WAYNE COUNTY
Storm Water Management Program
February 2007

Storm Water Management Standards (v 3.0)
Includes Program Clarifications, Errata and Revisions as of July 2015
Page intentionally left blank to facilitate double-sided printing
DOCUMENT UPDATES &
INTERNET ACCESS

Bound copies of the Wayne Storm Water Management Program documents and updates to them can be obtained for a fee at Wayne County's Permit Office

Permit Office
Division of Engineering
Wayne County Department of Public Services
33809 Michigan Avenue
Wayne, MI 48184-1738
(734) 595-6504

Instructions for Accessing Wayne County Storm Water Management Program Documents and Updates from the Internet

Using your internet browser, access the “Storm Water Management” page of the Wayne County website at http://www.waynecounty.com/1122.htm

1. The middle section of this “Storm Water Management” page has links to information about Wayne County’s Storm Water Management Program as follows:

   • Wayne County Storm Water Management Ordinance and Administrative Rules Summary
     Click on this title to obtain a summary of the Wayne County Storm Water Management Ordinance program and to access the Storm Water Management Ordinance and Administrative Rules documents. The direct link to this page is http://www.waynecounty.com/doe/1170.htm

   • Standards Manual
     Click on this title to access the Standards Manual. Each chapter and appendix of the Standards Manual is presented as a separate file. This format facilitates future revisions to the manual. Note that each page of the manual is dated. A comprehensive listing of pages revised since the February 2007 issuance of Version 3.0 of the manual is shown as the first item on this page and is entitled “Program Clarifications, Errata & Revisions”. The direct link to this page is http://www.waynecounty.com/doe/1172.htm

   • Supplemental Information
     Click on this title to access other guidance materials related to the Wayne County Storm Water Management Program but not included in the Standards Manual. The current version of the “Program Clarifications, Errata & Revisions” document is also available from this page. Please check this page periodically for new materials. The direct link to this page is http://www.waynecounty.com/doe/1174.htm
• Local Storm Water and Watershed Management Practices Constructed/Implemented in Southeast Michigan
Click on this title to access 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
  o Manufactured Treatment Systems and Underground Detention
  o Detention Ponds/Constructed Wetlands
  o Streambank Stabilization
  o Woody Debris Management
  o Green Buildings

The direct link to this page is http://waynecounty.com/doe/1190.htm

All documents are presented in .pdf format; Adobe Acrobat Reader™ software is required to view or print these documents. Adobe Acrobat Reader™ software is available free of charge at http://get.adobe.com/reader/

2. Applicants for construction approvals for storm water management systems should also visit the Wayne County Permit Office pages of the Wayne County website at http://www.waynecounty.com/dps/construction_permits.htm

This page presents additional information relevant to obtaining approvals for construction of storm water management systems, including:

• Construction Permit Application Kit
  o Frequently Asked Questions
  o Permit Application Form
  o Commercial Plan Checklist
  o Residential Plan Checklist
  o Plan Review Cost Schedule

• Rules, Specification And Procedures For Construction Permits
  o The latest rules, specifications, procedures and requirements applicable to all construction permit work in Wayne County

• Standard Plans For Permit Construction
  o Approved construction standards, typical drawings, details and notes for use in preparing construction plans
ACKNOWLEDGEMENTS

The Wayne County Storm Water Management Ordinance, Administrative Rules, and Standards Manual originally were developed during 1998-2000 in collaboration between Wayne County, local communities, engineering firms, developers, and other interested parties. Wayne County gratefully appreciates the perspective on and suggestions to the proposed program brought by the over 70 people who attended the two workshops or otherwise provided comments on the program.

Subsequent to the adoption of the regulations in October 2000, additional comments and suggestions have been made by a variety of interested parties. Numerous suggestions were made by the over 100 individuals who attended the first “Wayne County Storm Water Summit” in April of 2005. All of these comments and suggestions have been very helpful in crafting and implementing a realistic, workable storm water management program which is critical to our mutual efforts to protect and restore our water resources and reduce flood hazards.

The Wayne County Storm Water Management Ordinance, Administrative Rules, and Standards Manual were prepared by a Wayne County workgroup that also sees oversees implementation. The workgroup consists of staff from the Department of Corporation Counsel, Department of Environment (Land Resources Management, Facilities Management, Watershed Management), Department of Public Services (Engineering, Parks), and the Rouge River National Wet Weather Demonstration Project. The workgroup gratefully acknowledges the significant contributions made to the regulations and Standards Manual by Kathryn A. Buckner of the Buckner Law Group and Edward Kluitenberg of Camp Dresser & McKee.

The Wayne County Storm Water Management Ordinance, Administrative Rules, and Standards Manual originally were modeled on the storm water management programs administered by the Washtenaw County Drain Commissioner and by the Canton Community. Wayne County acknowledges the excellent work of these agencies and appreciates their willingness to serve as the models for our storm water management program. Unless otherwise noted, the photographs in the Standards Manual are courtesy of the Canton Community. From top left, the cover photographs were provided by the following photographers: Newburgh Lake by Michael Precious, Nankin Mills Grow Zone by Christine O’Meara, Bioretention at City of Wayne parking lot by Alicia Askwith, and Smith School grow zone/streambank stabilization by Matthew Best.

Development of the Wayne County Storm Water Management Ordinance, Administrative Rules, and Standards Manual was funded, in part, by the Rouge River National Wet Weather Demonstration Project. The Rouge River National Wet Weather Demonstration Project is funded, in part, by the United States Environmental Protection Agency (EPA) Grants #XP995743-01 through –09 and #C995743-01. The views expressed by the authors of these documents are their own and do not necessarily reflect those of EPA. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

February 2007
SUMMARY AND HISTORY

Administrative Rules

Amendment to the Wayne County Storm Water Administrative Rules, adopted by Wayne County Commission Resolution No. 2015-70-011

Storm Water Standards Manual

Chapter 4: Obtaining Storm Water Construction Approval (11 July 2008; 8 June 2011)

Chapter 6: General Design Standards (July 2015)

Chapter 7: Additional Requirements
  - Section 7.4: Easements (8 June 2009)
  - Section 7.12: Closed Conduits (11 July 2008)

Chapter 8: Specific Design Standards and Guidance for Best Management Practices
  - Section 8.1.1 Open Detention Basins (11 July 2008; July 2015)
  - Section 8.1.2 Retention Basins (July 2015)
  - Section 8.1.4 Outlets for Forebays and Open Detention Basins (11 July 2008)
  - Section 8.2.1 Forebays (July 2015)
  - Section 8.2.2 Bioretention (July 2015)
  - Section 8.2.3 Manufactured Treatment Systems (11 July 2008; 8 June 2009)
  - Section 8.3.2 Vegetated Swales (11 July 2008)

Chapter 11: Sample Calculations (July 2015)


Appendices
  - Appendix A: Engineer’s Certificate of Construction (11 July 2008)
  - Appendix E-4: Wayne County Parks Division, Permit Guidelines for Site Restoration (8 June 2009; 9 October 2009; July 2015)

Other Guidance Available from Wayne County Website
  - Other information not included in the Standards Manual which may be helpful in implementing the Wayne County Storm Water Management Program is available at http://waynecounty.com/doe/1174.htm
  - Information about the overall Wayne County construction permit process, including the Construction Permit Application Kit, is available at http://waynecounty.com/dps/construction_permits.htm
NOTE: In September 2009, the Department of Environment and Department Public Services were merged into a reorganized Department of Public Services. The names of and services provided by Divisions of the former Department of Environment and Department Public Services remain unchanged. Thus, references to the “Department of Environment” throughout all documents related to the Wayne County Storm Water Management Program are now to “Department of Public Services”. With the exception of Chapter 12 (Contacts), the Storm Water Management Standards Manual will not be updated to reflect the reorganization until the next release of the Storm Water Management Standards Manual.

### WAYNE COUNTY STORM WATER ADMINISTRATIVE RULES

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description of Change</th>
<th>Type of Change</th>
<th>Date(s) of Change</th>
</tr>
</thead>
</table>
| Chapter 2, Rule 202 | Revision to definitions:  
- Buffer strip  
- Free board  
New definition:  
- Top of Bank or Top of Embankment | Revision | July 2015 by Commission Resolution 2015-70-011 |
| Chapter 6, Rule 603D | Revisions to requirements for buffer strips | Revision | July 2015 by Commission Resolution 2015-70-011 |

### WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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</thead>
<tbody>
<tr>
<td>Preface:  Document Updates and Internet Access</td>
<td>All</td>
<td>Update Wayne County website addresses</td>
<td>Update</td>
<td>July 2015</td>
</tr>
</tbody>
</table>
| Chapter 3:  Administration and Regulations | 3-5 | Update website address for information about communities in which soil erosion and sedimentation control permits are issued by Wayne County:  
<table>
<thead>
<tr>
<th>Chapter 4: Obtaining Storm Water Construction Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>In June 2009, Wayne County Department of Public Services (DPS) published additional documents:</td>
</tr>
<tr>
<td>- Construction Permit Application Kit</td>
</tr>
<tr>
<td>- Rules, Specifications &amp; Procedures For Construction Permits</td>
</tr>
<tr>
<td>- Standard Plans For Permit Construction</td>
</tr>
<tr>
<td>See <a href="http://waynecounty.com/dps/construction_permits.htm">http://waynecounty.com/dps/construction_permits.htm</a></td>
</tr>
<tr>
<td>Clarify that Wayne County may require clean out of storm water systems prior to approval of final inspection and release of permits and remaining financial assurance.</td>
</tr>
<tr>
<td>Update 8 June 2009 Website address update: July 2015</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 6: General Design Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revised requirements for buffer strips</td>
</tr>
<tr>
<td>Revision July 2015</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 7: Additional Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 7.1.2, Closed Conduits (3rd paragraph, 1st bullet)</td>
</tr>
<tr>
<td>Clarify the definition of “outlet” in the hydraulic grade line (HGL) calculation (see Rule 711(B)(4)):</td>
</tr>
<tr>
<td>- For systems with forebays: The HGL starts at the crown of the pipe entering the forebay.</td>
</tr>
<tr>
<td>- For systems with underground detention systems: The HGL starts at the crown of the pipe entering the manufactured treatment structure.</td>
</tr>
<tr>
<td>Clarification 11 July 2008; 8 June 2009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 7.4, Easements</th>
</tr>
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<tbody>
<tr>
<td>Revise the text of Item 1 to read as follows: “1. An open County Drain or watercourse with a maximum bank to bank width that is 30 feet or greater must have an easement to the extreme width of the drain, plus 30 feet. The easement must be centered on the centerline of the drain or watercourse.”</td>
</tr>
<tr>
<td>Revision 8 June 2009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 7.6, County Park Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add reference to Appendix E-4 (Wayne County Parks Division, Permit Guidelines for Site Restoration).</td>
</tr>
<tr>
<td>Clarification 8 June 2009</td>
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</table>

<table>
<thead>
<tr>
<th>Section 7.8, Temporary Measures During</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update website address for information about Wayne County’s Soil Erosion and Sedimentation Control Program:</td>
</tr>
<tr>
<td>Errata 8 June 2009;</td>
</tr>
</tbody>
</table>
Wayne County Storm Water Management Program
Clarifications, Revisions, Updates, and Errata
July 2015

WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tr>
<td>4</td>
<td>Construction (last sentence in last paragraph)</td>
<td><a href="http://waynecounty.com/doe/soilerosion.htm">http://waynecounty.com/doe/soilerosion.htm</a></td>
<td>Clarification</td>
<td>July 2015</td>
</tr>
</tbody>
</table>

Chapter 8: Best Management Practices

**Section 8.1.1: Open Detention Basins**

| 8-3  | Design Standards | Revise specifications for buffer strips around detention basins | Revision | July 2015 |
| 8-8  | Attachment A     | Add figure illustrating different planting zones for open detention basins | Clarification | 11 July 2008 |
| 8-16C| Attachment C     | Add figure “Detail For Required Buffer Strips For Forebays, Open Detention Basins, And Retention Basins With Drainage Area Greater Than 5 Acres” | Revision | July 2015 |
|      | Various minor clarifications throughout | | Clarification | July 2015 |

**Section 8.1.2: Retention Basins**

| 8-17 | Design Standards | • Revise specifications for buffer strips around retention basins  
|      |                  | • Add reference to figure in Section 8.1.1, Attachment C | Revision | July 2015 |

**Section 8.1.3: Underground Detention Systems**

<p>| 8-19 | Preferred Design Elements and Materials | Identify components of underground detention systems to be tested, inspected and approved by Wayne County | Clarification | 9 October 09 |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>Paragraph</th>
<th>Description of Change</th>
<th>Type of Change</th>
<th>Date(s) of Change</th>
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</thead>
<tbody>
<tr>
<td>8-19</td>
<td>Preferred Design Elements and Materials (second paragraph)</td>
<td>Revise requirements for spacing of pipes for underground detention systems consisting of pipes</td>
<td>Revision</td>
<td>July 2013</td>
</tr>
<tr>
<td>8-19</td>
<td>Preferred Design Elements and Materials</td>
<td>Revise requirements for access to underground detention systems</td>
<td>Revision</td>
<td>9 October 09</td>
</tr>
<tr>
<td>8-20A</td>
<td>Preferred Design Elements and Materials</td>
<td>Revise list of approved storm water collection chamber (SCC) detention systems</td>
<td>Revision</td>
<td>July 2013</td>
</tr>
<tr>
<td>8-20A 8-20B</td>
<td>Preferred Design Elements and Materials; Installation</td>
<td>Revise specifications to allow use of storm water collection chambers (SCC) for underground detention systems</td>
<td>Revision</td>
<td>9 October 09</td>
</tr>
<tr>
<td>8-20A</td>
<td>Preferred Design Elements and Materials; Installation</td>
<td>Revise specifications for use of smooth-lined corrugated plastic pipe (CPE) to allow CPE with maximum size of 60-inches for all uses and to impose additional requirements for backfill cover for applications under pavement.</td>
<td>Revision</td>
<td>9 October 09</td>
</tr>
<tr>
<td>8-20A</td>
<td>Installation</td>
<td>Revise installation specifications to require underground detention system to be entirely enveloped with Geotextile fabric if soil conditions warrant.</td>
<td>Revision</td>
<td>8 June 2009</td>
</tr>
</tbody>
</table>
| 8-19 8-20A 8-20C | Preferred Design Elements and Materials (entire section is revised) | • Require access risers to be installed in underground detention systems made of pipes to allow for inspection and maintenance.  
• Provide new guidance for use of pumped outlets.  
• Revise materials specifications to allow for use of corrugated metal pipe (CMP), polymer coated corrugated steel pipe (PCCSP), and smooth-lined corrugated plastic pipe (CPE). | Revision | 11 July 2008 |
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<tbody>
<tr>
<td>8-20A</td>
<td>Installation (entire section is revised)</td>
<td>• Specify materials testing requirements, including revised contact number for Testing Lab.</td>
<td>Revision</td>
<td>11 July 2008</td>
</tr>
</tbody>
</table>
| 8-20B    |                                                                                          | • Revise installation specifications to require:  
  o backfill materials, backfill compaction, and minimum cover over pipe  
  o installation must be observed by Wayne County  
  o documentation of installation must be provided to Wayne County  
  • Revise contact number for scheduling inspection                                                                                                                                 | Revision       | 11 July 2008      |
| 8-21     | Example A: Flow Restrictor without Overflow  
Example B: Flow Restrictor with Overflow | Revise figures that illustrate example outlet structures                                                                                                                                                                | Revision       | 11 July 2008      |
| 8-22     | Example Forebay and Open Detention Basin Detail                             |                                                                                                           | Clarification  | 11 July 2008      |
|          | Preferred Design Elements and Materials (1st bullet point)                 | New guidance for use of pumped outlets                                                                                                                                                                                  | Clarification  | 11 July 2008      |
| 8-24     | Preferred Design Elements and Materials (last bullet point)                 | • Revise guidance for anti-seep collars  
  • New specifications for testing during riser fabrication  
  • New guidance and specifications for installation                                                                                                                                                          | Clarification  | 11 July 2008      |
| 8-25A    | Example Forebay and Open Detention Basin Detail                             | Revise example outlet detail                                                                                                                                                                                            | Clarification  | 11 July 2008      |
# Wayne County Storm Water Management Program
## Clarifications, Revisions, Updates, and Errata
### July 2015

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<tr>
<td><strong>Section 8.2.1: Forebays</strong></td>
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</tbody>
</table>
| 8-26 | Design Standards | • Revise specifications for buffer strips around retention basins  
• Add reference to figure in Section 8.1.1, Attachment C | Revision | July 2015 |
| **Section 8.2.2: Bioretention** | | | | |
| 8-29 thru 8-32 | Design Standards and Preferred Design Elements | Revisions to many Design Standards and Preferred Design Elements | Revision | July 2015 |
| 8-32 thru 8-33 | Materials | Revisions to material specifications for underdrain gravel blanket | Revision | July 2015 |
| 8-34D | New detail “Typical Bioretention Overflow Structure” | Clarification | July 2015 |
| **Section 8.2.3: Manufactured Treatment Systems** | | | | |
| 8-23 to 8-36D | All | • Include information about manufactured treatment systems approved for use  
• New Table 8.2.3-1: Peak Flow Rates for Various Models of Manufactured Treatment Systems Approved by Wayne County under This Section | Revision | 8 June 2009 |
| 8-35 | Description (2nd paragraph) | Add online reference to revised Manufactured Treatment Systems: Certification Procedure (March 2009)  
Revised reference (July 2015):  
| 8-35 | Design Standards (all) | Revise definitions of pollutant removal efficiency and required documentation | Revision | 11 July 2008 |
| 8-36 8-36A | Preferred Design Elements and Materials (all) | • Revise design flows  
• Make bypass structure optional  
• Revise loading specification  
• Impose new backfill cover requirement  
• Revise Materials specifications and testing requirements | Revision | 11 July 2008 |
## WAYNE COUNTY STORM WATER MANAGEMENT STANDARDS (V 3.0)

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<tbody>
<tr>
<td>8-36A</td>
<td>Installation (all)</td>
<td>Revision</td>
<td>11 July 2008</td>
</tr>
</tbody>
</table>
| 8-36B     | · Revise installation specifications to require:  
|           |   ○ backfill materials, backfill compaction, and minimum cover over pipe  
|           |   ○ installation must be observed by Wayne County  
|           |   ○ documentation of installation must be provided to Wayne County | 11 July 2008 |

### Section 8.3.2: Vegetated Swales

| 8-39      | Design Criteria (7th bullet) | Revise minimum slope to be 0.15% | Revision | 11 July 2008 |

### Chapter 11: Sample Calculations

| 11-8      | Section 11.2: Typical Storm Water Management System with Underground Detention | Include new Section 11.2 to provide sample calculations for design of an underground detention system at an example development site | Clarification | July 2015 |
| 11-13     | Section 11.3: Typical Storm Water Management System with Bioretention | Include new Section 11.3 to provide sample calculations for design of a bioretention system at an example development site | Clarification | July 2015 |

### Chapter 12: Contacts

<p>| All | Update references and websites for various agencies that may require permits and approvals for development projects in Wayne County | Update | July 2015 |
|     | Section 12.2 | Update references for Wayne County contacts to reflect September 2009 merger of the Department of Environment and Department Public Services into a reorganized Department of Public Services. | Update | 9 October 09 |
| All | Update website addresses for Wayne County departments to reflect new County website launched March 2009. | Update | 8 June 2009 |
| All | Revise contact information for agencies that may require other permits and approvals | Clarification | 11 July 2008 |</p>
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<td><strong>Wayne County Storm Water Management Standards (V 3.0)</strong></td>
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<td><strong>Appendix A: Engineer's Certificate of Construction</strong></td>
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<tr>
<td></td>
<td></td>
<td>- Revise example certificate</td>
<td>Revision</td>
<td>11 July 2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Specify contents of attachment required for systems that include vegetation specific to the functioning of a storm water management component that is not included on plant lists included in the Wayne County Storm Water Standards</td>
<td></td>
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<tr>
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<td></td>
<td><strong>Appendix B: Model Community Resolutions Accepting Long Term Maintenance of Storm Water Management Systems</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td><strong>Appendix B-1 (2nd paragraph)</strong></td>
<td>Correct citation to the Wayne County Storm Water Management Ordinance (Chapter 9 instead of Chapter 7)</td>
<td>Errata</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Appendix B-2 (2nd paragraph)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Appendix B-1 (3rd paragraph)</strong></td>
<td>Correct the citation to the Wayne County Administrative Rules</td>
<td>Errata</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Appendix E-4: Wayne County Parks Division, Permit Guidelines For Site Restoration</strong></td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td><strong>Appendix E-4</strong></td>
<td>Revised site restoration specifications for construction activities on property owned by Wayne County Parks</td>
<td>Revision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Table 1</td>
<td>Various corrections</td>
<td>Errata</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Appendix E-4</strong></td>
<td>New appendix describing site restoration specifications for construction activities on property owned by Wayne County Parks</td>
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CHAPTER 1: INTRODUCTION

This manual supplements the Wayne County Storm Water Management Ordinance, Chapter 95 (Stormwater Management) of the Code of Ordinances of the Charter County of Wayne, as amended (Enrolled Ordinance No. 2006-1114A (December 19, 2006)); and the Wayne County Storm Water Management Administrative Rules, as amended (Resolution No. 2006-1114B (December 19, 2006)). For ease of reference in this manual, the Wayne County Storm Water Management Ordinance, Administrative Rules, and this manual are collectively referred to as the “Storm Water Management Standards.”

The purpose of this manual is to outline key elements of the Ordinance and Rules and to assist with their implementation. The manual describes storm water management requirements that apply to development projects within Wayne County’s jurisdiction. Specifically, the manual describes:

- Performance standards for storm water management systems. The County established the performance standards to control flooding and manage the adverse water quality impacts that can result from property development.
- Design criteria for the various components of storm water management systems. Applicants for storm water construction approval select various components to meet the performance standards.
- Design and maintenance information for various Best Management Practices (BMPs). BMPs provide multiple environmental benefits, including managing water quantity and improving water quality.

Many development and construction projects that require Wayne County review and approval must conform to the Standards. In general, the types of projects that are subject to the Standards include:

- residential, commercial, and industrial subdivisions
- mobile and manufactured home parks
- projects that impact storm water runoff into or around new or existing
  - Wayne County Road rights-of-way;
  - County Road drainage facilities;
- storm sewer systems owned, operated, or controlled by the County; and
- projects that impact storm water runoff into or around Wayne County Drains
- projects that impact storm water into, on, or through properties owned by Wayne County (e.g., County parks)
- projects developed, designed or constructed by Wayne County
- projects that occur within and impact or may impact water quality or water resources in watersheds or sub-watersheds included in the County’s General Permit for municipal storm water discharges (“Storm Water Discharges from Municipal Separate Storm Sewer Systems (MS4s) Subject to Watershed Plan Requirements,” General Permit No. MIG619000).

If a proposed development presents unique flood control or water resources protection issues at a development site, on adjacent properties, or downstream of a development site, more stringent performance standards and design criteria than those described in the Standards may be imposed.

The obligation to enact and implement storm water standards was imposed upon the County, local governments, and other public agencies by Phase II of the federal National Pollution Discharge Elimination System (NPDES) storm water regulations. These obligations include the development, implementation, and enforcement of programs to manage storm water from development projects. Managing storm water will help to minimize flooding problems, erosion, and the loss of natural resources.

Chapter 4 describes how to obtain a Wayne County storm water construction approval for a project that is subject to the Wayne County Standards. Developers work with the Permit Office of the Engineering Division, Wayne County Department of Public Services, to obtain a storm water construction approval and implement the requirements of the Wayne County Standards. Chapter 12 lists contacts for
Wayne County’s storm water management program and other permitting agencies that may be involved in a development project.
CHAPTER 2: BACKGROUND

The entire land area that drains to a given waterbody (such as a lake or stream) is referred to as a watershed. Wayne County lies within portions of the following watersheds and subwatersheds:

• Combined Downriver (includes Ecorse Creek, Frank and Poet Drain, Blakely Drain, and Detroit River South watersheds),
• Lake St. Clair Direct Drainage,
• Rouge River (includes Rouge Middle 1, Upper Rouge, Rouge Lower 1, Rouge Main 3-4, Rouge Lower 2, and Rouge Middle 3 subwatersheds),
• Huron River (includes Middle Lower Huron River and Lower Huron River subwatersheds),
• Detroit River North, and
• Swan Creek.

All of the watersheds within Wayne County ultimately discharge to the Detroit River and/or Lake Erie.

Wayne County is authorized and obligated to implement a program to manage storm water runoff from development projects that occur within the portions of these watersheds that lie within Wayne County.

2.1 Storm Water Management Trends

New development brings buildings and other paved areas (called impervious surfaces) that increase the amount of rain water and snowmelt that runs off the areas onto other properties or into nearby rivers and streams. Traditional storm water management has involved controlling and managing the increased runoff from the developed areas, either by altering the downstream watercourse to increase its capacity for conveying flow (e.g. enclosing, paving, or straightening a drain), or by reducing the flood flow rates using a detention basin.

Modern storm water management recognizes not only flood control but also the water resource impacts of storm water runoff. Storm water runoff is a major source of pollution to and degradation of our waterways. As rainwater or snowmelt flows across the land, the runoff picks up ground pollutants (such as fertilizers and pesticides from lawns, oil and grease from parking lots and roads, animal waste, and household hazardous waste) and conveys the pollutants into the waterways. Storm water also picks up bacteria from septic systems, toxins from abandoned dumps, and sanitary sewage from improper sewer connections.

Recent reauthorizations of the Clean Water Act have reaffirmed the commitment to control storm water runoff as a source of water pollution. Just as the quantity of storm water is controlled to protect downstream interests, modern storm water management manages pollutants in storm water to prevent degradation of downstream water quality and to protect aquatic life and habitat. A brief history of the regulatory changes that have expanded requirements for controlling the pollutants in storm water follows.
Beginning in 1991, the federal Clean Water Act required communities with populations over 100,000 that were served by separate storm sewer systems to obtain National Pollution Discharge Elimination System (NPDES) permits. Phase I of the federal NPDES storm water regulations required communities to obtain NPDES permits in order to discharge storm water to creeks, streams and rivers. Construction sites greater than 5 acres in area and certain categories of industry also were required to obtain storm water discharge permits.

Beginning in 1999, Phase II of the federal NPDES storm water regulations was implemented. Phase II requires communities in urbanized areas with populations under 100,000 to obtain NPDES discharge permits. To obtain a permit, the Phase II regulations required municipal permit holders to reduce the discharge of pollutants in storm water runoff to the “maximum extent practicable” by developing and implementing programs to address a variety of stormwater issues, including “post construction storm water control.” In accordance with this requirement, municipal permit holders must require developers to construct permanent storm water management measures as part of their development projects. Communities and other public authorities subject to Phase II of the federal NPDES storm water regulations were required to apply for permits to discharge storm water to Michigan’s surface waters by March 10, 2003. Phase II of the program also required storm water permits for construction sites greater than 1 acre in area and additional categories of industry.

The Michigan Department of Environmental Quality (MDEQ) issues storm water discharge permits in Michigan. Communities operating separate storm water drainage systems in Michigan have two permit options: a watershed-based general permit, and a traditional general (jurisdictional) permit. Under either permit option, the community must meet the federal requirement to implement a program to ensure “post construction storm water control” from development projects. Wayne County and virtually all communities in Wayne County have coverage or have applied for coverage under the watershed-based permit option.

Additional information about the federal NPDES program and its implementation in Michigan and in Wayne County is provided in Chapter 3.

2.2 Wayne County’s Commitment

Wayne County, working with its partner citizens, businesses, communities and agencies, is committed to improving and protecting streams, rivers, and lakes for enhanced environmental quality and recreational opportunities, and for the protection of the public health and general well-being. This commitment includes flood control and water resource protection through storm water management.

Wayne County has been a leader in flood control and water resources protection through several ongoing and new initiatives. For example:

- For many years, Wayne County’s Rouge River National Wet Weather Demonstration Project has received national attention for its evaluation of different pollution control and river restoration techniques.

- Since 1987, the County’s illicit discharge elimination program has identified and eliminated failing septic systems and improper sanitary sewer connections, which contribute bacteria and pollutants to storm water runoff.

- In 1999, well in advance of the March 2003 federal deadline, Wayne County obtained a certificate of coverage under the voluntary, watershed-based Michigan General Storm Water Permit. Wayne County developed and implemented a wide range of storm water pollution prevention measures throughout the County under this voluntary permit.

- In March 2003, Wayne County applied for coverage under the re-issued, mandatory watershed-based General Permit (Permit No. MIG619000). Wayne County’s current certificate of coverage under the general permit is MIG6190040.

The Wayne County Storm Water Management Standards are a critical component of the County’s storm water
management efforts and are required under the County’s certificate of coverage and the General Permit. Under similar certificates of coverage and storm water permits, all Wayne County communities are required to implement storm water management programs to manage storm water runoff from new development. Application of similar standards to development projects across Wayne County under both the County’s program and local programs will maximize the effectiveness of storm water management within the County.
CHAPTER 3: ADMINISTRATION & REGULATIONS

The Wayne County Storm Water Management Standards are administered jointly by the Wayne County Department of Public Services (WCDPS) and the Wayne County Department of Environment (WCDOE). In addition to Wayne County, other agencies are involved with storm water management and may have jurisdiction over the design, construction and maintenance of storm water management systems. The storm water management authority of various agencies, including Wayne County, is summarized in this Chapter. Chapter 12 of this manual provides contact information for relevant state and county agencies.

3.1 Wayne County

**Drain Code, Act 40 of 1956, as amended**

This state law governs the construction and maintenance of established County Drains and drainage districts. The Drain Code specifies requirements for sewers, pumping equipment, and other structures and mechanical devices that are required to purify the flow of water in County Drains. The Drain Code provides for flood control projects, water management districts and sub-districts, and for flood control and drainage projects within such districts. The Code authorizes the assessment and collection of taxes in certain circumstances, and prescribes penalties for violations of the Code.

In Wayne County, for purposes of implementing and administering the Drain Code, the Director of WCDOE serves as the County Drain Commissioner.

**Subdivision Control Act, Act 288 of 1967, as amended**

This state law requires county drain commissioners to ensure that the drainage within platted subdivisions is adequate to address storm water management needs within the proposed subdivision and protects downstream land owners from flooding. Through the subdivision review process, drain commissioners are authorized to impose obligations upon developers to ensure that drains and natural watercourses, both inside and outside the plat, are improved to the Drain Commissioners’ standards when necessary for the proper drainage of a proposed subdivision.

The subdivision control act also requires county drain commissioners to ensure that storm water management systems necessary for proposed subdivisions are maintained in perpetuity by an appropriate governmental unit. Alternatively, drain commissioners must ensure that a governmental unit will oversee the performance of maintenance by a private entity, such as a property owner’s association. Drain commissioners may acquire jurisdiction over the drainage systems within subdivisions as deemed necessary for adequate operation and maintenance.

In Wayne County, the functions of the Drain Commissioner under the subdivision control act have been assigned to the Director of WCDOE.

**Mobile Home Commission Act, Act 96 of 1987**

This state law requires county drain commissioners to review and approve outlet drainage for proposed manufactured or mobile home parks. Proprietors are required to submit preliminary site plans for purposes of this review.

In Wayne County, the functions of the County Drain Commissioner under the mobile home commission act have been assigned to the Permit Office of the Engineering Division, WCDPS.

