City of Noblesville Stormwater Technical Standards Manual

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CHAPTER 100 POLICY AND PROCEDURES

SECTION 101 INTRODUCTION

101.01 Section Purpose

This manual provides technical standards for proper stormwater management and stormwater quality practices for those engineers, builders, contractors, land planners, and property owners contemplating some form of land alteration or improvement within the City of Noblesville. This Stormwater Technical Standards Manual is intended to establish the policies relating to stormwater management, stormwater quality practices, and flood control, submittal requirements and procedures for issuance of a stormwater permit, and procedures for inspection, testing and final acceptance of stormwater facilities.

The contents of the Manual are the result of a joint effort by Hamilton County, the City of Carmel, the Town of Fishers, the City of Noblesville, and the Town of Westfield. The regulations have been established to accomplish the following objectives:

- Provide for consistent, high quality project design and evaluation by consolidating current departmental standards and “policies” within a single document.
- Establish minimum requirements and standards for stormwater management plan submittals and project reviews.
- Facilitate more consistent review of stormwater permit applications and land alteration plans by the stormwater permit staff.
- Establish a standard for the proper and consistent installation of stormwater facilities, with a high level of workmanship, according to the approved stormwater management plan.
- Minimize the impacts of new development and redevelopment projects on existing stormwater management facilities.

This Manual was developed with the assumption that the user will possess a basic understanding of civil engineering design, construction, stormwater quality practices, or land alteration, depending upon the users particular area of expertise. Readers of the Manual which are not qualified by education and experience in the field of construction, engineering, stormwater quality practices, or land alteration should consult with a more qualified person or persons possessing professional expertise in one or more of these fields prior to application of the requirements set forth herein.

101.02 Provisions

This Manual, together with all future revisions, shall be referred to as **“The City of Noblesville Stormwater Technical Standards Manual”.** The City of Noblesville has been granted authority to “protect the safety, health, and general welfare of the citizens of the City of Noblesville by requiring compliance with standards and practices, which result in proper stormwater drainage and sediment control in the accomplishment of land alterations or other improvements.

101.03 Applicability

This Manual applies to all land altering projects as stated and defined in the City of Noblesville Ordinance No. 24-4-05 (An Ordinance Regulating Storm Water Runoff Associated With Construction And Post-Construction Activities In The City Of Noblesville). Any land alteration, within the jurisdiction of this Manual, must be accomplished in conformity with the stormwater requirements set forth herein. “Land Alteration” shall generally refer to any on-site or off-site action taken relative to land which either:

1. Changes the contour; or

2. Increases the runoff rate or volume; or

3. Changes the elevation; or

4. Decreases the rate at which water is absorbed; or

5. Changes the drainage pattern; or

6. Creates or changes a stormwater facility; or

7. Involves construction, enlargement, location or relocation of any building on a permanent foundation; or

8. Increases the delivery of point and/or non-point source pollution to streams; or

9. Relocates, encloses, or alters a stream or open channel stormwater conveyance; or

10. Creates an impoundment.

This Manual should be used in conjunction with the City of Noblesville's applicable stormwater management ordinance(s). Additional requirements related to land alteration may be found in the existing codes and ordinances of the City of Noblesville. Exceptions to the provisions of this Manual are provided in the City of Noblesville's applicable stormwater management ordinance(s). Additional variances or deviations from the requirements of this Technical Standards Manual may be granted by the City of Noblesville for a proposed Low Impact Development.

If the project site is located within a Hamilton County Regulated Drain Watershed, the applicant will need to check with the Hamilton County Surveyor's Office to learn if additional Surveyor's Office requirements specific to that regulated drain would apply to the site.

101.04 Stormwater Manual Organization

This Manual is organized to present the technical and engineering procedures and criteria needed to comply with the City of Noblesville stormwater regulations. Copies of the City of Noblesville's pertinent stormwater management ordinances are presented in the Appendices of this Chapter. In addition, the general design policy and procedures are presented.

Each chapter of this Manual contains an initial section that presents all of the policies and procedures that must be satisfied for approval. These policies and procedures shall be considered as design criteria that are unique for approval within the jurisdiction of this Manual.

101.05 Updating

The process of updating this Manual shall be through the City of Noblesville Board of Works. This Manual shall be periodically updated and revised, as necessary, to reflect current engineering practices and information applicable to the City of Noblesville. Users of this Manual are encouraged to obtain any and all updates and supplements to this Manual each time a land alteration project is considered. The ultimate responsibility for checking for and obtaining updated material shall be the responsibility of the user.

The most current standards shall be required for approval of a land alteration. The incorporation of outdated standards in the design, implementation, and construction of a land alteration shall be cause for the City of Noblesville to reject the proposed land alteration.

SECTION 102 PERMIT REQUIREMENTS AND PROCEDURES

102.01 Introduction

The project site owner shall submit an application for a stormwater management permit to the City of Noblesville. The application will include a Draft Notice of Intent letter (NOI) that would also act as permit application form, construction plan sheets, stormwater drainage technical report, a stormwater pollution prevention plan, and any other necessary support information. Specific information to be included in the application can be found in Section 102.03 below. One (1) copy of each required application material must be submitted to the City of Noblesville. Additionally, a digital copy of the construction plans is required in a format accepted by the City of Noblesville.

After the City of Noblesville receipt of the application, the applicant will be notified as to whether their application was complete or insufficient. The applicant will be asked for additional information if the application is insufficient. All plans, reports, calculations, and narratives shall be signed and sealed by a professional engineer or a licensed land surveyor, registered in the State of Indiana. The information provided will be reviewed in detail by the City of Noblesville and/or its plan review consultant(s). Once all comments have been received and review completed, the City of Noblesville will either approve the project or request modifications.

Once a permit has been issued, the project site owner must file a Notice of Intent a minimum of 48 hours prior to the commencement of construction activities. Notification shall be in the form of an updated NOI form. The submittal of the NOI must be provided to the City of Noblesville and the IDEM. The IDEM submittal must include a proof of publication, verification that the jurisdictional entity approved the plan, and a $100 fee. For the City of Noblesville, copies of the final, approved construction plans, stormwater drainage technical report, stormwater pollution prevention plan for construction sites, and post-construction stormwater pollution prevention plan shall also accompany the above-noted written notification and proof of publication. The number of required copies varies from case to case and should be determined by contacting the City of Noblesville. A pre-construction meeting is required to be held with the participation of the City of Noblesville and other entities involved prior to any grading activity to ensure that appropriate perimeter control measures have been implemented on the site and the location of any existing tiles has been properly marked.

Once construction starts, the project owner shall monitor construction activities and inspect all stormwater pollution prevention measures in compliance with the City of Noblesville's applicable ordinances and the terms and conditions of the approved permit. Upon completion of construction activities, as-built plans must be submitted to the City of Noblesville. A Notice of Termination (NOT) shall be sent to the City of Noblesville once the construction site has been stabilized and all temporary erosion and sediment control measures have been removed. The City of Noblesville, or a representative, shall inspect the construction site to verify the requirements for a NOT have been met in accordance with the Rule 5 (327 IAC 15-5). Once the applicant receives a "verified" copy of the NOT, they must forward a copy to IDEM. Permits issues under this scenario will expire 5 years from the date of issuance. If construction is not completed within 5 years, the NOI must be resubmitted at least 90 days prior to expiration. A flow chart of the major steps in the stormwater plan review/permit process is provided as Exhibit 102-1.

The different elements of a permit submittal for a Stormwater Management Permit approval include a Draft Notice of Intent (NOI), construction plans, a stormwater drainage technical report, a stormwater pollution prevention plan for active construction sites, a post-construction stormwater pollution prevention plan, and any other necessary supporting information. In addition, an updated NOI along with proof of publication of a public notice will need to be submitted directly to IDEM, with a copy provided to the City of Noblesville after the permit is approved. All plans, reports, calculations, and narratives shall be signed and sealed by a professional engineer or a licensed land surveyor, registered in the State of Indiana.

Specific projects or activities may be exempt from all or part of the informational requirements listed below. Exemptions are detailed in the applicable ordinances and "Applicability and Exemptions" Sections of Chapters 200 through 700. If a project or activity is exempt from any or all requirements of the ordinances or this Manual, an application should be filed listing the exemption criteria met, in lieu of the information requirements listed below. The level of detailed information requested below is not required from individual lots, disturbing less than 1 acre of land, developed within a larger permitted project site. Review and acceptance of such lots is covered under Section 102.07 of this Chapter.

102.02
Draft Notice of Intent

The NOI is a standard form developed by the Indiana Department of Environmental Management which requires general project information. As part of the City of Noblesville Stormwater Management Permit application package, the NOI form should be completed in full based on data and information available at the time of application.

An updated version of this form, accompanied by proof of publication in a newspaper of general circulation in the affected area that notified the public that a construction activity is to commence, will need to be resubmitted later after the stormwater management permit is granted and at least 48 hours prior to commencement of construction. The publication must include the following language:

> "(Company name, address) is submitting an NOI letter to notify **the City of Noblesville** and the Indiana Department of Environmental Management of our intent to comply with the requirements of **the City of Noblesville** Stormwater Management Ordinance, as well as the requirements of 327 IAC 15-5 and 327 IAC 15-13, to discharge stormwater from construction activities for the following project: (name of the construction project, address of the location of the construction project, and Parcel Identification Number). Run-off from the project site will discharge to (stream(s) receiving the discharge(s))."

102.03
Construction Plans

Construction plan sheets, 24" by 36" in size, with a scale of 1 inch = 20 feet, 30 feet, 40 feet, 50 feet or 60 feet, and an accompanying narrative report shall describe and depict the existing and proposed conditions. Note that in order to gain an understanding of and to evaluate the relationship between the proposed improvements for a specific project section/phase and the proposed improvements for an overall multi-section (phased) project, the detailed information requested herein for the first section/phase being permitted must be accompanied by an overall project plan that includes the location, dimensions, and supporting analyses of all detention/retention facilities, primary conveyance facilities, and outlet conditions. Construction plans need to include the following detailed items:

i. Title sheet which includes location map, vicinity map, operating authority, design company name, developer name, and index of plan sheets.

ii. A copy of a legal boundary survey for the site, performed in accordance with Rule 12 of Title 865 of the Indiana Administrative Code or any applicable and subsequently adopted rule or regulation for the subdivision limits, including all drainage easements and wetlands.

iii. A reduced plat or project site map showing the parcel identification numbers, lot numbers, lot boundaries, easements, and road layout and names. The reduced map must be legible and submitted on a sheet or sheets no larger than eleven (11) inches by seventeen (17) inches for all phases or sections of the project site.

iv. An existing project site layout that must include the following information:

a. A topographic map of the land to be developed and such adjoining land whose topography may affect the layout or drainage of the development. The contour intervals shall be one (1) foot when slopes are less than or equal to two percent (<2%) and shall be two (2) feet when slopes exceed two percent (>2%). All elevations shall be given in North American Vertical Datum of 1988 (NAVD). The horizontal datum of topographic map shall be based on Indiana State Plane Coordinates, NAD83. The map will contain a notation indicating these datum information. The names of adjoining property owners must be labeled on the map.

   a] If the project site is less than or equal to two (2) acres in total land area, the topographic map shall include all topography of land surrounding the site to a distance of at least one hundred (100) feet.

   b] If the project site is greater than two (2) acres in total land area, the topographic map shall include all topography of land surrounding the site to a distance of at least two hundred (200) feet.

b. Location, name, and normal water level of all wetlands, lakes, ponds, and water courses on or adjacent to the project site.
c. Location of all existing structures on the project site.
d. One hundred (100) year floodplains, floodway fringes, and floodways per current FIRM maps. Please note if none exists.
e. Identification and delineation of vegetative cover such as grass, weeds, brush, and trees on the project site.
f. Location of storm, sanitary, combined sewer, and septic tank systems and outfalls.
g. Land use of all adjacent properties.
h. Identification and delineation of sensitive areas as specified in Section 102.11 (below).
i. The location of regulated drains, farm drains, inlets and outfalls. Prior to construction plan design beginning, all existing regulated drains on the site are to be located, exposed, and invert shots taken to ensure the system is installed deep enough to provide drainage to the upstream watershed. This is also applicable if the site outlets into a regulated drain and no record drawings on the drain exists.
j. Location of all existing cornerstones within the proposed development and a plan to protect and preserve them.
k. Location of all known wells.
l. Location of known potential contaminant facilities.

v. A grading and drainage plan, including the following information:

a. All information from the existing site layout items listed above.
b. Location of all proposed site improvements, including roads, utilities, lot delineation and identification, proposed structures, and common areas.
c. One hundred (100) year floodplains, floodway fringes, and floodways. Please note if none exists.
d. Delineation of all proposed land disturbing activities, including off-site activities that will provide services to the project site.

e. Information regarding any off-site borrow, stockpile, or disposal areas that are associated with a project site, and under the control of the project site owner.
f. Proposed topographic information at one-foot contour interval.
g. Location, size, and dimensions of all existing streams to be maintained, and new drainage systems such as culverts, bridges, storm sewers, conveyance channels, and 100-year overflow paths/ponding areas shown as hatched areas, along with all associated easements.
h. Pipes and associated structures data, including sizes, lengths, and material
i. Location, size, and dimensions of features such as permanent retention or detention facilities, including natural or constructed wetlands, used for the purpose of stormwater management. Include existing retention or detention facilities that will be maintained, enlarged, or otherwise altered and new ponds or basins to be built.
j. Emergency flood routing path(s) and their invert elevations from detention facilities to the receiving system.
k. One or more typical cross sections of all existing and proposed channels or other open drainage facilities carried to a point above the 100-year high water and showing the elevation of the existing land and the proposed changes, together with the high water elevations expected from the 100-year storm under the controlled conditions called for by the City of Noblesville's applicable stormwater management ordinance(s), and the relationship of structures, streets, and other facilities.
l. A drainage summary, which summarizes the basic conditions of the drainage design, including site acreage, off-site/upstream acreage, allowable release rates, post-developed 10-year, and 100-year flows leaving the site, volume of detention required, volume of detention provided, and any release rate restrictions.
m. Arrows designating the direction of stormwater runoff.
n. Spot elevations appropriate to define elevations.

vi. Utility plan sheet(s) showing the location of all existing and proposed utility lines for the project, including all available information related to the utilities, such as pipe size and material, and invert elevations.

vii. Storm sewer plan/profile sheet(s) at a scale of 5 vertical and 50 horizontal showing the elevation, size, length, location of all proposed storm sewers. Existing and proposed ground grades, storm sewer structures elevations, and all existing and proposed utility crossings also must be included. The actual correct datum (not an assumed one) must be used for the profile sheets and all pipe inverts, top of casting elevations, casting types, structure numbers, and pipe slopes clearly labeled.

viii. A plat on the same sheet size used for recording, including the following information:

a. Legal description.
b. Cross reference to Rule 12.
c. Regulated drain statement and table.

ix. Proposed subdivision landscape plans

x. A copy of the subdivision covenants

xi. Any other information required by the City of Noblesville in order to thoroughly evaluate the submitted material.

102.04 Stormwater Drainage Technical Report

A written stormwater drainage technical report must contain a discussion of the steps taken in the design of the stormwater drainage system. Note that in order to gain an understanding of and to evaluate the relationship between the proposed improvements for a specific project section/phase and the proposed improvements for an overall multi-section (phased) project, the detailed information requested herein for the first section/phase being permitted must be accompanied by an overall project plan that includes the location, dimensions, and supporting analyses of all detention/retention facilities, primary conveyance facilities, and outlet conditions. The technical report needs to include the following detailed items:

i. A summary report, including the following information:

   a. Description of the nature and purpose of the project.
   b. The significant drainage problems associated with the project.
   c. The analysis procedure used to evaluate these problems and to propose solutions.
   d. Any assumptions or special conditions associated with the use of these procedures, especially the hydrologic or hydraulic methods.
   e. The proposed design of the drainage control system.
   f. The results of the analysis of the proposed drainage control system showing that it does solve the project's drainage problems and that it meets the requirements of the ordinance and these standards. This must include a table summarizing, for each eventual site outlet, the pre-developed acreage tributary to each eventual site outlet, the unit discharge allowable release rate used, the resulting allowable release rate in cfs for the post-developed 10-year and 100-year events, pre-developed 2-year flow rates in cfs as well as pre- and post-developed flow rates for 10- and 100-year events. The worksheet provided as Table 102-1 should be filled and submitted as part of the report. Any hydrologic or hydraulic calculations or modeling results must be adequately cited and described in the summary description. If hydrologic or hydraulic models are used, the input and output files for all necessary runs must be included in the appendices. A map showing any drainage area subdivisions used in the analysis must accompany the report.
   g. Soil properties, characteristics, limitations, and hazards associated with the project site and the measures that will be integrated into the project to overcome or minimize adverse soil conditions.
   h. A narrative and photographic record of the condition of the downstream receiving system.
   i. Identification of any other State or Federal water quality permits that are required for construction activities associated with the owner's project site.
   j. Proof of Errors and Omissions Insurance for the registered professional engineer or licensed surveyor showing a minimum amount of $1,000,000 in coverage.

ii. A Hydrologic/Hydraulic Analysis, consistent with the methodologies and calculation included in Chapters 200 and 300 of this Manual, and including the following information:

   a. A hydraulic report detailing existing and proposed drainage patterns on the subject site. The report should include a description of present land use and proposed land use. Any off-site drainage entering the site or any downstream restrictions should be addressed as well. This report should be comprehensive and detail all of the steps the engineer took during the design process.

b. All hydrologic and hydraulic computations should be included in the submittal. These calculations should include, but are not limited to the following: runoff curve numbers and runoff coefficients, runoff calculations, stage-discharge relationships, times-of-concentration and storage volumes.
c. Copies of all computer runs. These computer runs should include both the input and the outputs. Electronic copies of the computer runs with input files must also be included.
d. A set of exhibits should be included showing the drainage sub-areas and a schematic detailing of how the computer models were set up.
e. A conclusion which summarizes the hydraulic design and details how this design satisfies the City of Noblesville's applicable stormwater management ordinance(s).

102.05
Stormwater Pollution Prevention Plan for Construction Sites

A stormwater pollution prevention plan associated with construction activities must be designed to, at least, meet the requirements of the City of Noblesville's applicable stormwater management ordinance(s) and must include the following:

i. Location, dimensions, detailed specifications, and construction details of all temporary and permanent stormwater quality measures.
ii. Soil map of the predominant soil types, as determined by the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Soil Survey, or as determined by a soil scientist. Hydrologic classification for soils should be shown when hydrologic methods requiring soils information are used. A soil legend must be included with the soil map.
iii. 14-Digit Watershed Hydrologic Unit Code.
iv. An estimate of the peak discharge, based on the ten (10) year storm 24-hour event, of the project site for post-construction conditions.
v. Locations where stormwater may be directly discharged into groundwater, such as abandoned wells or sinkholes. Please note if none exists.
vi. Locations of specific points where stormwater discharge will leave the project site.
vii. Name of all receiving waters. If the discharge is to a separate MS4, identify the name of the municipal owner and the ultimate receiving water.
viii. Temporary stabilization plans and sequence of implementation.
ix. Permanent stabilization plans and sequence of implementation.
x. Temporary and permanent stabilization plans shall include the following:

   a. Specifications and application rates for soil amendments and seed mixtures.
   b. The type and application rate for anchored mulch.

xi. General construction sequence of how the project site will be built, including phases of construction.
xii. Construction sequence describing the relationship between implementation of stormwater quality measures and stages of construction activities.
xiii. Location of all soil stockpiles and borrow areas.
xiv. A typical erosion and sediment control plan for individual lot development.
xv. Self-monitoring program including plan and procedures.
xvi. A description of potential pollutant sources associated with the construction activities, which may reasonably be expected to add a significant amount of pollutants to stormwater discharges.

xvii. Material handling and storage associated with construction activity shall meet the spill prevention and spill response requirements in 327 IAC 2-6.1.

xviii. Name, address, telephone number, and list of qualifications of the trained individual in charge of the mandatory stormwater pollution prevention self-monitoring program for the project site.

102.06 Post-Construction Stormwater Pollution Prevention Plan

The post-construction stormwater pollution prevention plan must include the following information:

i. A description of potential pollutant sources from the proposed land use, which may reasonably be expected to add a significant amount of pollutants to stormwater discharges.

ii. Location, dimensions, detailed specifications, and construction details of all post-construction stormwater quality measures.

iii. A description of measures that will be installed to control pollutants in stormwater discharges that will occur after construction activities have been completed. Such practices include infiltration of runoff, flow reduction by use of open vegetated swales and natural depressions, buffer strip and riparian zone preservation, filter strip creation, minimization of land disturbance and surface imperviousness, maximization of open space, and stormwater retention and detention ponds.

iv. A sequence describing when each post-construction stormwater quality measure will be installed.

v. Stormwater quality measures that will remove or minimize pollutants from stormwater run-off.

vi. Stormwater quality measures that will be implemented to prevent or minimize adverse impacts to stream and riparian habitat.

vii. An operation and maintenance manual, both in hard copy and digital PDF format, for all post-construction stormwater quality measures to facilitate their proper long term function. This operation and maintenance manual shall be made available to future parties who will assume responsibility for the operation and maintenance of the post-construction stormwater quality measures. The manual shall include the following:

   a. Contact information for the BMP owner (i.e. name, address, business phone number, cell phone number, pager number, e-mail address, etc.).

   b. A statement that the BMP owner is responsible for all costs associated with maintaining the BMP.

   c. A right-of-entry statement allowing the City of Noblesville personnel to inspect and maintain the BMP.

   d. Specific actions to be taken regarding routine maintenance, remedial maintenance of structural components, and sediment removal. Sediment removal procedures should be explained in both narrative and graphical forms. A tabular schedule should be provided listing all maintenance activities and dates for performing these required maintenance activities.

   e. Site drawings showing the location of the BMP and access easement, cross sections of BMP features (i.e. pond, forebay(s), structural components, etc.), and the point of discharge for stormwater treated by the BMP.

102.07 Review of Individual Lots Within a Permitted Project

For individual lots disturbing less than 1 acre, developed within a larger permitted project, a formal review and issuance of an Individual Lot Plot Plan Permit will be required before a building permit can be issued. All stormwater management measures necessary to comply with the City of Noblesville's applicable stormwater management ordinance(s) must be implemented in accordance with permitted plan for the larger project.

The following information must be submitted to the City of Noblesville, for review and acceptance, by the individual lot operator (a contractor or subcontractor working on an individual lot) whether owning the property or acting as the agent of the property owner, as part of a request for review and issuance of an Individual Lot Plot Plan Permit that must be obtained prior to the issuance of a building permit.

A. The individual lot operator must complete a Residential Lot Plot Plan Permit Request and pay the applicable fee.
B. A certified site layout for the subject lot and all adjacent lots showing building pad location, dimensions, and elevations, and the drainage patterns and swales.
C. Erosion and sediment control plan that, at a minimum, includes the following measures:
   i. Installation and maintenance of a stable construction site access.
   ii. Installation and maintenance of appropriate perimeter erosion and sediment control measures prior to land disturbance.
   iii. Minimization of sediment discharge and tracking from the lot.
   iv. Clean-up of sediment that is either tracked or washed onto roads. Bulk clearing of sediment shall not include flushing the area with water. Cleared sediment must be redistributed or disposed of in a manner that is in compliance with all applicable statutes and rules.
   v. Adjacent lots disturbed by an individual lot operator must be repaired and stabilized with temporary or permanent surface stabilization.
   vi. Self-monitoring program including plan and procedures.
D. Name, address, telephone number, and list of qualifications of the trained individual in charge of the mandatory stormwater pollution prevention self-monitoring program for the project site.

The individual lot owner is responsible for installation and maintenance of all erosion and sediment control measures until the site is stabilized.

102.08
Changes to Plans

Any changes or deviations in the detailed plans and specifications after approval of the applicable stormwater management permit shall be filed with, and accepted by, the City of Noblesville prior to the land development involving the change. Copies of the changes, if accepted, shall be attached to the original plans and specifications.

102.09
Fee Structure

A. Fee Amount
As a condition of the submittal and the review of development plans by the City of Noblesville, the applicant shall agree to pay the City of Noblesville the applicable fee, as set by the City of Noblesville, with respect to the review of all drainage submittals, preliminary plans, final plans, construction plans and accompanying information and data.

B. Time of Payment
Before the City of Noblesville's approval of plans, the City of Noblesville will furnish a written statement to the applicant specifying the total amount due the City of Noblesville in connection with the review of the applicant's submittals, plans and accompanying information and data, including the amount required to be paid by applicant for review and pre-paid inspection fees.

As a condition of acceptance of final drainage plans by the City of Noblesville, applicant shall pay to the City of Noblesville the sum set forth in said statement. The City of Noblesville may issue such a billing statement before the project advances to the final acceptance stage, and such payment is due by applicant upon receipt of said billing statement regardless of whether the project is advanced to the final acceptance stage.

The City of Noblesville shall have the right to not accept the drainage improvements or to not accept the advancement of any project for which the applicable fees have not been paid.

C. Method of Payment

Fees shall be paid by one of the following methods:

- Certified Check
- Cashier's Check
- Money Order
- Such other methods as may be agreed in writing by the City of Noblesville

All checks shall be made payable to the City of Noblesville

D. Waiver of Payment

Fees may be waived for certain projects at the discretion of the City of Noblesville.

102.10 Performance Surety

As a condition of approval and issuance of the permit, the City of Noblesville shall require the applicant to provide assurance in the form of an irrevocable letter of credit or a bond when the stormwater management plan has been accepted, all applicable fees are paid, and before construction begins. Said assurance will guarantee a good faith execution of the stormwater drainage plan, the stormwater pollution prevention plan, the stormwater quality management plan, and any permit conditions. Specifically, the said assurance is intended to guarantee that the following be installed, and continuously monitored and maintained during the construction under the provisions of the City of Noblesville's applicable stormwater management ordinance(s) and this Technical Standards:

- Erosion and sediment controls
- Storm sewer system
- Sub-Surface Drains (SSD)
- Detention facilities
- BMPs

Performance sureties are to run to the City of Noblesville. Said surety shall be conditioned upon the following:

1. The completion of stormwater management improvements and installations shall be within two years from the recording of the final plat;
2. A sum shall be fixed and approved by the jurisdictional entity equal to one hundred ten percent (110%) of the total estimated cost of all stormwater management improvements and installations provided in the construction drawings and accompanying data to specifications cited herein based on the contractor's bid or an estimate prepared by a professional engineer registered in the state of Indiana. Said costs shall be for the installation and ongoing monitoring and maintenance during construction of erosion control measures and the construction and ongoing monitoring and maintenance during construction of storm drainage infrastructure, detention/retention facilities, and stormwater quality BMPs, as regulated under the City of Noblesville's

applicable stormwater management ordinance(s) and this Technical Standards. Assurances shall be for a minimum of $5,000.

3. Each public facility improvement or installation provided in the final plat or accompanying data shall have a separate surety and shall not have the performance surety provided in combination with any of the other public facility improvements and installations. Separate sureties may be issued for various items within the same public facility improvement or installation so that they can be released as work for each item is completed and accepted.
4. The performance surety shall be issued in the name of the owner or the developer.

102.11
Permit Terms and Conditions

In granting a stormwater management permit, the City of Noblesville may impose such terms and conditions as are reasonably necessary to meet the purposes of this Ordinance. The project site owner shall insure compliance with such terms and conditions. Non-compliance with the terms and conditions of permits will be subject to enforcement as described in the applicable ordinances.

The project site owner shall inform all general contractors, construction management firms, grading or excavating contractors, utility contractors, and the contractors that have primary oversight on individual building lots of the terms and conditions of the stormwater management permit and the schedule for proposed implementation.

It is the intent of the City of Noblesville to direct the community's physical growth away from sensitive areas and towards areas that can support it without compromising water quality. In the event that a project site is determined to impact or discharge to a Sensitive Area or is located in an Impact Drainage Area, the City of Noblesville may require more stringent stormwater quantity and quality measures than detailed in the applicable ordinances or in the latest edition of the Indiana Stormwater Quality Manual.

A. Determination of Sensitive Areas

Sensitive Areas include highly erodible soils, wetlands, threatened or endangered species habitat, outstanding waters, impaired waters, recreational waters, and surface drinking water sources. A listing of highly erodible soils, outstanding water, impaired water, recreation water, and surface drinking water sources can be found in the City of Noblesville Storm Water Quality Management Plan (SWQMP) - Part B and its updates. Any discharge from a stormwater practice that is a Class V injection well shall meet the Indiana groundwater quality standards. If wetlands are suspected on a site, wetland delineation shall be completed in accordance with the methodology established by the U.S. Army Corps of Engineers (COE) and the wetland addressed in accordance to the requirements of the law. If the presence of threatened or endangered species habitat is suspected on a site, the site must be evaluated and inspected by a professional experienced in such and the results reported to the City of Noblesville. Special terms and conditions for development determined to impact or discharge to any Sensitive Area shall be included in the stormwater management permit.

B. Determination of Impact Drainage Areas

The following areas shall be designated as Impact Drainage Areas, unless good reason for not including them is presented to the City of Noblesville.

i. A floodway or floodplain as designated by the most updated the City of Noblesville Code dealing with floodplain regulation.

ii. Land within 75 feet of each bank of any ditch within the Hamilton County Regulated Drainage System.

iii. Land within 75 feet of the centerline of any drain tile or enclosed conduit within the Hamilton County Regulated Drainage System.

The City of Noblesville is authorized, but is not required, to classify certain additional geographical areas as Impact Drainage Areas. In determining Impact Drainage Areas, the City of Noblesville shall consider such factors as land use, topography, soil type, capacity of existing drains, and distance from adequate drainage facility.

Land that does not have an adequate outlet, taking into consideration the capacity and depth of the outlet, may be designated as an Impact Drainage Area by the City of Noblesville. Special terms and conditions for development within any Impact Drainage Area shall be included in the stormwater management permit.

SECTION 103 CONSTRUCTION INSPECTION AND APPROVAL

103.01 Introduction

After the approval of the stormwater management permit, the City of Noblesville has the authority to conduct inspections of the work being done to ensure full compliance with the provisions of the applicable ordinances and this Manual, and the terms and conditions of the approved permit. The installed storm sewer shall not be accepted by the City of Noblesville until all requirements for inspection and testing described in this Manual are completed. Inspection of the stormwater drainage system and associated land grading and erosion control measures shall be completed by the City of Noblesville as set forth herein to ensure conformance with the approved site construction plan and supporting documents. Any portion of the stormwater facility not passing the tests prescribed herein shall be repaired or replaced to the extent required by the City of Noblesville, and retested.

103.02 General requirements

The Contractor and/or Owner shall provide written notice to the City of Noblesville of planned commencement of construction forty-eight (48) hours prior to such commencement. Copies of the final, approved construction plans, stormwater drainage technical report, stormwater pollution prevention plan for construction sites, and post-construction stormwater pollution prevention plan shall also accompany the above-noted written notification. The number of required copies varies from case to case and should be determined by contacting the City of Noblesville.

A pre-construction meeting is required to be held with the participation of the City of Noblesville and other entities involved prior to any grading activity to ensure that appropriate erosion control measures have been implemented on the site and the location of any existing tiles has been properly marked.

A stop-work-order shall be issued by the City of Noblesville for all projects that are proceeding without such notification. The City of Noblesville has the authority to conduct inspections of the work being done to ensure full compliance with the provisions of the applicable ordinances and this Manual, and the terms and conditions of the approved permit.

103.03 Testing

Once constructed, all storm sewer pipes and manholes shall be soil tight. The Contractor shall repair to the satisfaction of the City of Noblesville all visible points of possible bedding and/or backfill infiltration into the system. The method of repair shall be per the approval of the City of

Noblesville. When necessary, the Contractor shall remove and reconstruct as much of the work as is necessary to obtain a system that passes the minimum tests prescribed herein.

A. Mandrel Test for Plastic Pipes and Sub-Surface Drains Larger than 6 Inches in Diameter

No sooner than thirty (30) days after installation, all gravity flow storm sewers constructed of flexible pipe (PVC and HDPE) 33-inch in diameter or smaller and all Sub-Surface Drains (SSD) larger than 6 inches in diameter shall be mandrel trested. A representative of the City of Noblesville shall be present on-site during all mandrel tests. The City of Noblesville shall be given written notification of the proposed testing times and locations at least 48 hours prior to the intended time for beginning of the tests. Arrangements for the cost and supply of all equipment necessary to perform mandrel tests shall be the responsibility of the Contractor and Owner.

Mandrel tests shall be conducted under the supervision of the City of Noblesville or the City of Noblesville's Observer.

A seven and one-half (7-1/2) percent "GO/NO-GO" Mandrel Deflection Test shall be performed on all PVC and HDPE gravity storm sewer pipe.

These pipes shall be mandrel led with a rigid device sized to pass seven and one-half (7-1/2) percent or less deflection (OR deformation) of the base inside diameter of the pipe. The mandrel test shall be conducted no earlier than thirty (30) days after reaching final trench backfill grade.

The mandrel (GO/NO-GO) device shall be cylindrical in shape and constructed with nine (9) or ten (10) evenly spaced arms or prongs. Variations of mandrel diameter dimensions due to pipe wall thickness tolerances or ovality (from heat, shipping, poor production, etc.) shall not be deducted from the diameter dimension of the mandrel but shall be counted as par of the 7-1/2% or lesser deflection allowance. Each pipe material/type required to be Mandrel tested shall be tested with a mandrel approved by the City of Noblesville and meeting the requirements of this chapter. The mandrel diameter dimension shall carry a minimum tolerance of 0.01 inches.

The mandrel shall be hand pulled through all sewer lines and any section of sewer not passing the mandrel shall be uncovered, replaced or repaired, and retested.

The contact length (L) shall be measured between points of contact on the mandrel arm.

The Contractor shall provide proving rings to check the mandrel. Drawings of mandrels with complete dimensions shall be furnished by the Contractor to the City of Noblesville upon request for each diameter and specification of pipe.

PVC or HDPE pipes shall be inspected through visual recordings (via closed circuit television) with a walk through (visual survey) inspection with the contractor, developer, and a representative from the City of Noblesville required for pipes 36 inches in diameter or larger.

B. CMP and RCP Inspections

All reinforced concrete and corrugated metal storm sewer pipes that are 36-inch in diameter or larger shall be inspected through a walk through (visual survey) inspection with the contractor, developer, and a representative from the City of Noblesville.

All reinforced concrete and corrugated metal storm sewer pipes 33-inch in diameter or smaller are required to be inspected through closed circuit television viewing (CCTV) at the developer's or contractor's expense by the City of Noblesville's representative as described herein. In those instances where CCTV is a required part of the stormwater permits approval, this televised viewing shall be completed in conformance with these minimum guidelines. The inspection between manholes shall be conducted as follows:

1. A camera equipped with remote control devices to adjust the light intensity and one thousand (1,000) lineal feet of cable shall be provided. The camera shall be able to transmit a continuous image to the television monitor as it is being pulled though the pipe. The image shall be clear enough to enable the City of Noblesville to easily evaluate the interior condition of the pipe. The camera should have a digital display for lineal footage and project number and an audio voice-over shall be made during the inspection identifying any problems.

2. The pipe shall be thoroughly cleaned before the camera is installed and televising is commenced. Cleaning of the pipe shall be the responsibility of the owner.

3. The CD – Digital format, as directed by the City of Noblesville, of the entire storm sewer line and reproduction map indicating the pipe segment numbers of all the pipe that has been televised shall be submitted to the department for review and placement in their permanent file. The pipe should be flooded with clear water just prior to video recording to show any bellies or sags in the pipe.

These inspections shall be required in order to identify, as examples, excessive sedimentation, joint failures, excessive deflections (CMP), damaged coatings or pavings (CMP), structural defects misalignments, sags, or other system defects which have the potential of affecting the hydraulic performance, durability, or structural integrity of the line segment. Reference should be made to Chapter 400 of this manual for guidance on criteria sufficient to warrant rejection of the installed storm sewer system.

Excessive deflection of CMPs shall be considered to exist under the following conditions: variations from a straight centerline; elliptical shape in a pipe intended to be round; dents or bends in the metal. Metallic or bituminous coatings that have been scratched, scraped, bruised, or otherwise broken shall be considered acceptable criteria for rejection of the installed system.

Any pipe and/or joint found to be defective as a result of the televised viewing shall be required to be repaired or replaced to the satisfaction and approval of the City of Noblesville. A re-televising of that portion of the storm sewer line identified as needing repair or replacement shall be required.

C. Manhole and Box Inlet Inspection

Each manhole and/or box inlet structure within all storm sewer line segments shall be visually inspected by a representative of the City of Noblesville prior to backfill to ensure seams are sealed, pipes have concrete collars, and structure is watertight. A secondary inspection by a representative of the City of Noblesville shall be required to check for excessive leakage, backfill infiltration, or improper workmanship and materials. Manholes or box inlet structures which fail to meet minimum construction standards shall be repaired or, if necessary, replaced, and reinspected.

103.04 Release of Performance Sureties

Notice of the scheduled date for completion of construction shall be provided to the the City of Noblesville at least seventy-two (72) hours prior to its planned completion. The Contractor or

Owner will schedule the final inspection, the storm drain and site grading performance sureties will be released after submittal and approval by the City of Noblesville of the following information:

1. As-built drawings prepared under the supervision of and certified by a Professional Engineer or Land Surveyor registered in the State of Indiana, as described in Section 103.05 of this Manual.

2. For subdivided and platted or developments larger than two (2) acres, a copy of the maintenance surety, as required in Section 104-01 of this Manual, in a form approved by the City of Noblesville.

3. A "Certificate of Completion and Compliance" certifying that the completed storm drainage system and stormwater management facilities substantially comply with construction plans and the stormwater management permit as approved by the City of Noblesville.

That portion of the performance surety associated with the storm sewer system, detention facilities, and Post-Construction BMPs may be released by the jurisdictional entity prior to the release of performance surety associated with early permanent site stabilization or the installation of required erosion and sediment control measures for individual lots within a permitted subdivision. The performance surety associated with erosion and sediment control measures may only be released upon the final acceptance of the project and the issuance of the "verified" NOT in accordance with the requirements of Rule 5 (327 IAC 15-5), i.e., upon stabilization of the entire construction site and the removal of temporary erosion and sediment control measures, which may be achieved before or after the construction of all individual lots within a subdivision.

