APPENDIX A – FLOODING POTENTIAL TECHNICAL MEMORANDUM

TECHNICAL MEMORANDUM

TO:	Hala Flores, Anne Arundel County
FROM:	Mike Pieper, KCI Technologies
DATE:	January 18, 2010
SUBJECT:	Patapsco Non-Tidal Watershed Assessment - 01090525 Crossing Modeling Site Selection and Field Survey
COPIES	Bill Medina, KCI Technologies Nate Drescher, KCI Technologies Tara Ajello, CH2M HILL

INTRODUCTION

Stream crossing modeling is to be conducted by County staff for selected crossings in the Patapsco Non-Tidal Watershed. This technical memorandum reviews the selection criteria and process that was followed to select the sites for survey and modeling using HY-8 and provides relevant notes following the field survey. Draft sites were selected by KCI and reviewed by the County. The task was scoped and budgeted for the survey of 15 sites. Twenty-eight draft sites were selected and following review, 19 final sites were selected and surveyed.

SITE SELECTION

Selection Criteria

The consultant team selected the sites based on the criteria and process described below. The criteria were viewed strictly such that a crossing would be selected only if it met *all* of the criteria.

The selection criteria are as follows:

1. The crossing must be owned by the County.

2. The roadway at the crossings must be classified in the County's Master Transportation Plan as a Freeway, Principal Arterial, Minor Arterial, Collector, or Local.

3. Crossings may be selected if flooding will completely cut off an area from emergency services where the stream crosses a single or multiple access point(s) to a community or business area.

4. Crossings may be selected if overtopping is likely, determined by both the height of the road surface above the top of the structure and the channel and floodplain characteristics. In general, the vertical distance between top of roadway and stream water surface should be less than 20 feet to consider it for selection, under the

assumption that high stream crossings would not represent the most imminent flooding hazards. Field observations followed by QC and review of crossing photos were used to estimate overtopping likelihood.

Process

The procedure for selecting sites to be surveyed and modeled using HY-8 follows the criteria listed above. Crossings with flooding potential were flagged “Yes” during the fieldwork for the Physical Habitat Condition Assessment to indicate that it should be reviewed for inclusion in the survey and modeling. The database was updated following field work such that “Yes” indicates that the crossing was surveyed.

The site selection was conducted using base County GIS data and Crossing information from the Physical Habitat Condition Assessment. An ArcMap .mxd file was created. Important Features in ArcMap are listed below:

- *Contours*
- *Stream Reaches (updated from the Physical Habitat Condition Assessment)*
- *Crossings (point file from the Physical Habitat Condition Assessment)*
- *AACO Planimetric Road Edges*
- *AACO Transportation Centerline Road Class*
- *Subwatershed Boundaries*
- *Aerial Photography*
- *ADC – to determine ownership, State, Federal Roadways*

The Physical Habitat Condition Assessment Crossing information was utilized as a shapefile with the addition of several fields to the original crossings database table. The criteria were applied in the order that they are listed above (1-4). That is if the roadway associated with the crossing was not County owned (the first criteria) it was dropped from the list and not evaluated against the other criteria. If it was County owned then it would be evaluated against the second criteria and so on.

- County Ownership – Indicates whether or not the roadway at the crossing is County owned. Ownership was determined using the County GIS roadway layer, ADC mapping and other MSHA data. If the roadway was on the County roadway layer the road was assumed to be County owned, even if the road was unnamed.

- Road Class – Refers to the County Master Transportation Plan road classification system for roads within Anne Arundel County. (Freeway, Principal Arterial, Minor Arterial, Collector, and Local Road)
    - Only culverts intersecting the County Master Transportation Shapefile were included in the selected sites. Foot/trail bridges, culverts under interstates, driveway culverts, utility road culverts, SWM associated culverts, and farm field access culverts were all eliminated from HY8 culvert selection.

- Isolate – Refers to the potential for overtopped roads to completely cut off an area from emergency services where the stream crosses a single or multiple access point(s) to a community or business area. The planimetric roads and county master transportation plan were utilized to determine alternate routes from a particular culvert location.

- Overtop – Refers to the potential for stormwater to flow over a road embankment due to the magnitude of runoff. Contours, culvert dimensions, embankment height, drainage area, and upstream/downstream floodplain characteristics were all used to determine the potential for overtopping at all road culverts that intersected identified channels. In general, the vertical distance between top of roadway and stream water surface should be less than 20 feet, under the assumption that high stream crossings would not represent the most imminent flooding hazards.

Draft Selection Results

A total of 300 crossings were evaluated against the selection criteria. A total of 207 crossings did not meet the County ownership criteria and were thus eliminated. Ninety crossings were identified as being County owned and met the road classification category criteria. An additional 3 were labeled as unknown ownership because they are on the County layer but the roadway was not named, these were identified as Local roads. Those 3 unknown ownership crossings were retained for further evaluation for a total of 93 crossings remaining after criteria 1 and 2.

Of the 93 retained 53 did not isolate communities or businesses and one crossing was identified as having no access upstream and downstream for the required survey, leaving 41 for further evaluation.

Twenty-eight crossing met the Isolation criteria, and therefore met all of the selection criteria. These crossings were then individually evaluated for other site constraints that might render them either not surveyable, or unable to be modeled.

This exercise also identified several potential lower priority sites which are described below. These sites were highlighted for County review to determine final inclusion in the selected sites.

PN7011.C003 – This crossing isolates a cul de sac that has no residential properties but does intersect with a rail line access road which could present a safety issue during flooding. There is however also an access road on the opposite side of the line. (Eliminated in review)

PNB090.C002 – This crossing is downstream of crossing PNB090.C001, which is not being proposed for survey and modeling. Under high flow conditions, the upstream C001 crossing, which is constricted, may act as flood control therefore limiting the likelihood of C002 flooding and overtopping. (Included after review)

PNC066.C001 – This crossing is downstream of crossing PNC066.C004, a railroad crossing, which is not being proposed for survey and modeling. Under high flow conditions, the upstream C004 crossing, which is constricted, may act as flood control therefore limiting the likelihood of C001 flooding and overtopping. Further, the crossing is a bridge which would not be adequately modeled using HY-8. HEC-RAS would likely be needed. (Eliminated in review)

PNC065.C001 – This crossing is downstream of crossing PNC065.C002, a railroad crossing, which is not being proposed for survey and modeling. Under high flow conditions, the upstream C002 crossing, which is constricted, may act as flood control therefore limiting the likelihood of C001 flooding and overtopping. Further, the crossing is a bridge which would not be adequately modeled using HY-8. HEC-RAS would likely be needed. (Included after review)

PNB002.C002 – This crossing is located approximately 50 feet upstream of Deep Run. Modeling results using HY-8 for this site may be confounded by flooding and backwater effects of the downstream receiving waters. Water surface elevation for Deep Run would be required for accurate tail water conditions, derived from HEC-RAS or a gage analysis, if gage data is available. (Included after review)

Final Selection Results and Site Notes

County review revealed several sites that were not located on County owned roadways. Additionally field visits to several crossings allowed crews to confirm crossing status (ownership, flooding potential, and replacement schedule) and therefore eliminate additional crossings from the surveys. From the 28 draft sites, 9 were eliminated, therefore a total of 19 sites were surveyed.

Field work was initiated on December 8, 2009 and completed on January 12, 2010. Table 1 below provides a listing of the Draft sites, the status (date surveyed or not surveyed) and notes related to either reasons for elimination or field notes to assist with the modeling component of the project. Table 2 summarizes the surveyed crossings per subwatershed. Figure 1 shows the locations of the surveyed crossings in the watershed.

Table 1: Crossings Selected for Survey

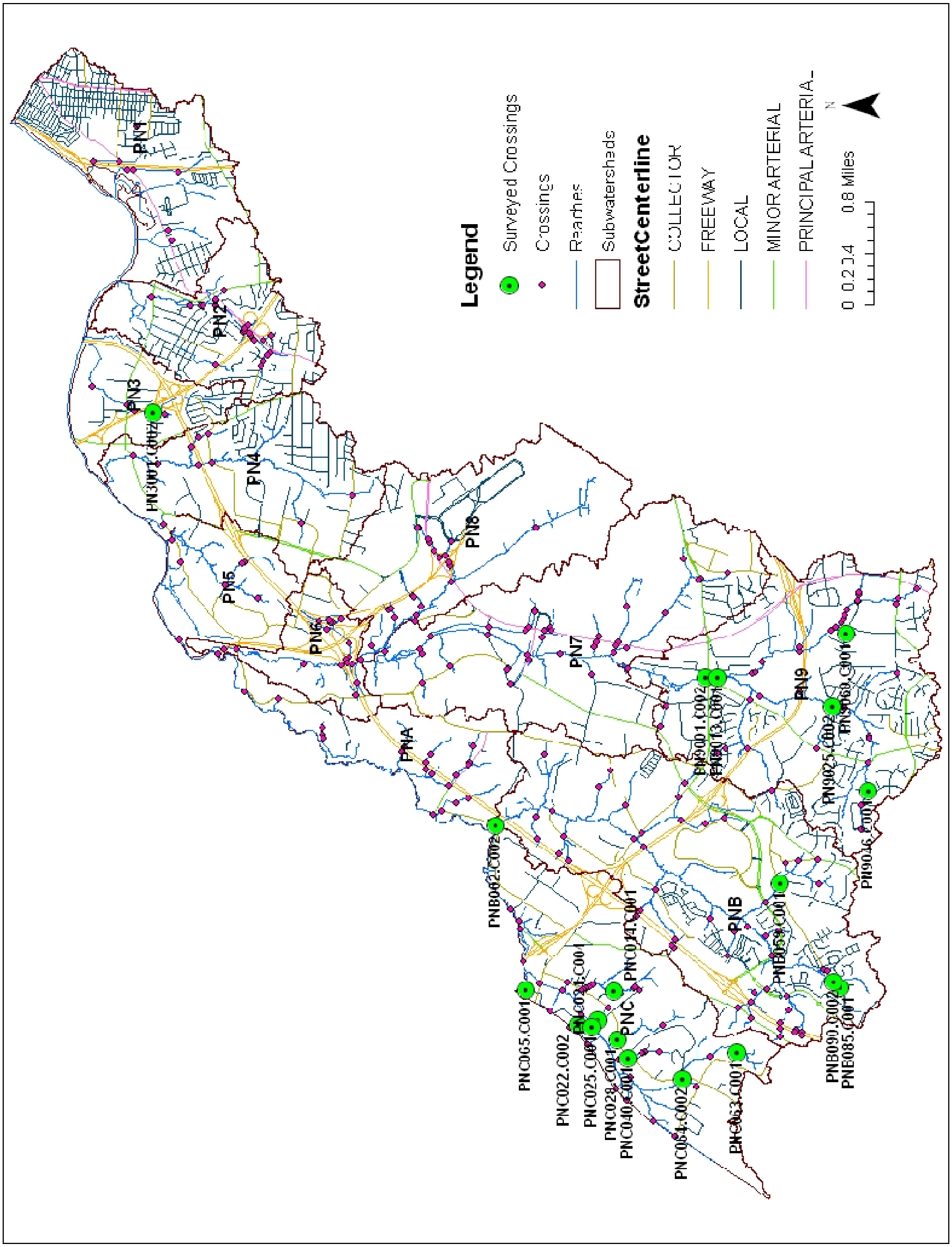
Crossing ID	Status	Notes
PN3001.C002	Surveyed 12/15/2009	Crossing damaged on upstream side
PN5010.C001	Not surveyed	Not County owned/maintained based on field visit
PN7011.C003	Not surveyed	Eliminated in County review based on ownership and isolate criteria
PN9001.C002	Surveyed 12/16/2009	Area is linked during flooding to PN9013.C001, HEC-RAS may be best modeling tool to capture complexities of the crossing
PN9013.C001	Surveyed 12/16/2009	Area is linked during flooding to PN9001.C002, HEC-RAS may be best modeling tool to capture complexities of the crossing
PN9025.C002	Surveyed 12/16/2009	Two spreadsheets used
PN9046.C001	Surveyed 12/15/2009	
PN9060.C001	Surveyed 12/15/2009	
PNA004.C002	Not surveyed	Eliminated due to influence of Deep Run flooding potential
PNB002.C002	Surveyed 1/12/2010	Close proximity to Deep Run which will likely control tailwater at this crossing, upstream I-295 crossing (PNB002.C001) may also control flows, HEC-RAS may be best modeling tool to capture complexities of the crossing, See notes above
PNB059.C001	Surveyed 12/11/2009	Four barrels total, two spreadsheets used
PNB085.C001	Surveyed 12/11/2009	Downstream crossing (PNB090.C001) may influence tailwater conditions
PNB090.C002	Surveyed 12/11/2009	Up crossing (PNB090.C001) may influence flows however high relief may mitigate the influence, See notes above
PNC006.C001	Not surveyed	Eliminated in County review based on ownership

Crossing ID	Status	Notes
PNC006.C005	Not surveyed	Eliminated - Grade Stakes at Site – culvert replacement planned, site photos included
PNC014.C001	Surveyed 1/12/2010	Barrel Type code is 'undefined' in HY8 model
PNC022.C002	Surveyed 12/15/2009	Flooding observations from County resident included
PNC024.C004	Surveyed 12/15/2009	
PNC025.C001	Surveyed 1/12/2010	
PNC026.C001	Not surveyed	Overtopping unlikely based on field visit
PNC028.C001	Surveyed 12/8/2009	Flooding observations from County resident included; A triple culvert crossing just downstream was investigated and was determined to not likely be influencing tailwater conditions.
PNC039.C003	Not surveyed	County Eliminated Site
PNC039.C004	Not surveyed	County Eliminated Site
PNC040.C001	Surveyed 12/8/2009	Crossing downstream (PNC040.C002) may effect tailwater condition, however C002 (2 ft diameter) is larger than C001 (1.5 ft diameter).
PNC063.C001	Surveyed 12/8/2009	Barrel Type code is 'undefined' in HY8 model
PNC064.C002	Surveyed 12/8/2009	
PNC065.C001	Surveyed 1/12/2010	Bridge with influencing cross-section upstream (PNC065.C001), HEC-RAS may be best modeling tool to capture complexities of the crossing, See notes above.
PNC066.C001	Not surveyed	Eliminated in County review based on ownership

Table 2: Surveyed Crossings by Subwatershed

SUBSHED	Total Crossings	Total Selected Draft	Total Surveyed Final
PN1	8	0	0
PN2	22	0	0
PN3	5	1	1
PN4	10	0	0
PN5	7	1	0
PN6	18	0	0
PN7	36	1	0
PN8	22	0	0
PN9	40	5	5
PNA	20	1	0
PNB	59	4	4
PNC	53	15	9
Grand Total	300	28	19

Figure 1: Surveyed HY8 Sites



APPENDIX B – LAND COVER BY SUBWATERSHED

Table B.1 - Land Cover

Subwatershed	Land Cover	Code	Acres	Percent of Watershed
Patapsco Non-Tidal Watershed	Airport	AIR	626.5	4.1%
	Commercial	COM	965.2	6.3%
	Forested Wetland	FRW	34.8	0.2%
	Industrial	IND	1283.3	8.4%
	Open Space	OPS	1699.6	11.1%
	Open Wetland	OPW	50.4	0.3%
	Pasture/Hay	PAS	1.7	0.0%
	Residential 1/2-acre	R12	313.9	2.1%
	Residential 1/4-acre	R14	1167.6	7.6%
	Residential 1/8-acre	R18	1167.9	7.6%
	Residential 1-acre	R11	510.6	3.3%
	Residential 2-acre	R21	623.9	4.1%
	Residential Woods	RWD	13.2	0.1%
	Row Crops	SRC	33.7	0.2%
	Transportation	TRN	1032.8	6.8%
	Utility	UTL	44.6	0.3%
	Water	WAT	81.4	0.5%
	Woods	WDS	5617.5	36.8%
	Total		**15,269**	100.0%
PN1	Commercial	COM	84.9	8.2%
	Industrial	IND	64.5	6.3%
	Open Space	OPS	114.5	11.1%
	Residential 1/2-acre	R12	16.5	1.6%
	Residential 1/4-acre	R14	4.7	0.5%
	Residential 1/8-acre	R18	475.1	46.9%
	Residential 2-acre	R21	1.3	0.1%
	Transportation	TRN	74.4	7.2%
	Water	WAT	18.1	1.8%
	Woods	WDS	176.5	17.1%
	Total		**1030.5**	100.0%
PN2	Commercial	COM	43.9	5.1%
	Industrial	IND	4.6	0.5%
	Open Space	OPS	83.8	9.8%
	Open Wetland	OPW	28.8	3.4%
	Residential 1/2-acre	R12	16.4	1.9%
	Residential 1/4-acre	R14	221.4	25.9%
	Residential 1/8-acre	R18	199.9	23.4%
	Residential 1-acre	R11	12.7	1.5%
	Residential Woods	RWD	13.2	1.5%
	Transportation	TRN	53.1	6.2%
	Utility	UTL	7.1	0.8%
	Water	WAT	4.3	0.5%
	Woods	WDS	166.6	19.5%
	Total		**855.8**	100.0%

Table B.1 - Land Cover

Subwatershed	Land Cover	Code	Acres	Percent of Watershed
PN3	Commercial	COM	20.4	3.9%
	Forested Wetland	FRW	12.0	2.3%
	Industrial	IND	131.4	25.0%
	Open Space	OPS	35.4	6.7%
	Open Wetland	OPW	11.8	2.2%
	Residential 1/2-acre	R12	5.1	1.0%
	Residential 1/4-acre	R14	90.7	17.2%
	Residential 1/8-acre	R18	5.5	1.1%
	Residential 1-acre	R11	3.1	0.6%
	Residential 2-acre	R21	1.9	0.4%
	Transportation	TRN	54.1	10.3%
	Utility	UTL	4.7	0.9%
	Water	WAT	8.1	1.5%
	Woods	WDS	142.1	27.0%
	Total		**526.3**	100.0%
PN4	Commercial	COM	134.5	11.4%
	Forested Wetland	FRW	12.7	1.1%
	Industrial	IND	165.9	14.1%
	Open Space	OPS	57.8	4.9%
	Residential 1/4-acre	R14	298.5	25.4%
	Residential 1-acre	R11	55.3	4.7%
	Residential 2-acre	R21	29.8	2.5%
	Transportation	TRN	67.6	5.7%
	Utility	UTL	10.8	0.9%
	Water	WAT	11.0	0.9%
	Woods	WDS	331.5	28.2%
	Total		**1175.3**	100.0%
PN5	Commercial	COM	44.1	7.7%
	Forested Wetland	FRW	2.4	0.4%
	Industrial	IND	10.4	1.8%
	Open Space	OPS	27.0	4.7%
	Open Wetland	OPW	3.9	0.7%
	Residential 1/4-acre	R14	7.2	1.3%
	Residential 1-acre	R11	25.6	4.5%
	Residential 2-acre	R21	22.9	4.0%
	Transportation	TRN	41.1	7.2%
	Utility	UTL	13.4	2.3%
	Water	WAT	16.9	2.9%
	Woods	WDS	359.4	62.6%
	Total		**574.5**	100.0%

Table B.1 - Land Cover

Subwatershed	Land Cover	Code	Acres	Percent of Watershed
PN6	Commercial	COM	67.6	15.7%
	Open Space	OPS	18.5	4.3%
	Residential 2-acre	R21	21.8	5.1%
	Transportation	TRN	73.8	17.1%
	Utility	UTL	3.0	0.7%
	Woods	WDS	246.0	57.1%
	Total		**430.7**	100.0%
PN7	Airport	AIR	93.1	4.9%
	Commercial	COM	31.1	1.6%
	Industrial	IND	274.5	14.4%
	Open Space	OPS	348.3	18.3%
	Open Wetland	OPW	5.9	0.3%
	Residential 1/2-acre	R12	91.0	4.8%
	Residential 1/8-acre	R18	1.0	0.1%
	Residential 1-acre	R11	21.8	1.1%
	Residential 2-acre	R21	37.4	2.0%
	Transportation	TRN	105.4	5.5%
	Water	WAT	0.3	0.0%
	Woods	WDS	897.7	47.1%
	Total		**1907.7**	100.0%
PN8	Airport	AIR	533.3	37.0%
	Commercial	COM	169.4	11.8%
	Industrial	IND	39.6	2.8%
	Open Space	OPS	342.3	23.8%
	Open Wetland	OPW	0.0	0.0%
	Residential 1-acre	R11	28.6	2.0%
	Residential 2-acre	R21	12.7	0.9%
	Transportation	TRN	75.4	5.2%
	Woods	WDS	239.0	16.6%
	Total		**1440.3**	100.0%
PN9	Commercial	COM	121.8	5.1%
	Forested Wetland	FRW	2.0	0.1%
	Industrial	IND	247.2	10.3%
	Open Space	OPS	182.1	7.6%
	Residential 1/2-acre	R12	142.7	5.9%
	Residential 1/4-acre	R14	437.8	18.2%
	Residential 1/8-acre	R18	316.3	13.2%
	Residential 1-acre	R11	55.9	2.3%
	Residential 2-acre	R21	81.0	3.4%
	Row Crops	SRC	33.7	1.4%
	Transportation	TRN	151.3	6.3%
	Water	WAT	9.6	0.4%
	Woods	WDS	619.8	25.8%
	Total		**2401.2**	100.0%

Table B.1 - Land Cover

Subwatershed	Land Cover	Code	Acres	Percent of Watershed
PNA	Commercial	COM	6.7	0.9%
	Forested Wetland	FRW	5.7	0.8%
	Industrial	IND	4.1	0.6%
	Open Space	OPS	46.1	6.5%
	Residential 1-acre	R11	5.2	0.7%
	Residential 2-acre	R21	95.9	13.5%
	Transportation	TRN	33.0	4.6%
	Utility	UTL	5.6	0.8%
	Woods	WDS	507.3	71.5%
	Total		**709.6**	100.0%
PNB	Commercial	COM	227.6	8.6%
	Industrial	IND	145.6	5.5%
	Open Space	OPS	352.7	13.3%
	Residential 1/2-acre	R12	8.3	0.3%
	Residential 1/4-acre	R14	107.3	4.1%
	Residential 1/8-acre	R18	168.9	6.4%
	Residential 1-acre	R11	206.5	7.8%
	Residential 2-acre	R21	62.5	2.4%
	Transportation	TRN	197.8	7.5%
	Water	WAT	11.2	0.4%
	Woods	WDS	1157.7	43.7%
	Total		**2646.1**	100.0%
PNC	Commercial	COM	13.2	0.8%
	Industrial	IND	195.5	12.4%
	Open Space	OPS	91.1	5.8%
	Pasture/Hay	PAS	1.7	0.1%
	Residential 1/2-acre	R12	33.9	2.2%
	Residential 1/8-acre	R18	1.3	0.1%
	Residential 1-acre	R11	95.9	6.1%
	Residential 2-acre	R21	256.7	16.3%
	Transportation	TRN	105.9	6.7%
	Water	WAT	1.8	0.1%
	Woods	WDS	773.9	49.3%
	Total		**1570.7**	100.0%

APPENDIX C – IMPERVIOUS LAND COVER AND OWNERSHIP

Table C.1 - Impervious Land Cover and Ownership

Sub-watershed	Land Cover and Ownership (WIP Sector)	Classname	Area (acres)	Percent of Watershed	Impervious Cover (acres)	Impervious % of Land Cover	% of Total Impervious Cover
Patapsco Non-Tidal Watershed	County - Private Agriculture Lands	Pasture/Hay	34.9	0.2%	0.5	1%	< 0.1%
	County - Private Commercial	Commercial	854.5	5.6%	664.4	78%	15.3%
	County - Private High Density Residential	Residential 1/8-acre	918.6	6.0%	328.8	36%	7.6%
	County - Private Industrial	Industrial	1,042.0	6.8%	793.9	76%	18.2%
	County - Private Low Density Residential	Residential 2-acre	1,009.6	6.6%	158.3	16%	3.6%
	County - Private Medium Density Residential	Transportation	1,460.3	9.6%	432.4	30%	9.9%
	County - Private Natural Resource Lands	Woods	3,039.8	19.9%	39.0	1%	0.9%
	County - Private Open Space	Open Space	689.3	4.5%	44.7	6%	1.0%
	County Board of Education	Transportation	98.2	0.6%	29.6	30%	0.7%
	County Roads and Facilities	Industrial	1,262.9	8.3%	593.7	47%	13.6%
	Maryland Aviation Administration	Industrial	2,175.5	14.2%	662.4	30%	15.2%
	Maryland Department of Transportation	Industrial	157.0	1.0%	16.7	11%	0.4%
	Maryland DNR Lands	Industrial	893.3	5.9%	5.4	1%	0.1%
	Maryland State Highway Administration	Industrial	1,078.9	7.1%	402.8	37%	9.3%
	Maryland State Institutional Lands	Industrial	41.9	0.3%	6.9	16%	0.2%
	Other DOD Facilities	Commercial	29.6	0.2%	23.4	79%	0.5%
	US Park Service	Industrial	462.0	3.0%	135.8	29%	3.1%
	US Postal Service	Industrial	20.4	0.1%	13.5	66%	0.3%
	Total		15,268.6	100.0%	4,352.2	29%	100.0%
PN1	County - Private Commercial	Commercial	51.8	5.0%	42.3	82%	10.3%
	County - Private High Density Residential	Residential 1/8-acre	351.1	34.1%	145.0	41%	35.3%
	County - Private Industrial	Industrial	59.5	5.8%	49.6	83%	12.1%
	County - Private Low Density Residential	Residential 2-acre	1.3	0.1%	0.1	11%	< 0.1%
	County - Private Medium Density Residential	Transportation	29.7	2.9%	10.3	35%	2.5%
	County - Private Natural Resource Lands	Woods	77.1	7.5%	1.0	1%	0.2%
	County - Private Open Space	Open Space	62.9	6.1%	0.4	1%	< 0.1%
	County Board of Education	Transportation	64.3	6.2%	18.6	29%	4.5%
	County Roads and Facilities	Industrial	162.9	15.8%	96.4	59%	23.4%
	Maryland DNR Lands	Industrial	66.9	6.5%	0.9	1%	0.2%
	Maryland State Highway Administration	Industrial	102.9	10.0%	46.7	45%	11.4%
	Total		1,030.4	100.0%	411.3	40%	100.0%

Table C.1 - Impervious Land Cover and Ownership

Sub-watershed	Land Cover and Ownership (WIP Sector)	Classname	Area (acres)	Percent of Watershed	Impervious Cover (acres)	Impervious % of Land Cover	% of Total Impervious Cover
PN2	County - Private Commercial	Commercial	28.3	3.3%	18.7	66%	7.4%
	County - Private High Density Residential	Residential 1/8-acre	157.4	18.4%	50.4	32%	20.0%
	County - Private Industrial	Industrial	4.6	0.5%	3.4	74%	1.3%
	County - Private Low Density Residential	Residential 2-acre	10.4	1.2%	2.2	21%	0.9%
	County - Private Medium Density Residential	Transportation	226.5	26.5%	70.2	31%	27.9%
	County - Private Natural Resource Lands	Woods	71.5	8.4%	1.1	2%	0.4%
	County - Private Open Space	Open Space	75.8	8.9%	1.8	2%	0.7%
	County Board of Education	Transportation	3.5	0.4%	2.2	64%	0.9%
	County Roads and Facilities	Industrial	123.7	14.5%	63.1	51%	25.1%
	Maryland DNR Lands	Industrial	76.6	8.9%	0.0	0%	0.0%
	Maryland State Highway Administration	Industrial	77.5	9.1%	38.7	50%	15.4%
	Total		855.8	100.0%	251.9	29%	100.0%
PN3	County - Private Commercial	Commercial	17.7	3.4%	12.6	71%	6.1%
	County - Private High Density Residential	Residential 1/8-acre	4.2	0.8%	0.7	16%	0.3%
	County - Private Industrial	Industrial	124.2	23.6%	102.4	82%	49.6%
	County - Private Low Density Residential	Residential 2-acre	4.5	0.9%	0.7	15%	0.3%
	County - Private Medium Density Residential	Transportation	80.0	15.2%	22.9	29%	11.1%
	County - Private Natural Resource Lands	Woods	42.9	8.2%	0.4	1%	0.2%
	County - Private Open Space	Open Space	10.8	2.1%	1.1	10%	0.5%
	County Roads and Facilities	Industrial	29.7	5.6%	21.3	72%	10.3%
	Maryland DNR Lands	Industrial	114.2	21.7%	1.7	2%	0.8%
	Maryland State Highway Administration	Industrial	32.6	6.2%	17.7	54%	8.6%
	US Park Service	Industrial	65.3	12.4%	25.0	38%	12.1%
	Total		526.3	100.0%	206.5	39%	100.0%
PN4	County - Private Commercial	Commercial	131.1	11.2%	98.0	75%	24.4%
	County - Private Industrial	Industrial	137.3	11.7%	92.5	67%	23.0%
	County - Private Low Density Residential	Residential 2-acre	80.1	6.8%	15.3	19%	3.8%
	County - Private Medium Density Residential	Transportation	268.7	22.9%	84.3	31%	21.0%
	County - Private Natural Resource Lands	Woods	204.0	17.4%	1.7	1%	0.4%
	County - Private Open Space	Open Space	40.5	3.4%	2.3	6%	0.6%
	County Roads and Facilities	Industrial	135.2	11.5%	72.0	53%	17.9%
	Maryland Aviation Administration	Industrial	11.8	1.0%	0.0	0%	0.0%
	Maryland DNR Lands	Industrial	99.7	8.5%	0.8	1%	0.2%
	Maryland State Highway Administration	Industrial	6.5	0.6%	5.3	82%	1.3%
	Maryland State Institutional Lands	Industrial	9.0	0.8%	5.7	64%	1.4%
	US Park Service	Industrial	31.1	2.6%	10.9	35%	2.7%
	US Postal Service	Industrial	20.4	1.7%	13.5	66%	3.4%
	Total		1,175.3	100.0%	402.5	34%	100.0%

Table C.1 - Impervious Land Cover and Ownership

Sub-watershed	Land Cover and Ownership (WIP Sector)	Classname	Area (acres)	Percent of Watershed	Impervious Cover (acres)	Impervious % of Land Cover	% of Total Impervious Cover
PN5	County - Private Commercial	Commercial	42.7	7.4%	32.9	77%	39.8%
	County - Private Industrial	Industrial	10.0	1.7%	6.1	61%	7.4%
	County - Private Low Density Residential	Residential 2-acre	43.9	7.6%	7.1	16%	8.6%
	County - Private Medium Density Residential	Transportation	13.3	2.3%	4.8	36%	5.7%
	County - Private Natural Resource Lands	Woods	167.1	29.1%	1.1	1%	1.3%
	County - Private Open Space	Open Space	33.3	5.8%	0.7	2%	0.8%
	County Roads and Facilities	Industrial	16.9	3.0%	8.3	49%	10.0%
	Maryland DNR Lands	Industrial	173.3	30.2%	1.0	1%	1.2%
	Maryland State Highway Administration	Industrial	32.2	5.6%	7.3	23%	8.8%
	US Park Service	Industrial	41.7	7.3%	13.5	32%	16.4%
	Total		574.5	100.0%	82.7	14%	100.0%
PN6	County - Private Commercial	Commercial	62.8	14.6%	44.7	71%	43.2%
	County - Private Low Density Residential	Residential 2-acre	20.4	4.7%	2.6	13%	2.5%
	County - Private Medium Density Residential	Transportation	12.1	2.8%	7.6	63%	7.3%
	County - Private Natural Resource Lands	Woods	35.1	8.1%	0.4	1%	0.3%
	County - Private Open Space	Open Space	7.0	1.6%	0.0	0%	< 0.1%
	County Roads and Facilities	Industrial	6.5	1.5%	5.2	81%	5.1%
	Maryland DNR Lands	Industrial	134.2	31.2%	0.2	0%	0.2%
	Maryland State Highway Administration	Industrial	114.4	26.6%	29.2	26%	28.3%
	Other DOD Facilities	Commercial	0.01	< 0.1%	0.0	0%	0.0%
	US Park Service	Industrial	38.2	8.9%	13.4	35%	13.0%
	Total		430.7	100.0%	103.3	24%	100.0%
PN7	County - Private Commercial	Commercial	66.0	3.5%	56.9	86%	12.6%
	County - Private High Density Residential	Residential 1/8-acre	0.8	< 0.1%	0.1	15%	< 0.1%
	County - Private Industrial	Industrial	160.9	8.4%	125.8	78%	27.9%
	County - Private Low Density Residential	Residential 2-acre	54.8	2.9%	7.0	13%	1.5%
	County - Private Medium Density Residential	Transportation	118.8	6.2%	36.6	31%	8.1%
	County - Private Natural Resource Lands	Woods	358.4	18.8%	3.2	1%	0.7%
	County - Private Open Space	Open Space	73.3	3.8%	3.3	5%	0.7%
	County Roads and Facilities	Industrial	85.9	4.5%	38.0	44%	8.4%
	Maryland Aviation Administration	Industrial	856.9	44.9%	128.2	15%	28.4%
	Maryland Department of Transportation	Industrial	24.6	1.3%	16.6	68%	3.7%
	Maryland State Highway Administration	Industrial	81.9	4.3%	34.7	42%	7.7%
	Maryland State Institutional Lands	Industrial	25.4	1.3%	0.4	2%	< 0.1%
	Total		1,907.7	100.0%	450.8	24%	100.0%

Table C.1 - Impervious Land Cover and Ownership

Sub-watershed	Land Cover and Ownership (WIP Sector)	Classname	Area (acres)	Percent of Watershed	Impervious Cover (acres)	Impervious % of Land Cover	% of Total Impervious Cover
PN8	County - Private Commercial	Commercial	128.7	8.9%	103.2	80%	14.3%
	County - Private Industrial	Industrial	33.4	2.3%	25.6	77%	3.6%
	County - Private Low Density Residential	Residential 2-acre	34.3	2.4%	5.8	17%	0.8%
	County - Private Medium Density Residential	Transportation	2.8	0.2%	2.1	74%	0.3%
	County - Private Natural Resource Lands	Woods	44.8	3.1%	0.5	1%	< 0.1%
	County - Private Open Space	Open Space	7.4	0.5%	0.2	3%	< 0.1%
	County Roads and Facilities	Industrial	35.0	2.4%	24.4	70%	3.4%
	Maryland Aviation Administration	Industrial	1,011.3	70.2%	490.7	49%	68.1%
	Maryland State Highway Administration	Industrial	113.0	7.8%	44.5	39%	6.2%
	Other DOD Facilities	Commercial	29.6	2.1%	23.4	79%	3.2%
	Total		1,440.3	100.0%	720.3	50%	100.0%
PN9	County - Private Agriculture Lands	Pasture/Hay	33.2	1.4%	0.5	2%	< 0.1%
	County - Private Commercial	Commercial	89.4	3.7%	56.0	63%	8.1%
	County - Private High Density Residential	Residential 1/8-acre	248.9	10.4%	70.6	28%	10.2%
	County - Private Industrial	Industrial	238.2	9.9%	175.9	74%	25.3%
	County - Private Low Density Residential	Residential 2-acre	122.2	5.1%	24.2	20%	3.5%
	County - Private Medium Density Residential	Transportation	523.7	21.8%	136.1	26%	19.6%
	County - Private Natural Resource Lands	Woods	346.1	14.4%	3.6	1%	0.5%
	County - Private Open Space	Open Space	56.6	2.4%	1.4	3%	0.2%
	County Board of Education	Transportation	30.3	1.3%	8.8	29%	1.3%
	County Roads and Facilities	Industrial	307.8	12.8%	137.6	45%	19.8%
	Maryland Aviation Administration	Industrial	32.5	1.4%	0.1	0%	< 0.1%
	Maryland Department of Transportation	Industrial	95.7	4.0%	0.1	0%	< 0.1%
	Maryland State Highway Administration	Industrial	269.0	11.2%	78.8	29%	11.4%
	Maryland State Institutional Lands	Industrial	7.5	0.3%	0.8	10%	0.1%
	Total		2,401.2	100.0%	694.4	29%	100.0%
PNA	County - Private Commercial	Commercial	6.5	0.9%	4.2	65%	9.6%
	County - Private Industrial	Industrial	4.1	0.6%	1.8	43%	4.0%
	County - Private Low Density Residential	Residential 2-acre	79.8	11.2%	6.6	8%	14.9%
	County - Private Medium Density Residential	Transportation	2.7	0.4%	0.3	12%	0.7%
	County - Private Natural Resource Lands	Woods	245.7	34.6%	8.7	4%	19.7%
	County - Private Open Space	Open Space	37.9	5.3%	0.1	0%	0.3%
	County Roads and Facilities	Industrial	8.7	1.2%	3.6	42%	8.2%
	Maryland Aviation Administration	Industrial	33.8	4.8%	0.9	3%	2.0%
	Maryland Department of Transportation	Industrial	12.5	1.8%	0.0	0%	0.0%
	Maryland DNR Lands	Industrial	213.9	30.1%	0.6	0%	1.4%
	Maryland State Highway Administration	Industrial	8.3	1.2%	4.4	53%	9.9%
	US Park Service	Industrial	55.8	7.9%	13.0	23%	29.4%
	Total		709.6	100.0%	44.3	6%	100.0%

Table C.1 - Impervious Land Cover and Ownership

Sub-watershed	Land Cover and Ownership (WIP Sector)	Classname	Area (acres)	Percent of Watershed	Impervious Cover (acres)	Impervious % of Land Cover	% of Total Impervious Cover
PNB	County - Private Commercial	Commercial	221.1	8.4%	189.8	86%	27.8%
	County - Private High Density Residential	Residential 1/8-acre	155.4	5.9%	61.9	40%	9.1%
	County - Private Industrial	Industrial	95.5	3.6%	75.0	79%	11.0%
	County - Private Low Density Residential	Residential 2-acre	224.3	8.5%	39.6	18%	5.8%
	County - Private Medium Density Residential	Transportation	125.7	4.8%	38.8	31%	5.7%
	County - Private Natural Resource Lands	Woods	773.1	29.2%	13.9	2%	2.0%
	County - Private Open Space	Open Space	243.2	9.2%	32.9	14%	4.8%
	County Board of Education	Transportation	0.1	< 0.1%	0.0	0%	0.0%
	County Roads and Facilities	Industrial	253.2	9.6%	95.4	38%	14.0%
	Maryland Aviation Administration	Industrial	207.3	7.8%	41.1	20%	6.0%
	Maryland Department of Transportation	Industrial	24.3	0.9%	0.0	0%	< 0.1%
	Maryland DNR Lands	Industrial	10.8	0.4%	0.1	1%	< 0.1%
	Maryland State Highway Administration	Industrial	138.0	5.2%	50.5	37%	7.4%
	US Park Service	Industrial	174.2	6.6%	44.7	26%	6.5%
	Total		2,646.1	100.0%	683.7	26%	100.0%
PNC	County - Private Agriculture Lands	Pasture/Hay	1.7	0.1%	0.0	0%	0.0%
	County - Private Commercial	Commercial	8.3	0.5%	5.1	62%	1.7%
	County - Private High Density Residential	Residential 1/8-acre	0.7	< 0.1%	0.1	21%	< 0.1%
	County - Private Industrial	Industrial	174.3	11.1%	135.8	78%	45.2%
	County - Private Low Density Residential	Residential 2-acre	333.6	21.2%	47.1	14%	15.7%
	County - Private Medium Density Residential	Transportation	56.5	3.6%	18.6	33%	6.2%
	County - Private Natural Resource Lands	Woods	674.0	42.9%	3.4	1%	1.1%
	County - Private Open Space	Open Space	40.5	2.6%	0.5	1%	0.2%
	County Roads and Facilities	Industrial	97.4	6.2%	28.3	29%	9.4%
	Maryland Aviation Administration	Industrial	21.8	1.4%	1.4	6%	0.5%
	Maryland DNR Lands	Industrial	3.7	0.2%	0.0	1%	< 0.1%
	Maryland State Highway Administration	Industrial	102.6	6.5%	44.9	44%	14.9%
	US Park Service	Industrial	55.7	3.5%	15.3	28%	5.1%
	Total		1,570.7	100.0%	300.6	19%	100.0%

APPENDIX D – URBAN BMP SUMMARY DATA

Table D.1 - Summary of Patapsco Non-Tidal Watershed BMPs by Type

Sub-watershed	BMP Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area
Patapsco Non-Tidal Watershed	Dry Detention	57	8%	416	9%
	Extended Detention Dry	116	17%	1250	27%
	Filtration	113	17%	248	5%
	Infiltration	274	41%	931	20%
	Wet Ponds	77	11%	29	1%
	Wetlands	7	1%	1608	35%
	Other	32	5%	154	3%
	TOTAL	**676**	**100%**	**4636**	**100%**
PN1	Dry Detention	4	11%	4	4%
	Extended Detention Dry	0	0%	0	0%
	Filtration	4	11%	3	3%
	Infiltration	21	57%	67	64%
	Wet Ponds	1	3%	1	1%
	Wetlands	0	0%	0	0%
	Other	7	19%	29	28%
	TOTAL	**37**	**100%**	**105**	**100%**
PN2	Dry Detention	2	4%	67	29%
	Extended Detention Dry	3	6%	58	25%
	Filtration	7	15%	14	6%
	Infiltration	34	71%	83	36%
	Wet Ponds	1	2%	9	4%
	Wetlands	0	0%	0	0%
	Other	1	2%	0	0%
	TOTAL	**48**	**100%**	**230**	**100%**
PN3	Dry Detention	4	19%	54	43%
	Extended Detention Dry	1	5%	4	3%
	Filtration	4	19%	2	2%
	Infiltration	9	43%	43	34%
	Wet Ponds	2	10%	23	18%
	Wetlands	0	0%	0	0%
	Other	1	5%	0	0%
	TOTAL	**21**	**100%**	**125**	**100%**
PN4	Dry Detention	3	5%	48	9%
	Extended Detention Dry	11	17%	130	25%
	Filtration	7	11%	30	6%
	Infiltration	31	48%	83	16%
	Wet Ponds	8	12%	122	23%
	Wetlands	4	6%	113	22%
	Other	1	2%	0	0%
	TOTAL	**65**	**100%**	**527**	**100%**

Table D.1 - Summary of Patapsco Non-Tidal Watershed BMPs by Type

Sub-watershed	BMP Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area
PN5	Dry Detention	1	7%	2	3%
	Extended Detention Dry	3	21%	10	18%
	Filtration	1	7%	6	10%
	Infiltration	6	43%	10	17%
	Wet Ponds	2	14%	30	52%
	Wetlands	0	0%	0	0%
	Other	1	7%	0	0%
	TOTAL	**14**	**100%**	**58**	**100%**
PN6	Dry Detention	1	7%	0	0%
	Extended Detention Dry	2	14%	10	14%
	Filtration	2	14%	7	9%
	Infiltration	6	43%	33	46%
	Wet Ponds	2	14%	22	31%
	Wetlands	0	0%	0	0%
	Other	1	7%	0	0%
	TOTAL	**14**	**100%**	**72**	**100%**
PN7	Dry Detention	12	17%	141	28%
	Extended Detention Dry	16	23%	207	42%
	Filtration	19	27%	40	8%
	Infiltration	15	21%	38	8%
	Wet Ponds	4	6%	70	14%
	Wetlands	0	0%	0	0%
	Other	4	6%	0	0%
	TOTAL	**70**	**100%**	**496**	**100%**
PN8	Dry Detention	6	11%	18	4%
	Extended Detention Dry	15	27%	196	48%
	Filtration	13	24%	27	6%
	Infiltration	16	29%	106	26%
	Wet Ponds	4	7%	46	11%
	Wetlands	1	2%	20	5%
	Other	0	0%	0	0%
	TOTAL	**55**	**100%**	**413**	**100%**
PN9	Dry Detention	14	10%	69	8%
	Extended Detention Dry	16	12%	240	27%
	Filtration	16	12%	41	5%
	Infiltration	70	51%	218	25%
	Wet Ponds	17	12%	290	33%
	Wetlands	2	1%	20	2%
	Other	3	2%	0	0%
	TOTAL	**138**	**100%**	**878**	**100%**

Table D.1 - Summary of Patapsco Non-Tidal Watershed BMPs by Type

Sub-watershed	BMP Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area
PNA	Dry Detention	0	0%	0	0%
	Extended Detention Dry	2	29%	15	30%
	Filtration	3	43%	15	30%
	Infiltration	2	29%	20	40%
	Wet Ponds	0	0%	0	0%
	Wetlands	0	0%	0	0%
	Other	0	0%	0	0%
	TOTAL	**7**	**100%**	**51**	**100%**
PNB	Dry Detention	7	4%	7	1%
	Extended Detention Dry	35	22%	276	20%
	Filtration	29	18%	54	4%
	Infiltration	40	25%	137	10%
	Wet Ponds	34	22%	927	66%
	Wetlands	0	0%	0	0%
	Other	12	8%	0	0%
	TOTAL	**157**	**100%**	**1401**	**100%**
PNC	Dry Detention	3	6%	7	2%
	Extended Detention Dry	12	24%	105	37%
	Filtration	8	16%	10	3%
	Infiltration	24	48%	93	33%
	Wet Ponds	2	4%	69	24%
	Wetlands	0	0%	0	0%
	Other	1	2%	0	0%
	TOTAL	**50**	**100%**	**282**	**100%**

Table D.2 - Anne Arundel County BMP Types and their Pollutant Removal Efficiencies

AA Co BMP Code	County Name	BMP Group	TN	TP	NOx	Cu	Zn	Pb	Fecal Coliform	TSS	Metals Average	MDE Code
DP	Detention Structure (Dry Pond)	Detention Dry	5	10	9	10	10	10	0	10	10	DP
UGVAULT	Underground Storage	Detention Dry	5	10	-2	29	29	29	50	10	29	UGS
BS	Bay Saver	Detention Dry	5	10	-2	29	29	29	50	10	29	BS
OGS	Oil Grit Separator	Detention Dry	5	10	-2	29	29	29	50	10	29	OGS
WQINLET	Water Quality Inlet	Detention Dry	5	10	-2	29	29	29	50	10	29	OGS
STMCEPTOR	Stormceptor	Detention Dry	5	10	-2	29	29	29	50	10	29	SC
SC	Stormceptor	Detention Dry	5	10	-2	29	29	29	50	10	29	SC
Pretreatment	Pretreatment	Detention Dry	5	10	-2	29	29	29	50	10	29	SC
UGS	Underground Storage	Detention Dry	5	10	-2	29	29	29	50	10	29	UGS
ED	Extended Detention	Extended Detention Dry	20	20	-2	29	29	29	50	60	29	EDSD
EDSD	Extended Detention Structure Dry	Extended Detention Dry	20	20	-2	29	29	29	50	60	29	EDSD
MB	Microbasin - Extended Detention Structure Dry	Extended Detention Dry	20	20	-2	29	29	29	50	60	29	EDSD
O-1	Dry Swale	Filtration	40	60	0	35	35	35	0	85	35	SW
O-2	Wet Swale	Filtration	40	60	0	35	35	35	0	85	35	SW
ASCD	Attenuation Swale/Check Dam	Filtration	40	60	0	35	35	35	0	85	35	CD
F-1	Surface sand filter	Filtration	40	60	0	35	35	35	0	85	35	SF
F-2	Underground sand filter	Filtration	40	60	0	35	35	35	0	85	35	SF
F-3	Perimeter sand filter	Filtration	40	60	0	35	35	35	0	85	35	SF
F-4	Organic filter	Filtration	40	60	0	35	35	35	0	85	35	BIO
F-5	Pocket Sand Filter	Filtration	40	60	0	35	35	35	0	85	35	SF
F-6	Bioretention Facility	Filtration	40	60	0	35	35	35	0	85	35	BIO
SF	Sand Filter	Filtration	40	60	0	35	35	35	0	85	35	SF
ATTENSWA	Attenuation Swale	Filtration	40	60	0	35	35	35	0	85	35	AS
AS	Attenuation Swale	Filtration	40	60	0	35	35	35	0	85	35	AS
SW	Grass Swale	Filtration	40	60	0	35	35	35	0	85	35	SW
POSAND	Pocket Sand Filter	Filtration	40	60	0	60	60	60	80	85	60	SF
C2/raingardens	Rain Gardens	Filtration	40	60	0	60	60	60	80	85	60	BIO
VB	Vegetated Buffer	Filtration	40	60	0	60	60	60	80	85	60	VB
BIO	Bioretention Facility	Filtration	40	60	0	85	85	85	90	85	85	BIO
SPSC	Regenerative Step Pool Storm Conveyance	Filtration	40	60	0	85	85	85	90	85	85	BIO
GBMP	Bioretention Facility	Filtration	40	60	0	85	85	85	90	85	85	BIO

Table D.2 - Anne Arundel County BMP Types and their Pollutant Removal Efficiencies

AA Co BMP Code	County Name	BMP Group	TN	TP	NOx	Cu	Zn	Pb	Fecal Coliform	TSS	Metals Average	MDE Code
ATTTRENCH	Attenuation Trench	Infiltration	50	70	0	0	0	0	0	90	0	DW
DW	Dry Well	Infiltration	50	70	82	30	21	21	90	90	24	DW
DWIT	Dry Well - Infiltration Trench	Infiltration	50	70	82	30	21	21	90	90	24	DW
DWITCE	Dry Well - Infiltration Trench with Complete Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	DW
DWITCE-2	Dry Well - Infiltration Trench with Complete Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	DW
C-2/drywells	Dry Well	Infiltration	50	70	82	30	21	21	90	90	24	DW
DWITCW	Dry Well - Infiltration Trench with Complete Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	DW
DWITPE	Dry Well - Infiltration Trench with Partial Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	DW
DWITWQE	Dry Well - Infiltration Trench with Water Quality Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	ITCE
EDSDITCE	Extended Detention Structure Dry, Infiltration Trench with Complete Exfiltration	Infiltration	50	70	81.64	29	29	29	60	90	29	ITCE
IB	Infiltration Basin	Infiltration	50	70	83.08	30	21	21	90	90	24	IB
IITCE	Infiltration Trench with Complete Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	ITCE
INPOND	Infiltration Basin No Outfall	Infiltration	50	70	83.08	30	21	21	0	90	24	IB
IT	Infiltration Trench	Infiltration	50	70	82	30	21	21	90	90	24	IT
ITVSW	Infiltration Trench, Extended Detention	Infiltration	50	70	81.64	29	29	29	90	90	29	IT
ITCE	Infiltration Trench with Complete Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	ITCE
ITCEMB	Infiltration Trench with Complete Exfiltration, Microbasin	Infiltration	50	70	82	30	21	21	90	90	24	ITCE
ITPE	Infiltration Trench with Partial Exfiltration	Infiltration	50	70	0	30	21	21	90	90	24	ITPE
ITWQE	Infiltration Trench with Water Quality Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	ITWQE
OGS	Oil Grit Seperator	Infiltration	50	70	47	-11	17	17	0	90	7.7	OGS

Table D.2 - Anne Arundel County BMP Types and their Pollutant Removal Efficiencies

AA Co BMP Code	County Name	BMP Group	TN	TP	NOx	Cu	Zn	Pb	Fecal Coliform	TSS	Metals Average	MDE Code
OGSITCE	Oil Grit Seperator Infiltration Trench with Complete Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	ITCE
PNDTR	Same as infiltration basin	Infiltration	50	70	83.08	30	21	21	0	90	24	IB
PP	Porous Pavement	Infiltration	50	70	0	99	99	99	90	90	99	PP
SB	Infiltration Basin	Infiltration	50	70	82	30	21	21	90	90	24	IB
WQITPE	Water Quality Infiltration Trench with Partial Exfiltration	Infiltration	50	70	82	30	21	21	90	90	24	ITWQE
WQP	Water Quality Trench	Infiltration	50	70	82	30	21	21	90	90	24	ITWQE
LS	Level Spreader	Other/Not BMPs	0	0	0	0	0	0	0	0	0	LS
C-1	Natural Area Conservation Credit	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
C-2	Disconnection of Rooftop Runoff	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
C-3	Disconnectiom of Non Rooftop Runoff	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
C-4	Sheet Flow to Buffers	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
C-5	Open Channel Use	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
C-6	Envrionmentally Sensitive Development	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
OTHER	Other	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
Redevelop	Redevelopment	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
Credits	Credits	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
RD	Redevelopment	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
Variance	Variance	Other/Not BMPs	0	0	0	0	0	0	0	0	0	Variance
Plantings	Plantings	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
Exempt	Exempt	Other/Not BMPs	0	0	0	0	0	0	0	0	0	Exempt
Other	Other	Other/Not BMPs	0	0	0	0	0	0	0	0	0	
PL	Plantings	Other/Not BMPs	0	0	0	0	0	0	0	0	0	

Table D.2 - Anne Arundel County BMP Types and their Pollutant Removal Efficiencies

AA Co BMP Code	County Name	BMP Group	TN	TP	NOx	Cu	Zn	Pb	Fecal Coliform	TSS	Metals Average	MDE Code
EDSW	Extended Detention Structure Wet	Wet Ponds	20	45	63	44	69	69	75	60	60.7	ESDW
ESDW	Extended Detention Structure Wet	Wet Ponds	20	45	63	44	69	69	75	60	60.7	ESDW
MP	Micro Pool	Wet Ponds	20	45	36	58	65	65	75	60	62.7	MP
P-3	Extended Detention Structure Wet	Wet Ponds	20	45	63	44	69	69	75	60	60.7	ESDW
EXPOND	Wet Pond	Wet Ponds	20	45	36	58	65	65	75	60	62.7	WP
P-2	Wet Pond	Wet Ponds	20	45	36	58	65	65	75	60	62.7	WP
SW	Wet Structure	Wet Ponds	20	45	36	58	65	65	75	60	62.7	WP
P-1	Micro Pool	Wet Ponds	20	45	36	58	65	65	75	60	62.7	MP
WP	Retention Structure (Wet Pond)	Wet Ponds	20	45	36	58	65	65	75	60	62.7	WP
P-4	Multiple pond system	Wet Ponds	20	45	36	58	65	65	75	60	62.7	WP
P-5	Pocket pond	Wet Ponds	20	45	36	58	65	65	75	60	62.7	WP
SM	Shallow Marsh	Wetlands	40	60	73	85	85	85	75	60	85	SM
W-1	Shallow Wetland	Wetlands	40	60	73	85	85	85	75	60	85	SM
RSC	Regenerative Wetland Seepage	Wetlands	40	60	73	85	85	85	75	60	85	SM
W-2	ED shallow wetland	Wetlands	40	60	73	85	85	85	75	60	85	SM
W-3	Pond/wetland system	Wetlands	40	60	73	85	85	85	75	60	85	SM
W-4	Pocket wetland	Wetlands	40	60	73	85	85	85	75	60	85	SM

APPENDIX E – BIOASSESSMENT REPORT AND QUALITY CONTROL TECHNICAL MEMORANDUM

Patapsco River Nontidal Watershed

Targeted Biological Monitoring and Assessment

2008

Anne Arundel County, Maryland

Prepared for and in collaboration with Anne Arundel County

Department of Public Works
Watershed and Ecosystem Services and Restoration Division
Watershed Management Program

ANNE ARUNDEL COUNTY
MARYLAND

DPW

KCI Technologies, Inc.
September 2008

KCI TECHNOLOGIES

Patapsco River Nontidal Watershed

Targeted Biological Monitoring and Assessment - 2008

September 2008

Prepared for:

Anne Arundel County
Department of Public Works
Watershed and Ecosystem Services and Restoration Division
Watershed Management Division

A.A. Co. Contract No. D406947

2664 Riva Road, P.O. Box 6675
Annapolis, Maryland 21401

Prepared by:

KCI Technologies, Inc.
10 North Park Drive
Hunt Valley, Maryland 21030
KCI Job Order No. 0302333.40

CONTENTS

FIGURES

TABLES

APPENDICES

1 Background and Objectives

Anne Arundel County, in an effort to improve its water quality and streams, initiated systematic and comprehensive watershed assessments and action plans for restoration and protection across the County. The Patapsco River Nontidal watershed targeted biological assessment and monitoring fulfills part of the County's water quality assessment requirements under their National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit issued by the Maryland Department of the Environment, and also assists the County in preparing TMDL implementation plans.

