APPENDIX C

URBAN BMP TECHNICAL MEMORANDUM

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URBAN BEST MANAGEMENT PRACTICES TECHNICAL MEMORANDUM

Subtask 2.2
Patapsco Tidal and Bodkin Creek Watershed Study

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Prepared For:
Anne Arundel County Department of Public Works
Watershed Assessment and Planning Program
2662 Riva Road
Annapolis, Maryland 21401

Prepared by:
LimnoTech
1705 DeSales St. NW, Suite 600
Washington, DC 20036

LimnoTech
Water | Environment | Scientists | Engineers

Introduction

Under Subtask 2.2 of the Patapsco Tidal and Bodkin Creek watershed study, LimnoTech worked with the Anne Arundel County Department of Public Works to develop a complete geospatial dataset of urban stormwater best management practices (BMPs) within the Patapsco Tidal and Bodkin Creek watersheds. In summary, the effort to develop the dataset entailed four primary steps:

- Step 1 - compiling existing data from multiple County and other agency sources;
- Step 2 - identifying BMPs inside the study area;
- Step 3 - performing research to fill any data gaps; and
- Step 4 - delineating BMPs drainage areas.

This Technical Memorandum documents the steps and procedures LimnoTech and the County performed to complete this task. These steps and procedures were performed in accordance with discussions with County personnel, and the County's Technical Memorandum dated June 7, 2007, entitled "*Anne Arundel County Comprehensive Watershed Studies, Subtask 2.2 – SWM facility maps*."

Step 1 - Compiling Existing Data

The first step in the process was to compile all of the existing BMP records associated with the Patapsco Tidal and Bodkin Creek watersheds. Several sources were utilized in this process. A unique ID was employed in the compiled dataset to identify the original BMP record and source. The following is a list and brief description of the data sources:

- **Urban BMP Database:** This dataset exists as a point shapefile that was derived from the Anne Arundel County Inspections and Permit urban stormwater management database. The dataset contains Anne Arundel County permitted public and private urban BMPs. Facilities permitted directly by other entities are not included in this dataset. This dataset was current through March 2010 and contained 10,680 BMP records.
- **Dry Pond BMP Dataset:** This point shapefile represented an incomplete record of dry pond BMPs from the Urban BMP Database that had been previously researched and snapped to a flow accumulation grid to facilitate drainage area delineations. A total of 64 dry ponds were in this dataset.
- **Field Verified BMP Dataset:** During the summer of 2010, LimnoTech and Versar collected limited information on BMPs encountered during stream assessment activities in the study area. The collected information included BMP type, a GPS recorded location, condition notes, and a photo. A total of 265 BMPs were included in this dataset.
- **Countywide BMP Polygon Dataset:** The Countywide BMP polygon shapefile represented an incomplete dataset of BMP polygons digitized from operating maps and As-built maps.

The spatial accuracy of these BMPs was considered to be correct. However, the dataset included only a subset of BMPs and lacked important attribute information. Many of these records were duplicates of BMPs contained in the Urban BMP Database. This dataset contained 703 BMP records.

- **Capital Improvement Program Restoration Project Dataset:** This dataset represents the location and drainage area of all of the County's Capital Improvement Program stream restoration and other watershed restoration projects.

- **Disconnected Non-rooftop Dataset:** Although not traditional BMPs, this dataset accounts for credits for disconnected impervious drainage areas, primarily roads, with no or limited curbing. The dataset was generated by identifying road segments and other impervious areas with less than 50% curbing.

- **Maryland State Highway Administration BMP Database:** LimnoTech contacted the Maryland State Highway Administration (SHA) to obtain a list of SHA owned BMPs in the study area. The dataset contained spatial and attribute data for 78 BMP records in the study area.

- **Maryland Aviation Administration BMP Database:** The County obtained a dataset of BMPs located at BWI Airport that are owned by the Maryland Aviation Administration (MAA). Of these BMPs, 111 are located within the study area.

Step 2 - Identifying BMPs Inside the Study Area

With a draft dataset of BMP records compiled from the sources listed above, LimnoTech worked to identify BMPs known or thought to be inside the study area and remove those BMP records known to be outside of the watershed. This also involved updating spatial locations for BMPs with inaccurate or incomplete spatial attributes. LimnoTech followed the protocols for this step as outlined in the County's June 2007 Technical Memo and in conversations with County personnel. As each BMP data source had different degrees of inherent spatial accuracy, the steps for confirming spatial locations varied among the sources. The procedures for each data source are provided below.

- **Urban BMP Database:** The data contained in this dataset is under review by the Department of Public Works' Infrastructure Management Division and the spatial locations for many BMP records are inaccurate or unknown. The following steps were taken to identify BMP locations in reference to the study area boundaries and update as appropriate:
    - The *XY_Source* field describes the source of the location data and was used to determine whether a BMP location was considered spatially accurate. This field was the primary level of screening for BMPs in the Urban BMP Database. Table 1 below provides the values in the database for the *XY_Source* field and indicates whether a particular value is considered spatially accurate. BMPs with spatially accurate sources were determined to be inside or outside of the study area. All BMPs identified inside the study area and BMPs with *XY_Source* values deemed to have questionable spatial accuracy were retained for further research and verification.

- The Parcel and the Structure Address GIS layers were used in tandem with tax account numbers and addresses to determine whether the retained BMPs with questionable spatial data were located inside or outside of the study area. All BMP records with spatial locations and matching tax accounts or addresses outside of the study area were removed from the draft dataset. BMP points located outside the study area, but with a tax account or address associated with a parcel inside the study area, were moved to the study area parcel/address only if other identifying information confirmed it. Unmatched BMPs and matched BMPs inside the study area were retained.

Table 1. Urban BMP Database XY_Sources

XY_Source	Considered Spatially Accurate (Y/N)
2007_To_MDE	No
CleanedbyHand	Yes
County Centroid	No
Hand Moved _2010	Yes
Hand Moved to Address	Yes
Hand placed on address	Yes
Hand placed on street	Yes
HandMovedfromCentroid	Yes
HandPlacedMay09	Yes
IP	No
IP_New09	No
IP_New09IP_New09	No
KCI 2008 GPS	Yes
Magothy Study	Yes
New09	No
PNTStudy	Yes
SevernStudy	Yes
SouthStudy	Yes
UpperPax Study	Yes
converted IP 27 to 83	No
corrected KCI	Yes

- For the records that still remained at this point, additional checks were performed to locate the remaining subset of BMP records. Looking at each BMP record individually, LimnoTech used various County tools to first positively identify a BMP record from the draft dataset and second to confirm or update its location. Specifically, LimnoTech used the Parcel GIS layer, Structure Address GIS layer, As-built records on CountyView, scanned grading and building permits, other archived electronic records, orthophotography, and GoogleMaps to assist in this process. A record was considered positively identified if two pieces of identifying information matched fields in the BMP dataset.

- **Dry Pond BMP Dataset:** Points in this dataset were previously snapped to the flow accumulation grid by the County and were accepted as spatially correct. All of the BMPs were found to be duplicates of BMPs in the Urban BMP Database. The duplicate records from the Urban BMP Database were identified for removal from the final dataset.

- **Field Verified BMP Dataset**: BMPs in the Field Verified dataset included a subset of BMPs from the Urban BMP Database as well as additional BMPs found during field activities. Any Field Verified BMP that matched a BMP from the Urban BMP Database was used to verify the spatial location of the Urban BMP then flagged for removal due its limited attribute data. All other Field Verified BMPs were retained and considered spatially accurate.

- **Countywide BMP Polygon Dataset:** BMP polygons from the Countywide BMP polygon shapefile were spatially accurate digitizations of BMPs. Although spatially accurate, the attribute data associated with these records was very limited. All of the BMPs were found to be duplicates of BMPs in the Urban BMP Database. The duplicate records from the Urban BMP Database were identified for removal from the final dataset.

- **Capital Improvement Program Restoration Project Dataset:** This dataset was considered spatially accurate. Project drainage areas that fell within the study area boundaries were retained.

- **Disconnected Non-rooftop Dataset:** The datasets representing roads and other impervious surfaces were considered spatially accurate. Portions of these impervious surfaces that fell within the study area boundaries were retained.

Resolving Duplicate Records

Given that data was compiled from multiple datasets, it is inevitable that there were duplicate records. Note that the degree of identifying information available made it very difficult to identify duplicates within an individual data source. As such, an effort to identify and remove duplicates was only rigorously performed between data sources. LimnoTech identified duplicate records by examining attributes and spatial locations. Best professional judgment was used to identify and remove duplicate records only when points were co-located with matching identifying attributes and structure types were they considered to be redundant.

- **Maryland State Highway Administration BMP Database:** SHA-owned BMPs were considered spatially accurate. The BMPs were intersected with the study area boundaries to identify those inside the study area.

- **Maryland Aviation Administration BMP Database:** Like the SHA dataset, BMPs owned by MAA were considered spatially accurate. The BMPs were intersected with the study area boundaries to identify those inside the study area.

Step 3 - Performing Research to Fill Data Gaps

LimnoTech researched data gaps concurrently with the step to confirm and update spatial locations at the County offices (see previous section). Looking at each BMP record individually, LimnoTech used County tools including As-builts on CountyView, scanned grading and building permits, and other archived electronic records to fill in data gaps. The following data were researched:

- **Drainage Area:** The design drainage area for the majority of records was found in the existing compiled datasets. For records with null or zero values, the scanned grading and building permits, archived records, and As-builts on CountyView were researched for the information. This data was captured in the final dataset in the field, *DA.*

- **Structure Type:** The structure type was documented using structure codes in accordance with the County BMP master list. For records with missing structure type information, the scanned grading and building permits, archived records, and As-builts on CountyView were researched for that information. This data was captured in the final dataset in the field, *WMTStruc_type*.

- **Built Date:** The BMP built date was only compiled if it existed in the original dataset or if it was revealed during the record research to identify spatial locations, drainage areas, or structure types. This data was captured in the final dataset in the field, *Built_Date*.

- **Ownership:** The BMP owner was only compiled if it existed in the original dataset or if it was revealed during the record research to identify spatial locations, drainage areas, or structure types. This data was captured in the final dataset in the field, *Ownership*.

Step 4 - Delineating BMP Drainage Areas

To properly account for load reductions associated with BMPs in the County's modeling efforts, LimnoTech and the County worked to delineate drainage areas for all BMPs. Drainage area delineations were handled differently depending on the BMP structure type, the original data source, and the accuracy of the BMP's spatial location. The *Delineate* field in the final dataset was created and populated to categorize the method used to determine the BMP drainage area. The *WMT_DA* field was used to capture the drainage area acreage in the final dataset.

- Drainage area polygons for BMPs associated with the **Urban BMP Database; Dry Pond BMP Dataset; Field Verified BMP Dataset;** and **Countywide BMP Polygon Dataset** were delineated as follows:
  - The points for BMPs with typically large drainage areas (*e.g.*, wet ponds, dry ponds, infiltration basins, wetlands) and with accurate spatial locations were snapped to the nearest flow accumulation grid cell that captured the approximate design drainage area. Occasionally, it was necessary to snap two points representing the same BMP. This was only done when the flow accumulation path was split and one point would not allow for appropriate drainage delineations. The drainage area was then delineated using the flow accumulation grid and the ArcHydro Batch Watershed Delineation tool. The *Delineate* field for all of these BMPs was marked as "Snapped."
  - The points for BMPs associated with rooftop drainage (*e.g.*, dry wells and dry well infiltration trenches) were placed on the building polygon centroid. The building polygon was then used to represent the BMP drainage area. For the few newer BMPs for which a building polygon did not yet exist in the County GIS layer, a building size was recorded or estimated from available information and an equivalent-sized polygon was created to represent the drainage area. The *Delineate* field for all of these BMPs was marked as "Building Footprint."
  - The points for the few BMPs that were designed for parcel or lot level stormwater management (*e.g.*, permeable pavement) and that were not delineated using the flow accumulation grid, were placed on the parcel or lot centroid. The associated parcel polygon was used to represent the BMP drainage area. The *Delineate* field for these BMPs was marked as "Lot Footprint."
  - For the few BMPs where the design drainage area was known, but only the general location of the BMP was known, an artificial circular drainage area polygon was

created. This was accomplished by calculating the radius of a circle with an area equivalent to the known drainage area. This radius was then used to draw a buffer around the general location of the BMP. The polygon created from this buffering step was used as the BMP drainage area. The *Delineate* field for these BMPs was marked as "Buffer."
    - For BMPs with no measurable water quality benefit (*e.g.*, pre-treatment BMPs), drainage areas were not created. The *Delineate* field for these BMPs was marked as "No WQ – No DA."
    - A small subset of BMPs with limited attributes and/or questionable spatial locations were categorized as "Missing Records" in the *Delineate* field. These BMPs will be researched further under another task as additional data becomes available.

- Drainage area polygons for the credits associated with the **Disconnected Non-rooftop Dataset** were generated by using the road segment length and the known road width.

- Drainage area polygons for BMPs associated with the **Capital Improvement Program Restoration Project Dataset; Maryland SHA BMP Database;** and **MAA BMP Database** were previously developed as part of the original dataset development. These drainage area polygons were used as-is with no modifications.

Once the drainage areas were created or compiled for each BMP in the final dataset, the County set up a topology to identify overlapping drainage areas. In those areas with overlapping drainage areas, best professional judgment was used to determine which BMP was predominantly managing a particular intersected drainage area. Overlapping DA segments were assigned to the closest BMP with the assumption that the closer a segment was to a particular BMP it was more likely to be treated by the closest facility. The drainage area polygon was then assigned to the predominant BMP. This was performed to ensure that only a single BMP managed a particular area and that the appropriate BMP was receiving the management credit.

Final Data Deliverables

In addition to this Technical Memo, the data deliverables for this subtask also included:

- a point shapefile representing all BMP locations with compiled, verified, and researched attributes; and
- a polygon shapefile representing the BMP drainage areas.

Summary of Findings

During the research efforts above, a total of 1,578[1] BMPs were confirmed to be in the Patapsco Tidal and Bodkin Creek Watersheds. These BMPs will be used for additional analyses in the watershed study, including the evaluation of water quality under various current and future development scenarios. An additional 504 BMPs were researched and are either missing information or are non-credit BMP types. These BMPs did not have drainage areas delineated (Table 2).

[1] Two BMPs were split into multiple pour points for delineation purposes. Therefore, a total of 1580 features exist in the BMP database.

Table 2. BMPs without Delineated Drainage Areas

BMP			Ownership				
			Private	**Public (DPW)**	**Public (Non-DPW)**	**Unknown**	**Total**
Missing Records	Filtration	Bioretention	32	2	2	3	39
		Attenuation Swale	4	-	-	-	4
		Sand Filter	6	5	3	1	15
	Infiltration	Dry Well	33	1	-	-	34
		Infiltration Trench	21	-	1	8	30
		Infiltration Trench with Complete Exfiltration	28	2	2	-	32
		Infiltration Trench with Partial Exfiltration	6	4	-	-	10
		Infiltration Basin	3	1	-	-	4
		Porous Pavement	3	-	-	-	3
	Other/Not BMPs	Credits	13	2	-	6	21
		Other	8	-	1	-	9
		Planting	3	-	-	-	3
	Detention Dry	Detention Structure (Dry Pond)	23	5	-	-	28
		Oil Grit Separator	6	4	-	-	10
		Underground Storage	2	-	-	-	2
		BaySaver	1	-	-	-	1
		Stormceptor	1	-	-	-	1
	Wet Ponds	Retention Structure (Wet Pond)	-	1	1	-	2
		Wet Structure	3	4	-	8	15
		Extended Detention Wet Structure	2	1	-	-	3
	Extended Detention Dry	Extended Detention Structure Dry	7	1	-	-	8
	Wetlands	Shallow Marsh	2	1	-	-	3
Missing Records Subtotal			**207**	**34**	**10**	**26**	**277**
No WQ - No DA	Filtration	Bioretention	1	-	-	-	1
	Other/Not BMPs	Credits	75	6	-	4	85
		Exempt	2	-	-	1	3
		Other	11	-	-	1	12
		Planting	113	2	1	10	126
No WQ - No DA Subtotal			**202**	**8**	**1**	**16**	**227**
GRAND TOTAL			***409***	***42***	***11***	***42***	***504***

The 1,578 BMPs have a total drainage area of 6,096 acres. This is 17% of the total Patapsco Tidal and Bodkin Creek watershed area (35,884 acres). BMP drainage areas range in size from 0.001 to 386.25 acres. As seen by the median drainage area size (0.09 acres), the majority of the BMPs manage relatively small areas. This is reinforced by the fact that only 5% of the delineated drainage areas are larger than 20 acres.

As seen in Table 3, private entities own 78% of the BMPs in the study area. These 1,232 BMPs account for 37.6% of the total drainage area. The DPW owns only 258 BMPs (16%), but the 2,359 acres (38.7%) of associated drainage area is the largest of the ownership types.

Table 3. BMPs by Ownership Type

Ownership	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)
Private	1232	78%	2292.8	38%	1.9	15.6	0.001	386.3	0.05
Public (DPW)	258	16%	2369.7	39%	9.2	14.6	0.004	141.8	3.09
Public (non-DPW)	22	1%	578.7	9%	26.3	37.2	0.084	140.1	7.10
Unknown	66	4%	868.6	14%	13.2	39.3	0.002	272.5	1.52
Total	1578	100%	6109.8	100%	3.9	18.0	0.001	386.3	0.09

The six BMP categories researched include: detention dry, extended detention dry, filtration, infiltration, wet ponds, and wetlands. By far, the greatest numbers of BMPs in the study area are classified as infiltration (73%). Infiltration BMPs drain a total area of 837 acres (14%). Wet Ponds account for only 7% of the BMPs by count, but manage 36% of the total managed drainage area (2,168 acres). Additional analysis of the BMPs by category is included in Table 4.

