DRAFT 2022
Stormwater Drainage Manual
Division of Sewerage and Drainage

THE CITY OF
COLUMBUS
ANDREW J. GINTHER, MAYOR
DEPARTMENT OF
PUBLIC UTILITIES

Preface – ~~Grandfathering of Existing~~Legacy Plans

1. Plans (CC, E or Final Site Compliance Plan (FSCP)) that have by the effective date of the ~~2021~~ 2022 Stormwater Drainage Manual (SWDM) been submitted for review will be subject to the ~~2012~~ 2021 SWDM. Construction of these plans shall begin within three months of plan approval or within six months of the effective date of the ~~2021~~ 2022 SWDM, whichever is later. If a CID is not paid and the first construction inspection scheduled within three months of plan approval or within six months of the effective date of the ~~2021~~ 2022 SWDM, whichever is later, then the plan approval shall expire. Projects with expired plans shall be resubmitted for review based on the requirements of the ~~2021~~ 2022 SWDM, including requirements for easements and bonds. All plans in an earlier state of design by the effective date of the ~~2021~~ 2022 SWDM will be subject to the requirements of the ~~2021~~ 2022 SWDM.

   If multiple phases are approved under the same plan, the CID is paid and construction begins for phase one, the additional phases would ~~be grandfathered~~not expire. If the additional phases are not part of the approved plan for phase one and the CID for phase one is not paid within the prescribed time frames, additional phases would ~~not be grandfathered~~expire.

2. All plans approved prior to the effective date of the ~~2021~~ 2022 SWDM shall begin construction within six months of the effective date of the ~~2021~~ 2022 SWDM. If a CID is not paid and the first construction inspection scheduled within six months of the effective date of the ~~2021~~ 2022 SWDM then the plan approval shall expire. Projects with expired plans shall be resubmitted for review based on the requirements of the ~~2021~~ 2022 manual, including requirements for easements and bonds.

3. At any future date, if a new plan utilizes a previously approved and constructed Stormwater Control Practice (SCP) to achieve compliance with the SWDM, that SCP will not be subject to the ~~2021~~ 2022 SWDM requirements.~~;~~ Full compliance with the current OEPA laws and regulations, including the Construction General Permit, will be required and may necessitate changes in this ~~2012~~ 2021 to ~~2021~~ 2022 SWDM transition approach.

Introduction

The City of Columbus (City) was founded in 1812 and has served as the state capital since 1816. The City has the largest population in the state of Ohio and a land area of nearly 226 square miles, making it the fifteenth largest city by area in the United States. The City's administrative structure and development regulations related to stormwater have evolved to address the City's growth. The Division of Sewerage and Drainage (DOSD) was created by ordinance in 1950 as a part of the Department of Public Service (renamed Department of Public Utilities in 1991). In 1994, the City created a Stormwater Management Program and established a stormwater utility fee to finance infrastructure improvement projects and implement programs designed to improve stormwater quality.

In 2006, the City adopted the Stormwater Drainage Manual (the Manual). The Manual sets forth the City's standards applicable to new development or redevelopment. Generally speaking, the Manual requires all public and private development to control stormwater leaving the site after construction for both water quality and water quantity.

In 2012, the City repealed the 2006 Stormwater Drainage Manual and adopted the 2012 Manual after convening a committee to review the 2006 Manual and its implementation. The committee reviewed the technical standards of the 2006 Manual, as well as the process for obtaining a variance from the Manual requirements.

In 2021, the City repealed the 2012 Stormwater Drainage Manual and adopted the 2021 Manual after convening ~~Following a similar process, in 2017 the City convened~~ a committee to review the 2012 Manual and its implementation. ~~The committee consisted of a variety of stakeholders, including developers, design professionals, environmental advocacy organizations and other interested governmental agencies.~~ The committee reviewed the technical standards of the 2012 Manual, as well as the process to obtain credits under the Stormwater Credit Rule. As a result of that review process, the City ~~is reissuing the Manual.~~committed to a process of continuous review and improvement of the Manual rather than periodic updates.

In 2022, after review by the Stormwater Drainage Manual committee, the City proposed administrative updates to clarify certain technical standards in the Manual. Because of these changes the City is reissuing the Manual.

Effective ~~May 16, 2021~~November X, 2022, the ~~2012~~ 2021 Stormwater Drainage Manual is repealed, and the ~~2021~~ 2022 Manual is in effect.

Purpose

Experience has shown that most of the more serious flooding, erosion, and water quality problems are "created." Usually this occurs from conveying more stormwater to a given area than can be carried away effectively. Ever increasing drainage problems emerge unless well-conceived, cooperative stormwater drainage and flood control programs are

undertaken throughout the entire watershed. The stormwater management goals of the City of Columbus, Ohio, are to prevent flooding, streambank erosion, and water quality degradation that may result from stormwater runoff from development and redevelopment projects.

The purpose of the Manual is to protect existing natural stormwater resources, convey and control stormwater in a safe and responsible manner, and meet water quality goals. The Manual is intended to provide information to the general public on the City's stormwater policies and design practices, as well as assist developers, engineers, and City staff in the preparation, review and approval of the Stormwater Management Report and Construction Drawings that must accompany private and public development proposals. This document is organized to facilitate specific design and submittal activities related to stormwater management infrastructure.

Stormwater management, particularly in the area of stormwater quality management, is an evolving science. The goal of the City is to be responsive to changes in stormwater policy and design brought forth by the natural progression of the industry. As such, the Manual will be updated as necessary to reflect accepted standard practice in stormwater management.

The City also recognizes that there may be instances where alternative stormwater standards may apply to protect sensitive ecological areas (i.e., Hellbranch Run and the Darby Creek watersheds) or to meet the goals of Total Maximum Daily Loads established by Ohio EPA. Where alternative standards conflict with the requirements of the Manual, the more stringent criteria shall apply.

~~Major~~ Changes from ~~2012~~ 2021 Manual

As noted above, the ~~2012~~ 2021 Manual was revised after an extensive review process. Subsequently the City committed to a process of continuous review and improvement of the Manual rather than periodic updates, and the refinements included in the 2022 Manual are a reflection of this.~~Some of the more significant changes include the following:~~

- ~~Applicability Matrix: The 2012 Manual provided applicability criteria in a list format. The 2021 Manual now prescribes applicability using a matrix to more clearly define which sections of the Manual apply to different types of construction activities.~~
- ~~Stormwater Controls: The 2021 Manual streamlines the Manual's Section 3 Stormwater Control criteria by referring to applicable Ohio EPA General Construction Stormwater permit criteria or Ohio Rainwater and Land Development Manual criteria when possible to avoid confusion regarding storm water control standards.~~

- ~~Variance process: the 2021 Manual has been updated to provide a public process that allows interested parties an opportunity to review and provide comments on variance requests before a final decision is made on the variance request.~~

- ~~Green Infrastructure: The City wants to encourage the use of green infrastructure to control stormwater. To accomplish this, the following changes have been made. First, the Manual criteria for green stormwater control practices is further refined. Second, the green infrastructure credit in the stormwater credit rule being revised simultaneously with the Manual.~~

Applicability

The Manual is being adopted as a rule of the Director of Public Utilities pursuant to the authority provided in Columbus City Code 1145.11, 1145.01 and 1149.04. Unless otherwise exempted, the Manual shall be used for all land-disturbing public and private projects that change existing stormwater flow, conveyance system, or stormwater pollutant discharges from applicable premises within the City of Columbus.

Stormwater Drainage Manual Applicability	**Sections**	**Construction, expansion, or redevelopment of commercial, industrial, institutional, residential, or multi-family residential facilities**	**Construction, reconstruction, improvement or modification of private and public transportation facilities**	**Construction activities that do not include the installation of any impervious surface**	**Expansion, construction, or reconstruction of one single-family dwelling or one two-family dwelling on a single parcel***
Stream Corridor and Wetland Protection	1.1 through 1.3 and 1.5	Applicable, except in Downtown District Boundary.	Applicable, except in Downtown District Boundary.	Applicable, except in Downtown District Boundary or for stream and wetland restoration projects, wetland mitigation activities, and projects undertaken solely to improve stormwater quality (e.g. stormwater retrofit).	Applicable

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Floodplain Compensation	1.4	Applicable.	Applicable, except for existing roadway widening projects.	Applicable, except for stream and wetland restoration projects, wetland mitigation activities, and projects undertaken solely to improve stormwater quality or undertaken solely to improve flood control (e.g. stormwater retrofit).	Applicable
Stormwater Conveyance	2	Applicable except for activities included in Ohio EPA's Routine Maintenance Exclusion	Applicable except for activities included in Ohio EPA's Routine Maintenance Exclusion	Applicable except for activities included in Ohio EPA's Routine Maintenance Exclusion	Applicable for improvements to publically owned stormwater infrastructure.
Flood Control (Detention)	3.1 and 3.2 and 3.4	Applicable if greater than 2,000 s.f. of added impervious surface, or greater than 10,000 s.f. of disturbed impervious area.	Applicable if greater than 2,000 s.f. of added impervious surface, or greater than 10,000 s.f. of disturbed impervious area.	Not applicable.	Not applicable.

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Post-construction Water Quality	3.3 and 3.4	See Ohio EPA Construction General Permit and Routine Maintenance Exclusion for applicability.	See Ohio EPA Construction General Permit and Routine Maintenance Exclusion for applicability.	See Ohio EPA Construction General Permit for and Routine Maintenance Exclusion for applicability.	See Ohio EPA Construction General Permit and Routine Maintenance Exclusion for applicability.
Construction Verification and As-built Surveys	4.1 and 4.2	Applicable if temporary sediment settling ponds or post-construction SCPs are ~~required~~included.	Applicable if temporary sediment settling ponds or post-construction SCPs are ~~required~~included.	Not Applicable unless the project includes the construction or retrofit of an SCP.	Applicable if temporary sediment settling ponds or post-construction SCPs are ~~required~~included.
Operation, Maintenance and Monitoring of Stormwater Controls	4.3 and 4.4	Applicable if post-construction SCPs are required.	Applicable if post-construction SCPs are required.	Not Applicable unless the project includes the construction or retrofit of an SCP.	Applicable if post-construction SCPs are required.
Stormwater Management Report	6	Applicable.	Applicable.	Applicable.	Applicable if post-construction SCPs are required.
Construction Drawings	7	Applicable.	Applicable.	Applicable.	Applicable if post-construction SCPs are required.

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Stormwater Pollution Prevention Plan	Section 7.1.5 and Appendix E	See Ohio EPA Construction General Permit, Ohio EPA Routine Maintenance Exclusion and Columbus Land Disturbance Regulation for SWPPP requirements	See Ohio EPA Construction General Permit, Ohio EPA Routine Maintenance Exclusion and Columbus Land Disturbance Regulation for SWPPP requirements	See Ohio EPA Construction General Permit, Ohio EPA Routine Maintenance Exclusion and Columbus Land Disturbance Regulation for SWPPP requirements	See Ohio EPA Construction General Permit, Ohio EPA Routine Maintenance Exclusion and Columbus Land Disturbance Regulation for SWPPP requirements

*Only includes single-family or two-family dwellings on a single parcel that are not part of a larger common plan of development.

The threshold~~s~~ of 2,000 square feet of impervious area ~~and~~ or 10,000 square feet of disturbed impervious area does not apply to a property or project that is part of a larger common plan of development.

The addition or disturbance of impervious area that is intended to be temporary shall not be considered applicable for Flood Control requirements unless the duration of the addition or disturbance will be longer than one year, unless otherwise approved by the Director or designee.

If the impervious area added consists of solar panels and the ground beneath the panels will be vegetated then the area of the panels may not be considered applicable for Flood Control requirements~~.~~ provided that the spacing, width, angle and height of the solar panels is designed to promote vegetative growth below the panels. The Ohio EPA's guidance on solar panel installations shall be referenced when determining the requirements for post-construction stormwater control practices.

If a proposed project consists of more than one site and each site is both greater than one-quarter mile apart from the others and is below the applicability thresholds—2,000 square feet or less of added impervious surface or 10,000 square feet or less of disturbed impervious surface—then the aggregation of the sites' impervious areas is not required to determine the applicability of Flood Control requirements.

Organization

To simplify the use of the Manual, it is organized into two parts. Part I of the Manual supports the layout, design, and maintenance of stormwater management facilities. Four sections make up this part of the Manual:

1. Preservation and Protection (Section 1) defines how to site the project in relation to any streams, floodplains, steep slopes, and wetlands within the project site.

2. Stormwater Conveyance (Section 2) provides design requirements for storm sewers, open watercourses, stream crossings, and other facilities intended to convey stormwater from the site.

3. Stormwater Controls (Section 3) provides design requirements for detention basins and stormwater quality control devices intended to control the rate, volume, and/or pollutant load in stormwater runoff.

4. Construction Verification, Operation, ~~and~~ Maintenance, and Monitoring of Stormwater Control Practices (Section 4) defines requirements for construction performance surety, as-built surveys and construction certification, practice inspection and maintenance, and maintenance and access easement requirements to allow for construction and maintenance in and around stormwater control practices~~maintenance responsibilities for stormwater controls and provides easement, access, inspection and reporting requirements~~.

Part II describes the City's submittal requirements related to stormwater management:

1. Private and Public Development Review Processes (Section 5) provides guidance on the review process for public and private development which propose to construct stormwater infrastructure within the City limits.

2. Stormwater Management Report submittal requirements (Section 6) are summarized in this section. The design for proposed stormwater systems shall be submitted to the City for review and approval in accordance with this section.

3. Stormwater Construction Drawings (Section 7) provides guidance on the information required for plan approval and presents plan details (including title, plan, profile, and cross section sheets) which shall be included in the construction plans.

Construction Requirements

The City's Construction and Materials Specifications (CMSC), current edition, and the Standard Construction Drawings maintained by the City shall govern the construction of stormwater facilities described in the Manual. All construction activity within the City must

also comply with the requirements stipulated by the OEPA and the City's Erosion and Sediment Control Regulations, whichever is more restrictive. Copies of the current CMSC and Standard Construction Drawings are available at the Department of Public Utilities, Utility Permits Office, 111 N. Front St., Columbus, Ohio, or online at: utilities.columbus.gov.

Variances

The City recognizes that there may be individual projects involving special or unusual design challenges such that strict adherence to the Manual will result in substantial hardship. An applicant may apply for a variance with regard to any requirement of this manual pursuant to the following terms.

1. Standard for granting a variance.

   All applicants must make a good faith effort to comply with the Manual. The good faith effort requires, at a minimum, developing a site plan that is in compliance with the Manual. The City recognizes that there are special circumstances, related to individual site conditions that may make compliance with the Manual an undue hardship. If such conditions exist, the applicant may pursue one or more of the following types of variances. As part of the variance process, the applicant may provide and the City may consider evidence of the economic impact of the Manual on the project. Please note, however, that a modest increase in the cost of the project or on the estimated rate of return does not justify a variance.

   a) Downtown: Type I variances are only applicable for redevelopment projects that occur in the Downtown Zoning District as defined in City Code 3359.03. See **Figure 1-1**. A Type I variance may be granted if an applicant demonstrates that full compliance with the Stormwater Drainage Manual is impracticable because of specific site conditions.

   b) Non Stream Protection: Type II variances are applicable to requests for a variance from anything in the Manual other than the stream protection issues. Examples include a request for a variance from the detention requirements or floodplain fill compensation of the Manual. A Type II variance may be granted if there are unique circumstances applicable to the site such that strict adherence to the requirements of the Manual will deprive the applicant of reasonable use of the land or result in substantial hardship to applicant.

   c) Stream Protection: Type III variances are applicable to requests for variances from the Manual's prohibitions on stream relocation or enclosure, and/or from the Manual's Stream Corridor Protection Zone ("SCPZ") requirements. As set forth in more detail in Section 1 of the Manual, the SCPZ is necessary to enhance and maintain water quality, protect the stream channel, conserve and protect habitat

and prevent damage to structures from erosion. A Type III variance may be granted if an applicant demonstrates both of the following:

i) there are unique circumstances applicable to the site such that strict adherence to the Manual will deprive the applicant of reasonable use of the land or result in substantial hardship to applicant; and

ii) the applicant has provided for sufficient mitigation to any impacts on the stream or Stream Corridor Protection Zone.

2. Variance Applications.

Type I Variance Application (Downtown): To obtain a Type I variance, applicant must submit an application meeting the standard set forth above.

A Type I variance application must include two site development plans: one that demonstrates full compliance, and one that is the preferred alternative. The application should support determining that the full compliance alternative is impracticable. Such information can include but is not limited to technical challenges of meeting the requirements of the Manual and projected loss of revenue. The Type I variance should also include the information required by the Variance Guidance Policy, which can be found online at utilities.columbus.gov

Type II Variance Applications (NonStream Protection): To obtain a Type II variance, applicant must submit an application meeting the standard set forth above.

A Type II variance application must include three site development plans: full compliance, minimal impact and preferred alternative. The application should provide supporting information explaining why the full compliance alternative is impracticable. Such information can include but is not limited to technical challenges of meeting the requirements of the Manual and projected loss of revenue. In addition, the application should include the information required by the Variance Guidance Policy, which can be found online at utilities.columbus.gov

Type III Variance Application (Stream Protection): To obtain a Type III variance, applicant must submit an application meeting the standard set forth above.

A Type III variance application must include three site development plans: full compliance, minimal impact and preferred alternative. The application should provide supporting information explaining why the full compliance alternative is impracticable. Such information can include but is not limited to documentation showing the technical challenges of meeting the requirements of the Manual or demonstrating the impact of the full compliance alternative on the overall economic viability of the site development plan. In addition, an application for a Type III variance shall demonstrate sufficient

mitigation for any impacts on the Stream Corridor Protection Zone or the stream. Mitigation shall be considered sufficient if it meets one of the following criteria.

a) If the impact is directly to the stream, the applicant must demonstrate that the predicted post-construction QHEI/HHEI will meet or exceed the existing QHEI/HHEI and the impact will not negatively affect stream geomorphology in the stream segment directly impacted. How such scores are calculated is set forth in the Variance Guidance Policy. If a stream is proposed to be enclosed into a storm sewer or otherwise eliminated, then an equivalent impaired stream length elsewhere must be remediated to demonstrate a substantial improvement of its QHEI/HHEI score to a maximum practicable extent.

b) If the impact is solely to the SCPZ, and not directly into the stream, then the required mitigation must be performed as follows:

   If a temporary impact is proposed, then the SCPZ must be restored to preserve or improve the existing SCPZ quality and function. If the proposed impact removes a portion of the SCPZ, then the applicant must provide adequate mitigation by creating equivalent mitigation SCPZ elsewhere or perform adequate ecological mitigation work on-site or off-site to replace functions lost as a result of the proposed impact. Proposed mitigation shall be considered sufficient if additional equivalent SCPZ is created, or SCPZ mitigation work is performed at the following ratios:

   On site: 1 to 1
   Adjacent site: 1 to 1.5
   Within same HUC-12: 1 to 2

   Generally, mitigation SPCZ will be considered equivalent if it performs the same function as the disturbed SPCZ; for instance, if the disturbed SPCZ includes trees, the mitigation SPCZ should include at least an equivalent number of trees.

   The current property owner may be responsible for existing unpermitted SCPZ and direct stream impacts which occurred in the past on his/her property while under the present or past ownership. If unauthorized impacts were caused by a previous site owner unrelated to the present owner, then the present property owner or his/her agent may contact the Plan Review–and Stormwater & Regulatory Management Section to determine the need for a SWDM Type III stream protection variance and the extents of the required mitigation. The applicant must provide sufficient evidence confirming that the unpermitted direct stream and/or SCPZ impacts were inflicted while the property was under a previous ownership. Such evidence may include dated aerial views, property transfer records, and other relevant information.

   Additional information regarding the Type III variance may be found within the Variance Guidance Policy, which is located online at www.columbus.gov/utilities.

3. Review Process for Variances

An applicant may request a preliminary meeting to discuss proposal and submittal content. Please contact Plan Review and Stormwater & Regulatory Management Section staff~~,~~ at 614-645-2793 or the Plan Review and Stormwater & Regulatory Management Section Manager at 614-645-8072. An applicant may also request that City personnel participate in meetings with other regulatory agencies, such as Ohio EPA, regarding the development. The City may not be able to attend every such meeting, but will work with the applicant to make the approval process as smooth as possible.

Once the application is received, the Plan Review and Stormwater & Regulatory Management Section will check it for completeness. If the application is complete, it will be posted on the City's website, sent by the Plan Review and Stormwater & Regulatory Management Section Manager to the Interested Party List for Variance Requests, and will be reviewed by the Plan Review and Stormwater & Regulatory Management Section Manager.

Comments on the variance request can be made up to fourteen days after a request is posted. If additional time is needed to comment on the request, a formal request for an extension for the comment period must be requested within the original comment period with an explanation of why more time is necessary.

After the public comment period ends, the Plan Review and Stormwater & Regulatory Management Section Manager may recommend an application be approved, and forward that recommendation to the Administrator. If the Manager does not immediately approve the application after initial review, the Manager may ask for additional information or forward the application to the Variance Review Committee (VRC) for additional consideration.

The VRC typically meets once each month to discuss pending variance requests. Generally, the VRC will review the variance application after the public comment period ends, at the meeting following receipt of the application. The VRC will take action on the application at that time, and the VRC will communicate with the applicant the results of the meeting. At the meeting, the VRC will do one of the following:

a) Recommend that the Administrator approve the variance request.

b) Request additional information from the applicant. Such a request shall be specific regarding what additional information is needed and why. The request may be communicated by email. The VRC will consider the additional information at the next scheduled VRC meeting.

c). The VRC will not request more information from an applicant more than twice. If, after the VRC has sought additional information from the Applicant two times, the

VRC still believes that the variance request is incomplete or otherwise unacceptable, it may recommend that the Administrator deny the variance request.

The Administrator shall act on the recommendation of the VRC Committee within 7 days of receiving it. Any person adversely affected by the action of the Administrator may appeal the decision pursuant to and in accordance with Section 1145.82 of the Columbus City Code.

If an application is resubmitted for the same project after it has been issued a proposed or final denial, the applicant shall pay a resubmittal fee of $5,000.

Expiration of Plans

Full compliance with OEPA laws and regulations, including the Construction General Permit, is required for projects developed within the City of Columbus. An approved Stormwater Management Report, Stormwater Construction Drawing, or Stormwater Pollution Prevention Plan may expire each time the OEPA issues a new Construction General Permit if permit coverage was never obtained or is not renewed. Projects for which Reports, Drawings, and Plans that have expired will be required to submit anew and will be reviewed for compliance with current City and OEPA regulations.

Definitions

For the purpose of the Manual, the following terms, phrases, and definitions shall apply and are provided here for quick reference and convenience. Words used in the singular shall include the plural, and the plural - the singular. Words used in the present tense shall include the future tense. The word SHALL is mandatory and not discretionary.

Administrator — The Administrator of the Division of Sewerage and Drainage, or his/her designee.

Agricultural Lands — Those lands in any agricultural use, including forestry.

Applicant — Any person or duly designated representative applying for a permit or other type of city, federal, or state regulatory approval to proceed with a project.

As-Built Survey – A survey shown on a plan or drawing prepared under the direction of a registered Professional Surveyor indicating the actual dimensions, elevations, ~~and~~ locations, ~~of any structures~~ and topography of stormwater control facilities after construction has been completed.

Best Management Practice (BMP) — Schedules of activities, programs, technology, processes, siting criteria, operating methods, measures, devices, prohibitions of practices, maintenance procedures, and other management practices used to prevent, control, remove or reduce the pollution of waters of the United States. BMPs also include, but are not limited to, treatment requirements, operating procedures, practices to control site runoff, spillage or leaks, waste disposal, or drainage from raw material. BMPs may include structural or nonstructural practices.

Building Structure — A building or any structure having a roof supported by columns or walls, or any series of structures separated only by "fire separations" but contained under a common roof or within common walls, and requiring a building permit in accordance with Title Forty-One of the Building Code that is used for shelter, occupancy, enclosure, or support of persons, animals, or property; or a combination of materials, other than a building, to form a construction that is safe and stable including, but not limited to, stadiums, gospel or circus tents, reviewing stands, platforms, staging, observation towers, sheds, coal bins, above grade gas or liquid storage tanks, or fences in excess of six (6) feet in height.

CC Drawings — Plans for stormwater infrastructure that are privately owned, capital projects or public sanitary sewer projects.

Check Storm — A lesser frequency event used to assess the hydraulic grade line, pavement spread, flood routing and hazard analysis, and critical locations where water can pond to appreciable depths.

City — The City of Columbus, Ohio.

Commercial Activity Areas — Outdoor areas where the following activities are conducted and are exposed to stormwater:

1. Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas, and

2. Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed.

3. Areas where high-risk materials, as defined by the director, are handled and stored, including but not limited to loading docks, fuel and other liquid storage/dispensing facilities; material bins, containers, stockpiles, and other storage containers; and waste dumpsters, bins, cans, tanks, stockpiles, and other waste containers.

Compensatory Floodplain Storage — Equivalent floodplain storage provided to counterbalance floodplain filling within designated FEMA floodplain boundaries.

Constructed Open Watercourses — Constructed drainage courses that confine and conduct a periodic flow of water in such a way that concentrates flow. For the purposes of the Manual, constructed open watercourses include swales or ditches that are constructed to convey stormwater runoff within development sites and along public and private roadway systems.

Construction — The building, assembling, expansion, modification or alteration of the existing contours of the site, the erection of buildings or other structures, or any part thereof, or land clearing where land clearing is the removal of some or any vegetation for a purpose or with intent to change the underlying usage of the land so cleared.

Culvert or Stream Crossing — A closed conveyance structure with open ends, designed to carry water through a roadway embankment.

Detention or to Detain — To retard or slow the discharge, directly or indirectly, of a given volume of stormwater runoff into surface waters or downstream system.

Development or Development Activity — The alteration, construction, installation, demolition or removal of a structure, impervious surface or stormwater system; or clearing, scraping, grubbing, killing or otherwise removing the vegetation from a site; or adding, removing, exposing, excavating, leveling, grading, digging, burrowing, dumping, piling, dredging or otherwise significantly disturbing the soil, mud, sand or rock of a site.

Discharge — The outflow of stormwater runoff from a project, site, aquifer, drainage basin or facility.

Division — Division of Sewerage and Drainage.

Drawer D — Plans for new or improved infrastructure associated with a private development project that is to be publicly owned and operated within a public right-of-way or in publicly owned easements, formatted to fit onto a "D" size drawing sheet.

Drawer E — Plans for new or improved infrastructure associated with a private development project that is to be publicly owned and operated within a public right-of-way or in publicly owned easements, formatted to fit onto an "E" size drawing sheet.

Easement — A grant by a Property Owner for the use of a specified portion of land for a specified purpose.

Erosion — The wearing or washing away of soil by the action of water due to either natural or manmade causes.

FEMA 100-year Floodplain — Any land area recognized by FEMA as susceptible to being inundated by flood waters with a one percent chance of annual recurrence, as defined on the FIS and FIRM for Franklin County and incorporated areas.

FEMA 100-year Floodway — The place in which water is likely to be the deepest and fastest; the area of the floodplain which should be reserved to allow floodwaters to move downstream without causing the 100-year peak flood water surface elevation to raise more than one foot, as defined on the FIS and FIRM for Franklin County and incorporated areas. (The maximum allowable surcharge for the City of Columbus is 0.5 feet.)

Forebays — Areas at detention basin inlets that are designed to trap coarse sediment particles and trash by separating a specified volume from the remainder of the basin with a lateral sill, rock-filled gabions, a retaining wall, or horizontal rock filters.

Groundwater — Water below the surface of the ground, whether or not flowing through known or defined channels.

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

Illicit Connection — means any man-made conveyance connecting an illicit discharge directly to a stormwater system.

Illicit Discharge — Shall be as defined in Columbus City Code Chapter 1145.

Impervious Surface — A surface which has been covered with a layer of material so that it is resistant to infiltration by water. Impervious surfaces include conventionally surfaced streets, roofs, sidewalks, paved parking lots, gravel parking lots, artificial turf surfaces, and other similar surfaces. A permanent wet pond is also considered to be an impervious surface.

Larger Common Plan of Development or Sale — As defined in the Ohio EPA Construction General Permit.

Maintenance — The action taken to restore or preserve the design functionality of any facility or system.

Major Outfall — A municipal separate storm sewer system (MS4) outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for MS4s that receive stormwater from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more).

Major Stormwater Routing Systems — An above ground conveyance system which routes stormwater from larger runoff events. This is often the portion of the total drainage system which collects, stores, and conveys runoff that exceeds the capacity of the minor system. It is usually less controlled than the minor system and will function regardless of whether or not it has been deliberately designed and/or protected against encroachment, including when the minor system is blocked or otherwise inoperable.

Minor Drainage Systems — Portions of a stormwater system within the urban environment including things such as catch basins, detention basins, and storm sewer pipes. The portion of the stormwater system that collects, stores and conveys frequently occurring runoff, and provides relief from nuisance and inconvenience. This system has been traditionally planned and constructed, and normally represents the major portion of the urban drainage infrastructure investment. Minor systems include curbs, gutters, ditches, inlets, access holes, pipes and other conduits, open channels, pumps, detention basins, water quality control facilities, etc.

ODOT L&D Manual — ODOT Design Manual in effect as of the date of the effective date of the SWDM or any applicable revisions or amendments.

Offsite — Taking place or located away from the site.

Ohio EPA Construction General Permit — Current version of the General Permit Authorization for Storm Water Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System issued by Ohio EPA and any revisions and amendments thereto.

Ohio EPA Routine Maintenance Exclusion — The conditions and activities defined in Ohio EPA's current Routine Maintenance Exclusion — Construction Activity Permitting and any revisions and amendments thereto.

Onsite — Taking place or located within the site.

Ordinary High-Water Mark — The point on one or both banks of a stream to which the presence and action of surface water is so continuous as to leave a distinctive mark by erosion, destruction, or prevention of terrestrial vegetation, predominance of aquatic vegetation, or other easily recognized characteristics. Where the bank or shore of any particular place is of such character that it is difficult or impossible to ascertain where the point of ordinary high–water mark is, it shall be established at the elevation of the ordinary high-water mark on the opposite bank.

Outfall — A point source where an MS4 discharges to Waters of the State and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels, or other conveyances which connect segments of the same stream or other Waters of the United States and are used to convey Waters of the State.

Parcel or Parcel of Land — A contiguous quantity of land in possession or owned by, or recorded as property of the same claimant person.

Person — Any individual, firm, corporation, governmental agency, business trust, estate, trust, partnership, association, two or more persons having a joint or common business interest, or any other legal entity.

Post-development or Post-construction — Site conditions at the completion of construction that pertains to the management of stormwater from a site.

Post-construction Stormwater Control Practice (SCP) — Is a permanent, structural practice intended to capture or treat stormwater runoff; reduce stormwater runoff rate or volume; or minimize contact between pollutant sources and precipitation or runoff.

Pre-development — The hydrologic and hydraulic condition of the project site immediately before development or construction begins.

Private Facility — Property or facility which is not owned by the City of Columbus.

Professional Engineer — A professional engineer licensed by the State of Ohio skilled in the practice of civil engineering and the engineer of record for the project under consideration.

Professional Landscape Architect — A person licensed by the State of Ohio to practice landscape architecture.

Public Facility — Property or facility which is owned by the City of Columbus.

Reasonably Close Conformity – Shall be as defined under Item 101.03 of the City's Construction and Materials Specifications (CMSC), current edition.

Redevelopment — A change to previously existing, improved real estate, including but not limited to the demolition or building of structures, filling, grading, paving, or excavating. For flood control determinations, the hydrologic and hydraulic condition of the project site prior to redevelopment shall be the condition of the project site immediately before plan submittal and shall remain applicable to the project site for a period of five years.

Riparian — Situated or dwelling on the bank of a stream or other body of water.

Roadside Ditch — An artificial watercourse designed to convey stormwater runoff generated from the roadway surface.

Roadway Widening Project – Roadway widening projects include any roadway project that widens an existing street or road to add contiguous travel lanes, including but not limited to contiguous lanes for vehicle or bicycle travel.

Runoff — Precipitation, snow melt, or irrigation water not absorbed by soil.

Sediment — Solid material, whether mineral or organic, that is in suspension, is being transported, or has been moved from its site of origin by water.

Site — Any tract, lot, or parcel of land or combination of tracts, lots, or parcels of land which is in one ownership, or contiguous and in diverse ownership where development is to be performed as part of a unit, subdivision, or project. For purposes of calculating runoff, the site shall be considered to be the limits of the disturbed area.

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

Stormwater — Discharges to surface waters that originate from precipitation events.

Stormwater Management Report — Refers to the approved detailed analysis and supporting documentation for the design of the stormwater system required for all construction.

Stormwater System — As defined in Columbus City Code Chapter 1149.

Stormwater Pollutants — Any liquid, solid, or semi-solid substance, or combination thereof, that enters stormwater runoff in concentrations or quantities large enough to contribute to the degradation of the beneficial uses of the body of water receiving the discharge or are prohibited by state law.

Stream — Streams shown on USGS 7.5 minute Quad maps as solid or dashed blue lines or a surface watercourse with a well-defined bed and bank, either natural or artificial, which confines and conducts continuous or periodic flowing water.

Stream Corridor Protection Zone — A zone that allows for the natural, lateral movement of open watercourses and prevents structures from being impacted by natural

streambank erosion. A corridor with natural vegetation is left in its natural state, typically vegetated to provide stream stabilization and water quality benefits through infiltration.

Streambank Erosion — The removal of streambanks by flowing water below the ordinary high water mark.

Streambed — The portion of a stream below the ordinary high-water mark where the erosion and deposition of sediments occur.

Substantially Affect Stormwater Drainage — Any change to the site drainage characteristics including, but not limited to, removal of existing or installation of new collection and conveyance features such as inlets, curb and gutter, underdrains, or the alteration of existing site grading that changes drainage direction or volume.

Swale — A man-made watercourse that may contain contiguous areas of standing or flowing water only following a rainfall event, or is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake, or is designed to take into account the soil erodibility, soil percolation, slope, slope length, and contributing area so as to prevent erosion and reduce the pollutant concentration of a given volume.

Terrestrial Vegetation — Upland vegetation and facultative upland vegetation, as defined in the City's Approved Native Plant Species for Stormwater Quality Best Management Practices, found in **Appendix B**.

Transportation Facilities — Systems used for the safe and efficient movement of people and goods on streets, highways, sidewalks, shared-use paths and transit systems.

Watershed — A region draining into a river, river system, or body of water.

Wetland Vegetation — Obligate hydrophyte, facultative wetland and facultative vegetation as defined in the Native Plant Species list. (Reference **Appendix B** for the City's list of approved native plant species.)

Wetlands — Those areas that are inundated or saturated by surface or groundwater with a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Acronyms

BDF	Basin Development Factor
BMP	Best Management Practice
CC	City of Columbus
CMSC	City of Columbus Construction and Materials Specifications

CN	Curve Number
Corps	Army Corps of Engineers
DOSD	Division of Sewerage and Drainage
ESC	Erosion and Sediment Control
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
HGL	Hydraulic Grade Line
HSG	Hydrologic Soil Group
IDF	Intensity-Duration-Frequency
L & D Manual	ODOT Location and Design Manual, Volume 2, Drainage Design
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly the SCS)
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
RLDM	Rainwater and Land Development Manual
SCP	Stormwater Control Practice
TND	Traditional Neighborhood Development
WQv	Water Quality Volume
SCS	The United States Department of Agriculture Soil Conservation Service (which is now the NRCS)
SWPPP/SWP3	Stormwater Pollution Prevention Plan
USGS	United States Geologic Survey

Part I – Stormwater Policy and Facility Design Criteria

Part I of the Manual supports the layout and design of stormwater management facilities. The City's Division of Sewerage and Drainage (part of the Department of Public Utilities) was granted the authority to generate design standards and to enforce rules governing stormwater management under Title 2 Administrative Codes, Section 221.05 of the Columbus City Code. Columbus City Code Title 11, Section 1145.11 grants the Director authority to adopt rules and regulations as necessary for administration of this chapter, Regulation of Sewer Use. In addition, Section 1145.~~71~~ 81 authorizes the Director to adopt regulations governing the quantity and quality of stormwater discharges from premises within the City, and from premises outside of the City which are tributary to the City's sewer system. Furthermore, Section 1149.04 authorizes the Director to promulgate rules as are necessary for the safe, economical, and efficient management and protection of the stormwater system. The City has determined that the stormwater management requirements set forth in the Manual are necessary to govern stormwater quantity and quality, and for the safe and efficient management of the stormwater system. This section provides the City's requirements for successfully designing the stormwater management facilities and the layout requirements that must accompany acceptable projects altering land use. These requirements are organized in three sections containing subsections for each pertinent element of the stormwater management system.

Section 1 Preservation and Protection

- Stream Protection Policy Statement
- Stream Identification
- Stream Corridor Protection Zone
- Floodplain Preservation and Developments within Special Flood Hazard Areas
- Wetland Policy

Section 2 Stormwater Conveyance

- General Criteria
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  - Onsite Stormwater Conveyance
  - Downstream Analysis
  - Agricultural Field Tiles
  - Stormwater System Diversions
- Hydrology Requirements
- Design of Minor Stormwater Conveyance Systems
  - Storm Sewers
  - Curbs Inlets and Catch Basins
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- Level Spreaders
- Open Watercourses

- Design of Major Stormwater Routing Systems

Section 3 Stormwater Controls

- General Criteria
- Stormwater Quantity Controls
  - Hydrologic Requirements
  - Acceptable Methods and Criteria
- Stormwater Quality Controls
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  - Parking Lot Storage
  - Underground Storage
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  - Infiltration Basin
  - Constructed Wetland
  - Shallow Constructed Wetlands
  - Bioretention Facilities
  - Sand Filters
  - Vegetated Filter Strips
  - Other Practices
- Water Quality Controls for Commercial Activity Areas
- Applicant-Proposed Stormwater Controls
- Illicit Discharge and Illegal Dumping Control

Section 4 Construction Verification, Operation, Maintenance, and Monitoring of Stormwater Control Practices

- Construction Surety for Stormwater Control Practices
  - Requirement to Provide Surety
  - Construction Guarantee Process
- Stormwater Control Practice Construction Verification
  - Timing of As-Built Survey and Certification
  - Post-Construction Stormwater Control Practice As-Built Survey Contents
  - Stormwater Control Practice Certification
- Stormwater Control Practice Maintenance Responsibilities
  - Stormwater Easements, Access, and Maintenance Requirements
  - Stormwater Control Practice Maintenance Plan
  - Maintenance Inspection Requirements
  - Stormwater Control Practice Monitoring Requirements

Section 1
Preservation and Protection

The City has determined that establishing a Stream Corridor Protection Zone along streams is necessary to protect structures from damage caused by natural erosion. A Stream Corridor Protection Zone may provide the following benefits:

- Reduce stream bank erosion and thereby protect structures;
- Add to the natural character and provide viewsheds within the community;
- Prevent or reduce flood related damage;
- Remove sediment, nutrients, and pollutants from the stormwater entering the stream;
- Provide shade that maintains cooler water temperatures;
- Maintain biological diversity;
- Maintain adequate flows of water to underground aquifers; and
- Provide greenway corridors for wildlife and to provide other environmental and aesthetic values.

Unless otherwise exempt, all development and redevelopment projects that include a portion of the Stream Corridor Protection Zone must minimize alterations of the stream, keep new structures out of the Stream Corridor Protection Zone, and maintain a riparian corridor along the stream to minimize streambank erosion and to protect stream habitat. Section 1 of the Manual provides stream protection standards for all development and redevelopment projects in the City.

1.1 Stream Protection Policy Statement

With the exception of roadside ditches and approved roadway crossings, all streams identified on the United States Geologic Survey (USGS) quad maps with solid or blue dashed lines and all watercourses having a defined bed and bank shall remain open and shall not be enclosed within a storm sewer or other engineered structure. A Stream Corridor Protection Zone shall be established that provides for adequate conveyance, water quality benefit and allows for the natural, lateral movement of streams to prevent structures from being impacted by natural streambank erosion. Streams may not be realigned or relocated.

1.2 Stream Identification

A stream is a surface watercourse with a well-defined bed and bank, either natural or artificial, which confines and conducts continuous or periodic flowing water. The Applicant shall identify and label all streams within the project site and/or streams receiving stormwater discharges from the project site on the master drainage plan (Section 6) submitted as part of the Stormwater Management Report. The Applicant shall provide information that supports the classification of streams with the Stormwater Management Report. Such information may include, but not be limited to, copies from USGS Quad sheets, photographs, FEMA maps, or soils maps showing the location of a stream and delineation of the upstream tributary area.

If the City determines that the submitted evidence is inconclusive, then they may require a site inspection and input from other sources of information including, but not limited to, the U.S. Army Corps of Engineers, Ohio EPA, ODNR, or the appropriate County Soil and Water Conservation District. Final determination regarding whether the watercourse or channel meets the classification of a stream for the purposes of the Manual shall be at the discretion of the Director or designee. Stream Corridor Protection Zones are not required along constructed open channels that are not classified as streams.

If the applicant has already received an approved stream and wetland delineation from the U.S. Army Corps of Engineers, the applicant must provide the approval for City review and the City may accept that delineation. The applicant may submit to the City its pending application with the Corps; however, an application that is pending and has not been approved by the Corps will not automatically be approved by the City.

1.3 Stream Corridor Protection Zone

A Stream Corridor Protection Zone consists of the stream and the riparian area along the stream. Its purpose is to allow the natural, lateral movement of open water courses, provide sufficient area for flood conveyance, protect water quality and prevent structures from being impacted by natural streambank erosion. To ensure natural streambanks are protected from erosion, outlet structures should be sited in locations that minimize erosion.

1.3.1 Stream Corridor Protection Zone Delineation

The total width of the Stream Corridor Protection Zone for streams shall be established using the following criteria, whichever is greater:

1. The Federal Emergency Management Agency (FEMA) designated 100-year floodway, or
2. Using the equation below with a minimum of 50 feet to a maximum of 250 feet. The zone shall be centered on the stream valley generally located at the point where both zone boundaries intersect equal elevations on either side of the stream. Where topography is flat the zone shall be centered on centerline of the stream:

   Stream Corridor Protection Zone, in feet of width[1] = $147(DA)^{0.38}$

   Where DA = drainage area of the stream in square miles, or
3. 50 feet from the top of each bank for fourth order streams or larger, or
4. For Big Darby Creek and Olentangy River watersheds, riparian setback requirements provided within the current Ohio EPA General Permit Authorization for Storm Water Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System ("Construction General Permit")

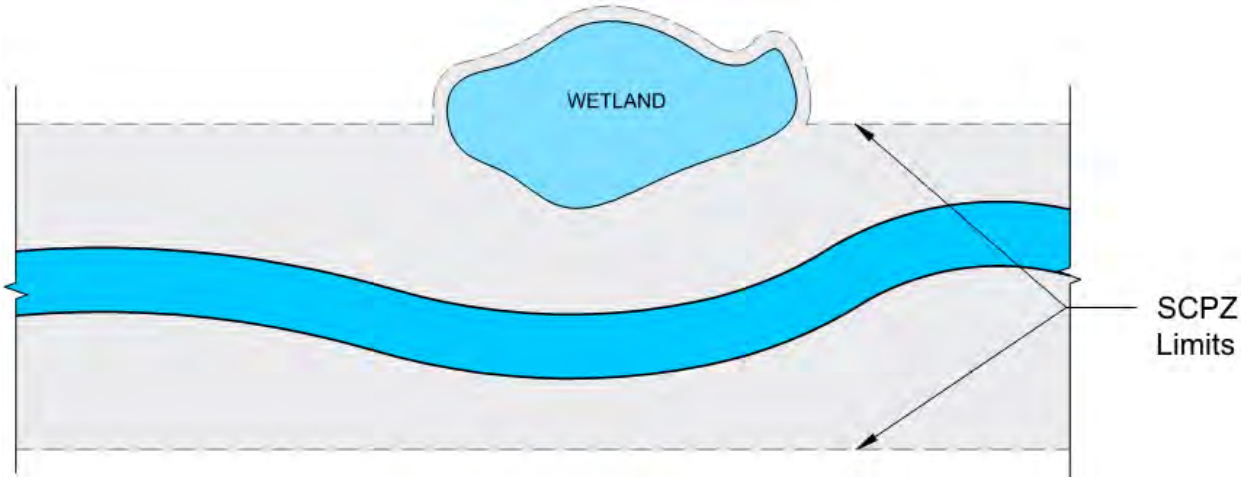
~~In most instances the Stream Corridor Protection Zone is located by placing its centerline over the centerline of the watercourse. However, individual site conditions including, but not limited to, topography and slope must be considered when determining the precise location of the Stream Corridor Protection Zone.~~ Refer to the latest edition of the Ohio Rainwater and Land Development Manual (ORLDM), Chapter 2, Section 2.5 for detailed guidance. For the purposes of Stream Corridor Protection Zone delineation, use stream setback guidelines in the ORLDM.

The width of the Stream Corridor Protection Zone shall be extended to include slopes that are greater than 15 percent and begin at a point within the Stream Corridor Protection Zone. The maximum width of the Stream Corridor Protection Zone extension shall be to the top of the slope or to a point up-slope, as measured horizontally, where the width of

[1]Equation is from the Rainwater and Land Development Manual by the Ohio Department of Natural Resources (ODNR) based on regional curve analysis for various watercourses measured in the eastern United States region.

the Stream Corridor Protection Zone is doubled, whichever is less. Slope protection widths may be extended beyond these limits at the City's discretion on a case-by-case basis.

Where wetlands ~~protected under federal or state law~~ are located partially within the Stream Corridor Protection Zone, the Stream Corridor Protection Zone shall be extended to include the full extent of the wetland area including any required setback. See Section 1.5 for more information on the City's Wetland Policy.



1.3.2 Permanent Protection of the Stream Corridor

The Stream Corridor Protection Zone shall be kept in as natural state as possible so that it can perform its inherent function of erosion protection, flood storage, and water quality protection. In order to ensure the permanent protection of the zone, the developer shall provide for the permanent protection of the zone.

The developer shall identify on the plat or plan and visibly delineate on the site the Stream Corridor Protection Zone prior to any construction on the site to prevent excursions onto the zone during construction. Such delineation must be submitted to the Director of Public Utilities or the Director's designee for review and approval prior to construction.

Encroachments (see Section 1.3.3 Prohibited Uses) constructed prior to March 2006 and that exist at the time the plat or plan is created may remain and shall not require a variance or mitigation unless as part of the project the existing encroachment is to be modified or reconstructed in a way that is beyond normal maintenance. For example, the resurfacing in kind of an existing parking lot is considered normal maintenance but converting a gravel lot to asphalt is not.

