Engineering Standards

Requirements, Rules, & Design

City of Sterling Heights
ENGINEERING

EFFECTIVE
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Accepted by:

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Per City Code - Chapter 53, Article VIII

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Ch. 1 Managing Stormwater Runoff

1.1 Purpose

This section sets forth design and construction standards to be used by the City of Sterling Heights in review of proposed stormwater management systems within its jurisdiction. These standards apply to all new development and redevelopment projects that disturb one (1) acre or more, including projects that are less than one (1) acre that are part of a larger common plan of development or sale that would disturb one (1) acre or more. The internal drainage for a site, as well as the downstream conditions will be reviewed in accordance with the objectives of managing both the quality and quantity of stormwater runoff. Every site is part of an overall watershed, and the system should be designed within this context.

These standards are the minimum requirements of the City and should not be construed as all-inclusive. The design engineer must also consider other requirements for entities at the federal, state, and county levels when developing stormwater management facilities. Exceptions will be considered and require approval by the City.

Stormwater drainage systems may consist of open ditches, swales, closed conduits or a combination of methods to convey stormwater. Drainage facilities shall be constructed in accordance with these minimum specifications for the City. Other standards may apply such as the Michigan Department of Transportation (MDOT), Macomb County Department of Roads (MCDR), Macomb County Public Works Office (MCPWO), Michigan Department of Environment, Great Lakes, and Energy (EGLE), and other outside agencies, which may be more stringent and shall be adhered to when applicable.

In no event shall the maximum design rate or volume of discharge exceed the maximum capacity of the downstream land, channel, pipe or watercourse to accommodate the flow. It is the proprietor's obligation to meet this standard. Should a stormwater system, as-constructed, fail to comply, it is the proprietor's responsibility to design and construct, or have constructed at their expense, any necessary additional and/or alternative stormwater management facilities. Such additional facilities will be subject to the City's review and approval.

1.2 Technical Infeasibility

The City recognizes that it is difficult to develop one set of uniform standards that are capable of accommodating all variables and unique site circumstances, specifically on smaller sites. Waivers from specific 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 City.

For projects where technical infeasibility exists, the design engineer must document and quantify that stormwater strategies, such as infiltration, evapotranspiration, water harvesting and water reuse, have been used to the maximum extent possible (MEP) and that implementation of these methods are infeasible due to site constraints and not economic considerations. The burden of proof of Technical Infeasibility lies with the design engineer. Documentation of technical infeasibility should include, but may not be limited to, engineering

calculations, geological reports, hydrological analyses and site maps. A determination that the performance design goals cannot be achieved on the site should include analyses that rule out the use of an adequate combination of infiltration, evapotranspiration, and water use measures. Adequate documentation must be submitted to the City of Sterling Heights Office of Engineering for review and final determination. Examples of site conditions that may prevent the application of Stormwater Best Management Practices (BMPs) to the MEP includes*:

1. The conditions on the site preclude the use of infiltration practices due to the presence of shallow bedrock, contaminated soils, high ground water or other factors, such as underground facilities, utilities or location of the development within a wellhead protection area.
2. The design of the site precludes the use of soil amendments, plantings of vegetation or other designs that can be used to infiltrate and evapotranspirate stormwater runoff.
3. Water harvesting and reuse are not practical or possible due to the volume of water used for irrigation, toilet flushing, industrial make-up water, wash-waters, etc. is insignificant to warrant the application of water harvesting and use systems.
4. Modifications to an existing building to manage stormwater are not feasible due to structural or plumbing constraints or other factors.
5. Sites where the site area is too small to accommodate adequate infiltration practices for the impervious area to be served.
6. Soils that cannot be sufficiently modified to provide reasonable infiltration rates.
7. Situations where site use is inconsistent with the capture and use of stormwater or other physical conditions on site that preclude the use of plants for evapotranspiration or bioinfiltration.
8. Retention and/or use of stormwater onsite or discharge of stormwater onsite by infiltration having an adverse effect on the site, gradient of surface or subsurface water, receiving watershed, or water body ecological processes.
9. Federal, state, or local requirements or permit conditions that prohibit water collection or make it technically infeasible to use certain stormwater quantity and quality management practices.

* Adapted from EPA Section 438 Technical Guidance December 2009.

A. Stormwater Management Approach

Stormwater Best Management Practices (BMPs) should be used that function together as a system to insure that the volume, rate, timing, and pollutant load of runoff remains similar to that which occurred under natural, pre-development conditions. This can be achieved through a coordinated network of structural and nonstructural methods designed to provide both source and site control.

1. Source Controls

Source controls reduce the volume of runoff generated on-site, and eliminate initial opportunities for pollutants to enter the drainage system. They are the best option for controlling stormwater and include the following key actions:

a. Preserve existing natural features that perform stormwater management functions, such as natural depressions, wetlands, and vegetation along streambanks.

b. Reduce the area of impervious surfaces through site planning. Minimize enclosed storm sewer systems and directly connected imperviousness by conveying stormwater through vegetated swales, where possible.

c. Where site conditions allow, use infiltration practices to reduce the volume of stormwater runoff.

d. Careful design and installation of erosion control mechanisms and rigorous maintenance throughout the construction period is imperative. Effective erosion control measures include minimizing the area and length of time that a site is disturbed by construction phasing, installing and maintaining effective erosion control measures, and promptly stabilizing disturbed areas.

2. Site Controls

Site controls are used after the implementation of source controls to convey, pre-treat, and treat (i.e., detain, retain or infiltrate) the stormwater runoff generated by development. The engineering and design techniques available to achieve these objectives is dictated by site configuration, soil type, and the receiving waterway, but some universal guidelines for controlling stormwater quality and quantity can be stated. The following four categories of site controls are listed in order of preference.

a. Infiltration - The most effective stormwater quality controls are infiltration practices, which reduce both the peak runoff rate and volume. Infiltration devices are most applicable to small drainage areas and sites with suitable soils and no potential for groundwater contamination.

b. Basins - The next most effective stormwater site controls are detention basins which reduce peak runoff rates. The following criteria apply to detention basins:

   1) Wet extended detention basins are generally preferable to dry detention basins, since they hold stormwater longer, allow more particulates to settle out, and remove some soluble pollutants.

   2) Where site conditions prohibit the use of a wet pond, basins should be designed to provide extended detention of stormwater to meet the channel protection criteria and promote settling of sediment. The use of additional water quality treatment practices will be necessary with dry extended

detention basins (see treatment trains). Conventional dry basins without extended detention outlets will not be allowed.

3) The discharge shall outlet within the drainage basin where flows originate and may not be diverted to another drainage basin, unless by approval of the City.

c. Conveyance - Excess runoff must be discharged into conveyance systems once other methods of reducing and treating stormwater on-site have been implemented and carried off-site to a suitable outlet. For this purpose, vegetated swales are generally preferred to curb and gutter systems and enclosed storm drains. Enhanced swale designs can increase the time of concentration and provide water quality benefits.

d. Filtering Systems and Manufactured Systems – Filtering practices and manufactured systems such as swirl concentrators may be used where adequate source controls cannot be integrated into the site design due to space constraints.

The preferred hierarchy of structural site controls provides a comprehensive framework for evaluating the place and function of individual practices within a stormwater management system. The most important practices are source controls that preserve and protect the natural environment. The use of source control measures will be credited accordingly. Many stormwater management practices can effectively achieve the Water Quality (WQ) Criteria if properly designed and constructed. A list of practices and their estimated percent Total Suspended Solids (TSS) reduction is provided in Table 1.1.

B. Acceptable Stormwater Management Practices

Table 1.1 provides the pollutant removal capabilities recognized by the City. BMPs that do not achieve the required TSS removal rate may be used as part of a treatment train. Third party testing of other BMPs may be submitted for review and acceptance.

Table 1.1 Typical Sediment Removal Rates of Stormwater Management Practices

Type	TSS Removal Rate (%)
Infiltration basin or trench*	89
Pervious pavement system	35
Dry well	89
Wet extended detention pond	80
Dry extended detention (ED) basin	49
Landscaped ED basin (no buffer)	50
Conventional dry detention	18
Constructed stormwater wetland	>80
Multiple pond or pond/wetland complex	>80
Retention basin	89

Grass swale	65**
Dry swale	81**
Wet (wetland) swale	87**
Vegetative filter strip	81
Bioretention	74
Sand filter	86
Cistern	15
Manufactured BMPs***(swirl concentrators, filter systems)	43
Catch basin w/sump and hooded outlet	20

*Depends on soils
** Depends on swale length and design
*** Depends on results of independent testing

C. Detention Basins

Detention basins store stormwater runoff temporarily before discharging into a waterway. Conventional dry detention basins are typically designed strictly for flood control and do not provide adequate channel protection and may not provide adequate water quality treatment. If a dry basin is proposed for a site, then it must either:

1. Have a staged outlet structure to provide extended detention of the Channel Protection Rate Control (CPRC) volume outlined in Section H.3,

2. Be hydraulically-connected to a second extended detention basin, or

3. The designer must demonstrate that alternative methods, such as infiltration, achieve both the Channel Protection Volume Control (CPVC) outlined in Section H.2 and CPRC criteria through stormwater credits.

Detention Basin Guidelines

Stormwater management planning should be addressed before the design stage:

1. The developer has an obligation to determine how the proposed development will impact the subwatershed and whether the proposed stormwater management approach is consistent with the watershed management plan and/or City's master plan.

2. The designer must ensure that the risk of flooding potential is minimized upstream and downstream of the proposed site.

3. Conduct a site evaluation. Identify unique or sensitive natural areas. Locate any springs near the proposed basin site and re-locate the basin if necessary to prevent instability of the detention berms and structures.

4. Try to integrate the basin into the site as a natural site amenity.

5. All utility lines and sanitary sewers should be located outside of the basin site. Verify that no local private wells will be affected by the proposed basin.

6. Collect soil samples from the site if a wet pond is proposed. Determine soil permeability and the ability to inhibit seepage and maintain a permanent pool. Determine the soils ability to support loads and maintain its shape.

7. Determine if the selected basin location will accommodate all of the required storage volumes.

8. All open channels that will discharge to the basin must be adequately vegetated to minimize erosion.

9. Verify City's requirements concerning basin safety and long-term maintenance.

10. If the basin is used to control sediment during development, then the design pool depth and design grade shall be restored prior to installing permanent landscaping and stabilization measures.

11. The retention storage is calculated as volume provided in the basin above the existing groundwater elevation.

12. An overflow facility from the retention basin must be provided. Elevations of surrounding buildings, development, or other features that would be impacted by a basin overflow must be indicated off-site overflow. The overflow route may not endanger any existing structures or features. Downstream drainage easements are required for the off-site overflow route.

13. One (1') foot of freeboard must be provided above the proposed storage elevation.

14. See Sterling Heights Engineering Design Standards for additional design information.

D. Infiltration Facilities

Infiltration facilities such as infiltration basins, infiltration trenches, dry wells, and permeable pavements may be considered where site conditions allow. Infiltration facilities temporarily store and infiltrate the water quality volume within forty-eight (48) hours and bypass larger flows. Design guidance is provided in USEPA, 2004 (Appendix A). The following requirements apply:

1. Initial Natural Resources Conservation Service (NRCS) soil classification (from soil survey) and feasibility testing should be performed to assess the feasibility of infiltration practices and to eliminate unsuitable areas. The minimum infiltration rate for infiltration practices is 0.5 in/hr as verified by soils analysis or field infiltration testing. Soils suitable for infiltration shall have less than 40% silt/clay and less than

20% clay.

2. Two borings or test pits and infiltration testing shall demonstrate an infiltration rate of $\geq$ 0.5 in/hr at a depth of 18 inches to 10 feet depending on the depth and type of practice proposed. Soil evaluation and investigation shall be conducted by soil scientists, design engineers, professional geologists, and other qualified professionals and technicians. The stormwater designer is strongly encouraged to directly observe the testing process to obtain a first-hand understanding of site conditions.
3. When in-situ infiltration rates are between 0.24 in/hr. and 0.5 in/hr., soils are marginally suitable for infiltration BMP's, and supplemental measures are required. Supplemental measures may include subsoil amendment, or an underdrain located at the top of the storage bed layer to maximize infiltration.
4. Structural infiltration devices such as basins and, to a lesser degree, trenches may suffer high failure rates due to clogging. Therefore, an aggressive maintenance program and upstream pre-treatment measures (such as swirl concentrators, sedimentation basins and grass filter strips) for at least 25% of the water quality volume shall be incorporated into any stormwater management system that employs infiltration devices (except dry wells receiving rooftop runoff).
5. Infiltration facilities may serve the following maximum drainage areas:
   a. Basins – 10 acres
   b. Trenches and permeable pavement – 5 acres
   c. Dry wells – 5,000 ft^2
6. The bottom of infiltration facilities shall be a minimum of two (2') feet from the seasonal high water table.
7. Infiltration practices shall not be used at stormwater "hotspot" sites (See Section H.1 Stormwater Hotspot for more information).
8. Heavy equipment shall not be allowed in contact with the bottom of infiltration facilities during construction.

