AN ASSESSMENT OF STORMWATER MANAGEMENT RETROFIT AND STREAM RESTORATION OPPORTUNITIES IN BENNETT CREEK WATERSHED, FREDERICK COUNTY, MARYLAND

Prepared for:
Frederick County
Division of Public Works
Frederick, Maryland

Prepared by:
Tetra Tech, Inc.

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1 INTRODUCTION

The Bennett Creek watershed is the fourth watershed to be selected for a retrofit assessment by the Frederick County National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit program. In phase one of the assessment, all available information on the condition of the watershed was gathered and probable stressors were identified using the steps outlined in the US EPA Stressor Identification Guidance Document (US EPA 2000, Tetra Tech 2008a). This report documents phase two of the assessment, in which priority restoration sites were identified in urban areas and projects were recommended to reverse, prevent, or slow stream and watershed degradation. The work was performed by Tetra Tech, under contract to the Frederick County Division of Public Works (Task Order No. 03, Contract # 05-CSC-10).

1.1 URBAN SOURCES AND ASSOCIATED STRESSORS AND RESPONSES

Pathways between stressor sources, the stressors they induce and the effects on the biological assemblage can be visualized through the use of conceptual models. Using guidance from the US EPA Stressor Identification Guidance Document, a conceptual model was developed to show general urban stressor sources, the stressors they induce and the effects on the biological assemblage. Although the stressor identification process does not describe a definitive cause and effect relationship between stressors and biological conditions, it is important to identify those stressors and stressor sources that are most likely contributing to observed conditions. Figure 1.1 summarizes the causal pathways through which urban sources can impact biota and contribute to degradation of aquatic resources. An additional summary that contains more detailed descriptions of the urban sources and associated environmental effects is provided in Table 1.1.

1.2 BENNETT CREEK WATERSHED STUDY AREA

The Bennett Creek watershed is an approximately 48 mi^2 subwatershed of the Lower Monocacy Basin, and lies in the southeastern portion of Frederick County and part of Montgomery County. The watershed is divided into 15 subwatersheds and 105 catchment areas (Figure 1.2). The watershed is mostly rural, with forest and agriculture comprising approximately 85% of the land use (Figure 1.3). Developed land consists mostly of low density residential areas, which occur mainly in the north, central and eastern portions of the watershed. Small areas of residential development also exist in the northwestern portion of the watershed. The Bennett Creek watershed has experienced fairly rapid urban and suburban growth in recent years, in part due to building restrictions and protected lands in neighboring Montgomery County (Frederick County DPW 2004). Valuable aquatic resources are located within the Bennett Creek watershed. This includes Bear Branch, the only pristine brook trout-bearing stream in all of the Lower Monocacy River Watershed (MDNR 2003a). Bear Branch and Furnace Branch, which flows through the DNR Monocacy River Natural Resources Management Area, are designated for Natural Trout waters and Public Water Supply. The Monocacy River, which flows along the western boundary of the watershed, is designated for Recreational Trout waters and Public Water Supply. The majority of streams in the Bennett Creek watershed are designated for Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply.

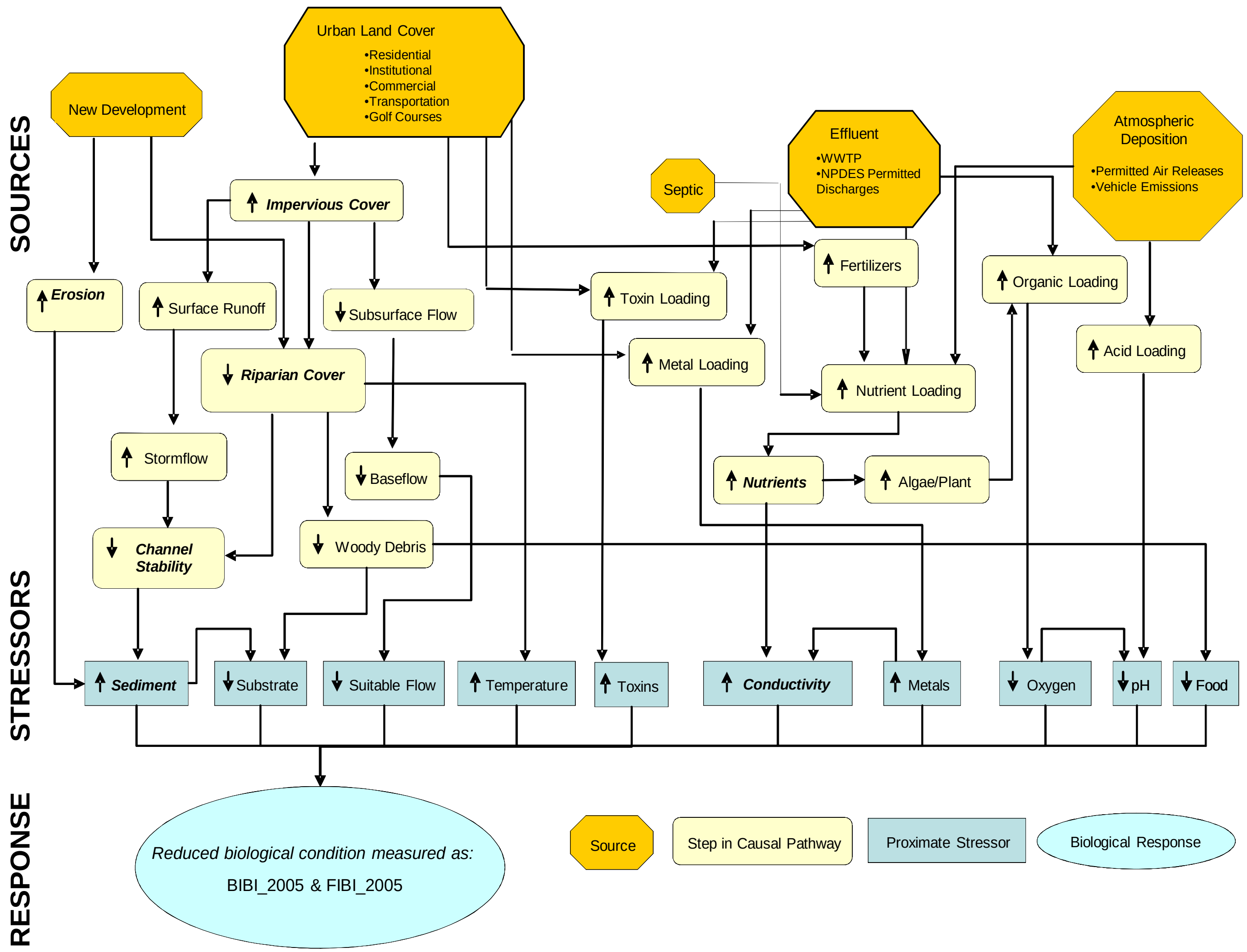

Figure 1.1. Conceptual model showing steps, causal pathways and proximate stressors related to urban sources.

Table 1.1. Major pollutants (stressors) in urban or suburban areas and their effect on streams (Fairfax County 2001).

Stressor	Source	Environmental Effect
Nutrients (Nitrogen and Phosphorous)	Improper use (over application) of lawn fertilizers.	Stimulate algae blooms. May reduce sunlight reaching stream bottom, limiting plant growth. Rapid accumulation of dead algae decomposes aerobically, robbing other stream animals of oxygen.
Toxics	Various. Underground storage tank leakage, surface spills, illegal discharges, chlorine from swimming pool drainage, etc.	Can have an immediate (acute) affect on stream biota if levels are high enough. May be chronic, eliminating the more sensitive species and disrupting ecosystem balance over time.
Sediment	Poorly managed construction areas, winter road sand, instream erosion, bare soils.	Clogs gills of fish and insects, embeds substrate, reducing available habitat and potential fish spawning areas.
Organic Loading	Sewage leaks, domestic and livestock wastes, yard wastes dumped into streams.	Human health hazard (pathogens), similar oxygen depletion situation as Nutrients. Causes benthic community shift to favor filter feeders as well as organisms with low oxygen requirements.
Exotic Species	Human transportation and release (intentional and unintentional).	Invade ecosystem and out compete native species for available resources (food and habitat). Some introduced intentionally to control other pests.
Thermal Loading	Water impoundments (lakes or ponds). Industrial discharges and power plants. Removal of riparian tree cover. Runoff from hot paved surfaces.	Biological community structure altered, shift to species tolerant of higher temperatures, sensitive species lost. Dissolved oxygen depletion.
Channel Alteration	In very urban areas, concrete, metal and rip-rap stabilization of stream banks. Stream channelization, flood erosion control.	Major habitat reduction/elimination, changes flow regime dramatically. Dramatic alteration of biological communities, can cause Thermal Loading and Sediment problems. Transfer erosion potential downstream.
Altered Hydrology	Conversion of forested/natural areas to impervious surfaces. Increases amount and rate of surface runoff and erosion.	Overall channel instability, habitat degradation or loss.
Riparian Loss	Development. Clearing or mowing of vegetation all the way up to stream banks.	Increase water temperature, greater pollutant input, less groundwater recharge, greater erosion potential from streambanks. Alters community composition.

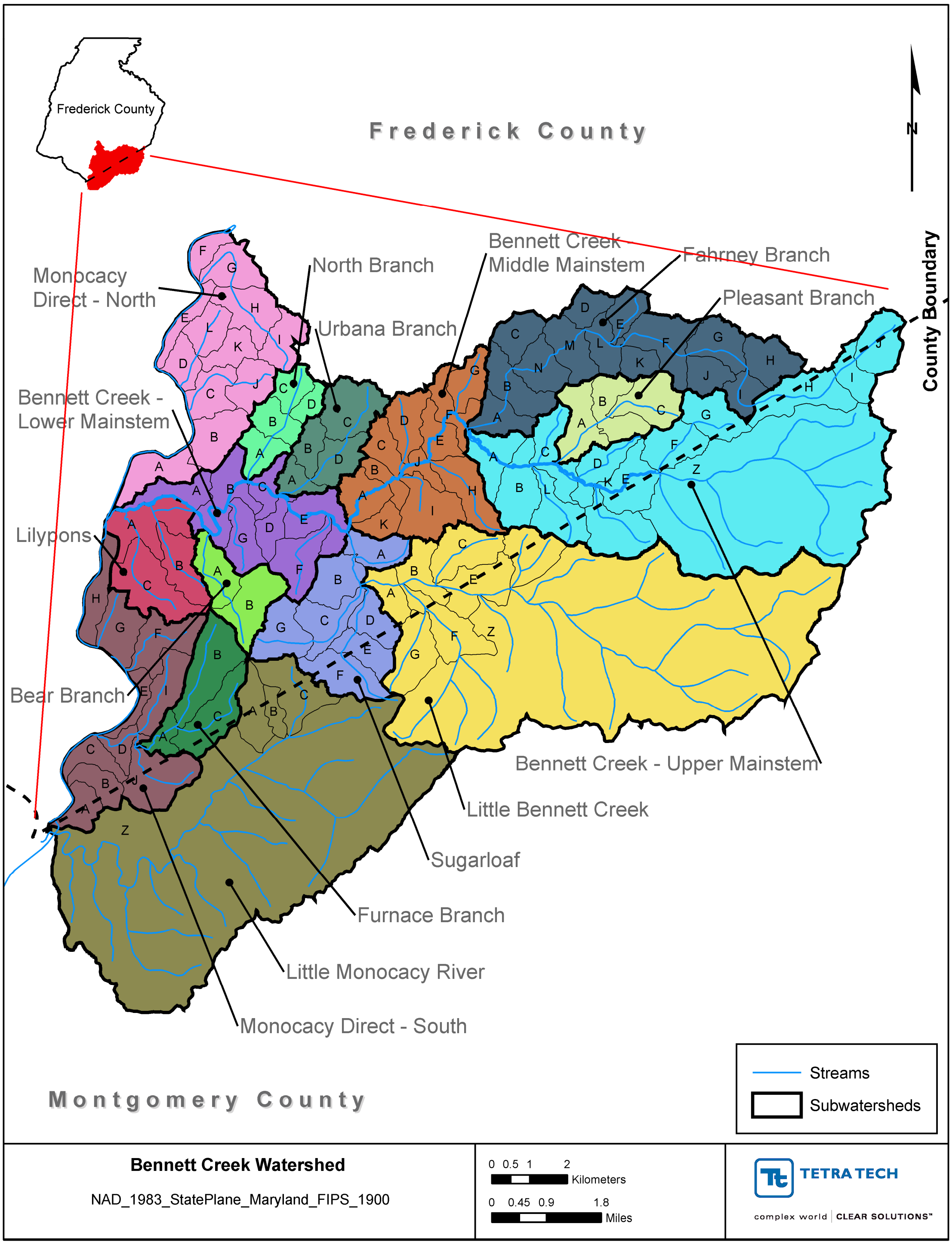

Figure 1.2. The Bennett Creek watershed is divided into 15 subwatersheds and 105 catchment areas (delineations were developed by Versar, Inc. in 2007).

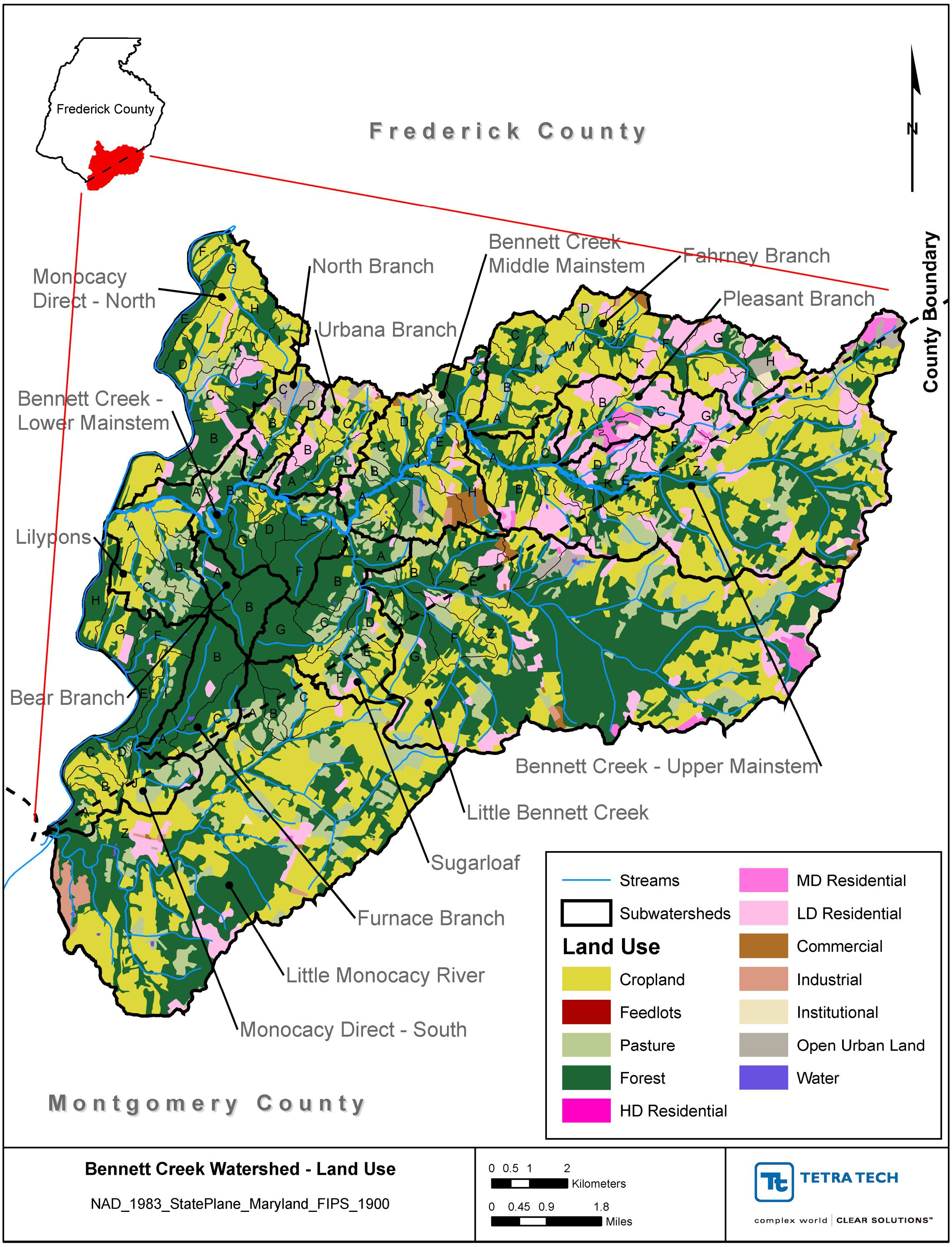

Figure 1.3. Land Use distribution for the Bennett Creek watershed.

1.3 GOALS AND GUIDELINES

The Bennett Creek retrofit assessment builds upon the studies conducted by the Maryland Department of Natural Resources (MDNR) in the Lower Monocacy River watershed. These include a watershed characterization report, a nutrient synoptic survey, a stream corridor assessment (SCA) and a watershed restoration action strategy (WRAS) (MDNR 2003a, MDNR 2003b, Czwartacki et al. 2004, Frederick County DPW 2004). The goal of the retrofit assessment is to provide the County and community stakeholders with information on the condition of this watershed, to identify the most likely stressor sources in the watershed, and to recommend projects to reverse, prevent, or slow stream and watershed degradation. Implementation of any suite of retrofit/restoration projects in the Bennett Creek watershed will be with the ultimate goal of improving or maintaining environmental conditions, in particular, with reducing or eliminating stressors and stressor sources.

For the Bennett Creek retrofit assessment, Tetra Tech worked in collaboration with County personnel to: 1) estimate stormwater pollutant loads for the Bennett Creek watershed; 2) set watershed-specific target loads for pollutants in a way that utilizes biological data; 3) use all available information to identify candidate projects in urban areas that will improve stormwater management; 4) conduct site visits to verify or refine proposed restoration approaches; 5) prioritize candidate projects in a way that factors in the guidelines outlined below; 6) summarize site information, proposed actions, predicted benefits, implementation issues and cost estimates for each of the candidate projects; and 7) develop conceptual designs and make monitoring recommendations for five high priority sites that utilize different restoration approaches. The following guidelines were taken into consideration when prioritizing sites:

- Candidate projects located on county-owned land were assigned higher priority because they offer the best opportunities for implementation via the County's Capital Improvement Program (CIP) program. Candidate projects located on private property were also considered if they impacted County-controlled infrastructure.
- One requirement of CIP projects is that they must cost more than $100,000. If a single candidate project did not meet the minimum cost requirement but could reasonably be combined with other projects in order to exceed the minimum cost threshold, it was acceptable to recommend the combined group of projects.
- Candidate projects that had high visibility, provided educational benefits and were likely to gain public acceptance were assigned higher priority.
- Candidate projects located in catchment areas with higher estimated pollutant loads were assigned higher priority (see Section 2.2 for details on pollutant loading estimates)
- Where opportunities existed, attempts were made to recommend candidate projects that had synergism with existing CIP projects.
- Candidate projects that did not meet the CIP guidelines were recommended to be implemented as Community Restoration Projects (CRP).

As mentioned earlier, the Bennett Creek watershed is the fourth watershed to be selected for a retrofit assessment by the Frederick County National Pollutant Discharge Elimination System

(NPDES) Municipal Separate Storm Sewer System (MS4) permit program. One of the goals of this program is to provide treatment for 10% of impervious areas that are currently not served by stormwater management (Perot et al. 2006). According to the 2002 NPDES Annual Report, there are 256 untreated urban impervious acres in the Frederick County portion of the Bennett Creek watershed. If the County were to provide stormwater management controls for 26 of these untreated acres, it would help satisfy the overall goals of the program.

There are many reasons why improving stormwater management is important. As shown in the conceptual model, failure to implement proper stormwater controls can have deleterious effects on the biological integrity of aquatic systems. Poor stormwater management practices impact many other aspects of aquatic resource management as well. Examples include damage to infrastructure and private property, reductions in economic, social and aesthetic benefits to local communities and increased treatment costs for drinking water. These impacts may have long-term, far-reaching effects not just in the Bennett Creek watershed, but also downstream in the Monocacy and Potomac Rivers and ultimately in the Chesapeake Bay.

2 METHODS

The process that was followed to identify the best candidate projects was modeled after previous retrofit assessment reports in Frederick County (Perot et al. 2003, 2005, 2006) and elsewhere in the mid-Atlantic region (Southerland et al. 1999, 2000; Roth et al. 2002). The general steps that were followed were: 1) evaluate existing data on stream condition and determine general problem types; 2) use all available data to identify candidate projects in urban areas; 3) use the general goals and guidelines set forth in Section 1.3 to prioritize candidate projects; and 4) recommend site-specific restoration approaches.

2.1 REVIEW OF EXISTING AND ONGOING WATERSHED STUDIES AND PROJECTS

One of the first steps taken was to review relevant literature to help gain a better understanding of the types of problems affecting the biological integrity of streams in the Bennett Creek watershed.

2.1.1 BENNETT CREEK WATERSHED ASSESSMENT

A watershed assessment report in which all available information on the Bennett Creek watershed was gathered, organized and analyzed was completed in 2008 (Tetra Tech). This report summarizes response indicators (biological), stressor indicators (physical, chemical, hydrologic, biological), source indicators (land use/land cover, NPDES permits, other), spatial and temporal distribution of data and data sufficiency. Information from this report was used to help identify priority restoration sites and to recommend projects to reverse, prevent, or slow stream and watershed degradation.

2.1.2 BENNETT CREEK STRESSOR IDENTIFICATION

Stressors were identified at random and targeted site locations throughout the Bennett Creek watershed by using a series of logical steps based on the US EPA Stressor Identification Guidance Document. Impairments were evaluated, candidate causes of impairment were described, relationships between causes, stressors and biotic conditions were assessed, and probable stressors were identified based on strength of evidence. Stressors varied among subwatersheds, but nutrient enrichment and habitat degradation were the most commonly cited candidate causes of impairment, followed by excessive sediment and turbidity.

2.1.3 LOWER MONOCACY WATERSHED RESTORATION ACTION STRATEGY

In May 2004, Frederick County completed the Lower Monocacy Watershed Restoration Action Strategy (WRAS) process, a grant-based, watershed planning process involving significant stakeholder input (DPW 2004). This process was established by the Maryland Department of Natural Resources (MDNR) and was carried out using U.S. Environmental Protection Agency's (USEPA) Section 319 Clean Water Act funds. The purpose of the WRAS program is to protect water quality and habitat in priority watersheds within the State of Maryland, particularly those with listed impairments and Total Maximum Daily Load pollution reduction requirements. This WRAS effort included a detailed assessment of five tributary streams to Bennett Creek: Bear Branch, Fahrney Branch, Pleasant Branch, North Branch and Urbana Branch.

Three reports that were generated by MDNR staff were included in the WRAS:

- Lower Monocacy River Watershed Characterization (MDNR 2003a)
- Nutrient Synoptic Survey (MDNR 2003b)
- Stream Corridor Assessment (SCA) (Czwartacki and Yetman 2004)

Through a collaborative process, the Lower Monocacy WRAS Steering Committee, which was comprised of 40 representatives and 25 organizations, reviewed the DNR data, organized 7 working groups to formulate goals and objectives, and communicated with and gathered input from landowners in the Bennett Creek watershed through a public meeting (DPW 2004). As a result of this process, 23 sites were listed as priorities for restoration in the Bennett Creek watershed.

2.1.4 STREAM CORRIDOR ASSESSMENT SURVEYS

In 2003, SCA surveys were conducted in five tributaries of the Bennett Creek watershed as part of the Lower Monocacy WRAS process (DPW 2004, Czwartacki et al. 2004). These tributaries included Bear Branch, Fahrney Branch, Pleasant Branch, North Branch and Urbana Branch. During the stream corridor assessment surveys (SCA), trained field crews walk the stream corridors and record information on observable environmental problems in the watershed. These problems include: inadequately buffered stream banks, erosion sites, fish barriers, pipe outfalls, channel alterations, trash dumping sites, exposed pipes and unusual conditions/comments. The stream corridor assessment surveys are limited in that they are not detailed scientific surveys and their ratings are subjective. However, they are valuable in helping to target future restoration efforts.

SCA crews assessed approximately 38 miles of stream in the Bennett Creek watershed. Results are summarized in Table 2.1. The most prevalent problems were inadequate buffers (15.3 miles) and erosion (12.4 miles), and many of the problem sites were rated ‘severe’ and ‘very severe.’ Twenty-three of the sites were identified as priority restoration sites in the Lower Monocacy WRAS report (DPW 2004). Problems cited at these sites include fish migration barriers, inadequate riparian buffers, free access of livestock (horses, cattle) to streams, exposure to future development, areas of accelerated erosion due to golf courses and residential developments, and failing septic systems.

2.1.5 NUTRIENT SYNOPTIC SURVEY

In 2003, nutrient synoptic surveys were conducted at 16 sites in the Bennett Creek watershed as part of the Lower Monocacy WRAS process (DPW 2004, MDNR 2003b). The report showed nitrogen ratings to be high at eight sites, moderate at seven, and baseline at one. The report states that the majority of the elevated nitrogen concentrations and yields appeared to be associated with animal and row crop agriculture (MDNR 2003b). Phosphorus ratings were baseline at eleven sites, moderate at four sites, and high at one site. The report states that elevated orthophosphate concentrations and yields appeared to be associated with phosphorus-rich soils in systems that had fine suspended sediment loads lingering in the water column several days after rain events, possibly due to drainage from ponds (MDNR 2003b). High nutrient ratings in the Bennett Creek watershed occurred in four of the subwatersheds: Fahrney, Pleasant, Bennett Upper and Bennett Lower.

In situ water quality measurements were also taken as part of the survey. Values for sites in the Bennett Creek watershed appeared to be normal, with neutral or basic pH values, conductivities ranging from 82 to 279 µS/cm, dissolved oxygen values ranging from 9.44 to 13.32 mg/L, and water temperature values ranging from 14.78 to 20.77°C.

Table 2.1. Summary of the results of the Stream Corridor Assessment Survey (SCA), which was conducted in areas of the Bennett Creek watershed in 2003 (Czwartacki et al. 2004).

Potential Problems	**Number**	**Estimated Length**	**Very Severe**	**Severe**	**Moderate**	**Low Severity**	**Minor**
Channel Alterations	4	1167 ft (0.22 miles)	0	0	0	0	4
Erosion Sites	44	80880 ft (15.32 miles)	15	13	5	9	2
Exposed Pipes	0	NA	0	0	0	0	0
Fish Barriers	20	NA	0	0	1	6	13
Inadequate Buffers	56	63350 ft (12.38 miles)	23	8	8	10	7
Pipe Outfalls	15	NA	0	1	2	1	11
Trash Dumpings	3	NA	0	3	0	0	0
Unusual Conditions	8	NA	0	4	0	4	0
Total	150		38	29	16	30	37

2.2 STORMWATER POLLUTANT LOAD MODELING

As part of the Bennett Creek retrofit assessment, Tetra Tech developed non-point source pollutant loading estimates for Bennett Creek watershed. The USEPA Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) Version 4.0 was used to predict the pollutant load from the non-point sources (U.S. EPA 2008).

For the Bennett Creek simulation, the literature-based default values for Frederick County in Maryland were used for the annual precipitation and the Universal Soil Loss Equation (USLE) parameters as an input to the STEPL model. The goal of this study was to simulate the pollutant contributions from the various land use types within each catchment. It is important to note that the transport of flow and pollutants downstream of each catchment was not considered. The STEPL model was used to model four pollutants: 5-day biological oxygen demand (BOD), total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS).

The STEPL model uses simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs), including Low Impact Development practices (LIDs) for urban areas. It computes surface runoff, nutrient loads and sediment delivery based on various land uses and management practices. The land uses considered are urban land, cropland, pastureland, feedlot, and forest. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the USLE and the sediment delivery ratio.

In this simulation, the pollutant sources such as farm animals, feedlots, and failing septic systems were not considered and it was assumed that there were no existing BMPs in the study area.

Hydrological Data. The STEPL model uses the average annual precipitation and the number of rainy days as hydrological input to compute the runoff. The default values of 43.99 inches average annual precipitation and 100 rainy days for the Frederick County in Maryland were used in this simulation.

Topographical Data. The Bennett Creek watershed was divided into 105 catchments for better resolution to calculate the pollutant loadings from the various land uses within each catchment independently. A Geographic Information System (GIS) exercise was performed to compute the drainage area for each catchment.

Land Use. The land uses with in Bennett Creek watershed were grouped into the following 12 categories: Low-density residential, Medium-density residential, High-density residential, Commercial, Industrial, Institutional, Open urban land, Cropland, Pasture, Forest, Water and Feedlots. A GIS exercise was performed to compute the area for each land use group within each catchment. These areas were used as an input to the STEPL model. Results can be found in Appendix Table A1.

Soils. A GIS exercise was performed to compute the area for each hydrologic soil group (HSG) within each catchment of the Bennett Creek watershed (descriptions of the soil groups can be found in Appendix B). The major HSG was then estimated within each catchment and was used as input to the STEPL model. The unknown values were assumed to be in group B. The HSG distribution within the Bennett Creek watershed is shown in Figure 2.1. Additional results can be found in Appendix Table A2.

Results. The total yearly pollutant loads expressed in pounds per acre were computed for each catchment to examine loadings independently of size and are shown in Appendix Table A3. Annual catchment loadings for biological oxygen demand, total nitrogen, total phosphorus, and total suspended solids are shown in Figures 2.2 through 2.5.

2.3 POLLUTANT LOAD REDUCTION ESTIMATES

Load reduction estimates were derived as follows:

1. 'Reference' subwatersheds were selected based on biological data. The Bennett Creek-Lower Mainstem and Bear Branch subwatersheds had the highest mean Index of Biological Integrity (IBI) scores at randomly selected sites within these subwatersheds (3.94 and 3.5, respectively); therefore these were chosen to represent the 'reference condition.'
2. The STEPL pollutant load estimates for the Bennett Creek-Lower Mainstem and Bear Branch subwatersheds were compiled into a table. Pollutant loading rates were weighted (based on area) and then summed.
3. The sum of the loading rates for each parameter was divided by the total area of the selected catchments to derive the target loading rates for BOD, TN, TP and TSS.
4. % load reduction required to attain the target loads was calculated for all the catchments.

The target loads that were established based on these calculations are shown in Table 2.2. From these numbers, percent reduction estimates were calculated and used as part of the site prioritization process. Percent reduction estimates for all catchments can be found in Appendix Table A4.

Table 2.2. Target loads for BOD5, TN, TP and TSS were set based on 'reference' condition subwatersheds that had the best index of biological integrity (IBI) scores. These were the basis for the numerical ratings that were assigned to sites based on STEPL pollutant load estimates.