No later than the conclusion of construction, the developer shall permanently delineate the Stream Corridor Protection Zone in an aesthetically harmonious manner, approved by the director, such that the location of the zone is apparent to casual observers and

permits access to the zone. Section 1.3.6 provides additional information on this requirement.

Language preventing Property Owners from constructing facilities and performing activities that are prohibited within the Stream Corridor Protection Zone, as described in Section 1.3.3, shall be shown on the plat and reflected on all deeds. Land designated as a Stream Corridor Protection Zone shall be placed in a Conservation Easement with the City stated as the Grantee.

That portion of a lot or parcel reserved as the Stream Corridor Protection Zone may be included in the total area for computing the density permitted by the particular underlying zoning district for that parcel, even if ownership of the Stream Corridor Protection Zone is subsequently transferred. The resulting increase in net density permitted on that portion of the lot or parcel located outside of the Stream Corridor Protection Zone is acceptable to the extent that the gross density for the total area does not exceed the density prescribed by the underlying zoning district.

1.3.3 Prohibited Uses in the Stream Corridor Protection Zone

Table 1-1 lists facilities/activities that are prohibited within the Stream Corridor Protection Zone. Where feasible and elevations permit, stormwater pipe outfalls shall be located outside the Stream Corridor Protection Zone and discharged into either a structural level spreader or a constructed open channel with appropriate protection from erosion.

Table 1-1

Facilities and Activities Prohibited in the Stream Corridor Protection Zone

Prohibited Facilities	Prohibited Activities*
▪ Buildings/structures (except bridges) ▪ Swimming pools ▪ Signs ▪ Billboards ▪ Fences ▪ Parking lots ▪ Electric lines that run parallel to the stream (with the exception of transmission lines) ▪ Utility lines or pipes that run parallel to the stream (except for necessary public sanitary, water, stormwater [see above] and public utility transmission lines as approved by the City) ▪ Telecommunications lines that run parallel to the stream (with the exception of transmission lines) ▪ Cable TV lines that run parallel to the stream ▪ Other improvements deemed unacceptable to the City	▪ Agriculture ▪ Industry/ commercial business ▪ Filling ▪ Excavation ▪ Ditching/diking ▪ Removal of topsoil, sand, gravel, rock, oil, gas ▪ Any other change in topography other than what is caused by natural forces ▪ Herbicides/pesticides ▪ Removal of native trees /vegetation except as approved by the City ▪ Mowing ▪ Depositing yard waste ▪ Dumping or burning of trash, garbage, rubbish, or other substances; ▪ Temporary or permanent storage or placement of any type of trailers, house trailers, equipment, machinery, cars, trucks

* Unless designated a permitted use by the City

1.3.4 Permitted Uses in the Stream Corridor Protection Zone

Uses permitted within the Stream Corridor Protection Zone include, but are not limited to, the following:

1. Passive uses including hiking, fishing, picnicking, and similar uses. Construction of paved trails to further such passive recreation uses is permitted; however, trails that become damaged due to natural erosion should not be repaired but should be moved upland or removed altogether,
2. Vegetation removal on existing levees and dikes,
3. Activities by City personnel that are necessary to maintain the function of any open watercourse and the West Columbus Local Protection Project (floodwall),
4. Removal of damaged or diseased trees.
5. Revegetation and/or reforestation with plantings of native species,
6. Public utility crossings (Those utilities owned by the City, suburb or any entity contracting with the City as defined by Title 11 of the City Code.),
7. Street crossings that are perpendicular, or as perpendicular to the Stream Corridor Protection Zone as feasible,
~~7.~~8. Private drive crossings,
~~8.~~9. Excavation for providing compensatory floodplain volume immediately adjacent to the channel,
~~9.~~10. Construction activities associated with properly permitted stream restoration projects,
~~10.~~11. Disturbances resulting from permitted stream and/or wetland mitigation projects provided the mitigation is to offset impacts to local protected wetlands (see Section 1.5), and
~~11.~~12. Activities related to enhancement of existing wetlands.

Disturbances within the Stream Corridor Protection Zone as a result of a permitted use must be mitigated through revegetation/reforestation, with the exception of vegetation removal for floodwall and dike/berm maintenance and inspection.

1.3.5 Applicability of Stream Corridor Protection Zones

A Stream Corridor Protection Zone is required for all projects subject to the Manual, except as follows:

Exemption 1 — Stream Corridor Protection Zones will not be required along existing streams located within the Downtown Zoning District as defined in City Code 3359.03 (See **Figure 1-1** at the end of this section).

Exemption 2 — Where the Stream Corridor Protection Zone for the Scioto River falls beyond the limits of the existing West Columbus Local Protection Project (floodwall), the limits of the Stream Corridor Protection Zone for the Scioto River shall end at the river side face of the floodwall or floodwall easement. Streams tributary to the Scioto River, however, that are not located within the downtown zoning district, will have a Stream Corridor Protection Zone based on their respective tributary area or floodway width as specified in Section 1.3.

1.3.6 Stream Corridor Protection Zone Signage Requirements

Upon the conclusion of site development activities, the developer shall permanently delineate the Stream Corridor Protection Zone (SCPZ) in accordance with the following requirements, such that the location of the SCPZ is apparent to casual observers and restricted activities are identified.

1.3.6.1 Signs

In all cases, SCPZ boundaries must be marked with appropriate signage. SCPZ signs and posts shall conform to Standard Drawing AA-S178 or AA-S179. The SCPZ signage shall have the following text:

STREAM CORRIDOR
PROTECTION ZONE
DO NOT MOW, SPRAY
OR DISTURB

SEE COLUMBUS.GOV/
UTILITIES/SCPZ
FOR RESTRICTIONS

Text shall be minimum 1 inch high white lettering conforming to Series B 2000 Standard Alphabet and Spacing (per ODOT Sign Design and Markings Manual). Text shall be white on a green (Pantone/PMS 342) background. Retroreflective materials shall not be used.

1.3.6.2 Markers

Wood bollards or fiberglass markers may be utilized in conjunction with required signs to delineate the boundary of the SCPZ. SCPZ Markers shall conform to Standard Drawing AA-S176 or AA-S177. SCPZ Markers shall have the following text:

N
O

M
O
W

Text shall be a minimum 3 inch high lettering conforming to Series B 2000 Standard Alphabet and Spacing (per ODOT Sign Design and Markings Manual). Text shall be green (Pantone/PMS 342) on a white background.

1.3.6.3 Placement

SCPZ signs and/or markers shall be placed at the SCPZ limits within the site per Table 1-2. In no case shall the distance between signs be more than 300 feet.

Table 1-2
SCPZ Sign and Marker Spacing

Application	Signs	Markers
Single Family Residential Developments:		
Where lots abut/intersect the SCPZ	At every other property line, such that every property has at least one sign	Between signs to denote angles/corners and at least every 150 feet*
In open spaces	At each property line and at least every 300 feet.	Between signs at angles/corners and at least every 150 feet
Multifamily, Commercial, Institutional and Recreational Developments	At each property line and at least every 300 feet.	Between signs at angles/corners and/or along curves and at least every 150 feet

*If the distance between the signs placed at every other property line is less than or equal to 150 feet, then markers are not required.

1.3.6.4 Fencing

Fencing may be utilized to delineate the Stream Corridor Protection Zone. Fencing must be pressure treated wood, wood/plastic composite, vinyl or ornamental metal. Chain link or wire fencing is not permitted. Fencing may not exceed 3 feet high, and must conform to Standard Drawing AA-S180. If fencing is installed, SCPZ signs may be installed on the fencing instead of on separate posts, in accordance with the spacing described in Table 1-2. If fencing is utilized, markers are not required.

1.4 Floodplain Preservation and Developments within Special Flood Hazard Areas

All development within FEMA designated Special Flood Hazard Areas is subject to conditions of the City of Columbus' Title 11 Water Sewer and Electric Code, Chapter 1150 Flood Plain Management.

The Division of Sewerage and Drainage prohibits the filling of FEMA designated floodplains without compensation due to potential for problems associated with flooding, erosion, and environmental impact. With the exception of fills associated with widening an existing public roadway and/or adding sidewalks or trails to an existing roadway corridor within a FEMA designated Flood Hazard Area, fill within the FEMA delineated 100-year floodplain must be compensated by removing an equivalent volume of material or greater. (Information on FEMA's 100-year floodplains can be obtained through ODNR's Geographic Information Management Systems metadata or directly through FEMA.) The amount of compensatory storage shall be determined by the volume of material removed above the ordinary high-water mark of the stream and below the 100-year flood elevation established for the area. The compensation area must have an unrestricted hydraulic connection to the affected stream and provide the same rate of flood storage capture and discharge over the course of the flood event as in pre-project conditions. First consideration shall be given to expanding the stream's existing floodplain next to the existing channel and within the limits of the development site. In instances where compensatory storage within the limits of the development site is proven to be technically impractical, the City may consider offsite compensatory storage as long as:

1. First consideration is given to performing compensatory storage by expanding the stream's existing floodplain next to the channel.
2. The mitigation is performed as close to the proposed fill area as possible.
3. The mitigation occurs within the same hydraulic reach of the same stream in which filling is proposed to occur.
4. Where the Applicant proposes to provide compensatory storage on property owned by others, the Applicant must submit a written agreement between such landowner and the Applicant wherein the landowner agrees to convey an easement or other property interest or right to the Applicant allowing compensatory storage, and to permanently maintain such area for flood storage purposes in the event that the City approves the Applicant's proposed project.

The same hydraulic reach is defined as the reach of a stream between the nearest features controlling the flood water elevations upstream and downstream from the proposed fill area.

Disturbances created within the Stream Corridor Protection Zone for the purpose of providing compensatory floodplain storage adjacent to the stream are permitted; however, all disturbances must be mitigated through reforestation and revegetation. A streambank restoration plan that incorporates bioengineering techniques shall be prepared for compensatory floodplain fill work that occurs immediately adjacent to the streambank. The streambank restoration plan shall be submitted as part of the Stormwater Management Report and Construction Plan submission (Part II) for the project. The means and methods for stream restoration work, including non-vegetative and vegetative materials, shall be shown in the plan. Streambank restoration plans shall be designed and constructed based on the bankfull discharge and able to withstand the inundation, stream velocities, and channel stresses associated with the 100-year flood

event without structural failure once vegetative cover is established. Streambank restoration plans shall be submitted with the construction plans. Guidance and further references for streambank stabilization techniques are provided under USDA's *Stream Corridor Restoration: Principles, Practices and Processes* and *Engineering Handbook.*

Embankment slopes proposed in compensatory storage areas must reasonably conform to the natural slopes adjacent to the disturbed area. The use of vertical retaining structures constructed of concrete, brick, block or other like-material is specifically prohibited. The use of crib walls with bioengineered fascines may be approved on a case-by-case basis.

1.5 Wetland Policy

The City of Columbus supports the preservation of existing wetlands and values the stormwater benefits that they provide. Wetlands have been determined to provide flood and storm control by the hydrologic absorption and storage capacity; pollution treatment by nutrient uptake from wetland plants and the filtering of silt and organic matter by settlement; protection of subsurface water resources by recharging ground water supplies; and wildlife habitat in nesting areas, feeding grounds, and cover for many species including migratory waterfowl, rare, threatened, or endangered wildlife species.

Jurisdictional and isolated wetlands on development sites shall be delineated and categorized by a qualified professional as required by the U.S. Army Corps of Engineers (Corps) and the Ohio Environmental Protection Agency (OEPA). Wetland boundaries shall be mapped in an acceptable electronic format and submitted to the Division of Sewerage and Drainage. Copies of all permit applications and any associated wetland mitigation plans shall also be submitted to the Division of Sewerage and Drainage with the Stormwater Management Report. The City may not approve stormwater management reports or plans prior to receipt of copies of approved Federal (404) and State (401) permits if the permits are required.

Where delineated wetlands ~~protected under federal or state law~~ are located partially within the Stream Corridor Protection Zone, the Stream Corridor Protection Zone shall be extended to include the full extent of the wetland area plus any setback from the wetland required by a Section 404 permit.

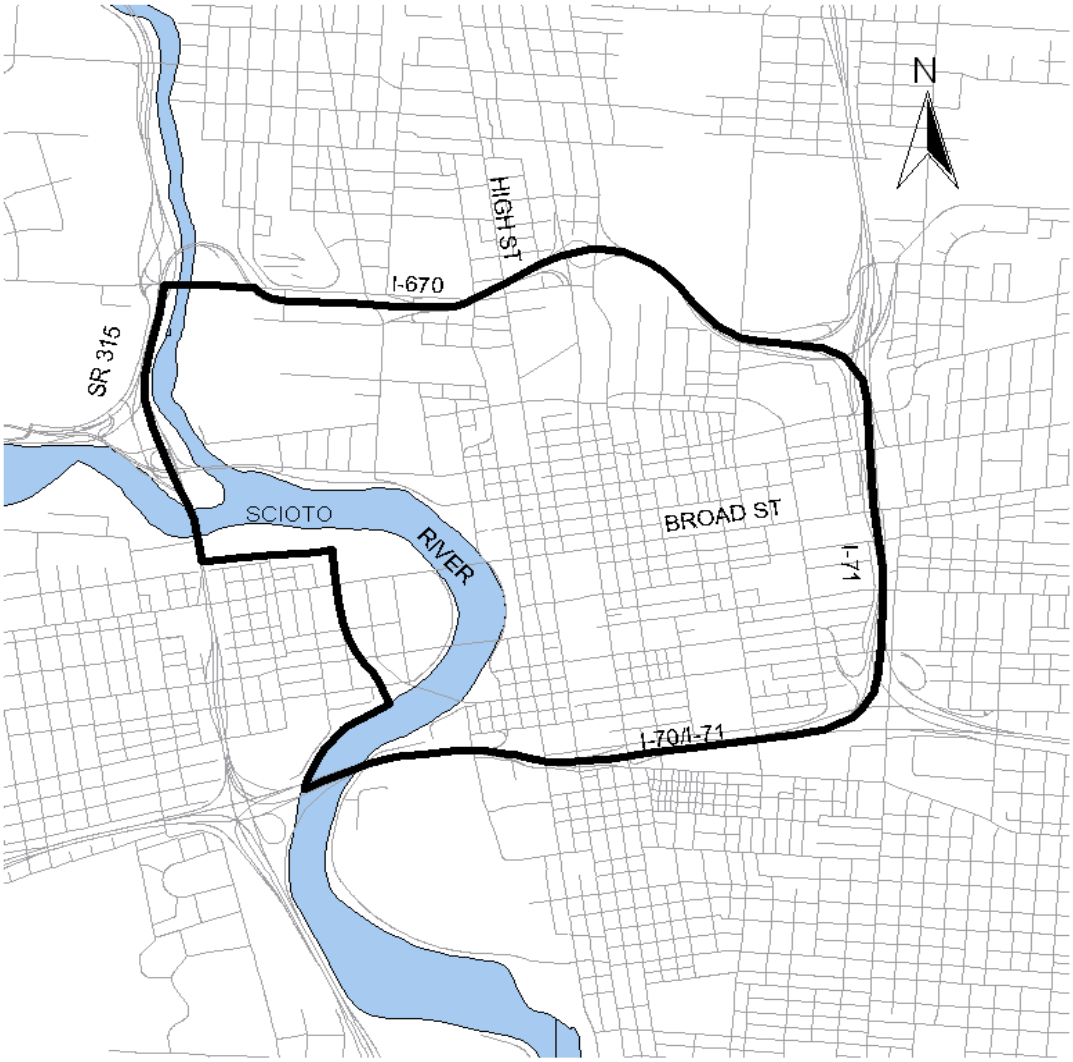
For impacted wetlands that fall outside the Stream Corridor Protection Zone, the City encourages the mitigation of proposed impacts to occur within the limits of the development site but not outside the HUC-12 subwatershed. To encourage onsite/intra-watershed wetland mitigation, the City will consider the location of mitigation projects within the Stream Corridor Protection Zones of properties that are located adjacent to a tributary stream provided that:

1. Impacts to isolated wetlands and associated mitigation plans are approved/permitted by the Corps and/or OEPA, and

2. Wetlands constructed for Section 404/401 mitigation purposes are not used to serve as a stormwater control practice to treat onsite stormwater runoff.

The stormwater system design for the project shall provide that the predevelopment quantity and quality of stormwater flows directed to any protected wetlands is maintained. Constructed wetlands (including bio-retention basins) shall not be considered subject to these requirements. Existing wetlands shall not be used for stormwater management or stormwater runoff quality treatment of the development site.

Figure 1-1
Downtown District Boundary per City Code 3359.03



Section 2
Stormwater Conveyance

This section describes the criteria and methodologies that shall be used to plan and design stormwater conveyance systems within the City of Columbus. Subsections include:

2.1 General Criteria
2.2 Hydrology Requirements
2.3 Design of Minor Stormwater Conveyance Systems
2.4 Design of Major Stormwater Routing Systems

2.1 General Criteria

The City's stormwater management goals are to prevent hazardous or detrimental flooding, streambank erosion, and water quality degradation that may result from stormwater runoff from development and redevelopment projects. This section presents general criteria for meeting this goal.

2.1.1 Offsite Tributary Area

Stormwater runoff from offsite upstream tributary areas that discharge to or across a development site shall be accommodated within the stormwater facilities planned for the development site. No stormwater management plans will be approved until it is demonstrated that offsite runoff will be adequately conveyed through the development site in a manner that will not cause or contribute to hazardous or detrimental upstream and downstream flooding and erosion. The estimation of the offsite flows must be done separately from the estimation of onsite flows (i.e., separate hydrographs for offsite areas must be determined).

2.1.2 Onsite Stormwater Conveyance

Stormwater runoff generated from the proposed development site shall be accommodated, in addition to offsite flows, within the stormwater facilities planned for the development. Onsite stormwater runoff shall be conveyed through the development site to adequate stormwater control practices designed in accordance with the requirements specified in Section 3 of the Manual. No stormwater management plans will be approved until it is demonstrated that onsite runoff will not cause flooding within the development site for the designated design storm.

2.1.3 Downstream Analysis

Onsite stormwater systems must discharge to one of the following offsite stormwater systems:

1. A stream,
2. An open channel system (generally excluding roadside ditches),
3. A storm sewer system adequately sized for the intended flows, or
4. A combined sewer system, only if discharging stormwater into either a stream, open channel system, or storm sewer system, is not available.

Additionally, while infiltration of stormwater is not considered "discharge" per se, it is an acceptable method of removing stormwater from a site where soil and groundwater conditions have been proven to be acceptable for this purpose. See Section 3.4.8 for design considerations.

If none of the options above is feasible then the Applicant must demonstrate that only sheet flow is being discharged with adequate quantity and quality controls in place, since concentrated flow may cause offsite erosion unless it is discharged into a conveyance system. In general, sheet flow occurs at the uppermost extent of an overland flow path before becoming concentrated. In developed areas, sheet flow lengths are typically no longer than 100 feet in pervious areas and 50 to 75 feet in impervious areas. Flow that has become concentrated must be converted to sheet flow using a level spreader (see Section 2.3.7) or other similar device. Flow from drainage areas with overland flow paths greater than 100 feet must discharge into one of the defined conveyance systems listed above.

The Applicant shall use one of the accepted hydrologic methods defined in Section 2.2.1, to demonstrate that the offsite stormwater system can convey existing offsite flows and projected onsite flows in a manner that does not increase downstream peak water surface elevations during the 1-year through the 100-year design storms and satisfies the various design criteria in the Manual. Downstream analysis shall be performed between the outlet of the onsite system and one of the following points:

1. The next increase in pipe diameter in an existing downstream storm sewer system,
2. The downstream face of the next bridge or culvert crossing in an open conveyance system (generally excluding roadside ditches), or
3. A point designated by the Administrator based upon known drainage issues in the downstream system.

In instances where it is determined that the existing downstream system(s) does not meet the criteria of the Manual, the Administrator will require that more stringent release rates from onsite detention facilities built for the development site be required, and/or require

the Applicant to provide the necessary downstream modifications to satisfy the conditions of this section.

The following sources of information may be utilized to establish downstream tailwater conditions:

1. Previous studies that may be on file at the City,
2. Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) and data, and/or
3. Calculations prepared by a Professional Engineer using standard engineering practice.

The Applicant must prepare a preliminary Stormwater Management Report (Section 6) that shall clearly show, through use of drawings, calculations, and narrative, how the proposed development project will comply with these requirements. One of the hydrologic calculation methods described in Section 2.2 must be used, and design criteria specified in the Manual shall be used to evaluate the offsite stormwater systems of the same type.

2.1.4 Agricultural Field Tile Systems

Agricultural field tiles are for agricultural drainage purposes only and, in general, may not be used as an outlet of any development or stormwater facility except in instances where the field tile is the only available outlet of the site. Field tiles that are discovered or intercepted during construction and do not exhibit evidence of conveying septic effluent or other illicit discharge shall be reconnected or connected into the proposed stormwater system. Field tiles that exhibit evidence of conveying septic effluent shall not be used for stormwater conveyance and shall be reported upon discovery to the City Health Department for resolution. Field tiles that exhibit evidence of conveying any illicit discharge as defined by the City's present NPDES Permit shall not be connected for stormwater conveyance and shall be reported upon discovery to the Department of Public Utilities.

Designers preparing plans for development on existing agricultural lands shall, at a minimum, contact the respective County Engineer's office and local Soil and Water Conservation District to confirm the existence and location of existing tile systems. All visible field tile outlets and locations shall be field located and shown on the stormwater management plans. Any plan information for field tile systems received from county agencies shall also be shown.

In the event that a development proposes to discharge into an existing downstream field tile system on an adjacent property, the following requirements shall apply:

1. Runoff from the proposed development plus offsite flows currently entering the field tile system must be restricted to no more than the development's "fair-share" of full-flow hydraulic capacity of the field tile system for all storms up to and including the

critical storm as defined in Section 3.2. The development's "fair-share" of the full-flow tile capacity is defined as the ratio of the development's tributary area to the total area tributary to the field tile system at the point of discharge. In no instance shall the release rate for any storm, up to and including the critical storm, exceed the 1-year predevelopment rate. Full-flow capacity, based upon the entire tributary area, shall be determined through a field survey and hydraulic evaluation of the receiving tile system to the nearest open watercourse.

2. An easement or other written owner agreement(s), as necessary, (such as making modifications to the downstream system) with the downstream owner is required for discharges to "private" (i.e., non-petitioned) field tile systems.

2.1.5 Combined Sewer Systems

Peak runoff rate from proposed developments into combined sewers shall be restricted to the allowable rate per section 3.2 or to the "fair-share" of the full-flow hydraulic capacity of the combined sewer, whichever is less. The development's "fair-share" of the full-flow capacity of the combined sewer is defined as the ratio of the development's storm drainage tributary area to the total storm drainage tributary area to the combined sewer at the point of connection after subtracting the dry weather flows in the combined sewer. It is possible that the storm drainage tributary area of the combined sewer may not be the same as the area contributing sanitary flow to the combined sewer system.

2.1.6 Stormwater System Diversions

The diversion of stormwater runoff from one watershed or receiving stormwater system to another is generally prohibited because such diversions have the potential to cause or exacerbate flooding, erosion, or water quality problems in receiving watercourses. For the purposes of the Manual, stormwater diversions are defined as the relocation of stormwater discharges from original receiving streams or stormwater systems to other systems that did not receive such discharges prior to construction. While it is recognized that stormwater runoff from small, onsite, tributary areas must be conveyed between catch basin subcatchments, the City will not allow the diversion of stormwater runoff from one major storm sewer system or open watercourse to another without proper documentation that includes proof of benefit and public comment. Stormwater system diversions between streams shall be considered on a case-by-case basis under circumstances where it can be shown that flooding and erosion will not increase and benefits to each watercourse can be achieved as a result of diverted flows. The diversion of any stormwater runoff from one stormwater system or watercourse to another shall be at the sole discretion of the Administrator or his/her designee.

2.2 Hydrology Requirements

The hydrology requirements provided in the Manual shall be used to determine the volume and discharge rate of stormwater from land areas. All Applicants shall satisfy the requirements of this section.

2.2.1 Acceptable Hydrologic Methods/Models

Tables 2-1 and **2-2** indicate which method must be used to design various components of the stormwater system. In general, the peak flow calculation methods (the maximum runoff flow rates at a given point as a result of a storm event) presented in Section 2.2.3 shall be used for designing conveyance systems such as stream crossings, storm sewer systems, small open channels, swales, roadside ditches, overland flow, shallow concentrated flow, roadway curbs, and storm sewer inlets. The City allows three methods for calculating stormwater runoff peak flows:

1. The Rational Method described in Section 2.2.3.1,
2. USGS Regression Equations described in Section 2.2.3.2, and
3. The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service or SCS) Curve Number method described in Section 2.2.3.3.

The fundamental hydrologic components defined in Section 2.2.2 shall be used in each of these methods.

Hydrograph methods better account for the timing of runoff in larger watersheds and storage provided by detention facilities and/or floodplains. Therefore the hydrograph methods presented in Section 2.2.4 may be used to size any drainage component, but must be used for downstream analysis and to design detention facilities. Section 2.2.4 defines acceptable hydrograph methods. Information regarding the water quality volume and water quality flow used to design water quality facilities is provided in Section 3.

Table 2-1

Applications of the Recommended Hydrologic Methods

Method	Manual Section	Rational Method (Section 2.2.3.1)	Regression Equations (Section 2.2.3.2)	NRCS (SCS) Curve Number Method (Section 2.2.3.3)	Approved Hydrograph Method (Section 2.2.4)	Water Quality Volume/Flow (Section 3.3)
Storm Sewers	2.3.2	√		√	√	
Curb Inlets & Catch Basins	2.3.3	√			√	
Culverts for Constructed Open Watercourses	2.3.4	√	√	√	√	

Culverts Constructed for Streams	2.3.4		√[1]		√	
Constructed Open Watercourses	2.3.8	√		√	√	
Downstream Analysis	2.1.3				√	
Detention Basins	3.4.1				√	
Water Quality Controls	3.3					√

Table 2-2

Constraints to Using Recommended Hydrologic Methods

Method	Size Limitation	Applicability
Peak Flow Methods		
▪ Rational Method	Up to 200 acres	Method can be used for estimating peak flows and the design of small conveyance systems.
▪ Regression Equations	Between 17 and 2600 acres with defined channels	Method can be used for estimating peak flows along streams. More specific size limitations are outlined in each of the USGS reports.
▪ NRCS (SCS) Curve Number Method	Peak flow for areas up to 640 acres[2]	Method can be used for estimating peak flows and the design of larger conveyance systems
Approved Hydrograph Methods	All drainage area sizes	Method can be used for estimating peak flows and hydrographs for all design applications
Water Quality	Limits set for each Structural Control	Method used for calculating the Water Quality Volume (WQ_v)

2.2.2 Hydrologic Components

2.2.2.1 Rainfall

Rainfall intensity-duration-frequency (IDF) curves for Central Ohio[3] (**Figure 2-1**) shall be used in conjunction with the appropriate hydrologic method and/or model defined in Sections 2.2.3 and 2.2.4 to determine design runoff volumes and intensities. In general, these curves shall be used directly where the rational formula is appropriate to calculate runoff. Design rainfall hyetographs distributed over a 24-hour period with the SCS Type II distribution are presented in **Table 2-3**. The 24-hour Type II rainfall distribution represents design rainfall intensities over a time of concentration range typical of a small

[1] For new culvert or culvert replacements developed under City CIP projects only.
[2] Mid-Ohio Regional Planning Commission, Stormwater Design Manual, 1977
[3] Bonnin, Martin, Lin, Parzybok, Yetkta, Riley, *NOAA Atlas 14, Volume 2, Version 3*, 2004

urban watershed, coupled with wet antecedent conditions at the time of peak rainfall intensity.

Figure 2-1

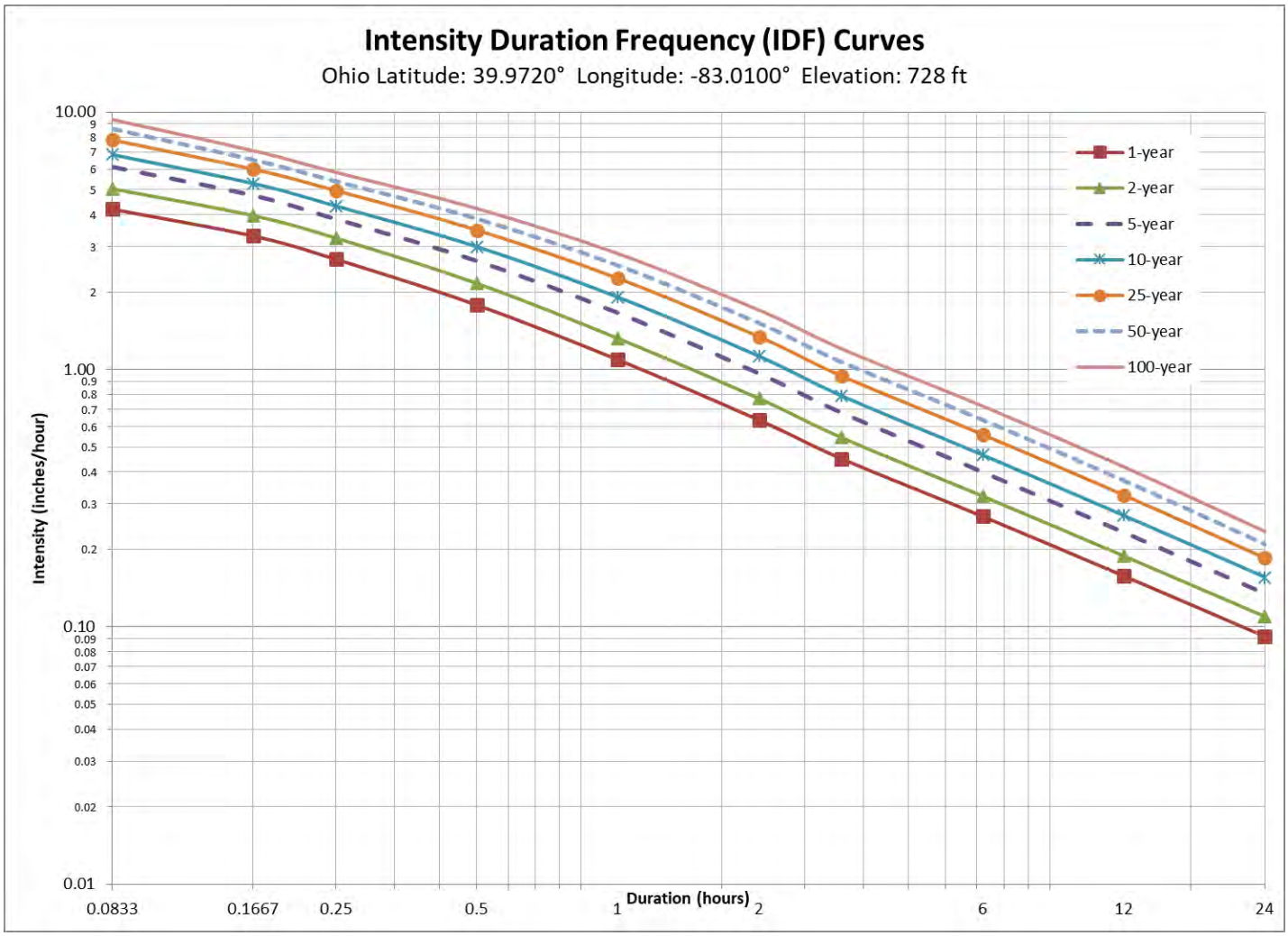


Table 2-3
Type II SCS Design Storm Hyetograph

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (in)						
			Frequency:	100-yr	50-yr	25-yr	10-yr	5-yr	2-yr	1-yr
			Duration:	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr
			Depth (in):	5.63	5.02	4.44	3.74	3.24	2.63	2.20
0:00	0			0.000	0.000	0.000	0.000	0.000	0.000	0.000
0:15	0.002	0.002		0.011	0.010	0.009	0.007	0.006	0.005	0.004
0:30	0.005	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
0:45	0.008	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
1:00	0.0108	0.0028		0.016	0.014	0.012	0.010	0.009	0.007	0.006
1:15	0.014	0.0032		0.018	0.016	0.014	0.012	0.010	0.008	0.007
1:30	0.017	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
1:45	0.02	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:00	0.023	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:15	0.026	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:30	0.029	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:45	0.032	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
3:00	0.0347	0.0027		0.015	0.014	0.012	0.010	0.009	0.007	0.006
3:15	0.038	0.0033		0.019	0.017	0.015	0.012	0.011	0.009	0.007
3:30	0.041	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
3:45	0.044	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
4:00	0.0483	0.0043		0.024	0.022	0.019	0.016	0.014	0.011	0.009
4:15	0.052	0.0037		0.021	0.019	0.016	0.014	0.012	0.010	0.008
4:30	0.056	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
4:45	0.06	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:00	0.064	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:15	0.068	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:30	0.072	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:45	0.076	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
6:00	0.0797	0.0037		0.021	0.019	0.016	0.014	0.012	0.010	0.008
6:15	0.085	0.0053		0.030	0.027	0.024	0.020	0.017	0.014	0.012
6:30	0.09	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
6:45	0.095	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:00	0.1	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:15	0.105	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:30	0.11	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:45	0.115	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
8:00	0.1203	0.0053		0.030	0.027	0.024	0.020	0.017	0.014	0.012
8:15	0.126	0.0057		0.032	0.029	0.025	0.021	0.018	0.015	0.013
8:30	0.133	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
8:45	0.14	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
9:00	0.1467	0.0067		0.038	0.034	0.030	0.025	0.022	0.018	0.015
9:15	0.155	0.0083		0.047	0.042	0.037	0.031	0.027	0.022	0.018
9:30	0.163	0.008		0.045	0.040	0.036	0.030	0.026	0.021	0.018
9:45	0.172	0.009		0.051	0.045	0.040	0.034	0.029	0.024	0.020
10:00	0.1808	0.0088		0.050	0.044	0.039	0.033	0.029	0.023	0.019
10:15	0.191	0.0102		0.057	0.051	0.045	0.038	0.033	0.027	0.022
10:30	0.203	0.012		0.068	0.060	0.053	0.045	0.039	0.032	0.026
10:45	0.218	0.015		0.084	0.075	0.067	0.056	0.049	0.039	0.033
11:00	0.236	0.018		0.101	0.090	0.080	0.067	0.058	0.047	0.040
11:15	0.257	0.021		0.118	0.105	0.093	0.079	0.068	0.055	0.046
11:30	0.283	0.026		0.146	0.131	0.115	0.097	0.084	0.068	0.057
11:45	0.387	0.104		0.586	0.522	0.462	0.389	0.337	0.274	0.229

Table 2-3 (continued)
Type II SCS Design Storm Hyetograph

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (in)						
			Frequency:	100-yr	50-yr	25-yr	10-yr	5-yr	2-yr	1-yr
			Duration:	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr
			Depth (in):	5.63	5.02	4.44	3.74	3.24	2.63	2.20
12:00	0.6632	0.2762		1.555	1.387	1.226	1.033	0.895	0.726	0.608
12:15	0.707	0.0438		0.247	0.220	0.194	0.164	0.142	0.115	0.096
12:30	0.735	0.028		0.158	0.141	0.124	0.105	0.091	0.074	0.062
12:45	0.758	0.023		0.129	0.115	0.102	0.086	0.075	0.060	0.051
13:00	0.776	0.018		0.101	0.090	0.080	0.067	0.058	0.047	0.040
13:15	0.791	0.015		0.084	0.075	0.067	0.056	0.049	0.039	0.033
13:30	0.804	0.013		0.073	0.065	0.058	0.049	0.042	0.034	0.029
13:45	0.815	0.011		0.062	0.055	0.049	0.041	0.036	0.029	0.024
14:00	0.825	0.01		0.056	0.050	0.044	0.037	0.032	0.026	0.022
14:15	0.834	0.009		0.051	0.045	0.040	0.034	0.029	0.024	0.020
14:30	0.842	0.008		0.045	0.040	0.036	0.030	0.026	0.021	0.018
14:45	0.849	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:00	0.856	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:15	0.863	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:30	0.869	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
15:45	0.875	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:00	0.881	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:15	0.887	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:30	0.893	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:45	0.898	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:00	0.903	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:15	0.908	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:30	0.913	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:45	0.918	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
18:00	0.922	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:15	0.926	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:30	0.93	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:45	0.934	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:00	0.938	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:15	0.942	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:30	0.946	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:45	0.95	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
20:00	0.953	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:15	0.956	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:30	0.959	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:45	0.962	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
21:00	0.9653	0.0033		0.019	0.017	0.015	0.012	0.011	0.009	0.007
21:15	0.968	0.0027		0.015	0.014	0.012	0.010	0.009	0.007	0.006
21:30	0.971	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
21:45	0.974	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:00	0.977	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:15	0.98	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:30	0.983	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:45	0.986	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
23:00	0.9892	0.0032		0.018	0.016	0.014	0.012	0.010	0.008	0.007
23:15	0.992	0.0028		0.016	0.014	0.012	0.010	0.009	0.007	0.006
23:30	0.995	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
23:45	0.998	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
0:00	1	0.002		0.011	0.010	0.009	0.007	0.006	0.005	0.004

2.2.2.2 Time of Concentration

A time of concentration shall be calculated for each drainage structure that is designed. This time of concentration relates the maximum amount of flow coming from any watershed to the amount of time it takes for the entire watershed to be contributing flow to the point of interest. Although some places in a watershed are "hydraulically" closer to the point of discharge than others, peak flow generation calculations with the Rational Method (Section 2.2.3.1) shall consider only the most hydraulically remote location in the largest drainage area contributing to the point of discharge. Time of concentration is defined by the amount of time it takes for the first drop of water from this location to reach the discharge point.[4]

The time of concentration (t_c) shall be calculated as the summation of overland flow time (t_o), the time of shallow concentrated flow (t_s), and the time of pipe or open channel flow (t_d). The travel time across any permanent wet surface shall be set to zero. The travel time across any dry basin that becomes wet (ponding) during the design event shall also be set to zero. The minimum time of concentration shall be five (5) minutes. Time of concentration calculations shall be based on the ultimate buildout land use for the tributary area. The time of concentration calculations shall assume that upstream, offsite, undeveloped areas will be served by storm sewers with a design flow velocity of 3.5 feet/sec.

Overland Flow or Sheet Flow

Overland flow, or sheet flow, is defined as flow that maintains a uniform depth across a sloping surface with no discernible channel. In general, sheet flow occurs at the upstream extent of an overland flow path. Sheet flow lengths are typically no longer than 100 feet in pervious areas, and 50 to 75 feet in impervious areas. The overland flow time shall be calculated using Manning's kinematic equation[5]:

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

where

t_o = Time of overland flow (hr),
n = Manning's roughness coefficient for sheet flow :
L = Flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = Slope of hydraulic grade line (land slope, ft/ft)

[4] Haestad Methods Engineering Staff, *Computer Applications in Hydraulic Engineering*, 2002
[5] United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986

Table 2-4 gives Manning's n values for sheet flow for various surface conditions. These n values are for very shallow flow depths less than or equal to 0.1 foot.

Table 2-4

Roughness Coefficients (Manning's "n") for Sheet Flow

Surface Description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Shallow Concentrated Flow

Beyond the maximum overland flow length defined in the previous section, sheet flow becomes concentrated flow and must be conveyed by a storm sewer, drainage ditch, or natural channel. The average velocity for shallow concentrated flow shall be determined from Figure 3-1 of NRCS TR-55[6], in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in Appendix F of NRCS TR-55.

Pipe or Open Channel Flow

The velocity of flow in an open channel or pipe shall be estimated using the Manning's Equation. The travel time for both shallow concentrated flow and open channel or pipe flow is calculated as follows[7]:

$$t_s \text{ or } t_d = L/(60V)$$

where:

t_s = Travel time for shallow concentrated flow in minutes

t_d = Travel time for open channel or pipe flow in minutes

[6] United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986

[7] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*

L = Flow length in feet
V = Velocity in fps

2.2.2.3 Soil Variables

The hydrologic soil group (HSG) associated with soils on the project site prior to development shall be defined by the NRCS Web Soil Survey[8]. Pertinent figures, tables, and infiltration parameters characterizing the soils native to the project site and the soils that will be re-graded, compacted or otherwise altered to a degree that changes their hydrologic characteristics shall be included in the Stormwater Management Report prepared for the project. Designers should be aware that hydrologic characteristics of soils on a given site can change significantly as a result of grading and compaction during construction. The use of different hydrologic soil groups that reflect the changes in post construction soil hydrology shall be considered when determining runoff estimates for post construction conditions.

2.2.3 Peak Flow Calculation Methods/Models

In general, peak flow calculation methods shall be used to design the stormwater conveyance systems or flow-through type water quality best management practices within a development. The following sections describe peak flow calculation methods acceptable for use within Columbus.

2.2.3.1 Rational Method

The rational method shall be used to estimate runoff from drainage areas smaller than 200 acres. Its use shall be limited to the evaluation and design of storm sewer systems, small open channels, swales, roadside ditches, overland flow, shallow concentrated flow, roadway curbs, and storm sewer inlets. Design discharge, "Q" is obtained from the equation:

$$Q = fCIA$$

where:

Q = Discharge in cubic feet per second
C = Coefficient of runoff, see **Table 2-5**. An average C is to be computed based on the percentage of each land use within the drainage area
f = C value correction factor for the design storm, listed in footnote 1 of **Table 2-5**
I = Average rainfall intensity in inches per hour from **Figure 2-1** for a given storm frequency and a duration equal to the time of concentration
A = Drainage area in acres

[8] United States Department of Agriculture, Natural Resource Conservation Service, *Web Soil Survey* is available at websoilsurvey.nrcs.usda.gov

Table 2-5
Runoff Coefficients "C" for Typical Land Uses in Columbus

Cover Type and Hydrologic Condition	Average percent impervious area[3]	Runoff Coefficient for Hydrologic Soil Group[1]			
		A	B	C	D
Fully developed urban areas (vegetation established) with average runoff conditions and I_a=0.2S					
Impervious Areas					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		0.94	0.94	0.94	0.94
Gravel streets and parking lots		0.88	0.88	0.88	0.88
Open space (lawns, parks, golf courses, cemeteries, etc.)					
Poor condition (grass cover <50%)		0.29	0.48	0.63	0.70
Fair condition (grass cover 50% to 75%)		0.07	0.30	0.48	0.58
Good condition (grass cover >75%		NA	0.19	0.39	0.50
Commercial and business (TND[2] – Town Center)	85	0.70	0.77	0.83	0.85
Industrial	72	0.52	0.67	0.75	0.80
Residential Districts by Average Lot Size					
Multi-family (TND[2] – Neighborhood Center)[3]	80	0.63	0.75	0.80	0.83
1/12 to 1/6 acre lots (TND[2] – Neighborhood General)[3]	75	0.56	0.70	0.77	0.83
h 1/8 acre (TND[2] – Neighborhood Edge)	65	0.44	0.60	0.72	0.77
¼ acre	38	0.19	0.40	0.56	0.65
½ acre	25	0.11	0.32	0.50	0.60
1 acre	20	0.08	0.29	0.48	0.58
Undeveloped or agricultural lands with average runoff conditions and I_a=0.2S					
Cultivated Land					
Without conservation treatment		0.35	0.52	0.67	0.75
With conservation treatment		0.21	0.34	0.46	0.52
Pasture, grassland, or range – continuous forage for grazing					
Poor: <50% ground cover or heavily grazed with no mulch		0.29	0.48	0.63	0.70
Fair: 50 to 75% ground cover and not heavily grazed		0.07	0.30	0.48	0.58
Good: >75% ground cover and lightly or only occasionally grazed		NA	0.19	0.39	0.50
Meadow – continuous grass, protected from grazing and generally mowed for hay		NA	0.16	0.34	0.46
Brush – brush-weed-grass mixture with brush the major element					
Poor: <50% ground cover		0.06	0.27	0.44	0.56
Fair: 50 to 75% ground cover		NA	0.13	0.32	0.44
Good: >75% ground cover		NA	0.06	0.25	0.37
Woods[5]					
Poor: forest litter, small trees, and brush are destroyed by heavy grazing or regular burning		0.06	0.27	0.44	0.56
Fair: woods are grazed but not burned, and some forest litter covers the soil		NA	0.18	0.37	0.48
Good: woods are protected from grazing, and litter and brush adequately cover the soil		NA	0.12	0.32	0.44
Farmsteads – buildings, lands, driveways, and surrounding lots		0.17	0.39	0.54	0.63

Notes:

NA – Method to derive value is not applicable for curve number values less than 40.

1 These runoff coefficients were calculated using curve numbers obtained from the USDA-NRCS Technical Release 55 *Urban Hydrology for Small Watersheds* assuming a 10-year, 24-hour storm. For larger design storms the runoff coefficients shall be increased using the following C value correction factors:

1.1 for the 25-year design storm

1.2 for the 50-year design storm

1.3 For the 100-year design storm

2 TND = Traditional Neighborhood Development

3 The average percent impervious area shown was used to develop the composite CN's which were then used to drive runoff coefficient values. Other assumptions are as follows: impervious areas are directly connected to the stormwater system, impervious areas have a runoff coefficient of 0.94 (or CN of 98), and pervious areas are considered equivalent to open space in good hydrologic condition.

The coefficient of runoff is expressed as a dimensionless decimal value that estimates the percentage of rainfall that becomes runoff. The residential runoff coefficients in **Table 2-5** shall be used for runoff projections using the rational formula. Runoff coefficients used to project onsite flows for multi-family, commercial, and industrial type developments must be calculated based on the actual impervious surface amounts planned for the development site. The estimation of offsite flows may be determined using the appropriate runoff coefficient for the undeveloped land uses and/or the categorical development types (residential, commercial, and industrial) listed in **Table 2-5**.

2.2.3.2 Regression Equations

The regression equations presented in USGS Report 93-135[9] is an accepted method for estimating design peak-discharge values for streams with drainage areas between 17 and 2600 acres. The application of this method is limited to the estimation of peak discharges for City funded culvert installation and replacement projects. The following equations shall be used for the various design storms:

$$Q_2 = 155\,(A)^{0.68}\,(P\text{-}30)^{0.5}\,(13\text{-}BDF)^{-0.5}$$

$$Q_5 = 200\,(A)^{0.71}\,(P\text{-}30)^{0.63}\,(13\text{-}BDF)^{-0.44}$$

$$Q_{10} = 228\,(A)^{0.74}\,(P\text{-}30)^{0.68}\,(13\text{-}BDF)^{-0.41}$$

$$Q_{25} = 265\,(A)^{0.76}\,(P\text{-}30)^{0.72}\,(13\text{-}BDF)^{-0.37}$$

$$Q_{50} = 293\,(A)^{0.78}\,(P\text{-}30)^{0.74}\,(13\text{-}BDF)^{-0.35}$$

$$Q_{100} = 321\,(A)^{0.79}\,(P\text{-}30)^{0.76}\,(13\text{-}BDF)^{-0.33}$$

where:

Q_N = peak discharge rate in cfs,

A = the drainage area in square miles,

P = average annual precipitation in inches = 37 inches for Columbus, and

BDF = the basin development factor.