Table 4. BMPs by Category

Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)
Detention Dry	105	7%	1684.8	28%	16.0	39.7	0.042	386.3	5.66
Extended Detention Dry	98	6%	839.2	14%	8.6	18.0	0.019	166.9	3.37
Filtration	94	6%	505.1	8%	5.4	35.3	0.005	340.9	0.37
Infiltration	1153	73%	837.0	14%	0.7	3.0	0.001	39.1	0.05
Wet Ponds	116	7%	2167.9	35%	18.7	34.3	0.023	272.5	7.48
Wetlands	12	1%	75.8	1%	6.3	10.7	0.101	31.7	0.56
Total	1578	100%	6109.8	100%	3.9	18.0	0.001	386.3	0.09

The majority of BMPs owned and maintained by the DPW are categorized as infiltration. These infiltration BMPs account for 40% of the DPW BMPs and drain 334 acres. In terms of BMP count, dry detention and wet ponds are the second and third most numerous BMPs owned by the DPW. BMPs categorized as dry detention have a total drainage area of 910 acres (38%) and wet ponds drain 682 acres (29%). Additional analysis of DPW owned BMPs is found in Table 5.

Table 5. Public (DPW) Owned BMPs

Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)
Detention Dry	62	24%	910.5	38%	14.7	14.4	0.050	61.4	10.79
Extended Detention Dry	27	10%	302.9	13%	11.2	9.7	0.078	39.6	9.44
Filtration	18	7%	96.4	4%	5.4	10.1	0.072	40.5	1.16
Infiltration	103	40%	334.3	14%	3.2	6.7	0.004	39.1	0.75
Wet Ponds	41	16%	682.4	29%	16.6	24.8	0.023	141.8	9.61
Wetlands	7	3%	43.2	2%	6.2	8.8	0.101	24.8	2.73
Total	258	100%	2369.7	100%	9.2	14.6	0.004	141.8	3.09

The smallest number of BMPs in the study area is owned by non-DPW public entities. These 22 BMPs account for 1.3% of the total number of BMPs identified in the study. An in-depth analysis of these BMPs is seen in Table 6.

Table 6. Public (Non-DPW) Owned BMPs

Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)
Detention Dry	-	-	-	-	-	-	-	-	-
Extended Detention Dry	8	36%	58.4	10%	7.3	8.4	0.169	24.5	4.62
Filtration	3	14%	7.4	1%	2.5	2.5	0.084	5.0	2.28
Infiltration	3	14%	5.7	1%	1.9	0.7	1.391	2.7	1.64
Wet Ponds	8	36%	507.2	88%	63.4	40.0	26.949	140.1	53.37
Wetlands	-	-	-	-	-	-	-	-	-
Total	22	100%	578.7	100%	26.3	37.2	0.084	140.1	7.10

Privately owned BMPs account for 78% of the BMPs identified in this study. A total of 1,022 of these BMPs can be classified as infiltration. These infiltration BMPs have a total drainage area of 400 acres. The dry detention category only makes up 3% of the private BMPs by number. However, dry detention accounts for 32% of the delineated drainage area (738 acres). Extended dry detention has the third greatest delineated drainage area (256 acres) and accounts for only 4% of the private BMPs. Additional analysis of the privately owned BMPs is included in

Table 7. Privately Owned BMPs

Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)
Detention Dry	40	3%	738.3	32%	18.5	62.1	0.042	386.3	1.71
Extended Detention Dry	53	4%	256.0	11%	4.8	5.9	0.019	25.2	2.47
Filtration	70	6%	399.6	17%	5.7	40.7	0.005	340.9	0.30
Infiltration	1022	83%	458.2	20%	0.4	2.0	0.001	31.7	0.04
Wet Ponds	44	4%	439.9	19%	10.0	16.7	0.043	73.2	3.69
Wetlands	3	0%	0.8	0%	0.3	0.2	0.125	0.5	0.20
Total	1232	100%	2292.8	100%	1.9	15.6	0.001	386.3	0.05

As seen in Table 8, a total of 66 BMPs did not have clear ownership. BMPs classified as infiltration are greatest in number (25) but account for only 39 acres of drainage. There are 23 wet ponds with a total drainage area of 538 acres. Table 8 discusses the BMPs with unknown ownership in greater detail.

Table 8. BMPs with Unknown Ownership

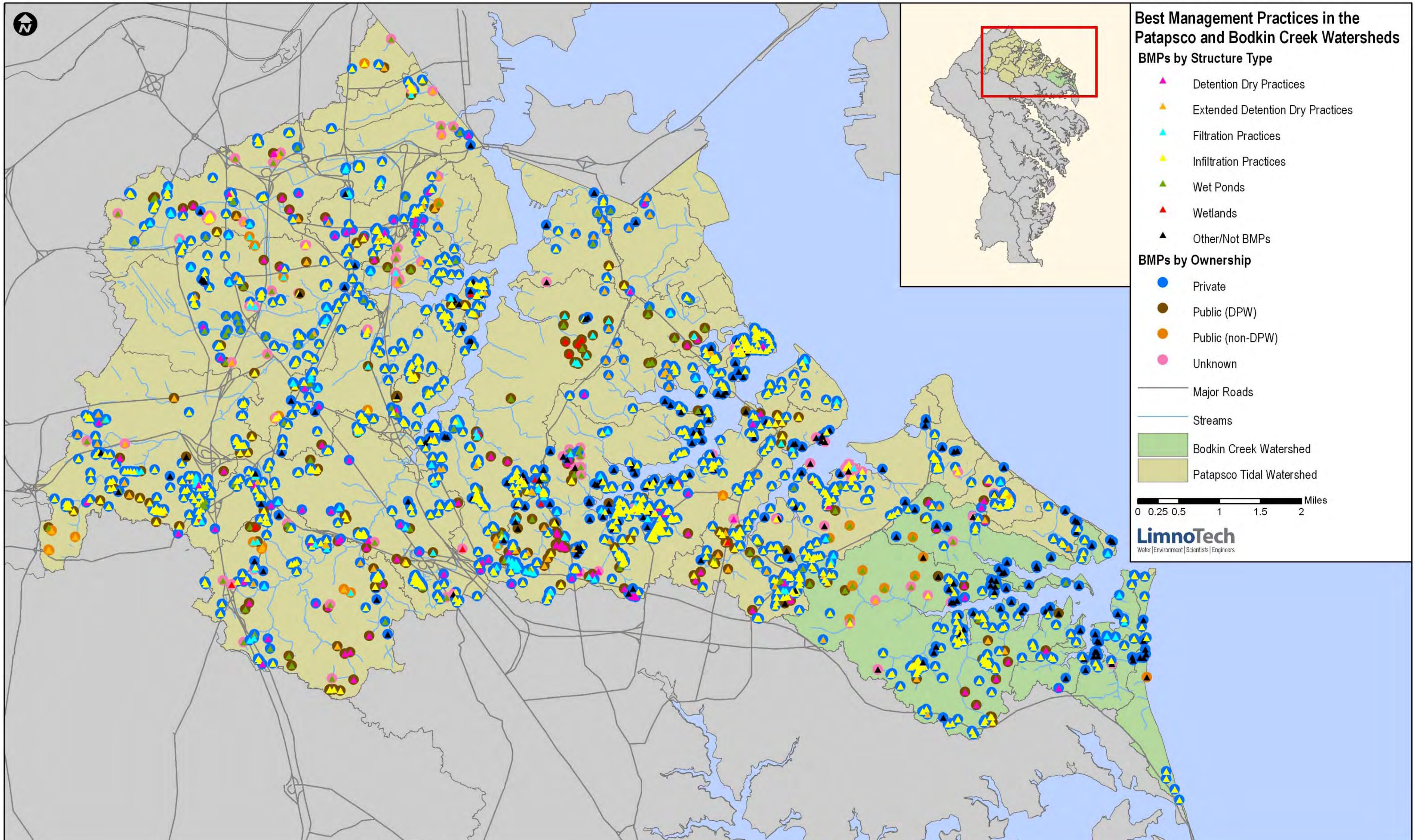
Category	Quantity	Percent by Quantity	Drainage Area (acres)	Percent by Drainage Area	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)
Detention Dry	3	5%	36.0	4%	12.0	10.7	0.963	22.3	12.75
Extended Detention Dry	10	15%	221.9	26%	22.2	51.4	0.126	166.9	3.00
Filtration	3	5%	1.7	0%	0.6	0.9	0.037	1.7	0.04
Infiltration	25	38%	38.8	4%	1.6	6.5	0.002	32.8	0.03
Wet Ponds	23	35%	538.4	62%	23.4	55.5	0.128	272.5	12.17
Wetlands	2	3%	31.8	4%	15.9	22.3	0.132	31.7	15.90
Total	66	100%	868.6	100%	13.2	39.3	0.002	272.5	1.52

Table 9 is a detailed analysis of all 1,578 BMPs identified and located in this study. The 2,082 researched BMPs are also represented in Figure 1. The BMPs are shown by structure type and ownership.

Table 9. Detailed Statistics on the Urban BMPs in the Patapsco Tidal and Bodkin Creek Watersheds

BMP Type		Quantity	Drainage Area (acres)	Mean Drainage Area (acres)	Standard Deviation (acres)	Minimum Drainage Area (acres)	Maximum Drainage Area (acres)	Median Drainage Area (acres)	Private Ownership	Public (DPW) Ownership	Public (non-DPW) Ownership	Unknown Ownership
Detention Dry	Detention Structure (Dry Pond)	87	1650.14	18.97	43.01	0.042	386.25	9.72	31	53	0	3
	Oil Grit Separator	12	28.77	2.40	2.26	0.167	5.74	1.53	4	8	0	0
	Underground Storage	6	5.87	0.98	1.56	0.078	4.14	0.43	5	1	0	0
Detention Dry Total		**105**	**1684.78**	**16.05**	**39.65**	**0.042**	**386.25**	**5.66**	**40**	**62**	**0**	**3**
Extended Detention Dry	Extended Detention Structure Dry	98	839.22	8.56	17.96	0.019	166.94	3.37	53	27	8	10
Extended Detention Dry Total		**98**	**839.22**	**8.56**	**17.96**	**0.019**	**166.94**	**3.37**	**53**	**27**	**8**	**10**
Filtration	Attenuation Swale	6	2.46	0.41	0.38	0.072	1.12	0.33	4	2	0	0
	Bioretention	65	404.86	6.23	42.20	0.005	340.90	0.31	54	9	0	2
	Pocket Sand Filter	1	0.68	0.68	-	0.679	0.68	0.68	1	0	0	0
	Sand Filter	19	38.68	2.04	3.70	0.076	15.53	0.73	11	4	3	1
	Step Pool Storm Conveyance	3	58.42	19.47	20.02	0.609	40.48	17.33	0	3	0	0
Filtration Total		**94**	**505.10**	**5.37**	**35.33**	**0.005**	**340.90**	**0.37**	**70**	**18**	**3**	**3**
Infiltration	Dry Well	315	25.99	0.08	0.35	0.003	5.48	0.04	314	1	0	0
	Dry Well - Infiltration Trench	1	0.03	0.03	-	0.026	0.03	0.03	1	0	0	0
	Dry Well - Infiltration Trench with Complete Exfiltration	21	0.83	0.04	0.01	0.026	0.06	0.04	21	0	0	0
	Dry Well - Infiltration Trench with Partial Exfiltration	2	0.07	0.03	0.01	0.029	0.04	0.03	2	0	0	0
	Infiltration Basin	39	332.54	8.53	10.46	0.001	39.05	4.25	19	19	0	1
	Infiltration Trench	274	132.40	0.48	2.11	0.001	31.66	0.06	234	28	0	12
	Infiltration Trench with Complete Exfiltration	376	252.73	0.67	2.24	0.004	23.41	0.05	333	29	2	12
	Infiltration Trench with Partial Exfiltration	122	88.47	0.73	2.10	0.004	19.55	0.09	95	26	1	0
	Porous Pavement	3	3.97	1.32	0.41	0.929	1.75	1.30	3	0	0	0
Infiltration Total		**1153**	**837.02**	**0.73**	**3.00**	**0.001**	**39.05**	**0.05**	**1022**	**103**	**3**	**25**
Wet Ponds	Extended Detention Wet Structure	38	418.15	11.00	14.45	0.082	63.06	5.62	22	14	0	2
	Micro Pool	3	32.88	10.96	9.05	0.849	18.31	13.72	1	2	0	0
	Retention Structure (Wet Pond)	60	1628.26	27.14	44.33	0.031	272.47	13.03	10	21	8	21
	Wet Structure	15	88.63	5.91	13.32	0.023	49.78	0.39	11	4	0	0
Wet Ponds Total		*116*	*2167.92*	*18.69*	*34.32*	*0.023*	*272.47*	*7.48*	44	41	8	23
Wetlands	Shallow Marsh	12	75.81	6.32	10.67	0.101	31.66	0.56	3	7	0	2
Wetlands Total		**12**	**75.81**	**6.32**	**10.67**	**0.101**	**31.66**	**0.56**	**3**	**7**	**0**	**2**
Total - All BMPs		***1578***	***6109.84***	***3.87***	***18.03***	***0.001***	***386.25***	***0.09***	***1232***	***258***	***22***	***66***

Figure 1. BMPs in the Patapsco Tidal and Bodkin Creek Watersheds



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APPENDIX D

CONCEPT DESIGN PLANS

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Project Overview

This project will retrofit an existing undersized, failing BMP draining a small subdivision with a regenerative storm conveyance (step-pool storm conveyance) system to improve water quantity and water quality management. The failing BMP is located at the end of 209th Street and drains into an unnamed perennial tributary of Stony Creek.

Project Type: BMP Retrofit with Regenerative Step Pools Storm Conveyance

Watershed: Tidal portion of the Patapsco River

Subwatershed: Stony Creek (Shed Code: PT0)

Location: Northeast end of 209th Street, Pasadena MD, near intersection with East Shore Road. (See Figure 1)

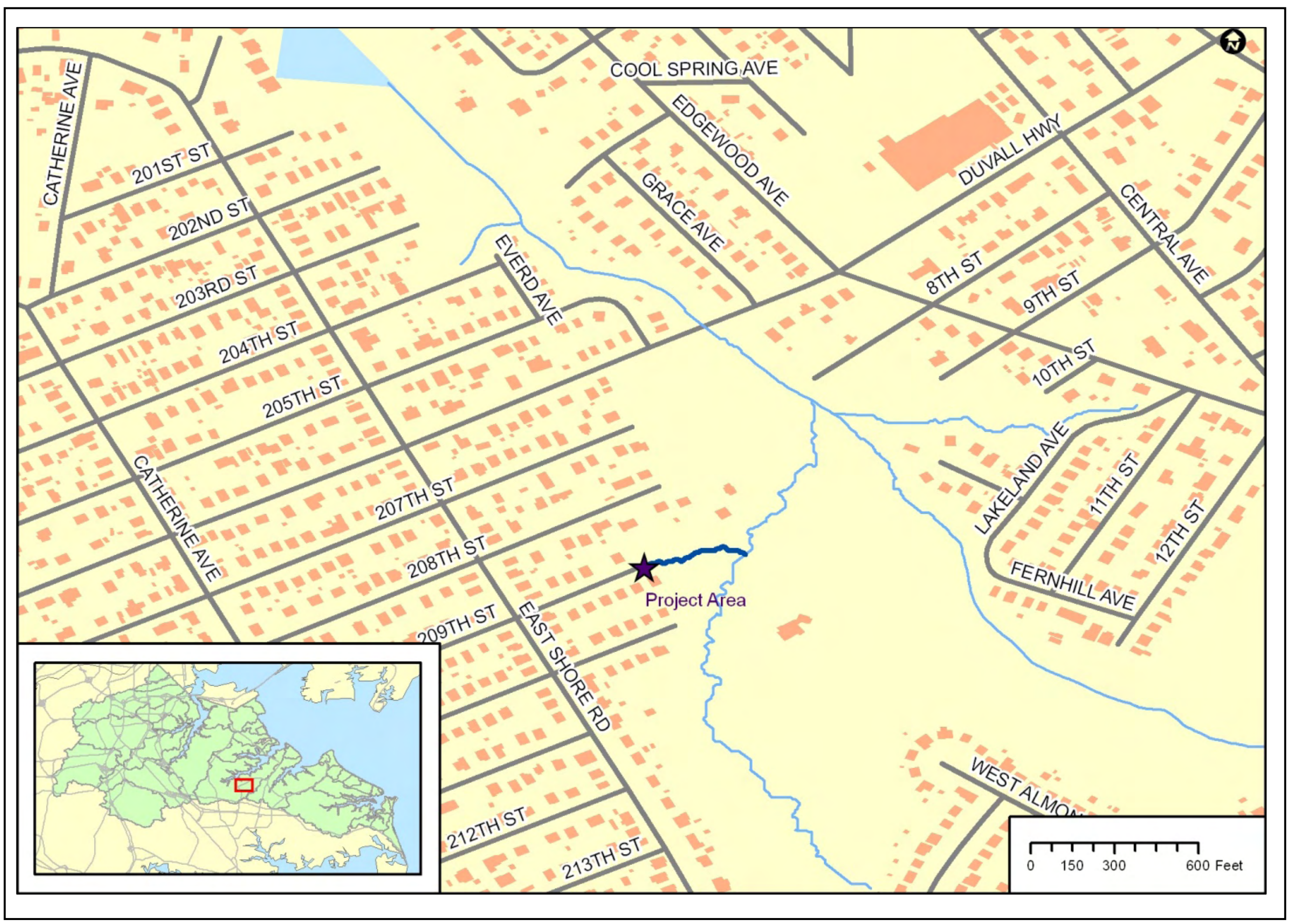

Figure 1 – Project Location Map

Drainage Area Characteristics

Existing Land Use: Residential (100%)

Drainage Area: 6.82 acres

Impervious Area: 3.42 acres

Surface Soils: Type B silt loam or loam, moderately well drained with moderate infiltration rate.

Hydrology:

Parameter	Value
Weighted Curve Number	85.13
Time of Concentration (hrs)	0.29
Peak Discharge 1-yr (cfs)	11.0
Peak Discharge 2-yr (cfs)	14.0
Runoff 1-yr (in.)	1.35
Runoff 2-yr (in.)	1.85

Figure 2 – Aerial Photo of Drainage Area

Project Benefits

Stream Stability: A regenerative storm conveyance retrofit will decrease peak and cumulative flows to the perennial receiving stream thus decreasing downstream bed and bank erosion.

Aquatic Habitat: Complete halt of erosion and a reduction in sediment pollutant loading from the existing channel draining the failing existing BMP will improve instream aquatic habitat. A decrease in thermal pollution is also expected to improve biotic health and habitat.

