ALAN BRUBAKER, P.E., P.S.
SUMMIT COUNTY ENGINEER

STORMWATER DRAINAGE MANUAL

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Performance Requirements
Part 1

Summit County Engineer

Stormwater Drainage Manual

Performance Requirements

Summit County Stormwater Management Manual
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PERFORMANCE REQUIREMENTS

1. PURPOSE

The purpose of the Summit County Stormwater Management Manual - Performance Requirements is to provide the standards and guidelines for permitting land development throughout the County while reducing the damaging effects of accelerated stormwater runoff, soil erosion, and sedimentation. Through these efforts, the public health, safety, and welfare, as well as the County's natural resources and environment, will be protected.

These standards and guidelines shall apply to all non-farm, earth-disturbing activities performed within all unincorporated areas of the County of Summit for the purpose of commercial, industrial, institutional, and residential land uses.

Any person(s) developing land within unincorporated areas of Summit County shall comply with these guidelines except:

* Additions or modifications to existing single family detached houses.
* Agricultural land management activities including crops, orchards, wood lots, sod farms and nurseries.
* Development on single family residential lots not subject to the Summit County subdivision regulations.

2. RIPARIAN SETBACK REQUIREMENTS

The County Engineer supports the Summit Soil and Water Conservation District establishing a riparian setback zone along streams is necessary to protect stream quality and to protect structures from damage caused by natural erosion. As such, any new development or redevelopment shall follow the most up-to-date Summit County Riparian Setback Ordinance regarding riparian and wetlands setback requirements. All proposed development within the County that effects riparian setbacks of streams and wetlands shall be submitted to the Summit Soil and Water Conservation District for review and approval.

3. WETLANDS

The County Engineer supports the preservation of existing wetlands, and recognizes the stormwater benefits that are provided from existing wetlands. The Summit County Engineer will not approve improvement plans, or final plats, until a permit from the Army Corps of Engineers and/or USEPA has been issued. In addition, construction in wetlands is prohibited under the conditions described in the current Summit County Riparian Setback Ordinance.

The Army Corps of Engineers and United States Environmental Protection Agency (USEPA) have jurisdiction over construction involving wetlands. A copy of the wetland delineation shall be submitted to the Summit County Engineer's Office.

Concentrated flow shall not be discharged to any wetland within the jurisdiction of the State of Ohio. Concentrated flow must be returned to sheet flow by means of a level spreader or other approved practice.

4. FLOODPLAIN PRESERVATION AND DEVELOPMENT WITHIN FLOOD HAZARD AREAS

All development within FEMA designated Special Flood Hazard Areas is subject to conditions of most updated Summit County Riparian Setback Ordinance. All development within close proximity to streams that have no defined FEMA designated Special Flood Hazard Areas is also subject to these same conditions. The Chief Building Official of Summit County acts as the Summit County Floodplain Coordinator. All construction drawings, calculations, etc... that involve floodplain determination and delineation shall be submitted to the Chief Building Official of Summit County for review and approval. A copy of all material submitted to, and received from, the Chief Building Official shall be submitted to the Summit County Engineer's Office.

5. DAMS

The Ohio Department of Natural Resources has jurisdiction over all dams within the State of Ohio. Ohio Dam Safety Laws are found in the Ohio Revised Code – (ORC) Title XV. The design and construction of all dams are required to follow the most updated law pertaining to dam design (Currently Section 1521 of the Ohio Revised Code and Chapter 1501:21 of the Ohio Administrative Code) and safety requirements. For any project within the County involving dams, a copy of all submittals and correspondence to and from the Ohio Department of Natural Resources shall be submitted to the Summit County Engineer Office.

6. BRIDGES

A bridge is defined as any structure of more than 10 foot width erected over a depression or an obstruction, such as water, railway, etc., to carry traffic or other moving loads. The length of the bridge is measured along the center of the roadway between undercopings of abutments or extreme limits of opening for multiple boxes.

The County Engineer design criteria for bridges constructed over open waterways is that the water surface elevation shall remain below the low chord of the bridge deck for the 24 hour storm having an average recurrence interval of 100 years.

Additional design criteria for bridges can be found in the latest edition and interim specifications for both the Ohio Department of Transportation's ODOT, Bridge Design Manual and the American Association of State Highway and Transportation Officials', AASHTO, Standard Specifications for Highway Bridges.

7. EROSION AND SEDIMENT CONTROL

The Summit Soil and Water Conservation District (SSWCD) has jurisdiction over erosion and sediment control features that have to be installed during the construction process. Consult the most updated version of the Ohio Department of Natural Resources' manual Rainwater and Land Development for additional information. SSWCD is also responsible for the review and approval of the water quality features.

The Summit County Engineer's Office will not approve improvement plans or final plats until SSWCD has approved the Stormwater Pollution Prevention Plan (SWPPP). The Summit County Engineer's Office will not provide inspection and will not accept uninspected construction if a site is not in compliance with the SWPPP.

The Ohio Environmental Protection Agency (OEPA) requires the Owner/Operator of any site where one (1) or more acre will be disturbed, to file a Notice of Intent and obtain an NPDES Permit. An SWPPP must be developed for the site and a copy retained on the building site. These items must be done twenty-one (21) days prior to the commencement of earth moving activities.

For all construction projects within the County, a copy of the SSWCD approval letter for the proposed SWPPP, and the SWPPP itself must be submitted to the Summit County Engineer's Office.

8. RUNOFF CONTROL CRITERIA

The following design criteria shall hold for runoff control related to all development:

8.1 To offset the effect of development, the Ohio Critical Storm method shall be used for all proposed developments within the County. The critical storm is based upon the percent increase in runoff volume between the before and after development conditions. Stormwater management shall be provided for all 24 hour storm events having average recurrence intervals ranging from 1 year to 100 years.

8.2 If the proposed development has more than one discharge point, stormwater management shall be provided for each location. At no point of discharge from the development shall the peak discharge exceed the pre-development peak discharges for all storm events.

8.3 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. The County Engineer 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.

8.4 Stormwater management facilities, such as dry, extended and permanent pool detention basins shall be designed to eliminate and reduce stormwater runoff impact of adjacent or downstream properties. No stormwater management facility shall be approved if the effect may cause an increase in peak discharge, volume, or velocity of runoff or change the point of entry of drainage onto another property during the runoff event.

8.5 Stormwater management facilities, such as dry, extended and permanent pool detention basins shall not be designed as in-line structures and shall not be placed within the limits of a designated floodplain.

9. CONVEYANCE SYSTEMS

The following design criteria shall hold for all conveyance systems that are part of new development or re-development projects:

9.1 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.

9.2 Onsite stormwater runoff shall be conveyed through the development site to adequate stormwater control facilities designed in accordance with the requirements specified in the Technical Manual. Drainage design must demonstrated that onsite runoff will not cause flooding within the development site for the designated design storms - the 1 through 100 year average recurrence intervals.

9.3 Onsite stormwater systems must discharge to one of the following offsite stormwater systems: 1) a stream, creek, or river; 2) an open channel system: or 3) A storm sewer system adequately sized for the intended flows.

If none of the three options is feasible, then only sheet flow is allowed to be discharged from the site with adequate quantity and quality controls in place. Flow that has become concentrated must be converted to sheet flow using a level spreader or other similar device before exiting the development site.

9.4 Tailwater considerations shall be required for the analysis and design of all stormwater conveyance systems. The following sources of information may be utilized to establish downstream tailwater conditions:

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

9.5 Major storm routing paths shall be provided to convey stormwater runoff that exceeds the capacity of the minor drainage system through the development to an

existing stream. 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 structures within and adjacent to the development.

10. STORM SEWERS

All storm sewers shall follow the criteria presented in the most updated ODOT Location and Design Manual, Vol. 2 Drainage Design. In addition to the requirements found in the ODOT Location and Design Manual, Vol. 2 Drainage Design, the following design criteria shall hold for all storms sewers:

10.1 All storm sewer systems shall be designed using Manning's Equation, or some other suitable friction equation. A Manning's roughness coefficient (n) of 0.015 shall be used to design storm sewer systems for all County-approved pipe materials, except for corrugated metal, which shall have a roughness coefficient (n) of 0.024. If an equation other than Manning's is used for design purposes, a list of roughness coefficients used must be submitted to the County Engineer for review and approval.

10.2 For proposed residential subdivisions, all basement elevations shall either be above the 25 year hydraulic grade line or equipped with a sump pump.

10.3 For all proposed development, the hydraulic grade line shall not exceed the window, grate, or casting elevation of any structure for the 25 year recurrence interval.

10.4 Storm sewers located within a roadway Right-of-Way that connect a private storm sewer system to a storm sewer owned by the County 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.

11. PAVEMENT DRAINAGE

Pavement drainage for all projects shall conform to the Federal Highway Administration Hydraulic Circular No. 22, "Urban Drainage Design Manual", and the most updated ODOT Location and Design Manual, Vol. 2 Drainage Design. Hydraulic analyses used to size and space inlets and catch basins can also be based on the methods presented in (FHWA) Hydraulic Engineering Circular No. 12 "Drainage of Highway Pavements".

In addition to the requirements found in the above referenced manuals, the following design criteria shall hold for all pavement drainage:

11.1 The design storm frequency shall be the 24 hour storm having an average recurrence interval of 5 years for all roadways.

11.2 For the purpose of estimating flow rates, the maximum time of concentration to the first inlet shall be 15 minutes.

11.3 The allowable spread of runoff for curb lanes shall be ½ of the lane width for the 10 year recurrence interval. The allowable depth of water on a roadway within the design spread during the 100 year recurrence interval shall be 1 inch below the top of the curb, or 5 inches maximum.

Pervious pavement can be used for new development or re-development projects to provide stormwater management. Sidewalks, driveways, parking lots, and residential streets can be constructed of pervious pavement. Design considerations and guidelines shall follow the EPA requirements.

12. CULVERTS

Culvert design and all materials used in construction of roadway culverts shall be based upon the most updated edition of the ODOT Location & Design Manual, Vol. 2 Drainage Design. Other acceptable design procedures are contained in the FHWA's Hydraulic Engineering Circular No. 5 (September 1985) and in the most updated FHWA's HY8 model. In addition to the requirements found in the above referenced manuals, the following design criteria shall hold for all culverts:

12.1 If the culvert is in the major 100 year flood routing path, the culvert shall meet the requirements of the Technical Manual dealing with the design of the stormwater routing system.

12.2 The headwater depth at the inlet of each roadway driveway culvert shall be at or below the near edge of pavement for driveway culverts conveying runoff along roadside ditches during the design storm.

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.

12.3 To ensure self-cleaning during partial depth flow, culverts shall have a minimum velocity of 2.5 feet per second at the design flow, with a minimum bottom slope of 0.5%.

12.4 Buoyancy protection shall be provided for all flexible culverts. This can be provided through the use of headwalls, endwalls, slope paving or other means of anchoring.

12.5 The culvert length and slope shall be chosen to approximate existing topography to the degree practicable. The culvert invert should be aligned with the channel bottom and the skew angle of the stream, and the culvert entrance should match the geometry of the roadway embankment.

12.6 Debris control shall be performed in a manner consistent with Hydraulic Engineering Circular No. 9 entitled Debris Control Structures (FHWA, 1971), which contains criteria pertaining to the design of debris control structures.

13. OPEN WATER COURSES

The requirements in this section are applicable to newly constructed open watercourses that are intended to convey flow to stormwater inlets, stormwater control facilities, streams, lakes, wetlands, or other water bodies during precipitation events. The following guidance documents may be used for evaluation, planning, and design of constructed open watercourses to supplement the design criteria provided in the Technical Manual:

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

The following design criteria shall hold for all open channels:

13.1 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.

13.2 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.

13.3 In general, parabolic and trapezoidal channel shapes shall be used for open watercourses within development projects. The channel shall be two-tiered. The first tier shall be designed to convey the bankfull discharge. The second tier shall be designed to convey the remaining runoff from the 10 year design storm.

13.4 Open channels shall be designed to flow under subcritical flow conditions at all times (Froude Number less than 1).

13.5 Open watercourses can also serve as a flood routing channel for the 100-year design storm.

13.6 Open watercourses may also be designed for stormwater quality control using criteria provided in the chapter of the Technical Manual dealing with water quality design.

13.7 All roadside ditches shall be designed in accordance with the latest edition of the ODOT Location & Design Manual, Vol. 2 Drainage Design.

14. END TREATMENTS

End treatment design shall follow the criteria presented in the most updated ODOT Location and Design Manual, Vol. 2 Drainage Design. In addition to the requirements found in the ODOT Location and Design Manual, Vol. 2 Drainage Design, the following design criteria shall hold for all storms sewers:

14.1 Channel protection is required to prevent erosion at the outlet of a culvert or storm sewer outfall where peak velocities exceed the maximum allowable velocity for the constructed channel lining materials, or the native vegetation that exists within an existing receiving stream during the design storm event.

15. POST CONSTRUCTION STORMWATER QUALITY CONTROL

For all construction activities involving the disturbance of one (1) or more acres of land, structural post-construction stormwater quality treatment best management practices (BMPs) shall be incorporated into the permanent drainage system for the site.

All post construction stormwater quality controls shall be designed based upon the criteria of the most updated ODNR Rainwater and Land Development Manual, and the Ohio EPA "Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (Construction General Permit)".

For redevelopment projects (i.e., developments on previously developed property), post-construction practices shall either ensure a 20 percent net reduction of the site impervious area, provide for treatment of at least 20 percent of the WQ_v, or a combination of the two.

For post construction requirements for linear projects, refer to the latest edition of the Ohio Department of Transportation Location & Design Manual.

Technical Requirements
Part 2

Summit County Engineer

Stormwater Drainage Manual

Technical Requirements

TECHNICAL REQUIREMENTS

1.0 INTRODUCTION

1.1 Purpose

The purpose of the Summit County Stormwater Management Manual -Technical Requirements is to provide the design standards and guidelines for development throughout the County.

These standards and guidelines shall apply to all non-farm, earth-disturbing activities performed within all unincorporated areas of the County of Summit for the purpose of commercial, industrial, institutional, and residential land uses.

Any person(s) developing land within unincorporated areas of Summit County shall comply with these guidelines except:

* Additions or modifications to existing single family detached houses.
* Agricultural land management activities including crops, orchards, wood lots, sod farms and nurseries.
* Development on single family residential lots not subject to the Summit County subdivision regulations.

