Upper Moreland School District Stormwater Management Plan and Curriculum Materials

Report

Prepared by

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Draft for Review

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1 INTRODUCTION

The project team led by the Center for Sustainable Communities, Temple University (CSC Project Team) was awarded a $40,000 grant from the Claneil Foundation to assist the administration of the Upper Moreland School District (UMSD) with developing a stormwater management plan for its high school and middle school campuses and providing guidance to its math and science curriculum committee on how to incorporate the stormwater facilities as outdoor laboratories in K-12 courses. This was a 1-year study that began in June 2008 and concluded with the publication of this report.

Context of the Study

Flooding and stormwater problems in Southeastern Pennsylvania have significantly increased since the 1950s due to widespread changes in land use and ineffective stormwater management, and now global warming. Global warming is making these problems more acute by producing more intense storms and increasing flood hazards in the most vulnerable parts of our region. Increased impervious surfaces, as well as substantial areas of natural landscape being converted to lawns on highly compacted soils, plus the lack of stormwater management controls, or the failure of stormwater management facilities due to poor construction or inept installation, all contribute to increased stormwater volume. Until the late 1970s, stormwater management was rarely practiced as part of land development in the region. Similar to most other school districts located in the older suburbs of Philadelphia, the UMSD in the heart of densely developed Montgomery County has no stormwater management on its 60+ acre campuses.

The UMSD and its Superintendent, Dr. Robert Milrod, have stepped forward to become a model of sustainable stormwater management, and, in the process, also become a leader in the region in environmental education. . To achieve this Dr. Milrod envisions developing a 5-year plan to incorporate sustainable stormwater management practices on all UMSD owned properties and to use the stormwater management facilities as outdoor laboratories to enhance its science and math curricula opportunities for K-12 students, and as a cornerstone of an environmental education program for other school districts in Southeastern Pennsylvania.

Scope of Study

The study was undertaken to develop a plan to incorporate sustainable stormwater management practices on all USMD owned properties and to integrate the stormwater best management practice (BMP) facilities into its science and math curricula. The study consisted of the following major tasks all of which influenced the recommendations included in this report and stormwater management plans:

- Meetings with Upper Moreland School District Administration and Math and Science Curriculum Committee
- Stormwater Improvement Analysis at Both Campuses
- Preliminary Cost Analysis
- Site Tour of the CSC's Stormwater Best Management Practices at the Pennypack Environmental Restoration Trust

Project Team

The members of the CSC Project Team who participated in this study are highlighted below including professional consultants.

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2 High School Stormwater Management Plan

