ARTICLE 8

STORM DRAINAGE SYSTEM

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SECTION 8-100 POLICY FOR ADEQUATE STORM DRAINAGE

The overall drainage system will consist of a major and a minor drainage system. Minor drainage systems will be designed to convey the ten-year event, and will consist of open channels and/or closed conduit drainage systems from the point of interception to the point of discharge in all developments. Major drainage systems shall evaluate the impact of the 100-year rainfall event as if the minor system has failed to function or did not exist. Either system may also involve the use of stormwater management facilities, wet or dry, and may include the use of larger regional facilities.

Equations presented herein are those that are most often used. Specific references for methods used are provided for the designer. The designer may choose to use methods other than those provided; however, the validity and applicability of those methods must be demonstrated and references provided. Concentrated flows for the ten-year event in excess of four (3) cubic feet per second (cfs), shall be conveyed by a designed storm drainage system or adequate existing natural channel. The review of all storm drainage systems shall be the responsibility of the Public Works Department and approved by the Director.

8-100.1 INTENT

It is the intent of this Article to require that performance of all drainage facilities meet or exceed applicable drainage laws.

8-100.2 REFERENCES

The following documents are included by reference for storm drainage design within the City of Manassas limits:

A. The revised 1992, or current edition, Virginia Erosion and Sediment Control Handbook. The handbook addresses State criteria for stormwater management and includes revised 1986, TR-55 methodology to be applied to control flooding and erosion.

B. The Northern Virginia BMP Handbook, published by NVPDC, 11/16/92. The bulletin a guide to be used whenever modifications to flowing streams are proposed.

C. The Virginia Department of Transportation Drainage Manual. prepared by the Location and Design Division, Hydraulic Section, adopted January 1, 1980, as amended, Virginia Department of Transportation.

D. The Virginia Department of Transportation Road and Bridge Specifications, latest edition.

E. Urban Stormwater Management, Course "C". The Virginia Soil and Water Conservation Commission, 203 Governor Street, Suite 206, Richmond, VA 23219.

F. Urban Hydrology for Small Watersheds (TR-55), Soil Conservation Services, Washington, D.C., National Technical Information Service, Springfield, VA 22161, June 1896.

G. TR-20 Project Formulation -- Hydrology Soil Conservation Service, Lanham, MD, National Technical Information Service, Springfield, VA 22161, May 1983

H. For definition of terms used within this Article, refer to Section 1-500 of this Manual.

8-110 GENERAL REQUIREMENTS

An evaluation shall be performed for all proposed drainage systems to ensure adequate hydraulic capacity for conveyance of the minimum ten-year event including, but not limited, to channels, stormwater management facilities, and conduits.

Hydraulic capacity must be verified with engineering calculations, in accordance with the procedures outlined in the Virginia Erosion and Sediment Control Handbook, The Virginia Department of Transportation Drainage Manual, or other methods acceptable to the Director.

The drainage system must have the hydraulic capacity to accommodate the maximum expected flow of surface waters from a drainage

area at a point of concentration for the duration and intensity of rainfall, as specified herein.

Determination of the size and capacity of the drainage system shall be based on the planned development, existing zoning, or the City's Comprehensive Plan, whichever is greater, within the watershed.

Due consideration must be given to infrequent events (100-year) resulting in quantities greater than minor system design capacity. The design for the major drainage system shall provide for overland relief of the 100-year event without flooding or damaging buildings and structures, without reliance upon the minor drainage system with exception to facilities already located within the flood limits.

The drainage system shall be designed:

A. To generally honor all natural drainage divides and create no adverse impact on downstream properties.

B. To account for all off-site and on-site surface water.

C. To convey discharge surface waters to a natural watercourse; i.e., a natural watercourse at the natural elevation.

D. To convey and discharge surface waters to a stormwater detention facility of sufficient capacity to accommodate the design-year event, as stipulated in Section 8-500 "Stormwater Management." The Director may require additional design criteria based on the watershed's special requirements, as identified in the City's Stormwater Master Plan.

E. To protect residences and other occupied structures from being inundated with stormwater.

The Owner or Developer may continue to discharge stormwater as sheet flow (non-concentrated) into a lower-lying property if at the same location and:

A. The post-development peak rate based on documentation and computations, including sheet flow, does not exceed the predevelopment peak rate; and

B. If the above conditions are not met, the developer must provide a drainage system satisfactory to the Director, to preclude adverse impacts upon adjacent or downstream properties.

The Owner or Developer may not discharge stormwater which has been artificially concentrated by a pipe, culvert, channel, or other drainage structure, onto or through lands of another without first obtaining and transferring to the City a permanent storm drainage easement to guarantee continuity of an outfall from the point of discharge to the nearest natural watercourse. Refer to Section 8-200 for Adequate Outfall.

If off-site downstream construction and easements are required to construct an adequate channel outfall, no permits shall be issued until such storm drainage easements, extending to the nearest natural watercourse have been obtained and recorded. It will be the responsibility of the Developer to obtain all off-site easements.

Storm sewer systems shall be designed in a manner such that their outfalls are designed to reduce erosion of surrounding soils.

A. Discharge at a natural watercourse:
   1. Generally, it is better to discharge at the 100-year flood-plain limits into an adequate channel leading to the main stream bed, rather than disturb the flood plain by extending the storm sewer system.
   2. If there is no well defined adequate receiving channel at the flood plain limits, one shall be constructed to the bed and banks of the main channel or other adequate receiving channel.

B. Discharge at other locations:
   1. Energy dissipation devises and/or friction channel linings shall be used when discharge velocities exceed the maximum permissible as defined by the Virginia Erosion and Sediment Control Handbook, Course "C," or at the discretion of the Director where non-uniform channel linings are

involved. *Refer to Chapter 3, Specification 1.36, Table 1.36A of the aforementioned handbook.*

Except as set forth in Section 8-630, paragraph two, Policy on Use in Flood Plain Areas, all drainageways, including overland relief pathways, must be separated from buildings. The lowest point of entry of all buildings shall be a minimum of twelve (12) inches vertically above the overland relief pathways.

Plans shall be prepared to preclude adverse impacts due to higher flow rates that may occur during construction. Refer to Article 4 of this Manual.

Drainage structures shall be designed and constructed in such a manner that they may be maintained at a reasonable cost and with methods and types of equipment currently used by the City. To facilitate design, construction, and maintenance, drainage facilities shall meet and conform to the City of Manassas and Virginia Department of Transportation Standards. Special designs shall be considered by the Director on a case-by-case basis provided they are designed and documented using acceptable methods.

In those cases in which the drainage plans of a proposed development do not satisfy these minimum requirements because necessary off-site facilities or improvements are lacking, the Developer shall delay development until the necessary off-site facilities or improvements are constructed or other arrangements, suitable to the Director, are made.

8-120 EASEMENTS

Easements must be provided for all publicly maintained storm sewer systems and area of concentrated flow. Areas of concentrated flow shall mean any improved drainageways (swales) concentrating flow from several lots, swales leading into culverts, and those stabilized existing drainageways handling the outfall of the culverts. Permanent ancillary structures; i.e., fences, sheds or decks shall be strictly forbidden within dedicated easements for areas of concentrated flows. Easements for natural streams shall not be required. If a drainage system terminates or begins short of a property line, an adequate easement must be dedicated to allow for future extension of the

system. Adequate access must be provided for all improved storm sewer systems. These easements are not required inside State rights-of-way.

Minimum easement widths. All storm sewer pipes or channels to be maintained by the City of Manassas shall be within dedicated storm drainage easements. These easements widths shall be in one foot increments.

The widths of drainage easements shall not be less than as prescribed in the following table and shall be shown on plan and profile sheets and record plats:

15” to 18” pipe	15’ easement
21” to 33” pipe	20’ easement
36” to 48” pipe	25’ easement
54” to 72” pipe	30’ easement

For trench depths greater than six (6) feet, five (5) feet additional easement width shall be required for each full five (5) feet increment of additional depth. All storm sewers shall be placed within the middle third of the easement. Unauthorized structural modifications including fences (six (6) feet and higher) and plantings will not be permitted within the easements without special approval.

8-130 GENERAL PIPE SYSTEM DESIGN

Before starting the detailed design of the pipe line, the design engineer must consider various controls which will govern the subsequent location, alignment, depth, size, and cost of the systems.

A. Consideration should be given to the location of existing outfalls or natural watercourses which are to be utilized, natural drainage divides, proposed roadway design features such as low and high points in the grade, super-elevated curves, street intersections, existing and proposed utility lines, and other existing and proposed storm drainage.

B. When an existing storm sewer is to be utilized, either partially or totally, it shall be necessary to ascertain the invert elevations for all pipes, drop inlets, catch basins, manholes, etc. This information should extend well beyond the limits of the proposed

project, both laterally and longitudinally, at least to the next access structure, and continuing to the point of hydraulic adequacy. The invert elevation of each pipe in a drop inlet or manhole shall be ascertained, as well as the type of pipe.

C. It is essential that all utilities in the area of existing or proposed drainage facilities be located horizontally and all gravity utilities located vertically in order to avoid future conflicts. This is particularly important in the case of gravity sanitary sewers because adjustment of such facilities would be difficult and costly.

D. Test pits will be required for crossings which involve gas lines, water and services, sanitary sewer crossings which have minimum clearance, and all fiber optic telephone service lines.

E. New storm sewers should generally be designed to convey the ten-year without surcharge. However, the system should be checked for the 50-year in situations where it would be necessary to prevent flooding of interstate highways, limited access highways, major arterials, and underpasses, or other depressed roadways where ponded water can only be removed through the storm sewer system.

F. The detailed design of the storm sewer pipe line can only proceed after taking into account the above parameters.

Size of storm sewer pipe shall be determined by the Mannning's Equation. For explanation and use, *Refer to Section 6.2.1, Chapter 2, of the Virginia Department Transportation Drainage Manual and Refer to Exhibit 41 in Appendix A.*

8-140 ENERGY AND HYDRAULIC GRADIENTS

The hydraulic gradient for a storm sewer system shall herein be defined as a line (water surface profile) connecting points to which water will rise in pipes, manholes and inlets throughout the system during the design flow. The energy gradient is a line drawn a distance V2/2g above the hydraulic gradient of the pipes. *Refer to Exhibit 16 in Appendix A.*

A. At storm sewer junctions, the total energy loss at the junction, H_L, is the difference in elevation between the energy grade lines of the upstream and downstream pipes. To establish these gradients for a system, it is necessary to start at a point where the hydraulic and energy gradients are known or can readily be determined.

B. When the energy and hydraulic gradients must be determined, the pipes are assumed to have uniform flow. For uniform gravity flow the friction loss in storm sewer pipes shall be determined by referring to Chapter 4, Section 8, of the Virginia Department of Transportation Manual.

C. Where a proposed drainage system is connected to an existing drainage system the hydraulic gradient shall be computed through the existing system until the stormwater contained within the system outfalls to daylight into an adequate conveyance channel or a natural watercourse to demonstrate hydraulic capacity.

   1. Information, including as-built information, as well as development plan system computations for the existing system, will be made available by the City to the engineer for those systems for which the City has this information.
   2. The Director may waive the requirements when it has been previously determined that the receiving system is known to have sufficient capacity.

New storm sewer systems shall be designed such that the hydraulic gradient is contained within the structures. In no instance shall the gradient

be five (5) feet above the crown of the lowest pipe at any structure, or within eighteen (18) inches below the gutter flow line elevation. The hydraulic gradient shall be determined for all storm sewer systems in which any pipe run experiences pressure flow as determined using VDOT methodology. Refer to Exhibit 43 in Appendix A.

In instances where the pressure flow is due to a restricted outfall condition entering a pond below water surface elevation, the hydraulic grade line shall not be higher than 1.5 foot below any manhole top or inlet throat opening. In cases where this design is unavoidable, the Director may approve an alternate design and allow less clearance.

Profiles shall show HGL location for pipes larger than thrity-six (36) inches in diameter.

8-150 FLOW DESIGN

The Manning equation shall be used for open channel analysis where uniform flow exists or can be reasonably assumed. The Bernoulli equation shall be used to analyze flow where changes in flow resistance, size, shape or slope of the channel occur. *Refer to Chapter 2, Section 6.2.1, of the Virginia Department of Transportation Drainage Manual.*

The computation of water surface profiles for channels involving changes in roughness, slope, shape and discharge should not be based on a nomograph solution.

8-160 WATER SURFACE PROFILE COMPUTATIONS

The U.S. Army Corps of Engineers, HEC-2 Water Surface Profile Method - This computer program may be used to model open channels, culverts, and bridges.

The Virginia Department of Transportation Drainage Manual method may also be used for the calculation of water surface profiles. *Refer to Chapter 2, Section 6.22, of the aforementioned Manual.*

Other methods may be utilized with prior approval of the Director.

8-170 RIPRAP

Riprap for channels shall be designed in accordance with the *Virginia Department of Transportation Drainage Manual, Chapter 2, Section 7.1.3. Outlet protection shall be designed using Virginia Erosion and Sediment Control Handbook, Specification 3.19.*

8-180 CULVERTS

Culverts shall be designed to account for ultimate right-of-way widths. Within embankments, culvert headwalls and endwalls shall be located a minimum of thirty (30) feet outside the edge of pavement of traffic lanes unless traffic is separated from the walls by a guardrail. This is required due to warrants other than the walls and the proposed topography. The culvert size and invert shall be considered.

8-180.1 CULVERT DESIGN CRITERIA

The design of culverts is dependent upon the type of control (inlet, outlet).

A. Inlet Control. Deemed to be the discharge capacity of a culvert as controlled at the culvert entrance by the depth of headwater (HW) and the entrance geometry, including the barrel shape and cross section area, and the type of inlet edge.

B. Outlet Control. Culverts flowing with outlet control can flow with the culvert barrel full or partially full for part or the entire length of the barrel. If the entire cross section of the barrel is filled with water for the total length of the barrel, the culvert is said to be in full flow or flowing full.

C. Both inlet control and outlet control computations must be performed.

Culverts located beneath roadways functionally classified as primary arterials shall be designed for the 50-year event without the headwater overtopping the roadways. The 25-year headwater shall be eighteen (18) inches below the elevation of the adjacent travel lane

edge of pavement. For roadways classified as a minor arterial shall be designed for a 25-year storm. Designs for a local or collector roadway shall meet the 10-year storm event requirements.

For actual culvert design procedures, refer to the current edition of the U.S. Department of Transportation Hydraulic Design of Highways Culverts (HDS-5). This report may be found in Chapter 3 of the current Virginia Department of Transportation Drainage Manual.

SECTION 8-200 ADEQUATE OUTFALL

An evaluation shall be performed for each proposed development to assure compliance with State Law and City Code concerning stormwater management.

Stormwater management must be verified with engineering calculations for the design-year event as defined herein, in accordance with the procedures outlined in the Virginia Erosion and Sediment Control Handbook, latest edition, or other methods approved by the Director.

8-200.1 STORMWATER MANAGEMENT REQUIREMENTS

Stormwater management shall consist of the following:

A. Discharge into an adequate channel.

B. Demonstration that the peak rate of from the site will not be increased after development for the design-year event.

C. A combination of A and B above which will allow the peak discharge rate from the development to pass down stream without overtopping the channel banks or causing erosion.

D. The selection of A, B, or C above shall be as listed in the following paragraphs for the various watersheds.

An adequate outfall within the City shall be defined as:

A. A well defined (i.e., with bed and banks) natural or man-made channel which is capable of conveying the post development for the design-year event, as defined herein for the particular shed in which the development is

proposed, without eroding or overtopping its banks. The 2-year frequency storm should be used for a natural channel and a 10-year frequency should be used for a man made channel. The channel should not overtop the banks or exceed the permissible velocity of the channel lining.

B. A well defined (i.e., with bed and banks) natural or man-made channel shall be considered adequate at any point where the total contributing drainage area is at least 100 times greater than the drainage area of the development site in question.

C. An analysis shall be performed downstream of the site subject to proposed development to verify the adequacy of the receiving system. This analysis shall be performed for a minimum distance of 300 feet downstream, and shall continue until the flow is discharged into a natural watercourse of sufficient capacity to convey the design-year event without overtopping or eroding its banks.

D. Concentrated stormwater leaving a development site shall only be discharged into a well defined (i.e., with bed and banks) natural (2- year design storm) or man-made (ten year design storm) outfall channel of sufficient hydraulic capacity, such that there is no overtopping or erosion downstream of the subject development for the release rate of the concentrated stormwater. This shall be required regardless of whether or not the peak discharge rate is changed by the development.

The design-year event for stormwater management shall be as listed in Section 8-210.1 of this Article.

8-210 HYDROLOGIC DESIGN - RATIONAL METHOD

This method is to be used for determining the design for sizing all storm sewer systems, including but not limited to, culverts, conduits and manmade stormwater conveyance channels with drainage divides less than 200 acres. Refer to Section 5.1.3, Chapter 1, of the Virginia Department of Transportation Drainage Manual for methodology. *Refer to Exhibit 1 in Appendix A for "C" factors.*

A. To estimate Time of Concentration (Tc), refer to Exhibit 1.

B. Use the rainfall peak intensity charts for the City of Manassas.

Refer to Exhibit 6 and Exhibit 7 in Appendix A.

The formula: $Q = C_f C i A$
Where:

Q	=	peak discharge in C.F.S.
C	=	coefficient (Exhibit 1 in Appendix A) based on the ultimate development of the drainage area as shown on the Comprehensive Map
C_f	=	Correction Factor for ground saturation
i	=	Rainfall intensity (Exhibit 8 in Appendix A)
A	=	drainage area, acres

1.0	10 years or less
1.1	25 years
1.2	50 years
1.25	100 years

In drainage areas larger than 200 acres, the latest editions of Technical Release 55 (TR-55), Urban Hydrology for Small Watersheds (UHSW), as developed by the Soil Conservation Service (SCS), Technical Release 20 (TR-20), the U.S. Army Corps of Engineers Flood Hydrograph Package, HEC-1, or any other method with the Department of Public Works prior approval shall be used for all storm drainage design. The SCS methodologies should be used to compute times of concentration and curve numbers.

8-210.1 RAINFALL FREQUENCIES

The following rainfall frequencies and durations are to be used when designing storm drainage systems:

A. For storm drainage systems that are located within public rights-of-way and/or will be included for maintenance under the State Highway System, the rainfall frequencies required by VDOT Drainage Manual shall be used with the exception that no system will be designed for less than a 10-year storm unless allowed elsewhere in this Manual.

B. The 2-year storm and the actual time of concentration shall be used for the design of all curb inlets, catch basins, or yard inlets, unless conditions require a higher frequency curve for design, as determined by the Director of Public Works.

C. For the design of all storm drainage systems not to be included in the State Highway System, the 25-year frequency storm shall be used for drainage areas larger than 600 acres. For storm drainage systems for drainage areas are equal to or less than 600 acres, the 10-year frequency storm shall be used.

D. Flood plain Studies shall be based on the 100-year storm.

E. A 2-hour storm duration shall be used if the Rational Formula is applied. A 24-hour storm duration shall be used for TR-55, TR-20, and HEC 1.

8-220 HEADWATER PRESSURE

Storm drainage systems shall not be designed based on headwater pressure in junctions such as curb inlets, manholes, etc. The location of the hydraulic grade line shall be calculated and submitted on all systems where it appears possible that the water surface elevation in junction structures may

approach the elevation of inlet throats or manhole covers during passage of the design storm flow. Without limiting the generality of the foregoing, the following system characteristics act to increase the possibility that interior water surface elevations will approach the level of inlet throats or manhole covers therefore, these characteristics should be avoided or their effects compensated for:

A. Numerous bends.
B. Shallow systems.
C. Junctions with directly opposed laterals.
D. Systems which rely on pipes flowing full at high velocities.
E. Systems with ineffective channelization.
F. Systems with numerous junction structures - extensive systems.

8-230 CRITERIA FOR ACCEPTABILITY OF SYSTEMS

Systems shall be acceptable where the hydraulic grade line for the applicable design storm flow is below the elevation of inlet throats or manhole covers and where, as provided for elsewhere in this Manual, the capacity of pipes flowing full by Manning's Formula equals or exceeds the applicable design storm flow. Systems not meeting these criteria are unacceptable.

Calculation of the hydraulic grade line shall include adequate consideration of head losses at all junction structures. The hydraulic grade line shall be computed by the method set forth in the VDOT's Manual. Other established methods may also be used with the approval of the Director of Public Works.

Measures for lowering hydraulic grade line include the following:

A. Increase pipe sizes thus reducing necessary velocities.
B. Eliminate bends (but do not, for instance, replace one 90 degree bend with two 45 degree bends).
C. Lower the system to provide deeper structures.
D. Eliminate opposing laterals by offsetting their centerline a distance equal to the sum of the diameters.
E. Limit the extent of individual systems.

F. Provide effective channelization.

G. Provide inlet shaping.

SECTION 8-300 GENERAL REQUIREMENTS FOR STORM DRAINAGE SYSTEMS

A schematic drainage plan showing probable areas for detention, major drainage systems being proposed, all existing drainage divides and any major changes in divides proposed must be submitted with the preliminary plan and any rezoning applications. The on-site drainage area shall be outlined on a schematic drawing which shall include contours at a two (2) foot interval. Each differential area shall be shown with respect to the point of concentration and the acreage shown thereon. The minimum acceptable scale shall be 1" = 100' unless otherwise approved by the Director of Public Works.

Off-site drainage areas contributing to the system being designed shall be shown on County topographic maps or other acceptable maps.

The storm sewer and culvert systems are to be shown on plan and profile on 24" x 36" sheets.

All construction information, including invert elevations (in and out), size, type of pipe, gauge, length and percent of slope shall be shown on plan and profile.

All storm sewer appurtenances shall be identified by the type and number (i.e., DI-1, DI-3B), including number and length of throats and locations on profile and/or on plan.

8-300.1 PIPE REQUIREMENTS

All pipes used for the construction of storm sewer systems shall be concrete. Concrete pipe, whether designated for use within the right-of-way of a public street or thoroughfare or beyond the limits of a street right-of way, shall meet the three-edge-bearing strength test requirements for ASTM C76 [Class III Beyond R/W Class IV in R/W] reinforced concrete pipe, latest revision. Culvert pipe classed as "seconds" by the manufacturer or pipe which has been rejected from another project shall not be permitted for use. Class will be increased

above these requirements based on height of cover. The laying length shall not be less than three (3) feet.