Detailed topographic site plans for each individual lot should be submitted to the Summit County Department of Building Standards concurrently with building permit submittals. Call the Summit County Department of Building Standards at (330) 630-7280 for more information on these requirements.

1.2 History

In 1984 a Stormwater Management Report commissioned by the office of the Summit County Engineer provided the only technical engineering reference source for standardized planning, design, and implementation guidelines of stormwater control facilities in Summit County. The resulting Stormwater Management Program was presented in two volumes:

Program Guidelines – establishing the purpose, criteria, regulations and means to administer and implement the Stormwater Management Program.

Technical Guidelines – providing an engineering reference source of standard design criteria, methodologies and design examples to establish stormwater control measures.

The long-range goal of the 1984 report recommended that regional stormwater management planning should be developed for the entire County on a watershed basis.

The Summit County Engineer’s office has used these guidelines in design of drainage improvements and the review of developments.

1.3 Revisions

The first revisions to the 1984 guidelines were approved in the spring of 2003. The following were the revisions incorporated at that time:

* The use of computers for design of drainage systems including data organization and analysis.

* The increasing importance of designing stormwater management systems for the control of runoff quality, as well as quantity.

* The 1984 Stormwater Management Program Guidelines Manual was noted as being difficult to interpret and vague in defining criteria.

* Easier to follow procedures and examples.

* Criteria were established that encouraged land development that limited the amount and acceleration of runoff that could be discharged from a site.

* Other county policies have been incorporated and consolidated into one manual.

This second set of revisions incorporates the following:

* The use of the critical storm method to size detention basins

* The post-construction requirements of Ohio Environmental Protection Agency (Ohio EPA) current permit for stormwater discharges associated with construction activity.

* The requirements of two current Ohio EPA National Pollutant Discharge Elimination System (NPDES) Phase II General Permits:

    * Ohio NPDES Permit No.: OHQ000001 for Small Municipal Separate Storm Sewer Systems
    * And, Ohio NPDES Permit No.: OHQ100000 for Small Municipal Separate Storm Sewer Systems Located Within Rapidly Developing Watersheds.

* Miscellaneous revisions to clarify ambiguities in the previous version of the text.

* The incorporation of updated precipitation data for Summit County.

* Better quality charts, tables, and graphics.

* The requirements of the Summit County Riparian Setback Ordinance.

* Separated the drainage manual into 2 manuals. One manual deals with performance guidelines. The other manual deals with technical guidelines.

* Added chapters dealing with general hydrology requirements, stormwater conveyance systems, outlet channel protection, as-built surveys and construction of BMPs.

* Added additional requirements for parking lot storage, underground storage, catch basin spacing, storm sewer design, culvert design, open watercourse design, water quality post-construction BMPs, operation and maintenance of post-construction BMPs.

* Changed the Infiltration/Recharge systems listing from “Optional” to “Preferred”.

* Updated the procedure for computing and outletting the water quality.

* Added new design guidelines for extended and permanent pool detention basins.

* Added additional references.

2.0 STORMWATER MANAGEMENT PLAN

2.1 Purpose

Stormwater runoff regulations and standards have been developed for the purpose of managing non-farm, earth-disturbing activities in order to control runoff in an effort to reduce or prevent flooding, soil erosion, sedimentation, and water quality degradation.

2.2 General Procedures for Planning and Designing Drainage Systems

The following list is offered as a general procedure for planning and designing a drainage system. Additional details on the elements of this list may be found in the following chapters of this manual. Users are cautioned that unique site conditions may require additional steps to be added to this general procedure.

1. Identify all applicable federal, state, and local regulations and criteria that will affect the design.

2. Compile background and existing data including soil types, rainfall characteristics, historical flood information, water quality data, groundwater conditions, locations of wetlands, and prior studies in the area.

3. Identify off-site areas that drain onto the site and incorporate the offsite flow into the drainage analyses.

4. Identify natural drainageways through the site.

5. Identify the location of outfalls for the project. Include their capacity and downstream constraints.

6. Delineate drainage areas.

7. Develop a preliminary system layout by roughly defining the flow routes.

8. Compute the runoff of storms ranging from the 1-year storm event to the 100-year storm event.

9. Define grades and alignments for open channels and storm sewers. Several preliminary layouts should be considered. Identify other factors that will influence the alignment and grade such as: utilities, buildings, erodibility of the soil, available right of way, etc.

10. Determine the amount of flow in the street and roughly space the inlets accordingly.

11. Calculate the preliminary sizes of the storm sewers.

12. Calculate the runoff flowing through each drainageway and determine the right of way required to convey the flows. Determine if the combined capacity of the street and storm sewer system is adequate to maintain surface flows within the allowable limits during a 100-year storm. Where drainageways consist of homeowner's yards, determine the 100–year flow path and the associated limits of the 100-year flow in order to define the perpetual drainage easements.

13. Conduct detailed hydrologic calculations to compute design flows at all drainage structures and at points of discharge from the site.

14. Calculate on-site and off-site flows.

15. Determine the size of the required stormwater detention/retention. Size the storage facility in accordance with the specified criteria and regulations.

16. Determine the location of stormwater storage facilities and how detention/retention will affect the rest of the system.

17. Locate and size inlets for the required system design frequency. Determine where carryover flow occurs and make necessary adjustments to the computations and the site design to accommodate the carryover flow.

18. Determine the 25-year, 24-hour hydraulic grade line for any stormwater facilities. Confirm that the hydraulic grade line is below all proposed basement elevations. Make adjustments to the grade, size, and/or alignment as required to comply with this criteria.

19. Check the function of the stormwater facilities during the 100-year storm event. Check that no 100-year storm flow path comes within 10 feet horizontally and one foot vertically of the finished floor of any adjacent building.

20. Verify that downstream systems can adequately convey peak discharges from the site.

21. Evaluate the operation of culverts and bridges. Define the area affected by the 100-year backwater flooding and verify that the backwater does not come within 10 feet horizontally and one foot vertically of any adjacent building finished floor.

22. Evaluate the function of the entire drainage and stormwater system for 24 hour storms ranging from the 1-year frequency through the 100-year storm event. Make any necessary adjustments.

23. Determine whether any onsite basin is classified as a dam under the regulations of the Ohio Department of Natural Resources regulations.

24. The design of any embankment basin shall include an analysis of the integrity and long–term stability of the embankment prepared by a registered geotechnical engineer.

25. If the project site contains any streams, rivers, lakes, wetlands or other surface waters, certain construction activities at the site may be regulated under the Clean Water Act (CWA) and/or state isolated wetland permit requirements. Sections 401 and 404 of the CWA regulate the discharge of dredged or fill material into surface waters and the impacts of such activities on water quality. Construction activities in surface waters which may be subject to CWA regulations and/or state isolated wetland permit requirements include, but are not limited to: sewer line crossings, grading, backfilling or culverting streams, filling wetlands, road and utility line construction, bridge installation and installation of flow control structures. If the project contains streams, rivers, lakes or wetlands or possible wetlands, the developer must be prepared to delineate the jurisdictional area regulated by the CWA, assess the impacts to this area, and submit the required forms and information to the appropriate U.S. Army Corps of Engineers District Office as listed below:

    Huntington, WV District (304) 529-5210 (Tuscarawas River Basin)
    (http://www.lrh.usace.army.mil/default.asp)

    Buffalo, NY District (716) 879-4329 (Lake Erie Basin)
    (http://www.lrb.usace.army.mil/index.html)

2.3 Submission Requirements

2.3.1 Stormwater Management Report

A stormwater management system shall be designed and incorporated into each development project proposed within the County. The design of proposed stormwater management systems shall be summarized in a bound stormwater management report and submitted to the County for review and approval. The report shall contain all pertinent stormwater calculations for detention/retention basins, storm sewers, culverts, open channels, and other stormwater management features, including best management practices (BMPs). The following components shall be included in, and considered part of, the report:

1) Master Drainage Plan (if applicable),
2) Calculations,
3) Drainage Maps/Drainage Area Delineations
4) Stormwater Quality BMP Maintenance Plan(s),
5) Easements (if applicable),
6) Subsurface investigation reports (if applicable), and
7) Non-County Submittals/Permits.

The master drainage plan shall be folded and inserted in a separate sleeved page(s) or pocket(s) of the report. Construction plans, including the Stormwater Pollution Prevention Plan, 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.

2.3.2 Drainage Plan Requirements

For developments three (3) 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. The master drainage plan should 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 drainage system, if requested by the County,
7) Pre-development and post-development major routing flow paths to and from stormwater control facilities,
8) Any streams or open water courses that traverse the property along with applicable riparian setbacks,
9) The location of proposed stormwater quality and quantity control facilities, storm drains, and constructed open watercourses proposed for the site,
10) Existing drainage structures, including field tile locations,
11) Lines designating the phases of multi-phase development projects,
12) Street layouts and existing and proposed utility lines,
13) Flood Hazard limits and classifications,
14) The boundary of each wetland and applicable setbacks on the site (at a minimum the wetland boundaries of the current phase of a multi-phase project shall be shown), defined during a jurisdictional determination under the requirements of a Section 401/404 permit, and the wetland setback boundary established under criteria in Section 1.1 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.

Additional information may be required by the County Engineer if deemed necessary to perform a complete and thorough review.

The master drainage plan(s) is to be prepared on a 24-inch by 36-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 County Engineer's Office.

2.3.3 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 County's stormwater management requirements. Specific requirements follow.

Floodplain Calculations

Calculations to determine the width of a stream floodplain shall be presented in the following format:

1) 100 year Floodplain Limits - Provide a copy of an existing FEMA map or study showing the limits of the 100-year floodplain throughout the entire property limits of the proposed development. For streams that have no previously mapped FEMA floodplain, hydrologic and hydraulic analyses shall be performed, consistent with FEMA requirements, to delineate the limits of the 100-year floodplain throughout the entire property limits of the proposed development.
2) 100-year Floodway Limits - Provide a copy of an existing FEMA map or study showing the limits of the 100-year floodway. For streams that have no previously mapped FEMA floodway, hydrologic and hydraulic analyses shall be performed, consistent with FEMA requirements, to delineate the limits of the 100-year floodway throughout the entire property limits of the proposed development.

The information required in Items 1) and 2) shall be considered valid for "existing conditions." If work is to be performed in or adjacent to a delineated floodplain, then the following additional steps are required.

3) Submit a separate plan sheet (24 in. by 36 in.) that shows all of the proposed work that will occur in or adjacent to the existing floodplain boundary.
4) Provide a copy of a map or study showing the limits of the 100-year floodplain throughout the entire property limits of the proposed development, based upon the proposed development shown on the submitted plan.
5) Provide a copy of a map or study showing the limits of the 100-year floodway throughout the entire property limits of the proposed development, based upon the proposed development shown on the submitted plan.
6) Provide a copy of an engineering report, signed and stamped by a registered professional engineer, that clearly demonstrates the effect that the proposed development will have upon the existing floodplain and floodway widths.
7) Provide a copy of all necessary permits, variances, including riparian setback requirements, necessary to perform work within the 100-year floodplain.

All floodplain and floodway calculations shall be submitted to the Summit County Building Department for review and approval. Final plan approval will not be granted by the County Engineer until floodway calculations have been reviewed and approved by the Summit County Building Department.

Impervious Area Calculations

Provide calculations that were used to quantify the amount of impervious area that existed pre-development and the amount 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. A percent impervious and composite runoff curve number should be computed for both pre- and post-development.

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 without surcharging. Calculations shall be prepared on a tabulation sheet.
2) Hydraulic Grade Line - Demonstrate that the sewer system is designed to convey the design storm 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. The HGL shall be shown on the same tabulation sheet.
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 allowable limits.
5) Pavement Spread - Provide calculations that demonstrate that the pavement spread limits do not exceed the design criteria.

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.
3) Design Storm - Provide calculations demonstrating that the headwater elevations for the design storm are within the limits specified in the Manual. 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 maximum allowable velocity limits.
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.

Constructed Open Watercourse Calculations

For constructed open watercourses, the Applicant shall submit calculations demonstrating that the design criteria as outlined in the Manual 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.
4) Bankfull Calculations - Provide the calculations used to determine the bankfull discharge and the depth of the channel during this event.

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. Demonstrate that the water elevation resulting from the 100 year storm event remains one foot below proposed or existing residential dwellings and places of business and meets the depth restrictions presented in the Manual. The flood elevation shall be shown on the master drainage plan for the project.

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 County include, but are not limited to, SWMM, TR-20, PONDPAK, and HEC-HMS. The County prefers methodologies that perform dynamic routing of hydrographs. The County will only allow methodologies that do not perform dynamic routing upon prior written approval. 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) Ohio 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 to determine the critical storm.
2) 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. Data should be provided for the 1 through 100 year recurrence intervals.
3) Maximum water surface elevation in the basin - Show the maximum water surface elevations for the 1 through 100 year recurrence intervals.
4) Stage-Storage Calculations - Show the calculations of the stage-storage relationship for each detention facility. If the basin is to provide water quality control also, show the stage-area relationship for the water quality segment of the basin separately from the stage-area relationship for the water quantity segment of the basin.

Water Quality Volume (WQ_V) Calculations

The Applicant shall prepare a set of water quality volume and facility sizing calculations for control facilities as required by this Manual. At a minimum, the following calculations shall be provided:

1) Water Quality Volume Calculations - Show the calculations of extended detention, permanent pool, water quality wetlands, 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 specified time period(s).
3) Area of Sand Filter and Bioretention Facilities - Provide calculations used to determine the size of sand filter and bioretention facilities.

Enhanced Swale and Filter Strip Calculations

The calculations for swales and filter strips shall be presented in the following format:

1) Water Quality Volume Calculations - Show the calculations of the water quality volume (WQ_V).
2) Time of concentration - Show calculations for determining the time of concentration.
3) Design Flow Rate - Show the calculations of the swale/filter strip design flow rate using the Rational Formula.
4) Geometry - Show the calculations of the swale/filter strip cross-section geometry using Manning's Equation. Demonstrate that the flow depth is no greater than the maximum flow depth specified for the design storm.

