Step Pool Storm Conveyance (SPSC) Workshop

Aka. Coastal Plain Outfall (CPO) & Regenerative Storm Conveyance (RSC)

sponsored by

Anne Arundel County
Department of Public Works
Bureau of Engineering
Watershed, Ecosystem, and Restoration Services

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presented by

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June 2, 7, and 9, 2010

Ron Bowen, P.E.

Agenda

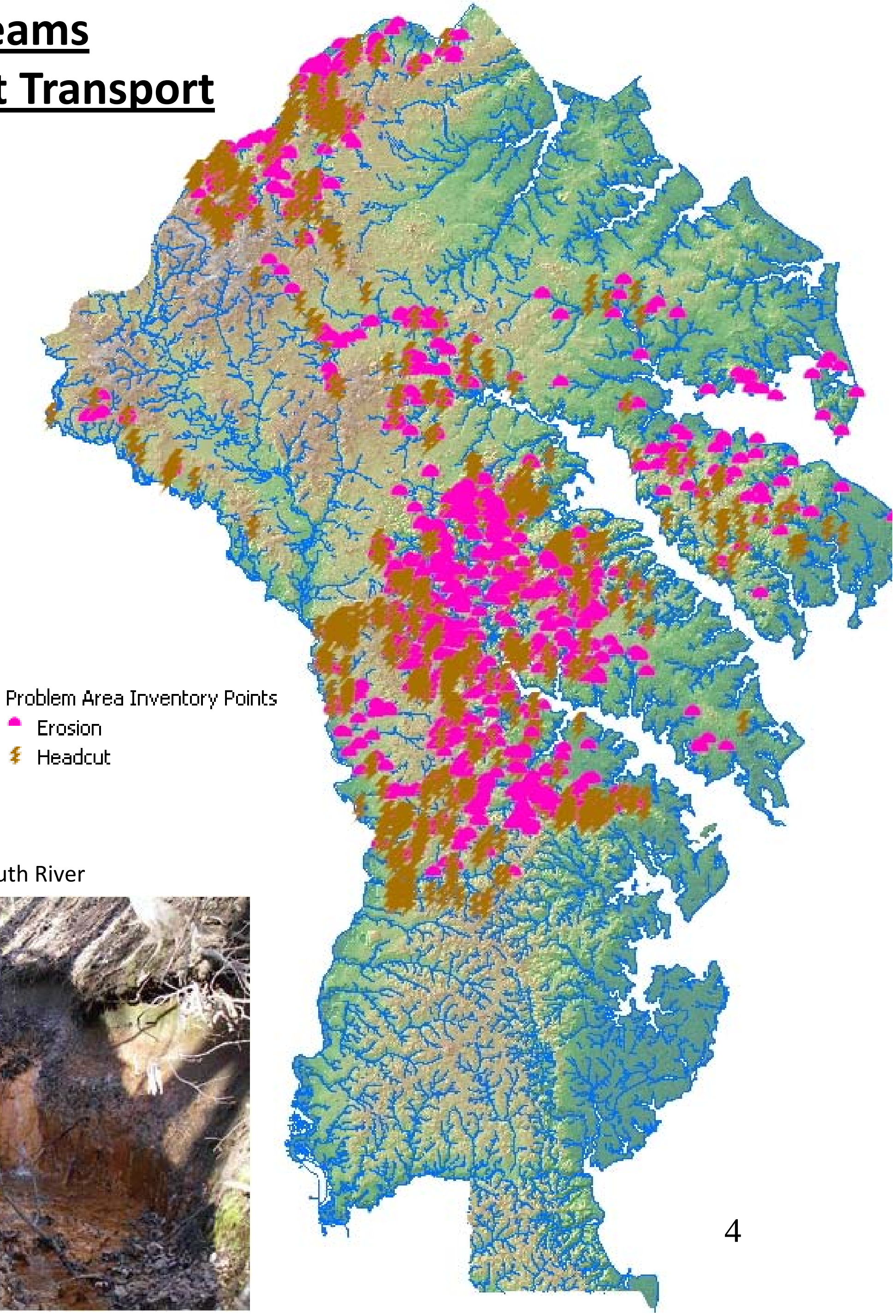
1. Overview of the current conditions/problems
2. Current SWM regulations
3. What is an SPSC system and when to use it?
4. SPSC implementation and a downstream investigation go hand in hand
5. SPSC Design Guidelines
6. Sizing an SPSC system

Land Abuse Creates Impact

Anne Arundel County is faced with the challenge and cost to improve conditions of degraded streams and storm infrastructure. (Sins of the Past, Budgetary Constraints)

Anne Arundel County Perennial Streams
Erosion and Headcut Impacts on Sediment Transport

Example of F and G channels – Highly Instable



Erosion in the Patuxent River

Headcut in the South River

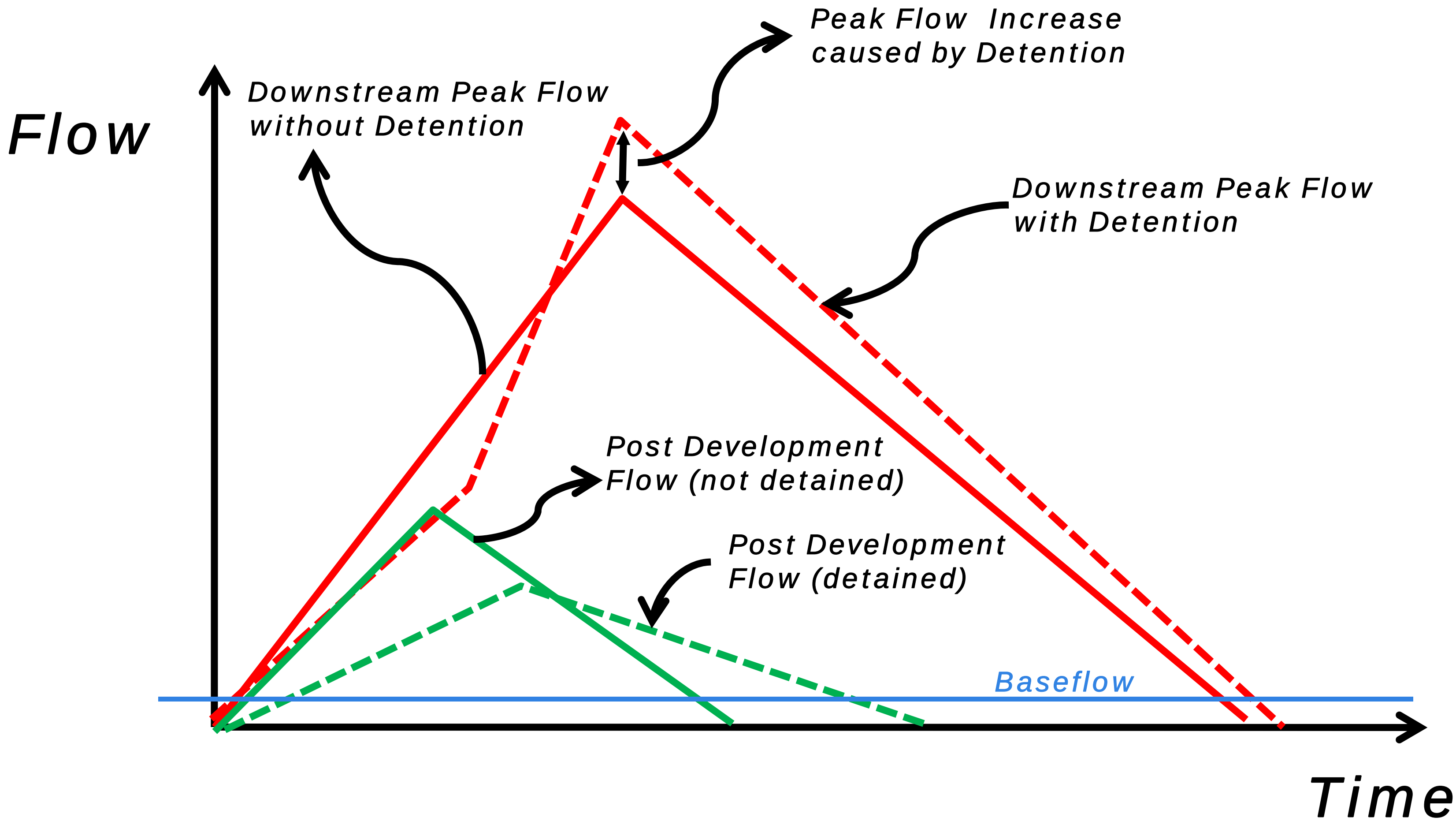
Stormwater Management Best Management Practices (BMPs)

SPSC

Infiltration	✓	*Conditional on underlying soil conditions*
Filtration	✓	*Sized for 100% Credit*
Wetland Creation	✓	*Seepage berm design*
Wet Ponds	✓	*Pools*
Extended Detention	✓	*Outflow is discharged as shallow groundwater seeps*

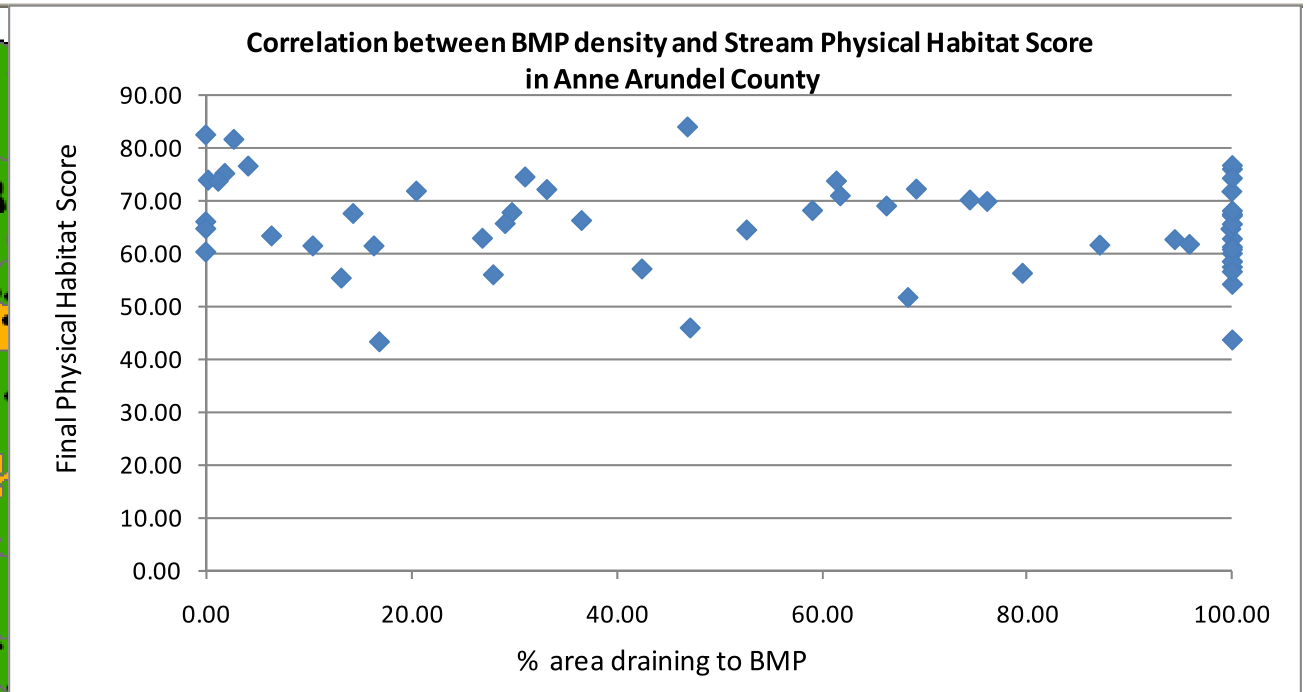
BMP Category Groups	Pollutant Removal Efficiencies in %		
	TN	TP	TSS
Detention Dry	5	10	10
Extended Detention Dry	20	20	60

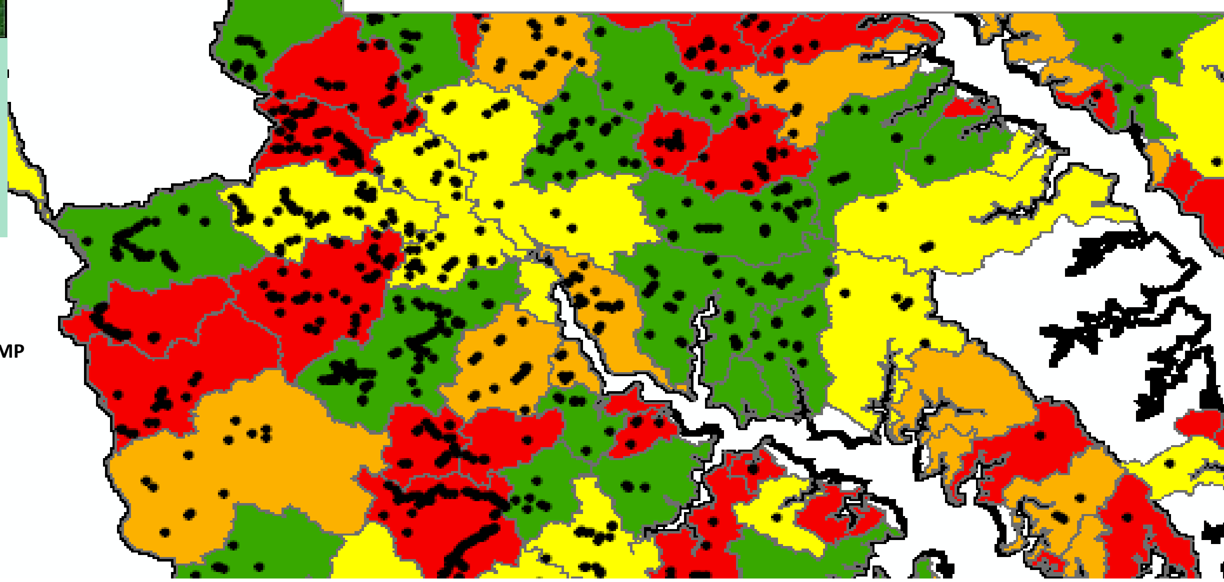
Undesired Consequences of Detention



- **Longer duration of higher flows**
- **Higher Peak Flows Downstream**

Conventional upland BMPs do not necessarily correlate with a stable downstream!





Stormwater detention ponds are wet structures that are often used to capture and detain stormwater runoff from residential and commercial areas.

Hard Engineering Solutions for conveyance

Not so hard!

Hard Engineering Solutions for conveyance

Not so hard!

Expensive restorations that don’t work and don’t provide water quality benefits

Harvesting the taming powers of the floodplain

Before Restoration – Rosgen G Channel

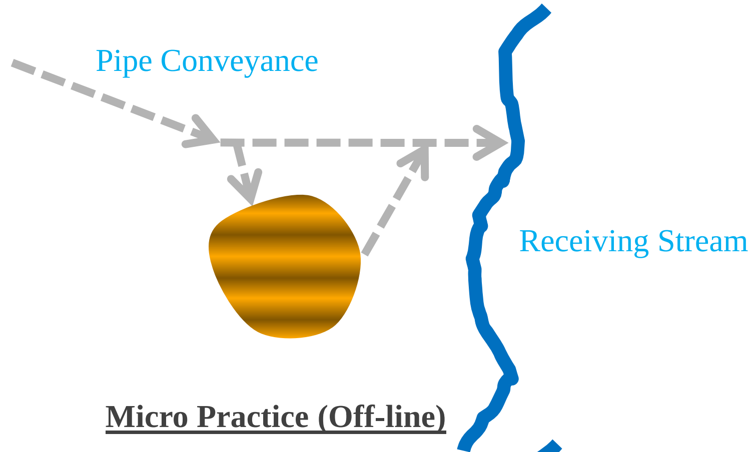
Any size floodplain bench is better than a hardened wall

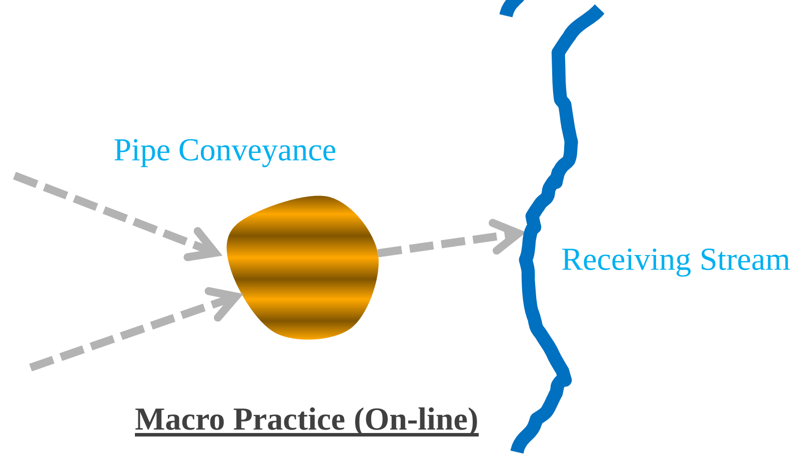
After Restoration – Rosgen B Channel

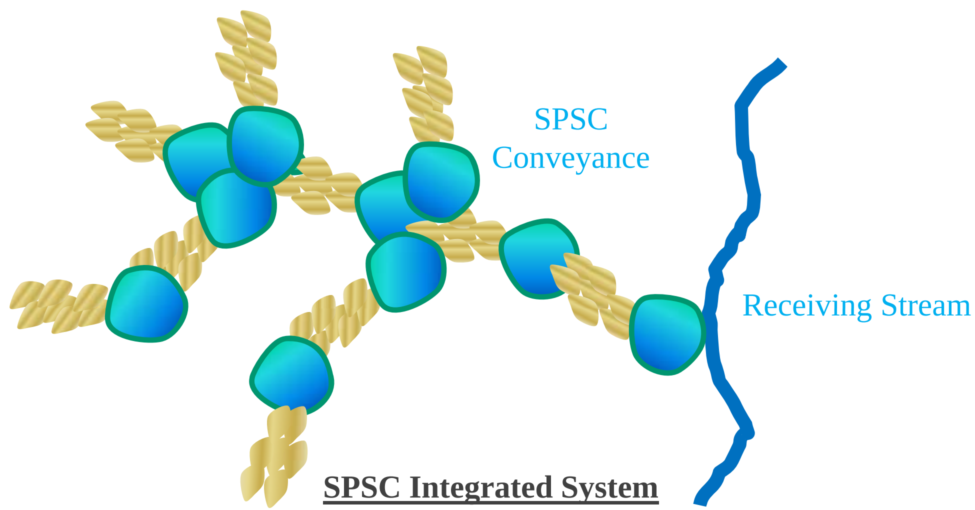
The larger and more accessible the floodplain is, the more sustainable the restoration

SPSC – What type of BMP are they?

SPSC are open-channel conveyance structures that convert, through attenuation pools and a sand seepage filter, surface storm flow to shallow groundwater flow.







SPSC – Are designed to provide:

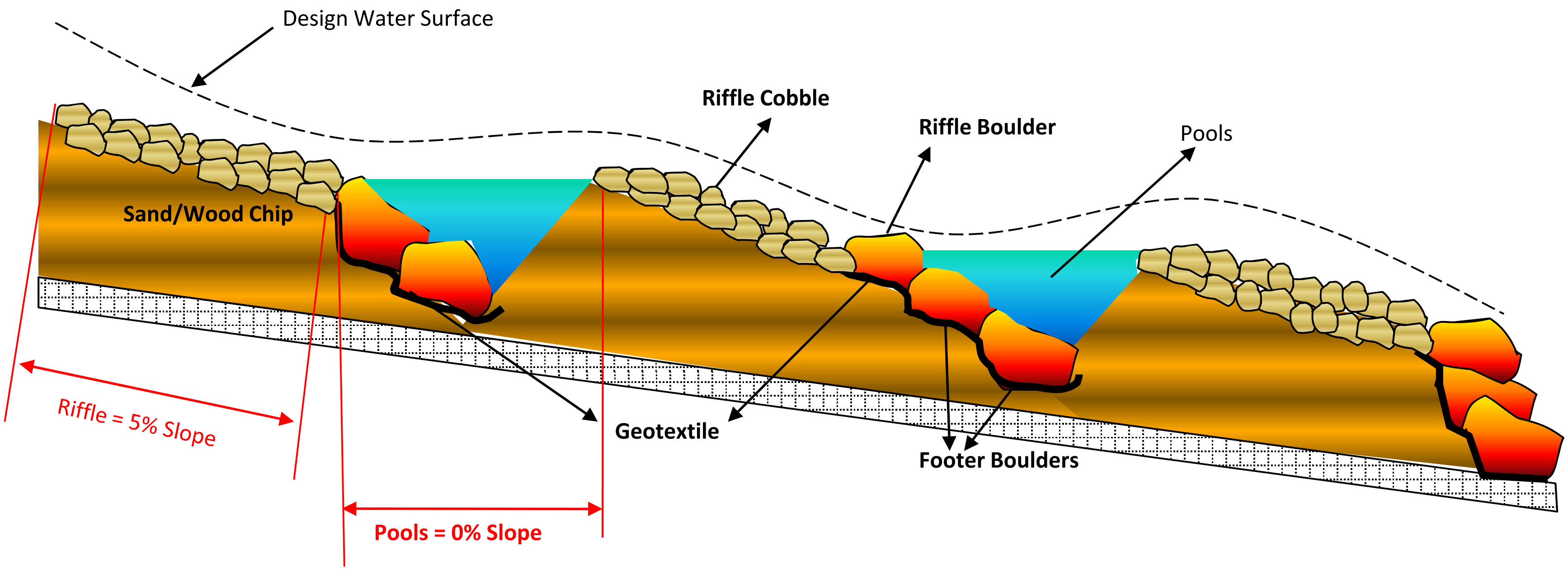
- Safe Conveyance

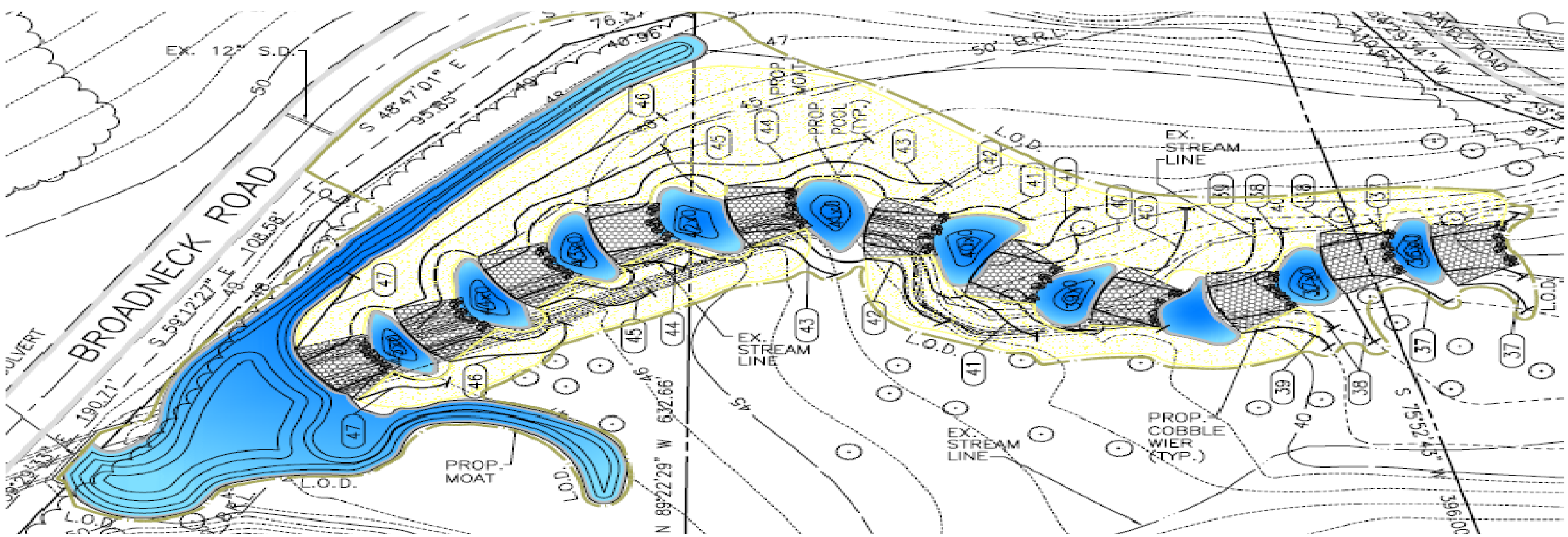
- Attenuation

- Energy Dissipation

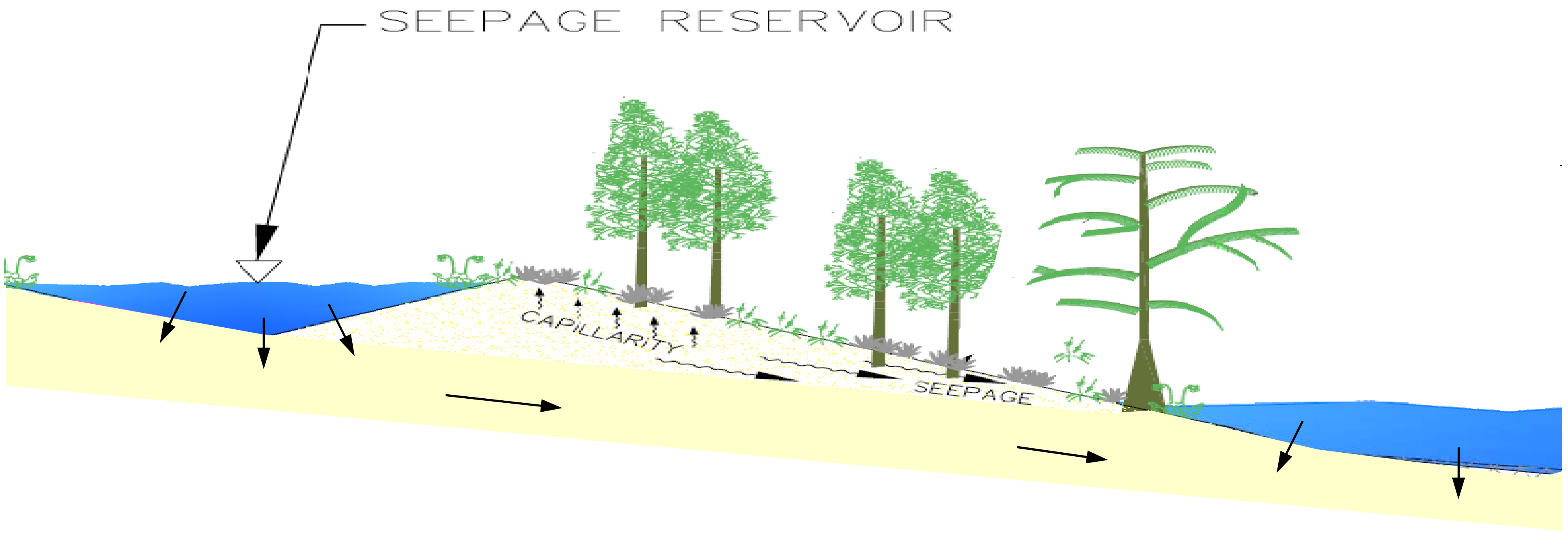
- Treatment

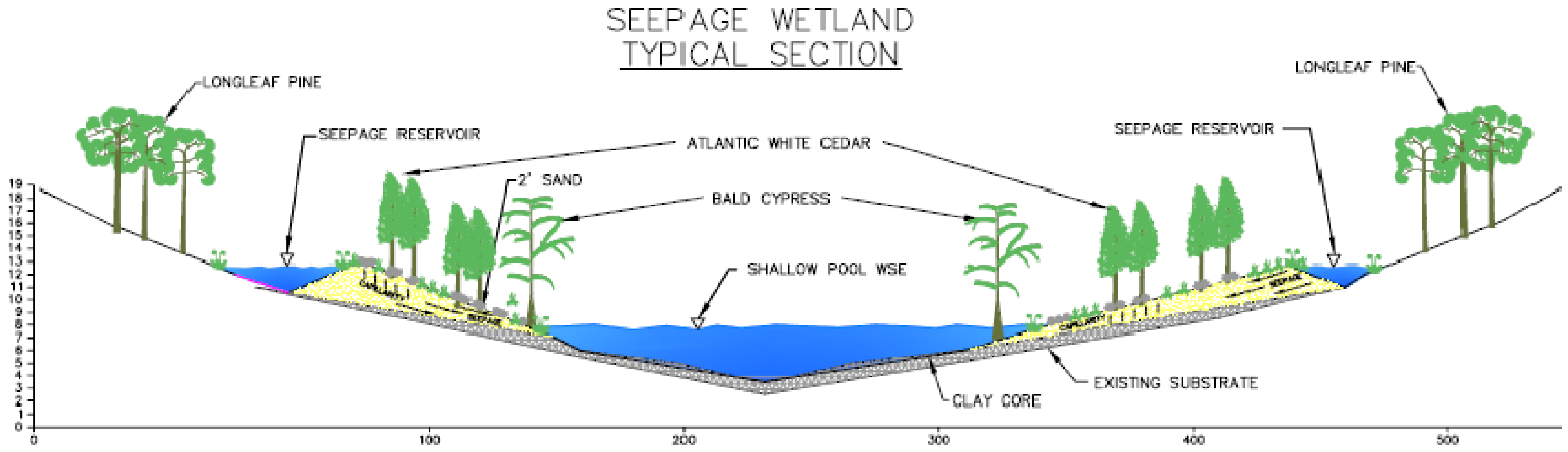
Functional Components of Step Pool Storm Conveyance (SPSC)





