VOLUME II

ARTICLE VII

BASIC DESIGN CRITERIA FOR STORM SEWERS, APPURTENANT STRUCTURES, DETENTION AND RETENTION BASINS

Section ST 701
Degree of Protection Required

The degree of protection required shall be adequate to handle the runoff as computed in accordance with Section ST 702 (a) through (e). The runoff shall include the area within the development site and all other areas draining thereto, with all areas considered as fully developed in accordance with the ultimate development planned in the Master Plan of Hamilton County. The following storm frequency will be used:

(1) Design frequency for sizing storm sewers and structures.....10 Year

(2) Design frequency for all Districts, not within a Special Flood Hazard area, to contain the hydraulic gradient within the storm drainage system (see ST 707)..... 100 Year

(3) Design frequency for all Districts, within a Special Flood Hazard area, to contain the hydraulic gradient within the storm drainage system (see ST 707)..... 100 Year

Section ST 702
Determination of Quantity of Runoff

(a) Rational Method (For Drainage Areas Not Exceeding 200 Acres)

Each portion of the storm water drainage system shall be capable of handling the peak flows of runoff as determined by the "Rational Method", Q = CIA where

Q = peak runoff quantity in cubic feet per second;

C = runoff coefficient varying with pervious and other characteristics of the drainage area;

I = Average intensity of precipitation in inches per hour during the period of tc minutes

tc = time of concentration, is the duration of rainfall in minutes

A = area in acres of the tributary watershed.

(b) Compare the Rational Method and the State of Ohio Bulletin 45 Method to

Obtain Peak Runoff for Drainage Areas Exceeding 200 Acres

The peak flow of runoff as obtained from the Rational Method shall be compared to the State of Ohio Department of Natural Resources Bulletin 45 method for drainage areas exceeding 200 acres. The higher value shall be used for peak runoff. The Bulletin 45 regression equation for area 3 of southwest Ohio (Table 3), is represented as $Q_T = aA^W S1^X E^Y Pz$. This equation applies only to the rural areas of southwest Ohio. For Hamilton County, use EXHIBIT NO. 20 (Sheet Numbers 1 thru 4 of 4) for procedure to follow to calculate peak runoff when considering the Bulletin 45 method. Sheet Number 1 of 4, the computation sheet, includes an urbanization factor that must be considered.

(c) Runoff Coefficients (C)

The runoff coefficient is the portion of the precipitation, expressed as a decimal that will reach the storm water drainage system. In the following table runoff coefficients are given, varying with the type of zoning of the area and the slope of the area. Interpolate for coefficient C when the slope occurs between flat slopes less than two percent (2%) and steep slopes six percent (6%) or greater. Calculate the average weighted coefficient C to reflect the actual existing. The following zoning classifications are to be used as a guide.

Zone District	Characteristics	Runoff Coefficient (C)	
		Flat Slope (Less than 2%)	Steep Slope (6% or Greater)
-----	Parks, cemeteries, golf courses, lawns, playgrounds or unimproved land	0.20	0.38
"AA"	Residence District on 1 acre or more lot	0.32	0.42
"A"	Residence District 20,000 sq. ft. lot	0.36	0.47
"A-2"	Residence District 14,000 sq. ft. lot	0.41	0.52
"B"	Residence District 10,500 sq. ft. lot	0.47	0.58
"B-2"	Residence District 7,500 sq. ft. lot	0.53	0.64
"C"	Residence District 6,000 sq. ft. lot	0.60	0.71
"D"	Residence District 5,000 sq. ft. lot	0.74	0.80
"DD"	Planned Multiple Residence District	0.77	0.84
"O"	Office District	0.80	0.87

"OO"	Planned Office District	0.80	0.87
"E"	Retail Business District	0.80	0.87
"EE"	Planned Business District	0.80	0.87
"EF"	Excavation and Landfill District	0.26	0.40
"F"	Light Industrial District	0.82	0.87
"FF"	Planned Light Industrial District	0.82	0.87
"FPM"	Flood Plain Management District	Established on Case-by-Case Basis	
"G"	Heavy Industrial District	0.85	0.90
"GG"	Planned Heavy Industrial District	0.85	0.90
"H"	Riverfront District	Established on Case-by-Case Basis	
"MHP"	Mobile Home Park District	0.77	0.84
-----	Parking lots (paved), roofs, driveways	0.90	0.94

(d) Intensity of Precipitation/(I) = Rainfall Intensity in In/Hr To find I, use the following precipitation formulas for various storm frequencies:

FREQUENCY, YEAR	PRECIPITATION FORMULA
1	$I = \frac{80}{tc+14}$
2	$I = \frac{106}{tc+17}$
5	$I = \frac{131}{tc+19}$
10	$I = \frac{170}{tc+23}$
25	$I = \frac{230}{tc+30}$
50	$I = \frac{250}{tc+27}$
100	$I = \frac{290}{tc+31}$

(e) Time of Concentration/TC = Duration of Rainfall in Minutes

(1) The time of concentration, in minutes, is the estimated time it will take the storm runoff, from the most remote part of the area, to reach the point of the storm drainage system under consideration. This includes the time for water to flow over roofs, through the roof gutters and downspouts, over the ground, turf areas, streets, through street gutters to the nearest inlet of the drainage system plus the time of flow in the sewer pipes to the point under consideration. The Overland Flow Chart (EXHIBIT NO. 4) may be used to determine tc, when applicable.

(2) Time of concentration, tc, to an inlet or catch basin may be used as follows for new developments in Hamilton County, if the most remote part of the contributing drainage area is less than 300 feet from the inlet or catch basin.

Type of Development	**Time of Concentration (tc)**
Small commercial, Industrial storage, office, retail, etc. buildings with parking lots	5 minutes
Subdivisions, other new developments	10 minutes

For lengths greater than 300 feet, calculate the time of concentration.

(3) Flow time in sewers may be determined from the hydraulic properties of the sewers, assuming average flow-full velocity at the proposed sewer slopes.

Section ST 703
Pipe Capacity and Design

Pipe size shall be determined using the following pipe roughness coefficients, and the design procedures indicated in Sections ST 704 thru 707:"n" value

(a) For concrete smooth flow pipe 30" in diameter or larger = 0.013

(b) For concrete smooth flow pipe 27" in diameter or smaller = 0.015

(c) For aluminized, zinc or asphalt coated CMP (acceptable only for privately maintained storm sewer systems) ODOT L&D Table 1105.2

(d) For PVC smooth flow pipe = 0.010

(e) For HDPE smooth flow pipe = 0.013

Section ST 704
Minimum Pipe Size

(a) The minimum diameter for storm sewer pipe that is to be publicly maintained shall be 12 inches.

(b) Private drain connections to publicly maintained storm sewer appurtenances are recommended to have a minimum 12" diameter. Also, see Section ST 709(c).

(c) Private storm sewer systems located three (3) feet or more beyond any building that may or may not originate from a building storm drainage system, are recommended to be six (6) inches or larger in diameter except as indicated in (b) above, with cleanouts provided for maintenance purposes. Private storm sewer systems shall be designed in accordance with these Rules and Regulations except for material and structure specifications.

Section ST 705
Minimum and Maximum Velocities

(a) Minimum Velocity

Minimum velocity in storm sewer pipe, when flowing full for the ten (10) year design storm, shall be not less than 2.5 feet per second.

(b) Maximum Velocity for Publicly and Privately Maintained Storm Sewer Systems.

Maximum velocity in storm sewer pipe shall not be more than 16 feet per second, when flowing full for the ten (10) year design storm except that the velocity in the last section of storm sewer pipe at the outlet end shall not exceed 12 feet per second based on the hydraulic gradient slope for the 10 year design storm. Erosion control measures at the inlet and outlet ends must comply with EXHIBIT NO. 30. Storm sewer pipe with flow velocities exceeding 16 feet per second and/or slopes greater than 15% will require special pipe as per Section ST 713(c) and/or key blocking to protect the pipe against erosion and displacement by shock.

Section ST 706
Gradients of Pipe

The sewer pipe shall be laid on such gradients so that the flow full velocities shall be kept within the maximum and minimum limits indicated in Section ST 705. Pipe sizes may also be controlled by flood conditions, and/or submerged outlet conditions (Refer to Section ST 1104(d).

Section ST 707
Hydraulic Gradients

(a) Starting at the outlet of the storm sewer and working upstream, the hydraulic gradient calculations are required to be submitted with any new, final improvement

plans to be reviewed and approved by the County Public Works Director, whenever storm sewer pipe systems exist, or are proposed. The one hundred (100) year hydraulic gradient must be developed for each storm pipe system in the development.