The basin development factor (BDF) is determined by subdividing the drainage basin into thirds (lower, middle, and upper) with two lines drawn across the basin that are perpendicular to the main channel and principal tributaries. Four aspects of the

[9] United States Geological Survey, USGS Report 93-135 *Estimation of Peak-Frequency Relations, Flood Hydrographs, and Volume-Duration-Frequency Relations of Ungaged Small Streams in Ohio*

stormwater system are then evaluated within each third of the basin and assigned a value of 1 or 0:

1. ***Channel modifications*** include any straightening, enlarging, deepening, and clearing made in the main drainage channel and principal tributaries. If at least 50 percent of the upstream channels in the basin are improved, then a value of 1 is assigned.
2. ***Channel linings*** include any length of the main drainage channels and principal tributaries that have been lined with an impervious material such as concrete. A value of 1 is assigned if at least 50 percent of the upstream channels have been lined.
3. ***Storm drains or storm sewers*** are defined as enclosed drainage structures (usually pipes) frequently used on secondary tributaries where drainage is received directly from streets or parking lots. A value of 1 is then assigned when more than 50 percent of the upstream secondary tributaries consist of storm drains.
4. ***Curb and gutter streets*** frequently empty into storm drains. If more than 50 percent of the upstream basin is developed with streets and highways constructed with curbs and gutters, then a value of 1 will be assigned.

Table 2-6 provides an example for calculating the overall BDF for the entire basin that has channel modifications throughout, no channel linings, and storm drains with curb and gutter streets in the lower two-thirds of the basin:

Table 2-6

Example Determination of the Basin Development Factor

Portion of Basin	Channel Modifications	Channel Linings	Storm Drains	Curb & Gutter Streets	Basin Development Factor
Lower 1/3	1	0	1	1	3
Middle 1/3	1	0	1	1	3
Upper 1/3	1	0	0	0	1
				Total:	7

2.2.3.3 The NRCS (SCS) Curve Number Method

The NRCS (SCS) Curve Number method, developed in 1969, partitions the total depth of rainfall into initial abstractions, retention, and effective rainfall. Worksheets 2 through 6 are available in the TR-55 publication and are acceptable methods for showing calculations described in this and other applicable sections. The following equation [10] is used to estimate runoff:

$$Q = (P-I_a)^2 / [(P-I_a) + S]$$

where:

[10] United States Department of Agriculture, Natural Resources Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986

Q = runoff depth (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in)
= 1000/CN-10,
CN= runoff curve number, and
I_a = initial abstraction (in)
= 0.2 * S

CN values range between 0 and 100, while practical CN values range from 30 to 98 where larger values are associated with more impervious land surface. Soil groups are classified by NRCS into four hydrologic groups: Groups A, B, C, and D. Group A soils have high infiltration rates while Group D soils have low infiltration rates. **Table 2-7** (adapted from SCS) shall be used to define curve numbers for normal antecedent moisture conditions (Type II) for various land uses and soil classifications. The residential curve numbers in **Table 2-7** shall be used for runoff projections using the SCS method. Curve numbers used to project onsite flows for multi-family, commercial, and industrial type developments must be calculated based on the actual impervious surface amounts planned for the development site. For example, an area with a directly connected impervious area (DCIA) of 70 percent with good grass cover on hydrologic soil group D soils would have the following curve number:

$CN = CN_{Impervious} * \%\ Imperviousness + CN_{pervious} * (1 - \%\ imperviousness)$

= 98 * 0.7 + 80 * (1-0.7)
= 93

The estimation of offsite flows may be determined using the appropriate curve numbers for the undeveloped land uses and/or the categorical development types (residential, commercial, and industrial) listed in **Table 2-7**. Additional information regarding the use of SCS's runoff curve number method is available in Technical Release 55 – *Urban Hydrology for Small Watersheds*.

The peak rate of runoff is then calculated as:

$q_p = q_u A_m Q F_p$

where:

q_p = peak discharge (cfs)
q_u = unit peak discharge (csm/in) (see **Figure 2-2**)
A_m = drainage area (mi^2)
Q = runoff depth (in)
Fp = pond and swamp adjustment factor (see **Table 2-8**)

Table 2-7 Runoff Curve Numbers (CN) for Typical Land Uses in Columbus[1]

Cover Type and Hydrologic Condition	Average percent impervious area[4]	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Fully developed urban areas (vegetation established) with average runoff conditions and I_a=0.2S					
Impervious Areas					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Gravel streets and parking lots (excluding right-ofway)[6]		96	96	96	96
Open space (lawns, parks, golf courses, cemeteries, etc.)					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover >75%		39	61	74	80
Commercial and business (TND[2] – Town Center)	85	89	92	94	95
Industrial	72	81	88	91	93
Residential Districts by Average Lot Size					
Multi-family (TND[2] – Neighborhood Center)[3]	80	86	91	93	94
1/12 to 1/6 acre lots (TND[2] – Neighborhood General)[3]	75	83	89	92	94
1/8 acre (TND[2] – Neighborhood Edge)	65	77	85	90	92
¼ acre	38	61	75	83	87
½ acre	25	54	70	80	85
1 acre	20	51	68	79	84
Undeveloped or agricultural lands with average runoff conditions and I_a=0.2S					
Cultivated Land					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture, grassland, or range – continuous forage for grazing					
Poor: <50% ground cover or heavily grazed with no mulch		68	79	86	89
Fair: 50 to 75% ground cover and not heavily grazed		49	69	79	84
Good: >75% ground cover and lightly or only occasionally grazed		39	61	74	80
Meadow – continuous grass, protected from grazing and generally mowed for hay		30	58	71	78
Brush – brush-weed-grass mixture with brush the major element					
Poor: <50% ground cover		48	67	77	83
Fair: 50 to 75% ground cover		35	56	70	77
Good: >75% ground cover		30[5]	48	65	73
Woods[5]					
Poor: forest litter, small trees, and brush are destroyed by heavy grazing or regular burning		45	66	77	83
Fair: woods are grazed but not burned, and some forest litter covers the soil		36	60	73	79
Good: woods are protected from grazing, and litter and brush adequately cover the soil		30[6]	55	70	77
Farmsteads – buildings, lands, driveways, and surrounding lots		59	74	82	86

Notes:

1 All CN values are from USDA-NRCS Technical Release 55 *Urban Hydrology for Small Watersheds* unless otherwise noted. Refer to this publication to obtain CN values for conditions not listed.

2 TND = Traditional Neighborhood Development

3 Curve numbers were calculated based upon percent of impervious area.

4 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the stormwater system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

5 Actual curve number is less than 30; use CN=30 for runoff computations

6 The curve number for gravel streets and parking lots without right-of-way is derived from the TR-55 values for gravel streets and roads that include right-of-way.

Figure 2-2

Unit Peak Discharge Determination

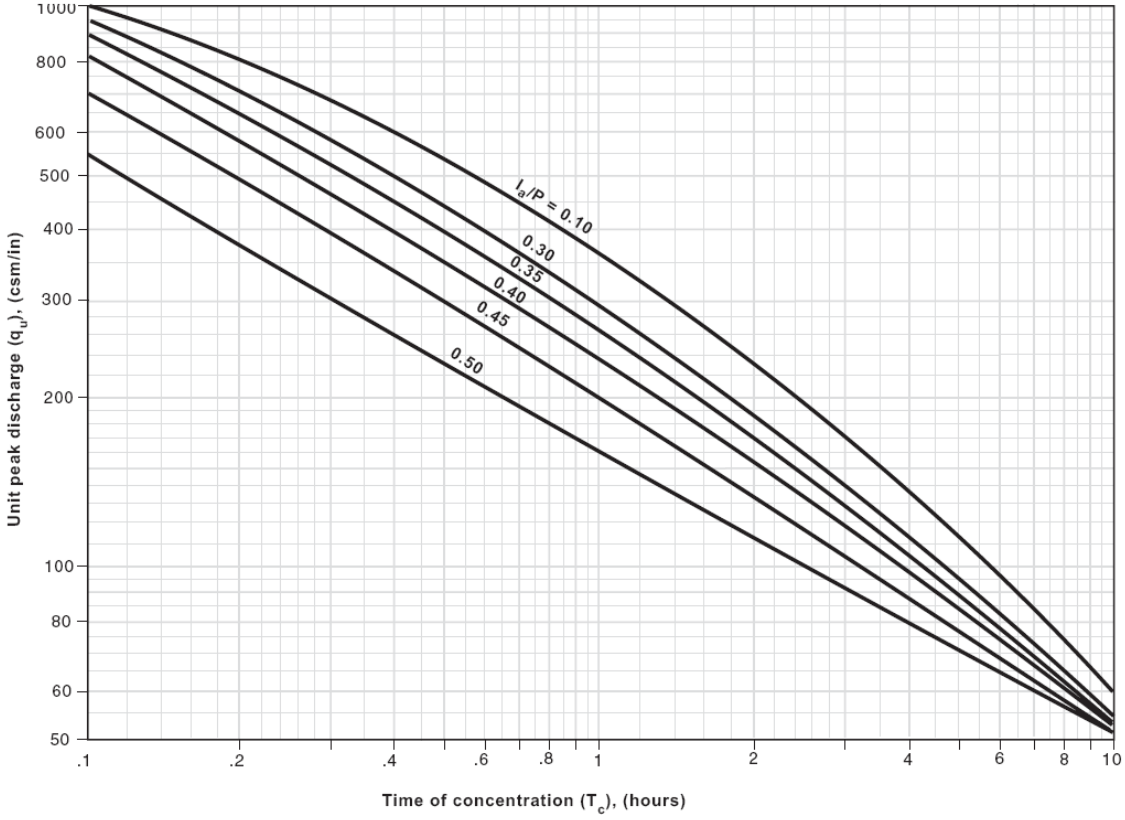


Table 2-8

Adjustment Factor (F_p) for Ponds and Swamps

Percentage of pond and swamp areas	***Fp***
0	**1.00**
0.2	**0.97**
1.0	**0.87**
3.0	**0.75**
5.0	**0.72**

(Note: Per TR-55 pgs.4-1:4-2, Include Adjustment Factor F_p if pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation.

2.2.4 Acceptable Runoff Hydrograph Development Methods

Peak flow methods are not appropriate for designing stormwater detention basins, evaluating downstream impacts on streams, and designing major conveyances with drainage areas larger than 200 acres. In these cases, the City requires that a hydrograph be developed and routed through the system to support design and/or evaluation. In addition, hydrograph methods may be used to design other elements of the stormwater system as part of a comprehensive hydrologic/hydraulic evaluation supported by computer models or other appropriate means. Designs using hydrograph methods shall be accepted if the results are presented in the format defined in the Manual for peak flow calculations.

Several methodologies are available for defining runoff hydrographs and routing them through the stormwater system. The City will accept the unit hydrograph methodology presented in this section, and may accept other equivalent methods if supported by proper documentation and a demonstrated record of successful application for stormwater system design. Furthermore, hydrograph methods are generally provided by common engineering computer software, such as the NRCS TR-20, the US Army COE HEC-1 models and U.S. EPA SWMM, which may be allowed if the model results are presented in the format defined in the Manual.

2.2.4.1 Rainfall Hyetographs

All runoff hydrographs shall be based upon a design storm hyetograph defined using the 24-hour design storm rainfall volumes for the City of Columbus extracted from **Figure 2-1**, and the 24-hour SCS Type II rainfall distribution. These design rainfall hyetographs for the various design storms referenced in the Manual are provided in **Table 2-3**.

2.2.4.2 Abstractions from Rainfall

For each catchment, abstractions from rainfall must be determined for each 15-minute rainfall volume within this hyetograph. Abstractions are comprised of depression storage and infiltration into the soil, and shall be based upon the soil and land cover characteristics of the catchment. The initial abstraction at the beginning of the design storm shall be based upon average soil moisture conditions. Changes in abstractions shall be tracked during the storm event as available depression storage and soil infiltration capacity is filled. The NRCS curve number methodology presented in Section 2.2.3.3 is accepted by the City for defining rainfall abstractions. Other methods, including the Green-Ampt and Horton's methods[11], for determining the change in soil infiltration during a precipitation event may be used with appropriate documentation at the discretion of the City.

2.2.4.3 Unit Hydrographs

A unit hydrograph is the hydrograph of direct runoff that results from one inch of excess rainfall generated uniformly over a watershed at a constant rate during a specified time.

[11] Mays, Larry, *Stormwater Collection Systems Design Handbook*, McGraw-Hill, 2001

The City will accept the SCS dimensionless unit hydrograph as the basis for developing runoff hydrographs.

This method uses the table at the right, in conjunction with the following equations, to develop a unit runoff hydrograph from each catchment for each 15 minute rainfall increment within the SCS Type II distribution:

$t_p = 0.666 * t_c$

and

$Q_p = P_e * 484 * A / t_p$

where:

t_p = time to peak, hours

t_c = time of concentration, hours, from Section 2.2.2.2

Q_p = peak flow rate from one inch of excess rainfall, cfs

P_e = excess rainfall during the 15 minute rainfall increment, in.

= total rainfall minus the abstraction to rainfall

A = watershed area, mi^2

The total hydrograph responding to the SCS Type II rainfall hyetograph from the catchment is determined by adding the individual unit hydrographs determined using the previous equation. The City will accept calculations based on computer models that use the SCS unit hydrograph method to develop runoff hydrographs. In addition, the City will consider use of alternative methods for developing runoff hydrographs, including the Snyder and Clark unit hydrograph methods included in the US Army COE HEC-1 model, and the kinematic wave method included in the US Army COE HEC-1 model and U.S. EPA SWMM.

SCS Dimensionless Unit Hydrograph

t/t_p	Q/Q_p
0.0	0.000
0.2	0.100
0.4	0.310
0.6	0.660
0.8	0.930
1.0	1.000
1.2	0.930
1.4	0.780
1.6	0.560
1.8	0.390
2.0	0.280
2.2	0.207
2.4	0.147
2.6	0.107
2.8	0.077
3.0	0.055
3.2	0.040
3.4	0.029
3.6	0.021
3.8	0.015
4.0	0.011
4.2	0.008
4.4	0.006
4.6	0.004
4.8	0.002
5.0	0.000

2.3 Design of Minor Stormwater Conveyance Systems

Flooding is a natural phenomenon accommodated within natural stormwater systems. During rainfall events of small to moderate size, stormwater runoff is contained within the banks, or the bankfull channel, of streams. During larger, less frequent storms, runoff overflows the channel banks into the surrounding floodplain. As areas develop, portions of the natural stormwater system are often replaced with underground storm sewers sized to collect and convey runoff from small to moderate storms. Properly designed developments will use streets or swales as a major storm conveyance system to convey runoff from larger, less frequent storms to the open channel stormwater system.

Proper planning for maintenance of stormwater conveyances is necessary to ensure they function as designed and do not cause inadvertent flooding. Periodic efforts are required to keep the systems clear from trash, sediment, vegetation, and other obstructions. The

designer shall give consideration to any easements that may be required to properly maintain the conveyance system

Effective stormwater system design depends upon how frequently the capacity of the minor storm conveyance system should be exceeded, and how severe the impact of flooding would be within the major storm conveyance system. Frequency is expressed as a probability of occurrence in any given year. For example, the 100-year design storm event is defined as a storm that has a 1% chance of occurring in any given year. While a 100-year storm event could occur more frequently than once in every 100 years, over a very long period of time the frequency of a storm of this magnitude occurring averages to once in a hundred years.

2.3.1 Curbed Roadways

Streets and roadways with curbs are part of the storm sewer system because they capture stormwater and convey it to storm sewer inlets. The spread and depth of water conveyed must be calculated to ensure that a hazardous condition is not created.

The purpose of **Table 2-9** is to define when spread analysis is to be performed for each type of project. If the characteristics of a new project match one or more of the "type of project" listed below, the project designer shall perform spread calculations. Unless a project is exempt (see below), it shall be the responsibility of the designer to verify that spread calculations are required with the City of Columbus Project Manager or plan reviewer prior to the start of design. The spread analysis, where required, shall be submitted with each plan submittal or as directed by the City of Columbus. A case-by-case exception for the need to provide spread calculations may be considered by the City of Columbus Project Manager (or assignee). Spread calculations may not be required if a significant hardship is found, or for public projects only the City has specifically excluded the completion of spread calculation within the scoping documents.

Table 2-10 provides guidance to the designer along with the criteria to apply when performing pavement spread analysis.

Table 2-9 Spread Calculation Triggers

Ref #	Type of project	Criteria	Mitigation
1	New Curbed Roadway Construction	Where a roadway does not currently exist	Additional drainage structures and/or green infrastructure required.

2	Storm sewer trunk line on curbed roadways where the storm sewer trunk line is to be publicly maintained, and the roadway is tributary to the new trunk sewer.	≥ 100' of continuous new or upsized storm sewer trunk line Public Project Exemptions: 1. Maintenance Projects (see definition)	Additional drainage structures and/or green infrastructure required. Storm sewer trunk line shall be designed pursuant to requirements set forth in the Columbus Storm Sewer Drainage Manual. The storm sewer trunk line shall be adequately designed to accept the roadway drainage.
3	Curbed roadway widenings	Only for the side of the road impacted by the widening. Exemptions: 1. Widening for a Right Turn Lane Only. The plan designer shall prove they have not significantly modified drainage characteristics of the roadway and have not increased the spread of any through lane adjacent to the widening, or the through lanes on connecting roadways	Additional drainage structures and/or green infrastructure required.
4	Curbed roadway narrowing (road diet)	Only for the side of the road impacted by the narrowing. Exemptions: 1. The limits of a New Green Infrastructure Bump Out. The bump out must contain Publicly Maintained Green Infrastructure designed to capture a portion of roadway drainage.	Additional drainage structures and/or green infrastructure required.
5	Adding curb to uncurbed roadway	≥ 100' continuous curb is added	Additional drainage structures and/or green infrastructure required.
6	Full depth reconstruction of a roadway	Exemptions: 1. Maintenance Projects (see definition)	Additional drainage structures and/or green infrastructure required.
7	Changes to grading outside the roadway that increase the tributary area to the roadway. To be considered for all projects.	If the tributary area is increased, spread calculations required to the next downstream catch basin.	Designer to provide tributary map indicating flows to the right-of-way. Mitigation is preferred outside of roadway. Additional drainage structures and/or green infrastructure required.

Other Notes/Comments

1. Where calculations indicate that the spread is deficient, the project shall correct spread within the limits of the project.
2. If inlet spacing calculations result in the inlet spacing less than 75', other alternatives must be considered and reviewed with the City of Columbus Project Manager for public projects, and the Private E-Plan or CC-Plan reviewer for private projects for potential solutions. These corrective measures may include regrading of roadway, cross slope improvements, additional catch basins at specific intervals, additional catch basins outside of the project limits, etc.
3. The project shall calculate spread based on all stormwater tributary to the project limits. Where stormwater enters the roadway upstream of the project, the designer shall evaluate spread utilizing hypothetical locations of inlets

upstream of the project to determine a reasonable design bypass flow entering the project limits. The designer shall assume the roadway upstream of the project is built to a 1.56% cross-slope and hypothetical inlets are spaced to meet current spread requirements. These hypothetical inlets will not be installed by the project.

4. Where upstream roadway stormwater enters the project limits, the first inlet shall be placed most nearest the upstream side of the project.
5. Spread calculations shall be completed for both sides of the roadway unless explicitly exempted or as noted in Table 2-9.

Exemptions:

1. Maintenance Projects
2. Stand Alone Sidewalk and Shared Use Path Projects
3. Curb Ramp Projects

Definitions to be Used for Spread Calculation Analysis:

Maintenance Projects – activities included in Ohio EPA's Routine Maintenance Exclusion regardless of total land disturbance

Storm Sewer Trunk Line – all storm sewer conduit and ~~manholes~~ maintenance holes that convey the collective waters of drainage structures.

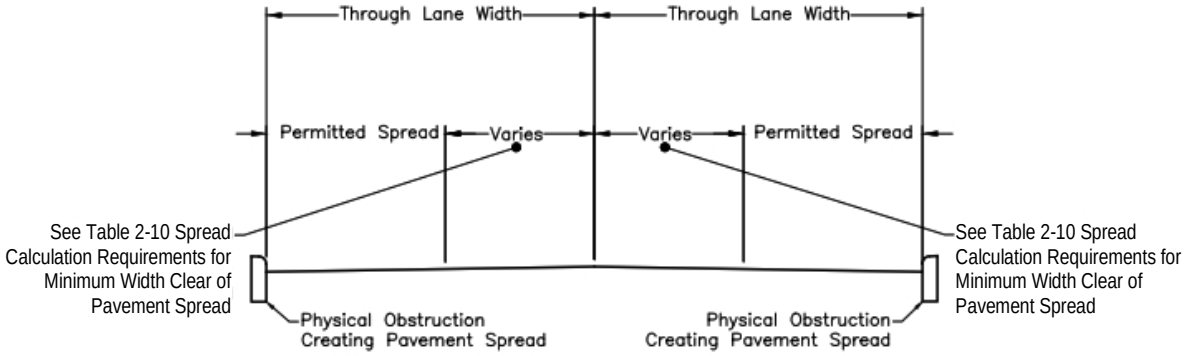
Table 2-10 Spread Calculation Requirements

Functional Classification or ADT	Design Speed	Design Storm Frequency	Minimum Width Clear of Pavement Spread[1] (Measured from the Left side of the Thru Lane)	
Interstate Highways	Refer to ODOT L&D Manual Volume 2, Section 1103			
Freeways and Expressways ≥ 4-Lanes (Non-Interstate)	Refer to ODOT L&D Manual Volume 2, Section 1103			
ADT > 9,000	≥ 45 mph	5-year	7 Feet for the right most thru lane	
	< 45 mph	5-year	1 Thru Lane Per Direction, 5 Feet ≥ 2 Thru Lanes Per Direction, 1 Thru Lane Free of Water	
	All	25-year	Meet associated spread for mph	Applies only at underpasses and sag points[6]
ADT 3,501 – 9,000	≥ 45 mph	2-year	7 Feet for the right most thru lane	
	< 45 mph	2-year	1 Thru Lane Per Direction, 5 Feet ≥ 2 Thru Lanes Per Direction, 1 Thru Lane Free of Water	
	All	10-year	Meet associated spread for mph	Applies only at underpasses and sag points[6]
ADT ≤ 3,500	> 35 mph	See Right	Utilize spread criteria from ADT 3,501 – 9,000	
	≤ 35 mph	2-year	May not exceed Crown Elevation	
	≤ 35 mph	5-year	May not exceed Crown Elevation	Applies only at underpasses and sag points[6]

Notes:

1. Minimum Width Clear of Pavement Spread is defined as the width of pavement clear of stormwater spread measured from the left side of the thru lane for each direction of vehicular traffic. The allowable depth of water on a roadway, within the design spread, shall be 1" below the top of curb or 5" maximum (i.e., no overtopping of curb allowed). Ponding of 6" is permissible when a barrier shape is provided adjacent to the pavement.

2. Typical Section of Minimum Width Clear of Pavement Spread



3. Other pavement spread computation requirements:
   - roughness coefficient (n) = 0.015 to be shown on spread computation table or worksheet
   - show allowable spread from above Table on spread computation table or worksheet
4. Use the values in Table 2-1 Intensity Duration Frequency (IDF) Curves for rainfall intensities.
5. ODOT CDSS Program is acceptable for use in City of Columbus Spread calculation submittals; however, if ODOT CDSS is NOT used, note (4) above prevails.
6. As it pertains to the spread calculations, underpasses and sag points are defined as depressed areas where stormwater cannot flood route away from a low-lying area and can only be conveyed through the storm sewer system. Depth of flood routing is defined in the Storm Water Drainage Manual per Section 2.4.

Table 2-11

Storm Sewers, Culverts, Level Spreaders, and Open Watercourses Design Criteria (Manual Sections 2.3.1, 2.3.3, 2.3.6 and 2.3.7)

Functional Classification	Storm Sewers		Culverts	Level Spreaders	Open Watercourses
	Design Storm*	Check Storm			
Freeways and Expressways ≥ 4-Lanes (Non-Interstate)	10-year	25-year	See Table 2-13	Used to prevent offsite erosion where onsite discharges cannot be directed to an offsite conveyance system. 1 cfs per 13 feet of level spreader length. Maximum length of level spreader not to exceed 130 feet.	Designed to carry the peak rate of runoff from a 10-year, 24-hour frequency storm. Those used for major storm routing shall be designed to convey the 100-year, 24-hour storm.
Major Arterial (ADT > 9,000)	10-year	25-year			
Minor Arterial and Collectors (ADT 3,501 – 9,000)	5-year	25-year			
Locals (ADT ≤ 3,500), Other Parking and Development Areas	2-year**	5-year**			

* For full pipe flow.
** Does not apply to storm sewer systems serving as outlets from detention facilities where flows are reduced per the City's stormwater control criteria (See Section 3).

2.3.2 Storm Sewers

Storm sewer systems are designed to collect and carry stormwater runoff from the first pavement, ditch inlet, or catch basin to the predetermined outlet. Storm sewers shall generally follow the alignment of the roadway, increasing in size as necessary to accept the flow from a series of inlets. Existing drainage patterns should be perpetuated insofar as practicable, and storm sewer outlets shall be located to minimize the possibility of actionable damage for the diversion of substantial volumes of flow.

Storm sewer calculations shall be summarized onto a Storm Sewer Computation Sheet and a Storm Sewer Check Sheet, presented in **Appendix A**, for each proposed sewer run. These sheets shall be submitted to the City as part of the Stormwater Management Report (see Section 6).

2.3.2.1 Storm Sewer Hydrology Requirements

The Rational Method shall be used to size storm sewers, as described in Section 2.2.3.1. The City will also accept storm sewer designs based on hydrograph methods in Section 2.2.4 as long as the results are tabulated in the referenced storm sewer computation and check sheets (**Appendix A**).

2.3.2.2 Storm Sewer Hydraulic Requirements

Pipe Sizing Criteria

All storm sewer systems shall be designed using Manning's Equation:

$$Q_f = (1.49/n)\, AR^{2/3}\, S^{1/2}$$

where:

Q_f = Full flow capacity of the storm sewer (cfs)
n = Manning's roughness coefficient
R = Hydraulic radius (feet)
= A/P
A = Cross-sectional area (feet^2)
P = wetted perimeter (feet)
S = Slope of the conduit
= vertical rise of the pipe (feet) / length of the pipe (feet)

A Manning's "n" or roughness coefficient of 0.013 shall be used to design storm sewer systems for all City-approved pipe materials.

Table 2-11 specifies the design storm frequency that shall be used to size storm sewers for various types of roadways. Storm sewer sizes may need to be increased as necessary to meet the allowable spread requirements.

Storm Sewer Layout Requirements

All storm sewer systems shall be deep enough to receive the flow from all possible nearby sources within the watershed. Crown elevations for storm sewers should be matched at junctions where possible. If the outlet elevation permits, the crown of the outlet pipe may be lowered.

Unless located within City Right-of-Way, storm sewers that are to be privately maintained shall have a minimum pipe inside diameter of eight inches. Storm sewers located within the City Right-of-Way that connect a private storm sewer system to a storm sewer owned by the City shall have a minimum inside diameter of 12 inches. Storm sewers that are to be publicly owned and maintained shall have a minimum inside diameter of 12 inches.

Storm sewers shall be designed to operate under subcritical flow conditions at all times because flow transients and/or small blockages may cause storm sewers built on supercritical slopes to surcharge unexpectedly. Drop ~~manholes~~ maintenance holes or other drop structures shall be used to maintain a mild pipe slope where ground slopes are steeper than critical slope. The maximum length between access structures shall be as follows:

1. Pipes under 60 inches in diameter – 300 feet
2. Pipes 60 inches in diameter and larger - 500 feet

All storm sewers shall be centered in the middle of easements established according to criteria in Section 2.3.2.4.

Endwalls shall be provided at all storm sewer outlets and shall conform to the most current edition of the City's Division of Sewerage and Drainage Standard Construction Drawings.

All storm sewers and their structures shall be kept away from building foundations or sanitary sewers as much as practicable to minimize stormwater inflow into these facilities. In instances where a proposed storm sewer will cross a sanitary sewer trench, watertight joints and trench dams shall be provided along the entire length of the proposed storm sewer from each ~~manhole~~ maintenance hole on either side of the crossing. If the storm and sanitary sewers are parallel and are within 5 feet of each other, water-tight joints and trench dams shall be installed along the entire run of the storm sewer until the distance between the storm sewer and sanitary sewer trenches exceed 5 feet.

Watertight joints and trench dams shall be specified for storm sewers that are to be located where the trench limits of the storm sewer are to be within 10 feet of a building foundation or a building setback line. Trench limits for storm and sanitary sewers, as referenced herein, shall be defined as the minimum trench limits listed in the City's Division of Sewerage and Drainage Standard Construction Drawings AA-S149, AA-S151, and AA-S153.

Hydraulic Grade Line and Energy Loss Considerations

The hydraulic grade line shall be calculated based on an observed or calculated tailwater depth in the receiving channel determined through downstream analysis or the following equation, whichever is greater:

$$T_w = (d_c + D)/2$$

where:

T_w = Tailwater depth (feet)
d_c = Critical depth in the pipe (feet)
D = Inside pipe diameter (feet)

The hydraulic grade line shall not exceed the window, grate, or casting elevation of any structure for the design storm frequency noted in **Table 2-11**.

Major energy losses within storm sewer systems are primarily caused by friction resistance between the fluid being conveyed and the pipe section conveying the flow. The following equation shall be used to calculate energy losses due to pipe friction:

$$H_{major} = S_f * L = [(Q_{HGL} * n)/(1.486 * A * R^{2/3})^2] * L$$

where:

H_{major} = Major energy loss due to friction (feet)
S_f = frictional slope (feet)

Q_{HGL} = Design flow (cfs)
n = Manning's roughness coefficient
A = cross-sectional area of the pipe (square feet)
R = hydraulic radius (feet) = cross-sectional area of the pipe (A) / wetted perimeter (P)
L = length of pipe (feet)

Applicants must use the the appropriate design flow (Q_{HGL}) as determined from **Table 2-11** and the following equation to check that the slope of the hydraulic grade line will not exceed the ground elevation:

$S_f = [(Q_{HGL}*n)/(1.486*A*R^{2/3})]^2$ where:

S_f = frictional slope (feet)
Q_{HGL} = Design flow (cfs)
n = Manning's roughness coefficient
A = cross-sectional area of the pipe (square feet)
R = hydraulic radius (feet) = cross-sectional area of the pipe (A) / wetted perimeter (P)
L = length of pipe (feet)

Flow Velocity Criteria
All storm sewers shall be designed and constructed to produce a minimum velocity of 3.0 feet per second (fps) when flowing full, unless it can be shown that this requirement cannot be met due to site conditions. In addition, storm sewers shall be designed for subcritical flow conditions with a maximum velocity of 15 ft/sec. The outlet ends of all storm sewers shall be provided with sufficient energy dissipators and erosion protection to withstand the projected full-flow velocity from the pipe.

2.3.2.3 Pipe Material, Bedding, Cover, and Encasement Requirements

All pipe material and accessories shall conform to the requirements in the CMSC and the stated requirements published in the current applicable ASTM standards and Manufacturers Specifications.

The cover, trench bedding and backfill design for all pipes in any street, highway, bikeway, or private road open to public travel shall conform to the requirements of the City's CMSC Section 901 and the City's Standard Construction Drawings. The bedding type (I or II) is specified in CMSC 901.11 for both rigid and flexible pipe.

In instances where the height of cover from the outside top of pipe to the ground surface or top of pavement surface is 36 inches or less, the engineer of record shall provide one of the following alternatives: signed and sealed drawings by the pipe manufacturer as part of the design plans, Class COC 8 concrete encasement per CMSC 901.12 from structure to structure for accepted pipe materials and dimensions or reinforced concrete pipe provided proper class of concrete pipe is specified by the engineer of record. The

following table is a guide for the class of pipe to use when the height of cover is 36 inches or less. In no case shall the height of cover be less than 12 inches.

If casing pipe is required for installation of a section of the storm sewer, then the entire length of the storm sewer from either end of casing pipe to the nearest structure must be encased in Class COC 8 concrete per CMSC 901.12.

Acceptable Class of Pipe When Height of Cover is 36 Inches or Less

Pipe Diameter (Inches)	Class of Pipe	Minimum D-Load
12	IV	2000
15	IV	2000
18	III	1250
21	III	1250
24	III	1250
27 or Larger	II	1000

Notes for height of cover table

1. The design of the proper class of concrete pipe is based on ODOT CMS 706.02, ASTM C-76 Specification for reinforced concrete round pipe, ASTM C-507 Specification for horizontal elliptical concrete pipe and ASTM C-655.

2. The installation type shall be Type 2.

3. The storm sewers in roadway and outside of roadway are designed for an AASHTO HS-20 live load condition.

4. The height of cover table assumes a soil density equal to 120 pounds per cubic foot.

2.3.1.4 Storm Sewer Easement Requirements

All storm sewers that are to be publicly owned and operated shall have a minimum easement of 20 feet centered on the sewer, or 5 feet beyond the minimum trench limits on either side of the trench (as specified in Standard Construction Drawings AA-S149, AA-S151, and AA-S153), whichever is greater. Additional easements shall also be provided along storm sewers within the public right-of-way but less than 10 feet from the right-of-way line. The added easement width shall be wide enough to provide a total access width (easement plus right-of-way) of 10 feet from the center of the storm sewer.

Storm sewer easements shall be expanded to include ancillary structures such as end treatments, outfall protection, and level spreaders that are publicly owned and maintained. The width of easements shall include the area of the ancillary structure plus 10 feet around the structure's perimeter.

2.3.3 Curb Inlets and Catch Basins

Stormwater inlets and catch basins direct surface runoff into a storm sewer system or culvert. The three types of stormwater inlet structures include curb inlets, catch basins, and combination inlets. Curb inlets consist of an opening in the side of a curb, catch basins are slotted inlets usually flush with the surrounding ground, and combination inlets have a curb opening and a catch basin with a slotted grate.

2.3.3.1 General Criteria

Inlets and catch basins shall be sized and spaced to restrict the spread of runoff along roadway surfaces and limit ponding in low areas. **Table 2-10** summarizes the allowable spread of runoff on various classifications of roadways.

The rational method (see Section 2.2.3.1) and a minimum time of concentration of 5 minutes shall be used to determine the amount of runoff that will be collected by the proposed inlet structures. Hydraulic analyses used to size and space inlets and catch basins shall be based on the methods presented in (FHWA) Hydraulic Engineering Circular No. 12 "Drainage of Highway Pavements" and Hydraulic Engineering Circular No. 22 "Urban Drainage Design Manual." **Table 2-12** summarizes the dimensions of the inlets and catch basins that are provided in the City's standard drawings. These dimensions may be used with the design aids (i.e., charts, graphs, nomographs, etc.) provided in the references cited above to assist in determining the capacity and spacing of the inlets and catch basins under different pavement and flow conditions.

Table 2-12
City Catch Basin Grate and Curb Inlet Dimensions

Standard Drawing	Shape	Clear Opening Area, A (ft^2)	Grate Length, L (ft)	Grate Width, W (ft)	Inlet Height $(ft)^2$
AA-S115	Round Catch Basin	2.9	3.0	3.0	-
AA-S116	Round Catch Basin	2.7	3.0	3.0	-
AA-S123	42" Curb Inlet	-	-	-	>4
AA-S123	60" Curb Inlet	-	-	-	>4
AA-S126	Standard Curb Inlet	-	-	-	6.25
AA-S128[1]	Combination Curb and Gutter – Standard	2.7	2.8	1.4	-
AA-S133	Square Catch Basin	2.5	3.9	2.1	-
AA-S138	Round Catch Basin	0.9	1.9	1.9	-
AA-S139	Square Catch Basin	1.9	1.6	2.0	-
AA-S140	Rectangular Catch Basin	1.1	1.8	1.2	-
AA-S141	Square Catch Basin	1.9	1.9	2.0	

1. The capacity of combination curb and gutters shall be calculated as a grate inlet. The additional capacity from the curb inlet is to serve as overflow when grate becomes blocked with debris.
2. Depth of inlet opening can vary depending on height of curb and capacity needs. A depression should be provided to achieve an inlet height of at least 4 inches.

2.3.3.2 Underpass or Sag Requirements

An underpass or sag condition is a point where water can be removed only through a storm sewer system. Inlets shall be placed in low areas such as sag curves along a highway, underpasses, and other depressions where runoff may concentrate and the only outlet is the storm sewer system. The number and type of inlets to be used to drain underpass or sag locations shall be designed to achieve the roadway classifications and storm frequencies provided in **Table 2-10**.

2.3.3.3 Inlets on Continuous Grade Requirements

At a minimum, the catch basin and/or curb inlet shall be placed at the point where the flow spread is projected to reach the maximum allowable spread listed in **Table 2-10**. In addition, a basin/inlet shall be placed at intersections where necessary to prevent the gutter flow from crossing the pavement. The City may require additional inlets at intermediary points if the flow in the gutter at design conditions might create a hazard to vehicular traffic, public safety, or property flooding. The projected gutter flow approaching each basin/inlet, the flow projected to enter each basin/inlet, and the flow projected to bypass each basin/inlet shall be provided in the Stormwater Management Report.

2.3.4 Culverts

The purpose of a culvert is to safely convey water from one side of a roadway or embankment to the other. The size and shape of the culvert should be such that it will carry a predetermined design peak discharge without the depth of water at the entrance or the velocity at the outlet exceeding allowable limits.

Section 1105 of the latest edition of the ODOT L&D Manual shall be used to design culverts unless alternative criteria are explicitly stated in this document. Other acceptable design procedures are contained in the FHWA's Hydraulic Engineering Circular No. 5[12] and in FHWA's HY8 model[13]. All materials used in construction of roadway culverts shall conform to the City's CMSC.

2.3.4.1 General Requirements

Stream crossings shall be located at a relatively straight and stable section of the stream. The horizontal and vertical alignment of the culvert shall generally follow the alignment of the stream at the crossing. Stream crossings at right angles to the stream are preferred to maximize hydraulic efficiency and minimize environmental impacts. If the skew angle of the culvert exceeds 45°, then either the roadway alignment or the culvert alignment (or both) shall be revised to achieve a skew angle less than 45°.

A single barrel round pipe shall be used where flow, headwater, tailwater, and pipe cover conditions allow. Where round pipes are not feasible, single barrel elliptical, pipe arch, box culvert, and three-sided structures shall be used, in order of preference. Where single barrel conduits are not feasible, multi-barreled culverts shall be used to minimize the disturbance to the stream channel and provide capacity for flows within the floodplain to minimize backwater.

2.3.4.2 Culvert Hydrology Requirements

The hydrologic computation methods specified in Section 2.2.1 shall be used to design culverts in the City. Culverts spanning open channels conveying onsite flows shall be designed according to the same method used to design other onsite drainage facilities. Culverts spanning streams shall be designed using the regression equations presented in Section 2.2.3.2.

[12] FHWA, Hydraulic Engineering Circular No. 5 *Hydraulic Charts for the Selection of Highway Culverts*, available from the Superintendent of Documents, U.S. Government Printing Office
[13] FHWA,*Culvert Analysis Microcomputer Program.* FHWA-EPD-87-101

2.3.4.3 Culvert Hydraulic Requirements

Design Storm Frequency
Table 2-13 provides the design storm frequencies that shall be used to design roadway and other stream crossings:

Table 2-13

Culvert Design Storm Frequency [14]

Functional Class or ADT	Design Storm Event
Interstate highways, other freeways, and expressways	50-year
ADT > 2000	25-year
ADT ≤ 2000	10-year

Types of Culvert Flow
Two types of flow may occur in a culvert: flow with inlet control and flow with outlet control. Designers shall determine the design flow regime for each culvert within the project, and use appropriate design nomographs for the appropriate flow condition, found in the drainage design aids contained in the ODOT L&D Manual.[15]

Tailwater Conditions
The designer shall perform hydraulic calculations necessary to determine the depth of flow in the outlet channel when the culvert is discharging the design flow. This determination shall take into account downstream constraints, obstructions, grades, confluences with other streams, or other hydraulic features that may create a backwater at the culvert outlet. The following sources contain information that might aid in establishing downstream tailwater conditions:

1. Previous studies that may be on file within the Division of Sewerage and Drainage, or
2. Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) and data.

The tailwater depth for the design frequency of the culvert shall be used to size the culvert.

Maximum Allowable Headwater
The headwater depth at the inlet of each roadway culvert shall not exceed any of the following conditions during the design storm listed in **Table 2-13**:

1. 2 feet below the near, low edge of the pavement for drainage areas 1000 acres or greater, and 1 foot below for culverts draining less than 1000 acres,
2. 2 feet above the inlet crown of the culvert or above a tailwater elevation that submerges the inlet crown in flat to rolling terrain,
3. 4 feet above the inlet crown of a culvert in a deep ravine,

[14] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*
[15] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*

4. 1 foot below the near edge of pavement for bicycle pathways, and
5. At or below the near edge of pavement for driveway culverts conveying runoff along roadside ditches.

In addition, the peak headwater depth during the 100-year frequency event shall be 1 foot below the finished grade adjacent to any existing or proposed building. Section 2.4 provides additional overtopping requirements related to culverts within major flood routing paths.

Manning's "n" Value

Acceptable materials for culverts, defined in CMSC Section 603, include concrete (non and reinforced), corrugated steel, bituminous corrugated steel, and precast box and concrete sections. With the exception of corrugated metal pipes, a Manning's "n" value of 0.013 shall be used for the hydraulic design of culverts. ODOT L&D Manual shall be used to determine acceptable "n" values for corrugated metal pipe.

Entrance Loss Coefficients

Table 2-14 shall be used to define (minor) entrance loss coefficients for culverts under outlet control conditions.

Maximum Allowable Outlet Velocity

The Applicant shall determine the cross-sectional area of flow from the culvert outlet, and use this area, the design flow, and other characteristics of the culvert to determine the outlet velocity at design conditions. If the outlet velocity is larger than the maximum velocity for the channel lining material that is listed in **Table 2-17**, then erosion protection and/or energy dissipaters shall be required to properly armor the receiving channel and control outlet velocities. Section 2.3.6 provides design requirements for rock protection and recommendations for energy dissipation devices at culvert outlets.

Table 2-14

Minor (Entrance) Loss Coefficients for Culverts under Outlet Control, Full or Partly Full Entrance Head Loss [16, 17]

Type of Structure and Design of Entrance	Coefficient K
Pipe, Concrete	
▪ Projecting from fill, socket end (groove-end)	0.2
▪ Projecting from fill, sq. cut end	0.5
▪ Headwall or headwall and wingwalls	
- Socket end of pipe (groove-end)	0.2
- Square-edge	0.5
- Rounded (radius = 1/2D)	0.2
▪ Mitered to conform to fill slope	0.7
▪ End-section conforming to fill slope	0.5
▪ Beveled edges, 33.7° or 45° levels	0.2
▪ Side – or slope – tapered inlets	0.2
Pipe or Pipe-Arch, Corrugated Metal	
▪ Projecting from fill (no headwall)	0.9
▪ Headwall or headwall and wingwalls square-edge	0.5
▪ Mitered to conform to fill slope, paved or unpaved slope	0.7
▪ End-section conforming to fill slope	0.5
▪ Beveled edges, 33.7° or 45° bevels	0.2
▪ Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
▪ Headwall parallel to embankment (no wingwalls)	
- Square – edged on 3 edges	0.5
- Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
▪ Wingwalls at 30° to 75° to barrel	
- Square-edged at crown	0.4
- Crown edge rounded to radius of ½ barrel dimension, or beveled top edge	0.2
▪ Wingwall at 10° to 25° to barrel, square-edged at crown	0.5
▪ Wingwalls parallel (extension of sides), square-edged at crown	0.7
▪ Side- or slope-tapered inlet	0.2

Bankfull Design Considerations

The designer shall check that culverts sized to meet the hydraulic design conditions in this section will also convey the bankfull discharge with minimal change to the bankfull

[16] Water Environment Federation and American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems*, 1992

[17] Federal Highway Administration, *Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5*, Report No. FHWA-IP-85-15, Washington DC, 1985

depth of flow in the adjoining channel sections, as compared to existing conditions. Exceptions to this requirement include:

1. Culverts with a rise of 30 inches or less,
2. The culvert invert is located on bedrock, and
3. The culvert slope exceeds 1%

The bankfull discharge shall be determined using a field-obtained stream cross-section from a portion of the stream that does not exhibit bank or bed erosion.[18] A hydraulic profile through the channel shall be prepared to demonstrate that the culvert does not alter existing water surface elevations at bankfull conditions. If significant changes in water surface elevation are determined, larger pipe sizes and/or alternative pipe shapes shall be used to reduce the impact. The methodology presented in ODOT's L&D Manual shall be used to analyze bankfull discharge conditions.

The City also requires that the inverts of culverts at stream crossings be depressed to minimize stream impacts. Depressed inverts shall be filled with substrate necessary for aquatic life to migrate through the culvert. The culvert design shall be based on the remaining pipe diameter and increased Manning's "n" after the invert has filled with substrate. **Table 2-15** shows the amount of invert depression that should be provided for different sized pipes.

Table 2-15

Allowable Conduit Invert Depression [19]

Pipe Diameter or Rise	Depression
< 36 inch	None
36 to 60 inch	6 inches
66 to 120 inch	12 inches
126 to 180 inch	18 inches
186 to 252 inch	24 inches
> 252 inch	30 inches

2.3.4.4 Culvert Layout Requirements

Culverts shall be aligned according to the general criteria in Section 2.3.4.1. It is preferable that the culverts be located at or near the low point of the roadway sag vertical curve to allow for major storm routing across the roadway and along the natural routing path of the existing open channel.

Minimum Pipe Size

Minimum pipe size for roadway culverts shall be based on the fill depth over the crown of the culvert, as specified in **Table 2-16**.

[18] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*
[19] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*

Table 2-16

Minimum Allowable Pipe Size for Various Fill Depths [20]

Fill Depth	Roadway Type	
	Freeway*	Other
<8 feet	24 inch	15 inch
8 feet to < 16 feet	30 inch	24 inch
16 feet to < 32 feet	36 inch	30 inch
> 32 feet	42 inch	36 inch

* or other multi-lane facilities with limited or controlled access

Structural and Cover Requirements

The cover and structural requirements for culverts shall be the same as specified for storm sewers in Section 2.3.2.3.

