Stormwater Best Management Practices in the Baltimore's Watershed 263: SLAMM and Crowdsourcing as tools in inventory and characterization

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Outline

Executive Summary

One environmental impact of urbanization is stormwater pollution. Early urban planners did not comprehend that their approaches would not only alter the land but also the rivers and streams. Features of stormwater pollution include the physical, chemical and ecological changes to waterways. In this project, I looked at some of the features of a 937-acre urban water shed in Baltimore City, water shed 263. The urban features in the water shed were developed and built during the 19th and 20th centuries. It is characterized by high density (one house per 0.7 acres) and a stormwater system that collects all of the rainfall in the water shed and runs it underground through pipes into the Patapsco River. Prior surveys of a sub-catchment (subcatchment O) in the water shed found that the chemical stormwater pollution was at levels two- to three-times higher than the national average. Efforts have been made to ameliorate the stormwater pollution by installing structural best management practices (BMPs) that infiltrate stormwater into the subsoil instead of discharging to surface waters. Many of the BMPs installed serve a dual purpose, benefiting the environment through pollution reduction and the neighborhood esthetically.

But installation of BMPs is only a start to improving water quality. The BMPs continued performance needs to be evaluated regularly. This project cataloged and observed a rain garden, stormwater curb extensions, a Filterra® system, and the tree plantings installed in subcatchment O. This data was collected to assess the BMPs' performance and for use in modeling the stormwater flows for the water shed. In addition, a framework was established to increase public input into performance of the BMPs both environmentally and esthetically. A web site was established as a repository for photographs with the intent of collecting a time-series of the condition and functioning of the BMPs. The proposed means to collect these photos is the use of cell phone cameras by concerned citizens and residents in the community.

Recommendations and Thoughts

- BMPs need to be placed in areas where they can effectively treat the largest volume of stormwater possible
- Maintenance of BMPs is required to preserve both the environmental and esthetic benefits of the BMPs
- Soil types need to be considered when establishing BMPs that depend on infiltration and engineered soils should be substituted when use of existing soils is inappropriate
- Tree planting should be used to increase the biodiversity and diverse species should be used in future planting
- Engaging the public to participate in continued data collection in the water shed will require a concerted effort that includes education and instruction to members of the neighborhood

- Significant “buy-in” from the community is needed for the goals and benefits of continued data collection framework to be valued by the water shed’s residents
- Modeling the behavior of stormwater in the water shed is necessary to evaluate the efficiency of the BMPs performance
- Further surveying of subcatchment O and the entire water shed is necessary, verification of the location of all storm drains in the water shed is one data collection effort that should be undertaken.
- Collaboration between Federal, State and local governments as well as private non-profits and the community in efforts to remediate the water shed need to continue and be made stronger

1. Introduction

Historically, the initial concern of controlling urban stormwater runoff was a matter of flood control. However, further concern for urban stormwater is its conveyance of many pollutants to the nation's waterways – including nitrogen, phosphorus, bacteria, hydrocarbons and heavy metals. (Brown, et.al., 2009; Collins, et.al. 2010; Hogan & Walbridge, 2007; Rosenquist, et.al. 2010; Pitt, et.al., 1995; Walsh , et.al., 2005). A typical urban stormwater collection system is a series concrete pipes, flumes, and catch basins receiving stormwater from rooftops, streets and parking lots. This labyrinth of impervious surfaces provides pollutants with a hydraulically efficient drainage system for contaminating receiving waters. *Urban Stream Syndrome* is the term for the situation created by this interconnection between the built and the natural environment (Walsh et.al. 2005).

The U.S. Congress realized the extent to which all stormwater had the potential to pollute the nation's waters, so it amended the Clean Water Act (33 U.S.C. §1342 et. seq.) and directed the U.S. Environmental Protection Agency (EPA) to regulate certain stormwater discharges. Discharges from urban settings were targeted under the Multiple Separate Storm Sewer (MS4) program (40 C.F.R. §122). This tasked cities with reducing the amount of pollution in stormwater through the use of stormwater best management practices or BMPs. BMPs are a wide range of structural and non-structural practices for reducing stormwater pollution. An array of studies has been done to research BMP effectiveness to remedy various aspects of *Urban Stream Syndrome*. One remedy the studies point to reductions impervious surfaces to treat urban storm runoff (Collins et.al. 2010; Hogan & Walridge 2007; Rosenquist, et.al. 2010; Walsh et.al. 2005; Walsh, Fletcher & Ladsson 2005; Hatt et.al. 2004; Paul & Meyer 2001; D'Arcy & Frost 2001; Pitt et.al. 1995).

Baltimore City is regulated under the EPA's MS4 program and has used certain BMPs to reduce its stormwater pollution. Watershed 263 (WS 263) is a rather troubled watershed within the city and a contributor to urban stream syndrome. The stormwater system in WS263 collects all rainfall and snow melt into underground pipes that empty into Patapsco River near Baltimore's Inner Harbor. The City, in partnership with a local non-profit (the Parks and People

Foundation), retrofitted and installed BMPs in WS263 to reduce the stormwater pollution from the watershed. Some of the BMPs installed in WS263 have been the removal of asphalt or concrete parking lots and the installation of bioretention structures. Some preliminary sampling results have shown some promising reductions in pollutant concentrations. Yet, pollutant loading rates have been difficult to obtain and there is no direct correlation of the pollution reduction to the BMPs. In addition, little performance data has been collected concerning the performance of these BMPs (e.g. is stormwater flowing into the structure).

One of the sampling areas within WS 263 is subcatchment O. This project looks to catalog and characterize the retrofit BMPs installed in subcatchment O as well as count and measure the street trees within the same area. This data collection will assist researchers as they attempt to model the stormwater flow in the watershed. In addition, this project looks to create a platform for expanded public participation concerning the implementation and continued performance of the BMPs.

2. Project Goals

The project seeks to establish a framework to assist in collecting the data necessary to track BMP installations and model the loading rates from stormwater samples within a representative subcatchment of WS 263. The Source Loading and Management Model (SLAMM) is a stormwater planning model which assists the user in planning cost-effective BMPs for a particular setting and has the advantage of being able to be applied on a small scale, like WS263 (Pitt & Vorhees, 2002). It requires an inventory and categorization of all the existing stormwater management features within a sampling area. Once these features are put into the model it can serve a dual purpose, first to determine the stormwater flows to calculate the existing pollutant loading rates and second, to assist planners in choosing the most advantageous and cost-effective BMPs to install in the future.

The project also looks to establish another framework that would encourage public participation beyond the planning stages to BMP implementation and maintenance through *crowdsourcing*. Crowdsourcing is an online phenomenon businesses use to outsource problems to the internet, in which the ‘crowd’ supplies a collection of data or content, or an individual from the ‘crowd’ solves an individual problem. In this case, crowdsourcing could be used as a means of public participation in the ongoing implementation, maintenance and accountability of stormwater retrofits within the subcatchment and hopefully to the entire watershed. A similar tool, *Citizens Connect App*, is currently being used in Boston to report potholes to the Department of Public Works (City of Boston.gov). SLAMM and crowdsourcing will be useful tools in retrofitting and restoring WS263 and improving the overall water quality in the catchment and contributing to the improvements needed in the Patapsco River.

Lastly, the project looks to begin the process of cataloging the street trees in subcatchment O. Street and park trees have been shown to reduce stormwater runoff through “canopy rainfall interception,” water storage and evaporation on leaves, and flow along trunk to pervious surfaces (Sanders, 1986; Xiao & McPherson, 2002; McPherson et.al. 2005; Nowak, 2006). While several variables, including tree size, individual storm events, and seasonality of rainfall impact street trees use a BMP, “trees have a relatively significant impact on runoff during small frequent storm events” and have the potential to be considered BMPs to satisfy EPA’s MS4 or Total Maximum Daily Load programs (Nowak, 2006). Some have quantified the benefits of trees as not only stormwater BMPs but also their esthetic value (Xiao & McPherson 2002; McPherson et.al. 2005). Because each urban area has its own climatic individuality, much of the research is not directly transferable but several models have been developed to assist in decision-making for urban forestry programs (Wang et.al. 2008). For this project, the number of street trees in subcatchment O will be counted on each city block and the diameter at breast height (dbh) for each tree will be measured.

The objectives in this project are to:

- Inventory the stormwater retrofit BMPs and street trees for a 39-acre subcatchment sampling area of WS 263
- Characterize, assess, and categorize these BMPs
- Photograph and record the global position for each BMP in a spreadsheet and produce an online website of the BMPs
- Review sites for future BMPs with similar data collection
- Count and measure the street trees in the catchment and catalog those results.

3. Background

- ***Urban Stream Syndrome***

Waterways impacted by *Urban Stream Syndrome* can be characterized as having “a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species” (Walsh et.al. 2005). One cause of the impacts appears to the correlation of impervious surface and its direct connection to the waterway (Walsh et.al. 2005; Walsh, Fletcher & Ladsson 2005; Hatt et.al. 2004). Moreover, increased impervious surfaces and the development of a sewer system for the conveyance of stormwater is all a product of urbanization and increased density. The neighborhoods in WS263 encompass a high density, long-established, urban section of Baltimore City. WS263 has a high percentage of impervious surfaces throughout the water shed and is a significant contributor to urban stream syndrome in the Patapsco River and Baltimore’s Inner Harbor.

Stormwater History

Urbanization has slowly expanded globally throughout the centuries culminating in the twentieth century’s modern city. Older cities’ planning schemes worked on a grid system of paved streets and alleys with a housing density of perhaps ten (10) or more houses per acre. Between the streets, alleys and rooftops, the percentage of impervious surface created from development could easily reach fifty percent (50%). As population density within cities increased, controlling runoff from rainfalls became critical for public safety and prevention of loss from flooding. Conveying water over land under these new conditions became unachievable and many cities developed underground stormwater pipes to carry rainfall runoff from neighborhoods to receiving waters. The predominant thought in stormwater management was safety and loss prevention. Thoughts of pollutant transmission were minimal because many early sewers combined stormwater and sanitary waste with little or no treatment prior to discharge into waterways.

Pollutants

As separate sanitary and stormwater sewers developed, the problem of pollution was thought to be resolved but stormwater itself poses its own difficulties. Urbanization impacts on streams goes beyond just pollutants, it affects the "physical, chemical and biological/ ecological" aspects of receiving streams (Paul & Meyer 2001). Impervious surfaces prevent rainfall from infiltrating into the soil, disrupting groundwater recharge, and can increase the amount of runoff up to five-fold. The increased volume of runoff as well as its increased velocity impacts the hydrology, geomorphology and temperature of receiving waters with smaller tributaries being affected more severely. Hydrology is impacted by reducing the time between the rain falling and when runoff begins (lag time) and increasing the intensity of the runoff in velocity and volume (hydrograph), stream banks are widened and sediment balances are disturbed geomorphologically, and temperature is increased (Paul & Meyer 2001). Urban stormwater is the source of many chemical pollutants to the nation's waterways – including nitrogen, phosphorus, hydrocarbons and heavy metals. (Rosenquist, et.al. 2010; Collins, et.al. 2010; Brown, et.al., 2009; Hogan & Walbridge, 2007; Walsh , et.al., 2005; Pitt, et.al., 1995).

Nitrogen and phosphorus are limiting factors to algae growth in water bodies. Algae blooms limit light penetration and decaying algae reduce oxygen levels in water, causing fish kills and creating dead zones. Metals, like mercury, can bio-accumulate in benthic species and potentially poison the food chain. Pesticides and other organic compounds associated with urban development (i.e. polychlorinated biphenyls, PCBs) are known carcinogens and mix with urban runoff. Stormwater flows into surface waters which are a main source of drinking water; therefore, drinking water can be contaminated by these pollutants, increasing the cost of water treatment and endangering human health. Urban streams' biodiversity of fish and invertebrates is vastly diminished, bacterial contamination is common in particular immediately after a rain event, and essential ecological processes and services are degraded due to increased impervious surfaces and urbanization (Paul & Meyer).

Impervious Surface

As the amount of impervious surface increases, so do its effects, sometimes exponentially. Several studies have found that reducing the amount of impervious surface (i.e. removing asphalt) and disconnecting or interrupting the direct discharge of surface flows to storm sewers can greatly improve water quality and still ease the risk of flooding (Walsh et.al 2005; Walsh, Fletcher & Ladson 2005; Hatt et.al. 2004). The pollution loading and water volumes of the total impervious surface (total imperviousness, TI) can be mitigated by reducing its direct connection to the storm sewer (drainage connection, DC). The disconnections can be determined and the reductions in impervious surface effects measured (effective imperviousness, EI) and formulated $TI \cdot DC = EI$ (Hatt et.al. 2004). To be effective these disconnections in flow should be vegetated retention or detention structures that can hold storm flows over an extended timeframe (Collins, et.al. 2010; Kadlec, 2005). Because nitrogen and phosphorus are the limiting factors for eutrophication and hypoxia, BMPs should seek to assist in removing these nutrients. For nitrogen removal, the nitrification/denitrification process needs to occur; this process follows an aerobic/anaerobic cycle. Recent stream restoration studies associate increased de-nitrification with increased "hydrologic residence times" which created periods of extended anoxia increasing the rate of nitrogen removal (Kaushal et.al. 2008). Phosphorus removal is associated with wetlands soils and biota, and the wetlands growth cycle (Kadlec, 2005). Wetlands require extended periods of inundation to form and function, and need to experience extended anaerobic periods. According to the 1987 *Army Corp of Engineers Wetlands Delineation Manual*, this requires an area to be "inundated or saturated to the surface continuously for at least 5% of the growing season" (U.S. ACOE, 1987). In addition, certain soil types are more efficient at removing metals and hydrocarbons (Clark & Pitt, 2007). Therefore, BMPs should be designed taking into consideration disconnecting impervious surfaces and creating conditions for pollutant removal.