(b) For most cases, head losses at catch basins, inlets, manholes, inlet manholes and angle changes in storm sewer alignment need not be taken into account in developing hydraulic gradients. The criteria to be used for the storm sewer design is considered adequate to compensate for these losses.

(c) The hydraulic gradient elevation at any catch basin, inlet, manhole, or inlet manhole, may not be higher than six (6) inches below the grate, inlet sill, manhole rim, or final surface grade, whichever is lower.

(d) The hydraulic gradient elevation at the outlet end of any storm sewer system shall begin at the highest water level elevation as computed or as recorded on FEMA or Consoer/Townsend flood studies for one hundred (100) year frequency storm, or if free outfall conditions exist, simply begin hydraulic gradient at the crown of the sewer pipe.

(e) Where the hydraulic gradient developed for existing storm sewer systems indicates surface flooding problems, the Developer's Engineer must submit a design scheme to assure that no proposed building will be subject to flooding.

Section ST 708
Manholes

(a) Storm sewer manholes are to be designated as State of Ohio Standard Number 1, 3, and 5 manholes, or Hamilton County Std.. CB3MH, Catch Basin/Manhole Plate 9.

(b) State of Ohio Standard Number 4 manhole may be approved by the County Public Works Director, where applicable for straight storm sewer alignment entering and leaving the manhole and uniform flow at the manhole (No drop in invert elevation through the manhole).

(c) Drop manholes may be required to reduce the slope of any sewer that has a velocity that exceeds the requirements of Section ST 705(b). Whenever possible, connections shall be made at inverts of manholes and the storm sewer crowns shall match.

(d) Manholes will not be approved where the depth from bottom invert to the manhole rim exceeds twenty-four (24) feet.

(e) Drop manholes generally shall be designated as State of Ohio Standard Number 3 or 5. However, to improve maintenance conditions, where continual, or nearly continual storm flow will occur, and where the drop exceeds six (6) feet, drop pipe details similar to that shown on the State of Ohio Standard Number 2 manhole drawing shall be provided and detailed on the improvement plans to fit the State of Ohio

Standard Number 3 or 5 manhole. Maximum drop pipe size shall be eighteen (18") diameters.

Section ST 709
Building, Parking Lot, or Other Private Storm Drain Connections to Publicly Maintained Storm Sewer System

(a) Any storm drain connections of private systems to public systems must be approved by the County Public Works Director.

(b) Storm Sewer Tap Permit and approval application shall be obtained from the County Public Works Director. All storm sewer taps shall be made at catch basins and manhole where practical. However, if necessary, tap shall be made at storm sewer pipes with approved bolted saddle and neatly drilled penetration, to correspond with private pipe inside diameter. All work shall be supervised and approved by the governing authority.

(c) Minimum pipe size of a private storm drain shall be twelve-inch (12") diameter within any public right-of-way. Except that this does not apply to owners who wish to make a storm sewer tap to convey an insignificant amount of runoff from downspouts yard drains, etc. The owner shall provide pipe size and material specifications that must be approved by the County Public Works Director. Also, refer to Section ST 704(b) and the County Engineer, where applicable.

(d) For additional information on private storm drain outlets, refer to the County Engineer Rules and Regulations Section E-206.

(e) Effluent from private sanitary sewer treatment systems will not be permitted to be directly connected to publicly maintained storm sewer systems, or allowed to enter a publicly maintained storm sewer system. See Section ST 602, and EXHIBIT NO. 1, Note Number 15 for additional information.

Section ST 710
Catch Basins, Inlets and Outlets

(a) General

(1) This section applies only to catch basins, inlets and outlets proposed to be located outside of any Special Flood Hazard Area. Design criteria for catch basins, inlets and outlets proposed to be located within any Special Flood Hazard Area are to be established on a case-by-case basis.

(2) For inlets and outlets consisting of headwalls, wingwall headwalls, no headwalls, etc., refer to Section ST 809 thru 811.

(3) Use EXHIBITS 4 through 19, where applicable, to submit catch basin design calculations, when deemed necessary by the Department of Public

Works, for review and approval, or similar forms that produce the same results.

(b) Design Criteria and Other Requirements for the CB-3A, CB-3, (CB3-M, Plate (12), (Catch Basin-Manhole CB-3MH, Plate 9)

For items (1) through (9) that follow, use the ten (10) year design frequency storm.

(1) Maximum runoff to any CB-3A shall not exceed 2.5 cfs, including any by-pass flow from upstream catch basins.

(2) Maximum runoff to any CB-3, CB3-M and CB-3-MH shall not exceed 4.0 cfs, including any by-pass flow from upstream catch basins.

(3) Maximum allowable spread of flow = 8.0 feet.

(4) Maximum allowable by-pass flow = 1.0 cfs, except at roadway intersections.

(5) Maximum allowable by-pass flow = 0.2 cfs at any roadway intersection.

(6) Catch basins shall be located upstream of all crosswalks and roadway intersections and shall be located at roadway low sag areas and at all low point cul-de-sacs. Catch basins shall be spaced at intervals of 300 feet unless it can be substantiated by calculations that a greater spacing will not cause a spread of flow greater than 8 feet (as measured from a point 6" inside the face of curb) or result in a bypass of more than 1.0 cfs."

(7) A minimum depth catch basin is allowed, provided that the required headwater available depth is insignificant and/or the minimum ground cover is (18") or greater over the top of the pipe.

(8) The Hamilton County Public Works Standard Drawing CB-3M Plate 10 is to be used to intercept one upstream or adjacent drainage structure at the beginning of a continuous sewer run or within a street intersection to avoid excessive sewer runs within the pavement area and/or penetrations into a manhole, such as:

CB2-2-A from rear yard to CB-3M
CB-3A from the other side of the street to CB-3M
CB-3 from around the corner to CB-3M
CB-3A from the same side of the street to CB-3M

(9) For roadways where the length exceeds 300' from its beginning to a low point cul-de-sac, provide extra CB-3A's, CB-3's, CB3-M's, or Catch Basin-Manhole CB-3-MH (Plate 9) located on the roadway curb on each side of the beginning of the cul-de-sac. In addition, provide at least one (1) CB-3, CB3-M or Catch Basin-Manhole CB-3-MH at the low point of the

cul-de-sac, and a ten (10) feet wide x 1'-0" deep "V" ditch from the back of the curb to the rear of the houses, for an overflow ditch.

(c) Design Criteria and Other Requirements for the CB2-2-A, CB2-2-B, CB2-3, CB2-4, CB2-5, and CB2-6 (off road catch basins)

For items (1) through (7) that follow, use the one hundred (100) year design frequency storm for flood protection purposes. Use the ten (10) year design frequency storm where there is no potential flooding of any existing or proposed buildings. An emergency overland relief swale shall be provided starting at the first catch basin then be continued down stream beyond buildings subject to flooding to next lowest reach of the drainage basin.

(1) The CB2-2-A and CB2-2-B will be approved in a publicly maintained storm sewer system provided its depth, as measured from the top of grate to flow line, does not exceed 4'-0".

(2) Off road closed storm drainage systems may be constructed with the use of catch basins instead of manholes or a combination of manholes and catch basins. Access for maintenance purposes must be provided to this type of system from a public roadway by easement.

(3) Maximum spacing between appurtenant structures shall be 300', regardless of design requirements.

(4) The capacity of the catch basin shall be equal to, or more than the calculated flow to it from any existing watercourse, drainage channel, swale, ditch, etc.

(5) Use EXHIBIT NOS. 17, 18 and/or 19 for determining the headwater depth from the windowsill and indicate on the improvement plans the number of windows required at any catch basin location. The top of water elevation at the catch basin obtained from using the headwater depth shall not exceed the top of the water elevation for the tributary watercourse, drainage channel, swale, ditch, etc. except that a slight headwater increase at the catch basin shall be allowed if no backwater will occur on adjacent private property.

(6) Use EXHIBIT NO. 22, entrance type (1) and obtain a headwater depth to determine a top of water elevation for the pipe size used and discharge Q_{10} entering the catch basin. This elevation must not be higher than the elevation obtained from EXHIBIT NOS. 17, 18 and/or 19 as explained in (5) above.

(7) An earthen dike except at low sump areas is required to be constructed immediately downstream from any field catch basin to create a sump condition. The earth dike generally shall be constructed at least

six (6) inches higher than the top of water elevation of the calculated flow to the catch basin from any existing watercourse, drainage channel, swale ditch, etc., unless this causes a flooding problem. The earth dike shall have a minimum 1'-0" width at the top and shall be located on the grading plan. The top of dike elevation shall be shown on the storm sewer system profile sheet.