Other Geometric Configurations (Wetland Seepage)





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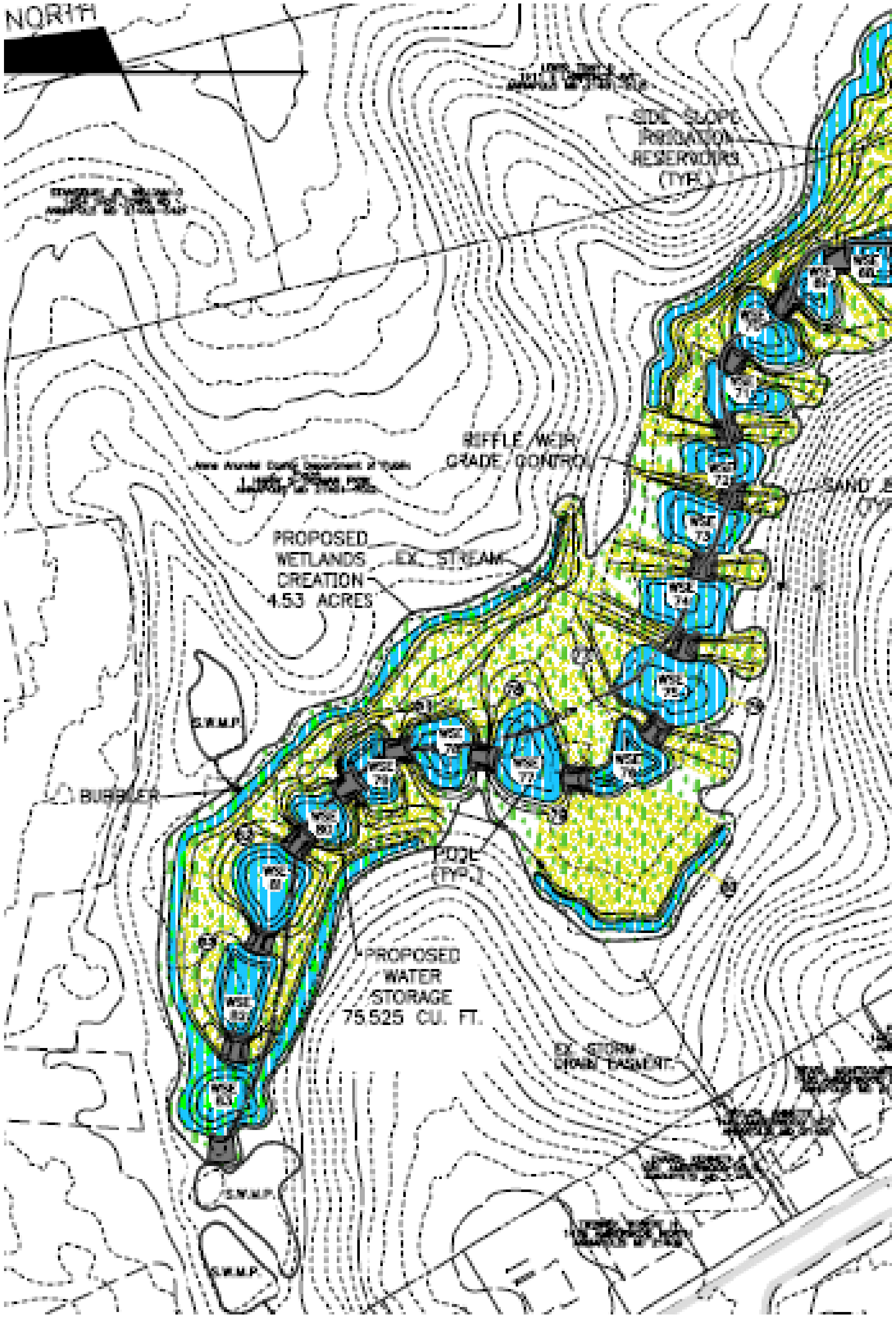
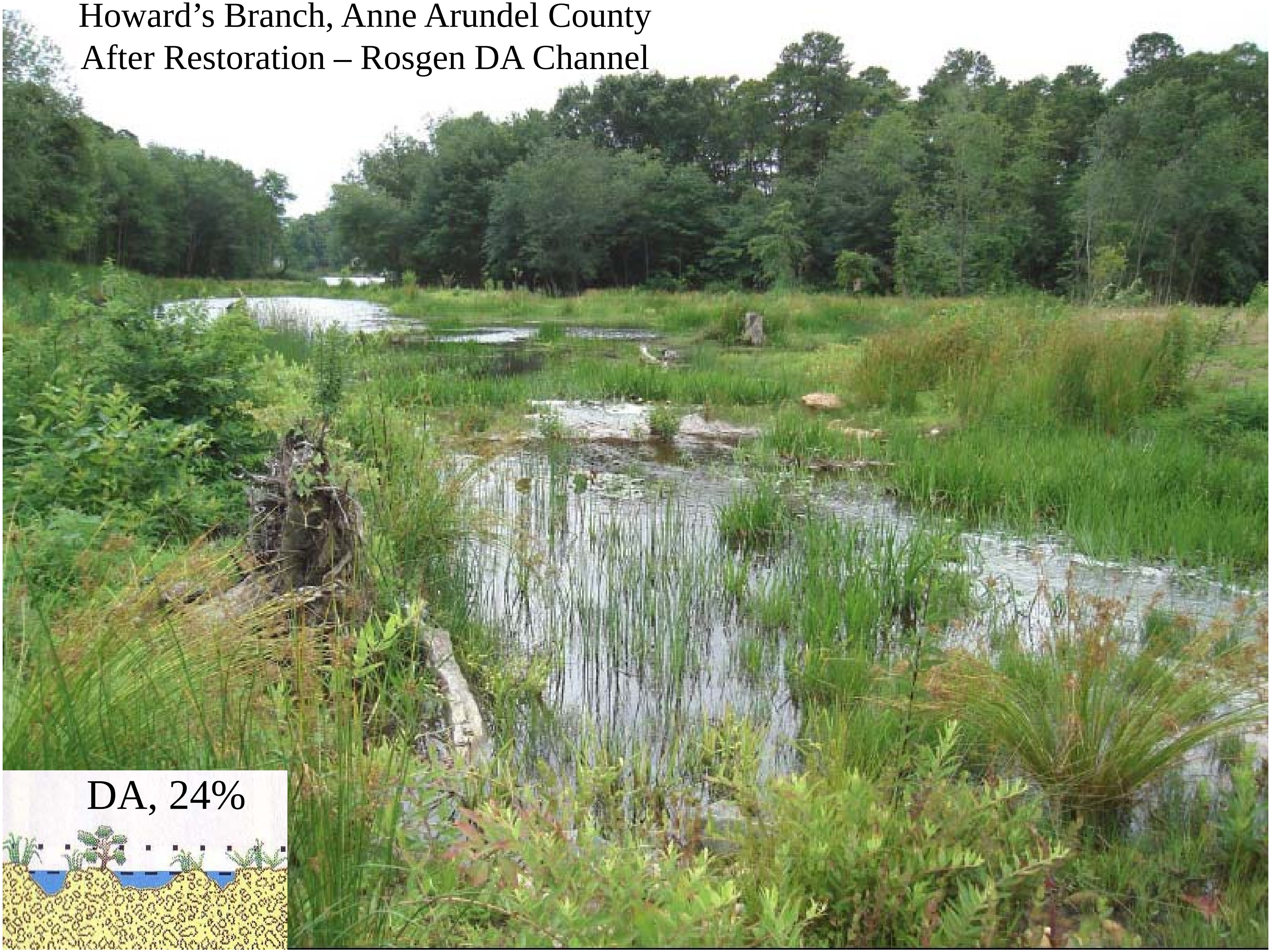


Home Port Farm, Anne Arundel County
After Restoration – Rosgen A/B Channel

The physical characteristics of the SPSC channel are best characterized by the Rosgen A or B stream classification types, where "bedform occurs as a step/pool, cascading channel which often stores large amounts of sediment in the pools associated with debris dams" (Rosgen, 1996).

Howard's Branch, Anne Arundel County
After Restoration – Rosgen DA Channel



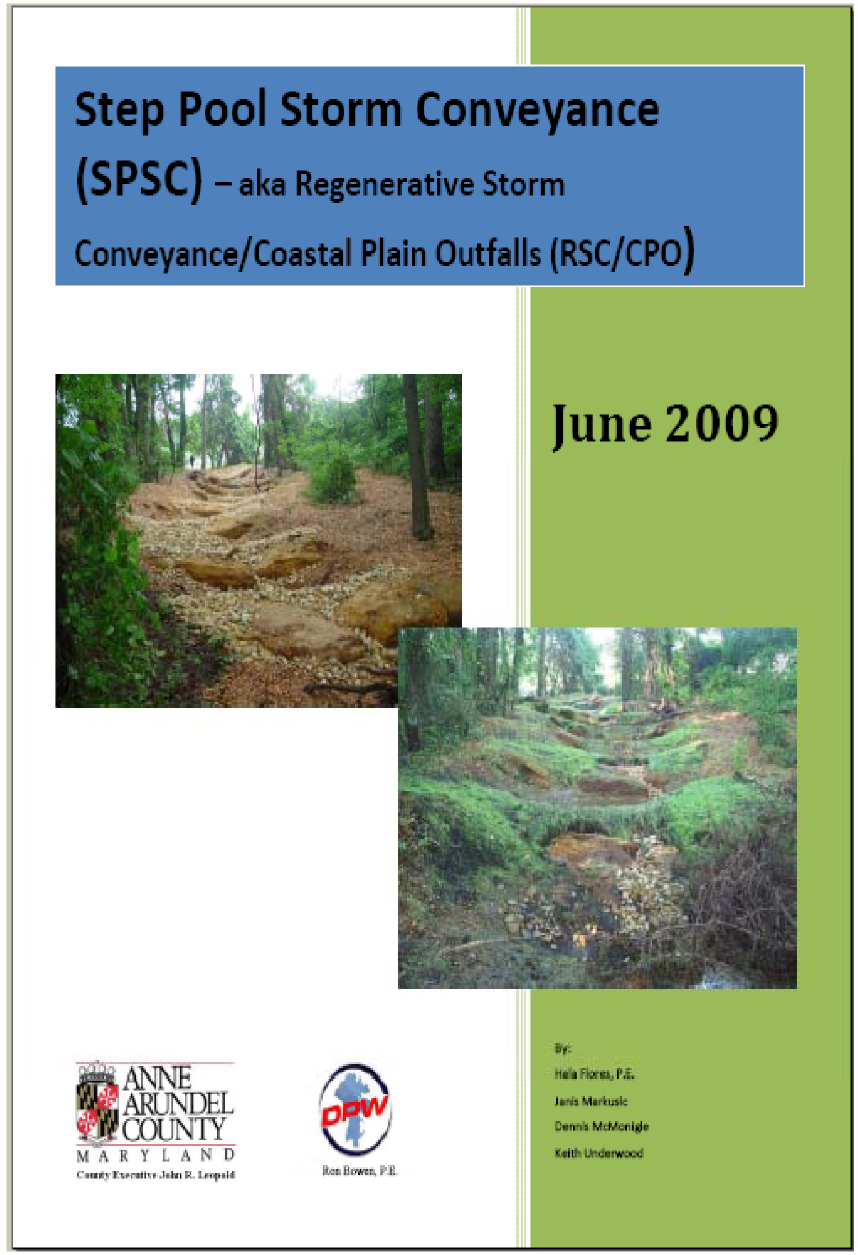
SPSC - Regulatory Requirements for Outfalls

Article 16

(76)~~(72)~~ "Regenerative step pool storm conveyance system" has the meaning stated in the County Procedures Manual.

(2) **MEP standard**. The MEP standard is met when channel stability is maintained, predevelopment groundwater recharge is replicated, non point source pollution is minimized, and ~~coastal plain outfalls and~~ regenerative STEP POOL STORM conveyance systems are employed to the extent possible on all public stormwater systems. Structural management practices may be used only if determined to be absolutely necessary.

(b) **Outfall requirements.** All new public stormwater outfalls shall be regenerative step pool storm conveyance system as detailed in the County Procedures Manual unless the applicable design standards contained in the County Procedures Manual cannot be met.


Step Pool Storm Conveyance (SPSC) – aka Regenerative Storm Conveyance/Coastal Plain Outfalls (RSC/CPO)

June 2009

ANNE ARUNDEL COUNTY
MARYLAND
County Executive John R. Leopold

DPW
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By:
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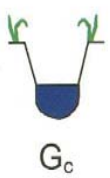
Anne Arundel County - Past Policy for assessing the adequacy/stability of downstream channels

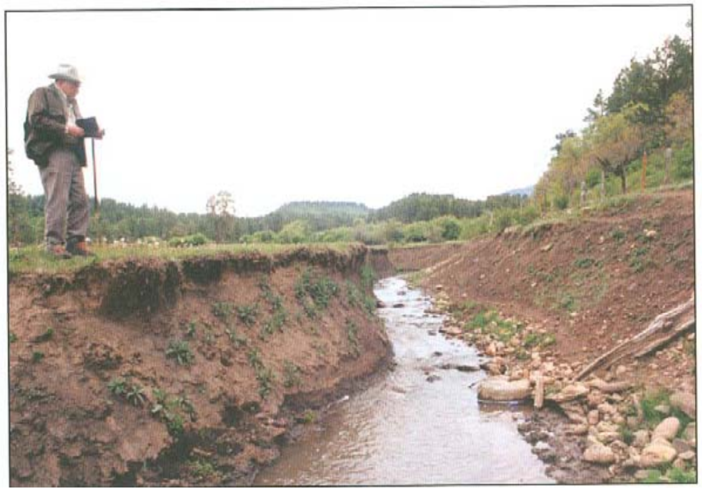
DPW Design Manual Chapter V - Storm Drains

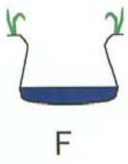
13- An outfall is the discharge point of the downstream extreme terminus of a culvert or a closed storm drain system. The outfall may be an existing/proposed closed storm drain system, open ground, stream, channel, or open water as ponds, lakes, shoulders, etc. An outfall is considered adequate if:

a. The receiving closed storm drain system is not surcharged by the design discharge from the outfall pipe.

b. The receiving open ground, stream, channel or open water can accommodate higher velocities and shear stress values than created by the design discharge from the outfall pipe.







Shear Stress Analysis for Streams with the Severn River

Predicting Erosion Areas

HEC-RAS tractive Forces → **Critical Shear Stress**

Anne Arundel County - Current Policy for accessing the adequacy/stability of downstream channels

County Code – Article 16

TITLE 1. DEFINITIONS AND GENERAL PROVISIONS

§ 16-1-101. Definitions.

In this article, the following words have the meanings indicated.

(1) "Accessory" has the meaning stated in Article 18 of this Code.

(2) "Adequate outfall" means an outfall that has adequate capacity and stability as determined in the County Procedures Manual.

Anne Arundel County SWM Procedures Manual

A. Establish the Point of investigation (POI)

1. The point of investigation is the point located downstream of the site, where the maximum post development runoff (based on current zoning) from the site is less than or equal to 10 percent of the total runoff to that point.
2. Runoff computations will be based on the 10 year storm.
3. Runoff Curve Numbers and times of concentration must be based on ultimate development conditions assuming no storage within existing BMPs located within the drainage area.

Anne Arundel County SWM Procedures Manual
Requirements for Downstream Analysis

b) If the site discharges to a clearly defined open channel, the following is required:

  i) Provide a photographic walking tour from the site outfall to the point of investigation.

  ii) If the site outfalls to more than one channel, the walking tour must address all channels.

  iii) Based on the review of the walking tour and any additional information provided by the Watershed Management Tool as administered by the Department of Public Works, further assessment may be required.

  iv) If further assessment is required then this must be accomplished using the Rapid Stream Assessment methodology as outlined in the Stream Assessment Protocol for Anne Arundel County. http://www.aacounty.org/DPW/Watershed/DownstreamAdequacyProtocols.cfm

5. Discharge leaves site in sheet flow condition.

  a) If discharge leaves the site via sheet flow, this condition must be maintained after development.

  b) The pre development linear discharge rate computed as cubic feet per second per foot, must be maintained after development.

Brief Overview:
Rapid Stream Assessment Protocols

- ***General Watershed Characterization***
  - Land Use and Imperviousness
  - Drainage Area and Bankfull Indicator Determination
- ***General Stream Characterization***
  - Rosgen Level II Classification (pebble count, slope determination, valley type, etc.)
- ***Lateral Stability Determination***
  - BEHI and NBS Evaluation
  - Bank armoring and localized versus widespread issues
- ***Vertical Stability Determination***
  - Incision Ratio
  - Headcuts, control points, depositional features
- ***Overall Reach Stability Determination***
  - Includes a variety of trend and reach-level evaluations

This is a field-based assessment! The consultants must leave the office to apply it correctly!

SPSC – Water Quality Retrofit/Mitigation

SWM Retrofit

- *Maybe used for SWM retrofit, credit is claimed using the impervious acre treated or the calculated pollutant load removed.*
- *Maybe used on redevelopment sites to retrofit existing impervious.*
- *Stabilizing existing outfalls.*
- *Replacement alternative for existing close storm-drain systems.*

Riva Annapolis Stormdrain Outfall Restoration

Before

Looking down stream from original outfall location.

Looking up stream from original outfall location.

Lower portion of stream reach.

After

Looking down stream from approximate original outfall location.

Looking up stream from approximate original outfall location.

Looking up stream from just below the approximate original outfall location.

Project Description: The project calls for the design and construction of a stable step pool stormwater conveyance outfall system for the Annapolis High School, to include groundwater recharge and bioretention.

Riva Annapolis Stormdrain Outfall Rehabilitation:

Data Constructed:	Nov-09
Linear Footage:	900 ft.
Drainage Area:	26.8 Acres
Impervious Treated:	12.25 Acres

Modeling Results:	TN (lbs/Acre/Yr)	TP (lbs/Acre/Yr)	TSS (lbs/Acre/Yr)
Exisitng Conditions	241.96	32.84	2.46
After Restoration	145.18	13.13	0.98
Percent Reduction	40%	60%	60%

Legend

- **Extent of Project Restoration**
- **Stream Reach**
- **Project Drainage Area**

0 125 250 500 Feet

Anne Arundel County
Department of Public Works
Bureau of Engineering
Watershed Ecosystem and Restoration Services

ANNE ARUNDEL COUNTY
M A R Y L A N D

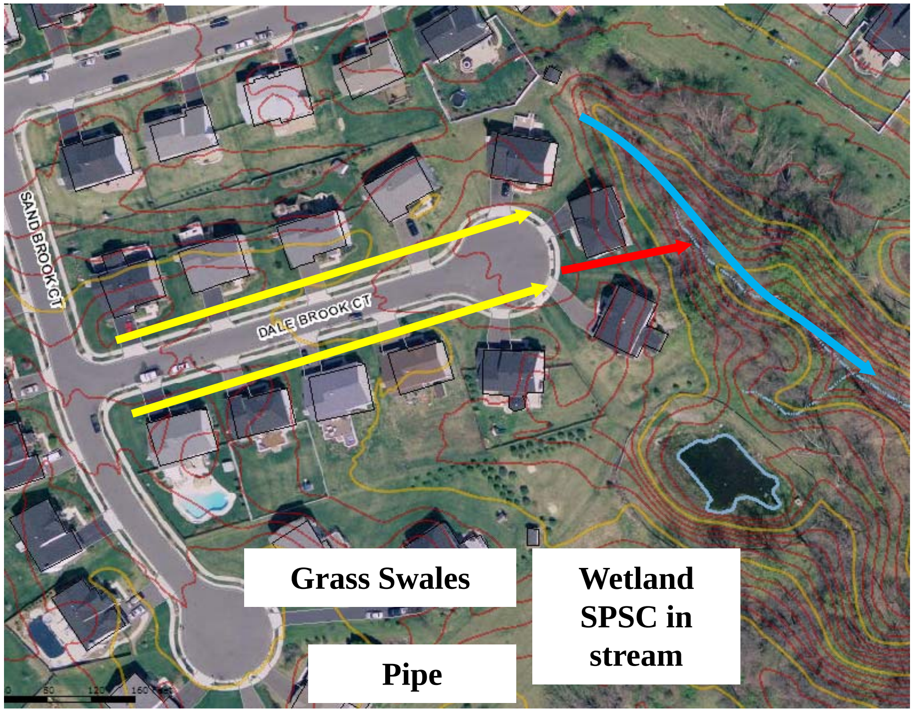
SPSC – Water Quality Mitigation

SWM Mitigation

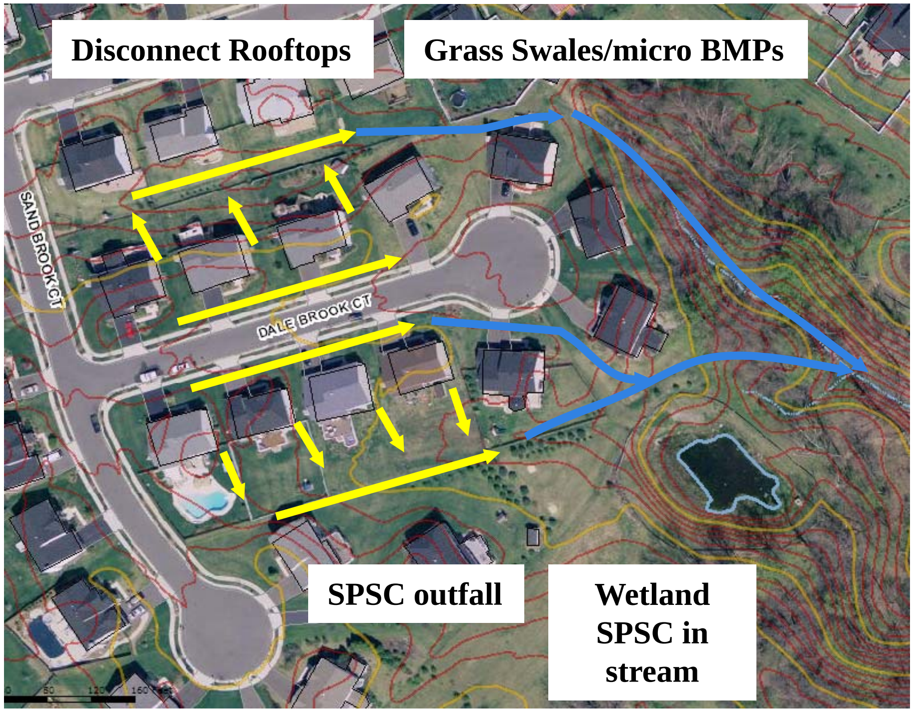
Maybe used as a structural facility to provide water quality control beyond the Maximum Extent Practical (MEP) levels.

Maybe integrated as part of an Environmental Site Design (ESD) with the condition that the SPSC system is hydraulically connected in a treatment chain to a micro BMP system or has an inflow point with a contributory drainage area that does not exceed 1 acre.

