Kansas City’s Overflow Control Program was developed to meet regulatory requirements related to reducing overflows from the combined sewer system and preventing overflows from the separate sewer system. The City and its regulatory partners have agreed to meet those objectives over a 25-year time period by completing a planned list of improvements targeted at capturing for treatment 88 percent of combined sewer flows and eliminating sanitary sewer overflows during a five-year rainfall event.
November 19, 2013

To the reader:

Kansas City Water Services is pleased to submit the final report for the Middle Blue River Basin Green Solutions Pilot Project which received Achievement of Full Operation on November 19, 2012. Pursuant to the City’s Consent Decree with U.S. EPA, this report has a required submittal date no later than 365 days after completion of the 100-acre green infrastructure pilot project.

As is outlined in the Consent Decree, this report provides a description of activities and work performed in the pilot project area; provides an evaluation of the effectiveness, implementability, and cost; outlines a plan for implementation in other areas of the Marlborough neighborhood; and outlines a plan for implementation of green infrastructure throughout the CSS.

Additionally, and as required by the Consent Decree, any report, plan, or other submission that the City is required to submit, including reports, plans or other submissions as required by its Current NPDES Permits, shall be signed and certified by an official or authorized agent of the City.

By signing below, I certify under penalty of law that the document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted, and that the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Thank you for your participation and cooperation in Kansas City’s Overflow Control Program. If you have any questions, please contact the undersigned at (816) 513-0203.

Sincerely,

Terry Leeds
Director, Kansas City Water Services

cc: Troy Schulte, City Manager, City of Kansas City, Missouri
Matthew J. Gigliotti, Assistant City Attorney, City of Kansas City, Missouri
# TABLE OF CONTENTS

**EXECUTIVE SUMMARY** .................................................................................................................. 1

**ACTIVITIES AND WORK PERFORMED** ............................................................................................ 8

- Project Background
  - Green Movement
  - Preliminary Analysis
  - Conceptual Design Phase
  - Design Phase
  - Consent Decree
  - Construction Phase

- Project Description ................................................................................................................................ 13
  - Typology of Green Infrastructure BMPs
  - Location & Distribution Maps

- Maintenance Strategies .......................................................................................................................... 21
  - Maintenance Service Agreement
  - Maintenance Service Agreement Cost
  - Maintenance Service Agreement Efficacy
  - Maintenance Manual
  - Maintenance Plan After Maintenance Service Agreement

- Public (Community) Outreach .................................................................................................................. 27
  - Public Involvement Plan
  - Public Outreach Activities

**EVALUATION OF EFFECTIVENESS, IMPLEMENTABILITY, AND COST** .................................................. 37

- Social

- Environmental

- Financial

**IMPLEMENTATION IN MIDDLE BLUE RIVER BASIN** .......................................................................... 53

**FUTURE IMPLEMENTATION THROUGHOUT COMBINED SEWER SYSTEM** .................................... 61

**Appendix** ............................................................................................................................................ 63
EXECUTIVE SUMMARY
The Middle Blue River Basin Green Solutions Pilot Project (pilot project) is the first green infrastructure project for the City of Kansas City’s Overflow Control Program. Kansas City’s interest and commitment to the use of green infrastructure dates back nearly a decade and involves many stakeholders. From the Wet Weather Community Panel to the City Council to professional engineers and residents, the pilot project has provided the City an opportunity to test the effectiveness of these desired improvements and determine if they would be applicable to other areas in the combined sewer system.

Through significant investment and public outreach, Kansas City has strived to meet the requirements of the Consent Decree with the implementation of this large-scale green infrastructure project, one of the first in the nation. The purpose of the project was to test a wide range of infrastructure solutions and streetscape improvements for reducing combined sewer overflows in a 100-acre area of the Middle Blue River Basin. This neighborhood presented itself with many challenges including land use mostly urban and mixed use and the age of the neighborhood, dating back to the 1940’s.

The planning for this large-scale green infrastructure project took place over four years beginning with a simple desktop analysis in 2008 and ending with the construction of the actual improvements in 2012. Throughout the entire planning and construction process, feedback from an extensive public involvement process and interdepartmental collaboration provided significant influence on the ultimate design. The green infrastructure techniques were developed in line with the ideals of sustainable development to help integrate stormwater management features into the human landscape.
The project was complete in November 2012 after 15 months of construction. In the end, approximately 135 vegetated BMPs and 27,490 square feet of non-vegetated BMPs were installed throughout the 100-acre project area. Some examples of the types of BMPs include rain gardens, bioretention, curb extension rain gardens, permeable paver sidewalk, and porous sidewalk. Although construction is complete, work continues in the form of maintenance. Beginning last November and continuing for the next two years, the BMPs in the pilot project area will be maintained through a service maintenance agreement.

The City has found that these improvements are, in fact, the actual reduction in volume at Outfall 069 is 292,000 gallons of stormwater and reducing the peak flow by 76 percent. Although the road to this result often veered in many directions, the City is excited about the results of the pilot project and will continue green infrastructure installation. BMPs are currently being planned in an additional 644 acres in the Middle Blue River Basin, applying lessons learned from the pilot project.

This project has provided a good case study for how an organization can implement innovative approaches to keeping stormwater out of the sewer system in older parts of a community. Coordination within the department, with other city departments and with outside agencies and organizations allowed for the City to be efficient with its resources, share ideas, and reduce the impacts on residents and business owners. As a pilot, this project encountered several challenges and barriers, all of which were treated as lessons learned. The City will continue to look at ways to make green infrastructure investments in other areas of the combined sewer system, all while continuing to learn and adapt with new approaches and technologies.
Troost Avenue after improvements
ACTIVITIES AND WORK PERFORMED
PROJECT BACKGROUND
The Middle Blue River Basin Green Solutions Pilot Project is a 100-acre area located in the Marlborough neighborhood of Kansas City. The pilot project is a portion of the larger Middle Blue River Basin Green Infrastructure project which consists of approximately 744 acres tributary to Outfalls 059 and 069. Of that total, 475 acres are tributary to Outfall 069 of which 100 acres is the pilot project. The remaining 269 acres are tributary to Outfall 059. Land use in the area is primarily residential, but does include commercial businesses along Troost Avenue. Overall, 34 percent of the total area tributary to Outfalls 059 and 069 is impervious. Sewage from the Middle Blue River Basin is delivered to the Blue River Wastewater Treatment Plant.

The Green Movement
The topic of green infrastructure in Kansas City’s Overflow Control Plan dates back to the mid 2000’s. During plan development, a mayoral-appointed Wet Weather Community Panel was convened comprised of citizens and key stakeholders in the community. Over the five years that they met, this group became the main drivers of the inclusion of green infrastructure in the Overflow Control Plan. Community Panel members asked that Water Services make substantial investments in green solutions in the early years of the Overflow Control Program. They pushed for green solutions to be installed where the public support and acceptance is strong and where amenities are created that improve the neighborhood’s quality of life and spurs further economic investment. Their push led to the City Council enacting an Administrative Regulation in 2007, “establishing the policy of the City to integrate green solutions protective of water in our City planning and development processes... and directing the City Manager to incorporate green solutions, when possible, in the City’s conceptual long-term control plan for sewer overflows.”

Middle Blue River Basin Green Solutions Pilot Project Area
Preliminary Analysis

The push for green infrastructure led to a comprehensive green review of the drafted components in the Overflow Control Program in the combined sewer system basins to identify locations where green solutions could replace, in whole or in part, gray infrastructure. In May 2008, a high altitude desktop analysis to determine this potential was conducted in three major basins- OK Creek, Brush Creek, and two sub-watersheds in the Middle Blue River Basin. The analysis focused on locations that would reduce the amount of water in the combined sewer system, reducing overflows and could also be considered amenities for the community. A preliminary desktop analysis was also conducted to assess the potential cost impact that would result from replacing previously identified “gray” improvements to green solutions in the Middle Blue River Basin. Results of the desktop analysis identified the two subwatersheds in the Middle Blue River Basin as the most attractive selection for green infrastructure implementation.

The analysis in the Middle Blue River Basin specifically considered approximately 744 acres of the basin tributary to Outfalls 059 (85th west of Woodland) and 069 (79th & Prospect). The analysis was conducted without detailed modeling of the system; however the analysis recommended that such an investment be made.

In the absence of detailed modeling, certain simplifying assumptions were necessary. A key assumption made was that the volume of storage in green solutions would result in an equal reduction in the volume of storage in the “gray” components of the current plan. Any change to that assumption that would result from more detailed modeling would be expected to result in the need for additional “green” storage. Another assumption was that each 1-mg of green storage would result in 0.5 mgd reduction in the capacity of downstream pumping stations and treatment facilities due to infiltration and evaporation.

“Green” storage technologies considered in the desktop analysis included:

- Catch basin retrofits in road and street rights-of-way;
- Curb extension swales;
- Replacement of sidewalks in road and street rights-of-way with permeable pavement;
- Replacement of pavement outside of road and street rights-of-way with permeable pavement; and
- Conversion of roof areas to green roofs.

The “gray” controls in the areas tributary to Outfalls 059 and 069 (storage tanks with screening facilities and outflow pumping stations) were, on a unit cost per gallon stored, the highest of all facilities in the Overflow Control Plan. The preliminary analysis focused on the potential for complete replacement of the “gray” components with “green” storage.

The results of this desktop analysis suggested that it may be cost-effective to pursue replacement of the “gray” components in the areas tributary to Outfalls 059 and 069 with “green” storage without impacting the desired level of control at those outfalls. The estimated capital cost to develop 2.375 million gallons of green infrastructure storage in the area tributary to Outfall 069 from the 2008 report was approximately $24.6 million, roughly 82 percent of the estimated capital cost of the “gray” storage tank and related facilities included in the draft Overflow Control Plan.

