

Washtenaw County Water Resources Commissioner
Rules and Guidelines

*Procedures & Design Criteria
For Stormwater Management Systems*



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Section I: Introduction

This edition

of the Rules of the Washtenaw County Water Resources Commissioner continues a stormwater management philosophy that considers stream channel protection and stormwater quality management in addition to flood control.

These revisions promote using stormwater as a resource, on-site, where possible, with strategies designed to better mimic the natural hydrology of an undeveloped site by promoting infiltration.

The following discussion outlines basic ideas and principles of stormwater management, and provides a conceptual foundation for the design standards contained in this document.

Significant information for these Rules was taken from the SEMCOG Low Impact Development Manual for Michigan. BMP design requirements, calculations and related figures are integrated throughout the document.

Impacts of Development On Water Quantity

The hydrology of a watershed changes immediately in response to site clearing and alterations to the natural landscape. A site's stormwater storage capacity is lost as vegetation is removed, natural depressions are graded, topsoil is removed, and wetlands are eliminated. If the soil is compacted and resurfaced with impervious materials, rainfall can no longer penetrate into the ground and so runs off of the land, often eroding soil and carrying pollutants that are harmful to waterways. These changes, along with the installation of drainage facilities, such as catch basins and pipes, greatly alter natural drainage patterns. Hydrological impacts will eventually cause changes in the physical condition of receiving waterways.

Changes in Watershed Hydraulic Cycle

- Volume of runoff increases. This raises the magnitude and frequency of severe flood events. In many areas of the county, existing flooding has already reached unacceptable levels requiring no increase in the volume of discharge.
- Frequency of bankfull floods increases. Bankfull floods fill the stream channel to the top of its banks, but do not spill over into the floodplain. Increased bankfull flooding subjects the stream channel to additional disturbance and unnatural aggradation and degradation.
- Flow velocities increase. This is due to the combined effect of increased runoff volume, reduced time of concentration, and smoother hydraulic surfaces.
- Stream flow fluctuations increase dramatically. Runoff rates and volumes are increased, concentrated and stop abruptly at the end of rainfall, leading to wide fluctuations in stream flow.

Increased flow fluctuations disrupt habitats and reduce the diversity of aquatic species regardless of water quality.

- Infiltration into the underlying groundwater is reduced. This in turn lowers the level of surface waters that are dependent on groundwater to maintain base flows.

Changes In Stream Morphology

- Channel widening and downcutting are the primary consequences of increased runoff and flow fluctuations.
- Streambank erosion is accelerated as channels are disturbed by undercutting, tree-falls and bank slumping.
- Sediment loads increase due to streambank erosion and construction site runoff. These sediments settle out and form shifting bars that often accelerate the erosion process by deflecting flow into sensitive bank areas.
- Increased sedimentation and channel widening modify aquatic habitats. Pools and riffles are eliminated as the stream adjusts to accommodate frequent floods. Sediment deposition destroys insect and benthic organism habitat as well as fish spawning areas.

Impacts of Human Activity on Water Quality

As described above, changes in land use contribute new or additional pollutants to stormwater runoff. In addition, the accompanying impervious surfaces provide rapid delivery of these pollutants into receiving waterways. Leaves, litter, animal droppings, exposed soil from construction sites, fertilizer and pesticides are all washed off of the land. Vehicles and deteriorating urban surfaces deposit trace metals, oil, and grease onto streets and parking lots. These and other toxic substances are carried by stormwater and conveyed through creeks, swales and storm drains into our rivers and lakes. The major categories of pollutants and their specific impacts are listed in Appendix B.

In short, the ecology of urban streams may be completely reshaped by shifts in hydrology, morphology and water quality that may accompany the development process. The stresses that these changes place on the aquatic community, although gradual and often not immediately visible, are profound: The Michigan Department of Environmental Quality has identified streams in the urban and urbanizing portions of Washtenaw County as requiring special initiatives to restore degraded habitats and improve water quality.

To mitigate stream impacts, it is necessary to reevaluate the way that stormwater and land development are managed. The following discussion provides a framework for this reevaluation, which must encompass the entire development process from land use planning and zoning to site design and construction. A

Section I: Introduction



benefit of this site design approach is often a net cost savings to the developer as shown in dozens of case studies.

Framework For The Design Of Stormwater Management Systems

*Note: The Rules of the Washtenaw County Water Resources Commissioner govern only the design of stormwater management systems within certain new development and redevelopment projects. The following discussion applies to all aspects of managing land and stormwater. **This framework will be the basis of discussion at the pre-application conference.***

Environmentally sensitive site planning can substantially reduce impacts associated with development. To this end, communities, regulatory agencies, and designers must begin to evaluate the impact of each individual development project over the long term, and on a cumulative watershed scale. Such an approach requires consideration of Best Management Practices (BMPs) that function together as a system to ensure that the volume, rate, timing and pollutant load of runoff remain similar to that which occurred under pre-development conditions. This can be achieved through a coordinated network of structural and non-structural methods designed to provide both source and site control. In such a system, each BMP by itself may not provide major benefits, but becomes very effective when combined with others.

Source Controls

Source controls reduce the volume of runoff generated on-site, encourage infiltration, and eliminate initial opportunities for pollutants to enter the drainage system. Source controls are the most effective options for controlling stormwater, and include the following key practices:

- Preservation of existing natural features that perform stormwater management functions. These include depressions, wetlands, woodlands and vegetative buffers along streambanks.
- Minimize impervious surface area using site planning to make efficient use of paved, developed areas and to maximize open space. Flexible street and parking standards and the use of alternative, permeable ground cover materials can also reduce impervious surfaces.
- Direct stormwater runoff from impervious areas to open vegetated areas such as swales and lawns rather than directly into the stormwater conveyance system.
- Design and use erosion control measures on site and include rigorous maintenance throughout the construction period. Effective erosion control measures include minimizing the area of site clearing and grading, and the immediate vegetative stabilization of disturbed areas.
- The soil erosion and sedimentation control (SESC)

construction sequence needs to protect infiltration areas from sediment and must include post-construction permeability testing and any necessary remediation prior to approval.

Site Controls

After the implementation of source controls, site controls are then required to infiltrate convey, pre-treat, and treat the stormwater runoff generated by developed sites. The range of engineering and design techniques available to achieve these objectives is to some degree dictated by site configuration, soil type, and the receiving waterway. For example, flat or extremely steep topography may preclude the use of grassed swales, which are otherwise preferable to curb and gutter systems. Likewise, sites upstream of cold-water fisheries may not be suitable for permanent wet retention/detention facilities that discharge heated surface water. Each site is unique, but some universal guidelines for controlling stormwater quality and quantity can be stated.

Preferred Hierarchy of Stormwater Runoff Controls

1. In general, the most effective stormwater runoff control is infiltration, which reduces both the runoff peak and volume, and prevents many pollutants from entering the surface water. Infiltration best management practices (BMPs) often are most effective when distributed throughout a site close to the sources of runoff and upstream of conveyance systems. Large scale infiltration measures such as basins and trenches receive more concentrated loading and are more likely to fail due to clogging. Therefore, an aggressive maintenance program and extensive upstream pre-treatment measures, such as oil/grit separators, sedimentation basins and vegetative filter strips, must be incorporated into any stormwater management system that employs these practices. Specific site conditions including soil type and water table elevation are key considerations.
2. The next most effective stormwater runoff controls reduce the runoff peak, and involve storage such as retention/detention. In the selection of an appropriate stormwater retention/detention facilities design, wet retention/detention facilities and extended retention/detention facilities are generally preferable to dry retention/detention facilities, as they hold stormwater longer, allowing more particulate matter to settle out. In addition, the aquatic plants and algae within retention/wet detention facilities take up soluble pollutants (nutrients) from the water column. These nutrients are then transformed into plant materials that settle to the retention/detention facility floor, decay, and are consumed by bacteria. As this biological process is dependent upon the presence of water, it does not occur in dry retention/detention facilities.
3. Where site conditions make the use of wet retention/detention infeasible, dry retention/detention facilities should be designed to provide extended detention of stormwater,

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to provide as much settling of particulate matter as possible. A notable exception to this practice occurs in areas where thermal impacts are of concern. As they hold stormwater longer, retention and extended wet detention facilities tend to increase the exposure of runoff to solar warming before release. Where thermal impacts are of primary concern, a balance must be struck between the goals of pollutant removal and the reduction of thermal impacts. Source controls and infiltration of stormwater, where feasible, are preferable approaches.

4. Once all possible methods of reducing and treating stormwater on-site have been implemented, excess runoff can be discharged into conveyance systems and carried off-site. Discharges must be at rates, velocities and volumes that will not cause adverse downstream impacts to property or waterways. For this purpose, vegetated swales with check dams are generally preferred to curb and gutter system and enclosed storm drains.

Regardless of the design, any stormwater system will lose effectiveness without regular maintenance. Depending on the specific BMP, maintenance must be performed at regular intervals. This may include inspection, sediment removal, maintenance of vegetation and structures, replacement of filters, and more. A maintenance and budget plan must be developed concurrent with the system design. The design must also include adequate access for maintenance.

The Role Of The Washtenaw County Water Resources Commissioner

The preferred hierarchy discussed above and summarized in Table 1 provides a comprehensive framework for evaluating the place and function of individual BMPs within a stormwater management system. While the most important BMPs are source controls that preserve and protect the natural environment, the Washtenaw County Water Resources Commissioner does not have legal authority to mandate all of these. We look to the staff and officials of local governments, as well as to developers and their design engineers and planners, to work together to implement source controls described earlier.

The Washtenaw County Water Resources Commissioner exercises authority over the design and construction of certain facilities that manage, convey and treat stormwater runoff. The Washtenaw County Water Resources Commissioner's Rules govern the design of such management facilities with the following objectives:

- Minimize stormwater runoff and impacts through source control and infiltration
- Incorporate design standards that control both water quantity and quality
- Encourage innovative stormwater management practices that meet the criteria contained within these rules
- Accommodate future maintenance of facilities by planning

for it as part of system design

- Establish maintenance plans and procedures to ensure effective long-term operation
- Make safety of facilities a priority
- Protect natural features
- Soil erosion and sedimentation control

Table 1
Hierarchy of Preferred Best Management Practices

Maintenance	Source Controls
	Preservation of the natural environment
	Minimization of impervious surfaces
	Use of vegetated swales and natural storage
	Stormwater Runoff Controls
	Infiltration of runoff on-site
	Stormwater retention/detention facilities
	Conveyance off-site

Section II: Plat and Plan Submission and Review Procedures



Part A.

PURPOSE & INTRODUCTION

1. All plats recorded with the Register of Deeds must conform to Act 288 of the Public Acts of 1967, as amended. Under this Act, the Water Resources Commissioner is responsible for ensuring that the drainage or stormwater management system of a subdivision is adequate for the development, and for protecting downstream landowners and resources. The procedures, standards and recommendations set forth in these Rules are designed for these purposes. Development (including redevelopment) of sites with impervious surfaces increases the rate and volume of stormwater runoff. Standard detention systems limit the rate of surface water runoff discharge but do not control the additional volume. In order to more closely mimic the natural hydrology of the undeveloped site, wherever feasible, based on a site's physical conditions, infiltration systems must be installed and integrated throughout the site by utilizing the infiltration BMPs listed within the rules.
2. In accordance with the provisions of Act 288, the Water Resources Commissioner has the authority, through the subdivision review process, to require that county drains and natural water courses, both inside and outside a plat, be improved to the standards established by the Water Resources Commissioner when necessary for the proper drainage of a proposed subdivision.
3. The Water Resources Commissioner will require water quantity controls and reduction of pollutant loading to improve water quality in accordance with the County's federally-mandated NPDES (National Pollutant Discharge Elimination System) stormwater permit to comply with the Clean Water Act and the Natural Resources Environmental Protection Act.
4. Under these rules, the Water Resources Commissioner will ensure that all stormwater facilities necessary for a proposed subdivision have an appropriate governmental unit responsible in perpetuity for performing maintenance or for overseeing the performance of maintenance by a private entity, such as a property owner's association. The appropriate forms may be obtained from the Water Resources Commissioner's Office. As specified in Act 288, the County Water Resources Commissioner may acquire jurisdiction over the drainage systems within subdivisions as deemed necessary for adequate operation and maintenance.
5. The general standards set forth herein will also be applied by the Water Resources Commissioner in the review of the following:
 - a. Site Condominium plans prepared under P.A. 59 of 1978, as amended, where local government ordinances require.
 - b. Mobile home plans prepared under P.A. 96 of 1987.
 - c. Applications for permits to discharge to a county drain under P.A. 40 of 1956, as amended.
 - d. Review of stormwater system plans in other classes of developments or re-developments, when requested by local governments.

PRE-APPLICATION MEETING

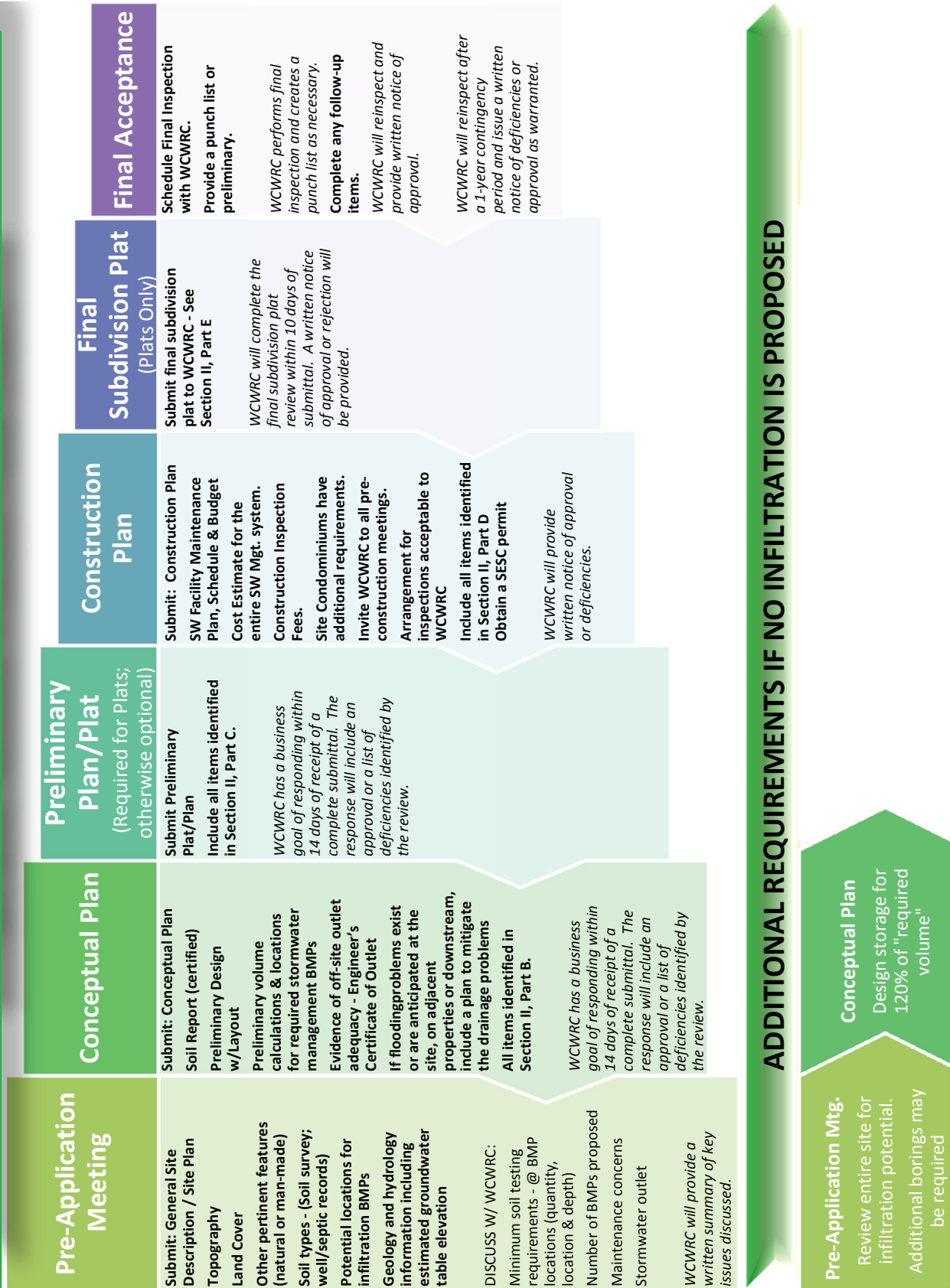
The Pre-Application Meeting is a required step for the design and construction of a site. The purpose of the meeting is to discuss the WCWRC rule requirements, changes and benefits of infiltration and green infrastructure, the minimum soil boring/test pit requirements, Best Management Practices (BMPs) proposed for use on the site, maintenance concerns, and the stormwater outlet. This meeting may allow for a faster, more cost-effective site design by identifying the stormwater management issues early in the process.

The Property Owner / Applicant will provide the following general information about the proposed development site for review during the meeting with the Water Resources Commissioner's Office:

- General Site Description / Site Plan
- Topography
- Land Cover
- Other pertinent features (natural or man-made)
- Soil types - (Soil survey; well/septic records)
- Potential locations for infiltration BMPs
- Geology and hydrology information including estimated groundwater table elevation

Section II: Plat and Plan Submission and Review Procedures

WCWRC Review Process Flow Chart



Section II: Plat and Plan Submission and Review Procedures



Part B.

CONCEPTUAL PLAN REVIEW REQUIREMENTS

Conceptual plan submittal and review is not a required step for the design and construction of a site. However, if a developer chooses to pursue a conceptual plan review, it may allow for a faster, more cost-effective entitlement process by identifying potential stormwater management issues early in the design phase of the project, particularly for unique sites or downstream issues. If conceptual plans are submitted, they shall include the following required information and will be submitted prior to the preliminary plat or plan:

1. A brief drainage narrative describing the proposed stormwater management system.
 - a. On-site drainage infrastructure.
 - b. Off-site drainage patterns of adjacent properties.
 - c. Evidence of off-site outlet adequacy by means of certification. See Engineer's Certificate of Outlet, Appendix L.
2. Calculations determining the detention or retention volume requirements for the development.
3. Proposed topography for the detention or retention basin(s) in one foot intervals.
4. Calculations verifying that the proposed topography provides the required detention or retention volumes.
5. Schematic layout for the proposed drainage collection system.
6. Soil types and location of proposed BMPs.
7. Existing natural features. (Worksheet 12).
8. Limits of disturbance (including consideration of topographical requirements for excavation).
9. If development is proposed in an area where flooding problems exist or are anticipated at the site, on adjacent properties or downstream, include a plan for how these issues will be addressed.

After reviewing Items 1-9 above, the WCWRC will then determine if the submittal is sufficient for approval. The submittal must be complete, correct and feasible in order to be conceptually approved. If it is determined that the information submitted is insufficient, a letter will be issued noting the deficiencies as determined by the review.

Section II: Plat and Plan Submission and Review Procedures

Part C

PRELIMINARY PLAN SUBMITTAL & APPROVAL

1. SUBMITTAL REQUIREMENTS

These requirements have been developed in the context of preliminary plat submittal under the Michigan Land Division Act. For all other categories of land development, including site condominiums and site plans, it is recommended that the following information be submitted:

- a. A preliminary plan showing the layout of the area intended to be subdivided or developed. This plan will be prepared under the direction of, and sealed by, a registered professional engineer. The preliminary plan shall be drawn to a standard engineering scale on sheets not exceeding 24" x 36".
- b. Three copies of the preliminary plan, prepared in accordance with the rules set forth in this section, will be submitted together with a letter of transmittal requesting that the preliminary plan be reviewed and, if found satisfactory, approved. The names of the proprietor and design firm, with mailing addresses, e-mail address, and fax and telephone numbers for each, will be included in the transmittal.
- c. Payment of applicable review fees is required before any review will commence. See the Fee Schedule, Section III, Part B.
- d. The proprietor will prepare a preliminary maintenance plan which must describe the mechanism to be established for long-term maintenance of the stormwater management system, and the responsible government agency for maintenance oversight if maintenance is to be performed by a private entity. Where jurisdiction exists, the Water Resources Commissioner may require that a county drainage district be established for future maintenance.
- e. Should the proprietor plan to subdivide or develop a given area, but wishes to begin with only a portion of the total area, the original preliminary plan must include the proposed general layout for the entire area. The first phase of the development will be clearly superimposed upon the overall plan in order to clearly illustrate the method of development that the proprietor intends to follow. Each subsequent plat or phase will follow the same procedure until the entire area controlled by the proprietor is developed.
- f. Final acceptance by the Water Resources Commissioner of a plan for only one portion or phase of the subdivision does not ensure final acceptance of any subsequent phases or the overall general plat for the entire area; nor does it mandate that the overall general plat or plan be followed as originally

proposed, if deviations or modifications acceptable to the Water Resources Commissioner are proposed.

- g. Preliminary plan approval shall remain in effect for one year. Extensions must be requested in writing.
- h. If development is proposed in an area where special drainage problems exist or are anticipated at the site, on adjacent properties or downstream, more stringent design requirements than are contained within Chapter II of these Rules may be required.

2. GENERAL INFORMATION REQUIREMENTS

All preliminary plans will include the following information:

- a. The location of the proposed development by means of a small location map.
- b. The township, city or village in which the parcel is situated.
- c. The section and part of section in which the parcel is situated.
- d. The number of acres to be developed.
- e. Contours, at 1-foot intervals or less with U.S.G.S. datum.
- f. The proposed drainage system for the development.
- g. The proposed street, alley and lot layouts and approximate dimensions.
- h. The location and description of all on-site and adjacent off-site features and easements (include liber/page) that may be relevant in determining the overall requirements for the subdivision. These features may include, but are not limited to the following:
 - Adjoining roads, subdivisions, and other developments.
 - Schools, parks and cemeteries
 - Drains, sewers, water mains, septic fields and wells.
 - High tension power lines, underground transmission lines, gas mains, pipelines, or other utilities.
 - Railroads
 - Existing and proposed easements
 - Natural and artificial watercourses, wetlands and wetland boundaries, floodplains, lakes, bays and lagoons
 - Designated natural areas
 - Soils description in accordance with the USDA NRCS standard soils criteria
 - Any proposed environmental mitigation features.
- i. Natural features that are located on the site shall be indicated, along with a description, and Worksheet 11, provided in Section IV of these Rules.
- j. Soil borings and/or test pits will be required (see Section V, Part D) at the location of all infiltration facilities, including but not limited to:
 - Bio Infiltration Systems and/or Rain Gardens
 - Porous Pavement
 - Dry Wells

Section II: Plat and Plan Submission and Review Procedures



- Structural Infiltration Beds
 - Subsurface Infiltration Beds
 - Infiltration Trenches
 - Vegetated Filter Strips
 - Bioswales
- k. Soil borings may be required at various other locations including the sites of proposed retention/detention facilities, and as needed in areas where high ground water tables exist.

3. DRAINAGE INFORMATION REQUIREMENTS

- a. Calculations used in designing all components of stormwater management systems must be submitted to the Water Resources Commissioner along with plans.
- b. All preliminary plans will include the following required stormwater management information:
- i. The overall stormwater management system for the proposed development with structure rim and invert elevations, culvert and storm sewer lengths and sizes as well as all surface stormwater conveyance top of bank and centerline elevations at 100' intervals. The preliminary plan must indicate how stormwater management will be provided and where the drainage will outlet.
 - ii. The location of any on-site and/or off-site stormwater management facilities and appropriate easements that will be dedicated to the entity responsible for future maintenance.
 - iii. A description of the drainage course that will be utilized as the stormwater outlet and evidence that it is adequate for the proposed discharge. It is noted that controlling flow to a rate that is equal to or below the pre-development rate may not be considered to be evidence of adequacy. **The Engineer's Certificate of Outlet, Appendix L**, must be provided including the signature and seal of the professional engineer responsible for determining adequacy.
 - iv. If no adequate watercourse exists to effectively handle the proposed discharge of stormwater additional measures must be taken. These measures may include volume control, acquisition of easements from downstream property owners, off site stormwater infrastructure construction, etc. If easements are required, Typical Easement Language is provided in **Appendix I**.
 - v. A map, at the U.S.G.S. scale, showing the drainage boundary of the proposed development and its relationship with existing drainage patterns, including any drainage originating outside the development that limits flows onto or across the development. Such off-site drainage shall be quantified.
 - vi. Proposed topography for all areas, both off and on site, to

be disturbed by construction. The proposed topography will be provided in one-foot contour intervals. If off-site grading is required, provide evidence of appropriate easements.

- vii. Any natural water courses and/or county drains passing through or adjacent to the proposed development, along with the following:
 - Area of upstream watershed.
 - Preliminary calculations of runoff from the upstream area for both the 100-year and 2-year recurrence interval 24-hour design storms, for fully developed conditions according to the current land use plan for the area.
 - Normal surface water elevation.
 - 100-year recurrence interval water elevation
 - viii. Determination of stormwater infiltration requirements.
 - ix. Calculations determining stormwater infiltration volume.
 - x. Calculations determining first flush and bankfull detention volumes.
 - xi. Calculations determining elevations of the first flush and bankfull detention volumes.
- c. The increased volume of water discharged due to the development of the site must not create adverse impacts to downstream property owners and water courses. Adverse impacts may include, but are not limited to flooding, excessive soil saturation, crop damage, erosion, and/or degradation in water quality or habitat.
- d. The proposed drainage plan will, in every way feasible, respect and conform to the natural drainage patterns within the site and the watershed in which it is located.
- e. In general, the Water Resources Commissioner will not accept responsibility for roadside ditches serving public roads. The Washtenaw County Road Commission maintains these if they are within the right-of-way of a public road.
- f. Proposed drainage should be consistent with any local stormwater management plans that may exist and/or comply with any ordinance in effect in the municipality/ies where the proposed development is located.

- a. The Water Resources Commissioner will approve or reject a preliminary plat within 30 days of its submittal. If the proposed preliminary plat is not approved as originally submitted, the Commissioner will notify the proprietor in writing, setting forth the reasons for withholding approval, and will state the changes necessary to obtain approval. If the Proposed preliminary plat as submitted meets all requirements, one approved copy of the preliminary plat will be returned to the proprietor. Approval of the preliminary plat is required before the Water Resources Commissioner will proceed with the review of final construction plans.
- b. Payment of all fees is a prerequisite to approval. See Section III.

Section II: Plat and Plan Submission and Review Procedures

Part D.

CONSTRUCTION PLAN SUBMITTAL & APPROVAL

All final plans shall include all the required Conceptual Plan Information, Preliminary Plan Information and the following information:

1. SUBMITTAL REQUIREMENTS

- a. For all projects to be reviewed by the Water Resources Commissioner, the proprietor will submit construction plans with a letter of transmittal requesting review and a permit application, if required.
- b. For platted subdivisions, review of construction plans by the Water Resources Commissioner will not proceed until preliminary plat approval has been granted. The Land Division Act gives no time limit in which final construction plans must be reviewed. The Water Resources Commissioner's office will review these plans in the shortest possible time based on the current work load.
- c. For all other developments, if a preliminary plan was not reviewed and approved by the Water Resources Commissioner, all aspects of **Preliminary Plan Submittal and Approval, Section II, Part C**, must also be adhered to during the construction plan review.
- d. If development is proposed in an area where special drainage problems exist or are anticipated at the site, on adjacent properties or downstream, more stringent design requirements than are contained within Chapter IV of these Rules may be required.
- e. Payment of applicable review fees is required before any review will commence. See the **Fee Schedule, Section III, Part B**.

2. CONSTRUCTION PLAN REQUIREMENTS

The Water Resources Commissioner will review construction plans to assure that adequate storm drainage will be provided and that the proposed stormwater management system provides adequately for water quantity and quality management to ensure protection of property owners, lands, and watercourses within both the proposed development and downstream.

- a. The names of the proprietor and design firm, with mailing addresses, e-mail address, and fax and telephone numbers for each, shall be included with the transmittal. Plans will be prepared under the direction of, and sealed by, a registered Professional Engineer and will be in accordance with Chapter IV & V of these Rules.

- b. Two complete sets of construction plans are required, drawn to scale no smaller than 1"=50', and on sheets no larger than 24" x 36". The plans shall be drawn to standard engineering scales. The construction plan submittal shall include all required information listed in Part B & C of this chapter, as well as the following, where applicable:
 - i. The property legal description, the total acreage, and a project location map. If the project is to be completed in phases, the number of acres in each phase shall also be included. Note: the legal description shall be referenced to a Public Land Survey System (PLSS) corner.
 - ii. The proposed project layout with all dimensions, including the proposed drainage system for the project.
 - iii. All easements necessary for operation and maintenance of the stormwater management system including access easements.
 - iv. Calculations used in designing all components of stormwater management systems including the following and all items stated under **Conceptual Plan Review Requirements, Section II, Part B**:
 - Number of acres, calculated to the nearest tenth of an acre contributing to each specific inlet/outlet.
 - Hydraulic gradient elevation, for both the 10-year and 100-year recurrence interval storm events (may be waived if there is no surcharging).
 - Maximum flow in cubic feet per second for both the 10-year and 100-year recurrence interval storm events.
 - Flow velocities for the 10-year recurrence interval storm event.
 - Channel sizing calculations for surface flow.
 - v. Topographical maps, as one-foot contour intervals or less on a NAVD88 vertical, showing existing and proposed grades, as well as off-site topography for at least 150' of the adjoining property. Maps will also show all existing watercourses, lakes and wetlands, and the extent of all off-site drainage areas contributing flow to the development.
 - vi. Locations of all drain fields as approved by the Washtenaw County Environmental Health Division and of all expansion areas. Drain fields shall not be located within drainage easements.
 - vii. Plans, profiles and details of all other utilities proposed on the site including water main, sanitary sewer and all other municipal, private and franchised utilities. In addition, the liber and page shall be provided for any existing drainage easements on the parcel(s) being developed, including county drains.
 - viii. Calculations, design data and criteria used for sizing all infiltration facilities, drainage structures, channels and retention/detention facilities including curve numbers

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or weighted runoff coefficient calculations.

- ix. Plans and details of proposed infiltration facilities with soil borings to verify that the facilities will function per the proposed design.
- x. Plans and details of proposed retention/detention facilities. Soil borings may be required at the sites of these facilities.
- xi. Plans, profiles and details of all road and storm sewers. The storm sewer details will include type and class and size of the pipe, length of run, percent of slope, invert elevations, rim elevations, and profile of the hydraulic gradient, as specified in this chapter of these Rules.
- xii. Storm sewer calculations indicating the number of acres, calculated to the nearest tenth of an acre, contributing to each specific inlet/outlet, the calculated hydraulic gradient elevation, maximum flow in cfs and the flow velocities for enclosed systems.
- xiii. A drainage area map, overlaid onto a copy of the site grading plan, which clearly shows the areas tributary to each inlet and/or retention/detention facility.
- xiv. Plans, profiles and details of all stormwater management system including but not limited to the following:
 - Bioretention Systems and or Rain Gardens
 - Porous Pavement
 - Dry Wells
 - Structural Infiltration Basins
 - Subsurface Infiltration Beds
 - Infiltration Trenches
 - Vegetated Filter Strips
 - Bioswales
 - Green Roofs
 - Water Reuse
 - Retention/Detention Facilities
- xv. Details of all drainage structures including but not limited to the following:
 - Manholes
 - Catch basins
 - Inlets
 - Outlet structures
 - Overflow structures
 - Check dams
- xvi. Plans and details of the proposed soil erosion and sedimentation control measures, both temporary during construction and permanent.
- xvii. All construction specifications for the stormwater management facilities.
- xviii. Stormwater management system maintenance plan providing for proactive maintenance tasks, schedule of maintenance tasks, annual budget and responsible parties.
- xix. Verification that all necessary easements have been obtained and are in proper format for recording with

the County Clerk/Registrar of Deeds Office.

- xx. For developments that require county drain and drainage district establishment, all information as specified in **Section II, Part E**, including fees and financial security.
- xxi. An overall plan showing all proposed storm drainage facilities with drainage easements shall be submitted. This sheet shall be overlaid on the overall road and utility plan and drawn to a scale no smaller than 1"=100'.

For platted subdivisions only: Platted subdivisions may receive final construction plan approval but shall not receive final plat approval until all requirements for establishment of a county drainage district are met. In such cases, the following items must be submitted prior to final plan approval in lieu of establishment of a county drain and drainage district:

- a. A cost estimate of the stormwater infrastructure to be prepared by the professional engineer responsible for the design.
- b. All permit applications and associated fees required for the completion of the construction.
- c. Construction inspection deposits equal to 10% of the cost estimate for the stormwater infrastructure but not less than \$2,500.00.

3. CONSTRUCTION PLAN APPROVAL

- a. When plans have been completed with computer aided design technology, copies of the electronic files of the final plan set shall be provided for those items that specifically relate to the storm drainage facilities and information required in these Rules. These items include, but are not limited to, storm sewers, swales, infiltration facilities, retention/detention facilities, grading plans, etc., as well as all available information such as complete site layout, sanitary sewer and water main plans, easements and topographic surveys. Note: Provide portable document format (pdf) versions of the final plan set.
- b. A stormwater facility maintenance plan, schedule and budget shall be submitted. This will be used in estimating the costs that will be associated with system maintenance.
- c. A cost estimate of the entire stormwater management system shall be submitted. This estimate shall include, but is not limited to the cost of all grading, construction, soil erosion control and materials. All fees associated with construction inspection, contingencies and letters of credit will be based on this estimate.
- d. Construction inspection deposits equal to 10% of the cost estimate for the stormwater infrastructure but not less than \$2,500.00
- e. For site condominiums, all items outlined in **Section II, Part E**, regarding final approval must be completed prior

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to approval of construction plans. Complete master deed documents, including by-laws and Exhibit B Drawings (D-size; 24"x36") must be submitted for the Water Resources Commissioner's review and approval prior to recording.

- f. The Water Resources Commissioner shall be invited to all pre-construction meetings with other agencies, utility companies and contractors. Prior to approval of the final construction plans, the proprietor will make arrangements acceptable to the Water Resources Commissioner for inspection during construction (including submittal of inspection reports) and for final verification of the construction by a Michigan registered professional engineer. These arrangements will include an inspection schedule that defines the specific junctures during construction when on-site inspection and written verification by a professional engineer will occur. **See Appendix E, Engineer's Certificate of Construction.**
- g. A soil erosion permit under "The Michigan Soil Erosion and Sedimentation Control Act," P.A. 451, Part 91 of 1994, as amended, will be obtained from the appropriate agency prior to any construction.
- h. Approval of construction plans by the Water Resources Commissioner's office is valid for one calendar year. If an extension beyond this period is needed, the proprietor will submit a written request to the Water Resources Commissioner for an extension. The Water Resources Commissioner may grant a one year extension of the approval. This extension may require updated or additional information if needed, and/or design modifications to meet the most current Rules of the Washtenaw County Water Resources Commissioner.
- i. Payment of all fees is prerequisite to approval.

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Part E.

FINAL SUBDIVISION PLAT SUBMISSION & APPROVAL

Final subdivision plat review will be completed by the Water Resources Commissioner's office within 10 days of submission by the proprietor. If the plat is not acceptable, a written notice of rejection and the reasons there for will be given to the proprietor. If the Water Resources Commissioner approves the plat, s/he will affix his/her signature to it and the plat will be executed. As a condition of final plat approval, the Water Resources Commissioner will require the following:

1. The municipal governing body in which the proposed development is located must approve the preliminary plat. Evidence of this approval shall be submitted to the Water Resources Commissioner's office with the final plat.
2. Before approval of the final plat, it must be demonstrated that all necessary Wetland, Floodplain, Inland Lakes and Streams, Erosion Control or other needed state, federal or local permits are in place.
3. A satisfactory agreement that assures long-term maintenance of all drainage improvements will be in place before submission of the final plat. Documentation of maintenance agreement shall be supplied to the Water Resources Commissioner.
4. Complete subdivision agreement (including deed restrictions) must be submitted for the Water Resources Commissioner's review and approval prior to recording. These agreements must include the appropriate easement language for the development. See **Appendix I, Typical Easement Language**.
5. Portable document format (pdf) drawings of the as-built stormwater management system will be submitted to the Water Resources Commissioner along with the final plat, or upon completion of system construction.
6. The proprietor will post a contingency deposit in an amount of not less than 10% of the approved construction cost estimate of the stormwater facilities. This contingency deposit will be held for one year after the date of completion of construction and a final inspection of the stormwater facilities is performed by the Water Resources Commissioner, or until construction and soil stabilization is complete on all lots in the development, whichever time period is longer.
 - a. This deposit may be in the form of cash, a letter of credit, or an escrow account. A letter of credit or escrow account established as a contingency deposit shall not have an expiration date and will contain the following clause regarding the expiration of the letter or the account:
"This letter of credit (or escrow account) shall expire upon receipt of a written statement by the Washtenaw County Water Resources Commissioner that the stormwater management system in the above-mentioned development has received final approval by the Washtenaw County Water Resources Commissioner."
7. Depending on the nature of the deposit, it will be returned to the proprietor or allowed to expire provided that all stormwater facilities are clean, unobstructed and in good working order and that the Water Resources Commissioner has received all required documents, certificates, and as-built drawings. It is the proprietor's responsibility to request a final inspection.
7. The following procedure shall apply when stormwater management facilities are constructed prior to submission of the Final Plat:
 - a. If the proprietor desires to construct the stormwater management facilities before submission of the final plat, construction plans as required in **Section II, Part D** will be submitted to, and approved by the Water Resources Commissioner's office before any work commences.
 - b. A construction inspection deposit equal to 10% of the cost estimate but not less than \$2,500.00 shall be submitted prior to construction plan approval. The proprietor will be responsible for inspection costs incurred by the Water Resources Commissioner.
 - c. If the drainage work involves crossing, tapping into, or other work within an existing county drain or its easement, a permit application must be submitted and approved by the Office of the Water Resources Commissioner prior to construction. This permit application will be accompanied by any necessary release of rights-of-way in recordable form, executed by all owners of interest. Prior to construction, copies of any required state, federal or local permits shall be submitted to the Water Resources Commissioner.
8. The following procedure shall apply when stormwater management facilities are constructed after submission of the Final Plat:
 - a. If the proprietor desires to have the plat recorded before completing the drainage improvements, he or she will enter into an agreement with the Water Resources Commissioner and post a cash deposit, letter of credit, or escrow account in an amount sufficient to complete construction of the stormwater management facilities, as determined by the proprietor's engineer and approved by the Water Resources Commissioner. See "Sample Agreement, **Appendix J**."
 - b. A letter of credit or escrow account established as completion assurance will contain the following clause regarding the expiration of the letter or the account:
"It is a condition of this letter of credit (or escrow account) that it shall be automatically renewed for additional

Section II: Plat and Plan Submission and Review Procedures

periods of one (1) year for the present or each future expiration date, unless at least 60 days prior to such date, the Washtenaw County Water Resources Commissioner is notified in writing via certified mail, that the credit (or account) will not be renewed for such an additional period.”

- c. Under this agreement, the time of completion of construction of stormwater management facilities will not extend for a period greater than one year from the original date of the agreement. If after this period the improvements are not completed, the Water Resources Commissioner may exercise the right, under the terms of the escrow account or letter of credit, to use proceeds of the proprietor’s deposit to fulfill the proprietor’s obligation under such agreement, at such time and in such manner as the Water Resources Commissioner may determine.
 - d. The financial assurance mechanism shall remain in place until construction and soil stabilization over 80% of the development is complete. Thereafter, the Water Resources Commissioner may refund portions of the original deposit as the work progresses. However, the amount of deposit retained by the Commissioner will at no time be reduced to less than the cost for completion of the remaining work, by the Water Resources Commissioner’s Office.
9. Payment of all fees and necessary securities is prerequisite to approval.
10. A final plat, when submitted to the Water Resources Commissioner for signature, will include the Water Resources Commissioner’s Certificate. The form of this certificate is as follows:

County Water Resources Commissioner’s Certificate

Approved on _____, as complying with Section 192 of Act 288, P.A. of 1967, and the applicable rules and regulations published by my office in the County of Washtenaw.

Evan N. Pratt, P.E.
Water Resources Commissioner



Section II: Plat and Plan Submission and Review Procedures



Part F.