**Parks and Airports, Act 90 of 1913, as amended**

This state law authorizes the County to purchase and own real estate to use as public parks and airports. Under Act 90, Wayne County is responsible for the care and control of park and airport property. As a corollary to this responsibility, the County may make reasonable rules and regulations respecting the use of the park and airport property by the public. These regulations include requirements and standards pertaining to the use of park
or airport property for the control of storm water drainage from neighboring properties.

**County Road Law, Act 283 of 1909, as amended**

The County Road Law authorizes county road commissioners to grade, drain, construct, surface, and otherwise maintain roads under their control. In addition, the law requires persons who desire to construct or perform any work within county road rights-of-way to obtain a permit from the county.

In Wayne County, the executive powers and duties of the County Road Commission are vested in the Roads Division of WCDPS.

**Riparian Rights**

Owners of land that are adjacent to natural watercourses have "riparian rights" associated with the ownership of water frontage. These rights include the right to hold the land up to the water's edge secure against the unauthorized use of the property or riparian waters by non-riparian landowners. Wayne County is a riparian landowner by virtue of owning park lands and other property adjacent to natural watercourses within county watersheds. As such, the County may reasonably restrict the use of these County lands for storm water drainage from neighboring properties.

**Wayne County Certificate of Coverage, MDEQ Storm Water General Permit**

As discussed in Chapter 2, the County’s certificate of coverage and the Michigan General Permit obligated the County to develop and implement the Storm Water Management Standards. The County’s compliance with the General Permit is coordinated by the Watershed Management Division of WCDOE.

**Wayne County Soil Erosion and Sedimentation Control Ordinance**

Wayne County adopted the Soil Erosion and Sedimentation Control Ordinance, Chapter 94 of the Code of Ordinances of Wayne County (1998) (the “SESC Ordinance”), in October 2001. The SESC Ordinance designates WCDOE as the County Enforcing Agency responsible for administration and enforcement of Part 91 (Soil Erosion and Sedimentation Control) of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, as amended. Pursuant to the SESC Ordinance, Wayne County reviews soil erosion and sedimentation control plans and issues permits for earth changes subject to the Ordinance. The SESC Ordinance incorporates the administrative rules promulgated by the State of Michigan under Part 91, and provides for:

- penalties and civil fines as provided under Part 91;
- consent agreements;
- municipal civil infraction citations and notices; and
- a schedule of civil fines authorized under the Wayne County Municipal Civil Infractions Ordinance, Chapter 2 of the Code of Ordinances of Wayne County (2000).

In numerous communities within Wayne County, LRMD administers the Michigan Soil Erosion and Sedimentation Control Act pursuant to the SESC Ordinance.

**Wayne County Solid Waste Ordinance**

Wayne County adopted amendments to the Solid Waste Ordinance, chapter 104 of the Wayne County Code of Ordinances (1998) (the “SW Ordinance”), in September 2004. Under the SW Ordinance, all new solid waste disposal areas that require a construction permit under state law must apply to Wayne County for storm water construction approval. Existing sanitary landfills must use a combination of retention basins, swales, and/or ditches to manage runoff from landfill areas. The SW Ordinance is administered and implemented by the Land Resource Management Division (LRMD) of WCDOE.

**Wayne County Sewer Use Ordinance**

The County adopted the Sewer Use Ordinance, chapter 101 of the Wayne County Code of Ordinances (1998), in 1995 and amended the ordinance in 1998. The sewer use ordinance requires permits for connections or alterations to county-owned storm water facilities or public storm water facilities connected directly or indirectly to County facilities. The ordinance governs design, construction, alteration and use of County sewer facilities, imposing discharge rate limitations, right-of-way requirements for County Drains and natural watercourses, design flow calculation methodology, sewer pipe specifications and construction requirements.

**Wayne County Storm Water Management Ordinance and Administrative Rules**

Wayne County enacted the Wayne County Storm Water Management Ordinance and Administrative Rules in 2000.
and amended the Ordinance and rules on August 7, 2003 and December 19, 2006. This manual was revised in August 2003 and January 2007 to conform to the amendments. The ordinance and rules, along with this manual, are collectively referred to as the "Storm Water Management Standards."

Wayne County applies the Storm Water Management Standards to the design, construction and maintenance of projects within County jurisdiction that impact storm water runoff. Detailed information about the County’s Storm Water Management Standards is provided in Chapter 5 of this manual.

3.2 Local Municipalities

The municipality or municipalities in which a proposed project is located may have local storm water management standards for design, construction and maintenance. Construction activities within the municipality may be subject to these local standards. The Wayne County Storm Water Management Standards do not limit the authority of municipalities within the County to develop and implement their own storm water management standards that are equal to or more stringent than the County Standards.

3.3 State of Michigan

3.3.1 Michigan Department of Transportation (MDOT)

MDOT is involved with all drainage facilities associated with any MDOT road right-of-way. A permit is required for any work within the right-of-way of any MDOT route. Contact MDOT or see the MDOT website (http://www.michigan.gov/mdot) for information about MDOT routes in Wayne County.

3.3.2 Michigan Department of Environmental Quality (MDEQ)

Subdivision Control Act, Act 288 of 1967, as amended

Under this Act, subdivisions that include a watercourse that drains an area of two square miles must meet prescribed standards for residential purposes and occupancy within a flood plain. These standards refer to such items as minimum lot area, street access, lowest finish floor elevation, and basement openings above the flood plain.

Michigan Natural Resource & Environmental Protection Act (NREPA), Act 451 of 1994, as amended

Part 31 - Water Resources Protection

Storm Water Management

MDEQ regulates storm water discharges pursuant to Part 31 of NREPA, which generally prohibits pollution of the State’s waters, obstruction and occupation of floodways, and any activity that would harmfully interfere with river and stream discharge characteristics. Through Part 31 and other state laws, MDEQ implements and administers Phases I and II of the federal storm water management regulations, which were established by the United States Environmental Protection Agency pursuant to the federal Clean Water Act. As noted previously, Phase I and II of the federal storm water management regulations authorize MDEQ to require permits for discharge of storm water from municipal separate storm sewer systems, certain categories of industry, and construction activity in which one or more acres of land are disturbed. These permits are part of the National Pollutant Discharge Elimination System (NPDES) permit program authorized by the federal Clean Water Act.

Phase I of the federal storm water regulations, promulgated by EPA in 1990, requires the implementation of storm water controls (1) at certain types of industrial facilities, (2) during “construction activity” that disturbs five or more acres of land and involves a point source discharge of storm water from the site during construction, and (3) operators of municipal separate storm sewer systems ("MS4s") serving populations greater than 100,000.

Phase II of the federal storm water program, promulgated by EPA in 1999, expanded the Phase I program by imposing storm water controls on (1) additional categories of industrial discharges, (2) smaller construction sites (sites that disturb between one and five acres of land), and (3) operators of municipal separate storm sewer systems ("MS4s") in urbanized areas with populations under 100,000. In Michigan, Phase II of the storm water program became effective March 10, 2003.
A summary of the Michigan’s requirements for discharges from construction sites, industrial sites, and municipal separate storm sewer systems is presented below.

**Construction Sites.** Michigan landowners responsible for construction activities disturbing 5 acres or more with a point source discharge to waters of the state may obtain permit coverage for their storm water discharges under the “Permit-by-Rule” developed by MDEQ. To obtain coverage under the Permit-by-Rule, an applicant first must obtain a Soil Erosion and Sedimentation Control (SESC) permit. An SESC permit may be obtained from WCDOE or from a local community that is a “Local Enforcing Agency” under Part 91 of NREPA.

After obtaining a SESC permit, the applicant submits a completed Notice of Coverage (NOC) form, with an application fee, to the MDEQ. After MDEQ receives the NOC and application fee, the permittee is deemed to be covered under the NPDES program. The permit requires, among other things, that the permittee appoint a storm water operator responsible for the supervision and inspection of the soil erosion control measures. The storm water operator must be certified by the MDEQ.

For construction activities disturbing between 1 and 5 acres, the landowner is required to obtaining a SESC permit from a local agency and comply with the provisions of the MDEQ Permit-by-Rule. Developers of such smaller sites need not submit a Notice of Coverage application to MDEQ.

**Industrial Sites.** Industrial facilities in Michigan that are subject to the NPDES program may obtain storm water discharge authorization by obtaining one of three types of permits: a generic baseline general permit, a generic general permit with monitoring requirements, or a site-specific individual permit. Approximately 4,000 industrial facilities in Michigan have obtained storm water discharge authorization under one of these permit programs.

Permitted industrial facilities must designate an individual at the facility who is responsible for exercising supervision and control over the control structures at the facility, eliminating any unauthorized non-storm water discharges, and developing and implementing a storm water pollution prevention plan for the facility, including structural and nonstructural control measures. The individual must be certified by MDEQ as a storm water operator.

**Municipal Separate Storm Sewer Systems.** Phase I of the federal storm water regulations applied to municipal separate storm sewer systems (MS4s) serving a population of 100,000 or more. The Phase I program initially required these larger MS4s to obtain a jurisdictional permit from MDEQ. Jurisdictional permits mandated implementation of prescriptive storm water control measures within the jurisdiction of the permittee, such as requirements for public education and public involvement, illicit discharge elimination, construction and post construction storm water controls, and good housekeeping and pollution prevention practices for municipal operations.

Phase I MS4 permittees are now eligible to coverage under a general MS4 storm water permits developed for the Phase II storm water program. MDEQ’s general permits identify the requirements that must be met by all public agencies applying for coverage. To obtain coverage, the public agency must prepare an application that sets forth its proposal for compliance with the requirements. MDEQ reviews the application, and, if it is satisfactory, issues a certificate of coverage to the applicant. The certificate of coverage constitutes a valid authorization to discharge storm water under the general permit.

As noted previously, Phase II of the federal storm water program expanded the Phase I program to apply to municipal separate storm sewer systems in urbanized areas with populations under 100,000. Two general permits are available to smaller MS4s: a traditional general (jurisdictional) permit, and a watershed-based general permit. The traditional general permit (Permit No. MIS040000) was promulgated in March 2003 and became effective April 1, 2003. Like the jurisdictional permit that was available to larger MS4s under Phase I, the traditional general permit contains prescriptive storm water control measures that must be implemented within the jurisdictional boundaries of the permittee. These include requirements for public education and public involvement, illicit discharge elimination, construction and post construction storm water controls, and good housekeeping and pollution prevention practices for municipal operations.
The watershed-based general permit was originally issued in 1998 (Michigan Storm Water General Permit (“General Permit” No. MIG610000) and was reissued in December 2002 as a mandatory permit, to be effective April 1, 2003 (Permit No. MIG619000). The watershed-based general permit addresses the same basic requirements as the traditional general permit but provides greater flexibility to MS4s in selecting and implementing storm water controls. The watershed-based general permit requires cooperative interaction with other public bodies outside of the permittee’s jurisdiction. This cooperative approach is designed to accomplish storm water quality improvements watershed-wide, and provides an added benefit of cost-sharing for some storm water controls. Watershed-wide controls means that many public bodies that discharge storm water to the same river or lake develop controls together, and implement them as part of a coordinated strategy.

Only operators of MS4s in “urbanized areas” are required to obtain a storm water permit pursuant to the federal Phase II regulations. “Urbanized areas” are delineated and defined by the federal Bureau of the Census. Virtually all of Wayne County is considered an urbanized area under the federal Phase II regulations. At the time of publication of this manual, Wayne County and most communities within Wayne County have coverage or have applied for coverage under the watershed-based general permit option. Two communities within Wayne County have applied for coverage under the traditional (jurisdictional) general permit option.

Flood Plains

Part 31 also controls flood plain occupancy. Under Part 31, a permit must be obtained from the MDEQ to fill or otherwise occupy a flood plain. The purpose of this control is to assure that watercourses, and the portion of the flood plains that are floodways, are not inhabited and are kept free and clear of interference or obstruction which would cause any undue restriction of floodway capacity. Part 31 also ensures that adequate provisions are proposed so that no flood damage will occur from proposed alterations.

Part 91 - Soil Erosion and Sedimentation Control

Part 91 of NREPA is designed to protect the waters of the State from sedimentation caused by soil erosion. Part 91 requires persons intending to cause earth changes to prepare soil erosion and sedimentation control plans. In addition, permits are required for earth changes that disturb one or more acres of land or that are within 500 feet of a lake or stream. Permits are issued by counties or local governments with programs approved by the MDEQ. In Wayne County, these permits are issued by LRMD unless the project is located in a community that is a Municipal Enforcing Agency. For a listing of the communities in which SESC permits are issued by Wayne County, please see the Wayne County website (www.waynecounty.com/doe/land).

Part 301 - Inland Lakes and Streams

Part 301 of NREPA controls the construction of channel modifications and utilities crossing streams, rivers, creeks and other watercourses in the State. Under Part 301, a permit must be obtained from the MDEQ to alter or modify any watercourse. This program regulates unlawful encroachment of these watercourses and specifies construction techniques for alterations and modifications.

Part 303 - Wetland Protection

Part 303 of NREPA provides for the preservation, management, protection, and use of wetlands. A permit is required for construction through, or alteration or use of, a wetland. The Act applies to wetlands that have a ground or surface water connection to a lake, pond, river, or stream; to any isolated wetlands that are greater than five acres in size; and in counties having a population of 100,000 or more, to any wetland determined to be essential to the preservation of the natural resources of the State from pollution, impairment, or destruction.

3.4 Federal Agencies

3.4.1 Federal Emergency Management Agency (FEMA)

The National Flood Insurance Program (NFIP), which was created by an act of Congress in 1968, was designed to reduce flood losses through local flood plain management and to provide protection for property owners against
potential losses through flood insurance. Some years later, FEMA was created and NFIP became a part of FEMA. FEMA collects data concerning flood hazards and is responsible for revising NFIP maps to conform to the data. Flood insurance maps are available from the local community or MDEQ. An application must be submitted to FEMA if any work will alter the existing floodplain.

3.4.2 U.S. Army Corps of Engineers (USACE)
State and federal law requires a joint permit from MDEQ and the USACE for certain activities in navigable waters or the waters of the United States.

Rivers and Harbors Act of 1899, Section 10
This Act requires USACE approval before commencing any work in or over navigable waters of the United States or that affects the course, location, condition or capacity of such waters. Typical activities requiring Section 10 permits include:
- Construction of piers, wharves, bulkheads, dolphins, marinas, ramps, floats, intake structure, and cable or pipeline crossings
- Dredging and excavation

Navigable waters are defined as waters that have been used in the past, are now used, or are susceptible to use as a means to transport interstate or foreign commerce up to the head of navigation. Further information on navigable waters in Wayne County can be obtained from the USACE.

Federal Clean Water Act, Section 404
Section 404 of the Clean Water Act requires USACE approval before discharging dredged or fill material into the waters of the United States. Waters of the United States includes essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters. Typical activities requiring Section 404 permits include:
- depositing of fill or dredged material in waters of the U.S. or adjacent wetlands;
- site development fill for residential, commercial, or recreational developments;
- construction of revetments, groins, breakwaters, levees, dams, dikes, and weirs; and
- placement of riprap and road fills.

Joint MDEQ/USACE Permit Application
MDEQ and the United States Army Corps of Engineers (USACE) have prepared a joint permit application to facilitate permit applications for projects under the jurisdiction of both of these agencies. The MDEQ/USACE “Joint Permit Application” package covers permit requirements pursuant to state and federal rules and regulations for construction activities where the land meets the water (including wetlands), often referred to as the land/water interface. It is intended to prevent duplication of state and federal requirements. The application covers activities on or for the following parts of the (NREPA):
- Part 301, Inland Lakes and Streams, of the NREPA;
- Part 303, Wetlands Protection, of the NREPA;
- Part 325, Great Lakes Submerged Lands, of the NREPA;
- Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the NREPA;
- Part 353, Sand Dune Protection and Management, of the NREPA;
- Part 323, Shorelands Protection and Management, of the NREPA; and
- Part 315, Dam Safety, of the NREPA.

Contact MDEQ or visit the MDEQ website (www.michigan.gov/deq) for more information on the joint permit.

3.5 Responsibilities
The Permit Office reviews the design of storm water management systems; the suitability of the materials proposed, work performed, and manner of performance; and the rate of work progress related to storm water management systems subject to the Ordinance, Rules and Standards. Storm water management systems that are part of a soil erosion and sedimentation control plan permitted by LRMD also are reviewed by LRMD.

Storm water management systems that are not within the jurisdiction of Wayne County’s Storm Water Management Program are reviewed by the local community.

It is the responsibility of the property owner to pay all appropriate fees and obtain approval from the appropriate jurisdictions to construct a storm water management system.
CHAPTER 4: OBTAINING STORM WATER CONSTRUCTION APPROVAL

This chapter provides a brief description of the requirements and procedures for obtaining storm water construction approval from Wayne County.

4.1 General Information

The types of projects which must obtain storm water construction approvals under the County’s Storm Water Management Standards include the following.

- **Certain projects that require permits or approvals from Wayne County under other programs.** Example projects include:
  - Work within a County road right-of-way or impacting any County road drainage facility.
  - Work that crosses, alters, or outlets into a County Drain.
  - Construction activities within, or in some cases, affecting Wayne County properties (such as Parks).

  These types of project require permits from the Permit Office of the Engineering Division, WCDPS, and must comply with the Wayne County Storm Water Management Standards.

- **Subdivisions.** WCDPS reviews and approves preliminary plats for platted subdivisions in Wayne County. Final plats are reviewed by WCDPS and approved by the Director of the Department of Environment or his delegate. Subdivisions must include storm water management systems that comply with the County’s storm water standards.

- **Multi-unit residential developments** (e.g. condominiums). WCDPS reviews construction permit applications for multi-unit developments. Multi-unit residential developments must include storm water management systems that comply with the County’s storm water standards.

- **To a certain extent, manufactured and mobile home parks.** WCDPS reviews and approves preliminary site plans for manufactured and mobile home parks in Wayne County. Certain aspects of drainage and storm water management from manufactured and mobile home parks must comply with the Wayne County Storm Water Management Standards.

  - **Construction activities that occur within and impact or may impact water quality or water resources in watersheds or sub-watersheds that are included in the County’s certificate of coverage.** Compliance with the storm water requirements in these projects is required by the County’s certificate of coverage and the Michigan General Storm Water Permit.

  - **Projects that require Soil Erosion and Sedimentation Control (SESC) permits from the County.** SESC permits generally are required for earth changes that disturb one or more acres of land or are within 500 feet of a lake or stream. Permittees are required to prepare soil erosion and sedimentation control plans. LRMD reviews and approves of these plans and issues of soil erosion control permits in communities that are not authorized to administer and enforce the soil erosion program.

Accordingly, Wayne County reviews various submittals for compliance with the Storm Water Management Standards. These include:

- requests for approval of preliminary site plans for manufactured and mobile home parks;
- requests for approval of preliminary plats for subdivisions;
- construction permit applications for subdivisions, multi-unit residential developments, manufactured and mobile home parks, and projects which impact County roads, parks, and drains (including taps, relocation, enclosing, etc.);
- requests for approval of final plats for subdivisions; and
- soil erosion and sedimentation control permit applications.
Applications for storm water construction approval associated with these types of projects, with supporting documentation, must be submitted to the Wayne County Permit Office. The Permit Office reviews development projects for compliance with:

- the Wayne County Storm Water Management Standards;
- Wayne County Standards and Specifications (and good construction practices) for work within a Wayne County road right-of-way, County Drain or County park; and
- Wayne County Subdivision Rules and Regulations and standards (for subdivided property).

A development project may require additional permits or approvals from different departments of Wayne County. Such additional permits may include:

- SESC permits;
- Sanitary sewer extension permits;
- permits for wells and private sewage disposal systems (septic systems); and
- approval to modify a County Drain or drainage district.

Chapter 12 provides contact information for Wayne County departments and other agencies whose approval may be required before construction may be initiated. Depending on the type of approvals required from other agencies or Wayne County departments, the Wayne County Permit Office may require proof of other approvals before issuing a storm water construction approval.

Before submitting an application for storm water construction approval, applicants should confirm that they have the latest information regarding the Wayne County Storm Water Management Standards. An applicant can obtain the amended Wayne County Storm Water Management Ordinance, Administrative Rules, and Standards Manual, and the latest version of the document “Program Clarifications, Errata, and Revisions,” if any (collectively, “Storm Water Program Documents”), from either the Permit Office or the Wayne County website (see the “Document Updates & Internet Access” page at the beginning of this manual).

4.2 Application Requirements

The application for storm water construction approval generally must include the following documents and information:

- Completed application form or transmittal. See Figure 4-1 for a copy of the application form. The form or transmittal must include general information needed to process the application, such as:
  - project name,
  - project location,
  - major cross roads in project vicinity,
  - city or township where project is located,
  - type of proposed work,
  - name of applicant,
  - contact person, telephone number and mailing address for both the owner and the engineer,
  - description of the work and any unique characteristics of the development, and
  - any other relevant information.

- Construction plans developed in accordance with the Wayne County Storm Water Standards and other applicable Wayne County requirements (see Section 4.3 below for the basic requirements for plans).

- Long-term maintenance plan for storm water management system, including legally binding instrument assuring maintenance of system in perpetuity. (See Exhibit B to Appendix C of this manual for a sample long-term maintenance plan).

- Payment of any applicable fees. As described in Section 4.4, applicants may be required to pay additional fees and provide financial assurances during the review process.

4.3 Requirements for Plans

Plans submitted with each application for construction approval should comply with the following general requirements:

- A minimum of three (3) sets of plans should be submitted for review.

- The maximum paper size should not exceed 24 inches x 36 inches.

- The scale of the drawings should be of a standard engineering scale. Plans should not be difficult to read.Typically a scale of 1 inch = 20 feet or 1 inch = 30 feet is used.
• The plans must be signed and sealed by a Professional Engineer (PE) registered in the State of Michigan.
• The title sheet should include the legal description of the site and a location map. Include major cross streets for reference.
• Include any symbols and line type legend.

For most projects, some or all the following sheets should be included in the plan sets submitted:
• Title sheet
• Existing topographical information (including existing utility information)
• Removal/ demolition sheet
• Typical sections and other details
• Site plan sheets
• Road profiles
• Utility plans
• Miscellaneous details (if any)
• Storm sewer profiles (including hydraulic grade lines)
• Storm sewer calculations table
• Storm water management system plan view, cross sections, calculations, details, and exhibits to the long-term maintenance plan
• Landscape plan
• Traffic/signing plan
• Drain easements (if required)
• Documentation of required approvals (if any) from other agencies

4.4 The Review Process

The review process begins when an applicant submits an application, payment for any relevant fees, and three (3) sets of plans, along with supporting documentation, to the Permit Office. A review number and a Review Engineer are assigned to each project. The Review Engineer performs an in-depth review of the project.

The review process may require more than one submittal of plans for the project to fulfill the County’s approval requirements. Applicants should take this into account when applying for construction approval.

Once the plans and all other required documentation have been approved by the Review Engineer, the Permit Office issues a storm water construction approval to the applicant. Upon receipt of the approval letter, the applicant must contact the Permit Coordinator identified in the approval letter for the exact amounts of the required fees and financial assurance. Financial assurance generally can be provided through use of a performance bond, a cash deposit, or letter of credit in an amount equal to the current estimate of the cost of completing the construction. See Chapter 9 of the Wayne County Storm Water Administrative Rules for additional information regarding financial assurance. All fees must be paid in full and proof of financial assurance provided prior to permit issuance. Once all requirements have been met, the Permit Office issues a permit to construct to the applicant.

Wayne County requires the township, city or village in which a project is located, or another public corporation or entity (e.g. drainage district) approved by the County, to assume long-term maintenance responsibility for all storm water management systems through a legally-binding instrument such as an ordinance, resolution, contract or equivalent instrument approved by the County. See Chapter 9 of this manual for further details.

A detailed outline of the process to obtain storm water construction approval and a permit to construct is shown in Figure 4-2 “Procedure for Obtaining a Construction Permit”.

4.5 Project-specific Requirements

The Wayne County Storm Water Management Standards requires that storm water management systems for development projects be sized to manage the entire upstream land area which drains to that location. This means that the drainage area to a storm water management system may include:
• offsite drainage areas, and
• areas within the project site which are already developed (if project involves expansion of existing facilities).

For projects proposing to utilize a storm water management system designed prior to the current version of the County’s Storm Water Management Standards, the original system, and in particular its ability to manage (additional) runoff from the development project, will be
reviewed for compliance with the Wayne County Storm Water Management Standards.

- If the County determines that an existing system can manage the additional flow from the proposed project and maintain compliance with the County’s current Storm Water Management Standards, the applicant may be permitted to use the existing system for managing storm water from the proposed project. The applicant must demonstrate that it has a legal right to utilize the existing system for storm water management.

- If the County determines that an existing system does not comply with the County’s current program, or that the existing system cannot manage the additional runoff in compliance with the Storm Water Management Standards, the applicant may not utilize the existing system for the proposed project unless:
  - the applicant brings the existing system into compliance with the Storm Water Management Standards; and
  - the applicant demonstrates that it has a legal right to utilize the existing system for storm water management.

Applicants that propose to utilize an established County Drain or an established drainage district (with or without modifications) for storm water management may be subject to additional requirements. (See Chapter 12 of this manual for contact information for the Wayne County Drain Office.) The Permit Office will not issue a storm water construction approval until all applicable requirements of the Wayne County Drain Commissioner have been satisfied. Note that County drain easements established prior to 1956 were not required by statute to be recorded immediately. It may be necessary to check the permanent records of the Wayne County Drain Commissioner (located within the Department of Environment) or the Wayne County Register of Deeds to see if a drain easement exists on the subject property.

Additional requirements may apply to condominium developments. For example, condominium lot lines must be shown on the plans. Buffer strips required by the Wayne County Storm Water Management Standards must be shown to lie outside of the condominium lot lines.

For Wayne County to ensure storm water management systems serving subdivisions are constructed in compliance with the Storm Water Management Standards, the storm water management system must be designed and included in the submission for preliminary plat approval.

Similarly, the storm water management system for mobile home parks must be designed and included in the submission for preliminary plat approval.

**4.6 Modifications of Approved Plans**

The permit holder is required to construct the project according to the permit to construct and the approved plans. If any modifications to the plans are desired after approval, a written request to modify the plans must be submitted to the Permit Office. The request must include the appropriate sheets from the plans with the proposed modification(s) clearly identified. It should be noted that proposals to change construction materials or manufacturers constitute plan modifications and must be submitted to the Permit Office for approval.

Failure to obtain prior approval of plan modifications is a violation of the Wayne County Storm Water Management Standards and may subject the permit holder to penalties in accordance with Chapter 9 of the Wayne County Storm Water Management Ordinance. Additionally, unless modifications are pre-approved, the permit holder may be unable to obtain a certification from a registered PE that the project has been constructed in accordance with approved plans and the permit to construct. Applicants must obtain a PE certification upon completion of the project before Wayne County will release the permit (see Section 4.7).

**4.7 Inspections and Permit Release**

After permit issuance, Wayne County periodically inspects the project during construction to ensure that construction proceeds in accordance with the approved plans and the permit to construct.

After construction of the storm water management system has been completed, a registered PE must certify that the storm water management system has been constructed in
accordance with the approved plans and the permit to construct (see Appendix A). Wayne County performs a final inspection of the completed project after receiving the engineer’s certification.

As described in Chapter 9, a permit for long-term maintenance of the storm water management system is issued contingent upon release of the permit to construct. A sample long-term maintenance permit is presented in Appendix C. Once the storm water management system has been constructed, inspected, and has been determined to be operating properly, the permit is released and any remaining financial assurances are returned to the permit holder.

4.8 Extensions of Approvals and Permits

Storm water construction approvals and construction plan approvals by the Permit Office are valid for one year. Permits to construct are valid for up to 2 years. If an extension beyond these periods is needed, the permit holder must submit a written request to the Permit Office for an extension. **Requests for extensions must be made to the Permit Office at least ten (10) working days before permit expiration.**

The Permit Office may grant extensions of up to one year for a permit to construct for a storm water management system. Updated plans, additional information, further review, additional permit and inspection fees, and additional financial assurance may be required to extend the permit. Please note that **failure to obtain any necessary extensions of construction approvals or permits is a violation of the Wayne County Storm Water Management Standards** and may subject the permit holder to penalties as described in the Chapter 9 of the Wayne County Storm Water Management Ordinance.
FIGURE 4-1

STORM WATER CONSTRUCTION APPROVAL
APPLICATION FORM
APPLICATION FOR A “C” PERMIT

C Permits are required for:

- Construction within a Wayne County Road Right-of-Way, County Drain, or County Park
- Storm water construction approval

Date_____________________________________________________________________________________

Project Name______________________________________________________________________________

Project Location____________________________________________________________________________

Major Cross Roads _________________________________________________________________________

City or Township ___________________________________________________________________________

Type of Proposed Work_______________________________________________________________________

Name of Applicant __________________________________________________________________________

Owner Contact Information:

Name ____________________________________________________________________________________

Mailing Address ____________________________________________________________________________

City, State, Zip ____________________________________________________________________________

Telephone _____________________________Fax ________________________________________________

Email ____________________________________________________________________________________

Engineer Contact Information:

Name ____________________________________________________________________________________

Mailing Address ____________________________________________________________________________

City, State, Zip ____________________________________________________________________________

Telephone _____________________________Fax ________________________________________________

Email ____________________________________________________________________________________

Description of Work, including any unique characteristics of the development and any other relevant information____________________________________________________________________________________________

REQUIRED INFORMATION TO BE ATTACHED TO THIS FORM:

- Payment of application fees
- For storm water construction approvals:
  - Long term maintenance plan for storm water management system, including legally binding instrument assuring maintenance of system in perpetuity
  - Documentation of compliance with any other Wayne County requirements

SUBMIT THIS FORM WITH APPLICABLE FEE PAYMENT AND INFORMATION TO Wayne County Permit Office 33809 Michigan Avenue, Wayne, MI 734-595-6504
FIGURE 4-2

PROCEDURE FOR OBTAINING A CONSTRUCTION PERMIT
**WAYNE COUNTY DEPARTMENT OF PUBLIC SERVICES**
**ENGINEERING DIVISION/PERMIT OFFICE**

**PROCEDURE FOR OBTAINING A CONSTRUCTION PERMIT**

**THE APPLICANT**
- Transmits to the County Permit Office an Application Letter/Form, provides 3 sets of plans for review, and pays any applicable fees

**WAYNE COUNTY**
- Assigns the project a review number and a Plan Review Engineer reviews the work

**THE APPLICANT**
- Revises the plans per the Plan Review Engineer’s comments and resubmits 3 sets of plans for approval

**WAYNE COUNTY**
- Sends the Applicant an Approval Letter

**THE APPLICANT**
- Contacts the Wayne County Permit Coordinator for fees and other permit issuance requirements. The applicant will satisfy all remaining issues and pay all fees.

**A Wayne County Construction Permit is issued and the project is assigned a permit number**

**THE PERMIT HOLDER**
- Contacts the Permit Office at least 3 working days prior to the start of work

**THE PERMIT HOLDER**
- Constructs the project in accordance with the permit and approved plans.

**WAYNE COUNTY**
- Authorizes construction under its jurisdiction
- Performs the inspections
- Contacts the Wayne County Lab for testing when required.

**THE PERMIT HOLDER**
- Completes all required work as specified within the permit and requests a final inspection

**WAYNE COUNTY**
- Performs the final inspection of the permitted work

**THE PERMIT HOLDER**
- Provides all water items that require completion or correction before the work may be deemed acceptable

**WAYNE COUNTY**
- Once the work is accepted, the permit will be "released"

**THE DEPOSITOR**
- Receives a refund of deposits or is required to pay the amount due

The procedure is complete.