Conceptual Design Phase

Based on recommendations from the desktop analysis and with support from the City Council and the Wet Weather Community Panel, the Overflow Control Program team developed a conceptual design report that identified general types and locations of BMPs for implementation within the pilot project area in the Middle Blue River Basin. Using the results and recommendations of the preliminary analysis, the work of the conceptual design report included:

- Monitoring of sewer flows and rainfall;
- Manhole and inlet inspections;

1 Kansas City- City Council Resolution No. 070830 accessed online at: [http://tinyurl.com/momy856](http://tinyurl.com/momy856)
• Cleaning and CCTV inspections of all sewers;  
• Smoke testing of all sewers;  
• Utility location surveys; and  
• Detailed modeling.

Hydrology for the pilot project area was developed in the runoff layer and used hydrologic equations, as well as precipitation and catchment data, to calculate storm runoff. The precipitation data used for calibration and verification was developed from rainfall gage data, and the precipitation data used to examine the overflow characteristics of the Basin previously developed by the City as design storms A through H. The design storm of interest in the simulations documented in this report is OCP Design Storm D (1.4 inches) which has a peak intensity of 0.6 in/hour and duration of 16.75 hours. Other runoff characteristics utilized and adapted parameters contained in the computer model previously developed by HDR, Inc., who served as the basin engineer for the Middle Blue River Basin under the OCP. The calibrated pilot project model was merged with the HDR model and Design Storm D was entered as precipitation data in the runoff layer. The model results were compared to the results of the HDR OCP Design Storm D modeling and the modified model’s peak discharge and total volume were 98 percent and 88 percent, respectively of the HDR peak and volume below the pilot project area. This was deemed acceptable and no further revisions were made.

The modeling analysis resulted in the amount of distributed storage required to reduce the amount of combined sewer overflows to seven overflow events in a typical year. From those results, a recommendation of BMP types was developed that included various configurations and combinations of rain gardens, bioretention cells, infiltration galleries and pervious paving. The concept report indicated that it was necessary for these BMPs to store approximately 56 percent of the pilot area runoff from Storm D, or approximately 300,000 gallons. Overall, the concept report recommended 344 total BMP units distributed throughout the pilot project area with a total opinion of probable construction cost of approximately $3.7 million adjusted to the Spring of 2010.

During the conceptual design phase, it was assumed that all BMPs would be located within the existing rights of way (ROW) of the public streets, primarily located between the curb or edge of pavement and the sidewalk. In locations where there was insufficient ROW behind the curbs, the improvements were constructed under the sidewalk on streets such as Troost and 75th Street. The conceptual design report also identified opportunities for locating BMPs in presently paved surfaces (curb extensions) or utilizing private property for BMPs and that those locations should be considered during final design if necessary to meet the project goals or other considerations. Although the primary purpose of green solutions was to intercept, detain, and control the amount of stormwater runoff that discharges to the sewer system, it is anticipated that the overall water quality of the runoff will also be improved.

**Design Phase**

In 2010, URS Corporation was hired as the design professional for this project along with subconsultants, Barr Engineering, Taliaferro & Browne, Vireo (formerly Patti Banks Associates), Delich Roth & Goodwillie, and Shockey Consulting. URS was also contracted to concurrently develop contract design documents to rehabilitate and repair the existing sewer system in the 100-acre pilot project area. The existing sewer system regularly exceeded capacity, leading to overflows discharging directly into streams and rivers. It was determined that including the rehabilitation of the sewer system along with the installation of green infrastructure would avoid future impacts to the green solutions and would reduce construction impacts to the neighborhood.

URS’s design focused almost exclusively within public ROW and consolidated many of the BMP locations, which led to fewer BMPs with greater storage capacity. The original concept of utilizing gravel voids for underground storage was
supplemented with underground pipe and storage cubes. Special emphasis was placed on designing BMPs that were easily accessible and maintained. Limiting the number of BMPs was also important in simplifying maintenance. For instance, it was determined that the large quantity of porous sidewalks originally proposed in the concept study was not practical due to the fact that debris from the street trees and grass from yard mowing would tend to clog the sidewalk. Therefore, the design included porous sidewalks only in areas where additional runoff reduction above the green solutions was necessary. The final design included approximately 135 vegetated BMPs and 27,490 square feet of non-vegetated BMPs with the goal of providing approximately 372,000 gallons of storage volume.

The BMP designs included elements such as special inlet structures, underdrain systems, screens, pipe and open celled below-grade storage systems, various planting palettes and engineered soils. The factors affecting the type of BMPs that were recommended included the right-of-way width, slope, soils, utilities, obstructions and public acceptance. The location of the BMPs took into account predicted runoff volume upstream of the inlet, slope, available right-of-way area, proximity to sewer line or curb inlet and other obstructions and conflicts.

The public outreach effort was a significant part of the design process. It became apparent with feedback received at public meetings that the community had additional neighborhood concerns beyond sewer overflows. Issues such as deficient sidewalks and streets, as well as public safety concerns were addressed. Water Services and other city leaders made the decision to include curbs and sidewalks, street repair, and traffic calming elements in the project. These additional elements included standard sidewalk and street improvements, but also enhanced the BMPs by incorporating porous/permeable sidewalk segments, traffic-calming curb extensions with BMPs, and traditional landscaping including tree replacement.

In keeping with the pilot project nature of this effort, various design elements were utilized to test their effectiveness and determine which green solutions should be implemented in future phases of the project. Initial results on the effectiveness are outlined in Section 3.

Consent Decree
On September 27, 2010, individual elements of the OCP became part of an enforceable document with the entry of a Consent Decree in United States District Court. The City and its regulatory partners agreed to meet those objectives over a 25-year time period by completing a planned list of improvements targeted at capturing for treatment 88 percent of combined sewer flows and eliminating sanitary sewer overflows during a five-year rainfall event. The OCP includes funding dedicated to developing green infrastructure pilot projects and partnerships in the combined sewer basins. As the first of its kind to be implemented, the pilot project represents just one component of the City’s commitment to utilize green solutions to control runoff as part of the Overflow Control Plan.

Construction Phase
Mega Industries was awarded the pilot project construction contract through a competitive bid process in March 2011. Bids were received from five Kansas City construction companies. The $4,246,000 contract was structured for a basic construction period of a year, plus a three year maintenance requirement. In November 2011, the contractor’s scope was modified to address changes in the project scope, including a three-month extension and additional funding in the amount of $930,000. Construction began in May 2011 and reached Achievement of Full Operation on November 19, 2012.

As stated previously, work to rehabilitate the existing sewer system was also included. Approximately 17,000 lineal feet of damaged and leaking combined sewers were rehabilitated, and more than 70 manhole structures were repaired or replaced within the project limits resulting in a
total system repair of the 100-acre area. The work included rehabilitation of the existing CSS using cured-in-place pipe (CIPP) for the public sewer lines. Trenchless technology, such as CIPP, pipe bursting, or open excavation was used for sanitary service laterals.

Construction work also included the development of hardscape, such as curbs and sidewalks. A majority if the hardscape work was completed in 2011, and landscaping began in early 2012 due to warm winter and early spring conditions.

PROJECT DESCRIPTION
Typology of Green Infrastructure BMPs
To achieve the objectives of the project, stormwater BMPs were designed and constructed to capture stormwater prior to entering the combined sewer system. Approximately 135 vegetated BMPs and 27,490 square feet of non-vegetated BMPs constructed are estimated to capture (infiltrate and store) 360,000 gallons of stormwater runoff from this 100-acre residential neighborhood. Stormwater BMPs used in this project include the following:

- 81 Rain gardens
- 53 Bioretention
- 1 Bioswale (2,000 square feet)
- 200 square feet of porous concrete gutter
- 22,220 square feet of porous concrete sidewalk
- 5,070 square feet of permeable paver sidewalk

Specific to the project area, different configurations of the above mentioned BMPs were used to expand the potential of a standard BMP in capturing stormwater runoff (Table 1).

Table 1: Project Specific BMP configurations

<table>
<thead>
<tr>
<th>BMP Type</th>
<th>Configurations</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain Garden</td>
<td>w/Cascade = 2</td>
<td>To control flows at steeper slopes</td>
</tr>
<tr>
<td></td>
<td>w/Curb extension = 12</td>
<td>To increase volume capture and calm traffic</td>
</tr>
<tr>
<td></td>
<td>Standard = 67</td>
<td></td>
</tr>
<tr>
<td>Bioretention</td>
<td>w/ Curb extension = 24</td>
<td>To increase volume capture and calm traffic</td>
</tr>
<tr>
<td></td>
<td>w/ below grade storage = 24</td>
<td>To capture overflows exceeding the capacity of the garden</td>
</tr>
<tr>
<td></td>
<td>w/ 4” slotted drain pipe = 2</td>
<td>To capture excess water when the bed reaches saturation point</td>
</tr>
<tr>
<td></td>
<td>w/ smart drain</td>
<td>Used instead of slotted drain pipe</td>
</tr>
</tbody>
</table>
Below grade pipes being installed on Lydia Avenue

Hardscape improvements in the pilot project area
Along with the varied BMPs, the project team designed multiple variations of BMP elements, such as inlets, underdrain systems, risers, trash screens, permeable pavement systems, and below-grade storage systems, as well as plant selections, to test new design details for the local climate and landscape.

Utilizing the narrow space within the right of way and maximizing the volume capture was a major challenge in this project; all BMPs had to be located within street rights of way. Because the overarching goal of the project was to reduce peak runoff rates, many of the BMPs collect and detain runoff in below-grade storage to allow a larger storage volume which was not available in the limited surface area. Surface features are largely located between street curbs and sidewalks, while below-grade storage systems are located beneath sidewalks and roads. Descriptions about each type of BMP used are listed on the following pages.