DRAINS UNDER THE JURISDICTION OF THE WATER RESOURCES COMMISSIONER

1. Drainage districts will not be altered when designing development drainage, except as provided under Sections 425 and 433 of Act 40, Public Act 1956 as amended.
2. Existing county drain easements will be indicated on plans and final plats and will be designated as "_____ " (County Drain. In addition, the liber and page shall be provided for any existing drainage easements on the parcel(s) being developed. County drain easements prior to 1956 were not required by statute to be recorded immediately; therefore, it may be necessary to check the permanent records of the Water Resources Commissioner's Office to see if a drain easement is in existence on the subject property.
3. Proposed modifications to county drains will require a permit application to the Office of the Water Resources Commissioner. State, federal and local permits may also be necessary.
4. A permit will be obtained from the Water Resources Commissioner prior to any work that affects a county drain, including tapping into or crossing. The permit must be obtained prior to construction plan approval.
 - a. Detailed construction plans along with the appropriate review fees shall be submitted for review with the permit application. These shall be prepared in accordance with **Section II, Part D.**
 - b. Payment of all fees is prerequisite to permit approval.
 - c. Upon receipt of an approved permit, the permittee must contact the Water Resources Commissioner 48 hours prior to the start of construction.
 - d. All work shall be completed in accordance with the plans and specifications approved by the Water Resources Commissioner.
 - e. A cash deposit in an amount satisfactory to the Water Resources Commissioner shall be deposited to insure satisfactory completion of the project in accordance with the approved plans. The permittee shall contact the Water Resources Commissioner to perform an inspection of the permitted activity.
 - f. The Water Resources Commissioner shall be notified in writing within 10 days of completion of an approved project.
 - g. Authority granted by a permit from the Water Resources Commissioner does not convey, provide, or otherwise imply approval of any other governing act, ordinance, or regulation, nor does it waive the permittee's obligation to acquire any federal, state, county, or local approval or authorization necessary to conduct the activity.

Part G.

APPEAL PROCEDURE

1. If the proprietor wishes to appeal a decision made by the Water Resources Commissioner, a written appeal may be filed within 14 calendar days of that decision. If an appeal is filed with the Water Resources Commissioner's office, an informal hearing will be scheduled within 21 calendar days from the date of the filing.
2. The informal hearing will allow the proprietor an opportunity to submit additional information or re-emphasize previously submitted data. The Water Resources Commissioner will then review the information and make a final decision, within 21 days of the informal hearing, and forward this final decision to the proprietor by first class mail.

Section III: Permit Requirements Review Fees

Part A.

PERMITS

A permit will be required for all activities crossing, modifying, discharging to a county drain or any work within a county drain easement. Submittals shall include all the following information:

1. A fully completed permit application including appropriate signatures.
2. Permit, review and inspection fees as specified in Table 2 below.
3. A drawing including the following information at a minimum:
 - a. Location of county drain easements on the property.
 - b. Descriptions of all construction activity within drain easement.
 - c. Dimensions and elevations of all facilities being proposed for construction within the drain easement.
 - d. Type of material used for construction of facilities within the drain easement.
 - e. Soil erosion and sedimentation control measures. Certain construction activities require that the County Water Resources Commissioner be assured of appropriate and timely completion of the permitted activity. In such cases, security in the form of cash or a letter of credit will be deposited with the Water Resources Commissioner prior to a permit being issued. These activities and minimum amount of security required are defined in Table 2 below.

Table 2

Permit Type	Permit Fee	Initial Review Fee \$105.00/hour	Initial Inspection Fee \$105.00/hour	Minimum Security Required
Minor Residential Permit	\$60.00	One hour	One hour	None
Tap-In Permit Open Drain	\$60.00	One hour	One hour	None
Tap-In Permit Enclosed Drain	\$60.00	Two hours	Two hours	\$1,000.00
Culvert Installation	\$60.00	One hour	One hour	\$500.00
Bored Crossing	\$60.00	Two hours	One hour	\$500.00
Open Cut Crossing	\$60.00	Two hours	Four hours	\$5,000.00
Bridge Crossing	\$60.00	Four hours	Four hours	\$2,000.00
Drain Clean Out	\$60.00	Two hours	Four hours	\$5,000.00
Construction Easement	\$60.00	Two hours	Two hours	None

Section III: Permit Requirements Review Fees



Part B.

FEES

1. Plan Review Fees

All review fees are charged at an hourly rate of \$105.00. A review of plans received by the Washtenaw County Water Resources Commissioner will not be scheduled or completed until the appropriate fee has been submitted. The initial review fee for all site plans or platted subdivisions is based on the acreage of the development and is outlined in Table 3. If the review fee initially submitted is not sufficient to complete the necessary reviews, additional fees will be invoiced. Additional reviews will not be completed until the additional invoiced amount is submitted.

Review time will be billed for all work necessary to complete the review process including but not limited to plan review, file research, meetings, predevelopment site inspections, telephone calls, etc.

2. Inspection Fees

Inspection fees are charged at an hourly rate. Inspections will not be performed until the appropriate fee has been submitted. The initial inspection fees will be 10% of the approved design engineers construction cost estimate. In instances where representatives of the local municipality will complete the inspection on behalf of the WCWRC this initial fee will be reduced to 5%. Once the initial inspection fee has been depleted, additional inspection time will be billed to the developer. Additional inspections will not be completed until the invoiced amount is submitted.

Inspection time will be billed for all work necessary to complete the inspection including inspection time, travel time, mileage costs, as built plan review, meetings, telephone calls, etc.

Any unused inspection fees will be returned upon completion of the required inspections.

Table 3

Development Size	Initial Fee
Less than 5 acres	\$400.00
5-20 acres	\$500.00
20-50 acres	\$625.00
50-100 acres	\$750.00
Over 100 acres	\$750.00 + \$4.00 per acre
Resubmittal Review	\$105.00 per hour*

*** Due prior to final approval**

Section IV: Computational Requirements For Stormwater Management Systems

Part A.

PURPOSE & INTRODUCTION

Each specific site proposed for development is unique due to soils, land cover, topography, location, etc. These unique characteristics make it difficult if not impossible to develop one set of uniform stormwater standards that is capable of accommodating all variables. Due to this, additional requirements not included in these standards, may be necessary to meet the intent of these rules. Also, waivers or variances from certain provisions of these standards may be requested when it can be demonstrated that this standard cannot be feasibly accommodated. In these situations alternatives consistent with the overall intent of these rules must be proposed for consideration and will be subject to the approval of the Water Resources Commissioner.

This section sets forth specific design and construction standards that will be used by the Water Resources Commissioner in review of proposed stormwater management systems in accordance with the objectives of managing both the quantity (volume and rate) and quality of stormwater runoff. A **Glossary of Terms** used throughout this section is provided in **Appendix A**.

Whereas basin design for flood control is concerned with capturing and detaining relatively infrequent, severe runoff events, such as the 10-, 25-, or 100-year recurrence interval storm, designs for channel protection and water quality control require that the more frequent storm events (e.g. up to the 2-year recurrence interval storm) must be addressed as well. The need for managing smaller storms is directly related to the need to mitigate the impacts of urbanization within Washtenaw County and the accompanying increase in impervious area, which affects surface water quality in two important ways.

First, eroded soil and other pollutants that accumulate on impervious surfaces, such as metals, fertilizers, pesticides, oils and grease, are flushed off by the early stage of runoff, which then carries a shock loading of these pollutants into receiving waterways. By capturing and treating the runoff from the first inch of rain, pollutants that are washed off of the land can be removed from stormwater before it flows offsite.

Second, as recent studies by the MDEQ have shown, development within the County has caused stream flow fluctuations to rise dramatically. As impervious surface area increases and opportunities for infiltration are reduced, the frequency and duration of bankfull flow conditions, typically represented by the 2-year recurrence interval storm event, have intensified. As a result, streams adjust their capacities to convey increased flows, leading to channel and bank erosion and the destruction of aquatic habitat.

Development of sites with impervious surfaces increases the rate and volume of stormwater runoff. Standard detention systems limit the

rate of surface water runoff discharge but do not control the additional volume. In order to more closely mimic the natural hydrology of an undeveloped site, infiltration systems must be installed and integrated throughout a site by utilizing the infiltration BMPs listed within these rules:

- Surface Infiltration Basins
- Subsurface Infiltration Beds
- Bioretention Areas
- Rain Gardens
- Pervious Asphalt, Concrete or Pavers
- Infiltration Trenches
- Other BMPs that provide infiltration (vegetated filter strips, bioswales or dry wells)

1. STORMWATER MANAGEMENT REQUIREMENTS ¹

Volume Treatment Considerations

To manage water quality, volume, rate and quantity, site stormwater management methods must be designed to treat the following:

- First flush volume; the runoff from the first inch of rain from the entire contributing watershed as determined by the Rational Method.

The methods selected to treat the first flush volume shall be designed on a site-specific basis to achieve either a minimum of 80 percent removal of TSS, as compared with uncontrolled runoff, or a discharge concentration of TSS that does not exceed 80 mg/l. Where site conditions do not generate TSS concentrations greater than 80 mg/l, water quality treatment of the runoff is not required.

Many BMPs are sufficient individually to achieve the required removal of TSS. Compliance can also be achieved through the use of a system of BMPs each achieving less than the required removal of TSS but, when properly applied as a system, achieve the required removal for the site.

- Bankfull volume; the 2-year recurrence interval /24 hour storm event, as determined by the NRCS Method.

Infiltration will be required for the **greater** of the following:

- The difference between the **pre-development** bankfull and **post development** bankfull volumes

OR

- The entire first flush volume

¹ Notes:

Individuals seeking to develop land within Washtenaw County are encouraged to contact local governments regarding their local stormwater BMP requirements. Standards in addition to those contained in these Rules may be in effect in special communities or creeksheds.

It is difficult or impossible to develop one set of uniform standards that is capable of accommodating all variables and unique site circumstances. Waivers or variances from special provisions of these standards may be requested, and alternatives consistent with the overall intent of stormwater quantity and quality management may be proposed, subject to the approval of the Water Resources Commissioner.

Section IV: Computational Requirements For Stormwater Management Systems



- 100-year recurrence interval storm event; as determined by the NRCS Method.

Soil borings and/or soil test pits will be required on all sites to determine the feasibility of infiltration. Where more impervious soils exist, BMPs must be engineered to properly dewater within 48 hours of the storm event. If the required infiltration for a site is unachievable, the developer/applicant must submit written proof and supporting documentation for review by the Water Resources Commissioner, and provide appropriate Best Management Practices to detain/retain the applicable stormwater volume and provide treatment to meet the first flush TSS removal requirements.

An infiltration system or systems may be an integral part of the storage device that is required to store the 100-year recurrence interval storm or may be a separate system or systems within the development that will provide for the required infiltration volume. Infiltration upstream of the storage device is preferred.

Detention/ Retention System Considerations

Controlling both extremely large events to prevent flooding, and more frequent events to mitigate water quality impacts and channel erosion, can be achieved partially through the proper design of detention/retention basins. Among alternatives, wet retention/detention facilities and constructed wetland marsh systems are more effective for achieving control of both stormwater volume and quality. The phosphorus removal capability of wet retention/detention facilities, wetland marsh systems and infiltration systems is superior to other storage BMPs.

BMP Considerations

Extensive literature is available on specific design concepts and alternatives, and selected references are available within this document's appendix. Diagrams and details for bioretention systems, rain gardens, pervious pavement, dry wells, green roofs and water reuse are contained within **Section V, Design Requirements for Stormwater Management Systems** of these rules. Several other Non-structural Best Management Practices (BMPs) are references within, **Section IV, Part D, Sizing Requirements for Non-structural Credits**. For additional information on BMP planning, design and implementation, refer to SEMCOG **Low Impact Development Manual for Michigan**- A Reference Guide for Implementers and Reviewers.

2. STORMWATER MANAGEMENT FOR REDEVELOPED SITES

If redevelopment is proposed on any existing site, the stormwater management performance must be brought up to the current standard for the redeveloped or newly constructed portion of the site. The methods of stormwater management must be the Standard method as described in this manual. The following must be addressed:

- If 50% or more of the site is slated for redevelopment, the

entire site will be subject to all the requirements of the current standards.

- All portions of the site that are slated for redevelopment will be subject to all the requirements of the current standards. This includes storage of the 100 year recurrence interval storm, bankfull storm flow rate control and the requirement of infiltrating the first flush storm volume for the newly constructed areas.
- Developed portions of the site not slated for construction will have retrofits made to the existing drainage system to provide quality treatment of runoff prior to leaving the site. This may be completed by traditional methods or the addition of mechanical treatment devices.
- Pavement reconstruction in connection with redevelopment will be considered new construction.

3. STORMWATER DISCHARGE REQUIREMENTS

- In no event will the maximum design rate of volume of discharge exceed the maximum capacity of the downstream land, channel, pipe or watercourse to accommodate the flow. It is the proprietor's/developer's obligation to meet this standard. Should a stormwater system, as built, fail to comply, it is the proprietor's responsibility to design and construct, or to have constructed at his/her expense, any necessary additional and/or alternative stormwater management facilities. Such additional facilities will be subject to the Water Resources Commissioner's review and approval.
- The allowable release rate from a facility designed for the flood control storage volume will not exceed 0.15 cfs per acre of the property being drained.
- A description of the drainage course that will be utilized as the stormwater outlet and evidence that it is adequate for the proposed discharge shall be provided. It is noted that controlling flow to a rate that is equal to or below the pre-development rate may not be considered to be evidence of adequacy. **The Engineer's Certificate of Outlet, Appendix L**, must be provided including the signature and seal of the professional engineer responsible for determining adequacy.
- If no adequate watercourse exists to effectively receive a concentrated flow of water from the proposed development, additional measures must be taken. These measures may include volume control, acquisition of easements from downstream property owners, off site stormwater infrastructure construction, etc. If easements are required, it is the responsibility of the developer to secure any necessary easement(s) from downstream property owners. **Typical Easement Language** is provided in **Appendix I**. See **Appendix N, Legal Opinion Regarding Need for Easements Downstream of Drainage District Outlets**.
- Discharge should outlet within the watershed where flows originate, and generally may not be diverted to another watershed.

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Part B. SIZING REQUIREMENTS—STANDARD METHOD COMPUTATIONS

1. STANDARD METHOD OVERVIEW

When calculating runoff using the Standard Method a two-step approach will be used.

Step 1.

Determine the first flush volume with the Rational Method. This method was chosen due to the underestimation of volume that the NRCS Curve Number Method yields for runoff less than one (1) inch.

Step 2.

Determine the bankfull and 100-year recurrence interval volumes with the NRCS Curve Number Method.

When determining the 100-year recurrence interval volume there are two assumptions that will be made.

Assumption 1.

Pre-development runoff volume will be the runoff from the site prior to development at a release rate of 0.15 cfs/acre.

Assumption 2.

The amount of post-development runoff volume equals the increase in runoff leaving the site above the pre-development release rate of 0.15 cfs/acre.

2. RUNOFF DETERMINATION – CURVE NUMBER METHOD

Introduction

The curve number method is the standard methodology and must be used to determine volumes for all developed sites. The hydrographs and equation shown in Figure 2 visually express the amount of required infiltration, post-development runoff and pre-development runoff at a fixed release rate of 0.15 cfs/acre. The amount of runoff (V_d) that must be managed via detention basins or through additional BMPs is expressed as the 100-year recurrence interval volume (V_{100}) less the required infiltration (V_{inf}) and less the pre-development runoff (V_p) volume. It is acceptable, often cost-effective (and preferred) to manage the detention volume (V_d) using infiltration also. The equation can be simply expressed as:

EQUATION

Detention Volume = 100-year Hydrograph Volume – Volume Infiltrated – Pre-development 100-year Hydrograph Volume

OR

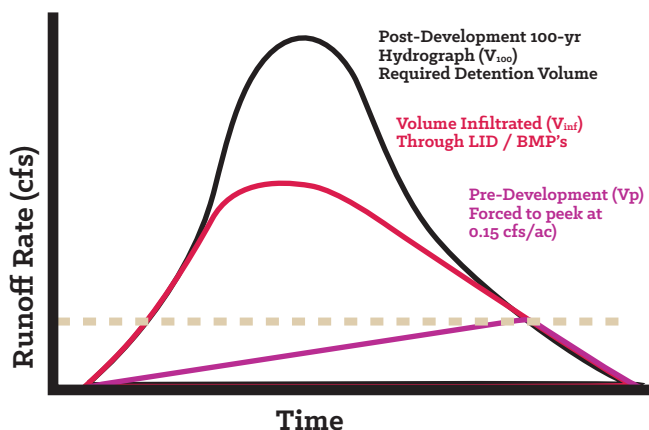
$$V_d = V_{100} - V_{inf} - V_p$$

Runoff Calculations

The Runoff Curve Number Method, developed by the Natural Resources Conservation Service (NRCS), 1986, is perhaps the most commonly used methods for estimating runoff volumes. In this method, runoff is calculated based on precipitation, curve number, watershed storage, and initial abstraction. When rainfall is greater than the initial abstraction, runoff is calculated by:

EQUATION

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$



Detention Volume = 100-yr Hydrograph Volume - Volume Infiltrated - Pre-Development 100-yr Hydrograph Volume

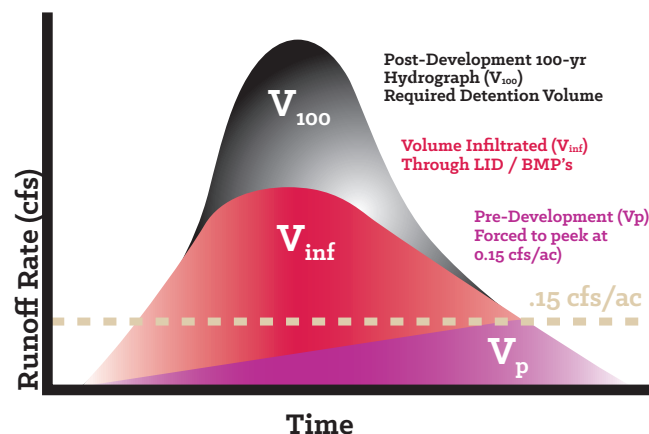


Figure 2. Detention Volume Hydrograph

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Q= runoff (in.)

P =rainfall (in.)

Ia=initial abstraction (in.)

S=potential maximum retention after runoff begins (in.)

Initial abstraction (Ia) includes all losses before the start of surface runoff: depression storage, interception, evaporation, and infiltration. Ia can be highly variable but NRCS has found that it can be empirically approximated by:

EQUATION

$$I_a = 0.2S$$

Therefore, the runoff equation becomes:

EQUATION

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Finally, S is a function of the watershed soil and cover conditions as represented by the runoff curve number (CN).

EQUATION

$$S = \frac{1000}{CN} - 10$$

To account for the allowable release rate of 0.15 cfs/ac, a modification to the SCS method was created to incorporate the time of concentration for the 100-year storm event calculations, where time of concentration can be calculated by:

EQUATION

$$T_c = \frac{L}{V * 3600}$$

T_c= time of concentration (hr)

L= length of flow path (ft)

V= velocity (fps)

This method utilizes the MDEQ unit peak flow rate calculation procedure described in the document, [Computing Flood Discharges for Small Ungaged Watersheds by Richard Sorrell \(2010\)](#). Equation 9.1 in the Computing Flood Discharges document was used in order to convert the unit hydrograph peak flow value (Q_p), expressed in units of cfs per square mile per inch of runoff into a corresponding inch of runoff:

EQUATION

$$Q_p = 238.6(T_c)^{-0.82}$$

The hydrograph peak flow value (Q_p) is used to then approximate the

pre-development runoff (V_p), where (V_p) holds a linear relationship between flow rates and flow volumes, noted as:

EQUATION

$$\frac{V_{100} - V_p}{V_{100}} = \frac{\Delta}{Q_p}$$

The rearrangement of the equation yields:

EQUATION

$$V_p = V_{100} - \frac{V_{100}\Delta}{Q_p}$$

V_p= pre-development 100-year volume (cf)

V₁₀₀= post-development 100-year volume (cf)

Δ = estimation of the difference between pre-development 100-yr and post-development 100-yr flow (efs)

To simplify the NRCS method, the change (Δ) in flow (Q_p) is used to determine the final 100-yr storm detention requirement based on peak flow (PF) from the site in cubic feet per second where:

EQUATION

$$PF = \frac{Q_p QA}{640}$$

The change (Δ) in flow can be quantified with the Area (A) in acres expressed as:

EQUATION

$$\Delta = PF - 0.15A$$

A = area (acres)

The 100-yr detention volume (V_{det}) can then be determined via substitution of (V_p) into the following:

EQUATION

$$V_{det} = \frac{\Delta}{Q_p} V_{100} - V_{inf}$$

V_{inf} = infiltration volume (cf)

V_{det}= detention volume (cf)

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Therefore, runoff can be calculated using only the curve number, rainfall and time of concentration. Curve numbers determined by land cover type, hydrologic condition, antecedent runoff conditions (ARC – sometimes referred to as antecedent moisture condition), and hydrologic soil group (HSG), see Table 4. Curve numbers for various land covers are based on an average ARC for annual floods and $I_a = 0.2S$. When estimating the **pre-development** bankfull runoff, use the curve number associated with Good Condition Woods or Meadow. A table can be found in Urban Hydrology for Small Watersheds (NRCS,1986) and various other references as well as **Section IV, Part E, Standard Method Runoff Volume Worksheets** within these Rules. See **Worksheets 1 through 12** titled **Standard Method Site Runoff Calculations** at the end of this section for a step-by-step procedure to determine runoff volumes.

Hydrologic Soil Groups

Soil properties influence the process of generating runoff from rainfall and must be considered in methods of runoff estimation. When runoff from individual storms is the major concern, the properties can be represented by a hydrologic parameter that reflects the minimum rate of infiltration obtained for a bare soil after prolonged wetting. The influences of both the surface and the horizons of the soil are therefore included.

Four hydrologic soil groups are used. The soils are classified on the basis of water intake at the end of long-duration storms occurring after prior wetting, an opportunity for swelling, and without the protective effects of vegetation. In the definitions of the groups that follow, the infiltration rate is the rate at which water enters the soil at the surface and is controlled by surface conditions. The transmission rate is the rate at which the water moves in the soil and is controlled by the horizons.

The hydrologic soil groups, as defined by NRCS soil scientists, are:

Group A.

Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B.

Soils having moderate infiltration rates when thoroughly wetted and consisting of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C.

Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes the downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water infiltration.

Group D.

Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential,

soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

For a full description on soil type see the MDEQ document, **Computing Flood Discharges for Small Ungaged Watersheds** by Richard Sorrell. For a list of acceptable curve numbers adapted from TR-55 see Table 4.

Land Cover Types

In the NRCS method of runoff estimation, the effects of the surface conditions of watershed are evaluated by means of land cover and land treatment classes. Land cover is the watershed cover and it includes every kind of vegetation, litter and mulch, fallow (bare soil) as well as non-agricultural uses such as water surfaces (lakes, wetlands, etc.) and impervious surfaces, such as roads, roofs, etc.

Land treatment applies mainly to agricultural land uses and includes mechanical practices such as contouring and terracing and management practices like grazing control and crop rotation. The classes consist of cover and treatment combinations actually to be found on watersheds.

For a full description on land cover types and the associated curve numbers see MDEQ document, **Computing Flood Discharges for Small Ungaged Watersheds** by Richard Sorrell.

3. RUNOFF DETERMINATION – COMPUTER BASED METHODS

More precise methodologies for predicting runoff, such as runoff hydrographs, are widely available, and may be required by the Water Resources Commissioner for sizing the drainage systems on large sites and/or smaller sites that are deemed potentially problematic. It is in the applicant's best interest to discuss acceptable alternatives for these or other unusual situations prior to site layout calculations. Acceptable alternative methods may include:

- U.S. Army Corps of Engineers HEC-HMS
- Natural Resources Conservation Service WinTR-20 and WinTR-55
- U.S. EPA's Stormwater Management Model (SWMM)
- Continuous Simulation (HSPF)
- Source Loading and Management Model (SLAMM_r)

Unless a continuous simulation approach to drainage system hydrology is used, all design rainfall events will be based on the NRCS Type II distribution, with an antecedent moisture

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Table 4. Commonly used curve numbers (CNs) from TR-55 (AMC2)

Cover Description	Curve Numbers for Hydrologic Soil Group			
	A	B	C	D
Cover Type and Hydrologic Condition	A	B	C	D
<i>Fully developed urban areas (vegetation established)</i>				
Open space (lawns, parks, golf course, cemeteries, etc):				
Poor condition (grass cover <50%)	68	79	86	89
Fair conditions (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Impervious areas:				
Paved parking lots, roofs, driveways, etc. (excluding right-of-ways)	98	98	98	98
Streets and Roads:				
Paved; curbs and storm sewers (excluding right-of-way)	98	98	98	98
Paved; open ditches (including right-of-way)	83	89	92	93
Gravel (including right-of-way)	76	85	89	91
Pasture, grassland or range - continuous forage for grazing				
Poor	68	79	86	89
Fair	49	69	79	84
Good	39	61	74	80
Meadow- continuous grass, protected from grazing and generally mowed for hay				
	30	58	71	78
Brush - brush-weed-grass mixture with brush the major element				
Poor	48	67	77	83
Fair	35	56	70	77
Good	30	48	65	73
Woods - grass combination (orchard or tree farm)				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods				
Poor	45	66	77	83
Fair	36	60	73	79
Good	30	55	70	77
Farmsteads- buildings, lanes, driveways and surrounding lots				
	59	74	82	86

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condition 2 (AMC 2). Computations of runoff hydrographs that do not rely on a continuous accounting of antecedent moisture conditions will assume a conservative wet antecedent moisture condition.

Computer programs such as HEC-HMS and NRCS UD-21 as well as MDEQ permit applications and other relevant information can be downloaded from the MDEQ website. **See Worksheets 1 through 12** for more information to determine the proposed development site runoff volume.

Note: Often a single, area-weighted curve number is used to represent a watershed consisting of multiple land cover types with different curve numbers. While this approach is acceptable if the curve numbers are similar, if the difference in curve numbers is more than 5, the use of weighted curve number will significantly reduce the estimated amount of runoff from the watershed. This is especially problematic with pervious/impervious combinations: “combination of impervious areas with pervious areas can imply a significant initial loss that may not take place.” (NRCS, 1986) Therefore, the runoff from different land cover types must be calculated separately and then combined. At a minimum, runoff volume from pervious and directly connected impervious areas should be estimated separately for storms less than approximately 4 inches (New Jersey Department of Environmental Protection, 2004 and Pennsylvania Department of Environmental Quality, 2006). When impervious areas are effectively disconnected from the drainage system, some runoff can be absorbed by pervious surfaces. To account for this, the Worksheets at the end of this section include credits for disconnection.

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Part C. COMPUTATIONAL REQUIREMENTS – STRUCTURAL CREDITS

The following structural Best Management Practices (BMP) can be utilized to reduce the amount of detention/retention required. In addition, bioretention, rain gardens, porous pavement, infiltration basins, subsurface infiltration beds, infiltration trenches, vegetated swales, dry wells, green roofs and water reuse can all be used to meet some or all of the first flush/bankfull infiltration requirement for sites with A, B and some C soil types. **See Chapter V, Design Requirements for Stormwater Management Systems and Section V, Part D, Item 2, Soil Infiltration Testing Guidelines. Refer to Worksheets 1 through 12** at the end of this section to calculate the runoff volumes and credits associated with structural BMPs.

For the purposes of site suitability, areas with tested soil infiltration rates as low as 0.1 inches per hour may be used for infiltration BMPs. However, in the design of these BMPs and the sizing of the BMP, the designer should incorporate a safety factor. A safety factor of two (2) must be used in the design of stormwater infiltration systems. Therefore a measured infiltration rate of 0.5 inches per hour should generally be considered as a rate of 0.25 inches per hour in design.

Infiltration systems can be modeled similarly to traditional detention basins. The marked difference with modeling infiltration systems is the inclusion of the infiltration rate, which can be considered as another outlet. For modeling purposes, it is convenient to develop infiltration rates that vary (based on the infiltration area provided as the system fills with runoff) **See Section 5, Part D, Item 5, Infiltration BMP Guidelines.**

BIORETENTION BASINS & RAIN GARDENS

(can be used to meet infiltration and storage requirements)

Infiltration Area Calculation

The Infiltration Area is the bottom area of a Bioretention Basin or Rain Garden defined as:

$$\frac{(\text{Area of Bioretention Basin or Rain Garden at Ponding Depth} + \text{Area of Bioretention Basin or Rain Garden at Bottom})}{\text{Divided by two}} = \text{Infiltration Area (Average Area)}$$

This is the area to be considered when evaluating the Loading Rate to the Bioretention Basin or Rain Garden.

Note: The Infiltration Period for infiltration BMPs is the time during which the bed is receiving runoff and is capable of infiltrating at the design rate. The infiltration period has been conservatively estimated as 6 hours.

Volume Reduction Calculations

The storage volume of a Bioretention Basin or Rain Garden is defined as the sum total of the surface and subsurface void volumes beneath the level of discharge invert. Inter-media void volumes may vary considerably based on design variations.

The volume of a Bioretention Basin or Rain Garden has three components:

1. Surface Storage Volume (ft³) = Bed Area (ft²) x Maximum Design Water Depth (ft)
2. Soil Storage Volume (ft³) = Length (ft) x Width (ft) x Depth (ft) x Void Ratio of Storage Material (%)
3. Infiltration Volume (ft³) (using 6 hours for infiltration credit)

$$\text{Total Bioretention Basin or Rain Garden Volume (ft}^3\text{)} = \text{Surface Storage Volume (ft}^3\text{)} + \text{Subsurface Storage} + \text{Infiltration Volume (ft}^3\text{)}$$

POROUS PAVEMENT

(can be used to meet infiltration and storage requirements)

Infiltration Area Calculations

The minimum infiltration area must be based on the following equation:

$$\text{Minimum Infiltration Area} = \frac{\text{Contributing impervious area (including pervious pavement)}}{5^*}$$

**The denominator or minimum infill area may be increased at the discretion of the Water Resources Commissioner depending on soil infiltration rate, e.g. where soils are Type A (rapidly draining).*

Volume Reduction Calculations

$$\text{Runoff volume} = \text{Depth}^* (\text{ft}) \times \text{Area} (\text{ft}^2) \times \text{Void Space (i.e. 0.30 maximum for aggregate)}$$

**Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.*

$$\text{Infiltration Volume (ft}^3\text{)} = \text{Bed bottom area (ft}^2\text{)} \times [\text{Infiltration design rate (in/hr)} \times \text{Infiltration period}^* (6\text{hr})] \times (1/12\text{'})$$

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INFILTRATION BASINS, TRENCHES AND SUBSURFACE BEDS

(can be used to meet infiltration and storage requirements)

Infiltration Area Calculations

The minimum infiltration area must be based on the following equation:

$$\text{Minimum surface area} = \text{Contributing impervious area} / 5^*$$

*May be increased at the discretion of the Water Resources Commissioner depending on soil infiltration rate, e.g. where soils are Type A (rapidly draining).

Volume Reduction Calculations

The following equation can be used to determine the approximate storage volume of an Infiltration Basin:

$$\text{Storage Volume (ft}^3\text{)} = \text{Average bed area (ft}^2\text{)} \times \text{Maximum design water depth (ft)}$$

$$\text{Subsurface storage/infiltration bed volume (ft}^3\text{)} = \text{Infiltration area (ft}^2\text{)} \times \text{Depth of underdrain material (ft)} \times \text{Void ratio of storage material used (\%)}$$

* Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.

$$\text{Infiltration Volume (ft}^3\text{)} = \text{Bed bottom area (ft}^2\text{)} \times [\text{Infiltration design rate (in/hr)} \times \text{Infiltration period}^* \text{ (6hr)}] \times (1'/12'')$$

DRY WELLS

(can be used to meet infiltration and storage requirements)

Infiltration Area

A Dry Well may consider both bottom and side (lateral) infiltration according to design.

Volume Reduction Calculations

The storage volume of a Dry Well is defined as the volume beneath the discharge invert. A Dry Well storage area must dewater within 48 hours of a storm event based on infiltration rates from field testing. The following equation can be used to determine the approximate storage volume of an aggregate Dry Well:

$$\text{Storage Volume} = \text{Dry well area (ft}^2\text{)} \times \text{Dry well water depth (ft)} \times 30\% \text{ (filled with open-graded stone)}$$

*Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.

$$\text{Infiltration Volume (ft}^3\text{)} = \text{Bed bottom area (ft}^2\text{)} \times [\text{Infiltration design rate (in/hr)} \times \text{Infiltration period}^* \text{ (6hr)}] \times (1'/12'')$$

BIOSWALE

(can be used to meet infiltration requirements)

Volume Reduction Calculations

If check dams are utilized within the Bioswale, the volume behind each check dam can be estimated from the following:

$$\text{Storage Volume (ft}^3\text{)} = 0.5 \times (\text{Length of Swale Impoundment Area per Check Dam}) \times (\text{Depth of Check Dam}) \times [(\text{Top Width of Check Dam}) + (\text{Bottom Width of Check Dam})] / 2$$

GREEN ROOFS

(can be used to meet infiltration and storage requirements)

Volume Reduction Calculations

Green roof covers may have both retention and detention volume components. The effectiveness of green roof covers will vary according to the design and the regional pattern of rainfall and will require local weather data for calculations. The green roof runoff credit will be determined by subtracting the difference between a standard roof and the proposed green roof runoff volumes.

Peak Rate Mitigation

Vegetated roof covers have a large influence on runoff peak rates derived from roofs. A general rule for vegetated roof covers is that rate of runoff from the covered roof surface will be less than or equal to that of open space on typical soils (i.e. NRCS curve number of about 65) for storm events with total rainfall volumes up to 3 times the maximum media water retention assembly.

WATER REUSE

(can be used to meet infiltration and storage requirements)

Volume Reduction

After water need is determined, use Table 2 to choose which structure will be large enough to contain the amount of water to be reused. The amount stored in the container is equal to the volume reduction. Where containers are used, the plans must list the volume for each container and show the connection point, for field verification. Approximated storage volumes can be estimated as:

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Table 2

Container	Volume
Rain Barrel	40-75 Gallons each
Cistern/ Above Ground Tank	200-12,000 Gallons

Peak Rate Mitigation

Overall, capture and reuse takes a volume of water out of site runoff and puts in back into the ground. This reduction in volume will translate to a lower overall peak rate for the site.

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Part D.

COMPUTATIONAL REQUIREMENTS - NON-STRUCTURAL CREDITS OR “SELF-CREDITING” BMPS

The use of Non-Structural BMPs is an important part of project’s stormwater management system and deserves to be properly credited in the calculation process. However, these Non-Structural BMPs must be correctly implemented to be effective. The use of these calculation credits for Non-Structural BMPs must be documented fully to the WCWRC.

The following Non-Structural BMPs are “self-crediting” in that the use of these BMPs automatically provides a reduction in impervious area and/or stormwater runoff (e.g., smaller curve number) and a corresponding reduction in the stormwater management requirements set forth by these Rules. When “self-crediting” BMPs are applied on a site, **the land cover area is not considered in the calculations** as a runoff contributor, therefore reducing the required amount of infiltration and/or storage. Additionally, the use of these BMPs may be affected by other regulations/guidance (Master Plans, zoning, subdivision, etc.).

These BMPs are strongly encouraged:

- Protect Natural/Special Value Features
- Protect/Conserve/Enhance Riparian Areas
- Protect/Utilize Natural Flow Pathways
- Preserve Open Space (e.g. clustering)
- Reduce Street Width/Area
- Reduce Parking Width/Area

Although these BMPs are self-crediting and are not further elaborated in these recommended procedures, **Worksheet 11, Natural Resources Inventory** have been provided and should be completed by applicants when these self-crediting BMPs are being proposed.

The following Non-Structural BMPs provide a quantitative stormwater benefit and are strongly recommended in addition to the aforementioned “self-crediting” Non-Structural BMPs.

- Minimize Disturbed Area
- Protection of Existing Trees (part of minimizing disturbance)
- Re-Vegetate and Re-Forest Disturbed Areas
- Rooftop Runoff (downspout) Disconnection
- Disconnection of Impervious Areas (Non-Roof)

For calculating volume peak rate reductions due to these non-structural BMPs, the NRCS method must be used in all cases except “Minimize Disturbed Area”, which may be used with both the Rational method and the NRCS method.

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Part E.

STANDARD METHOD RUNOFF VOLUME WORK SHEETS

W1

Determining Post-Development Cover Types, Areas, Curve Numbers, and Runoff Coefficients

Total Site Area = _____ ac

Total Site Area Excluding "Self- Crediting" BMPs = _____ ac^A

Rational Method Variables^B

Cover Type	Soil Type	Area (ft ²)	Area(ac)	Runoff Coefficient (c)	(C) (Area)

Total - $\sum(C)(Area) =$ _____
 Area Total - $\sum ac$ or $\sum sf =$ _____
 Weighted C - $\sum(C)(Area) / \sum ac$ or $\sum sf =$ _____

NRCS Variables^C

Pervious Cover Type	Soil Type	Area (ft ²)	Area(ac)	Curve Number	(CN) (Area)

Total - $\sum(CN)(Area) =$ _____
 Area Total - $\sum ac$ or $\sum sf =$ _____
 Weighted CN - $\sum(CN)(Area) / \sum ac$ or $\sum sf =$ _____

NRCS Variables^C

Impervious Cover Type	Soil Type	Area (ft ²)	Area(ac)	Curve Number	(CN) (Area)

Total - $\sum(CN)(Area) =$ _____
 Area Total - $\sum ac$ or $\sum sf =$ _____
 Weighted CN - $\sum(CN)(Area) / \sum ac$ or $\sum sf =$ _____

^A Use this area for the remainder of the runoff calculations
^B Required for first flush runoff calculations
^C Required for bankfull and 100-year runoff calculations

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W2

Standard Method Runoff Volume Calculations

First Flush Runoff Calculations (V_{ff})

A.

$$V_{ff} = (1") \left(\frac{1'}{12"} \right) \left(\frac{43560 ft^2}{1 ac} \right) AC$$

$$V_{ff} = (1") \left(\frac{1'}{12"} \right) \left(\frac{43560 ft^2}{1 ac} \right) (_____) (_____)$$

$$V_{ff} = _____ ft^3$$

A = Total Site Areas (ac) excluding "Self-Crediting" BMPs from Worksheet 1

C = Weighted Runoff Coefficient from Worksheet 1

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W3

Standard Method Runoff Volume Calculations

Pre-development Bankfull Runoff Calculations (V_{bf-pre})

A.

2 year/24 hour storm event

$$P = 2.35 \text{ in}$$

B.

The pre-development land cover will be **Good Cover Woods** or **Meadow**. Determine the associated soil hydrologic group for the entire site and choose the curve number.

$$CN = \underline{\hspace{2cm}}$$

C.

$$S = \frac{1000}{CN} - 10$$

$$S = \frac{1000}{\underline{\hspace{1cm}}} - 10$$

$$S = \underline{\hspace{2cm}} \text{ in}$$

D.

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)}$$

$$Q = \frac{(2.35-(0.2)(\underline{\hspace{1cm}}))^2}{(2.35+(0.8)(\underline{\hspace{1cm}}))}$$

$$Q = \underline{\hspace{2cm}} \text{ in}$$

E.

Total Site Area (sf) excluding "Self- Crediting" BMPs

$$\text{Area} = \underline{\hspace{2cm}} \text{ sf}$$

F.

$$V_{bf-pre} = Q \left(\frac{1}{12} \right) \text{Area}$$

$$V_{bf-pre} = (\underline{\hspace{1cm}}) \left(\frac{1}{12} \right) (\underline{\hspace{1cm}})$$

$$V_{bf-pre} = \underline{\hspace{2cm}} \text{ ft}^3$$

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W4

Standard Method Runoff Volume Calculations

Pervious Cover Post-Development Bankfull Runoff Calculations ($V_{bf-per-post}$)

A.

2 year/24 hour storm event

$$P = 2.35in$$

B.

Pervious Cover CN From Worksheet 1

$$CN = \underline{\hspace{2cm}}$$

C.

$$S = \frac{1000}{CN} - 10$$

$$S = \frac{1000}{\underline{\hspace{2cm}}} - 10$$

$$S = \underline{\hspace{2cm}} in$$

D.

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)}$$

$$Q = \frac{(2.35-(0.2)(\underline{\hspace{2cm}}))^2}{(2.35+(0.8)(\underline{\hspace{2cm}}))}$$

$$Q = \underline{\hspace{2cm}} in$$

E.

Pervious Cover Area from Worksheet 1

$$Area = \underline{\hspace{2cm}} sf$$

F.

$$V_{bf-per-post} = Q(1/12)Area$$

$$V_{bf-per-post} = (\underline{\hspace{2cm}})(1/12)(\underline{\hspace{2cm}})$$

$$V_{bf-per-post} = \underline{\hspace{2cm}} ft^3$$

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W5

Standard Method Runoff Volume Calculations

Impervious Cover Post-Development Bankfull Runoff Calculations ($V_{bf-imp-post}$)

A.

2 year/24 hour storm event

$$P = 2.35in$$

B.