Parameter	**Target**	**Units**
Biological Oxygen Demand (BOD5)	5.80	lbs/ac/yr
Total Nitrogen (TN)	2.82	lbs/ac/yr
Total Phosphorus (TP)	0.49	lbs/ac/yr
Total Suspended Solids (TSS)	350.06	lbs/ac/yr

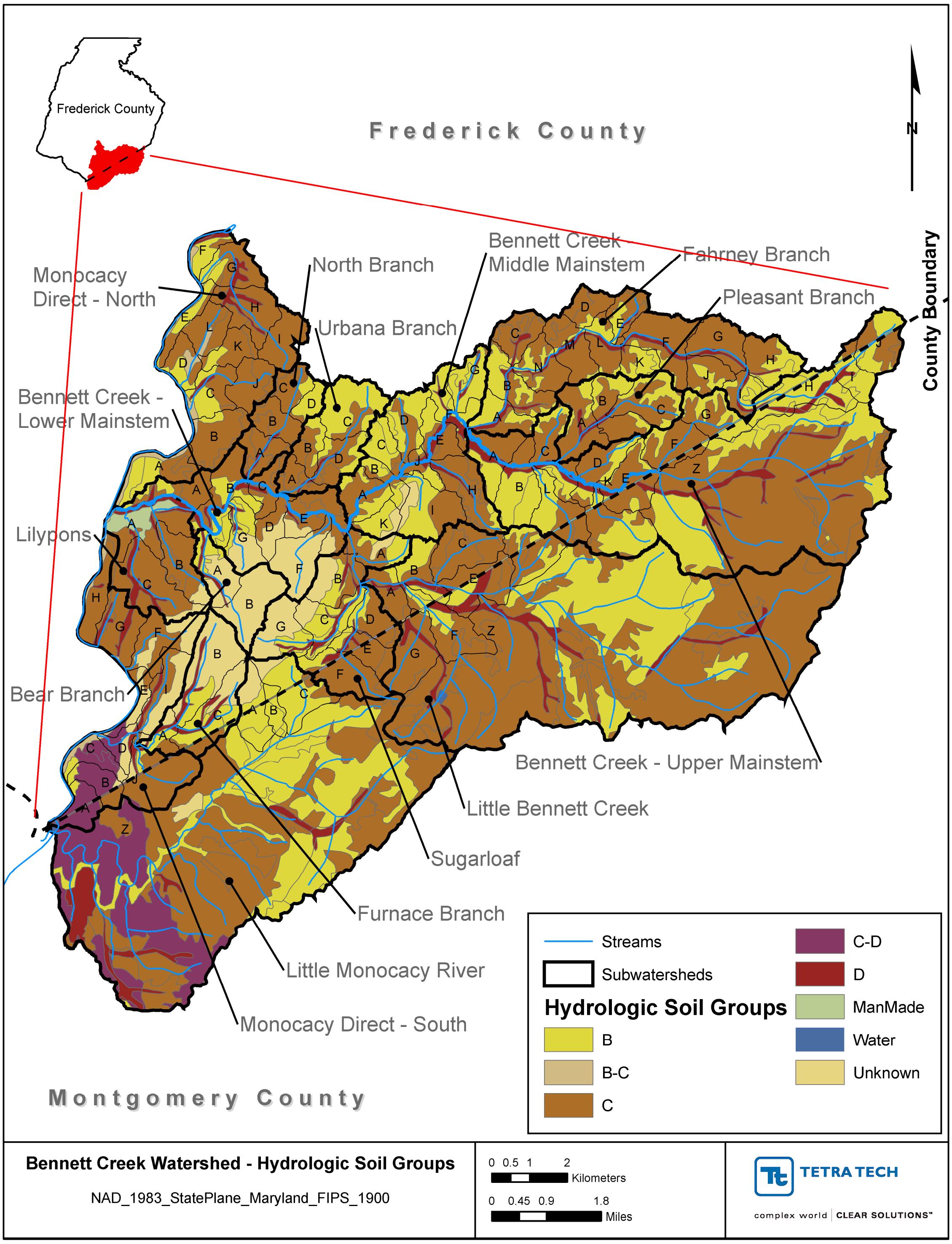

Figure 2.1. Soil Group (HSG) distribution in the Bennett Creek watershed. Descriptions of the soil groups can be found in Appendix B.

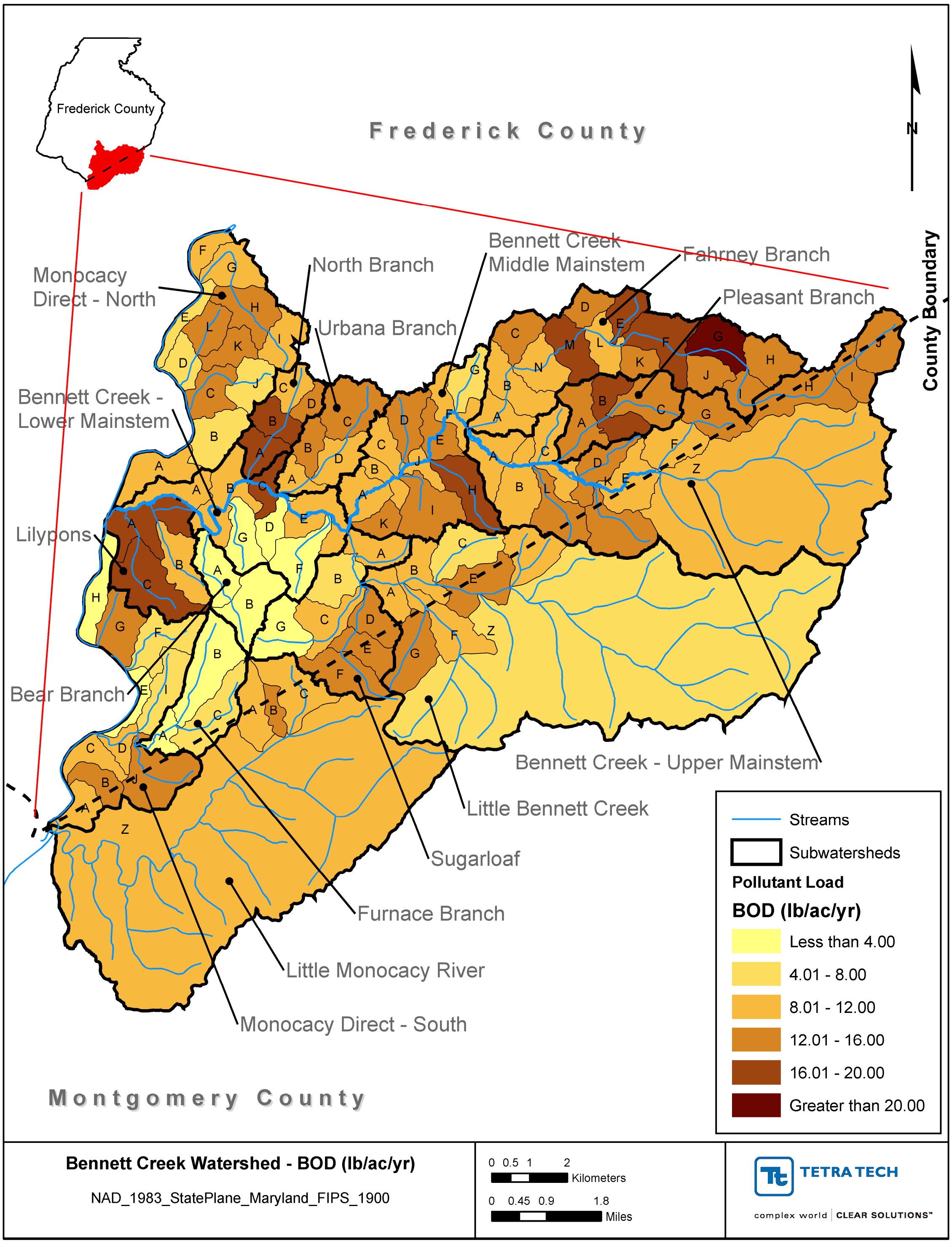

Figure 2.2. Annual pollutant loadings (lb/ac) for BOD in the Bennett Creek watershed.

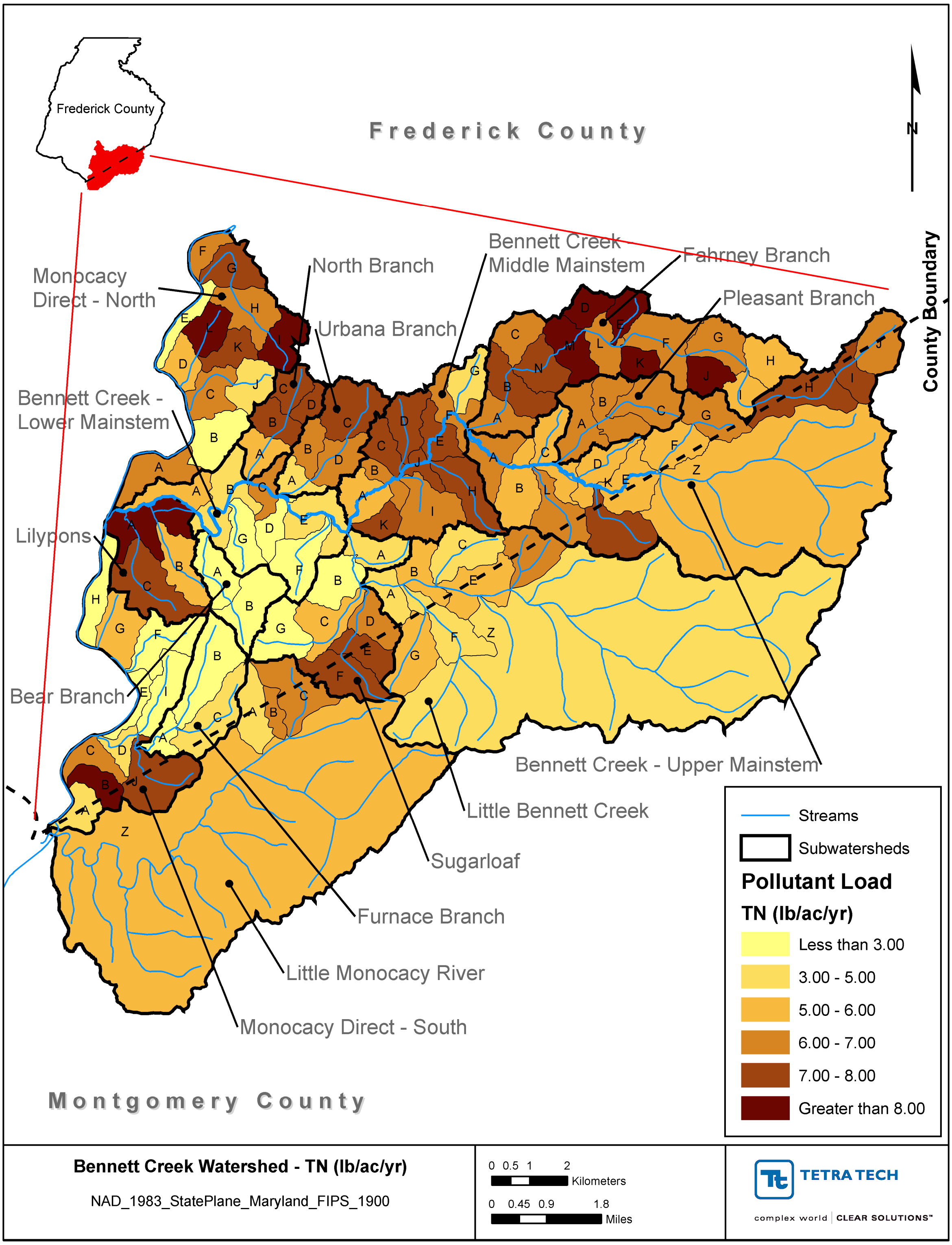

Figure 2.3. Annual pollutant loadings (lb/ac) for TN in the Bennett Creek watershed.

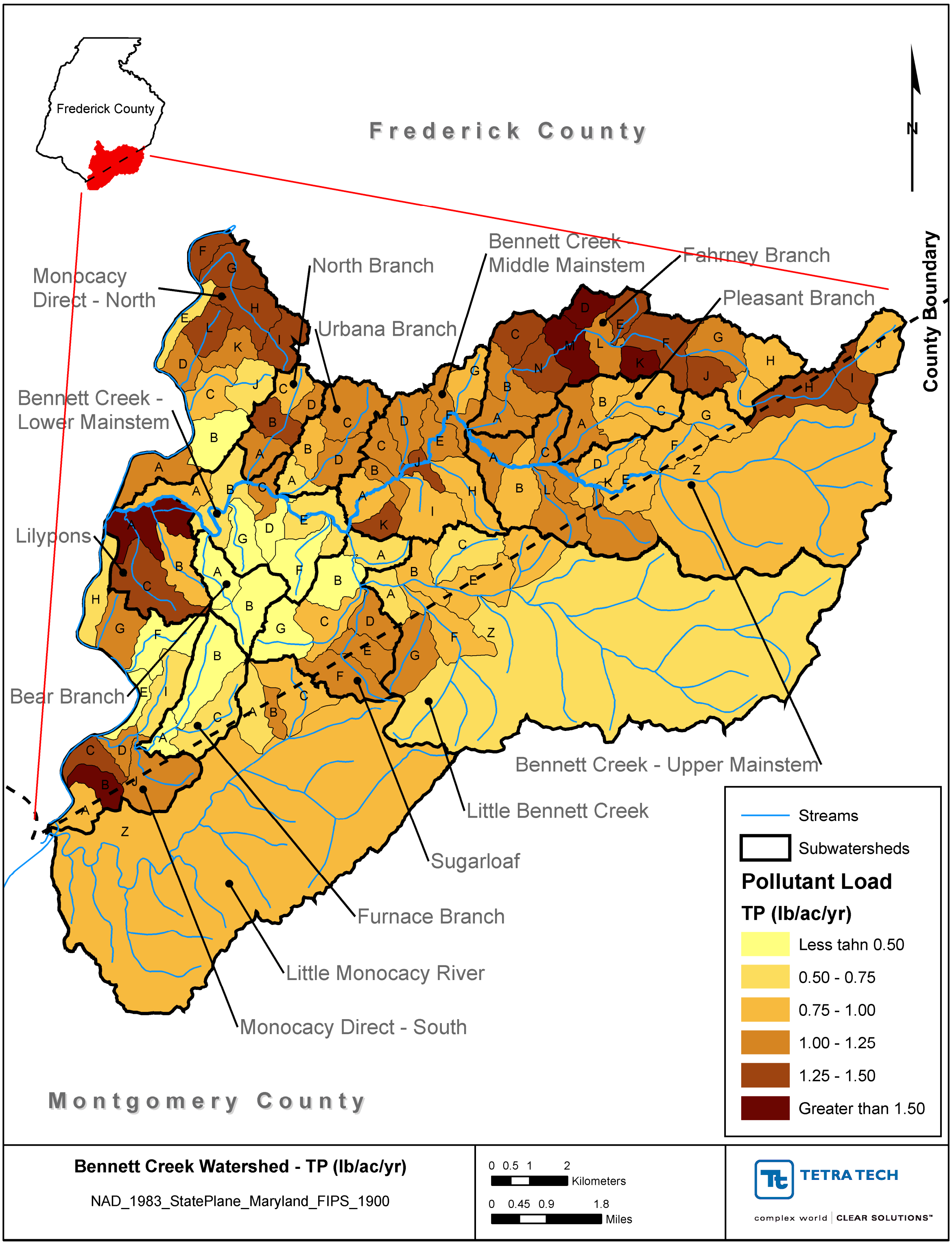

Figure 2.4. Annual pollutant loadings (lb/ac) for TP in the Bennett Creek watershed.

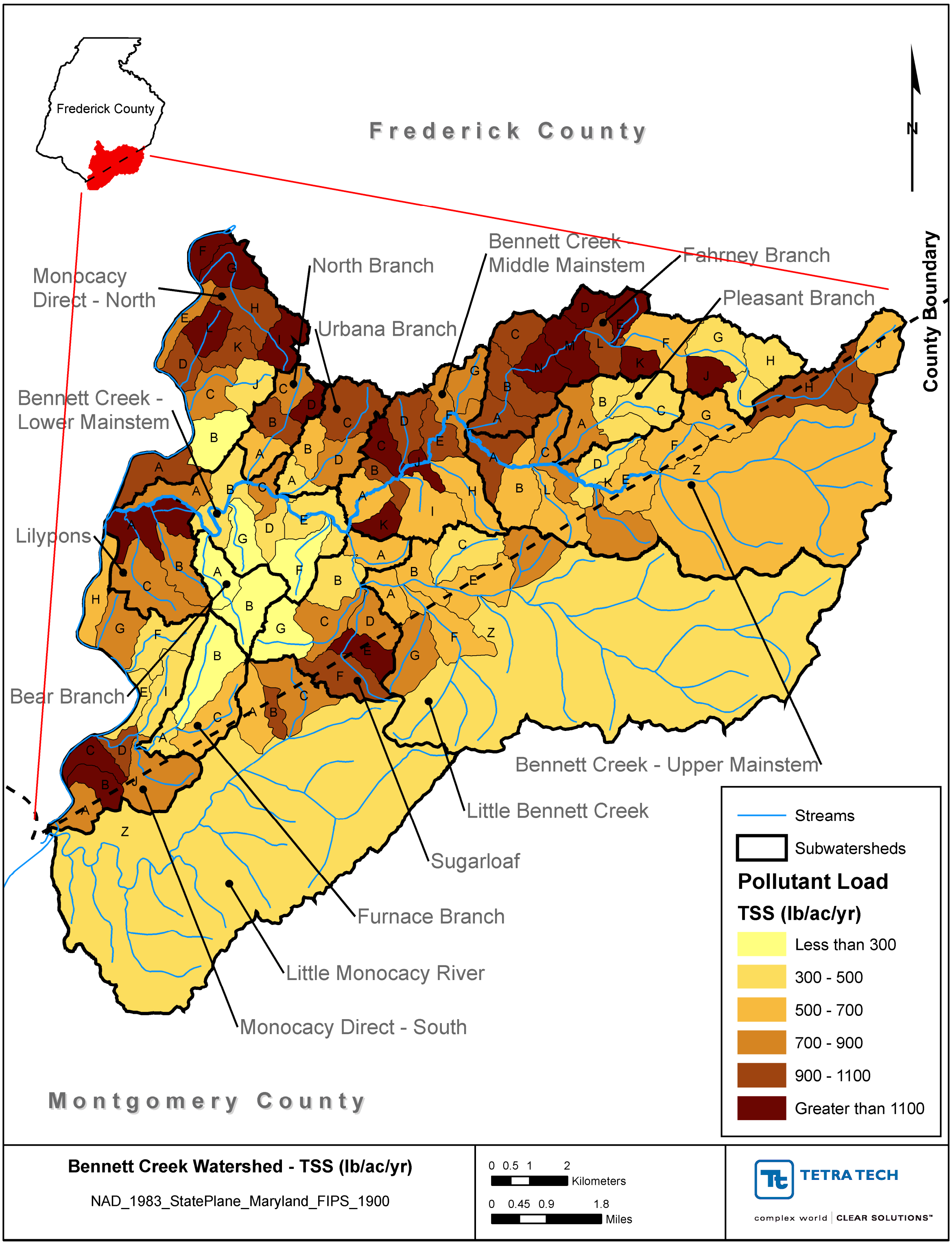

Figure 2.5. Annual pollutant loadings (lb/ac) for TSS in the Bennett Creek watershed.

2.4 GIS MAPPING

The initial list of candidate projects was compiled using GIS mapping/screening. A general overview of the screening process is outlined in Figure 2.6. Orthophotography, elevation/contour, land ownership, land use, stream, SCA and stormwater GIS layers were the primary GIS layers used in the site screening and site selection process. A list of the GIS layers that were compiled for this project are shown in Table 2.3. The main source of spatial data was Frederick County, although some additional data were gathered from other sources.

Table 2.3. GIS data layers that were used when identifying potential stormwater retrofit and stream restoration opportunities.

Feature	Source
Property boundaries	MD Property View 2006 tax maps
Roads & bridges	Frederick County
Hydrography	Frederick County
SWM Facilities	Frederick County
Stormwater Ponds	Frederick County
Stormwater Drain Areas	Frederick County
Stormwater Pipes	Frederick County
Stormwater Structures	Frederick County
Orthophotography	Frederick County
Parks and Protected Lands	Frederick County
County, City and Town boundaries	Frederick County
Subwatershed and model catchment boundaries	Versar, Inc.
County owned property: schools, parks, unimproved land	Frederick County
Streambank Erosion	MDNR SCA
Inadequate riparian buffer	MDNR SCA
Fish barriers	MDNR SCA
Pipe outfalls	MDNR SCA
Channel alteration	MDNR SCA
Unusual	MDNR SCA
Trash	MDNR SCA
Land use land cover	NLCD 2002
STEPL pollutant loading estimates	Tetra Tech, Inc.

2.5 FIELD VISITS

After the completion of the GIS screening process, field visits were conducted at 16 candidate sites that were believed to have the greatest potential. The field visit was conducted in March 2009 with County personnel and a representative from the Potomac Conservancy. During the field visit, sites were scored on a number of factors, including extent of problem, land ownership, educational benefits, accessibility, constraints, likelihood of public acceptability, economic feasibility, severity of threats to property/infrastructure, correctability, and severity of problems along the stream corridor. Descriptions of the scoring schemes used for each category can be found in Tables 2.4a-b. Scores for each factor range from 0 (lowest priority) to 3 (highest priority). It should be noted that stream corridor information was not available for two candidate projects, BM3 and LB1, because SCA data were not available for those sites and the stream corridor was not within view of the people conducting the field assessment. Additional information was also recorded. Existing BMPs were noted and evaluated (if present), known utilities or other constraints were noted, the proposed action was described and a site diagram was drawn. A copy of the field form that was used during the visit can be found in Appendix C.

2.6 PRIORITIZATION OF CANDIDATE PROJECTS

Following the field visit, scores for each of the categories described above were compiled for sites at which viable candidate projects had been identified. Next, an additional score was assigned to these sites based on STEPL pollutant loads within the catchment areas that the sites were located within (see Table 2.5 for the STEPL scoring scheme). All of the individual scores from the different categories were then normalized, multiplied by a weighting factor and summed to derive a total score. As shown in Table 2.6, a slightly different scoring scheme had to be used for the two candidate projects that lacked stream corridor data. Total scores were used to prioritize the candidate projects and were scaled in a way that gave higher priority to projects that received higher scores within a project type category (CIP or CRP). These calculations are similar to those that were used in the Ballenger Creek watershed and Linganore Creek reports (Perot et al. 2005, Perot et al. 2006). A summary of the weighting schemes, prioritization categories and distribution of scores among sites can be found in Table 2.6. Candidate projects and their ranking scores for each factor are listed in Appendix D.

Table 2.4a. Scoring scheme that was used to prioritize stream corridor problems at each site. Scores were either derived from the March 11, 2009 site visit or from SCA (2003) data. If multiple problems were recorded at a site, the problem with the highest (most severe) score was used in the final score calculations.

	Score			
Stream Corridor Problems	**0**	**1**	**2**	**3**
Erosion	None	Minor	Moderate	Severe
Exposed Pipe	None	Minor	Moderate	Severe
Pipe Outfall	None	Minor	Moderate	Severe
Inadequate Riparian Buffer	None	Minor	Moderate	Severe
Fish Barrier	None	Minor	Moderate	Severe
Habitat Condition	None	Minor	Moderate	Severe
Channel Alteration (man-made)	None	Minor	Moderate	Severe
Channel Alteration (livestock)	None	Minor	Moderate	Severe
Trash/Litter	None	Minor	Moderate	Severe
Other	None	Minor	Moderate	Severe

Table 2.4b. Scoring scheme for the additional considerations that were used to prioritize sites.

	Score		
Additional Considerations	**1**	**2**	**3**
Extent of problem	Localized	Moderate	Widespread
Ownership	Private	Private with Public Access	Public
Educational benefits	Minor (few individuals)	Moderate	Major (many individuals)
Accessibility	Very Difficult (both on foot and by a vehicle)	Moderate (easily accessible by foot but not easily accessible by a vehicle)	Very Easy (both by car and on foot)
Constraints	Lots	Moderate	Few
Likelihood of public acceptability	Low	Moderate	High
Economic feasability	Low	Maybe	High
Severity of threats to property/infrastructure	Minor	Moderate	Serious
Correctability	Very difficult (large expensive effort to correct)	Moderate (may require a small piece of equipment and some planning)	Minor (corrected quickly and easily using hand labor with minimal planning)

Table 2.5. Scoring scheme that was used to prioritize sites based on STEPL pollutant load estimates.

	Score			
STEPL % Target Reduction	**0**	**1**	**2**	**3**
	% Reduction Required			
Biological Oxygen Demand (BOD)	0	>0 and <30	30 to 60	>60
Total Nitrogen (TN)	0	>0 and <30	30 to 60	>60
Total Phosphorus (TP)	0	>0 and <30	30 to 60	>60
Total Suspended Solids (TSS)	0	>0 and <30	30 to 60	>60

Table 2.6. Summary of the weighting schemes, prioritization categories and distribution of scores among sites. NOTE: %Weight_2 was used to score sites LB1 and BM3 because stream corridor information was not available for these sites. %Weight_1 was used to score all of the other sites. For purposes of this table, scores were rounded up if they were assigned a 0.5 or 0.75 and were rounded down if they were assigned a 0.25. Actual scores for all the sites can be found in Appendix C.

Prioritization Categories and Sub-categories	Weight_1	Weight_2	# of Sites in Each Scoring Category			
			0	1	2	3
STEPL % Target Reduction	20	25				
Biological Oxygen Demand (BOD)				1	6	4
Total Nitrogen (TN)					9	2
Total Phosphorus (TP)				1	8	2
Total Suspended Solids (TSS)				5	4	2
Stream Corridor Problems	30	NA				
Erosion			2		4	3
Exposed pipe			5	1	3	
Pipe outfall			4	3	2	
Inadequate riparian buffer			3	5		1
Fish barrier			3	4	1	1
Habitat condition			4	3	2	
Channel alternation (man-made)			3	4	2	
Channel alternation (livestock)			9			
Trash/Litter			3	3	3	
Other			7	1	1	
Additional Considerations						
Ownership	10	15		4	1	6
Extent of problem	5	15			5	6
Accessibility	5	5				11
Constraints	5	5		1	4	6
Economic feasibility	5	5		1	6	4
Severity of threats to property/infrastructure	5	5		4	4	3
Correctability	5	5		7	4	
Educational benefits	5	15		2	4	5
Likelihood of public acceptability	5	5		2	2	7

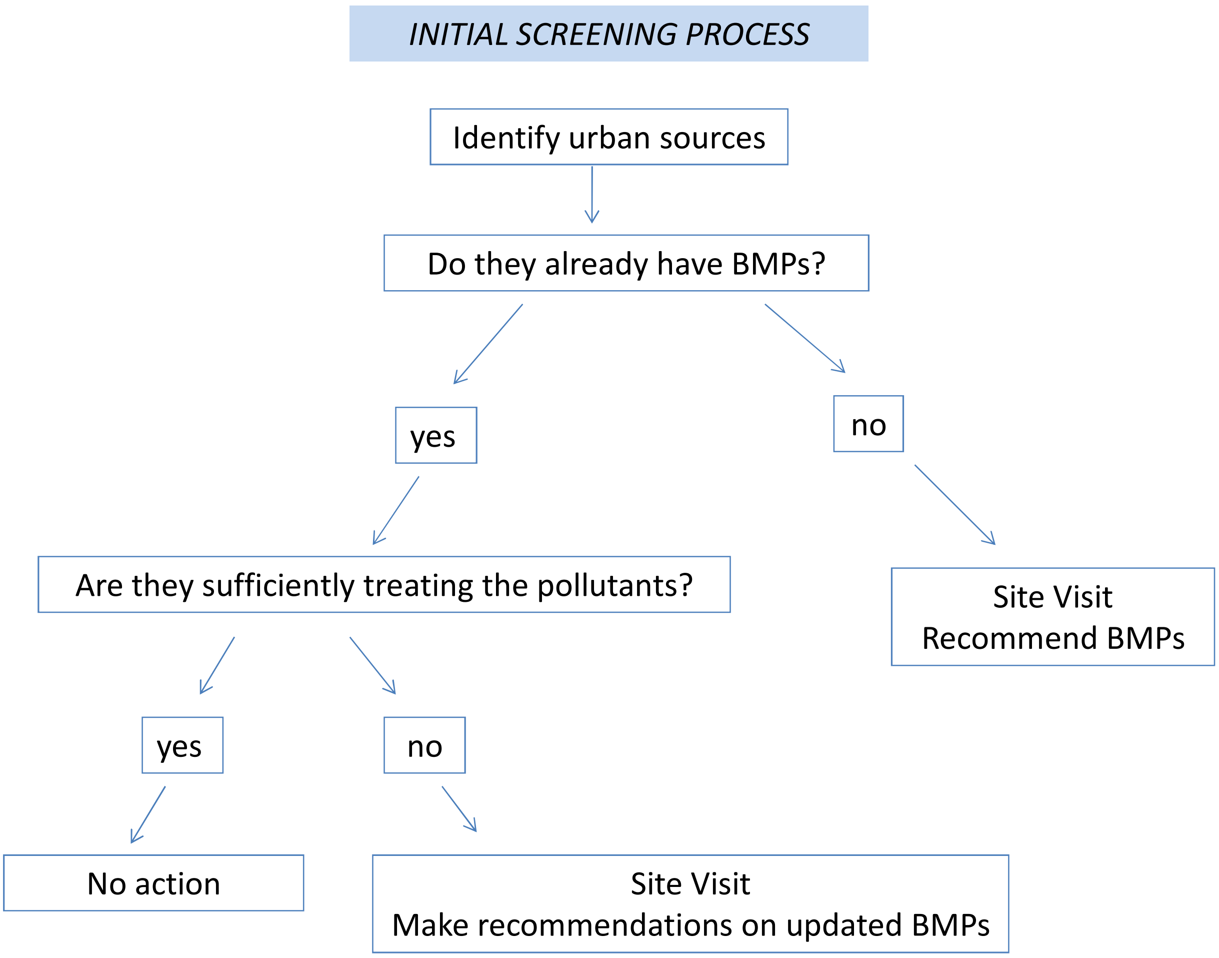

Figure 2.6. Overview of the steps that were followed during the initial screening process.

3 WATERSHED RESTORATION APPROACHES

Although land use within the Bennett Creek watershed is dominated by forest and agriculture, urbanization presents numerous challenges. In some parts of the watershed, rural areas are rapidly being transformed into urban areas. In other parts of the watershed, there are older existing urban areas that lack adequate stormwater management and BMPs, and these areas can be difficult to retrofit. Both of these scenarios can contribute to increased runoff and degradation of aquatic resources. It is possible to address some of these issues through the use of watershed restoration approaches.

3.1 RESTORATION APPROACHES

The restoration approaches that were proposed for the Bennett Creek watershed include: bioretention area and rain garden, gravel wetland, landscape infiltration, bioswale, stormwater pond retrofit, culvert retrofit, pipe outfall retrofit, green roof and stream restoration/bank stabilization. Additional information on these approaches and their maintenance requirements follow.

3.1.1 Bioretention Area and Rain Garden

Description: Bioretention is one of the most common low impact development (LID) stormwater management practices (UNHSC 2007). Surface runoff flows into landscaped depressions, where it ponds and infiltrates into the planting soil mix. The engineered planting soil mix and the vegetation in the bioretention provide water quality treatment and infiltration, which is similar to the natural landscape. When the in-situ soil has limited drainage capacity, an underdrain system with a gravel filled storage zone is required to discharge the treated water. During larger storms, excessive runoff is generally diverted past the facility to the storm drain system directly. Rain gardens are similar to the bioretention areas except they lack the underdrain system.

Maintenance: Major maintenance requirements for bioretention are to routinely inspect the treatment areas' components and repair or replace when necessary (LID Center 2005). Maintenance tasks including removal of accumulated sediment and debris, replacement of any dead or stressed plants, and replenishment of the mulch layer are recommended on an annual basis. Any eroded areas should be repaired as soon as they are detected. The control structure should be routinely inspected for clogging and structural soundness.