SPSC is not integrated with ESD



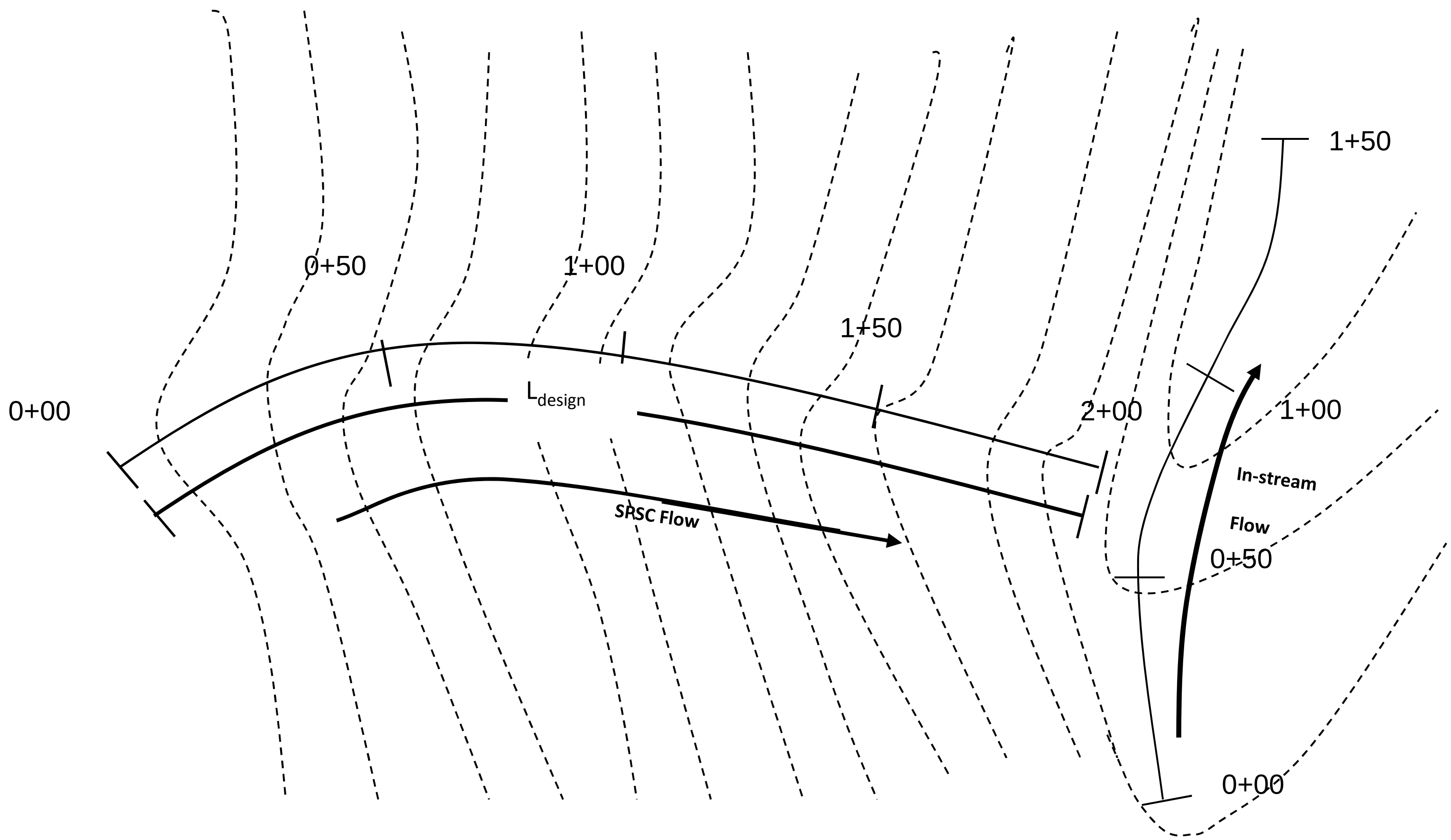
SPSC is integrated with ESD



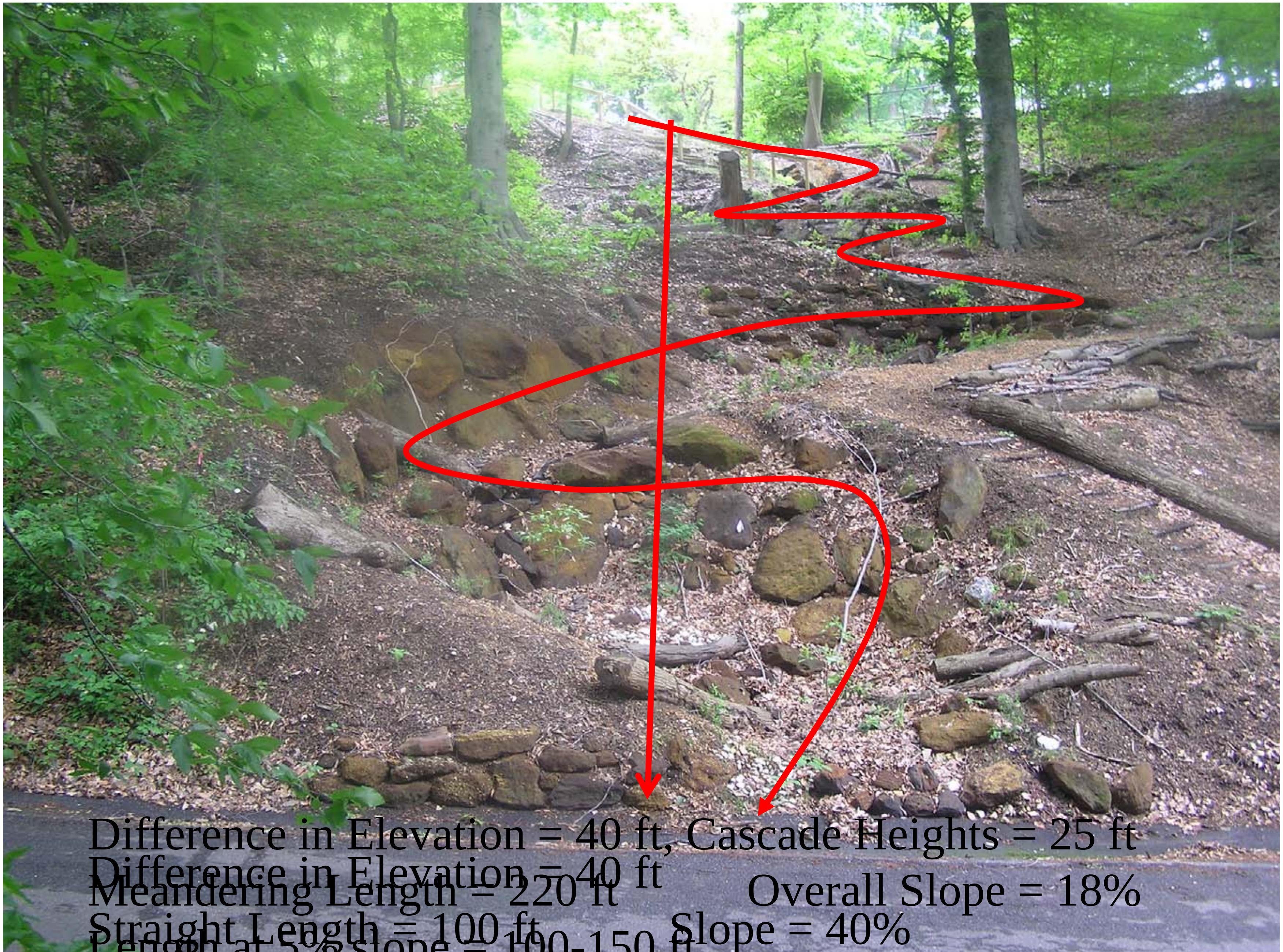
Mapping the SPSC Horizontal Alignment

The SPSC will be placed in the landscape following a curvilinear flow path whenever possible that generally follows the shape of the ravine or localized drainage path.

Minimize impacts to natural features. This could be accomplished through innovative/adaptive construction phasing and tree protection plans.



Mapping the SPSC Horizontal Alignment



Difference in Elevation = 40 ft, Cascade Heights = 25 ft

Difference in Elevation = 40 ft

Meandering Length = 220 ft Overall Slope = 18%

Straight Length = 100 ft Slope = 40%

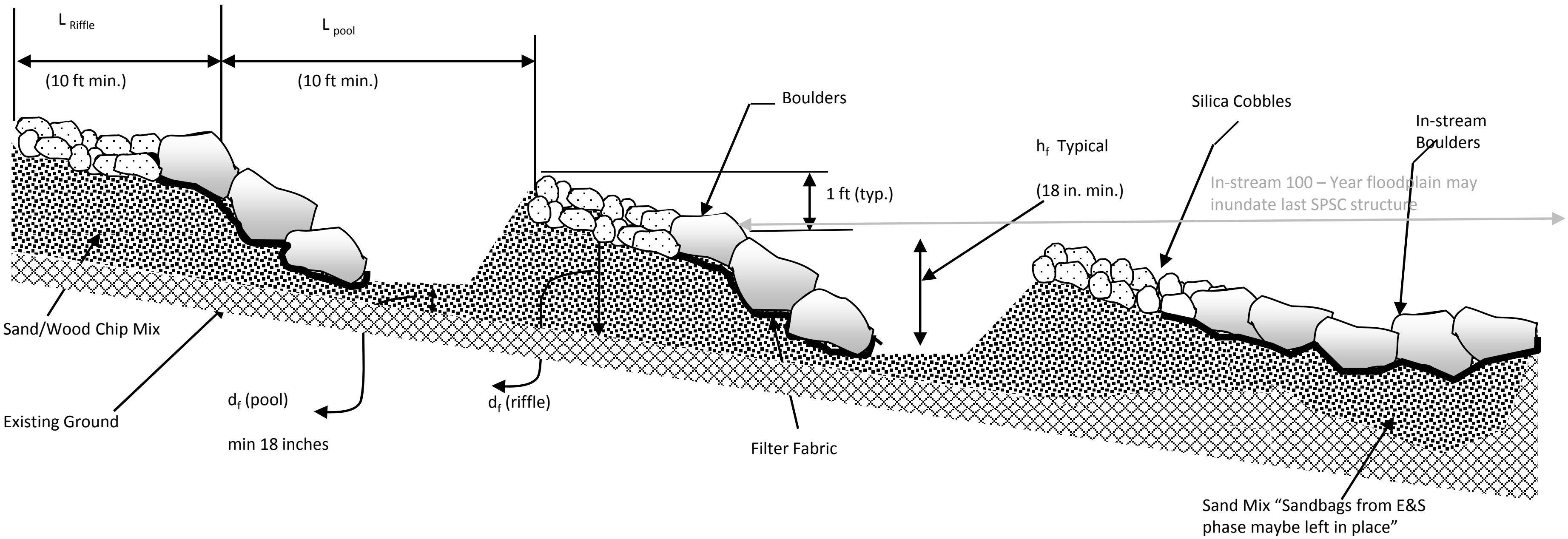
Length at 5% slope = 100-150 ft

Mapping the SPSC Vertical Alignment

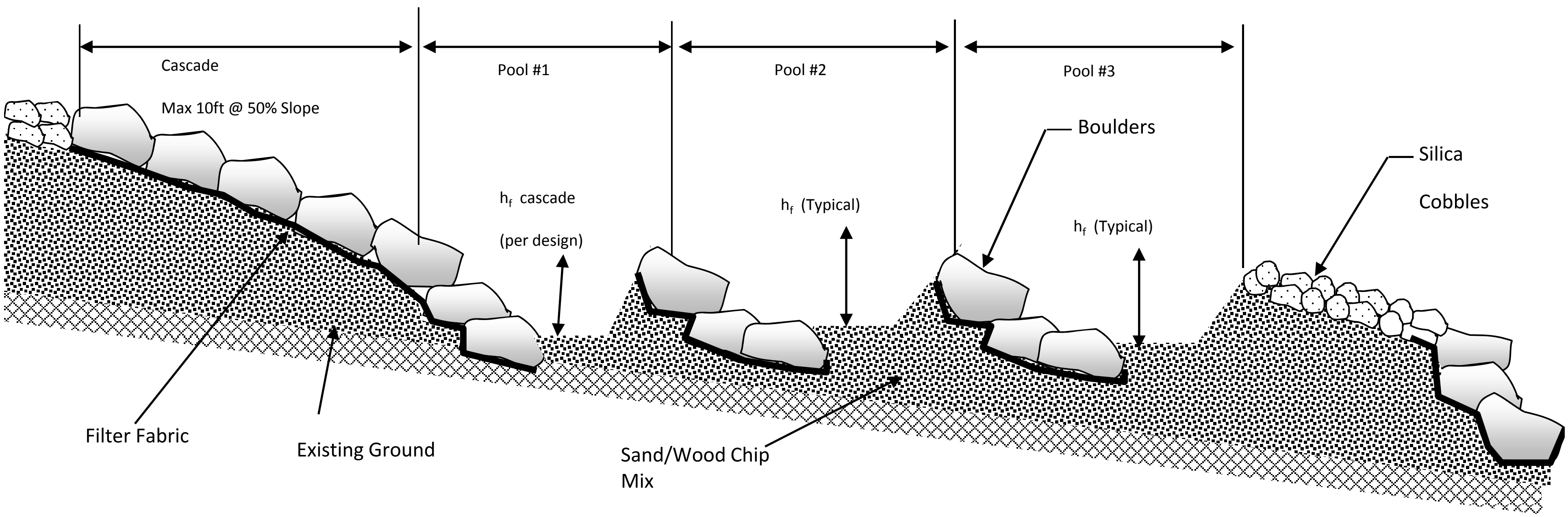
In the event that the proposed SPSC connects to an incised downstream channel, the elevation of the floodplain terrace shall be used as the downstream elevation. An in-stream weir design with a top of weir elevation set at the floodplain terrace is required at the tie-in location.

Notes and Preliminary Assumptions:

Length of Pool = Length of Riffle
Cascade and Weir boulders maybe placed at a maximum (1V:1H) slope
Cascades shall not be more than 5 ft in height at any single location
Cascades shall be followed by three consecutive pools
Un-armored Pool side slopes shall be laid back at 3H:1V
Special attention to paid at the inflow and outflow tie in locations



Mapping the SPSC Vertical Alignment



Cascade Profile – Three Pools following Cascade

Design the typical cross-section for the riffle/cascade

Design Criteria:

- Conveyance shall be designed to address the 100-year Peak Discharge

$$Area = \frac{2WD}{3} \qquad \text{Mathematical Solution}$$

$$Hydraulic \quad Radius = \frac{2W^2D}{3W^2 + 8D^2} \qquad \text{Chow, 1959}$$

$Q = (1.49/n)(A)(R_h)^{2/3}(S)^{1/2}$ Must be > or = Q_{100}

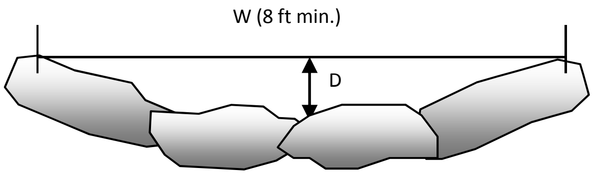
Where:

Q	=	100 year ultimate flow (cfs)
1.49	=	conversion factor
n	=	Manning's n, determined by USDA, 2006 equation
A	=	cross-section area of a riffle channel, which for a parabola = 2/3(W)(D), where W is top constructed width (ft) and D is the constructed depth (ft)
R_h	=	hydraulic radius (ft), calculated using Chow 1959 relationship for parabolas
S	=	average slope over entire length of project (ft/ft)
V	=	velocity in the riffle channel (ft/sec), V = Q/A

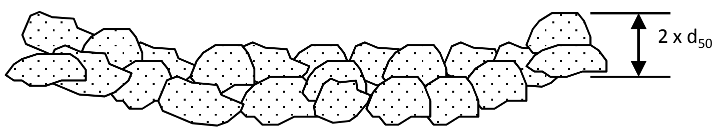
$n = D^{1/6} / (21.6 \log(D/d50) + 14)$, (USDA, 2006).

Where:

n	=	Manning's n, use 0.05 for cascades.
D	=	depth of water in the riffle channel associated with unmanaged 100-year Q_{design}, ft.,
d_{50}	=	cobble size, ft



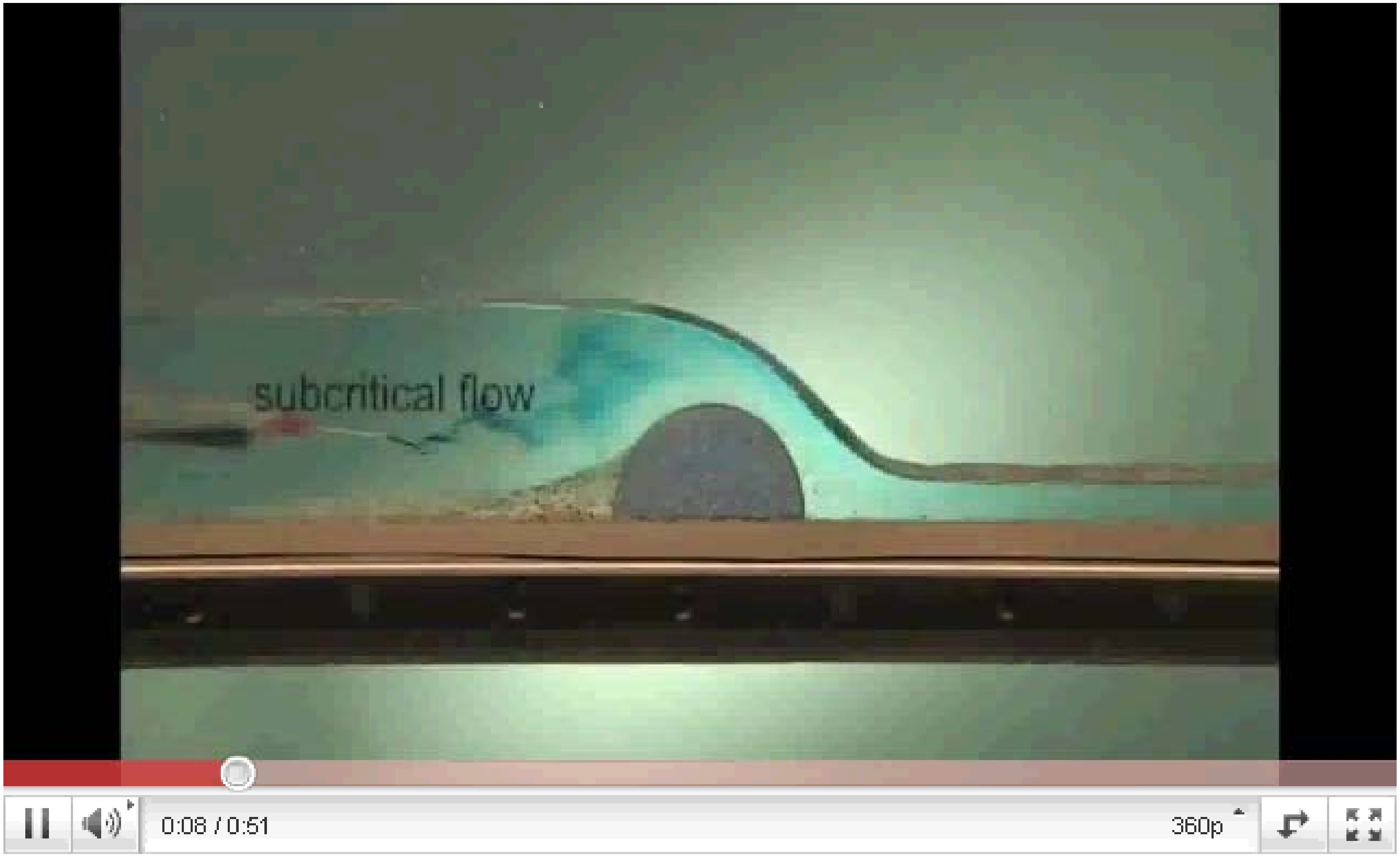
Riffle Section through Boulder



Riffle Section through Cobble

Design the typical cross-section for the riffle/cascade

Checking for Super Critical Flow:



Design the typical cross-section for the riffle/cascade

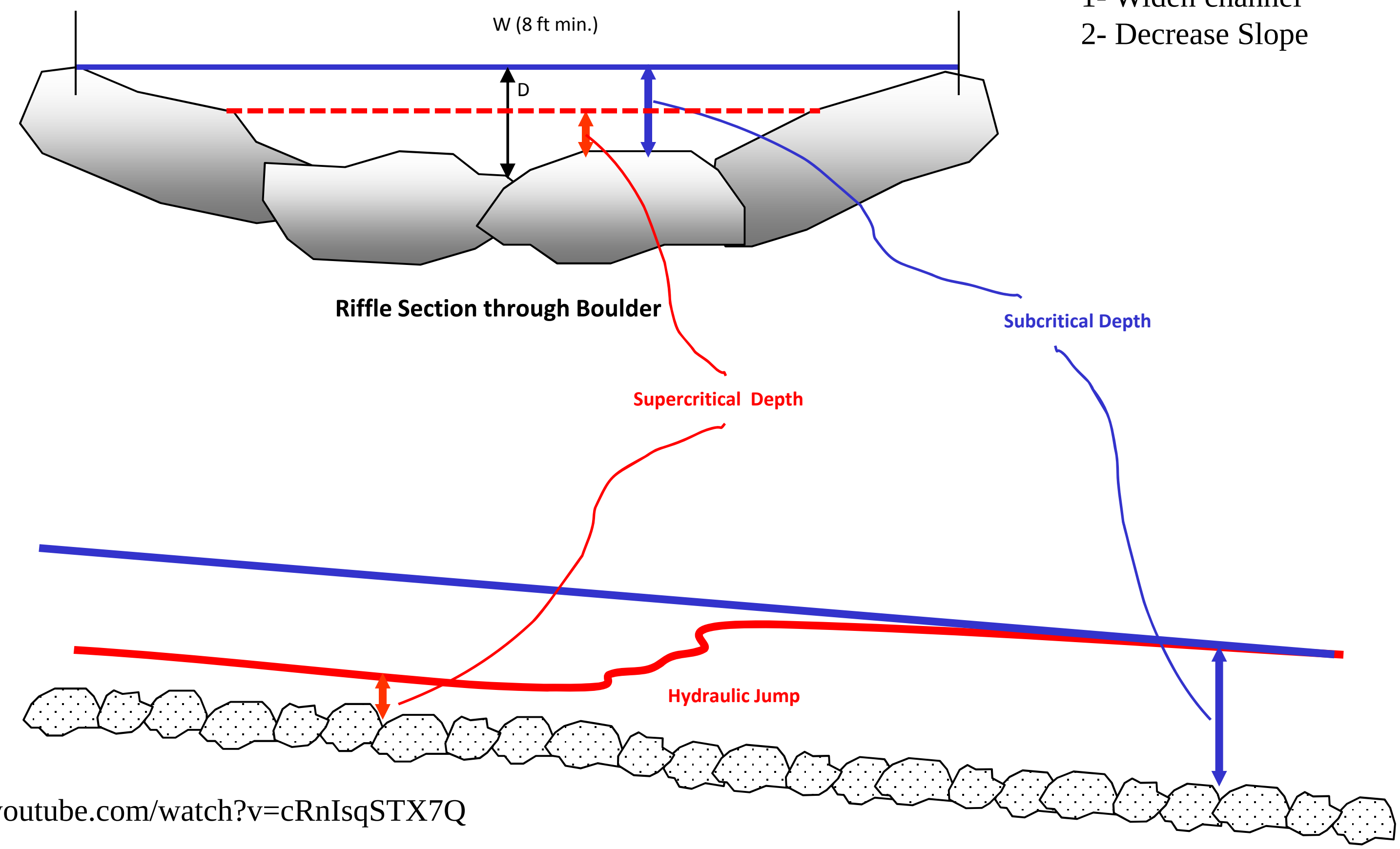
Checking for Super Critical Flow:

$$Fr = \frac{V}{\sqrt{gD}}$$

- Froude Number exceeding 1 indicates the flow is supercritical
- Froude Number = 1 indicates that the flow is critical
- Froude Number less than 1 indicates the flow is subcritical

To reduce the Froude number

1- Widen channel
2- Decrease Slope



http://www.youtube.com/watch?v=cRnIsqSTX7Q

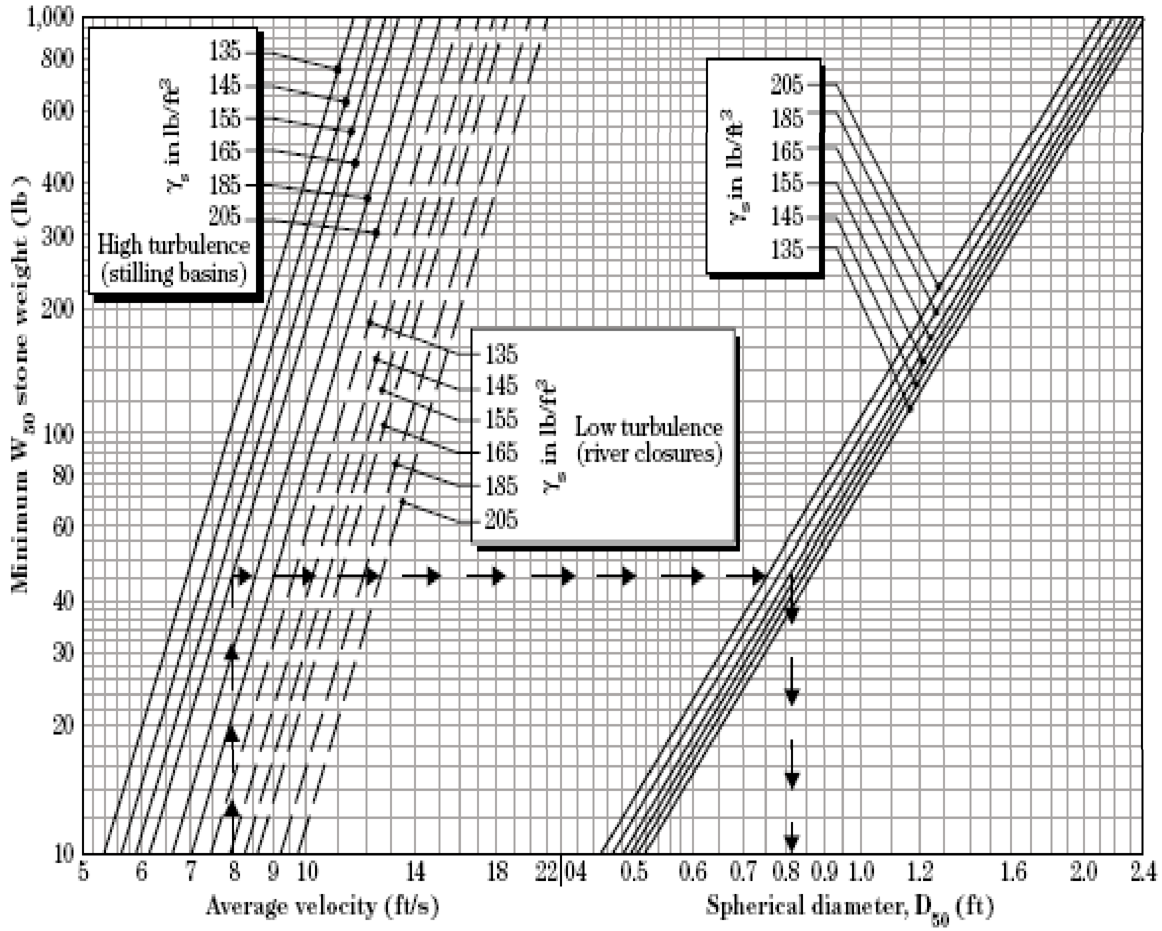
Checking/Sizing the Riffle Cobbles

Use a trial D_{50} = 6 inches

Actual Velocity Must be < Maximum Allowable Velocity

$$Maximum\ \ Allowable\ \ Velocity = C \times \left(2 \times g \times \frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{0.5} \times \left(D_{50}\right)^{0.5} \qquad Isbash\ \ Formula$$

NRCS 2007



Where:

C	= 0.86 for prevailing supercritical flow 1.2 for prevailing subcritical flow
g	= 32.2 ft/sec2
γ_s	= stone density (lb/ft3)
Γ_w	= water density (lb/ft3)
D_{50}	= cobble stone diameter (ft)

Do not use available tabulated solutions for the Isbash Curve Unless the assumptions are checked

Checking/Sizing the Riffle Cobbles

Some Cobbles are expected to move due to uncertainties in the design, i.e. flow, D_{50} sizing criteria, etc, only excessive movement and exposure of subgrade/extensive erosion would warrant action.