E. Enhanced Vegetated Swales

This group of water quality control facilities includes wet and dry conveyance swales, as well as bioretention facilities. The design of traditional grass swales can be enhanced to provide pollutant removal. The design of water quality grass channels is a rate-based design that uses Manning's equation to determine the velocity and depth based on channel slope and dimensions. The design of wet and dry swales is based on temporarily storing the water quality volume for a twenty-four (24) hour period (Claytor and Schueler, 1996 as referenced in Appendix A). All three channel designs also safely convey the 2-yr storm at non-erosive conditions and have adequate capacity for the 10-yr, 24-hr storm with at least six (6") inches of freeboard.

Bioretention areas are landscaped depressions that accept sheet flow from a grass filter strip and remove pollutants with mechanisms similar to a forested area. Design guidance is provided in USEPA, 2004 (Appendix A). All bioretention facility landscaping shall be reviewed and approved by the Sterling Heights Office of Planning

F. Media Filtering Systems

Filtering systems include sand filters, compost or peat/sand filters, and manufactured filtering devices. Filtering systems should be designed off-line to treat the water quality discharge for sites less than five (5) acres and to bypass larger flows from treatment. Pre-treatment of filtering systems must be provided. Stormwater filtering systems are recommended to treat the runoff from stormwater "hotspot" sites. Design guidance is provided in Claytor and Schueler, 1996 and USEPA, 2004 (Appendix A).

G. Sizing Criteria

It is important to recognize the difference in various components of a storm drainage system. Separate quality/quantity objectives can be met by managing various storm sizes differently with appropriate methods and criteria. Most of the historic methods of hydrologic analysis have been successfully used to control flooding from large storms. It is now possible, however, to provide drainage systems that also reduce other problems associated with stormwater runoff. A broader range of drainage objectives requires different drainage design tools, assumptions, and criteria for the study of each of the various rainfall classes.

The City's criteria address the entire frequency of rainfall events that are anticipated at developed sites. These criteria apply to all new and re-development projects that disturb one (1) acre or more, including projects less than one (1) acre that are part of a larger common plan of development or sale that would disturb one (1) acre or more. Certain stormwater management requirements may be modified by the City based on the receiving waters, the site's location within the watershed, and other site-specific factors. The City's stormwater management program is divided into four (4) management zones based on their relative rainfall frequency, as follows:

H.1 Water Quality Control
H.2 Channel Protection Volume Control
H.3 Channel Protection Rate Control-Extended Detention
H.4 Detention & Flood Control

H.1 Water Quality Control (WQC)

Water Quality Control (WQC), also commonly referred to as the First Flush volume, is required to limit post-development runoff Total Suspended Solids (TSS) concentrations to either of the following water quality standards: 80 mg/l, or 80% TSS reduction. WQC shall be implemented to the Maximum Extent Practicable (MEP) as outlined below.

The Water Quality Volume (V_{WQ}) is the runoff volume from a site, based on post-development site conditions of a 1.0-inch rainfall event. The V_{WQ} is calculated using the following equation:

$$V_{WQ}=3{,}630 \times 1.0 \times C \times A$$

where:

C is the runoff coefficient
A is the contributing area in acres
V_{WQ} is the required volume in cubic feet.

The V_{WQ} shall be managed to meet the water quality standards stated above with one, or any combination of the following BMP's:

a. Volume Reducing BMP's: See Part Section H.2 - Channel Protection Volume Control (CPVC).
b. Extended Detention: See Section Part H.3 - Channel Protection Rate Control (CPRC).
c. Mechanical Separator: Mechanical Separators shall be sized to provide treatment of the 1- year water quality peak flowrate using the following equation:

$$Q_{WQ}= C \times I_1 \times A$$

where:

C is the post-construction site runoff coefficient
$I_1 = 30.2033 \times P^{0.2203} / (Tc + 9.1747)^{0.8069}$
A is the contributing area in acres
Tc is the contributing area's time of concentration in minutes

d. Upstream tributary areas that have received CPVC are 100% credited for WQC.
e. Other (Swales, Filter Strips, etc.).

Treatment of the First Flush volume is automatically achieved if the CPVC requirements are met.

Calculating Water Quality Peak Flows

Detention basins, media filtration, infiltration, and most vegetative practices (bioretention, wet swales, dry swales, filter strips) are water volume based. However, certain water quality treatment practices use a flow rate as the design variable (a rate-based design). The water quality flow (Q_p) is the peak flow rate associated with the water quality design storm (P = 1"). The rate based design may be used for the design of the following:

a. Pre-manufactured stormwater quality treatment systems such as swirl concentrators, media filtration units, or multi-chamber treatment trains.

b. Grass-lined drainage channels (not wet or dry water quality swales which should be designed based on water quality volume).

c. Flow diversion structures for off-line stormwater treatment practices.

Stormwater Hotspots

Sites (regardless of property size) under City review that are determined to be stormwater "hotspots" may require a greater level of stormwater treatment. Stormwater filtration systems combined with pre-treatment practices may be required, at the City's discretion, to treat heavy metals, nutrients, dissolved pollutants, and total petroleum hydrocarbons. A stormwater hotspot is a land use or activity that generates higher than average concentrations of pollutants and may include, but is not limited to, the following:

a. Vehicle salvage yards and recycling facilities
b. Vehicle fueling stations
c. Vehicle service and maintenance facilities
d. Vehicle and equipment cleaning facilities
e. Fleet storage areas
f. Industrial sites (based on SIC codes)
g. Outdoor liquid container storage
h. Outdoor loading/unloading facilities
i. Public works storage areas
j. Facilities that generate or store hazardous materials
k. Commercial nursery
l. Auto dealer lots
m. Department of Transportation (DOT) storage areas
n. Other land uses and activities as determined by the City

H.2 Channel Protection Volume Control (CPVC)

Channel Protection Volume Control (CPVC) is necessary to protect natural watercourses from increased erosion and sedimentation as a result of increased imperviousness and runoff rates as development occurs. CPVC also promotes groundwater recharge and stabilizes flow rates and baseflow in our natural watercourses. The City may waive or reduce the CPVC requirements for certain developments that pose no or minimal threat to channel stability.

CPVC shall be implemented to the Maximum Extent Practicable (MEP). The Channel Protection Volume - Required ($V_{CP\text{-}R}$) is the post-development site runoff volume from a 1.20-inch rainfall event.

The following is a summary of the CPVC implementation process:

a. Implement land use practices that limit the increase in runoff volume, such as Low Impact Development (LID) practices including (but not limited to) promotion of naturalized areas (i.e. meadow or wooded areas vs. turf grass), reduced imperviousness practices, etc.

b. Calculate the Channel Protection Volume - Required (V_{CP-R}), which is the post-development site runoff volume from a 1.20-inch rainfall event using the equation:

$$V_{CP-R} = 3{,}630 \times 1.2 \times C \times A$$

where:

C is the post-development runoff coefficient
A is the contributing area in acres
V_{CP-R} is in cubic feet.

c. Provide adequate infiltration and/or storage/reuse BMPs, to the MEP, to provide the necessary CPVC. This may include (but is not limited to) bioretention, rain gardens, bioswales, pervious pavement, cisterns, green roofs, and infiltration trenches.

1) When the in-situ infiltration rate is above 0.5 in/hr., supplemental measures are not required.

2) When in-situ infiltration rates are between 0.24 in/hr. and 0.5 in/hr., soils are marginally suitable for infiltration BMP's, and supplemental measures are required. Supplemental measures may include subsoil amendment, or an underdrain located at the top of the storage bed layer to maximize infiltration.

3) When in-situ infiltration rates are less than 0.24 in/hr., infiltration is waived. When infiltration is waived, other volume reducing LID practices must be implemented to the MEP.

4) Infiltration BMP's shall completely dewater in less than 72-hours, consisting of 24-hour dewatering for the surface volume, and 48-hour dewatering of the void space (soil storage) volume. Water storage/reuse BMPs shall also be designed to fully dewater within 72-hours.

d. Pretreatment is required for all BMPs to remove fine sediment, trash, and debris to preserve the longevity and function of the BMPs.

1) Common methods of BMP pretreatment include mechanical separators, forebays, extended detention, vegetated filter strips, vegetated swales, constructed filters, and curb cuts with sediment traps.

e. To incentivize and encourage infiltration on all sites, the value of [Channel Protection Volume - Credit (V_{CP-C})] is applied towards the required 100-year detention volume (V_{100DET}). The V_{CP-C} is equal to the value [Channel Protection Volume – Provided (C_{PV-P})] with the following limitations. The value of [Channel Protection Volume - Credit] cannot exceed the value of the [Channel Protection Volume -Required ($V_{CP-C} \leq V_{CP-R}$)] for the site. The minimum allowable 100-year detention volume on a site is the extended detention volume ($V_{100DET} \geq V_{ED}$).

For underground infiltration BMP's that are not easily accessible for inspection and maintenance, such as underground detention system infiltration, this infiltration volume is not credited.

f. Infiltration BMP's are prohibited in areas containing contaminated soils/groundwater, wellhead protection areas, high groundwater (less than two (2') feet from bottom of infiltration bed to the seasonally high groundwater table) and in areas with hotspot activities and setback restrictions (foundations, property lines, drinking wells, septic fields, pavement, etc.) as defined in the standards. Design in these areas shall include the use of non-infiltrating runoff volume reducing BMP's to the MEP.

Refer to Part I of this section for CPVC and other MS4 permit required stormwater mapping and tracking requirements.

H.3 Channel Protection Rate Control-Extended Detention (CPRC)

Channel Protection Rate Control (CPRC) is necessary to protect natural watercourses from increased erosion and sedimentation as a result of increased imperviousness and runoff rates as development occurs. The CPRC shall be implemented to the Maximum Extent Practicable (MEP) as outlined below.

a. Extended Detention is required for the site's post-development runoff volume from a 1.9-inch rainfall event. This Extended Detention Volume (V_{ED}) shall be dewatered in 48-hours.

b. To calculate the required V_{ED}, which is the post-development runoff volume from a 1.9-inch rainfall event use the following equation:

$$V_{ED}=3{,}630 \times 1.9 \times C \times A$$

where:

C is the post-development runoff coefficient
A is the sites contributing area in acres
V_{ED} is the required extended detention volume in cubic feet

c. The extended detention requirement effectively maintains the 2-year pre-development peak flow rates, to the MEP, for new developments and reduces the existing 2-year peak flow rates for redevelopments.

H.4 Detention & Flood Control (DFC)

Safe conveyance of the 100-year, 24-hr storm must be provided from the site or through the detention basin with one (1') foot of freeboard. No permanent structures shall be allowed within the limits of the established 100-year floodplain for tributaries with a drainage area of two square miles or greater. No fill shall be allowed within the floodplain without an appropriate compensatory cut. The stormwater conveyance systems under the jurisdiction of the City shall have the minimum capacity of the 10-

year storm, with overflow capacity of the 100-year storm. Review of proposed projects by other local, county, state, or federal agencies may have additional capacity requirements such as at road crossings. The City may waive or reduce the Detention and Flood Control (DFC) requirements for certain developments that pose no or minimal threat to overbank flooding such as those directly discharging to enclosed drains that outlet to Lake St. Clair.

Detention and Flood Control (DFC) shall be implemented to manage the 100-year peak runoff rate for developed sites as outlined below. The allowable 100-year post-development peak flow rate (Q_{100ALL}) shall be approved by the City on a case-by-case basis and shall not exceed the lesser of the following:

a. The Variable Release Rate using the equation:

$$Q_{VRR} = 1.1055 - 0.206 \text{ Ln } (A)$$

where:

Q_{VRR} is in cfs/acre
A is the contributing site area in acres

b. The allowable release rate is based on the size of the development per the following table:

Development Size	Release Rate
2 acres or less	1.0 cfs/acre
Greater than 2 acres but less than 100 acres	$Q_{vrr} = 1.1055 - 0.206 \text{ Ln } (A)$
Greater than 100 acres	0.15 cfs/acre

c. Site-specific restricted flow rate due to downstream capacity limitations, or flooding.

d. Site approved prorated share of drain capacity. If downstream capacity is insufficient for the proposed development, the developer can make improvements that may include construction of additional off-site conveyance capacity, improvements to the existing drain, acquisition of easements from downstream property owners, etc. The developer is responsible for securing all necessary easement(s) from downstream property owners and is responsible for all improvement costs.

All stormwater discharges from the proposed development site shall outlet within the watershed where flows originated, unless approval is obtained from City. Offsite runoff shall bypass the proposed site's stormwater system. If this cannot be achieved, detailed hydrologic and hydraulic calculations shall be provided to the City to demonstrate no adverse impacts downstream for the 10-year and 100-year storms.

When calculating the required detention volume, all on-site contributing drainage areas shall be used in the calculation. Volume stored within the forebay and extended detention area may be applied towards the required detention volume. Please refer to **Appendix C** for typical detention basin profiles and stormwater design calculations. The required detention volume is based on the following:

The runoff volume from a 100-year storm using the following equation:

$$V_{100RUN} = 3{,}630 \times 5.2 \times C \times A$$

where:

C is the composite runoff coefficient for the contributing area
A is the contributing area in acres

The storage curve factor from the TR-55 modified curve using the following equation:

$$R = 0.206 - 0.15 \text{Ln} (Q_{100ALL}/Q_{100IN})$$

where:

Q_{100IN} is the 100-year post-development inflow rate

Calculate the Channel Protection Volume (V_{CP-C}). The V_{CP-C} is equal to the Channel Protection Volume-Provided (C_{PV-P}) on a site with the following limitations. The Channel Protection Volume-Credit cannot exceed the Channel Protection Volume-Required ($V_{CP-C} \leq V_{CP-R}$).