2.3.4 Easement Preparation Requirements

Dedicated easements to the County shall be provided to allow maintenance and access to all stormwater facilities located outside of public right-of-way that are to be publicly owned or operated. In areas maintained by private property owners, easements will be required for access purposes. These easements will allow County officials to inspect storm water

facilities and to perform maintenance in the event the owner should fail to maintain the improvements. 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.

When preparing easement documents for acceptance by the County, 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 PDF format.
3) 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, ditch or basin.
4) Contacts - For private stormwater development plans, the name, mailing address and phone number of the person who will sign or obtain the signatures on the easement document shall be provided.

2.3.5 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 and/or into nearby structures 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.

2.3.6 Non-County 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), Division of Soil and Water Resources 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 County may not approve stormwater management reports or plans prior to receipt of copies of approval Federal (404) and State (401) permits if the permits are required. Additionally, the County may not approve stormwater management reports or plans prior to receipt of an approved Stormwater Pollution Prevention Plan.

2.3.7 Construction Plans

Grading Plan

A 100-scale (or better) topographic map of the site shall be prepared to show existing and proposed contours at a one-foot interval or smaller. The proposed contours shall represent the final grade of the developed site. The grading plan shall demonstrate that the side yard and rear yard have positive drainage away from the building pad. The grading plan shall show all on-site soil types and will include the locations of any soil borings.

The developer shall be responsible for the approved final grading plans, and shall be responsible for all work within the right of way and easements necessary to convey the flow of water per the stormwater management plan.

All builders shall complete site improvements in conformance with the approved final grading plans. Detailed topographic site plans for each individual lot in a residential development should be submitted to the Summit County Department of Building Standards concurrently with building permit submittals. Call the Summit County Department of Building Standards for more information on these requirements.

All existing and proposed drainage swales and patterns, storm sewers, detention/retention basins, outlet structures, pavement, curbing, open space, wetlands, FEMA 100-year Zone A limits, and the 100-year flow path across the site shall be shown and clearly marked on the grading plan. The location of all drainage easements required around stormwater management facilities shall also be shown.

The grading plan must show the flow path for the runoff from the 100-year, 24-hour storm across the project site. This flow path must not encroach on any building or be a significant threat to public safety. The 100-year flow limits may not come within 10 feet horizontally, and one foot vertically of any adjacent building finished floor. A public drainage easement of a minimum width of 20 feet shall be provided for the flow path of the 100-year, 24-hour storm across the project site.

The grading plan must show the riparian setback as established by the Summit County Riparian Setback Ordinance and any Federal Emergency Management Agency (FEMA)

Zone A flood hazard boundaries as delineated on the most current FEMA Flood Insurance Rates Maps.

Plan and Profile Sheets

All existing and proposed utilities, storm sewers, inlets, manholes, catch basins, and culverts shall be shown and clearly marked. Storm sewer profiles shall be included and all existing and proposed utilities shown. Drainage design information shall be labeled – size, type, length, invert, top of grate elevation, slope, station and offset of all structures. Include details for all structures (catch basins, manholes, outlets, etc). Storm drain plan and profile sheets shall include the 25-year hydraulic grade line. Culvert profiles shall include the 25-year and 100-year peak discharges, and corresponding headwater elevations.

The plans shall also specify the type of channel and/or ditch protection with dimensions and thickness clearly labeled. Flow arrows showing direction of flow in ditches and underdrains shall be shown. Location of easements shall also be shown.

Plan and profile sheet requirements are only applicable to subdivision submittals.

Stormwater Pollution Prevention Plan (SWPPP)

A SWPPP shall be approved by the Summit Soil and Water Conservation District and included in the final plans before approval of plans by the County Engineer. Refer to the Summit Soil and Water Conservation District for specific requirements.

3.0 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.

3.1 Acceptable Hydrologic Methods/Models

Tables 1 and 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) shall be used for designing conveyances serving areas less than 200 acres (e.g., stream crossings, storm sewer systems, small open channels, swales, roadside ditches, overland flow, shallow concentrated flow, roadway curbs, and storm sewer inlets), although the rational Method is not recommended for use for drainage areas greater than 25 acres. The County suggests thee methods for calculating stormwater runoff peak flows:

1) SCS Hydrograph,
2) The Rational Method, and
3) USGS Regression Equations

Accepted use of the three listed methods above is dependent upon the Applicant's understanding of the limitations of each of these methods. Care should be taken to ensure that the method selected and used is applicable to each particular design or analysis. The applicant should consult published literature for each method listed above to fully understand the limitations of each method.

The fundamental hydrologic components defined in this section 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 may be used to size any drainage component, but must be used for downstream analysis and to design detention facilities. Hydrograph methods are preferred over peak flow methods for the design of all drainage components.

Table 1. Applications of the recommended hydrologic methods.

System Component	Rational Method	Regression Equations	Approved Hydrograph Method
Storm sewers	X		X
Curb inlets & catch basins	X		X
Culverts	X	X	X
Roadside Ditches	X		X
Constructed open channels		X	X
Downstream analysis			X
Detention basins/quantity control			X

Table 2. Constraints to using recommended hydrologic methods.

Method	Limitations	Applicability
Rational method	Development sizes up to 25 acres.	Method can be used for estimating peak flows and the design of small conveyance systems.
Regression equations	Must have defined channels. Size limitations outlined in each report.	Method can be used for estimating peak flows.
Approved hydrograph methods	No drainage size limitations	Method can be used for estimating peak flows and hydrographs for all design applications.

3.2 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 large drainage areas. In these cases, the County strongly suggests 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 drainage system as part of a comprehensive hydrologic/hydraulic evaluation supported by computer models or other appropriate means.

Several methodologies are available for defining runoff hydrographs and routing them through the drainage system. The County will accept the unit hydrograph methodology, and may accept other equivalent methods if supported by proper documentation and a demonstrated record of successful application for drainage system design. Furthermore, hydrograph methods are generally provided by common engineering computer software, such as the NRCS TR-20 (May 1983) and TR-55 (June 1986), and the US Army Corps of Engineers HEC-HMS (November 2006) models, and U.S. EPA SWMM, versions 5.0 (September 2006). When using software, it is always desirable to use the most updated version of a particular model.

3.3 Rainfall Data

All rainfall data used for the design or analysis of drainage components shall be obtained from the National Oceanic and Atmospheric Administration, National Weather Service (2004). Data from this site include rainfall intensity-duration-frequency (IDF) curves for Northeast Ohio, which can be used in conjunction when the rational method is appropriate to calculate runoff, and precipitation frequency estimates which can be used with other peak flow methods or with hydrograph methods. The National Weather Service rainfall data can be found at the following web site:

http://hdsc.nws.noaa.gov/hdsc/pfds/

The SCS Type II distribution temporal pattern shall be used with hydrograph methods described in Section 3.2 for the 5 year recurrence interval and all more severe return periods. For recurrence intervals less than 5 years, rainfall distributions developed by the National Weather Service (2004) shall be used.

The SCS Type II distribution temporal pattern is readily available in most hydrology software and the rainfall distributions developed by the National Weather Service can be found at the above reference web site.

3.4 Soil Variables

The hydrologic soil group (HSG) associated with soils on the project site prior to development shall be defined by the latest edition of the Soil Survey of Summit County, or NRCS Web Soil Survey. A table of the HSGs for the United States soil classifications is also provided in Appendix A of SCS Urban Hydrology for Small Watersheds, TR-55 manual (1986). 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 and engineers

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.

4.0 STORMWATER CONVEYANCE SYSTEMS

4.1 Offsite Tributary Area

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. If required, 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).

4.2 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. 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 storms - the 1 through 100 year average recurrence intervals.

4.3 Downstream Analysis

Onsite stormwater systems must discharge to an offsite stormwater system as described in the Performance Manual

In general, sheet flow occurs at the upstream extent of an overland flow path, rarely exceeding a length of 300 feet in mildly sloped, undeveloped areas. In developed areas, sheet flow lengths are typically no longer than 100 to 150 feet in pervious areas, and 50 to 75 feet in impervious areas. Flow from drainage areas with overland flow paths greater than 300 feet must discharge into one of the three defined conveyance systems listed in the Performance Manual.

The Applicant shall use one of the accepted hydrologic methods defined in this manual 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 this 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 County Engineer 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 County Engineer 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 improvements to satisfy the conditions of this section.

The Applicant must prepare a preliminary Stormwater Management Report 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 herein must be used, and design criteria specified in the Manual shall be used to evaluate the offsite drainage systems of the same type.

4.4 Design of Stormwater Routing System

Major storm routing paths shall be provided for as discussed in the Performance Manual. The major storm routing path shall begin along swales located between 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. 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 manual.

Where streets are designated as the major routing path, the depth of water shall not exceed 6 inches (to allow access for emergency vehicles) at the crown for local and collector streets. The depth of water shall not exceed a 4-inch depth at the gutter line 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 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 existing 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. The 100 year flood routing path shall be shown on the drainage plan that is to be submitted with the Stormwater Report. 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 shall be used to define the major storm routing path between the development and the nearest existing stream. The County may, at its discretion, require additional detention to provide an adequate major storm routing path downstream of the development.

4.5 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 manual. At a minimum, the following criteria shall apply to all stormwater controls:

1) Stormwater control facilities shall not be located within designated Federal Emergency Management Agency (FEMA) floodplain boundaries.
2) Discharges from stormwater control facilities shall be directed into an existing stream, either directly, or via a storm sewer or open channel conveyance system, or according to criteria in the Performance Manual.
3) Stormwater runoff shall not be diverted from an existing naturally occurring wetland that is preserved 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 sustained to the extent possible.

5.0 STORMWATER MANAGEMENT FACILITIES

5.1 Introduction

In order to satisfy the runoff control requirements presented in this manual, stormwater management measures will be necessary for most land development.

Surface stormwater management facilities are the most widely used measure for controlling peak discharge. Surface stormwater management facilities include:

Preferred:
Infiltration/recharge systems
Detention basins
Retention basins

A detention basin is a "dry pond" used to temporarily store or detain the excessive runoff generated during a storm. A retention basin is a "wet pond" that maintains a permanent pool of water, with storage volume above the normal water level.

Optional:
Parking lot storage
Underground conduits storage and storage tanks
Rooftop storage
Porous/Pervious pavement

5.2 General Procedures for Stormwater Management Facility Design

The basic steps for designing stormwater management facilities are as follows:

1. Determine basin location and type.

2. Determine the allowable maximum release rates.

3. Generate inflow hydrographs for the 1, 2, 5, 10, 25, 50 and 100-year storms.

4. Estimate the amount of storage required for each storm.

5. Design the basin to accommodate the necessary storage.

6. Develop storage vs. stage curve and discharge vs. stage curve for the basin.

7. Estimate elevations for the top of the basin and for the water surface for the various storms and determine feasibility with the grading design.

8. Determine preliminary size and configuration of the outlet structure.

9. Perform hydrologic routing computations through the preliminary outlet structure.

10. Based on results obtained in step 9 modify the grading and/or the outlet structure to achieve acceptable performance.

Much information in this manual is directed to the design of stormwater detention or retention basins, but the concepts can be applied to other stormwater facilities. Omission of such facilities is not intended to discourage their use since other measures may be more suitable in certain situations. Regardless of what device is selected, the facility should be assessed as to its maintenance, function, and impact.

5.3 Design Requirements

Design Frequency - Critical Storm Method

The peak rate of runoff from an area after development shall not exceed the peak rate of runoff from the same area before development for all storms from a one (1) year to a one hundred (100) year frequency. Determine the total volume of runoff from a one (1) year frequency, 24-hour storm event occurring on the entire pre-development site and the entire post- development site. Pick the critical storm from the following table using the percentage increase in volume of runoff due to the development:

Table 1. Critical storm requirements

If the % increase in runoff volume is:		
Equal to or greater than	And less than	The critical storm event to be used for onsite detention is:
0	10	1 year storm event
10	20	2 year storm event
20	50	5 year storm event
50	100	10 year storm event
100	250	25 year storm event
250	500	50 year storm event
500	------	100 year storm event

The peak rate of discharge from any storm having a frequency greater than or equal to the critical storm (a shorter return period), occurring over the development, shall not exceed the peak rate of runoff from a 1-year frequency storm, occurring over the same area, under pre development conditions. Storms of less frequent occurrence (a longer return period) than the critical storm, shall control the peak rate of discharge from the development to be no greater than the peak rate of runoff for the same frequency storm under pre-development conditions.

> Example: If the total runoff volume is shown to be increased by 35%, the critical storm is a 5 year storm. The peak rate of runoff (allowable discharge) for all storms up to the intensity of the critical storm shall be controlled so as not to exceed the peak rate of runoff from the 1-year frequency storm under pre-development conditions. The peak rate of runoff (allowable discharge) from a more intense storm need only be controlled to not exceed the pre-development peak rate of runoff from the same frequency storm.

The storm control structure shall be designed to only release the allowable discharge for each given storm frequency through the 100 year storm occurrence. Storage volume does not have to be provided for off-site upstream areas. Runoff from off-site areas can routed through the drainage system in the proposed development at the same frequency that was used for the on-site system.

5.4 Post Construction Stormwater Quality Control

The most updated Rainwater and Land Development Manual, developed by the Ohio Department of Natural Resources, and the NPDES general construction permit for the State of Ohio shall be the governing reference for the design, operation, and maintenance of all stormwater quality control facilities proposed for Summit County. As this manual and state permit is edited and updated, the most recent edition of the manual shall be utilized for the purpose of stormwater quality control.

Additional sources to consult during the design of stormwater quality controls, include:

1) Ohio EPA's Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (Construction General Permit), latest version (http://www.epa.state.oh.us/dsw/permits/CGP_renewal_final_s.pdf)
2) Ohio EPA's Post-Construction Q&A Document, latest version (http://www.epa.state.oh.us/dsw/storm/CGP-PC-Q&A.html).

5.4.1 Water Quality Volume for Large Construction Activities.

All construction activities involving the disturbance of one (1) or more acres of land, structural post-construction stormwater quality treatment best management practices (BMPs) shall be incorporated into the permanent drainage system for the site. The BMPs chosen must be sized to treat the water quality volume (WQ_v).