Structural Best Management Practices

Even prior to the cited research, efforts to reduce stormwater volume and velocities led to the use of vegetated retention/detention structures known as stormwater BMPs. (The BMPs discussed here a structural as opposed to procedural BMPs, which are policies and procedures to assist in changing behaviors and may be viewed as pollution prevention, P2, measures.) Reducing the volumes and velocity of stormwater from impervious surfaces was the initial mission of these BMPs but their ability to create improvements in water quality have led to more innovative BMPs and an entirely new land use planning scheme called “low-impact development” (LID). LID seeks to reduce the total imperviousness to near pre-development levels (Schuster et.al. 2008). Beyond large retention/detention ponds, engineers and planners are using vegetated roadside swales, bioretention structures, rain gardens, sand filters, and other disconnections between impervious surfaces and drainage systems to further reduce stormwater pollution. Some BMPs are more effective at reducing certain pollutants better than others. Sediments and other heavy particles fall out of suspension as flow rates are reduced. However, nutrients, pesticides, and heavy metals can require additional biotic components to treat pollutants (Wegner, et.al. 2009). For example, nitrogen removal requires a two-step process where nitrogen is assimilated or adsorbed into plant biomass. This is only temporary removal and the second process of anaerobic microbial denitrification is necessary to remove nitrogen permanently (Collins, et.al. 2010). This requires design criteria for BMPs that can allow for both aerobic and anaerobic processes to remove nitrogen.

Because the initial purpose of BMPs was to collect and store (retention) or collect and detain (detention) stormwater and mitigate flooding, BMPs were required to collect stormwater from significant rainfall events (typically 25-year storm) over a large catchment. Collection of that much rain water requires large land areas. In addition, for phosphorus removal, constructed wetlands required rather large land areas (Rosenquist, 2010). Often, the required land mass for such BMPs is the limiting factor in retrofitting established urban areas. Pond sizes can vary, deeper ponds need less surface area and shallow ponds vice versa. However, in developed urban areas neither depth (due to existing infrastructure) nor area (due to density) is readily available for large stormwater structures. Considering the high percentage of impervious surface and the limited design space, BMPs for urban retrofits must be more creative than retention/detention ponds and large constructed wetlands. It requires designing BMPs that collect and treat stormwater from smaller catchments, perhaps an acre or less. In the case of

WS263, rain gardens, curb extensions and bio-swales are being used to treat catchments as small as 0.25 acres to 1.5 acres. The cost to municipalities to retrofit stormwater facilities with any of these retrofit BMPs can be prohibitive, so cost-effectiveness and efficiency of the BMP design is crucial if cities expect to reduce their urban runoff pollution and meet MS4 requirements.

- ***The Source Loading and Management Model***

Because stormwater behaves erratically in urban settings (shorter lag time and increased hydrograph), taking direct measurements of stormwater flows is near impossible. WS263's underground storm system has no means to directly monitor flow. Therefore, modeling is required to determine stormwater flows. In addition, modeling flows can help in planning stormwater retrofits. The project looks at the Source Loading and Management Model as a tool to predict flow and cost-effectively plan future retrofits. Support data was collected for the model including the existing retrofit BMPs, acres of impervious surface infiltrated by the BMPs, and the number and size of street trees intercepting rainfall within a subcatchment of the water shed.

SLAMM has its beginnings in the 1970's as a "data reduction tool for use in early street cleaning and pollutant source identification projects" (Pitt & Vorhees, *a*) SLAMM was developed primarily into a planning tool for predicting stormwater flows and pollutants from a "broad variety of development conditions and the use of many combinations of common urban runoff control practices" (Pitt & Vorhees, *a*). "SLAMM is strongly based on actual field observations" and is specialized for use in "small storm hydrology" (Pitt & Vorhees, 2002). Because urban retrofits are typically for smaller catchments, a model that uses small storm hydrology is advantageous for proper BMP design.

In areas with a high percentage of impervious surfaces, like WS263, small storms generate a majority of the annual flow and pollution into the stormwater system. In Baltimore, rain events of one-tenth (0.10) to one-quarter (0.25) of an inch of rain are common events occurring on average several times per month. Larger storms associated with flooding are typically on the scale of the 1-percent annual chance (100-year) storm. The first flush of any storm carries the majority of the stormwater pollution load. Consequently, small storms can transport similar amounts of pollution as larger storms. Therefore, using a model designed to take into consideration small storm hydrology makes a great deal of sense when planning to retrofit urban stormwater BMPs. While earlier versions (winSLAMM 8.7) of SLAMM were criticized for not including green infrastructure BMPs (bioretention, green roofs etc.), more recent versions have evolved to include more green infrastructure. When compared with other stormwater models, SLAMM appears to most effective at comparing and contrasting costs of achieving pollution reductions (Elliott & Trowsdale, 2006; Burton & Pitt, 2002; Pitt, 2007).

Effective Use in an Urban Setting

SLAMM was developed out of EPA's *Storm and Combined Sewer Pollution Control Program* and its *National Urban Runoff Program* as well as projects and field studies in Ontario Canada and throughout the State of Wisconsin. The earliest users of the model were the Ontario Ministry of the Environment and the Wisconsin Department of Natural Resources (Pitt & Vorhees). A specific application of SLAMM was used in Madison, Wisconsin, where an urbanized watershed was looking to reduce its total suspended solids (TSS) load by 40 percent (Bannerman & Fries). Using SLAMM, the city was able to compare and contrast the costs and benefits of several BMPs, including sand filters, *Stormceptor®*, bioretention and high-efficiency street sweeping.

Madison's Lake Wingra watershed encompasses approximately 4,000 acres with medium density residential, open space and commercial land uses making up approximately 92 percent of the land use in the water shed (Bannerman et.al., 2003). SLAMM uses source areas (i.e. roofs, parking lots, small and large landscaping, etc.) as building blocks for calculating runoff volumes and pollutant loads for its land uses. Madison was able to calibrate SLAMM using rainfall records, runoff records and TSS loading collected by the U.S. Geological Survey from several neighboring watersheds in Wisconsin and Michigan. Next, Madison determined the TSS loads from different land uses, sub-watersheds and source areas and found that the majority of its TSS load came from four of the eight sub-watersheds. In addition, within those four sub-watersheds residential and commercial were the dominant land uses and commercial land use contributed more than of its share of TSS per acre. From this information, Madison looked at a selection of *regional* and *source area* stormwater BMPs to evaluate different combinations of BMPs to achieve its 40 percent reduction in TSS. Capital and maintenance costs were identified for each BMP and combinations of the alternative BMPs were compared and contrasted for cost-effectiveness to meet prospective goals (Bannerman & Fries).

Planning Cost-Effective Retrofits

The costs of different BMP applications in the Lake Wingra watershed ranged from $11 million to $37 million, which gave Madison a wide array of choices to achieve its TTS reduction goal. Madison also looked at each alternative and determined the cost to taxpayers through an annual utility fee per household, which ranged from $6 - $18. This fee took into consideration that commercial properties were a larger per acre contributor of TSS and commercial properties were made responsible for 55 percent of the utility fee (Bannerman & Fries). Having this range of alternatives gives localities the ability to make tradeoffs between land uses and source areas. In Madison, because commercial properties appear to be a major contributor of TSS compared to the size of their land use, they were held responsible for 55 percent of the utility fee. However, from another perspective, commercial property only contributed 31 percent of the total TSS load, while residential land use accounts for 51 percent (Bannerman & Fries). From this point of view, commercial land use is being taxed at a rate not in accord with its pollution input, which may be viewed as an inequity. Nevertheless, because Madison had a number of alternatives, it allowed for flexibility in how the city chose to retrofit its stormwater infrastructure as well as how to allocate its fee for services while keeping its economic attractiveness to businesses and residents. All municipalities have an interest in keeping an area economically viable for development is an underlying factor in municipal land use decision-making and the flexibility derived using SLAMM can benefit management of WS263.

Data Collection Required

To develop a watershed-specific model from SLAMM, several parameter inputs are required. There are six land use categories – residential, institutional, commercial, industrial, other urban, and freeway land. In addition to these land uses, SLAMM takes into consideration particular source areas – impervious and pervious. Examples of impervious source areas are driveways, freeways, parking lots (paved and unpaved), sidewalks, streets, alleys, and roofs. Pervious source areas are large and small landscaped areas, large "turf" areas, playgrounds, undeveloped, and other pervious areas. To illustrate this further, a residential land use could be defined as medium density with sources areas being roofs, sidewalks, streets, and driveways. Moreover, SLAMM can incorporate other support files including rainfall data, soil group, runoff coefficients, street delivery, and pollutant distribution data to refine the model for more accurate results (winSLAMM User's Manual). Once this data is collected, the model can be calibrated, as the City of Madison did, and the inputs of existing and potential BMPs can be input based on the desired pollution reduction outcome (Pitt, 2007).

Acquiring this data requires an intense survey of the watershed, some of which can be accomplished through online sources such as *Google earth*, *iTouchMap.com*, and *GPS Visualizer*. In subcatchment O, a previous survey was done for the Center for Watershed Protection and used for its *Stormwater Management Strategies for Subcatchment O* (CWP, 2007). The results of that survey combined with this project's survey of supporting data – the existing retrofit stormwater BMPs as well as a count and measurement of street trees – will provide significant input for SLAMM's use within the WS263.

- ***Public Participation and Crowdsourcing***

Expanding public participation in any aspect of public administration is a challenge. Little research was found concerning participation and environmental restoration. Increased public participation creates transparency in government and confidence that the public's voice is heard. Online tools are being used to inform the public of traditional channels for input but for the most part are not being used as effectively as possible. The project seeks to create a framework using crowdsourcing to expand contributions from people living in and concerned about WS263.

Public Participation in Environmental Restoration

In a case study done by Cassie Herringshaw (2010), she and her colleagues looked into the benefits of public participation in retrofitting an urban ecosystem. This research looked at riparian buffer restoration of a creek in Ames, Iowa. The project incorporated the public into the planning and construction portion of the restoration. The researchers held public meetings to discuss, instruct, and engage the public on urban water quality, stormwater, and non-point source pollution. The restoration project took place in Daley Park, where the surrounding neighborhood includes about sixty households and one-hundred and forty residents. Over a two year period the researchers held thirteen public meetings concerning the planning and implementation of the project. These meetings averaged seven public participants. (Herrringshaw et.al., 2010) Because this project was set in a public park in Ames, a city of over 50,000, its impact certainly goes beyond just that of its most proximate neighbors but public participation was still considerably low. The researchers understood the challenges at the onset of the project and stated their concerns regarding a “public that often lacks understanding of ecological principles” and the “difficulty integrating social … factors in studies of urban ecosystems” (Herringshaw, 2010). Engaging the public in almost any effort can be difficult. Attending hearings and meetings is an additional time consuming event for a public, whose resource of time is evermore constrained. In addition, the “learning curve” between the experts and the general public only adds to the challenges of the public meeting process. Nevertheless, surveys from participants in the Daley Park restoration acknowledged that the public was able to influence the project by expressing its preferences for placement of the riparian buffer and left the process with a greater knowledge of stormwater than prior to the project (Herringshaw, 2010).

However, the number of participants was still negligible and if public participation is to be encouraged, other means of engaging the public in the planning, implementation and even the monitoring and enforcement process need to be developed. This project will look at an online phenomenon called *crowdsourcing* to expand the public participation process.

Crowdsourcing and Open Source Production

Few online tools are being used to engage the public in planning or implementation of public projects and where the internet is being used to connect with residents, it is only to inform them where and when public meetings are being held and how to submit comments (e.g. the Government Printing Office's electronic Federal Register web site). Crowdsourcing is an online tool that can be used to expand and empower the public's participation in not only the planning but the performance of projects. The goal in this project is to establish a platform where the public can submit photographic BMP performance data in WS 263 as a means to increase their contribution as citizens.

Crowdsourcing and *open source production* are two examples of online information technology phenomena that gather individuals together to "create content, solve problems, even do corporate R&D" (Howe, 2006). Examples of open source production are the development of software such as *Linux*, *Apache,* and *Sendmail*, which are software programs developed in a "new production model in which a public good is voluntarily provided" (Osterloh et.al. 2006). Crowdsourcing has a broader view of using an online crowd. It looks beyond the development of software to gathering data and content, and outsource tasks to a broader market; however, it is not the same as open source production. The content, data, or problem solved by crowdsourcing becomes "the property of companies" and not part of the public domain (Brabham, 2008). The products can be provided to the companies voluntarily or purchased. While some crowdsourcing applications rely on a large group of amateur or professional crowds, like *iStockphoto*, other applications encourage the crowd through a bounty. Companies like *InnoCentive* and *Threadless* reward individuals in the crowd financially for their innovation or original product (Howe, 2006; Brabham, 2008). For the last two years, *Frito Lay* and *Pepsi* have crowdsourced Super Bowl advertisements (http://www.crashthesuperbowl.com/#/contest-info) with a crowdsourcing contest.

Moreover, crowdsourcing is beginning to be used as a means of public

Figure 1 – *Citizen's Connect App* can be used to report potholes or graffiti to the City. (City of Boston, 2011)

involvement in municipal operations. In 2009, Boston, Massachusetts, introduced its *Citizen's Connect App* for Apple's iPhone and has expanded its use to Android phones. The application allows Bostonians to photograph potholes, graffiti, etc. and report the problems directly to the city's Department of Public Works (DPW). The application uses the phone's global positioning system (GPS) to pinpoint the source of the complaint, then the photograph and address are sent to Boston's DPW. The user gets a tracking number so they can follow-up later on the results (Levenson, 2009). Boston is now looking to develop a application called *Street BUMP* (the Boston Urban Mechanic Profiler), which uses "the sensors on smart phones [to] provide the City with a near-real time picture of Boston's road conditions and the location of its potholes" (new urban mechanics, 2011). Interestingly, the development of the software to create *Street BUMP* is being crowdsourced through InnoCentive.

*Crowdsourcing Public Participation*Brabham (2009) suggests that crowdsourcing could be used for public participation in the urban planning process. He identifies urban planners' struggles to engage the public as with Herringshaw and speculates how to increase participation through crowdsourcing. While the face-to-face participation model has served its purpose, engaging the public online is a possible means of broadening the pool of participants. Brabham postulates that crowdsourcing could more fully engage the public and its non-expert knowledge and cites several studies where there is "tremendous success when non-experts engage in scientific problem solving and product design, often with solutions superior and more cost-effective then traditional research and development" (Brabham, 2009).