Calculate the required detention volume which is the product of the storage curve factor and the 100-year runoff volume minus the Channel Protection Volume-Credit using the equation:

$$V_{100DET} = (V_{100RUN} \times R) - V_{CP-C}$$

where:

R is the storage curve factor
$V_{100RUN} = 3{,}630 \times 5.2 \times C \times A$

The minimum allowable 100-year detention volume on a site is the extended detention volume ($V_{100DET} \geq V_{ED}$).

A forebay, mechanical separator, or BMP's are required as pretreatment for all detention and retention basins to facilitate cost effective sediment removal. Forebays are sized at 15% of the Water Quality Volume ($0.15 \times V_{WQ}$). See Part H.1 - Water Quality Control for Mechanical Separator design criteria.

A flood impact analysis may be required at the City's discretion to verify that there will be no adverse impacts on peak flow increase of the 10-yr, 24-hr, and 100-yr, 24-hr storms upstream or downstream of the property. The analysis shall be as determined by HEC-RAS or other acceptable methods. The City may require more restrictive DFC Criteria based on the flood impact analysis or where existing buildings or infrastructure are located within the 100-yr floodplain. When another authorized agency requires a model, then a copy of the approved model must be provided to the MCPWO for their records.

H. Stormwater Mapping and Tracking

The following stormwater system information shall be provided with the plans for stormwater management. Data shall be provided as part of the basis of design and also in GIS format for mapping and tracking to meet MS4 reporting requirements:

General Project Information

1. Project name
2. Project location
3. Project address & Parcel I.D. number
4. Applicant name and contact information
5. Engineer and owner name and contact information
6. Description of work and other relevant information
7. Construction plans developed in accordance with MCPWO requirements
8. Executed Stormwater Management O&M Agreement
9. Recorded Memorandum of Stormwater Management O&M Agreement

Site Area Characteristics

1. Site pre-development impervious area (ac), Runoff Coefficient C
2. Site post-development impervious area (ac), Runoff Coefficient C
3. Site pre-development pervious area (ac), SCS soil group, cover type, curve number
4. Site post-development pervious area (ac), SCS soil group, cover type and curve number

Site Stormwater Volume Characteristics

1. Site Channel Protection Volume - Required (cf)
2. Site Channel Protection Volume - Provided (cf)
3. Site Channel Protection Volume - Credited (cf)

GIS Data

A final component of the site plan review process is the submittal of a GIS shapefile containing, at a minimum, the layers listed below, which consist of points and polygons that reflect the key components of the stormwater system. This information will be provided only after the technical review is completed. The GIS shapefile must reflect the final approved design and include the following layers (use the layer naming conventions listed below for ease of storing and tracking the GIS data):

1. Development Site – Area (ac) and GIS area polygon (DSA -1, DSA-X)
    a. This area should reflect the entire area for which the stormwater system is designed.

2. Site Discharge Point(s), GIS **points** (D-1, D-2, etc.)
    a. These points should reflect the location of each site discharge point; this is typically the point of connection to a County Drain, city storm sewer, or other drainage feature downstream of the detention basin discharge structure.

3. Dry Detention Basins, GIS area (ac) **polygons** (DBASIN-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer.

4. Wet Detention Basins, GIS area (ac) **polygons** (WBASIN-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer.

5. Sediment Forebays, GIS area (ac) **polygons** (Forebay-1, etc.)
    a. The polygon should reflect the detention basin footprint up to and including the berm and any associated maintenance buffer.

6. Mechanical Separators, GIS **points** (MS-1, etc.)
    a. The points can be placed at a maintenance access point for each structure. If multiple mechanical separator units are proposed, create a point for each unit.

7. Bioretention/Bioswales – GIS area (ac), GIS **polygons** (BR-1, etc.)
    a. The polygon should reflect the bioretention/bioswale footprint including any maintenance or safety buffers.

8. Porous Pavement – GIS area (ac), GIS **polygons** (PP-1, etc.)

9. Cisterns/Rain Barrels, GIS **points** (RB-1, etc.) Inlet/catch basins with sump – GIS **points**

10. Inlet/catch basins no sump – GIS **points**

11. Manholes – GIS **points**

12. End Sections – GIS **points**

13. Main Line Stormsewer Pipe Sections – GIS **Lines**

The GIS shapefile approved during the site plan review shall also be as-built and submitted to the City for approval prior to issuance of any occupancy permits(s).

I. Inspections, Operations and Maintenance

Requirements for Inspections, Operations and Maintenance (O&M) are detailed in Part 2.5 and 2.6.

Ch. 2 Landscaping & Maintenance Standards

2.1 Purpose

The stability and effectiveness of many stormwater BMPs is dependent on well-established vegetation. Proper landscaping practices, appropriate selection of the types and species of vegetation, and adequate short-term maintenance are necessary to establish vegetation and prevent invasive plant species. Once BMPs are stabilized and functioning, periodic maintenance will be necessary to insure proper functioning condition. If a BMP does not require periodic sediment removal and maintenance, then it is not working to treat water quality.

2.2 Landscaping Requirements

A landscaping plan is required for any BMP used for stormwater credit. Incorporating regionally native plants into the design is required because these plants are better adapted to local climate and soil conditions and tend to need less long-term maintenance. The City may consider waivers from specific landscaping requirements.

Disturbed areas must be stabilized within five (5) days of final grading per Part 91, P.A. 451. Vegetative stabilization of all disturbed areas with slopes between 4:1 and 1:1 (H:V) should be completed with appropriate erosion control blankets rather than seed and mulch. Disturbed areas on flatter slopes may be stabilized with appropriate mulching or blankets. Areas exposed to channelized flow may require the use of erosion control blankets, turf reinforcement mats, stone revetment, or other measures to provide stabilization. Guidelines on the application of Rolled Erosion Control Products for permanent erosion control are provided in Appendix D.

A. Landscaping Plans should be developed to achieve a diverse mix of vegetation in riparian areas. A minimum of six (6) species should be selected from each applicable planting zone list (Appendix F, Tables F-1 to F-5).

B. Seed for plant species shall be applied at a minimum rate of 10 lb/ac in addition to the cover crop mix. A recommended minimum seeding rate for over-seeding partially vegetated areas or to supplement existing vegetation is 50% of the standard seeding rate (5 lb/ac).

C. A minimum four (4") inches of compost or relatively weed seed-free topsoil, and necessary soil amendments (as determined by soil testing) shall be tilled into compacted subsoils to a minimum depth of 8"-10" where vegetation is to be established on excavated subsoils. It is the designer's responsibility to consider specific site conditions and standard horticultural practices in the development of the Landscaping Plan.

2.3 Native Plantings

A. Swales

Swales are broad, shallow channels that primarily remove pollutants through sedimentation. Swales provide some control of runoff quantity and timing through infiltration and an increase in time of concentration. If the use of swales has been

approved by City to meet WQ Criteria or for stormwater credit, the swales should be vegetated predominantly with sod-forming grasses for cool humid regions such as:

1. Bentgrasses (*Agrostis spp.*)
2. Blue-Grasses (*Poa spp.*)
3. Fescues (*Festuca rubra and F. ovina*)
4. Perennial Ryegrass (*Lolium perenee).*

Wet Swales – Seed mixes for wet swales should also contain at least four (4) forb, grass, and/or sedge plant species (no trees or shrubs) from Table F-2 (in Appendix F).

Dry Swales – Seed mixes for dry swales should also contain at least four (4) forb, grass, and/or sedge plant species (no trees or shrubs) from Table F-3 (in Appendix F).

B. Upland Areas

Upland meadows or areas of re-forestation may be established to obtain stormwater credits. The planting materials for upland areas should coincide with Zone 5 (Table F-5 in Appendix F).

For upland areas where a 'no mow' mix of grasses is desired, a mixture of four (4) to six (6) fine fescue species should be used. Several proprietary mixes are available.

C. Prohibited Plant Species

Exotic, invasive plant species shall not be introduced within open county drains or BMPs used for stormwater credit. Invasive species can quickly take over a disturbed reach of stream and reduce adequate conveyance. For a re-vegetation project to control erosion, benefit water quality, and allow proper conveyance, invasive species must be restricted and controlled. Common species that should be prohibited and should be removed from riparian areas are outlined in Table F-6. Long-range management plans shall be provided by the proprietor for the ongoing removal of these plant species for BMPs used for stormwater credit.

2.4 Vegetation Maintenance for BMPs

The long-term maintenance plan for the development's storm water management practices and system (Appendix G) used for stormwater credit shall include provisions for establishing and maintaining vegetation. The first few years after planting are critical. The following periodic maintenance is required to establish plants through this phase:

A. While watering during the first year will be important, no supplemental watering will be required once native plantings are established. Extensive lawn irrigation may promote disease and lodging (breaking of stalks).

B. Access to newly seeded areas shall be limited with fencing, signage, or other appropriate methods.

C. Appropriate signage is required to insure preservation, reduce feeding of waterfowl, or to address safety issues.

D. The persons responsible for site maintenance shall be consulted and riparian residents should be educated regarding appropriate mowing and maintenance practices. Edging, temporary fencing, or other methods may be required to prevent mowing during the initial period of plant establishment. Permanent boundary markers and signage shall be installed to delineate the easement and identify "No Mow" or "Grow Zones" (See Appendix B). Areas in Zones 4 and 5 may be maintained annually by mowing or electrical trimming to a minimum height of 6"-8" in late fall or early spring to remove dead plant materials. More frequent trimming and mowing of riparian areas is not recommended.

E. Natural vegetation should be allowed to grow along open drains and natural streams to control erosion and provide some shading.

F. Periodically and following storm events, stabilized areas should be inspected for erosion and any rills or gullies repaired.

G. Following the first two growing seasons, determine if reinforcement plantings are needed.

H. The emergency overflow spillway, side slopes, and detention pond embankments may be trimmed once in the late fall or early spring to a minimum height of 6"-8" . Litter and debris shall be removed from the inlet and outlet structures and the general basin area at this time.

I. Excessive algae and ecologically invasive aquatic plant growth shall be removed to prevent decomposition, nutrient cycling, and associated nuisances.

2.5 Inspections

Prior to the approval of the final construction plans, the proprietor shall have made arrangements acceptable to the City 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.

2.6 Maintenance Requirements

An executed Stormwater Management Operations and Maintenance Agreement for the proposed stormwater system shall be submitted to the City prior to granting engineering site plan approval. The Stormwater Management Operations and Maintenance Agreement shall include but not limited to the following:

A. The locations of all the stormwater system components, structures and BMPs.

B. Specific maintenance requirements for the stormwater components including the required inspection cycle, personnel, training, inspection activities, and preventative maintenance required to ensure that the stormwater system functions properly.

C. The owner shall retain the services of a qualified individual, which may include a Licensed Professional Engineer, Certified Professional in Storm Water Quality (CPSWQ), NICET Certified Engineering Technologist in Stormwater and Wastewater System Inspection, or EGLE Certified Stormwater Operator (NPDES construction sites) to provide inspection and maintenance services.

D. A log of all inspections, maintenance activities and repairs are required. The log must provide, the date of activity, name of person performing activity and the description of activity performed.

E. Provisions for establishing and maintaining vegetation that is integral to the proper functioning of the stormwater system.

F. Identify the entity responsible for the maintenance and/or repair of the stormwater system, including modifying or reconstructing the system, if the system does not function as designed.

G. A schedule for implementing the activities necessary for proper functioning of the system.

H. A maintenance agreement must allow the City, including all elected and appointed officials, employees, volunteers and other individuals working on behalf of the City, the right to access, inspect, and maintain the stormwater system. The maintenance agreement shall allow the local community to complete the following:

    1. Inspect the structural or vegetative BMPs.
    2. Perform necessary maintenance or corrective actions neglected by the BMP owner.
    3. Track the transfer of the operation and maintenance responsibility of the BMP in the event ownership of the property changes.

I. A copy of the Stormwater Management Operations and Maintenance Agreement or Memorandum of Stormwater Management Operations and Maintenance Agreement shall be recorded at the Register of Deeds.

J. An example of the Agreement is included in the Appendix G.

Ch. 3 Pre-Application Meeting & Review Procedures

3.1 Pre-Application Meeting

The pre-application meeting is a recommended step (not required) for the design and construction of a site that is covered under these standards. There are no fees required for the pre-application meeting.

The purpose of the pre-application meeting is to discuss the City's standard requirements, existing site characteristics, identify existing in-situ soil conditions (which will determine whether infiltration will be required), Best Management Practices (BMPs) proposed for use on the site, long-term maintenance needs, and the capacity of the stormwater outlet. This meeting may allow for a faster, more cost-effective site design by identifying the stormwater management issues early in the design process.