The minimum pipe size for culverts and storm sewer systems shall be fifteen (15) inches. Culverts used under driveway entrances on ditch section streets shall also be a minimum of fifteen (15) inches.

Velocities in storm sewer pipes greater than twenty (20) fps based on 10-year frequency storms shall require approval of the Director of Public Works and, where allowed, will require the use of pipe manufactured with 6,000 psi concrete and meeting the strength requirements of ASTM C76 Class III, latest revision.

Storm sewer pipe sizes are to be determined by using Mannings Formula:

$$V = \frac{1.49}{n} r^{2/3} s^{1/2}$$

with a minimum coefficient of roughness for the following types of pipes:

Concrete pipe	0.013
Corrugated metal pipe culverts with paved invert	0.021
Field bolted arch pipe	0.030
*Polyvinyl Chloride Pipe (PVC)	0.009
Advanced Drainage System (ADS)	
*Limited to Roof Drains Only	

8-300.2 STORM SEWER SPREAD

Storm sewer systems must be constructed when the stormwater reaches an 8-foot spread, measured from the face of curb, on public streets with a pavement width up to thirty-six (36) feet; and when a ten (10) foot spread is reached on public streets greater than thirty-six (36) feet wide. (See Exhibit 42 in Appendix A.)

Drainage computation sheets shall be submitted on forms approved by the Department of Public Works attached to and made part of the development plans. This shall include consideration of on-site and off-site drainage, (See Exhibit 41 in Appendix A.)

All storm drainage systems shall be designed to, as a minimum, provide overland relief for the100-year storm without damaging or endangering nearby buildings.

Drainage arrows are to be shown on curb and gutter, storm sewers, ditches, on-site pavement and drainage divide maps.

8-300.3 UTILITY CROSSINGS

Desired minimum allowable distance between storm sewer and any other underground piping shall be one and one half (1½) feet. Concrete piers shall be provided in accordance with Standard Detail SS-4.2 of this Manual where the desired minimum crossing distance cannot be attained. The absolute minimum is six (6) inches. Where storm sewer lines cross sanitary sewer lines within three and one-half (3 1/2) feet, the use of ductile iron pipe may be required by the Engineer. Such requirements shall extend the limits of the excavation for the storm sewer so the bells of the sanitary main are at least ten (10) feet from the conflict point.

Headwater and tailwater computations must be submitted on standard forms approved by the Director of Public Works. (See Exhibit 13 in Appendix A).. The Hydraulic Engineering Circular #5, Bureau of Public Roads, shall be used for these computations. The maximum allowable headwater depth is that depth where the water does not exceed a height greater than eighteen (18) inches below the edge of the roadway shoulder, or where the depth of the ponded area equals fifteen (15) feet.

All major culvert designs will be in accordance with VDOT's drainage policy.

8-300.4 PAVED DITCHES

In storm drainage systems, permanent ditch liners of part-circle sections of bituminous or asbestos fiber pipe, or plastic or similar lightweight materials with nonrigid properties, are not acceptable. Ditch liners of part-circle sections of heavyweight, rigid pipe, such as cement concrete may or may not be acceptable depending on

conditions, means of jointing and anchoring provided, bedding indicated, etc. Ditch linings of poured concrete are generally acceptable for most situations.

In addition to other situations that require paved ditches, paved ditches shall be required in accordance with VDOT specifications. All paved ditches shall be shown on plan and profile by stationing and grade. A typical section of proposed ditch shall be shown on plans. Transitioning of paved ditches to other appurtenances shall be shown.

8-300.5 DRAINAGE STRUCTURES

A drainage structure shall be constructed at every change in line and grade or change in pipe culvert size. Where pickup of additional stormwater is required a standard yard inlet, curb inlet, or drop inlet shall be constructed. All storm sewer lines shall be straight between manholes, catch basins, or other appurtenances. At every structure there is required a 0.20 foot minimum drop in inverts.

The maximum distance uninterrupted by appurtenances shall be 500 feet if the pipe diameter is forty-two (42) inches or larger and shall be (300) feet for pipe diameters under forty-two (42) inches.

Generally there may not be a reduction in pipe size along the direction of flow except for SWM purposes.

8-300.6 MINIMUM AND MAXIMUM COVER

The minimum and maximum cover shall conform to VDOT standard PC-1 for all drainage pipes within the street right-of-way. When the storm sewer pipe is laid outside the street right-of-way, a minimum of one (1) foot cover or ½ pipe diameter, whichever is greater, shall be required. If the minimum cover requirements as set forth in this section cannot be met, then structural modifications may be submitted for approval by the Director of Public Works.

The ends, entry or exit, of any storm drain shall be provided with a standard endwall, headwall, curb inlet, yard inlet, flared end section or other appurtenance suitable for the intended use of the storm drain. However, twelve (12) inch and fifteen (15) inch diameter pipe culverts

under driveways from streets using open drainage ditches in lieu of an underground system with curb and gutter may not be required to have endwalls but will be required to have endsections.

8-300.7 STANDARD END WALLS AND ENDSECTIONS

Standard endwalls or end sections shall be constructed on all culvert pipes as noted above. Standard endwalls or end sections shall be constructed at the outlets of all storm sewer systems and at the inlet point of such systems where no other approved structure is required. All such structures shall be shown on the plan and profile drawings. The following guidelines will be used to determine whether an end section or endwall will be used.

A. On culverts or storm sewer inlets and outlets from fifteen (15) inches in diameter to twenty-four (24) inches in diameter, flared end sections will be used unless the height of fill and side slopes exceeds ten (10) feet or 2:1, respectively; in which case a standard headwall should be used. Generally speaking, if the headwater over diameter (HW/D) ratio is up to one and one-half (1 1/2), then a headwall or approved end treatment will be required provided it can be installed safely and not create a potential traffic hazard in the opinion of VDOT and the Department of Public Works.

B. On culverts or storm sewer inlets and outlets between twenty-four (24) inches and thirty-six (36) inches in diameter, either standard flared end sections or headwalls will be required depending upon the height of the fill, the quantity of water and its velocity for the design- year storm. Generally speaking, a flared end section can be used if the fills are ten (10) feet or less, HW/D is less than one and one-half (1 1/2), there is less than fifty (50) cfs inflow or if the installation of a headwall

would constitute a safety hazard in the opinion of the Department of Public Works.

C. If the culvert or storm sewer inlet and outlet exceeds thirty-six (36) inches in diameter, a standard headwall will be provided unless this headwall would constitute a safety hazard to the traveling public in the opinion of VDOT and the Department of Public Works, in which case a flared end section should be considered. It should also be noted that endsections are available for oval or elliptical concrete culverts from some manufacturers.

D. End walls and end sections which have pipes twenty-four (24) inches in diameter and larger which are installed in residential developments within the City of Manassas shall be provided with a minimum 42-inch high fence or protective railing.

E. The fence or protective railing shall be installed at the top of the end section or integrally on top of the endwall for the portion of the wall where the drop is greater than eighteen (18) inches.

F. The protective railing must have no opening greater than six inches.

G. The protective railing must be of corrosion resistant material and must not obstruct the overland relief.

H. All storm sewer pipes or systems including energy dissipating devices shall be constructed to the back of property line to protect adjacent properties. Where a storm system terminates at a rear property line above the toe of a fill slope, the storm sewer system shall be continued to the toe of the slope either by means of additional sewer pipe or paved ditch.

8-300.8 ANCHORS

Anchors will be required to prevent sliding when the slope exceeds 16%, and adequate erosion control shall be installed at the outlet to prevent undermining of the endwall. A cut-off wall will be required at outfalls of pipes systems exceeding 16% slopes. (See VDOT Road and Bridge Standards, Detail 101.27 for cut-off detail). Slopes over 20% are not acceptable unless specifically approved by the Director of Public Works.

8-300.9 STANDARD DETAILS

Structures and appurtenances for inlets, curb and gutter, endwalls, junctions, etc., shall conform to the current edition of the Road and Bridge Standards of VDOT unless approved otherwise in writing and on the plans by the Director of Public Works. The use of precast structures from an approved manufacturer as per VDOT will be allowed.

8-300.10 EXPANSION JOINTS

Expansion joints shall be placed in header curb, combination curb and gutter, and sidewalk as specified in VDOT's Road and Bridge Specifications. Where stationary structures such as manholes, etc., are within the limits of the curb and gutter, and sidewalk, an expansion joint shall be placed between the structure and the curb and gutter and sidewalk.

Adjacent concrete sections shall be dowelled to the structure.

An expansion joint will be installed at drop inlets in the adjacent curbing sections at a minimum of six (6) feet with a maximum of twenty (20) feet from the inlet structure. Curb and gutter construction shall be in sections of uniform length, approximately ten (10) feet, and no section shall be less than six (6) feet in length.

8-300.11 FLOW IN GUTTERS

Pavement gutter is defined, for purposes of this Manual, as the portion of a roadway adjacent to the curb which conveys water during

a storm event; gutter in this sense would include a portion of a travel lane. Gutter cross sections generally have a triangular shape with the gutter of uniform cross slope and the curb forming the near-vertical leg of the triangle. *Refer to Exhibit 20 and Exhibit 21 in Appendix A.*

The gutter pan is defined, for purposes of this Manual, as the portion of integral concrete curb and gutter which slopes downward to the face of the curb.

Modification of Manning's Equation is necessary for use in computing flow in triangular channels because the hydraulic radius in the equation does not adequately describe the gutter cross section, particularly where the top width of the water surface may be more than forty (40) times the depth at the curb. To compute gutter flow, horizontal spread, or gutter depth, Manning's Equation is integrated for an increment of width across the section. Refer to Chapter 4, Section 6.1 of the Virginia Department of Transportation Drainage Manual for methodology.

8-310 INLET DESIGN CRITERIA

The spread of water on roadway pavements shall be limited to eight (8) feet from the face of curb. All design shall utilize a minimum rainfall intensity of 3.5 inches per hour. For events resulting from greater rainfall intensities, the entire roadway section may be used for the conveyance of stormwater.

There are sites where it may reasonably be anticipated that the from storms with rainfall intensities greater than 3.5 inches per hour will overtax the interception facility to a point that excess flow may result in damage to adjacent property and roadway right-of-way. In these instances, a check storm with a rainfall intensity of 6.5 inches per hour should be run. If all of the is found to be contained within the roadway section, both at the site and "downstream", or if runoff escaping the road section is found to be non-damaging to adjacent property, or the interception facility fails to meet the check storm criteria, it must be redesigned to accommodate the check storm.

For spacing of inlets, refer to Virginia *Department of Transportation Drainage Manual, Chapter 4, Section 6.2, and refer to Exhibit 42 in Appendix A.*

Inlets located on continuous grade shall be designed to intercept all of the gutter flow. There will be cases, however, where it is desirable to reduce the length (due to inlet inefficiency) through the use of bypass. This does not infer that the bypass volume be neglected. Inlets which have bypass flows shall be clearly marked on the plans and bypass flow must be included in the total gutter flow contributing to the next downstream inlet. Generally, bypass flow should not exceed the capacity of the street gutter pan.

Where an inlet is located at the bottom of a sag vertical curve (referred to as a sump or low point) for roads classified as through collector or higher, all of the flow must be intercepted by the inlet. A minimum throat length of six (6) feet shall be required.

To properly drain sag vertical curves, it is required on roads classified as through collector or higher to place three (3) inlets in each curve; one (1) inlet at the low point and one flanking inlet on each side of the low point. The flanking inlets should be placed so that they will limit the spread in the low (flatter) gradient approaches to the sag point and will act in relief of the sag inlet if it should become clogged. *Refer to Chapter 4, Section 6.2, Table 4.1 of the Virginia Department of Transportation Drainage Manual for flanking inlet spacing.*

Where the pavement on a continuous grade is warped in transition between super-elevated and normal sections, water conveyed along the curb shall be intercepted at the point in transition where the cross slope of the road section is equal to one percent to maintain spread requirements; further, road pavement with less than one percent cross slope towards a curb and gutter section shall not be utilized to convey flow. All flow in areas of less than one percent cross slope, except at median header curb, shall be confined to the gutter pan. Water concentrated in a pavement gutter shall not escape the gutter and cross the travelway before interception by an inlet.

No reverse curb and gutter (Virginia Department of Transportation CG-6R) shall be allowed in public rights-of-way.

Inlets shall be placed on the high side of super-elevated sections such that flow does not leave the gutter pan.

Where curbs are used in cut slope areas, shall be collected through a system of ditches and inlets at the top of the cut slope prior to the flow traversing the slope and entering the right-of-way.

No concentrated flow greater than two cubic feet per second based upon the two-year event shall cross a sidewalk or curb.

When stormwater is being conveyed along the pavement gutter of a street with a longitudinal slope of less than two percent, a maximum of two cubic feet per second may cross the intersection of a street with less than 500 vehicles per day. Where the longitudinal grade is two percent or greater, four cubic feet per second may cross the intersection of a street with less than 500 vehicles per day.

No flows will be allowed to cross the intersections of streets with 500 or more vehicles per day.

When bridges are located adjacent to gutter sections, it will be necessary to coordinate the drainage design with the bridge designer. For bridges without deck drains, the flow from the entire bridge plus any flow crossing the bridge shall be collected in the storm sewer system. For bridges with deck drains, it will be necessary for the drainage designer to review each drain's size, type and location. The flow capacity of deck drains as well as their potential for clogging shall be fully considered and the storm sewer system designed accordingly.

The interception facilities for interstate highways, limited access highways and other major arterials should be designed so that the spread (based on a rainfall intensity of 3.5 in/hr.) does not exceed one-half (1/2) of the running lane width, and there is no significant damage to adjacent property during a storm whose rainfall intensity is determined by a 50-year recurrence interval and the actual time of concentration.

Under certain circumstances, such as underpasses or depressed roadway sections, where ponded water can only be removed through the storm sewer system, the 50-year storm (using the actual time of concentration) should be used as the check storm and excessive depth of ponding should be avoided.

8-310.1 GRATE INLETS AND YARD INLETS

Grate and yard inlets in a sump location shall be designed assuming 50 percent clogging. These inlets operate as weirs at shallow depths and as an orifice at greater depths. Grates of larger dimension and grates with more open area; i.e., with less space occupied by lateral and longitudinal bars, will operate as weirs to greater depths than smaller grates or grates with less open area. *Refer to Virginia Department of Transportation Drainage Manual, Chapter 4, Section 6.3, for specific grate inlet design. Refer to Exhibit 26 and Exhibit 27 in Appendix A.*

Grate inlets outside the travelway of public roads on continuous grade shall be designed assuming 50 percent clogging. Flow passing over the grate, if applicable, shall be collected at the next downstream inlet. *Refer to Chapter 4, Section 6.3, of the Virginia Department of Transportation Drainage Manual.*

Grate inlets are prohibited within commercial and residential entrances.

Grate inlets within parking lots and easements shall be a VDOT type applicable to the location relating to pedestrian safety, while grate inlets within grassed easements to be specied DI-1.

8-310.2 DROP INLETS

Interception capacity of a drop inlet is largely dependent on flow depth at the curb and curb-opening length.

Effective flow depth at the curb and consequently, drop inlet interception capacity and efficiency, is increased by the use of a local depression at the curb-opening or a depressed gutter to increase the proportion of the total flow adjacent to the curb. Local depression shall

be two (2) inches for curb inlets with CG-6 and one (1) inch for curb inlets with Virginia Department of Transportation CG-2.

Drop inlets in continuous grade situations are effective in the drainage of pavements where flow depth at the curb is sufficient for the inlet to perform efficiently. Curb-openings are relatively free of clogging tendencies and offer little interference to traffic operation. Drop inlets are required in the public right-of-way. *Refer to Exhibit 22 in Appendix A*.

The required method for determining the length of a drop inlet required for total interception of gutter flow is located in S*ection 6.4, Chapter 4, of the Virginia Department of Transportation Drainage Manual.*

For drop inlets in a sump condition, *refer to Exhibit 23 in Appendix A.*

8-320 OPEN CHANNELS

8-320.1 NATURAL WATER COURSES

Natural watercourses are the primary facilities for conveying stormwater runoff. For purposes of this Section, the term natural watercourse shall refer to the total conveyance facility, the stream (or low flow channel) and the adjacent flood plain.

The policy of the City of Manassas relative to natural watercourses shall be as follows:

A. Generally, any encroachment into the flood plain is not permitted unless authorized by the Director.

B. Whenever a natural watercourse must be relocated or otherwise modified, the extent of channel reach and degree of modification shall be the minimum necessary to provide compatibility of the channel and development. *Refer to Section 8-320.5 in Appendix A for specifics of stream modification.*

C. A narrative describing the stream's morphology (form and structure) and environment shall be conducted and documented in addition to the economic and engineering alternatives available for the particular location.

D. *Refer to Section 8-600,* Flood Plain Policy, for processing and analysis requirements.

E. Modified and relocated channels shall duplicate the existing stream and flood plain characteristics as nearly as possible. These characteristics shall include the stream width, depth, slope, flow regime, pool-riffle ratio, bank cover, side slopes and flow and velocity distribution.

F. A hydraulic analysis of the 25 and 50-year, in addition to the 100-year frequency floods may be required by the Director to comply with the City's Stormwater Management Master Plan or design criteria contained herein.

8-320.2 CONVEYANCE CHANNELS

Man-made channels are typically trapezoidal or other geometric sections and may be either natural or artificially lined. Hydraulic capacity shall be determined by the procedure outlined in Chapter 5 of the Virginia Erosion and Sediment Control Handbook. The computed velocity shall approximate the assumed velocity used to determine the Mannings's "n" value.

All open channels shall be designed to contain the ten-year event. Plans shall account for overland relief resulting from less frequent events.

The velocity of flow in open channels including bends is determined through the use of Manning's Equation and "n" values, and Bernoulli's equation. *Refer to Chapter 2, Section 6.2.1, and Chapter 2, Table 8.2, of the Virginia Department of Transportation Drainage Manual.*

The need, type and dimensions of lining for erosion control shall be based on the velocity associated with the ten-year event. The lining selected shall be consistent throughout the channel until it outfalls to a natural watercourse. For various channel configurations, *refer to the Virginia Department of Transportation Drainage Manual, Section 2.8, Chapter 2.*

Depending upon the location, safety, damage risk and environmental considerations, a less frequent event may be required for the design of these channels at the discretion of the Director.

Where an access strip is provided it shall have a maximum two percent cross slope within the required easement.

Maximum side slope for grass lined conveyance channels shall be three to one with a minimum longitudinal slope of one percent (two percent minimum recommended).

Conveyance channels with side slopes steeper than 3:1 shall be stabilized by paving, riprap, gabions or other approved measures.

Conveyance channels with longitudinal slopes less than one percent shall be paved.

Paved stormwater conveyance channels or channels with side slopes steeper than 3:1 are prohibited within or through residential subdivision building lots and in no case shall the top width of the channel be within twenty-five (25) feet of a residential property line; except that twelve (12) feet of the required 25-foot open area may be contained within a lot providing the additional square footage within the 12-foot area shall not be used in the computations for determining the minimum required lot area.

Stormwater conveyance channels conveying more than fifteen (15) cubic feet per second are prohibited within or through residential subdivisions and in no case shall the top width of the channel on an adjacent non-residential property be within twenty-five (25) feet of a residential property line.

The sides of all conveyance channels shall be extended until one (1) foot of freeboard is provided above the ten-year event water surface elevations within the conveyance channel.

8-320.3 ROADSIDE AND MEDIAN DITCHES

Roadside and median ditches shall meet the standards for stormwater conveyance channels.

Generally, side and median ditches shall be designed in accordance with prevailing geometric standards applicable to the particular class of roadway, with consideration of hydraulic capacity, erosion control and safety. Refer to Chapter 2, Section 2.1, and accompanying charts of the Virginia Department of Transportation Drainage Manual.

The ditch should provide sufficient hydraulic capacity to contain the estimated runoff from a ten-year frequency storm. The estimated runoff and attendant velocity for the two-year frequency storm is to be used for determining the needs, type and dimensions of special ditch lining for erosion control. Geometric configurations shall conform to appropriate safety standards.

8-320.4 LOT DRAINAGE SWALES

Swales for lot drainage shall conform to the standards for grass-lined conveyance channels based on the ten-year event.

An inlet shall be provided to intercept lot drainage flow when any of the following conditions apply:

A. The lot drainage swale extends more than 100 feet.

B. The lot drainage swale conveys more than three (1) cubic feet per second.

Lot drainage swales shall not discharge in excess of two (1) cubic feet per second across any sidewalk or curb based on the two-year event. *For more specifics, see Section 8-520 of this Manual.*

8-320.5 STREAM MODIFICATION

If stream and flood plain encroachment is unavoidable (i.e., highway embankment), a detailed evaluation by a registered Professional Engineer licensed in the Commonwealth of Virginia shall be made and sealed.

8-330 OUTLET PROTECTION

Provide erosion protection at the outlets of storm sewer lines and culverts based on outlet velocity in accordance with the following:

A. Two (2) fps to five (5) fps velocity: sod protection at the outlet (Kentucky Blue Grass or equally erosion resistant sod or other material).

B. Five (5) fps to eight (8) fps velocity: VDOT Class I, dry riprap [VDOT Spec 414.03 (a)] or current equivalent.

C. Eight (8) fps to eleven (11) fps velocity: VDOT Class II, dry riprap, [VDOT Spec 414.03 (a)] or current equivalent.

D. Eleven (11) fps to eighteen (18) fps velocity: VDOT grouted riprap [VDOT Spec. 414.03 (d)] or current equivalent.

E. Velocities in excess of eighteen (18) fps shall require special design energy dissipaters or impact basins. These structures may be designed in accordance with the following publications: Hydraulic Design of Stilling Basins and Energy Dissipaters, Engineering Monograph #24, U.S. Department of the Interior, Bureau or Reclamation; Design of Small Dams, U.S. Department of the Interior, Bureau of Reclamation, or similar text. Appropriate riprap protection should be provided in conjunction with these devices to prevent erosion and scour below the structure.