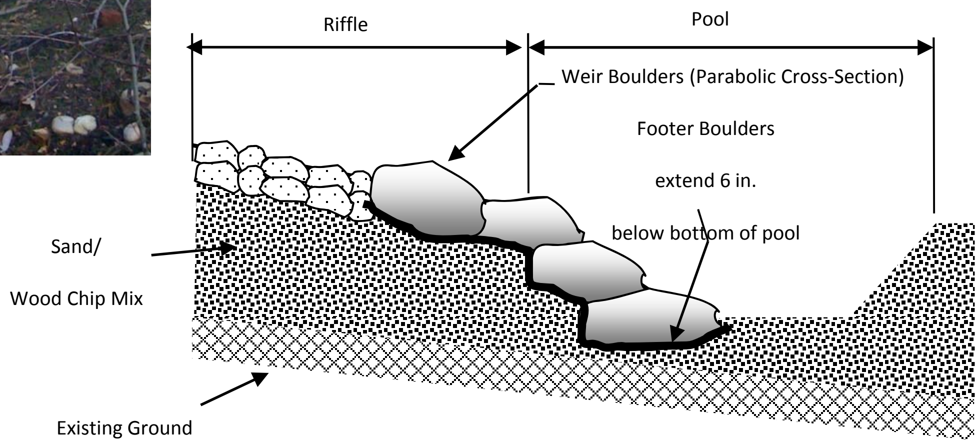
Designing the Rock Weir and pool

The rock weir shall take the cross-sectional shape of the riffle

Designing the Rock Weir and pool

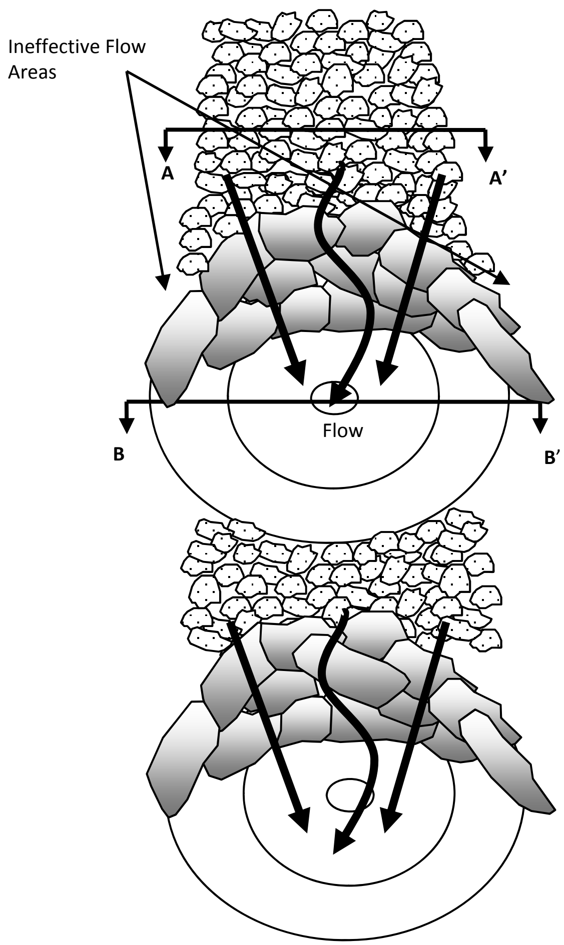
- **The sandstone boulders shall be sized to be at least 3-4 times heavier than the cobbles**

- **Sandstone boulders shall be layered with footer rocks to allow a minimum of six inch embedded-ness below the lowest excavated point in the pool**



Designing the Rock Weir and pool

- The Rock Weir shall be placed in a curvilinear manner to deflect the flow to the center of the pool



Designing the Rock Weir and pool

Pool Depth (h_f) shall not be less than 18 inches and shall not exceed 4 ft.

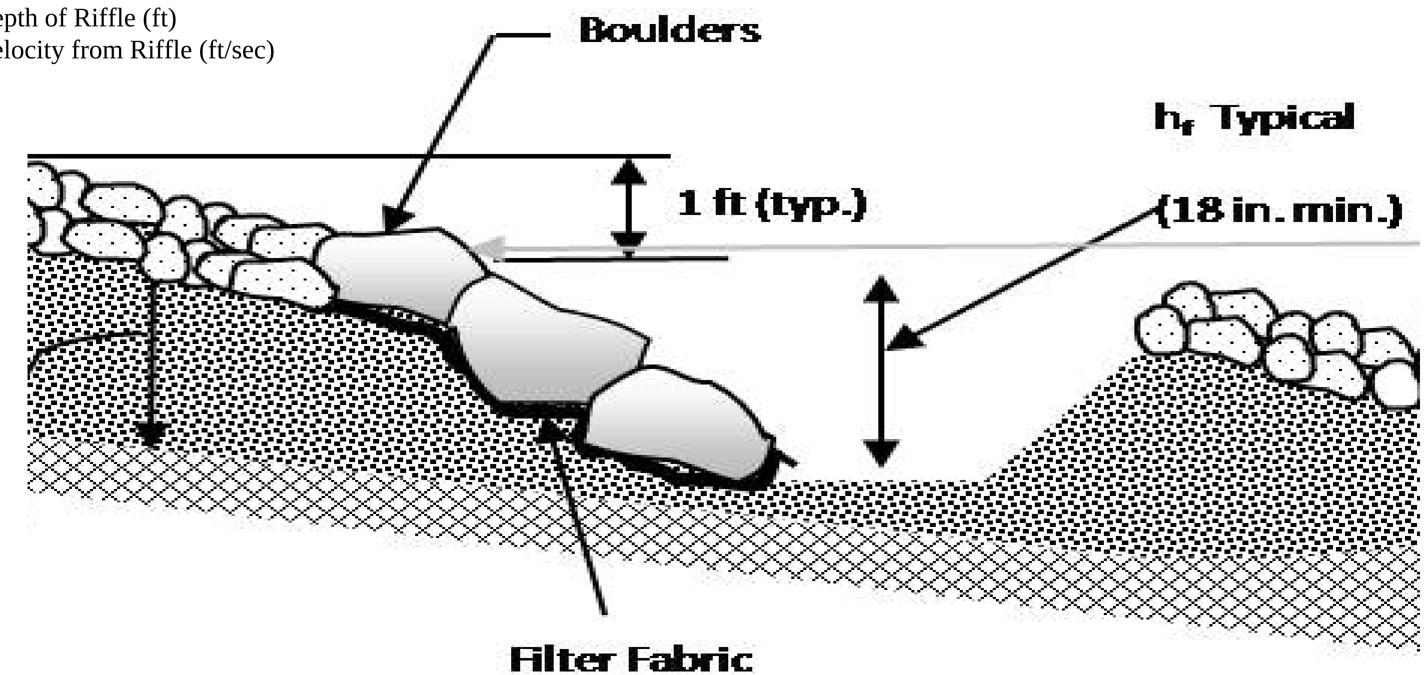
To ensure stability, the pools shall be constructed with a minimum side slope of 3H:1V.

$$h_f \text{ or } h_{f\,cascade} = D + \frac{V^2}{2g} - 0.25$$

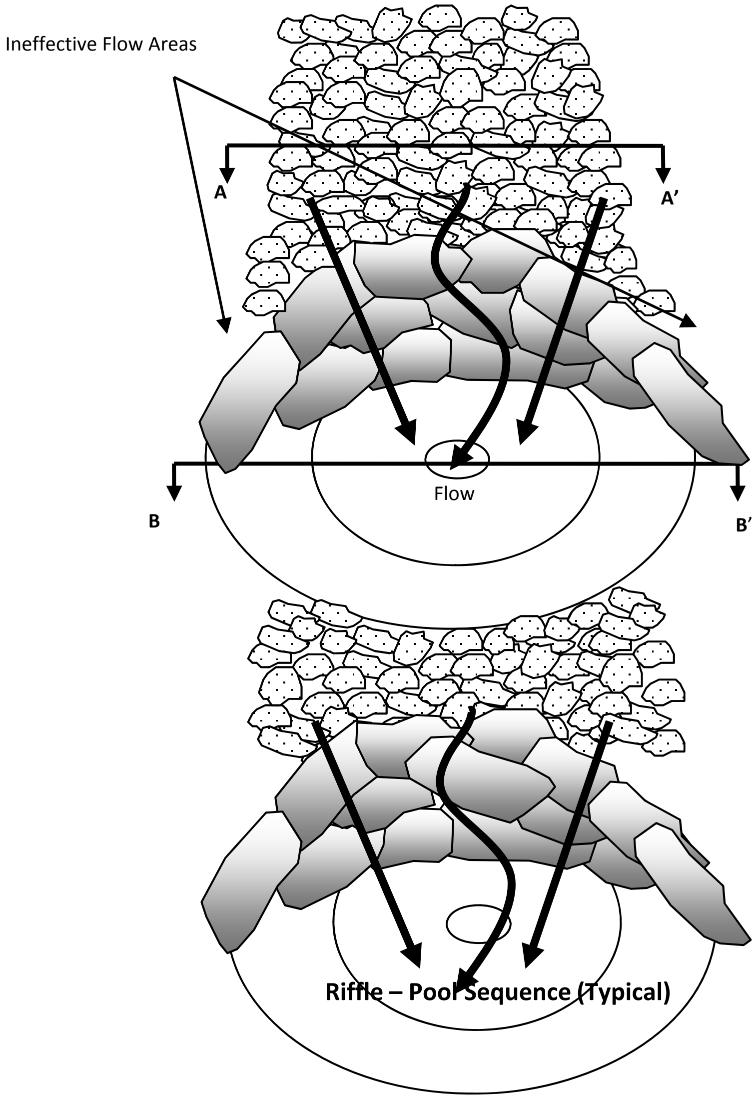
Ensures that velocity in the pool < 4 ft/sec

Where:

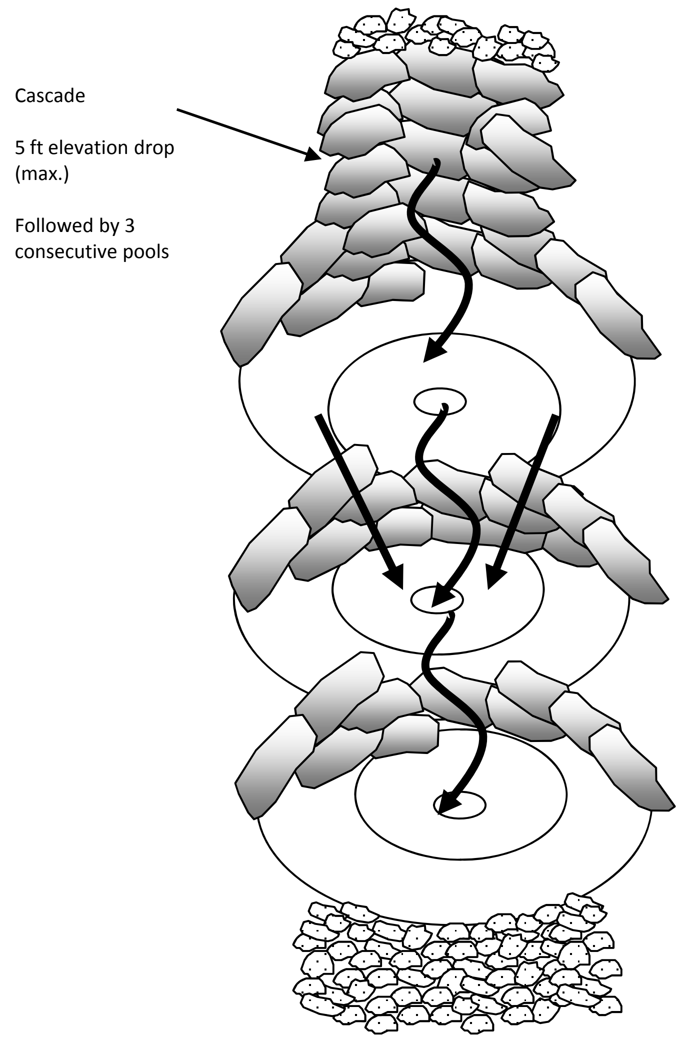
D = Incoming Depth of Riffle (ft)
V = Incoming Velocity from Riffle (ft/sec)



SPSC – Plan View
Riffle/Cascade/Pool Sequence



Riffle – Pool Sequence (Typical)

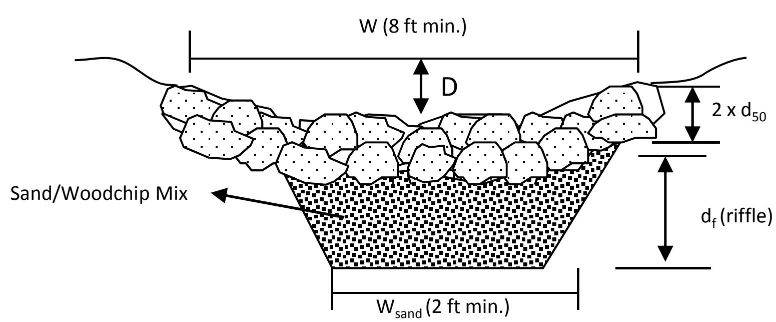


Cascade Sequence

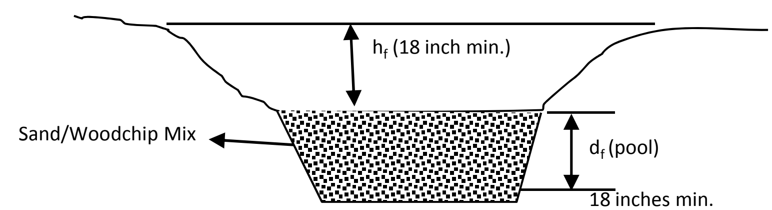
Designing the water quality sand filter system

The pretreatment, recharge, and water quality sizing criteria presented in the Anne Arundel County SPSC guidelines follow closely the State of Maryland's criteria for a typical stormwater filtering device.

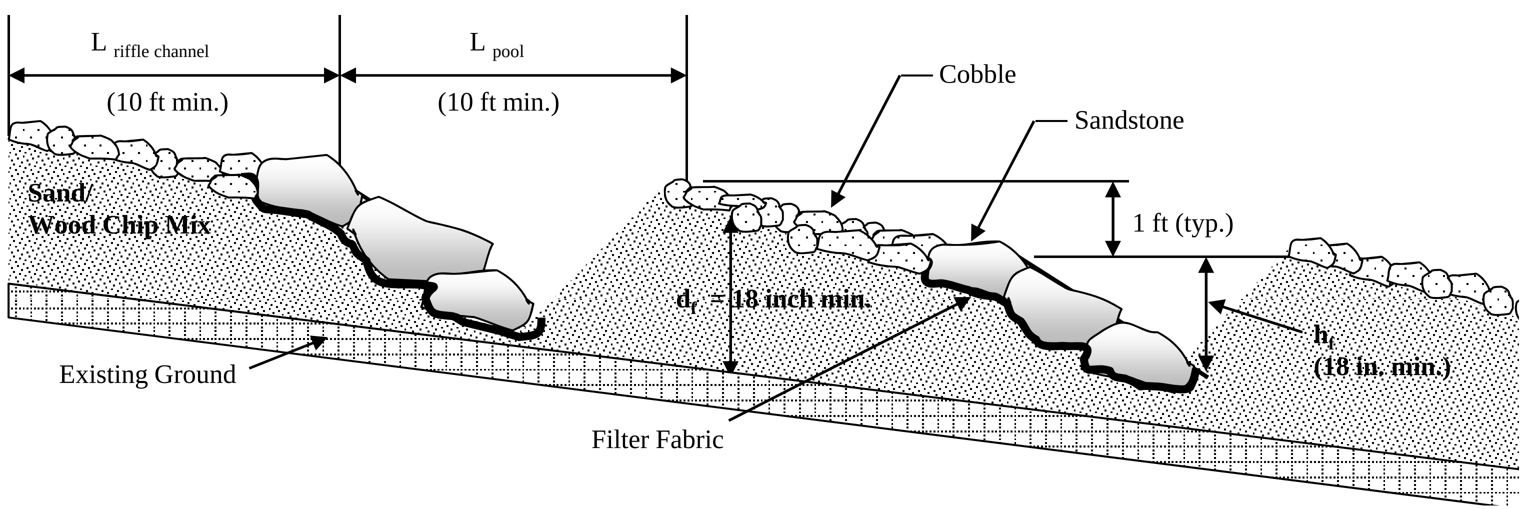
$$A_f = \frac{WQ_v \; x \; d_f}{K\,(h_f + d_f)\,t_f}, \qquad \textit{Filtering Sizing Criteria MDE } 2000$$



Riffle Weir Cross Section through Cobble

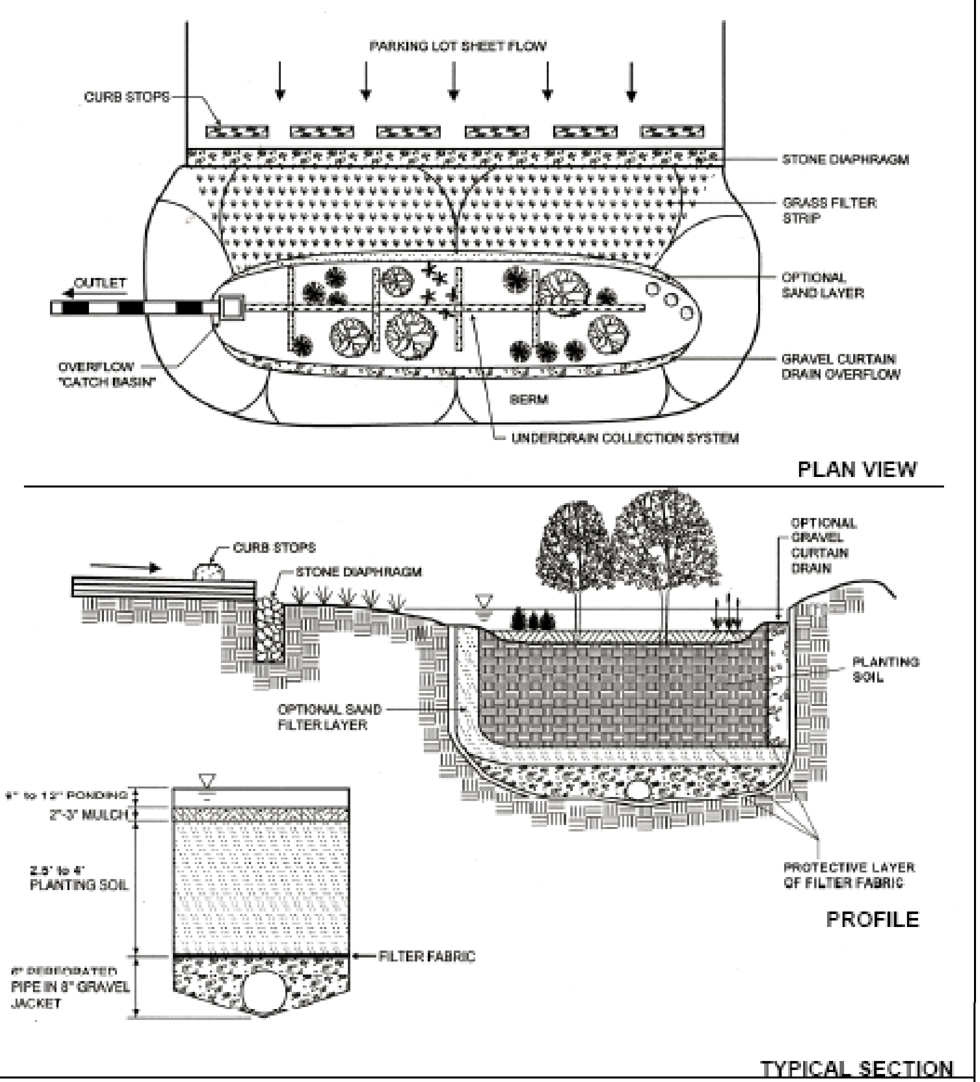


Pool Cross Section



Filtering Systems
Bioretention

F-6	Figure 3.17 Example of Bioretention	F-6



Bioretention combines open space with stormwater treatment.

Checking Storage/Quantity Management

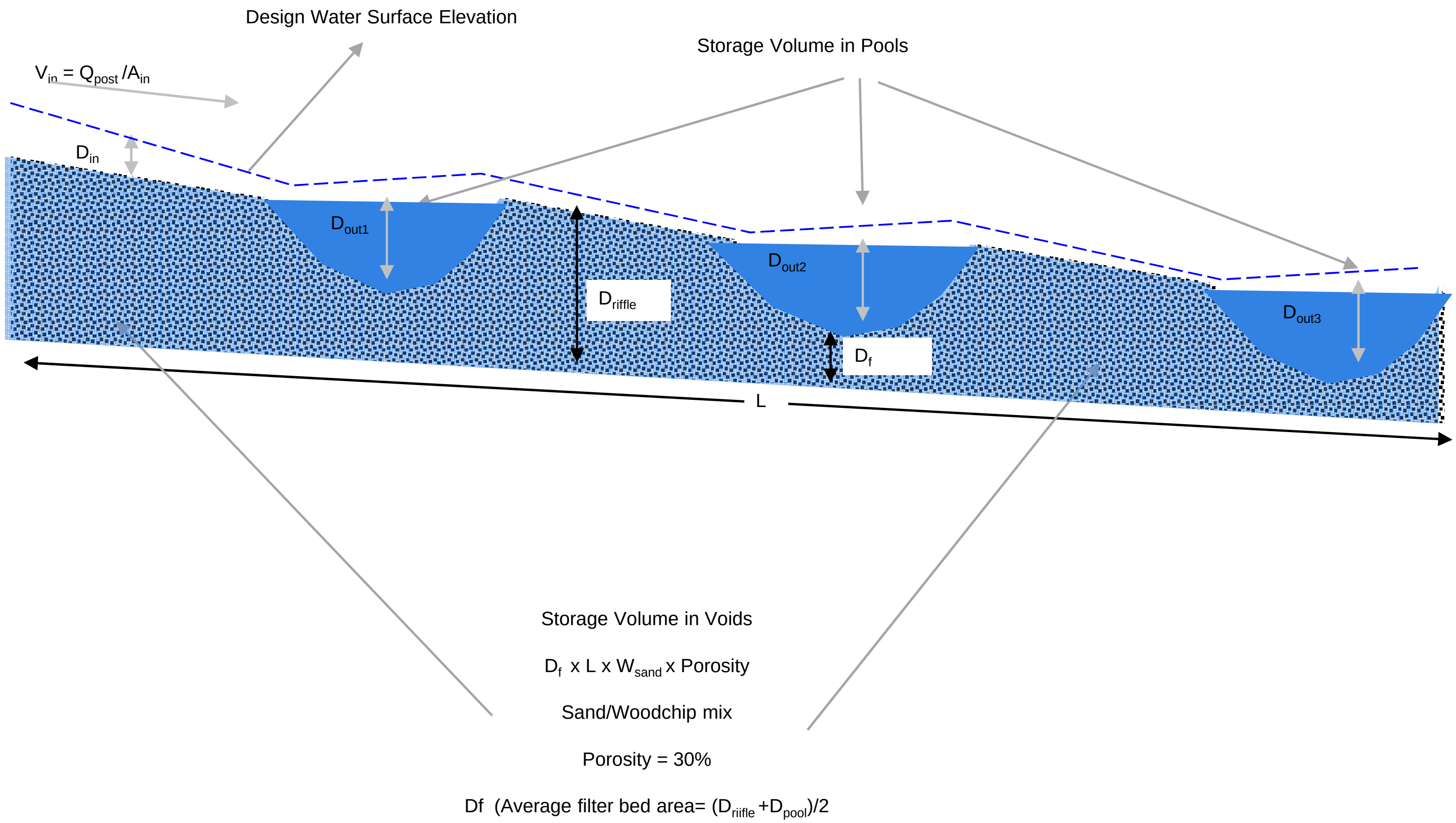
The proposed SPSC will satisfy peak management flow requirements if two conditions are met:

a- First, adequate storage volume within the pools and sand/woodchip voids shall be provided to meet the required storage volume/quantity management for the project

b- Second, it must be demonstrated that the design renders the hydraulic power equivalent to the predevelopment/desired hydraulic power through the proposed energy dissipation pools.

Checking Storage/Quantity Management

a- First, adequate storage volume within the pools and sand/woodchip voids shall be provided to meet the required storage volume/quantity management for the project



Checking Storage/Quantity Management

b- Second, it must be demonstrated that the design renders the hydraulic power equivalent to the predevelopment/desired hydraulic power through the proposed energy dissipation pools.