Anne Arundel County contracted KCI Technologies, Inc. to conduct a targeted assessment of the biological community and physical habitat in the Patapsco River Nontidal watershed during the Spring of 2008. The targeted assessment focuses on water quality, sampling and analysis of the benthic macroinvertebrate community, assessment of instream and riparian physical habitat conditions, and stream geomorphology.

The data collected and reported herein will be primarily utilized in the County's Watershed Management Tool (WMT), which is developed and maintained by the Department of Public Works, Watershed and Ecosystem Services and Restoration Division, Watershed Assessment and Planning Program. Within the WMT, relationships between biological condition, hydrology, water quality, and landuse are developed to support watershed and landuse planning and restoration goal setting. Additionally, the data can be used in the development and implementation of TMDL plans.

The biological data will also be beneficial for the ongoing County-wide Biological Monitoring and Assessment Program to further develop status, trends and problem identification for the portions of the County sampled. The Anne Arundel County portion of the Patapsco River Nontidal watershed (MDE 8-digit watershed 02130903, Baltimore Harbor) encompasses 15,286 acres and contains approximately 72 miles of nontidal stream channel. The watershed covers three primary sampling units (PSUs) defined by the County-wide monitoring and assessment strategy, Piney Run (PSU-01), Stony Run (PSU-02), and the Lower Patapsco (PSU-03). Piney Run and Stony Run were most recently assessed by the County in 2007 and the Lower Patapsco PSU was completed in 2004. A full County-wide watershed comprehensive study is anticipated for completion by 2009.

The Patapsco River Nontidal watershed was subdivided into 12 sub-basins by the County's Watershed Assessment and Planning Program for targeted site selection. Within these sub-basins, 11 targeted sites were selected, at which water quality sampling, benthic macroinvertebrate collection /assessment, physical habitat assessment, and geomorphic assessment were completed between April 10 and April 16, 2008.

The Patapsco River Nontidal watershed is part of Maryland's Patapsco/Back River basin. The Patapsco/Back River basin drains approximately 630 square miles of land, including portions of Anne Arundel, Baltimore, Carroll, and Howard Counties along the Western Shore of the Chesapeake Bay. The majority of the basin lies in the Piedmont physiographic province, but the current study area is located in the southern most portion of the basin, within the Coastal Plain physiographic province. Figure 1 – Vicinity Map shows the general location of the watershed as well as drainage areas to each sampling point.

2 Methods

The monitoring program includes chemical, physical and biological assessment conducted throughout the watershed. The sampling methods used are compatible with the Sampling and Analysis Plan for Anne Arundel County Biological Monitoring (SAP) (Tetra Tech, 2005) and the Quality Assurance Project Plan (QAPP) for Anne Arundel County Biological Monitoring and Assessment Program (Tetra Tech, 2004). All data were entered into Excel spreadsheets for inclusion into a geodatabase. A summary of these methods and the results of the 2008 monitoring are documented in this report.

Biological assessment methods within Anne Arundel County are designed to be consistent and comparable with the methods used by Maryland Department of Natural Resources (DNR) in their Maryland Biological Stream Survey (MBSS). All field crew leaders received recent training in MBSS protocols prior to the sampling. The County has adopted the MBSS methodology to be consistent with statewide monitoring programs and programs adopted by other Maryland counties. The methods have been developed locally and are calibrated specifically to Maryland's physiographic regions and stream types. MBSS physical habitat assessment parameters were collected for the Patapsco nontidal watershed. Physical habitat was also assessed using the EPA's Rapid Bioassessment Protocol (RBP) (Barbour et al., 1999) habitat assessment for low-gradient streams.

2.1 Selection of Sampling Sites

The sampling design employed a targeted approach with a total of 11 sites distributed throughout the study area on each of the major stream reaches, covering 11 non-tidal subwatersheds, as shown in Figure 2. A complete list of targeted sites along with the corresponding subwatershed name and code is displayed in Table 1. The primary goal was to establish adequate spatial coverage of the watershed. Additionally, data from the County-wide random sampling program was used in the site selection process. The watershed was sampled for the County-wide program in 2007. The targeted sites were generally selected in the downstream reaches of the Patapsco's tributaries and placed to fill gaps not covered by the County-wide assessment.

Table 1 – Sampling Sites and Corresponding Subwatersheds

Site ID	Subwatershed Name	Code
PANT-01-2008	Stony Run 3	PN8
PANT-02-2008	Stony Run 2	PN7
PANT-03-2008	Stony Run 1	PN6
PANT-04-2008	Unnamed Tributary	PN4
PANT-05-2008	Patapsco Mainstem	PN5
PANT-06-2008	Deep Run	PNA
PANT-07-2008	Deep Run	PNC
PANT-08-2008	Piney Run	PNB
PANT-09-2008	Patapsco Mainstem	PN3
PANT-10-2008	Holly Creek	PN2
PANT-11-2008	Stony Run 4	PN9

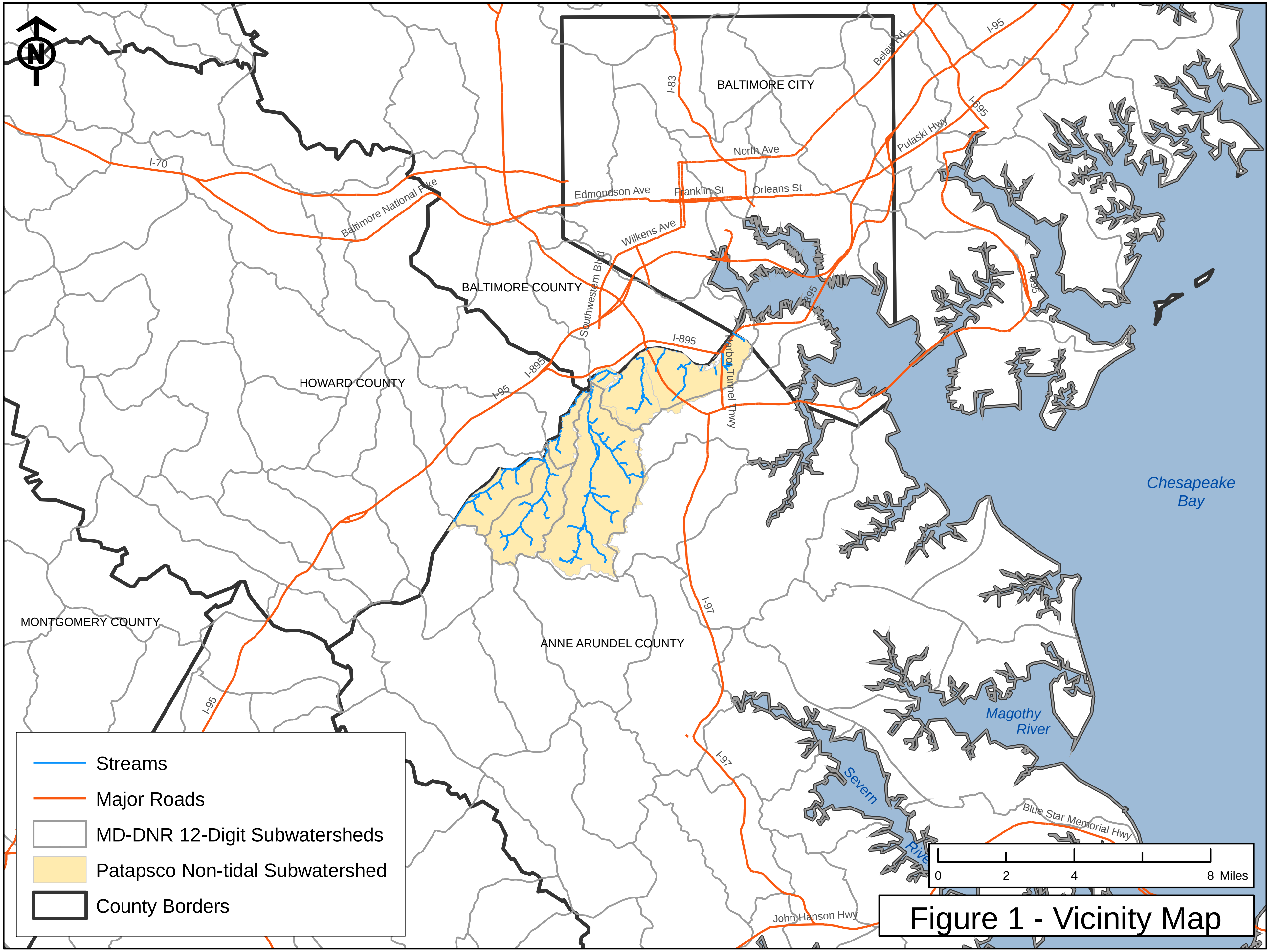


Figure 1 - Vicinity Map

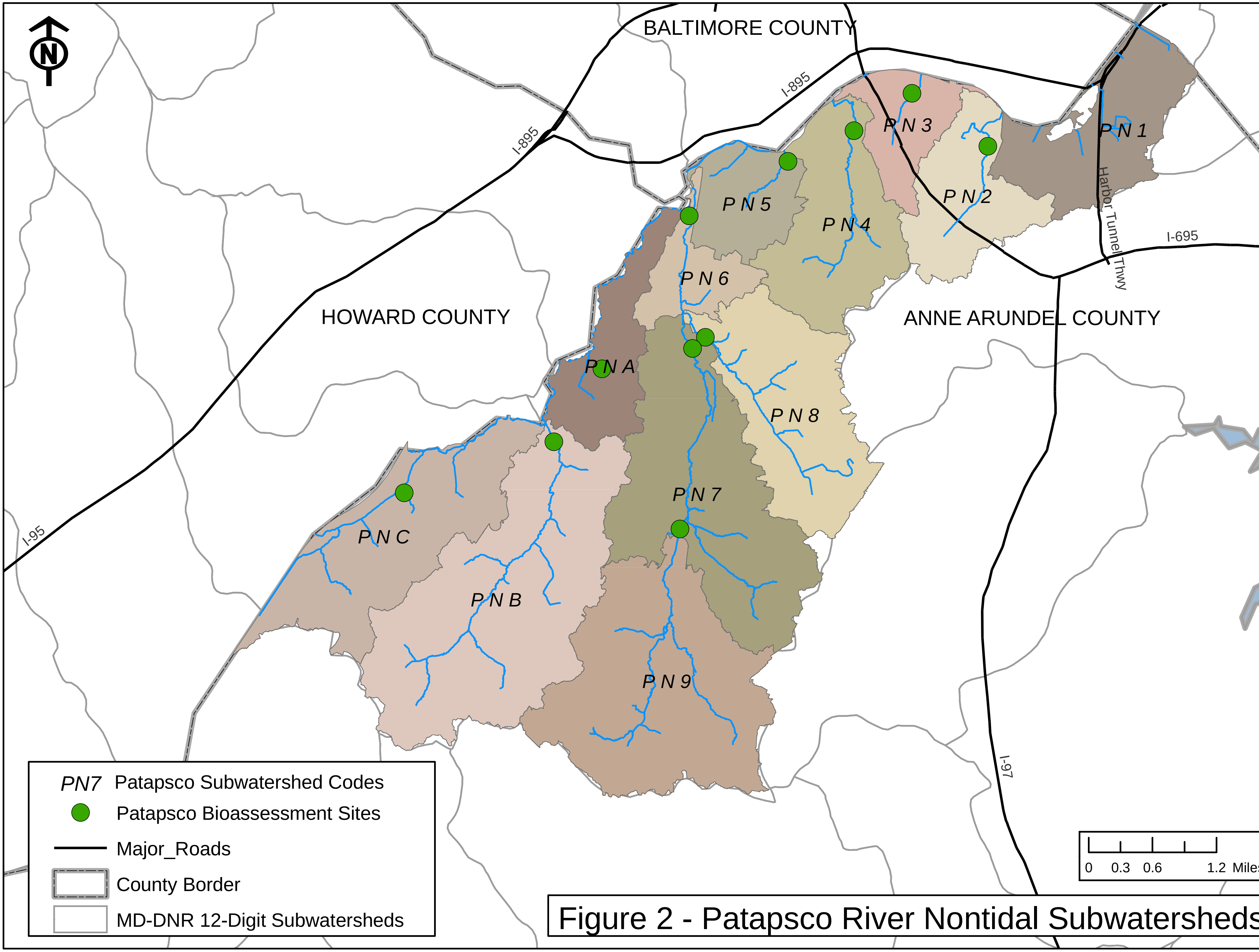


Figure 2 - Patapsco River Nontidal Subwatersheds

If the stream channel at the selected site was found to be unfit for sampling during the field visit, the site was moved to another sampleable reach either on the same stream, or in an adjacent sub-basin, pending approval by the Project Manager and the County. Conditions that would make a site unsampleable include predominant wetland or dry channel conditions, unsafe conditions, and lack of access due to property ownership issues. Desktop reconnaissance resulted in two of the initially selected sites being shifted slightly, one to avoid the influence of a road culvert and another to avoid a tidal influence. However, once in the field all targeted sites were able to be sampled.

Field crews used a Trimble® GPS unit and field maps with ortho-photography overlaid with the sites, streams and drainage areas to navigate to the proper site locations. Each sampling site is comprised of a 75-meter stream reach. The position of the reach mid-point was collected with the GPS unit, and the upstream and downstream ends were marked with tree tags. The tags were marked with the site name (i.e. PANT-01-2008) and either 0 m or 75 m to denote the downstream or upstream end, respectively.

A duplicate biological sample as well as duplicate *in situ* water quality measurements and physical habitat data were collected at one site as a Quality Assurance/Quality Control (QA/QC) sample. The sample was collected immediately upstream of site PANT-08-2008 in an area where the habitat was very similar to the original sampling site based on visual inspection. The duplicate site was selected in the field by the field crew at the time of the assessment. This method, as opposed to selecting the sites randomly or by desktop analysis, ensures that the stream type and habitat is similar, that no significant inputs of stormwater or confluences occur in the reach, and that the site is sampleable. The duplicate site is described further in the Quality Assurance and Quality Control section of the document (Appendix C).

2.2 Impervious Surface/GIS Analysis

Upon arrival at sampling locations, coordinates were recorded using a hand-held Trimble® GPS unit at the midpoint of each reach to create a point layer showing sampling locations accurate to within one meter. These sampling points were then snapped to the stream layer on the Digital Elevation Model (DEM) for the watershed using the ArcHydro toolset to delineate drainage areas to each sampling location. The DEM was generated by the Watershed Management Program based on the 2004 DNR DEM coverage. Before drainage areas were delineated, the DEM was modified with inclusion of County and State Highway Administration stormdrain layers, and streams in areas with low relief. The DEM was reconditioned utilizing terrain preprocessing functionality within the ArcHydro extension toolset.

The impervious surface acreage and percent was calculated for the drainage area to each site using a raster dataset of impervious land cover from 2004, maintained by the DPW, Bureau of Engineering, Watershed Assessment and Planning Program[1]. The GIS impervious layer was developed from 1-m satellite imagery during leaf-off conditions and represents the area of all impervious surfaces (roads, buildings, and parking lots). The results include all of the impervious surfaces and do not distinguish between connected versus disconnected surfaces.

The planimetric stream layer was used for locating sampling points and determining stream order. It should be noted, however, that the current planimetric stream layer used for stream ordering has limitations and, consequently, is programmed for update through upcoming watershed studies. Stream order, based on the planimetric stream layer, was not used in habitat assessment or BIBI calculations, but was included to demonstrate approximate stream size.

[1] Data custodian: Hala Flores, PWFLOR08@aacounty.org

2.3 Water Quality Sampling

To supplement the biological and physical sampling at each site, water quality was measured *in situ* and grab samples were collected for laboratory analysis of water chemistry parameters. Field water quality was measured at all monitoring sites, including the duplicate sites, according to methods prescribed in the County QAPP (Tetra Tech, 2004). Field tested parameters include pH, specific conductivity, dissolved oxygen, temperature, total dissolved solids, and turbidity. Measurements were collected from three locations within each sampling reach (upstream end, mid-point, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. Most in-situ parameters (i.e., temperature, pH, conductivity, total dissolved solids, and dissolved oxygen) were measured with a YSI 6920 series multiprobe, and turbidity was measured with a Hach 2100 Turbidimeter. Water quality meters were regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly. Field tested parameters include those listed below.

Water grab samples were collected from each site for laboratory analysis of water chemistry parameters. Samples were collected immediately upstream of the sampling reach and preserved and kept on ice for transport to the lab in accordance with MBSS protocols (DNR, 2007). All grab samples were analyzed by Martel Laboratories[2]. The laboratory used methods outlined in the Analytical Laboratory Standard Operating Procedures for the Maryland Biological Stream Survey (Kline and Morgan, 2006) or similar approved method. Water chemistry parameters tested for are listed below.

- Nutrients: Total Nitrogen, Total Kjeldahl Nitrogen, Nitrate, Nitrite, and Total Phosphorus
- Solids: Total Suspended Solids (TSS)
- Metals: Copper, Lead, and Zinc
- Bacteria: Fecal Coliform

2.4 Physical Habitat Assessment

Each biological monitoring site was characterized based on visual observation of physical characteristics and various habitat parameters, including the QC site. Both the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2002) were used to assess the physical habitat at each site. Both assessment techniques rely on subjective scoring of selected habitat parameters. To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photographs were taken from three locations within the sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction, for a total of six (6) photographs per site. Representative photographs for each site are included in Appendix D.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter is given a numerical score from 0-20 and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed are listed in Table 2

[2] Address: 1025 Cromwell Bridge Rd., Baltimore, MD

Table 2 – RBP Low Gradient Habitat Parameters

Low Gradient Stream Parameters	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian Vegetative Zone Width

The RBP habitat parameters for each reach are summed with a total possible score of 200. The total score is then placed into one of four categories (Table 3) based on their percent comparability to reference conditions. Since adequate reference condition scores do not currently exist for Anne Arundel County, the categories used in this report are based on reference conditions obtained from Prince George's County streams and watersheds (Stribling et al., 1999).

Table 3 – RBP Habitat Score and Ratings

Score	Percent Comparability	Narrative Rating
≥151	≥75.5	Comparable to Reference
126-150	63.0-75.0	Supporting
97-125	48.5-62.5	Partially Supporting
≤96	≤48.0	Non-supporting

Source: Stribling et al., 1999

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for the coastal plain streams. These parameters are used in calculating the PHI (see Table 4). Several of the parameters have been found to be drainage area dependent and are scaled accordingly. The drainage area to each point was calculated using GIS with County digital elevation model (DEM) topography as described in Section 2.2.

Table 4 – PHI Coastal Plain Parameters

Coastal Plain Stream Parameters	
Remoteness	Instream Habitat
Shading	Woody Debris and Rootwads
Epibenthic Substrate	Bank Stability

Each habitat parameter is given a value from 0-20. A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the final PHI score. The final scores are then ranked according to the ranges shown in Table 5 and assigned corresponding narrative ratings, which allows for a score that can be compared to habitat assessments done statewide.

Table 5 – PHI Score and Ratings

PHI Score	Narrative Rating
81.0 – 100.0	Minimally Degraded
66.0 – 80.9	Partially Degraded
51.0 – 65.9	Degraded
0.0 – 50.9	Severely Degraded

2.4.1 Vernal Pool Search

Vernal pools are defined by MBSS as "small, temporary bodies of water that provide vitally important habitat for many amphibians and aquatic invertebrates", typically being less than one acre (as small as one square meter) and not directly connected to a flowing stream (DNR 2007). Vernal pool searches were conducted in the 50 meters perpendicular to each 75 meter study reach. Information on the location and size of vernal pools as well as fish or amphibian species found in or immediately adjacent to the pool was recorded for each site.

2.5 Benthic Macroinvertebrate Sampling

Biological assessment using benthic macroinvertebrate sampling and analysis was completed at all sites including the QC site. Benthic macroinvertebrate collection follows the QAPP which closely mirrors MBSS procedures (DNR 2007). The monitoring sites consist of a 75-meter sampling reach, and benthic macroinvertebrate sampling is conducted during the spring index period (March 1st to May 1st). The sampling methods utilize systematic field collections of the benthic macroinvertebrate community. The multi-habitat D-frame net approach is used to sample a range of the most productive habitat types present within the reach. In this sampling approach, a total of twenty jabs are distributed among all available productive habitats within the stream system and combined into a single composite sample. Potential habitats include submerged vegetation, overhanging bank vegetation, leaf packs, stream bed substrate (i.e., cobbles, gravel, sand), and submerged organic matter (i.e., logs, stumps, snags, dead branches, and other debris).

2.5.1 Sample Processing and Laboratory Identification

Benthic macroinvertebrate samples were processed and subsampled according to the County QAPP and methods described in the MBSS *Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy* (Boward and Friedman, 2000). Subsampling is conducted to standardize the sample size and reduce variation caused by samples of different size. In this method, the sample is spread evenly across a gridded tray (100 total grids), and each grid is picked clean of organisms until a minimum count of 120 is reached. The 120 organism target is used to allow for specimens that are missing parts or are not mature enough for proper identification. For those sites with a final count of greater than 120 organisms, a post-processing subsampling procedure was conducted using an Excel spreadsheet application (Tetra Tech, 2006). This post-processing application is designed to randomly subsample all identified organisms within a given sample to a desired target number. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20 percent) but keeps the total number of individuals below the 120 maximum.

Identification of the subsampled specimens is conducted by Environmental Services and Consulting, LLC[3]. Taxa are identified to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha are identified to the family level while Nematoda is left at phylum. Individuals of early instars or those that may be damaged are identified to the lowest possible level, which could be phylum or order, but in most cases would be family. Chironomidae can be further subsampled depending on the number of individuals in the sample and the numbers in each subfamily or tribe. Most taxa are identified using a stereoscope. Temporary slide mounts are used to identify Oligochaeta to family with a compound scope. Chironomid sorting to subfamily and tribe is also conducted using temporary slide mounts. Permanent slide mounts are then used for final genus level identification. Results are logged on a bench sheet and entered into a spreadsheet for analysis.

[3] Address: 101 Professional Park Drive, STE 303, Blacksburg, VA

2.5.2 Biological Data Analysis

Benthic macroinvertebrate data was analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al., 2005a). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. The metrics selected fall into five major groups including taxa richness, composition measures, tolerance to perturbation, trophic classification, and habit measures.

Raw values from each metric are given a score of 1, 3 or 5 based on ranges of values developed for each metric. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned. Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions. These include the coastal plain, piedmont and combined highlands regions, divided by the Fall Line. The current study area is located within the coastal plain region. The following metrics and BIBI scoring were used for the analysis.

2.5.2.1 Coastal Plain BIBI Metrics *(Modified from Table 2-3 in Southerland et al., 2005a)*

Total Number of Taxa – Equals the richness of the community in terms of the total number of genera at the genus level or higher. A large variety of genera typically indicate better overall water quality, habitat diversity and/or suitability, and community health.

Number of EPT Taxa – Equals the richness of genera within the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

Number of Ephemeroptera Taxa – Equals the total number Ephemeroptera Taxa in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

Percent Intolerant Urban – Percentage of sample considered intolerant to urbanization. Equals the percentage of individuals in the sample with a tolerance value of 0-3. As impairment increases the percent of intolerant taxa decreases.

Percent Ephemeroptera – Equals the percent of Ephemeroptera individuals in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

Number Scraper Taxa – Equals the number of scraper taxa in the sample, those taxa that scrape food from the substrate. As the levels of stressors or pollution rise there is an expected decrease in the numbers of Scraper taxa.

Percent Climbers – Equals the percentage of the total number of individuals who are adapted to living on stem type surfaces. Higher percentages of climbers typically represent a decrease in stressors and overall better water quality.

Information on trophic or functional feeding group and habit were based heavily on information compiled by DNR and from Merritt and Cummins (1996). Scoring criteria are shown below in Table 6. The raw metric value ranges are given with the corresponding score of 1, 3 or 5. Table 7 includes the BIBI scoring ranges and related narrative ratings.

Table 6 - Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates

Metric	Score		
	5	3	1
Total Number of Taxa	≥22	14-21	<14
Number of EPT Taxa	≥5	2-4	<2
Number of Ephemeroptera Taxa	≥2.0	1-1	<1.0
Percent Intolerant Urban Taxa	≥28	10-27	<10.0
Percent Ephemeroptera Taxa	≥11	0.8-10.9	<0.8
Number Scraper Taxa	≥2	1-1	<1.0
Percent Climber Taxa	≥8.0	0.9-7.9	<0.9

Table 7 – BIBI Scoring and Rating

BIBI Score	Narrative Rating
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

2.6 Geomorphological Assessment

The goal of the physical monitoring was to create a geomorphic characterization of the stream channels in the watershed. Assessment techniques include the cross-sectional survey, substrate particle size analysis and measurement of channel slope. Additionally, a Rosgen Level II characterization (Rosgen, 1996) was completed for each stream reach based on field-collected data. Table 8 includes general descriptions for each channel type classification.

Table 8 – Rosgen Level II Channel Type Description

Channel Type	General Description (from Rosgen, 1996)
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.

2.6.1 Cross Section Analysis

Cross sections were surveyed at each monitoring station to develop a channel characterization and measurement of cross-sectional area and discharge. Methods followed the Draft SOP developed for the Countywide Biological Monitoring Program. Each cross-section was located at a representative riffle feature and was surveyed with a laser level and stadia rod.

The cross-sections include survey of the floodplain and all pertinent channel features including:

- Top of bank
- Bankfull elevation
- Edge of water
- Limits of point and instream depositional features
- Thalweg
- Floodprone elevation

Sinuosity was calculated based on the length of the field-surveyed profile and the straight-line distance between the top and bottom of each profile. The floodprone width is estimated at an elevation two times the bankfull depth.

Additional survey points were taken at the upstream, midpoint and downstream end of the sampling reach to obtain the slope through the reach so that estimates of discharge could be derived. Survey points for slope calculations were typically taken at top of riffle features, whenever possible, and bankfull and top of low bank measurements were also recorded.

The stream cross section, bed and bank material data and profile information (including slope) were analyzed using the Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.2L (Mecklenburg, 2004). The following values and ratios were calculated:

Sinuosity	Entrenchment ratio	Bankfull cross-section area
Slope	Bankfull height	Velocity
Floodprone width	Bankfull width	Discharge
Width / depth ratio	Mean depth	Shear stress

2.6.2 Particle Size Analysis

The channel bed and bank materials were characterized at each cross-section using pebble count analysis. A single pebble count, modified from the technique developed by Wolman (1954), was conducted in each reach to determine the composition of channel materials and the median particle size (D_{50}) for each site. The pebble count procedure was adapted from *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (Harrelson et al, 1994). Pebble counts measure the intermediate axis of 100 particles at 10 transects across the entire assessment reach. Transects were conducted within the entire bankfull channel and positioned based on the proportion of riffles/pools/runs in the assessment reach as estimated by visual inspection. The pebble counts provide roughness values necessary for calculations of velocity and discharge.

3 Results

Biological monitoring was conducted between April 10 and April 16, 2008. A total of 11 sites were visited. Additionally, one biological duplicate QC samples was collected immediately upstream of site PANT-08-2008. Presented below are the summary results for each assessment site. Maps of the Patapsco Nontidal watershed displaying the bioassessment results can be found in Figure 3 and Appendix B. For full bioassessment data and results, refer to Appendix A.

3.1 Impervious Surface Analysis

The results of the impervious surface analysis are listed below in Table 9 including general information about each sampling site. Stream order (Strahler) is based on the County's planimetric stream layer. Drainage areas ranged from 37.5 acres at site 06, to 6147.1 acres at site 03, the most downstream site on Stony Run. The median watershed size for the study area is 956.6 acres. Imperviousness ranged from 2.5 percent at site 06, to 52.1 percent at site 01, which drains a large portion of Baltimore Washington International Airport. The average imperviousness for the study area is 28.1 percent.

Table 9 – Site Characteristics/Imperviousness

Site	Date Sampled	Stream Order	Drainage Area (acres)	Impervious Area (acres)	Impervious Percent
PANT-01-2008	4/16/2008	3	1371.9	714.6	52.1
PANT-02-2008	4/16/2008	3	4214.3	1164.6	27.6
PANT-03-2008	4/16/2008	4	6147.1	1990.1	32.4
PANT-04-2008	4/11/2008	2	956.6	333.9	34.9
PANT-05-2008	4/10/2008	2	292.8	57.8	19.8
PANT-06-2008	4/14/2008	1	37.5	0.9	2.5
PANT-07-2008	4/11/2008	2	183.4	13.4	7.3
PANT-08-2008*	4/14/2008	3	2621.6	617.6	23.6
PANT-09-2008	4/10/2008	2	228.3	115.3	50.5
PANT-10-2008	4/10/2008	2	533.3	163.3	30.6
PANT-11-2008	4/11/2008	3	2249.5	628.7	28.0

*QC sampling was conducted at this site

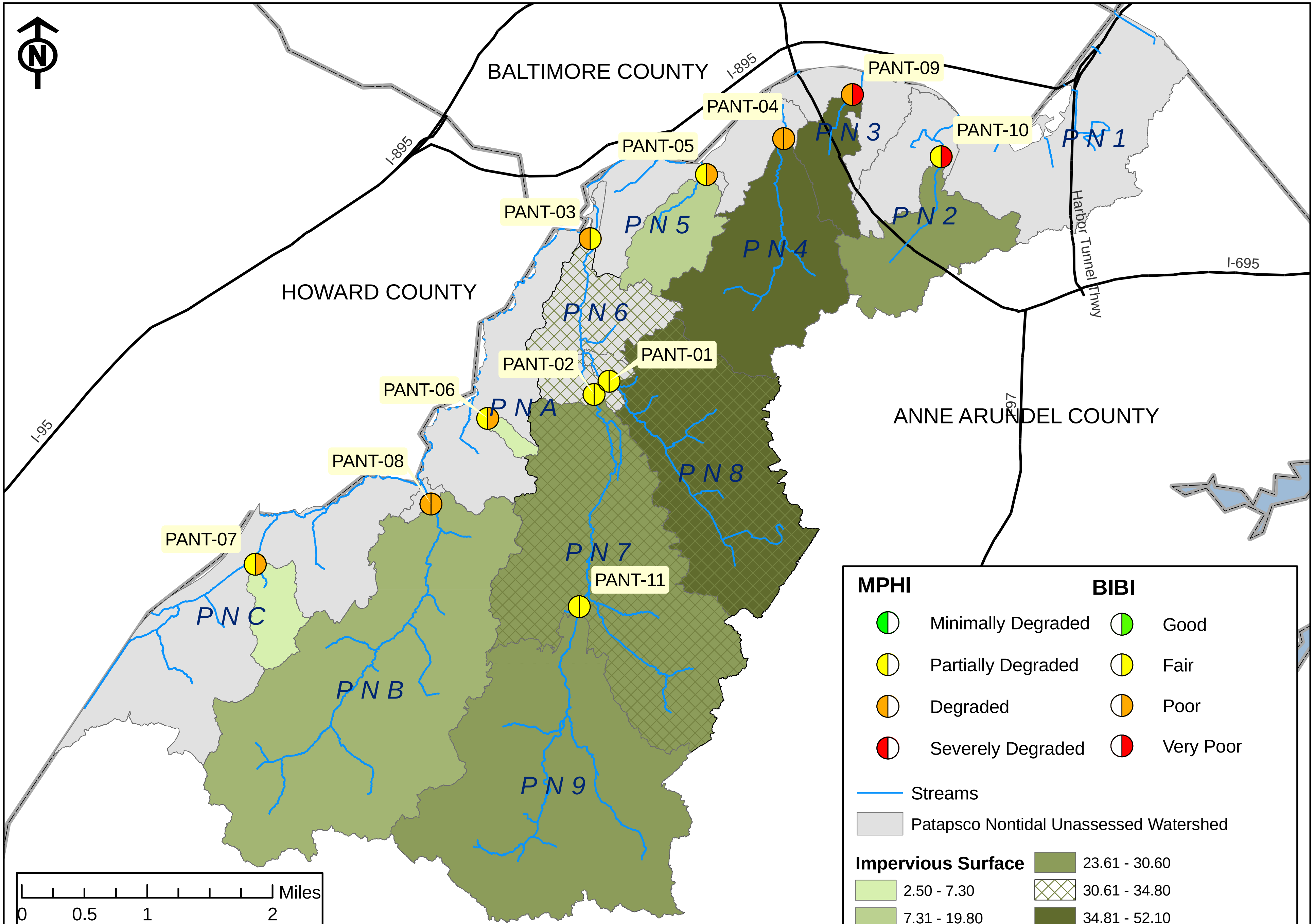


Figure 3 - Bioassessment Results Map

3.2 Water Quality

Instream water quality sampling was conducted in conjunction with macroinvertebrate sampling and occurred between April 10 and April 16, 2008. Table 10 presents the results of the instream water quality measurements.

The Maryland Department of the Environment (MDE) has established acceptable standards for several of the sampled parameters for each designated Stream Use Classification. Currently, there are no standards available for conductivity or TSS. Acceptable standards are listed in the *Code of Maryland Regulations (COMAR) 26.08.02.01-.03 - Water Quality*. The Patapsco River Nontidal watershed is listed in *COMAR* in Sub-Basin 02-13-09: Patapsco River Area. It is classified as a Use I stream, Water Contact Recreation, and Protection of Aquatic Life. Specific designated uses for Use I streams include water contact sports, fishing, the growth and propagation of fish, and agricultural, and industrial water supply. The acceptable standards for Use I streams are as follows:

- pH - 6.5 to 8.5
- DO - may not be less than 5 mg/l at any time
- Turbidity - maximum of 150 Nephelometer Turbidity Units (NTU's) and maximum monthly average of 50 NTU
- Temperature - maximum of 90°F (32°C) or ambient temperature of the surface water, whichever is greater

Table 10 – Instream Water Quality Results

Site	pH	Temperature (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)	Total Dissolved Solids (mg/L)
PANT-01-2008	6.67	9.76	11.95	3.58	578	376
PANT-02-2008	6.88	16.96	10.32	5.25	298	194
PANT-03-2008	6.26	9.80	11.07	3.57	388	252
PANT-04-2008	7.24	17.64	8.88	4.27	462	300
PANT-05-2008	7.23	15.50	9.77	8.00	358	233
PANT-06-2008	7.47	12.94	8.28	1.04	94	61
PANT-07-2008	7.23	11.50	9.93	4.00	164	107
PANT-08-2008	7.74	9.32	10.96	4.02	459	298
PANT-08 -2008QC*	7.55	10.33	11.69	3.84	446	290
PANT-09-2008	6.28	14.65	11.82	5.30	783	509
PANT-10-2008	6.51	12.20	10.81	1.30	473	307
PANT-11-2008	6.91	15.05	13.91	3.43	342	222
Study Mean	*6.95*	*13.21*	*10.70*	*3.98*	*400*	*260*
Standard Deviation	*0.46*	*2.81*	*1.48*	*1.81*	*180*	*117*

*QC sampling was conducted at this site, excluded from mean and SD.

Overall, *in situ* water quality parameters fell within COMAR limits for a Use I stream and are typical of a coastal plain stream. The shaded cells in Table 10 represent values that were outside acceptable COMAR limits. There were two sites with pH values recorded below the acceptable limit of 6.5, however, the remaining measurements were all within COMAR standards.

MDE has established numerical criteria for several water chemistry parameters measured as part of this water quality monitoring program (i.e., lead, copper, and zinc). These standards are listed in the Code of Maryland Regulations (COMAR) 26.08.02.03-2 Numerical Criteria for Toxic Substances in Surface Waters. While there are currently no specific nutrient criteria for Maryland surface waters, USEPA has developed a set of nutrient criteria guidelines for each nutrient ecoregion of the United States. The Maryland Western Shore Coastal Plain falls within Nutrient Ecoregion IX, therefore, ambient water quality criteria recommendations from this region were used for total phosphorus and total nitrogen comparisons (USEPA 2000). Applicable State and Federal water quality criteria for laboratory chemistry parameters are shown in Table 11.

Table 11 – State and Federal Water Quality Criteria for Sampled Parameters

Parameter (mg/L, except as noted)	Chronic	Acute	Reference
Metals (µg/L):			
Lead	2.5	65	COMAR 26.08.02.03-2
Copper	9	13	COMAR 26.08.02.03-2
Zinc	120	120	COMAR 26.08.02.03-2
Nutrients:			
Total P *(µg/L)*	36.56		EPA Recommended Criteria (EPA 822-B-00-019)
Total N	0.69		EPA Recommended Criteria (EPA 822-B-00-019)
TKN	None		—
Nitrate	None		—
Nitrite	None		—
TSS	500		1972 305(a) Report to Congress (EPA 440/9-74-001)
Fecal coliforms[1] *(MPN/100ml)*	400		—

[1]: No longer listed in COMAR for bacteriological criteria, however previous standard for Fecal coliforms was applied to allow for comparisons.

Laboratory water chemistry results are presented in Table 12. Measurement values reported below the Method Detection Limit (MDL) were assigned values of one-half the MDL to allow for summary statistics. Raw laboratory results, including MDL and analytical method for each parameter is included in Appendix D. There was one value that exceeded the COMAR numerical criteria for zinc (148 µg/L) measured at site PANT-06. All other metal concentrations were measured below acceptable COMAR limits, most of which were reported below the MDL. Total Nitrogen (TN) concentrations exceeded the EPA recommended criteria for all sites, while Total Phosphorus (TP) exceeded the criteria at three sites (PANT-07, -08, -09). While nutrients are generally elevated compared to EPA's Ecoregional Criteria, concentrations fall within more acceptable ranges as compared to MBSS-developed nutrient thresholds. MBSS developed ranges (i.e., Low, Moderate, and High) based on the distribution of data collected throughout Maryland during 2000-2004 (Southerland et al., 2005; Table 11). Using the MBSS threshold, one site (PANT-05) had a 'high' TN concentration (8.5 mg/L), and four others had 'moderate' TN levels. One site (PANT-09) had a 'high' TP concentration and three sites had 'moderate' concentrations. Additionally, two sites had 'high' Nitrite, while three sites had 'moderate' Nitrate. Fecal coliforms were elevated to potentially unsafe levels at two sites (PANT-07 and -10).

Table 12 – Laboratory Water Quality Results

Site	Zinc *µg/l*	Copper *µg/l*	Lead *µg/l*	TKN *mg/l*	Nitrate-Nitrite *mg/l*	Nitrate-N *mg/l*	Nitrite-N *mg/l*	Total P *mg/l*	Total N *mg/l*	TSS *mg/l*	Fecal Coliforms *mpn/100ml*
PANT-01	16	*1*	*1*	0.7	0.81	0.81	*0.01*	0.02	1.5	2	93
PANT-02	14	*1*	*1*	0.9	0.52	0.52	*0.01*	0.03	1.4	15	43
PANT-03	13	2.2	*1*	0.9	0.58	0.58	*0.01*	0.02	1.5	3	15
PANT-04	10	*1*	*1*	0.7	0.39	0.39	0.02	*0.01*	1.1	2	150
PANT-05	11	2.4	*1*	7.8	0.65	0.65	0.03	*0.01*	8.5	6	93
PANT-06	148	3.3	*1*	0.6	0.25	0.25	*0.01*	0.02	0.85	*0.5*	*1.5*
PANT-07	22	2.2	*1*	0.8	0.57	0.57	*0.01*	0.04	1.4	2	930
PANT-08	16	*1*	*1*	0.7	0.34	0.34	*0.01*	0.06	1	3	23
PANT-09	15	*1*	*1*	*0.25*	1.4	1.4	*0.01*	0.1	1.4	2	9
PANT-10	28	*1*	*1*	*0.25*	2.5	2.5	*0.01*	0.01	2.5	1	930
PANT-11	17	2.2	*1*	0.9	1.3	1.3	*0.01*	0.02	2.2	3	43
Study Mean	28	1.7	1	1.3	0.85	0.85	0.01	0.03	2.1	4	212
Standard Deviation	40	0.8	0	2.2	0.66	0.66	0.01	0.03	2.2	4	358

Shaded cells indicate exceedances of numeric or recommended criteria.
Italics indicate values reported below MDL and assigned values of ½ MDL

Table 13 – MBSS water quality thresholds for nutrients measured in 2000-2004 (Southerland et al., 2005b). All units are in mg/L.

Parameter	Low	Moderate	High
Nitrate–N	< 1.0	1.0 – 5.0	> 5.0
Nitrite–N	< 0.0025	0.0025 – 0.01	> 0.01
Total Nitrogen	< 1.5	1.5 – 7.0	>7.0
Total Phosphorus	< 0.025	0.025 – 0.070	> 0.070

3.3 Physical Habitat Assessment

The results of the RBP and PHI habitat assessments are presented in Table 14. The percent comparability to RBP reference scores ranged from 51.5 percent at site 07 to a high of 78.5 percent at site 02. Overall, one site (9 percent) was classified as 'Comparable to Reference.' Five sites (45.5 percent) were rated as 'Supporting' and five (45.5 percent) were rated as 'Partially Supporting.' There were no sites that received the lowest possible rating of 'Non-Supporting'. The lowest PHI score of 56.8 was recorded at site 08 while the highest score, 79.1 was recorded at site 01. Five sites were rated as 'Degraded', the lowest classification, and eight sites were rated as 'Partially Degraded.' There were no sites in the watershed that received the highest classification of 'Minimally Degraded' nor the lowest classification of 'Severely Degraded'.

No vernal pools were observed within the 50 foot riparian zone adjacent to each sampling reach. There were numerous standing pools observed within adjacent floodplain wetlands, however, all were hydrologically connected to the adjacent streams, unqualifying them from the status of a vernal pool.

Table 14 – Habitat Assessment Results

Site	Total RBP	Percent Reference	RBP Classification	PHI Score	PHI Narrative Rating
PANT-01-2008	147	73.5	Supporting	79.1	Partially Degraded
PANT-02-2008	157	78.5	Comparable to Reference	78.8	Partially Degraded
PANT-03-2008	129	64.5	Supporting	63.4	Degraded
PANT-04-2008	108	54.0	Partially Supporting	61.8	Degraded
PANT-05-2008	125	62.5	Supporting	77.8	Partially Degraded
PANT-06-2008	126	63.0	Supporting	78.7	Partially Degraded
PANT-07-2008	103	51.5	Partially Supporting	67.7	Partially Degraded
PANT-08-2008	112	56.0	Partially Supporting	56.8	Degraded
PANT-08 -2008QC*	113	56.5	Partially Supporting	57.9	Degraded
PANT-09-2008	107	53.5	Partially Supporting	63.8	Degraded
PANT-10-2008	114	57.0	Partially Supporting	70.5	Partially Degraded
PANT-11-2008	147	73.5	Supporting	75.3	Partially Degraded
Study Mean	125	62.5	Supporting	*70.3*	Partially Degraded
Standard Deviation	18	9.2	--	*8.1*	--

*QC sampling was conducted at this site, excluded from mean and SD.

3.4 Benthic Macroinvertebrates

The BIBI scores and ratings for each site are presented in Table 15. Overall, there were two sites (16.7 percent) rated as 'Very Poor,' and no sites rated as 'Good.' Four sites were rated as 'Fair' (41.7 percent) and five were 'Poor' (41.7 percent).

Table 15 – BIBI Summary

Site	BIBI Score	Narrative Rating
PANT-01-2008	3.3	Fair
PANT-02-2008	3.6	Fair
PANT-03-2008	3.9	Fair
PANT-04-2008	2.4	Poor
PANT-05-2008	2.7	Poor
PANT-06-2008	2.4	Poor
PANT-07-2008	2.7	Poor
PANT-08-2008	2.7	Poor
PANT-08 -2008QC*	3.6	Fair
PANT-09-2008	1.6	Very Poor
PANT-10-2008	1.6	Very Poor
PANT-11-2008	3.0	Fair
Study Mean	2.7	Poor
Standard Deviation	0.72	--

*QC sampling was conducted at this site, excluded from mean and SD.

An analysis of the percent abundance and percent occurrence was completed and the results of the top 30 taxa are shown in Tables 16 and 17, respectively. It should be noted, however, that because 12 separate taxa were present at three sites, a total of 34 taxa were included for percent occurrence. *Orthocladius*, a tolerant midge, was the most commonly collected genus making up over 21 percent of the total collected individuals. Of the top 30 taxa by percent abundance, 15 (50 percent) were in the family Chironomidae (midges).

The tolerant chironomids, *Orthocladius* and *Hydrobaenus* were found at 11 (100 percent) and 10 (91 percent) of sampling sites, respectively. One intolerant midges, *Micropsectra* (Tolerance value = 2.1) was found at 3 of the 11 sites (27 percent). By percent occurrence, chironomids (midges) make up over half (19) of the top 34 taxa. It should be noted that 12 taxa were found at 27.3 percent of sites, therefore, 34 taxa were used in place of the top 30 taxa by percent occurrence.

As shown in Tables 16 and 17, members of the family Chironomidae were dominant throughout the watershed. In general, the relative abundance of chironomids increases with increased perturbation. Table 18 lists all sites sampled and the percentage of identified individuals that were in the Chironomidae family. Site 06 contained the highest percentage of chironomids (94 percent) followed by sites 01 (88 percent) and 07 (85 percent). The lowest percentage was found at site 02, with 37 individuals (33 percent).

Table 16 – Percent Abundance (by top 30 taxa)

Final Identification	Order	Family	Functional Feeding Group	Habit[1]	Tolerance Value	Total Number of Individuals	Percent of collected individuals
Orthocladius	Diptera	Chironomidae	Collector	sp	9.2	283	21.1
Polypedilum	Diptera	Chironomidae	Shredder	cb	6.3	134	10.0
Tubificidae	Haplotaxida	Tubificidae	Collector	cn	8.4	91	6.8
Gammarus	Amphipoda	Gammaridae	Shredder	sp	6.7	90	6.7
Hydrobaenus	Diptera	Chironomidae	Scraper	sp	7.2	85	6.3
Simulium	Diptera	Simuliidae	Filterer	cn	5.7	65	4.8
Tanytarsus	Diptera	Chironomidae	Filterer	cb	4.9	41	3.1
Tvetenia	Diptera	Chironomidae	Collector	sp	5.1	35	2.6
Nemoura	Plecoptera	Nemouridae	Shredder	sp	2.9	30	2.2
Prosimulium	Diptera	Simuliidae	Filterer	cn	2.4	28	2.1
Cheumatopsyche	Trichoptera	Hydropsychidae	Filterer	cn	6.5	26	1.9
Micropsectra	Diptera	Chironomidae	Collector	cb	2.1	22	1.6
Cricotopus	Diptera	Chironomidae	Shredder	cn	9.6	21	1.6
Stenelmis	Coleoptera	Elmidae	Scraper	cn	7.1	21	1.6
Amphinemura	Plecoptera	Nemouridae	Shredder	sp	3.0	20	1.5
Rheocricotopus	Diptera	Chironomidae	Collector	sp	6.2	18	1.3
Thienemannimyia	Diptera	Chironomidae	Predator	sp	6.7	18	1.3
Macronychus	Coleoptera	Dryopidae	Scraper	cn	6.8	15	1.1
Brillia	Diptera	Chironomidae	Shredder	bu	7.4	14	1.0
Microcylloepus	Coleoptera	Elmidae	Collector	cn	4.8	14	1.0
Parametriocnemus	Diptera	Chironomidae	Collector	sp	4.6	14	1.0
Crangonyx	Amphipoda	Crangonyctidae	Collector	sp	6.7	13	1.0
Rheotanytarsus	Diptera	Chironomidae	Filterer	cn	7.2	13	1.0
Eukiefferiella	Diptera	Chironomidae	Collector	sp	6.1	12	0.9
Enchytraeidae	Haplotaxida	Enchytraeidae	Collector	bu	9.1	11	0.8
Ancyronyx	Coleoptera	Elmidae	Scraper	cn	7.8	10	0.7
Limnophyes	Diptera	Chironomidae	Collector	sp	8.6	10	0.7
Paratendipes	Diptera	Chironomidae	Collector	bu	6.6	8	0.6
Ameletus	Ephemeroptera	Ameletidae	Collector	sw	2.6	7	0.5
Caecidotea	Isopoda	Asellidae	Collector	sp	2.6	7	0.5

1 – Habit abbreviations: bu – burrower, cn – clinger, cb – climber, sp – sprawler, dv – diver, sk – skater.
QC sites were excluded from calculations.

Table 17 – Percent Occurrence (by top 30 taxa)

Final Identification	Order	Family	Functional Feeding Group	Habit [1]	Tolerance Value	Number of sites with this taxa	Percent of sites with this taxa
Orthocladius	Diptera	Chironomidae	Collector	sp	9.2	11	100.0
Hydrobaenus	Diptera	Chironomidae	Scraper	sp	7.2	10	90.9
Polypedilum	Diptera	Chironomidae	Shredder	cb	6.3	9	81.8
Simulium	Diptera	Simuliidae	Filterer	cn	5.7	9	81.8
Thienemannimyia	Diptera	Chironomidae	Predator	sp	6.7	8	72.7
Tubificidae	Haplotaxida	Tubificidae	Collector	cn	8.4	8	72.7
Cheumatopsyche	Trichoptera	Hydropsychidae	Filterer	cn	6.5	7	63.6
Tanytarsus	Diptera	Chironomidae	Filterer	cb	4.9	7	63.6
Tvetenia	Diptera	Chironomidae	Collector	sp	5.1	7	63.6
Calopteryx	Odonata	Calopterygidae	Predator	cb	8.3	6	54.5
Cricotopus	Diptera	Chironomidae	Shredder	cn	9.6	6	54.5
Rheotanytarsus	Diptera	Chironomidae	Filterer	cn	7.2	6	54.5
Brillia	Diptera	Chironomidae	Shredder	bu	7.4	5	45.5
Parametriocnemus	Diptera	Chironomidae	Collector	sp	4.6	5	45.5
Rheocricotopus	Diptera	Chironomidae	Collector	sp	6.2	5	45.5
Collembola	Collembola	not identified	Collector	sp	6	4	36.4
Enchytraeidae	Haplotaxida	Enchytraeidae	Collector	bu	9.1	4	36.4
Hydropsyche	Trichoptera	Hydropsychidae	Filterer	cn	7.5	4	36.4
Macronychus	Coleoptera	Dryopidae	Scraper	cn	6.8	4	36.4
Paratendipes	Diptera	Chironomidae	Collector	bu	6.6	4	36.4
Stenelmis	Coleoptera	Elmidae	Scraper	cn	7.1	4	36.4
Tipula	Diptera	Tipulidae	Shredder	bu	6.7	4	36.4
Ancyronyx	Coleoptera	Elmidae	Scraper	cn	7.8	3	27.3
Crangonyx	Amphipoda	Crangonyctidae	Collector	sp	6.7	3	27.3
Eukiefferiella	Diptera	Chironomidae	Collector	sp	6.1	3	27.3
Gammarus	Amphipoda	Gammaridae	Shredder	sp	6.7	3	27.3
Limnophyes	Diptera	Chironomidae	Collector	sp	8.6	3	27.3
Microcylloepus	Coleoptera	Elmidae	Collector	cn	4.8	3	27.3
Micropsectra	Diptera	Chironomidae	Collector	cb	2.1	3	27.3
Natarsia	Diptera	Chironomidae	Predator	sp	6.6	3	27.3
Phaenopsectra	Diptera	Chironomidae	Collector	cn	8.7	3	27.3
Pisidium	Veneroida	Pisidiidae	Filterer	bu	5.7	3	27.3
Tanypodinae	Diptera	Chironomidae	Predator	sp	7.5	3	27.3
Zavrelimyia	Diptera	Chironomidae	Predator	sp	5.3	3	27.3

1 – Habit abbreviations: bu – burrower, cn – clinger, cb – climber, sp – sprawler, dv – diver, sk – skater.
QC sites were excluded from calculations.