(d) Requirements Relating to Surface Flow Between Residential Homes or Other Type Buildings

Where a proposed drainage channel, swale, or ditch, etc., has surface flow that exceeds 2.5 cfs between residential homes or any other type buildings, located less than thirty (30) feet of each other, the storm water surface runoff must be collected in an approved catch basin, inlet, or culvert, and directed through an underground storm sewer system before it is permitted to flow between the buildings. The inlet structure should be located at least forty (40) feet away from any building if physically possible.

(e) Requirements Relating to Surface Flow Onto a Public Roadway

Where an existing watercourse, drainage channel, swale or ditch, other than an emergency overland relief swales, has a surface flow that exceeds 2.5 cfs, the flow is not permitted to be discharged onto the surface of the public roadway. Provide an inlet structure and storm sewer system to intercept the flow.

(f) Requirements for Submitting Storm Drainage Calculations to Determine Whether Flooding of Any Building Will Occur

Where catch basins and/or inlets are to be located in close proximity to any building, or where the site conditions may indicate a potential for flooding, the County Public Works Director may require headwater depth and/or storm drainage calculations to determine whether flooding of any building will occur. Also, refer to Section ST 810(c)(1).

(g) Requirements for Modifying Standard State of Ohio Catch Basins and/or Inlets in New Developments

(1) Modifying standard catch basins should be avoided, whenever possible. The County Public Works Director will approve modified catch basins and/or inlets, but the improvement plans must include all the necessary details and dimensions for review and approval.

(2) There may be cases in new developments, particularly, at a low point roadway cul-de-sac, where a proposed standard CB-3 is required, but is located at a driveway entrance. In this case, a heavy duty roll type frame and grate is required along with modification of other CB-3 details. It is recommended that an East Jordan Iron Works Inc., Catch Basin Curb Inlet Number 7391, a Neenah Foundry Company Inlet Frame and Double Grate Number R-3516, or an approved equivalent, be used. The catch basin masonry walls must support whatever frame is used, with the details included in the improvement plans.

(h) Various Other Requirements for Catch Basin and/or Inlets Proposed In Private Developments

	Separate Recommended Items
(1) Location	Recommended Type of Catch Basin and/or Inlet to be Used
Private roadway with curb and gutter	State of Ohio Standard Construction Drawing CB-3A, CB-3 Hamilton County Standard Drawing Plate 9 CB3-M or Hamilton County Standard Drawing Plate 10 Catch Basin-Manhole CB-3-MH. Other ype catch basins or inlets may be substituted.
Private roadway or private drive with side ditches and no curbs, existing watercourse, drainage channel, swale, ditch etc.	State of Ohio Standard Construction Drawing CB2-2-A (Depth not to exceed 4'-0" and used only at the beginning of a storm sewer system); otherwise, use State of Ohio Standard Construction Drawing CB2-3, CB2-4, CB2-5, OR CB2-6. Other type catch basins or inlets may be substituted.
Paved or unpaved parking lots.	State of Ohio Standard Construction Drawing CB2-2-B with heavy-duty frame and grate (Designate Type). Depth not to exceed 4'-0" otherwise, use CB2-3, CB2-4, CB2-5, or CB2-6 with full size grate. Use heavy-duty frames and grate (Designate Type). Other type catch basins or inlets may be substituted.
Private yards, other paved or unpaved areas	State of Ohio Standard Construction Drawing CB2-2-A, CB2-2-B, CB2-3, CB2-4, CB2-5, CB2-6. Other type catch basins or inlets may be substituted

(2) For any catch basins and/or inlets proposed in new developments that are not designated or identified as in Section ST 710(b) and (c), and EXHIBITS 10 through 19, the design data and design calculations must be submitted for review and approval. The design shall be in accordance with these Rules and Regulations.

(3) CB2-2-B's and CB2-3's through CB2-6's used in continuous runs such as in parking lots. Larger grates than those shown in the standard drawings may be provided to increase the flow to the catch basins thus reducing the number of catch basins required. The Developer must submit a parking lot drainage design scheme and design calculations for review and approval in all cases.

(4) The Developer will be required to submit a flood study, including storm drainage calculations and present a suitable scheme that will not worsen any existing or potential flooding problem related to the development using the one hundred (100) year design frequency storm.

Section ST 711
Detention Basin Design Criteria

(a) General

Detention basin/s are required for any new development, as indicated in Section ST 405, the design and details shall comply with these Rules and Regulations. It is recommended that the Engineer follow the procedure as indicated in EXHIBIT NOS. 33 and 34 and this section for developing detention basin design and details.

(b) Special

(1) When ever special or unusual field conditions require that a detention basin must be designed in a different manner than that indicated by this section, the Developer's Engineer must obtain approval from the County Public Works Director for the detention basin design and detail proposal, following the concept review procedures in Article XI, before proceeding with the final design.

(2) The design criteria for detention basins in these Rules and Regulations apply only to detention basins located outside of any special flood hazard area.

(3) Whenever the detention facility discharge pipe outlets near the bottom of a primary or major watercourse the design shall include a condition that the one hundred (100) year frequency flood is occurring at the same time the detention facility is at its high water level. Base Flood Elevation reference material is available at Hamilton County:

3.01 Consoer and Townsend Associates Storm Drainage and Open Space Master Plan.
3.02 Firm Flood Insurance Rate Map.
3.03 If the base flood elevation is not of record the designer shall determine the one

hundred (100) year base flood elevation by hydraulic analysis based on the field conditions.

(c) State of Ohio Permit for Construction of Dams

(1) A State of Ohio Construction Permit for construction of a detention basin dam is not required for:

1.01 A dam, which is or will be less than ten feet in height and which has or will have a storage capacity of not more than fifty acre-feet at the elevation of the top of the dam. For the purposes of this section the height of a dam shall be measured vertically from the natural stream bed or lowest ground elevation at the downstream or outside limit of the dam to the elevation of the top of the dam; (see dimension H, EXHIBIT NO. 34).

1.01 A dam, regardless of height, which has or will have a storage capacity of not more than fifteen (15) acre-feet at the elevation of the top of the dam.

1.03 A dam, regardless of storage capacity, which is or will be six (6) or less feet in height.

(2) Refer to Section ST 1104(e) for additional instructions, if a State of Ohio Construction Permit is required.

(d) Plans, Drainage Area Maps, Design Calculations, etc., Required

Most of the requirements for submitting Improvement Plans to the County Public Works Director for review and approval that include detention basin/s are covered under Articles IV and XI. When EXHIBIT NOS. 33 and 34 apply for developing the detention basin design and details, the Engineer shall include the following data, or any other related data necessary for proper review, in the submittal:

(1) Submit a topographic map delineating the off site and on site drainage areas that contribute runoff to the release structure. Also delineate on the map the flow line of the existing watercourse or drainage channel used to determine the most critical runoff length and calculate the ground slope based on the most critical runoff length for determining time of concentration (tc).

(2) Submit EXHIBIT NO. 4 for determining time of concentration (tc.) Use 5 minutes for small commercial sites.

(3) Submit EXHIBIT NO. 20 for determining discharge (Q_{100}) or (Q_{100}), whichever applies, for drainage areas exceeding 200 acres only.

(4) Submit EXHIBIT NOS. 17, 18, 19 and 21 through 28, when they apply, for the design of the primary spillway system.

(5) Submit EXHIBIT NO. 30 for determining size, type, width, and length of rock channel protection. Also refer to EXHIBIT NO. 34 for other rock channel protection controls.

(6) Submit EXHIBIT NO. 33 for determining required storage and other data relative to the detention basin.

(e) Formulas to be Used to Obtain Discharge (Q)

(1) The "Rational Method" formula, Q=cia, shall be used to determine the discharge as indicated in EXHIBIT NO. 33, for off site and on site drainage areas totaling 200 acres or less.

(2) When the runoff from a drainage area to a detention basin exceeds 200 acres, the design methods and formulas to be used for detention basin design must be established on a case-by-case basis. Consideration must be given to discharge as obtained by the method indicated in Section ST 702(b).