Water Quality: Reduced velocity and increased infiltration will enhance removal of suspended particles and associated nutrients. Additionally, uptake of dissolved nutrients and adsorption of oils and greases by the plant material yield secondary water quality benefits above and beyond the benefits achieved through the primary water quality sand/woodchip mix filter.

	Existing Conditions		
	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	84.6	22.2	2.1
Post-Restoration	50.8	8.9	0.4
% Diff.	40	60	80

Prepared by LimnoTech and Versar
in collaboration with Anne Arundel County

Conceptual Design

Design Parameters	Design 1 Value	Design 2 Value
Drainage acre (acre)	6.82	6.82
Percent Impervious (%)	50.7	50.7
Volumetric runoff coefficient (R_v)	0.51	0.51
Required Water quality volume (WQ_v) (ft^3)	12,378	12,378
Provided Water quality volume (WQ_v) (ft^3)	13,440	14,800
Peak discharge 100-year storm (ft^3/s)	43	43
Allowable flow through riffle (ft^3/s)	58	55
Total length (ft)	270	305
Elevation drop over length (ft)	10	10
Cobble d_{50} size (ft)	0.5	0.5
Top width of riffle channel (ft)	20	20
Depth of riffle channel (ft)	1.0	1.0
Length of riffle segments (ft)	8.0	8.0
Depth of pools (ft)	3.0	3.0
Length of pool segments (ft)	20.0	20.0
Sand filter depth (ft)	1.5	1.5
Width of sand filter (W_{sand}) (ft)	4.0	4.0
Required sand filter area (A_f) (ft^2)	848	848
Provided sand filter area (A_f) (ft^2)	1,080	1,200

Step pool conveyance systems utilize a series of shallow pools, riffle grade controls, native vegetation, and an underlying sand and compost media to filter, treat, detain, and safely convey drainage area runoff for a 1-inch rain event. The pools and riffles are also designed to safely convey peak discharge from a 100-year storm, which is approximately 43 ft^3/s.

Two conceptual design options are presented for the same step pool conveyance system to accommodate existing parcel/property considerations. Design 1 runs along the existing opportunistic drainage-way, which has formed as a result of the failed BMP (Figure 3). Design 2 runs within the thirty-foot-wide platted right-of-way (ROW), (i.e., “paper street”) beyond the existing BMP on 209th Street (Figure 4). The length of the proposed systems is 270 and 305 feet for Designs 1 and 2, respectively.

Ten pools and ten riffles are included in Design 1. Eleven pools and eleven riffles are included in Design 2. Each riffle and pool is 20 feet long. The elevation drop along the length is 10 feet for Design 1 and 11 feet for Design 2. The filtration beds are sized to manage the water quality volume (WQv) associated with a 1 inch storm. The proposed size of the filtration beds is 1,040 and 840 sq. ft. for Design 1 and 2, respectively. Design 2, although longer, has a narrower sand filter, hence the difference in total filtration area. The difference in length accounts for the difference in estimated construction cost between these two options. Ultimately, zoning, land planning, and ability to secure easements will likely be the deciding factor in choosing between the two design options.

Conceptual Design Plan

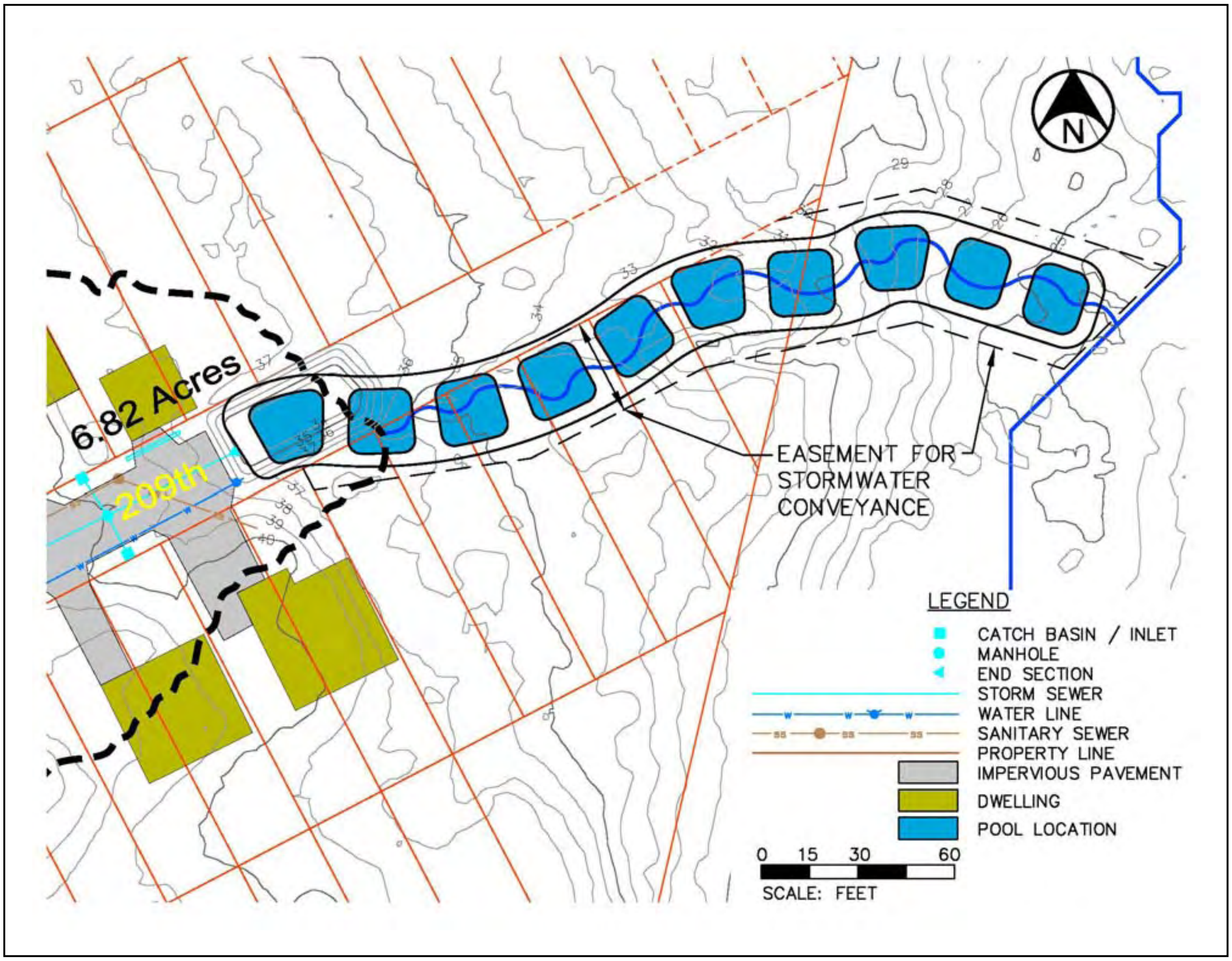

Figure 3 – Plan View of Step Pool Conveyance Retrofit, Design Option 1 along Existing Opportunistic Drainage Channel

Conceptual Design Plan

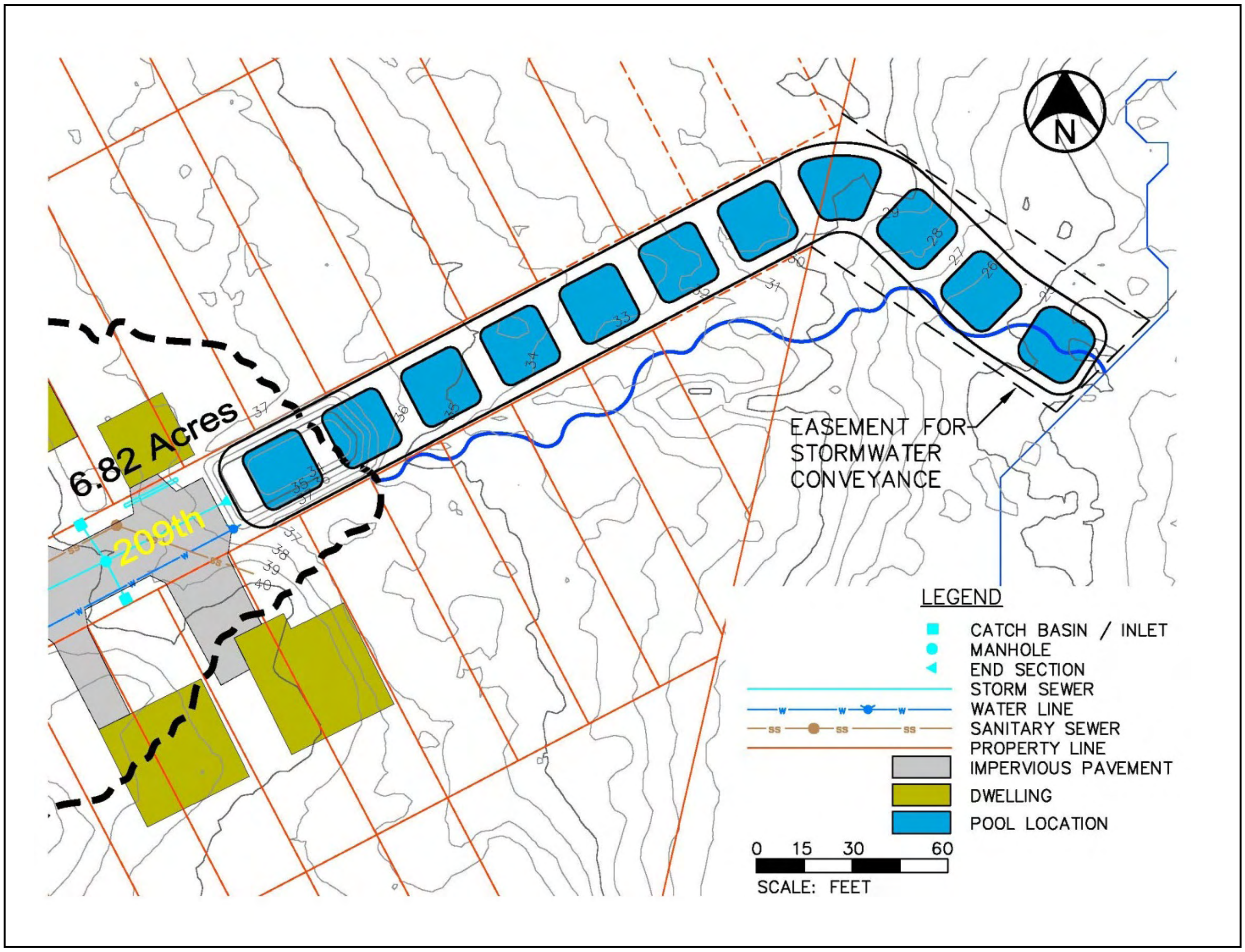

Figure 4 – Plan View of Step Pool Conveyance Retrofit, Design Option 2 along Existing Paper Street.

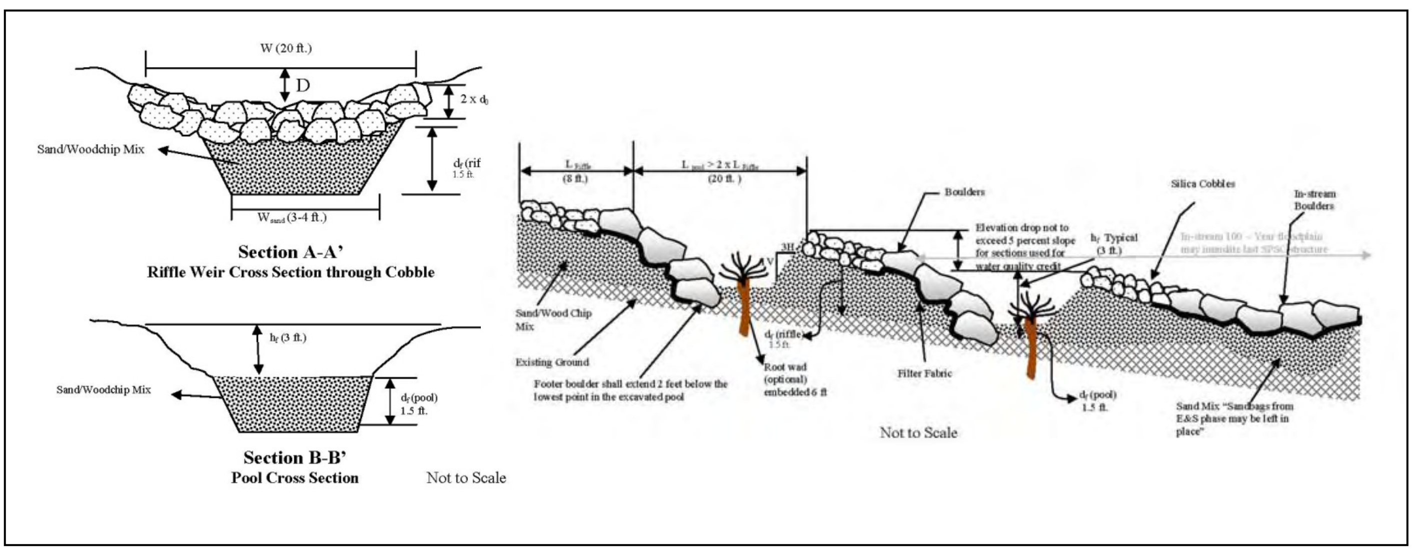

Figure 5 – Typical Profile and Cross Section of a Regenerative Storm Conveyance System (Modified from Anne Arundel County SPSC Design Guidelines)

Project Cost Estimate – Design Option 1

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% of total cost)	1	LS	$10,000.00	$10,000.00
Survey Stake Out (5% of total cost)	1	LS	$7,500.00	$7,500.00
Clearing and Grubbing	900	sy	$3.00	$2,700.00
Erosion and Sediment Control	1050	sy	$4.00	$4,200.00
Blaze Orange Fence	570	lf	$8.00	$4,560.00
Grading, Excavation, Backfilling	750	cy	$20.00	$15,000.00
STEP POOLS AND RIFFLES				
Sandstone Boulders	70	cy	$240.00	$16,800.00
Cobble Weir (D50 = 6" Rock)	70	cy	$75.00	$5,250.00
Geotextile	1100	sy	$4.00	$4,400.00
Wood Chips	70	cy	$25.00	$1,750.00
Sand Fill	80	cy	$50.00	$4,000.00
PLANTING				
Plants (Trees, Shrubs, Herbs, and SAV)	900	sy	$10.00	$9,000.00
TOTAL CONSTRUCTION COSTS				**$85,160.00**
ENGINEERING AND MANAGEMENT				
Engineering (10% of Construction or $10,000 min)				$10,000.00
Construction Management (15% of Construction)				$12,774.00
Contingency (20% of Total Construction)				$17,032.00
LEGAL IMPLICATION OF LAND ACQUISITION				
Land Acquisition/Easements	8,450	sf	$18.00	$152,100.00
TOTAL PROJECT COSTS				**$277,066.00**

Project Cost Estimate – Design Option 2

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% of total cost)	1	LS	$10,000.00	$10,000.00
Survey Stake Out (5% of total cost)	1	LS	$7,500.00	$7,500.00
Clearing and Grubbing	1020	sy	$3.00	$3,060.00
Erosion and Sediment Control	1,100	sy	$4.00	$4,400.00
Blaze Orange Fence	650	lf	$8.00	$5,200.00
Grading, Excavation, Backfilling	850	cy	$20.00	$17,000.00
STEP POOLS AND RIFFLES				
Sandstone Boulders	80	cy	$240.00	$19,200.00
Cobble Weir (D50 = 6" Rock)	80	cy	$75.00	$6,000.00
Geotextile	1,200	sy	$4.00	$4,800.00
Wood Chips	80	cy	$25.00	$2,000.00
Sand Fill	90	cy	$50.00	$4,500.00
PLANTING				
Plants (Trees, Shrubs, Herbs, and SAV)	1050	sy	$10.00	$10,500.00
TOTAL CONSTRUCTION COSTS				**$94,160.00**
ENGINEERING AND MANAGEMENT				
Engineering (10% of Construction or $10,000 min)				$10,000.00
Construction Management (15% of Construction)				$14,124.00
Contingency (20% of Total Construction)				$18,832.00
LEGAL IMPLICATION OF LAND ACQUISITION				
Land Acquisition/Easements	4,170	sf	$18.00	$75,060.00
TOTAL PROJECT COSTS				**$212,176.00**

Project Constraints

Easements: Both design options require investigation of property rights, planned future developments and ability to secure easements, which at this time is unclear. Design 2 along the existing paper street would render any future roadway too narrow for 2-way automobile traffic. Design 1 along the existing opportunistic drainage channel would run across lots proposed for additional development.

Site Access: The existing drainage way from the county-owned BMP crosses various parcels of undetermined ownership. The proposed limit of disturbance associated with Design 1 (existing drainage way) and Design 2 (paper street ROW) would include both the paper street and parcels of undetermined ownership. Unencumbered access to the site can be made via 209th Street.

Design/Construction: A topographical survey is necessary to confirm the potential extent of the conceptual design. A geotechnical survey should be completed to confirm the infiltration capacity of site soils. Potential construction staging areas are located upstream and downstream of the project extent. In the case of Design 2, the existing opportunistic drainage channel would need to be filled at this time.

Utilities: It is unlikely that there will be any utility conflicts as no water and sewer lines exist near the proposed limit of disturbance. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: Trees will need to be removed to make room for the new step pool system and additional trees will need to be removed to make room for machinery.

Erosion and Sediment Control: Sediment loads from the site will likely increase during construction because it will not be able to divert all stormflows during construction.

Project Photos

Photo 1 – Existing infiltration BMP at end of 209th Street in dry condition (looking downstream)

Photo 2 – Existing infiltration BMP at end of 209th Street filled with water and algae (looking downstream)

Photo 3 – Inadvertent spillway for existing infiltration BMP

Photo 4 – Existing infiltration BMP (looking upstream)

Photo 5 – Opportunistic channel draining infiltration BMP (looking upstream toward BMP)

Photo 6 – Opportunistic channel showing significant erosion (looking downstream)

Engineer Certification

Professional Certification. I hereby certify that these ***Concept 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.****)*

Project Manager: Hala Flores, P.E., Watershed Assessment and Planning Program Manager
License No. 28353, Expiration Date: January 02 2013

Conceptual Design Plan

Project Overview

This conceptual plan consists of a two phase restoration design intended to restore and stabilize two branches of an unstable stream and reconnect them with the floodplain. The restoration streams are two unnamed tributaries of Marley Creek that are briefly daylighted in the vicinity of the Granite Baptist Church. Phase 1 of the restoration focuses on the northern tributary. Phase 2 focuses on the southern branch.