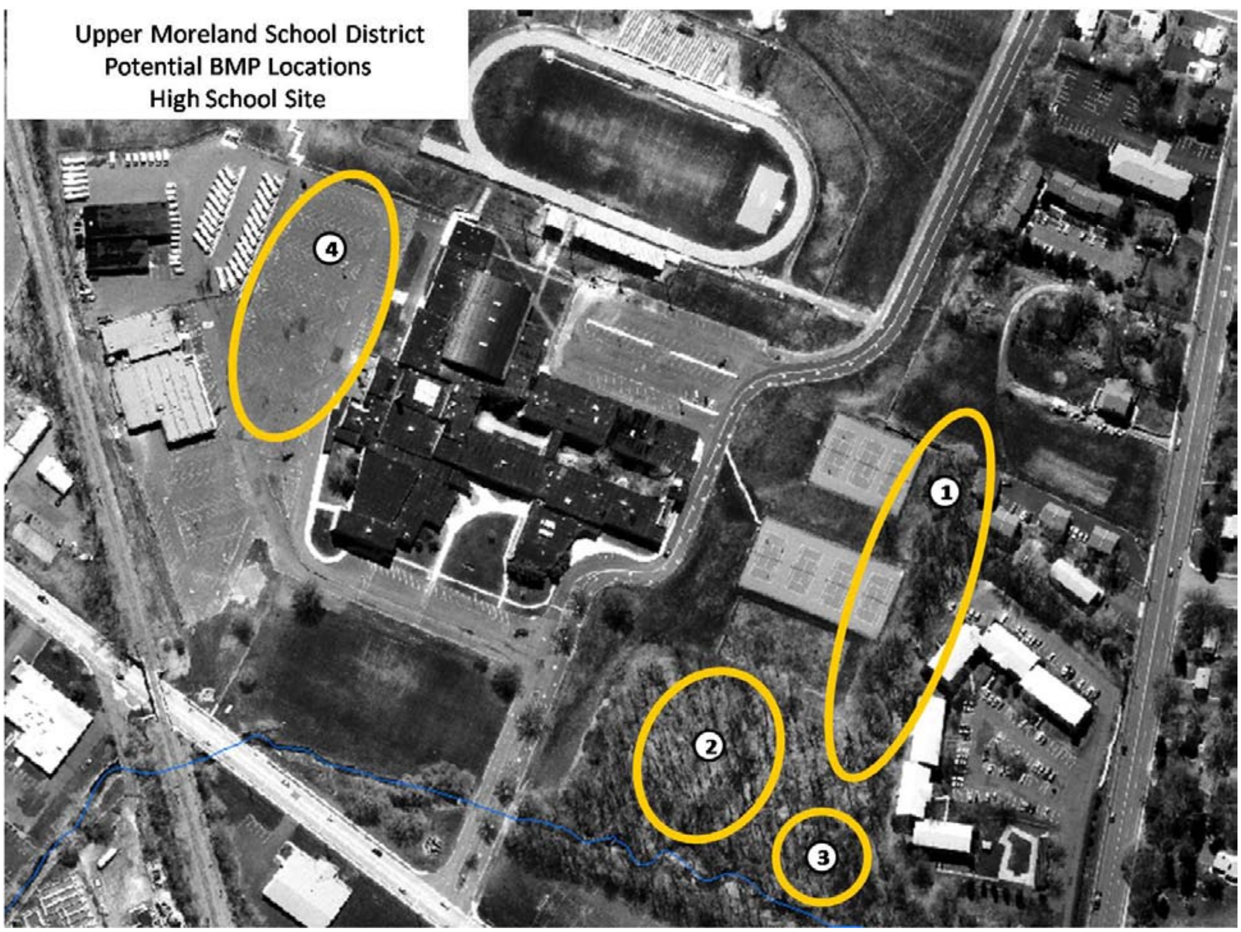
Field Observations

The CSC Project Team conducted extensive field observations on the High School campus to identify sites where new or improved stormwater management facilities could potentially be used to infiltrate or detain stormwater runoff as a means of sustainably managing stormwater on site. Swales, culverts or other structures in need of repair or locations where potential erosion damage control is recommended also were identified. Field investigations at the High School site concluded in October 2008.

Stormwater Management Plan

The stormwater management plan for the High School campus includes a range of naturalized stormwater BMPs. The naturalized BMPs are recommended for the wooded area located in the campus's northwestern quadrant. These are #1-3 shown of Figure 1. In addition, the CSC researchers highly recommend that the USMD install a groundwater interceptor system (#4) to address groundwater flows that are currently damaging the parking lot.

Figure 1 - High School Stormwater Management Plan



1. Swale with Small Check Dams

Adjacent to the tennis courts there currently is an erosion channel that is approximately 4 feet deep at points. The channel has been formed by the eroding force of stormwater runoff from the tennis courts and adjacent residential development. The channel follows the natural topography of the northwestern terrain, flows along the perimeter of the campus and drains into the existing creek.

The design goals of converting the existing erosion channel into a vegetated swale with small check dams would include:

- reducing the velocity of runoff flows
- capturing sediment (eroded soils) behind the small check dams

The design calls for regrading the erosion channel to create a meandering swale and placing logs along the length of the swale to create small check dams. The walls of the swale would be planted with wet woodland species and the upland areas with dry woodland species. The vegetation will once established will stabilize exposed soils and tree root systems.

Note: more detailed descriptions for each BMP will be included in the final draft. The details will highlight key aspects of the BMP design such as size of area draining into BMP, size of BMP, storage capacity, and monitoring equipment to be installed during construction.

