COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
TIDEWATER REGIONAL OFFICE
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L. Preston Bryant, Jr.
Secretary of Natural Resources

David K. Paylor
Director

Francis L. Daniel
Regional Director

STATE WATER CONTROL BOARD ENFORCEMENT ACTION SPECIAL ORDER BY CONSENT ISSUED TO SIX L'S PACKING COMPANY, INC. AND KUZZENS, INC.

Ground Water Withdrawal Permit Nos. GW0065700, GW0065800, GW0065900, GW0066000

SECTION A: Purpose

This is a Consent Order issued under the authority of Va. Code §62.1-44.15(8a) and §62.1-44.15(8d) between the State Water Control Board and Six L's Packing Company, Inc. for the purpose of resolving certain violations of the Virginia Ground Water Management Act of 1992 (Va. Code §62.1-254 *et seq.*) and its supporting regulations (9 VAC 610-210-10 *et seq.*).

SECTION B: Definitions

Unless the context clearly indicates otherwise, the following words and terms have the meaning assigned to them below:

1. "Act" means the Ground Water Management Act of 1992, Va. Code §62.1-254 *et seq.*

2. "Va. Code" means the Code of Virginia (1950), as amended.

3. "Board" means the State Water Control Board, a permanent citizens' board of the Commonwealth of Virginia as described in Va. Code §§ 10.1-1184 and 62.1-44.7.

4. "Department" or "DEQ" means the Department of Environmental Quality, an agency of the Commonwealth of Virginia as described in Va. Code § 10.1-1183.

5. "Director" means the Director of the Department of Environmental Quality.

6. "ESGWMA" means the Eastern Shore Ground Water Management Area, established by the State Water Control Board that encompasses the counties of Northampton and Accomack and all towns within their geographical boundaries. 9 VAC 25-620-10.

7. "Kuzzens" means Kuzzens, Inc., a wholly-owned subsidiary of Six L's Packing Company, Inc., a company certified to do business in Virginia, and its affiliates, partners, subsidiaries, and parents.

8. "Order" means this document, also known as a Consent Order.

9. "Permits" means ground water withdrawal permits for Machipongo Farm (GW0065700), Painter Farm (GW0065800), Christian Ames Farm (GW0065900) and Melfa Farm (GW0066000).

10. "Person" means any and all persons, including individuals, firms, partnerships, associations, public or private institutions, municipalities or political subdivisions, governmental agencies, or private or public corporations organized under the laws of this Commonwealth or any other state or country. 9 VAC 25-610-10.

11. "Regulations" mean 9 VAC 25-610-10 *et seq.* – the Ground Water Withdrawal Regulations

12. "TRO" means the Tidewater Regional Office of DEQ, located in Virginia Beach, Virginia.

13. "Well" means any artificial opening or artificially altered natural opening, however made, by which ground water is sought or through which ground water flows under natural pressure or is intended to be withdrawn.

14. "Withdrawal system" means (i) one or more wells or withdrawal points located on the same or contiguous properties under common ownership for which the withdrawal is applied to the same beneficial use or (ii) two or more connected wells or withdrawal points which are under common ownership but are not necessarily located on contiguous properties.

SECTION C: Findings of Fact and Conclusions of Law

1. Kuzzens, a person pursuant to 9 VAC 25-610-10, owns and operates the Machipongo, Painter, Christian Ames and Melfa Farms ("Farms") located in the ESGWMA. Kuzzens was issued the Permits on May 1, 2006 for the Farms, which are primarily tomato growing facilities.

2. The Act prohibits persons located in the ESGWMA from withdrawing, attempting to withdraw, or allowing the withdrawal of ground water within the ESGWMA except as authorized pursuant to a ground water withdrawal permit or as excluded

in 9 VAC 25-610-50. The operations at the Kuzzens Farms do not qualify for exclusion as outlined in the Act.

3. On June 20, 2007, DEQ compliance staff conducted inspections at the Farms and noted the following deficiencies:

Machipongo Farm (Northampton County):

- Seven wells were observed, of which, three (one active, two inactive) were unpermitted, not included in the May 1, 2006 permit.
- Three of the four permitted wells did not have the permit required in-line totalizing flow meters installed as required by the permit.
- The four permitted wells did not have the permit required DEQ well identification tags affixed to the well casings.

Painter Farm (Accomack County):

- Four wells were observed, of which, two (one active, one inactive) were unpermitted, not included in the May 1, 2006 permit.
- One of the two permitted wells did not have the permit required in-line totalizing flow meters installed.
- The two permitted wells did not have the permit required DEQ well identification tags affixed to the well casings.

Christian Ames Farm (Northampton County):

- Eight wells were observed, of which, five (two active, three inactive) were unpermitted, not included in the May 1, 2006 permit.
- Two of the three permitted wells did not have the permit required in-line totalizing flow meters installed.
- The three permitted wells did not have the permit required DEQ well identification tags affixed to the well casings.

Melfa Farm (Accomack County):

- Three wells observed, all permitted, one did not have the permit required in-line totalizing flow meters installed.
- The three permitted wells did not have the permit required DEQ well identification tags affixed to the well casings.

4. Part I, Paragraph 1 and Part II, Paragraph 2 of the Permits require that the withdrawal of ground water shall originate from the permitted withdrawal points (wells) and that the permittee shall notify DEQ in writing and obtain staff approval of any plans to construct any new wells for addition to the permitted well system. Kuzzens violated the Permits by failing to notify and obtain prior approval for the installation of ten wells (three active, seven inactive) at the Farms.

5. Part II, Paragragh 5 of the Permits requires the permittee to install in-line totalizing flow meters to read gallons, cubic feet, or cubic meters for all wells included in the Permits. Kuzzens violated the Permits by failing to install in-line totalizing flow meters in seven of the twelve permitted wells at the Farms by May 1, 2007.

6. Part I, Paragraph 7 of the Permits requires a DEQ well identification tag to be affixed to the well casings of each permitted well. Kuzzens violated the Permits by failing to affix DEQ identification tags to all twelve permitted wells at the Farms.

7. On September 26, 2007, DEQ issued Six L's Packing Company, Inc. Notice of Violation 2007-08-TRO-002 regarding the Farms operated by Kuzzens, addressing the allegations and applicable regulatory and statutory requirements listed in Section C.4 through C.6 of this Order.

8. On November 15, 2007 DEQ compliance staff conducted a follow-up inspection and observed that all active wells (permitted and unpermitted) at the Farms have had DEQ identification tags affixed to the well casings and all permitted wells had properly installed in-line totalizing flow meters.

9. On July 15, 2008, Kuzzens submitted information requested by DEQ Ground Water permitting staff that is required in order to modify the Permits to include the unpermitted wells at the Farms.

SECTION D: Agreement and Order

By virtue of the authority granted it pursuant to Va. Code §62.1-44.15(8a) and (8d) and upon consideration of Va. Code § 10.1-1186.2, the Board orders Six L's Packing Company, Inc., and Six L's Packing Company, Inc. agrees, to perform the actions described below and in Appendix A of this Order. In addition, the Board orders Six L's Packing Company, Inc., and Six L's Packing Company, Inc. voluntarily agrees, to a civil charge of $42,000 in settlement of the violations cited in this Order, to be paid as follows:

1. Six L's Packing Company, Inc. shall pay $10,500 of the civil charge within 30 days of the effective date of this Order. Payment shall be made by check,

certified check, money order or cashier's check payable to the "Treasurer of Virginia," delivered to:

Receipts Control
Department of Environmental Quality
Post Office Box 1104
Richmond, Virginia 23218

The payment shall include Six L's Packing Company, Inc.'s Federal ID number and shall identify that payment is being made as a result of this Order.

2. Six L's Packing Company, Inc. shall satisfy $31,500 of the civil charge by satisfactorily completing the Supplemental Environmental Project (SEP) described in Appendix B of this Order.

3. The net project cost of the SEP to Six L's Packing Company, Inc. shall not be less than the amount set forth in Paragraph D.2. If it is, Six L's Packing Company, Inc. shall pay the remaining amount in accordance with Paragraph D.1 of this Order unless otherwise agreed to by the Department. "Net project costs" means the net present after-tax cost of the SEP, including tax savings, grants, and first-year cost reductions and other efficiencies realized by virtue of project implementation. If the proposed SEP is for a project for which the party will receive an identifiable tax savings (e.g., tax credits for pollution control or recycling equipment), grants, or first-year operation cost reductions or other efficiencies, the net project cost shall be reduced by those amounts. The costs of those portions of SEPs that are funded by state or federal low-interest loans, contracts, or grants shall be deducted.

4. By signing this Order, Six L's Packing Company, Inc. certifies that it has not commenced performance of the SEP.

5. Six L's Packing Company, Inc. acknowledges that it is solely responsible for completing the SEP project. Any transfer of funds, tasks, or otherwise by Six L's Packing Company, Inc. to a third party, shall not relieve Six L's Packing Company, Inc. of its responsibility to complete the SEP as described in this Order.

6. In the event it publicizes the SEP or the SEP results, Six L's Packing Company, Inc. shall state in a prominent manner that the project is part of a settlement of an enforcement action.

7. The Department has the sole discretion to:

a. Authorize any alternate, equivalent SEP proposed by the Facility; and

b. Determine whether the SEP, or alternate SEP, has been completed in a satisfactory manner.

8. Should the Department determine that Six L's Packing Company, Inc. has not completed the SEP, or alternate SEP in a satisfactory manner, the Department shall so notify Six L's Packing Company, Inc. in writing. Within 30 days of being notified, Six L's Packing Company, Inc. shall pay the amount specified in Paragraph D.2., above, as provided in Paragraph D.1., above.

SECTION E: Administrative Provisions

1. The Board may modify, rewrite, or amend the Order with the consent of Six L's Packing Company, Inc., for good cause shown by Six L's Packing Company, Inc., or on its own motion after notice and opportunity to be heard.

2. This Order only addresses and resolves those alleged violations specifically identified herein, including those matters addressed in the Notice of Violation issued to Six L's Packing Company, Inc. on September 26, 2007. This Order shall not preclude the Board or the Director from taking any action authorized by law, including but not limited to: (1) taking any action authorized by law regarding any additional, subsequent, or subsequently discovered violations; (2) seeking subsequent remediation of the facility as may be authorized by law; or (3) taking subsequent action to enforce the Order. This Order shall not preclude appropriate enforcement actions by other federal, state, or local regulatory authorities for matters not addressed herein.

3. For the purposes of this Order and subsequent actions with respect to this Order, Six L's Packing Company, Inc. admits the jurisdictional allegations, factual findings, and conclusions of law contained herein.

4. Six L's Packing Company, Inc. consents to venue in the Circuit Court of the City of Richmond for any civil action taken to enforce the terms of this Order.

5. Six L's Packing Company, Inc. declares it has received fair and due process under the Administrative Process Act, Va. Code §§ 2.2-4000 *et seq.*, and the Groundwater Management Act, and it waives the right to any hearing or other administrative proceeding authorized or required by law or regulation, and to any judicial review of any issue of fact or law contained herein. Nothing herein shall be construed as a waiver of the right to any administrative proceeding for, or to judicial review of, any action taken by the Board to enforce this Order.

6. Failure by Six L's Packing Company, Inc. to comply with any of the terms of this Order shall constitute a violation of an order of the Board. Nothing herein shall waive the initiation of appropriate enforcement actions or the issuance of additional orders as appropriate by the Board or the Director as a result of such

violations. Nothing herein shall affect appropriate enforcement actions by any other federal, state, or local regulatory authority.

7. If any provision of this Order is found to be unenforceable for any reason, the remainder of the Order shall remain in full force and effect.

8. Six L's Packing Company, Inc. shall be responsible for failure to comply with any of the terms and conditions of this Order unless compliance is made impossible by earthquake, flood, other acts of God, war, strike, or such other occurrence. Six L's Packing Company, Inc. shall show that such circumstances were beyond its control and not due to a lack of good faith or diligence on its part. Six L's Packing Company, Inc. shall notify the TRO Regional Director in writing when circumstances are anticipated to occur, are occurring, or have occurred that may delay compliance or cause noncompliance with any requirement of the Order. Such notice shall set forth:

   a. the reasons for the delay or noncompliance;

   b. the projected duration of any such delay or noncompliance;

   c. the measures taken and to be taken to prevent or minimize such delay or noncompliance; and

   d. the timetable by which such measures will be implemented and the date full compliance will be achieved.

   Failure to so notify the TRO Regional Director within 24 hours of learning of any condition above, which the parties intend to assert will result in the impossibility of compliance, shall constitute a waiver of any claim of inability to comply with a requirement of this Order.

9. This Order is binding on the parties hereto, their successors in interest, designees and assigns, jointly and severally.

10. This Order shall become effective upon execution by both the Director or his designee and Six L's Packing Company, Inc. Notwithstanding the foregoing, Six L's Packing Company, Inc. agrees to be bound by any compliance date which precedes the effective date of this Order.

11. This Order shall continue in effect until the Director or Board terminates the Order in his or its sole discretion upon 30 days written notice to Six L's Packing Company, Inc. Termination of this Order, or any obligation imposed in this Order, shall not operate to relieve Six L's Packing Company, Inc. from its obligation to comply with any statute, regulation, permit condition, other order, certificate, certification, standard, or requirement otherwise applicable.

12. By its signature below, Six L's Packing Company, Inc. voluntarily agrees to the issuance of this Order.

And it is so ORDERED this 28th day of April, 2009.

Francis L. Daniel
Francis L. Daniel

Six L's Packing Company, Inc. voluntarily agrees to the issuance of this Order.

By: Gerard B. Odell Jr.

Date: Feb. 25, 2009

State of Florida
~~Commonwealth of Virginia~~
City/County of Collier

The foregoing document was signed and acknowledged before me this 25 day of February (month), 2009, by GERARD B. ODELL JR (name), who is COO (title) of Six L's Packing Company, Inc. on behalf of Six L's Packing Company, Inc.

Clara Santoro
Notary Public

My commission expires: July 24. 2012

CLARA SANTORO
MY COMMISSION EXPIRES
July 24, 2012
#DD 796455
Bonded thru Troy Fain Insurance
NOTARY PUBLIC, STATE OF FLORIDA

APPENDIX A

Six L's Packing Company, Inc. shall perform the SEP identified in Appendix B of this Order, in the manner specified below in this Appendix A:

1. The SEP, as described in Appendix B of this Order, is to be performed by Six L's Packing Company, Inc., is the engineering design and construction of stormwater management quality improvements including improved grass channel conveyances with multiple pre-filter rock check-dams that are constructed within the existing lateral and header ditches and include a terminus Type 1 Extended Detention Basin. The SEP location is Six L's Packing Company, Inc.'s Grapeland area tomato farm in Accomack County, Virginia.