103.05 As-built Drawings

As part of the final acceptance process, as-built drawings (a complete re-survey of the development reflecting all graded and constructed elements) of the stormwater facilities must be submitted to the City of Noblesville, as set forth herein, for the following types of developments:

- All platted subdivisions
- Industrial and commercial sites five acres and larger

After completion of construction of the project and before final project acceptance of the stormwater management plan (the issuance of a "verified" NOT), a professionally prepared and certified as-built drawings by a Professional Engineer or licensed Land Surveyor registered in the State of Indiana shall be submitted to the City of Noblesville for review. These as-built plans must be prepared and certified by the Engineer of Record, i.e., the company/engineer who originally prepared the survey associated with the construction plans. In addition to hard copies, digital copies of the as-built plans and finalized versions of all analyses, models, manuals, and reports that are consistent with the as-built conditions are required in digital formats accepted by the City of Noblesville. These plans shall include all pertinent data relevant to the completed storm drainage system and stormwater management facilities, and shall include:

A. Pipe size and pipe material

B. Invert elevations, top of casting elevations, swale flow lines, lot elevations, etc

C. Top rim elevations

D. Pipe structure lengths

E. BMP types, dimensions, and boundaries/easements

F. “As-planted” plans for BMPs, as applicable

G. Data and calculations showing detention basin storage volume

H. Data and calculations showing BMP treatment capacity

I. Certified statement on plans stating the completed storm drainage system and stormwater management facilities substantially comply with construction plans and the stormwater management permit as approved by the City of Noblesville.

In addition, any requirements established by the City of Noblesville Digital Submission Standards shall also be met.

103.06 Enforcement of Standards

Failure to comply with those minimum guidelines set forth by the manual may result in Enforcement Action per the Storm Water Management Ordinance.

SECTION 104 POST-CONSTRUCTION MAINTENANCE REQUIREMENTS

104.01 Maintenance Surety

Stormwater quantity and quality management facilities shall be maintained in good condition, in accordance with the Operation and Maintenance procedures and schedules listed in the latest editions of the Indiana Stormwater Quality Manual or requirements contained in this Manual, and the terms and conditions of the approved stormwater permit, and shall not be subsequently altered, revised, or replaced except in accordance with the approved stormwater permit, or in accordance with approved amendments or revisions in the permit. Following the completion of construction and before the release of maintenance sureties described below, the maintenance of stormwater quantity or quality facilities shall become the long-term responsibility of the owner of the facility

The property owner, developer, or contractor shall be required to file a three-year maintenance surety with the City of Noblesville, prior to the release of Performance Sureties. Specifically, the said assurance is intended to guarantee that the following be properly maintained after the construction under the provisions of the City of Noblesville’s applicable stormwater management ordinance(s) and this Technical Standards:

- Post-Construction Erosion and sediment controls
- Storm sewer system
- Sub-Surface Drains (SSD)
- Detention facilities
- Post-Construction BMPs

The maintenance surety shall further be conditioned upon owner, developer, or contractor satisfactorily completing, within the three-year period following the completion of construction, such corrective actions as the City of Noblesville may determine are reasonably necessary to remedy any damages to upstream or downstream channels or storm sewers resulting from the as-built development of the project.

Sureties are to run to the City of Noblesville. Said surety shall be conditioned upon the following:

1. A sum shall be fixed and approved by the jurisdictional entity equal to fifteen percent (15%) of the total estimated cost of all stormwater management improvements and installations provided in the construction drawings and

accompanying data to specifications cited herein based on an estimate prepared by a professional engineer registered in the state of Indiana. Said costs shall be for the installation and ongoing monitoring and post-construction maintenance of storm drainage infrastructure, detention/retention facilities, and stormwater quality BMPs, as regulated under the City of Noblesville's applicable stormwater management ordinance(s) and this Technical Standards. Assurances shall be for a minimum of $5,000.

2. Each public facility improvement or installation provided in the final plat or accompanying data shall have a separate surety and shall not have the maintenance surety provided in combination with any of the other public facility improvements and installations.
3. The maintenance surety shall be issued in the name of the owner, developer, contractor or other responsible party as determined by the City of Noblesville.

104.02 Post-Construction Inspection

The City of Noblesville has the authority to perform long-term, post-construction inspection of all public or privately owned stormwater quantity and quality facilities. The inspections will follow the Operation and Maintenance procedures included in this Manual and/or permit application for each specific BMP. The inspection will cover physical conditions, available water quantity and quality storage capacity and the operational condition of key facility elements. Noted deficiencies and recommended corrective action will be included in an inspection report. If deficiencies are found during the inspection, the owner of the facility will be notified by the City of Noblesville's Office and will be required to take all necessary measures to correct such deficiencies. If the owner fails to correct the deficiencies within the allowed time period, as specified in the notification letter, the City of Noblesville will undertake the work and collect from the owner using lien rights if necessary.

104.03 Release of Maintenance Sureties

The maintenance surety posted by the developer, owner, or the contractor shall run and be in force for a period of three (3) years from the date of release of the performance surety.

To verify that all enclosed drains are functioning properly, visual recordings (via closed circuit television) of such tile drains, paid for by the applicant, shall be required before release of maintenance sureties. These visual recordings will be scheduled at least 90 days prior to the expiration date of the maintenance surety. Reports summarizing the results of the noted visual recordings shall be reviewed and accepted by the City of Noblesville before maintenance sureties would be recommended to be released.

SECTION 105 OTHER REQUIREMENTS

105.01 Floodplain Management

Floodplain management shall be in accordance with the City of Noblesville's adopted floodplain regulations. In addition to these regulations, the following floodplain policy is adopted by the City of Noblesville.

The intent of Floodplain management is to protect against loss of property, protect human life, and maintain natural beneficial functions of floodplains in helping mitigate flooding and providing habitat and water quality benefits. Therefore, filling of the land in the floodplain of a regulated drain or any natural stream or watercourse, that has a contributing drainage area of 25 acres or more, located within the City of Noblesville is prohibited. The use of the floodplain area for detention/retention ponds or lakes is also prohibited. Floodplain boundaries are to be determined by using the 100-year Base Flood Elevation (BFE) as shown on the Flood Insurance Rate Maps (FIRM) of the Federal Emergency Management Agency (FEMA) and the Hamilton County 1-foot topographic data available on the Hamilton County GIS webpage.

A. If, during the process of using the BFE and the 1-foot topographic data, it is determined that the FIRM is incorrect, then a Letter of Map Revision (LOMR) to correct the FIRM is to be filed with FEMA. No filling of the floodplain, either the floodplain shown on the FIRM or the floodplain determined by the Floodplain Study, whichever is more conservative, will be allowed until an approved copy of the LOMR is provided to the City of Noblesville.

B. If a FIRM does not establish a 100-year BFE for a regulated drain, natural stream, or natural watercourse, the 100-year BFE shall be established through a site specific Floodplain Study performed by a Professional Engineer registered in the State of Indiana in accordance with the IDNR Hydraulic Modeling Guidelines.

   1. If the drainage area for the Floodplain Study is greater then 1 square mile at the farthest downstream point of the study, then the Floodplain Study must be submitted to IDNR – Division of Water for approval and to the City of Noblesville for review and comment. A copy of the final study, approved by IDNR-Division of Water, must be submitted to the City of Noblesville as part of the project requiring the study to be completed.

   2. If the drainage area for the Floodplain Study is less then 1 square mile at the farthest downstream point of the study, then the Floodplain Study must be submitted to the City of Noblesville for review and approval. The City of Noblesville will have the option to send the Floodplain Study to a consulting engineering firm for review and comment, should the accuracy of the Floodplain Study be in question. The cost of the consulting engineering firm's time will be the responsibility of the owner of the project and will need to be consented to in a written agreement prior to any review of the Floodplain Study by the consulting engineer.

C. The requirements of this section do not apply to the following:

   1. Agricultural uses such as crop production, pastures, orchards, tree farms, planting nurseries, vineyards, and general farming.

   2. Forestry, wildlife areas and nature preserves.

   3. County, City, or Township Parks

   4. Public Streets, bridges, and roadways, as long as the crossing structure are properly sized to convey the natural stream or watercourse and not raise the 100-year BFE.

   5. Regional Detention Basins approved by the City of Noblesville.

105.02
Grading and
Building Pad
Elevations

Maximum yard slopes are 3:1 where soil has been disturbed during construction processes. Finished floor elevation or the lowest building entry elevation must be no less than 6 inches above finished grade around the building. Also, the buildings' lowest entry elevation that is adjacent to and facing a road shall be a minimum of 15 inches above the road elevation.

All buildings shall have a minimum flood protection grade shown on the secondary plat. Minimum Flood Protection Grade of all structures fronting a pond or open ditch shall be no less than 2 feet above any adjacent 100-year local or regional flood elevations, whichever is greater, for all windows, doors, unsealed pipe entrances, window well rim elevations, and any other structure member where floodwaters can enter a building.

For all structures located in the Special Flood Hazards Area (SFHA) as shown on the FEMA maps, the lowest floor elevations of all residential, commercial, or industrial buildings shall be such that Lowest Floor elevation, including basement, shall be at the flood protection grade and therefore have 2 feet of freeboard above the 100-year flood elevation.

The Lowest Adjacent Grade for residential, commercial, or industrial buildings outside a FEMA or IDNR designated floodplain shall have two feet of freeboard above the flooding source's 100-year flood elevation under proposed conditions. Lowest Adjacent Grade is the elevation of the lowest grade adjacent to a structure, where the soil meets the foundation around the outside of the structure (including structural members such as basement walkout, patios, decks, porches, support posts or piers, and rim of the window well.

For areas outside a FEMA or IDNR designated floodplain, the Lowest Adjacent Grade (including walkout basement floor elevation) for all residential, commercial, or industrial buildings adjacent to ponds shall be set a minimum of 2 feet above the 100-year pond elevation or 2 feet above the emergency overflow weir elevation, whichever is higher. In addition to the Lowest Adjacent Grade requirements, any basement floor must be at least a foot above the permanent water level (normal pool elevation).

Special considerations, based on detailed geotechnical analysis, should be made prior to considering placement of any basement below the 100-year flood elevation of an adjacent flooding source or pond.

SITE OUTLET #	ITEM	PRE-DEVELOPMENT						POST-DEVELOPMENT					
		D.A. (ac)	Depress. Storage? (yes/no)	1-Yr.	2-Yr.	10-Yr.	100-Yr.	D.A. (ac)	Depress. Storage? (yes/no)	1-Yr.	2-Yr.	10-Yr.	100-Yr.
1	Default Unit Discharge Allowable Release Rate (cfs/acre)											0.1	0.3
	Basin-Specific Unit Discharge Allowable Release Rate, if any (cfs/acre)												
	Unit Discharge Allowable Release Rate Based on D/S Restrictions, if any (cfs/acre)												
	Adopted Unit Discharge Allowable Release Rate (cfs/acre)												
	Contributing Area of Development Site (ac) and Allowable Release Rate (cfs)												
	Total Contributing DA (ac) and Modeling Results (cfs)								no				

Table 102-1: Allowable Release rate Determination and Modeling Results

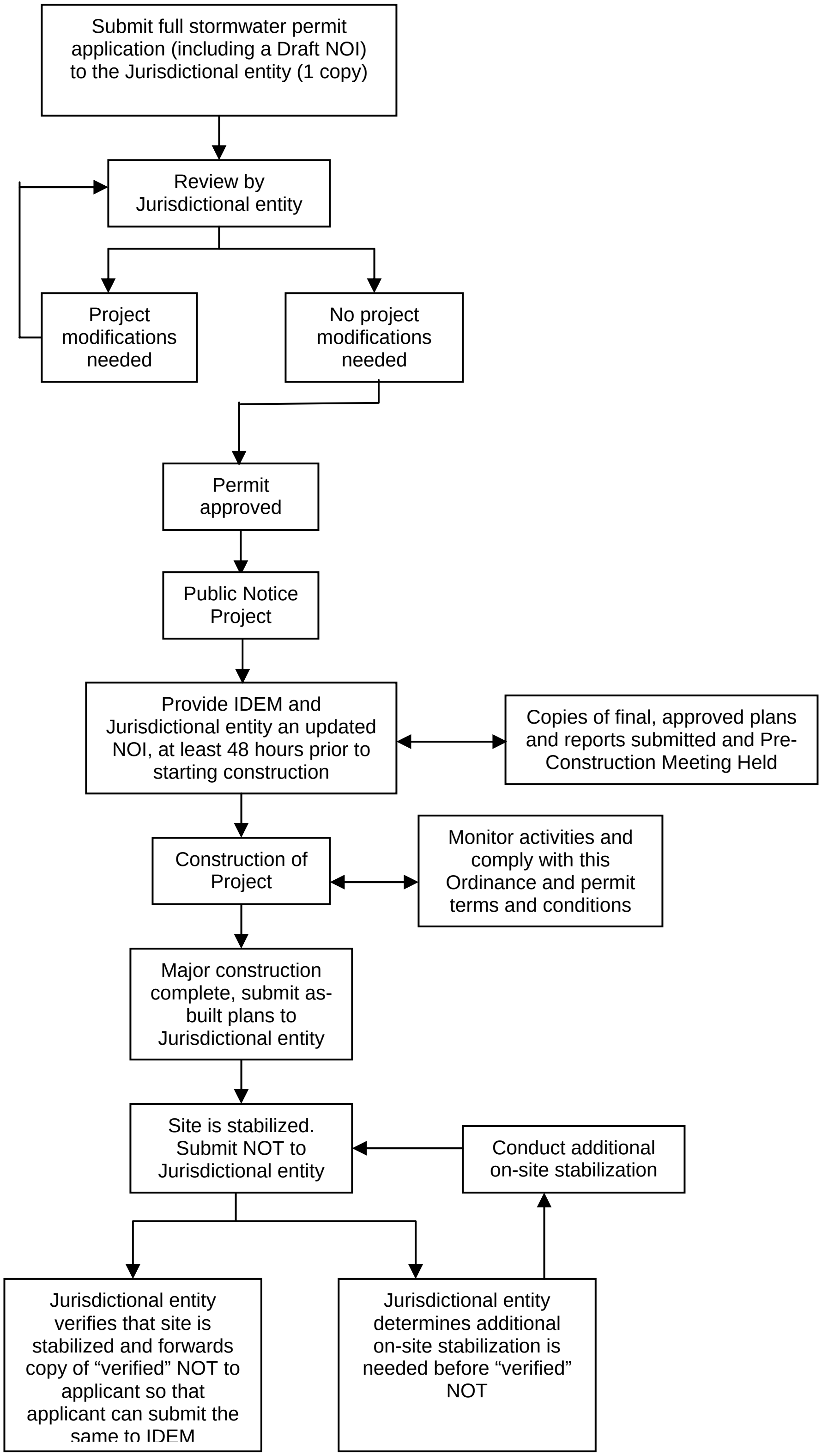

Exhibit 102-1: Flow Chart of the Stormwater Plan Review/Permit Process

CHAPTER 200 HYDROLOGY

SECTION 201 BASIC POLICIES AND REQUIREMENTS

The following section provides a list of design policies which must be applied during a hydrologic analysis performed within the City of Noblesville.

201.01 Abbreviations and Definitions

Following are discussions of concepts which will be important in a hydrologic analysis. These concepts will be used throughout the remainder of this chapter in dealing with different aspects of hydrologic studies.

Abbreviations

COE: United States Army Corps of Engineers

IDEM: Indiana Department of Environmental Management

IDNR: Indiana Department of Natural Resources

INDOT: Indiana Department of Transportation

NRCS: USDA-Natural Resources Conservation Service

USDA: United States Department of Agriculture

Definitions

Antecedent Moisture Condition: The index of runoff potential before a storm event. The index, developed by the Natural Resource Conservation Service (NRCS), is an attempt to account for the variation of the NRCS runoff curve number (CN) from storm to storm.

Catch Basin: A chamber usually built at the curb line of a street for the admission of surface water to a storm drain or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Channel: A portion of a natural or artificial watercourse which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. It has a defined bed and banks which serve to confine the water.

Culvert: A closed conduit used for the conveyance of surface drainage water under a roadway, railroad, canal or other impediment.

Curve Number:	The NRCS index that represents the combined hydrologic effect of soil, land use, land cover, hydrologic condition and antecedent runoff condition.
Depression Storage:	Non-riverine depressions in the earth where stormwater collects. The volumes are often referred to in units of acre-feet.
Design Storm:	A selected storm event, described in terms of the probability of occurring once within a given number of years, for which drainage or flood control improvements are designed and built.
Drainage Area:	The area draining into a stream at a given point. It may be of different sizes for surface runoff, subsurface flow and base flow, but generally the surface runoff area is considered as the drainage area.
Duration:	The time period of a rainfall event.
Hydrograph:	For a given point on a stream, drainage basin, or a lake, a graph showing either the discharge, stage (depth), velocity, or volume of water with respect to time.
Infiltration:	Passage or movement of water into the soil.
Inlet:	An opening into a storm drain system for the entrance of surface storm water runoff, more completely described as a storm drain inlet.
Major Drainage System:	Drainage system carrying runoff from an area of one or more square miles.
Minor Drainage System:	Drainage system carrying runoff from an area of less than one square mile.
Peak Discharge:	The maximum instantaneous flow from a given storm condition at a specific location.
Rainfall Intensity:	The rate at which rain is falling at any given instant, usually expressed in inches per hour.

Runoff: That portion of precipitation that flows from a drainage area on the land surface, in open channels, or in stormwater conveyance systems.

Storm Frequency: The time interval between major storms of predetermined intensity and volumes of runoff (e.g. a 5-yr., 10-yr., or 20-yr. storm).

Storm Sewer: A closed conduit for conveying collected storm water, while excluding sewage and industrial wastes. Also called a storm drain.

Swale: An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct stormwater into primary drainage channels and may provide some groundwater recharge.

Time of Concentration: The travel time of a particle of water from the most hydraulically remote point in the contributing area to the point under study. This can be considered the sum of an overland flow time and times of travel in street gutters, storm sewers, drainage channels, and all other drainage ways.

Watercourse: Any river, stream, creek, brook, branch, natural or man-made drainageway in or into which stormwater runoff or floodwaters flow either continuously or intermittently.

Watershed: The region drained by or contributing water to a specific point that could be along a stream, lake or other stormwater facilities. Watersheds are often broken down into subareas for the purpose of hydrologic modeling.

Symbol Table: To provide consistency within this chapter as well as throughout this manual the following symbols will be used. These symbols were selected because of their wide use in hydrologic publications. In some cases the same symbol is used in existing publications for more than one definition. Where this occurs in this chapter, the symbol will be defined where it occurs in the text or equations.

Symbols	Definition	Units
A	Drainage Area	acres
C	Runoff Coefficient	-
CN	NRCS-runoff curve number	
-		
D	Duration	hours
I	Rainfall intensity	in/hr
n	Manning roughness coefficient	-
Q	Rate of runoff	cfs

q_p	Peak rate of discharge	cfs
t_c or T_c	Time of concentration	min
V	Velocity	ft/s

201.02 Hydrologic Methods

Runoff rates shall be computed for the area of the parcel under development plus the area of the watershed flowing into the parcel under development. The rate of runoff which is generated as the result of a given rainfall intensity may be calculated as follows:

A. Development Sites Less than or Equal to 5 Acres in Size, With a Contributing Drainage Area Less than or Equal to 50 Acres and No Depressional Storage

The Rational Method may be used. A computer model, such as TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE), that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies may also be used along with a 24-hour duration NRCS Type 2 storm. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D). In the Rational Method, the peak rate of runoff, Q, in cubic feet per second (cfs) is computed as:

$$\mathbf{Q = CIA}$$

Where: C = Runoff coefficient, representing the characteristics of the drainage area and defined as the ratio of runoff to rainfall.

I = Average intensity of rainfall in inches per hour for a duration equal to the time of concentration (t_c) for a selected rainfall frequency.

A = Tributary drainage area in acres.

Values for the runoff coefficient "C" are provided in Table 201-1, which shows values for different types of surfaces and local soil characteristics. The composite "C" value used for a given drainage area with various surface types shall be the weighted average value for the total area calculated from a breakdown of individual areas having different surface types.

Rainfall intensity shall be determined from the rainfall frequency data shown in Table 201-2.

In general, the time of concentration (t_c) methodology to be used for all stormwater management projects within the City of Noblesville shall be as outlined in the U.S. Department of Agriculture (USDA) - NRCS TR-55 Manual. In urban or developed areas, the methodology to be used shall be the sum of the inlet time and flow time in the stormwater facility from the most remote part of the drainage area to the point under consideration. The flow time in the storm sewers may be estimated by the distance in feet divided by velocity of flow in feet per second. The velocity shall be determined by the Manning's Equation (see Chapter 300). Inlet time is the combined time required for the runoff to reach the inlet of the storm sewer. It includes overland flow time and flow time through established surface drainage channels such as swales, ditches, and sheet flow across such areas as lawns, fields, and other graded surfaces.

B. Development Sites Greater Than 5 Acres in Size or Contributing Drainage Area Greater than 50 Acres or With Significant Depressional Storage

The runoff rate for these development sites and contributing drainage areas shall be determined by a computer model that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies and the 24-hour NRCS Type 2 Rainfall Distribution. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D). 24-hour Rainfall depth for various frequencies shall be taken from Table 201-3. The NRCS Type 2 distribution ordinates are found in Table 201-4. Examples of computer models that can generate such hydrographs include TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE). These programs may be downloaded free of charge from the associated agencies' web sites. The computer models ICPR and Pond Pack may also be used. However, the latter computer software are proprietary. If interconnected ponds are utilized, the use of ICPR or Pond Pack may be required to appropriately model the more complex hydrologic and hydraulic relationships associated with such system. Other models may be acceptable and should be accepted by the City of Noblesville prior to their utilization.

C. Development Sites with Drainage Areas Greater than or Equal to One Square Mile

For the design of any major drainage system, as defined in Section 201.01, the discharge must be obtained from, or be accepted by, the IDNR. Other portions of the site must use the discharge methodology in the applicable section of this Chapter.

201.03
Design Storm
Frequencies

The design storm frequency is the basis for all runoff computations and stormwater facility designs. All stormwater facilities, whether private or public, and whether constructed on private or public property, shall conform to the design standards and other requirements contained herein.

1. All storm sewers, inlets, catch basins, and street gutters shall accommodate (subject to the "allowable spread" provisions discussed later in this Section), as a minimum, peak runoff from a 10-year return frequency storm calculated based on methodology described in Section 201.02. Additional discharges to storm sewer systems allowed in Section 501.06 must be considered in all design calculations. For Rational Method analysis, the duration shall be equal to the time of concentration for the drainage area. In computer based analysis, the duration is as noted in the applicable methodology associated with the computer program.

2. Primary, secondary, and collector street culverts, as noted by the City of Noblesville Thoroughfare Plan, and those providing the only access to and from any portion of any commercial or residential developments, shall be designed for 100-year frequency storm without overtopping the road. All other roadway culverts shall be designed for 50-year frequency storm without overtopping.

3. For portions of the system considered minor drainage systems, the allowable spread of water on Collector Streets is limited to maintaining two clear 10-foot moving lanes of traffic. One lane is to be maintained on local roads, while other access lanes (such as a subdivision cul-de-sac) can have a water spread equal to one-half of their total width. An overflow channel/swale between sag inlets and overflow paths or basin shall be provided at sag inlets so that the maximum depth of water that might be ponded in the street sag shall not exceed 7 inches measured from elevation of gutter.

4. Stormwater facilities functioning as a major drainage system as defined in Section 201.01 must also meet IDNR design standards in addition to the City of

Noblesville's standards. In case of discrepancy, the most restrictive requirements shall apply.

5. All channels and swales shall accommodate, as a minimum, peak runoff from a 10-year return frequency storm calculated based on methodology described in Section 201.02. For Rational Method analysis, the storm duration shall be equal to the time of concentration for the drainage area. In computer-based analysis, the duration is as noted in the applicable methodology associated with the computer program.

6. Channels with a carrying capacity of more than 30 cfs at bank-full stage shall be capable of accommodating peak runoff for a 50-year return frequency storm within the drainage easement.

7. The 10-year storm design flow for residential rear and side lot swales shall not exceed 4 cfs. The maximum length of rear and side lot swales before reaching any inlet shall not exceed 3 residential lots or 300 feet, whichever is shorter, unless designed as a stormwater quality BMP that meets the design criteria provided in Appendix 701-1 of Chapter 700.

8. Regardless of minimum design frequencies stated above, the performance of all parts of drainage system shall be checked for the 100-year flow conditions to insure that all buildings are properly located outside the 100-year flood boundary and that flow paths are confined to designated areas with sufficient easement.

TYPE OF SURFACE	RUNOFF COEFFICIENT ©
Non-Urban Areas	
Bare earth	0.55
Steep grassed areas (slope 2:1)	0.60
Turf meadows	0.25
Forested areas	0.20
Cultivated fields	0.30
Urban Areas	
All watertight roof surfaces	0.90
Pavement	0.85
Gravel	0.85
Impervious soils (heavy)	0.55
Impervious soils (with turf)	0.45
Slightly pervious soil	0.25
Slightly pervious soil (with turf)	0.20
Moderately pervious soil	0.15
Moderately pervious soil (with turf)	0.10
Business, Commercial & Industrial	0.85
Apartments & Townhouses	0.70
Schools & Churches	0.55
Single Family Lots < 10,000 SF	0.45
Lots < 12,000 SF	0.45
Lots < 17,000 SF	0.40
Lots > ½ acre	0.35
Park, Cemetery or Unimproved Area	0.30

TABLE 201-1: Runoff Coefficients © for Use in the Rational Method

Rainfall Intensity (Inches/Hour)						
Duration	*Return Period (Years)*					
	2	5	10	25	50	100
5 Min.	4.63	5.43	6.12	7.17	8.09	9.12
10 Min.	3.95	4.63	5.22	6.12	6.90	7.78
15 Min.	3.44	4.03	4.55	5.33	6.01	6.77
20 Min.	3.04	3.56	4.02	4.71	5.31	5.99
30 Min.	2.46	2.88	3.25	3.81	4.29	4.84
40 Min.	2.05	2.41	2.71	3.18	3.59	4.05
50 Min.	1.76	2.06	2.33	2.73	3.07	3.47
1 Hr.	1.54	1.80	2.03	2.38	2.68	3.03
1.5 Hrs.	1.07	1.23	1.42	1.63	1.91	2.24
2 Hrs.	0.83	0.95	1.11	1.37	1.60	1.87
3 Hrs.	0.59	0.72	0.84	1.04	1.22	1.42
4 Hrs.	0.47	0.58	0.68	0.84	0.99	1.15
5 Hrs.	0.40	0.49	0.58	0.71	0.83	0.97
6 Hrs.	0.35	0.43	0.50	0.62	0.72	0.85
7 Hrs.	0.31	0.38	0.44	0.55	0.64	0.75
8 Hrs.	0.28	0.34	0.40	0.49	0.57	0.67
9 Hrs.	0.25	0.31	0.36	0.45	0.52	0.61
10 Hrs.	0.23	0.28	0.33	0.41	0.48	0.56
12 Hrs.	0.20	0.24	0.29	0.35	0.41	0.48
14 Hrs.	0.17	0.22	0.25	0.31	0.36	0.42
16 Hrs.	0.16	0.19	0.23	0.28	0.32	0.38
18 Hrs.	0.14	0.17	0.20	0.25	0.29	0.34
20 Hrs.	0.13	0.16	0.19	0.23	0.27	0.31
24 Hrs.	0.11	0.14	0.16	0.20	0.23	0.27

Source: Purdue,A.M., et. al., "Statistical Characteristics of Short Time Incremental Rainfall", Aug., 1992. (Values in this table are based on IDF equation and coefficients provided for Indianapolis, IN.)

TABLE 201-2: Rainfall Intensities for Various Return Periods and Storm Durations

Rainfall Depth (Inches)						
Duration	*Return Period (Years)*					
	2	5	10	25	50	100
24 Hrs.	2.66	3.27	3.83	4.72	5.52	6.46

Source: Purdue,A.M., et. al., "Statistical Characteristics of Short Time Incremental Rainfall", Aug., 1992.(Values in this table are based on IDF equation and coefficients provided for Indianapolis, IN.)

TABLE 201-3: Rainfall Depths for Various Return Periods

Cumulative Percent of Storm Time	*Cumulative Percent of Storm Depth*
0	0
5	1
10	3
15	4
20	6
25	8
30	10
35	13
40	17
45	22
50	64
55	78
60	84
65	87
70	90
75	92
80	94
85	96
90	98
95	99
100	100

TABLE 201-4: NRCS Type 2 Rainfall Distribution Ordinates

CHAPTER 300 HYDRAULICS AND HYDRAULIC STRUCTURES

SECTION 301 INTRODUCTION

This chapter provides policies and technical procedures for analyzing the majority of stormwater facilities required for land alteration projects. However, more detailed analyses may be required depending on the specific site characteristics. Also, a set of standard detail drawings is available through the City of Noblesville Engineering Department that provides guidance on the design of various hydraulic structures that may not have been covered in this chapter. Adherence to the noted standard details shall be required in addition to other requirements in this chapter. In case of discrepancy, the most restrictive requirement shall apply.

301.01
Abbreviations and Definitions

Abbreviations

BMP: Best Management Practice

COE: United States Army Corps of Engineers

IDEM: Indiana Department of Environmental Management

IDNR: Indiana Department of Natural Resources

INDOT: Indiana Department of Transportation

NRCS: USDA-Natural Resources Conservation Service (formerly SCS)

USDA: United States Department of Agriculture

Definitions

Antecedent Moisture Condition: The index of runoff potential before a storm event. The index, developed by the Natural Resource Conservation Service (NRCS), is an attempt to account for the variation of the NRCS runoff curve number (CN) from storm to storm.

Catch Basin: A chamber usually built at the curb line of a street for the admission of surface water to a storm drain or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Channel: A portion of a natural or artificial watercourse which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. It has a defined bed and banks which serve to confine the water.

Culvert:	A closed conduit used for the conveyance of surface drainage water under a roadway, railroad, canal or other impediment.
Curve Number:	The NRCS index that represents the combined hydrologic effect of soil, land use, land cover, hydrologic condition and antecedent runoff condition.
Depression Storage:	Non-riverine depressions in the earth where stormwater collects. The volumes are often referred to in units of acre-feet.
Design Storm:	A selected storm event, described in terms of the probability of occurring once within a given number of years, for which drainage or flood control improvements are designed and built.
Drainage Area:	The area draining into a stream at a given point. It may be of different sizes for surface runoff, subsurface flow and base flow, but generally the surface runoff area is considered as the drainage area.
Duration:	The time period of a rainfall event.
Hydrograph:	For a given point on a stream, drainage basin, or a lake, a graph showing either the discharge, stage (depth), velocity, or volume of water with respect to time.
Infiltration:	Passage or movement of water into the soil.
Inlet:	An opening into a storm drain system for the entrance of surface storm water runoff, more completely described as a storm drain inlet.
Lowest Adjacent Grade	The elevation of the lowest grade adjacent to a structure, where the soil meets the foundation around the outside of the structure (including structural members such as basement walkout, patios, decks, porches, support posts or piers, and rim of the window well.

Major Drainage System:	Drainage system carrying runoff from an area of one or more square miles.
Minor Drainage System:	Drainage system carrying runoff from an area of less than one square mile.
Peak Discharge:	The maximum instantaneous flow from a given storm condition at a specific location.
Rainfall Intensity:	The rate at which rain is falling at any given instant, usually expressed in inches per hour.
Regulated Drain:	A drain subject to the provisions of the Indiana Drainage Code, I.C.-36-9-27
Runoff:	That portion of precipitation that flows from a drainage area on the land surface, in open channels, or in stormwater conveyance systems.
Storm Frequency:	The time interval between major storms of predetermined intensity and volumes of runoff (e.g. a 5-yr., 10-yr., or 20-yr. storm).
Storm Sewer:	A closed conduit for conveying collected storm water, while excluding sewage and industrial wastes. Also called a storm drain.
Stormwater Drainage System	All means, natural or man-made, used for conducting storm water to, through or from a drainage area to any of the following: conduits and appurtenant features, canals, channels, ditches, storage facilities, swales, streams, culverts, streets and pumping stations.
Stormwater Facility	All ditches, channels, conduits, levees, ponds, natural and manmade impoundments, wetlands, tiles, swales, sewers and other natural or artificial means of draining surface and subsurface water from land.

Swale:	An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct stormwater into primary drainage channels and may provide some groundwater recharge.
Tailwater:	The water surface elevation at the downstream side of a hydraulic structure (i.e. culvert, bridge, weir, dam, etc.).
Time of Concentration:	The travel time of a particle of water from the most hydraulically remote point in the contributing area to the point under study. This can be considered the sum of an overland flow time and times of travel in street gutters, storm sewers, drainage channels, and all other drainage ways.
Watercourse:	Any river, stream, creek, brook, branch, natural or man-made drainageway in or into which stormwater runoff or floodwaters flow either continuously or intermittently.
Watershed:	The region drained by or contributing water to a specific point that could be along a stream, lake or other stormwater facilities. Watersheds are often broken down into subareas for the purpose of hydrologic modeling.

To provide consistency within this chapter the following symbols will be used. These symbols were selected because of their wide use in hydrologic and hydraulic publications. In some cases the same symbol is used in existing publications for more than one definition. Where this occurs in this chapter, the symbol will be defined where it occurs in the text or equations.

Symbols	Definition	Units
A	Drainage area	acres
C	Runoff Coefficient	-
CN	NRCS-runoff curve number	-
D	Duration	hours
I	Rainfall intensity	in/hr
N	Manning roughness coefficient	-
Q	Rate of runoff	cfs
q_p	Peak rate of discharge	cfs
tc or Tc	Time of concentration	min
V	Velocity	ft/s

SECTION 302 STORMWATER DETENTION DESIGN

The following shall govern the design of any improvement with respect to the detention of stormwater runoff. Basins shall be constructed to temporarily detain the stormwater runoff that exceeds the maximum peak release rate authorized by this Ordinance. The required volume of storage provided in these basins, together with such storage as may be authorized in other on-site facilities, shall be sufficient to control excess runoff from the 10-year or 100-year storm as explained below in Sections 302.02 and 302.03. Also, basins shall be constructed to provide adequate capacity to allow for sediment accumulation resulting from development and to permit the pond to function for reasonable periods between cleanings.

302.01 Acceptable Detention Facilities

The increased stormwater runoff resulting from a proposed development should be detained on-site by the provisions of appropriate wet bottom or dry bottom detention facilities, parking lots, or other acceptable techniques. Measures that retard the rate of overland flow and the velocity in runoff channels shall also be used to partially control runoff rates.

302.02 Allowable Release Rates

General Release Rates

Control devices shall limit the discharge to a rate such that the post-developed release rate from the site is no greater than 0.1 cfs per acre of development for 0-10 year return interval storms and 0.3 cfs per acre of developed area for 11 - 100 year return interval storms. The above fixed general release rates may be set at a lower value by the City of Noblesville for certain watersheds if more detailed data becomes available as a result of comprehensive watershed studies conducted and/or formally approved and adopted by the City of Noblesville. The applicant shall confirm the applicable release rates with the City of Noblesville prior to initiating the design calculations to determine whether a basin-specific rate has been established for the watershed.

For sites where the pre-developed area has more than one (1) outlet, the release rate should be computed based on pre-developed discharge to each outlet point. The computed release rate for each outlet point shall not be exceeded at the respective outlet point even if the post developed conditions would involve a different arrangement of outlet points.

Site-Specific Release Rates for Sites with Depressional Storage

For sites where depressional storage exists, the general release rates provided above may have to be further reduced. If depressional storage exists at the site, site-specific release rates must be calculated according to methodology described in Chapter 200, accounting for the depressional storage by modeling it as a pond whose outlet is a weir at an elevation that stormwater can currently overflow the depressional storage area. Post developed release rate for sites with depressional storage shall be the 2-year pre-developed peak runoff rate for the post-developed 10-year storm and 10-year pre-developed peak runoff rate for the post-developed 100-year storm. In no case shall the calculated site-specific release rates be larger than general release rates provided above.

Note that by definition, the depressional storage does not have a direct gravity outlet but if in agricultural production, it is more than likely drained by a tile and should be modeled as "empty" at the beginning of a storm. The function of any existing depressional storage should be modeled using an event hydrograph model to determine the volume of storage that exists and its effect on the existing site release rate. To prepare such a model, certain information must be obtained, including delineating the tributary drainage area, the stage-storage relationship and discharge-rating curve, and identifying the capacity and elevation of the outlet(s).

The tributary area should be delineated on the best available topographic data. After determining the tributary area, a hydrologic analysis of the watershed should be performed, including, but not limited to, a calculation of the appropriate composite runoff curve number and time of concentration. Stage-storage data for the depressional area should be obtained from the site topography. The outlet should be clearly marked and any calculations performed to create a stage-discharge rating curve must be included with the stormwater submittal.

Also note that for determining the post-developed peak runoff rates, the depressional storage must be assumed to be filled unless the City of Noblesville can be assured, through a dedicated easement, that the noted storage will be preserved in perpetuity.

Downstream Restrictions

In the event the downstream receiving channel or storm sewer system is inadequate to accommodate the post-developed release rate provided above, then the allowable release rate may need to be reduced to that rate permitted by the capacity of the receiving downstream channel or storm sewer system. Additional detention, as determined by the City of Noblesville, may be required to store that portion of the runoff exceeding the capacity of the receiving sewers or waterways. When such downstream restrictions are suspected, the City of Noblesville may require additional analysis to determine the receiving system's limiting downstream capacity.

If the proposed development makes up only a portion of the undeveloped watershed upstream of the limiting restriction, the allowable release rate for the development shall be in direct proportion to the ratio of its drainage area to the drainage area of the entire watershed upstream of the restriction.

As an alternative, off-site drainage improvements may be required. Those improvements may include, but are not limited to, extending storm sewers, clearing, dredging, streambank stabilization, and/or removal of obstructions to open drains or natural water courses, and the removal or replacement of undersized culvert pipes as required by the City of Noblesville.

302.03 Methodology for Determination of Detention Storage Volume

A. Development Sites Less than or Equal to 5 Acres in Size, With a Contributing Drainage Area Less than or Equal to 50 Acres and No Depressional Storage

The required volume of stormwater storage may be calculated using the Rational Method and based on the runoff from a 100-year return period storm. A computer model, such as TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE), that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies may also be used along with a 24-hour duration NRCS Type 2 storm. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D).

The following 9-step procedure, based on the Rational Method, may be used to determine the required volume of storage

Step	Procedure
1.	Determine total drainage area in acres "A".
2.	Determine the parcel area tributary to each outlet and determine the post-development 100-year release runoff rate (Q_u) based on general release rates provided in Chapter 6 of these Technical Standards document.