2. Convert Farm Ponds to Upland Wet Ponds

As they exist today, the farm ponds provide minimal stormwater management. Retrofitting the farm ponds would add temporary storage during small rain events. In addition, once converted to upland wet ponds the farm ponds would be an excellent outdoor laboratory for math and science activities.

The design goals of converting the farm ponds to upland wet ponds would include:
- Reducing peak stormwater flows into the creek
- Providing stormwater storage
- Establishing aquatic and upland habitat

The design to retrofit the farm ponds entails excavating the ponds to a depth of 3 feet in order to provide stormwater storage capacity. A cement reinforcement wall would be constructed inside the current walls. The pond slopes and upland areas would be planted with wet woodland and woodland species.

3. Floodplain Constructed Wetland

Currently the stormwater runoff from the erosion channel flows directly into the creek. Constructing a wetland in the floodplain to receive these flows provides an opportunity to store the volume of small rain events and provide some nutrient transformation (into plant biomass). In addition, a constructed wetland would provide an excellent outdoor laboratory for math and science activities.

The design goals of creating a constructed wetland in the floodplain would include:

- Reducing peak stormwater flows into the creek
- Providing stormwater storage
- Providing nutrient removal through plant uptake
- Establishing or improving aquatic and floodplain habitat

To design for the wetland calls for excavating the terrain to a depth of 3 feet below the groundwater table, thereby creating a permanent pool. Wetland species would be planted along the slopes and upland areas of the wetland.

4. Groundwater Interceptor

There is a serious problem of deterioration of the paving of the parking lot east of the school building. The deterioration is caused by upwelling and breakthrough of groundwater; in short there are multiple springs throughout the parking area. The obvious cause of the situation is that the playing fields on the plateau above and south of the school and parking area provide a very large recharge area that feeds the groundwater flow beneath and through the parking lot (and also, according to school officials, into the elevator shaft at the northeast corner of the new addition to the school, which requires frequent and sometimes continual pumping). The fields are from approximately 35 to 50 feet higher than the parking lot, and there is thus a very great hydraulic head or pressure gradient pushing the groundwater beneath and through the parking lot surface.

The team advised the UMSD administration to have a proper groundwater investigation conducted at the base of the playing field plateau and beneath the parking lot, so that a groundwater interception system may be designed and constructed to capture and redirect the flow to the eastern boundary of the school property, away from the school building and parking lot.

Costs have not been provided for this recommendation.

