the soils or other subsurface media.

Applicants that propose to include one or more bioretention areas as components of a storm water management system also must submit a landscape plan for the development project. At a minimum, the landscape plan must specify soils and plant materials that the applicant proposes to include in a landscape, and describe the methods and planting techniques that the applicant proposes to utilize. Landscaping is included as regulated construction

activity for which financial assurance must be provided.

Preferred Design Elements

- Distributed placement of bioretention areas across a development site results in smaller, more manageable subwatersheds within the development site.
- On new residential subdivision lots or commercial lots, bioretention areas should be located near the source of the runoff generated from impervious surfaces. Facilities should be located near the perimeters and edges to maintain typical use of the property.
- Bioretention areas should not be located within 10 feet of building foundations unless the building design incorporates adequate waterproofing measures. Bioretention areas should not be located near wellheads or septic systems.
- Bioretention areas should not be located within 10 feet of public road rights of way.
- To minimize excess ponding, excess runoff should be diverted away from the bioretention by grading the elevation of maximum surface ponding equivalent to the elevation at which runoff is discharging into the bioretention area.
- A safe overland flow path for the excess runoff is recommended.
- Bioretention areas should be designed as off-line systems whenever possible. This is to prevent erosive flow of water within the facility.
- Sloped areas exceeding 20% should not be used for bioretention unless “weep-garden” designs are employed.
- Bioretention areas should not be built where wooded areas would need to be cleared, to make room for the facility.
- Bioretention areas should be located away from traveled areas such as public pathways to avoid compaction.
- In parking lot applications, bumper blocks or gapped curbing should be used to prevent entry of vehicles into the bioretention area.
- A raised underdrain has the effect of providing a storage area below the invert of the underdrain discharge pipe. The storage area is equal to the void space of the material used.

Filters

Filter material should be used between the gravel blanket around the underdrain and the planting soil above.

- A pea gravel diaphragm to filter water and soil before passing through to the underdrain gravel blanket is recommended. It should have a minimum thickness of 3-4 inches and a maximum thickness of 8 inches. Where situations permit, a greater depth may be appropriate, although the depth generally should not exceed 12 inches.
- A permeable filter fabric should be placed between the underdrain gravel blanket and the pea gravel diaphragm where the underdrain is located. The filter fabric should extend 2 ft to either side.
- Filter fabric may be placed along the "walls" of the bioretention area to help direct the water flow downward and to reduce lateral flows. For example, to prevent lateral flow under roads and parking lot pavement, filter fabric can be placed along the sidewalls of a bioretention area that is installed in the median strip or parking lot landscape island. The fabric should extend from the subgrade over the stone.



Rain Garden at Lathrup Village Offices (Photo courtesy of Lillian Dean, Southeastern Oakland County Water Authority)

Planting Soil

- The planting soil should have sufficient depth to provide adequate moisture capacity and to create space for root systems. There is a preferred mixture for planting soil used in

bioretention facilities (see "Material Specifications" below).

- Planting soil should be 4 inches deeper than the bottom of the largest root ball.

Plants

- Select plant materials that can tolerate extreme hydrologic changes, pollutant loading, and highly variable soil mixture conditions. Use of native plants is highly recommended. The material specification section below presents plant species recommended for bioretention areas.
- The minimum recommended caliper size for trees planted within a bioretention facility is 1 inch.
- Plant material and planting applications should meet guidelines set by the American Standard of Nursery Stock). Plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association (see "References" for this section).

Material Specifications

- **Planting Soil:** Planting soil should have a sandy loam, loamy sand, or loam texture per USDA textural triangle. Maximum clay content is <5%. The soil mixture should have pH between 5.5 and 6.5 with an organic content of 1.5 – 3.0 %. The soil mixture should have an infiltration rate greater than 0.5 in/hour. The soil should be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches. No other materials or substances should be mixed or dumped within the bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations. The planting soil should be free of Bermuda Grass, Quack Grass, Johnson Grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle, Tearthumb, or other noxious weeds.
- **Sand:** Sand should be clean and free of deleterious materials. For planting soil, MDOT Class II clean sand is recommended.
- **Mulch:** Mulch should consist of raw hardwood, MDOT Quality Product List (QPL). Grass clippings are unsuitable for mulch, primarily due to the excessive quantities of nitrogen built up in the materials.

- Geotextile fabric: Geotextile fabric should maintain a flow rate of 125 GPM per square foot. MDOT specifications are recommended (Table 910-1).
- Underdrain gravel blanket: The gravel blanket should be double washed, 1-1/2 inches in size. MDOT 4AA, 6A, or 6AA porous material is recommended.
- Pea Gravel: Pea gravel should be washed, river-run, round diameter, ¼ - ½ inches in size.
- Underdrain piping: A variety of materials can be used for underdrain piping, including heavy-duty PVC pipe and corrugated metal pipe. Other pipe materials may be used.
- Vegetation: The following is a partial listing of plants native to southeast Michigan that may be suitable for bioretention areas. The plants listed here are excellent for moist organic gardens that are “dry” within 48 hours of a rain. Check sun/shade conditions before planning and planting.

Wildflowers, sedges, and grasses

Beardtongue (*Penstemon digitalis*)
 Bergamot (Bee-Balm) (*Monarda fistulosa*)
 Black-Eyed Susan (*Rudbeckia hirta*)
 Blue Flag Iris (*Iris Virginica*)
 Blue Vervain (*Verbena hostata*)
 Boneset (*Eupatorium perfoliatum*)
 Canada Anemone (*Anemone canadensis*)
 Columbine (*Aquilegia canadensis*)
 Culver's Root (*Veronicastrum virginicum*)
 Indian Grass (*Sorghastrum nutans*)
 Joe-Pye Weed (*Eupatorium Maculatum*)
 Marsh Blazing Star (*Liatris spicata*)
 Missouri Ironweed (*Vernonia missurica*)
 New England Aster (*Aster novae-angliae*)
 Old-Field Cinquefoil (*Potentilla simplex*)
 Porcupine Sedge (*Carex hystericina*)
 Sneezeweed (*Helenium autumnale*)
 Spiderwort (*Tradescantia Ohiensis*)
 Swamp Goldenrod (*Solidago patula*)
 Swamp Milkweed (*Asclepias incarnata*)
 Tall or Green-Headed Coneflower (*Rudbeckia trilobum*)
 Tall Tickseed (*Coreopsis verticillata*)
 White Turtlehead (*Chelone glabra*)
 White Vervain (*Verbena urticifolia*)
 Wild Strawberry (*Fragaria virginiana*)

Shrubs

American Cranberrybush Viburnum (*Viburnum trilobum*)
 Black Chokeberry (*Aronia prunifolia*)
 Common Buttonbush (*Cephalanthus occidentalis*)
 Meadowsweet (*Spiraea alba*)
 Ninebark (*Physocarpus opulifolius*)
 Redosier Dogwood (*Cornus stolonifera*)
 Shrubby Cinquefoil (*Potentilla fruticosa*)
 Shrubby St. John's-Wort (*Hypericum prolificum*)
 Spicebush (*Lindera benzoin*)
 Steeplebush (*Spiraea tomentosa*)

Construction

Proper construction techniques (including proper grading), adequate landscaping, suitable soil mixtures, and approved materials are critical to the success of bioretention areas.

- The grading plan for the entire development project must clearly identify the bioretention areas. Grading of or construction traffic over those areas should be avoided.
- The area surrounding the bioretention areas should be stabilized prior to construction of the bioretention areas to minimize compaction and contamination of the bioretention site.
- Placement of the gravel over the underdrain must be done with care. Avoid dropping the gravel high levels from a backhoe or front-end loader bucket. Spill directly over underdrain and spread manually.
- Placement of the planting soil in the bioretention area should be in lifts of 12 to 18 inches and lightly compacted. Minimal compaction effort can be applied to the soil by tamping with a bucket from a dozer or backhoe. Do not use heavy equipment within the bioretention facility. Heavy equipment can be used around the perimeter of the basin to supply soils and sand. Grade bioretention materials with light equipment such as a compact loader or a dozer/loader with marsh tracks.
- Compaction will significantly contribute to design failure. Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are

to re-fracture the soil profile through the 12-inch compaction zone. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

- Rototill 2 to 3 inches of sand into the base of the bioretention facility before back filling the facility and placement of underdrain. Pump any ponded water before preparing (rototilling) base.
- In order to speed up the *natural* compaction process, presoaking the placed soil may be performed. Significant settlement can occur after the first presoak, and additional settlement may occur subsequent to the initial wetting. If time and construction scheduling permits, it is preferable to allow natural settlement to occur with the help of rain events to presoak the soil medium.



Construction of Rain Garden at Lathrup Village Offices
(Photo courtesy of Lillian Dean, Southeastern Oakland County Water Authority)

Maintenance

Proper maintenance will not only increase the expected life span of the facility, but will also improve aesthetics. Annual maintenance of plant material, soil layer and the mulch layer is required for the overall success of bioretention systems.

- Mulch should be re-applied once every six months, to maximize nitrogen uptake by the facility and to help control growth of unwanted plants. The mulch layer should be removed and replaced every 2 years.
- Mulch should be uniformly applied approximately 2 to 3 inches in depth. Piling mulch around the base of the tree is not recommended as the tree may become infested with pests and diseases. Mulch applied any deeper than three inches reduces proper oxygen and carbon dioxide cycling between the soil and

the atmosphere, and keeps roots from making good contact with the soil.

- Soils begin filtering pollutants immediately but can lose their ability to function in this capacity over time. Evaluation of soil fertility is important in maintaining an effective bioretention system. It is recommended that soils be tested annually and replaced when soil fertility is lost. Depending on environmental factors, this usually occurs within 5-10 years of construction.
- As with any garden, bioretention requires weeding to control growth of unwanted plants that can be invasive, consuming the intended planting, and destroying the aesthetic appeal. Weeding should be accomplished routinely and at least monthly.
- Water in the facility should infiltrate the system within 4-6 hours or less. Clogging or blockage of either the surface layer or fines obstructing the filter fabric used between the gravel bed/underdrain and the surrounding planting soil usually causes pooling water. Including a clean out pipe in the underdrain system will provide access for cleaning the system. Removing the mulch layer and raking the surface may correct the surface blockage problem. For blocked filter fabric, use lengths of small reinforcing bar (e.g., 2-3 ft of #4 rebar) to puncture the fabric with holes every 1-foot on center. If the soils themselves are causing the problem, punch holes in the soil or optionally, install a “sand window” at least 1 foot wide running vertically to the underdrain system elevation.
- If plants wilt during the heat of the day, but recover in the evening, watering is not necessary. The plants are simply conserving moisture. If they do not recover, watering is indicated. Another good rule of thumb is to stick a pencil or screwdriver about four inches into the soil. If the soil is moist at that depth, watering is not needed. If the soil is dry, and the shrubs or trees were planted within the last three years, watering is necessary.
- If any of the plants do not perform well, become diseased or die, they should be replaced.
- For trimming and harvesting, the current practice is to leave ornamental grasses and

perennial seed heads standing to provide winter interest, wildlife forage, and homes for beneficial insects. Plants should not be cut back until spring when new growth commences, and even then it is only done for neatness; it does not impact growth. Plants may be pinched, pruned, sheared or deadheaded during the growing season to encourage more flowering, a bushier plant, or a fresh set of leaves. Diseased or damaged plant parts should be pruned as they occur. If a plant is pest-infested, perform cleanup in fall to deny the pest a home. Trees and shrubs may be pruned for shape or to maximize fruit production.

- The properly designed bioretention area should thrive and allow planting materials to expand and propagate, eventually becoming overcrowded. If this occurs, perennial plants should be divided in spring or fall.
- By design, bioretention facilities are located in areas where nutrients (especially nitrogen) are significantly elevated above natural levels. Fertilization in such areas usually is unnecessary, because it is unlikely that soil fertility will be the limiting factor in plant growth. If soil fertility is in doubt, a simple soil test can resolve the question. If fertilization should become necessary, an organic fertilizer will provide nutrients as needed without disrupting soil life.
- Runoff flowing into bioretention facilities may carry trash and debris with it, particularly in commercial settings. Trash and debris should be removed regularly both to ensure that inlets do not become blocked and to keep the area from becoming unsightly.