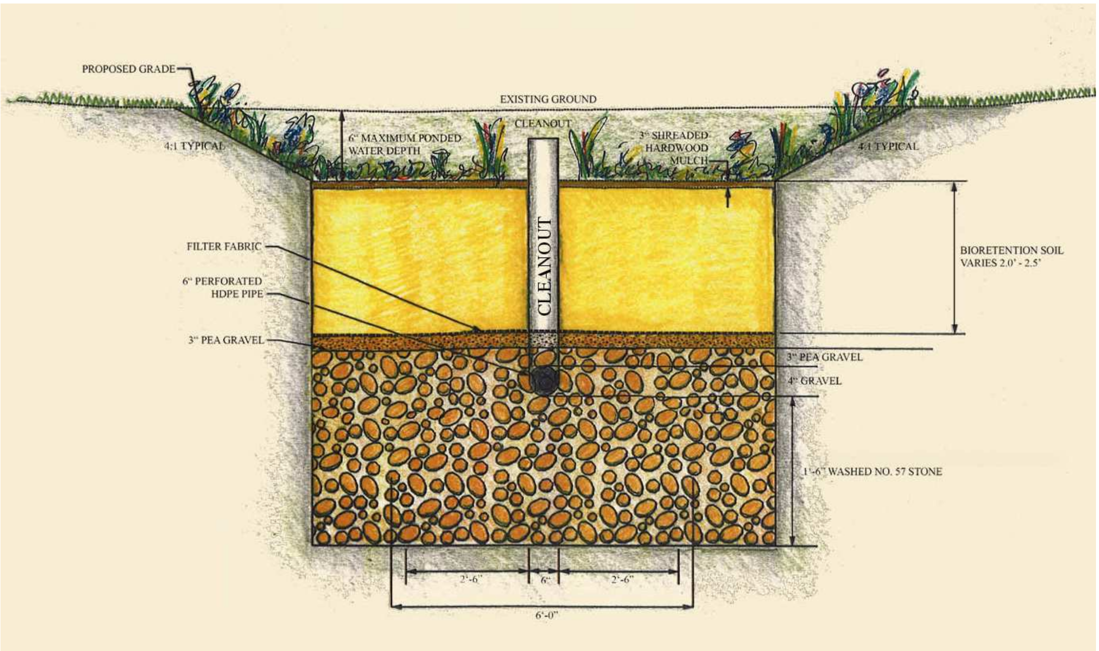

Figure 3.1. Components of a bioretention facility (PGDER 2001).

3.1.2 Gravel Wetland

Description: The gravel wetland is a recent innovation in LID stormwater management. The design consists of one pretreatment sediment forebay and two flow-through treatment basins that function as subsurface wetland (UNHSC 2007). The subsurface wetland relies on a dense root mat, crushed stone, and a microbe rich environment to treat water quality. Overall, the gravel wetland approximates the look and function of a natural wetland, effectively removing sediments and other pollutants commonly found in runoff, while enhancing the visual appeal of the landscape.

Maintenance: Recommended maintenance to the gravel wetland system mostly involves mowing and replacement of vegetation as needed. Sediment removal from the forebay, or any pretreatment device installed with this system will reduce maintenance on the treatment basins.

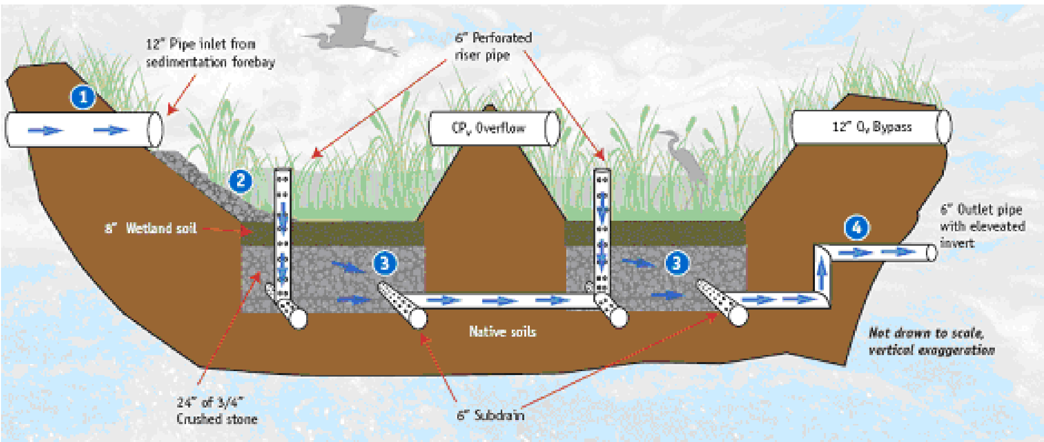

Figure 3.2. Design of the gravel wetland (excluding sediment forebay) (UNHSC, 2007).

3.1.3 Landscape Infiltration

Description: Landscape infiltration can be viewed as a simplified bioretention and is usually integrated into site design and required landscaping (City of Portland 2008). The system treats runoff through flow detention and pollutant settlement as water infiltrates. Landscape may include a variety of trees, shrubs, grasses, and groundcover appropriate for periodic inundation. The design allows for evapotranspiration and groundwater recharge and retains warm weather runoff.

Maintenance: Maintenance to landscape infiltration projects includes routine inspection of plants and trees, removal of sediment and debris, and replacement of dead or stressed plants.

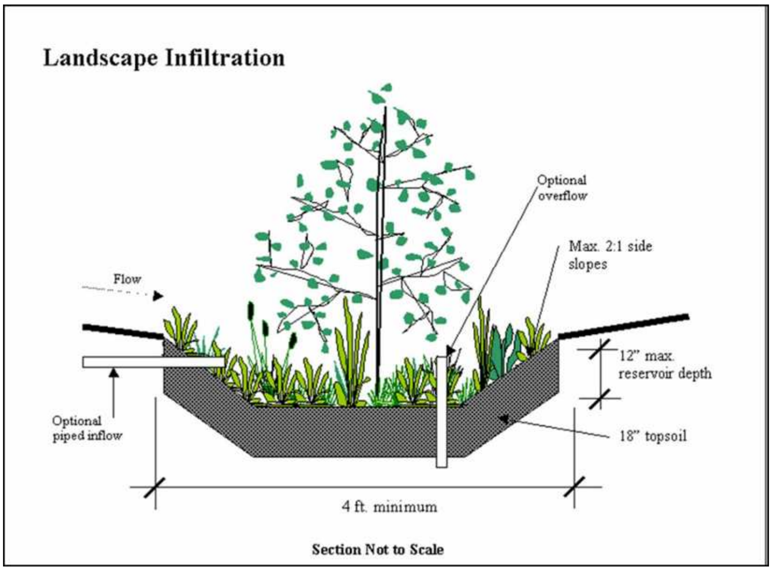

Figure 3.3. Design of the landscape infiltration (City of Portland, 2008).

3.1.4 Bioswale (Linear bioswale)

Description: Bioswales are modified vegetated swales, with the difference being bioretention media are used beneath the swale. Similar to bioretention areas, bioswales encourage infiltration in order to retain runoff volume and use a variety of physical, chemical, and biological processes to reduce runoff pollutant loadings. A gravel layer may be added at the bottom to enhance infiltration (Figure 3.4). Native and other appropriate plants could be used in the channel besides grass.

Maintenance: The primary maintenance for bioswales includes routine inspections of channel hydraulic efficiency and erosion, bioretention components, and the vegetation cover. Maintenance activities include routine mowing of grass and removing of debris and sediments.

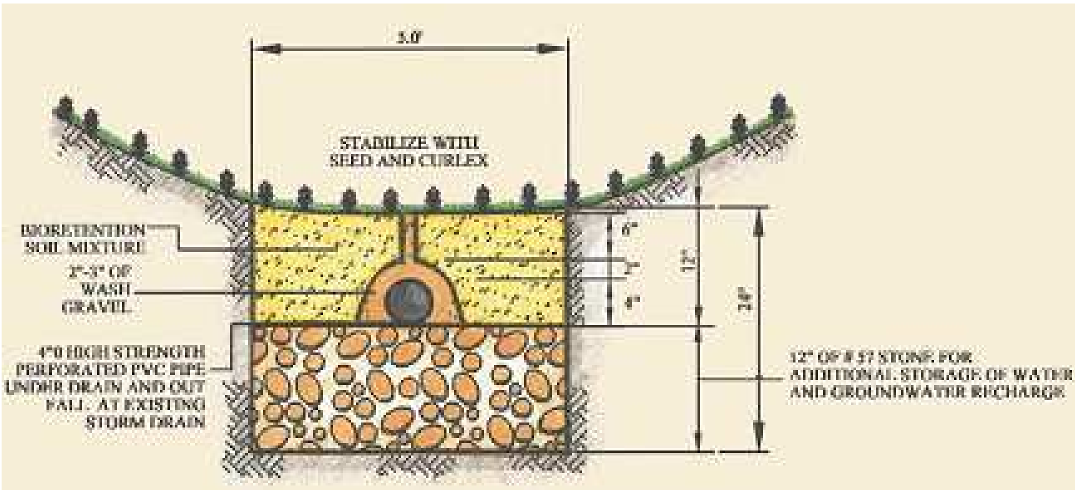

Figure 3.4. Design of linear bioswale (PGDER 2001).

3.1.5 Stormwater Pond Retrofit

Description: Options for retrofitting existing SWM ponds (AMEC 2005) that may be suitable for implementation include (Perot et al. 2006):

1. Increasing detention storage by means of additional excavation and grading.
2. Providing water quality improvements to facilities that currently only provide water quantity control. These facilities could be retrofitted to also provide water quality treatment by means of installing a micropool, sediment forebay, constructed stormwater wetlands, or by increasing the surrounding riparian buffer.
3. Modifying or replacing the existing riser structure and outlet controls to further reduce the discharge rate from the stormwater management facility. A riser is a structure, typically made of concrete with a metal grate on top, which controls the level of water in the stormwater pond.
4. Adding infiltration features such as sand filters or bioretention to promote greater peak flow reduction, groundwater recharge, and improve water quality treatment. A soil survey of the existing facility would be required to verify that this retrofit is suitable. Stormceptors, or equivalent LID products, could be installed in parking lots or other areas with a large percentage of impervious area. These devices are placed in the manhole and trap sediments and petroleum products before they flow into the pond.

Maintenance: The maintenance requirements of a retrofitted pond are not significantly more than a traditional stormwater pond. A typical pond is inspected by County personnel trained in dam safety and pond maintenance, looking at the dam, pipes, and riser structure to ensure it is functioning properly and not failing. Additional items that need to be inspected are any pretreatment facilities for clogging by sediments and large debris items. If sediments or clogging is evident, the area needs to be cleaned. If manufactured LID devices are used, manufacturer's maintenance recommendations need to be followed to ensure that devices function as designed (Perot et al. 2006).

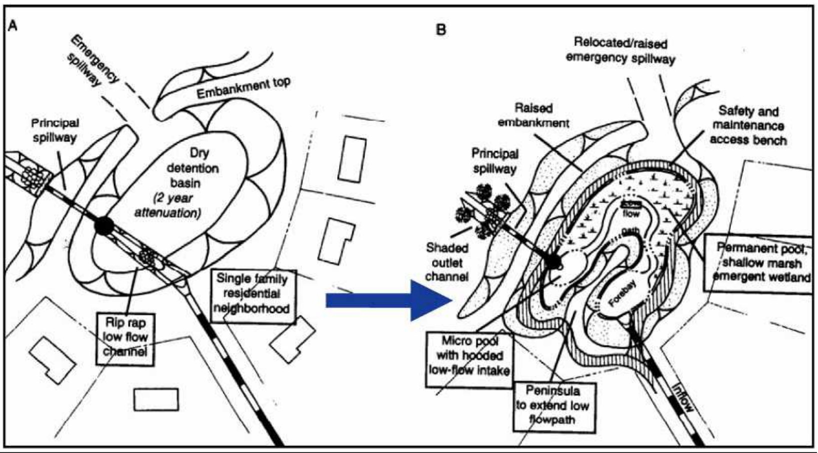

Figure 3.5. Stormwater Pond Retrofit (A. pre-retrofit pond; B. retrofitted pond) (Source: Schueler and Holland 2000)

3.1.6 Culvert Retrofit

Description: This stormwater retrofit option is installed upstream from existing road culverts by constructing a control structure and excavating a micropool. These projects are designed only for intermittent or ephemeral streams. The control structure will consist of a gabion or concrete weir that will detain and reduce stormwater flow; the micropool is a small pool that will infiltrate the first 0.1 – 0.2 inches of stormwater runoff, improving both water volume/velocity and water quality (AMEC 2005, Perot et al. 2006).

Maintenance: Maintenance of the micropool area is very minimal. The area needs to be inspected for large debris or sediments that may be clogging the area, dead or stressed plants, and erosion around the weir. Remove large debris, built-up sediments, and replace dead or stressed plants as necessary. If there is erosion around the weir, the area needs to be inspected and stabilized as necessary. These facilities have an expected life span of 25 years (Perot et al. 2006).

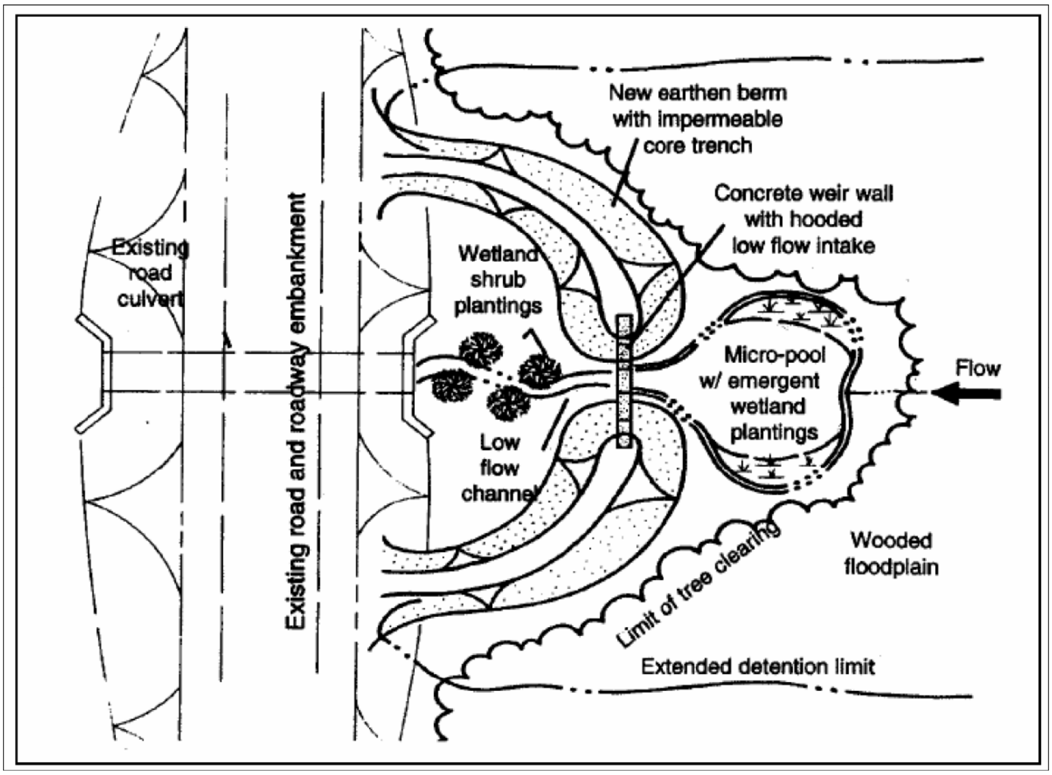

Figure 3.6. Culvert Retrofit (Source: Schueler and Holland 2000)

3.1.7 Pipe Outfall Retrofits (Off-Line Bioretention)

Description: This stormwater retrofit option is installed immediately downstream of a stormwater drainage pipe outfall. Flow splitters can be utilized to convey the water quality treatment volume to a sand filter, bioretention area, off-line wetland, or wet pond, while larger storms are allowed to bypass the retrofit (AMEC 2005, Perot et al. 2006).

Maintenance: Inspect the treatment area's components and repair or replace as necessary. This area is akin to a landscape feature in general maintenance needs, such as removal of accumulated sediment and debris, replacement of dead or stressed plants, and annual mulching (or as necessary). An observation well can be used to make sure the underdrain is not clogged and is working properly. These facilities have an expected life span of 25 years (Perot et al. 2006).

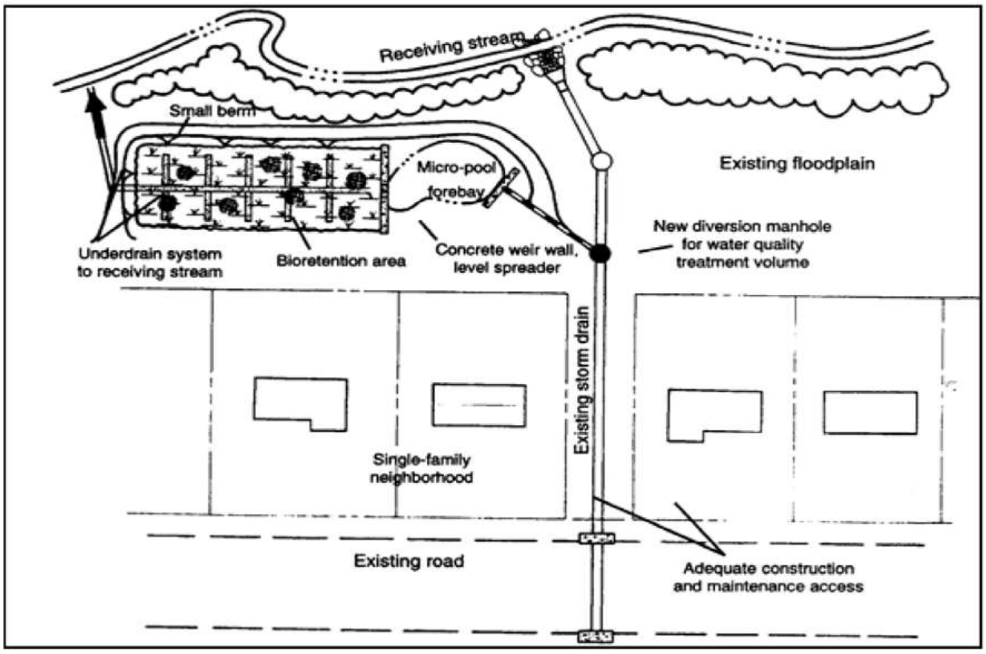

Figure 3.7. Pipe Outfall Retrofit (Source: Schueler and Holland 2000)

3.1.8 Green Roof

Description: Green roof technology, consisting of a layer of soil and vegetation on top of an impervious rooftop, can be applied to certain types of rooftops (such as carports) to provide a number of benefits (Perot et al. 2006).

Economic Benefits –

• Increase in life expectancy of rooftop and waterproofing (2-5 times) by providing protection against temperature extremes and ultra-violet light, thereby off-setting somewhat higher up-front installation costs

• Conversion of carports to green roofs is substantially less expensive than for buildings, yet provides equal benefit per square foot of impervious surface.

Ecological Benefits –
• Reduce stormwater runoff (30-100% of annual rainfall can be stored, relieving stormdrains and feeder streams)
• Reduce heat island effect (cooler air temperatures and higher humidity can be achieved through natural evaporation)
• Improve Air Quality (up to 85% of dust particles can be filtered out of the air)
• New habitat for plants, insects, and birds

Amenities –
• Overhead cover provides shade to reduce interior car temperatures during hot weather, reduces need to clear snow from parked cars, and provides shelter while entering/exiting the car during inclement weather
• Reduction of noise level due to less sound reverberation and improved sound insulation
• Visible green roofs provide a more aesthetic landscape

Maintenance: Once a green roof is well established, its maintenance requirements are usually minimal. Initial watering and occasional fertilization are required until the plants have fully established themselves, and periodically thereafter during drought conditions. Periodic trimming, weeding, inspection, and plant replacement is necessary (Perot et al. 2006).

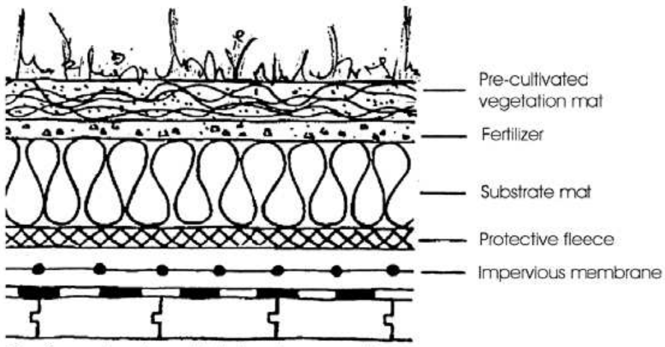

Figure 3.8. Green roof design (Source: Prince George's County 1999).

3.1.9 Stream Restoration/Bank Stabilization

Description: Streams damaged by erosive flows, excess sedimentation, and disruptive human activities are often not capable of re-establishing a stable form. Techniques to repair these damaged or degraded streams are now based on mimicking natural stream channels and the range of natural variability exhibited by nearby stable streams. Termed natural stream channel design, repairs focus on establishing natural stream channel shape, size, and habitat features. Restoration can range from minor repairs to restore bank stability to complete stream channel reconstruction (Perot et al. 2006).

Maintenance: Maintenance of natural stream channel design projects includes periodic inspection and monitoring to ensure that conditions remain within the expected range of variability. Post-construction plantings need to be monitored to ensure that they become well-established. In addition, periodic channel adjustments may be necessary after large flow events, especially while post-construction plantings become established (Perot et al. 2006).

Figure 3.9. Stream Restoration (upper left: concrete lined urban channel; lower right: restored stream) (Sources: M. Perot, Versar; unknown)

3.2 ESTIMATED COSTS

Estimated costs for the various restoration approaches are summarized in Table 3.1. It should be emphasized that these are general costs that are meant to aid in the planning process. Actual costs will vary depending on site-specific factors such as location, accessibility, land ownership and available resources. It also depends on the restoration approach (i.e. the costs of rain gardens can vary greatly (Coffman et al. 1999)). The main sources of cost information were the RSMeans Building Construction Cost Data (RSMeans 2005), RSMeans Environmental and Remediation Cost Data – Assemblies (RSMeans 2003), the Pennsylvania Stormwater Manual (2006) and the Tetra Tech report on LID BMPs near the Anacostia River (Tetra Tech 2008b). Unit costs were adjusted to 2009 levels using the Turner Construction Index (TCI 2009).

3.3 UTILITIES

If any of the proposed candidate projects are implemented, a careful evaluation of utility conflict needs to be conducted during the design phase. In Maryland, one can find out the name of every utility within the area of interest through the Miss Utility call-in program (Miss Utility 2009). Payment is required for this service.

Table 3.1. Watershed restoration practice types, unit costs, and source of costing information. Unit costs were adjusted to 2009 levels using the Turner Construction Index (TCI 2009). Units are: LF=linear feet, SF=square feet, LS=lump sum.

Practice Type	Description	Unit	Costing Source	2009 Unit Cost
Grass Swale	10-foot-wide swale	LF	Perot et al. 2006, RSMeans 2003 &2005	$13
Infiltration Trench	depth of trench - 4 feet; width of trench -3 feet; geotextile liner; crushed stone; vegetative cover	LF	Perot et al. 2006, RSMeans 2003 &2005	$214
Linear Rain Garden	depth of excavation - 4.5 feet; backfill, grading and compaction; planting soil and mulch; drainage swale; trees and shrubs	SF	Perot et al. 2006, RSMeans 2003 &2005	$22
Off-line Bioretention	depth of excavation - 4.5 feet; backfill, grading and compaction; planting soil and mulch; piping and overflow and cleanout outlets;	SF	Perot et al. 2006, RSMeans 2003 &2005	$25
Rain Gardens	depth of excavation - 4.5 feet; backfill, grading and compaction; planting soil and mulch; drainage swale; trees and shrubs	SF	Perot et al. 2006, RSMeans 2003 &2005	$22
Stream Restoration	Channel modifications using Natural Stream Channel Design principles and in-stream structures	LF	Perot et al. 2006, RSMeans 2003 &2005, Keystone Stream Team 2005	$472
SWM Pond Retrofit	wet pond excavation depth - 3 feet; clear and grub; backfill, grading and compaction; stone gabions; vegetative cover; wetland vegetation; clay liner; geotextile liner; rip-rap liner; riser outlet	SF	Perot et al. 2006, RSMeans 2003 &2005	$33
Green Roof		SF	PA Stormwater Manual 2006	$20
Culvert Retrofit		LS		$6,820
Gravel wetland		SF		$7
Bio-swale		SF	Tetra Tech 2008	$35
Linear bioswale	2-ft wide	LF	Tetra Tech 2008	$70
Linear bioswale	3-ft wide	LF	Tetra Tech 2009	$105
Pond Retrofit		SF	PA Stormwater Manual 2006	$4

4 SITE-SPECIFIC OPPORTUNITIES

Eleven candidate restoration projects were identified. Six of the sites are located in the Fahrney subwatershed and the others are located in the Urbana, Pleasant, Little Bennett, Bennett Upper and Bennett Middle subwatersheds. Locations of the project areas are shown in Figure 4.1, and site information, descriptions of the proposed restoration approaches and cost estimates are summarized in Table 4.1.

Candidate projects were divided into three types: CIP Tier 1, CIP Tier 2 and CRP. Recommendations on project type were based upon site scores[1] and land ownership. Candidate projects with scores of 75 or higher that are located on county-owned land were recommended as CIP Tier 1, those with scores of less than 75 that are located on county-owned land were recommended as CIP Tier 2 projects and those that are located on private land were recommended as CRP projects.

The proposed restoration approaches varied among projects. Wetlands, wet ponds or stormwater retrofits were recommended for three projects; bioretention areas, bioswales and/or rain gardens were recommended for eight projects; stream or channel restoration were recommended for three projects; culvert/bridge improvements were recommended for one project; and a pipe outfall retrofit was recommended for one project. At most of the sites, a combination of approaches were proposed.

The CIP Tier 1 projects present the best opportunities for implementation via Frederick County's CIP as either individual or grouped projects. Four projects were recommended as CIP Tier 1. These include a retrofit of the Englandtowne SWM Pond, a stream restoration project at Kemptown Park, and various LID projects at Kemptown Elementary School and Kemptown Park. Section 4.1 contains fact sheets with descriptions of the Tier 1 sites, proposed actions, predicted benefits, implementation issues and cost estimates. Approximate drainage areas that represent the areas being treated by the proposed restoration approaches are also included. It should be emphasized that these are not exact measurements but rather estimates based on existing data or on calculations performed in ArcMap using topographical, hydrological and impervious surface information. The fact sheets also contain maps and photographs of the proposed restoration locations. Detailed conceptual designs for each Tier 1 project can be found in Section 5 and recommendations on monitoring strategies can be found in Section 6.

Fact sheets were also developed for the CIP Tier 2 (Section 4.2) and CRP projects (Section 4.3). The two projects recommended as CIP Tier 2 are various LID approaches at Green Valley Elementary School and Urbana Park. The CRP projects are located on private lands. Some, such as Project ID BU2 (Persimmon Drive residential development) received total scores similar to Tier 1 sites and have similar needs for improvements. However, because projects on private land are unlikely to be eligible for implementation via the CIP, they were recommended as CRP projects. Successful implementation of the proposed CRP projects will require coordination with willing landowners.

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[1] See Section 2.6 and Appendix B for more details on site scores.

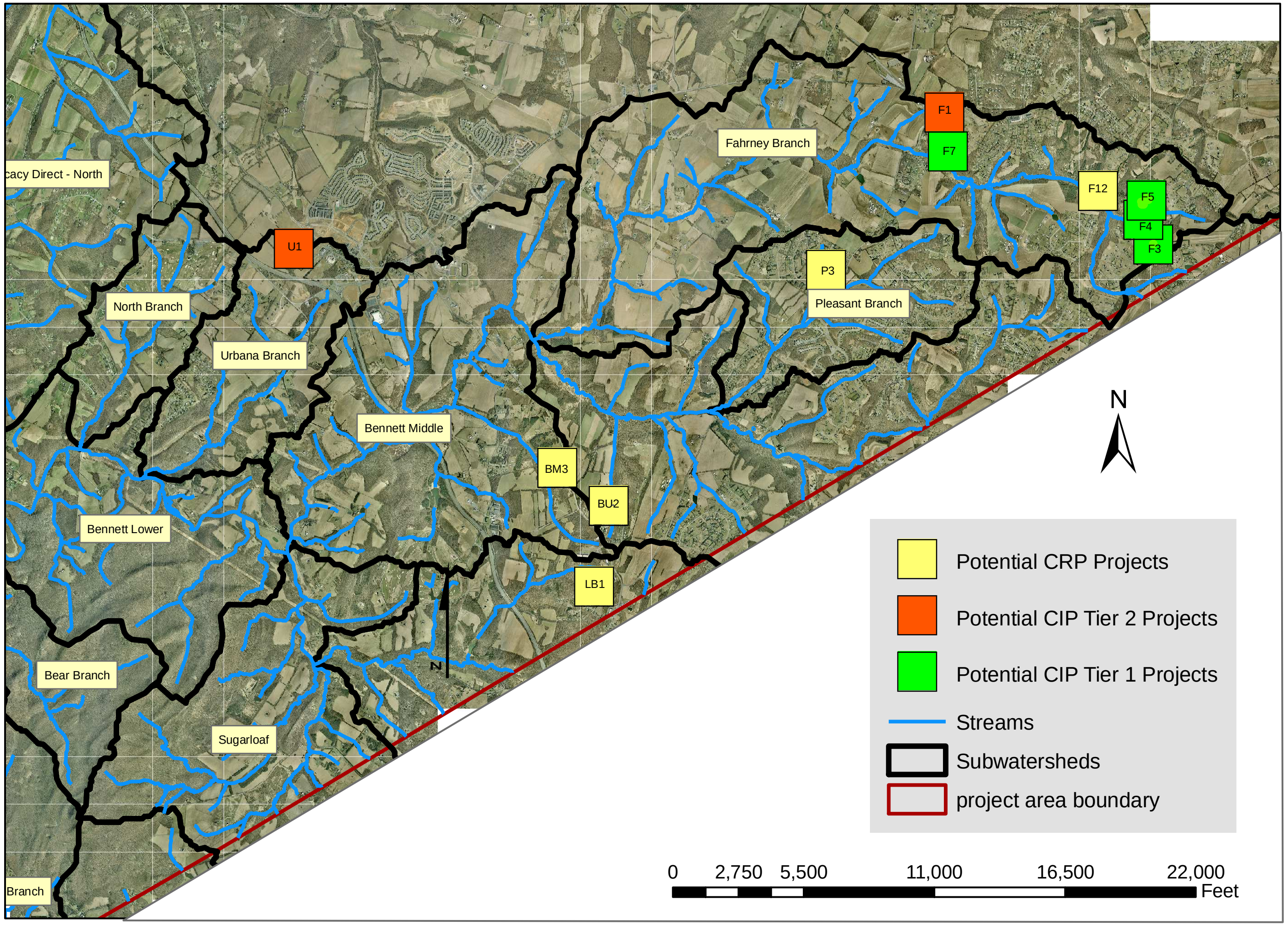


Figure 4.1. Locations of the candidate restoration projects.