The WQ_v shall be equivalent to the volume of runoff generated by 0.75 inches of rainfall within the watershed contributing runoff to the BMP and shall be determined according to the following:

$$WQ_v = C \times P \times A / 12 \times 1.2$$

where:

WQ_v = water quality volume in acre-feet
C = runoff coefficient appropriate for storms less than 1 inch (see equation below)
P = 0.75 inch precipitation depth
A = area draining into the BMP in acres
1.2 = additional volume factor to account for sediment storage

Runoff Coefficients for Water Quality

Runoff coefficients used to calculate the water quality volume **shall not** be obtained from the OEPA Phase II permit. Rather runoff coefficients shall be determined using the following equation:

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

where: I = fraction of the drainage area that is impervious

BMPs shall be designed such that the drain time is long enough to provide treatment, but short enough to provide storage available for successive rainfall events.

The engineer may request approval from the Summit County Engineer or Summit Soil and Water Conservation District to use alternative structural post-construction BMPs for sites less than 5 acres if the engineer can demonstrate that the alternative BMPs are equivalent in effectiveness to those listed in Ohio EPA General Permit. The target draw down times for these approved alternative structural post-construction BMPs shall be determined on a case-by-case basis by Summit County.

For sites greater than 5 acres, alternate BMPs must be approved by the OhioEPA, except where the entire WQ_v shall be infiltrated.

Construction activities shall be exempt from this condition if it can be demonstrated that the WQ_v is provided within an existing structural post-construction BMP that is part of a larger common plan of development.

5.5 Stormwater Management Facility Design Criteria

5.5.1 Extended (dry) and Permanent Pool (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 typically includes features to control water quality. 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.

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 County:

1) Detention basins shall not be located on uncompacted fill, on slopes 4 (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). 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 the 100 year, 24 hour storm event. The emergency spillway shall be designed to direct the flow to a suitable downstream flood routing path without erosion, scouring, or soil undermining, and to meet other pertinent Ohio Dam Safety requirements (if necessary). The emergency spillway shall incorporate a concrete structure to permanently establish the elevation of the spillway.
4) The basin shall be designed so that the peak water surface elevation in the basin does not overtop the basin embankment or flood structures around the basin.

5) Side slopes within and adjacent to the basin shall be 4 (H) to 1 (V) or flatter to prevent bank erosion and minimize safety risks when the basin is full. The maximum cross slope for the vehicle access driveway shall be 10 (H) to 1 (V). Maintenance access driveways shall be provided from a public right-of-way or private road to all major components of the basin. Maintenance access should be 12 feet wide, a maximum slope of 15% and be designed to withstand maintenance equipment and vehicles. The driveway shall consist of an approved material, such as a modular block porous pavement.

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 County 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) All inflow pipes to the detention basin that are not entirely submerged below the permanent pool elevation shall be designed with headwalls or endwalls. Rock channel protection 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.

8) If inflow to the facility is conveyed through an open watercourse, including a major storm routing path, the open channel conveyance system shall be designed in accordance with the requirements of this manual. Channel 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. Channel protection shall be designed 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 this manual. Such protection shall extend to the basin's bottom or 2 feet below the normal water elevation of any permanent pool.

9) 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.

10) 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. A detailed plan of the temporary sedimentation basin, including outlet structure design, shall be included in construction documents. 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.

11) Stormwater basins shall not be located within any jurisdictional waters, including wetlands.
12) The minimum freeboard required is 12” and shall be measured from the top of the basin embankment or slope to the 100-year water surface elevation in the basin.

Debris Control Requirements

Debris control structures (trash racks) for both wet and dry basins may be required at the basin inlet 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 (2005), available from the U.S. Department of Transportation, Federal Highway Administration. Orifices less than 1 inch in diameter are prohibited.

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 and the stormwater quality control requirements presented, 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, Amendment 1 pg 6-7 (January 1991), or NRCS Technical Note 709 - Dimensioning of Filter-Drainage Diaphragms for Conduits According to TR- 60 (April 1985).
3) Open channels receiving discharges from the facility shall be protected with rock channel protection designed according to criteria in this manual.
4) The outlet structure shall be sized to achieve the desirable release rates. This outlet shall be designed to resist plugging by meeting the following criteria. The County shall not allow a single orifice outlet to be used for a dry detention basin that is less than 4 inches in diameter. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller orifice diameter shall be permitted upon County approval if acceptable design practice is proven for site conditions. For basins that do not have micropools or permanent pools, single orifices shall be adequately protected from clogging by an acceptable external trash rack.
5) 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. Acceptable floatables control devices include perforated pipes, skimmers, baffles, inverted pipes, and other devices that the County determines to

be suitable. The detention basins shall be provided with an emergency drain, so that the basin may be emptied if the primary outlet becomes clogged and/or to drain the permanent pool to facilitate maintenance. The emergency drain shall be designed to drain by gravity where possible. 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.

Additional Layout Requirements for Dry Detention Basins

In addition to the requirements previously listed, the following shall apply to the design of dry detention basins for stormwater quantity control:

1) Dry detention basins shall be designed to drain toward the outlet or micropool in order to minimize standing water and saturated soil conditions that impede maintenance and mowing of the facility.
2) Dry detention basins shall include, where sufficient fall exists, underdrain to help maintain and drain the basin efficiently.
3) The minimum bottom width for dry detention basins shall be 12 feet to allow for vehicular access for maintenance. The detention basin bottom shall be sloped to drain, and such slopes shall be sufficient to mitigate against "flat spots" developing due to construction errors and soil conditions. The minimum transverse slope for the bottoms of such facilities shall be 2.0 percent.
4) Dry detention basins shall be provided with topsoil, and shall be seeded and mulched to prevent erosion. Grass, or other approved ground cover within the basin should be able to survive 48 hours under water. Jute and Excelsior matting shall be used as required to stabilize slopes and prevent erosion.

Additional Layout Requirements for Wet Detention Basins

In addition to the requirements previously listed, the following shall apply to the design of wet detention basins:

1) The depth of wet detention basins shall be no more than 8 feet below the basin’s normal water elevation. The County 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.

2) The perimeter of all permanent pool areas deeper than 4 feet shall be surrounded by an aquatic bench that extends at least 8 feet and no more than 15 feet outward from the normal water edge. The portion of the aquatic bench within 8 feet of the shoreline shall have an average depth of 6 inches below the permanent pool to promote the growth of aquatic vegetation. The remainder of the aquatic bench shall be no more than 15 inches below the permanent pool to enhance public safety, and to limit growth of dense vegetation in a manner that allows waves and mosquito predators to pass through the vegetation. The maximum slope of the aquatic bench shall be 10 (H) to 1 (V).
3) The designer shall prepare a landscaping plan for the aquatic bench. Plantings along the aquatic bench shall be selected with the aid of the Summit Soil and Water Conservation District. The plants selected 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.
4) Side slopes for wet basins shall be 4 (H) to 1 (V) from the maintenance berm down to the aquatic bench, and from the aquatic bench to the bottom of the basin.
5) At a minimum, wet detention basins shall be provided with topsoil, seeded and mulched, in all areas that are above the basin's permanent pool. Appropriate species shall be specified in areas along the perimeter of the basin at elevations higher than the permanent pool that are periodically inundated after storms. The Summit Soil and Water Conservation District should be consulted for a list of appropriate species.
6) A landscaping plan for the basin and buffer shall be submitted and approved to indicate how aquatic and terrestrial areas will be vegetatively stabilized and established.

5.5.2 Parking Lot Storage

Parking lot storage involves shallow ponding in specifically graded areas of a paved parking lot. The storage area(s) should be located in the least used portion of the parking facility.

Parking lot storage areas may be an inconvenience due to ponding during storms, clogging of flow control devices, and potential problems of icy conditions during cold weather. It is recommended that signage be placed in parking lot storage areas to warn pedestrians and motorists that the area is subject to periodic flooding.

The water depth in the storage area shall not exceed nine (9) inches for the 100-year storm.

It must be demonstrated that any grated inlet structure shall have sufficient opening capacity to convey the runoff from a 100-year storm event at the maximum depth of ponding in the parking lot.

Provisions shall be included for overflow of runoff from all storms events up to and including the 100-year storm event. Overflow provisions should also be included for probable clogging of the flow control devices.

The maximum limits of ponding during a 100-year storm event shall not come within 10 feet horizontally and one foot vertically of any adjacent building finished floor. The maximum limits of ponding for a 100-year storm event in the paved parking storage areas shall be indicated on the plans.

Additional requirements for parking lot storage:

1) Runoff from specific graded areas within a parking lot shall be controlled by orifices. The release rate of the flow from a parking lot storage facility shall meet the allowable post development runoff criteria. The minimum size outlet device shall be a 4-inch single orifice for water quantity control. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller diameter shall be permitted upon County approval.
2) A site with a parking lot storage facility shall employ a separate water quality treatment BMP that meets the water quality treatment criteria. This BMP may be located either downstream of the parking lot or integrated into the medians, landscaping, or other pervious areas of the parking lot.
3) The parking lot must have a minimum slope of 0.5% towards the outlet to ensure complete drainage following a storm. A slope of 1% or greater is recommended.
4) Dedicated Fire Lanes used for emergency equipment shall be free of ponding water for runoff events up to a 100-year event.
5) All Sanitary Sewer manholes located in these areas shall be equipped with water tight covers and chimney seals.

5.5.3 Underground Conduit Storage and Storage Tanks

Conduit structures, which are oversized or enlarged storm sewer pipes, and underground storage tanks or chambers are generally applied in urban area developments where land values are high and above-ground basins and ponds are undesirable. These methods are usually expensive and impractical for runoff control of large areas or for storm runoff from high intensity storms

Materials

Conduit structures shall be designed in accordance with the specified criteria for underground storage tanks, except special consideration shall be given to the structural strength and load-carrying capacity of the conduit as well as the bearing capacity of the soil. Perforated pipe may be used where soil conditions are favorable for infiltration methods

Underground storage tanks or chambers shall be designed and constructed in accordance with current practices.

Access

An access hatch or manway shall be provided for inspection and maintenance. All openings shall be properly secured to minimize unauthorized entry and safety hazards.

Overflow

Overflow provisions shall be included to accommodate the less frequent storms up to and including the 100-year storm runoff.

Draining

The storage tank shall include provisions for completely draining the tank. The minimum slope of the tank bottom shall be 0.5 percent.

Grated Inlet Structures

It must be demonstrated that any grated inlet structure shall have sufficient opening capacity to convey the runoff from a 100-year storm event at the maximum depth of ponding.

Additional requirements for underground storage:

1) Underground storage facilities shall not be used in instances where the County is to own or operate the facility.
2) If underground storage is to be used for a site, a plan for long term maintenance of the facility shall be provided to the County, including a health and safety plan for confined space entry. Access shall be provided over the inlet pipe and outlet structure. Access openings shall consist of a standard manhole frame and grate.
3) The release rate of the flow from a tank storage facility shall meet the allowable post development runoff criteria.

4) A site with an underground storage facility shall employ a separate water quality BMP that meets the water quality treatment criteria.
5) The minimum size outlet device shall be a 4-inch single orifice for water quantity control. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller diameter shall be permitted upon County approval.
6) 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.
7) All Underground facilities must meet all structural loading requirements for overburden and must support traffic loading.
8) Incorporating water quality treatment with underground storage will require the permission of the OhioEPA and the Summit County Engineer's Office.

5.5.4 Infiltration/Recharge Systems

Infiltration methods are designed to help restore the natural hydrologic system and promote water quality by allowing stormwater to percolate into the ground. Infiltration of stormwater reduces the amount of rainfall that becomes runoff. Infiltration also improves groundwater recharge.

The success of an infiltration/recharge system depends on the type of soils and groundwater system in the area. Soils with low permeability and shallow bedrock depths are poor locations for infiltration methods. Sediments, oils, and other debris can cause clogging of the soil surface. Adequate inspection and maintenance must be provided.

Infiltration/recharge methods are usually limited to handling relatively small sources of runoff such as roof drains, small parking lots, and tennis courts. Two specific infiltration methods are dry wells and infiltration trenches.

Supporting documentation shall be provided that demonstrates the permeability and infiltration capacity of all of the soils types or materials to be used in or below the infiltration/recharge area.

Dry Wells

Dry wells vary in depth from six feet to several hundred feet, depending on the depth of the permeable soil strata and the depth to bedrock. Diameters range from less than one foot up to several feet. Dry wells should be filled with crushed stone or washed two-inch gravel. Dry wells are most applicable for storing runoff from rooftops and other areas relatively free of sediment and debris.

Storage volume shall be computed and presented in the Stormwater Management Report.

Infiltration Trenches

Infiltration trenches consist of a shallow excavated trench, generally 3 to 10 feet deep, backfilled with a coarse stone aggregate, allowing for the temporary storage of storm runoff in the voids between the aggregate materials. The stored runoff then gradually infiltrates into the surrounding soil.

The permeability or final infiltration rate of the various soil classifications will be a limiting factor in the selection and location of infiltration trenches. Soil classes with infiltration rates from 0.52 inches/hour to not more than 2.4 inches/hour can be considered for the use of infiltration trenches.

The minimum recommended trench depth is 3 ft., which would include 2 ft. of the aggregate reservoir covered by 1 ft. of soil. In general, the trench should be designed as deep as possible to minimize the surface area. However, the soil infiltration rate below the trench will dictate the maximum depth.

The trench bottom must be deeper than 2 feet to avoid freezing, and shall be kept at least 5 feet above the bedrock and/or the seasonally high ground water table in the area. Infiltration trenches shall also be located at least 100 feet horizontally away from any water supply well.

The storage volume of the trench design is equal to the upstream runoff volume contributing to the trench times the pore volume ratio of the stone fill. The area of the bottom of the trench can be calculated using the following equation:

$$A_{\min} = \frac{V}{E \times T}$$

Where: A_{min} = area of the bottom of the trench (ft^2)
V = volume of fluid storage (ft^3) (trench volume less volume of stone)
E = exfiltration rate (ft/hr) (soil infiltration rate at the trench bottom)
T = drain time (hr)

The volume of water exfiltrating during the filling period of the trench may be significant for permeable soils.

The rock fill of the infiltration trench shall be clean, well graded, uniform size crushed rock. Poorly graded rock has less void space available for runoff storage and shall not be accepted.

The sides and top of the trench must be lined with geotextile to restrict the amount of sediment entering the structure. The top layer of the geotextile should be covered by a 6 to

12 inch layer of smaller sized gravel (0.75-in. diameter). This top layer of gravel and geotextile must be replaceable. The bottom of the trench must NOT be covered with geotextile, which can become clogged with sediment, preventing infiltration.