**Rain Gardens**

A rain garden is a small depression that is covered with mulch layer and generally planted with native prairie vegetation in the bottom of the depression and native or ornamental plants on the edges. Stormwater from the streets directed to the rain garden percolates through the mulch and into the soil (generally a mix of top soil and compost), where it is treated by a variety of physical, chemical and biological processes. Native vegetation in the garden has deep roots that help the stormwater soak into the soil. The mulch in the garden helps keep weeds down and holds moisture for the plants. The purpose of rain gardens is to not only catch stormwater off the streets and soak it into the ground but also to add variety and interest to the streetscape.

Pretreatment of stormwater runoff is provided either by turf grass filter strip along the length of garden or a curb cut and an inlet forebay arrangement which also allows for sediment collection. Rain gardens that receive the largest volumes of water have a 2-inch underdrain pipe that allows excess stormwater to drain out of the garden and return to the street. The underdrains assist with plant establishment in the first few years of plant growth. When the plants mature, the pipes will be capped if they are not needed for plant survival. The ends of the pipes are buried beneath the mulch on the downhill side of the garden and daylight along the curb below the rain garden. Excess runoff from extreme events bypasses the curb cuts to the rain gardens and flows to the combined sewer catch basins.
Bioretention basins, much like rain gardens, infiltrate stormwater and allow excess water to discharge to nearby curb inlets or outlet control structures. The bioretention units contain engineered soils (a mix of minimum 50 percent sand, topsoil, and compost) and an underdrain system which drains the garden bed to underground storage pipes. The drainage rate from the underdrain system is controlled with a small orifice to restrict flow rates into the combined sewer system which results in the reduction of peak flows.

Pretreatment of stormwater runoff is provided either by a turf grass filter strip along the length of garden or a curb cut and an inlet forebay arrangement which also allows for sediment collection. Excess runoff from extreme events bypasses the curb cuts to the bioretention basins and flows to the combined sewer catch basins.

Cascades
The cascade units consist of stepped rain gardens on steep streets connected by overflow weirs and drain pipes. Stormwater flows into the upper most garden through the inlet and forebay. A flow control weir with adjustable stoplogs determines the elevation at which the water in the first garden begins to flow into the second garden. The process is repeated from the second garden and finally to
the last garden. The lowest garden has a curb cut to allow stormwater to exit the garden back into the street. The two uppermost basins are bioretention gardens with underdrains and the lowermost basin is a rain garden. The retaining walls separating the gardens also have a drain pipe through the lower part of the wall to allow the upper gardens to fully drain after a period of time so that no permanent standing water is present.

**Curb Extensions**

Curb extensions serve to make rain gardens and bioretention units larger by moving the permanent concrete curbs further into the street. This also adds an additional function as a traffic calming device which encourages traffic to slow down on the residential streets where they are located.

**Below Grade Storage Systems**

The below grade storage systems consist of buried 36-inch storage pipes that allow water to slowly discharge back to the combined sewer. Stormwater flows into the storage pipes through an inlet/riser assembly located in the bioretention garden. The inlet/riser assembly contains a removable filter basket to prevent debris from entering the storage system. Stormwater also enters the storage pipes through the basin underdrain described in the bioretention section.
The stormwater held in the pipes drains to the sewer system through an outlet control structure. The control structure contains an outflow pipe and a riser pipe assembly with a small orifice to limit the rate of discharge. The outlet control structure is located in a manhole within the rain garden or bioretention basin. Additional access risers are located in nearby landscape areas, sidewalks, or streets, to allow additional access for cleaning the storage pipes.

### Permeable Paver with Underground Storage Cubes

Permeable pavements reduce stormwater runoff and its associated pollutants by conveying stormwater through a pavement surface, providing storage, and promoting in-situ stormwater infiltration. In the commercial corridor along Troost Avenue, pervious concrete paver sidewalks work in conjunction with the underground storage cubes. Underground storage cubes are used as below grade storage systems where utility conflicts and insufficient space make storage pipes impractical. The one cubic foot storage cubes are more versatile in that they can be assembled edge to edge in various configurations to fit in the available space and avoid utility conflicts. The stormwater runoff is filtered through the permeable paver sidewalk and through a layer of clean rock gravel prior to entering the storage cubes. The storage cubes are surrounded by smaller aggregate material and geotextile drainage fabric. The cube storage system is also sandwiched between two layers of structural geogrid to protect the cubes from surface vehicle loads at driveway locations. The system of storage cubes is piped to an outlet control structure which releases stormwater into the sewer system at a controlled rate.

### Porous Concrete Sidewalks

Porous concrete reduces stormwater runoff by capturing stormwater through the openings in the porous concrete. The stormwater then drains into a gravel bed underneath the porous concrete. From there, water that is not infiltrated into the ground enters a perforated PVC drain pipe which drains into a vegetated BMP, a curb inlet, or other drainage structure. There are two applications for the porous concrete pavement: sidewalk and gutter. The porous gutter is located only on 75th Street. It serves as a stormwater infiltration and conveyance device, collecting stormwater in the gutter along the curb, which then infiltrates through the porous concrete layer into a gravel bed beneath the concrete. Excess water that is not infiltrated into the soil is conveyed in a perforated PVC pipe which daylights to a rain garden or connects to an underground storage structure.
Troost Avenue underground and sidewalk improvements with storage cubes during construction

Troost Avenue permeable paver sidewalk being installed
Troost Avenue sidewalk improvements after construction
Location and Distribution
The pilot project involved the construction of green infrastructure in a 100-acre area in the Middle Blue River Basin. The area is located in a portion of the 75-year old Marlborough neighborhood. This urban neighborhood is mostly residential, with some commercial businesses along a major corridor - Troost Avenue.

The pilot project is roughly bounded by 73rd Street to 77th Terrace, and Holmes Avenue to The Paseo. In this combined sewer system area, less than one (1) inch of rain can cause overflow events. Due to flow characteristics in this watershed, it was determined that green infrastructure could successfully lower the number and volume of overflows by reducing peak flows in the combined sewer system.

MAINTENANCE STRATEGIES
Maintenance Service Agreement
The City is currently administering a three-year maintenance service contract. The contract is ongoing from November 2012 through November 2015 and is performed by the same contractor who installed the improvements during construction. Maintenance services that are provided to the green infrastructure elements within the purview of the service agreement are summarized below:

Trash removal from beds
• Weekly service (March through November)
• Monthly service (December through February)

Year-round, monthly tasks:
• Remove weeds
• Remove sediment
• Empty any debris collected in the riser baskets
• Stiff broom 20-foot length of uphill gutter for each bed
• Stiff broom 100-foot long porous gutter on 75th Street

Porous concrete being installed on 75th Terrace
Year-round, quarterly tasks
- Inspect underground storage pipes
- Refresh mulch as required to maintain a 3-inch layer

Year-round, semi-annual tasks
- Clean underground storage pipes
- Prune plants
- Vacuum underground storage pipes
- Vacuum porous sidewalks
- Stiff broom pervious pavers, add gravel to paver joints as needed

Post-rainfall inspections
- Inspect beds after every rainfall event of 1.0 inch or more over a period of 24 hours

In addition to the maintenance provided as part of the service agreement there is a plant material warranty provided by the contractor. The project contract documents include a special two-year warranty on all plant materials. For two years from the award of Achievement of Full Operation, the warranty covers defects including death or unsatisfactory growth, except for defects resulting from abuse or incidents that are beyond the Contractor’s control. The contractor is required to remove dead plants and replace immediately unless it is necessary to plant in the succeeding planting season. At the end of the two-year warranty period, the contractor is obligated to replace plant materials that are more than 25 percent dead or in an unhealthy condition, provided they have not been replaced once already.

The warranty provides useful protection; however, there is a limit of one replacement for each plant. The exception to this would be for plant replacements needed due to the contractor’s failure to comply with the following maintenance activities required by the two-year warranty: pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, adjusting stakes, resetting to vertical, sediment is being removed on a monthly basis in the pilot project area. The amount of sediment picked up has been in smaller amounts than the first pick-up event in November 2012.

Debris is emptied from the riser baskets each month. Porous concrete sidewalks are vacuumed to remove debris.
monitoring/treating for pests and disease, and replacing tree wrappings as required to establish healthy, viable plantings. The maintenance tasks required by the two-year warranty are in addition to the requirements from those of the service agreement, though they will often be performed concurrently.

**Maintenance Service Agreement Cost**

The service agreement for three years of maintenance was executed at the same time as the original project contract at a cost of $143,000. An additional porous pavement vacuuming cost of $29,818.06 for the three year period was added as a change order during the construction process, for a total cost of $172,818.06 for the entire service agreement. The contractor is required to submit pay applications quarterly for 1/12 the total amount. Service logs and post-rainfall inspection logs are submitted quarterly with the pay applications and they are reviewed by Water Services staff prior to approval of payment.

**Maintenance Service Agreement Efficacy**

Overall, the tasks required by the service agreement have been appropriate to the needs of the project. There are a few items not included in the service agreement that are necessary for the success of the project as a whole. The Green Solutions crew within the Stormwater Maintenance Division addresses the items that are not in the service agreement. This crew's primary task is to maintain other green infrastructure owned and maintained by Water Services, but they are also available on-call for the Middle Blue Pilot Project area. Their services include straightening or replacing curb markers that are damaged, replacing plants outside contractor warranty, mowing sod filter strips, installing mosquito prevention briquettes in needed locations, trimming plants in response to resident complaints, top-dressing the gravel parking space on Lydia Avenue, placing safety cones where hazards occur, and other unexpected needs that arise.