2. Six L's Packing Company, Inc. shall complete the design and submit the design for permitting the SEP construction within 45 days from the effective date of the Order.

3. Six L's Packing Company, Inc. shall complete construction of the SEP within 45 days of receiving an approved permit for the SEP construction.

4. Six L's Packing Company, Inc. shall submit progress reports to DEQ on the SEP on a monthly basis, due the 10th day of each month.

5. Six L's Packing Company, Inc. shall submit to DEQ a written final report on the SEP, verifying that the SEP has been completed in accordance with the terms of this Order, and certified either by a Certified Public Accountant or by a responsible corporate officer or owner. Six L's Packing Company, Inc. shall submit the final report and certification to the Department within 120 days from the effective date of the Order.

6. If the SEP has not or cannot be completed as described in the Order, Six L's Packing Company, Inc. shall notify DEQ in writing no later than 90 days from the effective date of the Order. Such notification shall include:

   a. an alternate SEP proposal, or
   b. payment of the amount specified in Paragraph D.2 as described in Paragraph D.1.

7. Six L's Packing Company, Inc. hereby consents to reasonable access by DEQ or its staff to property or documents under the party's control, for verifying progress or completion of the SEP.

8. Six L's Packing Company, Inc. shall submit to DEQ written verification of the final overall and net project cost of the SEP in the form of [a certified statement itemizing costs, invoices and proof of payment, or similar documentation] within 30 days of the project completion date. For the purposes of this submittal, net project costs can be either the actual, final net project costs or the projected net project costs if such projected net project costs statement is accompanied by a CPA certification or

certification from Six L's Packing Company, Inc. Chief Financial Officer concerning the projected tax savings, grants or first-year operation cost reductions or other efficiencies.

9. The SEP shall be designed, constructed, completed, operated, and maintained consistent with the guidelines of the USDA Natural Resource Conservation Service "Field Office Technical Guide" (FOTG), theVirginia Cooperative Extension Service's (VCES) "Protecting Water Quality Best Management Practices for Row Crops Grown on Plastic Mulch in Virginia", and the Eastern Shore Soil and Water Conservation District's (ESSWDC) "Conservation Resources for Plasticulture Farms on the Coastal Plain".

10. Documents to be submitted to DEQ, other than the civil charge payment described in Section D of the Order, shall be sent to:

    Mr. Francis L. Daniel
    DEQ – Tidewater Regional Office
    5635 Southern Blvd
    Virginia Beach, Virginia 23462

APPENDIX B

(The SEP proposal from Six L's Packing Company, Inc.)

February 12, 2009

SIX L'S PACKING COMPANY, INC. & KUZZENS, INC. PROPOSAL FOR SUPPLEMENTAL ENVIRONMENTAL PROJECT PRESENTED TO THE VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY REGARDING STATE WATER CONTROL BOARD ENFORCEMENT ACTION AND SPECIAL ORDER BY CONSENT

With Respect to Facilities with Ground Water Withdrawal Permit Nos: GW0065700, GW0065800, GW0065900, GW0066000

PROJECT SUMMARY

Six L's Packing Company and Kuzzens, Inc. (referred to herein as Owner) operates several agricultural facilities across Virginia's Eastern Shore that require use of water for a variety of activities primarily including crop irrigation, vegetable processing for packaging, and labor housing. This water is withdrawn from surface impoundments and permitted groundwater wells. Four of the Owners' regulated facilities were discovered to be in violation of Groundwater Withdrawal Permit conditions. As a result of this discovery and the subsequent issuance of a Notice of Violation (September 26, 2008), the Owner is faced with an enforcement action and special order by consent and the VDEQ , is recommending a civil penalty of as much as $49,500.

Pursuant to Virginia Code § 10.1-1186.2, the Owner desires to perform an environmentally beneficial project in partial settlement of the civil enforcement action. This document presents a Supplemental Environmental Project (SEP) to mitigate a portion of the civil charge. The SEP will be conducted in and benefit the region around the where the subject permit violations were incurred. This proposal follows requirements outlined in Enforcement Guidance Memorandum No. 3-2006 (9/19/2006) and meets the declared SEP program objectives.

1. Net Project Cost. While the proposed SEP has certain and several environmental benefits of financial value to the public, the actual costs to the Owner are estimated to be $46,500. This cost does not include the value of cropland permanently that is taken out of production as required to implement the proposed improvements. The Owner is not otherwise required by law or regulation to implement any aspect of this SEP. As a result of completion of this project, the Owner will not receive an identifiable tax savings (*e.g.*, tax credits for pollution control or recycling equipment), grants, or first-year operation cost reductions or other such efficiencies."

2. Benefits to the Public or Environment. This project will benefit the public and environment by significantly reducing discharges of sediments and nutrients to the local environment. Currently, an estimated 76,000-lbs of sediments that may contain agricultural nutrients are available to be transported from the subject property farmland and discharged annually into an adjacent wetland via stormwater runoff from farmland. This SEP is intended to remove approximately 62,500-lbs of sediment annually.

3. Innovation. The project uses an innovative approach to manage stormwater runoff from an agricultural field to reduce the release of pollutants, conserve natural resources, and protect ecosystems by replacing standard agricultural E&S practice with technology more commonly applied for management and treatment of urban stormwater runoff.

4. Impact on Minority or Low-Income Populations. There are no known impacts or damages to minority or low-income populations as a result of unmitigated stormwater runoff from this farm to the wetland, creek, or bay.

5. Multimedia Impact. This SEP provides benefit to the adjacent wetlands and associated habitat, to the downstream perennial waters, and to the Occohannock Creek, which ultimately drains into the Chesapeake Bay.

6. Pollution Prevention. The SEP improvements primarily remove sediments but also result in pollution prevention by treating and removing 10-20% of nitrogen and phosphorus nutrients from stormwater runoff annually.

SUPPLEMENTAL ENVIRONMENTAL PROJECT DESCRIPTION

Engineering Construction Plan

The owner operates a large tomato farm in the Grapeland area of Accomack County. This plasticulture operation for growing tomatoes utilizes plastic sheet film to cover mounded crop rows. This whole system approach allows controlled drip irrigation with measured application of fertilizer (fertigation) to result in production of high quality, high yielding horticultural products in an environmentally sound manner. Most of the plots on this farm are using drainage ditches that have been constructed to drain back to irrigation ponds thereby capturing and recycling water, sediments, and nutrients. There is one 22-acre plot within a Bojac fine sandy loam soil series that is not tied into this drain-back system because of relationships in topography and drainage patterns. Instead, this plot drains (as many agricultural farms do, toward ditches and established drainageways) unmitigated toward a wetland with intermittent stream.

This SEP provides stormwater quality management. Currently, the subject farm plot drains via shallow field ditches that drain into five lateral ditches used to convey the stormwater to a header ditch that runs parallel to the farm road (see Figure 2). The header ditch drains into the main ditch that bisects the farm plot and empties directly into a wide forested wetland drainageway. This intermittent drainageway has no discernable channel for approximately 500-ft until it finally displays a preferred drainage pathway. Further downstream, the drainageway becomes perennial and flows into an unnamed tributary of Occohannock Creek, which in turn drains into the Chesapeake Bay. Evidence of sedimentation is observed where the field ditches drain into the lateral ditches and also observed in the header and main ditches and is seen as sediment bedload within the forested wetland drainageway.

The SEP will include physical and topographic survey of the subject farm plot and upper section of the receiving forested wetland drainageway, wetland delineation, engineering design of stormwater management improvements, and the construction of these improvements. The construction plan will consist of a system of improved grass channel conveyances with multiple pre-filter rock check-dams that are designed and constructed within the existing lateral and header ditches and include a terminus Type 1 Extended Detention Basin. This sedimentation basin will contain a spillway impoundment engineered to produce the required storage volume, detention time, and velocity attenuation to facilitate sedimentation and nutrient removal. The spillway will contain rock protection against scour and erosion from the released water.

No wetlands will be disturbed by the construction project however the sedimentation basin will likely be located within the CBPA RPA buffer area. The SEP engineering plan will be submitted to Northampton County for review and approval. Preliminary discussions with the County have been met with a very favorable reception.

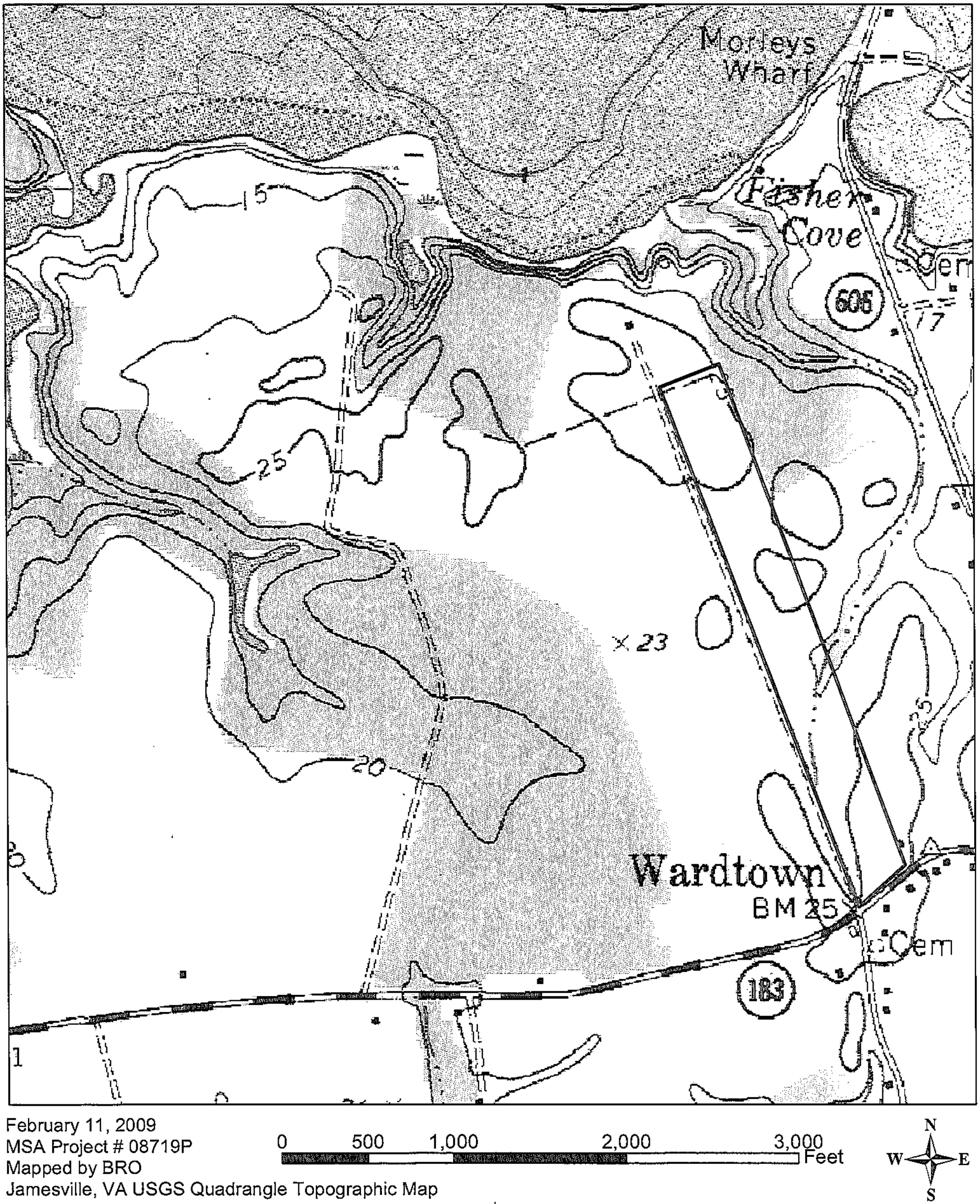
SEP Sequencing

- Wetland Delineation (1 day field)
- Physical and Topographic Survey (3 days surveying; 1-week drafting)
- Engineering Design (1-week)
- Agency/Municipal Reviews
- Construction of Pre-filter Rock Check Dams (1 week)
- Construction of Sedimentation Basin/Spillway; Establish E&S Controls (30 days)S
- Final Inspection/Documentation/Engineering Certificate of Completion (2 days)
- Time to complete = 30-days design and permitting; 45-days construction

Project Cost Estimates

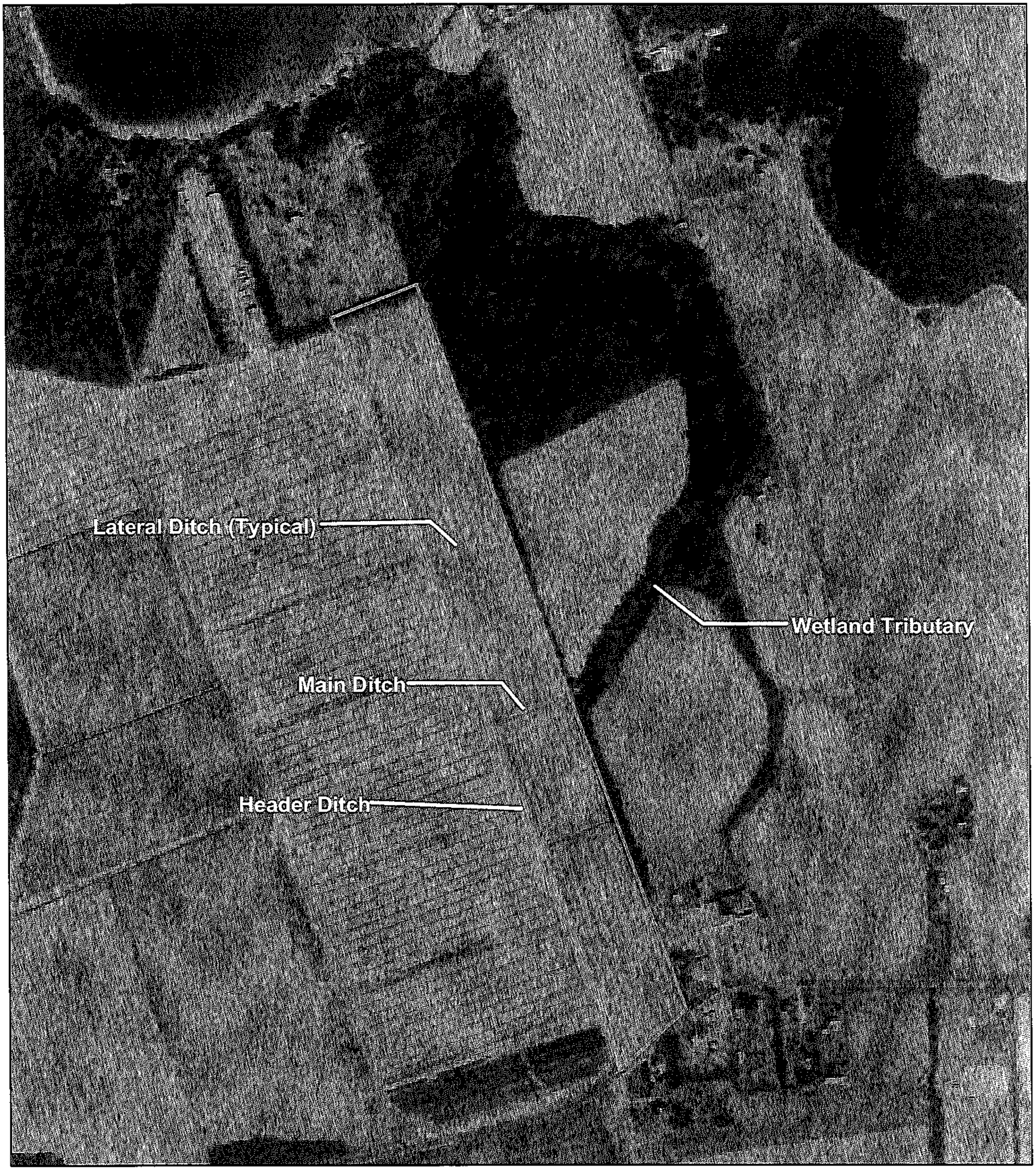
1) Wetland Delineation with ACOE Confirmation = $2,000
2) Physical and Topographic Survey = $2,500
3) Engineering Design = $8,500
4) Response to Agency/Municipal Reviews = $1,000
5) Construction of Pre-filter Rock Check Dams = $7,000
6) Construction of Sedimentation Basin/Spillway = $25,000
7) Final Inspection/Documentation/Report of Satisfactory Completion = $500
    - Net Estimated Project Cost: $46,500