Table 4.1. Total Scores, estimated costs and additional information on the candidate sites. Candidates within each project type are listed in order of highest priority to lowest (the higher the total score, the higher the priority).

Project Type	Project ID	Subshed	Project Name	Location	Ownership	Project Description	Estimated Cost	Total Score
CIP Tier 1	F7	Fahrney	Englandtowne SWM Pond	West side of Chaucer Ct. before cul-de-sac	Public - County Commissioners	Gravel wetland or wet pond, Stream restoration	$316,060 or $248,560	80.0
CIP Tier 1	F4	Fahrney	Kemptown Park - Stream Restoration	Church Rd	Public - County Commissioners	Channel restoration	$283,200	78.3
CIP Tier 1	F3	Fahrney	Kemptown ES	3456 Kemptown Church Rd	Public - Board of Education	Bioretention areas, Bioswales, Infiltration trenches, Pipe outfall retrofit	$424,530	76.7
CIP Tier 1	F5	Fahrney	Kemptown Park - LID	Church Rd	Public - County Commissioners	Bioretention areas, Bioswales, Rain gardens	$109,598	75.0
CIP Tier 2*	U1	Urbana	Urbana Park	3636 Urbana Pike	Public - County Commissioners	Bioretention areas, Bioswales, Landscape infiltration, Erosion control	$144,130	61.7
CIP Tier 2*	F1	Fahrney	Green Valley ES	11501 Fingerboard Road	Public - Board of Education	Biorention area, Green roof, Retrofit existing structure into an infiltration trench, Additional curb cuts	$197,500	58.3
CRP	BU2	Bennett Upper	Persimmon Residential	Persimmon Drive	Private	Bioretention areas, Bioswales, Culvert/bridge improvements, Stream and channel restoration	$1,062,550	78.3
CRP	P3	Pleasant	Pleasant Grove/Keating Residential	Keating Court	Private	Convert ditches into bioswales	$81,250	73.3
CRP	F12	Fahrney	Maryland Manor Residential	Maryland Manor	Private	Bioswales, Erosion control	$257,500	66.7
CRP	BM3	Bennett Middle	Long Fence	2520 Urbana Pike	Private - Commercial	Gravel wetland	$62,000	58.8
CRP	LB1	Little Bennett	Little Bennett Industrial	Hyatt Park off Tyler Road	Private - Industrial	Bioretention, Retrofit dry pond to gravel wetland, Bioswale repairs	$222,500	52.1

*These sites may also make good candidates for CRP project

4.1 CIP TIER 1 CANDIDATE PROJECTS

Frederick County Englandtowne SWM Pond

Project ID: F7
Project Name: Englandtowne SWM Pond
Location: West side of Chaucer Ct. before cul-de-sac
Ownership: Frederick County Commissioners

Total Score: 80.0
Project Type: Retrofit & Restoration
Subwatershed-Catchment: Fahrney-F
Total Dr. Area: 85 acres

Site Description: The stormwater structure that exists at this site was constructed in 1993. It is a detention pond (dry pond) with a metal pipe riser and barrel structure type that manages quantity. It is maintained by the FCDPW Bureau of Parks & Recreation. The channel downstream of the Englandtowne SWM Pond could be classified as a Rosgen Type F channel. The channel appears to be cut with machinery (i.e. bulldozer) and exhibits bare eroding banks. The upstream channel could be classified as a Rosgen Type G channel. The channel is actively eroding through the silt layer in the valley, and is progressing upstream (headcutting). This process is continuously feeding sediment into the SWM pond, which was designed to handle volume and rate of stormwater runoff, and was not designed to act as a sediment basin. The sediment that is dropping out in the basin is reducing the effectiveness of the SWM basin's original intent.

Proposed Action: Convert existing dry pond to add water quality treatment to the receiving runoff. Two options are proposed: 1. Install two gravel wetland cells and a sediment forebay; 2. Install a wet pond with a permanent pool and a sediment forebay. The stream restoration efforts upstream of the SWM pond should be undertaken prior to any improvements being constructed. This will help to prevent overloading of the sediment forebay in each of the two options for retrofit. The stream restoration proposed for the outlet channel of the SWM pond can be undertaken independently of the retrofit activities.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

Known Constraints: None.

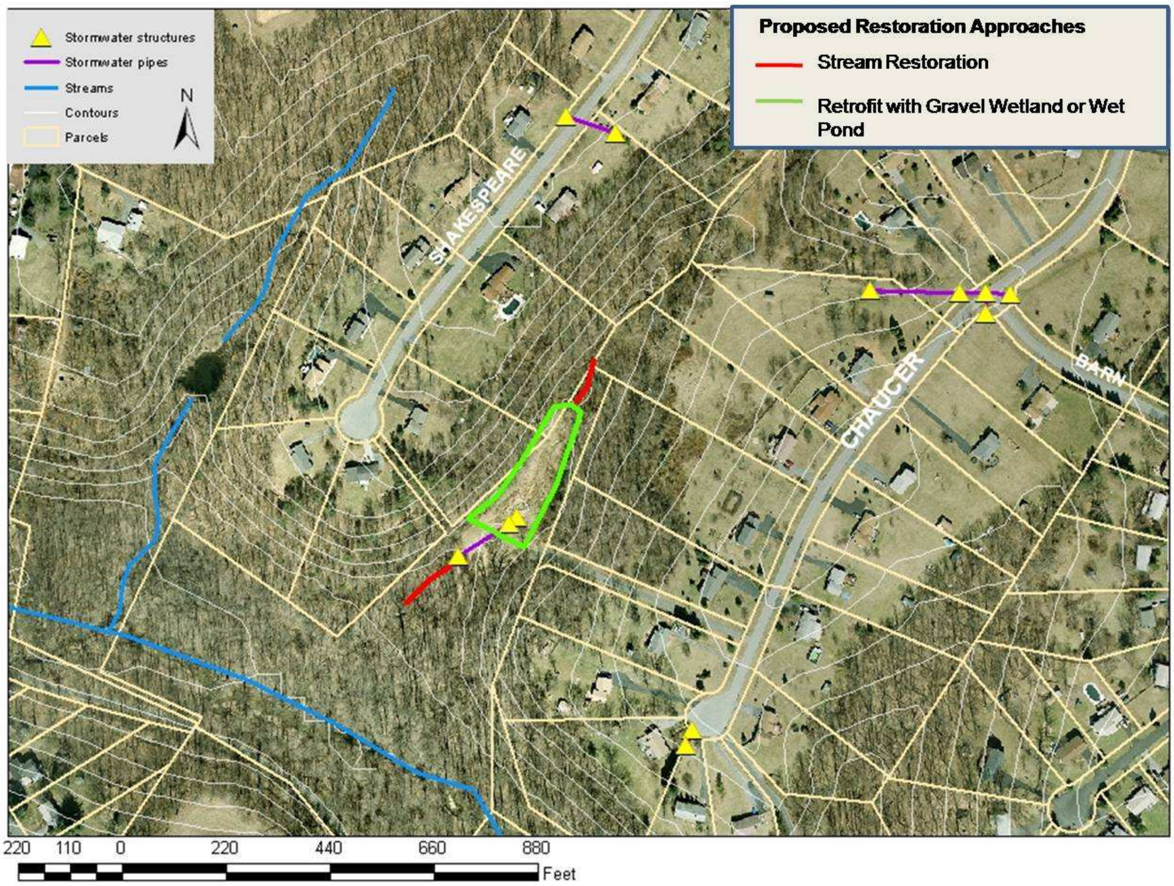
Planning Level Cost Estimate Option 1:

Option 1				
Proposed Restoration Approach	**Dimension**	**Units**	**Unit cost**	**Cost**
Gravel wetland	22,500	SF	$7	$157,500
Stream Channel Restoration (upstream)	80	LF	$472	$37,760
Stream Channel Restoration (downstream)	150	LF	$472	$70,800
Total Construction				**$266,060**
Design, Permitting, & Construction Management				**$50,000**
Estimated Project Cost				**$316,060**

Planning Level Cost Estimate Option 2:

Option 2				
Proposed Restoration Approach	**Dimension**	**Units**	**Unit cost**	**Cost**
Wet pond with sediment forebay and permanent pool	22,500	SF	$4	$90,000
Stream Channel Restoration (upstream)	80	LF	$472	$37,760
Stream Channel Restoration (downstream)	150	LF	$472	$70,800
Total Construction				**$198,560**
Design, Permitting, & Construction Management				**$50,000**
Estimated Project Cost				**$248,560**

Site Overview:



Frederick County Englandtowne SWM Pond
Project ID: F7
Project Name: Englandtowne SWM Pond

Option 1: The dimensions of the proposed restoration approaches in these diagrams are approximate.

Frederick County Englandtowne SWM Pond
Project ID: F7
Project Name: Englandtowne SWM Pond

Option 2: The dimensions of the proposed restoration approaches in these diagrams are approximate.

Frederick County Englandtowne SWM Pond
Project ID: F7
Project Name: Englandtowne SWM Pond

Additional Site Photos:

Frederick County Kemptown Park Stream Restoration

Project ID: F4
Project Name: Kemptown Park - Stream Restoration
Location: Church Rd
Ownership: Frederick County Commissioners

Total Score: 78.3
Project Type: Stream Restoration
Subwatershed-Catchment: Fahrney H
Stream Dr. Area: 34.3 acres

Site Description: Kemptown Park is located on a 72.6 acre parcel that borders the Kemptown Elementary School. There is severe erosion occurring along the stream corridor that lies within the park. The stream channel is entrenched and is exhibiting visible indicators of lateral migration and widening. The lateral migration and subsequent widening are threatening the integrity of the recently constructed stormwater structure, and are also increasing the sediment supply to downstream reaches of the stream. The entrenchment may be due in part to the constriction imposed by the walking trail crossing over the channel. Upgrades to this crossing (such as improving hydraulic capacity) can help to even out velocity profiles through the reach, and could provide secondary benefits by improving fish passage characteristics.

Proposed Action: Restore the impaired stream. It would be appropriate to do the stream restoration after completing the stormwater management facilities at Kemptown Elementary School.

Benefits: Channel protection, Prevent stream erosion.

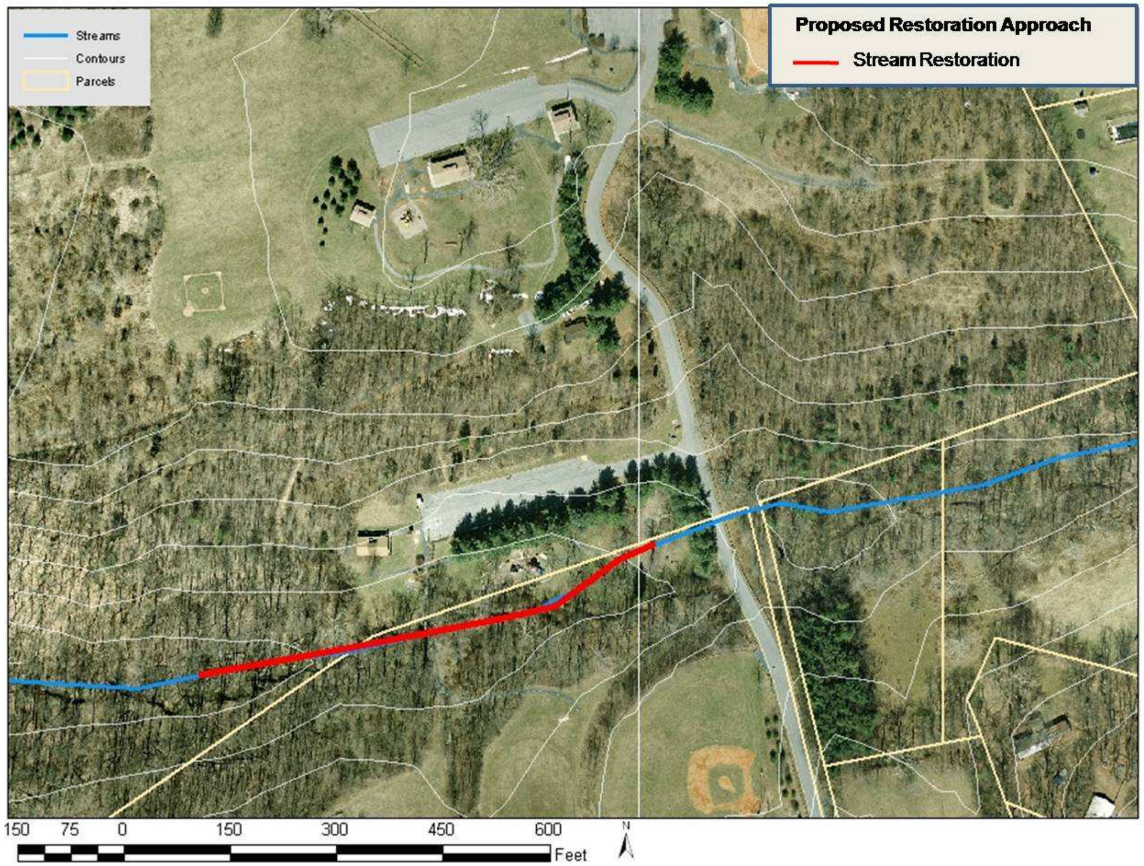
Known Constraints*:* None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Total Cost
Stream channel restoration	600	LF	$472	$283, 200

Frederick County Kemptown Park Stream Restoration
Project ID: F4
Project Name: Kemptown Park - Stream Restoration

Site Overview:



Frederick County Kemptown Park Stream Restoration
Project ID: F4
Project Name: Kemptown Park - Stream Restoration

Photos of the severe erosion occurring along the stream corridor:

Frederick County Kemptown Park Stream Restoration
Project ID: F4
Project Name: Kemptown Park - Stream Restoration

Photos of the existing stormwater structure:

Frederick County Kemptown Elementary School

Project ID: F3
Project Name: Kemptown Elementary School
Location: 3456 Kemptown Church Rd
Ownership: Frederick County Board of Education

Total Score: 76.7
Project Type: Multiple
Subwatershed-Catchment: Fahrney H
Impervious Area: 3.1 acres

Site Description: Kemptown Elementary School is located on a 39.5 acre parcel that borders Kemptown Park. There are some existing stormwater structures at this site but additional opportunities exist for various LID projects. In addition there is a pipe outfall area with a flat outlet apron that appears to need additional energy dissipation. This is located near the property boundary with Kemptown Park.

Proposed Action: Provide treatment for stormwater runoff in various places around the school by installing two bioswales, three bioretention areas and infiltration trenches. To address the problems associated with the pipe outfall, install a reinforced scour hole (with a level outlet) to dissipate kinetic energy.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

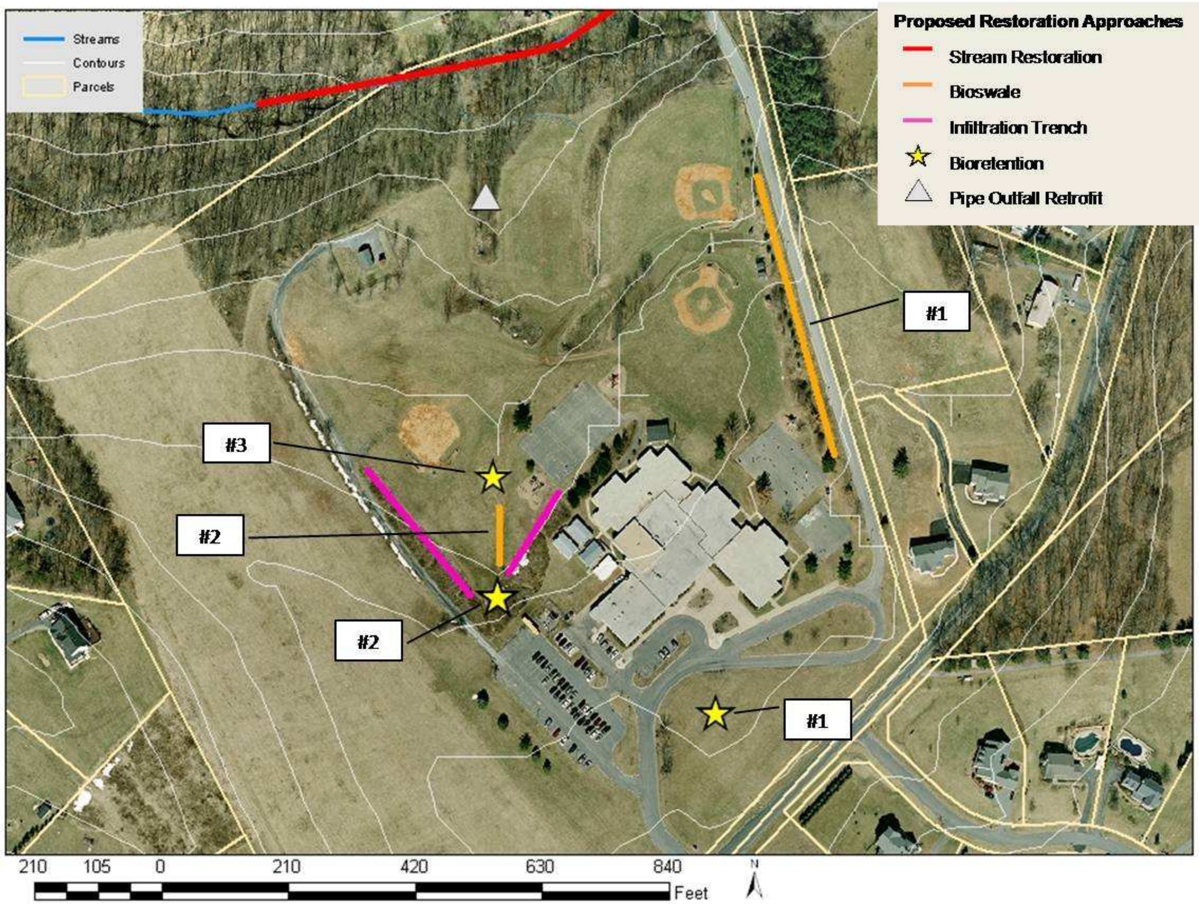
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Bioswale #1 (3-ft wide)	535	LF	$105	$56,175
Bioswale #2	433	SF	$35	$15,144
Bioretention #1	175	SF	$25	$4,365
Bioretention #2	2679	SF	$25	$66,964
Bioretention #3	595	SF	$25	$14,881
Pipe Outfall Retrofit		Lump Sum		$10,000
Infiltration Trench	500	LF	$214	$107,000
Total Construction				**$274,530**
Design, Permitting, & Construction Management				**$150,000**
Estimated Project Cost				**$424,530**

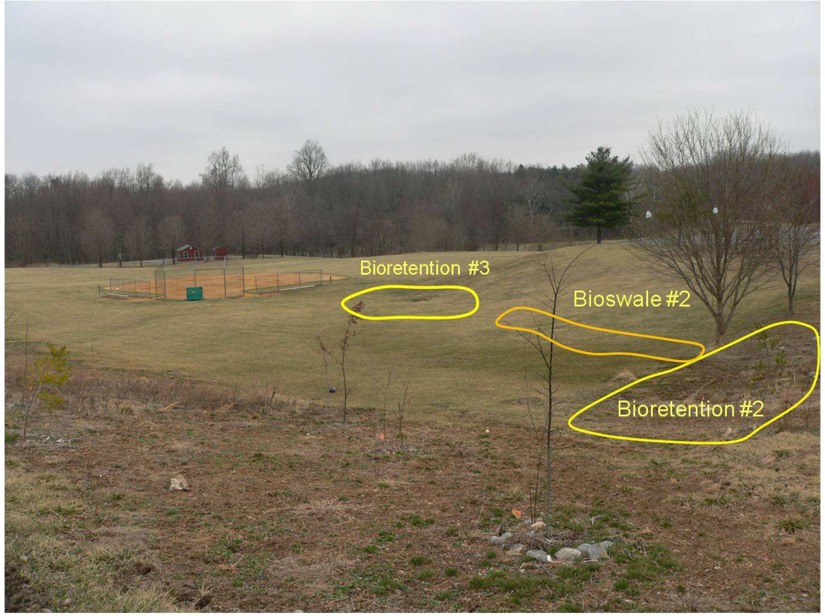
Frederick County Kemptown Elementary School
Project ID: F3
Project Name: Kemptown Elementary School

Site Overview:



Frederick County Kemptown Elementary School
Project ID: F3
Project Name: Kemptown Elementary School

Locations of some of the proposed restoration approaches (dimensions are approximate):



Frederick County Kemptown Park Stream Restoration
Project ID: F3
Project Name: Kemptown Elementary School

Additional Site Photos:

Frederick County Kemptown Park LID

Project ID: F5
Project Name: Kemptown Park LID
Location: Church Rd
Ownership: Frederick County Commissioners

Total Score: 75.0
Project Type: Multiple
Subwatershed-Catchment: Fahrney H
Impervious Area: 0.96 acres

Site Description: Kemptown Park is located on a 72.6 acre parcel that borders the Kemptown Elementary School. During the site visit, several opportunities for water quality improvements were noted, such as multiple low impact development opportunities near the parking lots and pavilions in the northern portion of the park.

Proposed Action: Provide treatment for stormwater runoff from the parking lots by installing a bioretention area and a linear bioswale. Install rain gardens to treat the roof runoff from the pavilions.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

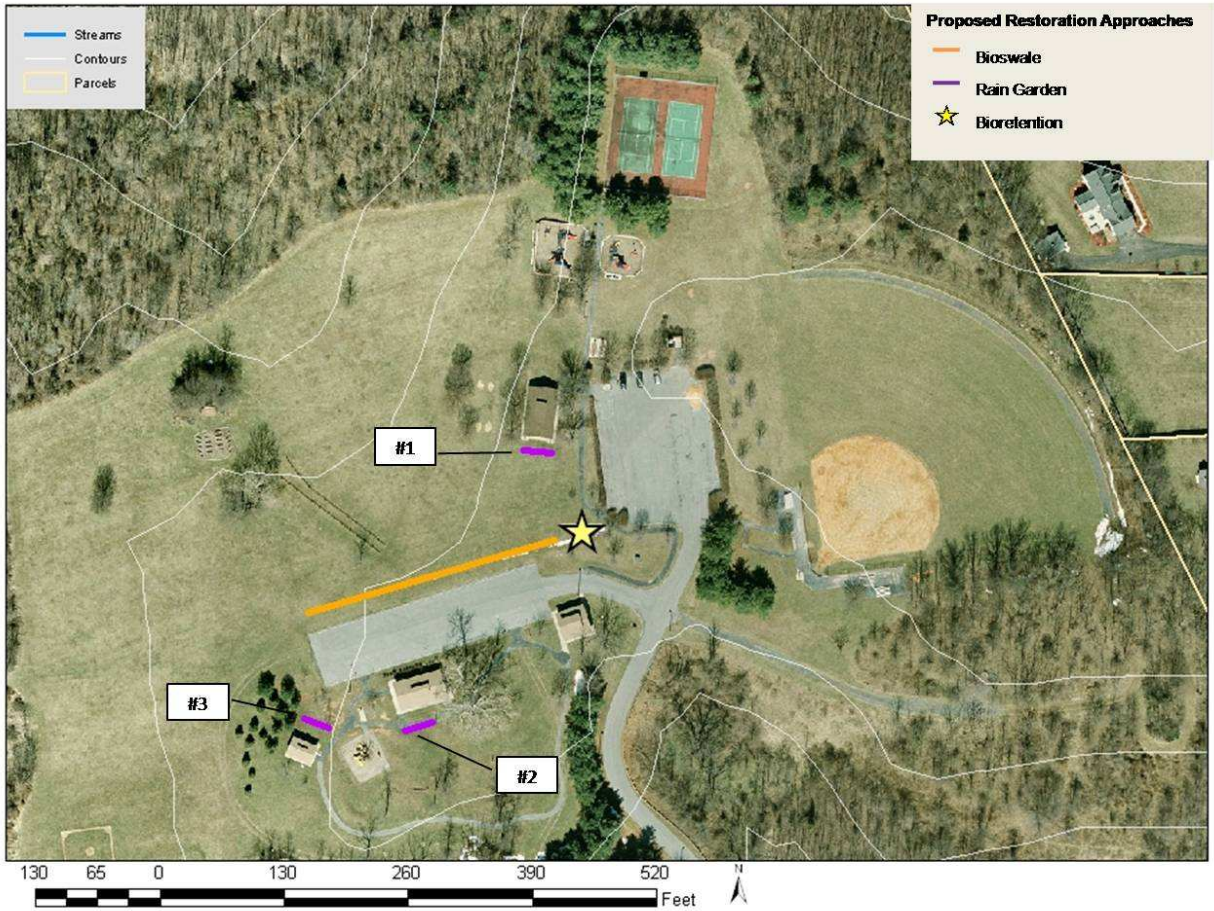
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Bioretention#1	887	SF	$25	$22,173
Linear bioswale #1 (3-ft wide)	320	LF	$105	$33,654
Rain garden for pavilion roof runoff #1	63	SF	$22	$1,379
Rain garden for pavilion roof runoff #2	79	SF	$22	$1,746
Rain garden for pavilion roof runoff #3	29	SF	$22	$646
Total Construction				**$59,598**
Design, Permitting, & Construction Management				**$50,000**
Estimated Project Cost				**$109,598**

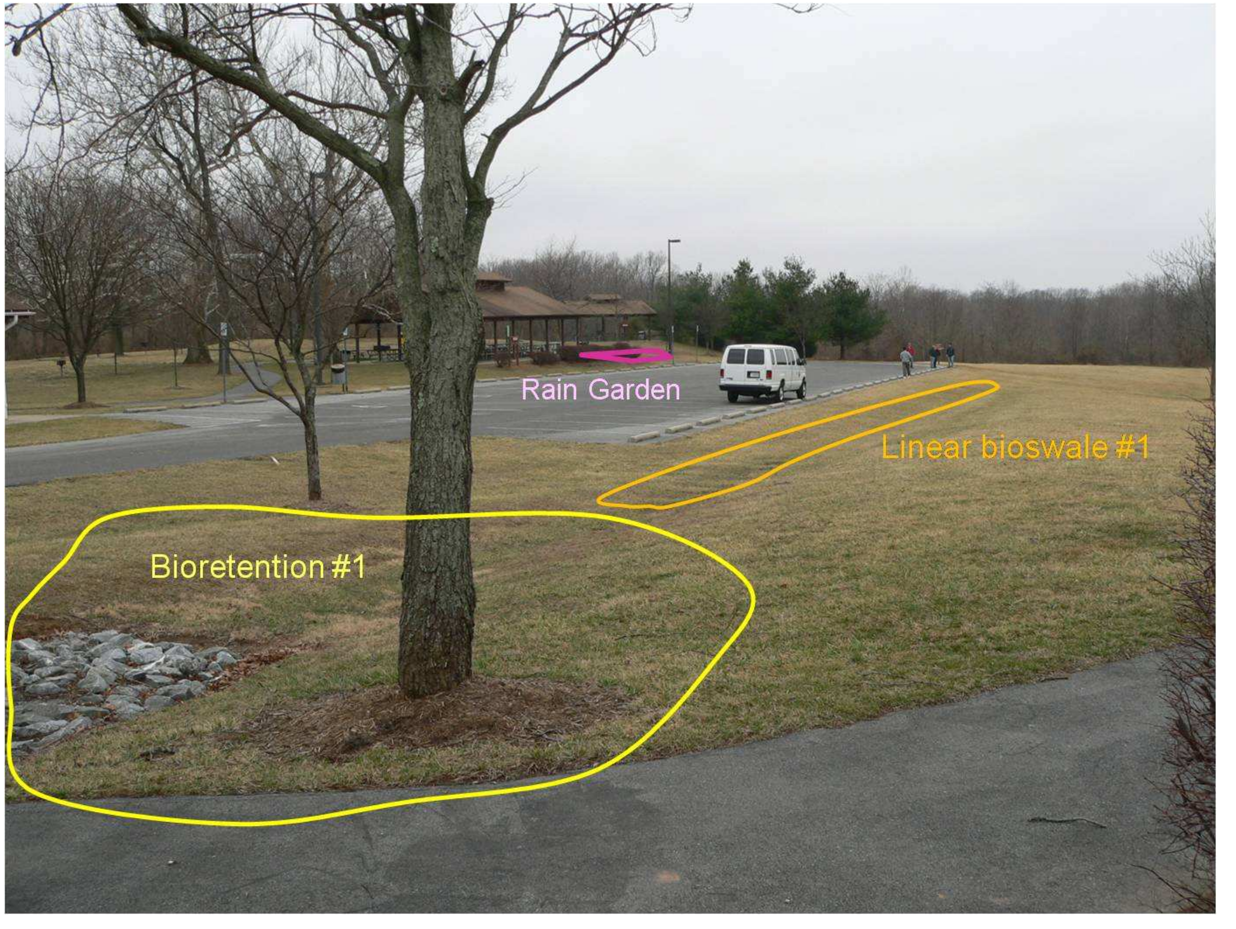
Frederick County Kemptown Park LID
Project ID: F5
Project Name: Kemptown Park - LID

Site Overview:



Frederick County Kemptown Park LID
Project ID: F5
Project Name: Kemptown Park - LID

Locations of some of the proposed restoration approaches (dimensions are approximate):



Frederick County Kemptown Park LID
Project ID: F5
Project Name: Kemptown Park - LID

Additional Site Photos:

4.2 CIP TIER 2 CANDIDATE PROJECTS

Frederick County Urbana Park

Project ID: U1
Project Name: Urbana Park
Location: 3636 Urbana Pike
Ownership: Frederick County Commissioners

Total Score: 61.7
Project Type: Multiple
Subwatershed-Catchment: Urbana C
Impervious Area: 0.72 acres

Site Description: Urbana Park is located on a 20.5 acre parcel near the Urbana Elementary School. There are a number of athletic fields located in the park, including tennis courts, baseball and soccer fields. During the site visit, no stormwater detention facilities were immediately visible, and the exiting flow path leads through the broad grassy area at the southwestern corner of the park. The neighboring farm field drains onto the park parcel. During the site visit, no significant problems were noted other than the bare eroded area at the base of a sycamore tree. However, there could be impacts in the receiving waters downstream. Water quality improvements could be realized through the creation of retention features, along with the volume improvements suggested for treating the remainder of the park.

