

HYDRAULIC DESIGN ADVISORY

HDA 06-03

DATE: AUGUST 14, 2006

SUBJECT: CULVERT OUTLET PROTECTION
ROAD AND BRIDGE STANDARD EC-1

SUPERSEDES: SECTION 8.3.2.6 OF THE 2002 VDOT DRAINAGE MANUAL

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A review of our current culvert outlet protection practices has indicated that a greater emphasis on the existing soil type is warranted to: 1) insure protection of the downstream channel or swale where material or lining in the downstream channel or swale may be unstable (erodible) under the anticipated velocities exiting the culvert, and 2) insure protection of the culvert end by providing measures to prevent the formation of a scour hole at the culvert outlet.

The type of material in the swale/channel at culvert outlets will need to be determined based on observations or field borings secured in accordance with the guidance found in Drainage Design Memorandum 1 (DDM1), Drainage Design Instructions, located in Chapter 15 of the VDOT Drainage Manual. The allowable velocity for natural material can be found in the table shown in Appendix 7D-2 of the VDOT Drainage Manual. The guidelines and procedures presented herein shall be implemented on all VDOT projects that: 1) have not progressed past the Right-of-Way stage or 2) have not progressed beyond the Pre-Advertisement Conference where right-of-way or easement will not be impacted or 3) will not result in any impacts to any conditions of secured water quality permits.

Highlights of the new procedures/details are:

1. Maintains current rip rap sizes for outlet velocities 8 fps and greater
2. Establishes new riprap size for outlet velocities up to 8 fps
3. Allows the use of EC-3 Type B for velocities less than 6 fps
4. Maintains current apron dimensions for culvert installations with a total hydraulic opening of less than 7 square feet.
5. Increases apron length to five times the height of the culvert for culvert installations with a total hydraulic opening of 7 square feet or greater.
6. Evaluates **need** for outlet protection based on 2 year culvert outlet velocity and allowable velocity of material in outlet channel or swale
7. Evaluates **type** of outlet protection required based on culvert outlet velocity for design discharge

The objectives of the new details/procedures are to:

1. Minimize impacts to right of way of easement areas at smaller culvert sites
2. Minimize length of stream impacts
3. Minimize need for outlet protection where channel/swale material will be stable for culvert outlet velocities
4. Provide alternative to riprap at sites with low outlet velocities
5. Satisfy DCR Minimum Standard 11

NEW OUTLET PROTECTION DETAILS

- Dimensions Of Outlet Protection Apron:
 - Type A Installation – Minimum 3H Length & Minimum 3S Width
 - Type B Installation – Minimum 5H Length & Minimum 3S Width
 - Where: S = Span of Culvert
H = Height of Culvert
 - For a multiple culvert line installations the largest S and H, dimensions of the individual culvert lines should be used in determining the minimum apron length dimensions.
- Outlet Protection Material
 - Class 1 – Standard EC-3 Type B
 - Class 2 – Class AI Dry Riprap
 - Class 3 – Class I Dry Riprap
 - Class 4 – Class II Dry Riprap

NEW OUTLET PROTECTION PROCEDURE

The following procedure shall be used to analyze the need for outlet protection on:

- All cross drain culverts
- All storm drain outlet pipes
- All entrance and crossover pipes with a diameter of 24” (or equivalent hydraulic opening) or greater

Step 1 - Determine if Culvert Outlet Protection is required for protection of swale or channel.

- A. Compute culvert outlet velocity for 2 year design storm.
- B. Compare 2 year design storm culvert outlet velocity to allowable velocity for outlet swale/channel material or lining.
 - Swale/channel material type based on field borings/observations or proposed lining.
 - Allowable velocity for natural swale/channel material based on VDOT Drainage Manual Chapter 7 - Appendix 7D-2.