---

**Projects requiring a Storm Water Management System must include a Long Term Maintenance Plan and will require a Maintenance Permit. (See Chapter 9 and Appendix C)**
CHAPTER 5: PERFORMANCE STANDARDS

Under the Wayne County Storm Water Management Standards, storm water management systems must be selected and designed with two main objectives: flood control and water resources protection. This chapter presents the performance standards that Wayne County has adopted to meet these two objectives.

In addition to adopting performance standards, Wayne County has established design standards for certain components of storm water management systems. These standards help ensure that each component is designed, operated and maintained such that the performance standards are met. A summary of the performance standards and design standards under the Wayne County Storm Water Management Standards is shown in the attached table. Chapters 6, 7, and 8 of this manual provide detailed information about standards and guidance for designing storm water management system components to satisfy the performance standards.

Applicants for storm water construction approval may select any combination of storm water management components to satisfy the performance and design standards provided that the selection: (1) complies with other requirements of the Wayne County Storm Water Management Standards; (2) complies with other local, county, state or federal requirements; (3) and does not conflict with existing local storm water management plans.

The performance standards described in this chapter pertain to permanent storm water management systems. Certain temporary storm water management measures are also required for some development projects which involve earth change activities. These temporary measures are described in Chapter 7.

5.1 Flood Control
The design of a storm water management system must incorporate elements for protecting against the effects of flooding. To control flooding, Wayne County has adopted the following minimum performance standards for storm water runoff from development projects:

- For storm water management systems with drainage areas greater than 5 acres, the peak flow rate of storm water runoff leaving the development site must not exceed 0.15 cfs/acre for a 100-year storm.
- For storm water management systems with drainage areas of 5 acres or less, the peak flow rate of storm water runoff leaving the development site must not exceed 0.15 cfs/acre for a 10-year storm.

5.2 Water Resources Protection
Designing a storm water management system to address water resources protection requires an understanding of the type of pollutants expected to be generated from the site during and after construction. With that understanding, the system and the maintenance plan that accompanies it must incorporate appropriate Best Management Practices (BMPs).

Wayne County has adopted the following minimum performance standard to minimize pollutants in storm water runoff from development projects:

- Storm water management systems must be designed and constructed to remove 80 percent or more of the total suspended solids load from the development site, as determined on an annual average basis.
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>General Design Standards</th>
<th>Additional Design Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rule 501: Flood Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determination of peak flow rate: Rule 601</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS must include detention system with flow restrictor or retention basin: Rule 602(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detention Systems: Rule 602(B)(1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sizing for flood control storage volume</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outlet / flow restrictor sizing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retention Basins: Rule 602(B)(2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sizing for flood control storage volume</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS must have adequate outlet, except that outlet not required for retention basins: Rule 602(C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS are prohibited in floodplain unless specific additional requirements satisfied: 602(D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Additional requirements: Rule 602(E)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS must follow natural drainage pattern</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS that include surface waters cannot be located within pre-existing surface water.</td>
<td></td>
</tr>
<tr>
<td><strong>Rule 502: Water Resources Protection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>80% average annual TSS removal: Rule 502(B)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS must include pretreatment system at the inlet to each detention system and/or retention basin. Rule 603(B). Swtreatment system must either</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Be designed such that the SWMS achieves adequate TSS removal, Rule 603(B)(1); or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Be sized to capture and gradually release the first flush volume: Rule 603(B)(2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWMS must capture and gradually release bank full flood, except retention basins not required to satisfy bank full flood requirements: Rule 603(C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Additional requirements: Rule 603(D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Buffer strip required for SWMS with surface waters (except bioretention areas and vegetated swales)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Landscape plan required for SWMS with surface waters</td>
<td></td>
</tr>
</tbody>
</table>

**Detention Systems/Retention Basins**
- Rule 701: Open Detention Basins
- Rule 702: Retention Basins
- Rule 703: Underground Detention Systems
- Rule 704: Reserved
- Rule 705: Reserved

**Pretreatment Systems**
- Rule 706: Forebays
- Rule 707: Bioretention Areas
- Rule 708: Manufactured Treatment Systems
- Rule 709: Reserved
- Rule 710: Reserved
<table>
<thead>
<tr>
<th>Performance Standard</th>
<th>General Design Standards</th>
<th>Additional Design Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rule 711: Conveyances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rule 801: Wetlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rule 802: County Parks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rule 803: County Roads</td>
</tr>
</tbody>
</table>

The information presented in this table is referenced to the Administrative Rules of the Wayne County Storm Water Management Standards.
CHAPTER 6: GENERAL DESIGN STANDARDS

Designing storm water management systems to meet the performance standards in the Wayne County Storm Water Management Standards is the responsibility of the applicant or its designee. Wayne County maintains the right to require applicants to modify storm water management system designs to ensure that the performance standards are satisfied. Applicants must evaluate the project’s impact over the long-term and on a watershed scale. Taking these factors into account, the following sections describe general design standards for storm water management systems.

Additional design standards for storm water management systems may be found in Chapters 7 and 8.

6.1 Determination of Peak Flow Rate

6.1.1 Rational Method
The Rational Method for calculating storm water runoff is generally acceptable for calculating peak flow rate at a particular location within a storm water management system. Alternative methods may be required when the County determines that another method is necessary to satisfy the requirements of the Standards (see Section 6.1.2).

To calculate peak flow rate using the Rational Method, an applicant must use the following Rational Method Formula:

\[ Q = C \times I \times A \]

where:
- \( Q \) = peak flow rate (cfs)
- \( C \) = runoff coefficient
- \( I \) = rainfall intensity (in/hr)
- \( A \) = drainage area (acres)

The peak flow rate for each component of a storm water management system must be calculated using a composite runoff coefficient, the entire tributary drainage area, and a design rainfall intensity adjusted based on time of concentration. Values for the various terms used in the Rational Method Formula in determining peak flow at a particular location must be determined as follows:

- Drainage area (\( A \)) means the entire upstream land area that drains to that location, including any off-site drainage area. (In general, drainage from off-site should not be passed through on-site storm water management facilities. However, there are situations where this is unavoidable.)

- Peak flow rate (\( Q \)) must be calculated with the assumption that off-site drainage areas are developed consistent with any applicable master land use plan, storm water standards and storm water master plan enacted by the local community in which the storm water management system is located, and the Wayne County Storm Water Management Standards.

- The composite runoff coefficient (\( C \)) must be based on the percentage of surface types in the drainage area upstream of that location. Surface types to be used are shown in the following table.
### MINIMUM ACCEPTABLE RUNOFF COEFFICIENTS

<table>
<thead>
<tr>
<th>Type of Surface</th>
<th>Runoff Coefficient (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Surfaces</td>
<td>1.00</td>
</tr>
<tr>
<td>Roofs</td>
<td>0.95</td>
</tr>
<tr>
<td>Asphalt or concrete pavements</td>
<td>0.95</td>
</tr>
<tr>
<td>Gravel, brick, or macadam surfaces</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Semi-pervious: lawns, parks, playgrounds

<table>
<thead>
<tr>
<th>Slope</th>
<th>4-8%</th>
<th>&gt;8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4%</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>4-8%</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>&gt;8%</td>
<td>0.30</td>
<td>0.35</td>
</tr>
</tbody>
</table>


- Applicable rainfall formulas for calculating rainfall intensity (I) are provided in the table below for several design storms. Calculation of rainfall intensity depends on the time of concentration (t), which is the time duration (in minutes) that is required for runoff from the most remote area of the watershed to reach the storm water management system component being designed.

### DESIGN RAINFALL INTENSITIES

<table>
<thead>
<tr>
<th>Design Storm</th>
<th>Intensity (in/hr) for t &lt; 60 min.</th>
<th>Intensity (in/hr) for t &gt; 60 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-year</td>
<td>151.8/(t+19.9)</td>
<td>162.3/(t+25.4)</td>
</tr>
<tr>
<td>50-year</td>
<td>212.5/(t+23.3)</td>
<td>230.3/(t+30.3)</td>
</tr>
<tr>
<td>100-year</td>
<td>233.7/(t+23.5)</td>
<td>294.0/(t+45.0)</td>
</tr>
</tbody>
</table>

Data from U.S. Weather Service Station Records for Detroit, 1896 - 1942

### INITIAL TIME OF CONCENTRATION

<table>
<thead>
<tr>
<th>Type of Land Use</th>
<th>Time of Conc. (t&lt; sub&gt;<em>o</em> &gt;) (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Units</td>
<td>15</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>15</td>
</tr>
<tr>
<td>Single family residential</td>
<td>20</td>
</tr>
<tr>
<td>Unimproved land</td>
<td>t&lt; sub&gt;<em>o</em> &gt; = L / (60 x V) and V = 0.48 x S&lt;sup&gt;0.5&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

where

- t< sub>_o_ > = initial time of concentration (minutes)
- L = length of overland sheet flow (feet)
- S = slope of overland sheet flow (%)
- V = velocity of overland sheet flow (ft/sec)

The time of concentration for a particular design storm varies with slope, surface cover, and the length of the surface flow path. Other variables, including anticipated rainfall intensity and infiltration capacity of the soil and surface cover, also affect the time of concentration.

For the most upstream end of the storm water management system, the time of concentration is referred to as the initial time of concentration and is determined in accordance with the following table.

For all other downstream locations in the storm water management system, the time of concentration (t) is the sum of (1) the initial time of concentration and (2) the travel time from the upstream end to the location being analyzed.

### 6.1.2 Alternative Methods

The Rational Method Formula may not be an adequate design tool for calculating storm water runoff from large drainage systems. Alternative runoff hydrograph prediction methods are widely available and may be required by the Permit Office for sizing the drainage systems on large sites and/or smaller sites that present unique flood control or water resources protection issues. Acceptable alternative methods are:

- Corps of Engineers HEC-RAS or HEC-HMS;
- Soil Conservation Service UD-21, TR-20 or TR-55; and
6.2 General Design Standards for Flood Control

Storm water management systems designed to satisfy the flood control performance standards described in Section 5.1 must include a detention system and/or retention basin that is designed and constructed in accordance with this Section.

6.2.1 Detention Systems

Generally, two types of detention systems are most often designed in Wayne County: open detention basins and underground detention systems.

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. The permanent pool in a traditional detention basin must be a minimum of 4 feet deep.

- Constructed wetlands, where over 50% of the surface area typically is covered by wetland vegetation. Permanent wetland pool depths vary between 0.5 and 3.0 feet depending on vegetation type.

Underground detention systems consist of one or more underground pipes or structures designed to provide the required storage volumes (both the bank full 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 bank full flood and for the maximum allowable release rate from the development site.

Additional design standards for open detention basins and underground detention systems is presented in Chapter 8.

**Flood Control Storage Volume**

Detention systems that are designed to meet the flood control performance standards described in Section 5.1 must provide enough flood control storage volume so as not to exceed the maximum allowable runoff rate for the site. Equations used to determine the required storage volume are shown in the box below.

### Detention Systems:

**Flood Control Storage Volume Requirements**

**Drainage Areas Greater Than Five Acres**

Detention of the 100-year storm is required to control flooding events. Volume required should be based on the following relationships:

- \[ Q_a = 0.15 \text{ cfs/acre} \times A \]
- \[ Q_o = \frac{Q_a}{A \times C} \]
- \[ T_{100} = -45 + \sqrt{\frac{19845}{Q_o}} \]
- \[ V_{s100} = \frac{17649 \times T_{100}}{(T_{100} + 45)} - 40 \times Q_o \times T_{100} \]
- \[ V_{t100} = V_{s100} \times A \times C \]

**Drainage Areas Five Acres or Less**

Detention of the 10-year storm is required for flood control purposes. Volume required should be based on the following relationships:

- \[ Q_a = 0.15 \text{ cfs/acre} \times A \]
- \[ Q_o = \frac{Q_a}{A \times C} \]
- \[ T_{10} = -19.9 + \sqrt{\frac{4530}{Q_o}} \]
- \[ V_{s10} = \frac{9108 \times T_{10}}{(T_{10} + 19.9)} - 40 \times Q_o \times T_{10} \]
- \[ V_{t10} = V_{s10} \times A \times C \]

where:

- \( Q_a \) = Maximum allowable outflow rate from the detention system (cfs)
- \( Q_o \) = Maximum allowable outflow rate per acre imperviousness (cfs /acre imperviousness)
6.2.2 Retention Basins

Retention basins are man-made surface waters designed to store storm water runoff and provide gravity settling of pollutants. Retention basins infiltrate storm water into the soil rather than discharging it to a surface water or closed conduit.

Flood Control Storage Volume

Retention basins are designed to meet the flood control performance standards described in Section 5.1 must provide enough flood control storage volume to retain the volume of storm water equal to the runoff from two consecutive 100-year storm events. The equation used to determine the required storage volume is shown in the box below.

\[
V_r = 2 \times 16500 \times A \times C
\]

where:

- \(V_r\) = Flood control storage volume of retention basin (ft³)
- \(A\) = Drainage area (acres)
- \(C\) = Runoff coefficient

6.2.3 Adequate Outlet

Storm water management systems must have an adequate storm water outlet. At a minimum, the capacity of the outlet must not exceed the discharge's reasonable share of the maximum capacity of the downstream closed conduit or watercourse, as determined by the County.

If the County determines that a proposed detention system does not have an adequate outlet, the applicant may be required to design and construct improvements to the downstream County Drain, watercourse, or closed conduit. The County will determine the extent to which downstream improvements are required.

6.2.4 Flood Plain Restrictions

Storm water management systems may not be constructed within a 100-year floodplain unless the storm water management system satisfies the requirements listed below. Construction within a 100-year floodplain must be approved by MDEQ as well as the County.

- The storm water management system must not diminish the net storage capacity of the floodplain. Compensatory storage is required for any reduction in floodplain storage capacity.
- The storm water management system must not negatively alter the conveyance of the watercourse.
- During a design storm event, the storage capacity of the storm water management system must remain available for detention of storm water runoff from the development site.
- The storm water management system must minimize disruption to the riparian habitat of the floodplain by developing and implementing a plan for minimizing disturbance that is acceptable to the County.

6.2.5 Additional Requirements

To the fullest extent possible, storm water management systems must follow the natural drainage patterns within the development site and within the watershed in which it is located.

Storm water management systems that include surface water components cannot be located within pre-existing surface waters.
6.3 General Design Standards for Water Resources Protection

6.3.1 Pretreatment Systems
Storm water management systems must include a pretreatment system at each inlet to each detention system and/or retention basin. The pretreatment system must either:

(1) Be designed and constructed such that the storm water management system achieves the pollutant removal rate (80% or more of the annual average total suspended solids load) specified by the water resources protection performance standard (see Section 5.2); and/or

(2) Be designed and constructed to capture the first flush and release it gradually to the detention system and/or retention basin over a period of twenty-four (24) hours.

If an applicant designs a system to capture and release the first flush (as described above in option 2), the storage volume required to capture the first flush for the area tributary to the pretreatment system must be calculated based on the following relationship:

\[ V_{ff} = 1815 \times A \times C \]

where:

- \( V_{ff} \) = first flush storage volume (ft\(^3\))
- \( A \) = drainage area tributary to inlet (acres)
- \( C \) = runoff coefficient

Additionally, for option 2, the pretreatment system must have a flow restrictor designed to gradually release the first flush storage volume over a period of twenty-four (24) hours. The 24-hour average allowable release rate must be determined in accordance with the following relationship:

\[ Q_{avg\ ff} = \frac{V_{ff}}{86400} \]

where:

- \( Q_{avg\ ff} \) = 24-hour average allowable outflow rate (cfs)
- \( V_{ff} \) = first flush storage volume (ft\(^3\))

If one or more forebays are used as pretreatment system(s), the volume of the forebays 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.

6.3.2 Bank Full Flood Requirements
Soil erosion from stream banks and channels is of special concern in Wayne County. As development activity increases impervious surface area, the frequency and duration of bank full flow conditions increases. As a result, streams naturally attempt to become wider and deeper to convey the increased flows. This process can lead to channel and bank erosion and the destruction of aquatic habitat.

To address this concern, each storm water management system (except for retention basins), must capture runoff from the bank full flood and release it gradually over a period of forty (40) hours. The storage volume necessary to capture and treat runoff from the bank full flood must be calculated based on the following relationship:

\[ V_{bf} = 5160 \times A \times C \]

where:

- \( V_{bf} \) = bank full flood storage volume (ft\(^3\))
- \( A \) = drainage area (acres)
- \( C \) = runoff coefficient

Additionally, the pretreatment system must have a flow restrictor designed to gradually release the bank full flood storage volume over a period of forty (40) hours. The 40-hour average allowable release rate must be determined in accordance with the following relationship:

\[ Q_{avg\ bf} = \frac{V_{bf}}{144000} \]

where:

- \( Q_{avg\ bf} \) = 40-hour average allowable outflow rate (cfs)
- \( V_{bf} \) = bank full flood storage volume (ft\(^3\))
For detention systems that are intended to meet both the flood control and water resources protection performance standard, the lower portion of the flood control storage volume can also be used to capture the bank full flood. With this approach, the total volume required is equal to the flood control storage volume, not the sum of the flood control and bank full storage volumes. The volume of the permanent pool within an open detention system does not satisfy any of the flood control or bank full storage volume requirements.

6.3.3 Additional Requirements
To protect water resources, Wayne County has adopted the following additional requirements to minimize pollutants in storm water runoff from development projects.

Buffer Strip
A buffer strip is a zone that is used for filtering direct storm water runoff into a storm water management system and for providing maintenance access to a storm water management system. A buffer strip must be established and/or preserved along the edge of any surface water in the development site (except for bioretention areas and vegetated swales).

- The minimum width of a buffer strip is 25 feet, except in the following circumstances:
  - The minimum width of a buffer strip is 15 feet if:
    - The buffer strip is around a retention basin, an open detention basin, or a forebay associated with an open detention basin or retention basin, and the drainage area to the retention basin, open detention basin, or forebay has a of 5 acres or less; or
    - The buffer strip is around a retention basin, an open detention basin, or a forebay associated with an open detention basin or retention basin, and (1) the retention basin, open detention basin, or forebay has a drainage area greater than 5 acres; and (2) no storm water from areas outside of or within the buffer strip enters the basin or forebay via direct sheet flow.
  - The minimum width of a buffer strip around bioretention areas is 2 feet.
  - The width of buffer strips is measured as follows:
    - The width of buffer strips along watercourses and around or along surface waters other than open detention basins, retention basins, forebays, and bioretention areas is measured from the top of bank of the watercourse and surface water.
    - The width of buffer strips around open detention basins, retention basins, and forebays is measured from the minimum freeboard elevation of the surface water.
    - The width of the buffer strip around or along bioretention areas is measured from the maximum water surface elevation of the ponding area associated with the bioretention area.

- Additional requirements for buffer strips associated with open detention basins and retention basins are described in Section 8.1.
- Additional requirements for buffer strips associated with forebays are described in Section 8.2.1.
- Additional requirements for buffer strips associated with bioretention areas are described in Section 8.2.2.
- The ground slope of a buffer strip should not be steeper than 1:6.
- Construction activities, paving, and chemical application, except for construction activities needed to create or establish the buffer strip, are prohibited in the buffer strip.

Landscape Plan
Because vegetation is an important part of many components of storm water management systems, a landscaping plan must be submitted to the County.

- The plan must depict landscaping elements that function as part of the storm water management system, including the buffer strip.
- The landscape plan must include (at a minimum) specifications for the soils and plant materials that the applicant proposes to include in the landscape; and a description of the methods and planting techniques that the
applicant proposes to utilize during landscape installation.

- The installation and maintenance of the landscaping described in the landscape plan is included as regulated construction activity for which the County may require financial assurance.

Guidance and requirements for landscaping plans are described in Chapter 8.

**Other**

Healthy streams have natural temperatures that are cooler than that of stormwater runoff. Applicants should consider incorporating landscaping or other features to minimize the temperature of storm water runoff, and the adverse effect that high water temperatures may have on the receiving water quality. For example:

- Provide trees or other means to shade open detention basins and certain other storm water management components.
- Provide an outlet structure for open detention basins which draws water from the (cooler) bottom of the basin.
CHAPTER 7: ADDITIONAL REQUIREMENTS

This chapter presents additional requirements that may apply to storm water management systems in Wayne County.

7.1 Storm Water Conveyances
Storm water management systems may use watercourses or structures such as closed conduits, culverts, or bridges as a means of conveying stormwater runoff. Watercourses and closed conduits must be designed to standards described in this section. Storm water runoff conveyed within or under County Roads must also meet the additional requirements described in Section 7.3.

7.1.1 Watercourses
Natural watercourses should be preserved whenever possible. The Permit Office will not approve modifications to natural watercourses (e.g., installing a concrete channel or enclosure) unless the modification is necessary to address a demonstrated public safety, health or welfare issue. When such modifications are deemed necessary, the appropriate governmental agencies must be contacted for review and approval.

The flow capacity of each reach of a watercourse that is part of a storm water management system must be equal to or greater than the peak flow rate for a 10-year storm. The flow capacity of a watercourse must be calculated in accordance with the “Manning Formula” as follows:

\[
Q = \frac{1.486 \times A \times R^{2/3} \times S^{1/2}}{n}
\]

where:
- \(Q\) = flow capacity (cfs)
- \(A\) = cross sectional flow area (ft²)
- \(n\) = Manning’s coefficient of roughness
- \(P\) = wetted perimeter (feet)
- \(R\) = hydraulic radius = \((A/P)\) in feet
- \(S\) = hydraulic gradient (ft/ft)

In general, a minimum “\(n\)” of 0.035 will be used for the roughness coefficient unless special treatment is given to the bottom and side slopes, such as sodding, riprap or paving.

7.1.2 Closed Conduits
The flow capacity of each reach of a closed conduit that is part of a storm water management system must be equal to or greater than the peak flow rate for a 10-year storm. The Manning Formula (shown above) must be used to determine the flow capacity of a closed conduit.

The invert elevation of each closed conduit entering a forebay with a permanent pool must be equal to or greater than the permanent pool elevation.

The hydraulic grade lines (HGLs) of closed conduits must meet both of the following requirements:

- The hydraulic grade line must be calculated based on 10-year storm flows, starting with the crown elevation at the outlet. This gradient must not be higher than 2.5 feet below the rim elevation at any upstream manhole location. However, exceptions may be granted in special circumstances such as for managing storm water in and around truck docks.
  - For systems with forebays: The HGL starts at the crown of the pipe entering the forebay.
  - For systems with underground detention systems: The HGL starts at the crown of the pipe entering the manufactured treatment structure.
- The rim elevation at any manhole location along the closed conduit upstream of a detention system must be at least one (1) foot above the design water level of the detention system.
The minimum and maximum allowable closed conduit velocities are 2.5 and 8.0 feet per second, respectively. The maximum allowable velocity within the conduit may only be exceeded where special provisions have been made to dissipate energy.

The maximum distance between manholes, catch basins, and inlets may not exceed 300 feet plus 100 additional feet for every 1 foot of diameter for closed conduits over 36 inches in diameter.

Manholes or junction chambers must be constructed at all closed conduit junctions and angle points and at all changes in conduit size and/or slope.

The inlets and outlets for all closed conduits require an end treatment and soil stabilization measures, and some closed conduits may also require a grate to prevent entry into the conduit by children and animals. The specific requirements, which depend on the size of the conduit and the location/configuration of the inlet or outlet, are provided in Section 8.3.1.

7.1.3 County Road Culverts and Bridges
Under separate requirements administered by the Wayne County Permit Office, special provisions apply to culverts and bridges that convey a watercourse under a County Road, whether the culvert or bridge will be newly constructed or will be constructed to replace an existing culvert or bridge. If the watercourse is a County Drain, see Sections 7.4 and 7.5 for additional requirements that may apply.

The hydraulic capacities of culverts and bridges must be calculated using a method approved by the County. All bridges and culverts also must be designed with adequate soil erosion protection.

Bridges that convey a watercourse under a County Road must be designed to pass the peak flow rate for a 100-year storm with no harmful increase in backwater elevations. The 100-year storm elevation upstream of a bridge also must be at least one (1) foot below the lowest elevation of either the bridge deck or the approach pavements to the structure.

Culverts that convey a watercourse under a County Road must be designed to convey at least the peak flow rate for a 10-year storm, as determined using the methods described in Section 6.1.1. Culverts that will be inundated by storms larger than the design storm established by the Michigan Department of Transportation or the Michigan Department of Environmental Quality must be designed with soil erosion protection that is adequate for the inundated condition.

7.2 Downstream Improvements
If the County determines that a proposed storm water management system does not include an adequate storm water outlet, the Applicant may be required to design and construct improvements to the downstream drain, watercourse or closed conduit. The County determines the extent to which downstream improvements may be required to provide an adequate storm water outlet.

7.3 County Roads
The County may establish additional or alternative requirements for storm water management systems in County Roads. Three such requirements are described below. Contact the Wayne County Permit Office for more information on these and other requirements.

1. The minimum diameter of closed conduits in County road rights-of-way is 12 inches.

2. As a general policy, Wayne County does not permit the discharge of storm water runoff from improved property abutting a County Road into the County Road storm drainage system. Exceptions to this policy can be made on the basis of economic hardship if (1) there are no other cost-feasible storm outlets available and (2) there is adjudged sufficient capacity in the Road storm drainage system. When exceptions are granted, the permitted storm discharge into the County Road storm drainage system is restricted to a discharge rate equal to the lesser of the following criteria based on a 10-year storm:
   - 0.103 cfs per station (100 feet) of County Road frontage available to the site;
   - 0.15 cfs per acre of area proposed to drain into the County Road drainage system.

3. Required design standards and construction specifications for storm water management systems in the County Road right-of-way must conform to Wayne County’s most current standards. Information regarding these standards can be obtained from the Permit Office.

7.4 Easements
Pursuant to the Drain Code, Wayne County generally requires the following minimum easement widths for established County Drains and other watercourses.
1. An open County Drain or watercourse with a maximum bank to bank width that is 30 feet or greater must have an easement to the extreme width of the drain, plus 30 feet. The easement must be centered on the centerline of the drain or watercourse.

2. An open County Drain or watercourse with a maximum bank to bank width that is less than 30 feet must have an easement equal to the extreme width of the drain, plus 24 feet. The easement must be centered on centerline of the drain or watercourse.

3. Enclosed County Drains with an internal diameter of 8 feet or less must have an easement of 20 feet centered on the centerline of the enclosure.

4. Enclosed County Drains with an internal diameter that exceeds 8 feet must have an easement of 25 feet centered on the centerline of the enclosure.

The easement widths described above govern generally. The County may require an alternative width if the County determines that additional easement is required for proper construction, or because of special circumstances. Note that Wayne County does not allow any buffer strips required under the Storm Water Management Standards to overlap with County Drain easements. Exceptions to the easement requirements described above are within the County’s sole discretion.

### 7.5 County Drains

Applicants who propose projects that would modify an established County Drain or an established drainage district may be subject to additional requirements. The Wayne County Drains Office is located within the Wayne County Department of Environment.

### 7.6 County Park Property

The County may establish additional or alternative requirements for storm water management systems in County park property or which outlet within County park property. For example, special provisions apply to inlets/outlets on County park property as described in Section 8.3.1 and Appendix E-1. Specific requirements for restoration of County Park property disturbed by construction are presented in Appendix E-4.

### 7.7 Wetlands

The natural drainage pattern of the land within a development site must not be altered in any way that may cause adverse affects to existing wetland areas. Untreated storm water will not be permitted to outlet directly into a natural or mitigation wetland area. The level of treatment required to discharge storm water runoff to a natural or mitigation wetland area is determined by MDEQ. However, at a minimum, storm water discharged into a natural or mitigation wetland must pass through a pretreatment system. The pretreatment system must be designed in accordance with the requirements described in Section 6.3.1.

In addition to Wayne County approval of the storm water management system for a development project, the design of any wetland created for mitigation must also be approved by MDEQ.

### 7.8 Temporary Measures during Construction

As described in Chapter 3, projects that involve earth change activities may need to implement temporary storm water management measures to comply with additional federal NPDES requirements that apply to construction activity that disturbs one or more acres of land. More information about the NPDES requirements is available from MDEQ’s Water Bureau; see Chapter 12 for contact information.

Projects that involve earth change activities also may need to implement temporary storm water management measures under the state Soil Erosion and Sedimentation Control (SESC) program and Wayne County’s Soil Erosion and Sedimentation Control Ordinance, Chapter 94 of the Code of Ordinances of Wayne County (2001). More information about these programs and the types of projects that require a permit under these programs is available in Chapter 3.

Projects within Wayne County that must obtain a SESC permit from WCDOE must comply with the measures described in this section. An overview of the permit process is shown in Figure 7-1. WCDOE will not issue a SESC permit for a project that requires a storm water construction approval from the Permit Office until storm water construction approval has been obtained. Additional information about Wayne County’s SESC program, and a downloadable copy of the permit application package, is available from the County’s website (http://waynecounty.wc/mygovt/doe/depts/lrmd/Programs/sesc/permit_info.aspx).

#### 7.8.1 General Earth Change Requirements

In conformance with the state SESC program and the SESC Ordinance, Wayne County generally requires the following temporary measures during construction:
The proposed work shall be carried out in accordance with approved earth change plans and in compliance with all requirements of the permit and state laws and regulations.

Earth changes must be conducted in a manner that effectively reduces accelerated soil erosion and resulting sedimentation.

Persons engaged in earth change activities must, in conformance with state law, implement and maintain acceptable soil erosion and sedimentation control measures that effectively reduce accelerated soil erosion.

Earth changes must be scheduled and completed in a manner that will limit the exposed area of any disturbed land for the shortest possible period of time, as determined by WCDOE.

Sediment caused by accelerated soil erosion must be removed from runoff water before it leaves the site of the earth change.

Temporary or permanent facilities designed and constructed for the conveyance of water around, through or from the earth change area must be designed to limit the water flow to a non-erosive velocity.

Temporary soil erosion control measures must be maintained until permanent soil erosion measures are installed and approved. Permanent soil erosion control measures must be maintained for a minimum of one year after the project passes WCDOE's "completion inspection."

Permanent soil erosion control measures for all slopes, channels, ditches, or any other disturbed land area must be completed within five calendar days after final grading or earth moving activity has been completed.

Soil tracked, spilled, dumped or deposited onto public streets, highways, sidewalks, or other public thoroughfares must be removed promptly.

Permittees shall notify the WCDOE as to when the "project completion" inspection can be made.

7.8.2 General Plan Requirements
Under state law and the SESC Ordinance, three sets of earth change plans must be submitted before regulated earth changes may commence. The plans must be sealed by a Professional Engineer or Landscape Architect registered in the State of Michigan.

Each set of earth change plans must include drawings of the earth change at a scale not more than 100 feet to the inch, including a legal description; a site location map which includes the proximity of any proposed earth change to lakes, streams or wetlands; existing contour intervals which clearly show the character of the land; proposed contour intervals which clearly show the future character of the land; and a description of the existing vegetation on the site.

Each set of earth change plans must also include details for the proposed earth changes, including:

- Location of the physical limits of each proposed earth change including the location of temporary soil stockpile areas. If soil is to be removed from the site, the location of the offsite disposal area must be identified.
- A description and location of all existing and proposed on-site drainage facilities, including detailed storm sewer plans, drainage arrows for surface drainage, and the ultimate drainage outlet for the site.
- Time and sequence of each proposed earth change with approximate dates for major grading activities, including site stripping, rough grading and cut and fill; construction of detention basin, roads and underground utilities, digging basements and backfilling lots; final grading, landscaping paving. This sequence must include a description of temporary erosion control measures to prevent sediment from leaving the project site during each of the proposed earth change activities. A description and location of all proposed temporary and permanent soil erosion control measures.
- Approved standard details of all temporary and permanent soil erosion control measures.

