



CITY OF RICHMOND
Stormwater Management Division

Appendix A:

Department of Community Development
Stormwater Management Division
900 East Broad Street-Room 500
Richmond, Virginia 23219
804 646-7586/ (fax) 804 646-5789

CHECKLIST FOR STORM DRAIN SYSTEM

GENERAL

- All plans shall be signed and sealed by a professional Engineer.
- All plans shall have a complete title block.
- All letters shall be neat and legible and of the same size for each sub-text.
- Label all existing and proposed work.
- All drawings shall be prepared at an appropriate scale.
- All plans shall show a north arrow.
- All existing drawings shall show the limits of proposed clearing/construction.

HYDROLOGY

Provide a drainage area map for all existing and proposed site conditions.

1. Existing site condition:

- Existing drainage area should include all sub-drainage areas. It should show size of drainage area, time of concentration, flow path, composite break down of the runoff coefficient, and arrow indicating direction of flow within each sub-drainage area.
- Clearly define each sub-drainage area and its drainage divide lines. It should reflect the contours, roofs, crown of roads, islands, etc.
- Show the type of soil on plan.
- Show existing contours at 2-foot intervals.
- Show all offsite drainage area.
- Show all flood plain limits, wetland, Chesapeake limits, etc.
- Show and label all existing slope 20 percent or more on plan.
- Show and label all sub-drainage areas.
- Show and label all existing drainage structures on plan. Existing storm drain pipes should show the length of the pipe, the size of the pipe, and the type of the pipe. Show the profile where applicable.
- All existing drainage computations must be shown on plans.



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2. Proposed site condition:

- Show and label all proposed sub-drainage areas. List size of drainage area, time of concentration, flow path, composite break down of the runoff coefficient, and arrows indicating direction of flow.
- Clearly define each sub-drainage area and its drainage divide lines. It should reflect the contours, roofs, crown of roads, islands, etc.
- Show proposed contours at 2-foot intervals.
- Show all offsite drainage area.
- Show all flood plain limits, wetland, Chesapeake limits, etc.
- Show and label all proposed drainage structures on plan. Show clearly how it ties into existing storm drain system. All proposed storm drain pipes should show the length of pipe, size of pipe and class of pipe on plan.
- All proposed drainage computations must be shown on plan.

HYDRAULICS

1. Culverts, storm drain and open channels designed to minimum 10-year criteria

- 10-year flow less than pipe capacity.
- 10-year HW/D < 1 for private entrance culverts within right-of-way.
- All calculations submitted on standard VDOT forms or other acceptable documentation.
- All RC pipes shall be Class III at a minimum within the Right Of Way.
- Dimensioned channel section with 10-year lining depth, side slopes, bottom width specified/shown in plan/profile.
- Open channel slopes < 0.75% shall be paved.
- Open channel/Storm sewer minimum slope 0.2%.
- Manhole steps required in structures 4-feet and greater in depth.
- Private driveway culvert crossing should be a minimum 20-foot length.
- Driveway culvert (RCP) should be sized based on 10-year design storm minimum.

2. Open Channel

- Rip-rap channels not acceptable in front or adjacent to single family homes unless further than 100-feet from homes or otherwise approved.
- Rip-rap channels can be used to rear of lots if no closer than 75-feet to homes.
- Where paved channels are steeper than 15%, anchor lugs are required every 10-feet, 'c-c'.



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- 9-inch freeboard (vertical wall) is required along outside radius of paved ditches.
- Maximum permissible flow velocity of 3.5 fps for grass ditches.
- Open channel depth less than 3', otherwise flow path shall be piped.
- Rip-rap lining a minimum of 24-inch thickness with geotextile fabric underlayment.
- Provide cross-section details for open channel section. Show and label the location of the section on plan. Show the section's depth of flow, velocity, discharge and channel lining 'n' value, etc.

3. Storm drain Profile

Each storm drain profile should be shown with the minimum information:

- Show the percent of grade and length.
- Show size and type of material.
- Show existing ground and proposed grade surface elevations along the centerline of the system.
- Show and label all existing and proposed storm drain structures to include rim elevations, inverts in and out, etc.
- All existing and proposed utilities that cross the proposed storm drain profile. Show its clearance. Minimum clearance is required.
- Show the hydraulic grade line on storm drain profile. All hydraulic grade lines must be supported with computations shown on plan.
- Provide a minimum cover of 3.5-feet for all storm drain structures.
- Provide a scale of 1: 5 vertical and 1: 10 horizontal.
- Show and analyze the outfall of the storm drain profile. Submit storm drain computations to support all drainage outfalls.
- Submit computations to support the MS-19 requirements.
- All storm drain computations must be shown on plans.
- Provide storm drain load protection where necessary such as cradle and encasement. Provide pipe loading table on plan.
- Provide protective fill for all storm drains with less than two feet of cover.
- Show all storm drain crossing with the appropriate clearances.