2.3.4.5 Culvert Easement Requirements

Culverts or portions of culverts and ancillary components (e.g., headwalls, endwalls, and erosion protection areas) shall be located entirely within the public right-of-way to provide future access and maintenance.

2.3.5 End Treatments

End treatments are used to dissipate energy and minimize erosion at the inlet and outlet of culverts and storm sewer outfalls. End treatments shall be provided at the inlet and outlet of all culverts (Section 2.3.4), excluding driveway culverts, and at the outlet of all storm sewer systems (Section 2.3.2). The selection of end treatment type is based on safety and economics. Construction of roadway culvert headwalls shall conform to the City's CMSC Sections 602, including Class COC 6 concrete for cast in place headwalls according to Sections 499 and 511 and reinforcing steel.

Cast in place pipe culvert endwalls shall be constructed of Class COC 6 concrete and designed per City Standard Construction Drawing AA-S165. Cast in place pipe culvert headwalls, 8 to 84 inches in diameter, shall be constructed per City Standard Construction Drawings AA-S166 and 167.

Precast pipe culvert endwalls approved for pipe culverts 8 to 60 inches in diameter, shall be constructed per City Standard Construction Drawing AA-S169. Precast headwalls approved for pipe culverts 8 to 36 inches in diameter shall be constructed per City Standard Construction Drawing AA-S168.

[20] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*

2.3.6 Outlet Channel Protection

2.3.6.1 Outlet Channel Protection Required

The appropriate channel protection shall be designed to prevent erosion at the outlet of a culvert or storm sewer outfall where concentrated flows generate peak velocities that exceed the maximum allowable velocity for the constructed channel lining materials listed in **Table 2-17,** or the native vegetation that exists within an existing receiving stream during the design storm event. This section provides general design criteria for two categories of outlet channel protection:

1. Rock Outlet Protection[21], suitable for outlet velocities up to 20 feet per second.

2. Energy Dissipation Devices, suitable for outlet velocities greater than 20 feet per second.

Table 2-17

Maximum Velocities for Channel Lining Materials [22,23]

Channel Lining Material	Maximum Allowable Velocity (ft/s)*
Streams	
▪ Sand	2.0
▪ Silt	3.5
▪ Firm Loam	3.5
▪ Fine Gravel	5.0
▪ Stiff Clay	5.0
▪ Graded Loam or Silt to Cobbles	5.0
▪ Coarse Gravel	6.0
▪ Shales and Hard Pans	6.0
Vegetated Channels (per CMSC 659)	
▪ Seed mixtures for urban areas	2.5**
▪ Other seed mixtures	2.5**
▪ Crown vetch	2.5**
▪ Established Seed or Sodded Channels	6.0
Flexible Linings	
▪ Slope Erosion Protection	Follow manufacturer's criteria
▪ Erosion Control Matting	
▪ Rock Channel Protection	Use shear stress analysis
Rigid lining [24]	
▪ Concrete	18
▪ Concrete block mat	18

* In addition, the maximum velocity shall not exceed the velocity under critical flow conditions at all depths within the channel up to the design flow depth.

** Velocity assumes newly seeded areas without erosion control matting provided.

[21] Ohio Rainwater and Land Development Manual
[22] American Association of State Highway Transportation Officials, *Model Drainage Manual,3rd Edition*, 2004
[23] Ohio Department of Transportation, *Location and Design Manual, Volume Two - Drainage Design*
[24] City of Greeley, Colorado, *Stormwater Drainage Design Criteria and Construction Specifications,* 2002

2.3.6.2 Rock Outlet Protection

Rock outlet protection may be used as transitions from culverts or storm sewer outfalls to stable channel sections. Rock outlet protection is constructed at a zero grade for a distance related to the outlet flow rate and tailwater depth. The use of this practice is restricted to outlet Froude (Fr) numbers less than or equal to 2.5. Rock outlet protection is commonly used because of the low cost and ease of installation. Unless otherwise noted below, acceptable design procedures for rock outlet protection may be found in the Ohio Rainwater and Land Development Manual.

Side Slope

If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal: vertical).

Alignment

The apron shall be located so there are no bends in the horizontal alignment.

Materials

The materials and placement of riprap shall conform to the requirements of the City's CMSC Section 601. At the discretion of the Division of Sewerage and Drainage, the use of flat stones (as referenced in CMSC 601.04) of native material may be used as a streambed liner where it can be demonstrated that the lining will remain stable.

2.3.6.3 Energy Dissipation Devices

Energy dissipation devices[25] are required to prevent scour at culvert and storm sewer outlets and minimize potential for downstream erosion whenever the outlet velocity exceeds 20 ft/sec or the outlet discharges under supercritical flow conditions. Since energy dissipaters function by creating a hydraulic jump, performance is dependent on tailwater conditions. If there is potential for high tailwater conditions in the downstream channel and an energy dissipation device is necessary, then the device shall be designed for low tailwater conditions while the downstream channel is sized to account for higher tailwater conditions. Outlet structures shall provide uniform redistribution or spreading of the flow without excessive separation and turbulence. The maximum velocity exiting an energy dissipation device shall not exceed the maximum velocity of the downstream channel lining in **Table 2-17**.

The following sections summarize key design criteria and provide corresponding references for the design of acceptable energy dissipation devices in the City.

Riprap Outlet Basins

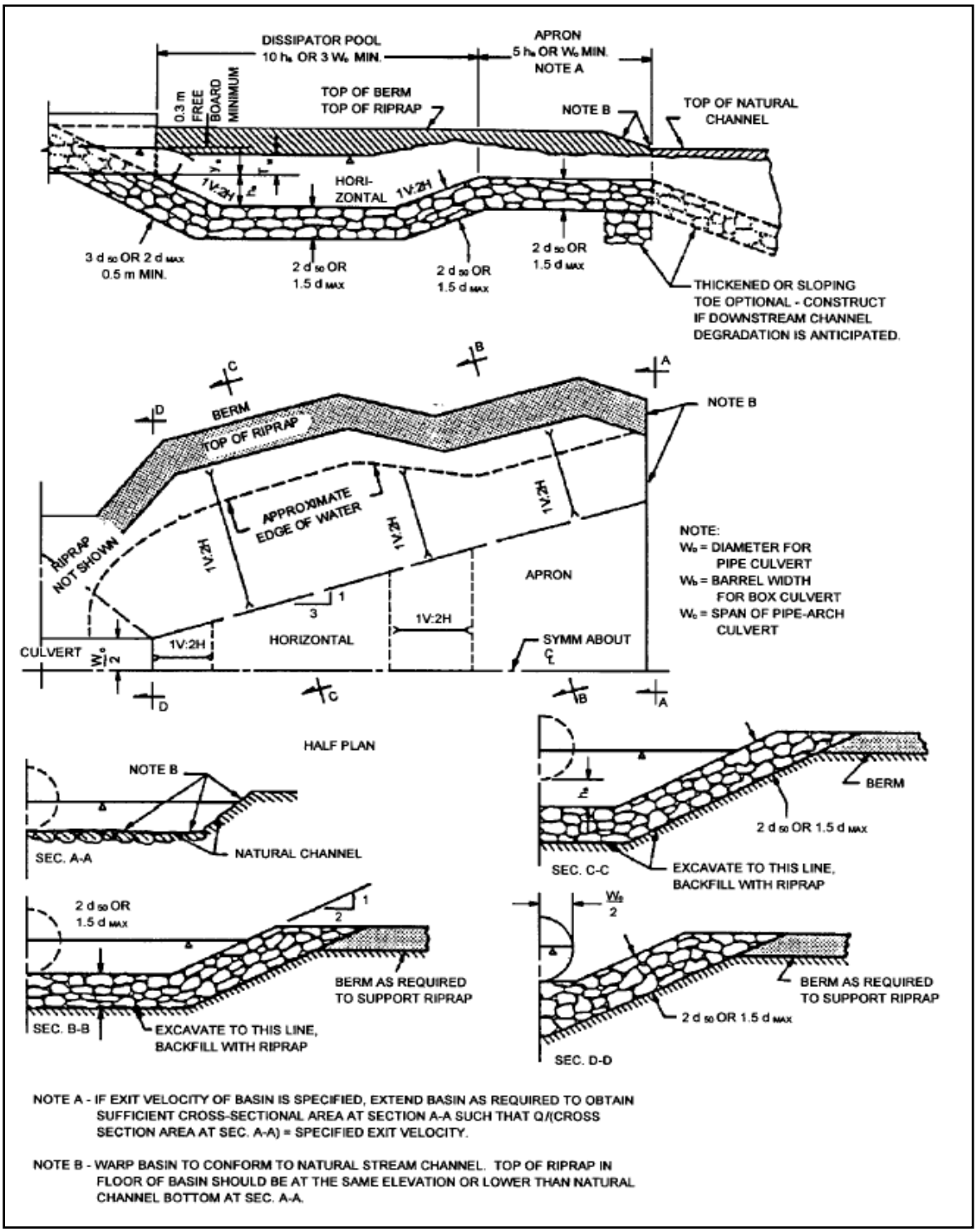
One approved method of energy dissipation at storm sewer and culvert outlets is a riprap outlet basin (**Figure 2-3**), which is composed of a dissipation pool and an apron lined with riprap of a median size (d_{50}). The dissipation pool is sized to the approximate depth of scour that would occur in a pad of riprap of size d_{50} if subjected to design discharge, and

[25] Atlanta Regional Commission, *Georgia Stormwater Management Manual*, Volume 2 (Technical Handbook), 1st Edition, August 2001

with a length sufficient to completely contain the hydraulic jump. These structures are generally used for transitions from culverts to stable channels where the Froude Number is less than 2.5. Riprap outlet basins shall be designed according to procedures contained in FWHA's HEC No. 14.

Figure 2-3

Riprap Outlet Basin Detail



NOTE A - IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS-SECTIONAL AREA AT SECTION A-A SUCH THAT Q/(CROSS SECTION AREA AT SEC. A-A) = SPECIFIED EXIT VELOCITY.

NOTE B - WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A-A.

Baffled Outlets

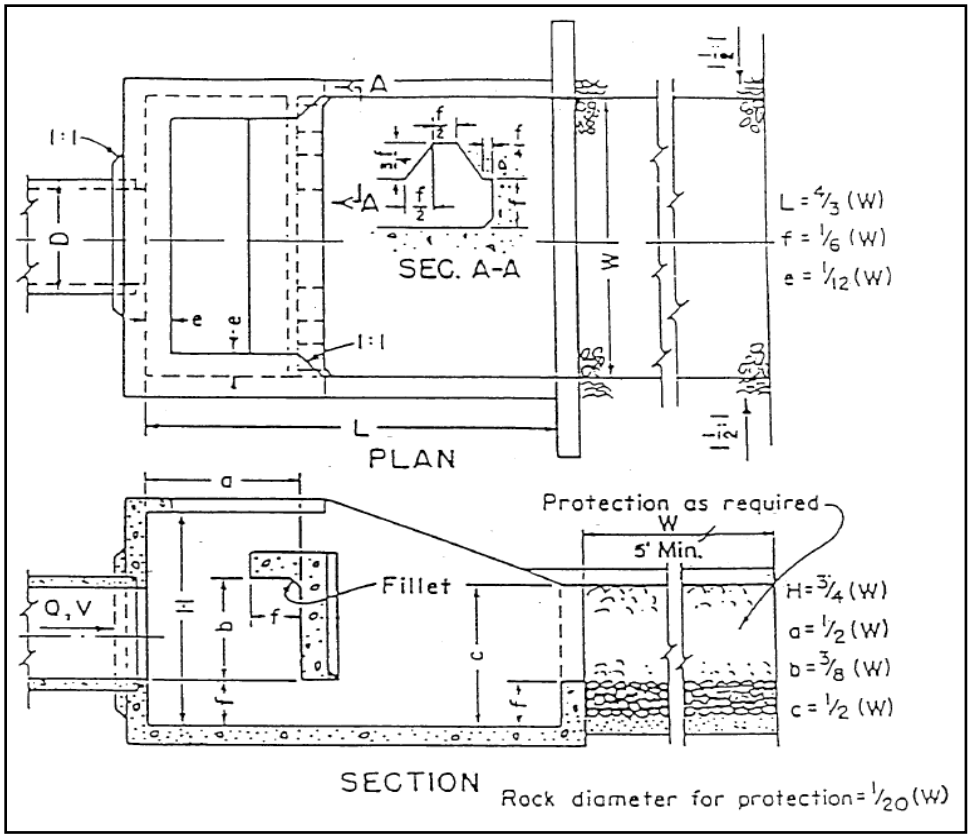
Baffled outlets (also known as Impact Basins – U.S. Bureau of Reclamation Type VI) consist of a boxlike structure with a vertical hanging baffle and an end sill (**Figure 2-4**). Energy is dissipated through the impact of water striking the baffle and the resulting turbulence. Baffled outlets may be used for outlets with a Froude number between 1 and 9 and velocities up to 50 feet/sec. Tailwater does not significantly affect the energy dissipation achieved by these structures. The U.S. Department of Interior's *Design of Small Canal Structures* report shall be used to design baffled outlets.

Forced Hydraulic Jump Basins

A forced hydraulic jump basin utilizes blocks, sills, or other roughness elements to impose exaggerated resistance to flow in order to shorten and stabilize the hydraulic jump. These types of energy dissipation are required where the design velocity and/or Froude Number exceed acceptable criteria for riprap aprons and basins, or when site constraints or environmental factors require that the length of energy dissipation be minimized. Acceptable designs include those developed by the U.S. Bureau of Reclamation, Colorado State University, and the U.S. Natural Resources Conservation Service at St. Anthony Falls Hydraulic Laboratory. The designer shall use design criteria provided in FHWA's HEC-14 *Design of Energy Dissipators for Culverts and Channels, FEMA P-679 Technical Manual: Outlet Works Energy Dissipators,* or other design criteria acceptable to the Division.

Figure 2-4

Baffled Outlet Detail



2.3.7 Level Spreaders[26, 27]

A level spreader is a structure designed to convert concentrated flow from stormwater runoff to sheet flow. Level spreaders have traditionally been used at detention basin outfalls where concentrated pipe flows are directed toward a stream or wetland and upstream of water quality BMPs (e.g., filter strips; see Section 3.3.6) where "treatment" of stormwater runoff is dependent on the velocity and depth of flow.

2.3.7.1 Use Restrictions

Use of level spreaders is limited by both the flow rate over the level spreader lip as well as the slope and ground cover across the downstream, sheet flow area. Research indicates that level spreader systems designed within parameters shown in **Table 2-18** are more prone to remain stable and reduce potential for flow re-concentration. Level spreaders may not be used where the criteria presented in **Table 2-18** cannot be met.

[26] Design standards adapted from North Carolina, Department of Environment and Natural Resources Division of Water Quality, *Stormwater Best Management Practices Manual,* 2007

[27] Design standards adapted from Hathaway, J.M. and Hunt, W.F., *Urban Waterways, Level Spreaders: Overview, Design, and Maintenance,* 2006

Table 2-18

Level Spreader Use Criterion

Ground Cover	Slope Limits	Level Spreader Length (ft.) Max.	Distance from Level Spreader Lip to Stream Bank	Length of Level Spreader per Maximum 1 cfs of Flow
Grass or thick ground cover	0 to 6 percent	130	No limit	13 feet
Forested	0 to 6 percent	130	0 to 99 feet	65 feet
Forested	0 to 6 percent	130	100 to 150 feet	50 feet
Forested	0 to 6 percent	130	> 150 feet	40 feet

2.3.7.2 Level Spreader Features

The following features are recommended for incorporation into a level spreader design to ensure proper function and longevity of the level spreader system. **Figure 2-5** and **Figure 2-6** illustrate the components of a level spreader system.

Level Spreader Lip

1. A level spreader channel, reinforced with rock or grass lining, should be installed along the upstream face of the level spreader lip to distribute flow equally along the entire length of the level spreader.
2. An underdrain system should be installed under the level spreader channel to prevent standing water during periods of no flow. The underdrain should outlet into a stormwater conveyance system.
3. The level spreader lip should be constructed of concrete and supported by an adequately sized concrete footing to prevent settlement and overturning.
4. The width of the level spreader lip should be at least three (3) times the diameter of the inlet pipe up to a maximum width of 24 inches.
5. The lip of the level spreader should be elevated 3 to 6 inches above the ground surface on the downstream side and not less than 9 inches from the invert of the level spreader channel along the upstream side.
6. The level spreader lip should be installed at zero percent grade and parallel to contours. Level spreaders may be curved, if needed, to fit site contours and ensure a level lip.
7. The downstream side of the level spreader lip should be protected to prevent erosion.

Bypass Channel

1. A bypass channel shall be provided for level spreaders intended to convey flows that exceed the capacity of the level spreader system.
2. The bypass channel must be sized and appropriately lined to convey the 10-year storm event without flooding or inducing channel erosion.
3. The use of turf reinforcement for channel lining is preferred over stone where adequate sunlight and channel velocities allow.

Figure 2-5

Level Spreader Plan View

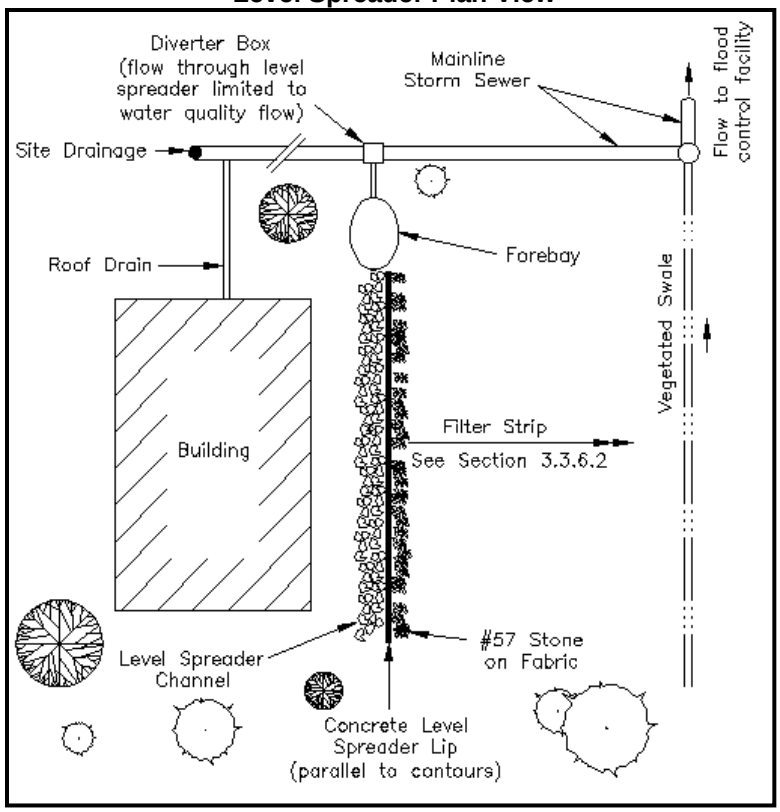
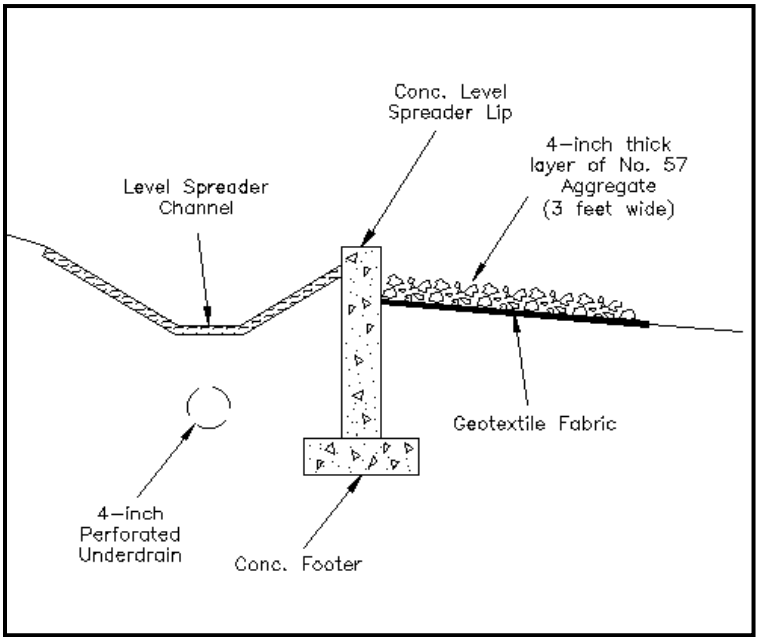


Figure 2-6

Level Spreader Cross Section View



2.3.8 Open Watercourses

The requirements in this section are applicable to newly constructed open watercourses that are intended to convey flow to stormwater inlets, stormwater control practices, streams, lakes, wetlands, or other water bodies during precipitation events. A constructed channel shall be shaped or graded to the required dimensions and established with a suitable lining as necessary to convey stormwater runoff without allowing channel erosion. The following guidance documents may be used for evaluation, planning, and design of constructed open watercourses to supplement the design criteria provided in the Manual:

1. NRCS Ohio Practice Standard 412, Grassed Waterways,
2. NRCS Engineering Field Handbook (EFH) Part 650, Chapter 7 – Grassed Waterways,
3. Agricultural Handbook 667, Stability Design of Grass-lined Open Channels, and
4. Federal Highway Administration, 1988, Design of Roadside Channels with Flexible Linings. Hydraulic Engineering Circular No. 15.

2.3.8.1 Channel Hydrology Requirements

The hydrologic computation methods specified in Section 2.2.1 shall be used to design open watercourses in the City. In most cases, open watercourses shall be designed according to the same method used to design other onsite drainage facilities.

2.3.8.2 Channel Hydraulic Requirements

Design Storm Frequency

Constructed open watercourses shall be designed to convey the 10-year design storm without causing erosion, sedimentation, or overbank flooding within and along the channel. Criteria in Section 2.4 shall be used if the channel will also serve as a flood routing channel for the 100-year design storm. . ODOT's L&D Manual, Drainage Design aids may be used for sizing open conveyances (at various side slopes). A ditch computation sheet (included in **Appendix A**) shall be used to present open channel calculations.

Cross Section Shape

Parabolic and trapezoidal channel shapes (**Figure 2-7**) shall be used for open watercourses within development projects. Side slopes shall be 3(H) to 1(V) or milder, with a minimum 2-foot bottom width for trapezoidal channels, unless alternative dimensions are approved by the City due to specific project conditions. Channel cross sections shall be designed such that erosion and sediment deposition is minimized.

Design Velocity

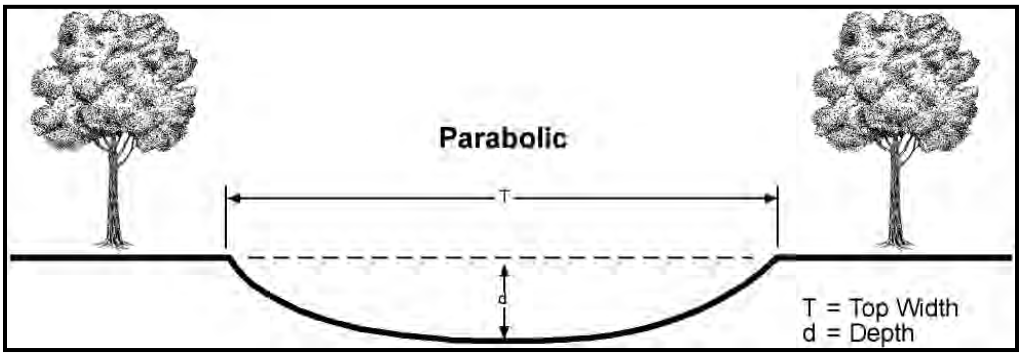
An open channel is categorized by its lining. There are three main types of channel linings: vegetated, flexible, and rigid. A vegetative lining, such as grass with mulch and sod and lapped sod, is required where site constraints and flow velocity conditions allow. Flexible linings include rock channel protection and cellular soil retaining mats and are typically less expensive than a rigid lining. The use of flexible linings, however, may

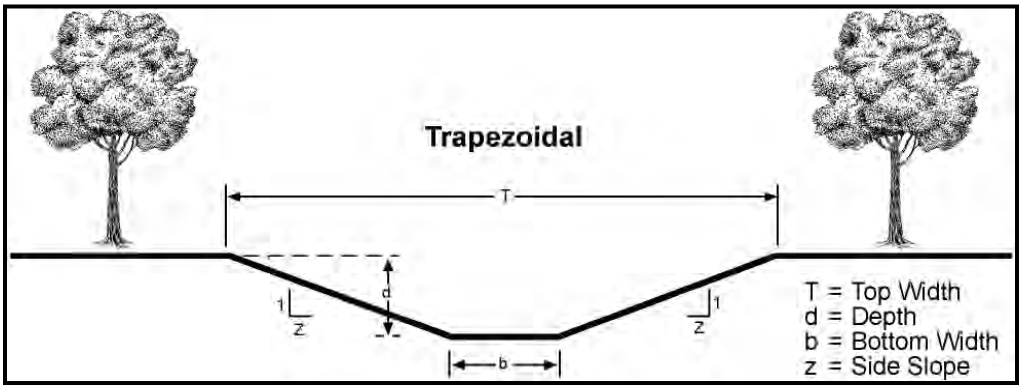
require the installation of a filter fabric or other means to protect the underlying soil, prevent washout, and prevent soil piping through the rock when using channel protection. Rigid linings include concrete and rigid block and are usually used where high velocities are unavoidable.

Final design of constructed open channels should be consistent with velocity limitations for the selected channel lining. Maximum velocity values for selected vegetated and non-vegetated lining categories are presented in **Table 2-17**. The Manning's Equation shall be used to design an open channel that satisfies the maximum velocity criteria in the previous sections:

Figure 2-7

Parabolic and Trapezoidal Channel Shapes for Open Watercourses





$$v = (1.49/n)\, R^{2/3}\, S^{1/2}$$

where:

v = average channel velocity (ft/s)
n = Manning's roughness coefficient
R = hydraulic radius (ft)
= A/P

A = cross-sectional area of the channel (ft^2)
P = wetted perimeter of the channel (ft)
S = slope of the energy grade line (ft/ft)

Recommended Manning's "n" values for open channels with vegetated and non-vegetated linings are provided in **Table 2-19**.

Critical Flow

Open channels shall be designed to flow under subcritical flow conditions at all times. A subcritical flow regime is characterized by a Froude Number less than 1.

Table 2-19

Manning's Roughness Coefficients (n) for Vegetative and Artificial Channels [28]

Channel Lining Category	Roughness Coefficient
Vegetated Lining:	
• Seeded	– 0.03 (for velocity determination only without erosion control matting on all channels) – 0.04 (for depth determination along roadside channels only) – 0.06 (for depth determination, except along roadside channels)
• Sod	– 0.04 (for velocity determination on all channels) – 0.04 (for depth determination along roadside channels only) – 0.06 (for depth determination, except along roadside channels)
Flexible Lining:	
• Slope Erosion Protection	0.04
• Erosion Control Matting	0.04
• Grouted Riprap	0.02
• Rock channel protection (typical for Type C/D*) – Small channels/ditches – Large channels	 0.06 0.04
Rigid Lining:	
• Concrete	0.015
• Bituminous	0.015
• Concrete Block Mat (tied)	0.021

* Note: Increase roughness coefficient by 15% for Type B RCP.

$$F = V/(gD)^{0.5} < 1$$

[28] Adapted from Federal Highway Administration, *Hydraulic Engineering Circular 15*, 1998. Reported in Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design.*

where:

F = Froude Number
D = hydraulic depth (ft)
= A / T
A = cross-sectional area of flow (ft^2)
T = top width of water surface (ft)
V = flow velocity (ft/sec)
g = acceleration due to gravity
= 32.2feet/sec^2)

The Stormwater Management Report shall demonstrate that the calculated Froude Number is less than 1 over the anticipated range of flow conditions within the channel.

Rock Channel Protection Shear Stress Analysis[29]

Type B, C or D rock channel protection shall be provided in accordance with CMSC Section 601.09. Type B, C or D rock channel protection shall only be placed outside of guardrails, barriers or other unobstructed areas provided outside of the traveled way for vehicles to stop safely or regain control.

The actual shear stress (r_{ac}) must be less than or equal to the allowable sheer stress (r_a) listed in **Table 2-20** for the rock channel protection type used. The actual shear stress shall be determined for the channel slope and the depth of flow during a 10-year design storm. The following equation is valid for discharges less than 50 cfs and with slopes less than 10%:

$r_{ac} = 62.4*D*S$

where:

D = depth of flow (feet)
S = channel slope (feet/feet)
r_{ac} = actual shear stress (lbs/$feet^2$)

Table 2-20

Allowable Shear Stress for Rock Channel Protection

Type of Rock Channel Protection	r_a (lbs/$feet^2$)
B	6
C	4
D	2

In extreme site conditions, Type B or C rock channel protection shall be utilized for lining channels with steep grades (slopes 10%-25%) that carry flow from the end of a cut section down to the lowest elevation on the bottom of the channel. FHWA's HEC-15 procedures for steep gradient channels shall be used with a safety factor of 1.5. The Division of Sewerage and Drainage shall be consulted if rock channel protection is proposed in instances where the peak flow during the 10-year design storm is greater than or equal to 50 cfs.

[29]Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*

Outlets
All constructed open watercourses shall have a structurally sound and stable outlet with adequate capacity to prevent ponding or flooding damage. Portions of open watercourses affected by backwater from streams during dry weather flow conditions shall be provided with a stable outlet as specified in Section 2.3.5.

2.3.8.3 Constructed Open Watercourse Easement Requirements

Constructed open watercourses that are to be publicly owned and maintained and lie outside the public right-of-way, shall be provided with an easement that includes:

1. The full width of the channel as measured from top-of-bank to top-of-bank plus ten feet on one side, or
2. A minimum width of 20 feet centered along the watercourse, whichever is greater.

Where onsite constructed open channels are designed to serve as a major flood routing path for offsite flows through the development, easement widths shall be extended to include the total flow width for the 100-year event.

2.4 Design of Major Stormwater Routing Systems

Major storm routing paths shall be provided to convey stormwater runoff that exceeds the capacity of the minor drainage system through the development to a downstream discharge point meeting the requirements of 2.1.3. The major storm routing path shall be designed such that the peak flood stage during the 100-year design storm is at least one-foot below the first floor elevation of the building structures within and adjacent to the development. The major storm routing path shall begin along swales located between building structures that drain individual properties, be directed to either roads, other public rights-of-way, or constructed open watercourses through the development, to the stormwater detention facility serving the development. This detention facility shall be designed to control the 100-year event without overtopping its embankment, according to criteria in Section 3.1.

A hydraulic analysis shall be required to verify that the peak water surface elevation during the 100- year design storm meets the design criteria cited in this section. For preliminary design purposes, the flow in the minor drainage system during the 100-year design storm event shall equal the design capacity of the minor system.

Where streets are utilized as the major routing path, the depth of water shall not exceed 18 inches (to allow access for emergency vehicles) at gutter line for local and collector streets.[30] The depth of water shall not exceed a 6-inch depth at the crown for arterial streets. This maximum depth criterion shall also apply where a major storm routing path crosses a street. The use of normal flow depths derived using the Manning's Equation

[30] Water Environment Federation & American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems,* 1992

will suffice for estimating inundation limits along streets. At culverts, the major storm shall be designed to flow across streets at low areas or` in sags of vertical curves. Street elevations shall be set to permit the major storm to flow across the street and to prevent damage to any existing or proposed building structure. Backwater calculations shall be performed along streams where a roadway crossing over these streams is proposed as part of the development. The backwater analysis shall proceed upstream from the roadway crossing to the boundary of the development site.

Where a major drainage way is located outside of a street right-of-way, easements shall be provided as defined in Section 2.3.8.3. The 100-year flood routing path shall be shown on the master drainage plan that is to be submitted with the Stormwater Management Report, as described in Section 6. Routing path illustrations shall include elevations along the routing path and other elevations necessary to show that the major storm is contained within the planned area and dedicated easements.

A downstream analysis conducted according to the criteria in Section 2.1.3 shall be used to define the major storm routing path between the development and the nearest discharge point. The City may, at its discretion, require additional detention and/or downstream modifications to provide an adequate major storm routing path downstream of the development.

Section 3
Stormwater Control Practices

This section provides criteria and guidance for the successful design of facilities that control stormwater discharges from development and redevelopment projects to prevent flooding, streambank erosion, and water quality impairment in downstream areas. Separate design criteria are provided for stormwater quantity and quality control facilities. In many cases quantity and quality controls are integrated into a single facility.

It is the City's policy to encourage the use of Green Infrastructure. Green Infrastructure can provide the same water quality and quantity benefits as traditional infrastructure while providing additional benefits such as water reuse, providing greenspace or habitat, and/or reducing greenhouse gas emissions. The City's Stormwater Service And Clean River Fee Crediting Mechanism Regulation provides a credit for incorporating Green Infrastructure into a development. Stormwater Control Practices (SCP) that qualify as Green Infrastructure are so noted as "GI". If an applicant proposes alternative control technologies that the applicant believes should be credited as GI, the applicant shall provide adequate documentation regarding the green benefits of the technology.

3.1 General Criteria

Stormwater runoff generated from onsite areas shall be controlled before it is released from the development site. Stormwater management reports or construction plans will not be approved until it is demonstrated that the onsite runoff will be controlled in a manner that is consistent with the criteria in this section. At a minimum, the following criteria shall apply to all stormwater controls described in Section 3.4.

1. Stormwater control facilities shall not be located within the Stream Corridor Protection Zone defined using criteria in Section 1.3 of the Manual.
2. Stormwater quantity control facilities shall not be located within designated Federal Emergency Management Agency (FEMA) 100 year floodplain boundaries.
3. Discharges from stormwater control facilities shall be directed into a stream, either directly as sheet flow from a level spreader, or via a storm sewer or open channel conveyance system, according to criteria in Section 2.1 of the Manual.
4. Stormwater runoff shall not be diverted from an existing naturally occurring wetland that is preserved according to City criteria in Section 1.5 and that is not approved for filling and/or removing (as necessary) via an approved Section 404 permit issued by the U.S. Army Corps of Engineers. Wetland hydrology shall be maintained to the extent possible. The quantity and quality of this runoff shall be controlled prior to its release to the wetland system according to criteria in Section 3.2 and 3.3 of the Manual.
5. Connections to a combined sewer require a device per standard drawing AA-S163 to prevent noxious odors from entering the storm sewer system. The device shall be

placed in the first upstream structure from the combined sewer. For private site developments this structure shall be on the private site.

6. When a stormwater sewer, detention structure, water quality structure, or other appurtenance are located within 30 inches of the exterior wall of an existing or proposed building, these facilities are subject to the Ohio Plumbing and Ohio Building Codes. The Plumbing and Building Codes take precedence over the Manual. The facilities must be shown on the building plan and submitted to the City Building Department for approval in addition to including them on the stormwater construction drawings (see Section 7). The stormwater construction drawings will be reviewed for sizing, flow, and detention requirements while the building plan will be reviewed for appropriate material selection and compliance to the Plumbing and Building Codes. Application for a preliminary plan review (PRPL) by the City Building Department is recommended prior to submittal of the storm CC plan.

7. A back~~flow~~water prevention device shall be required wherever ~~S~~storage capacity below the base flood elevation ~~shall not be included in total storage capacity calculations for stormwater control facilities located adjacent to or vertically within the 100 year floodplain boundary~~is utilized.

8. Stormwater control facilities shall not be located within the public right-of-way when the facility is necessary to satisfy the Manual's requirements for a privately owned project. When improvements to benefit a privately owned project are located in the public right-of-way, the stormwater control facilities shall not be located in the right-of-way. On site private stormwater control devices shall not detain water in storm sewer pipe located in the right-of-way.

9. Outlets shall be sized to achieve the release rates required under Section 3.2.1 and 3.3.1. The City will not allow the use of any orifice outlet that is less than 6 inches in diameter unless the design includes an anti-clogging device such as a screen or filter. Geotextile fabric is not considered an acceptable screen or filter for use on stormwater control outlets. Outlets and anti-clogging devices shall be accessible for routine maintenance, and any structure in which an outlet is located shall be of sufficient size to allow unobstructed access. Alternative outlet designs (e.g., V-notch weir, perforated) in lieu of orifice diameters smaller than 6 inches may be permitted upon City approval if acceptable design practice is proven for site conditions. If a single orifice outlet is used, it shall be designed with the following equation:

$$Q = A*C*(64.4*H)^{1/2}$$

where:

Q = orifice discharge rate, cfs
A = area of the orifice, ft^2
C = orifice coefficient
= 0.66 for material thicknesses less than the orifice diameter
= 0.80 for material thicknesses thicker than the orifice diameter
H = head, measured from the centerline of the orifice, ft

10. Stormwater control facilities that are intended to serve as a water quality SCP only, must be designed to safely bypass all storms in excess of the water quality event, up to and including the 100-year storm event, to an appropriately sized flood control facility.

11. In addition to the criteria required by the incorporation of the Ohio Rainwater and Land Development Manual design criteria herein, additional criteria are presented in subsequent sections that govern feasibility, conveyance, pretreatment, treatment, environmental/landscaping and maintenance requirements. The following major design considerations shall be addressed during design and documented in the Stormwater Management Report and Plan:

    a. ***Hydraulics*** —Design the facility with an outlet to control release rates and prevent clogging, provide storage for intense rain events, and install an observable high-flow bypass.

    b. ***Sediment Management*** — Design the facility with pre-treatment for coarse sediments and a sediment storage volume for finer sediments.

    c. ***Health & Safety*** — Design facilities containing a permanent pool with a submerged bench with a maximum slope of 15 (H) to 1 (V) to increase public safety.

    d. ***Aesthetics*** — Provide features that "hide" accumulated silt & debris and integrate the facility with overall site design.

    e. ***Maintainability*** — Design the facility to minimize the amount and frequency of maintenance, to ease required maintenance activities, and to eliminate emergency / extraordinary maintenance requirements. Design criteria in the Manual are intended to facilitate maintenance, are required for facilities that will be maintained by the City, and are recommended for other facilities. If a design is proposed that does not include some or all of these features, the maintenance plan shall explain how maintenance activities shall be performed.

    f. ***Accessibility*** — Design the facility to eliminate physical barriers (e.g., curbs and steep slopes) to entry for maintenance or emergency access, use strong, lightweight, non-corroding materials at access points (e.g., maintenance ~~man~~hole covers and doors) to underground facilities, and provide legal right of entry for publicly maintained basins.

    g. ***Durability*** — Design the facility to include strong, light-weight materials for "removable" features, reinforced concrete structures for "permanent" features, and hardy, disease-resistant native vegetation.

    h. ***Separation from buildings and sanitary sewers*** — Keep water quality controls that allow infiltration of runoff into the ground away from buildings, sanitary sewers, and building laterals to minimize infiltration/inflow into sanitary sewers.

i. ***Cold Weather Issues*** — Stormwater quality control facilities shall be designed to operate effectively under cold weather conditions. Design considerations include outlet configurations less susceptible to clogging due to ice formation, additional pre-treatment and/or sediment storage/disposal in areas where sand or other solids are used for pavement deicing, and salt-tolerant plants in controls that incorporate vegetation.

j. ***Mosquito and Vector Control*** — Design criteria are included in the Manual that minimize conditions causing mosquito breeding without significantly compromising the effectiveness of controls that rely upon permanent pools of water and vegetation. The following guiding principles apply:

   i. Areas of facilities outside the permanent pool shall be designed to drain completely toward the outlet or permanent pool within 72 hours of a precipitation event. Small depressions in paved, rip-rap, and/or vegetated areas shall not be allowed, and shall be eliminated if they form.

   ii. Wet detention basins and wetlands shall be designed to maximize habitats that promote colonization of the facility by mosquito predators (i.e., dragonflies, diving beetles, and mosquito fish). These facilities shall also incorporate large areas of open water to allow waves to propagate through vegetated areas, drowning mosquito larvae.

   iii. Underground and enclosed vaults containing certain stormwater quality controls are particularly susceptible to mosquito breeding. Facilities not intended to include a permanent pool of water shall be designed to drain without allowing standing water to remain, and shall not permit any trapped debris or sediment to create standing water. Screened vents or air-tight lids shall be used on all access structures, and traps shall be provided on inlet and outlet pipes to limit mosquito access to standing water.

   iv. The maintenance plan for the facility shall address mosquito monitoring and control activities, including periodic harvesting of aquatic vegetation, removal of invasive/exotic and/or emigrant vegetation, removal of trash, debris sediment accumulation, and cleaning/rejuvenation of media filters.

12. Access to stormwater control practices shall be provided as required per Section 4.3.

3.2 Stormwater Quantity Controls

Stormwater quantity control facilities shall be designed to control runoff from small, moderate, and large storm events before it is discharged offsite. The design criteria provided in this section are intended to minimize flooding downstream of the development site and to reduce streambank erosion. The stormwater management report for the project, prepared according to the guidelines and criteria in Section 6, shall show the location of the stormwater quantity control facilities and calculations defining how they were sized.

3.2.1 Hydrologic Requirements

The volume and distribution of rainfall for the storm events to be used for quantity control calculations shall be developed using the 24-hour rainfall intensity from **Figure 2-1**. This intensity shall be converted into a rainfall volume by multiplying it times 24 hours. The design rainfall hyetograph shall be developed by distributing this volume over the 24-hour period with the SCS Type II distribution (**Table 2-3**), as described in Section 2.2.2.1. Stormwater quantity control facilities shall be designed using one of the hydrograph methods defined in Section 2.2.4.

Onsite facilities to control post-development stormwater runoff from residential, commercial, and industrial development sites shall be designed according to the methodology presented below, which is derived from the critical storm method. Under this methodology the percent increase in post-development runoff volume from a site during a 1-year storm event shall be calculated in the following manner to determine the critical storm event:

1. Determine the total volume of runoff from a 1-year, 24-hour storm, occurring over each of the site's drainage areas before and after development, using the methodology in Section 2.2.4.

2. Determine the percent of increase in runoff volume due to development. Using this percentage, select the critical storm from **Table 3-1**.

Table 3-1

Critical Storm Determination

If the percent of increase in runoff volume is		The critical storm runoff rate will be limited to:
Equal to or greater than	**And less than**	
--	10	1-year
10	20	2-year
20	50	5-year
50	100	10-year
100	250	25-year

250	500	50-year
500	--	100-year

Runoff from storm events less than or equal to the critical storm event shall be released from the site at a rate no greater than the peak runoff during a 1-year storm event under pre-developed conditions[1]. Additionally, the peak runoff rate during the 100-year storm event shall be released at a rate less than or equal to the peak runoff rate during the 10-year storm event under pre-developed conditions (where the critical storm is more frequent than a 100-year storm).

The Administrator, or the Administrator's designee, reserves the right to require more stringent stormwater controls if it is determined that flood control benefits can be achieved in downstream portions of the watershed where flooding problems have been identified as existing prior to the proposed development.

[1] For development sites discharging into a field tile or combined sewer system, refer to Section 2.1.4 for more information regarding additional restrictions to the release rate.

3.2.2 Acceptable Methods and Criteria

Table 3-2
Characterization of Post-Construction Stormwater Controls

SCP Category	SCP Type	Quantity Control	Quality Control	Design Requirements	Green Infrastructure
Surface Controls	Dry Detention Pond	●	●	• OEPA CGP/Supplements • Columbus SWDM	
	Wet Detention Pond	●	●	• OEPA CGP/Supplements • Columbus SWDM	
	Constructed Wetland	●	●	• OEPA CGP/Supplements • Columbus SWDM	
	Shallow Constructed Wetland	●	●	• OEPA CGP/Supplements • Columbus SWDM	●
	Parking Lot Storage	●		• Columbus SWDM	
	Infiltration basin		●	• OEPA CGP/Supplements	
	Vegetated Filter Strips		●	• OEPA CGP/Supplements	
Underground Controls	Underground Detention System	●	●	• OEPA CGP/Supplements • Columbus SWDM	
	Permeable Pavement	●	●	• OEPA CGP/Supplements	●
Media Controls	Bioretention	●	●	• OEPA CGP/Supplements • Columbus SWDM	●
	Sand/Media Filter		●	• OEPA CGP/Supplements • Columbus SWDM	

Rooftop Controls	Green Roof	○	○	• OEPA CGP/Supplements	●
	Blue Roof	●		• Columbus SWDM	
	Rainwater Harvesting	○	○	• OEPA CGP/Supplements	●
Other Controls	Runoff Reduction	○	○	• OEPA CGP/Supplements	
	Soil Management	○	○	• OEPA CGP/Supplements	
	Pretreatment	○	○	• OEPA CGP/Supplements	

● – Practice is considered a stand-alone SCP per OEPA Construction General Permit.
○ – Practice is not considered a stand-alone post-construction SCP per OEPA Construction General Permit.

3.3 Stormwater Quality Controls

Stormwater quality control facilities shall be designed to control runoff from small storm events before discharged offsite. The design criteria provided in this section are in addition to the criteria detailed in the Ohio Construction General Permit and the Ohio Rainwater and Land Development Manual. The Stormwater Management Report for the project, prepared according to the guidelines and criteria in Section 6, shall include the rationale for selecting appropriate stormwater quality controls, a master drainage plan (if applicable) showing their location, and calculations defining how they were sized.

3.3.1 General Requirements

3.3.1.1 Stormwater Runoff Quality Control

All runoff from development sites shall be directed to one or more stormwater quality controls designed according to:

1. Appropriate currently effective Ohio EPA Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (Construction General Permit),
2. Supplemental documents prepared by Ohio EPA pertaining to the currently effective Construction General Permit Post-Construction criteria,
3. Appropriate currently effective Ohio Rainwater and Land Development Manual, and
4. Criteria provided in Section 3.

For projects where stormwater control practices providing water quality treatment have already been constructed, redevelopment of the site shall provide treatment of a water quality volume that is the greater of either treatment required as part of a previous design or as specified in the current Construction General Permit. In instances where conflicts exist between OEPA criteria and the criteria presented in this section, the more stringent standards shall apply.

Any development or redevelopment that discharges to the City's combined sewer system is exempt from the water quality controls required in this section. Whether a development is discharging to the combined sewer system will be determined by the City. An applicant may receive this determination by contacting the Plan Review and Stormwater & Regulatory Section Manager at the Department of Public Utilities. Water quality controls may be required for a development discharging to a combined sewer system in an area where sewer separation/stormwater redirection is planned by the City.

3.4 List of Controls

3.4.1 Dry and Wet Detention Basins

Detention basins are one method used to meet the peak flow control (allowable post-development runoff rate) requirements for a site. Their design may also include features to control water quality, as defined in Section 3.3. In instances where detention basins are utilized to provide water quantity and water quality controls, peak flow rate and drawdown time criteria for both water quantity and water quality shall be met.

General Requirements for All Detention Basins

All proposed dry and wet detention basins shall be designed according to the general criteria in this section, as well as any additional specific criteria Sections 3.4.1.1 and 3.4.1.2).