7.8.3 Wayne County Plan Requirements
Wayne County imposes additional requirements for earth change plans. In addition to the general plan requirements discussed above, the following design and maintenance features must be shown on the plan and included in the construction sequence:
• A perforated riser pipe with stone filter must be installed on all open detention basins and sediment basins on projects five acres or more in size.

• A temporary crushed rock tracking pad must be installed at the construction entrance and exit. This tracking pad must be maintained with fresh stone periodically. Construction traffic must be limited to designated entrance and exit.

• Street scraping and cleaning (sweeping) must be conducted on a regular schedule. At a minimum, one sweeping must occur each week, and one scraping must occur at the end of each workday.

• Paved storm sewer inlets must be protected by a single sheet of filter fabric conforming to Geotex Ill P as manufactured by Synthetic Industries, Inc. or equivalent woven monofilament filter fabric (ASTM flow rate = 110 gallons per minute/per square foot).

• Catch-all type inlet filters are required at all low points in the paved roads of multi-family housing projects.

• Rear yard (beehive-type) storm sewer inlets must be protected by a woven geotextile filter fence 24 inches in height securely fixed with lath and staples to hardwood stakes spaced no more than four feet on center. The silt fence must be trenched in a minimum of six inches into the ground.

• All catch basins and inlets in areas that are determined to be susceptible to flooding must have catch-all type inlet filters.

• An undisturbed, vegetative buffer strip of at least 25 feet must be retained around rivers, creeks, streams, wetlands, drains, and other sensitive areas.

• Straw mulch blankets must be used on 3:1 slopes or greater. (Three foot horizontal, one foot vertical)

• Ditches, swales, and other areas that will channel concentrated runoff must be stabilized within five days of construction. Temporary rock check dams must be installed to slow water to non-erosive velocities in areas of concentrated flow.

• Road rights-of way must be stabilized with seed and mulch within five days of completing utility work in the right of way.

• Areas of earth change that are disturbed beyond the fall seeding deadline (November 1) may require dormant seeding and straw mulch securely anchored to the ground.

• Single family lots, during construction, must have a silt fence barrier and a temporary crushed rock tracking pad installed as per the approved plan.

• A single family residence, prior to receiving a Certificate of Occupancy, must have a silt fence barrier, or 15 feet of mulch blanket installed back of the curb across the entire front of the lot. The silt fence must be trenched in a minimum of six inches into the ground.

• Rip rap must be immediately installed after construction of outlets and culverts.

7.8.4 Performance Deposit
WCDOE does not issue SESC permits for an earth change unless the permittee first posts with Wayne County a bond, certified check, or irrevocable bank letter of credit in the amount equal to that which would be required for the surety bond. If a bond is used, it must be executed by the permittee and a corporate surety with authority to do business in this state as a surety. The bond must be in the amount of the established total cost of the earth change work authorized by the permit, but in no case may the bond amount be for less than $1,500.00 per acre of earth change.

Each bond must provide assurance for the maintenance of the finished project for a period of one year after the "project completion" inspection is made. Deposits or bonds shall be submitted to the WCDOE with the permit application. Upon permit issuance, the bond will be posted with the County Clerk by the WCDOE.

No performance deposit is required for a permit classified as a single-family residence.
7.8.5 Inspections and Enforcement

Once an application for a permit is received by WCDOE and before a permit is issued, an initial site investigation is made in the field. After permit issuance, earth change inspections are made periodically to assure compliance with the permit, state law, and the SESC Ordinance. When all grading is complete and all permanent erosion control measures are installed, a project completion inspection is made prior to permit expiration. Finally, one year after the completion inspection, a final inspection is made to ensure that permanent erosion control measures are still functioning effectively.

NOTE: No earth change work (grading, excavation, fill, topsoil, stripping, etc.) within 500 feet of a lake, stream, or drain or that disturbs more than one acre of land may begin until a permit is issued under state law. Such earthwork which begins without a permit is violation of the law and subject to legal proceedings.

7.8.6 Extension of Permit

If the permittee is unable to complete the work within the 30 month permit period, he must present in writing to the WCDOE, a request for an extension of the permit. Requests for extension shall be made at least ten (10) days before permit expiration. If, in the opinion of the WCDOE, such an extension is warranted, additional time may be granted for the completion of the work. An additional permit and inspection fee is required to extend the permit.

7.8.7 Modifications of Approved Plans

All proposed modifications of the approved earth change plans must be submitted to and approved by the WCDOE. All necessary specifications and related reports shall be submitted with any proposal to modify the approved earth change plan. No earthwork in connection with any proposed modifications is permitted without the approval of the WCDOE.
FIGURE 7-1

PROCEDURE FOR OBTAINING A
SOIL EROSION AND SEDIMENTATION CONTROL PERMIT
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.

<table>
<thead>
<tr>
<th>Use For</th>
<th>To Control</th>
<th>Detention and Retention (Section 8.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved Areas</td>
<td>X</td>
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<tr>
<td>Vegetated Areas</td>
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<tr>
<td>Unstable Soils</td>
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<td>Development Projects</td>
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<tr>
<td>Increased Flow Variability</td>
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<tr>
<td>Floatable Materials</td>
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<td>Particulate Matter</td>
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<td>Dissolved Nutrients</td>
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<td>Water-soluble Materials</td>
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<td>Toxic Materials</td>
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<tr>
<td>Oil/Petroleum Products</td>
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<td>Soil Erosion</td>
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<tr>
<td>Riparian Corridor and Habitat Loss</td>
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Pretreatment Systems (Section 8.2)

<table>
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<tr>
<td>Forebays</td>
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<td>Bioretention Areas</td>
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Conveyance (Section 8.3)

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<tr>
<td>Vegetated Swales</td>
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Streambank Stabilization (Section 8.4)

<table>
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<tr>
<td>Live Stakes</td>
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<td>Live Fascines</td>
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<tr>
<td>Vegetated Geogrids</td>
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<td>Live Cribwall</td>
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<td>Brushmattress</td>
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<td>Log Placements</td>
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Vegetation and Riparian Corridor Management (Section 8.5)

<table>
<thead>
<tr>
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<tbody>
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</tr>
<tr>
<td>Vegetation</td>
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<tr>
<td>Riparian Buffers</td>
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<tr>
<td>No-Mow Zones</td>
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<tr>
<td>Woody Debris Management</td>
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</table>

February 2007
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.

• 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:
  o When an open detention basin has a drainage area 5 acres or less; or
  o 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 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 (*lilium 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)](Image)

**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 much 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

- Washtenaw County Water Resources Commissioner, Rules and Guidelines – Procedures and Design Criteria for Stormwater
• Management Systems, August 6, 2014 (and previous version May 15, 2000).
• Available from link on webpage http://www.ewashtenaw.org/government/drain
• Wild Ones Organization, http://www.wildones.org
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)

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

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)

<table>
<thead>
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<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carex <code>lurida</code></td>
<td>Bottlebrush sedge</td>
<td>Juncus effuses</td>
<td>Common rush</td>
</tr>
<tr>
<td>Carex vulpinoidea</td>
<td>Brown fox sedge</td>
<td>Leersia oryzoides</td>
<td>Rice cut grass</td>
</tr>
<tr>
<td>Echinochloa crusgalli</td>
<td>Barnyard grass</td>
<td>Scirpus acutus</td>
<td>Hard-stemmed bulrush</td>
</tr>
<tr>
<td>Elymus Canadensis</td>
<td>Canada wild rye</td>
<td>Scirpus atrovirens</td>
<td>Dark green rush</td>
</tr>
<tr>
<td>Glyceria striata</td>
<td>Fowl manna grass</td>
<td>Scirpus pungens</td>
<td>Chaiemaker’s rush</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scirpus validus creber</td>
<td>Great bulrush (softstem)</td>
</tr>
</tbody>
</table>

### Native Forbs (Minimum 9 species)

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

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

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

8-11 Revised: July 2015
### Edge Zone: Native Trees

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

### 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)

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calamagrostis canadensis</td>
<td>Blue joint grass</td>
<td>Glyceria striata</td>
<td>Fowl manna grass</td>
</tr>
<tr>
<td>Carex comosa</td>
<td>Bristly sedge</td>
<td>Juncus effusus</td>
<td>Common rush</td>
</tr>
<tr>
<td>Carex hystericina</td>
<td>Porcupine sedge</td>
<td>Leersia oryzoides</td>
<td>Rice cut grass</td>
</tr>
<tr>
<td>Carex stricta</td>
<td>Common tussock sedge</td>
<td>Panicum virgatum</td>
<td>Switch grass</td>
</tr>
<tr>
<td>Echinochloa crusgalli</td>
<td>Barnyard grass</td>
<td>Scirpus atrovirens</td>
<td>Dark green rush</td>
</tr>
<tr>
<td>Elymus canadensis</td>
<td>Canada wild rye</td>
<td>Scirpus validus creber</td>
<td>Great bulrush</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spartina pectinata</td>
<td>Prairie cord grass</td>
</tr>
</tbody>
</table>
### Upland Zone: Native Forbs (Minimum 9 species)

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

**Notes:**

- An quick growing species such as annual rye grass (*lilium 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

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ceanothus americanus</em></td>
<td>New Jersey tea (dry-mesic)</td>
<td><em>Lindera benzoin</em></td>
<td>Spicebush (mesic)</td>
</tr>
<tr>
<td><em>Cornus foemina</em></td>
<td>Gray dogwood</td>
<td><em>Physocarpus opulifolius</em></td>
<td>Ninebark (dry or mesic)</td>
</tr>
<tr>
<td>(C. racemosa)</td>
<td>(dry to wet-mesic)</td>
<td><em>Rhus aromatica</em></td>
<td>Fragrant sumac (dry)</td>
</tr>
<tr>
<td><em>Corylus americana</em></td>
<td>American filbert (dry or mesic)</td>
<td><em>Sambucus canadensis</em></td>
<td>Elderberry (wet-mesic)</td>
</tr>
<tr>
<td><em>Hamamelis virginiana</em></td>
<td>Witch-hazel (dry-mesic)</td>
<td><em>Viburnum dentatum</em></td>
<td>Arrowwood (dry-mesic)</td>
</tr>
</tbody>
</table>
### Upland Zone: Native Trees

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

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)

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

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

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

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

• **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 pondscaping 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
PERMANENT WATER POOL
(OPTIONAL FOR FOREBAY)

4 FT MIN. 100-YEAR WATER LEVEL

FREEBOARD ELEVATION 1 FT MIN.

TOP OF BANK

PERMANENT POOL LEVEL

MAINTENANCE ACCESS PATH

FENCE IF REQUIRED OR ALLOWED BY THE LOCAL MUNICIPALITY. TO BE PLACED OUTSIDE THE BUFFER STRIP AREA. (TYP.)

15 FT MIN. BUFFER STRIP
(IF SLOPES AWAY FROM THE BASIN)

1:6 (OR FLATTER)

25 FT MIN. BUFFER STRIP
(IF SLOPES INTO THE BASIN)

1:6 (OR FLATTER)

REQUISITED BUFFER STRIP FOR FOREBAYS, OPEN DETENTION BASINS, AND RETENTION BASINS
(DRAINAGE AREA GREATER THAN 5 ACRES)

NOT TO SCALE

8-16C Revised: July 2015
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 StormtechTM 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 ensure 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)

<table>
<thead>
<tr>
<th>DIAMETER (INCHES)</th>
<th>SIZE OF CORRUGATION</th>
<th>2 2/3-in x ½-in</th>
<th>3-in x 1-in</th>
<th>5-in x 1-in</th>
</tr>
</thead>
<tbody>
<tr>
<td>UP TO 30</td>
<td>0.079-in - 14 ga.</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>36 - 54</td>
<td>0.079-in - 14 ga.</td>
<td>0.079-in - 14 ga.</td>
<td>0.079-in - 14 ga.</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0.109-in - 12 ga.</td>
<td>0.079-in - 14 ga.</td>
<td>0.79-in - 14 ga.</td>
<td></td>
</tr>
</tbody>
</table>

- 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.
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 "H" series.

**EXAMPLE A: FLOW RESTRICTOR WITHOUT OVERFLOW**

NOT TO SCALE
* Oil/water separator is required for outflow pipe less than 12" dia.

Wayne County frame and cover type "A."

Rim elevation =

Flood control design water elevation =

Bankfull flood elevation =

Invert =

Seal between precast concrete flow restrictor wall & base with butyl rope

Precast concrete flow restrictor wall

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 H250 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

Flow restrictor wall front view

Number and size of holes as per design. Minimum 1" dia. Equally spaced, minimum 6" O/C.
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 (Qa)
    - 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 (Qa) 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 it's 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 it's 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.
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.

- 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.

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.

**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.**

**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, Tearthub, 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, 1/4 - 1/2 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*)

  - **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.

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.
- “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
Resources For Native Plant Material

  http://www.MNPPA.org

  http://www.macd.org/

- Wild Ones Organization.
  http://www.wildones.org/
Typical Bioretention Cross-Section

N.T.S.

Cover "C" Per
Wayne County S-15
Or Equal

EL.

2-ft ID

2-ft SUMP

CONCRETE RISER

CONCRETE BASE

6-in MAX ponding depth

6-in INVF. =

6-in HD PVC UNDERDRAIN

* 6-in HD PVC UNDERDRAIN

6-in PVC SCH. 80 OUTLET INV. =

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.
  - 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.
  - 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.
  - 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.
  - 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.
  - 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).
  - 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.
  - 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 \( \frac{1}{2} \) 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:
  - Concrete for pre-cast manufactured treatment systems should conform to ASTM C 857 and C 858.
  - Cement should be Type II Portland cement conforming to ASTM C 150.
  - 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.
  - Manufactured treatment systems constructed from cast-in-place concrete or reinforced concrete should conform to current Wayne County specifications for structural concrete.
  - Sections should have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.
  - Wall thicknesses should not be less than 6 inches or as otherwise shown on the dimensional drawings
  - 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.

- Internal aluminum plate components should be aluminum alloy 5052-H32 in accordance with ASTM B 209.
- 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):

- 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.
- 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.
- 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):

- The system and all required fittings should conform to AASHTO M294 Type S.
- Fittings and couplings must be noncorrugated, solid sleeve fabricated from polyethylene with a gasket on both sides of the joint.
- Split collar couplers are not allowed.
- 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
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:
  - MDOT Class II granular material for systems made of cast-in-place and pre-cast concrete
  - 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

<table>
<thead>
<tr>
<th>KSI Model</th>
<th>Chamber Size/Diameter (inches)</th>
<th>Peak Flow (cfs)</th>
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<td>36</td>
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Stormceptor STC™

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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.

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
catched 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.

- 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
  (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
- 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 www.healthylandscapes.com
- United States Environmental Protection Agency, Office of Water. Storm Water Technology Fact Sheet: Vegetated
http://www.epa.gov/owm/mtb/vegswale.pdf

References: Native Landscaping
  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
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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**


**Additional Resources**

- Project summaries, photos, location and contact information, weblinks, and other information for a variety of storm water and watershed management practices in the categories:
  - Bioretention / Low Impact Development / Native Landscaping
  - Manufactured Treatment Systems and Underground Detention
  - Detention Ponds/Constructed Wetlands
  - Streambank Stabilization
  - Woody Debris Management
  - Green Buildings
  - 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**

8.4.1 Live Stakes

Description
Live staking involves the insertion and tampering 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.

Note:
Rooted/sealed condition of the living plant material is not representative at the time of installation.

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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.

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


Additional Resources


- Project summaries, photos, location and contact information, weblinks, and other information for a variety of storm water and watershed management practices in the categories:
  - Bioretention / Low Impact Development / Native Landscaping
  - Manufactured Treatment Systems and Underground Detention
  - Detention Ponds/Constructed Wetlands
  - Streambank Stabilization
  - Woody Debris Management
  - Green Buildings


- 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

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).

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 (**Lilium 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:

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

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.
  o 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/managementBioretention.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
  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
  o Manufactured Treatment Systems and Underground Detention
  o Detention Ponds/Constructed Wetlands
  o Streambank Stabilization
  o Woody Debris Management
  o Green Buildings

- 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
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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Streamside Zone</th>
<th>Middle Zone</th>
<th>Outer Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Protect the physical integrity of the stream ecosystem</td>
<td>Provide distance between buffer and development</td>
<td>Prevent encroachment and filter backyard runoff.</td>
</tr>
<tr>
<td>Width</td>
<td>Minimum 25 ft. plus wetland and critical habitats</td>
<td>Up to 100 ft., depending on stream size</td>
<td>25 ft. minimum setback to structures</td>
</tr>
<tr>
<td>Vegetative Target</td>
<td>Undisturbed Mature Forest or undisturbed native vegetation</td>
<td>Managed forest or native vegetation</td>
<td>Forest encouraged, but usually turfgrass</td>
</tr>
<tr>
<td>Allowable Uses</td>
<td>Very Restricted footpaths, utility crossings</td>
<td>Restricted, Recreational and Storm Water BMPs</td>
<td>Unrestricted</td>
</tr>
</tbody>
</table>

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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 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.
CHAPTER 9:  LONG-TERM MAINTENANCE

The Wayne County Storm Water Management Standards require storm water management systems to be maintained in perpetuity to ensure that they function effectively as designed. Long-term maintenance generally begins when construction of the storm water system is complete and the County releases the storm water construction approval. The County issues a long-term maintenance permit for the project that identifies, among other things, the limits of the storm water system, the party responsible for maintenance, and the activities required to ensure that the system functions effectively. A sample long-term maintenance permit is presented in Appendix C to this manual.

This chapter describes general long-term maintenance requirements for storm water management systems approved by Wayne County. This chapter also identifies specific maintenance activities that should be performed for closed conduits and watercourses, and describes situations where storm water management components may be maintained by others (e.g., closed conduits operated by Wayne County or the Michigan Department of Transportation). Specific maintenance activities for open detention basins, retention basins, forebays, and other components of storm water management systems are described in Chapter 8 and in Table 1 of Exhibit B to the sample permit presented in Appendix C.

This chapter does not describe maintenance activities that are necessary during construction. Temporary measures that must be utilized during construction are described in Chapter 7.

9.1 Requirements for Long-Term Maintenance Plans

Applications for a storm water construction approval must be accompanied by a long-term maintenance plan for the storm water management system. The maintenance plan generally must include the following elements:

- The plan must identify the physical limits of the storm water management system and the party responsible for maintaining each system component.
- The plan must identify the manner in which the applicant will assure, through a legally binding instrument, that the storm water management system will be maintained in perpetuity.
- The plan must identify the preventative maintenance activities that are necessary to ensure that the system functions properly.
- The plan must provide for periodic monitoring of the system to determine whether the system is functioning properly.
- The plan must commit the entity responsible for maintenance to performing remedial actions necessary to repair, modify, or reconstruct the system in the event the system does not function properly as designed.
- The plan must set forth a schedule for implementing the activities necessary to ensure the proper functioning of the system.

The remainder of this section provides more information about the elements of an approvable long-term maintenance plan. A sample long-term maintenance plan is included as Exhibit B to the sample long-term maintenance permit presented in Appendix C.

9.1.1 Identifying the Limits of System and Responsible Entities

Long-term maintenance plans must define the physical limits of the storm water management system associated with the plan and identify the entity that is responsible for maintenance. Buffer strips and routes of access to components of a storm water management system for maintenance purposes should be identified. Typically, the limits of the system can be shown on a map or drawing that includes a legend that labels each component of the system and identifies the entity responsible for maintaining each component. A sample diagram is included as Exhibit
A to the sample long-term maintenance permit presented in Appendix C.

9.1.2 Ensuring Maintenance in Perpetuity

Agreement with Public Entity

A public entity, such as a local unit of government or a drainage district established under the Michigan Drain Code, must assume long-term maintenance responsibility for storm water management systems that require a Wayne County storm water construction approval. This maintenance responsibility must be assumed through a legally binding instrument (such as an ordinance, resolution, contract, or equivalent instrument approved by the County) as a condition of final project approval. The instrument is attached to and made a part of the long-term maintenance permit issued by the County. (See Appendix C.) Examples of options for establishing maintenance responsibility (e.g., a resolution from a local government accepting maintenance responsibility) are shown in Appendix B to this manual.

The public entity may perform the long-term maintenance of a storm water management system itself, or it may designate another entity (such as a homeowner’s association, condominium association, or property owner) to undertake this responsibility. The maintenance agreement entered into between the public entity and the person or organization that agrees to perform maintenance activities is attached to the maintenance permit. However, even if the responsibility for maintenance activities is designated to another entity, the public entity identified in the long-term maintenance permit remains ultimately responsible for ensuring that the required maintenance is performed.

A public entity annually may accept maintenance responsibility for all approved storm water systems within its jurisdiction through a single, legally-binding instrument. The instrument may identify one or more individuals within the organization who have authority to accept and execute maintenance permits for specific projects. To ensure the local government’s continued commitment to accepting maintenance, the instrument must be renewed or re-enacted by the entity at least annually. A copy of the primary instrument is attached to the maintenance permit for each project. Communities interested in establishing a single annual maintenance instrument are invited to contact the Wayne County Permit Office for additional information.

For certain types of projects, an applicant may submit a request to the Wayne County Drain Commissioner to establish the storm water management system as a County drainage district. Through the establishment of a drainage district, Wayne County finances, administers and performs maintenance of the storm water management system in accordance with the Drain Code. The listing of applicable projects and the process for requesting that the storm water management system be established as a County Drain are presented in Appendix D to this manual.

Notifying Future Property Owners

Long-term maintenance plans must describe in general terms the method or methods that will be relied on to ensure that maintenance is performed in perpetuity. Public entities that assume responsibility for the long-term maintenance of a storm water management system must prepare, execute and (if necessary) record any agreements, contracts, or other documents that may be required to ensure that maintenance occurs in perpetuity. Such documents must include a method of ensuring that subsequent property owners are notified of long-term maintenance obligations and that the property may be subject to limitations or restrictions related to storm water management.

There are a number of methods of providing notification to future property owners. For example:

- Maintenance agreements between a local community and a property owner can be recorded on the deed to the property with the Wayne County Register of Deeds.
- Maintenance agreements for storm water management systems in subdivisions can be included in the bylaws for the subdivision or homeowner’s association and/or included on the plat.
- Maintenance agreements in condominium developments may be included in the master deed,
bylaws, and/or rules and regulations associated with the development.

- Maintenance agreements for mobile home parks may be included in the community rules for the park.

### 9.1.3 Maintenance and Monitoring Activities

Typical long-term maintenance plans include a detailed description of the following elements:

- Maintenance activities for all components of the storm water system, including closed conduits, watercourses, outflow control structures, best management practices, and other related appurtenances. The plan must clearly identify the means of accessing storm water management components for purposes of maintenance, and identify the location of all access points.

- Debris removal from catch basins, watercourses, manufactured detention systems, manufactured treatment systems, forebays and detention basins.

- Dredging operations for watercourses, including detention basins and forebays. The County generally requires removal of sediment when the forebay volume is reduced by 30%.

- Detailed description of the procedures for both preventative and corrective maintenance activities. Preventative maintenance should include periodic inspections, adjustments, replacements, and record keeping of operations.

- A schedule for routine and non-routine inspection of all components of the system.

- Provision for maintenance of buffer strips.

- A description of ongoing landscape maintenance needs.

- Provision for necessary permits from others.

See Table 1 in Exhibit B to the sample long-term maintenance permit presented in Appendix C for an example listing of maintenance activities.

### 9.2 Closed Conduits

The Michigan Department of Transportation (MDOT) is responsible for maintaining storm sewers within its jurisdiction, such as those within state road rights-of-way. The Wayne County Department of Public Services (WCDPS) maintains County-owned storm sewers within County property (for example, County road rights-of-way including those within subdivision developments). The Wayne County Department of Environment (WCDOE) Facilities Management Division maintains storm sewers that enclose County Drains. In some cases, local governments conduct storm sewer maintenance on behalf of WCDPS or WCDOE through special agreements.

**Maintenance Activities**

Storm sewer operation is affected by the buildup of sediments and collection of debris such as paper, rags, and small branches. The frequency in which enclosures experience this problem depends on the storm sewer’s velocity, the street maintenance program, and the litter collection practices of adjacent development. Storm sewer inlets and outlets should be checked annually for clogging and the system should be cleaned as required. Regular pipe inspection should be made to verify that the piping is not cracked or broken. Grates on inlets, outlets and other storm sewer structures should be cleaned regularly, and sediment should be removed from structures when the accumulation reaches 30% of the structure’s volume.

Catch basins should be inspected at least twice a year for debris and sediment buildup. If debris accumulates in the outlet pipe, cleaning the catch basin can become much more time-consuming and expensive.

### 9.3 Watercourses

WCDPS maintains watercourses in County road rights-of-way that provide drainage for County roads. The WCDOE Facilities Management Division maintains watercourses that are designated as County Drains. The U.S. Army Corps of Engineers (USACE) maintains the lower Rouge River and the Detroit River within Wayne County.

Maintenance of watercourses other than those described above is a function sometimes performed by the local municipality or property owners. It should be noted that some watercourse maintenance activities may require a permit from another public agency (e.g., the Michigan Department of Environmental Quality or USACE). Chapter 3 of this manual provides an overview of select local, state, and federal regulations governing activities in watercourses. Chapter 12 of this manual provides contact information.
Maintenance Activities

Watercourses generally should be kept open to allow maximum water flow, storm water transport, and water quality improvements. Buildup of sediment and debris in watercourses can cause low flow problems, flooding problems and degradation of the water quality. Watercourses and the riparian corridor should be maintained according to the riparian corridor management techniques described in Sections 8.4 and 8.5.
CHAPTER 10: DEFINITIONS

NOTE: The definitions in this Chapter are set forth here for convenience and ease of reference, and are not intended to modify, supplant, expand, or replace definitions in the Ordinance or in rules promulgated pursuant to the Ordinance. Any conflict between the definitions in this chapter and the definitions in the Ordinance and/or rules should be resolved in favor of the Ordinance and/or rules.

Applicant - A person responsible for regulated construction activity on a development site who is seeking to obtain storm water construction approval.

Aquatic Bench or Safety Shelf - A bench, usually 4-feet to 5-feet wide, that is constructed around the inside perimeter of a permanent pool and that ranges in depth from zero to 12 inches. Normally vegetated with emergent plants, the bench augments pollutant removal, provides habitat, conceals trash and changes in water level, and enhances safety.

Bank Full Flood - The storm water generated by the 1.5-year storm.

Bare-Root Stock – Plants used as a component of vegetation for open detention basins and retention basins that are received with very little, if any, soil around the roots and are generally wrapped in Hessian cloth or plastic to prevent the roots from drying out.

Best Management Practice (BMP) - A practice or combination of practices that have been determined by the County to be the preferred method of preventing, minimizing, or reducing pollution and other effects of storm water and storm water runoff.

Bioretention Area – A component of a storm water management system that is comprised of a depressed land area that contains specific soil, plant materials, and other features and is used as a pretreatment system.

Borings - Cylindrical samples of a soil profile used to determine soil properties.

Bridge - A structure, including supports, built to carry a feature over a surface water or watercourse, with a clear span of more than 20 feet measured along the center of the feature being carried.

Buffer Strip - A zone that is used for filtering direct storm water and storm water runoff into a storm water management system and for providing maintenance access to a storm water management system.

Catch Basin - A belowground structure designed to collect and convey water into a storm sewer system.

CFS - Cubic feet per second.

Check Dam - A crushed rock or earthen structure used in vegetated swales to reduce water velocities, promote sediment deposition, and enhance infiltration.

Closed Conduit - An enclosed conveyance designed to carry storm water runoff such that the surface of the water is not exposed to the atmosphere, including without limitation storm sewers, culverts, closed County drains, and pipes.

Constructed Wetland - An open detention basin that uses a variety of water depths and wetland plants to provide pollutant removal.

Construction Activity - A human-made activity, including without limitation, clearing, grading, excavating, construction and paving, that results in an earth change or disturbance in the existing cover or topography of land, including any modification or alteration of a site or the “footprint” of a building that results in an earth change or disturbance in the existing cover or topography of land.

Conveyance - Any structure or other means of safely conveying storm water or storm water runoff within a storm water management system, including without limitation a watercourse, closed conduit, culvert, or bridge.

County - The Charter County of Wayne.
County Drains - Drains established pursuant to the Michigan Drain Code of 1956, MCL 280.1 et seq., as amended.

County Road – Roads and road rights-of-way within the jurisdiction of the County.

Culvert - A structure, including supports, built to carry a feature over a surface water or watercourse, with a clear span of less than 20 feet measured along the center of the feature being carried.

Design Storm - A rainfall event of specified size and return interval that is used to calculate the runoff volume and peak flow rate that must be handled by a storm water management system.

Design Water Level - The water surface elevation in a detention system at which the storage volume in the system (above the permanent pool water level, if any) equals the required flood control storage volume.

Detention or Detain - The temporary storage of storm water and storm water runoff to control peak flow rates and/or provide pollutant removal before discharging the water to a surface water or closed conduit.

Detention System – A component of a storm water management system, either aboveground or belowground, that detains storm water and storm water runoff. Detention systems may include, without limitation, open detention basins and underground detention systems.

Detention Time - The amount of time that a volume of water will be detained in a detention system.

Development Site - The property on which regulated construction activity will occur, is occurring, or has occurred.

Director - The Director of the Wayne County Department of Public Services or its designee.

Drain Commissioner - In Wayne County, the Drain Commissioner is an appointed position within the Department of Environment.

Drainage Area - The entire upstream land area from which storm water runoff drains to a particular location, including any off-site drainage area.

Easement - A legal right, granted by a property owner to another person, allowing that person to make limited use of the property involved for a specific purpose.

Edge Zone - The area within an open detention basin or retention basin between the permanent pool water surface elevation and the bank full elevation.

Emergency Spillway - A depression in the embankment of an open detention basin or retention basin that is used to pass flows in excess of the overflow structure capacity.

Fill - Earth or other substances that are added to land to change its contour.

Filter Fabric - Textile of relatively small mesh or pore size that is used 1) to allow water to pass through while keeping sediment out (permeable), or 2) to prevent both runoff and sediment from passing through (impermeable).

First Flush - Storm water runoff that occurs during the early stages of a storm as a result of the washing effect of storm water runoff on pollutants that have accumulated on the surface of the drainage area.

Floodplain - For a given flood event, that area of land adjoining a continuous watercourse that has been covered temporarily by water.

Flow Restrictor - A structure, feature, or device in a detention system or pretreatment system that is used to restrict the discharge from the system for specified design storm(s).

Forebay - A component of a storm water management system that is comprised of a surface water that is used as a pretreatment system.

Freeboard - The vertical distance from the design water level to the top of the embankment of an open detention basin or retention basin.
**Hydrograph** - A graph showing variation in the water depth or discharge in a watercourse or closed conduit over time.

**Infiltration** - The rate of absorption of water into the ground, usually expressed in terms of inches/hour.

**Manhole** - A structure that allows access into a closed conduit or other underground component of a storm water management system.

**Manning’s Formula** - A technique for estimating the hydraulic capacity of a closed conduit, watercourse, or other means of conveyance of storm water and storm water runoff.

**Manning’s Roughness Coefficient (“n”)** - A coefficient used in Manning’s Formula to describe the resistance to flow due to the roughness of a conveyance.

**Manufactured Treatment System** - A component of a storm water management system that consists of a manmade device or structure that is used as a pretreatment system.

**Open Detention Basin** - A component of a storm water management system that is comprised of a surface water that is used as a detention system.