References and Additional Resources

- American Hort. www.americanhort.org
- City of Wayne (MI), “City Hall Storm Water Quality Improvements Project Fact Sheet” and project summary, Clean Michigan Initiative Nonpoint Source Grant “City Hall Storm Water Quality Improvements”. Contact: Ramzi El-Gharib, City Engineer. Additional project information provided by Michelle West; Ayres, Lewis, Norris & May, Inc.
- Office of the Washtenaw County Water Resources Commissioner. Resources and

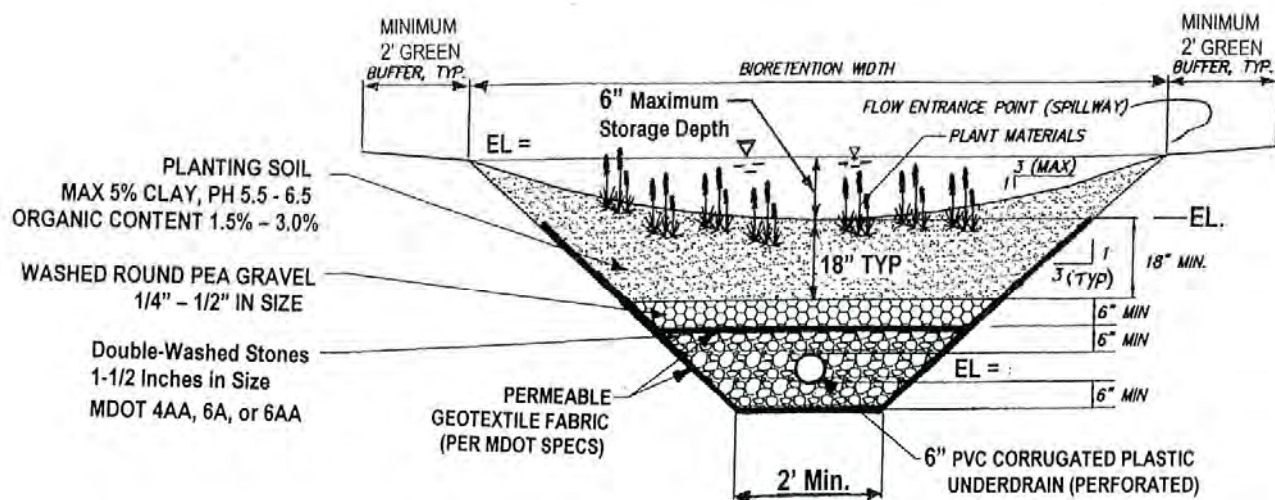
Techniques for Street Runoff Infiltration:

http://www.ewashtenaw.org/government/drain_commissioner/dc_webWaterQuality/street-runoff-infiltration/resources-and-techniques-for-street-runoff-infiltration

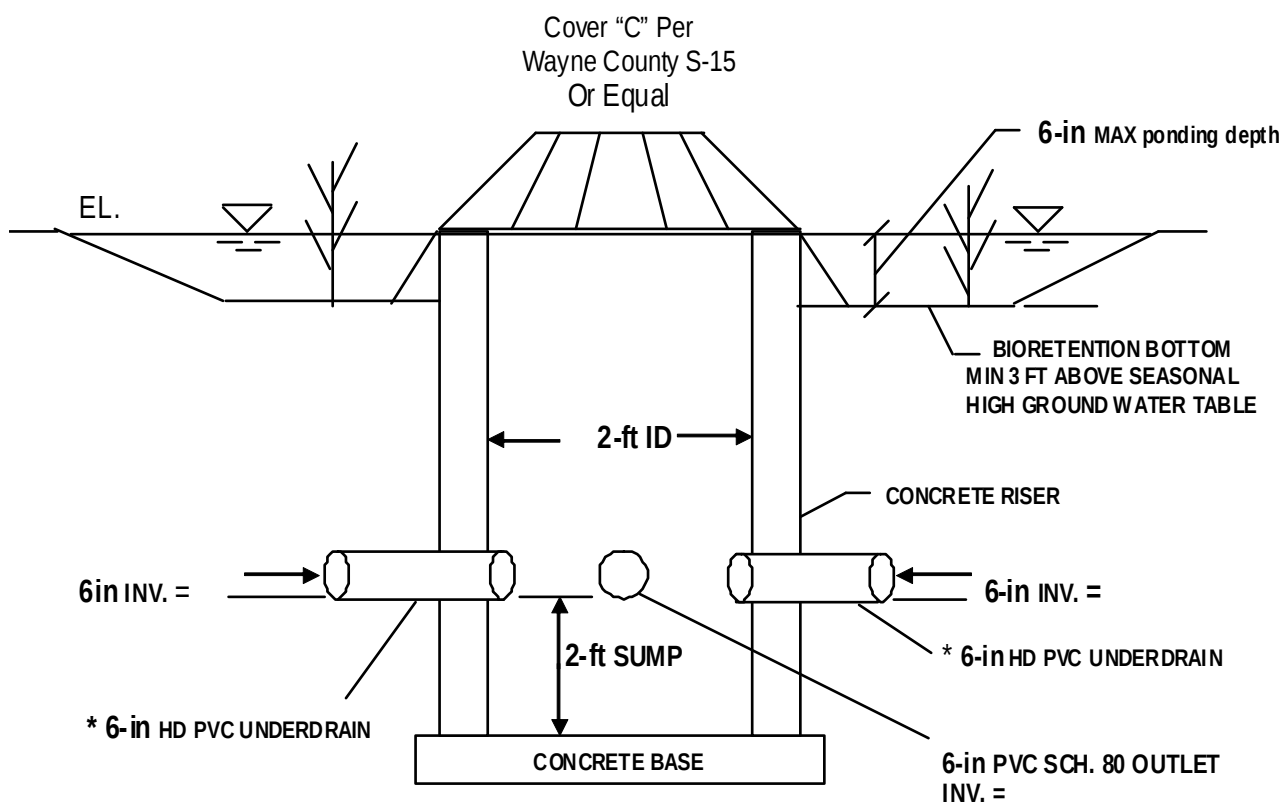
- Prince George’s County, Maryland. Stormwater Management Design Manual (September 2014) and its predecessor Bioretention Manual (November 2001).
<http://www.princegeorgescountymd.gov/sites/DPIE/Resources/Publications/design/Pages/default.aspx>
- Southeastern Oakland County Water Authority. Rain Gardens for the Rouge River: A Citizen’s Guide to Planning, Design, & Maintenance for Small Site Rain Gardens and other related publications.
http://www.socwa.org/lawns_gardens.shtml
- United States Environmental Protection Agency, Office of Water. Publications on green infrastructure (<http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm>) and storm water management (<http://water.epa.gov/polwaste/npdes/swbmp/PostConstruction-Stormwater-Management-in-New-Development-and-Redevelopment.cfm>)
- Wisconsin Department of Natural Resources (WDNR). Storm Water Post-construction Technical Standards
http://dnr.wi.gov/topic/stormwater/standards/postconst_standards.html
- “Local Storm Water and Watershed Management Practices Constructed/Implemented in Southeast Michigan”, available at
<http://www.waynecounty.com/doe/1190.htm>
Project summaries, photos, location and contact information, web links, and other information for a variety of storm water and watershed management practices in six categories including Bioretention / Low Impact Development / Native Landscaping
- Low Impact Development Center
www.lowimpactdevelopment.org
- Center for Watershed Protection
www.cwp.org and
<http://xn--www-rp0a.stormwatercenter.net/>

Resources For Native Plant Material

- Michigan Native Plant Producers Association.
<http://www.MNPPA.org>
- Michigan Association of Conservation Districts.
<http://www.macd.org/>
- Wild Ones Organization.
<http://www.wildones.org/>



Typical Bioretention Cross-Section
N.T.S.



TYPICAL BIORETENTION OVERFLOW STRUCTURE
NOT TO SCALE

* UNDERDRAIN PIPE SHOULD NOT BE PERFORATED WITHIN 5 FT OF THE OVERFLOW STRUCTURE

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8.2.3 Manufactured Treatment Systems

Description

Manufactured treatment systems are manmade devices or structures that are used to remove sediment and other particulate matter from storm water runoff. Manufactured treatment systems may be used at the inlets to underground detention systems, open detention basins, or retention basins. By removing settleable materials, pretreatment systems reduce the amount of material that accumulates in detention/retention systems, and the frequency at which accumulated materials must be removed. Manufactured treatment systems are particularly applicable in small development sites for meeting the water resources protection performance standard of the Wayne County Storm Water Management Standards.

Wayne County periodically evaluates various types of manufactured treatment systems for conformance with the design standards, preferred design elements, and materials specifications presented in this section. Please refer to the "Guideline for Wayne County Review of Manufactured Treatment Systems" document available from the Wayne County website for more information about the review process (see the "Supplemental Information" webpage at http://waynecounty.wc/mygovt/doe/depts/wqd/supplement_info.aspx). Please contact the Wayne County Permit Office (734-595-6504) for more information about which types of manufactured treatment systems have been reviewed by Wayne County under this procedure.

Design Standards

- Manufactured treatment systems must include a chamber or other device to accumulate and store settleable solids in a manner and a location that will prevent re-suspension of previously captured particulates.
- The system should be capable of removing 80% of the net annual Total Suspended Solids (TSS) load based on a 75-micron (and smaller) particle size for a gradation mix of "50-125" microns.
 - o Annual TSS removal efficiency estimates or models must be based on documented removal efficiency performance from certified full-scale independent studies (for example, laboratory tests) over a range of storm sizes.
 - o The tested full-scale model should be tested for efficiency under various flow rates at equal increments. The flow rate increments should start at a minimum of 10% of presumed capacity up to at least

25% above the presumed capacity. There should be a minimum of 3 tests at each incremental flow rate. The influent concentration should be a maximum of 300 mg/L.

- o Supporting engineering calculations and other relevant documentation for upscaling and downscaling the full-scale tests of select size units to other size units should be provided.
 - o Generally, annual TSS removal efficiency models should be corroborated by field tests performed by an independent third party using influent and effluent composite samples from a minimum of ten storms at one location.
 - o Procedures for submitting a manufactured treatment system to Wayne County for review for compliance with these criteria are documented in "Guideline for Wayne County Review of Manufactured Treatment Systems"; check the website for the most current version of this document (http://waynecounty.wc/mygovt/doe/depts/wqd/supplement_info.aspx).
 - o A water-lock feature must be incorporated into the design of the storm water treatment system to prevent the introduction of trapped oil and floatable contaminants to the downstream piping during routine maintenance and to ensure that no oil escapes the system during subsequent storm events.
 - o Peak flow rates for various models of manufactured treatment systems that have been approved by the County under this section are shown in Table 8.2.3-1.
- The installed manufactured treatment system (manufactured unit and surrounding soil structure) must sustain an HS20 loading as determined by a Professional Engineer licensed in the State of Michigan.
 - The minimum cover of backfill material should be recommended by the manufacturer and approved by the Permit Engineer.

Preferred Design Elements and Materials

Due to the potential for manufactured treatment systems to malfunction and/or create maintenance problems, Wayne County recommends that manufactured treatment systems incorporate the following design elements:

- Manufactured treatment systems should be designed to treat up to the peak flow rate for the design storm event (i.e., 10-year storm).

- Manufactured treatment systems should be designed so that they do not re-suspend trapped sediments or re-entrain floating contaminants at flow rates up to or exceeding those for the design storm event.
- The system pump-out volume should be less than ½ of the total system volume.
- The system should not create backwater in the upstream piping network for flows up to and including the design storm event.
- Direct access should be provided to the sediment and floatable contaminant storage chambers to facilitate maintenance. The storage chambers should have no appurtenances or restrictions within them which would prohibit removal of accumulated sediment and debris during maintenance.