Layout and Geometry Requirements

The following criteria shall be used to define the layout and geometry of all stormwater quantity and quality detention basins in the City:

1. Detention basins shall not be located on uncompacted fill, on slopes 2 (H) to 1 (V) or greater, or where infiltrating groundwater could adversely impact slope stability.
2. Detention basins shall be designed such that they readily accommodate flow from a site's major flood routing path(s) (see Section 2.4). Overland flow from a site shall be directed to a site's detention basin(s), to ensure that site runoff is controlled.
3. The basin shall be designed with an emergency spillway for storms that exceed basin capacity. The emergency spillway shall be designed to direct the flow exceeding basin capacity to a suitable downstream flood routing path without erosion, scouring, or soil undermining, and to meet applicable Ohio Dam Safety requirements. Emergency spillway design should assume that flow from an entire 100-year, 24-hour event is conveyed through the spillway while the basin is at its 100-year flood capacity.
4. The basin shall be designed so that the peak water surface elevation in the basin does not overtop the basin embankment or flood building structures around the basin. **Table 3-3** provides the peak water surface requirements for basins with different design intent.

Table 3-3

Peak Basin Water Surface Elevation Requirements

Basin Design Criteria	Peak Water Surface Elevation *
Water Quality Only – Larger Storms Bypassed	Peak water surface elevation during WQ_v must be 1 foot below the basin embankment elevation and the first floor elevations of building structures near the basin.
Water Quantity – No Dam Safety Requirements **	Peak water surface elevation during the 100-year design event must be 1 foot below the basin embankment elevation and the first floor elevations of building structures near the basin.
Basins Subject to Dam Safety Requirements **	Peak water surface elevation must satisfy Ohio dam safety requirements and be 1 foot below the floor elevation of building structures during the 100-year design event. Refer to ODNR requirements.

Note:

* Requirements for a 1-foot freeboard will be waived if the detention basin is to outlet directly to a stream. In such instances, the first floor elevations of building structures near the basin must be at least 1 foot above the top of the basin embankment.

** Section 1521.06 of the Ohio Revised Code lists those dams and embankments that are exempt from dam safety requirements.

5. Side slopes within and adjacent to dry detention basins and those side slopes above the permanent pools of wet detention basins shall be 4 (H) to 1 (V) or flatter to prevent bank erosion and minimize safety risks. The maximum cross slope for the vehicle access way shall be 10 (H) to 1 (V).

6. Detention basins shall be designed to limit the migration of groundwater from the basin towards sanitary sewers and building basements. In these cases, the City may require that a geotechnical analysis of the area be performed where the basin is proposed so that groundwater controls may be properly incorporated into the design. If the geotechnical analysis determines that exfiltration from the basin may increase infiltration into sanitary sewers or basements, then the facility design shall include compacted clay or a synthetic liner.

7. The Applicant shall submit preliminary design information to ODNR as necessary to determine the regulatory classification (Class I through Class IV) of any impoundment structures (e.g., dams, berms, embankments, levies) under Ohio dam safety regulations, and shall provide the City with documentation of ODNR's determination of the structure's classification. All impoundment structures that require a dam safety permit from ODNR (Class I through III impoundment structures) shall provide sufficient design information in the Stormwater Management Report to demonstrate that dam safety permit requirements will be satisfied, including a description of the fill materials, required compaction, and other features provided to satisfy ODNR dam safety requirements, limit seepage through the impoundment structure, and protect the integrity of the structure. An as-built certification of the fill compaction shall be

provided when construction is complete. See Ohio Administrative Code Section 1501:21 for additional information.

8. All inflow pipes to the detention basin that are not entirely submerged below the permanent pool elevation shall be designed with headwalls or endwalls according to criteria in Section 2.3.5. Rock outlet protection designed according to criteria in Section 2.3.6 shall be used to minimize erosion around the headwall or endwall, as well as along the side slopes of the basin under each inflow pipe or open channel.
9. If inflow to the facility is conveyed through an open watercourse, including a major storm routing path (Section 2.4), the open channel conveyance system shall be designed in accordance with Sections 2.3.6 and 2.3.8. Outlet protection shall be provided along any reaches within 20 feet of the 100-year high-water mark of the basin, or to the edge of the easement (for publicly maintained basins) surrounding the basin, whichever is wider. Outlet protection shall be designed according to criteria in Section 2.3.6 and shall be used where the peak flow velocity during the 10-year, 24-hour design storm exceeds the criteria for grass watercourses as presented in Section 2.3.8. Such protection shall extend to the basin's bottom or 2 feet below the normal water elevation of any permanent pool.
10. Woody vegetation may not be planted or allowed to grow on the embankment, within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the basin is encouraged to provide shade and moderate surface water temperatures.
11. Permanent stormwater quantity control basins, as defined herein, may be used as temporary sedimentation basins designed to control sedimentation during construction as long as collected sediments are removed, the design grade of the facility is restored, permanent vegetation is established, the temporary outlet is removed, and permanent outlet structure is constructed as designed. In instances where vegetation is not established, additional measures shall be taken to ensure that the area stabilized, including providing additional topsoil, additional seeding and mulching, or providing sodding in the areas where sparse ground cover occurs.

Debris Control Requirements

Debris control structures (trash racks) for both wet and dry basins may be required at the basin outlet if the potential exists for large debris to enter the detention basin through an open watercourse or large diameter inlet pipe. Debris control structures shall be designed using Hydraulic Engineering Circular No. 9, available from the U.S. Department of Transportation, Federal Highway Administration.

Outlet Facility and Outfall Protection Requirements

1. The detention basin shall be designed with an outlet control structure sized to meet the stormwater quantity control requirements presented in Section 3.2, the stormwater quality control requirements presented in Section 3.3, or both.
2. Seepage along any structure that extends through the embankment to the downstream slope shall be controlled using an anti-seep collar or drainage diaphragm.

The collar/ diaphragm shall be aligned approximately parallel to the centerline of the stormwater basin or approximately perpendicular to the direction of seepage flow, extending horizontally and vertically into the adjacent embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation. Appropriate criteria for establishing the minimum horizontal and vertical distances from the surface of the conduit may be obtained from NRCS Technical Release 60 dated July 2005, Chapter 45 of NEH Part 28 dated January 2007, and NRCS Conservation Practice Standard 378 dated September 2015.

3. Open channels receiving discharges from the facility shall be protected with rock outlet protection designed according to criteria in Section 2.3.6 of the Manual.

~~4. The detention basin outlet structure shall be designed to retain floatables, such as debris, oil, and grease within the basin up through and including the 100-year design storm event.~~

~~5.~~4. With exception of the emergency spillway, outlet devices that control flows in excess of the WQ_v shall be designed according to criteria in Section 3.2 and equipped with a removable trash rack.

~~6.~~5. The use of a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation of the permanent pool is a recommended method to reduce clogging of the WQ_v discharge pipe.

It is recommended that detention basins be provided with an emergency drain, where practicable, so that the basin may be emptied if the primary outlet becomes clogged and/or to drain the permanent pool to facilitate maintenance. If an emergency drain is used, the emergency drain should be designed to drain by gravity where possible. Where used, gravity pipes shall be made of approved materials as specified in Item 901 of the CMSC. If site conditions prevent gravity flow, the basin may be designed to drain by pumping. Basins requiring pumping may be provided with an emergency drain made of ductile iron pipe with mechanical joints and a quick connect coupling extended to the bottom of the basin at a point near the outlet structure. It is suggested that emergency drains have an elbow within the basin to prevent sediment deposition, and a diameter capable of draining the basin within 24 hours. The emergency drain should include an operable gate, plug valve, mud valve, ball valve, or sluice gate, which should be set and locked in the closed position. Valves or gates should be located inside of the riser at a point where they will not normally be inundated and can be operated in a safe manner.

3.4.1.1 Dry Extended Detention Basins

Dry extended detention basins are designed to capture stormwater during small to moderate rain events and slowly release the captured volume over a specified period of time. **Figure 3-1** provides a schematic drawing of a dry extended detention basin. The following criteria shall be used in addition to those found in Sections 3.1 and 3.4 to design dry extended detention basins intended to serve as water quality SCPs.

Layout Requirements for Dry Detention Basins

In addition to the requirements in Sections 3.1 and 3.4.1, the following shall apply to the design of dry detention basins for stormwater quantity control:

1. Dry detention basins shall be designed to balance evenly ~~distribute~~ spread flow across the ~~pond~~ bottom of the basin without scour or erosion and minimize standing water and saturated soil conditions that impede maintenance and mowing of the facility. ~~The maximum longitudinal slope towards the outlet shall be~~ a minimum of 0.5% and a ~~maximum of 1%, to minimize standing water and saturated soil conditions that impede maintenance and mowing of the facility~~. Channels across the basin are prohibited.
2. The minimum bottom width for dry detention basins shall be 12 feet to allow for vehicular access for maintenance.
3. Dry detention basins shall be provided with topsoil, and shall be seeded and mulched to prevent erosion (per CMSC Sections 653 and 659). Grasses seeded within the basin should be able to survive under water for the full duration of the basin drawdown time. Jute and Excelsior matting shall be used as required to stabilize slopes and prevent erosion.

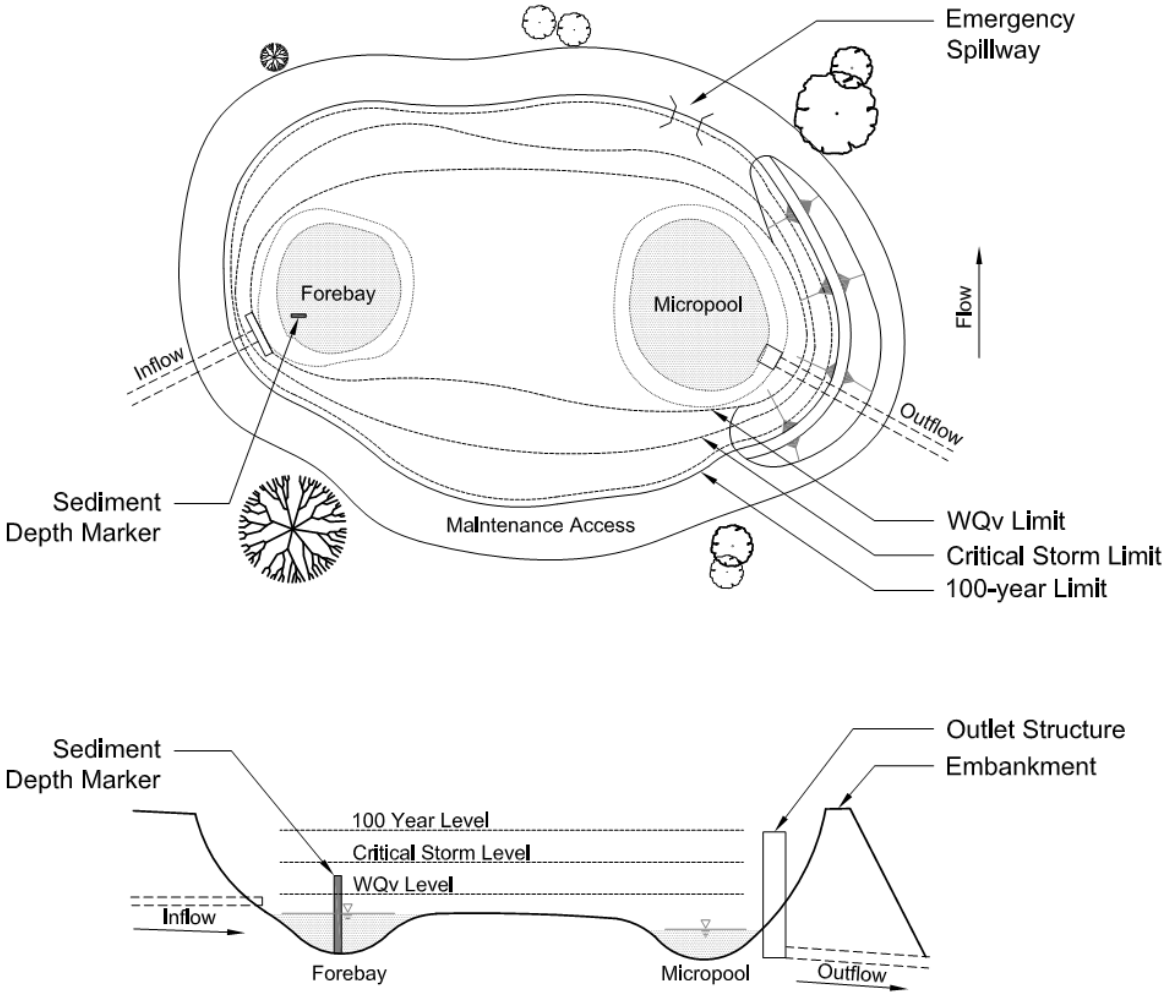


Figure 3-1. Schematic of a Dry Extended Detention Basin

Outlet Facility and Outfall Protection Requirements

Outlet designs shall provide the necessary drawdown time, route flood flows, resist clogging, and facilitate maintenance. The following criteria shall be used to design outlet facilities and outfall protection:

1. A micropool shall be provided at the outlet end of the basin. Direct maintenance access shall be provided to the micropool at a slope no steeper than 10 (H) to 1 (V). Micropool side-slopes shall not exceed 4 (H) to 1 (V).
2. Dry extended detention basins that are intended to serve as a stormwater quality control only, must be designed to safely bypass all storms larger than the WQ_v, up to and including the 100-year storm event (Section 2.2) to an appropriately sized stormwater quantity control facility.

3.4.1.2 Wet Extended Detention Basins

Wet extended detention basins provide a permanent pool of water overlain with an extended detention volume that drains following rainfall events. Basins designed according to the criteria in this section will provide settling for suspended solids entrained in the stormwater. **Figure 3-4** provides a schematic drawing of a wet extended detention basin. The following criteria shall be used in addition to those in Sections 3.1 and 3.4.1 to design extended wet detention basins.

Layout and Geometry Requirements

The layout and general requirements of extended wet detention basins shall meet the minimum requirements stipulated in this section:

1. Extended wet detention basins shall only be allowed under the following conditions:
   a) Where existing soils are categorized as hydrologic soil group C (HSG-C) or hydrologic soil group D (HSG-D),
   b) Where gravelly sands or fractured bedrock are not present, or
   c) Where a liner is installed to sustain the permanent pool of water thereby avoiding basins where the permanent pool partially or completely infiltrates into the ground.
2. The depths of open water areas within the basin shall be between 4-feet and 12-feet on average to prevent thermal stratification. ~~The perimeter of all deep pool areas (four feet or greater in depth) shall be surrounded by a submerged bench.~~
3. If desired, wetland plants may be incorporated into the basin design. A landscape plan for the basin shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation. A list of approved Native Plant Species for the Central Ohio area is provided in **Appendix B.**
4. The depth of wet detention basins shall be no more than 12 feet below the basin's normal water elevation. The City may approve deeper ponds that are to be privately owned and operated where practices (e.g. aeration) are proposed to prevent thermal stratification. The minimum bottom width of wet basins shall be 12 feet.

5. The perimeter of all permanent pool areas ~~deeper than 4 feet~~ shall be surrounded by a submerged bench that extends at least 8 feet and no more than 15 feet outward from the base of the adjacent slope, as illustrated below. The bench shall be no more than 24 inches below the permanent pool to enhance public safety and to limit growth of undesired vegetation. The submerged bench shall be sloped inward, and for unplanted benches shall be no steeper than 16 (H) to 1 (V) and no flatter than 30 (H) to 1 (V).

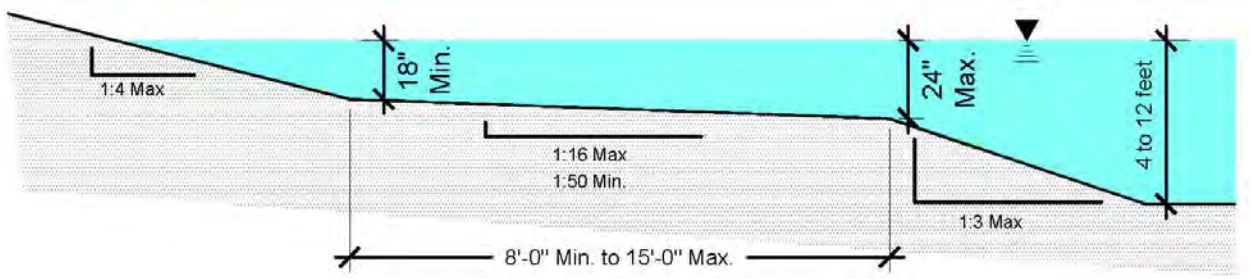


Figure 3-2. Schematic of a Submerged Bench

6. If plantings on the submerged bench are desired the portion of the submerged bench within 8 feet of the base of the adjacent slope shall have an average depth of 6 inches below the permanent pool and the designer shall prepare a landscape plan. No portion of a bench that has been planted shall have a slope steeper than 10 (H) to 1 (V) or flatter than 50 (H) to 1 (V). Plantings on the submerged bench shall be selected from the shallow water-emergent species in the list of Native Plant Species for the Central Ohio area, which is provided in **Appendix B.** These plants must be able to withstand prolonged inundation and be tolerant to road salts if receiving runoff from areas that are expected to be treated with salt-based deicing materials.

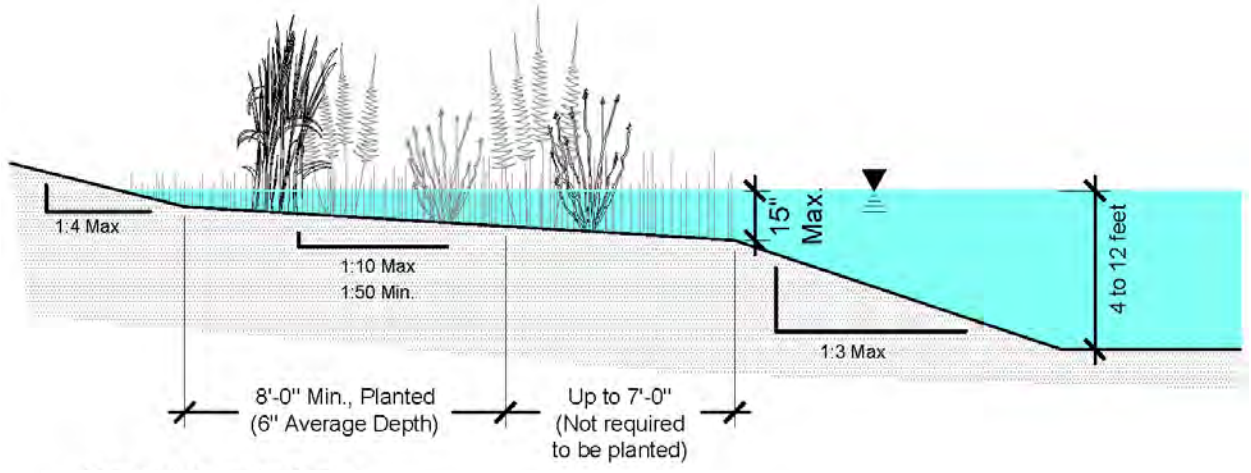


Figure 3-3. Schematic of a Submerged Bench with Plantings

7. Side slopes for wet basins shall be 4 (H) to 1 (V) down to the submerged bench, and 3 (H) to 1 (V) from the submerged bench to the bottom of the basin.

8. The purpose of the submerged bench is to promote public safety. If an applicant seeks a variance from the requirement of having a bench, the variance application shall specifically address this issue.
9. At a minimum, wet detention basins shall be provided with topsoil, seeded and mulched (per CMSC Sections 653 and 659), in all areas that are above the basin's permanent pool. Appropriate species listed in **Appendix B** shall be specified in areas along the perimeter of the basin at elevations higher than the permanent pool that are periodically inundated after storms.
10. Wet detention basins and stormwater wetlands should not be constructed any closer than 10,000 feet from the aircraft movement areas, loading ramps, or aircraft parking areas of a public-use airport (i.e., a publicly or privately owned airport open to public use) serving turbine-powered aircraft, or 5,000 feet from these areas of a public-use airport serving piston-powered aircraft as recommended by the Federal Aviation Administration (FAA), Advisory Circular Number 150/5200-33C. As an alternative, dry detention facilities and green roofs are stormwater best management practices that do not maintain a permanent pool of water and are not as likely to attract large numbers of waterfowl.

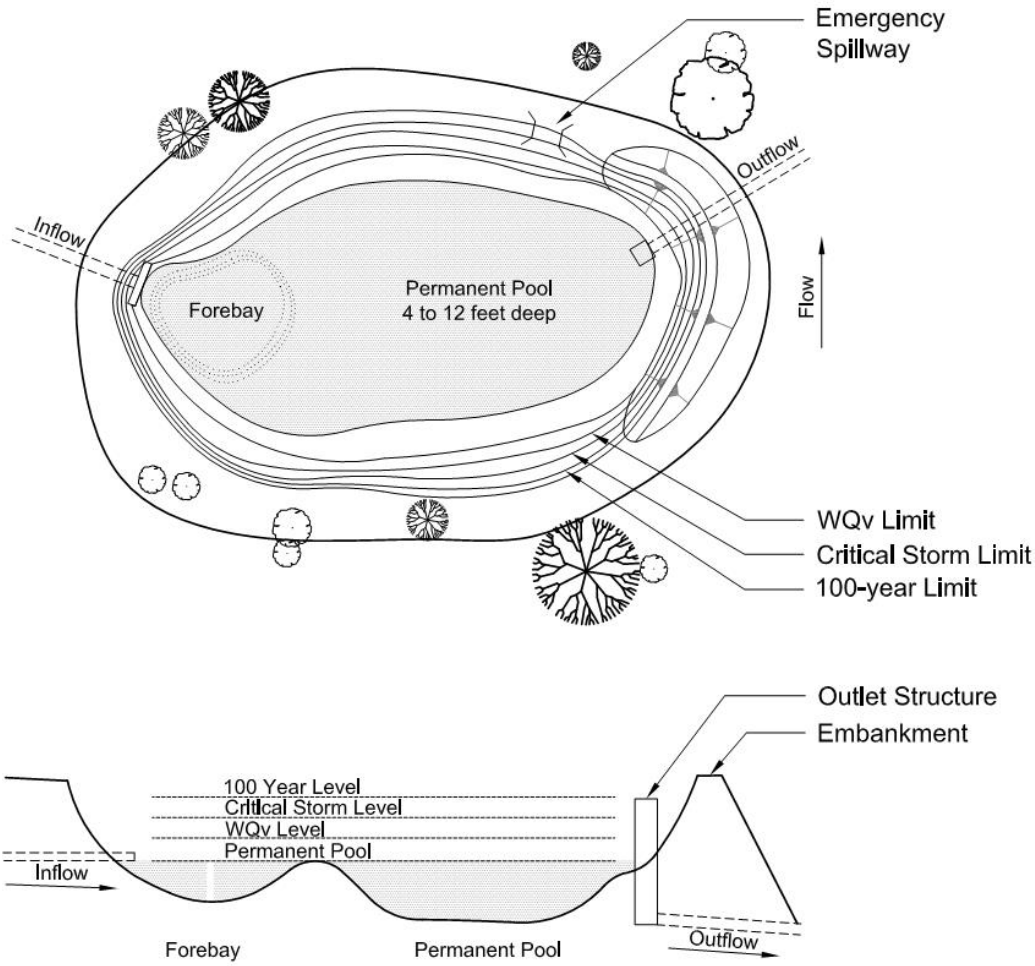


Figure 3-4. Schematic of a Wet Extended Detention Basin

3.4.2 Parking Lot Storage

Parking lot surface storage is a stormwater quantity control method allowing shallow ponding within paved portions of the parking lot during the design storm event. Parking lot storage is a convenient multi-use structural control method where impervious parking lots are planned. The following criteria shall apply to parking lot storage facilities:

1. Ponding in parking or traffic areas shall be designed for a maximum ponding depth of twelve (12) inches for all storms up to and including the 100-year event. Flood routing or overflow to a designed conveyance system must occur after the maximum depth is reached.
2. A site with a parking lot storage facility shall employ a separate water quality treatment SCP that meets the water quality treatment criteria presented in Section 3.3. This SCP may be located downstream of the parking lot.
~~2.~~3. Peak water surface elevation during the 100-year design event must be 1 foot below the basin embankment elevation and the first floor elevations of building structures near the basin.

3.4.3 Underground Storage

An underground storage system is any stormwater quantity or quality control method that employs underground chamber or chambers, either prefabricated or constructed in place, and has a designed release feature to control stormwater discharge. Underground storage may also include any void space of aggregate that is utilized in water quantity or water quality calculations. This method is most applicable where land is valuable or the site is constrained, such as in industrial, commercial, and redevelopment areas.

1. Conditions on Use
   a. Underground storage systems may not be placed in the public right-of-way unless the facility will be owned or operated by the City and the function of the facility is associated with a green infrastructure practice.
   b. The use of over-sized storm sewer pipes within the public right-of-way is not permitted.
   c. If the storage associated with bioretention basins and tree box systems is located within a 1:1 influence of roadway pavement then structural measures to support the pavement load must be provided.
   ~~c.~~d. An underground storage system located within the footprint of a building structure is subject to the Ohio Plumbing and Ohio Building Codes. The Plumbing and Building Codes take precedence over the Manual. The facilities must be shown on the building plan and submitted to the City Building Department for approval in addition to including them on the stormwater construction drawings (see Section 7).
2. Materials
   a. Storage vessels can be made from a variety of materials but due to concerns with corrosion and longevity, corrugated steel or aluminum coated steel systems are not permitted unless the corrugated material is made of solid aluminum.
   b. Manufacturer's recommendation shall be used for open graded backfill and stone per CMSC 703 shall be specified.
   c. The use of recycled concrete is not permitted.
3. Design and Construction Details
   a. Closed conduit systems
      i. Shall have an internal slope of not less than 0.20% generally in the direction from inlet to outlet to avoid negative slope installations.
      ~~ii. Perforated closed conduit systems are permitted but the storage in the surrounding stone backfill may not be included when calculating total system volume.~~
   b. Open Bottom Systems
      i. May use 3-sided or arched conduits.
      ii. May be installed flat to promote infiltration potential.

~~iii. The maximum porosity value to use for stone storage is 30% to account for potential sediment build-up in the stone storage.~~

~~iv.~~iii. When underdrains are used as an outlet device, the area of the perforations shall be twice the area of the outlet device to account for clogging and blockages caused by the stone backfill. The perforation area requirement shall be listed on the plans.

~~v.~~iv. For every ½ acre of infiltration bed, one observation well shall be installed in the stone aggregate to observe water levels during inspections.

c. All Systems

i. Underground systems shall have at least two man access points per system with a minimum inside diameter of 48 inches. Man access points shall be located at the main inlet to the system and at the outlet(s) for access, inspection, and maintenance. Additional points of entry are required based on the following:

1. An additional man access point within the interior of the system is required for every 10,000 square feet of system area to check for sediment buildup and have an additional access point for cleaning.
2. Systems shall have a chamber for pre-treatment at each point of inflow. Each chamber shall have a man access point at each end if the length of the chamber is greater than 150 feet. If the row length is less than 150 feet then only one man access point must be provided. A man access point shall be located over a sump if one is provided in the chamber.
3. The additional man access requirements may be waived for athletic and recreational field safety considerations.
4. Each water quality chamber shall have a man access point for inspection and cleaning.

ii. Weir walls used for outlet structures shall have sufficient access to both sides of the weir wall for inspection, repair, and maintenance activities.

1. Weir walls may be required in situations where failure or blockage of a small diameter outlet is anticipated to create a hazardous situation (e.g., flooding of public streets) or damage to property.

iii. A minimum 24-in-deep sump shall be provided in front of any outlet orifice of the system or from one chamber to another. Sufficient access to the sump shall be provided for maintenance.

iv. When using man access structures as the maintenance and inspection access point, lid size should be per AA-S112 or equivalent weight unless otherwise approved by the City as larger castings are more difficult to remove during inspections.

v. The maximum porosity value to use for stone storage is 40% to account for potential sediment build-up in the stone storage.

3.4.4 Green Roof Technologies (GI)

Green roofs are systems used to control runoff volume, improve air and water quality, and promote energy conservation. They typically include layers of drainage material and planting media on a high-quality membrane to minimize leakage. These systems use foliage and lightweight soil mixtures to potentially absorb, filter, and detain rainfall. Designers are encouraged to consider using approved plants from the list of Native Plants for the Central Ohio area that is found in **Appendix B** but it is recognized that the use of plants other than those provided on this last may be necessary. Green roofs shall be designed according to the criteria in the Ohio Rainwater and Land Development Manual.

3.4.5 Blue Roofs

A blue roof shall be designed to allow the temporary build-up of water above a roof waterproofing membrane, not exceeding the designed hydraulic head, for a defined period of time, to enable attenuation of stormwater at roof level, and which also controls the discharge of rainwater runoff at designed flow rates to meet design requirements.

Where roof detention requirements conflict with building code requirements, the building code shall prevail and stormwater detention shall be provided by alternate methods.

General Requirements for Blue Roofs

1. The outflow control device is typically a volumetric weir or orifice at one or several locations on the roof. Several manufactures have controlled flow roof drains that can be set to regulate the rate of runoff from the roof. The manufacturers typically provide sizing charts with flow rates based on ponding depth, typically 9.1 gallons per minute per inch of ponding. Custom weirs or orifices can also be designed at scupper outlets. When multiple outflow control devices are employed the total outflow shall not exceed the allowable peak outflow per section 3.2.1.
2. Roof drains shall be protected from debris with strainers.
3. A secondary outlet such as an independent roof drain or scupper is required above the water detention elevation. The secondary outlets release flows greater than the 100-year storm and also function as emergency overflows in the event the primary volumetric control device is obstructed. These outlet(s) shall have a combined capacity to safely pass the entire post-developed 100-year storm. The secondary outlet may be a vertical pipe, weir overflow, scupper, other suitable device, or combination of devices.
4. The roof drains and scuppers must comply with Construction Codes and building permit requirements. Per Ohio Administrative Code Section 1110.4 “Not less than two roof drains shall be installed in roof areas 10,000 (929 m2) or less and not less than four roof drains shall be installed in roofs over 10,000 square feet (929 m2) in area.” The total outflow rate of the roof drains shall not exceed the allowable peak flow rate as determined using the methodology in Section 3.2.1.
5. Signage shall be placed at each roof detention outlet and overflow device to advise maintenance workers of the intent of the restricted outlets. The sign text shall state:

   > “ROOF TOP STORMWATER DETENTION CONTROL DEVICE. MODIFICATION REQUIRES PERMIT FROM CITY OF COLUMBUS DEPARTMENT OF PUBLIC UTILITIES, DIVISION OF SEWERAGE AND DRAINAGE.”

6. A suitable waterproof membrane is required to detain the stormwater and to protect the building structure. The materials and design of the membrane and roof system shall be submitted with the building plans and specifications when submitted for a building permit.
7. The required detention volume will be determined by the procedures outlined in Section 3.2.1. Manufactured controlled release rate roof drains are available from the manufacturers with preset or adjustable flow rates. Custom orifice plates can

also be specified on roof drains or scuppers to more precisely control the outflow rates. The total release rate with the available roof area will determine the size of detention area(s).

8. The available roof area must exclude raised mechanical equipment pads, access hatches, skylights, and other roof top obstructions. The calculations must account for roof slope. Separate calculations must be submitted for each detention area of the roof. Multilevel roofs may provide detention when flow rate controls are added to each roof level.
9. Blue roofs are most effective on sites where the roof covers 90% or more of the site area and the roof is flat or nearly flat (less than 2% slope). Roof detention areas shall be significantly clear of mechanical equipment, access ways, and other obstructions that decrease storage capacity. Mechanical equipment may be installed on raised pads above the roof deck to raise the equipment above the ponding elevation.
10. Blue roofs shall be located away from trees, if possible, to prevent clogging of the roof drains by leaf litter.
11. Roof stormwater detention may be coupled with other detention areas, such as underground storage structures. The net outflow from the site must be below the allowable peak flow rate calculated per Section 3.2.1.

Additional Considerations for Blue Roofs

1. The stormwater plan review and approval is limited to the stormwater detention function of the blue roof. Load capacity, materials, and design of the roof support system shall be submitted with the building permit plans and specifications.
2. Installation of a roof leak detection system is recommended for roof detention. There are a variety of active and passive systems available on the market. Specifications for a leak detection system are not required with the storm drainage drawings and specifications but should be addressed in the Post Construction Inspection and Maintenance Schedule.

3.4.6 Permeable Pavement (GI)

Permeable (or pervious) pavement systems shall be designed according to applicable criteria in the Ohio Rainwater and Land Development Manual, and City Supplemental Specification(s). The use of permeable pavement systems for publically maintained roadways shall be limited to those approved by the City.

3.4.7 Rainwater Harvesting (GI)

Rainwater harvesting systems shall be designed according to the criteria in the Ohio Rainwater and Land Development Manual.

3.4.8 Infiltration Basin

Infiltration basins shall be designed according to the criteria in the Ohio Rainwater and Land Development Manual.

3.4.9 Constructed Wetlands

Constructed wetlands are systems that mimic the functions of natural wetlands by using physical and biological processes to treat stormwater. Constructed wetlands have both permanent pool zones and an extended detention zone which are sized to capture and release the calculated WQv. The shallow water zones in the permanent pool support emergent and riparian vegetation and the deep water zones in the permanent pool provide sediment and stormwater storage. Together, the diverse vegetative community and the storage provided combine to form an ideal environment for the removal of pollutants in stormwater. Similar in design to wet basins, constructed wetlands treat stormwater by providing an extended detention zone (above shallow permanent pools) sized to capture and release the calculated WQv. Constructed wetlands are depressed, heavily planted areas that are designed to receive flow during dry periods in order to support aquatic vegetation. In terms of size, the amount of surface area required for a constructed wetland is typically larger than that of a wet basin due to the limited allowable depths required for wetland design. Constructed wetlands that are supplied by surface water runoff from drainage areas less than 20 acres must rely on groundwater or other sources to sustain a permanent pool.

Layout and Geometry Requirements

The layout and geometric requirements of constructed wetlands shall meet the following minimum requirements:

1. Constructed wetlands shall only be allowed where soils categorized by the NRCS as HSG-C or HSG-D exist, where gravelly sands or fractured bedrock are not present, or where a liner is installed to sustain the permanent pool of water and avoid permanent pools that partially or completely infiltrate into the ground. This requirement does not apply to pocket wetlands where the permanent pool is sustained by a groundwater source.
2. The minimum length-to-width ratio for a constructed wetland shall be 3:1. Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet, to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.
3. Constructed wetlands shall be provided with a drain so that the facility can be emptied to allow maintenance activities and to dry bottom sediments (allowing natural oxidation of built-up organics). The drain shall be designed in accordance with the emergency drain systems required for detention basins as described in Section 3.2.3.1.
4. Deep water zones shall be placed within the forebay and around the primary outlet to minimize disruption of wetland vegetation during sediment removal operations. The remainder of the facility shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e., areas less than 18 inches deep) should vary depending on the vegetation selected. The bottom of the permanent pool between the deep and shallow water zones shall be sloped no steeper than 3 (H) to 1 (V).

5. The maximum depth of the extended detention zone above the permanent pool shall not exceed 2 feet to reduce stress on herbaceous wetland plants.
6. Permanent pool areas of wetlands that are deeper than 4 feet must be provided with a submerged bench per Section 3.2.3.3.
7. Wetland plants shall be placed in shallow pool areas (less than 4 feet). In instances where the basin is designed to support aquatic vegetation, a landscape plan for the wetland shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation. Woody vegetation may not be planted or allowed to grow on the embankment within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the wetland facility is encouraged to provide shade and moderate surface water temperatures. A list of approved Native Plant Species for the Central Ohio area is provided in **Appendix B**.

Pretreatment

Due to the sensitivity of wetland vegetation to sedimentation, a forebay, or other pretreatment feature, shall be provided at each inlet of all constructed wetlands.

Landscape Requirements

1. A landscape plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of appropriate plant species, planting plan, sequence for preparing the wetland bed (including soil amendments, if needed), and sources of plant material. The width of the vegetation zones and amount of emergent vegetation shall be limited to no more than 50 percent of the wetland area in order to control mosquitoes.
2. The shallow water zone shall be planted at a minimum density of 50 herbaceous plants per 200 square feet.
3. If a minimum vegetative coverage of 50 percent is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required.
4. Matted cattails detritus (cattails) shall not be planted in the wetland due to their invasive properties and their abilities to provide excellent mosquito habitats.
5. It is important to meet the required 0-12” depth for the shallow water zone correctly because plants installed there will not survive if the soils are dry or if the plants are covered by more than 12” of water.
6. At least six different of species of plants should be installed in the constructed wetland. A greater diversity of plant species will increase the resilience of the wetland to changing environmental conditions
7. The timing of installation for herbaceous plant survivability is from the average last spring frost for the wetland location until several weeks before the average first fall frost for the wetland location.
8. All landscape and reinforcement plans shall be signed by a registered landscape

architect, with direction provided by an experienced wetland scientist.

Outlet Facility and Outfall Protection Requirements

The outlet design requirements provided in Section 3.3.4.2 for wet extended detention basins shall apply to constructed wetlands. In addition, the outlet structure shall be designed to conduct continuous dry weather flow through the wetland system while maintaining normal pool elevations.

3.4.10 Shallow Constructed Wetlands (GI)

This section of the manual describes a stormwater wetland design intended to more closely resemble a natural wetland system, but which captures and treats stormwater runoff from surrounding new or redevelopment areas. Due to the treatment of direct runoff from urbanized areas, a wetland designed in accordance with these criteria is not suitable as mitigation for impacts to other existing wetlands, nor are these features intended to become jurisdictional waters of the United States. A properly maintained shallow constructed wetland will qualify as green infrastructure under the City's Stormwater Utility Credit Program.

Constructed wetlands are systems that mimic the functions of natural wetlands by using physical and biological processes to treat stormwater. Shallow constructed wetlands, illustrated in **Figure 3-5**, have both permanent pool zones and an extended detention zone, which are sized to capture and release the calculated WQv. The shallow water zones in the permanent pool support emergent and riparian vegetation and the deep water zones in the permanent pool provide sediment storage. Together, the diverse vegetative community and the storage provided combine to form an ideal environment for the removal of pollutants in stormwater.

In terms of size, the amount of surface area required for a shallow constructed wetland is typically larger than that of a wet basin, or a typical constructed wetland, due to the limited allowable ponding depths required for wetland design. Shallow constructed wetlands that are supplied by surface water runoff from drainage areas less than 20 acres are defined as shallow pocket wetlands. Pocket wetlands must rely on groundwater as an alternative source to sustain wetland hydrology. The following criteria shall apply to the design of shallow constructed wetlands and pocket wetlands.

General Criteria

All shallow constructed wetlands shall be designed according to the general criteria listed in Section 3.3.4.3, as well as specific criteria in this section.

Layout and Geometry Requirements

The layout and geometric requirements of shallow constructed wetlands shall meet the minimum requirements of Section 3.3.4.3, except where modified as described below. (Note: Item numbers below correspond with those in Section 3.3.4.3; items not listed remain unchanged from Section 3.3.4.3.)

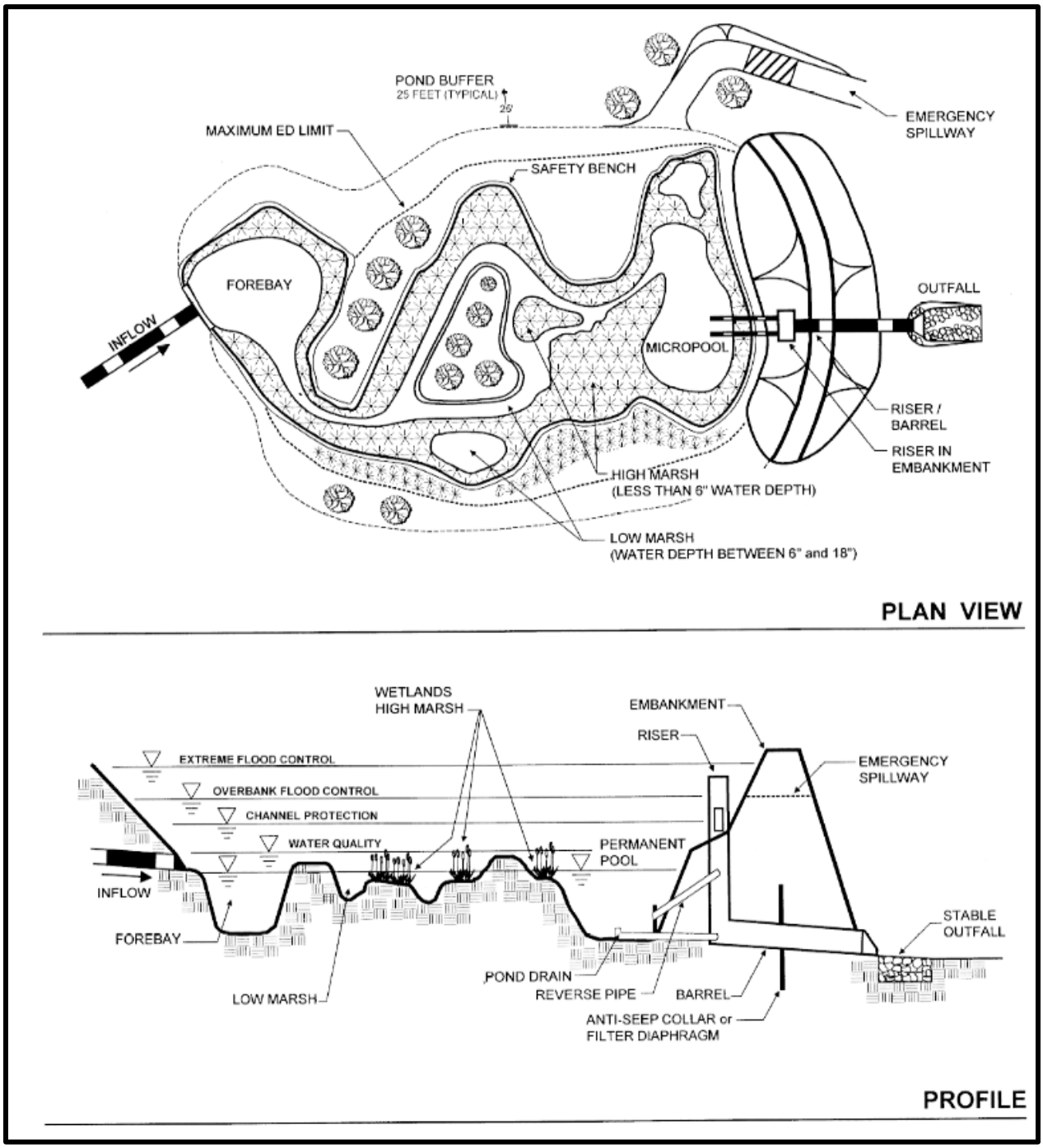


Figure 3-5. Schematic of a Typical Shallow Constructed Wetland

1. The minimum length-to-width ratio for a shallow constructed wetland shall be 2:1, although a length-to-width ratio of 3:1 or greater is preferred.
2. With the exception of shallow pocket wetlands, approximately 50 percent of the permanent pool volume defined in item 3, plus a sediment storage volume equal to at least 20 percent of the WQv, shall be placed in deep water zones (areas with depths greater than 18 inches). At a minimum, deep water zones shall be placed within the forebay and around the primary outlet to minimize disruption of wetland vegetation during sediment removal operations.

   The remainder of the facility shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e., areas less than 18 inches deep) shall vary to provide microtopography and promote the establishment of dense and diverse vegetative cover. Permanent pool depths of no more than 6 inches shall comprise at least 35 percent of the wetland surface area (the "high marsh zone"). Provision of depths of 3 inches or less in the high marsh zone is preferred for vegetation establishment. Depths of 6 to 18 inches (the "low marsh zone") shall comprise an additional 35 percent minimum of the wetland surface area.

   For shallow pocket wetlands requiring a permanent pool volume equivalent to the WQv, approximately 25 percent of the permanent pool volume, plus a sediment storage volume equal to at least 20 percent of the WQv, shall be placed in deep water zones (areas with depths greater than 18 inches). As with larger wetlands, the deep water zones shall be placed with the forebay and around the primary outlet to minimize disruption of wetland vegetation during sediment removal operations. The remaining 75 percent of the permanent pool volume shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e., areas less than 18 inches deep) shall vary to provide microtopography and promote the establishment of dense and diverse vegetative cover. Permanent pool depths of no more than 3 to 6 inches shall comprise at least 35 percent of the wetland surface area (the "high marsh zone"). Provision of depths of 3 inches or less in the high marsh zone is preferred for vegetation establishment. Depths of 6 to 18 inches (the "low marsh zone") shall comprise an additional 35 percent minimum of the wetland surface area.
3. Wetland plants shall be placed in all shallow pool areas (less than 18 inches deep). A landscaping plan for the wetland shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation, as described under the Landscape Requirements provided herein. Woody vegetation may not be planted or allowed to grow on the embankment within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the wetland facility is encouraged to provide shade and moderate surface water temperatures. A list of recommended plant species is provided in **Table B-3** in **Appendix B**.

Pretreatment

Due to the sensitivity of wetland vegetation to sedimentation, a forebay or other pretreatment feature, shall be provided at the inlets of all constructed wetlands that are to be either publicly or privately owned. Wetland forebays shall be no more than four feet in depth and shall meet the minimum requirements listed in Section 3.3.4.3.

Landscape Requirements

1. A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of the plan shall include:
    a) A scaled construction drawing that accurately delineates the landscaping zones and represents the plant material to be installed in each.
    b) A key/legend that identifies the plant material used in the planting plan. The symbols or hatching used to identify the plants will correlate with the plants and/or groups of plants identified in the plant list/table.
    c) A list/table of the selected native plant species, including scientific name, common name, quantity, container size, container type (e.g., bare root, plug, container, etc.), appropriate planting window and any other relevant information.
    d) Soil media specifications, topsoil stockpile location and/or source of topsoil if imported to the site.
    e) Notes with sequencing, soil and plant installation instructions and initial maintenance requirements (mulching, watering, installation of goose fence, etc.).
    f) Any other necessary information to communicate special requirements, materials or methods, such as specific plants that must be field located or approved.
    g) A description of the warranty period stipulating requirements for plant survival/replacement.
2. All shallow water zones 12 inches deep or less shall be planted at a minimum density of 50 herbaceous plants per 200 square feet.
3. Plant species and sizes must be selected based on the permanent pool depths. Woody plants should be installed at or above the normal pool elevation. Emergent wetland vegetation should be installed in depths of no more than 6 inches, such that no more than 50 percent of the plant height is submerged. Floating aquatic plants may be installed in zones 6-12 inches deep.
4. At least six different species of plants should be installed in the shallow constructed wetland. A greater diversity of plant species will increase the resilience of the wetland to changing environmental conditions. A list of approved Native Plant Species for wetlands in Central Ohio is provided in **Table B-3** in **Appendix B**.
5. Invasive species listed in **Table B-1** in **Appendix B**, including cattail species, shall not be planted in the wetland due to their invasive properties and support of mosquito habitat.
6. The timing of installation for herbaceous plant survivability is from the average last spring frost to the wetland location until several weeks before the average first fall frost for the wetland location.