Kuzzen's Grapeland Farm
Figure 1. USGS Topographic Vicinity Map Exhibit



February 11, 2009
MSA Project # 08719P
Mapped by BRO
Jamesville, VA USGS Quadrangle Topographic Map

Kuzzen's Grapeland Farm
Figure 2. 1994 Aerial Photograph Site Layout Exhibit



February 11, 2009
MSA Project # 08719P
Mapped by BRO
1994 Aerial Photograph from Virginia Gazetteer Geostat Aerials, Jamesville SE

0 250 500 1,000 1,500 2,000 Feet

N
W E
S

PRE-IMPROVEMENT CONDITIONS:

UNIVERSAL SOIL LOSS EQUATION (USLE)

A = R x K x LS x C x P

Symbol	Description	Value	Unit / Source
		Bojac fine sandy loam (BoA)	
R	rainfall and runoff factor	200	USDA, 1995
K	soil erodibility factor	0.24	USDA SCS, 1989
LS	slope length gradient factor (soil loss at site: 9% slope)	0.15	1% slope gradient, 100m slope length (Renard, et al., 1997)
C	crop/vegetation and management factor	0.4	seasonal horticulture (Wischmeier, 1978)
P	support practice factor	0.6	straight row farm; <2% slope (Brady, Weil, 1999)
A	potential annual erosion potential	1.728	tons/acre/year
Farm Area	contributing area for runoff production	22	acres
Erosion	potential mass of eroded sediment from the farm field	38.0	tons/year
		76,032	lbs/year
	Solids Produced	10,368	lbs/year (per 3-acre field drainage sector)

Symbol	Description	Value	Unit
ppt	annual average precipitation	45	in/year
CN	SCS Curve Number	67	
NRCS Hydrologic Soil Group		B	class
NRCS Hydrologic Soil Condition		Good	
S	Retention Volume	4.93	inches
R_s	Runoff Depth	40	in/year
I	Infiltration Depth	5	in/year
DA	drainage sector; area that drains through each check dam	3	ac
Q_{DA}	drainage volume through given drainage area	431,083	cf/year per rock check dam
		10,890	cf/1" storm event per rock check dam

PROPOSED STORMWATER MANAGEMENT PRACTICES:

Grass Channels with Check Dams		
Nitrogen Removal	20	% efficiency (1)
Phosphorus Removal	15	% efficiency (1)
Suspended Solids Removal	80	% efficiency (2)
Suspended Solids removed	8,294	lbs per check dam
	7	number of check dams
Total Suspended Solids removed	58,061	lbs per year
Suspended solids passing through check dams	17,971	lbs per year
Extended Detention, Level 1 Design		
Nitrogen Removal	10	% efficiency (3)
Phosphorus Removal	15	% efficiency (3)
Suspended Solids Removal	25	% efficiency (2)
Suspended Solids Removed	4,493	lbs (single detention basin)
TOTAL SOLIDS REMOVAL	**62,554**	**lbs/year**
percent efficiency	82	%

Sources:

Soil Survey of Northampton County Virginia, 1989. USDA - SCS.

Wischmeier, W.H., Smith, D.D., 1978. *Predicting Rainfall Erosion Losses*. Agricultural Handbook 537. USDA. Washington, DC, USA.

Brady, N.C., Weil, R.R., 1999. The Nature and Properties of Soils, 12th ed.Prentice Hall, Inc.

Renard, K.G., et al., 1997. Predicting Soil Erosion by Water: *A guide to conservation planning with the Revised Universal Soil Loss Equation*. Agricultrural Handbook no. 703. USDA. Washington, DC, USA.

Footnoted References:

1. Virginia DCR - Stormwater Design Specification No. 3: Grass Channels (Draft)
2. Design of Stormwater Filtering Systems, 1996. Claytor, R.A., and Schueler, T.R.; *Center for Watershed Protection*
3. Virginia DCR - Stormwater Design Specification No. 15: Extended Detention Ponds (Draft)

DRAFT VA DCR STORMWATER DESIGN SPECIFICATION No. 3

GRASS CHANNELS

VERSION 1.5

Note to Reviewers of the Stormwater Design Specifications

The Virginia Department of Conservation and Recreation (DCR) has developed an updated set of non-proprietary BMP standards and specifications for use in complying with the Virginia Stormwater Management Law and Regulations. These standards and specifications were developed with assistance from the Chesapeake Stormwater Network (CSN), Center for Watershed Protection (CWP), Northern Virginia Regional Commission (NVRC), and the Engineers and Surveyors Institute (ESI) of Northern Virginia. These standards and specifications are based on both the traditional BMPs and Low Impact Development (LID) practices. The advancements in these standards and specifications are a result of extensive reviews of BMP research studies incorporated into the CWP's National Pollution Removal Performance Database (NPRPD). In addition, we have borrowed from BMP standards and specifications from other states and research universities in the region. Table 1 describes the overall organization and status of the proposed design specifications under development by DCR.

Table 1: Organization and Status of Proposed DCR Stormwater Design Specifications; Status as of 9/24/2008

#	Practice	Notes	Status[1]
1	**Rooftop Disconnection**	Includes front-yard bioretention	2
2	**Filter Strips**	Includes grass and conservation filter strips	2
3	**Grass Channels**		2
4	**Soil Compost Amendments**		3
5	**Green Roofs**		1
6	**Rain Tanks**	Includes cisterns	2
7	**Permeable Pavement**		1
8	**Infiltration**	Includes micro- small scale and conventional infiltration techniques	2
9	**Bioretention**	Includes urban bioretention	3
10	**Dry Swales**		2
11	**OPEN**		
12	**Filtering Practices**		2
13	**Constructed Wetlands**	Includes wet swales	2
14	**Wet Ponds**		2
15	**ED Ponds**		2

[1] Codes: 1= partial draft of design spec; 2 = complete draft of design spec; 3 = Design specification has undergone one round of external peer review as of 9/24/08

Reviewers should be aware that these draft standards and specifications are just the beginning of the process. Over the coming months, they will be extensively peer-reviewed to develop standards and specifications that can boost performance, increase longevity, reduce the maintenance burden, create attractive amenities, and drive down the unit cost of the treatment provided.

Timeline for review and adoption of specifications and Role of the Virginia's Stormwater BMP Clearinghouse Committee:

The CSN will be soliciting input and comment on each standard and specification until the end of 2008 from the research, design and plan review community. This feedback will ensure that these design standards strike the right balance between prescription and flexibility, and that they work effectively in each physiographic region. The collective feedback will be presented to the BMP Clearinghouse Committee to help complement their review efforts. The Virginia Stormwater BMP Clearinghouse Committee will consider the feedback and recommend final versions of these BMP standards and specifications for approval by DCR.

The revisions to the Virginia Stormwater Management Regulations are not expected to become finalized until late 2009. The DCR intends that these stormwater BMP standards and specifications will be finalized by the time the regulations become final.

The Virginia Stormwater BMP Clearinghouse Committee will consider the feedback and recommend final versions of these BMP standards and specifications for approval by DCR, which is vested by the Code of Virginia with the authority to determine what practices are acceptable for use in Virginia to manage stormwater runoff.

As with any draft, there are several key caveats, as outlined below:

- Many of the proposed design standards and specifications lack graphics. Graphics will be produced in the coming months, and some of graphics will be imported from the DCR 1999 Virginia Stormwater Management (SWM) Handbook. The design graphics shown in this current version are meant to be illustrative. Where there are differences between the schematic and the text, the text should be considered the recommended approach.
- There are some inconsistencies in the material specifications for stone, pea gravel and filter fabric between ASTM, VDOT and the DCR 1999 SWM Handbook. These inconsistencies will be rectified in subsequent versions.
- While the DCR 1999 SWM Handbook was used as the initial foundation for these draft standards and specifications, additional side-by-side comparison will be conducted to ensure continuity.
- Other inconsistencies may exist regarding the specified setbacks from buildings, roads, septic systems, water supply wells and public infrastructure. These setbacks can be extremely important, and local plan reviewers should provide input to ensure that they strike the appropriate balance between risk aversion and practice feasibility.

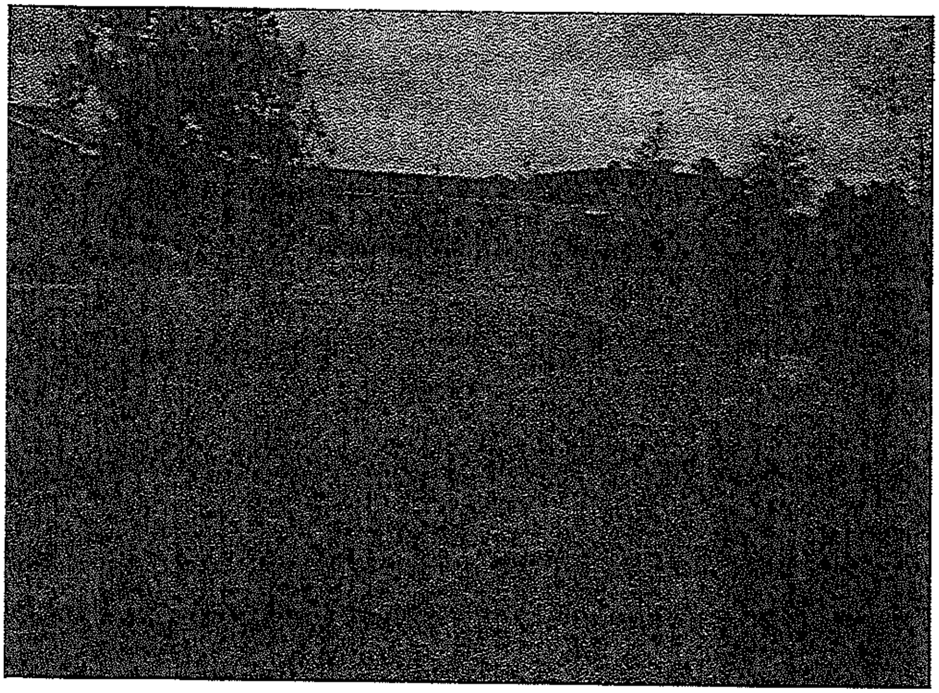
These practice specifications will be posted in Wikipedia fashion for comment on the Chesapeake Stormwater Network's web site at http://www.chesapeakestormwater.net, with instructions regarding how to submit comments, answers to remaining questions about the practice, useful graphics, etc. DCR requests that you provide an email copy of your comments, etc., to Scott Crafton (scott.crafton@dcr.virginia.gov). The final version will provide appropriate credit and attribution on the sources from which photos, schematics, figures, and text were derived.

Thank you for your help in producing the best stormwater design specifications for the Commonwealth.

DRAFT VA DCR STORMWATER DESIGN SPECIFICATION No. 3

GRASS CHANNELS

VERSION 1.5



SECTION 1: DESCRIPTION OF PRACTICE

Grass Channels can provide runoff filtering and treatment within the conveyance system and produce less runoff and pollutants than a traditional system of curb and gutter, storm drain inlets, and pipes. Grass channels provide a modest amount of runoff reduction and pollutant removal that varies depending on the underlying soil permeability (Table 1). Grass Channels, however, are not capable of providing the same stormwater functions as Dry Swales, as they lack the engineered soil media and storage volumes (see Design Specification No. 10). Their runoff reduction performance can be boosted when Soil Compost Amendments are added to the bottom of the swale (See Specification No. 4). Grass channels are a preferable alternative to both curb and gutter and storm drains as a stormwater conveyance system where development density, topography and soils permit.

SECTION 2: PERFORMANCE CRITERIA

Table 1: Stormwater Functions of Grass Channels

Stormwater Function	HSG Soils A and B	HSG Soils C and D	
	No CA [2]	No CA	With CA
Annual Runoff Reduction Rate	20%	10%	20%
Total Phosphorus Removal [1]	15%	15%	
Total Nitrogen Removal [1]	20%	20%	
Channel Protection	Moderate. RRv can be subtracted from CPv		
Flood Mitigation	Partial. Reduced Curve Numbers and Time of Concentration		

[1] Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate and will be higher than these percentages, as calculated using the Runoff Reduction Spreadsheet Methodology.
[2] CA= Compost Amended Soils, see Design Specification No. 4.
Sources: CWP and CSN (2008), CWP, 2007

SECTION 3: PRACTICE APPLICATIONS AND FEASIBILITY

Grass channels can be implemented on suitable development sites where development density, topography, and soils are suitable. Key constraints for grass channels include the following:

Contributing Drainage Area (CDA): The maximum contributing drainage area to a grass channel should be 5 acres and preferably less. When grass channels treat larger drainage areas, the velocity through the channel becomes too great to treat runoff or prevent erosion in the channel.