Materials Specifications

Manufactured treatment systems may be constructed from pre-cast or cast-in-place concrete or other materials approved by Wayne County and should meet the following specifications:

- For treatment systems made of cast-in-place or pre-cast concrete:
 - o Concrete for pre-cast manufactured treatment systems should conform to ASTM C 857 and C 858.
 - o Cement should be Type II Portland cement conforming to ASTM C 150.
 - o Treatment systems constructed from pre-cast concrete should be manufactured in accordance with ASTM C 478.
 - Sections should be cured by an approved method and should not be shipped until (1) at least 5 days have passed since fabrication and/or repair, and (2) the concrete has attained a compressive strength of 4,000 psi.
 - o Manufactured treatment systems constructed from cast-in-place concrete or reinforced concrete should conform to current Wayne County specifications for structural concrete.
 - o Sections should have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.
 - o Wall thicknesses should not be less than 6 inches or as otherwise shown on the dimensional drawings
 - o Openings should be sized to accept pipes of the specified size(s) and material(s), and should be sealed with hydraulic cement conforming to ASTM C 595M.

- o Internal aluminum plate components should be aluminum alloy 5052-H32 in accordance with ASTM B 209.
- o A bitumen sealant in conformance with ASTM C 990 should be utilized in affixing the aluminum swirl chamber to the concrete vault.
- For manufactured treatment systems (including smooth bubble and weir plates) fabricated from high density polyethylene (HDPE):
 - o Virgin HDPE material should be used, conforming with the minimum requirements of cell classification 424420C (4-in – 10-in diameter) and 435440C (12- in – 60-in diameter) per ASTM C 3350.
 - o The virgin HDPE material should be evaluated using the notched constant ligament-stress (NCLS) test as specified in Section 9.5 and 5.1 of AASHTO M294 and ASTM F2306.
 - o Weir and battle plates shall be welded at all interfaces between the plate and water quality unit.
- For manufactured treatment systems fabricated from corrugated polyethylene pipe (CPE):
 - o The system and all required fittings should conform to AASHTO M294 Type S.
 - o Fittings and couplings must be noncorrugated, solid sleeve fabricated from polyethylene with a gasket on both sides of the joint.
 - o Split collar couplers are not allowed.
 - o Weir and battle plates shall be welded at all interfaces between the plate and water quality unit.

Testing

The manufacturer of these systems must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior to fabrication to schedule inspection during fabrication. Wayne County inspects the material fabrication process to ensure that the manufacturer's testing of the product occurs at the applicable AASHTO or ASTM standards.

Installation

Manufactured treatment systems must be constructed to serve the capacity shown on the drawings and as specified in the approved permit plans. The system must be installed at elevations and locations shown on the approved plans, or as otherwise directed by the County.

A Wayne County Permit Engineer must observe the installation of all manufactured treatment systems. Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours days prior to installation to schedule inspection during

installation. Wayne County will not accept any manufactured treatment systems installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

The following procedures should be followed for installation of manufactured treatment systems:

- For concrete manufactured treatment systems, installation should conform to ASTM specification C 891 "Standard Practice for Installation of Underground Precast Utility Structures." Cast-in-place installation should follow Wayne County specifications for structural concrete. Installation procedures recommended by the manufacturer, if any, should also be consulted.
- For manufactured treatment systems made of materials other than concrete, installation procedures recommended by the manufacturer should be followed. These procedures should be included in the application package submitted to Wayne County for approval of the entire storm water management system for the development project.
- The base unit of the manufactured treatment system should be placed on a subbase consisting of MDOT Class II granular material of a minimum thickness of six inches, or greater after compaction by the "Controlled Density Method" to 95% of the Maximum Unit Weight. The granular subbase should be checked for level prior to setting and the pre-cast base section of the trap should be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5%, the base section should be removed and the granular subbase material re-leveled.
- For pre-cast concrete systems, prior to setting subsequent sections, a bitumen sealant that conforms to ASTM C 990 should be placed along the construction joint in the section that is already in place. Pre-cast sections should be set in a manner that will result in a watertight joint.
- For manufactured treatment systems made of materials other than concrete, prior to setting subsequent sections, a sealant that conforms to the specification recommended by the manufacturer should be placed along the construction joint in the section that is already in place. Sections should be set in a manner that will result in a watertight joint.
- For pre-cast concrete systems, holes made in the concrete sections for handling or other purposes should be plugged with a nonshrink grout or by using grout in combination with concrete plugs.
- For manufactured treatment systems made of materials other than concrete, holes made in the unit for handling or other purposes should be plugged with materials meeting

the specification recommended by the manufacturer for such materials.

- For pre-cast concrete systems, where holes must be cut in the pre-cast sections to accommodate pipes, cutting should be completed before the sections are set in place, to prevent any subsequent jarring which may loosen the mortar joints. For manufactured treatment systems made of materials other than concrete, field cutting of the system to accommodate pipes is not allowed.
- Backfill around the manufactured treatment system should consist of:
 - o MDOT Class II granular material for systems made of cast-in-place and pre-cast concrete
 - o MDOT 6A, 2G, or 34G material for systems made of HDPE or CPE
- All backfill materials should be placed in a balanced manner and such that there is no more than a 2 lift differential from one side to the other. Balanced lifts should be advanced across the width of the system, evenly along the length of the system throughout the backfilling process.
- All backfill materials should be placed in lifts of maximum 10-inches in depth.
- For each backfill lift, all materials should be compacted to a minimum of 95% (90% minimum required for backfill consisting of MDOT 6A material) of the backfill material's maximum unit weight at a moisture content not greater than the optimum. The maximum unit weight of the backfill material should be determined by the AASHTO T 180 or Michigan Cone Method. The frequency of the compaction testing should be one or more tests per lift of backfill around the trench of the structure.

Documentation of the following items relative to the installation of manufactured treatment systems is required to be submitted to the Wayne County Permit Engineer before permits and financial assurances before are released:

- All backfill materials are from Wayne County tested stock.
- All backfill materials were placed in lifts of maximum 10-inches.
- For each backfill lift, all materials were compacted to a minimum of 95% of the backfill material's maximum unit weight at moisture content not greater than optimum. If MDOT 6A backfill material was used, materials were compacted to 90% of the backfill material's maximum unit weight at moisture content not greater than optimum.

- The maximum unit weight of the backfill material was determined by the AASHTO T 180 or Michigan Cone Method.
- The compaction was tested a minimum of one test per lift of backfill around the trench of the structure.

Maintenance

Manufactured treatment systems should be maintained in accordance with the manufacturer's recommended schedule.

Table 8.2.3-1

**PEAK FLOW RATES OF VARIOUS MODELS OF MANUFACTURED TREATMENT SYSTEMS
APPROVED BY WAYNE COUNTY UNDER THIS SECTION**

Kennedy Solutions, Inc (KSI) Storm Water Treatment Systems

KSI Model	Chamber Size/Diameter (inches)	Peak Flow (cfs)
Series 350	36	1.8
Series 500	48	2.3
Series 750	48	3.3
Series 1000	48	4.1
Series 1250	48	5.0
Series 1500	60	6.2
Series 1750	60	7.4
Series 2000	60	8.3
Series 2500	60	9.8
Series 3000	60	11.3
Series 3500	60	13.8

Stormceptor STC™

Stormceptor STC™ Model	Peak Flow (cfs)
450	0.48
900	0.99
1200	1.27
1800	2.22
2400	3.48
3600	5.35
4800	8.75
6000	10.96
7200	13.98
11000	22.50

Vortechs™

Vortechs™ Model	Peak Flow (cfs)
1000	1.2
2000	2.1
3000	3.4
4000	4.5
5000	6.4
7000	8.3
9000	10.5
11000	13.1
16000	18.8

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8.3.1 Closed Conduit Inlet/Outlet Design

Description

To prevent soil erosion due to excessive velocities, end treatment and soil stabilization measures should be used with all inlets and outlets for closed conduits. Some types of outlets should also discharge to the watercourse at a prescribed elevation. In addition, a grate should be provided on some closed conduit inlets and outlets to prevent children or animals from entering the conduit.

End Treatments

All storm water enclosure inlets/outlets in a roadside ditch or adjacent to County Roads must have a flared end section type of end treatment for road safety purposes. The following requirements apply to storm water enclosure inlets/outlets which are not in a roadside ditch or adjacent to a roadway.

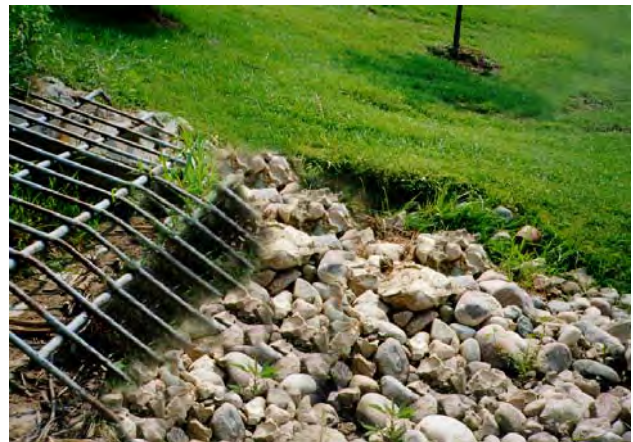
- For inlets/outlets on County park property, end treatments may be either the “reverse wingwall” headwall with a splash pan shown in the detail provided in Appendix E-1 of this manual, or the standard headwall described below.
- For enclosures 36 inches in diameter or smaller, the inlet/outlet treatment should be a flared end section (MDOT Standard Plan Series R-86-D (concrete) or R-88-D (steel)) or an outlet headwall (Standard Plan Series R-85).
- For enclosures larger than 36 inches in diameter, the inlet/outlet treatment should be either a site-specific designed concrete headwall or, if approved by the Permit Office for the specific location and under 84 inches in diameter, a flared end section (MDOT Standard Plan Series R-86-D (concrete) or R-88-D (steel)).

Soil Stabilization

Soil stabilization measures should be provided around each end treatment to prevent any soil erosion around the end

treatment or in the flow path leading to or from the end treatment. Storm sewer outlets located across from the cutting side of a watercourse also should include soil stabilization measures for the opposite embankment.

Soil stabilization measures may include riprap with geotextile fabric, revet mattresses, cobbles, stone, crushed rock, precast blocks, gabions. Depending on the location, the biotechnical streambank stabilization techniques described in Section 8.4 of this manual also may be appropriate. Crushed/broken concrete is not an acceptable substitute for riprap. Soil stabilization measures should be put in place immediately after final grading and before the inlet or outlet receives flow.



Filter fabric should be per MDOT specifications. Riprap placement and sizing should follow the specifications provided in Appendix E-2 of this manual.

Outlet Elevations

In general, the invert elevation of a closed conduit which outlets to a watercourse should be at or below the low water level of the watercourse. Special provisions may be required if the outlet is located on the cutting bank of a bend in the watercourse.

To minimize the possibility of backflow from a watercourse into an open detention basin, the permanent pool water

level in the detention basin should be at least 1 foot above the low water level in the watercourse.

Grates

Grates for animal protection should be provided for all storm water inlets/outlets within open detention basins, retention basins, and forebays. For other storm water inlets/outlets, grates for animal protection are only used for enclosures larger than 24 inches in diameter. Grates should comply with MDOT Standard Plan Series R-92-C.

Maintenance

Closed conduit inlets and outlets should be inspected periodically for signs of soil erosion and to identify any damage to the end treatment or grate. Any trash or debris caught on the grates should also be removed on a regular basis.

8.3.2 Vegetated Swales

Description

Vegetated swales are broad, shallow channels lined with vegetation that slow and filter storm water runoff and promote infiltration. Vegetated swales can serve as storm water management conveyance and may also be used to achieve a degree of stormwater treatment. Common applications include:

- Storm water conveyance within a development site.
Vegetated swales can replace curbs, gutters, and storm sewer systems along roads or and/or parking areas where local community standards and site conditions permit.
- Storm water management retrofit and redevelopment situations. The addition of grassed swales will provide some improvement in the amount of runoff and in water quality.

Vegetated swales are best suited for relatively small drainage areas such as areas of sheet drainage up to 2 acres (e.g. along roadways, around parking lots, and as buffers between properties). They may count both as part of the required storm water management system and toward local landscape and/or green space requirements.