7. The required 0-12” depth for the shallow water zone must be met; plants installed there will not survive if the soils are dry or if the plants are typically covered by more than 12” of water.
8. Soils may be severely compacted during the construction process, which may prevent root penetration and lead to premature mortality or loss of vigor of planted species. Accordingly, planting sites should be over-excavated and backfilled with uncompacted topsoil following the requirements of CMS 659.05 prior to planting. A minimum of 12 inches of topsoil should be provided in all planting areas.
9. Predation by Canada geese can decimate newly installed wetland vegetation. All landscape plans shall include provisions for goose exclusion fencing, with instructions for installation, maintenance and removal once vegetation is fully established.
10. If minimum vegetative coverage of 50 percent is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required.
11. All landscaping and reinforcement plans shall be signed by a registered engineer or registered landscape architect, with direction provided by an experienced wetland scientist.

Outlet Facility and Outfall Protection Requirements

The outlet design requirements provided in Section 3.3.4.3 shall apply to shallow constructed wetlands.

Summary of Design Requirements

The design requirements for shallow constructed wetlands and pocket wetlands are summarized in **Table 3-4**.

Table 3-4
Summary of Design Requirements for Shallow Constructed Wetlands

	Shallow Constructed Wetlands	**Shallow Pocket Wetlands**
Drainage Area	• Minimum 20 acres	• Less than 20 acres
Footprint	• Wetland area footprints should be 5-12% of the area draining to the wetland	
Side Slope	• No greater than 4 (H) to 1 (V), flatter is recommended	
Soil	• HSG-C or HSG-D soils • Pond liner required for HSG-A soils • No gravelly sands or fractured bedrock	• Soil requirements do not apply to shallow pocket wetlands where the permanent pool is sustained by groundwater
Conveyance	• Minimum length-to-width ratio of wetland to be 2 (L) to 1 (W): 3(L) to 1 (W) or greater is preferred. • Basins should be wedge-shaped, narrowest at the inlet and widest at the outlet	
Design Flows	• For extended detention, release 50% WQv in 8 hours and release 100% WQv in 24 hours	
Pre-treatment	• Size pre-treatment forebay to provide a minimum of 10% WQv • Forebay side slopes shall not exceed 4:1	

Outlet	• Outlet shall conduct continuous dry weather flow through wetland system while maintaining normal pool elevation	
Sizing	• Permanent pool (whichever is greater) o Sized to hold 2 times the volume of evapotranspiration during a 30-day drought at summer evaporation rates OR o The calculated WQv • Extended Detention: Equal to WQv	
Deep Water Zone	• 50% of permanent pool volume • Inundated 1 to 4 ft below permanent pool • 10-30% of wetland surface area • Sediment storage volume equal to at least 20% of WQv • Deep water zones shall be placed within the forebay and around the primary outlet at a minimum	• 25% or permanent pool volume • Inundated 1 to 4 ft below permanent pool • 10-30% of wetland surface area • Sediment storage volume equal to at least 20% of WQv • Deep water zones shall be placed within the forebay and around the primary outlet at a minimum
Shallow Water Zone	• 50% of permanent pool volume • 35-45% of wetland surface area inundated 0-6 inches below permanent pool • 35-45% of wetland surface area inundated 6-18 inches below permanent pool • Variable depths to provide microtopography • Shallow water zone occupies in total 70-90% of the wetland surface area	• 75% of permanent pool volume • 35-45% of wetland surface area inundated 0-6 inches below permanent pool • 35-45% of wetland surface area inundated 6-18 inches below permanent pool • Variable depths to provide microtopography • Shallow water zone occupies in total 70-90% of the wetland surface area
Landscaping	• The shallow water zone 12 inches deep and less shall be planted at a minimum density of 50 herbaceous plants per 200 square feet • Plant species and sizes must be selected based on the permanent pool depths • At least six different species of native plants shall be planted in the shallow water zone • Invasive species (Table B-1) are prohibited • Minimum of 12 inches of topsoil shall be provided in all planted areas • Goose exclusion fencing shall be provided	

3.4.11 Bioretention Facilities (GI)

A bioretention facility consists of a soil bed planted with native vegetation located above an underdrained gravel layer. Bioretention facilities are often sited adjacent to and used to treat runoff from paved surfaces such as parking lots. Stormwater quantity controls may either be integrated with the bioretention or provided in a separate downstream facility. Sites utilizing bioretention facilities for water quantity control must also meet the stormwater quantity control requirements of Section 3.2.

Layout and Geometry Requirements

1. The side slopes for bioretention facilities shall not exceed 4 (H) to 1 (V). In retrofit situations where 4 (H) to 1 (V) slopes are not obtainable, side slopes shall be landscaped to eliminate need for mowing and stabilized to prevent erosion. Above grade or landscape buffers shall be used in bioretention facilities directly adjacent to sidewalk, driveway, or street pavement when bioretention facilities have side slopes greater than 4 (H) to 1 (V) or a greater than 6-inch drop from top of pavement to top of bioretention facility installation.

Planting Soil (Filter Media) Requirements

The function of a bioretention facility is largely dependent on the characteristics of the planting soil (filter media) through which the runoff passes. Unless otherwise approved by the City, the filter media shall meet the requirements of City of Columbus Supplemental Specification 1604.

Bioretention facilities shall be planted with a mixture of grass and other hardy, vegetation that can withstand prolonged periods in a wet environment, and be tolerant to road salts if receiving runoff from areas to be treated with deicing materials. Vegetation shall be selected from the list of Native Plant Species is provided in **Appendix B**.

Underdrain and Outlet Requirements

1. A perforated pipe underdrain shall be provided beneath the planting soil. The pipe shall be generally orientated in the horizontal center and must extend at least 85% of the longitudinal length of the facility.
2. The perforated pipe shall have a minimum diameter of 6 inches and shall meet the requirements of Supplemental Specification 1610.
3. The pipe shall be surrounded by granular backfill of durable No. 57 aggregate, in accordance with CMSC Section 703.01, at least 4 inches beyond the outside diameter of the pipe. The use of crushed steel slag shall not be permitted where it will be routinely submerged.
4. The filter media and granular backfill shall be separated by at least 4 inches of durable No. 8 or 89 aggregate in accordance with CMSC Section 703.01. Depending on the gradation of the filter media, it may be necessary to provide a 4-inch-thick layer of sand, in accordance with CMSC Section 703.06, between the layer of No. 8 or 89 aggregate and the filter media. The designer shall use the methodology found in Chapter 26 of the USDA National Engineering Handbook Part 633 to confirm that water will flow through the system without causing movement of the filter media into

the aggregate layers or loss of any material into the underdrain.

5. An overflow designed to convey all storms up to and including the 100-year event shall be provided. Use of a vertical stand pipe or catch basin is recommended. For on-line facilities, this overflow may be designed to achieve the water quantity control criteria specified in Section 3.2.

Pretreatment

Flow entering the bioretention facility shall be limited to sheet flow to prevent eroding the side slopes of the facility. If flow has been concentrated prior to entering the bioretention facility, it shall be converted to sheet flow using a level spreader designed according to criteria in Section 2.3.7 or the energy of the flow shall be dissipated so that erosion within the facility does not occur.

3.4.12 Sand Filters

Stormwater sand filters are usually two-chambered facilities that include a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber.

Hydrology Requirements

Sand filters shall be designed to operate with consideration given to the different filtration rates of unclogged (new) and clogged (maintenance needed) media.

Filter Media Requirements

1. Sand (CMSC 703.02(A)) and gravel (CMSC 703.04) meeting the City's material specifications shall be used. The use of crushed steel slag shall not be permitted where it will be routinely submerged.
2. Geotextile fabrics shall not be used as a filter or material separator in sand filters. Established designs, such as the Austin and Delaware sands filters, that incorporate a geotextile fabric shall be re-designed to replace the specified geotextile fabric with graded aggregate layers that achieve the same intended function.

Underdrain and Outlet Requirements

All piping shall be Schedule 40 PVC per CMSC 720.07.

Pretreatment

A fixed vertical sediment depth marker should be installed in the sedimentation basin to indicate when 20% of the basin volume has been lost because of sediment accumulation.

3.4.13 Vegetated Filter Strips

Vegetated filter strips are typically used as a pre-treatment practice (see Section 3.4.14) and not generally allowed as a primary water quality control. This practice is only allowed as a primary control for pedestrian and shared use paths. The design requirements of this manual must be followed except for determining the width of the filter strip. The minimum filter strip width may be as allowed in the Ohio Department of Transportation's Location and Design Manual Volume 2.

3.4.14 Other Practices

The following practices do not qualify for use as primary, stand-alone SCPs and are not covered elsewhere in this regulation. When used in combination with stand-alone SCPs, these practices can reduce the size and maintenance frequency of primary structural controls.

3.4.13.1 Runoff Reduction and Soil Management

Use of the following practices shall be in accordance with the Ohio EPA's criteria for runoff reduction practices and soil management:

1. Impervious Area Disconnection
2. Grass Filter Strips
3. Grass Swales
4. Soil Management

3.4.13.2 Pretreatment practices

In most cases the aforementioned stand-alone SCPs require that stormwater be "pre-treated" before it reaches the facility. A variety of pretreatment practices are available to remove sediment and other pollutants that may clog or foul the SCP. Each of the following practices shall be designed as specified in the Ohio Rainwater and Land Development Manual and accordance with the listed criteria below, where applicable:

1. Swales
2. Forebays
    a. Direct maintenance access shall be provided to the forebay at a slope no steeper than 10 (H) to 1 (V).
    b. Forebay side-slopes shall not exceed 4 (H) to 1 (V).
    c. A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time.
    d. Forebays of basins must be constructed to provide an access point of sufficiently compacted material to support equipment necessary to perform the necessary routine maintenance for cleaning the structure.
3. Sumps
4. Flow-through devices
5. Grass filter strips

3.5 Water Quality Controls for Commercial Activity Areas

The stormwater quality controls defined in the previous sections are appropriate for most commonly-occurring stormwater pollutants. Some pollutant sources, however, are more difficult to control because they involve activities, materials, and/or wastes that are atypical of the commonly-occurring stormwater pollutants, in either the type or the concentration of the constituents found. These "high risk" pollutant sources must be either controlled separately or "pretreated" before being conveyed to a standard SCP.

A high-risk pollutant source is one possessing pollutant loads and/or concentrations that are different than typical urban runoff, as characterized by the USEPA National Urban Runoff Program (NURP), presenting an immediate threat to water quality, and/or interfering with the successful operation of other approved stormwater controls. These sources most commonly occur within commercial activity areas associated with commercial and industrial land uses. This section defines the types of businesses where such pollutants commonly are found, the specific activities known to generate these pollutants, and controls required in order to receive necessary development approvals from the City.

3.5.1 Businesses Subject to Controls for High-Risk Pollutant Sources

The controls in this section shall apply to the following business categories and/or activities:

1. Any business considered by U.S. EPA and Ohio EPA to involve industrial activities and require an NPDES permit for stormwater discharges from industrial activities. Such businesses are defined by Standard Industrial Classification (SIC) under 40 CFR 122.26. A comprehensive list of these businesses is not provided here, but largely falls within the following SIC Divisions:

   a) Division B Mining

   b) Division C: Construction

   c) Division D: Manufacturing

   d) Division E: Transportation, Communications, Electric, Gas, and Sanitary Services

   e) Division F: Wholesale Trade

   Any development containing an industrial activity, as defined by Ohio EPA, shall meet all applicable requirements of Ohio EPA's permit for stormwater discharges from industrial activities. To obtain coverage, a discharger must complete and submit the NOI form available from Ohio EPA along with the appropriate fee at https://epa.ohio.gov/dsw/ebs

   A copy of the NOI shall be submitted as part of the Stormwater Management Report.

2. Businesses involved in the sale, resale, recycling, repair, fueling, or cleaning of automobiles and other vehicles:
   a) Major Group 50: Wholesale Trade Durable Goods (including 5015 – Used Motor Vehicle Parts and 5093 – Scrap and Waste Materials)
   b) Major Group 51: Wholesale Trade Non-durable Goods (including 5171 – Petroleum Bulk Stations and Terminals)
   c) Major Group 55: Automotive Dealers and Gasoline Service Stations
   d) Major Group 75: Automotive Repair, Services, and Parking
3. Businesses that involve the preparation or sale of food:
   a) Major Group 54: Food Stores
   b) Major Group 58: Eating and Drinking Places
4. Other businesses that store or handle materials outdoors:
   a) Major Group 52: Building Materials, Hardware, Garden Supply, and Mobile Home Dealers
   b) Other businesses identified by the City with significant outdoor material or waste storage, handling, or disposal

3.5.2 Commercial Activity Areas Requiring Control

The control requirements in this section of the manual only apply to commercial activity areas of the businesses in the previous section, defined as outdoor areas where the following activities are conducted or are otherwise exposed to stormwater:

1. Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas,
2. Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed, and
3. Areas where the high-risk materials defined in **Table 3-5**[2] are handled and stored, including but not limited to loading docks, fuel and other liquid storage/dispensing facilities; material bins, containers, stockpiles, and other storage containers; and waste dumpsters, bins, cans, tanks, stockpiles, and other waste containers.

[2] City of Portland, OR, "Source Control Manual", Adopted August 2016

Table 3-5
Control Requirements for Materials Handling Areas

High Risk Materials	Low-Risk Materials	Exempt Materials
Required controls: Conduct activities indoors, as allowed by City regulations, or outdoors with controls defined in this section.	***Required controls***: Use temporary covers of plastic film or sheeting, with runoff directed to approved SCPs for the site.	***Required controls***: Direct runoff to approved SCPs for the site.
Materials to control: • Recycled materials with potential effluent • Corrosive materials (e.g., lead-acid batteries • Scrap or salvage goods • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material by-products with potential effluent • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human waste • Refuse as defined in CCC 4501.	***Materials to control:*** • Recycled materials without potential effluent • Asphalt concrete • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material by-products without potential effluent • Unwashed gravel/rock • Compost	***Materials to control:*** • Washed gravel/rock • Finished lumber • Rubber and plastic products (hoses, gaskets, pipe, etc.) • Clean concrete products (blocks, pipe, etc.) • Glass products (new, clean, or free of residual product) • Inert products • Materials with no measurable solubility or mobility in water • Materials with no hazardous, toxic, or flammable properties • Gaseous materials

3.5.3 Requirements for Commercial Activity Areas

Commercial activity areas that, in the judgment of the Administrator cannot be conducted indoors, shall be conducted within specified areas of the site designed to control stormwater quality. The Construction Drawings shall delineate commercial activity areas and show the location of any stormwater control measure. The Stormwater Management Report shall describe the commercial activity, the rationale for the control measure selected, and design information about the control measures. Stormwater runoff from each commercial activity area shall be controlled in the following manner:

1. Non-stormwater discharges from commercial activity areas, including discharges from any indoor areas, the lower floors of a multi-level parking structure, and/or areas under a roof, shall not be allowed to co-mingle with stormwater runoff from the remainder of the site.

2. The area shall be paved with asphalt or concrete unless otherwise approved by the Division of Sewerage and Drainage.

3. Non-stormwater discharges from commercial activity areas shall be directed to separate treatment systems approved by the Administrator that are able to adequately control stormwater pollutants generated within these areas. These systems include, but are not limited to the following:

   a) The City's separate sanitary sewer system, providing the discharge is permitted by the City, meets all applicable pretreatment requirements (determined by contacting the City's Industrial Waste Pretreatment Program at 614-645-5876), and is regulated with a shutoff valve. Disposal of stormwater runoff from commercial

activity areas to a sanitary sewer is limited to runoff from commercial activity areas associated with businesses covered under SIC 4952 Sewerage Systems and SIC 4953 Refuse Systems.

b) An oil/water separator to remove uncharacteristically high concentrations of oil and grease, with treated effluent discharged to the separate sanitary sewer system.

c) A system appropriate for the containment of hazardous material spills, designed as specified in Ohio Fire Prevention Code Section 1301: 7-7.

d) An industrial treatment system covered by a discharge permit issued by Ohio EPA.

4. For areas with potential to generate oil, grease, or high levels of trash and that have a drain connected to the storm sewer system, an oil/water separator shall be installed. High risk areas include:

    a. Trash receptacle areas for fast food restaurants.

    b. Outdoor vehicle recycling storage facilities.

    c. Other areas as determined by the City.

5. The following basic principles for integrated stormwater/wastewater management for commercial activity areas shall be followed:

    a) Only stormwater (i.e., runoff directly caused by a precipitation event) may enter storm drains (e.g., no wash water, spills, leaks, etc.) unless otherwise specifically allowed under the City's NPDES stormwater permit. Clean rinse waters (no cleaning agents but with potable water chlorine residual) may be allowed to run onto grassed areas to infiltrate.

    b) Stormwater/wastewater management strategies must be consistent with existing codes (e.g., building, plumbing, fire), sanitary sewer regulations, (e.g., pretreatment), and environmental regulations (e.g., HAZMAT, SPCC).

    c) Outdoor material cleaning, storage, handling, and disposal should be minimized.

6. Minimize potential exposure of commercial activity areas to stormwater by the following methods[3]:

    a) Minimize the size of the commercial activity area.

    b) Prevent rainfall from entering the area using a cover or roof, with a minimum overhang of 3 feet on each side for covers 10 feet high or less, a minimum overhang of 5 feet on each side for covers higher than 10 feet, and rooftop drainage directed to the stormwater system. The overhang shall be measured relative to the perimeter of the hydraulically isolated area it is to cover.

    c) Surround above ground liquid containers with a containment device with enough

[3] City of Portland, OR, "Source Control Manual", Adopted August 2016

capacity to capture at least 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

d) Isolate high-risk pollutant areas from stormwater run-on by berming or providing grade breaks around the area perimeter.

7. Where wash waters or comingling of precipitation or stormwater runoff with commercial activity areas are unavoidable, the Applicant shall propose one of the following disposal options depending upon the nature of the activity, the constituents involved, and other pertinent Federal, State, or City regulations:

   a) At the discretion of the Division of Sewerage and Drainage, dispose in a sanitary sewer, with appropriate restrictions and/or pretreatment. Disposal of stormwater runoff from commercial activity areas to a sanitary sewer is limited to runoff from commercial activity areas associated with businesses covered under SIC 4952 Sewerage Systems and SIC 4953 Refuse Systems.

   b) Direct to sump/containment, allow to evaporate, and sweep up residual.

   c) Direct to sump/containment, pump out, and haul to appropriate disposal facility.

3.6 Applicant-Proposed Stormwater Controls

Applicants proposing to use alternative SCPs must obtain approval of their design before submitting a permit application to ~~from~~ Ohio EPA. ~~In addition to Ohio EPA's approval,~~ Applicants proposing to use alternative SCPs must demonstrate that alternative or manufactured controls meet the performance standards specified in Section 3.1.

3.7 Illicit Discharge and Illegal Dumping Control

Illicit discharges to the storm sewer are prohibited under Columbus City Code, Chapter 1145.

Section 4
Construction Verification, Operation, Maintenance and Monitoring of Stormwater Control Practices

This section provides requirements to verify the completion and ensure successful performance of stormwater control practices once they have been constructed. Included in this section are requirements for construction performance surety, as-built surveys and construction certification, practice inspection and maintenance, and maintenance and access easement requirements to allow for construction and maintenance in and around stormwater control practices.

4.1 Construction Surety for Stormwater Control Practices

A construction performance guarantee in a form acceptable to the City shall be provided by the ~~applicant~~~~owner~~owner, where applicable, to guarantee the construction of the ~~required~~ included stormwater control practices in the event that the ~~applicant~~owner fails to do so in accordance with approved plans. The Permit Office within the Department of Public Utilities will receive performance guarantees for construction and post-construction stormwater control practices.

4.1.1 Requirement to Provide Surety

~~Applicant~~Owners proposing to construct temporary sediment settling ponds and sediment traps or post-construction stormwater control practices on private development sites shall furnish to the City a construction performance guarantee in amount of Ten Thousand Dollars ($10,000.00) prior to commencement of construction activity. The performance guarantee shall be in the form of a surety bond in a form acceptable to the City from a surety bonding company authorized to do business in the State of Ohio. The bond shall name the City of Columbus as Obligee and shall be signed by authorized representatives of the Owner and the surety company. The person signing on behalf of the surety shall provide evidence of authority to bind the surety. The surety bond shall be in the appropriate amount specified herein and will be released upon completion of the items specified under Section 4.1.2.

A notarized affidavit from the owner shall be required to grant permission for someone to provide the surety on the owner's behalf.

4.1.2 Construction Guarantee Process

~~Applicant~~Owners providing a surety bond for the construction of temporary sediment settling ponds, temporary sediment traps and permanent stormwater control practices under this regulation shall comply with the following standards.

1. Prior to construction, the ~~applicant~~owner shall furnish a surety bond satisfactory to the City in the amount of Ten Thousand Dollars ($10,000.00).

2. The surety bond will be returned to the ~~applicant~~owner when all of the following criteria are met.
   a. The temporary sediment settling ponds and sediment traps are either removed or converted to post-construction stormwater control practices based on City approval.

   b. The stormwater control practices are constructed and permanently stabilized.

   c. An as-built survey and engineering certification attesting to the conformity of construction to the approved plans or this regulation for all post-construction stormwater control practices, in accordance with Section 4.2, is received and accepted by the City.

   d. A Stormwater Control Practice Maintenance Plan, revised to reflect as-built conditions, has been received and approved by the City.

A new surety bond for an existing project will be required in instances where:

1. A new temporary sediment settling pond, temporary sediment trap or post-construction stormwater control practice is constructed to serve an added phase of a multiphase project, or

2. The ownership of an existing temporary sediment settling pond, temporary sediment trap or post-construction stormwater control practice changes.

No surety bond will be released without prior approval from the City.

4.2 Stormwater Control Practice Construction Verification

As-built surveys and certification are required to demonstrate that the construction of post-construction stormwater control practices was performed per the approved construction drawings, specifications and contracts. ~~Applicant~~Owners shall submit an as-built survey and engineering certification to the City of Columbus for post-construction stormwater control practices installed as part of any private development or public improvement project covered under this regulation.

4.2.1 Timing of As-built Survey and Certification

As-built survey and certification for post-construction stormwater control practices shall be performed upon conversion of a temporary sediment settling ponds and sediment traps, where applicable, the installation of all outlet components and at the conclusion of grading and stabilization of the practice. Practice conversion and finalization will include, but not be limited to:

1. Removal of the temporary riser and skimmer assembly,
2. Installation of the permanent outlet control structure, including any orifices or weirs,

3. If required through as-built survey to achieve compliance with this regulation, removal of sediment from storage areas, including the bottom of permanent pool areas, and
4. Final stabilization of disturbed areas in and around the practice.

Submittal of a certified as-built plan and approval by the City are required before a project is determined to be in compliance with this regulation. The certified as-built plan is to be submitted prior to release of the surety bond for commercial development or subdivision projects and final pay requests for public improvement projects by the City.

4.2.2 Post-Construction Stormwater Control Practice As-Built Survey Contents

As-built survey information shall be collected by, or under the direct supervision of, a licensed surveyor registered in the State of Ohio. Horizontal locations and vertical elevations shall be based on the same coordinate system and vertical datum used on the approved plans. The as-built survey is to be submitted to the City of Columbus, Department of Public Utilities, GIS Section in the form of red-lined construction drawings, in electronic format, and shall include the following items:

1. Location and type of practice inlet and outlet structures including but not limited to: catch basins, maintenance ~~man~~holes, headwalls, inlets, standpipes, level spreaders and spillways.
2. Invert elevations of practice inlet and outlet structures; orifice plate openings; weirs; and pipes, including underground storage chambers and underdrains located within the perimeter of the control practice.
3. For underground stormwater control practices, sizes and material of pipes, including underground storage chambers and underdrains associated with the control practice; orifice plate openings; weir openings; grate openings; and window openings that comprise the stormwater control practice.
4. Top of casting elevations of inlet and outlet structures including but not limited to: catch basins, maintenance ~~man~~holes, headwalls, inlets, standpipes that comprise the stormwater control practice.
5. Elevations along embankments and crests of level spreaders.
6. Cross sections of spillways, weirs and open channels that enter or exit the stormwater control practice.
7. Topography and storage volume of practices where above-ground stormwater storage is provided including grades below the normal pool of water, where applicable. Above-ground stormwater control practices shall include, but is not limited to, green roofs, blue roofs and above-ground storage components of bioretention facilities.
8. Topography and storage volume of practices where underground stormwater storage is provided. Underground storage areas include, but are not limited to: underground detention facilities, storage layers for pervious pavement systems

bioretention facilities and underground cisterns. This information must be obtained before the underground components and storage areas are buried.

9. Location and material of energy dissipation systems associated with inlets and outlets to and from the stormwater control practice.
10. Location and size of impervious reduction areas for previously developed areas.
11. A list of planted vegetation including plant species and number provided, if applicable.
12. Only when variations exist that are not in reasonably close conformity with the originally approved construction plans, an updated stormwater management report that includes calculations for the stormwater system that reflect field changes to demonstrate site compliance with City stormwater regulations that were in effect at the time of plan approval, reviewed and signed by the certifying Professional Engineer.

The approved *.TIFF drawings on file with the City of Columbus Department of Public Utilities shall be used as the basis for the as-built survey plans. Deviations from the approved plans shall be noted as redline mark-ups on the approved *.TIFF drawings and stamped or labeled as “As-Built” on each page.

4.2.3 Stormwater Control Practice Certification

The Professional Engineer or an engineer employed by the Engineering Firm that prepared and signed the construction drawings, shall certify, under seal, that the as-built post-construction stormwater control practices and associated components are in compliance with the approved construction drawings and with the requirements of this regulation. In instances where the Engineering Firm that prepared and signed the construction drawings is no longer in business, a Professional Engineer selected by the ~~Applicant~~Owner shall certify construction of the post-construction stormwater control practices. Where deviations from the approved construction plans are identified, the Professional Engineer shall submit supporting documentation with the as-built plans, which proves that the post-construction stormwater control practices will operate in compliance with the requirements specified in this regulation. The Professional Engineer shall include a signed and sealed Stormwater Control Practice As-built Certification form, available at https://www.columbus.gov/stormwater, with the as-built survey drawings.

4.3 Stormwater Control Practice Maintenance Responsibilities

It is essential that any approved stormwater control practice be properly maintained in order to assure its performance. To ensure that stormwater control practices are properly maintained, property on which stormwater control practices are constructed or installed and located thereon shall be owned and maintained in perpetuity by the ~~Applicant~~Owner’s parent company or a condo/homeowner’s association registered with the Ohio Secretary of State and possessing sufficient assessing authority on all individual owners of benefited properties within the planned community development area. Maintenance shall

include storm water inspections and all operation and maintenance responsibilities specified in the approved maintenance plan for the stormwater control practice.

4.3.1 Stormwater Easements, Access and Maintenance Requirements

After plan approval and prior to the submittal of a construction inspection deposit, the ~~Applicant~~Owner shall submit the following to the City of Columbus, Division of Sewerage and Drainage, ~~Private Development~~Plan Review and Stormwater & Regulatory Management Section:

1. Legal descriptions, associated exhibits and plats describing and depicting all required stormwater infrastructure easements. The ~~Applicant~~Owner shall convey, or cause to be conveyed, any required ~~storm~~ easements, prepared by and approved by the Real Estate Division of the City Attorney's Office. The easements shall grant the City the rights but not obligation, at any time, to:

    a. Inspect the stormwater control practices to ascertain whether the stormwater control practice and appurtenant facilities are built and functioning in accordance with any approved Plans, the Stormwater Control Practice Inspection and Maintenance Agreement, requirements of the then-current City of Columbus Stormwater Drainage Manual and generally accepted engineering standards.

    b. Construct the stormwater control practice in accordance with approved plans under the surety agreement should the ~~Applicant~~Owner fail to do so, and

    c. Maintain the stormwater control practice in accordance with approved maintenance plans should the owner of the stormwater control practice fail to perform maintenance activities.

2. A stormwater control practice inspection and maintenance agreement between the City and the ~~Applicant~~Owner for City signature. The inspection and maintenance agreement shall obligate each owner to inspect and maintain the stormwater control practice in accordance with approved stormwater control practice maintenance plans and shall be signed by each property owner served by the stormwater control practice. The stormwater control practice inspection and maintenance agreement will be recorded by the City. The model stormwater control practice inspection and maintenance agreement available ~~online at: https://www.columbus.gov/stormwater~~in Appendix E shall be used.

3. Reciprocal easement agreements for developments where runoff from multiple parcels under different ownership are controlled by a stormwater control practice located on a separate parcel. The reciprocal easement agreements shall be signed by each property owner whose property is served by the stormwater control practice. The reciprocal easement shall allow access for each property owner to the stormwater control practice for the purpose of inspecting and maintaining the stormwater control practice in accordance with the stormwater control practice inspection and maintenance agreement and stormwater control practice maintenance plan.

4.3.1.1 Easement and Access for Stormwater Control Practices

Unless otherwise ~~required~~ allowed by the City, easements shall be provided around the perimeter of each stormwater control practice and shall extend 15 feet beyond the maximum designed flood limits of the practice and its appurtenances. Appurtenances shall include but are not limited to, pretreatment measures such as forebay(s), benches, risers, outlet pipes, etc. Where the toe of a slope extends beyond 15 feet from the perimeter of a stormwater control practice the easement shall extend to the toe of the slope. An access easement, having a minimum width of 15 feet that extends from the easement around the stormwater control practice to the nearest public right-of-way, shall also be provided.

~~Applicant~~Owners shall provide to the City a maintenance vehicle accessway having a minimum width of 15 feet centered within the access easement. The accessway shall be located around the perimeter of each practice and to each inlet structure and outlet structure. Vehicle accessways shall have a cross slope no steeper than 10 (H) to 1 (V) and shall be sloped toward the direction of the stormwater control practice. For stormwater control practices that are to be owned by the City of Columbus, the vehicle accessway shall be stabilized with suitable materials (e.g., concrete, gravel, articulated block, geogrids, or other means of stabilization) adequate to prevent rutting by the maintenance vehicles. All access routes shall be designed to allow the turn-around of maintenance vehicles. The maintenance plan for the stormwater control practice shall address how maintenance access and operations will be performed if alternative measures are used.

4.3.2 Stormwater Control Practice Maintenance Plan

A maintenance plan for each stormwater control practice must be prepared and submitted for review by the City during the Plan approval process. The maintenance plan shall include all elements specified in the latest version of Ohio EPA's Construction General Permit. Inspection frequencies, maintenance frequencies and maintenance activities specified in stormwater control practice maintenance plans shall be in accordance with the City's Stormwater Control Practice Inspection and Maintenance Guidance Manual (IMGM).

The model Stormwater Control Practice Maintenance Plan available at https://www.columbus.gov/stormwater shall be used as the basis for Stormwater Control Practice Maintenance Plans. Submitted stormwater control practice maintenance plans shall be customized to appropriately suit the individual practice(s) that are to be constructed. Methods and frequencies for inspections and maintenance activities for stormwater control practices that are not presented in the IMGM shall be provided by the ~~Applicant~~Owner.

Stormwater Control Facility Maintenance plans shall be updated after construction of the stormwater practice to reflect any changes made to the original design during construction. The updated Stormwater Control ~~Facility~~ Practice Maintenance Plan shall be submitted to the City of Columbus, Department of Public Utilities, GIS Section along

with the as-built survey drawings and completed Stormwater Control ~~Facility~~ Practice Certification Form.

4.3.3 Maintenance Inspection Requirements

The purpose of maintenance inspections is to assure safe and proper functioning of the stormwater control practices. The Property Owner shall perform periodic inspections of the stormwater control practice and its appurtenances at a frequency stipulated in the approved Stormwater Control Practice Maintenance Plan. Inspections shall cover all elements for the stormwater control practice as defined in the stormwater control practice maintenance plan. Inspections shall include the completion of dated and signed inspection checklists provided in the Stormwater Control Practice Maintenance Plan and the notation of all deficiencies observed during the inspection. The Property Owner shall maintain copies of complete dated and signed inspection checklists in a maintenance inspection log, along with recorded dates and descriptions of maintenance activities performed by the Property Owner to remedy the deficiencies observed during prior inspections. The maintenance inspection log shall be kept on the property and shall be made available to the City upon request.

4.3.3.1 City Inspections

The City will inspect, at a frequency determined by the City, the stormwater control practice to determine whether the practice and appurtenant facilities are built and functioning in accordance with any approved Plans. The following records shall be maintained onsite and made readily available for review by the City during inspections:

1. The approved stormwater control practice maintenance plan, and
2. A complete and up-to-date maintenance inspection log that documents inspection and maintenance activities performed by the owner.

The City will provide written or electronic notification to owners of stormwater control practices of any deficient items noted during the inspection. In the event the stormwater control practice is not functioning properly and requires repair, the owner upon notice from the City, or otherwise, shall commence such repairs as needed in a timely manner. The owner shall use commercially reasonable efforts to timely perform the repairs, but except for events of force majeure, under no circumstances shall the time exceed ninety (90) days unless otherwise agreed in writing by the City.

If the owner fails to diligently complete the repair, the City shall have the right, but no obligation whatsoever, to enter upon the owner's property and perform the repair. If the City performs such repair as permitted herein, the owner shall fully and immediately reimburse City for the actual cost of the repair upon receipt of an invoice itemizing the cost, which shall include any costs and expenses of filing suit and/or attorney's fees.

4.4 Stormwater Control Practice Monitoring Requirements

As directed by the City or other governing body or jurisdictional entity (e.g. OEPA), ~~applicant~~owners that are developing lands within sensitive or protected watersheds may

be required to implement stormwater runoff monitoring. This monitoring may be required to be conducted during construction, post-construction, or both.

Monitoring may include activities such as the following: rainfall data, flow rate, dry or wet weather discharge sampling, seasonal monitoring, sampling of new stormwater conveyance systems, and/or sampling of effluent at stormwater outfalls that are constructed as part of the development project. Samples may be analyzed to determine the concentrations of total suspended solids, chemicals or oils and grease or any constituents of concern as determined by a governing body or jurisdictional entity. Reporting of monitoring results may also be required.

4.4.1 Construction Monitoring

The monitoring of stormwater discharges and associated record-keeping of monitoring results during construction activities shall be conducted in accordance with Ohio EPA's National Pollutant Discharge Elimination System (NDPES) General Permit Authorization for Storm Water Discharges Associated with Construction Activity.

4.4.2 Post-Construction Monitoring

~~Applicant~~Owners proposing to develop within the Big Darby Accord planning area, are required to implement post-construction stormwater monitoring as prescribed in the development site level monitoring requirements specified in the Big Darby Accord Watershed Master Plan. In instances where the collection of data using automatic sampling equipment is specified, flow-weighted composite samples shall be collected for analysis. Samples collected for flow-weighted composite shall be taken during the entire event or during the first three hours, whichever occurs first. Each sample shall be separated by a minimum period of fifteen minutes, or a maximum period of forty-five minutes, with a minimum of three samples per event.

Wet weather precipitation events shall be defined as greater than or equal to 0.25 inches of precipitation in 24-hours. Dry weather flow conditions shall be characterized as flows that occur seventy-two (72) hours or longer following the end of the last precipitation event. Analysis and collection of samples shall be performed in accordance with the methods specified in 40 CFR, Part 136. Where an approved Part 136 method does not exist, a suitable method shall be used and referenced in the annual sampling report described in this section.

~~Applicant~~Owners shall submit an annual sampling report to the Plan Review and Stormwater ~~and~~ & Regulatory Management Section that includes an evaluation of the monitoring data to characterize the seasonal quality of storm water discharges.

The Annual Report shall contain:

1. Project location
2. Sample location
3. The date and duration (in hours) of the storm event(s) sampled
4. Measurements or estimates of rainfall depths in inches of the storm event which generated sampled runoff

5. The duration (in hours) between the storm event sampled and the end of the previous measurable storm event
6. Analytical results

The annual sampling report for each calendar year January 1 through December 31 must be submitted not later than January 31 of the following year. ~~Applicant~~Owners must submit annual sampling reports to the following address:

City of Columbus
Division of Sewerage and Drainage
Plan Review and Stormwater ~~and~~ & Regulatory Management Section
1250 Fairwood Avenue, Room 1051
Columbus, Ohio 43206-2272

Part II – Submittal Requirements

Part II – Submittal requirements of the Manual contains guidelines and standards necessary to successfully navigate the City's process for review and approval of proposed development with regard to stormwater management. Section 5 discusses the City's approval process from the various departments prior to construction. Section 6 defines the information that shall be provided in a stormwater management report and the accompanying submittals. Section 7 presents stormwater construction drawing submittal requirements. Additional questions covering these sections should be directed to the administrator.

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Section 5
Private and Public Development Review Processes

Any new development, either public or private, proposing to construct stormwater infrastructure within the City, must receive approval from some or all of the following City departments/divisions prior to construction, including but not necessarily limited to: Division of Sewerage and Drainage, Division of Water, Division of Electricity, ~~Transportation~~ Division of Design and Construction, and the Recreation and Parks Department. Plans for stormwater infrastructure that is to be privately owned are subject to a different review process than facilities that will ultimately be publicly owned and operated. Stormwater plans for private infrastructure must be prepared in the format presented in Section 7 and submitted directly to the Building and Zoning Services, Site Engineering, Chief Plans Official at 111 N Front St, Columbus, Ohio 43215. Once received by the Chief Plans Official, the draft plans are assigned a CC number and routed to various City departments/divisions for review.

Stormwater improvements that are to be publicly owned and operated within public right-of-way or in publicly owned easements are incorporated into, and submitted with, the public roadway plans for the development. The public roadway plans are prepared on "E" size sheets (referred to as Drawer E plans) in a format specified by the ~~Transportation~~ Division of Design and Construction. While the format for Drawer E plans is different from the CC Drawing format specified in Section 6, the stormwater improvements that are to be incorporated into Drawer E Drawings must be designed in accordance with the standards in the Manual.

Where applicable, Applicant is required to submit proof of receipt of the following to the Division of Sewerage and Drainage prior to approval of CC or E plans:

1. Federal Individual or Nationwide (404) permit.
2. State Water Quality (401) certification.
3. ~~Written Ohio EPA approval for use of alternate post-construction BMPs on large sites or for small site plans submitted as part of a larger plan of development~~
4. ~~3.~~ Written Ohio EPA approval for any exception, waiver or other variance from conditions contained in the applicable Construction General Permit.
5. ~~4.~~ Written Ohio EPA approval of mitigation of isolated wetlands and/or isolated streams.

In addition to meeting different plan format requirements, the Applicant is required to procure approval of a preliminary plat for the development prior to the submission of Drawer E plans. More information on plan review and plat submittal processes is provided in the Columbus Development Guide available on the City's website.

A stormwater management plan is required for review and approval of stormwater systems for both CC Drawings and Drawer E drawing submittals. The elements of the stormwater management plan, such as stormwater calculations, maps, permits, etc., are outlined in Section 6. Since the plan format for Drawer E plans is not specified by the Division of Sewerage and Drainage, the plan preparation standards presented in the Manual are for CC Drawings only and are shown in normal typeface. Submittal requirements that are specific to only Drawer E plans are noted as such.

Section 6
Stormwater Management Report

A stormwater system shall be designed and incorporated into each development project proposed within the City. The design of proposed stormwater systems shall be summarized in a bound stormwater management report (Report) and submitted in both hard copy and digital (pdf) versions to the City for review and approval. The Report shall contain all pertinent stormwater calculations for detention/retention basins, storm sewers, culverts, open channels, Stream Corridor Protection Zone widths, and other stormwater management features, including stormwater control practices (SCPs) as specified in Part I of this document. The following components shall be included in, and considered part of, the Report:

1. Master Drainage Plan (if applicable),
2. Calculations,
3. ~~Stormwater Control Practice Maintenance Plan(s),~~
4. ~~4.~~3. Easements (if applicable),
5. ~~5.~~4. Subsurface investigation reports (if applicable),
6. ~~6.~~5. Non-City Submittals/Permits,
7. ~~7.~~6. Supporting documents from OEPA, ACOE, and any other state or federal agency, and
8. ~~8.~~7. Stormwater Design Summary.

The master drainage plan shall be folded and inserted in a separate sleeved page(s) or pocket(s) of the Report. Construction plans, including Stormwater Pollution Prevention Plans, and the CC Drawing Number Application Form (see Section 7), shall be submitted with the Report, but not attached to it. The Report shall contain divider pages with labeled tabs that clearly identify each component listed above. Each component of the Stormwater Management Report shall be prepared and submitted in accordance with the following requirements.

6.1 Master Drainage Plan Requirements

For developments five (5) acres or greater, or developments that are to be constructed in multiple phases, the general site layout, including the layout of the proposed stormwater system, shall be depicted on a separate master drainage plan. The master drainage plan(s) shall be based on the state plane coordinate system and show all existing and proposed features, including trees. The master drainage plan shall show all features indicated in the Manual, including but not limited to:

1. Project title,
2. North arrow and scale,

3. Project boundaries,
4. Existing and proposed topography at two-foot contour intervals covering the total development area and any offsite drainage areas tributary to the development site. The total upstream watershed(s) tributary to the development site shall be delineated,
5. Pre-development and post-development sub-basins, including onsite and offsite contributory area. The acreages shall be annotated,
6. The location and capacity of the immediate downstream receiving waterway or stormwater system, if requested by the City,
7. Pre-development and post-development major flood routing flow paths to and from stormwater control facilities,
8. Any streams, as defined in Section 1.2, that traverse the property and their respective Stream Corridor Protection Zones, including areas containing slopes 15 percent or greater that are adjacent to streams,
9. The location of proposed stormwater quality and quantity control facilities, storm drains, and constructed open watercourses proposed for the site,
10. Existing field tile locations,
11. Lines designating the phases of multiphase development projects,
12. Street layouts and existing and proposed utility lines,
13. Flood Hazard limits and classifications,
14. The boundary of each wetland on the site defined during a jurisdictional determination under the requirements of a Section 401/404 permit and the Stream Corridor Protection Zones surrounding wetlands associated with any stream established under criteria in Section 1.5 of the Manual, and
15. Identify all stormwater outfalls and provide state plane coordinates, size (e.g., diameter), and type (open channel or piped) of each outfall for each.

The master drainage plan(s) is to be prepared on a 22-inch by 34-inch sheet on a scale not to exceed 1 inch = 200 feet. Larger development projects will require multiple sheets with match lines. In the event there is significant offsite tributary area to the proposed project, a second additional master drainage plan showing the entire drainage area is required. Deviations from master drainage plan requirements for unique projects or circumstances may be permitted upon written approval from the Division of Sewerage and Drainage.

6.2 Calculation Requirements

Calculations shall be provided for all of the stormwater conveyance and stormwater control facilities required by the Manual and shall be stamped and sealed by a Professional Engineer registered in the State of Ohio. Calculations shall be organized and presented in a manner that demonstrates compliance with the City's stormwater management requirements. Specific requirements follow.

6.2.1 Stream Corridor Protection Calculations

Calculations to determine the width of the Stream Corridor Protection Zone for streams and wetlands shall be presented in the following format:

1. ***Stream Corridor Protection Zone Calculations*** — Provide calculations and/or jurisdictional determinations supporting the calculated width of the Stream Corridor Protection Zone based on the requirements of Sections 1.3 and 1.5. A contour map delineating the tributary area used to calculate the Stream Corridor Protection Zone for each stream shall be submitted.
2. ***100-year Floodway Limits*** — Provide a FEMA map showing the limits of the 100-year floodway overlain with the calculated Stream Corridor Protection Zone limits determined above. The limits of the Stream Corridor Protection Zone will be the greater of the calculated limits or the 100-year floodway.
3. ***Slope Protection*** — Existing slopes 15 percent or greater that are adjacent to streams as defined by this manual are part of the Stream Corridor Protection Zone and shall be identified and annotated on the master drainage plan.
4. ***Wetland Protection*** — Delineated wetland boundaries shall be identified and shown on the stormwater management site plan. The limits of the final Stream Corridor Protection Zone shall be extended to include the entire wetland boundary for wetlands that are partially located within the greater of the calculated limits of the preliminary zone or the limits of the 100-year floodway.

6.2.2 Compensatory Floodplain Fill Calculations

Demonstrate that any volume of fill placed in the 100-year floodplain (outside of the Stream Corridor Protection Zone) is compensated with an equal volume of material removed above the ordinary high water table and below the 100-year flood elevation. Show the volume calculations for the fill and the compensating storage.

6.2.3 Impervious Area Calculations

Provide calculations that were used to quantify the amount of impervious area that will be on the site once construction is complete. Impervious area calculations shall be provided in square feet and based on building footprint, paved parking, and private drive and sidewalk not within the public right-of-way.

6.2.4 Storm Sewer Calculations

Storm sewer calculations shall be presented in the following format:

1. ***Capacity*** — Demonstrate that the capacity of the storm sewer pipes is sufficient to convey the design storm on **Table 2-10** without surcharging. Calculations shall be prepared on the tabulation sheet provided in **Appendix A**.

2. ***Hydraulic and Energy Grade Line*** — Demonstrate that the sewer system is designed to convey the design storm on **Table 2-10** such that the HGL stays below the gutter line of the overlying roadway or the top of castings of the drainage structures outside the roadway. Also indicate the appropriate Manning's "n" value for the selected pipe material, and indicate the minor loss values at all applicable points in the system, according to criteria in Section 2.3.1. The HGL and EGL shall be shown on the tabulation sheet provided in **Appendix A**.
3. ***Tailwater*** — List all tailwater assumptions and their source for applicable design storm events.
4. ***Velocities*** — Tabulate the storm sewer flow velocities in each segment, and demonstrate that the sewers are designed to produce velocities within the limits specified in Section 2.3.1.2.
5. ***Pavement Spread*** — Provide calculations that demonstrate that the pavement spread limits do not exceed the criteria presented in Section 2.3.2.