Available Space: The footprint of a grass channel is approximately 5-15% of the size of the CDA.

Longitudinal Slope: Grass channels can be used on sites with longitudinal slopes of less than 4%, but preferably less than 2%. Steeper slopes create rapid runoff velocities that can cause erosion and do not allow enough contact time for infiltration or filtering, unless check dams are used.

Soils: Grass channels can be applied on sites with any type of soils. However, grass channels situated on Hydrologic Soil Group (HSG) D soils should have a maximum velocity of 1 foot per second (fps) during a one-inch storm.

Hydraulic Capacity: Grass channels are an on-line practice and must be designed with enough capacity to convey runoff from the 10-year storm and be non-erosive during the 2-year design storm. This means that the much of the surface dimensions are driven by the need to pass these larger storm events.

Depth to Water Table: Designers should ensure that the bottom of the grass channel is at least 2 feet above the seasonally high water table to ensure groundwater does not intersect the filter bed, as this could lead to groundwater contamination or practice failure.

Utilities: Designers should consult local utility design guidance for the horizontal and vertical clearance between utilities and the channels. Utilities can cross grass channels if they are specially protected (e.g., double-casing) or are located below the channel invert.

Hotspot Land Uses: Grass channels are not recommended to treat stormwater hotspots, due to the potential for infiltration of hydrocarbons, trace metals, and other pollutants into groundwater. For a list of designated stormwater hotspots, consult the Infiltration Design Specification (No. 8).

Minimum Setbacks: Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, utilities, and wells. As a general rule, grass channels should be setback at least 10 feet downgradient from building foundations, 50 feet from septic system fields and 100 feet from private wells.

SECTION 4: COMMUNITY AND ENVIRONMENTAL CONCERNS

The main concerns of adjacent residents are perceptions that grass channels will create nuisance conditions or will be hard to maintain. Common concerns include the continued ability to mow grass, landscape preferences, weeds, standing water, and mosquitoes. Dry swales are a much better alternative.

SECTION 3: DESIGN APPLICATIONS AND VARIATIONS

Designers should always check to see if dry swales can be installed at the site, given their greater runoff reduction and pollutant removal capability (see Specification No. 10).

The linear nature of grass channels makes them well-suited to treat highway or low-to-medium density residential road runoff, if there is an adequate right-of-way width and distance between driveways. Grass channels are not recommended when residential density exceeds 4 dwelling units per acre, due to a lack of available land and the frequency of driveway crossings along the channel. Grass channels can also provide pretreatment for other stormwater treatment practices.

SECTION 6: SIZING AND TESTING GUIDANCE

Unlike other stormwater practices, grass channels are designed base on a rate of flow. Designers must demonstrate that the channel will have the following:

- Maximum flow velocity of less than 1 foot per second for a 1-inch storm event.
- Minimum hydraulic residence through the channel of 10 minutes for the 2-year storm event.
- Maximum flow velocity of no more than 3 feet per second for the 2-year storm event.

- Sufficient channel capacity to safely convey the ten year design storm event. Peak flows from the 2-year and 10-year, 24-hour storm events must not overtop the channel banks nor create soil erosion.

(NOTE: As DCR moves forward, the above requirement will be driven by the Va. SWM Regulations (4 VAC 50-60-66 A 1 and B 1). MS-19 will be superceded.)

Detailed methods for sizing grass channels are provided in Appendix A.

SECTION 7: DESIGN CRITERIA

7.1: Level 1 and Level 2 Design

Grass channels have only one level of design. All channels must meet the minimum criteria outlined in Table 2 to qualify for the indicated level of runoff reduction.

Table 2 - Grass Channel Design Guidance
A maximum residential density of no more than 4 dwelling units per acre.
The bottom width of the channel should be between 4-8 feet wide.
Channel side-slopes should be no steeper than 3H:1V.
5 acre maximum contributing drainage area to any individual grass channel.
Length of the grass channel should be equal to or greater than the roadway length.
The longitudinal slope of the channel should be no greater than 2%. (Check dams may be used to break up slopes on steeper swales.)
Channel has a maximum flow velocity of less than 1 foot per second during a one-inch storm event.
The dimensions of the channel should ensure that runoff velocity is non-erosive during the 2-year storm event and safely convey the locals design storm (e.g., 10-year storm event).
Note 1: Runoff reduction can be increased if combined with soil compost amendments (Design Specification No. 4). **Note 2:** Where feasible, the dry swale is always the preferable option due to its greater runoff reduction and pollutant reduction capability.

7.2: Pretreatment

Pretreatment is recommended for grass channels to dissipate energy, trap sediments, and slow down runoff velocity. The nature of pretreatment depends on whether the channel will experience sheet flow or concentrated channel flow. Several reliable options are provided below:

***Check dams* (channel flow):** The most common form of pretreatment is the use of wooden or stone check dams (see Section 7.3).

***Tree Check dams* (channel flow):** These are street tree mounds that are placed within the bottom of grass channels up to an elevation of 9-12 inches above the channel invert. One side has a gravel or river stone bypass to allow runoff to percolate through (Cappiella et al, 2006).

***Grass Filter Strip* (sheet flow):** Grass filter strips extend a minimum of 10 feet from edge of pavement to the channel, with a slope of less than 5%.

***Pea Gravel Flow Spreader* (sheetflow):** Extends along the top of the bank to pretreat lateral runoff from the road shoulder to the channel and involves a 2-4 inch drop from a hard-edged surface into a gravel or stone diaphragm.

7.3: Check dams

Check dams may be used for pretreatment, to break up slopes, and to increase the hydraulic residence time in the channel. Check dams should be spaced based on the channel slope and ponding requirements, using the equations in Appendix A. Other design requirements for check dams are as follows:

- Check dams must be firmly anchored into the sideslopes to prevent outflanking and be stable during the design storm event.
- The maximum ponding depth in a swale should not exceed 18 inches at the most downstream point. The average ponding depth throughout the swale should be 12 inches.
- The check dam should be designed in such a manner to facilitate easy mowing.
- Each check dam should have a weep hole or similar drainage feature so it can dewater after storms.
- Armoring may be needed behind the check dam to prevent erosion, and the check dam shall be designed to spread runoff evenly over its surface.
- Check dams should be composed of wood or stone, or be configured with elevated driveway culverts.
- Individual swale segments formed by check dams or driveways should generally be at least 25 to 40 feet in length.

7.4: Geometry and Site Layout

- Grass channels should be designed with a trapezoidal or parabolic cross section. A parabolic shape is preferred for grass swales for aesthetic, maintenance, and hydraulic reasons. Trapezoidal channels will generally evolve into parabolic channels over time, so the initial trapezoidal cross-section design should be checked for capacity and conveyance assuming it is a parabolic cross-section.

- The bottom width of the channel should be between 4-8 feet wide. If a channel will be wider than eight feet, designers should incorporate berms, check dams, level spreaders, or multi-level cross sections to prevent braiding and erosion within the swale bottom.

- The slope of the channel should be between 1% and 2%, although slopes up to 4% are acceptable if check dams are used.

- The maximum flow depth for the water quality storm should correspond to 2/3 the height of the vegetation or about 4 inches.

- Grass channel side slopes should be no steeper than 4:1 for ease of mowing. Flatter slopes are encouraged where adequate space is available to aid in pretreatment of sheet flows entering the channel. Under no circumstances are side slopes to exceed 3:1 (H:V).

7.5: Compost Soil Amendments

Soil compost amendments can double the runoff reduction capability of a grass channel. Several design criteria apply when compost amendments are used:

- The compost amended strip should extend over the length and width of the channel bottom and be incorporated to a depth of 1 foot, as outlined in Design Specification No. 4.

- The amended area will need to be rapidly stabilized with perennial, salt tolerant grass species.

- For grass channels on steep slopes, it may be necessary to install a protective biodegradable geotextile fabric.

- Designers need to ensure that the final elevation of the grass channel meets original hydraulic capacity.

7.6: Planting Grass Channels

Designers should choose grass species that can withstand both wet and dry periods as well as relatively high velocity flows within the channel. For applications along roads and parking lots, salt tolerant species should be chosen. Taller and denser grasses are preferable, though the species of grass is less important than good stabilization. For a list of grass species suitable for use in grass channels, consult the Virginia Erosion Control Handbook.

Grass channels should be seeded at such a density to achieve a 90% turf cover after the second growing season. Grass channels should be seeded and not sodded. Seeding establishes deeper roots and sod may have muck soil that is not conducive to infiltration (Wisconsin DNR, 2007). Grass channels should be protected by a biodegradable erosion control fabric to provide immediate stabilization of the bed and banks.

SECTION 8: REGIONAL AND CLIMATE DESIGN ADAPTATIONS

8.1: Karst Terrain

Grass channels are an acceptable practice in the active karst regions of the Ridge and Valley province of the Bay watershed, as long as they do not treat hotspot runoff.

8.2: Coastal Plain

Grass swales work well at many coastal plain sites, where flat terrain, high water table, and low-head conditions are characteristic. In extremely flat terrain, designers may lack enough grade for check dams to drive the system. In these situations, the following design adaptations apply:

- The minimum depth to the seasonally high water table can be 1 foot.
- A minimum slope of 0.5% must be maintained to ensure positive drainage.
- The grass channel may have off-line cells and should be tied into the ditch system.

8.3: Steep Terrain

Grass swales are not practical in areas of steep terrain, although terracing a series of grass swale cells may work down slopes from 5 to 10%. The drop in slope between check dams should be limited to 1 foot, and be armored on the downslope side with suitably sized stone to prevent erosion.

8.4: Winter Performance

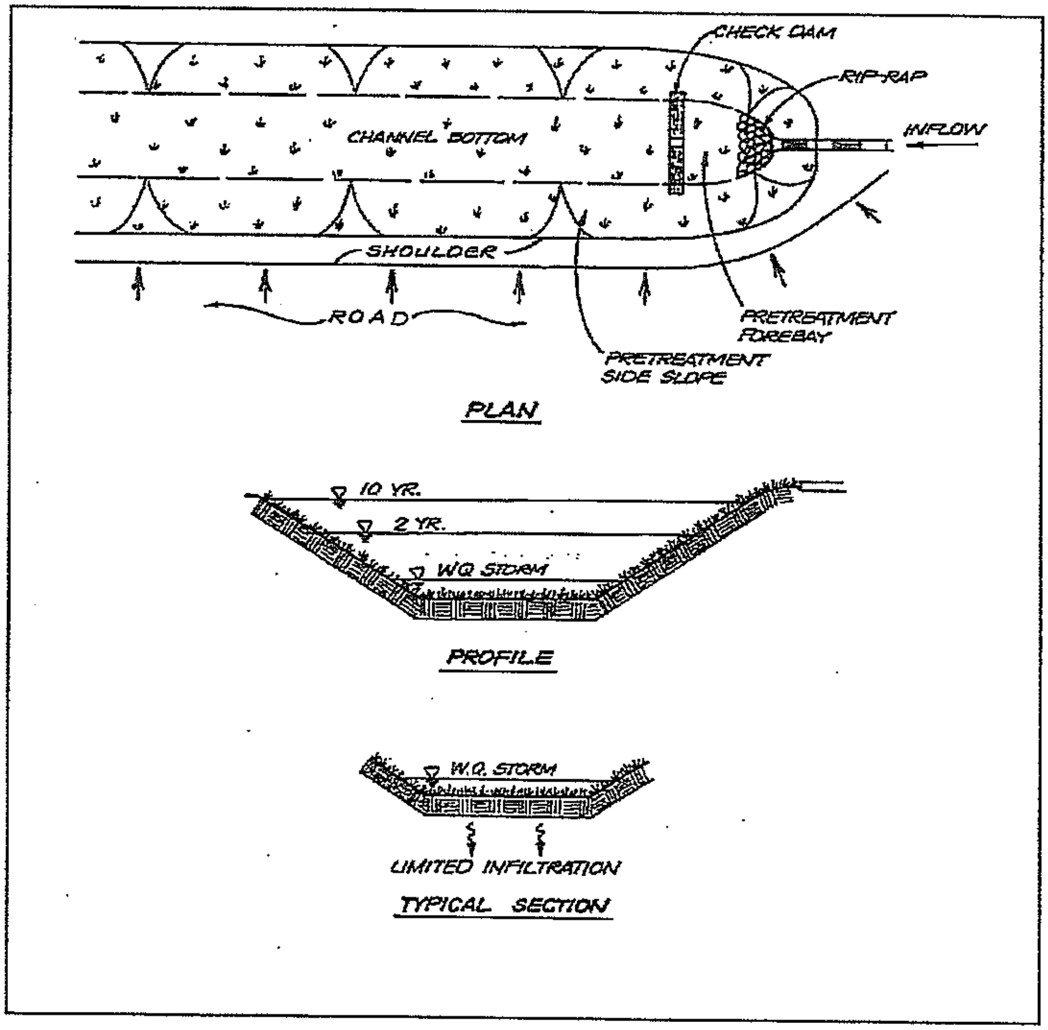
Grass swales can store snow and treat snowmelt runoff when they serve road or parking lot drainage. If roadway salt is applied in their contributing drainage area (CDA), grass swales should be planted with salt-tolerant species. Consult the Minnesota Stormwater Manual for a list of salt-tolerant grass species (MSSC, 2005).

(NOTE: For the Virginia spec we will need to develop a Virginia-specific reference – perhaps VDOT – or include a table of such species for Virginia, rather than refer to another State's specs. DCR will figure this one out.)

8.5: Linear Highway Sites

Grass swales are a preferred stormwater practice for linear highway sites.

SECTION 9: TYPICAL GRAPHIC DETAILS



SECTION 10: MATERIAL SPECIFICATIONS

Table 3: Design Specifications for Grass Channels	
Component	Specification
Grass	A dense cover of water-tolerant, erosion-resistant grass. The selection of an appropriate species or mixture of species is based on several factors including climate, soils, topography, and sun or shade tolerance. Grass species should have the following characteristics: a deep root system to resist scouring; a high stem density with well-branched top growth; water-tolerance; resistance to being flattened by runoff; and an ability to recover growth following inundation.
Check Dams	▪ Check dams should be constructed of a non-erosive material such as wood, gabions, riprap, or concrete. All check dams should be underlain with filter fabric conforming to local design standards. ▪ Wood used for check dams should consist of pressure treated logs or timbers, or water-resistant tree species such as cedar, hemlock, swamp oak, or locust. ▪ Computation of check dam material is needed based on surface area and depth used in design computations.(see Appendix A)
Diaphragm	Pea gravel used to construct pretreatment diaphragms should consist of washed, open graded course aggregate between 3 and 10 mm in diameter and must conform to local design standards.
Erosion Control Fabric	Where flow velocities dictate, biodegradable erosion control netting or mats conforming to Standard and Specification 3.36 of the Virginia Erosion and Sediment Control Handbook that are durable enough to last at least two growing seasons should be used.
Filter Fabric (check dams)	Needled, non-woven, polypropylene geotextile meeting the following specifications should be used: Grab Tensile Strength (ASTM D4632): $\geq$ 120 lbs Mullen Burst Strength (ASTM D3786): $\geq$ 225 lbs/in^2 Flow Rate (ASTM D4491): $\geq$ 125 gpm/ft^2 Apparent Opening Size (ASTM D4751): US #70 or #80 sieve

SECTION 11: CONSTRUCTION SEQUENCE AND INSPECTION

11.1: Construction Sequence

The following is a typical construction sequence to properly install a grass swale, although steps may be modified to reflect different site conditions. Grass channels should be installed at a time of year that is best to establish turf cover without irrigation. Some local agencies restrict planting to the following periods of time: February 15 through April 15, and September 15 through November 15.