Proposed Action: Provide treatment for stormwater runoff from the parking lot, road and tennis court by installing two bioretention areas, a landscape infiltration area, and two linear bioswales. To help control erosion in the southwestern corner of the park, bring in fresh topsoil with seeding, mulching and erosion control matting and rope this area off until the vegetation is established.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

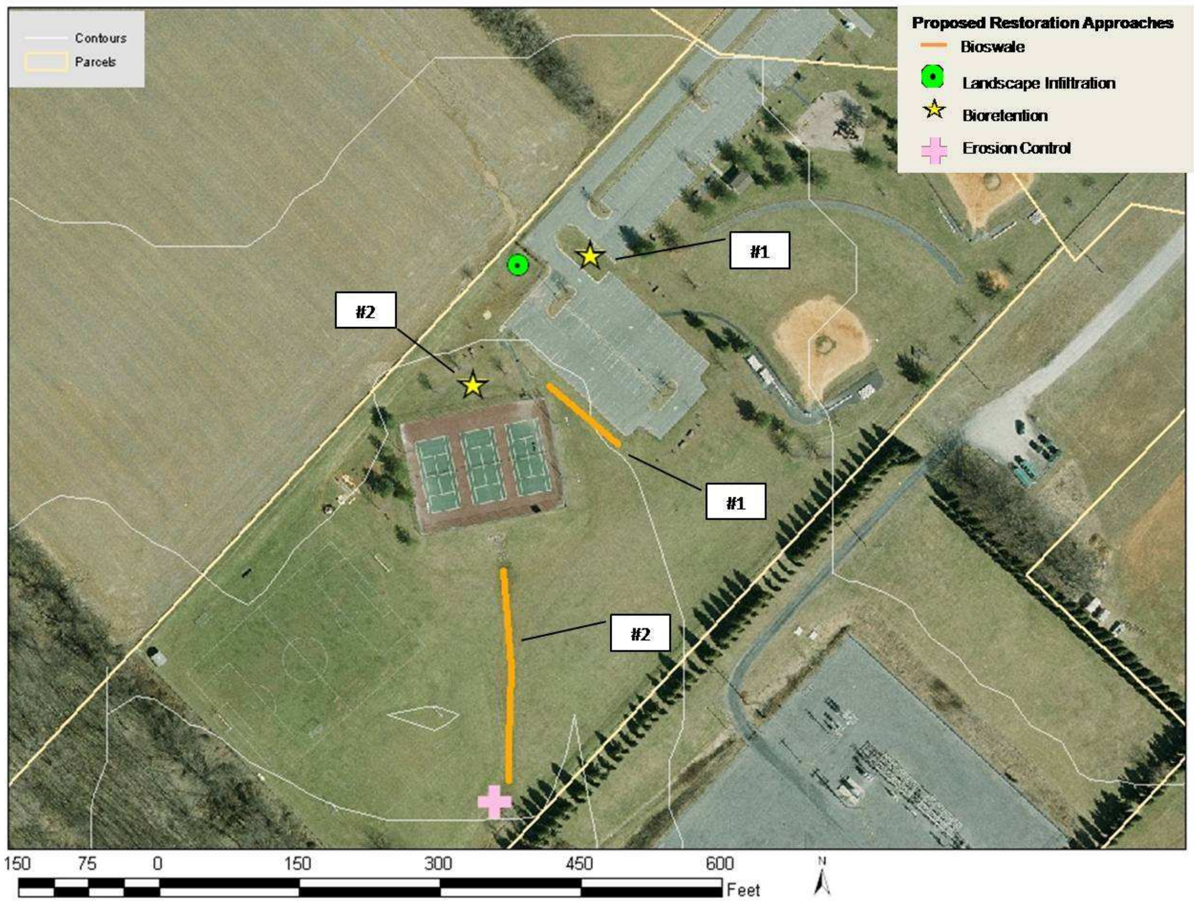
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Bioretention #1	270	SF	$25	$6,746
Bioretention #2	456	SF	$25	$11,409
Landscape infiltration	219	SF	$35	$7,650
Linear bioswale #1 (3-ft wide)	115	LF	$105	$12,075
Linear bioswale #2 (3-ft wide)	250	LF	$105	$26,250
Erosion control		Lump Sum		$10,000
Total Construction				**$74,130**
Design, Permitting, & Construction Management				**$70,000**
Estimated Project Cost				**$144,130**

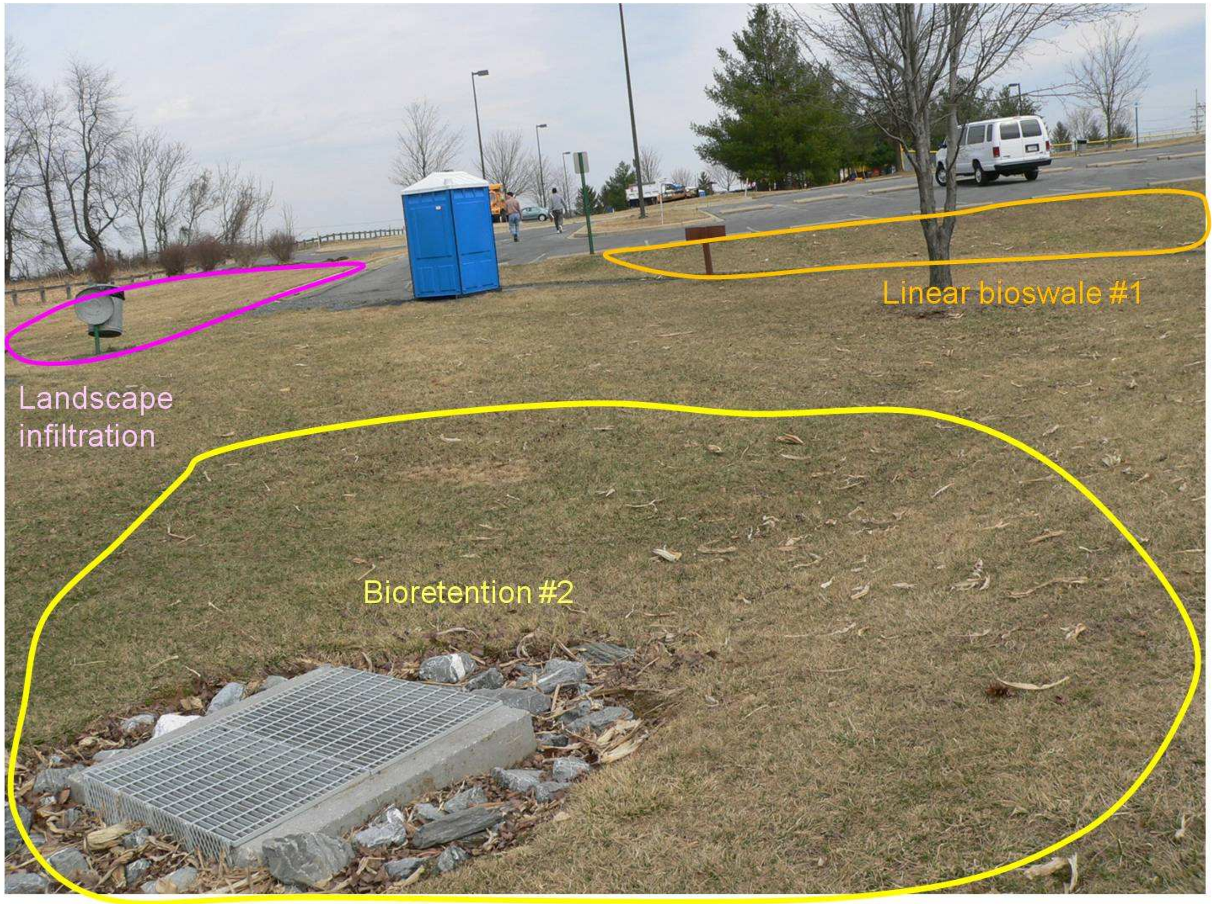
Frederick County Urbana Park
Project ID: U1
Project Name: Urbana Park

Site Map:



Frederick County Urbana Park
Project ID: U1
Project Name: Urbana Park

Locations of some of the proposed restoration approaches (dimensions are approximate):



Frederick County Urbana Park
Project ID: U1
Project Name: Urbana Park

Locations of some of the proposed restoration approaches (dimensions are approximate):

Frederick County Urbana Park
Project ID: U1
Project Name: Urbana Park

Additional Site Photos:

Frederick County Green Valley Elementary School

Project ID: F1
Project Name: Green Valley Elementary School
Location: 11501 Fingerboard Road
Ownership: Frederick County Board of Education

Total Score: 58.3
Project Type: Multiple
Subwatershed-Catchment: Fahrney F
Impervious Area: 0.6 acre

Site Description: Green Valley Elementary School is located on a 30 acre parcel. There are some existing stormwater structures at this site but there are opportunities for retrofits and additional LID projects. As a result of snow plowing, leaf litter and anti-skid gravel/silt have accumulated in the curb cut area. This material has formed a berm that is cutting off access to the existing facility. In addition, some channel erosion was evident at the downstream end of the outlet apron, indicating inadequate attenuation of velocities.

Proposed Action: Provide treatment for stormwater runoff from the parking lot by adding curb cuts and installing a bioretention unit within the parking lot island. Other potential projects include retrofitting the existing facility into an infiltration trench and replacing a section of the school's roof with a green roof. Removal of the leaf litter/gravel berm is also recommended. Removal of this debris can be accomplished through manual labor, and should be included within a regularly scheduled maintenance routine.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

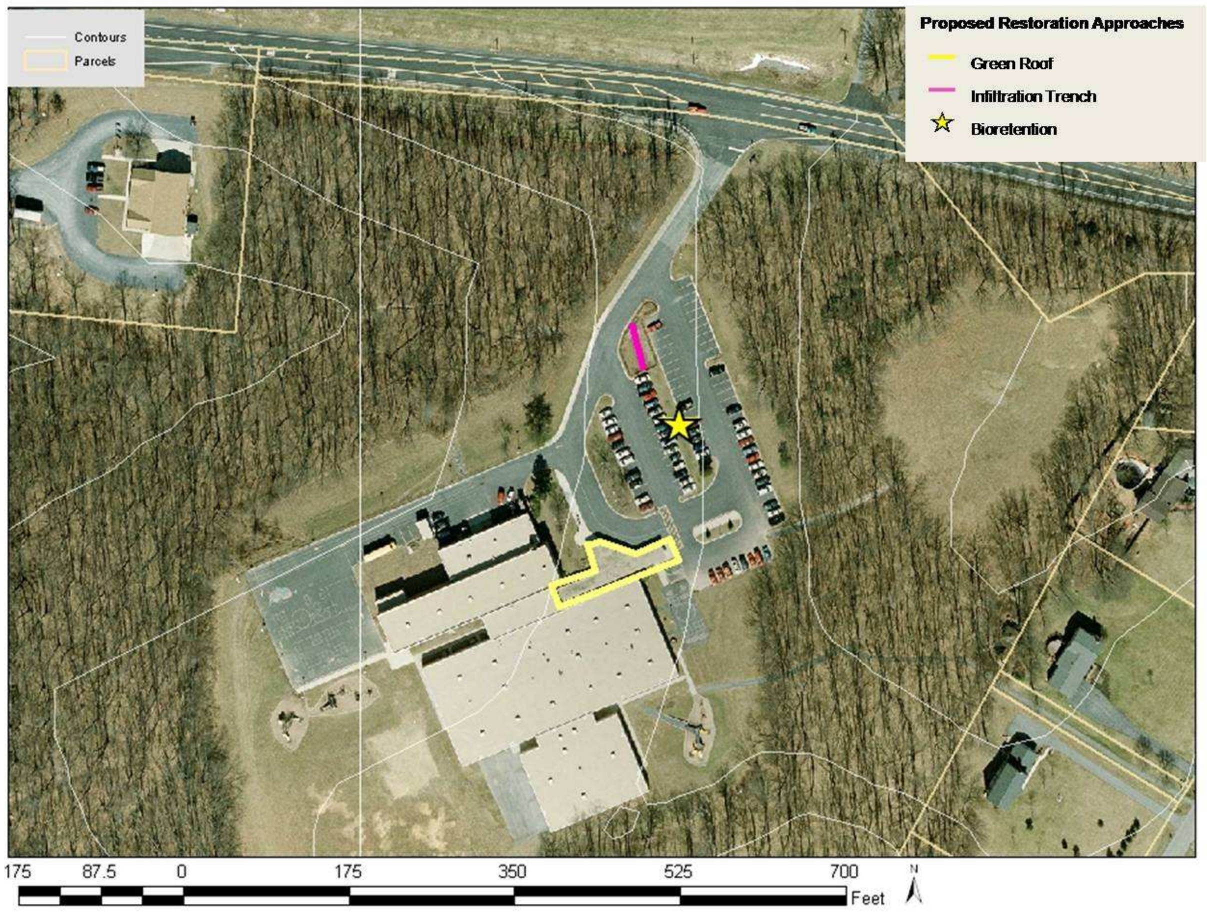
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Add curb cuts		Lump sum		$2,000
Retrofit facility into infiltration trench (Optional)		Lump sum		$20,000
Bioretention Unit within Parking Lot Island	1500	SF	$25	$37,500
Potential Green Roof Area	2900	SF	$20	$58,000
Total Construction				**$117,500**
Design, Permitting, & Construction Management				**$80,000**
Estimated Project Cost				**$197,500**

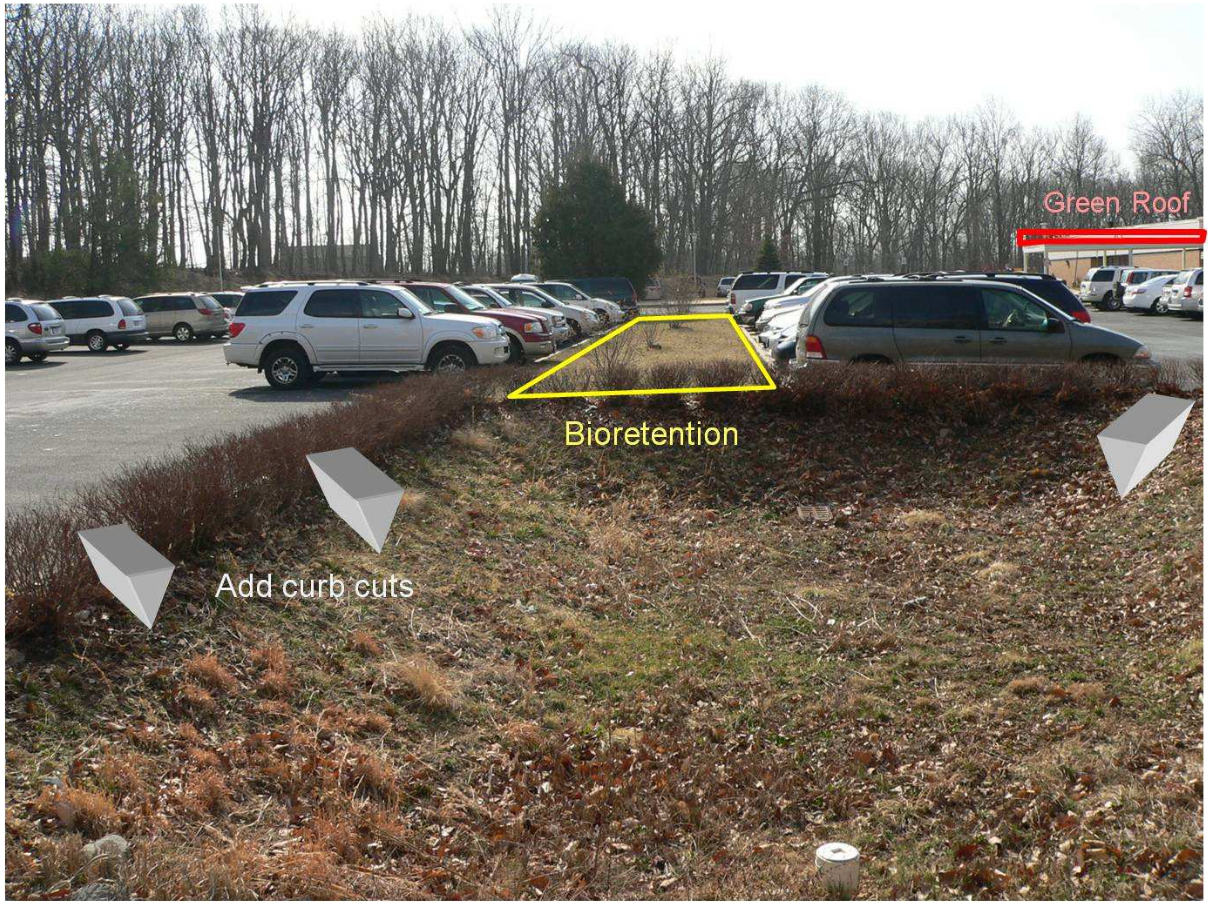
Frederick County Green Valley Elementary School
Project ID: F1
Project Name: Green Valley Elementary School

Site Overview:



Frederick County Green Valley Elementary School
Project ID: F1
Project Name: Green Valley Elementary School

Locations of some of the proposed restoration approaches (dimensions are approximate):



4.3 COMMUNITY RESTORATION PROJECTS

Frederick County Persimmon Residential

Project ID: BU2
Project Name: Persimmon Residential
Location: Persimmon Drive
Ownership: Private

Total Score: 78.3
Project Type: Multiple
Subwatershed-Catchment: Bennett Upper B
Stream Dr. Area: 59.7 acres

Site Description: This residential area is in close proximity to the stream corridor and lacks stormwater management facilities. The culvert at the Persimmon Drive stream crossing lacks adequate hydraulic capacity and is in need of repair. Several problems were noted along the stream corridor, including severe erosion, channel alternation (man-made), habitat degradation and a fish barrier. The inadequate hydraulic capacity of the culvert has resulted in the accumulation of a sediment wedge headward of the Persimmon Drive road prism. Blockages in the culvert (there was evidence of recent debris removal and sediment excavation by heavy equipment) have resulted in overtopping of the road surface (also clearly evident during the site visit). The increased kinetic energy within the channel downstream of Persimmon Drive during overtopping events, coupled with the deposition of bedload sediment in the floodplain immediately upstream of the crossing, has resulted in a degraded and rapidly eroding channel downstream. Leaning and toppled streamside trees were visible, with some trees potentially threating nearby residential improvements.

Proposed Action: Provide treatment for stormwater runoff by installing linear bioswales along the sides of the roads. Make improvements to the culvert and bridge and install two bioretention areas. Then restore the impaired stream corridor.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

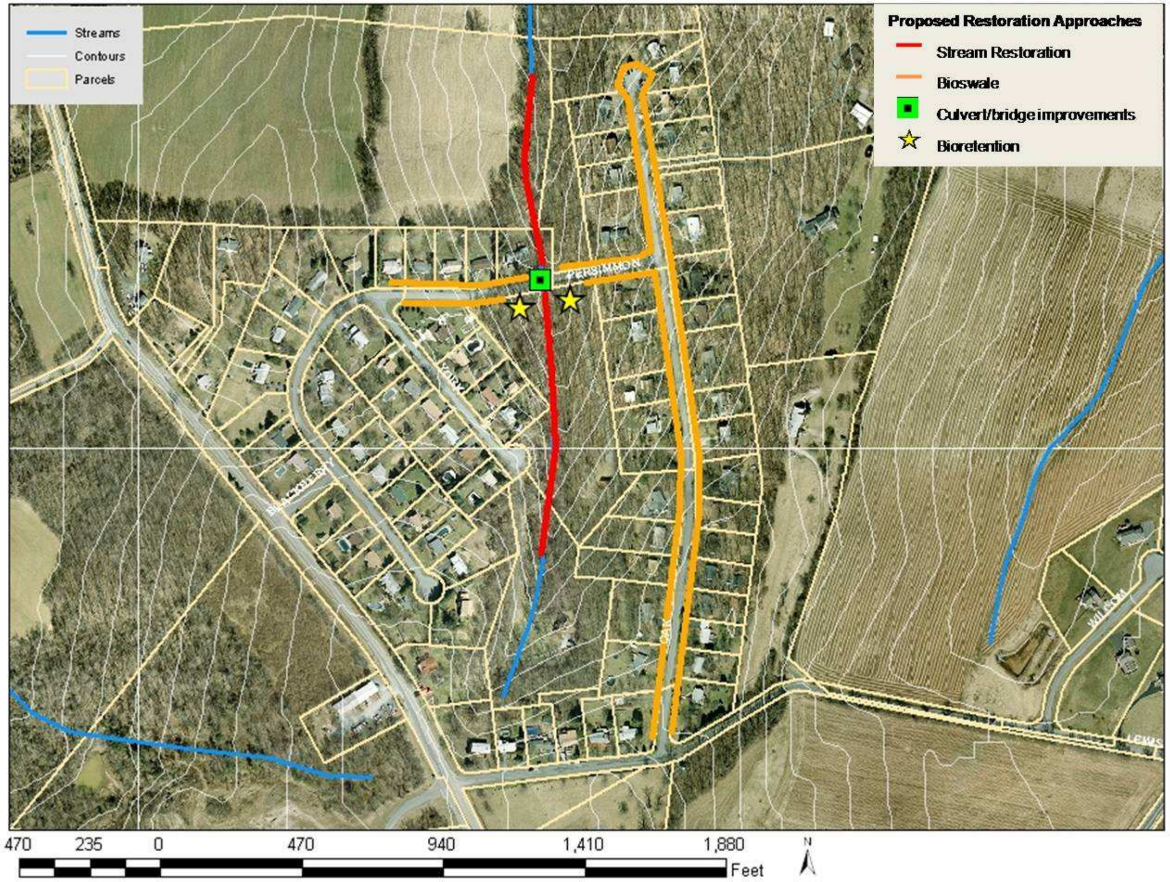
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Stream channel restoration	900	LF	$472	$424,800
Linear bioswale #1 (2-ft wide)	4250	LF	$70	$297,500
Linear bioswale #2 (2-ft wide)	1575	LF	$70	$110,250
Bioretention #1	400	SF	$25	$10,000
Bioretention #2	400	SF	$25	$10,000
Culvert/bridge improvements		Lump sum		$10,000
Total Construction				**$862,550**
Design, Permitting, & Construction Management				**$200,000**
Estimated Project Cost				**$1,062,550**

Frederick County Persimmon Residential
Project ID: BU2
Project Name: Persimmon Residential

Site Overview:



Frederick County Persimmon Residential
Project ID: BU2
Project Name: Persimmon Residential

Locations of some of the proposed restoration approaches (dimensions are approximate):

Frederick County Persimmon Residential
Project ID: BU2
Project Name: Persimmon Residential

Additional site photos:

Frederick County Pleasant Grove/Keating Residential

Project ID: P3
Project Name: Pleasant Grove/Keating Residential
Location: Keating Court
Ownership: Private

Total Score: 73.3
Project Type: Bioswales
Subwatershed-Catchment: Pleasant B
Impervious Length: 375 ft

Site Description: Keating Court is located in the Pleasant Grove residential development. There is no stormwater management in this development. During the SCA survey, severe erosion and inadequate riparian buffers were noted along the nearby stream corridor.

Proposed Action: Provide treatment for stormwater runoff by converting ditches into bioswales.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

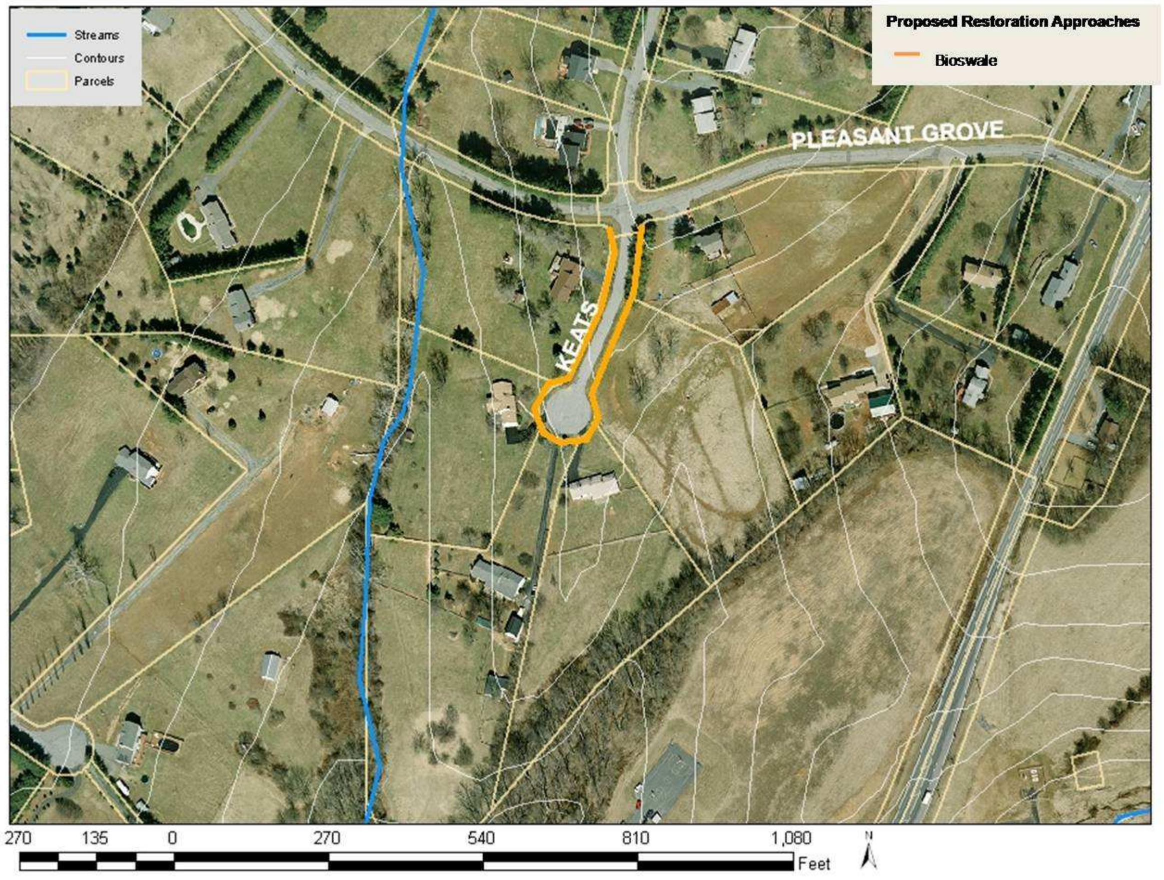
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Convert ditches into bioswales (2-ft wide)	875	LF	$70	$61,250
Total Construction				**$61,250**
Design, Permitting, & Construction Management				**$20,000**
Estimated Project Cost				**$81,250**

Frederick County Pleasant Grove/Keating Residential
Project ID: P3
Project Name: Pleasant Grove/Keating Residential

Site Overview:



Frederick County Pleasant Grove/Keating Residential
Project ID: P3
Project Name: Pleasant Grove/Keating Residential

Locations of some of the proposed restoration approaches (dimensions are approximate):

Frederick County Maryland Manor Residential

Project ID: F12
Project Name: Maryland Manor Residential
Location: Maryland Manor
Ownership: Private

Total Score: 66.7
Project Type: Bioswales
Subwatershed-Catchment: Fahrney G
Impervious Length: NA

Site Description: There is no stormwater management in this subdivision. At the end of the road, the water is ditched to the cul-de-sac and then runs into a landowner's backyard where it is causing erosion. During the site visit, minor-moderate erosion was noted along the stream corridor, which is located approximately 500 feet from the end of the road.

Proposed Action: Provide treatment for stormwater runoff and erosion control by installing linear bioswales along the sides of the roads. The problems in the landowner's backyard were fairly severe. The erosion control area would require more than topsoil and seeding alone. The property maps did not show a stormwater easement on the property so restoration options may be limited.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

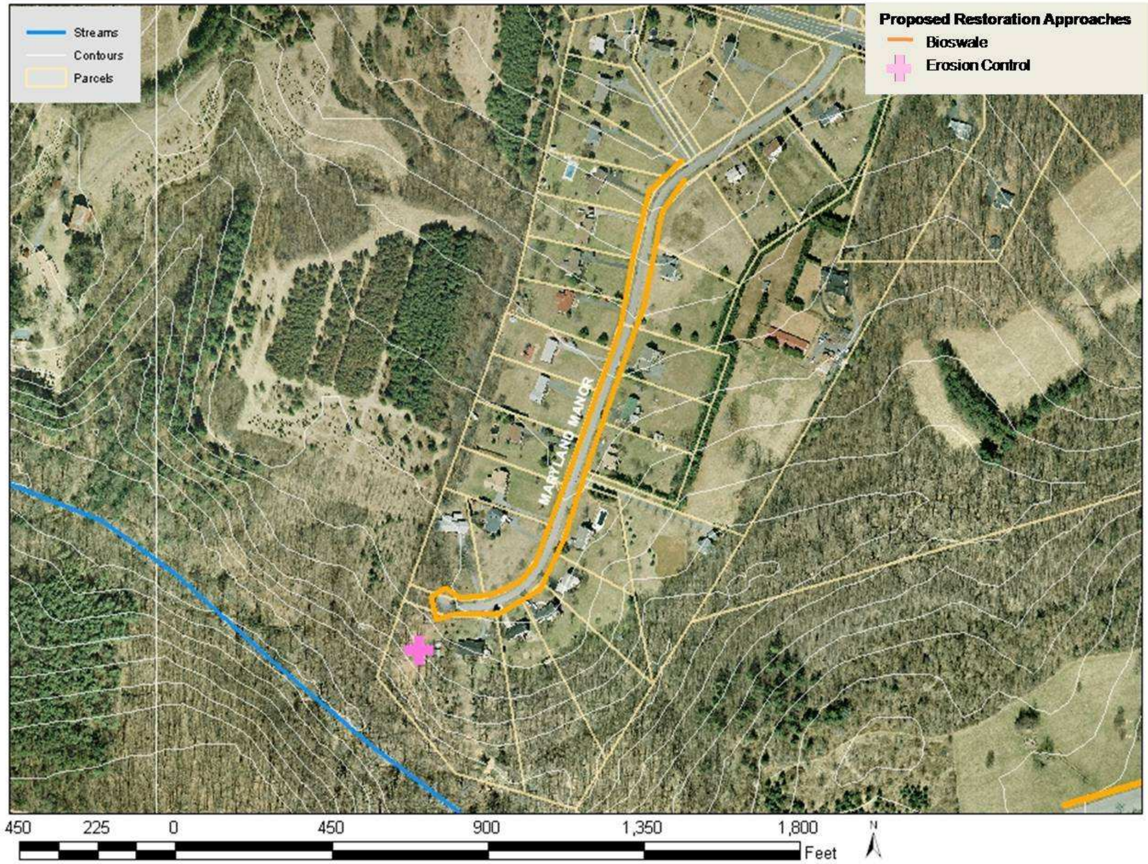
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Units	Unit cost	Cost
Erosion control		lump sum		$10,000
Linear bioswales (2-ft wide)	3250	LF	$70	$227,500
Total Construction				**$237,500**
Design, Permitting, & Construction Management				**$20,000**
Estimated Project Cost				**$257,500**

Frederick County Maryland Manor Residential
Project ID: F12
Project Name: Maryland Manor Residential

Site Overview:



Frederick County Maryland Manor Residential
Project ID: F12
Project Name: Maryland Manor Residential

Locations of some of the proposed restoration approaches (dimensions are approximate):

Frederick County Long Fence

Project ID: BM3
Project Name: Long Fence
Location: 2520 Urbana Pike
Ownership: Private

Total Score: 58.8
Project Type: Retrofit
Subshed-Catch: Bennett Middle H
Total Dr. Area: 2.7 acres

Site Description: This is a commercial lot with an existing stormwater structure. It is maintained by the Long Fence Company (contact: Larry Ritter). It is a detention pond (dry pond) with a metal pipe riser and barrel structure type that manages quantity.