(f) Determining Adjusted Pre-Development Runoff Coefficient c3

Definitions for pre-development runoff coefficients c_1, c_2, and c_3, and drainage areas a_1, a_2, and a_3 are indicated in EXHIBIT NO. 33. The adjusted pre-development runoff coefficient c_3 is to be obtained by using the values for c_1 (on site) and c_2 (off site) in the following table:

EXPLANATION AND FORMULAS ~ C_3		
LOCATION	**AREA**	**COEFFICIENT**
On Site Pre-Development	a_1	c_1
Off Site Existing	a_2	c_2
Adjusted Pre-Development	a_3	c_3
$c_3 = \frac{c_1a_1 + c_2a_2}{a_1 + a_2}$ $a_3 = a_1 + a_2$		

NOTE: Use runoff coefficient "C" factors per Section 702(c), except for renovation and replacement projects. For renovation and replacement projects, the pre-development coefficient C=0.45 is to be used, (within the area of the construction limits).

(g) Determining Adjusted Post-Development Runoff Coefficient c_6

Definitions for post-development runoff coefficients c_4, c_5, and c_6 are indicated in EXHIBIT NO. 33. The adjusted post-development runoff coefficient c6 is to be obtained by using the values for c_4 (on site) and c_5 (off site) in the following table:

EXPLANATION AND FORMULAS ~ C_6		
LOCATION	**AREA**	**COEFFICIENT**
On Site Post-Development	a_1	c_4
Off Site Existing	a_2	c_5
Adjusted Post-Developmer	a_3	c_6
$c_6 = \frac{c_4a_1 + c_5a_2}{a_1 + a_2}$ $c_5 = c_2$ $a_3 = a_1 + a_2$		

NOTE: When no off site runoff is tributary to the development and/or the detention/retention facility use the following:

Pre-Development Coefficient c_1

Post-Development Coefficient c_4

(h) Determining Time of Concentration as Defined in EXHIBIT NO. 33 for tc_{10} and tc_{100}

When applicable, use EXHIBIT NO. 4 (Overland Flow Chart), to obtain tc_{10} and tc_{100}, as follows:

(1) To obtain tc_{10}, use the critical runoff length as explained in Section ST 711(d)(1), the pre-development runoff coefficient c and the ground slope (in percent) as explained in Section ST 711(d)(1).

(2) To obtain tc_{100}, use the same length as in (1) above, the adjusted post-development runoff coefficient c and the same ground slope as in (1) above.

(i) Allowable Release Rates and Storage Volume Requirements

(1) The detention of storm water shall occur in 2 stages.

1.01 Stage 1 shall allow the discharge of a 1-year pre-developed peak rate.

1.02 Stage 2 shall allow the discharge of a 10-year pre-developed peak rate and provide for the detention of a post-developed site 100 year storm.

(2) The required detention and/or retention facility limits are to be recorded on a new easement or record plat for any new development requiring storm water storage. For additional information, see EXHIBIT NO. 1 and General Notes.

(j) Release Structures

(1) Typical release structure as shown in EXHIBIT NO. 34 shall be a modified ODOT Standard catch basin, with STD. windows, frame and removable grate.

CB2-2-A and CB2-2-B(depth less than 4'-0")
CB2-3, CB2-4, CB2-5, CB2-6 (depth greater than 4'-0")

For catch basins greater than 4'-0" depth ODOT steps are required per ODOT #MH-1 Std.
The construction details shall include dimensions and additional reinforcement as required for orifices or other openings, footings and supports for paved gutters, discharge pipes, anti-vortex walls or training walls.

1.01 Orifice wall penetrations are to be sleeved with an eight (8) inch length minimum of pipe through the wall.
1.02 Pipes, sleeves and openings are to be cast into concrete walls or grouted solid (watertight) all around into precast concrete or solid concrete masonry unit walls.
1.03 Concrete masonry unit walls with hollow cores will not be approved.
1.04 A thin plate with a hole in it used for discharge control will not be approved

(2) When orifice wall penetrations are used as discharge controls they may be arranged in various sizes, shapes and locations, the smallest size allowed is a 3" diameter orifice when a paved gutter or approach apron and debris trap are provided.

(3) When pipes are used as discharge controls, they may be arranged in various sizes and locations.

3.01 To determine the pipe size for various headwater conditions for pipes flowing full, the ODOT's Tube Control Culvert Flow procedure is to be used, (see EXHIBIT NO. 24) unless inlet conditions clearly exist. The smallest pipe size is to be 12" diameter with required discharge control orifice grouted solid into the end of the 12" pipe.
3.02 The release structure is to be constructed of reinforced concrete walls.
3.03 The pipe inlet end is to be protected with a headwall and/or riprap. The limits of the riprap is to be two pipe diameters from the edge of the pipe all around.

(4) Discharge pipe shall be designed for post-development Q_{100}, (see EXHIBIT NO. 33, Sheet. 2 of 2)

4.01 The Headwater HW_{100} should not be any higher than 6" below the release structure windowsill elevation. HW_{100} is to be checked for inlet and outlet control.
4.02 The discharge pipe shall be extended from the release structure to the toe of the dam and be terminate with a headwall conforming to details included on Plate No. 5 of these rules, or headwall as provided by designer and approved by the Director of Public Works, or continued and connected to an existing storm drainage system or well defined watercourse.
4.03 Rock channel protection or other type energy

dissipaters are to be placed at the outlet ends as required.
4.04 Water tight pipe joints or concrete encased pipes are required through the dam.
4.05 Reinforced concrete pad or flowable control density fill for supporting the discharge pipe are required, so that impervious fill material may be thoroughly compacted on each side and over the pipe. Anti-seep collars will be approved for rigid pipes instead of concrete pad.
4.06 No discharge pipe smaller than 12" diameter will be approved.

(5) Primary spillway design discharge (Q_{PS}) is to be routed through standard ODOT catch basin windows and grate to protect the detention facility in the event of a greater storm frequency than designed for or partial orifice plugging.

5.01 Minimum Q p.s.= Post-Development Q_{100} - Pre-Development Q_{10} (see EXHIBIT 33, Sheet 2 of 2)
5.02 To determine headwater height (h_1), size and number of windows required refer to EXHIBIT NO. 17, 18 and 19 or use orifice formula.
5.03 For underground storage (pipe or concrete vault) detention facilities, the Q_{PS} is to be routed over a weir or through an overflow pipe. A manhole is required to intercept the spillway and orifice controls and to connect the system to the discharge pipe.

(6) When the designer determines that Anti-vortex and training walls are necessary, the top elevation of the walls are to match the invert elevation of the emergency spillway.

(7) Release structures other than typical release structures, previously described, may be approved. However, the design and details must conform to the same Rules and Regulations.

(8) When the designer determines that a trash trap is required over the primary spillway, it shall be designed to be removable for maintenance purposes.

(k) NOT USED

(l) Maximum Release Rate

(1) The orifice formula for free-flow discharge is:

Q = ca $\sqrt{2gh}$ where:
Q = orifice discharge in cfs
c = coefficient of discharge
Note: Use c = .61
a = orifice cross-sectional area in square feet
g = gravitational acceleration constant = 32.2 ft/sec_2
h = height of water surface over center of orifice in feet

(2) The orifice formula for submerged discharge also is:

Q = ca $\sqrt{2gh}$, same as in (1) above, except that:
h = height of water measured as the difference between the water surface elevation on the outside of the release structure and the water surface elevation on the inside of the release structure.

(3) Dimensions h, as defined in (1) and (2) above, is represented by h_2, h_3 and h_4 on (4) below.