Design Criteria

- A maximum 150-foot distance of sheet drainage to the swale is recommended, with varying grades up to a maximum of 3%.
- If a storm sewer discharges into a swale, energy dissipation should be used at the point of inlet.
- The flow capacity of vegetated swales used as conveyance in storm water management systems must equal or exceed the peak flow rate for the 10-year storm.
- To reduce the possibility of erosion, swales should be designed with peak flows that do not exceed 5 cfs.
- Flow velocities in vegetated swales should range between a minimum of 2 ft/sec and a maximum of 5 ft/sec.
- Check dams may be used to reduce velocities, promote infiltration, increase storage and enhance water quality. Earthen check dams are not recommended because of their potential to erode. Toe protection is recommended for all check dams.
- The minimum acceptable longitudinal slope of a vegetated swale is 0.15% unless other techniques such as infiltration devices are employed.
- The maximum longitudinal slope of a vegetated swale should not exceed 3%, unless check dams are used.



Grassed swales can be used along roadsides and parking lots to collect and treat stormwater runoff

- Swale length should be a minimum of 200 feet wherever possible, to increase the contact time of storm water.
- A parabolic or trapezoidal shape is recommended, with side slopes no steeper than 3:1. Soil conditions, vegetative cover and maintenance ability should be considered when designing the side slopes.
- A minimum freeboard of 6 inches below the top of bank is recommended.
- The maximum recommended water depth for temporary pooling of water is 6 inches. A maximum of 3 inches to 4 inches is preferred for areas that receive high hydraulic loading or have soils with low infiltration rates. This should be done in combination with a smaller drainage area.
- Clearance between the swale invert and underground utilities should be addressed as part of the design process. A minimum clearance of 5 feet between swale invert and underground utilities is recommended unless special provisions are employed.
- There may be additional design criteria for vegetated swales adjacent to roads, particularly those under the jurisdiction of another agency (e.g., MDOT).
- Grading plans for the development project should clearly identify the location of vegetative swales in relation to the topography and physical location. The grading plans should clearly identify the routing of construction traffic such that it does not traverse the swale locations.
- Swales should follow the natural, pre-development drainage path when possible.



Vegetation Specifications

Applicants that propose to use vegetated swales as part of a storm water management system must submit a landscaping plan with the application for storm water construction approval. The landscaping plan is required because vegetation is essential to the proper functioning of the swale. Landscaping is part of the regulated construction activity for which financial assurance must be provided.

Vegetation should be uniform and should consist of fine, turf-forming water-resistant grasses. Deep-rooted native wetland and upland grasses are preferred for infiltration and reduced maintenance.

In areas with high groundwater and/or little slope, the southeast Michigan native plants suitable for bioretention areas (see Section 8.2.2) should be considered. The plants listed in Section 8.2.2 are excellent for moist organic areas that are “dry” within 48 hours of a rain.

Plant material and planting applications should meet guidelines set by the American Standard of Nursery Stock (see “References” on page 8-5). Plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association.

Maintenance

Maintenance of vegetated swales should be focused on keeping a dense, healthy vegetated cover and keeping up the hydraulic and removal efficiency of the channel. Maintenance activities related to the vegetated cover include mowing (with grass never cut shorter than the design flow depth), weed control, and re-planting/seeding of bare areas. “River friendly” lawn and garden practices (see References below) should be followed in the maintenance of vegetated swales.

Vegetated swales should periodically be cleared of debris and blockages. Periodic sediment cleanout should be done manually to avoid the transport of resuspended sediments in periods of low flow and to prevent a damming effect from sediment buildup.

Damaged areas (e.g., ruts or holes) within a channel should be repaired utilizing a suitable soil that is properly tamped and seeded.

Inlets and outlets should be inspected periodically for blockage, signs of soil erosion, and structural damage. Swales should be inspected for sediment accumulation semiannually and after rain events. Sediment that is impeding flow should be removed. Inlets, outlets, and appurtenances (e.g., grates) should be inspected annually for structural integrity. Outlets should be checked regularly for clogging and should be cleaned when necessary, especially after large storm events.

References

- American Standard of Nursery Stock, American Nursery & Landscape Association, <http://www.anla.org/applications/Documents/Docs/ANLStandard2004.pdf>
(Also document ANSI Z60.1-2004 of the American National Standards Institute (ANSI). www.ansi.org)
- International Storm Water Best Management Practices Database. www.bmpdatabase.org
- Michigan Department of Transportation. Drainage Manual. <http://www.michigan.gov/stormwatermgmt/0,1607,7-205-30101-93193--,00.html>
- Office of the Washtenaw County Drain Commissioner. Vegetated Swales Fact Sheet. Ann Arbor, MI. August 2004. www.ewashtenaw.org/government/drain_commissioner/dc_lid.html
- The following documents, published by the (SE MI) Healthy Lawns and Gardens Technical Advisory Committee, are available from Wayne County's website at <http://www.waynecounty.com/doe/watershed/mgmt/Bioreten tion.htm>
 - o “Healthy Law Care Tips”, Spring 2006.
 - o “Earth Friendly Fertilizers Recommended for Lake and River Water Quality Protection, Southeast Michigan”, 2006
 - o See also their website www.healthylandscapes.com
- United States Environmental Protection Agency, Office of Water. Storm Water Technology Fact Sheet: Vegetated

Swales. EPA-832-F-99-006. Washington, DC. September 1999.

<http://www.epa.gov/owm/mtb/vegswale.pdf>

References: Native Landscaping

- Michigan Association of Conservation Districts. "Gateway to Michigan's native Plants."
<http://www.macd.org/rollovers/nativeplants/nphome.html>
- United States Environmental Protection Agency
www.epa.gov/greenacres/
- Wild Ones Organization. Landscaping with Native Plants.
www.for-wild.org

Resources For Native Plant Material

- Michigan Native Plant Producers Association, "Plants and Seeds Source Guide" and "List of Member Nurseries".
<http://www.MNPPA.org>

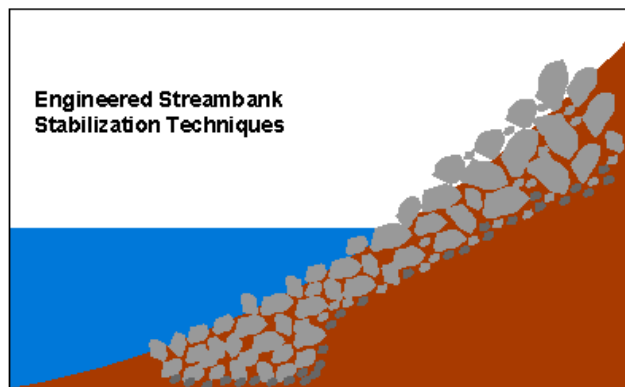
8.4 Streambank Stabilization

Description

Specific measures can be taken to stabilize streambanks and slopes from erosion. The best way to identify specific areas where streambank erosion controls are needed is to look at the entire watershed. Three techniques are used depending on area conditions and stabilization needs.

Engineered Techniques

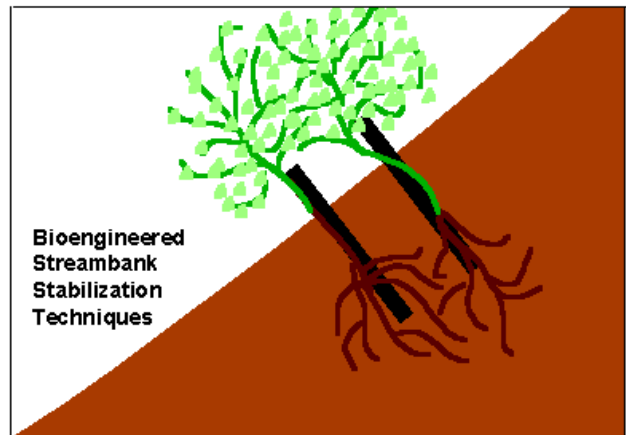
Engineered structures such as riprap, gabions and revetments may be used for streambank slopes that cannot be stabilized by vegetation. Engineered structures successfully control streambank erosion if constructed and maintained properly.



Riprap is a permanent cover of rock with geotextile fabric or a stone base underneath to provide stabilization. Riprap should be placed on slopes no steeper than 2H:1V. The top of the riprap should extend 3 feet above the ordinary high water mark. Gabions are flexible, woven wire cells filled with stone. They are generally composed of 2 to 6 cells with underlying supporting geotextile fabric. They can be used in lakes and steep shorelines. Revetments are stone, rock, or gabions filled with sand or grout which are placed at the toe of a bluff to protect against storm/wave action. This structure should be constructed on a stabilized slope less than 2H:1V. Filter fabric should be per MDOT specifications. Riprap placement and sizing should follow the specifications provided in Appendix E-2.

Bioengineered Techniques

Bioengineered streambank measures use embedded live plants to provide a barrier for earth movement, soil reinforcement, and hydraulic drains. Bioengineered

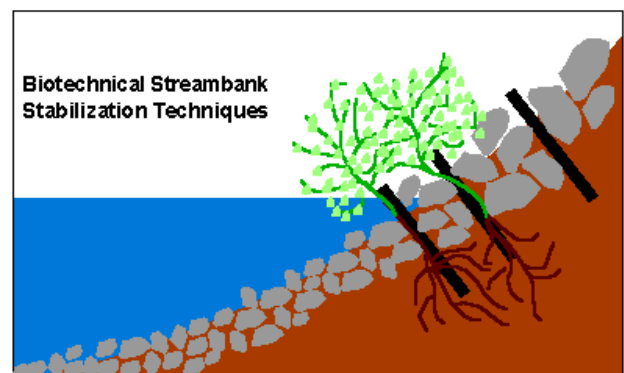


streambanks grow more successful with time as vegetation is established.

Many different types of bioengineered methods may be used. Live stakes are a type of living, woody plant cuttings capable of rooting and growing into mature plants. They should be placed in random configurations to produce a more natural effect. Joint staking is a system which installs willow stakes between rock placed previously on the channel. This increases the effectiveness of the rock base by providing a living root mass below. Brush mattress is a system of living units that form an immediate, protective cover over the channel bank to capture sediment. This system requires a large amount of live material intended to root and grow.

Biotechnical Techniques

Biotechnical measures use integrated plants and inert structural components to stabilize channel slopes, prevent erosion and provide a natural appearance.



Biotechnical methods are more successful as vegetation becomes established. Vegetated riprap, cellular grids, and grass systems may be used. Vegetated cellular grids are structural grids that are fastened to the slopes to help establish vegetation. Vegetation is planted within the grid units. Reinforced grass systems have been artificially augmented with mats, meshes or interlocking concrete blocks to increase the resistance to erosion over grass alone.

Bioengineered and Biotechnical methods may be used in a wide range of channel conditions from steep to low gradients.

Maintenance

Occasional site inspections should be conducted to ensure the streambank structures are stable. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.

References

- Streambank and Shoreline Protection Manual. Lake County Stormwater Management Commission, Lake County Planning, Building and Development Department U.S.D.A. - Natural Resources Conservation Service. January 2002.
- Stream Corridor Restoration: Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group (FISRWG 15 Federal agencies of the US government) October 1998.
- American Standard of Nursery Stock, American Nursery & Landscape Association, <http://www.anla.org/applications/Documents/Docs/ANLStandard2004.pdf>
(Also document ANSI Z60.1-2004 of the American National Standards Institute (ANSI). www.ansi.org)

Additional Resources

- “Local Storm Water and Watershed Management Practices Constructed/Implemented in Southeast Michigan”, available at <http://www.waynecounty.com/doe/watershed/mgmtPractices.htm>
- Project summaries, photos, location and contact information, weblinks, and other information for a variety of storm water and watershed management practices in the categories :
 - o Bioretention / Low Impact Development / Native Landscaping
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 - o Detention Ponds/Constructed Wetlands
 - o Streambank Stabilization
 - o Woody Debris Management
 - o Green Buildings
- Michigan Association of Conservation Districts. “Gateway to Michigan’s Native Plants.” <http://www.macd.org/rollovers/nativeplants/nphome.html>
- United States Environmental Protection Agency www.epa.gov/greenacres/
- Wild Ones Organization. Landscaping with Native Plants. www.for-wild.org

Resources For Native Plant Material

- Michigan Native Plant Producers Association, “Plants and Seeds Source Guide” and “List of Member Nurseries.” <http://www.MNPPA.org>

8.4.1 Live Stakes

Description

Live staking involves the insertion and tamping of live, rootable vegetative cuttings into the ground. If correctly prepared, handled and placed, the live stake will root and grow. A system of stakes creates a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Most willow species root rapidly and begin to dry out a bank soon after installation.