Proposed Action: Convert the existing dry pond to a gravel wetland to add water quality treatment to the receiving runoff.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

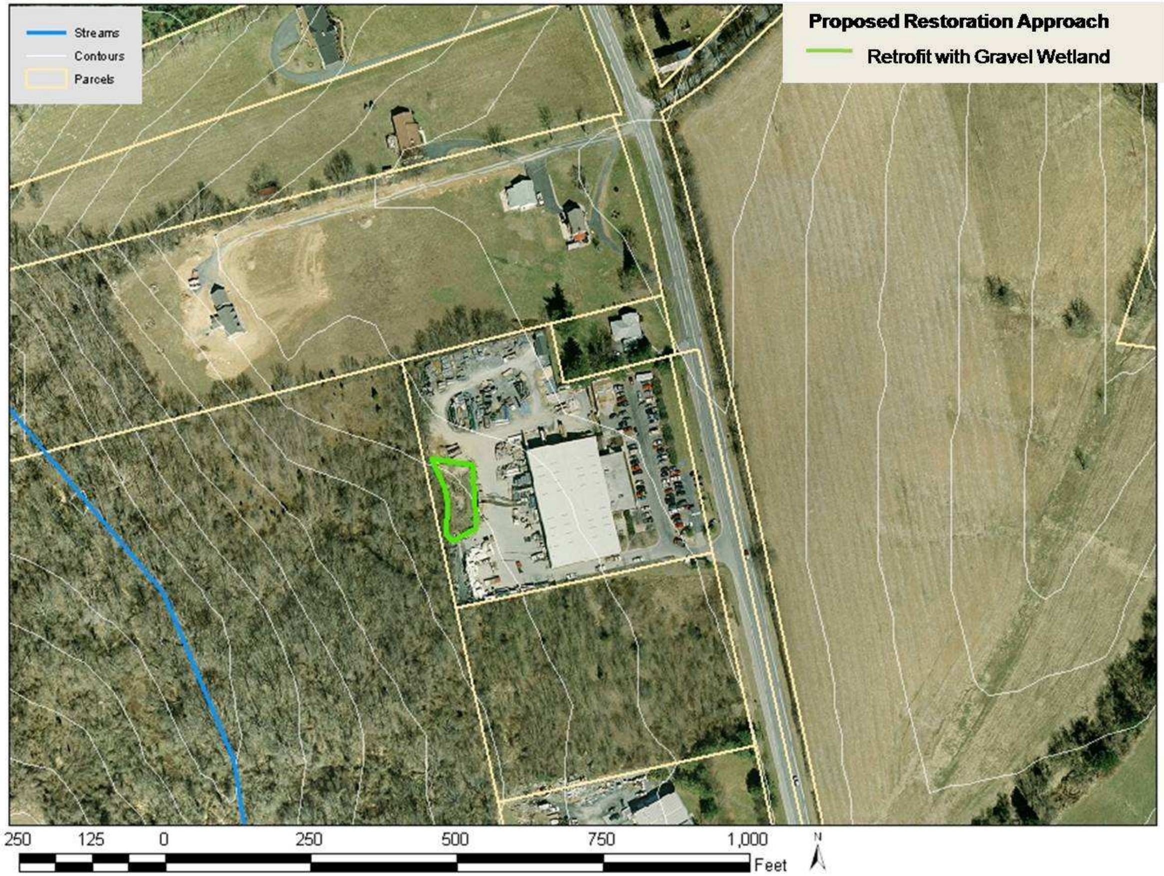
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Unit	Unit cost	Cost
Gravel wetland	6000	SF	$7	$42,000
Total Construction				**$42,000**
Design, Permitting, & Construction Management				**$20,000**
Estimated Project Cost				**$62,000**

Frederick County Long Fence
Project ID: BM3
Project Name: Long Fence

Site Overview:



Frederick County Little Bennett Industrial

Project ID: LB1
Project Name: Little Bennett Industrial
Location: Hyatt Park off Tyler Road
Ownership: Private

Total Score: 52.1
Project Type: Multiple
Subshed-Catch: Little Bennett C
Impervious area: NA

Site Description: There are opportunities for improvements to existing structures and also opportunities for an additional bioretention area in the Hyatt Park area. The existing stormwater structure that was evaluated is maintained by Nelson Tyler. It is a detention pond (dry pond) with a metal pipe riser and barrel structure type that manages quantity.

Proposed Action: Convert the existing dry pond to a gravel wetland to add water quality treatment to the receiving runoff. Make repairs to the existing swale to improve capture of runoff. Install a bioretention area along the road.

Benefits: Channel protection, stormwater quality control, peak flow reduction.

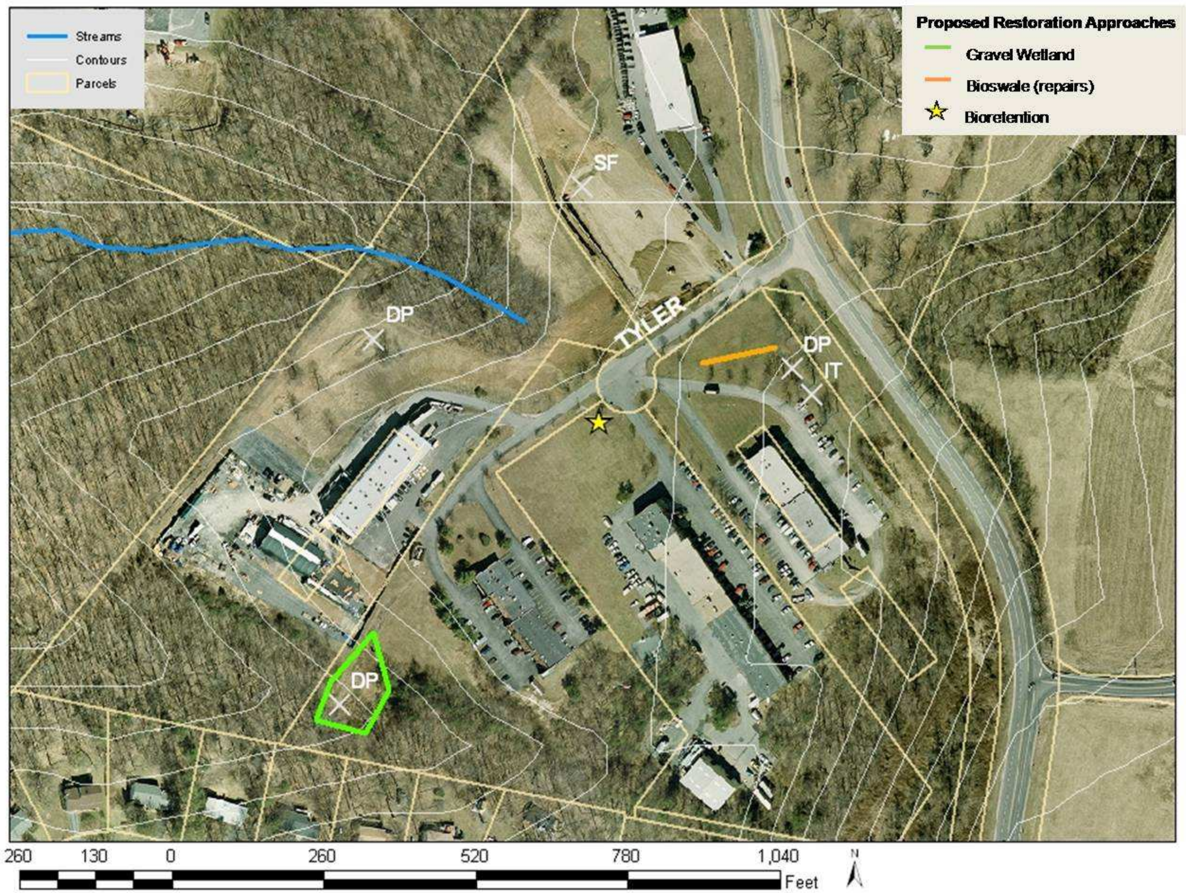
Known Constraints: None but need a careful evaluation of utility conflict during the design phase.

Planning Level Cost Estimate:

Proposed Restoration Approach	Dimension	Unit	Unit cost	Cost
Bioretention	800	SF	$25	$20,000
Retrofit dry pond to gravel wetland	10,000	SF	$7	$70,000
Swale repairs to improve capture of runoff (Bioswale 3-ft wide)	500	LF	$105	$52,500
Total Construction				**$142,500**
Design, Permitting, & Construction Management				**$80,000**
Estimated Project Cost				**$222,500**

Frederick County Little Bennett Industrial
Project ID: LB1
Project Name: Little Bennett Industrial

Site Overview: Existing stormwater structures are marked by gray X's. DP=detention structure, SF=sand filter and IT=infiltration.



5 TIER 1 CIP PROJECTS – BENEFITS AND COSTS

Further analyses were conducted to evaluate costs and benefits associated with the Tier 1 CIP candidate projects. Estimated pollutant removal was used to quantify the anticipated benefits of each project. Cost-benefit ratios varied among projects due to watershed and site-specific factors. The Kemptown Park stream restoration project was not included in these analyses because it is not a water quality treatment project.

5.1 MODELED BENEFIT OF TIER 1 CIP PROJECTS

To aid the County in the project selection process, pollutant load reductions that are anticipated to result from implementation of the Tier 1 projects were calculated and summarized in Tables 5.1 and 5.2. Two options are presented for the Englandtowne SWM pond project (F7), which is located in the Fahrney –F catchment. Based on the calculations, the gravel wetland is more effective at reducing catchment loads than the wet pond option, especially for TN, which was identified as a strong candidate stressor in the stressor identification process (Tetra Tech 2008a). The other two projects are located in the Fahrney-H catchment and are anticipated to provide modest reductions in pollutant loads.

5.2 COST-BENEFIT ANALYSIS OF TIER 1 CIP PROJECTS

Cost-benefit ratios were calculated for each project to help identify which ones are likely to be most cost effective. The parameters that were considered in this analysis were TP, TN and TSS. Results, which are shown in Table 5.3, are presented as unit costs for pollutant removal in dollars/pound/year. When evaluating costs, it is recommended that project life spans, which are anticipated to be 20 years or longer, are taken into consideration.

Table 5.1. Estimated percent reduction in catchment loads from each Tier 1 project. NA=not available.

Project ID	Subshed - Catchment	Project Name	BOD	TN	TP	TSS
F7	Fahrney-F	Englandtowne SWM Pond gravel wetland option	NA	9.51%	2.11%	5.85%
F7	Fahrney-F	Englandtowne SWM Pond wet pond option	5.05%	3.08%	1.88%	4.67%
F3	Fahrney-H	Kemptown Elementary School	4.81%	1.69%	0.75%	1.48%
F5	Fahrney-H	Kemptown Park - LID	0.61%	0.21%	0.15%	0.19%

Table 5.2. Estimated pollutant removal (lbs/year) for each Tier 1 candidate project. NA=not available.

Project ID	Subshed - Catchment	Project Name	BOD	TN	TP	TSS	COD	PB	CU	ZN	CD
F7	Fahrney-F	Englandtowne SWM Pond gravel wetland option	NA	328.2	14.0	21037.5	NA	NA	NA	8.4	NA
F7	Fahrney-F	Englandtowne SWM Pond wet pond option	497.3	106.1	12.5	16787.5	1912.5	3.1	1.5	5.5	20.4
F3	Fahrney-H	Kemptown Elementary School	236.8	36.4	2.2	2213.7	1360.4	3.9	0.3	4.0	0.0
F5	Fahrney-H	Kemptown Park - LID	30.2	4.6	0.5	280.9	173.7	0.5	0.0	0.5	0.0

Table 5.3. Cost benefit analysis for Tier 1 candidate projects.

Project ID	Subshed - Catchment	Project Name	Estimated Cost	Cost-Benefit Ratios		
				Reduction in Total Phosphorus ($/lb/year)	Reduction in Total Nitrogen ($/lb/year)	Reduction in Total Suspended Sediment ($/lb/year)
F7	Fahrney-F	Englandtowne SWM Pond gravel wetland	$316,060	$22,535.47	$963.05	$15.02
F7	Fahrney-F	Englandtowne SWM Pond wet pond	$248,560	$19,892.76	$2,343.14	$14.81
F3	Fahrney-H	Kemptown Elementary School	$424,530	$189,476.88	$11,677.01	$191.77
F5	Fahrney-H	Kemptown Park - LID	$109,598	$238,256.29	$23,859.64	$390.15

6 CONCEPTUAL DESIGNS AND MONITORING RECOMMENDATIONS

Conceptual designs were prepared for five candidate projects. These designs cover most of the different watershed restoration approaches that have been proposed in this report. The projects that were selected include the following high priority sites: 1. the gravel wetland or wet pond retrofit project at the Englandtowne SWM Pond (Site F7); 2. the stream restoration project at Kemptown Park (Site F4); 3. the bioretention area/bioswale/infiltration trench/pipe outfall retrofit project at Kemptown Elementary School (Site F3); 4. the bioretention area/bioswale/rain garden project at Kemptown Park (Site F5); and 5. the bioretention areas/bioswales/culvert/bridge improvements/stream and channel restoration project in the residential area on Persimmon Drive (Site BU2). Locations of the project sites are shown in Figure 6.1.

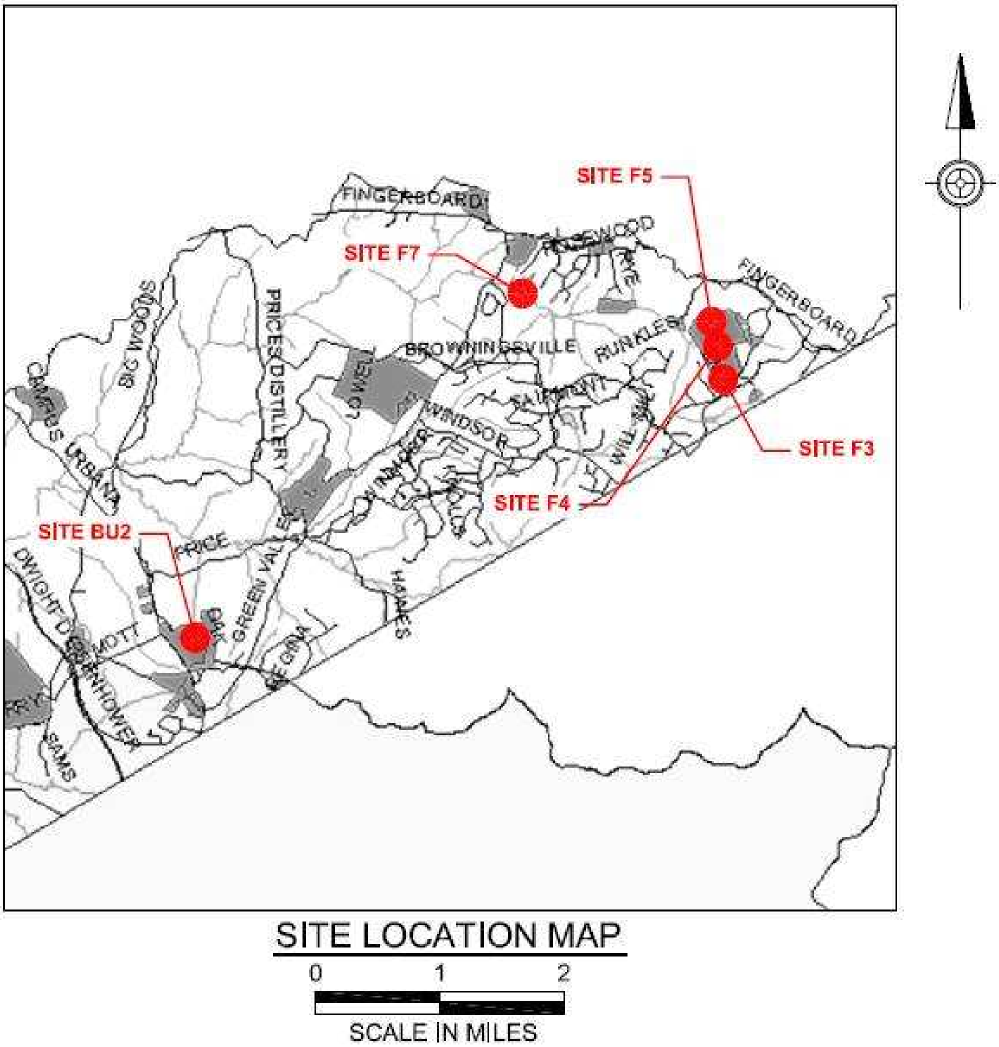
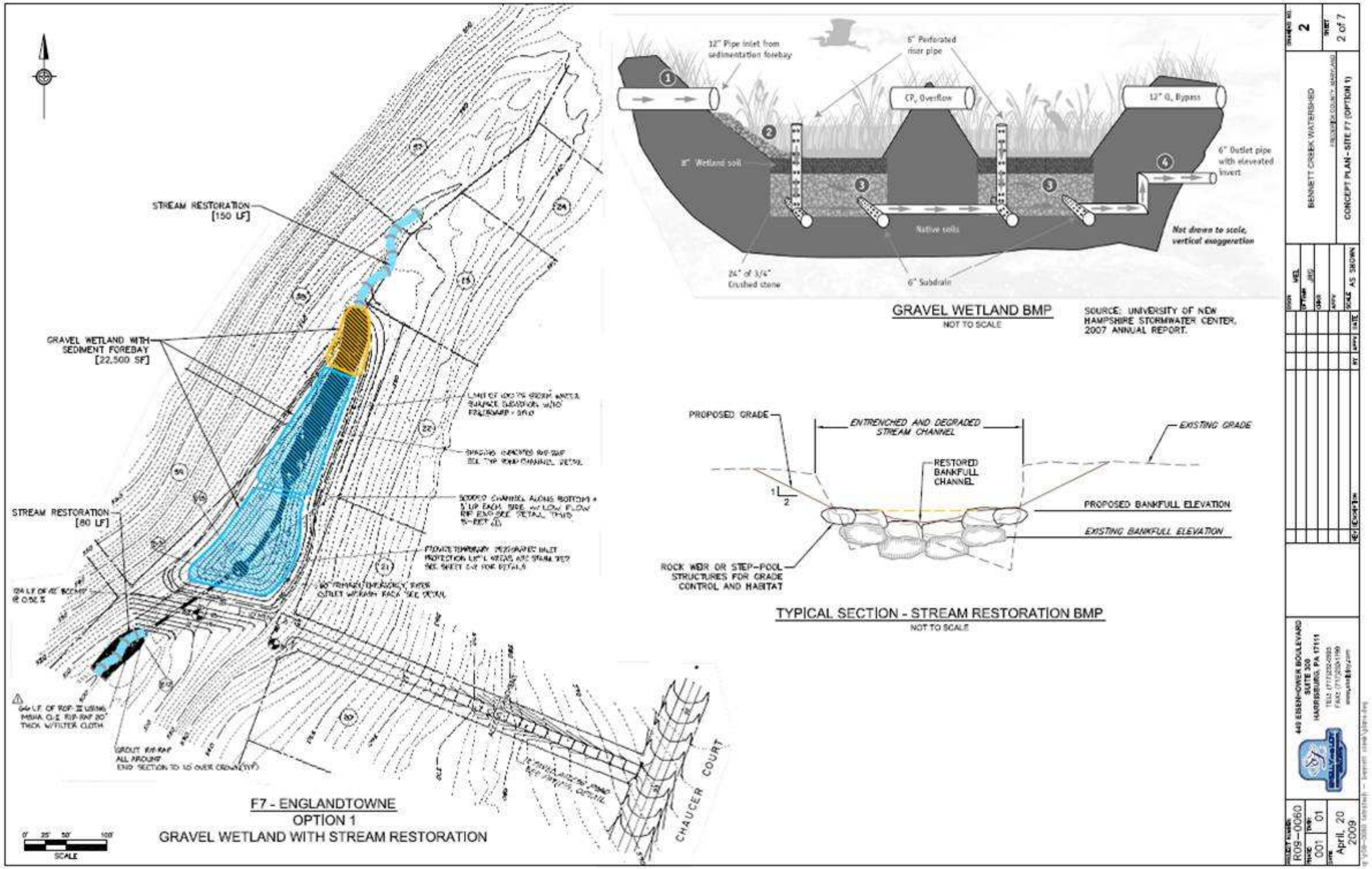
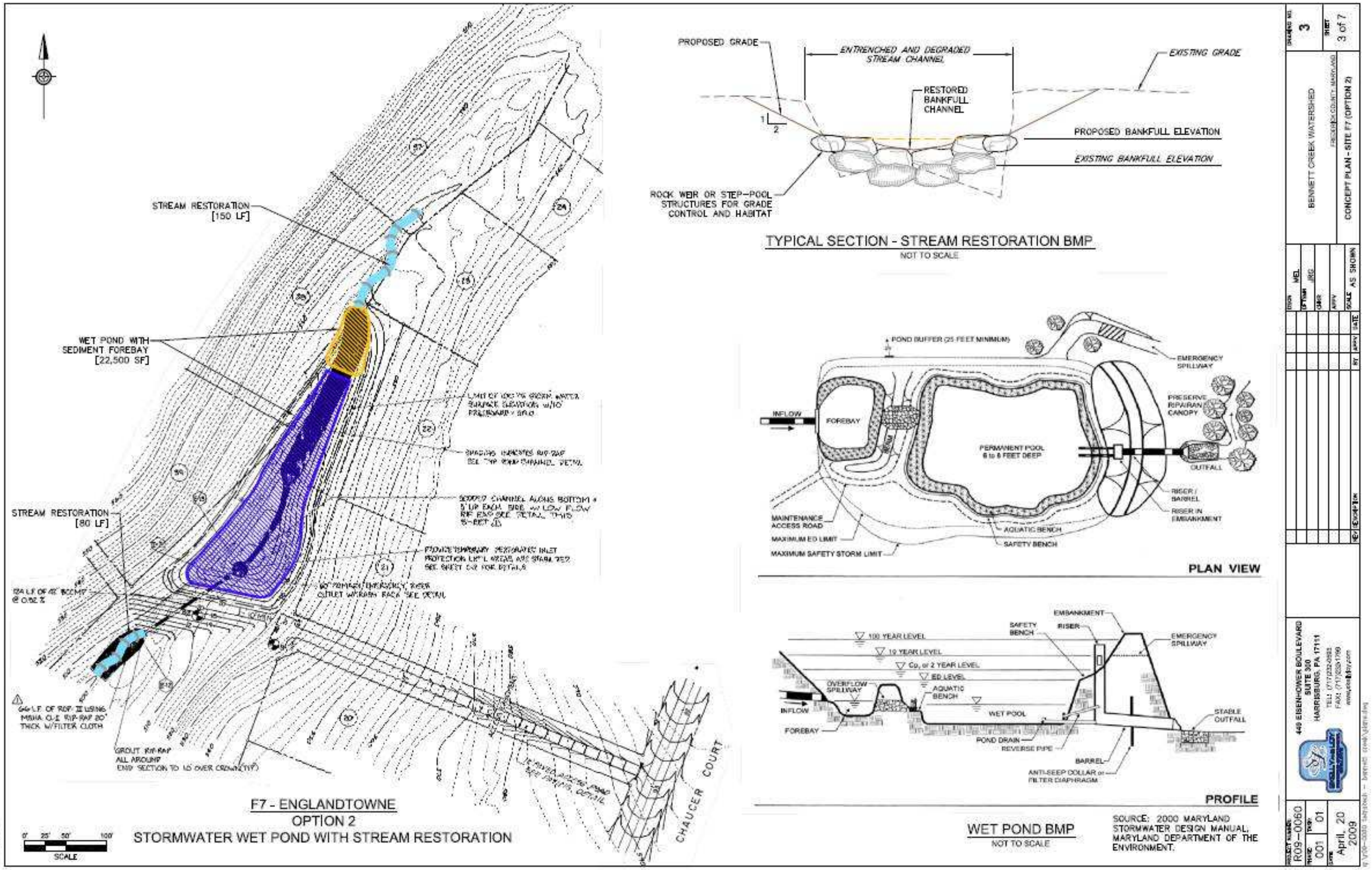


Figure 6.1. Site locations of the candidate projects for which conceptual designs were developed.

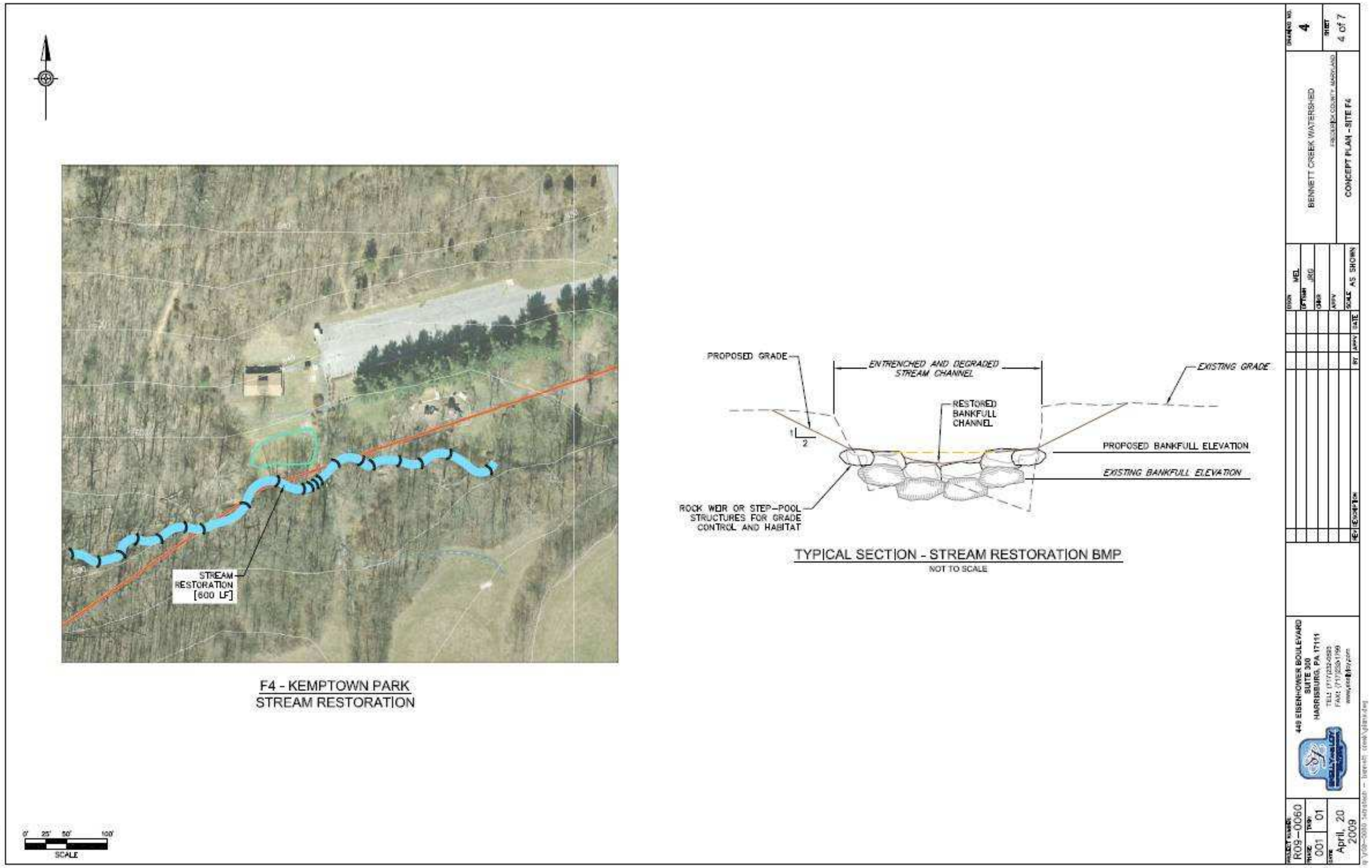
6.1 ENGLANDTOWNE SWM POND (F7) CONCEPTUAL DESIGN – OPTION 1



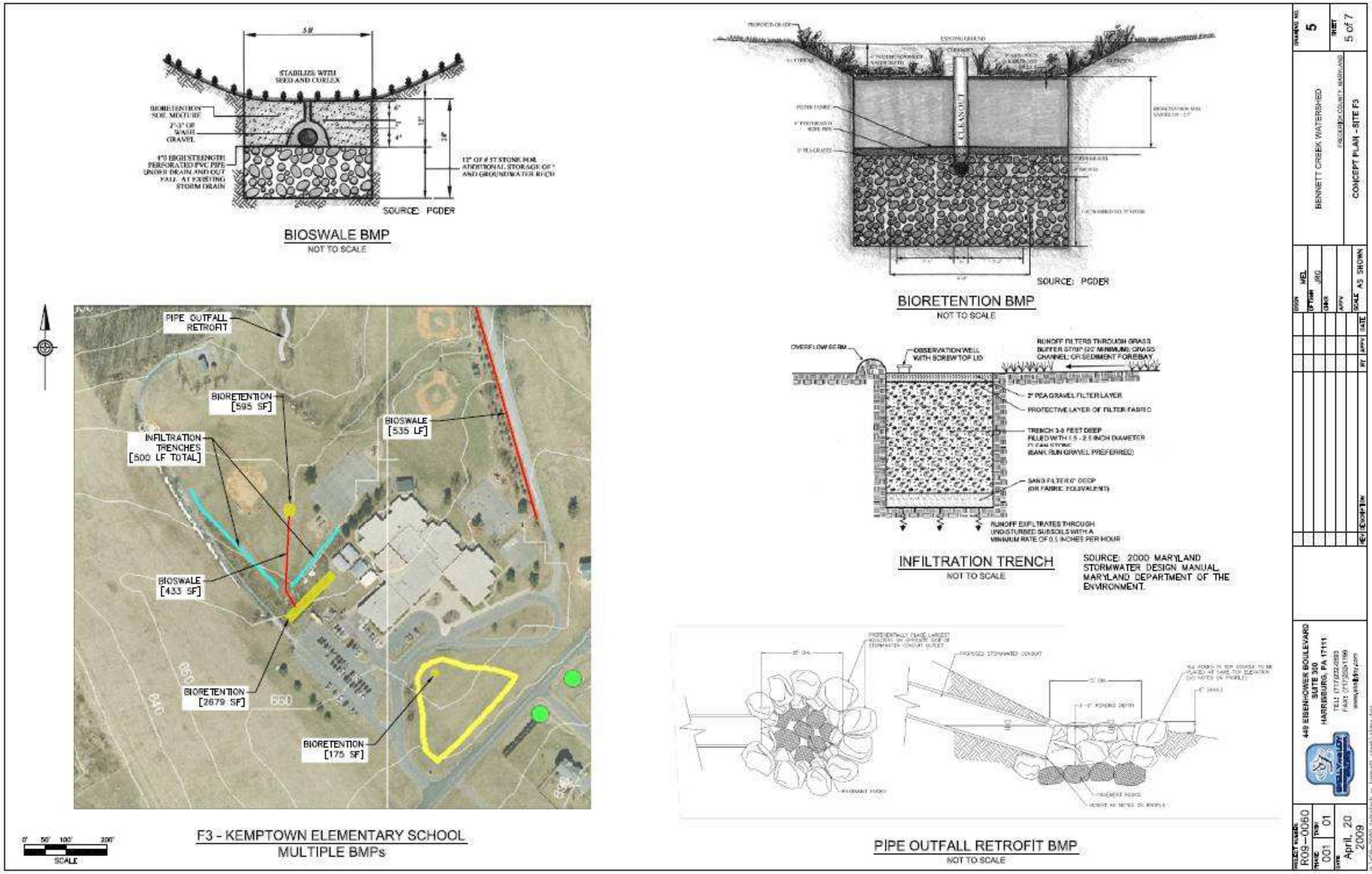
6.1 ENGLANDTOWNE SWM POND (F7) CONCEPTUAL DESIGN – OPTION 2