To promote continued infiltration, the bottom of the trench should be covered with an 8 inch layer of clean sand. An observation well, consisting of a perforated 4 inch diameter vertical pipe should be installed in the trench to monitor performance. The original depth of the observation well must be marked on the top of the well.

Sediment clogging and sealing off the permeable soil is the most common cause of infiltration trench failure. Runoff from the construction site shall not be allowed to flow to the trench until construction is complete and upslope areas have been stabilized. The infiltration trench design shall include a system for removing sediment from stormwater before it enters the structure, however this system shall not be used to control sediment during construction.

Vegetative buffers of at least twenty (20) feet in width are required upstream of the trench when the contributing runoff may be carrying sediment.

Rooftop Storage

Rooftop storage is surface storage provided on flat rooftops designed for temporary ponding with special roof drain controlled release features. Rooftop storage utilizes the built-in structural capacity of rooftops to store rainfall.

Existing structures conforming to local building codes should meet the support requirements for specified snow and live loading. This allowance can be utilized for stormwater without additional support, depending upon the structural condition of the building and roof. Modifications of roof drains to allow them to function as controlled release devices would be required.

Rooftop storage could be incorporated into the design of new buildings. Directing the water to lawn or infiltration/recharge areas is recommended.

The Summit County Engineer shall not be responsible for the review or approval of the proposed structural integrity of any building. The Summit County Engineer will only be responsible for the review of the stormwater criteria portions of any rooftop storage project. Maintenance responsibility will be the responsibility of the property owner.

Limitations of rooftop storage

The main disadvantages of rooftop storage are the periodic inspection and maintenance of the facilities. Such installations may not be readily accessible. Clogging and/or unauthorized removal of the flow control devices may occur, making routine inspections necessary.

Maximum Water Depth

The maximum water depth shall be determined by the developer's Design Engineer in accordance with the type of roof proposed for the building.

Live Load

The roof structure shall be designed for a minimum live load as specified in the local building codes in effect at the time of the design.

Slope

A minimum roof pitch of 0.25 in/ft to the outlet device shall be provided to assure complete drainage.

Overflow

Overflow drains shall be provided to accommodate major storms and shall be located above the maximum water depth. Roof scuppers are to be provided in parapet walls.

Waterproofing

The building structure shall be designed to provide a watertight roof.

Flow Control Device

The flow control device shall be in compliance with the local building code and the National Plumbing Code. Drain pipes and downspouts may be of standard design.

6.0 PAVEMENT DRAINAGE

6.1 Introduction

Proper drainage of roadway pavement is essential to the service life of streets and to traffic safety. A good drainage design can provide lower street maintenance costs and protect pavement and subgrades from unnecessary deterioration. Water on roadways slows traffic and contributes to accidents from hydroplaning, reduced visibility and icy conditions. Effective removal of runoff is influenced by geometric characteristics such as longitudinal slope, cross slope and type of curb and gutter section. These geometric features affect the location and spacing of inlets.

Design criteria can be found in the Performance Manual.

6.2 Curb Inlets and Catch Basins

Stormwater inlets and catch basins direct surface runoff into a storm sewer system or culvert. The four types of stormwater inlet structures include curb inlets, bump out 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 bicycle-safe grate.

Spacing of catch basins and inlets

The Rational Method is an acceptable method for the design of curb inlets and catch basins. When using the Rational Method, a maximum time of concentration of 15 minutes shall be used to determine the amount of runoff that will be collected by the proposed inlet structures. Additionally, engineering computer software that incorporates previously described hydrograph methods may be used in the sizing and spacing of inlets and catch basins.

Inlets on Continuous Grade Requirements

At a minimum, catch basins and/or curb inlets shall be placed at the point where the flow spread is projected to reach the maximum allowable spread. In addition, a basin/inlet shall be placed at intersections where necessary to prevent the gutter flow from crossing the pavement. The County 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.

7.0 STORM SEWERS

7.1 Introduction

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 for each proposed sewer run. These sheets are included at the back of the manual and shall be submitted to the County as part of the Stormwater Management Report. The Summit County Engineer's Office discourages enclosing open ditches into closed conduits.

7.2 Hydrology Requirements

The County recommends that storm sewer designs be based on hydrograph methods, as described earlier in the manual. The results are to be tabulated in the referenced storm sewer computation and check sheets.

7.3 Hydraulic Requirements

Tailwater Considerations

Downstream tailwater conditions shall be incorporated into the design of all storm sewer systems. When storm sewer systems outlet into storage structures, such as detention basins, water surface elevations of that structure effect flow in the proposed storm sewer and must be included in all design considerations and calculations. When storm sewer systems outlet into an existing municipal storm sewer or open channel, the water surface elevations in the sewer or open channel effect the flow in the proposed storm sewer and must be included in all design considerations and calculations.

All assumptions made regarding downstream tailwater conditions must be clearly described, and must be included in the Stormwater Management Report submitted to the County Engineer.

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 shall be matched at all junctions where possible and practical. If located within the road Right-of-Way, storm sewers that are to be privately maintained shall have a minimum pipe inside diameter of eight inches.

When outletting into an existing stream, storm sewers shall be designed to operate under subcritical flow conditions to help reduce outlet velocities entering the existing waterway. Drop manholes shall be required, or other drop structures shall be required to help maintain a mild pipe slope where ground slopes near streams 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 - 300 feet

All storm sewers shall be centered in the middle of easements established, whenever possible, according to criteria found in this manual. Headwalls shall be provided for at all storm sewer outlets and shall conform to the most updated edition of ODOT's Location and Design Manual, Vol. 2 Drainage Design.

All storm sewers and their structures shall be kept away from building foundations or sanitary sewers as much as practicable, or a minimum of 10 feet to minimize stormwater inflow into these facilities. See the local current building code to check for additional restrictions and/or requirements. 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 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. It shall be required of all sanitary sewer designs that the current Ohio EPA regulations regarding the construction of sanitary sewers be reviewed. If these regulations are more restrictive than the regulations found in this manual, the Ohio EPA regulations shall be followed.

7.4 Hydraulic Grade Line and Energy Loss Considerations

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

$$T_W = \frac{(d_c + D)}{2}$$

where: T_W = Tailwater depth (ft.)
d_c = Critical depth in the channel or pipe (ft.)
D = Depth of open channel, or the inside pipe diameter (ft.)

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:

$$H_{major} = S_f \times L = \frac{Q_{HGL} \times n}{(1.486AR^{2/3})^2} \times L$$

where: H_{major} = Major energy loss due to friction (ft.)
S_f = frictional slope (ft./ft.)
Q_{HGL} = Design flow (cfs)
n = Manning's roughness coefficient
A = cross-sectional area of the pipe ($ft.^2$)
R = hydraulic radius (ft.) = cross-sectional area (A) / wetted perimeter (P)
L = length of pipe (ft.)

When computing the hydraulic grade line, minor losses can be ignored.

7.5 Pipe Material, Bedding, Cover, and Encasement Requirements

The pipe material type and surrounding conditions shall be determined by the Applicant and specified in the Report, including the depth of cover, groundwater levels (if known), location of pipe with respect to roadways or highways, and type of proposed pavement. For pipes having equivalent materials and dimensions, the cover and structural requirements for storm sewer pipes provided in the most updated version of the ODOT L&D Manual, Vol. 2 Drainage Design shall be met. In instances where accepted pipe materials and dimensions are provided but structural criteria are not included in the ODOT L&D Manual, Vol. 2, the cover and structural design of the pipe shall be in accordance with the pipe manufacturer's recommendations, with a minimum allowable depth of 30 inches.

The trench bedding and backfill design for all pipes shall conform to the current ODOT specifications. In areas where the existing soil/ground conditions warrant an encasement, a Class A concrete encasement shall be required.

7.6 Easement Requirements

All storm sewers that are to be publicly 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, 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 and outfall protection 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. The construction of any accessory buildings, landscaping mounds or other landscaping features and fences that would interfere with the future maintenance of the sewer within said easement is prohibited, and this statement shall be noted on each record plat.

8.0 CULVERTS

8.1 Introduction

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.

8.2 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^{o}, then either the roadway alignment or the culvert alignment (or both) shall be revised to achieve a skew angle less than 45^{o}.

If the culvert is in the major 100 year flood routing path, the culvert shall meet the requirements of the section dealing with the design of the stormwater routing system.

8.3 Hydraulic Requirements

Types of Culvert Flow

Two main 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 in order to perform a proper design.

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 with the County Engineer's office, 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.

Entrance Loss Coefficients

Table 3 shall be used to define (minor) entrance loss coefficients for culverts under outlet control conditions.

Table 3. Minor (Entrance) loss coefficients for culverts under outlet control.

Type of Structure and Design of Entrance	Coefficient K
Concrete Pipe	
* Projected from fill, socket end (groove-end)	0.2
* Projected from fill, square cut end	0.5
* Headwall or headwall and wingwalls	
- socket end of pipe (groove-end)	0.2
- square edge	0.5
- rounded (radius = ½ D)	0.2
* Mitered to conform to fill	0.7
* End section conforming to fill slope	0.5
* Beveled edges	0.2
* Side or slope - tapered inlet	0.2
Corrugated metal - Pipe or Pipe Arch	
* Projecting from fill, no headwall	0.9
* Headwall of headwall and wingwalls, square edge	0.5
* Mitered to conform to fill	0.7
* End section conforming to fill slope	0.5
* Beveled edges	0.2
* Side or slope - tapered inlet	0.2
Reinforced Concrete Box	
* Headwall parallel to embankment, no wingwalls	
- square edged on 3 edges	0.5
- rounded on 3 edges, or beveled edges on 3 sides	0.2
* Wingwalls at 30^{o} to 70^{o} to barrel	
- square edged at crown	0.4
- crown edge rounded or beveled top edge	0.2
* Wingwalls at 10^{o} to 25^{o} 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

Table 3 was taken from FHWA, Report No. FHWA-IP-85-15 (1985).

8.4 Layout Requirements

It is preferable that 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.

8.5 Easement Requirements

Culverts or portions of culverts and ancillary components (e.g., headwalls, endwalls, and erosion protection areas) shall be located entirely within public right-of-way to provide future access and maintenance. Also, as directed by the County Engineer, an acceptable access drive, such as modular block porous pavement, may be required to allow maintenance access.

9.0 END TREATMENTS

9.1 Introduction

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, excluding driveway culverts, and at the outlet of all storm sewer systems. The selection of end treatment type is based on safety and economics.

9.2 Outlet Channel Protection

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 4, 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 Channel Protection and Riprap Aprons, suitable for outlet velocities up to 20 feet per second.
2) Energy Dissipation Devices, suitable for outlet velocities greater than 20 feet per second.

Rock Channel Protection and Riprap Aprons

Rock channel protection and riprap aprons at culvert and storm sewer outlets shall be designed as per the most updated ODOT L&D Manual, Vol.2, Drainage Design, and the detail for outlet protection found in most updated Rainwater and Land Development Manual.

Energy Dissipation Devices

Energy dissipation devices 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 material in Table 4.

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

Riprap Outlet Basins

One approved method of energy dissipation at storm sewer and culvert outlets is a riprap outlet basin, 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 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 (2006).

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. 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 ft./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 (1978) 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 or Small Canal Structures, or other design criteria acceptable to the County.

Table 4. Maximum velocities for channel lining materials

Channel Lining Material	Maximum Allowable Velocity (ft/s)
Natural Stream	
* Sand	2.0
* Silt	3.5
* Firm loam	3.5
* Fine gravel	5.0
* Stiff clay	5.0
* Grade loam or silt to cobbles	5.0
* Coarse gravel	6.0
* Shale or hard pans	6.0
Vegetated Channels	
* Seed mixtures	2.5
* Crown vetch	2.5
* Established seed or sodded	6.0
Flexible Lining	
* Slope erosion protection	follow manufacturer's criteria
* Erosion control matting	
* Rock channel protection	use sheer stress analysis
Rigid Linings	
* Concrete	18
* Concrete block mat	18

10.0 OPEN WATER COURSES

10.1 Introduction

The requirements in this section are applicable to newly constructed open watercourses that are intended to convey flow to stormwater inlets, stormwater control facilities, 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.

10.2 Channel Hydraulic Requirements

Cross Section Shape

In general, parabolic and trapezoidal channel shapes shall be used for open watercourses within development projects. The channel shall be two-tiered. The first tier shall be designed to convey the bankfull discharge. The second tier shall be designed to convey the remaining runoff from the 10 year design storm. Side slopes on both tiers shall be 3(H) to 1(V) or milder, with a minimum 2 foot bottom width for the first tier, for a trapezoidal channels, unless alternative dimensions are approved by the County 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, requires 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 4. Manning's Equation may be used to design an open channel that satisfies the maximum velocity criteria in this manual. Recommended Manning's n values for open channels with vegetated and non-vegetated linings are provided in the most updated ODOT L&D Manual, Vol. 2, Drainage Design. Computer engineering programs, such as HEC-RAS (January 2010) and SWMM (September 2006), may also be used in these designs.

10.3 Rock Channel Protection

Type B, C or D rock channel protection may be used to line the channel as long as the rock channel protection only is 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 (τ_{ac}) must be less than or equal to the allowable sheer stress (τ_a) listed in Table 6 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%:

$$\tau_{ac} = 62.4DS$$

where: D = depth of flow (ft.)
S = channel slope (ft./ft.)
τ_{ac} = actual shear stress (lbs/ft.^{2})

Table 5. Allowable shear stress for rock channel protection

Type of rock channel protection	τ_a (lbs/ft.^{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 County Engineer 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.

10.4 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 water courses

affected by back water from existing streams during dry weather flow conditions shall be provided with a stable outlet as specified in this manual.

Per the NPDES Phase II Construction permit, there shall be no concentrated discharges to waters of the State of Ohio. Level spreaders or other suitable practices must be used to return concentrated flow to diffuse flow.

10.5 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.
3) Easements for all watercourses must be within the “common area” of the subdivision.
4) An Access Road Easement which will extend along the entire length of the channel. This roadway shall consist of an approved modular block porous pavement or other surface approved by the County Engineer.

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.

10.6 General Procedure For Sizing Of Open Channel:

1. Determine the drainage area, A.

2. Determine the weighted coefficient of runoff, C, for the drainage area determined above. Table 6 lists average values that relates the runoff coefficient to land use and to the hydrologic group of the soil.

