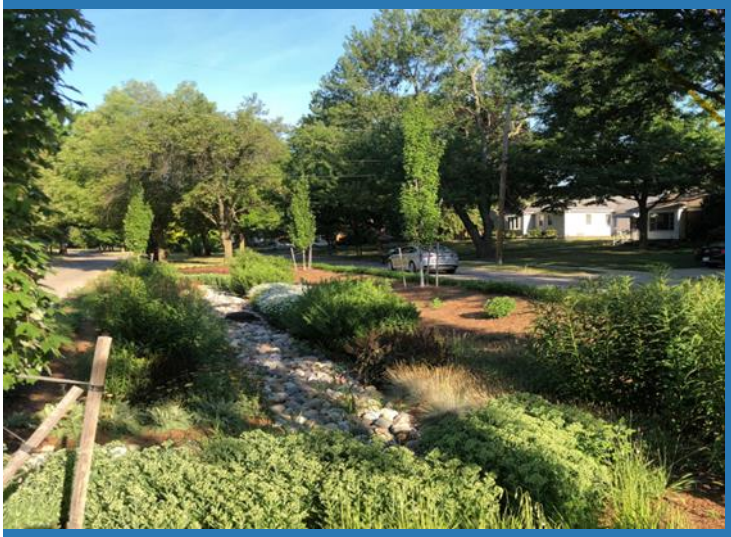
WRC
WATER RESOURCES COMMISSIONER
Jim Nash

OAKLAND COUNTY STORMWATER ENGINEERING DESIGN STANDARDS



Requirements, Rules, and Design Criteria for Stormwater Management

ADOPTED AUGUST 2021, REVISED APRIL 2025

WRC
WATER RESOURCES COMMISSIONER
Jim Nash

Table of Contents

Section 1 - Stormwater Standards Overview and Jurisdiction

Part A: Standards

The Environmental Protection Agency (EPA) through the Michigan Department of Environment, Great Lakes, and Energy (EGLE) requires the County of Oakland and other regulated entities to comply with the National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Separate Storm Sewer System (MS4) permit requirements. The purpose of these standards is to address Post-Construction Stormwater Runoff Controls required under this permit.

These standards are a result of regional collaboration between Oakland, Wayne, Macomb and Livingston Counties with the following overall objectives:

1. Provide a comprehensive framework for managing stormwater that addresses surface water quality, channel and infrastructure protection, localized flood control and long-term operations and maintenance.
2. Incorporate design standards that control both the quantity and quality of stormwater runoff.
3. Require volume reducing Low Impact Development design measures, or Stormwater Management Practices, such as infiltration, preservation of natural areas, enhanced vegetation and reduced imperviousness to control runoff volume to the Maximum Extent Practicable.
4. Strengthen the protection of natural features.
5. Protect public health, safety and welfare.
6. Promote economic development using straightforward and uniform drainage standards for site development throughout Oakland County, as well as across Southeast Michigan.
7. Provide guidelines and additional resources for the selection of effective structural and vegetative SMPs for development sites.
8. Enhance the sustainability of stormwater management practices in Oakland County including performance, longevity, safety, maintenance, community acceptance, and environmental benefits.
9. Establish a framework to increase the likelihood of long-term operation and maintenance of the stormwater management practices.
10. Use the most currently published, relevant rainfall statistics.
11. Promote a consistent design process by using a set of simple equations to determine runoff rates, detention volumes, water quality treatment and infiltration requirements.

WRC's Stormwater Rules address water quality, volume, and flood control to comply with the National Pollutant Discharge Elimination System Phase II permit requirements.

Part B: Authority

The Oakland County Water Resources Commissioner's (WRC) office will apply these standards within its legal authority and jurisdiction as outlined in the following regulations:

1. The Subdivision Control Act, Act 288 of the Public Acts of Michigan of 1967, as amended.
2. The Michigan Drain Code, Public Act 40 of 1956, as amended.
3. The Mobile Home Commission Act, Act 96 of the Public Acts of Michigan of 1987, as amended.
4. Part 31, MS4 General Permit, Water Resources Protection, Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Oakland County's MS4 permit covers regulated county stormwater systems under the jurisdiction of the OCWRC office (direct discharges to County Drains), the Oakland County Parks and Recreation Commission and the County of Oakland. The Road Commission for Oakland County should be contacted for applicable standards within their stormwater jurisdiction.
5. EGLE Wastewater Discharge Permit, Rule 323.2161a, Post-Construction Requirements.

To promote consistent regional site development stormwater practices, municipalities and other entities responsible for the management of stormwater systems and MS4 permit compliance are encouraged to adopt these standards. Additionally, municipalities that operate combined sewer systems and are party to CSO permit compliance are also encouraged to adopt these standards. Local municipalities may elect more restrictive standards and when conflicting standards arise, the more stringent requirements shall govern. These standards establish minimum requirements for the design, construction and maintenance of stormwater systems for subdivisions, site condominiums, commercial, industrial and other development and redevelopment projects.

All construction activity within the WRC's stormwater permitting authority will be reviewed by the WRC's Plan Review and Permitting Department to determine if the activity is regulated. The Department will use the following applicability criteria to assist in making this determination and to clarify which stormwater standards apply to the proposed construction activity.

These rules were developed in close coordination with Wayne, Macomb, and Livingston Counties, as well as the City of Detroit. This provides a generally consistent set of standards across Metro Detroit.

Part C: Applicability

These standards shall apply to development and redevelopment projects with construction activity greater than or equal to 1 acre, or part of a common plan of development resulting in a development or redevelopment activity greater than or equal to 1 acre in size, including without limitation, clearing, grading, excavating, construction, and paving that results in an earth change or disturbance in the existing cover or topography of land, including any external demolition, modification, or alteration of a site or the footprint of a building.

Common exemptions to these stormwater standards include the following:

1. Resurfacing of an asphalt, concrete, or similar surface (mill and fill) that does not expose the aggregate or subgrade or result in replacement of the onsite drainage system.
2. The practices of clearing, plowing, and tilling soil and harvesting for the purpose of crop production.
3. The project does not meet the development or redevelopment criteria in this standard.
4. The development or redevelopment project construction activity is less than 1.0 acre.
5. The development or redevelopment project is for one single family detached dwelling that is not part of a common plan of development.
6. The development or redevelopment project is for emergency maintenance and work performed to protect public health and safety.
7. The development or redevelopment project discharges solely to a Road Commission of Oakland County stormwater system or right-of-way.
8. Other exemptions listed herein or approved by the WRC Plan Review and Permitting Department.

To protect <u>all</u> water resources under WRC stormwater jurisdiction, WRC requires applicable standards to be implemented for development and redevelopment projects.

These standards supersede all previous versions and revisions, and updates will be available on **WRC'S WEBSITE**. The website includes registration information to receive notification of revisions and updates to these standards as they become available. These standards are intended to be a living document and updated as necessary to reflect ongoing changes in climate and regulatory conditions. Before submitting a site plan for stormwater permitting, please refer to the WRC website for the most recent version of the standards.

Many municipalities across Oakland County have adopted these rules in full or in part for new development and redevelopment projects.

Combined Sewer Districts

The WRC continues to collaborate with municipalities within Oakland County combined sewer districts to implement post-construction stormwater standards to reduce stormwater impacts to the various systems. Many of the combined sewer district municipalities also have separated stormwater systems and therefore have adopted stormwater standards. Please contact the municipality in which your project is located to determine what stormwater standards may apply.

Part D: County Drains

Permits

The permit application must be submitted through WRC's online portal before construction plans will be reviewed. Permit and inspection fees are determined on a site-specific basis after the review is completed. A permit shall be required from WRC prior to performing any work to a County Drain or its appurtenances. The following are examples of work:

1. Connecting to any part of an open ditch, enclosed drain or manhole or drainage structure of a County Drain. A tap can be a direct connection or a pipe outlet.
2. Crossing any part of an open ditch or enclosed pipe of a County Drain. Examples of crossings are utility lines, driveways, culverts, and bridges. A minimum clearance of five (5) feet for an open ditch drain and eighteen (18) inches for an enclosed drain must be maintained between the drain and any proposed utility or other underground crossings of the drain.
3. Relocating any part of a County Drain.
4. Enclosing any portion of an existing open-ditch County Drain.
5. Daylighting any portion of an existing enclosed County Drain.
6. Performing work within a County Drain easement.
7. When the installation of a fence, driveway, patio, pool, or other structure that does not have a foundation, encroaches into the County Drain easement.
8. Any development that will outlet stormwater directly to a County Drain.

The applicant shall submit one set of electronic construction plans. The plans must be prepared in accordance with the design standards presented herein and sealed by a Professional Engineer licensed in the State of Michigan. All pertinent design calculations must be submitted with the final construction plans. Preliminary plans may be submitted but are not required.

A permit shall be required from WRC prior to performing any work to a County Drain or its appurtenances.

Should the applicant plan to develop a site but intends to phase construction, the submitted preliminary plan must include the proposed general layout for the entire site. The first phase of the development must be clearly superimposed upon the overall plan in order to clearly illustrate the sequence of development that the applicant intends to follow. Each subsequent phase will follow the same procedure until the entire area controlled by the applicant is developed.

General Permit Information Requirements

All construction plans shall include the following information:

1. The location of the proposed development by means of a location map at sufficient scale.
2. Legal description for the parcel to be developed.
3. The number of acres to be developed.
4. Contours, at two-foot intervals or less, with U.S.G.S. datum.

5. Land Use Summary Table with USDA NRCS soil group classification.
6. Existing natural features, including wetlands and woodland areas.
7. The proposed drainage system for the development.
8. Existing and proposed easements.
9. The proposed street, alley and lot layouts and approximate dimensions.
10. Stormwater Management Practices (SMPs) Operations and Maintenance (O&M) table.
11. Manufactured treatment device certification, if applicable.
12. Known environmental concerns, if applicable.
13. WRC Storm Drain Notes and Detail Sheet

Supplemental documents to be included with the permit application:

1. Professional geotechnical report including but not limited to the following:
    a. Soil boring logs and location map.
    b. Infiltration testing methods, results, and location map.
    c. Professional Engineer or Professional Geologist's certification attesting to the results, conclusions, and recommendations within the geotechnical report.
2. Environmental Site Assessment (ESA) and/or "Due Care" plan, if applicable.
3. Executed copy of the Stormwater Management Operations and Maintenance Agreement or executed Memorandum of Stormwater Operation and Maintenance Agreement

Permit Requirements

1. The appropriate permit and inspection fee must be submitted before the permit is issued. Permit fees are determined on a site-specific basis.
2. Some permits may require a cash deposit, in an amount specified by the WRC Plan Review and Permitting Department to cover inspection services. The deposit shall be paid to ensure satisfactory completion of the project in accordance with the approved plans.
3. A notice of 48 hours must be given to the WRC Inspection Department prior to any construction affecting the County Drain. Failure to contact the WRC inspection Department of the work will result in forfeiture of all deposit money.
4. Flow shall be maintained in the drain at all times during construction.

A notice of 48 hours must be given to the WRC Inspection Department prior to any construction affecting the County Drain.

5. All work shall be completed in accordance with the plans and specifications approved by the WRC Plan Review and Permitting Department.
6. The contractor performing the work must have current applicable bonds with the WRC.

7. Work performed on the County Drain or its appurtenances must be performed in accordance with the Water Resources Commissioner's Storm Drain Notes and Details Sheet. The Storm Drain Notes and Details Sheet must be included in the plans.
8. A drain permit issued by the WRC Plan Review and Permitting Department will not relieve the applicant and/or the applicant's contractor of the responsibility of obtaining permits, approvals or clearances as may be required from federal, state or local authorities, the public utilities, and/or private property owners.
9. An as-built plan of the drain involvement must be submitted.
10. The WRC shall be notified within ten days of the completion of a project so that a final inspection of the permitted work can be performed.
11. All permit requirements must be completed prior to the WRC refunding any remaining inspection deposit money.
12. A permit shall expire when work has not commenced within one year of the date of issuance. The WRC may extend the permit for a period of time upon the request of the Owner/Developer in writing.
13. The WRC may revoke a permit if there is a violation of the conditions of the permit or if there is a misrepresentation or failure to disclose relevant facts in the application.
14. A drain permit is separate from a Soil Erosion Control permit and both must be obtained prior to the start of construction. WRC may require the drain permit to be approved prior to issuance of the Soil Erosion and Sedimentation Control Permit.

Drainage Districts and Easements

County Drain Drainage District limits must be followed when designing the site. Drainage Districts do not necessarily conform to existing topography. If drainage originating outside of a certain district is discharged within the district, a revision to the drainage district boundaries will be required. Contact the WRC regarding this process.

Drains constructed prior to 1956 may not have a recorded easement. However, the easement exists in the permanent records at the WRC office. Prior to 1956, easements for drainage purposes were not required to be recorded with the County Clerk; it was legally sufficient to have them on file at the drain office. Therefore, it may be necessary to record a new County Drain easement, depending upon the work that is proposed, and the County Drain involved. If a new easement is required, contact the WRC Office regarding this process.

Part E: Assets Under Local Jurisdictions

For discharges into a non-county asset, some municipalities may have more restrictive standards than presented herein and those standards would supersede these standards. For all non-county assets, it is recommended that designers still consider the following when designing their stormwater management systems to local jurisdiction codes:

1. Verify adequate outlet to municipality watercourses or pipes.
2. Consider all potential hydraulic restrictions at outlet and assume full tailwater conditions when calculating release rates from basins and hydraulic grade line through the pipe network.
3. Provide vertical separation (recommend two feet) between site stormwater design and receiving pipe or open watercourse.
4. Verify the development area that will trigger a stormwater review (some municipalities might have a threshold lower than 1 acre).
5. Determine whether the development is within a stormwater master planning area that could impact site specific standards for water quality and peak flow control.

Section 2 – Stormwater Management Requirements & Procedures

Part A: General Requirements

Introduction

The general standards set forth are applied by this office for the review of the following:

1. Applications for permits to discharge to a County Drain under P.A. 40 of 1956, as amended.
2. Review of stormwater system plans in other classes of developments or redevelopments, when requested by local governments.
3. Review of developments being established as Chapter 18 County Drains.
4. Subdivisions being established under Act 288 of the Public Acts of 1967.
5. Mobile home plans prepared under P.A. 96 of 1987.

Pre-Application Meeting

The pre-application meeting is a recommended step 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 WRC standard requirements, existing site characteristics, identify existing in-situ soil conditions (which will determine whether infiltration will be required), Stormwater Management Practices (SMPs) proposed for use on the site, long-term maintenance needs, and the capacity of the stormwater outlet. At this meeting, WRC staff will also confirm whether the development/redevelopment is within a drainage system that has a restricted outlet. This will determine the methodology that shall be used for determining the allowable peak discharge rate. 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 will provide the following general information about the proposed development site for review during the meeting with WRC staff:

1. General Site Description / Site Plan
2. Topography
3. Land cover
4. Known environmental concerns (e.g. contaminated soils, “Due Care” Plan)
5. Location of and characteristics of environmental features, including wetlands, undrained areas, woodland areas, etc.
6. Soil types - (Soil survey with USDA NRCS soil group classifications, well/septic records and, if available, soil borings)
7. Potential locations for infiltration SMPs
8. Site environmental history (i.e., Phase 1 ESA)

Electronic Submission of Application and Plans

All application submittals requiring a Drain, Water Main, Sanitary Sewer, and/or Soil Erosion permit from WRC must be made electronically via the **ENERGOV PERMIT PORTAL.**

1. Log into the WRC EnerGov Permit Portal and register as a user to be able to submit an application for review and approval.
2. Applications must be submitted by System and/or Property owners or their designated representatives.
3. Once an application has been submitted, the Applicant may invite others giving them permission to interact with the Application submittal process or simply to view the Permit Status.
4. Construction and site plans must be in PDF format with layers flattened, optimized and compressed.
5. JPG format is acceptable for documents or letters.
6. Maximum file size for each file should not exceed 50MB.
7. Below is the URL for the **WRC ENERGOV PERMIT PORTAL:**
    a. Full URL: https://oaklandcountymi-energovpub.tylerhost.net/apps/selfservice#/home

Land Use Summary for Stormwater Tracking & Mapping

Collecting data on site runoff characteristics is critical for the WRC Plan Review and Permitting Department and the local review jurisdiction (if applicable) to meet ongoing EGLE permit requirements. This is accomplished with a ***Land Use Summary Table*** which must be included on the O&M Plan Sheet of the submitted site plan (see table on the following page). Additionally, GIS-based site data (in the form of a shapefile) will be required as a condition of permit approval for new drains, relocated drains, or drain extensions. When required, the WRC will provide the applicant with the required GIS shapefile layers to be submitted.

Land Use Summary Table

A template of the **LAND USE SUMMARY TABLE** can be found on WRC's website.

Land Use Summary

Must be included on the Stormwater Calculations/O&M Plan Sheet

	Characteristic	Existing Conditions	Proposed Conditions
Pervious Area Land Use Data	**Total Development Area (ac)**	4.93 Acres	4.93 Acres
	Impervious Area (ac)	1.43 Acres	2.53 Acres
	Total Pervious Area (ac)	3.50 Acres	2.40 Acres
	Pervious Area Breakdown by Cover Type		
	Meadow/fallow/natural areas (non-cultivated)		
	Predominant NRCS Soil Type (A, B, C, or D)	C	C
	Improved areas (turf grass, landscape, row crops)	3.50 Acres	2.40 Acres
	Predominant NRCS Soil Type (A, B, C, or D)	B	C
	Wooded Areas		
	Predominant NRCS Soil Type (A, B, C, or D)	C	C
	Proposed Pond Area (acres)		
	CPVC Volume ***Calculated*** (cubic feet)		
	CPVC Volume ***Provided*** (cubic feet)		
	CPRC Volume ***Calculated*** (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 WRC 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.

Notes:

1. The Professional Engineer Certification Statement (see above) must be included with the Land Use Summary Table.
2. Areas to be shown to the nearest 0.01 acre.
3. 'Predominant' soil type shall be the soil type with the largest percentage coverage over the designated land use (e.g., if site is 70% Soil Type B and 30% Soil Type C, then list in the table as "Soil Type B")
4. USDA soil types cannot be used to determine site suitability for infiltration and meeting the CPVC volume standard; direct infiltration testing will be required to determine site suitability for infiltration.
5. If CPVC requirement is waived, enter ZERO for the 'CPVC Volume Provided'.
6. When more than one soil type exists in one area, assign the predominant soil type for that area.
7. Use NRCS/USDA Online Soil Survey Map to determine soil type (A, B, C, or D).

Submittal Requirements

In addition to the Land Use Summary table, the applicant must include the following stormwater system information in the submittal:

The Stormwater Design Checklist is a required component of each site plan submittal to help expedite the site plan review process.

1. Project name
2. Project location
3. City / Village / Township name
4. Applicant name and contact information
5. Engineer and owner names, including contact information
6. Description of work and other relevant information
7. **STORMWATER DESIGN CHECKLIST** (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)
        i. *NOTE: the stormwater review cannot be approved without the submittal of in-situ soil characteristics and infiltration tests, and, if applicable, evidence of existing soil contamination; this information is necessary to determine whether a Channel Protection Volume Control waiver may be granted.*
    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 or TAPE certification letter including all 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 WRC) 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).
8. Construction plans developed in accordance with WRC requirements.
9. Executed Stormwater Management O&M Agreement or Recorded Memorandum of Stormwater Management O&M Agreement.

Part B: Determination of Surface Runoff

Rational Method

The Rational Method assumes uniform rainfall intensity and is best suited for small or individual sites and can be used for sizing swales, open channels, enclosed drains, SMP volumes, manufactured treatment devices and culverts. For site design purposes, the Modified Rational Method will be used, which takes into consideration both land use and soil types. The Modified Rational Method will be used to determine flows for the 1-year, 10-year and 100-year storm events. The 1-year storm will be used to size manufactured treatment devices, flows into individual SMP's, and the Water Quality Volume (V_{WQ}). The Modified Rational Method is defined as follows:

Equation 1: Peak Runoff	
$Q = C \times I \times A$	
Q =	Peak Runoff (cubic feet/second)
C =	Composite Runoff Coefficient for the Drainage Area
I =	Average Rainfall Intensity (in/hr)
A =	Drainage area (acres)

Coefficient of Runoff

A representative coefficient of runoff, (C), will be used based upon the imperviousness of the contributing acreage. The range of this coefficient may vary from 0.20 to 1.00. The runoff coefficient calculation must be included with on the drainage breakup sheet with the submittal. Certain calculations require a composite runoff coefficient value. A composite runoff coefficient is calculated as follows:

Table 1: C Values		
Green Space	HSG A	0.20
	HSG B	0.30
	HSG C	0.35
	HSG D	0.50
Impervious Areas		0.95
Water		1.00

HSG = Hydrological Soil Group

Equation 2: Composite Runoff Coefficient for the Drainage Area	
$C = \frac{\sum_{i=1}^{n}(A_i \times C_i)}{\sum_{i=1}^{n} A_i}$	
C =	Composite Runoff Coefficient for the Drainage Area
n =	Total number of sub-areas
C_i =	Runoff coefficient for each sub-area
A_i =	Drainage area for each sub-area (acres)

Modified Rational Method

The Modified Rational Method will be used to calculate many of the required volumes. The value 3630 is a constant to convert the (inch)(acre) to ft^3 [1-inch = 1/12 ft; 1-acre = 43,560 ft^3]. The modified rational method is used to calculate the water quality volume (V_{WQ}), the Channel Protection Volume (V_{CPVC}), the Forebay Volume (V_F), the Extended Detention Volume (V_{ED}), and the 100-Year Storm Volume (V_{100R}).

Equation 3: Required Volume	
$V = 3{,}630\ x\ P\ x\ C\ x\ A$	
V =	Required volume (cubic feet)
P =	Precipitation depth (inches)
C =	Post-development composite runoff coefficient
A =	Contributing area (acres)

Table 2: Precipitation depths used within the Modified Rational Method		
	Precipitation depths (inches)	
90th percentile storm (1-inch) for Water Quality	P_{wq}=	1.00
1.30-inch for Channel Protection Volume Control	P_{cpvc}=	1.30
1.90-inch for Channel Protection Rate Control-Extended Detention	P_{cprc}=	1.90
15 percent of the Water Quality Volume for the Forebay	P_{fb}=	0.15
100-year 24-hour storm for Flood Control	P_{100}=	5.23

Time of Concentration

The time of concentration (T_c) is the time required for water to travel from the hydraulically most remote point of the drainage sub-area to a design point. The T_c is used in the Rational Method to estimate peak flow for sizing storm sewer systems, or for applying unit hydrographs and

NRCS curve number methods to generate and route runoff hydrographs for sizing storm sewer systems and stormwater controls.