8-330.1 OUTLET PROTECTION EXCEPTIONS

Placement of the above erosion control measures shall be performed in accordance with VDOT Standard #114.01, EC-1, with the following exceptions:

A. The length of the apron of erosion control shall be calculated by the following formula:

$$La = 0.37\ VoD^{1/2}$$

Where La = apron length required, in feet
Vo = outlet velocity, feet per second
D = diameter of pipe, in feet

B. The minimum depth of Class II riprap [VDOT Spec. 414.03 (r)] shall be thirty-six (36) inches.

8-330.2 EROSION CONTROL NOTES AND PROCEDURES

To eliminate the erosion problems and subsequent construction failures which occur at the outlets of storm sewer systems, the following guidance for laying out and designing storm sewer systems for future submissions is recommended:

A. The outlet end of the storm sewer system should, without exception, discharge directly into a stabilized existing drainageway.

B. The outlet end of the storm sewer system should be as compatible as possible with the grade, horizontal and vertical alignment and location of the existing drainageway into which it will discharge.

C. Placing outlet structures of storm sewer systems on fill material should be avoided. If the outlet is on fill, extra erosion protection is required.

D. Placing erosion protection at outlets on fill material should be avoided. Should it be necessary for some reason to deviate from items A and B above, the preferred alternative would be a stabilized ditch of adequate capacity to convey the design storm flow from the outlet structure to the existing drainageway. However, any

such deviation from above stated policy will be subject to the review and approval of the Director of Public Works.

Erosion protection shall be placed where curb and gutter ends on fill sections or any soil that has eroding characteristics as determined by the Director of Public Works.

SECTION 8-400 INSTALLATION OF DRAINAGE APPURTENANCES

8-410 GENERAL REQUIREMENTS

Prior to the construction of any storm drainage system, the owner's or developer's engineer or surveyor shall place adequate line and grade stakes and shall also set stakes and furnish grades so that all manhole tops can be set to finished grade, all in accordance with approved plans.

The engineer or surveyor shall then prepare suitable cut sheets in a clear and legible manner giving all necessary construction data. Two (2) sets of all cut sheets, certified by a professional engineer or land surveyor shall be submitted to the Department of Public Works. The Department of Public Works may perform a cursory review to verify conformance to the approved design.

Construction of storm drains and appurtenances shall be in accordance with approved plans and/or the cut sheets submitted to the Department of Public Works and with specifications contained herein. Good workmanship and standard construction procedures shall be applied for final inspection and approval by the Director of Public Works. If any substantial deviation is contemplated in location, line, or grade of any storm drain, masonry structure, or accessory from that shown on the approved construction plans, details of the proposed deviation shall be submitted to the Department of Public Works for review and approval before the changes are constructed.

8-420 TRENCHES

The provisions of Section 5-220 and 10-750 of this Manual shall apply to the construction of trenches to contain storm drainage systems.

8-430 BEDDING

Except of pipes within dams or embankments with permanent or temporary empoundments the bedding material for storm drainage pipes will be graded 57 stone placed to the springline of the pipes and 6 inches below the bottom of the pipe.

8-440 BACKFILLING

In addition to the provisions of Sections 7-230 and 10-760 of this Manual which shall govern the backfill procedures, all storm drainage pipe culverts shall be backfilled to a minimum depth of cover that meets the requirements of Section 8-300.5 of this Manual. Backfill and replacement in existing/proposed roads or rights-of-way shall be executed in full conformance with the requirements of Section 9-5100, 10-700 and Standard Detail TS-15.0 of this manual.

If necessary, when the storm drain occurs under curb and gutter, a minimum of nine (9) inches clearance from the bottom of the gutter may be permitted by the Director of Public Works.

8-450 JOINTING

Rubber Gasket: The use of rubber gaskets when joining pipes will be permitted provided that installation is in strict accordance with manufacturer's specifications and the recommended lubricant is used. The type of rubber gasket, lubricant, and pipe will be subject to approval by the Director of Public Works or his designated agent.

All joints that do not utilize a rubber gasket will be sealed with a masking material. The inside of the bell shall be coated before the pipes are connected. The top portion of the pipe from spring line to spring line shall also be coated after the pipe sections are properly connected.

All jointing must comply with the current criteria, standards, and specifications of VDOT.

8-460 CHANNELS

All ditches constructed for the open conveyance of stormwater shall be shown in cross-section on the approved plans. Ditches shall be constructed true to the approved cross-section and shall be constructed on a uniform grade and straight line with the longitudinal axis of the drainpipe unless otherwise approved by the Director of Public Works.

The side slopes shall be free from rocks and stumps and wild vegetation. After dressing the slopes to the proper cross-section, they shall be seeded with a grass type or sodded to prevent erosion in accordance with the Erosion and Sediment Control Manual.

SECTION 8-500 STORMWATER MANAGEMENT

8-510 POLICY AND GENERAL REQUIREMENTS

Policy and General Requirements: All development occurring within the City shall, as a minimum, either contain on-site or provide off-site SWM and BMP facilities, adequate to control increased runoff and to reduce or mitigate non-point source pollution generated by the applicable design storm to its predeveloped condition. The design shall include control of stream flow rates, water surface levels, and runoff volumes.

No application for a final plan of subdivision shall be approved unless it includes a plan describing the manner in which erosion, sediment, pollutant loading and stormwater resulting from the development will be controlled or managed or a waiver thereof. This plan shall indicate whether stormwater will be managed on-site or off-site, and the location and design criteria of facilities and type of management. No building permit shall be issued by the Building Official for any parcel or lot until a SWM and BMP plan, or waiver thereof, for the plat or parcel, shall have been approved as meeting all applicable requirements.

Every land developer/owner shall provide a SWM and BMP plan as a part of every site plan and subdivision plan submission unless a waiver of the requirements of the policy in the form of pro-rata share is approved.

Generally, Stormwater Management is considered to address the quantity of runoff while Best Management Practices address the quality of runoff.

While there are differences between performance criteria; the two management strategies will often be employed within the same structure or facility. Standards which apply for one (1) set of performance criteria will not lessen any performance criteria for the other.

If both SWM and BMP are provided within the same facility, the final design shall ensure that performance criteria and maintenance are compatible. Because of the nature of these facilities, reference to SWM may (but not necessarily) also imply BMP.

An acceptable SWM plan can be obtained:

A. By providing the necessary facilities within the project area.

B. By entering into a joint effort with other developers to provide multi-site facilities.

C. By entering into an agreement with the City, subject to prior approval by the Department of Public Works, which provides for a financial contribution for off-site SWM. Such contributions shall be held by the City and used only for SWM facilities within the major drainage basin within which the developer's project is located. The City itself may construct such facilities or may use the contributions to reimburse developers who provide SWM facilities in excess of their own needs.

D. By granting an easement or dedicating land for a larger SWM facility, subject to prior approval by the Department of Public Works, in lieu of the required on-site SWM.

E. When the City determines that additional storage capacity, beyond that required by the applicant for on-site SWM, is necessary in order to correct an existing problem, it may acquire from the applicant or owner, by

purchase or dedication, additional land as may be necessary, and/or participate financially in the construction of the SWM facility to the extent that it exceeds the required on-site SWM.

8-510.1 DESIGN CRITERIA AND PLAN REQUIREMENTS

Final SWM plans shall be submitted with final subdivision or site plans. They shall be subject to the applicable review and notification procedures and time schedules presented in Article 2 of this Manual. The basic criteria used in designing a facility are as follows:

A. Peak flows shall be computed by the methods set forth in Section 8-100. Rainfall frequencies and durations shall be determined using the provisions of this subsection.

B. The 10-year storm will be used in determining pre-developed flow except in critical watershed areas. The 24-hour SCS Type II rainfall distribution shall be used.

C. A 10-year storm will be used in determining the developed flow except in critical watershed areas. If the rational method is used, increments of this storm (5 or 10 minutes) are computed and compared to the predeveloped runoff to determine the amount of storage required. (See Exhibit 18 in Appendix A.)

D. In areas where high density developments exist or are shown on the Comprehensive Plan or the zoning map in the vicinity of the proposed developments, SWM facilities must also be designed to regulate the peak discharge from the 2-year storm unless the facility incorporates BMP structural controls.

E. In critical watershed areas, SWM facilities must be designed to regulate developed flows to the predevelopment levels for 2-year storm, 10-year, and 25-year storm events. A list of critical watersheds shall

be maintained by the Department of Public Works. Monetary contribution in addition to providing storage for the 10-year storm may be allowed by the Director of Public Works in lieu of regulating the 25-year storm. Requests for such substitutions must be made in writing.

F. Emergency spillways and ponds will be designed to pass the 100-year storm, assuming that the principal outlet structure is inoperative, unless, due to the height of the dam and the capacity of the impoundment, smaller frequency storms have to be considered during the design. The effect of the 100-year storm must be considered in the design of all SWM facilities. Dam design shall be performed in conformance with Section 8-900 of this Article.

G. The following information shall be included in the final SWM and BMP plan:

1. All information provided in the preliminary plan with any required changes.
2. All calculations, assumptions, and criteria used in the design of the storm sewer system and SWM facilities. This includes, but is not limited to, time of concentration, time of concentration flow paths, runoff curve numbers, soil types, runoff coefficients etc.
3. All plans and profiles or proposed storm sewers and open channels including horizontal and vertical controls, elevations, sizes, slopes and materials.
4. Locations, dimensions and design details required for the construction of all facilities. Details for installation of trash rack and antivortex device on all riser pipes, anti-seep collars.

5. Drainage area maps, soil maps, and land use maps.
6. For all SWM facilities, inflow and outflow hydrographs generated by the design storms for pre-developed and developed conditions.
7. Depth (elevation) versus volume of storage curve and depth (elevation) versus outflow curve. All formulas and assumptions used to develop these curves shall be included.
8. Contours of the finished project site that adequately describe the final topography.
9. Project specifications relative to erosion and sedimentation control. Refer to Sections 8-620.4, 8-620.5, 8-620.6, and Article 4 for more information on erosion and sediment control.
10. All deed restrictions, easements and rights-of-way.
11. A description of the operation and maintenance needs for all SWM and BMP facilities including a schedule for sediment removal and/or control. A maintenance agreement stating the ownership and maintenance responsibilities for all SWM and BMP control structures, during and after development. The identity of the responsible individual, corporation, association or other specific entity and the specific maintenance must be outlined on the plan and plat.
12. SWM Fact sheet (Exhibit 28 in Appendix A).
13. Percolation tests and calculations for gravel trenches or pits proposed to incorporate infiltration into soil.

The Department of Public Works reserves the right to require any additional calculations or information which may be necessary to evaluate the design of the facility.

8-510.2 LOCATION OF SWM AND BMP FACILITIES

In general SWM and BMP facilities shall be set back at least fifty (50) feet from any structure containing a dwelling unit and likewise, any dwelling unit shall be set back at least fifty (50) feet from any SWM and BMP facility. Unless authorized by the Zoning Ordinance, SWM and BMP facilities shall not be located in any required buffer areas and shall be set back from all property or ten (10) feet, whichever distance is greater.

Notwithstanding the provisions of the preceding paragraph, no SWM and BMP facility in non-residential districts shall be located within thirty (30) feet of any property line along which a buffer zone is required.

In agricultural districts and in single-family and townhouse developments, SWM and BMP facilities shall be located in lots which will be conveyed to, and maintained by, homeowner associations. In the absence of homeowner associations, SWM and BMP facilities may be located in individual homeowner's lots provided that the minimum lot area required is met outside the area devoted to the SWM and BMP facilities and flood plains and the area devoted to storm drainage systems including SWM and BMP shall not exceed twenty percent of the total area of the lot within which it is located. In no event shall SWM and BMP facilities be located within individual townhouse lots.

All required SWM and BMP setback areas shall be stabilized, provided all access easements remain clear, in accordance with Article 9 of this Manual. All measured distances shall be measured to the 100-year flood plain.

8-510.3 EASEMENTS REQUIREMENTS

As SWM and BMP facilities are designed to be permanent, a maintenance easement around the edge of the facility shall be

required. At minimum, the easement shall extend twenty (20) feet from the perimeter of the 100-year ponding area. However, all easements shall be large enough to contain the 100-year ponding level and all required freeboard, embankment, and all outlet structures. The private easements for percolation trenches, shall be a minimum of five (5) feet on each side of the trench.

8-510.4 ACCESS TO SWM AND BMP FACILITY

Access to the facility shall be contained in an easement of not less than twenty (20) feet in width and shall not exceed a grade of 20%. If the grade exceeds 10%, the access route shall be built in accordance with Category I pavement design as set forth in drawing TS-3.0 of this manual. This access easement must connect the facility with a public access, all weather road.

8-510.5 PROTECTION OF SWM AND BMP FACILITIES

The Department of Public Works may require protective devices in conjunction with SWM and BMP facilities. Protective devices shall be in the form of either a i) minimum four (4) foot high chain link fence; ii) split rail fence with wire backing or approved equivalent. Grades no steeper than 10:1, in the first ten (10) feet inner perimeter of the facility from the normal waterline shall be used and a shallow water depth, that is no more than two (2) feet, or alternate means of protection as approved by the Director of Public Works. A six (6) foot wide safety ledge outside the normal waterline should be provided adjacent to permanent wet pools at a slope no greater than 8%. The slope in back of this safety ledge should be no greater than 3:1. Wet ponds and ponds in industrial parks remotely located from residential developments and the public shall not require fencing. Permanent fencing, when required, shall be installed with a sixteen (16) foot wide gate where the access road enters the facility. Fencing shall be installed around the easement in such a manner to minimize obstruction of the emergency spillway. Adequate access must be provided within the facility for maintenance.

Signs should be posted five (5) feet from the waters edge warning individuals that they are not permitted in the wet area of any wet or dry pond. The sign should read as follows:

Adjacent to all wet ponds “No Trespassing - No Swimming, No Wading, No Boating.” These signs should be posted at least every 150 feet around each facility.

Adjacent to all dry ponds the signs should read “No Unauthorized Access - Caution Water Rises Quickly.”

The City’s policy is to not require fencing of stormwater management for private ponds or City maintained dry ponds when the above design criteria is met.

In areas where the above design criteria cannot be met the City will require fencing. The fencing may be for the total perimeter or for a portion of the perimeter depending upon the site parameters.

When siting regional stormwater facilities in existing residential areas fencing will be considered depending on the proximity the to residences.

Wet ponds to be maintained by the City will be fenced if located in an existing or proposed residential area.

Riser structure in wet or dry ponds should be fenced if they extend more than forty-two (42) inches from the ground or have open access on the top of structure.

8-510.6 EXEMPTIONS AND WAIVERS

Development exempt from City of Manassas SWM plan submission requirements are: (Refer to Section 8-730 for waiver of BMP.)

A. Any minor land disturbing activity involving less than five hundred (500) cubic yards of earthwork and less than two thousand five hundred (2500) square feet of disturbed area and which is promptly stabilized to prevent erosion and sedimentation, not including creation of paved or other impervious surfaces.

B. Accepted agricultural and management practices permitted by the Zoning Ordinance and/or in accordance with approved Siltation and Erosion Control Plan where required. Examples of such practices in an agricultural zoning district are: plowing, nursery operations such as the removal or transplanting of cultivated sod, shrubs and trees and tree cutting at or above existing ground; and logging operations leaving the stump, ground cover and root intact.

The Director of Public Works will consider granting a waiver of the requirements for on-site SWM in the following development categories:

A. Subdivisions of detached single family residential developments where:

Minimum Lot Size	Maximum Development Size
1 acre	5 acres
1/2 acre	2 acres
1/3 acre	1 acres
1/4 acre	1 acres
1/8 acre	1 acres

B. Subdivisions of multifamily residential developments which total two (2) acres or less.

C. Institutional developments in which there are two (2) acres or less of disturbed area and, included therein, one (1) acre or less of impervious area.

D. Industrial and commercial developments in which the total disturbed area is two-thirds (2/3) acre or less and included therein, one-third (1/3) acre or less of impervious area.

E. Any new projects which are additions, extensions and/or modifications to those developments listed in the above categories which have been granted a prior waiver under this policy shall be reevaluated for SWM for the entire site. Where the acreage limitations listed for each category are exceeded by the addition, extension and/or modification, SWM will be required.

Owners who have projects falling within these categories and who desire not to provide SWM for the site must request, in writing, that the requirements be waived. See Exhibit 10 in Appendix A for sample form to be used.

For purposes of clarity and administrative efficiency, the following statements shall apply to these guidelines and the resultant plans developed under them:

A. Institutional developments shall be defined as: churches, cemeteries, rescue squads, fire departments, hospitals, libraries, schools, day care centers, nursing convalescence homes and recreational facilities and their related building and parking lots.

B. All parking lots, as conventionally constructed, shall be considered impervious and therefore included in the impervious area considerations. (Specially designed treatments with proven results and accompanying supportive documentation may be considered pervious).

C. Resurfacing a previously approved or legally "nonconforming" impervious area shall not require SWM or BMP nor shall it be included as an addition of impervious area.

D. Impervious area calculations for buildings shall include all overhanging projections such as eaves, canopies and porticoes.

The Director of Public Works will also consider granting a waiver for on-site detention facilities for developments not falling within the waiver categories previously listed under the following conditions.

A. The hydraulic characteristics of the receiving stream or the environmental characteristics of the stream or the site are such that on-site management or detention of flows are contrary to sound engineering practices and detrimental to the environment;

B. The increased amount or velocity of stormwater generated by the development will have a minor detrimental effect on the receiving stream;

C. An off-site SWM facility has been identified for construction in the Capital Improvements Program, and the applicant will agree to a financial contribution or dedicate an easement or land for the construction thereof;

D. Two or more developments, including that of the applicant, have provided jointly, through reciprocal easements, or other means, for the management of stormwater;

E. Existing off-site SWM facilities provide the required control. In such cases, on-site SWM may be waived provided that the delivery system from the developing site to the off-site SWM facility is adequately protected against erosion.

F. Due to inadequate site availability for a suitable structure, or where the only feasible structure

would entail unreasonable cost, as determined by the Department of Public Works.

G. The waiver application shall include technical documentation and computations necessary to support any of the above items.

The Director of Public Works will consider granting a waiver for on-site detention facilities under the mentioned conditions, upon submission of a written request. A sample request form for such a waiver is shown in Exhibit 45 in Appendix A.

Monetary contribution will be substituted when on-site SWM is waived. This contribution will be computed per Section 8-510.9 of this Article.

Each request will be considered individually by the Director of Public Works. All applications for a waiver will receive a written response outlining the reasons for approval or denial of the application within thirty (30) days of receipt by the Director of Public Works.

It should be noted that in reviewing the waiver application, all storm drainage outfalls, receiving channels and channel capacities, velocities and other related storm drainage discharge considerations will be closely examined to determine the need for additional outfall treatment and/or channel protection needs. Further, the developer's engineer shall furnish the Department of Public Works a "declaration of adequacy" prior to granting a SWM waiver when adequacy of the receiving storm drain system is in question.

8-510.7 PRO RATA SHARE CONTRIBUTION

It is the City's intent to encourage the use of various methods of on-site detention of stormwaters to minimize the adverse effects of increased storm runoff on upstream and downstream drainage ways. However, where it is not in the best public interest, the Director of Public Works reserves the right to deny on-site detention and require a financial contribution from the developer. Conditions under which the

Director of Public Works might deny on-site detention could include, but not be limited, to the following:

A. Proximity of an existing or proposed off-site facility for handling stormwater flows.

B. When it is determined from the hydrologic and hydraulic model available to the Department of Public Works that detention will cause more harm than benefit.

8-510.8 PRO RATA SHARE VALUES

Payments received pursuant to this Section shall be expended for the administrative costs, land acquisition, design, construction, operation and maintenance of those drainage facilities for which payment was required. Payments will be deposited in interest bearing accounts for the benefit of the City; interest earned on such deposit shall be applied only for construction of those facilities for which the payment was required. It should be noted that this contribution is nonrefundable.

The payment of the applicable pro rata share calculated in the manner described below in Section 8-510.9 shall be predicated upon approval by the Council of a subdivision or a site plan.

In watersheds where a major off-site detention facility is planned, and funds are allocated towards the design of such facility, the subdivider or developer of land shall be required to pay a pro rata share of the cost of such facility or to dedicate land and or provide easements to be used for the proposed off-site central SWM facility or other improvements. When land is dedicated for a regional SWM facility, only the amount of land above what would be required for the development's on-site detention will count towards the pro rata share payment.

The Department of Public Works shall study and compute the total estimated cost of the ultimate SWM facilities required to serve a

watershed when and if such watershed is fully developed in accordance with the adopted Comprehensive Plan. The computation of estimated costs shall include any engineering study for the watershed, and the total cost of design, construction, operation, maintenance and easement acquisition. When this total cost is computed, it shall be updated annually by applying the Engineering News Record cost index factor to the construction costs. The above study, with its attendant cost figures, shall constitute the general drainage improvement program for the affected watershed. A list of the watersheds wherein major off-site facilities are planned and design funds allocated will be published once adopted by Council, and will be updated as needed.

A subdivider or developer of land may be required to contribute to the provision of reasonable and necessary drainage facilities located outside the property limits of the land owned or controlled by the subdivider or developer, but necessitated or required, at least in part, by the construction or improvement of his subdivision or development. In such case, and if a general drainage improvement program has been established, pro rata share shall be determined based on the total updated cost of the program.

8-510.9 PRO RATA SHARE CALCULATIONS

In watersheds where the total improvement costs for a particular drainage project have not been calculated, and where monetary contribution in addition to (critical watersheds) or in lieu of (waivers) on-site detention is allowed, the pro rata share shall be determined by the formula below. It shall in no event exceed the calculated cost required to provide full SWM in accordance with the applicable provisions of this Manual. Construction quantity estimates, certified by a professional engineer or land surveyor, will be submitted for the SWM facilities. The current City of Manassas bond estimate price list will be applied to the quantities to arrive at the calculated cost.