**Ordinance** - The Wayne County Storm Water Management Ordinance, as amended.

**Outflow Rate** - The rate of discharge in volume per unit time.

**Overflow Structure** - A structure designed to allow unrestricted discharge from a component of a storm water management system when the water level exceeds the design water level.

**Peak Flow Rate** - The maximum instantaneous rate of flow at a particular location within a storm water management system, usually in reference to a specific design storm event.

**Permanent Pool** - A pool in an open detention system or forebay that provides additional removal of pollutants through settling and biological uptake.

**Permit Office** - The Permit Office of the Wayne County Department of Public Services, Engineering Division.

**Person** - A natural person, trustee, court-appointed representative, syndicate, association, partnership, firm, club, company, corporation, business trust, institution, agency, government corporation, municipal corporation, city, county, municipality, district, or other political subdivision, department, bureau, agency or instrumentality of federal, state, or local government, or other entity recognized by law as the subject of rights and duties.

**Plug** – Plants used as a component of vegetation for open detention basins and retention basins that are raised as individual plants, each in a small container about the size of an ice cube.

**Pollutant** - Any substance introduced into the environment that may adversely affect the public health, safety, welfare, or the environment, or the usefulness of a resource.

**Pond Zone** - The area within an open detention basin or retention basin where the permanent water depths range from 0 to 3 ft deep.

**Ponding Area** – In bioretention areas, the area where excess storm water runoff is temporarily stored prior to infiltration into the ground.

**Pretreatment System** – A structure, feature, or appurtenance, or combination thereof, either aboveground or below ground, that is used as a component of a storm water management system to remove incoming pollutants from storm water and storm water runoff. Pretreatment systems may include, without limitation, forebays, manufactured treatment systems, and bioretention areas.

**Rational Method Formula** - A technique for estimating peak flow rates at a particular location within a storm water management system, based on the rainfall intensity, watershed time of concentration, and a runoff coefficient.
Regulated Construction Activity - Construction activity that is subject to the provisions of the Ordinance or a rule promulgated pursuant to the Ordinance.

Regulated Wetland - Any wetland protected by federal, state, or local laws or regulations.

Retention or Retain - The temporary storage of storm water and storm water runoff to provide gravity settling of pollutants and to promote infiltration into the soil, rather than to discharge the storm water or storm water runoff to a surface water or closed conduit.

Retention Basin - A component of a storm water management system that is comprised of a surface water that retains storm water and storm water runoff.

Return Interval - The average expected time interval between events of some kind.

Riprap - A combination of large stone, cobbles, and boulders used to line watercourses, stabilize banks, reduce runoff velocities, or filter out sediment.

Runoff Coefficient - The ratio of the volume of storm water runoff from a given drainage area over a given time period, to the total volume of precipitation that falls on the same drainage area over the same time period.

Safety Shelf – See the definition of Aquatic Bench.

Storm Water - Water resulting from precipitation, including without limitation rain, snow, and snowmelt.

Storm Water Construction Approval - An approval issued pursuant to the Ordinance and rules promulgated pursuant to the Ordinance.

Storm Water Management Program - Ordinances, orders, rules, regulations, and other mechanisms that provide for the management of storm water to prevent flooding and to ensure the restoration and/or protection of surface waters. Wayne County’s storm water management program consists of this Ordinance, rules or regulations promulgated under this Ordinance, the Storm Water Management Standards, and any other activities mandated by the Certificate of Coverage issued by MDEQ to the County pursuant to the Michigan General Storm Water Permit No. MIG619000.

Storm Water Management System - Any structure, feature or appurtenance subject to the Ordinance or a rule promulgated pursuant to the Ordinance that is designed to collect, detain, retain, treat, or convey storm water runoff, including without limitation buffer strips, swales, gutters, catch basins, closed conduits, detention systems, pretreatment systems, wetlands, pavement, unpaved surfaces, structures, watercourses, or surface waters.

Storm Water Runoff - The excess portion of precipitation that does not infiltrate the ground, but “runs off” and reaches a conveyance, surface water, or watercourse.

Surface Water - A body of water, including without limitation seasonal and intermittent waters, in which the surface of the water is exposed to the atmosphere, including without limitation lakes, open detention basins, forebays, watercourses, bioretention areas, retention basins, wetlands, and impoundments.

Time of Concentration - The time duration (typically in minutes) that is required for storm water runoff from the most remote area of the watershed to reach a given location in a storm water management system.

Total Suspended Solids - Particles or other solid material suspended in storm water or storm water runoff. “Total suspended solids” is commonly expressed in concentration (mg/l).

Underdrain - One or more underground pipes installed beneath bioretention areas, terraced side slopes, or other structures to facilitate conveyance of storm water runoff from beneath the structure to another part of the storm water management system.

Underground Detention System - One or more underground pipes and/or other structures that are utilized as a detention system.
Upland Zone – The area within an open detention basin or retention basin between the bank full elevation to the 100-year flood elevation and beyond.

Vegetated Swale – A conveyance, open to the atmosphere, consisting of a broad, shallow channel lined with vegetation to slow and filter storm water runoff and promote infiltration.

Watercourse - An open conduit, either naturally or artificially created, that periodically or continuously conveys water, including without limitation rivers, streams, vegetated swales, open channels, and open County drains.

Watershed - The complete area or region draining into a watercourse, surface water or closed conduit.

Weir - A structure that extends across the width of a surface water, watercourse or closed conduit and is used to impound or restrict the flow of water.

Wetted Perimeter – The length of the perimeter of a watercourse or closed conduit cross-section that is submerged and thereby causes resistance to flow.
CHAPTER 11: SAMPLE CALCULATIONS

11.1 TYPICAL STORM WATER MANAGEMENT SYSTEM WITH OPEN DETENTION BASIN

The following example is used to illustrate the calculations required to design a typical storm water management system. In this example, a single family residential development project is proposed on a 24-acre parcel of land and discharges to a water course. Determine the developed runoff coefficient, storm sewer, forebay, open detention basin, and outlet sizing requirements necessary for proper design of the storm water management system assuming no off-site area drains onto the parcel. The detention basin is intended to meet the flood control and water resource protection performance standards.

Runoff Volume Determination

In this example, the proposed land use for the site is as follows:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (A) (acres)</th>
<th>Runoff Coefficient (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>2</td>
<td>0.95</td>
</tr>
<tr>
<td>Lawn (Soil Group D, 3%)</td>
<td>19</td>
<td>0.45</td>
</tr>
<tr>
<td>Asphalt, concrete</td>
<td>3</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Runoff coefficient information may be found in Chapter 6 of this manual.

Calculate the weighted runoff coefficient:

$$ C = \sum (A_i \times C_i) / A $$

$$ C = \frac{[(2 \times 0.95) + (19 \times 0.45) + (3 \times 0.95)]}{(2+19+3)} = 0.55 $$

C = runoff coefficient
A = drainage area (acres)

Closed Conduit Sizing

This sample closed conduit calculation is for three runs of storm sewer pipe within the storm water management system. The following equations are used:

Rational Method

$$ Q = C \times I \times A $$

Q = peak flow rate (cfs)
C = runoff coefficient
I = rainfall intensity (in/hr)
A = drainage area (acres)

Rainfall Intensity

$$ I = \frac{151.8}{(t + 19.9)} $$

I = rainfall intensity (in/hr)
t = time of concentration, or the time duration (minutes) required for runoff from the most remote area of the watershed to reach the point of study. An initial time of concentration of 20 minutes should be used for single family residential land use.

Manning Formula

$$ Q = \frac{(1.486 \times A \times R^{2/3} \times S^{1/2})}{n} $$

Q = flow capacity (cfs)
A = cross sectional flow area (ft²)
n = Manning’s roughness coefficient
P = wetted perimeter (feet)
R = hydraulic radius (A/P in feet)
S = hydraulic gradient (ft/ft)

Calculations

Sample calculations for determining conduit sizes are illustrated in the table at the top of the following page. The calculations are based on a Manning’s roughness coefficient of 0.013.
Sample Calculations for Closed Conduit Sizing
For a 10-Year Storm Sewer Design

\( Q = C \times \frac{151.8}{(t+19.9)} \times A \)

| Storm Sewer Line | From Structure | To Structure | Incremental Area (Acres) | C Factor | Equivalent Area 100% Acres | Total Area 100% Acres | t Time (min) | I (inch per hour) | Q = CIA (cfs) | Pipe diam. (in) | Slope % | Length of Line (ft) | Manning Vel. in Pipe (ft/sec) | Time of Flow (min) | Manning Capacity of Sewer (cfs) | H.G. Elev. Upper End (ft) | Upper Invert Elev. (ft) | Lower Invert Elev. (ft) | Upper Structure Rim Elev. (ft) |
|------------------|----------------|--------------|-------------------------|---------|---------------------------|-----------------------|--------------|------------------|---------------|----------------|--------|-----------------------|--------------------------|--------------------------|-------------------------------|---------------------|---------------------|---------------------|
| CB1              | CB2            | 0.38         | 0.35                    | 0.13    | 0.13                      | 0.32                  | 3.80         | 0.51             | 12            | 0.50%          | 1.22  | 105                  | 3.23                    | 0.54                     | 2.54                          | 24.61               | 24.25               | 24.75               |
| CB2              | R1             | 0.48         | 0.40                    | 0.19    | 0.32                      | 3.75                  | 4.07         | 0.32             | 12            | 0.80%          | 4.07  | 105                  | 3.23                    | 0.54                     | 3.02                          | 24.59               | 24.12               | 23.50               |
| R1               | MH1            | 0.00         | 0.00                    | 0.00    | 0.32                      | 20.86                 | 1.21         | 0.80%           | 4             | 1              | 2.11  | 105                  | 3.23                    | 0.54                     | 24.50                          | 24.30               | 23.49               | 28.00               |

**Forebay Design**

Since the detention basin has only one inlet pipe, the basin will be designed with a single forebay with a permanent pool at elevation 100.5 feet. In accordance with the Ordinance and Rules, the forebay will be designed to capture the first flush runoff from the site and gradually release it over a period of 24 hours.

**Required Volume**

Determine the forebay volume required to store the first flush of runoff from the site.

\[ V_{ff} = 1,815 \times A \times C \]

\[ V_{ff} = 1,815 \times 24 \text{ acres} \times 0.55 = 23,958 \text{ ft}^3 \]

**Storage Provided**

The forebay storage volume provided should be shown in 1-foot (maximum) increments above the permanent pool water surface elevation (100.5 ft) as indicated in the table below. The incremental and cumulative storage volume provided at each elevation should be determined using the average surface area for that foot of depth.

The total storage volume provided in the forebay should be greater than or equal to the required forebay volume, which is the first flush storage volume. Determine the water surface elevation corresponding to the first flush storage volume by interpolation from the table of storage provided, as follows:

\[ Z_{ff} = \text{first flush storage elevation in forebay (ft)} \]

\[ Z_{ff} = 101.5 + (102.5 – 101.5) \times \left[ \frac{(23,958 – 11,542)}{(25,450 – 11,542)} \right] \]

\[ = 102.4 \text{ ft} \]

**Outlet Design**

In this example, the forebay outlet will be designed as shown in the detail included in Section 8.1.4. The vertical riser and riser outlet pipe will be the primary outlet for the forebay. The weir/spillway will be the secondary outlet, which conveys flow into the detention basin when the forebay is full.

The top of the riser will be set at the first flush storage elevation (102.4 ft). The riser outlet pipe will have an upstream invert elevation of 100.5 feet. The crest of the weir/spillway (between the forebay and the detention basin) will be set to match the top of the riser (elevation 102.4 ft).
Riser Outlet Pipe and Flow Restrictor Sizing

To gradually release the first flush storage volume over a period of 24 hours, the desired average release rate is:

\[ Q_{avg\ ff} = \frac{V_{ff}}{86,400} \]

\[ Q_{avg\ ff} = 23,958 / 86,400 = 0.277 \text{ cfs} \]

The riser outlet pipe and flow restrictor will be sized to convey the desired average release rate given the average head in the forebay. Numerous orifices will be placed in the riser to convey unrestricted flow from the forebay into the riser. The riser outlet pipe (calculations follow) and not these orifices will serve as the restrictor for flow out of the forebay.

It should be noted that a similar riser and flow restrictor design are used for controlling the maximum release rate from the detention basin, but the calculations (shown on pg. 11-7) are performed differently. The forebay outlet pipe flow restrictor is sized using the average head to achieve an average release rate, while the detention basin outlet pipe flow restrictor is sized using the maximum head to achieve a maximum allowable release rate.

Since the forebay has a trapezoidal cross section, 2/3 of the maximum head in the forebay is a reasonable approximation to the average head as follows:

\[ h_{avg} = 0.667 \times (Z_{ff} - Z_{out}) \]

where: \( Z_{out} \) = upstream crown elevation of riser outlet pipe (ft) assuming the outlet pipe is designed to flow full at 0.277 cfs

The riser outlet pipe and flow restrictor calculations for the forebay are performed based on two key assumptions:

1. The forebay is completely full and the downstream detention basin is completely empty when forebay dewatering begins. This means the forebay will dewater in about 24 hours for a storm whose runoff matches the first flush storage volume, but will dewater faster for smaller storms (due to the smaller volume), and will dewater slower in larger storms (due to the higher downstream head on the riser outlet pipe).
2. During dewatering of the forebay (only), there is free discharge from the forebay riser outlet pipe into the detention basin.

Use the orifice equation to determine the required riser outlet pipe diameter which will yield the desired average release rate and holding time.

\[ d_{out} = \text{assume 4 inches (0.33 ft) for calculating } h_{avg} \]

\[ Z_{out} = 100.5 + 0.33 = 100.83 \text{ ft} \]

\[ h_{avg} = 0.667 \times (102.4 - 100.83) = 1.05 \text{ ft} \]

\[ A_{out} = \frac{Q_{avg\ ff}}{(0.62 \times \sqrt{2} \times g \times h_{avg})} \]

\[ A_{out} = 0.277 / (0.62 \times \sqrt{2} \times 32.2 \times 1.05) \]

\[ = 0.0543 \text{ ft}^2 \]

\[ d_{out} = 0.263 \text{ ft (3.16 inches)} \]

Since the riser outlet pipe should be a minimum of 4 inches in diameter, a 3-inch diameter hole will be drilled in the end cap on the vertical run of the outlet tee to act as the flow restrictor. No recalculation of \( h_{avg} \) is needed since the selected riser outlet pipe diameter equals the assumed diameter used in calculating \( h_{avg} \).

\[ d_{out} = 4 \text{ inches (0.333 ft)} \]

\[ A_{o} = 0.0871 \text{ ft}^2 \]

\[ d_{o} = 3 \text{ inches (0.25 feet)} \]

\[ A_{o} = 0.0491 \text{ ft}^2 \]

The actual average release rate through the flow restrictor and outlet pipe is:

\[ Q_{avg\ ff} = 0.62 \times A_{o} \times \sqrt{2} \times g \times h_{avg} \]

\[ Q_{avg\ ff} = 0.62 \times 0.0491 \times \sqrt{2} \times 32.2 \times 1.05 \]

\[ = 0.250 \text{ cfs} \]
Actual holding time is:

\[ T_{ff} = \frac{V_{t_{ff}}}{(Q_{avg_{ff}} \times 3,600)} \]

\[ T_{ff} = 23,958 / (0.250 \times 3,600) = 26.6 \text{ hrs, or approximately 24 hrs --- O.K.} \]

**Riser Outlet Pipe Slope**

Determine riser outlet pipe slope to be consistent with earlier assumption that it is flowing full at the actual average release rate. Use Manning’s equation with \( n = 0.012 \) for PVC pipe.

\[ \text{Slope (ft/ft)} = \left(\frac{(Q_{avg_{ff}} \times n)}{(1.486 \times A_{out} \times R^{2/3})}\right)^{2} \]

\[ R = \frac{d_{out}}{4} = 0.333/4 = 0.083 \text{ ft} \]

Slope (ft/ft) = \((0.250 \times 0.012)/(1.486 \times 0.0871 \times 0.083^{2/3})\)^{2}

Slope = 0.0148 ft/ft (1.5 %)

Use 4 inch PVC pipe at 1.5 % slope.

Check velocity at full pipe flow condition against maximum allowable closed conduit velocity.

\[ V = \frac{Q_{avg_{ff}}}{A_{out}} = 0.250 / 0.0871 = 2.87 \text{ ft/sec} \]

2.87 < \( V_{max} \) of 8 ft/sec --- O.K.

**Outlet Weir Design**

The forebay outlet weir must be designed to convey flow from the forebay into the detention basin when the forebay 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. The calculation assumes there is free discharge from the forebay into the detention basin.

From the storm sewer design calculations using the Rational Method (not included), the peak flow rate entering the forebay is 25 cfs. In this example, the embankment elevation between the forebay and detention basin will be set at 103.0 feet. The crest elevation of the weir within the embankment is set at the first flush storage elevation of 102.4 ft. The required width of the weir is determined using the following weir equation:

\[ Q = C \times B \times H^{(3/2)} \]

where:

- \( Q \) = Peak flow rate (cfs)
- \( C \) = Coefficient (which varies with the type of weir)
- \( B \) = Bottom width of the weir (ft)
- \( H \) = Maximum allowable head on weir (ft)

For this example, a weir coefficient of 3.4 will be assumed to be representative.

\[ B = \frac{25}{[3.4 \times (103 - 102.4)^{(3/2)}]} = 15.8 \text{ ft} \]

Therefore, the width of the weir from the forebay into the detention basin will be specified as 16 ft.

**Open Detention Basin Design**

Since the site is larger than 5 acres, the maximum allowable outflow from this site is 0.15 cfs/acre for the 100-year storm. The open detention basin will be designed with a permanent pool at elevation 100.0 feet, after verifying that this is below the downstream invert of the 30 foot long forebay riser outlet pipe as follows:

\[ \text{Downstream Invert} = 100.5 - (0.0148 \times 30) = 100.06 > 100.0 \text{ --- O.K.} \]

**Required Volume**

Determine the flood control storage volume required.

\[ Q_{a} = \text{maximum allowable outflow rate from the detention system (cfs)} \]

\[ Q_{a} = 0.15 \text{ cfs/acre} \times A \]

\[ Q_{a} = 0.15 \text{ cfs} \times 24 \text{ acres} = 3.6 \text{ cfs} \]

\[ Q_{o} = \text{maximum allowable outflow rate per acre imperviousness (cfs/acre imperviousness)} \]

\[ Q_{o} = \frac{Q_{a}}{(A \times C)} \]

\[ Q_{o} = \frac{3.6}{(24 \times 0.55)} = 0.27 \text{ cfs/acre imperviousness} \]

\[ T_{100} = \text{Storage time defined as the instant storage begins until peak storage is attained (minutes)} \]
\[ T_{100} = -45 + \sqrt{19,845 / Q_o} \]
\[ T_{100} = -45 + \sqrt{19,845 / 0.27} = 226.1 \text{ minutes} \]

\[ V_s = \text{Maximum volume of water stored in the detention system per acre imperviousness (ft}^3/\text{acre imperviousness)} \]

\[ V_{s\,100} = \left[ \frac{17,649 \times T_{100}}{T_{100} + 45} \right] - 40 \times Q_o 	imes T_{100} \]

\[ V_{s\,100} = \left[ \frac{17,649 \times 226.1}{226.1 + 45} \right] - 40 \times 0.27 \times 226.1 = 12,278 \text{ ft}^3/\text{acre imperviousness} \]

\[ V_{t\,100} = \text{maximum volume of water stored in the detention system (ft}^3) \]

\[ V_{t\,100} = V_s \times A \times C \]

\[ V_{t\,100} = 12,278 \times 24 \times 0.55 = 162,070 \text{ ft}^3 \]

Determine the bank full flood storage volume (\(V_{t\,bf}\))

\[ V_{t\,bf} = 5,160 \times A \times C \]

\[ V_{t\,bf} = 5,160 \times 24 \times 0.55 = 68,110 \text{ ft}^3 \]

**Storage Provided**

The detention basin storage volume provided should be shown in one foot (maximum) increments above the permanent pool water surface elevation (100.0 ft) as indicated in the table shown at the top of the next column on this page. The incremental and cumulative storage volume provided at each elevation should be determined using the average surface area for that foot of depth. The volumes in this table include all volume in the detention basin, plus the portion of the forebay volume that is above the first flush storage elevation of 102.4 feet.

The total storage volume provided in the detention basin should be greater than or equal to the required flood control storage volume. Determine the water surface elevation corresponding to the bank full and 100-year flood by interpolation from the table of storage provided as described below.

The portion of the bank full flood to be captured in the detention basin is determined by subtracting the first flush storage volume provided in the forebay.

\[ V_{t\,bf - adjusted} = 68,110 - 23,958 = 44,152 \text{ ft}^3 \]

\[ Z_{bf} = \text{bank full flood storage elevation (ft)} \]

\[ Z_{bf} = 102.4 + (103.0 - 102.4) \times \left[ \frac{44,152 - 38,901}{60,542 - 38,901} \right] = 102.5 \text{ ft} \]

The portion of the flood control storage volume to be captured in the detention basin is also determined by subtracting the first flush storage volume provided in the forebay.

\[ V_{t\,100 - adjusted} = 162,070 - 23,958 = 138,112 \text{ ft}^3 \]

\[ Z_{100} = \text{flood control storage elevation (ft), also referred to as the design water level for the basin} \]

\[ Z_{100} = 104 + (105 - 104) \times \left[ \frac{138,112 - 101,209}{147,970 - 101,209} \right] = 104.8 \text{ ft} \]

**Storage Provided in Detention Basin and Forebay in Addition to First Flush Storage Volume**

<table>
<thead>
<tr>
<th>Elev. (feet)</th>
<th>Area (ft²)</th>
<th>Incremental Volumes (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basin Only</td>
<td>Forebay (only above elev. Zff)</td>
</tr>
<tr>
<td>100.0</td>
<td>13,103</td>
<td>---</td>
</tr>
<tr>
<td>101.0</td>
<td>15,631</td>
<td>---</td>
</tr>
<tr>
<td>102.0</td>
<td>18,359</td>
<td>---</td>
</tr>
<tr>
<td>102.4</td>
<td>19,506</td>
<td>14,902</td>
</tr>
<tr>
<td>103.0</td>
<td>21,287</td>
<td>16,466</td>
</tr>
<tr>
<td>104.0</td>
<td>24,415</td>
<td>19,232</td>
</tr>
<tr>
<td>105.0</td>
<td>27,744</td>
<td>22,198</td>
</tr>
</tbody>
</table>

**Outlet Design**

In this example, the detention basin outlet will be designed as shown in the detail in Section 8.1.4.
The vertical riser and riser outlet pipe will be the primary outlet for the detention basin. The overflow structure will be the secondary outlet, which will only receive flow when the flood control storage volume is exceeded. The emergency spillway is provided to convey flow out of the detention basin during extreme storm events or if the outlet pipe is clogged.

The top of the riser and the overflow structure will both be set at the design water level of (104.8 ft). The riser outlet pipe will have an upstream invert elevation of 100.0 feet. The minimum freeboard elevation will be 105.8 ft. The crest of the emergency spillway will be set at elevation 105.3 ft, or 6 inches below the freeboard elevation.

**Bank Full Flood Flow Restrictor Sizing**

To gradually release the bank full flood storage volume over a minimum of 40 hours, a number of holes will be drilled in the riser pipe at the permanent pool water elevation to act as the flow restrictor. The average release rate for the 40 hour period is calculated as follows:

\[
Q_{avg\,bf} = \frac{V_{t\,bf}}{144,000}
\]

\[
Q_{avg\,bf} = \frac{68,110}{144,000} = 0.47 \text{ cfs}
\]

The calculation above is based on the simplifying assumption that the portion of the bank full flood stored in the forebay and the portion stored in the detention basin can be handled as one common volume.

A number of 1-inch diameter holes will be drilled in the riser at elevation 100.0 feet. The number of holes will be selected to convey the average release rate for the bank full flood given the average head in the detention basin. Since the detention basin has a trapezoidal cross section, 2/3 of the maximum head on the orifice is a reasonable approximation for the average head on the orifice as follows:

\[
h_{avg\,us} = 0.667 \times (Z_{bf} - Z_{out})
\]

where \(Z_{out}\) = water surface elevation inside the riser

Use the orifice equation to determine the required number of holes which will yield the desired average release rate and holding time. Since the riser outlet pipe will be sized to convey the maximum allowable 100 year flood release rate, it will have negligible depth at 0.47 cfs and \(Z_{out}\) can be approximated as the upstream invert elevation of the riser outlet pipe.

\[
h_{avg\,us} = 0.667 \times (102.5 - 100.0) = 1.67 \text{ ft}
\]

\[
A_o = \frac{Q_{avg\,bf}}{(0.62 \times \sqrt{2 \times g \times h_{avg}})}
\]

\[
A_o = \frac{0.47 \text{ cfs}}{(0.62 \times \sqrt{2 \times 32.2 \times 1.67})}
\]

\[
= 0.0731 \text{ ft}^2
\]

\[
d_o = 1 \text{ inch (0.00545 ft}^2)
\]

Required number of 1-inch holes = \(0.0731/0.00545 = 13.4\)

Use fourteen 1-inch diameter holes at elevation 100.0.

The actual average release rate through the orifice for the assumed conditions is:

\[
Q_{avg\,bf} = 0.62 \times A_o \times \sqrt{2 \times g \times h_{avg}}
\]

\[
Q_{avg\,bf} = 0.62 \times 14 \times 0.00545 \times \sqrt{2 \times 32.2 \times 1.67}
\]

\[
= 0.491 \text{ cfs}
\]

Actual holding time for the bank full flood for the assumed condition is:

\[
T_{bf} = \frac{V_{t\,bf}}{(Q_{avg\,bf} \times 3,600)}
\]

\[
T_{bf} = \frac{68,110}{(0.491 \times 3,600)} = 38.5 \text{ hrs}, \text{ or approximately 40 hrs --- O.K.}
\]

**Check of Forebay Design Assumption**

In sizing the forebay outlet pipe and flow restrictor it was assumed that there was free discharge from the forebay riser outlet pipe into the detention basin when dewatering the forebay after a storm that just fills the first flush storage volume. Therefore it is necessary to verify that the bank full flood flow restrictor will pass the actual average release rate without inhibiting free discharge from the forebay riser outlet pipe.
The downstream crown elevation of the forebay riser outlet pipe is 100.39.

Use the orifice equation to determine the detention basin head for this condition.

\[
h = \left( \frac{Q_{avg} \cdot ft}{(0.62 \times x \cdot A)} \right)^2 / (2 \times g)\]

\[
h = \left[ 0.25 / (0.62 \times 14 \times 0.00545) \right]^2 / (2 \times 32.2) = 0.17 \text{ ft}
\]

Based on the bank full flood flow restrictor as designed, the water surface elevation in the detention basin when conveying the average release rate from the first flush volume is 100.17 feet. Therefore, the basin water surface will not inhibit free discharge from the forebay riser outlet pipe into the detention basin.

**Riser Outlet Pipe and Flood Control Flow Restrictor Sizing**

The riser outlet pipe and flow restrictor will be sized to convey the desired maximum allowable release rate (for the 100 year flood) at the design water level in the detention basin (104.8 feet). Numerous orifices will be placed in the riser above the bank full flood elevation to convey unrestricted flow from the detention basin into the riser. These orifices will not serve as a flow restrictor for the maximum release rate. As noted in the forebay outlet pipe flow restrictor calculations (see page 11-3), the calculations below are based on the maximum head on the riser rather than the average head as used for the forebay calculations.

\[
Q_{max} = Q_a = 3.6 \text{ cfs (from Storage Volume calculations)}
\]

\[
h_{max} = (Z_{100} - Z_{out})
\]

where: \( Z_{out} \) = upstream crown elev. of riser outlet pipe (ft) assuming the outlet pipe is designed to flow full at 3.6 cfs.

Determine the riser outlet pipe diameter to achieve the maximum release rate.

\[
d_{out} = \text{assume 10 inches (0.83 ft) for calculating } h_{max}
\]

\[
Z_{out} = 100.0 + 0.83 = 100.83 \text{ ft}
\]

\[
h_{max} = 104.8 - 100.83 = 3.97 \text{ ft}
\]

\[
A_{out} = \frac{Q_{max}}{(0.62 \times \sqrt{2 \times g \times h_{max})}}
\]

\[
A_{out} = \frac{3.6}{(0.62 \times \sqrt{2 \times 32.2 \times 3.97})} = 0.363 \text{ ft}^2
\]

\[
d_{out} = 0.680 \text{ ft (8.16 inches)}
\]

An 8-inch diameter outlet pipe without any orifice would achieve the desired maximum release rate. However, since it would require an excessive slope for the riser outlet pipe, a 10-inch diameter outlet pipe will be used instead with a flow restrictor. No recalculation of \( h_{max} \) is needed since the selected riser outlet pipe diameter equals the assumed diameter used in calculating \( h_{max} \). An 8-inch diameter hole will be drilled in the end cap on the vertical run of the outlet tee.

\[
d_{out} = 10 \text{ inches (0.833 ft)}
\]

\[
A_{out} = 0.545 \text{ ft}^2
\]

\[
d_o = 8 \text{ inches (0.667 ft)}
\]

\[
A_o = 0.349 \text{ ft}^2
\]

The actual maximum release rate through the flow restrictor and outlet pipe is:

\[
Q_{max} = 0.62 \times A_o \times \sqrt{2 \times g \times h_{max}}
\]

\[
Q_{max} = 0.62 \times 0.349 \times \sqrt{2 \times 32.2 \times 3.97} = 3.46 \text{ cfs}
\]

\( Q_{max} \) of 3.46 cfs < 3.6 cfs and within 10% of 3.6 cfs -- O.K.

**Riser Outlet Pipe Slope**

The riser outlet pipe slope must be selected consistent with the earlier assumption that it is flowing full at the actual maximum release rate. Use Manning’s formula with \( n = 0.012 \) for PVC pipe.

\[
\text{Slope (ft/ft)} = \frac{(Q_{max} \times n)/(1.486 \times A_{out} \times R^{2/3})^2}{R = d_{out}/4 = 0.833/4 = 0.208 \text{ ft}}
\]

\[
\text{Slope (ft/ft)} = \frac{(3.46 \times 0.012)/(1.486 \times 0.545 \times 0.208^{2/3})^2}{= 0.208 \text{ ft}}
\]
Slope = 0.0213 ft/ft (2.13 %)

Use 10 inch PVC pipe at 2.1 % slope.

Check velocity at full pipe flow condition against minimum and maximum allowable closed conduit velocities:

\[ V = \frac{Q_{\text{max}}}{A_{\text{out}}} = \frac{3.46}{0.545} = 6.35 \text{ ft/sec} \]

6.35 > \( V_{\text{min}} \) of 2.5 ft/sec; 6.35 < \( V_{\text{max}} \) of 8 ft/sec --- O.K.

**Overflow Structure Outlet Pipe Size and Slope**

The overflow structure outlet pipe must be sized to convey the peak flow rate into the storm water management system for the 10-year storm event. The calculation assumes there is free discharge from the overflow structure outlet pipe into the downstream surface water or closed conduit.

\[ \text{Slope (ft/ft)} = \left[ \left( \frac{Q \times n}{1.486 \times A \times R^{2/3}} \right) \right]^2 \]

\[ A = 3.98 \text{ ft}^2 \]

\[ R = \frac{d}{4} = 2.25/4 = 0.563 \text{ ft} \]

\[ \text{Slope (ft/ft)} = \left[ \left( \frac{25 \times 0.013}{1.486 \times 3.98 \times 0.563^{2/3}} \right) \right]^2 \]

\[ \text{Slope} = 0.00649 \text{ ft/ft (0.65%)} \]

Use 27 inch RCP at slope of 0.65%.