The service agreement is monitored by Water Services staff. Site visits to verify contractor compliance and monitor for potential problems were made once weekly for the first nine months of the service agreement. After the first nine months, site visits occur every other week with an additional visit in between if rainfall occurs. At each site visit a field observation report is created which documents observations in text and photographs. The field observation report is emailed to involved Water Services staff, the contractor, and the Green Solutions crew contacts. Problems observed during site visits are emailed to the contractor or the Green Solutions crew to be addressed. Per site visit, it takes two hours of driving and site observation, one hour
of field observation report preparation, and two to six hours of coordination regarding work needed. The site visit consists of driving streets of the pilot area, stopping at four to six locations (different each visit), and reviewing locations pending service.

With the many rainstorms we experienced in the spring of 2013, numerous tree branches fell in the project area. As a result, some residents piled fallen branches in the BMPs, impairing the plants. To address this challenge, Water Services met with City nuisance code enforcement personnel to craft a procedure. As a result, an outreach door hanger was created for use in cases where Water Services crew removes debris from rain gardens. The door hanger alerts the resident that debris was removed, explains that debris should not be placed in the gardens, and reminds the resident of debris set out rules. Additionally, in June 2013, a letter was mailed to addresses that have BMPs to introduce new residents to the project and to seek participation in rain garden stewardship. The letter included guidelines such as, “Grass clippings and leaves from your lawn should not be placed in rain garden basins.” Contact information for questions and comments was provided in the letter. Questions and comments from residents are recorded and addressed by Water Services.

**Maintenance Manual**

A maintenance manual was created as part of the design professional services for the pilot project. The manual includes specific instructions and photographs for each component of the project. Maintenance described in the manual is similar to the requirements of the service agreement with a few exceptions. For example, the maintenance manual instructs that sod filter strips need to be mowed, but the service agreement does not require mowing the sod filter strips. Meeting the instructions in the manual is not a requirement of the service agreement. For future maintenance after the three-year service agreement ends, it is recommended to have the terms of the service agreement match exactly the instructions in the manual to help avoid confusion and to encourage use of the manual.

**Maintenance Plan After Maintenance Service Agreement**

Coordination is underway at Water Services to plan the maintenance of the pilot project that will occur after the three year service agreement ends. The frequency, tasks, and timing of visits will be updated based on lessons learned over the life of the service agreement. Green infrastructure maintenance approaches used in other municipalities are under review to help inform decisions.

![Figure 3.5: Cascade - Inspection and Maintenance Points](image)

A maintenance manual was completed as part of the design professional’s services for the pilot project.
PUBLIC (COMMUNITY) OUTREACH
Public Involvement Plan

From the start of the plan development in 2008 through the end of construction, public input and outreach was treated as an integral part of the design process by both the City and design team. Technical design tasks were combined with extensive community involvement to gain support from neighboring residents and businesses and to measure how well the public involvement approaches were working in receiving support for the project. Outreach activities included community meetings, on-the-street meetings with residents, recruitment of block captains, engagement with neighborhood associations, outreach with business owners, door to door outreach, and distribution of information materials through numerous media including online, mailings, and door hangers.

Because of the input that was received, the design of the project was changed significantly to not only install green infrastructure, but also incorporate neighborhood improvements such as sidewalk and street repairs and the installation of curbs. These improvements further demonstrate that green infrastructure can benefit communities beyond reducing sewer overflows and reducing the amount of stormwater entering our combined sewer system.

Related to public outreach was a two-year coordination effort between City departments within Kansas City. Organized by City Councilwoman, Cindy Circo, the City organized monthly interdepartmental meetings with representatives from parks and recreation, community development, neighborhood and housing services, public works and water services departments to ensure that the City had a coordinated effort in completing this important project. Coordinating with utility companies occurred as well which accelerated neighborhood gas line work to coincide with project area construction.

Additional outreach occurred as part of grant work conducted by U.S. EPA (EPA). Called the Advanced Drainage Concepts (ADC) team, the EPA grant team worked on two projects in the pilot project area, both involving outreach with the residents. One project involved working with residents in the Marlborough neighborhood to install demonstration rain gardens and rain barrels as well as to disconnect downspouts that were connected to the sewer. Some of the private property rain gardens in the neighborhood are part of the monitoring program that EPA is conducting with UMKC and other local partners.
Demonstration rain barrels were painted as part of the U.S. EPA’s Advanced Drainage Concepts work in the pilot project area.
Public Outreach Activities

An extensive public outreach program occurred throughout all phases of the pilot project. Beginning with the conceptual design phase in 2008 and ending with construction in 2012, stakeholders and residents in the pilot project area were updated on project progress and were provided opportunities for feedback.


Public outreach for the pilot project began in October 2008 as part of the Conceptual Design Report. The public outreach approach focused on the residents and businesses located within the 100-acre pilot project area. The first outreach to the residents and business owners was through a letter from the then Overflow Control Program Manager, Terry Leeds. The letter informed the residents about smoke testing and field investigation activities that were taking place in the pilot area. The letter also gave a brief overview about the pilot project. In late 2008, a brand and website were created specifically for this project deemed “Target Green”. The website linked from the Water Services website.

In January 2009, Overflow Control Program team members met with two representatives from the Battleflood Heights Neighborhood Association, a neighborhood group located in the pilot project area. They were given an overview of the project and were asked to provide any initial thoughts and comments about the project. Soon to follow, a letter was mailed to all residents in the pilot project boundaries. The letter briefly described the project and asked for residents and business owners to attend a public meeting scheduled for later in the month. After that initial introductory letter, a follow-up fact sheet was mailed to each property owner and resident within the pilot area. The fact sheet expanded on information in the letter and provided example pictures and an approximate schedule of when the project will occur. The fact sheet and meeting announcement was posted on the project’s website.

At the January public meeting, approximately 80 people were in attendance; however only 15 of those attendees were actual residents or business owners. Other attendees included interested stakeholders in the community. At the meeting, participants were given an overview presentation about the Overflow Control Program and about the project. They were given opportunity to participate in a question and answer session. At the meeting, the ADC Team also presented information about the work that they would be conducting as part of their grant.

Participants were also given a survey to fill out at the first public meeting trying to gauge participants’ thoughts about the project, any concerns that they may have and how they prefer to receive information. The survey results indicated that residents were most concerned with crumbling streets, sidewalks and curbs. Others thought traffic and speeding was also an issue. Improving property values and beautifying the neighborhood were benefits that the meeting participants highly anticipated.

Other initial questions and comments from the first public meeting in January included:

- How many rain gardens will be installed?
- We need curbs and sidewalks.
- Who will maintain and collect the trash in the gardens?
- Can we receive a stormwater credit if we have our own rain garden?
- Why not use the vacant lots for larger rain gardens?
- What will be done to the existing damaged sewers?
- Maybe this project will help us to build a better, more connected community.
- The community needs something that connects us and gets us talking to one another.

Throughout the concept design phase, Overflow Control Program team members attended the Battleflood Heights Neighborhood association meetings and provided updates and answered questions about the project as they arose.
Design Phase: 2009–2010

In late summer and early fall 2009, the project went from a concept phase to the design phase. Follow-up with area residents and business owners took place in early October 2009 through a fact sheet sent by mail. The fact sheet gave area stakeholders an update on the project and invited residents and business owners to attend on-the-street meetings which were scheduled for mid to late October 2009. Fact sheets were also developed and mailed in January, May, July, and September of 2010. Public meetings and outreach activities were announced in each of the fact sheets. Additionally, door hangers were distributed before each public meeting and project signage was placed throughout the neighborhood. Emails were also distributed to residents and business owners who provided their email address to the project team.

The project team continued to attend neighborhood association meetings throughout the design phase. The neighborhood association in time became defunct and was rolled into a larger association encompassing several neighborhoods— the Marlborough Community Coalition. This group became the main contact for the neighborhood. The project team also worked with neighborhood residents called “block captains”. The block captains were contacted first about upcoming events in the neighborhood and provided feedback on proposed outreach ideas. They were also asked to spread the word about events.

Two meetings were held in the front yards of two block captains who volunteered to have the meetings on October 24, and 31, 2009. In total, 50 pilot project residents stopped by the meetings over the two weekend days. Residents were given information about the project and about the worked conducted by the ADC team. They were asked to identify their property on a map to determine where participants lived. They also filled out a survey and comment card. Councilmember Jan Marcason and Councilmember Cindy Circo were in attendance at one or both of the meetings. The key issues brought up by residents were again, curbs, sidewalks and street repairs in addition to speeding traffic. Concerns with maintenance and trash were also brought up.

The purpose of the May 22, 2010, Saturday morning breakfast meeting was to follow-up with residents about business owners after the on-the-street meetings held the previous October. The participants were given more information about the planned improvements for their neighborhood including sewer rehabilitation work and green solutions and participants were allowed an opportunity to provide input into the information presented. The event included a pancake breakfast and an opportunity to view maps of the pilot...
do during construction times. They were also given specific information about construction activities near their property. A total of 25 residents attended the meeting. The participants were given a take-home handout with contact information and tips on what to do during construction.

**Construction Phase: 2011–2012**

Public involvement in the pilot project area during the construction phase included door-to-door outreach and two public meetings. In late April and early May of 2011, door-to-door outreach for the pilot project area was conducted. The purpose of this outreach was to contact property owners and residents to inform them of the improvements that were to be made in the right-of-way in front of or adjacent to their property starting in the next few months. In addition, properties that were found to have downspouts connected to the sanitary sewer system were given educational materials explaining why the City would like for them to disconnect their downspouts.

A total of 147 of the 161 properties with BMPs planned in front of or adjacent to their property were contacted during the door-to-door outreach. Ten (10) properties were not contacted due to the property being vacant and four (4) properties were not contacted due to an unleashed dog or there was nowhere to leave information. Of the 147 residents contacted, 27 were property owners and 14 were renters. Materials were left at the remaining 106 addresses. Handouts to residents included “Public Meeting Announcement and Project Update” and “Why Should you Disconnect Your Downspout?”