When determining the time of concentration for a pipe network, an initial time of concentration of 20 minutes for the farthest upstream inlet will be used for residential developments and 15 minutes for commercial or industrial developments. For sites less than 5 acres, an initial time of concentration of 10 minutes will be used. The time of concentration is calculated using travel time for the 10-year discharge through the system where Manning's equation is used to compute velocity.

Table 3: Initial Times of Concentration for Developments	
Residential Developments over 5 acres	20 minutes
Commercial or Industrial Developments over 5 acres	15 minutes
Any development under 5 acres	10 minutes

Equation 4: Travel Time	
$T_t = \frac{\mathrm{L}}{3{,}600v}$	
T_t =	Travel time (hours)
L =	Flow length (feet)
v =	Average velocity (feet/second) as determined by Manning's equation for pipe flow

Equation 5: Average Velocity	
$v = K \times S^{1/2}$	
v =	Average velocity (feet/second)
S =	Slope of flow path (percent)t
K =	Coefficient K = 0.48 for Sheet Flow K = 1.20 for Swales or Shallow Drainage Course K = 2.10 for Ditches and Watercourses

Equation 6: Time of Concentration	
$T_c = \frac{\mathrm{L}}{60V}$	
T_C =	Time of concentration (minutes)
L =	Flow length (feet)
V =	Flow velocity (feet/second)

For overland flow, the velocity is calculated for each of the flow characteristic types present along the longest flow path across the drainage area.

Rainfall Intensity

The rainfall intensity used for stormwater design is based on NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 8 Version 2: Midwestern States, including Michigan, based on the average of the Pontiac WWTP, Troy-Rockwell, Eastpointe, Washington, Howell WWTP, Detroit Metro AP, and Wayne-Canton stations. This regional rainfall data average was then converted into an IDF curve equation used for all storm return periods for ease of use.

Equation 7: Average Rainfall Intensity	
$$I = \frac{30.20p^{0.22}}{(T_c + 9.17)^{0.81}}$$	
I =	Average rainfall intensity (in/hour)
p =	Design storm return period (years)
T_C =	Time of concentration (minutes)

Table 4: Regional* 24-Hour Average Rainfall Amounts	
Storm Event	Rainfall Amount (inch)
1 Year	2.07
2 Year	2.38
5 Year	2.87
10 Year	3.32
25 Year	4.02
50 Year	4.60
100 Year	5.23
*Region includes Livingston, Macomb, Oakland and Wayne counties	

Part C: Stormwater Conveyance

Stormwater conveyance systems may consist of open ditch drains, swales, closed conduits or a combination of methods to convey stormwater. Design and construction of stormwater conveyance will follow WRC's specifications, as a minimum. Other more stringent standards such as: Michigan Department of Transportation, Road Commission for Oakland County, or local community, shall also be followed.

For work involving County Drains, please refer to WRC construction specifications, available from WRC's website, for approved construction materials.

Drainage Structures

The flows to specific catch basin or inlet covers shall conform to the following:

1. Combination curb and gutter inlet (MDOT Cover K, or equivalent): A maximum of 3.1 ft^3/sec at 0% grade (sump condition) and then decreasing as grade increases.
2. Gutter inlet (MDOT Cover D, or equivalent): A maximum of 3.2 ft^3/sec as 0% grade (sump condition) and then decreasing as grade increases.
3. Rear yard or ditch inlet (MDOT Beehive Cover E, or equivalent): In general, a maximum of 2.5 ft^3/sec at 0% grade (sump condition), and then decreasing as grade increases. However, a smaller or larger maximum inflow may be allowed as is warranted by surrounding finished grading.

Drainage inlets or manholes shall be located as follows:

1. To assure complete positive drainage of all areas of the site.
2. At all low points of streets and rear yards. Runoff shall not flow across a street Intersection.
3. Maximum of 600 feet of drainage from any developed point on the site to a structure or SMP.
4. Manholes shall not be spaced more than 400 feet apart for pipes less than 48" in diameter. Longer pipe runs may be allowed for larger sized pipe, but in all cases maintenance access must be determined to be adequate.
5. Any change in pipe direction requires a manhole or catch basin.
6. All materials will be of such quality to guarantee a maintenance-free expectancy of at least 50 years and will meet all applicable A.S.T.M standards.

Stormwater Outlets

1. The velocity at a pipe outfall should be no greater than 10 ft/sec to prevent scouring. Outlet velocities greater than 5 ft/sec will require energy dissipation measures.
2. Riprap shall be installed at all outlets according to WRC's **STORM DRAIN NOTES AND DETAILS SHEET**.
3. Riprap may consist of minimum 8" diameter to 15" diameter fragmented limestone or other suitable rock set on a stone bedding underlain with geotextile fabric. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.

Outlet velocities greater than 5 ft/sec will require energy dissipation measures.

a. Cobblestone, broken concrete, or grouted riprap are not acceptable.

4. A bar screen is required for all pipe outlets and inlets 18” diameter and larger.
5. Outlets to open channels shall be installed at the bottom of the open channel with headwalls or flared end sections.

Enclosed Storm Drains

An enclosed storm drain system must be designed to accommodate the storm water runoff from a 10-year storm event from the site and any offsite contributing runoff. Manning’s Equation (Equation 8: 10-Year Flow Rate) will be used to check the pipe size.

Equation 8: 10-Year Flow Rate	
$Q_{10} = \frac{1.486}{n} \; x \; A_{pipe} \; x \; R^{2/3} \; x \; s^{1/2}$	
Q_{10} =	10-year flow rate (cubic feet/second)
n =	Manning coefficient of roughness (See Table Below)
A_{pipe} =	Cross-sectional area of pipe (square feet)
R =	Hydraulic radius of pipe (A_{pipe}/P) (feet)
P =	Wetted perimeter (feet)
s =	Pipe slope (ft/ft)

Table 5: n value based on pipe material	
Pipe Material	n value
smooth concrete pipe	0.013
approved flexible pipe (plastic)	0.013
unlined corrugated metal pipe	0.025

Refer to **WRC SPECIFICATION** “Materials- Storm Drain” for approved pipe materials for County Drains.

1. The hydraulic grade line is calculated for the entire system with an assumed downstream elevation of 0.80 x diameter of the outlet pipe or the permanent pool elevation, whichever is greater.
2. The enclosed storm drain should be designed to flow full, i.e. with the 10-year hydraulic grade line at or near the top of pipe. The pipe will be allowed to surcharge in certain circumstances, but the peak hydraulic grade line must be a minimum of one (1) foot below grade.
3. The minimum pipe size for storm drains accepting surface runoff is 12” diameter.

a. Rear yard pipes or sump pump collector pipes may be smaller but must be used in conjunction with a drainage swale that directs runoff to a minimum 12" diameter pipe structure.

4. Pipe joints shall have premium rubber gaskets designed to prevent excessive infiltration.
5. Storm drains shall be designed flowing full to have a minimum velocity of 2.5 ft/sec and a maximum velocity of 10 ft/sec.
6. The minimum depth of pipe shall be 42 inches from grade to the springline (i.e. horizontal midpoint) of the pipe.
7. In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts.

Watercourses

1. Appropriate permits from agencies such as the Michigan Department of Environment, Great Lakes, and Energy (EGLE) must be obtained and submitted to the WRC's office.
2. The SCS method, Rational Method, or other prior approved method will be used to determine the amount of flow contributing to the watercourse. All watercourses must be sized to accommodate the runoff from a 10-year storm event. WRC's office will use Manning's Equation (EQUATION 8: 10-YEAR FLOW RATE). to check the capacity of the watercourse. The appropriate values for "*n*" are as follows:

Table 6: n Value Based on Open Channel Conditions	
n value	Channel Condition
0.025-0.030	Maintained grass channel, rear yard swales
0.030-0.035	Natural channels, some grass and weeds, little or no brush
0.035-0.050	Dense growth of weeds, depth of flow greater than weed height
0.035-0.050	Some weeds, light brush on banks

3. Open channel flow velocities shall not cause sedimentation or erosion. In general, the minimum acceptable velocity will be 2.5 ft/sec.
4. Erosion protection shall be placed at bends, drain inlets and outlets, and other locations as required in all open ditches.
5. Side slopes of channels shall be no steeper than 1 foot vertical to 3 feet horizontal, unless fencing is provided. Ditches with steep grades shall be protected by sod, vegetation or other means to prevent scour.
6. All bridges shall be designed to provide a 2-foot minimum 100-year flood stage freeboard to the underside of the bridge. The bridge footings shall be deep enough to be below the frost line and to allow a 5-foot channel deepening. Bridge footings and columns may not be located within the open channel.

7. Areas within open drain rights-of-way, which have been cleaned, re-shaped or in any manner disturbed shall be seeded and mulched, sodded or re-vegetated with other plant materials.

Determination of Culvert Size

All culvert design calculations must be submitted to this office for review. Culverts serving an upstream watershed equal to or greater than two square miles will also require an EGLE permit (Part 31 of Water Resources Protection Act, Public Act 451 of 1994, as amended). Calculations must be sealed by a Professional Engineer and must include:

1. Delineation on a topographic map of the area contributing to the culvert.
2. Hydrologic calculations to determine the flow.
3. Hydraulic calculations used to determine the size of the culvert.
4. Calculations for depth of cover and expected loads.
5. When an existing culvert is proposed to be modified, backwater calculations and/or downstream calculations may also be required for review.
6. This office will use the Rational Method, SCS Method, or other prior approved method to determine the flow contributing to the culvert. Culverts are sized to pass a minimum 10-year storm event or the governing design storm of the watercourse, whichever is greater.
7. Profile showing the 10-year hydraulic grade line is contained within the culvert.
8. End sections must follow the **WRC STORM DRAIN NOTES AND DETAILS**.
9. The velocity within the culvert shall not cause sedimentation or erosion.
10. The Manning Equation or inlet headwater control or outlet tailwater control nomographs will be used to check the culvert design.

Part D: Channel Protection Volume Control Methods

Both onsite water quantity and quality must be managed to control flooding, reduce downstream erosion and protect water quality. Channel Protection Volume Control shall be implemented to the Maximum Extent Practicable (MEP) and follow WRC's MEP guidelines. Several non-structural and structural Stormwater Management Practices (SMPs) are referenced within this section.

The required Channel Protection Volume Control is based on the 1.30-inch rain depth over the site.

Equation 9: Required Channel Protection Volume Control Volume	
$V_{CPVC} = 3{,}630\ x\ 1.30\ x\ C\ x\ A$	
V_{CPVC} =	Required volume (cubic feet)
C =	Post-development composite runoff coefficient
A =	Contributing area (acres)

Non-Structural SMPs

The use of non-structural SMPs is an important part of a project's stormwater management system. The following non-structural SMPs are self-crediting; use of these SMPs automatically provides a reduction in impervious area and/or stormwater runoff resulting in a lessor runoff coefficient, larger time of concentration, and lower peak flows. A corresponding reduction in the stormwater management requirements set forth by these rules occurs. Additionally, the use of these SMPs may be affected by other regulations/guidance (Master Plans, zoning, subdivision, etc.). These SMPs are strongly encouraged:

1. Protect Natural/Special Value Features
2. Protect/Conserve/Enhance Riparian Areas
3. Protect/Utilize Natural Flow Pathways
4. Preserve Open Space (e.g. clustering)
5. Reduce Street Width/Area
6. Reduce Parking Width/Area
7. Minimize Disturbed Area (Cluster Developments)
8. Protection of Existing Trees (part of minimizing disturbance)
9. Re-Vegetate and Re-Forest Disturbed Areas
10. Rooftop Runoff (downspout) Disconnection
11. Disconnection of Impervious Areas (Non-Roof)

Structural SMP General Requirements

All runoff generated by a proposed development should be conveyed into a SMP for infiltration, evapotranspiration, and/or water quality treatment, to the MEP.

Infiltration SMPs should completely dewater in 72 hours including 24 hours for surface ponding and 48 hours for subsurface storage.

The following criteria will apply to the design of all SMPs:

1. Perform initial NRCS soil classification (from soil survey) and infiltration testing to determine the feasibility of infiltration practices and eliminate unsuitable areas.
2. In multi-ownership developments, locate SMPs facilities on common-owned property within an easement. SMPs facilities shall not be located on private lots, condominium units, or located within a County Drain, sewer, or water easements.
3. Infiltration/reuse SMPs are engineered to dewater surface water in 24-hours and completely within 72-hours from the end of a storm event. Dewatering is defined as having no excess stormwater from an event present in the SMP including both surface ponding and subsurface storage.
4. SMPs incorporating pumps are discouraged. In rare cases where pumping is justified, additional design provisions are required, including but not limited to backup power and gravity-based overflow routing.
5. A recommended vertical distance of 4 ft and a minimum vertical distance of 2 feet between the seasonal high-water table and bottom of infiltration facilities is required.
6. In areas where the infiltration rate varies across the development, the developer shall maximize the use of infiltration SMPs within areas of having the most favorable ($K_{sat} \geq 0.50$ inches/hour) soils.
7. Pre-treatment of all stormwater is required before entering a SMP facility to prevent premature failure of the system. Pre-treatment can be accomplished by the following:
    a. Vegetative Filter Strips
    b. Vegetative Swales
    c. System inlets with sumps
    d. Centralized infiltration SMPs (i.e. infiltration basins) pre-treatment consists of a forebay or manufactured treatment device
    e. Other methods of pre-treatment will be considered by this office on a case-by-case basis
8. The use of decentralized stormwater SMPs are preferred unless the developer can demonstrate that decentralized stormwater infiltration and/or Total Suspended Solids (TSS) removal is not practical.
9. The use of heavy equipment within infiltration areas should be avoided during construction to prevent compaction of soils. Locations of infiltration SMPs should be identified and sectioned off during construction to limit access.

10. Prior to installation of an infiltration SMP, the in-situ soils should be prepared by adding additional soil amendments (such as sand or compost) and/or through mechanical loosening of soil. Examples of mechanical loosening include rototilling or scarifying the soil with a long-toothed backhoe bucket. These techniques will improve infiltration underneath the infiltration SMP.
11. Generally, infiltration SMPs should be avoided in the following areas:
    a. In areas with compacted fill soils.
    b. In areas with high pollutant loads, including sites that receive constant sediment, trash, other debris, and places where chemicals are stored or handled.
    c. In areas where it will be difficult to access the SMP, on a regular basis, for maintenance or cleaning.
    d. In areas where materials, especially landscaping supplies, are stockpiled.
    e. In areas that are routinely wet.

Infiltration Testing

The infiltration testing must provide information related to the conditions at the bottom of the infiltration SMP. General infiltration test guidelines are as follows:

1. A minimum of one infiltration test is required for each proposed SMP. Larger SMPs require 1 infiltration test per ¼ acre (10,890 square feet).
2. If a site has more than ¼ acre (10,980 square feet) of green space proposed, 1 infiltration test is required within each separate green space over ¼ acre.
3. Any test used to determine infiltration rates for SMPs shall be performed at the location and extend to the bottom elevation of the proposed infiltration SMP.

A minimum of one infilration test is required for each proposed SMP. Each separate green space over ¼ acre requires an infiltration test.

4. Infiltration tests must not be conducted in the rain, within 24 hours of significant rainfall events (>0.5 inches), when the ground is frozen, or when the temperature is below freezing.
5. Infiltration tests must be conducted in the field.
6. All infiltration rates used for the design of SMPs must be certified by a Professional Engineer or Professional Geologist licensed in the State of Michigan and submitted to the WRC's Plan Review and Permitting Department.
7. Following all testing, the disturbed area must be restored.
8. Additional infiltration tests may be necessary due to subsurface variability, water table depth or topography. The WRC's Plan Review and Permitting Department will determine if more tests will be required.

Infiltration tests may include, but are not limited to, the following methods:

1. Test Pits used in conjunction with any of the infiltration tests listed below:

a. Double-ring Infiltrometer test – estimate for vertical movement of water through the bottom of the test area.

    i. ASTM 2003 Volume 4.08, Soil and Rock (I): Designation D 3385-03, Standard Test Method for Infiltration Rate of Soils in Field Using a Double-Ring Infiltrometer.

    ii. ASTM 2002 Volume 4.09, Soil and Rock (II): Designation D 5093-90, Standard Method of Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring.

b. Percolation tests – estimate for vertical movement of water through the bottom and sides of the test area.

c. Encased falling head permeability test – estimate for vertical movement of water through the bottom of the test area.

d. Guelph permeameter.

e. Constant head permeameter (Amoozemeter).

f. When using test pits, a minimum of 2 infiltration tests are required per test pit.

g. A safety factor of 0.5 must be applied to field measured K_{sat} values when designing infiltration systems.

2. Soil Borings

    a. The use of hollow-stem auger soil borings for infiltration tests are allowed only when constraints do not allow for test pits.

    b. A safety factor of 0.333 must be applied to the field measured K_{sat} value when designing infiltration systems. This is due to the limited sample and the inability to test in-situ soil characteristics when preforming a soil boring.

Note: Other tests selected by the design engineer that can accurately represent the in-situ infiltration rate may be used at the discretion of this office.

The following field measured infiltration (K_{sat}) values shall be used to determine the appropriate design methods for infiltration SMPs:

Table 7: Field Measured K_{sat} Values	
$K_{sat} \geq$ *0.50 in/hr*	No supplemental measures are required for Infiltration SMPs to provide the infiltration volume
0.50 in/hr$\geq K_{sat} \geq$ *0.24 in/hr*	Install supplemental measures, which may include subsoil amendment, or an underdrain placed at the top of the storage bed layer to ensure dewatering in the event underlying soils fail to provide adequate drawdown or dewatering time. If underdrains are selected, design shall allow stormwater to percolate through the soils first, with the underdrain serving as a secondary outlet, by placing the underdrain in the upper level of the SMP, with pipe perforations located along the underdrain invert.
$K_{sat} \leq$ *0.24 in/hr*	Soils are not suitable for infiltration. Alternative volume reducing LID practices must be used to the MEP to reduce stormwater volume.

SMP Volume Calculations

Infiltration based SMPs include bioretention basins (rain gardens), vegetated bioswales, porous pavement, infiltration basins, subsurface infiltration beds, dry wells, and infiltration trenches. These SMPs share the common feature of storing stormwater on the surface or in a subsurface matrix and allowing the water infiltrate over a period of 24 to 48 hours depending on the SMP. For SMPs that incorporate vegetation, stormwater runoff is also reduced through evapotranspiration. Other structural SMPs, such as vegetated roofs and water reuse (harvesting) systems can also provide volume reduction and be used to meet the Channel Protection Volume Requirement (CPVC). The calculations for the CPVC for common SMPs are defined within this section.

Bioretention Basin/Rain Garden

The storage volume of a Bioretention Basin or Rain Garden is defined as the sum of surface storage, subsurface void space within the engineered soil media and/or stone layer, and the infiltration volume occurring during a six-hour period. The infiltration volume is calculated using the in-situ infiltration rate of the underlying soils.

Equation 10: Average Infiltration Area	
$A_t = \frac{A_1 + A_2}{2}$	
A_t =	Average infiltration area (square feet)
A_1 =	Area of bioretention at ponding depth (square feet)
A_2 =	Bottom bioretention surface area (square feet)

Equation 11: Surface Storage Volume	
$V_{surface} = A_t \; x \; H$	
$V_{surface}$ =	Surface storage volume (cubic feet)
A_t =	Average infiltration area (square feet)
H =	Maximum SMP ponding depth (feet)

Equation 12: Storage Volume in the Soil and/or Stone Layer	
$V_{subsurface} = (h_{soil} \; x \; e_{soil} + h_{stone} \; x \; e_{stone}) \; x \; SA$	
$V_{subsurface}$ =	Storage volume in the soil and/or stone layer (cubic feet)
h_{soil} =	Engineered soil depth (feet)
h_{stone} =	Stone depth (feet) (if stone is present)
SA =	Average surface area (square feet)
e_{soil} =	Void ratio of engineered soil (unitless)
e_{stone} =	Void ratio of stone (unitless) (if stone is present)

Equation 13: Infiltration Volume During a Six Hour Period	
$V_i = \frac{K_{sat}\ x\ S_f\ x\ 6\ x\ A_t}{12in}$	
V_i =	Infiltration volume during a six-hour period (cubic feet)
K_{sat} =	Infiltration rate (inches/hour)
S_f =	K_{sat} safety factor
A_t =	Average infiltration area (square feet)

Equation 14: Total Bioretention Volume	
$V_{tbr} = V_{surface} + V_{subsurface} + V_i$	
V_{tbr} =	Total bioretention volume (cubic feet)
$V_{surface}$ =	Surface storage volume (cubic feet)
$V_{subsurface}$ =	Storage volume in the soil and/or stone layer (cubic feet)
V_i =	Infiltration volume during a six-hour period (cubic feet)

Six inches of freeboard shall be provided above the elevation of the design volume of a bioretention. The overflow may be set at the design elevation.

Bioswale

Bioswales are linear bioretention basins that convey stormwater in addition to providing infiltration. If check dams are utilized within the bioswale, the volume behind each check dam can be estimated using EQUATION 15: BIOSWALE STORAGE VOLUME.

The infiltration volume for Bioswales can be calculated using the BIORETENTION BASIN/RAIN GARDEN equations.

Equation 15: Bioswale Storage Volume	
$V_t = 0.5\ x\ L_{swale}\ x\ H_{swale}\ x\ \frac{W_t + W_b}{2}$	
V_t =	Storage volume (cubic feet)
L_{swale} =	Length of swale (feet)
H_{swale} =	Depth of swale check dam (feet)
W_t =	Top width of swale check dam (feet)
W_b =	Bottom width of swale check dam (feet)

Infiltration Basin/Trench

For Infiltration Basin and Trench calculations, use the BIORETENTION BASIN/RAIN GARDEN equations.