Check velocity at full pipe flow condition against minimum and maximum allowable closed conduit velocities:

\[ V = \frac{Q}{A} = 25 / 3.98 = 6.28 \text{ ft/sec} \]

6.28 > \( V_{\text{min}} \) of 2.5 ft/sec; 6.28 < \( V_{\text{max}} \) of 8 ft/sec --- O.K.

### 11.2 TYPICAL STORM WATER MANAGEMENT SYSTEM WITH UNDERGROUND DETENTION

The following example is used to illustrate the calculations required to design a typical storm water management system utilizing underground detention to meet the requirements of the Wayne County Storm Water Management Ordinance. In this example, a single family residential development project is proposed on a 2.5-acre parcel of land with 400 feet of road frontage and discharges to a Wayne County road storm system. Determine the developed runoff coefficient, storm sewer, mechanical forebay, underground detention system, and outlet sizing requirements necessary for proper design of the storm water management system assuming no off-site area drains onto the parcel. The detention system is intended to meet the flood control and water resource protection performance standards.

**Runoff Volume Determination**

In this example, the proposed land use for the site is as follows:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (acres)</th>
<th>Coefficient (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>0.5</td>
<td>0.95</td>
</tr>
<tr>
<td>Lawn (Soil Group D, 3%)</td>
<td>1.0</td>
<td>0.45</td>
</tr>
<tr>
<td>Asphalt, concrete</td>
<td>1.0</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Runoff coefficient information may be found in Chapter 6 of this manual.

Calculate the weighted runoff coefficient:

\[ C = \frac{\sum (A_i \times C_i)}{A} \]

\[ C = \frac{(0.5 \times 0.95)+(1.0 \times 0.45)+(1.0 \times 0.95)}{(0.5+1.0+1.0)} \]

\[ C = 0.75 \]

C = runoff coefficient; A = drainage area (acres)

**Closed Conduit Sizing**

This sample closed conduit calculation is for three runs of storm sewer pipe within the storm water...
management system. The following equations are used:

**Rational Method**

\[ Q = C \times I \times A \]

- \( Q \) = peak flow rate (cfs)
- \( C \) = runoff coefficient
- \( I \) = rainfall intensity (in/hr)
- \( A \) = drainage area (acres)

**Rainfall Intensity**

\[ I = \frac{151.8}{(t + 19.9)} \]

- \( I \) = rainfall intensity (in/hr)
- \( t \) = time of concentration, or the time duration (minutes) required for runoff from the most remote area of the watershed to reach the point of study. An initial time of concentration of 20 minutes should be used for single family residential land use.

**Manning Formula**

\[ Q = \left( \frac{1.486 \times A \times R^{2/3} \times S^{1/2}}{n} \right) \]

- \( Q \) = flow capacity (cfs)
- \( A \) = cross sectional flow area (ft^2)
- \( n \) = Manning’s roughness coefficient
- \( P \) = wetted perimeter (feet)
- \( R \) = hydraulic radius \((A/P)\) in feet
- \( S \) = hydraulic gradient (ft/ft)

**Calculations**

Sample calculations for determining conduit sizes are illustrated in the table at the top of the following page. The calculations are based on a Manning’s roughness coefficient of 0.013.

**Forebay Design**

Since the underground detention system has a mechanical forebay, first flush calculations are not needed.

---

**Underground Detention System Design**

The maximum allowable outflow from this site is 0.15 cfs/acre or 0.103 cfs per 100 feet of frontage, whichever is less (see section 7.3 of the storm ordinance). The underground detention system will be designed with an average invert elevation at 100.0 feet \((Z_o)\) after verifying that this is above the downstream invert at the discharge point.

**Required Volume**

Determine the flood control storage volume required.

\[ Q_a = 0.15 \text{ cfs/acre} \times A = 0.15 \text{ cfs} \times 2.5 \text{ acres} = 0.375 \text{ cfs} \]

Or

\[ Q_a = 0.103 \text{ cfs} \times (400' \text{ of Frontage} / 100) = 0.412 \text{ cfs} \]

Therefore, \( Q_a = 0.375 \text{ cfs} \) (The smaller value will be used)

\[ Q_o = \frac{Q_a}{(A \times C)} \]

\[ Q_o = \frac{0.375}{(2.5 \times 0.75)} = 0.20 \text{ cfs/acre imperviousness} \]

\[ T_{10} = -19.9 + \sqrt{\frac{4,530}{Q_o}} \]

\[ T_{10} = -19.9 + \sqrt{\frac{4,530}{0.20}} = 130.6 \text{ minutes} \]

\[ V_s = \text{Required volume of water stored in the detention system per acre imperviousness} \]

\( \text{(ft}^3 \text{/acre imperviousness)} \)
Sample Calculations for Closed Conduit Sizing  
For a 10-Year Storm Sewer Design

(Q = C x 151.8/(t+19.9) x A)

<table>
<thead>
<tr>
<th>Storm Sewer Line</th>
<th>From Structure</th>
<th>To Structure</th>
<th>Incr. Area (Acres)</th>
<th>C Factor</th>
<th>Equiv. Area 100% Acres CA</th>
<th>Total Area 100% Acres CA</th>
<th>C x I Time (min)</th>
<th>I (inch per hour)</th>
<th>Q = CIA (cfs)</th>
<th>Pipe diam (in)</th>
<th>Slope</th>
<th>Length of Line (ft)</th>
<th>Manning Vel. in Pipe (ft/sec)</th>
<th>Time of Flow (min)</th>
<th>Manning Capacity of Sewer (cfs)</th>
<th>H.G. Elev. Upper End (ft)</th>
<th>Upper Invert Elev. (ft)</th>
<th>Lower Invert Elev. (ft)</th>
<th>Upper Structure Rim Elev. (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB1</td>
<td>CB2</td>
<td>0.38</td>
<td>0.35</td>
<td>0.13</td>
<td>0.13</td>
<td>20.00</td>
<td>3.80</td>
<td>0.51</td>
<td>12</td>
<td>0.050%</td>
<td>105</td>
<td>3.23</td>
<td>0.54</td>
<td>2.54</td>
<td>24.61</td>
<td>24.75</td>
<td>24.22</td>
<td>27.75</td>
<td>11-10</td>
</tr>
<tr>
<td>CB2</td>
<td>R1</td>
<td>0.48</td>
<td>0.40</td>
<td>0.19</td>
<td>0.32</td>
<td>20.54</td>
<td>3.75</td>
<td>1.22</td>
<td>12</td>
<td>0.80%</td>
<td>78</td>
<td>4.07</td>
<td>0.32</td>
<td>3.20</td>
<td>24.59</td>
<td>24.12</td>
<td>23.50</td>
<td>27.75</td>
<td>11-10</td>
</tr>
<tr>
<td>R1</td>
<td>MH1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.32</td>
<td>20.86</td>
<td>3.72</td>
<td>1.21</td>
<td>4</td>
<td>0.80%</td>
<td>1</td>
<td>2.11</td>
<td>0.01</td>
<td>0.18</td>
<td>24.50</td>
<td>23.50</td>
<td>23.49</td>
<td>28.00</td>
<td>11-10</td>
</tr>
</tbody>
</table>

\[
V_{s\,10} = \left[\frac{(9,108 \times T_{10})}{(T_{10} + 19.9)}\right] - 40 \times Q_o \times T_{10}
\]

\[
V_{s\,10} = \left[\frac{(9,108 \times 130.6)}{(130.6 + 19.9)}\right] - 40 \times 0.20 \times 130.6
\]

\[
V_{s\,10} = 6,859 \text{ ft}^3 /\text{acre imperviousness}
\]

\[
V_{t\,10} = \text{Required volume of water stored in the detention system (ft}^3)\]

\[
V_{t\,10} = V_{s\,10} \times A \times C
\]

\[
V_{t\,10} = 6,859 \times 2.5 \times 0.75 = 12,861 \text{ ft}^3
\]

Determine the bank full flood storage volume \(V_{t\,bf}\)

\[
V_{t\,bf} = 5,160 \times A \times C
\]

\[
V_{t\,bf} = 5,160 \times 2.5 \times 0.75 = 9,675 \text{ ft}^3
\]

Storage Provided
The underground detention system storage volume should be equal or exceeds the required volume. In this example, 60-inch diameter pipe is selected with a total length of 660 ft consistent of two hearers and five runs.

Pipe size = 60 inch = 5 ft
Cross sectional area = \(D^2 \times \pi /4\)
\[
= 5^2 \times \pi /4 = 19.635 \text{ ft}^2
\]

Header Length = 35 ft
Run Length = 118 ft

Total Volume Provided
\[
= (2 \times 35 + 5 \times 118) \times 19.635
\]
\[
= 12,959 \text{ ft}^3 > 12,861 \text{ ft}^3, \text{ O.K.}
\]

Determine the water surface elevation corresponding to the bank full flood \((Z_{\bf})\) and 10-year flood \((Z_{10})\) by solving the circle segment formula, as follows:

\[
\frac{Z_{\bf}}{Z_{10}} = Z_{\bf} / Z_{10}
\]

Determine the segment area for bank full volume by dividing the required bank full volume over the total length of the provided detention system

\[
A_{bf} = \frac{V_{bf}}{\text{Total length}} = \frac{9,675}{660} = 14.66 \text{ ft}^2
\]

By solving the circle segment formula, the water depth is determined to be 3.50 ft.

\[
Z_{bf} = 100 + 3.50 = 103.50 \text{ ft}
\]

Determine the segment area for flood control volume by dividing the required flood control volume over the total length of the provided detention system

\[
A_{10} = \frac{V_{10}}{\text{Total length}} = \frac{12,861}{660} = 19.49 \text{ ft}^2
\]

By solving the circle segment formula, the water depth is determined to be 4.86 ft.
Outlet Design

In this example, the underground detention system outlet will be designed as shown in the detail in Section 8.1.3. The flow restrictor structure and the outlet pipe will be the primary outlet for the underground detention system.

The flow restrictor structure can be placed at any location (within the site limits) downstream the underground detention system. Assuming the outlet pipe is 4-inch in diameter with a slope of 3.33\% and located 15 ft downstream the underground detention system, the inlet invert of the flow restrictor structure shall be at elevation 99.5 ft (Z_{in}).

Bank Full Flood Flow Restrictor Sizing

To gradually release the bank full flood storage volume over a minimum of 40 hours, a number of holes will be drilled in the flow restrictor wear wall at the inlet invert. The average release rate for the 40 hour period is calculated as follows:

\[
Q_{avg\,bf} = \frac{V_{t\,bf}}{144,000}
\]

\[
Q_{avg\,bf} = \frac{9,675}{144,000} = 0.067 \text{ cfs}
\]

A number of 1.25-inch diameter holes will be drilled in the wear wall (at 6-inch minimum spacing) at elevation 99.5 feet. The number of holes will be selected to convey the average release rate for the bank full flood given the average head in the underground detention system. Since the underground detention system has a circular cross section, 1/2 of the maximum head of water depth plus the static head on the orifice is a reasonable approximation for the average head on the orifice as follows:

\[
h_{avg\,us} = 0.5 \times (Z_{bf} - Z_o) + (Z_o - Z_{out})
\]

Use the orifice equation to determine the required number of holes which will yield the desired average release rate and holding time.

\[
h_{avg\,us} = 0.5 \times (103.5 - 100.0) + (100 - 99.5) = 2.25 \text{ ft}
\]

\[
A_o = Q_{avg\,bf} / (0.62 \times \sqrt{2} \times g \times h_{avg})
\]

\[
A_o = 0.067 \text{ cfs} / (0.62 \times \sqrt{2} \times 32.2 \times 2.25) = 0.00898 \text{ ft}^2
\]

\[
d_o = 1.25 \text{ inch} (0.00852 \text{ ft}^2)
\]

Required number of 1.25-inch holes = 0.00898/0.00852 = 1.054

Use one 1.25-inch diameter holes at outlet elevation 99.5.

The actual average release rate through the orifice for the assumed conditions is:

\[
Q_{avg\,bf} = 0.62 \times A_o \times \sqrt{2} \times g \times h_{avg}
\]

\[
Q_{avg\,bf} = 0.62 \times 1 \times 0.00852 \times \sqrt{2} \times 32.2 \times 2.25 = 0.064 \text{ cfs}
\]

Outlet Pipe and Flood Control Flow Restrictor Sizing

The outlet pipe and flow restrictor will be sized to convey the desired maximum allowable release rate at the design water level in the underground detention system (104.86 feet). The calculations below are based on the maximum head in the detention system rather than the average head as used for the bank full calculations.

\[
Q_{max} = Q_a = 0.375 \text{ cfs}
\]

\[
h_{max} = (Z_{10} - Z_{out})
\]
Since the bank full orifice is contributing to the maximum allowable release rate, the actual flow rate shall be calculated to determine if additional holes are required.

\[ Q_{\text{max (bf)}} = 0.62 \times 1 \times 0.00852 \times \sqrt{2} \times 32.2 \times 5.36 = 0.098 \text{ cfs} < 0.375 \text{ cfs} \]

Since the bank full hole contribution discharge rate is less than the allowable flow rate, additional holes will be required. These additional holes shall be placed at the bank full elevation (103.5 ft).

\[ Q_{\text{max (adjusted)}} = 0.375 - 0.098 = 0.277 \text{ cfs} \]

The maximum depth of water on the additional holes shall be the design water level in the underground detention system (104.86 feet) minus the bank full water level (103.5 ft).

\[ h_{\text{max (adjusted)}} = (Z_{10} - Z_{bf}) = 104.86 - 103.5 = 1.36 \text{ ft} \]

Use the orifice equation to determine the required number of holes which will yield the desired maximum release rate.

\[ A_{o} = Q_{\text{max (adjusted)}} / (0.62 \times \sqrt{2} \times g \times h_{\text{max (adjusted)}}) \]

\[ A_{o} = 0.277 \text{ cfs} / (0.62 \times \sqrt{2} \times 32.2 \times 1.36) = 0.0477 \text{ ft}^2 \]

\[ d_{o} = 2.0 \text{ inch (0.02182 ft}^2) \]

Required number of 2.0-inch holes

\[ = 0.0477 / 0.02182 = 2.186 \]

Use two 2.0-inch diameter holes at elevation 103.5.

The actual maximum release rate through the orifice is:

\[ Q_{\text{actual}} = Q_{\text{max (bf)}} + 0.62 \times A_{o} \times \sqrt{2} \times g \times h_{\text{max adj}} \]

\[ Q_{\text{actual}} = 0.098 + 0.62 \times 2 \times 0.02182 \times \sqrt{2} \times 32.2 \times 1.36 = 0.351 \text{ cfs} < 0.375 \text{ cfs} \]

(within 10%) O.K.

**Flow Restrictor Outlet Pipe Slope**

The flow restrictor outlet pipe slope must be selected consistent with the earlier assumption that it is flowing full at the actual maximum release rate. In this example we will use 4-inch diameter outlet pipe and discharging to a Wayne County road storm system. Use Manning’s formula with \(n = 0.012\) for PVC pipe.

\[ \text{Slope (ft/ft)} = [(Q_{\text{max}} \times n)/(1.486 \times A_{\text{out}} \times R^{2/3})]^2 \]

\[ R = d_{\text{out}}/4 = 0.333/4 = 0.08333 \text{ ft} \]

\[ \text{Slope (ft/ft) = } [(0.375 \times 0.012)/(1.486 \times 0.0873 \times 0.0833^{2/3})]^2 \]

Slope = 0.0331 ft/ft (3.31 %)

**Use 4 inch PVC pipe at 3.31 % slope.**

Check velocity at full pipe flow condition against minimum and maximum allowable closed conduit velocities:

\[ V = Q_{\text{max}} / A_{\text{out}} = 0.375 / 0.0873 = 4.29 \text{ ft/sec} \]

4.29 > \(V_{\text{min}}\) of 2.5 ft/sec; 4.29 < \(V_{\text{max}}\) of 8 ft/sec --- O.K.
11.3 TYPICAL STORM WATER MANAGEMENT SYSTEM WITH BIORETENTION

The following example is used to illustrate the calculations required to design a typical storm water management system utilizing bioretention to meet the requirements of the Wayne County Storm Water Management Ordinance. In this example, bioretention is designed to treat stormwater discharged from a 0.8 acre site during a 10-year design storm.

Bioretention System Design Criteria

From Section 8.2.2, key design criteria related to calculation of storage volumes in bioretention areas include:

1. Bioretention should be used for drainage areas of less than 5 acres and preferably less than 1 acre. There should be a maximum distance of 150 feet of sheet drainage to each bioretention area.

2. The bottom of bioretention areas should be 3 feet or more above the seasonal high ground water table.

3. A maximum of 6 inches of ponding storage is allowed on top of bioretention areas.

4. A maximum of 20% void spaces in the planting soils and underdrain gravel blankets can be considered storage volume within the bioretention area.

5. Soil borings and field infiltration/laboratory tests must be used to determine characteristics of the in-situ soils at proposed bioretention areas. Bioretention areas should include underdrains and overflow structures if the subgrade soils below the bioretention areas are not sufficiently permeable.

6. Proper landscaping and maintenance of bioretention areas is essential and must conform to requirements specified in Section 8.2.2.

Bioretention System Design

In this example, the proposed land use for the site is as follows:

<table>
<thead>
<tr>
<th>Area (acre)</th>
<th>C</th>
<th>A x C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawn</td>
<td>0.40</td>
<td>0.25*</td>
</tr>
<tr>
<td>Gravel</td>
<td>0</td>
<td>0.85</td>
</tr>
<tr>
<td>Pavement + Roof</td>
<td>0.40</td>
<td>0.95</td>
</tr>
<tr>
<td>Total</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

\[ C_{ave.} = 0.60 \]

*Runoff Coefficient depends on soil type and ground slope (see Storm Water Manual page 6-2)

A (area) = 0.80 Acres
Frontage = 145 Feet

\[ Q_a \text{ (allowable)} = 0.15 \times A = 0.15 \times 0.80 = 0.12 \text{ cfs} \]

OR

\[ Q_a \text{ (allowable)} = 0.103 \times \text{Frontage/100} = 0.15 \text{ cfs} \]

Use the Smaller Value, \( Q_a = 0.12 \text{ cfs} \)

\[ T_{10} = -19.9 + \left( \frac{4530}{Q_a} \right)^{0.5} = 114.7 \text{ Minutes} \]

\[ V_{s,10} = \frac{9108 \times T_{10}}{(T_{10} + 19.9) - 40} \times Q_a \times T_{10} = 614.4 \text{ ft}^3/(acre-impervious) \]

\[ V_{t,10} = V_{s,10} \times A \times C = 3175 \text{ ft}^3 \text{ Required Storage Volume} \]

Calculation of the actual storage provided is shown in the table on the next page. These calculations assume the typical bioretention cross section detail presented in Section 8.2.2, and the following key design criteria as described above:

- Maximum 6 inches of ponding storage allowable on top of bioretention areas, and
- Maximum of 20% void spaces in the planting soils and underdrain gravel

The actual storage provided is estimated to be 3234 ft\(^3\), which is greater than the required storage volume of 3175 ft\(^3\) --- OK.
Provided Volume Within the Bioretention Area
(Based on Typical Bioretention Plan and Cross-Section)

<table>
<thead>
<tr>
<th>Elevation (Ft.)</th>
<th>Area (Ft²)</th>
<th>Volume (Ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponding Storage on Top (Maximum 6” Deep)</td>
<td>699.5</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td>699.0</td>
<td>3000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elevation (Ft.)</th>
<th>Area (Ft²)</th>
<th>Volume (Ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage in Planting Soils and Gravel Layers (Based on 20% Void Space)</td>
<td>699.0</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td>696.0</td>
<td>2000</td>
</tr>
</tbody>
</table>

Total Storage Provided = 3234 Ft³
3234 FT³ > 3175 FT³, OK
CHAPTER 12: CONTACTS

For all questions regarding Construction Approvals under Wayne County’s Storm Water Program, please contact:

Permit Office
Division of Engineering
Wayne County Department of Public Services
33809 Michigan Avenue
Wayne, MI 48184-1738
(734) 595-6504

For more information, including the construction permit application kit, see:
http://www.waynecounty.com/dps/construction_permits.htm

There may be other permits and approvals that you may need to acquire before starting your project.

12.1 Local Community

Your local community may require review and approval of site plans under a variety of programs:

- Zoning
- Soil Erosion and Sediment Control
- Storm Water Management
- Sanitary Sewer Service

Information about floodplains or flood elevations is maintained by the local community (not Wayne County).

12.2 Wayne County

Work within County Road Rights-of Way or Other County Property (e.g., County Parks)

Subdivision Site Plan Review
Permit Office
Division of Engineering
Wayne County Department of Public Services
33809 Michigan Avenue
Wayne, MI 48184-1738
(734) 595-6504

Erosion and Sedimentation Control Permits
Land Resource Management Division
Wayne County Department of Public Services
3600 Commerce Court
Wayne, MI 48184
(734) 326-3936

For more information, including a permit application kit, visit:
“http://waynecounty.com/doe/soilerosion.htm”

Information on County Drains and Modifications to County Drains and/or County Drainage Districts and to Petition for Drain Improvements or Creation of a Drainage District

Drain Office
Wayne County Department of Public Services
400 Monroe, Suite 400
Detroit, Michigan 48226
(313) 224-8116

Sanitary Sewer Extension Permits (applications are submitted through local community)

Philip Kurikesu, Permit Engineer
Wayne County Department of Public Services
Land Resource Management Division
3600 Commerce Court, Building E
Wayne, MI 48184-2803
Phone: (734) 326-5591

For more information, including a permit application kit, visit:
“http://waynecounty.com/doe/1029.htm”

Wells and Private Sewage Disposal Systems (Septic Tanks)

Environmental Health Division
Wayne County Department of Public Health
5454 Venoy Road
Wayne, MI 48184
Ph: 734-727-7400

See also for more information:
http://www.waynecounty.com/hhs/wellpermits.htm
http://www.waynecounty.com/hhs/onsitesewage.htm
12.3 State Agencies

12.3.1 Michigan Department of Transportation (MDOT)

Permits for Storm Water Drainage Affecting MDOT Right-of-Way

Taylor Transportation Service Center
Michigan Department of Transportation
6510 Telegraph Rd.
Taylor, MI 48180
Phone: 313-375-2400
Fax: 313-375-0822

Detroit Transportation Service Center
Michigan Department of Transportation
1050 Sixth Street
Detroit, MI 48226
(313) 965-6350
Fax: 313-965-6340

See also for more information:
http://michigan.gov/mdot/0,1607,7-151-9623_26662_26679_27267_48606-182161--.00.html

12.3.2 Michigan Department of Environmental Quality (MDEQ)

Storm Water Permits for Municipal, Industrial or Construction Site Discharges

MDEQ - Water Resources Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

See also for more information:
“http://michigan.gov/deq/0,4561,7-135-3313_3682_3716---,00.html”

Permits for Projects Involving Wetlands

MDEQ – Water Resources Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

See also for more information about wetlands regulation:
“http://michigan.gov/deq/0,4561,7-135-3313_3687---,00.html”

For permit application, see:
“http://michigan.gov/deq/0,1607,7-135-3307_29692_24403---,00.html”

Permits for Projects Involving Floodplains and Streambank Work

MDEQ- Land and Water Management Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

See also for more information, including permit application:
“http://michigan.gov/deq/0,1607,7-135-3307_29692_24403---,00.html”

12.4 Federal Agencies

12.4.1 Federal Emergency Management Agency (FEMA)

Permits for Activities Which May Alter Existing Flood Plains

MDEQ - Water Resources Division
Southeast Michigan District Office
27700 Donald Court
Warren, MI 48092-2793
(586) 753-3700

Flood Insurance Rate Maps (FIRMs), Flood Insurance Study (FIS) texts, and Other Flood-Map-Related Products

- Contact your local community
- FEMA Map Service Center, online at https://msc.fema.gov/portal

12.4.2 U.S. Army Corps of Engineers (COE)

Online at: http://www.lre.usace.army.mil/

Permits for Activities in Navigable Waters or Waters of the U.S., Activities which Impact Existing COE Civil Works Projects, or Other COE Jurisdiction

US Army Corps of Engineers, Detroit District
Regulatory Office
477 Michigan Avenue
Detroit, MI 48226-2550
Phone: (800) 493-6838, (313) 226-2218
Fax: (313) 226-6763
EMAIL: Regadmin.LRE_RegAdmin@usace.army.mil
Online at:
REFERENCES


Computing Flood Discharges for Small Ungauged Watersheds, Michigan Department of Environmental Quality, Land and Water Management Division (July 2000).


Low Impact Development Design Strategies: An Integrated Design Approach, Prince George’s County, Maryland Department of Environmental Resources Programs and Planning Division, June 1999


Page intentionally left blank to facilitate double-sided printing
Wayne County: Construction permit #: _______________
Review Number: _______________

Project Name: ________________________________________________
Project Address/Location: ________________________________________
City/Township of: _____________________________________________, Wayne County, Michigan.

I hereby certify that the construction and installation of the Storm Water Management System of the project known as _________________________________________ is complete as of the date ________________. All components of the storm water management system have been constructed and installed in accordance with the construction plans approved by the Wayne County Department of Public Services, Permit Office and comply with the Wayne County Storm Water Management Program.

Signed: ___________________________________
Licensed Professional Engineer (Michigan)

NOTE:
This certification must be stamped with the seal of a professional engineer licensed in the State of Michigan. The certificate submitted must be the original.

Please Return Certification to:
Department of Public Services - Permit Office
Attn: Division Permit Construction Manager
33809 Michigan Avenue
Wayne, Michigan 48184

Revised: 11 July 2008
Attachment A to
Engineer’s Certificate of Construction

THIS ATTACHMENT MUST BE COMPLETED IF:

1. The storm water management system contains elements where vegetation is critical to the functioning of a storm water management component, including but not limited to: Open Detention Basins, Bioretention Areas, Vegetated Swales, Streambank Stabilization, and Vegetation/Riparian Corridor Management.

2. Plantings incorporated into the system design are not included on plant lists in the Wayne County Storm Water Standards and were instead based on landscaping plans submitted by a Registered Landscape Architect (RLA).

Wayne County: Construction permit #: ________________
Review Number: ________________

Project Name: __________________________________________________________________
Project Address/Location: ________________________________________________________
City/Township of: ____________________________________________________________, Wayne County, Michigan.

I hereby certify that the plantings incorporated into the design of the Storm Water Management System for the project known as _______________________________________________ were completely and correctly installed as of the date ________________. The plantings were installed in accordance with the construction plans for the landscaping elements approved by the Wayne County Department of Public Services, Permit Office and comply with the Wayne County Storm Water Management Program.

Signed: ___________________________________
Registered Landscape Architect (Michigan)

Please Return Certification to:
Department of Public Services - Permit Office
Attn: Division Permit Construction Manager
33809 Michigan Avenue
Wayne, Michigan 48184

NOTE:
This certification must be stamped with the seal of a landscape architect licensed in the State of Michigan. The certificate submitted must be the original.

Revised: 11 July 2008
APPENDIX B

Model Community Resolutions
Accepting Long Term Maintenance Of Storm Water Management System

B.1: Model Community Resolution for Single Project

B.2: Model Annual Community Resolution
APPENDIX B-1
MODEL COMMUNITY RESOLUTION ACCEPTING
LONG TERM MAINTENANCE OF STORM WATER MANAGEMENT SYSTEM

Resolution No. ________________

At a Regular Meeting of the ____________________________ (Name of Community Governing Board) on ______________________ (date), the following resolution was offered:

WHEREAS, chapter 9 of the Wayne County Storm Water Management Ordinance (“Wayne County Ordinance”), requires storm water management systems to be maintained in perpetuity to ensure that the systems function properly as designed;

WHEREAS, Rule 1001 of the Wayne County Storm Water Management Administrative Rules (“Administrative Rules”) requires applicants for storm water construction approval to submit long term maintenance plans as part of an application for storm water construction approval;

WHEREAS, ____________________________________________ (“Developer”) has applied to the Wayne County Department of Public Services for a storm water construction approval with respect to a project named ____________________________________________ (“Project”) located at ____________________________________________ (City/Village/Township) in ________________ (City/Village/Township);

WHEREAS, Developer’s application for storm water construction approval has been assigned permit review number ______________________ (Insert permit review number).

WHEREAS, Developer submitted a plan to the County and (Community) entitled ____________________________________________ (Title, author, and date of Plan) (“Plan”) for long-term maintenance of the storm water management system(s) at the Project pursuant to Rule 801, which Plan has been tentatively approved by the County pending issuance of this resolution and has been accepted by (Community), and

WHEREAS, (Community) has agreed to assume jurisdiction and accept responsibility for long-term maintenance of storm water management system(s) at the Project in perpetuity;

NOW THEREFORE BE IT RESOLVED, that (Community) assumes jurisdiction over and accepts responsibility for long term maintenance of storm water management system(s) at the Project pursuant to the Wayne County Ordinance, the Administrative Rules, the Plan, and the storm water construction approval issued by Wayne County;

BE IT FURTHER RESOLVED, that approval be and is hereby granted, authorizing (Authorized Community Official) to execute, on behalf of (Community), Permit [No. ________________] for long term maintenance of storm water management system issued by Wayne County for the Project.

[Insert Certification Language of Local Community here]

Items in boxes MUST be included in the final resolution
APPENDIX B-2
ANNUAL COMMUNITY RESOLUTION ACCEPTING
LONG TERM MAINTENANCE OF STORM WATER MANAGEMENT SYSTEMS

Resolution No. ________________

At a Regular Meeting of the __________________________ (Name of Community Governing Board) on ______________________ [date], the following resolution was offered:

WHEREAS, chapter 9 of the Wayne County Storm Water Management Ordinance ("Wayne County Ordinance"), requires storm water management systems to be maintained in perpetuity to ensure that the systems function properly as designed;

WHEREAS, pursuant to chapter 4 of the Wayne County Ordinance, after reviewing and approving applications for storm water construction approval, Wayne County issues permits for the long-term maintenance of each storm water management systems, which permits are executed by Wayne County and the public entity that assumes jurisdiction over and accepts responsibility for long-term maintenance of the storm water management system;

WHEREAS, [Community] has agreed to assume jurisdiction over and accept responsibility in perpetuity for maintenance of all storm water management system(s) constructed within [Community] during the period referenced below, to ensure that the storm water management systems function properly as designed and constructed; and

WHEREAS, [Community] has designated [Name of Authorized Community Official], the __________________________ (Title of Individual) of [Community], as the person responsible for executing long-term maintenance permits on behalf of [Community] for the period referenced below.

NOW THEREFORE BE IT RESOLVED, that [Community] assumes jurisdiction over and accepts responsibility for long-term maintenance of all storm water management systems constructed within [Community] during the period _______________ through ______________, 20__ [period not to exceed one year] pursuant to the Wayne County Ordinance, the Administrative Rules, long-term maintenance plans for storm water management systems constructed within [Community], and the storm water construction approvals issued by Wayne County; and

BE IT FURTHER RESOLVED, that approval be and is hereby granted, authorizing __________________________ (Authorized Community Official) to enter into and execute, on behalf of [Community], long-term maintenance permits issued by Wayne County for storm water management systems constructed within [Community] during the period _______________ through ______________, 20__.