Table 18 – Chironomidae Analysis

Site	Total Chironomidae per site	Total number of individuals per site	Percent Chironomidae
PANT-01-2008	94	107	88
PANT-02-2008	37	111	33
PANT-03-2008	47	119	39
PANT-04-2008	86	108	80
PANT-05-2008	87	112	78
PANT-06-2008	108	115	94
PANT-07-2008	90	106	85
PANT-08-2008	87	107	81
PANT-08 -2008QC*	85	120	71
PANT-09-2008	75	108	69
PANT-10-2008	50	114	44
PANT-11-2008	61	117	52

3.5 Geomorphic Assessment

Based on the Rosgen Classification scheme, six sites are classified as C channels, two are classified as F channels, two are DA channels and one is a B channel (Table 19). Channel slopes throughout the watershed range from 0.003 ft/ft to 0.037 ft/ft. The majority of sites sampled have sand dominated channel substrates, followed by medium and fine gravel materials. Detailed summaries of the geomorphic data and stream types are included in Appendix E.

Table 19 – Geomorphic Assessment Results

Site	Rosgen Classification	Slope (ft/ft)	D50 (mm)	Channel Material
PANT-01-2008	C5	0.005	1.8	Sand
PANT-02-2008	DA5	0.005	0.2	Sand
PANT-03-2008	C4	0.003	6.7	Fine Gravel
PANT-04-2008	C4	0.012	13.0	Medium Gravel
PANT-05-2008	C5	0.011	0.3	Sand
PANT-06-2008	B5	0.037	0.7	Sand
PANT-07-2008	F5	0.008	0.3	Sand
PANT-08-2008	F4	0.009	12.0	Medium Gravel
PANT-09-2008	C4	0.004	4.0	Fine Gravel
PANT-10-2008	C4	0.011	11.0	Medium Gravel
PANT-11-2008	DA5	0.006	0.2	Sand

4 Site Conditions

The Patapsco River Nontidal watershed study area is made up of multiple small tributaries with average drainage areas of approximately 1700 acres. The two largest tributaries in the study area are Piney Run, which drains into Deep Run along the Howard County and Anne Arundel County border, and Stoney Run, which drains directly into the Patapsco River. Table 20 contains consolidated assessment results for each site to allow for easier comparisons of site specific conditions. Biological potential is limited by the quality of the physical habitat, which forms the template upon which biological communities develop (Southwood 1977). To examine the biological condition in comparison to the site's biological potential as defined by the habitat ratings (both RBP and PHI), a matrix was developed by plotting each station by biological rating on one axis and habitat rating on the other in order to determine whether they exceed, match, or fall short of their expected biological potential. The biological potential matrix for both RBP and PHI habitat ratings is shown in Table 21. The following section contains brief descriptions of the site-specific results and conditions.

Table 20 – Consolidated Assessment Results

Site	Sub-watershed Code	Drainage Area (acres)	Impervious Percent	BIBI Score	RBP Score	RBP Percent Reference	PHI Score	Rosgen Channel Type
PANT-01-2008	PN8	1371.9	52.1	3.3	147	73.5	79.1	C5
PANT-02-2008	PN7	4214.3	27.6	3.6	157	78.5	78.8	DA5
PANT-03-2008	PN6	6147.1	32.4	3.9	129	64.5	63.4	C4
PANT-04-2008	PN4	956.6	34.9	2.4	108	54.0	61.8	C4
PANT-05-2008	PN5	292.8	19.8	2.7	125	62.5	77.8	C5
PANT-06-2008	PNA	37.5	2.5	2.4	126	63.0	78.7	B5
PANT-07-2008	PNC	183.4	7.3	2.7	103	51.5	67.7	F5
PANT-08-2008	PNB	2621.6	23.6	2.7	112	56.0	56.8	F4b
PANT-09-2008	PN3	228.3	50.5	1.6	107	53.5	63.8	C4b
PANT-10-2008	PN2	533.3	30.6	1.6	114	57.0	70.5	C4b
PANT-11-2008	PN9	2249.5	28.0	3.0	147	73.5	75.3	DA5

Table 21 – Station Biological Potential Matrix

EPA RBP HABITAT RATING	BIOLOGICAL RATING				MBSS PHI HABITAT RATING	BIOLOGICAL RATING			
	GOOD	FAIR	POOR	VERY POOR		GOOD	FAIR	POOR	VERY POOR
Comparable		02			Minimally Degraded				
Supporting		01;03; 11	05;06		Partially Degraded		01;02; 11	05;06; 07	10
Partially Supporting			04;07; 08	09;10	Degraded		03;	04;08	09
Non-Supporting					Severely Degraded				

Green indicates stations where the biological community exceeded the habitat potential
Orange indicates stations where the biological community reached habitat potential
Pink indicates stations where the biological community did not reach the habitat potential

01 Stony Run – East Branch (Subwatershed PN8)

Site 01 is located along a segment of Stony Run situated approximately 100 meters north of the large parking garage at the end of Amtrack Way and has a drainage area of 1372 acres. This site has the highest percentage of imperviousness (52.1 percent) in the study area, primarily due to BWI Airport and other industrial land uses. The stream reach is classified as a C5 channel and received a 'Supporting' RBP habitat rating and a similar 'Partially Degraded' PHI rating. The biological condition was rated 'Fair' with a BIBI score of 3.29. However, the site was dominated by less sensitive Chironomids (88 percent), and less than one percent of the sample was comprised of individuals intolerant to urban stressors. Conductivity (578 uS/cm) and total dissolved solids (376 mg/L) were above average for the watershed, suggesting excessive urban runoff may be altering water quality. Additionally, total nitrogen was elevated at 1.5 mg/L.

02 Stony Run – Middle (Subwatershed PN7)

A third-order segment of Stony Run, this site is located between Ridge Road and the parking garage at the end of Amtrack Way, just upstream of the I-195 and I-295 interchange. The stream is situated within a broad floodplain surrounded by wetlands and composed of multiple branching, or anastomosing, channels (Rosgen type DA5). The stream drains a large area (4214 acres) that is fairly developed with 27.6 percent imperviousness. The overall habitat rating is 78.8 in the 'Partially Degraded' PHI category and 78.5 in the 'Comparable to Reference' RBP category. The biological condition was rated 'Fair' (BIBI = 3.57). Along with site 03, this site had the highest number of EPT taxa present (5). In stream measurements indicated acceptable water quality conditions, however laboratory analysis showed elevated total nitrogen concentrations (1.4 mg/L).

03 Stony Run – Lower (Subwatershed PN6)

Located on a fourth-order segment of Stony Run just upstream of River Road, this site has the largest drainage area (6147 acres) with high impervious cover (32.4 percent) due to increased development in and around BWI Airport. This site was rated 'Degraded,' for the PHI, and the RBP rating was similar and in the 'Supporting' category. This site had the highest number of taxa present (31) and also received the highest BIBI score of 3.86, placing the biological condition in the high end of the 'Fair' category. The stream is low gradient and meandering with numerous point-bars and dominated by gravel substrates, all characteristics of a C4 channel. The majority of water quality parameters were within the COMAR standards, however pH was below the acceptable limit at 6.26, likely due to the fact that the stream drains a large amount of wetlands which are naturally acidic. Total nitrogen was also elevated at 1.5 mg/L.

04 Unnamed Tributary to Patapsco River (Subwatershed PN4)

Site 04 is located on an unnamed tributary to the Patapsco River, just upstream of West Nursery Road and running parallel to Old Hammonds Ferry Road. Imperviousness is high (34.9 percent) in the moderately-sized drainage area of 957 acres due to the presence of several business and industrial parks, as well as residential land use in the subwatershed. The gravel dominated stream is slightly entrenched within a fairly broad (approximately 200 foot) floodplain characteristic of a C4 classification. Habitat rating scores were generally low, resulting in an RBP habitat rating of 'Partially Supporting' and a PHI rating of 'Degraded.' This site received a biological condition ratings of 'Poor' (BIBI = 2.43), primarily due to a complete lack of Ephemeroptera and only a single scaper taxon present in the subsample. Water quality parameters are within acceptable limits aside from slightly elevated total nitrogen (1.1 mg/L).

05 Unnamed Tributary to Patapsco River (Subwatershed PN5)

Site 05 is located just upstream of River Road along a 2nd order C5 channel with numerous point-bars and an abundance of woody debris. The channel was surrounded by a fairly broad wetland floodplain containing several overflow pools and a parallel side channel with less flow running along the opposite side of the valley before joining back up with the main channel. This was a relatively small drainage area (293 acres) with fairly high imperviousness (19.8 percent). Habitat assessment results were 'Supporting' (RBP) and 'Partially Degraded' (PHI) due in large part to wide riparian buffer and an abundance of woody debris providing habitat for biota. The benthic community had only a single EPT taxon and single scraper taxon, and was dominated by midges (*Orthocladius* and *Hydrobaenus*), resulting in a BIBI score of 2.71 and a 'Poor' rating. While *in situ* water quality was mostly comparable to other locations in the study area, this site had the highest concentration of total nitrogen (8.5 mg/L), well above the 'High' threshold developed by MBSS. It is possible that the high TN concentrations are a result of heavy fertilizer applications from residential land use upstream, but the exact source is uncertain.

06 Tributary to Deep Run (Subwatershed PNA)

This site is located on a small headwaters stream just upstream of I-295. It has the smallest drainage area (37.5) acres and also the lowest percent imperviousness at 2.5 percent, due to the predominantly forested land use. The stream was very small and shallow, with minimal flow making it difficult to collect benthic macroinvertebrate samples. The site is rated as 'Partially Degraded' by the PHI primarily due to its proximity to I-295 and low remoteness score. For RBP habitat, however, it was rated as 'Supporting' since it had high scores for bank stability, vegetative protection, and riparian buffers. This site had the lowest number of taxa (10) in the entire Patapsco watershed and received a BIBI score of 2.43, resulting in a 'Poor' biological rating. However, despite the low taxa diversity, this site was dominated by intolerant taxa such as the stoneflies *Nemoura* and *Amphinemura*, resulting in the highest percentage of individuals intolerant to urban stress (78.3 percent). This suggests that urban stressors such as sedimentation and altered hydrologic regimes are not causes of biological impairment. On the other hand, laboratory water quality results indicated high zinc concentrations exceeding both acute and chronic COMAR standards, which may be partly responsible for the 'Poor' biological health of this stream. Additionally, the lack of flow and diminutive size of the channel suggest that this stream my in fact be ephemeral in nature and run dry during the summer months.

07 Unnamed Tributary to Deep Run (Subwatershed PNC)

Site 07 has a drainage area of 183 acres and the second lowest imperviousness in the study area at 7.3 percent. The site is located downstream of Forest Avenue just before the confluence with Deep Run. The stream is entrenched with a low gradient and dominated by sand substrate, resulting in an F5 classification. The physical habitat scored 67.7 in the 'Partially Degraded' PHI category and 51.5 in the 'Partially Supporting' RBP category. The BIBI score was 2.7 in the 'Poor' range, which is essentially what would be expected based on the habitat scores. While the benthic sample had the highest percentage of climbers (34.9 percent) and second highest percentage of urban intolerant individuals (17.9 percent), the complete lack of Ephemeroptera, or any EPT taxa, resulted in a score of 2.71 and 'Poor' biological condition rating. While instream water quality was within normal ranges for all parameters, laboratory analysis indicated high concentrations of nutrients (TP = 0.57 mg/L, TN = 1.4 mg/L) and high fecal coliforms (930 MPN/100 ml), which may be a sign of sewage contamination.

08 Piney Run (Subwatershed PNB)

Site 08 is located on the mainstem of Piney Run, just upstream of I-295. The channel was classified as an F4 stream due to high entrenchment, unstable and eroding banks and a gravel substrate. Severe bank erosion was observed on two large cutbanks, potentially leading to significant sedimentation downstream. Additionally, evidence of recent stream stabilization was observed at this site. The presence of Arundel Mills Mall, MD Routes 100 and 176, and numerous business parks has resulted in 23.6 percent imperviousness in the 2621 acre drainage area. Water quality is generally good, with exception to elevated TP (0.06 mg/L) and TN (1.0 mg/l). The PHI habitat rating was 'Degraded' (56.8) matching well with the RBP rating from of 'Partially Supporting' (56.0). The channel had a broad riparian buffer and an adequate mix of rootwad, woody debris, and riffle habitats. However, large sections of the banks are highly unstable, while other areas have been stabilized. The BIBI score was 2.71, indicating a 'Poor' biological condition. Only one EPT taxon was present in the sample of 26 overall taxa, however, none were Ephemeroptera. Additionally, less than one percent of the individuals were intolerant to urban stressors, suggesting that these types of stressors (i.e., sedimentation, erosion, altered hydrology) are likely responsible for the observed biological impairment.

09 Unnamed Tributary (Subwatershed PN3)

Site 09, located on an unnamed tributary to the Patapsco River has a drainage area of 228 acres with 50.5 percent imperviousness due in large part to industrial parks, I-695 and I-295, and commercial land uses. The slight entrenchment, numerous point-bars, and gravel substrate led to a C4 channel classification. Physical habitat was rated 'Degraded,' for the PHI in part due to adjacent parking lots and poor habitat for biota. The RBP was similarly rated in the 'Partially Supporting' category. Conductivity (783 uS/cm) and total dissolved solids (509 mg/L) were the highest in the watershed, suggesting excessive urban runoff may be impacting the biota, although the exact source is uncertain. Additionally, pH (6.28) was below acceptable COMAR standards, and nutrients, both TN and TP, were elevated. Biological condition was rated 'Very Poor' with a BIBI score of 1.57, indicating significant biological impairment. Only 13 total taxa were present, none of which were sensitive EPT taxa. *Orthocladius*, a tolerant midge (Tol. val. = 9.2) was the dominant taxon present, comprising over half of the entire subsample. The severe biological impairment is likely due the high imperviousness of the watershed and associated stressors impacting the stream.

10 Holly Creek (Subwatershed PN2)

This site is located along Holly Creek, just upstream of Nursery Road in a predominantly residential neighborhood, and has a drainage area of 533 acres, 30.6 percent of which is impervious. The site received habitat ratings of 'Partially Supporting' (RBP) and 'Degraded' (PHI). The gravel dominated stream is slightly entrenched within a fairly broad floodplain and has numerous point-bars characteristic of a C4 classification. Laboratory water quality results indicate high TN (2.5 mg/L) as well as high fecal coliforms, possibly indicating septic or sewage leakage. The benthic community had only a single EPT taxon and single scraper taxon, and was dominated by pollution tolerant worms (Tubificidae) and midges (*Hydrobaenus*), resulting in a BIBI score of 1.57 and a 'Very Poor' rating. Total taxa was also very low (14) and climbers were entirely absent from the subsample. The high imperviousness of the drainage area likely contributes to the degraded habitat and impaired biological community.

11 Stony Run – Upper (Subwatershed PN9)

Site 11 is located along the upper portion of Stony Run, between Candlewood Road and Aviation Boulevard. The stream is situated within a broad floodplain surrounded by wetlands and has multiple branching, typical of a DA5 channel. The stream drains a large area (2250 acres) that is fairly developed with 28 percent imperviousness. There was an abundance of large woody debris and a variety of habitat types, with overall habitat ratings of 'Partially Degraded' (PHI) and 'Supporting' (RBP). The biological condition was rated 'Fair' (BIBI = 3.00), with a total of 26 taxa present. The benthic community was dominated primarily by amphipods (*Gammarus*) and midges (*Orthocladius*), but there were no sensitive Ephemeroptera taxa present in the subsample. Instream measurements indicated acceptable water quality conditions. However, water quality sampling showed elevated total nitrogen concentrations (2.2 mg/L).

5 Conclusions

While the targeted study design does not support assessment results at the overall watershed scale, general statements about the Patapsco Nontidal study area can be made based on site-specific results. Of the 11 sites assessed, 64 percent had impaired (i.e., 'Poor' or 'Very Poor') biological conditions and no sites were rated 'Good'. The biological results indicate a mean BIBI score of 2.71, which would be in the 'Poor' category. Two sites were rated as 'Very Poor' and the remainder received either 'Poor' (four sites) or 'Fair' (five sites) biological ratings. Chironomidae taxa dominated many of the samples and comprised seven of the top twelve taxa by percent occurrence. While some chironomid taxa are intolerant to stressors, the relevant abundance of chironomids tends to increase in urbanized drainages. Other prevalent taxa include the blackfly *Simulium* (Tol. val. = 5.7), Tubificidae*,* an intolerant worm family (Tol. val. = 8.4), and *Hydropsychidae*, a relatively tolerant caddisfly (Tol. val. = 6.5). The five most abundant taxa found throughout the study area were either tolerant (i.e., Orthocladius [Tol. val. = 9.2], Tubificidae, Hydrobaenus [Tol. val. = 7.2]) or relatively tolerant (i.e., *Polypedilum* [Tol. val. = 6.3], *Gammarus* [Tol. val. = 6.7]) to urban stressors. These findings suggest that urban stressors are prevalent in the watershed and are likely influencing biological communities.

Habitat scores for the RBP and PHI assessments were fairly well correlated (r squared = 0.50), and both indicate varying habitat conditions throughout the watershed. The majority of sites assessed were rated as either "Supporting" or "Partially Supporting" (45.5 percent each) by the RBP or "Partially Degraded" by the PHI (64 percent). On the high end of the scale only one site was rated 'Comparable to Reference' (RBP), while no site received a 'Minimally Degraded'(PHI) rating. On the other hand, no sites were rated in the most impaired category of either 'Non-Supporting'(RBP) or 'Severely Degraded'(PHI). RBP habitat scores and BIBI scores were also fairly well correlated (r squared = 0.45), and it is likely that physical habitat conditions are limiting the potential of biological communities in several subwatersheds.

Impervious surface coverage was very high throughout the study area with an average subwatershed imperviousness of 28.1 percent. Only two drainage areas had imperviousness below 10 percent, while seven sites had impervious drainages of 25 percent or greater. Water quality parameters were primarily within COMAR standards, however, nutrients were somewhat elevated from background levels. Additionally, fecal coliforms were high at two sites indicating possible sewage contamination. Another site had zinc concentrations exceeding the chronic standards for toxic substances, however, the source of contamination is not known and further investigation is warranted. Several sites (05, 06, 09, and 10) had impaired biological conditions not explained by physical habitat conditions, suggesting water quality may be responsible. For instance, PANT-05 had TN concentrations of 8.5 mg/L, well above background levels, and PANT-06 had zinc concentrations above acute and chronic toxicity levels.

The biological responses observed within many of the Patapsco nontidal subwatersheds are fairly consistent with those predicted by the Impervious Cover Model (Scheuler 1994), which concludes that most stream quality indicators (in this case benthic macroinvertebrates) decline when watershed impervious cover exceeds 10%, with severe degradation expected beyond 25% impervious cover. On the contrary, all sites located within the Stony Run subwatersheds (PN6, PN7, PN8 and PN9), despite having greater than 25 percent imperviousness, had "Fair" biological conditions. While the exact reason for the unexpected outcome is not known, it is hypothesized that the abundance of wetlands and connectivity to a broad floodplain throughout much of this subwatershed are mitigating some of the impacts of urban stressors typical of highly impervious drainages, such as increased peak discharges, increased runoff volume, and increased sedimentation. Nonetheless, urban stressors appear to be a primary cause of biological impairment observed throughout much of the watershed. Urban stressors likely occurring in the Patapsco Nontidal watershed include altered hydrologic regimes, increased sedimentation, degraded instream habitat, degraded riparian habitat, and increased nutrients from runoff.

6 References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington D.C.

Boward, D. and E. Friedman. 2000. Maryland Biological Stream Survey Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy. Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-00-6.

Harrelson, C.C, C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: An illustrated guide to field technique. Gen. Tech. Rep. RM-245. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Hill, C.R., Stribling, J.B., Gallardo, A.C. 2005. Documentation of Method Performance Characteristics. April 2005. Prepared by Tetra Tech, Inc., Owings Mills, Maryland for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Kline, K.M. and R.P. Morgan. 2006. University of Maryland Center for Environmental Science Appalachian Laboratory, Analytical Laboratory Standard Operating Procedures for the Maryland Biological Stream Survey. Frostburg, MD.

Maryland Department of the Environment. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02.03- Water Quality.

Maryland Department of Natural Resources (DNR). 2007. Maryland Biological Stream Survey Sampling Manual: Field Protocols. CBWP-MANTA-EA-07-01. Published by the Maryland Department of Natural Resources, Annapolis, MD. Publication # 12-2162007-190.

Mecklenburg, Dan. 2004. *The Reference Reach Spreadsheet*. Version 4.1 L. Ohio Department of Natural Resources.

Merritt, R.W. and Cummins, K.W. 1996 An Introduction to the Aquatic Insects of North America, 3rd edition, Kendall / Hunt Publishing Company.

Paul, M.J., Stribling, J.B., Klauda, R.J., Kazyak, P.F., Southerland, M.T., and N.E. Roth. 2002. A Physical Habitat Index for Freshwater Wadeable Streams in Maryland. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-03-4.

Schueler, T. 1994. "The Importance of Imperviousness." Watershed Protection Techniques 2(4): 100-111. Southerland, M.T., G.M. Rogers, M.J. Kline, R.P. Morgan, D.M. Boward, P.F. Kazyak, R.J. Klauda, S.A. Stranko. 2005a. New Biological Indicators to Better Assess the Condition of Maryland Streams. DNR-12-0305-0100. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD.

Southerland, M.T., L. Erb. G.M. Rogers, R.P. Morgan, K. Eshelman, M.J. Kline, K. Kline, S.A. Stranko, P.F. Kazyak, J. Killian, J. Ladell, J. Thompson. 2005b. Maryland Biological Stream Survey 2000-2004 Volume 14 : Stressors Affecting Maryland Streams. DNR-12-0305-0100. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-05-11.

Southwood, T.R.E. 1977. Habitat, the template for ecological strategies? Journal of Animal Ecology 46:337-365.

Stribling, J.B., E.W. Leppo, and C. Daley. 1999. Biological Assessment of the Streams and Watersheds of Prince George's County, Maryland. Spring Index Period 1999. PGDER Report No 99-1. Prince George's County, Dept. of Env. Rsrs., Programs and Planning Division, Largo, MD

Tetra Tech, Inc. 2004. Quality Assurance Project Plan for Anne Arundel County Biological Monitoring and Assessment Program. January 2004, Revision 1. Prepared by Tetra Tech, Inc., Owings Mills, Maryland, for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2005. Sampling and Analysis Plan for Anne Arundel County Biological Monitoring and Assessment Program. January 2005. Prepared by Tetra Tech, Inc., Owings Mills, Maryland for the Anne Arundel County Office of Environmental & Cultural Resources, Annapolis, Maryland.

Tetra Tech, Inc. 2006. Random Subsample Routine. Developed by Erik W. Leppo.

Wolman, M.G. 1954. *A Method of Sampling Coarse River-bed Material*. Transactions of American Geophysical Union 35: 951-956.

Appendix A: Benthic Macroinvertebrate Data

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	I	3	Predator	sp	8.1
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	5	Shredder	bu	7.4
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	2	Predator	cb	8.3
Insecta	Ephemeroptera	Baetidae	Centroptilum	Centroptilum	I	1	Collector	sw	2.3
Insecta	Diptera	Empididae	Chelifera	Chelifera	I	1	Predator	sp	7.1
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	1	Filterer	cn	6.5
Insecta	Odonata	Coenagrionidae	not identified	Coenagrionidae	I	1	Predator	cb	9
Insecta	Diptera	Chironomidae	Conchapelopia	Conchapelopia	P	2	Predator	sp	6.1
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	7	Shredder	cn	9.6
Clitellata	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	U	1	Collector	bu	9.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	6	Scraper	sp	7.2
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	3	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Natarsia	Natarsia	I	4	Predator	sp	6.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	P	3	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	7	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Paracladopelma	Paracladopelma	I	4	Collector	sp	6.6
Insecta	Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	P	1	Collector	sp	4
Bivalvia	Veneroida	Pisidiidae	Pisidium	Pisidium	U	1	Filterer	bu	5.7
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	28	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	P	3	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Psectrocladius	Psectrocladius	I	2	Shredder	sp	6.6
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	1	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	1	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Stenochironomus	Stenochironomus	I	2	Shredder	bu	7.9
Insecta	Diptera	Chironomidae	not identified	Tanypodinae	P	2	Predator	sp	7.5
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	P	1	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	2	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	3	Predator	sp	6.7
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	3	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	4	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	P	1	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	I	2	Scraper	cn	7.8
Insecta	Ephemeroptera	Baetidae	not identified	Baetidae	I	1	Collector	sw	2.3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	2	Filterer	cn	6.5
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	2	Shredder	cn	9.6
Insecta	Coleoptera	Elmidae	Dubiraphia	Dubiraphia	A	1	Scraper	cn	5.7
Crustacea	Amphipoda	Gammaridae	Gammarus	Gammarus	U	21	Shredder	sp	6.7
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	1	Filterer	cn	7.5
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	A	1	Scraper	cn	6.8
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	I	3	Scraper	cn	6.8
Insecta	Coleoptera	Elmidae	Microcylloepus	Microcylloepus	I	4	Collector	cn	4.8
Insecta	Coleoptera	Elmidae	Microcylloepus	Microcylloepus	A	5	Collector	cn	4.8
Insecta	Diptera	Chironomidae	Nanocladius	Nanocladius	I	1	Collector	sp	7.6
Insecta	Coleoptera	Elmidae	Optioservus	Optioservus	I	1	Scraper	cn	5.4
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	8	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	P	1	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	1	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paratendipes	Paratendipes	I	1	Collector	bu	6.6
Insecta	Plecoptera	Perlidae	Perlesta	Perlesta	I	3	Predator	cn	1.6
Insecta	Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	I	1	Filterer	cn	1.1
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	3	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	1	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	1	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	23	Filterer	cn	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	A	4	Scraper	cn	7.1
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	2	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	P	2	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	I	1	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	1	Predator	sp	6.7
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	11	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	P	1	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

PANT-03-2008

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Chironomidae	Ablabesmyia	Ablabesmyia	I	1	Predator	sp	8.1
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	I	1	Scraper	cn	7.8
Insecta	Ephemeroptera	Baetidae	Baetis	Baetis	I	1	Collector	sw	3.9
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	1	Shredder	bu	7.4
Crustacea	Decapoda	Cambaridae	not identified	Cambarinae	U	1	Shredder	sp	2.8
Insecta	Trichoptera	Hydropsychidae	Ceratopsyche	Ceratopsyche	I	1	Filterer	cn	5
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	4	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	Chimarra	I	2	Filterer	cn	4.4
Bivalvia	Veneroida	Corbiculidae	Corbicula	Corbicula	U	1	Filterer	bu	6
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	4	Shredder	cn	9.6
Insecta	Diptera	Empididae	not identified	Empididae	P	1	Predator	sp	7.5
Crustacea	Amphipoda	Gammaridae	Gammarus	Gammarus	U	42	Shredder	sp	6.7
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	1	Scraper	sp	7.2
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	I	2	Scraper	cn	6.8
Insecta	Coleoptera	Elmidae	Microcylloepus	Microcylloepus	A	5	Collector	cn	4.8
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	2	Collector	cb	2.1
Insecta	Plecoptera	Nemouridae	not identified	Nemouridae	I	1	Shredder	sp	2.9
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	7	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	P	1	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Paralauterborniella	Paralauterborniella	I	1	Collector	cn	6.6
Insecta	Diptera	Chironomidae	Paratendipes	Paratendipes	I	2	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	I	1	Collector	cn	8.7
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	P	1	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	2	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	2	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	1	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	5	Filterer	cn	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	3	Scraper	cn	7.1
Insecta	Diptera	Stratiomyidae	not identified	Stratiomyidae	P	1	Collector	sp	na
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	10	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	P	2	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	2	Predator	sp	6.7

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	1	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	6	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	1	Predator	cb	8.3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	2	Filterer	cn	6.5
Crustacea	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	U	4	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	2	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	3	Scraper	sp	7.2
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	1	Filterer	cn	7.5
Insecta	Trichoptera	Limnephilidae	Ironoquia	Ironoquia	I	1	Shredder	sp	4.9
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	3	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Microtendipes	Microtendipes	I	3	Filterer	cn	4.9
Insecta	Hemiptera	Veliidae	Microvelia	Microvelia	A	1	Predator	skater	6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	P	9	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	25	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	I	2	Collector	sp	7.7
Insecta	Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	I	3	Collector	cn	8.7
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	25	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	P	2	Filterer	cn	7.2
Insecta	Diptera	Chironomidae	Sympotthastia	Sympotthastia	I	1	Collector	sp	8.2
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	4	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	4	Predator	sp	6.7
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	11	Collector	cn	8.4

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Coleoptera	Dytiscidae	Agabus	Agabus	I	1	Predator	sw	5.4
Insecta	Ephemeroptera	Ameletidae	Ameletus	Ameletus	I	7	Collector	sw	2.6
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	1	Predator	cb	8.3
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	U	1	Collector	sp	4.1
Insecta	Diptera	Chironomidae	Diplocladius	Diplocladius	U	1	Collector	sp	5.9
Clitellata	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	I	2	Collector	bu	9.1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	6	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	17	Scraper	sp	7.2
Insecta	Coleoptera	Dytiscidae	Hydroporus	Hydroporus	U	1	Predator	sw	4.6
Insecta	Odonata	Libellulidae	not identified	Libellulidae	I	1	Predator	na	9
Clitellata	Lumbriculada	Lumbriculidae	not identified	Lumbriculidae	I	1	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	18	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	A	19	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	5	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	I	1	Collector	sp	4
Insecta	Diptera	Chironomidae	Paratendipes	Paratendipes	I	3	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	I	1	Collector	cn	8.7
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	8	Filterer	cn	5.7
Insecta	Odonata	Corduliidae	Somatochlora	Somatochlora	I	1	Predator	sp	1
Insecta	Diptera	Chironomidae	Sympotthastia	Sympotthastia	I	2	Collector	sp	8.2
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	P	5	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemanniella	Thienemanniella	P	4	Collector	sp	5.1
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	I	1	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	I	4	Predator	sp	5.3

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Plecoptera	Nemouridae	Amphinemura	Amphinemura	I	20	Shredder	sp	3
Crustacea	Isopoda	Asellidae	Caecidotea	Caecidotea	U	7	Collector	sp	2.6
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	3	Scraper	sp	7.2
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	1	Collector	cb	2.1
Insecta	Plecoptera	Nemouridae	Nemoura	Nemoura	I	30	Shredder	sp	2.9
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	2	Collector	sp	9.2
Insecta	Diptera	Simuliidae	Prosimulium	Prosimulium	I	28	Filterer	cn	2.4
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	19	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	1	Collector	sp	5.1
Insecta	Trichoptera	Philopotamidae	Wormaldia	Wormaldia	I	4	Filterer	cn	1.8

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	4	Shredder	bu	7.4
Insecta	Diptera	Ceratopogonidae	not identified	Ceratopogonidae	I	1	Predator	sp	3.6
Hexapoda	Collembola	not identified	not identified	Collembola	I	2	Collector	sp	6
Insecta	Diptera	Chironomidae	Corynoneura	Corynoneura	U	1	Collector	sp	4.1
Insecta	Diptera	Dixidae	Dixa	Dixa	I	2	Predator	sw	5.8
Clitellata	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	I	4	Collector	bu	9.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	U	9	Scraper	sp	7.2
Clitellata	Haplotaxida	not identified	not identified	Lumbricina	A	1	Collector	bu	10
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	U	19	Collector	cb	2.1
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	1	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	19	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Parachaetocladius	Parachaetocladius	I	2	Collector	sp	3.3
Insecta	Diptera	Chironomidae	Paracladopelma	Paracladopelma	P	2	Collector	sp	6.6
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	3	Collector	sp	4.6
Gastropoda	Basommatophor	Physidae	Physa	Physa	I	2	Scraper	cb	7
Bivalvia	Veneroida	Pisidiidae	Pisidium	Pisidium	P	3	Filterer	bu	5.7
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	16	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	P	11	Collector	sp	6.2
Insecta	Diptera	Chironomidae	not identified	Tanypodinae	I	1	Predator	sp	7.5
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Insecta	Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	P	2	Predator	sp	5.3

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Odonata	Coenagrionidae	Argia	Argia	I	1	Predator	cn	9.3
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	P	1	Predator	cb	8.3
Insecta	Diptera	Chironomidae	Cantopelopia	Cantopelopia	I	1	Predator	sp	6.6
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	10	Filterer	cn	6.5
Insecta	Diptera	Chironomidae	not identified	Chironomini	I	1	Collector	bu	5.9
Hexapoda	Collembola	not identified	not identified	Collembola	I	1	Collector	sp	6
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	1	Shredder	cn	9.6
Insecta	Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	I	1	Predator	sp	7.6
Insecta	Coleoptera	Dryopidae	Helichus	Helichus	I	1	Scraper	cn	6.4
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	6	Scraper	sp	7.2
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	I	1	Scraper	cn	6.8
Insecta	Diptera	Chironomidae	not identified	Orthocladiinae	A	1	Collector	bu	7.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	9	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	20	Collector	sp	9.2
Insecta	Coleoptera	Dryopidae	Oulimnius	Oulimnius	P	1	Scraper	cn	2.7
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	2	Collector	sp	4.6
Insecta	Diptera	Chironomidae	Paratendipes	Paratendipes	P	1	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	19	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	1	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	2	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	I	8	Filterer	cn	7.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	P	1	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Stempellinella	Stempellinella	I	1	Collector	cb	4.2
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	not identified	Tanypodinae	I	1	Predator	sp	7.5
Insecta	Diptera	Chironomidae	not identified	Tanytarsini	U	1	Filterer	na	3.5
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	4	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	P	4	Predator	sp	6.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	A	2	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	3	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	A	1	Scraper	cn	7.8
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	I	3	Scraper	cn	7.8
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	1	Shredder	bu	7.4
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	1	Predator	cb	8.3
Insecta	Ephemeroptera	Baetidae	Centroptilum	Centroptilum	I	1	Collector	sw	2.3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	6	Filterer	cn	6.5
Insecta	Diptera	Chironomidae	Chironomus	Chironomus	I	2	Collector	bu	4.6
Insecta	Diptera	Chironomidae	Cladotanytarsus	Cladotanytarsus	I	1	Filterer	-	6.6
Crustacea	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	U	2	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	I	2	Predator	sp	7.6
Gastropoda	Basommatophor	Ancylidae	Ferrissia	Ferrissia	U	2	Scraper	cb	7
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	I	1	Predator	sp	7.9
Crustacea	Amphipoda	Hyalellidae	Hyalella	Hyalella	U	1	Shredder	sp	4.2
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	3	Scraper	sp	7.2
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	2	Filterer	cn	7.5
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	I	2	Scraper	cn	6.8
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	A	2	Scraper	cn	6.8
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	P	17	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	20	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	I	1	Collector	sp	7.7
Insecta	Diptera	Chironomidae	Paratendipes	Paratendipes	I	1	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	24	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Potthastia	Potthastia	I	1	Omnivore	sp	0
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	2	Filterer	cn	5.7
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	not identified	Tanypodinae	P	1	Predator	sp	7.5
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	P	3	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	2	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	2	Predator	sp	6.7
Insecta	Diptera	Tipulidae	Tipula	Tipula	I	1	Shredder	bu	6.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	7	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	4	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Crustacea	Decapoda	Cambaridae	not identified	Cambarinae	I	2	Shredder	sp	2.8
Hexapoda	Collembola	not identified	not identified	Collembola	P	2	Collector	sp	6
Crustacea	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	I	6	Collector	sp	6.7
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	4	Shredder	cn	9.6
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	3	Scraper	sp	7.2
Insecta	Lepidoptera	not identified	not identified	Lepidoptera	I	1	Shredder	na	6.7
Clitellata	Haplotaxida	not identified	not identified	Lumbricina	U	5	Collector	bu	10
Clitellata	Lumbriculada	Lumbriculidae	not identified	Lumbriculidae	U	5	Collector	bu	6.6
Insecta	Diptera	Chironomidae	Natarsia	Natarsia	U	1	Predator	sp	6.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	U	63	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	3	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	1	Shredder	cb	6.3
Insecta	Diptera	Simuliidae	Simulium	Simulium	A	1	Filterer	cn	5.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	11	Collector	cn	8.4

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

PANT-10-2008

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	2	Shredder	bu	7.4
Crustacea	Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	U	1	Collector	sp	6.7
Clitellata	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	U	4	Collector	bu	9.1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	4	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	28	Scraper	sp	7.2
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	1	Filterer	cn	7.5
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	4	Collector	sp	8.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	7	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	I	3	Collector	sp	4.6
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	3	Filterer	cn	5.7
Crustacea	Amphipoda	Crangonyctidae	Stygobromus	Stygobromus	U	1	Collector	sp	6.5
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	1	Predator	sp	6.7
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	54	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	1	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Subphylum/Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	I	2	Scraper	cn	7.8
Insecta	Coleoptera	Elmidae	Ancyronyx	Ancyronyx	A	1	Scraper	cn	7.8
Insecta	Odonata	Coenagrionidae	Argia	Argia	I	2	Predator	cn	9.3
Insecta	Diptera	Chironomidae	Brillia	Brillia	I	1	Shredder	bu	7.4
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	I	1	Predator	cb	8.3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	1	Filterer	cn	6.5
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	I	3	Shredder	cn	9.6
Insecta	Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	I	1	Collector	bu	9
Insecta	Coleoptera	Elmidae	Dubiraphia	Dubiraphia	I	2	Scraper	cn	5.7
Crustacea	Amphipoda	Gammaridae	Gammarus	Gammarus	U	27	Shredder	sp	6.7
Insecta	Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	I	6	Scraper	sp	7.2
Insecta	Trichoptera	Limnephilidae	Ironoquia	Ironoquia	I	1	Shredder	sp	4.9
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	A	1	Scraper	cn	6.8
Insecta	Coleoptera	Dryopidae	Macronychus	Macronychus	I	3	Scraper	cn	6.8
Insecta	Diptera	Chironomidae	Nanocladius	Nanocladius	I	1	Collector	sp	7.6
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	P	1	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Orthocladius	Orthocladius	I	23	Collector	sp	9.2
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	P	1	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	I	10	Shredder	cb	6.3
Insecta	Diptera	Chironomidae	Potthastia	Potthastia	I	2	Omnivore	sp	0
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	2	Collector	sp	6.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	2	Filterer	cn	5.7
Insecta	Diptera	Chironomidae	Stempellinella	Stempellinella	I	1	Collector	cb	4.2
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	I	10	Scraper	cn	7.1
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	A	1	Scraper	cn	7.1
Insecta	Diptera	Chironomidae	Stenochironomus	Stenochironomus	I	1	Shredder	bu	7.9
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	I	4	Filterer	cb	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia	Thienemannimyia	I	1	Predator	sp	6.7
Insecta	Trichoptera	Leptoceridae	Triaenodes	Triaenodes	I	1	Shredder	sw	5
Clitellata	Haplotaxida	Tubificidae	not identified	Tubificidae	U	1	Collector	cn	8.4
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	P	1	Collector	sp	5.1
Insecta	Diptera	Chironomidae	Tvetenia	Tvetenia	I	2	Collector	sp	5.1

1 Life Stage, I - Immature, P- Pupa, A - Adult; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland; na idicates information for the particular taxa was not available.

Appendix B: Bioassessment Results Maps


Patapsco River Nontidal Subwatershed
2008 Targeted Bioassessment Results
Anne Arundel County
Department of Public Works
Watershed and Ecosystem Services and Restoration Division
Watershed Management Program
ANNE ARUNDEL COUNTY
M A R Y L A N D
DPW
Benthic Index of Biotic Integrity
Good
Fair
Poor
Very Poor
Maryland Physical Habitat Index
Minimally Degraded
Partially Degraded
Degraded
Severely Degraded
Elevation
High
Low
County Streams
Major Roads
N
0 0.25 0.5 1 Miles
Baltimore County
Baltimore City
Howard Coutny
Patapsco Non Tidal Watershed
Anne Arundel County
Prince George's County
PANT-09-2008 50.50% Impervious to sampling point
PANT-04-2008 34.90% Impervious to sampling point
PANT-10-2008 30.60% Impervious to sampling point
PANT-05-2008 19.80% Impervious to sampling point
PANT-03-2008 32.40% Impervious to sampling point
PANT-01-2008 52.10% Impervious to sampling point
PANT-06-2008 2.50% Impervious to sampling point
PANT-02-2008 27.60% Impervious to sampling point
PANT-08-2008 23.60% Impervious to sampling point
PANT-07-2008 7.30% Impervious to sampling point
PANT-11-2008 28.00% Impervious to sampling point
I-195
I-895
695
Harbor TunnelThwy
Harbor TunnelThwy
I-695
ArundelExpy
I-195
Paul Pitcher MemorialHwy

Patapsco River Nontidal Subwatershed
2008 Targeted Bioassessment Results
Anne Arundel County
Department of Public Works
Watershed and Ecosystem Services and Restoration Division
Watershed Management Program
ANNE ARUNDEL COUNTY
M A R Y L A N D
DPW
Land Use (2004)
Developed
Undeveloped (Includes Agriculture)
Water
County Streams
Major Roads
Drainage Areas to Sample Points
Maryland Physical Habitat Index
Minimally Degraded
Partially Degraded
Degraded
Severely Degraded
Benthic Index of Biotic Integrity
Good
Fair
Poor
Very Poor
N
0
0.4
0.8
1.6 Miles
Baltimore County
Baltimore City
Howard County
Patapsco Non Tidal Watershed
Anne Arundel County
Prince George's County
PANT-09-2008
50.50% Impervious
to sampling point
PANT-04-2008
34.90% Impervious
to sampling point
PANT-10-2008
30.60% Impervious
to sampling point
PANT-05-2008
19.80% Impervious
to sampling point
PANT-03-2008
27.6% Impervious
to sampling point
PANT-01-2008
52.09% Impervious
to sampling point
PANT-06-2008
2.50% Impervious
to sampling point
PANT-02-2008
27.60% Impervious
to sampling point
PANT-08-2008
23.60% Impervious
to sampling plot
PANT-07-2008
7.30% Impervious
to sampling point
PANT-11-2008
28.00% Impervious
to sampling point
I-195
I-895
I-695
Harbor Tunnel
Washington
State Highway 100
Dorsey
Church
Ordnance
Arundel
Hawkins Point
Baltimore Annapolis
Paul Pitcher Memorial

Appendix C: QA/QC Procedures and Results

Appendix C: Quality Assurance/Quality Control Procedures and Results

The monitoring program for the Patapsco River Nontidal watershed includes chemical, physical and biological assessment conducted throughout the watershed. The sampling methods used are compatible with the Sampling and Analysis Plan for Anne Arundel County Biological Monitoring (SAP) (Tetra Tech, 2005) and the Quality Assurance Project Plan (QAPP) for Anne Arundel County Biological Monitoring and Assessment Program (Tetra Tech, 2004). A summary of the Quality Assurance/Quality Control (QA/QC) procedures and results are included in this Appendix.

A quality assurance and quality control analysis was completed for the assessment work conducted in the Patapsco Nontidal watershed following the methods described by Hill et al. (2005). This analysis included performance characteristics of precision, accuracy, bias and completeness. Performance measures include:

- Precision (consistency) of field sampling and overall site assessments using intra-team site duplication
  - median relative percent difference (mRPD)
  - coefficient of variability (CV)
  - 90% confidence interval (CI)
- Bias of sample sorting and subsampling
  - percent sorting efficiency (PSE)
- Precision of taxonomic identification and enumeration
  - percent taxonomic disagreement (PTD)
  - percent difference in enumeration (PDE)
- Accuracy of data entry
  - number of errors/corrective actions
- Completeness
  - number of valid data points obtained as a proportion of those planned (Sampling and Analysis Plan, 2005).

Data that does not meet performance or acceptable criteria are re-evaluated to correct any problems or investigated further to determine the reason behind the results.

Field Sampling

All field crew leaders were recently trained in MBSS Spring Sampling protocols prior to the start of field sampling. All subjective scoring was completed with the input of all team members at the sampling site to reduce individual sampler bias.

Field water quality measurements were collected in-situ at all monitoring sites according to methods in the County QAPP. All in-situ parameters were measured with an YSI 6000 series multiprobe and the YSI650 data logging system except turbidity which was measured with a Hach 2100 Turbidimeter. Water quality equipment was regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

Sample buckets contained both internal and external labels. All chain-of-custody procedures were followed for transfer of the samples between the field and the identification lab.

Replicate (duplicate) samples were taken at ten percent of the overall sites (one site). This QC sample was collected just upstream of the original sampling location to determine the consistency and repeatability of the sampling procedures and the intra-team adherence to those protocols. The QC site was field-selected rather than randomly selected to ensure that the QC sites maintained similar habitat conditions to the original site. Duplicate samples included collection and analysis of the benthic macroinvertebrate community, completion of the RBP and the PHI habitat assessments, and measurement of *in situ* water chemistry. Photographs were also taken at duplicate sites. Duplicate samples were collected at site 08.

Precision

Performance characteristics calculated for the consistency of field sampling and overall site assessments using intra-team site duplication were:

- Relative Percent Difference (RPD)
- Coefficient of variability (CV)
- 90% Confidence Interval (CI)

Acceptable measurement quality objectives are listed in Table 1. DNR's MBSS protocols were used for the collection and analysis of macroinvertebrate data. In 2005, DNR updated their Benthic Index of Biotic Integrity (BIBI). These new metrics were used to calculate the BIBI presented in this report. The *Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program* (Hill et al. 2005) was completed using the original BIBI, and thus, does not include MQOs for all metrics used in the new BIBI. Therefore, provisional MQOs were used for those metrics (i.e., Number of Ephemeroptera Taxa , Percent Intolerant Urban, and Percent Climber) based on previous County approved MQOs (SAP, 2005).

Table 1 – Measurement Quality Objectives (Hill et al. 2005)

Attribute	MQO		
	Median RPD	CV	90% CI
Total Number of Taxa	<30	<20	±10
Number of EPT Taxa	<30	<20	±10
Number of Ephemeroptera Taxa	<30[1]	n/a	n/a
Percent Intolerant Urban	<30[1]	n/a	n/a
Percent Ephemeroptera	<30	<20	±10
Number of Scraper Taxa	<30	<70	±10
Percent Climber	<30[1]	n/a	n/a
B-IBI	<15	<10	±0.5

[1]Values derived from SAP (2005), n/a denotes not available

Results of performance characteristics using individual metric values are presented in Table 2. Results are shown for the site where a duplicate sample (i.e., sample pair) was collected and analyzed (08). Table 3 includes metric and BIBI scores and corresponding performance characteristics.

Table 2 – Individual Metric Values and Related Measures of Precision. Bold values exceed MQOs.

Site	Total Taxa	EPT Taxa	Ephem Taxa	% Intol Urban	% Ephem	Scraper Taxa	% Climbers
08	26	1	0	0.9	0.0	5	24.3
08-QC	27	3	1	1.7	0.8	5	26.7
CV	2.67	**70.71**	141.42	43.51	**141.42**	0.00	6.66
CI	1.16	2.32	1.16	0.93	0.93	0.00	2.78
RPD	3.77	**100.00**	**200.00**	**61.54**	**200.00**	0.00	9.41

Table 3 –Metric and Index Scores and Related Measures of Precision. Bold values exceed MQOs.

Site	Total Taxa Score	EPT Taxa Score	Ephem Taxa Score	% Intol Urban Score	% Ephem Score	Scraper Taxa Score	% Climbers Score	BIBI Score
08	5	1	1	1	1	5	5	2.7
08-QC	5	3	3	1	3	5	5	3.6
CV	0.00	**70.71**	70.71	0.00	**70.71**	0.00	0.00	**20.20**
CI	0.00	2.32	2.32	0.00	2.32	0.00	0.00	**1.04**
RPD	0.00	**100.00**	**100.00**	0.00	**100.00**	0.00	0.00	**28.57**

Both metric values and metric scores were compared to MQOs to determine exceedances. Two metric values, Number of EPT Taxa and Percent Ephemeroptera, exceeded the MQO for CV, due to minor differences observed between samples. Only a 0.8% difference in Percent Ephemeroptera separated the two samples, however, comparisons involving very small numbers tend to inflate CV values, and only minute differences in metrics can yield high CV numbers. Two more EPT taxa were found in the QC sample, which also resulted in a relatively high CV due to only one EPT taxa being found in the sample from site 08. A similar trend was observed when comparing sample pairs using RPD. Number of EPT Taxa, Number of Ephemeroptera Taxa, Percent Intolerant Urban, and Percent Ephemeroptera, all exceeded the MQOs for RPD. While the absolute difference between sample pair values was not large, the relative percent difference was inflated due to the small values being compared. This is especially true when comparing any sample with zero values to one with whole numbers, even if the difference is miniscule.

Four of the seven metrics scored identically, resulting in CV, CI, and RPD values of zero. On the other hand, three metrics (EPT Taxa, Ephemeroptera Taxa, and Percent Ephemeroptera) scored differently between the paired samples. Consequently, this resulted in different BIBI scores (and biological rating classifications), which exceeded the MQOs for CV, CI, and RPD. All of this variability can be attributed to the presence of a single Ephemeroptera specimen, *Centoptilum*, and two *Hydrophsyche* (Tricoptera) specimens in the 08QC sample. Since the new BIBI relies quite heavily on the sensitive order Ephemeroptera for three of seven total metrics, small differences in the presence of these taxa alone can significantly influence the variability of the entire BIBI. These three additional specimens in the 08QC subsample led to a score of three for all three metrics that incorporate Ephemereoptera, while sample 08 received scores of only one (1). For all three of these metrics, the values fell just on either side of the scoring thresholds, and with a non-continuous scoring method (i.e., 1, 3, or 5), the difference between scores of ‘1’ and

'3' results in performance characteristic values that will exceed the MQOs. This is also evident with the BIBI score, where a score of '3' for those three metrics bumps the score up from a 2.7 to a 3.6, resulting in exceedences for CV, CI, and RPD. However, considering that these samples are actually very similar taxonomically, with exception to a few heavily-weighted specimens, there is little need for corrective action.

Completeness

One hundred percent of the sampling effort was used at each of the sites samples, resulting in all field sampling data being complete.

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the MBSS procedures and the QAPP. For these samples 75 percent (nine samples) underwent quality control procedures for sorting. Table 4 shows the results of the sorting quality control checks. All samples sorted by laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked. Ten percent of samples sorted by experienced laboratory personnel were also checked. This procedure ensures that all sorted samples either initially exceed the MQO of >90% for PSE, or will exceed the MQO following QC checks by experienced sorters.

Table 4 – Percent Sorting Efficiencies (PSE) Per Sample.

Sample	Organisms Found by Primary Sorter	Organisms Found in QC Check	Total No. of Organisms	Percent Sorting Efficiency
PANT-02	130	122	252	51.6%
PANT-03	140	52	192	72.9%
PANT-04	127	19	146	87.0%
PANT-05	120	22	142	84.5%
PANT-06	178	33	211	84.4%
PANT-08	121	113	234	51.7%
PANT-08 QC	150	57	207	72.5%
PANT-09	122	12	134	91.0%
PANT-10	133	11	144	92.4%

Subsampling was conducted for those sites with greater than 120 organisms sorted and identified. A post-processing subsampling was conducted using a spreadsheet based method (Tetra Tech, 2006). This post-processing randomly subsamples the identified organisms to a desired target number for the sample. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20%) but keeps the total number of individuals below the 120 maximum.

Taxonomic Identification and Enumeration

One sample (03) was randomly selected for QC identification and enumeration by an independent lab. Original identification was completed by Environmental Services and Consulting, LLC[1] (ESC). Re-identification of the randomly selected sites was done by Aquatic Resources Center[2]. Each sample was identified to the genus level where possible. Individuals that were not able to be identified to genus level were identified to the lowest possible level, usually family, but in some cases order. For Chironomidae, individuals not identifiable to genus may have been identified to subfamily or tribe level.

Precision

Measures of precision were calculated for the identification consistency between the two randomly selected samples. These include percent difference in enumeration (PDE) and percent taxonomic disagreement (PTD).

The PDE compares the final specimen counts between the two taxonomy labs, whereas PTD compares the number of agreements in final specimen identifications between the two taxonomic labs. To meet required MQOs set by the QAPP, the PDE for each sample must be equal to or less than 5% , and the PTD must be equal to or less than 15%. Results for the taxonomic comparison and resulting values for PDE and PTD are found in Table 3.

The PDE was below the MQO value of 5% for the verification sample. Following re-identification by the secondary laboratory, the initial PTD (17.5%) slightly exceeded the acceptable MQO value of 15%. There were several minor discrepancies between laboratories concerning chironomids, primarily *Cricotopus* and *Orthocladius*, which are often difficult to separate from one another without associated lifestages. Upon closer inspection by the secondary laboratory, there were enough agreements to reduce the PTD to an acceptable value of 13.1%.

Data Entry

Accuracy

All data entered into Excel, or any other program used for site analysis were reviewed and checked for entry error. Any errors found were corrected and the database was deemed to be 100% accurate. Additionally, spreadsheet metric calculations were checked, and any errors found were corrected.