Pervious Pavement

For Pervious Pavement calculations, use EQUATION 12: STORAGE VOLUME IN THE SOIL AND/OR STONE LAYER to calculate the volume in the stone layer using H as the thickness of the open-graded stone below the pavement. For the infiltration volume use EQUATION 13: INFILTRATION VOLUME DURING A SIX HOUR PERIOD. Using the volumes calculated from equations 12 and 13, use the below equation to calculate the total volume of the Pervious Pavement system.

Equation 16: Total Pervious Pavement Volume	
$V_{tpp} = V_{stone} + V_i$	
V_{tpp} =	Total pervious pavement volume (cubic feet)
V_{stone} =	Stone storage volume (cubic feet)
V_i =	Infiltration volume (cubic feet)

Vegetated Roofs

Vegetated roofs, also known as green roofs or living roofs, are very effective as reducing rooftop runoff from small to medium sized storm events. Vegetated roofs reduce volume by intercepting rainfall in a layer of growing media and/or in a retention layer. The water then evapotranspirates back into the atmosphere. Volume reduction credit for a vegetated roofing system will be evaluated on a case-by-case basis since most vegetated roofing systems are proprietary.

Water Reuse

Water reuse consists of storage vessels, such as cisterns, which store a specified volume of stormwater runoff and release (reuse) the runoff volume for onsite irrigation or internal uses such as industrial water or sanitary systems. The total aggregate storage volume credit shall be equal to the total storage volume of all storage vessels identified in the site plan that also include a documented reuse plan. The reuse plan demonstrates how the stored water will be used in between rain events such that the storage vessels are ready to receive stormwater runoff from the next rainfall event.

The consideration of other volume reducing SMP's will be evaluated by WRC on a case-by-case basis.

Technical Infeasibility

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 WRC for review and final determination.

Examples of site conditions that may prevent the application of stormwater SMP's 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 groundwater or other factors, such as underground facilities, utilities or location of the development within a wellhead protection area.

The use of infiltration SMPs to the MEP is based on site constraints and not economic considerations.

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. 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.
8. Federal, state of local requirements or permit conditions that prohibit water collection or make it technically infeasible to apply LID practices.

*Adapted from EPA Section 438 Technical Guidance December 2009.

MEP Requirements

For sites that cannot achieve Channel Protection Volume Control (CPVC) utilizing infiltration, evapotranspiration, water harvesting, or water reuse SMPs, alternative practices must be used to meet this standard to the maximum extent practicable (MEP). In these conditions, MEP has been defined as addressing stormwater for an area equivalent to 15% of the proposed impervious area, known as the MEP Area. SMPs implemented to comply with the CPVC MEP requirements must comply with the submittal, review, design criteria, and procedures and be included in the stormwater maintenance agreement. Preapproved SMPs meeting the MEP requirements are listed in the following table:

Table 8: MEP SMP Credit		
SMP	Ratio (SMP Area to MEP Area)	Maximum Credit
Trees	1:1 1 sqft tree canopy = 1 sqft MEP area	100% of MEP area
Preservation of Trees	1:1 1 sqft tree canopy = 1 sqft MEP area	50% of MEP area
Native Plantings	1:1 1 sqft native plantings = 1 sqft MEP area	100% of MEP area
Preservation of Woodlands	1:1 1 sqft woodland area = 1 sqft MEP area	50% of MEP area
Preservation of Wetlands	1:1 1 sqft wetland = 1 sqft MEP area	50% of MEP area
Vegetated Roofs	1:1 1 sqft vegetated roof = 1 sqft MEP area	100% of MEP area
Natural Ponds	1:1 1 sqft pond area = 1 sqft MEP area	50% of MEP area

Other SMPs may be proposed to meet the MEP requirements but they will require further review by the WRC's Plan Review and Permitting Department to determine applicability. Preservation areas collectively can only account for 50% of the MEP area. Preservation areas include existing tree canopy, woodlands, wetlands, and natural pond SMPs.

SMPs used to meet the CPVC MEP requirement are considered a part of the stormwater system and are must be maintained in compliance with the Stormwater O&M Plan.

Native Trees

New native trees planted to meet the MEP criteria will be evaluated on a 1:1 basis based on their height at maturity. Trees are separated into three tree-size groups and each group is assigned an MEP area per tree. The MEP area of each relative tree size is as follows:

Table 9: MEP Area and Tree Sizing		
Relative Tree Size	Height at Maturity (ft)	MEP Area (sf) per Tree
Small	15 to <30	100
Medium	30 to 50	300
Large	Greater than 50	500

The following tables summarize the relative tree size based on the height of the tree at maturity for species listed on the Oakland County Parks Department's recommended list of trees. Trees selected for a development site are not limited to this list but must be native to Michigan.

Table 10: Small Trees (<30 ft height at Maturity) – 100 sq ft MEP Area/tree	
Common Name	Latin Name
American Hornbeam	*Carpinus caroliniana*
Downy serviceberry	*Amelanchier arborea*
Eastern Redbud	*Cercis canadensis*
Flowering Dogwood	*Cornus florida*
Sassafras	*Sassafras albidum*
Striped Maple	*Acer pensylvanicum*
Washington Hawthorn	*Cratageus phaenopyrum*

Table 11: Medium Trees (30-50 ft height at Maturity) – 300 sq ft MEP Area/tree	
Common Name	Latin Name
Black Gum	Nyssa sylvatica
Black Spruce	Picea mariana
Box Elder	Acer negundo
Eastern Hophornbeam	Ostrya virginiana
Eastern Red-cedar	Juniperus virginiana
Ohio Buckeye	Aesculus glabra
River Birch	Betula nigra

Table 12: Large Trees (>50 ft height at Maturity) – 500 sq ft MEP Area/tree	
Common Name	Latin Name
American Basswood	Tilia americana
American Elm	Ulmus americana
Balsam Fir	Abies balsamea
Black Cherry	Prunus serotina
Bur Oak	Quercus macrocarpa
Chinkapin Oak	Quercus muehlenbergii
Hackberry	Celtis occidentalis

General Tree Requirements

1. Check with local transportation officials for sight visibility requirements. Keep trees at least 30 ft away from street intersections to ensure visibility.
2. The minimum planted tree size is a 1-inch diameter at breast height (DBH). DBH refers to the tree diameter measured at 4.5 feet above the ground.
3. Select only small trees (<25 ft tall) for location under overhead power lines.

4. Trees should not be planted directly above underground water and sewer lines.
5. Planting trees near parking lots to reduce the heat island effect is encouraged. Planting trees within 3 feet of pavement should be avoided or tree boxes should be used. A tree with deep roots can also be considered to prevent damage to infrastructure.
6. Planting trees not included on the Oakland County Park's (OCP) list is allowed. If a tree not on the list is planted, a reference/source must be provided indicating the tree's height at maturity. Reference information must be submitted for review and approval for applicability.
7. Existing trees can be considered as a Tree SMP. To be eligible to earn MEP credit, any existing trees must be inspected by an ISA-certified arborist. The ISA-certified arborist must confirm that the trees are free of disease and healthy. They must also measure and report the existing tree's canopy to be counted towards the MEP area. For tree canopy areas not certified by an arborist, the MEP area for each tree will be based on the relative tree size. Any existing tree used for MEP credit must be included in the stormwater O&M agreement.
8. During construction, proper tree protection must be erected and maintained.
9. All MEP trees must be maintained in perpetuity. If an MEP tree dies and/or is removed, it must be replaced with tree(s) of similar height/canopy within 1 year of removal.

Additional Submittal Requirements

1. Location of the SMPs
2. A table of the trees to be planted. The format of the table should be as follows:

Table 13: Example MEP Tree Summary Table

Common Tree Name	Number of Trees Planted	Height at Maturity (ft)	Relative Tree Size	MEP Area (sf) per Tree	Total MEP Area (sf)	Source
Balsam Fir	5	>60	Large	500	2500	OCP Tree List
Box Elder	10	30-50	Medium	300	3000	OCP Tree List
Total	**15**	**-**	**-**	**-**	**5500**	**-**

Native Plantings

1. A native planting SMP is an area where plant species native to Michigan are planted. This SMP is an effective method to improve water quality, foster biodiversity, and protect local habitats. Native plants typically have deeper root systems which promote improved infiltration, and can reduce the required maintenance, watering, and need for fertilizer.
2. The area of the native planting SMP will be applied on a 1:1 basis when meeting the CPVC MEP requirement. Every square foot of native planting area counts towards one square foot of the MEP Area.
3. The following are requirements for native plantings:

4. Species of plants added to the native planting area should grow naturally in the Michigan ecosystem. Example lists of native plants are available at:
    a. Low Impact Development Manual For Michigan, Appendix C **LOW IMPACT DEVELOPMENT MANUAL FOR MICHIGAN: A DESIGN GUIDE FOR IMPLEMENTORS AND REVIEWERS**
    b. MSU Extension – Native Plants and Ecosystem Services: **SOUTHERN LOWER PENINSULA - NATIVE PLANTS AND ECOSYSTEM SERVICES**
    c. Landscaping for Water Quality: **LANDSCAPING FOR WATER QUALITY - GARDEN DESIGNS FOR HOMEOWNERS**
5. The native planting area should be clearly identifiable in the field. For example, surrounding the native planting area with a border to clearly demarcate the boundary. Signage is recommended to educate people and provide information such as a no-mow or grow zone. The border helps outline the SMP for maintenance tasks that differ between the practice and the surrounding areas.
6. Using fertilizer and pesticides in a native planting SMP is discouraged.
7. A list of native plantings must be included in the submittal.

Preservation of Existing Wetlands

Existing wetlands may count towards the MEP Area. The existing wetland would be applied on a 1:1 basis where a square foot of wetland counts towards one square foot of the MEP Area. This SMP only qualifies for up to 50% of the MEP Area. For example, a wetland with the same area as the MEP Area is limited to qualifying for only half of the CPVC MEP requirement. A conditions assessment completed by a professional wetland scientist must be included in the MEP submittal. This assessment must include the following:

1. Delineation of the wetland area
2. Assessment of existing plant species including a list of any invasive species present
3. Treatment and removal of invasive species if present
4. Continued monitoring and invasive species control included in the long term Operations and Maintenance plan

Preservation of Existing Woodlands

For sites where woodlands exist, the area can count towards the CPVC MEP Area requirement. The existing woodland area would be applied on a 1:1 basis where a square foot of preserved woodland area equates to one square foot of the MEP area. This SMP only qualifies for up to 50% of the MEP Area. For example, a wooded area with the same area as the MEP Area is limited to qualifying for only half of the CPVC MEP requirement. The following are requirements for preserving an existing woodland:

1. The existing woodland must be evaluated by an ISA-certified arborist. The certified arborist must review the site's wooded area and provide the following:
    a. A certified statement that the trees in the woodland area are healthy and free of disease

b. A list of any trees that need to be removed and a suggestion of tree species to replace them

c. A long-term maintenance plan for the woodland area

2. If the certified arborist identifies trees to be replaced, construction plans must label the trees being removed and specify the species replacing them

Vegetated Roofs

A vegetated roof, also known as a green roof, is a SMP that meets the CPVC MEP requirement on a 1:1 basis. Every square foot of green roof counts toward one square foot of the MEP Area. No additional runoff should be redirected to the SMP. The following are requirements for vegetated roofs:

1. All structural loading requirements must be verified by a licensed structural engineer
2. The SMP must be installed according to the manufacturer's recommendation
3. No additional impervious areas may be redirected to the vegetated roof
4. The SMP must have an outlet/overflow system for larger storms

Naturalized Pond

A pond or open body of water on a site may meet the CPVC MEP requirement. The SMP can be an existing waterbody on the site or an enhanced wet pond constructed with native plants and a permanent pool. A constructed wetland may also be considered for this SMP. Any plants utilized within the pond should be native to the Michigan ecosystem. The pond would be applied on a 1:1 basis where a square foot of the pond would count towards a square foot of the MEP area. This SMP only qualifies for up to 50% of the MEP Area.

MEP Summary Table

A template of the **MEP SUMMARY TABLE** can be found on WRC's website. This table must be included on stormwater plan sheets.

Table 14: MEP Summary Table				
Total Development Area (sf)				
Site Impervious Area (sf)				
MEP Area required (sf) Note: 15% of Site Impervious Area				
Maximum Allowed Preservation Areas (sf) Note: 50% of the MEP Area				
SMPs and their Associated MEP Area				
SMP	**No. of Trees**	**Area of SMPs (sf)**	**Max Credit**	**Equivalent MEP Area (sf)**
Trees:				
Small (100 sf per tree)			100%	
Medium (300 sf per tree)			100%	
Large (500 sf per tree)			100%	
Tree Preservation			50%	
Native Plantings			100%	
Wetland Preservation Areas			50%	
Woodland Preservation Areas			50%	
Vegetated Roofs			100%	
Natural Ponds			50%	
			Total	

Part E: Water Quality Control

Water quality control practices are required upstream of detention and retention basins. The water quality practice must be installed to treat all incoming flow into the basin. If there is no stormwater detention requirement, water quality treatment is still required to reduce Total Suspended Solids (TSS) concentrations to a maximum of 80 mg/L, or a 80% TSS removal before discharging from a site.

Water quality treatment is automatically achieved if Channel Protection Volume Control requirements are met using infiltration SMPs located upstream of a detention practice.

The Water Quality Volume can be calculated as follows:

Equation 17: Water Quality Volume	
$V_{WQ} = 3{,}3630\ x\ C\ x\ A$	
V_{WQ} =	Water Quality volume (cubic feet)
C =	Composite runoff coefficient
A =	Contributing area (acres)

The Water Quality Rate is used to size manufactured treatment devices and can be calculated using the following equation:

Equation 18: Water Quality Rate	
$Q_{WQ} = C\ x\ A\ x\ \frac{30.20}{(T_c + 9.17)^{0.81}}$	
Q_{WQ} =	Water Quality rate (cubic feet/second)
C =	Composite runoff coefficient
A =	Contributing area (acres)
Tc =	Time of concentration (minutes)

Manufactured Treatment Devices (Mechanical Separators)

Manufactured treatment devices (MTDs), or Mechanical Separators are used to remove sediment and other particulate matter from stormwater runoff. However, they are not to be used for soil erosion control during construction. The following are requirements for MTDs:

1. MTDs must be installed upstream of the stormwater detention system. If the site is not required to provide stormwater detention, an MTD must be installed upstream of the connection to the receiving system.
2. If the MTD is certified for inline use, then the internal bypass shall be designed utilizing the 10-year flow. If the specified MTD is not certified for inline use, the MTD shall be off-line to allow continuance of flow in the event the manufactured treatment device becomes obstructed.

3. Calculations for sizing MTDs shall be based on the following:
    a. The 1-year peak flow rain event (2.07" rainfall) using the Modified Rational Method as shown in EQUATION 18: WATER QUALITY RATE
    b. Site specific time of concentration (T_c) and associated rainfall intensity (I)
    c. The area shall include all post-developed, disturbed areas contributing to the MTD.
    d. Tributary areas of volume reducing SMPs, located within the overall contributing drainage area to the MTD, may be subtracted from the MTD's contributing drainage area for design purposes.
4. Any MTD proposed shall be certified by the New Jersey Department of Environmental Protection (NJDEP) or the State of Washington Department of Ecology Emerging Stormwater Treatment Technologies (TAPE).
    a. NJDEP
        i. The MTD shall conform to the standards set forth and certified by the NJDEP for **50% or 80% removal efficiency**, **AS DEFINED AT BY THE NJDEP**, including offline use, manhole diameter size, and custom or multiple units.
        ii. The NJDEP certified treatment flow rate (cfs) for a manufacturer and model shall be higher than the calculated peak discharge for a particular site and documentation of how the MTD meets the WRC water quality control standards shall be submitted.
    b. TAPE
        i. The MTD shall conform to the standards set forth and certified by TAPE for **Pretreatment or Basic Treatment** **AS DEFINED BY TAPE**, including offline use, manhole diameter size, and custom or multiple units.
        ii. The TAPE certified treatment flow rate (cfs) for a manufacturer and model shall be higher than the calculated peak discharge for a particular site and documentation of how the MTD meets the WRC water quality control standards shall be submitted.

Forebay Design

The purpose of the forebay is to capture and collect silt, trash and debris into one area, and prevent sediment buildup in the main flood control basin. The forebay must be a separate basin, which can be formed within the flood control basin by constructing a separation with an earthen berm, concrete retaining wall or other divider.

The required forebay volume (V_F) is the based on the 0.15-inch rainfall using the Modified Rational Method (Eq. 3). Please note that the design criteria below are for permanent forebays and not for soil erosion control requirements during construction.

The volume of the forebay may be credited towards the total stormwater detention volume for the site.

Equation 19: Required Forebay Volume	
$V_F = 545\ x\ C\ x\ A$	
V_F =	Forebay volume (cubic feet)
C =	Composite runoff coefficient
A =	Contributing area (acres)

When calculating the volume of an irregularly shaped basin or forebay, the WRC Plan Review and Permitting Department will use EQUATION 20: DESIGN FOREBAY VOLUME for calculating the volume of a frustum of a circular cone. The procedure consists of determining the volumes of successive layers of frustums and then summing these volumes to obtain the total volume of the basin.

Equation 20: Design Forebay Volume	
$V = \frac{H_1}{3}(A_1 + A_2 + (A_1\ x\ A_2)^{\frac{1}{2}})$	
V =	Forebay volume (cubic feet)
H_1 =	Difference in depth between two successive depth contours (feet)
A_1 =	Area of the basin within the outer depth contour (square feet)
A_2 =	Area of the basin within the inner depth contour (square feet)

1. The forebay must be designed to dewater using the same number of orifices required for the extended detention volume.
2. A permanent standpipe with gravel filter is required for the forebay outlet control structure.
3. The forebay must have a sump at a minimum of 3 feet below the outlet to capture sediment and prevent resuspension of sediment. The bottom of the basin must slope toward the sump area to capture the sediment.
4. The forebay must have a fixed sediment depth marker to measure the amount of sediment that has accumulated. The sediment must be removed when half of the sediment storage capacity has filled in.
5. The forebay is designed with the same general considerations given to Detention Basins. See PART G: DETENTION & FLOOD CONTROL.

Part F: Channel Protection Rate Control (Extended Detention)

A portion of the flood control storage volume is designated the Extended Detention Volume (V_{ED}). The V_{ED} is intended to control approximately a 2-year rate (1.90" rainfall) to the MEP to protect channels from erosive release rates. The V_{ED} is designed to release over a period of 48-hours to the MEP. The V_{ED} is calculated as follows:

Equation 21: Extended Detention Volume	
$V_{ED} = 6{,}897\ x\ C\ x\ A$	
V_{ED} =	Extended detention volume (cubic feet)
C =	Composite runoff coefficient
A =	Contributing area (acres)

Equation 22: Total head on the V_{ED} orifices in feet
$h_{ED} = Extended\ Detention\ Storage\ Elevation - V_{ED}\ Orifice\ Invert\ Elevation$

Equation 23: Number of 1" Holes Needed to Control the Extended Detention Release Rate	
$H_{ED} = \frac{V_{ED}}{4{,}666 \times \sqrt{h_{ED}}}$	
H_{ED} =	Number of 1" holes needed to control the extended detention release rate
h_{ED} =	Total head on the orifices (feet)

Note: This formula is used for 1" circular holes only.

Part G: Detention & Flood Control

General Detention System Design Requirements

The required 100-year detention volume (V_{100D}) is calculated based on the following:

1. The peak 100-year inflow (Q_{100IN}) from a particular site based on:
    a. The 100-year rain event using the Modified Rational Method.
    b. Site specific time of concentration (T_c).
    c. The area shall include all post-developed, onsite, areas contributing to the detention system.

Equation 24: 100-Year Post-Development Peak Inflow Rate	
$Q_{100IN} = C\ x\ I_{100}\ x\ A$	
Q_{100IN} =	100-year post-development peak inflow rate (cubic feet/second)
C =	Composite runoff coefficient
I_{100} =	100-year rainfall intensity (inches/hour)
A =	Contributing area (acres)

Equation 25: 100-Year Rainfall Intensity	
$I_{100} = \frac{83.3}{(T_c + 9.17)^{0.81}}$	
I_{100} =	100-year rainfall intensity (inches/hour)
T_C =	Site-specific time of concentration for the development (minutes)

The peak allowable 100-year discharge (Q_{100P}) is the lesser of:

1. The restricted rate for the drain (ft^3/Acre)
2. The prorated share of the drain's capacity (ft^3/Acre)
3. The Variable Release Rate (Q_{VRR}) (ft^3/Acre)

Prior to commencing with site plan design, contact WRC to confirm if the Drain has a restricted release rate.

Prior to commencing with site plan design, please contact the WRC Plan Review and Permitting Department to confirm if the Drain has a restricted release rate. Certain County Drains have limited hydraulic capacity. The allowable discharge to these drains will be dictated by the Water Resources Commissioner and may be more stringent than these design requirements. The chosen method to determine the 100-year post-development peak flow rate can have a significant impact on required detention pond volume.

Equation 26: Allowable Release Rate	
$Q_{VRR} = 1.1055 - 0.206\,x\,\ln(A)$	
Q_{VRR} =	Allowable release rate in cfs/acre (Max 1.0 cfs/acre)
A =	Contributing area (acres)

Note: The discharge rates are in cfs/acre, for Q_{100P} multiply by A.

The modified TR-55 storage curve is used to calculate the storage curve factor (R):

Equation 27: Storage Curve Factor	
$R = 0.206 - 0.15\,x\,\ln\left(\frac{Q_{100P}}{Q_{100IN}}\right)$	
R =	Storage curve factor
Q_{100P} =	100-year post-development allowable peak discharge flow rate (cubic feet/second)
Q_{100IN} =	100-year post-development peak inflow rate (cubic feet/second)

The total volume from the 100-year storm is based on EQUATION 1: PEAK RUNOFF:

Equation 28: Post-Development 100-Year Runoff Volume	
$V_{100R} = 18{,}985\,x\,C\,x\,A$	
V_{100R} =	Post-development 100-year runoff volume (cubic feet)
C =	Composite runoff coefficient
A =	Contributing area (acres)

The required 100-year detention volume V_{100D} is:

Equation 29: Required 100-Year Detention Volume	
$V_{100D} = (V_{100R}\,x\,R) - V_{CPVC}$	
V_{100D} =	Required 100-yr detention volume (cubic feet)
V_{100R} =	100-year runoff volume (cubic feet)
R =	Storage Curve Factor (dimensionless)
V_{CPVC} =	Provided CPVC volume (cubic feet)
	KEY RULE: $V_{100D} \geq V_{ED}$

Note: The Volume of Extended Detention (V_{ED}) and Forebay Volume (V_F) are counted toward the V_{100D} requirement.