Step 1: Protection during Site Construction. Ideally, grass channels should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. However, this is seldom practical given that the channels are a key part of the drainage system at most sites. In these cases, temporary ESC controls such as dikes, silt fences, and other erosion control measures should be integrated into the swale design throughout the construction sequence. Specifically, barriers should be installed at key check dam locations and erosion control fabric used to protect the channel.

Step 2: Grass channel installation may only begin after the entire contributing drainage area has been stabilized vegetatively. Any accumulation of sediments that does occur within the channel must be removed during the final stages of grading to achieve the design cross-section. Erosion and sediment controls for construction of the grass channel should be installed as specified in the erosion and sediment control plan. Stormwater flows must not be permitted into the grass channel until the bottom and side slopes are fully stabilized.

Step 3: Grade grass channel to final dimensions shown on plan.

Step 4: Install check dams, driveway culverts and internal pretreatment features as per plan. Fill to construct check dams should be placed in 8-12 inch lifts and compacted to prevent settlement. The top of the check dam should be constructed level at the design elevation.

Step 5 (Optional): Till the bottom to a depth of 1 foot and incorporate compost amendments per Design Specification No. 4.

Step 6: Add soil amendments as needed, hydro-seed bottom and banks of grass channel, and peg in erosion control fabric or blanket where needed. After initial planting, a biodegradable erosion control fabric conforming to Standard and Specification 3.36 of the Virginia Erosion and Sediment Control Handbook should be used.

Step 7: Prepare planting holes for any trees and shrubs and plant materials as shown in the landscaping plan, and water them weekly in the first two months. The construction contract should include a care and replacement warranty to ensure vegetation is properly established and survives during the first growing season following construction.

Step 8: Conduct final construction inspection and develop punchlist for facility acceptance.

11.2: Construction Inspection

Inspections during construction are needed to ensure that the grass channel is built in accordance with these specifications. An example construction phase inspection checklist for grass channels can be accessed at Center for Watershed Protection (CWP) website at

http://www.cwp.org/Resource_Library/Center_Docs/SW/pcguidance/Tool6.pdf .

The following are some common pitfalls that can be avoided by careful post-storm inspection of the grass channel:

- Make sure the desired coverage of turf or erosion control fabric has been achieved following construction, both on the beds and their contributing sideslopes.

- Inspect check dams and pretreatment structures to make sure they are at correct elevations, are properly installed, and are working effectively.

- Outfall protection/energy dissipation at concentrated inflow (?) should be stable.

The real test of a grass swale occurs after its first big storm. Minor adjustments are normally needed as part of this post-storm inspection, such as spot reseeding, gully repair, added armoring at inlets, or realignment of outfalls and check dam.

SECTION 12: OPERATION AND MAINTENANCE

12.1: Maintenance Agreements

All grass channels must be covered by a drainage easement to allow inspection and maintenance. If grass channel is located in a residential private lot, the existence and purpose of the grass channel shall be noted on the deed of record. Homeowners will need to be provided a simple document that explains their purpose and routine maintenance needs. Legally binding maintenance agreements are needed for all grass channels that not only specify the property owner's responsibilities but also authorize local agencies to access the property for inspection or corrective action.

12.2: Maintenance Inspections

Annual inspections are used to trigger maintenance operations such as sediment removal, spot revegetation and inlet stabilization. Several key maintenance inspection points are detailed in Table 4. Ideally, inspections should be conducted in the spring of each year. An example maintenance inspection checklist for grass channels can be accessed at CWP website at

http://www.cwp.org/Resource_Library/Center_Docs/SW/pcguidance/Tool6.pdf

12.3: Ongoing Maintenance

Once established, grass channels have minimal maintenance needs outside of the spring clean-up, regular mowing, repair of check dams, and other measures to maintain the hydraulic efficiency of the channel and a dense, healthy grass cover.

Table 4: Suggested Spring Maintenance Inspections/Cleanups for Grass Channels Activity
• Add reinforcement planting to maintain 90% turf cover. Reseed any salt killed vegetation.
• Remove any accumulated sand or sediment deposits behind check dams.
• Inspect upstream and downstream of check dams for evidence of undercutting or erosion, and remove and trash or blockages at weepholes.
• Examine channel bottom for evidence of erosion, braiding, excessive ponding, or dead grass.

• Check inflow points for clogging and remove any sediment.
• Inspect side slopes and grass filter strips for evidence of any rill or gully erosion and repair.
• Look for any bare soil or sediment sources in the contributing drainage area and stabilize immediately.

SECTION 13: REFERENCES

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APPENDIX A

Guidance on Water Quality Design and Check Dams for Grass Channels

(adapted from Northern Virginia Regional Commission, 2008)

Man-made channels should be designed to convey the 2-year and 10-year peak discharges within the channel. The maximum velocity for the 2-year peak discharge should be 3 feet per second.

(NOTE: As DCR moves forward, the above requirement will be driven by the Va. SWM Regulations (4 VAC 50-60-66 A.1 and B.1). MS-19 will be superceded.)

The hydraulic capacity of swales should be calculated using Manning's Formula. For grass swales, an "n" value of 0.2 should be used for flow depths up to four inches, decreasing to 0.03 at a depth of 12 inches (Haan et. al, 1994). For swales vegetated with a combination of native grasses, other types of ground covers, and shrubs, an "n" value of 0.15 should be used.

Water Quality Design Flow Method

For grass swales that function primarily as conveyance systems, a recommended swale design for water quality treatment based on the peak flow from a 2-inch **(NOTE: 2-year?)** 24-hour storm is used. The peak water quality flow should be increased along the swale length to reflect inflow. If a single design flow is used, the flow at the outlet should be used.

The peak water quality flow should be conveyed at a maximum depth equal to or less than 3 inches. The maximum velocity for the peak water quality flow should be 1.0 ft/sec. Flow velocity is computed using the continuity equation shown in Equation A-1.

The minimum hydraulic residence time (i.e., the time for water to travel the full length of the vegetated surface of the swale) should be about 10 minutes (Washington State Department of Ecology, 2005). If flow enters the swale at several locations, a nine minute minimum hydraulic residence time should be demonstrated for each entry point. Equation A-1 for flow velocity and A-2 for swale length are provided to design a minimum hydraulic residence time of ten minutes.

Equation A-1 Flow Velocity for Grassed Swales

$$V = Q / A$$

where:

V = the design flow velocity (ft/sec)
Q = the design flow (cfs)
A = the cross-sectional area (ft^2) of flow at design depth

Equation A-2 Grass Swale Length For Hydraulic Residence Time of Nine Minutes

$$L = 600V$$

where:

L = the minimum swale length (ft)
V = the design flow velocity (ft/sec)

The minimum length may be achieved with multiple swale segments connected by culverts with energy dissipaters. If flow enters the swale evenly along its entire length, then the minimum hydraulic residence time is taken as 20 minutes and twice the minimum swale length as determined using Equation A-2.

Where Check Dams Are Used

Check dams may be placed along the length of the swale to extend the detention of stormwater storage and to enhance water quality treatment. The maximum height of check dams should be 1.5 feet. As elsewhere along the swale, a minimum freeboard of six inches may be required at the top of the swale during the ten-year, 24-hour storm. Check dams should be located and sized so that the ponded water does not create a tailwater condition on incoming pipes and so the ponded water does not reach the toe of the upstream check dam. The length of the channel segment over which water ponds is a function of the slope of the swale and the height of the check dam as indicated in Equation A-3.

Equation A-3 Length of the Channel Segment for Check Dams

$$L = h / s$$

where:

L = the length of channel segment (ft)
h = the Height of check dam (ft)
s = the channel slope

Check dams should be designed to prevent erosion at locations where the check dams intersect the channel side walls. Channel segment lengths for various combinations of check dam height and channel slope that may be used for preliminary design are listed in Table A-1. Check dams should be anchored into the swale wall a minimum of two to three feet on each side according to the Virginia Erosion and Sediment Control Handbook (VESCH), 1992).

Table A-1 Channel Segment Length

Check Dam Height (ft)	Channel Slope %				
	1	2	3	4	5
0.5	50	25	16.7	12.5	10
1.0	100	50	33.3	25	20
1.5	150	75	50	37.5	30

The volume stored behind a check dam is the average channel cross-section area at the ponding elevation multiplied by the length of the channel reach subject to ponding. Because the channel cross-section area is zero at the head of the reach, the average cross-section area is one half of the cross-section area at the check dam. Equation A-4 is provided to size check dams for water quality enhancement.

Equation A-4 Storage Volume Behind an Individual Check Dam

$V_s = L \times 0.5A$

where:

V_s = the volume of storage (ft^3)
A = the cross-section area (ft^2) of flow at design depth
L = the length of channel segment (ft)

The channel cross-section area for a trapezoidal channel is determined using Equation A-5. The channel cross-section areas of a trapezoidal channel with 3:1 side slopes for various combinations of check dam height and bottom width that may be used for preliminary design are listed in Table A-2.

Equation A-5 Check Dam Channel Cross-Sectional Area (trapezoidal channel)

$A = by + Zy^2$

where:

b = the bottom width of the channel (ft)
y = the flow depth (ft)
Z = the side slope length per unit height (e.g., Z = 3 if side slopes are 3H:1V)

Table A-2 Channel Cross-section Area ft^2 (trapezoidal channel with side slopes at 3H:1V)									
Check Dam Height (ft)	Bottom Width (ft)								
	2	3	4	5	6	7	8	9	10
0.5	**1.75**	**2.25**	**2.75**	**3.25**	**3.75**	**4.25**	**4.75**	**5.25**	**5.75**
1.0	**5.00**	**6.00**	**7.00**	**8.00**	**9.00**	**10.00**	**11.00**	**12.00**	**13.00**
1.5	**9.75**	**11.25**	**12.75**	**14.25**	**15.75**	**17.25**	**18.75**	**20.25**	**21.75**

DRAFT VA DCR STORMWATER DESIGN SPECIFICATION No. 15

EXTENDED DETENTION (ED) PONDS

VERSION 1.5

Note to Reviewers of the Stormwater Design Specifications

The Virginia Department of Conservation and Recreation (DCR) has developed an updated set of non-proprietary BMP standards and specifications for use in complying with the Virginia Stormwater Management Law and Regulations. These standards and specifications were developed with assistance from the Chesapeake Stormwater Network (CSN), Center for Watershed Protection (CWP), Northern Virginia Regional Commission (NVRC), and the Engineers and Surveyors Institute (ESI) of Northern Virginia. These standards and specifications are based on both the traditional BMPs and Low Impact Development (LID) practices. The advancements in these standards and specifications are a result of extensive reviews of BMP research studies incorporated into the CWP's National Pollution Removal Performance Database (NPRPD). In addition, we have borrowed from BMP standards and specifications from other states and research universities in the region. Table 1 describes the overall organization and status of the proposed design specifications under development by DCR.

Table 1. Organization and Status of Proposed DCR Stormwater Design Specifications: Status as of 9/24/2008

#	Practice	Notes	Status [1]
1	**Rooftop Disconnection**	Includes front-yard bioretention	2
2	**Filter Strips**	Includes grass and conservation filter strips	2
3	**Grass Channels**		2
4	**Soil Compost Amendments**		3
5	**Green Roofs**		1
6	**Rain Tanks**	Includes cisterns	2
7	**Permeable Pavement**		1
8	**Infiltration**	Includes micro- small scale and conventional infiltration techniques	2
9	**Bioretention**	Includes urban bioretention	3
10	**Dry Swales**		2
11	**OPEN**		
12	**Filtering Practices**		2
13	**Constructed Wetlands**	Includes wet swales	2
14	**Wet Ponds**		2
15	**ED Ponds**		2

[1] Codes: 1= partial draft of design spec; 2 = complete draft of design spec;
3 = Design specification has undergone one round of external peer review as of 9/24/08

Reviewers should be aware that these draft standards and specifications are just the beginning of the process. Over the coming months, they will be extensively peer-reviewed to develop standards and specifications that can boost performance, increase longevity, reduce the maintenance burden, create attractive amenities, and drive down the unit cost of the treatment provided.

Timeline for review and adoption of specifications and Role of the Virginia's Stormwater BMP Clearinghouse Committee:

The CSN will be soliciting input and comment on each standard and specification until the end of 2008 from the research, design and plan review community. This feedback will ensure that these design standards strike the right balance between prescription and flexibility, and that they work effectively in each physiographic region. The collective feedback will be presented to the BMP Clearinghouse Committee to help complement their review efforts. The Virginia Stormwater BMP Clearinghouse Committee will consider the feedback and recommend final versions of these BMP standards and specifications for approval by DCR.

The revisions to the Virginia Stormwater Management Regulations are not expected to become finalized until late 2009. The DCR intends that these stormwater BMP standards and specifications will be finalized by the time the regulations become final.

The Virginia Stormwater BMP Clearinghouse Committee will consider the feedback and recommend final versions of these BMP standards and specifications for approval by DCR, which is vested by the Code of Virginia with the authority to determine what practices are acceptable for use in Virginia to manage stormwater runoff.

As with any draft, there are several key caveats, as outlined below:

- Many of the proposed design standards and specifications lack graphics. Graphics will be produced in the coming months, and some of graphics will be imported from the DCR 1999 Virginia Stormwater Management (SWM) Handbook. The design graphics shown in this current version are meant to be illustrative. Where there are differences between the schematic and the text, the text should be considered the recommended approach.

- There are some inconsistencies in the material specifications for stone, pea gravel and filter fabric between ASTM, VDOT and the DCR 1999 SWM Handbook. These inconsistencies will be rectified in subsequent versions.