PRO RATA COST SHARING FORMULA

A. LESS THAN OR EQUAL TO 40 PERCENT IMPERVIOUS

$/Acre = A x I

B. GREATER THAN 40 PERCENT IMPERVIOUS

$/Acre = B+ (I2 x C)

I = Imperviousness expressed as a percent (i.e., 40% = .40)

(See Exhibit 3 in Appendix A).

A = 3,400 X D

B = 400 X D

C = 6,000 x D

D = Current ENR Construction Cost Index/3,726

(ENR = Engineering News Record)

The developer may receive permission to either construct or provide the funds for the construction of more than his proportionate share of the downstream off-site drainage improvements so that he may proceed with the improvement of his land without damaging the properties of others. The City will endeavor to collect, on a pro rata basis, any excess funds expended beyond his proportionate share of the cost of such improvements from other properties within the watershed served by such drainage improvements when such properties are developed within a period of ten (10) years from the date that the drainage improvements are financed or constructed. These funds will be turned over without interest to the initial developer or his assigns.

8-510.10 RESERVED RIGHTS OF DISAPPROVAL

The Department of Public Works reserves the right to disapprove certain types of SWM and BMP systems for certain types of development. Systems designed in or adjacent to the right-of-way will only be approved if there is a well-defined method of maintenance approved by the Department of Public Works.

8-510.11 MODIFICATION TO APPROVED PLANS

Modification to an approved SWM and BMP plans which involves a change in control methods or techniques, or which involves the relocation or redesign of control measures, or which is necessary because soil or other conditions are not as stated on the approved application, should be approved under the procedures contained in Article 2 of this Manual. The City shall notify the applicant when such plan modification is required.

8-520 SITE GRADING PLANS

As a prerequisite to the issuance of building permits, site grading plans, prepared in accordance with the following subsections are required for all new single-family dwellings and additions to existing single-family dwellings where the generated disturbed area exceeds 5,000 square feet. For additions where disturbed areas are less than 5,000 square feet, a non-engineered plan may be submitted showing the land to be disturbed. The plan must locate the disturbed area by offsets to the property, show appropriate erosion control, and contain a signed statement by the owner that appropriate erosion control devices will be provided.

8-520.1 GENERAL REQUIREMENTS

To simplify the processing and review of grading plans for residential dwellings, the following items must be included on all plans:

A. Spot elevations are required to be shown at all building entrances, at driveway entrances, and at all changes in grade of the driveway. Spot elevations should be shown at each building or house corner.

B. Walkout basements should be indicated on the plans, showing the entrance and the appropriate spot elevations.

C. Land Disturbance Permits, discussed in Section 2-860, are required when no other permits are required (structures, additions, etc) on land disturbances greater than 5,000 square feet or proposed changes in grades or

cut/fill on any existing easement and shall comply with erosion control criteria as required by Article 4 of this Manual.

D. The minimum size allowed for a driveway culvert is fifteen (15) inches and the inverts for the pipe must be shown. All culverts must be designed to pass the ten (10) year storm. Culvert computations must be submitted with the grading plans.

E. For single family dwelling units, the minimum and maximum allowable driveway slopes are 2% and 15% respectively. The minimum driveway width is twelve (12) feet. A parking pad with a minimum of 360 square feet and twenty (20) feet wide and eighteen (18) feet deep shall be provided on all driveways for parking. The minimum and maximum grade on the parking pad is 2% and 5% respectively for houses that do not include a garage or carport for two or more vehicles. Where the driveway length is less than forty (40) feet, driveway entrances shall be aligned with garages and carports. The width of the CG-9D entrance shall be increased to provide proper access to the parking pad.

F. The lead walk and all risers must be shown on the plan and the elevations at all landings must be specified.

G. In subdivisions where yard lights are required, their locations must be shown on each individual lot.

H. The grading of the front of the lot along with whatever cuts and fills are proposed must be shown, in as much as they define the ditch line and the location of the driveway culvert.

I. Erosion controls are required for all areas on the lot where the ground will be disturbed. The original erosion controls for the subdivision are satisfactory for areas that

they will cover as long as the erosion controls will not be removed until all the construction on the lot is completed and the ground stabilized.

J. Lot grading plans shall be to a scale of one (1) inch equal to thirty (30) feet, or less on lots with areas of less than one (1) acre. A scale of one (1) inch as equal to fifty (50) feet is the maximum that will be allowed for lots of areas of one (1) acre or greater. All plans will have two (2) feet contours defining lot grading and must show the dimensions of the structures, lot dimensions, distances from structures to property lines, building restriction lines, and all other proposed changes at the time the plan is submitted.

K. All existing (platted) storm drainage and sanitary sewer easements will be shown.

L. The perimeter area immediately adjacent to a proposed dwelling should be graded in such a manner as to lead water away from the building. The slopes in this area must be no less than 2% and no greater than 10%. This slope transition area must be at least ten (10) feet wide in sites where cut or fill slopes are greater than 3:1.

M. Slopes steeper than 3:1 (where permitted) must be provided with special stabilization and the type of stabilization specified on the plan. Where feasible, benches or diversions shall be provided on slopes 3:1 and steeper, when the vertical height of slope exceeds fifteen (15) feet. Slopes steeper than 2:1 are not permitted.

N. Any proposed swales on a lot must be at a minimum of 2% slope but should preferably be at 3%. Any swale with steep longitudinal slope must be properly stabilized in

accordance with the Virginia Erosion and Sediment Control Handbook.

O. All retaining walls with a difference in grade on either side in excess of thirty-six (36) inches will be required to have a separate building permit in accordance with requirements of VUSBC and must meet the approval of the Zoning Administrator. All handrails shall meet VDOT or VUSBC requirements where applicable.

8-520.2 PLAN APPROVAL

Site grading plans must be approved prior to the issuance of a building permit. Site grading plans are required to be on the job site during construction and are used to check the final grading prior to the issuance of the occupancy permit. The permit will be refused if the plan and the on-site grading do not agree unless such deviation has been approved by the Director of Public Works as being substantially in accordance with the intent of the Manual. Preferably lot grading plans, for single-family lots should be incorporated in the final subdivision plans when submitted for review. This allows concurrent approval with the subdivision plan. Grading plans may also be submitted for review after approval and release of the subdivision plans. Site plans for townhouses must be included in the subdivision plan. No building permits will be issued until the subdivision plats have been recorded.

8-520.3 PLAN LEGEND

In order to simplify the review of lot grading plans and to insure that all items are easy to interpret, the following legend must be used:

------300------	: Existing Contour
____300____	: Proposed Contour
90.5	: Existing Spot Elevation
+90.5	: Proposed Spot Elevation
_____ _____	: Proposed Clearing Limit
____STB____	: Straw Bale Barrier
____DD____	: Diversion Dike
____SF____	: Silt Fence
o	: Yard Light

8-520.4 GRADING ALTERNATIVES

In the past, lot grading plans have been submitted in which several lots were graded so that they drained toward a general area of the rear yards, and the said drainage would then run in an open swale through the rear yard to some point where the swale was brought between two adjacent houses, then flowing over the sidewalk and into the street gutter to be subsequently intercepted by a curb inlet.

Few problems seem to arise with this method of routing stormwater if the volume of water so routed is relatively small. However, utilizing the side yards between houses as a route for a significant amount of surface water can create problems. Also, the discharge of such significant volumes of water at one point across the sidewalk is undesirable. Where the longitudinal grade of the street exceeds about 5% the water has a tendency to run downhill at or along the outer edge of the sidewalk rather than running directly into the street. This latter occurrence can create serious problems of erosion around and under sidewalks.

There are at least two general methods of avoiding such problems:

A. Install an adequate yard inlet (or yard inlets at intervals) in the mid-block drainage swale with the stormwater

being intercepted by the yard inlet and carried in an underground storm drainage pipe system between houses to connect with the storm sewer system in the street. If possible, this should be designed when the drainage plan is approved; otherwise, it would be necessary to revise the approved drainage plan to compensate for this occurrence, and if field construction of the streets has taken place, finished construction could be affected.

B. When water is collected in a mid-block drainage swale, the overlot grading should be designed such that it is frequently routed towards the street between houses so that only small amounts of water drain between one pair of adjacent houses, rather than bringing the entire volume of stormwater to the street between one adjacent pair of houses. This means, however, a solution may not always be adequate to prevent water so routed from running parallel with the steeper streets along the outer edge of the sidewalk, rather than running into the street.

Alternative A above would prevent this particular type of problem. In view of the foregoing, be advised as follows:

A. Lot grading plans for subdivision houses should all be designed so that if stormwater is collected in a mid-block swale along the rear yards and routed toward the street in an open swale running between two adjacent houses, the maximum allowable watershed area for such a surface swale passing between two adjacent houses shall be one (1.0) acre.

B. Statement A above is not to be construed to mean that surface swales discharging water toward the street between adjacent pairs of houses will automatically be approved so long as the watershed of each does not

exceed one (1) acre. Individual circumstances and other considerations such as the sidewalk erosion mentioned above, may lead to further requirements or detail in a particular case.

The storm drainage system plans for pipes, inlets, etc. (which are approved as a part of the street construction plans) are based upon a storm drainage map showing the areas contributing to flow at various inlets. Overlot grading plans should delineate the drainage divide lines to insure the originally approved drainage map is followed, or notation should be made on the plan that it conforms to the approved overall drainage plan.

8-520.5 DESIGNS FOR LOT GRADINGS

Designs for lot grading, and the siting and elevation of houses, should provide for protection of the house against flooding from storms exceeding the capacity of the normal design storm for which the pipe system is sized. Consideration of this factor will also provide protection against occasional blockage of pipes. Houses should not be sited in areas of depressed grading where overland relief flow out of the depressed area could only take place when ponded water reached an elevation higher than that of the first floor elevation of the house. Yard inlet(s) in any such depression is required, but not sufficient by itself since it can be blocked or its capacity exceeded by a storm exceeding the ten (10) year design storm.

The same requirement applies to houses located adjacent to street sags where, in the event of a storm greater than the design ten (10) year storm, water would tend to flood out the street and flow overland.

Where overlot grading and house location plans do not appear to meet this requirement, the Department of Public Works will require that hydraulic calculations be submitted proving the adequacy of the proposed plan to thus dispose of the design flood.

8-520.6 FHA CRITERIA

Where FHA lot grading criteria are mandatory but in conflict with the provisions of this Manual, the more restrictive criteria will be required.

8-520.7 FLOOD ELEVATIONS

Where design flood elevations have been established for larger streams adjacent to lots by flood plain studies, the entire grading lot and building pad shall be sited above the established flood elevation.

Further, such flood plain studies are based upon certain cross-sectional areas of flow in the flood waterway. Filling allowed in conjunction with overlot grading of any part of this waterway restricts the flow and raises the flood water surface. Therefore, if any such filling not accounted for in the flood plain study is proposed, it shall be accomplished by submittal of a suitable revised plan verifying conformance to applicable standards and a flood plain study to show the effect of the reduction in waterway area.

8-520.8 DESIGN OF TOWNHOUSE PROJECTS

Yard inlets and drainage swales are not acceptable within townhouse yards. All swales and yard inlets shall be place in unobstructed easements with ample access for maintenance.

Open channels for conveyances of storm drainage will not be considered in townhouse communities.

SECTION 8-600 FLOOD PLAIN POLICY

8-610 GENERAL REQUIREMENTS

Whenever the balance established by nature between a watershed and its naturally stabilized drainageways is disturbed by development of the watershed or modifications of the drainageways, some corrective measures must be taken to restore the balance and to avoid downstream flooding and damage. The need for corrective measures does not pre-empt any requirements established elsewhere in this Manual.

Therefore, it is recognized that some modifications may be made within flood plains, stream and/or drainageways in such a manner that the increased runoff from changes or modifications within the watershed may be accommodated. This shall be done without an unacceptable elevated flood plain or stream levels particularly within modified or developed areas. This may take the form of stream bed clearing, removal of obstructions, reduction of constrictions, stabilization of stream bottom and/or banks or areas to eliminate or reduce erosion, widening, deepening or realigning of streams to provide the necessary hydraulic characteristics to accommodate the anticipated stormwater flow without damaging adjacent properties. These modifications should include the removal of silt and debris which may clog or damage downstream drainage structures or property and the filling of drainage ponding areas and stagnant pools which are potential vermin shelters and mosquito breeding areas.

Flood plain studies will be required whenever the drainage area is greater than one hundred (100) acres.

Flood plain studies may be required with a drainage area greater than forty (40) acres if there are lots proposed adjacent to the stream or if the development is located in a high density area.

In such cases where the flood plain study is not required, a building restriction line may be shown on the plan, coinciding as a minimum, with the contour which is ten (10) feet above the flow line of the stream.

Minor flood plain studies may only be required with a drainage area less than forty (40) acres if there are lots proposed adjacent to the stream on which the proposed building site is less than ten (10) feet above the flow line of the stream. In lieu of a flood plain study, a building restriction line may be shown on the plan coinciding, as a minimum, with the contour which is ten (10) feet above the flow line of the stream. In addition to determining the one hundred (100) year flood plain, the Director of Public Works may require calculation of a floodway.

The area as established above shall be identified as a flood hazard area.

8-620 STUDY CRITERIA AND PLAN REQUIREMENTS

The items below provide a general guide as to the criteria to be used in the preparation of flood plain studies, and the information that should be provided on the plans and reports with the first site plan submission.

A. Friction coefficient - "n" factor both on-site and off-site shall be computed using the approved form (Exhibit 15 in Appendix A). Photographs of the stream, taken at appropriate cross-sections shall be submitted with the computations. The n factor must be approved prior to the submission of the flood plain study.

B. Drainage divides of contributing areas and their relation to the site in question at a maximum scale of one (1) inch equals one thousand (1,000) feet using the City topographic maps as a base.

C. The discharge (Q) and the Time of Concentration shall be determined from Section 8-200. Runoff curve numbers or coefficient of runoff shall be established based on development as shown on the latest Comprehensive (Land Use) Plan and consultation with the Department of Public Works.

D. Field or certified aerial run topography of the stream through the site, extending three hundred (300) feet up and downstream from the property lines or to a control section, if deemed necessary. Field run or certified aerial topography shall extend to cover the limits of the flood plain freeboard except in cases of abrupt change in the characteristics of the terrain. Additional topography may be required.

E. The field run cross-sections shall be perpendicular to the stream channel and/or flood plain and taken at all constrictions and other areas of change in the channel and/or flood plain.

F. Cross-sections shall be plotted at a scale of one (1) inch equals ten (10) feet vertically and one (1) inch equals fifty (50) feet horizontally. In cases of extremely flat terrain, a scale of one (1)

inch equals five (5) feet vertically and one (1) inch equals fifty (50) feet horizontally shall be used. The cross-sections shall show pre-developed and developed water surface elevations for the 100-year storms.

G. A profile of the stream bed indicating the elevation of water surface and invert of the stream every fifty (50) feet for the full length of the flood plain will be submitted with the cross-sections. The scale of the profile shall be one (1) inch equals five (5) feet vertically and one (1) inch equals fifty (50) feet horizontally. The profile shall show the 100-year water surface elevations for developed conditions.

H. For streams not identified in the Flood Insurance Study of Prince William County, provide 100-year discharge for pre-developed and developed conditions. The discharges shall be determined using the methodology stated in Section 8-210. The water surface elevations shall be computed using the methodology stated in Section 8-600 for minor flood plain studies, normal depth calculations, using Manning's equation, shall be accepted.

I. For streams identified in the Flood Insurance Study of Manassas City, the hydrologic and hydraulic analysis shall be prepared in conformance with the National Flood Insurance Program Regulations as stated in Parts 60, 65, 70 and 72 (Title 44) of the Code of Federal Regulations (CFR) as applicable. In addition, 100-year discharges and water-surface elevations for developed conditions shall be submitted for review.

J. A written description of the methodology used to determine hydrologic and/or hydraulic parameters.

K. Delineation of the 100-year flood boundaries predeveloped and developed conditions and floodway if required, and the location and alignment of cross-sections used in the hydraulic model.

1. This information should be shown on maps of suitable scale and topographic definition to provide reasonable accuracy.
2. All items should be labeled for easy cross-referencing to the hydrologic and hydraulic models and summary tables.
3. All lots and structures adjacent to the flood plain should be shown.

A. Source data, engineering documentation, and back-up data, for the previously mentioned items, as well as a reference list of other sources of information used.

B. The flood plain easements shall be placed on all plats and plans for the site. Flood plain easements shall coincide with the 100-year flood boundaries for developed conditions. A mathematical tie between the flood plain easement line and the lot property lines shall be required on the plats. Also, the plats are required to have the metes and bounds of the easements. The following note shall be clearly shown: "No use shall be made of, nor shall any improvements be made in the flood plain easement without specific authorization from the Department of Public Works."

C. Three (3) copies of the complete flood plain study and back-up data shall be submitted for review.

D. As-Built Plans. Once the flood plain modifications are completed, the flood plain study shall be resubmitted and shall include construction plans for as-built conditions, if applicable. This as-built package is required as per part 65.6 (C), Title 44, CFR, and will be submitted to FEMA to obtain a revision of the flood maps.

8-620.1 DETERMINATION OF FLOODWAY AND LIMITS OF THE REGULATORY FLOOD

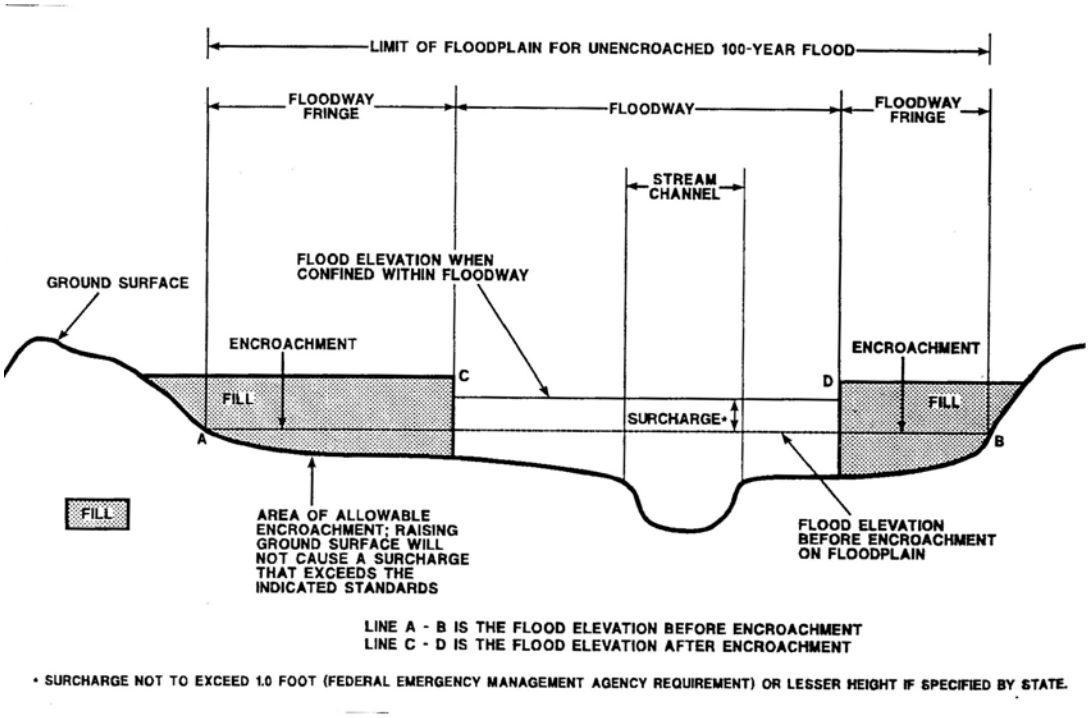
Calculation of water surface elevations and flood protection elevations shall be based upon a hydraulic analysis of the capacity of the stream channel and overbank areas to convey the regulatory flood (i.e., 100-year predeveloped flood). The Director of Public Works may allow use of the information for streams studied in detail in the Flood Insurance Study if it is determined to be an accurate representation of current flooding conditions.

Computation of the floodway required to convey the regulatory flood without increasing flood heights more than one (1) foot at any point must be furnished as part of any flood plain study. The actual floodway as shown on the floodway schematic shall not be filled or encroached unless it can be demonstrated that there is no increase in the 100-year flood elevation.

The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot any point.

Computation of increases in flood heights caused by an encroachment shall be based upon equal conveyance reduction on both sides of the watercourse within that reach. The Director of Public Works may allow use of the floodway delineation for streams studied in detail in the Flood Insurance Study if it is determined to be an accurate representation of current conditions.

FLOODWAY SCHEMATIC



8-620.2 BASIS FOR APPROVAL OF FLOOD PLAIN STUDIES

The procedure described herein is the method that will be used by the Department of Public Works in reviewing the computations for establishment of water surface elevations and balance of energy of flowing streams and their flood plains.

A. The examination of the topography of the flood plain area for the location of major constrictions, sharp changes of slope, or where the cross-section becomes narrow relative to the width of the channel.

B. Review of the plotted cross-sections of the stream.

C. The water surface profiles for the 100-year discharges shall be reviewed using a standard form (Appendix A). The following is a description of the variables used in Exhibit 14:

A = Cross-sectional area included below the assumed water level.

WP = Wetter perimeter per foot length of channel.

R = Hydraulic radius of cross-section which is equal to area in square feet divided by the wetted perimeter in feet.

n = Value of friction coefficient appropriate for the flood plain. (This value to be approved by the Director of Public Works.

C = Friction coefficient determined $\frac{1.49\,(R)^{1/6}}{n}$

Q = Design flow cubic feet per second.

V = Design flow divided by the area of the cross- section. V=Q/A

he = Computed velocity head at cross-setions.

L = Distance between cross-sections.

S = Slope of water surface.

Let “A” denote the downstream cross-section and Let “B” denote the upstream cross-section.

S(avg) = Average slope determined by averaging the value of S determined at previous cross-section.

hf = Friction loss determined from change of slope in water surface for any given condition.

$$SA = \frac{(VA)2}{C} \times \frac{(1)}{RA}$$

$$SB = \frac{(VB)2}{C} \times \frac{(1)}{RB}$$

$$hf = \frac{(SA + SB)}{2} L$$

ht = Other head loses.