At times, public participation can be seen as consensus-building effort or worse a procedural "check-the-box," but public cparticpation is better served when it is a means to educate and assemble comprehensive proposals from the public. The author cites James Surowiecki, *The Wisdom of Crowds*, for his recognition of how crowds aggregate thought and broaden ideas rather than constrain or diminish them. Brabham posits that crowdsourcing public participation would go beyond ideas to reviews of public proposals and possible voting for the best ideas. Because crowdsourcing integrates compensation, accepted and used nominations could be compensated through naming rights or discounted public services (i.e. tax credit). Drawbacks to crowdsourcing are the lack of access to the World Wide Web and differences in bandwidth. Solutions could include media centers with available access and bandwidth speed, which could be done through the public library system in many places in America. Also, there is the real need for the government to narrowly define the problem it wants to solve. Lastly, there is a need to police the participation when necessary, for example, to be sure the participants are truly stakeholders and not outsiders. Good identification software and reliance in the crowd to "self-regulate" help solve this situation (Brabham, 2009).

Project Scope of Crowdsourcing

This project is not looking to develop as sophisticated a tool as Boston's *Citizen's Connect App*. However, it could be the start of a similar concept for public participation in the stormwater retrofit plan for WS263. While *Citizen's Connect* is a complaint driven tool, the crowdsourcing tool used in WS263 is potentially an environmental management tool for the community. Certainly, it can be used as a means to inform the Baltimore City DPW of maintenance issues for the BMPs, but the intentions of this tool are to collect photographic data on the BMPs and their effectiveness in disconnecting impervious surfaces' direct discharge to the storm sewer. In addition, some BMPs have been created as amenities, introducing an esthetic value to the community. The esthetic value comes from the plantings flourishing and remaining amenities and not becoming dis-amenities. The intention of the website is to be a reservoir for photographs and data for the entire water shed but will initially contain photographs taken of the specific BMPs installed in subcatchment O. The crowdsourcing-participation photographs are taken with a "cell phone" camera and emailed to the website via an email address (WS263BMP@gmail.com). The address or street corner of the BMP will need to be included with the email so that the photograph can be properly catalogued. The system has been beta-tested and appears to working well, the task of downloading the photographs and transferring them to the website requires elementary knowledge of web design. The entire site or concept can be transferred to a non-profit group or to the city DPW for continued use.

- ***Street Trees***

Because small rain events contribute significantly to stormwater pollution, remedies that consider small events should be investigated. Street trees perform a needed service in ameliorating stormwater runoff, particularly during the smallest most frequent rainfall events. Urban forestry should not be seen as a panacea for stormwater management but it is certainly part of a treatment train for stormwater pollution. Unlike some structural BMPs whose applications and results are repeatable under different climatic conditions, urban forestry is highly dependent on the duration, intensity and seasonality of precipitation. It is also relies on the storage capacity of the tree canopy and whether a tree is deciduous or an evergreen, broad-leafed or not (Xiao & McPherson 2002; Wang et.al. 2008). Taking those factors into consideration, trees function as stormwater BMPs best during smaller more frequent events intercepting up to 40 percent of total precipitation and reducing “the frequency and magnitude of pollutant wash-off phenomenon” (Wang et.al. 2008). Beyond interception, trees increase the permeability of soils through root growth. Most developed urban soils are heavily compacted and resistant to absorption, root growth from tree planting decreases compaction and increases permeability (Sanders 1986; Wang et.al. 2008). In addition, the added canopy increases the lag time between rainfall and stormwater flows and elongates the hydrograph.

In addition, several BMPs, including the curb extensions in the study area, incorporate the use of trees and evapotranspiration for the treatment of stormwater. In these cases, engineered soils that meet the required code compaction standards for roads and sidewalks can be used to provide increased pore space for root growth and increased transpiration (Bartens et.al. 2009). The use of these engineered soils for newly planted street trees incorporated within sidewalks can be additionally beneficial over and above existing potentially compacted soils by encouraging deeper root penetration and overall growth, increasing the canopy and infiltration.

In subcatchment O, an extensive tree planting venture has begun. The majority of the trees in the subcatchment can be divided into three categories – street trees, perimeter trees and alley trees. Street trees line the streets and are planted in tree boxes, which gaps in the sidewalk. Perimeter trees are planted on vacant lots along its perimeter typically adjacent to the sidewalk. Alley trees grow in the rear of the houses and in general were not planted but occurred naturally. Many alley trees are invasive species like *Ailanthus altissima,* the tree of heaven. The project looks to catalog the street and perimeter trees because a complete index has not been collected. The project looks to count and measure (dhb) all of the street trees in the subcatchment, for future use in stormwater modeling for the entire watershed. Larger trees create a larger canopy for stormwater interception, particularly in smaller more frequent storms. Therefore the actual canopy can be modeled as well as the future canopy as smaller trees grow. With the number of vacant lots in the study area, many tree plantings are beyond just sidewalk incorporated street trees. The perimeter trees will be counted and measured also. For reasons of safety, the only trees not counted in the subcatchment were those in alleys or growing through dilapidated houses.

4. Project

- ***Study Area – WS 263 & Subcatchment O***

Watershed 263

The WS263 catchment is part of the Baltimore Ecosystem Study, within the long-term ecological research (LTER) network. Once focus of the LTER is integration “of hydrological processes on biological communities and from biological communities to the water cycle” known as “ecohydrology” (Moran et.al., 2008). The USDA Forest Service is working in WS263 to examine the role of urban forestry in stormwater management, as well as in improving the environments of the water shed’s neighborhoods through community involvement in the process. WS263, located in southwest Baltimore, is a 935-acre urbanized watershed that discharges to the Middle Branch of the Patapsco River. Some unique characteristics of this urban watershed are:

- approximately 75 percent impervious surfaces,
- all water running underground in separate storm sewers, and
- less than 6 percent tree cover.

The approximate borders of the watershed are Presstmen Ave to the North, Monroe Street to the west, Freemont Ave to the east, and the Patapsco River to the south (see Attachment 1).

The stormwater pollutant characteristics of this watershed are similar to those all across the state of Maryland: nutrients – nitrogen, in the form of nitrate plus nitrite and total kjeldahl nitrogen (TKN), and total phosphorus; metals – zinc, copper, and lead; organics – oil and grease in the form of total petroleum hydrocarbons (TPH); total suspended solids; bacteria; and physical pollutants, such as temperature, flow, pH and oxygen depletion. WS263 is being studied as a model urban watershed restoration project with goals of improving water quality through “community greening” (PPF, 2011). This project will examine the performance of stormwater BMPs in reducing pollutants through disconnected impervious surface, increased groundwater infiltration, and rainwater capture.

This watershed has an abnormally high level of impervious surface at 75 percent; whereas, 40 percent is typical in Baltimore City. Impervious surfaces include streets, sidewalks, roofs, or any surface that does not allow rainfall or snow melt to penetrate into the soil. Some areas of bare soil can be considered impervious or semi-permeable because of soil compaction. Of the total acreage, 201 acres are vacant lots (3061 lots = 0.07 acres per lot) some privately owned, others owned by Baltimore City or the State of Maryland. There are 218 acres of open space which includes neighborhood and regional parks, and schools. Not all open spaces consist of permeable surfaces, as many are covered with asphalt. While 40 percent tree cover is seen as an optimum for an urban landscape, tree cover in the watershed is approximately 5.5 percent with many invasive species dominating.

Subcatchment O

Subcatchment O is 39 acres, situated on the western portion of the waster shed and encompasses about eight square blocks (CWP, 2005). A manhole at the intersection of Baltimore Street, Gilmor Street and Frederick Avenue is the sampling point for the stormwater discharge from the subcatchment . The approximate subcatchment boundaries are Monroe Street and Bon Secours Hospital to the west, Baltimore Street to the south, Mount Street to the east, and Saratoga Street and Penrose Avenue to the north. There is a defined crest in the landscape to the west that delineates this subcatchment/watershed from the adjacent watershed. No other physical attributes differentiate this subcatchment from adjacent catchments. The area can be characterized as a residential community with few commercial and no industrial land use. Institutional land uses are the hospital and several churches. Many homes have been removed and a good deal of open space is available. Much of the open space is green and recently planted with perimeter trees. But impervious surfaces dominate the area with roofs, roads, alleys, sidewalks and parking lots (See figure 2 for an overview of the land cover).

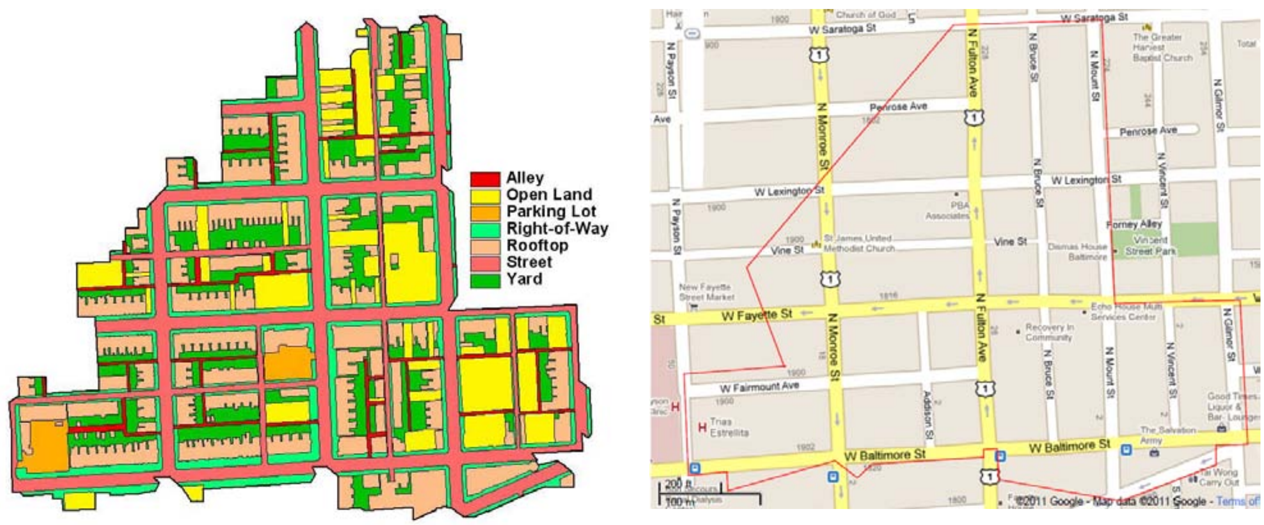

Figure 2 - Subcatchment O Land Cover **is shown to the left. Colors representing impervious surfaces dominate the subcatchment. The figure to the right gives an approximate outline of subcatchment O with the street names identified.** ***(CWP, 2005)***

Stormwater Management Strategy for Catchment O in Watershed 263

The Center for Watershed Protection (CWP) developed an extensive stormwater management (SWM) strategy for subcatchment O in 2005. CWP evaluated the area and found that the quality of the runoff as extremely poor, with some pollutant concentrations “two or three times the national average.” The survey also found the typical flow pattern in the subcatchment was from the roof to downspout, to a concrete back yard, to the alley, to the storm drain with “little opportunity for infiltration.” CWP also found that 75 percent of the neighborhoods in subcatchment O had a moderate to severe stormwater pollution potential. The resulting stormwater strategy outlined structural and nonstructural BMPs which included stormwater retrofits and citizen stewardship activities. The structural BMP recommendations were catch basin inserts, stormwater curb extensions, and street bio-filtration practices. These BMPs were suggested because of their ability to treat small catchments. (CWP, 2005). According to the Parks and People Foundation, several of these structural BMPs were installed and implemented through private grants and through the Baltimore City DPW.

The CWP strategy also included a section concerning the management of pollutants from "Open Lands." The simplest "Open Land" strategy is the planting of perimeter trees around open spaces. The benefit of this practice is to delineate vacant lots and establish the notion that the lot is not for dumping. Other strategies involved removing invasive species, amending the soils and planting native cover and trees, and removal of impervious cover (sites I-1, DPW). Lastly, the use of this open space for bio-retention or bio-filtration is the most complex strategies for open space (site PPF-2). The stormwater BMPs implemented in subcatchment O are described in table 1.

Watershed 263 Stormshed, Subcatchment O			
Baltimore City, MD			
39-acres stormshed that is monitored for water quality outcomes			
Demonstration bio-facilites			
Site Name	**Type**	**Location**	**Area (ac)**
B-1	Bioretention	Baltimore St. & Frederick Ave.	0.87
B-10	Curb Extension	N. Mount & Lexington Sts.	1.30
B-13	Curb Extension	W. Fayette & N. Mount St.	0.26
B-15	Curb Extension	Lexington St. & Fulton Ave.	1.63
C-10	Catch Basin Insert	Bruce at Baltimore	
C-12	Inlet modification	Fulton at Lexington NW	
C-13	Filterra	Fairmount & Fulton Ave.	0.20
C-B 9	Catch Basin Insert	Lexington at Mount (SW)	

F-3	Sand Filter	Alley between Fayette and Fairmount at Addison	
I-1 & PPF-3	Alley removal and Bio-Swale	Bruce St. & Fulton Ave.	0.04
PPF-2	Bio-Swale	N. Mount & Baltimore Sts.	0.75
DPW	Grubbing & new lawn with trees	1100 N. Vincent Street	1.50
Total			**7.11**

Table 1 - PPF report of bio-facilities in Subcatchment O (PPF, 2010)

The Parks and People Foundation estimated that these bio-facilities in table 1 will remove annually over 1100 pounds of total nitrogen, 20 pounds in total phosphorus and 2250 pounds of total suspended solids

- ***Methods and Data Collection***

This project is a survey of subcatchment O of WS263, to verify the installation and likely operational performance of the structural BMPs installed within the area, as well as to count and record the street trees within the this portion of the watershed. The survey data collected for this project including the photographs, tree counts, spreadsheets, etc., will add to the long-term data collection of the BES and will hopefully spark further surveys, data collection, and analysis in the watershed.

The methods used in this survey were simple. It encompassed a few days spent in the neighborhoods in subcatchment O, walking along streets and a few alleys photographing and videotaping structural BMPs and street trees. To evaluate the performance of the BMPs it was necessary to visit the area during a rainfall when runoff was produced, this was fortunate enough to happen. Photographs and measurements of the street trees were taken. The circumference, in inches, of the trees was taken at approximately four feet (4’) from the ground (breast height) and converted to diameter. A *Sony Cybershot* digital camera was used to photograph and videotape.