- While the DCR 1999 SWM Handbook was used as the initial foundation for these draft standards and specifications, additional side-by-side comparison will be conducted to ensure continuity.

- Other inconsistencies may exist regarding the specified setbacks from buildings, roads, septic systems, water supply wells and public infrastructure. These setbacks can be extremely important, and local plan reviewers should provide input to ensure that they strike the appropriate balance between risk aversion and practice feasibility.

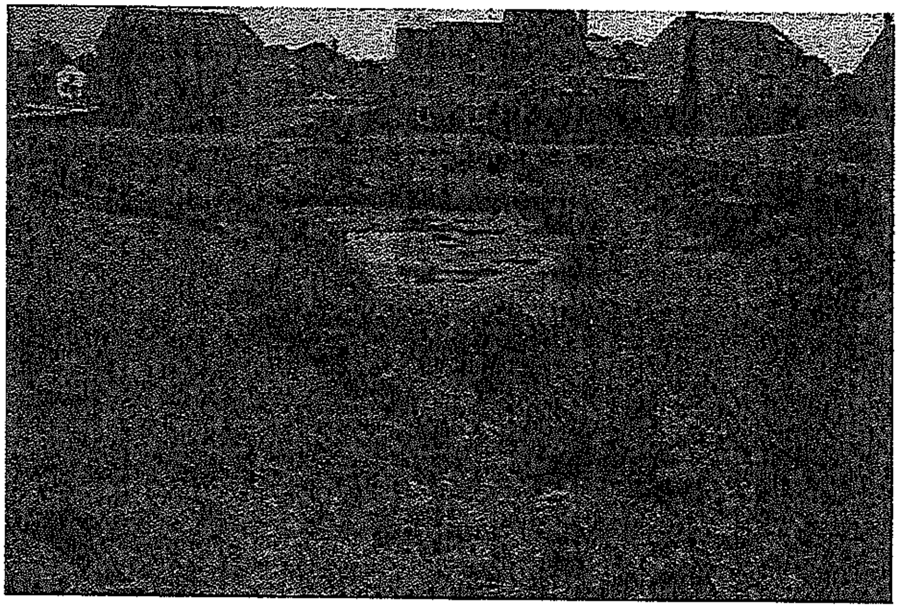
These practice specifications will be posted in Wikipedia fashion for comment on the Chesapeake Stormwater Network's web site at http://www.chesapeakestormwater.net, with instructions regarding how to submit comments, answers to remaining questions about the practice, useful graphics, etc. DCR requests that you provide an email copy of your comments, etc., to Scott Crafton (scott.crafton@dcr.virginia.gov). The final version will provide appropriate credit and attribution on the sources from which photos, schematics, figures, and text were derived.

Thank you for your help in producing the best stormwater design specifications for the Commonwealth.

DRAFT VA DCR STORMWATER DESIGN SPECIFICATION No. 15

EXTENDED DETENTION (ED) PONDS

VERSION 1.5



SECTION 1: DESCRIPTION OF PRACTICE

Extended Detention (ED) ponds rely on gravitational settling as their primary pollutant removal mechanism. Consequently, they generally provide fair to good removal of particulate pollutants but low or negligible removal for soluble pollutants, such as nitrate and soluble phosphorus. Extended Detention is different from stormwater detention, which is used for peak discharge or flood control purposes and often detains flows for just a few minutes or hours. This option relies on 12 to 24 hour detention of stormwater runoff after each rain event. An under-sized outlet structure restricts stormwater flow so it backs up and is stored within a pond or wetland. The temporary ponding enables particulate pollutants to settle and reduces stress on downstream banks. The use of ED alone generally has the lowest overall pollutant removal rate of any stormwater treatment option. As a result, ED is normally combined with wet ponds or constructed wetlands to maximize pollutant removal rates.

Designers should note that ED ponds are the final element in the roof to stream runoff reduction sequence, and **should only be considered after all other upland runoff reduction practices have been exhausted** and there is still a remaining water quality or channel protection volume to manage. Designers will need to submit documentation to the local plan review authority showing that all runoff reduction efforts were explored and were found to be insufficient.

SECTION 2: PERFORMANCE CRITERIA

Table 1: Summary of Stormwater Functions Provided by Wet Ponds		
Stormwater Function	**Level 1 Design**	**Level 2 Design**
Annual Runoff Reduction	0%	15%
Total Phosphorus Removal [1]	15%	15%
Total Nitrogen Removal [1]	10%	10%
Channel Protection	Moderate. (?) RRv can be subtracted from CPv (?)	
Flood Mitigation	Partial. (?) Reduced Curve Numbers and Time of Concentration (?)	
[1] Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate and will be higher than these percentages, as calculated using the Runoff Reduction Spreadsheet Methodology. **Sources:** CWP and CSN (2008), CWP, 2007		

SECTION 3. PRACTICE APPLICATIONS AND FEASIBILITY

The following feasibility issues need to be weighed when ED ponds are being considered as the final practice in a treatment train:

Space Required: A typical ED pond requires a footprint of 1-3% of its contributing drainage area, depending on the depth of the pond (the deeper the pond, the smaller footprint needed).

Contributing Drainage Area: A minimum contributing drainage area of 10 acres is recommended for ED ponds, in order to sustain a permanent micropool that prevents clogging. ED may still work on drainage areas less than 10 acres, but designers should be aware that these "pocket" ponds will typically have very small orifices that, depending on how they are installed, can be prone to clogging, cause fluctuating water levels, and generate future maintenance problems.

Available Hydraulic Head: The depth of an ED pond is usually determined by the amount of hydraulic head available on the site. The bottom elevation is normally set by the existing downstream conveyance system to which the ED pond discharges. Typically, a minimum of 6-10 feet of head is needed to construct an ED pond.

Minimum Setbacks: Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, and wells. Generally, ED ponds should be setback at least 10 feet from property lines, 25 feet from building foundations, 50 feet from septic system fields, and 100 feet from private wells.

Depth to Water Table and Bedrock: ED ponds are not allowed if the water table or bedrock will be within 2 feet of the floor of the pond.

Soils: The permeability of soils is seldom a design constraint for micropool ED ponds. Soil infiltration tests need to be conducted at proposed pond sites to estimate infiltration rates, which can be significant in Hydrologic Soil Group (HSG) A soils and some group B soils. Infiltration through the bottom of the pond is encouraged unless it will impair the integrity of the embankment. Geotechnical tests should be conducted to determine the infiltration rates and other subsurface properties of the soils underlying the proposed ED pond. If these tests indicate the site has active karst features, an alternative practice or combination of practices should be employed at the site. See Technical Bulletin No.1 (CSN, 2008) for guidance on stormwater design in karst terrain.

Trout Streams: The use of ED ponds in watersheds containing trout streams is restricted to situations where upland runoff reduction practices cannot meet the full channel protection volume. In these instances, a micrpool ED pond must be designed with (1) a maximum 12 hour detention time, (2) have the minimum pool volume needed to prevent clogging, (3) be planted with trees so it becomes fully shaded, and (4) be located outside of any required stream buffers.

Perennial streams: Locating dry ED ponds on perennial streams is strongly discouraged, and will require both a Section 401 and Section 404 permit from the appropriate state or federal permitting authority.

SECTION 4. COMMUNITY AND ENVIRONMENTAL CONSIDERATIONS

There are several community and environmental concerns related to ED Ponds to anticipate during design, as follows:

Aesthetics: ED ponds tend to accumulate sediment and trash, which residents are likely to perceive as unsightly and a nuisance. Fluctuating water levels in ED ponds also create a difficult landscaping environment. In general, designers should avoid designs that rely solely on dry ED.

Existing Wetlands: ED ponds should not be constructed within existing natural wetlands nor should they inundate or otherwise change the hydroperiod of existing wetlands.

Existing Forests: Designers can expect a great deal of neighborhood opposition if they do not make a concerted effort to save mature trees during ED pond design and layout. Optimally, the pond layout should be located and designed to avoid the need to cut down mature trees. Designers should also be aware that even modest changes in inundation frequency could kill upstream trees (Wright *et al.,* 2007).

Stream Warming Risk: ED ponds have less risk of stream warming than other pond options, but they can warm streams if they are unshaded or contain significant surface area in shallow pools. If an ED pond discharges to temperature-sensitive waters, its banks should be forested, it should contain the minimum pools to prevent clogging, and it should have a maximum detention time of 12 hours or less.

Safety Risk: ED ponds are generally considered to be safer than other pond options since they have few deep pools. Steep side-slopes and unfenced headwalls, however, can still create some safety risks.

Mosquito Risk: The fluctuating water levels within ED ponds have potential to create conditions that lead to mosquito breeding. Mosquitoes tend to be more prevalent in irregularly flooded ponds than in ponds with a permanent pool (Santana *et al.*, 1994). Designers can minimize the risk by combining ED with a wet pond or wetland.

SECTION 5. DESIGN APPLICATIONS AND VARIATIONS

ED is normally combined with other stormwater treatment options such as wet ponds, sand filters and constructed wetlands to enhance its performance and appearance. The most common design variations for ED include:

- Micropool Extended Detention
- Wet Extended Detention Pond (covered in the Wet Pond Design Specification, No. 14)
- Limited ED above Wetlands (Covered in the Constructed Wetlands Design Specification, No, 13)

Figure 1 illustrates several ED pond design variations. It is important to stress that ED ponds **should never be used as a standalone stormwater practice** due to their poor runoff reduction capability. Designers should always maximize the use of upland runoff reduction practices, such as rooftop disconnections, small scale infiltration, rain tanks, bioretention, grass channels, and dry swales, which reduce runoff at its source rather than treating the runoff at the terminus of the storm drain system. Upland runoff reduction practices can be used to satisfy most or all of the runoff reduction requirements at most sites, but an ED pond may still be needed to provide for any remaining channel protection requirements. Upland runoff reduction practices will greatly reduce the size, footprint and cost of the downstream ED pond.

SECTION 6: SIZING AND TESTING GUIDANCE

6.1: Overall Sizing

Designers can use a site-adjusted Rv or CN to the reflect use of upland runoff reduction practices to compute the remaining volume that must be treated by the ED pond using the accepted state or local runoff reduction calculation method. ED ponds are then designed to capture and treat the remaining runoff volume for the water quality storm and the channel protection storm, if needed. Runoff treatment credit may be taken for the entire water volume below the normal pool (including micropools, forebays, and shallow marsh areas), as well as any temporary extended detention above the normal pool.

To be eligible for the higher Level 2 design removal rates for water quality, the ED pond must be sized with 1.25 of the remaining Treatment Volume (but not any additional Channel Protection Volume).

6.2: The Shortcut Method

The kerplunk approach can be used to estimate the required volume for channel protection, using the NRCS methods presented in Appendix A. **(NOTE: There is some debate among engineers regarding the appropriateness and accuracy of the kerplunk method. DCR will consider further comments on this method before deciding whether to include the above reference to it.)**

6.3: Required Geotechnical Testing

Soil borings should be taken below the proposed embankment, in the vicinity of the proposed outlet area, and in at least two locations within the ED pond treatment area. Soil boring data is needed for the following reasons:

- To ascertain the physical characteristics of excavated material
- To determine its adequacy for use as structural fill or spoil
- To provide data for structural designs for outlet workers **(is this a correct term?)** (e.g., bearing capacity and buoyancy)
- To determine the compaction/composition needs for the embankment
- To determine the depth to groundwater and bedrock
- To evaluate potential infiltration losses (and the potential need for a liner).

SECTION 7: DESIGN CRITERIA

7.1: Level 1 and 2 ED pond Design Guidelines

The major design goal for Extended Detention basins in Virginia is to maximize nutrient removal and runoff reduction. To this end, designers may choose to go with the baseline design (Level 1), or choose an enhanced Level 2 design that maximizes nutrient and runoff reduction. To qualify for the higher nutrient reduction rates for Level 2 design, ED ponds must be designed with a treatment volume equal to 1.25(Rv)(A), and meet at least 6 of the 8 design factors shown in Table 2.

Table 2: Extended Detention (ED) Pond Guidance	
Level 1 Design (RR:0; TP:15; TN:10)	**Level 2 Design (RR:15; TP:15; TN:10)**
TV= (1)(Rv)(A) / 12	TV = (1.25)(Rv) (A) / 12
At least 15% of TV in permanent pool	More than 40% of TV in deep pool or wetlands
Flow path at least 1:1	Flow path at least 1:5 to 1
Average ED time of 24 hours or less	Average ED time of 36 hours
Vertical ED fluctuation exceeds 4 feet	Maximum vertical ED limit of 4 feet
Turf cover on floor	Trees and wetlands in the planting plan
Forebay and micropool	Additional cells or treatment methods (e.g., sand filter or bioretention on pond floor)
CDA less than ten acres	CDA greater than ten acres

7.1: Pretreatment Forebay

Sediment forebays are considered an integral design feature to maintain the longevity of ED ponds. One must be located at all major inlets to trap sediment and preserve the capacity of the main treatment cell.

- The forebay shall consist of a separate cell, formed by an acceptable barrier. Typical examples include earthen berms, concrete weirs, and gabion baskets.
- A major inlet is defined as an individual storm drain inlet pipe or open channel serving at least 10% of the ED pond's contributing drainage area.
- The forebay should be at least 4 feet deep and shall be equipped with a variable width aquatic bench for safety purposes. The aquatic benches should be 4-6 feet wide and placed 18 inches below the water surface. The total volume of all forebays should be at least 15% of the total WQv (inclusive).
- The forebay should be designed in such a manner that it acts as a level spreader to distribute runoff evenly across the entire bottom surface area of the main treatment cell.
- The bottom of the forebay can be hard material such as concrete, asphalt, or grouted riprap, in order to make sediment removal easier. A fixed vertical sediment depth marker should be installed in the forebay to measure sediment deposition over time.

7.3: Conveyance and Overflow

Internal Slope: The longitudinal slope through the pond should be approximately 0.5-1% to promote positive flow through the ED pond.

No Pilot Channels: Micropool ED ponds shall not have a low flow pilot channel but instead be constructed in a manner whereby flows are evenly distributed across the pond bottom to promote the maximum infiltration possible.

Adequate Outfall Protection: The ED pond shall have a stable outfall for the 10-year design storm event. The channel immediately below the pond outfall shall be modified to prevent erosion and conform to natural dimensions in the shortest possible distance. This is typically done by placing appropriately sized riprap over the filter fabric. This can reduce flow velocities from the principal spillway to non-erosive levels (3.5-5.0 fps). Flared pipe sections that discharge at or near the stream invert or into a step pool arrangement should be used at the spillway outlet.