In general, a majority of the property owners and residents were positive about the upcoming improvements.

On May 21, 2011, a public meeting was held at South-Broadland Presbyterian Church at 7850 Holmes Road. The meeting was designed to give the residents and businesses in the project area information about the forthcoming green infrastructure construction. In preparation of this meeting, signage was posted in the project areas.
announcing the event. Project staff also canvassed the area to distribute flyers and encourage the participation of residents by attending the meeting. The event included a pancake breakfast and an opportunity to learn more about what is going to occur on the streets of their neighborhood. The construction contractor was introduced as well as the utility representatives that were also going to be working in the project area.

Sixty-three (63) members of the community attended with 51 of them living within the project boundaries. Other stakeholders attending included the Blue River Watershed Association and the Marlborough Community Coalition. City officials present included newly inaugurated Mayor Sly James and City Council representatives Cindy Circo, Michael Brooks, John Sharp and City Manager Troy Schulte. Other City departments represented include City Planning and Development, Neighborhood & Community Services and Neighborhood Housing Services. The event included representatives from U.S. EPA Region VII and Mid-America Regional Council.

On December 13, 2011, a mid-construction meeting was held at South-Broadland Presbyterian Church at 7850 Holmes Road. Residents were informed about the meeting through a mailer that included a project update with pictures. Additionally, door hangers were placed on every door in the project area the weekend before the meeting. Block captains, local neighborhood contacts, were notified of the meeting in advance and were asked...
to spread the word. The purpose of this open house meeting was to give residents the opportunity to talk with City staff and project members about their experiences and discuss any issues that may need to be addressed. Four display boards showing separate sections of the project area were placed around the room. Residents were encouraged to visit the display board that showed their property area to learn more about the improvements and to talk with designers and City staff. They were shown information demonstrating how the green infrastructure would work through pictures and a video of the rain garden inundation testing. They were also shown pictures of equipment and materials that were being used in the neighborhood. Residents were paired up with a staff or project team member who worked with the resident to record their comments. Twenty residents attended the meeting.

On July 16, 2012, Mayor Sly James and Mayor Pro-Tem Cindy Circo along with Water Services Director, Terry Leeds, residents and invited guests participated in a press event to celebrate the Middle Blue River Basin Green Solutions Pilot Project. At the event, the Mayor recognized this pilot project area as the first “KC Green Neighborhood” in the City. New street sign toppers were installed throughout the neighborhood to recognize this designation.

Mayor Sly James presented the pilot project neighborhood as the first KC Green Neighborhood in Kansas City.
Project team members worked with the Blue River Watershed Association (BRWA) and New Reflections KC, a local workforce development program, to provide an opportunity for these local groups to conduct two rain barrel how-to workshops in the pilot project area. The project team met with the workforce to provide training on how to conduct a workshop and also to discuss the purpose and goals of the project, including information about the Overflow Control Program and the pilot project. Before the two workshops were held, the project team facilitated a mock workshop at an actual location. Project team members focused training on assembling/installing rain barrels with some discussion on downspout disconnection.

On Saturday, April 28 and Thursday, May 3, 2012 the pilot project team worked with BRWA and New Reflections KC to conduct the two workshops. Approximately 20 pilot area residents attended the two workshops. Each workshop began with an introduction that helped frame the problem that the City faces were told examples of how improvements on private property can help address that problem. New Reflections KC workers then gave a demonstration on how to install a rain barrel. The project team also described the importance of downspout disconnection. Workshop participants were provided with informational materials to take away about how to disconnect a downspout, install a rain barrel, and how to plant a rain garden. They were also given information about the City’s efforts to improve water quality and reduce sewer overflows through the installation of green solutions in the public right-of-way.

To recruit the workshop hosts, the project team members utilized a list of properties that were suspected to have downspouts connected to the sewer system. This information came from smoke testing that occurred in late 2008 and early 2009. Project team members conducted door-to-door outreach, placed phone calls, and mailed a flyer that explained that the host would receive a free rain barrel. The two locations where the workshops occurred were 1160 E. 76th Terrace and 7429 Flora Avenue. The project team worked with the residents to determine a good time and day for the workshop. Minimum preparation was needed by the resident in advance of the workshop. Property owners and residents in the neighborhood were invited to the workshops through mailers and from some door-to-door contact by BRWA. Yard signs were placed throughout the neighborhood a couple days in advance of the workshops as well.

Residents who attended the workshops received first priority to receive up to two of the 50 free rain barrels donated by Coca-Cola. Those not attending
the workshop were mailed a fact sheet with information on how to apply. There was a positive response rate to the offer of free rain barrels and they were quickly spoken for. Crews from New Reflections KC facilitated the scheduling and provided installation of the rain barrels for those who applied. The crews performed the installation of all 50 rain barrels for residents in the pilot project area between May and June 2012.

**Post-Construction: 2013**

In February 2013, a “lessons learned” meeting was held with residents in the pilot project. The purpose of the meeting was to allow for the residents to share their experiences and ideas on how the upcoming phases of the project can be improved. Although only eight residents were in attendance, their feedback was considered very beneficial. Comments and feedback ranged from ideas for better project coordination to specific concerns about the improvements adjacent to their project. Detailed feedback is outlined in Section 2.

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EVALUATION OF EFFECTIVENESS, IMPLEMENTABILITY, AND COST
EVALUATION OF EFFECTIVENESS, IMPLEMENTABILITY, AND COST

Project evaluation is discussed in this section by using the “Triple Bottom Line” concept as a framework for evaluating both criteria and outcome. This concept evaluates the project from the perspective of three dimensions of sustainability: social, environmental and financial, sometimes referred to as the three “Ps”: people, planet and profit.

It is important to note that during 2012, the Kansas City region experienced one of the worst droughts in its history. Pat Guinan, Missouri State Climatologist said, “January through November precipitation deficits exceeded 10 inches in many Missouri locations, and it ranked as the driest January through November period in more than 30 years”. The impacts from this drought had impacts on many facets of the project which are outlined in each section below.

SOCIAL (PEOPLE)

The People component is measured in terms of private property improvements, green job creation, quality of life, and community pride.

Private Property Improvements

“We are appreciative of what you have done for our area, and we just hope that the people in the neighborhood will actually see the same thing and take care of their properties to keep it up.” – Pilot project area resident, Tony Webb

The green infrastructure installations specific to the consent decree capture requirements for this project were completed in the rights-of-way and not on private property. However, the project involved interdepartmental partnerships and stakeholder collaboration to help improve the neighborhood on multiple levels. Private investment was encouraged at all public meetings and resources to assist with financing improvements were made available for residents.

Improvement programs extended to residents included:

- Low-Interest Home Loan Assistance
- Home Weatherization Program
- Home Remodeling Loan Programs
- KCPL Assistance Programs
- MGE Assistance Programs
- Emergency Home Repair Program
- KC Dream Home Program

The interest in making private property improvements was and still is high in the pilot project area. Many residents of the pilot project area are very impressed by the improvements in the area both from an aesthetic aspect and also functional environmental standpoint. In general, they are proud of the installation of the BMPs sidewalks, and rain barrels. Similarly, the residents from surrounding neighborhoods have observed the improvements made in the pilot project and are excited about the anticipation of similar improvements being made in their neighborhood as part of the next phase of the Middle Blue River Green Solutions plan for the additional acres within the basin.

Project area residents have expressed the desire to learn more about planting a rain garden or installing a rain barrel on their own private property. Residents are also interested in transforming vacant or neglected properties into large stormwater BMPs or community gardens. This interest was made evident when the EPA Region VII office carried out an environmental justice project in the pilot project area. The project involved planting eight rain gardens on private property and disconnecting downspouts and installing rain barrels.

Additional stormwater improvements were made on private property through assistance and partnership with Bridging the Gap as part of the WaterWorks! efforts. The City of Kansas City submitted an application and received funding from the Energy Efficiency and Conservation Block Grant program administered by the Department of Energy. While primarily focused on energy, the City’s application included a water conservation component – a nod to the emerging concept of
Rain gardens were installed on private property as part of the U.S. EPA Advanced Drainage Concepts work.
Missouri drought statistics
a “water-energy” nexus. The water conservation program was named “WaterWorks!” and has offered saving strategies to residents and businesses in six targeted areas identified in the grant application. Post-award, Water Services suggested inclusion of the Middle Blue River Basin Green Solutions Pilot Project area as an additional target area given the significant investment and activity level already occurring there.

This effort involved water conservation related to internal plumbing and external water conservation efforts, aimed at redirecting water away from the stormwater system. This focus of this external approach was to promote the infiltration of stormwater into the ground through rain garden or through “harvesting” the water using rain barrels or other storage mechanisms. Coordination of WaterWorks! with other Water Services programs aligned the sewer system field investigations work in the Middle Blue River Basin so that connected downspouts could be identified and addressed using WaterWorks! strategies. This allowed an enhanced level of targeting resources to occur and operated as an important precursor for future Water Services efforts to address private-side water management within the overall Overflow Control Program. Overall, 375 rain barrels were distributed throughout the City, a few of which were distributed in the Middle Blue River Basin.

In addition to the improvement programs above, Water Services partnered with Kansas City’s Neighborhood and Community Services Department, to test a new code enforcement process in the pilot project area. Residents and property owners were invited to a public meeting in February 2012 prior to the code enforcement sweep and were informed about the types of violations the City would be citing. Attendees also received information about assistance programs that they may be eligible to help pay for any needed improvements. In March, 2012, 341 properties were investigated. Of those properties, 97 were considered in violation of a nuisance or property maintenance code violation. Follow-up has indicated that abatement of over 90 percent of defects was observed in the project area.