3. Compute the product (CA) for the area contributing flow.

4. Determine the time of concentration, T_c, to the first drainage structure. If no drainage structure is present, than the T_c shall be determined to the first ditch segment. Each ditch segment shall be determined by a change in the cross section of the ditch or a change in slope.

5. Determine the rainfall intensity, I, for the time of concentration found above. The rainfall intensity shall be calculated as outlined in Section 3.3.

6. The design discharge, Q, to be used in to determine the required size of the channel section is the product (CA) x I.

7. By using Manning's Formula, determine the required channel section.

8. Check the design flow velocity to ensure it does not exceed allowable velocities based on channel surface treatments.

9. Compute the time of flow in the open channel between drainage structures and add to the time of concentration of the first drainage structure. Check the time of concentration for the area contributing to the second drainage structure, and use the larger of the two as the duration for the new value of rainfall intensity for computing the design flow from the second drainage structure to the third drainage structure. If no drainage structures are to be included with the design of the drainage system, then each segment of the ditch shall be replaced with the above mentioned structure respectfully. Each ditch segment can be determined by a change in the cross section of the ditch or change in slope.

10. Continue this process for the entire channel system. A channel computation worksheet similar to that provided in the Appendix shall be used to tabulate the required information.

11. Once a ditch or channel is sized, the correct ground cover to line the channel can be specified.

Table 6.
Rational Method Runoff Coefficients (C) for Summit County

		Runoff Coefficients for Hydrologic Soil Groups			
Cover Description		A	B	C	D
Cultivated agricultural land		0.17	0.3	0.43	0.50
Pasture or range land- continuous grazing		0.08	0.16	0.36	0.47
Meadow - protected from grazing		0.06	0.13	0.30	0.43
Woods		0.05	0.10	0.29	0.41
Woods/grass combination (orchard, tree farm, etc.)		0.07	0.14	0.33	0.45
Lawns, parks, golf courses, cemeteries, etc.		0.08	0.16	0.36	0.47
Paved streets, parking lots, roofs, driveways, etc.		0.96	0.96	0.96	0.96
Gravel areas		0.40	0.59	0.69	0.74
Residential Areas					
Average lot size	Average % Impervious Area				
⅛ acre or less	65	0.41	0.59	0.72	0.77
¼ acre	38	0.16	0.37	0.54	0.64
⅓ acre	30	0.12	0.32	0.50	0.61
½ acre	25	0.09	0.29	0.47	0.59
1 acre	20	0.06	0.26	0.45	0.57
2 acres	12	0.05	0.23	0.41	0.50
Dirt or graded areas		0.41	0.61	0.74	0.83

11.0 POST CONSTRUCTION STORMWATER QUALITY CONTROL

11.1 Introduction

Post construction stormwater quality control shall be incorporated into the Stormwater Pollution Prevention Plan. This plan shall be submitted to the Summit Soil and Water Conservation District for their review and approval. The County will not approve proposed stormwater plans without an approved SWPPP.

11.2 Acceptable Methods and Criteria

Four general categories of stormwater quality control facilities have been approved for use in the County:

1) Group 1 - Stormwater Basins/Wetlands
2) Group 2 - Media Filters (bioretention, infiltration, sand filters)
3) Group 3 - Vegetated Swales and Filter Strips
4) Group 4 - Controls for Commercial Activity Areas and Redevelopment

The most updated version of the Ohio Department of Natural Resources Rainwater and Land Development Manual presents guidance information that may be used to select appropriate control facilities for the site. The designer shall present written documentation in their SWPPP supporting selection of appropriate control measures based upon site conditions.

In addition to the requirements outlined in the Rainwater and Land Development Manual, the following considerations shall be included in all designs.

1) Maintainability - Design the facility to minimize the amount and frequency of maintenance, to ease required maintenance activities, and to eliminate emergency or extraordinary maintenance requirements. Design criteria in the Manual are intended to facilitate maintenance, are required for facilities that will be maintained by the County, 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. The County shall require the developer, if transferring maintenance responsibility down through title to a homeowners association to provide to the County a long term maintenance agreement, including an annual inspection log and reports.
2) Accessibility - Design the facility to eliminate physical barriers (e.g., curbs and steep slopes) to entry for maintenance or emergency access, use strong, lightweight, noncorroding materials at access points (e.g., manhole covers and doors) to underground facilities, and provide legal right of entry for publicly maintained basins. The developer shall provide an access road easement which will extend into the

site. This road shall consist of an approved material, such as modular block porous pavement.

3) Durability - Design the facility to include strong, light-weight materials for removable features, reinforced concrete structures for permanent features, and hardy, disease resistant vegetation. Native vegetation is encouraged where practicle.

4) 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.

5) Cold Weather Issues - Stormwater quality control facilities shall be designed to operate effectively under cold weather conditions. Design considerations include use of outlets that will not clog when frozen, 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. Bubbling systems shall be incorporated to reduce ice build up and to prevent the formation of an anaerobic zone in pond bottoms.
Snow removal: In ponds, wetlands, bioretention facilities, or Media filter areas adjacent to roadways and parking lots, the site should include signage to identify the area as a location where snow dumping is not allowed.

6) 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 principals apply:

   a. 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.
   b. 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.
   c. 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. 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.
   d. 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.

11.2.1 Stormwater Basins

Stormwater basins typically provide a combination of a permanent pool and/or extended detention to treat the entire WQ_V. Acceptable designs include:

1) Extended dry detention basin,
2) Permanent pool (wet) extended detention basin, and
3) Wetland extended detention.

See the Rainwater and Land Development Manual for examples of each type of basin.

Stormwater quality design features can be readily incorporated into stormwater basins that are designed to function as quantity control facilities, making them an attractive choice for stormwater controls. Stormwater basins that are intended to provide stormwater quantity as well as stormwater quality control shall be designed in accordance with the criteria presented in both this section and in the technical manual.

At a minimum, all stormwater basins shall be designed according to the general criteria provided in this manual. Additional design requirements are specified in the following sections. If a dam or spillway is part of the basin's design, the design and construction of the basin are required to follow Ohio law pertaining to dam design (Section 1521 of the Ohio Revised Code and Chapter 1501:21 of the Ohio Administrative Code) and safety requirements.

Extended (dry) Detention Basins

Extended dry detention basins are designed to capture stormwater during rain events and slowly release the captured volume over a specified period of time. The following criteria shall be used to design extended dry detention basins intended to serve as water quality BMPs.

Hydrology Requirements

The extended dry detention basin shall be sized to capture the WQv calculated according to the methodology in this manual. A minimum drawdown time of 48 hours shall be used to size the facility outlet, as described under the Outlet Facility and Outfall Protection Requirements later in this section. If a stormwater quality control basin is incorporated within a stormwater quantity control basin, the entire stormwater quantity design storm shall be routed through the stormwater quality portion of the basin when sizing the facility.

Layout and Geometry Requirements

See the Rainwater and Land Development Manual for specific details.

The layout and geometry of extended dry detention basins shall also meet the following requirement:

1) If water quantity control is provided by parking lot storage, the WQ_V shall not extend onto paved surfaces, except for pervious/porous pavement.

Pretreatment Requirements

See the Rainwater and Land Development Manual for specific details.

The pretreatment of extended dry detention basins shall also meet the following requirement:

1) A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time.

Outlet Facility and Outfall Protection Requirements

See the Rainwater and Land Development Manual for specific details.

The outlet facility and outfall protection of extended dry detention basins shall also meet the following requirements:

1) Drain down times shall be determined by routing a stormwater hydrograph through the control structure. The rainfall depth of the storm shall be 0.75 inches, the duration of the storm shall be 24 hours, and the temporal pattern used shall follow the guidelines presented in this manual.
2) The principal spillway for flows in excess of the WQv shall be designed according to criteria in this manual and equipped with a removable trash rack.
3) The outlet structure shall be designed to be non-clogging. See the current edition of the Rain Water & Land Development Manual for design guidance.
4) Water quality orifices less than 1 inch in diameter are prohibited.

Permanent Pool (wet extended) Detention Basins

Permanent pool 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. The following criteria shall be used to design extended wet detention

basins.

Hydrology Requirements

The volume of the permanent pool detention basin shall be 150% of the WQ_V, calculated according to the methodology in this manual.

1) This volume shall be split, with approximately 75% of the WQ_V placed in the permanent pool, and 75% of the WQ_V placed in the extended detention volume overlaying the permanent pool.
2) If a stormwater quality control basin is incorporated within a stormwater quantity control basin, the entire stormwater quantity design storm shall be routed through the stormwater quality portion of the basin when sizing the facility.
3) An additional 20% of the water quality volume shall be added to the permanent pool volume for sediment storage.

Layout and Geometry Requirements

The basin shall be shaped so as to maximize water quality treatment. Flow length to pond width shall be a minimum of 3:1. See the Rainwater and Land Development Manual for additional specific details.

Pretreatment

A forebay or other pretreatment feature shall be provided at the inlets of all basins that are to be publicly maintained. See the Rainwater and Land Development Manual for specific details.

Outlet Facility and Outfall Protection Requirements

See the Rainwater and Land Development Manual for specific details.

The outlet facility and outfall protection of permanent pool detention basins shall also meet the following requirement:

1) Drain down times shall be determined by routing a stormwater hydrograph through the control structure. The rainfall depth of the storm shall be 0.75 inches, the duration of the storm shall be 24 hours, and the temporal pattern used shall follow the guidelines presented in this manual.
2) The principal spillway for flows in excess of the WQ_V shall be designed according to criteria in this manual and equipped with a removable trash rack.
3) The outlet structure shall be designed to be non-clogging. See the current edition of the Rain Water & Land Development Manual for design guidance.

11.2.2 Wetland Extended Detention Basin

Similar in design to permanent pool basins, constructed wetlands treat stormwater by providing an extended detention zone (above shallow permanent pools) sized to capture and release the calculated WQ_V over a minimum time of 24 hours. Stormwater wetlands are depressed, heavily planted areas that are designed to maintain flow during dry periods in order to support aquatic vegetation. The amount of surface area required for a stormwater wetland is typically larger than that of a permanent pool basin due to the limited allowable depths required for wetland design. The following criteria shall apply to the design of stormwater wetlands.

General Criteria

All stormwater wetlands shall be designed according to the following criteria:

1) The general criteria for stormwater controls presented in this manual,
2) The general criteria for stormwater detention basins presented in this manual,
3) Owners of wetland systems must agree to provide a mosquito monitoring and control plan within the maintenance plan for the BMP. The owners shall be required to contract with The Summit County Board of Health to provide this service.
4) Specific criteria in this section, and
5) Stormwater wetland shall not be located within any jurisdictional waters, including wetlands, without obtaining a Section 404 Permit.

Layout and Geometry Requirements

See the Rainwater and Land Development Manual for specific details.

The layout and geometry of stormwater wetlands shall also meet the following requirements:

1) The permanent pool of any proposed stormwater wetland shall be at least two times the volume of evapotranspiration during a thirty day drought at summer evaporation rates or $0.75WQ_V$, whichever is greater. In cases where subsurface infiltration into and exfiltration out of the wetland are negligible, the summer evapotranspiration rates may be estimated as 0.75 times the pan evaporation rate of 0.2 inches/day. More rigorous water balance calculations may be required by the County where these simplifying assumptions are not valid and/or in all cases where the drainage area to the wetland is less than 20 acres.
2) Stormwater 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).
3) Cold Weather Considerations: Many of the cold weather concerns for wetlands are

similar to those outlined in this manual. Also, two other concerns with cold weather wetland design are as follows:
a. Due to the short growing season, planting schedules should incorporate relatively mature plants.
b. Due to high chlorides-grassed infiltration swales should be utilized prior to entry into the wetland. This will provide some infiltration of chlorides to reduce the shock to the wetland plants.

4) An additional 20% of the water quality volume shall be added to the wetland pool volume for sediment storage.

Pretreatment

See the Rainwater and Land Development Manual for specific details.

Landscape Requirements

1) A landscaping 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) If a minimum vegetative coverage of 70% is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required.
3) All landscaping 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

See the Rainwater and Land Development Manual for specific details.

11.2.3 Media Filters

Media filters remove pollutants by passing stormwater through a bed of sand, soil peat, or other media that filters particulate matter and/or absorbs the trapped pollutants. Two types of media filters are recommended by the County:

1) Bioretention Facility
2) Sand Filter

Other types of media filters will be considered by the County if sufficient information is

submitted to the County in support of the design, operation, and maintenance of the media filter.

Bioretention Facilities

A bioretention system consists of a soil bed planted with native vegetation located above an underdrained gravel or sand layer. Stormwater runoff entering the bioretention system is filtered first through the vegetation and then the soil bed before being conveyed downstream through the underdrain system, slowing the runoff velocity and treating stormwater runoff by absorption, decomposition, and filtration. Bioretention facilities are often sited adjacent to and used to treat runoff from paved surfaces such as parking lots. Sites utilizing bioretention facilities for water quality control must also meet stormwater quantity control requirements. Stormwater quantity controls may either be integrated into the bioretention system or provided in a separate downstream facility.

Hydrology Requirements

Bioretention facilities shall be designed to capture and store the WQ_V prior to filtration and shall provide a filtration time of no less than 24 hours (when the filter media is new) and no more than 40 hours (when the filter media is clogged and requires maintenance). A drawdown time of 40 hours shall be used for facility design. The following criteria shall apply to the design of bioretention facilities.

Layout and Geometry Requirements

See the Rainwater and Land Development Manual for specific details.

The layout and geometry of bioretention facilities shall also meet the following requirement:

1) If bioretention facilities are placed in areas where the water table is above the invert of the underdrain system, additional underdrains may be required to lower the ground water table.
2) Runoff from the tributary area of the bioretention facility shall be directed into a swale or other storage area sized to contain the entire WQ_V. This swale shall partially or completely overlay the bioretention facility, as long as the maximum depth of water over the filtering media is no more than 12 inches. Water shall not cover the media longer than 72 hours after a precipitation event.
3) Snow removal: areas adjacent to roadways and parking lots site should include signage to identify the area as a location where snow dumping is not allowed.

Planting Soil (Filter Media) Requirements

See the Rainwater and Land Development Manual for specific details.