3 Determine composite runoff coefficient "C_d" based on developed conditions and a 100-year return period.

4. Determine 100-year return rainfall intensity "I_d" for various storm durations "t_d" up through the time of concentration for the developed area using **Table 2-4**.

5. Determine developed inflow rates "Q_d" for various storm durations "t_d", measured in hours.

$$Q_d = (C_d)(I_d)(A_d)$$

6. Compute a storage rate "$S(t_d)$" for various storm durations "t_d" up through the time of concentration of the developed area.

$$S(t_d) = (Q_d) - (Q_u)$$

7. Compute required storage volume "S_R" in acre-feet for each storm duration "t_d". This assumes a triangular hydrograph of duration ($2t_d$) hours with a peak flow of $S(t_d)$ at t_d hours.

$$S_R = S(t_d)\left(\frac{t_d}{12}\right)$$

8. Select largest storage volume computed in Step 7 for any storm duration "t_d" for detention basin design.

9. Repeat Steps 2-8 of this process for the post-developed 10-year storm.

B. Development Sites Greater Than 5 Acres in Size or Contributing Drainage Area Greater than 50 Acres or With Significant Depressional Storage

All runoff detention storage calculations for these development sites shall be prepared using a computer model that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D). The 24-hour NRCS Type 2 Rainfall Distribution shall be utilized to determine the required storage volume. The allowable release rates shall be determined based on the methodologies provided in Section 302.02. Examples of computer models that can generate such hydrographs include TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE). These programs may be downloaded free of charge from the associated agencies' web sites. The computer models ICPR and Pond Pack may also be used. However, the latter computer software are proprietary. If interconnected ponds are utilized, the use of ICPR or Pond Pack may be required to appropriately model the more complex hydrologic and hydraulic relationships associated with such system. Other models may be acceptable and should be accepted by the City of Noblesville prior to their utilization.

302.04
Management of Off-Site Runoff

Runoff from all upstream tributary areas (off-site land areas) may be bypassed around the detention/retention facility without attenuation. Such runoff may also be routed through the detention/retention facility, provided that a separate, secondary outlet system is incorporated for the safe passage of such flows, i.e., not through the primary outlet of a detention facility. Unless the pond is being designed as a regional detention facility and therefore all off-site runoff to the pond retained, the primary outlet structure shall be sized and the invert elevation of the secondary outlet for bypassing off-site runoff determined according to the on-site runoff only. To accomplish this, the 100-year on-site runoff must be determined by temporarily ignoring the off-site runoff and routed through the pond and through the primary outlet pipe. The resulting pond elevation would be the invert elevation of the secondary outlet. Once the size and location of the primary outlet structure and the invert elevation of the secondary outlet for off-site runoff are determined by considering on-site runoff only, the size of the secondary outlet and the 100-year pond elevation is determined by routing the entire inflow, on-site and off-site, through the pond. Once the 100-year pond elevation is determined in this manner, the crest elevation of the open emergency weir noted in 302.10 (below) is set at that elevation.

Note that the efficiency of the detention/retention facility in controlling the on-site runoff may be severely affected if the off-site area is considerably larger than the on-site area. As a general guidance, on-line detention may not be effective in controlling on-site runoff where the ratio of off-site area to on-site area is larger than 5:1. Additional detention (above and beyond that required for on-site area) may be required by the City of Noblesville when the ratio of off-site area to on-site area is larger than 5:1.

302.05 General Detention Basin Design Requirements

1. The detention facility shall be designed in such a manner that a minimum of 90% of the maximum volume of water stored and subsequently released at the design release rate shall not result in a storage duration in excess of 48 hours from the start of the storm unless additional storms occur within the period. In other words, the design shall ensure that a minimum 90% of the original detention capacity is restored within 48 hours from the start of the design 100-year storm.

2. The 100-year elevation of stormwater detention facilities shall be separated by not less than 25 feet from any building or structure to be occupied. The Lowest Adjacent Grade (including walkout basement floor elevation) for all residential, commercial, or industrial buildings shall be set a minimum of 2 feet above the 100-year pond elevation or 2 feet above the emergency overflow weir elevation, whichever is higher. In addition to the Lowest Adjacent Grade requirements, any basement floor must be at least a foot above the normal water level of any wet-bottom pond. Special considerations, based on detailed geotechnical analysis, should be made prior to considering placement of any basement below the 100-year flood elevation of an adjacent flooding source or pond.

3. No detention facility or other water storage area, permanent or temporary, shall be constructed under or within twenty (20) feet of any pole or high voltage electric line. Likewise, poles or high voltage electric lines shall not be placed within twenty (20) feet of any detention facility or other water storage area.

4. All stormwater detention facilities shall be separated from any road right-of-way by a minimum of 50 feet, measured from the top of bank or the 100-year pool if no defined top of bank is present, using the most restrictive right-of-way possible. Use of guard rails, berms, or other structural measures may be considered in lieu of the above-noted setbacks.

5. Slopes no steeper than 3 horizontal to 1 vertical (3:1) for safety, erosion control, stability, and ease of maintenance shall be permitted.

6. Debris Guard designed in accordance with the City of Noblesville Engineering Standards shall be provided for any pipe or opening.

7. Outlet control structures shall be designed to operate as simply as possible and shall require little or no maintenance and/or attention for proper operation. For maintenance purposes, the outlet shall be a minimum of 0.5 foot above the normal water level of the receiving water body. They shall limit discharges into existing or planned downstream channels or conduits so as not to exceed the predetermined maximum authorized peak flow rate. If an outlet control structure includes an orifice to restrict the flow rate, such orifice shall be no less than 6 inches in diameter, even if the 6-inch diameter orifice results in a discharge that exceeds the predetermined maximum authorized peak flow release rates as determined using methodologies in Section 302.02.

8. Grass or other suitable vegetative cover shall be provided along the banks of the detention storage basin. Vegetative cover around detention facilities should be maintained as provided by restrictive covenants, policy or codes.

9. Debris and trash removal and other necessary maintenance shall be performed as provided by restrictive covenants, policy or codes.

10. No residential lots, or any part thereof, shall be used for any part of a detention basin, assumed full to the 100-year water surface elevation or the emergency overflow weir elevation, whichever is higher. Detention basins, assumed full to the 100-year water surface elevation or the emergency overflow weir elevation, whichever is higher, shall be placed within a common area either platted or legally described and recorded as a perpetual stormwater easement. A minimum of fifteen (15) feet horizontally from the top of bank of the facility, or the 100-year pool if no defined top of bank is present, shall be dedicated as permanent stormwater easement if the above-noted boundary of the common area does not extend that far.

11. Detention basins shall be designed with an additional ten (10) percent of available capacity to allow for sediment accumulation resulting from development and to permit the pond to function for reasonable periods between cleanings. Basins should be designed to collect sediment and debris in specific locations, such as a forebay, so that removal costs are kept to a minimum. For wet-bottom ponds, the sediment allowance may be provided below the permanent pool elevation. No construction trash or debris shall be allowed to be placed within the permanent pool. If the pond is used as a sediment control measure during active construction, the performance sureties will not be released until sediment has been cleaned out of the pond and elevations and grades have been reestablished as noted in the accepted plans.

302.06 Additional Requirements for Wet-Bottom Facility Design

Where part of a detention facility will contain a permanent pool of water, all the items required for detention storage shall apply. Also, a controlled positive outlet will be required to maintain the design water level in the wet bottom facility and provide required detention storage above the design water level. However, the following additional conditions shall apply:

1. Facilities designed with permanent pools or containing permanent lakes shall have a water area of at least one-half (0.5) acre with a minimum depth of eight

(8) feet. If fish are to be used to keep the pond clean, a minimum depth of approximately ten (10) feet shall be maintained over at least 25 percent of the pond area. The remaining pond area shall have no extensive shallow areas, except as required to install the safety ramp, safety ledge, and stormwater BMPs as required below. Construction trash or debris shall not be placed within the permanent pool. The pond design shall be according to the City of Noblesville Engineering Standards.

2. A safety ramp exit from the lake may be required in some cases and shall have a minimum width of twenty (20) feet and exit slope of 6 horizontal to 1 vertical (6:1). The safety ramp shall be constructed of suitable material to prevent structural instability due to vehicles or wave action.

3. Periodic maintenance is required in lakes to control weed and larval growth. The facility shall also be designed to provide for the easy removal of sediment that will accumulate during periods of reservoir operation. Maintenance shall be provided by restrictive covenants, policy or codes.

4. Methods to prevent pond stagnation, including but not limited to aeration facilities, shall be considered on all wet-bottom ponds. Design calculations to substantiate the effectiveness of proposed aeration facilities, and any impacts on the effectiveness of the pond's use as a stormwater BMP shall be submitted with final engineering plans. Agreements for the perpetual operation and maintenance of aeration facilities shall be included in the restrictive covenants of the development or as provided by policy or codes.

302.07 Additional Requirements for Dry-Bottom Facility Design

In addition to general design requirements, detention facilities that will not contain a permanent pool of water shall comply with the following requirements:

1. Provisions shall be incorporated into facilities for complete interior drainage of dry bottom facilities, including a minimum 1% bottom slope in all directions if tile underdrains are provided and a minimum of 2% if no underdrains are provided.. A positive/gravity outlet is required for the underdrains in all dry-bottom detention facilities.

2. For residential developments, the maximum planned depth of stormwater stored shall not exceed four (4) feet.

3. In excavated detention facilities, a minimum side slope of 3:1 shall be provided for stability.

302.08 Parking Lot Storage

Paved parking lots may be designed to provide temporary detention storage of stormwater on all or a portion of their surfaces. Depths of storage shall be limited to a maximum depth of six (6) inches. Ponding should in general, be confined to those positions of the parking lots farthest from the area served. Before such detention method is allowed, a perpetual maintenance agreement must be executed by the owner or the developer and filed with the City of Noblesville. In addition, the 100-year inundation boundary should be determined and clearly shown on the construction plans.

302.09
Detention Facilities in Floodplains

Except for projects exempted under Chapter 100, Section 105-01, no detention facilities are allowed to be placed within floodplains of any regulated drain or watercourse that has more than 25 acres of contributing drainage area, whether designated as such on FEMA maps or not.

302.10
Design of Detention Facility Emergency Spillways

Emergency overflow facilities such as a weir or spillway shall be provided for the release of exceptional storm runoff or in emergency conditions should the normal discharge devices become totally or partially inoperative. The overflow facility shall be of such design that its operation is automatic and does not require manual attention.

Emergency overflow facilities shall be designed to convey, without overtopping the detention facility banks, one and one-quarter (1.25) times the peak inflow discharge and peak flow velocity resulting from the 100-year design storm event runoff from the entire contributing watershed draining to the detention/retention facility, assuming post-development condition on-site and existing condition off-site.

The emergency overflow routing from the emergency overflow facility to an adequate receiving system must be positive (by gravity) and shown on the construction plans and on the secondary plat.

302.11
Acceptable Outlet

Design and construction of the stormwater facility shall provide for the discharge of the stormwater runoff from off-site land areas as well as the stormwater from the area being developed (on-site land areas) to an acceptable outlet(s) (as determined by the City of Noblesville) having capacity to receive upstream (off-site) and on-site drainage.

Outlets into regulated drains or natural watercourses shall provide a positive unobstructed or unrestrictive conveyance into said system. The following provisions shall be followed:

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1. All conveyances shall terminate into an approved adequate outlet.

2. All outlets, either open drain or storm sewer, shall extend to the regulated drain or natural watercourse.

3. All storm sewer shall extend to either a receiving storm sewer system or an open regulated drain or natural surface watercourse as approved by the City of Noblesville.

4. Storm sewers shall not outlet into rear yard swales

5. Underwater discharges shall not be allowed. All discharges into a watercourse, pond, or lake shall have the invert at or above the normal pool elevation or normal flow elevation for the receiving stream.

The flow path from the development outfall(s) to a regulated drain or natural watercourse (as determined by the City of Noblesville) shall be provided on an exhibit that includes topographic information. Any existing field tile encountered during the construction shall also be incorporated into the proposed stormwater drainage system or tied to an acceptable outlet. In addition, no activities conducted as part of the development shall be allowed to obstruct the free flow of flood waters from an upstream property.

Where the outfall from the stormwater drainage system of any development flows through real estate owned by others prior to reaching a regulated drain or watercourse, no acceptance shall be granted for such drainage system until all owners of real estate and/or tenants crossed by the outfall consent in writing to the use of their real estate through a recorded easement.

If an adequate outlet is not located on site, then further reduction in allowable release rates or off-site drainage improvements may be required. Those improvements may include, but are not limited to, extending storm sewers, clearing, dredging and/or removal of obstructions to open drains or natural water courses, and the removal or replacement of undersized culvert pipes as required by the City of Noblesville.

SECTION 303 OPEN CHANNEL DESIGN

303.01 Introduction

Open channel flow may be evaluated utilizing Manning's equation, however, restrictions within open channels, such as at open culverts or storm drains, may be required to be evaluated by more sophisticated design methods such as those listed in Section 303.03.

303.02 Mannings Equation

The waterway area for channels shall be determined using Manning's Equation, where:

$$A = Q/V$$

A = Waterway area of channel in square feet

Q = Discharge in cubic feet per second (cfs)

V = Steady-State channel velocity, as defined by Manning's Equation (See Section 305.02)

303.03 Backwater Method for Drainage System Analysis

The determination of 100-year water surface elevation along channels and swales shall be based on accepted methodology and computer programs designed for this purpose. Computer programs HEC-RAS, HEC-2, and ICPR are preferred programs for conducting such backwater analysis. The use of other computer models must be accepted in advance by the City of Noblesville.

303.04 Appurtenant Structures

The design of channels will include provisions for operation and maintenance and the proper functioning of all channels, laterals, travelways, and structures associated with the project. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design will also provide for necessary floodgates, water level control devices, and any other appurtenance structure affecting the functioning of the channels and the attainment of the purpose for which they are built.

The effects of channel improvements on existing culverts, bridges, buried cables, pipelines, and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement. Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge or governmental agency design requirements, whichever is greater.

303.05
Grading and Depth of Open Channels

1. The required channel cross-section and grade are determined by the design capacity, the material in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. The channel grade shall be such that the velocity in the channel is high enough to prevent siltation but low enough to prevent erosion. Velocities less than 2 feet per second are not acceptable, as siltation will take place and ultimately reduce the channel cross-section area. The maximum permissible velocities in vegetated-lined channels are shown in Table 303.01. In addition to existing runoff, the channel design should incorporate increased runoff due to the proposed development.

2. Where depth of design flow is slightly below critical depth, channels shall have freeboard adequate to cope with the effect of hydraulic jumps.

3. Along the streets and roads, the bottom of the ditch should be low enough to install adequately-sized driveway culverts without creating "speed bumps". The driveway culvert inverts shall be designed to adequately consider upstream and downstream culvert elevations.

4. Flow of a channel into a closed system is prohibited, unless runoff rate and head loss computations demonstrate the closed conduit to be capable of carrying the 100-year channel flow for developed conditions, either entirely or in combination with a defined overflow channel, with no reduction of velocity.

5. When the design discharge produces a depth of greater than three (3) feet in the channel, appropriate safety precautions shall be added to the design criteria based on reasonably anticipated safety needs.

6. Swale side slopes shall be no steeper than 3 horizontal to 1 vertical (3:1). Flatter slopes may be required to prevent erosion and for ease of maintenance. The swale design shall be according to the City of Noblesville Engineering Standards.

7. Minimum swale slopes are 1.0%, unless designed to act as a stormwater quality BMP. All flow shall be confined to the specific easements associated with each rear and side lot swale that are part of the minor drainage system. Unless designed to act as a stormwater quality BMP, vegetated swales shall have tile underdrains to dry the swales. (See the City of Noblesville Engineering Standards) Tile lines may be outletted through a drop structure at the ends of

the swale or through a standard tile outlet. Further guidance regarding this subject may be found in the latest edition of the Indiana Drainage Handbook.

8. Residential rear and side lot swales shall not exceed 300 feet in length to any inlet and shall not convey flow from more than 3 lots.

303.06
Channel Stability

Characteristics of a stable channel are:

a] It neither promotes sedimentation nor degrades the channel bottom and sides.

b] The channel banks do not erode to the extent that the channel cross-section is changed appreciably.

c] Excessive sediment bars do not develop.

d] Excessive erosion does not occur around culverts, bridges, outfalls or elsewhere.

e] Gullies do not form or enlarge due to the entry of uncontrolled flow to the channel.

Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bankfull flow, whichever is greater, using an "n" value for various channel linings as shown in Table 303.02. In no case is it necessary to check channel stability for discharges greater than that from a 100-year frequency storm.

Channel stability shall be checked for conditions representing the period immediately after construction. For this stability analysis, the velocity shall be calculated for the expected flow from a 10-year frequency storm on the watershed, or the bankfull flow, whichever is smaller, and the "n" value for the newly constructed channels in fine-grained soils and sands may be determined in accordance with the "National Engineering Handbook 5, Supplement B, Soil Conservation Service" (currently NRCS) and shall not exceed 0.025. This reference may be obtained by contacting the National Technical Information Service in Springfield. The allowable velocity in the newly constructed channel may be increased by a maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

a] The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.

b] Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are shown.

c] The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

Materials acceptable for use as channel lining are:

1. Grass (hand sown or hydroseed)
2. Revetment Riprap
3. Concrete
4. Hand Laid Riprap
5. Precast Cement Concrete Riprap
6. Gabions (or reno mattresses)

7. Coconut Mattings or erosion control blanket - only until grass is established

Use of bio-engineered (green solution) methods for lining materials is recommended and may be explored, as applicable. Other lining materials must be accepted in writing by the City of Noblesville. Materials shall comply with the latest edition of the INDOT, "Standard Specifications".

303.07 Drainage System Overflow Design

Ponding and overflow path throughout the development resulting from a 100-year storm event or from a flood route of an internal detention pond or off-site development or watershed, calculated based on all contributing drainage areas, on-site and off-site, in their proposed or reasonably anticipated land use and with the storm pipe system assumed completely plugged, shall be determined, clearly shown as hatched area on the plans, and a minimum width of 30 feet along the centerline of the overflow path contained in permanent drainage easements. A statement shall be added to the secondary plat that would refer the viewer to the construction plans to see the entire extent of overflow path as hatched areas. No fences or landscaping or any other above grade improvements can be constructed within the easement areas that may impede the free flow of stormwater. These areas shall be designated as flood routes and contained in common areas that are to be maintained in accordance with restrictive covenants, codes or policies. The Lowest Adjacent Grade for all residential, commercial, or industrial buildings shall be set a minimum of 2 feet above the highest noted overflow path/ponding elevation across the property frontage.

All buildings shall have a minimum flood protection grade shown on the secondary plat. Minimum Flood Protection Grade of all structures fronting a pond or open ditch shall be no less than 2 feet above any adjacent 100-year local or regional flood elevations, whichever is greater, for all windows, doors, pipe entrances, window wells, and any other structure member where floodwaters can enter a building.

The overflow path/ponding may be modeled as successive series of natural ponds and open channel segments. Consideration shall be given to the highest ground elevations along the overflow path. Ponds should be modeled similar to that discussed for modeling depressional areas in Section 302.02. Channels should be modeled according to modeling techniques discussed earlier in this Chapter. The calculations for determining the 100-year overflow path/ponding elevations may be based on hand calculation methods utilizing normal depth calculations and storage routing techniques or performed by computer models. Examples of computer models that either individually or in combination with other models can handle the required computations include TR-20, HEC-HMS, and HEC-1, combined with HEC-RAS. Other models may be acceptable and should be accepted by the City of Noblesville prior to their utilization.

Values in Table 303.03 may be utilized as an alternative to the above-noted detailed calculations for determining the required pad elevations of buildings near an overflow path.

If Table 303.03 is used, the City of Noblesville reserves the right to require independent calculations to verify that the proposed building pads provide approximately 2 feet of freeboard above the anticipated overflow path/ponding elevations.

In the case of existing upstream detention, an allowance equivalent to the reduction in flow rate provided may be made for upstream detention only when: (1) such detention and release rate have previously been accepted by the City of Noblesville official charged with the approval authority at the time of the acceptance, and (2) evidence of its construction and maintenance can be shown.

SECTION 304 CULVERTS/BRIDGES

304.01
Introduction

The design methods and criteria outlined or referred to within this section shall be used in the design and evaluation of culvert systems within the jurisdiction of this Manual. Computer models such as Federal Highway Administration's HY-8 may be used to perform culvert/bridge design computations.

Culverts under roadways, involving backwater and/or road overflow during the 100-year design storm, shall be analyzed utilizing the methodologies set forth in Section 303.03 of this manual for determination of the depth of flow over the culvert/roadway during the peak discharge from the 100-year design storm event, backwater elevations, downstream flow velocities and resulting channel scour impacts.

SECTION 305 STORM DRAINS/INLETS

305.01
Introduction

All storm sewers, whether private or public, and whether constructed on private or public property shall conform to the design standards and other requirements contained herein.

305.02
Storm Drain Pipe Design

Determination of hydraulic capacity for storm sewers sized by the Rational Method analysis must be done using Manning's Equation. where:

$$V = (1.486/n)(R^{2/3})(S^{1/2})$$

Then:

$$Q=(V)(A)$$

Where:

Q = capacity in cubic feet per second

V = mean velocity of flow in feet per second

A = cross sectional area in square feet

R = hydraulic radius in feet

S = slope of the energy grade line in feet per foot

n = Manning's "n" or roughness coefficient

The hydraulic radius, R, is defined as the cross sectional area of flow divided by the wetted flow surface or wetted perimeter. Allowable "n" values and maximum permissible velocities for storm sewer materials are listed in **Table 303.02**.

305.03
Backwater Method for Pipe System Analysis

Various computer modeling programs such as HYDRA, ILLUDRAIN, and STORMCAD are available for analysis of storm drains. Computer models to be utilized, other than those listed, must be accepted by the City of Noblesville. The use of submerged storm sewer outfalls is prohibited.

305.04
Minimum Velocity

Minimum and maximum allowable slopes shall be those capable of producing velocities of between 2.5 and 10 feet per second, respectively, when the sewer is flowing full. Maximum permissible velocities for various storm sewer materials are listed in **Table 305.01**.

305.05
Inlet Sizing and Spacing

Inlets or drainage structures shall be utilized to collect surface water through grated openings and convey it to storm sewers, channels, or culverts. The inlet grate opening provided shall be adequate to pass the design 10-year flow with 50% of the sag inlet areas clogged. An overload channel from sag inlets to the overflow channel or basin shall be provided at sag inlets. Inlet design and spacing may be done using the hydraulic equations by manufacturers or orifice/weir equations. Use of the U.S. Army Corps of Engineers HEC-12 computer program is also an acceptable method. Gutter spread on continuous grades may be determined using the Manning's equation, or by using **Figure 305.01**.

The maximum inlet spacing shall be 400 feet.

Further guidance regarding gutter spread calculation may be found in the latest edition of HERPICC Stormwater Drainage Manual, available from the Local Technical Assistance Program (LTAP). At the time of printing of this document, contact information for LTAP was:

Indiana LTAP
Purdue University
Toll-Free: (800) 428-7369 (Indiana only)
Phone: (765) 494-2164
Fax: (765) 496-1176
Email: inltap@ecn.purdue.edu
Website: www.purdue.edu/INLTAP/

SECTION 306 EASEMENTS

306.01
Introduction

Guidelines for minimum easement widths are provided below. More stringent requirements for stormwater easement size and additional covenants may be made by the City of Noblesville based upon individual size conditions.

Detention/retention basins shall be constructed within a common area either platted or legally described and recorded as a perpetual stormwater easement. A minimum of fifteen (15) feet horizontally from the top of bank of the facility shall be dedicated as permanent stormwater easement if the boundary of the above-noted common area does not extend that far.

Public street rights-of-ways will not be acceptable areas for construction of detention/retention facilities.

No drainage easement or a combination drainage and utility easement shall be located within a tree preservation easement.

306.02
Easement
Requirements

There shall be no trees or shrubs planted, nor any structures or fences erected, in any drainage easement, unless otherwise accepted by the City of Noblesville.

A. All new channels, drain tiles equal to or greater than 12 inches in diameter, inlet and outlet structures of detention and retention ponds, and appurtenances thereto as required by this Article, that are installed in subdivisions requiring a stormwater management permit from the City of Noblesville shall be contained within a minimum 30 feet of drainage easement (15 feet from centerline on each side) and shown on the recorded plat. New drain tiles refer to all sub-surface stormwater piping, tubing, tiles, manholes, inlets, catch basins, risers, etc.

B. A minimum of 25 feet from top of the bank on each side of a new channel shall be designated on the recorded plat as a Drainage Easement. If the top of bank is not vegetated according the development's landscape plan, a minimum 25-foot width of filter strip shall be installed within the drainage easement.

C. Rear-yard swales and emergency overflow paths associated with detention ponds shall be contained within a minimum of 30 feet width (15 feet from centerline on each side) of drainage easement.

D. A minimum of 15 feet beyond the actual footprint (top of the bank or the 100-year pond elevation if no top of bank is present) of stormwater detention facilities shall be designated as drainage easement. A minimum 20-foot width easement shall also be required as access easement from a public right-of-way to the facility, unless the pond is immediately next to a public right-of-way

E. The statutory 75-foot (each side) drainage easement for regulated drains already within the Hamilton County system may be reduced if the drain is re-classified by the County Surveyor as an Urban Drain.

SECTION 307 WATERCOURSE IMPROVEMENTS

307.01
Watercourse
Improvement

Whenever a residential subdivision or commercial development constructs improvements upon lands, which is traversed by a watercourse, the landowner/developer shall make improvements to said watercourse at the discretion of the City of Noblesville. These improvements shall consist of the following:

1. All debris and obstructions within the channel (bank to bank) shall be removed. This shall include but not be limited to logjams and trash.
2. Clear all trees which are dead and leaning at a 45 degree or greater angle or trees with roots that are exposed in the channel and potentially will fall into the

stream. In clearing, the tree shall be cut flush with the ground and treated with an EPA-approved brush killer.

3. All stream bank erosion shall be repaired in an acceptable manner approved by the City of Noblesville.
4. The above required improvements must be reflected on the overall design plans for the development and submitted to the City of Noblesville for prior approval.

307.01 Watercourse Maintenance

Entities owning property through which a watercourse passes, or such an Entity's lessee, shall keep and maintain that part of the watercourse in accordance any applicable City of Noblesville codes. In addition, the Entity or lessee shall maintain existing privately owned structures within or adjacent to a watercourse, so that such structures will not become a hazard to the use, function, or physical integrity of the watercourse. The Entity or lessee shall not place or construct a privately owned structure(s) or other impairment within or adjacent to the watercourse such that is an impairment or a detriment or in such a location that is in violation of the City of Noblesville codes.

TABLE 303.01

Maximum Permissible Velocities in Vegetal-Lined Channels (1)			
Cover	*Channel Slope Range (Percent)* **(3)**	*Permissible Velocity* **(2)**	
		Erosion Resistant Soils (ft. per sec.) **(4)**	*Easily Eroded Soils (ft. per sec.)* **(4)**
Bermuda Grass	0-5 5-10 Over 10	8 7 6	6 5 4
Bahia Buffalo Grass Kentucky Bluegrass Smooth Brome Blue Grama	 0-5 5-10 Over 10	 7 6 5	 5 4 3
Grass Mixture Reed Canary Grass	**(3)** 0-5 5-10	5 4	4 3
Lespedeza Sericea Weeping Lovegrass Yellow Bluestem Redtop Alfalfa Red Fescue	**(4)** 0-5 5-10	3.4	2.5
Common Lespedeza **(5)** Sudangrass **(5)**	**(6)** 0-5	3.5	2.5

(1) From Natural resource Conservation Service, SCS-TP-61, "Handbook of Channel Design for Soil and Water Conservation".

(2) Use velocities exceeding 5 feet per second only where good channel ground covers and proper maintenance can be obtained.

(3) Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

(4) Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

(5) Annuals - use on mild slopes or as temporary protection until permanent covers are established.

(6) Use on slopes steeper than 5 percent is not recommended.

TABLE 303.02

Typical Values of Manning's "n"		
Material	*Manning's "n"*	*Maximum Velocities (feet/second)*
◆ **Closed Conduits**		
Concrete	0.013	10
Vitrified Clay	0.013	10
HDPE	0.012	10
PVC	0.011	10
◆ **Circular CMP, Annular Corrugations, 2 2/3 x ½ inch**		
Unpaved	0.024	7
25% Paved	0.021	7
50% Paved	0.018	7
100% Paved	0.013	7
Concrete Culverts	0.013	10
HDPE or PVC	0.012	10
◆ **Open Channels**		
Concrete, Trowel Finish	0.013	10
Concrete, Broom Finish	0.015	10
Gunite	0.018	10
Riprap Placed	0.030	10
Riprap Dumped	0.035	10
Gabion	0.028	10
New Earth **(1)**	0.025	4
Existing Earth **(2)**	0.030	4
Dense Growth of Weeds	0.040	4
Dense Weeds and Brush	0.040	4
Swale with Grass	0.035	4

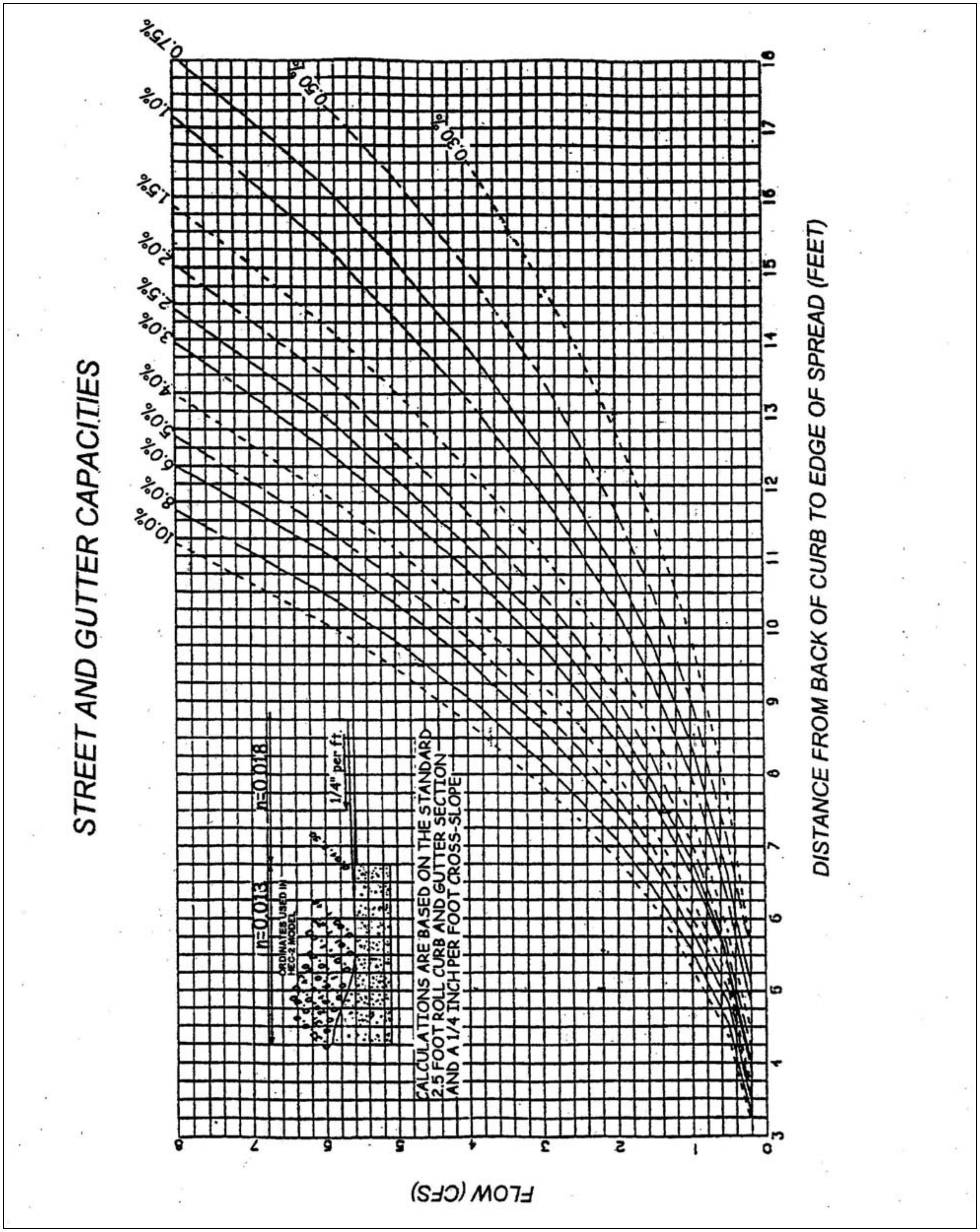
Source of manning "n" values: HERPICC Stormwater Drainage Manual, July 1995.

(1) New earth (uniform, sodded, clay soil)
(2) Existing earth (fairly uniform, with some weeds).

TABLE 303.03

Building Pad Elevations With Respect to Overflow Path Invert Elevations		
Drainage Area (acres)	**Building Pad Above Overflow Path Invert (ft.)**	**Building Pad Above Overflow Path Invert, if Overflow Path is in the Street (ft.)**
Up to 5	3.5	2.5
6-10	4.0	2.5
11-15	4.25	2.75
16-20	4.5	2.75
21-30	5.0	3.0
30-50	5.25	3.0

FIGURE 305.01
Street and Gutter Capacities (continuous grade)



CHAPTER 400 STORM SEWER PIPES AND OPEN CULVERT MATERIALS

SECTION 401 GENERAL

401.01
Minimum Size for Storm Sewers

The minimum diameter of all storm sewers shall be 12 inches. When the minimum 12-inch diameter pipe will not limit the rate of release to the required amount, the rate of release for detention storage shall be controlled by an orifice plate or other device, subject to acceptance of the City of Noblesville.

401.02
Materials

Storm sewer manholes and inlets shall be constructed of precast reinforced concrete. Material and construction shall conform to the latest edition of the Indiana Department of Transportation (INDOT) "Standard Specifications", Sections 702 and 720.

Pipe and fittings used in storm sewer construction shall be extra-strength clay pipe (ASTM C-12), ductile iron pipe (AWWA C-151), poly vinyl chloride pipe (AASHTO M252), polyethylene pipe (AASHTO M252 or AASHTO M294), or concrete pipe (AASHTO M170). Other pipe and fittings not specified herein or in Sections 907-908 of the latest edition of the INDOT “Standard Specifications” may be used only when specifically authorized by the City of Noblesville. Pipe joints shall be flexible and watertight and shall conform to the requirements of Section 906, of the latest edition of the INDOT "Standard Specifications". **If the storm sewer pipe is to be placed within a road right-of-way or in an area subject to loading, the pipe and fittings shall be Class III concrete. A higher class concrete may be required for cover depths in excess of 10 feet or less than 2 feet.**

CHAPTER 500 INSTALLATION OF STORMWATER FACILITIES

SECTION 501 GENERAL

501.01 Pipe Cover, Grade, and Separation from Sanitary Sewers

Pipe grade shall be such that, in general, a minimum of 2.0 feet of cover is maintained over the top of the pipe. If the pipe is to be placed under pavement, then the minimum pipe cover shall be 2.5 feet from top of pavement to top of pipe. Uniform slopes shall be maintained between inlets, manholes and inlets to manholes. Final grade shall be set with full consideration of the capacity required, sedimentation problems, and other design parameters. Minimum and maximum allowable slopes shall be those capable of producing velocities of between 2.5 and 10 feet per second, respectively, when the sewer is flowing full. Maximum permissible velocities for various storm sewer materials are listed in **Table 501-1**. A minimum of 2.0 feet of vertical separation between storm sewers and sanitary sewers shall be required. When this is not possible, the sanitary sewer must be encased in concrete or ductile steel within 5 feet, each side, of the crossing centerline.

501.02 Alignment

Storm sewers shall be straight between manholes and/or inlets.

501.03 Manholes/Inlets

All Manholes and Inlets must be pre-stamped with an appropriate message per the City of Noblesville Engineering Standards. Manholes and/or inlets shall be installed to provide human access to continuous underground storm sewers for the purpose of inspection and maintenance. The casting access minimum inside diameter shall be no less than 22 inches or a rectangular opening of no less than 22 inches by 22 inches. Manholes shall be provided at the following locations:

1. Where two or more storm sewers converge.
2. Where pipe size or the pipe material changes.
3. Where a change in horizontal alignment occurs.
4. Where a change in pipe slope occurs.
5. At intervals in straight sections of sewer, not to exceed the maximum allowed. The maximum distance between storm sewer manholes shall be as shown in **Table 501-2**.

   In addition to the above requirements, a minimum drop of 0.1 foot through manholes and inlet structures should be provided. Pipe slope should not be so steep that inlets surcharge (i.e. hydraulic grade line should remain below rim elevation).

   Manhole/inlet inside sizing shall be according to the City of Noblesville Engineering Standards. Note that the City of Noblesville Engineer may require the applicant to provide pre-treatment BMPs prior to discharge of the storm sewer line into a pond. .

501.04
Installation and Workmanship

Bedding and backfill materials around storm sewer pipes, sub-drains, and the associated structures shall be according to the City of Noblesville Engineering Standards. The specifications for the construction of storm sewers and sub-drains, including backfill requirements, shall not be less stringent than those set forth in the latest edition of the "INDOT Standard Specifications". Additionally, ductile iron pipe shall be laid in accordance with American Water Works Association (AWWA) C-600 and clay pipe shall be laid in accordance with either American Society of Testing Materials (ASTM) C-12 or the appropriate American Association of State Highway and Transportation Officials (AASHTO) specifications. Dips/sags on newly installed storm systems will not be allowed. Also, infiltration from cracks, missing pieces, and joints shall not be allowed. Variations from these standards must be justified and receive written acceptance from the City of Noblesville. All structures shall require inspection prior to backfill.

501.05
Special Hydraulic Structures

Special hydraulic structures required to control the flow of water in storm runoff drainage systems include junction chambers, drop manholes, stilling basins, and other special structures. The use of these structures shall be limited to those locations justified by prudent planning and by careful and thorough hydraulic engineering analysis. Certification of special structures by a certified Structural Engineer may also be required.

The use of Stormwater lift stations shall be at the discretion of the City of Noblesville.