Project Type: Stream Restoration

Watershed: Tidal portion of the Patapsco River

Subwatershed: Marley Creek (Shed Code: PTF)

Location: Behind Granite Baptist Church; off of Oakwood Road between Funke Road and Oakwood Station Road, near Route100. (Figure 1)

Figure 1 – Project Location Map

Phase 1 - Stream Restoration

This phase involves the restoration of the northern of the two unnamed tributaries of Marley Creek. The restoration will be used to stabilize the channel, reduce wet-weather velocities, prevent further downcutting and improve floodplain connection. The section of stream being restored in Phase 1 begins at the outfall under Oakwood Road. The stream currently runs between the Granite Baptist Church parking lot and playing fields then meanders through a series of other privately owned parcels. A walking bridge crosses the heavily incised streambanks on the Granite Baptist Church property. Based on current stream conditions, the Phase 1 restoration area has been further divided into two different reaches. The upper reach (Reach 1) has a significantly incised channel. The lower reach (Reach 2) is less incised but still impaired. A portion of Reach 2 also contains cement toe reinforcement that was historically installed in an effort to reduce erosion.

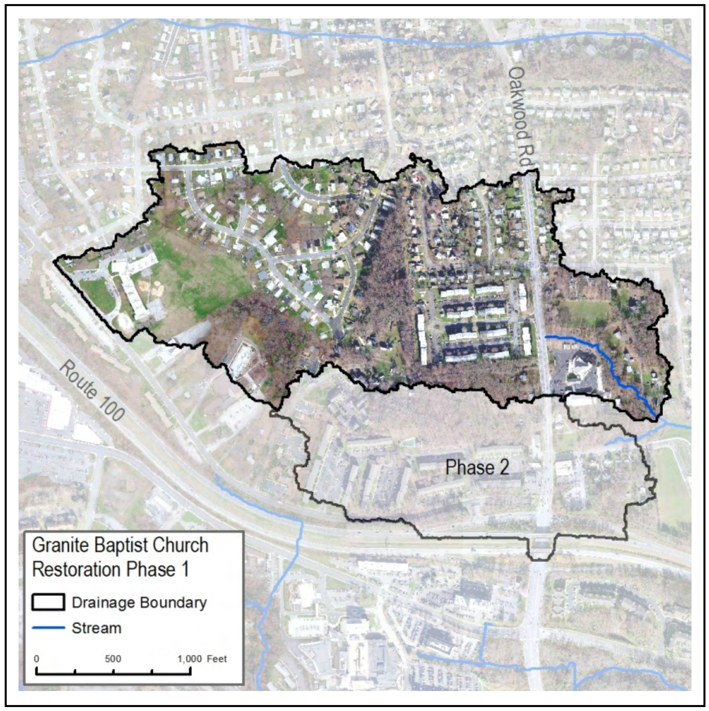

Figure 2 – Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Residential (73.3%), Woods/Open Space (13.8%), Commercial (10.7%), and Transportation (2.2%)

Drainage Area: 103.7 acres

Impervious Area: 38.8 acres

Surface Soils:
Type A (11.9 ac): sandy loam, well drained with high infiltration rates; Type B (39.1 ac): silt loam or loam, moderate infiltration rate; Type C (52.7 ac): sandy clay loam, low infiltration rates

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	78.85	0.977	57.0	85.0	0.97	1.40

Project Benefits

Stream Stability: Bank and bed stabilization measures will reduce peak velocities for flows by reconnecting the streambed with the floodplain. This will greatly improve stability within the restored stream.

Aquatic Habitat: Reductions in peak velocities and pollutant loadings will improve aquatic habitat.

Water Quality: Reduced velocity will limit further erosion and also reduce downstream transport of suspended particles and associated nutrients. The Maryland Department of the Environment (MDE) calculates potential water quality improvements based on a pound per linear foot of restoration per year basis.

	Existing Conditions		
	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	915.6	111.3	8.0
Post-Restoration	695.6	36.5	0

Impervious Surfaces: MDE applies an impervious acre credit of 1 acre restored for every 100 linear feet of stream restoration. Phase 1 of this project provides 11 acres of impervious area credit.

Conceptual Design

Design Parameters	Value
Total length (ft)	1,100
Elevation drop over length (ft)	22
Top width of riffle channel (ft)	12.0
Depth of riffle channel (ft)	1.2
Average length of riffle segments (ft)	60.0
Depth of pools (ft)	2.5
Average length of pool segments (ft)	40.0

The proposed plan will restore approximately 1,100 linear feet of the northern unnamed tributary that has become unstable and out of equilibrium with its watershed. The proposed conceptual design divides the stream into two restoration reaches: Reach 1 and Reach 2. Reach 1 begins at the Oakwood Road outfall and extends approximately 960 feet. Reach 2 begins at the end of Reach 1 and extends an additional 140 feet to a culvert north of Funke Road that carries the stream flow under a residential neighborhood. Reach 1 is highly incised with bank heights between 4 and 8 feet and channel widths up to 15 feet. The banks of Reach 2 are lower at approximately 2 feet, but evidence of bed and bank armoring is evident throughout the reach. Both Reach 1 and Reach 2 are classified as Rosgen G stream types.

The restoration concept for both reaches entails creating a Rosgen B characteristic stream channel that has improved access to floodprone areas, but that fits within the topographic and infrastructure constraints of the site. The design approach generally entails maintaining the existing stream location and bankfull geometry, but increasing the floodprone area where possible. Tight space constraints associated with the church and residential properties severely restrict the planform options. This is especially true in the upper portion of Reach 1. In this reach, smaller floodplain benches will be established within the existing incised stream channel and riffle weirs will be used to create a riffle-pool sequence and slow down stream velocities and decrease near-bank shear stresses. In downstream areas of Reach 1, existing low terraces will be re-graded to provide additional floodplain access and potential high flow storage and riparian wetland areas. Reach 2 will utilize a step-pool cascade to help meet the grade change across this section to the downstream inlet.

Additional means of bank and floodplain stabilization will be riparian plantings. The stream banks and riparian area of the reaches within the limit of disturbance will be cleared of invasives and revegetated with native plantings. Soil fabric lifts utilizing biodegradable matting will be utilized as appropriate to help stabilize certain portions of the stream bank until plants are rooted.

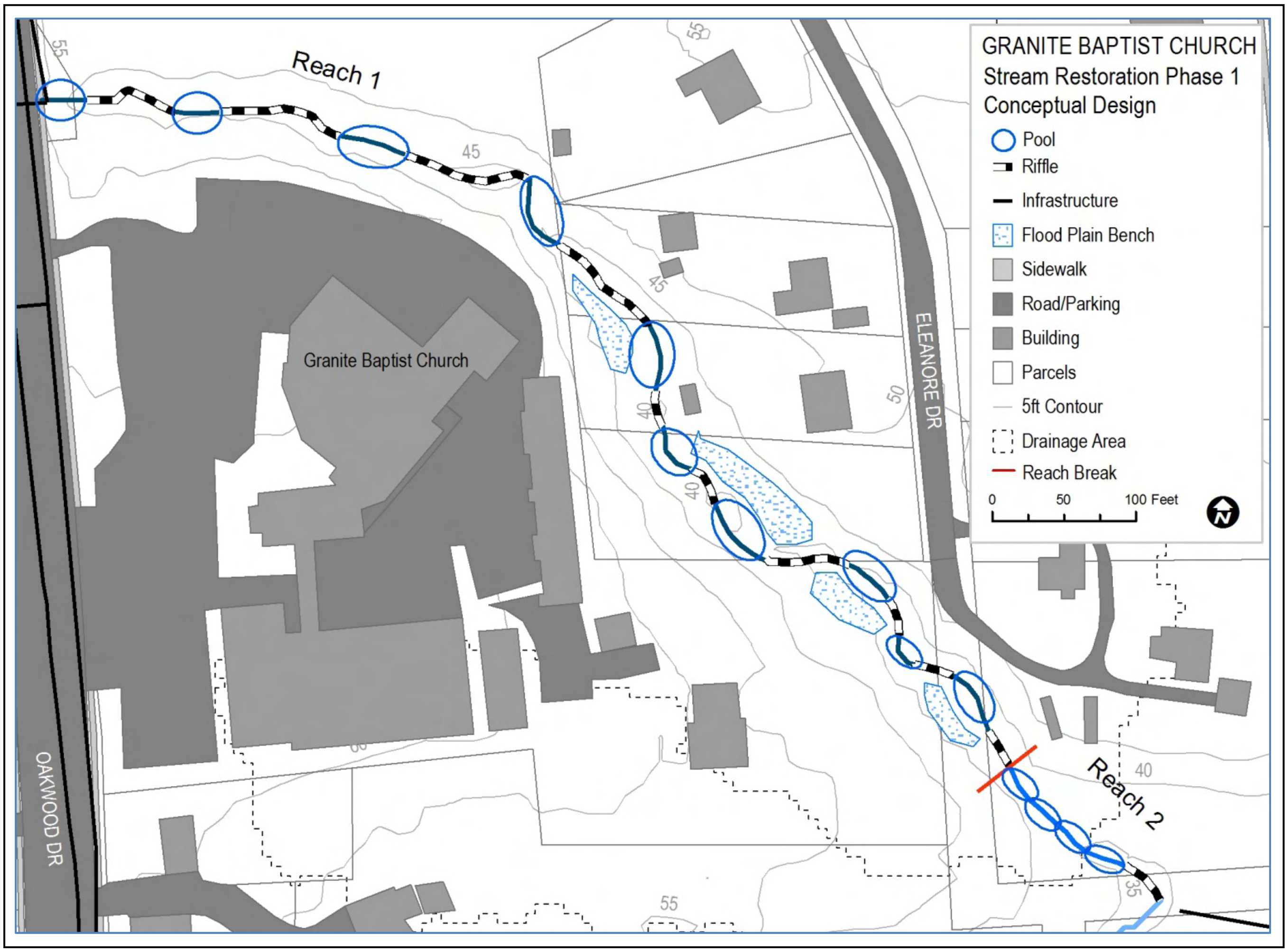

Figure 3 – Plan View of Reach Restoration

Project Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% of total cost)	1	LS	---	$8,281.00
Survey Stake Out (5% of total cost)	1	LS	---	$4,140.50
Clearing/Tree Removal	650	sy	$4.00	$2,600.00
Erosion and Sediment Control	650	sy	$4.00	$2,600.00
Blaze Orange Fence	500	lf	$8.00	$4,000.00
Remove Headwall	100	sy	$50.00	$5,000.00
Grading, Excavation, Backfilling	1,600	cy	$20.00	$32,000.00
STEP POOLS AND RIFFLES				
Sandstone Boulders	40	cy	$240.00	$9,600.00
Cobble Weir (D50 = 6" Rock)	30	cy	$75.00	$2,250.00
Geotextile	90	sy	$4.00	$360.00
Wood Chips	40	cy	$25.00	$1,000.00
Sand Fill	100	cy	$60.00	$6,000.00
STRUCTURES				
New Pond Riser	1	LS	$12,000.00	$12,000.00
New Manhole and Outfall piping to Cascade	1	LS	$2,400	$2,400.00
PLANTING				
Plants (Trees, Shrubs, Herbs, and SAV)	300	sy	$10.00	$3,000.00
TOTAL CONSTRUCTION COSTS				**$95,231.50**
ENGINEERING AND MANAGEMENT				
Engineering				$50,000.00
Construction Management (15% of Construction)				$14,284.73
Contingency (20% of Total Construction)				$19,046.30
TOTAL PROJECT COSTS				**$178,562.53**

Project Constraints

Site Access: Phase 1 of the Marley Creek tributary restoration crosses seven different parcels, so access agreements are needed along with establishing County easements for maintenance. The largest landowner along the stream is the Granite Baptist Church. Construction equipment should have access to a significant portion of the Phase 1 restoration area through the church parking lot and athletic fields. Access to downstream sections of Phase 1 will be more difficult due to multiple land owners, dense vegetation, and steep slopes.

Design/Construction: A topographical survey is necessary to confirm the potential extent of the conceptual design. The foot bridge currently crossing the incised stream on the Granite Baptist Church property will have to be removed and replaced with a structure satisfactory to the church. Appropriate floodway/wetland construction permits will need to be acquired.

Utilities: It is unlikely that there will be any utility conflicts as no water or sewer lines were observed near the proposed limit of disturbance. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: Thick vegetation and multiple large trees may need to be removed. A tree protection plan is recommended. Other environmental impacts are not anticipated for this design.

Erosion and Sediment Control: Proper erosion and sediment controls are required including downstream silt fencing. Stream diversion will likely be necessary during some restoration activities.

Project Photos

Photo 1 – Three outfall pipes from under Oakwood Drive.

Photo 2 – Pedestrian footbridge connecting the church parking lots to playing fields.

Photo 3 – Stream bank erosion threatening the church parking lot

Photo 4 – Stream bank erosion prevalent throughout the Phase 1 restoration area

Photo 5 – Cement armoring currently along downstream portion of Reach 2

Photo 6 – Inlet where stream returns to piped flow

Phase 2 - Stream Restoration

This phase involves the restoration of the southern of the two unnamed tributaries of Marley Creek. As with Phase 1, the restoration will be used to stabilize the channel, reduce wet-weather velocities, prevent further downcutting and improve floodplain connection. The stream reach being restored begins at the outfall just north of Funke Road. The majority of the restoration area runs through a wooded section of the Granite Baptist Chruch property. A small portion of the stream also crosses property associated with Woodside Elementary School. The reach has steep valley slopes along the south bank associated with Funke Road.

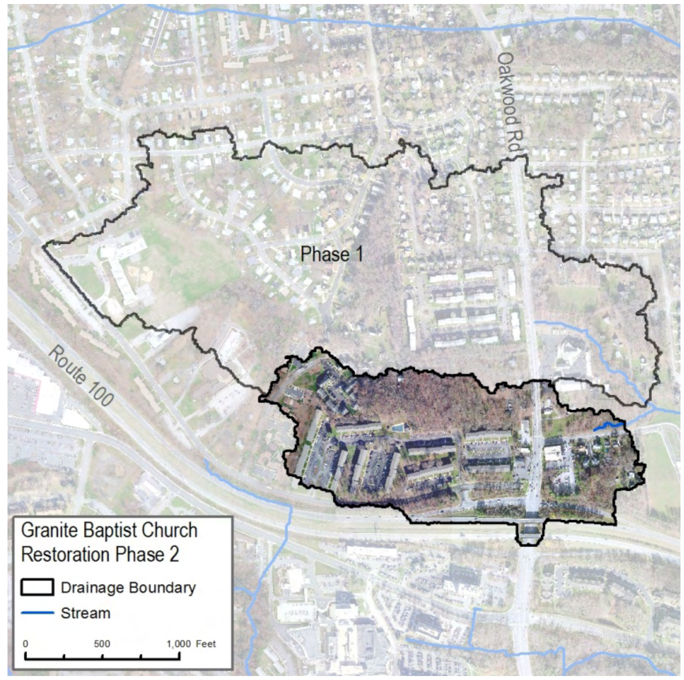

Figure 4 – Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Residential (59.6%), Woods/Open Space (17.9%), Transportation (14.6%), and Commercial (7.9%)

Drainage Area: 44.9 acres

Impervious Area: 20.4 acres

Surface Soils:
Type A (4.5 ac): sandy loam, well drained with high infiltration rates; Type B (5.3 ac): silt loam or loam, moderate infiltration rate; Type C (35.2 ac): sandy clay loam, low infiltration rates

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	82.5	0.615	40.0	56.0	1.18	1.65

Project Benefits

Stream Stability: Bank and bed stabilization measures will reduce peak velocities for flows by reconnecting the streambed with the floodplain. This will greatly improve stability within the restored stream.

Aquatic Habitat: Reductions in peak velocities and pollutant loadings will improve aquatic habitat.

Water Quality: Reduced velocity will limit further erosion and also reduce downstream transport of suspended particles and associated nutrients.

	Existing Conditions		
	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	469.7	60.8	5.1
Post-Restoration	371.7	27.5	0

Impervious Surfaces: The Phase 2 restoration will receive an impervious acre credit of 4.7 acres.

Conceptual Design

Design Parameters	Value
Total length (ft)	490
Elevation drop over length (ft)	14
Top width of riffle channel (ft)	10.0
Depth of riffle channel (ft)	1.0
Average length of riffle segments (ft)	40.0
Depth of pools (ft)	2.0
Average length of pool segments (ft)	40.0

The proposed plan will restore approximately 490 linear feet of the southern unnamed tributary that has become unstable and out of equilibrium with its watershed. The proposed conceptual design begins at the Funke Road outfall and extends through a forested area to the same culvert that receives flow from the Phase 1 tributary. The Phase 2 reach is slightly incised with bank heights between 2 and 3 feet and channel widths up to 12 feet. Bed and bank armoring is evident throughout the bottom one quarter of the reach. The channel is classified as a Rosgen G stream type.

The restoration concept for the Phase 2 reach entails creating a Rosgen B characteristic stream channel that has improved access to floodprone areas. The design approach for this reach entails generally maintaining the existing stream location and bankfull geometry and increasing the floodprone area where possible. Slight modifications in sinuosity may be possible. Re-grading the floodplain on the north-side of the stream will allow the establishment of accessible floodplain benches. Riffle weirs will be used to create a riffle-pool sequence and slow down stream velocities and decrease near-bank shear stresses.

Additional means of bank and floodplain stabilization will be riparian plantings. The stream banks and riparian area of the reaches within the limit of disturbance will be cleared of invasives and revegetated with native plantings. Soil fabric lifts utilizing biodegradable matting will be utilized as appropriate to help stabilize certain portions of the stream bank until plants are rooted.