Underdrain and Outlet Requirements

See the Rainwater and Land Development Manual for specific details.

Pretreatment

See the Rainwater and Land Development Manual for specific details.

Landscaping Plan

Consult with the Summit Soil and water Conservation District in developing a landscaping plan for the bioretention facility.

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. The two most common examples of sand filters used in the United States are the Austin sand filter (1996) and the Delaware sand filter, developed by Young (1996). The Austin sand filtration system is built at grade and is most commonly used for larger drainage areas that have both impervious and pervious surfaces. Delaware sand filter systems are installed underground, and thus are most commonly used for highly impervious areas where land available for structural controls is limited.

See the Rainwater and Land Development Manual for specific details.

Hydrology Requirements

Sand filters shall be designed to capture and store the WQ_V prior to filtration and shall provide a filtration time of no less than 24 hours (when the filter media is new), and no more than 40 hours (when the filter media is clogged and requires maintenance). A drawdown time of 40 hours shall be used for facility design.

11.2.4 Enhanced Swales and Filter Strips

Swales are shallow, mildly sloped trapezoidal channels and filter strips are sloped surfaces with a relatively mild longitudinal slope. The surface of both are typically composed of dense turf grass, and are effective at reducing runoff peaks and removing pollutants. They are designed to convey and/or store the water quality volume (WQ_V) at shallow depths,

preferably as sheet flow, with peak depths significantly less than the height of the grass. Under these conditions, vegetated swales, vegetated filter strips, and enhanced swales allow opportunities for infiltration and trapping of solids.

Currently criteria in Ohio EPA's Construction General Permit for Ohio limit use of vegetated swales and vegetated filter strips to projects that disturb less than 5 acres. Dry extended detention swales may be used for projects of any size.

Vegetated Swales

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade.

Hydrology Requirements

Vegetated swales are designed to treat the entire WQ_V from the tributary area. Since treatment occurs as stormwater flows through the swale, it is necessary to develop a design peak flow for the WQ_V representative of flow conditions that maximize treatment and retard flow. The following procedure shall be used to develop the design peak flow:

1) Determine the time of concentration for the area draining into the swale.
2) Define the peak intensity of the design storm producing the WQ_V using the intensity duration-frequency curve for northeast Ohio.
3) Use the rational method to determine the peak flow through the swale.

Layout and Geometry Requirements

The topography of the site shall be used or re-graded as needed to design a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls.

1) Swales are generally recommended for drainage areas less than 5 acres, with a total drainage area of 1 to 2 acres preferred.
2) Trapezoidal channels are normally recommended, but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
3) If the design peak for the WQ_V calculated is larger than 1 cfs, then more than one swale shall be provided in order to maintain sheet flow and shallow flow depths within the swale. Flow shall be distributed among the swales to keep peak flows during the WQ_V design event less than 1 cfs in each.

4) Use Manning's Equation to design the swale under peak WQ_V design storm conditions, using criteria within this section to establish design limits for the swale.
5) The swale shall be designed so that the water level does not exceed 3 inches at the design peak flow for the WQ_V.
6) It is recommended that longitudinal slopes along the swale shall not exceed 2.5 percent, and shall be milder if necessary to keep the peak velocity within the swale less than 0.9 ft./sec. However, longitudinal slopes may range between 2% and 6%. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.
7) The width of the swale should be determined using Manning's Equation, at the peak flow during the water quality design storm, using a Manning's n of 0.25. The maximum bottom width shall not exceed 10 feet unless a dividing berm is provided.
8) The swale shall have a length that provides a minimum hydraulic residence time, or the time it takes for the water to pass through the swale, of at least ten minutes. Regardless of the hydraulic residence time, the length of the swale shall not be less than 100 feet.
9) Swales may be designed to safely convey storms generating more than the WQ_V. The peak velocity of the 10 year design storm through the swale shall be non-erosive for the soil and vegetative cover provided (See Table 4). Three inches of freeboard should be provided.
10) The side slopes of the swale shall be no steeper than 4 (H) to 1 (V).

Vegetation Requirements

Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses, consult the most updated version of the Rainwater and Land Development for information regarding seeding and mulching, and topsoil. If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials. The surface shall be graded flat prior to placement of vegetation. Initial establishment of vegetation shall receive attentive care, including appropriate watering, fertilization, and prevention of excessive flow, until vegetation completely covers the area and is well established. Use of a permanent irrigation system to keep the vegetation alive and healthy during droughts may help provide maximal water quality performance.

Pretreatment Requirements

Runoff shall enter swales as sheet flow. The use of a level spreading device (vegetated berm, rock trench, etc.) shall be required to prevent concentrated flow from entering the

swale.

Vegetated Filter Strips

Grassed filter strips are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure.

Filter strips consume a large amount of space relative to other BMPs. They are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces.

Hydrology Requirements

Vegetated filter strips are designed to treat the entire WQ_V from the tributary area. Since treatment occurs as stormwater flows through the filter strip, it is necessary to develop a design peak flow for the WQ_V representative of flow conditions that maximize treatment and retard flow. The procedure defined in the section for vegetated swales shall be used to develop the design peak flow.

Layout and Geometry Requirements

Filter strips shall be gently sloping areas between 1 and 15 percent with a robust and diffuse vegetative cover. Concentrated flow shall not be allowed to occur along filter strips, as it causes erosion that effectively eliminates water quality benefits.

1) Filter strips are generally recommended for drainage areas less than 5 acres, with a total drainage area of 1 to 2 acres preferred.
2) Use Manning's Equation to design the filter strip under peak WQ_V design storm conditions, using criteria within this section to establish design limits for the strip. A wide channel assumption shall be used for determining cross-sectional parameters of the filter strip.
3) Only sheet flow shall be allowed to enter the filter strip. The maximum length of the overland flow path shall be no longer than 100 ft to prevent flow from concentrating, unless a level spreader is used to convert concentrated flow to sheet flow prior to entering the filter strip.
4) The filter strip shall be designed so that the water level does not exceed 1 inch at the design peak flow for the WQ_V.
5) Runoff flow velocities shall not exceed 1 foot/second across the filter strip.
6) The vegetative surface shall extend across the full width of the filter strip area. The

upstream boundary of the filter strip shall be located contiguous to the developed area.

7) The maximum length of the filter strip, measured in the direction of flow shall comply with the criteria for determining the maximum length of sheet flow provided in this manual.
8) Minimum length of the filter strip (in the direction of flow) shall be 15 feet.
9) The width of the filter strip shall be the same as the tributary area (i.e., no concentration of flow from the contributing area is allowed).
10) Both the top and toe of the slope shall be as flat as possible to encourage sheet flow and prevent erosion. The top of the filter strip shall be installed 2 to 5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.
11) Filter strips shall be designed to drain between storms and not allow pollutants to migrate into the ground water. To satisfy this requirement, filter strips may only be installed in areas where the seasonal ground water level is at least 2 feet below the filter strip, based on the Summit County Soil Survey or a soils report prepared to support project design.

Vegetation Requirements

The vegetation requirements for filter strips shall be identical to those provided for vegetated swales.

Pretreatment Requirements

The pretreatment requirements for filter strips shall be identical to those provided for vegetated swales.

Extended (dry) Detention Swales (also called exfiltration trenches)

Dry extended detention swales incorporate a combination of dry cells formed by check dams or other means and filtering media to treat stormwater runoff by settling, absorption, decomposition, and filtration. The practical applications for dry extended detention swales are low density residential projects or for very small impervious areas. Sites utilizing dry extended detention swales for water quality control may incorporate additional storage and outlet structures to meet the stormwater quantity control requirements of this manual.

Hydrology Requirements

Dry extended detention swales shall be designed to capture and store the entire WQ_V and release it in no less than 24 hours and no longer than 40 hours. Water retained within the swale may be released through an outlet at the downstream end of the swale and/or by infiltration into the soil. The native soils shall be replaced with a 30-inch deep layer of permeable soils underlain with an underdrain system.

The following criteria shall apply to the design of dry extended detention swales.

Layout and Geometry Requirements

1) The total recommended drainage area of a dry extended detention swale is 5 acres, with a total drainage area of 1 to 2 acres preferred. Multiple cells should be considered to distribute the flow and facilitate proper drainage of the facility.
2) Dry extended detention swales shall not be allowed in areas where bedrock is above the invert of the underdrain system.
3) In areas where the water table is above the invert of the underdrain system, additional subsurface drainage may be required to ensure proper performance of the detention swale.
4) In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosion as sheet flow is conveyed to the treatment area.
5) Dry extended detention swales should maintain a maximum ponding depth of one foot at the mid-point of the channel's longitudinal profile, and a maximum depth of 18 inches at the downstream end point of the channel for storage of the WQ_V. Check dams or similar structures may be installed along the longitudinal profile to meet this criteria.
6) The side slopes for dry extended detention swales shall not exceed 4 (H) to 1 (V).
7) Swales may be designed to safely convey storms generating more than the WQ_V. The peak velocity of the 10 year design storm through the swale shall be non-erosive for the soil and vegetative cover provided (See Table 4). Three inches of freeboard should be provided.

Permeable Soil Requirements

The function of a dry extended detention swale is largely dependent on the characteristics of the soils underlying the swale. The soil underlying the swale shall be replaced with a 30-inch layer of permeable soil underlain with an underdrain system in order to provide proper drainage of the swale. The following criteria shall be used:

1) The permeable soil for dry extended detention swales shall consist of a mixture of sand, topsoil, and compost with a pH range of 5.5 and 6.5, a range where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. In addition, the soil shall have infiltration rates greater than 0.5 inches per hour when saturated, achieved through the following standards(as recommended in the ODOT Location and Design Manual, Vol. 2, Drainage Design):
    a. 4 parts sand,
    b. 2 parts topsoil, and
    c. 2 parts compost.
2) Soil tests shall be performed for every 500 cubic yards of soil, with the exception of

pH and organic content tests, which are required only once per dry extended detention swale.

3) The minimum depth of the filter media shall be at least 30 inches.
4) Dry extended detention swales shall be planted with grass that can withstand prolonged periods in a wet environment. No vegetation with a deeper root zone shall be allowed within the swale.

Underdrain and Outlet Requirements

1) A perforated pipe underdrain shall be provided beneath the permeable soil. The underdrain shall have a minimum grade of 0.5 percent. The perforated pipe shall have a diameter of 6 inches, and shall meet the requirements of ODOT item number 706.06, 706.08, or 707.41. A granular backfill of durable No. 57 aggregate shall be provided up to a minimum of 4 inches above the outside diameter of the pipe.
2) The swale shall be designed to convey or divert all storms larger than the WQ_V up to and including the 100 year event. Storms larger than the WQ_V may be directed into a storm sewer system. Use of a vertical stand pipe or catch basin is recommended.

Pretreatment

Flow entering the dry extended detention swale shall be limited to sheet flow to prevent eroding the side slopes of the facility. If flow has been concentrated prior to entering the swale, it shall be converted to sheet flow using a level spreader device. In addition, the frequency of maintenance for dry extended detention swales may be reduced by providing filter strips around the facility. The purpose of the filter strip is to trap course sediments before they reach permeable soil thereby reducing maintenance and preserving infiltration capacity.

11.2.5 Applicant-Proposed Stormwater Control

There are many types of commercially-available proprietary systems for stormwater quality control. These systems include:

1) Hydrodynamic systems such as gravity and vortex separators,
2) Filtration systems,
3) Catch basin media inserts,
4) Chemical treatment systems, and
5) Prefabricated detention structures

This section provides stormwater treatment and quantity control criteria for vendors and/or Applicants requesting approval of these systems for use in the County. Stormwater controls proposed in lieu of those defined in this section must, at a minimum, meet the

performance standards established in this section.

Performance Standards for New Development Controls

The pollutant removal effectiveness for total suspended solids (TSS) that is achieved by the other stormwater quality controls in the Manual establish the required performance standard for alternative or manufactured facilities. Total suspended solids are defined as "matter suspended in stormwater, excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter (larger than coarse sand)". According to the USEPA (1995), typical urban runoff contains about 100 mg/L TSS. Extended dry and wet detention basins, vegetated swales, and sand filters designed according to the criteria in the Manual are effective at removing very small particles down to the range of 10 microns to 20 microns, achieving effluent TSS concentrations of 15 to 30 mg/l, on average.
Based on these statistics, the Applicant must demonstrate that the BMP is able to remove all particles larger than 15 microns and yield a maximum effluent concentration of 20 mg/L.

12.0 OPERATION AND MAINTENANCE OF STORMWATER CONTROLS

12.1 Introduction

This section provides requirements to ensure successful performance of stormwater control facilities once they have been constructed. Included in this section are requirements for as-built surveys, facility inspection and maintenance, and maintenance and access easement requirements to allow for maintenance in an around stormwater facilities.

12.2 Maintenance Responsibilities

It is essential that any approved stormwater control facility be properly maintained in order to assure its performance. The County can maintain eligible onsite detention basins and constructed wetlands designed to serve single-family residential developments. For the County to maintain these facilities, an agreement must be first reached with the developer and a fee structure put in place to compensate the County for work performed. To be eligible for County maintenance services, the owner of the stormwater detention basin or wetland must:

1) Have established vegetation within and around the facility, if applicable,
2) Have designed and constructed the facility in accordance with County standards and proven by as-built surveys,
3) Have the facility in proper working order at the time the County accepts maintenance responsibilities, and
4) Provide to the County specific, dedicated easement rights sufficient to perform required maintenance.

Onsite facilities, other than stormwater detention basins and constructed wetlands in single-family residential developments, shall be maintained by the Property Owner or, if applicable, a homeowners association. Onsite facilities constructed to serve privately-owned non-single family residential developments (i.e., multi family, commercial, industrial, etc.) shall be maintained by the Property Owner.

12.3 Easement and Access Requirements

For stormwater control facilities that are to be operated and maintained by the County, the Property Owner shall provide the County with an easement that includes a minimum of 20 feet beyond the area of the control facility when flooded during the 100 year event, appurtenances to the facility such as forebay(s), benches, risers, outlet pipes, etc., and a minimum width of 20 feet around the perimeter of the facility. For basins that are to be publicly maintained, the Property Owner shall provide an easement extending 20 feet

beyond the maximum flood limits of the facility around the basin and its appurtenances. A dedicated access easement, having a minimum width of 20 feet, shall also be provided that extends from the facility easement to the nearest public right-of-way.
For facilities that are to be maintained by a homeowners association, the developer shall provide to the County a minimum 20-foot wide easement for such inlet and outlet pipes, etc., conveying stormwater to a public conveyance system.