SUBDIVISION

For the MS-19 requirements, an analysis of the outfall of the proposed development shall be done so that the natural channel is extended to the receiving stream.

- If the drainage analysis fails to meet MS-19, stormwater management shall be required at the road construction plan stage of submission for a central facility.
- Any lots submitted for a building permit that is apart of a subdivision development shall not be considered as separate projects, rather the



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subdivision development as a whole, shall be considered as a single project. Therefore, the central stormwater management facility and the overall site grading plan shall govern.

- An overall site grading plan shall be required for the showing of the foot print of each lot, the finished floor elevations, lot sizes, set backs, bearings and distances of the boundaries, septic systems, and easements along with the erosion and sediment control measures in place.
- For land disturbing activity for single family dwellings on lots of 7,500 square feet or more, and not disturbing more than 2,500 square feet in a Chesapeake Bay area, an agreement-in-lieu of plan and surety bond may be substituted for an erosion and sediment control plan at the discretion of the plan approving authority.
- Stormwater management shall be required at the road construction plan stage of submission for a central facility. If stormwater management is not provided at the road construction plan stage of approval, then a note shall be added to the road construction plan that stormwater management shall be required at the site plan stage of submission.

STORMWATER MANAGEMENT PLANS

1. Plan (1" = 30')

- Property Lines, Property Owners
- Applicable Record Plats
- Easements (Structure, Pond, Outfall, Access)
- Existing Right-of-way
- Proposed Right-of-way
- Existing and Proposed Topography
- Existing Conditions and Proposed Improvements
- Test Boring and Bench Mark Locations
- Swales, Channels, Low-Flow Channels, Drains
- Outfall, Outfall Protection
- Soil Erosion and Sediment Control Plans
- Delineation of Disturbed Areas
- Vegetative Stabilization
- Delineation of 100-year Water Surface Elevation
- Access Road
 - Approved Plan and Profile of Public Row from which access will be obtained
 - Proposed Plan and Profile of Access Road
- Access Ramp
- References to Standard Specifications or Detail Design
- Coordinate ticks (250' intervals and bracket work)



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2. Profile (1" = 5' Vertical and 1" = 10' Horizontal)

- Storm drainage system entering device
- Low flow channel in basins (Pilot channel)
- Profiles of all devices
 - Existing ground
 - Proposed Grade
 - Pipes and other Utilities
 - Proposed Construction

3. Device Information

• Infiltration Device

- Soil Investigation Data
 - Soil borings locations
 - Soil classification
 - Strata profile
 - Water table elevation
 - Elevations of strata
- Plan View
 - Location and easements
 - Dimensions #1, #2, etc.
 - Label system
 - Type of system
 - Public/private_____/_____
- Water Surface Elevation of 10- and 100- year design storms Profile
 - Existing ground
 - Proposed grades
 - Existing/proposed storm drainage and utilities
 - Phreatic line
 - Core trench
 - Anti-seep collar
 - Depth of 2-, 10- and 100-year design storms
- Details and notes
 - Construction specifications
 - Inspection notes and schedule
 - Maintenance notes
 - Special structure details drawn to scale
 - Profiles and sections for embankment structures as required by VDOT Manual

• Attenuation Devices

- Plan
 - Location and Easements



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- Dimensions
- Label devices
- Show existing and new topography features
- Existing and proposed grading
- Design flow inundation areas
- Profile
 - Proposed system
 - System dimensioned
 - Label devices
 - Show existing and proposed ground lines
 - Show existing and proposed storm drainage and utilities
- Details and Notes
 - Construction and material specifications
 - Inspection schedule
 - Maintenance schedule
 - All special items detailed
- Detention and Retention Devices
 - Plan View
 - Proposed device shown and labeled
 - Existing and proposed contours
 - Access from public road
 - Maintenance access
 - Pipes and structures labeled
 - Easements
 - Location
 - Device labeled as to public/private
 - Topographic features existing and proposed profile
 - Profile View
 - Existing and proposed ground lines
 - Existing and proposed storm drainage and utilities.
 - Water Surface Elevations, Normal Pool, Emergency Spillway, 100-yr elevation
 - All information (sections and profiles) required by State standards.
 - Details and Notes
 - Materials and construction specifications
 - Inspection requirements and schedule
 - Maintenance schedules and requirements
 - All special items (items detailed to scale)
- Miscellaneous Items
 - Fence to be shown