Green Job Creation

Two separate opportunities for green jobs were developed during the pilot project. The first involved a local non-profit organization, Blue River Watershed Association (BRWA), and a local workforce development organization, New Reflections KC. New Reflections KC’s president is a local resident of the Marlborough neighborhood.
and has a vested interest in the neighborhood. Staff members were hired to fill new green jobs that included conducting two rain barrel how-to workshops and the installation of 50 rain barrels in the pilot project area.

Water Services also created several new green infrastructure maintenance positions. A total of five positions were created by Water Services due largely to the pilot project installations. Four positions are housed in the Stormwater Maintenance Division and include one Landscape Technician and three Equipment Operators. This four-person crew has been deemed the “Green Solutions” crew. One other position, housed in the Overflow Control Program, is a landscape architect charged with oversight of all green infrastructure installations through Water Services. In addition, the maintenance service agreement has supported private sector jobs.

Quality of Life

The housing stock in the Marlborough neighborhood was already established prior to annexation by the City of Kansas City in 1947. In the 1980’s, the area started changing from a predominately older population to a younger demographic made up of a broader racial mix and a larger number of single-parent families. As housing aged and suburban sprawl increased, income levels began to decline. According to the 2010 U.S. Census, the pilot project area is located in a neighborhood that consists of approximately 37 percent rental housing. The median household income was approximately $40,383, contrasting with the national average of $52,762. Approximately 16.1 percent of the residents were considered to be at or below the poverty level, contrasting with the national average of 14.3 percent. In 2010, the unemployment rate was 14.3 percent compared to the national average of approximately 9.5 percent.

In 2008, the Marlborough Community Coalition was formed by a group of concerned residents to reengage the residents to take pride in their neighborhood. Extensive collaboration was done with this group during the pilot project to address the needs of this aging area with such a broad history.

When outreach began, it was obvious that the citizens wanted the city to reinvest in their area. “We wanted to talk about the CSO’s, but the residents wanted to talk about sidewalks and maintenance,” stated Mayor Pro-Tem, Cindy Circo. They were worried about the speeding traffic through their streets, the safety of their residents and children, and the aging city infrastructure. Much of the area had unimproved streets with no curbs and sidewalks, while the areas with sidewalks had fallen into disrepair.

Source: 2010 Census- Jackson County, Missouri Census Tract 90
Plant types and colors varied throughout the pilot project area.
The pilot project provided a great opportunity to help improve the quality of life for residents while maximizing the benefit to the neighborhood. Crumbling streets were repaved, sidewalks were repaired, and damaged trees were replaced, beautifying the neighborhood. New sections of porous sidewalk, placed strategically throughout the area, test the technology’s ability to capture excess runoff from lawns and driveways while creating a walkable area for residents. New curbs and gutters define space for the rain gardens and route street runoff to the BMPs. Curb extensions were built to create a larger space for bioretention gardens, with the added benefit of slowing down traffic to make the neighborhood streets safer. Mixtures of native and ornamental plants lend color and variety to the landscape and will help Water Services determine what types of plants work best for rain gardens in a residential setting.

Community pride in this area of Kansas City has surged since the beginning of the pilot project. A once loosely organized neighborhood group strengthened. The group, the Marlborough Community Coalition, meets monthly and continues to actively seek projects and support from the City to improve their neighborhood, with much success.

Project Area Tours
Several tours of the Marlborough neighborhood have occurred in recent years, including:

- EPA press event- July 22, 2011
- Environment Excellence Business Network- June 29, 2012
- New Partners for Smart Growth- February 8, 2013
- Wet Weather Partnership Conference- May 22, 2013
- Congressional Spotlight Tour- May 30, 2013

The Environmental Excellence Business Network tour took place on June 29, 2012 in association with a local non-profit organization, Bridging the Gap, as part of their monthly meeting. After a presentation by WSD Overflow Control Program team members and a representative from the EPA regional office, a bus tour of the pilot area was given. More than
50 people attended the event which showcased the improvements and monitoring stations installed by EPA.

The New Partners for Smart Growth Conference, held February 7-9, 2013 in Kansas City, was hosted by the Local Government Commission and serves elected officials, municipal staff, consultants and community leaders dedicated to creating more livable and resource efficient communities. During the three-day conference, a tour was conducted through Marlborough, including the pilot project area. Organized by US EPA Region VII Sustainable Water Infrastructure Program Manager, the tour included a drive through the pilot project area along with other neighborhood landmarks and highlights.

The Wet Weather Partnership held their annual National Urban Wet Weather Workshop in Kansas City for the first time on May 21-23, 2013. On day two of the conference, Water Services hosted a bus tour of local green infrastructure throughout Kansas City. More than 35 bus tour attendees viewed three sites- DST’s 18Broadway demonstration site, the Kansas City Area Transportation Authority’s Troost MAX rain gardens, and the Middle Blue River Basin Green Solutions Pilot Project. Attendees had an opportunity to learn about project information from site experts at each of the three stops and tour each of the improvements. At the pilot project site, attendees learned about green infrastructure design, construction, and maintenance from Water Services’ engineers and landscape architect.

On May 30, 2013 more than 30 congressional staff members from Missouri and Kansas visited the Middle Blue River Basin Green Solutions Pilot Project as part of the Greater Kansas City Chamber of Commerce’s Congressional Spotlight Tour. While on the bus tour, attendees were given background information about the project by Mayor Pro Tem Cindy Circo and Water Services Director Terry Leeds. Once in the pilot project area, a neighborhood resident joined the group to discuss his experiences and benefits he has seen because of the pilot project. Water Services staff further demonstrated the storage features of the porous sidewalk by pouring buckets of water on the sidewalk. The Spotlight Tour, also known as the Regional Benchmarking Tour and Workshop for Congressional Staff Members, is a regional issues workshop highlighting key policy priorities, valuable job creation opportunities, innovation, and success stories in Greater Kansas City. The tour provided congressional staff the opportunity to meet regional leaders and get to know key decision-makers from across the metropolitan area.

Marlborough Catalyst Project

One of the projects that the Marlborough Community Coalition has advanced is the Catalyst project. The group received a grant from Mid-America Regional Council’s Planning Sustainable Places Program to hire a team of planning experts to lead a community planning process for all five neighborhoods of Marlborough, of which the pilot project is located. The project kicked off in May 2013 and is expected to be completed by November 2013.

The purpose of the project is to identify solutions to local challenges with regard to five topic areas—access to healthy food, sustainable property development, reuse of the Marlborough School building, creative growth in arts, culture, and social services, and mobility. The plan, initiated by the
The Marlborough Catalyst Plan is an initiative of the Marlborough Community Coalition to discover and develop the rich assets that the Marlborough community already has, and to craft an action plan that will transform this potential into a thriving place.
neighborhood group, will result in an action plan that will transform this potential into a thriving place to grow up, live and work.

The Catalyst Project presents a significant opportunity to build off of the investment that the City has made through the pilot project and to develop an integrated plan of action that will maximize the economic, social and environmental potential of the area. Of particular interest is the potential repurposing of the Marlborough School located in the pilot project area. Depending on use, the old school, as a new community center like entity, could provide great ongoing educational opportunities related to rainwater harvesting and further detention of runoff from the impervious surfaces of the grounds using green infrastructure approaches. In addition, Target Green coordination has been identified as one of four catalyst projects in the plan aimed to coordinate communication efforts and leverage the infrastructure investments for other identified neighborhood improvements.  

Perceptions and Reaction

“The fact that our neighborhood will have a national significant kind of program where we’re using permeable concrete, where we’re using basins where we can plant flowers in and recycle that water naturally, not only is it going to beautify the neighborhood, but it’s going to solve those stormwater issues and not using grey structures, but green ones.” - Marlborough Community Coalition President, Betty Ost-Everley

At the February 2013 “lessons learned” meeting, meeting attendees provided comments and feedback regarding their perceptions and reaction to the green infrastructure BMPs installed in their neighborhood. In general, residents understood the purpose of the pilot project and the technical reasoning behind the location of the BMPs. There was an overall appreciative of the improvements the project made to their neighborhood and although there was some initial inconvenience, the results are worth it. Most were appreciative of the curbs and sidewalks installed where there were none before. Most residents welcomed the aesthetic appeal added by the project saying it improved the look of the neighborhood. The improvement that the residents thought was most beneficial was the sewer system improvements, followed closely by the street resurfacing that occurred at the end of the project. The improvements are also being carried forward onto private property improvements with the planting of rain gardens and installation of rain barrels.

The resident responses to the project have not all been positive. Some residents have concerns that their property values have decreased because of the look and depth of the rain gardens. Several properties have lost access to on-street parking due to the location and depth of the rain gardens, which they feel takes away from their property values. Some are concerned about the use of the BMPs as trash receptacles and locations to put large bulky items such as couches. A key negative comment about the project revolved around the lack of consultation with residents when plant types were selected. Many were upset with the type of plant installed, including the way it looks and its height when grown and indicated that initial graphics and pictures did not accurately portray how the installed BMPs would look. Moving forward, the residents requested that accurate photos and graphics be shown, including what the BMPs would look like at various growth stages (at installation, in five years, etc.). There is also concern about the maintenance of the improvements after the three-year service maintenance agreement ends. Finally, residents want to be updated more often about the progress of a project, particularly when there are direct impacts on the residents.

ENVIRONMENTAL (PLANET)

The Planet component is measured in performance. Appropriately designed, constructed and maintained green infrastructure techniques are more sustainable than conventional drainage methods because they can mitigate many of the adverse effects of urban stormwater runoff on the environment. Mitigation of adverse effects is achieved through:

4 Source: Marlborough Catalyst Plan Study Team- BNIM and Marlborough Community Coalition
• Reducing runoff rates, thus reducing the risk of downstream surface flooding
• Reducing the additional runoff volumes and runoff frequencies that tend to be increased as a result of urban development and which can exacerbate flood risk and damage receiving water quality
• Encouraging natural groundwater recharge (where appropriate) to minimize the impacts on aquifers and river baseflows in the receiving catchment
• Reducing pollution concentrations in stormwater, thus protecting the quality of the receiving water body
• Acting as a buffer for accidental spills by preventing direct discharge of high concentrations of contaminants to the receiving water body
• Reducing the volume of surface water runoff discharging to combined sewer systems, thus reducing discharges of polluted water to watercourses via CSO spills
• Contributing to the enhanced amenity and aesthetic value of developed areas
• Providing habitats for wildlife in urban areas and opportunities for biodiversity enhancement.