The Property Owner/Applicant shall provide the following general information about the proposed development site for review during the meeting with the City.

1. Project name
2. Project location - Commonly known address(s) and Parcel I.D. number(s)
3. Applicant name and contact information
4. Engineer and owner names, including contact information
5. Description of work and other relevant information
6. ***Stormwater Design Narrative*** (separate document), consisting of the following minimum components:
    a. Summary of the proposed stormwater management system

    b. Geotechnical investigations (e.g., soil borings, infiltration tests, and/or an Environmental Site Assessment)

        1) *NOTE: the stormwater review cannot be approved without the submittal of in-situ soil characteristics and/or evidence of existing soil contamination; this information is necessary to determine whether the Channel Protection Volume Control standard will be required.*

    c. All stormwater calculations, including a list of all assumptions, site characteristics, and other information to support the calculations.

    d. If mechanical separators are to be used, attach the NJDEP certification letter including all NJDEP unit sizing and TSS removal efficiencies.

    e. Figures/schematics of the stormwater management system, including clear references to existing wetlands, floodplains, woodlands or other protected natural features.

f. Outlet hydraulic calculations, including (if requested by the City) calculations and certifications for the hydraulic capacity of the receiving system.

g. Operations & Maintenance (O&M) Plan for all proposed stormwater components (collection system, water quality treatment, infiltration, extended detention, and flood control) shall be included on the O&M Plan sheet(s).

3.2 Land Use Summary

The Land Use Summary must be completed and submitted with the Stormwater Design Narrative. This summary must also be included on the Engineering Site Plan.

Characteristic	Existing Conditions	Proposed Conditions
Total Development Area (ac)		
Impervious Area (ac)		
Total Pervious Area (ac)		
Pervious Area Breakdown by Cover Type		
Natural areas (non-cultivated)	x.xx acres	x.xx acres
Predominant NRCS Soil Type (A, B, C, or D)		
Improved areas (turf grass & landscape)	x.xx acres	x.xx acres
Predominant NRCS Soil Type (A, B, C, or D)		
Wooded Areas	x.xx acres	x.xx acres
Predominant NRCS Soil Type (A, B, C, or D)		
CPVC Volume ***Calculated*** (cubic feet)		
CPVC Volume **Provided** (cubic feet)		
CPRC Volume **Provided** (cubic feet)		

The Professional Engineer who signs and seals this site plan certifies that the values in this table reflect the City's stormwater calculations required for this development and that geotechnical investigations were performed that provide conclusive documentation that demonstrates whether infiltration (i.e., CPVC Volume Control) is practicable.

Appendix A. References

References

Annable, W., 2001, On the Design of Natural Channels: Decisions, Direction and Design, published in Natural Channel Systems conference proceedings, Niagara Fall, Canada.

Claytor, R. A. and T. R. Schueler, 1996, Design of Stormwater Filtering Systems. Huff, F.A. and J. R. Angel, 1992, Bulletin 71 – Rainfall Frequency Atlas of the Midwest (MCC Research Report 92-03).

Rosgen, D., 2006, River Assessment and Monitoring course – reference figures, Lubrecht Forest, MT.

Schueler, T. R., 1987, Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.

Stormwater Management Practices Design

Caraco, D. and Claytor, R. A., 1997, Stormwater BMP Design Supplement for Cold Climates, http://www.cwp.org/cold-climates.htm.

Center for Watershed protection (CWP), 1998, Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds.

Michigan Department of Environmental Quality, 1999, Stormwater Management Guidebook, http://www.michigan.gov/deq/0,1607,7-135-3313_3684_3725-9441--,00.html.

OCDC, Engineering Design Standards for Storm Water Facilities: Requirements, Rules and Design Criteria for Stormwater Management, 2006, http://www.oakgov.com/drain/assets/docs/Standards/engineering_design_standards_for_storm_water_fac_04_%20071.pdf

Pitt, R.and J. Voorhees, 2002, The Design and Use of Detention Facilities for Stormwater Management Using DETPOND, http://unix.eng.ua.edu/~rpitt/SLAMMDETPOND/WinDetpond/WinDETPOND%20user%20guide%20and%20documentation.pdf

USEPA, 2004, Stormwater Best Management Practice Design Guide – EPA/600/R-04/121, Vols. 1-3. http://www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121.htm.

Winogradoff, D. A., 2002, The Bioretention Manual, Prince George's County, MD, http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp.

BMP Monitoring

BMP monitoring should follow: USEPA and ASCE, 2002, Urban Stormwater BMP Performance Monitoring.

http://www.bmpdatabase.org/docs/Urban%20Stormwater%20BMP%20Performance%20Monitoring.pdf

Soil Erosion and Sediment Control Measures

- http://macdc.net/Resources/SoilErosionManual/
- Washington State, 2003, Integrated Streambank Protection Guidelines, http://wdfw.wa.gov/hab/ahg/ispgdoc.htm.
- Michigan Department of Management and Budget, SESC Guidebook, http://www.michigan.gov/dmb/0,1607,7-150-9152_32245---,00.html.

Additional Resources

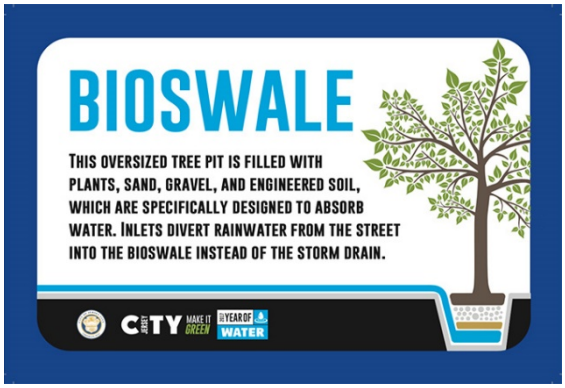
Additional resources on stormwater management practices can be found online at:

- www.lid-stormwater.net/intro/background.htm
- www.lowimpactdevelopment.org/brochures.htm
- http://cfpub.epa.gov/npdes/stormwater/m
- http://www.stormwatercenter.net/

Appendix B. Signage

Bioretention, Bioswale, and Rain Garden Signs

Bioretention, Bioswale, Rain Garden and other informational signs shall be installed at each water quality control facility as determined by the City. The proposed sign(s) shall be reviewed and approved by the City prior to installation. The sign(s) shall be made of durable metal construction and shall measure no smaller than 8" x 12" and no larger than 12" x 18". Below are some examples of possible sign options.



Appendix C. Design Reference

NOTE: Design References provided herein are listed as examples only. Please contact the City to ensure you are utilizing applicable design references and practices before incorporating into project design. Early coordination with the City is a crucial component of any site design.

It is the designer's responsibility to determine the most appropriate methods to calculate stormwater runoff volumes and flood peaks based on the best available data. Preferable approaches include statistical analysis of measure gauge station data, MDEQ's modified TR-55 Method, or the Rational Method, and computer models (PC-SWMM, HEC-1, HEC-RAS). Other models and methods should be submitted to the MCPWO for approval before finalizing designs. The methods and calculations shall be submitted to the MCPWO with the Project Plans.

Stormwater conveyance systems incorporating pumps shall not be permitted in developments with multiple owners, such as subdivisions and site condominiums unless the applicant is able to demonstrate that there is no feasible alternative.

A. Gauged Locations – Statistical Analysis

A statistical analysis of a gauging station record provides the most accurate hydrograph and discharge-probability relationship for a watercourse. Such information may be available from the Michigan Department of Environmental Quality or the U.S. Geological Survey (USGS). The available USGS gauge station data is online at: http://waterdata.usgs.gov/mi/nwis.

Peak flow information may be calculated at a gauged site may be extrapolate upstream or downstream, or to an adjacent watershed with similar drainage characteristics. The assumption that flows are a function of drainage area may not be appropriate if basin characteristics change from the gauged site. Flow duration and flood frequency curves can also be extrapolated by dividing the flows by an index flood discharge such as bankfull discharge or the mean annual flood (recurrence interval of 2.33 years). Such transfer methods may also be useful to calibrate models. Caution should be taken when extrapolating data.

B. MDEQ Method - Computing Flood Discharges for Small Ungaged Watersheds

For watersheds up to 20 square miles, the suggested method for determining surface runoff is the MDEQ modified TR-55 method spreadsheet "*Computing Flood Discharges for Small Ungaged Watersheds*" http://www.michigan.gov/deq/0,1607,7-135-3313_3684_3724-9324--,00.html (see Appendix A for Sorrell, 2003). The conveyance computations should be based on the Type II rainfall distribution, 10-year, 24-hr storm. The method will require the following information:

1. Drainage area
2. Rainfall data
3. Land use
4. Soil type
5. Time of concentration

C. Rational Method

The "Rational Method" may be used to determine surface runoff for small areas such as sizing swales, channels and culverts because the "Rational Method" assumes a uniform rainfall intensity. The limitations on the size of the drainage area can range from 20 to 200 acres depending on the complexity of the watershed. Larger sites should use a more appropriate method of determining flow.

The "Rational Method" is defined as follows:

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

Where:

Q = peak runoff (ft_3/s)
C = runoff coefficient
I = average rainfall intensity (inches/ hour) for a storm with a duration equal to the time of concentration
A = drainage area (acres)

Coefficient of Runoff

A realistic coefficient of runoff will be used based upon the imperviousness of the contributing acreage. The runoff coefficient (and calculation, if applicable) must be included with plan submittal. The following runoff coefficients may be used:

Multiple –Family (mid/high-rise), Commercial and Industrial	0.70
Multiple-Family (low-rise)	0.50
Single-Family Subdivisions / Condominiums	0.30
Golf Courses / Green spaces	0.20

Alternatively, a composite runoff coefficient is calculated as follows:

$$\overline{C} = \frac{\sum_{i=1}^{n} \left(A_i x C_i \right)}{\sum_{i=1}^{n} A_i}$$

Where:

Ci = runoff coefficient for each sub-area
n = total number of sub-areas
Ai = drainage area in acres for each sub-area

Table G-1 Minimum Acceptable Runoff Coefficients for use in Rational Methods

Surface Type	Runoff Coefficient		
Water surfaces	1.00		
Roofs	0.95		
Asphalt or concrete pavements	0.95		
Gravel, brick, or macadam surfaces	0.85		
Semi-pervious surfaces; lawns, parks, playgrounds	**Slope < 4%**	**Slope 4% - 8%**	**Slope > 8%**
Hydrologic Soil Group A	0.15	0.2	0.25
Hydrologic Soil Group B	0.25	0.3	0.35
Hydrologic Soil Group C	0.3	0.35	0.4
Hydrologic Soil Group D	0.45	0.5	0.55

Adapted from "Rules of the Washtenaw County Public Works Commissioner, Procedures for Design Criteria for Stormwater Management Systems." May 2000

From pg. 315 of *Introduction to Hydrology, Fourth Edition*, an adjustment to the C-factor is made based on the design event due to antecedent moisture conditions as follows:

Return Period (yrs)	Multiplier
2 - 10	1.00
25	1.10
50	1.20
100	1.25

Time of Concentration

An initial minimum time of concentration of 20 minutes may be used on single-family residential subdivisions or a minimum of 15 minutes for medium density residential, commercial and industrial sites. The design engineer may also use a calculated time of concentration, if desired. The methodology and computations must be submitted for review. The time of concentration for unimproved, pre-development lands will be checked using the following formulas (DEQ, 1999):

$$Tc = Length / (V \times 3600)$$

Where:

Tc = time of concentration
Length = distance from most distant point in the watershed (feet)
V = velocity (ft/sec)
3600 – converts seconds to hours

The velocity of the flood flow is determined from an empirical formula depending on the channel type:

Small tributary: $V = 2.1 \times S_{0.5}$

Waterway: $V = 1.2 \times S_{0.5}$

Sheet Flow: $V = 0.48 \times S_{0.5}$

Where, S = slope (percent)

When more than one type of flow exists, the individual flows should be summed up to find the total time of concentration.