When calculating the volume of an irregularly shaped basin or lake, WRC will use the formula for calculating the volume of a frustum of a circular cone. This formula is:

Equation 30: Design Detention Volume	
$V = \frac{H_1}{3}(A_1 + A_2 + \sqrt{A_1 x\, A_2})$	
V =	Forebay volume (cubic feet)
H_1 =	Difference in depth between two successive depth contours (feet)
A_1 =	Area of the basin within the outer depth contour (square feet)
A_2 =	Area of the basin within the inner depth contour (square feet)

General Detention Basin Requirements

1. Detention volume on a basin is defined as the volume of detention provided above the invert of the outflow pipe and calculated using EQUATION 30: DESIGN DETENTION VOLUME. Other calculation methods may be used subject to pre-approval, on a case-by-case basis.
2. Any volume provided below the invert of the outflow pipe is considered as a permanent pool of water and is not included as storage volume.
3. An irregular basin shape is preferred with flow entering the basin being evenly distributed to minimize stagnant zones. The distance between the inlet and the outlet should be maximized to obtain the greatest flow distance during periods of low flow. Baffles should be used if inlets and outlets cannot be placed on opposite sides of the basin.
4. Basin side slopes may not exceed 1 foot vertical to 6 feet horizontal for a wet basin or basins with a permanent water feature, and 1 foot vertical to 4 feet horizontal for a dry basin unless fencing is provided.
    a. Additional fencing may be required as needed, depending upon basin depth, depth of permanent pool, etc. Requirements regarding fencing will be evaluated on a case-by-case basis.
5. One foot of freeboard shall be provided above the 100-year stormwater elevation. A vertical distance of 0.50’ shall be provided between the 100-year storage elevation and the emergency overflow spillway. See APPENDIX C: REFERENCE MATERIALS for a schematic.
6. A primary overflow structure (standpipe or overflow manhole) shall be provided with its rim set at the 100-year storm elevation.
7. All basins must be permanently stabilized to prevent erosion.
8. Adequate, unrestricted maintenance access from a public or private right of-way to the detention system must be provided. The access must be on a slope of 6:1 or less, designed to withstand H25 loading, and will provide direct access to the detention or retention facility, forebay, control structure, and outlet.

9. Detention basins constructed by building up on existing grade must have compacted berms with a clay core keyed into native soils.
10. For dry basins, the use of swales or berms, on the bottom of the basin, is required to provide positive flow to the outlet.
11. In-line detention basins are strongly discouraged and are prohibited on watercourses having an upstream watershed greater than 2 square miles or on a County Drain. In-line basins are also prohibited if the waterway to be impounded traverses any area outside of the proposed development.
12. It is recommended that a permanent buffer strip of natural vegetation extending at least 15 feet in width beyond the freeboard elevation be maintained or restored around the perimeter of all stormwater storage facilities. No lawn care chemicals should be applied within the buffer area. This requirement should be cited in the Subdivision Restrictions, Maintenance Agreement and/or Master Deed documents.
13. Basin designs must include a landscaping plan that incorporates plant species native to the local region and indicates how aquatic and terrestrial areas will be vegetated, stabilized and maintained. It is recommended that native wetland plants be used in the basin design, either along the aquatic bench, fringe wetlands, safety shelf and side slopes, or within the shallow areas of the pools.
14. Infiltration of the REQUIRED CHANNEL PROTECTION VOLUME CONTROL VOLUME may be provided within the basin, but the CPVC may not be subtracted from the REQUIRED 100-YEAR DETENTION VOLUME.

Detention System Outlet and Overflow Structure Design

All detention systems must have a method of dewatering to the proposed bottom of storage. The use of an outlet control structure with internal weir or orifices appropriately sized to restrict the discharge rate to Q_{100P} and Q_{ED} is required. When checking the outlet rate the standard orifice equation will be used:

Equation 31: Allowable Outflow	
$Q_p = C_O \; x \; A_O \; x \; \sqrt{2 \; x \; g \; x \; h}$	
Q_P =	Allowable outflow in cubic feet per second
C_O =	Orifice coefficient (0.62 if standard opening)
A_O =	Orifice area in square feet
g =	Gravity constant (32.2 ft/s^2)
h =	Total head on orifice in feet

Equation 32: Total head on the 100-year orifices in feet
$h = 100 \; Year \; Storage \; Elevation - V_{ED}$ Storage Elevation
V_{ED} Storage Elevation = 100 Year Orifice Invert Elevation

For outlet control sizing, the minimum orifice size is 3" without clogging protection. If a 3" diameter orifice permits discharge in excess of the allowable outflow, then a different restricted outlet design will be required, such as a weir or standpipe with stone filter. The minimum orifice size for standpipe design is 1" diameter.

The following equations will be used to check weir design:

Equation 33: Discharge Over a Rectangular Weir	
$Q_{weir} = 3.33\ x\ L_{weir}\ x\ h_{weir}^{3/2}$	
Q_{weir} =	Discharge over the weir (cubic feet/second)
L_{weir} =	Length of weir crest (feet)
H_{weir} =	Head above the weir crest (feet)

Equation 34: Discharge Over a V-Notch Weir	
$Q_{weir} = 2.5\ x\ h_{weir}^{5/2}$	
Q_{weir} =	Discharge over the weir (cubic feet/second)
H_{weir} =	Head above the weir notch bottom (feet)

Equation 35: Discharge Over a Trapezoidal Weir	
$Q_{weir} = 3.367\ x\ L_{weir}\ x\ h_{weir}^{3/2}$	
Q_{weir} =	Discharge over the weir (cubic feet/second)
L_{weir} =	Length of weir crest (feet)
H_{weir} =	Head above the weir crest (feet)

Michael R. Lindeburg, P.E., Civil Engineering Reference Manual, Professional Publications, Inc., CA, 1999

1. The outlet pipe or drainage path must be designed to carry the flow from all on-site and off-site contributing drainage areas.
2. A cut-off collar or anti-seep diaphragm may be required to be installed around the outlet pipe within the bank of the basin, depending on the depth of storage in the basin.
3. All detention basins must have an overflow structure located at the design 100-year (V_{100D}) storage elevation. This structure will route the stormwater past the restrictor in emergency situations. The overflow must have the capacity to pass the 10-year on-site flow plus the off-site tributary flow. The overflow structure shall have a bar screen or trash hood.
4. All detention basins must also have an emergency overflow structure or spillway. The emergency overflow invert shall be set at the 100-year elevation plus 0.5 ft and be sized to convey the 100-year peak detention pond inflow rate plus the offsite tributary flow.

5. Calculations supporting the primary and secondary emergency overflow hydraulic capacities shall be submitted for review. An adequate flow path for detention system overflow (including easements, if necessary) shall be detailed in the site plan.
6. Use of a pumped outlet is discouraged. However, if no feasible gravity outlet is available, stormwater pump stations with emergency backup generators may be used.
7. For storm drain systems being established as Chapter 18 Drains, the restrictive orifice outlet must be grouted inside a minimum 12" diameter pipe located downstream of the Extended Detention standpipe. The restrictor must be sized for the on-site flow that is tributary to the basin. The basin overflow structure shall be sized to pass the on-site flow and the off-site tributary flow. Please see PART J: CHAPTER 18 DRAINS, for additional design requirements.
8. Label outlet control structures as permanent to distinguish between temporary soil erosion control structures and the permanent stormwater management outlet control structures.

Underground Detention Facilities

1. Complete details, calculations and specifications must be submitted for the facility. The underground facility must comply with all standards imposed on traditional facilities; including, but not limited to, a restricted outlet, overflow structure, overflow route, and a perpetual maintenance plan.
2. Both enclosed pipe and open bottom underground detention systems are allowed.
3. Void Space of aggregate bedding will be allowed using the following parameters:
    a. Using stone with a 40% void space, a 20% factor of Safety will be applied. Therefore, a 0.3 void ratio should be used in calculation to determine the allowed void storage volume.
    b. An Isolator row is required. The isolator row storage volume and restricted release rate should follow the requirements of forebays.
    c. In addition to an isolator row, upstream Infiltration practices or an MTD for TSS control is required.
4. Infiltration within an underground detention facility is allowed when field measured K_{sat} values are equal or greater than 5 inches per hour.
    a. Volume infiltrated within an underground detention facility cannot be subtracted from the required 100-year detention volume.
5. Underground detention facilities are prohibited in developments where the storm water detention facilities are under the jurisdiction or operation and maintenance of the WRC (e.g. Chapter 4, 20, or 18 county drains).

Utilizing Wetlands, Waterbodies and Natural Low Areas as an Ultimate Outlet

1. Prior to approval of any proposed plan to use existing wetlands or waterbodies for detention purposes, permits from the appropriate state and local agencies must be obtained. Proof of such permits must be submitted.

2. Calculations must be submitted that indicate the stage rise of the wetland or waterbody due to the developed runoff. Each site is entitled to their pro-rata share of the capacity of the wetlands.
3. A freeboard elevation must be established at one foot above the calculated stage rise.
4. The stage rise should be calculated from the ordinary high-water elevation.
5. There shall no direct discharge of stormwater to wetlands. The discharge must be routed through an upstream forebay or manufactured treatment device, followed by a level spreader or riprap, on the wetland fringe, prior to discharging to the wetlands.
6. A natural buffer strip is required around the perimeter. A drainage easement that encompasses the entire area on site, including freeboard and buffer strip, will be required. In addition, off-site easements may be necessary due to the increase in impoundment height.
7. The character of the wetlands must not be altered by the addition of the storm water. A control structure must be constructed at the outflow of the wetland area to release stormwater at a restricted rate as determined by these rules. The wetland must return to its normal water level within 48 hours.
8. Stormwater runoff directed to natural low areas will be considered the same as retention. The area must have the capacity to hold two consecutive 100-yr storm events and have a designated overflow route. Each site adjacent to the wetlands is entitled to their pro-rata share of the capacity of the depression for the land area tributary to it. A drainage easement that includes the entire area, including off-site properties, encompassing the freeboard elevation will be required.

Retention Basin Design

A “no-outlet” retention basin is only permissible subject to certain conditions that include, but are not limited to, the following:

1. There is no other available positive outlet for the stormwater runoff from the property. Every effort should be made to provide a means to de-water the basin, including a pump outlet and possible downstream improvements.
2. The Volume of the Retention Basin is calculated as follows:

Equation 36: Required Volume of Retention Basin	
$V_{RB} = (18{,}985\ x\ C\ x\ A\ x\ 2) - V_C$	
V_{RB} =	Total retention basin volume (cubic feet)
C =	Composite runoff coefficient
A =	Contributing area (acres)
V_c =	Volume of 100% SMP Credit (cubic feet)

3. The permeability of the soils shall follow all requirements set forth for large SMPs with the exception of the following:

a. The Basin shall be able to dewater a 100-year storm (V_{100R}) within 72 hours based on the infiltration rates.

b. When calculating the volume of storage, no credit will be given for infiltration volume within the basin. However, infiltration volume from upstream SMPs may be credited towards the total retention volume required.

4. An infiltration trench is not considered an acceptable substitution for permeable soils.
5. The general requirements for retention basins shall follow the requirements for detention basins.
6. An overflow route 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. The overflow route may not endanger any existing structures or features. Downstream drainage easements may be required for the overflow route.
7. The proprietor must submit a soil boring log taken within the basin bottom area to a depth of 25 feet below existing ground or 20 feet below proposed basin bottom elevation.
8. WRC reserves the right to require additional storage up to that required by two consecutive 100-year storm events based on the results of soils data or the overflow assessment.

Part H: Operations and Maintenance

Long-term Operations and Maintenance (O&M) Plans are required for County and Non-County Stormwater Systems directly connected to a County Stormwater System as summarized below. To facilitate routine inspections, all O&M requirements and documents listed below shall be incorporated into the plan set on dedicated O&M-specific plan sheets. When O&M responsibilities or requirements are modified or updated, the respective O&M Plan sheet(s) shall be updated accordingly.

The municipality is responsible for enforcement of the O&M requirements as outlined in the Stormwater Management O&M Agreement and their MS4 permit.

Operations and Maintenance Agreement Requirements

The following MS4 Permit O&M requirements apply to all regulated County Stormwater Systems owned, operated, and maintained by WRC's office, the Oakland County Parks and Recreation Commission and the County of Oakland, hereafter referred to as County Departments and all regulated Non-County Stormwater Systems owned, operated, and maintained by others, which directly connect to a County Stormwater System:

1. A fully executed Stormwater Management O&M Agreement (O&M Agreement) or Memorandum of Stormwater Management Operations and Maintenance Agreement is required prior to issuance of the Drain Permit. This agreement is between the municipality and the property owner. The municipality is responsible for the enforcement of the O&M requirements as outlined in the Stormwater Management O&M Agreement and their MS4 permit. This agreement shall consist of the following requirements, which will be reviewed and approved by WRC's Plan Review and Permitting Department:
    a. Municipality Enforcement: An O&M Agreement must allow the local government the right to access, inspect, and maintain, when necessary, the stormwater system including the following:
        i. Inspect the structural or vegetative SMPs;
        ii. Perform necessary maintenance or corrective actions to the stormwater management system neglected by the property owner;
        iii. Track the transfer of the operation and maintenance responsibility of the stormwater management system in the event ownership of the property changes.
    b. Legal Description: A legal description and reduced copy map to identify the land parcel(s) affected by this Agreement. This map shall be prepared for each site and must include a reference to a Subdivision Plat, parcel survey, or Condominium Master Deed, and a map to illustrate the affected parcel(s).
    c. Stormwater System Description and Map: A description of the stormwater system and its individual components and a location map of the entire stormwater system. This map must be prepared for each site and the scale of the map shall show necessary detail.
        i. Property information and property owner.

ii. Brief description of the stormwater system, drainage area, and its individual components.

Description of maintenance responsibility and manner of ensuring maintenance responsibility, such as employee and contractor O&M training requirements, certifications, and responsibilities.

d. Approved Construction Plan Sheet(s): The site-specific plan sheets to be recorded with the O&M agreement shall include the following:

i. Approved utility and stormwater plan sheets showing stormwater calculations, details, elevations, a location map, and engineer's certification of construction.

ii. O&M Table (see table below for example)

1. Specific short-term, intermediate, and long-term maintenance tasks.

2. Inspection and maintenance tasks, frequencies, and responsibilities.

iii. SMP detail sheets and/or manufacturer specifications

iv. Land use summary table

e. The O&M plan must be approved and signed by a certified person. The following certifications are approved by WRC: licensed Professional Engineer, National Green Infrastructure Certification Program (NGICP) by WEF, Construction Storm Water Operator (CSWO) certification by EGLE, or Certified Stormwater Manager (CSM) by American Public Works Association (APWA).

2. Memorandum of Stormwater Management Operations and Maintenance Agreement: This O&M Memorandum acknowledges a perpetual requirement of stormwater system operations and maintenance, which must be recorded with the Register of Deeds to put any future property owners, or interest holders, on notice of the Stormwater System and the Stormwater O&M Plan. This O&M Memorandum references the required Stormwater Management O&M Agreement, which resides with the local community to ensure consistency and periodic updates as necessary. A copy of this recorded memo **or** a copy of the recorded O&M Agreement is required to receive a drain permit from WRC.

3. The WRC will not accept responsibility of maintenance of any stormwater system unless it is being constructed as part of a County Drain.

4. Annual Stormwater System O&M Summary: Property owners and Individual County Departments are responsible for completing all O&M tasks and maintaining O&M records for their stormwater systems. Property Owners and County Departments must submit an Annual Stormwater System O&M Summary to WRC's Permitting Department upon request. The municipality is responsible for enforcement of the O&M requirements as outlined in the Stormwater Management O&M Agreement and their MS4 permit. The summary shall include the following:

a. Property information and property owner.

b. Description of the stormwater system, drainage area and its individual components.

c. Description of maintenance responsibility.

d. O&M matrix filled out for each SMP with inspection date, inspector, field notes, and signed certification of qualified inspector.

e. Maintenance or repairs needed for each SMP.

f. Maintenance or repairs completed to date for each SMP.

APPENDIX F: STORMWATER MANAGEMENT OPERATIONS AND MAINTENANCE AGREEMENT EXAMPLE is an approved **"**example" agreement, however, WRC's office recognizes that municipality-specific O&M agreements, ordinances and programs may also be proposed and submitted to WRC for approval. When developing alternative O&M programs for consideration, the municipality should reference EGLE's Post-Construction Stormwater Runoff Controls Program Compliance Assistance Document (available on EGLE's website) and their MS4 permit.

Operations and Maintenance Table Requirements

The Operations and Maintenance Table must include the following:

1. 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.
2. Provisions for establishing and maintaining vegetation that is integral to the proper functioning of the stormwater system.
3. 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.
4. A schedule for implementing the activities necessary for proper functioning of the system.

Example Operations and Maintenance Table

		Stormwater Management Practices			
Maintenance Inspection Activities	Notes	Bioretention Basin	Curb Cut Inlet	Cobble Spillways	Standpipe
Annual Maintenance					
Mowing	Initial mowing of the native plant areas (using flail mower) shall occur after one season of growth when the weeds are 10 inchers high or prior to invasive weeds setting seed. Mowed height shall be 5".	**1 time per year (April or May)**			
Weeding	Weeds shall be removed by hand. A selective herbicide shall be applied according to manufacturer's directions	**3 times per year (June, July, August)**			
Mulching	Depth shall be 2 inches typical shredded hardwood bark. Do not allow mulch to be deeper than 4 inches	**Inspect mulch beds in June and September. Replace as required**			
Erosion stabilization/control		**Inspect 2 times per year (fall and spring)**	**Inspect 2 times per year (fall and spring)**	**Inspect 2 times per year (fall and spring)**	
Erosion stabilization/control		**Inspect 2 times per year (fall and spring)**	**Inspect 2 times per year (fall and spring)**	**Inspect 2 times per year (fall and spring)**	
Remove trash, floatables, litter and/or debris accumulation		**1 time per month fall, spring, and summer**	**1 time per month fall, spring, and summer**	**1 time per month fall, spring, and summer**	
Inspect for and replace dead vegetation		**3 times per year (June, July, August)**			
Remove accumulated solids by vactoring					**Inspect every 3 years, clean out when sediment is over 40% of sump depth**

Note(s): *Mechanical separators follow the manufacturer's guidelines for operation and maintenance*

Part I: Work Involving County Drains

When a County Drain is the proposed outlet for a site's storm drainage system, the standards outlined herein regarding stormwater storage volume and allowable outflow must be followed. There may be cases where the existing outlet has limitations due to downstream conditions. In this situation, the discharge from the site will be restricted to conform to the governing downstream conditions. The allowable outflow from the proposed site will be limited to the pro-rata share of the capacity of the drain. The site's pro-rata equitable share of the outlet capacity should be calculated and shown on the construction plans.

There may also be cases where the outlet has already reached capacity. The burden is on the developer/proprietor to design and construct, at his expense, any necessary improvements to the downstream outlet. Such designs will be reviewed by WRC for adequacy.

Locations, easements and drainage service area boundaries for County Drains are available from WRC. Permanent structures may not be constructed within the easement of a County Drain. This includes stormwater storage facilities or SMPs. All basins and SMPs must be located entirely outside of the County Drain permanent easement.

Easements

1. Prior to 1956, County Drain easements were not required by statute to be recorded with the County Clerk; it was legally sufficient to have them on file at the drain commissioner's office. Therefore, it is necessary to check the permanent records of WRC to see if a drain easement is in existence on the subject property.

2. It may be necessary to record a new easement for that part of the County Drain that traverses the site. The existing easement may be abandoned in consideration for the granting of the new easement.

3. For open ditch drains, the easement must be at minimum, wide enough to include the extreme width of the open ditch drain plus 15' on each side measured from the top of bank. In addition, a vegetated buffer strip may be required. For enclosed drains, the easement must be a minimum of twenty (20) feet centered on the centerline of the pipe. However, larger pipe size, certain soil conditions, or depth of pipe may require larger easement widths.

4. The proposed easement must be submitted to this office for review. Upon completion of the project, the owner's engineer is required to provide the WRC Right-of-Way Department with an existing or "as-built" metes and bounds centerline description of the entire length of the drain through the referenced property. Upon submittal of the description, along with proof of property ownership, WRC Right-of-Way Department will prepare the necessary documents for execution by the owner(s).

5. This office must also be provided with one set of digital As-Built engineering drawings, cleaned of all background debris, showing plan, profile and the new easement of the drain.

6. Proposed County Drain easements shall be indicated on the plans as well as the plat and shall be designated as 'permanent private easement for the "Name" (County) Drain'. In addition, the following note must be added to the plat:

    a. The use of the word "private" does not limit in any way the scope of the easement granted to the "Name" (County) Drain Drainage District"

Drainage Service Areas (Districts)

1. A Drainage Service Area and Special Assessment District are each a legally established boundary for the area served by a County Drain. Drainage Service Areas do not always match the topographical area tributary to a County Drain. Drainage Service Areas shall not be violated when designing a drainage system.

2. Alterations to a Drainage Service Area and/or a Special Assessment District may be made by following the procedure established in the Drain Code. Approval must be granted by the Water Resources Commissioner or the Drainage Board.

Connections to County Drains

1. Taps to pipe and manholes shall be cored (sawed) wherever possible. If the tap cannot be cored, the proposed opening shall be star-drilled or cut with a concrete saw to establish a diameter prior to using a hammer to make the tap opening.

2. All taps shall be located to provide a minimum of one foot of manhole wall between tap openings.

3. Taps to manholes shall be pointed on the inside of the structure.

4. Taps shall be cut flush with the inside wall of the manhole and not protrude into the structure.

5. Depending on the location of the tap, manhole steps may need to be relocated at the applicant's expense.

6. No taps are allowed at a pipe joint.

7. Taps to open channel drains shall have a flared end section installed on a 42" minimum depth concrete footing. Taps 18" and larger to open channels shall have bar screens.