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- Gate (width and swing)
- Height of fence
- Location of fence
- Fence material and specifications
- Access
 - Site access
 - Easements
 - Aprons
 - Pavement materials
 - Dimensions and location
 - Maintenance access
 - Grades 15% max.
 - Materials
 - Width and dimensions
 - Typical Section
 - Side slopes 2:1 max.
 - Details
 - All permanent material to be equal to standard inlets and structures quality and materials.
 - Scale drawing and plan, profiles, and sections as required
 - Material specification on plan
 - Construction specification on plan

DESIGN REPORT

- 1. To be presented in bound 8 1/2" x 11" booklet**
- 2. Drainage ` existing and proposed conditions folded and tucked in (no fold outs)**
 - Color coded as required
 - 1" = 200' scale
 - Land use
 - Soils
 - Drainage flows
 - Streets named
 - Proposed and existing conditions
- 3. Narrative**
 - Explanation of method used
 - Findings of existing conditions
 - Proposed development
 - Best management investigation
 - Alternatives considered



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- Why chosen or abandoned
- Water quality benefits of design
- Peak management benefits of design

4. Signature and Seal of Professional Engineer

- Name
- Seal and Number
- Address (including zip code)
- Telephone Number (including area code)

5. Design Data

- Formulas and source of information
- Input determination for all computer programs
- TR-55 for storm sewer pipes for areas greater than 200 acres and hydrologic models for areas greater than 20 acres.
- Rational Method for storm sewer pipes for areas up to 200 acres and hydrologic models for areas up to 20 acres
- HEC-2 or HEC-RAS computer runs
- Details, nomographs, formulas determination
 - Existing peaks – 2- and 10-year storms
 - Proposed peaks – 2- and 10-year storms
 - Performance curve of device (elevation vs. discharge)
 - Hydrograph plot for proposed conditions 2- and 10-year storms
 - Water quality computations
- Conclusions and summary of results
- Design factors considered in design
 - Best management device
 - Clearances - vertical and horizontal
 - Benefits of design water quality and peak management
- Outfall Study
- Existing condition statement
 - Recommendations
 - Hydraulic analysis
- Proposed condition statement
 - Proposed flows
 - Proposed devices
 - Erosion prediction and measures taken to prevent erosion
 - MS-19 requirements



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FLOOD PLAIN

Determination of 100-year Flood Plain

- Ultimate condition (as zoned) 100-year storm
 - No credit for upstream management
 - No credit for upstream constrictions
 - Assume developed channel condition
- Determine existing natural channel grade in development
 - Profile along natural line boundary to boundary
 - Average grade line
- Inundation area for 100-year storm event
 - Hydraulic sections
 - HEC-II run or step method determination
 - HEC-RAS backwater analysis
 - Inundation area
 - Dedicated under subdivision
 - Not graded under building permit
 - Exemptions and waivers
 - FEMA forms



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GENERAL INFORMATION

1. Includes Tables, Charts

City of Richmond Storm Data

(These values shall be used in all submitted calculations)

24 hour rainfall depths, inches from VDOT Hydraulic Design Advisory 05-04.2 revised 2/1/08						
1 year	2 year	5 year	10 year	25 year	50 year	100 year
2.76	3.34	4.28	5.08	6.27	7.29	8.42

B, D, & E factors for determining rainfall intensity in the Rational and Modified Rational Methods from VDOT Hydraulic Design Advisory 05-03 dated 6/21/05							
	1 year*	2 year	5 year	10 year	25 year	50 year	100 year
B	46.61	57.69	54.99	47.91	41.66	36.88	33.15
D	11.06	11.50	10.75	9.25	7.75	6.50	5.25
E	0.84	0.85	0.78	0.72	0.65	0.60	0.56

* Factors derived by the City of Richmond from data in NOAA Atlas 14 for Richmond WSO Airport (44-7201)

$$I_f = \frac{B}{(T_c + D)^E}$$

Where: If = rainfall intensity for a given recurrence interval "f", inches/hour
Tc = watershed time of concentration, minutes

2. The types of stormwater management facilities are adapted from Virginia Stormwater Management Facilities Handbook (VSMH).
3. The types of stormwater quality facilities, Best Management Practices (BMP) are adapted from VSMH.

RECOMMENDATION

Department of Community Development Review Engineers have reviewed the reference plans, specifications, and computations and found them:

- _____ Acceptable
- _____ Not Acceptable- revise as noted for resubmittal
- _____ See attached letter of explanation