501.06
Connections to Storm Sewer System

To allow any connections to the storm sewer system, provisions for the connections shall be shown in the drainage calculations for the system. Specific language shall be provided in the protective covenants, on the record plat, or with the parcel deed of record, noting the ability or inability of the system to accommodate any permitted connections, for example, sump pumps and footing drains.

1. **Sump pumps** installed to receive and discharge groundwater or other stormwater shall be connected only into T off a rear yard subsurface drain (SSD), if applicable. When connection to the SSD is not possible, discharge pipe must daylight. Sump pumps installed to receive and discharge floor drain flow or other sanitary sewage shall be connected to the sanitary sewers. A sump pump shall be used for one function only, either the discharge of stormwater or the discharge of sanitary sewage, each being connected to the respective receiving system only.

2. **Footing drains and perimeter drains** shall be connected only into T off a rear yard subsurface drain (SSD), if applicable. When connection to the SSD is not possible, discharge pipe must daylight.

3. All **roof downspouts**, roof drains, or roof drainage piping shall discharge onto the ground and shall not be directly connected to the storm drainage system. Variation from this requirement may be requested and granted by the City of Noblesville in special circumstances. No downspouts or roof drains shall be connected to the sanitary sewers.

4. **Garage and Basement floor drains and water softener discharge** shall not be connected to the storm sewers.

5. **Swimming Pool drains** shall not be connected to the storm sewers unless the water is dechlorinated prior to being connected to the storm sewer.

In addition, none of the above mentioned devices shall be connected to any street underdrains, unless specifically authorized by the City of Noblesville.

TABLE 501-1

Typical Values of Manning's "n"		
Material	*Manning's "n"*	*Maximum Velocities (feet/second)*
Closed Conduits		
Concrete	0.013	10
Vitrified Clay	0.013	10
HDPE	0.012	10
PVC	0.011	10
Circular CMP, Annular Corrugations, 2 2/3 x ½ inch		
Unpaved	0.024	7
25% Paved	0.021	7
50% Paved	0.018	7
100% Paved	0.013	7
Concrete Culverts	0.013	10
HDPE or PVC	0.012	10
Open Channels		
Concrete, Trowel Finish	0.013	10
Concrete, Broom Finish	0.015	10
Gunite	0.018	10
Riprap Placed	0.030	10
Riprap Dumped	0.035	10
Gabion	0.028	10
New Earth **(1)**	0.025	4
Existing Earth **(2)**	0.030	4
Dense Growth of Weeds	0.040	4
Dense Weeds and Brush	0.040	4
Swale with Grass	0.035	4

Source of manning "n" values: HERPICC Stormwater Drainage Manual, July 1995.

(1) New earth (uniform, sodded, clay soil)
(2) Existing earth (fairly uniform, with some weeds).

TABLE 501-2

Maximum Distance Between Manholes	
Size of Pipe (Inches)	**Maximum Distance (Feet)**
All sizes	400

CHAPTER 600 EROSION AND SEDIMENT CONTROL FOR CONSTRUCTION SITES

SECTION 601 GENERAL

601.01
Purpose and
Background

The requirements contained in this Chapter are intended to prevent stormwater pollution resulting from soil erosion and sedimentation or from mishandling of solid and hazardous waste. Practices and measures included herein should assure that no foreign substance, (e.g. sediment, construction debris, chemicals) be transported from a site and allowed to enter any drainageway, whether intentionally or accidentally, by machinery, wind, rain, runoff, or other means.

The major pollutant of concern during construction is sediment. Natural erosion processes are accelerated at a project site by the construction process for a number of reasons, including the loss of surface vegetation and compaction damage to the soil structure itself, resulting in reduced infiltration and increased surface runoff. Clearing and grading operations also expose subsoils which are often poorly suited to re-establish vegetation, leading to longer term erosion problems.

Problems associated with construction site erosion include: transport of pollutants attached to displaced sediment; increased turbidity (reduced light) in receiving waters; and recreational use impairment. The deposited sediment may pose direct toxicity to wildlife, or smother existing spawning areas and habitat. This siltation also reduces the flow capacity of waterways, resulting in increased flood hazards to the public.

Other pollutants of concern during the construction process are hazardous wastes or hydrocarbons associated with the construction equipment or processes. Examples include concrete washoff, paints, solvents, and hydrocarbons from refueling operations. Poor control and handling of toxic construction materials pose an acute (short-term) or chronic (long-term) risk of death to aquatic life, wildlife, and the general public.

Also, a set of standard detail drawings is included in Chapter 300 as Appendix 301-1 that provides guidance on the design and installation of various hydraulic structures that may not have been covered in this chapter. Adherence to the noted standard details shall be required in addition to other requirements in this chapter. In case of discrepancy, the most restrictive requirement shall apply.

601.01
Abbreviations and
Definitions

The following abbreviations and definitions apply throughout this chapter:

Abbreviations

COE:	United States Army Corps of Engineers
IDEM:	Indiana Department of Environmental Management
IDNR:	Indiana Department of Natural Resources

INDOT:	Indiana Department of Transportation
MS4:	Municipal separate storm sewer system
NRCS:	USDA-Natural Resources Conservation Service
SWCD:	Soil and Water Conservation District
USDA:	United States Department of Agriculture

Definitions

Construction Activity:	Land-disturbing activities associated with the construction of infrastructure and structures. This term does not include routine ditch maintenance or minor landscaping projects.
Construction Plan:	A representation of a project site and all activities associated with the project. The plan includes the location of the project site, buildings and other infrastructure, grading activities, schedules for implementation and other pertinent information related to the project site. A stormwater pollution prevention plan is a part of the construction plan.
Construction Site Access:	A stabilized stone surface at all points of ingress or egress to a project site, for the purpose of capturing and detaining sediment carried by tires of vehicles or other equipment entering or exiting the project site.
Contractor or Subcontractor:	An individual or company hired by the project site or individual lot owner, their agent, or the individual lot operator to perform services on the project site.
Developer:	Any person financially responsible for construction activity; or an owner of property who sells or leases, or offers for sale or lease, any lots in a subdivision.
Erosion:	The detachment and movement of soil, sediment, or rock fragments by water, wind, ice, or gravity.
Erosion and Sediment Control Measure:	A practice or a combination of practices, to control erosion and resulting sedimentation.

Erosion and Sediment Control System:	The use of appropriate erosion and sediment control measures to minimize sedimentation by first reducing or eliminating erosion at the source and then as necessary, trapping sediment to prevent it from being discharged from or within a project site.
Final Stabilization:	The establishment of permanent vegetative cover or the application of a permanent nonerosive material to areas where all land disturbing activities have been completed and no additional land disturbing activities are planned under the current permit.
Grading:	The cutting and filling of the land surface to a desired slope or elevation.
Impervious Surface:	Surfaces, such as pavement and rooftops, which prevent the infiltration of storm water into the soil.
Individual Building Lot:	A single parcel of land within a multi-parcel development.
Individual Lot Operator:	A contractor or subcontractor working on an individual lot.
Individual Lot Owner:	A person who has financial control of construction activities for an individual lot.
Land-disturbing Activity:	Any manmade change of the land surface, including removing vegetative cover that exposes the underlying soil, excavating, filling, transporting, and grading.
Larger Common Plan of Development or Sale :	A plan, undertaken by a single project site owner or a group of project site owners acting in concert, to offer lots for sale or lease; where such land is contiguous, or is known, designated, purchased or advertised as a common unit or by a common name, such land shall be presumed as being offered for sale or lease as part of a larger common plan. The term also includes phased or other construction activity by a single entity for its own use. (may delete this definition)
Measurable Storm Event:	A precipitation event that results in a total measured precipitation accumulation equal to, or greater than, one-half (0.5) inch of rainfall.
MS4 Area :	A land area comprising one (1) or more places that receives coverage under one (1) NPDES storm water permit regulated by 327 IAC 15-13 or 327 IAC 5-4-6(a)(3) and 327 IAC 5-4-6(a)(4). (Define in text)

MS4 Operator:	"MS4 operator" means the person responsible for development, implementation, or enforcement of the minimum control measures for a designated MS4 area regulated under 327 IAC 15-13. (define in text)
Peak Discharge:	"Peak discharge" means the maximum rate of flow during a storm, usually in reference to a specific design storm event.
Permanent Stabilization:	The establishment, at a uniform density of seventy percent (70%) across the disturbed area, of vegetative cover or permanent nonerosive material that will ensure the resistance of the soil to erosion, sliding, or other movement.
Phasing of Construction:	Sequential development of smaller portions of a large project site, stabilizing each portion before beginning land disturbance on subsequent portions, to minimize exposure of disturbed land to erosion.
Project Site:	The entire area on which construction activity is to be performed.
Project Site Owner:	The person required to comply with the terms of this chapter, including either a developer or a person who has financial and operational control of construction activities, and project plans and specifications, including the ability to make modifications to those plans and specifications.
Sediment:	Solid material (both mineral and organic) that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface.
Sedimentation:	The settling and accumulation of unconsolidated sediment carried by storm water run-off.
Soil:	The unconsolidated mineral and organic material on the surface of the earth that serves as the natural medium for the growth of plants.
SWPPP:	or "Storm water pollution prevention plan" means a plan developed to minimize the impact of storm water pollutants resulting from construction activities.

Storm water quality measure:	A practice, or a combination of practices, to control or minimize pollutants associated with storm water run-off.
Strip Development:	A multi-lot project where building lots front on an existing road.
Subdivision:	Any land that is divided or proposed to be divided into lots, whether contiguous or subject to zoning requirements, for the purpose of sale or lease as part of a larger common plan of development or sale.
Temporary Stabilization:	The covering of soil to ensure its resistance to erosion, sliding, or other movement. The term includes vegetative cover, anchored mulch, or other non-erosive material applied at a uniform density of seventy percent (70%) across the disturbed area.
Tracking:	The deposition of soil that is transported from one (1) location to another by tires, tracks of vehicles, or other equipment.
Trained Individual:	An individual who is trained and experienced in the principles of stormwater quality, including erosion and sediment control, is certified by the Hamilton County SWCD, is a registered professional, or is a Certified Professional in Erosion and Sediment Control.

SECTION 602 BASIC POLICIES AND PROCEDURES

602.01 Applicability and Exemptions

The City of Noblesville will require a Stormwater Pollution Prevention Plan (SWPPP), which includes erosion and sediment control measures and materials handling procedures, to be submitted as part of the construction plans and specifications. Any project located within the City of Noblesville which falls under the jurisdictional authority of the City of Noblesville and includes clearing, grading, excavation, and other land disturbing activities resulting in the disturbance of 1 acre or more of total land area is subject to the requirements of this Chapter. This includes both new development and re-development. This chapter also applies to disturbances of less than one 1 acre of land that are part of a larger common plan of development or sale if the larger common plan will ultimately disturb one (1) or more acres of land, within the area under the jurisdictional authority of the City of Noblesville. Section 602.03 of this Chapter provides guidelines for calculating land disturbance. Projects meeting the coverage requirements of 327 IAC 15-5 (Rule 5) shall also be in compliance with 327 IAC 15-5.

The requirements under this Chapter do not apply to the following activities:

a. agricultural land disturbing activities; or
b. forest harvesting activities.

The requirements under this Chapter do not apply to the following activities, provided other applicable State permits contain provisions requiring immediate implementation of soil erosion control measures:

a. Landfills that have been issued a certification of closure under 329 IAC 10.
b. Coal mining activities permitted under IC 14-34.
c. Municipal solid waste landfills that are accepting waste pursuant to a permit issued by the Indiana Department of Environmental Management under 329 IAC 10 that contains equivalent stormwater requirements, including the expansion of landfill boundaries and construction of new cells either within or outside the original solid waste permit boundary.

For an individual lot where land disturbance is expected to be one (1) acre or more, the individual lot owner must complete their own notice of intent letter, apply for a stormwater permit from the City of Noblesville, and ensure that a sufficient construction and stormwater pollution prevention plan is completed and submitted in accordance with Chapter 100; regardless of whether the individual lot is part of a larger permitted project site.

An individual lot with land disturbance less than one (1) acre, located within a larger permitted project site, is considered part of the larger permitted project site, and the individual lot operator must comply with the terms and conditions of the stormwater permit approved for the larger project site. The stormwater permit application for the larger project site must include typical detailed erosion and sediment control measures for individual lots. In addition, these individual lots are required to submit Individual Lot Plot Plan Permit applications prior to receiving a building permit. Details of the permitting process are contained in Chapter 100.

It will be the responsibility of the project site owner to complete a stormwater permit application and ensure that a sufficient construction plan is completed and submitted to the City of Noblesville in accordance with Chapter 100 of this Standard. It will be the responsibility of the project site owner to ensure compliance with the City of Noblesville's applicable ordinances and standards during the construction activity and implementation of the construction plan, and to notify the City of Noblesville with a sufficient notice of termination letter upon completion of the project and stabilization of the site. However, all persons engaging in construction and land disturbing activities on a permitted project site must comply with the requirements of this Chapter and the City of Noblesville's applicable ordinances.

602.02 Policy on Stormwater Pollution Prevention

Effective stormwater pollution prevention on construction sites is dependent on a combination of preventing movement of soil from its original position (erosion control), intercepting displaced soil prior to entering a waterbody (sediment control), and proper on-site materials handling. The developer must submit to the City of Noblesville a SWPPP with detailed erosion and sediment control plans as well as a narrative describing materials handling and storage, and construction sequencing. The following principles apply to all land-disturbing activities and should be considered in the preparation of a Stormwater Pollution Prevention Plan within the City of Noblesville.

A. Minimize the potential for soil erosion by designing a development that fits the topography and soils of the site. Deep cuts and fills in areas with steep slopes should be avoided wherever possible, and natural contours should be followed as closely as possible.

B. Existing natural vegetation should be retained and protected wherever possible. Areas immediately adjacent (within 35 feet of top of bank) to watercourses and lakes also should be left undisturbed wherever possible. Unvegetated or vegetated areas with less than 70% cover that are scheduled or likely to be left inactive for 15 days or more must be temporarily or permanently stabilized with measures appropriate for the season to reduce erosion potential. Alternative measures to site stabilization may be acceptable if the project site owner or their representative can demonstrate they have implemented and maintained erosion and sediment control measures adequate to prevent sediment discharge from the inactive area.

C. All activities on a site should be conducted in a logical sequence so that the smallest practical area of land will be exposed for the shortest practical period of time during development.

D. The length and steepness of designed slopes should be minimized to reduce erosion potential. Drainage channels and swales must be designed and adequately protected so that their final gradients and resultant velocities will not cause erosion in the receiving channel or at the outlet. Methods for determining acceptable velocities are included in the Stormwater Technical Standards Manual.

E. Sediment-laden water which otherwise would flow from the project site shall be treated by erosion and sediment control measures appropriate to minimize sedimentation. A stable construction site access shall be provided at all points of construction traffic ingress and egress to the project site.

F. Appropriate measures shall be implemented to prevent wastes or unused building materials, including, garbage, debris, packaging material, fuels and petroleum products, hazardous materials or wastes, cleaning wastes, wastewater, concrete truck washout, and other substances from being carried from a project site by runoff or wind. Identification of areas where concrete truck washout is permissible must be clearly posted at appropriate areas of the site. Wastes and unused building materials shall be managed and disposed of in accordance with all applicable State statutes and regulations. Proper storage and handling of materials such as fuels or hazardous wastes, and spill prevention and cleanup measures (including having spill response equipment on-site) shall be implemented to minimize the potential for pollutants to contaminate surface or ground water or degrade soil quality.

G. Public or private roadways shall be kept cleared of accumulated sediment that is a result of runoff or tracking. Bulk clearing of accumulated sediment shall not include flushing the area with water. Cleared sediment shall be redistributed or disposed of in a manner that is in accordance with all applicable statutes and regulations.

H. Collected runoff leaving a project site must be either discharged directly into a well-defined, stable receiving channel, or diffused and released to adjacent property without causing an erosion or pollutant problem to the adjacent property owner.

I. Natural features, including wetlands, shall be protected from pollutants associated with stormwater runoff.

602.03
Calculating Total Area of Land Disturbance

In calculating the total area of land disturbance, for the purposes of determining applicability of this Chapter to the project, the following guidelines should be used:

A. Off-site construction activities that provide services (for example, road extensions, sewer, water, and other utilities) to a land disturbing project site, must be considered as a part of the total land disturbance calculation for the project site, when the activity is under the control of the project site owner.

B. Strip developments will be considered as one (1) project site and must comply with this Chapter unless the total combined disturbance on all individual lots is less than one (1) acre and is not part of a larger common plan of development or sale.

C. To determine if multi-lot project sites are regulated by the City of Noblesville, the area of land disturbance shall be calculated by adding the total area of land disturbance for improvements, such as, roads, utilities, or common areas, and the expected total disturbance on each individual lot, as determined by the following:

    i. For a single-family residential project site where the lots are one-half (0.5) acre or more, one-half (0.5) acre of land disturbance must be used as the expected lot disturbance.
    ii. For a single-family residential project site where the lots are less than one half (0.5) acre in size, the total lot must be calculated as being disturbed.
    iii. To calculate lot disturbance on all other types of projects sites, such as industrial and commercial projects project sites, a minimum of one (1) acre of land disturbance must be used as the expected lot disturbance, unless the lots are less than one (1) acre in size, in which case the total lot must be calculated as being disturbed.

602.04
Common Erosion and Sediment Control Practices

All erosion control and stormwater pollution prevention measures required to comply with the City of Noblesville's Ordinance shall meet the design criteria, standards, and specifications similar to or the same as those outlined in the latest editions of the "Indiana Drainage Handbook" and "Indiana Handbook for Erosion Control in Developing Areas", both published by the Indiana Department of Natural Resources, or other comparable and reputable references. **Table 602-1** lists some of the more common and effective practices for preventing stormwater pollution from construction sites. Details of each practice can be found in the Indiana Drainage Handbook, the Indiana Handbook for Erosion Control in Developing Areas, or in **Appendix 602-1**. These practices should be used to protect ***every*** potential pollution pathway to stormwater conveyances.

602.05
Individual Lot Controls

From the time construction on an individual lot begins, until the individual lot is stabilized, the builder must take steps to:

- protect adjacent properties from sedimentation
- prevent mud/sediment from depositing on the street
- protect drainageways from erosion and sedimentation
- prevent sediment laden water from entering storm sewer inlets.

A generic erosion control plan for individual lots is provided as **Exhibit 602-1**. A typical plan should include perimeter silt fence, stabilized construction entrance, curb inlet protection, drop inlet protection, stockpile containment, stabilized drainage swales, downspout extensions, temporary seeding and mulching, and permanent vegetation. Every relevant measure shall be installed at each individual lot site.

Construction sequence on individual lots should be as follows:

1. Clearly delineate areas of trees, shrubs, and vegetation that are to be undisturbed. To prevent root damage, the areas delineated for tree protection should be at least the same diameter as the crown.
2. Install perimeter silt fence at construction limits. Position the fence to intercept runoff prior to entering drainage swales.
3. Avoid disturbing drainage swales if vegetation is established. If drainage swales are bare, install erosion control blankets or sod to immediately stabilize.
4. Install drop inlet protection for all inlets on the property.
5. Install curb inlet protection, on both sides of the road, for all inlets along the property frontage and along the frontage of adjacent lots, or install temporary catch basin inserts in each inlet and frequently clean.
6. Install gravel construction entrance that extends from the street to the building pad.
7. Perform primary grading operations.
8. Contain erosion from any soil stockpiles created on-site with silt fence around the base.
9. Establish temporary seeding and straw mulch on disturbed areas.
10. Construct the home and install utilities.
11. Install downspout extenders once the roof and gutters have been constructed. Extenders should outlet to a stabilized area.
12. Re-seed any areas disturbed by construction and utilities installation with temporary seed mix within 3 days of completion of disturbance.
13. Grade the site to final elevations. Add topsoil as needed to minimize erosion of underlying soil and to quickly establish grass.
14. Install permanent seeding or sod.

All erosion and sediment control measures must be properly maintained throughout construction. Temporary and permanent seeding should be watered as needed until established. For further information on individual lot erosion and sediment control, please see the "Individual Lot Erosion and Sediment Control Plan and Certification" form in **Exhibit 602-1** or the IDNR, Division of

Soil Conservation’s pamphlet titled “Erosion and Sediment Control for Individual Building Sites”.

602.06 Inspection, Maintenance, Record Keeping, and Reporting

Following approval of the stormwater management permit by the City of Noblesville and commencement of construction activities, the City of Noblesville has the authority to conduct inspections of the site to ensure full compliance with the provisions of this Chapter, the *Indiana Stormwater Quality Manual*, and the terms and conditions of the approved permit.

A self-monitoring program must be implemented by the project site owner to ensure the stormwater pollution prevention plan is working effectively. A trained individual, acceptable to the City of Noblesville, shall perform a written evaluation of the project site by the end of the next business day following each measurable storm event. If there are no measurable storm events within a given week, the site should be monitored at least once in that week. Weekly inspections by the trained individual shall continue until the entire site has been stabilized and a “verified” copy of the Notice of Termination has been issued. The trained individual should look at the maintenance of existing stormwater pollution prevention measures, including erosion and sediment control measures, drainage structures, and construction materials storage/containment facilities, to ensure they are functioning properly. The trained individual should also identify additional measures, beyond those originally identified in the stormwater pollution prevention plan, necessary to remain in compliance with all applicable statutes and regulations. A standard form to record the self-monitoring/inspection results is provided as **Exhibit 602-2**.

The resulting evaluation reports must include the name of the individual performing the evaluation, the date of the evaluation, problems identified at the project site, and details of maintenance, additional measures, and corrective actions recommended and completed.

The stormwater pollution prevention plan shall serve as a guideline for stormwater quality, but should not be interpreted to be the only basis for implementation of stormwater quality measures for a project site. The project site owner is responsible for implementing, in accordance with this Chapter, all measures necessary to adequately prevent polluted stormwater runoff. Recommendations by the trained individual for modified stormwater quality measures should be implemented.

Although self-monitoring reports do not need to be submitted to the City of Noblesville, the City of Noblesville has the right to request complete records of maintenance and monitoring activities involving stormwater pollution prevention measures. All evaluation reports for the project site must be made available to the City of Noblesville, in an organized fashion, within forty-eight (48) hours upon request.

Practice No.	BMP Description	Applicability	Fact Sheet
1	Site Assessment	All sites	2
2	Construction Sequencing	All sites	CN - 101
3	Tree Preservation and Protection	Nearly all sites	1
4	Temporary Gravel Construction Entrance Pad	All sites	1
5	Wheel Wash	All sites	CN - 102
6	Silt Fence	Small drainage areas	1
7	Surface Roughening	Sites with slopes that are to be stabilized with vegetation	1
8	Temporary Seeding	Areas of bare soil where additional work is not scheduled to be performed for a minimum of 15 days	1
9	Mulching	Temporary surface stabilization	1
10	Erosion Control Blanket (Surface)	Temporary surface stabilization, anchor for mulch	1
11	Temporary Diversion	Up-slope and down-slope sides of construction site, above disturbed slopes within construction site	1
12	Rock Check Dam	2 acres maximum contributing drainage area	1
13	Temporary Slope Drain	Sites with cut or fill slopes	1
14	Straw Bale Dam	Small drainage areas	1
15	Fabric Drop Inlet Protection	1 acre maximum contributing drainage area	1
16	Basket Curb Inlet Protection	1 acre maximum contributing drainage area	1
17	Sandbag Curb Inlet Protection	1 acre maximum contributing drainage area	1
18	Temporary Sediment Trap	5 acre maximum contributing drainage area	1
19	Temporary Sediment Basin	30 acre maximum contributing drainage area	1
20	Dewatering Structure	Sites requiring dewatering	CN - 103
21	Dust Control	All sites	1
22	Spill Prevention and Control	All sites	CN - 104
23	Solid Waste Management	All sites	CN - 105
24	Hazardous Waste Management	All sites	CN - 106

Fact sheet Location: 1. Indiana Handbook for Erosion Control in Developing Areas, 1992 or later
2. Indiana Drainage Handbook, 1999 or later

TABLE 602-1: Common Stormwater Pollution Control Practices for Construction Sites

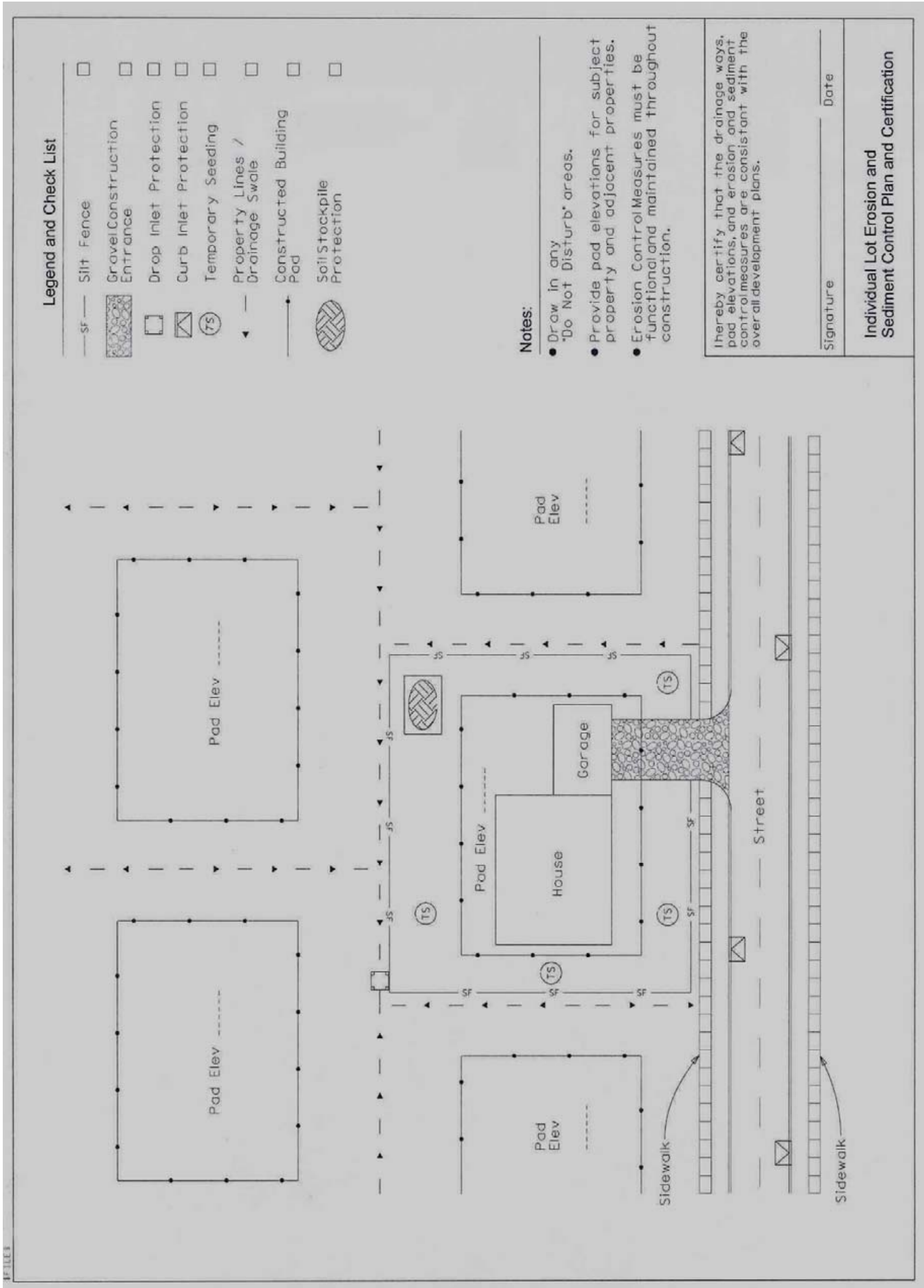


Exhibit 602-1.: Individual Lot Typical Erosion & Sediment Control Plan and Certification

Date: ______________________________
Project: ______________________________
Inspected by: ______________________________

Type of Inspection: ☐ Scheduled Weekly ☐ Rain Event

CONSTRUCTION SITE INSPECTION AND MAINTENANCE LOG

(To be Completed by Property Owner or Agent)

All stormwater pollution prevention BMPs shall be inspected and maintained as needed to ensure continued performance of their intended function during construction and shall continue until the entire site has been stabilized and a Notice of Termination has been issued. An inspection of the project site must be completed by the end of the next business day following each measurable storm event. If there are no measurable storm events within a given week, the site should be monitored at least once in that week. Maintenance and repair shall be conducted in accordance with the accepted site plans. This log shall be kept as a permanent record and must be made available to the City of Noblesville in an organized fashion, within forty-eight (48) hours upon request.

Yes	No	N/A	
			1. Is the site information posted at the entrance?
			2. Are all necessary permits attained and special provisions being implemented?
			3. Is a construction entrance installed and functioning properly?
			4. Are construction staging & parking areas restricted to areas designated on the plans?
			5. Are public and private streets clean of sediment, debris and mud?
			6. Are appropriate practices installed where stormwater leaves the site?
			7. Are all discharge points (outfalls) free of erosion or sediment transport?
			8. Has all silt fence been installed properly and being maintained? *(entrenched - upright - fabric not torn - terminated to higher ground - properly joined at ends)*
			9. Are sediment basins & traps installed according to plan & pipe or rock spillways functional?
			10. Are other sediment control barriers in place and functioning properly?
			11. Is the earthwork for erosion control practices properly graded, seeded and/or mulched?
			12. Are diversion swales and/or waterbars installed to plan & protected?
			13. Do perimeter practices have adequate capacity & do they need to be cleaned out?
			14. Is inlet protection installed properly on all functioning inlets & being maintained?
			15. Is catch basin insert protection installed where required & being maintained?
			16. Have swales and ditches been stabilized or protected?
			17. Are stormwater outlets adequately stabilized?
			18. Has temporary stabilization of disturbed ground been addressed? (dormant for 15 days?)
			19. Is permanent stabilization of disturbed ground progressing on all completed areas?
			20. Has hard or soft armoring been installed where natural vegetation will erode?
			21. Do water pumping operations have a protected outlet and discharge clear water?
			22. Are all dewatering structures functioning properly?

Date: ________________________________
Project: ________________________________
Inspected by: ________________________________

Type of Inspection: ☐ Scheduled Weekly ☐ Rain Event

			23. Is a designated equipment washout area established, clearly marked and being utilized?
			24. Is solid waste properly contained & a stable access provided to the storage & pickup area?
			25. Are fuel tanks and other hazardous materials safely stored and protected?
			26. Is spill response equipment on-site and easily accessible?
			27. Are temporary soil stockpiles in approved areas & properly protected?

If you answered "no" to any of the above questions, describe any corrective action which must be taken to remedy the problem and when the corrective actions are to be completed.

APPENDIX 602-1

CONSTRUCTION BMP FACT SHEETS

BMP CN – 101
CONSTRUCTION SEQUENCING

DESCRIPTION

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so that serious erosion and sedimentation problems can be avoided. Sequencing a construction project reduces the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

ADVANTAGE

1. Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of surface ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

DESIGN CRITERIA

1. Avoid rainy periods.
2. Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill slopes as the work progresses.

REFERENCE

City of Tacoma, Surface Water Management Manual, 2003 or later

BMP CN – 102
WHEEL WASH

DESCRIPTION

When a stabilized construction entrance is not preventing sediment from being tracked onto pavement, a wheel wash may be installed. Wheel washing is generally an effective BMP when installed with careful attention to topography. For example, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where the water from the dripping truck can run unimpeded into the street. Pressure washing combined with an adequately sized and surfaced pad with direct drainage to a large 10-foot x 10-foot sump can be very effective.

ADVANTAGES

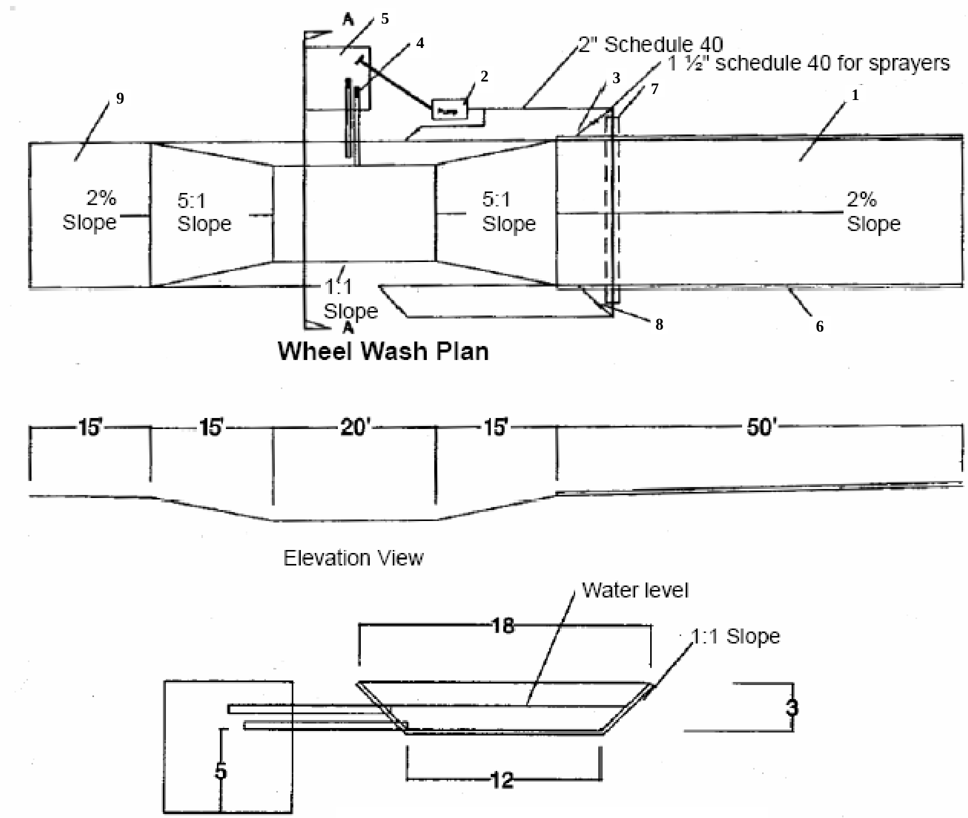
1. Wheel washes reduce the amount of sediment transported onto paved roads by motor vehicles.

DESIGN CRITERIA

1. Suggested details are shown in Figure CN-102-A. The City of Noblesville may allow other designs.
2. A minimum of 6 inches of asphalt treated base (ATB) over crushed base material or 8 inches over a good subgrade is recommended to pave the wheel wash.
3. Use a low clearance truck to test the wheel wash before paving. Either a belly dump or lowboy will work well to test clearance.
4. Keep the water level from 12 to 14 inches deep to avoid damage to truck hubs and filling the truck tongues with water.
5. Midpoint spray nozzles are only needed in extremely muddy conditions.
6. Wheel wash systems should be designed with a small grade change, 6 to 12 inches for a 10-foot-wide pond, to allow sediment to flow to the low side of pond to help prevent re-suspension of sediment.
7. A drainpipe with a 2- to 3-foot riser should be installed on the low side of the pond to allow for easy cleaning and refilling.
8. Polymers may be used to promote coagulation and flocculation in a closed-loop system. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 - 0.5 pounds per 1,000 gallons of water increases effectiveness and reduces cleanup time.
9. If PAM is already being used for dust or erosion control and is being applied by a water truck, the same truck can be used to change the wash water.
10. The wheel wash should start out the day with fresh water. The wash water should be changed a minimum of once per day.
11. On large earthwork jobs where more than 10-20 trucks per hour are expected, the wash water will need to be changed more often.
12. Wheel wash or tire bath wastewater shall be discharged to a separate on-site treatment system, such as closed-loop recirculation or land application, or to the sanitary sewer with proper local sewer utility approval.

REFERENCE

City of Tacoma, Surface Water Management Manual, 2003 or later



Section A-A
NTS

Notes:

1. Asphalt construction entrance 6 in. asphalt treated base (ATB).
2. 3-inch trash pump with floats on the suction hose.
3. Midpoint spray nozzles, if needed.
4. 6-inch sewer pipe with butterfly valves. Bottom one is a drain. Locate top pipe's invert 1 foot above bottom of wheel wash.
5. 8 foot x 8 foot sump with 5 feet of catch. Build so can be cleaned with trackhoe.
6. Asphalt curb on the low road side to direct water back to pond.
7. 6-inch sleeve under road.
8. Ball valves.
9. 15 foot. ATB apron to protect ground from splashing water.

Figure CN-102-A

BMP CN – 103
DEWATERING STRUCTURE

DESCRIPTION

Water which is pumped from a construction site usually contains a large amount of sediment. A dewatering structure is designed to remove the sediment before water is released off-site.

This practice includes several types of dewatering structures which have different applications dependent upon site conditions and types of operation. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the City of Noblesville.

DESIGN CRITERIA

1. A dewatering structure must be sized (and operated) to allow pumped water to flow through the filtering device without overtopping the structure.
2. Material from any required excavation shall be stored in an area and protected in a manner that will prevent sediments from eroding and moving off-site.
3. An excavated basin (applicable to "Straw Bale/Silt Fence Pit") may be lined with filter fabric to help reduce scour and to prevent the inclusion of soil from within the structure.
4. Design criteria more specific to each particular dewatering device can be found in Figures CN-103-A through CN-103-C.
5. A dewatering structure may not be needed if there is a well-stabilized, vegetated area onsite to which water may be discharged. The area must be stabilized so that it can filter sediment and at the same time withstand the velocity of the discharged water without eroding. A minimum filtering length of 75 feet must be available in order for such a method to be feasible.
6. The filtering devices must be inspected frequently and repaired or replaced once the sediment build-up prevents the structure from functioning as designed.
7. The accumulated sediment which is removed from a dewatering device must be spread on-site and stabilized or disposed of at an approved disposal site as per approved plan.