6.2.5 Culvert Calculations

Culvert calculations shall be presented in the following format:

1. ***100-year HGL*** — Demonstrate that the water elevation resulting from the 100-year storm event does not encroach into proposed or existing residential dwellings or places of business. The flood elevation shall be shown on the stormwater management master drainage plan for the project.
2. ***Bankfull Calculations*** — Provide the calculations used to determine the bankfull depth of the stream as required in Section 2.3.3.3.
3. ***Design Storm*** — Provide calculations demonstrating that headwater elevations are within the limits specified in Section 2.3.3.3. Hand calculations and the use of nomographs per Federal Highway Administration Hydraulic Design Series No. 5 or model output from computer programs such as HY-8 or similar may be used.
4. ***Velocities*** — Tabulate the culvert flow velocities, and demonstrate that the velocities do not exceed the velocity limits specified in Section 2.3.3.3.
5. ***Tailwater and Energy Loss*** — List all tailwater assumptions and their source for applicable design storm events. List the energy loss assumptions at the entrance/exit of the structure.

6.2.6 Constructed Open Watercourse Calculations

For constructed open watercourses, the Applicant shall submit calculations demonstrating that the design criteria in Section 2.3.7 have been satisfied. At a minimum, the following calculations shall be provided:

1. ***Design Velocity*** — Calculations showing that the channel lining can withstand the peak velocity during the 5-year design storm without erosion.

2. ***Channel Dimensions*** — Provide calculations showing the normal water depth, critical flow depth, and water surface width during the 10-year design storm.
3. ***100-year HGL*** — Demonstrate that the hydraulic grade line resulting from the 100-year storm event does not rise to within one foot of the finished grade adjacent to any buildings along the channel.

6.2.7 Flood Routing Calculations

Calculate the water surface profile along the major stormwater routing system using a standard step backwater profile calculation, or using a computer model able to compute backwater curves, such as HEC-RAS or U.S. EPA SWMM. Demonstrate that the water elevation resulting from the 100-year storm event does not encroach into proposed or existing residential dwellings and places of business and meets the depth restrictions presented in Section 2.4. The flood elevation shall be shown on the master drainage plan for the project.

6.2.8 Stormwater Detention Calculations

Calculations for stormwater detention facilities shall be based on methodologies that utilize dynamic hydrograph routing techniques (i.e., methods that allow variable inflows and outflows with respect to time and account for the basin's stage-storage-outflow characteristics). software/models that utilize this methodology and technique that are deemed acceptable to the City include, but are not limited to, SWMM, TR-20, PONDPAK, and HEC-1. The City will not accept methodologies that do not perform dynamic routing of hydrographs. If a model is used to perform stormwater detention calculations, the name and a description of the model must be provided, each model input parameter must be defined, and a complete set of model input data must be included. The calculations for detention facilities shall be presented in the following format:

1. ***Critical Storm Calculations*** — Show the calculations of the total volume of runoff from a one-year, 24-hour storm, before and after development. Show the calculations of percent increase in runoff volume, and reference **Table 3-1** in Section 3.2.1 to determine the critical storm.
2. ***100-year Storm Release Rate Calculations*** — Determine the maximum release rate for the 100-year storm event by calculating the 10-year peak pre-developed flow rate.
3. ***Basin Inflow and Outflow Hydrograph Calculations*** — Show the calculations or model input/output that produced the inflow and outflow hydrographs to and from the retention/detention basin. Hydrographs should be shown graphically, with a tabular summary of the peak flow and volume, for all design storms that were considered in the design process. The City will not accept calculations or model input that provide tabular listings of inflow and/or outflow hydrographs.
4. ***Stage-Storage Calculations*** — Show the calculations of the stage-storage relationship for each detention facility.

6.2.9 Water Quality Volume (WQv) and Water Quality Flow (WQf) Calculations for Post-Construction SCPs

The Applicant shall prepare a set of water quality volume and facility sizing calculations for control facilities required under Section 3.3 of the Manual. At a minimum, the following calculations shall be provided in accordance with Section 3:

1. ***Water Quality Volume Calculations*** — Show the calculations of extended detention, permanent pool, forebay, and sediment storage volumes and depths.
2. ***Water Quality Drawdown*** — Show calculations or model output that demonstrates the release of the WQ_v over the time period(s) specified.
3. ***Area of Sand Filter and Bioretention Facilities*** — Provide calculations used to determine the size of sand filter and bioretention facilities.
4. ***Water Quality Flow Calculations*** — Show the calculations of the water quality flow (WQ_f).
5. ***Design Flow Rate*** — Show the calculations of the design flow rate using the Rational Formula for SCPs sized using WQ_f.
6. ***Geometry*** — Show the calculations of the swale cross-section geometry using the Manning Equation. Demonstrate that the flow depth is no greater than the maximum flow depth specified for the design storm calculated above.

6.3 Stormwater Control Practice Maintenance Plan Requirements

The maintenance plan for the stormwater control practices on single-family residential, commercial, or industrial sites shall be prepared as required by Section 4.

6.4 Compensatory Floodplain Restoration Plan Requirements

Where floodplain fill is proposed, the stormwater management report shall include a site grading plan with supporting calculations indicating areas where floodplain fill and compensatory floodplain storage are proposed. The amount of compensatory storage and the methods used to provide the necessary compensatory storage shall be determined using the criteria in Section 1.4.

6.5 Easement Preparation Requirements

Dedicated easements to the City of Columbus shall be provided to allow construction, maintenance and access to all publicly-owned stormwater control practices located outside of public right-of-way and for all privately-owned stormwater control practices. Easements shall be designated on the construction plans as platted or deeded, existing or proposed. All existing easements shall be identified by the plat book and page number,

or official record number of the deed. Preliminary plats and/or easement descriptions and exhibits shall be included with the stormwater management report submittal and construction drawings.

All descriptions and drawings involving City owned property rights shall apply standard survey techniques. When preparing easement documents for acceptance by DOSD, the following guidelines must be followed:

1. ***Legal Descriptions*** — Shall be the original typed document prepared single spaced on letter size paper and also digitally in WORD form, signed, sealed and dated by a registered surveyor. Metes and bounds descriptions are required; centerline descriptions will not be accepted.
2. ***Pictorial Exhibit*** — Shall be the original document prepared on legal size paper, signed, sealed and dated by a registered surveyor and also digitally in ACROBAT (PDF) form.
3. ***Format*** — Documents are not to be labeled or referenced to as Exhibit A, B, or so on. This requirement does not apply to easements allowing, but not obligating, the City to access, construct and maintain stormwater control practices.
4. ***Required Language*** — Descriptions and/or pictorial exhibits shall not include caveats such as: subject to covenants, exceptions, or restrictions of record, nor shall they include a purpose such as: installing, replacing, and maintaining a storm sewer, or ditch.
5. ***Contacts*** — For private stormwater development plans, the name, mailing address, email, and phone number of the person who will sign or obtain the signatures on the easement document shall be provided.

When approved by the Division of Sewerage and Drainage, easement information will be sent to the Real Estate Division of the City Attorney's Office for Deed of Easement preparation. When the deed is prepared, the Real Estate Division will contact the designated contact person to obtain the signatures and return the signed originals. The Real Estate Division will record the deeds and process them for City Council acceptance. Signed Deeds of Easement must be returned to the Real Estate Division prior to the payment of construction inspection fees.

6.6 Subsurface Investigation Reports

A copy of any subsurface investigation reports and recommendations performed as part of the stormwater design process shall be included in the stormwater management report. Subsurface investigations and recommendations may be warranted in instances where exfiltration of stormwater into sanitary sewers is possible or where underlying soils of a wet detention basin are insufficient to maintain a permanent pool of water. Subsurface reports submitted with the stormwater management report must be prepared and signed by a professional engineer licensed in the State of Ohio and experienced in geotechnical engineering.

When infiltration SCPs are proposed, the criteria and procedures for infiltration testing may be found in Appendix A “Infiltration Testing for Stormwater Practice Design” of the most recent Provisional Practices addendum to Ohio’s Rainwater and Land Development Manual.

6.7 Non-City Submittals/Permits

A copy of the applications for the following permits/approvals that shall be included in the stormwater management report may include, but are not limited to:

1. Dam permits as issued by the Ohio Department of Natural Resources (ODNR) for detention pond embankments meeting ODNR dam criteria,
2. 401 Water Quality Certification Permits issued by the Ohio Environmental Protection Agency,
3. Industrial NPDES Stormwater Permit application to Ohio Environmental Protection Agency,
4. 404 Permits for impacts to regulated streams and wetlands issued by the U.S. Army Corps of Engineers, and
5. Notice of Intent for coverage under the Ohio Environmental Protection Agency NPDES Construction General Permit, and a copy of the stormwater pollution prevention plan prepared under this permit.

The City will not approve stormwater management reports or plans prior to receipt of copies of approved Federal (404) and State (401) permits if the permits are required and written Ohio EPA approval for exception, waiver or variance from conditions of the currently effective Construction General Permit or any other applicable permits.

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Section 7
Stormwater Construction Drawings

All stormwater improvement plans submitted for approval by the City of Columbus shall be prepared, signed, and sealed by a Professional Engineer who is licensed in the State of Ohio. Final plans shall be prepared and submitted in CCITT T.6 TIFF format at 300 or 400 dpi.~~on 22-inch x 34-inch high quality 4 mil thickness mylar using ink especially adapted to mylar~~. High quality photographic or Xerox mylar reproductions will be accepted with prior approval. Plans shall be in accordance with the City of Columbus CAD Digital Submission Standards. Title blocks shall be in accordance with DOSD standard. Stick on notes, signature block, and/or details will not be accepted. The tracings become the property of the City of Columbus, DOSD, upon approval of the drawings by the Administrator or the Director of the Department of Public Utilities. Copies of approved plans can be obtained from DOSD. Final submittal shall include digital files of all plan sheets in the TIFF format specified in the Digital Standards, digital file of the plan sheets in pdf format, CAD mapping of the project per the Digital Standards, and a digital copy of the stormwater management report in pdf format.

All revisions to the ~~tracings~~TIFF files, after they have been signed by the Director of Public Utilities, shall be made in black~~ ink~~. The original approved alignment, easement limits, maintenance ~~man~~holes, structure numbers, etc., shall be revised as directed by DOSD with a numbered triangle box shown inserted next to the revised work. A numbered triangle box shall then be placed in the revision block of the drawing border with a brief and concise verbal description of the change. Only three (3) relatively small revisions will be permitted on a tracing sheet. Any major revisions, or more than three (3) minor revisions, may require the submission of a new plan.

7.1 Minimum Plan Format Requirements

The following minimum for requirements apply to all CC Drawings submitted for review to DOSD and are included in the Plan Submittal Checklist as shown in **Exhibit C** of **Appendix C**.

7.1.1 Title Sheet

The Title Sheet shall contain the following items:

1. ***Title*** — All private storm sewer plan titles shall be formatted in the title block as follows:

   "Private Storm Sewer and Stormwater Facilities for [Insert Project Title]"

   The Project Title shall include the certified street address of the project site.

2. ***Location Map*** — This map shall show the relative location of the project to area streets and well known landmarks so as to determine the location of the project within the City at a quick glance.
3. ***Benchmarks*** — A suitable benchmark shall be provided for every 1,000 lineal feet of sewer shown on the plan, with a minimum of two (2) on each plan. The benchmarks shall be established through a bench circuit with elevations based on the most recent North American Vertical Datum (NAVD) determination. Benchmarks shall be on or within 100 feet of project limits.
4. ***Estimate of Quantities*** — An accurate estimate of those items being constructed under the stormwater plan shall be included. The description of the item shall be the same as that under the item description in the CMSC, current edition. The quantities for each phase of a phased project shall be shown separately. Stormwater Control Practice quantities taken from the individual SCP Tables of Quantities must be carried over into the Estimate of Quantities. Refer to 7.1.4.5 for information on the Tables of Quantities for Stormwater Control Practices.
5. ***Standard Drawings*** — All plans shall have a listing of the applicable Standard Construction Drawings which apply to the proposed work. Copies of standard drawings shall not be placed on the plan sheets.
6. ***General Notes*** — The general notes included in **Exhibit A** in **Appendix C** of the Manual shall be included on all plans where applicable. If space on the title sheet is insufficient, general notes may either be continued on the second sheet or moved in their entirety.
7. ***Special Notes*** — Any notes that the engineer preparing the plan feels may be required due to circumstances of the particular project should be included under these notes. Any special notes should follow the general notes and should be so titled: “Special Notes”. The engineer preparing the plans is responsible for making sure that all notes required to construct the project are provided in the plans.
8. ***Signature Block*** — Along with the necessary signature and date lines, the signature block (**Exhibit B** in **Appendix C** of the Manual) shall contain the following note:

   > “Signatures below signify only concurrence with the general purpose and general location of the project. All technical details remain the responsibility of the engineer preparing the plan. Approval for storm drainage only.”

9. ***Index Map*** – This map shall show the proposed storm sewers and stormwater control practices on the site. Map shall include proposed and existing storm sewers, structure numbers, property owners and parcel numbers for the subject site and adjacent properties, public right of ways, street names, and where applicable streams/ditches and flood plain boundaries. The proposed storm water improvements are to be the most prominent features.
10. ***Designer Contact Information*** – For the professional engineer signing the plan provide name, company, address, phone number, and email address.

11. ***100 Year Detention*** Table – Table shall include the required and proposed 100 year detention volume and elevations for each proposed stormwater detention feature on the site.
12. ***Summary of Post Construction Stormwater Control ~~Facilities~~ Practices Table*** – This table shall provide the Control Function, Drainage Area, Facility Type, Green Infrastructure area, and plan page number for each stormwater control/outlet structure on the plan.

    Whenever a proposed sewer is located on or near (within 100 feet) City Park property, a signature line and date line for the Director of Recreation and Parks Department shall be provided in the signature block.

7.1.2 Plan View

All plan sheets shall contain the following items:

1. ***North Arrow*** — Plans shall be orientated so that the north arrow is toward the top or left margin of the sheet. Slope of the sewer may be shown from either the left or the right side of the sheet but shall be consistent throughout the plan.
2. ***Structure Numbering*** — All sewer plans shall be submitted with continuous numbering for each stormwater structure included in the project. The lowest structure number shall be assigned to the most downstream structure on the longest run of sewer. Increasing structure numbers shall be assigned to each structure as the sewer run progresses upstream. Once all structures are assigned a number along the first sewer run, the next number is assigned to the most downstream maintenance ~~man~~hole on the next longest sewer run. The process is repeated until all stormwater structures have been assigned a number.
3. ***Scale*** — Plan views shall be prepared at horizontal scale of sufficient size as to show necessary detail. A horizontal scale of 1”=30’ is recommended.
4. ***Line Weights*** — Appropriate line weights are to be used for the various items shown on the plan. All items shown on the plan are to be labeled and clearly distinguishable from each other. For ease of distinction, the proposed sewer shall be the heaviest line weight used.
5. ***Point of Reference*** — All plans shall show a distance from some point of the proposed sewer system to an existing reference point outside the project site, accurate to within one foot. (Example: Street Intersection).
6. ***Property Information*** — All properties through which a stormwater management facility passes shall have indicated on the plans the Property Owner’s name, parcel acreage, parcel identification number, and the deed book and page number of the title instrument. This includes onsite and offsite properties. All iron pins found during the field survey shall be shown on the plans as “found iron pin”.
7. ***Impervious Surfaces*** — All impervious areas on the project site shall be shown and labelled. The impervious surfaces shall be prepared digitally using polygons on a

separate overlay, or layer, and shall include all building footprints, paved parking, private drives and sidewalks.

8. ***Streams*** — All streams as defined under Section 1.2 of the Manual shall be identified and shown and labeled on the plan. The limits and widths of all Stream Corridor Protection Zones and FEMA designated 100-year floodway and floodplain fringe areas shall also be shown. Areas of proposed fills within FEMA designated floodplains as well as areas where compensation for said fills is to be accomplished shall be shown on the plans. The amount of fill volume for which compensation must be made shall be annotated on the drawings.
9. ***Stormwater Control Practices*** — The size, location, and 100-year and maximum ponding limits of all proposed SCPs shall be provided on the plans. Easements for City access and maintenance (if required) to and around each facility shall also be shown.
10. ***Agricultural Field Tiles*** — All visible agricultural tile outlets and locations shall be field located and shown on the plans. Any plan information for field tile systems received from county agencies shall also be shown.
11. ***Utilities*** — All existing and proposed utilities and sewer lines within, or adjacent to, the project site shall be shown on the plan and clearly identified as to type, size, location, and ownership. The construction plan number (CC, RP, MM, etc.) of all existing sewers shall be shown. Storm utilities shall include all drainage swales, ditches, creeks, etc.
12. ***Structure and Pipe Annotation*** — All structures shall be labeled as to type and class (if applicable). The state plane coordinates of all proposed structures that are to be publicly owned shall be shown on the plan in tabular format. All pipes shall be delineated and annotated with their respective sizes, materials (if a particular material is specified), and distance measurements. Pipe distances for publicly owned storm sewers shall be determined from center-of-structure to center-of-structure.
13. ***Impervious Area Reduction*** — An exhibit shall be provided that makes clear which areas are used to provide the requisite water quality volume, in full or in part, by removal of existing impervious areas. This exhibit shall be provided separate from other details and may not be part of the demolition plan.

7.1.3 Profile View

All profile sheets shall contain the following items:

1. ***Scale*** — The horizontal scale of the sewer profile shall always be the same as the scale of the corresponding plan view unless approved otherwise by DOSD. The vertical scale for profiles shall be of sufficient size to show necessary detail. A vertical scale of 1”=5’ is recommended for use with horizontal scales set at 1”=30’.
2. ***Stationing*** — Storm sewer stationing, surface elevations above the centerline of the sewer, and invert elevations shall be provided at the beginning and end of all profiles and at all 100 foot station intervals below all profiles. All sewer plans shall be submitted

with continuous stationing along the storm sewer profiles. The first station (0+00) shall begin at the downstream end of the longest sewer run and shall increase in a downstream-to-upstream fashion. The stationing for the next longest continuous length of sewer shall be restarted at 0+00 and shall proceed in the same downstream-to-upstream manner as the first. The process is repeated for each succeeding section of shorter sewer length. Match lines and break lines, in profile views, shall be made at 100 foot stations, or at structures. Station equations or negative stationing in the profile view will not be accepted except by written approval. The centerline station of all right-of-ways crossed by the storm sewer centerline shall be indicated.

3. ***Utility and Other Crossing*** — All utility crossings, whether existing or proposed, shall be shown as accurately as possible (based on existing available records) on the sewer profiles and identified as to their type and size. Other crossings such as streets, alleys, driveways, streams, ditches, etc. shall be shown and identified by name, centerline, edge of pavement, etc.
4. ***Structure and Pipe Annotation*** — All structures shall be labeled as to type, centerline station location, invert and top of casting elevations, and all other pertinent information. Pipes shall be labeled with their respective sizes, slopes, and distances. Pipe distances and slopes shall be determined from center-of-structure to center-of-structure stationing. Existing structures shall be drawn using dashed lines and proposed structures shall be drawn using solid lines.
5. ***Backfill, Backing, and Encasement*** — If the proposed backfill for the proposed sewer line is to be different from that specified under Item 901 in the CMSC, the type of backfill, and the limits thereof, shall be identified in the profile. Concrete encasement, when used, shall also be shown in the profile with the limits specified. Where the proposed storm sewer will be in fill areas less than 36” above the proposed top of pipe, the fill shall be designated to be placed to this level prior to installation of the pipe.
6. ***Ground Surfaces*** — Existing and proposed ground surfaces shall be shown and clearly marked. Existing surfaces shall be shown as a dashed line. Proposed ground surfaces shall be shown as a solid line.

7.1.4 Details and Cross Sections

All detail and cross-section sheets shall contain the following items:

1. ***Open channels*** — Typical cross sections shall be shown for all proposed open channel systems including, but not limited to, flood routing swales, roadside ditches, and minor storm conveyance channels. Typical cross sections shall show the appropriate dimensions and side slope values for each channel.
2. ***Culverts*** — A profile along each roadway culvert shall be provided showing invert, roadway edge of pavement and/or top of curb, roadway centerline, and design storm and 100 year headwater surface elevations. A table with each profile shall also be provided showing the design and 100-year storm discharge values and their respective outlet velocities.

3. ***Post-Construction Stormwater Control Practices*** — Dimensioned cross sections, elevation views and plan views for each SCP shall be shown. Elevations at which accumulated sediments must be removed and the volume of sediment at these elevations shall be included. A table showing the required WQ_v and drawdown time as well as the designed storage and designed drawdown time of the facility shall be shown. A list of the types and number of any plantings, if required, shall be included on the plans.
4. ***Detention Basins*** — Cross sections of detention basins, wet or dry, shall be provided and dimensioned. Side slopes, basin bottom slope, the elevation of each inlet and outlet structure, and maximum water surface elevations for WQ_v storage, the critical storm, and the 100-year storm shall be annotated. An elevation view and plan view of each outlet riser structure shall be provided and annotated. Cross sections showing side slope, side slope information, bottom width dimensions, overflow weir elevations, bottom lining etc. shall also be shown. A separate section of the emergency overflow width shall be provided.
5. ***Tables of Quantities for Stormwater Control Practices*** — All proposed post-construction SCPs shall have individual Tables of Quantities detailing line items required to be constructed to complete the SCP in accordance with the plans and/or plan details based on the current CMSC. The quantities from such tables must be carried over to the overall Estimate of Quantities table as described under 7.1.1.4. Refer to Appendix D for a matrix of typical CMSC bid items which may be required with different types of SCPs.

7.1.5 Stormwater Pollution Prevention Plan

Upon submittal of final plans for mylar signature, the Applicant shall prepare and submit to the City a complete, stand-alone Stormwater Pollution Prevention Plan (SWP3) in accordance with Ohio EPA's Construction General Permit. The format of the SWP3 shall follow the Stand-alone SWP3 Template provided in Appendix E. At a minimum, the stand-alone SWP3 shall include:

1. Construction Pollution Prevention Plan

    a. Approved Construction Pollution Prevention SWP3 prepared in accordance with the City's Regulation for Control of Stormwater Pollution from Land Disturbance, current version

    b. Construction log book

2. Post-Construction Stormwater Control

    a. Approved Stormwater Management Report, including post-construction stormwater control facility calculations, as specified in Section 6.

    b. Approved Stormwater Management Plans as specified in this Section.

3. Post-Construction Stormwater control Operations and Maintenance Plan as specified in Section 4.

    a. Operations and Maintenance Agreement between the Applicant, Owner responsible for long-term maintenance of the stormwater control facility(ies) and the City

    b. Stormwater Control Facility Overview

    c. Operations and maintenance procedures

    d. Operations and maintenance Report Template for Owner use
        - Maintenance checklists
        - Maintenance schedules

The complete stand-alone SWP3 shall be submitted to the City in PDF format.

7.1.6 Specific Requirements for Blue Roofs

Plans with roof top storage must include the following:

1. Dimensional drawings with roof outline.
2. Delineation of detention area(s)
3. Location of primary, secondary outlets and emergency overflow.
4. Location of roof top mechanicals (i.e. HVAC) and access hatches. These areas are to be excluded from detention area.
5. Outlet device (roof drain, scupper, overflow, etc.) specification and size.
6. Rooftop cross-section showing slope of roof, and the 100 year and maximum depth of ponding.
7. If multiple areas; provide table of detention volume, 100 year elevation, and outflow control device for each area, total detention volume, and total required detention volume.
8. List the total roof top detention in the Summary of Post-Construction Stormwater Control Facilities on plan title sheet.
9. Include the roof drain or scupper manufacturer make and model information along with a note that no substitution is allowed. Specification must include orifice size and number of drains.

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Appendix A

Project ____________________

Sheet ____ of ____

DITCH COMPUTATION SHEET

DITCH INFORMATION
MANNING'S "n" FOR:

Calculated by: ______________________________ **Date:** ______________

Checked by: ________________________________ **Date:** ______________

Seeded Lining: _________________
Sod or Jute Mat Lining: ________________
Paved Lining: _____________________
Dumped Rock Channel Protection: ____________________

ALLOWABLE VELOCITY FOR (in f.p.s.)
Seeded Lining: ___________________
Sod or Jute Mat Lining: ________________

Design Frequency For:
Velocity __________________ Yrs
Depth _____________ Yrs

DITCH CALCULATIONS

Ref. No	Station		Side	Drainage Area		Time			Intensity		Runoff Coef	Coe. X A		CiA		1 depth dc (ft.)	Slope ft./ft.	Velocity in f.p.s	Depth in ft.	Ditch Time Check	Treatment		
	High Point	Point of Solution		(acres)	ε A (acres)	Overland	Ditch	ε t	Velocity	Depth		Δ CA	ε CA	Qv	Qd						Lining	Station From	Station To

STORM SEWER CHECK SHEET

PROJECT: DATE:

BY: CHECKED BY: CONSULTANT: RETURN INTERVAL:

M.H. or C.B. No.	Sta.	ε CA (acres)	ε t (minutes)	Rainfall Intensity (in/hr)	Discharge Q (cfs)	Length of pipe (ft)	Size of pipe (inches)	Slope of pipe, S (ft/ft)	Minor losses H_m f(t)	S_f (ft/ft)	Hf=S_f L (feet)	TW or 0.8 D Elev.	HW Elev.	Crit. Elev.	Remarks

Appendix B

Appendix B
Native Plant Species
For Stormwater Control Practices

Selection of Native Plant Species

We are fortunate in Ohio to have a great diversity of plants to choose from, including many that thrive under adverse conditions. Native plants can be found to suit a variety of sites: wet or dry, sun or shade, high or low fertility, and acidic or calcareous soils[1]. When used correctly, native plants may:

- **Promote Biodiversity:** Contributes to the ecological balance of flora and fauna that have evolved in the geographic area. Natives perpetuate the relationships that exist between native plants, the soils, and the many organisms that depend upon them for survival. Biodiversity is degraded through the destruction of natural landscapes and their invasion by exotic species. Because biodiversity has evolved over thousand of years, this loss is irreversible.
- **Save Time, Money, and Energy:** Native plants generally require less maintenance making the use of natives less expensive. Because they are adapted to a local region, they tend to resist damage from freezing, drought, common diseases, or herbivores.
- **Conserve Natural Resources:** Because they are adapted to the soils, temperatures and rainfall patterns, native plants typically require less irrigation and fertilization than traditional plantings. Many native species thrive in poor soils. Native plants, used wisely, can protect water quality by controlling soil erosion and moderating floods and droughts.
- **Attract Wildlife:** Native plants are the best choice for attracting and nourishing native wildlife. Birds, mammals, butterflies and other wildlife depend on the many characteristics that native plants provide. These species have evolved with the local bird, mammal, butterfly and insect populations and are therefore their best source of food and habitat.
- **Genetic Resource**. Native plants serve as an important genetic resource for future food crops. However, in the long run, natives will, in most cases, form self-sustaining plant communities that provide the keystone elements for ecosystem restoration. They are a vital component of any native ecosystem.

For large SCPs (e.g., extended detention basins and stormwater wetlands) a natural or "informal" look may be desired. In these cases, a wider diversity of native plants may be appropriate. Such deviations must be approved in advance by the City of Columbus through an official submittal of planting plans and any additional pertinent drawings or specifications.

What are invasive plants?

Invasive species are aggressive non-native plants introduced into environments where they did not evolve. These species are also referred to as exotics, aliens, weeds, and non-indigenous species.

Invasive species are aggressive non-native plants introduced into environments where they did not evolve. These species are also referred to as exotics, aliens, weeds, and non-indigenous species. Invasive species spread rapidly, displacing native species and disrupting natural ecosystems by changing the composition, structure and function of natural plant communities.

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[1] The Ohio State University Extension Bulletin 865

[2] Ohio Administrative Code 901:5-30-01

Appendix B
Native Plant Species
For Stormwater Control Practices

The species in **Table B-1** are prohibited from being planted within stormwater facilities. It is strongly recommended that these species be prevented from becoming established within stormwater facilities through removal during routine maintenance activities

Table B-1
Common Invasive Plants Found in Ohio

Botanical Name	Common Name
Ailanthus altissima	Tree of Heaven
Alliaria petiolata	Garlic mustard
Berberis thunbergii	Japanese barberry
Berberis vulgaris	Common Barberry
Bromus inermis	Smooth Brome
Butomus umbellatus	Flowering Rush
Celastrus orbiculatus	Oriental Bittersweet
Centaurea stoebe ssp. Micranthos	Spotted Knapweed
Cirsium arvense	Canada thistle
Coronilla varia	Crown vetch
Dipsacus fullonum	Common Teasel
Dipsacus laciniatus	Cutleaf Teasel
Egeria densa	Elodea
Elaeagnus angustifolia	Russian Olive
Elaeagnus umbellata	Autumn Olive
Epilobium hirsutum	Hairy Willow Herb
Euonymous alatus	Burning bush
Euonymous fortunei	Wintercreeper vine
Frangula alnus	Glossy Buckthorn
Hemerocallis fulva[1]	Day lily
Heracleum mantegazzianum	Giant Hogweed
Hesperis matronlis	Dames Rocket
Hibanobambusa tranquillans, Indocalamus tessellatus, Phyllostachys spp., Pleioblastus spp., Pseudosasa japonica, Sasa senanensis, Shibataea kumasaca	Bamboo

[1] See attached citations and reference list for source information regarding invasive Hemerocallis species

Appendix B
Native Plant Species
For Stormwater Control Practices

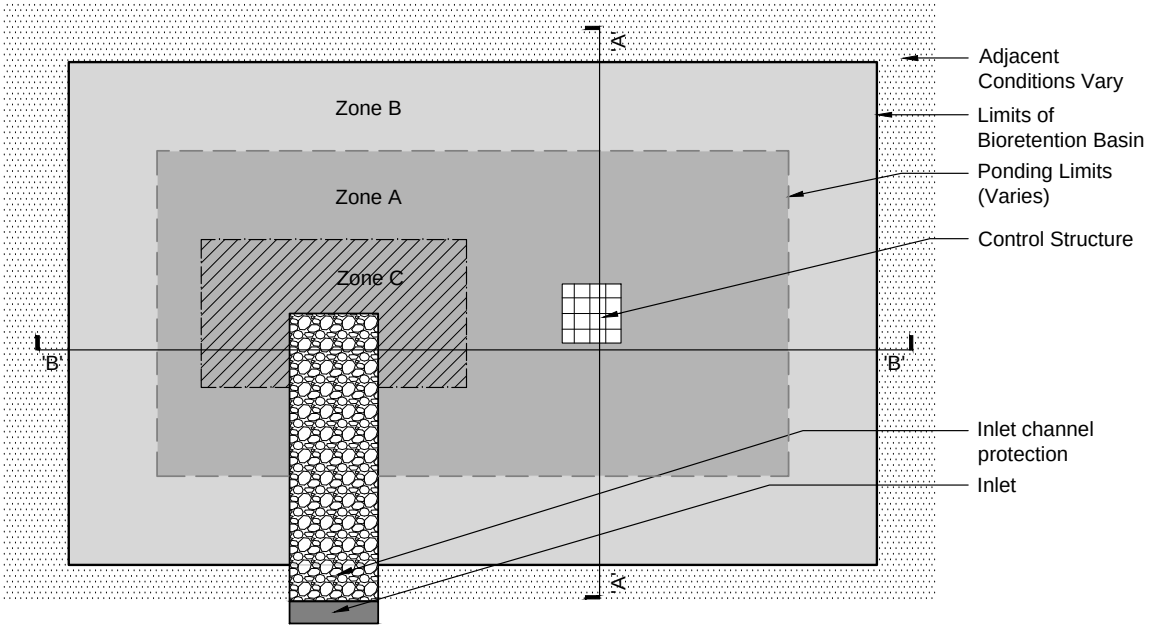
Hydrilla verticillata	Hydrilla
Hydrocharis morsus-ranae	European Frog-Bit
Iris pseudacorus	Yellow Iris
Ligustrum vulgare	Common privet
Lonicera maackii, L. morrowii, L. tatarica	Bush honeysuckle
Lonicera japonica	Japanese honeysuckle
Lythrum salicaria	Purple loosestrife
Lythrum virgatum	European Wand Loosestrife
Melilotus alba & M. officinalis	White & Yellow Sweet Clover
Microstegium vimineum	Japanese Stiltgrass
Myriophyllum aquaticum	Parrotfeather
Myriophyllum spicatum	Eurasian Water-Milfoil
Nymphoides peltata	Yellow Floating Heart
Phalaris arundinacea	Reed Canary Grass
Phragmites australis	Common Reed
Polygonum cuspidatum	Japanese knotweed
Potamogeton crispus	Curly-Leaved Pondweed
Pueraria montana var. lobate	Kudzu
Pyrus calleryana	Callery Pear
Ranunculus ficaria	Lesser celandine
Rhamnus cathartica	European Buckthorn
Rosa multiflora	Multiflora rose
Securigera varia	Crownvetch
Trapa natans	Water Chestnut
Typha angustifolia	Narrow-Leaved Cattail
Typha x glauca	Hybrid Cattail
Vinca minor	Periwinkle, Myrtle
Vincetoxicum nigrum	Black Swallowwort

Table B-2 and Table B-3 lists native plant species that are approved for use in stormwater control practices in the City of Columbus. The plants listed are generally available in nursery stock specializing in native plants. If no specific designation for use is shown, the designer must determine the survivability of the selected species based on site conditions.

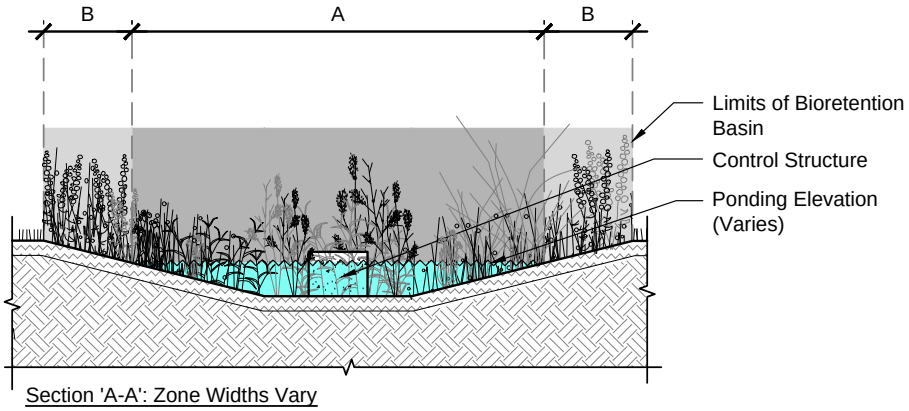
Appendix B
Native Plant Species
For Stormwater Control Practices

Figure B-1

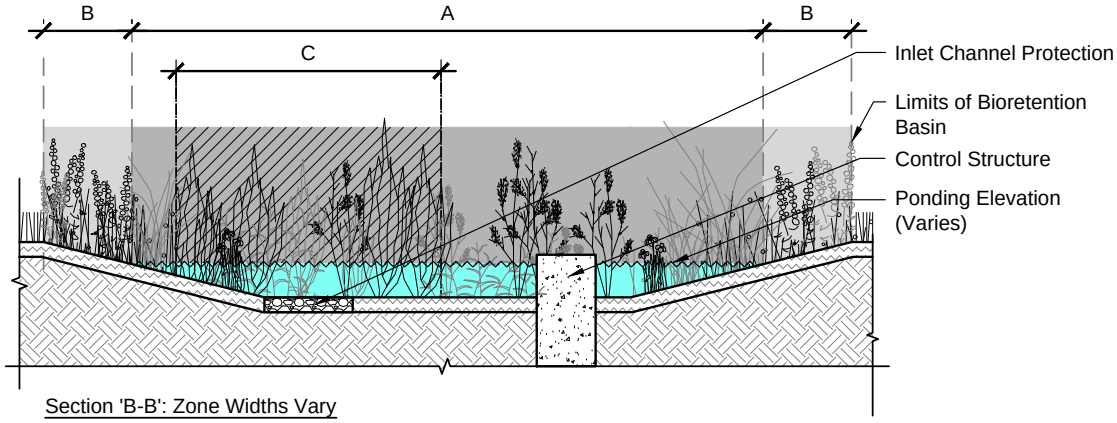
Water Tolerance Zones for SCP Plantings



Plan: Zone Widths Vary



Section 'A-A': Zone Widths Vary



Section 'B-B': Zone Widths Vary

Table B-2
Approved Native Plant Species[3]

Botanical Name	Common Name	Height*	Plant Selection Features						Salt Tolerant	Deer Resistant
			Shade	Sun	Wet	Ohio Native	Center Spacing	Plant Zone		
Perennials										
Amsonia 'Blue Ice'	Blue Ice Amsonia	1-1.5'					1.5-2'	B	Unknown	
Amsonia tabernaemontana 'Storm Cloud'	Storm Cloud Amsonia	2-2.5'	Part				2.5-3'	B		
Anemone canadensis	Meadow Anemone	1-2'	Part				2-2.5'	A		
Aquilegia canadensis	Wild Columbine	2-3'	Part				1-1.5'	B		
Asarum canadense	Wild Ginger	0.5-1'	Pt/Full				1-1.5'	B		
Asclepias tuberosa	Butterfly Weed	1-2.5'					1-1.5'	B	Moderate	
Athyrium filix-femina	Lady Fern	1-3'	Pt/Full				2-2.5'	B		
Athyrium filix-femina var angustum 'Lady in Red'	Lady in Red Fern	1.5-2.5'	Pt/Full				2-2.5'	B		
Baptisia alba	White Wild Indigo	2-4'	Part				2-2.5'	B		
Baptisia australis	Blue False Indigo	1-3'	Part				3-4'	B		
Campanula carpatica	Tussock Bellflower	1-3'	Part				1.5-2'	B	Unknown	
Chelone glabra	Turtlehead	2-3'	Part				2-2.5'	A/C		
Chelone obliqua	Red Turtlehead	2-3'	Part				1.5-2'	A/C		
Coreopsis lanceolata	Lanceleaf Coreopsis	1-2'					1-1.5'	B		
Dalea purpurea	Purple Prarie Clover	1-3'					1-1.5'	B		
Desmanthus illinoensis	Prarie Bundleflower	2-3'					2-2.5'	B		
Dryopteris marginalis	Marginal Wood Fern	1.5-2'	Pt/Full				1.5-2'	B	Unknown	
Echinacea 'Maui Sunshine'	Maui Sunshine Coneflower	2-3'	Part				1.5-2'	B		
Echinacea purpurea 'Butterfly Kisses'	Butterfly Kisses Purple Coneflower	1-1.5'	Part				1.5-2'	B		
Echinacea purpurea 'Cheyenne Spirit'	Cheyenne Spirit Purple Coneflower	1-2.5'					1.5-2'	B		
Echinacea purpurea 'Fatal Attraction'	Fatal Attraction Purple Coneflower	1.5-2'	Part				1.5-2'	B		
Echinacea purpurea 'PowWow White'	PowWow White Purple Coneflower	2-2.5'					1.5-2'	B		
Echinacea purpurea 'PowWow Wild Berry'	PowWow Wild Berry Purple Coneflower	2-2.5'					1.5-2'	B		
Echinacea purpurea 'Prairie Splendor'	Prairie Splendor Purple Coneflower	1-2'					1.5-2'	B		
Echinacea 'Sunrise'	Big Sky Sunrise Coneflower	2-3'	Part				1.5-2'	B		
Eryngium yuccifolium	Rattlesnake Master	4-5'					2-3'	B		
Eutrochium dubium 'Baby Joe'	Baby Joe Pye Weed	2-3'	Part				1.5-2'	A/C		
Eutrochium maculatum 'Red Dwarf'	Red Dwarf Joe Pye Weed	2-3'	Part						Unknown	
Helianthus mollis	Ashy Sunflower	2-4'					2-3'	B		Unknown
Iris versicolor	Blue Flag Iris	2-2.5'	Part				2-2.5'	A/C		
Iris virginica var. shrevei	Southern Blue Flag Iris	1.5-2'					1.5-2'	A/C		
Liatris microcephala	Small-Headed Blazing Star	1.5-2'					1-1.5'	B	Unknown	
Liatris spicata 'Kobold'	Dense Blazing Star	1.5-2.5'					1-1.5'	A		

[3] See attached citations and reference list for source information.