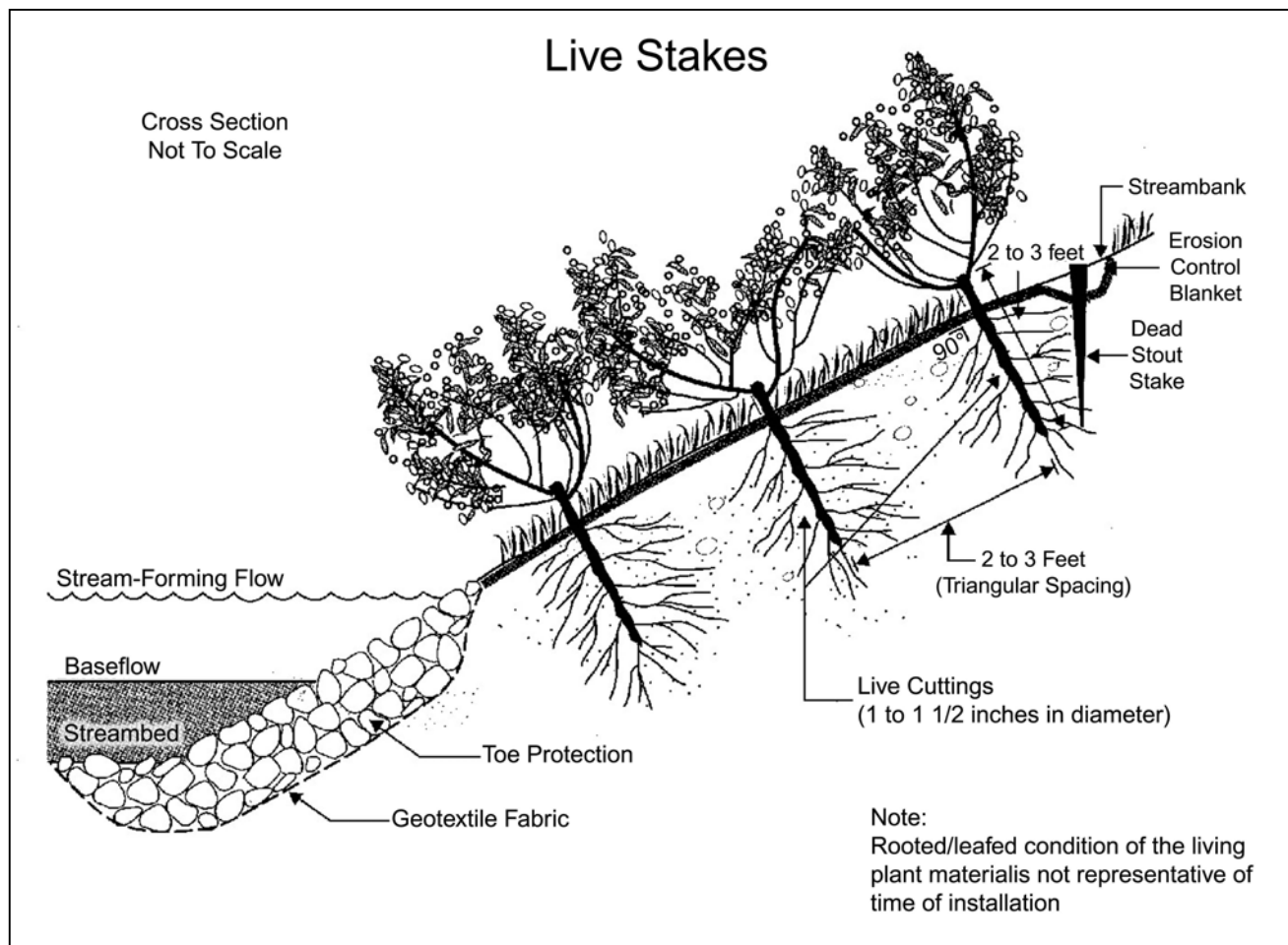
Applications and Effectiveness

- Effective streambank protection technique where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed
- Appropriate technique for repair of small earth slips and slumps that frequently are wet
- Can be used to peg down and enhance the performance of surface erosion control materials

- Improves conditions for natural colonization of vegetation from the surrounding plant community
- To stabilize intervening areas between other soil bioengineering techniques, such as live fascines
- Provide streamside habitat and shading
- Recommended slope < 3:1. This method is not applicable for slopes > 2:1

Maintenance

Occasional site inspections should be conducted to ensure the stakes are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.



8.4.2 Live Fascines

Description

Live fascines are long bundles of branch cuttings bound together in cylindrical structures. They should be placed in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow sliding.

Applications and Effectiveness

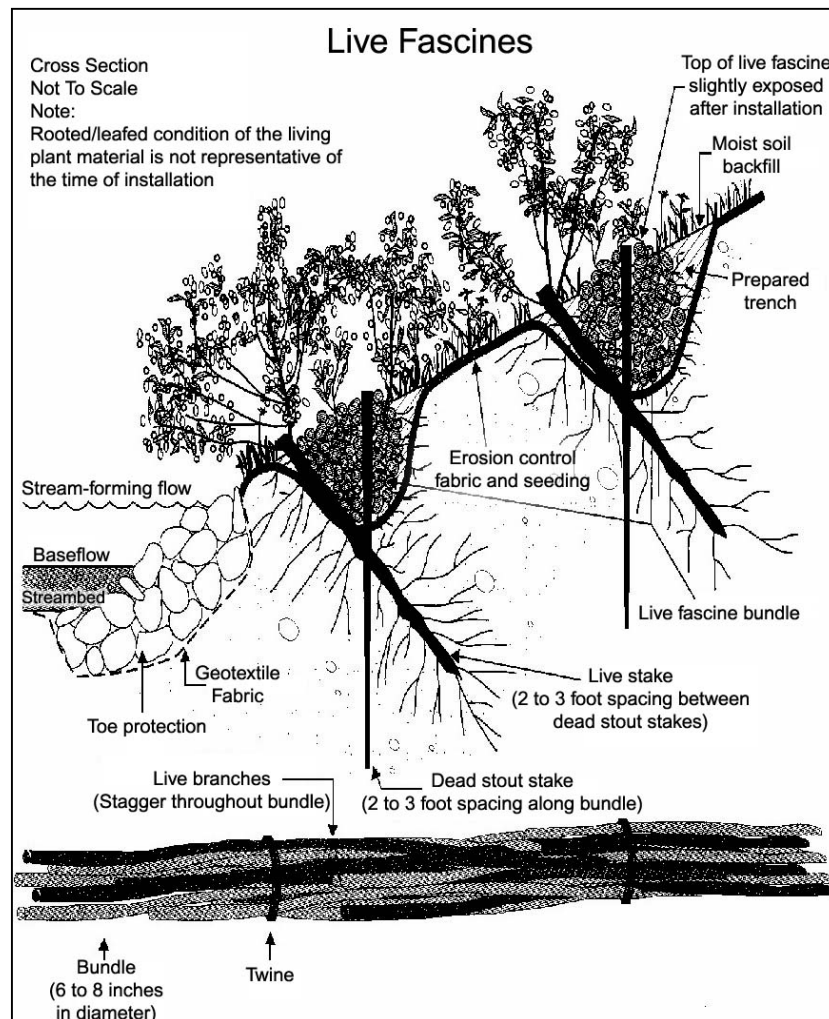
- Apply typically above bankfull discharge (stream forming flow) except on very small drainage area sites (generally less than 2,000 acres)
- Effective stabilization technique for streambanks
- When properly installed, this system does not cause much site disturbance
- Protect slopes from shallow slides (1 to 2 foot depth)
- Offer immediate protection from surface erosion

Capable of trapping and holding soil on streambank by creating small dam-like structures, thus reducing the slope length into a series of shorter slopes

- Serve to facilitate drainage where installed at an angle on the slope
- Improves conditions for colonization of native vegetation by creating surface stabilization and a microclimate conducive to plant growth

Maintenance

Occasional site inspections should be conducted to ensure the fascines are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.



8.4.3 Vegetated Geogrid

Description

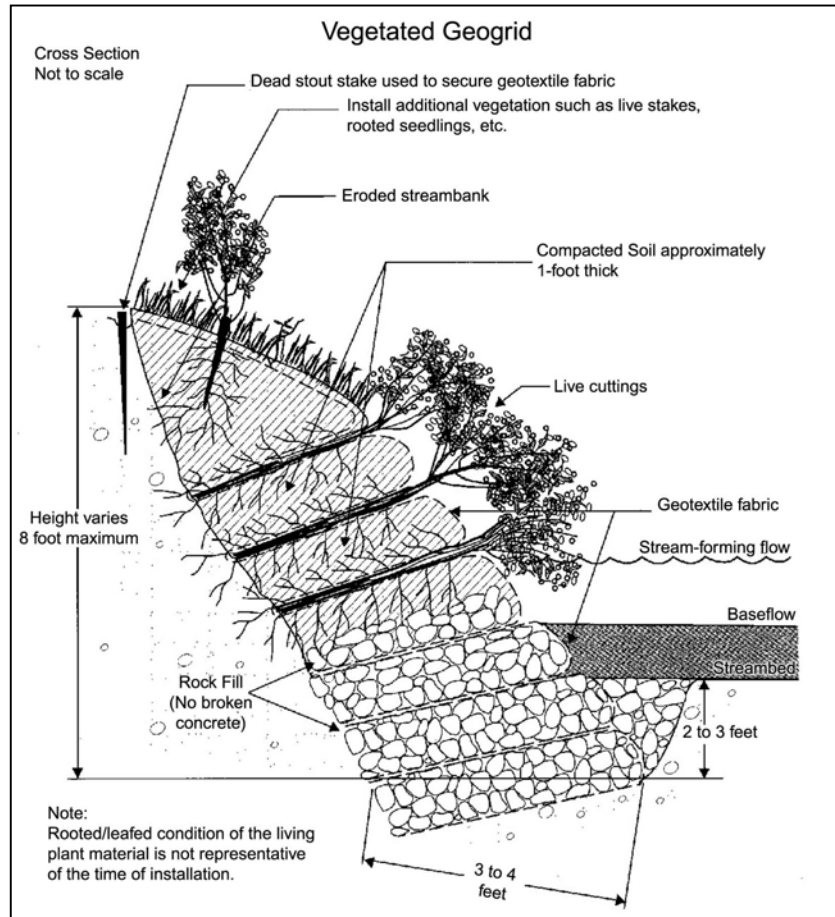
Vegetated geogrids use live branch cuttings that are placed between lifts of soil wrapped in a natural or synthetic geotextile material.

Applications and Effectiveness

- Used above and below stream-forming flow conditions
- Drainage areas should be relatively small (generally less than 2,000 acres) with stable streambeds
- The system must be built during low flow conditions
- Produces a well-reinforced new streambank
- Useful in restoring outside bends where erosion is a problem
- Capture sediment, which rapidly rebuilds to further stabilize the toe of the streambank
- Functions immediately after high water to rebuild the bank
- Produces rapid vegetative growth
- Improves conditions for colonization of native vegetation
- Vegetated geogrid can be placed on a 1:1 or steeper slope

Maintenance

Occasional site inspections should be conducted to ensure the geogrids are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.



8.4.4 Live Cribwall

Description

A live cribwall consists of a box-like interlocking arrangement of untreated log or timber members. Once the live cuttings root and become established, the subsequent vegetation gradually takes over the structural functions of the wood members.