Retarded flow = 0.2 (diff. in velocity head)

Accelerated flow = 0.1 (diff. in velocity head)

The mathematical expression for balance of energy follows the familiar hydraulic principles and takes the following form:

Water Level Elev. @ A + (VA) 2 + hf + ht = 2g

Water Level Elev. @ B + (VB) 2 = 2g

A reasonably close balance shall be obtained between the sections under consideration for energy balance.

In addition, the Director of Public Works shall also accept the use of the U.S. Army Corps of Engineers' HEC-2 Water Surface Profiles program.

-SCS's WSP2, Water Surface Profiles program.

D. Comparisons of determined values with any available gauge data, U.S.G.S. regional equations, or any existing reports by Federal, state, or local agencies shall be performed.

E. The hydrologic models shall be checked in the following areas:

1. Model representation of the watershed (schematic).
2. Tabular data for cross-sections and structures.
3. Precipitation data.
4. Drainage Areas.
5. Runoff Curve Numbers.
6. Times of Concentration.
7. Reservoir and channel routing parameters.
8. Miscellaneous items (assumptions, back-up data, other input parameters, etc.).

F. The hydraulic models shall be checked in the following areas:

1. Length of study and relationship with other cases.
2. Discharges check.
3. Starting water surface elevations.
4. Manning's "n" values and contraction and expansion coefficients.
5. Cross-section spacing and accuracy.
6. Bridge modeling.
7. Floodway computations, if applicable.
8. Miscellaneous Items (assumptions, critical depths, etc.).

G. The representation of the hydrologic and hydraulic analyses on the plans and profiles shall be thoroughly checked.

8-630 ENGINEERING GUIDELINES FOR DEVELOPMENT IN THE FLOOD PLAIN

In Residential Planned Communities and cluster developments, no individual lot or part thereof shall be platted within the one hundred (100) year flood plain.

In all other zones, with minimum lot area requirements, lots may be platted within the one hundred (100) year flood plain as long as the minimum lot area required by the particular zone is located outside the limits of the one hundred (100) year flood plain.

8-630.1 EFFECTS OF FILLS

Any filling within the one hundred (100) year flood plain of the original stream will frequently create an obstruction that will cause higher water levels upstream during flood flows. Such filling in flood plains is not usually allowed but in such cases as road crossings, SWM facilities, filling may be unavoidable. In such an event, hydrologic analyses shall be prepared and backwater curves should be carefully calculated based on the presence of the fill or other obstruction. Included shall be a comparison of the flood level at the upstream and downstream property line for pre-developed and developed conditions. Refer to Section 8-640.1 for other Flood Damage Control Standards.

8-630.2 DESIGN AND CONSTRUCTION OF DAMS

Any proposals for the construction of dams to form dry and wet ponds or lakes shall be fully supported by detailed engineering plans and calculations and shall generally include the following:

A. Inflow and outflow hydrographs for the 2-year, 10-year, and 100-year floods, and principal spillway hydrograph, emergency spillway, and freeboard hydrograph.

B. Design calculations and details for the principal spillway, emergency spillway, and outlet works.

C. Depth (elevation) versus volume of storage curve and depth (elevation) versus outflow curve. All formulas and

assumptions used to develop these curves shall be included.

D. Emergency spillway design calculations for ponds with storage in excess of two (2) acre-feet shall include a free board safety factor in accordance with practices set forth in the National Engineering Handbook, Chapter 4, of the SCS.

E. Embankment design computations, including seepage control, slope protection, freeboard calculations, and stability analysis.

F. Calculations or effects (if any) on established flood plain boundaries.

G. Description of the operation and maintenance plan for the facility, including an inspection schedule. The maintenance plan shall also include sediment deposition computations.

H. A dam break analysis shall be required for wet ponds with a dam height of fifteen (15) feet or greater and an impoundment capacity of twenty-five (25) acre-feet or greater.

I. Water quality impact assessment as may be required.

For any impoundment the design procedures, manuals, and criteria used by the United States Army Corps of Engineers, SCS, the Water and Power Resources Services (formerly the Bureau of Reclamation), the National Weather Service, and the Virginia Department of Conservation and Historic Resources may be used. In addition, other recognized design methods may be used with approval of the Department of Public Works.

Items to be considered in the design of dams should include, but are not limited to, the following:

A. Embankment:

Type of material, placement of material, compaction, permeability of material, settlement, vegetative cover, cross-section shape, stability, site geology, deformation and foundation contact conditions.

B. Seepage Considerations:
Placement of impervious material or zoning of embankment materials, foundation material, cut-off trench, drains and anti-seep collars, drainage blankets and internal drains, differential settlement, local ground water condition and foundation underseepage.

C. Riser and Culvert:
Materials, joint connections, trash control, clogging, anti-vortex device, structural strength and stability, flotation, lake drawdown device, and differential settlement.

D. Hydrology and Hydraulics:
Ultimate upstream land use, freeboard, erosive velocities, water surface fluctuation, storage capacity, spillway capacity, staff gauge, storm durations and distributions.

E. Downstream Area:
Existing development, existing zoning, ultimate land use, dam failure and analysis, and determination of inundated area with and without dam.

F. Maintenance:
Vehicular access, safety of dam and appurtenances.

G. Soils:
Soil structures and characteristics shall be investigated. Plans and data prepared by a professional engineer and subsurface investigations conducted by a professional geologist shall be submitted. These submissions should consider and offer design solutions for frost heave potential, shrink and/or swell potential, soil bearing

strength, water infiltration, soil settling characteristics, fill and backfilling procedures and soil treatment techniques as required to protect the improvements or structures.

8-630.3 TREES

Consistent with Section 3-310, trees which are dead or obviously dying will be removed during the construction phase. Any trees which would be adversely affected by construction activities so that they would die later, may be considered for removal and replacement.

8-630.4 SEDIMENTATION BASINS

In some locations, sedimentation basins or debris barriers may be situated in the watercourses for the control of silt or debris while upstream construction is taking place. The planning of these basins should include consideration of the necessity to remove these basins, and the trapped materials, when the construction process is completed. Planning must also consider the effects of these facilities on the surrounding environment. For instance, deposition of silt over the root system of trees over a period of time will kill these trees.

8-630.5 DEBRIS BASINS

Sedimentation basins are not normally acceptable as permanent facilities due to maintenance problems and the desirability over the long term of eliminating erosion rather than merely trapping a percentage of the eroded material. However, in particular instances there may be some merit to the installation of permanent debris barriers (designs may be found in BPR Publication Hydraulic Engineering Circular No. 9). The desirability of these will be assessed on an individual basis. Such permanent debris barriers, if approved, should be in a location accessible to heavy equipment and trucks and would primarily be for the purpose of trapping large debris such as dead tree limbs before such material could float downstream to block a culvert system. Location of such debris barriers should include consideration of flood water levels that could occur if the barrier had

trapped a considerable amount of such debris. A final step in the construction process should include the removal of any debris, rubbish, trash and waste construction material in a similar manner to that done for other portions of the development.

8-630.6 STABILIZATION OF WATERCOURSE

Once the adequate capacity of the watercourse has been established, the engineer should provide details of the work required to maintain a stable channel and flood plain, and to prevent erosion or other adverse affects which could place an extreme maintenance burden on future users of the area. All improvements and maintenance shall be as allowed. Every plan for areas containing a watercourse which is submitted to the City shall, in addition to the flood plain studies, be accompanied by a written report signed by a professional engineer and setting forth his study, conclusions, and recommendations regarding the following factors and any others that may be pertinent to particular conditions:

A. Pre-developed Watercourse Conditions: The originally existing conditions of the watercourse and flood plain area including such matters as probable velocities for the 2-year and 10-year storms under present watershed conditions (prior to development) particularly where no continuous channel improvements are proposed, the presence or absence of a meander pattern that may be shifting, areas of existing erosion processes, or where sedimentation is taking place, whether the watercourse appears to be perennial or merely wet weather, the material forming the bed of the natural channel (rock, cobbles, sediment and soil materials, etc.), the state of natural stability of banks and adjacent slopes, whether they are present within the flood plain abandoned or cut off former courses of the stream, natural levees, etc.

B. Effect of Developed Conditions on Existing Watercourse: For comparison, the velocity of the 2-year and 10-year flows, if the stream is left in an entirely natural condition, but after all of the watershed area has been completely developed according to the latest comprehensive plan, or in lieu of same according to reasonable estimates of future development (where no continuous channel improvements are planned). These comparative calculations are to serve as a guide in assessing the probable effect on the stream of increased water discharges.

C. Proposed Modifications: If the foregoing comparison, and other investigations made by the engineer, indicate that watershed environmental changes due to development will adversely affect the stream and probably create a heavy maintenance burden unless modifications are made to the channel, then a thorough discussion of proposed modifications necessary to eliminate undue maintenance shall be included. There are many factors involved in such modifications which are reasonably obvious including the use of concrete lining, rubble riprap lining, etc. Another aspect of possibly needed improvements could involve natural levees or abandoned portions of the old meander pattern. In certain areas these may form depressions with imperfect natural drainage which are swampy in times of heavy rainfall and could create mosquito complaints. In some cases, such areas may be somewhat removed from homes and sufficiently valuable as a natural environmental setting to remain.

D. Other Uses as Affected: Aside from the use of the areas as a channel in which to carry flood waters, other

proposed uses should also be covered in this report such as utility lines, road crossings, park and recreation areas and trails, etc., so that they may also be considered.

E. Detailed Hydraulic Considerations: Adequate measures shall be proposed to prevent erosion from any entering flows; i.e., pipes or streams. Channel changes or partial linings should take into consideration increased erosive forces at bends. Wave action in supercritical flow should be allowed for in linings. Riprap should be designed to withstand anticipated velocities. The effects of increased velocity on immediate downstream areas should be considered. Proposed channel changes which decrease velocity should be considered to determine if silt deposition will occur.

F. Effects on Downstream and Upstream Lands: The engineer's report shall include a discussion of the effects of increased runoff on developed downstream and upstream properties.

8-640 REQUIREMENTS FOR ACTIVITY IN FLOOD HAZARD AREAS

The data required under this Section and Section 8-750. shall be submitted to the Director of Public Works for technical evaluation and approval before a permit for any activity in a Flood Hazard Area can be issued.

A. Plans in triplicate, drawn to scale, showing the nature, location, dimensions and elevation of the lots, existing or proposed structures, fill, storage of materials, streets, water supply and sanitary facilities, flood proofing measures and the relationship of the above to the location of the channel.

B. A flood plain study as described in Section 8-600, if required, or the file number of the approved flood plain study.

C. Persons wishing to construct or repair bridges, culverts, embankments, channelizations, dams, reservoirs, and small ponds must obtain any necessary permits or certificates from the Federal or State agencies regulating these type of activities in the City's waterways. Any permits or certificates obtained from Federal or State agencies do not obviate the need to submit the required information and plans to the City and for review and approval of this information and plans.

The agencies that are often involved with, or regulate, construction on waterways are:

1. The U.S. Army Corps of Engineers
2. The Federal Emergency Management Agency
3. The Virginia Marine Resources Commission
4. The Division of Soil and Water Conservation of the Virginia Department of Conservation and Historic Resources
5. The SWCB.

Copies of correspondence with these agencies regarding the project shall be provided.

8-640.1 FLOOD DAMAGE CONTROL STANDARDS

All development permitted in the flood hazard district shall, at a minimum, comply with the following standards except, that the Director of Public Works may impose more restrictive standards as are warranted:

A. Generally

1. The developer must provide factual information that any proposed structure, or substantial modifications, will not adversely affect the predeveloped 100-year flood level; that the lowest part of the lowest floor level (including basement)

of the proposed structure is located at least eighteen (18) inches above the 100-year water surface elevation for developed conditions and the minimum horizontal distance of fifteen (15) feet is provided between the 100-year water surface and the structure proper; and that adequate emergency access is available to the structure during periods of maximum flooding. (The fifteen (15) foot setback requirement may be waived for specially designed commercial structures.) The applicant must specify the 100-year water surface elevation(s) on the plan.

2. Nonresidential structures, or parts thereof, may be constructed below the 100-year water surface elevation for developed conditions, provided these structures are designed to preclude or withstand inundation to an elevation of at least eighteen (18) inches above the 100-year water surface elevation and provided that they shall not cause an increase in flood levels during the one hundred (100) year storm event.
3. No uses shall be permitted in the flood plains, including fills and landfills, unless the applicant has demonstrated that the proposed uses, in combination with all other existing and reasonably anticipated uses, will not raise the water level of the predeveloped 100-year flood more than one-half (1/2) foot at any point.
4. New utilities will be located and constructed to minimize or eliminate flood damage.
5. Residential structures shall not be permitted within the floodways. Residential structures may not be constructed within flood plain areas unless it can be demonstrated that these structures or the filling associated with these structures do not cause an increase in the 100-year flood levels. The lowest floor elevation, including the basement,

for such structures shall be, a minimum of eighteen (18) inches above the regulatory flood level.

B. Fill

1. The fill must be sloped to provide positive drainage away from any building or structure and shall extend fifteen (15) feet beyond the limits of such building or structure to a point which is no lower than the regulatory flood elevation for the particular area.
2. All fill shall consist of soil or small rock materials only. Sanitary landfills shall be prohibited. The fill materials shall be compacted to provide the necessary permeability and resistance to erosion or scouring.
3. Fill slopes shall be no steeper than one (1) vertical unit to (3) three horizontal units, unless substantiating data justifying steeper slopes are submitted to and approved by the Director of Public Works.
4. The toe of fill shall not be within the designated floodway.
5. Compensatory excavation normally will be required for fills in the flood plain, unless waived for environmental reasons.

C. Placement of Building and Structures

1. All buildings and structures shall be designed, constructed and placed on the lot so as to offer the minimum obstruction to the flow of water.
2. The following shall not be placed or caused to be placed in the floodway: fences, except two-wire fences, other structures or other matter which may impede, retard to change the direction of the flow of water, or that will catch or collect debris carried by such water, or that is placed where the natural flow of the stream flood waters would carry the same downstream to the damage or detriment of either public or private property adjacent to the floodway areas.

D. Location of Access Roads:

1. The developer must provide factual information that any proposed development will not adversely affect the existing 100-year water surface elevation. The developer also must provide emergency access to the development during the 100-year flood.
2. In any case, where a road which provides access to a development or subdivision is inundated by the 100-year flood, along a stream included in the Federal Emergency Management Agency (FEMA) flood plain or otherwise; or is inundated by more than six inches for the 100-year overland relief for the storm drainage system, the Developer shall provide an access study. The study shall demonstrate the following.
    a. No dead end streets or isolated pockets are created.
    b. An alternate vehicular access route is available to bring emergency services to the opposite side of the road during flooded conditions at the point in question.
    c. The alternate vehicular access route must be along public streets or private streets only.
    d. The alternate vehicular route must be less than one (1) mile long.
    e. The alternate vehicular route must be above the 100-year flood elevation at all points.

E. Recreational vehicles placed on sites shall either: i) Be on the site for fewer than 180 consecutive days, be fully licensed and ready for highway use, or ii) Meet the permit requirements for placement and the elevation and anchoring requirements for manufactured homes in the Uniform Statewide Building Code. A recreational vehicle is defined as a vehicle which is:

1. built on a single chassis;

2. 400 square feet or less when measured at the largest horizontal projection;
3. designed to be self-propelled or permanently towable by a light duty truck; and
4. designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational camping, travel, or seasonal use. A recreational vehicle is ready for highway use if it is on wheels or jacking system, is attached to the site only by quick disconnect type utilities and security devices, and has no permanently attached additions.

F. Anchoring

1. All buildings or structures shall be firmly anchored to prevent movement or collapse from the action of the regulatory flood.
2. All air ducts, large pipes and storage tanks located at or below the regulatory flood elevation shall be firmly anchored to prevent flotation.
3. Minor Structures Anchored Against Flotation: Any minor structures which may be allowed within areas subject to major flooding (e.g., possible park structures, picnic tables, etc.) should be considered from the viewpoint of what will happen when a major flood occurs. Anchoring such structures will prevent them from being floated downstream to block a major culvert.

G. Floors: Wood flooring used below an elevation of eighteen (18) inches above the 100-year flood elevation shall be installed to accommodate a lateral expansion of the flooring, perpendicular to the flooring grain, without incurring structural damage to the building.

H. Electrical Systems:

1. All electrical water heaters, electric furnaces and other critical electrical installations shall be prohibited below an elevation of eighteen (18) inches above the regulatory flood elevation.
2. Electrical distribution panels shall be placed at least three (3) feet above the regulatory flood elevation. Separate electrical circuits serving areas below the regulatory flood elevation shall be dropped from above.

I. Plumbing and Other Mechanical Installations:

1. Water heaters, furnaces and other critical mechanical installations shall be prohibited below an elevation of eighteen (18) inches above the regulatory flood elevation.
2. All gas and oil supply systems shall be designed to preclude the infiltration of flood waters into the systems and discharges from the systems into flood waters. Additional provisions shall be made for the drainage of these systems in the even that flood water infiltration occurs.
3. No part of any on-site disposal system including drainfields shall be allowed within the 100-year flood plain.

J. Paints and Adhesives:

1. Adhesives used below an elevation of eighteen (18) inches above the regulatory flood elevation shall have a bonding strength that is unaffected by inundation.

K. Storage:

1. No materials that are buoyant, flammable, explosive or in times of flooding, could be injurious to human, animal or plant life shall be stored in the 100-year flood plain, unless they are properly anchored or flood proofed to preclude their causing damage to life or property.

L. Sanitary Sewers Designed for Flooding Conditions:

1. In considering the design of sanitary sewers through such areas (which are frequently subject to flooding) provisions should be made to prevent flood water infiltration into the sanitary sewerage system as would occur through ordinary vented manhole covers when placed at elevations below the flood surface. Further, aerial sewers passing across a stream on supports would be designed with consideration of possible erosive scour around pier footings, for the prevention of casual access by children to such utility installations; consideration should also be given to prevent creating a "picket fence" effect by using very closely placed piers which would act as a natural trap for debris.

8-640.2 NONCONFORMING USES OF STRUCTURES POLICY

A structure or the use of a structure or premises which was lawful before September 23, 1975, or the date of adoption of an applicable amendment to this article, but which is not in conformity with the provisions of this article, may be continued subject to the following conditions:

A. No structural alterations, additions or repairs of any nonconforming structure shall exceed 50% of its value at the time of its becoming a nonconforming use, unless the structure is permanently changed to a conforming use.

B. If such a use is discontinued for twelve (12) consecutive months, any future use of the building premises shall conform to this article.

C. If any nonconforming use of structure is destroyed by any means, including floods, to an extent of 50% or more of its value, it shall not be reconstructed, except in conformity with the provisions of this article. The Director of Public Works may permit reconstruction, if the use of structure is located outside

the floodway, and upon reconstruction, is adequately and safely flood proofed, elevated or otherwise protected.

8-640.3 CONFLICTING PROVISIONS POLICY

Whenever any provisions of this section impose a greater requirement or a higher standard than is required in any State or Federal regulation or other provision of this Manual, or other City ordinance or regulation, the provisions of this section shall govern. Whenever any provisions of any State or Federal statute or other provision of this Manual or other City ordinance or regulation impose a greater requirement or a higher standard than is required by this section, the provisions of the State or Federal statue or other provisions of this Manual or other City ordinance or regulation shall govern.

8-640.4 WARNING CONCERNING AREAS OUTSIDE FLOOD HAZARD DISTRICT AND DISCLAIMER OF LIABILITY

The degree of flood protection required by this article is considered reasonable for regulatory purposes. Larger floods may occur on rare occasions, or flood heights may be increased by man-made or natural causes, such as bridge openings restricted by debris. This article does not imply that areas outside the 100-year flood plain or land uses permitted within such districts will be free from flooding or flood damages. Additionally, the grant of a permit or approval of a site, subdivision or land development plan in an identified flood hazard area shall not constitute a representation, guarantee or warranty of any kind by any official or employee of the City of the practicability or safety of the proposed use and shall create no liability upon the City, its officials or employees.

8-640.5 PROCESSING OF SUBDIVISIONS AND DEVELOPMENT PLANS WITHIN OR IMMEDIATELY ADJACENT TO FLOOD HAZARD DISTRICT

If a subdivision or development plan proposes to modify the ground surface, the channel alignment, or proposes construction within the F-1 Zoning District or within the FHD Zoning Overlay, the following processing procedure shall apply:

A. Preliminary flood plain study and F-1 rezoning application or FHD overlay alteration application submitted for City review.
   1. Application is routed to the appropriate individuals to rezone from F-1 or FHD to another zoning designation.
   2. The application for F-1 rezoning or FHD alteration will be accepted only with the preliminary flood plain study.
   3. General plans of how the site will be removed from the flood plain.
   4. Director review and comments; study not included on Plan Review Schedule.
   5. After review and resubmission, if necessary, preliminary flood plain study may be approved by the City.

B. Preliminary flood plain study submitted for FEMA review.
   1. Applicant preparation of a preliminary flood plain study package for submission to the City, City transmittal to FEMA for review with City endorsement.
   2. FEMA notification to the City of approval by letter authorizing a FEMA "Conditional Map Amendment".
   3. Copy of FEMA notification transmitted to applicant.

C. Construction drawings submitted for City review.
   1. Preparation of construction drawings indicating how the site will be removed from the flood plain.

2. Director evaluation of construction drawings; drawings included on Plan Review Schedule.
3. Construction drawings approved; improvements bonded.

D. Rezoning application approved by Zoning Administration and City Council.
1. The rezoning will not be approved until the flood plain improvements are approved, bonded and constructed.

E. Development plan application submitted for City review.
1. Rezoning application must be approved; as-built construction drawings/final flood plain study included as part of the development plan application.
2. Director evaluation and endorsement of the final flood plain study. Thereafter the final flood plain study is routed to FEMA for review and approval with the City's approval.
3. FEMA notification to the City of approval by letter of an official "Map Amendment".

F. Development plan approved by the Public Works Department.
1. Development plan not approved until FEMA approval of a final flood plain study and issuance of "Map Amendments".