The data collected was compiled into a Microsoft excel spreadsheet (appendix A & B). The BMPs were described using the site names from the PPF (table 1). The impervious area treated was estimated through observation of stormwater flow and using an online tool, *GPS Visualizer* and the latitude and longitude for the inlets of the BMPs was determined using the online tool *iTouchMap.com*. Google Maps was also used as a backup verification of actual on-the-ground surveying. The cost data was obtained from Baltimore City DPW via the *Watershed 263 BMP Theme Park Virtual Tour* website. The trees were organized in the spreadsheet by segments of streets (e.g. West Baltimore Street from Gilmor Street to Mount Street). The total number of trees in that segment were counted and then broken down by size. Further surveying is needed to determine *genus* and *species*.

In addition, a webpage/website (www.flickr.com/photos/ws263) was established that included the data concerning the BMPs, photographs from the initial installation and photographs showing the current condition. An email account (WS263BMP@gmail.com) was established so that the BMPs' future conditions can be photographed using a digital camera or *cell phone* camera and emailed for posting on the webpage. This platform should encourage public participation in the long-term data collection of the BMPs' performance as well as a trigger for maintenance, and the BMPs status as an amenity or dis-amenity.

Stormwater Structures

Not all of the BMPs in table 1 could be surveyed. According to the Parks and People Foundation, sites C-10, C-B9, C-12 and F-3 are installed, however, they are inaccessible because they are underneath sidewalks and can only be observed by removing the manhole covers or removing the sidewalk, which should only be done in collaboration with the city DPW. Because we did not know that these BMP were inaccessible at the time of the survey and no one from the city DPW was available, these BMPs were not surveyed or assessed for this project. Nevertheless, with the exception of I-1/PPF 3, which was impervious cover removal, the remaining BMPs were photographed, cataloged and characterized. Appendix A contains the data collected concerning BMP sites B-1, B-10, B-13, B-15, C-13, PPF-2 and tree planting site DPW. Photographs of the BMPs were placed on a compact disc and submitted separately from this paper. The BMPs are identified by their street address or by the cross streets near the BMPs location.

- *Site B-1 – Biorentention tree pit at the corner of W. Baltimore St. and Frederick Ave.*

Site B-1 is a stormwater tree pit (bioretention) with two inlets, one on West Baltimore Street (Baltimore St.) and one on Frederick Avenue. It is a rather elaborate design compared with the curb extensions, with a combined consultation and construction cost of $170,446. Stormwater flows from the inlets into a concrete ante-chamber, which fills with stormwater and then the stormwater flows slowly into the tree pit. The ante-chamber appears to hold approximately 1,300 gallons of stormwater, 189 cubic feet. The catchment is approximately 0.8 acres consisting of all impervious surfaces – roofs, sidewalks, and roadways to the centerline of Baltimore St.,

Figure 4a (left) – Site B-1 on 8/4/09, shows a freshly installed tree pit with green vegetation, litter free, adding ambience to the neighborhood.
Figure 4b (right) – Site B-1 on 4/8/10, approximately two years later. While the photo is in early spring, there is sparse growth and it is after a rainfall, no water in the pit or in the ante-chamber.

Frederick Avenue and South Mount Street. Several of the buildings in the catchment are in serious disrepair with no roofs, in these cases rainfall is not collected as runoff but sits below street level in the basements of the buildings. During the survey, the inlets on both Frederick Avenue and Baltimore St. were clogged with leaves and some litter, eliminating the possibility of stormwater entering the tree pit and treating it. This was confirmed by observation, a rain event occurred on the day this BMP was surveyed and no stormwater flow entered either inlet and bypassed to the storm drain. The bypass was videotaped and posted on the website.

Also, this structure serves not only as a stormwater structure it is also a community amenity with an esthetic value. Photographs of the initial installation show a well-maintained and lush garden in an urban setting adding character to the neighborhood (figure 4a). However, the survey shows the structure to be in a rather diminished state, the plant life not as vibrant and the pit contained a fair amount of litter (Figure 4b). If this structure was installed to create a dual benefit – to the environment and socially to the neighborhood – it is failing to provide either, in fact it has created new social costs because it is a dis-amenity.

Lastly, the design of this BMP is questionable. Stormwater pollutants are typically concentrated in the “first flush” of a rainfall. This means that the first flush of smaller more frequent rains (less than 0.25 inches) will carry similar pollution amounts as the first flush of large storms (2 inches or more). In addition, the pollution loading rates during these small rainfalls will be higher because loading rates are correlated with flow volumes. Considering the observed conditions (lack of maintenance), the lack of benefits from these conditions, the capital costs, and diminished social benefits from litter, the bio-retention tree pit installed at site B-1 seems unjustified and the area better served by a simpler, more cost-effective bio-facility.

- *Curb Extensions*

The curb extensions installed in subcatchment O are identical to the engineer’s detail in figure 3. The curb extension is designed to interrupt the flow of stormwater in a curb directing the flow into small rip rap (stone) section and then into the first of three planting sections. The rip rap consists of four- to five-inch stone and is used to dissipate the velocity of the flow and collect sediment. The three planting sections are divided by concrete dikes which act as a spillway once the upstream section fills with storm water (figure 8 depicts this function). Each planting section contains grasses and is associated with one street tree. The last chamber has an outfall for heavy rains which incorporates any excess stormwater back into the existing curb and storm drain.

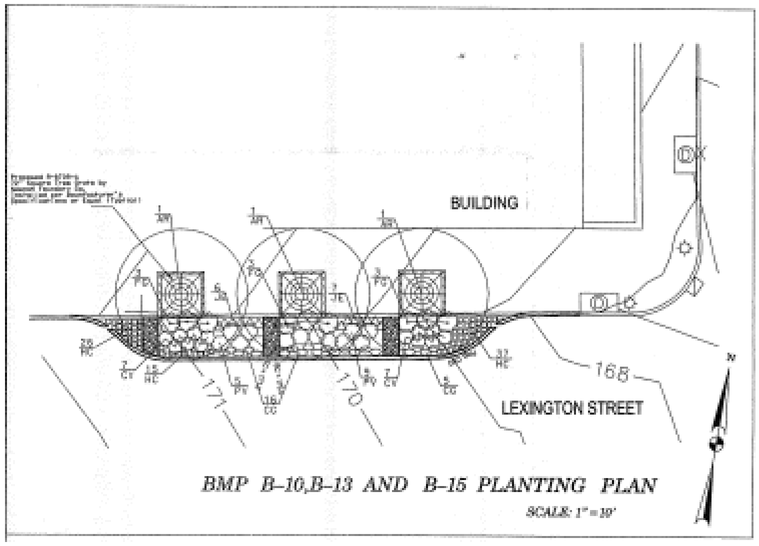

Figure 5 – Engineer's detail of a Stormwater Curb Extension used at sites B-10, B-13, & B-15. (City of Baltimore DPW, 2007) A full set of details for all the BMPs can be found at http://www.d2edesign.com/ws263_test2/ws26301.html

The curb extension is filled with engineered soils (Attachment 2) for greater treatment of stormwater pollutants. These curb extensions also serve as an amenity to the neighborhood, the plantings and trees have esthetic value; moreover, the curb extensions also serve as a traffic control. Similar bump outs are used by many communities to slow traffic through neighborhoods making roadways safer for pedestrian traffic. Curb extensions combine at least three types of benefits (one environmental and two social) offsetting the capital costs for the sites. The survey evaluated the three sites where the stormwater curb extensions were installed

- Site B-10

Site B-10 sits in front of 204 North Mount Street (Mount St.) and collects stormwater from the street centerline, alley and roofs on Mount St. from just above West Lexington Street to West Saratoga Street, and from several roofs on North Bruce Street between West Lexington and West Saratoga Streets (figure 6). The project's total cost was $92,739. The catchment area is approximately 1.30 acres (PPF). There are almost no pervious surfaces in this catchment. The flows from the alley may be reduced due to the number of alley trees and possible breaks in the concrete surfaces so the acreage may be smaller. The curb extension has three small trees (3-inch dbh) associated with it, planted when the BMP was installed. Stormwater was observed flowing into the curb extension, no debris or litter was in the curb to impede the flow. The first section of the curb extension was absorbing and infiltrating the flow.

Some sediment has filled the rip rap section but it is still serving the purpose of slowing the velocity of the stormwater flow. The BMP did contain some trash and litter, which takes away some of the esthetic value but the environmental benefits are being produced and the traffic control benefits are still applicable. The placement of this BMP is quite auspicious given of the amount of impervious surface treated. It has demonstrated itself as a useful and beneficial attribute.

Figure 6 – Site B-10 catchment – The inlet for the BMP is circled and the arrows show the direction of stormwater flows off roofs and along alleys and streets.

- Site B-13

Of the three curb extensions, Site B-13 on West Fayette Street (Fayette St.) treats the smallest catchment and cost $60,259. According to PPF's 2010 inventory, the site treats 0.26 acres of impervious surface. However, on the day this site was observed, the only stormwater flow reaching site B-13 was generated from a 175 foot section of North Bruce Street (Bruce St.) north of Fayette St, from centerline of Fayette St. from its intersection with Bruce St., and the sidewalk on Fayette St. This area is approximately 0.08 acres. The surrounding area is all open space, no roofs drain to this site, and no other impervious surfaces exist in this catchment (Figure 7). The curb extension has incorporated two very mature existing trees (20-inch dbh) and one newly planted tree (3-inch dbh).

Figure 7 – Site B-13 catchment – There is little impervious surface present in the catchment. The inlet is circled and the arrows show the direction of the stormwater flow. All of the roofs flow to green space, only the roads and sidewalks generate run off.

Stormwater was observed flowing into the curb extension, some debris and trash in the curb were impeding some flow and some bypassing was occurring. This was easily remedied by removing the debris. However, without this maintenance the debris could collect and create a complete bypass. A street sweeping/cleaning program needs to be in place to prevent this impediment to the flow. There are signs pertaining to the street sweeping program (*No Parking this Side of Street, Thursdays*) but the position of the inlet for the curb extension may not be in the range of the street sweeping machine.

The rip rap portion of the first section is relatively free of sediment and functioning well to dispel flow velocities. This curb extension was working although the flows in the BMP were minimal because little impervious surface drains to the area. While the design of the curb extension is highly effective in intercepting and treating stormwater in any rain event, the placement of this BMP in an area with little or no impervious cover is impractical.

- Site B-15

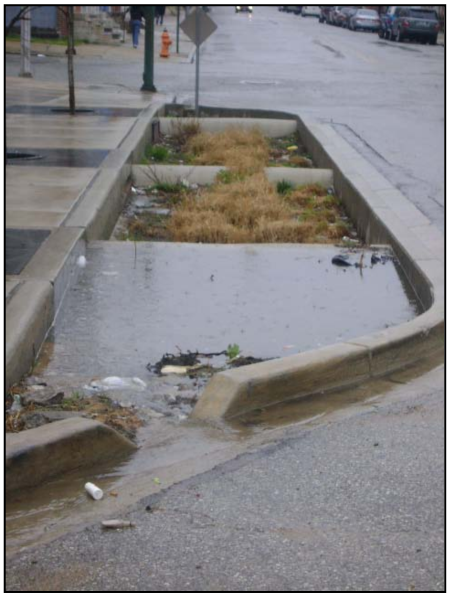

Figure 8 – Site B-15 – Stormwater observed flowing into the curb extension. The first section is filled with runoff and is spilling into the second section of the BMP.

Site B-15 is situated on West Lexington Street (Lexington St.), west of North Fulton Avenue (Fulton Ave.). This curb extension receives flows from the rooftops of homes on West Penrose Avenue (#1801 – #1813) and Lexington St. (#1800 – #1816) into the alley between Lexington St. and Penrose Ave., and from the roofs on Fulton Ave. (#200 - #226) into the alley behind Fulton. The alleys converge and pour the stormwater into the Lexington St. curb and into the curb extension B-15. Stormwater flow from the sidewalk and from the centerline up to 1816 W. Lexington St. also enters this BMP. PPF estimates the impervious surface treated as 1.63 acres and cost $77,933. There are three newly planted trees (3-inch dbh) associated with this BMP. Stormwater runoff was observed entering the structure, no debris or trash was impeding the flow and the first section was full and runoff was spilling into the next section. The rip rap is filling with sediment because of soil disturbance from work being done on a Fulton Ave. house. Clearing the sediment out of the rip rap is a maintenance issue here. There is some litter in the structure taking away some social value.

From the observation during a rainfall, this structure appears to be receiving the largest amount of flow. The other two curb extensions were observed during this same rainfall episode and neither had stormwater spilling into the second section. Perhaps the sediment discharge from the construction activity on Fulton Ave. deposited some finer soil particles effectively clogging the first section, impeding infiltration. The placement of this curb extension is favorable, it collects a good-sized catchment. It has provided an additional, seemingly unplanned, environmental benefit as a construction sediment trap. (Maryland law requires sediment controls for construction but only requires a sediment control plan when a soil disturbance is over 5,000 square feet. The property under construction on Fulton Ave. is not that large, so no plans were required and no sediment controls were installed.) The structure is providing environmental benefits and social benefits with little detraction due to litter. Of the three curb extension, this one appears to be providing the greatest benefits.

- Site C-13 – modified inlet using Filterra®

Filterra® is a proprietary stormwater bioretention system that removes total suspended solids, nitrogen, phosphorus, metals, and bacteria (www.filterra.com). The Filterra® system uses a oversized stormwater catch basin and fills it with a proprietary media that treats the stormwater and covers that media with mulch. Trees can be planted to increase esthetic value and process water and nutrients through evapotranspiration. An under drain is installed to collect the treated stormwater and in this case discharged to the storm sewer. This configuration provides a sampling point to verify the product's performance. The installation cost $49,940.