   <u>Portable Sediment Tank (see Figure CN103-A)</u>
   - The structure may be constructed with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the volume of water.
   - Sediment tanks will have a minimum depth of 2 ft.
   - The sediment tank shall be located for easy clean-out and disposal of the trapped sediment and to minimize the interference with construction activities.
   - The following formula shall be used to determine the storage volume of the sediment tank:

     Pump discharge (gallons/min.) x 16 = cubic feet of storage required
   - Once the water level nears the top of the tank, the pump must be shut off while the tank drains and additional capacity is made available.
   - The tank shall be designed to allow for emergency flow over top of the tank. Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

Filter Box (see Figure CN-103-B)

- The box selected should be made of steel, sturdy wood or other materials suitable to handle the pressure requirements imposed by the volume of water. Normally readily available 55 gallon drums welded top to bottom will suffice in most cases.
- Bottom of the box shall be made porous by drilling holes (or some other method).
- Coarse aggregate shall be placed over the holes at a minimum depth of 12 inches, metal “hardware” cloth may need to be placed between the aggregate and the holes if holes are drilled larger than the majority of the stone.
- As a result of the fast rate of flow of sediment-laden water through the aggregate, the effluent must be directed over a well-vegetated strip of at least 50 feet after leaving the base of the filter box.
- The box shall be sized as follows:

  Pump discharge (gallons/min.) x 16 = cubic feet of storage required

- Once the water level nears the top of the box, the pump must be shut off while the box drains and additional capacity is made available.
- The box shall be designed/constructed to allow for emergency flow over the top of this box.
- Clean-out of the box is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.
- If the stone filter does become clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and replaced.
- Using a filter box only allows for minimal settling time for sediment particles; therefore, it should only be used when site conditions restrict the use of the other methods.

Straw Bale/Silt Fence Pit (see Figure CN-103-C)

- Measure shall consist of straw bales, silt fence, a stone outlet (a combination of riprap and aggregate) and a wet storage pit oriented as shown in Figure CN-103-C.
- The structure must have a capacity which is dictated by the following formula:

  Pump discharge (gallons/min.) x 16 = cubic feet of storage required

- In calculating the capacity, one should include the volume available from the floor of the excavation to the crest of the stone weir.
- In any case, the excavated area should be a minimum of 3 feet below the base of the perimeter measures (straw bales or silt fence).
- The perimeter measures must be installed as per the guidelines found in fact sheets associated with STRAW BALE BARRIER and SILT FENCE BMPs.
- Once the water level nears the crest of the stone weir (emergency overflow), the pump must be shut off while the structure drains down to the elevation of the wet storage.
- The wet storage pit may be dewatered only after a minimum of 6 hours of sediment settling time. This effluent should be pumped across a well vegetated area or through a silt fence prior to entering a watercourse.
- Once the wet storage area becomes filled to one-half of the, excavated depth, accumulated sediment shall be removed and properly disposed of.

- Once the device has been removed, ground contours will be returned to original condition.

REFERENCE

United States Army Corps of Engineers, Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities, 1997 or later

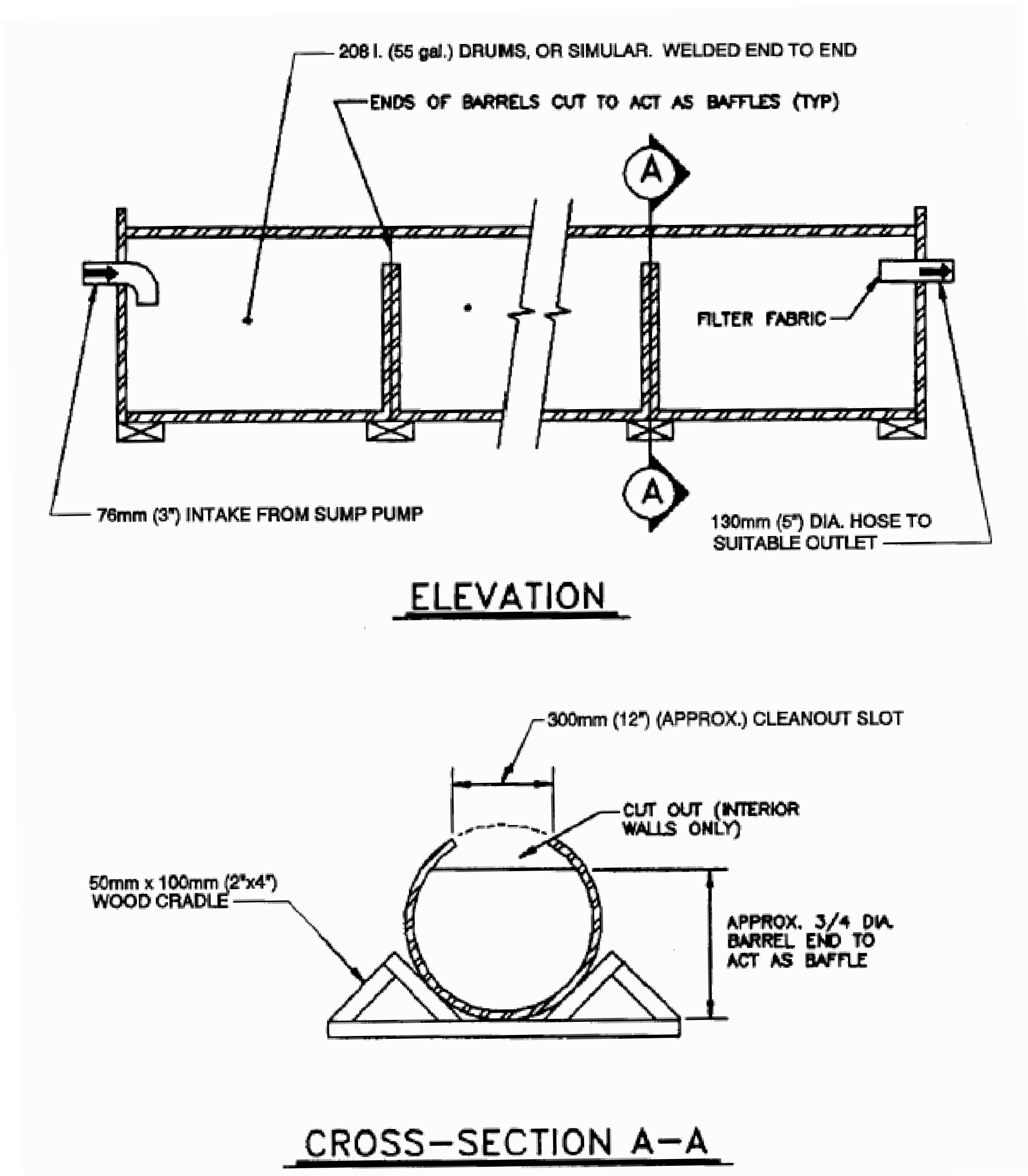


Figure CN-103-A
Portable Sediment Tank

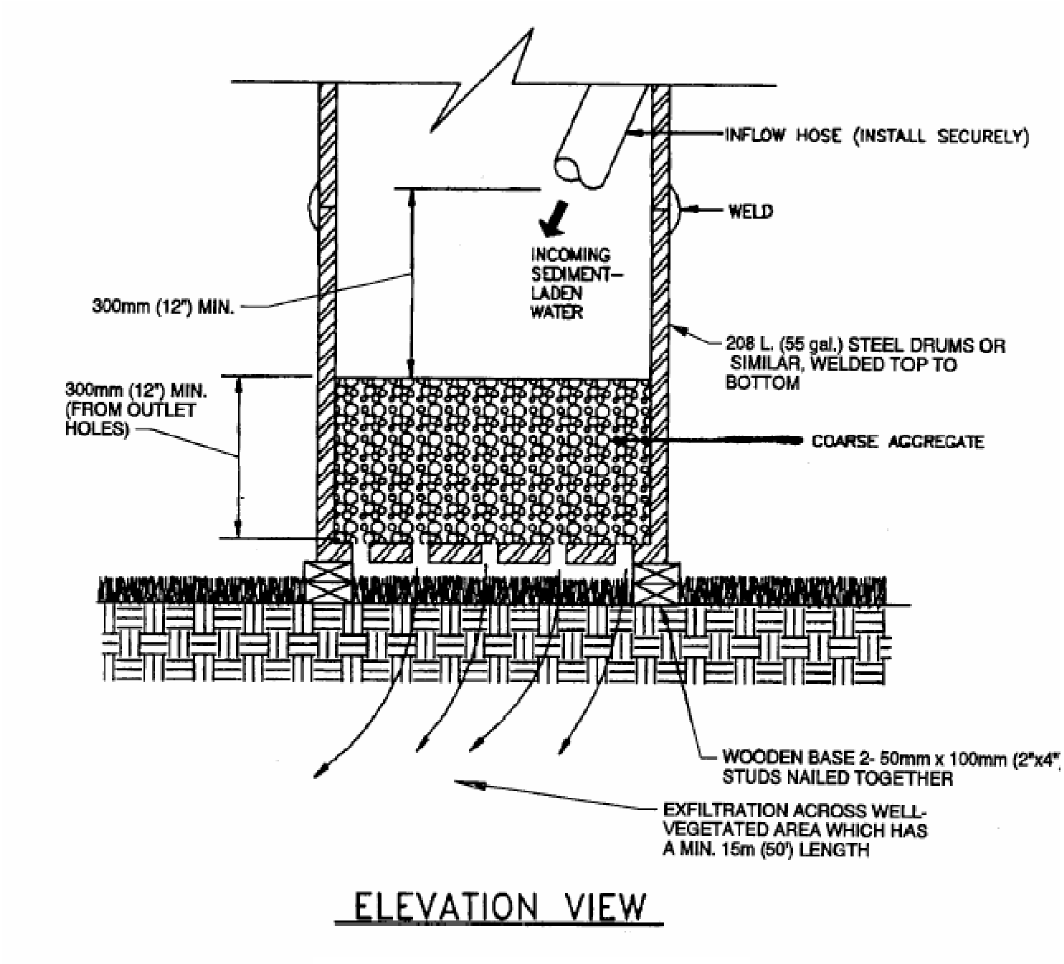


Figure CN-103-B
Filter Box

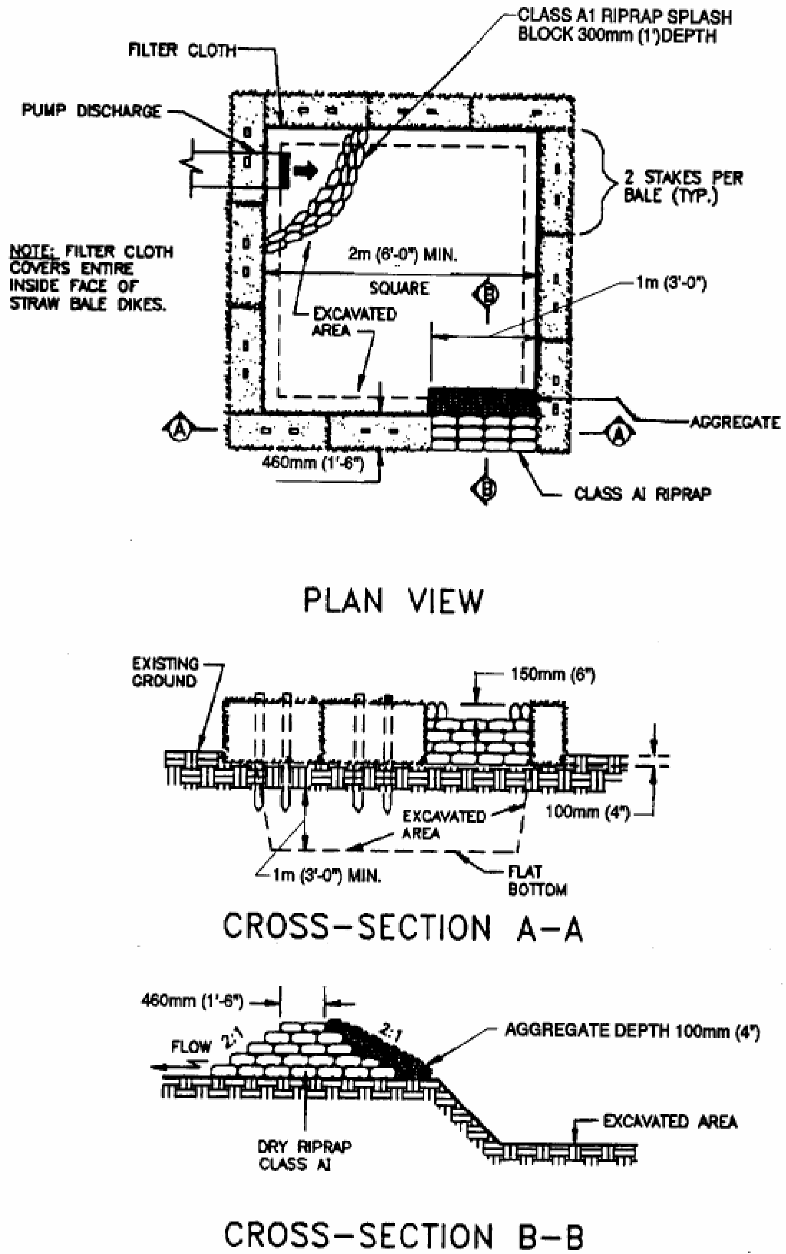


Figure CN-103-C
Straw Bale/Silt Fence Pit

BMP CN – 104
SPILL PREVENTION AND CONTROL

DESCRIPTION

These procedures and practices are implemented to prevent and control spills in a manner that minimizes or prevents the discharge of spilled material to the drainage system or watercourses.

This best management practice (BMP) applies to all construction projects. Spill control procedures are implemented anytime chemicals and/or hazardous substances are stored. Substances may include, but are not limited to:

- Soil stabilizers/binders
- Dust Palliatives
- Herbicides
- Growth inhibitors
- Fertilizers
- Deicing/anti-icing chemicals
- Fuels
- Lubricants
- Other petroleum distillates

To the extent that the work can be accomplished safely, spills of oil, petroleum products, sanitary and septic wastes, and substances listed under 40 Code of Federal Regulations (CFR) parts 110, 117, and 302 shall be contained and cleaned up immediately.

LIMITATIONS

1. This BMP only applies to spills caused by the contractor.
2. Procedures and practices presented in this BMP are general. Contractor shall identify appropriate practices for the specific materials used or stored on-site in advance of their arrival at the site.

DESIGN CRITERIA

1. To the extent that it doesn't compromise clean up activities, spills shall be covered and protected from stormwater runoff during rainfall.
2. Spills shall not be buried or washed with water.
3. Used clean up materials, contaminated materials, and recovered spill material that is no longer suitable for the intended purpose shall be stored and disposed of in conformance with BMP CN-106: Hazardous Waste Management.
4. Water used for cleaning and decontamination shall not be allowed to enter storm drains or watercourses and shall be collected and disposed of in accordance with BMP CN-106: Hazardous Waste Management.
5. Water overflow or minor water spillage shall be contained and shall not be allowed to discharge into drainage facilities or watercourses.

6. Proper storage, clean-up and spill reporting instruction for hazardous materials stored or used on the project site shall be posted at all times in an open, conspicuous and accessible location.
7. Waste storage areas shall be kept clean, well organized and equipped with ample clean-up supplies as appropriate for the materials being stored. Perimeter controls, containment structures, covers and liners shall be repaired or replaced as needed to maintain proper function.
8. Verify weekly that spill control and clean up materials are located near material storage, unloading, and use areas.
9. Update spill prevention and control plans and stock appropriate clean-up materials whenever changes occur in the types of chemicals used or stored onsite.

<u>Cleanup and Storage Procedures for Minor Spills</u>

- Minor spills typically involve small quantities of oil, gasoline, paint, etc., which can be controlled by the first responder at the discovery of the spill.
- Use absorbent materials on small spills rather than hosing down or burying the spill.
- Remove the absorbent materials promptly and dispose of properly.
- The practice commonly followed for a minor spill is:
    - Contain the spread of the spill.
    - Recover spilled materials.
    - Clean the contaminated area and/or properly dispose of contaminated materials.

<u>Cleanup and Storage Procedures for Semi-Significant Spills</u>

- Semi-significant spills still can be controlled by the first responder along with the aid of other personnel such as laborers and the foreman, etc. This response may require the cessation of all other activities.
- Clean up spills immediately:
- Notify the project foreman immediately. The foreman shall notify the City of Noblesville Emergency Management Agency's Hazardous Materials Response Team.
- Contain spread of the spill.
- If the spill occurs on paved or impermeable surfaces, clean up using "dry" methods (absorbent materials, cat litter and/or rags). Contain the spill by encircling with absorbent materials and do not let the spill spread widely.
- If the spill occurs in dirt areas, immediately contain the spill by constructing an earthen dike. Dig up and properly dispose of contaminated soil.
- If the spill occurs during rain, cover spill with tarps or other material to prevent contaminating runoff.

<u>Cleanup and Storage Procedures for Significant/Hazardous Spills</u>

- For significant or hazardous spills that cannot be controlled by personnel in the immediate vicinity, notify the local emergency response by dialing 911. In addition to 911, the contractor will notify the proper county officials. It is the contractor's responsibility to have all emergency phone numbers at the construction site.

- For spills of federal reportable quantities, in conformance with the requirements in 40 CFR parts 110,119, and 302, the contractor shall notify the National Response Center at (800) 424-8802.
- Notification shall first be made by telephone and followed up with a written report.
- The services of a spills contractor or a Haz-Mat team shall be obtained immediately. Construction personnel shall not attempt to clean up the spill until the appropriate and qualified personnel have arrived at the job site.

REFERENCE

California Department of Transportation, Construction Site BMP Manual, 2000 or later

BMP CN – 105
SOLID WASTE MANAGEMENT

DESCRIPTION

Solid waste management procedures and practices are designed to minimize or eliminate the discharge of pollutants to the drainage system or to watercourses as a result of the creation, stockpiling, or removal of construction site wastes.

Solid waste management procedures and practices are implemented on all construction projects that generate solid wastes.

Solid wastes include but are not limited to:

1. Construction wastes including brick, mortar, timber, steel and metal scraps, sawdust, pipe and electrical cuttings, non-hazardous equipment parts, styrofoam and other materials used to transport and package construction materials.
2. Landscaping wastes, including vegetative material, plant containers, and packaging materials.
3. Litter, including food containers, beverage cans, coffee cups, paper bags, plastic wrappers, and smoking materials, including litter generated by the public.

LIMITATIONS

1. Temporary stockpiling of certain construction wastes may not necessitate stringent drainage related controls during the non-rainy season.

DESIGN CRITERIA

1. Dumpsters of sufficient size and number shall be provided to contain the solid waste generated by the project and properly serviced.
2. Littering on the project site shall be prohibited.
3. To prevent clogging of the storm drainage system, litter and debris removal from drainage grates, trash racks, and ditch lines shall be a priority.
4. Trash receptacles with lids shall be provided in the contractor’s yard, field trailer areas, and at locations where workers congregate for lunch and break periods.
5. Construction debris and litter from work areas within the construction limits of the project site shall be collected and placed in watertight dumpsters at least weekly regardless of whether the litter was generated by the contractor, the public, or others. Collected litter and debris shall not be placed in or next to drain inlets, storm water drainage systems or watercourses.
6. Full dumpsters shall be removed from the project site and the contents shall be disposed of, off-site, in an appropriate manner.;
7. Litter stored in collection areas and containers shall be handled and disposed of by trash hauling contractors.
8. Construction debris and waste shall be removed from the site every two weeks.
9. Stormwater run-off shall be prevented from contacting stored solid waste through the use of berms, dikes, or other temporary diversion structures or through the use of measures to elevate waste from site surfaces.
10. Solid waste storage areas shall be located at least 50 ft from drainage facilities and watercourses and shall not be located in areas prone to flooding or ponding.

11. Except during fair weather, construction and landscaping waste not stored in watertight dumpsters shall be securely covered from wind and rain by covering the waste with tarps, plastic sheeting, or equivalent.
12. Dumpster washout on the project site is not allowed.
13. Notify trash hauling contractors that only watertight dumpsters are acceptable for use on-site.
14. Plan for additional containers during the demolition phase of construction.
15. Plan for more frequent pickup during the demolition phase of construction.
16. Construction waste shall be stored in a designated area. Access to the designated area shall either be well vegetated ground, a concrete or asphalt road or drive, or a gravel construction entrance, to avoid mud tracking by trash hauling contractors.
17. Segregate potentially hazardous waste from non-hazardous construction site waste.
18. Keep the site clean of litter debris.
19. Make sure that toxic liquid wastes (e.g., used oils, solvents, and paints) and chemicals (e.g., acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
20. For disposal of hazardous waste, see BMP CN-106: Hazardous Waste Management. Have hazardous waste hauled to an appropriate disposal and/or recycling facility.
21. Salvage or recycle useful vegetation debris, packaging and/or surplus building materials when practical. For example, trees and shrubs from land clearing can be converted into wood chips, then used as mulch on graded areas. Wood pallets, cardboard boxes, and construction scraps can also be recycled.
22. Prohibit littering by employees, subcontractors, and visitors.
23. Wherever possible, minimize production of solid waste materials.

REFERENCE

California Department of Transportation, Construction Site BMP Manual, 2000 or later

BMP CN – 106
HAZARDOUS WASTE MANAGEMENT

DESCRIPTION

These are procedures and practices to minimize or eliminate the discharge of pollutants from construction site hazardous waste to the storm drain systems or to watercourses.

This best management practice (BMP) applies to all construction projects.

Hazardous waste management practices are implemented on construction projects that generate waste from the use of:

- Petroleum Products,
- Asphalt Products,
- Concrete Curing Compounds,
- Pesticides,
- Acids,
- Paints,
- Stains,
- Solvents,
- Wood Preservatives,
- Roofing Tar, or
- Any materials deemed a hazardous waste in 40 CFR Parts 110, 117, 261, or 302.

DESIGN CRITERIA

<u>Storage Procedures</u>

1. Wastes shall be stored in sealed containers constructed of a suitable material and shall be labeled as required by 49 CFR Parts 172,173, 178, and 179.
2. All hazardous waste shall be stored, transported, and disposed as required in 49 CFR 261-263.
3. Waste containers shall be stored in temporary containment facilities that shall comply with the following requirements:
   - Temporary containment facility shall provide for a spill containment volume able to contain precipitation from a 24-hour, 25 year storm event, plus the greater of 10% of the aggregate volume of all containers or 100% of the capacity of the largest tank within its boundary, whichever is greater.
   - Temporary containment facility shall be impervious to the materials stored there for a minimum contact time of 72 hours.
   - Temporary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks accumulated rainwater and spills shall be placed into drums after each rainfall. These liquids shall be handled as a hazardous waste unless testing determines them to be non-hazardous. Non-hazardous liquids shall be sent to an approved disposal site.
   - Sufficient separation shall be provided between stored containers to allow for spill cleanup and emergency response access.
   - Incompatible materials, such as chlorine and ammonia, shall not be stored in the same temporary containment facility.

- Throughout the rainy season, temporary containment facilities shall be covered during non-working days, and prior to rain events. Covered facilities may include use of plastic tarps for small facilities or constructed roofs with overhangs. A storage facility having a solid cover and sides is preferred to a temporary tarp. Storage facilities shall be equipped with adequate ventilation.

4. Drums shall not be overfilled and wastes shall not be mixed.
5. Unless watertight, containers of dry waste shall be stored on pallets.
6. Paint brushes and equipment for water and oil based paints shall be cleaned within a contained area and shall not be allowed to contaminate site soils, watercourses or drainage systems. Waste paints, thinners, solvents, residues, and sludge that cannot be recycled or reused shall be disposed of as hazardous waste. When thoroughly dry, latex paint and paint cans, used brushes, rags, absorbent materials, and drop cloths shall be disposed of as solid waste.
7. Ensure that adequate hazardous waste storage volume is available.
8. Ensure that hazardous waste collection containers are conveniently located.
9. Designate hazardous waste storage areas on site away from storm drains or watercourses and away from moving vehicles and equipment to prevent accidental spills.
10. Minimize production or generation of hazardous materials and hazardous waste on the job site.
11. Use containment berms in fueling and maintenance areas and where the potential for spills is high.
12. Segregate potentially hazardous waste from non-hazardous construction site debris.
13. Keep liquid or semi-liquid hazardous waste in appropriate containers (closed drums or similar) and under cover.
14. Clearly label all hazardous waste containers with the waste being stored and the date of accumulation.
15. Place hazardous waste containers in secondary containment.
16. Do not allow potentially hazardous waste materials to accumulate on the ground.
17. Do not mix wastes.

<u>Disposal Procedures</u>

1. Waste shall be removed from the site within 90 days of being generated.
2. Waste shall be disposed of by a licensed hazardous waste transporter at an authorized and licensed disposal facility or recycling facility utilizing properly completed Uniform Hazardous Waste Manifest forms.
3. A certified laboratory shall sample waste and classify it to determine the appropriate disposal facility.
4. Make sure that toxic liquid wastes (e.g., used oils, solvents, and paints) and chemicals (e.g., acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for solid waste construction debris.
5. Properly dispose of rainwater in secondary containment that may have mixed with hazardous waste.
6. Recycle any useful material such as used oil or water-based paint when practical.

<u>Maintenance and Inspection</u>

1. A foreman and/or construction supervisor shall monitor on-site hazardous waste storage and disposal procedures.
2. Waste storage areas shall be kept clean, well organized, and equipped with ample clean-up supplies as appropriate for the materials being stored.

3. Storage areas shall be inspected in conformance with the provisions in the contract documents.
4. Perimeter controls, containment structures, covers, and liners shall be repaired or replaced as needed to maintain proper function.
5. Hazardous spills shall be cleaned up and reported in conformance with the applicable Material Safety Data Sheet (MSDS) and the instructions posted at the project site.
6. The National Response Center, at (800) 424-8802, shall be notified of spills of Federal reportable quantities in conformance with the requirements in 40 CFR parts 110, 117, and 302.
7. Copy of the hazardous waste manifests shall be provided to the owner.

REFERENCE

California Department of Transportation, Construction Site BMP Manual, 2000 or later

CHAPTER 700 POST-CONSTRUCTION STORMWATER QUALITY MANAGEMENT

SECTION 701 INTRODUCTION

701.01 Purpose and Background

The City of Noblesville has established a minimum standard that the measurement of the effectiveness of the control of stormwater runoff quality will be based on the management of Total Suspended Solids (TSS). This requirement is being adopted as the basis of the City of Noblesville stormwater quality management program for all areas of jurisdiction.

This chapter establishes minimum standards for the selection and design of construction water quality BMPs. The information provided in this Chapter establishes performance criteria for stormwater quality management and procedures to be followed when preparing a BMP plan for compliance. Post-Construction BMPs must be sized to treat the water quality volume, WQv, for detention-based BMPs or the water quality discharge, Qwq, for flow-through BMPs. Section 701.05 provides the methodology for calculating the WQv and Qwq values.

BMPs noted in this Chapter refer to post-construction BMPs, which continue to treat stormwater after construction has been completed and the site has been stabilized. Installing certain BMPs, such as bioretention areas and sand filters, prior to stabilization can cause failure of the measure due to clogging from sediment. If such BMPs are installed prior to site stabilization, they should be protected by traditional erosion control measures.

Conversely, detention ponds and other BMPs can be installed during construction and used as sediment control measures. In those instances, the construction sequence must require that the pond is cleaned out with pertinent elevations and storage and treatment capacities reestablished as noted in the accepted stormwater management plan.

Also, a set of standard detail drawings is included in Chapter 300 as Appendix 301-1 that provides guidance on the design and installation of various hydraulic structures that may not have been covered in this chapter. Adherence to the noted standard details shall be required in addition to other requirements in this chapter. In case of discrepancy, the most restrictive requirement shall apply.

701.02 Abbreviations and Definitions

BMP:	Best management practices can refer to structural measures (wetlands, ponds, sand filters, etc.) or non-structural measures (restrictive zoning, reduced impervious areas, etc.). BMPs are designed for the benefit of water quality and quantity. For the purposes of this chapter, BMPs refer to structural water quality BMPs.
BMP owner:	The owner of the BMP, typically the property owner. The BMP owner may also be the leasee of property in the case of long term leases of commercial or industrial zoned properties. The leasee is considered the BMP owner only if the lease specifically states that construction by the leasee must meet applicable local codes and regulations.
BOD:	Biochemical oxygen demand
Contributing drainage area:	Contributing drainage area refers to the total drainage area to a given point, including offsite drainage.
Effective Drainage Area:	Effective drainage area refers to the drainage area from a specific site, excluding offsite drainage, where offsite

	drainage either does not exist or where offsite drainage bypasses the site through culverts or other means.
Impervious Area:	Impervious areas are areas where the land surface has been altered to decrease the amount of rainwater infiltration. Impervious surfaces include paved roads, concrete driveways and rooftops.
Offline structure:	Offline structures are BMPs that treat only the water quality volume (WQv). Flows exceeding the WQv bypass the structure and re-enter the watercourse below the BMP.
Redevelopment:	Redevelopment means any construction, alteration, or improvement where structures are removed and/or replaced. Where the disturbance caused by redevelopment activities disturbs less than 0.5 acres, no water quality BMP plan shall be required. Staff has the discretion to exempt redevelopment activities disturbing up to 5% more area.
Stormwater Quality Management:	A system of vegetative, structural, and other measures that reduce or eliminate pollutants that might otherwise be carried by surface runoff.
Total P:	Total phosphorus
Total N:	Total nitrogen.
TSS:	Total suspended solids.
Treatment train:	A treatment train consists of more than one BMP in series treating stormwater runoff. Such configurations are necessary when BMPs individually cannot meet the TSS reduction goal stated in the Ordinance.
Watershed:	Watershed refers to the total drainage area contributing runoff to a single point.

701.03 Policy on Post-Construction Stormwater Quality Management

It is recognized that developed areas, as compared to undeveloped areas, generally have increased imperviousness, decreased infiltration rates, increased runoff rates, and increased concentrations of pollutants such as fertilizers, herbicides, greases, oil, salts and other pollutants. As new development and re-development continues in the City of Noblesville, measures must be taken to intercept and filter pollutants from stormwater runoff prior to reaching regional creeks, streams, and rivers. Through the use of Best Management Practices (BMP), stormwater runoff will be filtered and harmful amounts of sediment, nutrients, and contaminants will be removed. The City of Noblesville has established a minimum standard that the measurement of the effectiveness of the control of stormwater quality will be based on the management of Total Suspended Solids (TSS).

The project site owner must submit to the City of Noblesville, a Storm Water Pollution Prevention Plan (SWPPP) that would show placement of appropriate BMP(s) from a pre-approved list of BMPs specified in this chapter. The noted BMPs must be designed, constructed, and maintained according to guidelines provided or referenced in this chapter. Practices other than those specified in the pre-approved list may be utilized. However, the burden of proof as to whether the performance (minimum Ordinance-required TSS removal rate) and ease of maintenance of such practices will be according to guidelines provided in this chapter would be placed with the applicant. Details regarding the procedures and criteria for consideration of acceptance of such BMPs are provided in section 701.06.

In addition to the provisions of this chapter, the industrial site owners must also ensure that the SWPPP required under this chapter would incorporate measures that are consistent with requirements contained in IDEM Rule 6 (327IAC-15-6).

Gasoline outlets and refueling areas must install appropriate practices to reduce lead, copper, zinc, and hydrocarbons in stormwater runoff. These requirements will apply to all new facilities and existing facilities that replace their tanks.

701.04 Applicability and Exemptions

In addition to the requirements of Chapter 600, the stormwater pollution prevention plan, which is to be submitted to the City of Noblesville as part of the stormwater management permit application, must also include post-construction stormwater quality measures. These measures are incorporated as a permanent feature into the site plan and are left in place following completion of construction activities to continuously treat stormwater runoff from the stabilized site. Any project located within the City of Noblesville and includes clearing, grading, excavation, and other land disturbing activities resulting in the disturbance of 1 acre or more of total land area is subject to the requirements of this Chapter. This includes both new development and re-development, and disturbances of less than one (1) acre of land that are part of a larger common plan of development or sale if the larger common plan will ultimately disturb one (1) or more acres of land, within the area under the jurisdictional authority of the City of Noblesville.

The requirements under this chapter do not apply to the following activities:

A. agricultural land disturbing activities; or
B. timber harvesting activities; or
C. construction activities associated with a single family residential dwelling disturbing less than 5 acres, when the dwelling is not part of a larger common plan of development or sale; or
D. single family residential developments consisting of four or less lots; or
E. a single-family residential strip development where the developer offers for sale or lease without land improvements and the project is not part of a larger common plan of development of sale; or
F. individual building lots within a larger permitted project.

The requirements under this chapter do not apply to the following activities, provided other applicable State permits contain provisions requiring immediate implementation of soil erosion control measures:

A. Landfills that have been issued a certification of closure under 329 IAC 10.
B. Coal mining activities permitted under IC 14-34.
C. Municipal solid waste landfills that are accepting waste pursuant to a permit issued by the Indiana Department of Environmental Management under 329 IAC 10 that contains equivalent stormwater requirements, including the expansion of landfill boundaries and construction of new cells either within or outside the original solid waste permit boundary.

It will be the responsibility of the project site owner to complete a stormwater permit application and ensure that a sufficient construction plan is completed and submitted to the City of Noblesville in accordance with Chapter 100. It will be the responsibility of the project site owner to ensure proper construction and installation of all stormwater BMPs in compliance with this Ordinance and with the approved stormwater management permit, and to notify the City of Noblesville with a Notice of Termination letter upon completion of the project and stabilization of the site. However, all eventual property owners of stormwater quality facilities meeting the applicability requirements must comply with the requirements of this Chapter.

701.05
Post-Construction Stormwater Quality Management Calculations

Calculation of land disturbance should follow the guidelines discussed in Chapter 600.

The calculation methods as well as the type, sizing, and placement of all stormwater quality management measures, or BMPs shall meet the design criteria, standards, and specifications outlined in the *Indiana Stormwater Quality Manual* or this chapter. The methods and procedures included in these two references are in keeping with the above stated policy and meet the requirements of IDEM's Rule 13.

Structural Water Quality BMPs are divided into two major classifications: detention BMPs and Flow-through BMPs. Detention BMPs impound (pond) the runoff to be treated, while flow through BMPs treat the runoff through some form of filtration process.

DETENTION BMP SIZING

Water Quality Detention BMPs must be designed to store the water quality volume for treatment. The water quality volume, WQv, is the storage needed to capture and treat the runoff from the first one inch of rainfall. The water quality volume is equivalent to one inch of rainfall multiplied by the volumetric runoff coefficient (Rv) multiplied by the site area, or:

$$\mathbf{WQv = \frac{(P)\,(Rv)\,(A)}{12}}$$

where:
WQv = water quality volume (acre-feet)
P = 1 inch of rainfall
Rv = volumetric runoff coefficient
A = area in acres

The volumetric runoff coefficient is a measure of imperviousness for the contributing area, and is calculated as:

$$\mathbf{Rv = 0.05 + 0.009(I)}$$

Where:
I is the percent impervious cover

For example, a proposed commercial site will be designed to drain to three different outlets, with the following drainage areas and impervious percentages:

Subarea ID	On-site Contributing Area (acres)	Impervious Area %	Off-Site Contributing Area (acres)
A	7.5	80	0.0
B	4.3	75	0.0
C	6.0	77	0.0

Calculating the volumetric runoff coefficient for subareas A, B and C yields:

Rv (subarea A) = 0.05+0.009(80)=0.77
Rv (subarea B) = 0.05+0.009(75)=0.73
Rv (subarea C) = 0.05+0.009(77)=0.74

The water quality volumes for these three areas are then calculated as:

WQv (subarea A) = (1")(Rv)(A)/12=0.77(7.5)/12=0.48 acre-feet
WQv (subarea B) = 0.73(4.3)/12=0.26 acre-feet
WQv (subarea C) = 0.74(6.0)/12=0.37 acre-feet

Note that this example assumed no offsite sources of discharge through the water quality detention BMPs. If there were significant sources of off-site runoff (sometimes called runon for upstream areas draining to the site), the designer would have the option of diverting off-site runoff around the on-site systems, or the detention BMP should be sized to treat the water quality volume for the entire contributing area, including off-site sources.

FLOW THROUGH BMP SIZING

Flow through BMPs are designed to treat runoff at a peak design flow rate through the system. Examples of flow through BMPs include catch basin inserts, sand filters, and grassed channels. Another flow through BMP which is gaining popularity is a dynamic separator. Dynamic separators are proprietary, and usually include an oil-water separation component.

The following procedure should be used to estimate peak discharges for flow through BMPs (adopted from Maryland, 2000). It relies on the volume of runoff computed using the Small Storm Hydrology Method (Pitt, 1994) and utilizes the NRCS, TR-55 Method.

Using the WQv methodology, a corresponding Curve Number (CNwq) is computed utilizing the following equation:

$$CNwq = \frac{1000}{\left[10 + 5P + 10Qa - 10\sqrt{Qa^2 + 1.25QaP}\right]}$$

where:
CNwq = curve number for water quality storm event
P = 1" (rainfall for water quality storm event)
Qa = runoff volume, in inches = 1"×Rv = Rv (inches)
Rv=volumetric runoff coefficient (see previous section)

Due to the complexity of the above equation, the water quality curve number is represented as a function of percent imperviousness in **Exhibit 701-1**.

The water quality curve number, CNwq, is then used in conjunction with the standard calculated time-of-concentration, tc, and drainage area as the basis input for TR-55 calculations. Using the SCS Type II distribution for 1 inch of rainfall in 24-hours, the water quality treatment rate, Qwq, can then be calculated.

701.06
Pre-Approved BMPs

The City of Noblesville has designated a number of pre-approved BMP methods to be used alone or in combination to achieve the TSS removal stormwater quality goals according to the City of Noblesville's Ordinance. These BMP measures are listed along with their anticipated average TSS removal rates in **Table 701-1**. Pre-approved BMPs have been proven/are assumed to achieve the average TSS removal rates indicated in **Table 701--1**. Applicants desiring to use a different TSS removal rate for these BMPs must follow the requirements discussed above for Innovative BMPs. Details regarding the applicability and design of these pre-approved BMPs are contained within fact sheets presented in **Appendix 701-1**.

Note that a single BMP measure may not be adequate to achieve the water quality goals for a project. It is for this reason that a "treatment train", a number of BMPs in series, is often required for a project.

701.07
Innovative BMPs

BMPs not previously accepted by the City of Noblesville must be certified by a professional engineer licensed in State of Indiana and accepted through the City of Noblesville. ASTM standard methods must be followed when verifying performance of new measures. New BMPs, individually or in combination, must meet the Ordinance-required TSS removal rate at 50-125 micron range (silt/fine sand) without re-entrainment and must have a low to medium maintenance requirement to be considered by the City of Noblesville. Testing to establish the TSS removal rate must be conducted by an independent testing facility, not the BMP manufacturer.

701.08
Easement Requirements

All stormwater quality management systems, including detention or retention basins, filter strips, pocket wetlands, in-line filters, infiltration systems, conveyance systems, structures and appurtenances located outside of the right-of-way shall be designated as common areas or incorporated into permanent easements. For the purposes of access, monitoring, inspection, and general maintenance activities, adequate easement width, as detailed in Table 701-1, beyond the actual footprint of the stormwater quality management facility as well as a 20-foot wide access easement from a public right-of-way to each BMP shall be provided. The easement requirements noted in Table 701-1 and this section may be changed by the City of Noblesville as deemed necessary for specific cases.