If a subdivision or development plan proposes to modify the ground surface, channel alignment, or proposes construction within or contiguous to the predeveloped 100-year water surface elevation of any natural water course, permanent or intermittent, then the following processing procedure will apply:

A. A preliminary flood plain study shall be submitted for City review with the preliminary plat or preliminary development plan.
1. The study must include a general plan showing how the site will be removed from the flood plain.
2. Roadways crossing the 100-year flood plain shall be processed using the Zoning Ordinance.
3. The study is included on the plan review schedule subsequent to review and comment by the Director.

4. After review and any necessary resubmission, the preliminary flood plain study may be approved by the City.
5. City approval of the preliminary plat or plan.

B. Construction drawings submitted with final plat or final development plan for City review.

1. Construction drawings must indicate how the site will be removed from the flood plain and the relationship of the 100-year water surface to the proposed development.
2. Director evaluation and comment on the construction drawings; the drawings are included on the Plan Review Schedule.
3. Construction drawings are approved; the improvements are bonded.
4. City approval of the final plat or plan.

SECTION 8-700 BEST MANAGEMENT PRACTICES AND STORMWATER QUALITY

All development or redevelopment within the Chesapeake Bay Preservation Act Overlay District or within the Occoquan Reservoir Watershed shall incorporate water quality measures (Best Management Practices) designed to reduce the amount of water pollution generated thru nonpoint sources.

The SWCB and other agencies have developed manuals for BMP which set forth an economically feasible program to control nonpoint source pollution in State waters. Developers and engineers are encouraged to refer to these Manuals or to seek other better methods to achieve the same goal.

The most current edition of the "BMP Handbook for the Occoquan Watershed" prepared by the Northern Virginia Planning District Commission (NVPDC) shall be used in designing and reviewing BMP facilities.

8-700.1 POLLUTION LOADS

To provide for effective pollutant removal, required BMP volume shall be provided in facilities distributed properly within the site when required by the Director.

Pollutant Removal Rates for Dry Ponds

TABLE 1
Average Annual Pollutant Removal Rates
For Extended Detention Dry Ponds
(Source: NVPDC, November 1979)

Land Use	Sediment Percent	Phosphorus Percent	Total Nitrogen Percent
Large Lot Single Family (1/2 Acre +)(12 Percent Impervious)	88	33	21
Medium Density Single Family (Less than ½ Acre) 25 Percent Impervious)	89	40	35
High Rise Residential/Industrial (70 Percent Impervious)	93	43	23
Shopping Center (90 Percent Impervious)	94	47	24

Refer to Exhibit 33 in Appendix A which shows a profile of a typical extended detention dry pond.

8-700.2 METHODS TO ACHIEVE THE ABOVE GOALS

The following methods are considered acceptable:

A. Structural measures that store stormwater and rely upon solid settling processes to remove pollutants (minor modifications could practically convert a stormwater detention facility to a multipurpose facility satisfying both water quality and quantity needs). Extended detention ponds and wet ponds are examples of acceptable structural measures.

B. Volume control BMP like porous pavement, modular pavement, and infiltration pits or trenches (when the soil permeability allows it) are also encouraged for use.

C. Entering into a joint effort with other developers to provide appropriate multi-site facilities.

D. Entering into an agreement with the City, subject to prior approval by the Director of Public Works, which provides for a financial contribution for off-site SWM and BMP. Such contributions shall be held by the City and used only for SWM and BMP facilities within the major drainage basin within which the developer's project is located. The City itself may construct such facilities, or may use the contributions to reimburse developers who provide SWM facilities in excess of their own needs.

E. For a redevelopment site that is completely impervious as currently developed, restoring a minimum of 20% of the site to vegetated open space.

F. Preservation of existing or indigenous vegetation in conjunction with minimizing impervious cover.

1. In accordance with the C.B.P. Area Designation and Management Regulations (VR-173-02-01), the 100 foot buffer area is deemed to achieve a 75% reduction of sediments and a 40% reduction of nutrients. To achieve this effectiveness the method of flow over and through the buffer must be of a nature (generally sheet flow) that promotes sedimentation and nutrient uptake. A large drainage area resulting in high volumes or velocities flowing through a concentrated swale cannot be rationalized to have this effectiveness. Research has indicated that concentrated flows are not treated effectively in natural open spaces.
2. Large lot residential subdivisions (five (5) acre lots) are considered to meet this criteria.
3. For non-regional facilities, a one-for-one credit for those facilities serving off-site developed areas, which are not served by other BMP facilities, may be earned. These

credits may be used to compensate for uncontrolled on-site areas, provided the total area served by compensation does not exceed 30 percent of the total site.

8-710 DESIGN CRITERIA

Based on the rational method "C" factor, (refer to Section 8-120 of this Manual) determine the amount of BMP volume required per acre of the site from Exhibit 35 in Appendix A. BMP volumes may also be determined using percentages impervious pursuant to BMP handbook guidelines.

8-710.1 BMP VOLUME CRITERIA

Dry Ponds: Dry ponds may be considered BMP facilities when they provide a minimum of 50% of the BMP storage volume for the upstream drainage area.

Wet Ponds: Wet ponds may be considered BMP facilities if the normal pond volume is a minimum of three (3) times the required BMP volume, or storage is provided above the wet pool elevation.

When approved by the Director, one-third (1/3) of the volume stored at the permanent water surface may be used for BMP credit.

Open Area Credit. In areas not draining to a BMP facility, it is possible to receive BMP credit if the runoff is discharged by sheet flow over undeveloped, undisturbed open spaces.

Sediment Disposal. An on-site disposal area for pond sediment should be delineated on plans. It shall be sized to receive a minimum of two dredging cycles. The dredging cycle for extended detention dry ponds is once every five (5) to ten (10) years and for wet ponds, every fifteen (15) to twenty (20) years.

Extended detention dry ponds provide pollutant removal capability due to prolonged release periods (minimum forty (40) hours, maximum forty-eight (48) hours.)

Refer to Exhibit 33 in Appendix A, which shows a profile of a typical extended detention dry pond.

8-710.2 EXTENDED DETENTION BMP WET PONDS

Extended detention BMP wet ponds provide for a more efficient removal of pollutants due to the increased sediment settlement and by discharging the flow from below the water surface. Refer to Exhibit 34 in Appendix A, which shows the extended detention wet pond and riser configuration.

Soil permeability should be evaluated to determine the ability of the pond site to maintain a permanent pool of water.

Inadequate base flow can lead to nuisance situations such as unattractive vegetation and the development of mosquito breeding areas.

The use of aquatic plants located within a shallow portion of the pond is recommended to increase nutrient removal on a case by case basis.

If the soil at the pond site is too permeable to hold water, steps must be taken to reduce the seepage by sealing the floor of the pond.

Sealing may be done by using a clay blanket which contains a well graded mixture of soil containing at least 20% clay. The clay blanket must have a minimum thickness of twelve (12) inches and be spread uniformly in layers of six (6) to eight (8) inches. These layers are to be compacted under optimum moisture conditions using a sheepsfoot roller.

The use of man-made plastic pond lining may be allowed with prior approval of the Director. In such cases, details shall be made as part of the submission describing the exact type of liner.

For additional design criteria and examples of BMP facilities, refer to the BMP handbook for the Occoquan Watershed, Northern Virginia Planning District Commission, Annandale, Virginia, August 1987.

8-720 EXISTING BMP'S

For any redevelopment incorporating an existing BMP, the Engineer will also certify that the facility is in good working order and performing at the necessary level of service. Maintenance records may be necessary to verify that the facility has been operating correctly.

8-730 WAIVER OF BMP REQUIREMENTS

Any maintenance, alteration, use, or improvement to an existing structure which does not degrade the quality of surface water discharge, as determined by the Director of Public Works, may qualify for a waiver of the requirements of this subsection provided that it complies with all erosion and sediment control requirements of Article 4 of this Manual.

The Director of Public Works may also consider granting a waiver of BMP requirements for sites where the SWM requirements have been waived in accordance with Section 8-510.6 (A), (D), or (E).

8-740 FACILITIES NOT ALLOWED

Underground structures which detain flows and provide no in-ground percolation or have not been documented to reduce pollution loads are not allowed.

8-750 MAINTENANCE ACCEPTANCE OF STORM DRAINAGE AND SWM; BMP FACILITIES

All development that includes SWM/BMP facilities shall have a maintenance agreement to ensure its continued functioning. This agreement is to be recorded with the Plat for the property served by the facilities.

For owner maintained facilities, the maintenance agreement shall require the owner to provide for annual inspections to be performed by a professional engineer familiar with the design and operation of SWM/BMP facilities who shall provide a report addressing the matters set out in this section. The required cleaning, repairs, and reconstruction of the facilities should also be performed under the direction of registered professionals. The inspection report shall include the observations, measurements, or tests which were performed, and the schedule for repairs when needed. The

reports shall also include the inspector's qualifications. The certified reports shall be forwarded to the Department of Public Works before June 30 of each year. The Department of Public Works will review reports, and comment on the inspector's conclusions, and may perform inspections or maintenance as necessary. If the Department of Public Works requires additional maintenance, that maintenance shall be completed within thirty (30) days of such notification. If the Department of Public Works performs any maintenance, the owner may be responsible for all costs incurred resulting from the maintenance operation.

For City owned SWM/BMP facilities, the Department of Public Works will inspect and perform maintenance.

Easements shall be dedicated to public use during the land development process when the topography and the natural drainageways are altered. Drainage easements are required for the maintenance of storm sewer systems, open channels as defined by the Virginia Erosion and Sediment Control Handbook, improved drainageways of increased concentrated runoff and for SWM facilities where required by Section 8-500 of this Article. Access easements and driveways are necessary for emergency public access to maintain a drainageway or storm sewer system located on private property. Furthermore, drainage easements are intended to restrict private property owners from disturbing land contained in the easement in such a manner as to alter the drainageway to the detriment of neighbors upstream or downstream. Similarly, easements for underground pipes assure that no other permanent structures will be allowed therein.

In general, the City's drainage maintenance policy is to provide drainage maintenance services for drainage systems located in properly dedicated drainage easements in residential areas, which are approved, inspected and accepted by the City. In townhouse and condominium areas, only systems located in common areas, and not located in or under paved areas are accepted for maintenance. The property owners are required to provide normal, routine maintenance, such as grass mowing and removal of

small debris. Public maintenance responsibility will not be accepted for underground storage tanks/pipe systems or percolation trenches.

8-750.1 REGIONAL PONDS

For retention ponds (wet ponds) and dry ponds the City will accept ponds for public maintenance that are designed as regional ponds. All maintenance activities will be accepted to include mowing.

8-750.2 ACCEPTANCE OF EXISTING PONDS

Ponds constructed prior to November 1, 1995 will be maintained per the terms of the recorded maintenance agreement, covenants, record plat for the property or the approved site plan until such time as the owners/HOA requests in writing for the City to assume maintenance responsibilities. The maintenance responsibilities of the City will be as outlined in Section, 8-750.3, 8-750.4, and 8-750.5 of this Article.

In the event there is no HOA or pond maintenance agreement on a stormwater management pond located on two (2) or more residential properties, the City will maintain the pond in accordance with the sections noted above upon written requests by the property owners and the granting of necessary easements.

Any existing pond must meet the following criteria to be accepted:

1. Facilities/systems in properly dedicated and accepted easements.
2. Facilities/systems with adequate access.
3. Facilities constructed in accordance to plans approved by the City and operating to these plans.

Additional items for consideration by the City will be:

4. The existence of an enclosed storm sewer that enters and exits the pond.
5. The acceptance will assist in the flood protection of public roads.

8-750.3 SINGLE FAMILY DWELLING AND DUPLEX SUBDIVISIONS

The Department of Public Works shall maintain the SWM or BMP facilities and the storm drainage systems to prevent a potential safety hazard, significant impediment to flow or danger of severe flooding or erosion. Existing ponds will be governed by the acceptance criteria outlined in Section 8-750.2. For planned ponds routine maintenance is to be performed by the owner of the property on which the easement is located. Drainage facilities located within the public street right-of-way are the responsibility of Public Works to maintain. The following note defining the maintenance responsibility shall be shown on the subdivision plats and plans: "The owner of any property on which there is located an easement for storm drainage, BMP or Stormwater Management purposes shall be responsible for the following items of maintenance, where applicable: Grass mowing with reasonable frequency, and the removal of debris and other matter to the best of the owner's ability where such debris or matter has impeded, or threatens to impede, the free flow of stormwater. The owner's responsibility shall include notification of the City of Manassas Department of Public Works of (1) any defects with the structures, pipes, if applicable, and fencing within the easement; (2) any debris or other matter which is beyond the owner's ability to remove and (3) any excessive flooding, sedimentation or soil erosion within the area of the easement." Correction of these deficiencies within properly dedicated and accepted easements outside of the dedicated right-of-way of streets will be performed by the City if there is a safety hazard, significant impediment to flow of water or danger of severe flooding or erosion.

8-750.4 TOWNHOUSE AND CONDOMINIUM DEVELOPMENTS

The Department of Public Works shall assume major maintenance responsibility of the stormwater management or BMP facilities and/or of the storm drainage systems in townhouse/condominium developments for all planned ponds. Existing ponds will be governed by the acceptance criteria outlined in Section 8-750.2.

Major maintenance items which shall be performed with reasonable frequency will include correction of deficiencies to prevent a potential safety hazard, significant impediment to flow of water or danger of severe flooding, sedimentation and/or soil erosion. Other minor maintenance should be performed by the Homeowners' Association (or the property manager, where applicable). If the conditions outlined above are not met, then the storm drainage facilities and systems shall be maintained by the Homeowners' Association (or the property manager where applicable). In this case the note on the plat and plans shall be as follows: "The Homeowners' Association (or the property manager where applicable) of this development shall assume the total maintenance responsibility of the storm drainage system and/or the stormwater management or BMP facility located there in and contained in an easement properly dedicated to public use. If all of the five (5) conditions as outlined above are met, the maintenance responsibilities shall be shared by the Homeowners' Association (or the property manager, where applicable), the Department of Public Works, and the property owner who dedicated the easement in the event there is no Homeowners' Association. In this case the note on the plat and plans shall be as follows: "The Homeowners' Association (or the property manager, where applicable) of this development shall assume the total maintenance responsibility of the storm drainage systems located in

and under paved areas (i.e., parking lots, driveways, roads, sidewalks, and related facilities). The City of Manassas Department of Public Works shall only assume the major maintenance responsibility of the stormwater management or BMP facilities and of the storm drainage systems located entirely within open, common spaces, with an adequate access, and not in or under paved areas (i.e., areas located outside the parking lots, driveways, roads, sidewalks and related facilities,) and contained in an easement properly dedicated to public use."

The property owner who dedicates an easement for storm drainage, BMP, or stormwater management purposes shall be responsible for the following items where applicable:

A. Grass mowing with reasonable frequency and the removal of debris and other matter to the best of owner's ability where such debris or matter has impeded or threatens to impede the free flow of stormwater through any drainage structure.

B. Notifying the City of Manassas Department of Public Works of:
   1. Any defect in the fencing within the dedicated easement,
   2. Any debris or other matter which is beyond his ability to remove, and
   3. Any excessive flooding, sedimentation or soil erosion within the area of the dedicated easement."

Refer to Exhibit 33 in Appendix A, which shows a profile of a typical extended detention dry pond.

8-750.5 OFFICES, SHOPPING CENTERS, RENTAL MULTIFAMILY DWELLINGS, MOBILE HOME PARKS, COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL DEVELOPMENT

Maintenance of storm drainage systems and SWM or BMP facilities located in commercial, office, industrial, rental multifamily

dwellings, mobile home parks or similar developments shall be the responsibility of the property owner.

The following note shall be added to the plat and plans: "The owner of the fee title to the property on which an easement is shown for storm drainage, BMP or Stormwater Management purposes shall be responsible for maintenance of the storm drainage and Stormwater Management facilities located therein."

8-750.6 SUMMARY OF MAINTENANCE RESPONSIBILITIES FOR PONDS ACCEPTED BY THE CITY

Maintenance Of:					
Type of Use	**Aesthetics**	**Routine Maintenance (Mowing, etc.)**	**Major Drainage Items**	**Owner of Facility**	**Easement to City**
Single Family Detached	**Property Owner**	**Property Owner**	**City**	**Property Owner or HOA**	**Yes**
Attached Multi-Family	**Property Owner or HOA**	**Property Owner**	**City**	**Property Owner or HOA**	**Yes**
Commercial Industrial Institu.*	**Property Owner**	**Property Owner**	**Property Owner**	**Property Owner**	**Yes**
All Regional Facilities	**City**	**City**	**City**	**City**	**N/A**

**Ponds not accepted by City*

8-750.7PROVISIONS

The maintenance impact of stormwater management facilities is considered to be a primary concern to the City of Manassas and to the future operation of these facilities.

Engineers in the preparation of plans for construction shall include maintenance and operation of these facilities as one of the primary design considerations.

The following shall be included in the design of detention facilities:

A. Access-ways shall be designated on plans and cleared, graded, and constructed along with facility. These access-ways shall be a minimum of twelve (12) feet in width.

B. Proximity of facilities to public right-of-way shall be determined in order to minimize the length of required access-way.

C. Access shall be provided such that all portions of a facility are accessible.

D. Standard drainage easement agreements are not acceptable for access; therefore, special access easement agreements are to be executed which shall preclude planting of shrubs, construction of fences and other structures within the easement.

E. Grading of access ways to facilities and grading around facilities shall leave slopes which do not exceed eight% to allow for access by maintenance vehicles.

F. Major facilities including wet ponds, underground chambers, etc,. shall be accessible with at least one all-weather access roadway to include a minimum of a 12-foot wide surface to the satisfaction of the Director.

G. As these facilities are generally in close proximity to dwellings and may be subject to vandalism, principal spillways and other devices shall be designed to minimize unauthorized entry or tampering.

H. Underground chambers shall provide for two (2) or more access points for ventilation and cleaning and be large enough to accommodate cleaning equipment. Generally, the access, where possible, shall be a minimum of twenty (24) inches in diameter to facilitate maintenance and conform to City standards for access.

8-760 SWM/BMP AGREEMENTS

BMP Systems: The Department of Public Works shall accept the maintenance responsibility for BMP Structural Devices when they are eligible

for maintenance acceptance under Sections 8-750.1 and 8-750.2 and properly designed to ensure adequate access for maintenance.

Prior to the issuance of permits, owners of developments that show proposed SWM facilities, which will not be maintained by the City, will be required to execute a SWM maintenance agreement *(See Exhibit 28 in Appendix A)*. This agreement is designed to give the City the authority to maintain or reconstruct any SWM facility, if necessary, and to assure its long term operational and functional effectiveness.

SECTION 8-800 STORMWATER MANAGEMENT FACILITIES

8-810 GENERAL CRITERIA

Detention facilities (wet and dry), except those which are underground, shall be designed utilizing both a primary spillway and a separate, independent emergency spillway. Combined spillways shall only be permitted when provision for release of the emergency flow with protection of the embankment is employed and only with approval of the Director. The design which utilizes a combined spillway, shall incorporate a secondary access route for the facility. The primary spillway shall be designed to detain up to the 10-year event and control less frequent events. The emergency spillway shall then be designed to accommodate the entire undetained flow determined with use of the chart, without reliance upon the primary spillway, using the computed 10-year water surface elevation as the emergency spillway crest elevation. Refer to Exhibit 36 in Appendix A.

Stormwater management facilities shall not be located on any single family attached or detached residential lot. However, lots may extend into a wet pond to the permanent pool elevation. All lots which are constructed in accordance with the above shall comply with the setbacks required for the 100-year flood plain.

8-820 DETENTION PONDS

A detention pond is a water impoundment made by constructing a dam or an embankment or by excavating a pit.

Ponds which are constructed by the first method are referred to as embankment ponds, and those constructed by the second method are excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds, if the depth of water impounded against the embankment at the crest of the emergency spillway elevation is three (3) feet or more.

This standard shall also be applied to stormwater management ponds which are normally dry, wet ponds which are constructed as a site amenity and ponds which provide dual function. Also see Section 8-870 of this Article.

General. The following practices apply where it is determined that stormwater management, water supply or temporary storage is justified and it is feasible and practical to build a pond to meet local and State Law requirements.

Site Conditions. Site conditions shall be such that runoff from the design-year storms can be safely passed through:

A. A natural or constructed emergency spillway; or

B. A combination of a principal spillway and an emergency spillway.

Drainage Area. The drainage area above the pond must be protected against erosion to the extent that expected sediment will not shorten the planned effective life of the structure. The drainage area for wet ponds should be a minimum of five (5) acres for each acre-foot of water. These requirements may be reduced if a dependable source of ground water or diverted surface water contributes to the pond. The water quality shall be suitable for its intended use.

Depth. For a wet or dry pond, the topography and soils of the site shall permit storage of water at a depth and volume which will ensure a dependable supply, considering beneficial use, sediment, season of use, and evaporation and seepage losses.

Foundation. For either wet or dry ponds, the area on which the dam is to be placed shall consist of material that has sufficient bearing strength to support the dam without excessive consolidation. The foundation must

consist of or be underlain by relatively impervious material, which will prevent excessive passage of water. Where such foundation conditions do not exist, the engineer responsible for the technical design will determine if the site is feasible for the construction of a dam by fill displacement or other suitable methods to satisfy the intended purpose.

Reservoir Area. Where surface runoff is the primary source of water for a wet pond, the soils shall be impervious enough to prevent excessive seepage losses, or shall be of such nature that sealing is practical.

8-830 EMBANKMENT PONDS

Embankment ponds shall conform to all of the following:

A. Failure of the dam will not result in loss of life, in damage to homes, commercial or industrial buildings, highways classified as through collectors or higher, railroads; or in interruption of the use or service of public utilities.

B. The product of the storage times the effective height of the dam is less than 2,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam.

C. For dams in urban areas, the effective height of the dam is twenty (20) feet or less and the dam is hazard class (a). Urban ponds with effective height of greater than twenty (20) feet are to be designed in accordance with the requirements of SCS Technical release No. 60. Dams of thirty-five (35) feet in height and greater are prohibited.