(Potential + Kinetic + Static) $\text{Energies}_{\text{SPSC entrance}}$ =
(Potential + Kinetic + Static) $\text{Energies}_{\text{SPSC outlet}}$ + $\text{Head loss}_{\text{within SPSCsystem}}$

- Energy Dissipation =

Post Development Energy →

Pre Development Energy →

Checking Storage/Quantity Management

Hydraulic Power = γ x Q x S, where

γ is the unit weight of water = 62.4 lb/ft^3

Q corresponds to the MDE 2000 CPV or County Quantity Management requirement

S = slope of the outfall channel in %

Equate the predevelopment/design and post development hydraulic powers

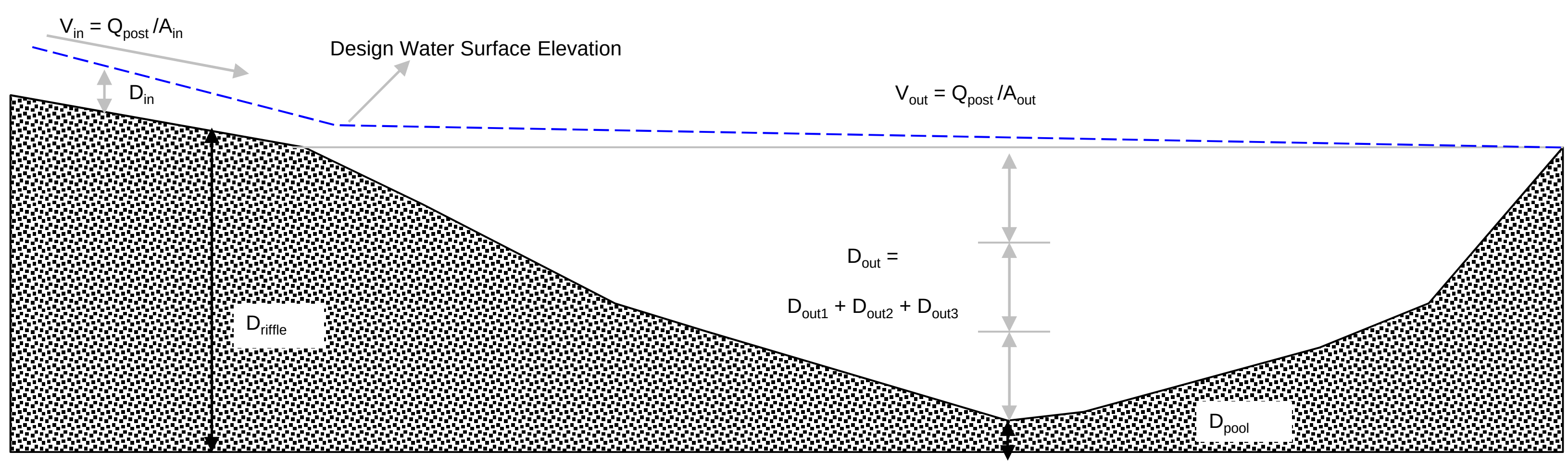
$$\gamma \times Q_{pre} \times (\Delta E/L_{pre}) = \gamma \times Q_{post} \times (\Delta E/L_{post})$$

Solve for the needed added stream length.

$$L_{add} = L_{pre} \times (Q_{Post}/Q_{Pre}) - L_{pre}$$

$$Friction\ head\ loss = \frac{f L_{add} V_{out}^{2}}{2 D_{out} g}$$

$$f = 8gRh^{-1/3}n^2 \qquad Chow, 1959$$



SPSC Material Specifications

Sand shall meet the requirements of AASHTO M43 size, #57, Section 02621.02.
Wood chips and mulch shall be in accordance with DPW standards and specs, section 02860.02.

Cobbles shall be composed of a well-graded mixture of stone size so that 50% of the pieces, by weight, shall be larger than the d_{50} size determined by using charts prepared by the US Department of Agriculture, Soil Conservation Service. The stone shall be silica cobbles and shall meet the following requirements as specified. A well graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the large voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size (e.g., 8" * 1.5 = 12").

Sandstone (aka, bog iron, ferracrete) is the only large type of boulder found on the coastal plain in Anne Arundel County. It is irregular and generally tabular in shape and neutral or acidic in pH. If material availability is of demonstrated concern, granite maybe used as a substitute. At no event can limestone (riprap) be used.

Finalize the cross-section and profile design

Develop a grading plan based on the preliminary profile and cross-section typical design.

Adjust the preliminary profile dimensions to accommodate site specific concerns/impacts. Minimum design parameters for hydraulic, water quality, and quantity management criteria should be rechecked based on adjustments to the riffle/pool channels to ensure that safe and adequate conveyance is still maintained.

The sand/woodchip mix filter bed shall have a minimum depth of 18 inches under the riffle channel and a minimum width of 4 ft and shall be placed as the substrate drainage material along the entire project length. The actual dimensions of the sand/woodchip mix filter bed will be determined based on the required water quality volume.

Typically, construction of the SPSC system shall begin at the downstream end and proceed upstream to the project outfall. The outlet pool is designed to be placed at the lowest point in the project reach. This is often in the receiving wetland or stream/ floodplain, but can also be located in upland settings where the SPSC system discharges to another stormwater BMP or adequate storm conveyance system.

Footer boulders shall be placed at the interface of the pools and riffles as specified.

Continue the process of alternating pools and riffles up through the system to the entry pool. If the entry pool ties to an existing pipe outfall, additional armoring of the pool maybe needed to address the pipe exit velocities associated with supercritical hydraulic conditions. The designer may elect to use a larger size pool at the project entry to dissipate the outfall velocity and/or to address pretreatment concerns.

If the SPSC is proposed below a pipe system, it is desirable that the top invert of the weir associated with the entry pool is set at or above the invert of the discharge pipe or culvert. It is the responsibility of the design engineer to check the adequacy of the upstream drainage system

Course woodchips and compost should be used throughout the limit of disturbance for site stabilization. All areas should be hydro-seeded.

It is advisable that excess materials, i.e., cobbles and boulders, be placed at the edge of the cross-section for use during the maintenance phase to correct any physical instability.

Develop the Planting Plan

A complete list of native plants can be found under
www.aacounty.org/IP/Resources/AANativePlants.pdf

Any plant substitutions must be approved by the project manager/reviewer before the substitute species are installed.

For projects within the airport zone, utilize MAA approved native plants

Pay special attention to use of native material, diversity, and dense placement of plant material within appropriate wetness zones throughout the site (MDE, 2000).

Spray down a minimum 3 inch layer of compost throughout the site.

Seed the entire site with Chewing Red Fescue.

Existing trees to be protected shall be marked clearly on the project plan view and planting plan.

The designer shall prescribe the use of course woody debris, ie. Inverted root wads, in the pool areas to enhance the soil porosity and create habitat for the biological community.

Develop Operation/Maintenance Plan

Routine/biannual maintenance of County-owned SPSC systems is prescribed for a period of **five years**.

This includes, but is not limited to,

- Mulching of devoid areas

- Diseased plant replacement and replanting if necessary

-Removal of excessive debris and invasive species.

-In the event that sediment accumulation exceed six inches in the first year, the contractor shall spray down an additional layer of compost and replant the pool bottoms.

- Direct maintenance access shall be provided to the pools and filter bed.

- A recorded maintenance agreement is required for all privately owned SPSC systems.

- The operation and maintenance design detail and schedule shall be shown on the asbuilt plan. For privately owned structures, the maintenance agreement shall be officially recorded and the recordation number shall be included on the approved grading plans.

Develop a Monitoring Plan

A monitoring plan must be prepared to address the specific restoration goals for the project and to ensure structural stability and plants survivability .

These components shall be monitored for **<u>3 years</u>** or as established in the plan review process.

Enforcement of the monitoring conditions shall be tied to the asbuilt approval process and release of SWM bond.

The monitoring plan for SPSC shall include annual vegetation survey to document that planted species have 80% survivability and a biannual physical stability assessment. At the discretion of the project manager, annual benthic macro invertebrate monitoring using the Anne Arundel County approved protocols and storm event chemical monitoring for nutrients and sediments may be required.

The monitoring plan shall also address all permit required project monitoring.

Construction Access

Sequence of Construction

Sequence of Construction

Innovative Outfall & Stream Restoration Techniques:

Step Pool Storm Conveyance (SPSC)

Riva 400 - Constructed in Dec 2009

Riva 400 Before Restoration (2004)

Conveyance

Stability

Habitat

Water Quality

Before Restoration

After Restoration

Central Sanitation Facility

Stretch Goal Requirements

Public Project

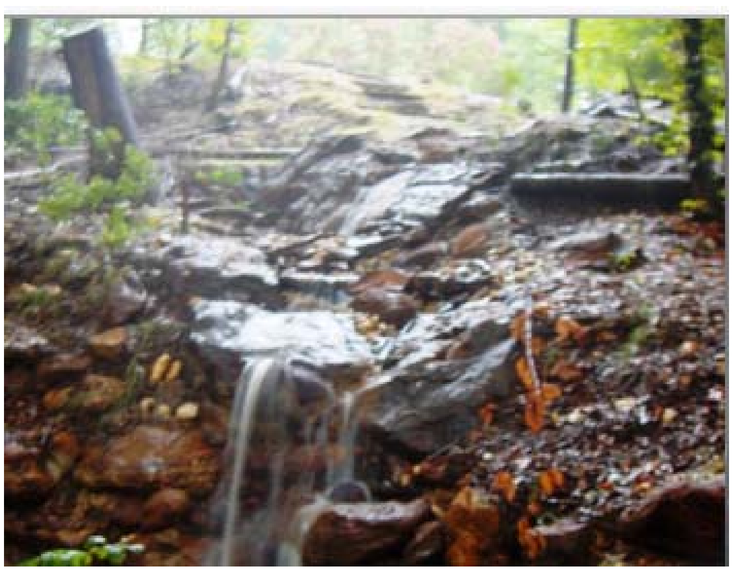
Saefern Outfall Restoration

Steep Slope Application

Community Project

Before Restoration

After Restoration



After Restoration

Carriage Hills

Outfall Restoration

Grant Project

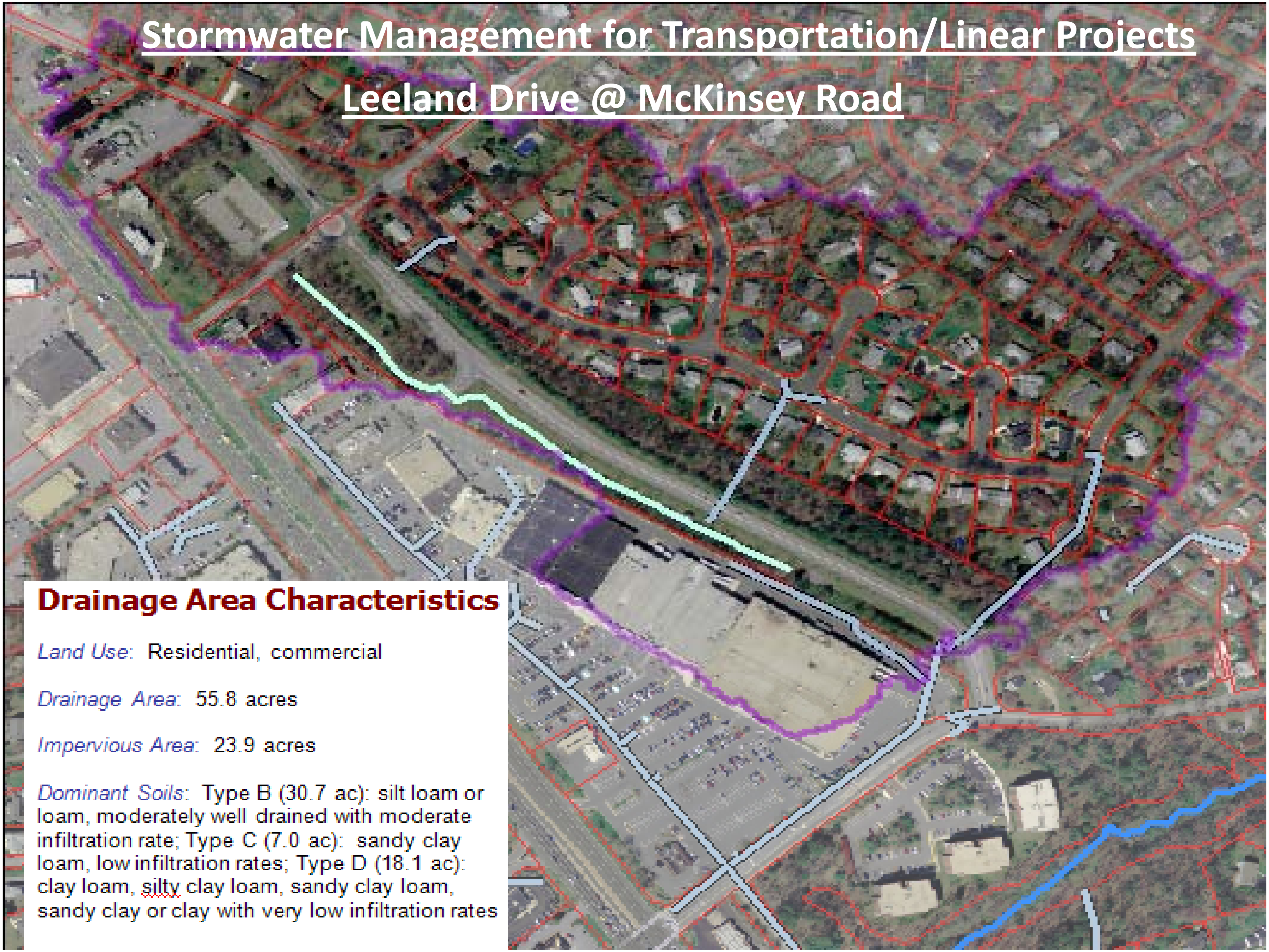
Before

Construction Complete February 2010

National Business Park
Effective Mitigation for Downstream Instabilities

Stormwater Management for Transportation/Linear Projects

Leeland Drive @ McKinsey Road



Drainage Area Characteristics

Land Use: Residential, commercial

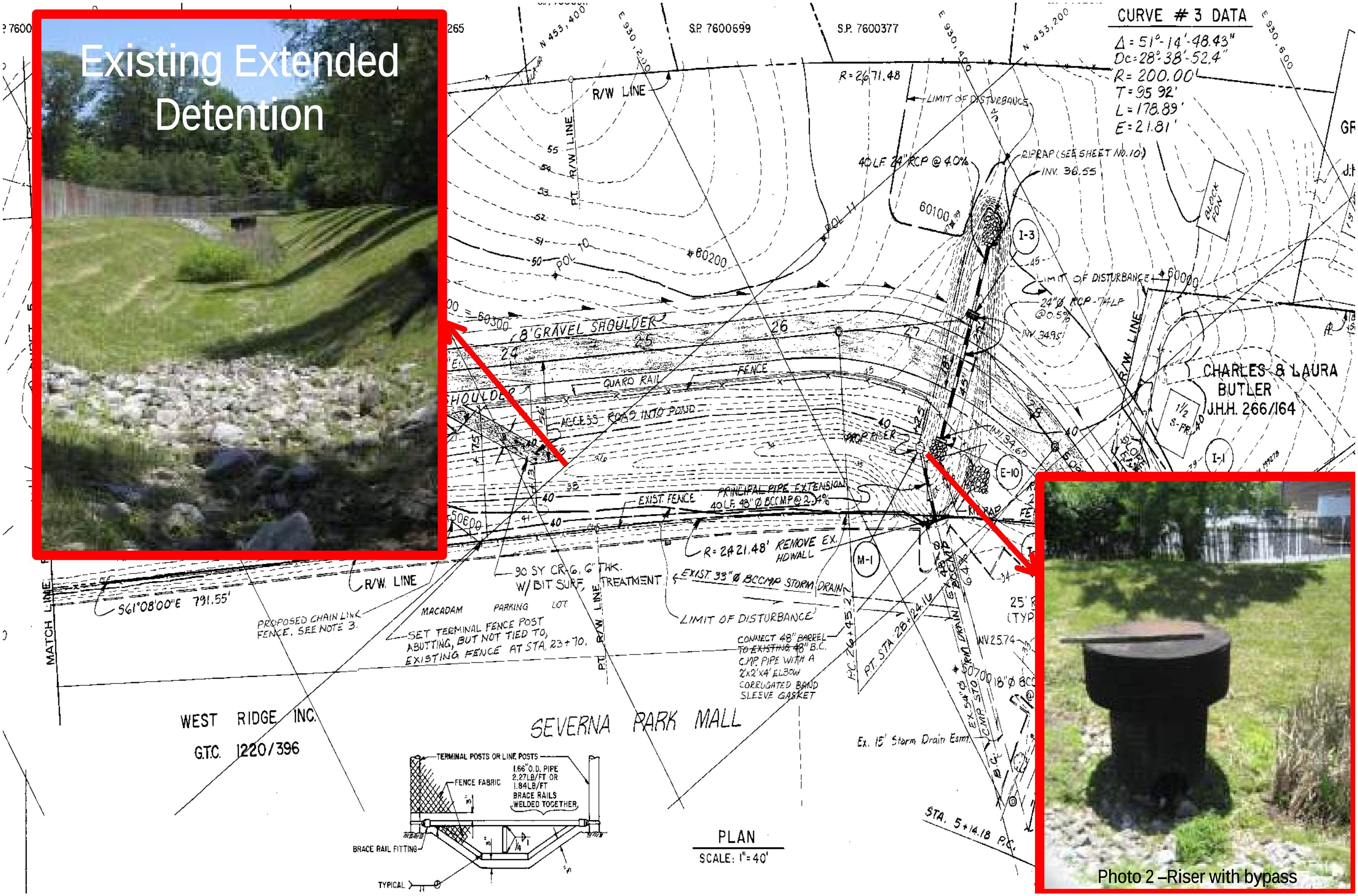
Drainage Area: 55.8 acres

Impervious Area: 23.9 acres

Dominant Soils: Type B (30.7 ac): silt loam or loam, moderately well drained with moderate infiltration rate; Type C (7.0 ac): sandy clay loam, low infiltration rates; Type D (18.1 ac): clay loam, silty clay loam, sandy clay loam, sandy clay or clay with very low infiltration rates

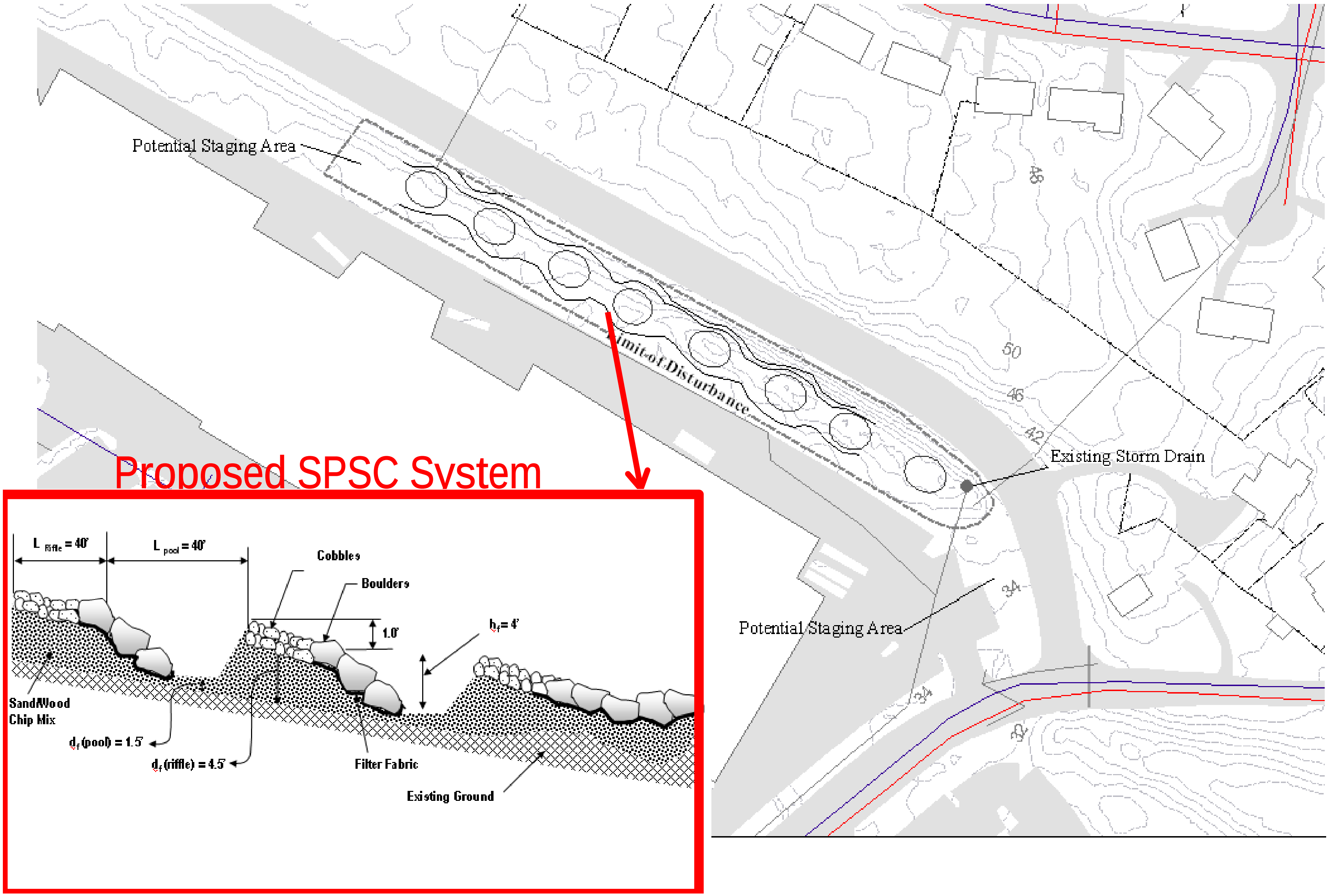
Stormwater Management for Transportation/Linear Projects

Leeland Drive @ McKinsey Road



Stormwater Management for Transportation/Linear Projects

Leeland Drive @ McKinsey Road



DPW Preliminary Engineer's Unit Cost Estimate for Step Pool Storm Conveyance (SPSC)..aka Coastal Plain Outfall (CPO)

For use in preparing bond estimates for development projects

ITEM	UNIT	UNIT PRICE
Mobilization - 10% of total Cost	LS	
Survey Stake Out - 5% of total Cost	LS	
Clearing and Grubbing	SY	$ 2
Erosion and Sediment Control (perimeter control + Diversion if needed)	SY	$ 4
Concrete/Pipe Removal	SY	$ 25
Sand Fill (Filter Bed Area)	CY	$ 60
Sandstone Boulders	CY	$ 240
Cobble Weir (D50 = 8" Rock)	CY	$ 90
Geotextile	SY	$ 4
Wood Chips (30% mix in Filter Bed Area)	CY	$ 25
Wood Chips (Surface 1 inch)	CY	$ 25
Excavation	CY	$ 20
Blaze Orange Fence	LF	$ 8
Compost	CY	$ 50
Plantings (Trees, Shrubs, Herbs, and SAV)	SY	$ 10
Temporary seed & Rye	SY	$ 1
Contingency - 5 % of Total Cost	LS	

Average Cost of SPSC System

$800/linear Feet

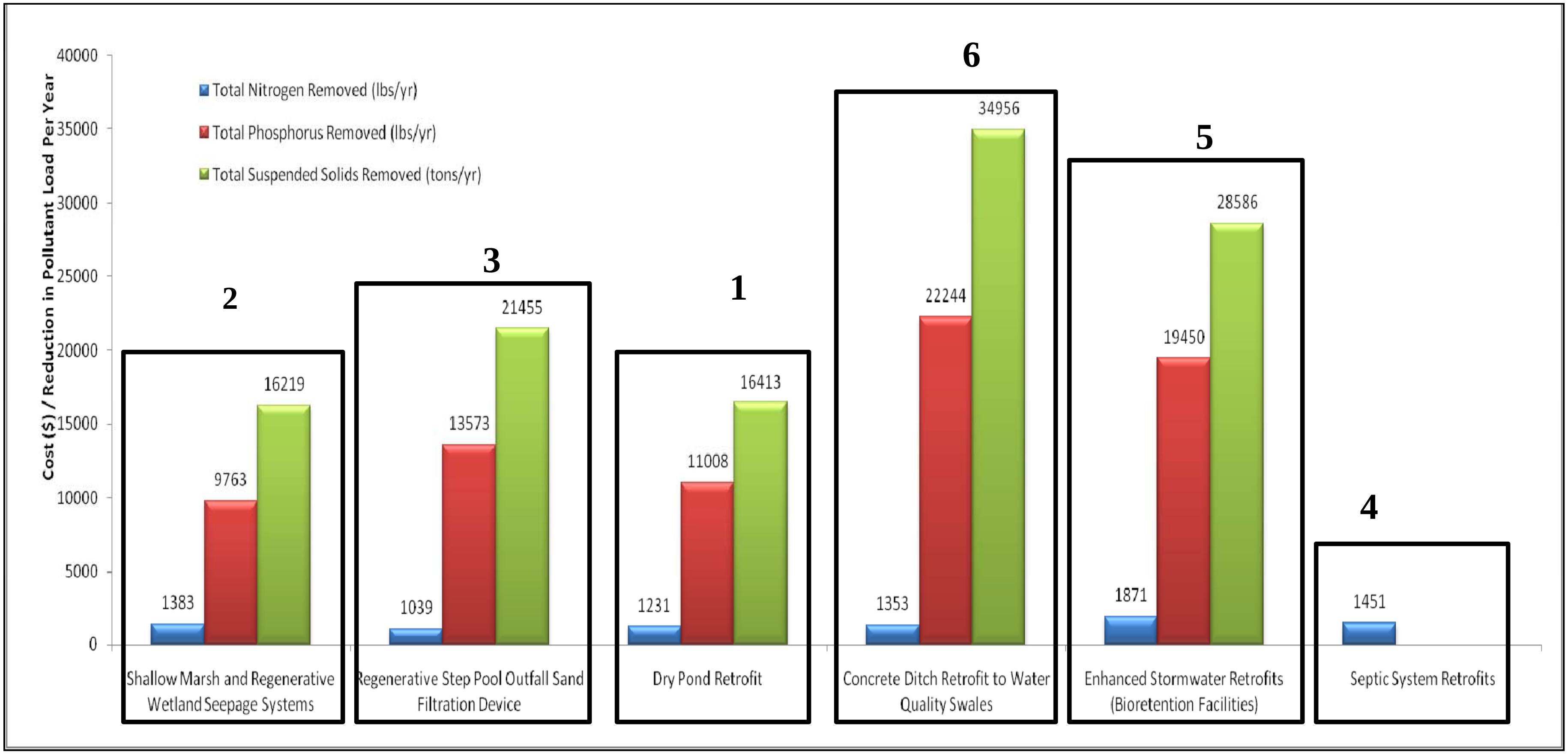
Prepared by: Hala Flores, P.E., Watershed Assessment and Planning Program Manager
Dennis Mcmonigle, Environmental Engineer Project Manager

Reviewed by: Janis Markusic, Ecological Assessment Program Manager

The unit cost estimate presented above is based on average cost encumbered by DPW through the CIP contract

Cost ($) **- Benefit** (Pollutant Reduction) **Ranking of various Restoration Implementation Strategies**

Adopted from the Comprehensive Magothy River Watershed Master Plan



Low ↑ Cost ↓ High

1- Dry Pond Retrofits with SPSC systems

2- Stream Restoration/ Wetland Seepage Systems

3- Outfall Restoration/ Step Pool Storm Conveyance

4- Septic System Retrofits

5- Upland Retrofits (Environmental Site Design)

6- Retrofit of Concrete Ditches

In summary

Requirements of the Stormwater Management Act of 2007

SPSC

Requirement		SPSC
1. Reduce downstream erosion in receiving streams	✓	Energy dissipation, hydraulic power reduction, and proper tie-in design
2. Capture and treat stormwater runoff to remove pollutants	✓	Filtration, infiltration, wet pools, wetlands, plantings, etc.
3. Maintain 100% of the average annual predevelopment groundwater recharge	✓	Integration with ESD design and enhanced groundwater recharge design
4. Prevent increases in the frequency and magnitude of out-of bank flooding from large, less frequent storms	✓	Storage and slow seepage release of the 100-year storm.