For stormwater control facilities that are to be operated and maintained by the County or a designated homeowners association, the Property Owner shall provide the County with a maintenance vehicle accessway having a minimum width of 20 feet. The accessway shall be located around the perimeter of each facility, into the bottoms of detention basins, 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 detention basin facilities). The vehicle accessway shall be stabilized with suitable materials (e.g., concrete, gravel, 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.

For stormwater control facilities that are to be privately operated and maintained, an access easement shall be granted to the County. A minimum 20' wide easement for access from the nearest public road R/W to the stormwater facility will be required. This 20' width will also be required around the perimeter of the stormwater control facility. The purpose of this easement is to provide access for routine inspections and will only be used for maintenance purposes should the property owner fail to provide required maintenance.

12.4 Maintenance Inspection and Reporting Requirements

The Property Owner, its administrators, executors, successors, heirs or assigns shall maintain the stormwater control facility or facilities in good working condition acceptable to the County and in accordance with the schedule of long term maintenance activities provided in the approved stormwater control facility maintenance plan for the stormwater control facility or facilities. Maintained infrastructure shall include all pipes and channels built to convey stormwater to the facility, as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater from the facility. "Maintain" is herein defined as good working condition so that these facilities are performing their design functions.

The purpose of maintenance inspections is to assure safe and proper functioning of the stormwater control facilities. The Property Owner shall perform periodic inspections of the stormwater control facility and its appurtenances at a frequency stipulated in the approved stormwater control facility maintenance plan. Inspections shall cover all elements for the stormwater control facility as defined in the stormwater control facility maintenance plan. Inspections shall include the completion of dated and signed inspection checklists provided in the stormwater control facility 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 County upon request. A copy of the Maintenance Inspection Log shall be submitted annually by December 31st of each year to the County Engineer's Office.

Where applicable, language explaining the maintenance, inspection, and reporting responsibilities in accordance with approved stormwater control facility maintenance plans shall be provided on the plat and recorded with all deeds to the property.

12.5 Maintenance Plan

A maintenance plan for privately-owned stormwater controls and for stormwater controls other than detention basins or constructed wetlands that are to be maintained by a homeowners association must be prepared and submitted for review and approval by the County for the Applicant during the Plan approval process. At a minimum, maintenance plans for stormwater controls shall include a method and frequency for the following activities:

1) Inspection of all permanent structures including post construction water quality structures,
2) Debris/clogging control through appropriate removal and disposal,
3) Vegetation control (mowing, harvesting, wetland plants),
4) Erosion repair,
5) Non-routine maintenance should include pollutant and sediment removal and the rejuvenation or replacement of filters and appropriate soils,
6) Disposal of collected pollutants, sediments, and filter media in accordance with local, state and federal regulations, and
7) Mosquito monitoring and abatement, encompassing inspections for conditions conducive to mosquito breeding, routine (e.g., vegetation control, debris and sediment removal) and non-routine (e.g., restoration of grade to eliminate ponding) activities to address these conditions, and conditions where the use of insecticides may be warranted.

As part of the maintenance plan, an agreement shall be reached with the Summit County Engineer's Office stating that if proper maintenance is not performed by the owner, the County will enter upon private property, perform all required maintenance, and bill the owner for all work performed.

13.0 AS-BUILT SURVEYS

As-built surveys will be required from the developer or property owner responsible for constructing stormwater facilities and conveyance systems. At a minimum, the developer shall field survey the location of each stormwater outfall and the outfall structure of each stormwater (quantity and quality) control structure that is constructed as part of the development site. Only stormwater outfalls that discharge directly into an open watercourse need to be located. A summary document shall be complete and submitted to the County Engineer Office for each outfall and stormwater control structure that were constructed as part of the project.

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 detention basins and wetlands that are to be owned and operated by the County. Additionally, as-built information shall be acquired for all installed storm sewer and all appurtenances to the storm sewer system. The County reserves the right to require as-built surveys on privately owned stormwater facilities if, in the opinion of the County Engineer:

1) The construction of the privately owned stormwater system may affect the performance of a publicly owned stormwater system, or
2) Final grading within a stormwater control facility or conveyance system appears to conflict with the approved grading plans.

The purpose of as-built surveys is to demonstrate conclusively that the facilities are constructed to the elevations, slopes, grades, and volumes shown on the approved plans on file with the County.

When ordered by the County to ensure that design grades and volumes within stormwater control facilities are achieved, an as-built survey shall be conducted once:

1) All structures on surrounding lots of a stormwater control facility are constructed and final lot grading for each lot is established, and
2) The conversion of a temporary sediment basin to a permanent stormwater control facility is complete after the site is built-out to the point where the temporary sediment basin is no longer needed. As-built surveys will only be accepted if they are conducted after the sediment in the temporary basin has been removed and regraded, vegetation has been established, and the permanent outlet structure(s) is in place.

As-built surveys shall be conducted by a Professional Surveyor registered in the State of Ohio and shall employ standard survey techniques. The Professional Surveyor performing the as-built survey shall be responsible for reduction of notes and any plotting necessary to make the notes interpretable. A final report and original field notes shall be furnished to the County for review and record purposes. A minimum of two bench marks that are

referenced to the same vertical datum as the construction plans shall be provided on the as-built survey drawings. As-built surveys shall be in addition to, and separate from, other construction surveys which the County or its agents may conduct. The developer, contractor, or other entity constructing the stormwater facilities shall correct the discrepancies necessary to ensure that the stormwater facility will function as designed. The as-built surveys shall be re-performed as necessary to demonstrate plan conformance.

14.0 REFERENCES

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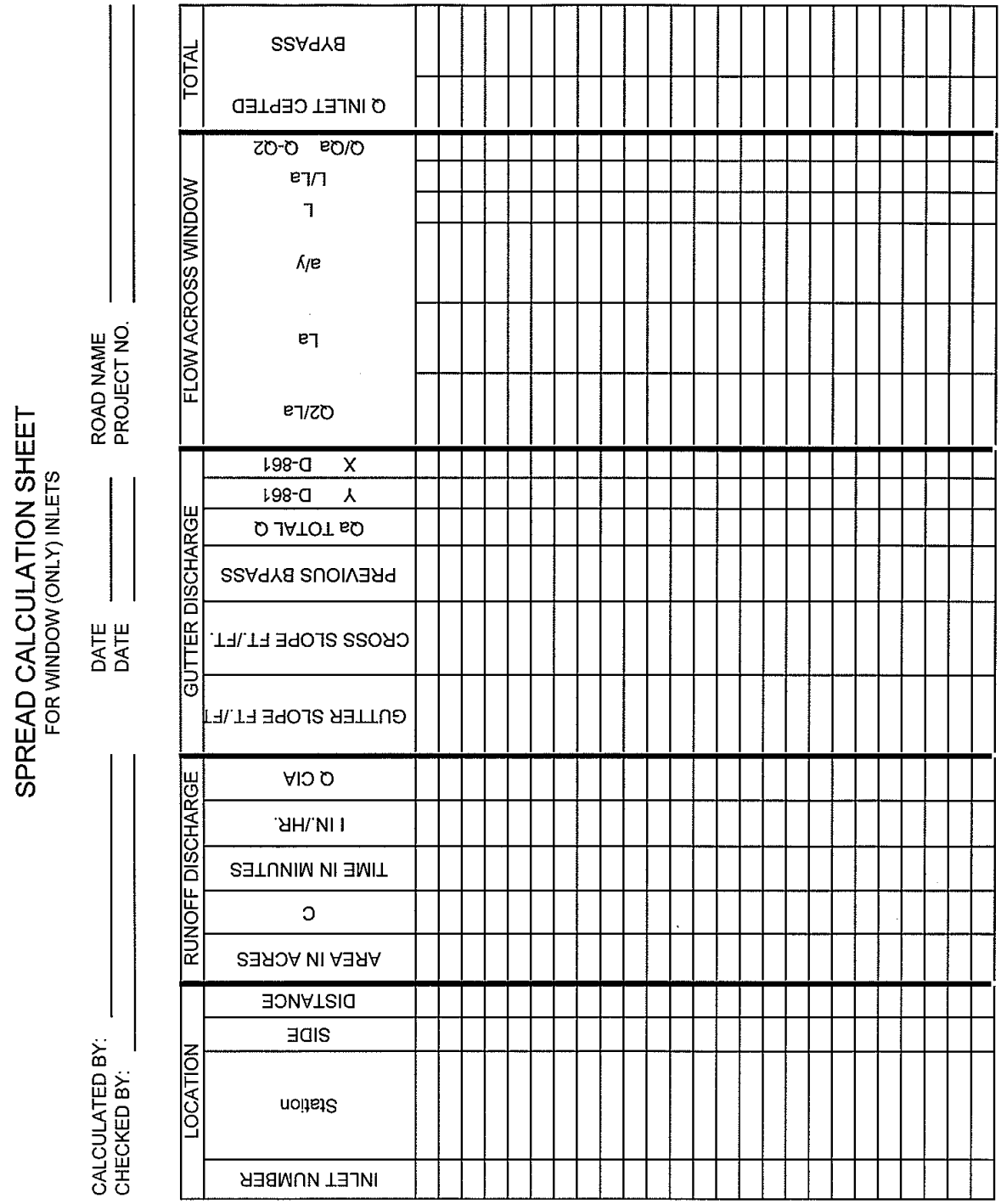
Appendix A

Design Aids


SPREAD CALCULATION SHEET
FOR WINDOW (ONLY) INLETS
CALCULATED BY:
CHECKED BY:
DATE
DATE
ROAD NAME
PROJECT NO.
LOCATION
INLET NUMBER
Station
SIDE
DISTANCE
RUNOFF DISCHARGE
AREA IN ACRES
C
TIME IN MINUTES
I IN./HR.
Q CIA
GUTTER DISCHARGE
GUTTER SLOPE FT./FT
CROSS SLOPE FT./FT.
PREVIOUS BYPASS
Qa TOTAL Q
Y D-861
X D-861
FLOW ACROSS WINDOW
Q2/La
La
a/y
L
L/La
Q/Qa Q-Q2
TOTAL
Q INLET CEPTED
BYPASS

Appendix A-2

STORM SEWER COMPUTATION SHEET

CALCULATED BY ______________________ DATE ________ JUST FULL CAPACITY ____________ PROJECT NO. __________

CHECKED BY ______________________ DATE ________

MANNING'S "n" ______________________ HYDRAULIC GRADIENT ____________ SHEET ______ OF ________

MANNING'S "n" ______________________

1	2	3	4		5		6		7	8		9		10	11	12	13	14	15	16	17	18	19	20	21
M.H. C.B. or I	Station	Slide	Drainage Area in Acres		Time of Concentration In Min.		Rainfall in Inches/Hour		Runoff Coef.	Column 7 x Column 4		Discharge inches (Col. 6 x Col. 8)		Size of Pipe Inches	Length of Pipe Feet	Slope of Piep Ft./Ft.	Inlet F/L of Pipe	Outlet F/L of Pipe	Mean Velocity Ft. Sec.	Just Full Capacity (….Year Q)	Frict. Slope Ft./Ft.	Head Losses Feet	Elevations of Hydr. Gradient (for 25 Year Q)	Grade of Cover Elev.	Remarks: Type of Struct. Protection
No.			ΔA	ΣA	Δt	Σt	i...	i...	C	ΔCA	ΣCA	Q...	Q...	θ	L	s_0	Elev.	Elev.	V_m	cfs	s_f	H	Elev.	Elev.	

CULVERT SIZE DESIGN

PROJECT: _____ DESIGNER: _____

DATE: _____

CULVERT DESCRIPTION (Entrance Type)	SIZE	Q	HEADWATER COMPUTATIONS										CONTROLLING HW	OUTLET CONT. SIZE OK IF HW>		OUTLET VELOCITY	COMMENTS
			INLET CONT		OUTLET CONTROL HW = H +h_b - LS_o												
			$\frac{HW}{D}$	HW	K_e	H	dc	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW		$\frac{D+(L+K_e)V^2}{2g}$	.75D		

SKETCH

DATA

Q_1 = ____ TAILWATER ELEV. ____ Q_1 = ____ YR. STM.

Q_2 = ____ TAILWATER ELEV. ____ Q_2 = ____ YR. STM.

FINAL DESIGN

SIZE ____ INLET ELEV ____ SKEW ____ HEADWALL_____
COVER ____ OUTLET ELEV ____ LENGTH SLOPE_____
VELOCITY ____ PROTECTION_____

OPEN CHANNEL COMPUTATIONS

PROJECT _____ DESIGNER _____

DATE _____

DISCHARGE								VELOCITY					CRITICAL FLOW				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Q	n_Q	s	$Ar^{2/3}$	w,y	T	h	V	n_V	$Ar^{2/3}$	A	$V_{max.}$	V	Z	$Z/w^{2.5}$	d_c/w	d_c	V_c

$Ar^{2/3} = nQ/1.49s^{1/2}$ $V = Q/A$ $Z = Q/g^{1/2}$

DITCH COMPUTATION SHEET

DONE BY _____ DATE _____ DITCH INFORMATION
CHECKED BY _____ DATE _____ MANNING'S "n" FOR:
SEEDED LINING _____
DESIGN FREQUENCY FOR: SOD OR JUTE MAT LINING _____
PAVED LINING _____
VELOCITY _____ YEARS _____ DUMPED ROCK CHANNEL PROTECTION _____
DEPTH _____ YEARS _____

PROJECT
SHEET ___ OF _____

ALLOWABLE VELOCITY FOR (in f.p.s.)

SEEDED LINING _____
SOD OR JUTE MAT LINING _____
DUMPED ROCK CHANNEL PROTECTION _____

DITCH CALCULATIONS

Ref. No.	Station		Side	Drainage area in Acres		Time			Intensity		Runoff Coef.	CEO. x A		CIA		Slope Ft./Ft.	Velocity in f.p.s.	Depth in ft.	Ditch in Time Check	Treatment		
																				Lining	Station	
	High Point	Point of Solution		ΔA	ΣA	Overland	Ditch			Depth		ΔCA	ΣCA	Qv	Qd						From	To