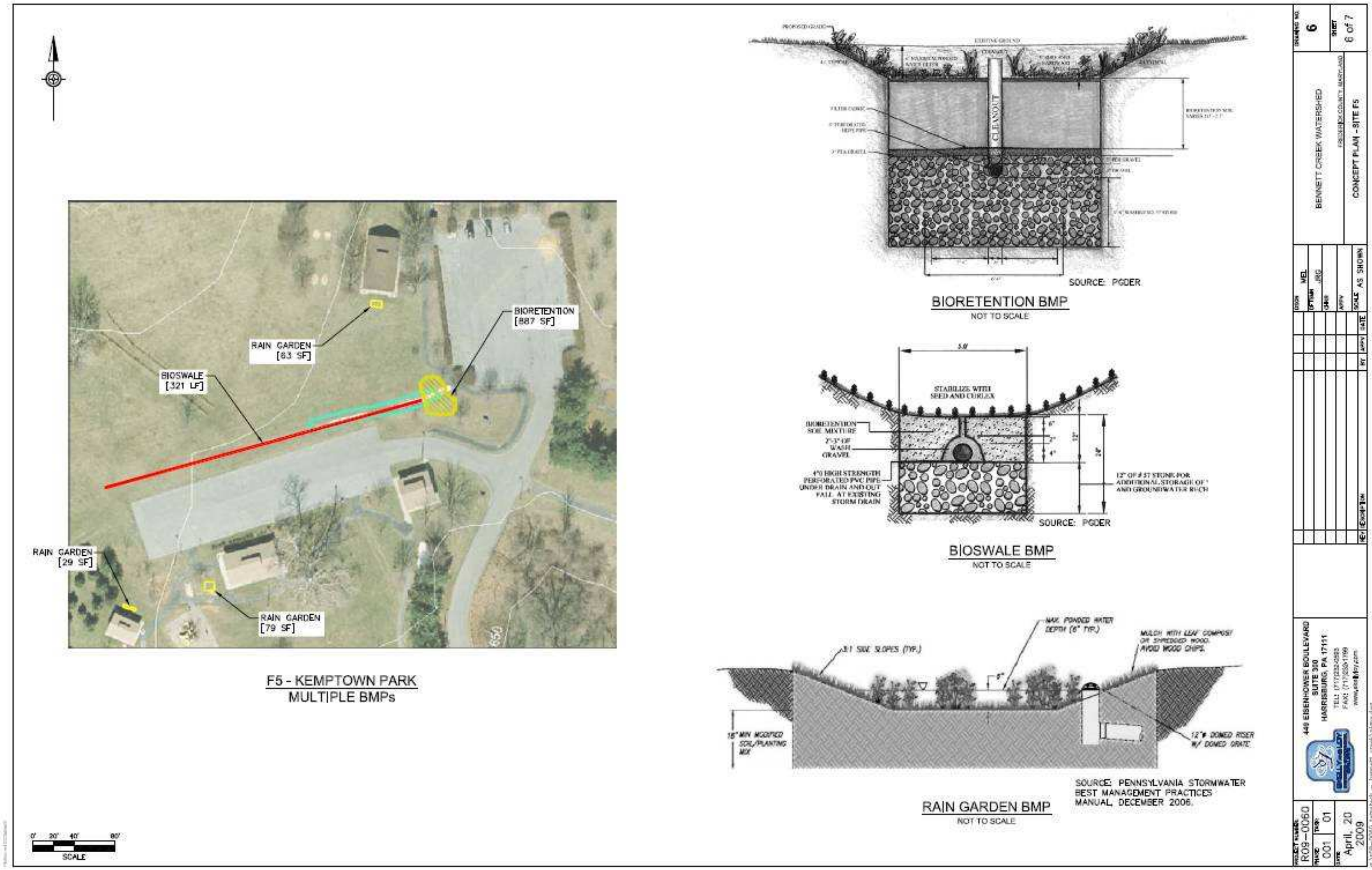
6.2 KEMPTOWN PARK STREAM RESTORATION (F4) CONCEPTUAL DESIGN



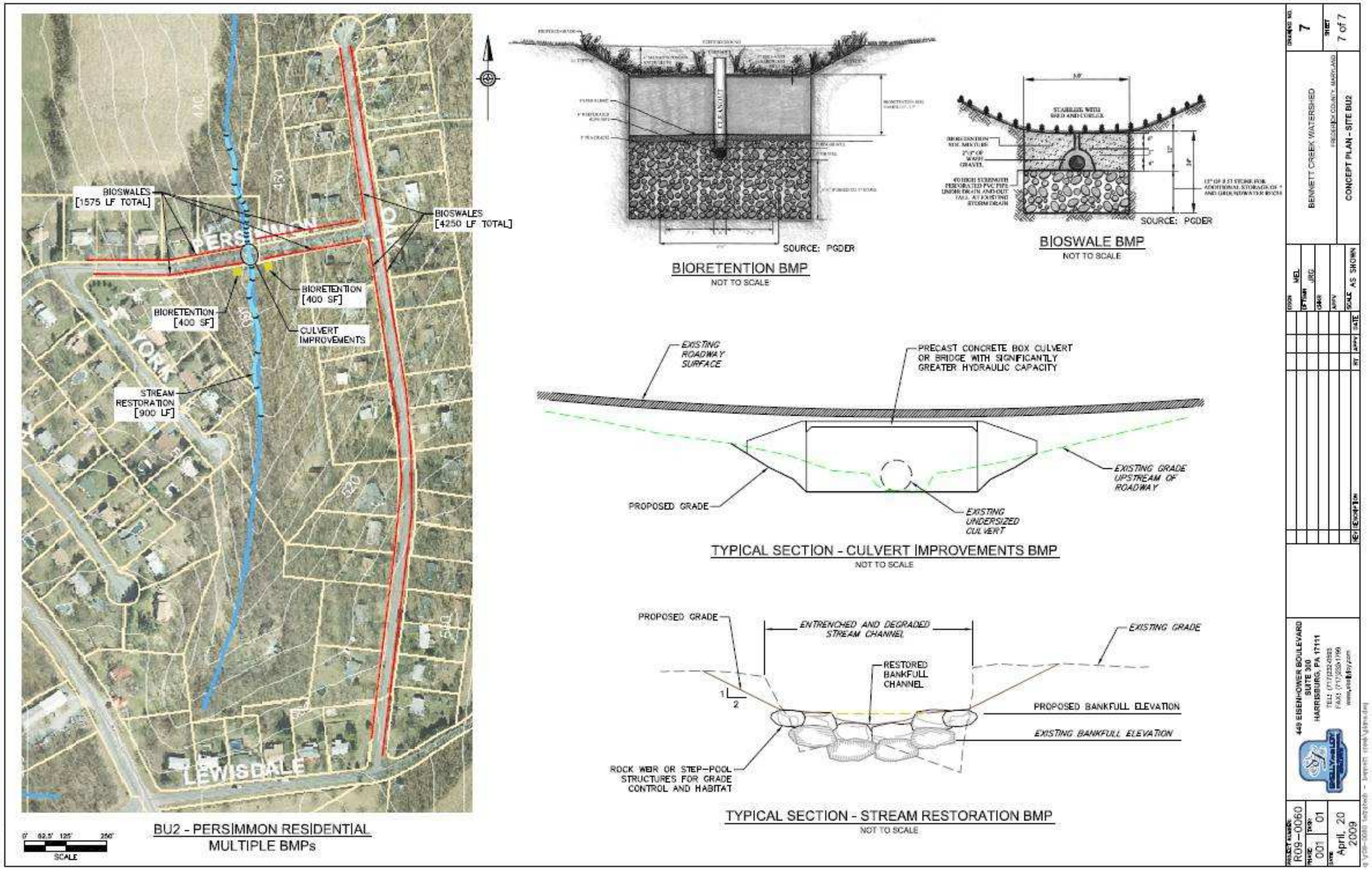
6.3 KEMPTOWN ELEMENTARY SCHOOL (F3) CONCEPTUAL DESIGN



6.4 KEMPTOWN PARK LID (F5) CONCEPTUAL DESIGN



6.5 PERSIMMON RESIDENTIAL (BU2) CONCEPTUAL DESIGN



7 MONITORING RECOMMENDATIONS

If resources permit, it is recommended that the effectiveness of the stressor reduction activities be monitored in areas where projects are implemented. Monitoring activities should be focused on those stressors the restoration projects are designed to control, which are largely degraded, instream physical habitat and elevated nutrients, and the incipient effects of storm runoff from impervious surfaces in the watershed (see stressor identification section of the Bennett Creek watershed assessment, Tetra Tech 2008a). Table 7.1 summarizes the stressors, measurement parameters, and techniques to be used to characterize the magnitude of stressors being produced at the candidate sites. In this section, recommendations are made on monitoring strategies for the five sites for which conceptual designs were developed. A single monitoring strategy that encompasses the multiple restoration approaches proposed at Kemptown Park and Kemptown Elementary School (Projects F4, F3, and F5) was recommended because the three candidate projects are located in close proximity to one another. Separate recommendations were made for Englandtowne SWM Pond (Project F7) and Persimmon Residential (Project BU2). The ensuing descriptions of different monitoring approaches are intended to provide objective demonstrations of effectiveness in stressor reduction, that is, to show that the project is doing what it was intended to do.

Table 7.1 Stressors, measurement parameters, and techniques to be used to characterize the magnitude of stressors being produced by the retrofit sites.

Stressor	Measurement parameters	Technique/indicator
Flashiness	mean daily flow	Automated logger (continuous), calculate Richards-Baker flashiness index
Erosion	TSS, MBSS physical habitat quality score	Automated storm water samples (laboratory analysis), MBSS physical habitat assessment
Elevated water temperature	degrees Celsius	Automated storm water sampler
Low dissolved oxygen	DO mg/L	Automated storm water sampler
Diminished complexity of physical habitat	MBSS physical habitat quality score	MBSS physical habitat quality assessment
Elevated nutrient concentrations	TP, TN, TKN, NOx	Automated storm water sampler, laboratory analysis

7.1 Englandtowne SWM Pond (Project F7)

The stressors targeted for management in the Englandtowne project are flashiness, erosion, elevated water temperature, low dissolved oxygen, diminished complexity of physical habitat and elevated nutrients. A single reach downstream of the SWM pond point of inflow will be assessed. The automated sampler should be placed approximately 50 meters downstream of the point of pond inflow. Physical habitat assessments and other measurements should be taken within the 100 meter reach downstream from that point. The automated sampling should be continuous for flow, temperature, and dissolved oxygen. The Richards-Baker (R-B) flashiness index, which uses flow data to quantify the frequency and rapidity of short-term changes in stream flow, would be calculated annually. Physical habitat quality assessments should be performed annually during the MBSS index period. Base flow grab samples for nutrients should be collected quarterly. Photos should be taken simultaneously with habitat assessments and potentially during storm flows. Sampling should begin at least 1-year prior to installation of the BMP or other restoration activity. There should be thorough photo-documentation during each site visit.

7. 2 Kemptown Restoration Opportunities (Projects F4, F3, and F5)

The stressors targeted for management in the three Kemptown projects are flashiness, erosion, elevated water temperature, low dissolved oxygen, diminished complexity of physical habitat and elevated nutrients. Further, due to their proximity to each other, it is recommended that a single location be monitored downstream of inflow from the three sites. The automated sampler should be placed approximately 50 meters downstream of the drainage ditch from the elementary school. Physical habitat assessments and other measurements should be within the 100 meter reach downstream from that point. The automated sampling should be continuous for flow, temperature, and dissolved oxygen. The R-B flashiness index would be calculated annually. Physical habitat quality assessments should be performed annually during the Maryland Biological Stream Survey (MBSS) index period. Base flow grab samples for nutrients should be collected quarterly. Photos should be taken simultaneously with habitat assessments and potentially during storm flows. Sampling should begin at least 1-year prior to installation of the BMPs or other restoration activities. There should be thorough photo-documentation during each site visit.

7.3 Persimmon Residential (Project BU2)

The stressors targeted for management in the Persimmon Residential project are flashiness, erosion, elevated water temperature, low dissolved oxygen, diminished complexity of physical habitat and elevated nutrients. Because the proposed restoration approaches are in close proximity to each other, it is recommended that a single location be monitored downstream of inflow from the problem areas. The assessment reach should be located downstream of the stream restoration reach but upstream of the Urbana Pike/Lewisdale Road intersection. The automated sampler should be installed at the furthest downstream end of the assessment reach (but will somehow need to be isolated from residential lots). Physical habitat assessments and other measurements should be taken within a 100 meter reach downstream from that point. The automated sampling should be continuous for flow, temperature, and dissolved oxygen. The R-B flashiness index would be calculated annually. Physical habitat quality assessments should be performed annually during the MBSS index period. Base flow grab samples for nutrients should be collected quarterly. Photos should be taken simultaneously with habitat assessments and potentially during storm flows. Sampling should begin at least 1-year prior to installation of the

BMPs or other restoration activities. There should be thorough photo-documentation during each site visit.

8 SUMMARY AND DISCUSSION

A limited number of urban areas are located in the Bennett Creek watershed. Most of these urban areas are concentrated in the north, central and eastern portions of the watershed in the Pleasant, Fahrney, Bennett Middle, Bennett Upper, North, Urbana and Monocacy Direct North subwatersheds. Urban sources in the watershed are primarily residential developments, schools, roads, parking lots and golf courses. Some of the older residential developments in the watershed do not have stormwater management controls. There are also a few small commercial and industrial developments in the watershed.

Eleven candidate urban watershed restoration projects were identified in this report. Of these, four are recommended as the best candidate projects for implementation through Frederick County's CIP program. Two other projects may also meet the requirements of the CIP program but were assigned lower priority. The remaining five projects are located on private property and were recommended as CRP projects. Six of the eleven candidate projects are located in the Fahrney subwatershed, which was rated as being most in need of restoration efforts in the Bennett Creek watershed assessment report (Tetra Tech 2008a).

Conceptual designs were developed for five candidate projects that are believed to be of the highest priority, have good potential for implementation and that represent the different types of restoration approaches that were proposed in this report. Recommendations on how to monitor the effectiveness of the stressor reduction activities at these sites were also included. The information in this report will aid the County in prioritizing and implementing projects. However, implementation of selected projects will require additional work, such as more in-depth evaluations of feasibility and constraints. In some instances it will also require contacting landowners and evaluating their willingness to participate.

In the stressor identification section of the Bennett Creek watershed assessment report, nutrient enrichment and habitat degradation were the most commonly cited candidate causes of impairment. These conditions were prevalent in problems areas in the Fahrney, Pleasant, Bennett Upper Mainstem and Monocacy Direct-North subwatersheds, where agricultural lands and residential developments were the most likely stressor sources. Excess sediment and turbidity were other probable causes of impairment at many of the impaired biological sampling sites in the Bennett Creek watershed. Frederick County has already done work to address some of these issues. Examples include the many backyard buffer projects that have been completed or are currently in progress. Most of these project areas are located in subwatersheds that have been identified as being most in need of restoration activities. These projects not only benefit the streams, but they also promote community involvement and provide educational benefits. We encourage the County to continue these efforts and to use this report as guidance for moving forward with stormwater management improvement opportunities in urban areas within the watershed.

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APPENDIX A

Table A1. Percent Land Use area for each catchment in the Bennett Creek watershed.

Catchment	Total Area (ac)	Low-density residential (%)	Medium-density residential (%)	Commercial (%)	Industrial (%)	Institutional (%)	Open Urban Land (%)	Cropland (%)	Pasture (%)	Forest (%)	Water (%)	Feedlots (%)
Bear Branch_A	365.2	5.1	0	0	0	0	0	0	7.4	87	0	0
Bear Branch_B	519.7	0	0	0	0	0	0	0	0	100	0	0
Bennett Creek - Lower Mainstem_A	305.7	10.6	0	0	0	0	0	19	21	49	0.6	0
Bennett Creek - Lower Mainstem_B	533.3	7.3	0	0	0	0	0	9.2	22	62	0	0
Bennett Creek - Lower Mainstem_C	219.1	17.1	0	0	0	0	0	26	18	40	0	0
Bennett Creek - Lower Mainstem_D	220.8	0	0	0	0	0	0	12	2.3	86	0	0
Bennett Creek - Lower Mainstem_E	473.9	2.5	0	0	0	0	0	4.7	20	72	0	0
Bennett Creek - Lower Mainstem_F	450.1	0	0	0	0	0	0	0	1.1	99	0	0
Bennett Creek - Lower Mainstem_G	344.8	0	0	0	0	0	0	6.4	4.9	89	0	0
Bennett Creek - Middle Mainstem_A	349.9	8.7	0	0	0	0	0	14	28	50	0	0
Bennett Creek - Middle Mainstem_B	163.1	0	0	0	0	0	0	10	34	55	0	0
Bennett Creek - Middle Mainstem_C	232.7	0	0	0	0	0	0	45	19	36	0	0
Bennett Creek - Middle Mainstem_D	346.5	0	2	3.9	0	3.9	0	55	5.4	29	0	0
Bennett Creek - Middle Mainstem_E	275.2	3.7	0	0.6	0	2.5	0	38	23	32	0	0
Bennett Creek - Middle Mainstem_F	282	2.4	0	0.6	0	11	0	32	12	42	0	0
Bennett Creek - Middle Mainstem_G	292.1	10.5	0	0	0	0	0	39	0	51	0	0
Bennett Creek - Middle Mainstem_H	485.8	11.9	0	28	0	0.7	0	32	2.5	25	0	0
Bennett Creek - Middle Mainstem_I	516.3	0	0	13.5	4	0	13.5	25	15	29	0.3	0
Bennett Creek - Middle Mainstem_J	135.9	5	0	0	0	0	0	55	2.5	38	0	0
Bennett Creek - Middle Mainstem_K	188.5	1.8	0	0	0	0	0	26	33	38	0.9	0
Bennett Creek - Upper Mainstem_A	383.9	0.4	0	0	0	0	0	51	9.3	39	0	0
Bennett Creek - Upper Mainstem_B	479	10.6	6	0	0	0.4	0	37	0	47	0	0
Bennett Creek - Upper Mainstem_C	446.7	14.1	0	0	0	0	0	46	0.4	40	0	0
Bennett Creek - Upper Mainstem_D	346.5	39.7	6.4	0	0	0	0	16	5.9	32	0	0
Bennett Creek - Upper Mainstem_E	453.5	22.5	0	0	0	0	0	32	4.1	42	0	0
Bennett Creek - Upper Mainstem_F	389	29.7	3.5	0	0	0	0	28	3.1	36	0	0
Bennett Creek - Upper Mainstem_G	402.5	59.9	2.5	0	0	0.4	0	19	7.2	9.7	0.8	0
Bennett Creek - Upper Mainstem_H	546.9	27.6	0	0	0	0	0	56	5.3	11	0.6	0
Bennett Creek - Upper Mainstem_I	246.3	7.6	2.8	0	4	0	0	42	20	24	0	0
Bennett Creek - Upper Mainstem_J	411	8.7	19.4	0	0	0	20.7	30	2.1	19	0	0
Bennett Creek - Upper Mainsterm_K	548.6	9.6	0.9	0	0	0	0	29	31	30	0	0
Bennett Creek - Upper Mainsterm_L	421.2	51.2	0	0	0	0	0	33	0.8	15	0.4	0
Bennett Creek - Upper Mainsterm_Z	5304.3	8.2	0.4	0.6	0	0.5	0.1	41	10	39	0	0
Fahrney Branch_A	304	1.7	0	0	0	0	0	51	3.9	43	0	0

Table A1. Continued…

Catchment	Total Area (ac)	Low-density residential (%)	Medium-density residential (%)	Commercial (%)	Industrial (%)	Institutional (%)	Open Urban Land (%)	Cropland (%)	Pasture (%)	Forest (%)	Water (%)	Feedlots (%)
Fahrney Branch_B	434.8	2.3	0	0	0	0	0	59	6.6	32	0	0
Fahrney Branch_C	288.7	0	0	0	0	0	0	59	0	41	0	0
Fahrney Branch_D	210.6	12.1	0	0	0	0	0	70	15	3.2	0	0
Fahrney Branch_E	225.9	3.8	0	15.8	5	0	0	65	0	11	0	0
Fahrney Branch_F	528.2	29.9	0	2.9	0	0.3	0	36	0	31	0	0
Fahrney Branch_G	373.7	43.2	0	1.4	0	0	0	8.6	11	36	0	0
Fahrney Branch_H	378.8	35	1.8	0	0	9.4	16.1	14	2.7	21	0	0
Fahrney Branch_I	219.1	62	0	0	0	0.8	0	0	16	22	0	0
Fahrney Branch_J	256.5	24.5	0	0	0	0	0	68	0	7.3	0	0
Fahrney Branch_K	191.9	28.3	0	0	0	0	0	64	0	8	0	0
Fahrney Branch_L	276.9	1.2	0	0	0	0	0	58	0	41	0	0
Fahrney Branch_M	387.3	6.6	0	0	0	0	0	77	0	17	0	0
Fahrney Branch_N	343.1	1	0	0	0	0	0	56	12	31	0	0
Furnace Branch_A	173.2	0	0	0	0	0	0	7.8	1	91	0	0
Furnace Branch_B	672.6	2.5	0	0	0	0	0	0	0	97	0.5	0
Furnace Branch_C	521.4	0	0	0	0	0	0	13	22	66	0	0
Lilypons_A	543.5	0	0	0	0	0	0	81	4.1	14	0.9	0
Lilypons_B	409.3	0	0	0	0	0	0	7.9	40	52	0	0
Lilypons_C	665.8	0	0	0	0	0	0	35	27	38	0	0
Little Bennett Creek_A	259.9	3.9	0	0	0	0	0	11	27	59	0	0
Little Bennett Creek_B	319.3	10.6	0	0	0	0	0	12	30	47	0	0
Little Bennett Creek_C	485.8	9.8	0	5.6	0	0	0	19	8	58	0	0
Little Bennett Creek_D	429.7	8.3	0.8	6.7	0	1.6	10.3	36	4.7	32	0	0
Little Bennett Creek_E	477.3	10.3	0	1.4	0	1.1	3.2	26	6.8	52	0	0
Little Bennett Creek_F	492.6	2.4	0	0	0	0	0	24	16	58	0	0
Little Bennett Creek_G	485.8	2.5	0	0	0	0.4	0	36	9.8	51	0	0
Little Bennett Creek_Z	10145	6.5	1.93	0.4	0	0.5	1.2	28	9.8	52	0.2	0
Little Monocacy River_A	351.6	0	0	0	0	0	0	4.4	33	62	0.5	0
Little Monocacy River_B	135.9	0	0	0	0	0	0	0	45	55	0	0
Little Monocacy River_C	514.6	0.3	0	0	0	0	0	36	18	46	0	0
Little Monocacy River_Z	10947	4.5	0.1	0.2	3	0.2	0.1	42	12	39	0.2	0
Monocacy Direct - North_A	414.4	6.6	0	0	0	0	0	49	7.8	31	5.7	0
Monocacy Direct - North_B	434.8	18	0	0.4	0	0.4	0	2.3	9.4	69	0.4	0
Monocacy Direct - North_C	348.2	19	0	0	0	0	0	18	27	35	2	0

Table A1. Continued…

Catchment	Total Area (ac)	Low-density residential (%)	Medium-density residential (%)	Commercial (%)	Industrial (%)	Institutional (%)	Open Urban Land (%)	Cropland (%)	Pasture (%)	Forest (%)	Water (%)	Feedlots (%)
Monocacy Direct - North_D	237.8	0	0	0	0	0	0.7	44	2.9	50	2.1	0
Monocacy Direct - North_E	195.3	0	0	0	1	0	0	11	0	70	17	0
Monocacy Direct - North_F	188.5	0	0	0	1	0	0	46	4.5	38	11	0
Monocacy Direct - North_G	356.7	0	0	0	0	0	0	75	0	25	0	0
Monocacy Direct - North_H	439.9	2.7	0	0	0	0	0	57	0.8	39	0	0
Monocacy Direct - North_I	334.6	0	0	0	0	0	0	78	2.5	19	0	0
Monocacy Direct - North_J	317.6	21.4	0	0	0	0	0.5	20	0	58	0	0
Monocacy Direct - North_K	241.2	12.7	0	0	0	0	0	38	24	25	0	0
Monocacy Direct - North_L	283.7	7.8	0	0	0	0	0	73	2.4	17	0	0
Monocacy Direct - South_A	258.2	0	0	0	0	0	0	28	9.9	55	6.6	0
Monocacy Direct - South_B	237.8	0	0	0	0	0	0	79	0	21	0	0
Monocacy Direct - South_C	246.3	0	0	0	0	0	0	59	0	34	7.6	0
Monocacy Direct - South_D	159.7	0	0	0	0	0	0	26	8.5	66	0	0
Monocacy Direct - South_E	154.6	0	0	0	0	0	0	0	0	90	9.9	0
Monocacy Direct - South_F	470.5	1.1	0	0	0	0	0	8.7	5.8	84	0.4	0
Monocacy Direct - South_G	414.4	11.5	0	0	0	0	0	37	1.6	48	1.2	0
Monocacy Direct - South_H	348.2	0	0	0	0	0	0	19	0	68	14	0
Monocacy Direct - South_I	400.8	0	0	0	0	0	0	14	8.1	78	0	0
Monocacy Direct - South_J	619.9	2.5	0	0	0	0	0	30	32	36	0	0
North Branch_A	258.2	27.6	0	0	0	0	0	11	15	46	0	0
North Branch_B	266.7	12.1	0	0	0	0	7	45	5.7	30	0	0
North Branch_C	225.9	0	0	0	0	0	57.1	37	3.8	1.5	0.8	0
North Branch_D	144.4	17.7	0	0	0	0	23.5	19	26	14	0	0
Pleasant Branch_A	429.7	33.2	4.7	0	0	0	0	37	4.4	21	0	0
Pleasant Branch_B	404.2	48.7	20.6	0	0	2.1	0	14	4.6	9.7	0	0
Pleasant Branch_C	455.2	61.2	3.4	0	0	0	3.4	19	0	13	0	0
Sugarloaf_A	322.7	3.7	0	0	0	0	0	3.7	31	62	0	0
Sugarloaf_B	389	0.9	0	0	0	0	0	3.5	11	84	0.4	0
Sugarloaf_C	390.7	0	0	0	0	0	0	13	32	55	0	0
Sugarloaf_D	305.7	11.1	0	0	0	0	0	27	27	35	0	0
Sugarloaf_E	283.7	0	0	0	0	0	0	33	37	31	0	0
Sugarloaf_F	477.3	8.5	0	0	0	0	0	49	18	25	0	0
Sugarloaf_G	450.1	0	0	0	0	0	0	3.4	0	97	0	0

Table A1. Continued…

Catchment	Total Area (ac)	Low-density residential (%)	Medium-density residential (%)	Commercial (%)	Industrial (%)	Institutional (%)	Open Urban Land (%)	Cropland (%)	Pasture (%)	Forest (%)	Water (%)	Feedlots (%)
Urbana Branch_A	191.9	22.1	0	0	0	0	0	4.4	2.7	71	0	0
Urbana Branch_B	222.5	42	0	0	0	0	0	25	8.4	24	0	0
Urbana Branch_C	528.2	13.5	0	0.6	0	2.6	9	51	7.1	16	0	0
Urbana Branch_D	324.4	11.5	0	0	0	0	0	35	15	38	0	0

Table A2. Major Hydrologic Soil Group for each catchment in the Bennett Creek watershed (acres).