[Insert Certification Language of Local Community here]

NOTE: Items in boxes MUST be included in the final resolution
APPENDIX C

Sample Long-Term Maintenance Permit

February 2007
WAYNE COUNTY
DEPARTMENT OF PUBLIC SERVICES
COUNTY OF WAYNE, MICHIGAN
33809 Michigan Avenue
Wayne, MICHIGAN 48184
(734) 595-6504

72 HOURS PRIOR TO ANY CONSTRUCTION, CALL (734) 595-6504 FOR INSPECTION
72 HOURS BEFORE YOU DIG DIAL MISS DIG 1-800-482-7161

DEPARTMENT OF PUBLIC SERVICES PERMIT NO.
ANY CONSTRUCTION, COUNTY OF WAYNE, MICHIGAN
C******

CALL (734) 595-6504
33809 Michigan Avenue
WYNE, MICHIGAN 48184

ISSUE DATE EXPIRES
REVIEW NO. WORK ORDER

PROJECT NAME ***********

LOCATION

CITY/TOWNSHIP: ***********

PERMIT HOLDER

***********

***********

***********

CONTACT

PHONE

24 HOURS PHONE

***********

***********

***********

CONTACT

PHONE

24 HOUR PHONE

***********

***********

***********

CONTRACTOR:

***********

***********

***********

DESCRIPTION OF PERMITTED ACTIVITY

Permit to maintain the storm water management system in accordance with the drawing attached as exhibit “A”, the terms of the Long-Term Maintenance Plan attached as exhibit “B”, and the Wayne County Storm Water Management Ordinance and Administrative Rules.

1. (Entity) shall assume jurisdiction over and accept responsibility for maintenance of the storm water management system(s) to ensure that the storm water management systems function properly as designed and constructed. (Entity’s) responsibilities under this permit shall include, without limitations, (a) any and all monitoring and preventative maintenance activities set forth in the plan; (b) any and all remedial actions necessary to repair, modify or reconstruct the system and (c) any other activities or responsibilities for maintenance of the storm water management system as may be set forth in the Ordinance, Administrative Rules, the plan or this permit.

2. (Entity) shall perform all monitoring, maintenance, remedial and other responsibilities required by the Wayne County Ordinance, Administrative Rules, the plan and this permit, in perpetuity and at its sole cost expense.

3. (Entity) shall prepare, execute and (if necessary) record any and all agreements, contracts and other documents that may be required to perform its obligations hereunder and ensure maintenance of storm water management systems at the project in perpetuity.

If Wayne County finds it necessary to adjust or relocate all or any portion of the permitted storm water management system, the (Entity) shall cause this adjustment or relocation to be accomplished at no expense to the County. Prior to any work being performed in the right-of-way, a permit shall be secured from the Wayne County Department of Public Services. See construction permit ******** for construction of ********

REQUIRED ATTACHMENTS:

EXHIBIT A:  Map Depicting Physical Limits of Storm Water Management System
EXHIBIT B:  Long Term Maintenance Plan
EXHIBIT C:  Binding Agreement (e.g., community resolution)

IN CONSIDERATION OF THE PERMIT HOLDER AND CONTRACTOR AGREEING TO ABIDE BY AND CONFORM WITH ALL TERMS AND CONDITIONS HEREIN, A PERMIT IS HEREBY ISSUED TO THE ABOVE NAMED TO CONSTRUCT, OPERATE, USE AND/OR MAINTAIN WITHIN THE ROAD RIGHT-OF-WAY, COUNTY EASEMENT AND/OR, COUNTY PROPERTY. THE PERMITTED WORK DESCRIBED ABOVE SHALL BE ACCOMPLISHED IN ACCORDANCE WITH APPROVED PLANS, MAPS, SPECIFICATIONS, AND STATEMENTS FILED WITH THIS OFFICE WHICH ARE INTEGRAL TO AND MADE PART OF THIS PERMIT. FURTHERMORE, THE GENERAL CONDITIONS AS WELL AS ANY REQUIRED ATTACHMENTS ARE INCORPORATED AS PART OF THIS PERMIT.

X

PERMIT HOLDER/AUTHORIZED AGENT

DATE

WAYNE COUNTY DEPARTMENT OF PUBLIC SERVICES

YCC/CAL

PREPARED BY

X

CONTRACTOR/AUTHORIZED AGENT

DATE

VALIDATED BY/FOR WAYNE COUNTY HIGHWAY ENGINEER

DATE
1. Specifications. All work performed under this permit shall be done in accordance with the approved plans, specifications, maps, statements, and special conditions filed with the County and shall comply with the Wayne County Permit Specifications included as an attachment to this permit.

2. Fees. The PERMIT HOLDER shall be responsible for all fees incurred by the County in connection with this permit and shall deposit the fees and costs as determined by the County at the time the permit is issued.

3. Bond. The PERMIT HOLDER and/or the CONTRACTOR shall furnish a bond in cash or certified check in an amount acceptable to the County to guarantee performance under the conditions of this permit. The County may use all or any portion of the bond which shall be necessary to cover any expense, including inspection costs, or damage incurred by the County through the granting of this permit. Should the bond be insufficient to cover the expenses and damages incurred by the County, the PERMIT HOLDER shall pay such deficiency upon billing by the County. If the bond amount exceeds the expenses and damages incurred by the County, the excess portion will be returned to the depositor. The excess performance bond provided for herein, when it cannot be returned, shall be deposited in the County Road Fund and become a part thereof unless claimed by the depositor within one year of the date of satisfactory completion of the construction authorized by this permit.

4. Insurance. The PERMIT HOLDER and/or the CONTRACTOR shall furnish proof of liability and property damage insurance in the form and amounts acceptable to the County with Wayne County named as an insured party. The PERMIT HOLDER or the CONTRACTOR shall maintain this insurance until the permit is released, revoked, or cancelled by the County.

5. Indemnification. The PERMIT HOLDER and/or the CONTRACTOR shall indemnify, hold harmless and defend Wayne County, the Wayne County Department of Public Services, its officials and employees against any and all claims, suits, and judgments to which the County, the Department, its officials and employees may be subject and for all costs and actual attorney fees which may be incurred on account of injury to persons or damage to property, including property of the County, whether due to negligence of the PERMIT HOLDER or the CONTRACTOR or to the joint negligence of the PERMIT HOLDER or the CONTRACTOR and the County, arising out of any and all work performed under this permit, or in connection with work not authorized by this permit, or resulting from failure to comply with the terms of this permit, or arising out of the continued existence of the work product that is the subject of his permit.

6. Start and Completion of Work. This permit shall not become operative until it has been fully executed by the County. The PERMIT HOLDER or the CONTRACTOR shall notify the County at least 72 hours before starting construction and shall notify the County when work is completed. The PERMIT HOLDER or the CONTRACTOR or their representative shall have copies of the executed permit and approved plans in their possession on the job site at all times.

7. Safety. The PERMIT HOLDER and the CONTRACTOR agree that all work under this permit shall be performed in a safe manner and to keep the area affected by this permit in a safe condition until the work is completed and accepted by the County and to furnish, install, and maintain all necessary traffic controls and protection in accordance with the Michigan Manual of Uniform Traffic Control Devices.

8. Underground Utilities. The PERMIT HOLDER or the CONTRACTOR shall contact all utility owners regarding their facilities prior to starting work and shall comply with all applicable provisions of Act 53, Public Acts of 1974, as amended. The presence or absence of utilities is based on the best information available, and the County is not responsible for the accuracy of this information. The PERMIT HOLDER and the CONTRACTOR assume all responsibility for the interruption and damage to underground utilities.

9. Assignability. This permit is not transferable and is not assignable without the written consent of the County.

10. Limitation of Permit. This permit does not relieve the PERMIT HOLDER and the CONTRACTOR from meeting any and all requirements of law, or of other public bodies or agencies. The PERMIT HOLDER and/or the CONTRACTOR shall be responsible for securing and shall secure any other permits or permission necessary or required by law from governmental agencies and jurisdictions, corporations, or individuals.

11. Restoration. The PERMIT HOLDER and the CONTRACTOR agree to restore the county road, the county road right-of-way, county drain easement or county park property to a condition equal to or better than its condition before work under this permit began.

12. Acceptance. Acceptance by the County of work performed does not relieve the PERMIT HOLDER and/or the CONTRACTOR of full responsibility for work performed or the presence of the permitted facility. The PERMIT HOLDER acknowledges that the County has no liability for the presence of the PERMIT HOLDER’S facility located within the county road right-of-way, county drain easement, or county park property.

13. Cost Responsibility. The design, construction, operation, and maintenance of all work covered by this permit shall be at the PERMIT HOLDER’S expense with the exception that the PERMIT HOLDER will not be responsible for maintaining road widenings or similar facilities which become part of the County roadway.

14. Revocation. This permit may be suspended or revoked at the will of the County and, upon order of the County, the PERMIT HOLDER and the CONTRACTOR shall surrender this permit, cease operations, and remove, alter or relocate, at their expense, the facilities for which the permit was granted. The PERMIT HOLDER and the CONTRACTOR expressly waive any right to claim damages for compensation resulting from the revocation of the permit.

15. Violation. This permit shall become immediately null and void if the PERMIT HOLDER or the CONTRACTOR violates the terms of this permit and the County may require immediate removal of the PERMIT HOLDER’S facilities and restoration of the County property, or the County may remove the facilities and restore the County property at the PERMIT HOLDER’S expense. The PERMIT HOLDER and the CONTRACTOR agree that in the event of a violation of the terms of this permit or in the event the work authorized by this permit is not satisfactorily completed by the permit expiration date, the County may use all or any portion of the performance bond to restore the County road right-of-way, drain easement, wastewater facility or park property as necessary for reasonably safe and efficient operations and maintenance, or to establish extraordinary maintenance procedures as required to assure reasonably safe and efficient operation of the County facility.

16. Design. The PERMIT HOLDER is fully responsible for the design of the permitted facility, such design being consistent with applicable County standards, specifications, guidelines, and requirements, and with good engineering practice.
EXHIBIT B

SAMPLE LONG-TERM MAINTENANCE PLAN

Property Information: ABC Subdivision
123 Example Road
City or Town, Michigan 48ZZZ

Applicant: [Name of Applicant]
[Address of Applicant]

Property Owner: [Name of Property Owner]
[Address of Property Owner]

Permit Number: [Insert Permit Number when available]

A. Physical Limits of the Storm Water Management System

[This section defines the physical limits of the storm water management system to be maintained in accordance with this long-term maintenance plan.]

The storm water management system (SWMS) subject to this Long-term Maintenance Plan (Plan) is depicted on Exhibit A to the Permit and includes without limitation the storm sewers, swales, manholes, catch basins, storm water inlets, forebay, detention basin, outlet structure, emergency overflow, buffer strip, and closed conduits and watercourses that convey flow from the detention basin to __________ [ADD other site specific elements (for example, manufactured treatment systems or underground detention) as necessary].

For purposes of this Plan, this storm water management system and all of its components as shown on Exhibit A is referred to as __________________ [name of SWMS].

B. Time Frame for Long-Term Maintenance Responsibility

[This section clearly defines the point at which long-term maintenance responsibility commences, particularly for large development sites.]

[Name of Applicant] is responsible for maintaining the [name of SWMS], including complying with applicable requirements of the local or Wayne County soil erosion and sedimentation control program, until Wayne County releases the construction permit. Long-term maintenance responsibility for the [name of SWMS] commences when defined by the maintenance permit issued by the County. Long-term maintenance continues in perpetuity.

C. Manner of Ensuring Maintenance Responsibility

[This section identifies the public entity responsible for long-term maintenance and defines the manner in which long-term maintenance of the storm water management system will be maintained in perpetuity. At a minimum, the plan must address the following two elements:]
• the legally-binding instrument with local unit of government(s) or another public corporation by which long-term maintenance is assumed in perpetuity, and

• a method of notifying subsequent property owners that long-term maintenance of the storm water management system is required and that the Property may be subject to limitations or restrictions related to storm water management.

Chapter 6 of the Standards Manual summarizes options that may be available for addressing these elements.

The following section presents an example method of establishing long-term maintenance.

Example: Agreement with Local Community

[City, Township, or other public entity] has assumed responsibility for long-term maintenance of [name of SWMS]. The resolution by which [City, Township, or other public entity] has assumed maintenance responsibility is attached to the Permit as Exhibit C. [Name of Property Owner], through a maintenance agreement with the [City, Township, or other public entity], has agreed to perform the maintenance activities required by this Plan. [City, Township, or other public entity] retains the right to enter the property and perform the necessary maintenance of the [name of SWMS] if [Property Owner] fails to perform the required maintenance activities.

To ensure that the [name of SWMS] is maintained in perpetuity, the map of the physical limits of the storm water management system (Exhibit A), this Plan (Exhibit B), the resolution attached as Exhibit C, and the maintenance agreement between the City and the Property Owner will be recorded with the Wayne County Register of Deeds. Upon recording, a copy of the recorded document will be provided to the County.

D. Long-Term Maintenance Plan and Schedule

[This section clearly identifies the monitoring, preventative, or remedial activities that will be completed for each element of the storm water management system. This section also includes a schedule for each activity.]

Table 1 identifies the maintenance activities to be performed, organized by category (monitoring/inspections, preventative maintenance, and remedial actions). Table 1 also identifies site-specific work needed to ensure that the storm water management system functions properly as designed. The following list supplements Table 1 and provides more information about site specific activities:

[Identify any additional requirements not shown on Table 1 in this section. For example:]

• While performing maintenance, chemicals should not be applied to the forebay, open detention basin, watercourses or anywhere in the 25 foot buffer strip around surface waters and along watercourses.
# Table 1
Long-Term Maintenance Schedule
ABC Subdivision, 123 Example Road, City or Town, Michigan 48ZZZ

<table>
<thead>
<tr>
<th>System Component</th>
<th>Catch Basins, Inlets &amp; Storm Sewers</th>
<th>Channels &amp; Vegetated Swales</th>
<th>Inlets to Pretreatment Systems and Detention/Retention Systems</th>
<th>Forebays</th>
<th>Open Detention Basins &amp; Retention Basins</th>
<th>Flow Restrictors, Overflow Structures &amp; Outlet Pipes</th>
<th>Emergency Spillways</th>
<th>Riprap</th>
<th>Buffer Strip</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance Activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Monitoring/Inspection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Inspect for sediment accumulation**/clogging of stone filter</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Annually</td>
</tr>
<tr>
<td>• Inspect for floatables, dead vegetation and debris</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Annually and after major events</td>
</tr>
<tr>
<td>• Inspect for erosion and integrity of banks and berms</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Annually and after major events</td>
</tr>
<tr>
<td>• Inspect all components during wet weather and compare to as-built plans</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Annually</td>
</tr>
<tr>
<td>• Monitor plantings/vegetation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>2 times per year</td>
</tr>
<tr>
<td>• Ensure means of access for maintenance remain clear/open</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Annually</td>
</tr>
<tr>
<td><strong>Preventative Maintenance</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Mowing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Up to 2 times/year, select areas only*</td>
</tr>
<tr>
<td>• Remove accumulated sediment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed**</td>
</tr>
<tr>
<td>• Remove floatables, dead vegetation and debris</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed</td>
</tr>
<tr>
<td>• Replace or wash/reuse stone riser filters</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed***</td>
</tr>
<tr>
<td>• Remove invasive plant species</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Annually</td>
</tr>
<tr>
<td><strong>Remedial Actions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Repair/stabilize areas of erosion</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed</td>
</tr>
<tr>
<td>• Replaced dead plantings, bushes, trees</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed</td>
</tr>
<tr>
<td>• Reseed bare areas</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed</td>
</tr>
<tr>
<td>• Structural repairs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As needed</td>
</tr>
<tr>
<td>• Make adjustments/repairs to ensure proper functioning</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>As-needed</td>
</tr>
</tbody>
</table>

* Not to exceed the length allowed by local community ordinance.
** Forebays, open detention basins, and retention basins to be cleaned whenever sediment accumulates to a depth of 6-12 inches or if sediment resuspension is observed.
*** Replace stone if it cannot be adequately cleaned.
Table 1 (Continued)
Long-Term Maintenance Schedule
ABC Subdivision, 123 Example Road, City or Town, Michigan 48ZZZ

<table>
<thead>
<tr>
<th>Maintenance Activities</th>
<th>Manufactured Treatment Systems</th>
<th>Underground Detention Systems</th>
<th>Bioretention Areas</th>
<th>Porous Pavement</th>
<th>Other Infiltration Features</th>
<th>Other Features</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monitoring/Inspection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Inspect for sediment accumulation**/clogging</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td>• Inspect for floatables, dead vegetation and debris</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually and after major events</td>
</tr>
<tr>
<td>• Inspect for erosion and integrity of system</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually and after major events</td>
</tr>
<tr>
<td>• Inspect all components during wet weather and compare to as-built plans</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td>• Monitor plantings/vegetation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td>• Ensure means of access for maintenance remain clear/open</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td><strong>Preventative Maintenance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Remove accumulated sediment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As needed</td>
</tr>
<tr>
<td>• Remove floatables, dead vegetation and debris</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As needed</td>
</tr>
<tr>
<td>• Re-apply / replace mulch layer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Reapply every 6 months. Replace every 2 years.</td>
</tr>
<tr>
<td>• Replace subsurface components (e.g., soil, underdrain systems, etc.)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Every 5 years or as needed (e.g., when water ponds more than 6 hours)</td>
</tr>
<tr>
<td>• Remove invasive plant species</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td>• Street sweeping of paved surfaces</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Semi-annually</td>
</tr>
<tr>
<td>• Other: Specify (e.g., recommended by manufacturer)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Remedial Actions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Repair/stabilize areas of erosion</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As needed</td>
</tr>
<tr>
<td>• Replaced dead plantings, bushes, trees</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As needed</td>
</tr>
<tr>
<td>• Reseed bare areas</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As needed</td>
</tr>
<tr>
<td>• Structural repairs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As needed</td>
</tr>
<tr>
<td>• Make adjustments/repairs to ensure proper functioning</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>As-needed</td>
</tr>
</tbody>
</table>

* Not to exceed the length allowed by local community ordinance.
** Manufactured treatment systems and underground detention systems to be cleaned according to manufacturer’s recommendations; at a minimum, whenever sediment accumulates to a depth of 6-12 inches or if sediment resuspension is observed.
APPENDIX D

Process to Establish Storm Water Management System as County Drain

February 2007
One option for meeting the requirement of ensuring maintenance of new storm water management systems in perpetuity is to establish the storm water management system as a County Drain upon completion of construction. Elements of this process include:

- The landowners transfer funds ($2500) to the drainage district at its inception to establish a “permanent maintenance fund” for “future maintenance” (provided by Section 433 of Michigan Drain Code).
- Maintenance is performed by the Drain Commissioner’s Office (Wayne County Department of Environment-Facilities Management Division). Maintenance costs in excess of the initial maintenance fund are assessed to the landowners (based upon the percentage owned by each in the district) as follows:
  - For the collection system and open waterways, $2500/mile can be assessed annually. If this amount is inadequate, there is provision for special assessments.
  - Costs for maintenance of detention ponds and other features are recovered through special assessments (Section 196 subsection 12).

At the request of a property owner/developer, Wayne County generally will consider an application for establishment of a new storm water system as a Chapter 18 Drain/drainage district for the following types of projects:

1. Projects where the storm water system lies on properties owned/operated by multiple parties
   a. Large or regional projects
   b. Subdivisions in townships.
2. Projects that present special circumstances of particular concern to the County, such as
   a. projects contiguous with/that discharge to County property (e.g., Drains, Parks)
   b. projects that have high potential for impacting adjacent or downstream County property (e.g., a County Road) if not maintained.

For applicable projects, a brief overview of the process required to establish a new storm water management system as a Chapter 18 Drain follows:

A. Landowner(s) submit written request to the Drain Commissioner for establishment of the storm water management system as a Drain and establishment of the drainage area to the storm water management system as a Drainage District. An example request is attached as Exhibit A.

B. Landowner(s) submit plans and specifications to Wayne County for review and approval. NOTE: The entire storm water management system must conform to County standards for materials and specifications.

C. Landowner(s) and County Drain Commissioner sign a written agreement to establish the storm water management system as a Drain and to establish the drainage area to the storm water management system as a Drainage District. An example agreement is presented at Exhibit B.
D. Landowner(s) pay costs to establish the Drain (administrative, inspection, permanent maintenance fund).
E. Landowner(s) attach permanent Drain easement to deed. Copies of all recorded easements must be provided to the Wayne County Drain Commissioner.
F. Landowner(s) obtains all necessary permits. Copies of all permits must be provided to the Wayne County Drain Commissioner.
G. Landowner(s) construct project with own funds.
H. County performs inspection during construction.
I. Landowner(s) provides As-Built Drawings for the development.
J. County accepts project.

Questions regarding this methodology should be directed to Ms. Kerreen Conley, Deputy Drain Commissioner at 313-224-7679.
Exhibit A

EXAMPLE REQUEST TO
ESTABLISH A COUNTY DRAIN AND DRAINAGE DISTRICT

Dear Mr. Heise:

We/I, as the owner/developer of the proposed ____________________________, which will be located in the City/Township of ______ near the intersection of ______ Road and _____ Road (see attached location map), request the following:

1. The establishment of the storm water management system for this property as a County Drain under the provisions the Michigan Drain Code of 1956 (as amended); and

2. The establishment of the drainage area to the storm water management system for this property as a Drainage District under the provisions the Michigan Drain Code of 1956 (as amended).

Please contact _________________________ at (___) ____________ as needed regarding this request.

Very truly yours,

Property Owner #1

Property Owner #2

Attachment: Location Map

Cc: Ms. Kerreen Conley, Deputy Drain Commissioner, Wayne County Department of Environment
AGREEMENT FOR THE ESTABLISHMENT OF THE
__________DRAIN AND THE ___________DRAIN
DRAINAGE DISTRICT PURSUANT TO SECTION 433 OF
ACT NO. 40 OF THE PUBLIC ACTS OF 1956, AS AMENDED

THIS AGREEMENT, made and entered into this ___ day of
___________________ 2005, by and between Kurt L. Heise, Director, Wayne County
Department of Environment and Wayne County Drain Commissioner, whose address is 415
Clifford, Detroit, Michigan 48226, hereinafter referred to as “Drain Commissioner” on behalf of the
proposed ____________ Drain Drainage District; and ________, a Michigan corporation, whose
address is ___________ and ________, a Michigan corporation, whose address is
____________________, a Michigan corporation, whose address is _____________, hereinafter
referred to as “Landowners”.

WITNESSETH:

WHEREAS, Section 433 of Act No. 40 of the Public Acts of 1956, as amended, authorizes
the Drain Commissioner to enter into an Agreement with Landowners to establish a drain which
was constructed by the Landowners to service an area on lands owned by Landowners as a County
Drain; and

WHEREAS, Landowners, pursuant to Sections 425 and 433 of Act No. 40 of the Public Acts
of 1956, as amended, wish to provide drainage service to their own lands and have requested
same to be established and dedicated as a County Drain under the jurisdiction of the Wayne
County Drain Commissioner; and

WHEREAS, Landowners have been advised and understand and agree to assume or have
already assumed the total cost of the construction of the Drain to include engineering, inspection,
easement acquisition, legal and administrative expenses and the Drain Commissioner’s similar
costs related or associated with this Agreement; and

WHEREAS, Landowners understand that the Drain constructed, or to be constructed,
pursuant to this Agreement, when finally accepted by the Drain Commissioner, will be known as
the __________ Drain (See Exhibit A for route and course description) and that the lands owned
by ___________ described in Exhibit B and the lands owned by ________ described in Exhibit C,
etc. will be known and constituted collectively as the _____________ Drains Drainage District; and

WHEREAS, Landowners further understand that as the owners of the lands included in this
Agreement in the Township/City of ______ in which said Drain and the lands to be drained thereby
are located, that these above described lands will hereafter be subject to assessments pursuant to
the Drain Code for the cost of construction, operation, inspection and maintenance of the Drain;
provided, however, such assessment obligation shall be based upon the percentage ownership of
the ____ acres of developable land approximately depicted on Exhibit E; and

WHEREAS, Landowners have agreed to assume and pay all costs as set forth herein; and

WHEREAS, Landowners have obtained, at their expense, a certificate from a registered
professional engineer satisfactory to the Drain Commissioner to the effect that the existing Drain is
the only reasonably available outlet for the proposed Drain and that there is sufficient capacity in
the existing outlet for the proposed Drain to serve as an adequate outlet, without detriment to or
diminution of the drainage service which the outlet presently provides. A copy of said certificate is
attached hereto as Exhibit F.

NOW, THEREFORE, in consideration of the promises and covenants of each, the parties
hereto agree to as follows:

1. The Drain Commissioner agrees to establish the _______ Drain as a County Drain,
subject to the provisions of this Agreement, upon the satisfactory completion of
the construction and inspection of the Drain. The route and course of the Drain is legally
described in Exhibit A. The ___________ Drainage District shall be established and
composed of the lands legally described in Exhibits B, C, D and E.

2. Landowners agree that construction of the drainage facilities shall comply with the
standards and specifications of the Wayne County Drain Commissioner’s Office and
consistent with the plans and specifications prepared by ________ for _______. Project
No. _______, dated _______ and in compliance with all generally accepted
construction methods.

3. Landowners agree to assume all costs of the project set forth in the above-mentioned
plans, specifications and project designs. This cost shall include all costs set forth in
this Agreement, and shall specifically include:

   a. Drain Commissioner’s actual attorney fees, recording costs, inspection and
ing engineering costs relative to the drafting and implementation of this Agreement.

   b. The establishment of a permanent maintenance fund pursuant to Section 433 in an
amount of 5% of the construction cost but not to exceed $2,500.00. This payment
shall not relieve the subject property from any future assessments levied pursuant to
the Drain Code of 1956, as amended.

4. The Landowners shall deposit the Balance Due with the Drainage District, to be used only for
the purposes set forth in this agreement.

5. It is agreed that the Landowners shall convey to the Drainage District a map and legal
description of the Drainage District as may be necessary to accomplish the purposes set forth
and do so without charge. Landowners have granted the necessary easements which consist
of the conveyance pipes and detention/retention basins based upon the plans and specifications referenced in paragraph 2 above. These easements do not include any storage facilities in the parking areas. If any changes are made to the plans or specifications, no alterations will be made to the Drain and the easement areas referenced above, unless approved by the Drain Commissioner which approval shall not be unnecessarily withheld, conditioned or delayed and any necessary easements resulting therefrom are conveyed.

6. The Landowners further agree to provide, without charge, one (1) set of reproducible mylar “Record Drawings” of the Drain as built, which shall include design calculations showing flow rates, imperviousness factors, drainage district and sub-districts, easements and rights-of-way, locations, and any other data needed by the Drainage District for proper Drain operation and future assessment.

7. The foregoing payment of the cost of the project is agreed and understood as being for the sole benefit of the Drainage District at large or part thereof, and that such payment shall not relieve the subject property from any future assessments levied pursuant to the Michigan Drain Code of 1956, as amended, for construction, improvements and/or maintenance of the Drain arising by virtue of this Agreement or proper and legal petitions, hearings and procedures on such petitions. Provided, however, such assessment obligations shall be based upon the percentage of ownership of the ___ acres of developable land approximately depicted on Exhibit E.

8. Landowners shall secure all necessary permits or authorizations as may be required by local, state or federal law and provide copies to the Drain Commissioner. The Drain Commissioner shall also be provided copies of all correspondence and reports involving any governmental agency with respect to the Drain.

9. Landowners agree that after the Drain is accepted by the Drain Commissioner that said lands shall hereafter be liable for assessments levied for all costs incurred by the Drainage District (based upon the percentage ownership of the ___ acres of developable land approximately depicted on Exhibit E), including for the operation, maintenance and improvement of the Drain, as provided by this Agreement and by the Drain Code of 1956, as amended.

10. Landowners agree to hold harmless and indemnify the Drain Commissioner and the Drainage District for any and all claims, damages, lawsuits, costs and expenses, including attorney fees, arising out of, or incurred as a result of, the construction, operation or maintenance of the Drain occurring prior to the Drain Commissioner’s final acceptance of the Drain as an established County Drain. Notwithstanding the foregoing, Landowners’ indemnity obligations under this Paragraph 11 shall not extend to any claims, damages, lawsuits, costs and expenses, arising out of the acts or omissions of the Drain Commissioner, its agents, employees and contractors, while on or about the land described in Exhibits B, C and D.

Nothing in this Agreement is to be construed to waive, alter, amend or modify any provision in statute or case law relative to the Drain Commissioner or Drainage District’s grant of governmental immunity.

11. Modification, amendments or waivers of any provisions of this Agreement may be made only by the written mutual consent of the parties.
12. This Agreement shall become effective upon its execution by the Landowners and by the Drainage District and shall be binding upon the successors and assigns of each party.

IN WITNESS WHEREOF the parties hereto have caused this agreement to be executed by their duly authorized officers as of the day and year first above written.

Kurt L. Heise
Wayne County Drain Commissioner

LANDOWNER A

By:
Its:

LANDOWNER B

By:
Its:

LANDOWNER C

By:
Its:
Appendix D: Process to Establish Storm Water Management System as County Drain
Exhibit A: Drain route and course description

Exhibit B: Legal description of lands in drainage district owned by LANDOWNER A

Exhibit C: Legal description of lands in drainage district owned by LANDOWNER B

Exhibit D: Legal description of lands in drainage district owned by LANDOWNER C

Add additional exhibits for additional landowners as necessary

Exhibit E: Assessment obligation by landowner (based upon the percentage ownership of the ____ acres of developable land)

Exhibit F: Certificate from a registered professional engineer specifying that the existing Drain is the only reasonably available outlet for the proposed Drain and that there is sufficient capacity in the existing outlet for the proposed Drain to serve as an adequate outlet.
APPENDIX E

MISCELLANEOUS DESIGN DETAILS

E-1: WAYNE COUNTY PARKS – OPTIONAL HEAD WALL DETAIL FOR STORM DRAIN OUTLET ON RIVER COURSES

E-2: RIPRAP SPECIFICATIONS

E-3: EXAMPLE TERRACED SIDE SLOPE DETAIL

E-4: WAYNE COUNTY PARKS DIVISION PERMIT GUIDELINES FOR SITE RESTORATION
APPENDIX E-1

Wayne County Parks
Optional HeadWall Detail For Storm Drain Outlet
On River Courses
NOTES

FOOTINGS TO BE POURED SEPARATE FROM HEADWALL USING 6 REINFORCING RODS FOR ANCHOR DOWELS.

FACE OF HEADWALL SHALL BE LOCATED 1 FT. OUTSIDE THE EDGE OF NORMAL WATER LEVEL.

HEIGHT OF HEADWALL WILL VARY ACCORDING TO THE CHARACTER OF THE BANK AT THE STRUCTURE.

REINFORCE HEADWALL (ABOVE FOOTING) WITH 1/2" O.C. BARS SPACED AT 16" MAX HORIZONTAL AND VERTICAL, AS SHOWN.

HEADWALL DETAIL - Storm Drain Outlet on River Courses

WAYNE COUNTY OFFICE OF PUBLIC SERVICE
Department of Parks
APPENDIX E-2

Riprap Specifications
Riprap

Definition

Riprap is a permanent cover of rock used to stabilize streambanks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows.

This BMP addresses using riprap to stabilize streambanks, line channels and provide stable outlets. For purposes of this BMP, “rock” can be used interchangeably with “stone”. For information on designing various types of stream liners (including vegetation and riprap), see the Stormwater Conveyance Channel BMP.

All work conducted below the ordinary high water mark of a lake or stream, or in a floodplain or wetland will require permits from the Michigan Department of Environmental Quality, Land and Water Management Division. This includes the placement of riprap. (See Exhibit 1 for a definition of ordinary high water mark).

Other Terms Used to Describe

Armoring
Energy Dissipator

Pollutants Controlled and Impacts

The use of riprap in channels and below concentrated flows protects stream banks and discharge channels from higher erosive flow velocities. This reduces downcutting and lateral cutting, which in turn decreases sediment input to a watercourse.