8. Riprap shall be installed at all outlets according to the WRC's **Storm Drain Notes and Details Sheet**. Riprap may consist of 8" to 15" diameter fragmented limestone or other suitable rock on a stone bedding underlain with geotextile fabric. Cobblestone, broken concrete or grouted riprap are not acceptable. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.

9. In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts.

10. Sump pump lines and connections shall not fall under the long-term operation and maintenance of WRC and will not become part of an established County Drain. Maintenance of such lines will be the responsibility of the property owners and shall be so specified in subdivision restrictive covenants or condominium master deed agreements.

Crossing County Drains

1. A minimum clearance of 5 feet is required between open swale/ditch inverts and underground utilities unless special provisions are employed. Special provisions include encasement of utility lines in concrete or installation of the utility inside a steel casing when crossing under the open channel.

2. All bridges shall be designed to provide a 2-foot minimum flood stage freeboard to the underside of the bridge. The bridge footings shall be deep enough to be below the frost

line and to allow a 5-foot channel deepening. Bridge footings and columns may not be located within the open channel.

3. A minimum clearance of 18 inches from the outside wall of an enclosed County Drain to any proposed utility or other underground crossing of the drain shall be provided.

Soil Erosion and Sediment Control

Soil erosion and sediment control devices shall be installed as required by the **WRC's Soil Erosion and Sedimentation Control Manual** within municipalities where the Soil Erosion and Sedimentation Control Program is administered by WRC. The following points should be kept in mind when designing an erosion control plan for a site:

1. Areas within open drain rights-of-way, which have been cleaned, re-shaped or in any manner disturbed shall be seeded and mulched or otherwise vegetated.
2. The smallest practical area of raw land should be exposed at one time during development.
3. When raw land is exposed during development, the exposure should be kept to the shortest practical period of time.
4. Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.
5. The permanent final vegetation and structures should be installed as soon as practicable in the development.
6. The development plan should be fitted to the topography and soil type so as to create the least erosion potential.
7. Wherever feasible, natural vegetation should be retained and protected.

Proposed SMP locations should be protected at all times during construction to prevent sedimentation and compaction of soils that could lead to underperformance or failure of SMPs. This includes but is not limited to stabilizing surfaces adjacent to SMPs and installing temporarily erosion and sedimentation control structures at outlets to SMPs.

Part J: Chapter 18 Drains

The purpose of this standard is to guide the Owner/Developers of new developments within Oakland County municipalities which require drainage systems to be established as County Drains in accordance with the provisions of Section 433, Chapter 18 of the Public Acts of 1956, as amended, the Michigan Drain Code.

The WRC will review the grading plan for sites that will be platted under Act 288 and a subdivision or site condominium included in the Chapter 18 Drain program. Positive drainage is required. Final lot grading inspection is under the jurisdiction of the local municipality. See APPENDIX B: LOT GRADING for details.

Plan requirements shall follow those identified in PART K: SUBDIVISIONS – SITES TO BE PLATTED UNDER ACT 288, Construction Plans with the following additions:

1. An O&M plan and recommended schedule for the perpetual maintenance of the complete storm drainage system. Note that a Stormwater Management Operation and Maintenance Agreement is not required for Chapter 18 County Drains; WRC will be responsible for the functional operation and maintenance of the stormwater management system once an Agreement is signed. Any maintenance desired specifically for aesthetics will be the responsibility of the property owner.
2. An access road shall be provided for all forebay and detention/retention facilities. The access road shall be designed to support heavy equipment (H25 loading).

Design of the Chapter 18 Drain shall follow the criteria set forth in Section 2, WRC Specification Materials-Storm Drain, and **WRC STORM DRAIN NOTES AND DETAILS**, with the following additional requirements:

Storm Drain Pipes:

- 12” Minimum Pipe Size
- 10-Year Storm Design
- 10-year Hydraulic Grade Line a Minimum 1 foot below Grade
- Velocity Less than 10 ft/s

Sump Pumps:

- Serving More than One (1) Dwelling Unit 8” Minimum Size
- Minimum Size for House Leads is 4”
- All Connections to Storm Drains are Pre-manufactured
- Refer to **WRC STORM DRAIN STANDARD DETAIL SHEET**

In areas where local ordinance requires sump pump leads to be connected into an enclosed system, these taps shall be made directly into storm sewer structures or into cleanouts.

Sump pump line connections shall not fall under the long-term operation and maintenance of the Water Resources Commissioner’s Office and will not become a part of an established County Drain. Maintenance of such lines will be the responsibility of the property owners and shall be so specified in the subdivision restrictions or condominium master deed agreements.

Stormwater Basins

Please refer to the equations in Section 2 PART G: DETENTION & FLOOD CONTROL Detention and Flood Control

Outflow from Basin

Outflow will be restricted per Section 2 PART G: DETENTION & FLOOD CONTROL. Downstream *effects of storm water discharge will be the major consideration in sizing the outlet.*

Outlets

Riprap shall be installed at all outlets according to the **WRC STORM DRAIN NOTES AND DETAILS SHEET**. Riprap may consist of minimum 8" diameter to 15" diameter fragmented limestone or other suitable rock underlain with geotextile fabric. Cobblestone, broken concrete or grouted riprap is not acceptable. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.

A bar screen is required for all pipe outlets and inlets 18" diameter and larger.

Stormwater Treatment

1. Sediment forebays or MTDs, and/or infiltration practices may be considered for stormwater treatment, but subject to WRC approval.
    a. Proposed MTDs must be selected and sized per Section 2 PART E: WATER QUALITY CONTROL.

All drainage systems will be evaluated on a case-by-case basis. Local conditions, requirements, or situations may all for exceptions to the above requirements, the published Design Criteria for Subdivisions, Standard Details, or other rules which may apply.

Easement Requirements

The Developer and/or Property Owner shall provide to this office permanent easements for the proposed County Drain drainage facilities. Easement requirements vary with the type of site being developed. If the site is a platted subdivision, the easements must be shown on the final digital plat and the standard WRC easement language must be included in the Deed Restrictions. If the site is a condominium development, the easements must be shown on the "Exhibit B" drawings and the standard WRC easement language must be included in the Master Deed. A copy of the proposed Deed Restrictions/Master Deed must be submitted to this office for review. A recorded copy must be on file at this office prior to the final construction plan approval.

Easement requirements are as follows:

1. The minimum acceptable easement for a storm drain shall be 20 feet wide. Extreme depth and/or large pipe may require a wider easement.
2. The minimum acceptable easement for 8" diameter sump pump lines shall be 12 feet wide.
3. The minimum acceptable easement for a detention/retention basin shall be 15 feet from the high water elevation or at the one (1) foot freeboard elevation, but may not be less than 15 feet.
4. Language for Subdivision Plats (Must be on Final Digital):

5. Use of the word “private” does not limit in any way the scope of the easement granted to the Name (County) Drainage District.

WRC reserves the right to modify the easement requirements at its discretion.

Typical Easement for Residential Developments

The following language shall be included in the deed restrictions for the subdivision:

. . . subject to a perpetual and permanent easement in favor of the Oakland County Water Resources Commissioner, the _____ _____ Drainage District, a Michigan statutory public corporation as represented by the Oakland County Water Resources Commissioner (referred to as "grantee") and grantee’s successors, assigns and transferees, in, over, under and through the property described on Exhibit A (or plat, liber, page) hereto, which easement may not be amended or revoked except with the written approval of grantee, and which contains the following terms and conditions and grants the following rights:

1. *The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connection with any type of drainage facilities or storm drain in any size form, shape or capacity;*
2. *The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit;*
3. *No owner in the subdivision shall build or convey to others any permission to build any permanent structures on the said easement;*
4. *No owner in the subdivision shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity or take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;*
5. *The grantee and its agents, contractors and designated representative shall have right of entry on, and to gain access to, the easement property;*
6. *It is understood that under Michigan law, the Drainage District is comprised of all of the owners of the subdivision and that any and all expenses, claims or damages in any way arising from or incident to the construction, operation and maintenance of the drain and easement will be assessed against the Drainage District.*

The rights granted to the Oakland County Water Resources Commissioner, the _____ _____ Drainage District, and their successors and assigns, under Section_____of these restrictions may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted thereunder shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

Typical Easement for Condominiums

The following language shall be included in the deed restrictions for the condominium complex:

. . . subject to a perpetual and permanent easement in favor of the Oakland County Water Resources Commissioner, the _____ _____ Drainage District, a Michigan statutory public corporation, as represented by the Oakland County Water Resources Commissioner (referred to as "grantee"), and grantee’s successors, assigns and transferees, in, over, under and through the property described on Exhibit A hereto, which easement may not be amended or revoked except with the written

approval of grantee, and which contains the following terms and conditions and grants the following rights:

1. *The easement shall be for the purposes of developing, establishing, constructing, repairing, maintaining, deepening, cleaning, widening and performing any associated construction activities and grading in connection with any type of drainage facilities, storm drains or related appurtenances, in any size form, shape or capacity;*
2. *The grantee shall have the right to sell, assign, transfer or convey this easement to any other governmental unit;*
3. *No owner in the condominium complex shall build or convey to others any permission to build any permanent structures on the said easement;*
4. *No owner in the condominium complex shall build or place on the area covered by the easement any type of structure, fixture or object, or engage in any activity or take any action, or convey any property interest or right, that would in any way either actually or threaten to impair, obstruct, or adversely affect the rights of grantee under the said easement;*
5. *The grantee and its agents, contractors and designated representatives shall have right of entry on, and to gain access to, the easement property;*
6. *It is understood that under Michigan law, the Drainage District is comprised of all of the owners of the condominium complex and that any and all expenses, claims or damages in any way arising from or incident to the construction, operation and maintenance of the drain and easement will be assessed against the Drainage District.*

The rights granted to the Oakland County Water Resources Commissioner, the_____ _____ Drainage District, and their successors and assigns, under Section_____of this master deed may not, however, be amended without the express written consent of the grantee hereunder. Any purported amendment or modification of the rights granted thereunder shall be void and without legal effect unless agreed to in writing by the grantee, its successors or assigns.

Request to Establish a County Drain

The Developer must first submit to this office one set of electronic construction plans and one digital copy, sealed by a Licensed Professional Engineer, for the proposed development along with a letter requesting that the development's drainage facilities be established as a County Drain. WRC's Engineering Design Standards for Storm Water Facilities and Standard Details for (County) Drains must be followed when designing the drain.

1. Submission of the following information is required:
2. Request to establish the _____ County Drain.
3. Engineer's certification of the adequacy of the drainage outlet.
4. Title work for the property being served by the Drain.
5. Names, titles, addresses or parties to execute the Drain Agreement.
6. Unified/Single property description with acreage, sidwell number(s) and a survey closure document.
7. Construction cost estimate for all drainage facilities.
8. All applicable fees and deposits.

9. Signed Deed Restrictions with County Drain language.
    a. Maps and legal description of any right of ways or off-site easements that may be necessary for drainage facilities.

Plan Submittal

Plan submittal must be in accordance with the regulations of the municipality where the development is located. It is the responsibility of the Developer to contact the municipality and confirm whether plans should be submitted directly to WRC or to the municipality first.

Plan submittal to WRC for Chapter 18 Drains should include the following:

1. All plan requirements as outlined in Section 1 PART D: COUNTY DRAINS
2. Construction Cost Estimate of the Stormwater Management System
3. Engineer's Certificate of Outlet (APPENDIX G: ENGINEER'S CERTIFICATE OF OUTLET FOR PROPOSED CHAPTER 18 DRAINS)

This office will review the construction plans and a determination will be made as to the adequacy of the design with respect to the Oakland County Water Resources Commissioner's requirements and to applicable laws and standards. If the local municipality has more stringent standards, then the municipality standards shall govern. Revisions to the plans or additional information may be requested at this time.

Construction of the stormwater management system may not begin until the construction plans have been approved. When the plans are approved, WRC will issue a letter of construction approval with conditions. When the conditions of the approval letter are met and applicable fees have been received, WRC will provide construction inspection of the stormwater management system. Once the inspections of the stormwater management system have been approved, completed, and closed out by WRC, then the Chapter 18 Drain Agreement may be signed by both parties.

If applicable, after the construction plans have been approved, this office will process the final subdivision plat as set forth in the Subdivision Control Act of 1967, as amended. In the case where the Chapter 18 Drain development will be a platted subdivision, the procedures for a preliminary and final plat as described in Section 2 Part K must also be followed.

To receive approval of the construction plans, a Licensed Professional Engineer must certify that the outlet for the proposed drain is adequate and will not cause detriment or diminution of the drainage services it now provides. An example of the Engineer's Certificate of Outlet may be found in APPENDIX G: ENGINEER'S CERTIFICATE OF OUTLET FOR PROPOSED CHAPTER 18 DRAINS.

Inspections

WRC's Inspection Department will provide full-time construction inspection of the storm drain system. Drainage facilities constructed without appropriate inspection by this office or its designated representative may not be accepted by this office as a County Drain.

The Developer and/or Property Owner are responsible for the liabilities, operation and maintenance of the storm drainage system until it is accepted for service by the Water Resource Commissioner's Office.

The WRC Inspection Department or its designated representative will perform daily inspection of the storm drainage facility construction. This is to ensure that the storm drainage system is

constructed according to the plans and specifications approved by this office.

The WRC Inspection Department will issue a series of construction inspection approvals at several milestones of the project, which will indicate that the contractors have successfully completed various phases of the construction.

WRC's Inspection Department must be notified 3 business days prior to commencing construction and for all acceptance inspections.

Full time inspection is required for all aspects of storm drain construction.

The system must be constructed in accordance with WRC's specifications.

All field changes must be pre-approved by the WRC Inspection Department prior to installation.

First Inspection

The purpose of the Construction Inspection approval is to release the underground contractor from responsibility for damage to the underground drainage system by others during future construction on this project site:

Requirements of the First Inspection:

1. All pipes and structures are to be free of dirt and debris.
2. Structures must be complete, plastered or pointed, channels, benches and castings in place.
3. All inlets and outlets must be completed with riprap in place.
4. All storm water detention/retention facilities and forebays must be constructed and stabilized.
5. All erosion control measures in place as well as a stated policy to maintain the soil erosion controls.
6. The storm drainage system must be completed and fully functional.

Second Inspection

The Second Inspection will be performed after the pavement has been completed. The purpose of the Second Inspection is to relieve the Pavement Contractor from responsibility for future damage to the storm drainage system.

Third Inspection

The purpose of the Third Inspection is to accept the drainage system for conditional maintenance and operation by the WRC and to relieve the Developer and/or Property Owner from the responsibility for maintenance of the storm drainage system.

The Developer and/or Property Owner are still responsible for the systems' integrity until the completion of the final accounting and acceptance by the WRC.

All easements for the operation and maintenance of the County Drain including "Exhibit B" drawings, offsite drainage easements and recorded Deed Restrictions or a Master Deed with the appropriate drain easement language, along with As-Built plans for the Drain, must be submitted to this office and approved prior to the WRC scheduling the Third Inspection.

The Third Inspection will consist of a thorough and complete inspection of the entire storm drain system. A punch list of any outstanding construction items will be prepared and forwarded to the Developer and/or Developer's representative for resolution. Once these punch list items have been addressed and corrected, then a Third Inspection approval may be issued.

The Third Inspection can be scheduled after the following requirements have been met:

1. All disturbed areas have been re-vegetated and that the right of ways and all easements, detention basins, forebays and swales are sodded or vegetated with an approved plant material. All easement area vegetation must be established.
2. That the local governing body has no objections to the finalization of the project.
3. That there are no outstanding soil erosion issues and no history of poor soil erosion practices by the Developer and/or Property Owner.
4. All required documents and fees have been submitted and approved.

Final Acceptance

One year after conditional acceptance of the Drain for operation and maintenance, the Developer is allowed to request, in writing, that a final accounting be made by this office. The project will be reviewed by the WRC's Plan Review and Permitting Department and the WRC's Inspection Department will perform a final walk-through inspection of the Drain when the following requirements have been met:

1. All conditions of the Agreement are satisfied.
2. The drain is functional and serviceable.
3. There are no outstanding liens or judgements against the storm drainage system.
4. A Developer's Declaration and Developer's affidavit are on file with the WRC.

If all the requirements have been met, a final accounting will be performed, and a letter of final acceptance will be issued along with any remaining refundable deposits.

Please note that if the Developer fails to complete the requirements of the Agreement, the project will be declared abandoned, and the storm drainage system will not be maintained by the WRC and all deposit moneys will be forfeited.

As-Built Drawings Requirements

Immediately following the completion of construction, the Developer and/or Property Owner shall furnish this office with a set of As-Built Drawings corrected to indicate as-built conditions. Upon approval of these drawings, the Developer and/or Property Owner shall submit one (1) set of reproducible drawings and one digital copy of the as-built construction drawings.

The following information shall be required on the as-built drawing and digital copy of the construction plan of the drain:

1. Cover sheet, which includes:
    a. Drain Name
    b. Location map with north arrow
    c. Drainage District (Property) legal description

   d. Storm sewer pipe manufacturer (type, class & joint)
   e. Manhole manufacturer
   f. Casting type and manufacturer
   g. Fitting type, class and manufacturer
2. General Site/Utility Plan with boundary designation
3. Grading Plan, which includes:
   a. Storm sewer as-built rim elevations
   b. As-built contours of all detention or retention basins and SMPs
   c. The location and permanent easement of all basin access drives
4. Plan and Profile views of all storm sewer 12” diameter and larger, which includes:
   a. As-built pipe length and slope
   b. As-built rim and invert elevations
   c. Show the sump pump lead locations on the plan view
   d. Road culverts with as-built information
   e. Top of pipe or invert elevation of the utility for all utility crossings. There should be a minimum of 18” clearance between the storm sewer and the utility
   f. Note any special bedding, undercutting or piling extent and depth
   g. The term AB should follow all verifications
5. Drainage Area Map Sheet
6. Hydraulic calculations for storm sewer pipe and design calculations for all detention or retention basins, basin overflow structures and drainage swales. The as-built volume of all basins must be calculated, and the operations and maintenance tables for each SMP must be included

The as-built plans must be submitted and approved prior to the third inspection being scheduled.

Agreement to Establish a County Drain

Upon approval of the third inspection and acceptance of the as-built drawings by the WRC, the Developer and/or Property Owner of Record must enter into an agreement to establish the new County Drain or Branch Drain of an existing legally established County Drain. A district enlargement may also be necessary for the Branch Drain. The Developer and/or Property Owner must provide this office with a copy of the Title Policy or other proof of ownership. A metes and bounds property description with closure and Sidwell numbers and the names, titles, addresses and companies of the people who will execute the Agreement shall also be submitted.

Once the WRC has received the above information, WRC will prepare an Agreement for signature by the involved parties. After the Agreement has been signed by all parties and notarized, WRC will have the Agreement recorded with the Oakland County Clerk’s Office. Until the Agreement is executed and recorded, the stormwater management system is the responsibility of the Developer and/or Property Owner.

Part K: Subdivisions – Sites to be Platted Under Act 288

Preliminary Plat

A preliminary or tentative plan showing the layout of the area intended to be platted shall be submitted by the Proprietor. This plan shall be prepared under the direction of and sealed by a registered professional engineer. The plan shall be drawn to a standard engineering scale no smaller than 1" = 100' and the sheet(s) of paper must not be larger than 24” x 36”. This preliminary plan is what the Subdivision Control Act of 1967 refers to in Section 111 as a "preliminary plat".

The WRC will review the grading plan for sites that will be platted under Act 288 and a subdivision or site condominium included in the Chapter 18 Drain program. Positive drainage is required. Final lot grading inspection is under the jurisdiction of the local municipality. See **APPENDIX B: LOT GRADING** for details.

Section 114, Sub-section (3) of the Subdivision Control Act of 1967 requires that the Water Resources Commissioner approve or reject preliminary plats within 30 days of their receipt.

Three copies of the preliminary plat, prepared in accordance with the following requirements, shall be submitted with a letter of transmittal requesting that the preliminary plan be reviewed and, if found satisfactory, approved. The names of the Proprietor and engineering or surveying firm with mailing addresses, telephone, e-mail, and fax numbers for each shall be included with the transmittal.

The preliminary plat shall include:

1. The location of the proposed subdivision with reference to the section and part of section in which the parcel is situated, the name of the township, city or village, a proposed legal description of the site, the number of acres proposed to be platted and a location map with north arrow.
2. The proposed street and alley layout and approximate lot and plat dimensions.
3. All on-site and off-site pertinent factors, the existence and description of which might be of value in determining the overall requirements for the subdivision, such as:
    a. Adjoining roads, subdivisions, and parcels.
    b. Railroads.
    c. High-tension tower lines, underground transmission lines and gas pipelines.
    d. Cemeteries and parks.
    e. Rivers, natural water courses, county drains, lagoons, slips, waterways, streams, lakes, bays, canals, wetlands, wetland boundaries and floodplains.
    f. Existing utilities; storm drains, sanitary sewers, water main, telephone, cable, or fiber optic lines.
    g. Existing and proposed easements for all drainage facilities, including SMP’s and buffer strips.
4. Contour information in two-foot intervals with North American Vertical Datum of 1988 (NAVD 88), or most current national datum, shall be shown on the same plan, otherwise it shall be submitted on a separate sheet.

5. A drainage map, using a United States Geological Survey (USGS) topographic map, or equivalent, that shows the existing drainage area and flow patterns and indicates the proposed drainage pattern.

Inasmuch as improper utility easement location can result in a change in plat layout, the Proprietor is advised to consult with the respective utility companies before presentation of the preliminary plan for approval.

In the case where the Proprietor wishes to subdivide a given area but wishes to begin with only a portion of the total area, the original plan shall include the proposed general layout for the entire area. The part that is proposed to be subdivided first shall be clearly superimposed upon the overall plan in order to clearly illustrate the method of development which the Proprietor intends to follow. Each subsequent plat shall follow the same procedure until the entire area controlled by the Proprietor is subdivided. The final acceptance of a subdivision that is a partial development of a larger general layout does not automatically insure the final acceptance of the overall layout. The intent is to permit some flexibility in the overall layout if future conditions make it desirable or necessary to make any changes.

If the proposed preliminary plan as submitted meets with all the requirements, one approved copy of the preliminary plan will be returned. Approval of the preliminary plan is recommended before proceeding with the preparation of final construction plans. If the proposed plan is not approved as originally submitted, the Commissioner notifies the Proprietor in writing setting forth the reasons for withholding approval and requests that the necessary changes be made, and the revised layout resubmitted.