Average Rainfall Intensity

The average rainfall intensity (I) shall be determined from Figure 2.1 for Tc > 60 min. or from the following equations:

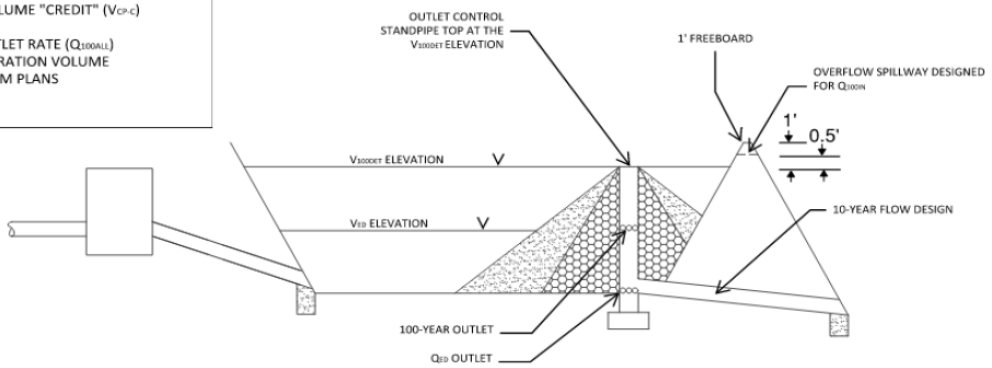
10-yr storm $I = 175/(T_c + 25)$

100-yr storm $I = 275/(T_c + 25)$

TYPICAL DETENTION BASIN WITH MECHANICAL SEPERATOR

REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

-CHANNEL PROTECTION VOLUME "CREDIT" (V_{CP-C})
-INFILTRATION RATES
-100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})
-MEP FOR ACHIEVED INFILTRATION VOLUME
-STORMWATER SYSTEM O&M PLANS



MECHANICAL SEPARATOR

REQUIRED WATER QUALITY TREATMENT IS 80 MG/L TSS, OR 80% TSS REMOVAL

SIZED BASED ON THE 1-YEAR WATER QUALITY PEAK FLOW RATE (Q_{WQ})

Q_{WQ}= (C)(A)(97/(Tc+30)

REPLACES FOREBAY REQUIREMENT

INSTALLED OFFLINE AND UPSTREAM OF ANY DETENTION OR RETENTION BASIN

NOTES:
-MUST BE NJDEP CERTIFIED
-EXCLUDES UPSTREAM CONTRIBUTING AREA'S WHERE 1-INCH WATER QUALITY CONTROL IS PROVIDED THROUGH OTHER BMP'S

EXTENDED DETENTION VOLUME (V_{ED})

EXTENDED DETENTION CONTROLS THE 2-YEAR BANK FULL RELEASE RATE BY DEWATERING THE V_{ED} OVER 48-HOURS

V_{ED}= (3,630)(C)(A)(P)
P_{ED}= 1.9

EXTENDED DETENTION OUTLET RATE

$Q_{ED}=(V_{ED})/(172,800)$

$H_{ED}=(V_{ED})/((4,800)(h)^{(1/2)})$

H_{ED}= NUMBER OF 1-INCH DEWATERING HOLES
h=TOTAL HEAD ON THE ORIFICES
NOTE: THIS EQUATION CONSIDERS THE AVERAGE HEAD TO BE 0.4 TIMES THE TOTAL HEAD

100-YEAR POST-CONSTRUCTION INLET RATE (Q_{100IN})

Q_{100IN}=(C)(A)(265/(TC+30))

100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})

THE ALLOWABLE 100-YEAR OUTLET RATE IS THE LESSER OF:

CITY RESTRICTED RATE FOR THE DRAIN (Q_R)
-PRO-RATED SHARE OF THE DRAINS CAPACITY (Q_P)
OR
-THE VARIABLE RELEASE RATE (Q_{VRR})

Q_{VRR}=1.1055 - 0.207LN(A)

100-YEAR DETENTION VOLUME (V_{100DET})

R=0.206-(0.15)(LN(Q_{100ALL}/Q_{100IN}))

R=STORAGE CURVE FACTOR

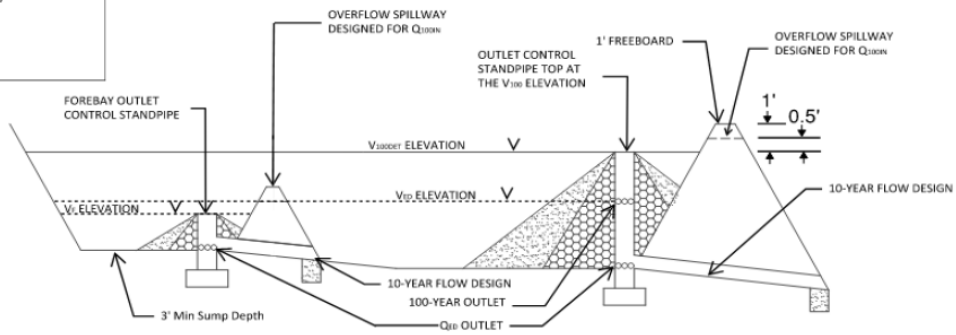
V_{100IN}=(3,630)(C)(A)(P)
P_{100} =5.23

$V_{100DET}=(V_{100IN})(R)-V_{CP-C}$

TYPICAL DETENTION BASIN WITH FOREBAY

REQUIRED PROFESSIONAL ENGINEER CERTIFICATIONS

-CHANNEL PROTECTION VOLUME "CREDIT" (V_{CP-C})
-INFILTRATION RATES
-100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})
-MEP FOR ACHIEVED INFILTRATION VOLUME
-STORMWATER SYSTEM O&M PLANS



FOREBAY VOLUME (V_F)

A FOREBAY FOR ALL INLETS SHALL CAPTURE SILT, SAND, TRASH AND DEBRIS FOR REMOVAL. THEY ARE SIZED AT 15% OF THE WATER QUALITY VOLUME (V_{WQ})

V_F =(3630)(C)(A)(P)
P_F =0.15

V_F IS A MINIMUM OF V_{WQ} WHEN DOWNSTREAM INFILTRATION IS PROPOSED

FOREBAY OUTLET SIZE

THE FOREBAY OUTLET SIZE IS THE SAME AS THE EXTENDED DETENTION OUTLET SIZE

NOTE: ALTERNATIVE FOREBAY OUTLETS REQUIRE PRE-APPROVAL FROM THE OCWRC

EXTENDED DETENTION VOLUME (V_{ED})

EXTENDED DETENTION CONTROLS THE 2-YEAR BANK FULL RELEASE RATE BY DEWATERING THE V_{ED} OVER 48-HOURS

V_{ED}= (3630)(C)(A)(P)
P_{ED} =1.9

EXTENDED DETENTION OUTLET RATE

$Q_{ED}=(V_{ED})/(172,800)$

$H_{ED}=(V_{ED})/((4,800)(h)^{(1/2)})$

H_{ED}= NUMBER OF 1-INCH DEWATERING HOLES
h=TOTAL HEAD ON THE ORIFICES
NOTE: THIS EQUATION CONSIDERS THE AVERAGE HEAD TO BE 0.4 TIMES THE TOTAL HEAD

100-YEAR POST-CONSTRUCTION INLET RATE (Q_{100IN})

Q_{100IN}=(C)(A)(265/(TC+30))

100-YEAR ALLOWABLE OUTLET RATE (Q_{100ALL})

THE ALLOWABLE 100-YEAR OUTLET RATE, IN CFS, IS THE LESSER OF:

- CITY RESTRICTED RATE FOR THE DRAIN (Q_R)
-PRO-RATED SHARE OF THE DRAINS CAPACITY (Q_P)
OR
-THE VARIABLE RELEASE RATE (Q_{VRR})

Q_{VRR}=1.1055 - 0.207LN(A)

100-YEAR DETENTION VOLUME (V_{100DET})

R=0.206-(0.15)(LN(Q_{100ALL}/Q_{100IN}))

R=STORAGE CURVE FACTOR

V_{100IN}=(3,630)(C)(A)(p)
P_{100} = 5.23

$V_{100DET}=(V_{100IN})(R)-V_{CP-C}$

Appendix D. Application Guidelines for Rolled Erosion Control Products

NOTE: Guidelines on rolled erosion control products are provided to promote the use of appropriate materials to stabilize slopes and channel stabilization applications. It is the designer's responsibility to select the appropriate materials based on local soil conditions and other site specific variables. The City accepts no responsibility for the misapplication of the guidelines contained herein.

Guidelines on rolled erosion control products are provided to promote the use of appropriate materials to stabilize slopes and channel stabilization applications. It is the designer's responsibility to select the appropriate materials based on local soil conditions and other site specific variables. The City accepts no responsibility for the misapplication of the guidelines contained herein.

The following guidelines are excerpt with permission from the Erosion Control Technology Council (ECTC) Standard Specification for Rolled Erosion Control Products (RECPs). The following guidelines apply to work which consists of constructing temporary and permanent installations to control erosion, enhance vegetation establishment, establishment, and survivability on slopes, channels, and includes installing RECPs. Rolled Erosion Control Products (RECPs) are defined by ECTC as a temporary degradable or long-term non-degradable material manufactured or fabricated into rolls designed to reduce soil erosion and assist in the growth, establishment and protection of vegetation. RECPs are designated as follows:

1. **Mulch control netting.** A planar woven natural fiber or extruded geosynthetic mesh used as a temporary degradable rolled erosion control product to anchor loose fiber mulches.

2. **Open weave textile.** A temporary degradable rolled erosion control product composed of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment.

3. **Erosion control blanket.** A temporary degradable rolled erosion control product composed of processed natural or polymer fibers mechanically, structurally or chemically bound together to form a continuous matrix to provide erosion control and facilitate vegetation establishment.

4. **Turf reinforcement mat.** A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.

Temporary Rolled Erosion Control Products

For applications where natural vegetation alone will provide sufficient permanent erosion protection, furnish a temporary rolled erosion control product with the necessary longevity and performance properties to effectively control erosion and assist in the establishment of vegetation under the anticipated immediate site conditions. The temporary rolled erosion control product shall conform to one of the following specifications and corresponding properties found in Table D-1A to D-1C.

Permanent Rolled Erosion Control Products

For applications where natural vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection, furnish a permanent rolled erosion control product with the necessary performance properties to effectively control erosion and reinforce vegetation under the expected long-term site conditions. The permanent erosion control product shall conform to one of the specifications and corresponding properties found in Table D-2.

The Erosion Control Technology Council (ECTC) is a non-profit organization. Its mission is to develop performance standards, uniform testing procedures, and guidance on the application and installation of rolled erosion control products (RECPs). The ECTC promotes the use of erosion control mats and blankets through industry leadership and education in the hope of making a broad contribution to the science of erosion control and environmental preservation. More information about ECTC can be obtained from their website http://www.ectc.org.

Table D-1A ECTC Standard Specification for Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide permanent erosion protection.

ULTRA SHORT-TERM - Typical 3 month functional longevity						
			Slope Applications*		Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	C Factor 2,5	Max. Shear Stress 3,4,6	Minimum Tensile Strength 1
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	5 lbs/ft (0.073 kN/m)
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	4:1 (H:V)	0.10 @ 4:1	0.5 lbs/ft^2 (24 Pa)	5 lbs/ft (0.073 kN/m)

1.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	0.15 @ 3:1	1.5 lbs/ft^2 (72 Pa)	50 lbs/ft (0.73 kN/m)
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	0.20 @ 2:1	1.75 lbs/ft^2 (84 Pa)	75 lbs/ft (1.09 kN/m)

* "C" factor and shear stress for Types 1.A., 2.A. and 3.A mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material.
1 Minimum Average Roll Values, Machine direction using ECTC Mod. ASTM D 5035.
2 "C" Factor calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions using Erosion Control Technology Council (ECTC) Test Method # 2.
3 Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #3.
4 The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 - 0.05.
5 Acceptable large-scale test methods may include ASTM D 6459, Erosion Control Technology Council (ECTC) Test Method # 2, or other independent testing deemed acceptable by the engineer.
6 Per the engineer's discretion. Recommended acceptable large-scale testing protocol may include ASTM D 6460, Erosion Control Technology Council (ECTC) Test Method #3 or other independent testing deemed acceptable by the engineer.

Table D-1B ECTC Standard Specification for Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide permanent erosion protection.

SHORT-TERM - Typical 12 month functional longevity						
			Slope Applications*		Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	C Factor 2,5	Max. Shear Stress 3,4,6	`Minimum Tensile Strength1
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	5 lbs/ft (0.073 kN/m)
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	4:1 (H:V)	0.10 @ 4:1	0.5 lbs/ft^2 (24 Pa)	5 lbs/ft (0.073 kN/m)
2.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	0.15 @ 3:1	1.5 lbs/ft^2 (72 Pa)	50 lbs/ft (0.73 kN/m)
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	0.20 @ 2:1	1.75 lbs/ft^2 (84 Pa)	75 lbs/ft (1.09 kN/m)

Table D-1C ECTC Standard Specification for Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide permanent erosion protection.

EXTENDED-TERM - Typical 24 month functional longevity						
			Slope Applications*		Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	C Factor 2,5	Max. Shear Stress 3,4,6	Minimum Tensile Strength1
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	5:1 (H:V)	0.10 @ 5:1	0.25 lbs/ft^2 (12 Pa)	25 lbs/ft (0.36 kN/m)
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5:1 (H:V)	0.25 @ 1.5:1	2.00 lbs/ft^2 (96 Pa)	100 lbs/ft (1.45 kN/m)
4	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1:1 (H:V)	0.25 @ 1:1	2.25 lbs/ft^2 (108 Pa)	125 lbs/ft (1.82 kN/m)

Table D-2 ECTC Standard Specification for Permanent Rolled Erosion Control Products

For applications where vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection.