Figure 9 – Filterra® diagram – The diagram shows a subterranean cross-section of the Filterra® unit. (Kelly & Ruby, 2010)

Site C-13 is located on W. Fairmount Ave. adjacent to the Bon Secours of Maryland Community Support building. The catchment for this area is 0.20 acres and includes a small section of Fairmount Ave and its side walk (up to the Addison Street) and the Bon Secours Community Support parking lot and roof. There are two trees planted in the Filterra® system (3-inch dbh). Stormwater was observed running into the system with no bypass, this is because the throat of the catch basin is large and an excessive amount of litter and debris would be required to clog it. The mulch in the catch basin looks very matted and decomposed. Speculation on maintenance would be unjustified because of unfamiliarity with the product. It appears to be functioning well, creating an environmental benefit and there is no litter or debris in the unit so its social benefits are not diminished.

- *Site PPF-2 – Bio-swale*

Unlike the previous BMPs, which, while recommended by the CWP strategy, are Department of Public Works projects, PPF-2 is a Parks and People Foundation *Greening Neighborhoods* project. The bio-swale PPF-2 appears to be integrated into an existing curb cut on Mount St., about 150 feet from Baltimore St. The curb cut spans the side walk and empties into a vacant lot. The drainage area for PPF-2 is the centerline of Mount St. extended up to Fayette St. PPF estimates the drainage area PPF-2 at 0.75 acres. Using GPS Visualizer, the survey estimates the drainage areas at 0.16 acres.

The bio-swale is cut on the vacant lot and turned parallel to the contributing road way. Stormwater is directed in a concentrated flow into the bio-swale and allowed to infiltrate into the soil. It does not appear that any engineered soils were installed to assist in treatment of stormwater. Infiltration appears to be the main means of treatment. The swales are about 25 feet in length and may extend across two townhouse (row house) lots.

The Parks and People Foundation's publication, *A Guide to Greening Neighborhoods Creating and Caring for Community Open Space*, gives a thorough treatment of how to plan, design, construct and care for open space projects like this bio-swale. The property where PPF-2 sits is owned by ATZ LCC, so presumably the Parks and People Foundation received permission to install and maintain this structure. Cost information on PPF-2 was not available but bio-swales. While there is no cost information, bio-swales appear to be an inexpensive and cost-effective measure to treat stormwater. In subcatchment O, there are many vacant lots for possible use with bio-swales. The city owns many of the vacant lots in the subcatchment and others are owned privately. To allow the bio-swales to persist the land should be put into trust or deed restricted for use. This would require further investment by either the City or a non-profit depending upon which is sponsoring the project. Considering the sales prices of the properties in the state tax records (http://sdatcert3.resiusa.org/rp_rewrite/index.aspx?county=03) investments in the vacant properties could be a little as $17 (see Attachment 3). The swales appear to be socially neutral except for a possible tripping hazard when crossing the lot. The existing bio-swale is lush with grass and blends into the green space and is hidden by some perimeter tree plantings. In addition, any bio-swales should be assessed for soil characteristics and where needed incorporate engineered soils for proper treatment of stormwater pollutants. These bio-swales could also be integrated into rain gardens on the properties for additional treatment and social value.

Street Trees

There are many street trees integrated into the sidewalks on the main thoroughfares, some planted recently (2- to 5-inch dbh), presumably as part of the CWP strategy implementation, others are more mature (10- to 20-inch dbh). The survey of the existing trees within the subcatchment counted, measured, and photographed the street trees and the trees growing on the perimeter of numerous vacant lots through the study area. Trees along alleys and inside decaying structures were not counted. Included in this count were the trees associated with the stormwater curb extensions. The *genus* and *species* of the trees was not documented or recorded. However, many of the newly planted trees are *Pyrus calleryana* (Bradford pear) and *Prunus sp.* (cherry). The trees planted within the curb extensions were *Forthergilla gardenii*, dwarf witch-alder. Although engineered soils were used in the street sections of the stormwater curb extensions, no engineered soils were used for the tree plantings associated with the curb extensions (*see* Attachment 2). Portions of the sidewalks did have to be removed to accommodate the BMPs and engineered soils could have been used to support the trees and shrubbery in the curb extensions.

There are existing tree boxes designated within the sidewalks on all of the blocks in the study area. Some tree boxes are empty with bare, compacted soil exposed. Other boxes have relatively mature trees (18-inch dbh). On Penrose Avenue, west of Monroe Street, only mature street trees are featured. Among the institutions within the subcatchment, Bon Secours Hospital and its treatment facilities all have well-maintained, mature, street trees encompassing them. The churches and commercial properties have mixtures of mature and newer street trees. The city and non-profits have exploited many vacant lots in the area for perimeter tree planting. Site DPW sits on the east side of Vincent Street behind Baltimore Street and Gilmor Avenue and it has been planted with at least a dozen trees across the entire lot, as was site I-1 and between Bruce Street and Fulton Avenue below Saratoga Street. Site DPW, from table-1 is a tree planting site incorporating one of the more complex CWP "Open Land" strategies. The site was cleared of invasive species , the soil amended and planted with new trees. The other vacant lot tree plantings placed trees along the perimeter of the lots adjacent to the sidewalks.

A separate compact disc containing photographs of the street and perimeter trees was submitted separately from the paper. The photographs are labeled with the "T" and the street where the trees are planted. The trees are further identified in the photos by whether they are on the north, east, south or west side of the street and which city block they are located. For example, T_Baltimore_btx_Mount_and_Fulton_north means the photograph shows the trees on the north side of Baltimore Street between Mount Street and Fulton Avenue.

Subcatchment O contains two hundred and ninety-eight street trees or perimeter trees (appendix B). Baltimore Street, Mount Street, and Fulton Avenue are the longest blocks in the study area and contain the most trees along their sidewalks, fifty, thirty-five and fifty-five, respectively. The most trees in one block is twenty-six along Fulton Avenue between Lexington and Saratoga Streets. These numbers are encouraging but aerial photographs of subcatchment O show a blotchy patterned tree canopy. Many of the trees are planted on vacant lots. With little sidewalk overhang, these trees are unable to intercept rainfall destined for streets or sidewalks. Certainly, they deter runoff from what could be depicted as open pasture but do not impact the runoff from impervious surfaces. With time, growth of the perimeter trees will create needed interception but that would also require proper maintenance by the city or non-profits. Over pruning can reduce interception rates (Xiao & McPherson, 2002), so a proper scheduling of maintenance with a longer timeframe between pruning should be considered.

Increases in tree canopy have been associated with reduced runoff during smaller, more frequent rain events. WS263 has an estimated canopy of 6 percent and subcatchment O looks to be consistent with that finding. Urban planners consider a 40 percent canopy to be an adequate size for cities. To achieve this goal will take time and continued efforts for more plantings.

- ***Discussion and Further Applications***

The objectives of this project were to support the work begun in WS 263, as a part of the BES, a National Science Foundation LTER project (www.beslter.org). Those objectives were:

- Inventory the stormwater retrofit BMPs and street trees for a 39-acre subcatchment sampling area of WS 263
- Characterize, assess, and categorize these BMPs
- Photograph and record the global position for each BMP in a spreadsheet and produce an online website of the BMPs
- Review sites for future BMPs with similar data collection
- Count and measure the street trees in the catchment and catalog those results.

The BES researches the Metropolitan Baltimore ecosystem using and integrating the biological, physical, and social sciences for that research. The data collected in this project supports research in all three areas.

The total imperviousness in the study area is characteristic of contributing to urban stream syndrome. Efforts are being made to disconnect impervious surfaces' direct connection to the storm sewer (sites B-1, B-10, B-13, B-15, C-13, PPF-2); therefore, reducing the total imperviousness and effectively reducing stormwater pollution (Walsh et.al. 2005a; Walsh et.al. 2005b). Moreover, further decisions about placement stormwater retrofits and quantifying pollution reductions are needed research within subcatchment O. Researchers are looking to use SLAMM as both a flow predictor (assisting quantification) and planning tool (assisting decision-making). The inventory of retrofit BMPs and trees would be used as support data within SLAMM. While this project does not provide all of the support data for using SLAMM, it did provide some. Because of the size of the catchment and the need for stormwater management options, the study area and WS263 would benefit from SLAMM's use to model flow and predict cost-effective stormwater alternatives.

Retrofit BMPs

Sites B-10 and B-15 collect and treat the largest acreage of impervious surfaces within subcatchment O with obvious flows entering the BMPs during a rain event on April 8, 2011. There was more flow at site B-15 than B-10. This may be due to the tree canopy in the alley between Mount and Bruce Streets. The placement of these two BMPs is effectively treating stormwater and reducing total imperviousness. The drainage areas for sites C-13 and B-13 are much smaller than B-10 and B-15. Both BMPs are functioning but their placement is questionable because of the reduced acreage treated. Site B-1 is not functioning properly and has a drainage area of less than an acre. Rating the performance of the BMPs, Site B-15's performance is best. B-15 is accomplishing all of its intended environmental and social benefits with minimal loss of social benefits due to litter and the additional benefit of sediment control. Site B-1 is the poorest performing BMP. It is not achieving any of its expected environmental benefits with greatly diminished social value due to collected trash and litter.

Costs

The cost of the various BMPs is quite variable. Site B-1 initially cost over $213,000 per acre to treat stormwater and is currently malfunctioning. The curb extensions varied in cost. It is unclear why there is a disparity in consultation and construction cost. Curb extensions B-10 and B-15 combined, averaged to just over $65,000 per acre to treat stormwater. Certainly cheaper than the tree pit and these were functioning. Site B-13 collected stormwater from a much smaller catchment at a cost of approximately $232,000 per acre to treat the stormwater. The inflated cost is due to improper placement than a structural malfunction or design and construction cost. According to Park and People Foundation the catchment is 0.26 acres but there is a great deal of open space around the structure. The upper portion of Bruce Street drainage to the system either runs into the open space or over to Mount Street (*see* figure 8). The survey estimate of drainage area is more like 0.08 acres. Therefore, the choice of where to install BMPs is critical to be cost-effective. Perhaps site B-13 would have been better served by another Filterra® system.

Retrofit BMP placement could be improved by knowing the location of all the storm drains in the subcatchment. Choosing larger catchments for curb extensions or another tree pit or rain garden is needed for future retrofits. In addition, the storm drain information would be needed for use with SLAMM and could be collected in a future survey.

Not included in the cost figures from the City are the ongoing operation and maintenance (O & M) costs for the BMPs. The inlet inserts not surveyed were presumably installed to collect sediment to reduce TSS and must need periodic cleaning. The curb extensions' O & M appears to be minimal, with a street sweeping program being part of its ongoing O & M costs. Certainly, the plants in the first chamber should be readily able to survive periodic inundation. In addition, the plants' ability to fix nitrogen and phosphorus should be considered. Maintenance costs of all the plants within the structures need to be considered – pruning, cutting and replacement of dead species.

Overall, the Filterra® system is less expensive to install than other BMPs, but if it can only treat small catchments then its use is limited. Although, there appear to be many small catchments within the study area and the Filterra® system may be the ideal BMP for those purposes. Once again maintenance costs to replace mulch and the longevity of the product's effectiveness needs to be considered. If the system is only useful for five years then replacement costs are prohibitive.

Future Placement of BMPs

Considering the typical subcatchment flow pattern, rooftop to alley to street, locating BMPs where they can intercept stormwater flows from alleys appears to be a most effective means of reducing total imperviousness. To take advantage of incorporating alleys into alleviating stormwater issues in the study area, any future survey of the stormwater catch basins should include the alleys. This will take additional help from members of the community to secure any potential risks (i.e. vicious dogs). In addition to surveying catch basins in the alleys, the trees should be counted, measured (where possible) and identified. The relatively simple design of the stormwater curb extension and its cost-effectiveness make it a prime candidate for further use throughout the water shed. The structures need to be incorporated into a site that collects rainfall from not only the street and sidewalk, but also the rooftops, rear yards, and alleys and not in areas dominated with pervious surfaces like site B-13.

Beyond Environmental Benefits

As amenities, many of these BMPs' esthetic value is diminished because litter collects in the structures. One of the strategies of the CWP document was to install community trash cans. This may reduce litter either being thrown into the BMPs or being blown into the BMPs from neighboring properties. This would help the structures keep its esthetic value. In addition, the plantings in the structures do not appear to thriving. Further research and long-term observation could determine if the plants chosen were the most effective. A positive benefit not identified previously is the traffic control that the curb extensions provide. Because this helps moderate traffic flow, sites opposite the current extensions should be considered for future projects to create a more complete traffic control amenity.

Infiltration

All of the bio-facilities depend partly or completely on infiltration as the answer to treating pollutants in stormwater. "Low-impact development" depends on infiltration. The drawback to stormwater infiltration is groundwater contamination. To combat groundwater contamination several procedures should be added to the design of a BMP. A methodology has been developed to access the potential for treatment of stormwater pollutants within soils (Clark & Pitt, 2007).

First the methodology requires a study of the pollutants unique to the stormwater in the catchment. This will determine what soil characteristics needed to remove the stormwater pollutants. Next soil permeability and classification (the sand-clay-loam triangle) is needed. Considering stormwater retrofits are being installed in the built environment, traditional means of soil identification like soils maps are outdated. Individual soil evaluations using soil borings and percolation tests may be the only reliable means to properly identify soils. Once the soil is identified, it can be determined if the soil has the ability to treat the stormwater's unique pollutants. If the soils are inappropriate to treat the pollutants then the use of an engineered soil with the properties needed to treat the pollutants can be substituted. In this manner groundwater contamination can be prevented. An additional benefit is that the soil information can be used within SLAMM, the soil types can be assembled into USDA hydrologic soil groups (A, B, C, D) and the appropriate run off curve assigned for use within the model.

Crowdsourcing

The crowdsourcing portion of the project had several challenges. The only instance of the public participation using crowdsourcing was in the City of Boston and the intended use of crowdsourcing in this project is similar to what could be considered in WS263 but to a different end. Certainly, crowdsourcing could be used to report problems to the DPW about the BMPs, but the project's intent was to increase future public participation in the greening process within the water shed and empower the public to engage in restoration. While this project did not engage the public directly, it established a platform for crowdsourcing public participation within subcatchment O.