Catchment	Total Area	HSG A	HSG B	HSG C	HSG D	HSG U	HSG B-C	HSG C-D	Water	Major HSG
Bear Branch_A	365.2	0	103.6	0	42.5	217.4	0	0	0	U
Bear Branch_B	519.7	0	0	0	1.7	518	0	0	0	U
Bennett Creek - Lower Mainstem_A	305.7	0	69.6	0	22.1	0	3.4	0	0	B
Bennett Creek - Lower Mainstem_B	533.3	0	248	0	57.8	0	0	0	0	B
Bennett Creek - Lower Mainstem_C	219.1	0	13.6	0	15.3	0	0	0	0	D
Bennett Creek - Lower Mainstem_D	220.8	0	1.7	0	1.7	110.4	0	0	0	U
Bennett Creek - Lower Mainstem_E	473.9	0	0	0	11.9	105.3	0	0	0	U
Bennett Creek - Lower Mainstem_F	450.1	0	0	0	0	419.5	0	0	0	U
Bennett Creek - Lower Mainstem_G	344.8	0	139.3	0	15.3	190.2	0	0	0	U
Bennett Creek - Middle Mainstem_A	349.9	0	129.1	0	0	0	0	0	0	B
Bennett Creek - Middle Mainstem_B	163.1	0	95.1	0	0	22.1	0	0	0	B
Bennett Creek - Middle Mainstem_C	232.7	0	203.8	0	0	0	0	0	0	B
Bennett Creek - Middle Mainstem_D	346.5	0	220.8	0	0	0	0	0	0	B
Bennett Creek - Middle Mainstem_E	275.2	0	83.2	0	59.5	0	0	0	0	B
Bennett Creek - Middle Mainstem_F	282	0	215.7	0	47.6	0	0	0	0	B
Bennett Creek - Middle Mainstem_G	292.1	0	270.1	0	17	0	0	0	0	B
Bennett Creek - Middle Mainstem_H	485.8	0	47.6	0	28.9	0	0	0	0	B
Bennett Creek - Middle Mainstem_I	516.3	0	249.7	0	0	73	0	0	0	B
Bennett Creek - Middle Mainstem_J	135.9	0	57.8	0	17	0	0	0	0	B
Bennett Creek - Middle Mainstem_K	188.5	0	125.7	0	0	51	0	0	0	B
Bennett Creek - Upper Mainstem_A	383.9	0	125.7	0	61.2	0	0	0	0	B
Bennett Creek - Upper Mainstem_B	479	0	365.2	0	25.5	0	0	0	0	B
Bennett Creek - Upper Mainstem_C	446.7	0	152.9	0	47.6	0	0	0	0	B
Bennett Creek - Upper Mainstem_D	346.5	0	113.8	0	18.7	0	0	0	0	B
Bennett Creek - Upper Mainstem_E	453.5	0	79.8	0	27.2	0	0	0	0	B
Bennett Creek - Upper Mainstem_F	389	0	62.8	0	0	0	0	0	0	B
Bennett Creek - Upper Mainstem_G	402.5	0	210.6	0	0	0	0	0	0	B
Bennett Creek - Upper Mainstem_H	546.9	0	460.3	0	67.9	0	0	0	0	B
Bennett Creek - Upper Mainstem_I	246.3	0	185.1	0	25.5	0	0	0	0	B
Bennett Creek - Upper Mainstem_J	411	0	208.9	0	0	0	0	0	0	B
Bennett Creek - Upper Mainsterm_K	548.6	0	324.4	0	3.4	0	0	0	0	B
Bennett Creek - Upper Mainsterm_L	421.2	0	200.4	0	5.1	0	0	0	0	B
Bennett Creek - Upper Mainsterm_Z	5304.3	0	1369	0	302.3	0	0	0	0	B

Table A2. Continued…

Catchment	Total Area	HSG A	HSG B	HSG C	HSG D	HSG U	HSG B-C	HSG C-D	Water	Major HSG
Fahrney Branch_A	304	0	166.5	0	45.9	0	0	0	0	B
Fahrney Branch_B	434.8	0	241.2	0	44.2	0	0	0	0	B
Fahrney Branch_C	288.7	0	6.8	0	30.6	0	0	0	0	D
Fahrney Branch_D	210.6	0	18.7	0	1.7	0	0	0	0	B
Fahrney Branch_E	225.9	0	61.2	0	13.6	0	0	0	0	B
Fahrney Branch_F	528.2	0	35.7	0	52.7	0	0	0	0	D
Fahrney Branch_G	373.7	0	0	0	32.3	0	0	0	0	D
Fahrney Branch_H	378.8	0	190.2	0	8.5	0	0	0	0	B
Fahrney Branch_I	219.1	0	124	0	27.2	0	0	0	0	B
Fahrney Branch_J	256.5	0	73	0	6.8	0	0	0	0	B
Fahrney Branch_K	191.9	0	149.5	0	3.4	0	0	0	0	B
Fahrney Branch_L	276.9	0	76.4	0	32.3	0	0	0	0	B
Fahrney Branch_M	387.3	0	27.2	0	39.1	0	0	0	0	D
Fahrney Branch_N	343.1	0	91.7	0	23.8	0	0	0	0	B
Furnace Branch_A	173.2	0	61.2	0	22.1	40.8	0	0	0	B
Furnace Branch_B	672.6	0	108.7	0	57.8	506.2	0	0	0	U
Furnace Branch_C	521.4	0	220.8	0	56.1	142.7	0	0	0	B
Lilypons_A	543.5	0	1.7	0	98.5	180	8.5	0	0	U
Lilypons_B	409.3	0	5.1	0	3.4	56.1	0	0	0	U
Lilypons_C	665.8	0	0	0	98.5	51	0	0	0	D
Little Bennett Creek_A	259.9	0	27.2	0	25.5	0	0	0	0	B
Little Bennett Creek_B	319.3	0	181.7	0	56.1	0	0	0	0	B
Little Bennett Creek_C	485.8	0	0	0	0	0	0	0	0	A
Little Bennett Creek_D	429.7	0	156.3	0	0	0	0	0	0	B
Little Bennett Creek_E	477.3	0	76.4	0	98.5	0	0	0	0	D
Little Bennett Creek_F	492.6	0	129.1	0	39.1	0	0	0	0	B
Little Bennett Creek_G	485.8	0	5.1	0	56.1	0	0	0	0	D
Little Bennett Creek_Z	10145	0	2692.1	0	385.6	0	1.7	0	18.7	B
Little Monocacy River_A	351.6	0	227.6	0	0	115.5	0	0	0	B
Little Monocacy River_B	135.9	0	132.5	0	0	0	0	0	0	B
Little Monocacy River_C	514.6	0	389	0	0	56.1	0	0	0	B
Little Monocacy River_Z	10946.7	0	3149	0	606.4	81.5	0	1962	5.1	B
Monocacy Direct - North_A	414.4	0	181.7	0	0	0	83.2	0	0	B

Table A2. Continued…

Catchment	Total Area	HSG A	HSG B	HSG C	HSG D	HSG U	HSG B-C	HSG C-D	Water	Major HSG
Monocacy Direct - North_B	434.8	0	28.9	0	0	0	13.6	0	0	B
Monocacy Direct - North_C	348.2	0	149.5	0	27.2	0	28.9	0	0	B
Monocacy Direct - North_D	237.8	0	81.5	0	0	0	39.1	0	0	B
Monocacy Direct - North_E	195.3	0	86.6	0	0	0	34	0	0	B
Monocacy Direct - North_F	188.5	0	103.6	0	39.1	0	25.5	0	0	B
Monocacy Direct - North_G	356.7	0	86.6	0	42.5	0	0	0	0	B
Monocacy Direct - North_H	439.9	0	0	0	73	0	0	0	0	D
Monocacy Direct - North_I	334.6	0	0	0	0	0	0	0	0	A
Monocacy Direct - North_J	317.6	0	0	0	0	0	0	0	0	A
Monocacy Direct - North_K	241.2	0	47.6	0	0	0	3.4	0	0	B
Monocacy Direct - North_L	283.7	0	8.5	0	1.7	0	28.9	0	0	B-C
Monocacy Direct - South_A	258.2	0	15.3	0	0	0	0	221	5.1	C-D
Monocacy Direct - South_B	237.8	0	20.4	0	0	10.2	0	144	0	C-D
Monocacy Direct - South_C	246.3	0	28.9	0	0	15.3	57.8	144	0	C-D
Monocacy Direct - South_D	159.7	0	0	0	17	67.9	6.8	67.9	0	U
Monocacy Direct - South_E	154.6	0	0	0	1.7	84.9	8.5	17	0	U
Monocacy Direct - South_F	470.5	0	0	0	5.1	212.3	0	0	0	U
Monocacy Direct - South_G	414.4	0	0	0	69.6	0	3.4	0	0	D
Monocacy Direct - South_H	348.2	0	0	0	8.5	1.7	49.3	0	0	B-C
Monocacy Direct - South_I	400.8	0	0	0	39.1	217.4	0	0	0	U
Monocacy Direct - South_J	619.9	0	25.5	0	23.8	37.4	0	11.9	0	U
North Branch_A	258.2	0	0	0	25.5	0	0	0	0	D
North Branch_B	266.7	0	0	0	1.7	0	0	0	0	D
North Branch_C	225.9	0	37.4	0	0	0	0	0	0	B
North Branch_D	144.4	0	129.1	0	0	0	0	0	0	B
Pleasant Branch_A	429.7	0	71.3	0	44.2	0	0	0	0	B
Pleasant Branch_B	404.2	0	137.6	0	13.6	0	0	0	0	B
Pleasant Branch_C	455.2	0	190.2	0	8.5	0	0	0	0	B
Sugarloaf_A	322.7	0	134.2	0	1.7	42.5	0	0	0	B
Sugarloaf_B	389	0	84.9	0	20.4	158	0	0	0	U
Sugarloaf_C	390.7	0	237.8	0	59.5	81.5	0	0	0	B
Sugarloaf_D	305.7	0	62.8	0	5.1	0	0	0	0	B
Sugarloaf_E	283.7	0	42.5	0	25.5	0	0	0	0	B

Table A2. Continued…

Catchment	Total Area	HSG A	HSG B	HSG C	HSG D	HSG U	HSG B-C	HSG C-D	Water	Major HSG
Sugarloaf_F	477.3	0	74.7	0	20.4	0	0	0	0	B
Sugarloaf_G	450.1	0	100.2	0	25.5	324.4	0	0	0	U
Urbana Branch_A	191.9	0	0	0	8.5	0	0	0	0	D
Urbana Branch_B	222.5	0	76.4	0	0	0	0	0	0	B
Urbana Branch_C	528.2	0	438.2	0	0	0	0	0	0	B
Urbana Branch_D	324.4	0	110.4	0	17	0	0	0	0	B

Table A3. Annual pollutant loadings for each catchment in the Bennett Creek watershed (lb/ac/yr).

Catchment	Total Area (acres)	BOD	TN	TP	TSS
Bear Branch_A	365.2	3.47	1.75	0.32	203.83
Bear Branch_B	519.7	0.86	0.64	0.19	97.7
Bennett Creek - Lower Mainstem_A	305.7	10.09	5.42	0.85	701.76
Bennett Creek - Lower Mainstem_B	533.3	8.27	4.29	0.64	492.33
Bennett Creek - Lower Mainstem_C	219.1	18.83	6.97	1.25	827.25
Bennett Creek - Lower Mainstem_D	220.8	3.03	2.07	0.43	338.86
Bennett Creek - Lower Mainstem_E	473.9	9.26	3.77	0.62	420.87
Bennett Creek - Lower Mainstem_F	450.1	1.14	0.77	0.21	114.45
Bennett Creek - Lower Mainstem_G	344.8	2.89	1.83	0.36	267.64
Bennett Creek - Middle Mainstem_A	349.9	10.62	5.53	0.82	677.73
Bennett Creek - Middle Mainstem_B	163.1	11.56	6.12	1.04	1086
Bennett Creek - Middle Mainstem_C	232.7	11.56	7.28	1.22	1123.45
Bennett Creek - Middle Mainstem_D	346.5	12.63	7.35	1.25	1039.31
Bennett Creek - Middle Mainstem_F	282	11.54	6.09	1.01	795.74
Bennett Creek - Middle Mainstem_G	292.1	7.78	4.99	0.9	729.56
Bennett Creek - Middle Mainstem_H	485.8	18.94	7.02	1	659.6
Bennett Creek - Middle Mainstem_I	516.3	14.81	6.76	0.93	677.13
Bennett Creek - Middle Mainstem_J	135.9	11.26	7.37	1.49	1526.46
Bennett Creek - Middle Mainstem_K	188.5	14.03	7.79	1.36	1427.69
Bennett Creek - Upper Mainstem_A	383.9	9.77	6.6	1.13	984.52
Bennett Creek - Upper Mainstem_B	479	9.16	5.1	0.89	644.3
Bennett Creek - Upper Mainstem_C	446.7	9.2	5.8	1.01	784.95
Bennett Creek - Upper Mainstem_D	346.5	12.69	5.31	0.82	460.63
Bennett Creek - Upper Mainstem_E	453.5	9.61	5.3	0.88	629.41
Bennett Creek - Upper Mainstem_F	389	11.06	5.4	0.88	580.64
Bennett Creek - Upper Mainstem_G	402.5	15.77	6.63	0.98	542.16
Bennett Creek - Upper Mainstem_H	546.9	13.75	7.95	1.28	972.57
Bennett Creek - Upper Mainstem_I	246.3	14.45	7.95	1.29	1094.61
Bennett Creek - Upper Mainstem_J	411	13.48	6.46	0.99	620.26
Bennett Creek - Upper Mainsterm_K	548.6	13.52	7.34	1.08	878.61
Bennett Creek - Upper Mainsterm_L	421.2	13.74	6.56	1.03	640.89
Bennett Creek - Upper Mainsterm_Z	5304.3	9.28	5.68	0.82	504.88
Fahrney Branch_A	304	8.91	6.17	1.1	965.48
Fahrney Branch_B	434.8	10.43	7.13	1.22	1048.38
Fahrney Branch_C	288.7	12.67	6.61	1.43	1047.67
Fahrney Branch_D	210.6	15.92	9.88	1.67	1504.33

Table A3. Continued…

Catchment	Total Area (acres)	BOD	TN	TP	TSS
Fahrney Branch_E	225.9	18.04	9	1.49	1233.59
Fahrney Branch_F	528.2	18.63	6.53	1.26	680.52
Fahrney Branch_G	373.7	21.06	6.08	1.05	464.58
Fahrney Branch_H	378.8	12.99	5.67	0.79	394.27
Fahrney Branch_I	219.1	14.95	5.7	0.77	371.06
Fahrney Branch_J	256.5	14.05	8.6	1.48	1227.89
Fahrney Branch_K	191.9	15.54	9.09	1.71	1616.05
Fahrney Branch_L	276.9	8.79	6.34	1.17	1028.88
Fahrney Branch_M	387.3	17.69	8.67	1.78	1265.09
Fahrney Branch_N	343.1	11.27	7.48	1.27	1124.52
Furnace Branch_A	173.2	2.54	1.72	0.41	360.37
Furnace Branch_B	672.6	1.28	0.78	0.21	102.2
Lilypons_A	543.5	17.93	9.11	1.81	1298.36
Lilypons_B	409.3	11.24	5.86	0.82	721.24
Lilypons_C	665.8	18.52	7.71	1.27	871.41
Little Bennett Creek_A	259.9	9.33	4.93	0.75	650.04
Little Bennett Creek_B	319.3	11.29	5.75	0.85	697.32
Little Bennett Creek_C	485.8	6.35	4.14	0.58	477.67
Little Bennett Creek_D	429.7	11.85	6.22	0.95	707.9
Little Bennett Creek_E	477.3	13.41	5.19	0.99	582.85
Little Bennett Creek_F	492.6	8.05	4.82	0.78	638.41
Little Bennett Creek_G	485.8	12.87	5.73	1.11	740.43
Little Bennett Creek_Z	10145	7.79	4.5	0.64	339.43
Little Monocacy River_A	351.6	9.22	4.77	0.69	605.56
Little Monocacy River_B	135.9	12.74	6.33	1.01	1078.6
Little Monocacy River_C	514.6	9.7	6.05	0.97	822.19
Little Monocacy River_Z	10946.7	9.37	5.79	0.81	451.13
Monocacy Direct - North_A	414.4	10.41	6.68	1.16	1020.76
Monocacy Direct - North_B	434.8	6.59	2.92	0.46	272.57
Monocacy Direct - North_C	348.2	12.72	6.39	0.95	766.51
Monocacy Direct - North_D	237.8	7.71	5.42	1.01	915.46
Monocacy Direct - North_E	195.3	4.33	2.63	0.71	838.75
Monocacy Direct - North_F	188.5	10.42	6.73	1.42	1562.49
Monocacy Direct - North_G	356.7	10.68	7.85	1.4	1240.23
Monocacy Direct - North_H	439.9	13.12	6.55	1.37	950.38
Monocacy Direct - North_I	334.6	9.04	8.67	1.37	1340.84

Table A3. Continued…

Catchment	Total Area (acres)	BOD	TN	TP	TSS
Monocacy Direct - North_J	317.6	4.66	3.64	0.53	412.24
Monocacy Direct - North_K	241.2	13.82	7.78	1.24	1074.69
Monocacy Direct - North_L	283.7	12.47	8.44	1.49	1304.59
Monocacy Direct - South_A	258.2	9.47	4.78	0.96	816.28
Monocacy Direct - South_B	237.8	14.17	8.23	1.68	1399.66
Monocacy Direct - South_C	246.3	11.22	6.48	1.38	1197.47
Monocacy Direct - South_D	159.7	10.71	4.91	1.1	927.06
Monocacy Direct - South_E	154.6	1.81	1.09	0.37	408.94
Monocacy Direct - South_F	470.5	4.76	2.25	0.49	302.55
Monocacy Direct - South_G	414.4	12.55	5.37	1.13	717.27
Monocacy Direct - South_H	348.2	3.96	2.73	0.62	609.99
Monocacy Direct - South_I	400.8	6.04	2.93	0.59	406.01
Monocacy Direct - South_J	619.9	12.38	7.07	1.04	874.67
North Branch_A	258.2	18.14	5.83	1.02	556.83
North Branch_B	266.7	16.73	7.15	1.38	945.51
North Branch_C	225.9	9.82	7.32	0.97	785.51
North Branch_D	144.4	14.79	7.96	1.2	1118.69
Pleasant Branch_A	429.7	13.47	6.68	1.07	727.67
Pleasant Branch_B	404.2	18.39	6.6	1	450.79
Pleasant Branch_C	455.2	14.5	6.01	0.89	427.32
Sugarloaf_A	322.7	9.19	4.64	0.67	568.89
Sugarloaf_B	389	4.06	2.26	0.4	301.99
Sugarloaf_C	390.7	10.03	5.45	0.81	701.67
Sugarloaf_D	305.7	12.63	6.88	1.06	895.84
Sugarloaf_E	283.7	13.95	8	1.23	1124.89
Sugarloaf_F	477.3	12.76	7.73	1.23	1028.5
Sugarloaf_G	450.1	1.31	0.97	0.25	149.78
Urbana Branch_A	191.9	10.38	3.15	0.7	345.76
Urbana Branch_B	222.5	13.19	6.28	0.99	674.94
Urbana Branch_C	528.2	12.66	7.61	1.19	919.1
Urbana Branch_D	324.4	10.99	6.36	1.03	856.62

Table A4. Percent load reduction required for each catchment to meet 'reference' condition (as determined from biological data).

Catchment	Total Area (acres)	Load Reduction Required BOD 5.8 (lb/ac/yr)	TN 2.82 (lb/ac/yr)	TP 0.49 (lb/ac/yr)	TSS 350.06 (lb/ac/yr)
Bear Branch_A	365.2	0%	0%	0%	0%
Bear Branch_B	519.7	0%	0%	0%	0%
Bennett Creek - Lower Mainstem_A	305.7	43%	48%	42%	50%
Bennett Creek - Lower Mainstem_B	533.3	30%	34%	23%	29%
Bennett Creek - Lower Mainstem_C	219.1	69%	60%	60%	58%
Bennett Creek - Lower Mainstem_D	220.8	0%	0%	0%	0%
Bennett Creek - Lower Mainstem_E	473.9	37%	25%	20%	17%
Bennett Creek - Lower Mainstem_F	450.1	0%	0%	0%	0%
Bennett Creek - Lower Mainstem_G	344.8	0%	0%	0%	0%
Bennett Creek - Middle Mainstem_A	349.9	45%	49%	40%	48%
Bennett Creek - Middle Mainstem_B	163.1	50%	54%	52%	68%
Bennett Creek - Middle Mainstem_C	232.7	50%	61%	59%	69%
Bennett Creek - Middle Mainstem_D	346.5	54%	62%	60%	66%
Bennett Creek - Middle Mainstem_E	275.2	55%	62%	58%	66%
Bennett Creek - Middle Mainstem_F	282	50%	54%	51%	56%
Bennett Creek - Middle Mainstem_G	292.1	25%	44%	45%	52%
Bennett Creek - Middle Mainstem_H	485.8	69%	60%	51%	47%
Bennett Creek - Middle Mainstem_I	516.3	61%	58%	47%	48%
Bennett Creek - Middle Mainstem_J	135.9	49%	62%	67%	77%
Bennett Creek - Middle Mainstem_K	188.5	59%	64%	64%	75%
Bennett Creek - Upper Mainstem_A	383.9	41%	57%	56%	64%
Bennett Creek - Upper Mainstem_B	479	37%	45%	44%	46%
Bennett Creek - Upper Mainstem_C	446.7	37%	51%	51%	55%
Bennett Creek - Upper Mainstem_D	346.5	54%	47%	40%	24%
Bennett Creek - Upper Mainstem_E	453.5	40%	47%	44%	44%
Bennett Creek - Upper Mainstem_F	389	48%	48%	44%	40%
Bennett Creek - Upper Mainstem_G	402.5	63%	58%	50%	35%
Bennett Creek - Upper Mainstem_H	546.9	58%	65%	61%	64%
Bennett Creek - Upper Mainstem_I	246.3	60%	65%	62%	68%
Bennett Creek - Upper Mainstem_J	411	57%	56%	50%	44%
Bennett Creek - Upper Mainsterm_K	548.6	57%	62%	54%	60%
Bennett Creek - Upper Mainsterm_L	421.2	58%	57%	52%	45%
Bennett Creek - Upper Mainsterm_Z	5304.3	38%	50%	40%	31%
Fahrney Branch_A	304	35%	54%	55%	64%
Fahrney Branch_B	434.8	44%	61%	59%	67%
Fahrney Branch_C	288.7	54%	57%	65%	67%
Fahrney Branch_D	210.6	64%	72%	70%	77%
Fahrney Branch_E	225.9	68%	69%	67%	72%
Fahrney Branch_F	528.2	69%	57%	61%	49%
Fahrney Branch_G	373.7	72%	54%	53%	25%

Table A4. Continued…

Catchment	Total Area (acres)	Load Reduction Required BOD 5.8 (lb/ac/yr)	TN 2.82 (lb/ac/yr)	TP 0.49 (lb/ac/yr)	TSS 350.06 (lb/ac/yr)
Fahrney Branch_H	378.8	55%	50%	37%	11%
Fahrney Branch_I	219.1	61%	51%	36%	6%
Fahrney Branch_J	256.5	59%	67%	67%	71%
Fahrney Branch_K	191.9	63%	69%	71%	78%
Fahrney Branch_L	276.9	34%	56%	58%	66%
Fahrney Branch_M	387.3	67%	68%	72%	72%
Fahrney Branch_N	343.1	49%	62%	61%	69%
Furnace Branch_A	173.2	0%	0%	0%	3%
Furnace Branch_B	672.6	0%	0%	0%	0%
Furnace Branch_C	521.4	23%	34%	25%	35%
Lilypons_A	543.5	68%	69%	73%	73%
Lilypons_B	409.3	48%	52%	40%	51%
Lilypons_C	665.8	69%	63%	61%	60%
Little Bennett Creek_A	259.9	38%	43%	34%	46%
Little Bennett Creek_B	319.3	49%	51%	42%	50%
Little Bennett Creek_C	485.8	9%	32%	15%	27%
Little Bennett Creek_D	429.7	51%	55%	48%	51%
Little Bennett Creek_E	477.3	57%	46%	50%	40%
Little Bennett Creek_F	492.6	28%	42%	37%	45%
Little Bennett Creek_G	485.8	55%	51%	55%	53%
Little Bennett Creek_Z	10145	26%	37%	23%	0%
Little Monocacy River_A	351.6	37%	41%	28%	42%
Little Monocacy River_B	135.9	54%	56%	51%	68%
Little Monocacy River_C	514.6	40%	53%	49%	57%
Little Monocacy River_Z	10946.7	38%	51%	39%	22%
Monocacy Direct - North_A	414.4	44%	58%	57%	66%
Monocacy Direct - North_B	434.8	12%	4%	0%	0%
Monocacy Direct - North_C	348.2	54%	56%	48%	54%
Monocacy Direct - North_D	237.8	25%	48%	51%	62%
Monocacy Direct - North_E	195.3	0%	0%	30%	58%
Monocacy Direct - North_F	188.5	44%	58%	65%	78%
Monocacy Direct - North_G	356.7	46%	64%	65%	72%
Monocacy Direct - North_H	439.9	56%	57%	64%	63%
Monocacy Direct - North_I	334.6	36%	68%	64%	74%
Monocacy Direct - North_J	317.6	0%	23%	7%	15%
Monocacy Direct - North_K	241.2	58%	64%	60%	67%
Monocacy Direct - North_L	283.7	54%	67%	67%	73%
Monocacy Direct - South_A	258.2	39%	41%	48%	57%
Monocacy Direct - South_B	237.8	59%	66%	71%	75%
Monocacy Direct - South_C	246.3	48%	57%	64%	71%

Table A4. Continued…

Catchment	Total Area (acres)	Load Reduction Required BOD 5.8 (lb/ac/yr)	TN 2.82 (lb/ac/yr)	TP 0.49 (lb/ac/yr)	TSS 350.06 (lb/ac/yr)
Monocacy Direct - South_D	159.7	46%	43%	55%	62%
Monocacy Direct - South_E	154.6	0%	0%	0%	14%
Monocacy Direct - South_F	470.5	0%	0%	0%	0%
Monocacy Direct - South_G	414.4	54%	48%	56%	51%
Monocacy Direct - South_H	348.2	0%	0%	20%	43%
Monocacy Direct - South_I	400.8	4%	4%	16%	14%
Monocacy Direct - South_J	619.9	53%	60%	52%	60%
North Branch_A	258.2	68%	52%	52%	37%
North Branch_B	266.7	65%	61%	64%	63%
North Branch_C	225.9	41%	62%	49%	55%
North Branch_D	144.4	61%	65%	59%	69%
Pleasant Branch_A	429.7	57%	58%	54%	52%
Pleasant Branch_B	404.2	68%	57%	51%	22%
Pleasant Branch_C	455.2	60%	53%	44%	18%
Sugarloaf_A	322.7	37%	39%	26%	38%
Sugarloaf_B	389	0%	0%	0%	0%
Sugarloaf_C	390.7	42%	48%	39%	50%
Sugarloaf_D	305.7	54%	59%	53%	61%
Sugarloaf_E	283.7	58%	65%	60%	69%
Sugarloaf_F	477.3	55%	64%	60%	66%
Sugarloaf_G	450.1	0%	0%	0%	0%
Urbana Branch_A	191.9	44%	11%	29%	0%
Urbana Branch_B	222.5	56%	55%	50%	48%
Urbana Branch_C	528.2	54%	63%	58%	62%
Urbana Branch_D	324.4	47%	56%	52%	59%

APPENDIX B

DESCRIPTIONS OF THE HYDROLOGIC SOIL GROUPS

Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A's generally have the smallest runoff potential and Ds the greatest.

Details of this classification can be found in 'Urban Hydrology for Small Watersheds' published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55.

Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Reference: http://www.ecn.purdue.edu/runoff/documentation/hsg.html

APPENDIX C

ProjectID ____________________ **Latitude (dec.deg)** ____________________

Project Name ____________________ **Longitude (dec.deg)** ____________________

Subwatershed ____

Location ____

Site/Problem Description ____

Existing BMPs Yes No

If yes, describe ____

Effectiveness Effective Not sure Not effective

Category	**Score**	**1**	**2**	**3**
Extent of problem		Localized	Moderate	Widespread
Ownership		Private	Private with Public Access	Public
Educational benefits		Minor (few individuals)	Moderate	Major (large # of individs)
Accessibility		Very Difficult (both on foot and by a vehicle)	Moderate (easily accessible by foot but not easily accessible by a vehicle)	Very Easy (both by car and on foot)
Constraints		Lots	Moderate	Few
Likelihood of public acceptability		Low	Moderate	High
Economic feasability		Low	Maybe	High
Severity of threats to property/infrastructure		Minor	Moderate	Serious
Correctability		Very difficult (large expensive effort to correct)	Moderate (may require a small piece of equipment and some planning)	Minor (corrected quickly and easily using hand labor with minimal planning)

Is the stream corridor visible from the project area? Yes No

If so, approximately how far is it from the project site

Are any problems visible along the stream corridor? Yes No

Please rate the severity of the problems along the stream corridor

Category	**Score**	**0**	**1**	**2**	3
Erosion		None	Minor	Moderate	Severe
Exposed Pipe		None	Minor	Moderate	Severe
Pipe Outfall		None	Minor	Moderate	Severe
Inadequate Riparian Buffer		None	Minor	Moderate	Severe
Fish Barrier		None	Minor	Moderate	Severe
Habitat Condition		None	Minor	Moderate	Severe
Channel Alteration (man-made)		None	Minor	Moderate	Severe
Channel Alteration (livestock)		None	Minor	Moderate	Severe
Trash/Litter		None	Minor	Moderate	Severe
Other		None	Minor	Moderate	Severe

Severe=problems that have a direct and wide reaching impact

Moderate=problems that have some adverse environmental impacts but the severity and/or length of affected stream is fairly limited

Minor=problems that do not have a significant impact on stream and aquatic resources

Type of Project CIP CRP Potential for both

Restoration Approach

Project Description/Proposed Action ____________________

Benefits of Proposed Action ____________________

Proposed dimensions of project area ____________________

Sequence of project events ____________________

Known utilities and other constraints ____________________

Item Description	Quantity	Units	Unit Cost	Total

Estimated total cost ____________________

Site Diagram

APPENDIX D

SCORES FOR SITES WITH STREAM CORRIDOR DATA

Step 1. Each site received a score from 0 to 3 (3 being worst, or most in need of attention) for the categories listed below.

Project ID	Weight	F7	F3	F4	F5	F1	BU2	U1	P3	F12
Stream Corridor Max Score	30	2.5	2	2	2	0	3	0	3	1.5
Average STEPL	20	2.5	1.75	1.75	1.75	2.5	2	2.5	2	2.5
Ownership	10	***3***	***3***	***3***	***3***	***3***	***1***	***3***	***1***	***2***
Extent of problem	5	2	3	3	3	2	3	3	2	3
Accessibility	5	3	3	3	3	3	3	3	3	3
Constraints	5	3	2	3	3	3	2	3	1	3
Economic feasibility	5	3	3	3	3	2	2	2	1	2
Severity of threats to property/infrastructure	5	1	3	3	1	2	3	2	2	1
Correctability	5	1	1	1	1	1	1	2	2	2
Educational benefits	5	2	3	3	3	3	2	3	2	1
Likelihood of public acceptability	5	2	3	3	3	3	3	3	3	2

Step 2. Scores were normalized by dividing by 3.

Project ID	Weight	F7	F3	F4	F5	F1	BU2	U1	P3	F12
Stream Corridor Max Score	30	0.83	0.67	0.67	0.67	0.00	1.00	0.00	1.00	0.50
Average STEPL	20	0.83	0.58	0.58	0.58	0.83	0.67	0.83	0.67	0.83
Ownership	10	1.00	1.00	1.00	1.00	1.00	0.33	1.00	0.33	0.67
Extent of problem	5	0.67	1.00	1.00	1.00	0.67	1.00	1.00	0.67	1.00
Accessibility	5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Constraints	5	1.00	0.67	1.00	1.00	1.00	0.67	1.00	0.33	1.00
Economic feasibility	5	1.00	1.00	1.00	1.00	0.67	0.67	0.67	0.33	0.67
Severity of threats to property/infrastructure	5	0.33	1.00	1.00	0.33	0.67	1.00	0.67	0.67	0.33
Correctability	5	0.33	0.33	0.33	0.33	0.33	0.33	0.67	0.67	0.67
Educational benefits	5	0.67	1.00	1.00	1.00	1.00	0.67	1.00	0.67	0.33
Likelihood of public acceptability	5	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.67

Step 3. Weights were multiplied by the normalized scores

Project ID	Weight	F7	F3	F4	F5	F1	BU2	U1	P3	F12
Stream Corridor Max Score	30	25.00	20.00	20.00	20.00	0.00	30.00	0.00	30.00	15.00
Average STEPL	20	16.67	11.67	11.67	11.67	16.67	13.33	16.67	13.33	16.67
Ownership	10	10.00	10.00	10.00	10.00	10.00	3.33	10.00	3.33	6.67
Extent of problem	5	3.33	5.00	5.00	5.00	3.33	5.00	5.00	3.33	5.00
Accessibility	5	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Constraints	5	5.00	3.33	5.00	5.00	5.00	3.33	5.00	1.67	5.00
Economic feasibility	5	5.00	5.00	5.00	5.00	3.33	3.33	3.33	1.67	3.33
Severity of threats to property/infrastructure	5	1.67	5.00	5.00	1.67	3.33	5.00	3.33	3.33	1.67
Correctability	5	1.67	1.67	1.67	1.67	1.67	1.67	3.33	3.33	3.33
Educational benefits	5	3.33	5.00	5.00	5.00	5.00	3.33	5.00	3.33	1.67
Likelihood of public acceptability	5	3.33	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.33

Step 4. Scores from each of the categories were summed to obtain a total score (the higher the score, the higher the priority)

Project ID	F7	F3	F4	F5	F1	BU2	U1	P3	F12
Total Score	80.00	76.67	78.33	75.00	58.33	78.33	61.67	73.33	66.67

SCORES FOR SITES WITHOUT STREAM CORRIDOR DATA

Step 1. Each site received a score from 0 to 3 (3 being worst, or most in need of attention) for the categories listed below.

Project ID	Weight	BM3	LB1
Average STEPL	25	2.25	1.25
Ownership	15	1	1
Extent of problem	15	2	2
Educational benefits	15	1	2
Accessibility	5	3	3
Constraints	5	2	2
Economic feasibility	5	2	2
Severity of threats to property/infrastructure	5	2	1
Correctability	5	2	1
Likelihood of public acceptability	5	1	1

Step 2. Scores were normalized by dividing by 3.

Project ID	Weight	BM3	LB1
Average STEPL	25	0.75	0.42
Ownership	15	0.33	0.33
Extent of problem	15	0.67	0.67
Educational benefits	15	0.33	0.67
Accessibility	5	1.00	1.00
Constraints	5	0.67	0.67
Economic feasibility	5	0.67	0.67
Severity of threats to property/infrastructure	5	0.67	0.33
Correctability	5	0.67	0.33
Likelihood of public acceptability	5	0.33	0.33

Step 3. Weights were multiplied by the normalized scores.

Project ID	Weight	BM3	LB1
Average STEPL	25	18.75	10.42
Ownership	15	5.00	5.00
Extent of problem	15	10.00	10.00
Educational benefits	15	5.00	10.00
Accessibility	5	5.00	5.00
Constraints	5	3.33	3.33
Economic feasibility	5	3.33	3.33
Severity of threats to property/infrastructure	5	3.33	1.67
Correctability	5	3.33	1.67
Likelihood of public acceptability	5	1.67	1.67

Step 4. Scores from each of the categories were summed to obtain a total score (the higher the score, the higher the priority).

Project ID	BM3	LB1
Total Score	58.75	52.08