PERMANENT1 - All categories of TRMs must have a minimum thickness of 0.25 inches (6.35 mm) per ASTM D 6525 and U.V. stability of 80% per ASTM D 4355 (500 hours exposure).					
			Slope Applications*	Channel Applications*	
Type	Product Description	Material Composition	Maximum Gradient	Maximum Shear Stress 4,5	Minimum Tensile Strength 2,3
5.A	Turf Reinforcement Mat	Turf Reinforcement Mat (TRM) – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three- dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	5:1 (H:V)	6.0 lbs/ft2 (288 Pa)	125 lbs/ft (1.82 kN/m)
5.B	Turf Reinforcement Mat		5:1 (H:V)	8.0 lbs/ft2 (384 Pa)	150 lbs/ft (2.19 kN/m)
5.C	Turf Reinforcement Mat		5:1 (H:V)	10.0 lbs/ft2 (480 Pa)	175 lbs/ft (2.55 kN/m)

1 For TRMs containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.

2 Minimum Average Roll Values, machine direction only for tensile strength determination using ASTM D 6818 (Supersedes Mod. ASTM D 5035 for RECPs).
3 Field conditions with high loading and/or high survivability requirements may warrant the use of a TRM with a tensile strength of 44 kN/m (3,000 lb/ft) or greater.
4 Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during a 30-minute flow event in large scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #3.
5 Acceptable large-scale testing protocol may include ASTM D 6460, Erosion Control Technology Council (ECTC) Test Method #3, or other independent testing deemed acceptable by the engineer.

Installation of Rolled Erosion Control Products (RECPs)

For the proper installation of RECPs follow: "*Installation Guide for Rolled Erosion Control Products (RECPs) Including Mulch Control Nettings (MCNs), Open Weave Textiles (OWTs), Erosion Control Blankets (ECBs), and Turf Reinforcement Mats (TRMs)",* available on the ECTC website at http://www.ectc.org/specifications.asp#table1.

ECTC also provides a visual educational tool, the *"RECP Installation DVD"* which gives step-by-step instruction on correct installation procedures. It includes information on site preparation; RECP placement; RECP stapling/staking; anchor trench details; and shingling of RECPs. Each of the three installation sections—slope, shoreline, and channel—is approximately eight minutes in length and is ideal for first-time installers or seasoned professionals. Available on DVD by request or by download on the ECTC website at http://www.ectc.org/DVD.asp.

Appendix E. Hydrologic Soils Group in Macomb County

Table E-1: Hydrologic Soils Groups and Soil Erosivity 'K'

Name	MUSYM	HSG	K Factor
Au Gres sand	AsB	B	0.15
Au Gres sand, loamy substratum	AuB	B	0.15
Blount L	BlA	C	0.43
Blount L	BlB	C	0.43
Boyer LS, 0-2% slopes	BrA	B	0.17
Boyer LS, 2-6% slopes	BrB	B	0.17
Boyer LS, 6-12% slopes	BrC	B	0.17
Boyer SL, 0-2% slopes	BsA	B	0.24
Boyer SL, 2-6% slopes	BsB	B	0.24
Boyer SL, 6-12% slopes	BsC	B	0.24
Boyer SL, 12-18% slopes	BsD	B	0.24
Boyer SL, 18-25% slopes	BsE	B	0.24
Boyer gravelly LS	BvB	B	0.10
Brevort-Selfridge complex	Bx	B	0.17
Celina loam, 0-2% slopes	CeA	C	N/A
Celina loam, 2-6% slopes	CeB	C	N/A
Ceresco fine SL	Cf	B	0.20
Cohoctah fine SL	Cm	D/B	0.24
Conover loam, 0-2% slopes	CvA	C	0.28
Conover loam, 2-6% slopes	CvB	C	0.28
Corunna SL	Cx	D	0.20
Del Ray loam, 0-2% slopes	DlA	C	0.43
Del Ray loam, 2-6% slopes	DlB	C	0.43
Del Ray-Metamora SL, 0-2% slopes	DmA	C	N/A
Del Ray-Metamora SL, 2-6% slopes	DmB	C	N/A
Dryden SL, 0-2% slopes	DrA	B	0.24
Dryden SL, 2-6% slopes	DrB	B	0.24
Edwards muck	Ed	D/B	N/A
Ensley-Parkhill complex	Ep	D/B	N/A
Fulton SL	FtA	D	0.24
Fulton L	FlA	D	0.43
Gilford SL	Gd	D/B	0.20
Gilford SL, silty subsoil	Gf	D/B	0.20
Granby LFS	Gm	D/A	0.17
Hoytville CL	Hy	D/C	0.24
Lamson FSL	La	D/B	0.28

Table E-1: Hydrologic Soils Groups and Soil Erosivity 'K'

Name	MUSYM	HSG	K Factor
Lapeer, SL, 2-6% slopes	LeB	B	0.24
Lapeer, SL, 6-12% slopes	LeC	B	0.24
Lapeer, SL, 12-18% slopes	LeD	B	0.24
Lapeer, SL, 18-25% slopes	LeE	B	0.24
Lenawee CL	Lh	D/B	0.24
Leawee-Selfridge complex	Lk	B	N/A
Linwood muck	Lm	D/A	N/A
Locke SL, 0-2% slopes	LoA	B	0.20
Locke SL, 0-2% slopes	LoB	B	0.20
Locke very cobbly SL	LoC	B	N/A
Lupton muck	Lu	D/A	N/A
Made land	Md	B	0.21
Metamora fine SL	MeA	B	0.20
Metamora fine SL	MeB	B	0.20
Metea sand, 0-2% slopes	MnA	B	0.15
Metea sand, 2-6% slopes	MnB	B	0.15
Miami L, 2-6% slopes	MoB	B	0.37
Miami L, 6-12% slopes	MoC	B	0.37
Miami L, 12-18% slopes	MoD	B	0.37
Miami L, 18-25% slopes	MoE	B	0.37
Minoa FSL	MsB	C	0.28
Nappanee L	NaA	D	0.37
Nappanee CL, 0-2% slopes	NaB	D	0.37
Nappanee CL, 2-6% slopes	NaC	D	0.37
Oakville FS	OaB	A	0.15
Oakville FS, loamy substratum	OkB	A	0.15
Parkhill L	Pa	D	0.24
Paulding C	Pc	D	0.28
Sanitary land fill	Sa	N/A	N/A
Saranac CL	Sc	D/C	0.24
Selfridge FS, 0-2% slopes	SdA	B	0.15
Selfridge FS, 2-6% slopes	SdB	B	0.15
Selfridge-Lamson complex	SeA	B	N/A
Selfridge-Lenawee complex	SfB	B	N/A
Shoals L	Sh	C	0.37
Sims CL	Sl	D	0.24
Sisson FSL, 2-6% slopes	SmB	B	0.24
Sisson FSL, 6-12% slopes	SmC	B	0.24
Sloan L	Sn	D/B	0.28

Table E-1: Hydrologic Soils Groups and Soil Erosivity 'K'

Name	MUSYM	HSG	K Factor
Spinks LS, 0-2% slopes	SpA	A	0.15
Spinks LS, 2-6% slopes	SpB	A	0.15
Spinks LS, 6-12% slopes	SpC	A	0.15
Tawas muck	Ta	D/A	N/A
Toledo SICL	Ts	D	0.28
Toledo C	Tt	D	0.28
Urban land	Ur	N/A	N/A
Wasepi LS, 0-2% slopes	WsA	B	0.17
Wasepi LS, 2-6% slopes	WsB	B	0.17
Wasepi SL	WtA	B	0.20
Wasepi SL, silty subsoil	WtB	B	0.20
Wasepi-Au Gres complex	WvB	B	N/A
Willette muck	Wx	D/A	N/A

Appendix F. Plant Lists

Table F-1 Species List for Planting Zone 1 (Adapted from Shaw & Smidt, 2003)

Zone 1 Submergent zone	3-6 feet of water
Scientific Name	Common Name
Forbs and Ferns	
Brasenia schreberi	Water shield
Ceratophyllum demersum	Coontail
Elodea Canadensis	Elodea
Lemna trisulca	Lesser duckweed
Myriophyllum exalbesieus	Water milfoil
Nelumbo lutea	Lotus (Threatened in Michigan)
Nuphar lutea	Yellow water-lily
Nymphaea odorata	White water-lily
Potamogeton illinoensis	Illinois pondweed
Potamogeton natans	Floating-leaved pondweed
Potamogeton pectinatus	Sago pondweed
Ranunculus flabellaris	Yellow water crowfoot
Spirodela polyrrhiza	Giant duckweed
Urticularia vulgaris	Bladderwort
Vallisneria americana	Wild celery
Woffia columbiana	Watermeal

Table F-2 Species List for Planting Zone 2

Zone 2 Emergent zone	0-18 inches of water
Scientific Name	Common Name
Trees and Shrubs	
Cephalanthus occidentalis	Buttonbush
Ilex verticillata	Winterberry
Physocarpus opulifolius	Ninebark
Forbs and Ferns	
Acorus calamus	Sweet flag
Alisma trivale	Water plantain
Caltha palustris	Marsh marigold
Polygonum amphibium	Water smartweed
Pontederia cordata	Pickerelweed
Sagittaria latifolia	Broadleaved arrowhead
Sparganium eurycarpum	Giant burreed
Grasses, Sedges and Rushes	
Carex aquatilis	Water sedge
Carex lacustris	Lake sedge

Table F-2 Species List for Planting Zone 2 (Continued)

Carex stricta	Tussock sedge
Juncus balticus	Baltic rush
Juncus effuses	Soft rush
Scirpus acutus	Hardstem bulrush
Scirpus fluviatilis	River bulrush
Scirpus pungens	Three-square bulrush
Scirpus validus	Soft-stem bulrush

Table F-3 Species List for Planting Zone 3

Zone 3 Wet meadow zone	**Permanent moisture**
Scientific Name	**Common Name**
Trees and Shrubs	
Amorpha fruticosa	Indigo bush
Salix nigra	Black willow
Sambucus pubens	Red-berried elder
Forbs and Ferns	
Anemone canadensis	Canada anemone
Angelica atropurpurea	Angelica
Asclepias incarnate	Marsh milkweed
Aster lanceolatus (simplex)	Panicle aster
Aster novae-angliae	New England aster
Aster puniceus (A. luncidulus)	Swamp aster
Bidens cernua	Beggarsticks
Boltonia asteroids	Boltonia
Chelone glabra	Turtlehead
Eryngium yuccifolium	Rattlesnake master (Threatened in Michigan)
Eupatorium maculatum	Joe-pye-weed
Eupatorium perfoliatum	Bonset
Euthanmia graminifolia	Grass-leaved goldenrod
Gentiana andrewsii	Bottle gentian
Helenium autumnale	Sneezeweed
Impatiens capensis	Jewelweed
Iris versicolor	Blueflag
Liatris spicata	Marsh (Dense) blazingstar
Lilium superbum	Turk's-cap lily
Lobelia cardinalis	Cardinal flower
Lobelia siphilitica	Blue lobelia
Lysimachia thrysiflora	Tufted loosestrife
Onoclea sensibilis	Sensitive fern

Table F-3 Species List for Planting Zone 3 (Continued)

Osmunda regalis	Royal fern
Physostegia virginiana	Obedient plant
Potentilla palustris	Marsh cinquefoil
Pycnanthemum virginianum	Mountain mint
Scutterlaria lateriflora	Mad-dog skullcap
Silphium perfoliatum	Cup plant (Threatened in Michigan)
Thalictrum dasycarpum	Tall meadowrue
Verbena hastata	Blue vervain
Vernonia missurica	Ironweed
Veronicastrum virginicum	Culver's root
Grasses, Sedges and Rushes	
Andropogon gerardii	Big bluestem
Bromus ciliatus	Fringed brome
Calamagrostis canadensis	Canada blue-joint grass
Carex bebbii	Bebb's sedge
Carex comosa	Bristly (Cosmos) sedge
Carex crinita	Fringed sedge
Carex hystericina	Porcupine sedge
Carex lacustris	Lake Bank sedge
Carex languinosa	Wooly sedge
Carex lasiocarpa	Wooly needle sedge
Carex retrorsa	Retrorse sedge
Carex stipata	Awl-fruited sedge
Carex vulpinoidea	Fox sedge
Eleocharis obtusa	Blunt spikerush
Elymus canadensis	Canada Wild Rye
Elymus riparius	River Bank Wild Rye
Elymus virginicus	Virginia Wild Rye
Equisetum fluviatile	Horsetail
Glyceria grandis	Giant manna grass
Glyceria striata	Fowl manna grass
Juncus balticus	Baltic rush
Juncus effusus	Soft rush
Juncus torreyi	Torrey rush
Leersia oryzoides	Rice-cut grass
Panicum virgatum	Switchgrass
Scirpus atrovirens	Green bulrush
Scirpus cyperinus	Woolgrass
Scirpus fluviatilis(Schoenoplectus f.)	River bulrush

Table F-3 Species List for Planting Zone 3 (Continued)

Scirpus americanus (Schoenoplectus pungens)	Three-square bulrush
Scirpus validus(Schoenoplectus tabernaemontani)	Soft-stem bulrush
Spartina pectinata	Prairie cord grass