Structure Classification. All structures (dams) will be reviewed and classed according to factors and procedures outlined in 520.21 of Subchapter C, Subpart C - Dams, National Engineering Manual and supplemented herein. The class ("a", "b", and "c") as contained in this document is related to the damage that might result from a sudden major breach of the earth embankment. Structure classification and land use of runoff determination must take into consideration the anticipated changes in land use throughout

the expected life of the structure. The valley downstream, and the relationship of the site to industrial and residential areas all have a bearing on the amount of potential damage in the event of a failure. The classification of a dam is determined only by the potential hazard from failure, not by the criteria selected for design.

A. Classification factors in the National Engineering Manual

1. Class "a". Structures located in rural, agricultural, or urban areas dedicated to remain in flood tolerant usages where failure may damage non-resident buildings, agricultural land, flood plains, or City and County roads.
2. Class "b". Structures located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, or minor railroads or cause interruption of use or service of relatively important public utilities.
3. Class "c". Structures located where failure may cause loss of life, serious damage to homes, industrial, and commercial buildings, important public utilities, main highways, or railroads.

B. When structures are spaced so that the failure of an upper structure could endanger the safety of a lower structure, the possibility of a multiple failure must be considered in assigning the structure classification of the upstream structure. Additional safety can be provided in either structure by:
1. Increasing the retarding storage, and/or
2. Increasing the emergency spillway capacity.

C. The following types of embankment structures are prohibited in the City of Manassas.

1. Class "a" structures with a storage height product of 2,000 or greater, and/or an effective dam height of thirty-five (35) feet and greater.
2. Class "b" Structures.
3. Class "c" Structures.

8-830.1 IMPOUNDMENT LAWS

Federal criteria requires that dams, where the resulting impoundment is greater than fifty (50) acre-feet and whose depth exceeds twenty-five (25) feet must be certified by the State agency responsible for dam safety (The Department of Conservation and Historic Resources in Virginia).

This requirement excludes impoundments having a dam height less than six (6) feet regardless of storage or having less than fifteen (15) acre-feet of storage regardless of the height of the dam. Refer to Exhibit 36 in Appendix A.

8-830.2 APPROXIMATE METHOD FOR DETERMINING DANGER REACH LENGTH

This method is based on information contained in the Soil Conservation Service TSC - Technical Note - Engineering UD16, which was issued on July 3, 1969, and shall be performed for all embankment structures which have an embankment height exceeding fifteen (15) feet and or those which impound more than twenty-five (25) acre-feet of water.

This method is based on the following:

A. The dam is assumed to fail when the water depth is at the top of the dam.

B. The peak rate of the breached hydrograph is based on data supplied by the Bureau of Reclamation for actual dam failures.

C. The method is based upon a valley flood routing method taken from the Journal of the Proceedings of the ASCE,

Hydraulics Division, May 1964, "Hydrology of Spillway Design", by Franklin F. Snyder.

The graph, as shown in Exhibit 37 in Appendix A, has the width of the valley below the dam in feet versus the length of reach per acre-foot of storage behind the dam for a depth (above bank full stage) at the lower end equal to one (1) foot. Actual storage is to be calculated from the top of dam and the width of the valley would normally be the 100-year frequency storm flood plain.

Two examples of how to use this graph are as follows:

Example 1

A developer wishes to build a lake for stormwater management and recreation. It has been determined that the height of the dam will be ten (10) feet, and that there would be approximately eight (8) acre-feet of storage behind the dam. From visual observation, it is noted that there are some homes located on the flood plain 1,500 feet below the dam site. It has also been determined that the average width of the valley is 400 feet. An analysis must be made to determine if there would be a danger to these homes if the dam failed.

Using the above information, enter the left side of the graph with a valley width of 400 feet, move horizontally to the curve labeled H = ten (10) feet, go down vertically and read 160 feet at the bottom of the graph. This value is for one (1) acre-foot of storage. It is determined that there are eight (8) acre-feet of storage, so multiply 160 feet by eight (8) and obtain 1,280 feet. This is the distance below the dam where the depth of flow in the flood plain would be one (1) foot if the dam would fail.

Since the homes were located 1,500 feet downstream from the dam, this would indicate that there would be little, if any, damage to these homes as a result of a sudden breach of the dam. This would indicate that the dam would be a low hazard, and that Class "a" design criteria could be used in the

design of the dam if the flood plain is to remain in flood tolerant usage.

Example 2

Same as Example 1, except that the height of the dam is fifteen (15) feet. Entering the graph again with a valley width of 400 feet and going across to the curve labeled H = 15 feet and then going vertically down, the length of reach would be equal to 210 feet for one (1) acre-foot of storage for depth (lower) = one foot. Eight acre-feet of storage is necessary, therefore multiply 210 times eight and obtain 1,680 feet. This is the distance below the dam where the depth of flow in the flood plain would be one (1) foot if the dam would fail.

Since the homes were located 1,500 feet downstream from the dam, this would indicate that the depth of flow at the homes would be greater than one foot and would probably cause serious damage to these homes. This would indicate that the dam would be a higher hazard structure than Class "a" and would therefore be prohibited within the City of Manassas.

This is an approximate method and more detailed valley routings will give more precise answers. This method should not be used if there is not a uniform valley width, or if there is any downstream obstruction, such as a road fill, an undersized pipe, etc.

8-840 SELECTING THE STORMWATER MANAGEMENT POND SITE

The selection of a suitable stormwater management pond site should begin in the preliminary stage of the development, with a view of selecting the site that proves most practical and economical.

A pond with a normal pool planned as a site amenity may incorporate the required stormwater management function; or a stormwater management pond may, with modification, be utilized as a site amenity.

A wet pond utilized as a site amenity should be located at a site where the valley is narrow, side slopes are relatively steep, and the slope of the valley floor will permit a large deep basin. Such sites tend to minimize the area of shallow water is a permanent pool is being considered; however, they should be examined carefully for adverse geologic conditions. In urban and suburban areas, large areas of shallow water should be avoided due to excessive evaporation losses and the growth of aquatic plants.

Consideration must also be given to any legal requirements. The landowners are responsible for obtaining all necessary and required easements of rights to discharge.

As previously noted the pond should not be located where sudden release of the water, due to failure of the dam, would result in loss of life, injury to persons, damage to residences or industrial buildings, railroads or highways, or cause interruption of use or service of public utilities. A site which presents one (1) or more of these hazards is unsuitable and will not be approved.

A check should be made to ensure that no buried pipelines, cables, or other utilities exist in the construction area. Where such a site must be used, the utility owners should be contacted prior to foundation investigation and utility relocation out of the embankment and impoundment area will be the responsibility of the developer.

Engineering Surveys. Once the location of the pond or reservoir has been determined, sufficient engineering surveys shall be performed so that the information required for stormwater management pond design can be obtained.

8-840.1 GEOLOGIC INVESTIGATIONS

All designs for wet ponds shall have a geologic investigation performed. Analysis shall be performed for dry ponds which have an embankment height greater than fifteen (15) feet and/or those which impound more than twenty-five (25) acre-feet and/or those whose draw down time exceeds twenty-four (24) hours.

The requirements of a foundation for an earthfill dam are that it provide stable support for the embankment under all conditions of saturation and loading, and that it provide sufficient resistance to seepage to prevent excessive loss of water. Adverse foundation conditions can lead to failure of a dam due to cracking, piping, sliding, settlement or uplift.

The foundation conditions under the proposed dam sites shall be investigated to ensure that the site is suitable and that a safe structure can be designed. The extent of the foundation examination will depend on the complexity of the conditions encountered and on the height of the dam. The "Unified System of Soil Classification" shall be used in foundation investigations and these logs shall be accurately located and shown on the final design plans.

Borings should be taken or test pits excavated at intervals along the centerline of the dam. The depth and spacing of the borings or pits should be sufficient to determine the suitability of the foundation.

Borings should also be taken along the centerline of the principal spillway to ensure an adequate foundation for the pipe and riser.

If a permanent pool is being considered, adequate soils investigations will be needed in the proposed pool area to be assured that excessive seepage will not be a problem.

In most cases, it is necessary to bypass excess storm runoff around the embankment of a pond through an excavated spillway. For economic reasons, suitable material excavated from the spillway should be used in the earthfill. Therefore, soil borings should be made along the approximate centerline of the proposed spillway to determine the type of material that will be encountered, its erodibility, and its suitability for use in the embankment. If additional borrow material is needed, soil borings should be made in the selected borrow areas in order to estimate the kinds and amounts of suitable fill materials available.

Materials selected for construction of a dam must have sufficient strength for the dam to remain stable and provide sufficiently low permeability, when compacted, to prevent harmful seepage through the dam.

A record or log of each boring or test pit should be made showing the location depth and classes of materials encountered. The location of each boring should be marked on the ground, so it can be referenced to other or more detailed surveys.

All information developed during the design process should be recorded in the form of an engineering plan for the pond.

8-840.2 EARTH EMBANKMENT

Top Width. The minimum top width of the dam is shown below. When the embankment top is to be used as a maintenance access road, the minimum top width is to be the width of the proposed access road plus the top width as determined below.

Total Height of Embankment (Feet)	Minimum Top Width (Feet)
14 or less	8
15 – 19	10
20-24	12
25-34	14
35	

Side Slopes. The upstream and downstream side slopes of the settled embankment shall not be less than:

Fill Material	Slope Upstream	Slope Downstream
Clayey Sand, Clayey Gravel, Sandy clay, Silty Sand, Silty Gravel	3:1	2:1
Silty Clay, Clayey Silt	3:1	3:1

Wave Erosion Protection. Where needed to protect the face of the dam, special wave protection measures such as berms, riprap, sand-gravel, soil cement or special vegetation shall be provided. Refer to the Virginia Department of Transportation Drainage Manual.

Freeboard. The vertical interval between the elevation of the water surface in the reservoir with the emergency spillway flowing at design depth and the minimum elevation at the top of the settled embankment is the freeboard, and shall equal or exceed one (1) foot; in addition, the minimum difference in elevation between the crest of the emergency spillway and the settled top of dam shall be two (2) feet.

Allowance for Settlement. The design height of the dam shall be increased by the amount needed to ensure that the design top elevation will be maintained after all settlement has taken place. If a minimum required density is specified, the increase shall be five%.

Foundation Cutoff. A cutoff trench of relatively impervious material shall be provided under the dam and into the abutments, as required, and be deep enough to extend into a relatively impervious layer except:

A. In those cases where a layer of relatively impervious material thick enough to provide stability exists at the surface of the foundation; or

B. In those cases where a layer of such material does not exist at a reasonable depth.

The cutoff shall be located at or upstream from the centerline of the dam. Where such a layer does not exist at a reasonable depth, the engineer responsible for the technical design shall provide a geotechnical analysis, demonstrating that the site is feasible for the construction of a dam.

The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill and compaction operations, with the minimum width being four (4) feet, and

shall have side slopes no steeper than one (1) foot horizontal to one (1) foot vertical.

Seepage Control. Seepage control is to be included:

A. If pervious layers are not intercepted by the cutoff;

B. If seepage may create swamping downstream;

C. If needed to ensure a stable embankment; or

D. If special problems, such as fractured rock, etc., require drainage for a stable dam.

Seepage control may be accomplished by:

A. Foundation, abutment or embankment drains;

B. Reservoir blanketing; or

C. A combination of these measures.

Foundation drains are to be considered when the normal water depth in the pond is greater than fifteen (15) feet (measured from the low point at the centerline of the dam).

8-840.3 SPILLWAYS

Emergency spillways for all ponds will be designed to provide the required detention and to pass the full volume of the maximum probable flood (as defined in *Exhibit 36 in Appendix A)*.

Principal Spillways. A conduit, with needed appurtenances, shall be placed under or through the dam except where a weir type structure is used.

The principal spillway shall be designed to provide the detention required and control the release rate for those design-year events stipulated for each major water shed.

The crest elevation of the inlet or riser shall be at least one (1) foot below the crest elevation of the earth emergency spillway. The inlet or riser shall be sized to pass design-year flow without the reliance of the emergency spillway.

The inlet or riser size for pipe drops shall be such that the flow through the structure goes from weir-flow control to pipe-flow control without going into orifice-flow control in the riser. The inlets and outlets

shall be designed and analyzed to function satisfactorily for the full range of flow and hydraulic head anticipated. The riser shall be analyzed for flotation, using water at the principal spillway crest elevation, and assuming all orifices and pipes are plugged. The factor of safety against flotation shall be 1.2 or greater.

Size. The capacity of the pipe conduit shall be adequate to discharge long duration, continuous, or frequent flows without flowing through the emergency spillways. The diameter of the pipe shall not be less than twelve (12) inches.

Conduits under or through the dam shall be reinforced concrete. The conduits shall be capable of withstanding the external loading without yielding, buckling or cracking. Conduit strength shall not be less than Class III. The inlets and outlets shall be structurally sound and made from materials compatible with the pipe. All conduit joints are to be made watertight by the use of gaskets.

Excavation for Placement. Where excavation into existing or compacted ground is required in order to obtain the proper elevation for the conduit, this excavation shall be of sufficient width to accommodate the conduit, anti-seep collars, earth hauling and hand operated compaction equipment. The side slopes of the excavation shall not be steeper than one to one.

Multiple Conduits. Where multiple conduits are used, there shall be sufficient space between the conduits and the installed anti-seep collars to allow for backfill material to be placed between the conduits by the earth moving equipment and for easy access by hand operated compaction equipment. This distance between conduits shall be equal to or greater than the pipe diameter or width opening but not less than two (2) feet.

Anti-Seep Collars. Anti-seep collars shall be installed around all conduits through earth fills of all wet ponds and for all dry ponds whose draw down time exceed twenty-four (24) hours. Impoundment structures incorporating anti-seep collars shall use the design criteria in

the Virginia Erosion & Sediment Control Handbook, Latest Edition, and the following:

A. Sufficient collars shall be placed to increase the seepage length along the conduit by a minimum of 15% of the pipe length located within the saturation zone.

B. The assumed normal saturation zone shall be determined by projecting a line with a slope of four (4) horizontal to one (1) vertical from the point where the normal water elevation touches the upstream slope of the fill to a point where this line intersects the invert of the conduit. All fill located below this line may be assumed to be saturated.

C. For ponds that are normally dry, the starting elevation shall be the maximum water surface elevation in the pond when the principal spillway storm is routed through the structure.

D. Maximum collar spacing shall be fourteen (14) times the minimum projection of the collar measured perpendicular to the pipe.

E. Minimum collar spacing shall be five (5) times the minimum projection of the collar measured perpendicular to the pipe.

F. All anti-seep collars and their connections to the conduit shall be water tight. Antivortex Devices. Drop inlet spillways are to have adequate antivortex devices.

Safety Guardrails and Trash Racks. Trash racks shall have openings no larger than ¾ of the conduit diameter or width opening, but in no case less than six (6) inches in its smallest dimension. Racks and rails should be used when it is necessary to prevent clogging or when a safety hazard exists. Flat grates for trash racks are not acceptable, a three dimensional rack must be provided.

All ponds in urban areas shall be analyzed for safety. Low stage inlets on ponds that are normally dry shall have adequate trash racks. Velocity of water through the trash rack opening at design flows shall not exceed three feet per second.

Drain Pipe. A pipe with a suitable valve shall be provided to drain the pool area where needed for maintenance. The principal spillway conduit may be used as a pond drain when located so as to accomplish this function.

A narrative detailing how the pond is to be drained for maintenance and who is responsible shall accompany all plan submittals.

Emergency Spillways. A separate, independent emergency spillway shall be provided for each dam, the purpose of which is to provide for safe passage of the maximum probable flood (MPF) without damage to the embankment.

Capacity. The minimum capacity of emergency spillways shall be that required to pass the peak flow expected from the maximum probable floods (MPF). The routing shall start with the design water surface at the elevation of the crest of the principal spillway. Refer to Exhibit 36 in Appendix "A."

Emergency spillways are to provide for passage of the design flow at a non-erosive velocity to a point downstream where the dam will not be endangered.

Cross Section. Excavated earth spillways shall be trapezoidal and shall be located in undisturbed earth. The side slopes shall be stable for the material in which the spillway is to be constructed but not steeper than 2:1. For dams having effective heights exceeding 20 feet, the emergency spillway shall have a bottom width of not less than ten (10) feet.

When natural spillways are used, a dike shall be constructed from the end of the dam to prevent the flow from impinging on the toe of the dam. The dike shall have a freeboard of one (1) foot above design flow.

Permissible Velocities. Earth spillways shall be designed for non-erosive velocities through the control section and for a reasonable distance below the spillway. The maximum permissible velocity for the

grass or grass mixture to be used shall be selected from the following table:

PERMISSIBLE VELOCITY FOR VEGETATED SPILLWAYS [1]

VEGETATION	PERMISSABLE VELOCITY			
	Erosion-Resistant Soils [2] Slope of Exit Channel		Easily Eroded Soils [3] Slope of Exit Channel	
	pct 0-5 ft/s	pct 10-5 ft/s	pct 0-5 ft/s	pct 10-5 ft/s
Kentucky Bluegrass Smooth Brome Tall Fescue Reed Canarygrass	7	6	5	4
Sod-Forming Grass-Legume Mixes	5	4	4	3
Lespedeza Sericea Weeping Lovegrass Yellow Bluestem Native Grass Mixtures	3.5	3.5	2.5	2.5

[1] SCS-TP-61

[2] Those with a higher clay content and higher plasticity. Typical soil textures are silty clay, sandy clay, and clay.

[3] Those with a high content of fine sand or silt and lower plasticity, or non plastic. Typical soil textures are fine sand, silt, sandy loan, and silty loam

The capacity of the spillway shall be determined using vegetal retardants representing an unmowed condition. The maximum velocity shall be determined with a vegetal retardants representing a closely mowed condition.

Excavated earth spillways shall have an inlet channel, control section, and an exit channel. Upstream from the control section, the inlet channel shall be level for the minimum distance of twenty-five (25) feet and shall have side slopes equal to three (3) to one (1) or greater.

The flow shall enter the spillway through the inlet channel. The maximum depth of flow (Hp) located upstream from the level part shall be controlled by the inlet channel, level part, and exit channel. *Refer to Exhibit 17 in Appendix A.*

Excavation of the inlet channel or the exit channel, or both, may be omitted where the natural slopes meet the minimum slope requirements. The direction of slope of the exit channel must be such that discharge will not flow against any part of the dam. Wing dikes, sometimes called kicker levees or training levees, can be used to direct the outflow to a safe point of release. The spillway should be excavated into the earth for the full length and width of the spillway. *Refer to Exhibit 33 in Appendix A.*

If this is not practical the end of the dam and any earthfill constructed to confine the flow, shall be protected by vegetation or riprap. The entrance to the inlet channel should be widened so it is at least 50% greater than the bottom width of the level part. The inlet channel should be reasonably short and shall be planned with smooth, easy curves for alignment. It shall have a slope toward the reservoir of not less than 2% to ensure drainage.

The inlet channel may be curved to fit existing topography, but exit channels shall be straight for a minimum distance well beyond the downstream toe of the dam at the lowest point in the valley.

The grade of the exit channel of an excavated earth spillway shall fall within the range established by discharge requirements and permissible velocities. The exit channel shall terminate only where the design flow may be discharged without damage to the earth embankment.

With the required discharge capacity, the degree of retardance, permissible velocity, and the natural slope of the exit channel known, the bottom width of the level and exit sections and the depth of the flow (Hp) can be computed from the figure in *Exhibit 17 in Appendix A* which shows discharge per foot of width. The natural slope of the exit channel should be altered as little as possible.

Structural Emergency Spillways

Pipes, culverts, chutes or drops, when used for principal spillways or principal-emergency or emergency spillways, shall be

designed in accordance with the principles set forth in the Engineering Field Manual for Conservation Practices; National Engineering Handbook, Section 5 "Hydraulics"; Section 11, "Drop Spillways." The minimum capacity of a structural spillway shall be that required to pass the peak flow expected. The routing shall start with the water surface at the elevation of the design storm.

Structural emergency spillways may only be approved after an independent structural review of the design is completed by a structural engineer familiar with hydraulic structures, selected by the Director. All costs of this review shall be borne by the Developer.

8-850 EXCAVATED PONDS

General. Excavated ponds, with contributing watershed areas of more than ten (10) acres which create a failure hazard, shall be designed as embankment ponds. Excavated ponds, that are normally dry (SWM ponds) and include a pipe outlet control system, shall be designed using same the principal and emergency spillways design criteria as that for embankment ponds.

Side Slopes. Side slopes of excavated ponds shall be such that they will be stable and shall not be steeper than two (2) horizontal to one (1) vertical.

Inlet Protection. Where surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Placement of Excavated Material. The material excavated from the pond shall be placed in one of the following ways so that its weight will not endanger the stability of the pond side slopes and where it will not be washed back into the pond by rainfall. Refer to Exhibit 31 in Appendix A.

A. Uniformly spread to a height not exceeding three (3) feet with the top graded to a continuous slope away from the pond.

B. Uniformly placed or shaped reasonably well with side slopes no steeper than two (2) to one (1) for the excavated material

behind a berm width equal to the depth of the pond but not less than twelve (12) feet.

C. Shaped to a designed form that blends visually with the landscape.

D. Used for low embankment and leveling.

E. Hauled away.

8-860 WET PONDS

All wet ponds are considered an amenity and must be a part of the approved preliminary plan. In the event that physical, topographic, or other engineering constraints would make a previously approved wet pond impractical, the preliminary plan must be modified and reapproved by the Planning Commission so that the Director may approve a dry detention facility. Additionally, if it is determined that a previously approved preliminary plan with a dry pond is found to be not practical because of an unusual physical, topographic or other engineering constraints, a wet pond may be approved by the Director.

In addition, wet ponds shall conform to the following:

Excavation and shaping required to permit the reservoir area to suitably serve the planned purpose shall be included in the construction plans. Reservoirs constructed or created shall incorporate the following requirements:

A. All wet ponds shall have a drain pipe. A devise to take overflow from the bottom, rather than the top, is advisable but not required.