- C. If two year design storm culvert outlet velocity is equal to or less than allowable velocity for swale/channel material, no Culvert Outlet Protection is required for swale/channel protection.
 - **Go to Step 2.**
- D. If two year design storm culvert outlet velocity is greater than allowable velocity for swale/channel material, Culvert Outlet Protection is required.
 - **Go to Step 3.**

Step 2 - Determine Culvert Outlet Protection required for culvert end protection

- A. Compute culvert outlet velocity for culvert design storm.
- B. If culvert outlet velocity for culvert design storm is less than 6 fps, Culvert Outlet Protection is not required for culvert end protection.
 - **Stop**
- C. If culvert outlet velocity for design storm is 6 fps or greater, Culvert Outlet Protection is required for culvert end protection.
 - **Go to Step 3.**

Step 3 – Determine Class of Culvert Outlet Protection to use.

- A. When Culvert Outlet Protection is required by either Step 1 or Step 2, the Class of EC-1 to be specified shall be based on the culvert design storm outlet velocity with the following velocity limitations.
 - EC-1 Class 1 – maximum outlet velocity is 6 fps.
 - EC-1 Class 2 – maximum outlet velocity is 8 fps.
 - EC-1 Class 3 – maximum outlet velocity is 14 fps.
 - EC-1 Class 4 – maximum outlet velocity is 19 fps.
 - Use Special Design Culvert Outlet Protection for outlet velocity greater than 19 fps.
- **Go to Step 4**

Step 4 - Determine Type of EC-1 Installation to use.

- A. When Culvert Outlet Protection is required by either Step 1 or Step 2, specify the Type of Installation to use based on the total hydraulic opening of the culvert installation.
 - Use Type A Installation for culvert installations with a total hydraulic opening of less than 7 square feet.
 - Use Type B Installation for culvert installations with a total hydraulic opening of 7 square feet or greater.

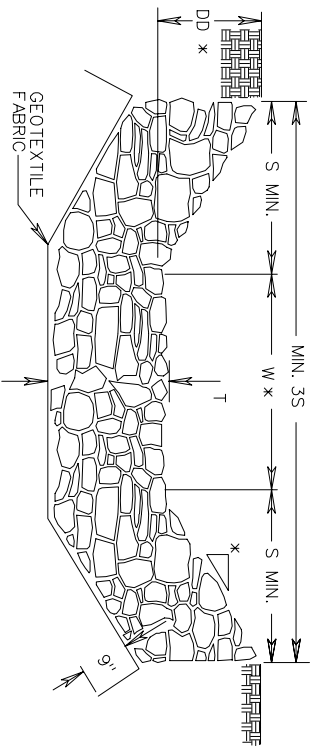
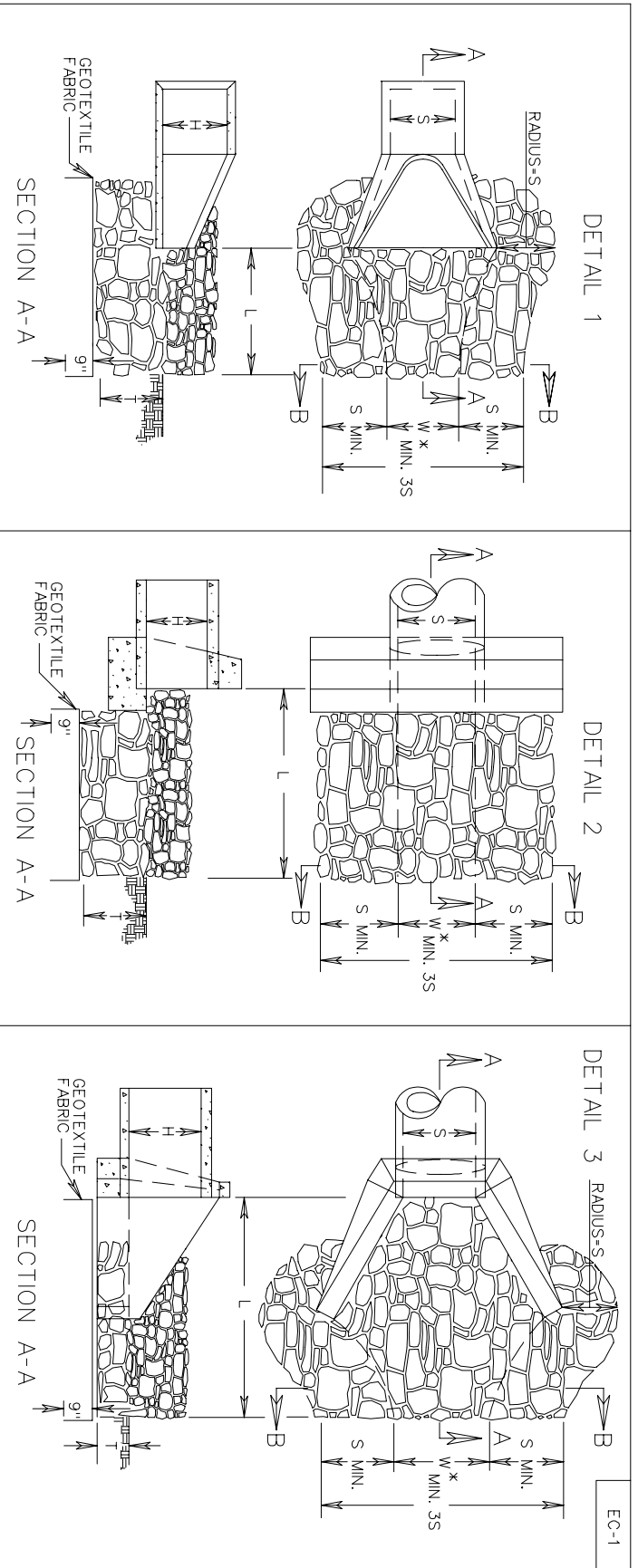
PLAN DESCRIPTION