Table F-4 Species List for Planting Zone 4

Zone 4 Floodplain zone	**Flooded during snowmelt and large storms**
Scientific Name	**Common Name**
Trees and Shrubs	
Acer saccharinum	Silver maple
Alnus incana	Speckled alder
Aronia melanocarpa	Black chokeberry
Betula nigra	River birch
Celtis occidentalis	Hackberry
Cephalanthus occidentalis	Buttonbush
Cornus amomum	Silky dogwood
Cornus sericea	Red-osier dogwood
Physocarpus opulifolius	Ninebark
Populus deltoids	Eastern cottonwood
Quercus bicolor	Swamp white oak
Salix discolor	Pussy willow
Salix exigua	Sandbar willow
Salix nigra	Black willow
Sambucus pubens	Red-berried elder
Spiraea alba	Meadowsweet
Viburnum lentago	Nannyberry
Viburnum trilobum	High bush cranberry
Forbs and Ferns	
Anemone Canadensis	Canada anemone
Aster puniceus (A. luncidulus)	Swamp aster
Boltonia asteroides	False aster
Impatiens capensis	Jewelweed
Lobelia cardinalis	Cardinal flower
Lobelia siphilitica	Blue lobelia
Lysimachia thrysiflora	Tufted loosestrife
Physostegia virginiana	Obedient plant
Potentilla palustris	Marsh cinquefoil
Scutterlaria lateriflora	Mad-dog skullcap
Silphium perfoliatum	Cup plant (Threatened in Michigan)

Table F-4 Species List for Planting Zone 4 (Continued)

Symplocarpus foetidus	Skunk cabbage
Vernonia missurica	Ironweed
Grasses, Sedges and Rushes	
Carex comosa	Bristly (Cosmos) Sedge
Elymus virginicus	Virginia wild rye
Elymus canadensis	Canada Wild Rye
Elymus riparius	River Bank Wild Rye
Leersia oryzoides	Rice-cut grass
Panicum virgatum	Switchgrass
Scirpus atrovirens	Green bulrush
Spartina pectinata	Prairie cord grass

Table F-5 Species List for Planting Zone 5

Zone 5 Upland zone	**Seldom or never inundated**
Scientific Name	**Common Name**
Trees and Shrubs	
Cornus racemosa	Gray dogwood
Populus tremuloides	Quaking aspen
Quercus bicolor	Swamp white oak
Viburnum lentago	Nannyberry
Viburnum trilobum	American cranberry
Forbs and Ferns	
Agastache scrophulariaefolia	Giant hyssop
Allium stellatum	Prairie wild onion
Arisaema triphyllum	Jack-in-the-pulpit
Artemisia ludoviciana	Prairie sage
Asclepias tuberosa	Butterfly milkweed
Aster laevis	Smooth aster
Aster lanceolatus (simplex)	Panicled aster
Aster macrophyllus	Bigleaf aster
Aster pilosus	Frost aster
Athyrium filix-femina	Lady fern
Boltonia asteroids	False aster
Epilobium angustifolium	Fireweed
Galium boreale	Northern bedstraw
Helianthus grosseserratus	Sawtooth sunflower
Heuchera richardsonii	Prairie alumroot
Monarda fistulosa	Wild bergamot
Onoclea sensibilis	Sensitive fern
Potentilla palustris	Marsh cinquefoil

Table F-5 Species List for Planting Zone 5 (Continued)

Pteridium aquilinum	Bracken fern
Pycnanthemum virginianum	Mountain mint
Ratibida pinnata	Yellow coneflower
Rudbeckia subtomentosa	Brown-eyed Susan (Threatened in Michigan)
Smilacina racemosa	False Solomon's seal
Solidago flexicaulis	Zig-zag goldenrod
Solidago riddellii	Riddell's goldenrod
Solidago rigida	Stiff goldenrod
Tradescantia ohiensis	Ohio spiderwort
Veronicastrum virginicum	Culver's root
Zizia aurea	Golden alexanders
Grasses, Sedges and Rushes	
Andropogon gerardii	Big bluestem
Panicum virgatum	Switchgrass
Schizachyrium scoparium	Little bluestem
Sorghastrum nutans	Indian grass

Table F-6 Prohibited Invasive Species List

Scientific Name	Common Name	National Wetland Category	Type
Acer ginnala	Amur maple	Upland	Tree
Acer platanoides	Norway maple	Upland	Tree
Agropyron repens	Quake grass	Facultative Upland	Grass
Alliaria petiolata	Garlic mustard	Facultative	Forb
Alnus glutinosa	Black alder	Facultative Wetland	Tree
Arctium minus	Common burdock	Upland	Forb
Berberis thunbergii	Japanese barberry	Facultative Upland (-)	Shrub
Berberis vulgaris	Common barberry	Facultative Upland	Shrub
Bromus inermis	Hungarian brome, smooth brome	Upland	Grass
Celastrus orbiculatus	Oriental bittersweet	Upland	Vine
Centaurea maculosa	Spotted knapweed	Upland	Forb
Cirsium arvense	Canada thistle	Facultative Upland	Forb
Cirsium vulgare	Bull thistle	Facultative Upland (-)	Forb
Convolvulus arvensis	Field-bindweed	Upland	Forb
Coronilla varia	Crown vetch	Upland	Forb
Cotoneaster microphyllus	Cotoneaster	Upland	Shrub
Ctonoeaster pannosus	Cotoneaster	Upland	Shrub
Cotoneatser lacteus	Cotoneaster	Upland	Shrub
Dipsacus laciniatus	Cut-leaved teasel	Upland	Forb
Elaeagnus umbellata	Autumn olive	Facultative Upland	Shrub

Table F-6 Prohibited Invasive Species List (Continued)

Euonymus alata	Burningbush	Upland	Shrub
Euonymus fortunei	Wintercreaper	Upland	Vine
Euphorbia esula	Leafy spurge	Upland	Forb
Fallopia japonica	Japanese knotweed	Upland	Forb
Festuca pratensis (elatior)	Meadow fescue	Facultative Upland (-)	Grass
Hendra helix	English ivy	Upland	Vine
Hesperis matronalis	Dame's rocket	Upland	Forb
Ligustrum obtusifolium	Border privet	Upland	Shrub
Ligustrum vulgare	Common privet	Facultative (-)	Shrub
Lonicera japonica	Japanese honeysuckle	Facultative Upland	Vine
Lonicera maackii	Maack's or amur honeysuckle	Upland	Shrub
Lonicera morrowi	Morrow's honeysuckle	Upland	Shrub
Lonicera tatarica	Smooth tartarian honeysuckle	Facultative Upland	Shrub
Lonicera x bella	Showy bush honeysuckle	Upland	Shrub
Lythrum salicaria	Purple loosestrife	Obligate Wetland	Forb
Melilotus alba	White sweet clover	Facultative Upland	Forb
Melilotus officinalis	Yellow sweet clover	Facultative Upland	Forb
Miscanthus sinensis	Chinese silver grass	Upland	Grass
Myriophyllum spicatum	Eurasian water milfoil	Obligate Wetland	Forb
Pachysandra terminalis	Pachysandra	Upland	Forb
Pastinaca sativa	Wild parsnip	Upland	Forb
Phalaris arundinacea	Reed canary grass	Facultative Wetland (+)	Grass
Phalaris canariensis	Canary grass	Facultative Upland	Grass
Phragmites australis	Reed	Facultative Wetland (+)	Grass
Polygonum cuspidatum	Japanese knotweed	Facultative Upland	Forb
Polygonum sachalinense	Giant knotweed, japanese bamboo	Upland	Forb
Rhamnus cathartica	Common/european buckthorn	Facultative Upland	Tree
Rhamnus frangula	Glossy buckthorn, tallhedge	Facultative (+)	Shrub
Rhamnus utilis	Buckthorn	Upland	Shrub
Rosa multiflora	Multiflora rose	Facultative Upland	Shrub
Rumex crispus	Curly or sour dock	Facultative (+)	Forb
Spiraea japonica	Japanese spiraea	Upland	Shrub
Taxux cuspidata	Japanese yew	Upland	Shrub
Typha angustifolia	Narrow leaf cattail	Obligate Wetland	Forb
Typha x glauca	Hybrid cattail	Obligate Wetland	Forb
Ulmus pumila	Siberian elm	Upland	Tree

Appendix G. Agreement for Maintenance of Stormwater Management Practices.

AGREEMENT FOR MAINTENANCE OF STORMWATER MANAGEMENT PRACTICES

[Owners Name], as "Owner(s)" of the property described below, in accordance with _____ (City's Regulations), agrees to install and maintain stormwater management practice(s) on the subject property in accordance with approved plans and conditions. The Owner further agrees to the terms stated in this document to ensure that the stormwater management practice(s) continues serving the intended function in perpetuity. This Agreement includes the following exhibits:

Exhibit A: Legal description of the real estate for which this Agreement applies ("Property").
Exhibit B: Location map(s) showing a location of the Property and an accurate location of each stormwater management practice affected by this Agreement.
Exhibit C: Long-term Maintenance Plan that prescribes those activities that must be carried out to maintain compliance with this Agreement.

Note: After construction has been verified and accepted by the City for the stormwater management practices, an addendum(s) to this agreement shall be recorded by the Owner showing design and construction details and provide copies of the recorded document to the City. The addendum may contain several additional exhibits.

Through this Agreement, the Owner(s) hereby subjects the Property to the following covenants, conditions, and restrictions:

1. The Owner(s), at its expense, shall secure from any affected owners of land all easements and releases of rights-of-way necessary for utilization of the stormwater practices identified in Exhibit B and shall record them with the Macomb County Register of Deeds. These easements and releases of rights-of-way shall not be altered, amended, vacated, released or abandoned without prior written approval of the City.

2. The Owner(s) shall be solely responsible for the installation, maintenance and repair of the stormwater management practices, drainage easements and associated landscaping midentified in Exhibit B in accordance with the Maintenance Plan (Exhibit C).

3. No alterations or changes to the stormwater management practice(s) identified in Exhibit B shall be permitted unless they are deemed to comply with this Agreement and are approved in writing by the City.

4. The Owner(s) shall retain the services of a qualified inspector (as described in Exhibit C – Maintenance Requirement 1) to operate and ensure the maintenance of the stormwater management practice(s) identified in Exhibit B in accordance with the Maintenance Plan (Exhibit C).

5. The Owner(s) shall annually, by December 30th, provide to the City records (logs, invoices, reports, data, etc.) of inspections, maintenance, and repair of the stormwater management practices and drainage easements identified in Exhibit B in accordance with the Maintenance Plan. Inspections are required at least after every major rain event.

6. The City or its designee is authorized to access the property as necessary to conduct inspections of the stormwater management practices or drainage easements to ascertain compliance with the intent of this Agreement and the activities prescribed in Exhibit C. Upon written notification by the City or their designee of required maintenance or repairs, the Owner(s) shall complete the specified maintenance or repairs within a reasonable time frame determined by the City. The Owner(s) shall be liable for the failure to undertake any maintenance or repairs.

7. If the Owner(s) does not keep the stormwater management practice(s) in reasonable order and condition, or complete maintenance activities in accordance with the Plan contained in Exhibit C, or the reporting required in 3 above, or the required maintenance or repairs under 4 above within the specified time frames, the City is authorized, but not required, to perform the specified inspections, maintenance or repairs in order to preserve the intended functions of the practice(s) and prevent the practice(s) from becoming a threat to public health, safety, general welfare or the environment. In the case of an emergency, as determined by the City, no notice shall be required prior to the City performing emergency maintenance or repairs. The City may levy the costs and expenses of such inspections, maintenance or repairs plus a twenty percent (20%) administrative fee against the Owner(s). The City at the time of entering upon said stormwater management practice for the purpose of maintenance or repair may file a notice of lien in the office of the Macomb County Register of Deeds upon the property affected by the lien. If said costs and expenses are not paid by the Owner(s), the City may pursue the collection of same through appropriate court actions and in such a case, the Owner(s) shall pay in addition to said costs and expenses all costs of litigation, including attorney fees.

8. The Owner(s) hereby conveys to the City an easement over, on and in the property described in Exhibit A for the purpose of access to the stormwater management practice(s) for the inspection, maintenance and repair thereof, should the Owner(s) fail to properly inspect, maintain and repair the practice(s).

9. The Owner(s) agrees that this Agreement shall be recorded and that the land described in Exhibit "A" shall be subject to the covenants and obligations contained herein, and this agreement shall bind all current and future owners of the property.

10. The Owner(s) agrees in the event that the Property is sold, transferred, or leased to provide information to the new owner, operator, or lessee regarding proper inspection, maintenance and repair of the stormwater management practice(s). The information shall accompany the first deed transfer and include Exhibits B and C and this Agreement. The transfer of this information shall also be required with any subsequent sale, transfer or lease of the Property.

11. The Owner(s) agree that the rights, obligations and responsibilities hereunder shall commence upon execution of the Agreement.