SPSC Design Calculator

HOME | GOVERNMENT | BUSINESS | RESIDENTS | VISITORS | EMPLOYMENT | NEWS | EVENTS

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DPW HOMEPAGE
CUSTOMER SERVICE
DPW TELEVISION
UTILITIES
RECYCLING/TRASH
ENGINEERING
HIGHWAYS
CONTACT US

SEARCH:

Google™ Custom Search

Heritage Complex
2662 Riva Road
Annapolis, MD. 21401
(410) 222-7500

Home > Department of Public Works > Watershed Ecosystems and Restoration Ser > Watershed Ecosystems and Restoration Services

Email Print

Step Pool Storm Conveyance (SPSC) Systems

SPSC systems are open-channel conveyance structures that convert, through attenuation ponds and a sand seepage filter, surface storm flow to shallow groundwater flow. These systems safely convey, attenuate, and treat the quality of storm flow. These structures utilize a series of constructed shallow aquatic pools, riffle grade control, native vegetation, and an underlying sand/woodchip mix filter bed media. The physical characteristics of the SPSC channel are best characterized by the Rosgen A or B stream classification types, where "bedform occurs as a step/pool, cascading channel which often stores large amounts of sediment in the pools associated with debris dams" (Rosgen, 1996). The pretreatment, recharge, and water quality sizing criteria presented in these guidelines follow closely the State of Maryland's criteria for a typical stormwater filtering device. These structures feature surface/subsurface runoff storage seams and an energy dissipation design that is aimed at attenuating the flow to a desired level through energy and hydraulic power equivalency principles.

SPSC design guidelines

SPSC Design Calculator - Last updated May 6, 2010 **(Excel Spreadsheet requires enabled macros)**

Quick Links

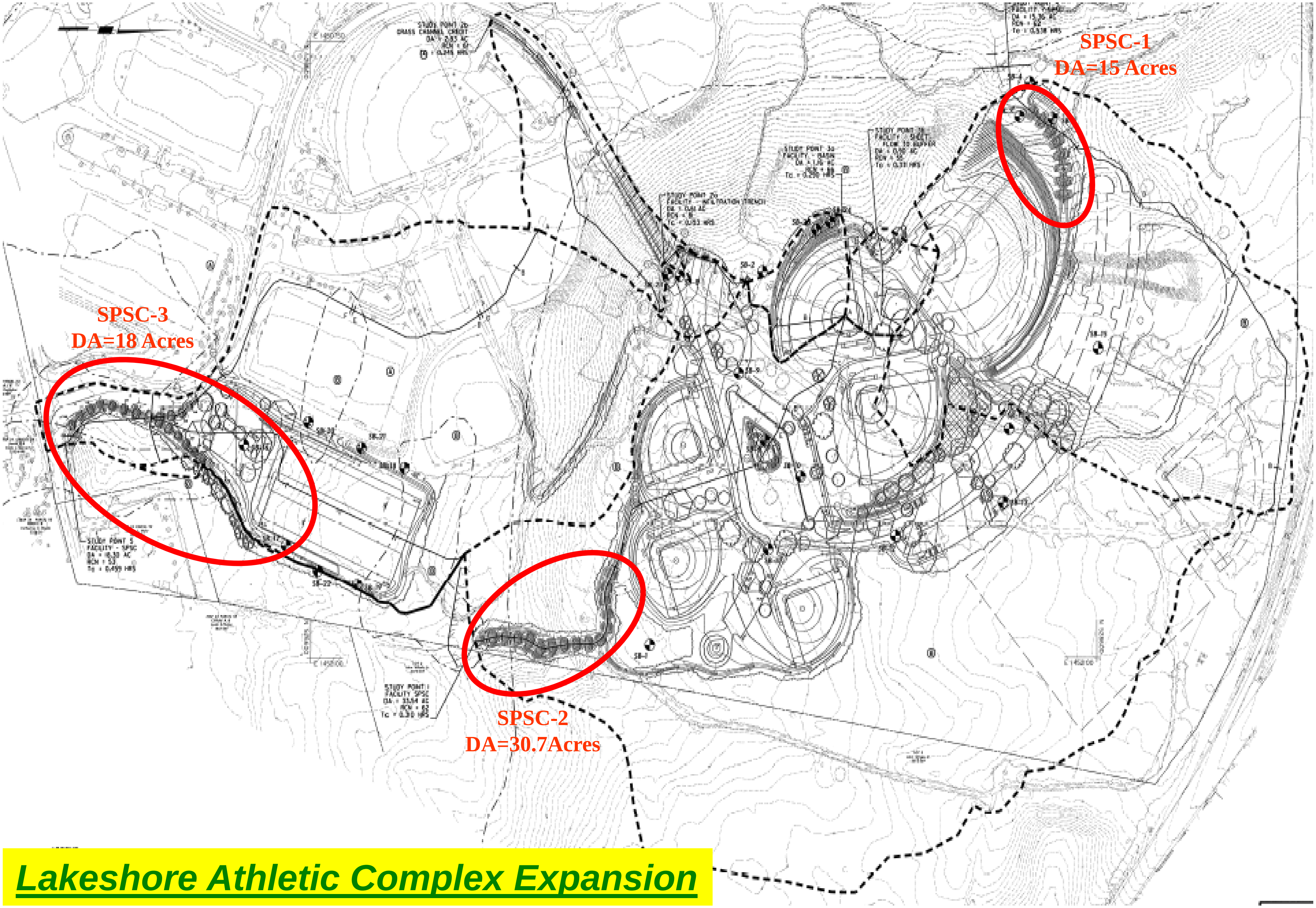
Contact DPW

Comprehensive Watershed Studies

Watershed Mapping Application **(internet explorer)**

Anne Arundel County, MD. 44 Calvert Street Annapolis, MD. 21401 | Telephone: (410) 222-7000 | Suggestions | Disclaimer

SPSC Design Calculator



Lakeshore Athletic Complex Expansion

SPSC Design Calculator

Lakeshore Athletic Complex Expansion

Required Design Input Parameters

SPSC-2	Discharge (cfs)		
	1-year	10-year	100-year
Pre- development	1.2	37	89.3
Post-development	6.1	56.3	117.1
Tc = 20.6 minutes			
Length Available (ft):	500		
Elevation Drop (ft):	17.5		
Required Input for Water Quality Determination:			
Drainage Area (Acres):	30		
Impervious Area (Acres):	2.5		

TR-20, current landcover conditions (Pre-development)

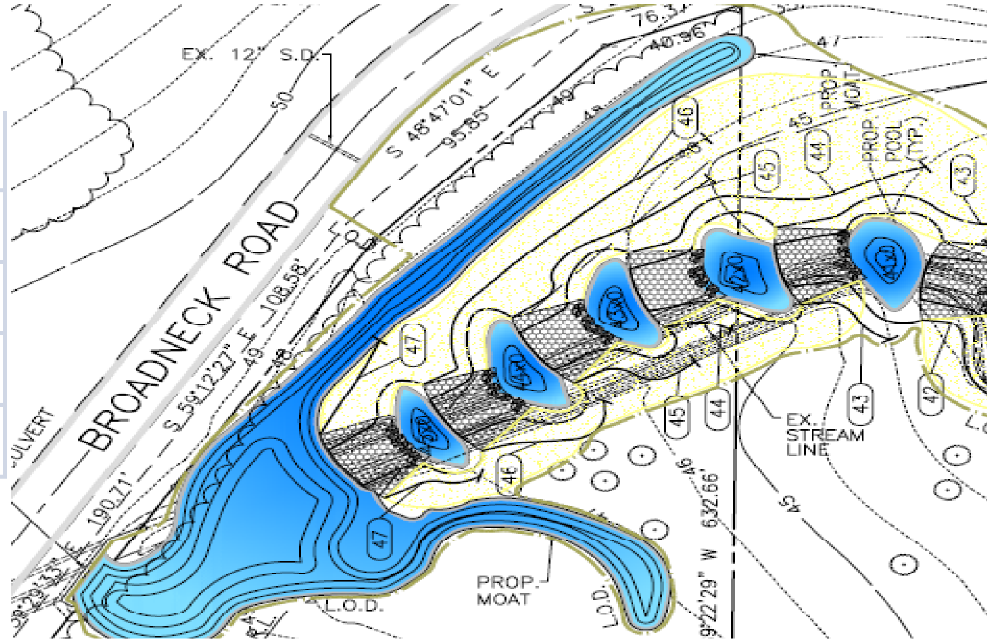
TR-20, ultimate landcover conditions without SPSC, with/other BMPs (Post-development)

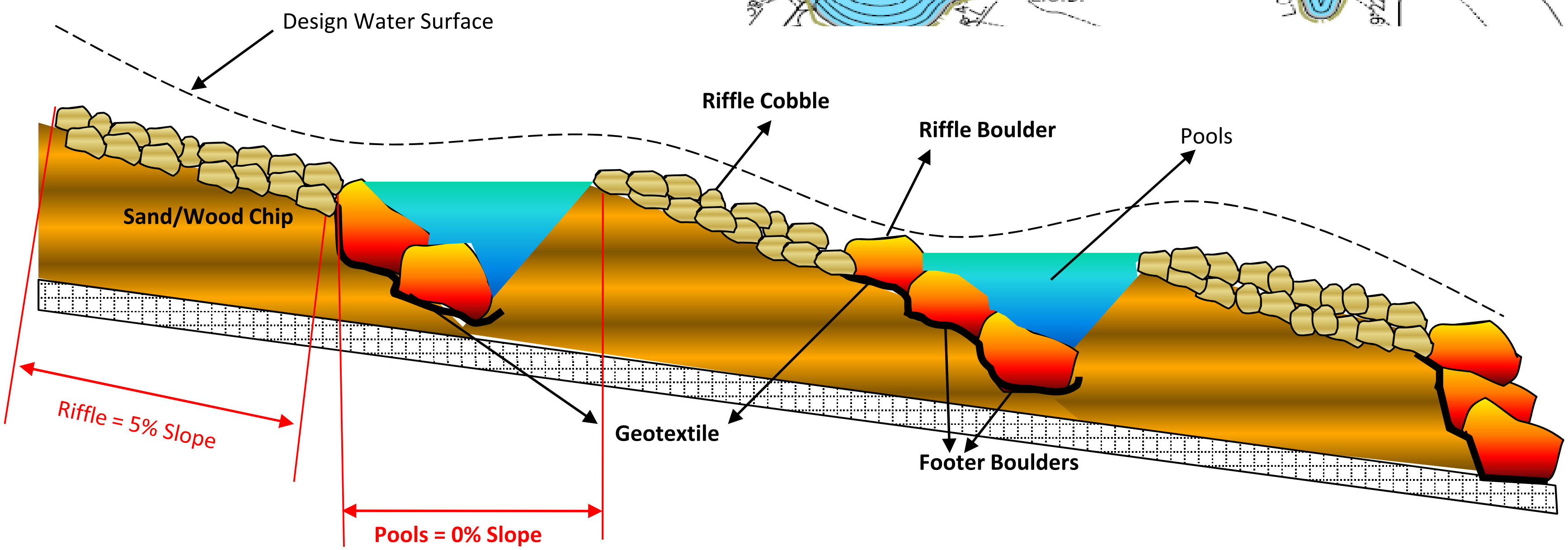
SPSC Design Calculator

Lakeshore Athletic Complex Expansion

Required Design Input Parameters (Trial Values)

Cobble D_{50} (ft):	0.5
Width of Riffle (ft):	20
Depth of Riffle (ft):	1
Depth of Sand Filter (ft):	3
Width of Sand Filter (ft):	4





SPSC Design Calculator

Lakeshore Athletic Complex Expansion

(Trial Values)

Trial

1. If Conveyance is not adequate	1- Widen Riffle Section 2- Deepen Riffle Section (max. recommended 2 ft.) 3- Use wetland seepage lateral berm configuration.
2. If storage volume is not adequate	1- Increase SPSC length 2- Deepen pools (max. 4 ft) 3- Increase number of pools 4- Deepen sand filter 5- Widen sand filter
3. If total energy is not adequately dissipated	1- Increase SPSC length 2- Increase number of pools 3- Deepen pools (max. 4 ft) 4- Shorten riffles/cascades 5- implement downstream tie-in

SPSC Workshop

Session 2 - Field Visits

SPSC Workshop

Session 3 – Case Studies

East West Boulevard – Phase 3

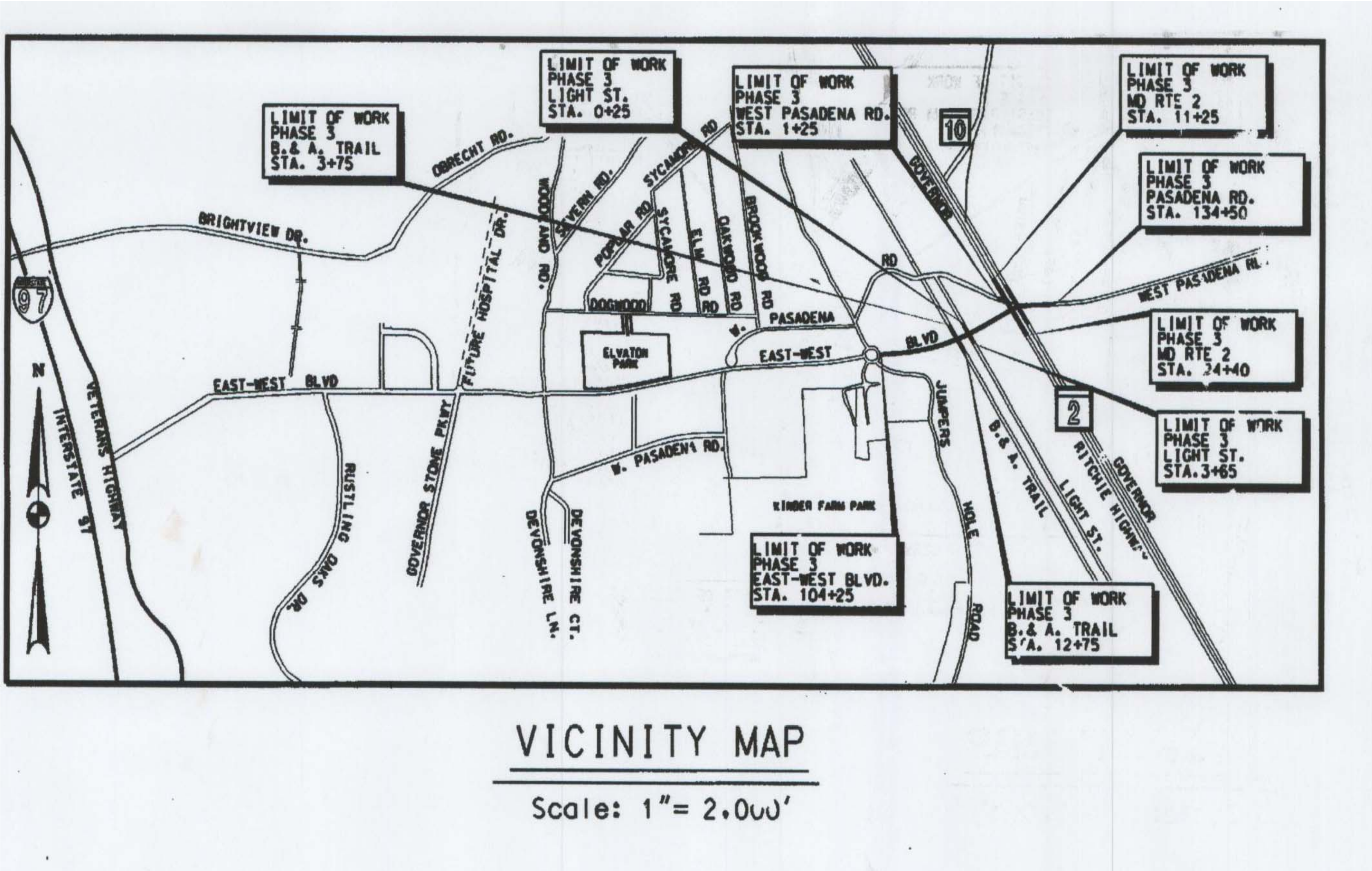
Dennis Mcmonigle

Marley Fire Station

Rajan Nigam
Dennis Mcmonigle

Lakeshore Athletic Complex

Joan Viennas
Hala Flores

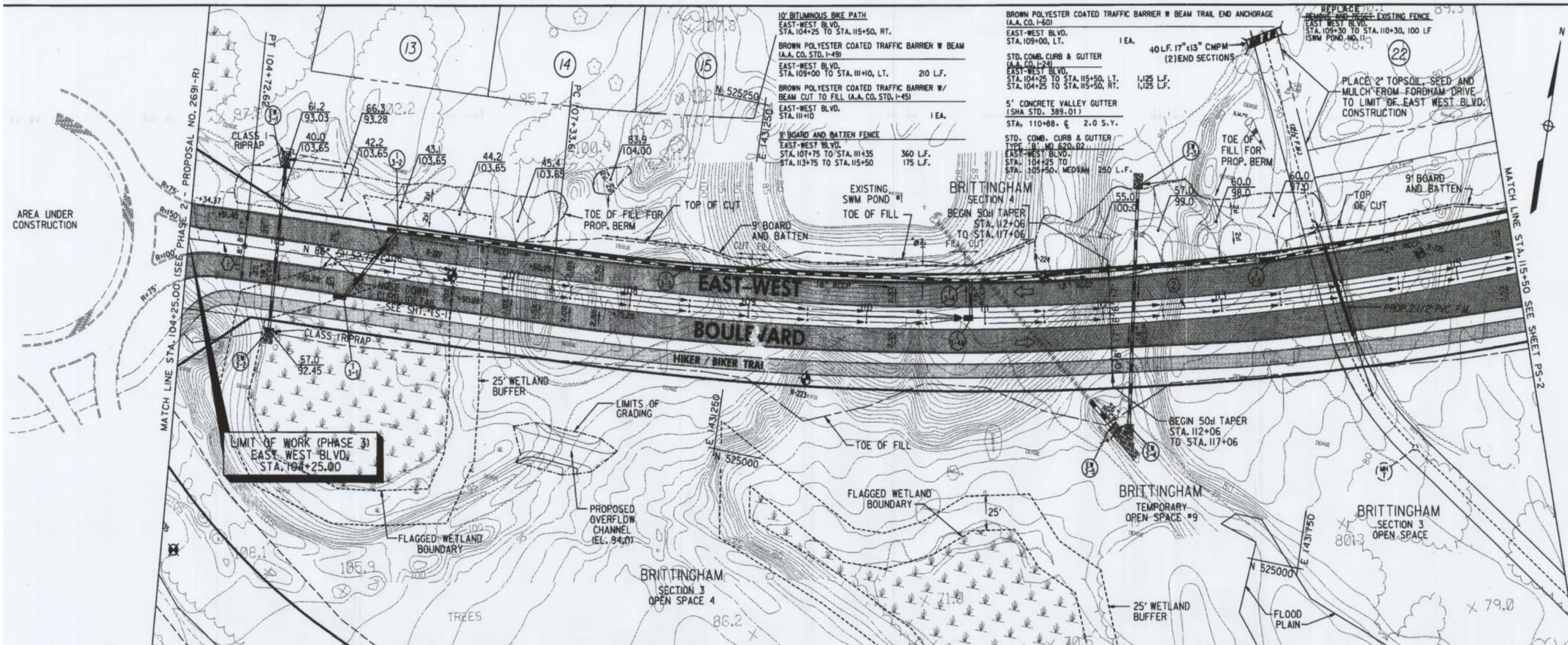


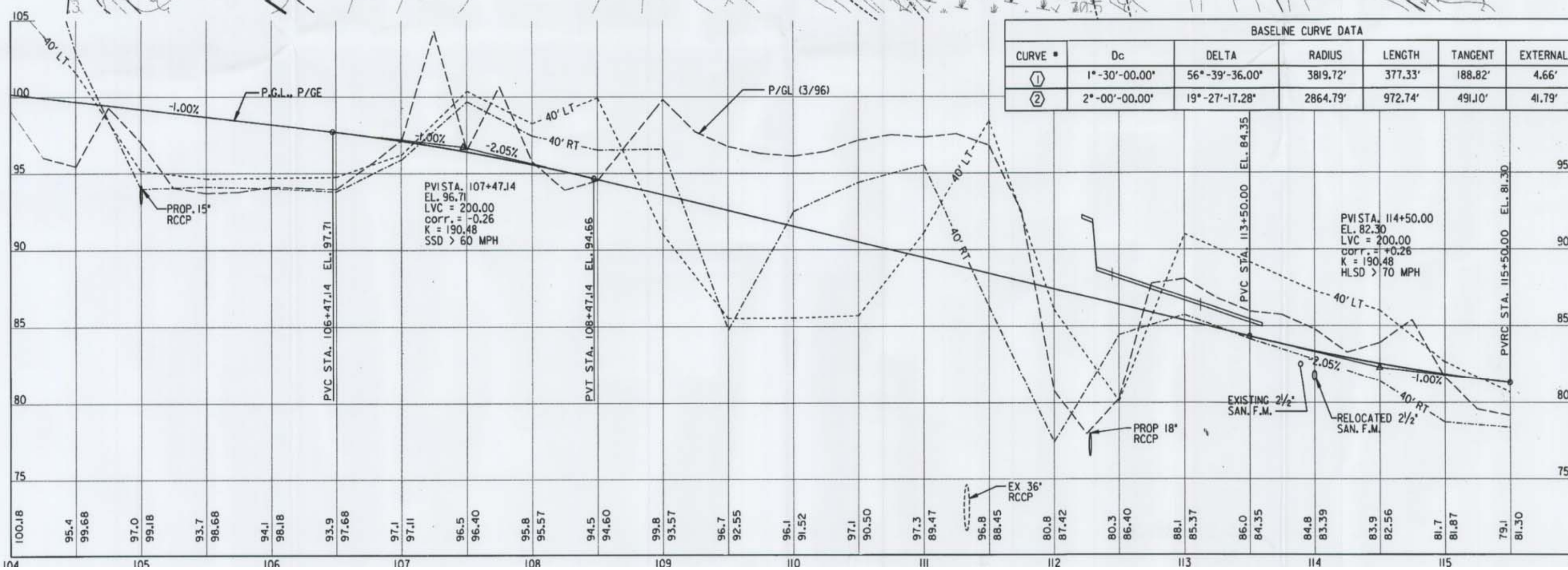
VICINITY MAP

Scale: 1"= 2,000'

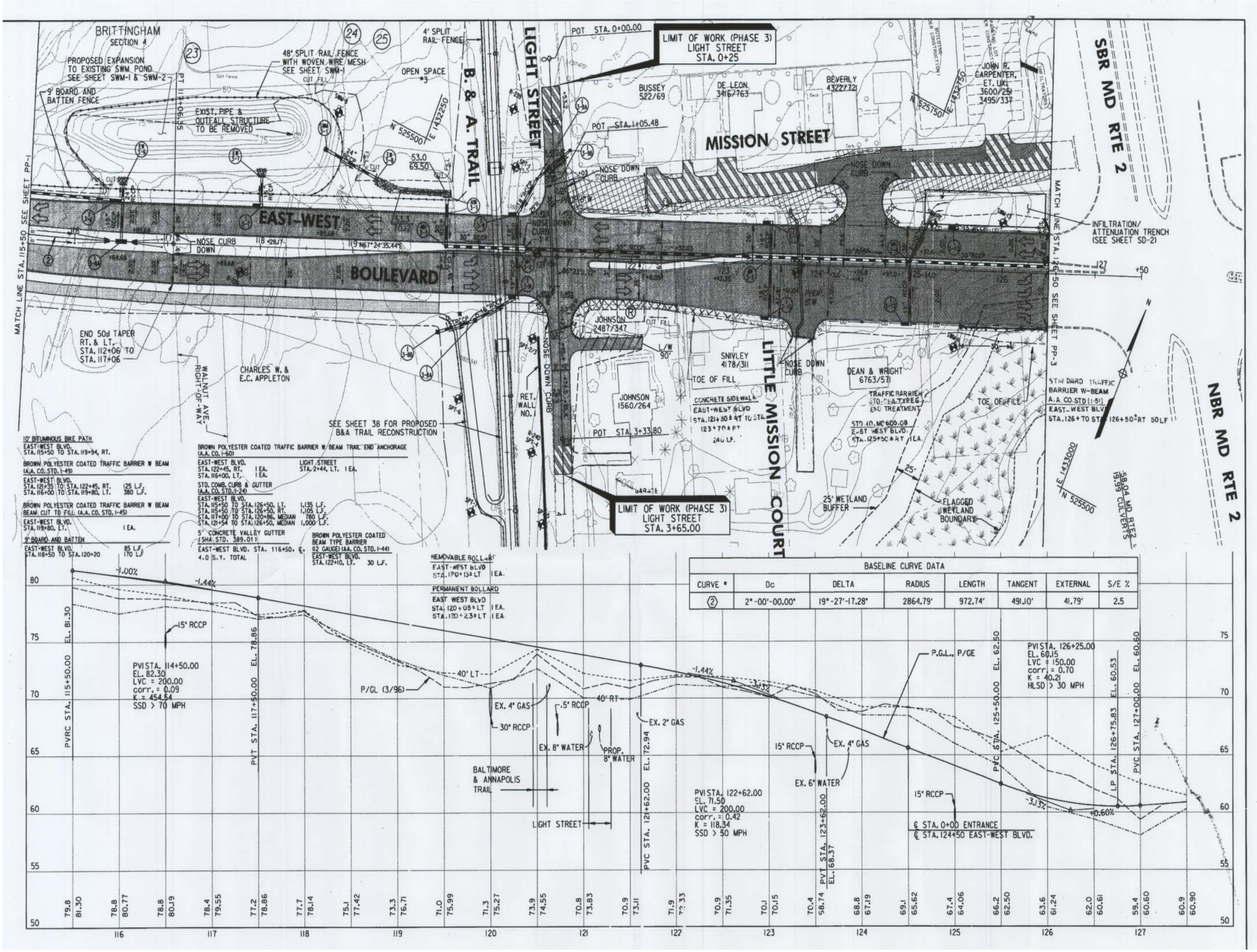
Design Consultant: RK&K

County PM: Kenneth Fleming, P.E.