3 MIDDLE SCHOOL STORMWATER MANAGEMENT PLAN

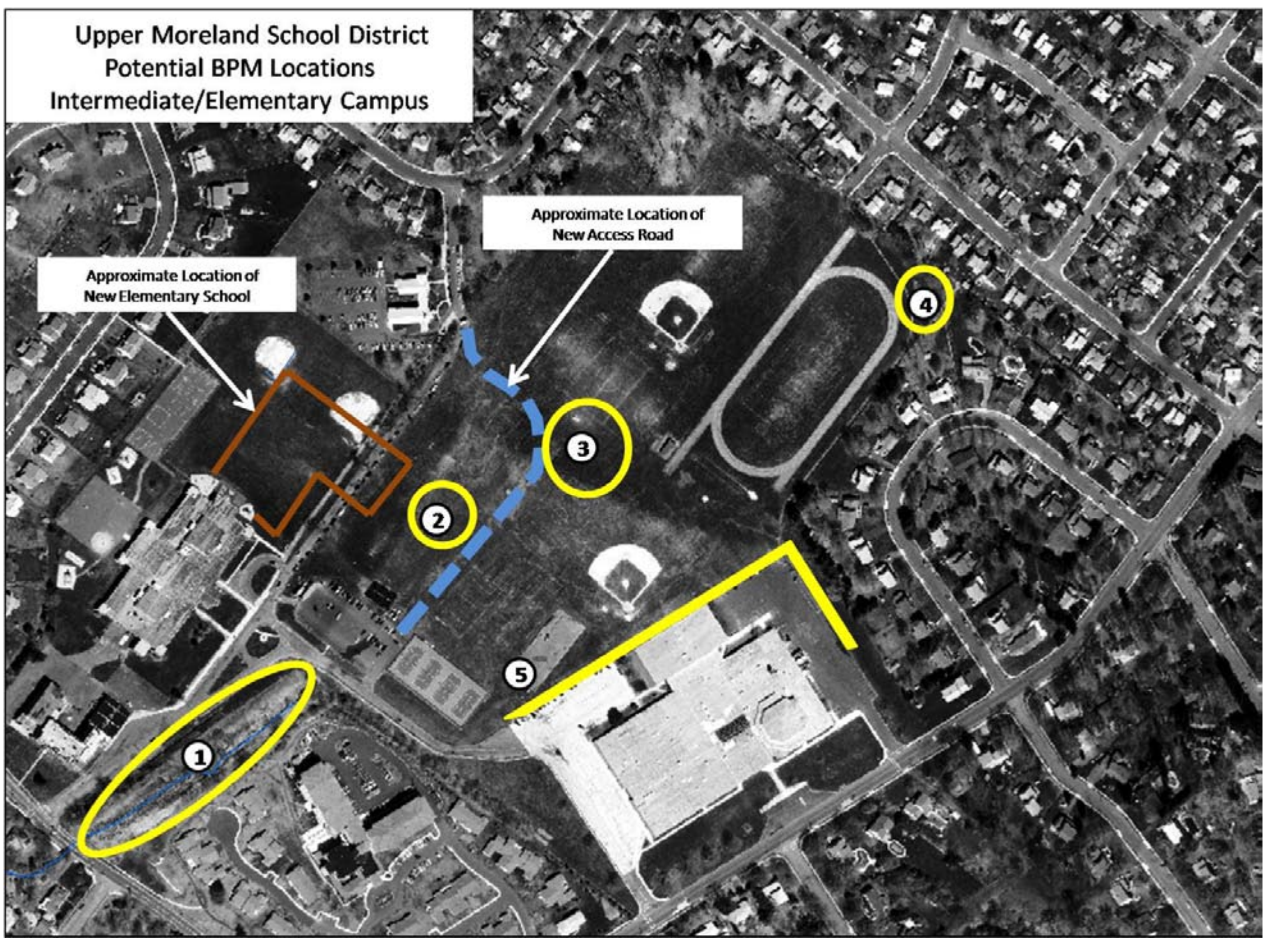
Field Observations

The CSC Project Team conducted extensive field observations on the Middle School campus to identify sites where new or improved stormwater management facilities could potentially be used to infiltrate or detain additional runoff as a means of managing stormwater on site. Basins, culverts or other structures in need of repair or locations where potential erosion damage control is recommended also were identified. Field investigation at the Middle School site concluded in January 2009.

Stormwater Management Plan

The stormwater management plan for the Middle School campus includes a range of naturalized and traditional stormwater management facilities. The naturalized BMPs are recommended for the existing basin along Byberry Avenue and in three locations throughout the campus. These are the circles numbered 1-4 on Figure 2. The more traditional stormwater management facility, number 5, is recommended to infiltrate stormwater runoff from the Middle School building and parking lots.

Figure 2 - Middle School Stormwater Management Plan



1 – Byberry Avenue Basin Upland Wet Pond Retrofit

The existing stormwater basin situated perpendicular to Byberry Avenue is overgrown and is a candidate for retrofit to create an upland wet pond stormwater management facility. The retrofit would provide additional stormwater storage. In addition the site would serve as an excellent outdoor laboratory for math and science activities.

The design goals of retrofitting the existing basin include:

- Adding storage capacity
- Reducing downstream peak flows
- Creating aquatic and upland habitat

To achieve these goals the retrofit design calls for excavating to a depth that intersects the groundwater table. This would create a permanent pool of water or pond. The size of the existing outlet structure would be reduced allowing stormwater to be stored and slowly released to the stream. After excavation the site would be planted with wetland species.

2, 3 and 4 – Rain Gardens/Upland Wetlands

The existing campus grounds do not provide sufficient onsite stormwater management. To create a more sustainable model of stormwater management, three rain gardens are proposed. One rain garden (#2) would be adjacent to the K-2 building and would receive stormwater flows from the roof gutter leader. The two other rain gardens would be placed between the ball fields (#3) and at the far end of the track (#4). Retrofitting the campus grounds in such a manner would provide additional stormwater storage. In addition these sites would serve as an excellent outdoor laboratory for math and science activities.

The design goals of retrofitting the existing basin include:

- Creating storage capacity
- Infiltrating stormwater
- Creating aquatic and upland habitat

To design for each of the approximately ¼ acre rain gardens entails excavating to a depth of three feet to create a small basin. After excavation the site, the existing soils would be amended to enhance infiltration and the slopes and upland areas would be planted with wetland species.

5 – Infiltration Trenches

Currently the stormwater runoff from the extensive roof and parking lots of the Middle School is managed by a storm drain system. To create a more sustainable stormwater management system for these impervious surfaces a series of trenches are recommended for the perimeter of the parking lot and school building. The trenches will capture and infiltrate stormwater runoff from the parking areas, access roads, walkways and roof top of the Middle School.

The design goals of the infiltration trenches include:

- Infiltrating stormwater
- Creating storage capacity

The designs for the trenches entail excavating to a depth of 5 feet and width of 5 feet. The earthen walls of the trenches would be lined with filter material before filling with well sorted stone. To increase the temporary storage capacity of the trenches a 36 inch perforated pipe would be placed in the middle of the stone bed.

4 MONITORING ACTIVITIES FOR CURRICULUM DEVELOPMENT

Introduction to the Monitoring Activities

The monitoring activities outlined herein provide descriptions of the depth and scope of monitoring activities that could be conducted at each site. The monitoring activities reflect the range of testing required to develop a keen understanding of how the BMP facilities function. Additional monitoring protocol ranging from guides for volunteer wetland and water quality monitoring and to Army Corps of Engineers wetland monitoring are included in Section 6 Recommended Resources for the use of the Math and Science Curriculum Committee in developing hands-on lessons.

Upland Stormwater Wet Ponds, Floodplain Wetland, Rain Gardens/Upland Wetland

Stormwater wet ponds have been included in the stormwater management plan for both campuses. On the High School campus the wet ponds would result from the retrofitting of the farm ponds. On the Middle School campus one wet pond would be created by retrofitting the existing stormwater basin near Byberry Avenue. A floodplain constructed wetland is recommended on the High School property. Three Rain Gardens/Upland Wetlands are proposed for the Middle School campus. Because the design and function of these stormwater management facilities, which are designed to resemble naturally occurring wet landscape features, are very similar the monitoring activities apply.

Monitoring Activities

Monitoring at the wet ponds should lag the completion of construction by 4-5 months in order to give the vegetation sufficient time to establish. While the upland stormwater wet ponds provide important non-point source stormwater retention, it is recommended that the monitoring program focus on recording the establishment of upland wetland structure and function (primarily vegetation and hydrology). Wetland structure and function monitoring should occur on an annual basis and during peak vegetation (mid-August through the end of September).

Wetland Habitat Structure and Function:

- Biological Diversity and Abundance. Biological assessments are important to evaluating the contribution of the wet ponds to regional habitat and biological diversity. Monitoring aquatic macroinvertebrates records the establishment of colonies essential in fostering vertebrate diversity and density. Macroinvertebrate samples should be collected from three replicate samples plus a submerged leaf litter sample. The assessment should include counts of the numbers of individuals, diversity of species and tolerance of species.
- Soil Conditions. Monitoring wetland soil conditions is important to assess pollutant and nutrient retention and to provide indirect measures of wetland function. Five soil core samples should be collected randomly from each plot. These samples should be analyzed for organic content, texture, particle size and development of hydric characteristics.
- Sedimentation Rate Monitoring a wetland system's sediment retention provides information on wetland function. Sediment traps should be placed in each plot's

inlet area. Trap data should be collected annually and should include in field measurement of the depth of sediment followed by dried weight and volume of sediments collected.