Collecting, storing and presenting photo-data was made relatively simple through digital technology and the internet. Using flickr® as the website was the simplest and most inexpensive means to convey a time-series of the condition and function of the BMPs within the project. One of the drawbacks to flickr® is that a full explanation of the effort to collect a photo-retrospective of the BMPs could not be included with the photo galleries. Besides its ease and low-cost, flickr® allows for groups to be formed so other stakeholders can add photographs to the site somewhat seamlessly. However, the preferable way to capture new photographs of the BMPs is to rely on the community to take photographs and email them to the website. Because a person must transfer the photograph from the email account onto the web site, the email process allows for quality control and quality assurance of photographs and information on the website. Photographs were taken using a cell phone camera and texted to the email address as a beta-test of the process. A problem with this method is that without proper instruction, photographs may not be labeled with a site identification or address information. In this case, the person receiving the data via email would need first-hand knowledge of the BMPs to properly store and post the photographs on the website. Also improper instruction can lead to erroneous photographs being taken (e.g. photos of the storm drain inlet instead of the BMP), which happened in one of the beta-test for the project.

Figure 10 – QR code (Wikipedia) – An image like this could used to instruct and educate the public about the efforts to increase participation in the WS263 restoration efforts.

One possible solution to the challenges encountered in the project (e.g. in identifying a particular BMP) and to the dilemma of engaging the public could be to use quick response or QR codes (figure 10). QR codes are two-dimensional bar codes developed in Japan whose expanded use is being used in "commercial tracking applications and convenience-oriented applications aimed at mobile phone users (termed mobile tagging)" (Wikipedia, 2011). If a cell phone is equipped with a QR code reader, it will interpret the code which could be text, an email address or a website's URL. QR codes can be generated for free at several websites (i.e. http://qrcode.kaywa.com/). For future application of this project, individual QR codes can be generated for each BMP and either painted on the curb or printed on a small metal reflective plate and posted at the site of the BMP. The QR codes could include instructions on taking and submitting photographs to the website, as well as a explanation of the efforts of the BES and LTER. The use of QR codes both individualizes each BMP and as QR codes are becoming more recognizable, they engage the public because the code can include explanatory text of the project's intention and its request for public participation.

5. Conclusion

In conclusion, this survey has identified that many of the strategies recommended by the CWP document are being implemented within subcatchment O. Implementation of these strategies does not appear haphazard but quite deliberate. Some criticisms would be the cost-effectiveness and placement of some BMPs. However, other BMPs and the tree plantings (as BMPs) appear to be functioning well. A greater diversity of tree species seems appropriate and that diversity should be seen as an amenity and therefore an additional benefit to the community and the ecosystem. The survey of the BMPs and the trees will serve the purpose of support data for SLAMM but a survey of the storm drains throughout the study area, the number of dilapidated homes, and the alleys will be necessary to further refine any modeling done with SLAMM in subcatchment O and WS263. Using crowdsourcing to increase public participation beyond planning into implementation and compliance is rudimentary, but with further development could empower communities to not only hold their government officials accountable, but also become a source of community pride and further renewal and investment.

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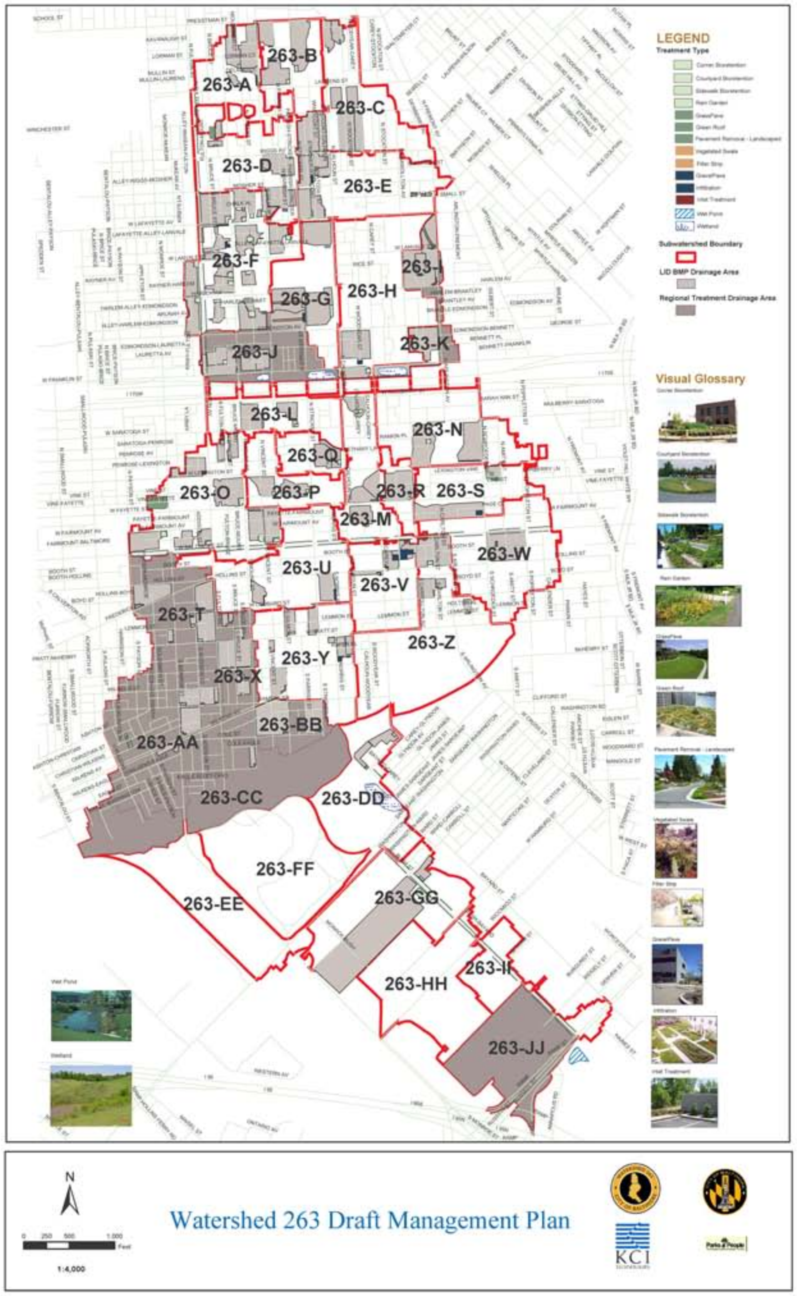
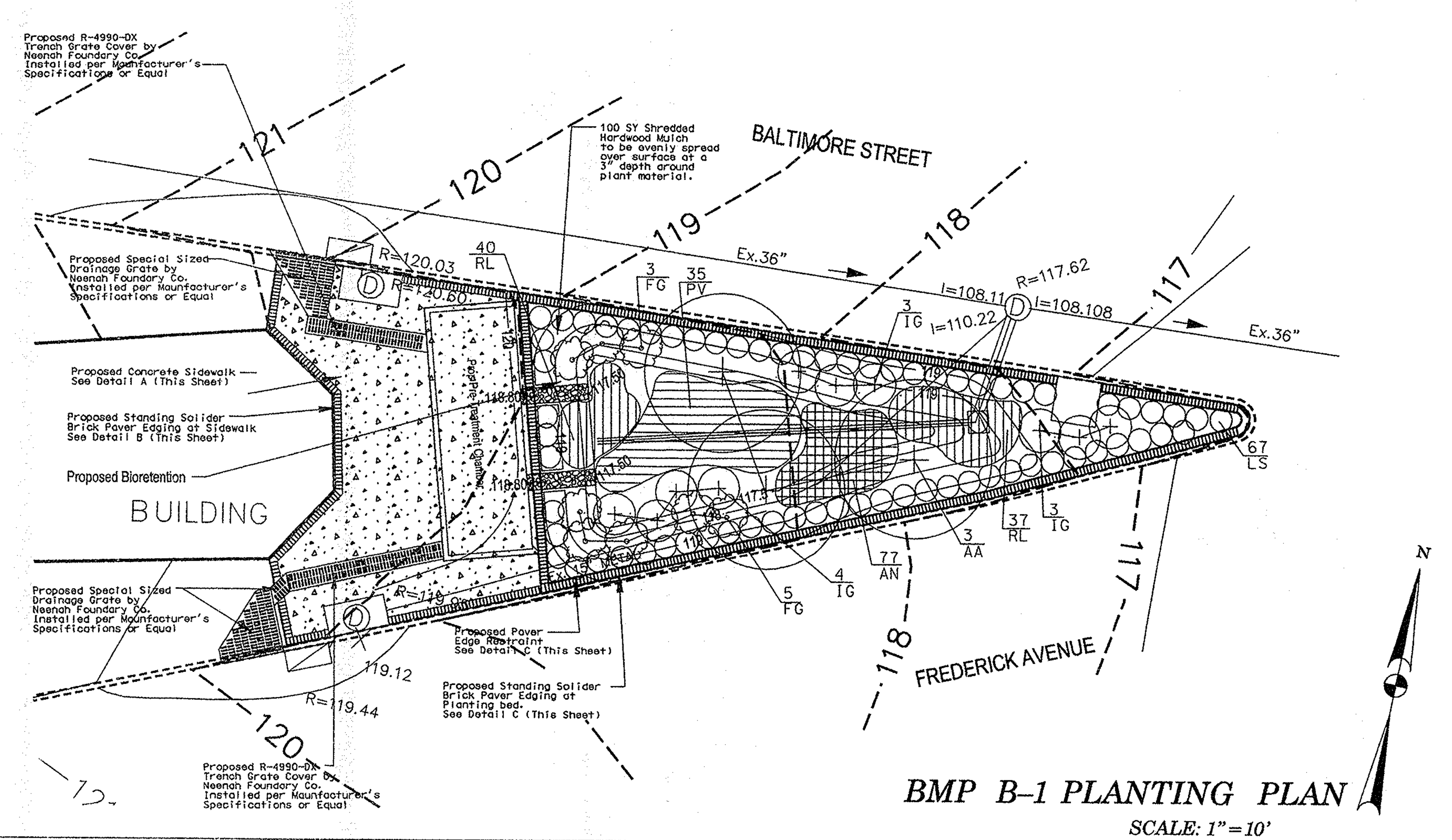
Attachment 1



Attachment 2



BMP B–1 PLANTING PLAN

SCALE: 1" = 10'

PLANT SCHEDULE FOR BMP B-1

SYMBOL	BOTANICAL NAME	COMMON NAME	QUANITY	SIZE	ROOT	SPACING
AA	Amelanchier arboea	Downy Serviceberry	3	2" CAL	B & B	AS SHOWN
FG	Fothergilla gardenii	Dwarf witch-alder	8	24" HT	CONT.	AS SHOWN
IS	Ilex glabra 'Shamrock'	Shamrock Inkberry	10	24" HT	CONT.	AS SHOWN
AN	Aster novae-angliae	New England Aster	77	1 GAL.	CONT.	12" O.C.
LS	Liriope spicata	Lily Turf	67	1 GAL.	CONT.	18" O.C.
PV	Panicum virgatum 'Hanse Herms'	Hanse Herms Switchgrass	35	2 GAL.	CONT.	24" O.C.
RL	Rudbeckia lanciniata 'Goldquelle'	Gold Coneflower	77	1 GAL.	CONT.	18" O.C.

100 Square Yards Double Shredded Hardwood Mulch @ 3" Depth

PLANTING GENERAL NOTES

1. All plant material shall meet the requirements set forth in the American Standard for Nursery Stock published by the American Association of Nurserymen, 1250 I Street, N.W., Suite 500, Washington, D. C., latest edition.
2. All plant material shall meet the descriptions given on the plans and as described herein. Botanical names shall prevail over common names.
3. Quantities shown on the landscape plans shall take precedence over the plant materials list.
4. No plant substitutions shall be made without prior written approval of the client or the client's representative.
5. All balled and burlapped stock shall have root wrapping material made of synthetics or plastics removed at the time of planting. The top on-third of burlap shall be removed once the plant is firmly placed in its planting pit, to provide adequate percolation of water through the root ball.
6. All plants shall be watered thoroughly twice during the first 24 hour period after planting. All plants shall then be watered weekly or more often if necessary during the first growing season.
7. All plants shall be planted within the planting season– March 15 through May 30 and September 1 through November 15. The above periods may be extended or reduced according to weather and soil conditions at the risk of the contractor. However, no frozen or excessively wet materials will be permitted at any time.
8. Plant Pruning, Edging and Mulching:
   a. Each tree or shrub shall be pruned in an appropriate manner to its particular requirements. In accordance with accepted standard practice. Broken or bruised branches shall be removed with clean cuts made on an angle from the bark ridge to the branch.
9. The contractor shall maintain survival of plants for one growing season.

CURB EXTENTION SEQUENCE OF CONSTRUCTION

1. Subsequent to final grading and stabilization of site, excavate rain garden area to proper dimensions.
2. Install gravel envelope, geotextile, underdarain, and observation well.
3. Place and loosely compact planting soil.
4. Install plants at proper depth and location.
5. Mulch the surface of the bioretention area to a thickness of 2 to 3 inches.
6. Water and fertilize according to the plan and specifications and as necessary.

MATERIALS SPECIFICATION FOR RAINGARDENS

MATERIAL	SPECIFICATION	SIZE	NOTES
Plantings	See Schedule This Sheet	N/A	Planting are site specific
Planting Soil (2*' to 4' deep)	Sand: 30% to 60% Silt: 30% to 55% Clay 0% to 25%	N/A	USDA soil types loamy sand, sandy loam or loam
Mulch	Shredded Hardwood	N/A	Aged six months minimum
Geotextile	Class "C" – apparent opening size(ASTM-D-4751), grab tensile strength (ASTM-D-4632), puncture resistance (ASTM-D-4833)	N/A	Use as necessary beneath underdrains only
Underdrain			
Gravel	AASHTO M-43 #57 or #67	*" to *"	
Piping	F 758, Type PS 28 or ASSHTO M-278	4" to 6" rigid schedule 40 PVC, SDR35 or HDPE	*" perforations @ 6" on center, 4 holes per row; min. or 3" gravel over pipes; gravel not necessary beneath pipes

SPECIFICATIONS FOR BIORETENTION PLANTING

I. BIORETENTION AREA SOIL SPECIFICATIONS

A. Planting Soil

The rain garden area shall consist of a planting soil having a composition of ar least 10 to 25 percent clay and shall be of a sandy loam or loamy sand texture. Loamy soils may be utilized for the planting soil but must consist of 35% sand. In addition, the furnished planting soil shall be of uniform composition, free of stones, stumps, roots or similar objects larger than one inch (1"), brush, or any other material or substance which may be harmful to plant growth, or a hindrance to planting or maintenance operations.