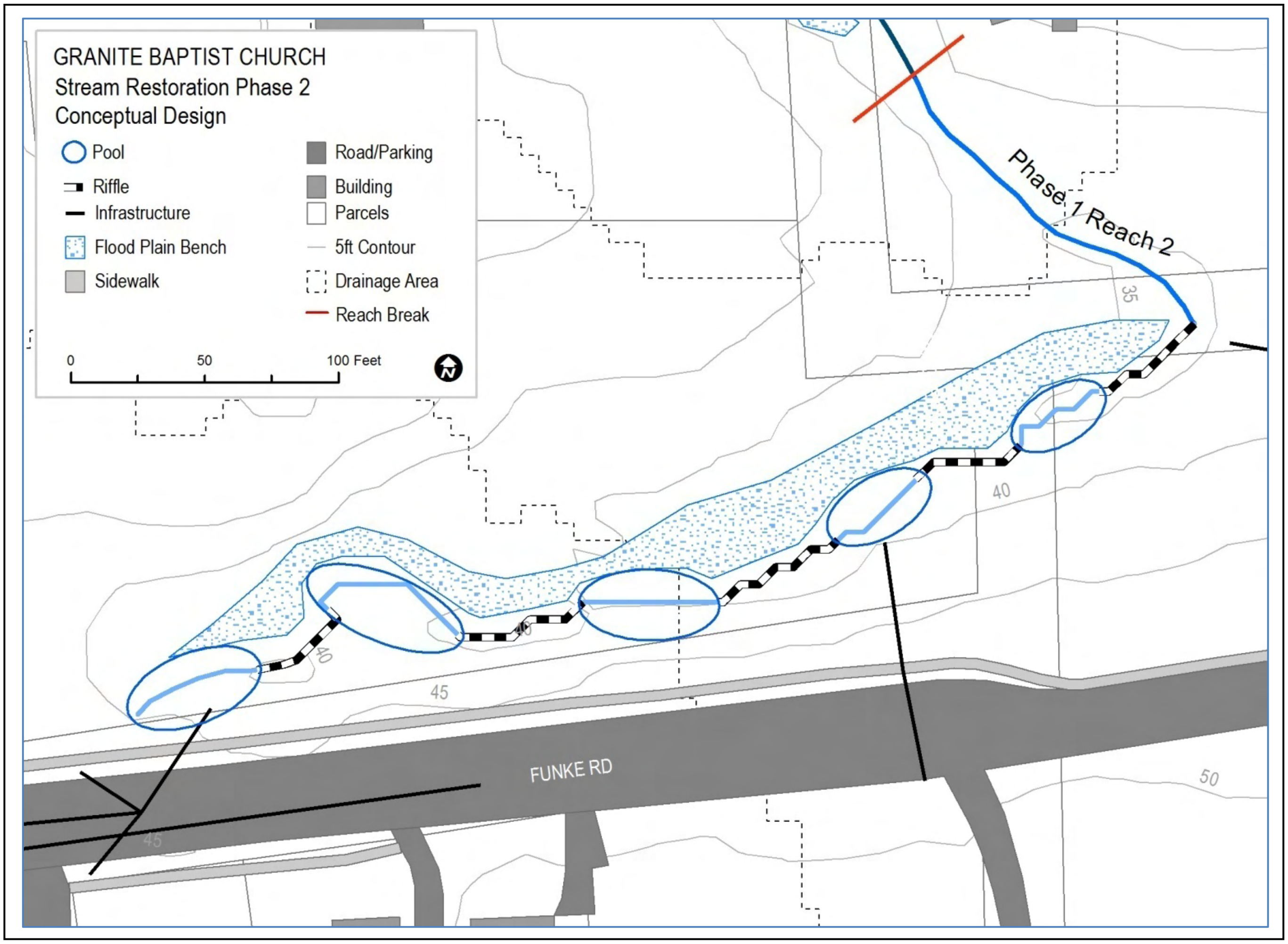

Figure 5 – Plan View of Reach Restoration

Project Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% of total cost)	1	LS	---	$8,281.00
Survey Stake Out (5% of total cost)	1	LS	---	$4,140.50
Clearing/Tree Removal	650	sy	$4.00	$2,600.00
Erosion and Sediment Control	650	sy	$4.00	$2,600.00
Blaze Orange Fence	500	lf	$8.00	$4,000.00
Remove Headwall	100	sy	$50.00	$5,000.00
Grading, Excavation, Backfilling	1,600	cy	$20.00	$32,000.00
STEP POOLS AND RIFFLES				
Sandstone Boulders	40	cy	$240.00	$9,600.00
Cobble Weir (D50 = 6" Rock)	30	cy	$75.00	$2,250.00
Geotextile	90	sy	$4.00	$360.00
Wood Chips	40	cy	$25.00	$1,000.00
Sand Fill	100	cy	$60.00	$6,000.00
STRUCTURES				
New Pond Riser	1	LS	$12,000.00	$12,000.00
New Manhole and Outfall piping to Cascade	1	LS	$2,400	$2,400.00
PLANTING				
Plants (Trees, Shrubs, Herbs, and SAV)	300	sy	$10.00	$3,000.00
TOTAL CONSTRUCTION COSTS				**$95,231.50**
ENGINEERING AND MANAGEMENT				
Engineering				$50,000.00
Construction Management (15% of Construction)				$14,284.73
Contingency (20% of Total Construction)				$19,046.30
TOTAL PROJECT COSTS				**$178,562.53**

Project Constraints

Site Access: Phase 2 of the Marley Creek tributary restoration crosses two different parcels, so access agreements are needed along with establishing County easements for maintenance. The largest landowner along the stream is the Granite Baptist Church. Construction equipment should have access to the restoration area via Funke Road or via a drive way owned by the church off of Oakwood Road. Access via Funke Road will be more difficult due to dense vegetation and steep slopes.

Design/Construction: A topographical survey is necessary to confirm the potential extent of the conceptual design. Appropriate floodway/wetland construction permits will need to be acquired.

Utilities: It is unlikely that there will be any utility conflicts as no water or sewer lines were observed near the proposed limit of disturbance. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: Thick vegetation and multiple large trees may need to be removed. A tree protection plan is recommended. Other environmental impacts are not anticipated for this design.

Erosion and Sediment Control: Proper erosion and sediment controls are required including downstream silt fencing. Stream diversion will likely be necessary during some restoration activities.

Project Manager: Hala Flores, P.E., Watershed Assessment and Planning Program Manager
License No. 28353, Expiration Date: January 02 2013

Project Photos

Photo 7 – Outfall from under Funke Road.

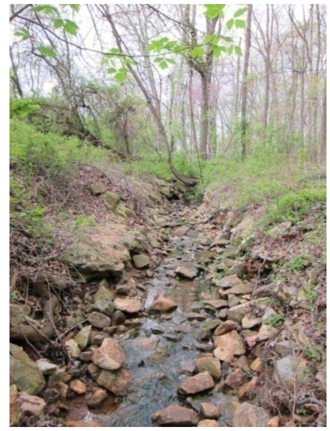

Photo 8 – Downstream portion of Phase Two, looking upstream.

Photo 9 – Stream bank and bank debris

Photo 10 – Stream bank erosion prevalent throughout the restoration area

Photo 11 – Cement armoring currently along downstream portion Phase Two.

Photo 12 – Inlet where both stream reaches return to piped flow

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Project Overview

This conceptual plan consists of a stormwater to the maximum extent practicable (MEP) retrofit of Century Towne Road. Runoff from this road and associated feeder streets are contributing to severe erosion downstream of the stormwater collection system outfall. This plan features the use of bioretention and pervious pavement in the right of way to reduce the volume of runoff and improve water quality.

Project Type: Stormwater to the Maximum Extent Practicable (MEP) Retrofit

Watershed: Tidal portion of the Patapsco River

Subwatershed: Marley Creek (Shed Code: PTG)

Location: Century Towne Road is the main street accessing the Elvaton Towne Condominiums. The road is fed by Shetlands Lane to the North and Elvaton Towne Road to the East. (Figure 1)

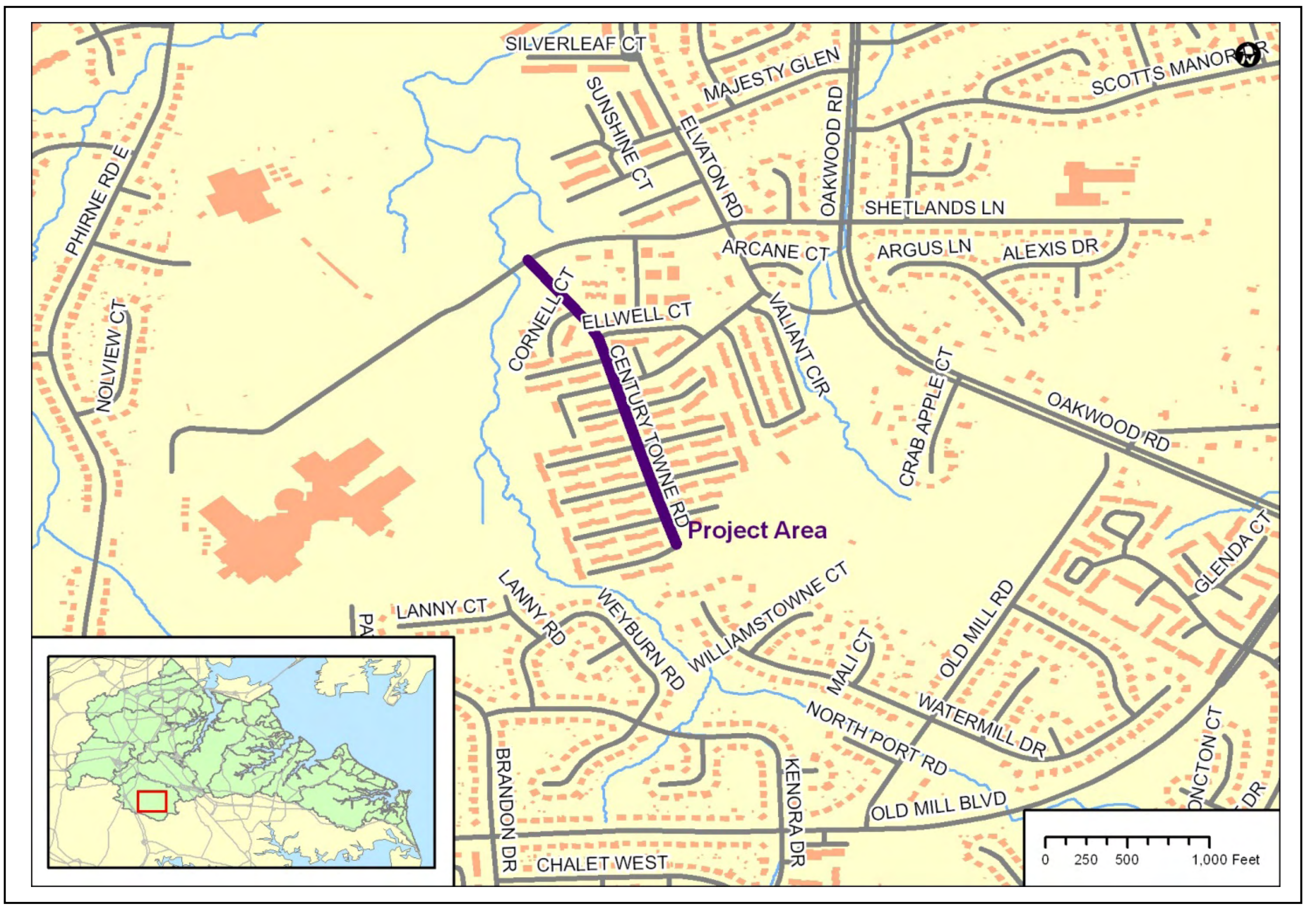

Figure 1 – Project Location Map

Project Description

Century Towne Road is owned and maintained by Anne Arundel County. The County has classified this street as a "Local Road". The road is approximately 40 feet wide and curbed. Within the public right of way, a green space and sidewalks exist on both sides of Century Towne Road. As seen in Figure 2, there are a number of trees within this residential drainage. Currently, a stormwater collection system with 16 catch basins transports water to an outfall just upstream of the Shetlands Lane crossing. 10 drainage areas have catch basins located within the public right of way (ROW) and are prime opportunities for retrofits of stormwater management to the MEP.

Figure 2 – Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Residential (99.3%), Transportation (0.4%), Woods (0.3%)

Drainage Area: 17.09 acres

Impervious Area: 10.27 acres

Surface Soils: 90% Hydrologic Soil Group B, 10% Hydrologic Soil Group C

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	85.465	0.269	27.0	38.0	1.37	1.88

Project Benefits

Water Volume Reductions: Through a combination of bioretention cells and pervious pavement, the quantity of water entering the degraded Marley Creek will be reduced. Both practices capture the flow of water along Century Towne Road. To the degree permitted by the underlying soils, water will infiltrate into the ground. All other water will be stored in the stormwater MEP practice media and have a delayed discharge into Marley Creek.

Traffic Calming: The bioretention curb extensions are similar in design to chokers. Chokers are an approved Anne Arundel County traffic control technique. By decreasing the width of Century Towne Road, traffic speeds should decrease by 3 to 5 miles per hour (Anne Arundel County 2007).

Street Beautification: The plantings associated with the bioretention cells will provide aesthetic improvements to the current road.

Water Quality: The installation of bioretention and pervious pavement practices along Century Towne Road will result in the following improvements to water quality.

	Existing Conditions		
	TN lbs/yr	**TP lbs/yr**	**TSS tons/yr**
Pre-Restoration	241.4	25.4	2.6
Post-Restoration	120.7	10.2	0.3
% Diff.	50	60	90

Conceptual Design

The conceptual design for ESD practices along Century Towne Road focuses on the use of bioretention and pervious pavement to capture stormwater runoff. 24 bioretention cells (4,946 square feet) and 17 strips of pervious pavement (9,538 square feet) have been initially identified to address the calculate water quality volume from a 1inch storm. The location of these practices represents the maximum treatment available in publically owned right-of-ways within the drainage area. In an effort to route more stormwater through the practices it will also be necessary to seal off five catch basins located on Gatewood Court, Hardmoore Court, Ingram Court, Jumpers Court, and Elwell Court.

Wherever possible, bioretention cells coincide with current catch basin locations. The plan calls for 10 of these basins to be retrofitted. This includes creating a curb bumpout into the current roadway. The catch basin will then be removed and the bioretention underdrain will connect directly to the existing stormwater lateral. At proposed ESD locations not coinciding with a current catch basin, a new connection to the stormwater infrastructure will have to be made. Depending on the situation this will necessitate the creation either a new connection or manhole. All bioretention cells will have underdrains unless further soil investigations prove that the infiltrations rates are sufficient to preclude them.

Soil media within the bioretention cells will consist of four different layers of media. The top layer shall include two to three inches of double shredded hardwood mulch to protect the soil media from erosion, reduce weed growth, retain moisture, and provide some filtration. The second layer shall be an engineered media of approximately 85% sand, 10% soil fines, and 5% organic leaf compost. The soil media shall also have a phosphorus index (P-index) between 10 and 30 to ensure that phosphorus is captured in the media. Infiltration rates need to be between one and four inches per hour and the porosity should be approximately 25%. The third bioretention layer is a choking layer used to prevent downward movement of the engineered media. The choking layer shall be either a needled non-woven geotextile fabric or a 4-inch layer of washed sand over a 2-inch layer of washed gravel (ASTM No.8 or No. 89). The choice of choking layer will depend on the head space available. The final layer of the bioretention cell is a stone drainage layer. This layer provides additional temporary storage capacity for larger storm events and protects the underdrain. The stone layer shall be comprised of washed ASTM No. 57 gravel.

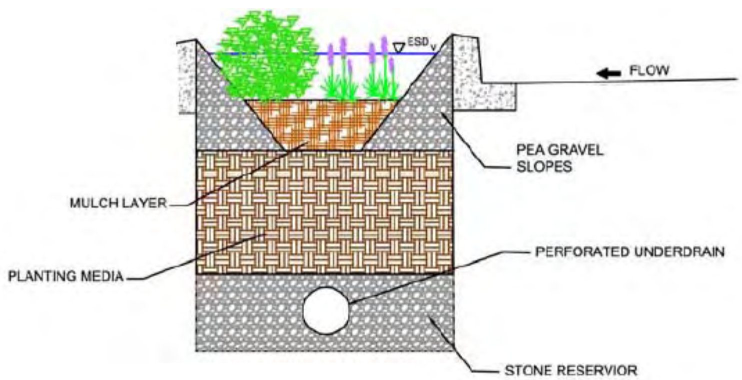

Figure 3 – Typical Cross Section of Bioretention (MDE 2009)

Pervious pavement strips have also been selected to enhance stormwater storage. A key and practical benefit of pervious pavement is that it permits residents to continue to park along Century Towne Road. Pervious pavement allows for stormwater runoff to percolate through the permeable media into the subgrade. The quantity of runoff detention depends upon the depth of gravel substrate beneath the pavement and elevation of the underdrain. Pervious pavement practices will be connected through their underdrains to bioretention cells. This will allow for connection to the stormwater system. The pervious pavement materials can be either asphalt or concrete depending on the County's preference. Pavers may also be considered but they are normally a proprietary design.

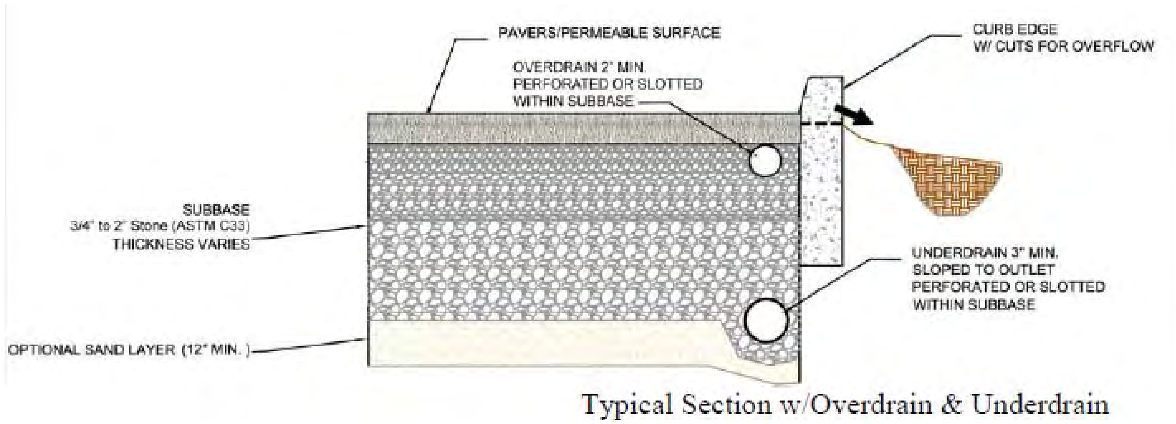

Figure 4 – Typical Pervious Pavement Section (MDE 2009)

Drainage	Estimated Depth of Practice (ft)	Bioretention Surface Area (sq ft)	Pavement Surface Area (sq ft)	Available Volume (cu ft)[1]	WQv (cu ft)	% of WQv Captured
1	3.5	669	937	1,687	686	246
2	3.5	272	381	686	756	91
3	3.5	276	487	802	3,562	23
4	3.5	731	2686	3,588	7,192	50
5	3.5	254	912	1,224	2,615	47
6*	3.5	-	-	-	935	-
7	3.5	752	1342	2,199	1,362	161
8	3.5	512	654	1,225	5,889	21
9*	3.5	-	-	-	3,410	-
10	3.5	381	444	866	6,986	12
11	3.5	555	1019	1,653	2,593	64
12	3.5	544	676	1,281	691	185
Total[2]	**-**	**4946**	**9538**	**15209**	**32332**	**47**

* : The catch basins serving these drainage areas are on private property and too far away from the ROW to reroute flow.