Sewer Rehabilitation

As was outlined previously in Section 2, sewer rehabilitation was conducted in the pilot project area. This rehabilitation effort was performed prior the construction of any surface improvements (green infrastructure) so as to minimize future disturbances to the green solutions and the neighborhood.

The rehabilitation included lining of approximately 130 linear feet of 8-inch sewer pipe; 5,700 linear feet of 10-inch sewer pipe; 4,275 linear feet of 12-inch sewer pipe; 1,875 linear feet of 15-inch sewer pipe; 1,650 linear feet of 18-inch sewer pipe; 2,025 linear feet of 21-inch sewer pipe; 675 linear feet of 24-inch sewer pipe; 475 linear feet of 27-inch sewer pipe; 475 linear feet of 30-inch sewer pipe; 550 linear feet of 36-inch sewer pipe; and 475 linear feet of 42-inch sewer pipe. The rehabilitation also included approximately 6,100 linear feet of 6-inch/4-inch sanitary sewer service lines; the installation of up to 317 cleanouts on sanitary sewer service laterals; the rehabilitation of 56 existing manholes, including new frames, covers, and grade rings; and 850 vertical linear feet of cementitious liner, with all accessories and appurtenances.

There are at least three direct environmental benefits as a result of the sewer rehabilitation work. First, pipe rehabilitation removes sources
of inflow and infiltration to the system, thereby reducing flow in the pipe and, ultimately, reducing the frequency and volume of overflows. Specific modeling results quantifying the amount of flow removed from the system during wet weather events is not available due to flow meters being removed during this rehabilitation phase and not reinstalled until after construction of green solutions was underway. The second environmental benefit resulting from rehabilitation efforts is the containment of wastewater and other pollutants within the pipe system. Post-rehab flows within the pipe network increased due to an overall improved system prior to the installation of the green infrastructure. The flows are well contained and are conveyed downstream to the appropriate storage or treatment facility. The third environmental benefit is a result of structural repairs made to the sewer system. Structural failures in the system can cause basement backups due to flow constrictions. Restoring the capacity of the sewer network reduces the likelihood of future basement backups.

**Green Infrastructure**

Following construction, the City is conducting routine maintenance and hydraulic monitoring of the green solutions BMPs. The various BMP types and variations will be studied to determine the best approach for the climate and soils conditions in Kansas City once enough data is gathered. Cost effectiveness, constructability, public acceptance, ease of maintenance are all factors that will help the City to select the best approaches going forward and to develop standard details for use on further projects.

**Overall Effectiveness**

URS developed a hydraulic model of the pilot project area using the XPSWMM hydraulic modeling software. In October 2012, URS delivered the XPSWMM hydraulic model and a report “XP-SWMM Hydraulic Model – BMP Impact and Calibration”. Reliable post-construction BMP flow data was not available at the time this model was developed and delivered. Therefore the hydraulic model...
model was calibrated to Darcy’s Law equations using peer-reviewed, published literature values for parameters such as soil mix type, hydraulic conductivity, and soil porosity. Since then, Water Services has undertaken further flow monitoring from April 2013. There were two interim flow and rainfall data submittals; the data through July 8th, 2013 was received on August 13, 2013 and the data through August 13, 2013 was received on August 21, 2013.\(^5\)

The precipitation data used for calibration and verification was developed from rainfall gauge data, and the precipitation data used to examine the overflow characteristics of the basin were previously developed by OCP as design storms A through H. The design storm of interest in the simulations documented in this report is OCP Design Storm D and has a total depth of rainfall of 1.4 inches.

There are seven flow meters providing coverage of the pilot project area and the control area. Four primary meters were utilized to capture flow data for the pilot project area and an associated control area where no improvements were planned under the pilot project. It should be noted that of the four pilot area flow meters, only the flow data for meter UMKC 01 was available at this time. Therefore the hydraulic model was calibrated to the flow for this meter.

After evaluation of the rainfall and flow metering data, it was determined that three storm events were best suited for model calibration and verification. The selected precipitation events were entered into the model and model output was compared to corresponding flow meter output (UMKC 01)\(^5\) for all four storms to determine the correlation between metered and modeled flow rates and volumes. See Appendix A for the calibration and verification hydrographs.

The design storage amount was 372,000 gallons, reduced to the current as-constructed BMP storage volume of approximately 360,000 gallons when three BMPs were not able to be constructed due to conflicts with below ground utilities. The three BMPs represented a storage volume of approximately 12,000 gallons.

Modeling results indicate that there is a reduction in flow after the improvements have been made. The model predicted effective storage volume in the pilot area is approximately 292,000 gallons. This is the runoff that is captured by the BMPs and therefore does not pass through the pilot area outlet. The ratio of as-constructed storage (360,000 gallons) to the reduction of volume passing through the pilot area outlet (292,000 gallons) results in an efficiency ratio of approximately 1.23.

The peak flow from the pilot project area was reduced by 76 percent (12.1 cfs to 2.9 cfs) and the peak volume was reduced by approximately 36 percent (108,600 cf to 69,600 cf). The reduced peak diminishes the flow through the outfall by about 32 percent (45.6 cfs to 30.9 cfs).\(^6\) See a summary in Table 2 below.

Table 2: Comparison of Pre-Existing Conditions and Calibrated BMP Model Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-Existing Conditions Model</th>
<th>Calibrated BMP Model</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak Flow (cfs)</td>
<td>Total Volume (cf)</td>
<td>Peak Flow (cfs)</td>
</tr>
<tr>
<td>Pilot Area Outlet</td>
<td>12.1</td>
<td>108,600</td>
<td>2.9</td>
</tr>
<tr>
<td>CSO 069</td>
<td>45.6</td>
<td>184,000</td>
<td>30.9</td>
</tr>
</tbody>
</table>

\(^5\) There is only one flow meter at the outlet of the pilot area; therefore it is not possible to use the hydraulic model to evaluate the efficacy of individual BMP operation. However, the model can be used to evaluate the aggregate impact of the BMP installations.

\(^6\) Three separate hydraulic models predicted peak flow reductions in the pilot area that were within 0.5 cfs of each other.
The calibrated hydraulic model was used to simulate the existing system for Design Storms A through H. The goal of the analysis was to determine the annualized flow volume reduction at the outlet of the pilot area.

The total annual volume passing through the pilot project area outlet for each class of storm was determined by multiplying the number of storms by the average flow for the storm. This sum is then totaled over all of the design events which occur in the “Design Year”. The Design Year total volume for all of the storms from the pilot project area was found to be over 42 MG. Additionally, the analysis indicates that the annual flow volume passing through the outlet is reduced from about 42 MG to about 35 MG.

Because the pilot project area accounts for 20.4 percent of the area modeled upstream of Outfall 069, this indicates that the volume estimate for placing green storage in the pilot project area was reasonable, given that the goal is proportional to the distribution of storage throughout the basin. It is anticipated that additional BMP installations upstream of Outfall 069 will further reduce the peak flow and volume at Outfall 069.

Additional Flow Rate Analysis

The City is working with the EPA’s Office of Research and Development on monitoring the green solutions. These efforts will be accomplished through a team consisting of MARC, University of Missouri-Kansas City (UMKC), Professor Robert Pitt (University of Alabama), Bergman & Associates, and Tetra Tech. The team, called the Advanced Drainage Concepts (ADC) Team, conducted an inundation test at one of three rain gardens in November 2012. The ADC Team worked with the City to provide two staff members to release water into the rain garden to simulate stormwater runoff. The garden captured the water for nearly an hour, before it overflowed back into the street. Two monitoring devices kept track of flow data within the rain garden itself. After the inundation test was complete, the water drained from the rain garden within 10 minutes. After the rain garden inundation test, water was sprayed from the fire hose onto a nearby porous pavement sidewalk. The water on the sidewalk drained immediately and did not runoff.

FINANCIAL (PROFIT)

The Profit component includes a summary of the cost to implement this particular green infrastructure project. The total cost to implement the pilot project, including the engineering fee to design the project as well as the total construction dollars spent, was approximately $10.4 million. It is important to note that this total cost includes several project components that were not necessarily required as a part of the green infrastructure improvements.
Examples of such additional improvements include the following:

**Complete Sewer Rehabilitation**

The rehabilitation of the entire sewer system within the pilot project was not necessary in order to construct the distributed storage elements. This sewer rehabilitation effort was implemented to improve the efficiency of the system, repair structural defects, address deferred maintenance issues and reduce basement backups. The direct cost of the sewer rehabilitation effort was approximately $175,000 for design and $2,792,094.11 for construction.

**Street Improvements**

The strategic decision to improve the neighborhood streets by constructing curbs, gutters and sidewalks was made early in the design process. This decision was made based upon direct feedback from the area residents and stakeholders. The incorporation of these neighborhood amenities into the design resulted in increases to the project cost. The improved street cross section had an approximate increase of $250,000 for the engineering fee and approximately $960,000 for construction costs. In addition, a majority of the streets within the pilot project area were resurfaced at the end of construction which cost slightly more than $210,000. In total, street improvements accounted for an additional $1,420,000 to the project cost.

Table 3 below provides detailed estimates for the cost of green infrastructure associated with the pilot project.