B. The minimum surface area should be one-half acre. A minimum of 80% of the shoreline shall be sloped such that the water depth is three (3) feet extending six (6) feet from the waters edge and shall have a minimum 6-foot depth over at least one-third of the surface area with a portion at least eight feet deep. *Refer to Exhibit 34 in Appendix A.*

8-870 VISUAL RESOURCE DESIGN -- WET AND DRY PONDS

Ponds in areas of high public visibility and those associated with recreation are to receive careful visual design. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material and plantings are to relate visually to their surroundings and to their function.

The embankment can be shaped to blend with the natural topography. The edge of the pond can be shaped so it is generally curvilinear, rather than rectangular. Excavated material can be shaped so the final form is smooth, flowing and fitting to the adjacent landscape, rather than angular geometric mounds. Where feasible, islands can be added for visual interest and wildlife value. Shrubs along one quarter of the shoreline to benefit other wildlife are permissible. Shoreline trees on ponds over three (3) acres are required.

Landscape Planning. A pond's apparent size is not always the same as its actual size. For example, the more sky reflected on the water surface, the larger a pond appears. A pond completely surrounded by trees will appear smaller than a pond the same size without trees or some shoreline trees. The shape of a pond should complement its surroundings. Irregular shapes with smooth, flowing shorelines generally are more compatible with the lines of countryside landscape. Peninsulas, inlets, or islands can be formed to create interest in the configuration of the water's edge. *Refer to Exhibit 21 in Appendix A.*

The pond should be located and designed to use the existing landform, vegetation, water, and structures with minimum disturbance. Landforms can often form the impoundment with minimum excavation. Openings in the vegetation can be used to avoid costly clearing and grubbing. Existing structures such as stone walls and trails can be retained to control pedestrian and vehicular traffic and minimize disruption of existing use. In the area where land and water meet, vegetation and landform can provide interesting reflections on the water's surface, guide attention to or from the water, frame the water to emphasize it, and direct passage around the pond.

In some situations a curved dam alignment is more desirable than a straight alignment. Curvature may be used to retain existing landscape elements, reduce the apparent size of the dam, blend the dam into surrounding natural landforms, and provide a natural-appearing shoreline.

Finish-grading techniques used to achieve a smooth landform transition include slope rounding at the top and bottom of cuts or fills and on side slope intersections, and slope warping to create variety in the horizontal and vertical pitch of finished slopes. Additional fill can be placed on the backslope and abutments of the dam, if needed, to achieve this landform transition. *Refer to Exhibit 29 in Appendix A.*

Density and height of vegetation can be increased progressively from the water's edge to the undisturbed vegetation. In this way the cleared area will look more natural. Feathering can be accomplished by selective clearing, installation of new plants, or both.

Ponds of rectangular shape shall not be used where the resulting straight lines would be in sharp contrast to surrounding landscape patterns. A pond can be excavated in a rectangular form and the edge shaped later with a blade scraper to create an irregular configuration.

Planning the placement or disposal of the material excavated from the pond.

A. If waste material is not removed from the site, it must be placed so hat its weight does not endanger the stability of the side slopes and rainfall does not wash the material back into the pond. If material is stacked, it shall be placed with side slopes no steeper than the natural angle of repose of the soil. Waste material shall not be stacked in a geometric mound but shaped and spread to blend with natural landforms in the area. Because most excavated ponds are in flat terrain, the waste material may be the most conspicuous feature in the landscape. Interrupting the existing horizon with the top of the waste mound should be avoided. *Refer to Exhibit 31 in Appendix A.*

B. Waste material can also be located and designed to be functional. It can screen undesirable views, buffer noise and wind, or improve the site's suitability for recreation. In shaping the material, there should be no less than twelve (12) feet between the toe of the fill and the edge of the pond.

8-880 POND PLANS

The following information shall be shown on all stormwater management ponds:

A. Watershed Map. Watershed maps shall be shown on plans submitted for approval. Bar scales shall be used. The map shall show the watershed boundary; the drainage pattern; location of bridges and culverts and other structures that affect the flow of water; location of roads, buildings, property lines and fences and north arrow.

B. Plan View. The plan view should indicate the lines of survey, center line of dam or pond, tie to property line, and key cross section lines with corresponding station numbers. The plan will contain an accurate contour map of the structure site and adjacent area. When this map is shown on a plan-profile sheet, the plan scale should be the same as the profile. The contour interval should be one (1) or two (2) feet. The plan view should show in detail the following:

1. The spillways and fill locations will be referenced to control lines or hubs.
2. All benchmarks, soil borings, borrow pits, fences, buildings, roads, bridges, springs, wells or other improvements that influence the design or construction of the proposed work.
3. Property lines.
4. Names of property owners.
5. Contour at permanent and design stormwater line.
6. Contour map of flooded area. The scale of this map may be one (1) inch = 20 feet where it can incorporate the details of

the local plan, to one (1) inch = 200 feet where a separate map would be required. The size, as determined by the scale and required details, vary from a one sheet combination of all maps and the profile, to an individual sheet for this map alone. The object of this map is to indicate with reasonable accuracy:

a. Contours of the area flooded permanently at a maximum contour interval of two (2) feet when needed for design.

b. Contours of the area temporarily flooded by spillway storage above the elevation of the crest of the principal spillway. These contours shall be on a one (1) foot vertical interval.

Profile of Principal and Emergency Spillway. The profile shall be plotted at a scale of one (1) inch equals ten (10) feet horizontally and one (1) inch equals five (5) feet vertically on profile paper. Profiles shall be plotted with flow going from left to right. The following shall be shown:

A. Principal Spillway. The spillway must be shown on the profile at the correct station and elevation. The following elevations shall be clearly labeled:

1. The crest of the spillway.
2. The top of outlet apron or invert of pipe spillway at the outlet.
3. The water surface at maximum stage of design storm.
4. The top of the earthfill (settled height).

B. Emergency Spillway. The spillway must be shown on the profile at the correct station and elevation. The following shall be clearly shown:

1. Crest of the spillway.
2. Length of the control section.
3. Slope of the approach channel.
4. Slope of the exit channel.
5. The existing ground elevation along the centerline.

C. For both spillway profiles, the location and elevation of rock, gravel or soil strata that affects the design or location of the structure, shall be shown.

D. Cross Sections. Cross sections shall be plotted as viewed looking downstream. All cross sections should be plotted on cross section paper. The profile station for each cross section plotted should be centered directly below the cross section on the data sheet. When possible, the cross section should be plotted to the same horizontal and vertical scale, thereby giving an undistorted cross section.

The cross section along the centerline of the proposed earthfill shall show the following information:

A. Elevations and important dimensions of the principal spillway in proper relation to the cross section showing the elevations of crest, apron, and top of weir or headwall.

B. The top of the earthfill as constructed and its final settled height.

C. The elevation of earthfill berms, if applicable.

D. The elevation and dimensions of the emergency spillway.

E. The location and descriptions of soil borings taken along or near the centerline of the proposed structure.

F. The depth of the core trench.

Cross sections through the fill or embankment area shall show the following information:

A. The side slopes of the fill.

B. The top width of the embankment.

C. The elevation of top of fill as constructed and its settled height.

D. The existing and proposed ground lines.

E. Property line, if applicable.

F. Core trench dimensions and location.

G. Foundation drain.

H. The elevation of earthfill berms, if applicable.

I. The location of any fences,

J. Stations and centerline or baseline.

It may be possible to show this information on the profile of the principal spillway.

Other Details as Needed.

A. Seeding and mulching specifications for the fill, spillway, and borrow areas.

B. Pipe and riser construction details supplemented with details of appurtenant structures including but not limited to trash racks, anti-seep collars, propped outlet, concrete reinforcing, fencing.

C. Construction notes required to assist in layout, construction, and checking of the completed practice.

D. Notes and details from qualified soils engineer.

8-890 ROOFTOP DETENTION

8-890.1 DESIGN CRITERIA

Roof top storage shall be an appropriate design to detain up to the ten-year, two-hour event, and emergency overflow provisions shall be adequate to discharge the 100-year, 30-minute event.

- A roof design in the City of Manassas is currently based on a snow load of thirty (30) pounds per square foot or 5.8 inches of water. Assuming a reasonable factor of safety, properly designed roofs are structurally capable of holding three (3) inches of detained stormwater.
- Roofs calculated to store depths greater than three (3) inches shall be required to show structural adequacy of the roof design and to be approved by the City of Manassas Building Official prior to approval by the Director.

No less than two (2) roof drains shall be installed in roof areas of 10,000 square feet or less, and at least four (4) drains in roof areas over 10,000 square feet in area. Roof areas exceeding 40,000 square feet shall have one (1) drain for each 10,000 square foot area. *Refer to Exhibit 39 in Appendix "A".*

Emergency overflow measures adequate to discharge the 100-year, 30-minute event without unnecessary risk to life or property must be provided.

- If parapet walls exceed three inches in height, the designer shall provide openings (scuppers) in the parapet wall sufficient to discharge the 100-year, 30-minute storm flow at a water level not exceeding five (5) inches.
- A scupper shall be provided for every 20,000 feet of roof area, and the invert of the scupper shall not be more than 3.5 inches above the roof level. (If such openings are not practical, then detention rings shall be sized accordingly).

Detention rings shall be placed around all roof drains that do not have controlled flow. *Refer to Exhibit 23 in Appendix A.*

A. The number of holes or size of openings in the rings shall be computed based on the area of roof drained and runoff criteria.

B. The minimum spacing of sets of holes is two (2) inches center-to-center.

C. The height of the ring is determined by the roof slope and in no case shall the height of the ring exceed three (3) inches.

D. The diameter of the rings shall be sized to allow the 100-year design storm to overtop the ring (overflow design is based on weir computations with the weir length equal to the circumference of the detention ring).

E. Conductors and leader shall also be sized to pass the expected flow from the 100-year design storm.

The maximum draw down time of the roof shall exceed seventeen (17) hours.

The City of Manassas will accept Josam Manufacturing Company and Zurn Industries, Inc. market "controlled-flow" roof drains, or other approved equivalents.

Access for inspection shall be provided for all roof drains.

8-890.2 PLAN PREPARATION

Computations required on all development plans:

A. The roof area in square feet.

B. The storage volume provided at three-inch depth.

C. The maximum allowable and calculated discharge rate.

D. Inflow-outflow hydrograph analysis or acceptable charts (For Josam Manufacturing Company and Zurn Industries, Inc. standard drains, the peak discharge rates as given in their charts are acceptable for drainage calculation purposes without requiring full inflow-outflow hydrograph analysis).

E. The number of drains required.

F. The size of openings required in detention rings.

G. The size of rings to accept openings and to pass the 100-year design storm.

8-8100 UNDERGROUND DETENTION

8-8100.1 GENERAL REQUIREMENTS

All underground detention facilities shall have prior approval of the Director.

Private underground stormwater management facilities utilizing corrugated metal pipe (CMP) will be approved, if the conditions listed below are satisfied:

A. Pipe must be aluminum CMP or aluminized steel CMP.

B. All access structures, manholes, inlets, and control structures must be reinforced concrete meeting Virginia Department of Transportation standards.

C. Calculations must be submitted to demonstrate that the structure will withstand the expected traffic loading in paved area.

D. All construction details must be provided.

E. Structures must not be placed under the main site accessways or within ten (10) feet of the public right-of-way.

Underground systems conveyed to the City must be constructed entirely of reinforced concrete.

8-8100.2 DESIGN CRITERIA

Underground detention shall be a closed tank or pipe system.

Sediment traps and trash racks shall be provided. These should be placed near maintenance access points.

All underground facilities shall have at least two (2) points of access to facilitate maintenance. The Director may require additional access points if it is necessary for the required maintenance.

All underground detention facilities shall have spillways designed to accommodate the design-year event, while providing detention for the 2-year event as required.

All facilities shall provide for adequate overland relief for runoff in excess of the ten-year event. Routing of the 100-year event through the underground detention facility is not required.

Peak runoff rates from the facility shall be less than or equal to both of the design-years' pre-development runoff rates.

For single conduit facilities that carryoff off-site water or those to be publicly maintained, easements shall be determined and recorded based on a vertical one-to-one slope starting at the tank's invert and extending around the perimeter of the tank.

For large facilities with multiple conduits, an easement shall be provided which shall extend from the outside vertical edge of the conduit at a one-to-one slope to finished grade to allow for major replacements.

Refer to Exhibit 19 in Appendix "A" for classes of backfill.

8-8100.3 PLAN PREPARATION

Plans shall accurately show the alignment of the structure and all appropriate easements.

All corners and junctions of conduits shall be shown on all plans. These shall include the invert elevations of the tank if applicable.

A profile of the tank or conduit, including sufficient sections, shall be shown.

Details of gravel bed, tank, or conduit construction and entrance and outfall structures shall be shown.

Plan views of structures consisting of multiple sections shall include flow arrows.

8-8110 POROUS PAVEMENT

The use of porous pavement shall be allowed only with prior approval of the Director.

The use of porous pavement shall not be allowed for any public facility.

8-8110.1 DESIGN CRITERIA

Soil tests shall be conducted in accordance with Sections 10-400 and 10-600 of this Manual.

A. In addition to these tests, a percolation test shall be performed.

B. An outflow "hydrograph" shall be developed based on the absorption and percolation rate of both subgrade and pavement and supplemental subdrainage.

Projected traffic counts and live loading calculations are required.

The mix (gradation) including density of both the subgrade and the porous pavement, shall be designed and sealed by a professional registered engineer certified by the State of Virginia with background in pavement design.

Preparation of the site and the placement of the pavement shall be done under the direct supervision of a professional engineer registered in the State of Virginia.

Pavement density tests shall be made within three hours of placement and shall be compared with engineers calculations.

Prior to final inspection, a second density test shall be made and results compared with the previous test.

The construction plans shall contain:

A. Engineering calculations, including design mix criteria and specifications.

B. Calculation of the 10-year peak inflow rate.

C. Storm routing calculations shall be provided as required by the Director.

D. Calculations for nominal percolation rates based on the closure of voids due to sediment deposition.

E. Provisions for freeze/thaw action and approved deicing chemicals shall be noted.

All future repairs (sealing, overlays) shall be done only with the approval of the Director and shall be in accordance with guidelines outlined above.

8-8120 REGIONAL FACILITIES

Regional facilities shall be determined based on the area of the drainage shed associated with the specific structure as follows:

- The drainage area to the structure shall be no less than 100 acres to be considered for a regional facility.
- The facility shall serve more than two sites.

The Director shall ultimately decide, based on the above criteria and the future benefit to the public, whether the facility is to be accepted as a regional facility.

These facilities shall be located such that they conform to those areas outlined within the Stormwater Management Master Plan for possible regional facilities. Other sites may be approved at the discretion of the Director.

Sites which are conveying their stormwater to a regional facility shall convey their stormwater through closed conduit, or adequate open channels. These systems shall have duly recorded easements.

Regional facilities shall be designed such that they retain a permanent pool of water with continuous release, and be of adequate volume and depth to become an amenity to the community.

For guidelines for dam design, *refer to Section 8-920 of this Article.*

If buildings are to be constructed downstream from the facility where failure would result in loss of life, the probable maximum flood elevation shall be determined and a building restriction zone setback established which is similar to the restrictions for flood plains. *Refer to Section 8-600 of this Article.*

SECTION 8-900 DAMS DESIGN AND CONSTRUCTION STANDARDS

8-910 REGULATIONS

Virginia Department of Historic Resources, Division of Soil and Water Conservation (VDHR, SWC)

Construction of impoundments with a dam height of twenty-five (25) feet and greater of those with a height greater than six (6) feet and impoundment capacity greater than 50 acre-feet requires compliance with the State of Virginia standards under the Virginia Impounding Structure Regulations, Chapter 8.1, Title 62.1 Code of Virginia, as amended, and the corresponding Virginia Department of Historic Resources Division of Soil and Water Conservation Regulation, No. 9. Permits for construction and operation of these dams are issued by Virginia Department of Historic Resources Division of Soil and Water Conservation.

A copy of the design must be submitted to the City of Manassas in order to receive the Directors approval for a grading or public improvement plan prior to the City forwarding the design to the Virginia Soil and Water Conservation District. The grading or public improvement plan must also include an erosion and sediment control plan in accordance with the provisions in Article 4 of this Manual.

8-910.1 CITY OF MANASSAS REGULATIONS

It is the policy of the City of Manassas that compliance with the criteria set forth within this Article shall be required for the design and

construction of dams within City limits that are not under the jurisdiction of the Virginia Department of Historic Resources.

The design procedures and criteria in this Article have been compiled for the use of persons involved in the design and construction of impoundment structures of sufficient size to represent a potential hazard to downstream properties.

The City of Manassas will review all dam designs and regulate those intended to impound water except as exempted below:

A. Any existing or proposed dam regulated by the Federal Government or the Virginia Department of Historic Resources Division of Soil and Water Conservation.

B. All dams formed by highway embankments

1. The Virginia Department of Transportation has special design criteria for permanently impounding water upstream of highway embankments.
2. The Director shall approve such impoundments only upon favorable recommendation from the Virginia Department of Transportation.

Refer to Exhibit 36 in Appendix A for a graphical representation of impoundments which are regulated by the State Department of Historic Resources.

Except as exempted above, highway embankments shall not be used as dam embankments within the City. This does not restrict the use of culverts with a headwater condition during rainfall events without a permanent surface elevation.

An inspection and maintenance agreement shall be executed with the City by the owner and recorded among the land records of the Prince William Judicial Center prior to plan approval.

A permit from the City shall also be required for dam construction.

Dams regulated by the City of Manassas shall be designed by a Professional Engineer licensed in the State of Virginia with expertise in the fields of geotechnical engineering, hydraulics, and dam design.

During construction, the owner shall employ an engineer licensed in the State of Virginia to inspect the construction of the dam, to file weekly reports with the Director covering construction progress including soil and compaction test data.

Record drawings with as-built information shall be submitted to the Director at the completion of construction and shall include soil classification, compaction and density test results, and concrete test results, to document the physical and structural soil characteristics of the facility.

After completion of construction, the owner's construction engineer shall certify, in writing, that the dam was constructed in accordance with the approved plans and specifications.

8-920 DESIGN CRITERIA

All dam and embankment designs shall conform to the practices accepted by the State Department of Historic Resources, the Army Corps of Engineers, SCS Design of Small Dams or others as approved by the Director. All dam and embankment designs shall conform to the requirements of Sections 8-820, 8-830, 8-840, 8-850, 8-860, 8-870, and 8-880 of this Article.

Storage Volume. An evaluation of the topography of the drainage area to the proposed wet pond is necessary to ensure that an adequate baseflow exists to maintain a permanent pool of water. The Maryland Water Resources Administration has developed a table which gives guidance on sizing a pond based on the watershed size, the type of development and the soil types (Md DNR, 1986).

Dams shall be designed based on hydrology methods developed in SCS TR-55 or TR-20.

A. All designs shall incorporate emergency spillways, the design of which shall be based on the undetained 100-year event. The spillway elevation shall be no lower than the computed ten-year

water surface elevation. An examination of the flood plain created by the passing of the 100-year storm shall also be conducted and delineated on submitted plans.

B. All embankments shall be designed with a top width and side slopes appropriate for the material used to construct them.

C. Compaction standards to be employed are to be stated on the plans.

D. The embankment design shall take into account settlement based on compaction and type of material used.

E. Side slopes above the permanent pool elevation shall be no steeper than three to one.

F. The top of the embankment shall be a minimum of one (1) foot and a maximum of two (2) feet above the computed 100-year water surface elevation.

G. Core trench, anti-seep collars, erosion protection on upstream face and outlet protection shall be considered in the design and a detail shall be included on the plans.

H. Any riser employed shall be designed to overcome buoyant forces. Risers shall also incorporate trash racks with anti-vortex devices.

Dam Failure.

A. As determined by the Director, a dam failure analysis is required for facilities with embankments higher than fifteen (15) feet and less than twenty-five (25) feet with a capacity greater than fifteen (15) acre feet, and those with an embankment height between six (6) and fifteen (15) feet with a capacity greater than twenty-five (25) acre feet.

B. As part of the overall dam design, the engineer shall determine the segment of stream valley downstream from the dam that would experience an increased flood depth resulting from a potential dam failure.

C. Two types of danger reach analysis are to be investigated.

1. For the first analysis, the engineer shall route the next highest design storm through the proposed spillway system.

   Refer to Exhibit 36 in Appendix "A".

   a. If the dam may fail as a result of overtopping, a danger reach analysis shall be performed.
   b. If overtopping does not occur, a downstream analysis is not required.

2. The second analysis shall consider a dam failure as a result of internal erosion with the pond or lake level at normal pond elevation. Analysis of this type will not be required for dams without a permanent pool.

D. Where required, the analysis shall be conducted to a point downstream where the dam break flood depth, danger reach length, has attenuated to within one (1) foot or less of the flood depth that would be experienced without the dam.

E. If the dam break analysis shows a potential for flooding of habitable structures, the engineer and owner shall increase the spillway capacity and downstream channel capacity where applicable.

F. References used in dam design, construction, and maintenance.

1. BMP Handbook for the Occoquan Watershed. Northern Virginia Planning District Commission, Chapter 3, Annandale, Virginia, August 1987
2. Virginia Erosion and Sediment Control Handbook. Chapter 3, Section 1.26
3. Army Corps of Engineers Technical Manuals
4. Division of Conservation and Historic Resources
5. SCS Design of Small Dams

G. Easements

Easements shall be provided for vehicular access for maintenance of the facility and its appurtenances.

SECTION 8-1000 INSPECTION AND ACCEPTANCE

8-1010 INSPECTION

All storm sewers shall be inspected by the City of Manassas Inspection Department at periodic intervals during construction.

These inspections shall include a visual check of all storm sewer and appurtenances for damages related to construction, pipe size, alignment, grade, structure type and backfill requirements.

8-1020 FINAL APPROVAL

All damage as determined by the above inspection shall be corrected (replaced or repaired) to the satisfaction of the Director before acceptance.

Testing as required by the Director prior to acceptance shall be done in the same manner as that in Section 10-600 and Section 10-780 of this Manual.

Storm sewers shall be clean and free of debris and sediment prior to acceptance by the City.

The Director shall accept all storm sewer, appurtenances, and detention facilities when it has been determined that the field engineering and construction has been completed as stated in the approved plans, the structures are in place, and the ground around them stabilized in accordance with the final plans.