1 : Bioretention based on k = 0.5 ft/day, tf= 2.0 days, hf = 0.5 ft; Previous pavement based on assumed void space of 0.3

2 : This total does not include the water quality volume associated with drainages 6 and 9

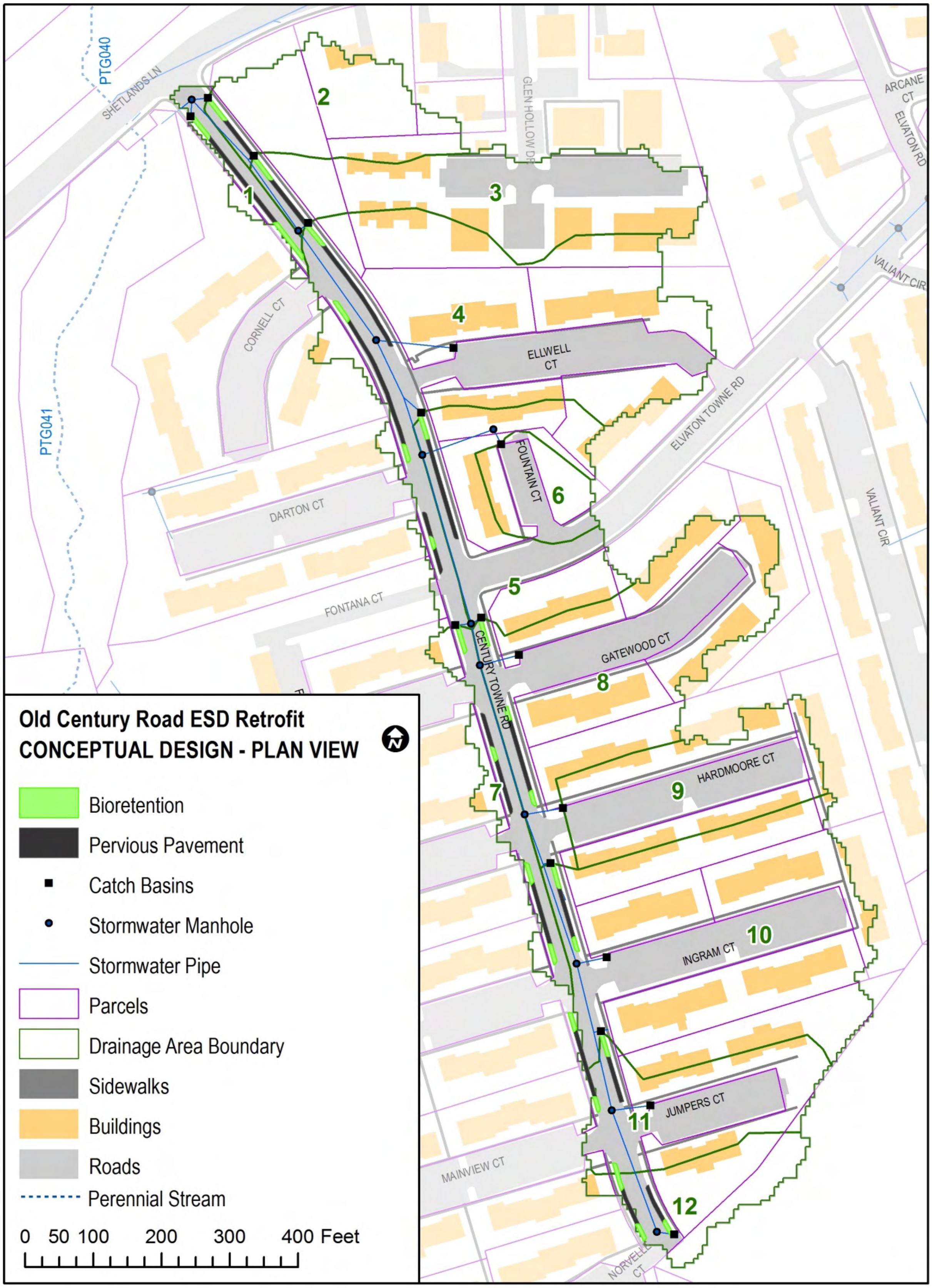

Figure 5 – Plan View of ESD Retrofit

Project Cost Estimate

Sub-Drainage	Item	Unit Cost ($/Unit)	Units		Cost
1	Bioretention	$32.50	669	sq ft	$21,743
	Pervious Pavement	$15.00	937	sq ft	$14,055
2	Bioretention	$32.50	272	sq ft	$8,840
	Pervious Pavement	$15.00	381	sq ft	$5,715
3	Bioretention	$32.50	276	sq ft	$8,970
	Pervious Pavement	$15.00	487	sq ft	$7,305
4	Bioretention	$32.50	731	sq ft	$23,758
	Pervious Pavement	$15.00	2,686	sq ft	$40,290
	New Manhole/Connection	$15,000.00	2	mh/conn.	$30,000
5	Bioretention	$32.50	254	sq ft	$8,255
	Pervious Pavement	$15.00	912	sq ft	$13,680
7	Bioretention	$32.50	752	sq ft	$24,440
	Pervious Pavement	$15.00	1,342	sq ft	$20,130
	New Manhole/Connection	$15,000.00	2	mh/conn.	$30,000
8	Bioretention	$32.50	512	sq ft	$16,640
	Pervious Pavement	$15.00	654	sq ft	$9,810
10	Bioretention	$32.50	381	sq ft	$12,383
	Pervious Pavement	$15.00	444	sq ft	$6,660
11	Bioretention	$32.50	555	sq ft	$18,038
	Pervious Pavement	$15.00	1,019	sq ft	$15,285
	New Manhole/Connection	$15,000.00	1	mh/conn.	$15,000
12	Bioretention	$32.50	544	sq ft	$17,680
	Pervious Pavement	$15.00	676	sq ft	$10,140
	New Manhole/Connection	$15,000.00	1	mh/conn.	$15,000
				Subtotal	$393,815
				Engineering (15% Cost)	$59,072
				Contingency (25% of Sub-Total + Engineering)	$113,222
				Total Estimated Cost	**$566,109**

Project Constraints

Public Property Boundary: All work must be completed within the ROW to allow for proper maintenance and ownership rights. In order to change the flow paths associated with some of the feeder streets to Century Towne Road, five private catch basins will need to be sealed. This will force water into the ROW for treatment.

Design/Construction: A topographical survey is necessary prior to further design. The survey needs to include the invert elevations of all retrofitted catch basins and manholes. Additionally, the survey should confirm the sub-drainage area delineations. Final design will also require geotechnical investigations. Infiltration testing and borings of the project location soils needs to be completed to better inform design.

Utilities: There may be underground utilities along the right of way. This has the potential to reduce the depth of the stormwater management practices. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: The majority of this concept plan is confined to the paved portion of Century Towne Road. A tree protection plan is recommended to ensure that tree root systems are properly maintained and avoided during construction. Other environmental impacts are not anticipated for this design.

Erosion and Sediment Control: Proper erosion and sediment controls are required during construction. It will be necessary to block off some catch basins during retrofits to ensure that excess solids are not entering the stormwater collection system or newly constructed practices.

References

Anne Arundel County. Neighborhood Traffic Control Guidelines (E.5). July 1, 2007. Page 8. Available at http://www.aacounty.org/DPW/Highways/Resources/Traffic_Control_Techniques.pdf

Maryland Department of Environment. 2009. Maryland Stormwater Design Manual, Volumes I&II. Chapter 5 – Enviornmental Site Design. Figures 5.3 & 5.14.

Project Photos

Photo 1 – Century Towne Road, looking north to the intersection with Shetland Lane.

Photo 2 – Catch basin near intersection of Century Towne Road and Shetlands Lane.

Photo 3 – Century Towne Road looking north at Gatewood Court

Photo 4 – Current level of residential parking along Century Towne Road (~7:00 am)

Photo 5 – Century Towne Road looking north at Ingram Court

Photo 6 – Parking along Century Towne Road (~7:00 am)

Engineer Certification

*Professional Certification. I hereby certify that these **Concept 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**)*

Project Manager: Hala Flores, P.E., Watershed Assessment and Planning Program Manager
License No. 28353, Expiration Date: January 02 2013

Project Overview

This conceptual plan restores and stabilizes two consecutive reaches of a highly incised and unstable stream and reconnects them with the floodplain. The restoration reaches are part of an unnamed tributary of Marley Creek in the vicinity of the Old Mill Middle School and Senior High School complex. The project is broken into two restoration reaches: Reach 1 is the upstream reach and Reach 2 is the downstream reach.

Project Type: Stream Restoration

Watershed: Tidal portion of the Patapsco River

Subwatershed: Marley Creek (Shed Code: PTG)

Location: East of the Old Mill school complex and west of Century Towne Road off of Shetlands Lane and Elvaton Road. (Figure 1)

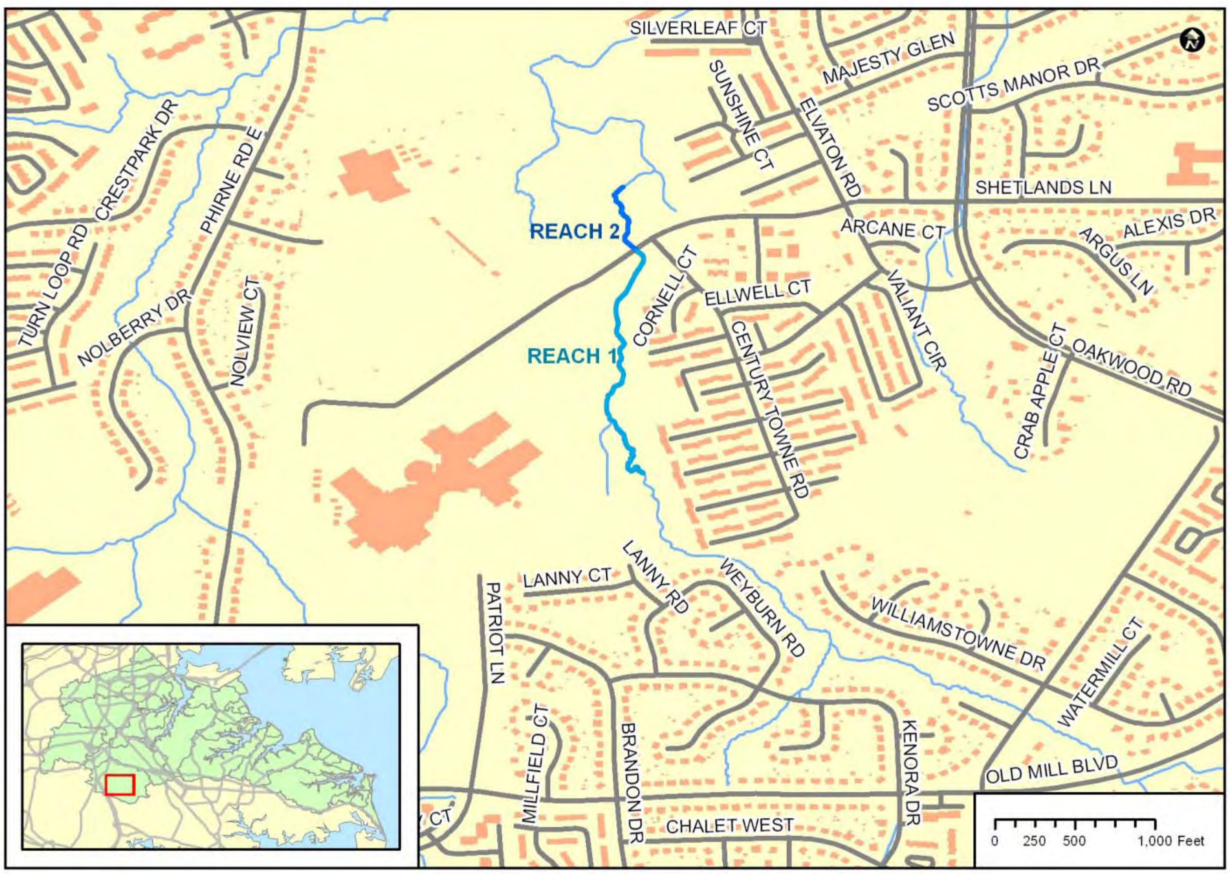

Figure 1 – Project Location Map

Reach 1 - Stream Restoration

This phase involves the restoration of the upstream reach of an unnamed tributary of Marley Creek. This reach is deeply incised and a large head cut (6+ ft) threatens previously restored stream reaches immediately upstream. The restoration will be used to stabilize the channel, reduce wet-weather velocities, prevent further downcutting and headcut migration, and improve floodplain connection. The section of stream being restored begins at the end of the previous upstream restoration project located across from the western end of Longtowne Court. The restoration reach currently runs through a forested area between a townhouse development based around Century Towne Road and grassed fields associated with the Old Mill school complex. This reach terminates at the bridge culvert that runs under Shetlands Lane and the upstream end of another highly impaired reach (Reach 2).

Figure 2 – Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Residential (76.1%), Woods/Open Space (15.7%), Commercial (3.5%), and Transportation (4.7%)

Drainage Area: 407.5 acres

Impervious Area: 134.5 acres

Surface Soils:
Type A (13.4 ac): sandy loam, well drained with high infiltration rates; Type B (290 ac): silt loam or loam, moderate infiltration rate; Type C (99.3 ac): sandy clay loam, low infiltration rates

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	79.65	1.22	189.0	281.0	1.01	1.46

Project Benefits

Stream Stability: Bank and bed stabilization measures will reduce peak velocities for flows by reconnecting the streambed with the floodplain. This will greatly improve stability within the restored stream.

Aquatic Habitat: Reductions in peak velocities and pollutant loadings will improve aquatic habitat.

Water Quality: Reduced velocity will limit further erosion and also reduce downstream transport of suspended particles and associated nutrients. Furthermore, subsurface flow and increased infiltration will also improve water quality. The Maryland Department of the Environment (MDE) calculates potential water quality improvements based on a pound per linear foot per year basis.

	Existing Conditions		
	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	3,271.8	112.1	9.5
Post-Restoration	3,051.8	37.3	0

Impervious Surface: MDE applies an impervious surface acre credit of 1 acre restored for every 100 feet of stream restoration. Reach 1 restoration provides 11 acres of impervious area credit.

Conceptual Design

Design Parameters	Value
Total length (ft)	1,100
Elevation drop over length (ft)	10
Bankfull discharge (cfs)	200
Top width of riffle channel (ft)	15.0
Depth of riffle channel (ft)	1.2
Average length of riffle segments (ft)	50.0
Depth of pools (ft)	2.5
Average length of pool segments (ft)	50.0

The proposed plan will restore approximately 1,100 linear feet of Reach 1. This reach is highly incised with bank heights between 4 and 6 feet and channel widths up to 15 feet. Reach 1 is classified as a Rosgen G stream type. A 6-foot headcut at the upstream end of the reach is threatening an earlier stream restoration project.

The restoration concept for Reach 1 entails continuing the earlier upstream restoration design. This will involve creating a Rosgen C characteristic stream channel that has improved access to floodprone areas. The design approach generally entails maintaining the existing channel alignment with modifications to the profile with some cutting and filling and increases in the floodprone area where possible. Slight modifications in sinuosity may be possible. A sewer line that runs parallel to the stream on the western side will need to be avoided, especially at the downstream end of the reach, where the sewer line is within five feet of the stream. Mirroring the upstream design, riffle weirs will be used to create a riffle-pool sequence and slow down stream velocities and decrease near-bank shear stresses. In those areas with existing low terraces, re-grading will provide additional floodplain access and potential high flow storage and riparian wetland areas.

Conceptual Design Plan

The previous upstream restoration utilizes stone boulder toe protection in certain areas. In Reach 1, the design approach will be to utilize a softer approach to bank stabilization, including bioengineering and soil fabric lifts. Additional means of bank and floodplain stabilization will include riparian plantings.