Application

Land Use
All land uses.

Soil/Topography/Climate
The rock to be used as riprap must be capable of withstanding freezing and thawing and the flow or wave action of the water where it is used. The soil texture on the site and whether seepage is occurring are factors in determining the need and thickness of filters beneath the riprap.

When to Apply
Riprap used at outlets should be in place before the outlet is discharging. Streambank grading should be done when it is most feasible to bring stone to the site. Riprap should be placed as soon after grading as possible.

Where to Apply
Riprap is most often used in streambanks, on slopes, and at outlets.

Relationship With Other BMPs

Riprap is often used in making Stabilized Outlets, in Streambank Stabilization (including bioengineering techniques), and Slope/Shoreline Protection. Filters should be used underneath riprap to...
help stabilize the soils.

**Specifications**

**General Considerations:**
Riprap structures should be designed by licensed professional engineers or other persons qualified in the design of such structures.

**Stone Type**
The material used for riprap should be fieldstone or rough unhewn quarry stone. Stone should be hard, angular, and of such quality that it will not disintegrate on exposure to water or weathering. It should also be chemically stable, capable of withstanding freezing and thawing, and suitable in all other respects for the intended use.

Because it is not as aesthetically pleasing as rock, broken concrete is a less favorable riprap alternative. If concrete is used, it should be clean and otherwise meet design criteria. Asphalt should *not* be used as riprap.

**Riprap Size**
Riprap comes in a variety of sizes. The appropriate size to use primarily depends on the intended use of the structure. For example, the size of riprap used to stabilize streambanks depends on the velocity of the water.

Structural design is usually based on the diameter of stone in the mixture for which a percentage, by weight, will be smaller. For example, $D_{50}$ indicates a mixture of stones in which 50 percent of the stone by size would be larger than the diameter specified, and 50% would be smaller than the stone size specified. In other words, the design is based on the average size of stone in the mixture.

Table 1 lists some typical riprap by weight, spherical diameter and corresponding rectangular dimensions. These stone sizes are based on an assumed specific weight of 165 lbs./ft$^3$.

<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>Mean Spherical Diameter (in)</th>
<th>Typical Rectangular Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Spherical Diameter (in)</td>
<td>Typical Rectangular Shape</td>
</tr>
<tr>
<td></td>
<td>Length (in)</td>
<td>Width, Height (in)</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>18</td>
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<tr>
<td>100</td>
<td>13</td>
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<td>6000</td>
<td>49</td>
<td>83</td>
</tr>
<tr>
<td>8000</td>
<td>54</td>
<td>90</td>
</tr>
</tbody>
</table>

Source: USDA Soil Conservation Service

RIP-2
Gradation
Riprap should be composed of a well-graded mixture down to the one-inch size particle such that 50 percent of the mixture by weight is larger than the $D_{50}$ size as determined from the design procedure. For the purposes of this BMP, a well-graded mixture is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture should not be more than 1.5 times the $D_{50}$ stone size.

After determining the riprap size that will be stable under the flow conditions, the designer should consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size.

Riprap structures for **streambank stabilization** should be designed to be stable for bank-full flows in the reach of the channel being stabilized.

Thickness
For both streambank stabilization and outlets, the minimum thickness of the riprap layer should be 1.5 times the $D_{50}$ diameter, or 6 inches, whichever is greater. **A geotextile or stone filter must be placed under the riprap to prevent water from removing the underlying soil material through the voids in the riprap.** (Removal of the soil material leaves cavities behind the riprap and failure of the riprap may result). The filter may consist of smaller sized stone (usually 2"), a geotextile material, or a combination of both. Stone filters should be a minimum of 6 inches thick, and greater if the area has high seepage pressures. Follow the specifications below.

Granular (Stone) Filter Blanket. For dumped riprap, a filter ratio of 5 or less between successive layers will result in a stable condition. The filter ratio is defined as the ratio of $D_{15}$ size of the coarser layer to the $D_{85}$ size of the finer layer. An additional requirement for stability is that the ratio of the $D_{15}$ size of the coarse material to the $D_{15}$ size of the fine material should exceed 5 and be less than 40. A further requirement is that the ratio of the $D_{50}$ size of the coarse material to the $D_{50}$ size of the fine material not exceed 40. These requirements can be stated as follows:

\[
\frac{D_{15} \text{ (coarser layer)}}{D_{85} \text{ (finer layer)}} < 5 < \frac{D_{15} \text{ (coarser layer)}}{D_{15} \text{ (finer layer)}} < 40
\]

\[
\frac{D_{50} \text{ (coarser layer)}}{D_{50} \text{ (finer layer)}} < 40
\]

The filter requirements apply between the bank material and the filter blanket, between successive layers of filter blanket material if more than one layer is used, and between the filter blanket and the stone cover.

If a single layer of filter material will not satisfy the filter requirements, one or more additional layers of filter material must be used. In addition to the filter requirements, the grain size curves for the various layers should be approximately parallel to minimize the infiltration of the fine material into the coarser material. Not more than 5 percent of the filter material should pass the No. 200 sieve.

The minimum thickness of each layer of granular filter material shall be 6 inches, or 3 times the $D_{50}$ size of the filter, whichever is greater.

**Synthetic (Geotextile) Filter Fabric.** The Filters BMP includes information on geotextile materials which may be used may be used in place of or in conjunction with granular filters. Always check manufacturer’s specifications to ensure that the filter fabric selected meets the tensile strength and
durability requirements for the determined rock size. Some guidance in selecting filter fabric is given below.

The following particle size relationships must exist:

For filter fabric adjacent to granular materials containing 50 percent or less (by weight) of fine particles (less than 0.075 mm):

a) \[
\frac{D_{85 \text{ base}} \text{(mm)}}{\text{EOS filter fabric (mm)}} > 1
\]

b) Total open area of filter fabric is less than 36 percent.

For filter fabric adjacent to all other soils:

a) EOS less than U.S. Standard Sieve No. 70.

b) Total open area of filter is less than 10 percent.

No filter fabric should be used with less than 4 percent open area or an EOS smaller than U.S. Standard Sieve No. 100.

Stream Bank Protection and Channel Lining

See Exhibit 1 for applications.

**General Planning Considerations:**

1. Slopes on which riprap is used to stabilize streambanks should be no steeper than 1.5:1.

2. All bare soil on the slope above the riprap should be stabilized with seed and mulch, or sod. See the Vegetative BMPs.

3. When riprap is used in conjunction with other vegetative practices or bioengineering, the riprap should extend 1 foot above the ordinary high water mark. When only riprap is being used for bank stabilization, the top of the riprap should extend 3 feet above the ordinary high water mark. See Exhibit 1 for an explanation of the ordinary high water mark.

4. Determine a means of accessing the site before designing any riprap structure.

5. Determine how the riprap will be placed on the site. If the rock is to be dumped, it must be done in a manner which will not cause separation of the small and large stones. If rock is to be dumped over a bank and placed by hand, it must be done so that it does not create more erosion. Consider using aluminum or wooden shutes to roll rock down a bank to the waters’ edge.

6. If riprap placement requires re-configuring banks or slopes, the filter should be placed as soon after the banks are prepared as possible. Placement of riprap should follow immediately after the placement of the filter.

7. The finished surface should not have pockets of finer materials which would flush out and

RIP-4
weaken the structure. Some hand placing should be done to provide a stable surface.

8. Riprap used both at the outlet of storm sewers and to protect an eroding bank, should be designed to accommodate both uses. Riprap used as outlet protection should be constructed before the pipe or channel begins to operate.

**Design:**

**Stone Size Selection for Streambank Stabilization:**

The design method described below is adapted from *Design of Stable Channels with Flexible Linings, Hydraulic Engineering Circular No. 15* of the Federal Highway Administration. It is applicable to both straight and curved sections of channel where the flow is not perpendicular to the bank of the channel.

A. **Straight Sections of Channel.**

   This design method determines a stable rock size for straight and curved sections of channels. It is assumed that the shape, depth of flow, and slope of the channel are known. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3:1, the stone size must be increased accordingly. The final design size will be stable on both sides of the channel and the bottom.

   1. Enter Exhibit 3 with the maximum depth of flow (feet) and channel slope (feet/foot). Where the two lines intersect, choose the $d_{50}$ size of stone.

   2. If channel side slopes ($z$) are steeper than 3:1, continue with step 3, if not, the procedure is complete.

   3. Enter Exhibit 4, with the side slope and the base width to maximum depth ratio ($B/d$). Where the two lines intersect, move horizontally left to $K_1$. Record $K_1$.

   4. Determine from Exhibit 5, the angle of repose ($\alpha_r$) for the $d_{50}$ size of stone. The angle of repose is the angle in which the rocks will lay in relation to the bank. Banks should be designed so that the natural angle of repose of the stone mixture is greater than the slope of the bank being stabilized. (Use $\alpha_r=42^\circ$ for $d_{50}$ greater than 1.0 ft. Do not use riprap on slopes steeper than the angle of repose for the size of stone.)

   5. Enter Exhibit 6, with the side slope ($z$) of the channel and the angle of repose ($\alpha_r$) for the $d_{50}$ size of stone. Where the two lines intersect, move vertically down to read $K_2$. Record $K_2$.

   6. Compute $d'_{50} = d_{50} \times K_1/K_2$, where $d'_{50}$ is to determine the correct size stone for the bottom and side slopes of straight sections of channel.

B. **Curved Sections of Channel**

   1. Compute the radius of the curve ($R_o$), measured at the outside edge of the bottom.

   2. Compute the ratio of the top width of the water surface ($B_s$) to the radius of the curve ($R_o$), $B_s/R_o$.

   3. Enter Exhibit 7, with the ratio $B_s/R_o$. Move vertically until the curve is intersected.
4. Compute $d_{50c} = d'_{50} \times K3$, where $d_{50c}$ is the correct size stone for bottom and side slopes of curved sections of channel.

C. Design Example Problems:

**Problem #1**
**Given:** A trapezoidal channel 3 feet deep ($d$), with an 8-foot bottom ($B$), 2:1 side slopes ($z$), and a 2 percent slope. **Calculate:** A stable riprap size for the bottom ($B$) and side slopes ($z$) of the channel.

![Diagram of a trapezoidal channel with a 2% grade and side slopes of 2:1.](image)

**Solution:**
1. From Exhibit 3, for a 3-foot deep channel on a 2 percent grade: $d_{50} = 0.75$ feet or 9 inches.
2. Since the side slopes ($z$) are steeper than 3:1, continue with Step 3.
3. From Exhibit 4 for $B/d = 2.67$ and $z = 2$; $K1 = 0.8$
4. From Exhibit 5 for $d_{50} = 9$ inches; $Ar = 41^\circ$
5. From Exhibit 6 for $z = 2$ and $Ar = 41^\circ$; $K2 = 0.75$
6. $d'_{50} = d_{50} \times \frac{K1}{K2} = 0.75 \times \frac{0.8}{0.75} = 0.8$ feet
   
   $0.8 \text{ ft} \times 12 \text{ inches} = 9.6 \text{ inches}$

   Use $d'_{50} = 10$ inches

**Problem #2**
**Given:** The preceding channel in Problem #1 has a curved section with a radius of 50 feet at the outside edge of the bottom. **Calculate:** A stable riprap size for the bottom and side slopes of the curved section of channel.

**Solution:**

1. Radius of curvature, $Ro = 50$ feet
2. Top width at water surface,

   $Bs = 8 + (2 \times 3 \times 2) = 20$ feet

   $Bs/Ro = 20/50 = 0.40$
3. From Exhibit 7 for Bs/Ro = 0.40; K3 = 1.1

4. \( d_{50c} = d'_{50} \times K3 = 0.84 \times 1.1 = 0.92 \text{ feet} \)

   Use \( d_{50c} = 1.0 \text{ ft} = 12 \text{ inches} \)

**Length/Thickness/Height of Streambank Area to be Riprapped**

Refer back to page RIP-3 for specifications on the proper thickness.

**Length:** The appropriate length of channel in which rock should be placed should be at least the entire eroded section that is being protected, plus a minimum of 10 feet upstream and downstream of the eroded area. Be sure that the stone on the upstream and downstream ends are trenched in to prevent dislodging.

Where riprap is used only for slope or bank protection and does not extend across the bottom at the channel, riprap should be “keyed in” as shown in Exhibit 2.

**Height:** Install riprap to a height of three feet above the ordinary high water mark, or 1 foot above the ordinary high water mark if used in conjunction with bioengineering techniques. All exposed soil above the riprap should be stabilized according to the vegetative BMPs.

**Design Example Problem:**

A streambank has an ordinary high water mark of 3 feet, an 8 foot bottom width, 2:1 side slopes and a two percent slope. There is a 75 foot long curved bank that is eroding. Determine the proper rock size, appropriate stone gradation, and dimensions of the riprap.

1. Refer to example Problems #2 to solve for the proper stone size. Use a \( D_{50} \) stone size of 12 inches.

2. This riprap will be placed to a height of 6 feet (3 feet above the ordinary high water mark). The depth will be 24 inches: \([1.5 \times (\text{stone size of 12 inches}) = 18 \text{ inches} + 0.5 \text{ foot granular stone = total of 24 inches}]\).

3. The length of area covered with riprap will be the eroded area (75 feet) + 10 feet upstream and downstream = 95 feet.

4. A geotextile fabric will be installed beneath the riprap.

**Construction:**

1. Where grading is required, grade the site according to the grading plan. Grade only when stone is ready to be placed.

2. Compact gravel subgrades according to design. Any fill that is used should be compacted to a density approximating that of the surrounding undisturbed area.

3. Install geotextile filter fabrics according to the manufacturer’s specification. Always bury both the upper-most and toe of the geotextile fabric to prevent unravelling. (Basic installa-
tion techniques are discussed in the Filters BMP. Spread granular filters in uniform layers according to the design.

4. Install riprap. If riprap is dumped, hand place any rocks that need to be moved to fit the design.

**Maintenance of Riprap on Stream Banks**

Inspections should be made of all sites immediately after the first rainfall following installation of riprap. This is particularly important in areas where riprap that is displaced during the storm would impact culverts. Thereafter, ripraped sites should be checked following large storms, especially those which are near or exceed the storm frequency used in the design. Displaced riprap should be removed from its downstream location and new riprap placed according to the specifications above.

**Outlets**

**General Considerations for Outlets**

1. How and when to use a riprapped outlet should be made based on criteria given in the Stabilized Outlets BMP.

2. The outlet structure should be designed in conjunction with the conveyance system (i.e. pipe, outlet of a Sediment Basin, etc.) from which the water is outletted. There should be no overfall from the end of the pipe/outlet to the outlet structure (i.e. the pipe/outlet should not be suspended above the outlet structure).

3. The outlet structure should be in place before water is released from the conveyance system.

4. Additional protection may be required on the opposite bank or downstream to prevent in-stream erosion.

5. There should be no overfall from the end of the apron to the receiving channel streambed.

**Stone Size Selection for Outlets**

1. The median stone diameter, $d_{50}$, in feet, shall be determined from the formula:

   $$d_{50} = \frac{0.02}{TW} \frac{Q}{D_o}^{4/3}$$

   Where TW is tailwater depth above the invert of the culvert in feet,
Q is the pipe discharge in cfs for the conduit design storm, or the 25-year storm, whichever is greater, and

\[ D_o \] is the maximum inside culvert width in feet.

2. Fifty percent by size of the riprap mixture should be larger than the median size stone designated as \( d_{50} \) and 50% should be smaller. The largest stone size in the mixture should be 1.5 times the \( d_{50} \) size. The riprap should be reasonably well-graded.

**Outlet Dimensions**

Refer to Exhibit 8.

1. **Length**: The length of the apron, \( L_a \), should be determined using the following formula:

\[
L_a = \frac{1.7Q}{D_o^{3/2}} + 8D_o
\]

for culverts flowing up to 1/2 full.

\[
L_a = \frac{3.0Q}{D_o^{3/2}}
\]

for culverts flowing at or above 1/2 full

Where \( Q \) and \( D_o \) are as described above.

2. **Width**: Where there is a well-defined channel downstream of the apron, the bottom width of the apron should be at least equal to the bottom width of the channel. The structural lining should extend at least one foot above the tailwater elevation, but no lower than two-thirds of the vertical conduit dimension above the conduit invert.

Where there is **no** well-defined channel immediately downstream of the apron (i.e. as may apply to **Sediment Basins**) width, \( W \), of the outlet end of the apron should be as follows:

For tailwater elevation greater than or equal to the elevation of the center of the pipe:

\[ W = 3D_o + 0.4L_a \]

For tailwater elevation less than the elevation of the center of the pipe:

\[ W = 3D_o + L_a \]

Where \( L_a \) is the length of the apron determined from the formula above and \( D_o \) is the culvert width.

The width of the apron at the culvert outlet should be at least three times the culvert width.

3. The side slopes should be 2:1 or flatter.

4. The bottom grade should be level (0.0%).

5. There should be no overfall from the end of the apron to the receiving channel streambed.
6. There should be no overfall at the end of the apron or at the end of the culvert.

7. There should be no bends or curves at the intersection of the conduit and apron.

Stone Size and Gradation
1. The median stone diameter, $D_{50}$, in feet shall be determined from the formula,

   \[ D_{50} = \frac{0.02}{TW} \left( \frac{Q}{D_o} \right)^{4/3} \]

   Where $Q$ and $D_o$ are as defined under apron dimensions and TW is tailwater depth above the invert of culvert in feet.

2. The largest stone size in the mixture shall be 1.5 times the $D_{50}$ size. The riprap shall be reasonably well graded.

3. Gabions or precast cellular blocks may be substituted for riprap if the $D_{50}$ size calculated above is less than or equal to the thickness of the gabions or concrete revetment blocks. See the Shoreline/Slope Stabilization BMP.

Design Example Problem:
Given: a maximum inside culvert width, $D_o$ of 1.5 ft., a flow ($Q$) of 14/5 cfs, and a tailwater elevation, TW, of 0.7 feet, determine the appropriate design dimensions of the apron ($h_a$ and $W$), and the $D_{50}$ stone size.

Solution:
Using \( L_a = \frac{1.7Q}{D_o^{3/2}} + 8D_o \)

\( = \frac{1.7 \times 14.5}{(1.5)^{3/2}} + 8 \times 1.5 \)

\( L_a = 25.4 \) feet, rounded up = 26 feet

Since TW < 0.5 $D_o$, use $W = 3D_o + L_a$

\( = 3 \times 1.5 + 26 \)

\( W = 30.5 \) feet, rounded up = 31 feet

Using \( D_{50} = \frac{0.02}{TW} \frac{Q}{D_o}^{4/3} \)

\( = \frac{0.02 \times 14.5}{0.7} \times 1.5^{4/3} \)

\( D_{50} = 0.58 \) feet, converted and rounded = 7 inches
**Maintenance**

Inspections should be made of all sites immediately after the first rainfall following installation of riprap. This is particularly important in areas where riprap that is displaced during the storm would impact culverts. Thereafter, riprapped sites should be checked following large storms, especially those which are near or exceed the storm frequency used in the design. Displaced riprap should be removed from its downstream location and new riprap placed according to the specifications above.

**Exhibits**

Formulas included in this BMP were taken from the Rhode Island Soil Erosion and Sediment Control Handbook, Rhode Island Dept. of Env. Mgt., 1989.


Exhibit 2: Length and Height of Riprap. MDEQ, Surface Water Quality Division.


Exhibit 8: Configuration of Conduit Outlet Protection where there is no well defined channel downstream. Standards for Soil Erosion and Sediment Control in New Jersey, New Jersey Soil Conservation Committee, 1980.
Exhibit 1

Ordinary High Water Mark

All raw soil above permanent riprap should be covered with riprap, sod or seeded and mulched.

The ordinary high water mark is the normal water level, which on a river is where the grass stops and the bare soil starts.

No stream banks should be unprotected for 5 days or more

Exhibit 2

Riprap Placement: Length, Thickness, Height

Length to stabilize: cut bank, plus a minimum of 10 feet on both sides.

Height to stabilize: usually three feet above the Ordinary High Water Mark; can be less on hydrologically stable streams.

"Keying in"

Use geotextile (filter) fabric to prevent erosion caused by seepage

T = Thickness = 1.5 times the maximum stone diameter, but no less than 6 inches

Z = Side Slope

Exhibit 3

Maximum Depth of Flow for Riprap-Lined Channels

Exhibit 4
Distribution of Boundary Sheer Around Wetted Perimeter of Trapezoidal Channels


Exhibit 5
Angle of Repose for Riprap Stones

Exhibit 6
Ratio of Critical Shear on Sides to Critical Shear on Bottom


Exhibit 7
Ratio of Maximum Boundary Shear in Bends to Maximum Bottom Shear in Straight Reaches

Exhibit 8
Configuration of Conduit Outlet Protection Where There is no Well-Defined Channel Downstream

\[ W = 3D_0 + 0.4L_a \quad \text{(Tailwater} \geq 0.5 \quad D_0 \text{)} \]

\[ W = 3D_0 + L_a \quad \text{(Tailwater} < 0.5 \quad D_0 \text{)} \]

APPENDIX E-3

Example Terraced Side Slope Detail
ALL TERRACING MATERIALS MUST BE APPROVED BY THE LOCAL COMMUNITY

EXAMPLE OF TERRACING DETAIL
NOT TO SCALE
APPENDIX E-4

Wayne County Parks Division
Permit Guidelines for Site Restoration
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PERMIT GUIDELINES FOR SITE RESTORATION
Revised: 1 July 2015

General Guidelines:
1. The Contractor shall be responsible at no expense to the Owner, for any damage to Park property, including but not limited to; athletic fields, boardwalks, bridges, comfort stations, fences, lawns, paved pathways, picnic shelters, planting material, playground structures, signs and site furnishings.
2. The Contractor shall provide and maintain a safe and adequate travel route at all times for Park visitors throughout the duration of the Project. All equipment shall be stored in a manner that is safe to Park visitors and approved by the Wayne County Parks Design Staff.
3. The Contractor shall be responsible for contacting and coordinating with all pertinent utility companies at least 72 hours in advance of any digging to familiarize themselves with all underground utilities, pipes and structures. The Contractor shall assume sole responsibility for any cost incurred due to damage of any utilities.
4. The Contractor shall not willfully proceed with the construction as designed when it is obvious that unknown obstructions and/or grade differences exist. Such conditions shall be immediately brought to the attention of the Wayne County Parks Design Staff. The Contractor shall assume full responsibility for all necessary revisions due to failure to give proper notification.
5. Any discrepancies between dimensioned layout and actual field conditions shall be immediately brought to the attention of the Wayne County Parks Design Staff. The Contractor shall assume full responsibility for all necessary revisions due to failure to give proper notification.
6. The Contractor shall be responsible for any coordination with subcontractors as required to accomplish installation operations.
7. The Contractor shall provide and maintain positive surface drainage.

Lawn Restoration
1. All lawn that is disturbed due to construction activities shall be restored to its original state by the Contractor at no expense to the Owner.
2. Remove diseased or unsatisfactory lawn growth. Do not bury into soil. Remove topsoil containing foreign materials, including oil drippings, stone, gravel, and construction materials.
3. All disturbed areas shall be rough graded to meet the existing adjoining grades and any extraneous materials, i.e. rocks, wood, construction debris or equipment shall be removed and disposed of in a legal manner.
4. After rough grade is met, all disturbed lawn areas shall receive a minimum of 4" of clean, fertile, friable, topsoil of sandy loam character, free of any extraneous material. It will be the Contractor’s responsibility to supplement any salvaged topsoil supply to meet the minimum 4" depth.

5. Following the installation of topsoil, the approval of final grade by the Wayne County Parks Design Staff shall be required prior to reseeding of disturbed areas.

6. Apply a starter fertilizer (15-30-15) at a rate of 5lbs. per 1,000 sf thoroughly and evenly via a mechanical rotary or drop type spreader.

7. Perform seeding operations immediately after preparation of disturbed areas and when soil is dry and winds do not exceed 5 m.p.h. Apply recommended seed via a mechanical rotary or drop type spreader. After seeding, rake or drag surface of soil lightly to incorporate seed into top of soil. Areas that are identified to be seeded prior to construction shall be designated on drawings. The following seed mix is recommended, however alternates can be submitted Wayne County Parks Design Staff for review.

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<tr>
<th>Seed</th>
<th>Purity</th>
<th>Germination</th>
<th>Mixture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky Bluegrass</td>
<td>99%</td>
<td>85%</td>
<td>10%</td>
</tr>
<tr>
<td>Turf-Type Perennial Ryegrass</td>
<td>99%</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>Creeping Red Fescue</td>
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<td>20%</td>
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<td>Hard Fescue</td>
<td>97%</td>
<td>85%</td>
<td>20%</td>
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<tr>
<td>Turf-Type Tall Fescue</td>
<td>98%</td>
<td>85%</td>
<td>35%</td>
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</tbody>
</table>

Seeding application rate: 7lbs. per 1,000 sf.

8. Immediately following seeding operations, the Contractor shall install straw mulch in a uniform manner with continuous coverage over all seeded areas. Anchor straw by mechanical means or with a liquid tackifier at a rate of 60 gals. per acre.

9. Hydroseeding applications may be utilized for establishing new lawns using a mixture of specified fertilizer, tackifier at a rate of 60 gals. per acre, wood cellulose fiber mulch at a rate of 2,000 lbs. per acre and specified seed mix.

10. Water newly seeded areas. The Contractor shall maintain adequate soil moisture until new grass is established.

**Grow Zones Restoration**
1. All “Grow Zones” that are disturbed due to construction activities shall be restored to their original state.
2. “Grow Zones” shall be located in the field prior to construction by the Contractor and the Wayne County Parks Design Staff.
3. The Contractor shall consult with the Wayne County Parks Design Staff prior to restoration for the recommended Seed Mix and application method(s).

**Tree Inventory Plan**
1. Any person wishing to perform land clearing or grubbing activities, remove or transplant trees of any D.B.H. within Park Property of Wayne County shall not do so until they have received approval from the Permits office.
2. Applicant shall submit a Tree Inventory Plan that is performed by a registered land surveyor or certified arborist and includes the following:
   a. Topographic information delineating both existing and proposed contours.
b. Existing and proposed structures, utilities and pavement.

c. Property lines, R.O.W. and easements that are applicable.

d. The location and approximate drip line of all existing deciduous trees 6” D.B.H. or greater and existing evergreen trees 10’ height or greater.

   i. These trees shall be tagged in the field by identifying numbers using non-corrosive metal tags and shown on the plan with their respective number.

e. All existing deciduous trees 6” D.B.H. or greater and existing evergreen trees 10’ height or greater shall also be identified on a list using both their common and botanical names with their corresponding number. Please also indicate size and condition. Those trees that meet the Landmark Tree Requirements below shall also be identified.

f. Identify clearly all existing deciduous trees 6” D.B.H. or greater, existing evergreen trees 10’ height or greater and any Landmark Trees that are proposed to be removed.

g. The location of all replacement trees according to the Tree Replacement Standards below. Applicant shall also furnish a plant list that includes quantities, common and botanical names, size, root type and spacing.

h. A table including the total number of deciduous trees 6” D.B.H. or greater, evergreen trees 10’ height or greater on site, landmark trees, total number of trees proposed to be removed and the total number of replacement trees required.

i. The location of tree protection fence and associated details per Wayne County Parks Standards shall also be included on the plan.

3. Landmark Trees are any existing tree in good condition that are 24” D.B.H. or greater or is of a type and D.B.H. equal to or greater than those shown on the list below.

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Landmark D.B.H. (inches)</th>
</tr>
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<tbody>
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<td>Abies species</td>
<td>Fir</td>
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<tr>
<td>Acer species</td>
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<td>Aesculus glabra</td>
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<td>Sassafras albidum</td>
<td>Sassafras</td>
<td>14</td>
</tr>
<tr>
<td>Taxodium distichum</td>
<td>Bald Cypress</td>
<td>12</td>
</tr>
<tr>
<td>Tilia americana</td>
<td>Basswood</td>
<td>18</td>
</tr>
<tr>
<td>Tsuga canadensis</td>
<td>Eastern Hemlock</td>
<td>12</td>
</tr>
<tr>
<td>Ulmus americana</td>
<td>American Elm</td>
<td>18</td>
</tr>
</tbody>
</table>

**Tree Replacement**

1. Any person wishing to remove trees that are in good condition shall do so in accordance with the following schedule:

<table>
<thead>
<tr>
<th>Size of Removed Tree</th>
<th>Number of replacement trees to removed tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous Tree 6” D.B.H. or greater</td>
<td>3:1 (minimum 2.5” caliper)</td>
</tr>
<tr>
<td>Evergreen Tree 10’ height or greater</td>
<td>3:1 (minimum 8’ height)</td>
</tr>
<tr>
<td>Landmark Tree (see list)</td>
<td>1:1 (number of caliper inches = D.B.H. inches)</td>
</tr>
</tbody>
</table>

2. All replacement trees shall be of similar species to those being removed. Replacement trees shall be nursery grown and comply with ANSI Z60. Species, proposed size and any substitutions must be approved by the Wayne County Parks Design Staff prior to shipment or installation. Installation shall be per Wayne County Parks Standards. The suggested plant list is indicated below.

**Replacement Plant suggestions:**

**Canopy Trees**
- Acer rubrum – Red Maple
- Acer saccharum – Sugar Maple
- Carya ovata – Shagbark Hickory
- Fagus grandifolia – American Beech
- Lirodendron tulipifera – Tulip Tree
- Nyssa sylvatica – Black Gum
- Ostrya virginiana – Ironwood
- Platanus occidentalis – Sycamore
- Quercus bicolor – Swamp White Oak
- Quercus imbricaria – Shingle Oak
- Quercus macrocarpa – Bur Oak
- Quercus rubra – Red Oak
- Tilia americana – Basswood

**Evergreen Trees**
- Abies concolor – White Fir
- Picea glauca – White Spruce
- Picea pungens – Colorado Spruce
- Pinus Strobus – White Pine
- Taxodium distichum – Bald Cypress
- Tsuga Canadensis – Eastern Hemlock

**Flowering Trees**
- Amelanchier canadensis – Serviceberry
- Cercis canadensis – Eastern Redbud
- Cornus florida – Flowering Dogwood
- Crataegus crus-galli inermis ‘Crusader’
- Malus species – Crab Apple
**Bike Paths**

1. All County Bike Paths within or in close proximity of construction limits shall be adequately barricaded for the duration of construction. Appropriate signage shall be installed where necessary to adequately inform visitors of the construction zone and directions for an alternative route.

2. All Bike Paths removed or damaged as a result of construction shall be replaced with 3.5” depth bituminous pavement. The section of pavement shall include an 8” depth 21AA aggregate base compacted per current MDOT standards, 2” depth 13A leveling course, tack coat and a 1.5” depth 36A wearing course. The bituminous pavement shall be installed per current MDOT installation methods.

**Road Shoulders**

1. All Road shoulders shall be restored with 4” of topsoil and seeded as specified. No gravel will be allowed beyond the asphalt shoulder. Shoulder restoration shall meet all current MDOT standards.

**Park Drives**

1. All Park Drives that are within or in close proximity to construction limits shall be replaced and restored to their original state. Construction applications shall meet all current MDOT standards and project specifics should be taken into consideration prior to commencement of restoration.

2. All construction equipment and materials remaining on site following construction period shall be removed and disposed of off site.

Through the Permits Office, the Wayne County Parks Design Staff shall review all construction permits within or in close proximity to Park property prior to issuance of a permit.

Please contact: Elizabeth Iszler, Chief of Planning and Design: (734) 261-4312