In accordance with Section 560.120 of Act 288, the preliminary plat approval is valid for two years. If construction plans have not been submitted within that time, a new preliminary plat must be submitted and approved. The two-year period may be extended if applied for by the proprietor and approved by the Water Resources Commissioner in writing.

Conceptual Plan Review Requirements

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

A brief drainage narrative describing the proposed stormwater management system.

On-site drainage infrastructure.

Off-site drainage patterns of adjacent properties.

Evidence of off-site outlet adequacy by means of certification. See Engineer's Certificate of Outlet in APPENDIX G: ENGINEER'S CERTIFICATE OF OUTLET FOR PROPOSED CHAPTER 18 DRAINS.

1. Calculations determining the detention or retention volume requirements for the development.
    a. Proposed topography for the detention or retention basin(s) in one-foot intervals.
    b. Known environmental concerns and "Due Care" plans.

c. Calculations verifying that the soils provide the percolation rate required for the selected SMPs.

2. Schematic layout for the proposed drainage collection system.
3. Evidence of in-situ soil permeability (including soil types and infiltration testing), prevailing groundwater levels, and the location of proposed SMPs.
4. Soil types and areas of each soil based on USDA Soil Conservation Service classification system. (Please note that this is *not* a substitute for geotechnical investigations to demonstrate in-situ soil permeability).
5. Existing natural features, including wetlands and woodland areas.
6. Limits of disturbance (including consideration of topographical requirements for excavation).
7. Existing FEMA flood zones (Zone A or AE), if applicable.
8. If the development is proposed in an area where flooding problems exist or are anticipated at the site, on adjacent properties or downstream, include a plan for how these issues will be addressed.

After the above items, the WRC will determine if the submittal is sufficient for conceptual approval. The submittal must be complete, correct, and feasible in order to be conceptually approved. If it is determined that the information submitted is insufficient the WRC will advise the applicant of the deficiencies.

Application for Review

An application shall be submitted by the Owner/Developer or the Design Engineer on behalf of the Owner/Developer through WRC's **EnerGov Permit Portal**. Application for review shall be made prior to the start of any work requiring a permit from WRC.

For project sites that will be developed in phases, an application is required for the initial work and new applications will be required for additional work not indicated on the original application.

WRC will perform a cursory review of the plans and will advise the applicant if an application fee is required. The total review, permit, and inspection fees will be determined upon completion of the review.

The review period begins upon the receipt of a completed application, plans and application fees.

Drainage Requirements

The preliminary plat must include the general drainage scheme for the proposed subdivision, or the plan will be rejected. The general drainage scheme shall indicate how storm drainage will be provided and where it will outlet. Preliminary calculations for detention and contributing off-site flow must be included on the plan. Additionally, the preliminary plat shall indicate locations of proposed SMP's, soil types and percolation rate(s).

Drainage proposed for subdivisions shall conform to established County Drain districts, existing natural drainage patterns and community master plans. The design shall consider the effect that the drainage proposed in the subdivision has upon the entire drainage basin.

The preliminary plat shall indicate in general, on a USGS topographic map, any drainage originating outside of the subdivision limits which has previously flowed onto or across the

subdivision, as well as any natural watercourses and County Drains that traverse or abut the subdivision.

The preliminary plat shall indicate in general any proposed onsite and/or offsite facilities, proposed or existing, required to conduct the drainage to an adequate outlet.

The Water Resources Commissioner's office is not responsible for roadside ditches. Road drainage ditches are under the jurisdiction of the Road Commission for Oakland County (RCOC) or other authority. Any drainage plan that proposes to outlet storm water to a road ditch must be approved by the RCOC or authority that has jurisdiction.

The Water Resources Commissioner shall require that the developer provide assurance of adequate maintenance and inspection of the installation of both the external and internal storm drainage facilities.

Easement Requirements

The following minimum easement widths are required for all storm drainage facilities within the boundaries of the subdivision:

1. Open drains and watercourses:
    a. The extreme width of the drain or watercourse plus 15 feet from top of bank on both sides of the channel.
2. Enclosed drains:
    a. A minimum of twenty (20) feet centered on the centerline of the pipe. However, larger pipe size, certain soil conditions, or depth of pipe may require larger easements.
3. Rear yard drains:
    a. For pipe sizes less than 12 inches in diameter, a minimum of twelve (12) feet centered on the centerline of the pipe.
4. Pump stations, detention/retention basins and other storm drainage facilities shall have sufficient easement area to allow for operation and maintenance of the entire facility, including freeboard area, the banks, and any berms at the top of the banks.
5. SMPs and buffer strips shall have adequate easements to maintain and/or replace the device.

Easement widths for legally established County Drains shall be determined by the WRC. In general, these will conform to the above referenced requirements. Additional easements may be required by the Water Resources Commissioner's office should soil, construction conditions or other circumstances so warrant.

Easement information shall be shown on the preliminary plan, final construction plans and final plat.

The wording relative to easement information shown on the final plat shall be as specifically required by the Water Resources Commissioner's office. All County Drain easements shall be labeled as follows: "Permanent private easement for the NAME County Drain". In Addition, restrictive deed covenants for the development shall include county drain language as described in the appendix.

WRC reserves the right to modify easement requirements at its discretion.

Subdivision Construction Plans

The Proprietor will submit final construction plans that have been prepared under the direction of, and sealed by, a Professional Engineer licensed in the State of Michigan with a completed application form. The Water Resources Commissioner's Office will review the plans for adequacy of stormwater management design to ensure that the proposed storm water drainage system has the capacity to handle all contributing flow without diminution of the existing off-site natural drainage patterns.

One set of complete, electronic final construction plans shall be submitted. The plans must be drawn to a scale not smaller than 1" = 50' on sheets no larger than 24" x 36" and designed in accordance with the design criteria presented herein.

Required Information

The plans should include, at minimum, the following:

1. A cover sheet which includes a site legal description and location map with north arrow and the number of acres proposed to be platted. For phased developments, clearly indicate the phase limits and the number of acres in each phase.
2. Subdivision layout of lots, roads, and all existing and proposed easements.
3. Plans, profiles and details of all road and storm sewers. The storm sewer details will include type and class and size of the pipe, length of run, percent of slope, invert elevations, rim elevations, and profile of the hydraulic gradient.
4. A description of the drainage course that will be utilized as the stormwater outlet and evidence that it is adequate for the proposed discharge. It is noted that controlling flow to a rate that is equal to or below the pre-development rate may not be considered to be evidence of adequacy. The Engineer's Certificate of Outlet must be provided, including the signature and seal of the professional engineer responsible for determining adequacy.
5. Plans and details of the soil erosion and sedimentation control measures. Indicate which measures are temporary or permanent and the party responsible for maintaining the control measures.
6. Plans, cross-section views and details of the detention or retention basins and the outlet. If an existing basin on or off-site will be used, then as-built information must be provided.
7. Topographic map or maps at two-foot contour intervals with North American Vertical Datum of 1988 (NAVD 88), or most current national datum, showing existing topography and proposed grades of the entire area to be subdivided, as well as offsite topography for at least 150' of the adjoining property to the extent that off-site contributing flow can be determined. All off-site contributing flow must be accommodated. This map or maps shall also show all existing watercourses, lakes, and swamps.
8. Calculations, design data and criteria used for sizing all infiltration facilities, drainage structures, open channels and retention/detention facilities including curve numbers or weighted runoff coefficient calculations.
9. Storm drain calculations indicating the number of acres, calculated to the nearest tenth of an acre, contributing to each specific inlet/outlet, the calculated hydraulic gradient elevation, maximum flow in ft^3/sec and the flow velocities for enclosed systems. The

calculations shall also include detention/ retention and runoff coefficient calculations as well as design calculations for all drainage swales and overflow structures. Overflow structures must be sized to pass all contributing off-site flow.

10. Specifications governing construction, i.e. material specifications, pipe bedding, construction notes, compaction requirements, etc.
11. Maximum flow in cubic feet per second for both the 10-year and 100-year recurrence interval storm events.
12. Flow velocities for the 10-year recurrence interval storm event.
13. Locations of all drain fields and of all expansion areas. Drain fields shall not be located within drainage easements.
14. Plans and details of proposed infiltration facilities with soil test pits or other testing methods detailed elsewhere in these rules, to verify that the facilities will function per the proposed design.
15. Plans and details of proposed retention/detention facilities. Soil borings may be required at the sites of these facilities.
16. A drainage area map, overlaid onto a copy of the site grading plan, which clearly shows the sub-areas tributary to each drainage structure, SMP and/or retention/detention facility, including acreage curve number (CN) and runoff coefficient (C factor) for each sub-area.
17. Plans, profiles, and details of all stormwater management system including but not limited to the following:
    a. Porous Pavement
    b. Dry Wells
    c. Structural Infiltration Basins
    d. Subsurface Infiltration Beds
    e. Infiltration Trenches
    f. Vegetated Filter Strips
    g. Bioretention Systems/Bioswales (Rain Gardens)
    h. Green Roofs
    i. Water Reuse
    j. Retention/Detention Facilities
18. Engineer’s certificate attesting to the infiltration rate of the soils being used for SMPs.
19. Details of all drainage structures including but not limited to the following:
    a. Manholes
    b. Catch basins
    c. Inlets
    d. Outlet structures

e. Overflow structures

f. Check dams

1. A Stormwater Management Operation and Maintenance Agreement, plan, and a proposed schedule for the perpetual maintenance of the complete storm drainage system. Indicate who will be the primary party responsible (i.e. municipality or homeowners' association) for the maintenance. If a Homeowners Association will be the primary party responsible for maintenance of the stormwater system, an appropriate governmental unit shall be named as having underlining authority in perpetuity for overseeing the maintenance of the system, including the responsibility to perform maintenance in the event the Homeowners Association fails to do so. The responsibility for maintenance of the stormwater system shall be included in the subdivision deed restrictions and recorded with the plat. An example of a Stormwater Management Operation and Maintenance Agreement may be found in Appendix F. A copy of the subdivision deed restrictions and executed Agreement must be submitted to the Water Resources Commissioner prior to construction plan approval.

Review Time

The Proprietor shall prepare and submit a preliminary plat and final construction plans to WRC prior to submitting a final plat for approval. WRC shall tentatively approve or reject the preliminary plat within 30 days. A preliminary plat must be submitted and approved prior to submitting the final construction plans. Approval of the preliminary plat and final construction plans is required prior to the Water Resources Commissioner signing the final plat. The construction plan approval is valid for one (1) year. The one-year period may be extended if applied for by the proprietor and approved by WRC in writing.

Changes to the Plans

Approval of the final construction plans is intended to be final approval, and the actual signing of the plat is only a formality, as long as there are no changes in the final construction plans from what was approved. If either the Proprietor or the Water Resources Commissioner find it advantageous to make changes before the plat is presented to the Water Resources Commissioner for signature, such changes can be made, provided that the same procedures outlined above are repeated with each change in the layout. The Proprietor is reminded that approval of the proposed subdivision by the local governing body is also required under the Plat Act. Such changes shall be incorporated in the layout and revised construction plans shall be resubmitted even though the original layout may have already been approved by the Water Resources Commissioner. If the Proprietor does not present his plat to the Water Resources Commissioner for approval within a period of one year after receiving approval of the final construction plans, it may be necessary that he resubmit the construction plans for review in the light of new information which may have become available during the interim.

Final Plat

The Proprietor shall submit the final plat to the Water Resources Commissioner for certification. The plat will be reviewed for accurate drainage easements and equivalence with the approved construction plans. If the Commissioner approves the plat, he will affix his signature to it and the plat will be executed. If the Water Resources Commissioner rejects the plat, written notice of such rejection and the reasons therefore are given to the Proprietor within ten days.

Prior to the Proprietor submitting the final plat for certification, the following is required:

1. Approval of the preliminary plat.
2. Approval of the final construction plans.
3. Assurance of adequate maintenance and inspection of the installation of both the external and internal storm drainage facilities.
4. A soil erosion and sedimentation control permit under Part 91 of Act 451 of the Public Acts of 1994 as amended.
5. Payment by the Proprietor of the plat review fee, according to the latest schedule posted on WRC's website: www.oakgov.com/water.
6. A minimum, non-refundable application fee is required upon submittal of the preliminary plat and the construction plans.
7. Easements:
    a. Easement provisions shall conform to the widths indicated in "Preliminary Plat Easement Requirements" of this Section.
    b. All drainage easements, including freeboard, SMPs and buffer strips, shall be so designated on the plans as well as on the plat.
    c. All existing easements are to be shown and identified on the plat including the Liber and Page.
    d. Existing County Drain easements shall be indicated on the plans as well as the plat and shall be designated as "XX feet wide easement for the "Name" (County) Drain as recorded in Liber___ , Page___".
    e. In cases where storm water is discharged to a drain or watercourse on adjoining private property, an improvement to the drain and an agreement with the property owner may be necessary. An off-site drainage easement will be required if:
        1. The watercourse is not depicted as a blue line on a USGS map.
        2. It is not indicated on the MIRIS map.
        3. The watercourse is not considered wetlands by the governing municipality.

Part L: Mobile Home Developments

Public Act 96 of 1987, The Mobile Home Commission Act, requires a developer of a Mobile Home Park to submit a preliminary plan to the Water Resources Commissioner.

Preliminary Plan

1. The preliminary plan shall include the location, layout, general design, and a general description of the project. The following information shall be submitted for review:
2. Calculations, design data and criteria used for sizing all infiltration facilities, drainage structures, channels and retention/detention facilities including curve numbers or weighted runoff coefficient calculations.
3. Plans and details of proposed infiltration facilities with soil test pits or other testing methods detailed elsewhere in these rules, to verify that the facilities will function per the proposed design.
4. Plans and details of proposed retention/detention facilities. Soil borings may be required at the sites of these facilities.

Outlet Drainage

The Water Resources Commissioner must review and may approve the outlet drainage for the Mobile Home Park. The design requirements covered in these standards will be used for this review. All pertinent design calculations must be submitted. The interior drainage within the park will not be reviewed by this office unless the park storm drain system is to be established as a County Drain under Chapter 18 of the Drain Code.

WRC may approve or reject preliminary plans within 60 days of their receipt; otherwise the plan is considered approved.

Mobile home park construction plans are reviewed by the Mobile Home Commission.

Appendices

Appendix A: Terms and Definitions

100-Year Storm: A rainfall depth that has a 1% chance of being exceeded in a given year.

10-year Storm: A rainfall depth that has a 10% chance of being exceeded in a given year.

1-year Storm: A rainfall depth that has a 100% chance of being exceeded in a given year.

90th Percentile Storm: A rainfall depth in which 90 percent of the rainfall events that produce runoff will be less than or equal to this depth.

Aquatic Bench or Safety Shelf: A bench, usually 4-feet to 5-feet wide, that is constructed around the inside perimeter of a permanent pool with depths that range from 0 inches to 12 inches. Typically vegetated with emergent plants, the bench augments pollutant removal, provides habitat, conceals trash, changes in water level, and enhances safety.

CFS: Cubic feet per second.

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

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

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

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

County Drain: Drains established pursuant to the Michigan Drain Code of 1956, MCL 280.1 et seq., as amended, that are under the jurisdiction of the WRC.

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

Design Storm: The rainfall event used as the basis of design for stormwater drainage facilities.

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

Detention System: A component of a stormwater management system, either aboveground or belowground, that detains stormwater and stormwater runoff. Detention systems can be classified as follows:

1. **Dry Detention Basin:** A basin that remains dry except for short periods following rain storms or snow melt events.

2. **Wet Detention Basin:** A basin that contains a permanent pool of water that will effectively remove nutrients in addition to other pollutants.
3. **Underground Detention System:** One or more underground pipes and/or other structures that are utilized as a detention system.
4. **Constructed Wetland:** An open detention basin that uses a variety of water depths and wetland plants to provide pollutant removal and provide temporary storage of stormwater runoff to prevent downstream flooding and the attenuation of runoff peaks.

Discharge: The flow rate of water passing through the outlet at a given time, usually expressed as cubic feet per second (CFS).

Disturbed Area: An area where human activity has removed or altered the natural vegetative soil cover and the soil is susceptible to erosion.

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

Easement: A legal right, granted by a property owner to another entity, allowing that entity to make limited use of the property involved for a specific purpose. Easements are recorded on the title to the land and transfer with the sale of land.

Emergency Spillway: A channel constructed in the embankment of an open detention or retention basin that is used to control flows in excess of the overflow structure capacity to prevent erosion of the berm.

Floodplain: For a given flood event, that area of land adjoining a continuous watercourse that has been covered temporarily by water. This design standard, the term floodplain includes all physical floodplains weather or not they have been officially mapped by FEMA.

Flow Path: The distance that a parcel of water travels through a stormwater detention pond or wetland. It is defined as the distance between the inlet and outlet, divided by the average width. [defines the time of concentration calculation] – or just move it to the Tc definition.

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

Freeboard: The vertical distance from the design water level to the top of the embankment of an open detention basin or retention basin.

Groundwater Table: The uppermost extent of naturally existing water beneath the earth's surface between saturated soil particles and rock that supplies wells and springs. At least two feet of separation is required between the normal groundwater elevation and the bottom of the bioretention filter media.

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

Infiltration Rate: The rate of infiltration (inches/hour) of in-situ soils at the base (subgrade) of a designed SMP, as determined by on-site soil evaluation certified by a Professional Engineer. Also referred to as Saturated Soil Conductivity (K_{sat}) or In-Situ Infiltration Rate.

Inlets: A stormwater collection structure designed to collect and convey surface water into the stormwater management system via a grated cover.

1. **Catch Basin:** A stormwater collection structure designed to collect and convey surface water from a paved area into the stormwater management system. A catch basin is normally 4 feet in diameter, is designed so that stormwater is collected via a grate cover and sediment falls to the bottom of the catch basin sump not directly into the storm drain.
2. **Rear Yard Catch Basin:** A stormwater collection structure designed to collect and convey surface water from an unpaved area into the stormwater management system. A rear yard catch basin is normally 4 feet in diameter, is designed so that stormwater is collected via a grate cover and sediment falls to the bottom of the catch basin sump not directly into the storm drain.

ISA-Certified Arborist: An arborist who is a professional tree care expert and has met the International Society of Arboriculture (ISA) requirements to become certified. An arborist can become certified if they have at least three-years experience in the tree care industry, have passed the exam and follow a code of ethics.

Level-Spreader: A device used to spread stormwater runoff uniformly over the ground surface as sheet flow to prevent concentrated, erosive flow from occurring, and to enhance infiltration.

Manhole: A stormwater structure designed to allow access into a closed conduit or other underground component of a stormwater management system. A manhole has a minimum diameter of 4 feet, is designed with a concrete flow channel at the bottom of the manhole and is fitted with a solid cover.

Manufactured Treatment Device: A pre-fabricated stormwater treatment structure utilizing settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to remove pollutants from stormwater runoff. The TSS removal rate for manufactured treatment devices must meet the NJDEP certification of the pollutant removal rates.

Maximum Extent Practicable: The implementation of best management practices by a public body to comply with an approved storm water management program as required by a national permit for a municipal separate storm sewer system, in a manner that is environmentally beneficial, technically feasible, and within the public body's legal authority.

MEP Area: On sites where infiltration is deemed impractical, the site is required to implement climate resilient SMPs whose area equates to 15% of the proposed impervious area. This 15% of the proposed impervious area is the MEP Area.

Municipal Separate Storm Sewer System (MS4): A system of conveyances that include, but are not limited to, catch basins, curbs, gutters, ditches, man-made channels, pipes, tunnels, and/or storm drains, and similar means of collecting or conveying runoff that do not connect with a wastewater collection system or treatment plant and instead discharge into Waters of the State.

Native Plants: Plant species that occurs naturally in the Southeast Michigan ecosystem, and habitat without direct or indirect human actions.

Natural Resources Conservation Service (NRCS): A federal agency of the United States Department of Agriculture (USDA) that works with farmers, ranchers, forest landowners, local and state governments, and other federal agencies to maintain healthy and productive working landscapes, and to protect our natural resources through conservation.

Non-structural SMPs: Stormwater runoff treatment techniques that use natural measures to reduce pollution levels that do not involve the construction or installation of devices (e.g. management actions). [site SMPs]

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

Outlet Control Structure: A horizontal pipe or series of pipes or vertical riser pipe designed to gradually release stormwater from a pond over a 24 to 48-hour interval.

Overflow Structure: A structure designed to allow unrestricted discharge from a component of a stormwater management system when the water level exceeds the design water level. [cross reference with emergency overflow]

Peak Discharge or Flow Rate: The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Permanent Pool: A pool in a wet detention system that provides additional removal of pollutants through settling and biological uptake.

Pervious or Porous Pavement: Traditionally impervious surfaces designed to allow stormwater to be stored in a layer of open graded stone and then infiltrate into the ground. (Pervious Concrete, Pervious Asphalt, Pervious Pavers)

Professional Engineer (PE): Only an engineer licensed in the State of Michigan may prepare, sign and seal, and submit engineering plans and drawings for approval. PEs must continuously demonstrate their competency and maintain and improve their skills by fulfilling the State of Michigan continuing education requirements.

Rational Method Formula: A technique for estimating peak flow rates at a particular location within a stormwater management system, based on the rainfall intensity, watershed time of concentration, and a runoff coefficient. Q = CIA

Release Rate: The rate of discharge in volume per unit time from a detention facility [reference PEAK flow and differentiate between pre-vs post and prescribed rate]

Retention Basin: The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass. Retention is discouraged under all circumstances unless there is no practical way to provide an outlet. Pre-treatment in the form of infiltration SMPs, sediment forebays, and mechanical separators is required for sediment removal.

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

Riser: A vertical pipe extending from the bottom of a basin that is used to control the discharge rate from the basin for a specified design storm. When this is used for soil erosion control during construction it is considered temporary.

Runoff: The excess portion of precipitation that does not infiltrate into the ground, but “runs off” into streams, water bodies, and/or storm sewers.

Runoff Coefficient: The ratio of the amount of water that is NOT absorbed by the surface to the total amount of water that falls during a rainstorm [define and differentiate from percent impervious] – cross reference with rational method. State when it is used and when CN is used.