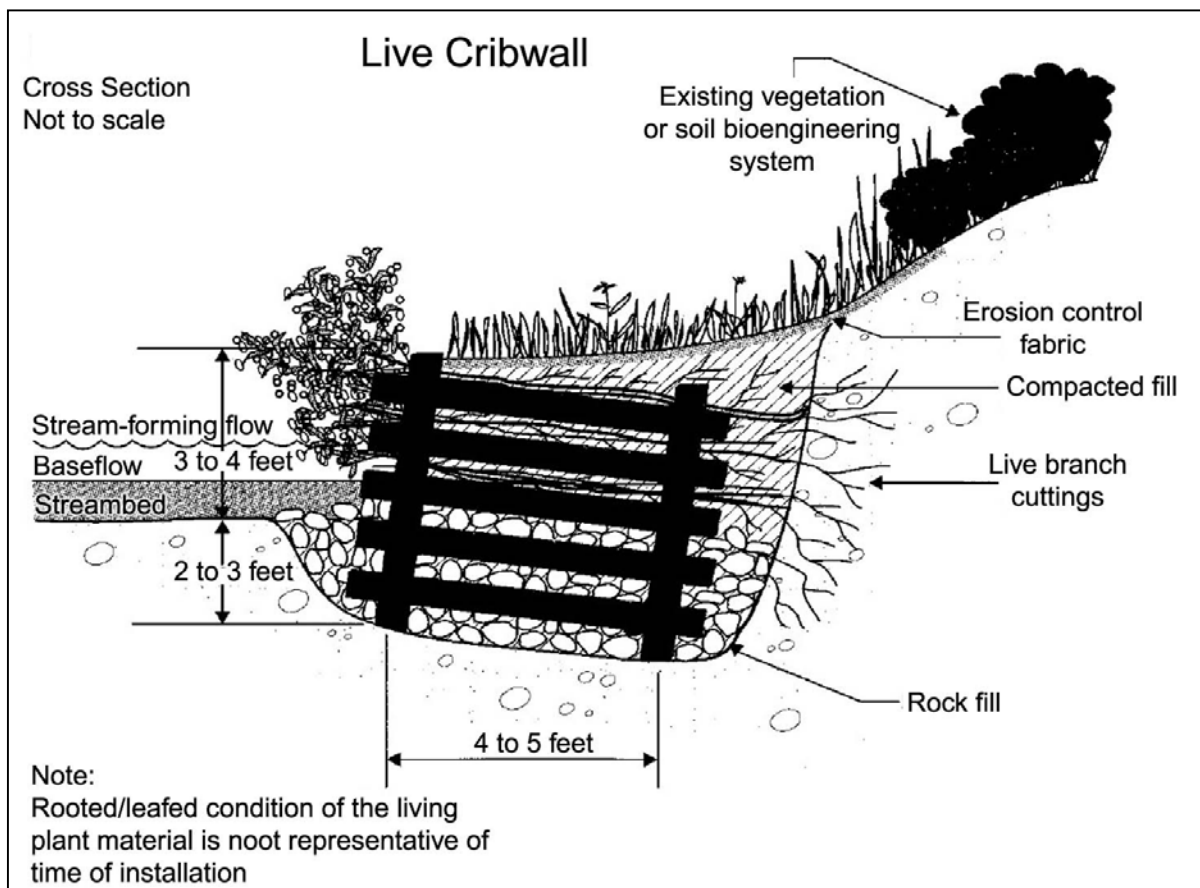
Applications and Effectiveness

- Effective on outside bends of stream where strong currents are present
- Appropriate at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness
- Appropriate above and below water level where stable streambeds exist
- Useful where space is limited and a more vertical structure is required
- Effective in locations where an eroding bank may eventually form a split channel

- Maintains a natural streambank appearance
- Provides excellent habitat
- Provides immediate protection from erosion, while established vegetation provides long-term stability
- Supplies effective bank erosion control on fast flowing streams
- Should be tilted back or battered if the system is built on a smooth, evenly sloped surface
- Can be complex and expensive

Maintenance

Occasional site inspections should be conducted to ensure the cribwalls are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.



8.4.5 Brushmattress

Description

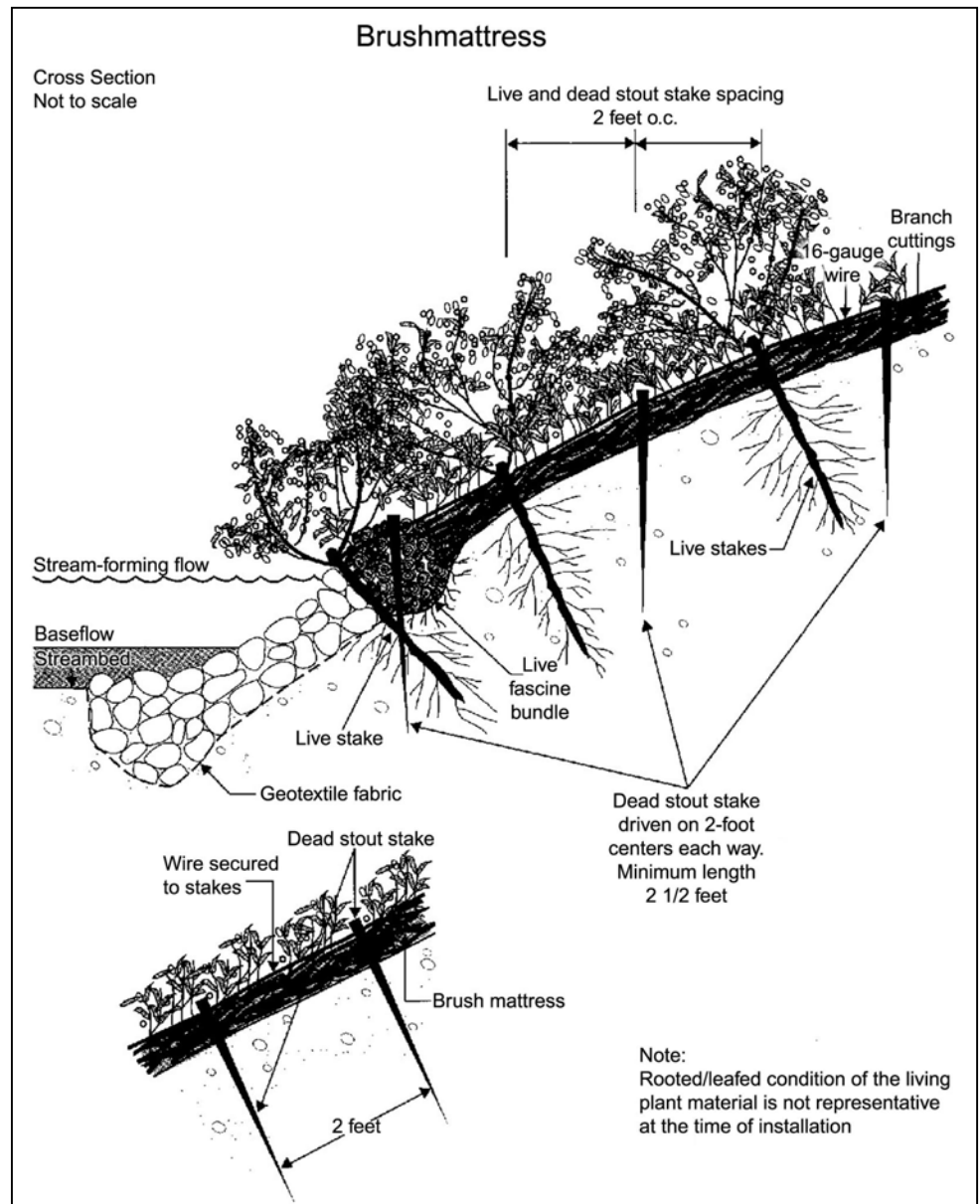
A brushmattress is a combination of live stakes, live fascines, and branch cuttings installed to cover and stabilize streambanks. Application typically starts above stream-forming flow conditions and moves up the slope.

Applications and Effectiveness

- Forms an immediate, protective cover over the streambank
- Captures sediment during flood conditions
- Rapidly restores riparian vegetation and streamside habitat
- Improves conditions for colonization of native vegetation
- Recommended slope <3:1. This method is not applicable for slopes >2:1

Maintenance

Occasional site inspections should be conducted to ensure the brushmattress are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.



8.4.6 Log Placements

Description

Log Placements (a technique of woody debris management) are constructed from whole trees that are usually cabled together and anchored by earth anchors, which are affixed to the bank.

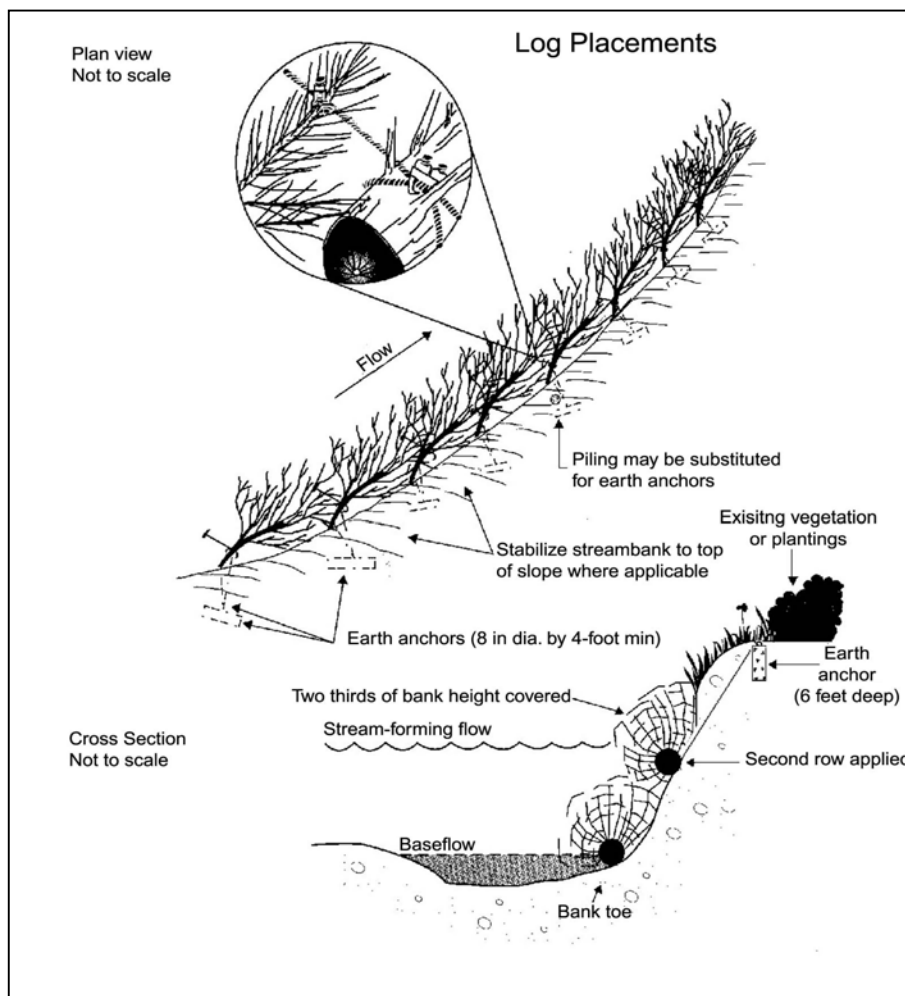
- Has a limited life and needs to be replaced periodically, depending on climate and duration of tree species used.
- May be damaged in streams where heavy ice flows occur.

Applications and Effectiveness

- Uses inexpensive, readily available materials to form semi-permanent protection.
- Captures sediment and enhances conditions for colonization of native species; creates habitat in riparian corridor.
- Has self-repairing abilities following damage after flood events if used in combination with soil bioengineering techniques.
- Not appropriate near bridges or other structures where there is high potential for downstream damage if the placement dislodges during flood events.

Maintenance

Occasional site inspections should be conducted to ensure the logs are intact and functional. Vegetated areas should be checked for removal of undesirable vegetation and pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any streambank stabilization measures.