701.09
Inspection, Maintenance, Record Keeping, and Reporting

After the approval of the stormwater management permit by the City of Noblesville and the commencement of construction activities, the City of Noblesville has the authority to conduct inspections of the work being done to ensure full compliance with the provisions of this chapter, this document, and the terms and conditions of the approved permit.

Stormwater quality facilities shall be maintained in good condition, in accordance with the Operation and Maintenance procedures and schedules listed in the *Indiana Stormwater Quality Manual* or this document, and/or the terms and conditions of the approved stormwater permit, and shall not be subsequently altered, revised, or replaced except in accordance with the approved stormwater permit, or in accordance with approved amendments or revisions in the permit. Checklists provided in **Appendix 701-2** or equivalent forms must be completed and maintained by the owner.

The City of Noblesville also has the authority to perform long-term, post-construction inspection of all public or privately owned stormwater quality facilities. The inspections will follow the operation and maintenance procedures included in this document and/or permit application for each specific BMP. The inspection will cover physical conditions, available water quality storage capacity and the operational condition of key facility elements. Noted deficiencies and recommended corrective action will be included in an inspection report.

BMP Description	Anticipated Average % TSS Removal Rate[D]	Fact Sheet	Maintenance Easement Requirements
Bioretention[A]	75	PC-101	25 feet wide along the perimeter
Constructed Wetland	65	PC-102	25 feet wide along the outer perimeter of forebay & 30 feet wide along centerline of outlet
Underground detention	70	PC-103	20 feet wide strip from access easement to tank's access shaft & 30 feet wide along centerline of inlet and outlet
Extended Dry Detention	72	PC-103	25 feet wide along the outer perimeter of forebay & 30 feet wide along centerline of outlet
Infiltration Basin[A]	87	PC-104	25 feet wide along the perimeter
Infiltration Trench[A]	87	PC-105	25 feet wide along the perimeter
Media Filtration – Underground Sand	80	PC-106	25 feet wide along the perimeter
Media Filtration – Surface Sand	83	PC-106	25 feet wide along the perimeter
Storm Drain Insert[C]	NA[B]	PC-107	20 feet wide strip from access easement to chamber's access shaft
Filter Strip	48	PC-108	25 feet wide along the length on the pavement side
Vegetated Swale	60	PC-109	25 feet wide along the top of bank on one side
Wet Pond	80	PC-110	25 feet wide along the outer perimeter of forebay & 30 feet wide along centerline of outlet

Notes:

A. Based on capture of 0.5-inch of runoff volume as best available data. Effectiveness directly related to captured runoff volume, increasing with larger capture volumes.
B. The removal rate for this category varies widely between various models and manufacturers. Independent testing should be provided, rather than the manufacturer's testing data.
C. Must provide vendor data for removal rates.
D. Removal rates shown are based on typical results. These rates are also dependent on proper installation and maintenance. The ultimate responsibility for determining whether additional measures must be taken to meet the Ordinance requirements for site-specific conditions rests with the applicant.

TABLE 701-1: Pre-approved Post-construction BMPs

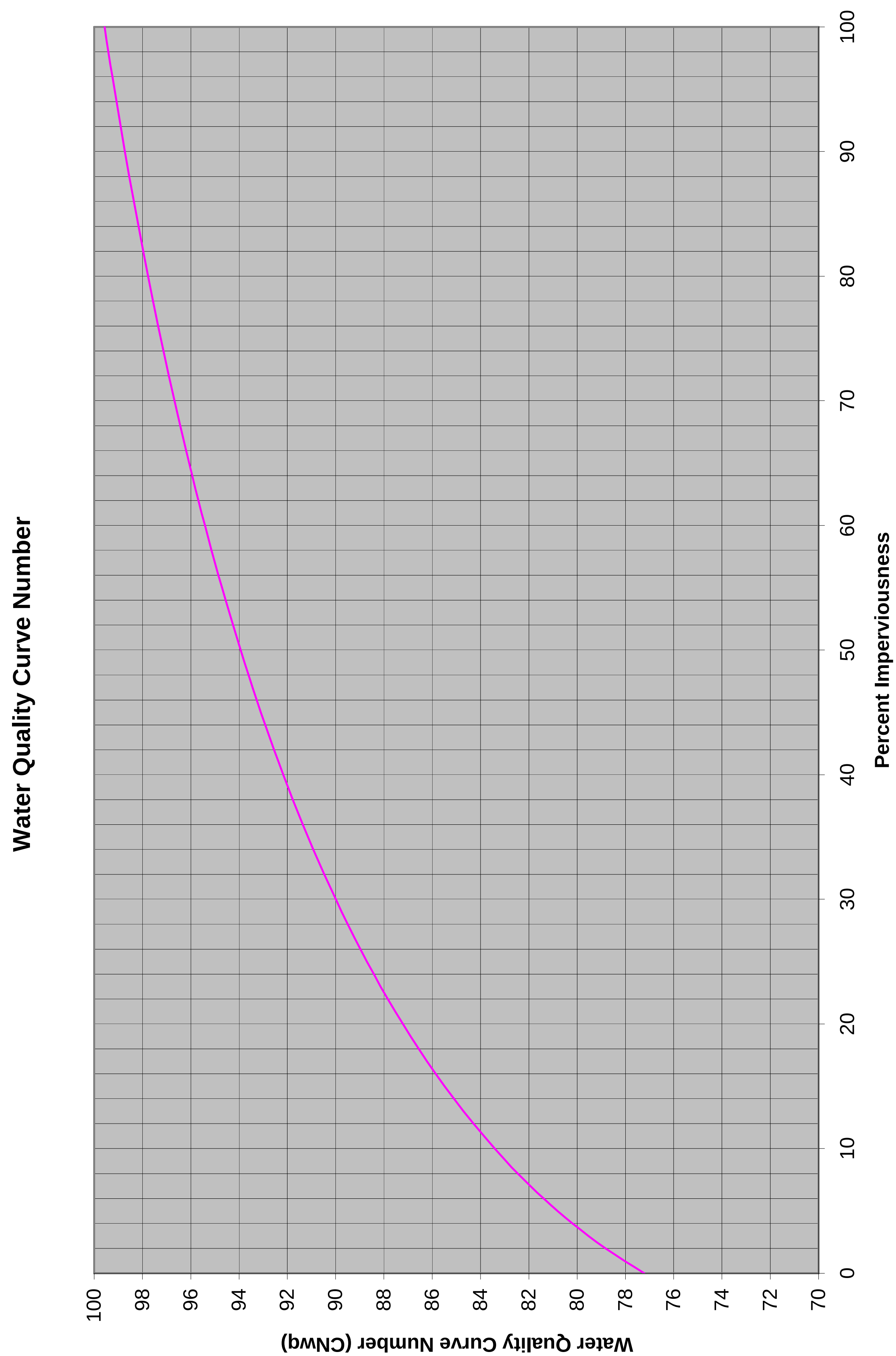


Exhibit 701-1: Curve Number Calculation for Water Quality Storm Event

APPENDIX 701-1

POST-CONSTRUCTION BMP FACT SHEETS

BMP PC – 101
BIORETENTION FACILITY

DESCRIPTION

Bioretention is a best management practice (BMP) developed in the early 1990's by the Prince George's County, MD, Department of Environmental Resources (PGDER). Bioretention utilizes soils and both woody and herbaceous plants to remove pollutants from stormwater runoff. As shown in Figure PC-101A, runoff is conveyed as sheet flow to the treatment area, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff passes first over or through a sand bed, which slows the runoff's velocity, distributes it evenly along the length of the ponding area, which consists of a surface organic layer and/or ground cover and the underlying planting soil. The ponding area is graded; its center depressed. Water is ponded to a depth of 6 inches and gradually infiltrates the bioretention area and/or is evapotranspired. Bioretention areas are applicable as on-lot retention facilities that are designed to mimic forested systems that naturally control hydrology. The bioretention area is graded to drain excess runoff over a weir and into the storm drain system. Stored water in the bioretention area planting soil infiltrates over a period of days into the underlying soils.

The basic bioretention design shown below can be modified to accommodate more specific needs. The bioretention BMP design can be modified to include an underdrain within the sand bed to collect the infiltrated water and discharge it to a downstream storm drain system. This modification may be required when impervious subsoils and marine clays prevent complete infiltration in the soil system. This modified design makes the bioretention area act more as a filter that discharges treated water than as an infiltration device.

COMPONENTS

1. Grass Buffer Strip -Designed to filter out particulates and reduce runoff velocity.
2. Sand Bed -Further reduces velocity by capturing a portion of the runoff and distributes it evenly along the length of the ponding area. Also provides aeration to the plant bed and enhances infiltration.
3. Ponding Area -Collects and stores runoff prior to infiltration.
4. Organic/Mulch Layer -Provides some filtering of runoff, encourages development of beneficial microorganisms, and protects the soil surface from erosion.
5. Planting Soil -Provides nourishment for the plant life. Clay particles within the soil also remove certain pollutants through adsorption.
6. Plants -Provides uptake of harmful pollutants.

ADVANTAGES

1. If designed properly, has shown ability to remove significant amounts of dissolved heavy metals, phosphorous, TSS, and fine sediments.
2. Requires relatively little engineering design in comparison to other stormwater management facilities (e.g. sand filters).
3. Provides groundwater recharge when the runoff is allowed to infiltrate into the subsurface.
4. Enhances the appearance of parking lots and provides shade and wind breaks, absorbs noise, and improves an area's landscape.

5. Maintenance on a bioretention facility is limited to the removal of leaves from the bioretention area each fall.
6. The vegetation recommended for use in bioretention facilities is generally hardier than the species typically used in parking lot landscapes. This is a particular advantage in urban areas where plants often fare poorly due to poor soils and air pollution.

LIMITATIONS

1. Low removal of nitrates.
2. Not applicable on steep, unstable slopes or landslide areas (slopes greater than 20 percent).
3. Requires relatively large areas.
4. Not appropriate at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
5. Clogging may be a problem, particularly if the BMP receives runoff with high sediment loads.

DESIGN CRITERIA

1. Calculate the volume of stormwater to be mitigated by the bioretention facility using the water quality volume calculations outlined in Section 701-05.
2. The soil should have infiltration rates greater than 0.5 inches per hour, otherwise an underdrain system should be included (see # 11).
3. Drainage to the bioretention facility must be graded to create sheet flow, not a concentrated stream. Level spreaders (i.e. slotted curbs) can be used to facilitate sheet flow. The maximum sheet flow velocity should be 1 ft/s for the planted ground cover and 3 ft/s for mulched cover.
4. Soil shall be a uniform mix, free of stones, stumps, roots or other similar objects larger than 1-inch in diameter. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations. The planting soil shall be free of noxious weeds.
5. Planting soil shall be tested and meet the following criteria:

Planting Soil Criteria	
pH range	5.2-7.0
Organic matter	1.5-4.0%
Magnesium	35 lbs. per acre, minimum
Phosphorus P_2O_5	75 lbs. per acre, minimum
Potassium K_2O	85 lbs. per acre, minimum
Soluble salts	not to exceed 500 ppm
Clay	0-25% by volume
Silt	30-55% by volume
Sand	35-60% by volume

6. It is very important to minimize compaction of both the base of the bioretention area and the required backfill. When possible, use excavation hoes to remove original soil. If excavated using a loader, the excavator should use a wide track or marsh track equipment, or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high pressure tires will cause excessive

compaction resulting in reduced infiltration rates and storage volumes and is not acceptable. Compaction will significantly contribute to design failure.

7. Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are to refracture the soil profile through the 12 inch compaction zone. Substitute methods must be approved by the engineer. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment. Rototill 2 to 3 inches of sand into the base of the bioretention facility before back filing the required sand layer. Pump any ponded water before preparing (rototilling) base.
8. When back filling topsoil over the sand layer, first place 3 to 4 inches of topsoil over the sand, then rototill the sand/topsoil to create a gradation zone. Backfill the remainder of the topsoil to final grade.
9. Mulch around individual plants only. Shredded hardwood mulch is the only accepted mulch. Shredded hardwood mulch must be well aged (stockpiled or stored for at least 12 months) for acceptance. The mulch should be applied to a maximum depth of 3-inches.
10. The plant root ball should be planted so 1/8th of the ball is above final grade surface.
11. If used, place underdrains on a 3 feet wide section of filter cloth followed by a gravel bedding. Pipe is placed next, followed by the gravel bedding. The ends of underdrain pipes not terminating in an observation well shall be capped.
12. The main collector pipe for underdrain systems shall be constructed at a minimum slope of 0.5%. Observation wells and/or clean-out pipes must be provided (one minimum per every 1,000 square feet of surface area).
13. Size an emergency overflow weir with 6-inches of head, using the Weir equation: $Q=CLH^{3/2}$ Where C= 2.65 (smooth crested grass weir)
    Q= flow rate H = 6-inches of head L = length of weir
14. Bioretention areas should be at least 15 feet wide with a 25 foot width preferable, and a minimum length of 40 feet long. Generally, the length-to-width ratio should be around 2 to 1 to improve surface flow characteristics.
15. The plant soil depth should be 4 feet or more to provide beneficial root zone, both in terms of space and moisture content.
16. The depth of the ponding area should be limited to no more than 6 inches to limit the duration of standing water to no more than 4 days. If an underdrain system is used, the depth of the ponding area should be limited to no more than 1 foot. Longer ponding times can lead to anaerobic conditions that are not conductive to plant growth. Longer periods of standing water can also lead to the breeding of mosquitoes and other pests.
17. The bioretention area should be vegetated to resemble a terrestrial forest community ecosystem, which is dominated by understory trees, a shrub layer, and herbaceous ground covers. Three species each of both trees and shrubs are recommended to be planted at a rate of 1000 total trees and shrubs per acre. The shrub-to-tree ratio should be 2:1 to 3:1. Trees should be spread 12 feet apart and the shrubs should be spaced 8 feet apart.

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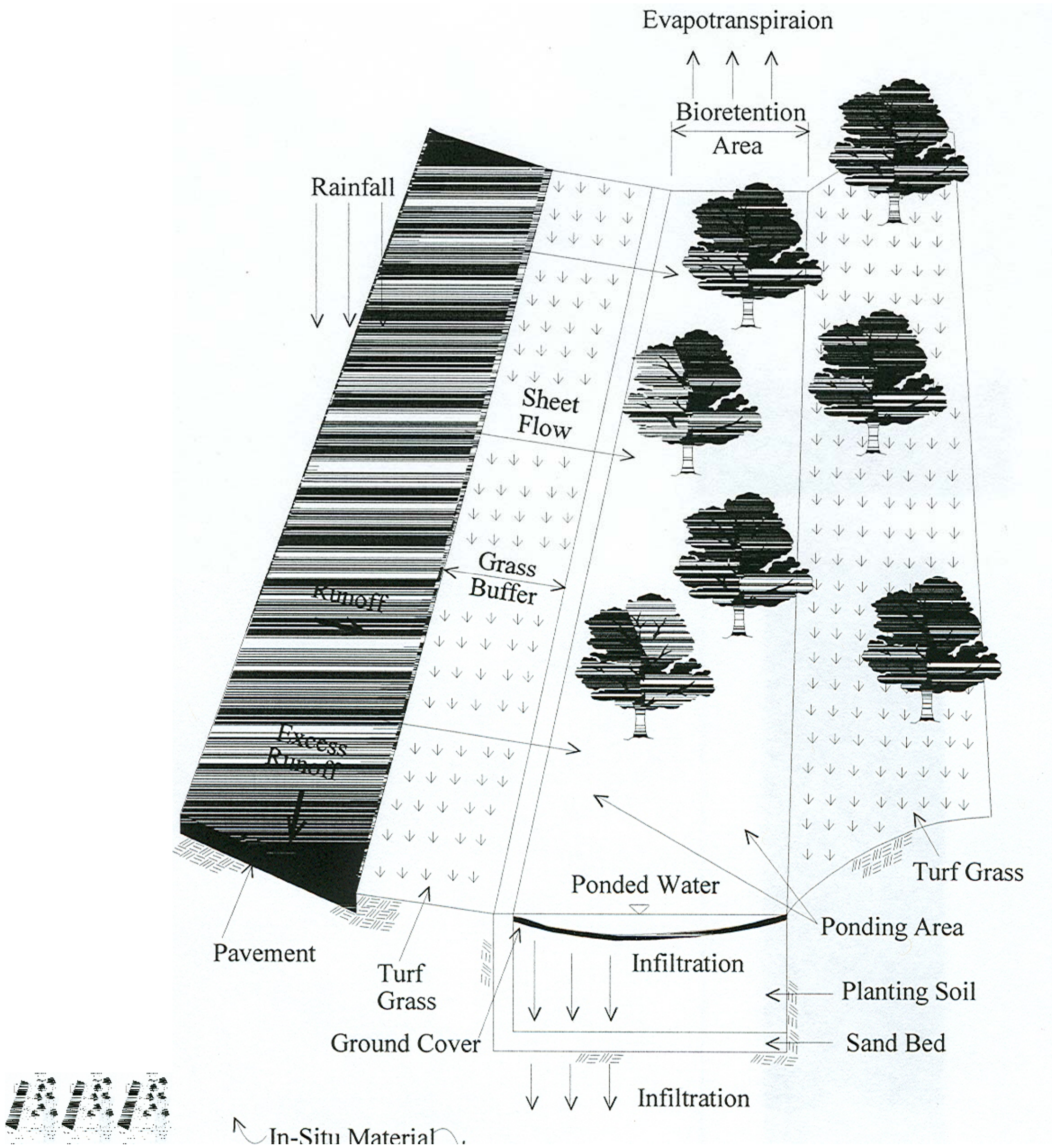

Figure PC-101A
Schematic of Bioretention Area (SUSMP, 2002)

BMP PC – 102
CONSTRUCTED WETLANDS

DESCRIPTION

Wetlands provide physical, chemical, and biological water quality treatment of stormwater runoff. Physical treatment occurs as a result of decreasing flow velocities in the wetland, and is present in the form of evaporation, sedimentation, adsorption, and/or filtration. Chemical processes include chelation, precipitation, and chemical adsorption. Biological processes include decomposition, plant uptake and removal of nutrients, plus biological transformation and degradation. Hydrology is one of the most influential factors in pollutant removal due to its effects on sedimentation, aeration, biological transformation, and adsorption onto bottom sediments (Dormann, et al., 1988). The large surface area of the bottom of the wetland encourages higher levels of adsorption, absorption, filtration, microbial transformation, and biological utilization than might normally occur in more channelized water courses.

A natural wetland is defined by examination of the soils, hydrology, and vegetation which are dominant in the area. Wetlands are characterized by the substrate being predominantly undrained hydric soil. A wetland may also be characterized by a substrate which is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. Wetlands also usually support hydrophytes, or plants which are adapted to aquatic and semiaquatic environments. Natural and artificial wetlands are used to treat stormwater runoff. Figure PC-102A illustrates an artificial wetland used for treating stormwater runoff.

The success of a wetland will be much more likely if some general guidelines are followed. The wetland should be designed such that a minimum amount of maintenance is required. This will be affected by the plants, animals, microbes, and hydrology. The natural surroundings, including such things as the potential energy of a stream or a flooding river, should be utilized as much as possible. It is necessary to recognize that a fully functional wetland cannot be established spontaneously. Time is required for vegetation to establish and for nutrient retention and wildlife enhancement to function efficiently. Also, the wetland should approximate a natural situation as much as possible, and unnatural attributes, such as a rectangular shape or a rigid channel, should be avoided (Mitsch and Gosselink, 1993).

1. *Natural Wetland Systems*. Existing wetlands perform storm water treatment in the same fashion as constructed wetlands. However, current policy of the Indiana Department of Environmental Management prohibit the use of existing wetlands as a pollution control measure. Therefore, the use of existing wetlands as a proposed BMP cannot be accepted under any circumstance by the City of Noblesville without the prior written acceptance by IDEM for such proposed pollution control use.

2. Constructed (*Artificial) Wetlands.* Site considerations should include the water table depth, soil/substrate, and space requirements. Because the wetland must have a source of flow, it is desirable that the water table is at or near the surface. This is not always possible. If runoff is the only source of inflow for the wetland, the water level often fluctuates and establishment of vegetation may be difficult. The soil or substrate of an

artificial wetland should be loose loam to clay. A perennial base flow must be present to sustain the artificial wetland. The presence of organic material is often helpful in increasing pollutant removal and retention.

Wetland vegetation can be categorized as emergent, floating, or submerged. Emergent vegetation is rooted in the sediments, but grows through the water and above the water surface. Floating vegetation is not rooted in the sediments, and has aquatic roots with plant parts partly submerged or fully exposed on the water or surface. Submerged vegetation includes aquatic plants such as algae or plants rooted in the sediments, with all plant parts growing within the water column. Pollutant removal rates generally improve with an increase in the diversity of the vegetation.

The depth of inundation will contribute to the pollutant removal efficiency. Generally, shallow water depths allow for higher pollutant removal efficiencies due to an increased amount of adsorption onto bottom sediments (Dormann, et al.,1988). Flow patterns in the wetland will affect the removal efficiency also. Meandering channels, slow-moving water and a large surface area will increase pollutant removal through increased sedimentation. Shallow, sheet flow also increases the pollutant removal capabilities, through assimilative processes. A deep pool sometimes improves the denitrification potential. A mixed flow pattern will increase overall pollutant removal efficiency (Dormann, et al., 1988).

Using a site where nearby wetlands still exist is recommended if possible. A hydrologic study should be done to determine if flooding occurs and saturated soils are present. A site where natural inundation is frequent is a good potential site (Mitsch and Gosselink, 1993). Loamy soils are required to permit plants to take root (Urbonas, 1992)

ADVANTAGES

1. Constructed wetlands offer natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal.
2. Constructed wetlands can offer good treatment following treatment by other BMPs, such as wet ponds, that rely upon settling of larger sediment particles (Urbonas, 1992). They are useful for large basins when used in conjunction with other BMPs.
3. Wetlands which are permanently flooded are less sensitive to polluted water inflows because the ecosystem does not depend upon the polluted water inflow.
4. Can provide uptake of soluble pollutants such as phosphorous, through plant uptake.
5. Can be used as a regional facility.

LIMITATIONS

1. Although the use of natural wetlands may be appear to be more cost effective than the use of constructed wetlands; environmental, permitting and legal issues prohibit the use of natural wetlands for this purpose.
2. Wetlands require a continuous base flow.
3. If not properly maintained, wetlands can accumulate salts and scum which can be flushed out by large storm flows.
4. Regular maintenance, including plant harvesting, is required to provide nutrient removal.
5. Frequent sediment removal is required to maintain the proper functioning of the wetland.

6. A greater amount of space is required for a wetland system than is required for an extended/dry detention basin treating the same amount of area.
7. Although constructed wetlands are designed to act as nutrient sinks, on occasion, the wetland may periodically become a nutrient source.
8. Wetlands which are not permanently flooded are more likely to be affected by drastic changes in inflow of polluted water.
9. Cannot be used on steep unstable slopes or densely populated areas.
10. Harvested wetlands may require special disposal methods, due to heavy metal uptake.
11. Threat of mosquitoes.
12. Hydraulic capacity may be reduced with plant overgrowth.

DESIGN CRITERIA

The wetland may be designed as either a stand-alone BMP, or as part of a larger non-point source treatment facility in conjunction with other devices, such as a wet pond, sediment forebay, or infiltration basin. Basic design elements and considerations are listed below.

1. *Volume.* The wetland pond should provide a minimum permanent storage equal to three-fourths of the water quality volume. The full water quality capture volume should be provided above the permanent pool. Calculate the water quality volume to be mitigated by the wetland using the method of Section 701-05.
2. *Depth.* A constant shallow depth should be maintained in the wetland, at approximately 1 ft or less (Schueler, 1987; Boutiette and Duerring, 1994), with 0.5 ft being more desirable (Schueler, 1987). If the wetland is designed as a very shallow detention pond, the pond should provide the full water quality capture volume above the permanent pool level. The permanent wetland depth should be 6 to 12 inches deep. The depth of the water quality volume above the permanent pool should not exceed 2 ft (Urbonas, 1992). Regrading may be necessary to allow for this shallow depth over a large area.

   It may also be beneficial to create a wetland with a varying depth. A varying depth within the wetland will enable more diverse vegetation to flourish. Deep water offers a habitat for fish, creates a low velocity area where flow can be redistributed, and can enhance nitrification as a prelude to later denitrification if nitrogen removal is desired. Open-water areas may vary in depth between 2 and 4 ft (Urbonas, 1992).

3. *Surface Area.* Increasing the surface area of the pond increases the nutrient removal capability (Boutiette and Duerring, 1994). A general guideline for surface area is using a marsh area of two to three percent of the contributing drainage area. The minimum surface area of the pond can also be calculated by determining the nutrient loading to the wetland. The nutrient loading to a wetland used for stormwater treatment should not be more than 45 lbs/ac of phosphorus or 225 lbs/ac of nitrogen per year. The pond could be sized to meet this minimum size requirement if the annual nutrient load at the site is known (Schueler, 1987). If unknown, the nutrient loads can be estimated using the methodology of Chapter 8.
4. *Longitudinal Slope.* Both wetland ponds and channels require a near-zero longitudinal slope (Urbonas, 1992).
5. *Base flow.* Enough inflow must be present in the wetland to maintain wetland soil and vegetation conditions. A water balance should be calculated. Dependence on groundwater for a moisture supply is not recommended.

$$S = Qi + R + Inf - Qo - ET$$

Where:
S = net change in storage
Qi = stormwater runoff inflow
R = contribution from rainfall
Inf = net infiltration (infiltration – exfiltration)
Qo = surface outflow
ET = evapotranspiration

6. *Seeding.* It is important that any seed which is used to establish vegetation germinate and take root before the site is inundated, or the seeds will be washed away. Live plants (plugs) should be considered for areas inundated even during construction.
7. *Length to Width Ratio.* The pond should gradually expand from the inlet and gradually contract toward the outlet. The length to width ratio of the wetland should be 2:1 to 4:1, with a length to width ratio of 3:1 recommended (Urbonas, 1992)
8. *Emptying Time.* The water quality volume above the permanent pool should empty in approximately 24 hours (Urbonas, 1992). This emptying time is not for the wetland itself, but for the additional storage above the wetland. Failure to approach this criteria is often the source of failure for constructed wetlands planned for the base of a water quantity storage facility.
9. *Inlet and Outlet Protection.* Inlet and outlet protection should be provided to reduce erosion of the basin. Velocity should be reduced at the entrance to reduce resuspension of sediment by using a forebay. The forebay should be approximately 5 to 10 percent of the water quality capture volume. The outlet should be placed in an offbay at least 3 ft deep. It may be necessary to protect the outlet with a skimmer shield that starts approximately one-half of the depth below the permanent water surface and extends above the maximum capture volume depth. A skimmer can be constructed from a stiff steel screen material that has smaller openings than the outlet orifice or perforations.
10. *Infiltration Avoidance.* Loss of water through infiltration should be avoided. This can be done by compacting the soil, incorporating clay into the soil, or lining the pond with artificial lining.
11. *Side Slopes.* Side slopes should be gradual to reduce erosion and enable easy maintenance. Side slopes should not be steeper than 4:1, and 5:1 is preferable (Urbonas, 1992).
12. *Open Water.* At least 25 percent of the basin should be an open water area at least 2 ft deep if the device is exclusively designed as a shallow marsh. The open water area will make the marsh area more aesthetically pleasing, and the combined water/wetland area will create a good habitat for waterfowl (Schueler, 1987). The combination of forebay, outlet and free water surface should be 30 to 50 percent, and this area should be between 2 and 4 ft deep. The wetland zone should be 50 to 70 percent of the area, and should be 6 to 12 inches deep (Urbonas, 1992).
13. *Freeboard.* The wetland pond should be designed with at least 1 ft of freeboard (Camp, Dresser and McKee, 1993).
14. *Use with Wet Pond.* Shallow marshes can be established at the perimeter of a wet pond by grading to form a 10 to 20 ft wide shallow bench. Aquatic emergent vegetation can be established in this area. A shallow marsh area can also be used near the inflow channel for sediment deposition (Schueler, 1987).
15. *Shape.* The shape is an important aspect of the wetland. It is recommended that a littoral shelf with gently sloping sides of 6:1 or milder to a point 24 to 28 inches below the water

surface (Mitsch and Gosselink, 1993). Bottom slopes of less than one percent slope are also recommended.

16. *Soils*. Clay soils underlying the wetland will help prevent percolation of water to groundwater. However, clay soils will also prevent root penetration, inhibiting growth. Loam and sandy soils may then be preferable. A good design may be use of local soils at the upper layer with clay beneath to prevent infiltration (Mitsch and Gosselink, 1993).

17. *Vegetation.* Vegetation must be established in the wetland to aid in slowing down velocities, and nutrient uptake in the wetland. A dependable way of establishing vegetation in the wetland is to transplant live plants or dormant rhizomes from a nursery. Emergent plants may eventually migrate into the wetland from upstream, but this is not a reliable source of vegetation. Transplanting vegetation from existing wetland areas is not encouraged, as it may damage the existing wetland area. Seeding is more cost effective, but is also not reliable. Vegetation should be selected by a qualified wetland scientist.

18. *Forebay.* A forebay may be provided to partially protect proposed wetland plantings from sediment loadings. If a forebay is provided, the forebay volume should be about 5 to 10 percent of the water quality volume.

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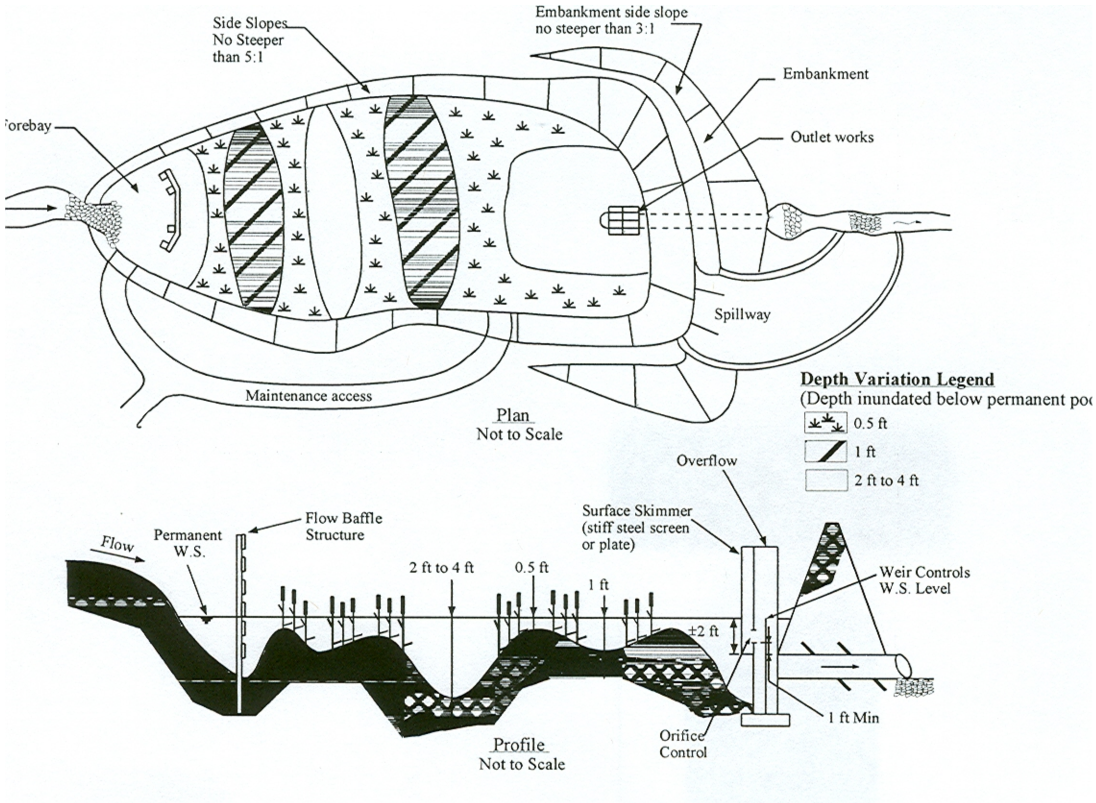

Figure PC-102A
Typical Constructed Wetland Components (SUSMP, 2002)

BMP PC – 103
EXTENDED DRY DETENTION BASINS OR UNDERGROUND DETENTION TANKS

DESCRIPTION

Extended dry detention basins are depressed basins that temporarily store a portion of stormwater runoff following a storm event. Underground detention tanks function similar to detention basins. However, since underground detention tanks are located below ground, the surface above these systems can be utilized for other more useful needs (parking lots, sidewalks, landscaping adjacent to buildings, etc). Water is controlled by means of a hydraulic control structure (orifice and/or weirs) to restrict outlet discharge. The extended dry detention basins and underground detention tanks normally do not have a permanent water pool between storm events. The objectives of both systems are to remove particulate pollutants and to reduce maximum runoff values associated with development to their pre-development levels. Detention basin facilities may be berm-encased areas or excavated basins. Detention tank facilities may be corrugated metal pipe, concrete pipe, or vaults. Figures PC-103A and PC-103B show typical components of Extended Dry Detention and Underground Detention Tanks.

ADVANTAGES

1. Modest removal efficiencies for the larger particulate fraction of pollutants.
2. Removal of sediment and buoyant materials. Nutrients, heavy metals, toxic materials, and oxygen-demanding particles are also removed with sediment substances associated with the particles.
3. Can be designed for combined flood control and stormwater quality control.
4. May requires less capital cost and land area when compared to wet pond BMP.
5. Downstream channel protection when properly designed and maintained.

LIMITATIONS

1. Require sufficient area and hydraulic head to function properly.
2. Generally not effective in removing dissolved and finer particulate size pollutants from stormwater.
3. Some constraints other than the existing topography include, but are not limited to, the location of existing and proposed utilities, depth to bedrock, location and number of existing trees, and wetlands.
4. Extended dry detention basins have moderate to high maintenance requirements.
5. Sediments can be resuspended if allowed to accumulate over time and escape through the hydraulic control to downstream channels and streams.
6. Some environmental concerns with using extended dry detention basins, include potential impact on wetlands, wildlife habitat, aquatic biota, and downstream water quality.
7. May create mosquito breeding conditions and other nuisances.

DESIGN CRITERIA

EXTENDED DRY DETENTION BASINS:

Criteria	Consideration
Storage volume	Calculate the volume of stormwater to be mitigated by the extended dry detention basin using the method in Section 701-05. Provide a storage volume for 120 percent of the water quality volume. The additional 20 percent of storage volume provides for sediment accumulation and the resultant loss in storage volume.
Emptying time	A 24- to 48-hour emptying time should be used for the runoff volume generated from water quality volume, with no more than 50 percent of the water quality volume being released in 12 hours.
Basin geometry	Shape the pond with a gradual expansion from the inlet and a gradual contraction toward the outlet, thereby limiting short circuiting. The basin length to width ratio should be not less than 4
Two-stage design	A two-stage design with a lower frequency pool that fills often with frequently occurring runoff minimizes standing water and sediment deposition in the remainder of the basin can enhance water quality benefits. The bottom stage should store 10 to 25 percent of the water quality volume.
Low-flow channel	Conveys low base flows from the forebay to the outlet. Erosion protection should be provided for the low-flow channel.
Basin side slopes	Slopes should be stable and gentle enough to limit rill erosion and facilitate maintenance access and needs. Side slopes should be no steeper than 4:1 (H:V), preferably flatter.
Inlet	Dissipate flow energy at basin's inflow point(s) to limit erosion and promote particle sedimentation.
Forebay design	Provide the opportunity for larger particles to settle out in an area that has, as a useful refinement, a solid surface bottom to facilitate mechanical sediment removal. The forebay volume should be 5 to 10 percent of the water quality volume.
Outlet design	Use a water quality outlet that is capable of slowly releasing the water quality over a 24- to 48-hour period. A perforated riser can be used in conjunction with orifices and a weir box opening above it to control larger storm outflows. An anti-seep collar should be considered for the outlet pipe to control seepage.
Perforation protection	Provide a crushed rock blanket of sufficient size to prevent clogging of the primary water quality outlet while not interfering significantly with its hydraulic capacity.

Dam embankment	The embankment should be designed not to fail during a 100-yr and larger storm. Embankment slopes should be no steeper than 3:1 (H:V), preferably 4:1, and flatter, and planted with turf-forming grasses. Poorly compacted native soils should be excavated and replaced. Embankment soils should be compacted to at least 95 percent of their maximum density.
Vegetation	Bottom vegetation provides erosion control and sediment entrapment. Basin bottom, berms, and side-sloping areas may be planted with native grasses or with irrigated turf, depending on the local setting.
Maintenance access	Access to the forebay and outlet area shall be provided to maintenance vehicles. Maximum grades should be eight percent, and a solid driving surface of gravel, rock, concrete, gravel-stabilized turf, or other approved surface should be provided.

UNDERGROUND DETENTION TANKS:

Criteria	Consideration
Storage volume	Calculate the volume of stormwater to be mitigated by the extended dry detention basin using the method in Section 701-05. Provide a storage volume for 120 percent of the water quality volume. The additional 20 percent of storage volume provides for sediment accumulation and the resultant loss in storage volume.
Emptying time	A 24- to 48-hour emptying time should be used for the runoff volume generated from water quality volume, with no more than 50 percent of the water quality volume being released in 12 hours.
Tank geometry	Tank should be constructed to fit within the site layout.
Low-flow outlet	Conveys low base flows from the tank to the outlet.
Outlet design	Use a water quality outlet that is capable of slowly releasing the runoff volume generated from 0.75-inches of rainfall over a 24- to 48-hour period.
Overflow design	Runoff volume generated from a storm greater than the water quality event (See Section 701-05) should be diverted via a flow splitter placed at the tank entrance or an overflow weir/orifice system designed in conjunction with the outlet of the tank.
Maintenance access	Access to the tanks shall be provided for maintenance personal.