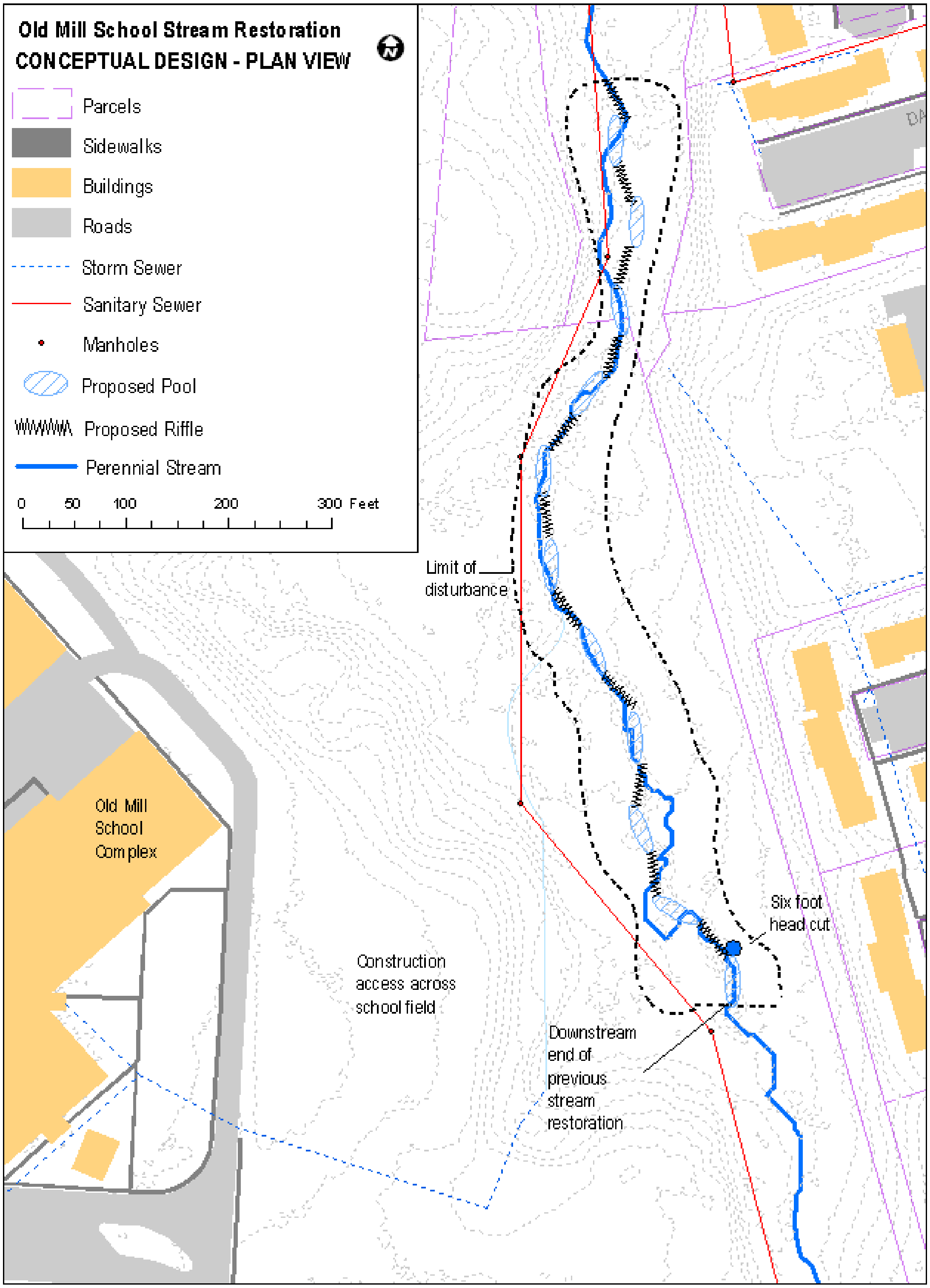

Figure 3 – Plan View of Reach 1 Restoration

Project Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% of Total Costs)	1	LS	-	$25,930.00
Survey Stake Out (5% Total Costs)	1	LS	-	$12,965.00
Erosion and Sediment Control	9,600	sy	$4.00	$38,400.00
Blaze Orange Fence	2,200	lf	$2.50	$5,500.00
Clearing/Tree Removal	4,800	sy	$8.00	$38,400.00
STREAM RESTORATION				
Excavation, Grading and Filling	2,500	cy	$20.00	$50,000.00
Sandstone Boulders	183	cy	$240.00	$43,920.00
Natural Fiber Matting	4,800	cy	$5.00	$24,000.00
PLANTING				
Plants (Trees, Shrubs, Herbs, and SAV)	4,800	sy	$10.00	$48,000.00
TOTAL CONSTRUCTION COSTS				$287,115.00
ENGINEERING AND MANAGEMENT				
Engineering (25% of Construction)				$71,778.75
Construction Management (15% of Construction)				$43,067.25
Contingency (20% of Total Construction)				$57,423.00
TOTAL PROJECT COSTS				$459,384.00

Project Constraints

Site Access: Reach 1 is entirely on property owned or controlled by Anne Arundel County, including the Board of Education. Construction equipment should have access to the restoration area through the field adjacent to the Old Mill school complex.

Design/Construction: A topographical survey is necessary to confirm the potential extent of the conceptual design. Appropriate floodway construction permits will need to be acquired.

Utilities: A sewer line was observed near the proposed limit of disturbance. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: Thick vegetation and multiple large trees may need to be removed. A tree protection plan is recommended. Other environmental impacts are not anticipated for this design.

Erosion and Sediment Control: Proper erosion and sediment controls are required including downstream silt fencing. Stream diversion will likely be necessary during some restoration activities.

Project Photos

Photo 1 – Deeply Incised Segment Downstream of Headcut

Photo 2 – Severe Bank Erosion in Upstream Portion of Reach

Photo 3 – Continuing Moderate Bank Erosion at Mid-reach

Photo 4 – Reach Begins to Reconnect with Floodplain at Downstream End

Photo 5 – Pool at Restored Reach Upstream

Photo 6 – Stone Toe Protection at Restored Upstream Reach

Phase 2 - Stream Restoration (Instream Weir)

This phase involves the restoration of the downstream reach of an unnamed tributary of Marley Creek. This reach has experienced extreme erosion from flow through the bridge culvert that runs under Shetlands Lane. An 8 ft elevation drop across 100 feet of boulder bed protection at the downstream end of the culvert highlights the erosive potential from significant storm flow. The restoration will utilize strategically placed low head rock weirs to encourage upstream sedimentation and gradual reconnection of the channel with the adjacent floodplain. The weirs will need to be placed in phases over time to gradually bring the bed elevation up to an appropriate level. This conceptual design concerns the placement of the first phase of weirs. The section of stream being restored begins at the bridge culvert and ends approximately 440 ft downstream.

Figure 4 – Aerial Photo of Drainage Area

Drainage Area Characteristics

Existing Land Use: Residential (76.0%), Woods/Open Space (15.7%), Transportation (4.7%), and Commercial (3.5%)

Drainage Area: 439 acres

Impervious Area: 148.5 acres

Surface Soils:
Type A (13.4 ac): sandy loam, well drained with high infiltration rates; Type B (312.8 ac): silt loam or loam, moderate infiltration rate; Type C (105.9 ac): sandy clay loam, low infiltration rates

Hydrology:

	Weighted CN	Time of Conc (hrs)	Flow - 1 yr (cfs)	Flow - 2 yr (cfs)	Runoff - 1 yr (in)	Runoff - 2 yr (in)
Existing	80.0	1.31	197.0	292.0	1.03	1.48

Project Benefits

Stream Stability: Reconnecting the streambed with the floodplain will reduce peak velocities and erosive forces and greatly improve stability within the restored stream.

Aquatic Habitat: Reductions in peak velocities and pollutant loadings will improve aquatic habitat.

Water Quality: Reduced velocity will limit further erosion and also reduce downstream transport of suspended particles and associated nutrients. For stream restoration projects, MDE calculates the potential water quality benefits based on the number of linear feet restored.

	Existing Conditions		
	TN lbs/yr	**TP lbs/yr**	**TSS tons/yr**
Pre-Restoration	3,603.3	185.8	16.5
Post-Restoration	3,515.3	155.8	0

Impervious Surfaces: Based on the linear feet of restoration, Reach 2 will provide 4.4 acres of impervious area credit.

Conceptual Design

Design Parameters	Value
Total length (ft)	440
Elevation drop over length (ft)	9.3
Bankfull discharge (cfs)	218
Bankfull width (ft)	32
Bankfull depth (ft)	2.9
Weir height (ft)	1.5 to 2.9
Weir length (ft)	40

The proposed plan will restore approximately 440 linear feet of Reach 2. This reach is highly incised with bank heights between 6 and 8 feet throughout the reach. Areas of extreme bank erosion up to 20 feet were encountered in upstream portions of the reach.

The restoration concept for Reach 2 entails using a series of strategically placed rock weirs to encourage upstream sedimentation and build-up of the channel bed behind each weir. This gradual build-up will allow the stream to eventually reconnect with the floodplain. With the existing channel geometry, the bankfull channel width is approximately 32 ft and the bankfull depth is 2.9 ft. To convey flows exceeding the channel forming bankfull flow in the floodplain, the existing bed elevation will need to be raised between five feet at the upstream end and 1.5 feet at the downstream end. Figure 4 shows a rough approximation of the future bed elevation. To achieve this, a series of weirs will need to be placed in phases over time. This conceptual design addresses the first phase of weir placement. In this first phase, four weirs of 4 feet will be placed along the reach. Weirs will be approximately 40 feet long and approximately 32 feet wide (or sufficiently wide to fill the incised channel width). Weirs will be spaced approximately every 60 feet.

Monitoring of the sedimentation behind each weir will be critical for determining spatial and temporal placement of additional weirs in the future. Some bioengineering (e.g., live staking, planting, fiber matting) may be needed on the exposed banks.

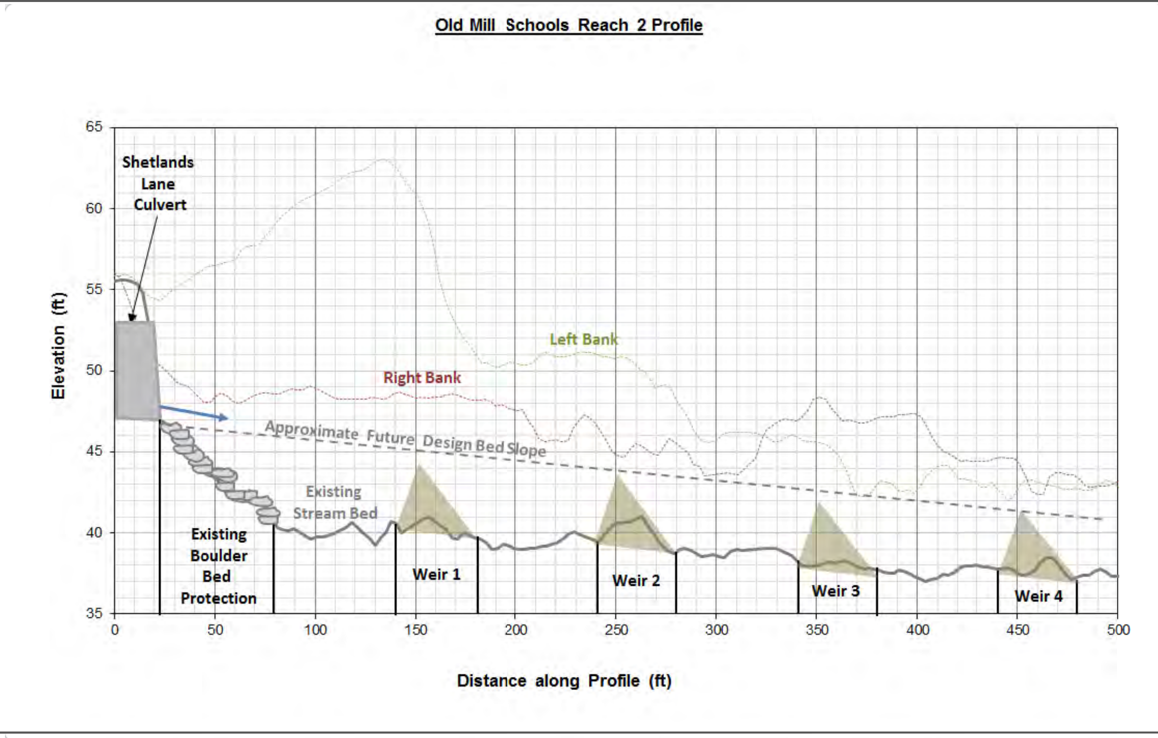

Figure 4 – Profile Views of Reach 2 Restoration

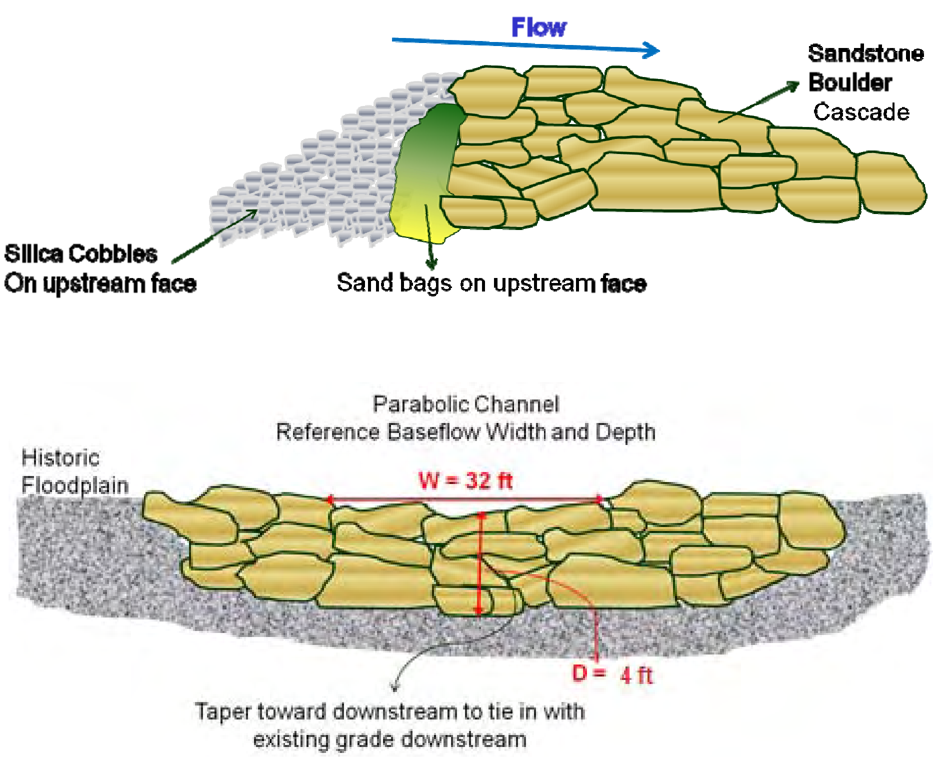

Figure 5 – Cross Section and Profile of Reach 2 Instream Weirs

Conceptual Design Plan

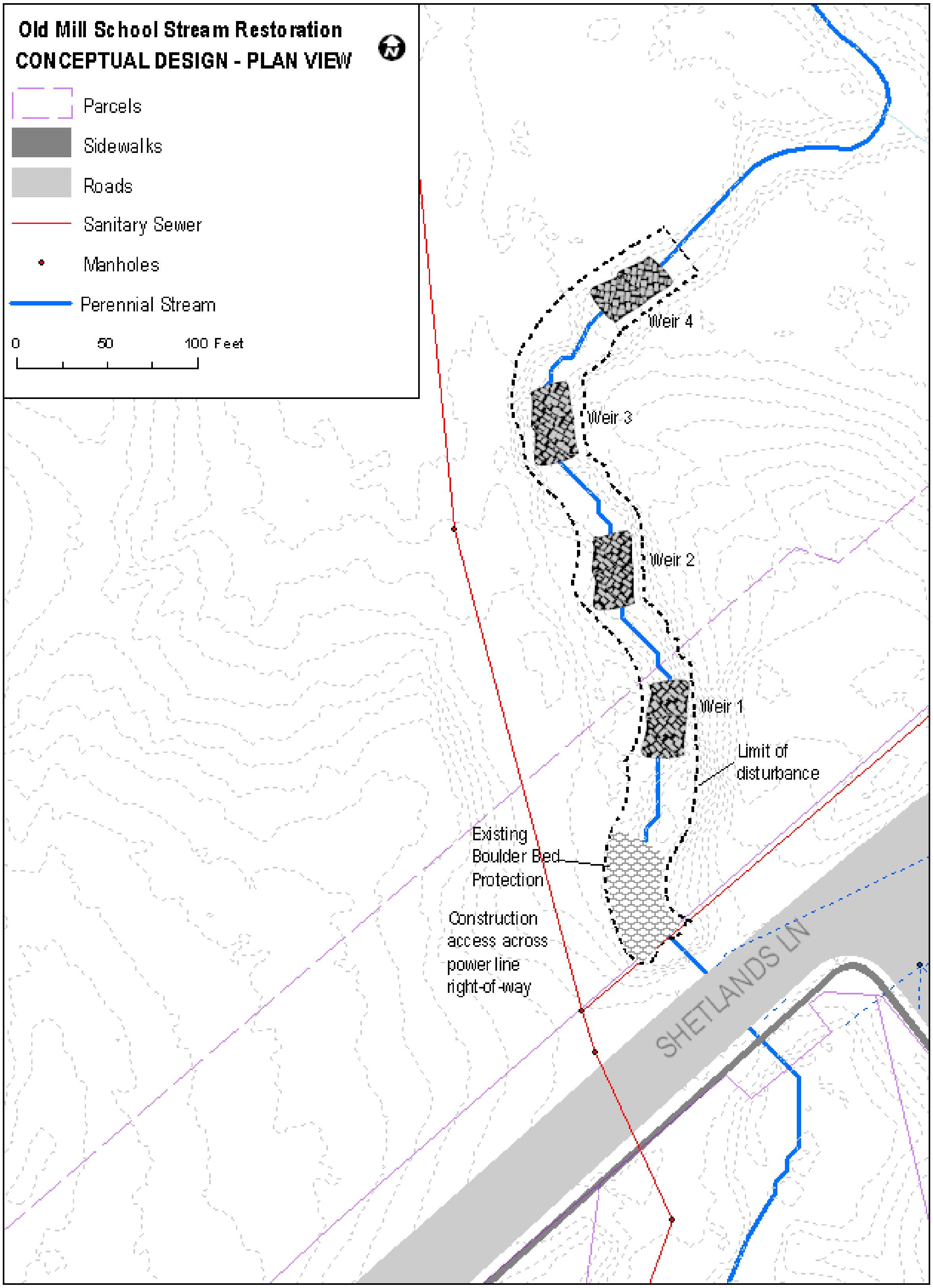

Figure 6 – Plan View of Reach 2 Restoration

Project Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% of Total Costs)	1	LS		$5,867.50
Survey Stake Out (5% Total Costs)	1	LS		$2,933.75
Erosion and Sediment Control	2,000	sy	$4.00	$8,000.00
Blaze Orange Fence	900	lf	$2.50	$2,250.00
WEIRS				
Material Placement	265	cy	$20.00	$5,300.00
Sandstone Boulders	190	cy	$240.00	$45,600.00
Cobble Weir (D50 = 6" Rock)	55	cy	$75.00	$4,125.00
Sand Bags	20	cy	$60.00	$1,200.00
TOTAL CONSTRUCTION COSTS				$76,446.25
ENGINEERING AND MANAGEMENT				
Engineering (15% of Construction)				$11,466.94
Construction Management (15% of Construction)				$11,466.94
Contingency (20% of Total Construction)				$15,289.25
TOTAL PROJECT COSTS				$114,669.38

Project Constraints

Site Access: Reach 2 flows through property owned by Anne Arundel County Board of Education and through a power line right-of-way owned by Baltimore Gas and Electric. Access agreements will be needed along with County easements for maintenance. Assuming access is granted, construction equipment should be able to enter the restoration area from Shetlands Lane through the right-of-way below the power lines.