Saturated Soil Conductivity (K_{sat}): The rate of infiltration (inches/hour) of in-situ soils at the base (subgrade) of a designed SMP, as determined by on-site soil evaluation certified by a Professional Engineer. Also referred to as Infiltration Rate or In-Situ Infiltration Rate.

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

Sheet Flow: Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel. Maximum allowable sheet flow length is 100 feet.

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

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

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

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

Stormwater: Water resulting from precipitation, including without limitation rain, snow, snowmelt. Also referred to as “runoff”.

Stormwater Management Plan: Ordinances, orders, rules, regulations, and other mechanisms that provide for the management of stormwater to prevent flooding and to ensure the restoration and/or protection of surface waters.

Stormwater Management Practice (SMP): Structural and non-structural practices and techniques that mitigate the adverse impacts caused by land development on water quality and/or water quantity.

1. **Buffer Strip:** A zone that is used for filtering direct stormwater and stormwater runoff into a stormwater management system and for providing maintenance access to a stormwater management system.
2. **Cistern:** Containers that store large quantities of stormwater above or below ground. They can be used on residential, commercial, and industrial sites.
3. **Dry well:** Small infiltration pits or trenches filled with aggregate that receive clean runoff primarily from rooftops.
4. **Green Infrastructure (GI):** Management of wet weather flows using SMPs that use or mimic natural processes and result in improved water quality, evapotranspiration, or infiltration. This is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits and reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.
5. **Green Roof:** Conventional rooftops that include a thin covering of vegetation allowing the roof to function more like a vegetated surface. The layer thickness varies between 2-6 inches and consists of vegetation, waterproofing, insulation, fabrics, growth media, and other synthetic components.

6. **Pervious Pavement:** An infiltration technique that combines stormwater infiltration, storage, and structural pavement that consists of a permeable surface underlain by a storage reservoir.
7. **Vegetated Filter Strip:** Uniformly graded vegetated surface located between pollutant source areas and downstream receiving waters.
8. **Vegetated Swale:** A conveyance, open to the atmosphere, consisting of a broad, shallow channel lined with vegetation to slow and filter stormwater runoff and promote infiltration. (Note: this swale has no in-soil storage)
9. **Bioretention:** A water quality practice that utilizes landscaping plantings and soil media to treat stormwater runoff by collecting it in shallow depressions before being absorbed by the soil and vegetation. There are three main types of bioretention.
    a. **Rain Garden:** A small, simple bioretention system associated with single family homes or small commercial development. This system has no regulated infiltration rate and as such only qualifies for the water quality requirement. However, as such this system does not require infiltration testing to construct or maintain.
    b. **Bioretention Basin:** A large bioretention system associated with commercial and industrial development. This system has water quality, volume reduction capabilities, and requires infiltration testing.

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

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

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

Tailwater: The depth of water at the downstream end of a culvert or crossing. [mention potential for tailwater to impact detention pond outlet]

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

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

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

Watercourse: A natural or artificial channel for flowing water.

Watershed: The complete area or region of land draining into a single outlet, watercourse, surface water, or closed conduit that is separate from other watersheds by a divide.

Waters of the State (Michigan): Any groundwater, lakes, including the Great Lakes bordering the state, rivers, streams, and all other water courses and bodies of water within the jurisdiction of the state including wetlands.

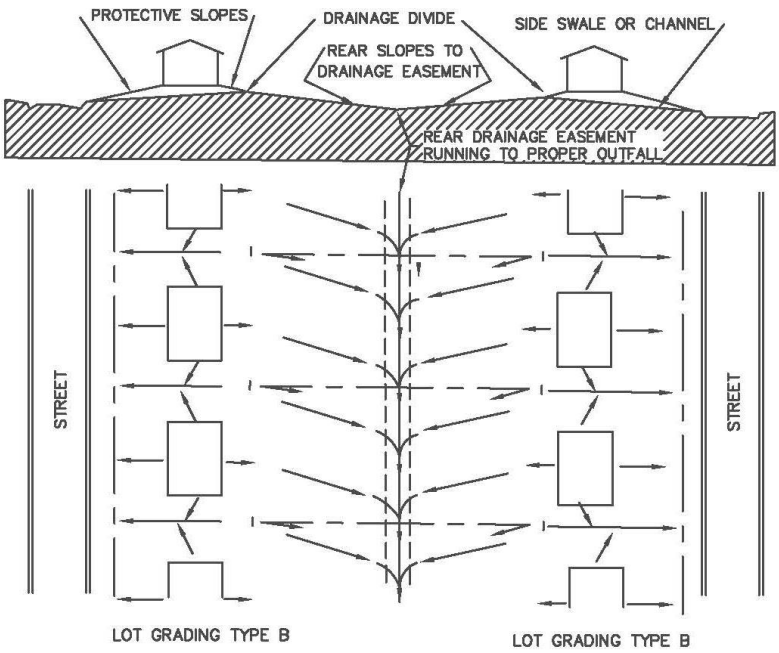
Weir: A structure that extends across the width of a body of water, channel, watercourse, or closed conduit, and is used to impound, measure, or in some way alter the flow of water through the channel.

Wetland: An area that is saturated by surface or groundwater with vegetation adapted for life under those soil conditions, such as swamps, bogs, fens, marshes and estuaries.

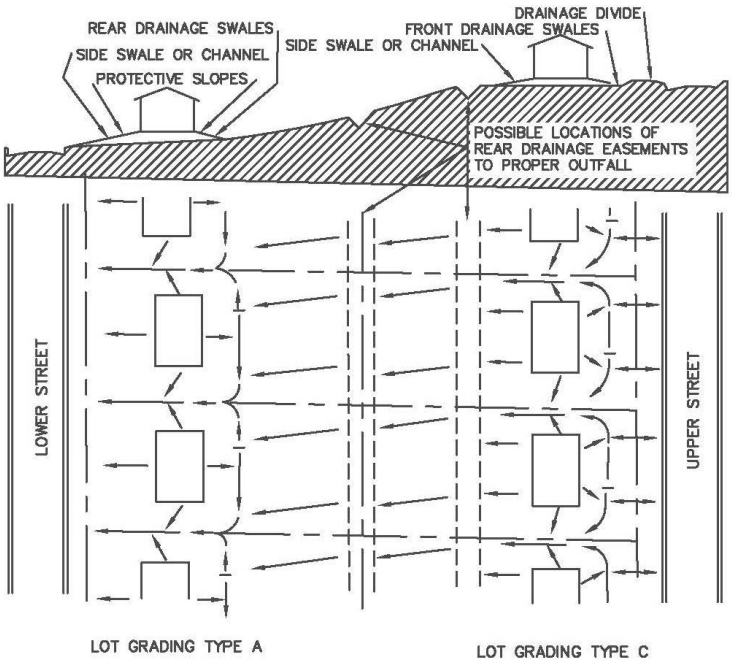
Appendix B: Lot Grading

The Oakland County Water Resources Commissioner will review the grading plan for sites that will be platted under Act 288 and a subdivision or site condominium included in the Chapter 18 Drain program. Positive drainage is required. Final lot grading inspection is under the jurisdiction of the local municipality. The minimum requirements are as follows:

1. The grading of the lot shall be such that surface runoff is directed away from homes and towards swales, ditches or drainage structures. Provision for drainage either by filling and grading or by providing some type of outlet shall be made for all areas within the proposed subdivision.
2. A proposed finished floor grade and proposed lot grading must be shown for each home or structure. A minimum of ½ foot of fall is required away from the home and between lots. Proposed grades may be indicated with spot grades or contours. A distinction between existing and proposed grades should be evident on the plans.
3. Where a walkout or daylight basement is proposed, sufficient grades should be shown at the location of the walkout to indicate positive drainage away from the walkout. Additional spot grades at the house corners and rear yard should be shown.
4. Where finished grades indicate a substantial amount of drainage across adjoining lots, a drainage swale of sufficient cross-section and slope shall be provided on the lot line to intercept this drainage.
5. Sufficient off-site topography must be shown to determine the extent of contributing runoff. Provisions must be made to accommodate the off-site contributing flow.
6. Lots that lie within a flood plain shall satisfy the EGLE and FEMA requirements for subdivisions within a flood plain. In no case will the filling of a lot be permitted if the flood plain is so restricted as to cause possible flooding or back up of the stream.



***Block Grading Type 4**: Valley Along Rear Lot Lines*



***Block Grading Type 3**: Steep Cross Slope*

Appendix C: Reference Materials

Site Plan Example 1

The example site is a proposed commercial development. Total development area of the site is 10.32 acres consisting of primarily HSG Type B soils under a mixture of impervious cover, turf grass, meadow and woods. Infiltration tests conducted on the site yielded an observed infiltration rate of 1 inch/hour. A minimum of one infiltration test per SMP location is required, but for this example, a single infiltration rate is applied. A mechanical separator or sediment forebay is not required given the use of infiltration SMPs for water quality treatment. The site has a 1% slope.

Area, A	10.32	acres
Proposed Impervious Acres	4.80	acres
Proposed Pervious Acres	5.52	acres
Infiltration Rate	2	in/hr
Runoff Coefficient, C	0.59	
100-yr peak intensity	6.31	in/hr

Infiltration Feasibility

Test pit infiltration tests were performed at the bottom of each proposed infiltration SMP and resulted in a 2 inch/hour infiltration rate for each SMP. No supplemental measures are required for infiltration SMPs at this site.

K_{sat} Values	
Ksat ≥ 0.50 in/hr	No supplemental measures are required for Infiltration SMPs to provide the infiltration volume
0.50 in/hr≥ Ksat ≥ 0.24 in/hr	Install supplemental measures, which may include subsoil amendment, or an underdrain placed at the top of the storage bed layer to ensure dewatering in the event underlying soils fail to provide adequate drawdown or dewatering time. If underdrains are selected, design shall allow stormwater to percolate through the soils first, with the underdrain serving as a secondary outlet, by placing the underdrain in the upper level of the SMP, with pipe perforations located along the underdrain invert.
Ksat ≤ 0.24 in/hr	Soils are not suitable for infiltration. Alternative volume reducing LID practices must be used to the MEP to reduce stormwater volume.

Land Use Summary

	Characteristic	Existing Conditions	Proposed Conditions
Pervious Area Land Use Data	Total Development Area (ac)	10.32	10.32
	Impervious Area (ac)	0	4.80
	Total Pervious Area (ac)	10.32	5.52
	Pervious Area Breakdown by Cover Type		
	Meadow/fallow/natural areas (non-cultivated)	4.00 acres	0 acres
	Predominant NRCS Soil Type (A, B, C, or D)	Type A	Type A
	Improved areas (turf grass, landscape, row crops)	2.32 acres	5.05 acres
	Predominant NRCS Soil Type (A, B, C, or D)	Type A	Type A
	Wooded Areas	4.00 acres	0 acres
	Predominant NRCS Soil Type (A, B, C, or D)	Type A	Type A
	Proposed Pond Area (acres)		0.47
	Required CPVC Volume (cubic feet)		28,733
	Provided CPVC Volume (cubic feet)		***29,400***
	Required ED Volume (cubic feet)		41,994
	Provided ED Volume (cubic feet)		***42,000***

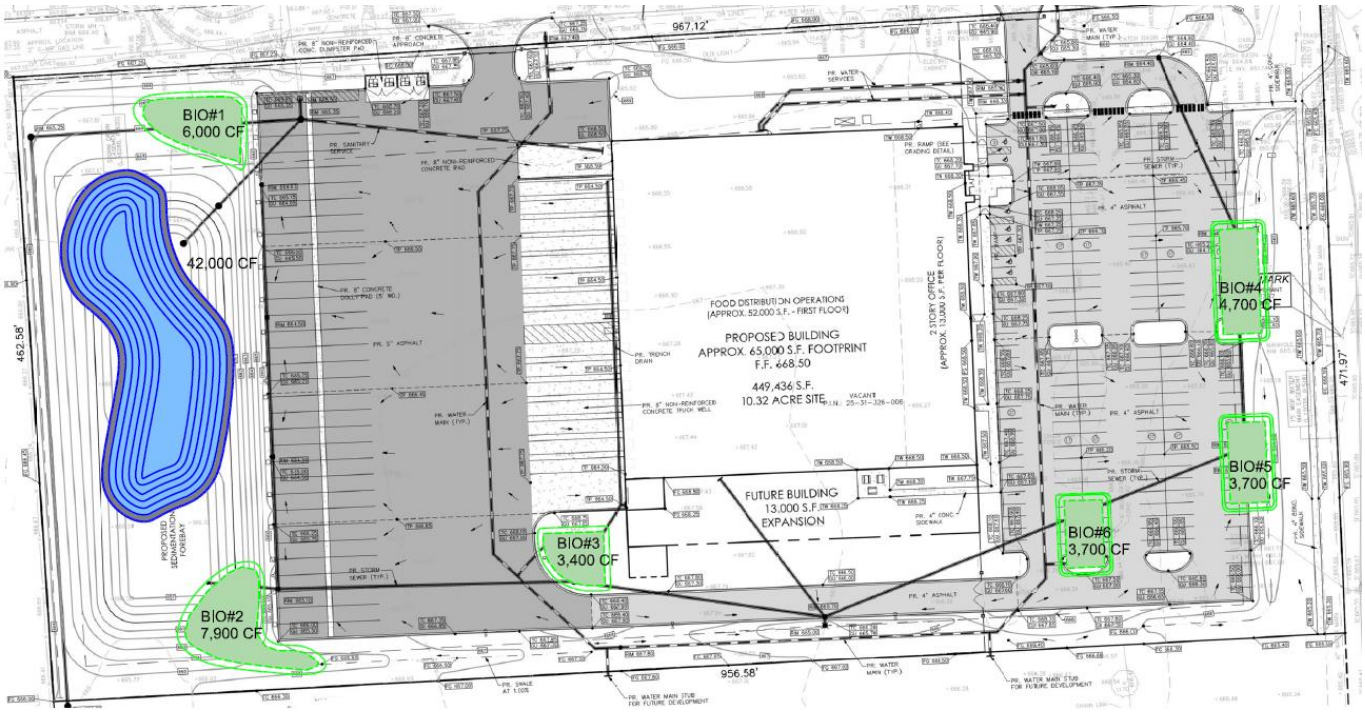


Figure 1 - Example 1 Commercial Site

C Values		
Green Space	HSG A	0.20
	HSG B	0.30
	HSG C	0.35
	HSG D	0.50
Impervious Areas		0.95
Water		1.00

Calculate the Composite Runoff Coefficient

$$C = \frac{\sum_{i=1}^{N}(A_i \times C_i)}{\sum_{i=1}^{N} A_i}$$

$$C = \frac{(4.80 \times 0.95) + (5.05 \times 0.20) + (0.47 \times 1)}{10.32} = 0.59$$

Calculate Time of Concentration

<u>Sheet Flow</u>

$$v = K \times S^{0.5}$$

$$v = 0.48 \times 1^{0.5} = 0.48\frac{ft}{s}$$

$$T_t = \frac{\mathrm{L}}{3600v}$$

$$T_t = \frac{120\ \mathrm{ft}}{3600\left(0.48\frac{ft}{s}\right)} = 0.0694\ hrs = 4.2\ min$$

Waterway Flow

$v = K \times S^{0.5}$

$v = 1.2 \times 1.3^{0.5} = 1.37 \frac{ft}{s}$

$T_t = \frac{\mathrm{L}}{3600v}$

$T_t = \frac{300\ \mathrm{ft}}{3600\left(1.37\frac{ft}{s}\right)} = 0.0609\ hrs = 3.7\ min$

Pipe Flow

$v = 3\frac{ft}{sec}$ (From pipe network calculations – not shown)

$T_t = \frac{\mathrm{L}}{3600v}$

$T_t = \frac{1300\ \mathrm{ft}}{3600\left(3\frac{ft}{s}\right)} = 0.1204\ hrs = 7.2\ min$

T_c = 4.2 min + 3.7 min + 7.2 min = 15.1 min

Calculate 100-year Peak Intensity

$I_{100} = \frac{83.3}{(T_c + 9.17)^{0.81}}$

T_c = 15.1 minutes

$I_{100} = \frac{83.3}{(15.1 + 9.17)^{0.81}} = 6.29\frac{in}{hr}$

Calculate Channel Protection Volume Required

$V_{CPVC} = 3{,}630\ x\ 1.30\ x\ C\ x\ A$

$V_{CPVC} = 3{,}360\ x\ 1.30\ x\ 0.59\ x\ 10.32\ acres = 28{,}733\ cubic\ feet$

Calculate Channel Protection Rate Control: Extended Detention Required

$V_{ED} = 6{,}897\ x\ C\ x\ A$

$V_{ED} = 6{,}897\ x\ 0.59\ x\ 10.32\ acres = 41{,}994\ cubic\ feet$

Calculate 100-year Peak Inflow

$Q_{100IN} = C\ x\ I_{100}\ x\ A$

$I_{100} = 6.29\frac{in}{hr}$ (Calculated on previous page)

$$Q_{100IN} = 0.59\ x\ 6.29\frac{in}{hr}\ x\ 10.32\ acres = 38.30\ cfs$$

Determine the Peak Allowable 100-year Discharge

Q_{100P} is the lesser of:

1. The restricted rate for the drain (ft^3/Acre)
2. The prorated share of the drain's capacity (ft^3/Acre)
3. The Variable Release Rate (Q_{VRR}) (ft^3/Acre)

Prior to commencing with site plan design, please contact the WRC Plan Review and Permitting Department to confirm if the Drain has a restricted release rate. In this example, it is assumed the drain capacity is capable of receiving the runoff from the site and the variable release rate will be utilized.

Calculate the Variable Release Rate

$$Q_{VRR} = 1.1055 - 0.206\ x\ \ln(A)$$

$$Q_{VRR} = 1.1055 - 0.206\ x\ \ln(10.32\ acres) = 0.625\frac{cfs}{acre}$$

$$Q_{100P} = Q_{VRR}\ x\ A$$

$$Q_{100P} = 0.625\frac{cfs}{acre}\ x\ 10.32\ acres = 6.45\ cfs$$

Calculate Storage Curve Factor

$$R = \ 0.206 - 0.15\ x\ \ln\left(\frac{Q_{100P}}{Q_{100IN}}\right)$$

$$R = \ 0.206 - 0.15\ x\ \ln\left(\frac{6.45\ cfs}{38.30\ cfs}\right) = 0.473$$

Calculate the 100-year Runoff

$$V_{100R} = 18{,}985\ x\ C\ x\ A$$

$$V_{100R} = 18{,}985\ x\ 0.59\ x\ 10.32\ acres = 115{,}596\ cubic\ feet$$

Calculate the 100-year Storage Volume

$$V_{100D} = V_{100R}\ x\ R$$

$R = 0.474$ (Calculated on Previous Page)

$V_{100D} = 115{,}596\ x\ 0.473$ = 54,677 cubic feet

The site plan must be designed to accommodate the following volumes:

- V_{CPVC}: 28,733 cubic feet
- V_{ED}: 41,994 cubic feet
- V_{100D}: 54,677 cubic feet

* If the volume control requirement is met, the CPVC volume can be subtracted from (credited against) the 100-year flood control volume.

Outlet Calculations

Note: If the CPRC volume is at or above the flood control volume, a single control (CPRC) is only for the orifice. Volume above the 100-year allowable will be controlled by the outlet pipe (overflow weir). Additionally, for pipe sizing downstream of the detention pond, supporting calculations would need to be provided (not shown here).

100-year Detention Orifice Calculations

For purposes of this example, h = 3.6 ft

$$Q_p = C_O \times A_O \times \sqrt{2 \times g \times h}$$

$$6.45\ cfs = 0.62 \times A_O \times \sqrt{2 \times 32.2\ \times\ 3.6}$$

$$A_O = 0.68\ sq\ ft = 97.92\ sq\ inches = \pi r^2$$

$$r = 5.58\ inches$$

0.62 used for standard orifice opening

h = total head on orifice in feet (100-Year Detention elevation – Extended Detention elevation)

~11” orifice opening will be needed

Extended Detention Orifice Design

For purposes of this example, h_{ED} = 5.0 ft

$$h_{ED} = Extended\ Detention\ Storage\ Elevation - Orifice\ Invert\ Elevation$$

$$H_{ED} = \frac{V_{ED}}{4{,}666 \times \sqrt{h_{ED}}} = \frac{41{,}994\ cubic\ ft}{4{,}666 \times \sqrt{5}} = 4.02$$

H_{ED} = Number of 1” holes needed to control the extended detention release rate

h_{ED} = Total head on the orifices (feet)

Use 4 – 1” orifices for the V_{ED}.

Infiltration SMP Calculations

Average Infiltration Area (Bioretention Cell 1)

$$A_t = \frac{A_1 + A_2}{2}$$

$$A_t = \frac{2{,}650\ sf + 3{,}500\ sf}{2} = 3{,}075\ square\ feet$$

Surface Storage Volume (Bioretention Cell 1)

$$V_{ss} = A_t\ x\ H$$

$V_{ss} = 3{,}075\ sf\ x\ 1\ ft = 3{,}075\ cubic\ feet$

Subsurface Storage Volume (Bioretention Cell 1)

$V_{soil} = h\ x\ SA\ x\ e$

Void ratio 0.30 (max)

$V_{soil} = 1.5\ ft\ x\ 3{,}075\ sf\ x\ 0.3 = 1{,}384\ cubic\ feet$

Infiltration Storage (Bioretention Cell 1)

$$V_i = \frac{K_{sat}\ x\ S_f\ x\ 6\ x\ A_t}{12in}$$

$$V_i = \frac{2\frac{in}{hr}\ x\ 0.5\ x\ 6\ x\ 3{,}075\ sf}{12in} = 1{,}538\ cubic\ feet$$

Bioretention Total Storage Volume (Bioretention Cell 1)

$V_{tbr} = V_{ss} + V_{subsurface} + V_i$

$V_{tbr} = 3{,}075\ cf + 1{,}384\ cf + 1{,}538\ cf = 5{,}997\ cubic\ feet$

Rounded to 6,000 cubic feet.