Impervious Cover CN From Worksheet 1

$$CN = \underline{\hspace{2cm}}$$

C.

$$S = \frac{1000}{CN} - 10$$

$$S = \frac{1000}{\underline{\hspace{2cm}}} - 10$$

$$S = \underline{\hspace{2cm}} in$$

D.

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)}$$

$$Q = \frac{(2.35-(0.2)(\underline{\hspace{2cm}}))^2}{(2.35+(0.8)(\underline{\hspace{2cm}}))}$$

$$Q = \underline{\hspace{2cm}} in$$

E.

Impervious Cover Area from Worksheet 1

$$Area = \underline{\hspace{2cm}} sf$$

F.

$$V_{bf-imp-post} = Q(1/12)Area$$

$$V_{bf-imp-post} = (\underline{\hspace{2cm}}) (1/12)(\underline{\hspace{2cm}})$$

$$V_{bf-imp-post} = \underline{\hspace{2cm}} ft^3$$

Section IV: Computational Requirements For Stormwater Management Systems

W6

Standard Method Runoff Volume Calculations

Pervious Cover Post-Development 100-year Storm Runoff Calculations ($V_{100\text{-per-post}}$)

A.

100-year Storm Event

$$P = 5.11in$$

B.

Pervious Cover CN From Worksheet 1

$$CN = \underline{\hspace{2cm}}$$

C.

$$S = \frac{1000}{CN} - 10$$

$$S = \frac{1000}{\underline{\hspace{1cm}}} - 10$$

$$S = \underline{\hspace{2cm}} in$$

D.

$$Q_{100\text{-per}} = \frac{(P-0.2S)^2}{(P+0.8S)}$$

$$Q_{100\text{-per}} = \frac{(5.11-(0.2)(\underline{\hspace{1cm}}))^2}{(5.11+(0.8)(\underline{\hspace{1cm}}))}$$

$$Q_{100\text{-per}} = \underline{\hspace{2cm}} in$$

E.

Pervious Cover Area from Worksheet 1

$$Area = \underline{\hspace{2cm}} sf$$

F.

$$V_{100\text{-per-post}} = Q(1/12)Area$$

$$V_{100\text{-per-post}} = (\underline{\hspace{1cm}})(1/12)(\underline{\hspace{1cm}})$$

$$V_{100\text{-per-post}} = \underline{\hspace{2cm}} ft^3$$

Section IV: Computational Requirements For Stormwater Management Systems



W7

Standard Method Runoff Volume Calculations

Impervious Cover Post-Development 100-year Storm Runoff Calculations ($V_{100\text{-imp-post}}$)

A.

100-year Storm Event

$$P = 5.11in$$

B.

Impervious Cover CN From Worksheet 1

$$CN = \underline{\hspace{1cm}}$$

C.

$$S = \frac{1000}{CN} - 10$$

$$S = \frac{1000}{\underline{\hspace{1cm}}} - 10$$

$$S = \underline{\hspace{1cm}}in$$

D.

$$Q_{100\text{-imp}} = \frac{(P-0.2S)^2}{(P+0.8S)}$$

$$Q_{100\text{-imp}} = \frac{(5.11-(0.2)(\underline{\hspace{1cm}}))^2}{(5.11+(0.8)(\underline{\hspace{1cm}}))}$$

$$Q_{100\text{-imp}} = \underline{\hspace{1cm}}in$$

E.

Impervious Cover CN From Worksheet 1

$$Area = \underline{\hspace{1cm}}sf$$

F.

$$V_{100\text{-imp-post}} = Q\left(\frac{1}{12}\right)Area$$

$$V_{100\text{-imp-post}} = (\underline{\hspace{1cm}})\left(\frac{1}{12}\right)(\underline{\hspace{1cm}})$$

$$V_{100\text{-imp-post}} = \underline{\hspace{1cm}}ft^3$$

Section IV: Computational Requirements For Stormwater Management Systems



W9

Standard Method Runoff Volume Calculations

Runoff Summary & Onsite Infiltration Requirement

A. Runoff Summary from Previous Worksheets

First Flush Volume (V_{ff}) _____ ft³

Pre-Development Bankfull Runoff Volume (V_{bf-pre}) _____ ft³

Pervious Cover Post-Development Bankfull Volume ($V_{bf-per-post}$) _____ ft³

Total BF Volume ($V_{bf-post}$)

Impervious Cover Post-Development Bankfull Volume ($V_{bf-imp-post}$) _____ ft³

_____ ft³

Pervious Cover Post-Development 100-year Volume ($V_{100-per-post}$) _____ ft³

Total 100-year Volume (V_{100})

Impervious Cover Post-Development 100-year Volume ($V_{100-imp-post}$) _____ ft³

_____ ft³

B. Determine Onsite Infiltration Requirement

Subtract the Pre-Development Bankfull from the Post-Development Bankfull volume

Total Post-Development Bankfull Volume ($V_{bf-post}$) _____ ft³

Pre-Development Bankfull Runoff Volume (V_{bf-pre}) _____ ft³

Bankfull Volume Difference _____ ft³

Compare the Bankfull Volume Difference with the First Flush Volume. The **greater** of the two is the Onsite Infiltration Requirement.

Onsite Infiltration Requirement (V_{inj}) _____ ft³

Section IV: Computational Requirements For Stormwater Management Systems

W₁₀

Standard Method Runoff Volume Calculations

Detention/Retention Requirement

Detention

A. $Q_p = 238.6 T_c^{-0.82}$ $Q_p = 238.6(\text{---})^{-0.82}$
 Peak of the Unit Hydrograph $Q_p = \text{---} \text{ cfs/in-mi}^2$

B. Total Site Area (ac) excluding "Self-Crediting" BMPs Area = ac

C.
 $Q_{100} = Q_{100\text{-per}} + Q_{100\text{-imp}}$ $Q_{100} = \text{---} + \text{---}$
 Note: $Q_{100\text{-per}}$ and $Q_{100\text{-imp}}$ from W6 and W7, respectively $Q_{100} = \text{---} \text{ in}$

D. Peak Flow (PF) = $\frac{Q_p \left(\frac{\text{cfs}}{\text{in-mi}^2} \right) Q_{100}(\text{in}) \text{Area}(\text{ac})}{640}$ $PF = \frac{(\text{---})(\text{---})(\text{---})}{640}$
 $PF = \text{---} \text{ cfs}$

E. $\Delta = PF \text{ (cfs)} - 0.15 \text{ Area}(\text{ac})$ $\Delta = (\text{---}) - 0.15 (\text{---})$
 $\Delta = \text{---} \text{ cfs}$

F. $V_{\text{det}} = \frac{\Delta \text{ (cfs)}}{PF \text{ (cfs)}} V_{100} \text{ (ft}^3\text{)} - V_{\text{inf}} \text{ (ft}^3\text{)}$ $V_{\text{det}} = \frac{(\text{---})}{(\text{---})} (\text{---}) - (\text{---})$
 $V_{\text{det}} = \text{---} \text{ ft}^3$
 $V_{\text{det}} = \text{Required Detention (ft}^3\text{)}$

Retention

A. $V_{\text{ret}} = 2(V_{100})$ $V_{\text{ret}} = 2(\text{---})$
 $V_{\text{ret}} = \text{---} \text{ ft}^3$

Section IV: Computational Requirements For Stormwater Management Systems



W11

Standard Method Runoff Volume Calculations

Determine Applicable BMPs and Associated Volume Credits

Proposed BMP ^A	Area (ft ²)	Storage Volume ^B (ft ³)	Ave. Design Infiltration Rate (in/hr)	Infiltration Volume During Storm ^C (ft ³)	Total Volume Reduction ^D (ft ³)
Porous Pavement w/Infiltration Bed					
Infiltration Basin					
Subsurface Infiltration Bed					
Infiltration Trench					
Rain Garden/Bioretention					
Dry Well					
Bioswale					
Vegetated Filter Strip					
Green Roof					

Total Volume Reduction Credit by Proposed Structural BMPs (ft³) _____

Runoff Volume Infiltration Requirement (V_{inf}) from Worksheet 9 - _____

Runoff Volume Credit (ft³) = _____

^A Complete checklist from Chapter VI for each Structural BMP type
^B Storage volume as defined in individual BMP write-ups
^C Approximated as the average design infiltration rate over 6 hours multiplied by the BMP area:
 Infiltration Rate x 6 hours x BMP Area x Unit Conversions = Infiltration Volume (ft³)
^D Total Volume Reduction Credit is the sum of the Storage Volume and the Infiltration Volume During Storm

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W₁₂

Natural Features Inventory

1. Provide Natural Resources Map. This map should identify waterbodies, floodplains, riparian areas, wetlands, woodlands, natural drainage ways, steep slopes and other natural features.
2. Summarize the existing extent of each natural resource in the Existing Natural Resources Table.
3. Summarize total proposed Protected/Undisturbed Area.
4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once (include as either floodplain or wetland, not both).

Existing Natural Resources	Mapped (yes, no, n/a)	Total Area (ac)	Protected/Undisturbed Area (ac)
Waterbodies			
Floodplains			
Riparian Areas			
Wetlands			
Woodlands			
Natural Drainage Area			
Sleep Slopes, 15%-25%			
Steep Slopes, over 25%			
Special Habitat Areas			
Other			
TOTAL EXISTING (ac)			

Section IV: Computational Requirements For Stormwater Management Systems



Acceptable Curve Numbers and Runoff Coefficients for Stormwater Calculations

	Cover Description	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Commonly Used Curve Numbers (from TR-55; AMC2)	Cover Type and Hydrologic Condition				
	<i>Fully developed urban areas (vegetation established)</i>				
	Open space (lawns, parks, golf course, cemeteries, etc):				
	Poor condition (grass cover <50%)	68	79	86	89
	Fair conditions (grass cover 50% to 75%)	49	69	79	84
	Good condition (grass cover >75%)	39	61	74	80
	Impervious areas:				
	Paved parking lots, roofs, driveways, etc. (excluding right-of-ways)	98	98	98	98
	Streets and Roads:				
	Paved; curbs and storm sewers (excluding right-of-way)	98	98	98	98
	Paved; open ditches (including right-of-way)	83	89	92	93
	Gravel (including right-of-way)	76	85	89	91
	Pasture, grassland or range - continuous forage for grazing				
	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
	Meadow- continuous grass, protected from grazing and generally mowed for hay	30	58	71	78
	Brush - brush-weed-grass mixture with brush the major element				
	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
	Woods - grass combination (orchard or tree farm)				
	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
	Woods				
	Poor	45	66	77	83
	Fair	36	60	73	79
Good	30	55	70	77	
Farmsteads- buildings, lanes, driveways and surrounding lots	59	74	82	86	
Wetlands					
No standing water that contributes to runoff	78	78	78	78	
With standing water	98	98	98	98	

	Type of Surface	Runoff Coefficient		
		Slope <4%	Slope 4-8%	Slope >8%
Commonly Used Runoff Coefficients	Water Surfaces	1.00		
	Roofs	0.95		
	Asphalt or concrete pavements	0.95		
	Gravel, brick or macadam surfaces	0.85		
	Semi-pervious: lawns, parks, playgrounds			
	Hydrologic Soil Group A	0.15	0.20	0.25
	Hydrologic Soil Group B	0.25	0.30	0.35
	Hydrologic Soil Group C	0.30	0.35	0.40
	Hydrologic Soil Group D	0.45	0.50	0.55

Section IV: Computational Requirements For Stormwater Management Systems

Part E

COMPUTATIONAL REQUIREMENTS – CONVEYANCE SYSTEMS

1. FLOW DETERMINATION

Acceptable methods of determining the flow rate required to size storm piping systems, open channels and culverts are listed below. The proprietor’s engineer may use any of the methods listed or another if approved by the Water Resources Commissioner:

- Rational method (maximum drainage area of 120 acres)
- USDA NRCS Curve Number Method
- The Michigan Department of Environmental Quality (MDEQ) *Computing Flood Discharges at Small Ungaged Watersheds* method

The rational method of calculating stormwater runoff is generally acceptable for highly impervious sites less than 120 acres in size. However, it may not be considered an adequate design tool for sizing large drainage systems.

The Rational Formula is outlined as follows:

Where:

- Q_p= peak runoff rate (cfs)
- C= the runoff coefficient of the area
- I = the average rainfall intensity (in/hr) for a storm with a duration equal to the time of concentration of the area
- A = the size of the drainage area (acres)

Table 6. Runoff Coefficients

Type of Surface	Runoff Coefficient		
Water Surfaces	1.00		
Roofs	0.95		
Asphalt or concrete pavements	0.95		
Gravel, brick or macadam surfaces	0.85		
Semi-pervious: lawns, parks, playgrounds	Slope <4%	Slope 4-8%	Slope >8%
Hydrologic Soil Group A	0.15	0.20	0.25
Hydrologic Soil Group B	0.25	0.30	0.35
Hydrologic Soil Group C	0.30	0.35	0.40
Hydrologic Soil Group D	0.45	0.50	0.55

All composite runoff coefficients must be based on the values shown in the Table 6 below. The slopes listed for the semi-pervious surfaces are the proposed finished slope of the tributary area. Rainfall intensities for Washtenaw County are outlined as follows in Table 7.

Table 7. Intensity Formulas (24 hour storms)

Recurrence Interval	Rainfall Intensity
1 yr	72/(T+25)
5 yr	145/(T+25)
10 yr	175/(T+25)
25 yr	215/(T+25)
50 yr	245/(T+25)
100 yr	275/(T+25)

Manning’s formula shall be used to size the open channel or pipe system in most cases. In situations where a backwater condition exists, the Standard Backwater procedure or other method acceptable to the WCWRC must be used.

Manning’s formula is outlined as follows:

EQUATION

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

A minimum “n” of 0.035 will be used for the roughness coefficient for open channels. See Table 8 below for roughness coefficients, or contact WCWRC about unusual situations.

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3. OPEN CHANNELS

Streams, drains and other open channels will be expected to withstand all events (capacity and stability) up to the 10-year flow without increased erosion or deposition. Open channel velocities will neither be erosive nor cause siltation. Modifications to an Inland Lake or Stream, as defined by the MDEQ, will require a permit from the MDEQ and must be designed and constructed as per MDEQ requirements. Specific requirements for the sizing of created open channel conveyance systems (swales, ditches, drains) are as follows:

- The minimum acceptable average channel velocity for the design storm will be 2.0 ft/sec, and the maximum acceptable velocity will be 6.0 ft/sec.
- Sheer stress on the channel bed and banks shall be taken into account.
- Vegetation establishment with native plants is preferred over “lawn” type grasses. Open channels shall be designed as per the FHWA’s, Design of Roadside Channels with Flexible Linings (HEC No. 15) or per other methods approved by the Water Resources Commissioner.
- Riprap shall be used where necessary and shall be designed to be stable for the 10-year flow rate. Computations must be provided to demonstrate riprap stability and be based on applicability to the specific situation. Riprap stability computational procedures are provided in the FHWA publications HEC No. 15 (Design of Roadside Channels with Flexible Linings), HEC No. 14 (Hydraulic Design of Energy Dissipators for Culverts and Channels) and HEC No. 11 (Design of a Riprap Revetment) and the NRCS National Engineering Handbook, Part 654.

4. ENCLOSED DRAINS & PIPING SYSTEMS

Enclosed drains and piping systems shall be designed for the 10-year flow. Specific requirements for the sizing of enclosed systems are as follows:

- Enclosed storm drains and piping systems will be sized to accommodate the 10-year flow, with the hydraulic gradient maintained below the top of the pipe.
- In a situation where a piping system outlets to a detention or retention facility, the 2-year recurrence interval pond water surface elevation must be used for the starting water surface elevation in the 10-year recurrence interval pipe capacity computations.
- Catch basin or inlet covers must be designed to accept the 10-year design storm while maintaining spread to the curb gutter section, or as required by the agency regulating the roadway (MDOT, WCRC, etc.)
- Pipe full flowing velocity will be greater than 3 ft/sec and less than 10 ft/sec.
- Pipe inverts will be such that all selections drain completely during dry weather.

5. CULVERT SIZING

Under Michigan State Law, Part 31, Water Resources Protection of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, crossroad culverts draining areas of two square miles or greater must be reviewed and approved by the MDEQ.

Culverts draining an area of two (2) square miles or greater of upstream watershed will be sized by the proprietor’s engineer and approved by the MDEQ, Washtenaw County Road Commission (if applicable) and Washtenaw County Water Resources Commissioner.

Table 8. Manning Roughness Coefficients for Various Surfaces

Boundary Material	n value	Boundary Material	n value
HDPE pipe, smooth lined	0.011	Brick	0.016
Concrete pipe	0.013	Riveted steel	0.018
Vitrified clay pipe	0.014	Rubble	0.025
Cast iron pipe	0.015	Gravel	0.029
HDPE pipe, unlined	0.018	Riprap	0.033
Finished concrete	0.012	Natural channels with stones & weeds	0.035
Planed wood	0.012	Natural channels in poor condition	0.060
Unplaned wood	0.013	Natural channels with heavy brush	0.100
Unfinished concrete	0.014		

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Specific requirements for the sizing of culverts are as follows:

- a. At a minimum, culverts will be designed to convey the peak 10-year storm flow with the velocity not exceeding 8 ft/sec.
- b. The 100-year recurrence interval storm must pass the embankment with no adverse increase in water elevation occurring off of the site or flooding of structures within the proposed development. A minimum of one foot of freeboard is required.
- c. The discharge velocity from culverts should consider the effect of high velocities, eddies, or other turbulence on the natural channel, downstream property and roadway embankment.
- d. The culvert exit velocity shall not cause downstream channel erosion or scour.
- e. Sizing of culvert crossings will consider entrance and exit losses as well as tailwater conditions on the culvert. Once the design flow is determined, the required size of the culvert will be determined by one of the following methods, as applicable to the situation:
 - “Mannings” formula
 - Inlet headwater control/outlet tailwater control nomographs (FHWA, Hydraulic Design of Highway Culverts (Hydraulic Design Series No. 5))
 - FHWA’s HY-8 computer program
 - ACOE’s HEC-RAS computer program
 - Other methods approved by the Water Resources Commissioner
- f. The maintenance plan for the stormwater system shall include inspection and maintenance of culverts, wingwalls, headwalls, and other appurtenances along with vegetation management and erosion management (including scour) within 20 feet of the inlet and outlet. No tree growth shall be permitted in these areas.

6. REQUIREMENTS – MDEQ

For sites that impact streams with upstream watersheds equal to or greater than two (2) square miles, approval by the MDEQ is required, pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The MDEQ will compute the runoff rate at no charge. The MDEQ requires applicants to use the UD-21 method by NRCS in lieu of the rational method. This method was developed for small watersheds by NRCS, and can be used for watersheds up to 10 square miles.

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Section V: Design Requirements For Stormwater Management Systems

Part A.

PURPOSE & INTRODUCTION

Both onsite water quantity and quality must be managed to control flooding, reduce downstream erosion and protect water quality. Infiltration will be required for the difference between the pre-development bankfull flood and the proposed post development bankfull flood or the first flush volume, whichever is greater. To manage that portion of proposed runoff that is not managed through infiltration or other upline BMPs, detention basins must be designed to capture and treat up to a 100-year recurrence interval storm event. Retention basins with no outlet will be capable of storing two consecutive 100-year recurrence interval storms.

In developments that have county drainage districts and drains established, the maintenance of standard stormwater infrastructure and stormwater BMPs is the responsibility of the governing association of the development. In the event that the governing association does not complete the required maintenance, the Water Resources Commissioner will complete maintenance that is deemed necessary to assure appropriate operation of the stormwater system. Maintenance that is required solely for aesthetic purposes will not be completed by the Water Resources Commissioner.

1. EASEMENTS

Wording relative to easements will be specifically required by the Water Resources Commissioner. If a county drain is to be established under the Michigan Drain Code, related easement language will be depicted on final plats and condominium Exhibit B drawings (in pdf format) as follows: “ __ foot wide private easement to Washtenaw County Water Resources Commissioner and the ____ Homeowner’s (or Condominium) Association for drainage.”

The typical easement language specified in **Appendix I** will be included in the subdivision deed restrictions or condominium master deed. The location and purpose of drainage easements should be clearly described in subdivision deed restriction or condominium master deeds. Language will be included within the subdivision deed restriction or condominium master deed that clearly notifies property owners of the presence of stormwater management facilities and accompanying easements, as well as restrictions on the use or modification of these areas.

Easement widths will be determined by the Water Resources Commissioner and be situated in such a way as to allow

maximum maintenance access, for example, offsetting them from the centerline. In general, easement widths will conform to the following:

- a. Open channels and watercourses: A minimum of 50 feet total width. Additional width may be required in some cases, including by not limited to: watercourse with floodplains delineated by FEMA; sandy soils, steep slopes, at access points from road crossings.
- b. Open swales (cross lot drainage): minimum of 30 feet total width.
- c. Enclosed storm drains: A minimum of 20 feet will be required, situated in such a way as to allow maximum maintenance access. Additional width will be required in some cases. These may include but are not limited to, pipe depths exceeding 4 feet from the top of pipe, sandy soils and steep slopes.
- d. Retention/detention basins or other stormwater management facilities will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, spoils, deposition and other activities identified in the development’s stormwater management plan.

Drain fields (septic areas) must not be located within drainage easements.

2. MAINTENANCE

Stormwater Management System Maintenance Plans

Maintenance plans will be submitted with all construction plans and included in the subdivision agreement or master deed documents of all subdivisions and site condominiums. These plans must include the following information:

- a. An annual maintenance budget itemized in detail by task. The financing mechanism must also be described.
- b. A copy of the final approved drainage plan for the development that delineates the facilities and all easements, maintenance access, and buffer areas.
- c. A listing of appropriate tasks defined for each component of the system, and a schedule for their implementation. The following areas will be covered:
 - i. Maintenance of facilities such as pipes, channels, outflow control structures, infiltration devices and other structures.
 - ii. Debris removal from catch basins, channels and basins.
 - iii. Dredging operations for both channels and basins to remove sediment accumulation. Stormwater system maintenance plans must require sediment removal when sediment reaches a depth of equal to 50% of the

Section V: Design Requirements For Stormwater Management Systems



depth of the forebay or 12 inches, whichever is less.

- d. The party responsible for performing each of the various maintenance activities described will be recorded with final approved plans and plats.
- e. A detailed description of the procedure for both preventative and corrective maintenance activities. The preventative maintenance component will include:
 - i. Periodic inspections (at least annually), adjustments and replacements.
 - ii. Record-keeping of operations and expenditures.
- f. Provision for the routine and non-routine inspection of all components within the system:
 - i. Wet weather inspections of structural elements and inspection for sediment accumulation in detention basins must be conducted annually, with as-built plans in hand. Inspections should be carried out by the appropriate party reporting to the responsible agency or owner.
 - ii. Housekeeping inspections, such as checking for trash, should take place at least twice per year.
- g. A description of ongoing landscape maintenance needs. Landscaping must consist of low maintenance and/or native plant species. The proprietor will monitor the viability of plantings for at least one year after establishment and plantings will be replaced as needed. Subsequent monitoring must be conducted by the landowner or development association. The Water Resources Commissioner is not responsible for landscape maintenance.
- h. Provision for the maintenance of vegetative buffers by landowner, development associations, conservation groups or public agencies. Buffers must be inspected annually for evidence of erosion or concentrated flows through or around the buffer.
- i. A sample maintenance plan and annual budget is illustrated in **Appendix K**.

Maintenance Responsibility

- a. Property deed restrictions or condominium master deed documents will specify the entities responsible for inspection and maintenance of the stormwater management facilities and the timeframe for these activities. Primary responsibility will fall upon the Homeowners Association or Condominium Association with a governmental agency having secondary responsibility. The restrictions or documents will also specify that the governmental entity with secondary responsibility may perform inspections and complete maintenance in lieu of the primary when it is found to be necessary and assess costs associated with these activities against the property owners within the subdivision or condominium and other entities as determined

appropriate.

- i. Routine maintenance of stormwater management facilities will be completed per the schedule submitted with the construction plans or within 30 days of receipt of written notification by the responsible governmental entity that action is required, unless other acceptable arrangements are made with the supervising governmental entity.
 - ii. Emergency maintenance will be completed within 36 hours of written notification unless threat to public health, safety and welfare requires immediate action.
- b. For systems with multiple individual users, such as site condominiums or subdivisions, the proprietor may fulfill the obligation to ensure that a governmental entity will be responsible for drainage system maintenance by establishing a county drainage district, or any other similar mechanism approved by the Water Resources Commissioner, to provide for the permanent maintenance of stormwater management facilities and necessary funding.

If a county drain is not established, the proprietor will submit evidence of a legally binding agreement with another governmental agency responsible for maintenance oversight.

- c. A legally binding maintenance agreement will be executed before final project approval is granted. The agreement must be included in the property deed restrictions or condominium master deed documents so that it is binding on all subsequent property owners.

Section V: Design Requirements For Stormwater Management Systems

Part B.

DESIGN REQUIREMENTS NATURAL WETLANDS & FLOODPLAINS

1. WETLANDS

This section governs natural wetlands (as distinct from stormwater wetland systems that are constructed expressly for stormwater management purposes), when a natural wetland is incorporated in an overall stormwater management scheme.

- a. Wetlands will be protected from damaging modification and adverse changes in runoff quality and quantity associated with land developments. Approval of the final plan will be contingent upon securing all necessary wetland permits from MDEQ and local governments.
- b. Direct discharge of untreated stormwater to a natural wetland is prohibited. All runoff from the development will be pre-treated to remove sediment and other pollutants prior to discharge to a wetland. Such treatment facilities will be constructed before property grading begins, and proved to be fully functional prior to acceptance.
- c. Site drainage patterns will not be altered in ways that will modify existing water levels in protected wetlands without proof that all applicable permits from the MDEQ and/or local government agencies have been obtained.
- d. A qualified professional with specific wetland expertise will oversee wetland construction, re-construction, and/or modification, and provide professional certification of construction in accordance with the approved plans..
- e. A fifteen (15) foot permanent buffer strip, vegetated with non-woody plant species, will be maintained or restored around the periphery of wetlands. **See Appendix M, General Guide to Native Plant Species** to begin development of wetland buffer planting plans.
- f. Wetlands shall be protected during construction by appropriate soil erosion and sediment control measures.

2. FLOODPLAINS

- a. All necessary floodplain permits from the MDEQ and local governments must be in place prior to final plan approval.
- b. It is the responsibility of the developer to demonstrate that any activity proposed within a 100-year floodplain will not diminish flood storage capacity.
- c. In certain instances an analysis to determine the 100-year floodplain may be required. Where available, the community flood insurance study shall be used.
- d. Compensatory storage will be required for all lost floodplain storage.
- e. The placement of storage facilities or infiltration BMPs within the 100-year floodplain is prohibited.

Section V: Design Requirements For Stormwater Management Systems



Part C.

DESIGN REQUIREMENTS STORAGE FACILITIES

1. GENERAL REQUIREMENTS

All runoff generated by proposed development surfaces must be conveyed into a stormwater BMP or storage facility for water quality treatment and retention/detention prior to being discharged from the site. The following criteria will apply to the design of all stormwater BMPs, retention and detention facilities.

- a. Utilization of Low Impact Development stormwater BMPs, green roofs, infiltration trenches or water reuse cisterns are preferred options for mitigation. At a minimum, BMPs must be used for infiltration of the first flush or the difference between the pre-development bankfull and the developed bankfull, whichever is the largest calculated runoff volume.
- b. Stormwater must be pre-treated by passage through a sediment forebay prior to entering into retention/detention facilities. Sediment forebays function to reduce incoming water velocity, and to trap and localize incoming sediments making their removal easier during maintenance. Sediment forebays may extend the flow path of stormwater, increasing its residence time. Infiltrating water requires more extensive pre-treatment prior to discharge to an infiltration system. Acceptable pretreatment measures include vegetative channels, vegetative filter strips, filter fabric and/or other methods.
- c. Whereas detention basin design for flood control is concerned with relatively infrequent, severe runoff events, such as the 25-, 50- or 100-year recurrence interval storms, design for water quality benefit is concerned with controlling the more frequent storm events (e.g. 2-year recurrence interval storm or less). The negative impacts of erosive “bankfull” floods are reduced by capturing and detaining the 2-year recurrence interval storm.
- d. Also of importance to water quality is the capture and treatment of the “first flush”, a term used to describe the initial washing action that stormwater has on impervious surfaces. Pollutants that have accumulated on these surfaces are flushed clean by the early stages of runoff, which then carries a shock loading of these pollutants into receiving waterways. The majority of all pollutants that are washed off the land can be removed from stormwater before it leaves the site by capturing and treating the first inch of runoff.

- e. Treatment of the “bankfull” flood and “first flush” may be accomplished via the design of three stage basins (bankfull, first flush and “100-year” recurrence interval storm). These basins control stormwater discharge rates for both extreme events to prevent flooding and more frequent events to mitigate water quality impacts and channel erosion.
- f. Public safety will be a paramount consideration in stormwater system and retention/detention facility design. Providing a safe design for stormwater storage is the engineer’s responsibility. Retention/detention facility designs will incorporate gradual side slopes, vegetative and barrier plantings, and safety shelves. Where further safety measures are required, the proprietor is expected to include them within the proposed development plans.
- g. BMPs and retention/detention facilities must be located on common-owned property in multi-ownership developments such as subdivisions and site condominiums, and not on private lots or condominium units.
- h. For land divisions, the retention/detention system must be located in a drain easement.
- i. When discharge is within a watershed where thermal impacts are a primary concern, deep wet retention/detention facilities or dry retention/detention facilities may be preferred. In addition for extended dry detention/retention facilities, first flush and bankfull requirements may be reduced to twelve (12) hours. **See Section VI, Areas of Special Concern.** Shade plantings on the west and south sides of facilities are encouraged. Infiltration of stormwater must be considered where site conditions allow.
- j. Requirements for stormwater quantity control may be waived with computational justification for developments in the downstream-most locations of a watershed, although quality management will still be necessary. Determinations will be made on an individual site basis. Proposals for waivers must be presented at the pre-application or conceptual design phase.
- k. Additional water quality measures must be installed at sites where land uses are identified as pollutant hotspots. **See Appendix C. Stormwater Pollutant Hotspots.**
- l. An adequate area shall be provided for future temporary staging of spoils from maintenance of storage facilities, prior to ultimate disposal. This area will be protected such that no runoff will be directed back into the stormwater management system or onto private property. For subdivisions and site condominiums, a permanent easement dedicated to the Water Resources Commissioner or other governmental agency with long-term maintenance responsibility must be provided over the staging area.
- m. Where finished grades indicate a substantial amount of drainage across adjoining lots, a drainage swale of sufficient width, depth and slope will be provided on the lot line to intercept this drainage. To ensure that property

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owners do not alter or fill drainage swales, easements will be required over areas deemed necessary by the Water Resources Commissioner, as stipulated in **Section II, Part C, Subsection 3**. Areas within open drain easements that have been cleaned, reshaped or distributed in any manner will be stabilized with appropriate protection and vegetation measures immediately.

2. PROHIBITIONS

- a. Stormwater management systems incorporating pumps are not permitted in developments with multiple owners, such as subdivisions and site condominiums.
- b. In-line detention basins are strongly discouraged in all circumstances, and are prohibited on watercourses greater than 2 square miles upstream or on a county drain. In-line basins are also prohibited if the waterway to be impounded traverses any area outside of the proposed development.
- c. The placement of retention/detention basins within a 100-year floodplain is prohibited.
- d. Storage within regulated local, state or federal wetlands is prohibited.

3. TESTING REQUIREMENTS – DETENTION/RETENTION SYSTEMS

For detention/retention systems, the proprietor must submit a soil boring log, taken within the basin bottom area to a depth of 25 feet below existing ground or 20 feet below proposed basin bottom elevation. Information regarding the seasonal groundwater elevations must also be provided.

4. BASIN INLET/OUTLET DESIGN REQUIREMENTS INLET/OUTLET DESIGN

- a. Outlets must be designed for the protection of the receiving waterway.
- b. Velocity dissipation measures will be incorporated into basin designs to minimize erosion at inlets and outlets, and to minimize the resuspension of pollutants.
- c. The distance between inlets and outlets will be maximized. The length and depth of the flow path across basins and marsh systems can be maximized by:
 - i. Increasing the length to width ratio of the entire design.
 - ii. Increasing the dry weather flow path within the system to attain maximum sinuosity. Inlets and outlets should be offset at opposite longitudinal ends of the basin.
- d. The use of dual outlets, risers, V-notched weirs or other

designs that assure an appropriate detention time from all storm events is required.

- e. Where a pipe outlet or orifice plate is to be used to control discharge, it will have a minimum diameter of 4 inches. If this minimum orifice size permits release rates greater than those specified in these rules, an alternative outlet design that incorporates self-cleaning flow restrictors will be required. Examples include perforated risers and “V” notch orifice plates that provide the required release rate. Calculations verifying this rate will be submitted to the Water Resources Commissioner for approval.
- f. Any backwater effects on the outlet structure caused by the downstream drainage system will be evaluated when designing the outlet.

Riser Design

- a. Inlet and outlet barrels and risers will be constructed of reinforced concrete, corrugated metal or smooth lined corrugated plastic pipe. The minimum diameter for riser pipes is 48”.
- b. Riser pipes must be set into a cast-in-place concrete base or properly grouted to a pre-cast concrete base. All riser pipes constructed of material other than concrete must be set into a cast-in-place base.
- c. All orifice configurations must consist of the minimum number of holes with the largest diameter that meet the detention requirements. The minimum acceptable orifice size is 0.75”.
- d. A gravel filtration jacket consisting of 3” washed stone and 1” washed stone must be placed around all riser pipes. The orifice configuration must be wrapped with hard wire mesh with an appropriate opening size to prevent any stone from passing through the orifice. The 3” stone must be placed immediately adjacent to the riser pipe with the 1” stone covering the larger stone. The gravel jacket must extend sufficiently above all orifice patterns.
- e. Hoods or trash racks must be installed on the riser to prevent clogging. Grate openings must be a maximum of three inches to center.
- f. The riser must be placed near or within the embankment, to provide for ready maintenance access.
- g. Where feasible, a drain for completely de-watering wet retention/detention facilities should be installed for maintenance purposes.
- h. All outlets will be designed to be easily accessible by heavy equipment required for maintenance purposes.

Piping Requirements

- a. Anti-seep collars should be installed on any piping passing through the sides or bottom of the basin to prevent leakage through the embankment.
- b. Pipe inverts will be such that all sections will drain completely during dry weather.

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5. STORAGE FACILITY COMPONENTS & CONFIGURATION

Sediment Forebay

Sediment forebays will be applied at the inlet of all storage facilities, to provide energy dissipation and to trap and localize incoming sediments. The capacity of the forebay will be equivalent to 5% of storage volume required based on the area tributary to the inlet.

EQUATION

$$V_{fb} = 0.05 \cdot V_{s,100}$$

The forebay will be a separate basin, which can be formed by gabions, a compacted earthen berm, or other suitable structure. Exit velocities from the forebay must not be erosive during the 2-year recurrence interval design storm.

Spillway

All basins will have provisions for a defined emergency spillway, routed such that it will flow unobstructed to the main outflow channel.

- i. The emergency spillway elevation will be set at the elevation of the maximum retention/detention facility design volume.
- ii. The spillway will be sized to pass the maximum design flow tributary to the retention/detention facility.

Slopes

For safety purposes and to minimize erosion, basin side slopes will not be steeper than one-foot vertical to five feet horizontal (5:1). Steeper slopes may be allowed if perimeter fencing at least 6 feet in height is provided. In general, the side slopes must not be flatter than one-foot vertical to 20 feet horizontal (20:1) and must not be steeper than one-foot vertical to 3 feet horizontal (3:1).

A minimum of one foot of freeboard will be required above the 100-year recurrence interval stormwater elevation on all detention/retention facilities.

Wet Detention Facility

Storage volume on a gravity outflow wet basin is defined as, "the volume of detention provided above the invert of the outflow device." Any volume provided below the invert of the outflow device will not be considered as detention. At a minimum, the volume of the permanent pool should be at least 2.5 times the first flush volume for the area managed.

$$\text{Volume of Permanent Pool (ft}^3\text{)} = 2.5 \times \text{First Flush Volume (ft}^3\text{)}$$

Wet detention facility configuration will be as follows:

- i. Surface area to volume ratio must be maximized to the extent feasible.
- ii. In general, depths of the permanent pool must be varied and average a minimum of three (3) feet.
- iii. A minimum length to width ratio of 3:1 is preferred unless structural measures are used to extend the flow path.
- iv. Wedge-shaped retention/detention facilities that are narrower at the inlet and wider at the outlet with irregular shorelines are preferred.
- v. A shelf, a minimum of 4 feet wide at a depth of one foot, will surround the interior of the perimeter to provide suitable conditions for the establishment of aquatic vegetation, and to reduce the potential safety hazard to the public.
- vi. To avoid drawdown, a reliable supply of baseflow and/or groundwater will be required.

6. VEGETATIVE PLANTINGS ASSOCIATED WITH RETENTION/DETENTION FACILITIES

Basin designs will be accompanied by a landscaping plan that incorporates plant species native to the local region and indicates how aquatic and terrestrial areas will be vegetated, stabilized and maintained.

Native wetland plants shall be used in the retention/detention facility design, either along the aquatic bench, fringe wetlands, safety shelf and side slopes, or within the shallow areas of the pools.

A permanent buffer strip of natural vegetation extending at least 15 feet in width beyond the freeboard elevation will be maintained or restored around the perimeter of all stormwater storage facilities. No lawn care chemicals may be applied within the buffer area. This requirement is to be cited in the subdivision restrictions of master deed documents.

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7. EASEMENTS

Retention/detention basins or other stormwater management facilities will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, spoils, deposition and other activities identified in the development's stormwater management plan.

8. MAINTENANCE

Maintenance Access

Adequate maintenance access from a public or private right-of-way to the stormwater storage basin will be provided. The access will be on a slope of 5:1 or less, stabilized to withstand the passage of heavy equipment, and will provide direct access to the forebay, control structure, and the outlet.

Forebay Maintenance

Direct maintenance access to the forebay will be provided for heavy equipment.

A permanent vertical depth marker shall be installed in the forebay to measure sediment deposition over time, with annual documentation. Stormwater system maintenance plans will require that sediment be removed when sediment reaches a depth of equal to 50% of the depth of the forebay or 12 inches, whichever is less.

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Part D. DESIGN REQUIREMENTS – INFILTRATION BMPs

The phrase “infiltration BMPs” describes a wide range of stormwater management practices aimed at infiltrating some fraction of stormwater runoff from developed surfaces into the soil horizon. Infiltration BMPs include several types, based on construction and performance similarities.

- Surface Infiltration Basins
- Subsurface Infiltration Beds
- Bioretention Areas
- Rain Gardens
- Pervious Asphalt, Concrete or Pavers
- Infiltration Trenches
- Other BMPs that provide infiltration: vegetated filter strips, bioswales and dry wells

Specific design requirements for infiltration BMPs as well as other BMPs follow in Parts D-O. Refer to the Soil Infiltration Testing Guidelines below to determine if a site is adequate for infiltration BMPs.

1. ROLE OF INFILTRATION BMPs

Infiltration BMPs are among the most beneficial approaches to stormwater management for a variety of reasons including:

- Reduction of the peak rate of runoff
- Reduction of the volume of runoff
- Removal of a significant portion of particulate-associated pollutants and some portion of solute pollutants.
- Recharge of groundwater and maintenance of stream baseflow.
- Allow for overlay of stormwater system with landscape requirements (such as parking lot islands) for more efficient land use.
- Allow potential use of undevelopable setbacks or road easements for stormwater management.

Quantitatively, infiltration BMPs replicate the natural hydrologic regime. During periods of rainfall, infiltration BMPs reduce the volume of runoff and help to mitigate potential flooding events. During periods of reduced rainfall, recharged water serves to provide baseflow to streams and maintain in-stream water quality. Qualitatively, infiltration BMPs are known to remove non-point source pollutants from runoff through a complex mix of physical, chemical, and biological removal processes. Infiltration promotes maintenance of the natural temperature regimes of stream systems, cooler in

summer, warmer in winter, which can be critical to the aquatic ecology. Because of the ability of infiltration BMPs to reduce the volume of runoff, there is also a corresponding reduction in erosive “bankfull” conditions and downstream erosion channel morphology changes.

Infiltration BMPs are designed to infiltrate some portion of runoff during every rainfall event. During small storm events, a large percentage of the runoff may infiltrate, whereas during large storm events, the volume that infiltrates may only be a small portion of the total runoff. However, because most of the local rainfall occurs in small (less than 1-inch) events, the annual benefits of an infiltration system are significant.