8.5 Vegetation and Riparian Corridor Management

Description

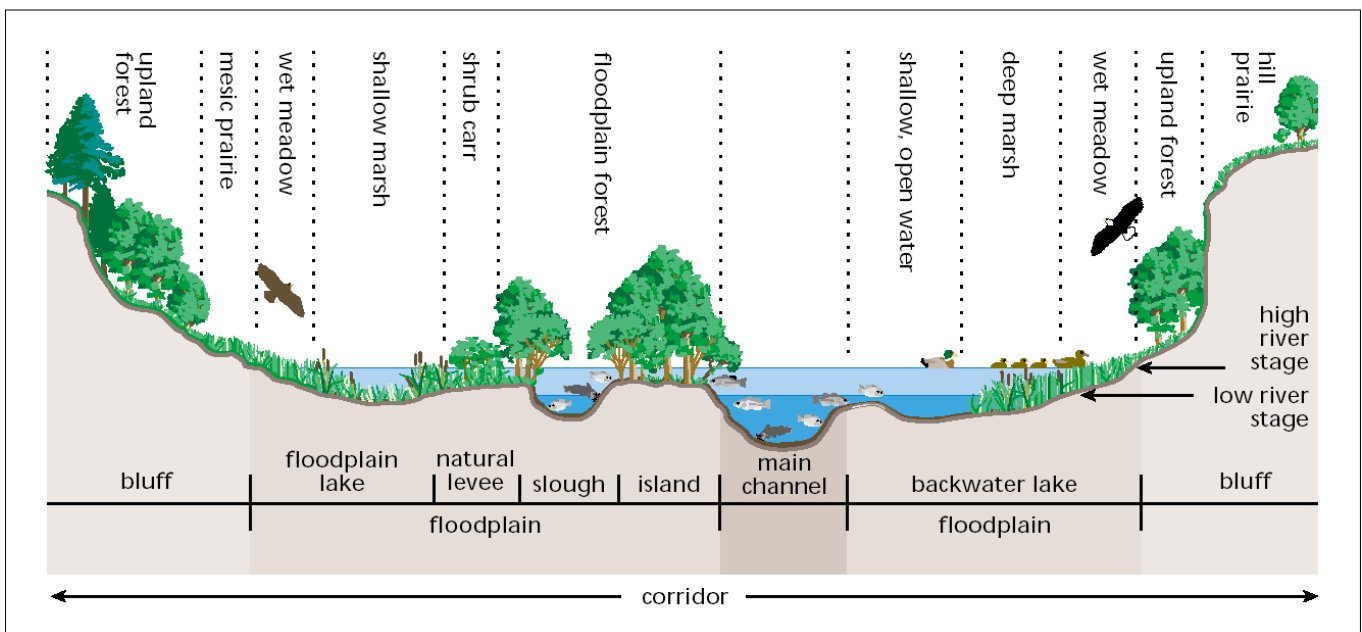
Vegetated riparian zones (areas adjacent to lakes, streams and rivers,) have the capacity to protect, or buffer, water resources from the impacts of storm water runoff from agricultural, urban, or other land uses. Healthy riparian zones filter out sediments, nutrients, and other chemicals contained in storm water runoff. They also absorb the erosive energy in runoff by increasing infiltration which provide for aquifer recharge, water storage and gentle release. A healthy, functioning riparian area and associated upland can dramatically improve fish and wildlife habitat, erosion control, low flow conditions, and water quality. Development and management decisions must be designed with these processes in mind.

Riparian Corridor Management (RCM) is a system of management practices that are designed to protect the environment while allowing for a mixed use of surrounding riparian area. It is a combination of techniques that protect and in some cases, improve water quality and biodiversity. These techniques include, but are not limited to:

- Riparian Buffers
- No-Mow "Grow Zones"
- Woody Debris Management

Maintenance

Occasional site inspections should be conducted to ensure the riparian corridor area is intact and stable. All appropriate government agencies should be contacted and approval granted prior to beginning any work within the riparian corridor.



References

- Streambank and Shoreline Protection Manual. Lake County Stormwater Management Commission, Lake County Planning, Building and Development Department U.S.D.A. - Natural Resources Conservation Service. January 2002.
- Stream Corridor Restoration: Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group (FISRWG 15 Federal agencies of the US government) October 1998.
- American Standard of Nursery Stock, American Nursery & Landscape Association, <http://www.anla.org/applications/Documents/Docs/ANLStandard2004.pdf>
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- Michigan Association of Conservation Districts. “Gateway to Michigan’s Native Plants.” <http://www.macd.org/rollovers/nativeplants/nphome.html>
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- Wild Ones Organization. Landscaping with Native Plants. www.for-wild.org

Resources For Native Plant Material

- Michigan Native Plant Producers Association, “Plants and Seeds Source Guide” and “List of Member Nurseries.” <http://www.MNPPA.org>

8.5.1 Vegetation

Description

Vegetation for storm water management systems may include:

- Sodding,
- Seeding, and/or
- Establishing vegetation specific to the function of the storm water system (e.g., plantings in constructed wetlands or in bioretention areas).



Black-Eyed Susan

Wherever possible, the use of native plants and “no mow zones” is encouraged. Native landscaping uses plants that have been growing in southeast Michigan since before European settlers arrived. These plants are adapted to the local climate and conditions, and have numerous advantages:

- Typically require less water and fertilizer than non-native species; many are naturally resistant to pests.
- The deep roots of some native wildflowers help absorb storm water and help decompose storm water pollutants.
- Installation costs for native plants can be as much as 40% less than those of traditional perennial beds.
- Long-term maintenance costs for native landscapes can be up to 50% less expensive than those for turf and other traditional landscapes.

Plant selection and placement should reflect various zones in the area to be landscaped. Some sections may typically have wet, saturated soils while other areas may be drier. The amount of sunlight the area will receive each day should also be considered.

Proper installation by experienced landscape contractors is critical to the success of vegetation for storm water management systems, particularly for those using native landscaping.

Many local communities have landscaping requirements; it is recommended that any local landscaping requirements

be reviewed prior to designing vegetation for storm water management systems.

Sodding Specifications

Sod should consist of a dense, well-rooted growth of perennial sod, free from noxious weeds and objectionable grasses. Nursery sod should have been grown in a prepared seedbed, and regularly fertilized and maintained according to established practices for at least two years before cutting. Sod should be cut into rectangular sections with straight cut edges. Pieces may vary in length from 18 inches to 6 feet and should be a uniform width between 10 and 18 inches. Sod should be no less than 1 inch thick if used on flat areas, and 1.5 inches thick if used on slopes. Grass should be mowed to a length of no less than 3 inches before the sod is cut. Broken or damaged sod should not be used. Sod should be taken from a loam soil (rather than from peat, for example) so that the sod will not break, crumble, tear, or otherwise be unavoidably damaged during cutting, transporting, and laying. Local community landscaping specifications may require approval of sod in its original location before cutting operations begin. Staking sod with wooden pegs may be required in certain areas (e.g., sandy soils).

Areas to be sodded should be prepared with topsoil (at least 3 inches deep), all large clods and lumps should be pulverized, and rocks, roots and other foreign matter should be raked out. The area should be graded and made smooth and uniform to conform to the finished grades and cross sections shown on the construction plans. Fertilizers (preferably earth-friendly formulations) should be applied before sod is laid.

Sodding generally should take place in the spring from the time the ground is workable until June 1 and after August 15 until the time the ground becomes unworkable. Sod should not be placed when the temperature is 32°F or less. Local community landscaping requirements may place additional restrictions on when sodding may occur. Sodded areas should be watered regularly until permanent growth is established.

Seeding Specifications

Areas to be seeded should be prepared with topsoil (at least 3 inches deep), all large clods and lumps should be pulverized, and rocks, roots and other foreign matter should be raked out. The area should be graded and made smooth and uniform to conform to the finished grades and cross sections shown on the construction plans. Fertilizers (preferably earth-friendly formulations) should be applied just prior to seeding.

Seeding mixtures should be from the previous year's crop, and should be composed of certified seed of the purity, germination and proportions by weight specified for the intended use.

Seeding should take place in the spring from the time the ground is workable until June 1 and during the period September 1 through October 10. Local community landscaping requirements may place additional restrictions on when seeding may occur. Seed should not be sown during periods of high winds. Do not cover seed more than ¼-inch deep.

Recently seeded areas should be mulched using loose mulch (straw in air-dry condition) or turf mulch blankets. The mulch may also need to be anchored using a tackifier or netting. Seeded areas should be watered regularly until permanent growth is established.

Seed Mixtures

Seed mixtures and the rate of sowing seeds are dependent on the type of area to be seeded. Local requirements for seed mixtures should also be consulted.

It is recommended that seed mixtures for areas within storm water management systems contain a mixture of species that will provide temporary cover (e.g., quick growing species such as annual rye (*Lolium multiflorum*) and those to provide the permanent cover.

Adjacent to Wayne County Roads: Refer to Wayne County Department of Public Services specifications for turf establishment. Currently, MDOT seed mixture THM from specification 917 is preferred (Creeping Red Fescue – 50%, Perennial Rye Grass - 20%, Kentucky Bluegrass - 30%), applied at a rate of 200 pounds per acre.

Buffer Strips: Use of native landscaping materials is preferred within buffer strips adjacent to water bodies. An example native seed mixture appropriate for use in buffer strips follows:

<u>Buffer Seed</u>			
<u>Botanical Name</u>	<u>Common Name</u>	<u>Rate</u>	<u>Per Acre</u>
<i>Allium cernuum</i>	Nodding Wild Onion	10	oz./acre
<i>Andropogon scoparius</i>	Little blue-stem	3	lb./acre
<i>Asclepias tuberosa</i>	Butterflyweed	8	oz./acre
<i>Aster lateriflorus</i>	Calico aster	2	oz./acre
<i>Aster novae-angliae</i>	New England aster	5	oz./acre
<i>Carex vulpinoidea</i>	Fox Sedge	2	oz./acre
<i>Echinacea purpurea</i>	Purple cone flower	8	oz./acre
<i>Elymus Canadensis</i>	Canada Wild Rye	8	oz./acre
<i>Heliopsis helianthoides</i>	False Sunflower	3	oz./acre
<i>Liatris spicata</i>	Dense blazing star	7	oz./acre
<i>Lolium multiflorum</i>	Annual rye	200	lb./acre
<i>Monarda fistulosa</i>	Bee-balm	4	oz./acre
<i>Panicum virgatum</i>	Switch grass	5	oz./acre
<i>Penstemon digitalis</i>	Foxglove beardstongue	5	oz./acre
<i>Physotegia virginiana</i>	Obedient plant	3	oz./acre
<i>Pycnanthemum virginianum</i>	Mountain Mint	2	oz./acre
<i>Rudbeckia hirta</i>	Black-eyed Susan	4	oz./acre
<i>Solidago speciosa</i>	Showy goldenrod	4	oz./acre
<i>Verbena stricta</i>	Hoary vervain	3	oz./acre

Section 8.1.1 presents seed mixtures for upland areas associated with open detention basins; these mixtures are also appropriate for buffer strips.

Bioretention Areas: See Section 8.2.2 for seed mixtures and plant species appropriate for use in bioretention areas.

Vegetated Swales: See Section 8.3.2 for seed mixtures appropriate for use in vegetated swales.

Open Detention Basins and Retention Basins: See Section 8.1.1 for seed mixtures and plants appropriate for use in open detention basins and retention basins.

Maintenance

Maintenance activities related to vegetated areas are specific to the type of vegetation established, but all maintenance plans should include provision for re-

planting/seeding of bare areas and removal of invasive species (e.g., weeds in turf grass, purple loosestrife in native plantings).