The planting soil shall be free of plants or plant parts of Bermuda grass, Quack grass, Johnson grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle or others as specified.

It shall not contain toxic substances harmful to plant growth.

The planting soil shall be tested and meet the following requirements:

pH range	5.5 – 6.5	Phosphorous – P_2O_5	100 lbs./acre
Organic Matter	1.5 – 4.0%	Potassium – K_2O	85 lbs./acre
Magnesium – Mg	35 lbs./acre	Soluble Salts	Not to Exceed 500 ppm

The following testing frequencies shall apply to the above soil constituents:
pH, Organic Matter: 1 test per 90 cubic yards, but no more than 1 test per Bioretention Area
Magnesium, Phosphorus, Potassium, Soluble Salts: 1 test per 500 cubic yards, but no less than 1 test per borrow source.

One (1) grain size analysis shall be performed per 90 cubic yards of planting soil, but no less than 1 test per Bioretention Area.

B. Mulch Layer Specifications

A mulch layer shall be provided on top of planting soil. An acceptable mulch layer shall include single or double shredded hardwood and be placed to a uniform thickness of 2 to 3 inches.

Of the approved mulch products all must be well aged, uniform in color, and free of foreign material including plant material. Well aged mulch is defined as mulch that has been stockpiled or stored for a least twelve (12) months.
Bioretention Area to be remulched on an annual basis. Grass clipping should not be used.

C. Sand Specifications

The sand shall be free of deleterious material and rocks greater than one inch (1") in diameter.

D. Compaction

Soil shall be placed in lifts less than eighteen inches (18") and lightly compacted (minimal compactive effort) by tamping with a bucket from a dozer or a backhoe.

II. CURB EXTENTION AREA PLANT SPECIFICATIONS

General Planting Specifications

* Root stock of the plant material shall be kept moist during transport from the source to the job site and until planted.
* Walls of planting pit shall be dug so that they are vertical.
* The diameter of the planting pit must be a minimum of six inches (6") larger than the diameter of the ball of the tree.
* The planting pit shall be deep enough to allow 1/4" of the ball to be above the existing grade. Loose soil at the bottom of the pit shall be tamped by hand.
* The appropriate amount of fertilizer is to be placed at the bottom of the pit (see below for fertilization rates).
* The plant shall be removed from the container and placed in the planting pit by lifting and carrying the plant by its ball (never lift by branches or trunk).
* Set the plant straight and in the center of the pit so that the top of the ball is approximately 1/4" above the final grade.
* Backfill planting pit with existing soil.
* Make sure plant remains straight during backfill procedure.
* Never cover the top of the ball with soil. Mound soil around the exposed ball (1/4").
* Trees shall be braced by using 2" by 2" white oak stakes only as necessary and for the first growning season. Stakes are to be equally spaced on the outside of the tree ball. Utilizing mesh strapping around the tree and wire to braced to the stakes.

Fertilization

* Tree and Shrub fertilizer shall be a 21 gm. tightly compressed, long lasting, slow release (2 year fertilizer tablet with a minimum guaranteed analysis of 20-10-5:

Total Nitrogen (N) – 20%	Available Phosphoric Acid (P_2O_5) – 10%
Water Soluble Organic Nitrogen – 7%	Soluble Potash (K_2O) – 5%
Water Insoluble Organic Nitrogen – 13%	

* For containerized trees and shrubs, place the fertilizer tablet(s) in the bottom of the planting pit according to the following rates:

1 ga. Container	1 ea. 21 gm. Tablets	5 ga. Container	3 ea. 21 gm. Tablets
3 ga. Container	2 ea. 21 gm. Tablets	7 ga. Container	5 ea. 21 gm. Tablets

Planting Non-Grass Ground Cover

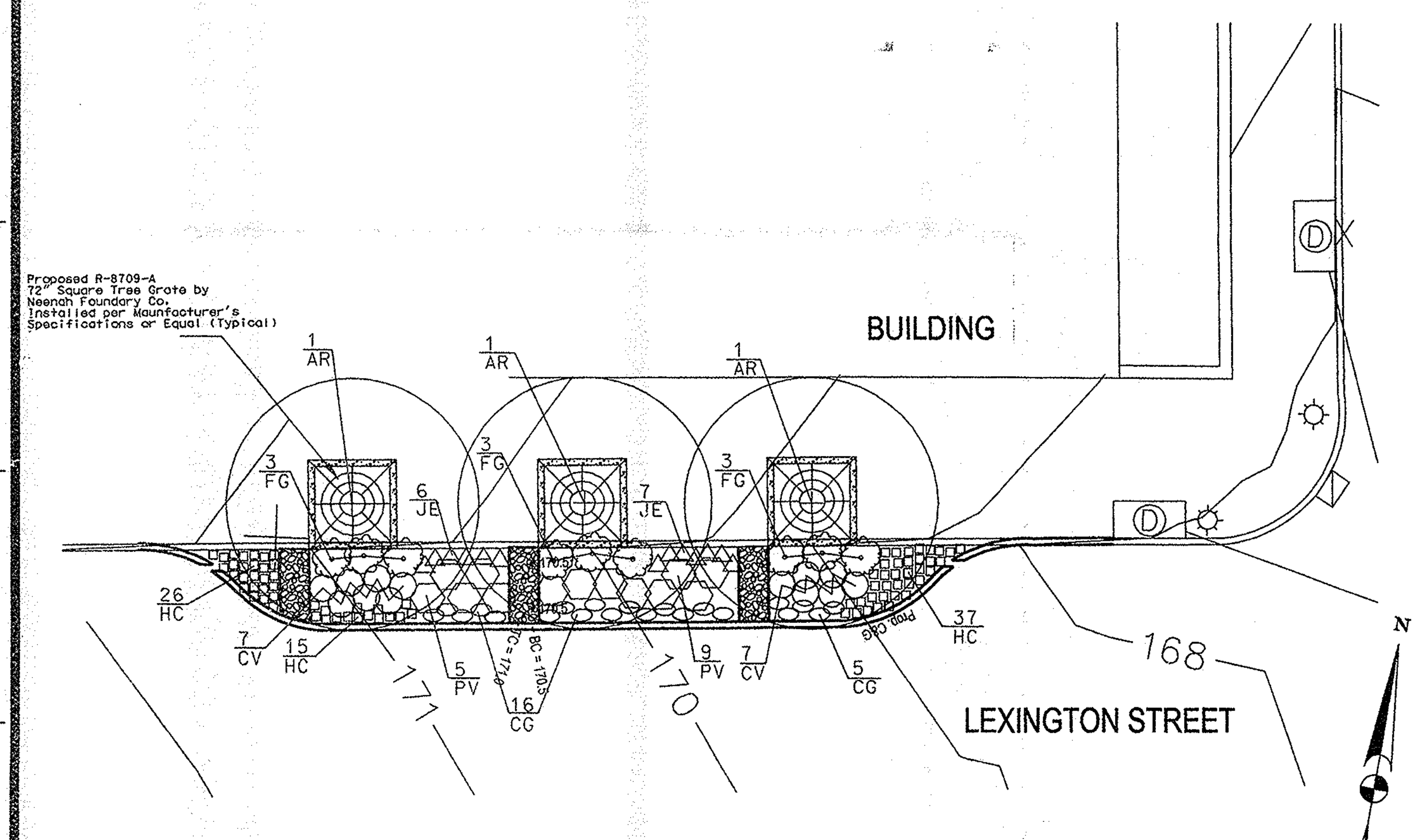
* The ground cover planting holes shall be dug through the mulch with one of the following: hand trowel, shovel, bulb planter or hoe (this does not apply to grasses or legumes).
* Before planting, biodegradable pots shall be split, and non-biodegradable pots shall be removed. Root systems of all potted plants shall be split or crumbled.
* The ground cover shall be planted so that the roots are surrounded by the soil below the mulch, Potted plants shall be set so that the top of the pot is even with the existing grade. The roots of bare root plants shall be covered to the crown.
* The mulched and planted ground cover bed with a pre-emergent herbicide.
* The entire ground cover bed shall be thoroughly watered.

Planting Grass Ground Cover

* Grasses and legume seed shall be tilled into the soil to depth of at least two inches (2") by either harrowing or discing. Fertilizer shall be applied at the same rate and utilizing the same process for non-grass ground cover. Grass and legume plugs shall be planted following the non-grass ground cover planting techniques.

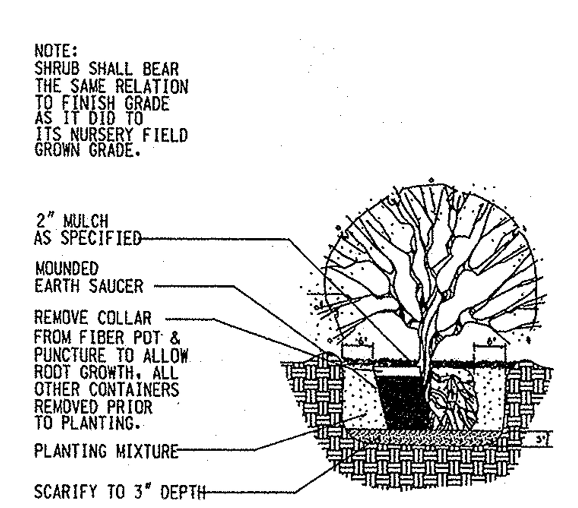
Fertilizer

* All ground covers shall be fertilized with a 10-6-4 analysis fertilizer as a wet application at the rate of 3 lbs. per 100 square feet of the bioretention area prior to planting non-grass ground cover or as part of the grass seed ground cover.

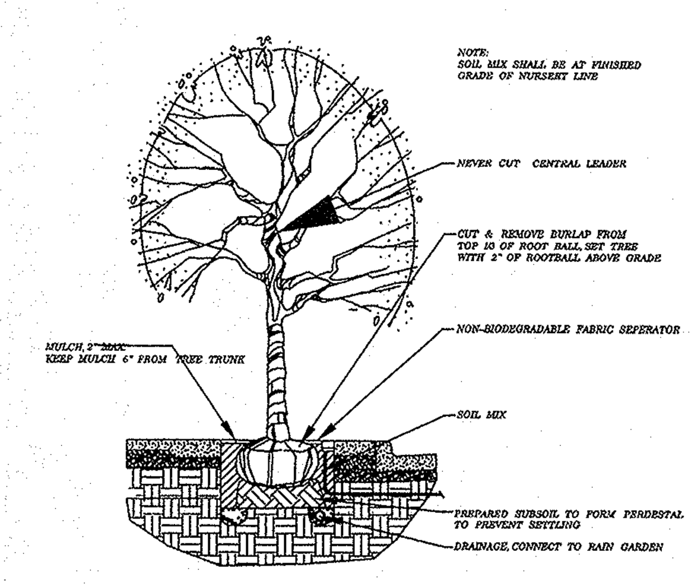


BMP B–10,B–13 AND B–15 PLANTING PLAN

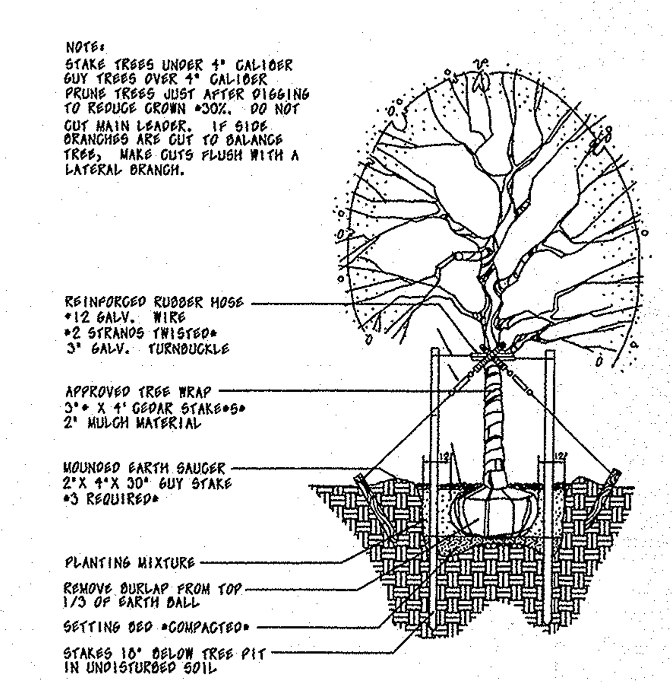
SCALE: 1" = 10'



PLANTING DETAIL/SHRUBS
NTS



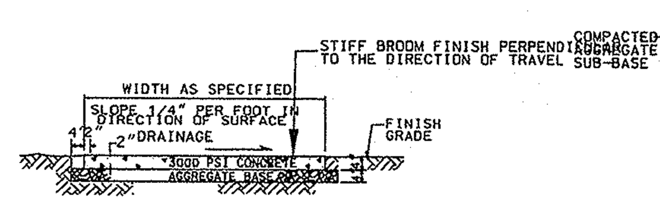
TREE PIT
NO SCALE



PLANTING DETAIL/DECIDUOUS TREES

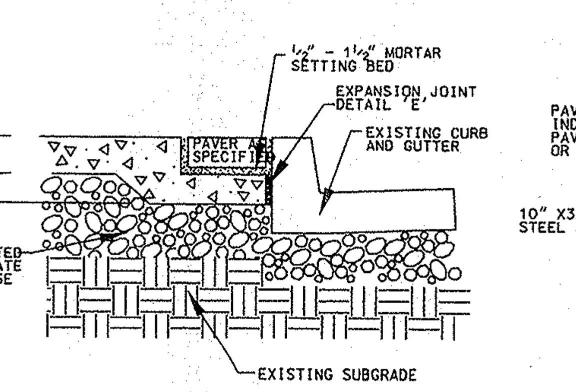
PLANT SCHEDULE FOR BMP B-10, B-13 AND B-15

SYMBOL	BOTANICAL NAME	COMMON NAME	QUANITY	SIZE	ROOT	SPACING
AR	Acer rubrum 'October Glory'	October Glory Red Maple	3	3" CAL.	B & B	AS SHOWN
FG	Fothergilla gardenii	Dwarf witch-alder	9	24" HT	CONT.	AS SHOWN
CG	Carex gracilis	Graceful Sedge	21	1 GAL.	CONT.	12" O.C.
CV	Coreopsis verticillata 'Golden Shower'	Golden shower Tickseed	13	1 GAL.	CONT.	18" O.C.
HC	Hypericum calycinum	St. John's Wort Groundcover	78	1 PT.	CONT.	8" O.C.
JE	Juncus effuses 'Spiralis'	Curly Soft Rush	13	1 GAL.	CONT.	12" O.C.
PV	Panicum virgatum 'Heavy Meta'	Heavy Metal Switchgrass	14	2 GAL.	CONT.	AS SHOWN



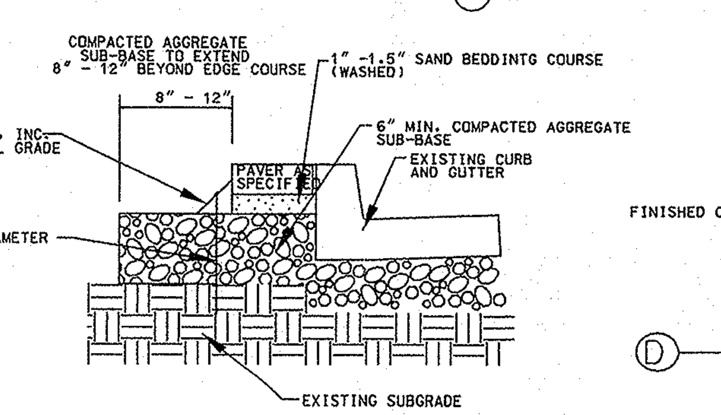
NOTE:
CONTRACTION JOINTS, SPACED AT INTERVALS, SHALL BE INSTALLED IN THE SIDEWALK CONCRETE TO FORM SQUARE PANELS. EXPANSION JOINTS SHALL BE INSTALLED WITHIN THE SIDEWALK AT LOCATIONS SHOWN ON THE PLANS.