2. SOIL INFILTRATION TESTING GUIDELINES

Site design must first include use of all feasible areas for infiltration until the first flush requirement is met. Most sites with enough soils to infiltrate more will likely cost less to build than hard infrastructure. A pre-application meeting with WCWRC is required during the design phase of infiltration BMPs. There must be adequate soil testing at each proposed BMP location and a soil testing plan must be developed. The soil testing plan must be presented to WCWRC for approval prior to performing testing. Tests done without approval by WCWRC may require additional testing. The purpose of the soil infiltration testing is to:

- Determine the type of soil present on a site as NRCS Soil Classifications A, B, C or D.
- Determine which infiltration BMPs are suitable at the site and at what locations.
- Obtain the required data for infiltration BMP design.
- Determine design groundwater elevation.

Soil Testing must be conducted early in the conceptual or preliminary design of the project so that information developed in the testing process can be used to direct the design. There should be a preliminary understanding of potential BMP locations prior to testing, and adjustments can be made as necessary based upon test results.

The soil investigation and evaluation may be conducted by geotechnical engineers, soils scientists, sanitarians, design engineers, licensed geologists, and other qualified professionals and technicians. If the design engineer is not experienced in soils, a professional experienced in observing and evaluating soils conditions, such as a professional soils scientist, can provide a reliable analysis of the soil conditions. The soil testing report must be certified by a registered geotechnical engineer.

Soil infiltration testing is a process to obtain the necessary data for the design of the stormwater mitigation methods. The requirements for soil testing are:

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Step 1. Background Evaluation

Prior to performing field testing and compiling a site plan, an inventory and review of the property must occur and include, but not be limited to the following, which shall be presented at the pre-application meeting by the applicant.

- Existing mapped soils and USDA NRCS Hydrologic Soil Group Classifications.
- Existing geology
- Existing streams, water bodies, wetlands, hydric soils, floodplains, alluvial soils, stream classifications, headwaters and first order streams.
- Existing topography, slope, drainage patterns and watershed boundaries.
- Existing land cover/use boundaries.
- Other natural or man-made features or conditions that may impact the design, such as historic uses or existing buildings.
- Potential locations for infiltration BMPs.
- Site environmental history (i.e., Phase I ESA)

Step 2. Test Pits

Test pits or deep holes allow visual observation of the soil horizons and conditions both horizontally and vertically. The use of soil borings as substitute for test pits is not allowed, as visual observation is narrowly limited in the boring and soil horizons cannot be observed in-situ.

The test pit or deep hole will be a backhoe-excavated trench, 2.5 to 3 feet wide, to a depth of between 72 and 90 inches, or until bedrock or fully saturated conditions are encountered. The trench must be benched at a depth of 2-3 feet for access and infiltration testing. The following conditions shall be noted and described:

- Soil horizons (measured from ground surface)
- Soil texture and color for each horizon
- Color patterns
- Observance of pores or roots
- Estimated type and percent coarse fragments
- Observance of hardpan or limiting layers
- Depth to water table (measured from ground surface)
- Depth to bedrock (measured from ground surface)

Following all testing, the test pits must be filled with the excavated soil and the topsoil replaced. At no time should the test pit be accessed if there is a presence of unstable material or if site constraints preclude entry.

The test pit must provide information related to the conditions at the bottom of the infiltration BMP. If the proposed BMP will be greater than 90 inches below the existing grade, deeper test pit excavation will be required.

General test pit guidelines are as follows:

- For single-family residential subdivisions with on-lot infiltration BMPs, one test pit per lot is necessary within 100 feet of the proposed BMP area. At the pre-application meeting, the suitability of test pits for septic meeting this requirement can be determined.
- For multi-family and high-density residential developments, one test pit per BMP area or acre is necessary.
- For large infiltration areas, such as basins, commercial, institutional and industrial, multiple test pits must be evenly distributed at the rate of four to six pits per acre of BMP area, based on discussions during the pre-application meeting.

Additional soil test pits may be necessary due to subsurface variability, water table depth or topography. The WCWRC will determine if more or fewer test pits will be required.

Step 3. Infiltration Testing

Infiltration tests must be conducted in the field. Infiltration tests must not be conducted in the rain or within 24 hours of significant rainfall events (>0.5 inches), or when the temperature is below freezing. At least one test should be conducted at the proposed bottom elevation of an infiltration BMP, and a minimum of two tests per test pit are required. The methodologies for the tests include:

- Double-ring Infiltrometer test – estimate for vertical movement of water through the bottom of the test area.
- Percolation tests – estimate for vertical movement of water through the bottom and sides of the test area.
- Encased falling head permeability test – estimate for vertical movement of water through the bottom of the test area.

Other acceptable test methods that are available:

- Constant head double-ring infiltrometer
- ASTM 2003 Volume 4.08, Soil and Rock (I): Designation D 3385-03, Standard Test Method for Infiltration Rate of Soils in Field Using a Double-Ring Infiltrometer.
- ASTM 2002 Volume 4.09, Soil and Rock (II): Designation D 5093-90, Standard Method of Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring.
- Guelph permeameter
- Constant head permeameter (Amoozemeter)

3. SOIL INFILTRATION TESTING METHODOLOGIES

Double-Ring Infiltrometer

A double-ring infiltrometer consists of two concentric metal rings driven into the ground and filled with water. The outer ring helps prevent divergent flow while the drop in water level or volume in the inner ring is used to calculate infiltration rate. The infiltration rate is the amount of water per surface area and

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time unit which penetrates soils. The diameter of the inner ring should be 50-70 percent of the diameter of the outer ring, with a minimum inner ring diameter of four inches.

Equipment for double-ring infiltrometer test:

- Two concentric cylinder rings six inches or greater in height with an inner ring diameter equal to 50-70 percent of the outer ring diameter.
- Water supply
- Stopwatch or timer
- Ruler or measuring tape
- Flat wooden board for driving cylinders uniformly into soil
- Rubber mallet
- Log sheets for recording findings

Procedure for double-ring infiltrometer:

- Prepare level testing area
- Place outer ring in testing area; place flat board on ring and drive ring into soil a minimum of two inches.
- Place inner ring in center or outer ring; place flat board on ring and drive ring into soil a minimum of two inches. The bottom rim of both rings should be at the same level.
- The test area should be presoaked immediately prior to testing. Fill both rings with water to the rim at 30-minute intervals for one hour. The minimum water depth should be four inches. The drop in water level during the last 30 minutes of presoaking period should be applied to the following standard to determine the time interval between readings:
 - If water level drop is two inches or more, use 10-minute measure intervals.
 - If water level drop is less than two inches, use 30-minute measurement intervals.
- Obtain a reading of the drop in water level in the center ring at appropriate time intervals. After each reading, refill both rings to water level indicator mark or rim. Measurement to the water level in the center ring should be made from a fixed reference point and should continue at the interval determined until a minimum of eight readings are completed or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of ¼ inch or less of drop between the highest and lowest readings of four consecutive readings.
- The drop that occurs in the center ring during final period or the average stabilized rate, expressed as inches per hour, should represent the infiltration rate for that test location.

Percolation Test

Equipment for percolation test:

- Post hole digger or auger
- Water supply
- Stopwatch or timer

- Ruler or measuring tape
- Log sheets for recording findings
- Knife blade or sharp-pointed instrument (for soil scarification)
- Course sand or fine gravel
- Object for fixed reference point during measurement (nail, toothpick, etc.)

Procedure for percolation test:

This percolation test methodology is based largely on the criteria for onsite sewage investigation of soils. A 24-hour pre-soak is generally required as infiltration systems, unlike wastewater systems, will not be continuously saturated.

- Prepare level testing area
- Prepare hole having a uniform diameter of 6-10 inches and depth of 8-12 inches. The bottom and sides of the hole should be scarified with a knife blade or sharp-pointed instrument to completely remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Loose material should be removed from the hole.
- (Optional) Two inches of coarse sand or fine gravel may be placed in the bottom of the hole to protect soil from scouring and clogging of the pores.
- The drop in the water level during the last 30 minutes of the final presoaking period should be applied to the following standard to determine the time interval between readings for each percolation hole:
 - If water remains in the hole, the interval for readings during the percolation test should be 30 minutes.
 - If no water remains in the hole, the interval for readings during the percolation test may be reduced to 10 minutes.
- After the final presoaking period, water in the hole should be again adjusted to a minimum depth of six inches and readjusted when necessary after each reading. A nail or marker should be placed at a fixed reference point to indicate the water refill level. The water level depth and hole diameter should be recorded.
- Measurement to the water level in the individual percolation holes should be made from a fixed reference point and should continue at the interval determined from the previous step for each individual percolation hole until a minimum of eight readings are completed or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of ¼ inch or less of drop between the highest and lowest readings of four consecutive readings.
- The drop that occurs in the percolation hole during the final period, expressed as inches per hour, should represent the percolation rate for that test location.
- The average measured rate must be adjusted to account for the discharge of water from both the sides and bottom of

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the hole and to develop a representative infiltration rate. The average final percolation rate should be adjusted for each percolation test according to the formula:

Encased Falling Head Permeability Test*

*Source: Portland Stormwater Management Manual

The encased falling head procedure is utilized to evaluate the vertical infiltration rate without allowing any lateral infiltration. This test is not appropriate in gravelly soils or in other soils where a good seal with the casing cannot be established.

Equipment for encased falling head permeability test:

- 6-inch diameter casing
- Water supply
- Stopwatch or timer
- Ruler or measuring tape
- Log sheets for recording findings
- Object for fixed reference point during measurement (nail, toothpick, etc.)

Procedure for encased falling head permeability test:

- Embed a solid 6-inch diameter casing into the native soil at the elevation of the proposed BMP bottom. Ensure the embedment provides a good seal around the pipe casing so the percolation will be limited to the 6-inch plug of the material within the casing. This method can also be used when testing within hollow stem augers, provided the driller and tester are reasonably certain that a good seal has been achieved between the soil and the auger.
- Fill the pipe with clean water a minimum of 1 foot above the soil to be tested, and maintain this depth for at least 4 hours (or overnight if clay soils are present) to presoak the native material. Any soil that sloughed into the hole during the soaking period should be removed. In sandy soils with little or no clay or silt, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.
- To conduct the first trial of the test, fill the pipe to approximately 12 inches above the soil and measure the water level to the nearest 0.01 foot (1/8 inch). Alternative water head heights may be used for testing provided the presaturation height is adjusted accordingly and the water head height used in infiltration testing is 50% or less than the water head height in the proposed stormwater system during the design storm event. The level should be measured with a tape or other device with reference to a fixed point. The top of the pipe is often a convenient reference point. Record the exact time.
- Measure the water level to the nearest 0.01 foot (1/8 inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2-hours in slower soils) or until all of the water has drained. In faster draining soils (sands and gravels),

it may be necessary to shorten the measurement interval in order to obtain a well defined infiltration rate curve. Successive trials should be run until the percent change in measured infiltration rate between two successive trials is minimal. The trial should be discontinued if the infiltration rate between successive trials increases. At least three trials must be conducted. After each trial, the water level is readjusted to the 12 inch level. Enter results into the data log sheets.

- The average infiltration rate over the last trial should be used to calculate the unfactored infiltration rate. The final rate must be reported in inches per hour.
- Upon completion of the testing, the casing should be pulled and the test pit backfilled.

$$\text{Infiltration Rate} = (\text{Percolation Rate}) / (\text{Reduction Factor})$$

Where the Reduction Factor is given by:

$$R_f = \frac{2d_1 - \Delta d}{DIA} + 1$$

Where:

d_1 = Initial Water Depth (in)

Δd = Average/Final Water Level Drop (in)

DIA = Diameter of the Percolation Hole (in)

The percolation rate is simply divided by the reduction factor, as calculated above, to yield the representative infiltration rate. In most cases, the reduction factor varies from about two to four depending on the percolation hole dimensions and water level drop – wider and shallower tests have lower reduction factors because proportionately less water exfiltrates through the sides.

4. CONSIDERATION OF INFILTRATION RATE IN DESIGN AND MODELING APPLICATION

For the purposes of site suitability, areas with tested soil infiltration rates as low as 0.1 inches per hour may be used for infiltration BMPs. However, in the design of these BMPs and the sizing of the BMP, the designer should incorporate a safety factor. A safety factor of two (2) must be used in the design of stormwater infiltration systems. Therefore a measured infiltration rate of 0.5 inches per hour should generally be considered as a rate of 0.25 inches per hour in design.

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Infiltration systems can be modeled similarly to traditional detention basins. The marked difference with modeling infiltration systems is the inclusion of the infiltration rate, which can be considered as another outlet. For modeling purposes, it is convenient to develop infiltration rate that vary (based on the infiltration area provided as the system fills with runoff) for inclusion in the Stage-Storage-Discharge table (SSDT).

5. INFILTRATION BMP GUIDELINES

The purpose of these guidelines is to provide designers, reviewers, and other interested parties with specific instructions for the successful construction and long-term performance of infiltration BMPs. These guidelines fall into three categories:

- Site conditions and constraints
- Design considerations
- Construction requirements

a. Site Conditions and Constraints

- i. It is necessary to maintain at least a 3-foot clearance above the seasonally high water table for most BMPs (e.g., basins serving large areas). This reduces the likelihood that temporary groundwater mounding will affect the system, and allows sufficient distance of water movement through the soil to assure adequate pollutant removal. Note: The clearance above the seasonally high water table for rain gardens can be 2-feet.
- ii. Soils underlying infiltration devices should have infiltration rates between 0.1 and 10 inches per hour, which in most developments should result in reasonably sized infiltration systems. Where soil permeability is extremely low, infiltration may still be possible but the surface area required could be large, and other volume reduction methods may be warranted. Undisturbed Hydrologic Soil Groups A, B, and C often fall within the acceptable range and cover most of the state. Soils with rates in excess of 6.0 inches per hour may require an additional soil buffer (such as an organic layer over the bed bottom) if the Cation Exchange Capacity (CEC) is less than 10 and pollutant loading is expected to be significant.
- iii. Infiltration BMPs must be sited to minimize any risk to groundwater quality, at least 50 horizontal feet from individual water supply wells, 75 horizontal feet from community or municipal Type IIb and III water supply wells and 200 horizontal feet from community or municipal Type I or IIa water supply wells. Horizontal separation distances or buffers may

also be appropriate from special geologic features, such as fractures, traces and faults, depending on water supply sources.

- iv. Infiltration BMPs should be sited so that they present no threat to sub-surface structures, typically at least 10 feet down gradient or 100 feet up gradient from building basement foundations (see specific BMP for applicable setbacks) and 100 feet from septic system drainfields unless specific circumstances allow for reduced separation distances.
- v. In general, soils of Hydrologic Soil Group D will not be suitable for infiltration. Similarly, areas of floodplains and areas in close proximity to wetlands and streams will generally not be suitable for infiltration (due to high water table and/or low permeability). In developing areas that were previously used for agricultural purposes, the designer should consider the past patterns of land use. Areas that were suitable for cultivation without tilling will likely be suitable for some level of infiltration. Areas that were left out of cultivation often indicate locations that are too wet or too rocky, and will likely not be suitable for infiltration.

b. Design Considerations

- i. Infiltration facilities may not be placed on compacted fill. Infiltration in native soil without prior fill or disturbance is preferred but not always possible. Areas that have experienced historic disturbance or fill are suitable for infiltration provided sufficient time has elapsed and the soil testing indicates the infiltration is feasible. In disturbed areas it may be necessary to infiltrate at a depth that is beneath soils that have previously been compacted by construction methods or long periods of mowing. Such areas must be tilled to 18 inches or more.
- ii. A level infiltration area (1.5% or less slope) is preferred. Bed bottoms should always be graded into the existing soil mantle, with terracing as required to construct flat structures. Sloped bottoms tend to pool and concentrate water in small areas, reducing the overall rate of infiltration and longevity of the BMP. Infiltration areas should be flat or nearly so. Note: Bioswales proposed with flat bottoms and grass vegetation do not work and will not be approved.
- iii. The soil mantle should be preserved to the maximum extent possible, and excavation should be minimized. Those soils that do not need to be disturbed for development should be left undisturbed. Macropores can provide a significant mechanism for water movement in infiltration systems, and the extent of macropores often decreases with depth. Maximizing the soil mantle also increases the pollutant removal

Section V: Design Requirements For Stormwater Management Systems

capacity and reduces concerns about groundwater mounding. Therefore, excessive excavation for the construction of infiltration systems is strongly discouraged.

- iv. Isolate “hot spot areas.” Site plans that include ‘hot spots’ have special design considerations. ‘Hot spots’ are most often associated with some industrial uses and high traffic – gasoline stations, vehicle maintenance areas, and high intensity commercial uses (fast food restaurants, convenience stores, etc.). These “hot spots” are defined in Section VIII, Part C. Infiltration may occur in areas of hot spots provided pretreatment and pollution prevention measures are suitable to address concerns. Pretreatment requirements need to be analyzed, especially for ‘hot spots’ and areas that produce high sediment loading. Pretreatment devices that operate effectively in conjunction with infiltration include grass swales, vegetated filter strips, settling chambers, oil/grit separators, constructed wetlands, sediment sumps, and water quality inserts. Selection of pretreatment should be guided by the pollutants of greatest concern, site by site, depending upon the nature and extent of the land development under consideration. Selection of pretreatment techniques will vary depending upon whether the pollutants are of particulate (sediment, phosphorus, metals, etc.) versus soluble (nitrogen, dissolved phosphorus, and others) nature. Types of pretreatment (i.e., filters) should be matched with the nature of the pollutants expected to be generated. For example gas stations require hydrocarbon filters in all catch basins on the site.
- v. The loading ratio of impervious area to bed bottom area must be considered. One possible reason for infiltration system failure is the design of a system that attempts to infiltrate a substantial volume of water in a very small area. Infiltration systems may work better when the water is “spread out”. The loading ratio describes the ratio of impervious drainage area to infiltration area, or the ratio of total drainage area to infiltration area. In general, the following loading ratios are recommended (some situations, such as highly permeable soils, may allow for higher loading ratios):
 - Maximum impervious loading ratio of 5:1 relating impervious drainage area to infiltration area.
 - A maximum total loading ratio of 8:1 relating total drainage area to infiltration area.

- vi. In retention/detention facilities where soil amendments and/or underdrains are present the hydraulic head or depth of water may be required to be limited. The total effective depth of water should generally not be greater

than two feet. The design of any infiltration system must avoid any excessive pressure and potential sealing of the bed bottom. Typically the water depth is limited by the loading ratio and the drawdown time, and is not an issue.

- vii. Drawdown time must be considered. In general, infiltration BMPs should be designed so that they completely empty within 48 hours.
- viii. All infiltration BMPs should be designed with a positive overflow that discharges excess volume in a non-erosive manner, and allows for controlled discharge during extreme rainfall events or frozen bed conditions. Infiltration BMPs should never be closed systems dependent entirely upon infiltration in all situations. Discharge must be directed in a manner to avoid property damage and have an unimpeded route to a receiving channel or outlet.
- ix. Geotextiles should be incorporated into the design as necessary in certain infiltration BMPs. Infiltration BMPs that are subject to soil movement and deposition must be constructed with suitably permeable non-woven geotextiles to prevent movement of fines and sediment into the infiltration system. The designer is encouraged to err on the side of caution and use geotextiles as necessary at the soil/BMP interface.
- x. For basins, the middle of the basin excavation should include larger diameter rock fill for the infiltration area, covered with geotextile fabric to collect sediment.

c. Construction Requirements

- i. Do not compact soil infiltration beds during construction. Prohibit all heavy equipment from the infiltration area and minimize all other traffic. Equipment should be limited to vehicles that will cause the least compaction, such as low ground pressure (maximum 4 pounds per square inch) tracked vehicles.
- ii. Protect the infiltration area from sediment until the surrounding site is completely stabilized. Methods to prevent sediment from washing into BMPs should be clearly shown on plans. Runoff from construction areas should be prevented from draining to infiltration BMPs, with techniques such as diversion berms, and immediate vegetative stabilization.
- iii. Where vegetation is a component of an infiltration BMP, it must be established prior to putting the device into use.
- iv. All infiltration areas shall be tested for permeability after construction, and must perform to design permeability.

Note for all construction steps: Erosion and sediment control methods must adhere to latest requirements of the Michigan DEQ’s Soil Erosion and Sedimentation Control Program

Section V: Design Requirements For Stormwater Management Systems



Part F. DESIGN REQUIREMENTS – BIORETENTION BASINS

1. GENERAL REQUIREMENTS

Bioretention systems are flexible in design and can vary in complexity according to site conditions and runoff volume requirements. Bioretention areas are not to be confused with constructed wetlands or wet retention/detention facilities, which permanently pond water. They can increase time of concentration and store additional volume below grade. Typically bioretention systems have planted native vegetation beds atop 3-5 feet of amended soils. Bioretention areas are larger, neighborhood scale vegetated infiltration areas. They have a deeper amended soil depth. If an underdrain is used there will be no allowance for infiltration credits. See Figure 3 and Figure 4 for more detail on bioretention systems.

Deeper-rooted plants perform best, but any vegetation is acceptable – grass, annuals, grasses, shrubs, trees or a combination of these.

Bioretention basins require maintenance a minimum of twice/year, early in the growing season and in the fall, to prevent noxious weed proliferation. This can include hand weeding, burns, herbicide or mowing. Planning tools shall be included to provide management that ensures their long-term functionality (deed restrictions, covenants, easements, budget, etc.). A maintenance plan is required. See **Low Impact Development Manual for Michigan** for guidance.

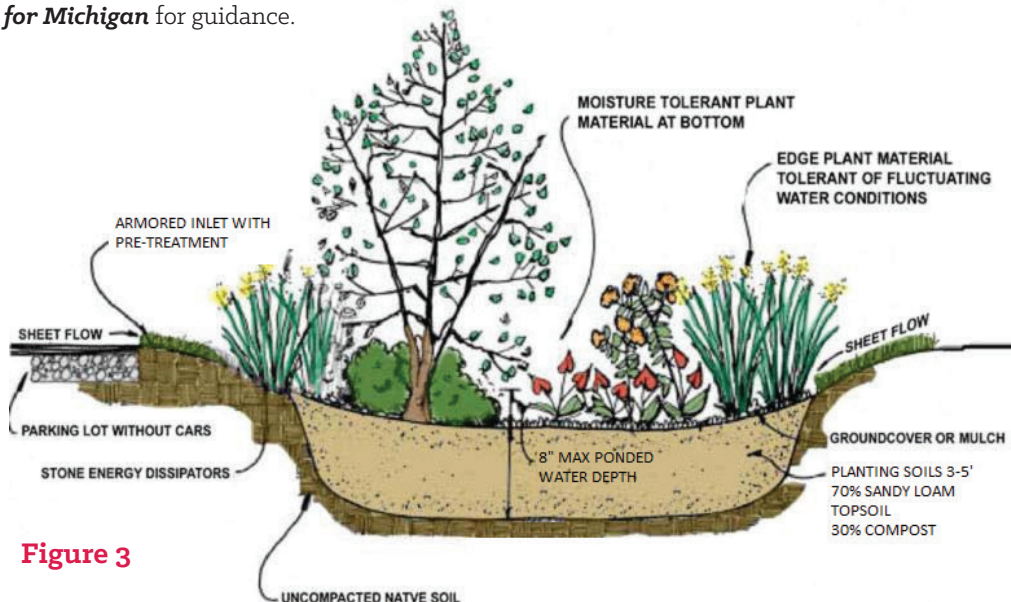


Figure 3

Figure adapted from Prince George's County, MD, Department of Environmental Resources

2. PROHIBITIONS

Bioretention will not be allowed in the following:

- Within floodplains
- Where the estimated high ground water elevation will be within 3 feet of the bottom of the facility.

3. SETBACKS

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	10
Public Water Supply Well	10
Septic System Drainfield (primary & reserve)	50

Setback Distances

*minimum with slopes directed away from building

Section V: Design Requirements For Stormwater Management Systems

4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines **Part D, Design Requirements for Infiltration BMPs.**
- b. The overall site shall be evaluated for potential infiltration systems early in the design process.

5. BASIN COMPONENTS/CONFIGURATION

The primary components (and subcomponents) of a bioretention system are:

Pretreatment

(where required, **See Part D.5, "Infiltration Guidelines"**)

Flow enters through a pretreatment device suitable for site conditions and pollutants of concern prior to entry into the bioretention system. The pretreatment device can be a forebay, sump or other design as appropriate. The device must be designed to that sediment is captured and that regular removal can occur. The sediment removal method must be included in the maintenance plan.

- Runoff emanating from defined hot spot requires pretreatment
- See **Low Impact Development Manual for Michigan**, Table 8.2 for guidance.

Flow Entrance

Water may enter via:

- An inlet (e.g. flared end section)
- Sheet flow into the facility over grassed areas
- Curb cuts with grading for sheet flow entrance
- Roof leaders with direct surface connection
- Trench drain
- Pipe

In all cases entering velocities must be non-erosive.

Positive Overflow

- Will discharge runoff during large storm events when the subsurface/surface storage capacity is exceeded or when the ground is frozen. Discharge must be directed in a manner to avoid property damage and have an unimpeded route to a receiving channel or outlet.
- Examples include beehive yard basin, curb inlet, catch basin, weir, etc.

Bioretention Facility Area

- Maximum depth of ponding is 8 inches. However, if sufficient infiltration capacity can be demonstrated, additional ponding may be allowed above grade. Ponding shall not exceed 8" for more than 6 hours after the design event.
- An overflow must be provided and must be directed in a manner to avoid property damage and have an unimpeded route to a receiving channel or outlet.
- Plants must be salt tolerant if in a location that would receive snowmelt chemicals

Planting

Proper plant selection is essential for bioretention areas to be effective. Typically, native floodplain or wet meadow plant species are best suited to the variable environmental conditions encountered in a bioretention system. Live perennial plant material in plug or gallon-potted form should be utilized and installed on 1'-2' centers. Seed is not an acceptable method for plant establishment below the storage elevation unless a method of germination and stabilization is provided. Planting with seed has highly unreliable results due to water flows displacing seed. If proposed, the application method and seed mix must be submitted for approval. Upon installation, vegetative establishment must be documented and approved as per the soil erosion and sedimentation control permit. Perennials, grasses, shrubs and trees are acceptable plantings.

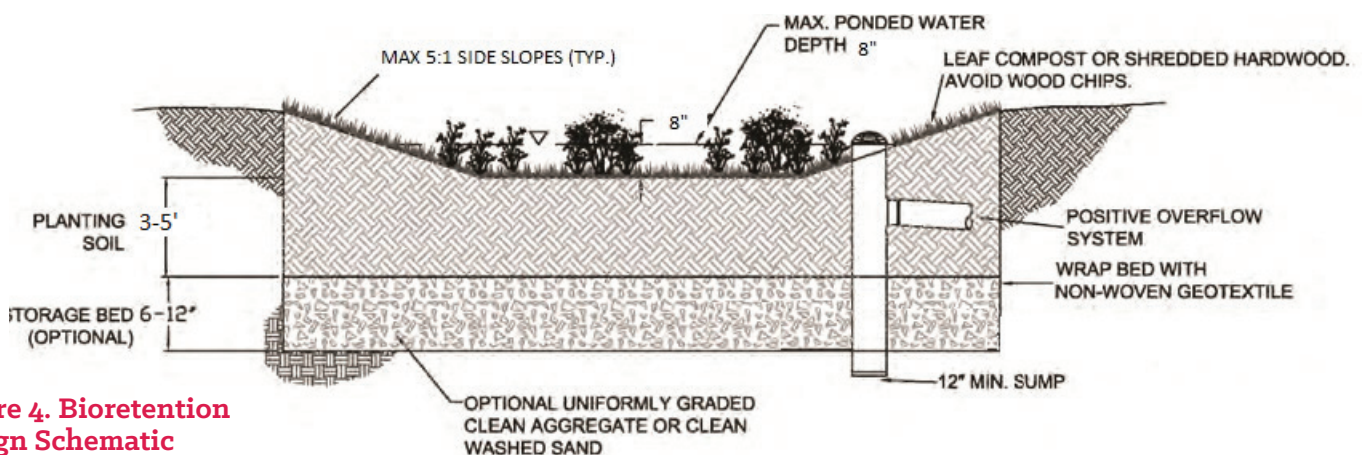


Figure 4. Bioretention Design Schematic

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Permanent vegetative cover must comply with soil erosion and sedimentation control guidelines.

Planting periods will vary, but in general, planting should be from mid-March through early June, or mid-September through mid-October.

Planting soil must be a loam topsoil capable of supporting a healthy vegetative cover. Soils must be amended with a composted organic material. Soils must be free of construction debris and subsoils. A recommended soil blend is 20-30% compost. Planting soil must be 4 inches deeper than the bottom of the largest root ball.

Soils must have a clay content less than 10% (a small amount of clay is beneficial to absorb pollutants and retain water), be free of toxic substances and unwanted plant material and have a 20-30% organic matter content. Additional organic matter can be added to the soil to increase water holding capacity (tests should be conducted to determine volume storage capacity of amended soils).

Wood chips must be avoided as they tend to float during inundation periods. Shredded mulch is preferred.

1. Surface Storage Volume (ft³) = Bed Area (ft²) x Average Design Water Depth
2. Soil Storage Volume (ft³) = Length x Width x Depth x Void Ratio of Storage Material
3. Infiltration Volume = Bed Bottom Area (ft²) x Infiltration design rate (in/hr) x 6* (hr) x (1/12)
**Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate. This has been conservatively estimated as 6 hours.*

Bioretention System Volume = Surface Storage Volume + Soil Storage Volume + Infiltration Volume

Sizing Criteria

- a. **Surface area** is dependent upon storage volume requirements but should generally not exceed a maximum loading ratio of 5:1 (impervious drainage area to infiltration area; see Design Requirements for Infiltration Systems for additional guidance on loading rates.)
- b. **Surface side slopes** must be gradual. The maximum allowable slope for bioretention systems is 5:1.
- c. **Surface ponding depth** must not exceed 8 inches and will empty within 48 hours.
- d. **Ponding area** must provide sufficient surface area to meet required storage volume without exceeding the design ponding depth. The subsurface storage/infiltration bed is used to supplement surface storage where appropriate.

6. EASEMENTS

Bioretention systems shall have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, spoils deposition, and other activities identified in the development's stormwater system maintenance plan.

7. CALCULATIONS

Infiltration Area

The infiltration area is the bottom area of the bioretention system defined as:
(Area of Bioretention System at Ponding Depth + Bottom Area of Bioretention System) Divided by 2 = Infiltration Area (Average Area)

This is the area to be considered when evaluating the Loading Rate to the bioretention system.

Volume Reduction Calculations

The storage volume of a bioretention system is defined as the sum total of the surface and subsurface void volumes beneath the level of the discharge invert. Inter-media void volumes may vary considerably based on design variations.

The volume of a bioretention system has three components:

8. CONSTRUCTION

The following is a typical construction sequence; alterations will be necessary depending on design variations.

Note for all construction steps: Erosion and sediment control methods must adhere to the latest requirements of the Michigan DEQs Soil Erosion and Sedimentation Control Program.

- a. Install temporary sediment control BMPs as shown on the plans.
- b. Complete site grading, minimizing compaction as much as possible. If applicable, construct curb cuts or other inflow entrances but provide protection so that drainage is prohibited from entering the bioretention system construction area.
- c. Excavate the bioretention system to the proposed invert depth and scarify the existing soil surfaces. Do not compact in-situ soils.
- d. Backfill the bioretention system with amended soil as shown on plans and specifications. Overfilling is recommended to account for settlement. Light hand tamping is acceptable if necessary.
- e. Presoak the planting soil prior to planting vegetation to aid

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in settlement.

- f. Complete final grading to achieve proposed design elevations, leaving space for upper layer of compost, mulch or topsoil as specified on plans.
- g. Mulch and install erosion protection at surface flow entrances where necessary.
- h. Plant vegetation according to planting plan.
- i. Once the drainage area is completely and permanently stabilized, the bioretention system should be brought online.
- j. Removal of weeds and unwanted species is usually needed in the first 1-3 years following installation.
- k. Permeability shall be reverified by infiltration prior to acceptance.

9. MAINTENANCE

Properly designed and installed bioretention systems require regular maintenance.

- a. While vegetation is being established, hand weeding or other weed control methods will be required. Thereafter, twice annual weeding is typical. Invasive plants should be controlled early in their establishment before they spread.
- b. Fall and spring cleanup must be performed including cutting down dead perennials, removal of weeds and removal or mulching of leaves and stems.
- c. Mulch must be re-spread when erosion is evident and be replenished annually. Once every 2 to 3 years the entire area may require mulch replacement.
- d. Bioretention systems must be inspected at least two times per year for sediment buildup, erosion, vegetative conditions, etc. Sediment must be removed from forebay and riprap/stone protected areas at least twice per year. Sediment should be removed before its accumulation negatively impacts the performance of the pretreatment device.
- e. During periods of extreme drought, bioretention systems may require watering.
- f. Bioretention systems must not be mowed.
- g. Trees and shrubs must be inspected twice per year to evaluate health.
- h. Invasive species must be removed on an annual basis and disposed of in compliance with local, state and federal regulations.

Part F.

DESIGN REQUIREMENTS – RAIN GARDENS

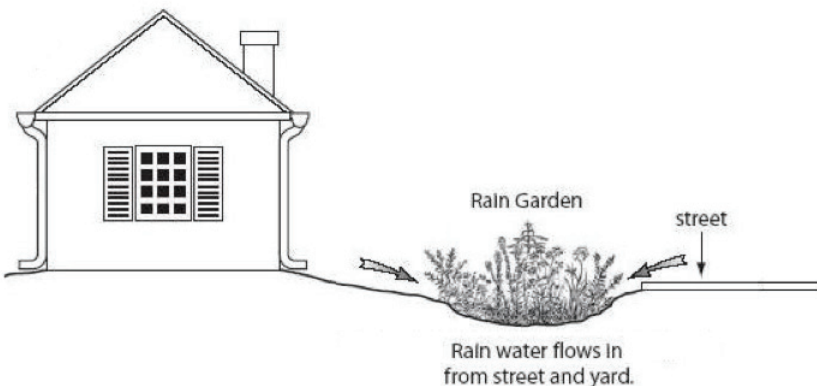
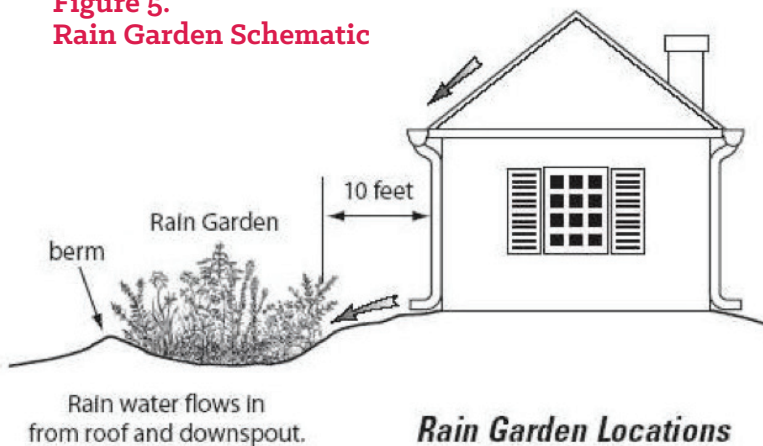
1. GENERAL REQUIREMENTS

Rain gardens can be useful in new construction or retrofit projects. They are shallow detention areas that are sized to store small storms and overflow in larger events. Rain gardens can pool up to 8” of runoff. Typically, soils in Washtenaw County allow these basins to infiltrate their design storage in a short period of time. Deeper-rooted vegetation expedites this process. Under-drainage is not typical. Construction typically involves grading, amendment with compost and a controlled overflow.

Deeper-rooted plants perform best, but any vegetation is acceptable – grass, annuals, grasses, shrubs, trees or a combination of these.

Rain gardens require maintenance a minimum of twice / year, early in the growing season and in the fall, to prevent noxious weed proliferation. This can include hand weeding, burns, herbicide or mowing. Planning tools shall be included to provide management that ensures their long-term functionality (deed restrictions, covenants, easements, budget, etc.). A maintenance plan is required. **See Low Impact Development Manual for Michigan** for guidance.

Figure 5. Rain Garden Schematic



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2. PROHIBITIONS

Rain Gardens will not be allowed in the following:

- a. Areas with known pollution as identified by the MDEQ.
- b. Where the estimated high ground water elevation will be within 2 feet of the bottom of the facility.
- c. Where snow removal activities will repeatedly pile snow and salt, which may damage plants.

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	10
Public Water Supply Well	10
Septic System Drainfield (primary & reserve)	50

*minimum with slopes directed away from building

4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements within the Design Requirements for Infiltration BMPs section.
- b. The overall site must be evaluated for potential infiltration systems early in the design process.

5. RAIN GARDEN COMPONENTS/ CONFIGURATION

The primary components (and subcomponents) of a rain garden system are:

Pretreatment

(where required *See Part D.5 "Infiltration Guidelines"*)

- Flow through a pretreatment device suitable for site conditions and pollutants of concern prior to entry into the rain garden.
- Runoff emanating from defined hot spot requires pre-

treatment See *Low Impact Development Manual for Michigan*, Table 8.2 for guidance.

- Runoff emanating from paved surfaces requires a sediment sump sufficient for heavy sands to drop out. This can be a small depression or stone berm sufficient to dissipate energy.
- Rooftop runoff requires no pre-treatment.

Flow Entrance

- Water may enter via an inlet (e.g. flared or stone end section), sheet flow, curb cuts, roof leaders, swale, etc.
- Entering velocities must be non-erosive

Positive Overflow

- Rain gardens will require an overflow outlet, for periods when the subsurface/surface storage capacity is exceeded.
- Examples include beehive yard basin, curb inlet, catch basin, weir, road right-of-way, etc.
- An overflow area is required to convey discharge safely within an easement to the storage facility, road right-of-way, swale, drain, or other adequate drainage facility. Discharge must be directed in a manner to avoid property damage and have an unimpeded route to a receiving channel or outlet.

Ponding Area

- Maximum depth of ponding is 8 inches.
- Soils within infiltration areas should be turned to a depth of 18" and amended with compost and/or topsoil to create planting soils with a minimum 20-30% organic material (compost), 70-80% topsoil.
- Amended soil must be 4" deeper than the largest root ball.

Planting

- Plant species shall be selected to tolerate saturated spring conditions and dry summer conditions. See *Low Impact Development Manual for Michigan*, Appendix C for guidance.
- Establishment by seed is appropriate only for larger gardens distant from points of viewing. Planting with seed has highly unreliable results due to water flows displacing seed. If proposed, the application method and seed mix must be submitted for approval. Upon installation, vegetative establishment must be documented and approved as per the soil erosion and sedimentation control permit. Rain gardens planted close to entryways and pedestrian gathering spaces should be planted with nursery-grown plants.
- Optimal planting time is between mid-May and mid-June or mid-September to mid-October. Other planting times require irrigation for plant establishment.
- Plants shall be planted at a density sufficient to achieve cover within the first two years. A guideline to achieve

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this is to plant them at distances “on center” equal to their expected ultimate height.

- A minimum of 2” depth shredded mulch shall be required to retain soil moisture and control weeds in year 1. The second growing season, the garden should be densely covered with plants and should inhibit weeds without additional mulch.

6. EASEMENTS

Rain Gardens shall have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and other activities identified in the development’s stormwater system maintenance plan.

7. CALCULATIONS

Infiltration Area

The infiltration Area is the bottom area of the rain garden defined as:

(Area of Rain Garden at Ponding Depth + Bottom Area of Rain Garden) Divided by 2 = Infiltration Area (Average Area)

This is the area to be considered when evaluating the Loading Rate to the rain garden.

Volume Reduction Calculations

The storage volume of a rain garden is defined as the sum of the surface and subsurface void volumes beneath the level of the discharge invert. Inter-media void volumes may vary considerably based on design variations.

The volume of a Rain Garden has three components:

1. Surface Storage Volume (ft³) = Bed Area (ft²) x Average Design Water Depth
2. Soil Storage Volume (ft³) = Length x Width x Depth x Void Ratio of Storage Material
3. Infiltration Volume = Bed Bottom Area (ft²) x Infiltration design rate (in/hr) x 6*(hr) x (1/12)

**Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate. This has been conservatively estimated as 6 hours.*

$$\text{Rain Garden Volume} = \text{Surface Storage Volume} + \text{Subsurface Storage} + \text{Infiltration Volume}$$

Sizing Criteria

- a. **Surface area** is dependent upon storage volume requirements but should generally not exceed a maximum loading ratio of 5:1 (impervious drainage area to infiltration

area; see Design Requirements for Infiltration Systems for additional guidance on loading rates.)