[1] Address: 101 Professional Park Drive, STE 303, Blacksburg, VA
[2] Address: 545 Cathy Jo Circle, Nashville, TN

Table 3 - Taxonomic Identification and Enumeration Results

Order	Family	Subfamily	Tribe	EcoAnalysts Sample ID	PANT-03 Taxonomist 1	PANT-03 Taxonomist 2	PANT-03 # of agreements
Diptera	Chironomidae	Tanypodinae	Pentaneurini	Ablabesmyia	1	1	1
	Chironomidae	Tanypodinae	Pentaneurini	Thienemannimyia	2	2	2
	Chironomidae	Orthocladiinae	-	Brillia	1	1	1
	Chironomidae	Orthocladiinae	-	Cricotopus	4	4	4
	Chironomidae	Orthocladiinae	-	Orthocladius	8	6	6
	Chironomidae	Orthocladiinae	-	Cricotopus/Orthocladius	0	3	2
	Chironomidae	Orthocladiinae	-	Tvetenia	6	9	6
	Chironomidae	Orthocladiinae	-	Hydrobaenus	1	1	1
	Chironomidae	Orthocladiinae	-	Rheocricotopus	2	2	2
	Chironomidae	Chironominae	Chironomini	Paralauterborniella	1	1	1
	Chironomidae	Chironominae	Chironomini	Paratendipes	2	2	2
	Chironomidae	Chironominae	Chironomini	Phaenopsectra	1	1	1
	Chironomidae	Chironominae	Chironomini	Polypedilum	2	1	1
	Chironomidae	Chironominae	Tanytarsini	Tanytarsus	12	16	12
	Chironomidae	Chironominae	Tanytarsini	Rheotanytarsus	1	1	1
	Chironomidae	Chironominae	Tanytarsini	Micropsectra	2	0	0
	Simuliidae	-	-	Simulium	5	5	5
	Stratiomyidae	-	-	Stratiomyidae	1	0	0
	Empididae	-	-	Empididae	1	1	1
Coleoptera	Elmidae	-	-	Ancyronyx	1	1	1
	Dryopidae	-	-	Macronychus	2	0	0
	Elmidae	-	-	Microcylloepus	5	7	5
	Elmidae	-	-	Stenelmis	3	3	3
Decapoda	Cambaridae	Cambarinae	-	Cambarinae	1	1	1
Amphipoda	Gammaridae	-	-	Gammarus	42	38	38
Ephemeroptera	Baetidae	-	-	Baetidae	0	1	1
	Baetidae	-	-	Baetis	1	0	0
Haplotaxida	Tubificidae	-	-	Tubificidae	1	0	0
Plecoptera	Nemouridae	-	-	Nemouridae	1	1	1
Trichoptera	Hydropsychidae	-	-	Ceratopsyche	1	0	0
	Hydropsychidae	-	-	Cheumatopsyche	4	5	4
	Hydropsychidae			Hydropsyche	0	1	0

Order	Family	Subfamily	Tribe	EcoAnalysts Sample ID	PANT-03 Taxonomist 1	PANT-03 Taxonomist 2	PANT-03 # of agreements
	Philopotamidae	-	-	Chimarra	2	2	2
	Polycentropodidae	-	-	Polycentropus	0	1	0
Polychaeta	Sabellidae	-	-	Manayunkia	0	1	0
Veneroida	Corbiculidae	-	-	Corbicula	1	1	1
Mollusca	Physidae	-	-	Physidae	0	2	0
				Total	118	122	106
				PDE			1.67
				PTD			13.11

Appendix D: Laboratory Water Quality

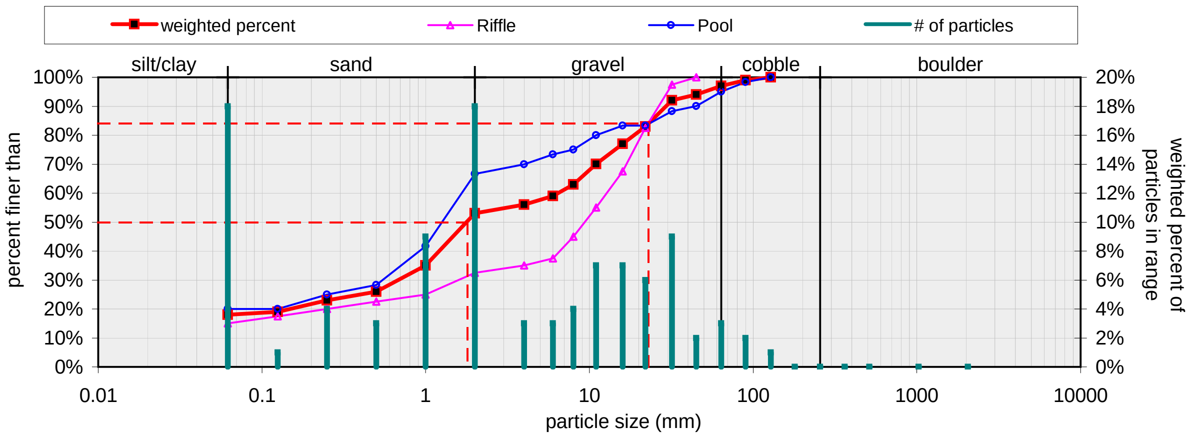
Parameter	Units	Analytical Method	Method Detection Limit	PANT-01	PANT-02	PANT-03	PANT-04	PANT-05	PANT-06	PANT-07	PANT-08	PANT-09	PANT-10	PANT-11
Zinc	*µg/l*	*EPA 200.8*	*10*	16	14	13	10	11	148	22	16	15	28	17
Copper	*µg/l*	*EPA 200.8*	*2*	<2	<2	2.2	<2	2.4	3.3	2.2	<2	<2	<2	2.2
Lead	*µg/l*	*EPA 200.8*	*2*	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Kjeldahl Nitrogen	*mg/l*	*SM 4500NH3-C*	*0.5*	0.7	0.9	0.9	0.7	7.8	0.6	0.8	0.7	<0.5	<0.5	0.9
Nitrate-Nitrite	*mg/l*	*SM 4500N03-H*	*0.02*	0.81	0.52	0.58	0.39	0.65	0.25	0.57	0.34	1.4	2.5	1.3
Nitrate-Nitrogen	*mg/l*	*SM Calc*	*0.02*	0.81	0.52	0.58	0.39	0.65	0.25	0.57	0.34	1.4	2.5	1.3
Nitrite- Nitrogen	*mg/l*	*SM 4500N02B*	*0.02*	<0.02	<0.02	<0.02	0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phosphrous	*mg/l*	*SM 4500P-E*	*0.01*	0.02	0.03	0.02	<0.02	<0.02	0.02	0.04	0.06	0.1	0.01	0.02
Total Nitrogen	*mg/l*	*SM Calc*	*0.5*	1.5	1.4	1.5	1.1	8.5	0.85	1.4	1	1.4	2.5	2.2
Total Suspended Solids	*mg/l*	*SM 2540 D*	*1*	2	15	3	2	6	<1	2	3	2	1	3
MPN Fecal Coliforms	*mpn/100 ml*	*SM 9221E*	*2*	93	43	15	150	93	<3	930	23	9	930	43

Appendix E:Geomorphic Data

PANT-01-2008

Weighted pebble count by bed features ---

40% riffle 60% pool

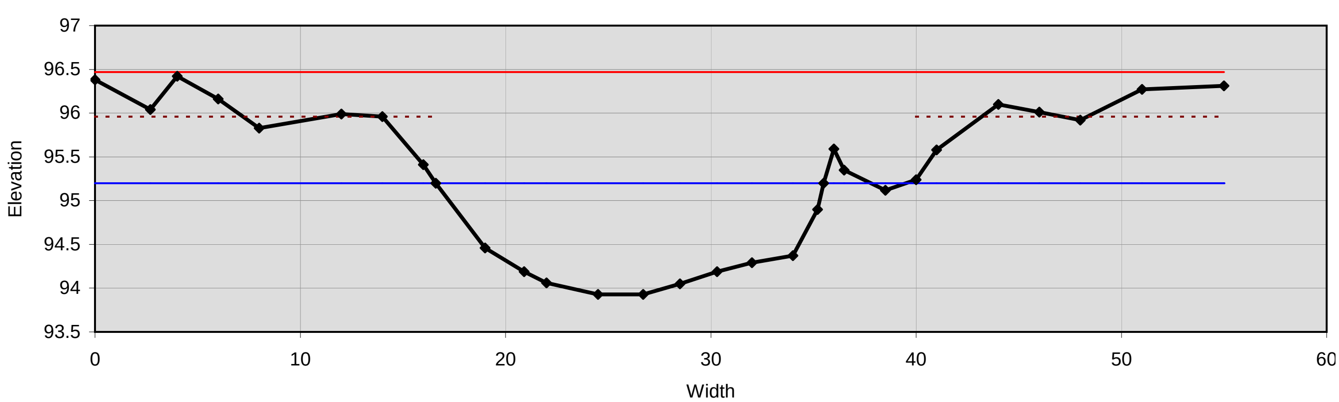


Size (mm)	
D16	0.062
D35	1
D50	1.8
D65	8.8
D84	23
D95	51

Size Distribution	
mean	1.2
dispersion	20.9
skewness	-0.1

Type	
silt/clay	18%
sand	35%
gravel	44%
cobble	3%
boulder	0%
bedrock	0%

Cross-section



Bankfull Dimensions	
17.8	x-section area (ft.sq.)
20.6	width (ft)
0.9	mean depth (ft)
1.3	max depth (ft)
21.0	wetted perimeter (ft)
0.8	hydraulic radius (ft)
23.8	width-depth ratio

Flood Dimensions	
400.0	Width flood prone area (ft)
19.4	entrenchment ratio
2.0	low bank height (ft)
1.6	low bank height ratio

Flow Resistance	
0.028	Manning's roughness

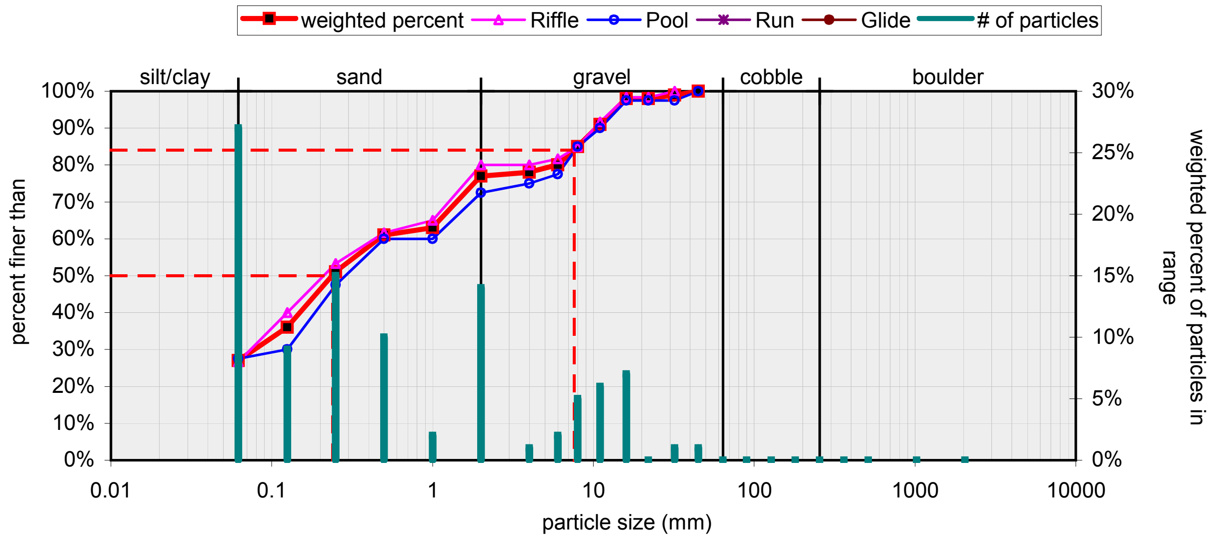
Bankfull Flow	
3.5	velocity (ft/s)
61.5	discharge rate (cfs)
0.51	channel slope (%)

Sinuosity	Channel Type
1.19	C5

PANT-02-2008

Weighted pebble count by bed features ---

60% riffle 40% pool

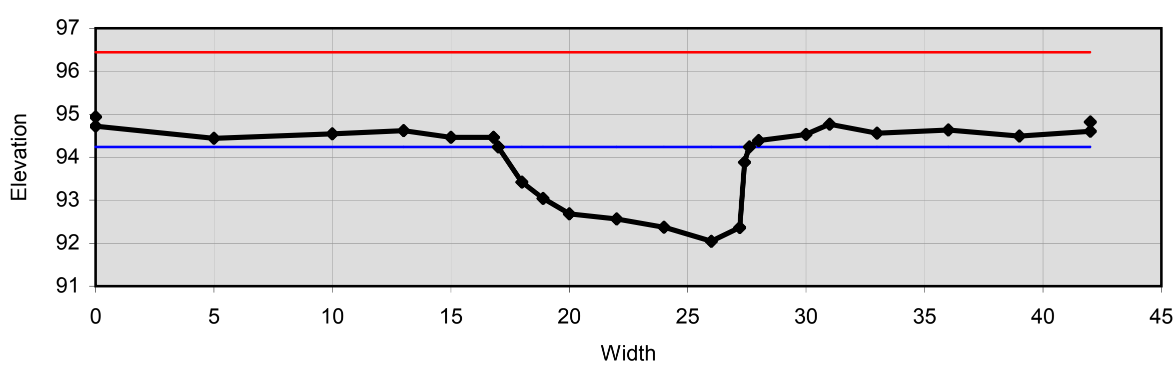


Size (mm)	
D16	0.062
D35	0.12
D50	0.24
D65	1.1
D84	7.6
D95	14

Size Distribution	
mean	0.7
dispersion	17.8
skewness	0.3

Type	
silt/clay	27%
sand	50%
gravel	23%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
16.4	x-section area (ft.sq.)
10.6	width (ft)
1.5	mean depth (ft)
2.2	max depth (ft)
12.7	wetted perimeter (ft)
1.3	hydraulic radius (ft)
6.8	width-depth ratio

Flood Dimensions	
400.0	Width flood prone area (ft)
37.7	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Flow Resistance	
0.021	Manning's roughness

Bankfull Flow	
5.8	velocity (ft/s)
95.3	discharge rate (cfs)
0.46	channel slope (%)

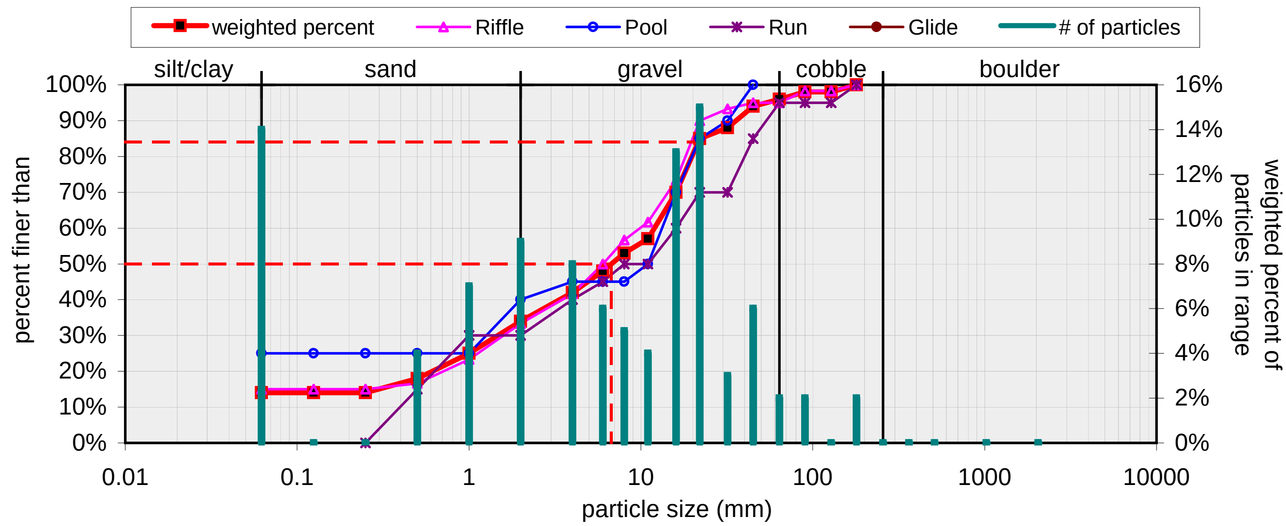
Sinuosity	Channel Type
1.05	DA5

Graphical Summary

PANT-03-2008

Weighted pebble count by bed features ---

60% riffle 20% pool 20% run

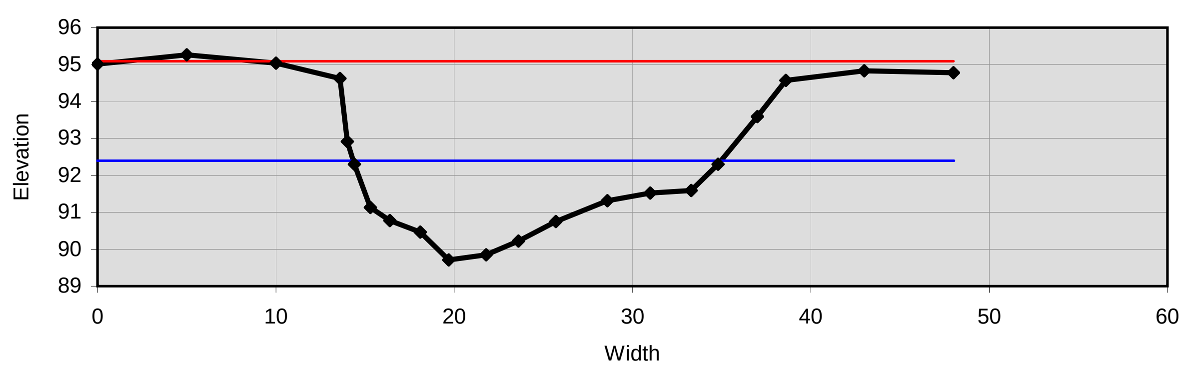


Size (mm)	
D16	0.35
D35	2.2
D50	6.7
D65	14
D84	22
D95	54

Size Distribution	
mean	2.8
dispersion	11.2
skewness	-0.3

Type	
silt/clay	14%
sand	20%
gravel	62%
cobble	4%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
31.7	x-section area (ft.sq.)
20.6	width (ft)
1.5	mean depth (ft)
2.7	max depth (ft)
21.9	wetted perimeter (ft)
1.4	hydraulic radius (ft)
13.4	width-depth ratio

Flood Dimensions	
300.0	Width flood prone area (ft)
14.5	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Flow Resistance	
0.025	Manning's roughness

Bankfull Flow	
4.4	velocity (ft/s)
137.9	discharge rate (cfs)
0.3	channel slope (%)

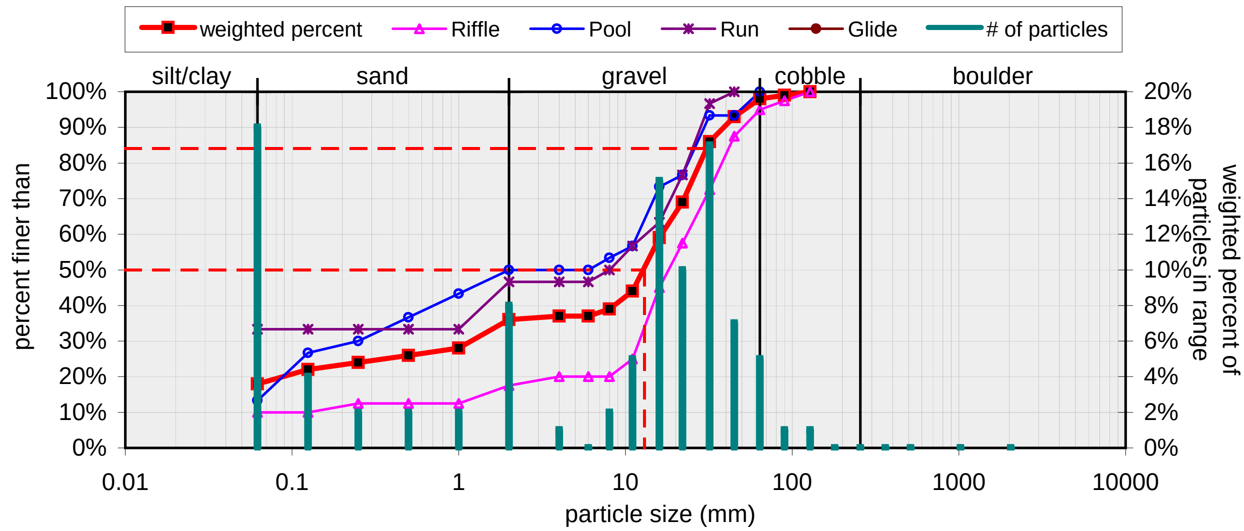
Sinuosity	Channel Type
1.24	C4

Graphical Summary

PANT-04-2008

Weighted pebble count by bed features ---

40% riffle 30% pool 30% run

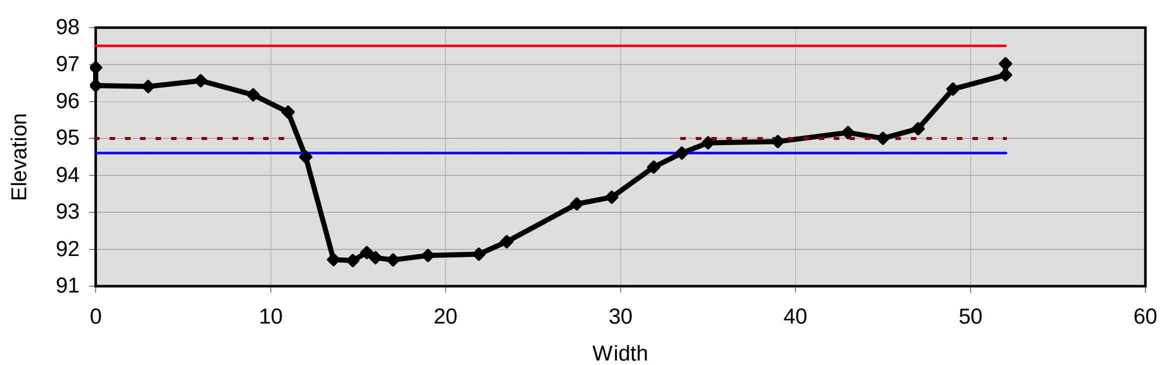


Size (mm)	
D16	0.062
D35	1.8
D50	13
D65	19
D84	31
D95	52

Size Distribution	
mean	1.4
dispersion	106.0
skewness	-0.6

Type	
silt/clay	18%
sand	18%
gravel	62%
cobble	2%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
42.1	x-section area (ft.sq.)
21.6	width (ft)
1.9	mean depth (ft)
2.9	max depth (ft)
23.6	wetted perimeter (ft)
1.8	hydraulic radius (ft)
11.1	width-depth ratio

Flood Dimensions	
175.0	Width flood prone area (ft)
8.1	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Flow Resistance	
0.040	Manning's roughness

Bankfull Flow	
6.0	velocity (ft/s)
252.1	discharge rate (cfs)
1.2	channel slope (%)

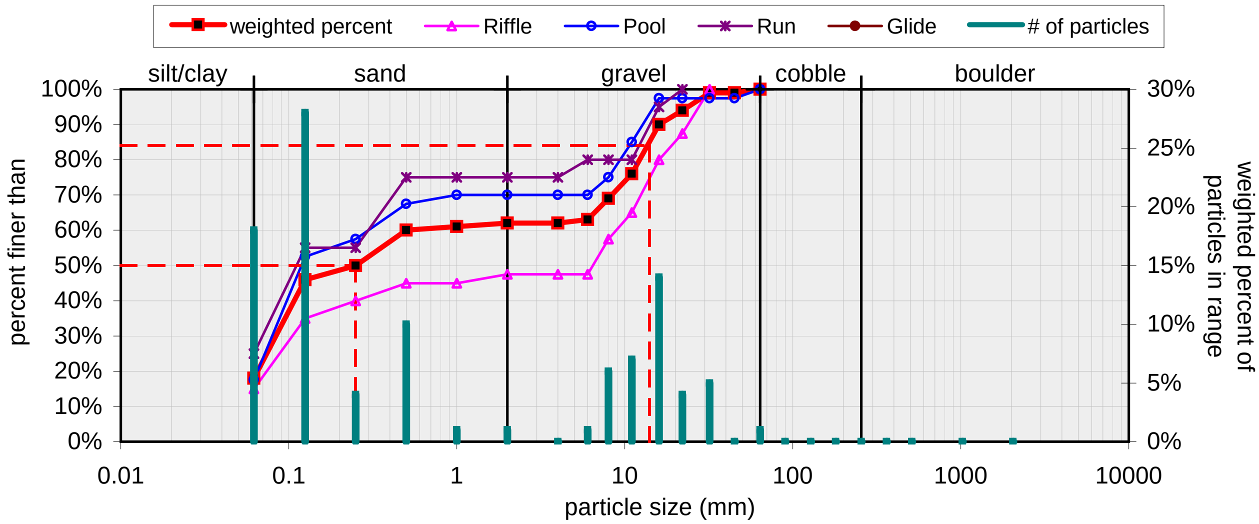
Sinuosity	Channel Type
1.11	C4

Graphical Summary

PANT-05-2008

Weighted pebble count by bed features ---

40% riffle 40% pool 20% run

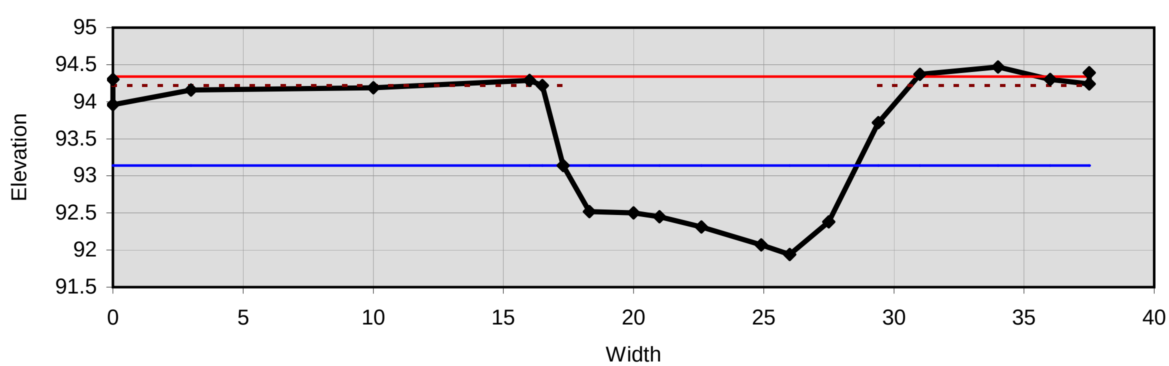


Size (mm)	
D16	0.062
D35	0.095
D50	0.25
D65	6.6
D84	14
D95	24

Size Distribution	
mean	0.9
dispersion	30.0
skewness	0.4

Type	
silt/clay	18%
sand	44%
gravel	38%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
8.6	x-section area (ft.sq.)
11.3	width (ft)
0.8	mean depth (ft)
1.2	max depth (ft)
11.8	wetted perimeter (ft)
0.7	hydraulic radius (ft)
14.8	width-depth ratio

Flood Dimensions	
32.9	Width flood prone area (ft)
2.9	entrenchment ratio
2.3	low bank height (ft)
1.9	low bank height ratio

Flow Resistance	
0.026	Manning's roughness

Bankfull Flow	
4.8	velocity (ft/s)
41.0	discharge rate (cfs)
1.1	channel slope (%)

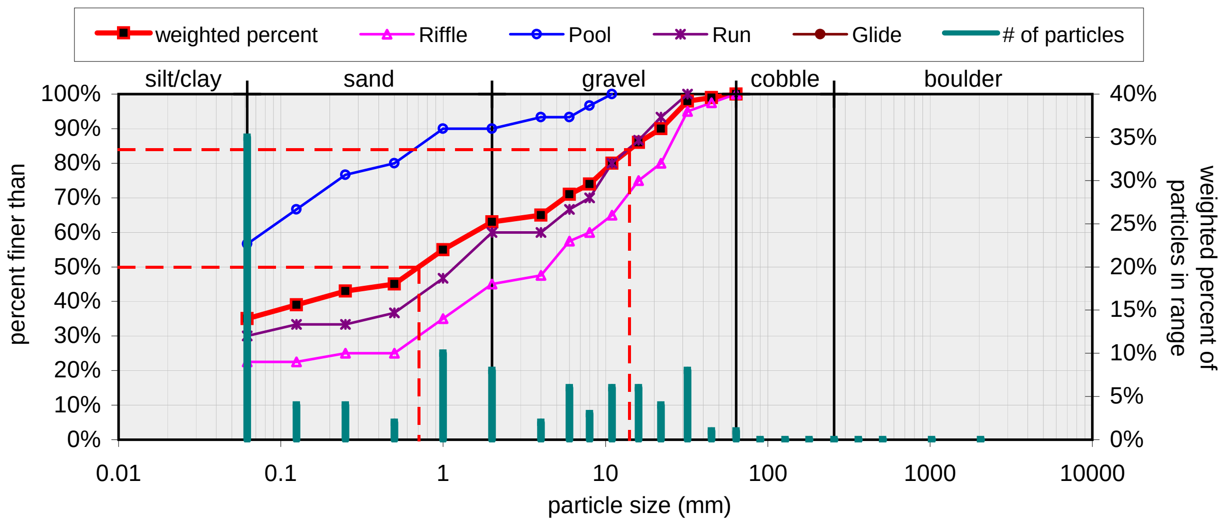
Sinuosity	Channel Type
1.11	C5

Graphical Summary

PANT-06-2008

Weighted pebble count by bed features ---

40% riffle 30% pool 30% run

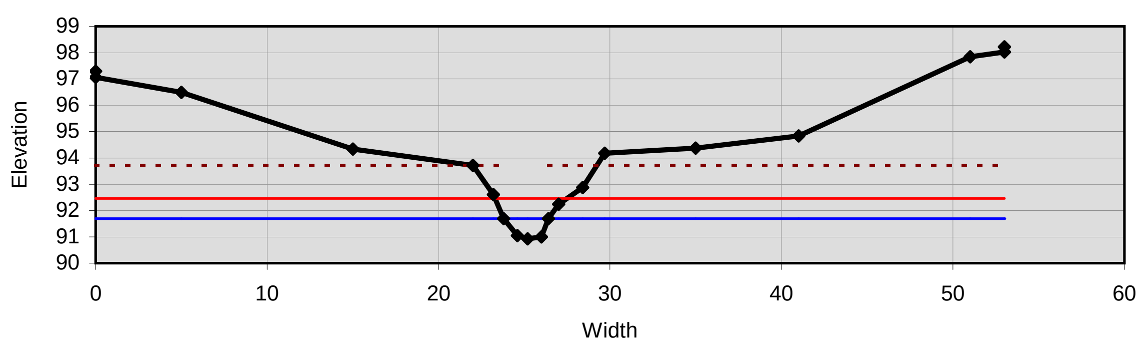


Size (mm)	
D16	0.062
D35	0.062
D50	0.71
D65	4
D84	14
D95	28

Size Distribution	
mean	0.9
dispersion	15.6
skewness	0.1

Type	
silt/clay	35%
sand	28%
gravel	37%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
1.4	x-section area (ft.sq.)
2.6	width (ft)
0.5	mean depth (ft)
0.8	max depth (ft)
3.2	wetted perimeter (ft)
0.4	hydraulic radius (ft)
4.8	width-depth ratio

Flood Dimensions	
4.2	Width flood prone area (ft)
1.6	entrenchment ratio
2.8	low bank height (ft)
3.6	low bank height ratio

Flow Resistance	
0.030	Manning's roughness

Bankfull Flow	
5.4	velocity (ft/s)
7.6	discharge rate (cfs)
3.7	channel slope (%)

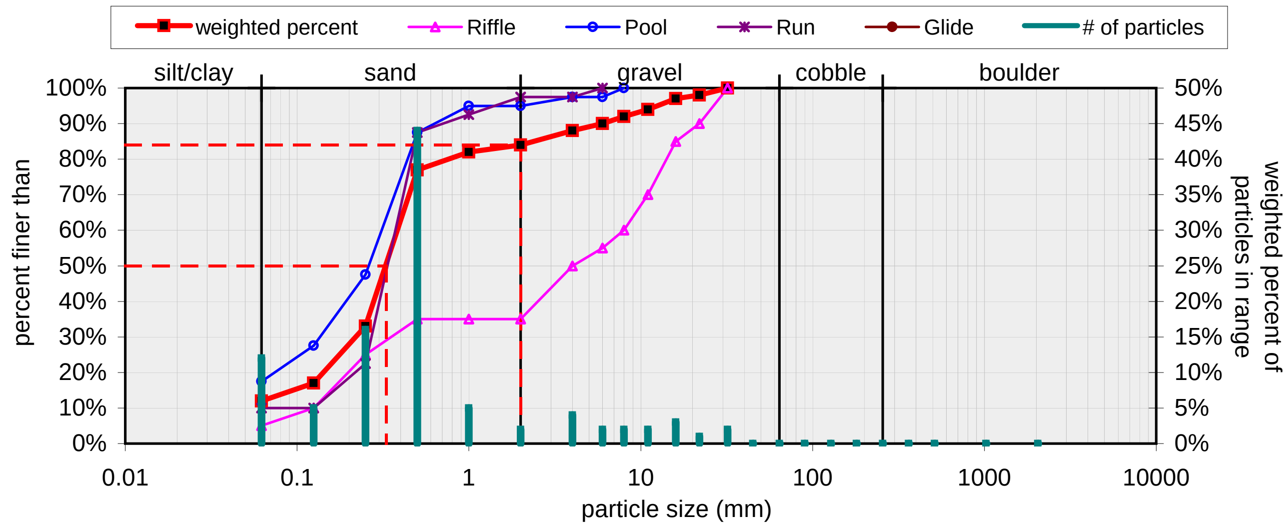
Sinuosity	Channel Type
1.12	B5

Graphical Summary

PANT-07-2008

Weighted pebble count by bed features ---

20% riffle 40% pool 40% run

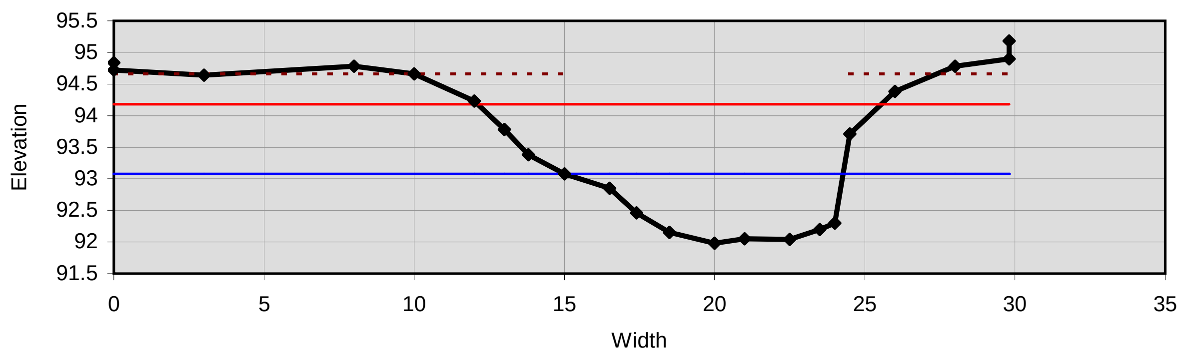


Size (mm)	
D16	0.11
D35	0.26
D50	0.33
D65	0.41
D84	2
D95	12

Size Distribution	
mean	0.5
dispersion	4.5
skewness	0.1

Type	
silt/clay	12%
sand	72%
gravel	16%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
7.0	x-section area (ft.sq.)
9.3	width (ft)
0.8	mean depth (ft)
1.1	max depth (ft)
10.0	wetted perimeter (ft)
0.7	hydraulic radius (ft)
12.2	width-depth ratio

Flood Dimensions	
13.4	Width flood prone area (ft)
1.4	entrenchment ratio
2.7	low bank height (ft)
2.4	low bank height ratio

Flow Resistance	
0.025	Manning's roughness

Bankfull Flow	
4.1	velocity (ft/s)
28.9	discharge rate (cfs)
0.8	channel slope (%)

Sinuosity	Channel Type
1.07	F5

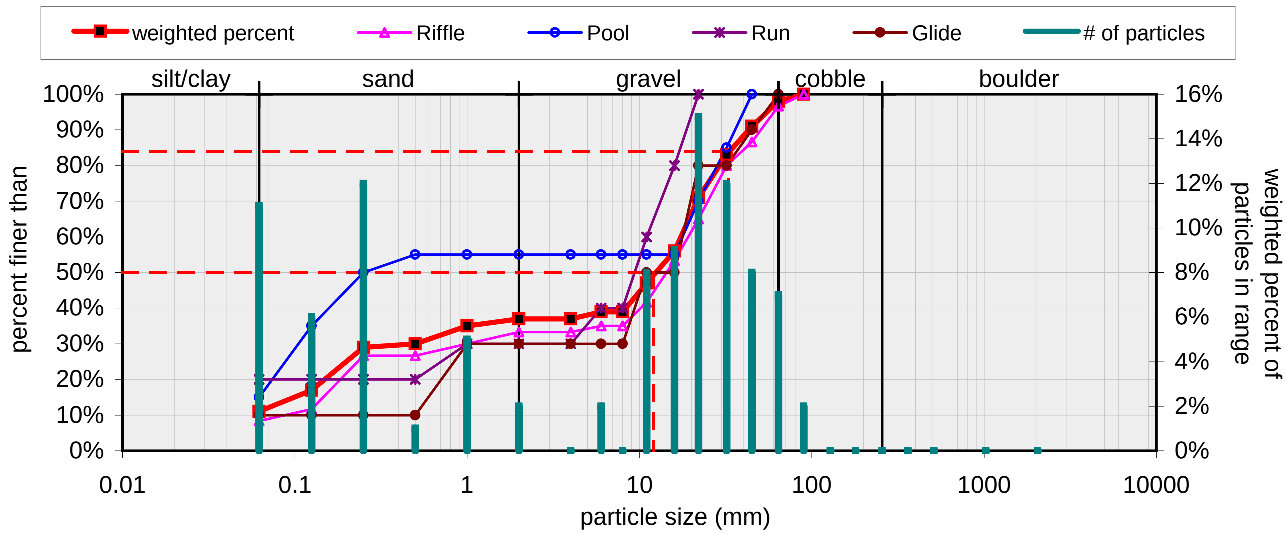
Patapsco Nontidal Watershed
Biological Monitoring and Assessment
Summary Geomorphological Data

Anne Arundel County
2008

PANT-08-2008

Weighted pebble count by bed features ---

60% riffle 20% pool 10% run 10% glide

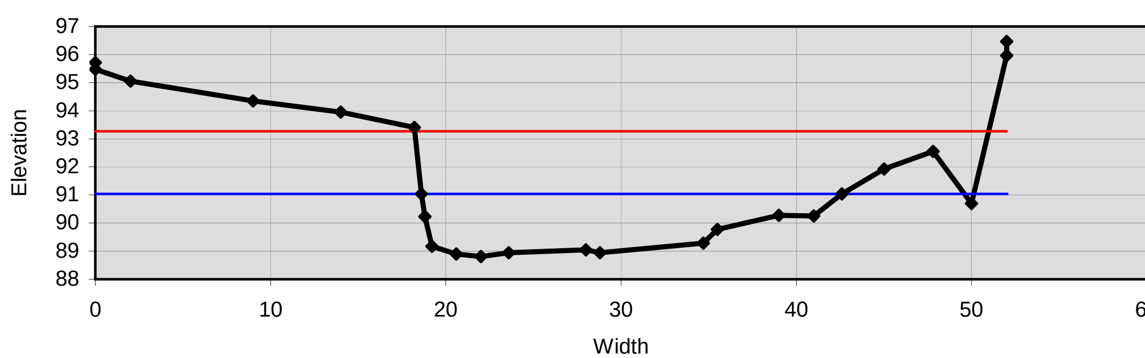


Size (mm)	
D16	0.11
D35	1
D50	12
D65	19
D84	33
D95	55

Size Distribution	
mean	1.9
dispersion	55.9
skewness	-0.5

Type	
silt/clay	11%
sand	26%
gravel	61%
cobble	2%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
39.0	x-section area (ft.sq.)
24.5	width (ft)
1.6	mean depth (ft)
2.2	max depth (ft)
26.7	wetted perimeter (ft)
1.5	hydraulic radius (ft)
15.4	width-depth ratio

Flood Dimensions	
32.8	Width flood prone area (ft)
1.3	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Flow Resistance	
0.030	Manning's roughness

Bankfull Flow	
6.2	velocity (ft/s)
240.9	discharge rate (cfs)
0.9	channel slope (%)

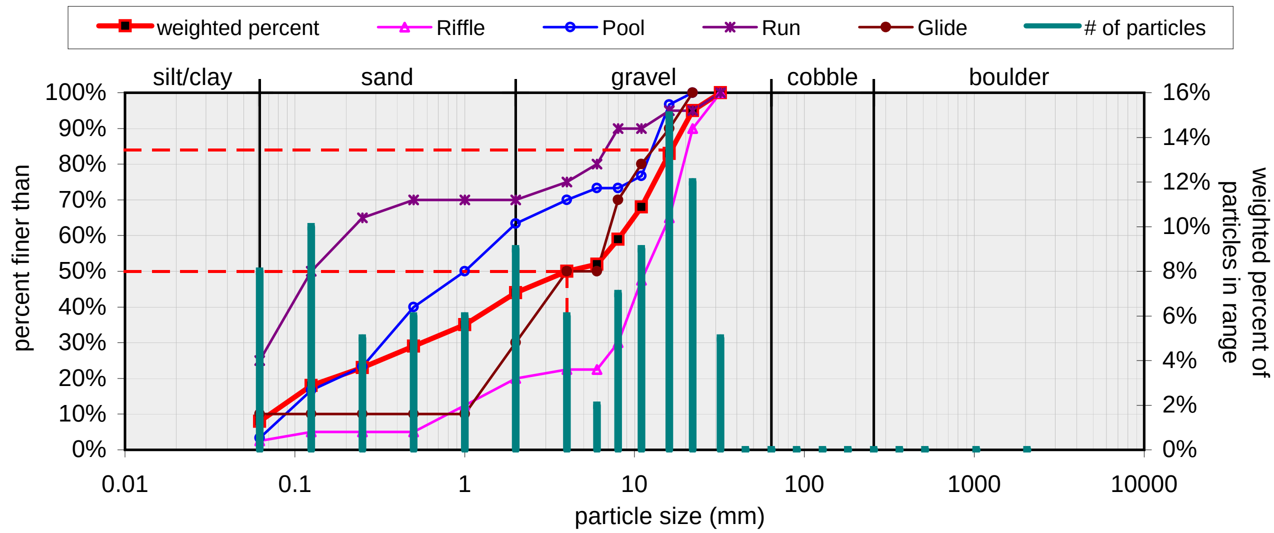
Sinuosity	Channel Type
1.16	F4

Graphical Summary

PANT-09-2008

Weighted pebble count by bed features ---

40% riffle 30% pool 20% run 10% glide

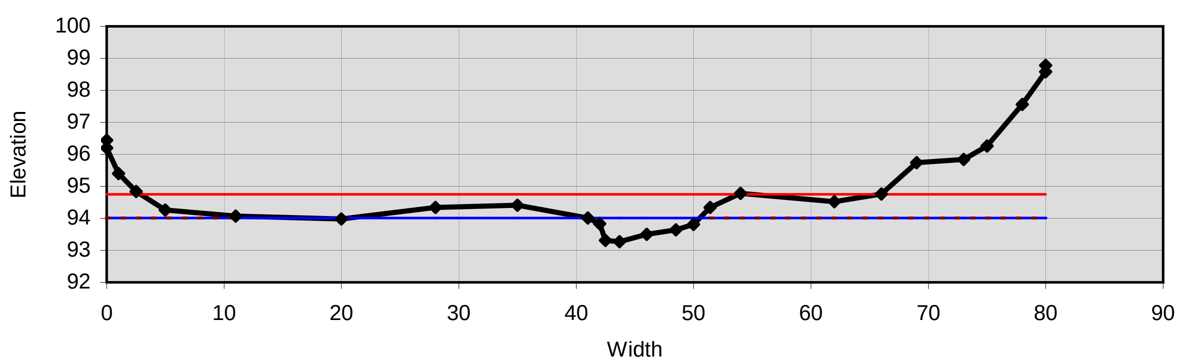


Size (mm)	
D16	0.11
D35	1
D50	4
D65	9.9
D84	16
D95	22

Size Distribution	
mean	1.3
dispersion	20.2
skewness	-0.3

Type	
silt/clay	8%
sand	36%
gravel	56%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
4.2	x-section area (ft.sq.)
13.2	width (ft)
0.3	mean depth (ft)
0.7	max depth (ft)
13.5	wetted perimeter (ft)
0.3	hydraulic radius (ft)
41.0	width-depth ratio

Flood Dimensions	
61.8	Width flood prone area (ft)
4.7	entrenchment ratio
0.7	low bank height (ft)
1.0	low bank height ratio

Flow Resistance	
0.029	Manning's roughness

Bankfull Flow	
1.5	velocity (ft/s)
6.3	discharge rate (cfs)
0.4	channel slope (%)

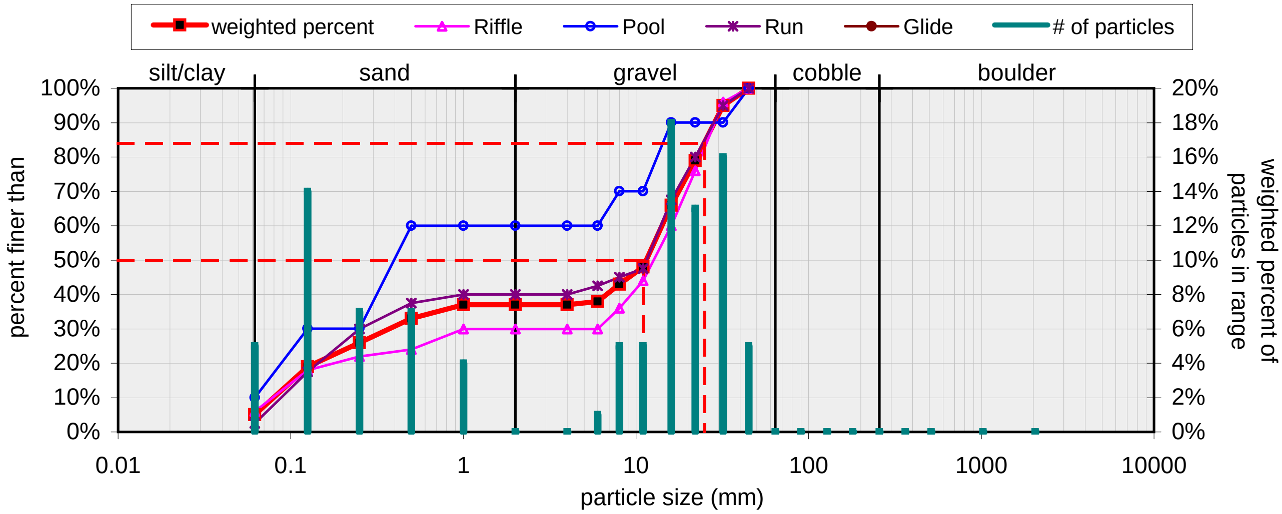
Sinuosity	Channel Type
1.12	C4

Graphical Summary

PANT-10-2008

Weighted pebble count by bed features ---

50% riffle 10% pool 40% run

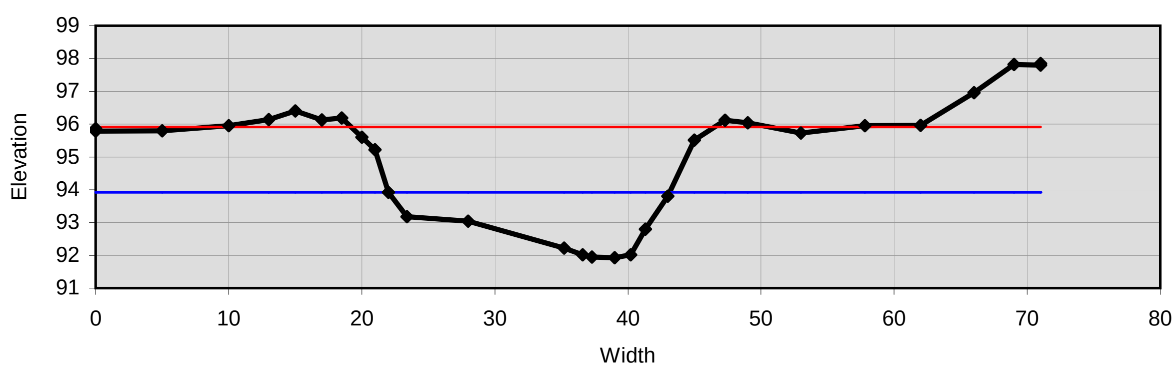


Size (mm)	
D16	0.11
D35	0.71
D50	11
D65	16
D84	25
D95	32

Size Distribution	
mean	1.7
dispersion	51.1
skewness	-0.5

Type	
silt/clay	5%
sand	32%
gravel	63%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
25.8	x-section area (ft.sq.)
21.1	width (ft)
1.2	mean depth (ft)
2.0	max depth (ft)
22.0	wetted perimeter (ft)
1.2	hydraulic radius (ft)
17.3	width-depth ratio

Flood Dimensions	
47.8	Width flood prone area (ft)
2.3	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Flow Resistance	
0.027	Manning's roughness

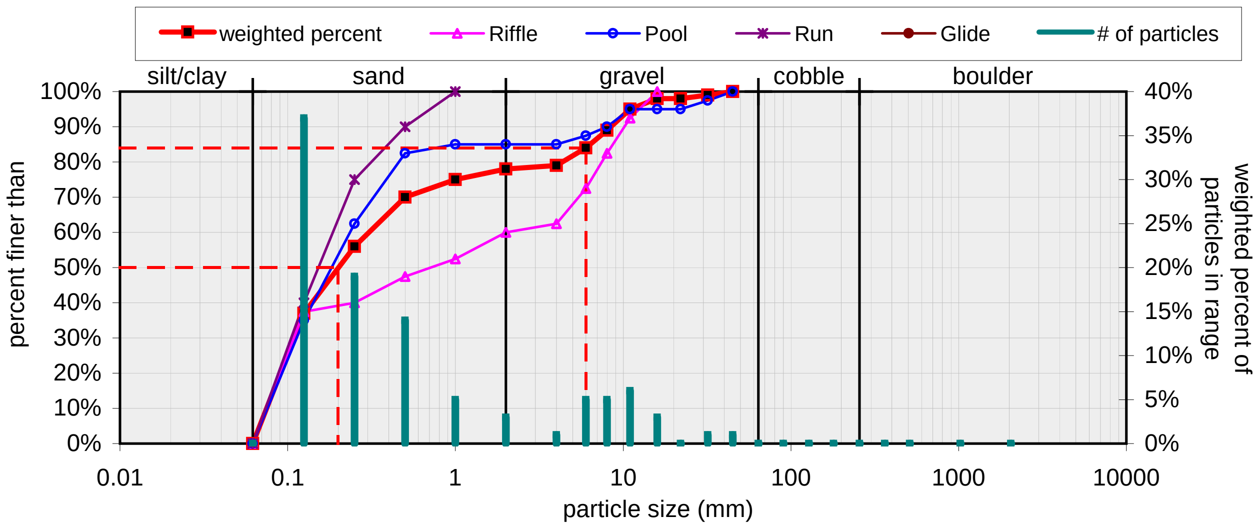
Bankfull Flow	
6.4	velocity (ft/s)
164.2	discharge rate (cfs)
1.1	channel slope (%)

Sinuosity	Channel Type
1.29	C4

PANT-11-2008

Weighted pebble count by bed features ---

40% riffle 40% pool 20% run

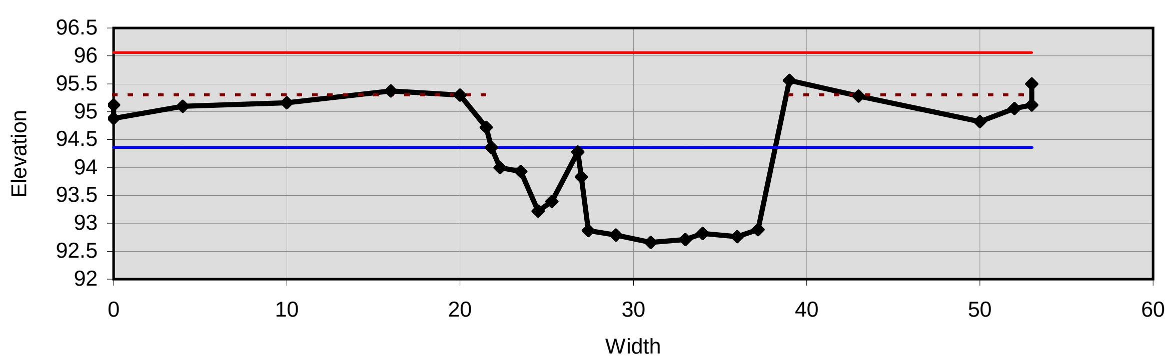


Size (mm)	
D16	0.084
D35	0.12
D50	0.2
D65	0.39
D84	6
D95	11

Size Distribution	
mean	0.7
dispersion	16.2
skewness	0.4

Type	
silt/clay	0%
sand	78%
gravel	22%
cobble	0%
boulder	0%
bedrock	0%

Cross Section



Bankfull Dimensions	
19.8	x-section area (ft.sq.)
16.4	width (ft)
1.2	mean depth (ft)
1.7	max depth (ft)
18.7	wetted perimeter (ft)
1.1	hydraulic radius (ft)
13.6	width-depth ratio

Flood Dimensions	
400.0	Width flood prone area (ft)
24.4	entrenchment ratio
2.6	low bank height (ft)
1.6	low bank height ratio

Flow Resistance	
0.021	Manning's roughness

Bankfull Flow	
5.5	velocity (ft/s)
108.9	discharge rate (cfs)
0.6	channel slope (%)

Sinuosity	Channel Type
1.11	DA5

Graphical Summary

Appendix F: Site Photographs

Biological Assessment Photos

PANT_01 Facing downstream at the midpoint of reach

PANT_01 Facing upstream at the downstream end of reach

PANT_02 Facing downstream at the downstream end of reach

PANT_02 Facing upstream at the upstream end of reach

Biological Assessment Photos

PANT_03 Facing downstream at the midpoint of reach

PANT_03 Facing upstream at the upstream end of reach

PANT_04 Facing downstream at the downstream end of reach

PANT_04 Facing upstream at the upstream end of reach

Biological Assessment Photos


PANT_05 Facing upstream at the downstream end of reach


PANT_05 Facing downstream at the upstream end of reach


PANT_06 Facing downstream at upstream end of reach


PANT_06 Facing upstream at the upstream end of reach

Biological Assessment Photos

PANT_07 Facing downstream at midpoint of reach

PANT_07 Facing downstream at downstream end of reach

PANT_08_ Facing downstream at midpoint of reach

PANT_08 Facing upstream at the midpoint of reach

Biological Assessment Photos

PANT_08 QC Facing downstream at midpoint of reach

PANT_08 QC Facing upstream at midpoint of reach

PANT_09 Facing downstream at the midpoint of reach

PANT_09 Facing upstream at the midpoint of reach

Biological Assessment Photos

PANT_10 Facing downstream at the downstream end of reach

PANT_10 Facing upstream at the upstream end of reach

PANT_11 Facing upstream at the midpoint of reach

PANT_11 Facing upstream at the upstream end of reach

MEMORANDUM

TO:	Hala Flores, P.E. Watershed Management Program Department of Public Works
FROM:	Michael Pieper Natural Resources Management KCI Technologies, Inc.
DATE:	December 30, 2009
SUBJECT:	Patapsco River Nontidal Watershed Year 2009 Targeted Biological Monitoring and Assessment Quality Assurance/Quality Control Technical Memorandum KCI Job Order No. 01-090525 Task 3.1

Quality Assurance/Quality Control Procedures and Results

The monitoring program for the Patapsco River Non-Tidal watershed includes chemical, physical and biological assessment conducted throughout the watershed. The sampling methods used are compatible with the Sampling and Analysis Plan for Anne Arundel County Biological Monitoring (SAP) (Tetra Tech, 2005) and the Quality Assurance Project Plan (QAPP) for Anne Arundel County Biological Monitoring and Assessment Program (Tetra Tech, 2004). A summary of the Quality Assurance/Quality Control (QA/QC) procedures and results are included in this memorandum.