- Vegetation. Monitoring of plant communities is essential to evaluating wetland function as vegetation impacts hydrology, sedimentation, and habitat suitability.
  - Native plant species planted for soil and water erosion control around the ponds should be evaluated for their establishment rates. General information about the vegetation should be obtained by sampling the site with transect or plot methodologies. Five permanent transects or plots should be established through the wet ponds. Nested quadrants, which include 5 x 5 m for sampling trees/shrubs and 0.5 x 0.5 m for sampling herbaceous plants, should be randomly located along the transects or plots. The following vegetation properties should be recorded: total vegetation cover, species richness, relative dominance, and Shannon-Winner diversity index. For each species, the survival rate should be tallied annually. Ten plants of each species should be tagged and growth rates of elongating shoots and leaves should be measured monthly. The presence and management of any invasive non-native species should be recorded.
  - Submerged and emergent species planted inside the stormwater ponds should be evaluated for their growth. Survival rate should be tallied annually. Growth rate should be measured using the method mentioned above. Biomass should be sampled from a random set of 25 x 25 cm quadrants. Vegetation and litter in each quadrate should be clipped at ground level. Roots should be sampled by inserting a 6-cm diameter soil core 17 cm deep in the center of each quadrant. Roots should be separated out from the soil core. Plant materials should be sorted to species and weighted separately after drying.

Stormwater Quantity:

It is very difficult to measure flows entering into or leaving the wet ponds because there are no specific entry or exit points and there is a groundwater component. Instead, stormwater will enter the wet ponds via overland flow and in the case of the farm ponds overflow from the higher ponds into the lower ponds. In addition, not all stormwater will flow out of the wet pond as some will evapotranspire from the surface of the pond as well as through plant uptake. Therefore, stormwater quantity monitoring should be limited to measuring and recording the volume of water retained in the wet ponds.

- Stormwater levels within the stormwater wetland should be monitored by installing a transducer into a monitoring well located within the wet pond. Water levels should be recorded at 5 minute intervals.
- Stormwater levels also could be monitored by installing a depth measuring stick. Then the diminishing water level would be recorded at 5 minute intervals.
- Rainfall should measured by a rain gauges installed at the High School and Middle School campuses. Then using the BMP designed catchment areas, the students can estimate the volume of stormwater flows entering each of the BMPs.

Stormwater Quality:

For the BMPs with standing pools of stormwater, water quality could be measured by temperature and pH sampling. Sediment removal is a way to measure improvement in water quality. This type of monitoring is addressed under wetland habitat structure and function monitoring.

Infiltration Trenches

During the construction of the infiltration trenches monitoring wells and equipment should be installed. The monitoring wells would consist of 5-foot long, 1-inch diameter slotted PVC tubes. Pressure transducers should be installed at the base of the wells to measure the depth of water in each trench. If installing pressure transducers is too costly, water levels after storm events could be measured using 6-foot long dip sticks inserted into the monitoring wells.

Monitoring Activities

Monitoring should commence immediately upon construction and installation of monitoring equipment. Due to the nature of this BMP, wetland structure and function monitoring and plant nutrient uptake monitoring are not recommended. Stormwater management monitoring should occur on a wet weather basis and evaluate performance based on measuring and monitoring the following stormwater management parameters:

Stormwater Quantity:

The effectiveness of these BMPs to capture, retain and infiltrate stormwater should be monitored using the following methods:

- Stormwater levels within each of the trenches should be recorded at 15-minute intervals at each of the three monitoring wells.
- Rainfall should measured by a rain gauge installed at the Middle School campus. Then using the surface area of the parking lot and/or building, the students can estimate the volume of stormwater flows being infiltrated by the trenches.

Stormwater Quality:

Not applicable to this type of BMP.

Swale and Check Dams

A meandering swale with several small check dams is included on the High School stormwater management plan. In addition, restoration of the channel way eroded by high velocity and high volume runoff is recommended. The banks of the swale would be planted with dry and wet woodland species.

Monitoring Activities

Monitoring at the swale should lag the completion of construction by 4-5 months in order to give the vegetation sufficient time to establish. It is recommended that the monitoring program focus on recording the establishment of woodland and wet woodland vegetation and sedimentation. Vegetation monitoring should occur on an annual basis and during peak vegetation (mid-August through the end of September). However, sedimentation monitoring could be conducted year round.

Vegetation Monitoring:

- Monitoring of plant communities is essential to evaluating wetland function as vegetation impacts hydrology, sedimentation, and habitat suitability.
  - Native plant species planted for soil and water erosion control along the swale should be evaluated for their establishment rates. General information about the vegetation should be obtained by sampling the site with transect or plot methodologies. Five permanent transects or plots should be established through the swale. Nested quadrants, which include 5 x 5 m for sampling trees/shrubs and 0.5 x 0.5 m for sampling herbaceous plants, should be randomly located along the transects or plots. The following vegetation properties should be recorded: total vegetation cover, species richness, relative dominance, and Shannon-Winner diversity index. For each species, the survival rate should be tallied annually. Ten plants of each species should be tagged and growth rates of elongating shoots and leaves should be measured monthly. Deer control measures should be implemented at all newly vegetated sites. The presences and management of any invasive non-native plants should be recorded.

Sedimentation Rate Monitoring:
The small check dams are designed to slow stormwater flows by allowing water to collected behind the dam. Dams will be placed along the length of the swale to mimic tree trunks or limbs obstructing rain flows. As the water slows and pools any sediment that it has captured such as soil eroded from the channel's banks will settle out. Sediment traps should be placed on the upstream side of each check dam. The sediment data should be collected annually, or more frequently, and should include in field measurement of the depth of sediment followed by dried weight and volume of sediments collected.

5 IMPLEMENTATION & COSTS

The implementation of the stormwater management plans can be achieved through a phased implementation approach. The first phase would concentrate on implementing the priority stormwater management improvements identified in collaboration during the UMSD Math and Science Curriculum Committee meeting on April 15. At this meeting CSC researchers, UMSD administration and faculty identified priority stormwater management facilities based on their importance to developing outdoor laboratory modules for K-12 courses. The priority facilities are noted in bold in the tables below. The numbers in the tables below correspond to the numbering systems used on the conceptual stormwater management plans.

Table 1 – Cost Estimate for High School Campus

Stormwater BMP	**Cost**
1. Swale and Small Check Dams	$35,000
2. Farm Ponds Conversion of Upland Wet Ponds	$59,500
3. Floodplain Constructed Wetland	$55,000
Total	**$149,500**

Table 2 – Cost Estimate for Middle School Campus

Stormwater BMP	**Cost**
1. Byberry Avenue Basin Retrofit	$72,500
2. Rain Garden/Upland Wetland	$30,500
3. Rain Garden/Upland Wetland	$30,500
4. Rain Garden/Upland Wetland	$30,500
5. Trenches	$342,000
Total	**$508,000**

6 RECOMMENDED RESOURCES

Technical Resources

Army Corps of Engineers – Wetlands Engineering Handbook. *Section 8 Monitoring and Evaluating Success* http://www.stormingmedia.us/95/9539/A953973.html

Pennsylvania Stormwater Best Management Practices (BMP) Manual. http://www.depweb.state.pa.us/watershedmgmt/cwp/view.asp?a=1437&q=529063&watershedmgmtNav=|

EPA – Methods for Evaluating Wetland Conditions. #8 Volunteer Wetland Biomonitoring http://www.epa.gov/waterscience/criteria/nutrient/guidance/wetlands/#modules

EPA – Methods for Evaluating Wetland Conditions. #9 Developing and Invertebrate Index of Biological Integrity of Wetlands http://www.epa.gov/waterscience/criteria/nutrient/guidance/wetlands/#modules

EPA – Methods for Evaluating Wetland Conditions. #10 Using Vegetation to Monitor Environmental Conditions http://www.epa.gov/waterscience/criteria/nutrient/guidance/wetlands/#modules

Volunteer Monitoring Guides

Environmental Alliance for Senior Involvement (EASI) - Senior Environmental Corps Water Quality Monitoring Field Manual. http://www.water-research.net/Waterlibrary/watermanual/wqfieldmanual.pdf

EPA – Volunteer Wetland Monitoring. An introduction and resources guide. http://www.epa.gov/OWOW/wetlands/monitor/#vol

Pennsylvania Department of Environmental Protection – Designing Your Monitoring Program. Pennsylvania's Citizens Monitoring Program. http://www.depweb.state.pa.us/watershedmgmt/cwp/view.asp?a=1431&q=493545