Table B-2
Approved Native Plant Species[3]

Botanical Name	Common Name	Height*	Plant Selection Features						Salt Tolerant	Deer Resistant
			Shade	Sun	Wet	Ohio Native	Center Spacing	Plant Zone		
Liatris squarrosa	Scaly Blazing Star	1-2'					1-1.5'	B	Unknown	
Lobelia cardinalis	Cardinal Flower	2-4'	Part				1-1.5'	A		
Lobelia cardinalis 'Black Truffle'	Black Truffle Cardinal Flower	3-4'	Part				2-3'	A		
Lupinus perennis	Sundial Lupine	3-4'					1.5-2'	B		
Monarda fistulosa	Wild Bergamot	2-4'	Part				2-2.5'	B		
Onoclea sensibilis	Sensitive Fern	3-4'	Pt/Full				3-4'	A/C		
Penstemon digitalis	Foxglove Beardtongue	3-5'					1.5-2'	B		
Phlox stolonifera 'Home Fires'	Home Fires Creeping Phlox	0.5-1'	Part				1'	B	Unknown	
Phlox stolonifera 'Sherwood Purple'	Sherwood Purple Creeping Phlox	0.5-1'	Part				1'	B		
Phlox subulata 'Emerald Blue'	Emerald Blue Moss Phlox	0.25-0.5'					1-1.5'	B	Moderate	
Phlox subulata 'Snowflake'	Snowflake Phlox	0.25-0.5'	Part				1-1.5'	B		
Polygonatum biflorum	Solomon's Seal	1-3'	Pt/Full				1'	B		
Pycnanthemum tenuifolium	Slender Mountain Mint	2-3'	Part				2-3'	A/B/C		
Rudbeckia fulgida 'Goldsturm'	Goldsturm Coneflower	2-2.5'					1.5-2'	B		
Silene regia	Royal Catchfly	3-4'	Part				1.5-2'	B	Unknown	
Symphyotrichum ericoides 'Snowflurry'	Snowflurry Heath Aster	0.25-0.5'					1-1.5'	B		
Symphyotrichum laeve	Smooth Blue aster	2-4'					1-1.5'	B		
Symphyotrichum novae-angliae 'Kickin Lilac Blue'	Kickin' Lilac Blue New England Aster	1.5-2'					2.5-3'	A		
Symphyotrichum novae-angliae 'Purple Dome'	Purple Dome New England Aster	1.5-2'					2.5-3'	A	Moderate	
Symphyotrichum novae-angliae 'Vibrant Dome'	Vibrant Dome New England Aster	1.5-2'					1-1.5'	A/B		
Symphyotrichum oblongifolium 'Raydons Favorite'	Raydon's Favorite Aromatic Aster	2-3'					1-1.5'	B		
Symphyotrichum oblongifolium 'October Skies'	October Skies Aromatic Aster	1.5-2'					2'	A		
Grasses/Sedges										
Bouteloua curtipendula	Side-oats Grass	1.5-2.5'					1-1.5'	B		
Bouteloua gracilis 'Blonde Ambition'	Blue grama Grass	1-2.5'					1-1.5'	B		
Carex frankii	Frank's Sedge	1-2'	Part				1-1.5'	A		
Carex haydenii	Hayden's Sedge	1-1.5'	Pt/Full				1-1.5'	A	Unknown	
Carex pensylvanica	Pennsylvania Sedge	0.5-1'	Pt/Full				1	B		
Carex stricta	Tussock Sedge	1-3'	Part				1-1.5'	A		
Carex vulpinoidea	Fox Sedge	1-3'	Part				1.5-2'	A/C		
Deschampsia cespitosa	Tufted Hair Grass	2-3'	Part				1.5-2'	A/C		
Panicum virgatum 'Cape Breeze'	Cape Breeze Switch-Grass	2-3'	Part				2-3'	B/C		
Panicum virgatum 'Cheyenne Sky'	Cheyenne Sky Switch-Grass	2-3'	Part				2-3'	A/B/C		
Panicum virgatum 'Heavy Metal'	Heavy Metal Switch-Grass	4-5'					2-3'	B/C		
Panicum virgatum 'Northwind'	Northwind Switch-Grass	4-6'	Part				2-3'	B		

Table B-2
Approved Native Plant Species[3]

Botanical Name	Common Name	Height*	Plant Selection Features						Salt Tolerant	Deer Resistant
			Shade	Sun	Wet	Ohio Native	Center Spacing	Plant Zone		
Panicum virgatum 'Shenandoah'	Shenandoah Switch-Grass	3-4'	Part				2-3'	B		
Schizachyrium scoparium 'Carousel'	Carousel Little Bluestem	2-2.5'					2-3'	B		
Schizachyrium scoparium 'Standing Ovation'	Standing Ovation Little Bluestem	2-4'					1.5-2'	B		
Schizachyrium scoparium 'The Blues'	The Blues Little Bluestem	2-4'					1.5-2'	B		
Schizachyrium scoparium 'Smoke Signal'	Smoke Signal Little Bluestem	2-4'					1.5-2'	B		
Sporobolus heterolepis	Prairie Dropseed	2-3'					2.5-3'	B	Moderate	
Sporobolus heterolepis 'Tara'	Tara Prairie Dropseed	2-2.5'					2.5-3'	B	Moderate	
Shrubs										
Aronia melanocarpa 'Autumn Magic'	Autumn Magic Black Chokeberry	3-6'	Part				4-5'	B		
Aronia melanocarpa 'Ground Hog'	Ground Hog Black Chokeberry	8-14"	Part				2.5-3'	B		
Aronia melanocarpa 'Low Scape Mound'	Low Scape Mound Black Chokeberry	1-2'	Part				1.5-2'	B		
Aronia melanocarpa 'Morton'	Morton Iroquois Beauty Black Chokeberry	2-3'	Part				3-4'	A/B	Moderate	
Aronia melanocarpa 'Viking'	Viking Black Chokeberry	3-6'	Part				6'	B		
Cephalanthus occidentalis	Buttonbush	5-12'	Part				5-6'	C		
Cornus sericea 'Farrow' Arctic Fire	Farrow Arctic Fire Red Twig Dogwood	3-4'	Part				4'	A/C		
Cornus sericea 'Kelseyi'	Kelseyi Dwarf Dogwood	2-2.5'	Part				2-3'	A/C		
Hypericum frondosum 'Sunburst'	Sunburst Golden St.-John's-Wort	3-4'	Part				3-4'	B	Unknown	Unknown
Hypericum kalmianum 'Blue Velvet'	Blue Velvet St.-John's-Wort	2-3'	Part				3-4'	A/B		Unknown
Hypericum kalmianum 'Gemo'	Gemo St. John's Wort	2-3'	Part				3-4'	B		
Ilex verticillata 'Jim Dandy'	Jim Dandy Winterberry	3-6'	Part		Low pH		6-8'	A/B/C		
Ilex verticillata 'Nana'	Nana Red Sprite Winterberry	2.5-3'	Part		Low pH		4'	A/B/C		
Itea virginica 'Henry's Garnet'	Henry's Garnet Sweetspire	3-4'	Pt/Full				4-6'	A/B		
Itea virginica 'Sprich' Little Henry	Little Henry Dwarf Sweetspire	1.5-2.5'	Part				2-3'	A/B	Unknown	
Physocarpus opulifolius 'Seward' Summer Wine	Summer Wine Ninebark	4-6'	Part				4-6'	B		Unknown
Physocarpus opulifolius 'Tiny Wine'	Tiny Wine Ninebark	3-4'	Part				3-4'	B		Unknown
Rhus aromatica 'Grow-Low'	Grow-Low Fragrant Sumac	1.5-2'	Part				6'	B		
Deciduous Trees										
Acer rubrum 'Autumn Flame'	Autumn Flame Red Maple	40-60'	Part				40'	A/B		
Acer rubrum 'Franksred' Red Sunset	Red Sunset Red Maple	40-50'	Part				40'	A/B		
Acer rubrum 'October Glory'	October Glory Red Maple	40-50'	Part				40'	A/B		
Acer rubrum 'Sun Valley'	Sun Valley Red Maple	20-35'	Part				25'	A/B		
Amelanchier arborea	Downy Serviceberry	15-25'	Part				20'	B		
Amelanchier laevis	Serviceberry	15-40'	Part				40'	B		
Betula nigra 'Dura Heat'	Dura Heat River Birch	30-40'	Part				35'	A/B		
Celtis occidentalis 'Prairie Pride'	Prairie Pride Hackberry	40-60'	Part				50'	A/B		

Table B-2
Approved Native Plant Species[3]

Botanical Name	Common Name	Height*	Plant Selection Features						Salt Tolerant	Deer Resistant
			Shade	Sun	Wet	Ohio Native	Center Spacing	Plant Zone		
Cercis canadensis	Redbud	20-30'	Part					B		
Cornus florida	Flowering Dogwood	15-30'	Part				25'	B		
Cornus racemosa	Panicled Dogwood	10-15'	Part				15'	A/B		
Gleditsia triacanthos f. inermis 'Skycole' Skyline	Skyline Thornless Honeylocust	60-80'					60'	B		
Nyssa sylvatica	Black Gum	30-50'	Part		Low pH		30'	A		
Ostrya virginiana	American Hop Hornbeam	25-40'	Part				30'	B		
Platanus occidentalis	American Sycamore	75-100'					80'	A/B		
Quercus bicolor	Swamp White Oak	50-60'	Part				60'	A/B		
Quercus macrocarpa	Bur Oak	60-80'	Part				60'	B		
Quercus palustris	Pin Oak	60-70'					60'	A/B		

Legend

Note:	Designer shall consider long term maintenance requirements when making plant selections.
	= Suitable Plant
Height	For installations within ROW: ≤2.5' suitable for bioretention bottom or side slopes; ≤3' suitable for bottom of bioretention only * Suitability for ROW basin bottom/slope assumes basin bottom is depressed at least 6" below street centerline; top of plants at maturity within ROW basins shall be ≤2.5' above street centerline grade. Heights and spacing represent typical ranges. Varying site conditions affect plant sizes and should be considered when selecting plants.
Native	= Native to Ohio region or Eastern United States
Wet	= May be suitable for use at locations within the basin near inlets or in basins with large runoff ratios (impervious runoff area to area of basin > 10:1)
Sun	= Plant performs well in full sun to part shade
Shade	= Plant performs well in part shade to full shade

Appendix B
Native Plant Species
For Stormwater Control Practices

Figure B-2

Water Tolerance Zones for SCP Wetland Plantings

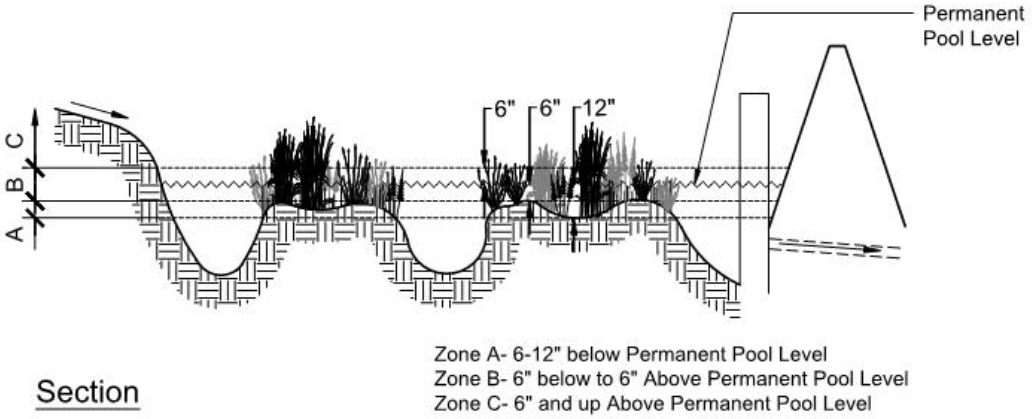


Table B-3

Approved Native Plant Species for Detention and Stormwater Wetlands[3]

Botanical Name	Common Name	Height	Center Spacing	Colonization	Plant Zone	Salt Tolerant	Deer Resistant
Perennials							
Alisma subcordatum	Southern Water-Plantain	2-3'	1.5-2'	Rapid	A		
Iris versicolor	Blue Flag Iris	2-2.5'	2-2.5'	Moderate	A		
Lycopus americanus	American Water-Horehound	2-3'	1-2'	Rapid	A		
Peltandra virginica	Green Arrow Arum	2-3'	1.5-2'	Moderate	A		
Nymphaea odorata	Fragrant Water-lily	0-1'	1.5-3'	Rapid	A		
Pontederia cordata	Pickerelweed	2-3'	0.5-1.5'	Rapid	A		
Sagittaria latifolia	Common Arrowhead	1-4'	1-3'	Moderate	A		
Sparganium eurycarpum	Giant Bur-Reed	3-4'	1.5-2'	Rapid	A		
Asclepias incarnata	Swamp Milkweed	4-5'	2-3'	Rapid	A/B		
Eupatorium fistulosum	Hollow-Stemmed Joe Pye Weed	7-10'	1-2'	Rapid	A/B		
Eupatorium perfoliatum	Common Boneset	4-6'	3-4'	Rapid	A/B		
Helenium autumnale	Common Sneezeweed	3-4'	2-3'	Rapid	A/B		
Lobelia siphilitica	Great Blue Lobelia	2-3'	1-1.5'	Moderate	A/B		
Rudbeckia laciniata	Green-Headed Coneflower	2-9'	1.5-3'	Moderate	A/B		
Symphyotrichum novae-angliae	New England Aster	3-6'	2-3'	Rapid	A/B		
Verbena hastata	Blue Vervain	2-6'	1-2'	Rapid	A/B		
Verbesina alternifolia	Wingstem	4-8'	2-6'	Rapid	B		
Monarda didyma	Bee-Balm	2-4'	2-3'	Moderate	B/C		
Pycnanthemum virginianum	Virginia Mountain-Mint	2-3'	1-2'	Moderate	B/C		
Asclepias tuberosa	Butterfly Weed	1-2.5'	1-1.5'	Slow	C		
Chamaecrista fasciculata	Partridge-Pea	1-3'	1-3'	Rapid	C		
Desmodium canadense	Canada Tick-Trefoil	3-4'	1.5-2'	Moderate	C		
Echinacea purpurea	Purple Coneflower	2-5'	1.5-2'	Moderate	C		
Heliopsis helianthoides	Smooth Oxeye	4-6'	3-4'	Rapid	C		
Phlox pilosa	Downy Phlox	1-1.5'	1-1.5'	Moderate	C		
Ratibida pinnata	Gray-Headed Coneflower	4-6'	1-2'	Rapid	C		
Rudbeckia hirta	Black-Eyed Susan	2-3'	1-2'	Moderate	C		
Rudbeckia triloba	Three-Lobed Coneflower	2-3'	1-1.5'	Rapid	C		
Symphyotrichum laeve	Smooth Blue Aster	2-4'	1-1.5'	Moderate	C		
Grasses/Sedges/Rushes							
Bolboschoenus fluviatilis	River Bulrush	4-6'	1.5-2'	Rapid	A		
Carex lurida	Bottlebrush Sedge	1-2'	1-2'	Rapid	B		
Carex scoparia	Pointed Broom Sedge	2-3'	1-1.5'	Moderate	B		
Carex vulpinoidea	Fox Sedge	1-3'	1.5-2'	Moderate	B		
Eleocharis obtusa	Blunt Spike-Rush	1-1.5'	0.5-0.75'	Moderate	B		
Eleocharis palustris	Small's Spike-Rush	1-2'	1-2'	Moderate	B		
Glyceria striata	Fowl Manna Grass	4-6'	2-3'	Moderate	A		
Scirpus atrovirens	Green Bulrush	3-4'	1-1.5'	Rapid	A		
Elymus virginicus	Virginia Wild Rye	3-4'	1-1.5'	Moderate	A/B		
Juncus effusus	Soft Rush	2-4'	2-4'	Rapid	A/B		
Schoenoplectus pungens	Three-Square	2-5'	0.5'	Moderate	A/B		
Scirpus cyperinus	Wool Grass	4-6'	2-3'	Moderate	A/B		

Table B-3

Approved Native Plant Species for Detention and Stormwater Wetlands[3]

Botanical Name	Common Name	Height	Center Spacing	Colonization	Plant Zone	Salt Tolerant	Deer Resistant
Andropogon gerardii	Big Bluestem	4-6'	2-3'	Moderate	B/C	■	■
Juncus tenuis	Path Rush	0.5-2'	0.5-2'	Rapid	B/C	■	■
Panicum virgatum	Switch Grass	3-6'	2-3'	Rapid	B/C	■	■
Agrostis perennans	Autumn Bent Grass	1-3'	1-1.5'	Moderate	C		■
Elymus canadensis	Canada Wild Rye	4-6'	1.5-2'	Rapid	C	■	■
Schizachyrium scoparium	Little Bluestem	6-8'	6-8'	Moderate	C	■	■
Sorghastrum nutans	Indian Grass	4-6'	1.5-2'	Rapid	C	■	■
Shrubs							
Cephalanthus occidentalis	Buttonbush	5-12'	5-6'	Moderate	A	■	■
Salix exigua	Sandbar Willow	12-20'	6-8'	Rapid	A	■	■
Aronia arbutifolia	Red Chokeberry	6-10'	3-5'	Slow	A/B	■	
Cornus amomum	Silky Dogwood	6-12'	6-12'	Rapid	A/B		■
Cornus sericea	Red-Osier Dogwood	6-9'	7-10'	Rapid	A/B	■	■
Salix sericea	Silky Willow	10-12'	8-12'	Rapid	A/B	■	■
Sambucus canadensis	Common Elderberry	8-12'	6-8'	Rapid	A/B	■	■
Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush	6-8'	1-2'	Rapid	A/B	■	■
Aronia melanocarpa	Black Chokeberry	3-6'	3-6'	Slow	B/C	■	
Cornus racemosa	Panicled Dogwood	10-15'	15'	Rapid	B/C		■
Viburnum lentago	Nannyberry	12-15'	8-12'	Rapid	B/C	■	
Rhus typhina	Staghorn Sumac	15-25'	20-30'	Rapid	C	■	
Viburnum prunifolium	Black-Haw	12-15'	8-12'	Rapid	C	■	
Deciduous Trees							
Betula nigra	River Birch	40-70'	30-50'	Moderate	A/B	■	■
Platanus occidentalis	American Sycamore	75-100'	80'	Rapid	A/B	■	■
Quercus bicolor	Swamp White Oak	50-60'	60'	Rapid	A/B	■	■
Quercus palustris	Pin Oak	60-70'	60'	Rapid	A/B	■	■
Salix amygdaloides	Peachleaf Willow	40-60'	60'	Rapid	A/B	■	
Salix discolor	Pussy Willow	10-20'	4-12'	Rapid	A/B	■	
Salix nigra	Black Willow	30-60'	30-60'	Rapid	A/B	■	■
Acer rubrum	Red Maple	40-70'	30-50'	Moderate	B/C	■	■
Amelanchier laevis	Serviceberry	15-40'	40'	Moderate	B/C	■	■
Quercus macrocarpa	Bur Oak	60-80'	60'	Moderate	B/C	■	■
Acer saccharum	Sugar Maple	40-80'	30-60'	Slow	C		
Aesculus glabra	Ohio Buckeye	20-40'	20-40'	Moderate	C		■
Cercis canadensis	Redbud	20-30'	35'	Moderate	C	■	
Fagus grandifolia	American Beech	50-80'	40-80'	Slow	C	■	■
Liriodendron tulipifera	Tulip Tree	60-90'	30-50'	Rapid	C		
Quercus alba	White Oak	50-80'	50-80'	Slow	C	■	■
Quercus rubra	Red Oak	50-75'	50-75'	Rapid	C	■	
Robinia pseudoacacia	Black Locust	30-50'	20-35'	Rapid	C	■	■

Legend

Note:	Designer shall consider long term maintenance requirements when making plant selections.
■	= Suitable Plant
Height	Heights and plant widths represent typical ranges. Varying site conditions affect plant sizes and should be considered when selecting plants.
Center Spacing	

Appendix B
Native Plant Species
For Stormwater Control Practices

Citations and References for Native Plant Species:

"901:5-37-01 Prohibited Noxious Weeds." *Ohio Administrative Code*, codes.ohio.gov/oac/901%3A5-37.

Andreas, Barbara K.; Mack, John J.; and McCormac, James S. 2004 Floristic Quality Assessment Index (FQAI) for Vascular Plants and Mosses for the State of Ohio. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group. Columbus, Ohio.

Barnes, Linda Sue. "Listing Hemerocallis Fulva as an Invasive Species. ." *American Hemerocallis Society*, oldsite.daylilies.org/AHSinforeleaseinvasives.pdf

City of Portland Bureau of Environmental Services. 2004. Stormwater Management Manual. Chapter 2.7 and Appendix F. *available at* www.portlandonline.com/bes

Czarapata, Elizabeth. 2005. Invasive Plants of the Upper Midwest. University of Wisconsin Press.

Hendricks, B. (n.d.). Plants Tolerant of Deicing Salt in Soils - Klyn Nurseries Inc. Retrieved March 1, 2019, from http://klynnurseries.com/resources/plants_on_a_high_sodium_diet.doc

"Invasive Plants of Ohio." *Ohio Invasive Plants Council*, www.oipc.info/invasive-plants-of-ohio.html.

Jull, Laura G. "Winter Salt Injury and Salt Tolerant Landscape Plants." *City of Dane*, Board of Regents of The University of Wisconsin System, 2009, Winter Salt Injury and Salt-tolerant Landscape Plants.

Mack, John J. 2004. Integrated Wetland Assessment Program. Part 4: Vegetation Index of Biotic Integrity (VIBI) and Tiered Aquatic Life Uses (TALUs) for Ohio wetlands. Ohio EPA Technical Report WET/2004-4. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois. 1997. Prepared by USDA Natural Resources Conservation Service's Chicago Metro Urban and Community Assistance Office
In cooperation with
US Environmental Protection Agency, Region 5
US Fish and Wildlife Service, Chicago Field Office
US Army Corps of Engineers, Chicago District

Native Ohio Tree Species Suitable for Planting within 1,000 feet of State Wild, Scenic and Recreational Rivers. 2005. Ohio Department of Natural Resources, Division of Natural Areas and Preserves.

Ohio DNR, Division of Natural Areas and Preserves; and The Nature Conservancy. 2000. Ohio's Invasive Plant Species. ODNR DNAP (614) 265-6453 or ODNR Div of Wildlife (614) 265-6309. TNC (6114) 717-2770

Appendix B
Native Plant Species
For Stormwater Control Practices

"OHIO'S INVASIVE PLANT SPECIES." *Ohio Department of Natural Resources*, Apr. 2000, ohiodnr.gov/portals/0/pdfs/invasives/ohio-invasive-plants-r0400.pdf.

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Swearingen, J., B. Slattery, K. Reshetiloff, and S. Zwicker. 2010. Plant Invaders of Mid-Atlantic Natural Areas, 4th ed. National Park Service and U.S. Fish and Wildlife Service. Washington, DC. 168pp.

Thunhorst, Gwendolyn A. 1993. Wetland Planting Guide for the Northeastern United States; Plants for Wetland Creation, Restoration, and Enhancement. Environmental Concern, Inc.; St Michaels MD 21663.

USDA, NRCS. 2019. The PLANTS Database (http://plants.usda.gov, 7 March 2019). National Plant Data Team, Greensboro, NC 27401-4901 USA.

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Appendix C

EXHIBIT A
General Notes
To Be Included Within the CC-Plans

- THE CITY OF COLUMBUS CONSTRUCTION AND MATERIALS SPECIFICATIONS (CMSC), 2018 EDITION, REVISION **(mm/dd/yyyy)**, **INCLUDING ALL REVISIONS AND SUPPLEMENTS THERETO, SHALL GOVERN ALL CONSTRUCTION ITEMS THAT ARE A PART OF THIS PLAN UNLESS NOTED OTHERWISE.** ***[note revision as per DPU Administrator 10/3/2018]***

- The Contractor shall notify the following Divisions at least 24-hours in advance of anticipated start of construction:

  Division of Sewerage and Drainage (614) 645-7102

  Division of Design and Construction (Construction Section) (614) 645-0433

- The Contractor is responsible for the investigation, location, support, protection, and restoration of all existing utilities and appurtenances whether shown on these plans or not. The Contractor shall expose all utilities or structures prior to construction to verify the vertical and horizontal effect on the proposed construction. The Contractor shall call, toll free, the Ohio Utilities Protection Service (1-800-362-2764) 48-hours prior to construction and shall notify all utility companies at least 48-hours prior to work in the vicinity of their underground lines.

- Construction of this project may not begin until the easements indicated have been recorded by the City.

- The Developer/Owner shall, prior to any construction operation, deposit with the City the total estimated costs for inspection and where required a repaving guarantee.

- Any modification to the work as shown on these drawings must have prior written approval by the Administrator, Division of Sewerage and Drainage.

- All plastic sewer lines shall be deflection tested after installation in conformance with the requirements of item 901 of the City of Columbus, Construction and Material Specifications, current version.

- All concrete pipe, storm and sanitary sewer structures will be stamped or have such identification noting that said pipe, storm and sanitary structures have been inspected by the City of Columbus and meets their specifications. Pipe and structures without proper identification will not be permitted for installation.

- Erosion and sediment control measures are required as part of this project. Erosion and Sediment Control measures specific to this site may be found on Sheet No. __ of this plan. Land-disturbing activities must comply with all provisions of the Division of Sewerage and Drainage Regulation for Control of Stormwater Pollution from Land Disturbance. All land-disturbing activities shall be subject to inspection and site investigation by the City of Columbus and/or the Ohio EPA.

- It is the responsibility of the site owner to notify the City of Columbus two working days prior to commencement of initial site land disturbance on any site of one or more acres. This includes site clearing, grubbing and any earth moving. Primary erosion and sediment control practices are mandated by regulation to be in place from the beginning of the construction activity. Please contact the Stormwater and Regulatory Management Section at (614) 645-6311. Details of this requirement may be found in the Regulation for Control of Stormwater Pollution from Land Disturbance. Failure to comply may result in enforcement action..

  THIS NOTE SHALL BE ADDED TO ANY PLAN **WHERE CITY OF COLUMBUS PARK PROPERTY MAY BE INVOLVED IN THE LIMITS OF CONSTRUCTION:**

  "The Contractor is hereby notified to contact the City Forester of the Recreation and Parks Department (Phone: (614) 645-3350) 24-hours prior to any construction in or near the park property."

- The Contractor shall ensure there is a surveyor's level and rod on the project for use in performing grade checks whenever sewer line structures or pipe are being installed. The Contractor shall make this equipment available for use and assist the City inspector in performing grade checks when requested by the inspector. The inspector will make all reasonable attempts to confine requests for assistance in performing grade checks to times convenient to the Contractor.

  These checks will be performed to ensure the following:
  1. Proper placement of each structure.
  2. Proper installation of initial runs of pipe from a structure.
  3. Grade, after an overnight or longer shutdown.
  4. Grade, at any other time the inspector has reason to question grade of installation.

  Grade checks performed by the City inspector in no way relieve the Contractor of the ultimate responsibility to ensure construction to the plan grade.

- The amount of fill within designated FEMA floodplain areas onsite is ____ C.Y. The amount of fill compensated within designated FEMA floodplain areas onsite is ____ C.Y.

- The ponding or detention areas shown on the plans are a part of the storm sewer facilities. The Developer/Owner will assume the responsibility to maintain the ponding or detention areas so as not to reduce the water storage areas. If the Owner does not maintain the ponding and detention areas, the plan will become void and the City will plug the sewer at the outlet.

  As a condition of final acceptance, the property owner shall be responsible for providing as-built surveys to verify the final grades and elevations of stormwater control facilities. At the completion of construction, the Owner/Developer shall field survey the stormwater detention facility to verify that the facilities are constructed according to approved plans. Should a discrepancy between the plans and constructed grades exist, the design storage of the detention facility shall be restored by the Owner/Developer as directed by the City of Columbus.

- Immediately after placement of any conduits, the contractor shall construct the end treatments required by the plans at both the outlet and inlet ends. This shall include headwalls, concrete, rip rap, rock channel protection, sodding, pouring bottoms, mudding lift holes, etc.

Exhibit B
Sample Signature Block
To Be Included on the Cover Sheet of the CC Plans

APPROVALS: SIGNATURES BELOW SIGNIFY ONLY CONCURRENCE WITH THE GENERAL PURPOSES AND GENERAL LOCATION OF THE PROJECT. ALL TECHNICAL DETAILS REMAIN THE RESPONSIBILITY OF THE ENGINEER PREPARING THE PLANS. APPROVAL FOR STORM WATER DRAINAGE ONLY.

	DATE	ADMINISTRATOR, DIVISION OF SEWERAGE AND DRAINAGE	DATE
ADMINISTRATOR, DIVISION OF POWER	DATE	CITY ENGINEER,/ADMINISTRATOR, DIVISION OF DESIGN AND CONSTRUCTION	DATE
ADMINISTRATOR, DIVISION OF WATER	DATE		DATE
	DATE		DATE

- FOR PROJECTS NEAR PARK PROPERTY

DIRECTOR, DEPARTMENT OF RECREATION AND PARKS	DATE

Note: Refer to DOSD digital submittal standards for current title block format.

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Exhibit C - Plan Review Checklist for CC Drawings

Plans

_____ **Registered Engineer signature and seal**
_____ **22” x 34” paper size**
_____ **22” x 34” mylar (final plans only)**
_____ **Digital submittal on disk/CD**
_____ **Completed CC-drawing application form**
_____ **Easement Descriptions and Exhibits**
_____ **Seven (7) sets of check prints**

Master Drainage Plan

_____ **Project Title**
_____ **North arrow and scale**
_____ **Project boundaries**
_____ **Existing and proposed topography at two-foot contour intervals**
_____ **Pre-development and post-development sub-basins**
_____ **Location and capacity of the immediate downstream receiving waterway or drainage system**
_____ **Pre-development and post-development major routing flow paths**
_____ **Soil type by sub-basin**
_____ **Streams and Stream Corridor Protection Zones**
_____ **Proposed stormwater facilities**
_____ **Existing field tile locations**
_____ **Lines designating the phases of multiphase development projects**
_____ **Lot lines, streets, right-of-ways, setbacks, and easements**
_____ **Flood Hazard limits and classifications**
_____ **Regulated wetlands**
_____ **All outfalls identified with major outfalls clearly labeled**

Calculations

_____ **Stream Corridor Protection Zone and Floodplain Compensation**
- _____ **Stream Corridor Protection Zone sizing calculations**
- _____ **Floodplain fill volume calculations**
- _____ **Compensatory floodplain fill volume calculations**

_____ **Impervious Area**

_____ **Storm sewers**
- _____ **Pipe sizing calculations**
- _____ **Hydraulic grade line check calculations**
- _____ **Pavement spread calculations**
- _____ **Inlet spacing/capacity calculations**
- _____ **Inlet tributary area map(s)**

_____ **Culverts**
- _____ **Hydrologic calculations**
- _____ **Hydraulic calculations/overtopping analysis**
- _____ **Tributary area map**

_____ **Constructed Open Watercourses**
- _____ **Ditch sizing calculations**
- _____ **Tributary area map**
- _____ **HEC-2 analysis, if required**

_____ **Flood routing**
- _____ **Hydrologic calculations**
- _____ **Hydraulic calculations**

_____ **Stormwater Quantity Controls**
- _____ **Predeveloped flow calculations**
- _____ **Post developed flow calculations**
- _____ **Critical Storm determination calculations**
- _____ **Stage-discharge curve**
- _____ **Stage-storage curve**
- _____ **Routing calculations**
- _____ **Storage Volume Table (shown on plans)**

_____ **Stormwater Quality Controls**
- _____ **Water quality volume (WQv) calculations**
- _____ **Drawdown calculations**
- _____ **Required areas for media filters (Group 2)**
- _____ **Design and design flow rate for swale and filters strips (Group 3)**
- _____ **SCP Maintenance plan**
- _____ **Commercial Activity Areas**
  - _____ **Location shown and area clearly delineated**
  - _____ **Standard Industrial Classification (SIC) identified**
  - _____ **Materials handling areas clearly delineated**
  - _____ **High-risk and low-risk pollutant source identified**

_____ **On-site storm and sanitary sewer systems including discharges and outfalls shown**
_____ **If applicable, oil/water separator, spill containment (110% of volume stored) and treatment systems shown**
_____ **Area covered from rainfall with cover or roof of required dimensions**
_____ **Area graded to minimize runoff**
_____ **Appropriate methods for material disposal shown including sanitary sewer or other**

Easement Descriptions

_____ **Legal Descriptions**
_____ **Legal size paper**
_____ **Registered surveyor signature and seal**

_____ **Exhibits**
_____ **Legal size paper**
_____ **Registered surveyor signature and seal**

_____ **Owner Name**
_____ **Mailing address**
_____ **Phone number**

Title Sheet

_____ **Correct project title**
_____ **Location map**
_____ **Bench marks**
_____ **Estimated quantities**
_____ **Standard drawings**
_____ **General notes**
_____ **Signature block**

Plan View

_____ **North Arrow orientation**
_____ **Proper structure numbering**
_____ **Scale**
_____ **Reference point**
_____ **Property information**
_____ **Stream identification**
_____ **SCPZ limits**

- _____ **100 year flood plain limits (if different from SCPZ limits)**
- _____ **Floodplain fill and compensatory volume location and limits**

_____ **Stormwater facilities size, types, and location**

- _____ **Water quality controls**
- _____ **Detention facilities (include maximum ponding limits)**
- _____ **Storm sewers**
- _____ **Open channels**
- _____ **Flood routing**
- _____ **Culverts**

_____ **Proposed and existing easements**
_____ **Agricultural field tiles**
_____ **Existing and proposed utilities**
_____ **Proper structure and pipe annotation**
_____ **Stormwater Pollution Prevention Plan (SWP3)**

Profile View

_____ **Scale**
_____ **Stationing**
_____ **Utility, street, driveway, and stream crossings**
_____ **Proper structure and pipe annotation**
_____ **Granular backfill and encasement limits**
_____ **Proper ground surface line types**

Details and Cross Sections

- _____ **Open channel and flood routing swale cross-sections**
- _____ **Culvert profiles**
  - _____ **Elevation information**
  - _____ **Flow and velocity data**
- _____ **Stormwater Control Practice details**
  - _____ **Plan view**
  - _____ **Elevation view**
  - _____ **Volume and drawdown data**
  - _____ **Planting list**
- _____ **Detention Ponds**
  - _____ **Cross section(s)**
  - _____ **Elevation information**
  - _____ **Forebay details**
  - _____ **Outlet structure details**

Appendix D

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	203	Excavation	CY	●	●	●		●		●	●	●			
CMSC	203	Embankment	CY	●	●	●	●	●	●	●	●	●			
CMSC	203	Linear Grading	LF							●	●	●			
CMSC	204	Subgrade Compaction	SY						●						
CMSC	207	Construction Seeding and Mulching	SY	●	●					●	●	●			
CMSC	207	Perimeter Filter Fabric Fence	LF	●	●	●	●	●	●	●	●	●			
CMSC	207	Straw Wattles	LF	●	●	●	●	●	●	●	●	●			
CMSC	207	Inlet Protection	LF	●	●	●	●	●	●	●	●				

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	207	Compost Sock/Berm	LF	●	●	●	●	●	●	●	●	●			
CMSC	207	Sediment Basins and Dams (includes basin skimmer)	CY	●	●										
CMSC	207	Sediment Removal	CY	●	●	●	●	●	●	●	●	●			
CMSC	509	Epoxy Coated Reinforcing	Pounds	●	●	●	●	●							
CMSC	511	Class COC_ Concrete,_	CY	●	●	●	●	●							
CMSC	601	Slope Protection	SY	●	●					●	●	●			

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	601	Rock Channel Protection, Type_	CY	●	●	●	●	●	●	●	●	●			
CMSC	602	Endwall, Pipe Size_, per AA-SXXX	CY	●	●	●	●	●	●	●	●				
CMSC	602	Headwall, Pipe Size_, per AA-SXXX		●	●	●	●	●	●	●	●				
CMSC	603	Conduit, Size_, Type_	LF	●	●	●	●	●	●			●			
CMSC	604	Manholes, Type_	EA	●	●	●	●	●	●						
CMSC	604	Inlets, Type_	EA	●	●	●	●	●	●						
CMSC	604	Catch Basins, Type_	EA	●	●	●	●	●	●						
CMSC	604	Outlet Structure	EA	●	●	●	●	●	●						
CMSC	609	Curb, Type_	LF						●			●			
CMSC	623	Construction Layout Stakes	LS	●	●	●	●	●	●	●	●	●			

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	624	Mobilization	LS	●	●	●	●	●	●	●	●	●			
CMSC	627	Reboundable Traffic Post – (Color) Installed	EA				●								
CMSC	651	Topsoil Stockpiled	CY	●	●	●	●	●	●	●	●	●			
CMSC	652	Placing Stockpiled Topsoil	CY	●	●	●	●	●	●	●	●	●			
CMSC	653	Topsoil Furnished and Placed	CY	●	●	●	●	●	●	●	●	●			
CMSC	655	Tree Protection during Construction	LS	●	●	●	●	●	●	●	●	●			
CMSC	659	Topsoil	CY	●	●	●	●	●	●	●	●	●			
CMSC	659	Commercial Fertilizer	Ton	●	●	●	●	●	●	●	●	●			
CMSC	659	Lime	Acres	●	●	●	●	●	●	●	●	●			

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	659	Seeding and Mulching, Class _	SY	●	●	●	●	●	●	●	●	●			
CMSC	659	Water	M Gallons	●	●	●	●	●	●	●	●	●			
CMSC	660	Sodding Unstaked	SY	●	●	●	●	●	●	●	●	●			
CMSC	661	Tree Seedling (Size), (Species)	EA	●	●		●								
CMSC	661	Perennials, (Size), (Species)	EA	●	●		●								
CMSC	661	Groundcover and Vines (Size), (Species)	EA	●	●		●								
CMSC	661	Deciduous Shrub (Size), (Species)	EA	●	●		●								
CMSC	661	Evergreen Shrub (Size), (Species)	EA	●	●		●								

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	661	Deciduous Tree (Size), (Species)	EA	●	●		●								
CMSC	661	Evergreen Tree (Size), (Species)	EA	●	●		●								
CMSC	671	Erosion Control Mat, Type_	SY	●	●					●	●	●			
CMSC	901	_" Storm Pipe, with Type_ Bedding	LF	●	●	●	●	●	●						
CMSC	901	_" Storm Pipe, with Type_ Bedding , with Item 911 Compacted Backfill	LF	●	●	●	●	●	●			●			
CMSC	901	_" Storm Pipe, with Type_ Bedding , with Item 912 Compacted Backfill	LF	●	●	●	●	●	●			●			

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
CMSC	902	Increased or Decreased Earth Excavation	CY	●	●	●	●	●	●			●			
CMSC	910	Plain Concrete Encasement of _" Diameter Pipe	LF	●	●	●	●	●	●						
CMSC	910	Reinforced Concrete Encasement of _" Diameter Pipe	LF	●	●	●	●	●	●						
CMSC	911	Compacted Backfill	CY	●	●	●	●	●	●			●			
CMSC	912	Compacted Granular Backfill	CY	●	●	●	●	●	●			●			
CMSC	913	Channel Construction, Unpaved	LF	●	●					●		●			
CMSC	915	Cleanout, Size_	EA	●	●	●	●	●	●						

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
DPU Std. Dwgs.	Special	Orifice Plate (AA-S145)	EA	●	●	●	●	●	●						
GI Supp. Specs.	SS1602	Excavation for Green Infrastructure Facilities	CY				●		●						
GI Supp. Specs.	SS1602	Subgrade Preparation for Green Infrastructure Facilities	SY				●		●						
GI Supp. Specs.	SS1602	Clay Barrier or Berm for Green Infrastructure Facilities	CY				●		●						
GI Supp. Specs.	SS1603	Tree Protection Fencing for Green Infrastructure Facilities	LF	●	●	●	●	●	●	●	●	●			
GI Supp. Specs.	SS1604	Bioretention Soil	CF				●								

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
GI Supp. Specs.	SS1604	Bioretention Mulch	CF				●								
GI Supp. Specs.	SS1604	Edging, PVC/Steel	LF				●								
GI Supp. Specs.	SS1609	Green Infrastructure Period of Establishment Season 2	LS				●								
GI Supp. Specs.	SS1610	_" Pipe Underdrains for Green Infrastructure	LF				●		●						
GI Supp. Specs.	SS1610	Green Infrastructure Aggregate, Type_	CY				●		●						
GIDG	Special	Above Grade Barrier, Fencing (GIDG DC 1.2)	LF				●								

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
GIDG	Special	Curb Cut (GIDG DC 2.2 or DC 8.2)	EA				●								
GIDG	Special	Flared Curb (GIDG DC 2.2 or DC 8.2)	EA				●								
GIDG	Special	At Grade Inlets, Gutter Apron (GIDG DC 2.2)	EA				●								
GIDG	Special	At Grade Inlets, Trench Channel and Cover/Drain (GIDG DC 2.2)	LF				●								
GIDG	Special	Energy Dissipation, Splash Pad, Type_ (GIDG DC 2.2)	SF				●								
GIDG	Special	Observation Well (GIDG DC 7.3)	EA				●		●						
GIDG	Special	Anti-Seep Collar (GIDG DC 7.4)	EA				●		●						

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
GIDG	Special	Utility Sleeve, Size_ (GIDG DC 7.4)	LF				●		●						
	Special	Pervious Pavement: Concrete Pavers	SF						●						
	Special	Underground Detention: Chamber Component, Size_, Type_ (Vault, Pipe, etc.)	LF			●									
	Special	Stone Detention Storage, for Pervious Pavement and Underground Detention System, CMSC Spec.	CY			●			●						

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
	Special	Underground Detention System: Access Structures (if different from CMSC Item 604 structures)	EA			●									
	Special	Hydrodynamic Separator, Type_	EA			●									
	Special	Filter media	CF					●							
	Special	Filter Diaphragm	EA	●	●										
	Special	Anti-seep Collar (NRCS, CPS 378)	EA	●	●										
	Special	Sediment Depth Marker (forebays)	EA	●			●	● (Sedimentation basins)							

Spec. Reference	Item No.	Item Description		Detention Basins (wet/Dry)	Constructed Wetlands	Underground Detention Systems	Bioretention Facilities	Media Filters	Permeable Pavement	Swales	Filter Strips	Level Spreaders	Green Roof	Blue Roof	Rainwater Harvesting
	Special	As-built Survey and Engineering Certification for Temporary Sediment Basins	LS	●	●										
	Special	As-built Survey and Engineering Certification for Post-Construction Stormwater Control Practice	LS	●	●	●	●	●	●	●	●	●			

City of Columbus, Department of Public Utilities
Sediment Settling Pond and Sediment Trap Volume Verification Form

DATE:

Project Name:

Construction Drawing No.:

Owner Name:

I hereby certify that:

1. According to as-built survey, the sediment storage and dewatering storage volumes provided in the constructed temporary sediment settling pond or sediment trap equals or exceeds the volumes required by the plans, and

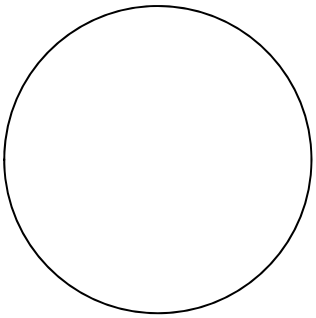
2. Upon construction, the as-built sediment storage and dewatering storage volumes for each sediment settling pond and sediment trap included in the SWP3 are as follows.

Sediment Pond and Sediment Trap As-built vs. Plan Volumes

Basin No.	***Dewatering Zone <u>As-built</u> Volume: (CY)***	***Dewatering Zone <u>Plan</u> Volume: (CY)***	***Sediment Storage Zone <u>As-built</u> Volume: (CY)***	***Sediment Storage Zone <u>Plan</u> Volume: (CY)***

Signed _____ Print _____ Date _____

<<Name of consulting firm>>



(P.E. Stamp here.)

9/18/2019

Appendix E

Stormwater Pollution Prevention Plan

Stormwater Pollution Prevention Plan

for development at

InsertProjectName

CC00000

located at

InsertSiteAddress

Ohio EPA Permit No. 4GC00000*AA

Part I – Stormwater Pollution Prevention Plan

Project Name
Project Location

Estimated Construction Start
Estimated Construction Completion

Site Owner
Contact Information

Site Operator (if different than owner)
Contact Information

Site Contractor
Contact Information

Name and Title Person Responsible for Amending the SWPPP
Contact Information

SWPPP Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

SWPPP Prepared By:
Signature and Date:
Printed Name:
Contact Information:

Operator Name:
Signature and Date:
Printed Name:
Contact Information:

Table of Contents

Part I – Stormwater Pollution Prevention Plan

Appendices:

1. Site Description

   Refer to Part III G of Ohio EPA' General Permit for Storm Water Discharges Associated with Construction Activity (Construction General Permit) for a complete description of all items that must be included in the site description. All items not included elsewhere shall be described here:
   - Nature and type of construction activity
   - Total site area and area of disturbance, including off-site borrow and storage
   - Total impervious area (existing, new, and total after construction)
   - Soil data (include borings in an appendix)
   - Prior land uses
   - Condition of on-site streams
   - Receiving waters

2. Schedule of Construction

   Describe the proposed sequence of construction for all work associated with the site, not just that shown on the stormwater plan. In general, the SWPPP shall depict and describe controls at four major stages:
   - Clearing and demolition
   - Grading
   - Construction of infrastructure (sewers, buildings, parking lots, roads)
   - Post-construction

   These phase are not only to be described here but also shown on associated plan sheets.

3. Calculations

   If not included in Appendix G, include calculations for
   - Temporary sediment basins
   - Water Quality Volume
   - Sizing of post-construction stormwater control practices

4. Controls

   4.1. Erosion Control Practices
   4.2. Sediment Control Practices
   4.3. Dewatering Activities

5. Stream Corridor Protection Zone (SCPZ)

6. Non-sediment Pollutant Controls

7. Inspections

   Describe the schedule of inspections.

8. Erosion and Sediment Control BMP Maintenance

   Describe the schedule/frequency for routine maintenance.

Project Title

Plan Number(s)

Contractor & Subcontractor Acknowledgement

I have been informed of the terms and conditions of Ohio's stormwater general permit for construction activities (CGP) and have reviewed and understand the conditions and responsibilities of this Stormwater Pollution Prevention Plan ("SWPPP"); I acknowledge my responsibilities under the Permit and SWPPP.

Company Name: _____

Signature: _____ Date: _____

Printed Name: _____

SWPPP Role: _____

Company Name: _____

Signature: _____ Date: _____

Printed Name: _____

SWPPP Role: _____

Company Name: _____

Signature: _____ Date: _____

Printed Name: _____

SWPPP Role: _____

Company Name: _____

Signature: _____ Date: _____

Printed Name: _____

SWPPP Role: _____

Company Name: _____

Signature: _____ Date: _____

Printed Name: _____

SWPPP Role: _____

Part II - Stormwater Control Practice Maintenance Plan

Stormwater Control Practice

Maintenance Plan

for

InsertProjectName

CC00000

located at

InsertSiteAddress

Created: Month Day, Year

Last Revised: Month Day, Year

Part II - Stormwater Control Practice Maintenance Plan

Project Name: _____

City of Columbus Approved
Construction Drawing Number: _____

Project Owner Name and
Contact Information: _____

Date: _____

Project Ownership Adjustments

Update contact information upon change in the property ownership.

Project Owner Name and
Contact Information: _____

Date: _____

Project Owner Name and
Contact Information: _____

Date: _____

Project Owner Name and
Contact Information: _____

Date: _____

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APPENDICES

1.0 STORMWATER CONTROL PRACTICE OVERVIEW

The following plan provides inspection and maintenance procedures associated with the post-construction water quantity and quality controls associated with the (Name) project. The post-construction Stormwater Controls Practices (SCP) and associated inspection and maintenance procedures are required per the City of Columbus Stormwater Drainage Manual to assure long-term adequacy of the stormwater management systems.

Stormwater quantity and quality treatment for (Name) project will be addressed by managing stormwater runoff from the site using the SCP(s) listed here and described in Section 2.0.

Example: Dry detention basin with a water quality drawdown time of no less than 48 hours; wet detention basin with a water quality drawdown time of no less than 24 hours; underground detention basin with water quality pretreatment.

The location of the SCP's are identified on the exhibits provided within Appendix B.

2.0 SCP INSPECTION AND MAINTENANCE REQUIREMENTS

All inspection and maintenance of the proposed SCP(s) is the responsibility of the (Site Owner/Developer), until such time as the development is transferred to a Homeowners Association or a new Owner; hereinafter referred to as the SCP Operator. The SCP Operator is obligated to perform inspections and required maintenance in perpetuity for all privately owned SCPs, as outlined in this manual and as per the City's Stormwater Drainage Manual (include link to manual). Inspection and maintenance includes trash and debris removal, weed control, and mowing, as well as performing structural repairs as-needed to ensure the continued operation of the SCP in conformance with the design.

The SCP Operator shall complete the Inspection and Maintenance forms attached in Appendix D, demonstrating that the inspection and maintenance is being performed and documented at the frequency indicated on the forms. The forms shall be kept on file and made available to the City of Columbus upon request.

The SCP Operator: (Company)
(Name of Responsible Person)
(Address)
(e-mail/phone no.)

The designation of the SCP Operator shall be revised on the plan cover page whenever the inspection and maintenance responsibility is transferred, such as a HOA or new site ownership.

The City will inspect, at a frequency determined by the City, the stormwater control practice to determine whether the practice and appurtenant facilities are built and functioning in accordance with any approved plans. The following records shall be maintained onsite and made readily available for review by the City during inspections:

1. The approved stormwater control practice maintenance plan, and
2. Completed SCP inspection and maintenance forms that document the inspection and maintenance activities performed by the owner.

The City will provide written or electronic notification to owners of stormwater control practices of any deficient items noted during the inspection. In the event the stormwater control practice is not functioning properly and requires repair, the owner upon notice from the City, or otherwise, shall commence such repairs as needed in a timely manner. The owner shall use commercially reasonable efforts to timely perform the repairs, but except for events of force majeure, under no circumstances shall the time exceed ninety (90) days unless otherwise agreed in writing by the City.

If the owner fails to diligently complete the repair, the City shall have the right, but no obligation whatsoever, to enter upon the owner's property and perform the repair. If the City performs such repair as permitted herein, the owner shall fully and immediately reimburse City for the actual cost of the repair upon receipt of an invoice itemizing the cost, which shall include any costs and expenses of filing suit and/or attorney's fees.

3.0 SCP INSPECTION AND MAINTENANCE PROCEDURES

SCP Inspection Features

The purpose of maintenance inspections is to assure safe and proper functioning of the stormwater control practices. The SCP Operator shall inspect and maintain the SCP's including all pipes and channels built to convey stormwater to the SCP's, as well as structures, improvements, and vegetation provided to control the quantity and quality of stormwater. SCP Inspection & Maintenance Fact Sheets are located within Appendix C. The fact sheets outline specific SCP features that are to be inspected and maintenance procedures. The location of the SCP's, project specific details, and specifications are identified on the exhibits provided within Appendix B.

Inspection Frequency

The inspection and maintenance frequency shall coincide with the frequencies outlined within the Inspection and Maintenance Guidance for Stormwater Control Practices manual (include manual link).

1. Establishment Period Inspection and Maintenance (This inspection requirement can be removed if plantings are not part of the SCP design).

   This inspection is required for SCP's that have plants that are required to be established as part of the overall SCP functionality. The establishment period lasts for two growing seasons after the plants have been installed. The SCP shall be inspected on a monthly basis during this period. Upon completion of the establishment period, the SCP shall be routinely inspected and maintained.

2. Routine Inspection and Maintenance

   The SCP shall be inspected and maintained on a quarterly basis at a minimum.

Inspection and Maintenance Reporting

Inspections shall include the completion of dated and signed inspection forms provided in the Appendix D and the notation of all deficiencies observed during the inspection. Additional inspection forms are available within the City of Columbus Inspection and Maintenance Guidance for Stormwater Control Practices manual (include manual link). The SCP Operator shall maintain copies of complete dated and signed inspection forms, along with recorded dates and descriptions of maintenance activities performed by the SCP Operator to remedy the deficiencies observed during prior inspections. The inspection and maintenance forms shall be kept on the property and shall be made available to the City upon request.

Appendix A:

Stormwater Control Practices Post-Construction Inspection and Maintenance Agreement

- Include a signed copy of the agreement

Appendix B:

Exhibits

- Site Map
    - Plan view with site features
    - Storm sewer system
    - SCP locations and outlet structures
    - Stormwater outfall locations and outlet protection
    - Maintenance access easements
    - Stream corridor protection zone and wetland buffers
- SCP Details
    - Outlet structure profiles and details with as-built elevations
    - SCP cross sections with as-built elevations
    - Underground structure details
- Planting Plan
    - Plant types, locations, quantities
- Material Specifications – SCP specific that are to be reference when SCP components need to be replaced
    - Bioretention basin – sand, engineered soil, mulch
    - Sand filter – sand

Appendix C:

SCP Inspection & Maintenance Fact Sheets

- Include a copy of the SCP specific inspection and maintenance fact sheet from the Inspection and Maintenance Guidance for Stormwater Control Practices manual

Appendix D:

SCP Inspection & Maintenance Forms

- Include a copy of the SCP specific inspection report from the Inspection and Maintenance Guidance for Stormwater Control Practices manual
- Include copies of completed inspection and maintenance reports
- Provide copies to the City upon request