A quality assurance and quality control analysis was completed for the assessment work conducted in the Patapsco Non-Tidal watershed for the 2009 sampling period following the methods described by Hill et al. (2005). This analysis included performance characteristics of precision, accuracy, bias, and completeness. Performance measures include:

- Precision (consistency) of field sampling and overall site assessments using intra-team site duplication
    - relative percent difference (RPD)
    - coefficient of variability (CV)
    - 90% confidence interval (CI)
- Bias of sample sorting and subsampling
    - percent sorting efficiency (PSE)
- Precision of taxonomic identification and enumeration
    - percent taxonomic disagreement (PTD)
    - percent difference in enumeration (PDE)

- Accuracy of data entry
    - number of errors/corrective actions
- Completeness
    - number of valid data points obtained as a proportion of those planned (Sampling and Analysis Plan, 2005).

Data that does not meet performance or acceptable criteria are re-evaluated to correct any problems or investigated further to determine the reason behind the results.

Field Sampling

All field crew members were recently trained in MBSS Spring Sampling protocols prior to the start of field sampling. All subjective scoring was completed with the input of both team members at the sampling site to reduce individual sampler bias.

Field water quality measurements were collected *in situ* at all monitoring sites according to methods in the County QAPP. All *in situ* parameters were measured with an YSI® Professional Plus series multiprobe water quality meter, except turbidity which was measured using a Hach® 2100 Turbidimeter. Water quality equipment was regularly inspected, maintained and calibrated to ensure proper usage and accuracy of the readings. Calibration logs were kept by field crew leaders and checked by the project manager regularly.

Sample buckets were properly labeled using both internal and external labels. All chain-of-custody procedures were followed for transfer of the samples between the field and the laboratory for processing and identification.

Replicate (duplicate) samples were taken at ten percent of the overall sites (i.e., one site). This QC sample was collected just upstream of the original sampling location to determine the consistency and repeatability of the sampling procedures and the intra-team adherence to those protocols. The QC site was field-selected rather than randomly selected to ensure that the QC sites maintained similar habitat conditions to the original site. Duplicate samples included collection and analysis of the benthic macroinvertebrate community, completion of the RBP and the PHI habitat assessments, and measurement of *in situ* water chemistry. Photographs were also taken at duplicate sites.

Precision

Performance characteristics calculated for the consistency of field sampling and overall site assessments using intra-team site duplication were:

- Relative Percent Difference (RPD)
- Coefficient of variability (CV)
- 90% Confidence Interval (CI)

Acceptable measurement quality objectives are listed in Table 1. DNR's MBSS protocols were used for the collection and analysis of macroinvertebrate data. In 2005, DNR updated their Benthic Index of Biotic Integrity (BIBI). These new metrics were used to calculate the BIBI presented in this data. The *Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program* (Hill et al. 2005) was completed using the original BIBI, and thus, does not include MQOs for all metrics used in the new BIBI. Therefore, provisional MQOs were used for those metrics (i.e., Number of Ephemeroptera Taxa, Percent Intolerant Urban, and Percent Climber) based on previous County approved MQOs (SAP, 2005).

Table 1 – Measurement Quality Objectives (Hill et al. 2005)

Attribute	MQO		
	RPD	CV	90% CI
Total Number of Taxa	<30	<20	±10
Number of EPT Taxa	<30	<20	±10
Number of Ephemeroptera Taxa	<30[1]	n/a	n/a
Percent Intolerant Urban	<30[1]	n/a	n/a
Percent Ephemeroptera	<30	<20	±10
Number of Scraper Taxa	<30	<70	±10
Percent Climber	<30[1]	n/a	n/a
B-IBI	<15	<10	±0.5

[1]Values derived from SAP (2005), n/a denotes not available

Results of performance characteristics using individual metric values are presented in Table 2. Results are shown for the site (PN6010.G001) where a duplicate sample (i.e., sample pair) was collected and analyzed (PN6010.G201 is the duplicate sample for PN6010.G001). Table 3 includes metric and BIBI scores and corresponding performance characteristics.

Table 2 – Individual Metric Values and Related Measures of Precision. Bold values exceed MQOs.

Site	Total Taxa	EPT Taxa	Ephem Taxa	% Intol Urban	% Ephem	Scraper Taxa	% Climbers
PN6010.G001	31	6	0	3.6	0.0	4	9.0
PN6010.G201	29	4	0	6.6	0.0	4	8.5
CV	4.7	**28.3**	0.0	**41.6**	0.0	0.0	4.2
CI	2.3	2.3	0.0	3.5	0.0	0.0	0.6
RPD	6.7	**40.0**	0.0	**58.8**	0.0	0.0	5.9

Table 3 - Metric and Index Scores and Related Measures of Precision. Bold values exceed MQOs.

Site	Total Taxa Score	EPT Taxa Score	Ephem Taxa Score	% Intol Urban Score	% Ephem Score	Scraper Taxa Score	% Climbers Score	BIBI Score
PN6010.G001	5	5	1	1	1	5	5	3.33
PN6010.G201	5	3	1	1	1	5	5	3.00
CV	0.0	**35.4**	0.0	0.0	0.0	0.0	0.0	6.4
CI	0.0	2.32	0.0	0.0	0.0	0.0	0.0	0.3
RPD	0.0	**50.0**	0.0	0.0	0.0	0.0	0.0	9.1

Both metric values and metric scores were compared to MQOs to determine whether any metrics exceeded the stated MQOs. One metric value, *Number of EPT Taxa*, exceeded the MQO for CV.

Two more EPT taxa were found in the PN6010.G001sample, which resulted in a relatively high CV. When comparing sample pairs using RPD, two metric values, *Number of EPT Taxa* and *Percent Intolerant Urban*, exceeded the MQOs for RPD. While the absolute difference between sample pair values was relatively small, the relative percent difference was inflated due to the small numbers being compared. For instance, the difference in *Percent Intolerant Urban* between PN6010.G001 (3.6 %) and PN6010.G201 (6.6 %) was only three percent but resulted in an RPD of 58.8. If the *Percent Intolerant Urban* values for the same two samples were 33.6% and 36.6%, a difference of three percent, the RPD would drop significantly to 8.55, which is well below the stated MQO.

Six of the seven metrics scored identically, resulting in CV, CI, and RPD values of zero. Only one metric, *EPT Taxa*, scored differently between the paired samples, and the difference between the two scores was large enough to result in CV and RPD values that exceeded the MQOs. The difference in scores can be attributed to the presence of one additional Trichoptera specimen and one additional Plecoptera specimen in the PN6010.G001sample. Based on the Coastal Plain scoring criteria for the *Number of EPT Taxa* metric, a sample containing between two and four EPT taxa receives a BIBI score of ‘3’; and a sample containing five or more EPT taxa receives a BIBI score of ‘5’. Even though the sample pair differed only by two EPT taxa, the difference in metric scores results in performance characteristic values that exceed MQOs. However, considering that these samples are actually very similar taxonomically and in composition, there is no apparent need for corrective action.

Completeness

Sampling and assessments were performed at all 15 sites targeted for data collection, thus, field sampling and assessment is 100 percent complete.

Laboratory Sorting and Subsampling

Bias

All sorting was completed following the MBSS procedures and the QAPP. All samples sorted by laboratory personnel in training (i.e., not consistently achieving >90% sorting efficiency) were checked by a qualified laboratory QA officer. Ten percent of samples sorted by experienced laboratory personnel were also checked. This procedure ensures that all sorted samples either initially exceed the MQO of >90% for PSE, or will exceed the MQO following QC checks by experienced sorters. For these samples, 75 percent (12 samples) were checked by a laboratory QA officer and assessed for Percent Sorting Efficiency (PSE). Table 4 shows the results of the sorting quality control checks.

Table 4 - Percent Sorting Efficiencies (PSE) Per Sample.

Sample	Organisms Found by Primary Sorter	Organisms Found in QC Check	Total No. of Organisms	Percent Sorting Efficiency
PNC031.G001	129	12	141	91.5%
PNB045.G001	118	16	134	88.1%
PNB030.G001	129	5	134	96.3%
PN9025.G001	123	6	129	95.3%
PN7053.G001	142	2	144	98.6%
PN7065.G001	132	1	133	99.2%
PN2011.G001	123	3	126	97.6%
PN3001.G001	121	0	121	100.0%
PN8006.G001	122	4	126	96.8%
PN8027.G001	122	0	122	100.0%
PN5010.G001	121	3	124	97.6%
PN1014.G001	169	8	177	95.5%

Subsampling was conducted for those sites with greater than 120 organisms sorted and identified. A post-processing subsampling procedure was conducted using a spreadsheet based method (Tetra Tech, 2006). This post-processing procedure randomly subsamples the identified organisms to a desired target number for the sample. Each taxon is subsampled based on its original proportion to the entire sample. In this case, the desired sample size selected was 110 individuals. This allows for a final sample size of approximately 110 individuals (±20%) but keeps the total number of individuals below the 120 maximum.

Taxonomic Identification and Enumeration

One sample (PN5010.G001) was randomly selected for re-identification and enumeration by an independent taxonomic laboratory. Primary identification was completed by Environmental Services and Consulting, LLC[1] (ESC). Re-identification of the randomly selected site was done by Aquatic Resources Center[2]. Each sample was identified to the genus level where possible. Individuals that were not able to be identified to genus level were identified to the lowest possible level, usually family, but in some cases order. For Chironomidae, individuals not identifiable to genus may have been identified to subfamily or tribe level.

Precision

Measures of precision were calculated for the identification consistency between the two randomly selected samples. These include percent difference in enumeration (PDE) and percent taxonomic disagreement (PTD).

[1] Address: 516 Roanoke Street, Christiansburg, VA
[2] Address: 545 Cathy Jo Circle, Nashville, TN

The PDE compares the final specimen counts between the two labs, whereas PTD compares the number of agreements in final specimen identifications between the two taxonomic labs. To meet required MQOs set by the County, the PDE for each sample must be equal to or less than 5%, and the PTD must be equal to or less than 15%. Results for the taxonomic comparison and resulting values for PDE and PTD are found in Table 3.

The PDE was below the MQO value of 5% for the verification sample following re-identification by the primary and secondary laboratories, although the initial PTD (37.2%) exceeded the acceptable MQO value of 15%. There were several discrepancies between laboratories with the identification of specimens in the Chironomidae (primarily, *Chaetocladius*) and Simuliidae families (specifically, *Simulium* and *Stegopterna*). Many of the specimens in the Simuliidae family were not fully mature (i.e., early instars), which made it difficult to key to the target level due to underdeveloped characteristics. There were also minor differences in the identification of worms of the Enchytraeidae, Lumbricidae, Naididae, and Tubificidae families. Upon closer inspection by both laboratories, there were enough agreements to reduce the PTD to an acceptable value of 4.5%.

Data Entry

Accuracy

All data entered into Excel, or any other program used for data analysis, were reviewed and checked for entry error. Any errors found were corrected and the final data set was deemed to be 100% accurate. Additionally, spreadsheet metric calculations were checked, and any errors found were corrected.

Table 5 - Taxonomic Identification and Enumeration Results

Order	Family	Subfamily	Tribe	Sample ID	PN5010.G001 Taxonomist 1	Taxonomist 2	# of agreements
Diptera	Chironomidae	-	-	Chironomidae	1	1	1
	Chironomidae	Chironominae	Chironomini	Polypedilum	1	1	1
	Chironomidae	Diamesinae	Diamesini	Diamesa	1	1	1
	Chironomidae	Orthocladiinae	-	Chaetocladius	15	15	15
	Chironomidae	Orthocladiinae	-	Diplocladius	9	9	9
	Chironomidae	Orthocladiinae	-	Eukiefferiella	22	22	22
	Chironomidae	Orthocladiinae	-	Orthocladiinae	1	0	0
	Chironomidae	Orthocladiinae	-	Orthocladius	4	0	0
	Chironomidae	Orthocladiinae	-	Orthocladius/Cricotopus	0	4	4
	Chironomidae	Orthocladiinae	-	Parakiefferiella	0	1	0
	Chironomidae	Orthocladiinae	-	Parametriocnemus	2	2	2
	Chironomidae	Orthocladiinae	-	Smittia	1	1	1
	Simuliidae	-	-	Prosimulium	0	1	0
				Simuliidae	1	0	0
	Simuliidae	-	-	Simulium	6	6	6
	Simuliidae	Simuliinae	Prosimuliini	Stegopterna	8	8	8
	Tipulidae	-	-	Tipula	8	8	8
Coleoptera	Dytiscidae	-	-	Agabus	2	3	2
	Dytiscidae	-	-	Dytiscidae	1	0	0
	Dytiscidae	-	-	Heterosternuta	0	1	0
Collembola	-	-	-	Collembola	3	3	3
Amphipoda	Crangonyctidae	-	-	Stygobromus	3	3	3
Haplotaxida	Enchytraeidae	-	-	Enchytraeidae	6	6	6
	-	-	-	Lumbricina	1	0	0
	Lumbricidae	-	-	Lumbricidae	2	2	2
	Naididae	-	-	Specaria	2	3	2
	Tubificidae	-	-	Tubificinae	1	1	1
Plecoptera	Nemouridae	-	-	Amphinemura	1	1	1
	-	-	-	Capniidae/Leuctridae	4	4	4
Trichoptera	Hydropsychidae	-	-	Diplectrona	3	3	3
	Hydropsychidae	-	-	Hydropsychidae	1	1	1
	Limnephilidae	-	-	Ironoquia	1	1	1
				Total	111	112	107
				PDE			0.45
				PTD			4.46

APPENDIX F – PRIORITY PARCELS FOR PRESERVATION

Table F.1 - 100 Highest Rated Parces for Preservation

Rank	Parcel ID	Subwatershed Code	Area (acres)	Ranking Score	Priority Rating	Address	City
1	13367	PN6	14.633	74.2	High	PATAPSCO STATE PARK	LINTHICUM HEIGHTS
2	7330	PN9	17.747	64.2	High	FLOOD PLAIN	DORSEY RUN
3	13720	PNB	0.134	64.0	High	2409 CLUBHOUSE DR	ENCLAVE AT ARUNDEL PRES
3	13786	PNB	0.101	64.0	High	7785 CRYSTAL BROOK WAY	ENCLAVE AT ARUNDEL PRES
5	8144	PNC	0.768	63.1	High	MONTEVIDEO RD	JESSUP
6	13705	PNB	0.033	61.7	High	7671 ELMCREST RD	ENCLAVE AT ARUNDEL PRES
6	13782	PNB	0.033	61.7	High	2336 ASBERRY RD	ENCLAVE AT ARUNDEL PRES
6	13793	PNB	0.045	61.7	High	2331 ASBERRY RD	ENCLAVE AT ARUNDEL PRES
9	824	PN1	0.083	59.7	High	310 HOFFMAN AVE	GRAYS PARK
9	13512	PN6	0.317	59.7	High	OLD ELKRIDGE LANDING RD	LINTHICUM HEIGHTS
9	4881	PNA	19.088	59.7	High	7068 RIDGE RD	HARMAN PROP
9	7415	PNB	1.899	59.7	High	7135 WRIGHT RD	HANOVER
9	11968	PNB	0.990	59.7	High	WATTS AVE	HANOVER
9	12952	PNC	1.294	59.7	High	1863 MONTIVEDEO RD	DORSEY
9	13800	PNC	0.937	59.7	High	1912 GINA NICOLE CT	NICOLE HAVEN
16	8301	PNB	3.734	59.7	High	WRIGHT RD	HANOVER
17	4893	PN7	14.802	58.6	High	ELKRIDGE LANDING RD	ELKRIDGE LANDING
18	993	PN2	0.232	58.6	High	8 LAKEVIEW AVE	RIDGEWAY MANOR
18	12479	PNB	0.037	58.6	High	7647 SANDHURST LANE	LANSHIRE AT VILL OF DORC
20	12640	PN1	0.072	57.5	High	WASHINGTON AVENUE	WEST BROOKLYN
20	8188	PNC	0.530	57.5	High	B & O RAILROAD	JESSUP
22	13727	PNB	1.092	57.3	High	REC AREA	ENCLAVE AT ARUNDEL PRES
22	13795	PNB	0.033	57.3	High	2337 ASBERRY RD	ENCLAVE AT ARUNDEL PRES
24	8131	PNB	2.906	56.4	High	1525 DORSEY RD	HANOVER
24	13668	PNB	9.506	56.4	High	MILESTONE PKWY	ARUNDEL PRESERVE
24	8101	PNC	1.091	56.4	High	1914 MONTEVIDEO RD	HAROLD MILLS PROPERTY
24	8206	PNC	1.035	56.4	High	1733 MAPLE AVE	LENNOX PARK
24	12855	PNC	1.575	56.4	High	7431 WIGLEY AVE	NICOLE HAVEN
29	4916	PN5	2.776	56.4	High	FURNACE RD	PATAPSCO
29	12783	PNB	8.983	56.4	High	7700 MILESTONE PKWY	ARUNDEL PRESERVE
31	2289	PN1	0.088	55.3	High	EMMITT AVE	PATAPSCO PARK
31	7205	PN1	1.133	55.3	High	600 HAMMONDS LN	SHICKTON PROPERTY
31	2045	PN2	0.168	55.3	High	ANNAPOLIS RD	ARUNDEL HILLS ANNEX
31	5926	PN2	0.172	55.3	High	ANNAPOLIS RD	ARUNDEL HILLS ANNEX
31	7556	PN2	0.172	55.3	High	ANNAPOLIS RD	ARUNDEL HILLS ANNEX
31	7266	PN7	2.533	55.3	High	1250 STONEY RUN RD	STONEY RUN
31	9587	PNB	2.670	55.3	High	7701 MILESTONE PKWY	ARUNDEL PRESERVE

Table F.1 - 100 Highest Rated Parces for Preservation

Rank	Parcel ID	Subwatershed Code	Area (acres)	Ranking Score	Priority Rating	Address	City
31	11798	PNB	34.674	55.3	High	CLARK RD	ARUNDEL MILLS
31	8593	PNC	1.339	55.3	High	7175 OHIO AVE	LENNOX PARK
31	8605	PNC	6.411	55.3	High	RACE RD	HANOVER
41	13321	PN2	65.967	55.3	High	PATAPSCO STATE PARK	RAYNOR HEIGHTS
42	13706	PNB	0.033	55.1	High	7675 ELMCREST RD	ENCLAVE AT ARUNDEL PRES
42	13716	PNB	0.152	55.1	High	2304 SYCAMORE PLACE	ENCLAVE AT ARUNDEL PRES
42	13726	PNB	0.137	55.1	High	2305 SYCAMORE PLACE	ENCLAVE AT ARUNDEL PRES
42	13768	PNB	0.045	55.1	High	7658 ELMCREST RD	ENCLAVE AT ARUNDEL PRES
42	13780	PNB	0.045	55.1	High	2334 ASBERRY RD	ENCLAVE AT ARUNDEL PRES
47	5169	PN1	0.072	54.2	High	12TH AVE	BROOKLYN PARK
47	13694	PN9	5.960	54.2	High	FLOOD PLAIN	LINPRO HARMANS PROPERTY
47	12064	PNB	0.330	54.2	High	MD RT 100 #78713	HANOVER
47	11841	PNC	0.258	54.2	High	1705 FOREST CREEK DR	FOREST CREEK PROPERTY
51	517	PN1	0.068	53.1	High	304 HOFFMAN AVE	GRAY'S PARK
51	5407	PN6	0.359	53.1	High	RIDGE RD	HANOVER
51	11872	PN6	4.542	53.1	High	RIDGE RD	HANOVER
51	8009	PNB	0.046	53.1	High	1436 PANGBOURNE WAY	CHESHIRE VLGE OF DORCH
51	8026	PNB	0.033	53.1	High	1507 MARTOCK LN	HAMPSHIRE/VLG DORCHESTER
51	7924	PNB	0.033	53.1	High	1505 MARTOCK LN	HAMPSHIRE/VLG DORCHESTER
51	8305	PNB	0.041	53.1	High	1512 MARTOCK LN	HAMPSHIRE/VLG DORCHESTER
51	8048	PNB	0.039	53.1	High	1554 PENZANCE WAY	DORSET VLGE OF DORCHSTER
51	8059	PNB	0.046	53.1	High	1503 PANGBOURNE WAY	CHESHIRE AT VLGE OF DORC
51	8328	PNB	0.033	53.1	High	1535 OAKLEY LN	HAMPSHIRE/VLG DORCHESTER
51	8703	PNB	0.033	53.1	High	1520 MARTOCK LN	HAMPSHIRE/VLG DORCHESTER
51	8841	PNB	0.046	53.1	High	1429 PANGBOURNE WAY	CHESHIRE VLGE OF DORCH
51	9297	PNB	0.792	53.1	High	7221 RIDGE RD	STONEY RUN
51	9498	PNB	0.199	53.1	High	7782 ROTHERHAM DR	YORKSHIRE VLGS OF DORCH
51	12689	PNB	0.040	53.1	High	1551 RUTLAND WAY	RUTLAND AT VILL OF DORCH
51	12112	PNB	0.082	53.1	High	1725 ALLERFORD DR	KENT AT VILLAGE OF DORCH
51	12776	PNB	0.053	53.1	High	2110 SPLIT CREEK LN	ENCLV ARNDL PRSVE
51	12262	PNB	0.054	53.1	High	7526 HELSTON CT	SUFFOLK AT VILL OF DORCH
51	12306	PNB	0.039	53.1	High	1503 RUTLAND WAY	RUTLAND AT VILL OF DORCH
51	12428	PNB	0.046	53.1	High	7713 CLAY BRIDGE CT	ENCLV ARNDL PRSVE
51	13767	PNB	0.959	53.1	High	7696 DORCHESTER BLVD	SHOPS AT ARNDL PRSVE
51	13990	PNB	8.948	53.1	High	7478-7482 NEW RIDGE RD	HANOVER
51	8240	PNC	0.115	53.1	High	7298 RACE RD	DORSEY
51	8704	PNC	1.879	53.1	High	RACE RD	HANOVER

Table F.1 - 100 Highest Rated Parces for Preservation

Rank	Parcel ID	Subwatershed Code	Area (acres)	Ranking Score	Priority Rating	Address	City
51	9058	PNC	1.866	53.1	High	RACE RD	NR HANOVER
51	9198	PNC	2.079	53.1	High	#78747 DORSEY RD	PARKWAY INDUST CTR II
51	13798	PNC	5.500	53.1	High	MONTEVIDEO RD	JESSUP
51	13867	PNC	0.904	53.1	High	1923 MONTEVIDEO RD	REDMOND PROPERTY
79	12020	PNB	0.159	53.1	High	7718 SUFFOLK WAY	WILLOWBEND
79	7469	PNC	1.948	53.1	High	OHIO AVE	LENNOX PARK
81	13506	PN5	5.515	53.1	High	1226 FURNACE RD	PATAPSCO
81	9497	PNB	1.280	53.1	High	1904 RIDGEWOOD RD	RIDGEWOOD ESTATES
83	9559	PNB	3.465	52.9	High	1902 YOUSE AVE	W WATERS YOUSE PROP
83	11241	PNB	5.447	52.9	High	YOUSE AVE	W WATERS YOUSE PROP
85	4914	PN5	1.402	52.0	High	1112 FURNACE RD	PATAPSCO
85	7144	PN5	0.315	52.0	High	1220 GLORIA AVE	SHIRKEY HEIGHTS
85	6760	PN5	0.471	52.0	High	1219 GLORIA AVE	SHIRKEY HEIGHTS
85	13490	PN5	241.235	52.0	High		
85	9241	PN7	7.097	52.0	High	STONEY RUN RD	HANOVER
85	13254	PN9	0.583	52.0	High	7590 BUCKINGHAM BLVD	BUCKINGHAM
85	5350	PNA	6.154	52.0	High	1336 HANOVER RD	RIDGE RD
85	13361	PNA	1.055	52.0	High	RACE RD	HANOVER
85	12207	PNB	0.036	52.0	High	7651 SANDHURST LANE	LANSHIRE AT VILL OF DORC
85	8581	PNC	0.170	52.0	High	7153 OHIO AVE	LENNOX PARK
95	12739	PNB	0.062	51.7	High	2237 BRIMSTONE PL	ENCLAVE AT ARUNDEL PRES
95	12750	PNB	0.064	51.7	High	2276 BRIMSTONE PL	ENCLAVE AT ARUNDEL PRES
95	12371	PNB	0.066	51.7	High	7759 CRYSTAL BROOK WAY	ENCLAVE AT ARUNDEL PRES
95	13946	PNB	0.035	51.7	High	7638 ELMCREST RD	ENCLAVE AT ARUNDEL PRES
99	4871	PN7	0.174	50.8	High	RIDGE RD	HANOVER
99	8637	PNC	8.754	50.8	High	7237 FOREST AVE	LENNOX PARK

APPENDIX G – RESTORATION PROJECTS

Table G.1 - Potential Restoration Sites - Dry and Wet pond retrofit

Storm	Ownership	BMP Type	Acres to Retrofit (subshed)	Impervious Acres to Retrofit (subshed)	Current Condition			Pollutant Reduction		
					TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)
98	CountyPrivate	DP	3.1	0.2	2.8	0.7	0.1	0.99	0.33	0.04
139	CountyPrivate	DP	22.1	8.5	82.6	23.8	2.2	28.92	11.92	1.68
149	CountyPrivate	DP	48.0	23.0	240.1	54.6	6.4	84.03	27.29	4.77
171	CountyPrivate	DP	87.1	7.9	92.0	23.0	1.9	32.21	11.52	1.45
717	CountyPrivate	DP	57.8	15.4	165.3	41.9	3.2	57.85	20.95	2.43
1155	CountyPrivate	DP	4.4	2.8	25.8	7.8	0.8	9.02	3.88	0.58
3939	CountyPrivate	DP	1.6	0.9	8.2	2.2	0.2	2.88	1.09	0.12
8823	CountyPrivate	DP	2.9	2.1	39.1	3.3	0.7	13.67	1.67	0.51
3963	CountyPrivate	DP	0.2	0.1	0.7	0.2	0.0	0.25	0.11	0.02
55	CountyPrivate	WP	30.0	21.1	372.1	39.4	6.3	74.41	5.91	1.58
154	CountyPrivate	WP	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
361	CountyPrivate	WP	10.1	8.0	75.7	11.8	2.4	15.14	1.77	0.60
685	CountyPrivate	WP	55.7	33.3	625.1	64.8	10.1	125.02	9.71	2.53
726	CountyPrivate	WP	10.4	6.5	61.0	16.3	1.2	12.20	2.44	0.29
728	CountyPrivate	WP	30.3	23.9	446.8	60.4	4.5	89.37	9.06	1.11
822	CountyPrivate	WP	13.9	3.7	44.8	10.4	0.7	8.96	1.56	0.18
1621	CountyPrivate	WP	37.0	11.5	132.7	30.9	2.1	26.53	4.63	0.53
1748	CountyPrivate	WP	15.8	13.0	111.6	20.2	3.8	22.31	3.03	0.96
2329	CountyPrivate	WP	0.2	0.1	0.6	0.2	0.0	0.11	0.03	0.00
4455	CountyPrivate	WP	10.2	6.4	111.2	11.3	1.9	22.25	1.69	0.47
5122	CountyPrivate	WP	65.0	46.3	421.8	118.3	9.8	84.36	17.74	2.45
6135	CountyPrivate	WP	11.1	4.1	44.0	14.3	1.6	8.80	2.14	0.41
42	CountyPublic	DP	3.7	1.3	15.5	3.6	0.2	5.44	1.82	0.18
843	CountyPublic	DP	5.4	2.3	17.3	6.3	0.5	6.05	3.15	0.35
853	CountyPublic	DP	52.6	13.8	107.4	41.7	3.4	37.57	20.83	2.57
1081	CountyPublic	DP	22.5	13.6	126.5	24.8	4.1	44.26	12.40	3.07
1082	CountyPublic	DP	4.0	2.5	24.0	6.6	0.6	8.42	3.28	0.42
1220	CountyPublic	DP	21.5	7.3	56.7	19.8	1.3	19.85	9.92	1.00
1439	CountyPublic	DP	42.4	15.1	146.2	32.0	5.1	51.17	16.01	3.83
2886	CountyPublic	DP	8.7	3.3	35.3	9.2	0.7	12.36	4.61	0.55
10520	CountyPublic	DP	1.4	0.6	4.2	1.6	0.1	1.48	0.81	0.10
113	CountyPublic	WP	95.8	70.5	578.5	172.3	13.8	115.70	25.85	3.44
602	CountyPublic	WP	30.8	11.2	125.2	29.4	2.0	25.05	4.42	0.51

Table G.1 - Potential Restoration Sites - Dry and Wet pond retrofit

					Current Condition			Pollutant Reduction		
Storm	Ownership	BMP Type	Acres to Retrofit (subshed)	Impervious Acres to Retrofit (subshed)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)
617	CountyPublic	WP	16.2	6.6	49.7	17.6	1.2	9.95	2.64	0.30
796	CountyPublic	WP	10.8	4.5	51.1	12.0	0.8	10.22	1.81	0.21
802	CountyPublic	WP	27.9	13.0	98.7	34.6	2.4	19.73	5.19	0.59
803	CountyPublic	WP	36.1	10.6	86.0	29.8	2.1	17.20	4.47	0.51
806	CountyPublic	WP	20.9	8.0	62.4	21.8	1.5	12.47	3.28	0.37
807	CountyPublic	WP	94.4	25.7	192.4	68.6	4.7	38.48	10.29	1.18
808	CountyPublic	WP	18.5	7.7	87.0	20.7	1.5	17.40	3.11	0.37
836	CountyPublic	WP	34.6	11.7	78.3	32.4	2.4	15.67	4.86	0.59
854	CountyPublic	WP	33.5	13.2	123.9	45.4	4.6	24.78	6.82	1.16
2463	CountyPublic	WP	39.0	14.9	112.0	41.0	3.0	22.40	6.15	0.76
3146	CountyPublic	WP	39.5	20.2	191.0	34.1	6.3	38.21	5.12	1.57
6134	CountyPublic	WP	0.8	0.0	0.4	0.1	0.0	0.07	0.01	0.00

Table G.2 - Potential Restoration Sites - Impaired Outfalls

				Current Condition			Pollutant Reduction		
Outfall Feature ID	**Rating**	**Acres to outfall (subshed)**	**Impervious Acres to Outfall (subshed)**	**TN (lbs/year)**	**TP (lbs/year)**	**TSS (Tons/year)**	**TN (lbs/year)**	**TP (lbs/year)**	**TSS (Tons/year)**
L02D7O001	Very Poor	34.13	13.82	322.1	39.1	2.9	128.86	23.48	2.44
M01E8O001	Very Poor	36.12	21.40	465.7	57.8	4.2	186.27	34.70	3.55
M01F6O001	Very Poor	134.18	78.13	1648.1	216.3	16.8	659.23	129.78	14.32
M02A7O001	Very Poor	107.20	35.99	726.2	78.1	9.6	290.47	46.86	8.17
M02C6O001	Very Poor	48.84	18.46	398.4	50.4	3.6	159.37	30.23	3.02
M02C7O011	Very Poor	78.59	33.45	642.0	88.5	6.3	256.80	53.07	5.39
M02D1O001	Very Poor	102.95	48.80	1080.5	133.5	9.8	432.19	80.11	8.31
M03A4O001	Very Poor	0.82	0.62	11.1	1.5	0.1	4.42	0.89	0.09
M03D1O009	Very Poor	29.99	21.15	202.2	53.7	4.0	80.90	32.24	3.39
G08G5O001	Poor	18.93	6.17	46.3	16.1	1.1	18.53	9.65	0.93
G09D2O008	Poor	1.99	0.39	4.0	1.1	0.1	1.61	0.67	0.07
G09E1O012	Poor	0.07	0.03	0.3	0.1	0.0	0.13	0.06	0.01
G09F2O001	Poor	0.19	0.10	1.0	0.3	0.0	0.41	0.18	0.03
G09G1O001	Poor	0.06	0.01	0.1	0.0	0.0	0.04	0.01	0.00
G09H4O001	Poor	0.05	0.05	0.4	0.2	0.0	0.17	0.09	0.01
H06E8O001	Poor	12.54	2.81	27.3	5.2	0.9	10.93	3.14	0.79
H06H8O001	Poor	42.52	26.22	231.1	44.8	8.1	92.42	26.90	6.87
H07D6O001	Poor	10.20	3.19	38.4	9.5	0.7	15.35	5.72	0.63
H07E1O001	Poor	10.48	3.06	31.9	9.4	1.1	12.76	5.62	0.94
H07E4O001	Poor	2.18	1.06	11.7	3.4	0.3	4.70	2.06	0.29
H07G1O005	Poor	6.88	5.95	51.3	8.8	1.8	20.52	5.27	1.51
H07H2O001	Poor	24.67	13.84	122.7	25.0	3.7	49.06	15.00	3.17
H07H2O002	Poor	67.59	45.74	408.3	102.3	10.4	163.33	61.41	8.81
H07H3O001	Poor	3.88	3.32	28.6	4.9	1.0	11.45	2.95	0.84
H07H4O008	Poor	46.26	17.49	170.6	42.9	4.6	68.23	25.76	3.93
H08B6O001	Poor	96.67	27.54	208.5	74.4	5.1	83.41	44.63	4.33
H08B7O004	Poor	19.29	6.73	40.4	19.2	1.5	16.18	11.54	1.24
H08E1O001	Poor	29.94	4.93	62.1	15.3	1.3	24.84	9.17	1.07
H08E8O001	Poor	48.65	20.55	209.9	63.2	5.6	83.94	37.94	4.79

Table G.2 - Potential Restoration Sites - Impaired Outfalls

				Current Condition			Pollutant Reduction		
Outfall Feature ID	**Rating**	**Acres to outfall (subshed)**	**Impervious Acres to Outfall (subshed)**	**TN (lbs/year)**	**TP (lbs/year)**	**TSS (Tons/year)**	**TN (lbs/year)**	**TP (lbs/year)**	**TSS (Tons/year)**
H08F1O001	Poor	3.62	1.43	14.6	4.6	0.5	5.86	2.79	0.44
H08F5O001	Poor	27.91	12.97	98.7	34.6	2.4	39.46	20.77	2.00
H08G4O001	Poor	1.58	0.13	1.4	0.5	0.0	0.56	0.28	0.03
H08G4O003	Poor	34.66	10.52	84.7	29.3	2.0	33.87	17.60	1.72
H08G5O001	Poor	13.10	6.05	70.2	16.4	1.1	28.10	9.84	0.94
H08H7O001	Poor	13.25	5.96	66.8	15.6	1.0	26.70	9.35	0.89
H08H7O004	Poor	12.39	4.34	49.1	11.6	0.8	19.64	6.94	0.67
H08H8O001	Poor	14.84	6.59	49.0	17.4	1.2	19.61	10.42	1.02
H09B6O009	Poor	0.06	0.03	0.4	0.1	0.0	0.15	0.05	0.01
H09E2O019	Poor	42.34	16.68	124.6	46.4	3.6	49.82	27.85	3.03
I04F5O013	Poor	5.25	4.59	25.8	10.4	0.7	10.33	6.23	0.63
I04G4O001	Poor	19.66	14.91	89.1	36.1	2.7	35.63	21.65	2.27
I04G4O007	Poor	1.92	0.69	4.3	1.7	0.1	1.74	1.05	0.11
I04G4O009	Poor	0.25	0.19	1.1	0.4	0.0	0.44	0.27	0.03
I04G6O012	Poor	0.25	0.17	1.2	0.6	0.1	0.48	0.35	0.05
I04H7O017	Poor	51.72	13.39	92.2	29.8	3.3	36.86	17.88	2.77
I04H8O017	Poor	27.09	19.67	120.7	49.1	3.7	48.27	29.44	3.17
I06A7O001	Poor	87.12	35.45	327.7	62.4	10.9	131.10	37.45	9.28
I07A1O001	Poor	0.17	0.11	1.1	0.2	0.0	0.42	0.14	0.03
I07A1O006	Poor	47.87	14.76	145.4	37.0	5.2	58.14	22.18	4.40
I07B6O001	Poor	29.75	7.29	76.4	17.4	2.0	30.54	10.47	1.68
I07B6O003	Poor	1.55	1.24	10.7	1.9	0.4	4.28	1.14	0.32
I07H8O011	Poor	0.19	0.17	1.4	0.2	0.0	0.57	0.15	0.04
I08D4I001	Poor	0.65	0.18	2.2	0.5	0.0	0.88	0.30	0.03
I08G4O001	Poor	15.74	6.59	74.2	19.8	1.7	29.69	11.87	1.47
I09A1O009	Poor	28.26	7.30	44.4	22.1	1.8	17.78	13.27	1.54
I09E1O001	Poor	3.16	0.50	4.7	1.5	0.1	1.86	0.91	0.09
I09E1O006	Poor	18.83	6.80	52.7	18.5	1.2	21.10	11.09	1.06
J02H4O008	Poor	15.16	7.77	149.2	17.7	2.3	59.67	10.59	1.93
J02H4O011	Poor	1.08	0.80	15.3	2.3	0.2	6.12	1.39	0.19
J02H7O012	Poor	4.10	1.89	20.8	6.1	0.6	8.33	3.64	0.52
J04A6O004	Poor	3.41	1.82	11.3	4.4	0.3	4.50	2.64	0.29

Table G.2 - Potential Restoration Sites - Impaired Outfalls

				Current Condition			Pollutant Reduction		
Outfall Feature ID	Rating	Acres to outfall (subshed)	Impervious Acres to Outfall (subshed)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)
J04A7O021	Poor	2.50	0.16	1.4	0.3	0.1	0.57	0.19	0.05
K02A4O001	Poor	0.26	0.19	3.5	0.3	0.1	1.41	0.18	0.05
K02B8O006	Poor	12.68	8.49	77.7	14.2	2.7	31.07	8.51	2.30
K02C4O009	Poor	7.73	7.32	62.8	10.8	2.2	25.13	6.45	1.85
K02C6O001	Poor	22.89	14.39	268.5	30.4	3.7	107.41	18.24	3.11
K02D5O001	Poor	0.76	0.54	4.7	0.8	0.2	1.89	0.49	0.14
K02E4O001	Poor	29.42	24.44	424.8	37.3	7.4	169.93	22.38	6.27
K03A1O007	Poor	1.46	0.54	5.6	1.6	0.2	2.23	0.98	0.16
K03B1O001	Poor	33.82	13.97	156.8	38.7	3.5	62.72	23.25	2.94
K03C2O001	Poor	48.03	17.50	403.1	48.8	3.3	161.23	29.30	2.79

Table G.3 - Potential Restoration Sites - Streams

Reach	Length	Rating	Acres to BMP (subshed)	Impervious Acres to Stream	Current Condition			Pollutant Reduction		
					TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)
PN2003	1671	Degraded	502	162.7	3474.8	454.0	38.1	1389.93	272.41	22.85
PN5008	991	Degraded	54	13.6	294.7	44.7	5.0	117.86	26.84	3.03
PN5010	2205	Degraded	84	10.7	196.4	32.3	2.9	78.54	19.40	1.72
PN5016	1567	Degraded	81	28.8	567.7	75.7	6.1	227.07	45.45	3.66
PN7001	1691	Degraded	1603	442.0	7603.3	932.7	132.1	3041.34	559.62	79.28
PN7019	699	Degraded	550	125.7	2022.2	291.6	36.4	808.90	174.94	21.81
PN8001	2183	Degraded	178	98.9	1128.9	243.6	21.4	451.56	146.17	12.85
PN8006	2521	Degraded	677	348.0	6443.2	866.8	65.0	2577.27	520.08	38.97
PN8016	2289	Degraded	79	37.0	667.1	86.7	7.7	266.83	52.03	4.61
PN8025	1158	Degraded	100	82.8	1540.5	210.6	16.1	616.22	126.35	9.64
PN9019	2498	Degraded	149	33.0	686.0	93.9	7.5	274.40	56.34	4.49
PNA011	997	Degraded	103	15.3	305.2	29.8	3.5	122.06	17.90	2.09
PNB002	340	Degraded	40	5.4	133.2	16.3	2.2	53.27	9.77	1.32
PNB015	280	Degraded	512	143.8	2422.4	236.3	38.3	968.94	141.80	22.97
PNB019	173	Degraded	30	11.4	216.4	24.5	3.8	86.55	14.70	2.28
PNB043	821	Degraded	1043	269.5	5114.8	737.7	60.0	2045.92	442.64	36.01
PNB065	1058	Degraded	111	15.8	323.8	52.7	6.0	129.54	31.59	3.62
PNB086	525	Degraded	110	4.5	167.0	17.9	1.9	66.81	10.74	1.12
PNC009	498	Degraded	33	2.3	72.6	8.2	0.8	29.05	4.91	0.45
PNC068	817	Degraded	213	91.8	1747.9	195.0	30.0	699.17	116.99	18.01
PN5001	400	Severely Degraded	87	9.2	228.6	21.9	3.3	91.44	13.13	1.98
PN6004	1176	Severely Degraded	544	172.3	2825.0	449.9	48.2	1129.99	269.95	28.92
PN8012	1760	Severely Degraded	58	12.8	249.7	24.6	4.1	99.87	14.78	2.46
PN8014	863	Severely Degraded	126	57.9	436.1	142.5	12.4	174.42	85.53	7.47
PN8019	407	Severely Degraded	6	2.2	42.2	6.8	0.8	16.86	4.08	0.47
PN8021	161	Severely Degraded	8	3.6	61.9	9.8	1.1	24.78	5.88	0.68
PN8023	253	Severely Degraded	18	7.6	136.2	19.6	1.8	54.48	11.76	1.10
PN8027	489	Severely Degraded	3	1.3	22.9	3.1	0.3	9.15	1.84	0.17
PN8028	226	Severely Degraded	9	6.5	115.6	17.0	1.6	46.25	10.20	0.98
PN8030	547	Severely Degraded	119	41.3	794.3	105.8	8.9	317.73	63.45	5.32
PN8050	92	Severely Degraded	28	17.8	336.4	50.6	5.1	134.56	30.36	3.04
PN9037	1095	Severely Degraded	1730	443.3	7484.7	1259.3	117.9	2993.86	755.58	70.76
PN9059	2046	Severely Degraded	69	11.3	285.2	33.0	2.4	114.08	19.80	1.44

Table G.3 - Potential Restoration Sites - Streams

Reach	Length	Rating	Acres to BMP (subshed)	Impervious Acres to Stream	Current Condition			Pollutant Reduction		
					TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)	TN (lbs/year)	TP (lbs/year)	TSS (Tons/year)
PNA013	2106	Severely Degraded	16	0.8	26.5	3.2	0.4	10.58	1.91	0.23
PNB004	1324	Severely Degraded	24	0.1	20.7	1.6	0.2	8.26	0.95	0.12
PNB008	200	Severely Degraded	28	7.6	153.5	16.2	2.6	61.41	9.71	1.57
PNB026	1646	Severely Degraded	388	80.3	1736.7	227.4	24.7	694.68	136.42	14.84
PNB030	1957	Severely Degraded	357	145.0	2774.4	389.1	34.2	1109.77	233.44	20.50
PNC006	1526	Severely Degraded	121	9.0	270.3	30.5	2.7	108.12	18.28	1.63
PNC024	987	Severely Degraded	37	6.3	158.6	19.6	1.5	63.45	11.73	0.90
PNC040	674	Severely Degraded	77	6.3	193.3	22.4	1.9	77.31	13.43	1.13

Table G.4 - Potential Restoration Sites - LID/ESD Retrofit

PIN	Ownership	Acres to Retrofit (subshed)	Impervious Acres to Retrofit (subshed)	Current Condition TN (lbs/year)	Current Condition TP (lbs/year)	Current Condition TSS (Tons/year)	Pollutant Reduction TN (lbs/year)	Pollutant Reduction TP (lbs/year)	Pollutant Reduction TSS (Tons/year)
14012009800000000000000	AAC Board Of Ed	11.33	2.68	25.64	6.77	0.51	12.8	4.7	0.5
14003045600000000000000	AAC Board Of Ed	19.07	6.10	45.87	14.72	1.09	22.9	10.3	1.0
01018021500000000000000	AAC Board Of Ed	7.06	2.05	25.70	4.92	0.38	12.9	3.4	0.3
02019002500000000000000	AAC Board Of Ed	4.06	2.45	22.07	5.81	0.42	11.0	4.1	0.4
04009027500000000000000	AAC Board Of Ed	3.49	2.24	19.89	5.32	0.38	9.9	3.7	0.3
01023007900000000000000	AAC Board Of Ed	5.84	1.36	27.46	3.66	0.27	13.7	2.6	0.2
04006060600000000000000	AAC Board Of Ed	41.99	12.71	112.14	30.88	2.41	56.1	21.6	2.2
08021005000000000000000	AAC Rec & Parks	21.72	4.74	43.43	10.91	0.91	21.7	7.6	0.8
14012049400000000000000	AAC Rec & Parks	0.03	0.00	0.03	0.01	0.00	0.0	0.0	0.0
04014059200000000000000	AAC Rec & Parks	1.34	0.07	0.95	0.20	0.02	0.5	0.1	0.0
01012057100100000000110	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
02007002600080000000019	AAC Rec & Parks	0.21	0.03	0.30	0.10	0.01	0.1	0.1	0.0
02007002600080000000020	AAC Rec & Parks	0.21	0.03	0.30	0.10	0.01	0.1	0.1	0.0
02007002600080000000018	AAC Rec & Parks	0.21	0.03	0.30	0.10	0.01	0.1	0.1	0.0
01012057100100000000102	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01018034100000000000000	AAC Rec & Parks	14.55	2.19	39.84	5.59	0.45	19.9	3.9	0.4
01012057100100000000100	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01012057100100000000118	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01012002600000000000108	AAC Rec & Parks	0.03	0.00	0.08	0.01	0.00	0.0	0.0	0.0
01012057100100000000120	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
04010094300000000000000	AAC Rec & Parks	2.27	0.18	2.23	0.58	0.05	1.1	0.4	0.0
01012057100100000000104	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01012057100100000000112	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01012057100100000000106	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
04003087400000000000000	AAC Rec & Parks	11.70	2.35	42.37	6.29	0.47	21.2	4.4	0.4
01012057100100000000124	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01012057100100000000122	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
01012057100100000000114	AAC Rec & Parks	0.45	0.14	1.95	0.30	0.02	1.0	0.2	0.0
04006007900000000000000	AAC Rec & Parks	4.90	0.60	13.94	1.50	0.14	7.0	1.1	0.1
02007002600080000000021	AAC Rec & Parks	0.21	0.03	0.30	0.10	0.01	0.1	0.1	0.0

Concept Restoration Plan Site Selection Candidate:

Airport Square Dry Pond Retrofit

ADC Map/Grid: 4938 C8

Drainage Area: 217 Acres

Imperviousness: 129 Acres (59%)

Subwatershed: Unnamed Patapsco River Tributary PN4

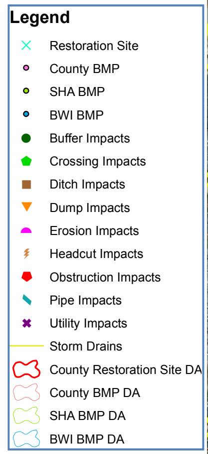
Subwatershed Ranking for Restoration Scores:

Combined: 14 / 42.91 / Very Poor
Patapsco Non-Tidal: 5 / 44.60 / Fair

Reach Segment: PN4027

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored - SWM
Patapsco Non-Tidal: Not Scored - SWM



Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

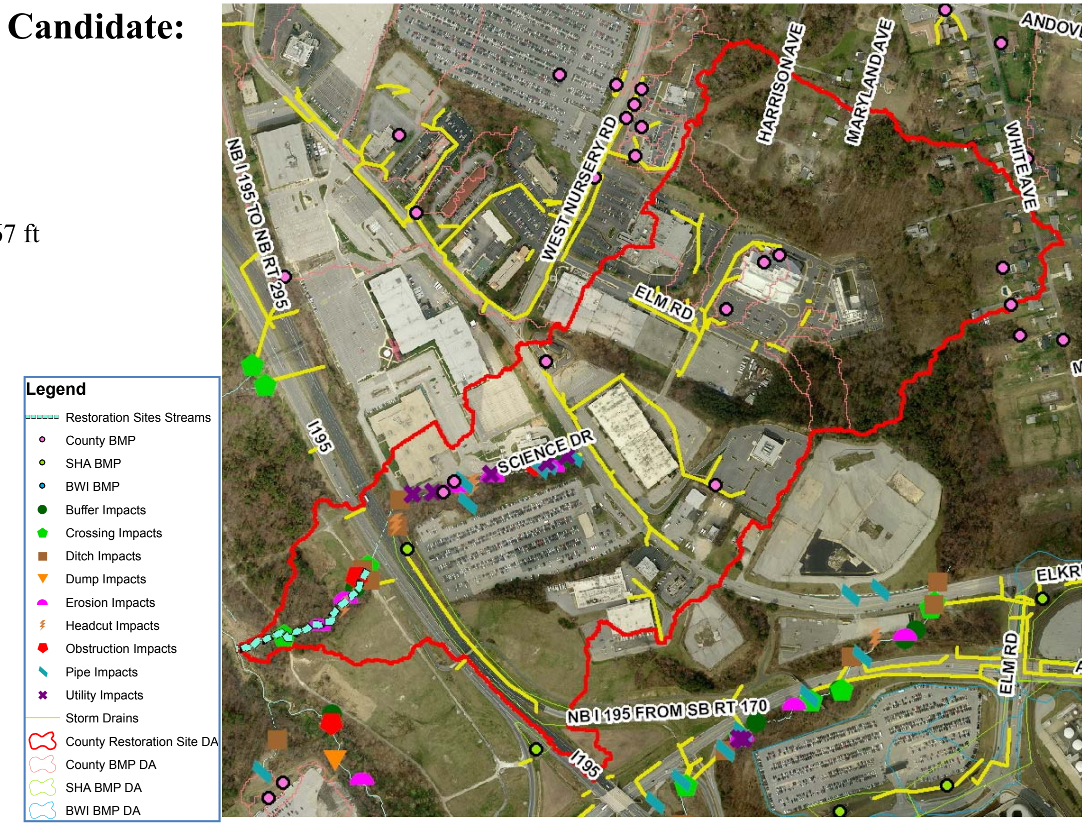
Concept Restoration Plan Ranking:

The project received an overall score of 11 placing it in a tie for eighth highest ranking of 8 out of 23 restoration sites. The project received one of the second lowest tiered scores for design construction (low cost per impervious acre treated) and existing BMP treatment (low BMP treatment according to urban BMP layer). One of the lowest scores for property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Airport Square Dry pond Retrofit	2	2	1	1	2	3	11	8

Concept Restoration Plan Site Selection Candidate:

Amtrak Station Stream Restoration



ADC Map/Grid: 4937 K10.

