



CITY OF GRAND RAPIDS, MI

**STORMWATER SYSTEM
TECHNICAL REFERENCE MANUAL (TRM)**

May 2013

Updated January 27, 2014

**STORMWATER SYSTEM
TECHNICAL REFERENCE MANUAL (TRM)**

MAY 2013

Updated January 27, 2014

City of Grand Rapids, MI
Environmental Protection Services Department
1300 Market Avenue
Grand Rapids, MI. 49503

Tt Project Number: 200-12737-12006 Task 001

P:\IER\12737\200-12737-12006\Docs\Reports\SW Technical Manual\SW Tech Ref Manual 2013-05-31.docx

TABLE OF CONTENTS

1.0	INTRODUCTION	1
1.1	Applicability	1
1.2	Authority	2
1.3	Organization of this Document	2
1.4	References.....	3
1.4.1	Ordinance.....	3
1.4.2	City of Grand Rapids Sustainability Plan	3
1.4.3	City of Grand Rapids Standard Construction Specifications.....	3
1.4.4	Michigan Low Impact Development Manual	3
1.4.5	DEQ Guidebook of BMPs	3
1.4.6	Additional References.....	3
2.0	STORMWATER SYSTEM PURPOSE AND PRINCIPLES	5
2.1	Purpose for the City's Stormwater System.....	5
2.2	General Principles	5
2.2.1	City Connections.....	5
2.2.2	Adjacent Properties	5
2.2.3	Natural Systems	5
2.2.4	Public Conveyances	5
3.0	PLAN REVIEW PROCEDURES AND SUBMITTAL	7
3.1	Preliminary Plan Review	7
3.1.1	Purpose and Applicability	7
3.1.2	Submittal Requirements.....	7
3.2	Final Plan Review	8
3.2.1	Purpose and Applicability	8
3.2.2	Submittal Requirements.....	8
3.2.3	Existing Site Conditions.....	8
3.2.4	Proposed Development Intensity	9
3.2.5	Public Drainage System Capabilities	9
3.2.6	Local Neighborhood Concerns	9
3.3	Operation and Maintenance (O&M) Plan.....	9
3.4	Permits and Associated Fees.....	9
3.5	Post-Construction Revisions and Certifications.....	10
3.6	Soil Erosion and Sedimentation Control Plan.....	10

3.6.1	Purpose and Applicability	10
3.6.2	General Requirements.....	11
3.6.3	Modifications to Approved Plan or Permit	11
3.6.4	Submittal Requirements.....	11
3.6.5	Basic Design Principles and Construction Methods	16
3.6.6	Construction Sequencing	16
3.6.7	Soil Erosion Protection	16
3.6.8	Construction Access Routes.....	16
3.6.9	Watercourses.....	16
3.6.10	Earth Structures.....	17
3.6.11	Area limitation	17
3.6.12	Concentrated Flows.....	17
3.6.13	Stockpiles.....	17
3.6.14	Vegetative Measures	17
3.6.15	Velocity Control.....	17
3.6.16	Sediment Basins.....	17
3.6.17	Silt Fence and Diversions	18
3.6.18	Storm Drain Inlet Protection.....	18
3.6.19	Other Controls.....	18
4.0	STORMWATER MANAGEMENT DESIGN GUIDANCE	19
4.1	Hydrology	19
4.1.1	Design Storms	19
4.1.2	Water Quality Treatment Volume.....	23
4.1.3	Stream Bank Protection Criteria	25
4.1.4	Conveyance.....	25
4.1.5	Flood Control	25
4.1.6	Exemptions	25
4.1.7	Hydrologic Calculations	25
4.2	Hydraulic Calculations.....	26
4.2.1	Pressure Versus Gravity Flow.....	26
4.2.2	Energy Losses	27
4.2.3	Gravity Flow	29
4.3	Stormwater Control Measures	29
4.3.1	Common Elements.....	29
4.3.2	Bioretention.....	30
4.3.3	Capture Reuse	31

4.3.4	Constructed Filter.....	32
4.3.5	Basins.....	32
4.3.6	Pervious Pavement.....	34
4.3.7	Vegetated Filter Strips	35
4.3.8	Vegetated Roof	35
4.3.9	Water Quality Devices.....	36
4.3.10	Other Approved Stormwater Control Measures	36
4.4	Conveyance Systems	36
4.4.1	Connections.....	36
4.4.2	Emergency Overland Flow Way Easement	37
4.4.3	Natural Channels.....	37
4.4.4	Streambank Stability.....	37
4.5	Open Channels.....	37
4.5.1	Low Flow	37
4.5.2	Slopes.....	37
4.5.3	Shape.....	37
4.5.4	Velocity Limitations	37
4.6	Culverts.....	37
4.6.1	Application Categories.....	37
4.6.2	General.....	38
4.6.3	Allowable Headwater.....	38
4.6.4	Design Tailwater.....	38
4.6.5	End Treatments	39
4.6.6	Velocity Limitations	39
4.6.7	Length, Slope, and Size.....	40
4.7	Storm Sewers	40
4.7.1	General Approach	40
4.7.2	Pipe Size and Length.....	40
4.7.3	Slopes and Hydraulic Gradient	40
4.7.4	Minimum Clearances	41
4.8	Manning's n Values.....	41
4.8.1	Basic Principles.....	41
4.8.2	Tabular Interpretations.....	42
4.8.3	Photographic Interpretations	43
4.9	Outlet Protection	43
5.0	SOIL EROSION AND SEDIMENT CONTROL STANDARDS	45

5.1	Basic Principles.....	45
5.2	Construction Sequencing	45
5.2.1	Installation.....	45
5.2.2	Exposed Area	45
5.2.3	Removal	45
5.3	Soil Stabilization.....	46
5.3.1	Timing.....	46
5.3.2	Vegetative Measures	46
5.3.3	Earth Structures.....	46
5.3.4	Watercourses.....	46
5.3.5	Stockpiles.....	46
5.4	Flow Barriers	46
5.4.1	Areas < 1 Acre	46
5.4.2	Concentrated Flows.....	46
5.4.3	Velocity Control.....	46
5.5	Inlet Protection.....	47
5.5.1	Storm Drains	47
5.5.2	Construction Entrances	47
5.6	Sediment Traps and Basins.....	47
5.6.1	Temporary sediment traps.....	47
5.6.2	Check dams	47
5.6.3	Sediment Basins.....	47
6.0	SPECIAL CONDITIONS AND CONSTRAINTS	49
6.1	Environmentally Sensitive Areas.....	49
6.2	Floodplain Encroachments.....	49
6.3	Contaminated Sites	49
6.4	Offset.....	50
7.0	GLOSSARY	51
8.0	REFERENCES	57

Appendix A - Detention Basin Easement Agreements and Operation Agreement

Appendix B - Outlet Protection, Volume 2, Chapter 10 of the Nashville and Davidson County, TN, Stormwater Management Manual

TABLES

Table 4.1.1-2 Rainfall Depths	21
Table 4.1.1-3 Design Storm Hyetograph Data.....	23
Table 4.1.2-1 Non-Exceedance Storm Percentile	24
Table 4.1.7-1 Approved Calculation Methodologies.....	26
Table 4.2.2-1 Head Loss Coefficient for Manholes/Junctions.....	28
Table 4.3.2-1 Vegetated SCM Design Criteria	31
Table 4.3.3-1 Capture Reuse Design Criteria	32
Table 4.3.4-1 Constructed Filter Design Criteria.....	32
Table 4.3.5-1 Basin Design Criteria.....	34
Table 4.3.6-1 Pervious Pavement Design Criteria.....	35
Table 4.3.7-1 Vegetated Filter Strips Design Criteria.....	35
Table 4.3.8-1 Vegetated Roof Design Criteria	36
Table 4.6.5-1 Culvert Entrance Loss Coefficients	39
Table 4.7.2-1 Structure Spacing.....	40
Table 4.8.2-1 Manning’s n values for Artificial Channels.....	42

FIGURES

Figure 3.6.4-1 Keying System for Soil Erosion and Sedimentation Control Measures.....	14
Figure 4.1.1-1 Rainfall IDF Curve.....	22
Figure 4.1.2-1 Non-Exceedance Storm Percentile.....	24

ACRONYMS

BMP	Best Management Practice
cfs	cubic feet per second
CN	Curve Number
CPD	Condition Prior to Development
CSDS	City Stormwater Drainage System
EPA	Environmental Protection Agency
ESD	Environmental Services Department
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
LID	Low Impact Development
MDEQ	Michigan Department of Environmental Quality
MDOT	Michigan Department of Transportation
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly Soil Conservation Service, SCS)
O&M	Operations and Maintenance
RCP	Reinforced Concrete Pipe
SCM	Stormwater Control Measure
SCS	Soil Conservation Service (now the NRCS)
SDST	Site Development Stormwater Tool
SESC	Soil Erosion and Sedimentation Control
SWMM	Stormwater Management Model
TR-55	NRCS Technical Release No. 55 of June 1986. Urban Hydrology for Small Watersheds
USDOT	United States Department of Transportation

1.0 INTRODUCTION

The Grand Rapids Stormwater Management Program has several components. These components include ordinances, as contained in the City Code, the Stormwater System and Combined Sewer NPDES applications and permits, this Technical Reference Manual (TRM), a Stormwater Asset Management and Capital Improvement Plan and the Stormwater Management Master Plan for the City, including detailed watershed plans. Each of these documents is bound separately.

This Technical Reference Manual (TRM) sets forth the specific City standards for stormwater management that are to be applied to projects. The manual also provides the design criteria and methods for how projects are to be implemented. Furthermore, the standards and criteria in this manual enables the City to provide effective and efficient review of design data, and to provide applicants with clear guidance in preparing stormwater management plans that further the City's goal for smart sustainable land use and stormwater management. It is not intended that these minimum requirements be blindly applied in every situation. Design conditions vary and there is no substitute for professional judgment of an experienced engineer. In all cases, this judgment should be applied.

Stormwater management is an evolving science. The City's goal in preparing this manual is to enact standards reflecting the most innovative, creative, environmentally and cost-effective practices available that incorporate the City's commitments to smart sustainable land use, urban design and improved environmental quality and natural systems. To achieve this goal as stormwater science evolves, this manual will be revised and updated as necessary to reflect accepted new standard stormwater management practices and control measures.

Through the standards and practices incorporated in this manual, the City encourages the use of stormwater treatment and engineering methods that allow for groundwater recharge and that manage stormwater as close to its source as possible. The use of site development methods such as conservation design, smart growth, green infrastructure, integrated site design, and sustainable development are practices and methods that can help achieve these goals, and are reflected in the standards in this manual. Specifications for stormwater control measures (SCMs) that use vegetation and soil media to filter, treat or infiltrate stormwater have been incorporated into this manual. Use of these practices is encouraged in Grand Rapids where suited to site and development conditions, and consistent with the standards in this manual. The City encourages the use of distributed stormwater management practices for large multi-parcel developments.

1.1 APPLICABILITY

To improve the quality of stormwater and to prevent or reduce the introduction of pollutants and sediments into the City Stormwater Drainage System (CSDS) and mitigate the frequency and severity of flooding from stormwater, the requirements in the following sections shall apply to all proposed development or redevelopment projects in the City of Grand Rapids that involve the drainage of surface runoff from impervious areas with a total surface area of one thousand (1,000) square feet or more.

The City will review all stormwater related submittals for general compliance with these specific standards. An acceptance by the City does not relieve the applicant from the responsibility of ensuring all systems are safe and that calculations, plans, specifications, construction, and record drawings comply with normal engineering standards, this design manual, and other applicable local, state, and federal rules and regulations.

The City Manager or designee may require more stringent requirements than would normally be required under these standards, depending on special conditions and/or environmental constraints.

1.2 AUTHORITY

Through the Grand Rapids Code of Ordinances, Title II – Utilities and Services, Chapter 32 – City Stormwater Drainage Systems, the City is authorized to establish minimum design standards for stormwater discharge release rates and require dischargers to implement on-site retention, detention or other methods necessary to control the rate and volume of surface water runoff discharged into the CSDS when:

- a) A parcel or property is being developed or redeveloped in a manner that increases the impervious surface area of the property; or
- b) The discharge exceeds the City-calculated pre-development discharge characteristics for the subject property and the City Manager determines that the discharge contributes to an identified drainage, flooding or soil erosion problem.

The City also has authority under Title II – Utilities and Services, Chapter 32 – City Stormwater Drainage Systems, Section 2.242, to require dischargers to implement pollution prevention measures, or other methods necessary to prevent or reduce the discharge of pollutants into the CSDS.

The City is designated as the Municipal Enforcing Agent for Soil Erosion and Sedimentation Control (SESC) to enforce the provisions in this manual, under Title II – Utilities and Services, Chapter 32 – City Stormwater Drainage Systems, Article 5 – Soil Erosion and Sedimentation Control, as well as those of Part 91, Soil Erosion and Sedimentation Control of the Natural Resources and Environmental Protection Act, 1994 PA 451 as amended (Part 91) and the administrative (rules) promulgated under Part 91.

1.3 ORGANIZATION OF THIS DOCUMENT

Chapter 2, Stormwater System Purpose and Principles, provides the purpose of the City’s stormwater system and the guiding principles of its design and operation.

Chapter 3, Plan Review Procedures and Submittal, discusses the procedures that must be considered by developers when submitting a site plan to the City for review and outlines the City’s site plan review process.

Chapter 4, Stormwater Management Design Guidance, begins with the specific design criteria required to design stormwater control measures in terms of the rate, volume, and water quality. Climatological information is provided on the rainfall patterns and acceptable methods for calculating site stormwater runoff. The chapter then provides standards and criteria to ensure the safe and effective flow of stormwater through flow paths, treatment facilities, and the physical storm drainage system in a manner consistent with protection of public health, safety, and welfare; the safety and function of properties, roads and improvements; and maintaining and improving water and environmental quality in the City of Grand Rapids and its surface waters. It also defines the approved stormwater treatment and control measures and practices for use in the City of Grand Rapids. Design guidance and requirements for each type of control measure are presented here.

Chapter 5, Soil Erosion and Sedimentation Control Standards, provides standards and guidelines for the preparation of soil erosion and sediment control plans that protect the quality of Grand Rapids' waters and the municipal separate storm sewer system (MS4) from excessive erosion and sedimentation resulting from construction and operation of development.

Chapter 6, Special Conditions and Constraints, provides guidelines for designing stormwater management facilities on contaminated and brownfield sites within the City. This chapter also includes references to the City’s ordinance for requirements on environmentally sensitive areas and floodplain encroachments.

Chapter 7, Glossary, provides definitions for terms used in this manual and other common stormwater related terms.

Chapter 8, References, lists books, articles and journals presented in the document.

1.4 REFERENCES

1.4.1 Ordinance

Standards and stormwater control requirements are dictated by the City of Grand Rapids Title II – Utilities and Services, Chapter 32 – City Stormwater Drainage System Ordinance (found on Municode site). In the case of conflict between the stormwater ordinance and this manual, the ordinance takes precedence.

1.4.2 City of Grand Rapids Sustainability Plan

The Sustainability Plan is a multi-year document that promotes responsibility of the City to provide core services while promoting economic prosperity, ensuring social equity, and protecting the integrity of the natural environment for all citizens. The Plan lays out specific economic, social and environmental targets, setting the framework of the City’s priorities, which include sustainability and low impact development.

1.4.3 City of Grand Rapids Standard Construction Specifications

This document contains standard construction specifications, including design details and drawings required for work and materials in the City of Grand Rapids. The original document, created in 1993, and all revisions since then, can be accessed on the City’s website, <http://www.grcity.us/engineering-department/Documents/1993%20GR%20Standard%20Spec%20v9.pdf>.

1.4.4 Michigan Low Impact Development Manual

The Michigan Low Impact Development (LID) Manual provides guidance on how to apply LID to new, existing and redevelopment sites. It includes technical guidance for how to design, construct, and maintain specific LID facilities, as well as providing a broader scope for managing stormwater through policy decisions, including ordinances, master plans and watershed plans. The City of Grand Rapids uses this manual for technical guidance on designing specific LID facilities. An electronic copy of the Michigan LID Manual can be found on the SEMCOG website, www.semcog.org.

1.4.5 DEQ Guidebook of BMPs

The DEQ Guidebook of BMPs was prepared in response to a need to address runoff and wind-generated pollution in Michigan. It helps developers, contractors, city and township planners, engineers, architects, and local citizens to control runoff from construction sites, urban areas, and large recreational areas. The primary mechanism used to prevent nonpoint sources from impacting watersheds is Best Management Practices (BMPs). This manual provides design guidance for BMPs associated with controlling runoff from the sites mentioned. An electronic copy of the DEQ Guidebook of BMPs can be found on the MDEQ website, http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714-118554--,00.html.

1.4.6 Additional References

1.4.6.1 Green Grand Rapids

This document is an update to the citywide 2002 Master Plan. It focuses on the importance of green infrastructure, sustainability and quality of life while maintaining the competitive edge for attracting and retaining residents and businesses in the City of Grand Rapids. It also includes discussion on the zoning ordinance revision and how green infrastructure fits in with the City’s plan. The document can be

accessed on the City's website, <http://grcity.us>.

1.4.6.2 MDOT Drainage Manual

The MDOT Drainage Manual provides design professionals with guidance for the design of drainage facilities, specifically for MDOT projects. In some cases, the City of Grand Rapids may not have specific design criteria and guidance for stormwater management facilities. The MDOT drainage manual is a good reference to use in such cases. An up-to-date copy of the drainage manual can be found on MDOT's website, <http://www.michigan.gov/stormwatermgmt/0,1607,7-205--93193--,00.html>.

2.0 STORMWATER SYSTEM PURPOSE AND PRINCIPLES

As urban areas continue to develop and sites redevelop, the volume of stormwater runoff increases due to the increase in impervious areas. Previously, stormwater management philosophy concentrated only on getting the stormwater runoff out of sight as quickly as possible and only addressed the effects of peak flow rates being generated. However, with the enactment of the National Pollutant Discharge Elimination System (NPDES) Stormwater Permit regulations, the current philosophy of stormwater management focuses on a more integrated approach that acknowledges the aspects of volume, rate, and quality, as well as the relationship between groundwater and surface water.

In an effort to standardize procedures for stormwater management facilities and adopt the current philosophy of stormwater management, the City of Grand Rapids has developed the standards contained in this TRM. It is intended that these standards will facilitate planning and design processes.

2.1 PURPOSE FOR THE CITY'S STORMWATER SYSTEM

The principal purpose of the City's Stormwater System is to provide drainage of publicly owned properties and rights-of-way within the City limits. A secondary purpose is to convey stormwater runoff from privately owned property, provided the discharge from the property does not exceed the System's capacity and is free of excessive pollutants and sediments. The conveyance of stormwater runoff from private property is a secondary purpose, in that the City is not obligated to extend or improve the system for the sole purpose of conveying stormwater runoff from private property.

2.2 GENERAL PRINCIPLES

2.2.1 City Connections

A property owner can discharge surface water that does not contain pollutants into the City's stormwater system at a rate not to exceed the pre-development runoff rate for that property, provided the owner obtains the appropriate permits needed to connect to the City's stormwater system to construct the improvement.

2.2.2 Adjacent Properties

Property owner can discharge surface water that does not contain pollutants onto adjacent properties, provided that the owner's property has historically discharged surface water onto those adjacent properties, that the location and character of that discharge is essentially the same as the historical discharge location and character, and that the discharge cannot feasibly be directed into the City's stormwater system.

2.2.3 Natural Systems

A property owner can discharge surface water that does not contain pollutants into water bodies, rivers, streams, creeks, and natural drainage swales that are on or adjacent to their property, provided that the owner's property has historically discharged surface water into those adjacent water bodies, rivers, streams, creeks, and natural drainage swales, and that the location and character of that discharge is essentially the same as the historical discharge location and character, or that it does not cause an adverse impact.

2.2.4 Public Conveyances

Developers of private property that must construct a stormwater conveyance system for off-site flows passing through a proposed development can be given consideration to obtain cost sharing from the City. Conditions for such cost sharing shall be as approved by the City Manager.

3.0 PLAN REVIEW PROCEDURES AND SUBMITTAL

The purpose of this section is to provide guidelines and requirements for stormwater management when submitting a site plan for review and approval.

3.1 PRELIMINARY PLAN REVIEW

3.1.1 Purpose and Applicability

The purpose of the preliminary plan review is to give any person desiring to make improvements to property within the City an opportunity to have his or her plans reviewed at the early planning stages for compliance with the City's Stormwater System Ordinance, Chapter 32, and any current City policies which may apply to the proper disposal of surface water drainage from their site. The preliminary plan review as outlined herein shall be applicable for:

- a) Meeting the drainage review requirements under Article 6A, "Site Plan Review," Chapter 61, "Zoning," of the City Code;
- b) Check-print reviews on plans for public improvements;
- c) Any similar review request.

The preliminary plan documents should be reviewed and made available to the party requesting the review within ten (10) working days after receipt by the Stormwater Management Section of the Utilities Department. Reviewed documents should be marked either Preliminary Approval, Preliminary Approval as Noted, Resubmit with Additional Information, or Not Approved. A brief explanation should be provided when submitted documents are marked Resubmit or Not Approved. Generally, copies of the reviewed documents will not be retained by the Stormwater Management Section of the Utilities Department; therefore, it is the requesting party's responsibility to maintain these documents once they have been returned. The requesting parties shall include the approved preliminary plans with the plans submitted for final approval. When preliminary approval is required and the approved preliminary plans are not provided, the preliminary plan review process may need to be repeated, which could result in a delay in obtaining final plan approval.

The preliminary plan review and approval is a planning tool to assist in determining the major drainage requirements for a contemplated development. It does not convey any kind of approval by other governmental agencies, nor does it authorize or permit the construction of any of the contemplated improvements shown or described in the submitted documents.

3.1.2 Submittal Requirements

Plans submitted to the City for preliminary plan review must have sufficient information to enable a complete and thorough evaluation of site grading and drainage. Plans shall provide adequate detail of the hydrology and hydraulics of the existing site and proposed development. Plans and specifications shall be of sufficient scale and detail, including supplemental data and calculations, to facilitate the evaluation of the potential impact of the proposed development upon the City's Stormwater System, adjacent properties, water bodies, rivers, streams, creeks, and drainage ways. Guidelines for preparing a site plan and drainage plan documents can be obtained on the City's website, <http://grcity.us>.

Helpful Suggestion: *If the scale selected for the site plan is at one inch equals fifty (50) feet or greater (i.e., 40, 30, 20 feet, etc.), the site plan drawn for the Preliminary Review can also be used in preparing the site plan for Final Review and for the Grading and Soil Erosion Control site plan.*

3.2 FINAL PLAN REVIEW

3.2.1 Purpose and Applicability

The Final Plan Review is to check for compliance with the City's Stormwater System Ordinance, Chapter 32, and any current City policies that may apply for the proper disposal of surface water drainage from property within the City requiring a permit to construct a proposed improvement. A final plan review by the City Manager or designee for administering the City's Stormwater System will be required for the following permits:

- a) Industrial and commercial building permits;
- b) Residential building permits when:
 - i. the property is within 500 feet of the 100-year floodplain or adjacent to a wetland, creek stream, lake, water body, or
 - ii. the property is encumbered with a public easement for storm water drainage, or
 - iii. requested by the Inspection Services Supervisor;
- c) Grading and Soil Erosion Control permits;
- d) Parking Area Construction permits.

The final plan documents should be reviewed and made available to the party requesting the review within three (3) working days after receipt by the Stormwater Management Section of the Utilities Department, provided a previously approved preliminary plan is submitted with the final plans. Reviewed documents should be marked either Approved, Approved as Noted, Resubmit with Additional Information, or Not Approved. A brief explanation should be provided when documents are marked Resubmit or Not Approved.

The final plan review and approval for drainage is to evaluate the proposed improvement project and submitted documents for compliance with the City's drainage requirements as a condition of the requested construction permit. It does not convey approval or authorization to begin construction of any of the contemplated improvements shown or described on the permit documents prior to issuance of the appropriate permit(s).

3.2.2 Submittal Requirements

The submitted document package for final plan review for Stormwater Management should include a site plan(s) as specified under Section 3.1 of this manual, along with any supplemental data, calculations, easement descriptions, restrictive covenants, and special agreements, and any documents receiving preliminary review approval to facilitate the evaluation for compliance with the City's drainage requirements and the proposed improvement's potential impact upon the City's Stormwater System, adjacent properties, water bodies, rivers, streams, creeks, and drainage ways.

The City may require additional information or design effort to address site specific conditions before issuing a permit or recommending approval by the Planning Commission, or the City Commission. The following site specific conditions may require additional information and design effort beyond those required in the checklist:

3.2.3 Existing Site Conditions

Additional site design considerations may be needed where there are steep slopes, floodplains, wetlands or waterways associated with or adjacent to the site.

3.2.4 Proposed Development Intensity

Additional site design considerations may be needed with higher intensity developments, which have limited remaining areas for managing the site's stormwater runoff.

3.2.5 Public Drainage System Capabilities

Additional site design considerations may be needed where the public drainage system into which the site discharges has special limitations (e.g., a combined sewer, a history of downstream flooding, or existing downstream erosion problems).

3.2.6 Local Neighborhood Concerns

Additional site design considerations may be needed to address neighborhood concerns about drainage and related impacts caused by the proposed project.

3.3 OPERATION AND MAINTENANCE (O&M) PLAN

All structural and vegetative SCMs installed shall include a plan for maintaining maximum design performance through long term O&M. The O&M plan will ensure that the SCMs continue to meet the water quality and water quantity controls outlined in this manual. The applicant shall provide a stormwater O&M plan and agreement that at a minimum shall include:

- a) The names and addresses of the property owners and the owners of all components of the stormwater systems;
- b) The names and addresses of the persons responsible for O&M;
- c) The names and addresses of the persons responsible for financing O&M and emergency repairs;
- d) A statement that the property owners consent to the terms and conditions of the drainage plan;
- e) Stipulations for the terms and conditions under which the parties shall be responsible for maintenance of the system, and the penalties and remedies in the event that one or more parties damages the system or otherwise violates the terms of agreement;
- f) A statement that authorizes the City, upon written notice to the property owners, to enter, repair and maintain the system and recover all associated costs in the event the system deteriorates based on the sole judgment of the City Manager to the point of posing a threat to surface waters, public improvements, health, safety or property;
- g) The signatures of the owners and any other persons to be bound by the agreement.

The agreement shall be recorded in the land records prior to issuance of any permit to construct the system and associated improvements.

3.4 PERMITS AND ASSOCIATED FEES

City of Grand Rapids storm sewer permits must be obtained prior to commencement of construction. In addition, applicants must obtain any and all permits or authorizations from all other relevant agencies. Any plans requiring connection to existing conveyance systems not under the control of the City (i.e., County drains, MDOT drains, etc.) must be approved by the appropriate entity, and documentation of approvals, permits, etc., must be provided to the City before final/site construction plans are submitted for approval.

A helpful guide for determining applicable permits required consistent with State laws and rules is located at the following website: <http://www.michigan.gov/deq/0,4561,7-135-6830-89034--,00.html>. Other

permit requirements, such as those required by the Kent County Drain Commissioner, may apply depending upon the proposed location of discharge and other factors.

Approved final site/construction plans are valid for one year. The one year period may be extended if applied for by the applicant and approved by the City in writing.

Approval of the final site/construction plans is intended to be final approval. If either the applicant or the City find it advantageous to make changes before the final site plan/plat is presented to the City for signature, such changes can be made, provided that the same procedures outlined above are repeated with each change in the layout.

3.5 POST-CONSTRUCTION REVISIONS AND CERTIFICATIONS

Once construction is completed, the following items should be addressed to reflect all changes that may have occurred during construction:

- a) Formal “as-built” construction plans of the site as actually constructed; and
- b) Final certification by an Engineer stating that the final construction meets all of the original stormwater management design parameters.

3.6 SOIL EROSION AND SEDIMENTATION CONTROL PLAN

3.6.1 Purpose and Applicability

The Soil Erosion and Sedimentation Control Plan Review is to check for compliance with the City Codes regarding soil erosion and sediment control (SESC), and the City Stormwater System Rules and Regulations, and including any current City policies that may apply to the same.

The City of Grand Rapids is committed to enforcing the provisions of Part 91, Soil Erosion and Sedimentation Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451 as amended (Part 91) and the administrative rules promulgated under Part 91. Additional, City-specific requirements enforced by the City are detailed in the Code of Ordinances, Under Title II – Utilities and Services, Chapter 32 – City Stormwater Drainage Systems, Article 5 – Soil Erosion and Sedimentation Control.

The land owner shall obtain an SESC permit when any earth change activity that is associated with any of the following conditions occurs:

- a) A commercial or industrial development project with some type of earth change involving areas greater than two thousand five hundred (2,500) square feet
- b) A plat, subdivision, Planned Unit Development, Planned Industrial Development, or multi-family residential unit development
- c) A parking area greater than one thousand (1,000) square feet
- d) Any earth change within five hundred (500) feet of a wetland, creek, stream, lake, water body, or floodplain
- e) A requirement of a Corrective Action Notice, Consent Order, or Compliance Order
- f) A condition of approval by the Planning Commission, Board of Zoning Appeals, or City Commission
- g) A condition of a building permit to assure that the proposed earth change will have adequate soil erosion and sedimentation controls to protect the neighborhood, the CSDS and the environment

- h) Any earth change involving an area greater than or equal to, one (1) acre

Exemptions from obtaining an SESC permit are allowed in the following circumstances:

- a) Earth changes undertaken by Authorized Public Agencies designated under the Natural Resources and Environmental Protection Act, MCL 324.101 et seq., Part 91, Soil Erosion and Sedimentation Control. However, such entities performing work on behalf of the Authorized Public Agency, must obtain an Authorization to Proceed with Earth Change and comply with all control design requirements found herein.
- b) Exemptions provided for in Sections 9115 and 9115a of Part 91 and Rule 323.1705.

Grading and Soil Erosion control permit applications and accompanying documents should be reviewed within ten (10) working days after receipt by the City Manager or designee for administrating the City's Grading and Soil Erosion Control program and should be marked either Approved, Approved As Noted, Resubmit with Additional Information, or Not Approved. A brief explanation should be provided when documents are marked Resubmit or Not Approved.

The Grading and Soil Erosion Control permit conveys approval or authorization for the earthwork and erosion control as shown on the plans. It does not convey authorization or approval of other aspects of the proposed improvement project such as public drainage facilities, utilities, parking areas, driveways, sidewalks, or buildings and major structures. Additional permits may be required before construction begins.

3.6.2 General Requirements

A SESC permit or Authorization to Proceed must be obtained by the land owner, or any other person participating in any earth change requiring a permit, prior to the start of any construction, earth change, or any other work which could cause soil to be exposed to potential erosion.

The SESC permit application and permit or the Authorization to Proceed and application shall be administered and enforced as a component of a consolidated application and permit called the Land Use and Development Permit required by Chapter 67 of the Code.

Failure to obtain an SESC permit or Authorization to Proceed prior to beginning any earth change requiring a permit is a violation of Chapter 32 of the Code of Ordinances, Under Title II – Utilities and Services.

3.6.3 Modifications to Approved Plan or Permit

All modifications to, or deviations from, the permit or the proposed earth change as shown on the approved SESC plan or Authorization to Proceed must be submitted to and approved by the City Manager.

Nothing in this chapter shall preclude emergency action being taken to prevent or mitigate conditions that would be injurious to the environment, the public health, safety or welfare. Any emergency actions taken, which interfere or modify any natural or artificial drain, shall be reported by the property owner or the applicant on behalf of the property owner to the City Manager upon occurrence. The owner or applicant shall prepare a detailed report including appropriate drawings and shall file these with the City Manager within five (5) days. The report shall include location, date and time thereof, type of emergency action and follow-up corrective actions taken. Failure to notify the City Manager at the time of the occurrence and failure to file a detailed report shall be separate violations of this Chapter. Every day the permittee fails to comply with this section shall constitute a separate violation of this Chapter.

3.6.4 Submittal Requirements

The applicant for a Soil Erosion and Sedimentation Control permit shall submit four (4) copies of the site

grading and soil erosion control plans (file copy, field copy, applicant's copy, and Stormwater Review copy), along with the completed application, application fee, and bond. If these are not provided at the time the application is submitted, the application, except for the review fee, may be returned and marked "Resubmit", and a second application fee will be required when the application is resubmitted.

Site plans should be prepared in accordance with the following requirements:

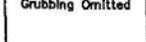
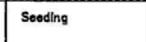
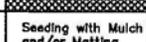
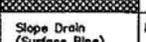
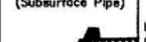
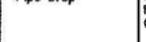
- a) A vicinity sketch at a scale of one (1) inch equals one hundred (100) feet (1" = 100') indicating the site location as well as the adjacent properties within five hundred (500) feet of the site boundaries.
- b) A sketch showing any upstream drainage areas that would contribute stormwater runoff flows to the site, with an estimate of the runoff from the upstream drainage area. This sketch may be included with the vicinity sketch described in "A" above, or as part of the site plan.
- c) A site plan(s) at a one inch equals fifty (50) feet or larger scale, with elevation contours at 2-foot intervals for the existing site conditions and the proposed final contours shall be shown. Spot elevations may be substituted for elevation contours for sites with less than 20,000 square feet of area and when the proposed earthwork is less than 1/2 foot multiplied by the site area. Maximum paper size shall be 22 inches by 34 inches.
- d) The site plan(s) shall show or include the following:
 1. Name, address, telephone number of the owner, developer and petitioner, and the engineer/architect responsible for stormwater system design;
 2. North arrow, legend, and scale;
 3. Existing and proposed property boundaries and easements including dimensions, permanent parcel or lot number, and plat name;
 4. Location of any structure(s) on or within one hundred (100) feet of the site;
 5. Location of any proposed additional structures or development on the site;
 6. Any existing wetland areas, stream, creeks, drainage ditches and any other drainage features located on or within 500 feet of the site;
 7. The locations where surface water crosses the property boundaries flowing either from or onto adjacent properties indicating the direction of flow, estimated rate of flow in cubic feet per second for the 2-year, 10-year and 100-year return frequency rain events, and the type of flow (i.e., sheet flow, channeled flow, etc.);
 8. The approximate location and elevations of the 100-year Emergency Overland Flow Way within the site;
 9. The location of both existing and proposed stormwater control measures, showing the dimensions and slopes and labeled public or private, existing or proposed;
 10. The route or method for discharging surface water from the site into the public stormwater system should appear on the site plan. Also shown shall be the size or description of the public stormwater facility into which the site will discharge;
 11. The site's total area, total existing and proposed impervious area (i.e., roof, pavement, sidewalk and patio, etc.) and total existing and proposed pervious areas;
 12. Stormwater control measure data; estimated maximum temporary storage volume, estimated maximum area, estimated maximum depth, design storm frequency, and

release rate;

13. The location and details of the permanent “stormwater control measures” intended to be utilized for improving the quality of the surface water being discharged from the site;
 14. The location and any necessary details of the soil erosion and sedimentation controls to be utilized during the construction. These controls should be indicated on the plan by using the Keying System for Standard Soil Erosion and Sedimentation Control as presented in Figure 3.3.2-1. Each type of erosion control key used in the plan shall be shown in the legend, with a symbol and brief description;
 15. A construction schedule indicating the anticipated starting and completion dates of the development sequence and the time of exposure of each area prior to the completion of effective permanent soil erosion and sedimentation control measures. This should be in the form of a bar chart shown on the plan;
 16. A program proposal for the continued maintenance of all permanent soil erosion and sediment control measures that remain after project completion, including the designation of the person responsible for the maintenance. Maintenance responsibilities shall become a part of any sales or exchange agreement for the land on which the permanent soil erosion control measures are located.
 17. A signed statement of the quantity of excavation and fill and the soil type involved, including data used for making these determinations.
 18. A statement recognizing the City’s right to enter the property for the purpose of inspection.
 19. Provisions regarding the City’s right to perform, or cause to be performed, any required O&M if the responsible persons fail or refuse to do so, and the obligation of the property owner to fully reimburse the City for all costs and expenses incurred by the City in connection with such activity.
- e) Other information or data required by the City Manager or designees for administering the City's Soil Erosion Control Program and the City's Stormwater Management Program.

A checklist of SESC plan items required by the City can be found on their website, <http://grcity.us>.

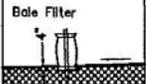
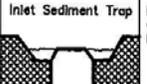
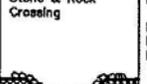
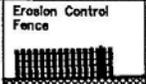
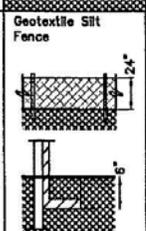
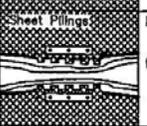
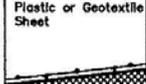
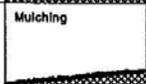
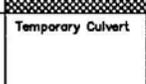
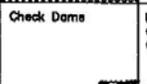
Figure 3.6.4-1 Keying System for Soil Erosion and Sedimentation Control Measures

● Applicable Soil Erosion and Sedimentation Control Measures																				
A = SLOPES B = STREAMS AND WATERWAYS C = SURFACE DRAINAGEWAYS D = ENCLOSED DRAINAGE (INLET & OUTFALL CONTROL) E = LARGE FLAT SURFACE AREAS F = BORROW AND STOCKPILE AREA G = ADJACENT PROPERTIES																				
KEY	DETAIL	CHARACTERISTICS	A	B	C	D	E	F	G	KEY	DETAIL	CHARACTERISTICS	A	B	C	D	E	F	G	
1	 Selective Grading & Shaping	Water can be diverted to minimize erosion Flatter slopes ease erosion problems	●							12	 Berm & Ditch	Diverts water to a prepared drainageway May be used at intervals across slope face to reduce effective slope length	●							
2	 Grubbing Omitted	Saves cost of grubbing, provides new sprouts Retains existing root mat system, reduces wind fall at new forest edge Discourages equipment entrance	●							13	 Filter Berm	Constructed of gravel or stone Intercepts and diverts runoff to stabilized areas or prepared drainage systems Slows runoff and collects sediment	●							
3	 Seeding	Inexpensive and very effective Stabilizes soil, thus minimizing erosion Permits runoff to infiltrate soil, reducing runoff volume Should include prepared topsoil bed	●	●	●	●				14	 Brush Filter	Uses slash and logs from clearing operation Can be covered and seeded rather than removed							●	
4	 Seeding with Mulch and/or Matting	Facilitates establishment of vegetative cover Effective for drainageways with low velocity Easily placed in small quantities by inexperienced personnel Should include prepared topsoil bed	●	●	●	●				15	 Slope Drain (Surface Pipe)	Prevents erosion on slopes when runoff cannot be diverted to edges of slope area Usually temporary Can be constructed or extended as grading progresses	●							
5	 Sodding	Provides immediate protection Can be used on steep slopes where seed may be difficult to establish Easy to place; may be repaired if damaged Should include prepared topsoil bed	●	●	●	●				16	 Slope Drain (Subsurface Pipe)	Prevents erosion on slopes when runoff cannot be diverted to edge of slope area Usually permanent Can be constructed as grading progresses	●							
6	 Vegetative Buffer Strip	Slows runoff velocity Filters sediment from runoff Reduces volume of runoff on slopes	●	●						17	 Pipe Drop	Reduces runoff velocity Removes sediment and turbidity Can be designed to handle large volumes of flow							●	
7	 Riprap, Rubble, (Energy Dissipator)	Used where vegetation is not easily established Effective for high velocities or high concentrations Permits runoff to infiltrate soil Dissipates energy flow at system outlets	●	●						18	 Pipe Spillway	Removes sediment and turbidity from runoff May be part of permanent erosion control plan							●	
8	 Aggregate Cover	Stabilizes soil surface, thus minimizing erosion Permits construction traffic in adverse weather May be used as part of permanent base construction of paved areas						●		19	 Energy Dissipator	Slows runoff velocity to non-erosive level Permits sediment collection from runoff							●	
9	 Benches	Reduces runoff velocity by reducing effective slope length Collects sediment Provides access to slopes for seeding, mulching maintenance	●							20	 Sediment Trap	May be constructed of a variety of materials Traps sediment and reduces velocity of flow Can be cleaned and expanded as needed Initial excavation less than or equal to 5 cu. yds							●	
10	 Diversion Berm	Diverts water from vulnerable areas Collects and directs water to prepared drainageways May be placed as part of normal construction operation	●							21	 Sediment Basin	Traps sediment Releases runoff at non-erosive rates Controls runoff at system outlets Initial excavation greater than 5 cu. yds May be excavation, excavation/fill or other							●	
11	 Diversion Ditch	Collects and diverts water to reduce erosion potential May be incorporated in permanent project drainage systems	●							22	 Sod Filter	Inexpensive and easy to construct Provides immediate protection Protects areas around inlets from erosion								●

City of Grand Rapids, Michigan
Utilities Department
Stormwater Management Section

Keying System for
Soil Erosion and Sedimentation
Control Measures

Figure 3.6.4-1 Keying System for Soil Erosion and Sedimentation Control Measures con't

● Applicable Soil Erosion and Sedimentation Control Measures																					
KEY	DETAIL	CHARACTERISTICS	A	B	C	D	E	F	G	KEY	DETAIL	CHARACTERISTICS	A	B	C	D	E	F	G		
23		Inexpensive and easy to construct Can be located as necessary to collect sediment May be used in conjunction with snow fence for added stability	●	●	●	●	●	●	●	31		Easy to shape Collects sediment May be cleaned and expanded as needed									
24		Traps sediment and reduces velocity of flow Diverts water to prepared drainageway May be stacked as necessary	●	●	●	●	●	●	●	32		May be rock or clean concrete-masonry rubble Minimizes stream turbidity Inexpensive May also serve as ditch check or sediment trap									
25		Used as backing for bales or other materials Usually snow fence May be used to minimize wind erosion	●	●	●	●	●	●	●	33		May be 6A type stone, small rocks or similar-sized clean concrete-masonry rubble Minimizes stream turbidity Relatively inexpensive May be used as ditch check or sediment trap									
26		Uses geotextile and posts or poles at 6'-0" maximum spacing May be constructed or prepackaged Easy to construct and locate as necessary	●	●	●	●	●	●	●	34		Protects erodible bank areas from stream currents during construction Minimal disruption when removed									
27		Temporary cover for erosion prone areas Must have 1' minimum shingle lap and be held down by pins or weights	●	●	●	●	●	●	●	35		New channel keeps normal flows away from construction									
28		Used alone to protect exposed areas for short periods Protects soil from impact of falling rain Preserves soil moisture and protects germinating seed from temperature extremes	●	●	●	●	●	●	●	36		Permits work to continue during normal stream stages Controlled flooding can be accomplished during periods of inactivity									
29		Eliminates stream turbulence and turbidity Provides unobstructed passage for fish and other water life Capacity for normal flow can be provided with storm water flowing over roadway	●	●	●	●	●	●	●	37		Reduces flow velocity Catches sediment Can be constructed of logs, straw, hay, rock, lumber, masonry, or sand bags									
30		Easy to install at inlet Keeps culvert clean and free flowing May be constructed of lumber or logs	●	●	●	●	●	●	●	38		Controls sedimentation in large streams Causes minimal turbidity Can be constructed of steel sheet, wood, rock, sand bags, etc.									
										39	See Figure 5.4.1-1	Easy to install Protects storm sewers during construction.									

NOTES:

THIS SHEET PROVIDES THE KEY TO THE NUMBERED EROSION CONTROL ITEMS SHOWN ON THE CONSTRUCTION PLANS. SOME ITEMS SHOWN ARE PAY ITEMS ILLUSTRATED IN DETAIL ON OTHER STANDARD PLANS. OTHERS ARE REQUIRED CONSTRUCTION PRACTICES AND MAY NOT NECESSARILY BE SEPARATE PAY ITEMS. REFER TO CURRENT STANDARD SPECIFICATIONS FOR OTHER CONTROLS, MEASUREMENTS, AND PAY ITEMS.

AGGREGATES PLACED IN STREAMS SHOULD CONTAIN A MINIMUM OF FINES.

ALL TEMPORARY EROSION CONTROL MEASURES SHALL BE REMOVED AT THE COMPLETION OF CONSTRUCTION UNLESS ORDERED BY THE ENGINEER TO BE LEFT IN PLACE. CARE SHALL BE TAKEN DURING REMOVAL TO MINIMIZE SILTATION IN NEARBY DRAINAGE COURSES.

EROSION AND SEDIMENTATION CONTROL ITEMS ARE SHOWN IN LINE DRAWINGS TO SUGGEST GENERAL CONCEPTS. ACTUAL CONSTRUCTION MAY BE VARIED TO REFLECT MATERIALS USED AND SPECIFIC SITE PROBLEMS, SUBJECT TO THE APPROVAL OF THE ENGINEER.

COLLECTED SILT AND SEDIMENT SHALL BE REMOVED PERIODICALLY TO MAINTAIN THE EFFECTIVENESS OF THE SEDIMENT TRAP OR SEDIMENTATION BASIN.

TEMPORARY EROSION AND POLLUTION CONTROL PROVISIONS SHALL BE COORDINATED WITH THE PERMANENT CONTROL FEATURES TO ASSURE EFFECTIVE CONTROL OF WATER POLLUTION DURING CONSTRUCTION OF THE PROJECT.

IN PLANNING SEDIMENT TRAPS AND SEDIMENTATION BASINS, THE WATERWAY AREA MUST BE INCREASED SO AS TO EFFECTIVELY REDUCE THE STREAM VELOCITY.

City of Grand Rapids, Michigan Utilities Department Stormwater Management Section	Keying System for Soil Erosion and Sedimentation Control Measures
---	---

3.6.5 Basic Design Principles and Construction Methods

The design of soil erosion and sedimentation control systems involves the application of planning, scheduling, and control actions that will minimize the adverse impacts of erosion, transport, and deposition of soil. The following five basic principles are essential elements that must be incorporated in a sound soil erosion and sedimentation control plan prior to the disturbance of the site:

- a) The project shall be, to the greatest extent possible, planned to harmonize with the natural topography, soil types, waterways and existing vegetation found at the site.
- b) Soils shall be exposed for the shortest possible time and involve the smallest area possible.
- c) On-site erosion control measures shall be utilized to prevent erosion from the site to the greatest extent possible.
- d) Sedimentation control measures shall be utilized to prevent soils from being washed off the site.
- e) An ongoing inspection and maintenance program shall be developed and approved by EPDS prior to any disturbance of soil on the site.

The planning process shall identify potential soil erosion and sedimentation control problems before soils on the site are disturbed. Vegetative control measures are required for all disturbed areas and generally shall include filter strips, temporary or permanent seeding, sodding, mulching and erosion-control blankets. Structural control measures are required when runoff leaves a disturbed site and generally include sediment traps, diversions, sediment basins and permanent drainage facilities.

The soil erosion and sedimentation control plan shall include appropriate construction specifications for all control measures. These specifications shall be developed by the design engineer as required to address site-specific conditions. Typical specifications may be obtained from the *Guidebook of Best Management Practices for Michigan Watersheds*.

3.6.6 Construction Sequencing

Soil erosion and sedimentation control measures shall start with erosion protection where soil is disturbed and follow with proper conveyance and filtering measures and placing sediment basins/traps at low points before runoff leaves the site. This process is called the treatment train.

All temporary soil erosion and sedimentation control measures shall be removed after the final site stabilization is achieved.

3.6.7 Soil Erosion Protection

The surface of stripped areas shall be protected from soil erosion immediately after the final grade is reached. Temporary erosion protection should be maintained until permanent cover is established.

3.6.8 Construction Access Routes

A stabilized mat of aggregate, underlain with filter fabric material, shall be located at any point where vehicular traffic will be entering and leaving a construction site. When the tracking of soil offsite becomes a particular problem, a wash station(s) and/or street sweeping shall be required to reduce soil tracked offsite.

3.6.9 Watercourses

The bed and banks of a watercourse shall be continuously stabilized as work progresses along the watercourse.

No soil, rock, debris, or any other material shall be dumped or placed into a stream or into such proximity

that it may readily slough, slip, or erode into a stream, unless such dumping or placing is authorized by the City Manager and when applicable, the U.S. Army Corps of Engineers, for such purposes as, but not limited to, construction of bridges, culverts, and erosion control structures.

3.6.10 Earth Structures

Stabilization measures shall be applied to earthen structures such as dams, dikes and diversions immediately after installation.

3.6.11 Area limitation

- a) Disturbed areas draining one (1) acre or less are to be protected by a flow barrier such as silt fences or straw bales to control runoff. Vegetated filter strips shall not be used as a primary device but can be used as a backup in conjunction with other control measures.
- b) Disturbed areas larger than one (1) acre shall have sediment controls, such as a sediment basin, in addition to flow barriers.

3.6.12 Concentrated Flows

Concentrated runoff shall not be allowed to flow down cut or filled slopes. Runoff shall be contained within an adequate temporary or permanent channel, flume or slope drain structure.

3.6.13 Stockpiles

If a stockpile of soil is to remain in place more than three (3) days, soil erosion and sedimentation control measures shall be provided such as a tarp cover, sediment trap around the stockpile or seed and mulch.

3.6.14 Vegetative Measures

For vegetative soil stabilization measures, plants shall be selected which are appropriate to the season and site conditions. Adequate seedbed preparation shall be provided for plants to germinate and grow.

Permanent vegetation shall not be considered established until ground cover is achieved. Ground cover is achieved when it provides adequate cover with a density of at least 90% and is mature enough to control soil erosion satisfactorily and to survive adverse weather.

3.6.15 Velocity Control

Stormwater conveyance facilities that are either temporary or permanent in nature shall be designed to prevent erosive velocities.

3.6.16 Sediment Basins

Concentrated stormwater runoff and runoff from drainage areas, which exceed the design capacity of silt fence or inlet protection, shall pass through a sediment basin. For common drainage locations that serve an area with 10 or more acres disturbed at one time, a temporary sediment basin must be provided until final stabilization of the site. The permittee may request approval to use alternative controls if it can demonstrate the alternative controls are equivalent in effectiveness to a sediment basin. It is recommended that the smallest sediment basins and/or sediment traps be used for drainage locations serving less than 10 acres.

The sediment basin shall be sized to provide capacity of equal volume to contain one inch of runoff from the entire drainage area (approximately 3,600 cubic feet/acre). When determining the total contributing drainage area, off-site areas and areas which remain undisturbed by construction activity must be included unless runoff from these areas is diverted away from the sediment basin and is not co-mingled with sediment-laden runoff. The depth of the sediment basin must be less than or equal to 5 feet with a

minimum depth of 2 feet. The configuration between inlets and the outlet of the basin must provide at least two units of length for each one unit of width (> 2:1 length:width ratio). Sediment must be removed from the sediment basin when the design capacity has been reduced by 40 percent. When designing sediment basins, the permittee must consider public safety, especially as it relates to children, as a design factor.

3.6.17 Silt Fence and Diversions

Sheet flow runoff from denuded areas shall be intercepted by silt fence or diversions to protect adjacent properties, streams, and stream corridor protective zones from sediment transported via sheet flow. When intended to provide sediment control, silt fence shall be placed on a level contour. The use of other sediment barriers designed to control sheet flow runoff shall be at the discretion of the City Manager.

Stormwater diversion practices shall be used to keep runoff away from disturbed areas and steep slopes where practicable. Such devices, which include swales, dikes or berms, may receive stormwater runoff from areas up to 10 acres.

3.6.18 Storm Drain Inlet Protection

Storm drain inlets shall be protected with sediment trapping and filter control devices during construction. Sediment shall be removed from the storm sewer, to the extent possible, prior to final approval.

3.6.19 Other Controls

No solid (other than sediment) or liquid waste, including building materials, shall be discharged in stormwater runoff. The permittee must implement all necessary control measures to prevent the discharge of non-sediment pollutants to the stormwater management system or surface waters of the state. Under no circumstance shall concrete trucks wash out directly into an open channel, storm sewer or surface waters of the state. No exposure of stormwater to waste materials is allowed.

4.0 STORMWATER MANAGEMENT DESIGN GUIDANCE

This section addresses the specific design criteria required to design stormwater control measures in terms of the rate, volume and water quality. Climatological information is provided on the rainfall patterns and acceptable methods for calculating site stormwater runoff.

4.1 HYDROLOGY

As urban areas continue to develop and sites redevelop the volume of stormwater runoff increases due to the increase in impervious areas. Previously, stormwater management philosophy concentrated only on getting the stormwater runoff out of sight as quickly as possible and only addressed the effects of peak flow rates being generated. However, with the enactment of the National Pollutant Discharge Elimination System (NPDES) Stormwater Permit regulations, the current philosophy of stormwater management focuses on a more integrated approach that acknowledges the aspects of volume, rate, and quality as well as the relationship between groundwater and surface water.

In an effort to standardize design procedures for stormwater management facilities and adopt the current philosophy of stormwater management, the City of Grand Rapids has developed the standards contained in this manual. It is intended that these standards will facilitate site planning and design processes.

4.1.1 Design Storms

The Grand Rapids Stormwater Management Program has established some watershed-specific design capacity requirements as part of the detailed watershed planning process. To the extent that a detailed watershed plan is available, each individual project will be evaluated according to how it meets the objectives of the watershed plan in which the project is located. When no watershed-specific requirements are available, the uniform guidelines established below may be applied as appropriate.

Guiding Principle: *The selection of the design storm for the sizing of any particular stormwater management facility should consider the existence and adequacy of the Emergency Overland Flow Way and the risks should a storm event of greater intensity and duration occur. If the Emergency Overland Flow Way is inadequate, nonexistent, or uncertain, or if there are unacceptable risks to public safety and property, then the design engineer must determine a more appropriate and conservative design storm than the minimums suggested in this manual.*

The design of all facilities should be based on the design storm return interval; i.e., the probability that the storm will occur in any one year. For example, the 100-year storm has a one percent probability of being met or exceeded in any one year. The 25-year storm has a four percent probability of being met or exceeded in any one year. The developer shall meet the minimum design requirements summarized in the table below and discussed in further detail in the sections below.

Table 4.1.1-1 Hydrologic Design Criteria Summary

Variable	Design Event	Applies to:	Peak Flow Limit	Description	Freeboard Requirements	Emergency Overflow	Exceptions
Water Quality Treatment Volume	90% non-exceed.	Sites (parcels) and roadways	NA	Retain or treat runoff from the entire site.	NA	NA	Redevelopment sites must treat runoff from the disturbed area of the proposed site.
Stream Bank Protection	2-yr, 24-hr	Sites (parcels) and roadways discharging directly to an open channel	Allowable release rate of 0.05 cfs/acre	Provide detention as necessary to meet peak flow limits.	NA	NA	None
Capacity to Discharge to City Collection System	10-yr, 24-hr	Roadside swales, ditches, collector systems (storm drain pipes and culverts)	Less than or equal to 80% of CPD	Provide detention as necessary to meet peak flow limits.	HGL preferred below crown of pipe. HGL at least 1 ft. below ground surface.	NA	New development sites are required to limit the peak flow rate to be less than or equal to the CPD.
	5-yr, 24-hr	Temporary construction channel	Less than or equal to CPD	Provide detention as necessary to meet peak flow limits	Provide 1 ft. of freeboard between the design storage elevation and any nearby structures or other facilities.	NA	None
Flood Control for Discharge to City Collection System	25-yr, 24-hr	Trunk Systems	Less than or equal to 80% of CPD	Provide detention as necessary to meet peak flow limits.	HGL preferred below crown of pipe. HGL at least 1 ft. below ground surface.	NA	New development sites are required to limit the peak flow rate to be less than or equal to the CPD.
	25-yr, 24-hr	Storage facilities with adequate downstream floodways	Less than or equal to 80% of CPD	Provide detention as necessary to meet peak flow limits.	Provide 1 ft. of freeboard between the design storage elevation and any nearby structures or other facilities.	Provide spillway capacity for a 10-year, 24-hour storm event. Provide overland flow way for the portion of the 100-year storm event that the storage facility does not manage.	New development sites are required to limit the peak flow rate to be less than or equal to the CPD.
	100-yr, 24-hr	Storage facilities without adequate downstream floodways	Less than or equal to 80% of CPD	Provide detention as necessary to meet peak flow limits.	Provide 1 ft. of freeboard between the design storage elevation and any nearby structures or other facilities.	Provide spillway capacity for a 10-year, 24-hour storm event. Provide overland flow way for the portion of the 100-year storm event that the storage facility does not manage.	New development sites are required to limit the peak flow rate to be less than or equal to the CPD.

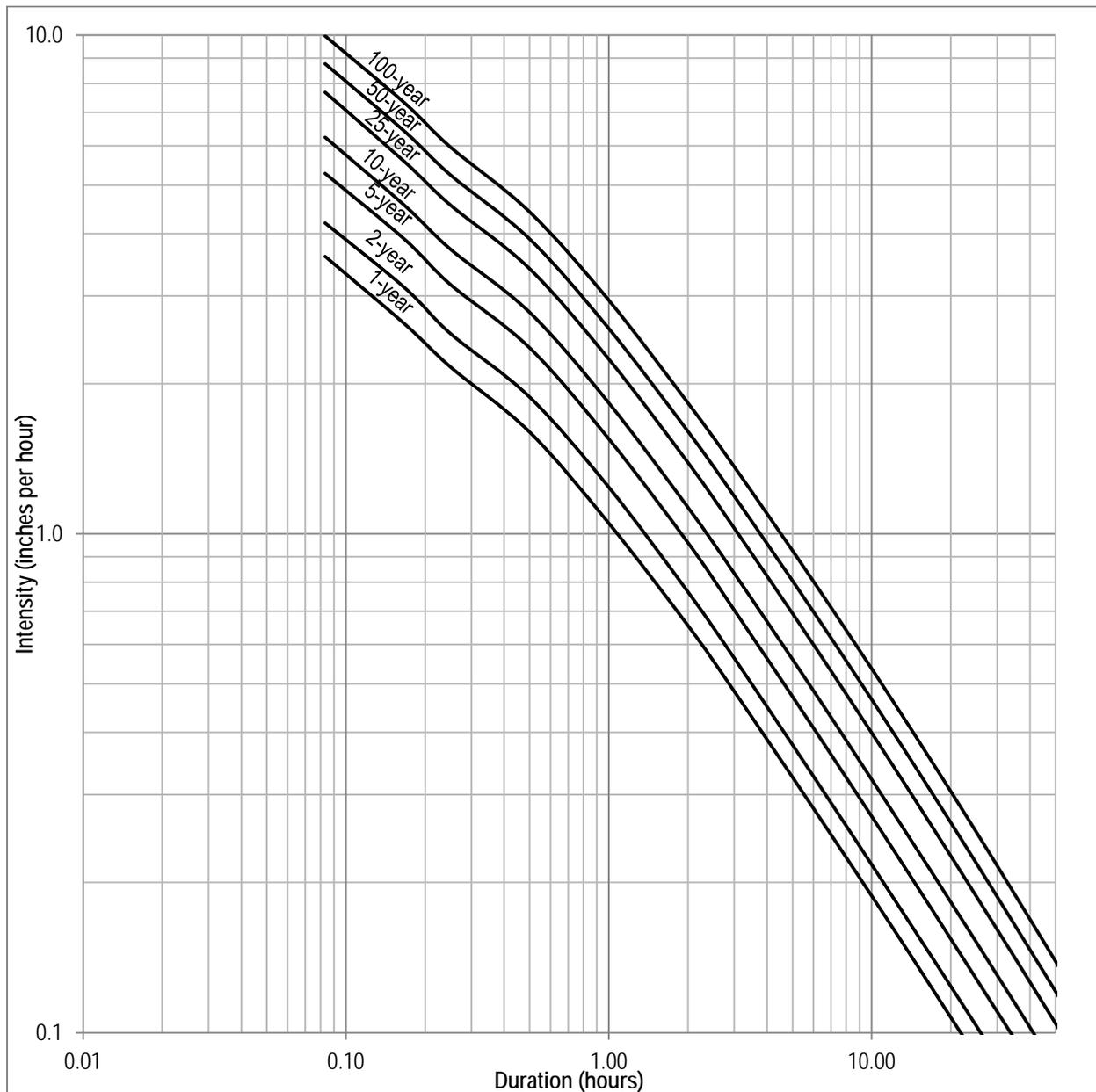
Rainfall values for the various design storm frequencies using the rainfall depths can be obtained from Table 4.1.1-2.

Table 4.1.1-2 Rainfall Depths

Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
5-min	0.300 (0.261-0.347)	0.352 (0.306-0.408)	0.442 (0.383-0.514)	0.522 (0.448-0.610)	0.638 (0.524-0.780)	0.733 (0.581-0.908)	0.832 (0.628-1.06)
10-min	0.439 (0.382-0.508)	0.515 (0.448-0.597)	0.648 (0.561-0.753)	0.764 (0.656-0.893)	0.934 (0.767-1.14)	1.07 (0.851-1.33)	1.22 (0.919-1.55)
15-min	0.535 (0.466-0.619)	0.628 (0.547-0.728)	0.790 (0.684-0.918)	0.932 (0.800-1.09)	1.14 (0.935-1.39)	1.31 (1.04-1.62)	1.49 (1.12-1.89)
30-min	0.801 (0.698-0.928)	0.941 (0.819-1.09)	1.18 (1.02-1.37)	1.39 (1.20-1.63)	1.70 (1.40-2.08)	1.95 (1.55-2.42)	2.21 (1.67-2.82)
60-min	1.06 (0.919-1.22)	1.24 (1.07-1.43)	1.55 (1.34-1.80)	1.83 (1.57-2.14)	2.24 (1.84-2.74)	2.58 (2.05-3.20)	2.94 (2.22-3.75)
2-hr	1.31 (1.15-1.50)	1.53 (1.34-1.76)	1.92 (1.67-2.21)	2.26 (1.96-2.63)	2.78 (2.30-3.39)	3.21 (2.57-3.96)	3.66 (2.79-4.65)
3-hr	1.45 (1.27-1.66)	1.69 (1.48-1.93)	2.11 (1.84-2.43)	2.50 (2.17-2.89)	3.08 (2.57-3.75)	3.57 (2.87-4.40)	4.09 (3.13-5.18)
6-hr	1.69 (1.49-1.92)	1.96 (1.73-2.23)	2.45 (2.15-2.80)	2.91 (2.53-3.34)	3.60 (3.02-4.36)	4.19 (3.39-5.13)	4.82 (3.72-6.07)
12-hr	1.95 (1.73-2.20)	2.25 (1.99-2.55)	2.81 (2.48-3.19)	3.33 (2.91-3.79)	4.13 (3.49-4.98)	4.82 (3.93-5.87)	5.56 (4.33-6.96)
24-hr	2.22 (1.98-2.49)	2.56 (2.28-2.88)	3.18 (2.82-3.59)	3.77 (3.31-4.26)	4.66 (3.97-5.58)	5.43 (4.47-6.58)	6.27 (4.92-7.80)
2-day	2.55 (2.28-2.84)	2.91 (2.61-3.25)	3.59 (3.20-4.02)	4.22 (3.73-4.74)	5.19 (4.44-6.16)	6.02 (4.98-7.23)	6.92 (5.47-8.53)
3-day	2.81 (2.53-3.12)	3.18 (2.86-3.54)	3.87 (3.46-4.31)	4.51 (4.00-5.05)	5.49 (4.72-6.49)	6.34 (5.27-7.57)	7.26 (5.77-8.91)

NOAA Atlas 14, Volume 8, Version 2 for Grand Rapids International Airport (ID 20 3333), accessed May 24, 2013. Numbers in parenthesis are precipitation frequency estimates at lower and upper bounds of the 90% confidence interval.

Figure 4.1.1-1 Rainfall IDF Curve



When a runoff hydrograph is required, a design storm event should be used as input to hydrologic calculations. The selection of the storm duration and distribution affects the resulting runoff volume and the peak discharge rate. Because of this, the total storm volume and distribution should be selected to produce total runoff volume and peak runoff rates that are independent of the tributary area. The following characteristics of the design storm shall be used:

- a) A 24-hour rainfall volume should be used.
- b) The rainfall distribution for the design storm should be in accordance with the Natural Resource Conservation Service (NRCS) Type II Rainfall Distribution.
- c) The total rainfall volume and distribution using NRCS Type II data are provided in Table 4.1.1-3, using half-hour increments for various recurrence intervals.

Table 4.1.1-3 Design Storm Hyetograph Data

Frequency	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	90%
Duration	24-hr							
Depth	2.22-in	2.56-in	3.18-in	3.77-in	4.66-in	5.43-in	6.27-in	0.99-in
Hour								
0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.5	0.015	0.017	0.021	0.025	0.030	0.036	0.041	0.006
1.0	0.015	0.017	0.021	0.025	0.031	0.036	0.041	0.007
1.5	0.015	0.017	0.021	0.025	0.031	0.036	0.041	0.007
2.0	0.015	0.017	0.021	0.025	0.031	0.036	0.042	0.007
2.5	0.015	0.017	0.021	0.025	0.031	0.036	0.042	0.007
3.0	0.015	0.017	0.022	0.026	0.032	0.037	0.043	0.007
3.5	0.015	0.018	0.022	0.026	0.032	0.037	0.043	0.007
4.0	0.016	0.018	0.022	0.026	0.033	0.038	0.044	0.007
4.5	0.016	0.018	0.023	0.027	0.033	0.039	0.045	0.007
5.0	0.016	0.019	0.024	0.028	0.035	0.040	0.046	0.007
5.5	0.017	0.020	0.025	0.029	0.036	0.042	0.048	0.008
6.0	0.018	0.021	0.026	0.030	0.038	0.044	0.051	0.008
6.5	0.019	0.022	0.027	0.032	0.040	0.047	0.054	0.009
7.0	0.021	0.024	0.029	0.035	0.043	0.050	0.058	0.009
7.5	0.022	0.026	0.032	0.038	0.047	0.055	0.063	0.010
8.0	0.025	0.029	0.036	0.042	0.052	0.061	0.070	0.011
8.5	0.028	0.032	0.040	0.048	0.059	0.069	0.079	0.013
9.0	0.032	0.037	0.046	0.055	0.068	0.079	0.091	0.014
9.5	0.038	0.044	0.054	0.064	0.080	0.093	0.107	0.017
10.0	0.045	0.052	0.065	0.077	0.095	0.110	0.128	0.020
10.5	0.055	0.063	0.078	0.093	0.115	0.134	0.154	0.024
11.0	0.067	0.078	0.097	0.114	0.141	0.165	0.190	0.030
11.5	0.109	0.125	0.156	0.185	0.228	0.266	0.307	0.048
12.0	0.790	0.912	1.132	1.342	1.659	1.933	2.233	0.353
12.5	0.196	0.226	0.281	0.333	0.412	0.480	0.554	0.088
13.0	0.074	0.086	0.107	0.126	0.156	0.182	0.210	0.033
13.5	0.059	0.068	0.085	0.101	0.124	0.145	0.167	0.026
14.0	0.049	0.056	0.070	0.083	0.103	0.120	0.138	0.022
14.5	0.041	0.047	0.059	0.070	0.086	0.100	0.116	0.018
15.0	0.035	0.040	0.050	0.059	0.073	0.085	0.099	0.016
15.5	0.030	0.035	0.043	0.051	0.063	0.074	0.085	0.013
16.0	0.027	0.031	0.038	0.045	0.056	0.065	0.075	0.012
16.5	0.024	0.027	0.034	0.040	0.050	0.058	0.067	0.011
17.0	0.022	0.025	0.031	0.037	0.045	0.053	0.061	0.010
17.5	0.020	0.023	0.029	0.034	0.042	0.049	0.056	0.009
18.0	0.019	0.022	0.027	0.032	0.039	0.046	0.053	0.008
18.5	0.018	0.020	0.025	0.030	0.037	0.043	0.050	0.008
19.0	0.017	0.019	0.024	0.029	0.035	0.041	0.048	0.008
19.5	0.016	0.019	0.023	0.028	0.034	0.040	0.046	0.007
20.0	0.016	0.018	0.023	0.027	0.033	0.039	0.045	0.007
20.5	0.016	0.018	0.022	0.026	0.033	0.038	0.044	0.007
21.0	0.015	0.018	0.022	0.026	0.032	0.037	0.043	0.007
21.5	0.015	0.017	0.022	0.026	0.032	0.037	0.042	0.007
22.0	0.015	0.017	0.021	0.025	0.031	0.036	0.042	0.007
22.5	0.015	0.017	0.021	0.025	0.031	0.036	0.042	0.007
23.0	0.015	0.017	0.021	0.025	0.031	0.036	0.041	0.007
23.5	0.015	0.017	0.021	0.025	0.031	0.036	0.041	0.007
24.0	0.015	0.017	0.021	0.025	0.030	0.036	0.041	0.006

Based on Froehlich 2009

4.1.2 Water Quality Treatment Volume

The City requires that the developer must provide for capture and treatment of the water quality treatment volume defined in Table 4.1.1-1. The correspondence rainfall depth for the water quality treatment volume is defined in Table 4.1.2-1 and illustrated in Figure 4.1.2-1. Non-exceedance storm percentiles are

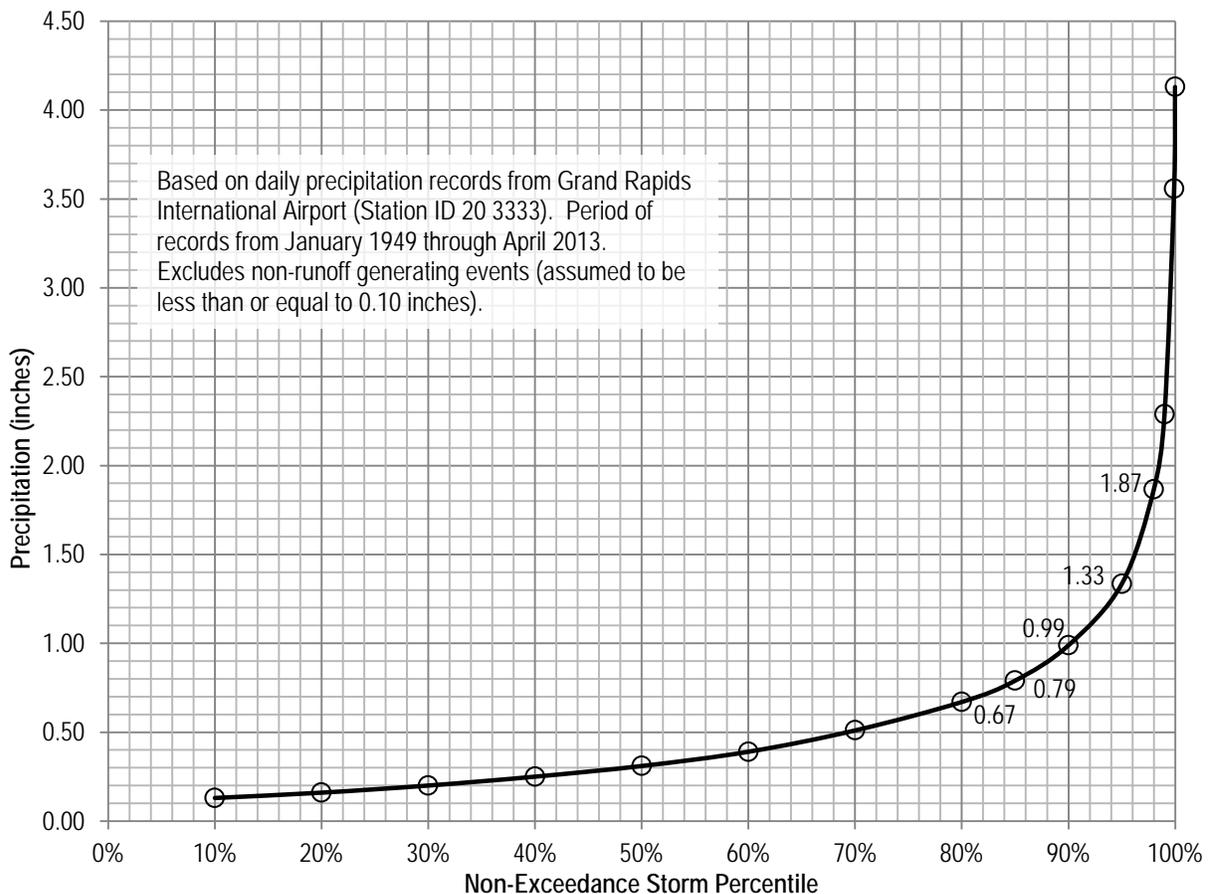
based on daily precipitation records from the Grand Rapids International Airport (NOAA Station ID 20 3333) for the period of records from January 1949 through April 2013. Non-exceedance storm percentiles calculations exclude non-runoff generating storm events which were assumed to be rainfall events less than or equal to 0.10 inches.

Treatment can be addressed by retaining the minimum required water quality treatment volume, capturing, filtering then releasing it, or filtering the water through a hydrodynamic device. One or more SCMs are to be implemented when necessary in a configuration that results in effective treatment for the required volume.

Table 4.1.2-1 Non-Exceedance Storm Percentile

Percentile	Precipitation (inches)
80%	0.67
85%	0.79
90%	0.99
95%	1.33
98%	1.87
99%	2.29
99.9%	3.56
99.99%	4.13

Figure 4.1.2-1 Non-Exceedance Storm Percentile



4.1.3 Stream Bank Protection Criteria

The intent of stream bank protection criteria is not to eliminate all channel erosion, as erosion is a normal aspect of river behavior. Rather, the objective is to maintain a level of stream erosion such that the channel can continue to support aquatic life and support natural erosion processes. The stream bank protection criteria apply to channels where excessive erosion and stream bank degradation is present.

The stream bank protection criteria require limiting the peak discharge rate from a site for the design storm specified in Table 4.1.1-1.

4.1.4 Conveyance

Stormwater drainage systems may consist of natural streams, channels, vegetated swales, open ditches, closed conduits or a combination of methods to convey stormwater. Drainage facilities shall be constructed in accordance with the City's minimum specifications presented in this manual. Other standards may apply depending on location of the outlet.

The full build-out 100-year, 24-hour design storm shall be routed through the on-site storm sewer system and stormwater controls to determine the effects on the on-site system, adjacent property, and downstream areas. Even though the conveyance systems may be designed for smaller storm events, overall the site should be designed appropriately to safely pass the resulting flows from the full build-out 100-year storm event with no flood water entering habitable structures or causing significant damage.

4.1.5 Flood Control

Prior to beginning the design of on-site stormwater facilities, the developer should contact the City to determine if any downstream restrictions have been identified that would further restrict the discharge of stormwater from the proposed site.

At a minimum, designs should be based on meeting the flood control requirements in Table 4.1.1-1. The volume that is captured and managed in various SCMs occurring on the site may be subtracted from the required flood control volume. Design must consider the ability of the downstream facilities to safely transport the stormwater discharge as identified in Table 4.1.1-1.

Discharge rates more stringent than those derived from the established criteria may be imposed if the downstream conditions, such as limited capacity for enclosed conveyance pipes, limitations on flows to those used in the FEMA modeling, or other specific restrictions are identified.

Under no circumstances shall the proposed site development diminish the storage capacity in the 100-year floodplain. Compensatory storage due to a proposed site development will be required for all lost floodplain storage typically on a 2 to 1 replacement ratio.

4.1.6 Exemptions

Sites disturbing an area less than 1,000 square feet that are not part of a large development plan shall not be required to meet water quality and water quantity control requirements presented in this manual.

4.1.7 Hydrologic Calculations

In general, required control and treatment are intended to provide protection from flooding and stream channel erosion while preventing degradation of water quality within the watershed and ideally reducing degradation from those sites that have been previously altered.

Two categories of hydrologic calculations are generally considered. The first involves establishing a peak flow for the sizing of storm sewer systems, culverts, or open channels. The second involves the routing of peak flows through stormwater control facilities (i.e. detention basins, rain gardens, etc.).

Many different methods are available to calculate runoff from site development. Calculations are required

for the condition prior to development, the uncontrolled runoff, and the runoff after including stormwater controls.

Table 4.1.7-1 identified the approved methodologies to use for generating a rainfall distribution curve and calculating and routing runoff. Other methodologies may be allowed as approved by the City Manager but may require additional review time.

Table 4.1.7-1 Approved Calculation Methodologies

Process Description	Approved Methodologies*
Rainfall hyetograph	NRCS Type II Distribution
Surface runoff generation	NRCS Curve Number Approach (HYMO, TR-20, TR-55) EPA SWMM Hydrology SDST Spreadsheet
Storm Sewer System Sizing	Rational Method NRCS Curve Number Approach (HYMO, TR-20, TR-55) EPA SWMM
Routing flow on site through SCMs and stormwater controls	EPA SWMM SDST Spreadsheet
Routing flow offsite through municipal collection system	EPA SWMM

*Or as approved by City Manager or his designee

More details on hydrologic calculations are available from the NRCS in the National Engineering Handbook Part 630, Hydrology. Chapters within the handbook address topics such as hydrologic soil groups, hydrologic soil-cover complexes, time of concentration, and hydrographs. Other suggested references include books by Linsley, Kohler and Paulhus (1983), Bedient and Huber (1988), Chow, Maidment and Mays (1988) or Wanielista and Yousef (1993).

4.2 HYDRAULIC CALCULATIONS

Hydraulic calculations are used to size conduits or open channels to handle the design flows calculated from hydrologic calculations. The hydraulic capacity of a storm sewer conduit or culvert can be calculated for the two types of conditions typically referred to as gravity and pressure flow. Open channel facilities are evaluated considering only gravity flow.

Hydraulic procedures provided in this section represent a summary of information from publications by Brater and King (1976), Chow (1959), the American Society of Civil Engineers (1992), the University of Missouri (1958), the American Iron and Steel Institute (1980), and the American Concrete Pipe Association (1978 and 1980). These publications should be consulted if additional details are required.

4.2.1 Pressure Versus Gravity Flow

In general, if the hydraulic grade line is above the crown of a pipe, pressure flow hydraulic calculations are appropriate. Conversely, if the hydraulic grade line is below the crown of a pipe, gravity flow calculations are appropriate. Storm sewer systems should generally be designed as gravity systems.

For storm sewers designed to operate under pressure flow conditions, inlet surcharging and possible manhole lid displacement can occur if the hydraulic grade line rises above the ground surface. A design based on gravity conditions must be carefully planned as well, including evaluation of the potential for excessive and inadvertent flooding created when a storm event larger than the design storm pressurizes the system.

Existence of the desired flow condition should be verified for design conditions. Storm sewer systems can alternate between pressure and gravity flow conditions from one section to another.

The discharge point of the storm sewer system usually establishes a starting point for evaluating the

condition of flow. If the discharge is submerged, as when the water level of the receiving waters is above the crown of the storm sewer, the exit loss should be added to the water level and calculations for head loss in the storm sewer system started from this point. If the hydraulic grade line is above the pipe crown at the next upstream manhole, pressure flow conditions exist; if it is below the pipe crown, then gravity flow calculations should be used at the upstream manhole.

When the discharge point is not submerged, a flow depth should be calculated at a known control section to establish a starting elevation. The hydraulic grade line is then projected from the starting elevation to the upstream manhole unless flow is super-critical, and then calculations start upstream and go in the downstream direction. Pressure flow calculations may be used at the manhole if the hydraulic grade is above the pipe crown.

The assumption of straight hydraulic grade lines is not entirely correct, since backwater and drawdown conditions can exist, but is generally reasonable. It is also usually appropriate to assume the hydraulic grade calculations begin at the crown of the outlet pipe for simple, nonsubmerged systems. If additional accuracy is needed, as with very large conduits or where the result can greatly affect design, backwater and drawdown curves should be developed.

4.2.2 Energy Losses

The following energy losses should be considered for storm sewer systems:

- a) Friction
- b) Entrance
- c) Exit

Additional energy loss parameters should be evaluated for complex or critical systems. The following losses are especially important when failure to handle the design flood has the potential to flood off-site areas:

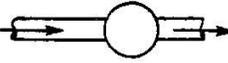
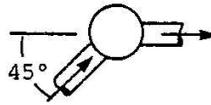
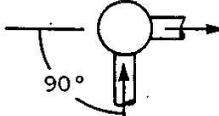
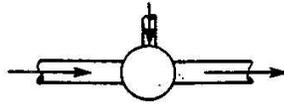
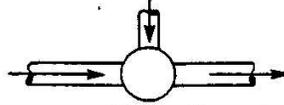
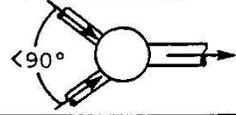
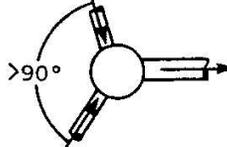
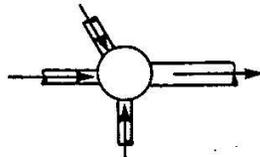
- a) Expansion
- b) Contraction
- c) Bend
- d) Junction and manhole

The energy loss coefficient, K , is different for each category of pipe form loss and should be based on operating characteristics of the specific system. Values for the entrance loss coefficient are the same as those developed for culverts (Section 4.6). Expansion and contraction loss coefficients for circular pipes can be selected based on data from Brater and King (1976).

The bend loss coefficient for storm sewer systems can be evaluated using a graphical relationship between the angle of a bend and the loss coefficient, as presented by the Denver Regional Council of Governments (1969).

Losses associated with junctions and manholes should be evaluated with the procedures reported by the University of Missouri (1958). Although details of the procedures are not given in this manual, the application of important results is discussed below; and head loss coefficients for typical manholes and junctions are presented in Table 4.2.2-1.

Table 4.2.2-1 Head Loss Coefficient for Manholes/Junctions

Single Pipe Junctions		
Type of Manhole/Junction		Head Loss Coefficient (K)
Trunkline only with no bend at junction		0.5
Trunkline only with 45° bend at junction		0.6
Trunkline only with 90° bend at junction		0.8
Multiple Pipe Junctions		
Type of Manhole/Junction		Head Loss Coefficient (K)
Trunkline with one small lateral		0.6
Trunkline with one large lateral		0.7
Two roughly equivalent entrance lines with angle of <90° between lines		0.8
Two roughly equivalent entrance lines with angle of >90° between lines		0.9
Three or more entrance lines		1.0

Reference: Golding (1987).

Note: Above values of K are to be used to estimate energy or head losses through surcharged junctions/manholes in pressure flow portions of a storm sewer system. The energy loss equation is $h_j(\text{ft}) = K \frac{[v(\text{ft}/\text{sec})]^2}{64.4}$

with v = larger velocity in main entrance or exit line of junction/manhole.

4.2.3 Gravity Flow

The capacity of storm sewers and open channels designed to operate under gravity flow conditions should be sized using Manning's Equation.

Storm sewer or open channel capacity calculations based on Manning's Equation can be made using procedures published by Brater and King (1976), the American Concrete Pipe Association (1978 and 1980), Chow (1959), and the American Iron and Steel Institute (1980).

4.3 STORMWATER CONTROL MEASURES

The purpose of this section is to define the recommended stormwater control measures for use in the City of Grand Rapids. Design requirements for each stormwater control measure are presented in table format.

4.3.1 Common Elements

While there are numerous variations and unique site-specific design elements for each stormwater control measure, several common elements exist that have been included in this section rather than repeated within each guidance table. Note that the discussion of the common design elements covered in this section is not intended to be comprehensive; the designer is expected to use sound engineering practices in the design of all elements of the stormwater control measures.

4.3.1.1 Energy Dissipation

Energy dissipation is expected to be incorporated at all inlets and outlets to prevent erosion, scour, and sloughing of the soil. A typical method to dissipate energy from water flow is by constructing a layer of rock for the water to flow over. The specified size, shape and weight of the rock are a function of the velocity of the water, the geometry of the protected channel or bank, and the magnitude of wave energy. A geotextile blanket must also be placed beneath the rock. Forebays may also be used for energy dissipation as well as to promote settling of sediment particles.

4.3.1.2 Pedestrian Areas

Care should be taken when designing near pedestrian access points so that pedestrians are able to safely exit from a vehicle onto a level surface without risking a large drop or getting wet. Vehicle car doors must be able to be opened.

4.3.1.3 Dewater Time

For stormwater control measures, other than those which are designed to maintain a permanent pool and pervious pavement, it is assumed that the entire facility (surface and subsurface) drains within 72 hours.

4.3.1.4 Outlet

The outlet of a stormwater control measure shall be designed to meet the hydraulic requirements and minimize vandalism, clogging from trash and debris, and the need for maintenance. Access for maintenance shall be provided.

4.3.1.5 Vector Control Considerations

Stormwater control measures that are designed to temporarily hold water shall drain within 72 hours to prevent the establishment of mosquito colonies. Rain barrels and cisterns shall be covered and include appropriate screens and other features to prevent the entrance of mosquitos.

4.3.1.6 Native Plantings

The incorporation of native plantings into the design of all stormwater control measures requiring vegetation is encouraged.

4.3.1.7 Construction Staging for Vegetated Stormwater Control Measures

The use of vegetation and soil-based treatment systems as outlined in this chapter requires careful attention to construction staging and phasing. Protection of soils from compaction and disturbance during site preparation and construction, the soil amendment, the installation of soil and filter media, and the timing, placement and techniques used in planting, all affect the ultimate efficacy of these stormwater control measures. Therefore, a construction and phasing plan shall be included for all vegetated stormwater control measures to ensure proper construction, function, and treatment.

4.3.1.8 Geotechnical Report for Infiltration Facilities

Geotechnical reports are required for sites where an infiltration facility is proposed and should include enough information to address the following site information requirements:

- Types of soil and subsurface materials underlying the infiltration facility
- Infiltration rates, locations, and test dates at the infiltration facility location
- Permeability test
- Proximity to surface water
- Proximity of the seasonal high ground water table beneath the bottom of the infiltration facility

The infiltration rate shall be measured at a depth equal to the proposed bottom grade of the facility.

4.3.1.9 Location Restrictions

Stormwater control facilities should not be constructed in a regulatory floodplain unless approved by the City Manager or designee.

4.3.1.10 Buffer Zones

There should be a 50-foot buffer zone measured from the waterline of the design high-water elevation outward perpendicular to the waterline, around any stormwater management facility. No residential-type structure should be built within this buffer zone.

4.3.2 Bioretention

Traditional bioretention describes a shallow stormwater basin or landscaped area that utilizes a soil media and vegetation to capture and treat runoff. It may also be referred to as a rain garden. There are numerous design configurations for bioretention, which primarily function to remove stormwater pollutants from runoff; although, they may also be used to partially or completely meet quantity control requirements from smaller tributary areas.

4.3.2.1 Vegetated Swale

A vegetated swale (also referred to as a bioretention or infiltration swale) is a modified swale that uses a soil media to improve water quality, reduce the runoff volume, and modulate the peak runoff rate while also providing conveyance of excess runoff. It performs the same functions as grassed swales by serving as a conveyance structure and filtering and infiltrating runoff, but because soil media is used, they provide enhanced infiltration, water retention, and pollutant removal. Vegetated swales may be used in conjunction with pretreatment control measures such as vegetated filter strips or other sediment capturing devices to prevent sediment from accumulating in the swale.

4.3.2.2 Planter Box

A planter box is a variation of traditional bioretention. It performs the same function but is contained within a concrete box which allows it to be incorporated into constricted areas such as along a street corridor or attached to a building along the foundation. Planter boxes are often categorized as flow-through planter boxes or infiltrating planter boxes. The infiltrating planter boxes have an open bottom to

allow infiltration into the underlying soils. Flow-through planter boxes are completely lined and have an underdrain system to convey flow that is not taken up by plants to areas that are appropriate for drainage, typically away from building foundations.

Table 4.3.2-1 below presents design criteria for the vegetated stormwater control measures described above.

Table 4.3.2-1 Vegetated SCM Design Criteria

Design Criteria	Bioretention	Vegetated Swale	Planter Box
Bottom Slope	Flat	1%-6%	Flat
Bottom Width	No requirement	2-8 feet	No requirement
Under drain	6-inch perforated PVC placed to meet dewatering requirement if needed; cleanout at terminal ends	6-inch perforated PVC placed to meet dewatering requirement if needed; cleanout at terminal ends	6-inch perforated PVC placed to meet dewatering requirement if needed; cleanout at terminal ends
Side Slopes	3:1 (H:V)	4H:1V or flatter	Vertical retaining wall
Freeboard	6 to 12 inches	6 to 12 inches	6 to 12 inches
Emergency Spillway	Ensure nearby structures are protected	Ensure nearby structures are protected	Ensure nearby structures are protected
Pretreatment	Required	Required	Required
Soil Permeability	0.5 inches/hour minimum	0.5 inches/hour minimum	0.5 inches/hour minimum if applicable
Depth to Groundwater	Bottom of practice to be ≥ 2 feet above or use impermeable liner	Bottom of practice to be ≥ 2 feet above or use impermeable liner	Bottom of practice to be ≥ 2 feet above or use impermeable liner

4.3.3 Capture Reuse

Capture reuse, also referred to as rainwater harvesting, is the practice of collecting rainwater and re-using it for purposes such as irrigation and non-potable building uses. With regard to stormwater, the City's standard does not allow rainwater harvesting to be used to meet stormwater requirements. However, rainwater harvesting is encouraged as a water conservation and efficiency practice.

Two capture reuse systems are addressed in this chapter including rain barrels and cisterns. A rain barrel is an above-ground prefabricated storage receptacle with an automated overflow diversion system that collects and stores stormwater runoff from the roof of a structure that would have otherwise been routed into a storm drain. A cistern is either an above or underground storage component of a rainwater harvesting system typically larger than 80 gallons.

Specific design criteria for rain barrels and cisterns are provided in Table 4.3.3-1 Capture Reuse Design Criteria.

Table 4.3.3-1 Capture Reuse Design Criteria

Design Criteria	Rain Barrel	Cistern
Bottom Slope	Not applicable	Not applicable
Bottom Width	No requirement	No requirement
Underdrain	Not applicable	Not applicable
Side Slopes	Not applicable	Not applicable
Freeboard	No requirement	No requirement
Emergency Spillway	Required; must be directed away from the building foundation; must not cause excessive erosion or water damage, or must be diverted to the public storm sewer or other approved location	Required; must be directed away from the building foundation; must not cause excessive erosion or water damage, or must be diverted to the public storm sewer or other approved location
Pretreatment	No requirement	Include a debris excluder prior to entering the storage tank
Soil Permeability	No requirement	No requirement
Depth to Groundwater	Bottom of practice to be ≥ 2 feet above to prevent buoyancy (or provide buoyancy calculations)	Bottom of practice to be ≥ 2 feet above to prevent buoyancy (or provide buoyancy calculations)

4.3.4 Constructed Filter

A constructed filter, (or a media filter) preceded by a pretreatment chamber is a treatment system that is used to remove particulates and solids from stormwater runoff through settling and filtering. The system may be constructed underground in a concrete vault or above ground using earthen berms. Stormwater diverted to the system travels through the pretreatment chamber and into the constructed filter. Media is typically sand, peat, compost, granular activated carbon, perlite (or other inorganic materials). Design criteria to be used in the design of constructed filters are shown in Table 4.3.4-1.

Table 4.3.4-1 Constructed Filter Design Criteria

Design Criteria	Constructed Filter
Maximum Bottom Slope	Pretreatment chamber: no requirement Constructed filter: Flat
Bottom Width	No requirement
Underdrain	6-inch perforated PVC pipe as necessary
Side Slopes	4H:1V or flatter and vegetated or vertical concrete walls
Freeboard	Pretreatment chamber: ≥ 6 inches Constructed filter: ≥ 12 inches
Emergency Spillway	Ensure nearby structures are protected
Pretreatment	Pretreatment chamber is required
Soil Permeability	No requirement
Depth to Groundwater	Bottom of practice to be ≥ 2 feet above to prevent buoyancy (or provide buoyancy calculations)

4.3.5 Basins

The basins include detention basins, retention basins, stormwater wetlands, and extended dry detention basins. Common elements of these basins are the inclusion of a forebay and micropool to help settle out sediment. The basin inlet discharges into the forebay while the micropool is used before water leaves the basin through the outlet.

4.3.5.1 Detention Basins

Detention basins are large facilities designed to prevent downstream flooding by attenuating stormwater runoff peak flows. Residential structures shall be constructed at least fifty feet away from the design high water elevation of a detention basin, or twenty feet from a floodway or areas subject to a base flood. They

are to be dewatered within 24 hours after a rain event has ended. They are typically designed without a permanent pool of water, although some include forebays and/or micropools which may hold water. Typically, dry detention basins are minimally effective in removing pollutants compared to other stormwater control measures.

4.3.5.2 Retention Basins

Retention basins are large facilities are typically designed with a permanent pool of water plus additional storage above the level of the permanent pool. During a storm event, stormwater enters the basin and is stored temporarily as it is slowly released through infiltration into the soil to groundwater. A safety bench and planted aquatic bench are required around the perimeter of a wet pool. The presence of a mechanical aerator, such as a fountain in the middle of the pond, may be used to make the site more attractive, deter the growth of unwanted vegetation, and make the habitat more suitable for fish. A method should be provided to drain a permanent pool to facilitate maintenance.

4.3.5.3 Stormwater Wetlands

Stormwater wetlands are constructed shallow marsh systems designed and placed to use the natural processes of wetland vegetation, soils, and their associated biological activity to provide treatment for stormwater runoff. As engineered facilities, stormwater wetlands have less biodiversity than natural wetlands but still require a base flow to support the aquatic vegetation present. Stormwater wetlands depend on flow from the contributing drainage area rather than groundwater flow as their base flow source. Because of this, they tend to require large contributing drainage areas to obtain adequate base flow to function well.

4.3.5.4 Extended Dry Detention

Extended dry detention basins are large facilities typically designed without a permanent pool of water, although some include forebays and/or micropools which may hold water. The outlets are designed such that stormwater runoff is detained for a period of time, typically 24 hours to 72 hours. The temporary storage allows sediment to settle out; overall, however, extended dry detention basins are minimally effective in removing pollutants compared to other stormwater control measures. Design Criteria for all four types of basins are presented in Table 4.3.5-1.

Table 4.3.5-1 Basin Design Criteria

Design Criteria	Detention	Retention	Stormwater Wetland	Extended Dry Detention
Bottom Slope	2% minimum	Flat	< 8%	No requirement
Bottom Width	No requirement	No requirement	No requirement	No requirement
Underdrain	3-inch minimum outlet pipe. If more restrictive flows are required, an alternative design must be provided.	Optional: 3-inch minimum outlet pipe. If more restrictive flows are required, an alternative design must be provided.	None	Optional: 3-inch minimum outlet pipe. If more restrictive flows are required, an alternative design must be provided.
Side Slopes	4H:1V or flatter for basins > 2 feet deep. A permanent enclosure shall be provided for slopes exceeding 6H:1V, or an average depth that exceeds 3 feet	4H:1V or flatter for basins > 2 feet deep and shall be surrounded by a dense wetland type vegetation barrier a minimum of 20 ft wide with a water depth in the barrier not to exceed 2 ft deep	3H:1V or flatter; deep pool areas require a perimeter safety bench	4H:1V or flatter for basins > 2 feet deep. A permanent enclosure shall be provided for slopes exceeding 6H:1V, or an average depth that exceeds 3 feet
Freeboard	12 inches	12 inches	6-12 inches	12 inches
Emergency Spillway	Required with a capacity for the 10-year, 24-hour storm event	Required with a capacity for the 10-year, 24-hour storm event	Ensure nearby structures are protected	Required with a capacity for the 10-year, 24-hour storm event
Pretreatment	Include forebay or other sediment removal device	Include forebay or other sediment removal device	Include forebay or other sediment removal device	Include forebay or other sediment removal device
Soil Permeability	Not applicable	Not applicable	Native soil type should support retention of water in wetland	Test infiltration; 0.5 inches/hr minimum if designing with infiltration
Depth to Groundwater	Bottom of system to be \geq 2 feet above or use impermeable liner	Depending on underlying geology, may need liner to ensure water retention	Not applicable	Bottom of system to be \geq 2 feet above or use impermeable liner
Outfalls	Shall discharge to a defined downstream system with adequate capacity to handle the flow. When discharging to an open channel, an energy dissipater and/or other soil erosion protection must be provided	Shall discharge to a defined downstream system with adequate capacity to handle the flow. When discharging to an open channel, an energy dissipater and/or other soil erosion protection must be provided	A bottom drain is required	Shall discharge to a defined downstream system with adequate capacity to handle the flow. When discharging to an open channel, an energy dissipater and/or other soil erosion protection must be provided

4.3.6 Pervious Pavement

Pervious pavements contain small voids that allow stormwater to drain through the pavement to an aggregate reservoir and then either infiltrate into the soil, or flow through an underdrain to the storm drain network. Pervious pavements include pervious concrete, pervious asphalt, interlocking concrete pavers, concrete grid pavers, and plastic grid pavers.

Pervious pavement is typically used to replace traditional impervious pavement for most pedestrian and vehicular applications except high-volume/high-speed roadways. Pervious pavements have been used successfully in pedestrian walkways, bike paths, sidewalks, driveways, parking lots, and low-volume roadways. Several design options are available for using pervious pavements to intercept, contain, filter, and, where appropriate, infiltrate stormwater on site. Pervious pavements can be installed across an entire street width or an entire parking area. Alternatively, they can be installed in combination with

impermeable pavement to infiltrate runoff; several applications use pervious pavement in parking lot lanes or parking stalls to treat runoff from adjacent impermeable pavements. Pervious pavement design criteria are shown in Table 4.3.6-1.

Table 4.3.6-1 Pervious Pavement Design Criteria

Design Criteria	Pervious Pavement
Bottom Slope	Minimal slope
Bottom Width	No requirement
Underdrain	6-inch perforated PVC pipe as necessary
Side Slopes	Not applicable
Freeboard	Not applicable
Emergency Spillway	Downstream inlet
Pretreatment	Divert runoff from sediment sources away from pavement
Soil Permeability	No requirement, if underdrain is proposed
Depth to Groundwater	Bottom of system to be ≥ 2 feet above or use liner

4.3.7 Vegetated Filter Strips

Vegetated filter strips are bands of dense, permanent vegetation with uniform slope, primarily designed to provide water quality pretreatment between a runoff source and another stormwater control measure. The inflow source for a filter strip must be conveyed as sheet flow. Typically this is accomplished by installing a level spreader system immediately upstream of the filter strip. Vegetated filter strips are well suited for treating runoff from roads, parking lots, and disconnected downspouts. They may also be used along streams to treat agricultural runoff and may be referred to as buffer strips. Filter strips provide water quality improvement primarily through vegetative filtering and infiltration. Reductions in runoff volume from small storms can be achieved if the soils are sufficiently pervious, sheet flow is maintained along the entire length and width of the strip, and contact time is long enough for infiltration to occur. Specific design criteria to be used with the design of vegetated filter strips are listed in Table 4.3.7-1.

Table 4.3.7-1 Vegetated Filter Strips Design Criteria

Design Criteria	Vegetated Filter Strip
Bottom Slope	Filter strip: 1% to 5% longitudinal Level Spreader: 0%
Width	10 to 100 feet
Length	Minimum length of 30 feet; length must be less than that at which sheet flow concentrates
Underdrain	Optional: Beneath level spreader
Side Slopes	Not applicable
Freeboard	Not applicable
Emergency Spillway	High flow bypass upstream of level spreader
Pretreatment	Sediment forebay or riprap lined level spreader
Soil Permeability	No requirement
Depth to Groundwater	Bottom of system to be ≥ 2 feet above or use liner

4.3.8 Vegetated Roof

Vegetated roofs, also referred to as green roofs, are used to introduce vegetation onto sections of roof to reduce imperviousness and absorb and filter rainfall. Vegetated roofs consist of a layer of soil media and vegetation that filter, absorb, and retain/detain the rain that falls upon them. Rainfall that infiltrates into the vegetated roof is lost to evaporation or transpiration by plants, or, once the soil has become saturated, percolates through to the drainage system and is discharged through the roof downspouts. Vegetated roofs may cover large sections of a roof while maintaining access for utilities, maintenance, or recreation. Vegetated roofs are most often applied to buildings with flat roofs, but can be installed on roofs with slopes with the use of mesh stabilization panels, or battens. Design criteria to be applied in the design of vegetated roofs are presented in Table 4.3.8-1.

Table 4.3.8-1 Vegetated Roof Design Criteria

Design Criteria	Vegetated Roof
Bottom Slope	Same as pitch of roof; refer to manufacturer's specs for maximum pitch
Width	Dependent on vegetated roof use and manufacturer's specs
Underdrain	Perforated conduit and/or drainage layer per manufacturer's specs
Side Slopes	Not applicable
Freeboard	Not applicable
Emergency Spillway	Roof drain installed to protect roof from flooding per manufacturer's specs
Pretreatment	Not applicable
Soil Permeability	Not applicable
Depth to Groundwater	Not applicable

4.3.9 Water Quality Devices

Water quality devices typically consist of catch basin controls or stand-alone vaults that prevent sediment, oils, floatable trash, and debris from being transmitted through the collection system. For instance, several catch basin insert devices are available that use screens, baffles, filter fabrics, and absorbents to capture and retain pollutants within the catch basin. Oil-water separators, sedimentation tanks, gross solids removal screens, and hydrodynamic separators (flow-through devices with a settling or separation unit) are examples of proprietary devices that can be used to remove sediments and other stormwater pollutants. A variety of devices and manufacturers exist, and new products are continually emerging.

The use of water quality devices, other than for retrofit or redevelopment situations where site constraints limit the use of other stormwater control measures, is discouraged. These devices are recommended to be used in conjunction with other control measures as part of a stormwater treatment train (stormwater control measures in series). However, these controls are generally considered pretreatment devices, as they provide limited treatment when compared to other control measures.

4.3.10 Other Approved Stormwater Control Measures

Other stormwater control measures may be recommended to satisfy stormwater management requirements if the drainage plan for the site demonstrates to the satisfaction of the City Manager that these stormwater control measures achieve effluent quality and runoff volume reduction equivalent to recommended stormwater control measures, and can be adequately maintained.

4.4 CONVEYANCE SYSTEMS

The purpose of this section is to provide standards and criteria to ensure the safe and effective flow of stormwater through flow paths, treatment facilities, and the physical storm drainage system in a manner consistent with protection of public health, safety and welfare, the safety and function of properties, roads and improvements; and maintaining and improving water and environmental quality in the City of Grand Rapids and its surface waters.

The designer should specify the materials for the system and design the system for at least a 50-year life span.

4.4.1 Connections

Stormwater discharges should not be connected to a sanitary sewer. However, if no portion of the Stormwater System is available within a reasonable distance from the proposed discharge point, and provided that every reasonable means is made to reduce the amount of the stormwater discharged into the sanitary sewer, and provided such a discharge will not cause a hydraulic overload of the sanitary sewer, a discharge of stormwater into the sanitary sewer may be considered for approval. Such approval is to be

obtained from the City Manager or his or her designee responsible for administering the City's Wastewater System.

Roof drains, which are connected to the public underground drainage system, shall pass through a pressure relief structure or catch basin before connecting to the public drainage system.

4.4.2 Emergency Overland Flow Way Easement

Whenever a stormwater facility is constructed for-a design storm less than the 100-year storm (base flood) an emergency overland flow way and easements should be provided to convey or store that portion of the 100-year runoff which the facility does not manage. The easements are to be on a form approved by the City Attorney and recorded with the Kent County Register of Deeds.

4.4.3 Natural Channels

Natural stream and channel systems are to be conserved.

4.4.4 Streambank Stability

Streams and channels shall be designed and constructed to avoid streambank erosion in accordance with the guidance provided in the DEQ Guidebook of BMPs which can be found on the MDEQ's website.

4.5 OPEN CHANNELS

4.5.1 Low Flow

Low-flow sections should be considered in the design of channels with large cross sections. Channels with design flows greater than 100 cfs will be considered to have large cross sections.

4.5.2 Slopes

Channel slopes should be stabilized against erosion by either adequate vegetation or protective armoring.

Channel side slopes should be stable throughout the length.

4.5.3 Shape

Trapezoidal or parabolic cross sections are preferred; triangular or 'V' shaped channels are not allowed.

4.5.4 Velocity Limitations

The final design of artificial open channels should be consistent with the velocity limitations found in the DEQ Guidebook of BMPs.

4.6 CULVERTS

4.6.1 Application Categories

For consistency, culvert applications are divided into two major categories, cross drains and side drains:

- a) **Cross Drain.** A cross drain is a culvert placed transversely under roadway sections, with end walls or some other end treatment. Because cross-drain installations are normally under pavement, they should have at least premium joint-RCP to prevent soil migration. Leaking joints can cause uneven and differential settling of road surfaces or adjacent buildings.
- b) **Side Drain.** This culvert is generally a pipe used longitudinally in roadway ditches under driveways or graded connections.

4.6.2 General

Culverts should be designed to convey the appropriate design storm listed in Table 4.1.1-1 for the collection system.

Culverts should be sized using the nomographs presented in *USDOT FHWA Highway Design Series Number 5 report, "Hydraulic Design of Highway Culverts"* or using the following approved computer software programs:

- a) HY8 (FHWA Culvert Analysis Software)
- b) HEC-RAS (Hydraulic Engineering Center – Riverine Analysis Systems)

As presented in the FHWA report, the two basic types of culvert control sections are inlet and outlet control. The control section for inlet control is just inside the entrance, and critical depth occurs at or near this location. The control section for outlet control is located at the barrel exit or downstream from the culvert. Either partially full subcritical flow or full pipe pressure flow conditions can occur.

If inlet control exists, the culvert barrel could possibly carry more flow than the inlet will accept, and if this is the case, a tapered inlet could be used to increase capacity up to the outlet capacity. If outlet control exists, the culvert barrel would have to be increased to add capacity. Once a culvert size has been determined from the nomographs, reductions may be warranted if storage occurs at the culvert embankment.

4.6.3 Allowable Headwater

The allowable headwater elevation can be established from an evaluation of land use upstream of the culvert and the proposed or existing roadway elevation. In general, the constraint that gives the lowest allowable headwater elevation should establish the basis for hydraulic calculations. The following criteria should be considered:

- a) **Flood Elevations.** Non-damaging or permissible upstream flooding elevations (e.g., existing buildings or flood insurance rate map elevations) should be identified and headwater kept below them.
- b) **Maximum.** Headwater depth for the design discharge should not exceed a height greater than 1.5 feet below the edge of the shoulder of a road.
- c) **Channel Capacity.** Headwater depth for the design discharge should not cause water to rise above the top of approach channels adjacent to improved land or above the established floodplain elevations.
- d) **Backwater Impacts.** Level pool backwater conditions should be evaluated upstream from the culvert to ensure that building flooding does not occur for the 100-year, 24-hour design storm.

4.6.4 Design Tailwater

The hydraulic conditions downstream of the culvert site should be evaluated to determine a tailwater depth for the design discharge. If the culvert outlet is operating in a free-fall condition (e.g., a cantilever pipe), the critical depth and equivalent hydraulic grade line should be determined. For culverts that discharge to an open channel, the normal depth of flow in the channel must be evaluated. Guidance for performing these evaluations is available in the USDOT, FHWA (1985) report.

4.6.5 End Treatments

Selecting end treatment facilities should be consistent with hydraulic requirements, and give proper consideration to bank stability, safety, and costs. Entrance loss coefficients (k_e) summarized in Table 4.6.5-1 shall be used in design.

Table 4.6.5-1 Culvert Entrance Loss Coefficients

Type of Structure and Design of Entrance	Entrance Coefficient, k_e
Pipe, concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square-cut end	0.5
Headwall or headway and wingwalls	
Socket end of pipe (groove-end)	0.2
Square edge	0.5
Rounded (radius = 1/12 D)	0.2
Mitered to conform to fill slope	0.7
End section conforming to fill slope ^a	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or sloped-tapered inlet	0.2
Pipe or Pipe Arch, Corrugated Metal	
Projecting from fill (no headway)	0.9
Headway or headway and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End section conforming to fill slope ^a	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headway parallel to embankment (no wingwalls)	
Square-edged on three edges	0.5
Rounded on three edges to radius of 1/12 barrel dimension, or beveled edges on three sides	0.2
Wingwalls at 30° or 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

- (a) End section conforming to fill slope, made of either metal or concrete, is the section commonly available from manufacturers. From limited hydraulic tests, the sections are equivalent in operation to a headway in both inlet and outlet control. End sections that incorporate a closed taper in their design have a superior hydraulic performance.

4.6.6 Velocity Limitations

Both minimum and maximum velocities should be considered when designing a culvert. A minimum velocity of 2.5 feet per second when the culvert is flowing full shall be used to ensure a self-cleaning condition during partial depth flow.

The maximum velocity should be consistent with channel stability requirements at the culvert outlet. If velocities exceed permissible velocities for the outlet lining material, the installation of outlet protection or energy dissipation may be necessary.

4.6.7 Length, Slope, and Size

The length and slope of a culvert should be based on the channel bottom of the stream or channel being conveyed, the geometry of the roadway embankment, and the skew angle of the culvert. A culvert slope in close proximity to the existing topography should be chosen. The minimum culvert size is 12 inches.

4.7 STORM SEWERS

4.7.1 General Approach

The design of storm sewer systems is usually an iterative process involving the following four steps:

- a) System Layout. Selection of inlet locations and development of a preliminary plan and profile patterns.
- b) Hydrologic Calculations. Determination of design flow rates and volumes to convey the design storm event shown in Table 4.1.1-1 for collection systems.
- c) Hydraulic Calculations. Determination of pipe sizes required to carry design flow rates and volumes.
- d) Outfall Design. Outlet protection to prevent erosion or detention/retention to control peak discharge rates may be required because of site constraints or release-rate performance standards.

4.7.2 Pipe Size and Length

A minimum pipe size of 12 inches is recommended for public systems and 6 inches for private systems. Designs should use standard pipe size increments. The span-by-height format is used for reporting box culvert dimensions; e.g., in the dimension 10 feet by 7 feet, the span is 10 feet and the height is 7 feet.

Storm sewer pipes in the City's right of way shall be constructed of Concrete Pipe (ASTM C-14 Class 1 through 3 or C-76 Class I-V), Vitrified Clay Pipe (ASTM C-700 or National Clay Pipe Institute's Specification ER 4-67), PVC Truss Pipe (ASTM D-2680), PVC Solid-wall Pipe (ASTM D-3034, SDR-35) or Ductile Iron Pipe (ANSI A 21.50 Class 53, lined in accordance with ANSI A 21.51).

Manhole spacing shall not exceed the values shown in Table 4.7.2-1, below without approval from the City Manager.

Table 4.7.2-1 Structure Spacing

Pipe size	Structure Spacing
72-inches and smaller	350 feet
Larger than 72-inches	700 feet

4.7.3 Slopes and Hydraulic Gradient

The minimum slope for storm sewers shall be one that produces a velocity of 2.5 feet per second when the storm sewer is flowing full. For pipe less than 18 inches in diameter, the minimum grade should be 0.5 percent, unless the designer can demonstrate that self-cleaning velocities can be achieved in the design storm flow.

Systems should generally be designed for non-pressure conditions. The elevation of the hydraulic gradient for the design storm shall be at least 1.0 foot below ground elevation excluding losses.

4.7.4 Minimum Clearances

Minimum clearances for storm sewer pipe should comply with the following criteria:

- a) **Road Base.** A minimum of 1 foot is required between the bottom of the road base material and the outside crown of the storm drain.
- b) **Utility Conflicts.** For utility conflicts that involve crossing a storm drain, the minimum design clearance between the outside of the pipe and the outside of any conflicting utility should be 0.5 foot. Electrical transmission lines or gas mains should never come into direct contact with the storm sewer.
- c) **Utility Placement.** Storm sewer systems should not be placed parallel to or below existing utilities, which could cause utility support problems. The recommended clearance is two feet (10 feet for water main) extending from each side of the storm drain and one-on-one side slopes from the trench bottom.
- d) **Manholes.** No utility lines shall pass through any manhole or pipe. The utility line shall be offset in such a way as to provide adequate clearance between the crossings. When a sanitary line or other utility must pass through a manhole, the greatest possible clearance from the bottom of the flow channel shall be provided with a minimum of one foot clearance.

4.8 MANNING'S N VALUES

Manning's formula, as presented in Chow (1959), is an accepted method for performing open-channel flow capacity calculations, when uniform flow conditions represent design conditions. The selection of an appropriate resistance coefficient, known as the Manning's n value, is a key variable that requires experience and can significantly affect the results obtained. This section provides a summary of standard tables and references, which provide a consistent basis for evaluating and assigning Manning's n values. The material begins with a general discussion of basic principles for assigning n values followed by information from tabular and photographic interpretations.

4.8.1 Basic Principles

The factors presented in this section should be studied and evaluated with respect to type of channel, degree of maintenance, seasonal requirements, and other considerations as a basis for selecting an appropriate design value of Manning's n. Consideration should also be given to the probable condition of the channel when the design event is anticipated. Values representing a freshly constructed channel are rarely appropriate as a basis for design capacity calculations.

The following basic principles should be considered when selecting the value of Manning's n:

- a) **Turbulence.** Generally, retardance increases when conditions tend to induce turbulence and decreases when they reduce turbulence.
- b) **Physical Roughness.** Consider the physical roughness of the bottom and sides of the channel. Fine particle soils on smooth, uniform surfaces result in relatively low values of n. Coarse materials, such as gravel or boulders, and pronounced surface irregularities cause higher values of n.
- c) **Vegetation.** The value of n will be affected by the height, density, and type of vegetation. Consider the density and distribution of the vegetation along the reach and the wetted perimeter, the degree to which the vegetation occupies or blocks the cross section of flow at different depths, and the degree to which the vegetation may be bent (shingled) by flows of different depths. The n value will increase in the spring and summer as vegetation grows and foliage develops and will diminish in the fall as the vegetation becomes dormant.

- d) **Cross Section.** Channel shape variations, such as abrupt changes in channel cross sections or alternating small and large cross sections, will require somewhat larger n values than normal. These variations in channel cross sections become particularly important if they cause the flow to meander from side to side.
- e) **Meandering.** A significant increase in the value of n is possible if severe meandering occurs in the alignment of a channel. Meandering becomes particularly important when frequent changes in the direction of curvature occur with relatively small radii of curvature.
- f) **Channel Stability.** Active channel erosion or sedimentation will tend to increase the value of n, since these processes may cause variations in the shape of a channel. Also consider the potential for future erosion or sedimentation in the channel.
- g) **Obstructions.** Obstructions such as log jams or deposits of debris will increase the value of n. The level of this increase depends on the number, type, and size of obstructions.
- h) **Field Observations.** Deciding on natural channel n values requires field observations and experience. Special attention is required in the field to identify floodplain vegetation and to evaluate possible roughness variations with flow depth. To be conservative, it is better to use a higher resistance for capacity calculations and a lower resistance for stability calculations.

4.8.2 Tabular Interpretations

Recommended Manning's n values for artificial channels with rigid, unlined, temporary, and riprap linings are given in Table 4.8.2-1.

Table 4.8.2-1 Manning's n values for Artificial Channels

Lining Category	Lining Type	'n' Value for Depth of Flow Range		
		0-0.5 ft	0.5-2.0 ft	> 2.0 ft
Rigid	Concrete (broom or float finish)	0.015	0.013	0.013
	Gunite	0.022	0.020	0.020
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.023	0.020	0.020
	Rock Cut	0.045	0.035	0.025
Temporary	Woven Paper Net	0.016	0.015	0.025
	Jute Net	0.028	0.022	0.019
	Fiberglass Roving	0.028	0.021	0.019
	Straw with Net	0.065	0.033	0.025
	Curled Wood Mat	0.066	0.035	0.028
	Synthetic Mat	0.036	0.025	0.021
Gravel Riprap	1-inch (2.5-cm) d50	0.044	0.033	0.030
	2-inch (5-cm) d50	0.066	0.041	0.034
Rock Riprap	N/A	n=0.0395 (d50) ^{1/6} d50 = Diameter of stone for which 50 percent, by weight, of the gradation is finer, in feet		

4.8.3 Photographic Interpretations

An independent check on the interpretation of field conditions using photographs can be accomplished using the Federal Highway Administration Report, FHWA-TS-84-204, (-USDOT, FHWA, 1984). Photographs of typical channel and floodplain conditions are contained in this report with assigned Manning's values.

This report could be taken into the field to provide a guide for selecting n values if a photograph similar to actual field conditions is included in the report. An alternative would be to compare photographs obtained from the field to similar report photos, if available.

4.9 OUTLET PROTECTION

Transitions from closed conduits such as culverts, storm sewers, or other flow concentrating devices create the potential for erosion and scour due to high velocities. The magnitude of this concern and the potential need for outlet protection measures should be evaluated as part of the design of stormwater management facilities. A general procedure for evaluating the need for outlet protection and for selecting and sizing corrective measures is presented in Appendix B. This information is copied from Volume 2, Chapter 10 of the *Stormwater Management Manual for Nashville and Davidson County, Tennessee*. It is used with permission and provided as background information for use on individual projects as determined by the design engineer.

5.0 SOIL EROSION AND SEDIMENT CONTROL STANDARDS

Construction and land development activities that impact existing topography, vegetative cover, and hydrologic characteristics often increase the potential for soil erosion and sediment transport. Specific control measures to mitigate adverse impacts are required by Chapter 143 of the City Code. An erosion and sediment control plan is required to address regulatory requirements.

5.1 BASIC PRINCIPLES

The design of erosion and sediment control systems involves the application of common sense planning, scheduling, and control actions that will minimize the adverse impacts of soil erosion, transport, and deposition. The following five basic principles govern the development and implementation of a sound erosion and sediment control plan:

- a) The project should be planned to take advantage of the topography, soils, waterways, and natural vegetation at the site.
- b) The smallest practical area should be exposed for the shortest possible time.
- c) On-site erosion control measures should be applied to reduce the gross erosion from the site.
- d) Sediment control measures should be used to prevent off-site damage.
- e) A thorough maintenance and follow-up program should be implemented.

In practice, these principles should be tied together in the planning process, which identifies potential erosion and sediment control problems before construction begins. Vegetative control measures are required for all disturbed areas and generally include filter strips, temporary seeding, permanent seeding, sodding, mulching, and erosion-control blankets. Structural control measures are required when runoff leaves a disturbed site and generally include sediment traps, diversions, sediment basins, and permanent drainage facilities.

The erosion and sediment control plan should include appropriate construction specifications for all control measures. These specifications should be developed by the design engineer as required to address site-specific conditions. Typical specifications may be obtained from the *Michigan Soil Erosion and Sediment Control Guidebook* and the *Guidebook of BMPs for Michigan Watersheds*, both available from the Michigan Department of Environmental Quality (MDEQ).

5.2 CONSTRUCTION SEQUENCING

Erosion and sediment control measures should be placed sequentially to provide control measures from the point at which soil is disturbed to the point at which runoff leaves the site (i.e., start with erosion protection where soil is disturbed, and follow with proper conveyance and filtering measures and placing sediment basins/traps at low points before discharge). This process is called the Treatment Train.

5.2.1 Installation

Sediment and erosion control devices should be functional before land is otherwise disturbed.

5.2.2 Exposed Area

Land-clearing activities should be scheduled to expose the smallest practical area for the shortest possible time.

5.2.3 Removal

All temporary erosion and sediment control measures should be removed within 30 days after the final

site stabilization is achieved or after the temporary measures are no longer needed.

5.3 SOIL STABILIZATION

5.3.1 Timing

The surface of stripped areas should be permanently or temporarily protected from soil erosion within 7 days after final grade is reached. Stripped areas not at final grade which will remain undisturbed for more than 15 day should be protected from erosion within 7 days of being denuded. Temporary protection should be maintained until permanent cover is established.

5.3.2 Vegetative Measures

For vegetative soil stabilization measures, plants should be selected which are appropriate to the season and site conditions. Plants must be able to germinate and grow, and adequate seedbed preparation should be provided.

5.3.3 Earth Structures

Stabilization measures should be applied to earthen structures such as dams, dikes, and diversions immediately after installation.

5.3.4 Watercourses

The bed and banks of a watercourse should be stabilized immediately after work in the watercourse is completed.

5.3.5 Stockpiles

If a stockpile of soil is to remain in place more than 7 days, erosion and sediment control measures should be provided.

5.4 FLOW BARRIERS

5.4.1 Areas < 1 Acre

Disturbed areas draining less than 1 acre should be protected by a flow barrier (including filter fences, straw bales, or equivalent) to control all site runoff. Vegetated filter strips should not be used as a primary device but as a backup in conjunction with other control measures such as silt fences. Typical temporary inlet barrier details for ditch inlets, curb inlets, and storm sewer systems are presented in Figure. 5.4.1-1.

5.4.2 Concentrated Flows

Concentrated runoff should not flow down cut or fill slopes unless contained within an adequate temporary or permanent channel, flume or slope drain structure.

5.4.3 Velocity Control

Temporary or permanent stormwater conveyance facilities should be designed such that non-erosive velocities are achieved.

5.5 INLET PROTECTION

5.5.1 Storm Drains

Storm drain inlets should be protected with sediment trapping or filter control devices during construction.

5.5.2 Construction Entrances

A stabilized mat of aggregate, underlain with filter fabric material, should be located at any point where vehicular traffic will be entering and leaving a construction site.

5.6 SEDIMENT TRAPS AND BASINS

5.6.1 Temporary sediment traps

These may be used to detain sediment-laden stormwater runoff from drainage areas of 5 acres or less. Temporary sediment traps should have an initial storage volume below the crest of the overflow structure of 3,600 cubic feet per acre of drainage area as recommended by the State of Michigan.

5.6.2 Check dams

These may be used to reduce velocities and trap sediment in small open channels with tributary drainage areas of 10 acres or less. Typical details for check dam applications are presented in the DNR Guidebook.

5.6.3 Sediment Basins

These may be used to trap sediment from tributary drainage areas up to 150 acres. Sediment basins are generally only 70 to 80 percent effective and should be used as a backup control measure together with erosion control measures such as seeding and mulching, which should be considered primary erosion control measures.

6.0 SPECIAL CONDITIONS AND CONSTRAINTS

6.1 ENVIRONMENTALLY SENSITIVE AREAS

Special requirements for environmentally sensitive areas are presented in the City's Code of Ordinances, Title V – Zoning and Planning.

6.2 FLOODPLAIN ENCROACHMENTS

Standards for floodway and floodplain protection on land within the City are included in the City's Stormwater Ordinance. Refer to the Grand Rapids Code of Ordinances, Title II – Utilities and Services, Chapter 32 – City Stormwater Drainage System, Article 6 – Floodplain Standards.

6.3 CONTAMINATED SITES

Preparing contaminated/brownfield sites for redevelopment often requires capping of contaminated soils, creating even larger impervious surfaces. The challenge for managing stormwater on brownfield sites is allowing this capping while mitigating the impervious surface conditions that can negatively impact local waterways.

Direct infiltration on a brownfield site may introduce additional pollutant loads to groundwater and nearby surface waters. Stormwater management planning needs to take into account the need to prevent the mobilization of contaminants and their mitigation to groundwater and surface waters.

A key component of using green infrastructure for brownfield sites is treatment and storage of stormwater, rather than complete infiltration. Site location within the watershed is very important. In particular, groundwater recharge areas should avoid low impact development practices that promote infiltration, and use techniques that directly discharge treated stormwater instead. Furthermore, new and redeveloped sites near brownfields should use green infrastructure practices to prevent additional runoff from flowing onto potentially contaminated sites.

Below are the main things to consider during design of stormwater management at a brownfield site:

- a) Differentiate between groups of contaminants with respect to their mobility/risk to groundwater as a way to better minimize risks
- b) Keep clean stormwater separate from contaminated soils to prevent leaching, spreading of contaminants
- c) Careful placement of buildings and other impervious surfaces can act as caps of contaminated soils
- d) Prevent soil erosion, specifically of contaminated soils, using vegetation, such as existing trees, and structural practices like swales or sediment basins
- e) All new development on and off the brownfield site should include measures to minimize runoff

Vegetated roofs (also referred to as green roofs) can be used effectively on brownfield sites to retain much of the stormwater that falls on the roof. This SCM is very effective in areas where subsurface systems are not feasible.

Another option for brownfield sites is the capture and reuse of stormwater for non-potable uses; this can include runoff storage in rain barrels for irrigation of green roofs or landscaped areas, or in cisterns that store rainwater for toilet flushing and other uses.

Stormwater control measures that provide infiltration in areas of contaminated soil are prohibited.

6.4 OFFSET

Development projects and redevelopment projects are required to control the effects of stormwater runoff, including water quantity and water quality, in accordance with this manual and the City's NPDES Phase I Stormwater Permit. However, due to severe site restrictions, the construction of on-site SCMs for a very limited number of development and redevelopment sites may not be feasible, sufficient or practical.

In those isolated instances, the City recognizes that construction on-site SCMs, even where it is physically possible, may not be the most effective method for controlling stormwater runoff. Therefore, the City has established a stormwater offset option to constructing on-site SCMs to be used only in these limited instances. The stormwater offset and offset fee system is established in such a way as to facilitate development and redevelopment on sites which could otherwise not be developed or redeveloped in the manner proposed, reduce costs for stormwater management, and avoid unnecessary delays for the developer.

However, it should be noted that the clear intent of the water quantity and water quality criteria as outlined in this manual is to encourage on-site compliance with these rules wherever possible, and as such offsets are to be used only as a last resort.

The City must determine that on-site SCMs are neither practical nor the most effective method of controlling stormwater runoff.

Offsets may be used in the following specific situations:

- a) The use of on-site SCMs cannot meet the water quantity and water quality requirements of the City's stormwater ordinance and this manual
- b) The use of off-site areas drainage to on-site SCMs cannot meet the water quantity and water quality requirements
- c) Construction of on-site SCMs is not feasible, sufficient or practical

In these situations, the City may allow an applicant to provide an offset or pay an offset fee to meet the water quantity and/or water quality requirements. Applicants must make every effort to provide at least some stormwater treatment on the project site, and if necessary, comply through a combination of on-site SCMs and offsets.

An applicant must demonstrate that full compliance with the water quantity and water quality requirements of this manual is not feasible or practical at the site using on-site stormwater SCMs. Supporting documentation, including but not limited to, detailed information about current or historic land use, soil borings, or soil contamination analyses, shall be submitted to the City with the request to use offsets or pay offset fees.

Any measure or practice that is used for an offset cannot be a measure that would have been required under existing laws, regulations, statutes, or permits. For example, the restoration of a wetland required as mitigation for another purpose cannot also be used as a stormwater offset. Similarly, any reforestation required under a conservation program cannot also be used as an offset.

Examples of offset options or opportunities include:

- a) Constructing a new SCMs where structural or non-structural SCMs previously did not exist
- b) Converting an existing SCM to achieve higher water quantity and water quality removals
- c) Modifying the existing conveyance network to enhance pollutant removal
- d) Reducing the imperviousness of an existing property

7.0 GLOSSARY

90 Percent Non-Exceedance Event. The storm where 90 percent of the runoff producing storm rainfalls are equal to or less than the specified value.

Bankfull Flow. The condition where stream flow fills a stream channel to the top of the bank and at a point where the water begins to overflow onto a floodplain. For incised channels, where the channel has been downcutting, bankfull flow may no longer reach the floodplain.

Baseflow. Streamflow that is the result of discharge from groundwater not due to stormwater runoff.

Berm. A shelf that breaks the continuity of a slope; a linear embankment.

Best Management Practice (BMP). Structural and non-structural practices and techniques that mitigate the adverse impacts caused by land development on water quality and/or water quantity. Often termed “stormwater control measure (SCM).”

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

Buffer. A zone of variable width located along both sides of a natural feature (e.g., stream or forested area) and designed to provide a protective area along a corridor.

Channel. A natural stream that conveys water; a ditch excavated for the flow of water.

Check Dam. Small temporary dam constructed across a swale or drainage ditch to reduce the velocity of concentrated stormwater flow.

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

City Manager. The City Manager of the City of Grand Rapids and any persons designated to act on behalf of the City Manager in the administration or enforcement of this Chapter.

Condition Prior to Development. The condition prior to development is defined as the condition of the land surface at the time the permit application is submitted.

Constructed filter. Structures or excavated areas containing a layer of sand, compost, organic material, peat, or other filter media that reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants.

Contributing drainage area (CDA). The drainage area that contributes to a constructed or natural wetland.

Credit. Used in the design process to emphasize the use of stormwater control measures that, when applied, alter the disturbed area in a way that reduces the volume of runoff from that area.

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

Detention. The stormwater management practice of temporarily detaining runoff, typically in a detention basin on site, before releasing it downstream at a controlled rate.

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

Earth Change. A human-made change in the natural cover or topography of land, including cut and fill activities, which may result in or contribute to soil erosion or sedimentation of the waters of the state.

Earth change does not include the practice of plowing and tilling soil for the purpose of crop production.

Environmental Features. Such features shall include rivers, wetlands, streams, water bodies, or other sensitive environmental areas that may influence water quality and/or stormwater discharge rates. Such features do not include artificial water bodies such as industrial mining pits and concrete-lined canals, areas with existing riparian floodwalls, or decorative landscape ponds. Boundaries of features shall be determined by a qualified, credentialed consultant using methods accepted by Federal, State or regional permitting agencies, including the Michigan Department of Environmental Quality and the U.S. Army Corps of Engineers.

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

Evaporation. Phase change of liquid water to water vapor.

Evapotranspiration. The combined process of evaporation and transpiration (transpiration is the conversion of liquid water to water vapor through plant tissue).

Floodplain. Areas adjacent to a stream or river that are subject to flooding during a storm event that has a likelihood of occurrence of 1/100 in any given year.

Freeboard. The distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping due to unforeseen conditions.

Green Infrastructure. The network of open space, woodlands, wildlife, habitat, parks, and other natural areas which sustain clean air, water, and natural resources, and enhance quality of life.

Green Roof. Also vegetated roof. Green roofs are used to introduce vegetation onto roof tops allowing the roof to function more like a vegetated surface. The soil media depth is dictated by the intended use for the space which can range from being solely a water quality treatment mechanism (i.e. extensive green roof) to a recreational space for building tenants (i.e. intensive green roof).

Groundwater Recharge. The replenishment of existing natural water-bearing subsurface layers of porous stone, sand, gravel, silt or clay via infiltration.

H:V. Horizontal to vertical ratio.

Headwater. The source of a river or stream. Typically a very small, permanently flowing or intermittent, waterway from which the water in a river or stream originates.

Herbaceous. Plants whose stem die back to the ground after each growing season.

Hotspot. Areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

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

Infiltration Practices. Stormwater control measures (bed, trench, basin, well, etc.) that allow for rainfall to soak into the soil mantle.

Lake. The Great Lakes and all natural and artificial inland lakes or impoundments that have definite banks, a bed, visible evidence of a continued occurrence of water, and a surface area of water that is equal to, or greater than, 1 acre. "Lake" does not include sediment basins and basins constructed for the sole purpose of stormwater retention, cooling water, or treating polluted water.

Level Spreader. A device for distributing stormwater uniformly over the ground surface as sheet flow to prevent concentrated, erosive flows and promote infiltration.

Low Impact Development (LID). Activities that mimic a site's presettlement hydrology by using design

techniques that are spatially distributed, decentralized micro-scale controls that infiltrate, filter, store, evaporate, and detain runoff close to its source.

Native Plants. Plants that historically co-evolved with the local ecology, geology and climate.

Nonpoint Source Pollution. Pollution that does not come from a point source, such as a wastewater treatment plant, and are normally associated with precipitation and runoff from the land or percolation.

Nonstructural SCMs. 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).

Offset. A stormwater management practice that counterbalances, counteracts, or compensates for something else; compensating equivalent.

Outfall. The point where stormwater drainage discharges from a pipe, ditch, or other conveyance system to receiving waters.

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

Pervious. See Permeable.

Peak Discharge Rate. The maximum instantaneous rate of flow (volume of water passing a given point over a specific duration, such as cubic feet per second) during a storm, usually in reference to a specific design storm event.

Planter Box. A stormwater control measure typically constructed near streets and buildings to capture and treat stormwater. The facility typically contains plants and/or trees to assist with the treatment process.

Permittee. Holder of a stormwater drainage or soil erosion and sedimentation control permit or contractor working under Authorization to Proceed.

Pervious Pavement. A stormwater control measure that has the function of a structural pavement while also capturing, treating, storing, evaporating, and sometime infiltrating stormwater through the pervious surface of the pavement to an underlying storage reservoir.

Phase I Stormwater Regulations. The first phase of the National Pollutant Discharge Elimination System (NPDES) program which targets municipal separate storm sewer systems (MS4s) serving a population over 100,000 and construction activity disturbing five or more acres and for numerous types of industrial facilities.

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

Pretreatment. Techniques used to provide storage and removal of coarse materials, floatables, or other pollutants from stormwater before it is discharged downstream to a water body or another stormwater control measure.

Rain Barrel. A barrel designed to capture and store small volumes of stormwater runoff from a roof for reuse for gardening and landscaping.

Rain Garden. A stormwater control measure featuring plants established in a shallow depression allowing stormwater to infiltrate through a soil media.

Riparian Buffer. The strip of land adjacent and running parallel to a stream or river (sometimes also used for lakes) where development is restricted or prohibited. The buffers should be vegetated with herbaceous and woody native plants, or left in their natural state. Buffers filter stormwater before it reaches the

waterbody and slow the stormwater velocity.

Riparian Corridor. Interchangeable with Riparian Buffer.

Retention. Preventing stormwater from leaving a developed or developing site through infiltration, evaporation, or evapotranspiration.

Sheet Flow. Overland flow of stormwater across the ground or another surface like a rooftop, taking the form of a thin, continuous layer of water, and not a concentrated flow as in a pipe, culvert, channel, ditch, or stream.

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 Erosion and Sedimentation Control Program (SESC). The activities of a county or local enforcing agency or authorized public agency for staff training, developing and reviewing development plans, issuing permits or Authorization to Proceed, conducting inspections, and initiating compliance and enforcement actions to effectively minimize erosion and off-site sedimentation during construction.

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 consisting of precipitation runoff or snowmelt.

Stormwater Control Measures (SCM). Used interchangeably with the term best management practice (BMP).

Stormwater Retention Basin. An area which is constructed to capture surface water runoff and which does not discharge directly to a lake or stream through an outlet. Water leaves the basin by infiltration and evaporation.

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

Stream. A river, creek, or other surface watercourse which may or may not be serving as a drain as defined in Act No. 40 of the Public Acts of 1956, as amended, being §280.1 et seq. of the Michigan Compiled Laws, and which has definite banks, a bed, and visible evidence of the continued flow or continued occurrence of water, including the connecting waters of the Great Lakes.

Stream Bank Protection. Stormwater management practices to provide protection of stream banks with excessive erosion and degradation.

Structural SCMs. Devices constructed for temporary storage and treatment of stormwater runoff.

Swale. A shallow stormwater channel that can be vegetated with some combination of grasses, shrubs, and/or trees designed to slow, filter, and often infiltrate stormwater runoff.

Total Suspended Solids (TSS). The total amount of particulate matter that is suspended in the water column.

Transpiration. The conversion of liquid water to water vapor through plant tissue.

Two-year Storm. A stormwater event which occurs on average once every two years or statistically has a 50% chance of occurring in a given year.

Vegetated Filter Strip. Uniformly graded vegetated surface located between pollutant source areas and downstream receiving waters.

Water Quality Treatment. Capture and treatment of a stormwater event through filtration or retention techniques. Treatment is defined as removing total suspended solids such that the effluent has a maximum concentration of 80 mg/L.

Waters of the State. The Great Lakes and their connecting waters, inland lakes and streams as defined in rules promulgated under Part 31, and wetlands regulated under Part 303 of Michigan's Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended.

Watershed Plan. A plan that identifies and implements actions needed to resolve water quality and quantity concerns. Plan assesses the current nature and status of the watershed ecosystem; identifies short and long-term goals, the actions needed to meet those goals; and includes a method for progress evaluation.

Wetland. As defined by Michigan's wetland statute, Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

Wet Pond/Constructed Wetland. Surface or underground structures that provide temporary storage of stormwater runoff to prevent downstream flooding and the attenuation of runoff peaks.