Design/Construction: A topographical survey is necessary to confirm the potential extent of the conceptual design. A sediment transport analysis will help confirm that there is sufficient sediment supply in the watershed to support the low head weir concept. Appropriate floodway construction permits will need to be acquired.

Utilities: A sewer line was observed parallel to and crossing the proposed limit of disturbance. Miss Utility should be contacted prior to initiation of construction activities.

Environmental Impacts: Environmental impacts are not anticipated for this design.

Erosion and Sediment Control: Traditional erosion and sediment control measures may not be needed for this design.

Project Photos

Photo 7 – Triple Barrel Culvert from under Shetlands Lane

Photo 8 – Extreme Bank Erosion Downstream of Culvert

Photo 9 – Severe Bank Erosion

Photo 10 – Continued Severe Bank Erosion at Downstream End of Reach

Engineer Certification

*Professional Certification. I hereby certify that these **Concept 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**)*

Project Manager: Hala Flores, P.E., Watershed Assessment and Planning Program Manager
License No. 28353, Expiration Date: January 02 2013

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Project Overview

This project will install a bioretention facility in a community recreation area owned by the Old Mill Community Association, Inc. Drainage from the area is currently unmanaged and has two separate discharge locations. The eastern half of site is mostly grass and forested areas. The western portion consists of a recreation facility and an asphalt parking lot. The proposed bioretention facility will treat stormwater from the western portion.

Project Type: Bioretention Facility

Watershed: Tidal portion of the Patapsco River

Subwatershed: Marley Creek (Shed Code: PTG)

Location: The site is located off of Chalet Drive, south of Old Mill Road, approximately 1 mile east of Interstate 97 in Millersville, Maryland. (See Figure 1)

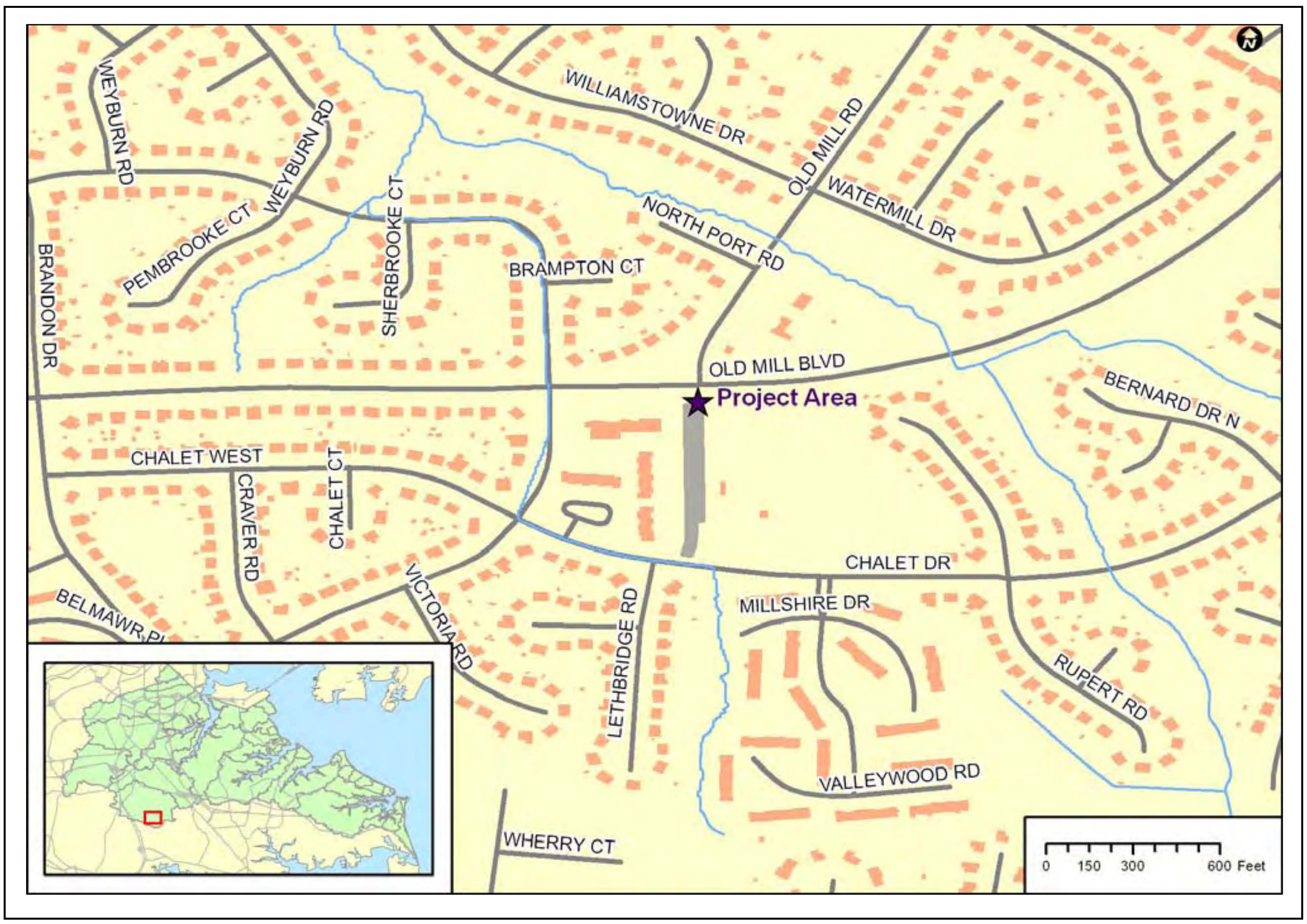

Figure 1– Project Location

Old Mill Community Association Bioretention Facility

Conceptual Design Plan

Drainage Area Characteristics

Existing Land Use: Open Space

Drainage Area: 3.16 acres

Impervious Area: 1.27 acres

Surface Soils: The soils within the drainage area are PgB, Patapsco-Fort-Mott-Urban land complex. PgB consists of Sandy eolian deposits over loamy fluviomarine deposits and are classified as Type B Hydrologic Soils.

Hydrology:

Parameter	Value
Weighted Curve Number	82.08
Time of Concentration (hrs)	0.114
Peak Discharge 1-yr (cfs)	5.0
Peak Discharge 2-yr (cfs)	7.0
Runoff 1-yr (in.)	1.11
Runoff 2-yr (in.)	1.55

Figure 2 – Aerial Photo of Drainage Area

Project Benefits

Water Quality: The bioretention and stone diaphragm allows for filtration and sequestration and/or processing of most stormwater pollutants and therefore benefits downstream water quality. Type B subsoils will allow for groundwater infiltration as well.

Aquatic Habitat: Temporary ponding created by the bioretention system with controlled release decreases peak flows to downstream receiving waters, thus decreasing bed and bank erosion. Erosive forces will be reduced thereby protecting instream aquatic habitat of receiving stream. A decrease in thermal pollution is also expected. Erosion of the bioretention itself is controlled by use of the stone diaphragm.

	Existing Conditions		
	TN lbs/yr	TP lbs/yr	TSS tons/yr
Pre-Restoration	24.7	35.5	3.2
Post-Restoration	14.8	14.2	0.6
% Diff.	40	60	80

Conceptual Design

Currently, stormwater runoff flows into two separate catch basins at the end of the recreation area parking lot (See Figure 3). From there flow is conveyed through a storm sewer and eventually discharges into the Chesapeake Bay. This concept removes the six inch curb along the north side of the parking lot and replaces the inlet grates, sealing them with solid covers. To provide pre-treatment, and minimize erosion of the raingarden proper, the drainage will be redirected across a two foot wide stone diaphragm and a grassed filter strip prior to reaching the bioretention facility. The bioretention acts primarily as a filtration system and is sized to treat the water quality volume (WQv) for a one-inch storm event. Recharge volume is provided within a stone-filled reservoir directly below the bioretention facility. Per MDE regulations, an overflow structure will restrict storage volume to one foot above the bioretention area. The overflow structure also provides a collection point for the facility's perforated underdrains prior to discharge back to the existing storm sewer system, as well as a cleanout for maintenance of the underdrains. Additionally, a shallow drainage swale shall be constructed between the parking lot and the western property line. This will direct runoff to the bioretention and stop it from entering the parking lot and/or sheet flowing towards the neighboring property to the west.

Design Parameters	Required
Drainage area (acre)	3.16
Percent Impervious (%)	40.2
Volumetric runoff coefficient (R_v)	0.41
Soil specific recharge factor (S)	0.26
Water quality volume (WQ_v) (ft^3)	4,703
Water quality volume provided (WQ_v) (ft^3)	4,869
Recharge volume (Re_v) (ft^3)	1,222
Recharge volume provided (Re_v) (ft^3)	1,222
Temporary storage volume (V_{temp}) (ft^3)	3,527
Temporary storage volume provided (V_{temp}) (ft^3)	3,221
Channel protection volume (CP_v) (ft^3)	N/A
Overbank flood protection volume (Q_p) (ft^3)	N/A
Extreme flood volume (Q_f) (ft^3)	N/A
Total bioretention filter soil depth (d_f) (ft)	4.5
Weighted coefficient of permeability (k) (ft/day)**	1.08
Average ponding depth (h_f) (ft)	0.5
Soil porosity (n)	0.4
Bioretention residence time (t_f) (day)	2
Minimum bioretention area (A_f) (ft^2)	1,959
Minimum bioretention area provided (A_f) (ft^2)	2,705
Recharge storage depth (d) (ft)	1.13
Recharge storage depth provided (d) (ft)	1.13
** 3" mulch, k=2.0; 3.5' soil, k=3.5; 9" Sand, k=3.5	

Conceptual Design Plan

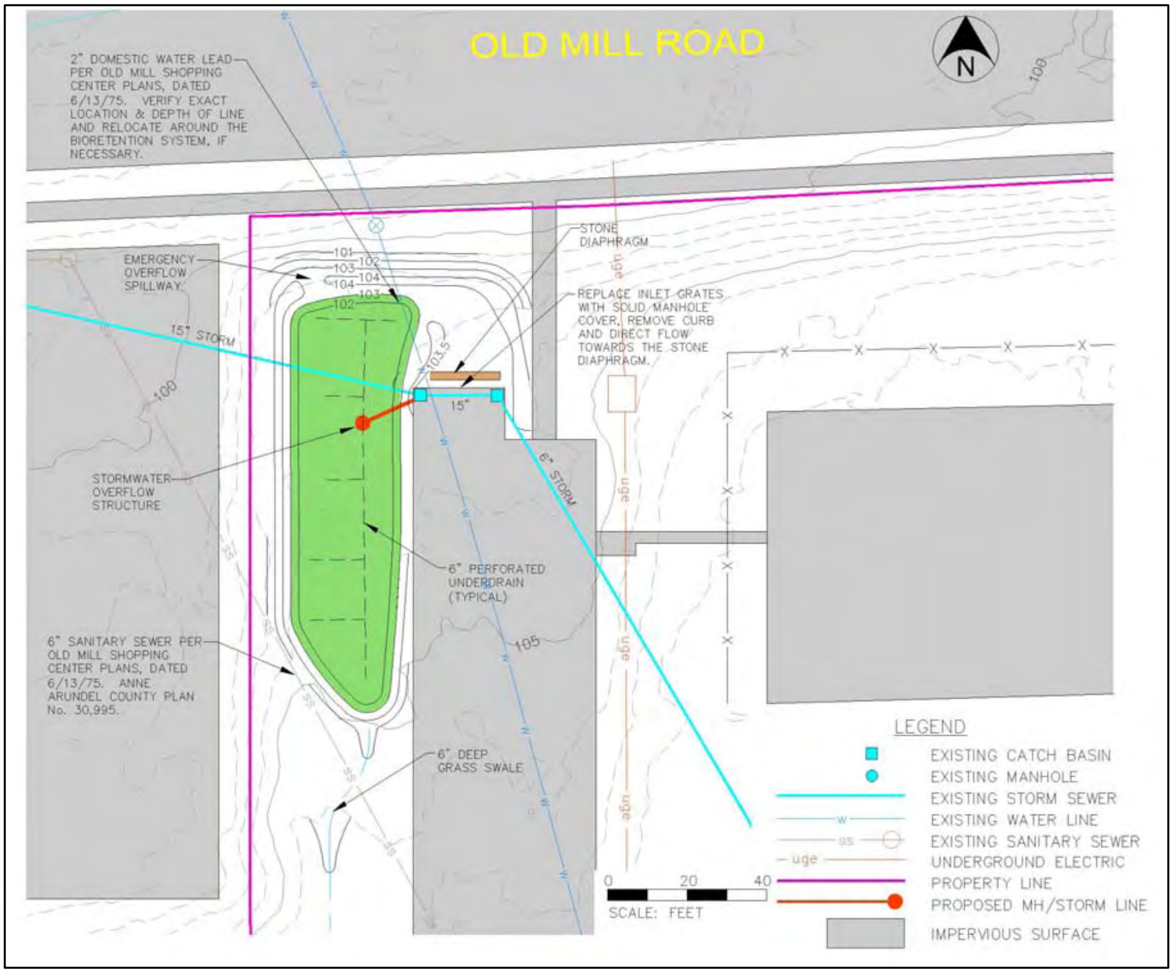

Figure 3 – Plan View of Bioretention Conceptual Design

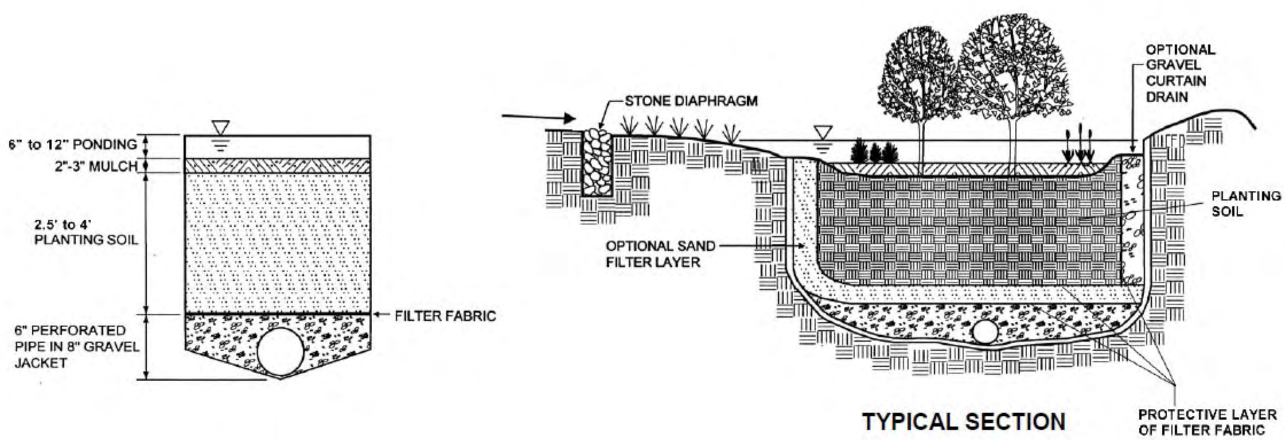

Figure 4 – Cross Section View of Typical Bioretention Facility (Source: Maryland Stormwater Manual)

Project Cost Estimate

Item Description	Quantity/Units		Unit Cost	Subtotal Cost
SITE PREP AND GRADING				
Mobilization/Demobilization (10% Total Cost)	1	LS	---	$5,000.00
Erosion and Sediment Control	1150	sy	$4.00	$4,600.00
Grading, Excavation, Backfilling	750	cy	$20.00	$15,000.00
BIORETENTION FACILITY				
Planting Soil Mix	350	cy	$18.00	$6,300.00
Geotextile	420	sy	$3.00	$1,260.00
Rock Fill	140	cy	$45.00	$6,300.00
Mulch (3” cover)	300	sy	$5.00	$1,500.00
Sand Fill	75	cy	$60.00	$4,500.00
Overflow Manhole	1	LS	---	$2,000.00
6” PVC Underdrain	175	lf	$12.00	$2,100.00
Relocate 2” Domestic Water Lead	40	lf	$20.00	$800.00
PLANTING				
Plants (Trees, Shrubs, Herbs, and SAV)	300	sy	$10.00	$3,000.00
TOTAL CONSTRUCTION COSTS				**$52,360.00**
ENGINEERING AND MANAGEMENT				
Engineering (15% of Construction or $10,000 min)				$10,000.00
Construction Management (15% of Construction)				$7,854.00
Contingency (20% of Total Construction)				$10,472.00
TOTAL PROJECT COSTS				**$80,686.00**

Project Constraints

Site Access: The Park is owned by the Old Mill Community Association, Inc. The proposed limit of disturbance associated with the project lies entirely within the site's property lines and can be accessed from Chalet Drive.

Design/Construction: A topographic survey is essential, and a geotechnical survey should be completed to confirm infiltration capacity of the soils under the proposed bioretention device.

Utilities: County records show an existing 2-inch water lead located within the northeast corner of the proposed bioretention system which may need to be rerouted (See Figure 3). Also, a 6-inch sanitary sewer lead discharges from the pool area into sewer system located within the Old Mill Shopping Plaza west of the park but will not impact the designs. The exact location of all utilities will be determined during the survey phase of the project. Additionally, Miss Utility should be contacted prior to commencement of any construction activities.

Environmental Impacts: There are several medium-sized trees located along the western property line. All land disturbances should maintain a minimum of ten feet of clearance from the base of the tree and preferably remain outside of the tree canopy drip-line.

Erosion and Sediment Control: Proper erosion and sedimentation controls are required during construction activities as per county regulations.

Project Photos

Photo 1 – Location of Storm Inlets, looking north

Photo 2 – Grade along Old Mill Road, looking southeast

Photo 3 – Proposed Bioretention Facility Location, looking north. Parking lot to the right.

Engineer Certification

*Professional Certification. I hereby certify that these **Concept 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.**)*

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