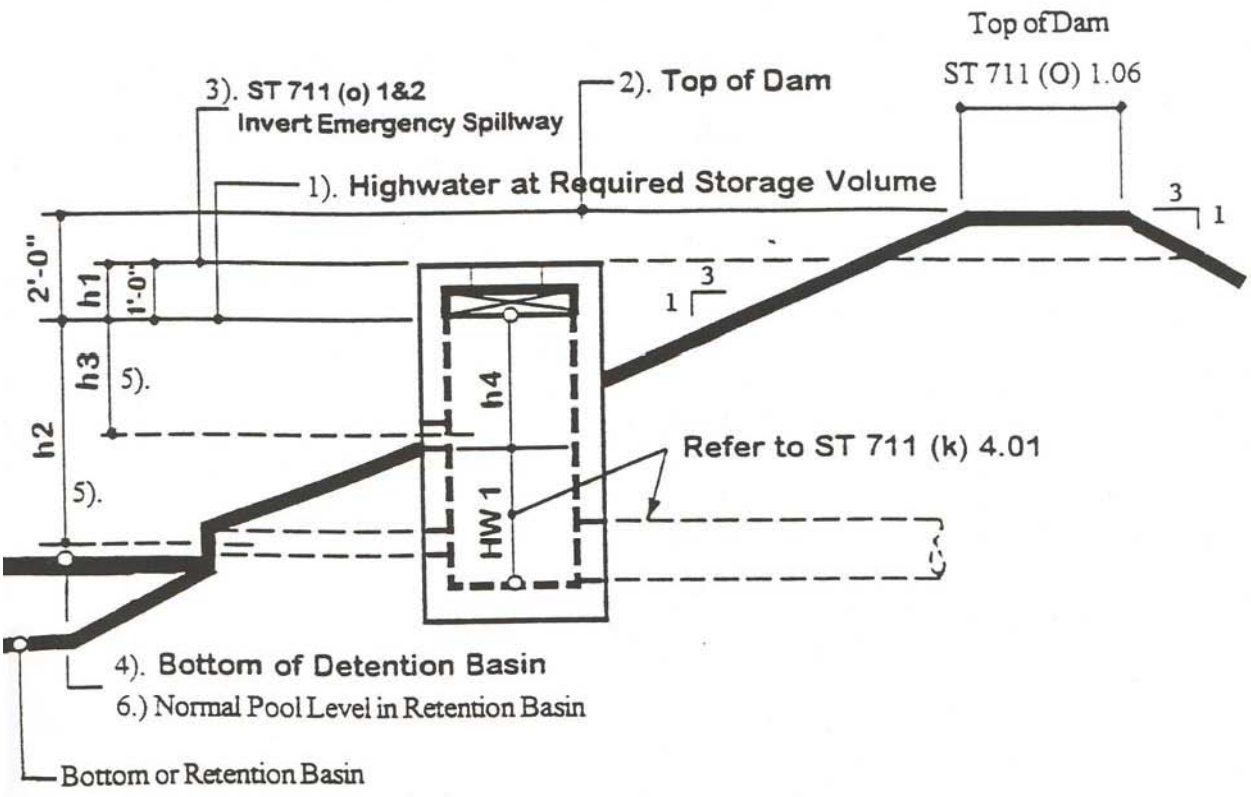
They are as follows:

h_2 = height of water over center of bottom orifice occurring at pre Q_1 or pre Q_{10} maximum release rate, which ever applies.

h_3 = height of water over center of top orifice occurring at pre Q_{10} maximum release rate. Sized for pre Q_{10} - pre Q_1 capacity.

h_4 = h as defined in (J)(4)(4.01) above, occurring at pre Q_{10} maximum release rate.

(4) Standard Outlet Control Structure (STD, ODOT catch basin as shown) refer to ST711(n)3.



1) Maximum release rate pre Q10 occurs at high water level at required storage volume (ST 711(n)1).
2) Top of dam shall be flood control elevation for buildings upstream and adjacent to detention basin.
3) Invert of emergency spillway shall be used for calculating the beginning of the hydraulic gradient for all storm sewers that terminate within the detention basin.
4) Provide paved gutter ODOTMC-5 for low flow routing and housekeeping purposes.
5) Provide 3" minimum diameter pipe or orifice for maintenance purposes.
6) Public Storm Drainage Systems tributary to retention pond shall not have submerged outlet pipes at normal pool level.

NOTE: All details and notes above apply to Detention and Retention Basins except (4) and (6) or as noted.

(5) The following table may be used as an aid when designing circular orifice openings for maximum release rate.

RADIUS AND AREA OF CIRCULAR ORIFICE OPENINGS

Orifice Diameter (Inches)	Radius (Feet)	Area (Sq. Ft.)	Orifice Diameter (Inches)	Radius (Feet)	Area (Sq. Ft.)
*3	0.125	0.049	10	0.417	0.545
*3½	0.146	0.06	10½	0.43	0.601
*4	0.167	0.087	11	0.458	0.66
*4½	0.188	0.110	11½	0.479	0.721
*5	0.208	0.136	12	0.500	0.785
*5½	0.229	0.165	12½	0.521	0.852
6	0.250	0.196	13	0.542	0.922
6½	0.271	0.230	13½	0.563	0.994
7	0.292	0.267	14	0.583	1.069
7½	0.312	0.307	14½	0.604	1.147
8	0.333	0.349	15	0.625	1.227
8½	0.354	0.394	16	0.667	1.396
9	0.375	0.442	17	0.708	1.576
9½	0.396	0.492	18	0.750	1.767

* Generally acceptable in parking lots only. See Section ST 711(q) for additional controls

(6) If pipes are used instead of orifices to control maximum release rate, the release structure and pipe requirements must conform to (I)(3) and (I)(4) above.

The following table indicates which EXHIBIT NO. is to be used when designing for the proper pipe sizes in controlling maximum release rate:

TO DETERMINE HEADWATER DEPTH HW WHEN OUTLET CONTROL GOVERNS			
Pipe Type	**Pipe Diameter**	**Applicable Storm Event**	**Exhibit No. To Use**
Concrete or Other Smooth Surface Pipe	*12" or Greater	Pre Q_1 per Section ST 711(j) or Pre Q_{10} as per EXHIBIT NO. 33	22
Corrugated Metal Pipe	Same As Above	Same As Above	26

Or

TO DETERMINE HEADWATER DEPTH HW WHEN INLET CONTROL GOVERNS			
Pipe Type	**Pipe Diameter**	**Applicable Storm Event**	**Exhibit No. To Use**
Concrete or Other Smooth Surface Pipe	*12" or Greater	Pre Q_1 per Section ST 711(j) or Pre Q_{10} as per EXHIBIT NO. 33	24
Corrugated Metal Pipe	Same As Above	Same As Above	27
* For pipe diameters less than 12", but in no case less than 6" as per Section ST 711(k)(3), headwater depth (HW) and head (H), whichever applies, must be determined by other methods. It is not recommended to use pipe diameter less than 12" to control maximum release rate.			

(m) NOT USED

(n) NOT USED

(o) Emergency Spillway (refer to EXHIBIT NO. 34)

(1) An emergency spillway is required with every retention and detention facility. The emergency spillway design discharge (Q_{es}) is to be routed safely downstream to an existing well defined watercourse or storm drainage system/

1.01 Q_{es} (emergency spillway discharge) = Q_{ps} (Primary spillway discharge)

1.02 The emergency spillway is to be routed through a standard ODOT paved gutter MC-5 (or DM-2.1M) sloped at ¼" per foot overtop of dam with invert 1'-0" minimum above the primary spillway window sill. Turn down edge of paved gutter 4'-0" minimum along slope of upstream and downstream face of dam. Construct per ST 805 (b)(2) or as detailed by designer.

1.03 Weir formula for design of emergency spillway

$Q_{es} = 2.7\ L(H)^{3/2}$

L = Length of the emergency spillway at the invert in feet. The invert is to be at least 1'-0" above the release structure windowsill.

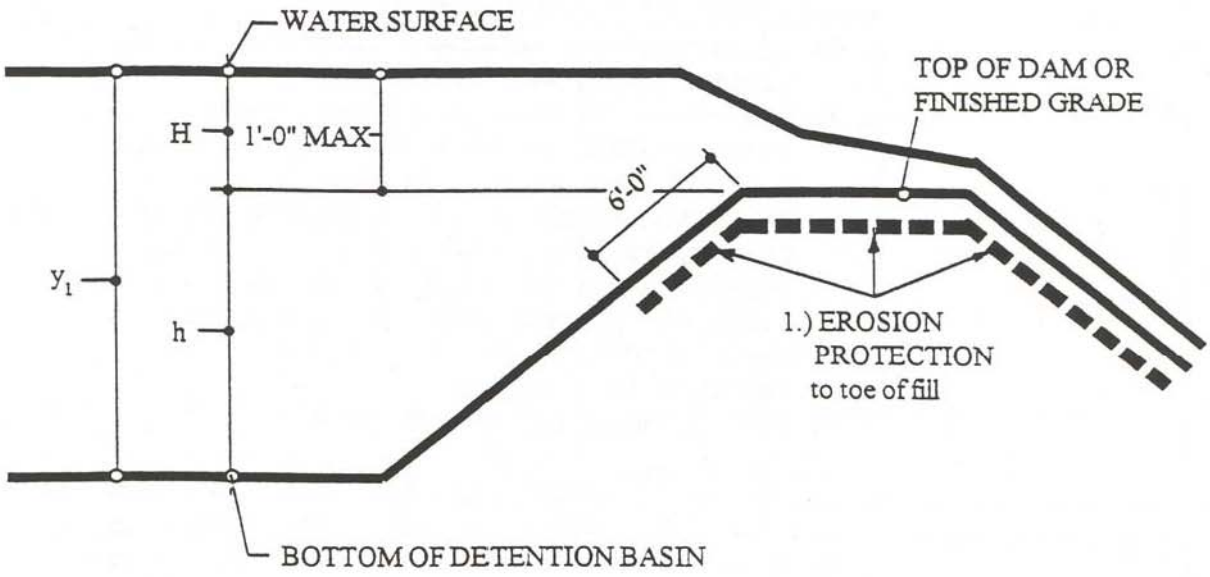
H = Height of emergency spillway flow above the invert. Height of design flow is to be at least 6" below the top of the dam.