Drainage Area: 131 Acres, Restoration **Stream Length:** 867 ft

Imperviousness: 58 Acres (44%)

Subwatershed: Stony Run 3 PN8

Subwatershed Ranking for Restoration Scores:

Combined: 8 / 39.81 / Very Poor
Patapsco Non-Tidal: 3 / 40.41 / Poor

Reach Segment: PN8014

Stream Reach Ranking for Restoration Scores:

Combined: 28/55.79/ Very Poor
Patapsco Non-Tidal: 8/55.71/ Very Poor

Description:

This project site was selected because it received the eighth lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 28th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for contributing imperviousness, headcuts, and other infrastructure impacts.

Concept Restoration Plan Ranking:

The project received an overall score of 12 placing it in a tie for tenth highest ranking of 10 out of 23 restoration sites. The project received one of the lowest tiered scores for design construction (low cost per impervious acre treated) and one of the second lowest s tiered scores for existing BMP treatment (low BMP treatment according to urban BMP layer). Property ownership (state owned parcel/floodplain) scored in the second highest tiered group. Facility access (adjacent to public ROW) scored in the second lowest tiered group because of minor constraints associated with state owned property and public ROW..

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Amtrak Station Stream Restoration	1	2	2	2	2	3	12	10

Concept Restoration Plan Site Selection Candidate:

Andorick Acres Dry Pond Retrofit

ADC Map/Grid: 5055 J9

Drainage Area: 21 Acres

Imperviousness: 7 Acres (33%)

Subwatershed: Stony Run IV PN9

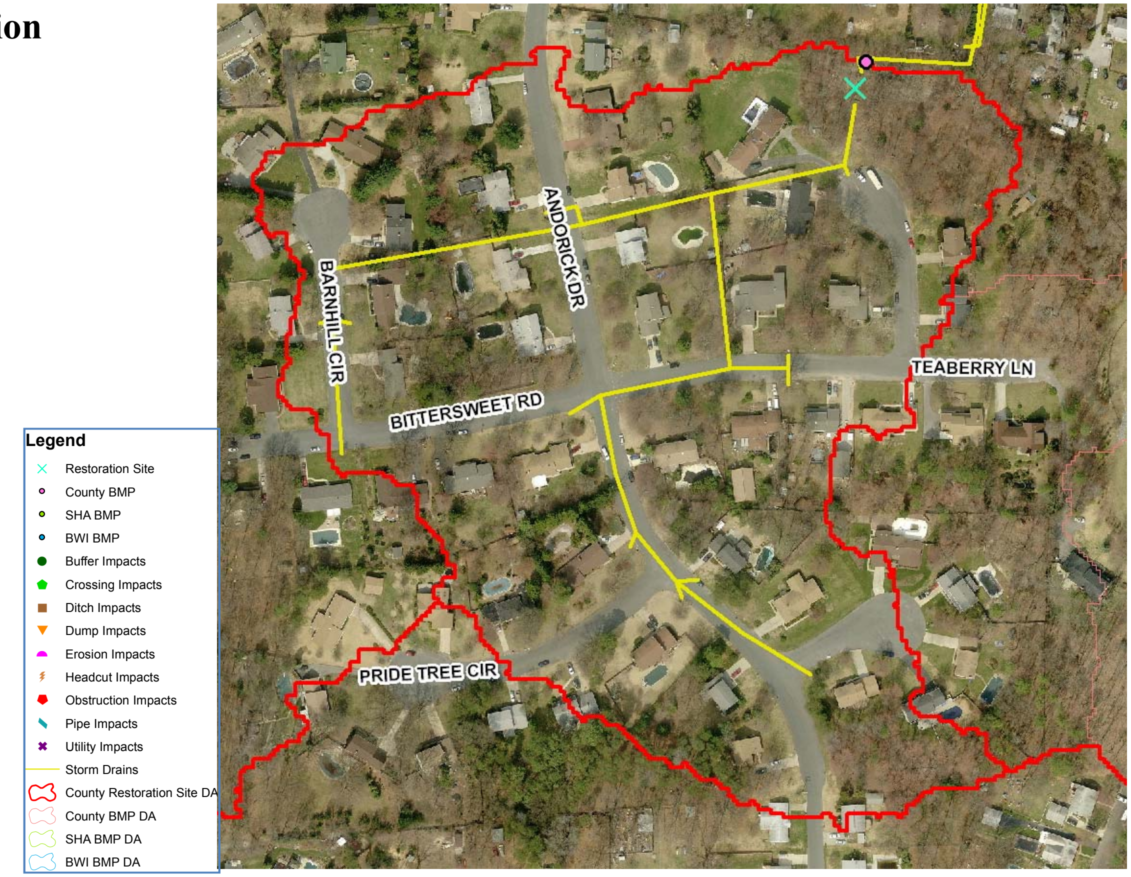
Subwatershed Ranking for Restoration Scores:

Combined: 26 / 48.19 / Very Poor
Patapsco Non-Tidal: 4/ 44.57 / Poor

Reach Segment: NA

Stream Reach Ranking for Restoration Scores:

Combined: NA
Patapsco Non-Tidal: NA



Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

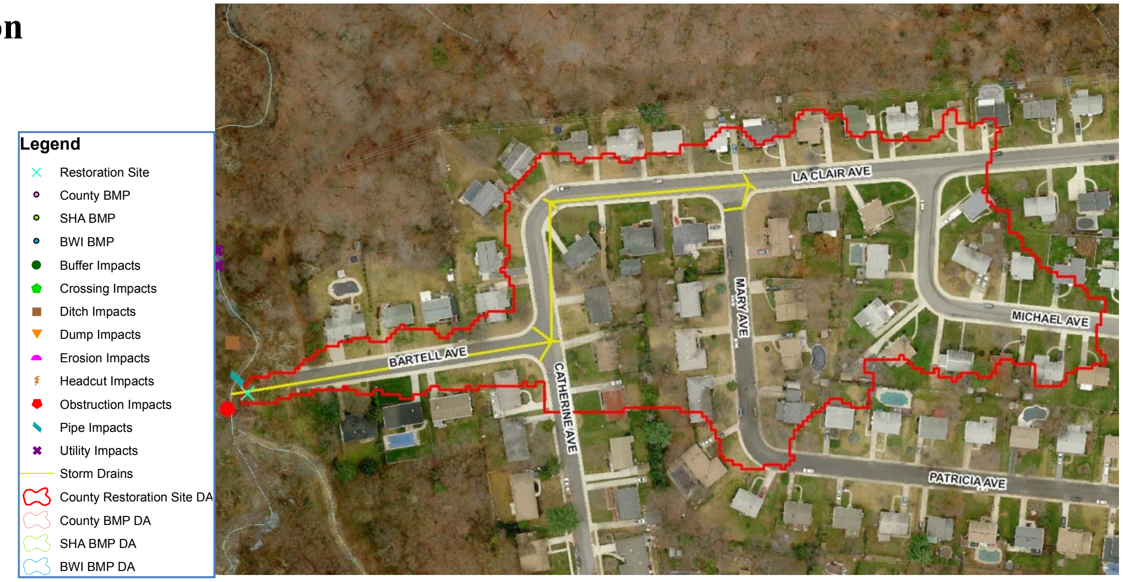
Concept Restoration Plan Ranking:

The project received an overall score of 10 placing it in a tie for third highest ranking of 3 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Andorick Acres Dry Pond Retrofit	2	1	1	1	2	3	10	3

Concept Restoration Plan Site Selection Candidate:

Bartell Ave. SPSC



ADC Map/Grid: 4938 D7

Drainage Area: 7.9Acres

Imperviousness: 3.8 Acres (48%)

Subwatershed: Unnamed Patapsco River Tributary PN4

Subwatershed Ranking for Restoration Scores:

Combined: 14 / 42.91 / Very Poor
Patapsco Non-Tidal: 5 / 44.60 / Fair

Reach Segment: PN4015

Stream Reach Ranking for Restoration Scores:

Combined: 597/81.05/Fair
Patapsco Non-Tidal: 79/81.05/Fair

Description:

This project site was selected because it provides an opportunity to install a step pool stormwater conveyance system and provide stormwater management treatment in an area that currently is not served by stormwater management. The addition of this project will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Ranking:

The project received an overall score of 10 placing it in a tie for third highest ranking of 3 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Bartell Ave. SPSC	2	1	1	1	2	3	10	3

Concept Restoration Plan Site Selection Candidate:

Buckingham Nursery Dr. Stream Restoration

ADC Map/Grid: 5055 J7

Restoration Stream Length: 2,045 ft.

Drainage Area: 386 Acres

Imperviousness: 86.9 Acres (23%)

Subwatershed: Patapsco Mainstem PN9

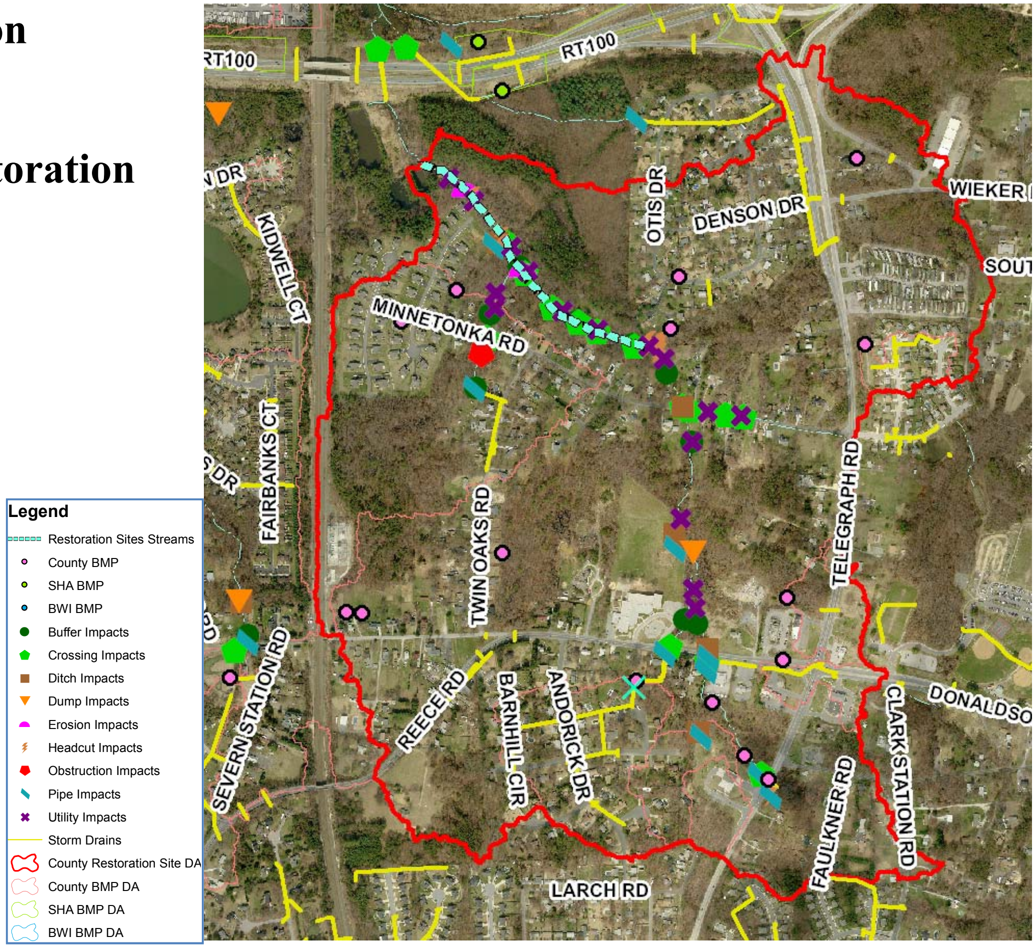
Subwatershed Ranking for Restoration Scores:

Combined: 26 / 48.19 / Very Poor
Patapsco Non-Tidal: 4 / 44.57 / Poor

Reach Segment: PN9059

Stream Reach Ranking for Restoration Scores:

Combined: 6/47.89/ Very Poor
Patapsco Non-Tidal: 2/47.89/ Very Poor



Description:

This project site was selected because it received the second lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 6th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for MPHI habitat and Rosgen level one classification.

Concept Restoration Plan Site Selection Candidate:

Cambium Ct. Dry Pond Retrofit

ADC Map/Grid: 5055 G5

Drainage Area: 18.4 Acres

Imperviousness: 7.7 Acres (42 %)

Subwatershed: Stony Run IV PN9

Subwatershed Ranking for Restoration Scores:

Combined: 26 / 48.19 / Very Poor
Patapsco Non-Tidal: 4/ 44.57 / Poor

Reach Segment: NA

Stream Reach Ranking for Restoration Scores:

Combined: NA
Patapsco Non-Tidal: NA

Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored poorly.

Concept Restoration Plan Ranking:

The project received an overall score of 11 placing it in a tie for eighth highest ranking of 8 out of 23 restoration sites. The project received one of the second lowest tiered scores for design construction (low cost per impervious acre treated) and one of the lowest s tiered scores for existing BMP treatment (low BMP treatment according to urban BMP layer). Property ownership (county owned parcel/floodplain) scored in the second highest tiered group because of community land ownership with county SWM easement. Facility access (adjacent to public ROW) scored in the lowest tiered group because of close proximity to county ROW and easement access for water and sewer.

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Cambium Court Dry Pond Retrofit	2	1	2	1	2	3	11	8

Concept Restoration Plan Site Selection Candidate:

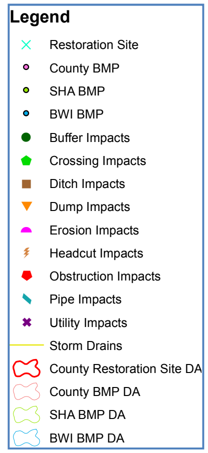
Concorde Circle Dry Pond Retrofit

ADC Map/Grid: 4938 B8

Drainage Area: 60 Acres

Imperviousness: 32 Acres (53%)

Subwatershed: Unnamed Patapsco River Tributary PN4



Subwatershed Ranking for Restoration Scores:

Combined: 14 / 42.91 / Very Poor
Patapsco Non-Tidal: 5 / 44.60 / Poor

Reach Segment: NA

Stream Reach Ranking for Restoration Scores:m

Combined: NA
Patapsco Non-Tidal: NA

Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Ranking:

The project received an overall score of 9 placing it in the highest ranking of 1 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Concorde Circle Dry Pond Retrofit	1	1	1	1	2	3	9	1

Concept Restoration Plan Site Candidate:

Crestwood Rd. Stream Restoration

ADC Map/Grid: 5055 A3

Restoration Stream Length: 1,526 ft.

Drainage Area: 185 Acres

Imperviousness: 16 Acres (9%)

Subwatershed: Deep Run PNC

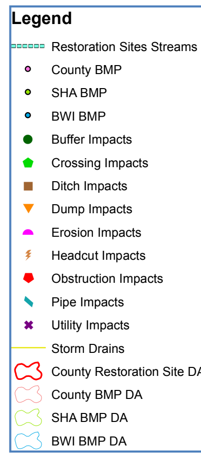
Subwatershed Ranking for Restoration Scores:

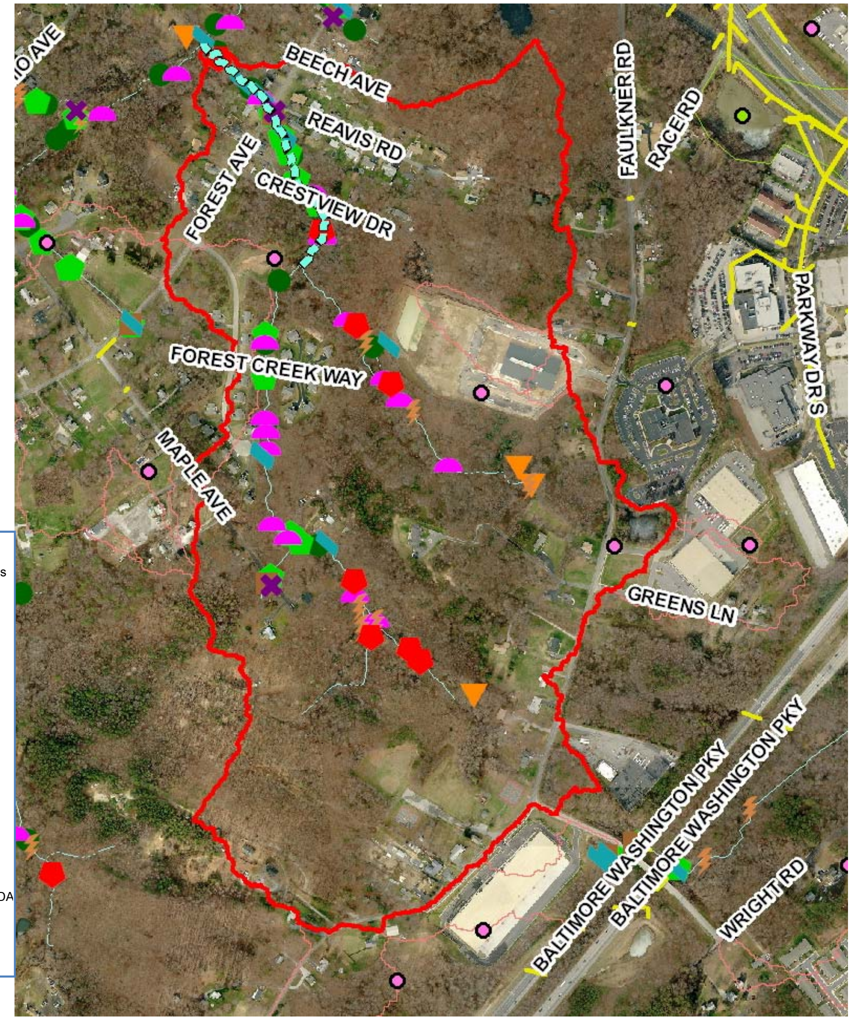
Combined: 86 / 61.35 / Poor
Patapsco Non-Tidal: 10 / 65.70 / Good

Reach Segment: PNC006

Stream Reach Ranking for Restoration Scores:

Combined: 6/47.89/ Very Poor
Patapsco Non-Tidal: 2/47.89/ Very Poor





Description:

This project site was selected because it received the second lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 10th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for MPHI habitat, Rosgen level one classification, and buffer impacts.

Concept Restoration Plan Site Candidate:

Forest Ave. Stream Restoration

ADC Map/Grid: 5054 K4

Restoration Stream Length: 673 ft.

Drainage Area: 86 Acres

Imperviousness: 7 Acres (8%)

Subwatershed: Deep Run PNC

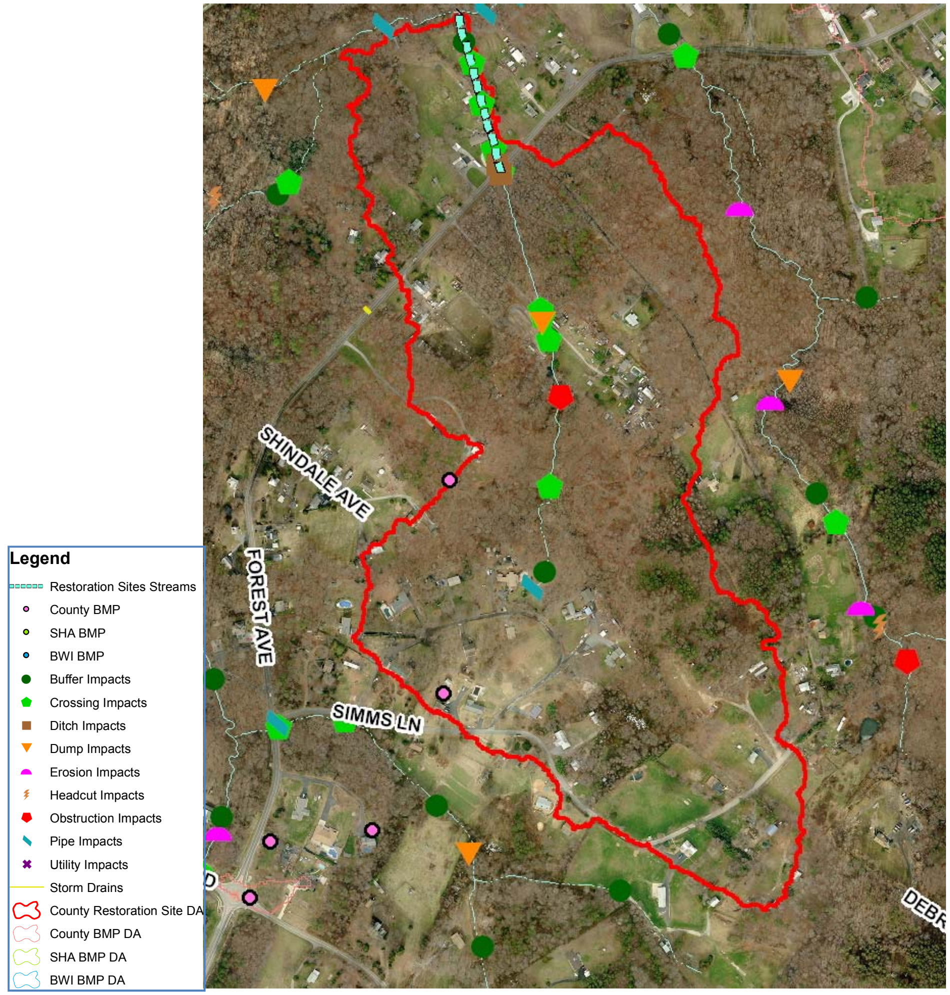
Subwatershed Ranking for Restoration Scores:

Combined: 86 / 61.35 / Poor
Patapsco Non-Tidal: 10 / 65.70 / Good

Reach Segment: PNC040

Stream Reach Ranking for Restoration Scores:

Combined: 6/47.89/ Very Poor
Patapsco Non-Tidal: 2/47.89/ Very Poor



Description:

This project site was selected because it received the 2nd lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 6th for all reaches assessed in the completed watershed studies. The stream reach received a poor score for MPHI rating and buffer impairments.

Concept Restoration Plan Site Selection Candidate:

Harbor Valley Stream Restoration

ADC Map/Grid: 4939 A5

Drainage Area: 172 Acres, **Restoration Stream Length:** 3,100 ft.

Imperviousness: 79.1 Acres (46%)

Subwatershed: Patapsco Mainstem PN1

Subwatershed Ranking for Restoration Scores:

Combined: 3 / 34.49 / Very Poor
Patapsco Non-Tidal: 1 / 29.66 / Very Poor

Closest Downstream Reach Segment: PN1012

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored - Intermittent
Patapsco Non-Tidal: Not Scored – Intermittent

Description:

This project site was selected because it provides an opportunity to restore a piped stream segment and restore it to a functioning aquatic habitat and by providing treatment to an area that currently is not served by stormwater management. This project site falls within the Patapsco Mainstem (PN1) subwatershed. This subwatershed received a combined score of 34.49 and places it in the very poor priority ranking making the subwatershed an ideal candidate for restoration work.

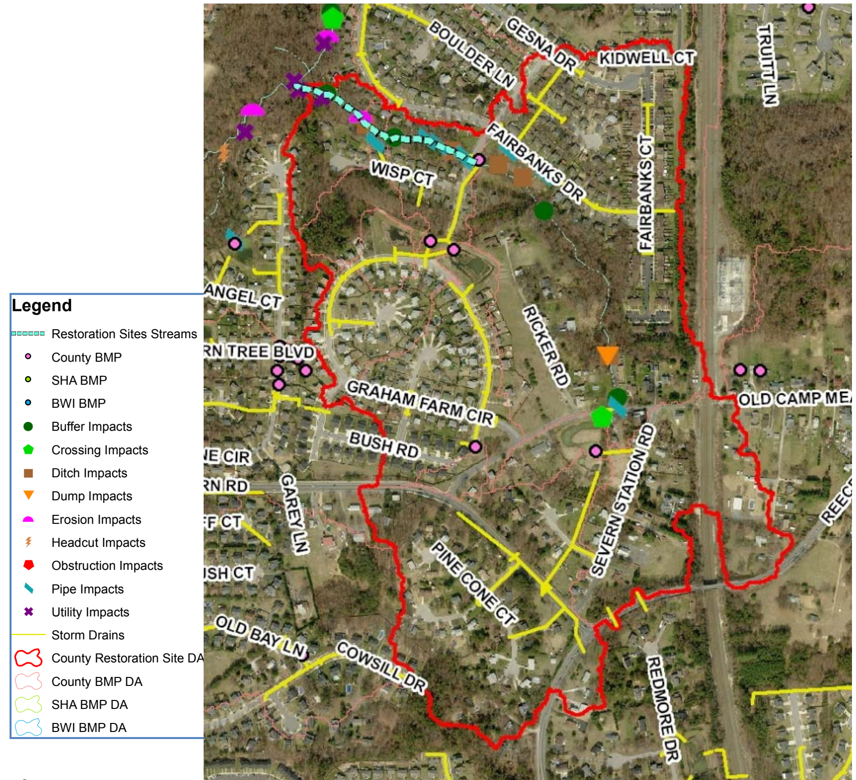
Concept Restoration Plan Ranking:

The project received an overall score of 12 placing it in a tie for tenth highest ranking of 10 out of 23 restoration sites. The project received one of the second lowest tiered scores for design construction (low cost per impervious acre treated) and one of the lowest tiered scores for existing BMP treatment (low BMP treatment according to urban BMP layer). Property ownership (county owned parcel/floodplain) scored in the second highest tiered group because of community land ownership with county SWM easement. Facility access (adjacent to public ROW) scored in the lowest tiered group because of close proximity to county ROW and easement access for water and sewer.

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Harbor Valley Stream Restoration	2	1	2	2	2	3	12	10

Concept Restoration Plan Site Selection Candidate:

Harman Woods Stream Restoration



ADC Map/Grid: 5055 H8

Drainage Area: 142 Acres, **Restoration Stream Length:** 1,094 ft.

Imperviousness: 41 Acres (29 %)

Subwatershed: Stony Run IV PN9

Subwatershed Ranking for Restoration Scores:

Combined: 26 / 48.19 / Very Poor
Patapsco Non-Tidal: 4/ 44.57 / Poor

Reach Segment: PN9037

Stream Reach Ranking for Restoration Scores:

Combined: 118 / 65.26 / Very Poor
Patapsco Non-Tidal: 31/ 65.26 / Poor

Description: This project site was selected because it received the 31st lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 118th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for Rosgen level one classification, and contributing imperviousness. In addition, the site may have the potential for a SPSC system upstream of the stream restoration site.

Concept Restoration Plan Ranking:

The project received an overall score of 13 placing it in ranking of 12 out of 23 restoration sites. The project received one of the second lowest tiered scores for design construction (low cost per impervious acre treated) and one of the highest tiered scores for existing BMP treatment (high percentage of BMP treatment according to urban BMP layer). Property ownership (county owned parcel/floodplain) scored in the second highest tiered group because of community land ownership with county SWM easement. Facility access (adjacent to public ROW) scored in the lowest tiered group because of close proximity to county ROW and easement access for water and sewer.

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Harman Woods Stream Restoration	2	4	1	1	2	3	13	12

Concept Restoration Plan Site Selection Candidate:

Harmans Park SPSC

ADC Map/Grid: 5055 F6

Drainage Area: 9 Acres

Imperviousness: 3.3 Acres (37%)

Subwatershed: Stony Run IV PN9

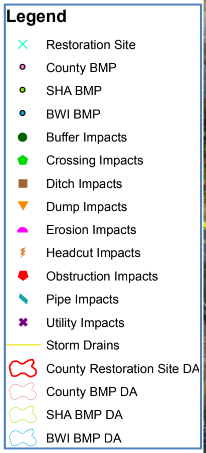
Subwatershed Ranking for Combined: 26 / 48.19 / Very Poor

Patapsco Non-Tidal: 4 / 44.57 / Poor

Reach Segment: NA

Stream Reach Ranking for Restoration Scores:

Combined: NA
Patapsco Non-Tidal: NA



Description:

This project site was selected because it provides an opportunity to install a step pool stormwater conveyance system and provide stormwater management treatment in an area that currently is not served by stormwater management. The addition of this project will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Ranking:

The project received an overall score of 9 placing it in a tie for the highest ranking of 1 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Harmans Park SPSC	2	1	1	1	1	3	9	1

Concept Restoration Plan Site Selection Candidate:

Jerome Ave Dry Pond Retrofit

ADC Map/Grid: 4938 E6

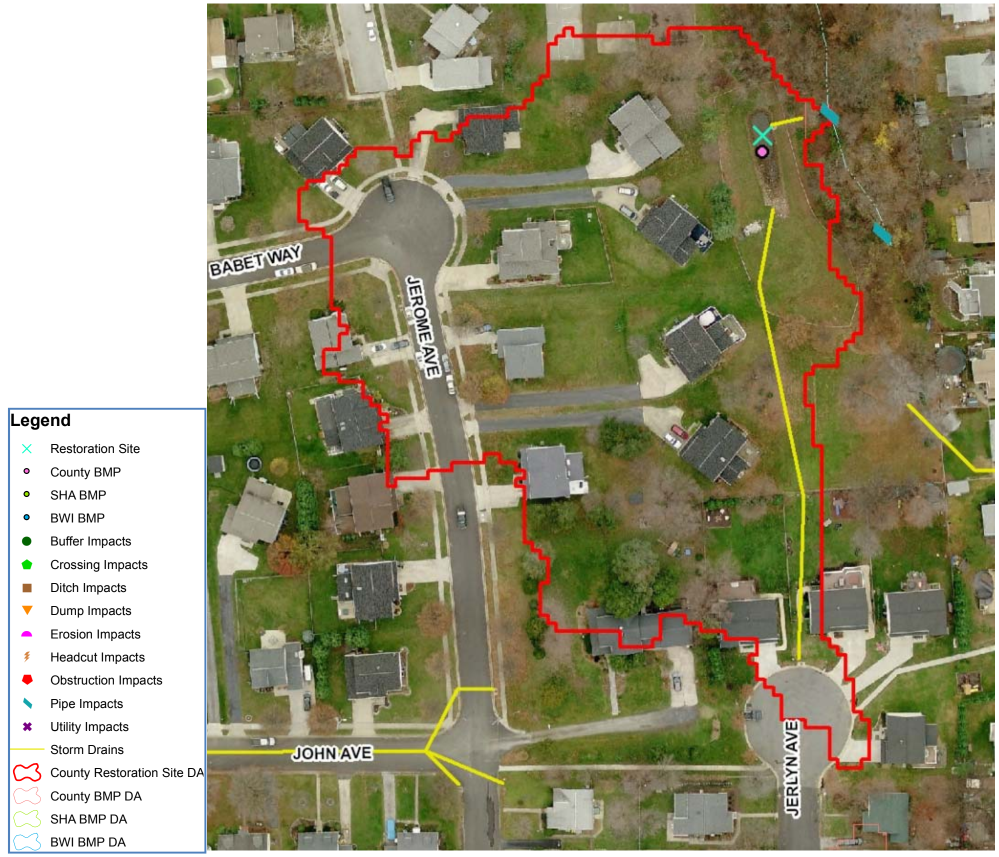
Drainage Area: 3.7 Acres

Imperviousness: 1.3 Acres (35%)

Subwatershed: Unnamed Patapsco River Tributary PN3

Subwatershed Ranking for Restoration Scores:

Combined: 7 / 39.48 / Very Poor
Patapsco Non-Tidal: 2 / 35.65 / Poor



Reach Segment: NA

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored - Ephemeral
Patapsco Non-Tidal: Not Scored - Ephemeral

Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Site Selection Candidate:

Nursery Road Business Park Dry Pond Retrofit

ADC Map/Grid: 4938 E5

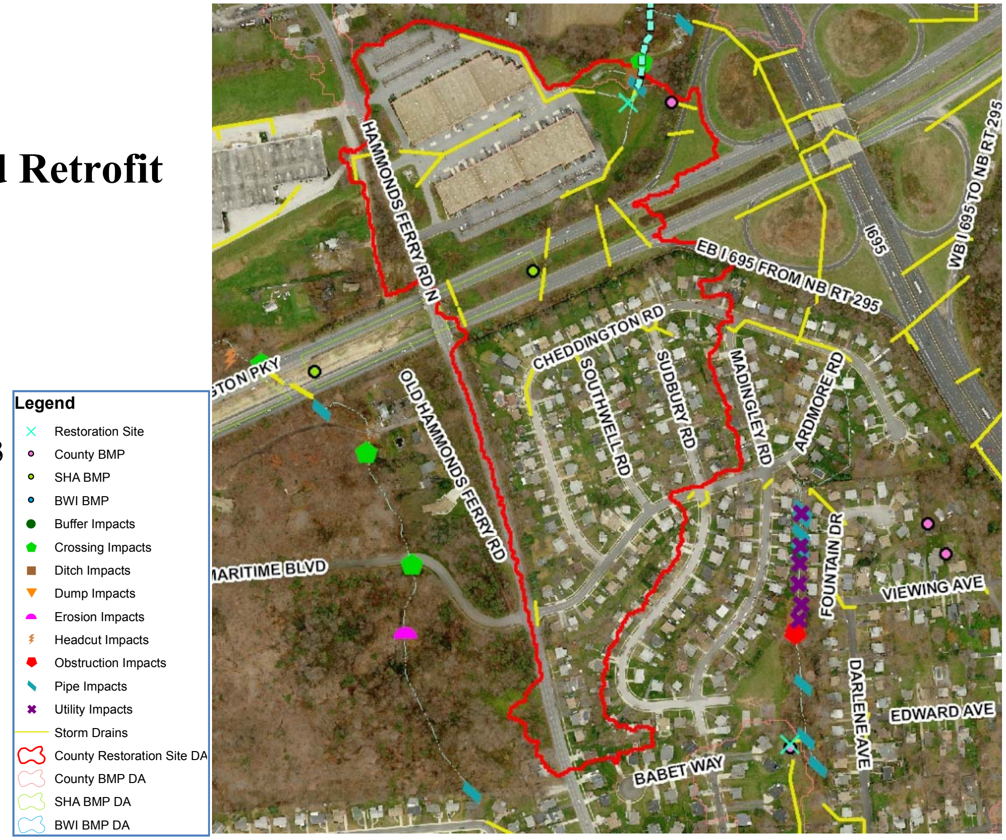
Drainage Area: 48 Acres

Imperviousness: 23 Acres (48%)

Subwatershed: Unnamed Patapsco River Tributary PN3

Subwatershed Ranking for Restoration Scores:

Combined: 7 / 39.48 / Very Poor
Patapsco Non-Tidal: 2 / 35.65 / Poor



Reach Segment: PN3009

Stream Reach Ranking for Restoration Scores:

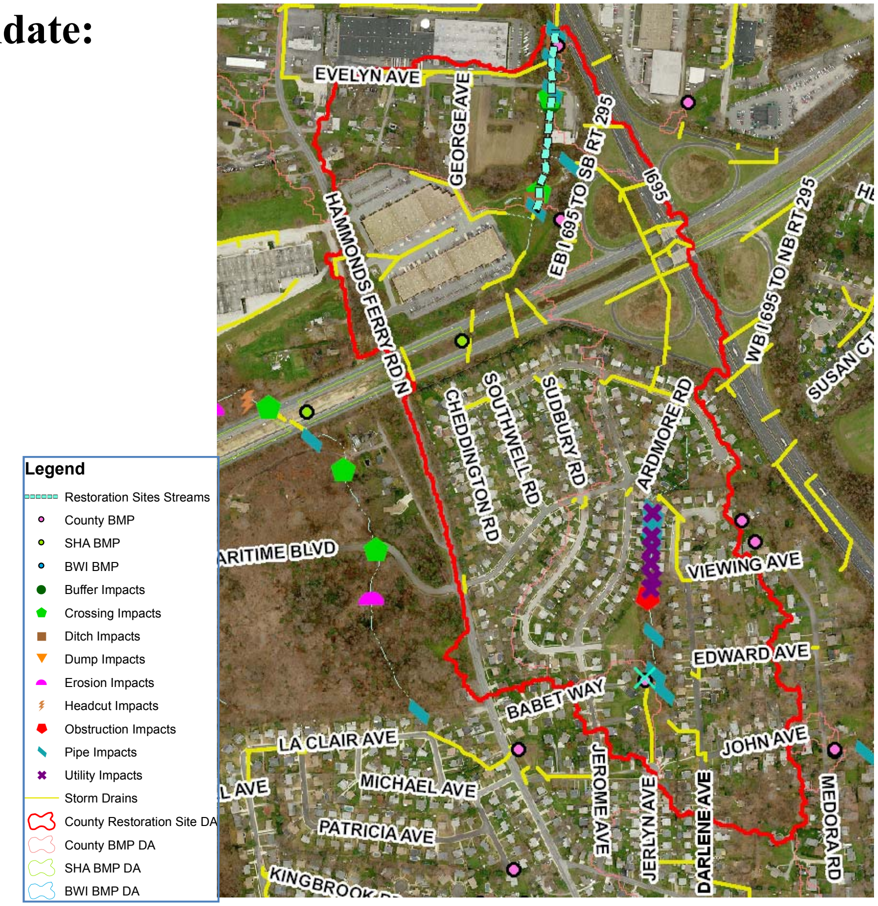
Combined: Not Scored - SWM
Patapsco Non-Tidal: Not Scored - SWM

Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Site Selection Candidate:

Nursery Road Business Park SPSC



ADC Map/Grid: 4938 E5

Drainage Area: 132 Acres

Imperviousness: 52 Acres (39%)

Subwatershed: Unnamed Patapsco River Tributary PN3

Subwatershed Ranking for Restoration Scores:

Combined: 7 / 39.48 / Very Poor
Patapsco Non-Tidal: 2 / 35.65 / Poor

Reach Segment: PN3001

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored - Intermittent
Patapsco Non-Tidal: Not Scored - Intermittent

Description:

This project site was selected because it represents an opportunity to incorporate an SPSC/stream restoration project within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the stream channel will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Site Candidate:

Ohio Ave. Stream Restoration

ADC Map/Grid: 5055 A2

Restoration Stream Length: 1,010 ft.

Drainage Area: 28 Acres

Imperviousness: 5.1 Acres (18%)

Subwatershed: Deep Run PNC

Subwatershed Ranking for Restoration Scores:

Combined: 86 / 61.35 / Poor
Patapsco Non-Tidal: 10 / 65.70 / Good

Reach Segment: PNC003

Stream Reach Ranking for Restoration Scores:

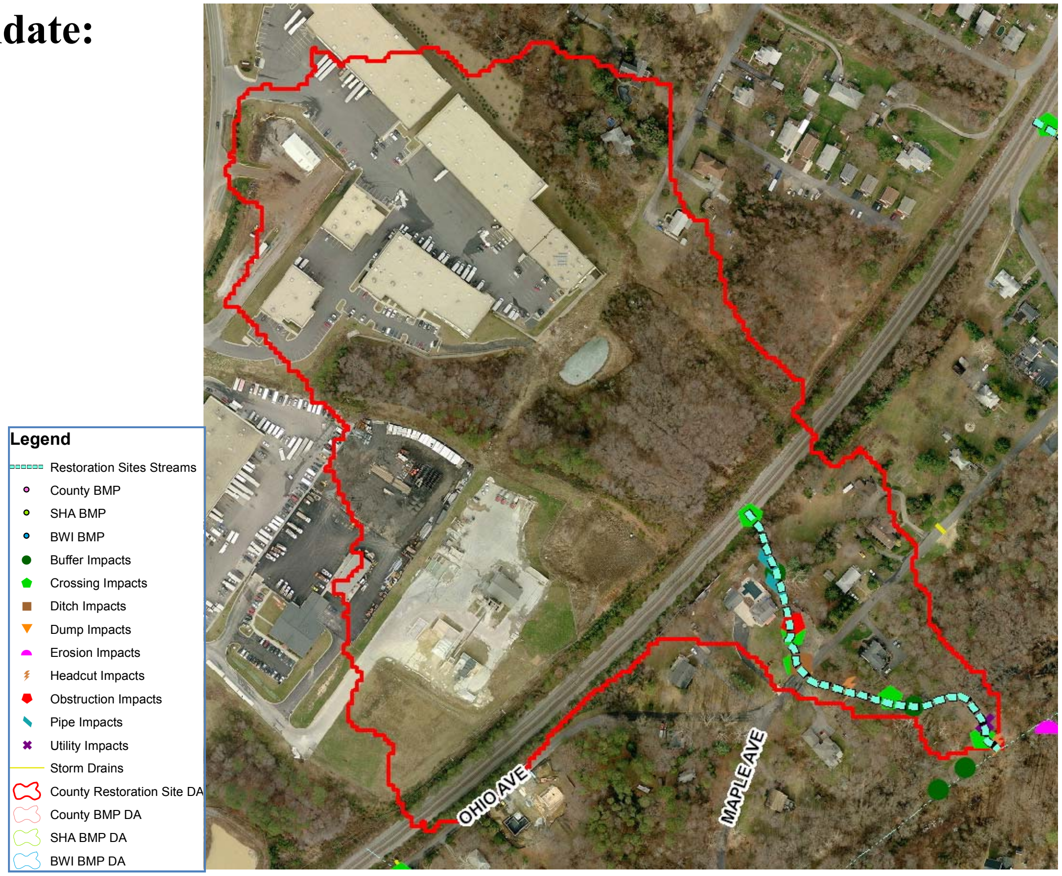
Combined: 12/51.05/ Very Poor
Patapsco Non-Tidal: 5/51.05/ Very Poor

Description:

This project site was selected because it received the fifth lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 12th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for MPHI habitat, Rosgen level one classification, and headcut impacts.

Concept Restoration Plan Site Candidate:

Ohio Ave. Stream Restoration II



ADC Map/Grid: 5054 K3

Restoration Stream Length: 888 ft.

Drainage Area: 37 Acres

Imperviousness: 15 Acres (40%)

Subwatershed: Deep Run PNC

Subwatershed Ranking for Restoration Scores:

Combined: 86 / 61.35 / Poor
Patapsco Non-Tidal: 10 / 65.70 / Good

Reach Segment: PNC022

Stream Reach Ranking for Restoration Scores:

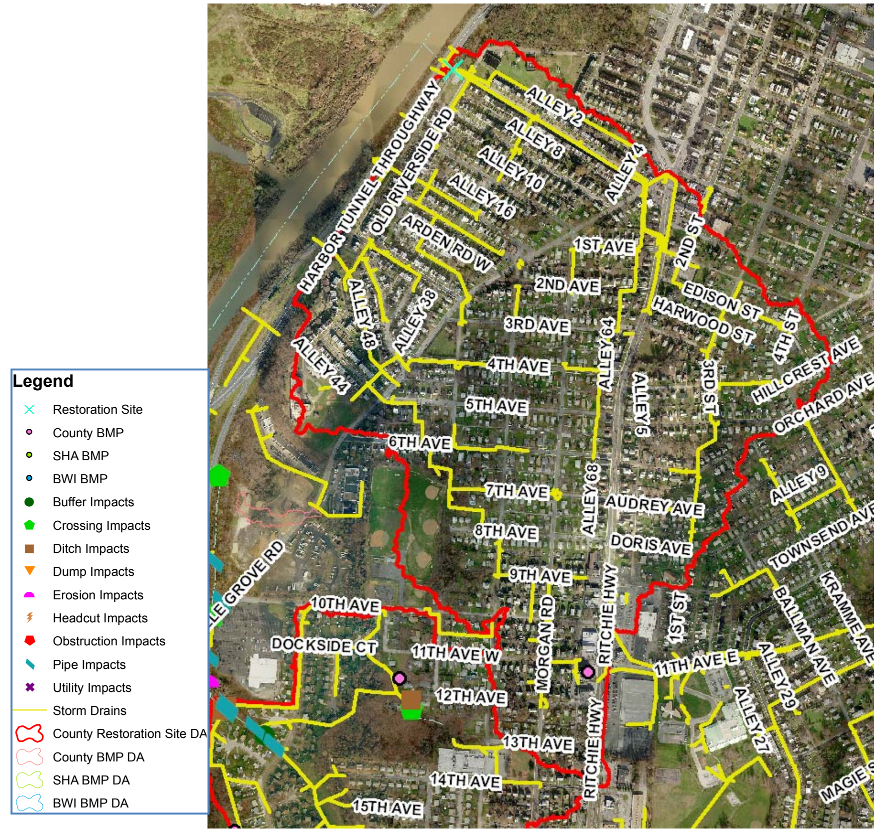
Combined: 4/46.32/ Very Poor
Patapsco Non-Tidal: 1/46.32/ Very Poor

Description:

This project site was selected because it received the 1st lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 4th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for contributing imperviousness, buffer impairments, and potential for emergency road crossing impairment.

Concept Restoration Plan Site Selection Candidate:

Old Riverside Road SPSC



ADC Map/Grid: 4938 B3

Drainage Area: 285 Acres

Imperviousness: 154.3 Acres (54%)

Subwatershed: Patapsco Mainstem PN1

Subwatershed Ranking for Restoration Scores:

Combined: 3 / 34.49 / Very Poor
Patapsco Non-Tidal: 1 / 29.66 / Very Poor

Closest Downstream Reach Segment: PN1017

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored - Concrete
Patapsco Non-Tidal: Not Scored – Concrete

Description:

This project site was selected because it provides an opportunity to convert a series of concrete ditches into a step pool stormwater conveyance system and provide stormwater management treatment to an area that currently is not served by stormwater management. The project site would be an ideal location because the current concrete ditch abuts county owned lands. This type of restoration project will provide an opportunity to provide stormwater management to an area that is currently not being served. This project site falls within the Patapsco Mainstem (PN1) subwatershed. This subwatershed received a combined score of 34.49 and places it in the very poor priority ranking making the subwatershed an ideal candidate for restoration work.

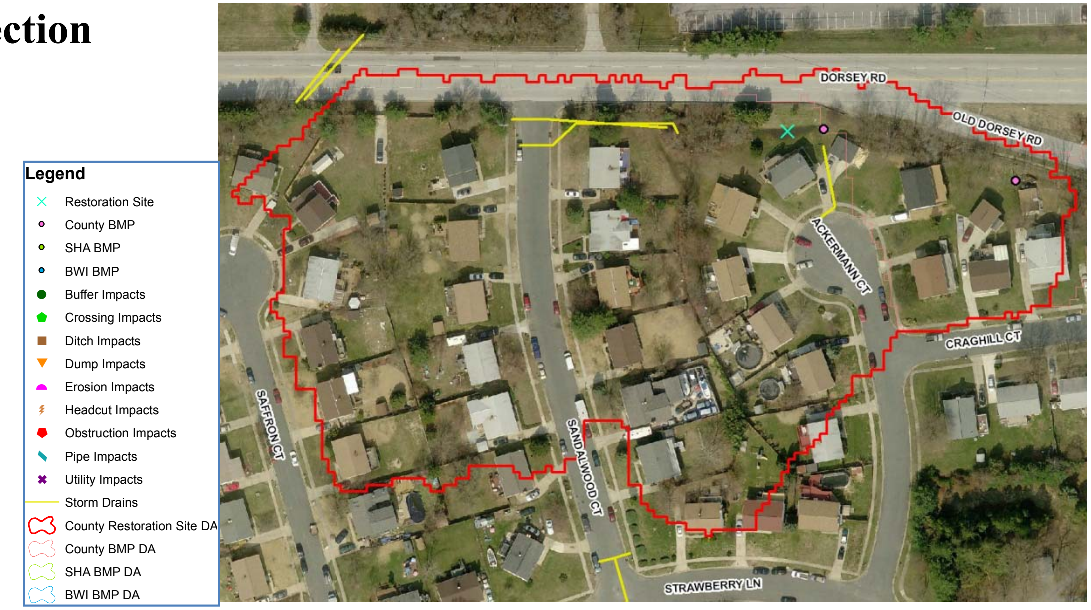
Concept Restoration Plan Ranking:

The project received an overall score of 10 placing it in a tie for third highest ranking of 3 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Old Riverside Road SPSC	2	1	1	1	2	3	10	3

Concept Restoration Plan Site Selection Candidate:

Sandalwood Dry Pond Retrofit



ADC Map/Grid: 5055 G5

Drainage Area: 6.5 Acres

Imperviousness: 2.7 Acres (42 %)

Subwatershed: Stony Run IV PN9

Subwatershed Ranking for Restoration Scores:

Combined: 26 / 48.19 / Very Poor
Patapsco Non-Tidal: 4/ 44.57 / Poor

Reach Segment: NA

Stream Reach Ranking for Restoration Scores:

Combined: NA
Patapsco Non-Tidal: NA

Description:

This project site was selected because it represents a dry pond within a subwatershed that scored very poorly both overall and within the Patapsco Non-Tidal watershed. Retrofitting the dry pond will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Site Candidate:

Sandalwood SPSC

ADC Map/Grid: 5055 H6

Drainage Area: 9.5 Acres

Imperviousness: 4.0 Acres (42 %)

Subwatershed: Stony Run IV PN9

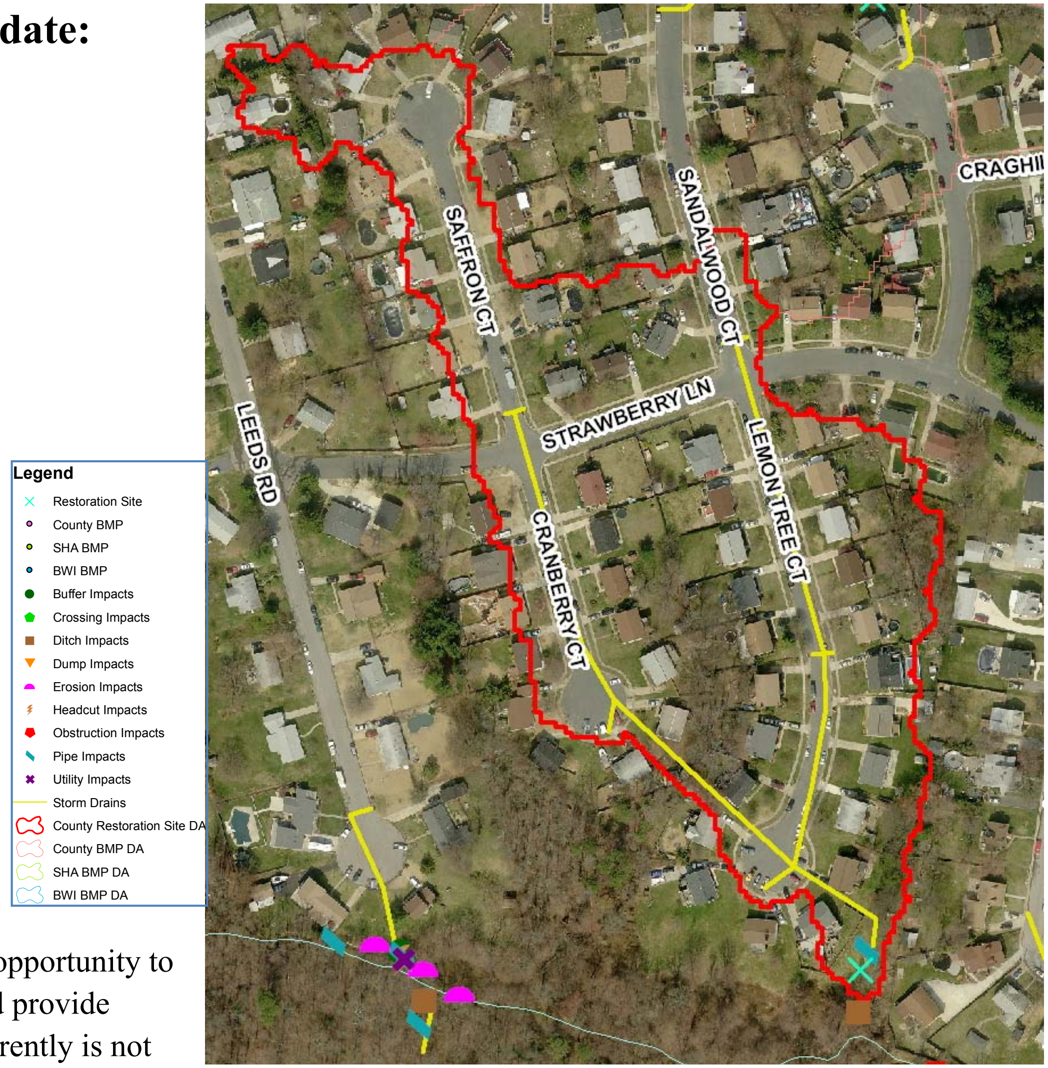
Subwatershed Ranking for Restoration Scores:

Combined: 26 / 48.19 / Very Poor
Patapsco Non-Tidal: 4/ 44.57 / Poor

Reach Segment: NA

Stream Reach Ranking for Restoration Scores:

Combined: NA
Patapsco Non-Tidal: NA



Description:

This project site was selected because it provides an opportunity to install a step pool stormwater conveyance system and provide stormwater management treatment in an area that currently is not served by stormwater management. This project site falls within the Stony Run IV (PN9) subwatershed. This subwatershed received a combined score of 48.19 and places it in the poor priority ranking making the subwatershed an ideal candidate for restoration work.