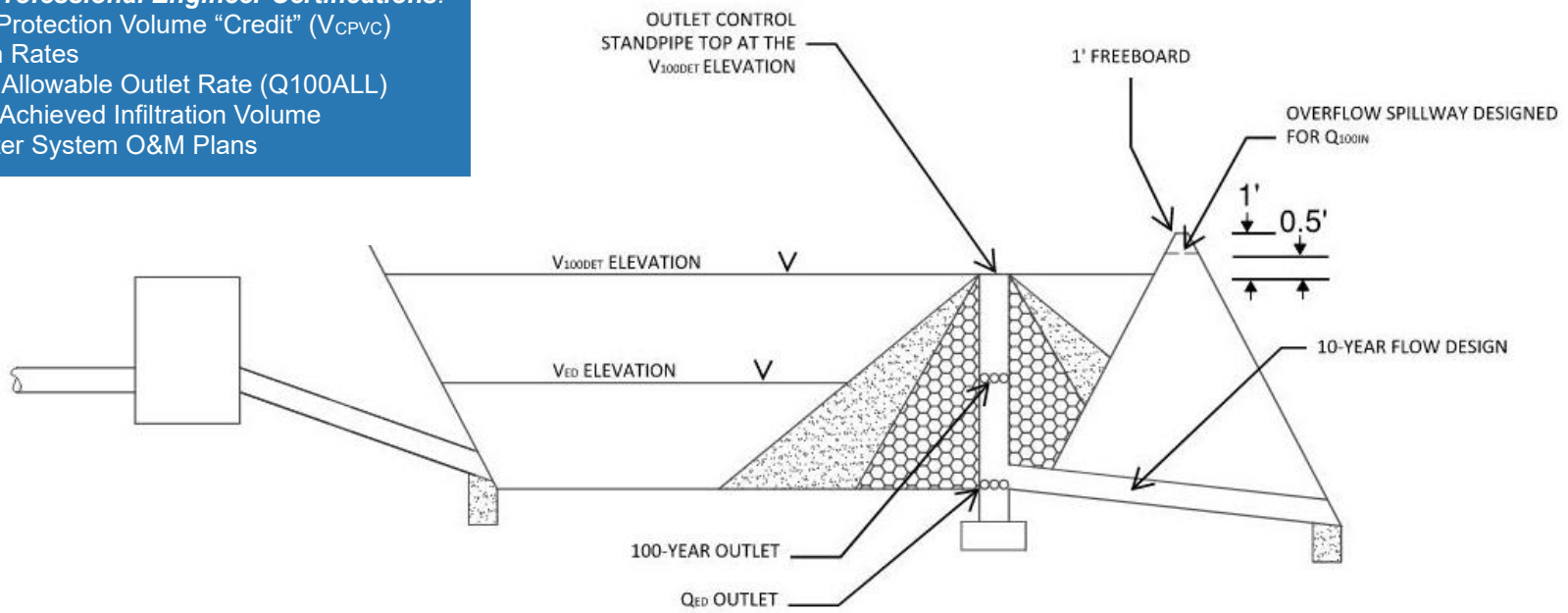
Summary of Bioretention Cell Storage

Location	Bottom Contour Area (SF)	Top Contour Area (SF)	Avg Area (SF)	Surface Storage (CF)	Soil Storage (CF)	Infiltration Storage (CF)	Total Storage (CF) (Rounded)
1	2,650	3,500	3,075	3,075	1,384	1,538	6,000
2	3,300	4,800	4,050	4,050	1,823	2,025	7,900
3	1,400	2,100	1,750	1,750	788	875	3,400
4	1,400	2,400	1,900	1,900	855	950	3,700
5	2,000	2,800	2,400	2,400	1,080	1,200	4,700
6	1,400	2,400	1,900	1,900	855	950	3,700
Total Volume Provided				**15,075**	**6,785**	**7,538**	**29,400**

Total volume provided by infiltration SMPs exceeds the required Channel Protection Volume (28,733 cf).

Typical Detention Basin with Mechanical Separator

Required Professional Engineer Certifications:
- Channel Protection Volume "Credit" (V_{CPVC})
- Infiltration Rates
- 100-Year Allowable Outlet Rate (Q100ALL)
- 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})

$Q_{WQ}= (C)(I_1)(A)$

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

$V_{ED}= (6,897)(C)(A)$

EXTENDED DETENTION OUTLET RATE

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

$H_{ED}=(V_{ED})/((4,666)(h)^{(1/2)})$

H_{ED}= NUMBER OF 1-INCH DEWATERING HOLES
h=TOTAL HEAD ON THE ORIFICES

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

$Q_{100IN}=(C)(I_{100})(A)$

$I = [(30.2033)(P^{0.2201})]/[(T_C + 9.1747)^{0.8069}]$

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

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

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

$Q_{VRR}=1.1055 - 0.206LN(A)$

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

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

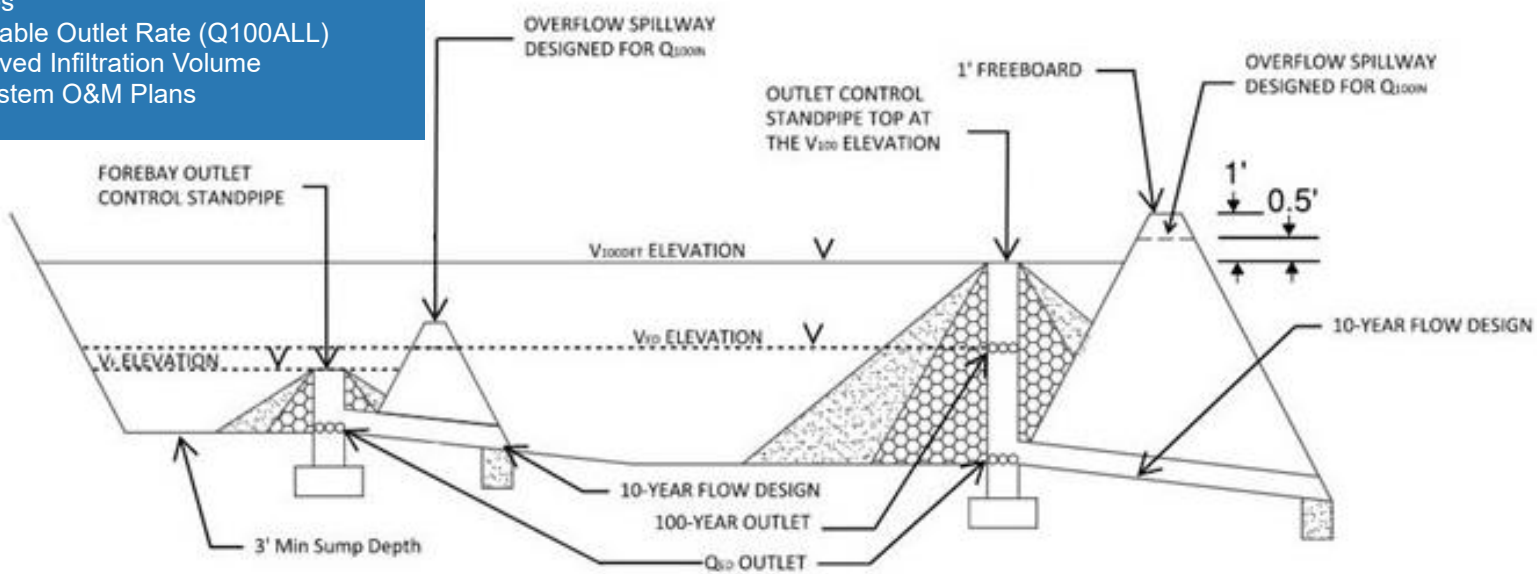
R=STORAGE CURVE FACTOR

$V_{100RUN}=(18,900)(C)(A)$

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

Typical Detention Basin with Forebay Cross Sections

Required Professional Engineer Certifications:
- Channel Protection Volume "Credit" (V_{CPVC})
- Infiltration Rates
- 100-Year Allowable Outlet Rate (Q100ALL)
- 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})

$Q_{WQ}= (C)(I_1)(A)$

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

$V_{ED}= (6,897)(C)(A)$

EXTENDED DETENTION OUTLET RATE

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

$H_{ED}=(V_{ED})/((4,666)(h)^{1/2})$

H_{ED}= NUMBER OF 1-INCH DEWATERING HOLES
h=TOTAL HEAD ON THE ORIFICES

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

$Q_{100IN}=(C)(I_{100})(A)$

$I = [(30.2033)(P^{0.2203})]/[(T_c + 9.1747)^{0.8093}]$

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

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

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

$Q_{VRR}=1.1055 - 0.206LN(A)$

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

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

R=STORAGE CURVE FACTOR

$V_{100RUN}=(18,900)(C)(A)$

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

Appendix D: Standard Variables

TC: Contributing Area Time of Concentration (Minutes)

A: Contributing Area (Acres)

C: Composite Post-Construction Runoff Coefficient for the Drainage Area

H_{ED}: Number of 1-inch Holes Required for Dewatering

Q_{ED}: Extended Detention Outlet Rate (CFS)

Q_{100IN}: 100-year Post-Construction Inlet Rate (CFS)

Q_{100ALL}: 100-year Allowable Outlet Rate (CFS) is the lesser of Q_R, Q_P, Q_{VRR}

Q_R: Restricted Outlet Rate (CFS) – Request from OCWRC office

Q_P: Pro-rated Share of the Drain Capacity (CFS)

Q_{VRR}: Variable Release Rate (CFS)

Q_{WQ}: 1-year Water Quality Design Rate for Mechanical Separators (CFS)

R: Storage Curve Factor

V_F: Forebay Volume (CF)

V_{ED}: Extended Detention Volume Required (CF)

V_{ED-P}: Extended Detention Volume Provided (CF)

V_{100IN}: 100-year Inlet Volume (CF)

V_{100DET}: 100-year Detention Volume (CF), where $V_{100DET} = V_{100RUN} \times R - V_{CP-C}$

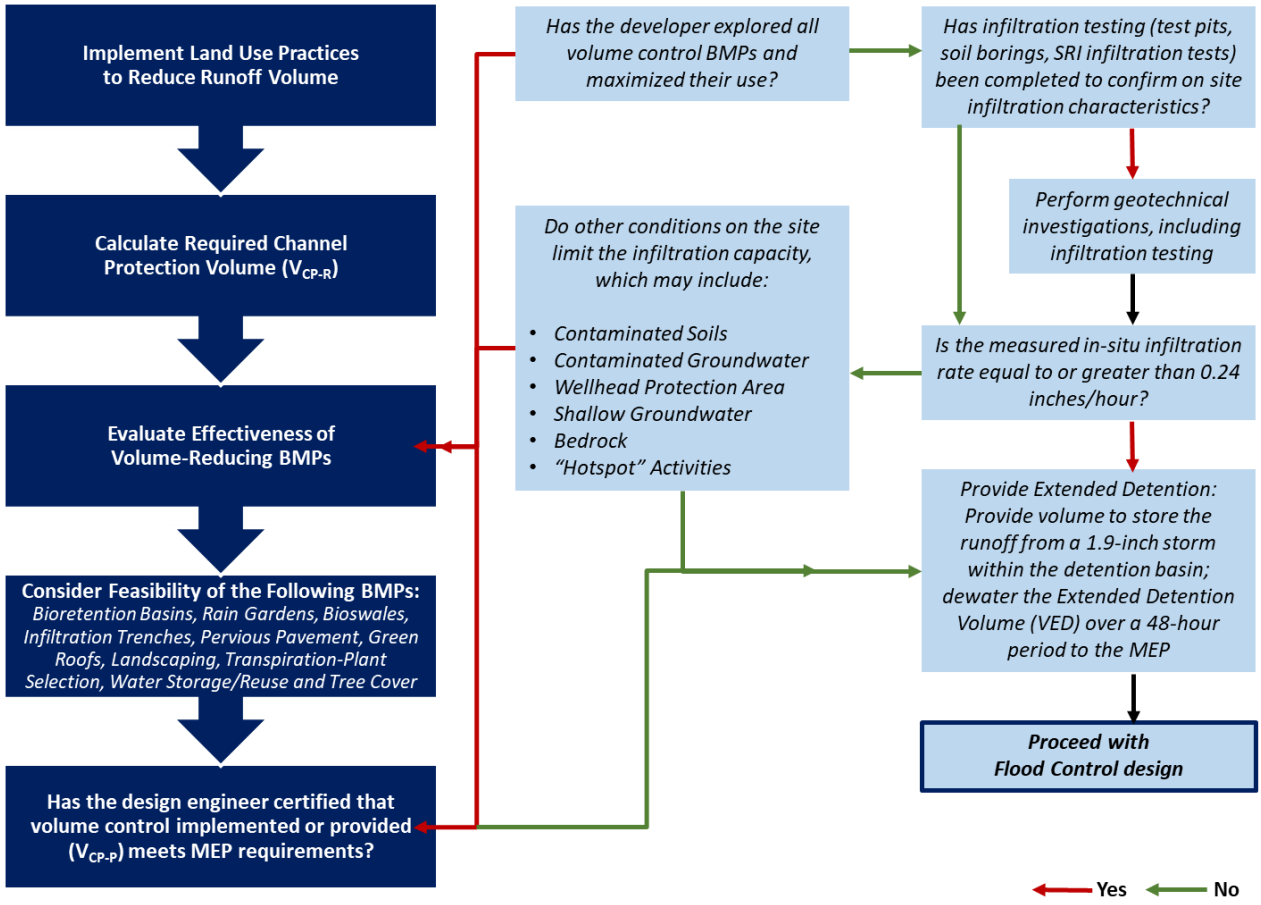
V_{CPVC}: Channel Protection Volume - Required (CF)

V_{CP-P}: Channel Protection Volume - Provided (CF)

V_{CP-C}: Channel Protection Volume - Credit (CF), where $V_{CP-C} = V_{CP-P}$ and $V_{CP-C} \leq V_{CPCR}$

V_{WQ}: Water Quality Volume (CF)

Appendix E: Channel Protection Flow Chart



Appendix F: Stormwater Management Operations and Maintenance Agreement Example

This Agreement is made on [DATE], by and between [Community Name], (hereinafter "Community") whose address is [address] and [Owner Name], whose address is [address], (hereinafter "Owner"). Community and Owner agree as follows:

Article I. The Subject Property.

1.1 Owner owns the property located at and commonly known as [address or general description] (hereinafter the "Subject Property"). The legal description of the Subject Property is set forth at ***Exhibit A***.

Article II. The Stormwater System.

2.1 Owner, in accordance with Oakland County Stormwater Standards and State Municipal Separate Storm Sewer System permit requirements, agrees to install and maintain a Stormwater System on the Subject Property in accordance with approved plans and conditions. The Stormwater System is set forth at ***Exhibit B***.

2.2 After construction has been verified and accepted by the Community for the Stormwater System, the Owner shall file with the Community the "as-built" documents showing the design and construction details and shall reference this Agreement.

2.3 The Stormwater System will be governed by the terms and conditions in this Agreement.

Article III. The Stormwater O&M Plan.

3.1 The Owner shall be solely responsible for the installation, maintenance, and repair of the Stormwater System, drainage easements, and associated landscaping identified in Exhibit B in accordance with the Stormwater Management Operations and Maintenance Plan, hereinafter the "Stormwater O&M Plan" set forth at ***Exhibit C*** to this Agreement.

3.2 The Stormwater O&M plan is subject to approval by the Community.

3.3 The Owner agrees that the Stormwater O&M Plan is intended to and will serve the Subject Property in perpetuity.

3.4 The Owner, at its expense, shall secure from any affected owners of land all easements and releases of right-of-way necessary for implementation of the Stormwater O&M Plan and shall record them with the Oakland 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 Community.

3.5 No alterations or changes to the Stormwater O&M Plan shall be permitted unless they are deemed to comply with this Agreement and are approved in writing by the Community.

3.6 The Owner 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 O&M Plan.

3.7 The Owner shall annually, by December 30th, provide to the Community records (logs, invoices, reports, data, etc.) of inspections, maintenance, and repair of the Stormwater System in compliance with the Stormwater O&M Plan.

3.8 The Community agrees to enforce compliance with the annual inspection, maintenance and repair records as set forth in 3.7 above, such enforcement may require an ordinance.

Article IV. Access and Enforcement.

4.1 The Community or its designee is authorized to access the property as necessary to conduct inspections of the Stormwater System, implication of the Stormwater O&M Plan, or drainage easements to ascertain compliance with the intent of this Agreement.

Upon written notification by the Community or their designee of required maintenance or repairs, the Owner shall complete the specified maintenance or repairs within a reasonable time frame determined by the Community. The Owner shall be liable for the failure to undertake any maintenance or repairs so that the public health, safety and welfare shall not be endangered nor the road improvement damaged.

4.2 If the Owner does not keep the Stormwater System in reasonable order and condition, or complete maintenance activities in accordance with the Stormwater O&M Plan, or the reporting required in 3.7 above, the Community is authorized, but not required, to perform the specified inspections, maintenance or repairs in order to preserve the intended functions of the Stormwater System and prevent the Stormwater System from becoming a threat to public health, safety, general welfare or the environment.

4.3 In the case of an emergency, as determined by the Community, no notice shall be required prior to the Community performing emergency maintenance or repairs. The Community may levy the costs and expenses of such inspections, maintenance or repairs against the Owner.

The Community, at the time of entering upon said Stormwater System for the purpose of maintenance or repair, may file a notice of lien in the office of the Register of Deeds of Oakland County upon the property affected by the lien. If said costs and expenses are not paid by the Owner, the Community may pursue the collection of same through appropriate court actions and in such a case, the Owner shall pay in addition to said costs and expenses all costs of litigation, including attorney fees.

4.4 The Owner hereby conveys to the Community an easement over, on and in the property described in Exhibit A for the purpose of access to the Stormwater System for the inspection, maintenance and repair thereof, should the Owner fail to properly inspect, maintain and repair the Stormwater System.

Article V. Term and Covenants.

5.1 The Owner agrees that this Agreement shall bind all current and future owners of the property.
The Owner agrees in the event that the Subject 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 System and Stormwater O&M Plan. 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 Subject Property.

5.2 The Owner agrees that the rights, obligations and responsibilities hereunder shall commence upon execution of the Agreement.

Article VI. The Memorandum.

6.1 The Owner shall record with the Oakland County Register of Deeds a Memorandum of Stormwater Management Operations and Maintenance Agreement which serves as notice of this Agreement in a title search, the template for which is set forth at ***Exhibit D*** to this Agreement.

Article VII. Claims and Authority.

The Owner, its agents, representatives, successors and assigns shall defend, indemnify and hold Community harmless from and against any claims, demands, actions, damages, injuries, costs or expenses of any nature whatsoever, hereinafter “Claims”, fixed or contingent, known or unknown, arising out of or in any way connected with the design, construction, use, maintenance, repair or operation (or omissions in such regard) of the Stormwater System, appurtenances, connections and attachments thereto which are the subject of this Agreement. This indemnity and hold harmless shall include any costs, expenses and attorney fees incurred by Community in connection with such Claims or the enforcement of this Agreement.

7.1 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.

IN WITNESS WHEREOF, the Owner and Community have executed this agreement on the day and year first above written.

Owner

By: _____

Its: _____

STATE OF MICHIGAN)

)ss.

_____ COUNTY)

The foregoing instrument was acknowledged before me on this_____ day of , 20 ___, by _____, the of _____.

_____

Notary Public

Community

By: _____

Its: _____

STATE OF MICHIGAN)

)ss.

_____ COUNTY)

The foregoing instrument was acknowledged before me on this_____ day of , 20 ___, by _____, the of _____.

_____

Notary Public

Explanation of Exhibits

Exhibit A – Legal Description: Provide a legal description and reduced copy map to identify the land parcel(s) affected by this Agreement. This exhibit must be customized for each site. It must include a reference to a Subdivision Plat, Certified Survey number, or Condominium Plat, and a map to illustrate the affected parcel(s).

Exhibit B – Stormwater System Description and Map: Provide a written description and location map of the Stormwater System. This exhibit must be customized for each site. Map scale must be sufficiently large enough to show necessary detail.

Exhibit C – Stormwater O&M Plan: This exhibit explains the basic function of the stormwater management operation and maintenance plan, schedule, and budget providing the minimum specific maintenance activities and frequencies for each practice. The minimum elements of this exhibit include a description of the drainage area and the installed Stormwater System, a description of the specific maintenance activities which should include the following in addition to specific maintenance actions:

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

The plan must include maintenance tasks and schedules. Refer to the Low Impact Development Manual for Michigan for maintenance task checklists for permanent SMPs and create a table of applicable maintenance tasks and schedules.

Exhibit D – Template for Memorandum of Stormwater Management Operations and Maintenance Agreement: This exhibit contains a template for said Memorandum to be recorded with the County Register of Deeds to put any future owners, or interest holders, on notice of the Stormwater System and the Stormwater System O&M Plan.

WRC
WATER RESOURCES COMMISSIONER
Jim Nash

Memorandum of Stormwater Management Operations and Maintenance Agreement

The “Owner” _____ and the “Community” _____ have entered into a Stormwater Management Operations and Maintenance Agreement dated _____ for real property located in the State of Michigan, County of Oakland, City of _____ and further described as follows:

[real property description]

Commonly known as: _____

Parcel ID: _____

The Stormwater Management Operations and Maintenance Agreement provides for a stormwater management operation and maintenance plan for a stormwater system located on the real property. It authorizes easements for the local community to take enforcement action if the Agreement is breached. This Agreement runs with the land, binds all current and future owners of the real property and serves the real property in perpetuity.

Owner:

By: _____

Its: _____

STATE OF MICHIGAN)

)ss.

_____ COUNTY)

The foregoing instrument was acknowledged before me on this_____ day of , 2017, by _____, the of _____.

_____

Notary Public

WRC
WATER RESOURCES COMMISSIONER
Jim Nash

Recording Fee: $15.00
Drafted by and Return to:

Appendix G: Engineer's Certificate of Outlet for Proposed Chapter 18 Drains

Engineer's Certificate of Outlet

Date:

To: Oakland County Water Resources Commissioner
Building 95 West – One Public Works Drive
Waterford, Michigan 48328-1907

Attention: _____

Reference: (Project Name and Location)

ENGINEER'S CERTIFICATION

This is to certify that existing drain or watercourse (select one) is the only reasonable outlet for the proposed (name of development), located in the city/township/village (select one) of _____and that the existing drain or watercourse (select one) has sufficient capacity to serve as an adequate outlet for (name of development)without detriment or diminution of the drainage services which the outlet presently provides.

Name:_____

Professional Engineer's License No.: _____

Seal: