1CITY OF ROCHESTER HILLS

ENGINEERING DESIGN STANDARDS

CHAPTER 4

Stormwater Management

Executive Summary

In Rochester Hills, we have transformed from a rural area (approximately 1970's) to a suburban area (1990's). Much of our development occurred rapidly from the late 80's through to the early/mid 90's. This development created impervious surfaces (paved, built, or otherwise altered areas where water cannot infiltrate), leading to important changes in groundwater and stream systems, i.e. increased downstream flooding, stream channel erosion, reduced infiltration, increased pollutant transport, degradation of water quality and aquatic habitat, and increased water temperature. In roughly the late 1970's, our city adopted flood control standards based in part on the standards of the Oakland County Drain Commissioner (OCDC). The flood control standard, which controls only large storms, helped to control the impact of development on downstream flooding. Recently, with the promulgation of the NPDES Phase II rules and current research/technology, it became apparent that smaller storms, which are more common, passed untreated, undetained water through the detention basins that were typically used to meet the flood control standard. The smaller storms are now causing significant stream channel and environmental damage. In order to comply with the NPDES Phase II rule, become current with technology, and to better protect the waters of the City of Rochester Hills and down stream communities, we have updated our stormwater management design standards to include:

1. Ground water recharge.
2. Pre-treatment.
3. Water quality.
4. Channel protection.
5. Modified flood control.
6. Operation and maintenance responsibilities.

It should be noted that stormwater management is evolving quickly. Extensive literature has recently become available, and technologies are changing for the better each day. Many states across the nation have created their own stormwater guidance manuals, including Maryland, Minnesota, Wisconsin, New Jersey, Washington, Pennsylvania, and Virginia. These manuals are hundreds to thousands of pages long, and some contain two to three volumes. Almost all of these manuals were written by a committee of stormwater professionals/stakeholders. In an effort to be efficient, we chose not to recreate an elaborate stormwater design manual. Instead we have stated our objectives, and require that appropriate state manuals regarding stormwater management practice, selection, design, and implementation be referenced. In particular, we are requiring that the EPA fact sheets at:

http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5

And/or The Minnesota Stormwater Manual, November 2005 @
http://www.pca.state.mn.us/publications/wq-strm8-14.pdf

Or the 2004 Connecticut Stormwater Quality Manual @
http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325704
Or the PA stormwater best management practices manual @
http://164.156.71.80/WXOD.aspx?fs=2087d8407c0e00008000071900000719&ft=1

Or the 2000 Maryland Stormwater Design Manual @
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Or other handbooks or other manuals approved by the City of Rochester Hills to aid in selection, design, and implementation of stormwater management practices.

Also note, SEMCOG has obtained a grant from the MDEQ to create a Michigan Low Impact Development (LID) guidance manual. The projected date for completion is May 2008. When this manual is complete, it will likely take the place of the EPA's website and other state manuals that we have been referencing in the interim.

Since technology is evolving so quickly, and we will likely run into important issues with the way these standards are required, we reserve the right to update referenced manuals and our standards from time to time.

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STORMWATER MANAGEMENT

SECTION 1.0 PURPOSE

In order to protect the health, safety, and general welfare of the residents of the City of Rochester Hills, comply with Rochester Hills' MS4 general permit no. MIG619000, as well as to protect, sustain, and enhance the surface and ground water resources of the City of Rochester Hills, drainage and stormwater management practices shall be utilized as directed herein to achieve the following objectives:

A. Accommodate site development and redevelopment in a manner that protects public safety and is to the maximum extent practicable consistent with (or re-establishes) the natural hydrologic characteristics of each watershed and sustains ground water recharge, stream baseflows, stable stream channel (geomorphology) conditions, the carrying capacity of streams and their floodplains, ground water and surface water quality, and aquatic living resources and their habitats.

B. Minimize the increased volume of stormwater generated from development

C. Protect natural infiltration and ground water recharge rates in order to sustain ground water supplies and stream baseflows.

D. Maintain runoff characteristics of the site after completion of development that are consistent with the carrying capacity and stable channel conditions of the receiving streams.

E. Protect water quality by removing and/or treating pollutants prior to discharge to ground and surface waters throughout the City of Rochester Hills, and to protect, restore, and maintain the chemical, physical, and biological quality of ground and surface waters.

F. Protect instream channels and geomorphology conditions of the receiving streams; protect their flood carrying capacity and aquatic habitats and to reduce instream erosion and sedimentation.

G. Reduce flooding impacts and prevent a significant increase in surface runoff rates and volumes, predevelopment to post-development, which could worsen flooding downstream in the watershed, enlarge floodplains, erode stream banks and create other flood-related health-welfare-property losses; in general, to preserve and restore the natural flood-carrying capacity of streams and their floodplains.

H. Protect adjacent lands from adverse impacts of direct stormwater discharges.

I. Ensure effective long-term operation and maintenance of all permanent stormwater management facilities.

J. Maintain natural drainage patterns and encourage the use of natural drainage systems.

K. Treat and release stormwater as close to the source of runoff as possible using a minimum of structures and maximizing reliance on natural processes.

SECTION 2.0 APPLICABILITY

The following construction projects shall be regulated by these standards:

A Land development and redevelopment (included but not limited to plats, single family detached site condo and site plans.

B. Construction projects requiring an engineering land improvement permit (LIP).

SECTION 3.0 STORMWATER MANAGEMENT PLAN

For all activities regulated by these Standards in accordance with Section 2.0, the Applicant shall submit a stormwater management plan and report prepared by a Professional Engineer licensed in the State of Michigan, which shall contain, but not be limited to, the following:

A. Suitable maps and drawings showing all existing natural and constructed drainage facilities affecting the subject property.

B. Hydrologic (watershed) and water feature boundaries, including all areas flowing to the proposed project, existing streams (including first order and intermittent streams), springs, lakes, ponds, or other bodies of water within the project area.

C. Sufficient topographical information with elevations to verify the location of all ridges, streams, etc. (two-foot contour intervals within the project's boundaries and for proposed offsite improvements; for slopes greater than fifteen percent (15%), five foot (5') contours are acceptable).

D. Notes pertaining to and locations of existing standing water, areas of heavy seepage, springs, wetlands, streams, and hydrologically sensitive areas.

E. A drainage area map showing all sub-watershed areas, runoff coefficients, acreage of drainage area, general type of soils with hydrologic soil group (HSG) noted, estimated permeabilities in inches per hour, location and results of all soil tests and borings, and proposed stormwater management system in plan view shall be included with the plans.

F. 100-year flood elevations for any Special Flood Hazard Areas on or within one hundred feet (100') of the property.

G. Description of current and proposed ground cover and land use. The total area and runoff coefficient for each drainage area noted.

H. A plan of the proposed stormwater drainage system attributable to the activity proposed, including runoff calculations, stormwater management practices to be applied both during and after development, and the expected project time schedule.

I. The design computations for all proposed stormwater drainage systems, including storm-drain pipes, inlets, runoff control measures and culverts, drainage channels, and other features, facilities, and stormwater management practices

J. A grading plan, as required under Chapter 5 of the City of Rochester Hills Engineering Design Standards; including all areas of disturbance, of the subject activity. The total area of disturbance shall be noted in square feet and acres.

K. A plan of the erosion and sedimentation procedures to be utilized as required under Chapter 11 of the City of Rochester Hills Engineering Design Standards and/or as required by the Oakland County Drain Commission (OCDC).

L. A delineation of the pathways of all concentrated flow (that is, flow other than overland sheet flow).

M. The effect of the project (in terms of runoff volumes and peak flows) on adjacent properties and on any other stormwater collection system that may receive runoff from the project site and specifics of how erosion and flooding impacts to adjacent properties will be avoided or otherwise mitigated.

N. An operation and maintenance plan consistent with the requirements of Section 5.0. Such a plan should clearly explain how the proposed facilities operate and the functions they serve.

O. The name of the development, the name and address of the property owner and Applicant, and the name and address of the individual or firm preparing the plan.

P. A north arrow, submission date, scale and revision dates as applicable shall be included on each page of all plans submitted.

Q. Construction details sufficient to completely express the intended stormwater design components consistent with these standards.

SECTION 4.0 STORMWATER MANAGEMENT DESIGN STANDARDS

Subsection 4.1 Design Goals, Principles and Standards

<u>Design Goals</u>

Applicants shall adhere to a holistic design process incorporating the goals listed below. The design goals are:

A. Minimize the volume of runoff that must be collected, conveyed, treated and released by stormwater management facilities. Site design should implement runoff volume reduction techniques such as those described in Appendix A.

B. Maintain to the maximum extent practicable the natural infiltration process and rate, and infiltrate runoff at its source;

C. Remove and/or treat pollutants at the source or during conveyance;

D. Provide for peak flow attenuation; and

E. Attenuate runoff to protect the instream channel of the receiving stream.

General Principles

The following general principles apply to all applicable activities pursuant to Section 2.0:

A. Incorporate Low Impact Development (LID) practices to minimize the amount of stormwater generated on site, encourage the disconnection of impervious land cover, and maximize the use of pervious areas for stormwater treatment and on site rainfall infiltration by working towards the following core set of principles:

   1. Integrate stormwater management early in site planning activities
   2. Use natural hydrologic functions as the integrating framework
   3. Focus on prevention rather than mitigation
   4. Emphasize simple, nonstructural, low-tech, and low cost methods
   5. Manage as close to the source as possible
   6. Distribute small-scale practices throughout the landscape
   7. Create a multifunctional landscape

   Site design should implement runoff reduction techniques such as those described in Appendix A. See list of references in Appendix C for further detail on accomplishing these principles.

B. Conventional stormwater management (i.e. curb and gutter and piped systems) should be reduced to the maximum extent practicable, as they will result in the alteration of predevelopment hydrology be reducing recharge, increasing pollutant concentrations, elevating water temperatures and increasing the velocity of flows.

C. Infiltration of surface water runoff at its source is to be the primary mechanism for stormwater management. Infiltration practices include, but are not limited to those outlined in the publications listed in Section 4.3. Infiltration practices shall adhere to the following criteria:

   1. In choosing methods of infiltration, preference shall be given to the combination of surface and subsurface infiltration methods.

   2. Applicants shall first consider minimum disturbance/minimum maintenance techniques combined with site grading that distributes runoff to reduce concentration. Next, Applicants shall consider depression areas combined with subsurface infiltration practices, followed by other subsurface measures, including but not limited to porous paving and perforated pipe storage.

   3. The use of multiple infiltration features and facilities that provide for the following is encouraged:

      a. Discourage concentration of flows,
      b. Encourage disconnection of flows,
      c. Infiltrate as close to the source of runoff as possible, and
      d. Reduce visual impact.

      Note: An example of promoting the concepts listed above is choosing a design method to address runoff collected from rooftops and conveyed to the surface by downspouts. The “disconnection of flows” can be accomplished by directing the downspouts over pervious surfaces rather than impervious surfaces. This can be taken one step further by directing the downspouts in to infiltration facilities close to the source of the runoff. This promotes the idea of infiltrating as close to the source of runoff as possible and discourages the concentration of flows.

4. Where high water tables, subsurface contamination, or other site constraints preclude achieving the required infiltration volume, additional LID practices and alternative stormwater management practices should be implemented to reduce to the maximum extent practicable the total volume of stormwater released to surface waters.

5. Infiltration areas should be designed to maintain any broad and even infiltration pattern, which existed prior to development. Such facilities should use the natural topography and vegetation in order to blend in with the site. Infiltration designs, which do not provide this, may be used if the Applicant demonstrates to the City of Rochester Hills satisfaction that alternative approaches would be more effective, more harmonious with the existing environment and is easily maintained.

6. Surface level stormwater infiltration facilities should be as shallow as possible while still achieving the requirements of these standards.

D. To reduce the need for large wet and/or dry detention basins designed to satisfy the peak flow attenuation requirements, other innovative stormwater management practices located close to the source of runoff generation shall be considered, including a combination of practices (e.g., rooftop storage, porous pavement, open vegetated channels, bioretention and infiltration trenches). Where basins are necessary, wet ponds shall be considered first, then dry ponds. In addition, underground storage is strongly discouraged and is not to be used to increase impervious surface.

E. Site hydrology and natural infiltration patterns shall guide site design, construction and vegetation decisions. All channels, drainage ways, swales, natural streams and other surface water concentrations shall be maintained and incorporated into design decisions unless changes can be justified to enhance natural runoff and/or infiltration patterns or reduce health/safety issues on the basis of other design objectives of these standards.

Minimum Performance Standards

The following minimum performance standards shall apply to all applicable activities, pursuant to Section 2.0:

A. Structural and/or non-structural stormwater management practices that provide, promote or otherwise make best possible use of infiltration on-site shall be considered first and foremost in all site designs. Stormwater infiltration practices shall be designed in accordance with the sizing criteria as described in Section 4.3.1 of these standards.

B. Water quality management shall be provided through the use of structural and/or non-structural stormwater management practices. Water quality stormwater management practices shall be designed to remove a minimum eighty percent (80%) total suspended solids (TSS). A stormwater management practice complies with this requirement if it is:

1. Sized to capture the prescribed water quality volume (per Section 4.3.1.2).

2. Selected, designed and implemented based upon appropriate reference materials such as the EPA's BMPs fact sheets at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5 and/or The Minnesota Stormwater Manual, November 2005 @ http://www.pca.state.mn.us/publications/wq-strm8-14.pdf, or the 2004 Connecticut Stormwater Quality Manual @ http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325704 , or the PA stormwater best management practices manual @ http://164.156.71.80/WXOD.aspx?fs=2087d8407c0e00008000071900000719&ft=1 , or the 2000 Maryland Stormwater Design Manual @ http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp or other handbooks or manuals approved by the City of Rochester Hills.

3. Constructed in accordance with all permits and approved plans and specifications; and

4. Maintained per an approved operation and maintenance agreement.

5. Rate based Manufactured Treatment Devices (MTD) shall be designed according to Section 4.3.5 not as indicated above.

C. Stormwater discharges from land uses or activities with higher potential for pollutant loadings (hotspots) may require the use of specific structural stormwater management practices and pollution prevention practices. In addition, stormwater from a hotspot land use shall be provided with proper pretreatment prior to infiltration. For the purpose of these standards, the sites/facilities listed in Section 4.1.3.E.I-v. below, are considered hotspots.

D. Certain industrial sites may be required to prepare and implement a stormwater pollution prevention plan and file notice of intent as required under the provision of the EPA Industrial Stormwater NPDES Permit Requirements. Other industrial sites storing significant quantities of chemicals/wastes should also prepare a prevention plan. Sites that are required by EPA to prepare a plan include, but are not limited to:

1. Vehicle salvage yards and recycling facilities;
2. Vehicle and equipment cleaning facilities;
3. Fleet storage areas for buses, trucks etc.;
4. Vehicle (service and maintenance);
5. Landscaping/nursery facilities;
6. Facilities that generate or store hazardous materials;
7. And, in some cases, service provider storage yards.

E. Conveyance structures/channels shall be designed and adequately sized so as to protect the properties receiving runoff from impacts of flooding and erosion. Drainage easements and amendments thereto from adjoining properties may be required to ensure the drainage way and the property and shall also establish the operation and maintenance requirements for the drainage way.

F. All stormwater management practices shall have an Operation and Maintenance Plan pursuant to Section 5.3 of these standards and an enforceable Operation and Maintenance Agreement per Section 5.4 of these standards to ensure the system functions as designed and to provide remedies for system failure.

G. Stormwater runoff generated from development and discharged directly into a jurisdictional wetland or waters of the United States and their adjacent wetlands shall be treated by an approved stormwater management practice prior to release into a wetland. Natural wetlands shall not be used to meet the minimum design requirements for stormwater management or stormwater runoff quality treatment, except when used as part of a treatment train that incorporates a portion of the outer zone (filter strip) of the wetland's riparian buffer as a stormwater outfall. In such instances, the discharge velocity from the terminal end of a pipe or associated energy dissipation practice shall not exceed two feet per second for the two-year frequency storm event. Where such a management strategy is used, all feasible methods shall be used to convert concentrated flow to uniform, shallow sheet flow before entering the outer zone of the wetland's riparian buffer. In addition, it shall be demonstrated that such an approach will not cause erosion.

H. The post development peak discharge rate shall not exceed 0.2 cfs/acre for the 25-year storm event. as described in Section 4.3.1.D.

I. The bankfull storm event or the 1-year 24-hour storm event shall be attenuated for at least 24 hours (i.e. the stormwater will be released over a minimum of 24 hours) as described in Section 4.3.1.C.

Subsection 4.2 Stormwater Runoff Calculation Methods

A. For parcels of land with an area of 120 acres or less, the Rational Formula (Q=CIA) shall be calculated as I = 175/T+25), for a 10-year frequency, one hour intensity storm, in which T is the time of concentration in minutes and I is the intensity in inches per hour. The initial T is generally 20 minutes for residential areas and 15 minutes for high runoff areas, such as commercial and office space. All composite runoff coefficients shall be based on the values shown in the table below. The slopes listed for the semi-pervious surfaces are the proposed finished slope of the tributary area.

Type of Surface	**Runoff Coefficient**		
Water Surfaces	1.00		
Roofs	0.95		
Asphalt or concrete pavements	0.95		
Gravel, brick, or macadam surfaces	0.85		
Green Roofs (< 4 in)*	0.50		
Green Roofs (4 – 8 in)*	0.30		
Green Roofs (9 –20 in)*	0.20		
Green Roofs (> 20 in)*	0.10		
Porous asphalt or concrete pavements**	0.10		
Paving stones (a.k.a. unit pavers)**	0.10 – 0.70 (as specified by manufacturer)		
Grass Pavers (a.k.a. turf blocks)**	0.15 – 0.55 (see table below)		
Semi-pervious; lawns, parks, playgrounds	Slope <4%	Slope 4%-8%	Slope >8%
Hydrologic Soil Group A	0.15	0.20	0.25
Hydrologic Soil Group B	0.25	0.30	0.35
Hydrologic Soil Group C	0.30	0.35	0.40
Hydrologic Soil Group D	0.45	0.50	0.55

* Referenced from The State of Minnesota Sustainable Building Guidelines – Version 2.0, Worksheet S-1

** Referenced from the Massachusetts Low Impact Development Toolkit, Fact Sheet #6.

B. More precise methodologies for predicting runoff such as runoff hydrographs are widely available, and may be required by the City of Rochester Hills Engineering Division for sizing the drainage systems on large sites and/or smaller sites that are deemed potentially problematic. Acceptable alternative methods include:

1. U.S. Army Corps of Engineers HEC-HMS, HEC-1
2. Natural Resources Conservation Service UD-21, TR-20 and TR-55
3. U.S. EPA's SWMM
4. Continuous simulation (HSPF)

C. Unless a continuous simulation approach to drainage system hydrology is used, all design rainfall events will be based on the SCS Type II distribution.

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

E. For sites with upstream watersheds equal to or greater than two (2) square miles, approval of the MDEQ is required, pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The MDEQ will compute the runoff rates at no charge. The MDEQ requires applicants to use the UD-21 method by SCS in lieu of the rational method. This method was developed for small watersheds by SCS, and can be used for watersheds up to 10 square miles. Computer programs such as HEC-HMS, HEC-1 and HEC-RAS, DEQ permit applications, and other relevant information, can be downloaded from the MDEQ web site.

Subsection 4.3 Design Standards for Stormwater Management Practices

A. The EPA's BMPs fact sheets @ http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5 and/or The Minnesota Stormwater Manual, November 2005@ http://www.pca.state.mn.us/publications/wq-strm8-14.pdf, or the 2004 Connecticut Stormwater Quality Manual @ http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325704 , or the PA stormwater best management practices manual @ http://164.156.71.80/WXOD.aspx?fs=2087d8407c0e00008000071900000719&ft=1 , or the 2000 Maryland Stormwater Design Manual @ http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp, or other handbooks or manuals approved by the City of Rochester Hills shall serve as a guide for the selection, design, and implementation of stormwater management practices.(A list of additional manuals is provided in Appendix C).

   Pursuant to the design options recommended in the above documents, the following standards shall be adhered to:

Subsection 4.3.1 Stormwater Management Practices-Sizing Criteria

The following sizing criteria shall be followed at all sites required to meet the standards of Section 2.0.

Stormwater Recharge and Infiltration

A. Impervious and disturbed surfaces from development alter the natural hydrologic cycle by discharging stormwater directly to streams, rather than allowing it to infiltrate through the soils and into groundwater as it did before development. This increases flooding and reduces the base flow to streams that is needed in the summer months when there is little precipitation. The increased runoff from impervious surfaces also increases stream temperatures, since pavement and other impervious surfaces absorb substantial amounts of heat in the summer due to their dark coloring and lack of shade, which is transferred to runoff passing over the surface. The result is runoff that is dramatically warmer than natural groundwater inflow would have been under a natural hydrologic cycle. The purpose of this criterion is to maintain existing recharge rates to preserve existing groundwater levels and stream base flows.

1. All storms up to one half inch (½”) must be captured and infiltrated on-site. The volume of water to be infiltrated shall be calculated using the following equation:

   Re_v =1,815 (A)(C),
   Where:
   Re_v = recharge volume (ft^3)
   C = weighted runoff coefficient
   A = site area in acres
   1,815 = 0.5 inch (½”) rainfall x 3,630 to convert ac-in to cf.

2. The maximum depth of an infiltration system shall be one and a half feet (1½’) unless the infiltration rate is greater than one half inches (½”) per hour, in such case, the system may be deeper and must be capable of infiltrating the recharge volume within a 48-hour period.

3. Recharge should not be concentrated to one area. It should be distributed to multiple areas throughout the site.
4. Site design should implement runoff reduction techniques such as those described in Appendix A.

<u>Water Quality</u>

A. Development also impacts the water quality of streams, ponds, lakes and wetlands. As impervious area increases, the volume and velocities of stormwater increase, often resulting in erosion of soils. Pollutant deposits on the land surface also increase as the intensity of land use increases. These materials are then washed off by rain and runoff, increasing the pollutant load to receiving waters. Thus, it is important that stormwater management practices (SMP) are used to handle water quantity as well as treat water quality. The water quality volume should include the first flush of storms, as this is where the majority of pollutants are collected and discharged.

   1. The water quality volume required to be treated shall be calculated as:

      WQv =1,815 (A)(C),
      Where:
      WQv = water quality volume (ft3)
      C = weighted runoff coefficient
      A = site area in acres
      1,815 = one half inch (½”) rainfall x 3,630 to convert ac-in to cf.

   2. The water quality stormwater management practice (SMP) shall meet the minimum performance criteria of Section 4.1. A short list of acceptable structural and nonstructural water quality SMP’s are listed below (Acceptable SMP Options, Pages 15-16). This is not an all-inclusive list, the design engineer is encouraged to select other structural and/or non-structural SMPs that are best suited for their site and meet the water quality requirement.

B. As a basis for design, the following assumptions may be made:

1. Multiple Drainage Districts: When a project contains or is divided by multiple drainage districts, the WQv volume shall be addressed for each drainage district.

2. Offsite Drainage Areas: The WQv shall be based on the runoff coefficient of the proposed site. Offsite existing impervious areas may be excluded from the calculation of the water quality volume requirements.

<u>Channel Protection (Bankfull)</u>

A. Many storm water management practices focus on controlling peak flow rates for larger storms, including the 10-year, 25-year, 50-year, and 100-year storms. This does not address the increased duration at which those high flows occur because of the increased volume of water from development compared to pre-development. For example, although the peak flows are kept the same, there is a much greater volume of water leaving the site under developed conditions and the streams have higher flows for longer durations than they did under predevelopment conditions. In addition, because the impervious development has limited recharge, base flow during non-storm event times is lower. The purpose of this criterion is to limit the total amount of time that a receiving stream exceeds an erosion-causing threshold, based on pre-developed conditions.

    1. The volume and storage provided for controlling the bank full flood will be equal to or in excess of the runoff from a 1-year, 24-hour storm, which can be determined by:

       Cpv =6,788(A)(C),
       Where:
       Cpv = channel protection volume (ft3)
       C = weighted runoff coefficient
       A = site area in acres
       6,788 = 1.87 inch rainfall x 3,630 to convert ac-in to cf.

    2. The release rate from the bank full storage volume will be such that this volume will be stored not less than 24 nor more than 48 hours.

<u>Flooding Protection (Overbank)</u>

A. The goal of this criterion is to prevent flood damage to conveyance systems and infrastructure and reduce minor flooding caused by overbank floods. Overbank floods are defined as floods, which exceed the bankfull capacity of the channel and spill over to the floodplain where they can damage property and structures. The key management objective is to protect downstream structures (houses, businesses, culverts, bridge abutments, etc.) from increased flows and velocities from upstream development

    1. The over bank flood protection volume shall be calculated to detain the volume of runoff from the entire site, resulting from a 25-year frequency storm.

    2. The allowable release rate from the over bank flood protection volume shall be 0.2 cfs per acre, but in no case shall exceed the capacity of the receiving stream or body of water. In the event that the receiving stream cannot properly convey the 0.2 cfs per acre design discharge, the discharge shall be limited to the existing capacity of the

receiving stream. Hydraulic calculations shall be submitted showing the existing capacity of the receiving stream for review.

3. In general, the Oakland County, “A Simple Method of Detention Basin Design” method by Glen Yrjanainen shall be used.

Extreme Flooding Protection

A. The site shall provide a safe overflow for the 100 year storm event.

Pretreatment

A. To prevent premature failure, the design of stormwater management practices (SMPs) shall include a pre-treatment device or method that will trap sand and sediments to avoid clogging the treatment mechanism. Infiltration of stormwater from the SMP into underlying soils and eventually groundwater aquifers is an important beneficial component of the device. Pre-treatment basins must be designed and located to be easily inspected and accessible to facilitate maintenance.

    1. The pretreatment device shall be sized to accommodate a one-year storm event. The “Detention Time” method of design from the OCDC Erosion Control Manual should be used to calculate the volume of storage.

Acceptable SMP Options

This section sets forth six (6) acceptable groups of SMPs that can be used to meet the sizing criteria. The SMP groups are:

A. Stormwater Ponds/Basins

    1. Wet Pond/Pocket Pond
    2. Wet Extended Detention Pond
    3. Multiple Pond System
    4. Dry Extended Detention Basin
    5. Dry Detention Basin

B. Stormwater Wetlands

    1. Shallow Marsh
    2. Extended Detention Wetland
    3. Pond/Wetland System

C. Infiltration Practices

    1. Infiltration Trench
    2. Infiltration Basin
    3. Porous Pavement

D. Filtering Practices

    1. Surface Sand Filters

2. Underground Sand Filters
3. Perimeter Sand Filter
4. Bioretention

E. Open channel practices

1. Dry Swale
2. Wet Swale

F. Others

1. Manufactured Treatment Device (MTD)
2. Rain Barrels/Cisterns
3. Green Roof

G. Non-structural SMPs

1. Natural area conservation
2. Disconnection of rooftop runoff
3. Disconnection of non-rooftop runoff
4. Sheet flow to buffers
5. Open channel use
6. Impervious cover reduction
7. Soil Amendment & Restoration

The Applicant should not limit themselves in designing only within these groups of SMP, if there is a creative option that can effectively meet the volume criteria stipulated in Sections 4.3.1, then the City of Rochester Hills/Engineering Division and/or outsource consultant will review its suitability and determine if it is a viable alternative to the above mentioned groups.

To clarify structural SMP nomenclatures, we have included Table 1, which lists some of the various widely referenced structural practices and provides a brief description of each. For example, one person may use the term "wet pond" to describe a retention pond. Another may use the term a "retention pond" to describe an infiltration basin because runoff is "retained" within the pond until it is infiltrated into the ground. Both are technically correct, since a wet pond "retains" runoff in a permanent pool, and an infiltration basin "retains" runoff within the underlying soils of the basin.

Table 1: Naming Convention of Common Structural Stormwater Management Practices for Water Quality Management and Treatment (Adapted from CWP, 2002)

SMP Group	Practice Name	Practice Description
Ponds/Basins* *Basins dewater and do not have a permanent pool. Ponds have a permanent pool.	Dry Detention Basin	Dry basins or vaults are generally designed to temporarily detain runoff from a set of defined storm frequencies to provide peak flow attenuation for flood control purposes.
	Dry Extended Detention Basin	Basins that treat a prescribed water quality volume through extended detention, a design option that holds runoff over a fixed detention time.
	Wet Pond	Ponds that provide storage for a water quality volume in a permanent pool.
	Wet Extended Detention Pond	Ponds that treat a water quality volume by detaining runoff above the permanent pool for a specific minimum detention time.
	Multiple Pond System	A group of inter-connected ponds that collectively treat a water quality volume.
Wetlands	Shallow Marsh	Constructed wetlands that provide water quality treatment primarily in a wet shallow marsh.
	Extended Detention Wetland	Wetland systems that treat a portion of a water quality volume by detaining storm flows above the marsh surface.
	Pond/Wetland System	Wetland systems that treat a portion of a water quality volume in a permanent pool of a wet pond that precedes that shallow marsh wetland.
	Gravel Wetland	Wetland systems composed of wetland plant mats grown in a gravel matrix.
Infiltration	Infiltration Trench	Infiltration practices that store a water quality volume in the void spaces of a gravel trench or within a chamber or vault before being infiltrated into underlying soils.
	Infiltration Basin	Infiltration practices that store a water quality volume in a surface depression, before being infiltrated into underlying soils.
	Porous Pavement	Permeable pavement surface with a stone reservior underneath. The reservoir temporarily stores surface runoff before infiltrating it into the subsoil.
Filters	Surface Sand Filter	Filtering practices that treat stormwater by settling out larger particles in a sediment chamber, and then filtering stormwater through a sand matrix.
	Underground Sand Filter	Filtering practices that treat stormwater as it flows through an underground sediment chamber and then into a sand-matrix filtering chamber.
	Perimeter Sand Filter	Filters that incorporate a shallow sediment chamber and a sand filter bed as parallel vaults.
	Organic Filter	Filtering practices that use an organic medium such as compost in the filter, or incorporate organic material in addition to sand (e.g., peat/sand mixture).
	Bioretention	Practices that incorporate shallow depressions with vegetation that treat stormwater as it flows through a soil matrix.
Open Channels	Dry Swale	Open vegetated channels or depressions explicitly designed to detain and promote the filtration of stormwater runoff into a prescribed underlying soil media.
	Wet Swale	Open vegetated channels or depressions with wetland vegetation designed to retain water or intercept groundwater for water quality treatment.
	Grass Channel	Open vegetated channels or depressions designed to convey and detain a water quality volume at a very slow maximum velocity with a minimum residence time.
Other Practices	Manufactured Treatment Device (MTD)	Prefabricated stormwater treatment structures that utilize settlling filtration, absorptive/adsorptive materials, vortex separation, or other appropriate technology to remove pollutants from stormwater runoff.
	Filter Strips	Vegetated areas with prescribed dimensions and slopes, designed to treat sheet flow runoff from adjacent surfaces and remove pollutants through filtration and infiltration (a.k.a., grass filter strips, filter strips, and forested buffers).

Subsection 4.3.2 Stormwater Conveyance System (Open Channel, Drainage Way, and Storm Sewers)

General

A. Applicants are encouraged to design conveyance systems that encourage infiltration and improve water quality wherever possible.

B. Wherever conveyance channels are necessary, drainage shall be maintained by an open channel with landscaped banks designed to carry the 10-year frequency rainfall event. All open channels shall be designed with one foot (1') of freeboard above the design water surface elevation of the design runoff condition.

C. Flood relief channels shall be provided and designed to convey the runoff from the 100-year frequency rainfall event, such that positive discharge of this runoff to an adequate receiving stream or conveyance system occurs without harmful affects.

D. Where drainage swales are used in lieu of or in addition to storm sewers, they shall be designed to carry the required runoff without erosion and in a manner not detrimental to the properties they cross. Drainage swales shall be provide a minimum of two percent (2%) but shall not exceed a grade of nine percent (9%). Drainage swales used strictly for conveyance are not the same as Open Vegetated Channels. Design standards for Open Vegetated Channels are provided in the following section.

E. Use of grassed swales or open vegetated swales in lieu of curbing to convey, infiltrate and/or treat stormwater runoff from roadways is encouraged.

Open Vegetated Channels

A. Open Vegetated Channels are conveyance systems that are engineered to also perform as water quality and infiltration practices. Such systems can be used for the conveyance, retention, infiltration and filtration of stormwater runoff.

B. Open Vegetated Channels primarily serve a water quality function (WQv), they also have the potential to augment infiltration. Examples of such systems include, but are not limited to: dry swales, wets swales, and grass channels.

C. Open Vegetated Channels shall be designed to meet the following minimum standards:

   1. The channel shall be designed to safely convey the ten-year frequency storm event with a freeboard of at least twelve inches (12"). Freeboard is the difference between the elevation of the design flow in the channel and the top elevation of the channel.

   2. The peak velocity of the runoff from the ten –year storm shall be non-erosive for the soil and ground cover provided in the channel.

   3. The longitudinal slope shall be no greater than four percent (4%) to qualify for water quality treatment.

   4. Channels shall be trapezoidal in cross section.

5. Channels shall be designed with moderate side slopes of 1V:4H. Flatter side slopes may be necessary under certain circumstances.

6. The maximum allowable ponding time in the channel shall be less than 48 hours.

7. Channels (for example, dry swales) may require an underdrain in order to function and dewater.

8. Channels shall be designed to temporarily store the WQv within the system for a maximum period of 48 hours and a minimum period of one (1) hour.

9. Landscape specifications shall address the grass species, wetland plantings (if applicable), soil amendment and hydric conditions present along the channel.

10. Accumulated sediment within the channel bottom shall be removed when twenty-five (25%) of the original WQv volume has been exceeded.

11. Check dams along the channel length may be warranted.

12. The bottom of dry swales shall be situated at least two feet (2') above the seasonal high water table.

13. A minimum vertical clearance of five feet (5') is required between open swale/ditch inverts and underground utilities unless special provisions are employed.

D. Additional design information for Open Vegetated Channels is available in Design of Stormwater Filtering Systems (CWP, 1996).

Natural Streams and Channels

A. Natural streams and channels are to be preserved. Natural swales and channels should be preserved, whenever possible.

B. If channel modification must occur, the physical characteristics of the modified channel will duplicate the existing channel in length, cross-section, slope, sinuosity, and carry capacity.

Storm Sewers

A. Sizing/Hydraulics

1. Storm sewer systems shall be designed for a 10-year frequency rainfall event.

2. Storm sewer design velocities, capacities, and friction losses shall be based on Manning's equation.

$$Q = \frac{1.49\ AR^{2/3}S^{1/2}n}{n}$$

3. Mannings coefficient for concrete pipe shall be n = 0.013. Coefficients for other pipe types shall be obtained from sources, such as, Stormwater Conveyance Modeling and Design, First Edition, 2003 Haestad Methods, Inc.

4. Minimum design velocity shall be two and a half feet (2½') per second, and maximum velocity shall be ten feet (10 fps) per second, with pipe flowing full.

5. Submerged systems are not allowed. Submerged systems are storm sewers that are entirely or in part below the outlet surface elevations and do not dewater.

6. Surcharging under design conditions is permitted provided the surcharged hydraulic grade line (HGL) is maintained at or lower than one foot (1') below the rim elevations of all upstream structures.

7. The hydraulic grade line must be calculated for the entire system. The hydraulic grade will be assumed to start at the elevation 0.80 x pipe diameter of the outlet pipe or the high water level (HWL), which ever is higher.

8. Minimum and maximum design slopes, for concrete pipe, shall be as follows:

Pipe Diameter (inches)	Minimum Slope (feet per 100 feet) > 2.5 fps	Maximum Slope (feet per 100 feet) < 10 fps
12	0.32	4.88
15	0.24	3.60
18	0.20	2.84
21	0.16	2.32
24	0.14	1.92
27	0.12	1.64
30	0.10	1.44
36	0.08	1.12
42	0.06	0.92
48	0.05	0.76
54	0.04	0.64
60	0.04	0.56

B. Location

1. Storm Sewers

a. In-line catch basins on storm lines greater than 18" are prohibited.

b. Storm sewers shall generally be located on the same sides of streets as water mains, and generally within the street right-of-way, 7 ½ feet from Northerly and Easterly street right-of-way lines.

c. Easements for sewers not located within a street R.O.W. shall have a minimum width of twenty feet (20'), centered upon the sewer. Such easements shall be reserved to benefit or dedicated to the Homeowner's Association, with restrictions against use or occupation of easements, by the property owners and/or by other utilities, in any manner, which would restrict sewer maintenance or repair operations.

d. For subdivisions, storm sewers shall be located in the public road right-of-way or in easements adjacent to the public road right-of-way. Storm sewers shall not be located in rear yards except to pick up rear yard drainage or in unusual circumstances or for sump pump discharge lines.

e. The horizontal alignment of sewers which are not proposed to generally follow street, drive, or parking area pavements, shall parallel property lines or building lines, with clearance distances sufficient to accommodate the full width of the proposed easement.

f. Horizontal clearance between storm pipes and sanitary sewer and water lines shall be a minimum of ten feet (10’).

g. Horizontal separation from buildings shall be a minimum of ten feet (10’) or distance, which will allow a 1:1 slope to the base of the foundation, whichever is greater.

h. All storm sewers located beneath pavement or a traveled portion of a roadway shall have a minimum of three and a half feet (3½’) of cover.

i. Vertical separation distances between storm sewers and other buried storm sewers and other buried utility lines should be at least eighteen inches (18”).

2. Catch Basin and Inlets

a. Catch Basin outlet pipes will incorporate a floatable trap device that captures floatable debris and oils, provides for pipe maintenance access, stainless steel hardware, oil and gas resistant gaskets, and is designed to prevent siphoning according to the following:

i. In “Heavy Traffic and Pollutant Load” areas a floatable trap outlet in every catch basin is required. This includes, but is not limited to, gas stations, convenience stores, fast foot restaurants, vehicle repair facilities, stores with “drive through” service (i.e. banks, drug stores, dry cleaners, coffee shops), loading docks, distribution facilities, hospitals, school bus loading areas, maintenance facilities, light industrial sites, “dumpster areas”, parking and roadway areas of shopping centers close to the stores, etc. The exception will be where a catch basin cannot be maintained. An oil-absorbing boom may also be required in structures that receive heavy hydrocarbon loading.

ii. In “Moderate Traffic and Pollutant Load” areas, floatable trap outlets will be located in catch basins so as surface water passes through no more than one (1) catch basin that does not have a floatable trap. This includes, but is not limited to, office buildings, multi-residential complexes, schools (other than bus areas), most shopping mall parking areas, mixed retail commercial facilities, municipal/government buildings, athletic/entertainment/recreational facilities, non-fast food restaurants, special event/remote parking areas, etc. The downstream structures (prior to discharge) are most critical, and oil-absorbing booms may be useful if heavier hydrocarbon loading is expected.

iii. In “Low Traffic and Pollutant Loading” areas, floatable trap outlets will be located so as surface water passes through no more than two (2) catch basins that do not have a floatable trap. This includes, but is not limited to, grassy or vegetated areas, single family residences, parks, parking for offices within residences, flow excess from permeable paving areas, etc.

NOTE: A large site may have different areas, just like it may have different runoff coefficients. For instance, a shopping mall may have a heavy traffic roadway and loading/unloading areas as well as a remote parking area. Therefore, apply the appropriate placement criteria to each area of the site to arrive at the total number of floatable trap equipped catch basins for the project.

b. Minimum sump depth is 2’ for catch basins that do not require a floatable trapoutlet.

c. Minimum sump depths for catch basins equipped with floatable trap outlets is 36”.

d. Surface water flows shall not exceed the intake capacity of the structure casting.

e. At all low points in gutters, and in swales and ditches, where applicable.

f. At the upstream curb return, if more than two hundred feet (200’) downstream of a high point in the gutter.

g. At maximum intervals of six hundred feet (600’) along a continuous slope.

h. Such that there is a maximum pavement length per structure as follows:

   ii. 300 lineal feet for a catch basin or inlet at a low point; and
   iii. Vane grates shall be provided on relief basins when the longitudinal slope of road is four percent (4%) or greater.

i. Such that, where low point exists in the gutter line, no more than two relief basins shall be used in either direction in advance of the low point, (i.e., 4 relief basins would be possible). When a total of two or more relief basins are used in such a system, a double catch basin will be placed at the low point.

j. At tee intersections, catch basins may only be installed at the property line extended, on the leg of the tee.

k. Drainage structures shall not be located in line with sidewalks.

l. Typically, depending on surface types, no more than one (1) acre of area should be tributary to one standard catch basin. Catch basins may be doubled in order to provide for additional capacity.

3. Manholes

a. Depending on pipe size, Manholes should be located at:

1. All changes in alignment
2. Points where the size of the sewer changes
3. Points where the grade of sewer changes
4. The junction of sewer lines
5. Street intersections or other points where catch basins or inlets are to be connected.

b. Manhole spacing for storm sewers shall be as follows:

Diameter of Sewer	**Maximum Manhole Spacing**
12” – 18”	400 ft.
21” – 30”	450 ft.
36” & 42”	500 ft.
48”	550 ft.
54”& 60”	600 ft.
66” & larger	650 ft.

c. Where future connections to a manhole are anticipated, stubs with watertight bulkheads shall be provided.

C. Materials

1. Covers for Manholes, Catch Basins and Inlets

a. Manhole frame and cover shall be EJIW 1040, Type A cover, or equivalent.

b. Manhole and catch basin covers shall include “Dump no waste! Drains to Waterways” or approved similar message.

c. Catch basin and inlet frame and cover shall be as follows:

i. EJIW 7045, or equal, for use with barrier curb and gutter, and with concrete pavement with integral curb.

ii. EJIW 7065, or equal, for use with mountable curb and gutter, and with concrete pavement with mountable integral curb.

iii. EJIW 7085, or equal, for use with B-2 or rolled curb.

iv. EJIW Type O Beehive Grate, or equal, for use on open ditch structures and catch basins located in swales in easements outside the public street right-of-way.

v. Vane grates, EJIW 70so with type M6 vane grate and Ti back, shall be provided when the longitudinal slope of road is four percent (4%) or greater.

2. Pipe/Structure Type

a. Minimum pipe size for sewers, catch basin leads and inlet leads shall be twelve inches (12”) nominal internal diameter.

b. Reinforced Concrete Sewer Pipe shall conform to the requirements of ASTM Designation: C76. Joints shall conform to the requirements of ASTM Designation. C443 Joints and Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets. All catch basin leads and inlet leads shall be ASTM C76-Class IV pipe.

   i. Alternate type of storm sewer pipe is allowable under the following conditions:

      - The development is non-residential.
      - Location of the storm sewer is on private property.
      - The alternate pipe must meet or exceed the performance requirements referenced in the specifications.
      - The City Engineer reserves the right to accept or reject the use of alternate pipe proposed in non-residential developments.
      - Aluminized CSP will be permitted after an on site soil analysis indicates pH ranges of 5.0-9.0 and resistivity of 1500 ohm-cm and greater.
      - The City of Rochester Hills Engineering Construction Specifications, Materials-storm drain pipe, are adhered to. (The Specifications are attached at the end of these design standards).

c. Roof and sump leads shall be Schedule 40 PVC or SDR 23.5.

d. Eccentric cones shall be provided on all structures, regardless of the material used (precast reinforced concrete, manhole block, or brick), to provide a true vertical face for placement of manhole steps. Manhole steps shall be steel, encased with polypropylene plastic, equivalent to M.A. Industries, Inc. PS1 or PS1-B, as appropriate. A minimum of four inch (4”) and a maximum of twelve inch (12”) HDPE or concrete grade rings shall be placed on the cone section of all precast concrete, and concrete block, structures.

D. Miscellaneous

1. Bar Grates

   a. A pre-fabricated bar screen should be designed to be self-cleaning so as to minimize plugging with debris and be installed on all storm sewers eighteen inch (18”) in diameter and larger. Except when dealing with an open channel to enclosed system (i.e. cross culvert), where it is a straight pass through transition, in such case, the city engineer shall determine if bar grates are necessary.

2. Special Drainage Structures

a. Preliminary plans for special structures and appurtenances required for storm sewer systems shall be submitted to the City Engineer for review and comment, prior to their inclusion in the construction drawings.

3. Pumps

a. Stormwater management systems incorporating pumps shall not be permitted. Variances of this requirement will be considered only as a measure of last resort, subsequent to demonstration that no alternative system designs are feasible. Where pumps are absolutely necessary, an alternate method of draining shall be provided.

4. Taps

a. Connections must be made at manholes, except when the receiving storm sewer pipe is twenty-seven inch (27") or larger.

5. Roof Leads and Sump Lines

1. Sump pump discharge lines are required to be connected to an approved drainage system.

2. Residential roof leads are not permitted to discharge to the sanitary sewer or storm sewer system.

E. Plan Criteria

1. Plan and Profile General

a. All storm sewers shall be shown in Plan and Profile, with the profile generally shown below the plan view. All structures and end-sections shall be sequentially labeled in both plan and profile views.

b. Scale of plan portion of sheet shall be no smaller than one inch (1") = fifty feet (50'), with scale of profile portion of sheet one inch (1") = fifty feet (50') horizontal and one inch (1") = five feet (5') vertical.

c. All elevations shall be on U.S.G.S. datum.

2. Plan View

a. Existing topography and all existing and planned surface and underground improvements in streets and easements in which sewer construction is proposed, and in contiguous areas if pertinent to design and construction.

b. Street names, street and easement widths, all other street and easement survey information, subdivision names, lot numbers and frontage dimensions, and permanent parcel numbers and frontage dimensions for all unplatted parcels.

c. Location, length, size, material type, and direction of flow of each section of proposed sewer between manholes.

d. Locations of all manholes and other sewer appurtenances and special structures, with proposed rim elevations for all inlets and catch basins.

e. Reference benchmarks, established at intervals not greater than 1,200 feet and convenient to the proposed construction, with identification, location, description and established elevation listed. Generally, at least two benchmarks shall be noted on each sheet.

f. A tabulated list of quantities of construction pay items appearing on that sheet.

3. Profile View

a. Profile portion of sheet shall appear below companion plan portion, generally projected vertically, and shall show at least the following:
    ii. Size, slope, type and class of pipe, and controlling invert elevations for each section of proposed sewer between manholes.

    iii. Limits of special backfill requirements.

    iv. Profile, over centerline of proposed sewer, of existing and proposed finished ground and pavement surfaces.

    v. Profile of hydraulic grade line staring at the elevation of 0.80 x pipe diameter of the outlet pipe or the HWL of the pond, whichever is greater.

    vi. Location of existing and proposed utilities crossing the line of the sewer or otherwise affecting sewer construction.

    vii. Location, by station, of every proposed manhole, with manhole number, invert elevation of all inlet and outlet pipes, and top of casting elevation.

    viii. Show end section footing detail.

b. Manholes shall be identified by numbers assigned consecutively, and increasing in magnitude in the direction opposite to the direction of flow.

c. All catch basin and inlet leads shall be laid on slope no flatter than one percent (1%).

d. Types of covers and grates for structures shall be shown.

Subsection 4.3.3 Stormwater Ponds/Basins

The following guidelines have been adopted from the “Storm Water Management Standards Manual by the Maumee River Regional Storm Water Coalition and the Maumee River RAP Urban Runoff Action Group” and the “Washtenaw County Drain Commissioners Design Criteria for Subdivisions Storm Water Management Systems”. Some portions have been modified/ommitted as appropriate for the City of Rochester Hills.

General

A. Wet ponds will be preferred to extended dry basins. Dry basins providing extended storage will be accepted only when the development site's physical characteristics or other local circumstances make the use of a wet pond infeasible.

B. Stormwater Ponds/Basins shall be located on common-owned property in multi-ownership developments such as subdivisions and site condominiums, and not on private lots or condominium units.

C. Shade plantings on west and south sides of facilities should be provided.

D. Stormwater Ponds/Basins shall discharge to a natural watercourse, established drainage system, or drainage area where a dedicated easement exists for the purpose of drainage. In no case shall a pond/basin or system discharge onto adjacent property without an easement or the property owner's permission.

E. Sediment Forebay

   1. A sediment forebay should be used to isolate gross sediments as they enter the storm water storage facility and to simplify sediment removal. The sediment forebay should consist of a separate cell formed by an earthen berm, gabion, or loose riprap wall.

   2. The sediment forebay shall be sized to contain the water quality volume and be a minimum of three feet (3') deep.

   3. Exit velocities from the forebay shall not be erosive.

   4. Direct maintenance access shall be provided to the forebay.

   5. A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment accumulation.

F. In-line detention ponds/basins are not permissible.

G. Interior side slopes of dry basins should not exceed 1:6 (V:H), unless unfeasible, steeper slopes are permissible under the following conditions: Side slopes steeper than 1:6 (V:H) require a safety bench starting at the design surface water elevation (25 year), sloping inward at a maximum of 6% slope, and at a minimum width of 5'. The side slope, below the downward slope end of the safety bench, shall not be steeper than 1:3 (V:H). Chain link fence may be substituted for the safety bench. Fences shall be a minimum of 6 feet high vinyl clad chain link with a locking access gate, 8 feet wide. Alternate types of fencing may be permitted, for aesthetic purposes, subject to approval by the Engineering Division.

H. Stormwater management systems incorporating pumps shall not be permitted. Variances of this requirement will be considered only as a measure of last resort, subsequent to demonstration that no alternative system designs are feasible. Where pumps are absolutely necessary, an alternate method of draining shall be provided.

I. A minimum one-foot (1’) freeboard is required above the 25-year stormwater elevation on all stormwater ponds/basins.

J. All ponds/basins must be designed with a 100-year storm overflow to control flooding. The overflow shall discharge to an existing drainage system. If a weir overflow is used sufficient erosion protection must be incorporated into the design. Calculations for the overflow design must accompany the plans.

K. The principal spillway will be sized to pass the maximum design flow tributary to the pond/basin.

L. Vegetative Plantings Associated with Stormwater Ponds/Basins.

1. Ponds/basins and wetland designs will be accompanied by a landscaping plan that incorporates native plants and indicates how aquatic and terrestrial areas will be vegetated, stabilized and maintained.

2. Whenever possible, native wetland plants should be encouraged in the pond/basin design, either along the aquatic bench, fringe wetlands, safety shelf and side slopes or within shallow areas of the pools

3. A permanent buffer strip of natural vegetation extending at least twenty five feet (25’) in width beyond the freeboard elevation will be maintained or restored around the perimeter of all stormwater ponds/basins. No lawn care chemicals shall be applied to the buffer area.

M. Easements and Access

1. For all new residential development, the property in which the pond/basin is located upon must be contained in an easement reserved or dedicated for detention purposes only.

2. A minimum twenty-foot (20’) wide maintenance access easement shall be provided.

3. At a minimum, a twelve-foot (12’) wide gravel access drive shall be located within the above easement for maintenance purposes.

<u>Pond/Basin Inlet/Outlet Design</u>

A. Velocity dissipation measures will be incorporated into pond/basin designs to minimize erosion at inlets and outlets, and to minimize the resuspension of pollutants.

B. To the extent feasible, the distance between inlet and outlets will be maximized. The length and depth of the flow path across ponds/basins shall be maximized by:

1. Increasing the length to width ratio of the entire design.
2. Increasing the dry weather flow path with the system to attain maximum sinuosity.
3. Inlets and outlets should be offset at opposite longitudinal ends of the basin.

C. Storage shall be required for all site runoff. Detention is not required for flows originating offsite that flow through the site. The restrictor size, designed for onsite runoff storage, shall not be upsized to pass through offsite flows.

D. The use of dual outlets, risers, V-notched weirs or other designs that assure an appropriate detention time for all storm events is required.

E. The outlet will be protected from clogging. Methods, such as a weir, or incorporating self cleaning trash racks, or using proprietary flow control devices (i.e. Hydro-Brakes and Reg-U-Flow) or other innovative designs shall be used. A reverse slope submerged orifice with trash rack or a hooded, broad crested weir is recommended options. If a reverse-slope pipe is used, an adjustable valve may be necessary to regulate flows and the invert of the pipe drawing from the pool should be at least eighteen inches (18") from the bottom to prevent sediment discharge.

F. Where a pipe outlet or orifice plate is to be used to control discharge, it will have a minimum diameter of four inches (4"). If this minimum orifice size permits release rates greater than 0.2 cfs/acre, an alternative outlet design that incorporates self-cleaning flow resrictors will be required. Examples include perforated risers, proprietary flow control devices, and "V" notch orifice plates that provide the required release rate. Calculations verifying this rate will be required for approval.

G. The hydraulic grade (H.G.) of the receiving waterway must be investigated to assure it is not higher than the pond/basin outlet H.G. If the H.G. of the receiving waterway is higher, the design engineer shall provide a method to allow a positive outflow at the required discharge rate.

H. OCDC SO-2 (Riser) detail and design standards shall be adhered to.

I. The riser shall be placed near or within the embankment to provide for ready maintenance access.

J. Orifices used to maintain a permanent pool level shall withdraw at least one foot (1') below the surface of the water.

K. Where feasible, a drain for completely de-watering wet ponds should be installed for maintenance purposes.

L. All outlets will be designed to be easily accessible for heavy equipment required for maintenance purposes.

M. Anti-seep collars shall be installed on any piping passing through the sides or bottom of the pond/basin to prevent leakage throughout the embankment.

N. Storm sewers serving as an outlet for stormwater ponds/basins shall be designed in accordance with the standard requirements for other storm sewers in the design.

<u>Wet Ponds</u>

A. Facility Sizing

1. The volume of permanent pool shall equal twice the water quality volume.

B. Pond Configuration

1. The wet basin shall be configured as a two-stage facility with a sediment forebay and a main pool.

2. The pond should be wedge-shaped, narrowest at the inlet and widest at the outlet.

3. The outlet should be located at the opposite and farthest end of the pond from the inlet.

4. The minimum length to width ratio shall be 3:1 where feasible. If it is not feasible to construct a pond with such dimensions, baffles or islands should be used to achieve the flow path length.

C. Depth

1. The depth of the pond should be variable, with the average depth between three (3) and six (6) feet.

2. The deep section of the pool should have a minimum depth of three feet (3'). This prevents resuspension of sediments by wind turbulence.

3. The maximum depth of the permanent pool shall be ten feet (10'). Ponds deeper than this depth may be subject to stratification and promote anoxic conditions at the pond bottom, releasing sediment-bound pollutants into the water column.

D. Pond Side Slopes/Benches

1. Interior side slopes of wet ponds should not exceed 1:6 (V:H), unless unfeasible, steeper slopes are permissible under the following conditions: Side slopes steeper than 1:6 (V:H) require two safety benches. One should start at the design surface water elevation (25 year). The other should extend from the wet pool elevation and slope inward to a maximum depth of 18 inches (also considered an aquatic bench). Both benches should be a maximum of 6% slope and a minimum width of 5'. The aquatic bench should be landscaped with appropriate native plantings. Slopes below the safety/aquatic benches shall not be steeper than 1:3 (V:H). Chain link fence may be substituted for the safety bench located above the design surface elevation which eliminates the need for the aquatic bench. Fences shall be a minimum of 6 feet high vinyl clad chain link with a locking access gate, 8 feet wide. Alternate types of fencing may be permitted, for aesthetic purposes, subject to approval by the Engineering Division.

<u>Extended Detention Basins</u>

A. A two-stage design is required, with separate outlet controls to detain both the first flush volume and larger rain events.

1. Lower Stage: The lower stage should contain a shallow, permanent pool designed to store and treat the water quality volume. This pool should be managed as a shallow

marsh or wetland and average six to twelve inches (6”-12”) in depth. A sediment basin upstream for the lower stage must also be incorporated into the design.

2. Upper Stage: The upper stage should be sized for the 25-year storm event, as defined by the Oakland County Drain Commissioner (OCDC), and should be graded to remain dry except during large storms.

   a. A low flow channel, constructed of natural permeable material (no cunettes permitted), stabilized against erosion, will be provided through the dry portion of the pond. This channel should have a minimum grade of one half percent (0.5%) and the remainder of the pond should drain toward this channel at a grade of at least one percent (1%). The low flow channel should end at the lip of the lower stage, where riprap or gabion baffles should be placed to prevent scour and resuspension of pollution particles.

Subsection 4.3.4 Underground Detention Facilities

General

The City strongly discourages underground detention. However, if after meeting the concerns addressed in the city policy regarding underground detention, the following should be adhered to:

Design Considerations

A. Applicability

   1. These standards are appropriate for all underground pipe or vault detention, whether intended to detain flood and/or channel protection volume, or temporarily store a portion of the water quality volume. Pipes or vaults may be located below vehicular or non-vehicular areas, and must be a minimum of ten feet (10’) horizontally from other utilities. Underground detention is not acceptable in single family residential or townhouse developments.

B. Design Storm

   1. The facility must be sized to provide storage for the channel protection volume, flood protection volume, and/or recharge volume, with safe conveyance of larger flows through the facility. In addition, the hydraulic grade (H.G.) of the receiving water way must be investigated to assure it is not higher than the pond/basin outlet H.G. If the H.G. of the receiving waterway is higher, the design engineer shall provide a method to allow a positive outflow at the required discharge rate.

   2. One (1) foot of freeboard is required.

C. Groundwater

   1. In general, underground storage should not be located in areas of shallow groundwater. In situations, where groundwater is encountered, additional design requirements may be necessary.

D. Geotechnical Analysis

1. Soil borings must be performed in the location of the proposed detention facility in order to determine presence and location of fill materials, soil type, or groundwater. Borings must extend to a minimum of two feet (2') below a facility.

<u>Specifications and Details</u>

A. Outlet Structure

1. The outlet structure shall be composed of concrete, and may be cast in place or precast. Precast structures must be monolithic, including the control weir. Structures must be designed for H-20 loading at a minimum. Direct access to both side of the control structure is required.

B. Overflow Weir Sizing Criteria

1. The overflow weir in the control structure must be designed to safely pass larger flows through the facility.

C. Low Flow Outlet Orifice

1. The low flow orifice may be no smaller than four inches (4") in diameter and must be protected by a trash rack. Expanded metal or perforated half-round CMP should be used. All trash racks must be removable. The surface area of the trash rack perforations must exceed the low flow orifice area by a ratio of at least 5:1. For orifice sizes.

D. Storage Pipe

1. All storage pipes must be circular, and must be a minimum of forty-eight inches (48") in diameter. Metal, HDPE, or concrete may be used. Crossover connections must be provided between storage pipes, and these must be a minimum of forty-eight inches (48") in diameter, also. Pipes may not be closer together than one half (½) the inside pipe diameter, or three feet (3'), whichever is greater. Minimum cover must be per the manufacture's specifications, based on the design load and considering flotation where required. PH and resistivity test may be required if metal pipe is proposed, on a case-by-case basis, wherever soil acidity is a concern.

E. Metal Pipe

1. Metal storage pipe must be aluminized, Type 2, and must be designed for the appropriate loading (pipes may not be less than 14-gauge). Pipe ends must be matched and numbered by the manufacturer. Coupling bands must be per the City of Rochester Hills Engineering Construction Specifications, Materials – Storm Drain Pipe.

F. Concrete Pipe

1. Concrete pipe must meet ASTM C76. Joints must meet ASTM C443.Only circular pipe may be used.

G. HDPE Pipe

1. High Density Polyethylene pipe is acceptable for use in underground storage facilities. Concrete manholes must be used at all HDPE pipe connections. Pipe installation must comply with ASTM D2321.

H. Concrete Vaults

1. Concrete vaults may be used for underground detention, with design approved by the Engineering Division on a case by case basis.

I. Pipe Bedding

1. Must be per the bedding details on the storm system detail sheets or the manufactures specification/details, whichever is greater.

J. Access

1. All facility access manholes must be thirty-six inch (36”) diameter. Manhole steps shall be provided. Concrete manholes must be used for access to HDPE pipes. Manhole access is required at least in corners of the system and where necessary to allow proper jetting operations and entry for maintenance.

Subsection 4.3.5 Manufactured Treatment Devices (MTD)

<u>General Performance and Design Specifications</u>

A. If a manufactured treatment device (MTD) is proposed to help achieve better storm water quality, it must be capable of treating the peak stormwater quality flow rate, which is, the one year, one half inch (0.5”) rain event which occurs within 15 minutes using the rational method. Use a 15 minute time of concentration for commercial sites and a 20 minute time of concentration for residential sites.

B. The MTD must remove eighty percent (80%) or more of OK 110 (110 um sized particles) based on test results indicated on the third party testing selection guide, provided in Section 4.3.5.3B.

C. Rain events larger than the 1 year, 15 minute rain event shall bypass without causing any resuspension of trapped sediments and without causing re-entrainment of floatable contaminants.

D. All MTDs should be configured as off-line units unless a detailed hydraulic analysis is provided. The analysis must demonstrate the up- and downstream pipes will have capacity and surcharging created by high rainfall storms will not result in loss of previously captured material.

E. The treatment system must prevent oil and floatable contaminants from entering downstream piping during routine maintenance and during rain events. The use of a floatable trap should be used to meet this requirement.

F. Direct vehicular access must allow complete and unrestricted access to the entire bottom of the chamber from the top.

G. The private manufactured treatment device (MTD) should be located outside the City right-of-way.

H. There can be no points of constriction in the system to cause plugging or flooding.

I. System must be built to withstand HS-20 loads.

Maintenance Guidelines

A. The treatment system shall be maintained according to the manufacturer's recommendations. An Operations and Maintenance Manual (O&M manual) must be provided for review specific to the model. See notes below for information to include in the O&M manual.

   The following notes/maintenance items should be included in an Operations and Maintenance Manual (O&M manual):

   1. The maximum sediment depth should be clearly specified.

   2. Graphical and written description of sediment measuring procedure. This should include the use of a dipstick tube equipped w/ a ball valve. (e.g. sludge judge).

   3. Oil removal procedure during routine cleanout.
   4. The O&M manual should specify if entry into the manufactured treatment device (MTD) should be considered an OSHA confined space and guidelines followed.

   5. The inspection frequency should be according to the manufacturer recommendation and approved by the Engineering Division. In no case should it be less than six (6) months.

   6. Off-line configurations must include inspection and maintenance of connecting manhole and diversion weir.

   7. Detail drawing of proposed MTD should be included.

   8. Note in manual to clean unit immediately if there is a hydrocarbon spill (e.g gasoline or oil).

   9. A note should be provided indicating disposal of all sediment must be in accordance with all federal, state and local requirements.

Plan Submittals

A. Calculations associated with the sizing and selection of the appropriate model for the selected type of treatment system shall be included in all plan submissions.

B. The selection of the MTD model should be based on the following third party selection guide: (adopted by the City of Indianapolis).

MTD	MTD Model	Max Treatment Flow (cfs)
Stormceptor® [1]	STC 450	0.3
	STC 900	0.64
	STC 2400	1.06
	STC 4800	1.77
	STC 7200	2.47
	STC 11000	3.53
	STC 16000	4.94
Downstream Defender® [1]	4 Foot Diameter	1.3
	6 Foot Diameter	4.1
	8 Foot Diameter	9.4
	10 Foot Diameter	17.7
VortSentry®	VS30	0.26
	VS40	0.58
	VS50	1.07
	VS60	1.77
	VS70	2.70
	VS80	3.90
Vortechs® [1]	1000	0.6
	2000	1.0
	3000	1.6
	4000	2.3
	5000	3.2
	7000	4.1
	9000	5.2
	11000	6.4
	16000	9.3
	PC1319 or 1319 CIP	10.9

MTD		MTD Model	Max Treatment Flow (cfs)
		PC1421 or 1421 CIP	12.7
		1522 CIP	14.6
		1624 CIP	16.6
		1726 CIP	18.7
		1827 CIP	21.0
		1929 CIP	23.4
		2030 CIP	25.9
		2131 CIP	28.5
		2233 CIP	31.3
		2334 CIP	34.2
		2436 CIP	37.3
		2538 CIP	40.4
		2639 CIP	43.7
		2740 CIP	47.2
		2842 CIP	50.7
		2943 CIP	54.4
		3045 CIP	58.2
		3146 CIP	62.2
		3349 CIP	70.5
		3958 CIP	98.4
		4060 CIP	103.5
Aqua-Swirl™ [2]		AS-2	0.29
		AS-3	0.50
		AS-4	0.75
		AS-5	1.20
		AS-6	1.70
		AS-7	2.30
		AS-8	3.00
		AS-9	3.80
		AS-10	4.70
		AS-12	6.80
CDS Technologies [1,2]	**Inline**	PMIU20_15_4	0.33
		PMIU20_15	0.33
		PMSU20_15_4	0.33
		PMSU20_15	0.33
		PMSU20_20	0.52
		PMSU20_25	0.75
		PMSU30_20	0.94
		PMSU30_30	1.41
		PMSU40_30	2.12
		PMSU40_40	2.82
	Offline	PSWC20_15	0.33
		PSWC20_20	0.52

MTD		MTD Model	Max Treatment Flow (cfs)
		PSWC20_25	0.75
		PSWC30_20	0.94
		PSWC30_30	1.41
		PSWC40_30	2.12
		PSWC40_40	2.82
		PSWC56_40	4.23
		PSWC56_53	6.58
		PSWC56_68	8.93
		PSWC56_78	11.75
	Offline	PSW30_30	1.41
		PSW50_42	4.23
		PSW50_50	5.17
		PSW70_70	12.22
		PSW100_60	14.10
		PSW100_80	21.62
		PSW100_100 [b]	30.08
ADS STORMWATER QUALITY UNITS		3620WQB	0.7
		3640WQB	1.6
		4220WQB	0.86
		4240WQB	1.83
		4820WQB	1.13
		4840WQB	2.39
		6020WQB	1.47
		6040WQB	3.12

[1] *Temporary Approval*
[2]*Off-line use only*

SECTION 5.0 OPERATION AND MAINTENANCE RESPONSIBILITIES

Subsection 5.1 General Responsibilities

A. The Owner/Developer of a property is responsible for the proper installation and initial function of the stormwater management system in accordance with the approved Stormwater Management Plan. All temporary soil erosion and sedimentation control measures shall be removed or converted to their permanent configuration in accordance with an approved erosion control plan. It is required that the Oakland County Drain Commissioner (OCDC) determine and approve when sufficient stabilization has occurred on a site in order to convert to the permanent stormwater management facilities.

B. The Owner/Developer is responsible for the proper operation and maintenance of the stormwater management system during and after construction. An Operation and Maintenance Plan consistent with the requirements of Section 5.3 shall be prepared for review and approval by the engineering division.. The operation and maintenance plan will become an exhibit to the operation and maintenance agreement.(See Section 5.3 and 5.4 for further detail.)

C. Approval and Transfer of Stormwater Operation and Maintenance (O&M) Responsibilities.

1. The City of Rochester Hills requires that the stormwater management system is operated and maintained by the individual property owners or an owners/homeowners association or similar entity, or an organization capable of carrying out maintenance responsibilities. However, the Developer is responsible for O & M until:

   a. Evidence of final approval by OCDC is received indicating the site has been sufficiently stabilized to convert to the permanent stormwater management system.

   b. The stormwater management system is cleaned and free of sediment, as well as defects and/or damage corrected.

   c. Evidence that the stormwater management system has been transferred to an association or relevant owner, as well as approval of the transfer by the City of Rochester Hills.

Subsection 5.2 Ownership and Maintenance

All stormwater management systems identified within an approved Stormwater Management Plan shall be owned and maintained by one of the following entities:

A. Individual On Property Stormwater Management Systems

1. Where individual on-property stormwater management systems are proposed, the land development plan shall contain a note designating the entity responsible for operation and maintenance of the on-property system consistent with an approved Operation and Maintenance Plan.

B. Owners, Homeowners or Condominium Association Ownership

Where an association is created to own and manage the stormwater management system, the subdivision and/or land development plan shall contain a note designating the entity responsible for construction and/or maintenance of the stormwater management system consistent with an approved Operation and Maintenance Plan.

Subsection 5.3 Operation and Maintenance Plan

An Operation and Maintenance Plan shall be prepared to identify the ownership, operation and maintenance responsibilities and as-built conditions for all stormwater management systems. At a minimum, the operation and maintenance plan shall include the following:

A. Any obligations concerning perpetuation and/or maintenance of natural drainage or infiltration facilities, and other facilities identified within the Stormwater Management Plan. Ownership of and responsibility for operation and maintenance of stormwater management systems, including names and contact information, shall be required.

B. A description of the permanent stormwater management practices on the site, explaining how each practice is intended to function and operate over time. All drainage and access easements shall be depicted and any site restrictions to be recorded against the property shall be identified on the plan. All such easements and restrictions shall be perfected to run with the land and be binding upon the landowner and any successors in interest.

C. A description of the actions, budget and schedule for operating and maintaining the stormwater management system. This description should be written in a clear manner, consistent with the knowledge and understanding of the intended user.

D. A general description of operation and maintenance activities and responsibilities for systems held in common or on-property, including but not limited to: lawn care, vegetation maintenance, clean out of accumulated debris and sediment (including from grates, trash racks, inlets, etc.), liability insurance, maintenance and repair of stormwater management systems, landscaping and planting, payment of taxes and construction of any kind associated with the use, benefit and enjoyment of the facilities by the owners. In particular, a description of routine facility operation and day-to-day management requirements (as needed) and a description of routine maintenance actions and schedules necessary to ensure proper operation of stormwater management systems shall be submitted.

E. Assurances that no action will be taken by any property owner to disrupt or in any way impair the effectiveness of any stormwater management system, setting forth in deed restrictions the ability of the City of Rochester Hills to take corrective measures if it is determined, at any time, that stipulated permanent stormwater management systems have been eliminated, altered, or improperly maintained.

F. Parties responsible for the long term operation and maintenance of stormwater management systems shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least ten (10) years. These records shall be submitted to the City of Rochester Hills as established by the Operation and Maintenance Plan or if otherwise required by the City of Rochester Hills.

Subsection 5.4 Operation and Maintenance Agreement

A. The owner of any land upon which permanent stormwater management systems and/or BMPs will be placed, constructed or implemented, as described in an approved Stormwater Management Plan and the Operations and Maintenance Plan, shall provide the City of Rochester Hills a Stormwater System Operations and Maintenance Agreement that includes:

   1. The Operations and Maintenance Plan, or a summary thereof,

   2. Legal Description of the development property and,

3. Map of the development with the Stormwater System depicting components and access and/or drainage Easements.

4. In cases where the predevelopment offsite drainage is dependent on draining through the development, the agreement shall provide for that right of flow.

B. The Operation and Maintenance Agreement shall be submitted to the City Engineering Division, executed and in recordable form, acceptable to the City for acceptance and recording.

C. Other items or conditions may be included in the Operation and Maintenance Agreement where determined necessary to guarantee the satisfactory operation and maintenance of all permanent stormwater systems and BMPs. The agreement shall be subject to the review and approval of the City of Rochester Hills.

SECTION 02710

MATERIALS - STORM DRAIN PIPE

PART I – GENERAL

1.01 GENERAL

The purpose of this specification is to establish provisions for substitution of the storm drain pipe and joint that has been specified on the Plans. Substitutions may be approved by the Owner, provided the flow capability and pipe (external load supporting) strength is equal to or exceeds that of the pipe specified on the Plans.

Alternate type of storm sewer pipe is allowable under the following conditions:

1. The development is non residential
2. Location of the storm sewer is on private property.
3. The alternate pipe must meet or exceed the performance requirements of this section.
4. The City Engineer reserves the right to accept or reject the use of alternate pipe proposes in non-residential developments.
5. Aluminized CSP will be permitted after an on site soil analysis indicates pH ranges of 5.0-9.0 and resistivity of 1500 ohm-cm and greater.

1.02 VIDEO INSPECTION

As a means of insuring proper installation of the sewer pipe, the contractor shall video inspect, according to the city of Rochester Hills video inspection standards, 100% of the storm sewer pipe 12” and larger in diameter. The contractor shall provide 24 hours notice to the city of Rochester Hills prior to video inspection, so a representative may be present. Rochester Hills will be provided with a digital copy of the video inspection and log in accordance with the city of Rochester Hills video inspection standards.

Projects that must meet this requirement are:

1. All public projects or projects being constructed on public property.
2. Any project involving a development, subdivision, site condominium, condominium, or association.
3. Any project the will result in more then one owner responsible for the operation and maintenance of the complete storm drainage system.

1.03 CONCRETE PIPE TESTING

All pipe and pipe joints material shall meet the current American Society for Testing and Materials (ASTM) specifications designation number as called for on the plans or elsewhere in these Contract Documents.

The manufacturer or seller shall furnish specimens for testing equal to 0.5% of order, but not less than 2 specimens of each size and type. The specimens may be selected from the job by the testing laboratory or by the Engineer if he so chooses.

Pipe 54" in diameter and over may be tested by taking suitable core samples and subjecting the cores to strength tests.

When approved by the Owner, tests may be conducted at the pipe manufacturer's yard by the independent testing laboratory. The Engineer may choose to witness the tests.

Pipe shall be tested at the expense of the Contractor by an independent testing laboratory approved by the Owner. Copies of the tests shall be furnished to the Owner, Inspector and the Engineer. The signature of the representative of the independent testing laboratory must appear on the test reports.

The Engineer reserves the right to visually inspect and reject any pipe at the site of the work which appears to have defects or imperfections.

1.04 PLASTIC PIPE TESTING

All pipe shall be certified by the manufacturer to meet applicable ASTM specification requirements. Certification forms, together with a report of the test results, shall be provided the inspector with pipe deliveries and copies shall be forwarded to the Engineer or Owner.

Certification forms shall include project name, location, contractor and test lot number. Lot sizes shall be acceptable to the Engineer.

All pipe fittings shall be suitably marked to provide manufacturer's name, lot or production number. ASTM Designation, PVC, nominal diameter, and SDR number, where applicable. Fittings, however, need not contain lot or production number. Pipe shall have a "home" mark. Truss Pipe with an absence of filler material at the ends greater than one-fourth (1/4") inch deep shall be subject to rejection or acceptable repair.

The completed installation shall at no point have out-of-round pipe deflections greater than 5%. Deflectometer or go/non-go gauging tests may be required prior to acceptance of pipelines, at the discretion of engineer. No more than 50% of installed lines will be mandrel tested unless deflection tests results are unsatisfactory.

PART II – PRODUCTS

2.01 REINFORCED CONCRETE PIPE

Shall be in accordance with ASTM C76 standards. Modified groove tongue joint with approved rubber gasket (current ASTM C443, except as such Specifications relate to infiltration limitations).

Lubricant, as supplied by the pipe manufacturer, shall be used on the groove and on the tongue in making up joints. The joints shall be coupled in accordance with the pipe manufacturer's requirements.

2.02 REINFORCED CONCRETE ELLIPTICAL CULVERT STORM DRAIN

Shall be in accordance with ASTM Designation C-507-79, Class HE-1 through HE-IV or VE-II through VE-VI.

Tongue and groove bituminous (DeWitt #10) joint with inside cement pointing.

2.03 CORRUGATED STEEL PIPE

All corrugated steel pipe for storm sewers shall be Aluminized Type 2 formed with a external spiral rib. Hydraulic capacity must be equivalent to concrete pipe (N=0.013) for storm sewer calculations.
a. For underground detention systems, pipe materials must be Aluminized Type 2, and may be either $2^{2}/_{3}$" x ½" corrugation, or 3" x 1" corrugation with gauge as specified by design engineer.

All corrugated steel pipe shall be joined together with a watertight circumferentially corrugated steel coupling band furnished with two (2) rubber gaskets or bell and spigot end. Gasket shall be manufactured from a elastomeric material and shall meet the reqirements of MTM 723.04, (MDOT): Where field jointing of non re-rolled end pipe is required. A 12" wide flat gasket with a minimum 12" wide flat or dimple band will be required. All pipe entering a concrete or block manhole shall be sealed with a minimum 12" wide external gasket. Additionally, all joints in storm sewers and underground detention systems, will be wrapped with a 18" wide non woven (4 oz. min.) geotextile.
In underground detention systems, a 12" wide flat gasket with a flat band may be used as an alternate to rubber gasket system.

Gauge thickness shall be as specified on the plans, but in no case be less than the following:
18"-30" = 16ga; 36"-48" = 14 ga; 54"-60" = 12ga; 66"-78" = 10ga.

All pipe connections to the side wall of main-line corrugated steel pipe shall be of the diameter specified on the plans, and shall consist of similar steel pipe that connects or taps into the main-line pipe wall using a pre-fabricated steel saddle plateor factory welded connection.

2.04 POLYVINYL CHLORIDE (PVC) PIPE
(4") to (36")
Material shall be PVC Composite (Contech Truss) Pipe - ASTM D-2680 or PVC Solid Plastic Pipe - ASTM D-3034, SDR 35 or PVC (Contech A2000) Pipe - ASTM F949. Pipe to be made of PVC compound having a minimum cell classification of 12454.

Gaskets for PVC pipe and fittings shall be of the elastomeric type. Gasket joints shall be installed in accordance with procedures specified by the pipe manufacturer. Joints shall meet the requirements of MTM 723.04 (MDOT). Care should be taken to insure all joints being pushed to the full home position and held tightly in home position during any grade or line adjustments.

Haunching, bedding, and backfill materials for pipe (4"-36") shall be as shown on the detail sheet.

2.05 HIGH DENSITY POLYETHYLENE (HDPE) PIPE
(8" – 48")

1. HDPE – ASTM F-2306; AASHTO M-294.
2. Joints to be bell and spigot with gaskets to be elastomeric type. Joint performance to meet the requirements of MTM 723.04 (MDOT).

3. Haunching, Bedding, and backfill materials for HDPE (8"- 48") shall be as shown on the detail sheet and must consist of class I (crushed stone) meeting MDOT 21a,22a, or 6a gradation.

2.06 MANHOLE, CATCH BASIN AND INLET BLOCK AND BRICK

Brick shall be made of clay or shale, and shall be whole, thoroughly and evenly burned, of close and uniform texture, free from cracks and warps, with true even faces and uniform in shape and size. Brick shall show a minimum average compressive strength of 2,000 pounds per square inch and an average absorption of water in twenty-four (24) hours of not more than 25% of the dry weight.

Concrete brick shall conform to the requirements for concrete building brick of ASTM C-55-75, Grade N-1.

Concrete block for manholes, catch basins, and inlets shall conform to ASTM C139-73 with the following exceptions:

The blocks shall be solid curved blocks with the inside and outside surfaces curved to the required radii. The blocks shall have tongue and groove or other approved type of joint at the ends so that the units interlock to form a strong, rigid structure. Curved blocks shall have the inside and outside surfaces parallel.

The nominal dimensions of the block shall be 18 inches maximum for length, 8 inches maximum for depth (height), and 6 inches minimum for width (thickness). The length shall be measured along the chord on the convex face of the block. The tolerances of ASTM C 129-73 shall apply. Where the specified wall thickness on the standard plans is 12 inches, a multiple block wall of two 6 inch wide blocks is permitted. All blocks in one structure shall be of the same height dimension. The blocks shall be designed for length so that only full length or half length blocks are required to lay the circular wall of any one course.

Blocks intended for use in the cones or tops of manholes or other structures shall have such shape as may be required to form the structure as shown on the plans with inside and outside joints not to exceed 1/4 inch in thickness.

The mortar shall be composed of one (1) part of a combination of Portland Cement and hydrated lime and three (3) parts of fine aggregate, by volume. The combination of cement and lime shall consist of 90% of Portland Cement and 10% of hydrated lime, by volume. In lieu of the above combination of cement and lime, a standard brick mortar cement may be used if approved by the Engineer.

All Manhole, Catch Basin, or Inlet Structure Steps shall be M.A. Industries, Inc., Numbers PS-1-B or PS-2-PFS or approved equal.

2.07 PRECAST MANHOLES

All precast manhole sections and bases shall be 4000 lbs per square inch concrete as determined by core test or cylinders.

Unless otherwise noted on the drawings or in the Supplemental Specifications, precast reinforced concrete manhole sections shall meet the requirements of current ASTM C-478.

Precast manhole tees for 48" and larger storm drains shall be the same class pipe as that specified on the plans, but shall be a minimum ASTM C-76-79 Class IV. The manhole riser shall meet the requirements of current ASTM C-478.

2.08 STORM DRAIN STUBS

Four (4") inch to ten (10") inch diameter stubs shall be PVC Composite (Contech Truss) Pipe or PVC Solid Plastic Pipe as specified under Section 2.04, or approved alternate. Stubs twelve (12") inches and larger shall be ASTM C76 Class IV Reinforced Concrete Pipe or as otherwise noted. Maximum pipe length of stubs shall be eight (8') feet.

PART III EXECUTION

NOT USED.

END OF SECTION

DEFINITIONS

Attenuate – To reduce the magnitude of the flow rate by increasing the time it takes to release a specified volume of runoff (for example the 1 year, 24 hour storm event). Attenuation is a method of reducing the peak flow rates for post development compared to the peak flow rates in predevelopment. Stormwater Detention is a method often used for attenuation.

Baseflow – Portion of stream discharge derived from ground water; the sustained discharge that does not result from direct runoff or from water diversions, reservoir releases, piped discharges, or other human activities.

Best Management Practice (BMP) – Methods, measures or practices to prevent or reduce surface runoff and/or water pollution, including but not limited to, structural and non-structural stormwater management practices and operation and maintenance procedures.

CFS – Cubic Feet per Second.

Channel - A natural or artificial watercourse that conveys, continuously or periodically, flowing water.

Concentrated Storm Runoff - Surface runoff from rainfall events, which converges and flows primarily through water conveyance features such as swales, gullies, waterways, channels or storm sewers and which exceeds the maximum specified flow rates of filters or perimeter controls intended to control sheet flow.

Design Storm - The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a 25-year storm (4% chance of occurring in any one year)) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems.

Detention or To Detain - The prevention of, or to prevent, the discharge, directly or indirectly, of a given volume of stormwater runoff into surface waters by temporary storage.

Dry Pond – See Table 1: Naming Convention of Common Structural Stormwater Management Practices for Water Quality Management and Treatment.

Discharge – The release of water from a project, site, aquifer, drainage basin, or other point of interest. The rate and volume of flow of water such as in a stream, generally expressed in cubic feet per second (volume per unit of time).

Ditch -A man-made open drainage-way in or into which excess surface water or groundwater drained from land, stormwater runoff, or floodwaters flow either continuously or intermittently.

Drainage Area - That land area contributing runoff to a single point, and that is enclosed by a ridgeline.

EPA -Environmental Protection Agency.

Easement – A right of use of a specified portion of land of another for a specified purpose.

Erosion – The wearing away of land surface by water or wind which occurs naturally from weather or runoff, but is often intensified by human activity.

FEMA – Federal Emergency Management Agency.

First Order Stream – Upper-most perennial tributary in a watershed that has not yet confluenced with another perennial stream. The confluence of two first order streams forms a “second” order stream.

Ground Water – Water that occurs in the subsurface and fills or saturates the porous openings, fractures and fissures of under-ground soils and rock units.

Hotspots – An area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

Hydrologic Soil Groups (HSG) – the US Department of Agriculture, Natural Resources Service classifies soil types into four hydrologic soil groups:

- Group A soil are typically sands, loamy sands or sandy loams. Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
- Group B soils are typically silt loams or loams. They have a moderate infiltration rate when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture.
- Group C soils are typically sandy clay loams. They have low infiltration rates when thoroughly wetted and consists chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
- Group D soils are typically clay loams, silty clay loams, sandy clays, silty clays or clays. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, soils with permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Hydrology – The study of the properties, distribution, circulation and effects of water on the Earth's surface, soil and atmosphere.

Hydrograph - A graph of discharge versus time for a selected point in the drainage system.

Impervious Surface - A surface, which has been compacted or covered with a layer of material so that it is resistant to infiltration by water. It includes semi-pervious surfaces such as compacted clayey soils, as well as most conventionally surfaced streets, roofs, sidewalks, parking lots, and other similar surfaces. Net Increase of Impervious Surface refers to the difference between the existing impervious coverage and the total impervious surface proposed.

Infiltration – Movement of surface water into the soil, where it is absorbed by plant roots, evaporated into the atmosphere, or percolates downward to recharge ground water.

Intensity - The depth of accumulated rainfall per unit of time.

Intermittent Stream – A defined channel in which surface water is absent during a portion of the year, as ground water levels drop below the channel bottom.

Level Spreader – A low earthen berm constructed perpendicular to the direction of slope and extending across the width of the slope for the purpose of intercepting surface runoff and spreading it behind the berm to enhance infiltration and reduce erosion and runoff from the slope. The purpose of a level spreader is to prevent concentrated, erosive flows from occurring and to spread out stormwater runoff uniformly over the ground as sheet flow.

Low Impact Development (LID) – LID is an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Techniques are based on the premise that stormwater management should not be seen as stormwater disposal. Instead of conveying and managing / treating stormwater in large, costly end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater through small, cost-effective landscape features located at the lot level. These landscape features, known as Integrated Management Practices (IMPs), are the building blocks of LID. Almost all components of the urban environment have the potential to serve as an IMP. This includes not only open space, but also rooftops, streetscapes, parking lots, sidewalks, and medians. LID is a versatile approach that can be applied equally well to new development, urban retrofits, and redevelopment / revitalization projects.

Maintenance -The action taken to restore or preserve the as-built functional design of any facility or system.

MS4 - Municipal Separate Storm Sewer System.

NOAA - National Oceanic and Atmospheric Administration.

NRCS – Natural Resources Conservation Service.

National Pollution Discharge Elimination System (NPDES) – Created in 1972 under the Clean Water Act to authorize discharges to local receiving waters only pursuant to governmental permits, in an effort to reduce point source and non-point source pollutants.

New Development – Any activity regulated by this standard that is not considered a redevelopment, as defined in these standards.

Non-structural Stormwater Management Practices - Passive, site design approaches or regulatory approaches that positively impact water quality and reduce or minimize the generation of stormwater runoff without requiring the construction of specific or discrete stormwater management control structures.

Percolation Rate – The rate of movement of water under hydrostatic pressure through interstices of rock or soil. For stormwater analysis, it is typically measured as a distance per unit of time (e.g., inches per hour).

Rainfall Intensity -The depth of accumulated rainfall per unit of time.

Rate - Volume per unit of time.

Receiving Waters – Any water bodies, watercourses or wetlands into which surface waters flow.

Recharge – The replenishment of ground water through the infiltration of rainfall, other surface waters, or land application of water or treated wastewater.

Redevelopment -An existing developed property and/or a graded, altered and compacted site (as of or after the date of adoption of these standards) that is proposed for reconstruction.

Retention or To Retain - The prevention of direct discharge of stormwater runoff into receiving waters or water bodies by permanent containment in a pond or depression; examples include systems which discharge by percolation to ground water, exfiltration, and/or evaporation processes.

Wet Pond –see Table 1: Naming Convention of Common Structural Stormwater Management Practices for Water Quality Management and Treatment.

Riparian – Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

Riparian Buffer – An area of land adjacent to a body of water and managed to maintain the integrity of stream channels and shorelines to 1) reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrients and other chemicals, and 2) supply food, cover and thermal protection to fish and other wildlife.

Runoff – see Stormwater.

SLAMM – Source Loading and Management Model. This model is based on small storm hydrology and pollutant runoff from urban land uses. Pollutant sources are identified and both structural and nonstructural stormwater practices can be accounted for in the model.

SCS – Soil Conservation Service.

SWMM – Stormwater Management Model. EPA developed this model for analyzing stormwater quantity and quality associated with runoff from urban areas. Both single event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. Information on SWMM is available at http://www.epa.gov/ceampubl/swater/swmm/index.htm.

Sediment – Fragmented material that originated from weathering rocks and decomposing organic material that is transported by, suspended in, and eventually deposited in the streambed.

Sedimentation – Occurs when sediment particles that have been suspended within flowing water are deposited on the stream bottom or floodplain.

Sheet Flow – A flow process associated with broad, shallow water movement on sloping ground surfaces that is not channelized or concentrated.

Storm Event - The storm of a specific duration, intensity, and frequency.

Stormwater or Runoff - The flow of water overland and/or in water bodies that results from and occurs during and immediately following a rainfall event.

Stormwater Management – The mechanism for controlling stormwater runoff for the purpose of reducing downstream erosion, water quality degradation, and flooding, and mitigating the adverse effect of changes in land use on the aquatic environment.

Stormwater Management Plan - The approved detailed analysis, design, and drawings of the stormwater management system required for all construction.

Stormwater Management Practices (SMPs) -The designed and/or constructed features which infiltrate, treat, collect, convey, channel, store, inhibit, or divert the movement of stormwater; such practices include structural and non-structural practices.

Structure -Anything constructed or installed with a fixed location on the ground, or attached to something having a fixed location on the ground.

Structural Stormwater Management Practices - Any measures that require the design and construction of a facility to help reduce or eliminate a non-point source of pollution and control stormwater.

Stormwater Management System - All facilities and natural features used for the movement of stormwater through and from a drainage area, including, but not limited to, any and all of the following; conduits, pipes and appurtenant features: channels, ditches, culverts, streets, swales, gutters as well as all watercourses, water bodies and wetlands.

Subgrade -The top elevation of graded and compacted earth underlying roadway pavement.

Subsurface Infiltration – are designed to bypass surface soils and transmit runoff directly to subsurface soils and eventually groundwater. Examples included infiltration trenches and dry wells.

Surface Infiltration - allows stormwater runoff to percolate into surface soils. The percolated water may percolate down into subsurface soils and meet groundwater, or it may be underdrained into subsurface pipes.

Swale - An artificial or natural waterway which may contain contiguous areas of standing or flowing water only following a rainfall event, or is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake, or is designed to take into account the soil erodibility, soil percolation, slope, slope length, and contributing drainage area so as to prevent erosion and reduce the pollutant concentration of any discharge.

USDA – United States Department of Agriculture.

USDOT FHWA – United States Department of Transportation Federal Highway Administration.

Water Body - Any natural or artificial pond, lake, reservoir, or other area which ordinarily or intermittently contains water and which has a discernible shoreline and receives surface water flow.

Watercourse – A permanent or intermittent stream or other body of water, whether natural or man-made, which gathers or carries surface-water.

Water Table – The upper most level of saturation of pore space or fractures by subsurface water in an aquifer. Seasonal High Water Table refers to a water table that rises and falls with the seasons due either to natural or man-made causes.

Watershed - Land area that drains to a common water body.
Wetlands -Land areas that are inundated or saturated by surface or groundwater with a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (wetlands generally include swamps, marshes, bogs, and similar areas); or areas that are defined and delineated in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, dated January 10, 1989, and as may be amended from time to time; or as further defined and delineated by the United States Army Corps of Engineers, the United States Environmental Protection Agency, the Michigan Department of Environmental Protection, or the City of Rochester Hills..

APPENDIX A: Non-Structural Stormwater Management Practices

NON-STRUCTURAL STORMWATER MANAGEMENT PRACTICES ALTERNATIVE APPROACH FOR MANAGING STORMWATER RUNOFF

Stormwater Discussion

Land development can dramatically alter the hydrologic cycle of a site, and ultimately, an entire watershed. Prior to development, native vegetation can either directly intercept precipitation or draw that portion that has infiltrated into the ground and return it to the atmosphere through evapotranspiration. Development can remove this beneficial vegetation and replace it with lawn or impervious cover, reducing the site's evapotranspiration and infiltration rates. Clearing and grading a site can remove depressions that store rainfall. Construction activities may also compact the soil and diminish its infiltration ability, resulting in increased volumes and rates of stormwater runoff from the site. Impervious areas that are connected to each other through gutters, channels, and storm sewers can transport runoff more quickly than natural areas. This shortening of the transport or travel time quickens the rainfall-runoff response of the drainage area, causing flow in downstream waterways to peak faster and higher than natural conditions. These increases can create new and aggravate existing downstream flooding and erosion problems and increase the quantity of sediment in the channel. Filtration of runoff and removal of pollutants by surface and channel vegetation is eliminated by storm sewers that discharge runoff directly into a stream. Increases in impervious area can also decrease opportunities for infiltration, which, in turn, reduce stream base flow and groundwater recharge. Reduced base flows and increased peak flows produce greater fluctuations between normal and storm flow rates, which can increase channel erosion. Reduced base flows can also negatively impact the hydrology of adjacent wetlands and the health of biological communities that depend on base flows. Finally erosion and sedimentation can destroy habitat from which some species cannot adapt.

In addition to increases in runoff peaks, volumes, and loss of groundwater recharge, land development often results in the accumulation of pollutants on the land surface that runoff can mobilize and transport to streams. New impervious surfaces and cleared areas created by development can accumulate a variety of pollutants from the atmosphere, fertilizers, animal wastes, and leakage and wear from vehicles. Pollutants can include metals, suspended solids, hydrocarbons, pathogens, and nutrients.

In addition to increased pollutant loading, land development can adversely affect water quality and stream biota in more subtle ways. For example, stormwater falling on impervious surfaces or stored in detention or retention basins can become heated and raise the temperature of the downstream waterway, adversely affecting cold water fish species such as trout. Development can remove trees along stream banks that normally provide shading, stabilization, and leaf litter that falls into streams and becomes food for the aquatic community.

Alternative Approach

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate depends upon the soil types and its conditions.
Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approach:

Preserving Natural Drainage Features. Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern **--** streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimizes the amount of grading on site.

Protecting Natural Depression Storage Areas. Depressional storage areas have no surface outlet, or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release-rate characteristics of depressions should be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

Avoiding introduction of impervious areas. Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways and other features producing impervious surfaces should be evaluated to minimiz***e*** impacts on runoff.

Reducing the Hydraulic Connectivity of Impervious Surfaces. Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are routing of roof runoff over lawns and reducing the use of storm sewers. Site grading should promote increasing travel time of stormwater runoff, and should help reduce concentration of runoff to a single point in the development.

Routing Roof Runoff Over Lawns. Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. By routing roof drains and crowning the driveway to run off to the lawn, the lawn is essentially used as a filter strip.

Reducing the Use of Storm Sewers. By reducing use of storm sewers for draining streets, parking lots, and back yards, the potential for accelerating runoff from the development can be greatly reduced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a "reasonable" time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

Reducing Street Widths. Street widths can be reduced by either eliminating on-street parking or by reducing roadway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets, which ultimately could lower maintenance.

Limiting Sidewalks to One Side of the Street. A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle/recreational trails that follow back-of-lot lines. Where appropriate, backyard trails should be constructed using pervious materials.

Using Permeable Paving Materials. These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low use surfaces such as driveways, overflow parking lots, and emergency access roads.

Reducing Building Setbacks. Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

Constructing Cluster Developments. Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

In summary, a careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly stormwater control measures. Other benefits include reduced potential of downstream flooding, water quality degradation of receiving streams/water bodies and enhancement of aesthetics and reduction of development costs. Beneficial results include more stable base flows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

APPENDIX B: Operation and Maintenance Agreement

STORMWATER BEST MANAGEMENT PRACTICES OPERATIONS AND MAINTENANCE AGREEMENT

THIS AGREEMENT has intentionally been left blank for later insertion.

APPENDIX C: LIST OF REFERENCES

CITED AND ADDITIONAL SOURCES OF INFORMATION

Note: The cited references directly support the standards, while the additional sources of Information provide guidance to users of the standards. The additional sources of information listed below are by no means exhaustive or complete. It is expected that this list will be updated and amended over time.

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