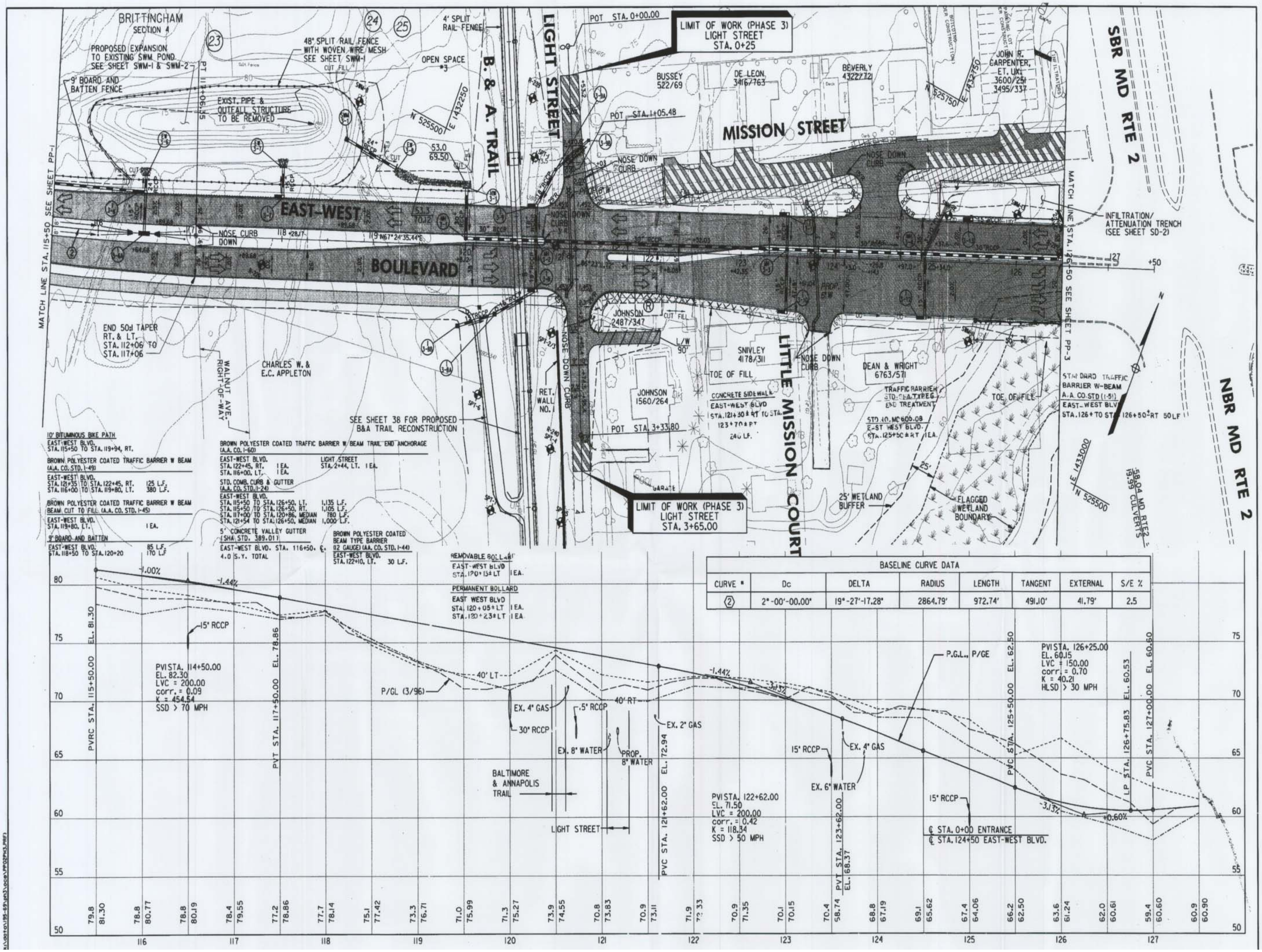
BASELINE CURVE DATA							
CURVE #	Dc	DELTA	RADIUS	LENGTH	TANGENT	EXTERNAL	S/E %
⟨1⟩	1°-30'-00.00"	56°-39'-36.00"	3819.72'	377.33'	188.82'	4.66'	2.0
⟨2⟩	2°-00'-00.00"	19°-27'-17.28"	2864.79'	972.74'	491.10'	41.79'	2.5



BASELINE CURVE DATA							
CURVE #	Dc	DELTA	RADIUS	LENGTH	TANGENT	EXTERNAL	S/E %
②	2°-00'-00.00"	19°-27'-17.28"	2864.79'	972.74'	491.10'	41.79'	2.5

East-West Boulevard – Phase 3

East-West Boulevard – Phase 3

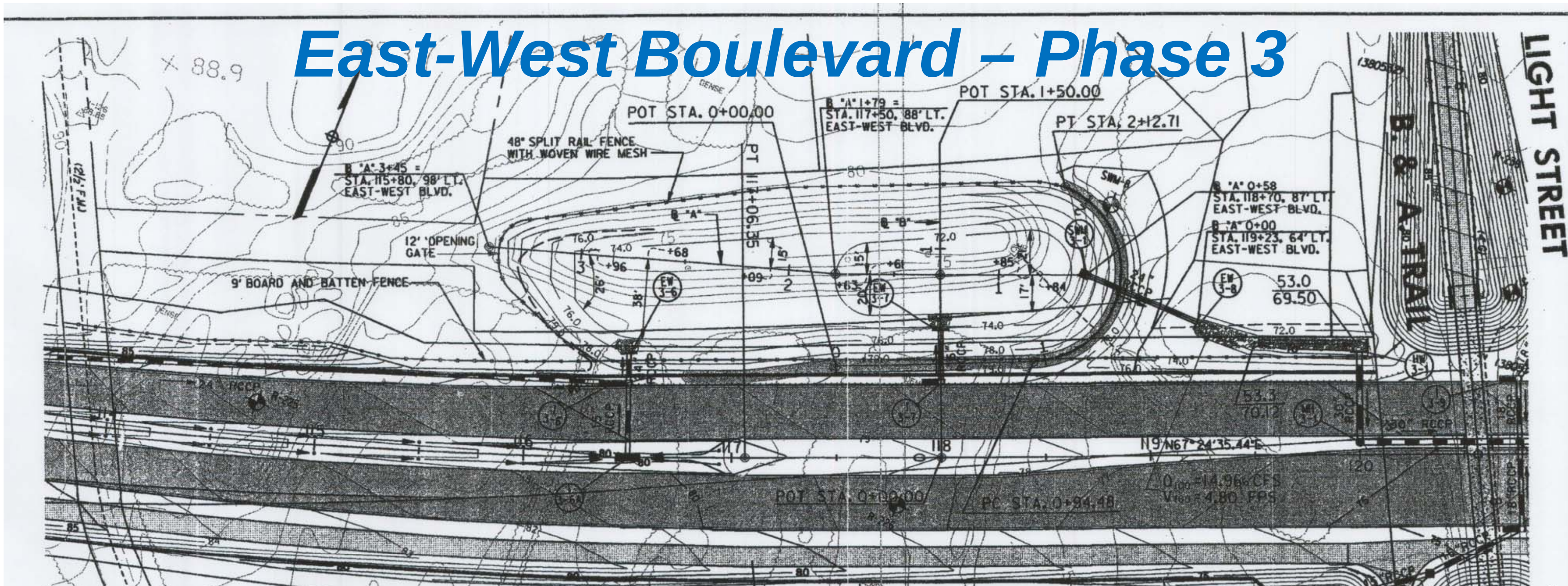


BASELINE CURVE DATA							
CURVE #	Dc	DELTA	RADIUS	LENGTH	TANGENT	EXTERNAL	S/E %
2	2°-00'-00.00"	19°-27'-17.28"	2864.79'	972.74'	491.10'	41.79'	2.5

East-West Boulevard – Phase 3

East-West Boulevard – Phase 3

East-West Boulevard – Phase 3



Exploring SPSC opportunities

East-West Boulevard – Phase 3

Exploring SPSC opportunities

East-West Boulevard – Phase 3

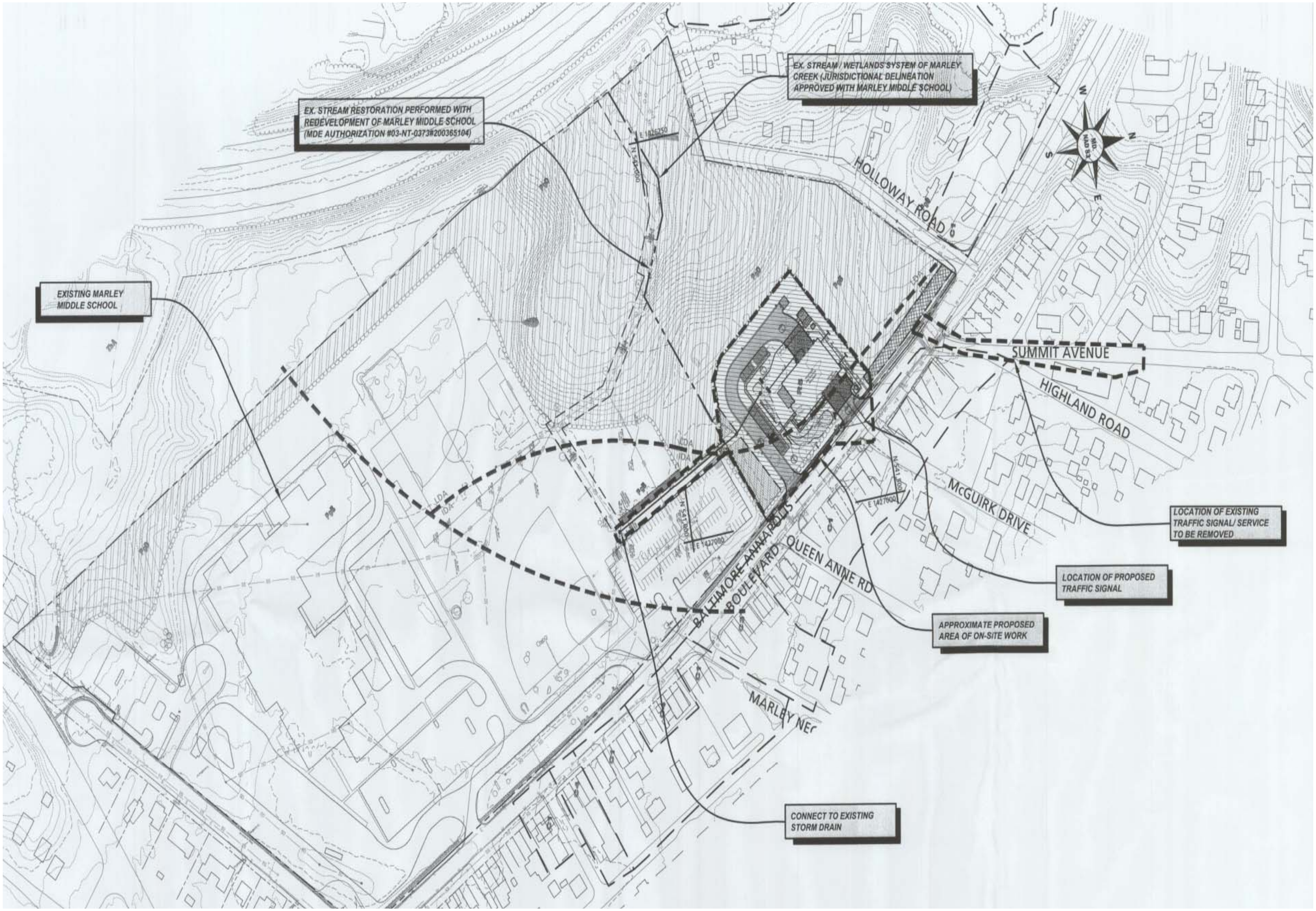
GRADING PERMIT PLANS
FOR THE
MARLEY FIRE STATION

TAX MAP 16, BLOCK 3, PARCEL 21, LOT 2
7726 BALTIMORE ANNAPOLIS BOULEVARD
GLEN BURNIE, MARYLAND, 21060
THIRD DISTRICT   ANNE ARUNDEL COUNTY
PROJECT NO.:F529600   CONTRACT NO.:F529601

OVERALL MAP
SCALE: 1"=200'

Design Consultant: WGM & Bay Engineering   County PM: Rajan Nigam

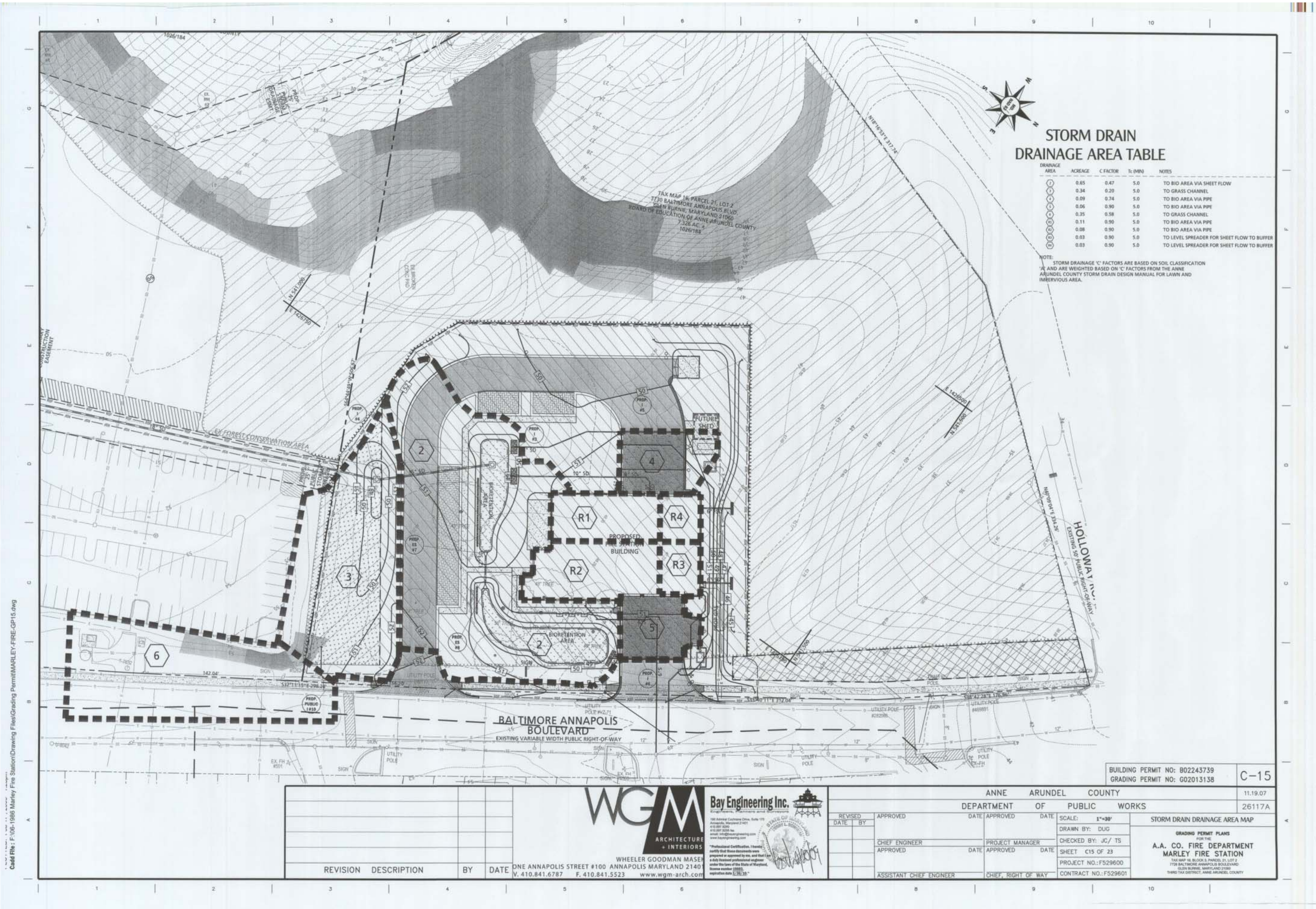
Exploring SPSC opportunities



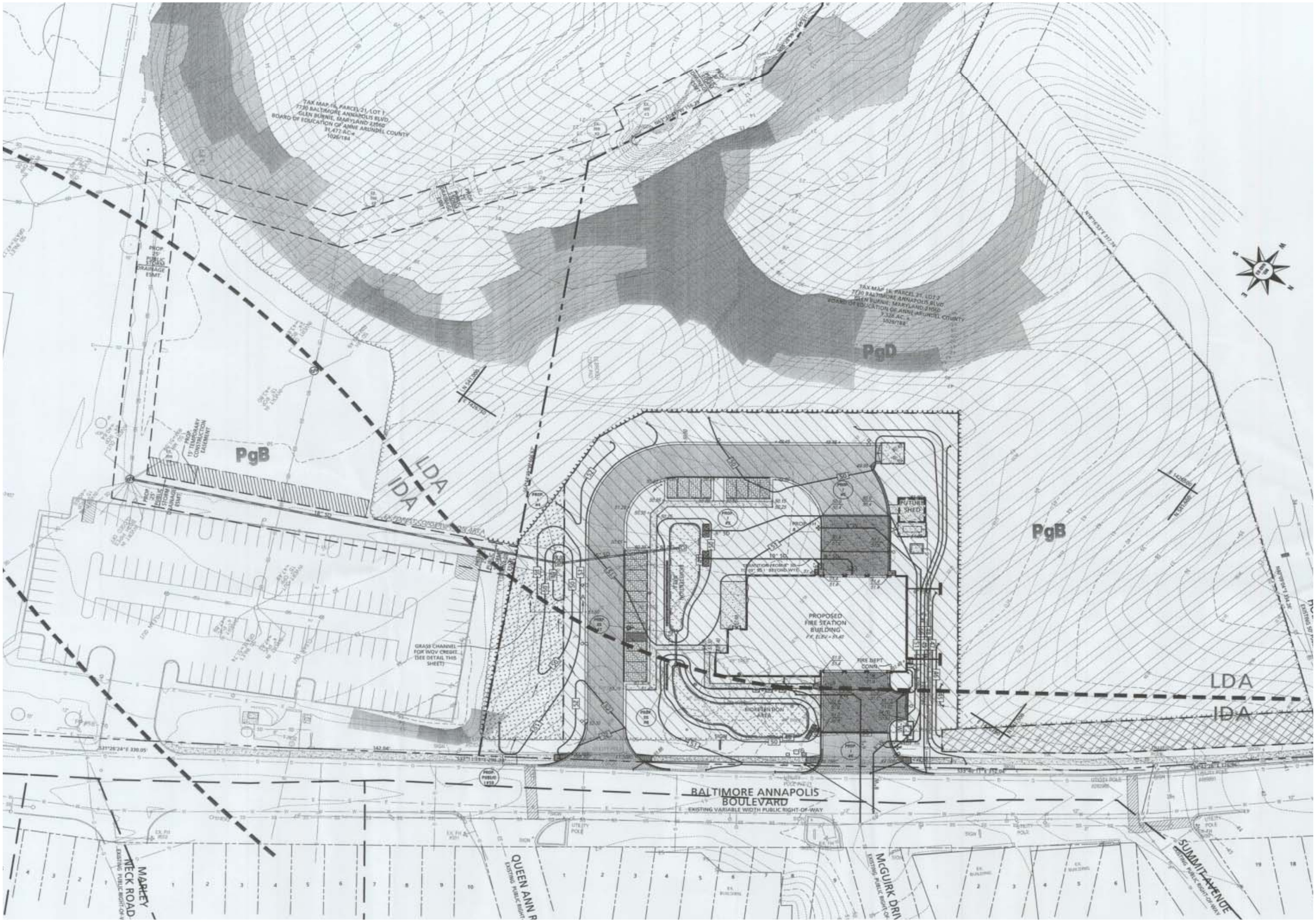
Site Photographs

Site Photographs

Exploring SPSC opportunities

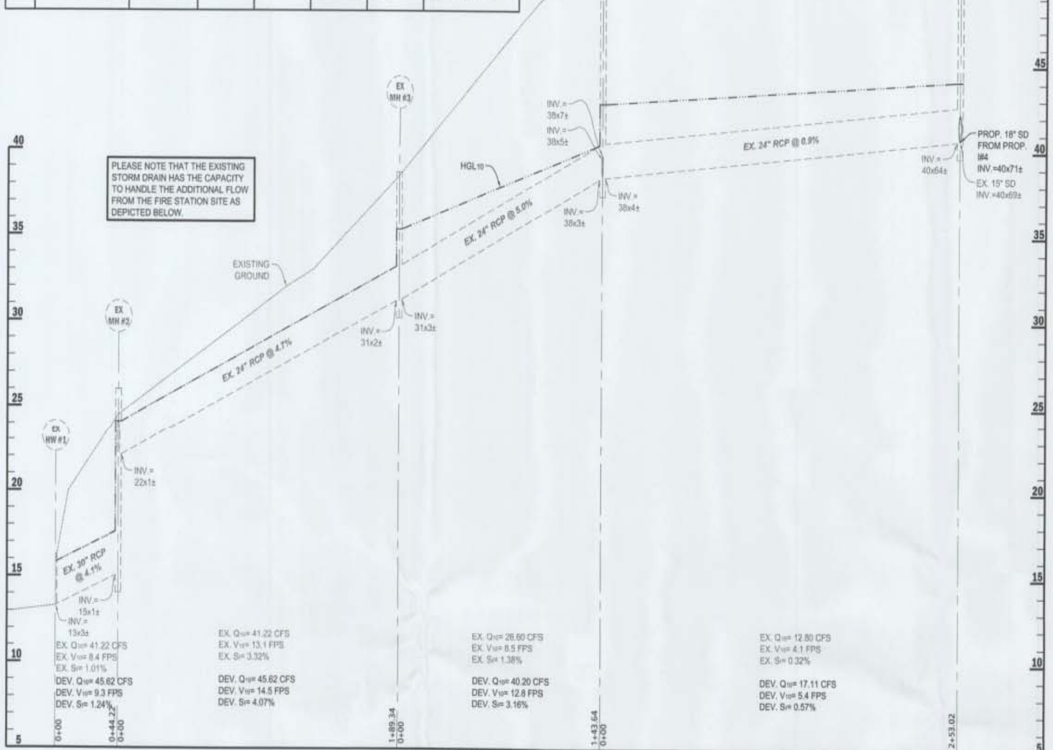


Exploring SPSC opportunities



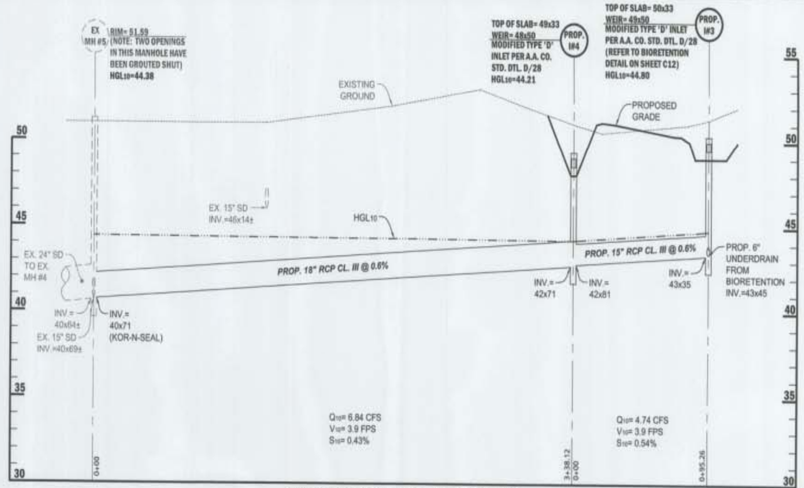
STORM DRAIN INLET SCHEDULE

INLET NO.	DESCRIPTION	TOP CURB OR GRATE ELEV.	PIPE SIZE / INV. IN	PIPE SIZE / INV. IN	PIPE SIZE / INV. IN	PIPE SIZE / INV. OUT	A.A. COUNTY STD. DETAIL NO.
3	TYPE 'D' INLET	TOP 50x33	15" / 42x95	6" / 43x45	-	15" / 43x35	D/28
4	TYPE 'D' INLET	TOP 49x33	15" / 42x81	-	-	18" / 42x71	D/28
5	TRENCH DRAIN	GR 50x5				6" / 48x21	SEE DETAIL ON SHT C9
6	TRENCH DRAIN	GR 50x0				6" / 48x61	SEE DETAIL ON SHT C9