1.04 The top of the dam is to be 10'-0" width minimum or in cases of nominal size dams 4'-0" width minimum. In either case, the paved gutter shall extend the full width of the top of the dam and be turned down 2'-0" on both sides of the dam.

1.05 Unavoidable overtopping of the dam shall be allowed if no dam construction is required or the dam is constructed straight across a ravine and the abutment ends are keyed straight into impervious undisturbed material. The total length of the dam shall be designed as a broad crested weir.

1.06 Broad Crested Weir / Emergency Spillway

Note: Broad Crested Weir shall not be allowed unless no other option is available (see 1.05).



FORMULA: $q = 0.433 \sqrt{2g} \left(\frac{y_1}{y_1 + h}\right)^{\frac{1}{2}} H^{\frac{3}{2}}$

q = Discharge per unit length

g = Gravitational acceleration constant (32.3 ft/sec^2)

h = Height of dam

H = Crest of water above top of dam

$y_1 = h + H$

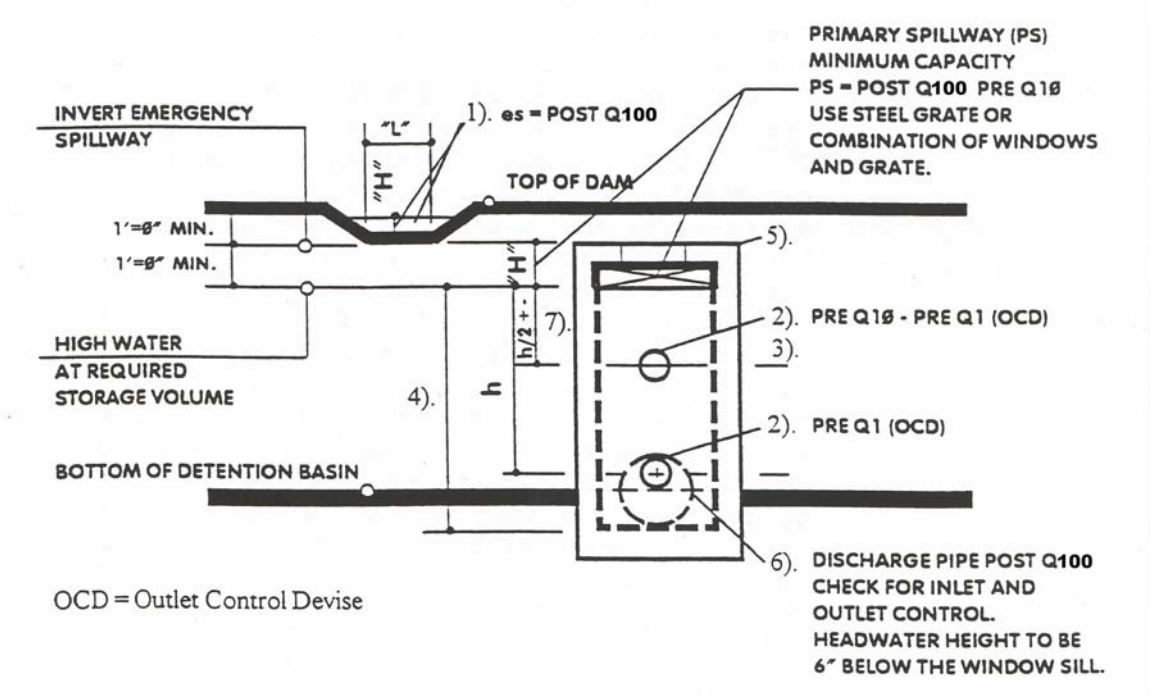
(1) Erosion Protection: Refer to item (2) in this section and or owner's Geotechnical Engineer's Report.

(2) Erosion protection for the dam shall be provided, so that the emergency spillway may be routed safely downstream from the detention facility. The upstream face, top of dam and downstream face at the gutter or broad crested weir shall be lined with concrete pavement, rock protection, sod, seeded geotechnical fabric, etc., whichever is required for erosion protection.

(3) If site conditions indicate that an emergency and primary spillway system is not feasible as recommended in these Rules and Regulations, especially on small sites where the drainage area to a detention basin is less than one (1) acre, the Engineer may submit preliminary plans of the proposed detention basin in accordance with Section ST 1102(b) for review and approval before proceeding with final design. The proposed detention basin shall provide for an emergency spillway if a primary spillway system is not used. The emergency spillway shall be designed to allow the post Q_{100} storm (as obtained from EXHIBIT No. 33) to continue downstream in the event of plugging or partial plugging of the system proposed to control maximum release rate.

(4) Standard Outlet Control Structure and Outlet Control Devices (STD, ODOT catch basins as shown).

NOTE: OCD – Metal plate with a hole will not be allowed.



1) Broad crested weir may be used instead of emergency spillway ditch is unavoidable (see Section ST 711 (0)5).

2) If pipes are used instead of wall penetrations the pipe size is to be determined by tube control.

3) Second OCD may not be required for insignificant size detention facility.

4) 4'-0" or greater depth outlet control structures required STD ODOT manhole rungs.

5) Provide anti-vortex walls at outlet control/primary spillway if required by Engineer.

6) Crown of discharge pipe shall match crown of OCD or drop down lower to allow free out fall from OCD pipe or penetration. If inverts match, check OCD for submerged outlet control.

7) Second OCD location shall be adjusted to suit normal size pipe.

(p) Detention Basin Construction

Detention basin construction shall conform to the following specifications or designed and sealed by an Ohio Registered Geotechnical Engineer and details as shown on EXHIBIT NO. 34 (Sheets 1, 2, and 3 of 3), when applicable. The Rules and Regulations as listed in

Section ST 711(a)(1) and (2) also apply. Specifications for construction of the detention basin are as follows:

(1) Scope - The work shall consist of all site preparation, excavation, earth fill, construction of storm sewer/s, release structure/s, discharge pipe/s, paved gutter, reinforced concrete emergency spillway, rock channel slope protection, earth dam, temporary erosion and sediment control, placing of topsoil and vegetative treatment and any other item required as shown on the approved improvement plans.

(2) Site Preparation - The foundation area and borrow area will be cleared of all trees, stumps, roots brush, rocks, and other debris. All cleared material will be removed from the site. The foundation area will be stripped to a minimum depth of six (6) inches. After stripping, an examination of the foundation area will be made and all pockets of organic soil, sand, and gravel and other unsuitable material will be removed. After excavation is complete, all slopes within the foundation area will be no steeper than 1:1 and will be shaped to accommodate compaction equipment. Borrow areas will be stripped of all vegetation, organic matter, and other unsuitable materials.

(3) Impervious Cutoff Trench, Release Structure/s and Discharge Pipe/s - A cutoff trench, as detailed on the approved Improvement Plans and similar to that shown in EXHIBIT NO. 34 (Sheet Nos. 1 and 2 of 5), consisting of relatively impervious material shall be provided under the earth dam. The material shall consist mainly of clay, with some silt, sand, and gravel. The cutoff shall extend along the centerline of the earth dam and be deep enough to extend into a relatively impervious layer. In all cases the minimum depth shall be three (3) feet. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall be no steeper than 1:1. Prior to backfilling, the excavated cutoff trench should be examined for unanticipated unsuitable material, which will require additional excavation. The cutoff trench will be backfilled with the most impervious material available from the designated borrow area/s. Placement, compaction, and moisture requirements are the same as specified for earth fill as indicated in (5) below. Before the impervious core is constructed as specified in (4) below, the release structure/s and discharge pipe/s, with reinforced concrete pads when required as indicated in Section ST 711 j 4.05, are to be constructed. They shall be placed on a firm foundation to the lines and grades as shown on the plans. Selected backfill material shall be placed in 4 inch horizontal layers and compacted with hand operated power tampers. Special care shall be taken to prevent lifting the pipe by pressure exerted by tamping earth under the haunches of the pipe. Moisture control and compaction requirements will be equivalent to that specified for the earth fill. At least

three (3) feet of impervious fill and earth fill, with limits designated on the approved Improvement Plans, shall be compacted over the discharge pipe/s, using either hand operated power tampers or lightweight power driven tampers. Additional fill required over discharge pipe/s shall be constructed as indicated in (4) and (5) below.