8.0 REFERENCES

- American Concrete Pipe Association. 1980. *Concrete Pipe Handbook*. Vienna, Virginia. American Iron and Steel Institute. 1980. *Modern Sewer Design*. Washington, D.C.
- American Public Works Association. 1981. *Urban Stormwater Management*. Special Report No. 49. Chicago, Illinois.
- American Society of Civil Engineers. 1992. *Manual of Engineering Practice No. 77, Design and Construction of Urban Stormwater Management Systems*. New York. (Also published as Water Systems Environment Federation MOP FD-20. Washington, D.C.).
- Bedient, P. G. and Huber, W. C. 1988. *Hydrology and Floodplain Analysis*, Reading, MA: Addison-Wesley Publishing Co.
- Brater, E. F., and H. W. King. 1976 *Handbook of Hydraulics*. 6th ed. New York: McGraw-Hill Book Co.
- Chow, V. T. 1959. *Open Channel Hydraulics*. New York: McGraw-Hill Book Co.
- Chow, V. T., ed. 1964. *Handbook of Applied Hydrology*. New York: McGraw-Hill Book Co.
- Chow, V.T., Maidment, D. R., and Mays, L. W. 1988. *Applied Hydrology*, New York: McGraw-Hill Book Co.
- Cowan, W. L. (1956.) "Estimating Hydraulic Roughness Coefficients." *Agricultural Engineering* 37. 7: pp. 473-75.
- Denver Regional Council of Governments. 1969. *Urban Storm Drainage Criteria Manual*. Wright-McLaughlin Engineers, Denver, Colorado.
- Engman, E. T. 1983. "Roughness Coefficients for Routing Surface Runoff." In *Proceedings of the Conference on Hydraulic Engineering* (pp. 560-565). New York: American Society of Civil Engineers.
- French, R. H. 1985. *Open-Channel Hydraulics*. New York: McGraw-Hill Book Co.
- Froehlich, D. C. 2009. *Mathematical Formulations of NRCS 24-Hour Design Storms*. Journal of Irrigation and Drainage Engineering, March/April 2009. Errata 2010.
- Golding, B. L. 1987. *Storm Sewer Analysis and Design Utilizing Hydrographs*. Orlando, Florida: Hilber Engineering Software.
- Huber, W. C., and R. E. Dickinson, 1988. *Storm Water Management Model User's Manual, Version 4*. EPA-600/3-88-001a (NTIS FB88/236641/AS) U.S. Environmental Protection Agency, Athens, Georgia.
- Huber, W. C., et al. 1975. *Storm Water Management Model Users' Manual, Version II*. EPA-670/2-75-017, Cincinnati, Ohio. U.S. Environmental Protection Agency.
- Israelson, C. E., et al. 1980. *Erosion Control During Highway Construction, Manual on Principles and Practices*. National Cooperative Highway Research Program Report 221. Washington, D.C.: Transportation Research Board, National Research Council.
- Jens, S. W. and McPherson, M. B. 1964. "Hydrology of Urban Areas." In V. T. Chow, ed., *Handbook of Applied Hydrology*. New York: McGraw-Hill Book Co.
- Kaltenbach, A.B. 1963. "Storm Sewer Design by the Inlet Method." *Public Works*, January, pp. 86-89.
- Linsley, R. K., Jr., Kohler, M. A., and Paulhus, J.L.H. 1982. *Hydrology for Engineers* (3rd ed.) New York: McGraw- Hill Book Co.
- Maidment, D. R. (editor-in-chief) 1993. *Handbook of Hydrology*, New York: McGraw-Hill Book

- Co.1985. *Head Losses at Selected Sewer Manholes*. Special Report No. 52. Chicago, Illinois: American Public Works Association.
- Mason, J. M., Jr. and Rhomberg, E. J. 1982. "On-Site Detention—The Design Process. " *Public Works* 113, 12: pp. 34-36.
- , 1983. On-Site Detention--Design Example. *Public Works* 114, 2: pp. 48-51.
- McKinnon, R. J. 1984. "Simplifying Stormwater Detention Basin Discharge Control Determinations." *Public Works* 115, 6: pp. 68-69.
- Mein, R. G. 1980. "Analysis of Detention Basin Systems." *Water Resources Bulletin* 16, 5:pp.824-29.
- Michigan Department of Natural Resources. *Dam Safety Guidebook, Michigan Edition*. Lansing, Michigan.
- Michigan Department of Natural Resources. *Guidebook of Best Management Practices for Michigan Watersheds*. Lansing, Michigan.
- Michigan Department of Natural Resources. *Soil Erosion and Sedimentation Control Guidebook*. Lansing, Michigan.
- Palmer, V. J. 1946. "Retardance Coefficients for Low Flow in Chamois Lined with Vegetation." *Transactions of the American Geophysical Union* 27, II: pp. 187-97.
- Ragan, R. M. (December 1971.) *A Nomograph Based on Kinematic Wave Theory for Determining Time of Concentration for Overland Flow*. Report No. 44. College Park, Maryland: University of Maryland, Civil Engineering Department.
- Rossmiller, R L. (July 27-29, 1982.) " Outlet Structure Hydraulics for Detention Facilities." In *Proceedings of the 1982 International Symposium on Urban Hydrology, Hydraulics, and Sediment Control*, pp. 341-355. Lexington, Kentucky: University of Kentucky.
- Sandvik, A. 1985. "Proportional Weirs for Stormwater Pond Outlets." *Civil Engineering*, March, ASCE, pp. 54-56.
- Temple, D. M., Robinson, K. M., Ahring, R. M., and Davis, A. G. 1987. *Stability Design of Grass-Lined Open Channels*. Agriculture Handbook No. 667. Washington, D.C.: U.S. Department of Agriculture.
- Terstriep, M.L., and J. B. Stall. 1972. "The Illinois Urban Drainage Area Simulator, ILLUDAS," Bulletin 58. Champaign, Illinois, Illinois State Water Survey.
- U.S. Army Corps of Engineers. 1981. *HEC-1 Flood Hydrograph Package*, Users' Manual. Computer Program 723-X6-L2010, Davis, California.
- U.S. Army Corps of Engineers. 1982. *HEC-2 Water Surface Profiles*, Users Manual. Generalized Computer Program 723-X6-L202A. Davis, California.
- U.S. Department of Agriculture. March 1947. *Handbook of Channel Design for Soil and Water Conservation*. Technical Paper No. 61 (TP-61). Stillwater, Oklahoma.
- U.S. Department of Agriculture, Soil Conservation Service. 1956. *Hydraulics*. National Engineering Handbook, Section 5 (NEH-5).
- U.S. Department of Agriculture, Soil Conservation Service. 1972. *Hydrology*. National Engineering Handbook, Section 4 (NEH-4). Washington, D.C.
- U.S. Department of Agriculture, Soil Conservation Service. 1983. *Computer Program for Project Formulation*. Technical Release No. 20 (TR-20). Washington, D.C.

- U.S. Department of Agriculture, Soil Conservation Service. 1986. Urban Hydrology for Small Watersheds. Technical Release No. 55 (TR-55). NTIS No. PB87- 101580. National Technical Information Service, Springfield, Virginia 22161.
- U.S. Department of Transportation, Federal Highway Administration. August 1961. *Design Charts for Open Channel Flow*. Hydraulic Design Series No. 3 (HDS-3). Washington, D.C.
- U.S. Department of Transportation, Federal Highway Administration. May 1965. *Design of Roadside Drainage Channels*. Hydraulic Design Series No. 4 (HDS-4). Washington, D.C.
- U.S. Department of Transportation, Federal Highway Administration. 1980. Hydraulic Flow Resistance Factors for Corrugated Metal Conduits, FHWA-TS-80-216, Washington, D.C.
- U.S. Department of Transportation, Federal Highway Administration. September 1983. *Hydraulic Design of Energy Dissipators for Culverts and Channels*. Hydraulic Engineering Circular No. 14 (HEC-14). Washington, D.C.
- U.S. Department of Transportation, Federal Highway Administration. 1984. *Drainage of Highway Pavements*. FHWA-TS-84-202. Hydraulic Engineering Circular No. 12 (HEC-12). Washington, D.C.
- U.S. Department of Transportation, Federal Highway Administration. April 1984. *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains*. FHWA-TS-84-204. McLean, Virginia. 62.
- U.S. Department of Transportation, Federal Highway Administration. 1984. *Hydrology*. Hydraulic Engineering Circular No. 19 (HEC-19). Washington, D.C.
- U.S. Department of Transportation, Federal Highway Administration. 1985. *Hydraulic Design of Highway Culverts*. Hydraulic Design Series No. 5 (HDS-5). FHWA-IP-85-15. McLean, Virginia.
- U.S. Department of Transportation, Federal Highway Administration. 1986. *Bridge Waterways Analysis Model (WSPRO)–User's Manual*. HY-7. FHWA-IP-87-3. McLean, Virginia.
- U.S. Department of Transportation, Federal Highway Administration. 1986. *Design of Stable Channels with Flexible Linings*. Hydraulic Engineering Circular No. 15 (HEC-15). Washington, D.C.
- Viessman, W., Jr., J. W. Knapp, G. L. Lewis, and T. E. Harbaugh. 1977. *Introduction to Hydrology*. 2nd ed. New York: IEP, A Dun-Donnelley Publisher.
- Wanielista, M. P., and Yousef, Y. A. 1993. *Stormwater Management*, New York: John Wiley and Sons, Inc.
- Williams, J. R., and R. W. Hann, Jr. 1972. "HYMO: A Problem-Oriented Computer Language for Building Hydrologic Models." *Water Resources Bulletin*, Vol. 8, 1: pp. 79-86.
- 1973. "HYMO: Problem-Oriented Computer Language for Hydrologic Models, User's Manual." ARS-S9, Riesel, Texas. Southern Region Agricultural Research Service, U.S. Department of Agriculture.
- Wischmeier, W. H. and D. D. Smith. 1978. *Predicting Rainfall Erosion Losses--A Guide to Conservation Planning*. Agriculture Handbook No. 537. Washington, D.C.: U.S. Department of Agriculture, Science and Education Administration.

Appendix A
Detention Basin Easement Agreements
and
Operation Agreements

DETENTION BASIN EASEMENT

THIS INDENTURE, entered into this _____ day of _____, 20____, between _____, hereinafter referred to as Grantor, and THE CITY OF GRAND RAPIDS, a Michigan Municipal Corporation, 300 Monroe Avenue, N.W., Grand Rapids, Michigan 49503, hereinafter referred to as City.

WITNESSETH:

WHEREAS, the Grantor is the owner of real property in the City of Grand Rapids, County of Kent, and State of Michigan, as described below and,

WHEREAS, the Grantor, in order to develop said property in the manner that it desires, finds it desirable to construct a storm water detention basin on the property and to give the City certain easement rights therein,

NOW, THEREFORE, it is agreed as follows:

1. In consideration of the sum of One Dollar (\$1.00), the receipt of which is hereby acknowledged, the Grantor does hereby grant, warrant and convey to the City an easement for storm water detention over, across and within the following described land in the City of Grand Rapids, County of Kent, State of Michigan, described as follows:

2. The City shall have the right to detain water in the easement area without incurring liability for any injury, death, or damage resulting from the operation of the detention basin and the outlet control structure.

3. The Grantor will construct the outlet control structure and maintain the storm water detention basin area, including any necessary erosion protection. The Grantor hereby agrees to assume liability for injuries, deaths or damages attributable to the construction or existence of the storm water detention basin and outlet control structure and agrees to hold the City, its officers, employees, and agents harmless for the same, it being acknowledged by Grantor that such facilities are constructed at the request of the Grantor.

4. Maintenance inspection of said drainage facilities shall be performed by the Grantor, and failure of the City to notify the Grantor of deficiencies shall not relieve Grantor of its maintenance responsibilities as specified herein.

5. The City shall have the right to enter upon the detention basin easement area and adjacent areas as necessary to inspect construction and/or maintenance. In the event that the herein described detention basin area becomes impaired due to improper maintenance, the City may order the Grantor to perform necessary maintenance immediately. If such ordered maintenance is not completed within sixty (60) days of such order, the City may perform such maintenance or have such maintenance performed at the Grantor's expense. If there is an immediate threat to public health, safety or welfare, resulting from the

impairment, the City may make such repairs at the Grantor's expense in less than the normal sixty (60) days. All costs, incurred by the City, shall be billed to the Grantor and shall become a lien against the property.

6. The Grantor shall have the tight to use of the detention basin easement area in any manner that Grantor deems fit, provided that the Grantor does not interfere with the intended use of the easement area, and provided that no permanent structure of any kind be placed in or over the storm water detention basin easement area, as described,. If any such structure is so placed thereon, the City shall have the right to remove the same without consent, express or implied, from the Grantor, and the actual cost thereof shall be borne by the Grantor.

7. The rights and obligations of this agreement shall run with the property described herein and shall be binding upon the owner's heirs, successors and assigns thereof.

IN WITNESS WHEREOF, the Grantor has hereunto set their hands and seals the day and year first above written.

SIGNED, SEALED AND DELIVERED

IN THE PRESENCE OF:

_____ By _____

DETENTION BASIN EASEMENT (Plats)

THIS INDENTURE, entered into this _____ day of _____, 20____ between _____, hereinafter referred to as Grantor, and THE CITY OF GRAND RAPIDS, a Michigan Municipal Corporation, 300 Monroe Avenue, N.W., Grand Rapids, Michigan 49503, hereinafter referred to as City.

WITNESSETH:

WHEREAS, the Grantor is developing certain property located in the City of Grand Rapids, County of Kent, known as _____

_____ and,

WHEREAS, the Grantor, in order to develop said property in the manner that it desires, finds it desirable to construct a storm water detention basin on the property and to give the City certain easement rights therein.

NOW, THEREFORE, in consideration of the respective covenants contained herein, the parties agree as follows:

1. In consideration of the sum of One Dollar (\$1.00), the receipt of which is hereby acknowledged, the Grantor does hereby grant, warrant and convey to the City as easement for storm water detention over, across and within the following described land in the City of Grand Rapids, County of Kent, State of Michigan, described as follows:

2. The Grantor agrees for itself, its heir, administrators, successors, and assigns, that it shall be the property owner's responsibility to maintain the easement area grounds including the removal of debris in such a manner that the proper functioning of the detention basin is not interfered with, and, that the property owner will not make any changes in size, shape, capacity, rate of inflow, rate of outflow or changes in any other characteristic of the detention pond without the prior written approval of the City, which approval can only be given by way of amendment to this instrument, properly recorded.

3. The Grantor further agrees that said easement given to the City in paragraph I above shall be illustrated by notice on the deed of each of the lots within the plat. There shall also be a restriction on the deed forbidding any and all construction or alteration to the area described in the easement. The Notice shall say:

NOTICE:

THE LANDOWNER IS FORBIDDEN TO DO ANY CONSTRUCTION, FILLING, OR ALTERATION TO THE LAND LOCATED WITHIN A DRAINAGE OR DETENTION AREA EASEMENT. THIS SHALL FORBID ALL CONSTRUCTION--PERMANENT OR TEMPORARY--CHANGES IN GRADING, THE DEPOSITING OF ANY MATERIAL IN THE EASEMENT OR THE REMOVAL OF ANY DIRT MATERIAL FROM THE EASEMENT.

THE LANDOWNER UPON WHOSE PROPERTY IS LOCATED THE DETENTION BASIN OR DRAINAGE EASEMENT SHALL BE RESPONSIBLE FOR ANY NECESSARY GROUNDS MAINTENANCE AND DEBRIS REMOVAL.

THE CITY OF GRAND RAPIDS SHALL BE RESPONSIBLE FOR THE MAINTENANCE AND CONTROL OF THE HYDRAULIC FUNCTIONING OF THE DETENTION BASIN PURSUANT TO MCLA 560.192, et al, OR A SUCCESSOR STATUTE. COST FOR MAINTENANCE BY THE CITY MAY BE CHARGED AGAINST THE PROPERTY OWNERS WITHIN THE PLAT PURSUANT TO MCLA 560.192a OR ITS SUCCESSOR STATUTE. THE PROPERTY OWNER ON WHOSE PARCEL THE EASEMENT RESTS IS RESPONSIBLE FOR THE TURF MAINTENANCE.

THE GRANTOR, ITS HEIRS, ADMINISTRATORS, SUCCESSORS AND ASSIGNS, WHICH INCLUDES EACH OF THE SUBSEQUENT LOT OWNERS WITHIN THE PLAT, SHALL SAVE AND HOLD THE CITY OF GRAND RAPIDS HARMLESS AND INDEMNIFY THE CITY FOR ANY DAMAGE RESULTING FROM A CLAIM OR SUIT FOR INJURY, DEATH OR DAMAGE RESULTING FROM THE CONSTRUCTION, OPERATION, AND EXISTENCE OF THE DETENTION BASIN.

4. The grantor, its heirs, administrators, successors, and assigns, including each of the subsequent lot owners within the plat shall save and hold the City, its officers, employees and agents harmless and indemnify the City against any claim or suit which seeks damages for an injury, death, or damage resulting from the construction, operation and existence of the detention pond.

5. The City agrees to maintain the detention basin outlet in accordance with the provisions of MCLA, 560.192, et al. It is further understood that a provision of these statutes allow the City to specially assess the property owners in the plat if it so chooses under MCLA 560.192a.

6. In the event the basin grounds are not properly maintained or changes are made to the easement area pursuant to paragraph 2 above which impair the function of the detention basin or drainage easement, the City may order the property owner(s), upon whose property the changes are located, or improper maintenance occurs to make the necessary repairs or maintenance immediately. If such ordered repairs or maintenance are not completed within thirty (30) days, the City may make such repairs or perform such maintenance or, have said repairs or maintenance made at the property owner's expense. If there is an immediate threat to public health, safety, or welfare, resulting from the impairment, the City may make such repairs in less than the normal thirty (30) days. All costs incurred by the City shall be billed to the property owner(s) and shall become a lien against

DETENTION BASIN AGREEMENT

THIS AGREEMENT is made _____, between THE CITY OF GRAND RAPIDS, a Michigan Municipal Corporation, 300 Monroe Avenue, N.W., Grand Rapids, Michigan 49503 (the "City"), and _____ (the "Developer").

WITNESSETH

WHEREAS, the developer is developing certain property located in the City of _____ County of Kent, more particularly described as follows:

(SEE ATTACHED EXHIBIT "A")

, and

WHEREAS, as part of its development plans, the Developer is proposing to construct a private detention basin on a portion of the above property to control the rate of surface water runoff, such detention basin to be located on and within the area, more particularly described as follows:

(SEE ATTACHED EXHIBIT "B")

, and

WHEREAS, any alteration in the size, shape, inlets or outlets of such detention basin or any improper maintenance of such basin, could have a detrimental impact on the public storm sewer system into which said detention basin flows.

NOW, THEREFORE, in consideration of the respective covenants contained herein, the parties agree as follows:

1. The Developer will not make any change in the size, shape, capacity, rate of inflow, rate of outflow, or in any other characteristic of the detention basin without the prior written approval of the City, which approval may only be given by way of amendment to this instrument, properly recorded.

2. The Developer will properly maintain the detention basin so that it will function in such a manner which will not have an adverse impact on the public storm sewer system into which it flows.

3. If the Developer should make any alteration in the size, shape, capacity, rate of inflow, rate of outflow, or in any other characteristic of the detention basin without obtaining the prior written approval of the City, or if the developer should fail to properly maintain the detention basin, the city shall have the unqualified right to disconnect the private storm sewer lateral running from the detention basin into the public storm sewer at the point where said private lateral connects to the public storm sewer.

4. The Developer hereby agrees to indemnify, save and hold the City, its officers, employees and agents harmless from and defend them against all claims, suits, causes of action, judgments, and all expenses and attorney fees pertaining thereto, for injuries or death to persons and damages to property attributable to the construction, maintenance or existence of said drainage facilities,

storm water detention basin, and outlet control structure, or as a result of any disconnection the City makes pursuant to the preceding paragraph. The Developer hereby agrees to assume all liability for injuries or deaths to persons and damages to property attributable to the construction, maintenance or existence of said drainage facilities, storm water detention basin, and outlet control structure or resulting from any disconnection the City makes pursuant to the preceding paragraph.

5. This instrument shall be executed in recordable form and shall be recorded with the Kent County Register of Deeds.

6. This agreement shall be binding upon and shall inure to the benefit of the parties, their heirs, administrators, successors and assigns.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed as of the day and year first above written.

WITNESSED:

CITY OF GRAND RAPIDS, A
Michigan Municipal Corporation

By: _____
_____, Mayor

Attest: _____
_____, City Clerk

(DEVELOPER)

By: _____

Its: _____

STATE OF MICHIGAN)

) ss

COUNTY OF KENT)

On this ___ of _____, 20__ , before me, the subscriber, a Notary public in and for said County, personally appeared _____, MAYOR OF THE CITY OF GRAND RAPIDS, to me known to be the same person who executed the within agreement, who has acknowledged the same to be his free act and will.

Notary Public, Kent County, Michigan
My Commission Expires

STATE OF MICHIGAN)

) ss

COUNTY OF KENT)

On this ____ of _____, 20__ , before me, the subscriber, a Notary public in and for said County, personally appeared _____, to me known to be the same person who executed the within agreement, who has acknowledged the same to be his free act and will.

Notary Public, Kent County, Michigan
My Commission Expires

Drafted by Utilities Department
Grand Rapids Michigan 49503
December 5, 1994