Concept Restoration Plan Site Selection Candidate:

Shipley Road SPSC

ADC Map/Grid: 4938 D7

Drainage Area: 18.1 Acres

Imperviousness: 6.5 Acres (36%)

Subwatershed: Unnamed Patapsco River Tributary PN4

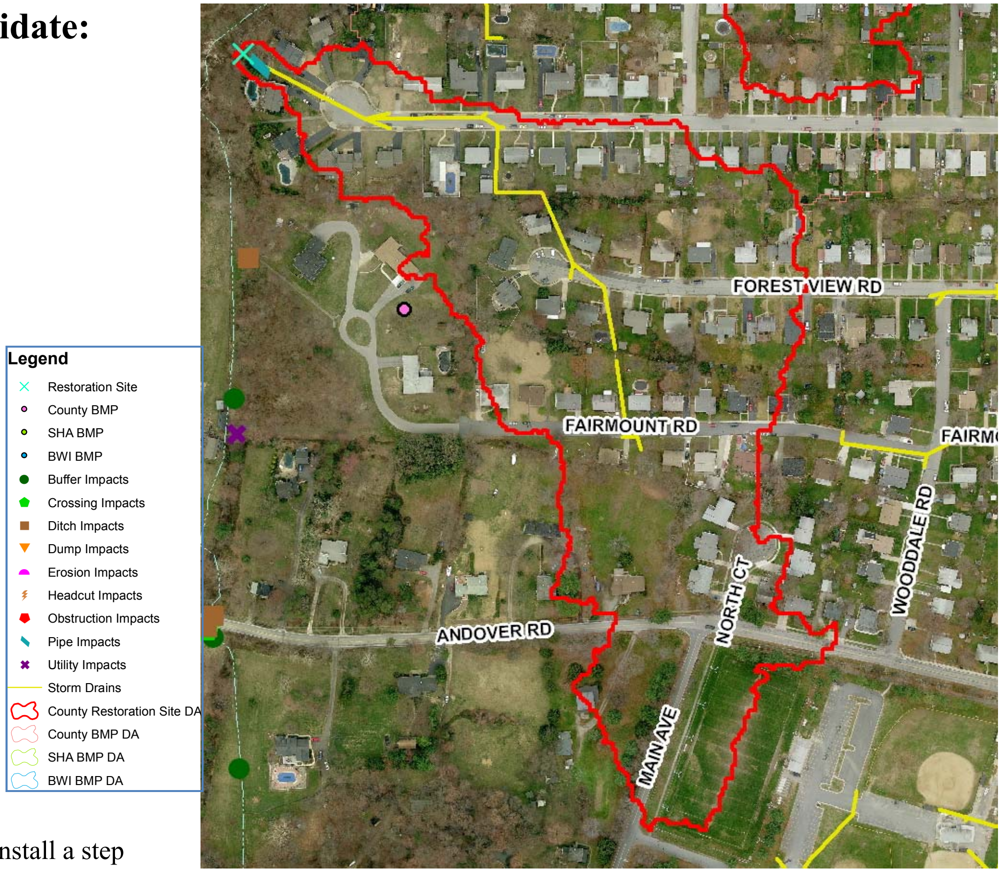
Subwatershed Ranking for Restoration Scores:

Combined: 14 / 42.91 / Very Poor
Patapsco Non-Tidal: 5 / 44.60 / Fair

Reach Segment: PN4023

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored: Ephemeral
Patapsco Non-Tidal: Not Scored: Ephemeral



Description:

This project site was selected because it provides an opportunity to install a step pool stormwater conveyance system and provide stormwater management treatment in an area that currently is not served by stormwater management. The addition of this project will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

Concept Restoration Plan Ranking:

The project received an overall score of 10 placing it in a tie for third highest ranking of 3 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Shipley Road SPSC	2	1	1	1	2	3	10	3

Concept Restoration Plan Site Selection Candidate:

Stony Run Stream Restoration

ADC Map/Grid: 4937 J9

Restoration Stream Length: 6,231 ft.

Drainage Area: 1,440 Acres

Imperviousness: 720 Acres (50%)

Subwatershed: Stony Run 3 PN8

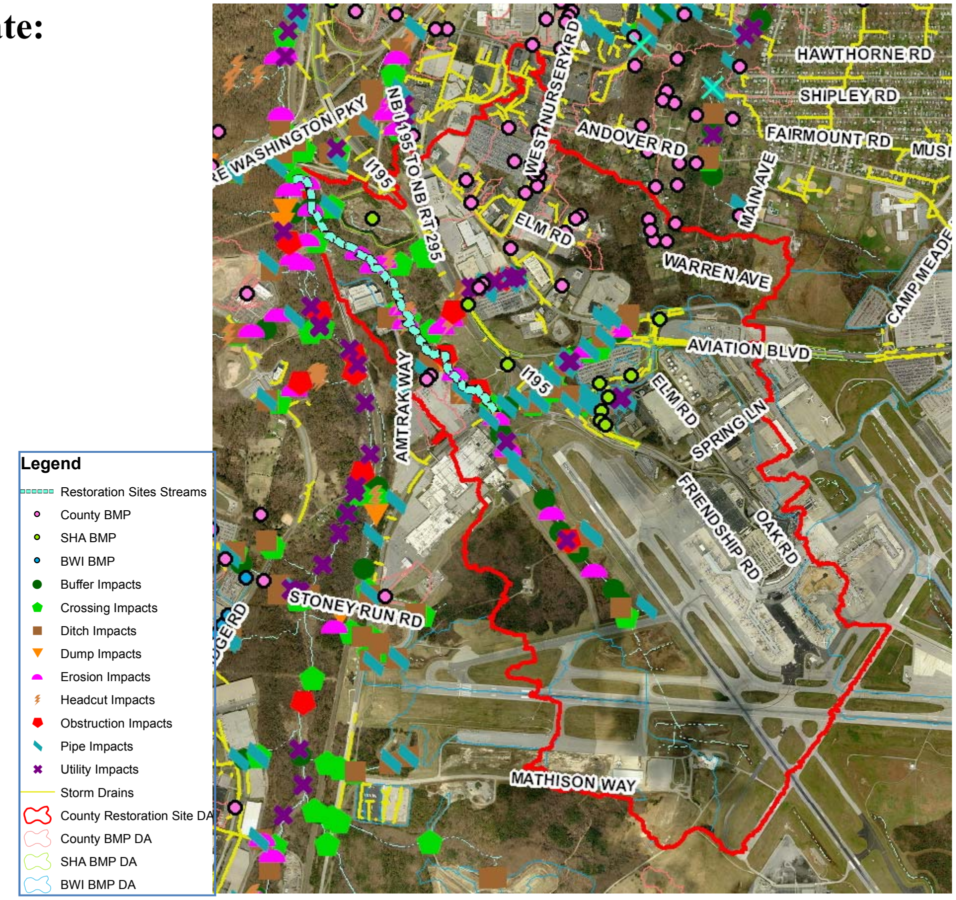
Subwatershed Ranking for Restoration Scores:

Combined: 8 / 39.81 / Very Poor
Patapsco Non-Tidal: 3 / 40.41 / Poor

Reach Segment: PN8012

Stream Reach Ranking for Restoration Scores:

Combined: 75/62.11/ Very Poor
Patapsco Non-Tidal: 18/62.11/ Poor



Description:

This project site was selected because it recently experienced a sewer main breach due to eroded stream channel exposing a buried sewer main. The degraded stream reach received the eighteenth lowest score for stream restoration in the Patapsco Non-Tidal watershed and a combined restoration ranking of 75th for all reaches assessed in the completed watershed studies. The stream reach received poor scores for Rosgen level one classification and contributing imperviousness.

Concept Restoration Plan Ranking:

The project received an overall score of 10 placing it in a tie for third highest ranking of 3 out of 23 restoration sites. The project received one of the lowest scores for design construction (low cost per impervious acre treated), existing BMP treatment (low BMP treatment according to urban BMP layer), property ownership (county owned parcel/floodplain) and facility access (adjacent to public ROW).

Project Name	Design Construction Score	Existing BMP Treatment	Property Ownership	Facility Access	Public Outreach	Complaint	Total Score	Rank
Stony Run Stream Restoration	2	1	1	1	2	3	10	3

Concept Restoration Plan Site Selection Candidate:

Woodland Road SPSC

ADC Map/Grid: 4938 C8

Drainage Area: 22 Acres

Imperviousness: 8.6 Acres (39%)

Subwatershed: Unnamed Patapsco River Tributary PN4

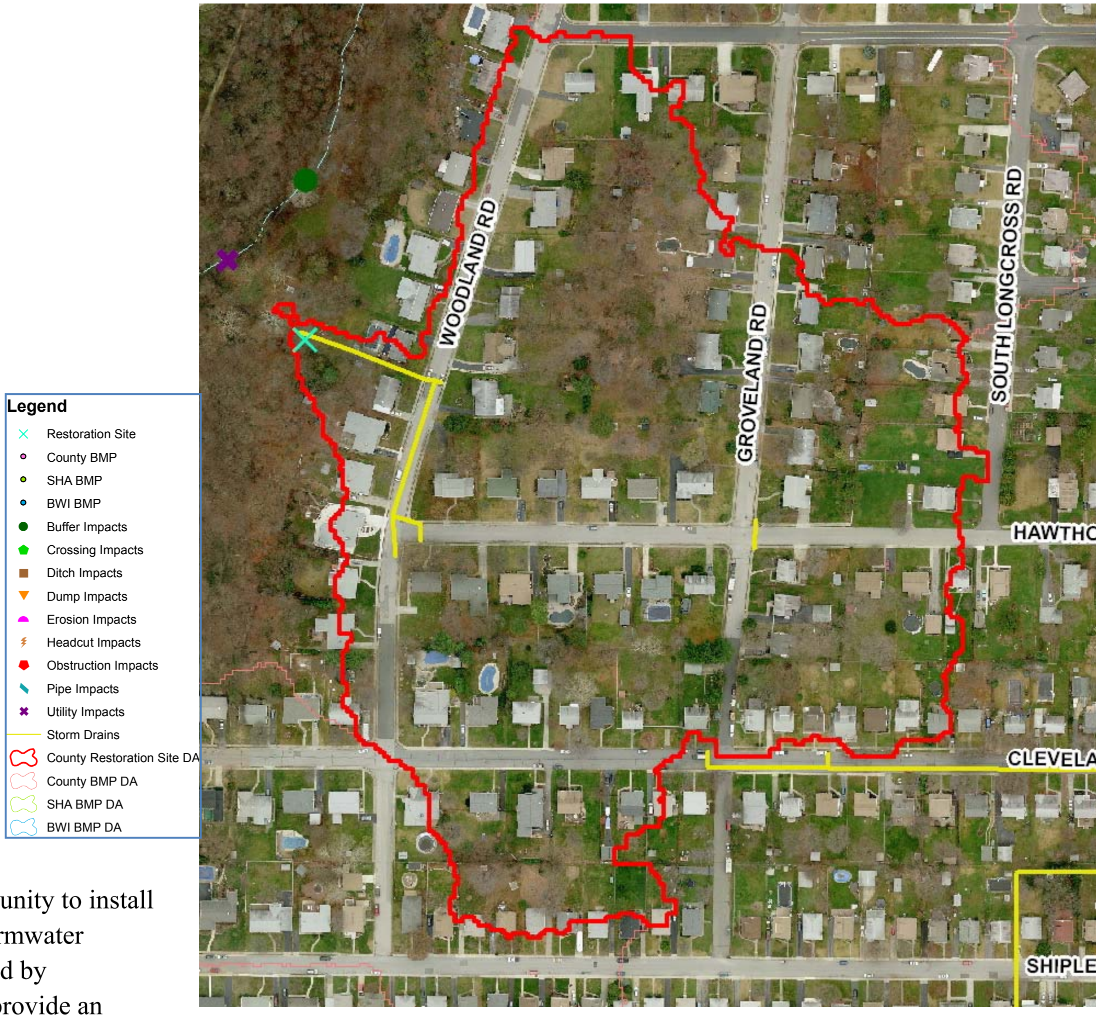
Subwatershed Ranking for Restoration Scores:

Combined: 14 / 42.91 / Very Poor
Patapsco Non-Tidal: 5 / 44.60 / Fair

Reach Segment: PN4019

Stream Reach Ranking for Restoration Scores:

Combined: Not Scored - Intermittent
Patapsco Non-Tidal: Not Scored - Intermittent



Description:

This project site was selected because it provides an opportunity to install a step pool stormwater conveyance system and provide stormwater management treatment in an area that currently is not served by stormwater management. The addition of this project will provide an opportunity to increase the level of nutrient reduction treatment in a subwatershed that has scored very poorly.

APPENDIX H – CONCEPTUAL DESIGN PLANS

PROJECT OVERVIEW

An existing dry pond is currently the only stormwater management provided for the 60-acre drainage area. The pond drains to unamed Patapsco River Tributary PN4. Currently, there are 16 acres of impervious surface within the drainage area to the facility. A retrofit of this facility is proposed, to convert this dry pond to a shallow wetland. This will increase water quality treatment within the facility.

PROJECT TYPE: Dry Pond to Shallow Wetland Conversion

WATERSHED: Patapsco Non-Tidal

SUBWATERSHED: Unnamed Patapsco River Tributary (PN4)

PROJECT LOCATION: Intersection of Concorde Circle and Winterson Road

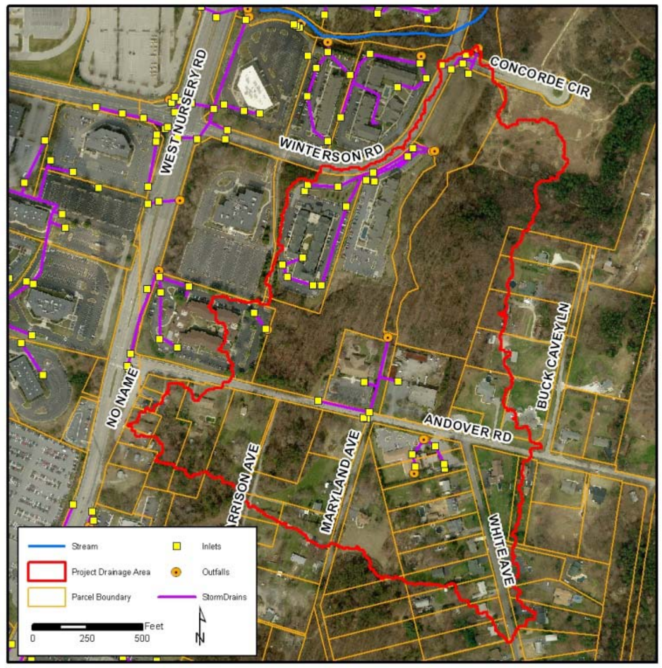


FIGURE 1: DRAINAGE AREA MAP

DRAINAGE AREA CHARACTERISTICS

LAND COVER: Existing Conditions: Predominately wooded and residential, with the majority of the residential use consisting of lots over half an acre in size. Approximately 13% of the existing land use is commercial development.

DRAINAGE AREA: 60.30 acres

IMPERVIOUS AREA: Existing Conditions: 15.85 acres

WIP SECTORS: County Private Commercial
County Private Low Density Residential
County Private Medium Density Residential
County Private Open Space
County Private Natural Resource Lands
County Roads and Facilities

DOMINANT SOILS: Predominately Hydrologic Soil Group B (45.7 acres), with Group C (10.6 acres) and Group D (4.0 acres) also present.

HYDROLOGY:

	Weighted CN	Time of Conc (hrs)	Flow – 1 yr (cfs)	Flow – 2 yr (cfs)	Flow – 10 yr (cfs)	Runoff – 1 yr (in)	Runoff – 2 yr (in)	Runoff – 10 yr (in)
EXISTING:	71.9	0.62	24	41	105	0.63	0.99	2.34

PROJECT BENEFITS

WATER QUALITY: The wetland will provide water quality benefits through retention of stormwater flows, and by allowing sediments to settle out of the water column. Additionally, the wetland vegetation will remove significant quantities of nutrients. The pollutant removal efficiencies for a shallow wetland can be expected to be near 40% for TN, 60% for TP, and 60% for TSS.

HYDROLOGY: The permanently inundated portions of the shallow marsh are proposed to be excavated. This will enable the pond to provide water quality volume without reducing the peak management volume currently provided by the dry pond. The water quality volume is provided in a proposed forebay, low marsh, high marsh, and deep micropool. Channel protection volume storage is provided above the inundated surface, and overbank flood protection is provided in the upper portions of the pond.

AQUATIC HABITAT: Improved water quality within the receiving stream channel will reduce stress on aquatic organisms. Furthermore, the wetland itself will provide additional habitat for aquatic organisms and riparian species.

STREAM STABILITY: The stream channel below the facility is currently experiencing erosion. The proposed water quality treatment will be contained primarily within excavated portions of the facility. Extended 24-hour detention of the 1-year storm event is provided above the permanent pool. This will significantly reduce frequent storm event discharges to the unstable stream channel below the facility.

	TP lbs/yr	TN lbs/yr	NOx lbs/yr	FC mpn/yr	TSS tons/yr	Metal lbs/yr
PRE-REST.	22	514	406	$3.31E^{10}$	2.02	14
POST-REST.	9	308	110	$0.82E^{10}$	0.81	2
% DIFF.	60	40	73	75	60	85

PROJECT CONSTRAINTS

PROPERTY OWNERSHIP: The facility and the surrounding areas are currently commercially owned. Concorde Circle appears to have been constructed to facilitate future construction in the adjacent property.

FACILITY ACCESS: The facility is currently located at the intersection of Winterson Road and Concorde Circle. Concorde Circle is currently a dead end street and is not being used. Access and staging/stockpiling could be provided from Concorde Circle with little or no impact to surrounding residents or businesses.

DESIGN/ CONSTRUCTION: A geotechnical investigation should be conducted to determine if groundwater is within four feet of the existing surface. Ideally, excavation will intercept groundwater, which will help sustain the wetlands during extended periods of drought. Additionally, if any permanent retention volume is provided at higher elevation than the existing pond bottom, there may be a reduction in peak management. This should be investigated to determine if discharges are increased and/or flood elevations are increased within the facility.

ENVIRONMENTAL IMPACTS: Minimal clearing would be required to access the facility. Some brush and small-diameter woody vegetation exists within the pond. The facility should not be classified as Waters of the US, or as jurisdictional wetlands, since this is not an inline facility. As such, there should not be significant impact to sensitive environmental features. However, an environmental assessment of the facility and surrounding area should be conducted as part of the design process. The project as proposed will provide a net increase of nearly 30,000 square feet of wetlands.

UTILITIES: It is not anticipated that any existing utilities are present within the existing facility.

EROSION AND SEDIMENT CONTROL: A sediment and erosion control plan will be required for this project. There is currently no baseflow through the facility; however, construction will last for an extended period of time. Diversions should be installed at inflow areas to convey the storm flows to the existing riser. The low flow orifice of the riser should be blocked to prevent sediment from excavation activities from leaving the site.

CONCEPTUAL DESIGN

The existing dry pond will be converted into a shallow wetland to provide water quality treatment for the entire 60-acre drainage area. A forebay is proposed at the inflow from the storm drain and the main upstream channel. A 1-foot deep low flow channel will be provided that will meander through the bottom of the facility at a 0% grade, before entering a 4-foot deep micropool adjacent to the pond embankment. The remaining facility will consist of 0.5-foot deep high marsh area, with shallower, gently sloping areas transitioning out of the wetland.

The entire shallow marsh area is proposed to be landscaped with a mixture of permanently inundated wetland vegetation and shallow periodically-inundated vegetation. The vegetation will provide nutrient uptake and habitat.

Facility Sizing Criteria

	Target	**Provided**	**% of Target**
Ex. Water Quality Volume (WQv) (ft^3)	62,726	144,556*	100%
Ex. Channel Protection Volume (Cpv)	86,249	106,234	100%

* Channel Protection Volume can be counted towards the Water Quality Volume in a retrofit project per Anne Arundel County.

Shallow Wetland Design Parameters			
	Target	Provided	% of Target
Wetland Surface Area	42,778 sf (1.5 % of Total D.A.)	27,511 sf (1.0% of total DA)	64%
Deepwater Zone (≥ 4 feet)	25,605 cf (25% WQv)	12,764 cf (12% WQv)	50%
High Marsh Zones (≤ 6 inches)	9,629 sf (35% Total) Surface	9,629 sf (35% total surface)	100%
Low Marsh Zones (≤ 1.5 feet)	17,882 sf (65% Total) Surface	17,882 sf (65% total surface)	100%

The pond is currently providing peak management, and this is not proposed to be impacted significantly. To prevent a reduction of peak management, the shallow wetland will be excavated into the bottom of the facility. An orifice plate will be installed on the existing low flow orifice within the riser to reduce the cross-sectional area and provide 24-hour extended detention of the 1-year storm event (channel protection volume). The remaining volume within the facility will reduce discharges for less frequent storm events.

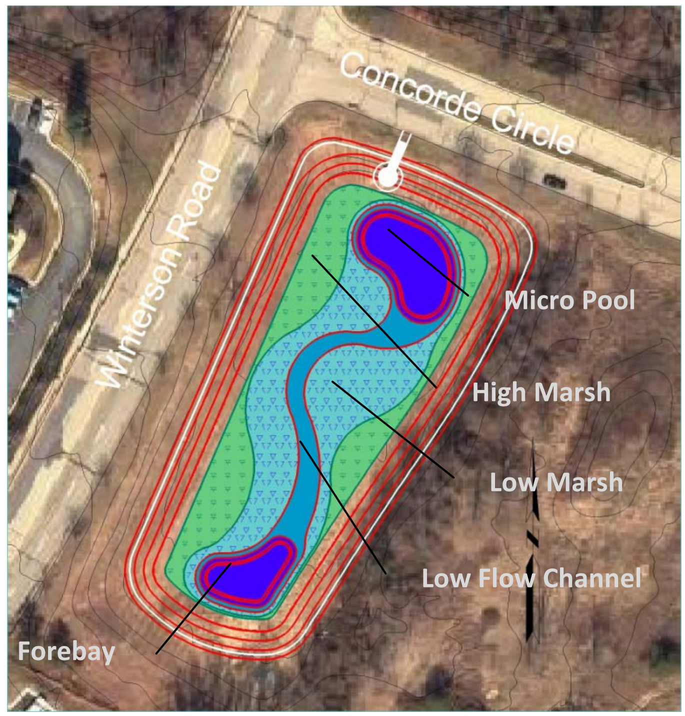


FIGURE 2: PROPOSED HYDROLOGIC ZONES

Water quality within a shallow wetland facility is primarily provided within three zones: micropools, low marshes, and high marshes. For the proposed facility, the forebay and micropool will be four feet deep, the low marsh less than 1.5 feet, and the remaining area will consist of high marsh at one-half foot deep. The entire facility will be heavily vegetated to promote nutrient uptake.

The water quality volume is computed based on existing land use conditions and does not account for additional water quality treatment facilities or water quality credits available elsewhere within the subwatershed. The facility as proposed provides 100% of the existing water quality volume for the contributing drainage area. It is generally desirable to limit the area of the deep pools and provide a greater percentage of the available footprint to shallow areas; however, this results in a net reduction of water quality treatment volume.

The channel protection volume is computed based on existing land use conditions within the subwatershed. Due to the eroded downstream channel, the 24-hour extended detention of the 1-year storm event was given priority. The extended detention storage will be provided by reducing the cross-sectional area of the low flow orifice within the existing riser, or by replacing the riser if necessary. This storage is provided above the permanent pool elevation. The full existing condition channel protection volume is provided with additional storage volume available above for reduction of less frequent storm flows.

A review of the as-built drawings should be conducted, or a geotechnical investigation performed along the embankment to ensure that any proposed increase in water surface elevation does not exceed the existing top of the embankment's impervious clay core. If no core exists, a geosynthetic clay liner should be provided along the upstream portion of the embankment, or additional excavation conducted to ensure no water surface elevations are increased for design storms.

CONCEPTUAL DESIGN PLAN

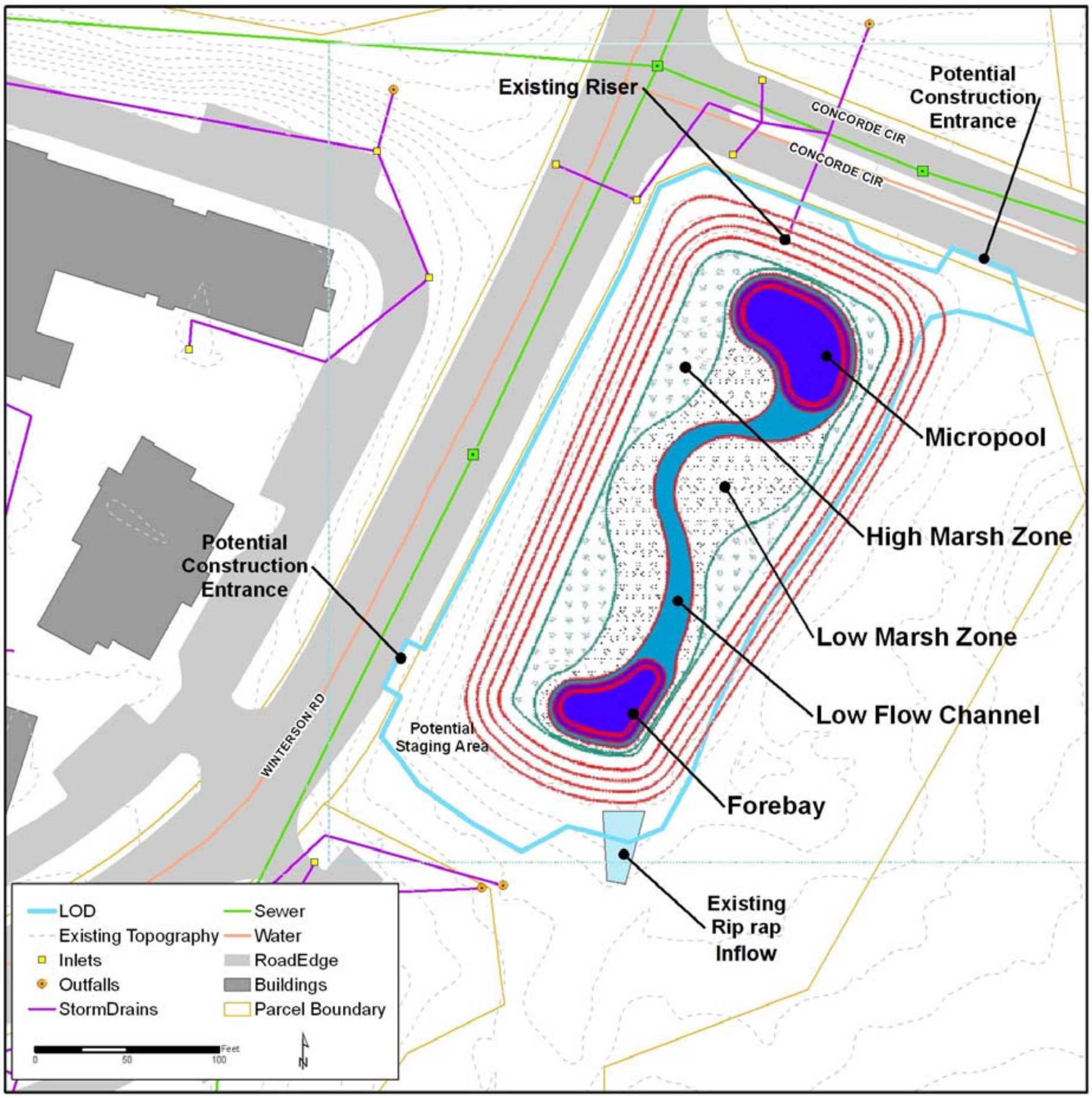


FIGURE 3: PLAN VIEW OF SHALLOW WETLAND CONCEPT

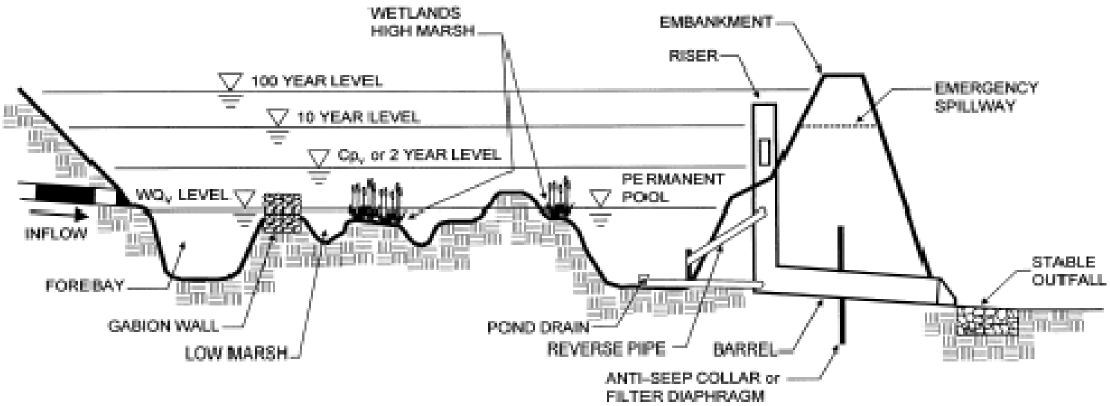


FIGURE 4: TYPICAL SHALLOW WETLAND, CROSS SECTION PROFILE (FROM MARYLAND STORMWATER DESIGN MANUAL, MDE 2009)

PROJECT COST ESTIMATE

ITEM	QTY	UNITS	UNIT COST	TOTAL
Site Work				
Clear and Grub	1.0	AC	$5,000.00	$5,000
Pond Construction				
Grading and Excavation (Class I)	1,419	CY	$45.00	$63,870
Riser	1	LS	$5,000.00	$5,000
Rip Rap Stabilization	60	LF	$50.00	$3,000
SWM Landscaping	5,790	SY	$9.00	$52,110
			Direct Construction Subtotal	$128,980
Indirect Costs				
E/SC, MOT, MOS (10% of Directs or $3,000)	1	LS	$12,898.00	$12,898
Construction Stakeout (2% of Directs)	1	LS	$2,579.60	$2,580
			Base Construction Cost	$144,458
			Mobilization (10% of Directs or $1,000)	$12,898
			Subtotal	$157,356
			Contingency (30%)	$47,207
			Construction Subtotal	$204,562
			Envt'l Studies / Permitting (5% of Construction or $5,000)	$10,228
			Engineering and Surveys (25%of Construction or $40,000)	$51,141
			Total Capital Cost	**$265,931**

EXISTING CONDITIONS SITE PHOTOS

PHOTO 2: VIEW OF POND FROM CONCORDE CIRCLE

PHOTO 1: EXISTING RISER STRUCTURE

PHOTO 3: EXISTING RISER AND EMBANKMENT

PHOTO 4: EXISTING RIP RAP INFLOW

ENGINEER CERTIFICATION

*Professional Certification: I hereby certify that these **Conceptual Design Plan** documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland. (note: design plans are conceptual and are **not for construction**)*

License No. 31201, *Expiration Date:* 1/24/13

#28353 1/2/2013

STATE OF MARYLAND
JAMES A. TOMLINSON
No. 31201
PROFESSIONAL ENGINEER

STATE OF MARYLAND
HALA E. FLORES
No. 283..
REGISTERED
PROFESSIONAL ENGINEER

PROJECT OVERVIEW

An existing drainage channel connecting the Shipley Road cul de sac to a Patapsco River tributary is inadequate. The existing rip rap and gabion basket channel protection measures are failing, creating an incised channel and delivering sediment to downstream reaches. The project will retrofit the site with a step pool storm conveyance (SPSC) which will provide water quantity and quality management.

PROJECT TYPE: Step pool storm conveyance

WATERSHED: Patapsco Non-Tidal

SUBWATERSHED: Unnamed Patapsco River Tributary (PN4)

PROJECT LOCATION: Terminus of Shipley Road cul de sac

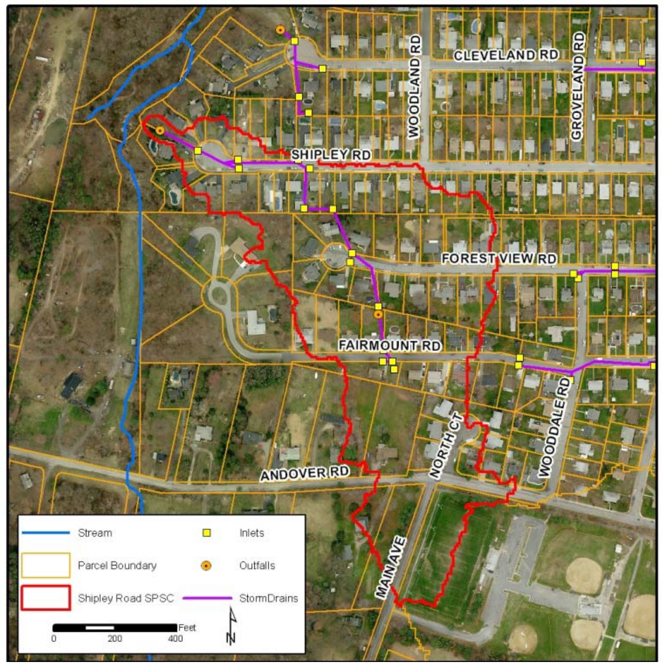


FIGURE 1: DRAINAGE AREA MAP

DRAINAGE AREA CHARACTERISTICS

LAND COVER: Existing: Land use in the drainage area is dominated by residential use (15.2%) with smaller amounts of open space (8.7%), low density residential (4.3%) and transportation (3.4%).

DRAINAGE AREA: 18.11 acres

IMPERVIOUS AREA: 6.5 acres (36%)

WIP SECTORS: County – Private Medium Density Residential
County – Private Low Density Residential
County – Private Open Space
County Roads and Facilities

DOMINANT SOILS Soil composition in the drainage area is dominated by C type (15.19 acres) making up 83.9 percent of the drainage area. Smaller amounts of B type (2.77 acres, 15.3 percent) and D type (0.15 acres, 0.8 percent) are also present.

HYDROLOGY:

	Weighted CN	Time of Conc (hrs)	Flow – 1 yr (cfs)	Flow – 2 yr (cfs)	Runoff – 1 yr (in)	Runoff – 2 yr (in)
EXISTING:	80.80	0.265	23	33	1.07	1.53

PROJECT BENEFITS

WATER QUALITY: The SPSC system is designed to provide subsurface flow and increase infiltration, creating removal of suspended particles and nutrients. The associated plant material provides an additional level of treatment as dissolved nutrients are taken up. Typical removal rates are estimated at the following assuming 100% of the water quality volume is treated: total phosphorus (TP) 60%, total nitrogen (TN) 40%, nitrate and nitrite (NOx) 0%, fecal coliform bacteria (FC) 90%, total suspended solids (TSS) 85% and metals 85%. The site designed as proposed is estimated to treat 54% of the existing water quality volume. The resulting estimated pollutant removals are provided in the table below.

HYDROLOGY: The SPSC's attenuation pools and seepage element converts surface flow to shallow groundwater flow, thereby reducing peak surface discharge and velocity.

AQUATIC HABITAT: Downstream aquatic habitat and biota will benefit from reduced peak flows, reduced sediment load, and a decrease in inflow temperature, which translates to more suitable and stable habitat for benthic, macroinvertebrates, herpetofauna, and fish.

STREAM STABILITY: Bed and bank stability in the impacted drainage channel will be greatly improved and the sediment/phosphorus source will be reduced. Downstream stability will be improved via reduction of peak discharge and velocity.

PUBLIC OUTREACH: The project is not in a highly visible situation and is therefore not suited to have a public outreach component.

	TP lbs/yr	TN lbs/yr	NOx lbs/yr	FC mpn/yr	TSS tons/yr	Metal lbs/yr
PRE-REST.	7	77	36	$1.69E^{10}$	1.03	4.0
POST-REST.	4.8	60	36	$0.87E^{10}$	0.56	2.2
% DIFF.	32	22	0	49	46	46

PROJECT CONSTRAINTS

PROPERTY OWNERSHIP: Private property borders both sides of a 15 foot wide drainage and utility easement. County right-of-way access and permanent easements will be necessary. A full plat search will be necessary to confirm the easement and a metes and bounds survey will be necessary to determine exact locations.

FACILITY ACCESS: Access from Shipley Road is narrow between addresses 618 and 620 Shipley Road. An apparent HOA right-of-way (owner indicated as PLS Shipley Inc.) exists between 620 and 622 Shipley Road, but would require a more extensive access route and additional clearing. Access along the utility may be gained along the existing utility easement; however, the LOD and grading footprint would likely impact lots 618 and 620 located on either side of the outfall. Care should be taken to minimize impacts to root zones of existing landscaped vegetation.

DESIGN/ CONSTRUCTION: A topographical survey of the site will be necessary. Geotechnical investigations may be necessary to confirm slope stability characteristics.

ENVIRONMENTAL IMPACTS: The site is partially forested and some clearing of immature edge species vegetation should be anticipated. No wetlands exist within the proposed LOD, and the drainage channel is likely to be classified as ephemeral.

UTILITIES: A sanitary sewer line runs under Shipley Road but does not appear to be within the LOD. Miss Utility should be contacted prior to construction.

EROSION AND SEDIMENT CONTROL: Proper erosion and sediment controls will be required. Because the stream is ephemeral, a permanent stream diversion and pump around is not likely to be necessary.

CONCEPTUAL DESIGN

The site length is 70 feet from the outlet of the 27-inch reinforced concrete pipe to the confluence with the downstream channel. Because the site is located in a residential setting, the design attempts to minimize impacts to private property and the associated cost in acquiring easements while still achieving a water quality and quantity benefit. To minimize grading and maintain a zone of consistent grade just downstream of the outfall, closest to residential structures, a 10-foot riffle at a 5% slope is proposed at the outfall. Additionally the riffle is followed by a 20-foot pool with a max depth of 3 feet. The top width of the riffle is 15 feet and the channel thread follows closely the existing

Design Parameter	Value
Drainage area (acre)	18.11
Percent Impervious (%)	36
Volumetric runoff coefficient (R_v)	0.37
Water Quality volume (WQ_v) (ft^3)	24,552
Peak discharge 100-year storm (ft^3/s)	109
Total length (ft)	70
Elevation drop over length (ft)	6
Cobble d_{50} size (ft) (riffle)	0.5
Top width of riffle channel (ft)	15
Depth of riffle channel (D) (ft)	2.1
Depth of pools (h_f) (ft)	3
Length of riffle segments (ft)	10
Length of pool segments (ft)	20
Slope of riffle segments	0.05
Slope of pool segments	0.00
Cascade length (ft)	10

contours, both measures to minimize grading on private property while still conveying safely the 100-year design event (109 cfs).

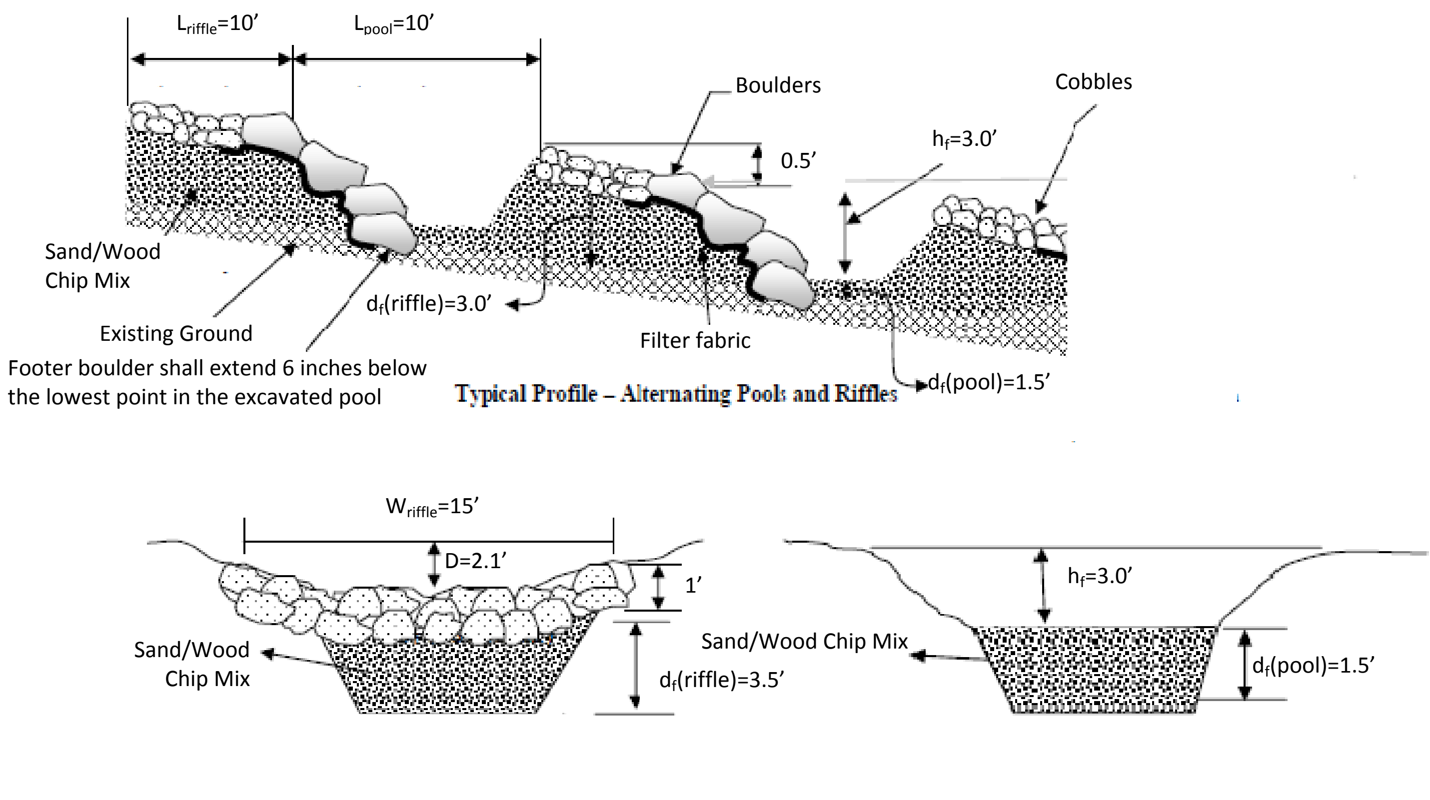
Design Parameters (con't)	Value
Elevation drop over cascade (ft)	4
Elevation drop in cascade pools (3) (ft)	1.5
Cascade width (ft)	15
Cascade depth (ft)	1.2
Cobble d_{50} size (ft) (cascade)	1.5
Sand filter depth at pools (d_f(pool)((ft)	1.5
Sand filter depth at riffles (df(riffle)) (ft)	3.5
Width of sand filter (W_{sand}) (ft)	15
Area of sand filter (Af) (ft^2)	900

The overall existing site slope is 8.5%; therefore, one 10-foot cascade segment with a 4-foot elevation drop was necessary to maintain proper slopes for water quality treatment and tie-in elevations. The lower slope cascade (40% rather than typical 50%) reduces the velocity over the cascade. The 10-foot pools following the cascade fall 0.5 feet between each pool for a total elevation loss of 1.5 feet.

The conceptual design manages the peak flow related to the 1-year storm event. Due to constraints on the length of the channel and the resulting sand filter area, the project as proposed will result in treatment of 54% of the water quality volume.

CONCEPTUAL DESIGN TYPICAL DETAILS

FIGURE 2: TYPICAL DETAILS



Typical Profile – Alternating Pools and Riffles

Riffle Weir Cross Section Through Cobble

Pool Cross Section

Details modified from *Design Guidelines for Step Pool Storm Conveyance*, Anne Arundel County Government Department of Public Works. November 2010 edition.

CONCEPTUAL DESIGN PLAN

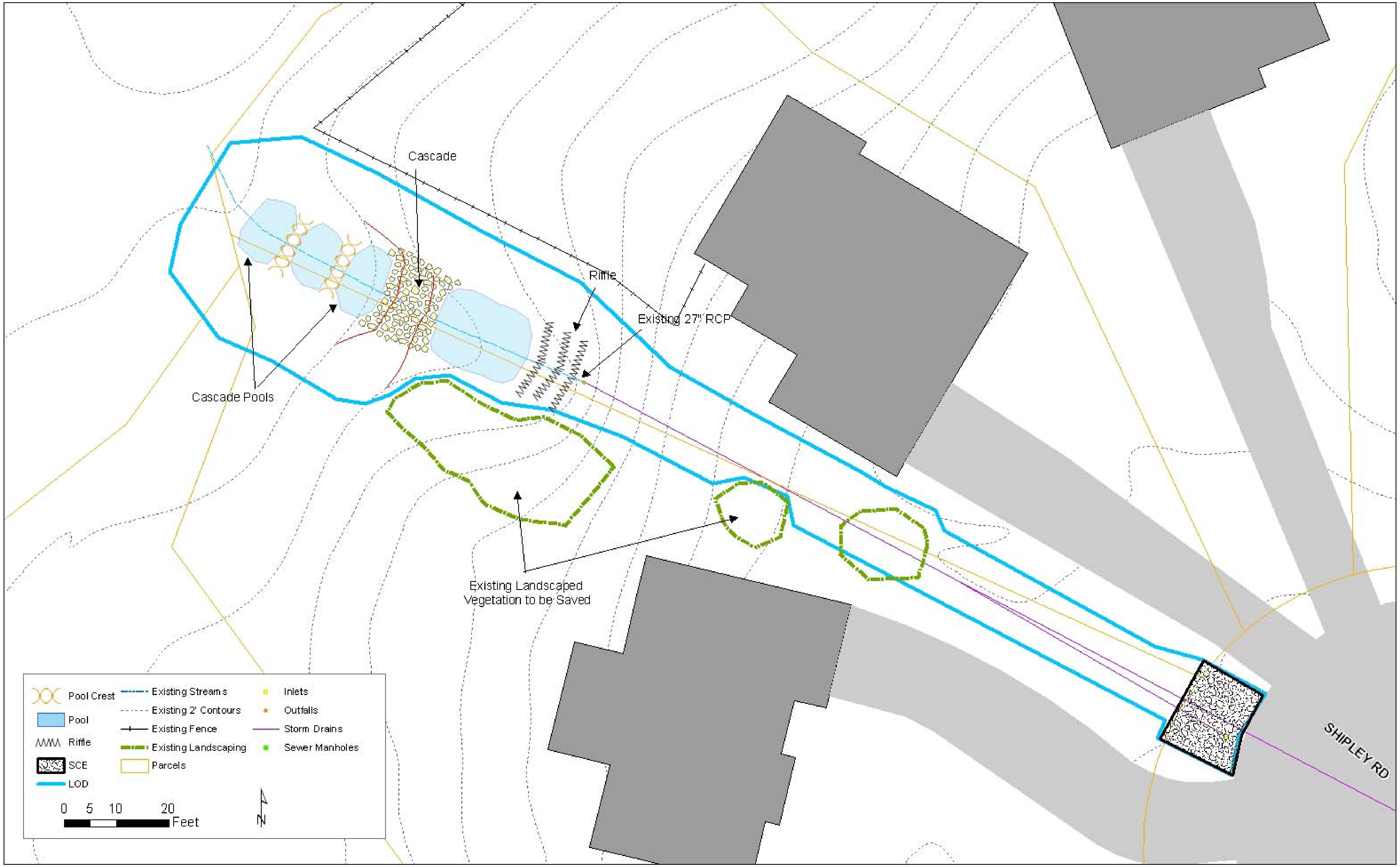


FIGURE 3: CONCEPTUAL DESIGN PLAN SITE SKETCH

PROJECT COST ESTIMATE

ITEM	QTY	UNITS	UNIT COST	TOTAL
Site Work				
Clearing and Grubbing	350	SY	$ 8	$ 2,800
Erosion and Sediment Control (includes SCE)	540	SY	$ 4	$ 2,160
Stabilized Construction Entrance	1	LS		$ 1,500
Concrete/Pipe Removal	20	SY	$ 50	$ 1,000
Blaze Orange Fence	510	LF	$ 2.50	$ 1,275
SPSC Construction				
Excavation	175	CY	$ 20	$ 3,500
Sand Fill (Filter Bed Area)	70	CY	$ 60	$ 4,200
Sandstone Boulders (D50 = 1.5ft stone)	25	CY	$ 240	$ 6,000
Cobble Weir (D50 = 0.5ft stone)	25	CY	$ 90	$ 2,250
Geotextile	55	SY	$ 4	$ 220
Wood Chips (30% mix in Filter Bed Area)	30	CY	$ 25	$ 750
Wood Chips (surface 1 inch)	6	CY	$ 25	$ 150
Plantings (Trees, Shrubs, Herbs, and SAV)	230	SY	$ 20	$ 4,600
Permanent seeding	418	SY	$ 1	$ 418
Outfall (27 inch standard end section)	1	LS		$ 2,500
			Direct Construction Subtotal	$ 33,323
Indirect Costs				
Construction Stakeout (5%)	1	LS		$ 1,666
Mobilization (10% of Directs or $1,000)	1	LS		$ 3,332
Easement (permanent only)	800	SF	$ 20	$ 16,000
			Base Construction Cost	$ 20,998
			Subtotal	$ 54,321
			Contingency (30%)	$ 16,296
			Construction Subtotal	$ 70,618
			Envt'l Studies / Permitting (5% of Construction or $5,000)	$ 5,000
			Engineering and Surveys (30%of Construction or $50,000)	$ 50,000
			Total Capital Cost	**$ 125,618**

EXISTING CONDITIONS SITE PHOTOS

PHOTO 1: UPSTREAM SECTION OF EXISTING RIP RAP CHANNEL

PHOTO 2: VIEW OF SCOUR HOLE FROM TOP OF HEADCUT

PHOTO 1: FAILING GABION BASKET FACING UPSTREAM

28353 1/2/2013.

STATE OF MARYLAND
HALA E. FLORES
No. 28353
REGISTERED
PROFESSIONAL ENGINEER

ENGINEER CERTIFICATION

*Professional Certification: I hereby certify that these **Conceptual Design Plan** documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland. (note: design plans are conceptual and are **not for construction**)*

License No. 31201*, Expiration Date:* 1/24/13

STATE OF MARYLAND
JAMES A. TOMLINSON
No. 31201
PROFESSIONAL ENGINEER

PROJECT OVERVIEW

This project takes a community approach to the reduction of stormwater runoff and pollutant loading. It encompasses several green infrastructure techniques, including green alleys, porous pavement, and rain gardens (bioretention) within a neighborhood in Brooklyn Park. Note that the green infrastructure measures presented here are chosen for a pilot project within the Brooklyn Park neighborhood. These efforts could be expanded across the whole neighborhood and/or watershed.

FIGURE 1: DRAINAGE AREA MAP

Project Location: This neighborhood is within subwatershed PN1 and is bounded on the North by the City of Baltimore, on the West by the Patapsco River, on the East by Belle Grove Road, and on the south by Riverview Road.

DRAINAGE AREA CHARACTERISTICS

LAND USE: Existing - High density residential (1/8 acre)

DRAINAGE AREA: Please see details by individual measure.

IMPERVIOUS AREA: Please see details by individual measure and note that neighborhood is completely built out, evidenced by no change in imperviousness from existing to future.

WIP SECTORS: Predominately county private high density residential and county roads

DOMINANT SOILS Udorthents (Hydrologic Soil Group [HSG] C)

Acres	Alley 1	Alley 2	Alley 3	Alley 4	PP-1	RG 1*	RG2	TOTAL of ALL MEASURES
Drainage Area	2.10	1.75	2.03	3.13	0.29	1.74	0.72	11.77
Existing Impervious Area	1.62	1.27	1.37	2.00	0.15	0.88	0.51	7.81
Future Impervious Area	1.62	1.27	1.37	2.00	0.15	0.88	0.51	7.81

* Includes information for both Anne Arundel County and estimates for Baltimore City

HYDROLOGY:

	Green Infrastructure Measure	Weighted CN	Time of Conc (hrs)	Flow – 1 yr (cfs)	Flow – 2 yr (cfs)	Runoff – 1 yr (in)	Runoff – 2 yr (in)
EXISTING/FUTURE:	Alley-1	85.2	0.09	4	6	1.35	1.85
	Alley-2	88.3	0.049	4	6	1.56	2.1
	Alley-3	89.0	0.043	5	7	1.62	2.16
	Alley-4	87.6	0.134	7	9	1.53	2.05
	PP-1	84.4	0.022	1	1	1.31	1.8
	RG-1	85.0	0.112	2	3	1.34	1.84
	RG-2	89.4	0.032	2	2	1.67	2.21

PROJECT BENEFITS

WATER QUALITY: Porous pavement, rain gardens, and green alleys provide significant water quality benefits through filtration, sedimentation, and infiltration. As these various green infrastructure techniques involve similar pollutant removal mechanisms, the removal efficiencies can be expected to be 40-50% for TN, 60-70% for TP, and 85-90% for TSS. In addition to these chemical pollutants, green infrastructure can also effectively address thermal impacts through infiltration, heat exchange, evapotranspiration, shading, etc.

HYDROLOGY: Compared to conventional stormwater measures, green infrastructure techniques have the added benefit of reducing the overall volume of runoff in addition to peak flow rates. This project would be expected to reduce runoff significantly from these areas, especially during more frequent storm events. This will produce runoff characteristics more similar to natural conditions.

AQUATIC HABITAT: Improved water quality, thermal properties, and reduced runoff volumes will reduce stress on aquatic biota.

STREAM STABILITY: By reducing the volume of stormwater runoff, the use of green infrastructure is recognized as one of the best ways to protect stream channels from erosion. Reduced flow rates and volumes during more frequent storm events will also reduce sediment transport.

PUBLIC OUTREACH: This project should have a strong public outreach component due to the fact that it is associated with improving neighborhood amenities such as recreational parks and alleys. In addition to educational signage, one or more neighborhood meetings could be held to inform local residents and solicit input. Upon project completion, a ribbon cutting ceremony could involve a number of activities including some geared towards neighborhood children (e.g., using water balloons to demonstrate how the porous pavement basketball court works).