- b. **Surface Side slopes** must be gradual. The maximum allowable slope for a rain garden is 3:1.
- c. **Surface ponding depth** must not exceed 8 inches.
- d. **Ponding area** must provide sufficient surface area to meet required storage volume without exceeding the design ponding depth. The subsurface storage/infiltration bed is used to supplement surface storage where appropriate.
- e. **Planting soil depth** must be at least 18 inches where only herbaceous plant species will be utilized. If trees and woody shrubs will be used, soil media depth may be increased depending on plant species (native soils can be used as planting soil or modified on many sites).

8. CONSTRUCTION

The following is a typical construction sequence; however alterations will be necessary depending on design variations.

Note for all construction steps: Erosion and sediment control methods must adhere to the latest requirements of the Michigan DEQs Soil Erosion and Sedimentation Control Program.

- a. Install temporary sediment control BMPs as shown on the plans.
- b. Complete site grading, minimizing compaction as much as possible. If applicable, construct curb cuts or other inflow entrances but provide protection so that drainage is prohibited from entering the rain garden construction area.
- c. Excavate the rain garden to the proposed invert depth and scarify the existing soil surfaces. Do not compact in-situ soils.
- d. Backfill the rain garden with amended soil as shown on plans and specifications. Overfilling is recommended to account for settlement. Light hand tamping is acceptable if necessary.
- e. Presoak the planting soil prior to planting vegetation to aid in settlement.
- f. Complete final grading to achieve proposed design elevations, leaving space for upper layer of compost, mulch or topsoil as specified on plans.
- g. Plant vegetation according to planting plan.
- h. Mulch and install erosion protection at surface flow entrances where necessary.
- i. Once the drainage area is completely and permanently stabilized, the rain garden should be brought online.
- j. Removal of weeds and unwanted species is usually needed in the first 1-3 years following installation.

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9. MAINTENANCE

Properly designed and installed bioretention systems require regular maintenance.

- a. While vegetation is being established, hand weeding or other weed control methods will be required. Thereafter, twice annual weeding is typical. Invasive plants should be controlled early in their establishment before they spread.
- b. Fall and spring cleanup must be performed including cutting down dead perennials, removal of weeds and removal or mulching of leaves and stems.
- c. Mulch must be re-spread when erosion is evident and be replenished annually. Once every 2 to 3 years the entire area may require mulch replacement.
- d. Bioretention systems must be inspected at least two times per year for sediment buildup, erosion, vegetative conditions, etc. Sediment must be removed from forebay and riprap/stone protected areas at least twice per year. Sediment should be removed before its accumulation negatively impacts the performance of the pretreatment device.
- e. During periods of extreme drought, bioretention systems may require watering.
- f. Bioretention systems must not be mowed.
- g. Trees and shrubs must be inspected twice per year to evaluate health.
- h. Invasive species must be removed on an annual basis and disposed of in compliance with local, state and federal regulations.

Part G.

DESIGN REQUIREMENTS – PERVIOUS PAVEMENT

1. GENERAL REQUIREMENTS

Pervious pavement is an infiltration technique that combines stormwater infiltration, storage, and structural pavement. It consists of permeable surface underlain by a storage reservoir. Pervious pavement is well suited for parking lots, walking paths, sidewalks, playgrounds, plazas, athletic courts, and other similar uses. It has also been successful on roadways. Variations on the surface material include: Porous Asphalt, Pervious Concrete, Permeable Paver Blocks, or Reinforced Turf (see Figure 6 and Figure 7).

- a. Pervious pavement and infiltration beds must not be placed on areas of recent fill or compacted fill. Any grade adjustments requiring fill must be done using the stone sub-base material. Areas of historical fill (>5 years) may be considered for pervious pavement.
- b. The bed bottom is not compacted; however the stone sub-base is placed in lifts and lightly rolled according to specifications.
- c. Bed bottoms must be level or nearly level. Sloping bed bottoms will lead to areas of ponding and reduced stormwater distribution within the bed.
- d. All systems must be designed with an overflow system. Water within the subsurface stone bed must never rise to the level of pavement surface. Inlets can be used for cost-effective overflow structures. All beds must empty within 48 hours.
- e. Infiltration beds must also be able to convey and mitigate the peak of less-frequent, more intense storms such as the 100-year recurrence interval. Control in beds is usually provided in the form of an outlet control structure. A modified inlet box with an internal weir and low-flow orifice is a common type of control structure. The specific design of these structures may vary, depending on factors such as allowable discharge rate and storage requirements, but it always must include positive overflow from the system.
- f. The subsurface bed and overflow may be designed and evaluated in the same manner as a detention basin to demonstrate the mitigation of peak flow rates. In this manner, the need for a detention basin may be eliminated or the basin may be significantly reduced in size.
- g. A weir plate or weir within an inlet or overflow control structure may be used to maximize the water level in the stone bed while providing sufficient cover for overflow pipes.
- h. Perforated pipes may be used to evenly distribute runoff over the entire bed bottom. Continuously perforated pipes must connect structures (such as cleanouts and inlets). Pipes must lay flat and provide the uniform distribution of water. Depending on size, these pipes may provide additional storage volume.
- i. Infiltration areas must be located within the immediate project area in order to control runoff at its source. Expected use and traffic demands must also be considered in pervious pavement placement.
- j. An impervious water stop should be placed along infiltration bed edges where pervious pavement meets standard impervious pavements.
- k. The underlying infiltration bed is typically 12 to 36 inches deep and comprised of clean, uniformly-graded aggregate. A maximum of 30% will be approved for void space when determining storage volumes. AASHTO No. 3, which ranges 1.5 – 2.5in in gradation, is often used. Depending on local aggregate availability, both larger and smaller sized aggregate have been used. The critical requirements are that the aggregate be uniformly- graded, clean washed, and contain a significant void content. The depth of the bed is a function of stormwater storage requirements, frost depth considerations, site grading, and anticipated loading.
- l. While most pervious pavement installations are underlain by an aggregate bed, alternative subsurface storage products may also be employed.
- m. All pervious pavement installations must have a backup method for water to enter the stone storage bed in the event that the pavement fails or is altered. In uncurbed lots, this backup drainage may consist of an unpaved 2 ft wide stone edge drain connected directly to the bed. In curbed lots, inlets with sediment traps may be required at low spots. Backup drainage elements will ensure that functionality of the infiltration system if the pervious pavement is compromised.
- n. In those areas where the threat of spills and groundwater contamination is likely, pretreatment systems may be required before any infiltration occurs. In hot spots, such as truck stops and fueling stations, the appropriateness of pervious pavement must be carefully considered. A stone infiltration bed located beneath standard pavement, preceded by spill control and water quality treatment, may be more appropriate.

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2. PROHIBITIONS

Pervious pavement will not be allowed in the following:

- Areas with known pollution as identified by the MDEQ
- Within floodplains
- Where the estimated high ground water elevation will be within 3 feet of the bottom of the facility.

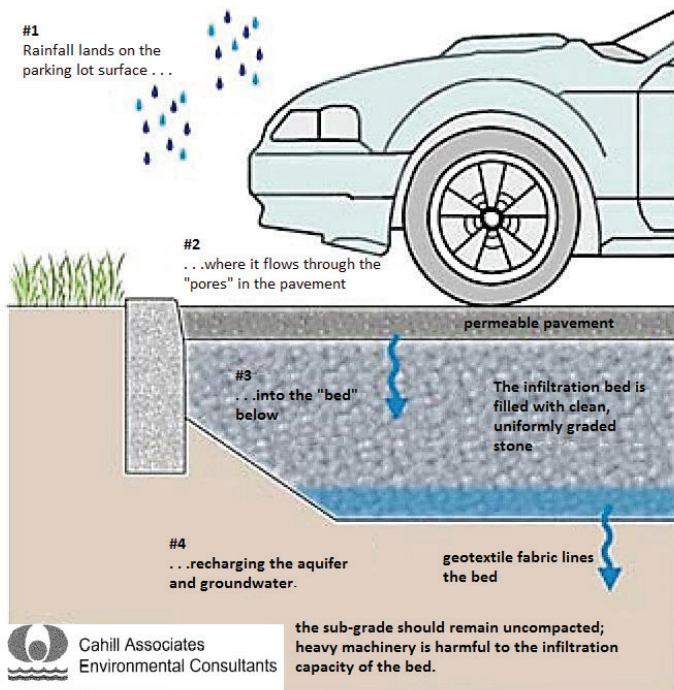


Figure 6. Pervious Pavement with infiltration

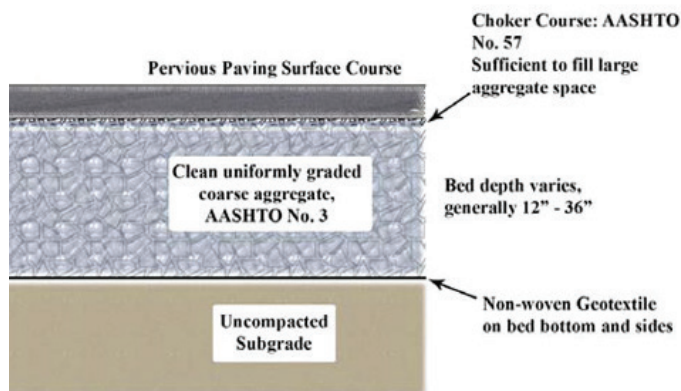


Figure 7. Pervious Pavement example cross-section*
 * An experienced civil or geotechnical engineer shall design the cross-section and mix design based on site-specific conditions.

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	50
Type IIb and III Public Water Supply Well	75
Septic System Drainfield (primary & reserve)	100
Type I and IIa Public Water Supply Well	200

*minimum with slopes directed away from building

4. TESTING REQUIREMENTS

- Follow the Soil Infiltration Testing Guidelines for testing requirements (**Part D**).
- The overall site must be evaluated for potential infiltration systems early in the design process.

5. CALCULATIONS

Infiltration Area

The minimum infiltration area must be based on the following equation:

$$\text{Minimum Infiltration Area} = \text{Contributing impervious area (including pervious pavement)} / 5$$

Volume Reduction

$$\text{Runoff Volume} = \text{Depth}*(\text{ft}) \times \text{Area} (\text{ft}^2) \times \text{Void Space (i.e. 0.30 for aggregate)}$$

*Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.

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Infiltration Volume = Bed Bottom Area (ft²) x Infiltration design rate (in/hr) x 6*(hr) x (1/12)

**Infiltration Period (6) is the time when bed is receiving runoff and capable of infiltrating at the design rate. This has been conservatively estimated as 6 hours.*

6. CONSTRUCTION

The following is a typical construction sequence; however, alternations will be necessary depending on design variations.

- a. Due to the nature of construction sites, pervious pavement and other infiltration measures must be installed toward the end of the construction period. Once the site is stabilized and erosion control is no longer required, the bed is excavated to its final grade and the pervious pavement system is installed.
- b. The existing subgrade under the bed areas must NOT be compacted or subject to excessive construction equipment traffic prior to geotextile and stone bed placement. Completed subgrade must be approved by the jurisdiction having authority prior to geotechnical installation.
- c. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding, this material must be removed with light equipment and the underlying soils scarified to a minimum depth of 6 inches with a York rake (or equivalent) and light tractor. All fine grading must be done by hand. All bed bottoms must be at level grade.
- d. Earthen berms (if used) between infiltration beds must be left in place during excavation. These berms do not require compaction if proven stable during construction.
- e. Geotextile bed aggregate must be placed immediately after approval of subgrade preparation. Geotextile is to be placed in accordance with manufacturer's standards and recommendations. Adjacent strips of geotextile must overlap a minimum of 18 inches. It must also be secured at least 4 feet outside of bed in order to prevent any runoff or sediment from entering the storage bed. This edge strip must remain in place until all bare soils contiguous to beds are stabilized and vegetated. As the site is fully stabilized, excess geotextile along bed edges can be cut back to bed edge.
- f. Clean (washed) uniformly-graded aggregate is to be placed in the bed in 8-inch lifts. Each layer must be lightly compacted, with the construction equipment kept off the bed bottom. Once bed aggregate is installed to the desired grade, a +/- 1 in. layer of choker base course aggregate (AASHTO #57) must be installed uniformly over the surface in order to provide an even surface for paving.
- g. After final pervious asphalt or concrete installation, no vehicular traffic of any kind must be permitted on the

pavement surface until cooling and hardening or curing has taken place, and in no case within the first 72 hours.

- h. The full permeability of the pavement surface must be tested by application of clean water at the rate of at least 5 gpm over the surface, using a hose or other distribution device. All applied water must infiltrate directly without puddle formation or surface runoff.
- i. Control of sediment is critical. Rigorous installation and maintenance of erosion and sediment control measures is required to prevent sediment deposition on the pavement surface or within the stone bed. Non-woven geotextile may be folded over the edge of the pavement until the site is stabilized. The designer should consider the site placement of pervious pavement to reduce likelihood of sediment deposition. Surface sediment must be removed by a vacuum sweeper and must not be power-washed into the bed.

7. MAINTENANCE

- a. In developments that have county drainage districts and drains established, pervious pavement stormwater credits will be provided as determined by the calculations set forth in these standards. Maintenance of pervious pavement will be the responsibility of the owner or governing association of the development and the deed restrictions and covenants for the development shall state such, including the annual testing and recording of permeability. The Water Resources Commissioner will not maintain nor accept easements over pervious pavement. In the event that pervious pavement in the drainage district is not maintained, the Water Resources Commissioner will take the appropriate legal action to enforce the deed and covenants.
- b. Prevent Clogging of Pavement Surface with Sediment
 - i. Vacuum pavement twice per year
 - ii. Maintain planted areas adjacent to pavement
 - iii. Immediately clean any soil deposited on pavement
 - iv. Do not allow construction staging, soil/mulch storage, etc. on unprotected pavement surface
 - v. Clean inlets draining to the subsurface bed twice per year
- c. Snow/Ice Removal
 - i. Do not apply abrasives such as sand or cinders on or adjacent to pervious pavement
 - ii. Snow plowing is fine but should be done carefully (i.e. set the blade slightly higher than usual)
 - iii. Salt application is acceptable, although more environmentally –benign deicers are preferable. The need for application of salt and other deicers should be minimal, as water does not pond and freeze on top of properly operating pervious pavement.

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- d.** Repairs
 - i.** Surface shall never be seal-coated
 - ii.** Damaged areas less than 50 sq. ft. can be patched with pervious or standard pavement
 - iii.** Larger areas should be patched with an approved pervious asphalt or pervious concrete, or as approved by the WCWRC.
 - iv.** Pervious pavers must be repaired/replaced with similar pervious paver block material or turf reinforcement system.
 - v.** Pervious pavers and gravel pavers may require the addition of aggregate on an annual basis or as needed, in order to replenish material used to fill in the open areas of the pavers. Turf pavers may require reseeding as needed if bare areas appear.

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Part H.

DESIGN REQUIREMENTS – DRY WELLS

1. GENERAL REQUIREMENTS

- a. Dry Wells are sized to temporarily retain and infiltrate stormwater runoff from roofs of structures. A dry well usually provides stormwater management for a limited roof area. Care should be taken not to hydraulically overload a dry well based on bottom area and drainage area. (**See Part D, Design Requirements for Infiltration Systems**)
- b. Dry Wells must drain-down within 48 hours. Longer drain-down times reduce Dry Well efficiency and can lead to anaerobic conditions, odor and other problems.
- c. Dry Wells are not recommended when their installation would create a significant risk for basement seepage or flooding. Ten feet of separation is required between Dry Wells and building foundations. However, this distance may be reduced with permission from the Water Resources Commissioner. Reduced separation distances may warrant that an impermeable liner be installed on the building side of the Dry Well and/or the bottom of the dry well to be sloped away from the building.
- d. The design depth of a Dry Well must take into account frost depth to prevent frost heave.
- e. A removable filter with a screened bottom must be installed in the roof leader below the surcharge pipe in order to screen out leaves and other debris. (See Figure 8.)
- f. Adequate inspection and maintenance access to the Dry Well will be provided. Observation wells not only provide the necessary access to the well, but they also provide a conduit through which pumping of stored runoff can be accomplished in case of slowed infiltration.
- g. Though roofs are generally not a significant source of runoff pollution, they can still be a source of particulates and organic matter, as well as sediment and debris during construction. Measures such as roof gutter guards, roof leader clean-out with sump, or an intermediate sump box can provide pretreatment for Dry Wells by minimizing the amount of sediment and other particulates that may enter it.

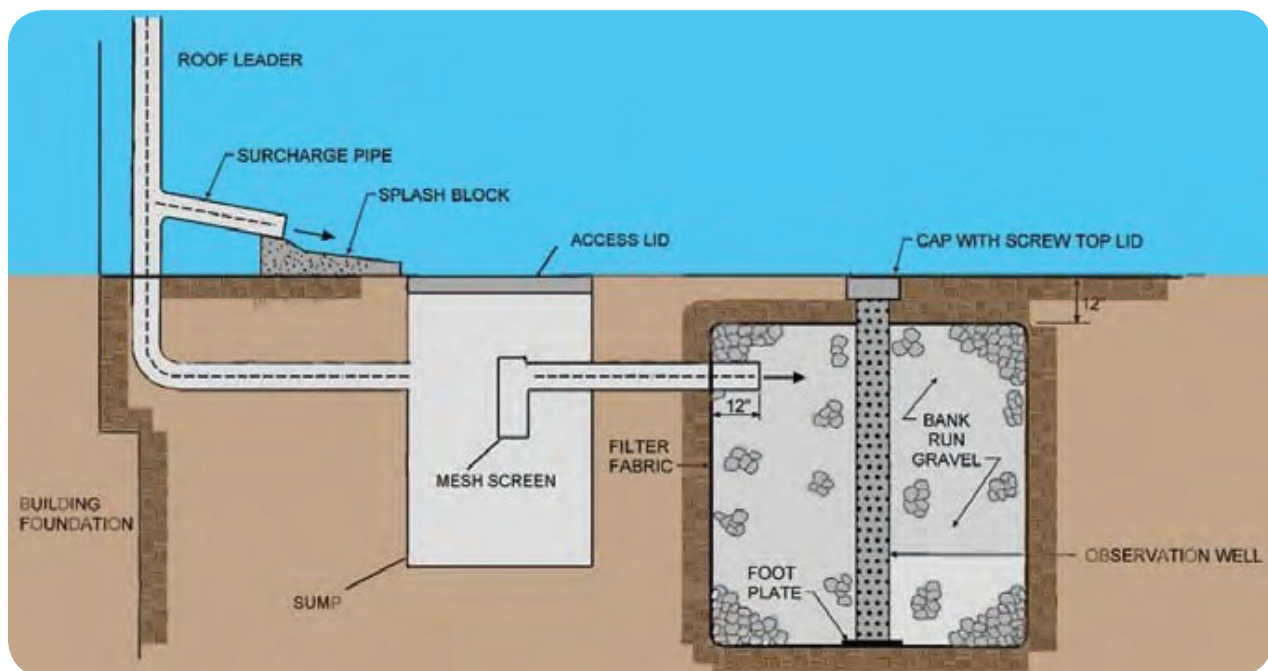


Figure 8. Dry Well Detail with sediment pretreatment catch basin

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2. PROHIBITIONS

Infiltration facilities will not be allowed in the areas that follow

- a. Areas with known pollution as identified by the MDEQ
- b. Within floodplains
- c. Where the estimated high ground water elevation will be within 3 feet of the bottom of the facility.

As with other infiltration practices, Dry Wells may not be appropriate for “hot spots” or other areas where high pollutant or sediment loading is expected without additional design considerations. Dry Wells are not recommended within a specified distance to structures or subsurface sewage disposal systems. (See Infiltration System Guidelines)

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	10
Type IIb and III Public Water Supply Well	75
Septic System Drainfield (primary & reserve)	50
Type I and IIa Public Water Supply Well	200

*minimum with slopes directed away from building

4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements within **Part D**.
- b. The overall site must be evaluated for potential infiltration systems early in the design process.

5. INLET/OULET DESIGN

A Dry Well is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from the roofs of structures. Roof leaders usually connect directly into the Dry Well.

All Dry Wells must be able to convey system overflows to downstream drainage systems. System overflows can be incorporated either as surcharge (or overflow) pipes extending from roof leaders or via connections to more substantial infiltration areas.

6. COMPONENTS/ CONFIGURATION

Dry Wells typically consist of 18 to 48 inches of clean washed, uniformly graded aggregate with 30% void capacity (AASHTO No. 3, or similar). Typically 40% void space is acceptable; however, a 25% reduction was incorporated as a safety factor. Dry Well aggregate is wrapped in a non-woven geotextile, which provides separation between the aggregate and the surrounding soil. Typically, Dry Wells will be covered in at least 12-inches of soil or 6-inches of gravel or riverstone. An alternative form of Dry Well is a subsurface, prefabricated chamber. A variety of prefabricated Dry Wells are currently available on the market.

7. EASEMENTS

Dry Wells will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, and other activities identified in the development’s stormwater system maintenance plan.

8. CALCULATIONS

Volume Reduction Calculations

The storage volume of a Dry Well is defined as the volume beneath the discharge invert. The following equation can be used to determine the approximate storage volume of an aggregate Dry Well:

$$\text{Storage Volume} = \text{Dry well area (ft}^2\text{)} \times \text{Dry well water depth (ft)} \times 30\% \text{ (if stone filled)}$$

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**Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.*

Infiltration Volume = Bed Bottom Area (ft²) x Infiltration design rate (in/hr) x Infiltration period* (hr) x (1/12)

**Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate, not to exceed 48 hours.*

Infiltration Area

A dry well may consider both bottom and side (lateral) infiltration according to design.

9. CONSTRUCTION

The following is a typical construction sequence; however, alterations will be necessary depending on design variations.

- a. The infiltration area must be protected from compaction prior to installation.
- b. Dry wells must not be placed on areas of recent fill or compacted fill. Any grade adjustments requiring fill must be done using the stone sub-base material. Areas of historical fill (>5 years) may be considered for Dry Wells.
- c. Install Dry Wells during later phases of site construction to prevent sedimentation and/or damage from construction activity.
- d. Installation and maintenance of proper Erosion and Sediment Control Measures must be followed during construction.
- e. Excavate Dry Well bottom to a uniform, level uncompacted subgrade free from rocks and debris. Do NOT compact subgrade. To the greatest extent possible, excavation should be performed with the lightest practical equipment. Excavation equipment should be placed outside the limits of the Dry Well.
- f. Completely wrap Dry Well with nonwoven geotextile. (If sediment and/or debris have accumulated in Dry Well bottom, remove prior to geotextile placement.) Geotextile rolls must overlap by a minimum of 24 inches within the trench. Fold back and secure excess geotextile during stone placement.
- g. Install continuously perforated pipe, observation wells, and all other Dry Well structures. Connect roof leaders to structures as indicated on plans.
- h. Clean-washed uniformly graded aggregate is to be placed in 6 inch lifts. Each layer must be lightly compacted with the construction equipment kept off the bed bottom.
- i. Fold and secure nonwoven geotextile over trench with a minimum overlap of 12 inches.
- j. Place a 12 inch lift of approved topsoil over trench, as indicated on plans.
- k. Topsoil stabilization and seed must be applied to the disturbed area.

- l. Connect surcharge pipe to roof leader and position over splashboard.
- m. Do not remove Erosion and Sediment Control measures until site is fully stabilized.

10. MAINTENANCE

As with all infiltration practices, Dry Wells require regular and effective maintenance to ensure prolonged functioning. The following represent minimum maintenance requirements for Dry Wells:

- a. Inspect Dry Wells at least four times a year, as well as after every storm exceeding one inch.
- b. Dispose of sediment, debris/trash, and any other waste material removed from a Dry Well at suitable disposal/recycling sites and in compliance with local, state, and federal waste regulations.
- c. Evaluate the drain-down time of the Dry Well to ensure the maximum time of 48 hours is not being exceeded. If drain-down times are exceeding the maximum, drain the Dry Well via pumping and clean out perforated piping, if included. If slow drainage persists, the system may need replacing.
- d. Regularly clean out gutters and ensure proper connections to facilitate the effectiveness of the dry well.
- e. Replace filter screen that intercepts roof runoff as necessary.
- f. If an intermediate sump box exists, clean it out at least once per year.

Section V: Design Requirements For Stormwater Management Systems

Part I.

DESIGN REQUIREMENTS – STRUCTURAL INFILTRATION BASINS

1. GENERAL REQUIREMENTS

- a. Infiltration Basins are sized to temporarily retain and infiltrate stormwater runoff from areas five to 50 acres with slopes less than 20 percent. An Infiltration Basin is typically one large or several small impoundments meant to detain and infiltrate runoff. (See Figure 9) Care should be taken not to hydraulically overload an Infiltration Basin based on bottom area and drainage area. (See *Design Requirements for Infiltration Systems, Part D.*)
- b. Infiltration Basins must drain-down within 48 hours. Longer drain-down times reduce Infiltration Basin efficiency and can lead to anaerobic conditions, odor and other problems.
- c. Infiltration Basins are not recommended when their installation would create a significant risk for basement seepage or flooding. 15 feet of separation is required between Infiltration Basins and building foundations.
- d. A 6-inch interceptor layer of sand must be applied to the bottom of the basin to filter out sediment and debris.
- e. Adequate inspection and maintenance access to the Infiltration Basin will be provided.
- f. A maintainable engineered structure, such as an infiltration trench, must be placed in the bottom of the Infiltration Basin.

2. PROHIBITIONS

Infiltration facilities will not be allowed in the areas that follow:

- a. Areas with known pollution as identified by the MDEQ
- b. Within a floodplain
- c. Where the estimated high ground water elevation will be within 3 feet of the bottom of the facility.

As with other infiltration practices, Infiltration Basins may not be appropriate for “hot spots” or other areas where high pollutant or sediment loading is expected without additional design considerations. Infiltration Basins are not recommended within a specified distance to structures of subsurface sewage disposal systems. (See Infiltration System Guidelines)

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	50
Type IIb and III Public Water Supply Well	75
Septic System Drainfield (primary & reserve)**	100
Type I and IIa Public Water Supply Well	200

*minimum with slopes directed away from building

**50 feet from septic systems with a design flow less than 1,000 gallons per day

Figure 9. Infiltration Basin Schematic

Section V: Design Requirements For Stormwater Management Systems



4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements within **Part D**.
- b. The overall site must be evaluated for potential infiltration systems early in the design process.

5. COMPONENTS/ CONFIGURATION

The primary components (and subcomponents) of an Infiltration Basin system are:

Pretreatment (where required)

- Flow through a vegetated buffer strip, water quality inlet, etc. prior to entry into the Infiltration Basin System.

Flow Entrance

Water may enter via:

- An inlet (e.g. flared end section)
- Sheet flow into the facility over grassed areas
- Curb cuts with grading for sheet flow entrance
- Roof leaders with direct surface connection
- Trench drain

In all cases entering velocities must be non-erosive.

Positive Overflow

Infiltration basin design will include a positive overflow that will discharge runoff during large storm events when the subsurface/surface storage capacity is exceeded.

- Examples include a structural outlet or emergency spillway.
- Discharge must be directed in a manner to avoid property damage and have an unimpeded route to a receiving channel or outlet.

Ponding Area

- Slopes will not exceed 5:1
- Top of berm widths must be at least two feet wide
- An overflow must be provided
- Plants must be salt tolerant if in a location that would receive snowmelt chemicals

Planting

Proper plant selection is essential for Infiltration Basins to be effective. Typically, native floodplain or wet meadow plant species are best suited to the variable environmental conditions encountered in an Infiltration Basin system. In most cases, seed is not the preferred method for plant establishment in an Infiltration Basin system. The fluctuating water levels make it difficult for the seed to readily establish, while the random nature of seeding produces a look that is too wild for many

situations. Instead, it is recommended that live plant material in plug or gallon-potted form should be utilized and installed on 1'-2' centers.

If shrubs and trees are included in an Infiltration Basins area, at least three species of shrub and tree should be planted. Shrub to tree ratio should be between 2:1 and 3:1. Use an experienced landscape architect to design a native planting layout.

Planting periods will vary, but planting should be from mid-March through early June, or mid-September through mid-November.

Planting Soil must be a loam soil capable of supporting a healthy vegetative cover. Soils must be amended with a composted organic material. A recommended soil blend is 20-30% organic material (compost), 20-30% sand, and 20-30% topsoil. Planting soil must be 4 inches deeper than the bottom of the largest root ball.

Soils must have clay content less than 10% (a small amount of clay is beneficial to absorb pollutants and retain water), be free of toxic substances and unwanted plant material and have a 5-10% organic matter content. Additional organic matter can be added to the soil to increase water holding capacity (tests should be conducted to determine storage capacity of amended soils).

6. EASEMENTS

Infiltration Basins will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment spoils deposition, and other activities identified in the development's stormwater system maintenance plan.

7. CALCULATIONS

Volume Reduction Calculations

The following equation can be used to determine the approximate storage volume of an Infiltration Basin:

$$\text{Storage Volume (ft}^3\text{)} = \text{Average bed area (ft}^2\text{)} \times \text{Maximum design water depth (ft)}$$

$$\text{Subsurface storage/infiltration bed volume (ft}^3\text{)} = \text{Infiltration area (ft}^2\text{)} \times \text{Depth of underdrain material (ft)} \times \text{Void ratio of storage material (\%)}$$

**Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.*

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Infiltration Volume (ft³) = Bed bottom area (ft²) x [Infiltration design rate (in/hr) x Infiltration period* (hr)] x (1/12)

**Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate. Not to exceed 48 hours.*

Infiltration Area

The minimum infiltration area of the Infiltration Basin is defined as:

Minimum surface area = Contributing impervious area / 5*

**May be increased at the discretion of the Water Resources Commissioner depending on soil infiltration rate, e.g. where soils are Type A or rapidly draining.*

- b. Inspect for sediment accumulation, outlet control structure damage, erosion control measures, signs of water contamination/spills and slope/berm stability.
- c. Mowing should occur only as required for vegetative cover.
- d. Dispose of sediment, debris/trash, and any other waste material removed from the Infiltration Basins at a suitable disposal/recycling site and in compliance with local, state, and federal waste regulations.
- e. Evaluate the drain-down time of the Infiltration Basin to ensure the maximum time of 48 hours is not being exceeded. If slow drainage persists, the system may need rehabilitation.

8. CONSTRUCTION

The following is a typical construction sequence; however, alterations will be necessary depending on design variations.

- a. The infiltration area must be protected from compaction prior to installation.
- b. Infiltration Basins must not be placed on areas of recent fill or compacted fill. Any grade adjustments requiring fill must be done using the stone sub-base material. Areas of historical fill (>5 years) may be considered for infiltration basins.
- c. Installation and maintenance of proper Erosion and Sediment Control Measures must be followed during construction.
- d. Excavate Infiltration Basin bottom to a uniform, level uncompacted subgrade free from rocks and debris. Do NOT compact subgrade. Excavation should be performed with the lightest practical equipment. Excavation equipment should be placed outside the limits of the Infiltration Basin.
- e. Topsoil stabilization and seed must be applied to the disturbed area.
- f. Do not remove Erosion and Sediment Control measures until site is fully stabilized.
- g. Permeability shall be reverified by infiltration prior to acceptance.

9. MAINTENANCE

As with all infiltration practices Infiltration Basins require regular and effective maintenance to ensure prolonged functioning. The following represent minimum maintenance requirements for Infiltration Basins:

- a. Inspect Infiltration Basins after every storm exceeding one inch.

Part J.

DESIGN REQUIREMENTS – SUBSURFACE INFILTRATION BEDS

1. GENERAL REQUIREMENTS

- a. Subsurface Infiltration Beds are sized to temporarily retain and infiltrate stormwater runoff from areas no greater than 10 acres. A Subsurface Infiltration Bed is typically a rock storage bed below the surface meant to detain and infiltrate runoff. (See Figure 10.)
- b. Subsurface Infiltration Beds must drain-down within 48 hours. Longer drain-down times reduce Subsurface Infiltration Bed efficiency and can lead to anaerobic conditions, odor and other problems.
- c. Subsurface Infiltration Beds are not recommended when their installation would create a significant risk for basement seepage or flooding. Fifteen feet of separation is required between Subsurface Infiltration Beds and building foundations.
- d. The Subsurface Infiltration Bed must be wrapped in non-woven geotextile filter fabric to prevent the migration of the subsoils into the stone voids.
- e. The underlying infiltration bed is typically 12-36 inches deep and comprised of clean, uniformly graded aggregate with approximately 30% void space. Typically 40% void space is acceptable; a 25% reduction is incorporated as a safety factor. AASHTO No. 3, which ranges 1.5-2.5 inches in gradation, is often used. Depending on local aggregate availability, both larger and smaller size aggregate has been used. The critical requirements are that the aggregate be uniformly graded, clean washed, and contain a significant void content. The depth of the bed is a function of stormwater storage requirements, frost depth considerations, site grading, and anticipated loading. Infiltration beds are typically sized to mitigate the increased runoff volume from a 2-yr design storm.
- f. An overflow device must be incorporated into the design of the subsurface infiltration bed.
- g. Perforated pipes may be used to evenly distribute runoff over the entire bed bottom. Continuously perforated pipes must connect structures (such as cleanouts and inlets). Pipes must lay flat and provide for uniform distribution of water. Depending on size, these pipes may provide additional storage volume.
- h. Adequate inspection and maintenance access or perforated pipe cleanouts to the Subsurface Infiltration Bed will be provided.

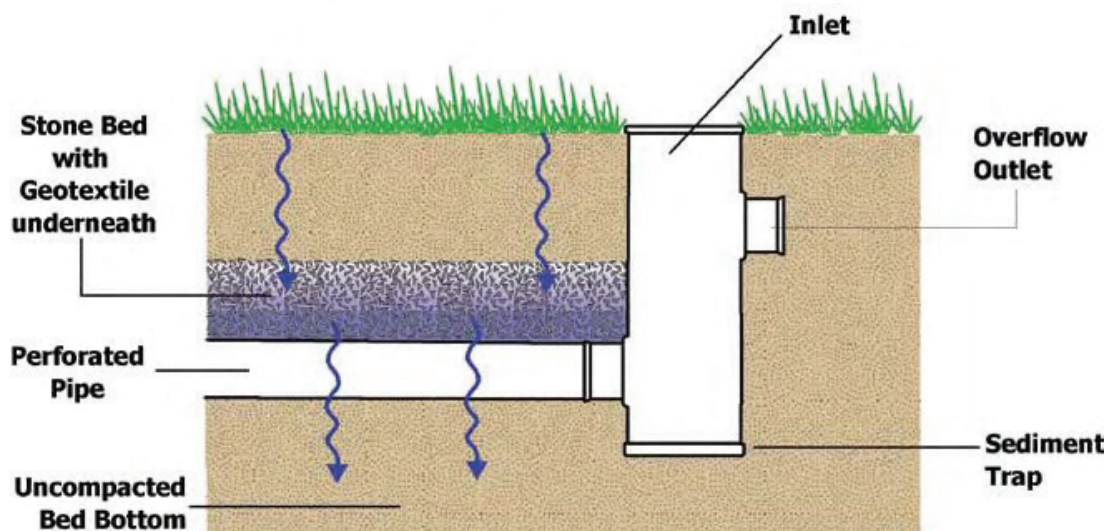


Figure 10. Subsurface Infiltration Bed Schematic

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2. PROHIBITIONS

Infiltration facilities will not be allowed in the following areas:

- a. Areas with known pollution as identified by the MDEQ
- b. Within floodplains
- c. Where the estimated high ground water elevation will be within 3 feet of the bottom of the facility.

As with other infiltration practices, Subsurface Infiltration Beds may not be appropriate for “hot spots” or other areas where high pollutant or sediment loading is expected without additional design considerations. Subsurface Infiltration Beds are not recommended within a specified distance to structures of subsurface sewage disposal systems. (See Infiltration System Guidelines)

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	50
Type IIb and III Public Water Supply Well	75
Septic System Drainfield (primary & reserve)**	100
Type I and IIa Public Water Supply Well	200

*minimum with slopes directed away from building

**50 feet from septic systems with a design flow less than 1,000 gallons per day

4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements within the Design Requirements for Infiltration BMPs section.
- b. The overall site shall be evaluated for potential infiltration systems early in the design process.

5. INLET/ OUTLET DESIGN

A Subsurface Infiltration Bed is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from nearby impervious areas. Roof leaders, inlets and catch basins usually connect directly into the Subsurface Infiltration Bed. All Subsurface Infiltration Beds must be able to convey system overflows to downstream drainage systems. System overflows

can be incorporated either as surcharge (or overflow) pipes or via connections to more substantial infiltration areas.

6. COMPONENTS/ CONFIGURATION

Subsurface Infiltration Beds typically consist of 12 to 36 inches of clean washed, uniformly graded aggregate with 30% void capacity (AASHTO No. 3 or similar). Typically 40% void space is acceptable; however a 25% reduction was incorporated as a safety factor. Subsurface Infiltration Bed aggregate is wrapped in a non-woven geotextile, which provides separation between the aggregate and the surrounding soil. Typically, Subsurface Infiltration Bed will be covered in at least 12-inches of soil or 6-inches of gravel or riverstone. An alternative form of Subsurface Infiltration Beds is a subsurface, prefabricated perforate pipe chamber. A variety of prefabricated perforated pipes are currently available on the market for Subsurface Infiltration Bed applications.

7. EASEMENTS

Subsurface Infiltration beds will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment spoils deposition, and other activities identified in the development’s stormwater system maintenance plan.

8. CALCULATIONS

Volume Reduction Calculations

The following can be used to determine the approximate storage volume of a Subsurface Infiltration Bed:

$$\text{Subsurface storage/infiltration bed volume (ft}^3\text{)} = \text{Infiltration area (ft}^2\text{)} \times \text{Depth of underdrain material (ft)} \times \text{Void ratio of storage material (\%)}$$

*Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.

$$\text{Infiltration Volume (ft}^3\text{)} = \text{Bed bottom area (ft}^2\text{)} \times [\text{Infiltration design rate (in/hr)} \times \text{Infiltration period* (hr)}] \times (1/12)$$

*Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate. Not to exceed 48 hours.

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Infiltration Area

The minimum infiltration area of the Subsurface Infiltration Bed is defined as:

Minimum surface area = Contributing impervious area /5*

**May be increased at the discretion of the Water Resources Commissioner depending on soil infiltration rate, e.g. where soils are Type A or rapidly draining.*

9. CONSTRUCTION

The following is a typical construction sequence; however, alterations will be necessary depending on design variations.

- a. The infiltration area must be protected from compaction prior to installation.
- b. Subsurface Infiltration Beds must not be placed on areas of recent fill or compacted fill. Any grade adjustments requiring fill must be done using the stone sub-base material. Areas of historical fill (>5 years) may be considered for Subsurface Infiltration Beds.
- c. Install Subsurface Infiltration Beds during later phases of site construction to prevent sedimentation and/or damage from construction activity.
- d. Installation and maintenance of proper Erosion and Sediment Control Measures must be followed during construction.
- e. Excavate Subsurface Infiltration Bed bottom to a uniform, level uncompacted subgrade free from rocks and debris. Do NOT compact subgrade. To the greatest extent possible, excavation should be performed with the lightest practical equipment. Excavation equipment should be placed outside the limits of the Subsurface Infiltration Bed.
- f. Completely line Subsurface Infiltration Bed with non-woven geotextile. (If sediment and/or debris have accumulated in the Subsurface Infiltration Bed bottom, remove prior to geotextile placement.) Geotextile rolls must overall by a minimum of 18 inches within the trench. Fold back and secure excess geotextile during stone placement.
- g. Observation wells must be installed on both ends of the Subsurface Infiltration Bed. Connect inlets, catch basins and roof leaders to the Subsurface Infiltration Bed as indicated on plans.
- h. Clean-washed uniformly grated aggregate is to be placed in 6-inch lifts. Each layer must be lightly compacted with the construction equipment kept off the bed bottom.
- i. Fold and secure non-woven geotextile over trench with a minimum overlap of 18-inches.
- j. Place a 6-inch lift of approved topsoil over trench, as indicated on plans.
- k. Topsoil stabilization and seed must be applied to the

disturbed area.

- l. Do not remove Erosion and Sediment Control measures until site is fully stabilized.

10. MAINTENANCE

As with all infiltration practices, Subsurface Infiltration Beds require regular and effective maintenance to ensure prolonged functioning. The following represent minimum maintenance requirements for Subsurface Infiltration Beds:

- a. Dispose of sediment, debris/trash, and any other waste material removed from a Subsurface Infiltration Bed at suitable disposal/recycling sites and in compliance with local, state, and federal waste regulations.
- b. Evaluate the drain-down time of the Subsurface Infiltration Bed to ensure the maximum time of 48 hours is not being exceeded. If drain-down time are exceeding the maximum, drain the Subsurface Infiltration Bed via pumping and clean out perforated piping, if included. If slow drainage persists, the system may need replacing.
- c. Regularly clean out inlets, catch basins and gutters to ensure proper connections to facilitate the effectiveness of the Subsurface Infiltration Bed.
- d. Replace filter screen that intercepts roof runoff as necessary.
- e. If an intermediate sump box exists, clean it out at least once per year.