“River friendly” lawn and garden practices (see list of Resources below) should be followed in the maintenance of vegetated areas. For grassed areas that are mowed, these practices include:

- “Mow high”: Proper mowing and use of a mulching mower is important and will not contribute to thatch problems. Proper mowing at the correct heights and frequencies with a sharp blade is very important for lawn health. Mowing at heights between 2 and 3 inches is best to encourage deeper roots, discourage weeds and reduce evaporation.
- Soil compaction and thatch build-up result in shallow roots and reduced water infiltration and air flow. Mechanical soil aeration, vertical mowing (thatch removal) and coring can help loosen compacted soil. It is not unusual for lawns to contain shallow top soil and compaction from frequent vehicle access and foot and animal traffic.
- Thatch is a dense layer of dead grass, stems, and roots that develops between the soil surface and the growing grass. While some thatch is normal and desirable, excessive thatch problems are often a sign of over-watering and improper mowing. Mechanical de-thatching in the early fall is recommended for lawns with more than one inch of thatch build-up.
- “Don’t Guess, Soil Test”: Apply only the amount of lime and fertilizer the grass actually needs. The only way to know is to test the soil.
- For fertilizing:
 - o Consider compost or other organic fertilizer sources as they provide a slow, steady release of nutrients over time.
 - o Consider fertilizer that contains at least 50% water insoluble nitrogen. Read the label.
 - o Recycle lawn clippings. Recent research at the University of Connecticut has shown that fertilizer needs can be reduced by 50% or more when using recycled clippings.
 - o Most lawns will not need more than 2 lbs. N/1,000 sq. ft. per season. Apply no more than 1 lb. of N/1,000 sq. ft. per application.

- o Apply one application in May and another application in September. Do not apply fertilizer after October 15th to reduce pollution risk.
- o Proper application methods such as measuring the actual area to be treated and calibrating the spreader is also very important--this ensures that proper amount of fertilizer is applied. Avoid spreading fertilizer on paved areas or near storm drains or drinking water wells. Sweep up these areas with a broom, do not wash with a hose. A drop spreader can allow for more accurate control around critical areas. Compost and other organic fertilizers are still sources of nutrients, so they should be applied at the proper rate and time using sound application methods.
- Use Integrated Pest Management techniques if pests become a problem.
- Newly planted, sodded or seeded areas should receive the equivalent of 1 inch of water per week, for the first 6 to 8 weeks, either via rainfall or irrigation.
- For seeded areas, do not pull weeds while seed is germinating and seedlings are establishing or desirable plants may be uprooted with the weeds.

Native landscapes are, by design, less maintenance intensive than traditional landscapes. The initial maintenance period (3-5 years post-installation) is the most critical to the success of the project. Maintenance considerations for native landscapes include:

- Control of non-native species is required to create healthy native plant communities. Depending on the size of the landscaped area, this can be accomplished through prescribed burns or mowing (large areas) or weeding (small areas).
- If any of the plants do not perform well, become diseased or die, they should be replaced.
- For trimming and harvesting, the current practice is to leave ornamental grasses and perennial seed heads standing to provide winter interest, wildlife forage, and homes for beneficial insects. Plants should not be cut back until spring when new growth commences, and even then it is only done for neatness; it does not impact growth. Plants may be pinched, pruned, sheared or deadheaded during the growing season to encourage more flowering, a bushier plant, or a fresh set of leaves. Diseased or damaged plant parts should

be pruned as they occur. If a plant is pest-infested, perform cleanup in fall to deny the pest a winter home. Trees and shrubs may be pruned for shape or to maximize fruit production.

- The properly designed native landscape should thrive and allow planting materials to expand and propagate, eventually becoming overcrowded. If this occurs, perennial plants should be divided in spring or fall.

References

- Michigan Department of Transportation Specifications, <http://www.michigan.gov/mdot>

Resources: River Friendly Lawn Care and Native Plants

- The following documents, published by the (SE MI) Healthy Lawns and Gardens Technical Advisory Committee, are available from Wayne County's website at <http://www.waynecounty.com/doe/watershed/mgmtBioretention.htm>
 - o "Healthy Law Care Tips", Spring 2006.
 - o "Earth Friendly Fertilizers Recommended for Lake and River Water Quality Protection, Southeast Michigan", 2006
 - o See also their website
 - o www.healthylandscapes.com

Additional Resources

- "Local Storm Water and Watershed Management Practices Constructed/Implemented in Southeast Michigan", available at <http://www.waynecounty.com/doe/watershed/mgmtPractices.htm>

Project summaries, photos, location and contact information, weblinks, and other information for a variety of storm water and watershed management practices in the categories:

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 - o Green Buildings

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- United States Environmental Protection Agency www.epa.gov/greenacres/
- Wild Ones Organization. Landscaping with Native Plants. www.for-wild.org

Resources For Native Plant Material

- Michigan Native Plant Producers Association, "Plants and Seeds Source Guide" and "List of Member Nurseries". <http://www.MNPPA.org>

8.5.2 Riparian Buffers

Description

Buffers zones are areas of vegetation between the river and the surrounding land use. These areas are critically important because they absorb sediments, chemical nutrients, and other substances, provide for aquifer recharge and dramatically increase benefits such as fish and wildlife habitat, erosion control, forage, late season stream flow, and water quality. These areas can be created and maintained at low or no cost. There are several types of buffers including, no-mow grow zones, native plant buffers, and forested buffers.

Application

- The minimum recommended width is 25 feet.
- Protection of more sensitive areas may require 100+ feet.
- Lawns, mowers, fertilizers or other chemicals should not be used in buffer zones.
- Native plants are more effective for use in buffer zones.

Economic Benefits

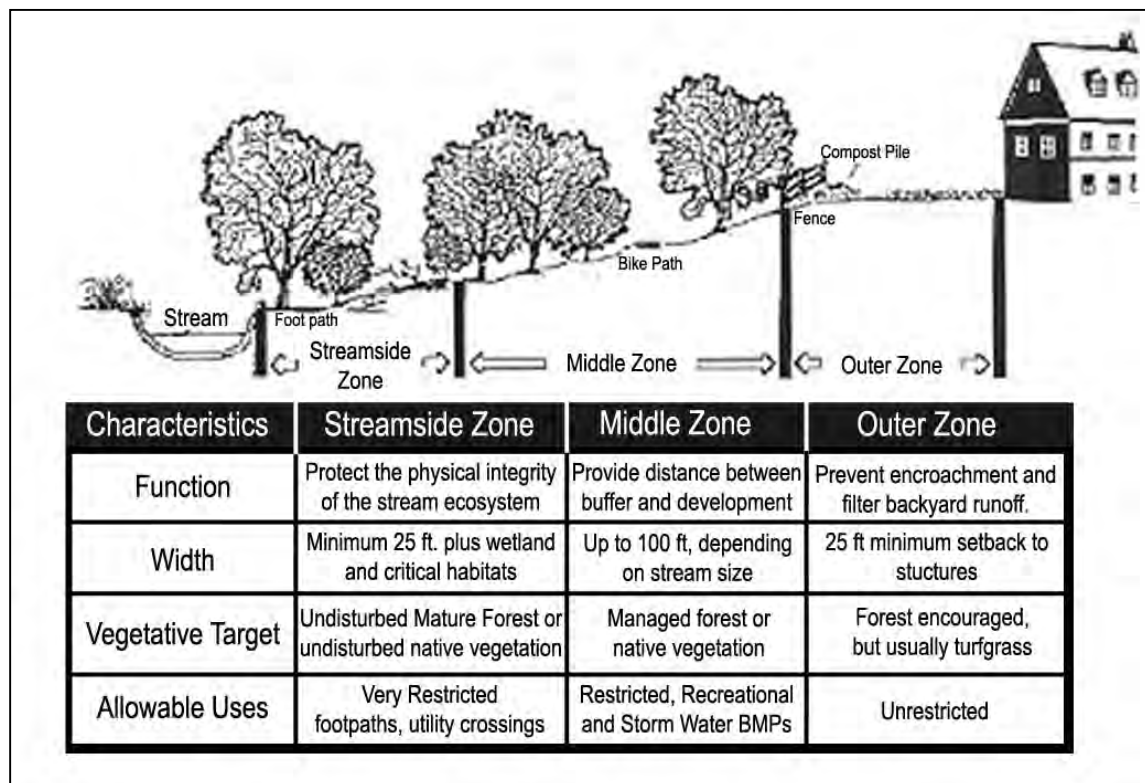
- Protect against property loss from flood damage and stream erosion
- Protect water quality of public drinking water supplies
- Support the recreation and tourism industry

Social Benefits

- Protect clean surface waters for public recreation
- Provide natural fences, visual screens, and noise control
- Offer places for nature study, camping and fishing
- Aesthetically appealing

Water Quality Benefits

- Recycle nutrients within the vegetation
- Filter sediment before it reaches the stream
- Reduce the force and power of runoff entering the stream from stormwater
- Provide space for flood waters to flow naturally



Physical Stream Benefits

- Increase ground water recharge
- Stabilization of stream banks
- Reduce bank erosion (which can be a major source of sediment to a stream)
- Moderate stream flow (by allowing runoff to infiltrate and recharge the stream throughout the year instead of only after storms)

Biological Benefits

- Protect fish and wildlife cover
- Provide food for aquatic habitat
- Provide shade for fish
- Act as a link to allow wildlife movement

Maintenance

Occasional site inspections should be conducted to ensure the riparian buffer area is intact and stable. Vegetated areas should be checked for removal of undesirable vegetation (invasive species). Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any riparian buffer project.

8.5.3 No-Mow “Grow Zones”

Description

No-mow “grow zones” are a type of riparian buffer. They challenge conventional wisdom of what a yard should be by designating at least a portion of home lots as “no-mow” zones, allowing grasses, shrubs and local naturally seeding plants to grow, providing food for birds and other critters.

Along a creek, pond or wetland, creating a buffer zone by simply not mowing along the shoreline is the easiest and least expensive method. Turf grasses will grow 12-24 inches tall before going to seed. Creating a curving edge that separates the buffer from your lawn and any pathways to the water will also give your property a pleasing, natural appearance. Over time, shrubs and trees will naturally fill in and provide a more diverse plant cover.

Applications and Effectiveness

- Effective buffer technique where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed

- Appropriate technique to provide a cheap effective buffer for all land uses along riparian areas.
- Enhance conditions for natural colonization of vegetation from the surrounding plant community
- Produce streamside habitat

Maintenance

Occasional site inspections should be conducted to ensure the areas are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation (invasive species). Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any riparian buffer measures.



8.5.4 Woody Debris Management

Description

One of the challenges in river maintenance and riparian corridor management is how we look at logjams. In the recent past, logjams were thought to be a significant problem and were completely removed from stream channels. New studies have now shown that logjams help reduce erosion, provide habitat for fish and wildlife and are an important part of the natural processes of a river system. Now it is recommended to leave most logjams in place. Woody debris management (WDM) is the process of determining what to do about wood in the river; move, remove or add, and how best to do that work. The Clean and Open method of woody debris management has been specifically developed to give some initial guidance on how to manage a logjam, while preserving the benefits they provide and minimizing the problems they can create. The following example method is designed to be part of a larger river maintenance/riparian corridor management plan, but can be used at individual sites effectively.

Benefits

There are many benefits to utilizing woody debris management techniques, such as the clean and open method, for riparian maintenance. The clean and open method is beneficial for river maintenance in five ways.

1. Preserves and increases fish and wildlife habitat.
2. Reduces localized flooding and erosion while still maintaining the flow reduction benefits that logjams provide.
3. Increases and/or maintains the river's aesthetic value.
4. Meets requirements of storm water pollution prevention initiatives (SWPPI) from the General Stormwater permit by creating and maintaining habitat, preserving riparian vegetation and reducing erosive flows.
5. This method saves money by reducing the need to use heavy machinery and extensive restorative work.

Example – Clean and Open Method

1. Does not require a MDEQ permit (There is no change to the stream bed or bank)
2. Evaluate logjam by size, impact and safety to determine whether method is appropriate.

3. Before starting any work, evaluate and address all safety concerns.
4. Remove litter (man-made materials) with minimal log removal
5. Move loose, floating logs to allow **minimal** opening at center of stream flow - technically known as the thalweg. Use a handsaw or chain saw to make the opening just wide enough to allow flow through logjam.
6. Lop off branches near the water surface so that they do not trap smaller pieces and form large accumulations.
7. Loose wood can be added to each logjam end or removed. Leave any removed woody debris on floodplain or in riparian corridor. This creates additional riparian habitat.
8. Multiple volunteers can still be involved.

Maintenance

Occasional site inspections should be conducted to ensure the stakes are intact and stable. Vegetated areas should be checked for removal of undesirable vegetation and slight pruning. Site washouts should be repaired immediately. All appropriate government agencies should be contacted and approval granted prior to beginning any Woody debris management techniques.