- ____ Sq. Yds. Standard EC-1 Class ____ Required
Type ____ Installation

Road and Bridge Standard drawing 114.01 and Road and Bridge Specification Section 414 are being revised to incorporate the new protection measure details outlined in this HDA. (See attached draft standard drawing)

Due to the process for making revisions to the Road and Bridge Standards and Specifications, it may be early fall of this year before the revisions to the standard drawing and specifications are formally published. In the interim, this HDA will serve as authorization to incorporate these changes, as appropriate, into ongoing activities.

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TYPE OF OUTLET PROTECTION MATERIAL	MAXIMUM OUTLET VELOCITY (FOR DESIGN STORM)	MINIMUM "T"
CLASS 1 EC-3 TYPE B	6 fps	NA
CLASS 2 CLASS A1 DRY RIPRAP	8 fps	20"
CLASS 3 CLASS I DRY RIPRAP	14 fps	26"
CLASS 4 CLASS II DRY RIPRAP	19 fps	38"

NOTES:

1. FOR MULTIPLE LINE INSTALLATIONS, DIMENSION S IS TO GOVERN THE PROTECTION OUTSIDE THE CHANNEL WIDTH (W).
 2. ON ANY INSTALLATION REQUIRING CULVERT OUTLET PROTECTION WHERE NO ENDWALL OR ENDSECTION IS SPECIFIED ON THE PLANS, CONSTRUCTION IS TO BE IN ACCORDANCE WITH DETAIL 2 SHOWN ABOVE.
 3. GEOTEXTILE FABRIC TO BE INSTALLED UNDER CLASS 2, 3, AND 4 MATERIALS IN ACCORDANCE WITH THE SPECIFICATIONS.
 4. S = DIAMETER OF CIRCULAR CULVERT OR SPAN FOR BOX, ELLIPTICAL OR ARCH CULVERT. H = DIAMETER OF CIRCULAR CULVERT OR RISE/HEIGHT FOR BOX, ELLIPTICAL OR ARCH CULVERT.
 5. PLAN AND SECTION DETAILS DEPICT CLASS 2, 3, AND 4 MATERIALS. FOR CLASS 1 INSTALLATION DETAILS SEE EC-3 TYPE B STANDARD DRAWING.
- * USE TYPICAL SECTION SHOWN ON PLANS FOR SIDE SLOPE, BOTTOM WIDTH AND DEPTH OF CHANNEL OR MATCH EXISTING DITCH OR NATURAL GROUND.

OUTLET PROTECTION MINIMUM LENGTH (L)	
TYPE A INSTALLATION	3H
TYPE B INSTALLATION	5H

SPECIFICATION REFERENCE

204
245
303
414

CULVERT OUTLET PROTECTION

VIRGINIA DEPARTMENT OF TRANSPORTATION

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114.01