(4) Impervious Core - An impervious core, similar to that shown in EXHIBIT NO. 34 (Sheet 2 of 5), consisting of relatively impervious material, as indicated in (3) above, shall be provided along the centerline of the earth dam. The impervious core shall be placed in horizontal lifts with a maximum thickness of six (6) inches prior to compaction. Unless otherwise specified on the plans, each lift shall be compacted with at least four (4) passes of the sheepsfoot roller (200-psi minimum rating).

(5a) Earth Fill - Prior to beginning placement of earth fill, the release structures and discharge pipes shall be placed on firm foundation to the line and grades shown on the plans then the surface of the foundation area will be scarified to a depth of six (6) inches and compacted to the same requirements as specified for earth fill below. Fill material shall be free of all sod, roots, frozen soil, stones larger than six (6) inches diameter, and other objectionable material. The material shall consist mainly of sand and gravel with some silt and clay. The placing and spreading of the fill material shall begin at the lowest point in the foundation area and shall be placed in horizontal lifts with a maximum thickness of six (6) inches prior to compaction. Unless otherwise specified on the plans, each lift will be compacted with at least four (4) passes of sheepsfoot roller (200-psi minimum rating). The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill. The moisture content of the fill material being placed must be maintained within the limits required to permit satisfactory compaction.

(5b) All soil embankments shall be constructed as per ODOT 203 under the supervision of a qualified soils engineer. The Soils Engineer registered in the State of Ohio shall furnish a certificate in duplicate to the County Public Works Director certifying the location and degree of compaction of such fills.

(6) Topsoil - The topsoil stockpiled during site preparation shall be placed as a top dressing on the surface of the earth fill and borrow area. Provide additional topsoil if necessary to obtain a minimum 3" depth throughout these areas.

(7) Borrow Area - All borrow areas shall be graded in such a manner that they can be drained and re-vegetated.

(8) Temporary Erosion and Sediment Control - Provision for temporary erosion and sediment control during construction of detention basin generally shall follow the Rules and Regulations of Section ST 414. The details shall be shown on the Temporary Erosion and Sediment Control Plan included with the Improvement Plans.

(q) Parking Lot Detention Basin

Parking lot detention basin design criteria shall be the same as for detention basin design except that intermediate storage design and primary spillway design is not required. Use EXHIBIT NO. 33 to obtain volume of storage required maximum release rate, etc. Other controls for parking lot detention basin design area as follows:

(1) The maximum storage depth in automobile parking spaces shall not exceed 7 inches during the 100 year design storm.

(2) An emergency flood route shall be provided to allow the post Q_{100} storm to continue downstream without causing flooding problems. The emergency flood route system shall be designed to limit the maximum depth of water in the parking lot to a maximum of 9 inches. Openings in adjacent buildings, including drain outlets for window wells, basements, sump pumps and foundations, shall be at least 1'0" above the 100 year flood elevation.

(3) Recommended release structure/s for parking lot/s are shown on EXHIBIT NO. 34, Sheet 3 of 5. Removable plates in release structure/s that are to be privately maintained will not be approved.

(4) Maximum release rate q_0, as obtained from EXHIBIT NO. 33, shall be discharged through the release structure/s generally using either weir/s or orifice/s. Some weir and orifice formulas are shown in Section ST Nos. 711(l)(1) & (2) and ST 711(o)(1.03). Minimum orifice openings shall not be less than three (3) inches when paved parking lots are used and four (4) inches when unpaved parking lots are used. Unpaved parking lots to be used as detention basins are not recommended because of maintenance problems with mud, debris, etc.

(5) The maximum surface slope recommended for paved parking lot detention basin/s is five (5) percent and the minimum surface slope is one half (0.5) percent. For unpaved parking lots, if used, the minimum slope shall be one (1) percent.

(r) Other Type Detention Basins

Underground storage detention structure design criteria shall be the same as for detention basin design except that intermediate storage design and primary spillway design may or may not be required, depending on whether site conditions allow for their use. Use EXHIBIT NO. 33 to obtain volume of storage required maximum release rate, etc. Other controls for underground storage detention structures are as follows:

(1) A flood routing system is required. When a primary spillway system has not been designed in the storage structure, the flood routing shall be designed to allow the post Q_{100} storm (as obtained from EXHIBIT NO. 33) to continue downstream, without causing flooding problems. The flood routing system shall be located above ground and any potential downstream flooding problems must be investigated.

(2) The underground storage detention structures generally shall be constructed of reinforced concrete.

Various other types of detention basins, such as rooftop storage, oversized storm sewer pipe storage, dry-well storage, impoundments utilizing fills of existing roadways, etc., generally are acceptable.

(s) Miscellaneous Items

(1) Detention basin/s located inside of Special Flood Hazard Areas generally will not be approved. Any detention basin proposed within any Special Flood Hazard Area must conform to the following:

1.01 The detention basin design and detail must meet the requirements of the Flood Damage Prevention Regulations (EXHIBIT NO. 36).

1.02 The detention basin design criteria must be established on a case-by-case basis.

(2) The use of pumps in any detention basin system is not permitted.

(3) If fencing is provided by an Owner or Developer, a gate or gates large enough to permit trucks and equipment to enter the detention basin site for maintenance purposes must be provided.

(t) As-built for Detention / Retention Basins

Following installation and prior to the release of the subdivision bond or the certificate of occupancy for commercial projects, actual field verified "As-Built" drawings (prepared by a Land Surveyor registered in the State of Ohio) must be submitted to the Hamilton County Department of

Public Works. Drawings shall be on tracing cloth or film (mylar). The following minimum information must be included:

(1) Complete plan view of the entire detention / retention basins and / or storm sewer systems.

(2) Contours generated by the survey or field shots for parking lot detention.

(3) Length, grade, size, and material of all pipes.

(4) Horizontal angles at all horizontal changes in pipe runs or state plane coordinates on all storm structures (preferred).

(5) Drainage structures are to be referenced by way of two (2) offset dimensions, one (1) from the right-of-way line and one (1) from the nearest lot line or state plane coordinates on all storm structures (preferred).

(6) Invert elevations of all pipes and orifices.

(7) Type, invert and top elevation of all structures.

(8) Q1, Q10, and Q100 release rates.

(9) Volume measured to the Q100 window or weir elevation.

(10) Surveyor's seal and signature.

Section ST 712

Retention Basin Design Criteria

(a) General

Retention basin design criteria shall be the same as for detention basin design criteria except as modified herein.

Whenever special or unusual field conditions require that a retention basin must be designed in a different manner than that indicated by this Section, the Developers/Engineer must obtain approval from the County Public Works Director for the retention basin design and detail proposal, following the concept review procedures in Article XI, before proceeding with the final design.

(b) Allowable Release Rates and Storage Volume Requirements

Refer to Section ST 711(i) for design criteria and other Rules and Regulation. The storage volume shall be that amount of stored runoff above the normal pool level as shown on ST 711 (o)(4).

(c) Release Structures

Release structure/s will be required in all retention

basins, refer to ST 711 (j) as follows:

(1) The release structure shall be constructed of reinforced concrete, pre-cast concrete or solid masonry footing and walls so as to be watertight. Hollow or metal material is unacceptable.

(2) The bottom of the footing shall be at least 3'-6" below the proposed ground line.

(d) Primary Spillway System

A primary spillway system must be provided with every retention basin to provide for passage of storm water overflow in the event of plugging or partial plugging of the openings in the side of the release structure with debris, as per ST 711 (o)(4). The primary spillway system shown provides for excess storm water to flow through the top of the release structure above the window sill level and outlet through the discharge pipe, the same as recommended for detention basins.

(e) Maximum Release Rate

Refer to Section ST 711 for maximum release rate design criteria and other Rules and Regulations.

(f) Emergency Spillway

An emergency spillway is required with every retention basin to provide for passage of storm water overflow in the event of plugging or partial plugging of the openings in the release structure, including the opening at the top of the release structure that is required for the primary spillway system as indicated in Section ST 711 (o) 1 through 5.

(g) Retention Basin Construction

Retention basin construction must conform to the applicable Rules and Regulations as listed in Section ST 711, and also the following:

(1) The impervious cutoff trench "d" dimension shall be 6'-0" minimum. Unless design by a Geotechnical Engineer. Refer to Section ST 711(p) and EXHIBIT NO. 34, Sheet 2 of 3, for all other impervious earth core details and Rules and Regulations.

(2) For any new development requiring a retention basin, details shall be included on the Improvement Plans that provide for the complete draining of the ponded area to allow for inspection, debris removal, built up sediment deposit removal or any other maintenance item, a maintenance pipe, having a 12" minimum diameter, is recommended to be used.