Section V: Design Requirements For Stormwater Management Systems

Part K.

DESIGN REQUIREMENTS – INFILTRATION TRENCHES

1. GENERAL REQUIREMENTS

- a. Infiltration Trenches are sized to temporarily retain, infiltrate and convey stormwater runoff from areas no greater than five (5) acres. An Infiltration Trench is typically a linear trench with a rock storage bed below the surface.
- b. Infiltration Trenches must drain-down within 48 hours. Longer drain-down times reduce Infiltration Trench efficiency and can lead to anaerobic conditions, odor and other problems.
- c. Infiltration Trenches are not recommended when their installation would create a significant risk for basement seepage or flooding. Fifteen feet of separation is required between Infiltration Trenches and building foundations.
- d. The Infiltration Trench must be wrapped in non-woven geotextile filter fabric to prevent the migration of the subsoils into the stone voids.
- e. The underlying infiltration bed is typically comprised of clean, uniformly-graded aggregate with approximately 30% void space. Typically 40% void space is acceptable; however, a 25% reduction was incorporated as a safety factor. AASHTO No.3, which ranges 1.5-2.5in in gradation, is often used. Depending on local aggregate availability, both larger and smaller size aggregate may be used. The critical requirements are that the aggregate be uniformly graded, clean washed, and contain a significant void content. The depth of the bed is a function of stormwater storage requirements, frost depth considerations, site grading, and anticipated loading. Infiltration Trenches are typically sized to mitigate the increased runoff volume from a 2-yr design storm.
- f. A water quality inlet or catch basin with sump is required for all surface inlets to avoid standing water for periods greater than 48 hours.
- g. Perforated pipes along the bottom of the bed may be used to evenly distribute runoff over the entire bed bottom. Continuously perforated pipes must connect structures (such as cleanouts and inlets). Pipes must lay flat along the bed bottom and provide for uniform distribution of water. Depending on size, these pipes may provide additional storage volume.
- h. Adequate inspection and maintenance accesses or cleanouts to the Subsurface Infiltration Bed will be provided.

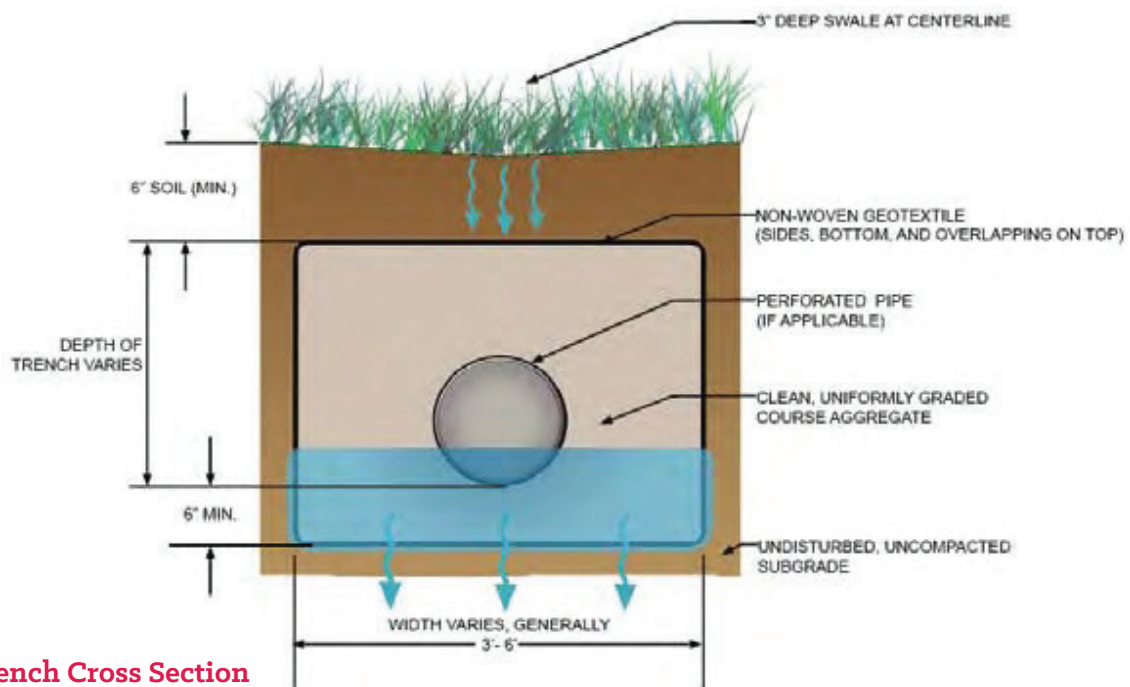


Figure 11.
Infiltration Trench Cross Section

Section V: Design Requirements For Stormwater Management Systems



2. PROHIBITIONS

Infiltration facilities will not be allowed in the following areas:

- a. Areas with known pollution as identified by the MDEQ
- b. Within floodplains
- c. Where the estimated high ground water elevation will be within 3 feet of the bottom of the facility.

As with other infiltration practices, Infiltration Trenches may not be appropriate for “hot spots” or other areas where high pollutant or sediment loading is expected without additional design considerations. Infiltration Trenches are not recommended within a specified distance to structures of subsurface sewage disposal systems. (See Infiltration System Guidelines)

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	50
Type IIb and III Public Water Supply Well	75
Septic System Drainfield (primary & reserve)**	100
Type I and IIa Public Water Supply Well	200

*minimum with slopes directed away from building

**50 feet from septic systems with a design flow less than 1,000 gallons per day

4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements within **Part D**.
- b. The overall site must be evaluated for potential infiltration systems early in the design process.

5. INLET/OUTLET DESIGN

An Infiltration Trench is a subsurface storage facility that temporarily stores, infiltrates and conveys stormwater runoff from nearby impervious areas. Inlets and catch basins with sumps connect directly to the Infiltration Trench.

All Infiltration Trenches must be able to convey system overflows to downstream drainage systems. System overflows

can be incorporated either through surcharge (or overflow) pipes or via connections to more substantial infiltration areas.

6. COMPONENTS/CONFIGURATION

Infiltration Trenches typically consists of clean washed, uniformly graded aggregate with 30% void capacity (AASHTO No.3, or similar). Typically 40% void space is acceptable; however, a 25% reduction was incorporated as a safety factor. Infiltration Trench aggregate is wrapped in a non-woven geotextile, which provides separation between the aggregate and the surrounding soil. Typically, Infiltration Trenches will be covered in at least 12-inches of soil or 6-inches of gravel or river stone. An alternative form of Infiltration Trench is a subsurface, prefabricated perforated pipe chamber. A variety of prefabricated perforated pipes are currently available on the market for Infiltration Trench applications.

7. EASEMENTS

Infiltration Trenches will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment spoils deposition, and other activities identified in the development’s stormwater system maintenance plan.

8. CALCULATIONS

Volume Reduction Calculations

The following equation can be used to determine the approximate storage volume of an Infiltration Trench.

$$\text{Subsurface storage/infiltration bed volume (ft}^3\text{)} = \text{Infiltration area (ft}^2\text{)} \times \text{Depth of underdrain material (ft)} \times \text{Void ratio of storage material (\%)}$$

*Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.

$$\text{Infiltration Volume (ft}^3\text{)} = \text{Bed bottom area (ft}^2\text{)} \times [\text{Infiltration design rate (in/hr)} \times \text{Infiltration Period* (hr)}] \times (1/12)$$

*Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate. Not to exceed 48 hours.

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Infiltration Area

The minimum infiltration area of the Infiltration Trench is defined as:

$$\text{Minimum surface area} = \text{Contributing impervious area} / 5^*$$

**May be increased at the discretion of the Water Resources Commissioner depending on soil infiltration rate, e.g. where soils are Type A or rapidly draining.*

9. CONSTRUCTION

The following is a typical construction sequence; however alterations will be necessary depending on design variations.

- a. The infiltration area must be protected from compaction prior to installation.
- b. Infiltration Trenches must not be placed on areas of recent fill or compacted fill. Any grade adjustments requiring fill must be done using the stone sub-base material. Areas of historical fill (>5 years) may be considered for Infiltration Trenches.
- c. Install Infiltration Trenches during later phases of site construction to prevent sedimentation and/or damage from construction activity.
- d. Installation and maintenance of proper Erosion and Sediment Control Measures must be followed during construction.
- e. Excavate Infiltration Trench bottom to a uniform, level uncompacted subgrade free from rocks and debris. Do NOT compact subgrade. To the greatest extent possible, excavation should be performed with the lightest practical equipment. Excavation equipment should be placed outside the limits of the Subsurface Infiltration Bed.
- f. Completely wrap Infiltration Trench with non-woven geotextile. (If sediment and/or debris have accumulated in Infiltration Trench bottom, remove prior to geotextile placement.) Geotextile rolls must overlap by a minimum of 24 inches within the trench. Fold back and secure excess geotextile during stone placement.
- g. Install continuously perforated pipe, observation wells, and all other Infiltration Trench structures. Connect inlets and catch basins to trench as indicated on approved plans.
- h. Clean-washed, uniformly graded aggregate is to be placed in 8-inch lifts. Each layer must be lightly compacted with the construction equipment kept off the bed bottom.
- i. Backfill perforated pipe with clean-washed uniformly graded aggregate in 8-inch lifts, lightly compacted between lifts.
- j. Fold and secure non-woven geotextile over trench with a minimum overlap of 16-inches.
- k. Place a 6-inch lift of approved topsoil over trench, as indicated on approved plans.

- l. Topsoil stabilization and seed must be applied to the disturbed area.
- m. Do not remove Erosion and Sediment Control measures until site is fully stabilized.

10. MAINTENANCE

As with all infiltration practices, Infiltration Trenches require regular and effective maintenance to ensure prolonged functioning. The following represent minimum maintenance requirements for Infiltration Trenches.

- a. Inspect Infiltration Trenches at least four times per year, as well as after every storm exceeding one inch.
- b. Dispose of sediment, debris/trash, and any other waste material removed from a Infiltration Trench at suitable disposal/recycling sites and in compliance with local, state, and federal waste regulations.
- c. Evaluate the drain-down time of the Infiltration Trench to ensure the maximum time of 48 hours is not being exceeded. If drain-down times are exceeding the maximum, drain the Infiltration Trench via pumping and clean out perforated piping, if included. If slow drainage persists, the system may need replacing.
- d. Regularly clean out inlets, catch basins and gutter and ensure proper connections to facilitate the effectiveness of the Infiltration Trench.
- e. Replace filter screen that intercepts roof runoff as necessary.
- f. If an intermediate sump box exists, clean it out at least once per year.

Section V: Design Requirements For Stormwater Management Systems



Part I.

DESIGN REQUIREMENTS – VEGETATED FILTER STRIPS

1. GENERAL REQUIREMENTS

Vegetated Filter Strips are planted permanent linear features meant to slow and infiltrate overland runoff as well as filter out sediments. To be effective, stormwater entering the Vegetated Filter Strip must be sheet flow. Typically this type of BMP is used with other BMPs such as a level spreader to increase the stormwater mitigation potential.

2. PROHIBITIONS

Vegetated Filter Strips will not be allowed in the following:

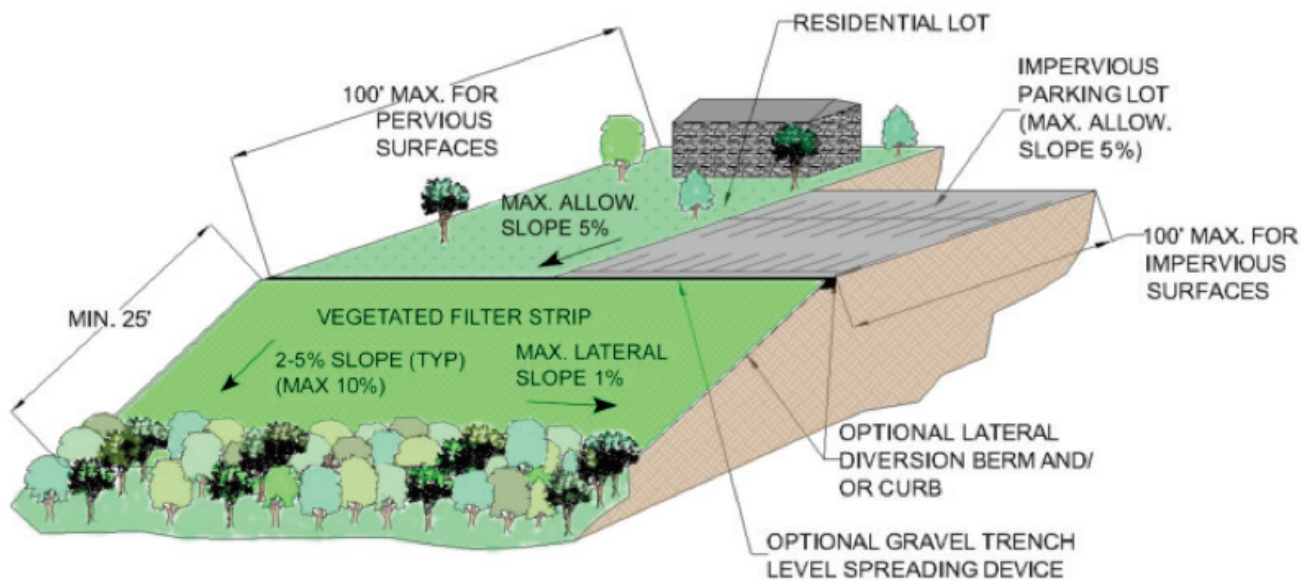
- a. Areas with known pollution as identified by the MDEQ
- b. Within floodplains
- c. Where the estimated high ground water elevation will be within two (2) feet of the bottom of the facility.

3. SETBACKS

Setback Distances - N/A

4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements with **Part D**, Design Requirements for Infiltration BMPs.
- b. The overall site must be evaluated for potential infiltration systems early in the design process.



FILTER STRIP SLOPE IS A FUNCTION OF VEGETATIVE COVER, HYDROLOGIC SOIL GROUP, SOIL TYPE, AND SLOPE

Figure 12. Vegetated Filter Strip

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5. VEGETATED FILTER STRIP COMPONENTS/CONFIGURATION

Proper plant selection is essential for Vegetated Filter Strip areas to be effective. Native, salt-tolerant, drought tolerant and erosion resistant plant species are suited to the variable environmental conditions encountered in a Vegetated Filter Strip. See the **Low Impact Development Manual for Michigan** for a comprehensive list of acceptable Vegetated Filter Strip plants.

Planting periods will vary, but in general vegetation should be planted from mid-March through early June, or mid-September through mid-November.

Planting soil must be a loam soil capable of supporting healthy vegetative cover. A recommended soil blend is 20-30% organic material (compost), 20-30% sand, and 20-30% topsoil. Planting soil must be 4 inches deeper than the bottom of the largest root ball, or native soils in-situ at a depth of eight (8) inches.

Soils must have clay content less than 10% (a small amount of clay is beneficial to absorb pollutants and retain water), and be free of toxic substances and unwanted plant material. (Tests should be conducted to determine volume storage capacity of amended soils.)

6. EASEMENTS

Vegetated Filter Strips will have sufficient easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, spoils deposition and other activities identified in the development's stormwater maintenance plan.

7. CALCULATIONS

Volume Reduction Calculation

Typically Vegetated Filter Strips do not have significant volume reducing capacity. However, it is entirely possible to infiltrate and evapotranspire during a storm event. To account for the volume reduction, it is recommended to weight the curve number of the drainage area with that of the Vegetated Filter Strip.

The cover type of the Vegetated Filter Strip must be considered in the volume reduction calculation. Areas with turf grass should not be used in the volume reduction calculation for a Vegetated Filter Strip.

Sizing Criteria

- a. **Surface area** is dependent upon storage volume requirements but should generally not exceed a maximum lading ratio of 6:1 (impervious drainage area to infiltration area; see Design Requirements for Infiltration Systems for additional guidance on loading rates.)
- b. **Surface Side slopes** must be gradual. The maximum allowable slope for Vegetated Filter Strips is 3:1.
- c. **Planting soil depth** must be at least eight inches where only herbaceous plant species will be utilized. If trees and woody shrubs will be used, soil media depth may be increased depending on plant species.

8. CONSTRUCTION

The following is a typical construction sequence; however, alterations will be necessary depending on design variations. Note for all construction steps: Erosion and sediment control methods must adhere to the latest requirements of the Michigan DEQ's Soil Erosion and Sedimentation Control Program.

- a. Install temporary sediment control BMPs as shown on the plans.
- b. Begin construction of the Vegetated Filter Strip only when the upper gradient has been significantly stabilized.
- c. Complete site grading, minimizing compaction as much as possible. If applicable, construct curb cuts or other inflow entrances but provide protection so that drainage is prohibited from entering the Vegetated Filter Strip construction area.
- d. Grade the Vegetated Filter Strip as proposed on approved plans and scarify the existing soil surfaces. Do not compact in-situ soils.
- e. Do not compact the subgrade of gravel trenches.
- f. Presoak the planting soil prior to planting vegetation to aid in settlement.
- g. If used, sod must be staggered and placed tightly to avoid gaps and channelization. A roller must be used on the sod to remove and prevent any air pockets.
- h. Seeded Vegetated Filter Strips must be stabilized with mulch blankets and staked to prevent erosion.
- i. Install erosion protection at surface flow entrances where necessary.
- j. Erosion control must be present until the site is fully stabilized.
- k. Once drainage area and Vegetated Filter Strip are completely and permanently stabilized after one full grow year, the Vegetated Filter Strip should be brought online.

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9. MAINTENANCE

Properly designed and installed Vegetated Filter Strips require regular maintenance.

- a. Removal of weeds and unwanted species is usually needed within the first 1-3 years following installation.
- b. If a sediment control device, such as a stone trench or level spreader is installed, it shall be inspected quarterly for the first two years following construction and then twice a year thereafter.
- c. Sediment and debris must be removed when build up exceeds two inches in depth in the Vegetated Filter Strip, level spreader or stone trench.
- d. Disposal of sediment, debris/trash, and any other waste material shall be disposed/recycled at a suitable site, in compliance with local, state, and federal waste regulations.
- e. Rills and gullies must be filled in with topsoil and stabilized with seed and mulch blankets.
- f. Detritus (e.g. dead/decomposing leaves) may also need to be removed approximately twice per year. Perennial planting may be cut down at the end of the growing season, or beginning of the next.
- g. Invasive species must be removed on an annual basis and disposed of in compliance with local, state, and federal regulations.
- h. If used, grass cover must be maintained and mowed at a height of 4-6 inches.

Section V: Design Requirements For Stormwater Management Systems

Part M.

DESIGN REQUIREMENTS – BIOSWALES

1. GENERAL REQUIREMENTS

Bioswales are shallow densely planted channels meant to convey stormwater runoff as well as filter out other sediments. Check dams shall be installed per the **Low Impact Development Manual for Michigan** to improve sediment capture and increase the time of concentration. If appropriate, clean washed aggregate and perforated pipe can be introduced into the system to enhance the storage capacity of the bioswale. If an underdrain is used there will be no allowance for infiltration credits.

2. PROHIBITIONS

Bioswales will not be allowed in the following:

- Areas with known pollution as identified by the MDEQ

3. SETBACKS

Setback Distances

Setback from	Minimum Distance(feet)
Property Line	10
Building Foundation/Basement*	15
Private Well	10
Public Water Supply Well	10
Septic System Drainfield (primary & reserve)	50

*minimum with slopes directed away from building

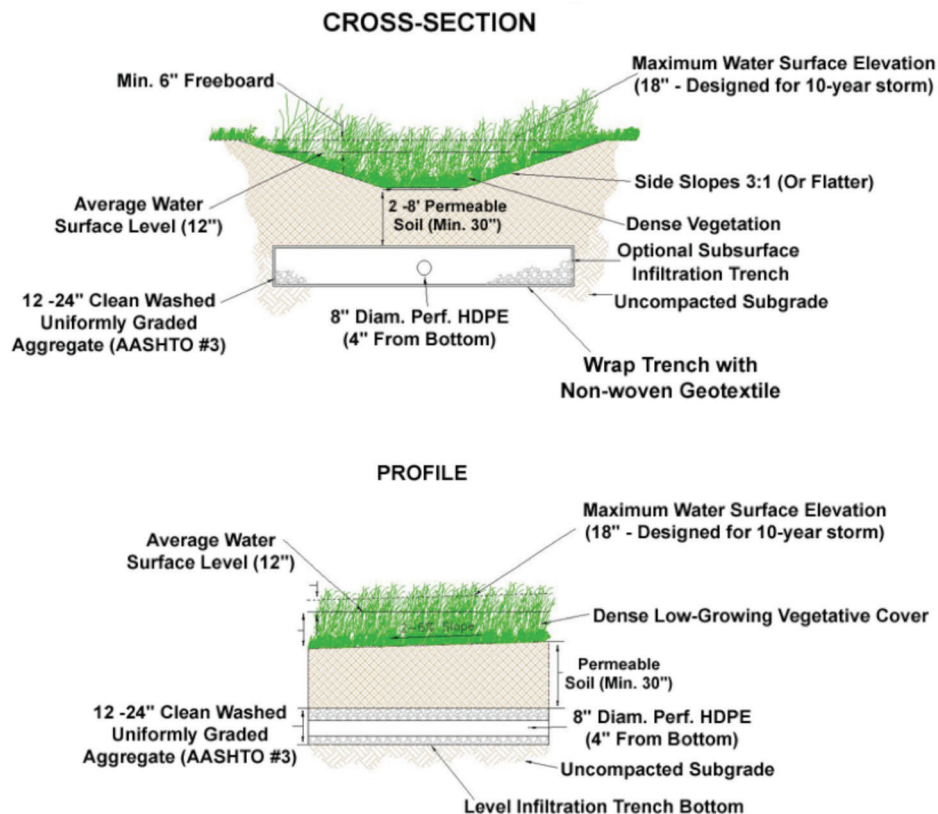


Figure 13. Bioswale Cross-Section & Profile

Section V: Design Requirements For Stormwater Management Systems



4. TESTING REQUIREMENTS

- a. Follow the Soil Infiltration Testing Guidelines for testing requirements with **Part D, Design Requirements for Infiltration BMPs**.
- b. The overall site shall be evaluated for potential infiltration systems early in the design process.

material and have a 5-10% organic matter content. Additional organic matter can be added to the soil to increase water holding capacity. Tests should be conducted to determine volume storage capacity of amended soils.

Establishment should include full erosion control blankets or the equivalent.

5. BIOSWALE COMPONENTS/ CONFIGURATION

The primary components (and subcomponents) of a Bioswale are:

Flow Entrance

Water may enter via:

- An inlet (e.g. flared end section)
- Sheet flow into the facility over grassed areas
- Curb cuts with grading for sheet flow entrance
- Roof leaders with direct surface connection through a gravel trench
- Pipe

In all cases entering velocities must be non-erosive sheet flow.

Positive Overflow

- Bioswales will discharge runoff to a suitable downstream conveyance or storage area.
- Bioswales must be designed to include proper overflow paths for events above the 10-year recurrence interval.
- Discharge must be directed in a manner to avoid property damage and have an unimpeded route to a receiving channel or outlet.

Ponding Area (Water Surface Level/Elevation)

- Overflow must be provided over check dams
- Maximum ponding depth (water surface level) of 18 inches at the end of channel.
- The use must be within banks.

Proper plant selection is essential for Bioswales to be effective. Native salt-tolerant, drought tolerant and erosion resistant plant species are suited to the variable environmental conditions encountered in a Bioswale. See **Appendix M**.

Planting periods will vary, but in general vegetation should be planted from mid-March through early June, or mid-September through mid-November.

Planting soil must be a loam soil capable of supporting healthy vegetative cover. A recommended soil blend is 20-30% organic material (compost), 20-30% sand, and 20-30% topsoil. Planting soil must be 12 inches deep along the bottom of the Bioswale. Soils must have clay content less than 10% (a small amount of clay is beneficial to absorb pollutants and retain water), be free of toxic substances, construction debris and unwanted plant

6. EASEMENTS

Bioswales will have sufficient WCWRC easements for maintenance purposes. Easements will be sized and located to accommodate access and operation of equipment, spoils deposition and other activities identified in the development's stormwater system maintenance plan.

7. CALCULATIONS

Volume Reduction Calculations

The following equation can be used to determine the approximate storage volume of a Bioswale:

$$\text{Storage Volume (ft}^3\text{)} = \text{Average bed area (ft}^2\text{)} \times \text{Maximum design water depth (ft)}$$

**Depth is the depth of the water stored during a storm event, depending on the drainage area, conveyance to the bed, and outlet control.*

$$\text{Infiltration Volume (ft}^3\text{)} = \text{Bed bottom area (ft}^2\text{)} \times [\text{Infiltration design rate (in/hr)} \times \text{Infiltration Period* (hr)}] \times (1/12)$$

**Infiltration Period is the time when bed is receiving runoff and capable of infiltrating at the design rate. Not to exceed 48 hours.*

Infiltration Area

The minimum infiltration area of the Infiltration Trench is defined as:

$$\text{Minimum surface area} = \text{Contributing impervious area} / 5^*$$

**May be increased at the discretion of the Water Resources Commissioner depending on soil infiltration rate, e.g. where soils are Type A or rapidly draining.*

Sizing and Design Criteria

- a. **Surface area** is dependent upon storage volume requirements (impervious drainage area to infiltration area; see Design Requirements for Infiltration Systems for additional guidance on loading rates.)

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- b. **Surface Side slopes** must be gradual. The maximum allowable slope for Bioswales is 3:1.
- c. **Surface Ponding depth** must not exceed 12 inches throughout the Bioswale and 18 inches at the end point and will empty within 24 hours.
- d. **Ponding area** must provide sufficient surface area to meet required storage volume without exceeding the design ponding depth. A subsurface storage/infiltration bed can be used to supplement surface storage where appropriate.
- e. **Planting soil depth** must be at least eight inches where only herbaceous plant species will be utilized. If trees and woody shrubs will be used, soil media depth should be increased depending on plant species. Native soils can be used as planting soil or modified on many sites.
- f. Rills and gullies must be filled in with topsoil and stabilized with seed and mulch blankets.
- g. Detritus (e.g. dead/decomposing leaves) must be removed approximately twice per year. Perennial planting may be cut down at the end of the growing season, or early in the next growing season.
- h. Invasive species must be removed on an annual basis and disposed of in compliance with local, state, and federal regulations.

8. CONSTRUCTION

The following is a typical construction sequence; however, alterations will be necessary depending on design variations.

Note for all construction steps: Erosion and sediment control methods must adhere to the latest requirements of the Michigan DEQ's Soil Erosion and Sedimentation Control Program.

- a. Install temporary sediment control BMPs as shown on the plans.
- b. Begin construction on the Bioswale only when upper gradient has been significantly stabilized.
- c. Complete site grading, minimizing compaction as much as possible.
- d. Rouge grade the Bioswale as proposed and scarify the existing soil surfaces. Deposit and spread planting soil. Do not compact in-situ soils.
- e. Presoak the planting soil prior to planting vegetation to aid in settlement.
- f. Install erosion protection.
- g. Erosion control must be present and maintained for the first 75 days following the first storm event of the season.

9. MAINTENANCE

- a. Properly designed and installed Bioswales require regular maintenance.
- b. Annually inspect the Bioswale for channel and slope uniformity.
- c. Inspect check dams annually and correct when signs of altered water flow are identified.
- d. Sediment and debris must be removed when build up exceeds 50% of ponding depth in the Bioswale.
- e. Dispose of sediment, debris/trash, and any other waste material removed from a Bioswale at a suitable disposal/recycling site, in compliance with local, state, and federal waste regulations.

Part N.

DESIGN REQUIREMENTS – GREEN ROOFS

1. GENERAL REQUIREMENTS

- a. Engineered media must have a high mineral content. Engineered media for extensive vegetated roof covers is typically 80% to 97% non-organic.
- b. 2-6 inches of non-soil engineered media; assemblies that are 4 inches and deeper may include more than one type of engineered media
- c. Vegetated roof covers intended to achieve water quality benefits should not be fertilized
- d. Temporary irrigation may be necessary to establish plants. Thereafter, irrigation is generally not required (or even desirable) for optimal stormwater management using vegetated covers
- e. Internal building drainage, including provisions to cover and protect deck drain or scuppers, must anticipate the need to manage large rainfall events without inundating the cover.
- f. The roof structure must be evaluated for compatibility with the maximum predicted dead and live loads and documented by a structural engineer on a sealed design. Typical dead loads for wet extensive vegetated covers range from 8 to 36 pounds per square foot. Live load is a function of rainfall retention. For example, 2 inches of rain equals 10.4 lbs. per square foot of live load.
- g. Waterproofing underlying a green roof must be resistant to biological and root attack. In many instances a supplemental root fast layer is installed to protect the primary waterproofing membrane from plant roots. Root barriers must be thermoplastic membranes of at least 30 mils bonded by hot-air fusion.

SINGLE MEDIA ASSEMBLIES

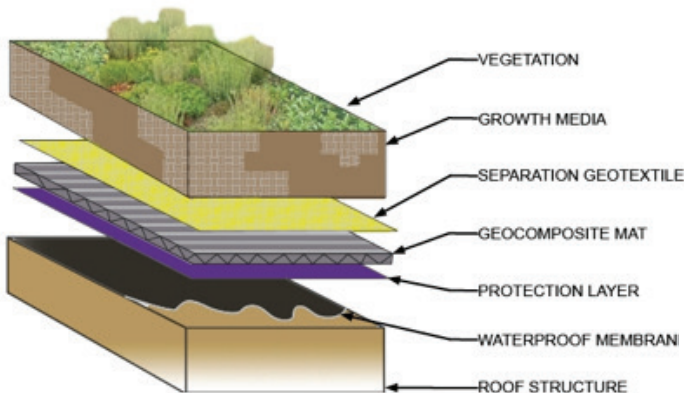


Figure 14. Single Media Green Roof Detail

DUAL MEDIA WITH SYNTHETIC RETENTION/DETENTION LAYER

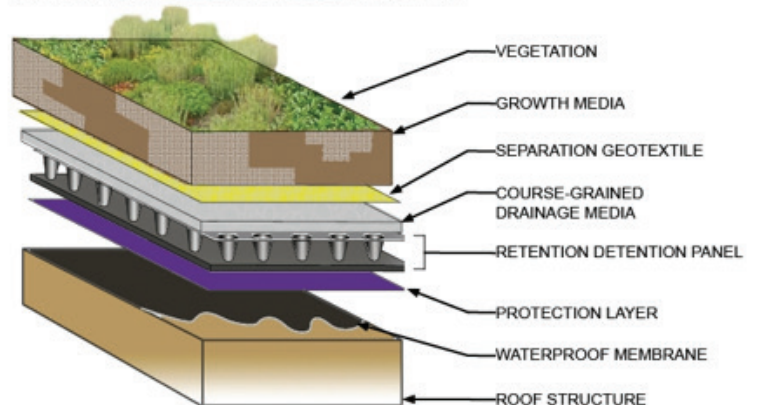


Figure 15. Dual Media Green Roof Detail

Section V: Design Requirements For Stormwater Management Systems

2. CALCULATIONS

Volume Reduction Calculations

All vegetated roof covers have both retention and detention volume components. Benchmarks for these volumes can be developed from the physical properties described below.

- Maximum media water retention
- Field capacity
- Plant cover type
- Saturated hydraulic conductivity
- Non-capillary porosity

Peak Rate Mitigation

Vegetated roof covers can exert a large influence on runoff peak rates derived from roofs. An evaluation of peak runoff rates requires either computer simulation or measurements made using prototype assemblies.

A general rule for vegetated roof covers is that rate of runoff from the covered roof surface will be less than or equal to that of open space on typical soils (i.e., NRCS curve number of about 65) for storm events with total rainfall volumes up to 3 times the maximum media water retention of the assembly. For example, a representative vegetated roof cover with a maximum moisture retention of 1 inch will react like open space for storms up to and including the 3-inch magnitude storm.

Green roof stormwater credits will be provided as determined by the calculations provided by the applicant and approved by the WCWRC.

3. CONSTRUCTION

The following is a typical construction sequence; however, alterations will be necessary depending on design variations.

- a. Visually inspect the completed waterproofing to identify any apparent flaws, irregularities, or conditions that will interfere with the security or functionality of the vegetated cover system. The waterproofing should be tested for watertightness by the roofing applicator.
- b. Institute a program to safely install the vegetated roof system.
- c. Introduce measures to protect the finished waterproofing from physical damage.
- d. If the waterproofing materials are not root fast, install a root-barrier layer.
- e. Layout key drainage and irrigation components, including drain access chambers, internal drainage conduit, confinement border units, and isolation frames (for rooftop utilities, hatches and penetrations).
- f. Walkways and paths must be installed for maintenance

projects with public access.

- g. Test for irrigation systems (This may be relevant for roof gardens but not for extensive green roofs designed for stormwater management.)
- h. Install the drainage layer. Depending on the variation type, this could be a geocomposite drain, mat, or drainage media.
- i. Cover the drainage layer with the separation fabric (in some assemblies, the separation fabric is pre-bonded to a synthetic drainage layer). The separation fabric should be readily penetrated by roots, but must provide a durable separation between the drainage and growth media layers.
- j. Install the upper growth media layer (dual media assemblies only). Growth media must be a soil-like mixture containing not more than 15% organic content.
- k. Establish the cover plantings from cuttings, seed, plugs, pre-grown mats, or trays.
- l. Provide protection from wind disruptions as warranted by the project conditions and plant establishment method.

** In some installations slope stabilizing measures can be introduced as part of the roof structure and will be already in-place at the start of the construction sequence.*

4. MAINTENANCE

- a. It will be the responsibility of the property owner or governing association of the development to maintain the green roof and deed restrictions and covenants for the development shall state such. The Water Resources Commissioner will not accept easements nor maintain green roofs. In the event that a green roof in the drainage district is not maintained, the Water Resources Commissioner will take the appropriate legal action to enforce the deed and covenants.
- b. Irrigation will be required as necessary during the plant establishment period and in times of drought.
- c. During the plant establishment period, three or four visits to conduct basic weeding, fertilization, and infill planting is recommended. Thereafter, only two visits per year for inspection and light weeding should be required (irrigated assemblies will require more intensive maintenance).
- d. The soluble nitrogen content of the soil must be adjusted to between one and five parts per million, based on soil tests.

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Part O.

DESIGN REQUIREMENTS – WATER REUSE

1. GENERAL REQUIREMENTS

- a. Identify opportunities where water can be reused for irrigation or used for indoor greywater reuse. From this, calculate the water need for the intended uses. For example, if a 2,000 SF landscaped area requires irrigation for 4 months in the summer at a rate of 1" per week; the designer must determine how much water will be needed to achieve this goal, and how often the storage unit will be refilled via precipitation. The usage requirements and the expected rainfall volume and frequency must be determined.
- b. Rain barrels and cisterns should be positioned to receive rooftop runoff.
- c. Provide for the use or release of stored water between storm events in order for the necessary stormwater storage volume to be available.
- d. If cisterns are used to supplement greywater needs, a parallel conveyance system must be installed to separate reused stormwater or greywater from other potable water piping systems. Do not connect to domestic or commercial potable water systems.
- e. Household water demands must be considered when sizing a system to supplement residential greywater.
- f. Pipes or storage units must be clearly marked "Caution: Reclaimed water, Do Not Drink".
- g. Screens must be used to filter debris from storage units.
- h. Protect storage elements from direct sunlight by positioning and landscaping. Limit light into devices to minimize algae growth.
- i. The proximity to building foundations must be considered from overflow conditions. Overflow discharge must be a minimum of 10' from building foundation.
- j. Climate is an important consideration, and capture/reuse systems must be disconnected and emptied during winter to prevent freezing.
- k. Cisterns must be watertight (joints sealed with nontoxic waterproof material) with a smooth interior surface, and capable of receiving water from rainwater harvesting system.
- l. Covers and lids must have a tight fit to keep out surface water, animals, dust and light.
- m. Positive outlet for overflow must be provided a few inches from the top of the cistern.
- n. Observation risers must be at least 6" above grade for buried cisterns.
- o. Reuse may require pressurization. To add pressure, a pump, pressure tank and fine mesh filter can be used which adds to the cost of the system, but creates a more usable system.
- p. Rain barrels require a release mechanism in order to drain empty between storm events. Connect a soaker hose to slowly release stored water to a landscaped area.

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2. INLET/OUTLET DESIGN

Stormwater is conveyed to the rain barrel or cistern through a downspout. A small pump affixed to the structure will allow the stored stormwater to be removed and used. Positive outlet for overflow should be provided a few inches from the top of the cistern.

3. COMPONENTS/CONFIGURATION

Rain Barrels

Commonly, rooftop downspouts are connected to a Rain Barrel (container) that collects runoff and stores water until needed for a specific use. Rain barrels are often used at individual homes where water is reused for garden irrigation, including landscaped beds, trees, or other vegetated surfaces. Other uses include commercial and institutional. See Figure 16 for more detail on Rain Barrels.

Cistern/Above Ground Tank

A Cistern or Above Ground Tank is a container or structure that has a greater capacity than a rain barrel. Cisterns and Above Ground Tanks may be comprised of fiberglass, concrete, plastic, brick or other materials and can be stored underground or on the surface. The storage size can range from 200 gallons to 12,000 gallons. See Figure 17 for more detail on Cisterns/Above Ground Storage Tanks.

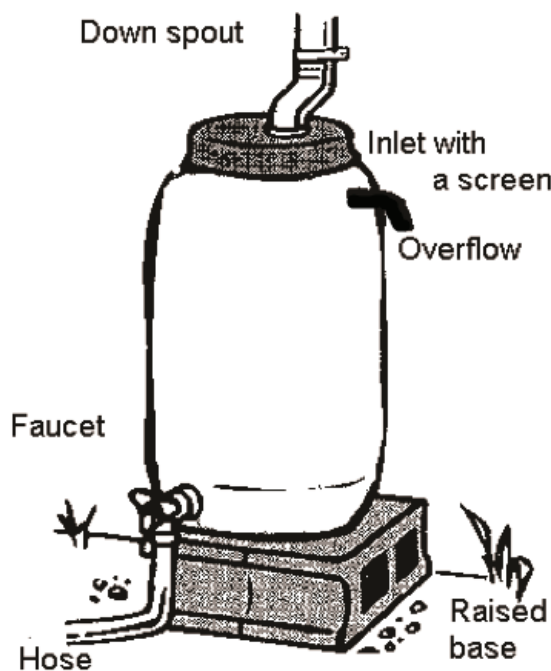


Figure 16. Rain Barrel Detail

4. CALCULATIONS

Volume Reduction

The amount of water stored in the container is equal to the volume reduction.

Water Reuse Structure Capacity:

Rain Barrel	40-75 gallons
Cistern/Above Ground Tank	200-12,000 gallons

Peak Rate Mitigation

Overall, capture and reuse takes a volume of water out of site runoff and puts it back into the ground. This reduction in volume will translate to a lower overall peak rate for the site.

Water Quality

Pollutant removal takes place through filtration of recycled primary storage, and/or natural filtration through soil and vegetation for overflow discharge. Quantifying pollutant removal will depend on design. Sedimentation will depend on the area below outlet that is designed for sediment accumulation, time in storage, and maintenance frequency. Filtration through soil will depend on flow draining to an area of soil, the type of soil (infiltration capacity), and design specifics (stone bed, etc.).