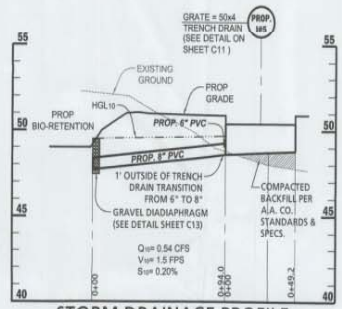
STORM DRAINAGE PROFILE

SCALE: 1"=4' VERTICAL; 1"=40' HORIZONTAL



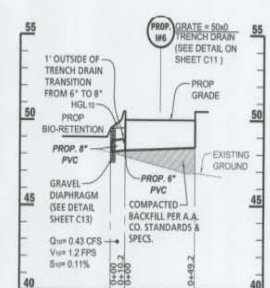
STORM DRAINAGE PROFILE

SCALE: 1"=4' VERTICAL; 1"=40' HORIZONTAL



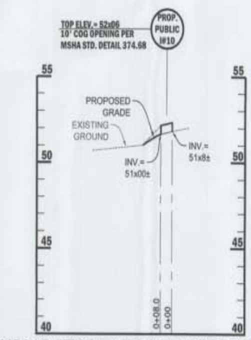
STORM DRAINAGE PROFILE

SCALE: 1"=4' VERTICAL; 1"=40' HORIZONTAL



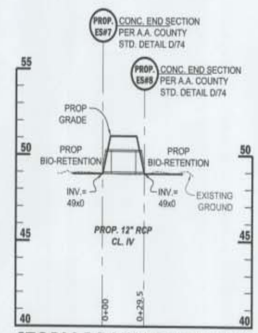
STORM DRAINAGE PROFILE

SCALE: 1"=4' VERTICAL; 1"=40' HORIZONTAL



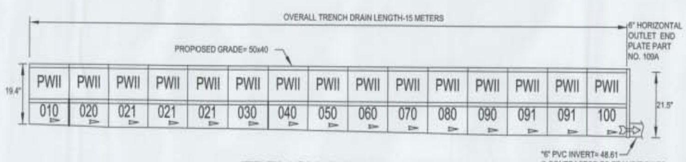
PUBLIC STORM DRAINAGE PROFILE

SCALE: 1"=4' VERTICAL; 1"=40' HORIZONTAL



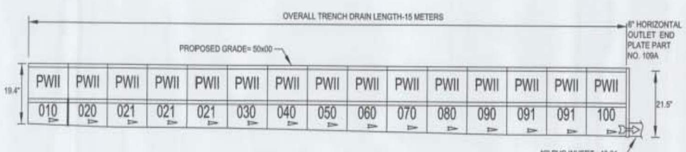
STORM DRAINAGE PROFILE

SCALE: 1"=4' VERTICAL; 1"=40' HORIZONTAL



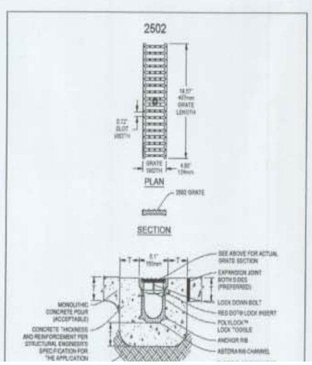
TRENCH DRAIN DETAIL #I-5

SCALE: NONE



TRENCH DRAIN DETAIL #I-6

SCALE: NONE



PUBLIC STORM DRAIN STRUCTURE SCHEDULE

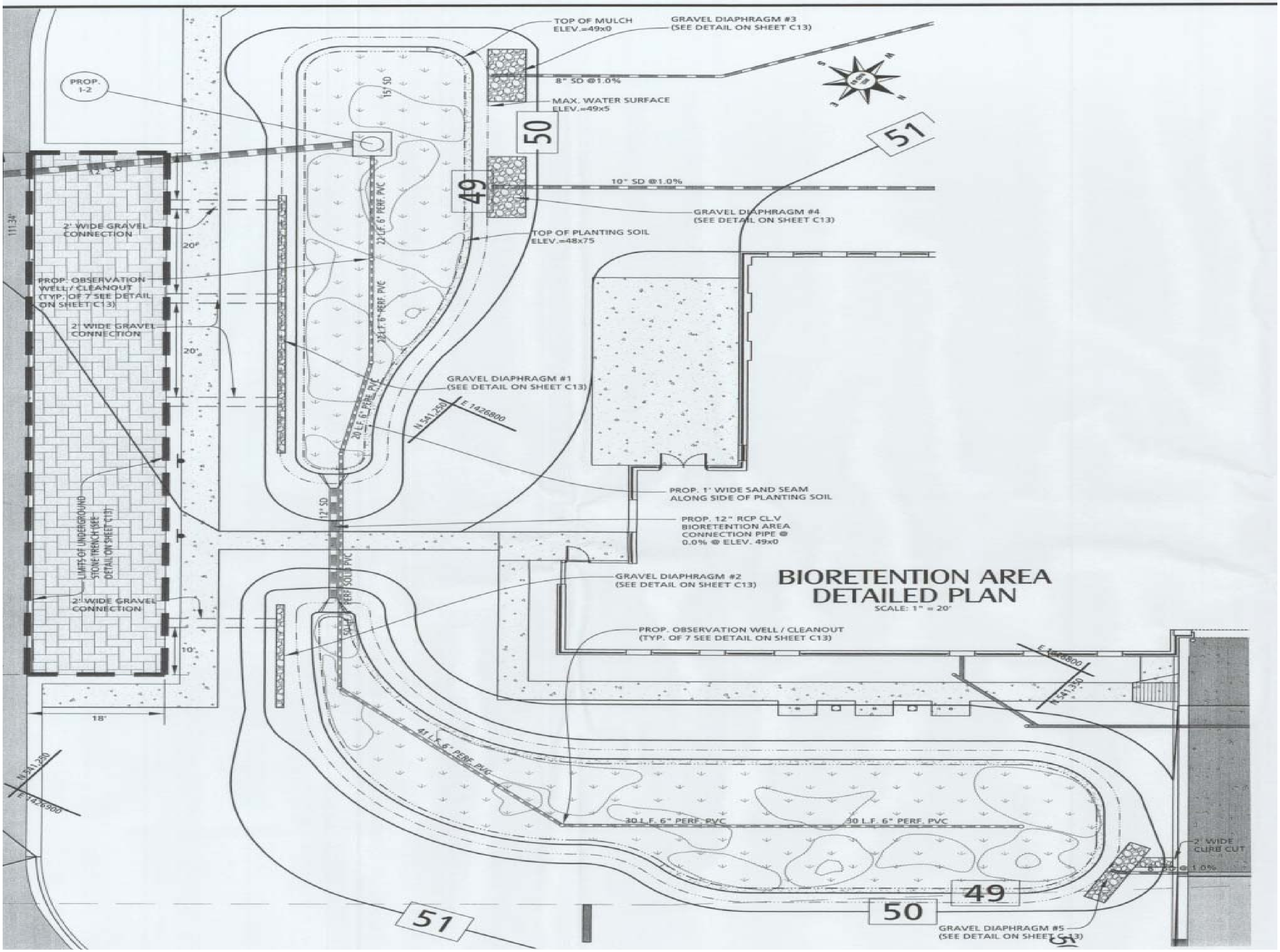
INLET NO.	DESCRIPTION	TOP CURB OR GRATE ELEV.	PIPE SIZE / INV. IN	PIPE SIZE / INV. OUT	A.A. COUNTY STD. DETAIL NO.
10	10' COG OPENING	52x06	-	51x00*	MD 374.68

* THE INV. OUT AS SPECIFIED IN THE CHART REFERS TO THE TROUGH ELEVATION AT THE BACK OF THE SIDEWALK WHERE IT ENTERS THE SWALE

BUILDING PERMIT NO: B02243739
GRADING PERMIT NO: G02013138

BIORETENTION AREA DETAILED PLAN

SCALE: 1" = 20'



STORMWATER MANAGEMENT NOTE

STORMWATER MANAGEMENT FOR THIS SITE IS PROVIDED IN ACCORDANCE WITH THE ANNE ARUNDEL COUNTY STORMWATER MANAGEMENT PRACTICES AND PROCEDURES MANUAL AND THE MDE 2000 MARYLAND STORMWATER DESIGN MANUAL, AS DESCRIBED BELOW:

WATER QUALITY VOLUME

WATER QUALITY VOLUME IS PROVIDED THROUGH THE USE OF STORMWATER MANAGEMENT CREDITS AND THE CONSTRUCTION OF A BIORETENTION AREA. THE BIORETENTION AREA IS REQUIRED TO PROVIDE 1961CF OF WATER QUALITY VOLUME. THIS REQUIREMENT IS MET IN THE BIORETENTION AREA. THE REMAINDER OF PROPOSED ONSITE IMPERVIOUS AREA DRAINS TO THE WOODED AREA SURROUNDING THE SITE AND MEETS THE REQUIREMENTS OF THE SHEET FLOW TO BUFFER CREDIT. IN ADDITION, THE GRASS CHANNEL CREDIT IS UTILIZED FOR A PORTION OF IMPERVIOUS AREA WITHIN BALTIMORE-ANNAPOLIS BOULEVARD THAT IS DIRECTED ON-SITE TO MINIMIZE THE FLOW ACROSS THE PROPOSED ENTRANCES.

RECHARGE VOLUME

THE RECHARGE VOLUME IS PROVIDED THROUGH THE USE OF STORMWATER MANAGEMENT CREDITS AND WITHIN THE GRAVEL RESERVOIR BENEATH THE ECO-STONE PAVER SYSTEM. THE TOTAL RECHARGE VOLUME REQUIRED FOR THE AREA DRAINING TO THE BIORETENTION AREA IS 569 CF. THIS IS PROVIDED IN THE GRAVEL RESERVOIR. THE REMAINDER OF PROPOSED IMPERVIOUS AREA DRAINS TO THE WOODED AREA SURROUNDING THE SITE AND MEETS THE REQUIREMENTS OF THE SHEET FLOW TO BUFFER CREDIT. IN ADDITION, THE GRASS CHANNEL CREDIT IS UTILIZED FOR A PORTION OF IMPERVIOUS AREA WITHIN BALTIMORE-ANNAPOLIS BOULEVARD THAT IS DIRECTED ON-SITE TO MINIMIZE THE FLOW ACROSS THE PROPOSED ENTRANCES.

CHANNEL PROTECTION

NOT REQUIRED DUE TO DIRECT DISCHARGE TO TIDAL WATERS AND LOCATION WITHIN THE CRITICAL AREA.

OVERBANK FLOOD PROTECTION

NOT REQUIRED DUE TO DIRECT DISCHARGE TO TIDAL WATERS AND LOCATION WITHIN THE CRITICAL AREA.

EXTREME FLOOD VOLUME

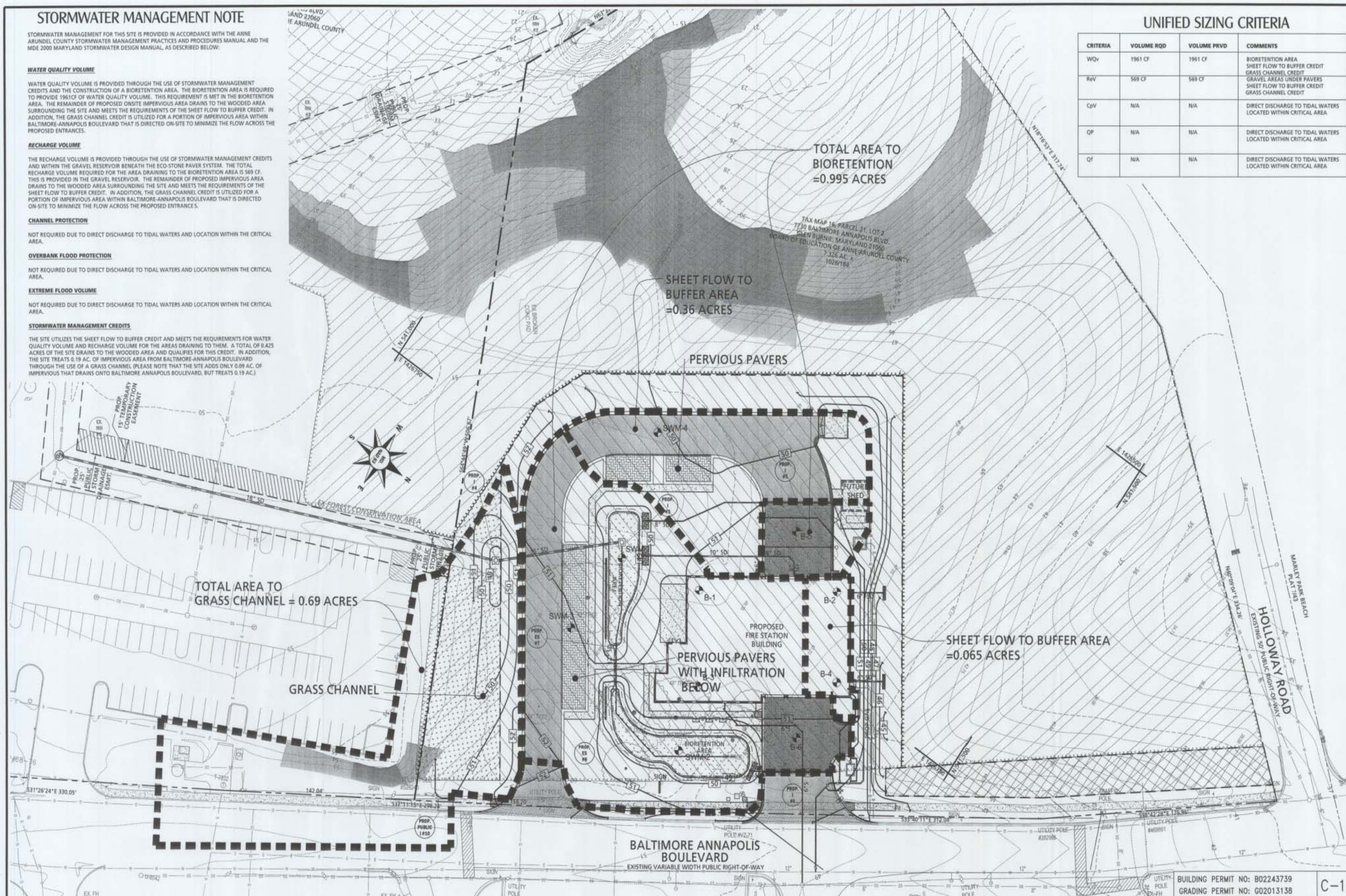
NOT REQUIRED DUE TO DIRECT DISCHARGE TO TIDAL WATERS AND LOCATION WITHIN THE CRITICAL AREA.

STORMWATER MANAGEMENT CREDITS

THE SITE UTILIZES THE SHEET FLOW TO BUFFER CREDIT AND MEETS THE REQUIREMENTS FOR WATER QUALITY VOLUME AND RECHARGE VOLUME FOR THE AREAS DRAINING TO THEM. A TOTAL OF 0.425 ACRES OF THE SITE DRAINS TO THE WOODED AREA AND QUALIFIES FOR THIS CREDIT. IN ADDITION, THE SITE TREATS 0.19 AC. OF IMPERVIOUS AREA FROM BALTIMORE-ANNAPOLIS BOULEVARD THROUGH THE USE OF A GRASS CHANNEL (PLEASE NOTE THAT THE SITE ADDS ONLY 0.09 AC. OF IMPERVIOUS THAT DRAINS ONTO BALTIMORE ANNAPOLIS BOULEVARD, BUT TREATS 0.19 AC.)

UNIFIED SIZING CRITERIA

CRITERIA	VOLUME RQD	VOLUME PRVD	COMMENTS
WQv	1961 CF	1961 CF	BIORETENTION AREA SHEET FLOW TO BUFFER CREDIT GRASS CHANNEL CREDIT
ReV	569 CF	569 CF	GRAVEL AREAS UNDER PAVERS SHEET FLOW TO BUFFER CREDIT GRASS CHANNEL CREDIT
CpV	N/A	N/A	DIRECT DISCHARGE TO TIDAL WATERS LOCATED WITHIN CRITICAL AREA
QP	N/A	N/A	DIRECT DISCHARGE TO TIDAL WATERS LOCATED WITHIN CRITICAL AREA
Qf	N/A	N/A	DIRECT DISCHARGE TO TIDAL WATERS LOCATED WITHIN CRITICAL AREA



SHA WATER QUALITY TREATMENT

(PLEASE NOTE THAT THE ONLY FACILITY ON-SITE THAT TREATS IMPERVIOUS AREA FROM BALTIMORE-ANNAPOLIS BOULEVARD IS THE GRASS CHANNEL)

*TYPE OF BMP: GRASS CHANNEL
*SHA IMPERVIOUS AREA TREATED: 0.19 AC.
*COORDINATES: N541,165 E1,426,892
*OWNER / RESPONSIBLE PARTY FOR MAINTENANCE: ANNE ARUNDEL COUNTY

BUILDING PERMIT NO: B02243739
GRADING PERMIT NO: G02013138

C-16

WGM ARCHITECTURE + INTERIORS
WHEELER GOODMAN MASEK
ONE ANNAPOLIS STREET #100 ANNAPOLIS MARYLAND 21401
V. 410.841.6787 F. 410.841.5523 www.wgm-arch.com

Bay Engineering Inc.

REVISION	DESCRIPTION	BY	DATE

ANNE ARUNDEL COUNTY
DEPARTMENT OF PUBLIC WORKS

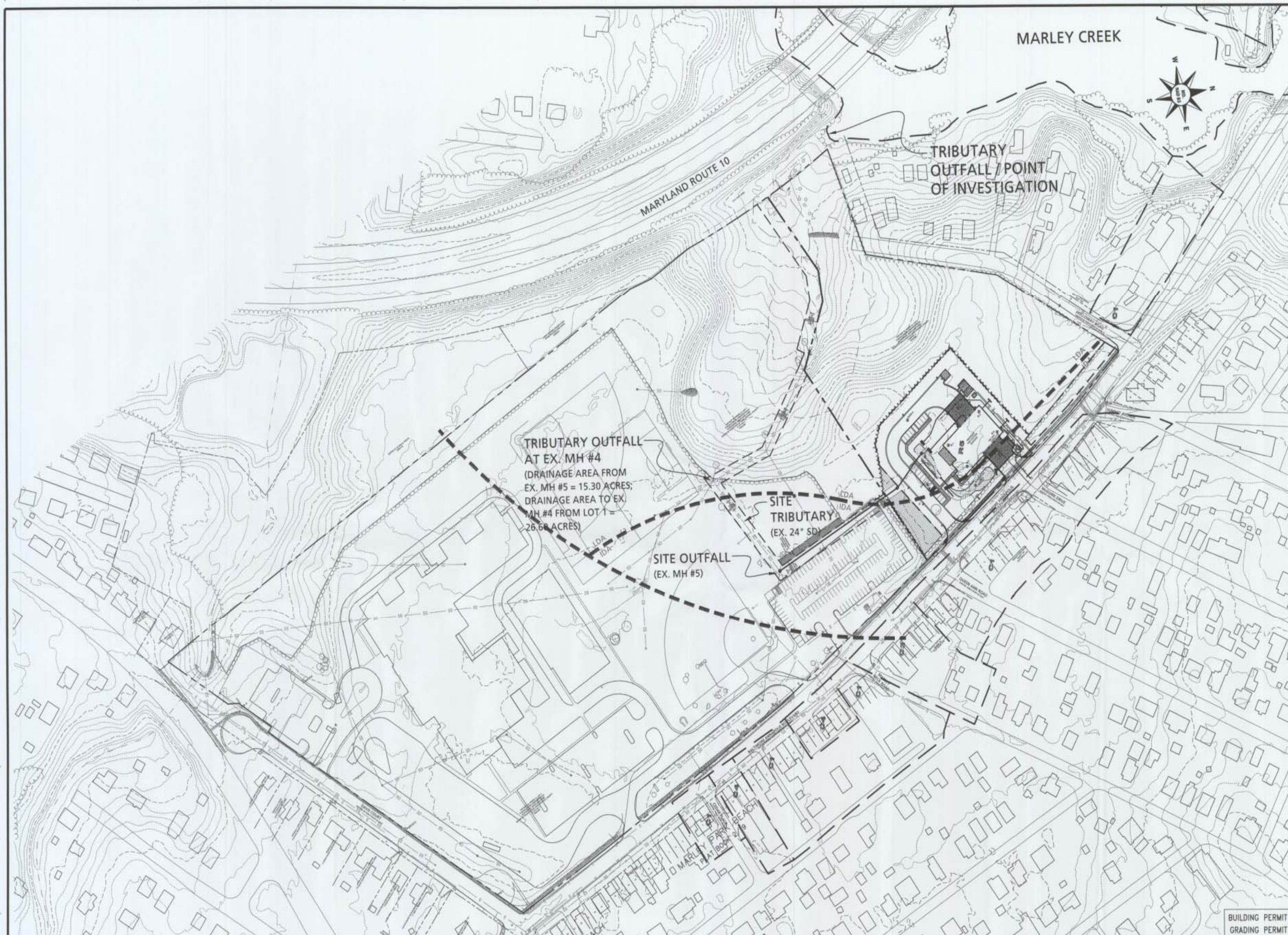
11.19.07
26117A

REVISED DATE	BY	APPROVED	DATE	APPROVED	DATE
		CHIEF ENGINEER		PROJECT MANAGER	
		APPROVED	DATE	APPROVED	DATE
		ASSISTANT CHIEF ENGINEER		CHIEF, RIGHT OF WAY	

SCALE: 1"=30'
DRAWN BY: DUG
CHECKED BY: JC/ TS
SHEET C16 OF 23
PROJECT NO.: F529600
CONTRACT NO.: F529601

SWM DRAINAGE AREA MAP

GRADING PERMIT PLANS
FOR THE
A.A. CO. FIRE DEPARTMENT
MARLEY FIRE STATION



BUILDING PERMIT NO: B02243739
GRADING PERMIT NO: G02013138

C-17

REVISION DESCRIPTION	BY	DATE

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ARCHITECTURE + INTERIORS
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Bay Engineering Inc.
Engineers, Planners and Surveyors

"Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, license number 19593, expiration date 3/30/10."

ANNE ARUNDEL COUNTY
DEPARTMENT OF PUBLIC WORKS

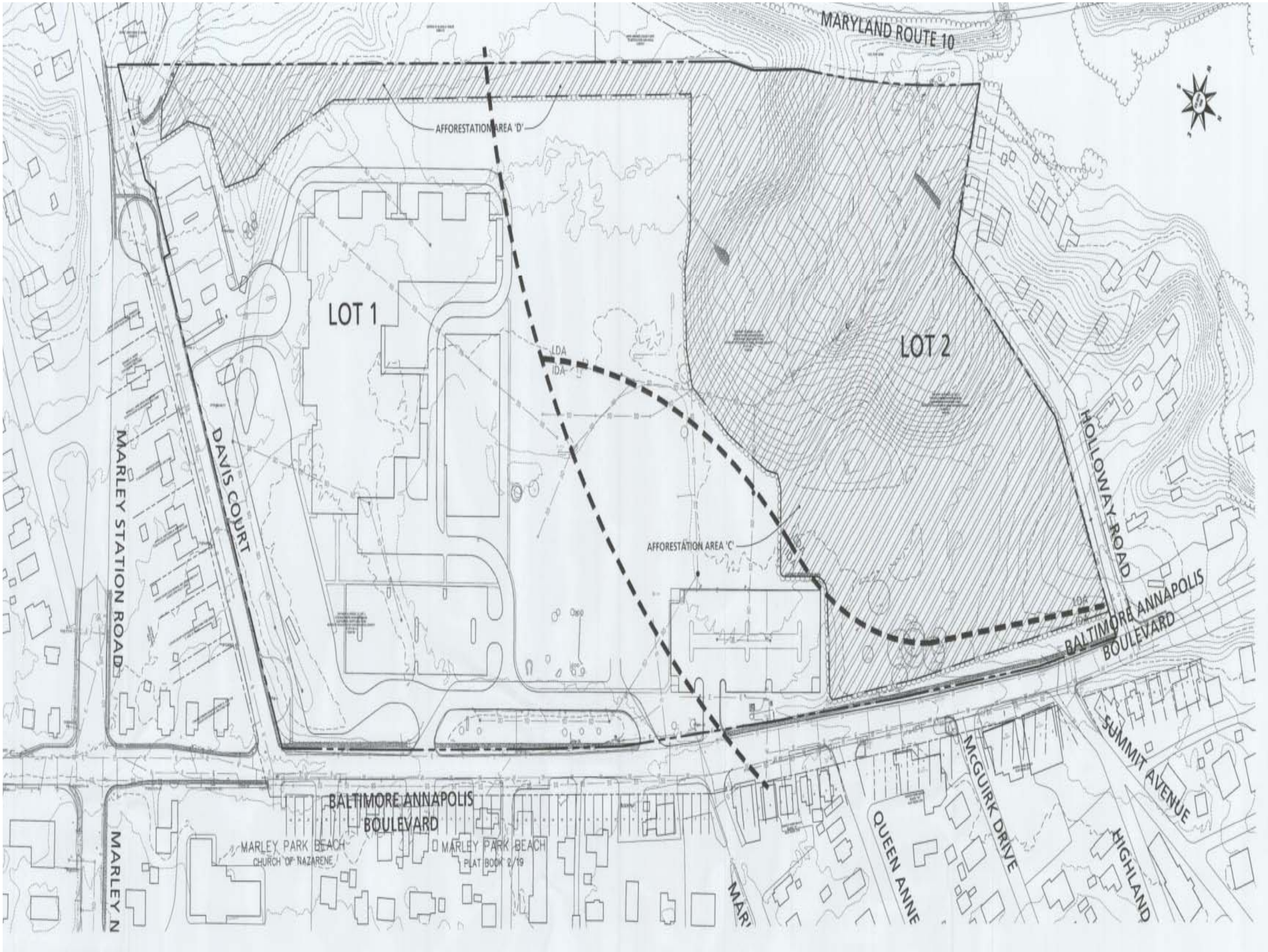
11.19.07
26117A

REVISED DATE	BY	APPROVED	DATE	APPROVED	DATE
		CHIEF ENGINEER		PROJECT MANAGER	
		APPROVED	DATE	APPROVED	DATE
		ASSISTANT CHIEF ENGINEER		CHIEF, RIGHT OF WAY	

SCALE: 1"=100'
DRAWN BY: DUG
CHECKED BY: JC/ TS
SHEET C17 OF 23
PROJECT NO.: F529600
CONTRACT NO.: F529601

DOWNSTREAM ANALYSIS MAP

GRADING PERMIT PLANS
FOR THE
A.A. CO. FIRE DEPARTMENT
MARLEY FIRE STATION
TAX MAP 10, BLOCK 3, PARCEL 21, LOT 2
7726 BALTIMORE ANNAPOLIS BOULEVARD
GLEN BURNIE, MARYLAND 21060
THIRD TAX DISTRICT, ANNE ARUNDEL COUNTY


MARYLAND ROUTE 10
AFFORESTATION AREA 'D'
LOT 1
LOT 2
LDA
IDA
AFFORESTATION AREA 'C'
LDA
IDA
MARLEY STATION ROAD
DAVIS COURT
HOLLOWAY ROAD
BALTIMORE ANNAPOLIS BOULEVARD
BALTIMORE ANNAPOLIS BOULEVARD
SUMMIT AVENUE
McGUIRK DRIVE
QUEEN ANNE
HIGHLAND
MARLEY PARK BEACH
CHURCH OF NAZARENE
MARLEY PARK BEACH
PLAT BOOK 2/19
MARLEY N

SPSC Case Studies
Lakeshore Athletic Complex

Design Consultant: GPI

County PM: Joan Viennas

Lakeshore Athletic Complex

Lakeshore Athletic Complex

Original SWM Concept/Sketch

Lakeshore Athletic Complex

Original SWM Grading

Lakeshore Athletic Complex

Adopted SWM Design

Lakeshore Athletic Complex Expansion
Proposed Instream Weir: Future Construction with Dog Park

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