Inlet Protection: Inlet areas should be stabilized to ensure that non-erosive conditions exist during storm events up to the overbank flood event (i.e., Q_{10}). Inlet pipe inverts should generally be located at or slightly below the forebay pool.

Primary Spillway: This shall be designed with acceptable anti-flotation, anti-vortex and trash rack devices. The spillway shall be generally accessible from dry land.

On-line ED ponds: These need to be designed to detain the local design storm to protect infrastructure (e.g., the 10-year storm event) and be capable of safely passing extreme storm events (e.g., 100 year design storm event). At least 1 foot of freeboard shall be provided above the design high water for the 10-year storm.

Dam Safety Permits: Certain classes of ED ponds with high embankments or large drainage areas require a small pond or dam safety review from the local review authority, soil conservation district, or state dam safety agency. Dam safety regulations should be strictly followed during ED pond design to ensure that downstream property and structures are adequately protected.

7.3: Internal Design Features

Micropool: ED ponds shall be constructed with a micropool near the outlet. It's purpose is protect the outlet from clogging and deposition. The depth of the micropool should be at least 4 feet deep, and the design should limit draw-down to no more than 2 feet during a 30 day summer drought (for the water balance method, see Section 6.2 of the Constructed Wetlands Design Specification, No 13).

Side Slopes: Side slopes leading the ED pond should generally be between 4:1 and 5:1 (H:V). Mild slopes promote better establishment and growth of vegetation and contribute to easier maintenance and a more natural appearance.

Long Flow Path: ED ponds should have an irregular shape and a long flow path from inlet to outlet to increase residence time and pond performance. The minimum length to width ratio for ED ponds shall be 1:1, as measured from length from inlet to outlet versus average width. To qualify for Level 2 design, the ED pond shall have a length to width ratio of 1.5:1 or greater.

Required Storage: The total water quality storage may be provided by a combination of permanent pool, shallow marsh and/or extended detention storage. The storage needed for channel protection must be provided by temporary ED only.

Vertical Extended Detention Limits: The maximum ED water surface elevation shall not extend more than 5 feet above the basin floor or normal pool. The maximum vertical elevation for ED over shallow wetlands is 1 foot. The bounce effect is not as critical for larger flood control storms (e.g., the 10-year design storm) and these events can exceed the 5-foot vertical limit if they are managed by a multi-stage outlet structure.

Low Flow Orifice: Unless the drainage area to an ED pond is unusually large, the ED orifice shall be less than 6 inches in diameter. Small diameter pipes are prone to chronic clogging by organic debris and sediment. Designers should always look at upstream conditions to assess the potential for higher sediment and woody debris loads. The risk of clogging in such small openings can be reduced by:

- Sticking to a minimum orifice diameter of 3 inches or greater.
- Protecting the ED low flow orifice by installing a reverse-sloped pipe that extends to mid-depth of the permanent pool or micropool.
- Providing an over-sized forebay to trap sediment, trash and debris before it reaches the ED low flow orifice.
- Installing a trash rack to screen the low flow orifice.

Orifice Protection: A low flow orifice shall be provided that is adequately protected from clogging by either an acceptable external trash rack (recommended for an orifice that is a minimum of 3 inches in diameter) or by internal orifice protection that may allow for smaller diameters (recommended for an orifice that is a minimum of 1inch in diameter).

Alternative Orifice Protection: Alternative methods are to employ a broad crested rectangular, V-notch, or proportional weir protected by a half-round CMP that extends at least 12 inches below the normal pool.

Safety Features:

- The principal spillway opening shall not permit access by small children. End walls above pipe outfalls greater than 48 inches in diameter shall be fenced to prevent a hazard.
- An emergency spillway and associated freeboard shall be provided in accordance with applicable local or state dam safety requirements. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.
- Both the safety bench and the aquatic bench may be landscaped to prevent access to the pool.

7.4: Landscaping and Planting Plan

A landscaping plan shall be provided that indicates the methods used to establish and maintain vegetative coverage within the ED pond and its buffer. Minimum elements of a plan include: delineation of pondscaping zones, selection of corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed) and sources of native plant material.

- The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the stormwater wetland and buffers. The planting plan should allow the pond to mature into a native forest in the right places yet keep mowable turf along the embankment and all access areas. The wooded wetland concept proposed by Cappiella *et al*., (2005) may be a good option for many ED ponds.

- Woody vegetation may not be planted or allowed to grow within 15 feet of the toe of the embankment and 25 feet from the principal spillway structure.

- A buffer should be provided that extends 25 feet outward from the maximum water surface elevation of the ED pond. Permanent structures (e.g., buildings) should not be constructed within the buffer. Existing trees should be preserved in the buffer area during construction.

- For more guidance on planting trees and shrubs in ED pond buffers, consult Cappiella et al (2006).

7.5: Maintenance Reduction Features

Several ED pond maintenance problems can be addressed during design. Good maintenance access is needed so crews can remove sediments from the forebay, alleviate clogging and make riser repairs.

- Adequate maintenance access must extend to the forebay, micropool, riser, and outlet and be designed to allow vehicles to turn around.

- The riser should be located within the embankment for maintenance access, safety, and aesthetics. Access to the riser should be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls.

- Access roads shall be constructed of load bearing materials, shall have a minimum width of 12 feet, and shall possess a maximum profile grade of 15%. Steeper grades are allowable with stabilization techniques such as a gravel road.

- A maintenance right-of-way or easement shall extend to an ED pond from either a public or private road.

- Designers should check to see whether sediments can be spoiled on-site or must be hauled.

SECTION 8: REGIONAL AND CLIMATE DESIGN ADAPTATIONS

11.1: Karst Terrain

Active karst regions are found in much of the Ridge and Valley province of Virginia and complicate both land development in general and stormwater management design in particular. Designers should always conduct geotechnical investigations in karst terrain to assess this risk in the planning stage. Because of the risk of sinkhole formation and groundwater contamination in regions with active karst, ED ponds **are highly restricted**. If these studies indicate that less than 3 feet of vertical separation exist between the bottom of the ED pond and the underlying active karst layer, ED ponds should not be used. If ED ponds are used they must have an acceptable liner per the specs in BDS No. 14.

11.2: Coastal Plain

The lack of head and high water table of many coastal plain sites significantly constrain the application of ED ponds. Excavating ponds below the water table creates what are known as dugout ponds. In such ponds, the Treatment Volume is displaced by groundwater, reducing pond efficiency and mixing and creating nuisance conditions. No credit for water quality volume may be taken for areas below the seasonally high water table. In general, **shallow constructed wetlands are a superior alternative to ED ponds for the coastal plain environment.**

11.3: Steep Terrain

ED ponds are highly constrained at development sites with steep terrain.

11.4: Winter Performance

Winter conditions can cause freezing problems within inlets, flow splitters, and ED outlet pipes due to ice formation. The following design adjustments are recommended for ED ponds installed in higher elevations of Virginia:

- Not submerging inlet pipes
- Increasing the slope of inlet pipes by a minimum of 1% to discourage standing water and potential ice formation in upstream pipes
- Placing all pipes below the frost line to prevent frost heave and pipe freezing
- Designing low flow orifices in the micropool to withdraw at least 6 inches below the typical ice layer
- Placing trash racks at a shallow angle to prevent ice formation

- Increasing sediment forebay to 25% of the total treatment volume to accommodate higher sand loadings due to winter road maintenance

SECTION 9. TYPICAL GRAPHIC DETAILS

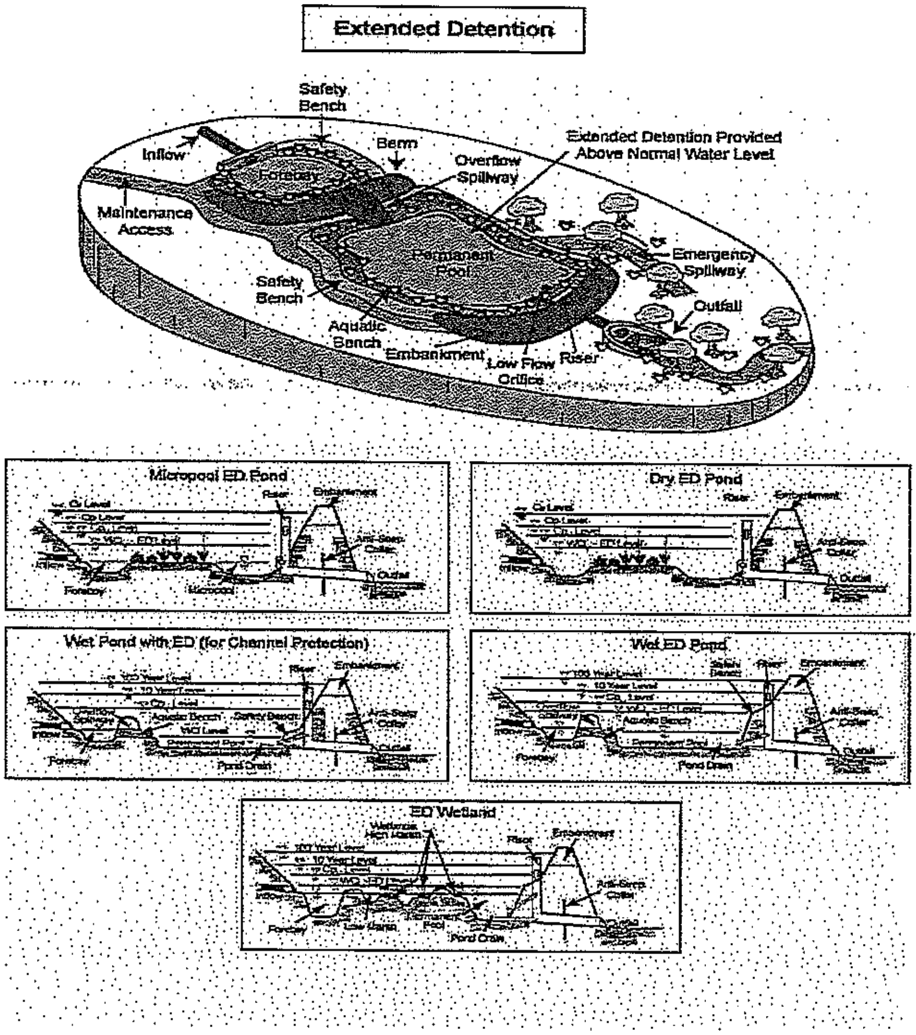


Figure 1. Extended Detention Pond Schematics

SECTION 10: MATERIAL SPECIFICATIONS

ED ponds generally use materials on site except for plantings, inflow and outflow devices such as piping and riser materials, possibly stone for inlet and outlet stabilization, and filter fabric for lining banks or berms.

The basic material specifications for earthen embankments, principal spillways, vegetated emergency spillways, and sediment forebays should be as specified in Appendices A, B, C and D of the Wet Pond Design Specification, No. 14 (those practices as set forth in the 1999 Virginia Stormwater Handbook, Volume 1).

When reinforced concrete pipe is used for the principal spillway to increase its longevity, O-ring gaskets (ASTM C-361) should be used to create watertight joints, and they should be inspected during installation.

SECTION 11: CONSTRUCTION SEQUENCE AND INSPECTION

11.1: The following is a typical construction sequence to properly install a dry ED pond. The steps may be modified to reflect different dry ED pond designs, site conditions, and the size, complexity, and configuration of the proposed facility:

Step 1: Use of ED pond as an ESC Control. An ED pond may serve as a sediment basin during project construction. If this is done, the volume should be based on the more stringent sizing rule (erosion and sediment control or water quality). Installation of the permanent riser should be initiated during the construction phase, and design elevations should be set with final cleanout and conversion in mind. The bottom elevation of the ED pond should be lower than the bottom elevation of the temporary sediment basin. Appropriate procedures should be implemented to prevent discharge of turbid waters when the basin is being converted into an ED pond.

Step 2: Stabilize Drainage Area. ED ponds should only be constructed after the contributing drainage area to the pond is completely stabilized. If the proposed pond site will be used as a sediment trap or basin during the construction phase, the construction notes should clearly indicate that the facility will be dewatered, dredged, and re-graded to design dimensions after construction is complete.

Step 3: Assemble construction materials on-site, make sure they meet design specifications, and prepare any staging areas.

Step 4: Clear and strip the project area to desired sub-grade.

Step 5: Install project ESC controls, including temporary dewatering devices, erosion and sediment controls, and stormwater diversion practices prior to construction. All areas surrounding the pond that are graded or denuded during construction are to be planted with turfgrass, native planting, or other approved methods of soil stabilization.

Step 6: Excavate core trench and install pipe spillway.

Step 7: Install the riser or outflow structure and ensure the top invert of the overflow weir is constructed level at the design elevation.

Step 8: Construct the embankment and any internal berms in 8-12-inch lifts compacted with appropriate equipment.

Step 9: Excavate/grade until the appropriate elevation for the bottom of the ED pond is reached and desired contours and acceptable side slopes are achieved.

Step 10: Construct emergency spillways in cut or structurally stabilized soils.

Step 11: Install outlet pipes including downstream rip-rap apron protection.

Step 12: Stabilize exposed soils with temporary seed mixtures appropriate for the pond buffer. All areas above the normal pool should be permanently stabilized by hydroseeding or seeding over straw.

Step 13: Plant the pond buffer area, following the pondscaping plan (see Section 7.5).

11.2: Construction Inspection

Multiple construction inspections are critical to ensure that stormwater ponds are properly constructed. Inspections are recommended during the following stages of construction:

- Pre-construction meeting
- Initial site preparation (including installation of project E&S controls)
- Excavation/Grading (interim/final elevations,)
- Installation of embankment/riser/primary spillway and outlet
- Implementation of pondscaping plan and vegetative stabilization
- Final Inspection (develop punch list for facility acceptance)

A construction inspection form for ED ponds can be accessed at CWP website at

http://www.cwp.org/Resource_Library/Center_Docs/SW/pcguidance/Tool6.pdf .

For larger ED ponds, the expanded construction inspection form provided in Appendix B of CWP (2004) should be used.

SECTION 12: OPERATION AND MAINTENANCE

12.1: Maintenance Agreements

A legally binding and enforceable maintenance agreement should be executed between the pond owner and the local review authority. Agreements should specify the property owner's responsibilities and the municipality's right to enter the property for inspection or corrective action. Agreements must require annual inspection and maintenance and should attach an inspection checklist. Access to ED ponds should be covered by a drainage easement to allow inspection and maintenance.

It is also recommended that the maintenance agreement include a list of qualified contractors that can perform inspection or maintenance services, as well as contact information for owners to get local or state assistance to solve common nuisance problems, such as mosquito control, geese, invasive plants, vegetative management and beaver removal. CWP (2004) provides some excellent templates on how to respond to these problems.