(A) TYPICAL SIDEWALK SECTION
NTS



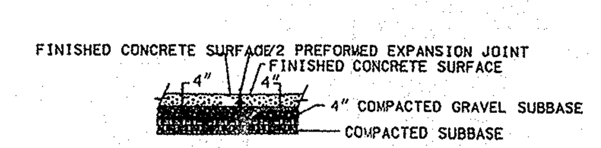
NOTE:
1. EDGE RESTRAINT TO BE PAVE TECH, INC. INDUSTRIAL STREGTH & FLEXIBLE FOR PROPOSED RADII, OR EQUAL.
2. EDGING TO BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS.
3. PAVER TYPE AND COLOR TO BE SELECTED BY OTHERS.

(B) CONCRETE SIDEWALK PAVER EDGING
NTS

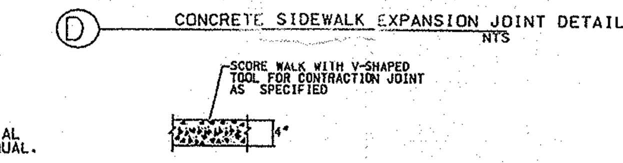


NOTE:
1. EDGE RESTRAINT TO BE PAVE TECH, INC. INDUSTRIAL STREGTH & FLEXIBLE FOR PROPOSED RADII, OR EQUAL.
2. EDGING TO BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS.
3. PAVER TYPE AND COLOR TO BE SELECTED BY OTHERS.

(C) PLANTING BED PAVER & EDGE RESTRAINTS
NTS



(D) CONCRETE SIDEWALK EXPANSION JOINT DETAIL
NTS



(E) CONCRETE SIDEWALK CONTRACTION JOINT DETAIL
NTS

LANDSCAPING C19

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER AND WASTEWATER
WATERSHED 263 ENVIRONMENTAL RESTORATION CONTRACT NO.ER4015

6-13-07

No.	REVISION	DATE	BY
1	60%	11/21/07	E.D.N'D.F

GREENHORNE & O'MARA
CONSULTING ENGINEERS
6110 FROST PLACE LAUREL, MD 20707
PHONE: (301) 982-2800 FAX: (301) 220-2619
www.g-and-o.com
FLORIDA GEORGIA MARYLAND • NORTH CAROLINA PENNSYLVANIA VIRGINIA WEST VIRGINIA

EA Engineering, Science and Technology, Inc.
111 Market Place, Suite 1020
Baltimore, MD 21202
410-468-4054 phone
410-468-4057 fax

BMP B10, B13, B15 AND B1
PLANTING PLAN

E.D.N'D.F DESIGN	SCALE
E.D.N'D.F DRAWN	19 OF 19
CHECKED	SHEET
11/21/07 DATE	0469 PROJ No. / FILE No.

Attachment 3

Maryland Department of Assessments and Taxation
Real Property Data Search (vw6.2A)
BALTIMORE CITY

Go Back
View Map
New Search
GroundRent Redemption
GroundRent Registration

Account Identifier: Ward - 19 Section - 05 Block - 0179 Lot - 039

Owner Information

Owner Name:	ECHO HOUSE MULTI SERVICE CENTER	**Use:**	RESIDENTIAL
		Principal Residence:	NO
Mailing Address:	1705 W. FAYETTE ST BALTIMORE MD 21223	**Deed Reference:**	1) /06169/ 00931 2)

Location & Structure Information

Premises Address	**Legal Description**
1712 W FAYETTE ST BALTIMORE 21223-1707	16-3X98-3

Map	Grid	Parcel	Sub District	Subdivision	Section	Block	Lot	Assessment Area	Plat No:
0019	0000	0000		0000	05	0179	039	3	Plat Ref:

Special Tax Areas	Town	NONE
	Ad Valorem	
	Tax Class	

Primary Structure Built	Enclosed Area	Property Land Area	County Use
		1,568 SF	11320

Stories	Basement	Type	Exterior

Value Information

	Base Value	Value	Phase-in Assessments	
		As Of 01/01/2009	As Of 07/01/2010	As Of 07/01/2011
Land	9,400	9,400		
Improvements:	0	0		
Total:	9,400	9,400	9,400	9,400
Preferential Land:	0			0

Transfer Information

Seller: MAYOR & CITY COUNCIL		**Date:**	11/18/2004	**Price:**	$17
Type: NON-ARMS LENGTH OTHER		**Deed1:**	FMC /06169/ 00931	**Deed2:**	
Seller: ANNELLEN ROAD DEVELOPMENT		**Date:**	11/10/1997	**Price:**	$4,675
Type: ARMS LENGTH IMPROVED		**Deed1:**	SEB /06819/ 00468	**Deed2:**	
Seller:		**Date:**		**Price:**	
Type:		**Deed1:**		**Deed2:**	

Exemption Information

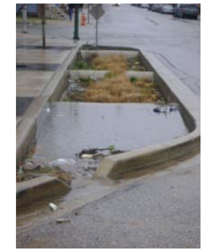
Partial Exempt Assessments	Class	07/01/2011	07/01/2012
County			0.00
State			0.00
Municipal			0.00

Tax Exempt:
Exempt Class:

Special Tax Recapture:
* NONE *

Appendix A - Retrofit Stormwater Best Management Practices (BMPs) in Subcatchment O of Watershed 263

Stormwater BMP type	ID #	Location (street address)	Location (street corner)	latitude	longitude	area treated (acres)	Consultation costs	Construction costs	Total cost	category	current state	photograph
Stormwater Tree Pit (Baltimore Street inlet)	B-1	1609 W. Baltimore St.	SW corner of W. Baltimore and N. Gilmor Streets	39.288289	-76.642908	0.32	$59,598	$110,848	$170,446	bioretention	not operating, inlet cloged with leaves	
Stormwater Tree Pit (Frederick Road inlet)	B-1	1610 Frederick Ave.	NW corner of Frederick Road and S. Gilmor Street	39.288183	-76.642901	0.39				bioretention	not operating, inlet cloged with leaves	
Stormwater Curb Extension	B-13	1716 W. Fayette St.	NW corner of W. Fayette and N. Mount Streets, on Fayette	39.289611	-76.644343	0.08	$27,594	$32,665	$60,259	bioretention	functioning, debris in curb creating some bypass	
Stormwater Curb Extension	B-10	204 N. Mount St.	NW corner of W. Lexington and N. Mount Streets, on Mount	39.290994	-76.643991	1.11	$27,372	$65,367	$92,739	bioretention	functioning	

Modified inlet	C-13	1808 W. Fairmount Ave	NW corner of W. Fairmount Ave and N. Fulton St., on Farimount	39.288967	-76.645489	0.20	$16,383	$33,557	$49,940	Filterra	functioning well	
Stormwater Curb Extension	B-15	1800 W. Lexington Street	NW corner of W. Lexington and N. Fulton Ave, on Lexington	39.290648	-76.645752	1.63	$27,594	$50,339	$77,933	bioretention	functioning well	
Impervious Cover Removal	I-1		alley between N. Bruce St and N. Fulton Ave. 75 feet south of Saratoga St.	39.291768	-76.644933	0.04	$16,002	$22,933	$38,935	asphalt removal	Grass growing	
curb cut	PPF 2	15 N. Mount St.	E side of Mount St. 165 feet N of Baltimore Street	39.28878	-76.643727	0.16				Bio-swale	functioning, needs built up sediments removed	
Grubbing lawn and tree planitng	DPW	2 N. Vincent St.	E side of Vincent St. Behind alley for Baltimore St.	39.28892	-76.642972	0.21				tree planting	tree buds present and grass growing	

Appendix B - Street Trees in WS 263 Subcatchment O						
Street	Hundred Block	street side	circumference (inches)	π	diameter breast height (inches)	count
Frederick Ave.						
between Gilmor & Mount	1600	North	7	3.14	2	1
total						**1**
W. Baltimore St.						
between Gilmor & Mount	1600	North	15	3.14	5	5
		South	9	3.14	3	2
		South	25	3.14	8	1
between Mount & Fulton	1700	North	20	3.14	6	2
		North	15	3.14	5	4
		South	54	3.14	17	1
		South	11	3.14	4	2
		South	55	3.14	18	1
		South	36	3.14	11	1
between Fulton & Monroe	1800	North	8	3.14	3	1
			33	3.14	11	1
			34	3.14	11	1
			52	3.14	17	1
			11	3.14	4	1
			24	3.14	8	1
			29	3.14	9	1
	1800	South	30	3.14	10	1
			15	3.14	5	1
			9	3.14	3	1
between Monroe & Payson	1900	North	7	3.14	2	8
	1900	South	37	3.14	12	2
			20	3.14	6	3
			8	3.14	3	8
total						**50**

W. Fayette St.						
between Gimor & Mount	1600	South	17	3.14	5	3
			36	3.14	11	3
between Mount & Fulton	1700	North	64	3.14	20	2
			6	3.14	2	1
		South	64	3.14	20	1
			6	3.14	2	2
			10	3.14	3	1
between Fulton & Monroe	1800	North	17	3.14	5	7
		South	40	3.14	13	7
			12	3.14	4	1
between Monroe & Payson	1900	North	36	3.14	11	1
			9	3.14	3	4
		South	54	3.14	17	2
			9	3.14	3	4
total						**39**

W. Lexingotn St.						
between Mount & Fulton	1700	North	7	3.14	2	1
		South	7	3.14	2	3
Between Fulton & Monroe	1800	North	37	3.14	12	5
			10	3.14	3	3
		South	37	3.14	12	3
			13	3.14	4	3
total						**18**

W. Fairmount Ave						
between Fulton & Monroe	1800	North	9	3.14	3	2
			100	3.14	32	1
between Monroe & Payson	1900	North	30	3.14	10	2
			18	3.14	6	4
		South	30	3.14	10	1
total						**10**

Vine St.						
between Fulton & Monroe	1800	South	10	3.14	3	10
between Monroe & Payson	1900	South	13	3.14	4	7
total						**17**
Penrose Ave.						
west of Fulton	1800	North	55	3.14	18	1
		South	55	3.14	18	3
total						**4**

S. Mount St.						
between Baltimore & Frederick	0	East	36	3.14	11	1
		West	24	3.14	8	1
total						**2**

N. Gilmor St						
between Baltimore & Fayette	0	East	55	3.14	18	1
		West	22	3.14	7	4
			55	3.14	18	3
total						**8**

N. Vincent St.						
between Baltimore & Fayette	0	East	7	3.14	2	12
		West	23	3.14	7	3
			9	3.14	3	6
total						**21**

N. Mount St.						
between Baltimore & Fayette	0	East	14	3.14	4	13
		West	14	3.14	4	4
between Fayette & Lexington	100	East	41	3.14	13	3
			10	3.14	3	4
		West	6	3.14	2	1
between Lexington & Saratoga	200	East	17	3.14	5	5
			32	3.14	10	1
		West	9	3.14	3	3
			75	3.14	24	1
total						**35**

N. Bruce St.						
between Lexington & Saratoga	200	West	15	3.14	5	4
			6	3.14	2	4
total						**8**

N. Fulton Ave						
between Baltimore & Fayette	0	East	45	3.14	14	1
			8	3.14	3	2
			15	3.14	5	2
			32	3.14	10	1
			17	3.14	5	1
		West	17	3.14	5	8
			37	3.14	12	1
between Fayette & Lexington	100	East	17	3.14	5	2
			22	3.14	7	1
			37	3.14	12	1
			48	3.14	15	1
		West	17	3.14	5	8
between Lexington & Saratoga	200	East	6	3.14	2	6
			10	3.14	3	3

			15	3.14	5	7
			25	3.14	8	1
		West	6	3.14	2	6
			36	3.14	11	1
			25	3.14	8	2
total						**55**

N. Monroe St.						
between Baltimore & Fayette	0	East	5	3.14	2	5
			22	3.14	7	2
		West	5	3.14	2	9
between Fayette & Lexington	100	East	77	3.14	25	1
			7	3.14	2	3
		West	16	3.14	5	4
			7	3.14	2	3
total						**27**

N. Addison St						
between Fairmount & Fayette	0	West	6	31.4		3
total						3
total number of trees in Subcatchment O						298