The following information incorporates water quality information across all 7 green infrastructure measures. Please note that the information included for Rain Garden 1 in the totals below is incomplete because pollutant load modeling was not performed for the Baltimore City portions of the drainage area.

	Existing Conditions (Average Annual Pollutant Loading, Average Annual for Runoff Volume)						
	TP lbs/yr	TN lbs/yr	NOx lbs/yr	FC mpn/yr	TSS tons/yr	Metal lbs/yr	Average Annual Runoff Volume (inches)
PRE-REST.	15	127	42	4.3E+10	1.11	5	30
POST-REST.	4.8	66	42	4.3E+09	0.12	0.19	4.5
% DIFF.	68%	48%	0%	90%	89%	96%	85%

PROJECT CONSTRAINTS

PROPERTY OWNERSHIP: Although interspersed throughout the neighborhood, all the proposed measures are on County property (road right-of-way and park land). Part of the drainage area leading to RG1 includes area from Baltimore City but the measure is wholly on County property and drains to a County outfall.

FACILITY ACCESS: All of the proposed measures are easily accessible from the existing road/alley network. Monitoring could be achieved through any number of accessible drainage structures such as overflow structures or monitoring wells.

DESIGN/ CONSTRUCTION: Similar green alley projects have been successfully implemented in other areas such as Chicago, IL and Richmond, VA. The main challenges appear to be the relatively narrow right-of-way, existing improvements near the alleys (fences, etc.), and being able to provide access to residences during construction.

ENVIRONMENTAL IMPACTS: As this project targets an upland developed neighborhood, minimal environmental impacts are expected. Detailed soil testing should be performed to augment the soil survey information, refine infiltration rates, and look for possible constraints. The Brooklyn Park neighborhood includes several areas in the Critical Area. Green Alley 1, 2, and 3 and Rain Garden 2 are wholly contained in the and Intensely Developed Area (IDA). Green Alley 4 is partially contained in the IDA. Rain Garden 1 and Porous Pavement Basketball Court are wholly contained in the Resource Conservation Area (RCA). Although these measures will actually reduce the amount of imperviousness in the Critical Area, there will still likely be permits to be filed for working in these areas.

UTILITIES: The proposed measures generally avoid areas with known utility conflicts although some of the alleys have overhead electric wires that must be accounted for. Detailed utility surveys must be performed prior to construction and Miss Utility should be contacted.

EROSION AND SEDIMENT CONTROL: E&S controls will be important especially to protect the green infrastructure measures from sedimentation during construction (e.g., preventing sediment-laden runoff from washing or being tracked onto a porous pavement). Measures to control offsite sedimentation should be relatively straight-forward (e.g., inlet protection).

CONCEPTUAL DESIGN

Design Parameter	Effect
Recharge Volume	Exceed
Water Quality Volume	Meet (98% on average)
Channel Protection	Largely achieve through infiltration
Flood Control	Partially mitigated

This conceptual design was developed on a neighborhood scale by looking at existing opportunities for managing stormwater using green infrastructure on public property. This particular neighborhood is a good area for a green alley program due to the number and configuration of alleys. This program could be a model for other areas with alley networks. In addition to alleys, the neighborhood also has County park land that could be used for stormwater management. Specifically, two rain gardens and a porous pavement basketball court are proposed. The proposed measures have been conceptually sized to manage the water quality volume from the drainage area they serve. If soil conditions are favorable, this volume could be largely infiltrated rather than being discharged, which will also significantly address the channel protection volume. Although the concepts will have some benefit during larger storm events associated with flooding (e.g., the 10-year, 24-hour storm), they are specifically targeted towards smaller events.

ALLEYS / POROUS PAVEMENT:

Green Infrastructure Measure	Alley / Court Area (SF)	Alley Length (ft)	Infiltration Trench Depth (ft)	Infiltration Trench Width (ft)	Infiltration Trench Area (SF)	Total Capture Volume (in.)	Water Quality Volume, WQv (in.)	Percent of WQv
Alley 1	7,200	530	2.0	8.5	4,505	0.56	0.74	75%
Alley 2	7,600	600	2.0	8.5	5,100	0.76	0.70	108%
Alley 3	7,850	560	2.0	8.5	4,760	0.61	0.66	93%
Alley 4	12,000	800	2.0	8.5	6,800	0.57	0.63	91%
Porous Court (PP1)	3,800	---	1.0	---	3,800	1.98	0.52	381%
Total	38,000	2,500	---	---	25,000	0.66	0.67	98%

RAIN GARDENS:

Green Infrastructure Measure	Rain Garden Area (SF)	Surface Storage Capacity (CF)	Gravel Storage Volume (CF)	Total Capture Volume (in.)	Water Quality Volume, WQv (in.)	Percent of WQv
Rain Garden 1	4,000	2,000	800	0.77	0.76	102%
Rain Garden 2	2,400	1,200	480	1.12	0.68	165%

CONCEPTUAL DESIGN PLAN

FIGURE 2: CONCEPT PLAN LAYOUT

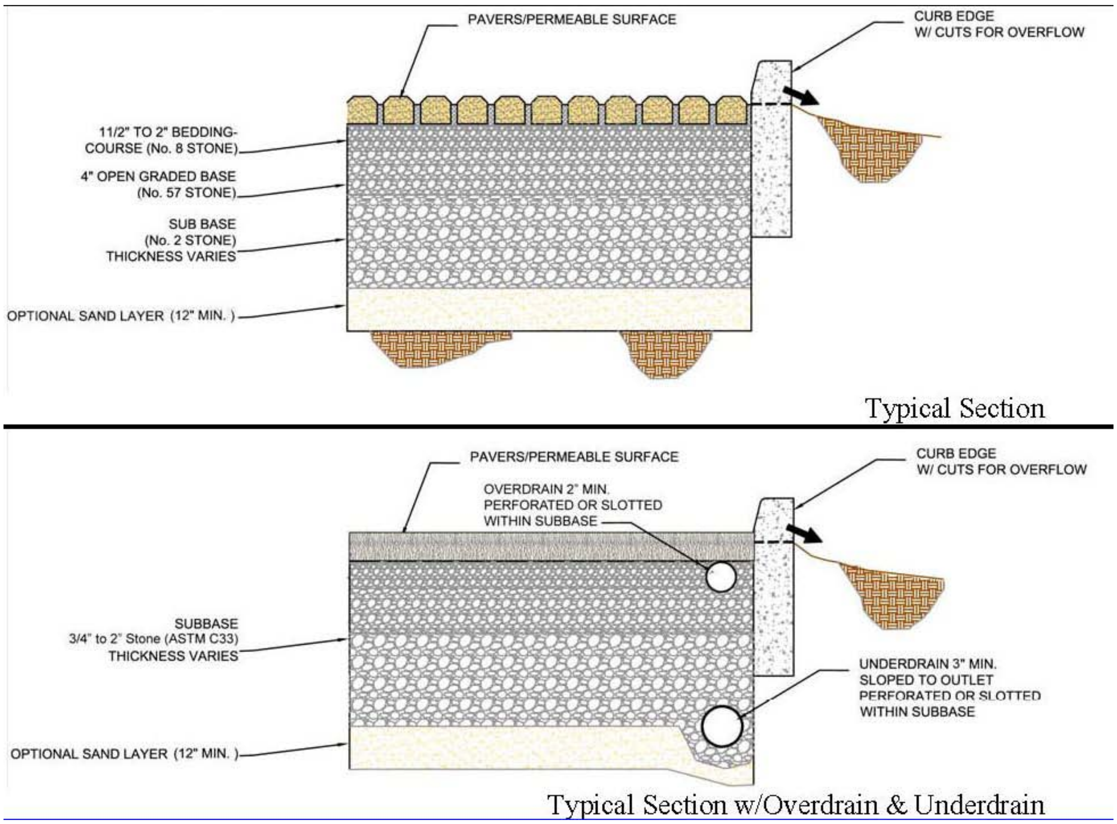


FIGURE 3: EXAMPLE POROUS PAVEMENT DETAILS (FROM MARYLAND STORMWATER DESIGN MANUAL, MDE 2009)

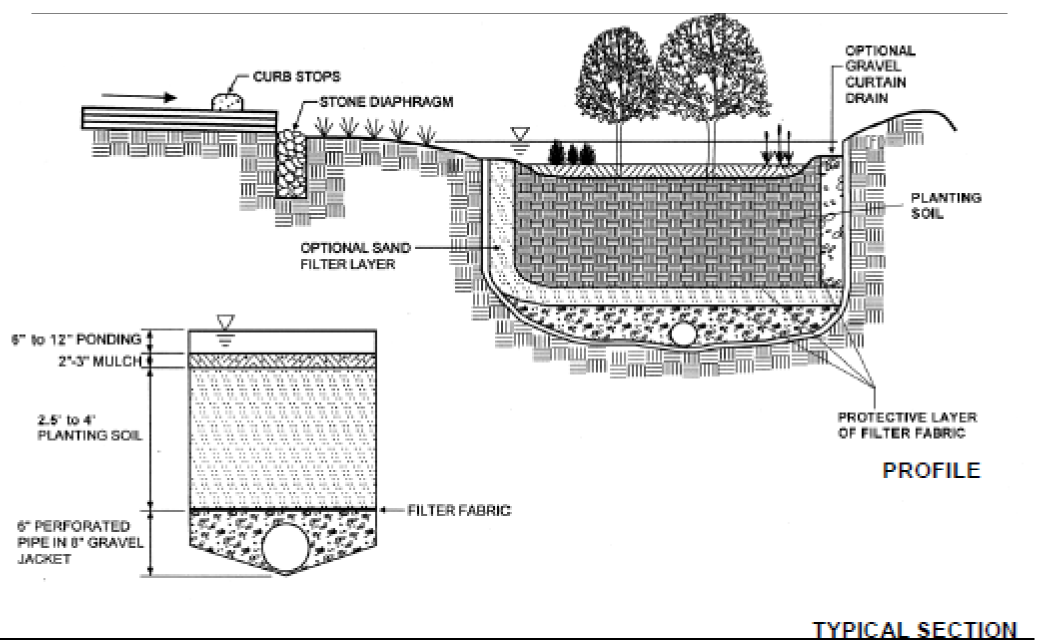


FIGURE 4: EXAMPLE RAIN GARDEN DETAILS (FROM MARYLAND STORMWATER DESIGN MANUAL, MDE 2009)

EXAMPLE RENDERINGS OF PRE AND POST RESTORATION

FIGURE 5: RENDERINGS OF PRE AND POST CONSTRUCTION GREEN ALLEY EXAMPLE

FIGURE 6: RENDERINGS OF PRE AND POST CONSTRUCTION GREEN ALLEY EXAMPLE (LOWER END OF ALLEY 3)

PROJECT COST ESTIMATE

A detailed cost estimate for one of the green infrastructure measures has been included here for illustration purposes. Costs for all measures were calculated and a $/sq ft of footprint was also developed and used in the summary table below. In terms of Total Capital Cost, the Green Alleys and Basketball Court porous pavement measures typically cost approximately $16/sq ft while the rain gardens cost $22/sq ft. However, a more meaningful way to examine these costs is to look at the marginal costs of the green infrastructure upgrades. That is, how much more the green infrastructure improvements will cost over a typical alleyway improvement project (i.e., pavement reconstruction as much of the alleys are in need of rehabilitation). Green infrastructure projects integrated with an existing capital improvement plan (i.e., identifying when these alleyways will be repaved) is a very cost effective approach. In the detailed example below, the marginal cost of the green infrastructure measures for Alley 4 is only $79,000 (i.e., if performed during an existing re-paving project) while the project from scratch costs $182,000.

TABLE: DETAILED COST ESTIMATE FOR ALLEY 4

Description	Unit	Capital Cost per Unit	Alley 4		Alley 4 - Conventional Reconstruction & Marginal GI Costs		
			Quantity	Capital Cost	Quantity	Conventional Capital Cost	Marginal GI Cost
Demolition / Excavation / Hauling / Disposal	$yard^3$	$35.00	678	$23,722	296	$10,376	$13,347
Crushed Stone	$yard^3$	$30.00	588	$17,627	222	$6,667	$10,960
Planting Soil	$yard^3$	$40.00	0	$0	0	$0	$0
Non-woven Geotextile	$yard^2$	$3.00	944	$2,833	0	$0	$2,833
EPDM water / root barrier	$yard^2$	$8.00	25	$200	0	$0	$200
Overflow Riser w/ Sump and Catch Basin	Unit	$600.00	1	$600	0	$0	$600
Solid or Perforated HDPE pipe and bedding	ft	$7.00	400	$2,800	0	$0	$2,800
Porous Asphalt Surface Course	ft^2	$2.20	6,800	$14,960	0	$0	$14,960
Asphalt Treated Permeable Base Course	ft^2	$2.00	6,800	$13,600	0	$0	$13,600
Conventional Asphalt (Type 7 and Type 3)	ft^2	$3.20	5,200	$16,640	12,000	$38,400	-$21,760
Plantings for Rain Garden	ft^2	$3.75	0	$0	0	$0	$0
Trees - Deciduous, 2" caliper	Unit	$350.00	0	$0	0	$0	$0

Description	Unit	Capital Cost per Unit	Alley 4		Alley 4 - Conventional Reconstruction & Marginal GI Costs		
			Quantity	Capital Cost	Quantity	Conventional Capital Cost	Marginal GI Cost
Direct Construction Subtotal				**$92,983**		**$55,442**	**$37,540**
E/SC, MOT, MOS (5% of Directs)	L.S.	5%	1	$4,649	1	$2,772	$1,877
Construction Stakeout (2% of Directs)	L.S.	2%	1	$1,860	1	$1,109	$751
Base Construction Cost				$99,491		$59,323	$40,168
Mobilization (10% of Directs or $1,000)	L.S.	10%	1	$9,298	1	$5,544	$3,754
Subtotal				$108,790		$64,867	$43,922
Contingency (30%)	L.S.	30%	1	$32,637	0.75	$19,460	$13,177
Construction Total				$141,427		$84,328	$57,099
Envt'l Studies / Permitting (4% of Construction)	L.S.	4%	1	$5,657	0.75	$2,530	$3,127
Engineering and Surveys (25% of Construction)	L.S.	25%	1	$35,357	0.75	$15,811	$19,545
Total Capital Cost				**$182,000**		**$103,000**	**$79,000**

TABLE COST SUMMARY

Green Infrastructure Measure	Unit Cost/ SF	Area (SF)	Approximate Total Capital Cost	Approximate Cost of Conventional Capital Project	Approximate Marginal Cost of GI Measure
Alley 1	$16	7,200	$ 115,200.00	$64,800.00	$50,400.00
Alley 2	$16	7,600	$ 121,600.00	$68,400.00	$53,200.00
Alley 3	$16	7,850	$ 125,600.00	$70,650.00	$54,950.00
Alley 4	$16	12,000	$ 192,000.00 *	$108,000.00	$84,000.00
Porous Court (PP1)	$16	3,800	$ 60,800.00	$34,200.00	$26,600.00
Rain Garden 1	$22	4,000	$ 88,000.00	$34,000.00**	$54,000.00

Green Infrastructure Measure	Unit Cost/ SF	Area (SF)	Approximate Total Capital Cost	Approximate Cost of Conventional Capital Project	Approximate Marginal Cost of GI Measure
Rain Garden 2	$22	2,400	$ 52,800.00	$20,400.00**	$32,400.00
Total			**$ 756,000.00**	$401,000.00	$356,000.00

*Note: Using the average cost per SF of $16, provides a slightly higher cost ($192,000) for Alley 4 than the detailed cost estimate ($182,000).

**Conventional park improvement project with new landscaping

MAINTENANCE

Maintenance of porous pavements such as those proposed for the green alleys and the basketball court typically involves vacuuming with a street cleaning unit two times per year (two times is an average, areas that receive a lot of sediment and debris may require more frequent cleaning whereas pristine areas may require less). This is often in line with municipal street cleaning programs and the same equipment can often be used (in a vacuum mode). In addition to vacuuming, drainage structures connected to the porous pavement systems should be cleaned as necessary. Landscaped areas adjacent to the porous pavements should also be maintained to minimize sediment washing onto the pavement surface. Maintenance for rain gardens is similar to maintenance required for other landscaped areas – watering during establishment, spot weeding, mulching, pruning, erosion repair, trash removal, etc. In addition, sediment and debris should be removed from the rain garden and drainage structures as necessary.

EXISTING CONDITIONS SITE PHOTOS

PHOTO 1: EXISTING ALLEY WAY (NOTE THE POOR PAVEMENT CONDITION)

PHOTO 2: EXISTING BASKETBALL COURT FOR PROPOSED POROUS PAVEMENT PROJECT

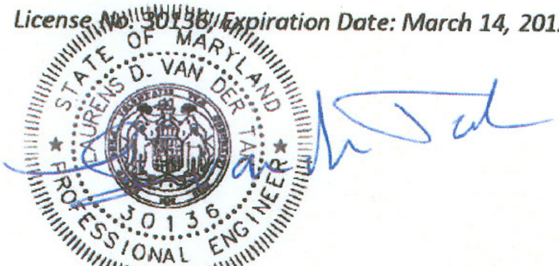
PHOTO 3: EXISTING SITE FOR POTENTIAL BIORETENTION/ RAIN GARDEN

ENGINEER CERTIFICATION

*Professional Certification: I hereby certify that these **Conceptual Design Plan** documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland. (note: design plans are conceptual and are **not for construction**)*

License No. 30136, Expiration Date: March 14, 2012

28353 1/2/2013



This project includes 950 linear feet of existing channel that is degraded and entrenched with several utility concerns. The channel has a forested buffer to the south with development encroaching upon the channel to the north. This project would include a 520-foot Step Pool Storm Conveyance (SPSC) in the upstream portion of the site and regrading and stabilization of the stream banks to allow access to the floodplain in the downstream 430-foot portion of the site. The existing buffer can be enhanced through the removal of invasive species and the establishment of native species.

PROJECT LOCATION: Extends along Science Drive between Elkridge Landing Road (upstream limit) to I-195 (downstream limit).

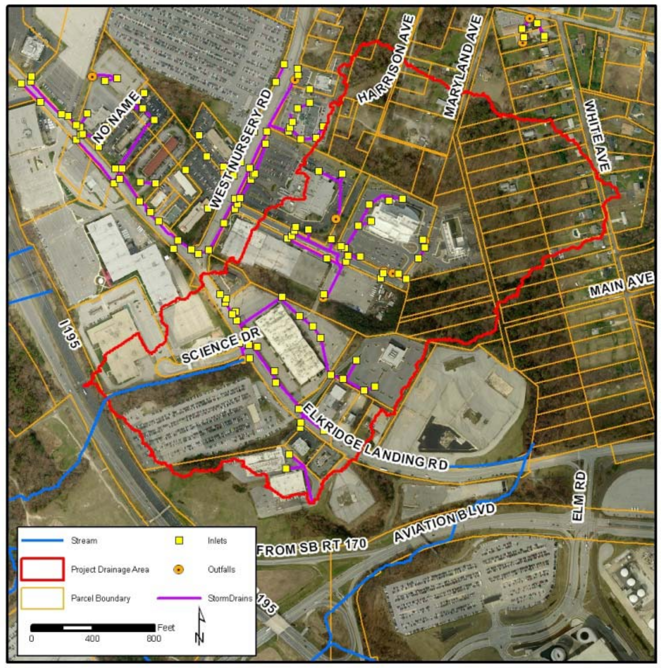


FIGURE 1: DRAINAGE AREA MAP

DRAINAGE AREA CHARACTERISTICS

LAND USE: Existing conditions land cover within the drainage area is mixed, but is dominated by commercial (46%) and woods (27%). Low density residential use (14%) is limited to the northeastern fringe of the drainage area. Industrial uses, located centrally in the drainage, make up 12% of the area. The remainder is scattered areas of open space.

DRAINAGE AREA: 108.87 acres

IMPERVIOUS AREA: 52.04 acres (48%)

WIP SECTORS:
County Private Commercial
County Private Low Density Residential
County Private Open Space
County Private Industrial
County Private Natural Resource Lands
County Roads and Facilities
Other DOD Facilities

DOMINANT SOILS Predominately Hydrologic Soil Group B (60.9 acres), with Group D (22.8 acres), Group C (20.8 acres) and A (4.3 acres) also present.

HYDROLOGY:

			Peak Discharges (cfs)				Runoff (inches)			
	Weighted CN	Time of Conc (hrs)	1 yr	2 yr	10 yr	100 yr	1 yr	2 yr	10 yr	100 yr
EXISTING:	78.67	0.47	88	131	284	474	0.96	1.39	2.94	4.91

PROJECT BENEFITS

WATER QUALITY: The SPSC system is designed to provide subsurface flow and increase infiltration, creating removal of suspended particles and nutrients. The associated plant material provides an additional level of treatment as dissolved nutrients are taken up. Typical removal rates are estimated at the following assuming 100% of the water quality volume is treated: total phosphorus (TP) 60%, total nitrogen (TN) 40%, nitrate and nitrite (NOx) 0%, fecal coliform bacteria (FC) 90%, total suspended solids (TSS) 85% and metals 85%. The site designed as proposed provides a sand filter bed area capable of treating 100% of the existing condition water quality volume. The resulting estimated pollutant removals are provided in the table below.

Implementation of this project will provide a reduction in sediment supply by stabilizing eroding banks and scouring channel substrate. Removal of fine clays, silts, and sands will improve downstream water clarity and bed substrate habitat. Introduction of phosphorus bound to the soils will be reduced. More frequent floodplain access and better root mat connectivity will enhance cycling and uptake of nutrients such as phosphorus and nitrogen.

HYDROLOGY: The SPSC systems's attenuation pools and seepage element converts surface flow to shallow groundwater flow, thereby reducing peak surface discharge and velocity. In the downstream portions of the site, the proposed restoration will be designed to better manage peak flows and runoff. The creation of a floodplain bench will hydrologically connect the riparian vegetation to the stream channel.

AQUATIC HABITAT: Aquatic habitat will be improved through increasing the variation of instream habitat and increased ecological function. Maintenance of a low flow channel, a reduction in instream channel shear stress, and reduction of channel sedimentation will allow for more stable epibenthic substrate and better colonization potential by benthic macroinvertebrate species.

STREAM STABILITY: The stream bed and banks will be stabilized to reduce scour and loss of soil. Stabilized riffles will provide grade control. Bank protection will stabilize unwanted lateral migration, particularly in reaches where infrastructure protection is critical.

PUBLIC OUTREACH: The project is located near the BWI Trail but is generally surrounded by commercial development; therefore public outreach potential is limited.

	Existing Conditions					
	TP lbs/yr	TN lbs/yr	NOx lbs/yr	FC mpn/yr	TSS tons/yr	Metal lbs/yr
PRE-REST.	70	800	449	$9.37E^{10}$	9.12	57
POST-REST.	28	480	449	$0.937E^{10}$	1.37	9
% DIFF.	60	40	0	90	85	85

PROJECT CONSTRAINTS

PROPERTY OWNERSHIP: The project stream is located on two private properties. A 50-foot 50-year floodplain easement buffers the property boundary (25 feet on each side) that runs the length of the project parallel to Science Drive. Much of the project is within the easement. Costs for permanent easements were included under the assumption that the County may need to provide easement for structural portions of the project such as the SPSC riffle structures.

FACILITY ACCESS: The site can be accessed from either Elk Ridge Landing Road, Science Drive, or possibly the parking area of adjacent commercial developments. Access is possible from the existing easement described above. Property owner coordination will be necessary.

DESIGN/ CONSTRUCTION: Will require cooperation from private land owners. The upstream and downstream extents terminate at culverts located under roadways.

ENVIRONMENTAL IMPACTS: Stream/wetland permitting will be necessary and stream closure periods may affect timing of work. No major environmental constraints are anticipated with this project although Maryland Aviation Authority (MAA) will likely require approval of the proposed design plan.

UTILITIES: A sewer line with several manholes parallels the channel, including a section of exposed pipe and an exposed stand pipe. Several stormwater outfalls drain into the channel. A utility box and several monitoring wells are within the project area. This concept plan is developed without the costs associated with any potential relocation or replacement of utilities.

EROSION AND SEDIMENT CONTROL: This project will require a pump around practice and typical E&S controls.

CONCEPTUAL DESIGN

The existing conditions description is organized below by dividing the channel into 3 reaches based on observed characteristics and desktop measurements.

The most upstream reach, Reach 1, is approximately 360 linear feet and is entrenched and over-widened. The average channel slope is 2.2%. The banks are 3 to 4 feet in height and the channel is 5 to 6 feet in width. The tops of southern banks are generally well-vegetated with woody and herbaceous species in addition to invasive species. This reach would most likely be classified as a Rosgen G/F type stream.

Reach 2, approximately 160 linear feet, has the highest slope (~3.8%) and similar characteristics to Reach 1. The banks are lower in height but the channel remains 5 to 6 feet in width. A sanitary sewer line runs parallel to the channel, and the sewer and a stand pipe are exposed within a section of Reach 2. Reach 2 is encroaching on adjacent improved private properties as it widens. The top of banks on the southern bank are well-vegetated, similar to Reach 1. This reach would most likely be classified as a Rosgen F type stream.

Reach 3, approximately 430 linear feet, has the lowest gradient (~1.16%) and although over-widened, it is less entrenched with more access to the floodplain. The banks are approximately 2 to 3 feet in height. The tops of banks on the southern side are also well-vegetated but have large areas of bare soil. This reach would most likely be classified as a Rosgen F type stream.

The approach to the restoration design is two-fold; incorporating a SPSC in the top half of the site (Reaches 1 and 2), and restoring a more traditional stream channel in the lower section (Reach 3). A SPSC cascade is utilized to make up the higher Reach 2 slope in the middle portion of the site.

Design Parameter	Value
Drainage area (acre)	108.87
Percent Impervious (%)	48
Volumetric runoff coefficient (R_v)	0.48
Water Quality volume (WQ_v) (ft^3)	189,775
Peak discharge 100-year storm (ft^3/s)	474
Step Pool Storm Conveyance Reach (1 and 2)	
Total length (ft)	520
Elevation drop over length (ft)	14
Cobble d_{50} size (ft) (riffle)	0.5
Top width of riffle channel (ft)	40
Depth of riffle channel (D) (ft)	2.3
Depth of pools (h_f) (ft)	4
Length of riffle segments (ft)	10
Length of pool segments (ft)	30
Slope of riffle segments	0.100
Slope of pool segments	0
Cascade length (ft)	10
Total Elevation drop over cascade (ft)	3
Total Elevation drop in cascade pools (ft)	0
Cascade width (ft)	40
Cascade depth (ft)	1.6
Cobble d_{50} size (ft) (cascade)	1.5
Sand filter depth at pools (d_f(pool)((ft)	1.5
Sand filter depth at riffles (df(riffle)) (ft)	4
Width of sand filter (W_{sand}) (ft)	40
Area of sand filter (Af) (ft^2)	16,000
Stream Channel Reach (3)	
Total Length (ft)	430
Elevation drop over length (ft)	5
Overall Slope (%)	0.016
Stone toe protection size (ft)	2
Length of riffle segments (ft)	60
Depth pools (ft)	2
Length of pools (ft)	60

The SPSC includes a series of 9 riffle/pool segments in the Reach 1 stream segment. Each riffle is 10 feet long with a slope of 0.10, dropping 1.0 feet per riffle. The riffles, at 40 feet wide and 2.3 feet deep, pass the 100-yr design discharge without exceeding allowable velocity and shear stress thresholds. The riffle/pool segment transitions into a cascade at the upstream end of Reach 2. Reach 2 is the segment with the highest slope (3.8%). The 10-foot cascade is followed by a series of 3 cascade pools, 20 feet in length each. The channel drops 3 feet through the cascade section at a slope of 30%. The cascade is followed by 2 additional riffle/pool segments, at the same dimensions and slope as the Reach 1 features, before transitioning into Reach 3.

The strategy for Reach 3 is to convert the channel to an urban Rosgen B type stream along roughly the existing channel alignment and profile with some increase in sinuosity and floodprone width. In this approach the bankfull channel was designed to be 2 feet deep with an adequate width to convey a discharge between the 1-year and 2-year events, 151 and 208 cfs, respectively. Additionally, adjustments to the channel were made to maintain B-channel morphology and avoid creating supercritical flows. Lastly, the tie-in slopes above the bankfull elevation were designed to maintain channel stability at the future 10-year discharge of 402 cfs.

A limited hydraulic analysis of the proposed channel cross sections determined that the bankfull channel widths necessary to convey the discharge at a depth of 2 feet are 18, 16, and 21 feet for Reach 3. Subcritical flows are maintained, but required an increase in channel width to maintain the conveyance at the lower slope. In all cases, the channel cross section is shaped to maintain a minimum water depth at baseflow to provide a more stable and permanent instream habitat.

Design considerations for channel stability at the future 10-year discharge included floodplain benches of varying widths and various tie-in slopes to meet existing grades. The main driver in this evaluation was the existing topography. If the existing channel was not significantly incised, a flood prone area or floodplain bench was incorporated. For incised segments, primarily Reach 2, the floodplain benches did not reduce the flow depths sufficiently to provide significant reductions in channel shear stress and required excessive excavation to create. For these segments, tie-in slopes of 2:1 or less seem to be feasible. In Reaches 1 and 3, tie-in slopes could be as flat as 10:1 to form a functional flood prone area.

Pending a more detailed hydrologic and hydraulic analysis, placement of resistant bed materials, such as cobbles, or other grade control structures such as riffle grade controls or cross-vanes, may be required to prevent channel incision in Reach 3. Bank protection such as a combination of bioengineering or stone toe protection should be considered to prevent continued widening and protect infrastructure. Wherever practical and feasible (based on shear stress and canopy cover), bioengineering materials can be used throughout the reaches to enhance the riparian buffer in addition to riparian plantings of native species. While selection of bed, bank and toe protection is not fully feasible at the conceptual stage, several alternative typical details are provided in Figure 3 and provide various levels of stone and bioengineering solutions.

CONCEPTUAL DESIGN PLAN

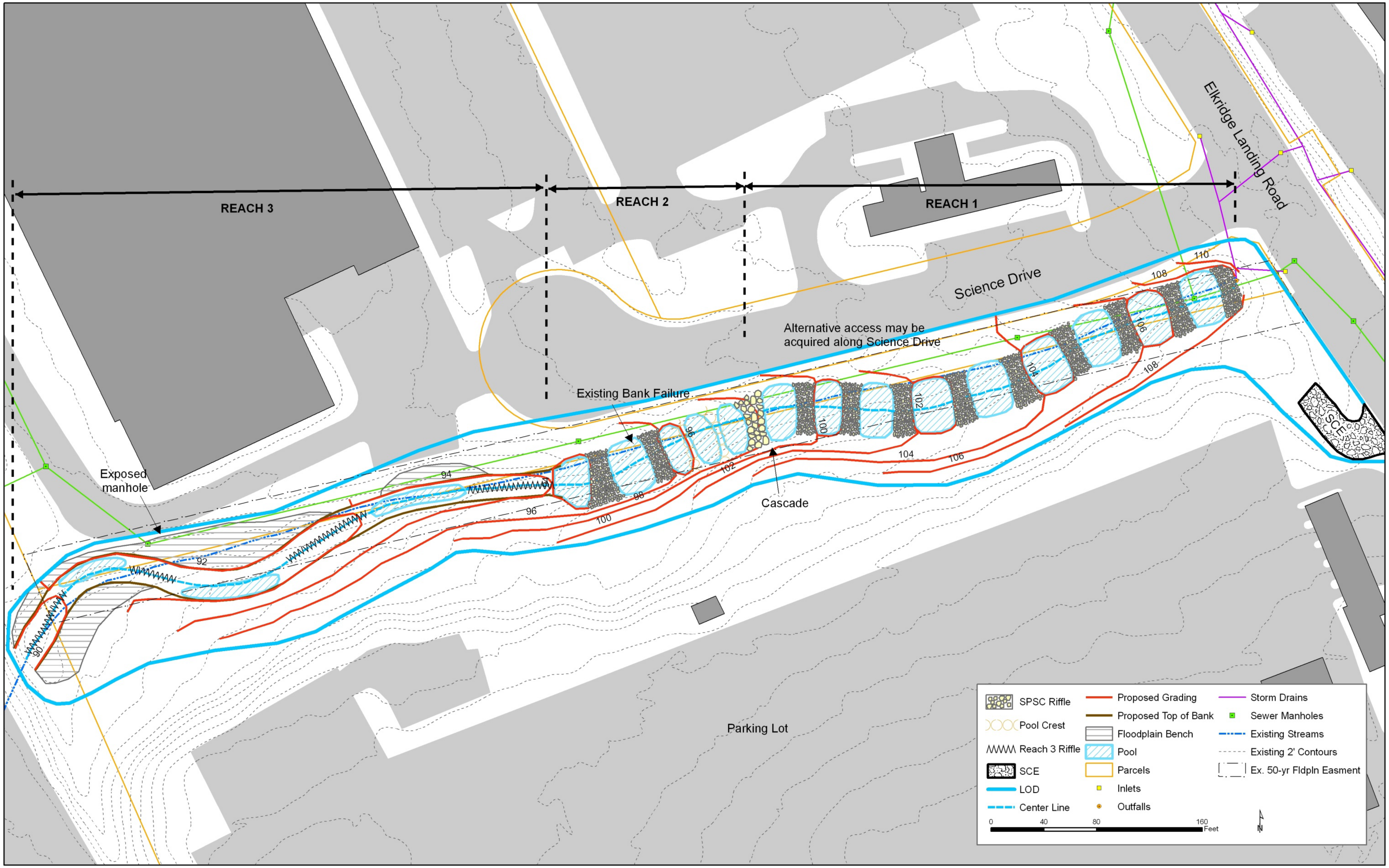
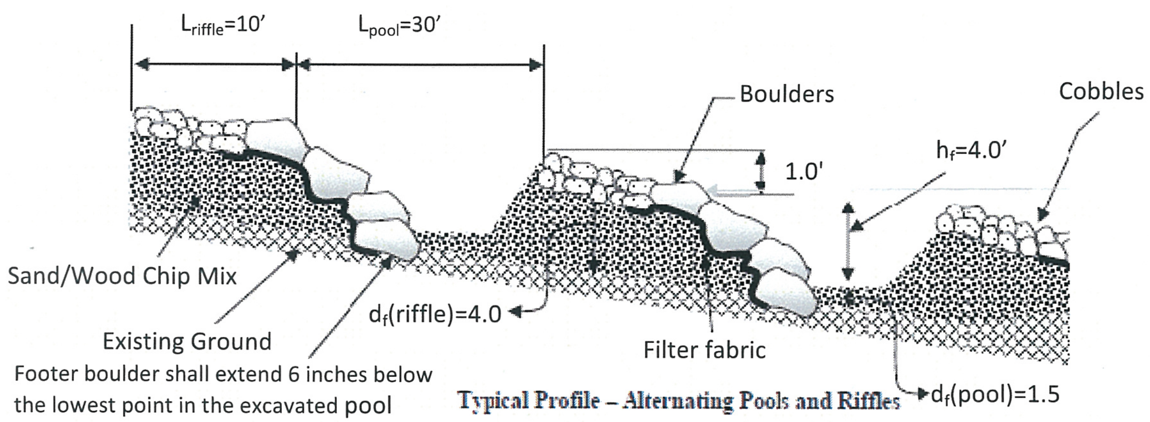
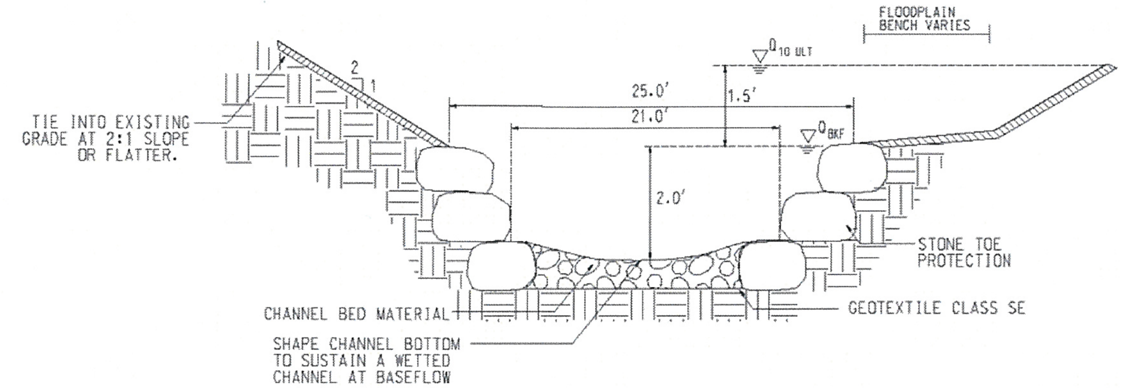


FIGURE 2: PLAN VIEW CONCEPTUAL SITE SKETCH

CONCEPTUAL DESIGN DETAILS



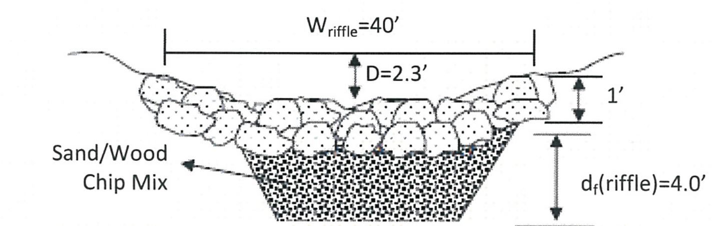
Typical Profile – Alternating Pools and Riffles



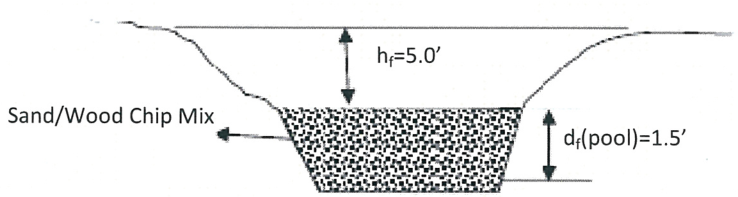
REACH 3 – TYPICAL SECTION

NOT TO SCALE

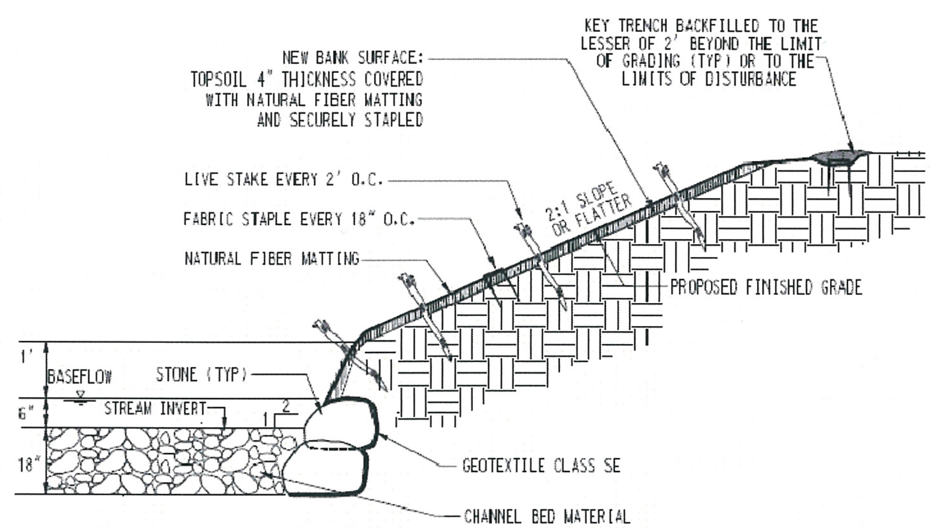
NOTE: DIMENSIONS APPROXIMATE - BASED ON ASSUMED SLOPES AND TR-20 FLOWS PROVIDED BY ANNE ARUNDEL COUNTY



Riffle Weir Cross Section Through Cobble

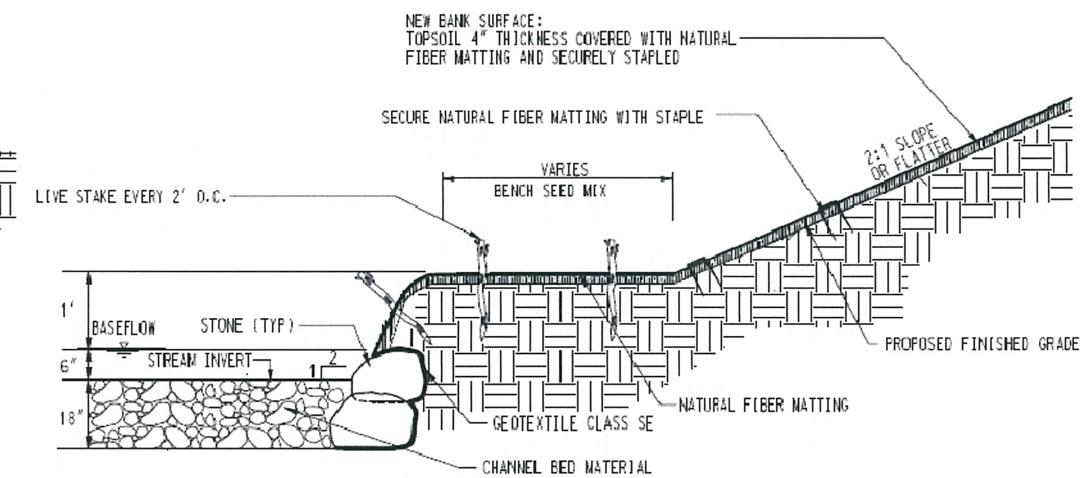


Pool Cross Section



TYPICAL SINGLE STONE TOE PROTECTION DETAIL WITHOUT BENCH

NOT TO SCALE



TYPICAL SINGLE STONE TOE PROTECTION DETAIL WITH BENCH

NOT TO SCALE

SPSC Details modified from *Design Guidelines for Step Pool Storm Conveyance*, Anne Arundel County Government Department of Public Works. November 2010 edition.

PROJECT COST ESTIMATE

ITEM	QTY	UNITS	UNIT COST	TOTAL
Site Work				
Clearing and Grubbing	7,400	SY	$ 8	$ 59,200
Erosion and Sediment Control	11,200	SY	$ 4	$ 44,800
Stabilized Construction Entrance	1	LS		$ 2,000
Concrete/Pipe Removal	20	SY	$ 50	$ 1,000
Blaze Orange Fence	2,450	LF	$ 2.50	$ 6,125
SPSC Construction				
Excavation	2,320	CY	$ 20	$ 46,400
Sand Fill (Filter Bed Area)	940	CY	$ 60	$ 56,400
Sandstone Boulders (D50 = 1.5ft stone)	130	CY	$ 240	$ 31,200
Cobble Weir (D50 = 0.5ft stone)	270	CY	$ 90	$ 24,300
Geotextile	350	SY	$ 4	$ 1,400
Wood Chips (30% mix in Filter Bed Area)	400	CY	$ 25	$ 10,000
Wood Chips (surface 1 inch)	35	CY	$ 25	$ 875
Plantings (Trees, Shrubs, Herbs, and SAV)	1,740	SY	$ 20	$ 34,800
Permanent seeding	8,880	SY	$ 1	$ 8,880
Outfall (48 inch standard end section)	1	LS		$ 3,500
Stream Reach 3				
Grading - channel realignment	1,000	CY	$ 20	$ 20,000
Stone Toe Protection	420	LF	$ 70	$ 29,400
Grade control structures	4	EA	$ 5,000	$ 20,000
Natural fiber matting	3,400	SY	$ 5	$ 17,000
Permanent seeding	3,400	SY	$ 1	$ 3,400
Plantings (Trees, Shrubs, Herbs, and SAV)	2,000	SY	$ 20	$ 40,000
			Direct Construction Subtotal	$ 460,680
Indirect Costs				
Construction Stakeout (5%)	1	LS		$ 23,034
Mobilization (10% of Directs or $1,000)	1	LS		$ 46,068
Easement (permanent only)	1340	SF	$ 20	$ 26,800
			Base Construction Cost	$ 95,902
			Subtotal	$ 556,582
			Contingency (30%)	$ 166,975
			Construction Subtotal	$ 723,557
			Envt'l Studies / Permitting (5% of Construction or $5,000)	$ 36,178
			Engineering and Surveys (30%of Construction or $50,000)	$ 217,067
			Total Capital Cost	**$ 976,801**

EXISTING CONDITIONS SITE PHOTOS

PHOTO 1: VIEW OF FAILING IMBRICATED WALL

PHOTO 2: VIEW OF EXPOSED SANITARY SEWER STANDPIPE

PHOTO 3: DOWNSTREAM END OF SITE AND RTE I-195 CROSSING

ENGINEER CERTIFICATION

Professional Certification: I hereby certify that these ***Conceptual Design Plan*** *documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland. (note: design plans are conceptual and are* ***not for construction****)*

License No. 31201*, Expiration Date:* 1/24/2013

#28353 1/2/2013

STATE OF MARYLAND
JAMES A. TOMLINSON
No. 31201
PROFESSIONAL ENGINEER

STATE OF MARYLAND
HALA E. FLORES
No. 28353
REGISTERED
PROFESSIONAL ENGINEER

APPENDIX I – WIP CORE STRATEGIES FOR POTENTIAL RESTORATIONS IN THE PATAPSCO NON-TIDAL WATERSHED

Anne Arundel County
WIP Core Strategies for Potential Restorations in the Patapsco Non-Tidal Watershed

WIP Restoration Parameter Description for Dry & Wet Ponds:
Publically and privately owned dry ponds approved prior to 2002 were not sized to treat the required water quality volume and are a consideration for the Anne Arundel County Bay TMDL WIP retrofit. Dry ponds provide limited peak flood attenuation and have suboptimal pollutant removal efficiencies when compared with other BMP types. The Shallow wetland marsh, Regenerative Step Pool Storm Conveyance, and/or the constructed wetland BMP are recommended as viable retrofit scenarios. All public and private dry ponds approved prior to 2002 were selected regardless of the pond or subwatershed condition assessment.
Publically and privately owned wet ponds approved prior to 2002 were not sized to treat the required water quality volume and are a consideration for the Anne Arundel County Bay TMDL WIP retrofit. Wet ponds provide limited water quality benefit through the permanent pool and peak flood attenuation. Wet ponds have suboptimal pollutant removal efficiencies when compared with other BMP types. The Shallow wetland marsh, Regenerative Step Pool Storm Conveyance, and/or the constructed wetland BMP are recommended as viable retrofit scenarios. All public and private wet ponds approved prior to 2002 were selected regardless of the pond or subwatershed condition assessment.

Dry Pond Current Condition:

AA Co BMP Code	County Name	TN	TP	TSS
DP	Detention Structure (Dry Pond)	5	10	10

Wet Pond Current Condition:

AA Co BMP Code	County Name	TN	TP	TSS
WP	Retention Structure (Wet Pond)	20	45	60

Restored Condition:

AA Co BMP Code	County Name	TN	TP	TSS
SPSC	Regenerative Step Pool Storm Conveyance	40	60	85
SM	Shallow Marsh	40	60	60
W-1	Constructed Wetland	40	60	60

WIP Restoration Parameter Description for Degraded & Severely Degraded Stream Reaches:
Streams within this restoration scenario were selected from the completed watershed studies. So far, seven out of the twelve major Anne Arundel County watersheds have been assessed. Degraded and severely degraded physical habitat conditions are based on the overall ranking from the individual watershed stream ranking scenarios. Ranking indicators include stream habitat, stream morphology, such as Rosgen classifications, contributory percent imperviousness, and infrastructure impairments, such as inadequate stream buffers, erosion, head cuts, dumpsites, and potential road overtopping. Degraded streams fall into the second lowest ranking quartile. Severely degraded streams fall into the lowest ranking quartile. With exception to the Patapsco Tidal and Bodkin Creek watersheds, which were based on DNR 2003 Established Maryland Biological Stream Survey Habitat Assessment Metrics. Five metrics are utilized for habitat assessment and include the following: instream habitat, epifaunal substrate, pool quality, riffle quality, and velocity depth diversity. Degraded streams received an MPHI rating score of 61-66. Severely degraded streams received an MPHI rating score of 37–60. To be conservative in claiming credit, the drainage areas were created using the centroid of the stream as opposed to using the most downstream location.

Current Condition:

AA Co BMP Code	County Name	TN	TP	TSS
N/A	No Treatment	0	0	0

Restored Condition:

AA Co BMP Code	County Name	TN	TP	TSS
RSC	Regenerative Wetland Seepage	40	60	60

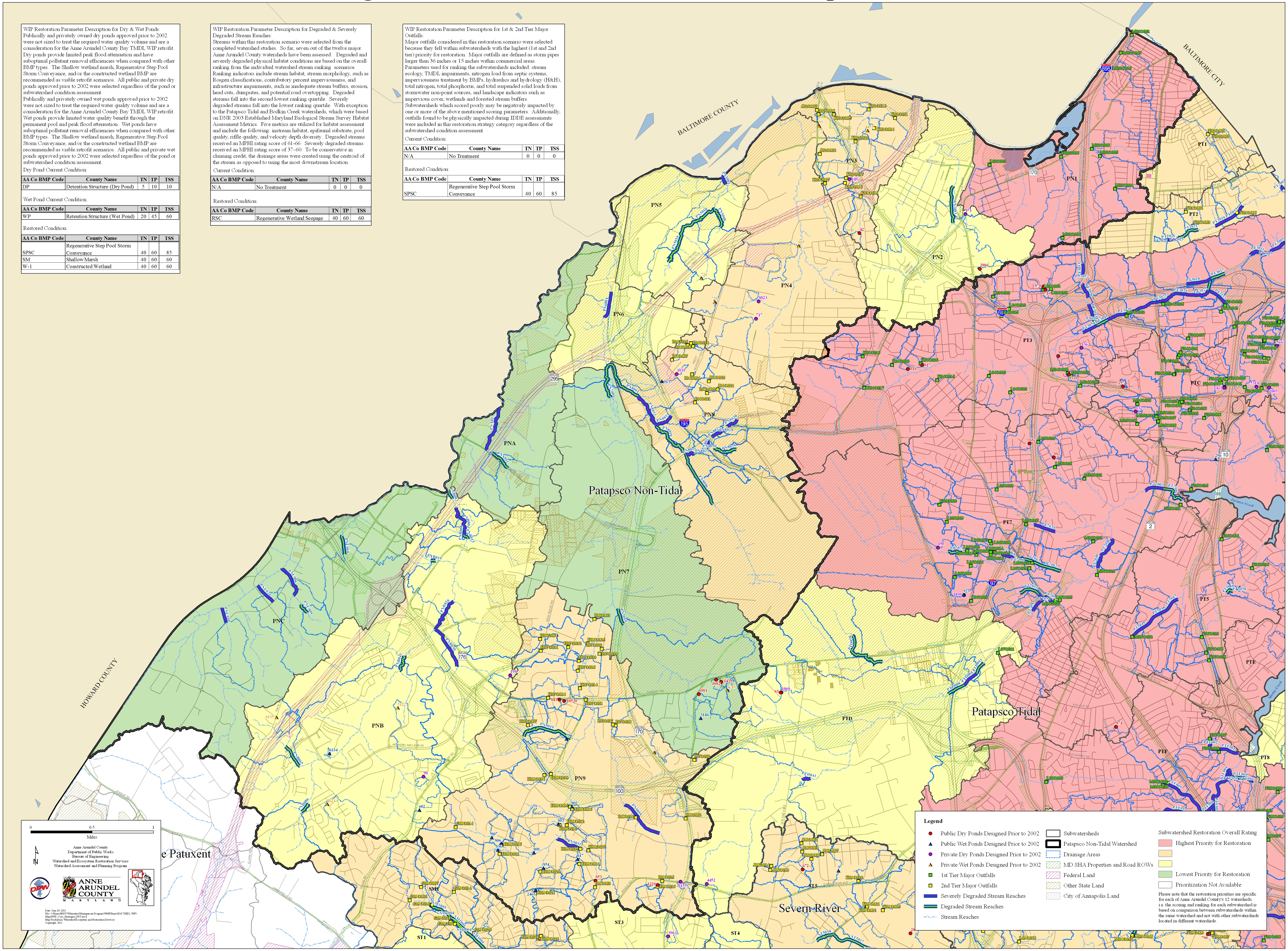
WIP Restoration Parameter Description for 1st & 2nd Tier Major Outfalls:
Major outfalls considered in this restoration scenario were selected because they fell within subwatersheds with the highest (1st and 2nd tier) priority for restoration. Major outfalls are defined as storm pipes larger than 36 inches or 15 inches within commercial areas.
Parameters used for ranking the subwatersheds included: stream ecology, TMDL impairments, nitrogen load from septic systems, imperviousness treatment by BMPs, hydraulics and hydrology (H&H), total nitrogen, total phosphorus, and total suspended solid loads from stormwater non-point sources, and landscape indicators such as impervious cover, wetlands and forested stream buffers.
Subwatersheds which scored poorly may be negatively impacted by one or more of the above mentioned scoring parameters. Additionally, outfalls found to be physically impacted during IDDE assessments were included in this restoration strategy category regardless of the subwatershed condition assessment.

Current Condition:

AA Co BMP Code	County Name	TN	TP	TSS
N/A	No Treatment	0	0	0

Restored Condition:

AA Co BMP Code	County Name	TN	TP	TSS
SPSC	Regenerative Step Pool Storm Conveyance	40	60	85



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

Date: June 29, 2011
File: J:\Shared\ENV\Watershed Management Program\WMPShare\2010 TMDL WIP\Maps\WIP_Core_Strategies_PNT.mxd
Map Production: Watershed Ecosystem and Restoration Services