12.2: Maintenance Inspections

Maintenance of ED ponds is driven by annual inspections that evaluate the condition and performance of the facility (see Table 3). Based on inspection results, specific maintenance tasks will be triggered. An annual maintenance inspection form for ED ponds can be accessed at the CWP website at

http://www.cwp.org/Resource_Library/Center_Docs/SW/pcguidance/Tool6.pdf.

A more detailed maintenance inspection form is also available from Appendix B of CWP (2004).

Table Suggested Annual Maintenance Inspection Points for ED ponds
Activity
• Measure sediment accumulation levels in forebay.
• Monitor the growth of wetland plants, trees, and shrubs planted. Record species and approximate coverage, and note presence of any invasive plant species.
• Inspect the condition of stormwater inlets to the pond for material damage, erosion, or undercutting.
• Inspect upstream and downstream banks for evidence of sloughing, animal burrows, boggy areas, woody growth, or gully erosion that may undermine embankment integrity.
• Inspect the pond outfall channel for erosion, undercutting, rip-rap displacement, woody growth, etc.
• Inspect condition of principal spillway and riser for evidence of spalling, joint failure, leakage, corrosion, etc.
• Inspect condition of all trash racks, reverse sloped pipes, or flashboard risers for evidence of clogging, leakage, debris accumulation, etc.
• Inspect maintenance access to ensure it is free of woody vegetation and check to see whether valves, manholes, or locks can be opened and operated.
• Inspect internal and external pond side slopes for evidence of sparse vegetative cover, erosion, or slumping, and repair immediately.
Note: For a more detailed maintenance inspection checklist, see Appendix B in CWP (2004) Stormwater Pond and Wetland Maintenance Guidebook.

12.2 Common Maintenance Issues

ED ponds are prone to a risk of clogging at the low flow orifice. These aspects of pond plumbing should be inspected at least twice a year after initial construction. The constantly changing water levels in ED ponds make it difficult to mow or manage vegetative growth. The bottom of ED ponds often become soggy, and water-loving trees such as willows may take over. The maintenance plan should clearly outline how vegetation in the pond and its buffer will be managed or harvested in the future. Periodic mowing of the stormwater buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or forest.

The maintenance plan should schedule a shoreline cleanup at least once a year to remove trash and floatables that tend to accumulate in the forebay, micropool, and on the bottom of ED ponds.

Frequent sediment removal from the forebay is essential to maintain the function and performance of an ED pond. Maintenance plans should schedule cleanouts every 5-7 years, or when inspections indicate that 50% of the forebay capacity has been lost. Designers should also check to see whether removed sediments can be spoiled on-site or must be hauled away. Sediments excavated from ED ponds are not usually considered toxic or hazardous, and can be safely disposed by either land application or land filling.

13. REFERENCES

The following references and resources were used to develop this master specification.

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Cappiella, K. et al . 2007. Urban Watershed Forestry Manual: Part 3: Urban Tree Planting Guide. USDA Forest Service. Center for Watershed Protection. Ellicot City, MD

Cappiella, K., L. Fraley-McNeal, M. Novotney and T. Schueler. 2008. The next generation of stormwater wetlands. *Wetlands and Watersheds Article No. 5.* Center for Watershed Protection. Ellicott City, MD

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Maryland Department of Environment (MDE). 2000. Maryland Stormwater Design Mnaual. Baltimore, MD

Schueler, T., D. Hirschman, M. Novotney and J. Zielinski. 2007. Urban stormwater retrofit practices. *Manual 3 in the Urban Subwatershed Restoration Manual Series.* Center for Watershed Protection, Ellicott City, MD

Virginia Department of Conservation and Recreation (VA DCR). 1999. Virginia Stormwater Mnagement Handbook. Volumes 1 and 2. Division of Soil and Water Conservation. Richmond, VA

APPENDIX A
Channel Protection Method for ED Ponds

Step 1: Compute the runoff volume produced from the post-development 1-year, 24-hour design storm event, using TR-55 and adjusted CNs to account for upland runoff reduction.

Step 2: Use the Kerplunk method, which assumes the pond volume (above the permanent pool or basin floor) instantaneously fills up. Determine the storage volume and Cpv maximum invert elevation using the short-cut method shown below. **(NOTE: There is some debate among engineers regarding the appropriateness and accuracy of the kerplunk method. DCR will consider further comments on this method before deciding whether to include the above reference to it.)**

Step 3: Set the Cpv orifice invert below the permanent pool elevation and size the initial orifice diameter to drain the entire Cpv volume in 24 hours.

Step 4: Compute the average peak discharge rate for the Cpv event (i.e., Cpv/24).

Step 5: Using TR-20, route the runoff through the pond and check to make sure the peak discharge for Cpv does not exceed twice the average discharge, and that it meets the minimum 12-hour detention time.

NOTE: No permanent pool is involved in the design, although a micropool is recommended to keep the orifice from clogging.

In most cases, an extended detention pond is utilized following one or more non-pond BMPs to provide storage for channel protection and flood control design storms. In some cases, the non-pond water quality BMP can be incorporated within the extended detention pond if adequate pretreatment is provided (e.g., a sand filter or bioretention in the pond floor).

Shortcut Sizing for Channel Protection: Storage Volume Estimation

This Appendix presents the TR-55 (NRCS, 1986) "short-cut" sizing technique, used to size practices designed for extended detention and slightly modified to incorporate the flows necessary to provide for channel protection. The method was modified by Harrington (1987) for applications where the peak discharge is very small compared with the uncontrolled discharge. This often occurs in sizing detention for the 1-year 24-hour design storm event.

Using TR-55 guidance, the unit peak discharge (q_u) can be determined based on the Curve Number and Time of Concentration (Figure A-1). Knowing q_u and T (extended detention time), q_O/q_i (peak outflow discharge/peak inflow discharge) can be estimated from Figure A-2.

Then using q_O/q_i, Figure A-3 can be used to estimate V_S/V_r. For a Type II or Type III rainfall distribution, V_S/V_r can also be calculated using the following equation:

$$V_S/V_r = 0.682 - 1.43\,(q_O/q_I) + 1.64\,(q_O/q_I)^2 - 0.804\,(q_O/q_I)^3$$

Where: V_S = required storage volume (acre-feet)
V_r = runoff volume (acre-feet)
q_O = peak outflow discharge (cfs)
Q_I = peak inflow discharge (cfs)

The required storage volume can then be calculated by:

$$V_S = \frac{(V_S/V_r)(Q_d)(A)}{12}$$

Where: V_S and V_r are defined above
Q_d = the developed runoff for the design storm (inches)
A = total drainage area (acres)

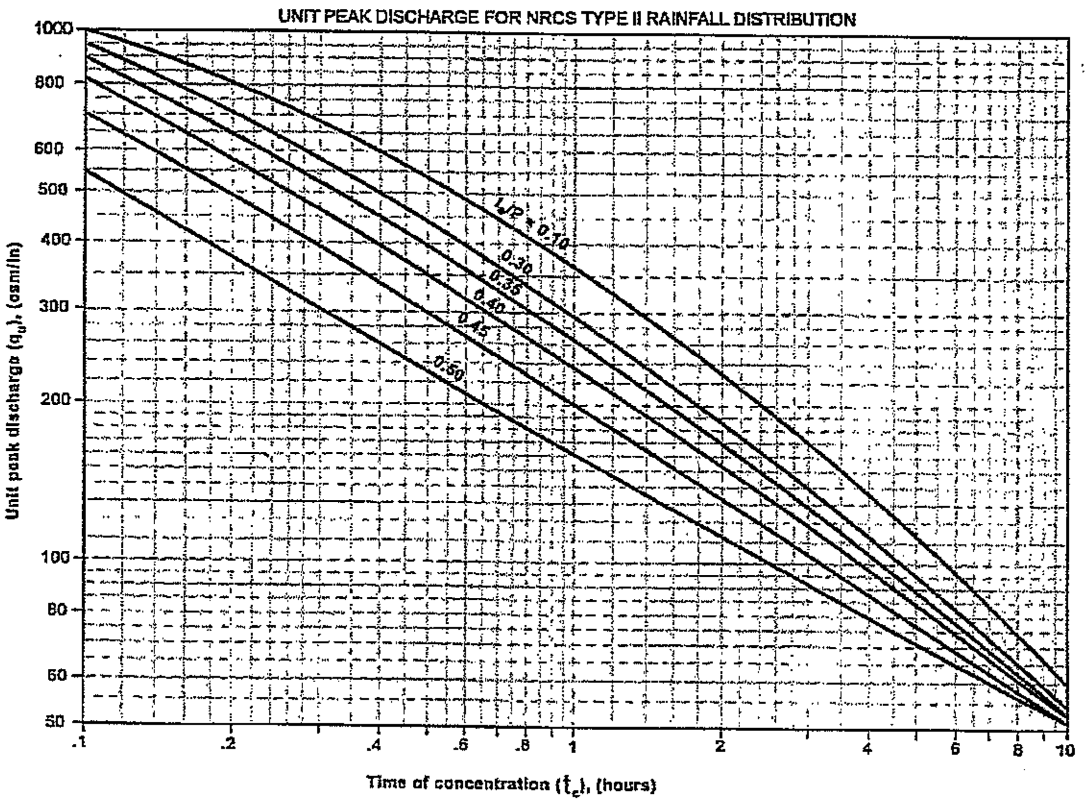

Figure A-1. Unit Peak Discharge for Type II Rainfall Distribution (Source: NRCS, 1986)

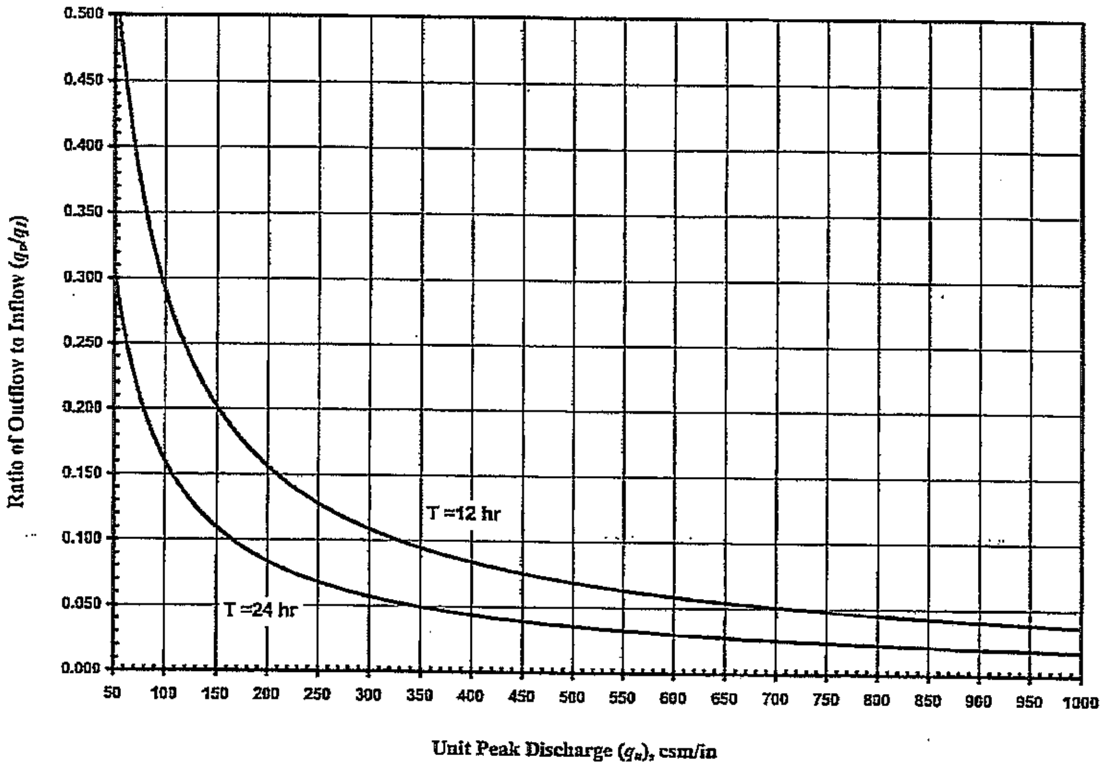

Figure A-2. Detention Time vs. Discharge Ratios
(Source: adopted from Harrington, 1987)

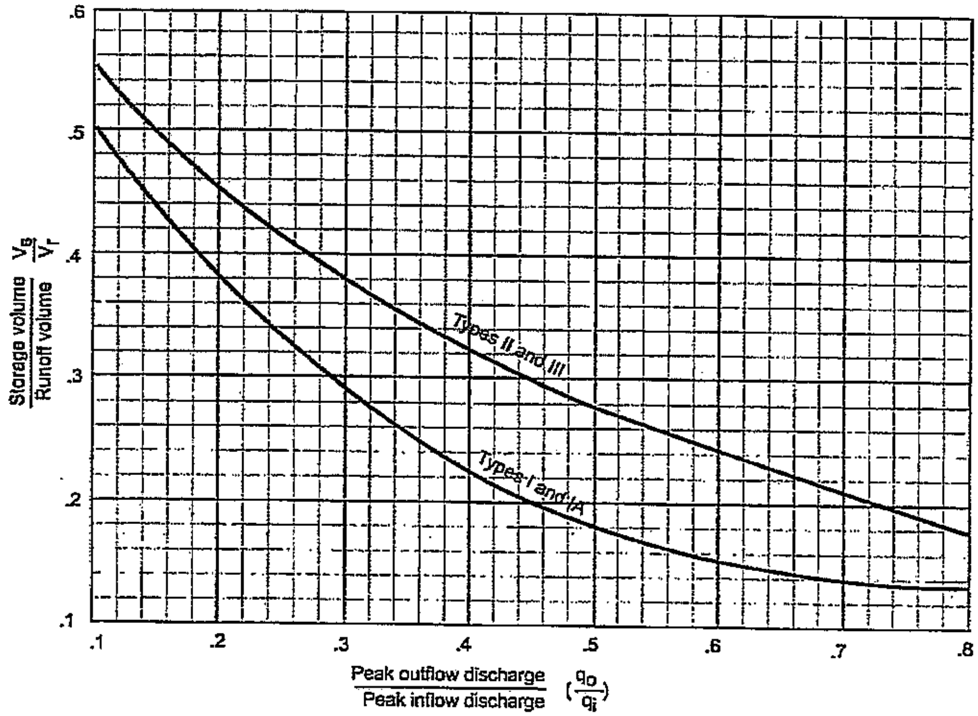

Figure A-3. Approximate Detention Basin Routing For Rainfall Types I, IA, II, and III (Source: NRCS, 1986)