(h) Miscellaneous Items

(1) Aeration devices such as fountains are recommended to reduce or prevent water stagnation.

(2) If fencing is provided, a gate or gates large enough to permit trucks and equipment to enter the retention basin site for maintenance purposes must be provided.

(3) Retention basins proposed to be located within any Special Flood Hazard Area shall conform to Section ST 711(s)(1).

(4) A permanent maintenance width around the perimeter of any retention basin shall be shown on the easement or record plat as indicated in Section ST 1104 (e)(4).

(5) The alternate retention basin scheme may be considered at sites where the available vertical depth at the retention basin location is so restrictive that the maximum release rate (q0 = pre Q_{10}) must enter the top of the release structure. This condition may prevent the use of a primary spillway system and may eliminate the possibility of providing for intermediate storage. In that event, the retention basin must be designed as follows:

5.01 The opening at the top of the release structure must be large enough to receive the maximum release rate as obtained and controlled by the applicable design criteria and Rules and Regulations of Section ST 711.

5.02 The top (crest) of the emergency spillway shall be at least three (3) inches higher than the high water level calculated by using the maximum release rate q0 = pre Q_{10}, or at least one (1) foot higher than the window sill elevation of the release structure, whichever is higher.

5.03 The emergency spillway shall be designed to allow the post Q_{100} storm (as obtained from EXHIBIT NO. 33) to continue downstream in the event of plugging or partial plugging of the system proposed to control maximum release rate.

5.04 For General and Special Design Criteria explanation, see ST 711(a) and ST 711(b).

Section ST 713
Specifications for Construction and Materials

(a) Culvert pipe material shall be as specified for Type "A" conduit 603.02 and meet pertinent contents of Specification 706.02.

(b) Unless otherwise indicated in Article VII of these Rules and Regulations, the design, materials, and construction shall be as specified in the latest edition of the State of Ohio Department of Transportation "Construction and Material Specifications", the State of Ohio Department of Transportation "Standard Construction Drawings". Unless otherwise specified, concrete storm sewer pipe shall be Type “B” Conduit 706.02 Class IV with Class B bedding as per 603.06. Backfilling is to comply with 603.10 and 603.11 for all storm sewers. Certification of proper backfill compaction shall be provided by a qualified geotechnical testing firm contracted by the developer for all trenches and fills supporting storm sewers.

NOTE: Conduit Types A, B and C are as indicated in Section 1104 of the State of Ohio Department of Transportation "Location and Design Manual".

(c) Smooth flow Polyvinyl Chloride (PVC) and high density polyethylene (HDPE) storm sewer pipe may be specified for Type “B” and Type “C” conduits. The type of pipe and ASTM or AASHTO numbers must appear on the plans and profiles. Also, the pipe shall be stamped by the manufacturer prior to shipment for field verification. Thermoplastic (PVC and HDPE) pipe shall comply with the specifications that follow:

SCOPE: This specification covers smooth flow integral bell and spigot Polyvinyl Chloride (PVC) and smooth flow integral bell and spigot High Density Polyethylene solid and profile wall non-perforated pipe and fittings, 12" to 60" nominal inside diameter for the use in gravity flow storm sewer and drainage applications.

PIPE: All pipe and fittings shall be manufactured and tested in accordance with the specifications listed in TABLE 1. The pipe stiffness, for all diameters, at 5% deflection, shall be as follows in TABLE 1 when tested in accordance with ASTM D2412.

TABLE 1 - PIPE STIFFNESS (p.s.i.)

Specification	**Material**	**Diameter (in.)**											
		12	15	18	21	24	27	30	36	42	48	54	60
ASTMD3034	PVC	46	46										
ASTM F679	PVC			46	46	46	46	46	46				
ASTM F949	PVC	50	50	50	50	50	50	50	50				
ASTM F794	PVC	46	46	46	46	46	46	46	46	46	46		
ASTM F-1803	PVC				46	46	46	46	46	46	46	46	46
AASHTO M294 Type S or D	HDPE	50	42	40	-	34	-	28	22	20	18	16	14

DEPTH OF COVER: The maximum depth of cover for Thermoplastic pipe shall be ten (10) feet. Consideration of twenty (20) foot cover minimum pipe stiffness of 46 if it is installed as per ASTM D2321, and certified by an approved testing firm.

JOINING SYSTEM: Joints shall consist of a bell and spigot gasket system meeting the requirements of ASTM D3212.

MATERIAL:

Pipe and Fittings: PVC materials shall have a minimum cell classification of 12454C or 12364C as defined in ASTMD1784. HDPE material shall be made of virgin material that conforms with the requirements of 335400C as described in ASTM D 3350.

Gaskets: Elastomeric Gaskets shall be manufactured in accordance with ASTM F477.

INSTALLATION: All Thermoplastic pipe and fittings supplied to meet this specification shall be installed in accordance with ASTM D2321.

TESTING: All Thermoplastic sewer pipe shall be mandrel tested for excessive deflection no sooner than 60 days after final grade/backfill has been completed. The contractor shall provide a 9 arm 5% go/no go mandrel (ASTM 02412) used for this test. The average inside diameter shall be used as the datum to measure the 5% deflection. Any sewer line not passing the 5% deflection test as determined by the Hamilton County Public Works Department shall be repaired or replaced at the contractor's expense. Any sewer line requiring repair or replacement shall be retested for deflection after 60 days.

CERTIFICATION: Prior to being installed, the contractor shall submit plant certifications from the manufacturer certifying the product used is in compliance with the appropriate National Specification listed herein. Any material not meeting these requirements will be rejected.

(d) For storm drains constructed on grades in excess of 15% ductile iron pipe (AWWA C151 Class 52) shall be used.

Key Blocking is required as follows:

(1) For grades 15% through 25%, key blocks every other joint.

(2) For grades greater than 25%, key block every joint.

(3) Use Type B key block (see Std. Drawing Plate 11).

(4) No differentiation between cut and fill slope on the above grades if Section ST 415 is adhered to.

Backfilling of Trenches

Excavations for structures, manholes, catch basins, flush holes, water valve chambers etcetera, which are not located within the existing or proposed street pavement area shall be backfilled with granular material compacted in layers. In such cases a one inch (1") maximum diameter weep hole, formed by tubing, shall be cast into the base of storm manholes and catch basins to provide drainage for water that may accumulate in the granular material. The backfilling shall consist of furnishing, transporting, placing and compacting in layers, porous granular aggregate meeting ODOT Standards for backfill material, from the bottom of the excavation, up to an elevation twelve inches (12") below the final grade live or cross section of the sub grade, as shown on the approved plan. The stability at sub grade (12" thickness) must be equal to that immediately adjacent to the excavation. Incorporation of additional material such as soil fines, crushed stone, CLSM-CDF and so forth, may be necessary to achieve this requirement. For other sub grade requirements refer to Section 307 Preparation of Sub grade in the Rules and Regulations of the Hamilton County Engineer.

All mainline and lateral trenches between the pavement limits and for backfill of excavations for manholes, catch basins, flush holes, water valve chambers, etc. which are located under the pavement, shall be backfilled with Controlled Low Strength Material-Controlled Density Fill (CLSM-CDF) as described in Addendum "A" of the Hamilton County Engineer's Permit Manual.

As an alternate to the requirements described in the previous paragraph, excavation, bedding and backfill for all lateral trenches between pavement limits and for backfill of excavations for manholes, catch basins, flush holes, water valve chambers, etc. which are located wholly or in part under the pavement, shall be done in accordance with sections 603.05, 603.11, and 603.10 of the ODOT Construction and Materials Specifications (C&M.S.) The final twelve inches (12") shall be compacted in accordance with Section 307 of this manual. Density tests shall be performed and certification shall be provided by an approved geotechnical firm, documenting that the backfill was so placed and including actual satisfactory test results for the compacted layers.

All trench backfill, other than for mainline and lateral trenches~~,~~ within the right-of-way and/or utility easements adjacent and parallel thereto shall be compacted in layers to achieve a density of not less than ninety-five percent (95%) (and to sub grade requirements at sub grade level). Compaction tests shall be made by a certified testing firm, approved by the Hamilton County Engineer and employed by the developer. (See Appendix "G" in the Rules and Regulations of the Hamilton County Engineer for testing procedures.)

In trench locations or excavation for structures where the use of controlled low strength material-controlled density fill (CLSM-CDF) is not required, it can be used as an alternate backfill material, in which case the requirements for compaction testing will be waived.