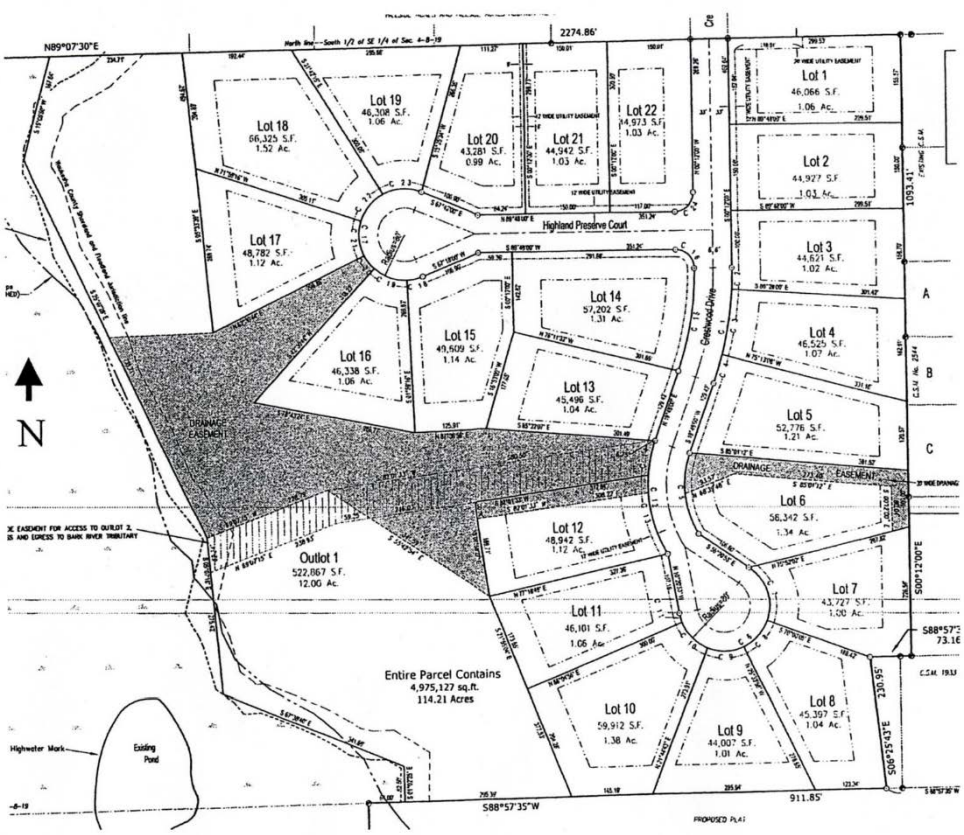
12. The parties whose signatures appear below hereby represent and warrant that they have the authority and capacity to sign this agreement and bind the respective parties hereto.

Exhibit A – Legal Description (Sample)

The following description and reduced copy map identifies the land parcel(s) affected by this Agreement.

[*Note: An example legal description is shown below. This exhibit must be customized for each site, including the minimum elements shown. It must include a reference to a Subdivision Plat, Certified Survey number, or Condominium Plat, and a map to illustrate the affected parcel(s).*]

Project Identifier: Clinton Preserve Subdivision Acres: 40
Date of Recording: October 22, 2006
Map Produced by: ABC Engineering, P.O. Box 20, Clinton Twp., MI
Legal Description: **Lots 1 through 22 of Clinton Preserve Subdivision, located in the Southwest Quarter (SW1/4) of Section 16, Township 2N, Range 13E (Clinton Township) Macomb County, Michigan.**
[If no land division is involved, enter legal description as described on the property title here.]



Drainage Easement Restrictions: Shaded area on map indicates a drainage easement for stormwater collection, conveyance, and treatment. No buildings or other structures are allowed in these areas. No grading or filling is allowed that may interrupt stormwater flows in any way. See Exhibit C for specific maintenance requirements for stormwater management practices within this area. See subdivision plat for details on location.

Exhibit B – Location Map (Sample)
Stormwater Management Practices Covered by this Agreement

[*An example location map and the minimum elements that must accompany the map are shown below. This exhibit must be customized for each site. Map scale must be sufficiently large enough to show necessary details.*]

The stormwater management practices covered by this agreement are depicted in the reduced copy of a portion of the construction plans, as shown below. The practices include on wet detention basin, two forebays, two grass swales (conveying stormwater to the forebays) and all associated pipes, earthen berms, rock chutes, and other components of these practices. All of the noted stormwater management practices are located within a drainage easement in Outlot 1 of the subdivision plat as noted in Exhibit A.

Subdivision Name: **Clinton Preserve Subdivision**
Stormwater Practices: **Wet Detention Basin #1, forebays (2), grass swales (2)**
Location of practices: **All that part of Outlot 1, bounded and described as follows:**
[If no land division is involved, enter a metes and bounds description of the easement area.]
Titleholders of Outlot 1: **Each Owner of Lots 1 through 22 shall have equal (1/22) undividable interest in Outlot 1** [For privately owned stormwater management practices, the titleholder(s) must include all new parcels that drain to the stormwater management practice.]

Figure 1
Plan View of Storm Water Practices

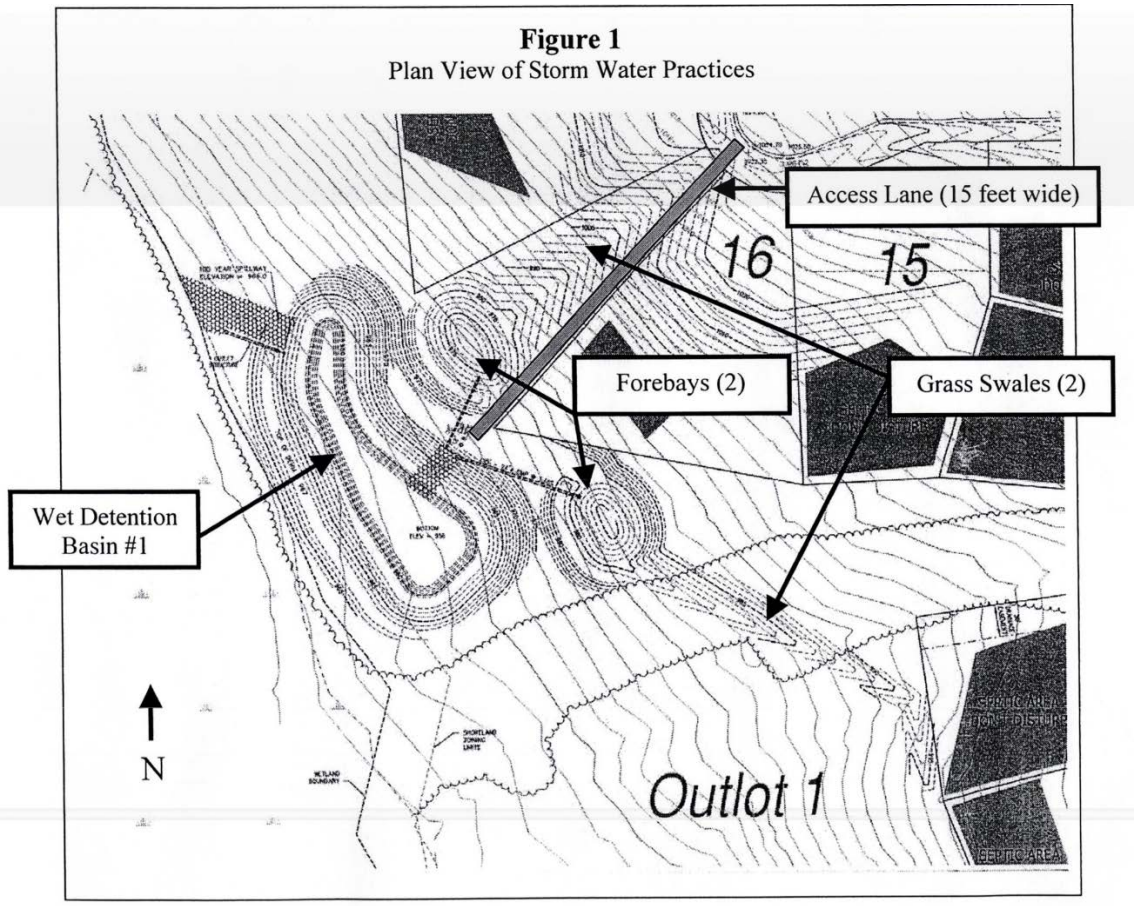


Exhibit C
Stormwater Practice Maintenance Plan

[Example Maintenance Plan language is provided below. The exhibit must be customized for each site. The minimum elements of this exhibit include: a description of the drainage area and the installed stormwater management practices, a description of the specific maintenance activities for each practice which should include in addition to specific actions:

- *Employee training and duties,*
- *Routine service requirements,*
- *Operating, inspection and maintenance schedules, and*
- *Detailed construction drawings showing all critical components and their elevations.]*

This exhibit explains the basic function of each of the stormwater practices listed in Exhibit B and provides the minimum specific maintenance activities and frequencies for each practice. The maintenance activities listed below are aimed to ensure these practices continue serving their intended functions in perpetuity. The list of activities is not all inclusive, but rather indicates the minimum maintenance that is expected to be performed for these practices. Vehicle access to the stormwater practices is shown in Exhibit B. Any failure of a stormwater practice that is caused by lack of maintenance will subject the Owner(s) to enforcement of the provisions listed in the Agreement by the City.

System Description

The wet detention basin "A" shown in Exhibit B is designed to treat the water quality volume, provide extended detention of the bankfull event, and maintain pre-development downstream peak flows. The basin has two forebays located at the low end of two grass swales. In addition to conveyance, the grass swales detain, filter and infiltrate the runoff from smaller storms. Each forebay is 5 feet deep and is connected to the main pool by 18 and 24 inch metal pipes that outlet onto a rock chute. The forebays allow coarse sediments to settle, thus reducing maintenance frequency of the main basin. The main pool will remove a portion of the fine sediment. The locations, dimensions, elevations and details of the practices and structures are provided in Figures 1, 2 and 3.

The main basin receives runoff from a 67.1 acre drainage area (41.2 acres within the subdivision and 25.9 acres off-site drainage from the east). During high rainfall or snow melt events, the water level will temporarily rise in the basin and slowly drain back down to the elevation of the control structure. The water level is controlled by a 12-inch concrete pipe extending through the berm in the northwest corner of the basin (Figures 1 and 3). On the face of the 12-inch pipe is a metal plate with a 3-inch drilled orifice. This orifice restricts the outflow rate and controls the water level at elevation 962.5. Washed 2-inch stone is placed in front of the orifice to prevent clogging. During extreme runoff events high flows may enter the grated concrete riser or flow over the rock lined emergency spillway.

Maintenance Requirements

The following activities will be completed to ensure the proper function of the stormwater practices described above:

1. All personnel providing inspection and maintenance services shall be a registered Civil Engineer, Certified Professional in Storm Water Quality (CPSWQ), NICET Certified Engineering Technologist in Stormwater and Wastewater System Inspection, or an MDEQ Certified NPDES (construction site) Stormwater Operator.

2. An inspection and maintenance schedule will be developed and a log will be kept of all inspections, maintenance activities, and repairs. The log will provide the date of the activity, the name of the person providing the service and a description of the activity.

3. The practices will be inspected after each major rain event (such as >2.2 inches over 24 hours) for general condition.

4. All outlet pipes, the trash rack on the outlet riser and the stone in front of the restricted orifice will be inspected at least quarterly to ensure there is no blockage from floating debris or ice and that the water level is as designed. Any blockage will be removed immediately and irregularities in water level corrected. The washed stone around riser structures will be replaced at least every two years.

5. The vegetation in and around the basin, in the swales and buffer strips will be inspected semi-annually to assess growth, survival and percent cover. Plants will be replaced and areas will be seeded as appropriate.

6. The two swales planted with native sedges, grasses, and wildflowers shall be established and preserved to allow the free flow of runoff. No woody plants such as bushes or trees or buildings or structures will be allowed in the swale areas. The swales will not be mowed. They may be maintained by string trimming to a minimum height of 6" before April 1 to remove dead plant materials. Woody plants may be trimmed to the ground every few years. Invasive plant species and pests shall be controlled through IPM practices.

7. No grading or filling will be done that will interrupt flows.

8. Grass, swales, inlets and outlets will be checked after heavy rains and periodically (minimum of quarterly) for signs erosion. Eroding areas will be repaired immediately to prevent premature sediment build-up in the forebays or main basin. Appropriate erosion control blankets will be utilized in repairing grassed areas.

9. No trees or woody plants will be planted or allowed to grow on the berms of the basin. The berms will be inspected annually and any woody plants will be removed.

10. If floating algae or weed growth becomes a nuisance (decay, odors, etc.), it will be removed from the basin and/or forebays and placed in an appropriate upland site away from drainage areas. Wetland vegetation will be established and maintained along the waters edge for esthetic and pollutant removal purposes.

11. The forebays and main basin will be inspected annually for sediment accumulation. Sediment in the forebays or the basin will be removed when it has accumulated to a level of 3 feet below the outlet elevation or when 60 percent of the volume has been filled (typically every 5 to 10 years). All excavated sediment will be placed in an appropriate upland site and stabilized to avoid erosion.

12. No grading or filling of the basin or berm will be done except during sediment removal.

13. A minimum 25-foot buffer of native plants will be maintained around the forebays and basin for aesthetics, stabilization, pollutant removal, and goose deterrent purposes. The buffer strip and the grass filters may be maintained by string trimming to a minimum height of 6" before April 1 to remove dead plant materials, allow for erosion inspection, and prevent blockage of structures.

Appendix H. Examples of Bioswales, Bioretention Cells, and Underground Retention

Bioswales

Bioretention Cells

Underground Retention