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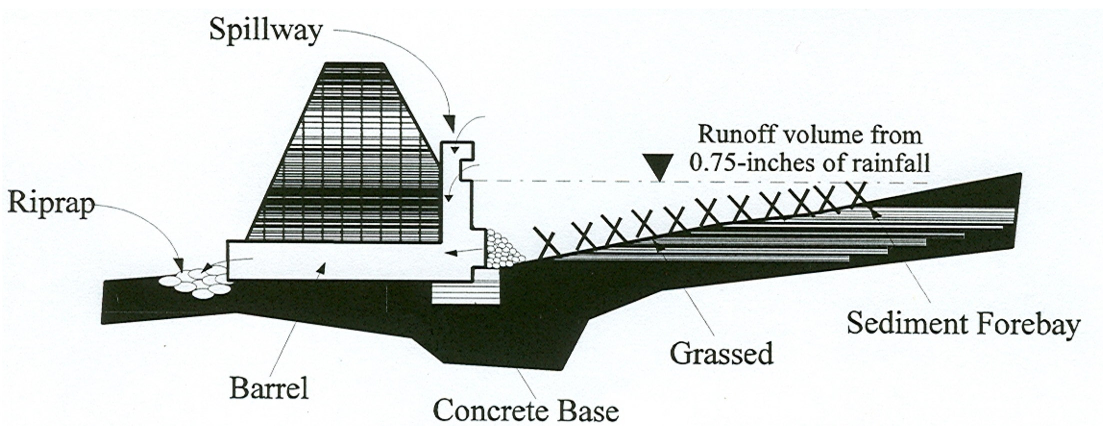

Figure PC-103A
Typical Extended Dry Detention Components (SUSMP, 2002)

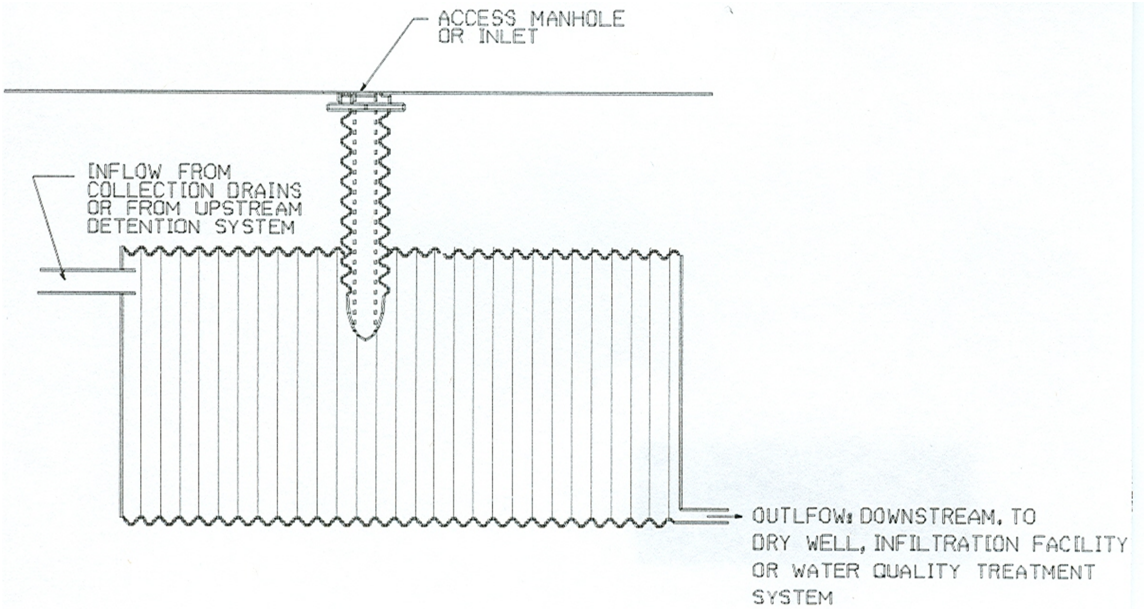

Figure PC-103B
Typical Underground Detention Components (SUSMP, 2002)

BMP PC – 104
INFILTRATION BASINS

DESCRIPTION

An infiltration basin is a surface pond which captures first-flush stormwater and treats it by allowing it to percolate into the ground and through permeable soils. As the stormwater percolates into the ground, physical, chemical, and biological processes occur which remove both sediments and soluble pollutants. Pollutants are trapped in the upper layers of the soil, and the water is then released to groundwater. Infiltration basins are generally used for drainage areas between 5 and 50 acres (Boutiette and Duerring, 1994). For drainage areas less than 5 acres, an infiltration trench or other BMP may be more appropriate. For drainage areas greater than 50 acres, maintenance of an infiltration basin would be burdensome, and an extended/dry detention basin or wet pond may be more appropriate. Infiltration basins are generally dry except immediately following storms, but a low-flow channel may be necessary if a constant base flow is present.

Infiltration basins create visible surface ponds that dissipate because water is infiltrated through the pond bottom, while infiltration trenches hide surface drainage in underground void regions and the water is infiltrated below the rocks. Infiltration basins effectively remove soluble pollutants because processes such as adsorption and biological processes remove these soluble pollutants from stormwater. This kind of treatment is not always available in other kinds of BMPs.

Several types of infiltration basins exist. They can be either in-line or off-line, and may treat different volumes of water, such as the water quality volume or the 2-year or 10-year storm. A full infiltration basin is built to hold the entire water quality volume, and the only outlet from the pond is an emergency spillway. More commonly used is the combined infiltration/detention basin, where the outflow is controlled by a vertical riser. Excess flow volume spills over the drop inlet at the top of the riser, and very large storms will exit through the emergency spillway. Other types of basins include the side-by-side basin, and the off-line infiltration basin. The side-by-side basin consists of a basin with an elevated channel to carry base flows running along one of its sides. Storm flows also flow through the elevated channel, but overflow the channel and enter the basin when they become deep enough. An off-line infiltration basin is used to treat the first flush runoff, while higher flows remain in the main channel.

ADVANTAGES

1. High removal capability for particulate pollutants and moderate removal for soluble pollutants.
2. Groundwater recharge helps to maintain dry-weather flows in streams.
3. Can minimize increases in runoff volume.
4. When properly designed and maintained, it can replicate pre-development hydrology more closely than other BMP options.
5. Basins provide more habitat value than other infiltration systems.

LIMITATIONS

1. High failure rate due to clogging and high maintenance burden.
2. Low removal of dissolved pollutants in very coarse soils.
3. Not suitable on fill slopes or steep slopes.
4. Risk of groundwater contamination in very coarse soils, may require groundwater monitoring.
5. Should not be used if significant upstream sediment load exists.
6. Slope of contributing watershed needs to be less than 20 percent.
7. Not recommended for discharge to a sole source aquifer.
8. Cannot be located within 100 feet of drinking water wells.
9. Metal and petroleum hydrocarbons could accumulate in soils to potentially toxic levels.
10. Relatively large land requirement.
11. Only feasible where soil is permeable and there is sufficient depth to bedrock and water table.
12. Need to be located a minimum of 10 feet down gradient and 100 feet up gradient from building foundations because of seepage problems.
13. Infiltration facilities could fall under additional regulations of IDEM or IDNR regarding waste disposal to groundwater.

DESIGN CRITERIA

Designing an infiltration basin is a process in which several factors are examined. The soil type and the drainage area are important factors in infiltration basin design. If either one of these two is inappropriate, the infiltration basin will not function properly. The steps in the design of an infiltration basin are listed below.

1. *Drainage Area.* Drainage areas between 5 and 50 acres are good candidates for infiltration basins. Infiltration trenches might be more appropriate for smaller drainage areas, while retention ponds are more appropriate for larger drainage areas (Schueler, 1987).
2. *Soils.* The site must have the appropriate soil, or the basin will not function properly. It is important that the soil be able to accept water at a minimum infiltration rate. Soils with an infiltration rate of less than 0.3 inches per hour, are not suitable sites for infiltration basins. Soils with a high percentage of clay are also undesirable, and should not be used if the percentage of clay is greater than 30. Generally, areas with fine to moderately fine soils are prevalent should not be considered as sites, because these soils do not have a high infiltration rate. Soils with greater than 40 percent combined silt/clay also should not be used. A series of soil cores should be taken to a depth of at least 5 feet below the proposed basin floor elevation to determine which kinds of soils are prevalent at the potential site.
3. *Volume.* Calculate the volume of stormwater to be mitigated by the infiltration basin using the methods in Section 701-05.
4. *Slope.* The basin floor should be as flat as possible to ensure an even infiltration surface and should not be or greater than 5 percent slope. Also, side slopes should have a maximum slope of 3 horizontal to 1 vertical (Schueler, 1987).
5. *Vegetation.* Vegetation should be established as soon as possible. Water-tolerant reed canary grass or tall fescue should be planted on the floor and side slopes of the basin (Schueler, 1987). Root penetration and thatch formation maintains and sometimes

improves infiltration capacity of the basin floor. Also, the vegetation helps to trap the pollutants by growing through the accumulated sediment and preventing resuspension. The vegetation also helps reduce pollution levels by taking up soluble nutrients for growth and converting them into less available pollutant forms.

6. *Inlet.* Sediment forebays or riprap aprons should be installed to reduce flow velocities and trap sediments upon entrance to the basin. Flow should be evenly distributed over the basin floor by a riprap apron. The inlet pile or channel should enter the basin at floor level to prevent erosion (Schueler, 1987).
7. *Drainage Time.* The basin should completely drain within 24 hours to avoid the risk of it not being empty before the next storm. Overestimation of the future infiltration capacity can result in a standing water problem. Ponds with detention times of less than six hours are not effectively removing pollutants from the storm flows (Schueler, 1987). The most common problem is setting the elevation and size of the low-flow orifice. If the orifice is too large, runoff events pass through the basin too quickly. If the low-flow orifice diameter is too narrow, there is a risk of creating an undesirable quasi-permanent pool.
8. *Buffer Zone.* A 25 foot buffer should be placed between the edge of the basin floor, and the nearest adjacent lot (Schueler, 1987). The buffer should consist of water tolerant, native plant species that provide food and cover for wildlife. This buffer zone may also act as a screen if necessary.
9. *Access.* Access to the basin floor should be provided for light equipment (Schueler, 1987).
10. *Water Table.* The basin floor should be a minimum of 10 feet above the water table.
11. *Maximum Depth.* The maximum allowable depth is equal to the infiltration rate multiplied by the maximum allowable dewatering time (24 hours).
12. *Freeboard.* A minimum of 2 feet of freeboard should be available between the spillway crest and the top of the dam (Dormann, et al., 1988).
13. *Emergency Spillway.* The emergency spillway should be able to safely pass the 100-year flood.
14. *Surface Area of the Basin Floor.* If the surface area of the basin floor is increased, the infiltration rate and quantity of runoff which can be infiltrated will be increased. Larger surface areas can also help compensate for clogging on the surface.

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BMP PC – 105
INFILTRATION TRENCHES

DESCRIPTION

An infiltration trench is basically an excavated trench that has been lined with filter fabric and backfilled with stone to form an underground basin. Runoff is diverted into the trench and either infiltrates into the soil, or enters a perforated pipe underdrain and is routed to an outflow facility. The depths of an infiltration trench generally range between 3 and 8 feet (Schueler, 1987) and may change when site-specific factors are considered. Smaller trenches are used for water quality, while larger trenches can be constructed if stormwater quantity control is required (Schueler, 1987). Trenches are not usually feasible in ultra-urban or retrofit situations where the soils have low permeability or low voids (Schueler, 1992). They should be installed only after the contributing area has stabilized to minimize runoff of sediments.

Infiltration trenches and infiltration basins follow similar design logic. The differences are that the former is for small drainage areas and stores runoff out of sight, within a gravel or aggregate matrix, whereas the latter is for larger drainage areas and water is stored in a visible surface pond.

Infiltration trenches effectively remove soluble and particulate pollutants. They can provide groundwater recharge by diverting 60 to 90 percent of annual urban runoff back into the soil (Boutiette and Duerring, 1994). They are generally used for drainage areas less than 10 acres, but some references cite 5 acres as a maximum size drainage area (Schueler, 1987, 1992). Potential locations include residential lots, commercial areas, parking lots, and adjacent to road shoulders. Trenches are only feasible on permeable soils (sand and gravel), and where the water table and bedrock are situated well below the bottom of the trench (Boutiette and Duerring, 1994; Schueler, 1987). Trenches are frequently used in combination with grassed swales. Trenches should not be used to trap course sediments, because the large sediment will clog the trench. Grass buffers can be installed to capture sediment before it enters the trench.

ADVANTAGES

1. Provides groundwater recharge.
2. Trenches fit into small areas.
3. Good pollutant removal capabilities.
4. Can minimize increases in runoff volume.
5. Can fit into medians, perimeters, and other unused areas of a development site.
6. Helps replicate pre-development hydrology and increases dry weather base flow.

LIMITATIONS

1. Slope of contributing watershed needs to be less than 20 percent.
2. Soil should have infiltration rate greater than 0.3 inches per hour and clay content less than 30 percent.
3. Drainage area should be between 1 to 10 acres.
4. The bottom of infiltration trench should be at least 4 feet above the underlying

bedrock and the seasonal high water table.

5. High failure rates of conventional trenches and high maintenance burden.
6. Low removal of dissolved pollutants in very coarse soils.
7. Not suitable on fill slopes or steep slopes.
8. Risk of groundwater contamination in very coarse soils, may require groundwater monitoring.
9. Infiltration facilities could fall under additional regulations of IDEM or IDNR regarding waste disposal to groundwater.
10. Cannot be located within 100 feet of drinking water wells.
11. Need to be located a minimum of 10 feet down gradient and 100 feet up gradient from building foundations because of seepage problems.
12. Should not be used if upstream sediment load cannot be controlled prior to entry into the trench.
13. Metals and petroleum hydrocarbons could accumulate in soils to potentially toxic levels.

DESIGN CRITERIA

Infiltration trenches can be categorized both by trench type, and as surface or below ground. Special inlets are required for underground trenches to prevent sediment and oil or grease from clogging the infiltration trench (Schueler, 1987). Surface trenches are commonly used where land is not limiting and underground trenches are better suited for development with minimal land availabilities.

1. *Volume.* Calculate the volume of stormwater to be mitigated by the water quality volume calculation in Section 701-05.
2. *Dimensions.* Generally, soils with low infiltration rates require a higher ratio of bottom surface area to storage volume (Northern Virginia Planning District Commission and Engineers and Surveyors Institute, 1992). The following formulas can be used to determine the dimensions of the infiltration basin:

$$H_{Tmax}=E*t_{max}/P$$

$$H_{Tmin}=E*t_{min}/P$$

$$A=V/[E*t_{max}]$$

Where:

H_{Tmax}, H_{Tmin} = Maximum and minimum trench depths (ft)

E = Infiltration rate in length per unit time (ft/hr).

t_{max}, t_{min} = Maximum and minimum target drain-time (hr)

P= Pore volume ratio of stone aggregate (% porosity/100).

V= Fluid storage volume requirement (ft^3)

A= Trench bottom surface area (ft^2).

The actual storage volume of the facility is the void ratio multiplied by the total volume of the trench. The available land and other constraints such as depth to bedrock or water table are used to determine the final dimensions of the trench.

3. *Buffer Strip/Special Inlet.* A grass filter strip a minimum of 20 feet should surround the trench on all sides over which surface flow reaches an above-ground trench. A special inlet can be used to prevent floatable material, solids, grease, and oil from entering trenches which are located below ground.
4. *Filter Fabric.* The bottom and sides of the trench should be lined with filter fabric soon after the trench is excavated. The fabric should be flush with the sides, overlap on the order of 2 feet over the seams, and not have trapped air pockets. As an alternative, 6 inches of clean, washed sand may be placed on the bottom of the trench instead of filter fabric.
5. *Grass Cover.* If the trench is grass covered, at least 1 foot of soil should be over the trench for grass substrate.
6. *Surface Area.* The surface area of the trench can be engineered to the site with the understanding that a larger surface area of the bottom of the trench increases infiltration rates and helps to reduce clogging and that depth may be limited by seasonal groundwater.
7. *Surface Area of the Trench Bottom.* Pollutant removal in a trench can be improved by increasing the surface area of the trench bottom. This is done by adjusting the geometry to make the trench shallow and broad, rather than deep and narrow. Greater bottom surface area increases infiltration rates and provides more area and depth for soil filtering. In addition, broader trench bottoms reduce the risk of clogging at the soil/filter cloth interface by spreading infiltration over a wider area.
8. *Distance from Wells and Foundations.* The trench should be at least 100 feet of any drinking water supply well, and at least 10 feet down gradient and 100 feet up gradient from building foundations (Schueler, 1987).
9. *Drain Time.* The drain time should be between two and three days. The total volume of the trench should drain in 48 hours. The minimum drain time should be 24 hours.
10. *Backfill Material.* The backfill material in the trench should have a D_{50} sized between 1.5 and 3 inches and clay content should be limited to less than 30 percent. The porosity of the material should be between 0.3 and 0.4.
11. *Observation Well.* An observation well of 4 to 6 inches diameter PVC should be located in the center of the trench and the bottom should rest on a plate. The top should be capped. The water level should be measured after a storm event. If it has not completely drained in three days, some remedial work may need to be done.
12. *Overflow Berm.* A 2 to 3 inch emergency overflow berm on the downstream side of the trench serves a twofold purpose. First, it detains surface runoff and allows it to pond and infiltrate to the trench. The berm also promotes uniform sheet flow for runoff overflow.

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BMP PC – 106
MEDIA FILTRATION

DESCRIPTION OF SAND FILTERS

Media filters are two-stage constructed treatment systems, including a pretreatment settling basin and a filter bed containing sand or other filter media. Various types of sand filter designs have been developed and implemented successfully in space-limited areas. The filters are not designed to treat the entire storm volume but rather the water quality volume (Section 701-05), that tends to contain higher pollutant levels. Sand filters can be designed so that they receive flow directly from the surface (via inlets or even as sheet flow directly onto the filter bed) or via storm drain pipes. They can be exposed to the surface or completely contained in underground pipe systems or vaults.

While there are various designs, most intermittent sand filters contain four basic components, as shown schematically in Figure PC-106A and discussed below:

1. *Diversion Structure.* Either incorporated into the filter itself or as a stand alone device, the diversion structure isolates the WQV and routes it to the filter. Larger volumes are bypassed directly to the storm drain system.
2. *Sedimentation Chamber.* Important to the long-term successful operation of any filtration system is the removal of large grained sediments prior to exposure to the filter media. The sedimentation chamber is typically integrated directly into the sand filter BMP but can also be a stand alone unit if space permits.
3. *Filter Media.* Typically consists of a 1-inch gravel layer over an 18 to 24 inch layer of washed sand. A layer of geotextile fabric can be placed between the gravel and sand layers.
4. *Underdrain System.* Below the filter media is a gravel bed, separated from the sand by a layer of geotextile fabric, in which is placed a series of perforated pipes. The treated runoff is routed out of the BMP to the storm sewer system or another BMP.

ADVANTAGES

1. May require less space than other treatment control BMPs and can be located underground.
2. Does not require continuous base flow.
3. Suitable for individual developments and small tributary areas up to 100 acres.
4. Does not require vegetation.
5. Useful in watersheds where concerns over groundwater quality or site conditions prevent use of infiltration.
6. High pollutant removal capability.
7. Can be used in highly urbanized settings.
8. Can be designed for a variety of soils.
9. Ideal for aquifer regions.

LIMITATIONS

1. Given that the amount of available space can be a limitation that warrants the consideration of a sand filter BMP, designing one for a large drainage area where there is room for more conventional structures may not be practical.
2. Available hydraulic head to meet design criteria.
3. Requires frequent maintenance to prevent clogging.
4. Not effective at removing liquid and dissolved pollutants.
5. Severe clogging potential if exposed soil surfaces exist upstream.
6. Sand filters may need to be placed offline to protect it during extreme storm events.

DESIGN CRITERIA

1. *Treatment Rate.* Calculate the flow rate of stormwater to be mitigated by the media filtration according to the method in Section 701-05.
2. *Surface Area of the Filter.* The following equation is for a maximum filtration time of 24 hours:

A. Surface Systems or Vaults

Filter area (ft2) = 3630SuAH/K(D+H)

Where: Su = unit storage (inches-acre)
A = area in acres draining to facility
H = depth (ft) of the sand filter
D = average water depth (ft) over the filter taken to be one-half the difference between the top of the filter and the maximum water surface elevation
K = filter coefficient recommended as 3.5

This equation is appropriate for filter media sized at a diameter of 0.02 to 0.04 inches. The filter area must be increased if a smaller media is used.

B. Underground Sandfilter Systems

a. Compute the required size of the sand filter bed surface area, AF. The following equation is based on Darcy's law and is used to size the sand filter bed area:

AF (ft2) = 24(WQV)(df)/ [k (hf + df) tf]

Where: Af = sand filter bed surface area (ft2)
WQV = Water quality treatment volume (ft3)
df = sand filter bed depth (ft)
k = filter coefficient recommended as 3.5 (ft/day)
hf = average height of water above the sand bed (ft)= hmax/2
hmax = elevation difference between the invert of the inlet pipe and the top of the sand filter bed (ft)
tf = time required for the runoff to filter through the sand bed (hr). (Typically 24 hr).

Note: 24 in the equation is the 24hr/day constant.

b. Choose a pipe size (diameter). The selection of pipe size should be based on site parameters such as: elevation of the runoff coming into the sand filter system, elevation of downstream connection to which the sand filter system outlet must tie into, and the minimum cover requirements for live loads. A minimum of 5' clearance should be provided between the top of the inner pipe wall and the top of the filter media for maintenance purpose. Use:

$D = d + 5$

Where:
D = pipe diameter (ft)
d = depth of sand filter and underdrain pipe media depth (ft)
= dg + df
dg = underdrain pipe media depth = 0.67’
df = sand filter bed deph (ft): 1.5 to 2.0 feet

c. Compute the sand filter width(based on the pipe geometry):

$$Wf = 2\,[R^2 - (R - d)^2\,]^{0.5}$$

Where:

Wf = filter width (ft)
R = pipe radius (ft) = D/2

d. Compute the filter length:

$$Lf = Af/\,Wf$$

Where:
Lf = filter length (ft)

3. *Configuration*

A. Surface sand filter

Criteria for the settling basin.
a. For the outlet use a perforated riser pipe.
b. Size the outlet orifice for a 24 hour drawdown
c. Energy dissipater at the inlet to the settling basin.
d. Trash rack at outlets to the filter.
e. Vegetate slopes to the extent possible.
f. Access ramp (4:1 or less) for maintenance vehicles.
g. One foot of freeboard.
h. Length to width ratio of at least 3:1 and preferably 5:1.
i. Sediment trap at inlet to reduce resuspension.

Criteria for the filter.
a. Use a flow spreader.
b. Use clean sand 0.02 to 0.04 inch diameter.
c. Some have placed geofabric on sand surface to facilitate maintenance.
d. Underdrains with:
- Schedule 40 PVC.
- 4 inch diameter.
- 3/8 inch perforations placed around the pipe, with 6 inch space between each perforation cluster.
- maximum 10 foot spacing between laterals.

- minimum grade of 1/8 inch per foot.

B. Underground sand filter

Criteria for the settling tank (if required).

a. Use orifice and/or weir structure for the outlet.

b. Size the outlet orifice or weir for a 24 hour drawdown time

c. Provide access manhole for maintenance.

Criteria for the filter.

a. Use a flow spreader.

b. Use clean sand 0.02 to 0.04 inch diameter.

c. Some have placed geofabric on sand surface to facilitate maintenance.

d. Underdrains with:

- Schedule 40 PVC.
- 4 inch diameter
- 3/8 inch perforations placed around the pipe, with 6 inch space between each perforation cluster.

e. Provide access manhole for maintenance.

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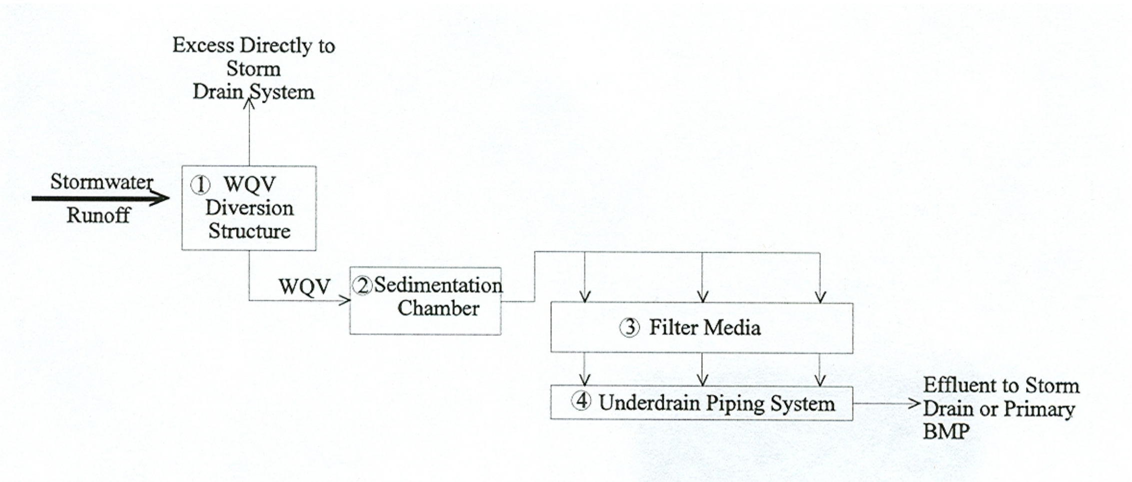

Figure PC-106A
Typical Media Filtration Schematic (SUSMP, 2002)

BMP PC – 107
STORM DRAIN INSERTS

DESCRIPTION

Storm drain inserts can be a variety of devices that are used in storm drain conveyance systems to reduce pollutant loadings in stormwater runoff. Most storm drain inserts reduce oil and grease, debris, and suspended solids through gravity, centrifugal force, or other methods. BMPs such as these can be particularly useful in areas susceptible to spills of petroleum products, such as gas stations. Figure PC-107A illustrates one of many different types of storm drain inserts. Trapped sediments and floatable oils must be pumped out regularly to maintain the effectiveness of the units.

ADVANTAGES

1. Prefabricated for different standard storm drain designs.
2. Require minimal space to install.

LIMITATIONS

1. Some devices may be vulnerable to accumulated sediments being resuspended during heavy storms.
2. Can only handle limited amounts of sediment and debris.
3. Maintenance and inspection of storm drain inserts are required before and after each rainfall event.
4. High maintenance costs.
5. Hydraulic losses.

DESIGN CRITERIA

1. Calculate the minimum flow rate to be mitigated by the storm drain insert using the methods in Section 701-05.
2. Select unit which meets Ordinance-required TSS removal rate for design flow rate.
3. Provide an overflow to bypass flows greater than the water quality treatment rate.

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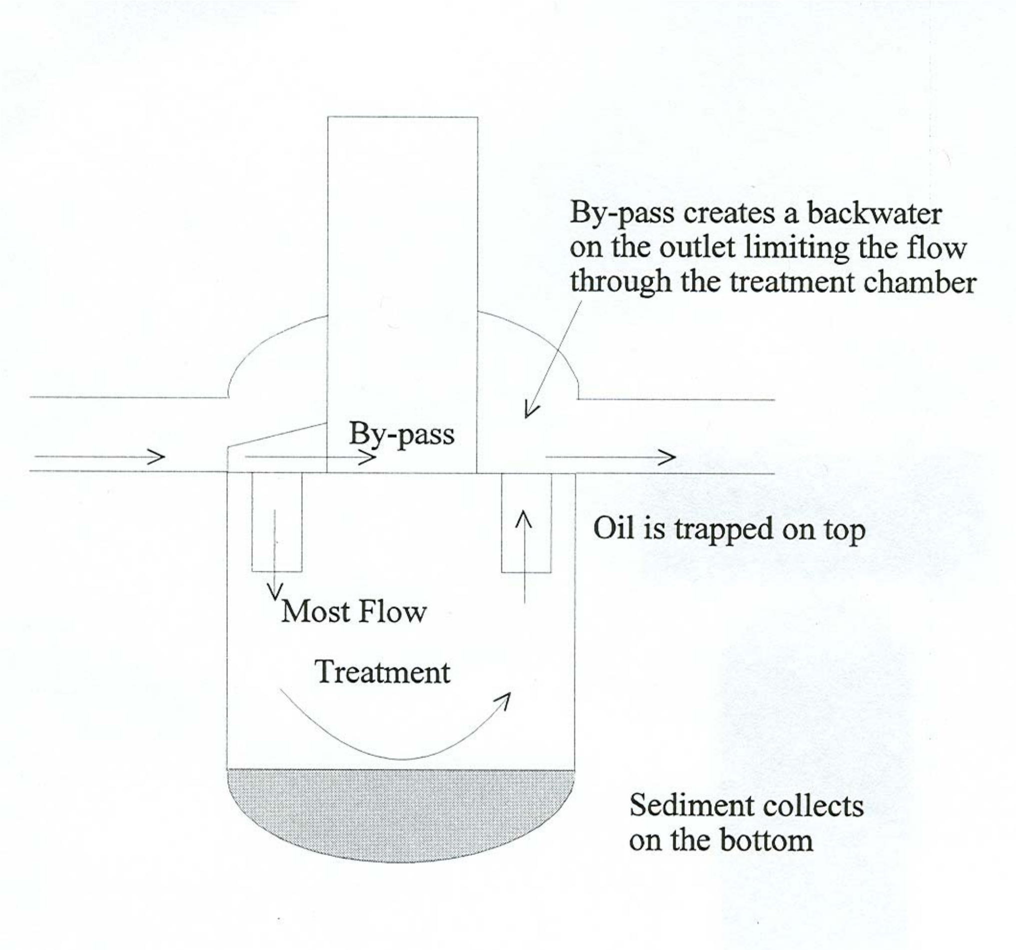

Figure PC-107A
Typical Storm Insert Schematic (SUSMP, 2002)

BMP PC – 108
VEGETATION FILTER STRIPS

DESCRIPTION

Vegetated filter strips, also known as vegetated buffer strips, are vegetated sections of land similar to vegetated swales, except they are essentially flat with low slopes, and are designed only to accept runoff overland sheet flow (Schueler, 1992). They may appear in any vegetated form from grassland to forest, and are designed to intercept upstream flow, lower flow velocity, and spread water out as sheet flow (Schueler, 1992). The dense vegetative cover facilitates conventional pollutant removal through detention, filtration by vegetation, and infiltration into soil (Yu and Kaighn, 1992). Wooded and grass filter strips have slightly higher removal rates. Dissolved nutrient removal for either type of vegetative cover is usually poor, however wooded strips show slightly higher removal due to increased retention and sequestration by the plant community (Florida Department of Transportation, 1994).

Although an inexpensive control measure, vegetated filter strips are most useful in contributing watershed areas where peak runoff velocities are low, as they are unable to treat the high flow velocities typically associated with high impervious cover (Barret, et al., 1993). Similar to vegetated swales, filter strips can last for 10 to 20 years with proper conditions and regular maintenance. Life expectancy is significantly diminished if uniform sheet flow and dense vegetation are not maintained. Figures PC-108A and PC-108B illustrate a typical Buffer Strip and its schematic.

ADVANTAGES

1. Lowers runoff velocity (Schueler, 1987).
2. Slightly reduces runoff volume (Schueler, 1987).
3. Slightly reduces watershed imperviousness (Schueler, 1987).
4. Slightly contributes to groundwater recharge (Schueler, 1987).
5. Aesthetic benefit of vegetated “open spaces” (Colorado Department of Transportation, 1992).
6. Preserves the character of riparian zones, prevents erosion along streambanks, and provides excellent urban wildlife habitat (Schueler, 1992).

LIMITATIONS

1. Filter strips cannot treat high velocity flows, and do not provide enough storage or infiltration to effectively reduce peak discharges to predevelopment levels for design storms (Schueler, 1992). This lack of quantity control dictates use in rural or low density development.
2. Requires slope less than 5%.
3. Requires low to fair permeability of natural subsoil.
4. Large land requirement.
5. Often concentrates water, which significantly reduces effectiveness.
6. Pollutant removal is unreliable in urban settings.

DESIGN CRITERIA

1. Successful performance of filter strips relies heavily on maintaining shallow unconcentrated flow (Colorado Department of Transportation, 1992). To avoid flow channelization and maintain performance, a filter strip should:

    (1) Be equipped with a level spreading device for even distribution of runoff,
    (2) Contain dense vegetation with a mix of erosion resistant, soil binding species,

(3) Be graded to a uniform, even and relatively low slope,

(4) Laterally traverse the contributing runoff area (Schueler, 1987),

(5) The area to be used for the strip should be free of gullies or rills that can concentrate overland flow (Schueler, 1987),

(6) Filters strip should be placed 3 to 4 feet from edge of pavement to accommodate a vegetation free zone (Washington State Department of Transportation, 1995). The top edge of the filter strip along the pavement should be designed to avoid the situation where runoff would travel along the top of the filter strip, rather than through it. Dilhalla, et al., (1986) suggest that berms be placed at 50 to 100 feet intervals perpendicular to the top edge of the strip to prevent runoff from bypassing it (as cited in Washington State Department of Transportation, 1995),

(7) Top edge of the filter strip should follow the same elevation contour. If a section of the edge of the strip dips below the contour, runoff will tend to form a channel toward the low spot,

(8) Filter strips should be landscaped after other portions of the project are completed (Washington State Department of Transportation, 1995). However, level spreaders and strips used as sediment control measures during the construction phase can be converted to permanent controls if they can be regraded and reseeded to the top edge of the strip.

2. Filter strips can be used on an up gradient from watercourses, wetlands, or other water bodies, along toes and tops of slopes, and at outlets of other stormwater management structures (Boutiette and Duerring, 1994). They should be incorporated into street drainage and master drainage planning (Urbonas, 1992). The most important criteria for selection and use of this BMP are soils, space, and slope, where:

(1) *Soils and moisture are adequate to grow relatively dense vegetative stands.* Underlying soils should be of low permeability so that the majority of the applied water discharges as surface runoff. The range of desirable permeability is between 0.06 to 0.6 inches/hour (Horner, 1985). Common soil textural classes are clay, clay loam, and silty clay. The presence of clay and organic matter in soils improves the ability of filter strips to remove pollutants from the surface runoff (Schueler, 1992). Greater removal of soluble pollutants can be achieved where the water table is within 3 feet of the surface (i.e., within the root zone) (Schueler, 1992). Filter strips function most effectively where the climate permits year-round dense vegetation.

(2) *Sufficient space is available.* Because filter strip effectiveness depends on having an evenly distributed sheet flow, the size of the contributing area and the associated volume runoff have to be limited (Urbonas, 1992). To prevent concentrated flows from forming, it is advisable to have each filter strip serve a contributing area of five acres or less (Schueler, 1987). When used alone, filter strip application is in areas where impervious cover is low to moderate and where there are small fluctuations in peak flow.

(3) *Longitudinal slope is five percent or less.* When filter strips are used on steep or unstable slopes, the formation of rills and gullies can disrupt sheet flow (Urbonas, 1992). As a result filter strips will not function at all on slopes greater than 15 percent and may have reduced effectiveness on slopes between 6 to 15 percent.

3. The design should be based on the same methods detailed for swales. The referred geometry of a filter strip is rectangular, and this should be used when applying the design procedures of vegetated swales.

4. The following provisions apply specifically to filter strips (Horner, 1993):

(1) Slopes should be no greater than 15 percent and should preferably be lower than 5 percent, and be uniform throughout the strip after final grading.

(2) Hydraulic residence time normally no less than 9 minutes, and in no case less than 5 minutes.

(3) Average velocity no greater than 0.9 feet/second.
(4) Manning's friction factor (*n*) of 0.02 should be used for grassed strips, *n* of 0.024 if strip is infrequently mowed, or a selected higher value if the strip is wooded.
(5) The width should be no greater than that where a uniform flow distribution can be assured.
(6) Average depth of flow (design depth) should be no more than 0.5 inches.
(7) Hydraulic radius is taken to be equal to the design flow depth.
(8) A minimum of 8 feet is recommended for filter strip width.

5. Filter strips function best with longitudinal slopes less than 10 percent, and ideally less than 5 percent. As filter strip length becomes shorter, slope becomes more influential. Therefore, when a minimum strip length of 20 feet is utilized, slopes should be graded as close to zero as drainage permits (Schueler, 1987). With steeper slopes, terracing through the use of landscape timber, concrete weirs, or other means may be required to maintain sheet flow.
6. Calculate the flow rate of stormwater to be mitigated by the vegetated filter strip using the Method outlined in Section 701-05.
7. Another design issue is runoff collection and distribution to the strip, and release to a transport system or receiving water (Horner, 1985). Flow spreader devices should be used to introduce the flow evenly to the filter strip (Urbonas, 1992). Concentrated flow needs to use a level spreader to evenly distribute flow onto a strip. There are many alternative spreader devices, with the main consideration being that the overland flow spreader be distributed equally across the strip. Level spreader options include porous pavement strips, stabilized turf strips, slotted curbing, rock-filled trench, concrete sills, or plastic-lined trench that acts as a small detention pond (Yu and Kaighn, 1992). The outflow and filter side lip of the spreader should have a zero slope to ensure even runoff distribution (Yu and Kaighn, 1992). Once in the filter strip, most runoff from significant events will not be infiltrated and will require a collection and conveyance system. Grass-lined swales are often used for this purpose and can provide another BMP level. A filter strip can also drain to a storm sewer or street gutter (Urbonas, 1992).
8. Filter strips should be constructed of dense, soil-binding deep-rooted water resistant plants. For grassed filter strips, dense turf is needed to promote sedimentation and entrapment, and to protect against erosion (Yu and Kaighn, 1992). Turf grass should be maintained to a blade height of 2 to 4 inches. Most engineered, sheet-flow systems are seeded with specific grasses. The grass species chosen should be appropriate for the climatic conditions and maintenance criteria for each project.
9. Trees and woody vegetation have been shown to increase infiltration and improve performance of filter strips. Trees and shrubs provide many stormwater management benefits by intercepting some rainfall before it reaches the ground, and improving infiltration and retention through the presence of a spongy, organic layer of materials that accumulates underneath the plants (Schueler, 1987). As discussed previously in this section, wooded strips have shown significant increases in pollutant removal over grass strips. Maintenance for wooded strips is virtually non-existent, another argument for using trees and shrubs. However, there are drawbacks to using woody plants. Since the density of the vegetation is not as great as a turf grass cover, wooded filter strips need additional length to accommodate more vegetation. In addition, shrub and tree trunks can cause uneven distribution of sheet flow, and increase the possibility for development of gullies and channels. Consequently, wooded strips require flatter slopes than a typical grass cover strip to ensure that the presence of heavier plant stems will not facilitate channelization.