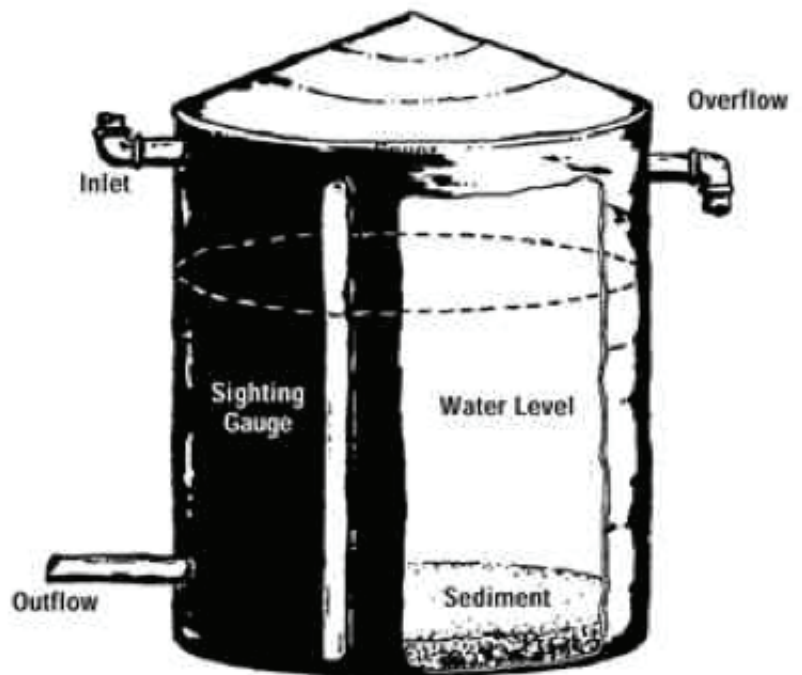


Figure 17. Cistern Detail

Section V: Design Requirements For Stormwater Management Systems



5. MAINTENANCE

Rain Barrels

- a. Inspect rain barrels four times per year, and after major storm events.
- b. Remove debris from screen as needed.
- c. Replace screens, spigots, downspouts and leaders as needed.
- d. To avoid damage, drain container prior to winter, so that water is not allowed to freeze in the device.
- e. It is the responsibility of the owner to maintain any pumps affixed to the rain barrel.

Cisterns

- a. Flush cisterns to remove any sediment.
- b. Brush the inside surfaces and thoroughly disinfect twice per year.
- c. To avoid damage, drain container prior to winter, so that water is not allowed to freeze in the device.
- d. It is the responsibility of the owner to maintain any pumps affixed to the cistern.

Section V: Design Requirements For Stormwater Management Systems

Part P.

DESIGN REQUIREMENTS – CONVEYANCE SYSTEMS

1. GENERAL REQUIREMENTS

- a. All structures will be constructed in accordance with governing specifications including Michigan Department of Transportation, Washtenaw County Road Commission, and the City or Township. In the event of no other governing specifications, the latest edition of the Michigan Department of Transportation standards will be observed.
- b. Stormwater conveyance systems incorporating pumps shall not be permitted in developments with multiple owners, such as subdivisions and site condominiums.

2. NATURAL STREAMS AND CHANNELS

- a. Natural streams are to be preserved. Natural swales and channels should be preserved, whenever possible.
- b. If channel modification must occur, the physical characteristics of the modified channel will duplicate the existing channel in length, cross-section, slope, sinuosity, and carrying capacity. For proposed drain modifications, the WCWRC may require restoration/rehabilitation to a more natural (historical) channel design.
- c. Streams and channels will be explored to withstand all events up to the 100-year storm without increased erosion. Armoring banks with riprap and other manufactured materials will be accepted only where erosion cannot be prevented in any other way, such as by the use of vegetation.

3. VEGETATED SWALES/OPEN DITCHES

Open swale/ditch drainage systems are preferred to enclosed storm sewers where applicable governmental standards and site condominiums permit. Swales will be required to:

- a. Follow natural, pre-development drainage paths insofar as possible.
- b. Be well vegetated, wide and shallow.
- c. Open ditch flow velocities will be neither siltative nor erosive. The minimum acceptable velocity will be 2.0 ft./sec., and the maximum acceptable velocity will be 6.0 ft./sec.
- d. Open ditch slopes will depend on existing soils and vegetation. However, the minimum acceptable slope is 1.5%, unless other techniques such as infiltration devices are implemented. Maintenance for such devices must be

detailed in the overall maintenance plan.

- e. Side slopes of ditches shall be no steeper than 3:1. Soil conditions, vegetative cover and maintenance ability will be the governing factors for determining side slope requirements.
- f. Slopes and bottoms of open ditches and swales will be stabilized to prevent erosion.
- g. Swale length shall be a minimum of 200 feet whenever possible, to increase the contact time of stormwater. The maximum length will be based on soil type, slope and catchment area.
- h. A minimum clearance of 5 feet is required between open swale/ditch inverts and underground utilities unless special provisions are employed. Special provisions, for example, could be the encasement of utility lines in concrete when crossing under the channel. In no case will less than 2 feet of clearance be allowed.
- i. Permanent metal or plastic markers will be placed on each side of the drain to show the location of underground utilities.
- j. All bridges will be designed to provide a 2-foot minimum flood stage freeboard to the underside of the bridge. Footings will be at least one foot below the invert grade of the channel. Depending on soils, additional footing depth may be required.
- k. A series of check dams to drop structures across swales shall be provided to enhance water quality performance and reduce velocities.
- l. Designers should consider integrating additional redundant pollutant removal enhancement features such as stilling basins and stone infiltration trenches.

4. ENCLOSED DRAINAGE STRUCTURES

Enclosed storm drain systems will be sized to accommodate the 10-year storm, with the hydraulic gradient kept below the top of the pipe.

- a. Restricted conveyance systems designed to create backflow into stormwater storage facilities are not permitted.
- b. Drainage structures will be located as follows:
 - i. To assure complete positive drainage of all areas of the subdivision.
 - ii. At all low points of streets and rear yards.
 - iii. Such that there is no flow across a street intersection.
 - iv. For smaller enclosed pipes, 12 to 24 inches in diameter, manholes will not be spaced more than 400 feet apart. Longer runs may be allowed for larger sized pipe but in all cases maintenance access must be deemed adequate by the Water Resources Commissioner.
- c. The catch basin or inlet covers shall be designed to accept the 10-year design storm. No ponding of water should occur during this storm event.

Section V: Design Requirements For Stormwater Management Systems



- d.** Discharge from enclosures will be as follows:
 - i.** All outlets will be designed so that velocities will be appropriate to, and will not damage, receiving waterways.
 - ii.** Outlet protection using riprap or other approved materials will be provided as necessary to prevent erosion.
 - iii.** The soils above and around the outlet will be compacted and stabilized to prevent piping around the structure. Riprap extending 3 feet above the ordinary high water mark is required for all outlets.
 - iv.** When the outlet empties into a detention/retention facility, channel or other watercourse, it will be designed such that there is no free overfall from the end of the apron to the receiving waterway.
- e.** Pipe will conform to the following criteria:
 - i.** The minimum pipe acceptable pipe diameter is 12 inches.
 - ii.** In order to avoid accumulation of sediment in the drain, pipe will be designed to have minimum velocity flowing full of 3 ft/sec., with the exception of sediment chambers.
 - iii.** The maximum allowable velocity flowing full will be 10ft/sec.
 - iv.** Pipe joints will be such as to prevent excessive infiltration or exfiltration.
 - v.** All materials will be of such quality as to guarantee a maintenance-free expectancy of at least 50 years and will meet all appropriate A.S.T.M standards.
 - vi.** The minimum depth of pipe shall be 42 inches from grade to the springline of the pipe.
- f.** In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts approved by the Water Resources Commissioner.
- g.** Sump pump lines and connections shall not fall under the long term operation and maintenance of the Water Resources Commissioner's Office and will not become part of an established county drain. Maintenance of such lines will be the responsibility of the property owners, and shall be so specified in subdivision rules or condominium master deed agreements.

Section V: Design Requirements For Stormwater Management Systems

Part Q.

DESIGN REQUIREMENTS – LOT GRADING

1. GENERAL REQUIREMENTS

Approval of final lot grading is the responsibility of the local municipality. The Water Resources Commissioner's Office is not responsible for the inspection of, or enforcing corrections to, final lot grading. It is the Water Resources Commissioner's responsibility to ensure that the overall plan is consistent with sound stormwater management and drainage practices. The subdivision stormwater management plan will provide for the following:

- a. The grading of lots will be such that surface runoff is away from homes and toward swales, ditches or drainage structures. Provision for drainage through properly graded stormwater conveyance systems will be made for all areas within the proposed subdivision.
- b. Where finished grades indicate a substantial amount of drainage across adjoining lots, a drainage swale of sufficient width, depth and slope will be provided on the lot line to intercept this drainage. To ensure that property owners do not alter or fill drainage swales, easements will be required over areas deemed necessary by the Water Resources Commissioner.



Section VI: Areas of Special Concern

THE MIDDLE HURON RIVER PHOSPHORUS TOTAL MAXIMUM DAILY LOAD (TMDL)

Excessive phosphorus in the waters of the Huron River is responsible for excess weed growth and algal blooms that have interfered with recreational uses of the River's impoundments and are undermining aesthetic as well as ecological health values. In 1996, the Huron River Watershed Council working on behalf and in partnership with 21 communities in the watershed – most within Washtenaw County, and the MDEQ agreed upon a strategy to meet significant goals of reduction of phosphorus loading to the Huron River. Much of the reductions, necessary to meet MDEQ imposed Total Maximum Daily Load (TMDL) requirements must be achieved through improving the quality of stormwater runoff.

Many BMPs, such as wet extended retention/detention facilities and wetland systems, have demonstrated superior phosphorus reduction ability. These as well as other mentioned in the rules should be used in the Middle Huron River watershed as the BMPs of choice whenever feasible.

THE PAINT CREEK AND JOHNSON CREEKS – THERMALLY SENSITIVE STREAMS

The Paint Creek and Johnson Creek are cold-water streams that support aquatic life sensitive to increases in water temperature. Until 1995, both creeks were stocked each spring by the Michigan Department of Natural Resources with over 7,000 brown trout. Angler license fees and federal excise taxes that are paid on fishing tackle pay for stocking. At this time, the MDNR has discontinued the trout stocking of Paint Creek. It is hoped that this stocking will be resumed.

The Paint Creek and the Johnson Creek are also inhabited by naturally occurring, thermally sensitive fish populations. In addition to the fish that have been stocked in the past, the Paint Creek has its own brown trout population, and it also supports a small population of steelhead that occasionally run up the stream from Lake Erie. The Johnson Creek is home to native populations of red side dace (a threatened species), black side dace and mottled sculpin. All these species are negatively impacted by increases in water temperature.

Some of the most effective stormwater site controls involve storage facilities such as retention and detention facilities. Where thermal impact is not a major concern, wet retention/detention facilities are generally preferable to dry retention/detention facilities, and retention/detention facilities that detain stormwater for an extended period of time are required where wet retention/detention facilities are not feasible. However, wet and extended detention retention/detention facilities tend to increase the exposure of runoff to solar warming before releasing it. Therefore, where thermal impacts are a concern, such as in the Paint Creek and Johnson Creek watersheds, extended detention requirements may be reduced. Shade plantings on the west and south sides of facilities to provide additional protection against solar warming are also strongly encouraged. Retention facilities provide another option. Infiltration approaches to stormwater management are encouraged where soils and site conditions allow.

TOTAL MAXIMUM DAILY LOADS (TMDLS) IN WASHTENAW COUNTY

A TMDL is a document that describes the process used to determine how much pollutant load a lake or stream can assimilate. TMDLs are required by the federal Clean Water Act for water bodies that do not meet Water Quality Standards.

Water Body	Parameter
Johnson Creek	Dissolved Oxygen
Paint Creek	Dissolved Oxygen
Detroit River	E. coli
Geddes Pond (Huron River)	E. coli
Honey Creek	E. coli
Paint Creek	E. coli
Saline River	E. coli
Ford Lake and Belleville Lake	Phosphorus
Malletts Creek	Sediment
Paint Creek	Sediment

Section VII: Soil Erosion, Sedimentation and Pollution Control



Discharge of sediment or other polluting materials to a waterway that is under the jurisdiction of the Water Resources Commissioner, either within or outside of the subdivision, will be considered pollution to a county drain, and hence a violation of section 280.423 of the Michigan Drain Code. Under the Michigan Drain Code, pollution of a county drain is a criminal misdemeanor, punishable by fine of \$25,000 or imprisonment.

1. SOIL EROSION/ SEDIMENTATION CONTROL

All erosion control measures will be regularly inspected and maintained.

During Construction

- i. The development plan shall fit the topography and soil so as to create the least erosion potential.
- ii. An approved soil erosion permit from the local enforcing agent, as well as a National Pollution Discharge Elimination System (NPDES) permit where applicable, will be required.
- iii. Sediment shall not be permitted to leave the site. Recommended procedures to achieve this goal are as follows:
 - Wherever feasible, natural vegetation should be retained and protected.
 - The smallest practical area of raw land should be exposed at any one time (i.e. only areas under active construction).
 - The entire site should be planted with temporary vegetation immediately after mass grading operations.
 - Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.
- iv. Areas within open drain easements that have been cleaned, reshaped or disturbed in any manner will be stabilized with seed and mulch or sod as quickly as possible.
- v. All storm sewer facilities that are or will be functioning during construction will be protected, filtered, or otherwise treated to prevent sediment from entering the system. Construction activities will be complete before the construction of any stormwater management facilities susceptible to clogging such as infiltration devices.

Permanent Erosion Control Measures

- i. Best management practices will be utilized to remove pollutants, including sediment, from stormwater runoff before entering any natural watercourse, protected wetland, county drain or other body of water. Pollutant removal methods will include capture and treatment of the first flush and bankfull storm events, as previously described in these standards. In addition, receiving waters shall be protected as previously described.
- ii. Permanent erosion protection will be placed at bends,

drain inlets and outlets, and other locations as needed in all open ditches. Headwalls, grouted riprap, soil bioengineering methods, or other stabilization measures will be provided where necessary to prevent erosion.

- iii. Outlets to ditches will be placed at the average low water elevation of the watercourse. Outlet velocities will be non-erosive.
- iv. Ditches with steep grades or unstable soils will be protected by sod, vegetative erosion control, geotextile fabric, riprap or other means to prevent scour.
- v. All detention/retention basins will be permanently stabilized to prevent erosion.

2. SOILEROSION/ SEDIMENTATION CONTROL

- a. Discharge of runoff that may contain oil, grease, toxic chemicals, or other polluting materials is prohibited. Measures will be employed to reduce and trap pollutants and meet any prevailing federal, state, or local water quality requirements.
- b. In commercial and industrial developments where large amounts of oil and grease may accumulate, appropriate methods for separating pollutants will be required. See **Appendix C, Stormwater Pollutant Hotspots**. When used, oil and grit separators will be installed offline or in locations where flow velocities have been determined to be lower than scouring velocity in a 10-year storm. Where such facilities are proposed, a maintenance program, including an identified method for site and waste disposal is required.
- c. For sites where chemicals may be stored and used (e.g. certain commercial and industrial developments) a spill response plan must be developed that clearly defines the emergency steps to be taken in the event of an accidental release of harmful substances to the stormwater system.
- d. Structures designed to remove trash and other debris from stormwater will be installed as required on stormwater management facilities prior to their outlet.
- e. Additional water quality protection measures may be required depending on the nature and location of the development and receiving waters.

Section VIII: Appendix

Part A.

GLOSSARY OF TERMS

1% Annual Chance Storm

(also known as the 100-year storm) This size storm has a 1% chance of occurring in a given year. The 1% annual chance flood does not refer to a storm event that only happens once every 100 years.

Antecedent Moisture Content (AMC)

The quantity of moisture present in the soil at the beginning of a rainfall event. The Soil Conservation Service has three classifications, AMC I, II and III.

A.S.T.M.

American Society for Testing Materials

Backwater

The increased depth of water upstream of a restriction or obstruction, such as a dam, bridge or culvert.

Bankfull Flood

A condition where flow completely fills the stream channel to the top of the bank. In undisturbed watersheds, this occurs on average every 2 years and controls the shape and form of natural channels.

Barrel

The concrete or corrugated metal pipe that passes runoff from the riser through the embankment, and finally discharges to the pond's outfall.

Base Flow

The portion of stream flow that is not due to runoff from precipitation, usually supported by water seepage from natural storage areas such as ground water bodies, lakes or wetlands.

Best Management Practices (BMP)

A practice or combination of practices that prevent or reduce stormwater runoff and/or associated pollutants.

Bioretention

A water quality practice that utilizes landscaping and soils to treat stormwater runoff by collecting it in shallow depressions before filtering through a fabricated soil medium.

Borings

Cylindrical samples of soil profile used to determine infiltration capacity.

Buffer Strip

A zone where plantings capable of filtering stormwater are established or preserved, and where construction, paving and chemical applications are prohibited.

Catch Basin

A collection structure below ground designed to collect and convey water into the storm sewer system. It is designed so that sediment falls to the bottom of the catch basin and not directly into the pipe.

Check Dam

1. An earthen, aggregate or log structure, used in grass swales to reduce velocity, promote sediment deposition, and enhance infiltration.
2. A log or gabion structure placed perpendicular to a stream to enhance aquatic habitat.

Cistern

Containers that store large quantities of stormwater above or below ground. They can be used on residential, commercial, and industrial sites.

County Drain

An open or enclosed stormwater conveyance system that is under the legal jurisdiction of the Water Resources Commissioner's Office for construction, operation and maintenance.

Culvert

A closed conduit used for the passage of surface water under a road, or other embankment.

Curve Number (CN)

Determines the volume of stormwater removed from rainfall before runoff begins. It's based on land cover type, hydrologic condition, antecedent runoff condition and hydrologic soil group (HSG). The CN is a component in the NRCS Curve Number method for calculating storm runoff.

Design Storm

A rainfall event of specified size and return frequency, (e.g., a storm that occurs only once every 2 years). Typically used to calculate the runoff volume and peak discharge rate to or from a BMP.

Detention

The temporary storage of storm runoff, to control peak discharge rates and provide gravity settling of pollutants.

Detention Basin

A constructed basin that temporarily stores water before discharging

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into a surface water body. Basins can be classified into four groups:

- 1. Dry Detention Basin**
A basin that remains dry except for short periods following large rain storms or snow melt events. This type of basin is not effective at removing pollutants.
- 2. Extended Dry Detention Basin**
A dry detention basin that has been designed to increase the length of time that stormwater will be detained, typically between 24-40 hours. This type of basin is not effective at removing nutrients such as phosphorus and nitrogen, unless some type of treatment is incorporated into the lower stage of the design (i.e., forebay, shallow marsh, etc.).
- 3. Wet Detention Basin**
A basin that contains a permanent pool of water that will effectively remove nutrients in addition to other pollutants.
- 4. Extended Wet Detention Basin**
A wet detention basin that has been designed to increase the length of time that stormwater will be detained, typically between 24-40 hours.

Detention Time

The amount of time that a volume of water will remain in a detention basin.

Discharge

The rate of flow or volume of water passing a point in a given time. Usually expressed as cubic feet per second (cfs).

Disturbed Area

An area in which the natural vegetative soil cover has been removed or altered and is susceptible to erosion.

Drainage area

The area of a watershed usually expressed in square miles or acres.

Drawdown

The gradual reduction in water level in a pond BMP due to the combined effect of infiltration, evaporation and discharge.

Dry well

Small infiltration pits or trenches filled with aggregate that receive clean runoff primarily from rooftops.

Easement

A legal right, granted by a property owner to another entity, allowing that entity to make limited use of the property involved for a specific purpose. The Water Resources Commissioner secures temporary and permanent easements adjacent to county drains for the purpose of construction and maintenance access. Easements are recorded on the title to the land and transfer with the sale of land.

Erosion

The wearing away of land surface by running water, wind, ice, or other geological agents.

Extended Detention

A stormwater design feature that provides for the holding and gradual release of stormwater over a longer period of time than that provided by conventional detention basins, typically 24-40 hours. Extended detention allows pollutants to settle out before stormwater is discharged from the basin.

Extended Detention Control Device

A horizontal pipe or series of pipes or vertical riser pipe designed to gradually release stormwater from a pond over a 24-40 hour interval.

Fill

Added earth that is designed to change the contour of the land.

Filter Fabric

Textile of relatively small mesh or pore size. The two major classifications are as follows:

- 1. Permeable.** This allows water to pass through while holding sediment back.
- 2. Impermeable.** This type prevents both runoff and sediment from passing through.

First Flush

The delivery of a highly concentrated pollutant loading during the early stages of a storm, due to the washing effect of runoff on pollutants that have accumulated on the land. For the purposes of these Rules, first flush is the runoff from the first inch of precipitation.

Floodplain

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

Flow Path

The distance that a parcel of water travels through a stormwater detention pond or wetland. It is defined as the distance between the inlet and outlet, divided by the average width.

Flow Splitter

An engineered, hydraulic structure designed to divert a portion of stream flow to a BMP located out of the channel, or to direct stormwater to a parallel pipe system, or to bypass a portion of baseflow around a pond.

Forebay

A small, separate storage area near the inlet to a detention basin, used to trap and settle incoming sediments before they can be delivered to the basin.

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Freeboard

The space from the top of an embankment to the highest water elevation expected for the largest design storm to be stored or conveyed. The space is required as a safety margin in a pond, basin or channel.

French Drain

A subgrade drain consisting of a trench filled with aggregate to permit movement through the trench and into the soil. The trench may also contain perforated pipe to enhance the efficiency of the system.

Gabion

A rectangular box of heavy gage wire mesh that holds large cobbles and boulders. Used in streams and ponds to change flow patterns, stabilize banks, or prevent erosion.

Green Roof

Conventional rooftops that include a thin covering of vegetation allowing the roof to function more like a vegetated surface. The layer thickness varies between 2-6 inches and consists of vegetation, waterproofing, insulation, fabrics, growth media, and other synthetic components.

Ground Water

Naturally existing water beneath the earth's surface between saturated soil particles and rock that supplies wells and springs.

Ground Water Table

The upper surface or top of the saturated portion of the soil or bedrock layer, indicates the uppermost extent of groundwater.

Hydraulic Radius

The area of a stream of conduit divided by its wetted perimeter.

Hydrograph

A graph showing the variation in stage or discharge in a stream or channel, over time, at a specific point along the stream.

Impervious Surface

A surface that prevents the infiltration of water into the ground such as roofs, streets, sidewalks, driveways, parking lots, and highly compacted soils.

Infiltration

The absorption of water into the ground expressed in terms of inches/hour.

Infiltration Capacity

The maximum rate at which the soil can absorb falling rain or melting snow. Usually expressed in inches/hour, or centimeters/second.

Infiltration Practices

Best management practices (bed, trench, basin, well, etc.) that allow for rainfall to soak into the soil mantle.

In-line Detention

Detention provided within the flow-carrying network.

Invert

The elevation of the bottom interior surface of a conduit at any given cross section.

Level-Spreader

A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow i.e., not through channels. The purpose of level spreaders is to prevent concentrated, erosive flow from occurring, and to enhance infiltration.

Low Impact Development (LID)

Activities that mimic a site's pre-development hydrology by using design techniques that are spatially distributed, decentralized micro-scale controls that infiltrate, filter, store, evaporate and detain runoff close to its source.

Manhole

A structure that allows access into the sewer system.

Manning's Roughness Coefficient ("n")

A coefficient used in Manning's Equation to describe the resistance to flow due to the surface roughness of a culvert or stream channel.

Mean Storm

Over a long period of years, the average rainfall event, usually expressed in inches.

Mitigation

Making something less harsh or severe. LID mitigates by lessening the impacts of stormwater runoff from impervious surfaces.

Multiple Pond System

A collective term for a cluster of pond designs that incorporate redundant runoff treatment techniques within a single pond or series of ponds. These pond designs employ a combination of two or more of the following: extended detention, permanent pool, shallow marsh or infiltration.

Native Plants

Plants that historically co-evolved with the local ecology, geology and climate. EPA has categorized native (pre-development by Europeans) plant groups by Ecoregions.

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Natural Wetland

Land characterized by the natural presence of water sufficient to support wetland vegetation.

Non-point Source Pollution

Stormwater conveyed pollution that is not identifiable to one particular source, and is occurring at locations scattered throughout the drainage basin. Typical sources include erosion, agricultural activities, and runoff from urban lands.

Non-structural BMPs

Stormwater runoff treatment techniques that use natural measures to reduce pollution levels that do not involve the construction or installation of devices (e.g. management actions).

Off-line BMP

A water quality facility designed to treat stormwater that has been diverted outside of the natural watercourse or storm sewer system.

Off-site Detention

Detention provided at a regional detention facility as opposed to storage on site.

One Hundred Year Flood (100-year flood)

The flood that has a 1 percent chance of occurring in any given year.

Ordinary High Water Mark

The line between upland and bottomland which persists through successive changes in water level, below which the presence of water is so common or recurrent that the character of the soil and vegetation is markedly different from the upland.

Orifice

An opening in a wall or plate.

Peak Discharge

The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Permeable

Allows liquid to pass through. Porous. Also pervious, the opposite of impervious.

Pervious

See permeable.

Pervious Pavement

An infiltration technique that combines stormwater infiltration, storage, and structural pavement that consists of a permeable surface underlain by a storage reservoir.

Petition (Under P.A. 40 of 1956)

A legal request to the Water Resources Commissioner to perform maintenance or construction, or to establish a drainage district. Either the township or individual(s) can petition to have work performed or a district established.

Pilot Channel

A riprap or vegetated low flow channel that routes runoff through a BMP to prevent erosion of the BMP surface.

Planter Box

A device containing trees and plants near streets and buildings constructed to prevent stormwater from directly draining into sewers.

Plat, Platting Process

A legal procedure, and the document that depicts it, whereby a larger piece of property is divided into smaller sections, and is accompanied by a full description of the original property, the dimension of each lot to be subdivided, and all relevant deed restrictions and easements.

Plunge Pool

A small permanent pool located at either the inlet to, or outfall from a BMP. The primary purpose of the pool is to dissipate the velocity of stormwater runoff, but it can also provide some pre-treatment.

Pocket Wetlands

A stormwater wetland design adapted for small drainage areas with no reliable source of baseflow. The surface area of pocket wetlands is usually less than a tenth of an acre. The pocket wetland is usually intended to provide some pollutant removal for very small development sites.

Pre-development

Time period before significant human change to the landscape. For the purpose of this manual, pre-development will follow the LID design calculations, where pre-development is further defined as either woods or meadow in good condition. This definition will not represent the actual pre-development condition of all land in Michigan. It does provide a simple, conservative value to use in site design that meets common LID objectives.

Pretreatment

Technique to capture or trap coarse sediments within runoff, before they enter a BMP to preserve storage volumes or prevent clogging. Examples include swales, forebays and micropools.

Proprietor

Any person, firm, association, partnership, corporation or any combination thereof.

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Protected Wetland

Any wetland protected by state law or local government regulation.

Public Land Survey System (PLSS)

The PLSS is the surveying method used historically over the largest fraction of the United States to survey and spatially identify land parcels before designation of eventual ownership, particularly for rural, wild or undeveloped land.

For the purposes of this document -- the drawing and legal description must follow the standards of MI Public Act 132 of 1970 - Certified Surveys and reference a PLSS corner. For platted subdivisions, the description must reference a lot corner with the name, liber and page of the subdivision. Note: Where PLSS corners do not exist, Private Claims corners may be accepted at the discretion of the WCWRC.

Rain Barrel

A barrel designed to retain small volumes of stormwater runoff for reuse for landscaping.

Rain Garden

Landscape elements that combine plantings and depressions that allow water to pool for a short time (e.g., a few days) after a rainfall and then be slowly absorbed by the soil and vegetation.

Rational Formula

A simple technique for estimating peak discharge rates for very small developments, based on the rainfall intensity, watershed time of concentration, and a runoff coefficient.

Release Rate

The rate of discharge in volume per unit time from a detention facility.

Retention

The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

Retention Basin

A stormwater management facility designed to capture runoff that does not discharge directly to a surface water body. The water is "discharged" by infiltration or evaporation. Also known as a Wet Pond.

Return Interval

A statistical term for the average time of expected interval that an event of some kind will equal or exceed given conditions (e.g., a stormwater flow that occurs every 2 years).

Reverse Slope Pipe

A technique for regulating extended detention times that is resistant to clogging. A reverse slope pipe is a pipe that extends downward from the riser into the permanent pool and sets the water surface

elevation of the pool. The lower end of the pipe is located up to 1 foot below the water surface.

Riparian Lands

Land directly adjacent to a surface water body (e.g., lake, stream, creek).

Riprap

A combination of large stones, cobbles and boulders used to line channels, stabilized banks, reduce runoff velocities or filter out sediment.

Riparian Buffer

An area next to a stream or river (sometimes also used for lakes) where development is restricted or prohibited. The buffers should be vegetated with herbaceous and woody native plants, or left in their natural state. Buffers filter stormwater before it reaches the water body and slows the stormwater velocity.

Riparian Corridor

The area adjacent to a stream or river (sometimes also used for lakes) that preserves water quality by filtering sediments and pollutants from stormwater before it enters the waterbody, protects banks from erosion, provides storage area for flood waters, preserves open space, and provides food and habitat for wildlife.

Riser

A vertical pipe extending from the bottom of a basin that is used to control the discharge rate from the basin for a specified design storm.

Routing

The derivation of an outflow hydrograph for a given reach of stream or detention pond from known inflow characteristics. The procedure uses storage and discharge relationships and/or wave velocity.

Runoff

The excess portion of precipitation that does not infiltrate into the ground, but "runs off" and reaches a stream, water body or storm sewer.

Runoff Coefficient

The ratio of the amount of water that is NOT absorbed by the surface to the total amount of water that falls during a rainstorm.

Sediment

Soil material that is transported from its site of origin by water. May be in the form of bed load, suspended or dissolved.

Sheetflow

Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

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Short Circuiting

The passage of runoff through a BMP in less than the theoretical or design detention time.

Soil Erosion

The increased loss of the land surface that occurs as a result of the wearing away of land by the action of wind, water, gravity, or a combination of wind, water, gravity or human activities.

Soil Group, Hydrologic

A classification of soils by the Soil Conservation Service into four runoff potential groups. The groups range from “A Soils” which are very permeable and produce little runoff, to “D Soils” which are relatively impermeable and produce much more runoff.

Spillway

A depression in the embankment of a pond or basin, used to pass peak discharges in excess of the design storm.

Stabilization

The establishment of vegetation or the proper placement, grading, or covering of soil to ensure its resistance to soil erosion, sliding, or other earth movement.

Stormwater Runoff

Rainfall or snowmelt that runs off the land and is released into our rivers and lakes.

Stormwater Wetland

A conventional stormwater wetland is a shallow pool that creates growing conditions suitable for the growth of marsh plants. Stormwater wetlands are designed to maximize pollutant removal through wetland uptake, retention and settling. These constructed systems are not located within delineated natural wetlands.

Stream

By MDEQ definition: “a river, creek, or surface waterway that may or may not be defined by Act 40, P.A. of 1956; has definite banks, a bed, and visible evidence of continued flow or continued occurrence of water, including the connecting water of the Great Lakes.” Even if water flow is intermittent, it is classified as a stream.

Structural BMPs

Devices constructed for temporary storage and treatment of stormwater runoff.

Swale

A natural depression or wide shallow ditch used to temporarily convey, store, or filter runoff.

Tailwater

The depth of water at the downstream end of a culvert or crossing.

Time of Concentration

The time it takes for surface runoff to travel from the hydraulically farthest portion of the watershed to the design point.

Timing

The relationship in time of how runoff from subwatersheds combines within a watershed.

Underdrain

Perforated pipe installed to collect and remove excess runoff.

Vegetated Filter Strip

Uniformly graded vegetated surface located between pollutant source areas and downstream receiving waters.

Watershed

The complete area or region of land draining into a common outlet such as a river or body of water.

Weir

A structure that extends across the width of a channel, and is used to impound, measure, or in some way alter the flow of water through the channel.

Wetland

An area that is saturated by surface or groundwater with vegetation adapted for life under those soil conditions, such as swamps, bogs, fens, marshes and estuaries.

Wetland Mitigation

A regulatory term that refers to the process of constructing new wetland acreage to compensate for the loss of natural wetlands during the development process. Mitigation seeks to replace structural and functional qualities of the natural wetland type that has been destroyed. Stormwater wetlands typically do not count for credit as mitigation, because their construction does not replicate all the ecosystem functions of a natural wetland.

Wet Pond/Constructed Wetland

Surface or underground structures that provide temporary storage of stormwater runoff to prevent downstream flooding and the attenuation of runoff peaks.

Wetland Perimeter

The wetted surface of a stream or culvert cross-section that causes resistance to flow. The water to surface interface is a distance, typically expressed in feet.

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Part B.

MAJOR CATEGORIES OF NON-POINT SOURCE POLLUTANTS AND ASSOCIATED IMPACTS

SEDIMENTS

Source: Construction sites, agricultural lands and other disturbed and/or non-vegetated lands, including eroding stream banks.

Impacts: Once deposited, sediment can decrease the storage capacity of a water body, as well as smother organisms that dwell on the bottom and destroy their habitat. Suspended sediment can lower the transmission of light through water, and interfere with animal respiration and digestion. Contaminated sediments act as a reservoir for particulate forms of pollutants, such as organic matter, phosphorus, or metals that can be released later.

NUTRIENTS (E.G. PHOSPHORUS & NITROGEN)

Source: Septic systems, fertilizers, animal waste, detergents and plant debris.

Impacts: Slow moving waters become choked with nutrient induced algae and weeds that take up dissolved oxygen in the water needed by fish and other aquatic life. This reduction in dissolved oxygen can also cause pollutants trapped within sediments to be released back into the water column.

TEMPERATURE ENHANCEMENT

Source: Impervious surfaces collect heat and warm stormwater as it passes over them and into receiving waterways. The creation of storage ponds and impoundments, and the removal of trees and other vegetation that shade streambanks increases the surface area of water exposed to solar heating.

Impacts: Temperature enhancement severely interferes with cold-water organisms such as trout and stoneflies, and may cause their extinction in intensively developed areas.

TOXIC COMPOUNDS

Source: Pesticides, road de-icing materials, motor vehicles, industrial activities, atmospheric deposition, and illicit dumping and sewage connections.

Impacts: Toxic substances can degrade the appearance of water surfaces, lower dissolved oxygen, stress sensitive flora and fauna, pose health risks and enter into the aquatic food chain.

BACTERIA

Source: Animal waste (including pets and birds), failing septic systems and illicit sewer connections.

Impacts: Increased bacteria levels can pose health risks and close or restrict the use of recreational areas.

LITTER & DEBRIS (ORGANIC & NON-ORGANIC)

Source: Urban and suburban landscapes contribute grass clippings and leaves. Non-organic debris is generated by careless disposal practices, e.g., street litter.

Impacts: Litter, leaves and trash wash through the storm drain system, clogging pond outlets and creating large debris jams within streams and floodplains. In addition, organic materials require oxygen to decompose and so lower the level of dissolved oxygen available to aquatic life.

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Part C. STORMWATER POLLUTANT HOTSPOTS

The following land uses and activities are deemed stormwater hotspots:

- Vehicle salvage yards and recycling facilities #
- Vehicle service and maintenance facilities including gas stations
- Vehicle and equipment cleaning facilities #
- Fleet storage areas (bus, truck, etc.) #
- Industrial sites (for SIC codes outlined in Appendix D-6)
- Marinas (service and maintenance) #
- Outdoor liquid container storage
- Public works storage areas
- Facilities that generate or store hazardous materials #
- Commercial container nursery
- Other land uses and activities as designated by an appropriate review authority

Indicates that the land use or activity is required to prepare a stormwater pollution prevention plan under the EPA Stormwater Multi-Sector General Permit Program (see http://www.epa.gov/npdes/pubs/msgp2008_appendixd.pdf).

Additional water quality measures must be installed at sites where land uses are identified as pollutant hotspots. The water quality treatment devices utilized must address the pollutants of concern for the site. For example, hydrocarbon filters will be required in all catch basins at gas stations; sediment removal devices will be required at commercial nurseries, etc.

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Part D.

CONSTRUCTION, OPERATION & MAINTENANCE OF CLUSTER WASTEWATER TREATMENT SYSTEMS, COMMUNITY DRAIN FIELDS & OTHER SANITARY TREATMENT FACILITIES UNDER THE MICHIGAN DRAIN CODE

Section 280.433 of the Michigan Drain Code authorizes the establishment of county drainage districts for the purpose of construction, operation and maintenance of sanitary wastewater treatment facilities. Special assessment districts can be set up through procedures similar to those utilized for stormwater management (drainage) districts under the Code. The facilities may be constructed privately with jurisdiction subsequently assumed by the County Water Resources Commissioner for operation, maintenance and replacement or may be constructed by the Water Resources Commissioner. Once a drainage district is established and operating, all future costs and responsibilities rest with the special assessment district.

To date, the Washtenaw County Water Resources Commissioner has not been involved with the operation of sanitary treatment facilities. Because, however, inquiry has been made regarding policies relative to such systems, the following preliminary guidance has been drafted to describe the terms and conditions under which establishment of drainage districts to manage operations of sanitary facilities may be considered. (It is assumed that facilities will be constructed by the private developer, and jurisdiction subsequently assumed by the Water Resources Commissioner.)

- In order to be considered by the Washtenaw County Water Resources Commissioner, the system must be proposed to alleviate an existing health problem, or to allow clustering of development so as to preserve natural features and open space in a proposed new development. A minimum of 50% preserved open space will be required.
- Formal written request from the local government in which the district would be located is a prerequisite to consideration of establishment of a county drainage district for cluster

systems, community drain fields or other waste treatment facilities. Private developers' proposals will not be considered unless accompanied by request of the affected community(ies).

- Approval must be obtained for system design and installation by the Office of the Water Resources Commissioner, County Environmental Health Division, as well as MDEQ where required.
- The private developer of the system will pay all administrative, technical review and inspection costs. The developer must fund the cost of review of plans, and supervision of installation, by an independent professional engineer under contract to the Office of the Washtenaw County Water Resources Commissioner.
- The system must be warranted, at the developer's expense, through 2 freeze-thaw periods.
- A maintenance program and a contract for ongoing maintenance with a private or public entity acceptable to the Office of the Water Resources Commissioner must be in place. Costs should be borne by the Condominium or Subdivision Association of the area served, though the Water Resources Commissioner will have necessary work performed and levy special assessments to cover the cost incurred should the homeowners' association fail to fulfill this obligation. A schedule for reporting to the Water Resources Commissioner, as well as a timeframe for response by the homeowners' group upon notification of needed maintenance must be specified in the Rules or Agreement governing its operation.
- A clear definition must be set forth in the Subdivision Agreement or Condominium Master Deed as to those facilities that remain the responsibility of individual property owners for operation, maintenance and replacement, verses those that fall under jurisdiction of the county drainage district. All property owners will bear equally in paying costs of any service, repair or replacement of the County portions of the system.
- Provision must be made for annual inspection of the system by the Washtenaw County Environmental Health Division, or its designee, at the property owners' expense.
- An escrow fund sufficient to cover replacement of the system shall be established in the name of the drainage district at the time the County assumes responsibility.

Other terms and conditions may be developed to serve site specific needs on a case-by-case basis.

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Part E.

ENGINEER'S CERTIFICATE OF CONSTRUCTION

Date: _____

Development Name: _____

Township of: _____

Section: _____

Washtenaw County, Michigan

I hereby certify that the construction of the drainage facilities of the subdivision known as _____
_____ is complete and that:

1. I have supervised inspection of the construction.
2. All improvements to date have been installed in accordance with construction plans approved by the Washtenaw County Water Resources Commissioner.
3. Reports of construction material tests have been filed with the Washtenaw County Water Resources Commissioner.