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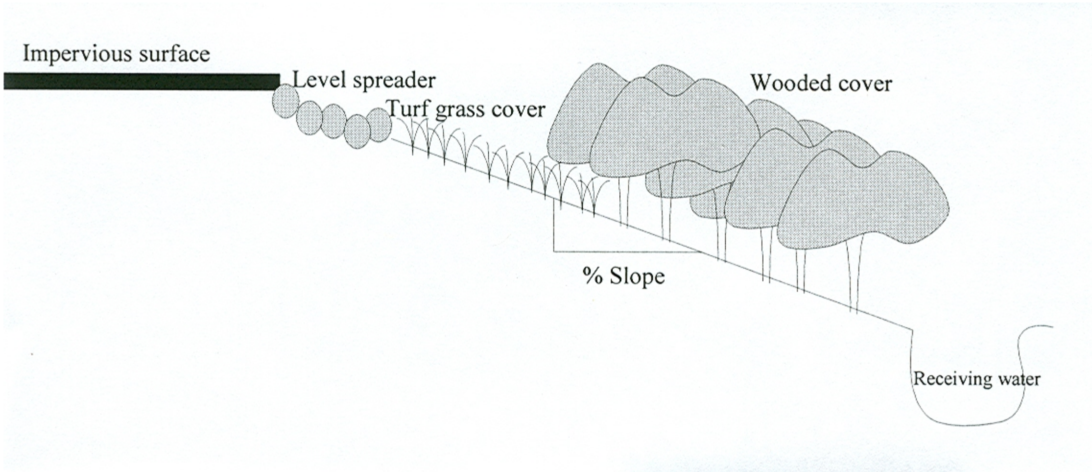

Figure PC-108A
Typical Buffer Strip (SUSMP, 2002)

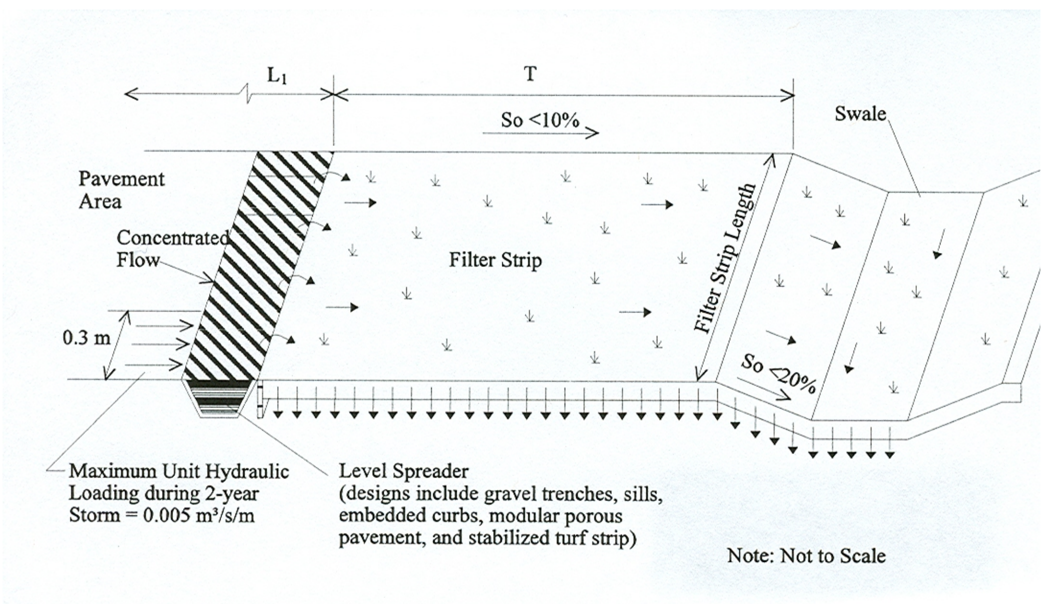

Figure PC-108B
Typical Buffer Strip Schematic (SUSMP, 2002)

BMP PC – 109
VEGETATIVE SWALE

DESCRIPTION

Vegetated swales are shallow vegetated channels to convey stormwater where pollutants are removed by filtration through grass and infiltration through soil. They look similar to, but are wider than, a ditch that is sized only to transport flow. They require shallow slopes and soils that drain well. Vegetated swale designs have achieved mixed performance in pollutant removal efficiency. Moderate removal rates have been reported for suspended solids and metals associated with particulates such as lead and zinc. Runoff waters are typically not detained long enough to effectively remove very fine suspended solids, and swales are generally unable to remove significant amounts of dissolved nutrients. Pollutant removal capability is related to channel dimensions, longitudinal slope, and type of vegetation. Optimum design of these components will increase contact time of runoff through the swale and improve pollutant removal rates. Vegetated swales are primarily stormwater conveyance systems. They can provide sufficient control under light to moderate runoff conditions, but their ability to control large storms is limited. Therefore, they are most applicable in low-to-moderate sloped areas as an alternative to ditches and curb and gutter drainage. Their performance diminishes sharply in highly urbanized settings. Vegetated swales are often used as a pretreatment measure for other downstream BMPs, particularly infiltration devices. Enhanced vegetative swales utilize check dams and wide depressions to increase runoff storage and promote greater settling of pollutants.

ADVANTAGES

1. Relatively easy to design, install and maintain.
2. Vegetated areas that would normally be included in the site layout, if designed for appropriate flow patterns, may be used as a vegetated swale.
3. Relatively inexpensive.
4. Vegetation is usually pleasing to residents.

LIMITATIONS

1. Irrigation may be necessary to maintain vegetative cover.
2. Potential for mosquito breeding areas.
3. Possibility of erosion and channelization over time.
4. Requires dry soils with good drainage and high infiltration rates for better pollutant removal.
5. Not appropriate for pollutants toxic to vegetation.
6. Large area requirements may make this BMP infeasible for some sites.
7. Used to serve sites less than 10 acres in size, with slopes no greater than 5 percent.
8. The seasonal high water table should be at least 2 feet below the surface.
9. Buildings should be at least 10 feet from the top of bank

DESIGN CRITERIA

Several criteria should be kept in mind when beginning swale design. These provisions, presented below, have been developed through a series of evaluative research conducted on swale performance.

Criteria for optimum swale performance (Horner, 1993)		
Parameter	***Optimal Criteria***	***Minimum Criteria****
Hydraulic Residence Time	9 min	5 min
Average Flow Velocity	≤0.9 ft/s	***N/A***
Swale Width	8 ft	2 ft
Swale Length	200 ft	100 ft
Swale Slope	2 - 6%	1%
Side Slope Ratio (horizontal:vertical)	4 : 1	2 : 1

Note: * Criteria at or below minimum values can be used when compensatory adjustments are made to the standard design. Specific guidance on implementing these adjustments will be discussed in the design section.

The procedures described below were set forth by Horner, and unless otherwise cited, are set forth in *Biofiltration for Stormwater Runoff Quality Control*, published in 1993. The following steps are recommended to be conducted in order to complete a swale design:

(1) Determine the flow rate to the system.
(2) Determine the slope of the system.
(3) Select a swale shape (skip if filter strip design).
(4) Determine required channel width.
(5) Calculate the cross-sectional area of flow for the channel.
(6) Calculate the velocity of channel flow.
(7) Calculate swale length.
(8) Select swale location based on the design parameters.
(9) Select a vegetation cover for the swale.
(10) Check for swale stability.

Recommended procedures for each task are discussed in detail below.

1. *Determine Flow Rate to the System.* Calculate the flow rate of stormwater to be mitigated by the vegetated swale using the methods outlined in Section 701-05. Runoff from larger events should be designed to bypass the swale, consideration must be given to the control of channel erosion and destruction of vegetation. A stability analysis for larger flows (up to the 100-yr 24-hour) must be performed. If the flow rate approaches or exceeds 1 ft/s, one or more of the design criteria above may be violated, and the swale system may not function correctly (Washington State Department of Transportation, 1995). Alternative measures to lower the design flow should be investigated. Possibilities include dividing the flow among several swales, installing detention to control release rate upstream, and reducing developed surface area to reduce runoff coefficient value and gain space for biofiltration (Horner, 1993).
2. *Determine the Slope of the System.* The slope of the swale will be somewhat dependent on where the swale is placed, but should be between the stated criteria of one and six percent.
3. *Select a Swale Shape.* Normally, swales are designed and constructed in a trapezoidal shape, although alternative designs can be parabolic, rectangular, and triangular. Trapezoidal cross-sections are preferred because of relatively wider vegetative areas and ease of maintenance (Khan, 1993). They also avoid the sharp corners present in V-shaped and rectangular swales, and offer better stability than the vertical walls of rectangular swales.
4. *Determine Required Channel Width.* Estimates for channel width for the selected shape can be obtained by applying Manning's Equation:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

Where:
Q = Flow (ft3/s).
A = Cross-sectional area of flow (ft2).
Rh = Hydraulic radius of flow cross section (ft).
S = Longitudinal slope of biofilter (ft/ft).
n = Manning's roughness coefficient.

A Manning's n value of 0.02 is used for routine swales that will be mowed with some regularity. For swales that are infrequently mowed, use a Manning's n value of 0.024. A higher n value can be selected if it is known that vegetation will be very dense (Khan, 1993).

Because the channel is wide, the hydraulic radius approaches the flow depth. Substituting the geometric equations for a trapezoidal channel into Manning's equation, the bottom width (wb) and the top width (wt) for the trapezoid swale can be computed using the following equations:

$$w_b = \frac{Qn}{1.486 y^{1.67} S^{0.5}} - Zy \quad \text{and} \quad w_t = w_b + 2Zy$$

Where:
Q = Flow rate in ft3/s.
n = Manning's roughness coefficient
y = Depth of flow.
Z = The side slope in the form of Z:1.

Typically, the depth of flow in the channel (y) is set at 3 to 4 inches. Flow depth can also be determined by subtracting 2 inches from the expected grass height, if the grass type and the height it will be maintained is known. Values lower than 3 to 4 inches can be used, but doing so will increase the computed width of the swale (Washington State Department of Transportation, 1995).

Swale width computed should be between 2 to 8 feet. Relatively wide swales (those wider than 8 feet are more susceptible to flow channelization and are less likely to have uniform sheet flow across the swale bottom for the entire swale length. The maximum width for swales is on the order of 10 feet, however widths greater than 8 feet should be evaluated to consider the effectiveness of the flow spreading design used and the likelihood of maintaining evenness in the swale bottom. Since length may be used to compensate for width reduction (and vice versa) so that area is maintained, the swale width can be arbitrarily set to 8 feet to continue with the analysis.

5. *Calculate Cross-Sectional Area.* Compute the cross-sectional area (A) for the swale.
6. *Calculate the Velocity of the Channel Flow.* Channel flow velocity (V) can be computed using the continuity equation

   V (ft/sec)=Q(cfs)/A(ft2)

This velocity should be less than 0.9 ft/s, a velocity that was found to cause grasses to be flattened, reducing filtration. A velocity lower than this maximum value is recommended to achieve the 9-minute hydraulic residence time criterion, particularly in shorter swales (at V = 0.9

ft/s, a 485-ft swale is needed for a 9-min residence time and a 269-ft swale for a 5-min residence time).

If the value of V suggests that a longer swale will be needed than space permits, investigate how the design flow Q can be reduced, or increase flow depth (y) and/or swale width (wt) up to the maximum allowable values and repeat the analysis.

7. *Calculate Swale Length.* Compute the swale length (L) using the following equation:

   L=60Vtr
   Where:
   L=length required to achieve residence time
   *t*r = Hydraulic residence time (in minutes).
   V=velocity of channel flow (ft/sec)
   Use tr = 9 min for this calculation.

   If a swale length greater than the space will permit results, investigate how the design flow Q can be reduced. Increase flow depth (y) and/or swale width (wb) up to the maximum allowable values and repeat the analysis. If all of these possibilities are checked and space is still insufficient, t can be reduced, but to no less than 5 minutes. If the computation results in L less than 100 ft, set L = 100 ft and investigate possibilities in width reduction. This is possible through recalculating V at the 100-ft length, recomputing cross-sectional area, and ultimately adjusting the swale width wb using the appropriate equation.

8. *Select Swale Location.* Swale geometry should be maximized by the designer, using the above equations, and given the area to be utilized. If the location has not yet been chosen, it is advantageous to compute the required swale dimensions and then select a location where the calculated width and length will fit. If locations available cannot accommodate a linear swale, a wide-radius curved path can be used to gain length.

   Sharp bends should be avoided to reduce erosion potential. Regardless of when and how site selection is performed, consideration should be given to the following site criteria:

   Soil Type. Soil characteristics in the swale bottom should be conducive to grass growth. Soils that contain large amounts of clay cause relatively low permeability and result in standing water, and may cause grass to die. Where the potential for leaching into groundwater exists, the swale bottom may need to be sealed with clay to protect from infiltration into the resource. Compacted soils will need to be tilled before seeding or planting. If topsoil is required to facilitate grass seeding and growth, use 6 inches of the following recommended topsoil mix: 50 to 80 percent sandy loam, 10 to 20 percent clay, and 10 to 20 percent composted organic matter (exclude animal waste).

   Slope. The natural slope of the potential location will determine the nature and amount of regrading, or if additional measures to reduce erosion and/or increase pollutant removal are required. Swales should be graded carefully to attain uniform longitudinal and lateral slopes and to eliminate high and low spots. If needed, grade control checks should be provided to maintain the computed longitudinal slope and limit maximum flow velocity (Urbonas, 1992).

   Natural Vegetation. The presence and composition of existing vegetation can provide valuable information on soil and hydrology. If wetland vegetation is present, inundated conditions may exist at the site. The presence of larger plants, trees and shrubs, may provide additional stabilization along the swale slopes, but also may shade any grass cover established. Most grasses grow best in full sunlight, and prolonged shading should be avoided. It is preferable that vegetation species be native to the region of application, where establishment and survival have been demonstrated.

9. *Select Vegetative Cover.* A dense planting of grass provides the filtering mechanism responsible for water quality treatment in swales. In addition, grass has the ability to grow through thin deposits of sediment and sand, stabilizing the deposited sediment and preventing it from being resuspended in runoff waters. Few other herbaceous plant species provide the same density and surface per unit area. Grass is by far the most effective choice of plant material in swales, however not all grass species provide optimum vegetative cover for use in swale systems. Dense turf grasses are best for vegetative cover.

   In areas of poor drainage, wetlands species can be planted for increased vegetative cover. Use wetland species that are finely divided like grass and relatively resilient. Invasive species, such as cattails, should be avoided to eliminate proliferation in the swale and downstream.

   Woody or shrubby plantings can be used for landscaping on the edge of side slopes, but not in the swale treatment area. Trees and shrubs can provide some additional stabilization, but also mature and shade the grass. In addition, leaf or needle drop can contribute unwanted nutrients, create debris jams, or interfere with waterflow through the system. If landscape plantings are to be used, selection and planting processes should be carefully planned and carried out to avoid these potential problems.

10. *Check Swale Stability.* The stability check is performed for the combination of highest expected flow and least vegetation coverage and height. Stability is normally checked for flow rate (Q) for the 100-yr, 24-h storm unless runoff from larger such events will bypass the swale. Q can be determined using the same methods mentioned for the initial design storm computation. The maximum velocity (Vmax) in ft/s, that is permissible for the vegetation type, slope, and soil conditions should be obtained.

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BMP PC – 110
WET PONDS

DESCRIPTION

IMPORTANT NOTE: The material presented in this fact sheet is intended to apply to a case where a wet pond is being utilized as a post-construction stormwater quality BMP only. When the pond is being designed as a multi-purpose facility acting both as a water quality BMP and a wet-bottom detention pond described in Chapter 300, several design features must be modified to accommodate both purposes and requirements. Minimum requirements for a wet-bottom detention pond stated in Chapter 300 must be met and supersede any conflicting requirements in this fact sheet when water quality BMP features are added to a wet-bottom detention pond.

The wet pond is a facility which removes sediment, Biochemical Oxygen Demand (BOD), organic nutrients, and trace metals from stormwater runoff. This is accomplished by slowing down stormwater using an in-line permanent pool or pond affecting settling of pollutants. The wet pond is similar to a dry pond, except that a permanent volume of water is incorporated into the design. The drainage area should be such that an adequate base flow is maintained in the pond. Biological processes occurring in the permanent pond pool aid in reducing the amount of soluble nutrients present in the water, such as nitrate and ortho-phosphorus (Schueler, 1987).

The basic elements of a wet pond are shown below. A stabilized inlet prevents erosion at the entrance to the pond. It may be necessary to install energy dissipaters. The permanent pool is usually maintained at a depth between 3 and 8 ft. The shape of the pool can help improve the performance of the pond. Maximizing the distance between the inlet and outlet provides more time for mixing of the new runoff with the pond water and settling of pollutants. Overflow from the pond is released through outlet structures to discharge flows at various elevations and peak flow rates. The outfall channel should be protected to prevent erosion from occurring downstream of the outlet.

Soil conditions are important for the proper functioning of the wet pond. The pond is a permanent pool, and thus must be constructed such that the water must not be allowed to infiltrate from the permanent portion of the pool. It is difficult to form a pool in soils with high infiltration rates soon after construction. Eventually, however, deposition of silt at the bottom of the pond will help slow infiltration. If extremely permeable soils exist at the site (hydrologic soil group A or B), a geotextile or clay liner may be necessary. Typical components of a Wet Pond are illustrated in Figures PC-110A.

ADVANTAGES

1. Wet ponds have recreational and aesthetic benefits due to the incorporation of permanent pools in the design.
2. Wet ponds offer flood control benefits in addition to water quality benefits.
3. Wet ponds can be used to handle large drainage areas.
4. High pollutant removal efficiencies for sediment, total phosphorus, and total nitrogen are achievable <u>when the volume of the permanent pool is at least three times the water quality volume</u> (the volume to be treated).
5. A wet pond removes pollutants from water by both physical and biological processes, thus they are more effective at removing pollutants than extended/dry detention basins.
6. Creation of aquatic and terrestrial habitat.

LIMITATIONS

1. Wet ponds may be feasible for stormwater runoff in residential or commercial areas with a combined drainage area greater than 20 acres but no less than 10 acres.
2. An adequate source of water must be available to ensure a permanent pool throughout the entire year.
3. If the wet pond is not properly maintained or the pond becomes stagnant; floating debris, scum, algal blooms, unpleasant odors, and insects may appear.
4. Sediment removal is necessary every 5 to 10 years.
5. Heavy storms may cause mixing and subsequent resuspension of solids.
6. Evaporation and lowering of the water level can cause concentrated levels of salt and algae to increase.
7. Cannot be placed on steep unstable slopes.
8. Embankment may be regulated as a dam by IDNR.

DESIGN CRITERIA

1. *Hydrology*. If the device will also be used for stormwater quantity control, it will be necessary to reduce the peak flows after development to the levels described in Chapter 6.
2. *Volume*. Calculate the volume of stormwater to be mitigated by the wet pond using the water quality volume calculations in Section 701-05. The volume of the permanent pool should be 3 times this water quality volume.
3. *Pond Shape*. The pond should be long and narrow and generally shaped such that it discourages "short-circuiting." Short-circuiting occurs when storm flows bypass the pond and do not mix well with the pool. Short-circuiting can be discouraged by lengthening the pond or by installing baffles which slow water down and lengthen the distance between the inlet and outlet. A length to width ratio of no less than 2:1, with 4:1 being preferred, will help minimize short circuiting. Also, the pond should gradually expand from the inlet and gradually contract toward the outlet. Several examples of ponds shaped to reduce short-circuiting are shown below. [See Figure PC-110B]
4. *Depth*. The depth of the water quality pond is important in the design of the pond. If the pond is too shallow, sediment will be easily resuspended as a result of wind. Shallow ponds should not be used unless vegetation is adequate to stabilize the pond. If the pond is too deep, safety considerations emerge and stratification may occur, possibly causing anoxic conditions near the bottom of the pond. If the pond becomes anoxic, pollutants adsorbed to the bottom sediments may be released back to the water column. The average depth should be 3 to 6 ft, and depths of more than 8 ft should be avoided (Schueler, 1987). A littoral zone of 6 to 18 inches deep that accounts for 25 to 50 percent of the permanent pool surface for plant growth along the perimeter of the pool is recommended, the littoral shelf will also enhance safety.
5. *Vegetation.* Planting vegetation around the perimeter of the pond can have several advantages. Vegetation reduces erosion on both the side slopes and the shallow littoral areas. Vegetation located near the inlet to the pond can help trap sediments; algae growing on these plants can also filter soluble nutrients in the water column. Thicker, higher vegetation can also help hide any debris which may collect near the shoreline. Native turf-forming grasses or irrigated turf should be planted on sloped areas, and aquatic species should be planted on the littoral areas (Urbonas, et al., 1992). Vegetation can benefit wildlife and waterfowl by providing food and cover at the marsh fringe. A shallow, organic-rich marsh fringe provides an area which enables bacteria and other microorganisms to reduce organic matter and nutrients (Schueler, 1987).
6. *Side Slopes.* Gradual side slopes of a wet pond enhance safety and help prevent erosion and make it easier to establish dense vegetation. If vegetation cannot be established, the unvegetated banks will add to erosion and subsequently the sediment load. It is recommended that side slopes be no

greater than 3:1. If slopes are greater than this, riprap should be used to stabilize the banks (Schueler, 1987).

7. *Hydraulic Devices*. An outlet device, typically a riser-pipe barrel system, should be designed to release runoff in excess of the water quality volume and to control storm peaks. The outlet device should still function properly when partial clogging occurs. Plans should provide details on all culverts, risers, and spillways. Calculations should depict inflow, storage, and outflow characteristics of the design. Some frequently used design details for extending detention times in wet ponds are shown and described below (Schueler, 1987). [See Figure PC-110C]

    a. *Slotted Standpipe from Low-Flow Orifice, Inlet Control (dry pond, shallow wet pond, or shallow marsh).* An "L"-shaped PVC pipe is attached to the low-flow orifice. An orifice plate is located within the PVC pipe which internally controls the release rate. Slots or perforations are all spaced vertically above the orifice plate, so that sediment deposited around the standpipe will not impede the supply of water to the orifice plate.

    b. *Negatively Sloped Pipe from River (wet ponds or shallow marshes)* This design was developed to allow for extended detention in wet ponds. The release rate is governed merely by the size of the pipe. The risk of clogging is largely eliminated by locating the opening of the pipe at least 1 ft below the water surface where it is away from floatable debris. Also, the negative slope of the pipe reduces the chance that debris will be pulled into the opening by suction. As a final defense against clogging, the orifice can be protected by wire mesh.

    c. *Hooded Riser (wet ponds).* In this design, the extended detention orifice is located on the face of the riser near the top of the permanent pool elevation. The orifice is protected by wire mesh and a hood, which prevents floatable debris from clogging the orifice.

8. *Inlet and Outlet Protection.* The inlet pipe should discharge at or below the water surface of the permanent pool. If it is above the pool, an outlet energy dissipater will protect the banks and side slopes of the pond to avoid erosion. The stream channel just downstream of the pond outlet should be protected from scouring by placing riprap along the channel. Also, the slope of the outlet channel should be close to 0.5 percent. Riprap between 18 and 30 inches should be used. If the outlet pipe is less than 24 inches, 9 to 12 inches riprap may be used. Stilling basins may also be installed to reduce flow velocities at the outfall (Schueler, 1987).

9. *Forebay.* A forebay may be installed as part of the wet pond to capture sand and gravel sediment. The forebay should be easily accessible for dredging out the sediment when necessary and access to the forebay for equipment should be provided. The forebay volume should typically be 5 to 10 percent of the water quality volume. If there are multiple inlets to the detention facility, each forebay should be sized based on the portion of water quality volume attributed to the particular inlet.

10. *Emptying Time*. A 12 to 48 hour emptying time may be used for the water quality volume above the permanent pool (Urbonas, et al., 1992).

11. *Freeboard.* The pond embankment should have at least 2 ft of freeboard above the emergency spillway crest elevation (Schueler, 1987).

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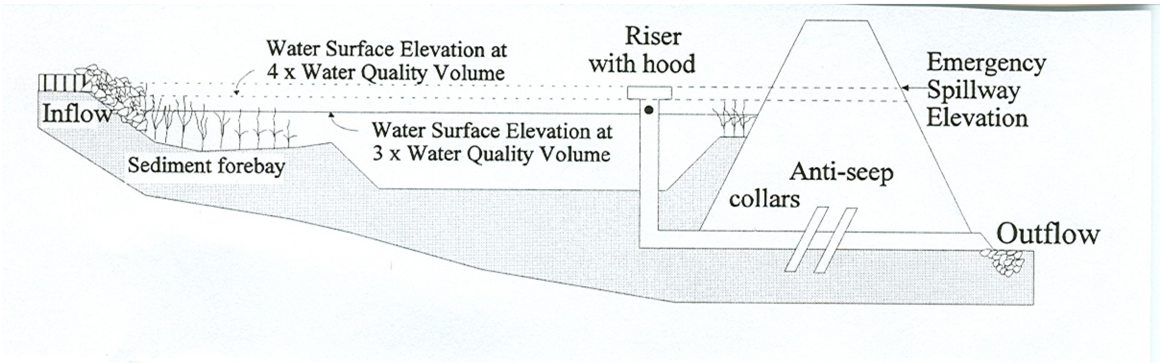

Figure PC-110A
Typical Wet Pond Components (SUSMP, 2002)

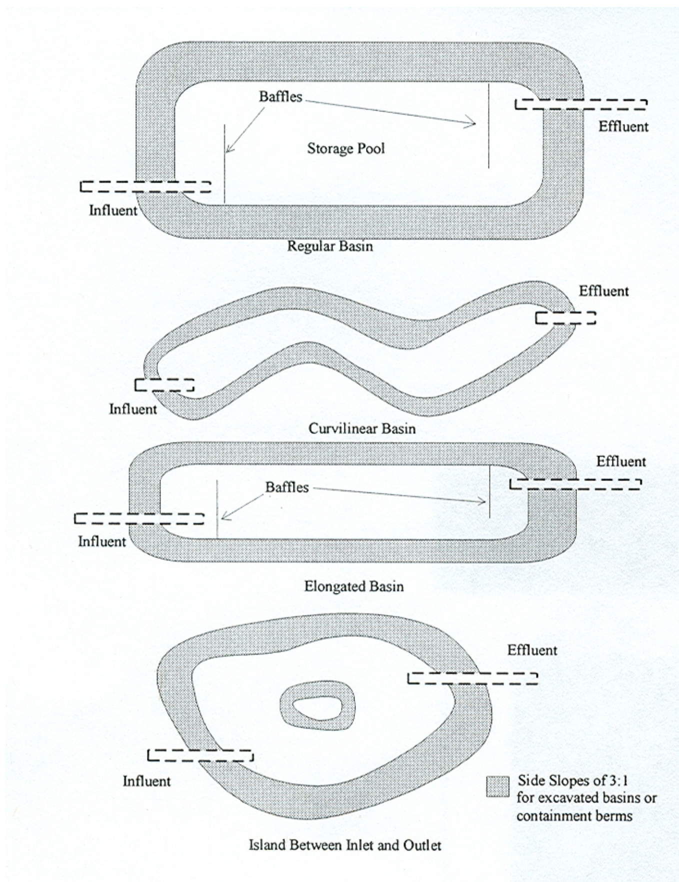

Figure PC-110B
Strategies to Increase residence time in detention facilities (SUSMP, 2002)

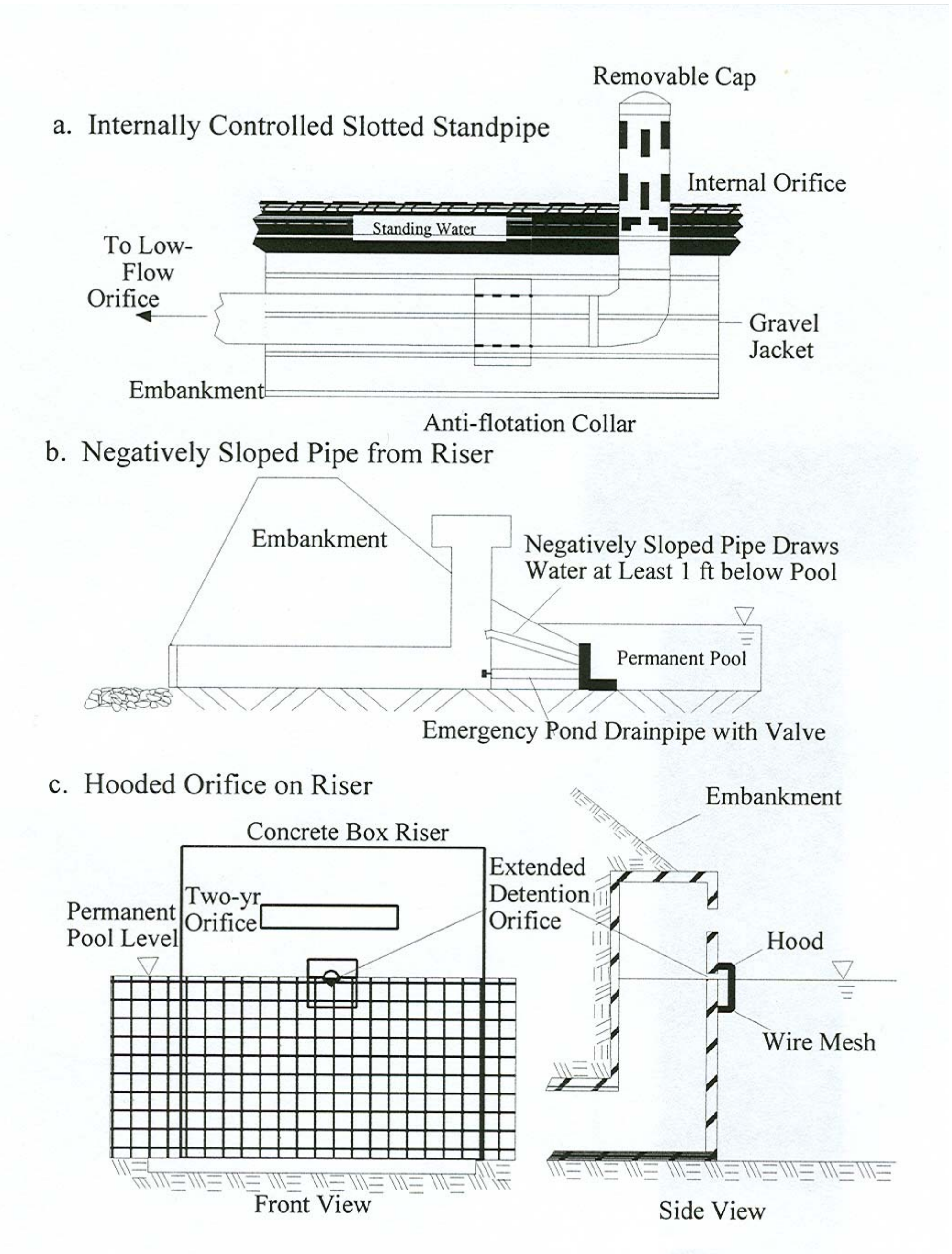

Figure PC-110C
Typical Outlet Structure Modifications to increase residence time of water quality volume (SUSMP, 2002)

APPENDIX 701-2

POST-CONSTRUCTION BMP INSPECTION CHECKLISTS

Bioretention Operation, Maintenance, and Management Inspection Checklist

Project: ____

Location: ____

Date: ______________________ **Time:** ________________

Inspector: ______________________ **Title:** ________________

Signature: ____________________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Debris Cleanout		
Bioretention and contributing areas clean of debris (litter, branches, etc.)		
No dumping of yard wastes into BMP		
2. Vegetation		
Plant height not less than design water depth but not greater than 6 inches		
Observed plant types consistent with accepted plans		
Plants covering greater than 85% of total BMP surface area		
Plant community appears thick and healthy		
No evidence of erosion		
3. Sediment Deposits/Accumulation		
No evidence of sediment buildup around check dams or energy dissipaters.		
Sumps are not more than 50% full of sediment		
Sediment is not >20% of BMP design depth.		

4. Filter Bed		
Would become dry between storms		
Filter bed is not blocked or filled inappropriately.		
5. Outlet/Overflow Spillway		
Good Condition, no need for repair		
No evidence of erosion or downstream scour.		
Outlets are free of blockages.		

Actions to be Taken:

Wetland Operation, Maintenance, and Management Inspection Checklist

Project: ______________________________

Location: ______________________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ______________________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Embankment and Emergency Spillway		
Healthy vegetation with at least 85% ground cover.		
No signs of erosion on embankment.		
No animal burrows.		
Embankment is free of cracking, bulging, or sliding.		
Embankment is free of woody vegetation.		
Embankment is free of leaks or seeps		
Emergency spillway is clear of obstructions.		
2. Riser and Principal Spillway		
Low flow outlet free of obstruction.		
Trash rack is not blocked or damaged.		
Riser is free of excessive sediment buildup		
Outlet pipe is in good condition.		

Control valve is operational		
Outfall channels are stable and free of scouring.		
3. Wetland		
Plants covering greater than 85% of total wetland surface area (excluding open water areas)		
Observed plant types consistent with accepted plans		
No evidence of excessive sediment accumulation in wetland area		
Water depths consistent with accepted plans		
No evidence of erosion on banks.		
Wetland areas clean of debris (litter, branches, etc.)		
No evidence of dumping of yard wastes into BMP		
4. Forebay		
Sediment is being collected by forebay(s)		
Forebay is not in need of cleanout (less than 50% full)		

Actions to be Taken:____

Infiltration Trench Operation, Maintenance, and Management Inspection Checklist

Project: ______________________________

Location: ______________________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ______________________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Debris Cleanout		
Trench surface clear of debris		
Inflow pipes clear of debris		
Overflow spillway clear of debris		
Inlet area clear of debris		
2. Sediment Traps or Forebays		
Obviously trapping sediment		
Greater than 50% of storage volume remaining		
3. Trench		
Trench dries out between storms		
No evidence of sedimentation in trench		
Sediment accumulation doesn't yet require cleanout		
4. Inlets		
Good condition		
No evidence of erosion		

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
5. Outlet/Overflow Spillway		
Good condition, no need for repair		
No evidence of erosion		
6. Aggregate Repairs		
Surface of aggregate clean		
Top layer of stone does not need replacement		
Trench does not need rehabilitation		

Actions to be Taken:

Infiltration Basin Operation, Maintenance, and Management Inspection Checklist

Project: ____________________

Location: ____________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ____________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Debris Cleanout		
Basin bottom clear of debris		
Inlet clear of debris		
Outlet clear of debris		
Emergency spillway clear of debris		
2. Sediment Traps or Forebays		
Obviously trapping sediment		
Greater than 50% of storage volume remaining		
3. Vegetation		
Mowing done when needed		
No evidence of erosion		
4. Drying Out		
Basin dries out between storms		

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
5. Sediment Cleanout of Basin		
No evidence of sedimentation		
Sediment accumulation does not yet require cleanout		
6. Inlets		
Good condition		
No evidence of erosion		
7. Outlets/Overflow Spillway		
Good condition, no need for repair		
No evidence of erosion		
8. Structural Repairs		
Embankment in good repair		
Side slopes are stable		
No evidence of erosion		
9. Fences/Access Repairs		
Fences in good condition		
No damage which would allow undesirable entry		
Lock and gate function adequate		
Access point in good condition		

Actions to be Taken:____

Media Filtration Operation, Maintenance, and Management Inspection Checklist

Project: ______________________________

Location: ______________________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ______________________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Debris Cleanout		
Contributing areas clean of debris		
Filtration facility clean of debris		
Inlet and outlets clear of debris		
2. Oil and Grease		
No evidence of filter surface clogging		
Activities in drainage area minimize oil and grease entry		
3. Vegetation		
Contributing drainage area stabilized		
No evidence of erosion		
Area mowed and clippings removed		
4. Water Retention Where Required		
Water holding chambers at normal pool		
No evidence of leakage		

Actions to be Taken: ______________________________

Filter Strip Operation, Maintenance, and Management Inspection Checklist

Project: ______________________________

Location: ______________________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ______________________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Vegetation		
Observed plant types consistent with accepted plans		
Vegetation is healthy		
Plants covering greater than 85% of total BMP surface area		
Grass height not more than 6 inches		
No evidence of concentrated flows		
No evidence of erosion		
2. Level Spreader		
Lip of spreader showing no signs of erosion		
Sediment noted in spreader?		

Actions to be Taken: ______________________________

Vegetated Swale Operation, Maintenance, and Management Inspection Checklist

Project: ____________________

Location: ____________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ____________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Debris Cleanout		
Contributing drainage areas free from debris		
2. Vegetation		
Mowing performed when needed		
No evidence of erosion		
3. Check Dams or Energy Dissipaters		
No evidence of flow going around structure		
No evidence of erosion at the downstream toe		
Soil permeability		
4. Sediment Forebay		
Sediment cleanout not needed (clean out when 50% full)		

Actions to be Taken: ____________________

Detention Pond Operation, Maintenance, and Management Inspection Checklist

Project: ______________________________

Location: ______________________________

Date: ____________________ **Time:** ____________________

Inspector: ____________________ **Title:** ____________________

Signature: ______________________________

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
1. Embankment and emergency spillway		
Healthy vegetation with at least 85% ground cover.		
No signs of erosion on embankment.		
No animal burrows.		
Embankment is free of cracking, bulging, or sliding.		
Embankment is free of woody vegetation.		
Embankment is free of leaks or seeps		
Emergency spillway is clear of obstructions.		
Vertical/horizontal alignment of top of dam “As-Built”		
2. Riser and principal spillway		
Low flow outlet free of obstruction.		
Trash rack is not blocked or damaged.		
Riser is free of excessive sediment buildup		
Outlet pipe is in good condition.		
Control valve is operational		
Outfall channels are stable and free of scouring.		

Maintenance Item	Satisfactory/ Unsatisfactory	Comments
3. Permanent Pool (Wet Ponds)		
No Evidence of undesirable vegetation		
No accumulation of floating or floatable debris		
No evidence of shoreline scour or erosion		
4. Sediment Forebays		
Sediment is being collected by forebay(s)		
Forebay is not in need of cleanout (less than 50% full)		
5. Dry Pond Areas		
Healthy vegetation with at least 85% ground cover.		
No undesirable woody vegetation		
Low flow channels clear of obstructions		
No evidence of sediment and/or trash accumulation		
6. Condition of Outfall into Ponds		
No riprap failures		
No evidence of slope erosion or scouring		
Storm drain pipes are in good condition, with no evidence of non-stormwater discharges		
Endwalls/Headwalls are in good condition		