Signed: _____

Registered Professional Engineer

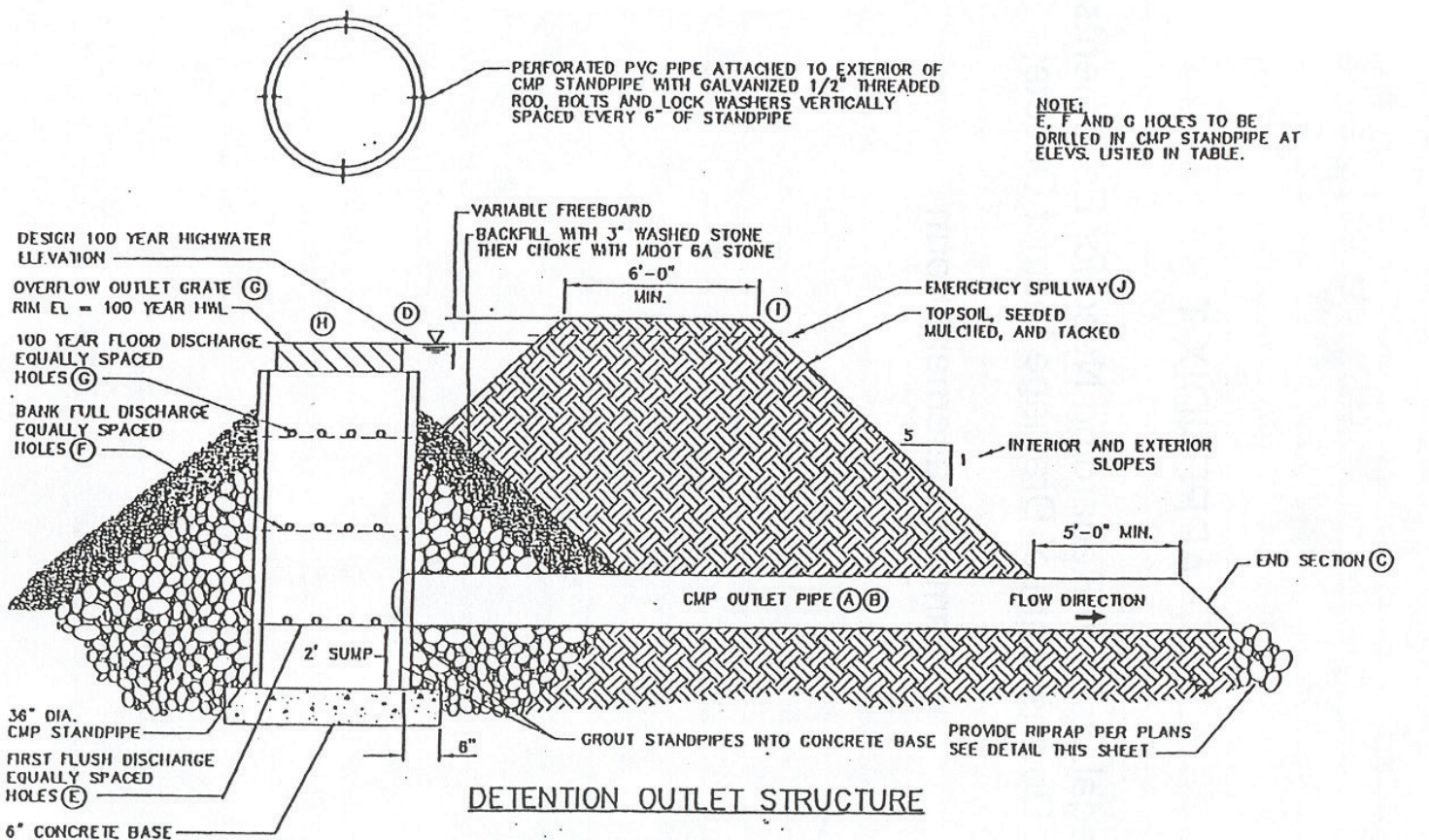
Note: The engineer's certificate must be stamped with the engineer's seal.

The certificate submitted must be the original.

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Part F.

EXAMPLE THREE STAGE OUTLET DESIGN



DETENTION OUTLET SCHEDULE

OUTLET PIPE LENGTH (A)	OUTLET PIPE SLOPE (B)	END SECTION INVERT (C)	100-YEAR HWL (D)	FIRST FLUSH DISCHARGE INV/ORIFICE SIZE (E)	BANK FULL DISCHARGE INV/ORIFICE SIZE (F)	100 YEAR FLOOD DISCHARGE INV/ORIFICE SIZE (G)	TOP OF STAND PIPE ELEVATION (H)	POND CREST ELEVATION (I)	EMERGENCY SPILLWAY ELEVATION (J)

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Part G.

RAINFALL PRECIPITATION DATA

Precipitation Frequency Data: Washtenaw County, Michigan

The following table indicates the expected design precipitation for a particular duration and recurrence interval. The data was obtained from NOAA Atlas 14, Volume 8, Version 2, -- Point Precipitation Frequency Estimates for Michigan at the Ann Arbor weather station.

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)¹

DURATION	AVERAGE RECURRENCE INTERVALS (YEARS)						
	1 YR.	2 YR.	5 YR.	10 YR.	25 YR.	50 YR.	100 YR.
30 min.	0.768	0.906	1.14	1.33	1.61	1.83	2.05
1 hour	0.969	1.14	1.44	1.70	2.07	2.38	2.69
2 hours	1.17	1.38	1.75	2.07	2.54	2.92	3.33
3 hours	1.30	1.53	1.93	2.29	2.82	3.27	3.74
6 hours	1.55	1.79	2.22	2.62	3.23	3.75	4.31
12 hours	1.82	2.06	2.50	2.91	3.54	4.09	4.68
24 hours	2.09	2.35	2.83	3.26	3.93	4.50	5.11

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

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Part H.

HYDROLOGIC SOIL GROUPS FOR WASHTENAW COUNTY

Soil properties influence the process of generation of runoff from rainfall and must be considered in methods of runoff estimation. The soils are classified on the basis of water intake at the end of the long-duration storms occurring after prior wetting and after an opportunity for swelling, and without the protective effects of vegetation. The hydrologic soil groups, as defined by the NRCS are:

- A.** Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission and low runoff potential.
- B.** Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- C.** Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- D.** Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious

SOIL SERIES	GROUP	SOIL SERIES	GROUP	SOIL SERIES	GROUP
Adrian	D/A	Kendallville	B	Pewamo	D/C
Blount	C	Kibbie	B	Riddles	B
Boyer	B	Kidder	B	Sebewa	D/B
Boyer-Kidder	B	Lamson-Colwood	D/B	Seward	B
Brookston	D/B	Macomb	B	Sisson	B
Cohoctah	D/B	Matherton	B	Sloan	D/B
Conover	C	Metamora	B	Spinks	A
Conover-Brookston	D/B	Miami	B	Spinks-Oshtemo	B
Dixboro-Kibbie	B	Morley	C	St. Clair	D
Edwards	D/B	Nappanee	D	Tedrow	B
Fox	B	Oakville	A	Thetford	A
Gilford	D/B	Oshtemo	B	Wasepi	B
Granby	D/A	Owosso	B	Wauseon	D/B
Houghton	D/A	Palms	D/A	Ypsi	C
Hoytville	D/C	Pella	D/B		

The first group is the native or undrained classification when the water intake has not been changed by artificial drainage. The second group is the classification after artificial drainage improvements. For use in the determination of developed runoff only the undrained classification will be accepted.

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Part I.

REQUIRED EASEMENT & DISTRICT LANGUAGE FOR CHAPTER 18 DRAINAGE DISTRICTS

LANGUAGE REQUIRED FOR PLATTED SUBDIVISIONS

The following language shall be included in a section of the subdivision deed restrictions that describes the drainage district.

...subject to a perpetual and permanent easement in favor of the Washtenaw County Water Resources Commissioner, the _____ Drainage District, (collectively referred to as “grantee”), and grantee’s successors, assigns and transferees, in, over, under and through the property described on the plat (liber, page) hereto, which easement may not be amended or revoked except with the written approval of grantee, and which contains the following terms and conditions and grants the following rights:

1. The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connections with any type of drainage facilities or storm drains, in any size, form, shape or capacity;
2. The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit for the purposes identified in subsection (1) above;
3. No owner in the subdivision shall build or convey to others any permanent structures on the said easement;
4. No owner in the subdivision shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity to take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;
5. The grantee and its agents, contractors and designated representative shall have right of entry on, and to gain access to, the easement property;
6. All owners in the subdivision release grantee and its successors, assigns or transferees from any and all claims to damages in any way arising from or incident to the construction and maintenance of a drain or sewer or otherwise rising from or incident to the exercise by grantee of its rights under the said easement, and all owners covenant not to sue grantee for such damages.

The rights granted to the Washtenaw County Water Resources Commissioner, the _____ Drainage District, and their successors and assigns, under Section _____ of these restrictions may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted there under shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

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LANGUAGE REQUIRED FOR SITE CONDOMINIUMS

The following language shall be included in a section of the Master Deed that describes the drainage district.

...subject to a perpetual and permanent easement in favor of the Washtenaw County Water Resources Commissioner, the _____ Drainage District, (collectively referred to as “grantee”), and grantee’s successors, assigns and transferees, in, over, under and through the property described on Exhibit B hereto, which easement may not be amended or revoked except with the written approval of grantee, and which contains the following terms and conditions and grants the following rights:

1. The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connections with any type of drainage facilities or storm drains, in any size, form, shape or capacity;
2. The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit for the purposes identified in subsection (1) above;
3. No owner in the condominium shall build or convey to others any permanent structures on the said easement;
4. No owner in the condominium shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity to take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;
5. The grantee and its agents, contractors and designated representative shall have right of entry on, and to gain access to, the easement property;
6. All owners in the condominium release grantee and its successors, assigns or transferees from any and all claims to damages in any way arising from or incident to the construction and maintenance of a drain or sewer or otherwise arising from or incident to the exercise by grantee of its rights under the said easement, and all owners covenant not to sue grantee for such damages. The rights granted to the Washtenaw County Water Resources Commissioner, the _____ Drainage District, and their successors and assigns, under Section _____ of these restrictions may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted there under shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

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Part J.

THIS DOCUMENT IS GENERATED BY THE WATER RESOURCES COMMISSIONER'S OFFICE. THE FOLLOWING IS FOR REFERENCE ONLY AND SHOULD NOT BE GENERATED FOR FILING PURPOSES.

(SAMPLE AGREEMENT FORM ATTACHED)

This agreement must be recorded with the Washtenaw County Register of Deeds. Therefore, it must abide by the following recording requirements:

1. Use full names. For example, do not write "John and Mary Doe". Write "John Doe and Mary Doe".
2. Signatures must be original and names must be typed or printed beneath signatures. MCLA 565.201 Sec. 1(a)
3. No discrepancy shall exist between names printed in the notary acknowledgment and as printed beneath signatures. MCLA 565.201Sec. 1(b)
4. Instruments conveying or mortgaging property shall state the marital status of all male grantors/mortgagors. MCLA 565.221
5. The address of the grantees in each deed of conveyance or assignment of real estate shall contain the street number address or post office address. MCLA 565.201 Sec. 1(d)
6. The name and address of the person who drafted the document must appear on documents executed in Michigan. MCLA 565.201a, 565.203
7. Documents purporting to convey or encumber real estate executed in Michigan require an acknowledgement by a judge, clerk of a court of record or a notary public within this state. MCLA 565.8; form: LAND 565.47, MCLA 565.265; 565.267
8. A certified copy of the death certificate or proof of death must be recorded or have been recorded and referenced by Liber and Page on said document when "survivor" is indicated on the document. MCLA 565.48
9. Court orders must be certified and sealed by the clerk of the court. MCLA 565.401,; 565.411
10. The document submitted for recording must be legible. MCLA 565.201 Sec. 1(f)(iv).
11. Documents must have a margin of unprinted space at least 2 1/2 inches at the top of the first page and at least 1/2 inch on all remaining sides of each page. MCLA 565.201 Sec 1(f)(i)
12. Documents must display on the first line of print on the first page, a single statement identifying the recordable event that the instrument evidences. MCLA 565.201 Sec. 1 (f)(ii) Sec. 3
13. The type on the form must be printed with black ink; type size at least 10-point type. MCLA 565.201 Sec. 1 (f) (iii)(iv)
14. The paper on which the document is printed must be white and not less than 20-pound weight. MCLA 565.201 Sec. 1 (f)(iv)
15. The size of the document and any attachment thereto must be at least 8 1/2 inches by 11 inches; at most 8 1/2 inches by 14 inches. MCLA 565.201 Sec. 1 (f) (v)(vi)

NUMBER OF LOTS	FEE
1-50	\$1,500
51-100	\$2,000
101-150	\$2,500
151-200	\$3,000
201-250	\$3,500
251-300	\$4,000
301+	\$5,000

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AGREEMENT TO ESTABLISH THE PROJECT_NAME DRAIN DRAINAGE DISTRICT

THIS AGREEMENT, made and entered into this _____ day of _____, 20____, by and between EVAN N. PRATT, Washtenaw County Water Resources Commissioner, (COMMISSIONER) acting for and on behalf of the PROJECT_NAME DRAIN DRAINAGE DISTRICT (P.O. Box 8645, Ann Arbor, MI 48107), of the County of Washtenaw, State of Michigan, a municipal corporation, hereinafter referred to as the DISTRICT, and OWNER_DEVELOPER, (ADDRESS), hereinafter referred to as the DEVELOPER.

WITNESSETH:

WHEREAS, Section 433 of Act Number 40 of the Public Acts of 1956, Michigan, as amended, The Drain Code, authorizes the COMMISSIONER to enter into an agreement with a landowner and developer, if any, to establish an existing private drain which was constructed by the landowner or developer to service an area on his, or her own land as a County or Intercounty Drain; and

WHEREAS, COMMISSIONER, acting on behalf of the PROJECT_NAME DRAIN DRAINAGE DISTRICT, will have under his jurisdiction the PROJECT_NAME DRAIN (DRAIN); and

WHEREAS, the COMMISSIONER, through and by the DISTRICT, is in charge of operation and maintenance of the PROJECT_NAME DRAIN to service lands in the PROJECT_NAME DRAIN DRAINAGE DISTRICT; and

WHEREAS, the PROJECT_NAME DRAIN will be a County Drain located in TOWNSHIP_SECTION; and

WHEREAS, the DEVELOPER has provided storm drainage for the lands comprised within the PROJECT_NAME DRAIN DRAINAGE DISTRICT, described in Exhibit A as attached and made a part hereof.

WHEREAS, the DEVELOPER further understands that as the freeholder and owner of the lands included in this Agreement in the TOWNSHIP of TOWNSHIP_SECTION in which said PROJECT_NAME DRAIN and the lands to be drained thereby are located, that these lands as described in Exhibit A known as the PROJECT_NAME DRAIN DRAINAGE DISTRICT will be subject to assessments for the cost of construction, operation, inspection and maintenance of the DRAIN; and

WHEREAS, these lands being drained, thereby, and to be assessed, therefore, are in the PROJECT_NAME DRAIN DRAINAGE DISTRICT; and

WHEREAS, the DEVELOPER, pursuant to Section 433 of the Drain Code, as amended, desires to establish his or her private drain as a County Drain; and

WHEREAS, the DEVELOPER, has agreed to assume the total cost of said improvement; and

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WHEREAS, a certificate has been obtained from a registered professional engineer retained by the DEVELOPER to the effect that the existing drain is the only reasonably available outlet for the 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 that the outlet presently provides.

NOW, THEREFORE, in consideration of the premises and covenants of each, the parties hereto agree to as follows:

1. The DISTRICT agrees to establish the PROJECT_NAME DRAIN as a County Drain upon the execution of this Agreement by the DISTRICT and the DEVELOPER.
2. The stormwater drainage facilities of the PROJECT_NAME shall be constructed under the supervision, direction and control of the DISTRICT according to plans, specifications and project designs approved by the DISTRICT and on file in the Office of the Washtenaw County Water Resources Commissioner.
3. The DEVELOPER agrees hereto to assume the cost of the project set forth in the above-mentioned plans, specifications and project designs. Said cost shall include:
 - a. Administrative Fees for the establishment of the PROJECT_NAME DRAIN
 - b. Actual expenses incurred by the DISTRICT for inspection and construction of the DRAIN.
 - c. A construction contingency item computed as ten percent (10%) of the construction cost as determined by the DISTRICT provided, should any balance remain in the contingency fund, such balance shall be refunded to the DEVELOPER upon the following terms and conditions:
 - i. A period of one (1) year shall expire after final acceptance of the project by the DISTRICT at which time the DEVELOPER shall request that the DISTRICT make a final inspection.
 - ii. The DISTRICT shall proceed with final inspection of the project, and following such inspection, the DISTRICT shall make the necessary correction of any defects on the project payable out of contingency funds.
 - iii. At such time as the corrections have been completed by the DISTRICT, the DISTRICT shall issue a final acceptance of the project, and, the DEVELOPER shall file with the DISTRICT a sworn Statement that all claims for amounts due for labor, materials and equipment furnished for this work have been paid in full, or he or she shall so file in lieu thereof, a sworn statement showing in detail the nature and amount of all unpaid claims for said labor, materials and equipment. The Contractor shall also submit a Contractor's Declaration and Affidavit. The remaining contingency balance may then be refunded to the DEVELOPER.
 - d. The establishment of a permanent maintenance fund in an amount of 5% of the construction cost but not to exceed \$2,500.00.

The DEVELOPER'S cost to the DISTRICT to establish the DRAIN, incidental of actual construction expenses, is hereby determined as follows:

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- i. Administrative fees \$ _____
- ii. Estimated Inspection \$ _____
10% of project cost; unused monies to be returned to the DEVELOPER upon final acceptance of the project. DEVELOPER may secure services of a certified professional engineer for inspection; in such cases, inspection procedures and schedule must be approved by the Office of the Washtenaw County Water Resources Commissioner.
- iii. Contingency \$ _____
10% of project cost.
- iv. Permanent Maintenance Fund \$ _____

- Total Cost: \$ _____

- 4. The DEVELOPER shall forthwith deposit said Balance Due with the DISTRICT, to be used only for the purposes herein set forth and agreed upon.
- 5. The DEVELOPER shall provide the COMMISSIONER and/or the DISTRICT with a Letter of Credit, Escrow account, or cash in the sum of 100% of the construction cost of the DRAIN, to remain in effect until construction acceptance of the project by the DISTRICT.
- 6. It is agreed that the DEVELOPER shall convey to the DISTRICT the final plat or condominium documents, description of the drainage district and such easement and Rights-of-Way as may be necessary to accomplish the purposes herein set forth, and legal description (referenced to a Public Land Survey System (PLSS) corner) of route and course of drain, and do so without charge therefore.
- 7. The DEVELOPER further agrees to provide, without charge, one (1) set of reproducible mylar (D-size; 24" x 36") and one (1) portable document format (pdf) "Record Drawings" of the drain as built, which shall include design calculations showing flow rates, imperviousness factors, drainage district and sub-districts and any other data needed by the DISTRICT for proper drain operation.
- 8. The DEVELOPER further agrees to provide to the DISTRICT, without charge, one (1) copy of the Master Deed Agreement, as recorded with the Washtenaw County Clerk/Registrar of Deeds for condominium developments.
- 9. The foregoing payment of the cost of the project is agreed and understood as being for the sole benefit of the PROJECT_NAME DRAIN 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 proper and legal petitions and hearings and procedures thereon.

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10. It is agreed that the maintenance of these drainage facilities shall be consistent with the COMMISSIONER'S normal standards and requirements. This maintenance does not include such items as lawn cutting, litter pick-up, etc.
11. This Agreement shall become effective upon its execution by the DEVELOPER and by the DISTRICT and shall be binding upon the successors and assigns of each party.

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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.

PROJECT_NAME DRAIN DRAINAGE DISTRICT,
County of Washtenaw, State of Michigan, acting as Its governing body, the Washtenaw County Water Resources Commissioner

By: Evan N. Pratt
Washtenaw County Water Resources Commissioner

OWNER_DEVELOPER

By:-----
(Print Here)

Its: -----

Drafted by: Deborah L. Shad
Office of the Water Resources Commissioner
P.O. Box 8645
Ann Arbor MI 48107-8645

When recorded, please return to:
Office of the Water Resources Commissioner
P.O. Box 8645
Ann Arbor MI 48107-8645

Section VIII: Appendix



ACKNOWLEDGMENT

STATE OF MICHIGAN)
)
COUNTY OF WASHTENAW)

On this _____ day of _____ 20__ before me, a Notary Public in and for said County, appeared EVAN N. PRATT, Washtenaw County Water Resources Commissioner, to me personally known to be the person described in and who executed the foregoing instrument and acknowledged the same to be her free act and deed.

Ronald E. Mann, Notary Public
Washtenaw County, Michigan

Acting in: Washtenaw County
My Commission Expires: -----

Section VIII: Appendix

ACKNOWLEDGMENT

STATE OF MICHIGAN)
)
 COUNTY OF WASHTENAW)

On this _____ day of _____ 20__ before me, a Notary Public in and for said County, appeared _____, to me personally known, who being duly sworn did say that s/he is the _____ of _____, and that said instrument was signed in behalf of said _____ by authority of its Board of Directors and the said Board acknowledged said instrument to be the free act and deed of said signatory.

_____, Notary Public

_____ County, Michigan

Acting in: _____

My Commission Expires _____.

Section VIII: Appendix



ATTACHMENT A.

DRAINAGE DISTRICT APPLICANT INFORMATION SHEET

The following are the sole owners of the following lands:

Tax Code Number/Parcel Number

Located in Section TOWNSHIP_SECTION, County of Washtenaw, State of Michigan which encompasses the lands in the proposed PROJECT_NAME DRAIN DRAINAGE DISTRICT.

Following are the names and addresses of all persons who are required to sign the final plat or master deed agreement as proprietors:

OWNER_DEVELOPER
Address

Section VIII: Appendix

Part K.

MAINTENANCE PLAN & BUDGET

SAMPLE MAINTENANCE PLAN & BUDGET

“XYZ” Leasing Company Stormwater Management System Maintenance Plan

1. Responsibility for Maintenance

- a. During construction, it is the developer’s responsibility to perform the maintenance.
- b. Following construction, it will be the responsibility of “XYZ” Company to perform the maintenance.
- c. The Master Deed will specify that routine maintenance of the stormwater facilities must be completed within ____ days of receipt of written notification that action is required, unless other acceptable arrangements are made with the (Township of _____), (Washtenaw County Commissioner) or successors. Emergency maintenance (i.e. when there is endangerment to public health, safety or welfare) shall be performed immediately upon receipt of written notice. Should “XYZ” Company fail to act within these time frames, the (Township) (County) or successors may perform the needed maintenance and assess the costs against “XYZ” Company.

2. Source of Financing

“XYZ” Company is required to pay for all maintenance activities on a continuing basis.

3. Maintenance Tasks and Schedule

- a. See the charts on the next two pages: The first describes maintenance tasks during construction to be performed by the developer, the second describes maintenance tasks by “XYZ” Company.
- b. Immediately following construction, the developer will have the stormwater management system inspected by an engineer to verify grades of the detention and filtration areas and make recommendations for any necessary sediment.

Refer to the **Low Impact Development Manual for Michigan** for maintenance task checklists for permanent BMPs and create a table of applicable maintenance tasks and schedules for the project.

The BMP maintenance checklists in the LID Manual include:

- Detention (ponds, basins, wetlands)
- Infiltration (basins, trenches)
- Bioretention
- Bioswales, vegetated filter strips

Section VIII: Appendix



MAINTENANCE TASKS AND SCHEDULE DURING CONSTRUCTION

TASKS	COMPONENTS										SCHEDULE	
	Storm Sewer System	Catch Basin Sumps	Catch Basin Inlet Casings	Ditches and Swales	Outflow Control Structure	Rip-Rap	Filtration Basins	Storm Detention Areas	Wetlands	Emergency Overflow		
Inspect for sediment accumulation	X	X		X	X		X	X				Weekly
Removal of sediment accumulation	X	X		X	X		X	X				As needed* & prior to turnover
Inspect for floatables and debris			X	X	X		X	X				Quarterly
Cleaning of floatables and debris			X	X	X		X	X				Quarterly & at turnover
Inspection for erosion				X	X		X	X				Weekly
Re-establish permanent vegetation on eroded slopes				X	X		X	X				As needed & at turnover
Replacement of Stone					X							As needed* & prior to turnover
Mowing			X	X	X	X	X	X				0 to 2 times per year
Inspect Stormwater system components during wet weather and compare to as-built plans (by professional engineer reporting to XYZ Co.)				X	X		X	X				Annually and at turnover
Make adjustments or replacements as determined by annual wet weather inspection	X	X	X	X	X	X	X	X	X	X	X	As needed

*as needed means when sediment has accumulated to a maximum of one foot depth

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PERMANENT MAINTENANCE TASKS AND SCHEDULE

TASKS	COMPONENTS								SCHEDULE
	Catch Basin Inlet Casings	Ditches and Swales	Outflow Control Structure	Rip-Rap	Filtration Basins	Storm Detention Areas	Wetlands	Emergency Overflow	
Inspect for sediment accumulation		X	X		X	X			Annually
Removal of sediment accumulation		X	X		X	X			Every 2 years as needed
Inspect for floatables and debris	X	X	X		X	X			Annually
Cleaning of floatables and debris	X	X	X		X	X			Annually
Inspection for erosion		X	X		X	X			Annually
Re-establish permanent vegetation on eroded slopes		X			X	X			As Needed
Replacement of Stone			X						Every 3-5 years as needed
Clean Streets									Semi-Annually
Mowing		X			X	X			0-2 times per year
Inspect Stormwater system components during wet weather and compare to as-built plans (by professional engineer reporting to XYZ Co.)	X	X	X	X	X	X	X	X	Annually
Make adjustments or replacements as determined by annual wet weather inspection	X	X	X	X	X	X	X	X	As needed
Keep records of all inspections and maintenance activities and report to XYZ Co.									Annually
Keep records of all costs for inspections, maintenance and repairs. Report to XYZ Co.									Annually

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TASKS	COST
Annual inspection for sediment accumulation	\$100.00
Removal of sediment accumulation every 2 years as needed	\$500.00
Inspect for floatables and debris annually and after major storms	\$100.00
Removal of floatables and debris annually and after major storms	\$150.00
Inspect system for erosion annually and after major storms	\$100.00
Re-establish permanent vegetation on eroded slopes as needed	\$350.00
Replacement of stone	\$100.00
Mowing 0-2 times per year	\$400.00
Inspect structural elements during wet weather and compare to as-built plans every 2 years	\$150.00
Make structural adjustments or replacements as determined by inspection as needed	\$400.00
Have professional engineer carry out emergency inspections upon identification of severe problems	\$200.00
A. Total Annual Budget	\$2,550.00

Note: Maintenance Plans and budgets vary widely due to the size and unique characteristics of each stormwater management system proposed. Appendix K is intended for use as a starting point in the development of an appropriate maintenance plan specific to the size and components of each system.

Section VIII: Appendix

Part I.

ENGINEER'S CERTIFICATE OF OUTLET

Date: _____

Development Name: _____

City, Village or Township of _____ Section _____

Washtenaw County, Michigan

I hereby certify that the existing drain is the only reasonably achievable stormwater outlet for the proposed stormwater management system and that the existing drain has sufficient capacity to serve as an adequate outlet for the proposed system, without detriment to or diminution of the drainage serve that the existing outlet presently provides.

Signed: _____
Registered Professional Engineer

NOTE: The engineer's certificate must be stamped with the engineer's seal.
The certificate submitted must be the original.

Section VIII: Appendix



Part M.

RAIN GARDEN PLANT LIST

Refer to the **Low Impact Development Manual for Michigan, Appendix C** - for extensive plant information.

PERENNIALS

Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
<i>Actaea rubra</i>	Red Baneberry	White	12-36"	May	N	Sh	M, Ms
<i>Adiantum pedatum</i>	Maidenhair Fern	n/a	12"	n/a	N	P, Sh	M, Ms
<i>Allium cernuum</i>	Nodding Wild Onion	Lt. Lavender	12"	Sept-Oct	N	Sn, P	D, M, Ms
<i>Anemone canadensis</i>	Canada Anemone	White	12"-20"	May-July	N	Sn, P, Sh	M, Ms
<i>Anthyrium filix-femina</i>	Lady Fern	n/a	24"-36"	n/a	N	Sn, P	M, Ms
<i>Aquilegia canadensis</i>	Columbine	Red/Yellow	12-36"	May	N	P, Sh	D, M, Ms
<i>Asarum canadense</i>	Wild Ginger	Maroon	8"	May	N	P, Sh	M, Ms
<i>Asclepias incarnata</i>	Swamp Milkweed	Pink/Purple	3-4'	July	N	P, Sh	M, Ms, W
<i>Aster dumosus 'Woods Light Blue'</i>	Woods Blue Aster	Lavender	1-2'	Aug-Oct	C	Sn, P	D, M, Ms
<i>Aster laevis</i>	Smooth Aster	Lt. Blue/Lavender	4-5'	Sept-Oct	N	Sn, P	D, M, Ms
<i>Aster novae-angliae</i>	New England Aster	Deep Purple	4-5'	Sept-Oct	N	Sn, P	D, M, Ms
<i>Baptisia australis</i>	Baptisia or False Indigo	Blue	3-4'	June	N	Sn	D, M, Ms
<i>Carex grayii</i>	Gray's Sedge	n/a	18"	May/June	N	P, Sh	M, Ms
<i>Carex hystericina</i>	Porcupine Sedge	n/a	2-3'	June-Oct.	N	Sn, P	Ms, W
<i>Carex muskingumensis</i>	Palm Sedge	n/a	2-3'	June-Oct.	N	Sn, P, Sh	M, Ms, W
<i>Carex sprengelii</i>	Sprengel's Sedge	n/a	18"	May/June	N	P, Sh	D, M, Ms
<i>Carex stipata</i>	Common Fox Sedge	Green	24"	May	N	Sn, P, Sh	D, M, Ms
<i>Carex vulpinoidea</i>	Brown Fox Sedge	n/a	2-3'	June-Oct.	N	Sn, P, Sh	D, M, Ms, W
<i>Caulophyllum thalictroides</i>	Blue Cohosh	Green	24"	April	N	Sh	Ms
<i>Chelone lyonii 'Hot Lips'</i>	Hot Lips Turtlehead	Pink	2-3'	Aug-Sept	C	Sn, P	D, M, Ms
<i>Echinacea purpurea</i>	Purple Coneflower	Pink/Lavender	3'-3.5'	July-Aug	N	Sn, P	D, M, Ms
<i>Eryngium yuccifolium</i>	Rattlesnake Master	White/Lt. Green	3'	July-Sept.	N	Sn	D, M, Ms
<i>Eupatorium maculatum</i>	Joe Pye Weed	Dusky Pink	5-6'	July-Aug	N	Sn, P	D, M, Ms
<i>Eupatorium rugosum</i>	White Snakeroot	White	2'-4'	July-Sep	N	P, Sh	M
<i>Fragaria virginiana</i>	Wild Strawberry	White	6-12"	May-June	N	Sn, P, Sh	D, M, Ms
<i>Geranium maculatum</i>	Wild Geranium	Lavender	12"-24"	May-June	N	Sn, P, Sh	D, M, Ms
<i>Helianthus divaricatus</i>	Woodland Sunflower	Yellow	3'-5'	Jul-Aug	N	Sn, P	D, M, Ms
<i>Helianthus grosseserratus</i>	Sawtooth Sunflower	Yellow	5'-8'	Aug-Oct	N	Sn	D, M, Ms

Native Plant: N = Native plant which can be obtained from any members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native
Sun/Shade: Sn = Sun P = Part Sun Sh = Shade
Moisture: D = Dry M = Medium Ms = Moist W = Wet

Section VIII: Appendix

PERENNIALS (CONT'D)

Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
<i>Hibiscus moscheutos</i>	Rose Mallow	Pink	4'-6'	Aug-Sept	N	Sn	M, Ms, W
<i>Hydrophyllum virginianum</i>	Virginia Waterleaf	Lavender	1-1.5'	May-June	N	Sh	M, Ms, W
<i>Iris virginica</i>	Blue Flag Iris	Lt. Blue/Lavender	2-3'	May-June	N	Sn, P, Sh	M, Ms, W
<i>Liatris spicata</i>	Blazing Star	Pink/Purple	3-5'	July	N	Sn, P	M, Ms
<i>Liatris spicata 'Kobold'</i>	Kobold Blazing Star	Pink/Purple	2'	July	C	Sn, P	M, Ms
<i>Lobelia cardinalis</i>	Cardinal Flower	red	3'	July-Aug	N	P, Sh	M, Ms
<i>Lobelia siphilitica</i>	Blue Lobelia	blue purple	30"	July-Sept	N	Sn, P, Sh	M, Ms
<i>Matteuccia struthiopteris</i>	Ostrich Fern	n/a	36"	n/a	N	P, Sh	M, Ms
<i>Monarda punctata</i>	Horsemint	White-Pink	18-30"	July-Aug	N	Sn, P	D, M, Ms
<i>Onoclea sensibilis</i>	Sensitive Fern	n/a	12-24"	n/a	N	Sn, P, Sh	M, Ms, W
<i>Osmunda claytoniana</i>	Interrupted Fern	n/a	12-24"	n/a	N	P, Sh	M, Ms, W
<i>Panicum virgatum</i>	Switch Grass	n/a	4-6'	Aug.-Sept.	N	Sn	D, M, Ms, W
<i>Penstemon digitalis</i>	White Beardtongue	White	3-4'	June	N	Sn, P	D,M,Ms
<i>Phlox divaricata</i>	Woodland Phlox	Blue	.5-1'	April-June	N	P, Sh	M, Ms
<i>Physostegia virginiana</i>	Obedient Plant	Pink	2-3'	Sept-Oct	N	Sn, P	D, M, Ms
<i>Potentilla simplex</i>	Common cinquefoil	Yellow	6-12"	May-June	N	Sn, P	D, M
<i>Ranunculus hispidus</i>	Swamp Buttercup	Yellow	1'	May	N	Sn, P	M, Ms, W
<i>Ratibida pinnata</i>	Yellow Coneflower	Yellow	4-6'	July-Oct.	N	Sn	D, M, Ms
<i>Rudbeckia hirta</i>	Black-eyed Susan	Yellow	1-3'	July-Oct	N	Sn, P	D, M, Ms
<i>Silphium laciniatum</i>	Compass Plant	Yellow	4-7'	July-Aug.	N	Sn	D, M, Ms, W
<i>Silphium terebinthinaceum</i>	Prairie Dock	Yellow	8'	Aug.	N	Sn	D, M, Ms
<i>Smilacena stellata</i>	Starry-false Solomon's Seal						
<i>Solidago flexicaulis</i>	Zig Zag Goldenrod	Yellow	2-3'	Aug.-Oct.	N	P, Sh	D, M, Ms
<i>Solidago riddellii</i>	Riddell's Goldenrod	Yellow	3-4'	Aug	N	Sn	Ms, W
<i>Solidago rigida</i>	Rigid Goldenrod	Yellow	3-4'	July	N	P, Sh	D, M, Ms, W
<i>Sporobolus heterolepis</i>	Prairie Dropseed	n/a	2'	Aug.-Sept.	N	Sn	D, M, Ms
<i>Stylophorum diphyllum</i>	Wood Poppy	Yellow	1-2'	April-June	N	P, Sh	M, Ms
<i>Thalictrum dioicum</i>	Early Meadow Rue	Pale Green	1.5-2'	April-May	N	P, Sh	M, Ms
<i>Verbena hastata</i>	Blue Vervain	Purple	4-6'	June-August	N	Sn	D, M, Ms
<i>Veronicastrum virginicum</i>	Culver's Root	White	4-6'	July-August	N	Sn, P, Sh	D, M, Ms

Native Plant: N = Native plant which can be obtained from any members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native

Sun/Shade: Sn = Sun P = Part Sun Sh = Shade
Moisture: D = Dry M = Medium Ms = Moist W=Wet

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SHRUBS AND TREES

Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
<i>Cercis canadensis</i>	Red Bud	Pink	25'	May	N	Sn, P, Sh	D, M, Ms
<i>Cornus sericea</i>	Red-twig Dogwood	White	5-8'	May-June	N	Sn, P	D, M, Ms, W
<i>Ilex verticillata</i>	Winterberry-Male	White	4-6'	June-July	C	Sn	M, Ms, W
<i>Itea virginica</i>	Sweetspire	White	4'	May-June	C	Sn, P, Sh	M, Ms
<i>Nyssa sylvatica</i>	Blackgum	White	30'-60'	May-June	N	Sn, P	D, M, Ms, W
<i>Potentilla fruticosa</i>	Potentilla	Yellow	3-4'	June-July	C	Sn	D, M, Ms
<i>Sambucus canadensis</i>	Elderberry	White	5-10'	June-July	N	Sn, P	D, M, Ms, W
<i>Viburnum dentatum</i>	Arrowwood Viburnum	White	3-4'	May-June	C	Sn, P	D, M, Ms, W
<i>Viburnum lentago</i>	Nannyberry	White	5-7'	June	N	Sn, P	M, Ms, W

Native Plant: **N** = Native plant which can be obtained from any members of the Michigan Native Plant Producers Association: www.mnppa.org
C = Cultivar of a native

Sun/Shade: **Sn** = Sun **P** = Part Sun **Sh** = Shade
Moisture: **D** = Dry **M** = Medium **Ms** = Moist **W** = Wet

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PLANTS FOR BIO-RETENTION AREAS ONLY (NOT SUITABLE FOR RESIDENTIAL-SCALE RAIN GARDENS)

Scientific Name	Common Name	Bloom Color	Height	Bloom Time	Native?	Sun/Shade	Moisture
<i>Aesclepias syriaca</i>	Common Milkweed	Pink	3'-4'	Jun-Aug	N	Sn	D, M, Ms
<i>Andropogon gerardii</i>	Big Bluestem	Green	5'-7'	Jul-Aug	N	Sn	D, M, Ms, W
<i>Euaptirum perfoliatum</i>	Boneset	White	3'-5'	Jul-Sep	N	Sn, P	M, Ms, W
<i>Helianthus giganteus</i>	Tall Sunflower	Yellow	5'-8'	Aug-Oct	N	Sn, P	M, Ms, W
<i>Monarda fistulosa</i>	Bee-balm	Lavender	2'-4'	Jul-Aug	N	Sn	D, M, Ms
<i>Ratibida pinnata</i>	Yellow Coneflower	Yellow	3'-5'	Jul-Sep	N	Sn	M, Ms
<i>Solidago caesia</i>	Blue-stemmed goldenrod	Yellow	2'-3'	Aug-Oct	N	Sn, P, Sh	D, M
<i>Tradescantia ohiensis</i>	Spiderwort	Blue	2'-3'	May-Jul	N	Sn, P	D, M, Ms
<i>Vernonia missurica</i>	Ironweed	Purple	4'-6'	Aug-Sep	N	Sn, P	M, Ms, W

Native Plant: N = Native plant which can be obtained from any members of the Michigan Native Plant Producers Association: www.mnppa.org

C = Cultivar of a native

Sun/Shade: Sn = Sun P = Part Sun Sh = Shade

Moisture: D = Dry M = Medium Ms = Moist W = Wet

Section VIII: Appendix



Part N.

LEGAL OPINION REGARDING NEED FOR EASEMENTS DOWNSTREAM OF DRAINAGE DISTRICT OUTLETS

LAW OFFICES OF

HUBBARD, FOX, THOMAS, WHITE & BENGTON, P.C.

THOMAS A. BENGTON	MICHAEL	5801 WEST MICHIGAN AVENUE	HARRY D. HUBBARD (1995-1993)
G. WOODWORTH	DONALD B.	P.O. BOX 80357	DONALD G. FOX (1910-1992)
LAWRENCE, JR		LANSING, MICHIGAN 46908-0857	JONATHON R. WHIM (1942-1996)
GARY L. TRCPOD		TELEPHONE (517) 886-7176	
H. KIRBY ALBRIGHT		FACSIMILE (517) 886-1080	
PETER A. TEHOLIZ			
GEOFFREY H. SEDLEIN			
RYAN M. WILSON			
JAMES F. MAURO			
STACY L. HISSONG			
WILLIAM O. CRINO			
JOHANNA C. CAREY			
TAMMY S. CLARK			

OF COUNSEL:
ALLISON K. THOMAS

Via Fax 734-994-2459 & US Mail

Ms. Janis A. Bobrin
Washtenaw County Drain Commissioner
Courthouse Annex Bldg.
P.O. Box 8645
Ann Arbor, MI 48107-8645

Dear Ms. Bobrin:

You have asked our opinion as to what a Drainage District should require under a 433 Agreement to protect the Drainage District from liability due to sheet flow from a development's drainage district.

As a general rule an upland owner has the right to natural drainage flow over and across the adjacent lower properties. Any instance where the natural surface-flow of water is increased or concentrated, and a neighboring property receives more surface water resulting from the change, the increase in flow constitutes a trespass. If there is an increase in water on neighboring lands, the Drainage District could be liable for damages under the cause of action of trespass- nuisance. Therefore, to protect the Drainage District from future liability, flooding easements should be required for adjacent properties of a development when the development's drainage "sheet flows" onto neighboring properties.

Section VIII: Appendix

HUBBARD LAW FIRM

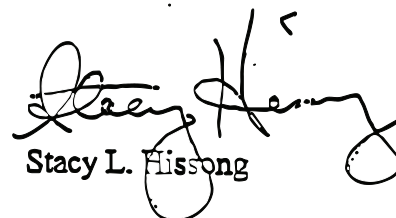
Ms. Janis A. Bobrin
May 27, 1999
Page 2

Please note that Section 433 of the Drain Code envisions the requirement of securing an adequate outlet. Subsection (7) of Section 433 states that a registered engineer must certify that the outlet for the existing drain is the only reasonable available outlet for the drain and that there is sufficient capacity in the existing outlet for the proposed drain to serve as an adequate outlet without detriment or diminution of the drainage service which the outlet presently provides.

Should you have any questions relative to these issues, please do not hesitate to contact Geoff Seidlein or myself.

Sincerely,

HUBBARD, FOX, THOMAS,
WHITE & BENGTS ON, P.C.



Stacy L. Hissong