<table>
<thead>
<tr>
<th>Total Pilot Project Cost</th>
<th>$10,410,311.44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minus Sewer Rehabilitation &amp; Construction Costs</td>
<td>-$2,967,094.11</td>
</tr>
<tr>
<td>Minus Street Improvements Costs</td>
<td>-$1,420,000.00</td>
</tr>
<tr>
<td><strong>Total Green Infrastructure Cost</strong></td>
<td><strong>$6,023,217.29</strong></td>
</tr>
</tbody>
</table>

As previously documented, the constructed storage volume within the pilot project is 360,320 gallons. This results in a cost per constructed gallon of approximately $16.72.
IMPLEMENTATION IN MIDDLE BLUE RIVER BASIN
IMPLEMENTATION IN MIDDLE BLUE RIVER BASIN

Due to the initial success of the pilot project, it is not unreasonable to conclude that expansion of the stormwater BMP concept to the remainder of the Middle Blue River Basin would produce a similar reduction of the peak flow at the Outfalls 069 and 059. When moving forward, Water Services is stressing the importance of applying the “lessons learned” as discussed in Section 3 along with social, environmental and financial impacts discovered throughout the pilot project to the planning and design of future green infrastructure projects.

In order to continue the momentum of the pilot project and to advance toward the Consent Decree deadline for the work in this basin, Water Services has recently formalized contracts with two design professional firms to continue work in the Middle Blue River Basin for the design and installation of green infrastructure. Work has already begun on conceptual designs and final designs are expected in the fall of 2014.

Social impacts through public feedback from the pilot project seemed enthusiastic and supportive of the project. However, there were common threads in the issues and concerns voiced. Residents of the Marlborough neighborhood value off-street parking. Some frustration was voiced because parking had been removed in front of homes in favor of the green storage facilities. Some residents suggested that larger facilities should be utilized, but not located directly in front of homes. It was advocated that this approach will gain more public acceptance if fewer homeowners were personally affected by the facilities.

Full implementation of the pilot project has allowed the City to gain an understanding of the environmental impacts to the watershed. Hydraulic monitoring and modeling within the watershed has proven to decrease volume and flow in the combined sewer system due to the construction of green infrastructure. According to the results of the hydraulic model, green infrastructure BMPs as utilized in the pilot project are a feasible option to effectively reduce runoff volume and peak flows in areas with shallow slopes. The pilot project did not have many areas with slopes steeper than 5 percent, so a conclusive determination of the best ways to manage runoff in differing terrain was unable to be evaluated. The two sub-basins tributary to Outfalls 059 and 069 will provide the City with an opportunity to evaluate a wider variety of terrain and on a larger scale since the terrain and parcel attributes differ from the 100-acre pilot project area. The sub-basins include areas with open spaces which include parks, city-owned green space, medians, boulevards, and undeveloped low lying drainageways, none of which were seen in the pilot project area. In addition, the 644 acres also includes multi-family residential complexes.

Financial evaluations show green infrastructure costs for the pilot project at $16.72 per gallon of storage provided for a total of $6.5 million. A portion of the construction costs were to install new curbs and gutters to increase the stormwater runoff capture efficiency and other ancillary improvements to repair the existing infrastructure throughout the pilot area. For future projects, the City will look at ways to minimize the costs of ancillary improvements and use existing infrastructure to effectively route and capture the runoff therefore reducing the total project costs. The anticipated costs for installation of the remaining green infrastructure projects for both Outfalls 059 and 069 are $16.9 million, which does include minimal repair of pavements, sidewalks, curbs and gutters, and other necessary repairs to existing infrastructure due to the disruption caused by the installation of the proposed BMPs.

It is possible that not all of the various types of BMPs used in the pilot project will be used in future projects. After more data is gathered, specific BMPs may be preferred over others based on performance, construction and maintenance costs, aesthetic appeal or other advantages. One of the defining attributes of the pilot project was that all green infrastructure improvements were constructed within the existing city right-of-way. Most were constructed between the curb and the sidewalk and
The next phases of green infrastructure improvements will include two sub-basins that drain to Outfall 059.
The next phases of green infrastructure improvements will include three sub-basins that drain to Outfall 069.
underground detention was used where insufficient surface storage existed. Even so, the method of distributed storage proved to be sufficient in meeting the required performance of the project. Although the pilot project had no BMPs installed on private property, it is possible that lower construction and maintenance costs would result from larger but fewer BMPs on vacant lots or other public property. Future projects in this or other sewersheds could be used to test the effectiveness and viability of these types of larger BMPs.

When evaluating scale and types of green infrastructure to be used, the individual watershed characteristics have to be considered on a case by case basis. Watershed topography, available existing areas, larger areas of publicly owned property, limiting the number of people affected, and maintenance considerations all play a critical role to developing the correct project approach. When larger areas of open green space and publicly owned properties are available, larger centralized BMPs should be a component of the design; when a highly populated area is being considered for green infrastructure, smaller distributed BMPs would be appropriate.

Because of the differences in watershed characteristics and land use, the conceptual design plans for these areas are deviating from the distributed storage strategies used with the pilot project. The approach for the remaining area has shifted from a significant number of distributed storage sites to fewer centralized storage sites. Within the remaining area, there are ample opportunities to increase the size and reduce the total number of facilities constructed while still accomplishing the storage volume goals required. The approach is to maximize the available open green space to the greatest extent practical and maintain the distributed storage green infrastructure components. The remaining areas also provide an opportunity for private/public partnerships to maintain the ancillary benefits to the area and the transition of vacant or dangerous properties into useful spaces, strategies that were not included in the pilot project.

Understanding how stormwater is conveyed in each sub-basin is critical to the implementation of green infrastructure in the watershed being considered. The following includes details about each of the areas tributary to Outfalls 059 and 069.

**Outfall 059**
The 269-acre sub-basin to Outfall 059 differs significantly from the pilot project area with...
increased slopes and increased open spaces. Much of the approach from the pilot project will not apply to this area. The slopes in this BMP sub-basin have gradients in some areas exceeding 20 percent, much higher than the pilot project area. Significant slopes can limit the capability of linear off-street green infrastructure BMPs, similar to what was installed in the pilot project area. Because of these differences, linear off-street BMPs will probably not be applied to this sub-basin.

Although the upper portion of this sub-basin has limited available open space, the lower portions have several opportunities. Those areas, combined with low-lying areas throughout the sub-basin, will provide cost-effective alternatives capable of detaining large volumes of stormwater runoff. The open areas being designed are already within natural drainage paths. Portions of these green areas are on existing city-owned parcels and others are on private property and will acquire land acquisition. The current approach focuses on open areas and areas currently owned by the City, maximizing these areas and then continuing to distributed storage throughout the watershed as more storage needs are identified.

The approach helped to find the most cost-effective and efficient green infrastructure solutions to meet the storage volume required for Outfall 059. The anticipated costs for Outfall 059 are $6.9 million for the 270 acre drainage area. Green infrastructure costs are estimated to be $6.8 million per constructed gallon of storage provided.

### Outfall 069

The lower portions of the 375-acre sub-basin area to Outfall 069 also differs from the pilot project area with increased slopes and increased open spaces; however the upper portions of the sub-basin are similar to the pilot project. Because of this range, some approaches from the pilot project, such as smaller scale BMPs, will probably be used but a different approach will be used in other areas.

At the bottom of the areas with steep slopes is a natural drainage path, running along an existing easement and parcel line continuing through the local park, Arleta Park. Additional stormwater flow from the surrounding impervious surfaces will be diverted to the low-lying area and routed to Arleta Park for detention. Portions of Arleta Park will likely be converted to BMPs, tying the improvement into the existing function of the park. Another area being implemented in the future phase is a large unmaintained city-owned parcel located downstream of a major boulevard. The medians within the boulevard can be used as open swales to route and decrease flow, before entering into the city-owned parcel. The city-owned parcel will be improved to incorporate green infrastructure.
components and detain large volumes of stormwater runoff, maximizing the available area. Like Outfall 059, the current approach in this sub-basin capitalizes on the available areas currently owned by the City and continues to take advantage of the right-of-way where the topography lends itself to distributed storage.

The anticipated costs for Outfall 069 are $10 million for the 375 remaining acres. The stormwater volume requirements are estimated to be 1.2 million gallons distributed throughout the watershed. Green infrastructure costs are estimated to be $8.30 per constructed gallon of storage provided. The approach of maximizing available open areas helped to find the most cost-effective and efficient green infrastructure solutions to meet the storage volume required for Outfall 069.

**Maintenance Approach**

Changes are also recommended with regard to maintenance in the green infrastructure areas in moving forward. A running list of items continues to be compiled as issues and successes arise which will help ensure that lessons learned will not be forgotten in the implementation of future green infrastructure projects. The items listed below represent the lessons learned from the maintenance

Alternative solutions for how to deal with sediment control will be explored when moving forward.

Management of weeds in permeable paver areas will be explored.

Work will continue on locating improvements away from utilities while also coordinating the work to be complete.

Off-the-shelf curb markers will be used for future projects for their ease of replacement and potential for lower replacement cost.
of the pilot project to date. More will be added as they are encountered.

- If curb extensions are used, the inner radius should be a minimum of ten feet to ensure that street sweepers can clean the entire curb line. The five foot radius used on the pilot project was too small and the street sweeper cannot reach the entire curb line.
- Explore alternatives to the use of concrete sumps with impervious bottoms for pretreatment sediment control. Make sure that forebays and curb inlets with sumps for sediment do not pond water longer than 48 hours. Holes on the sides of the sumps were not sufficient to drain water from the sumps. Concrete forebays with impervious sumps hold water for too long causing odor and the risk of providing mosquito breeding areas. Pretreatment using sod filter strips (only applicable to streets without curbs or with ribbon curbs) are easier to manage.
- Have a plan for how sod filter strips will be mowed. Include it in the service agreement if possible. Residents should be expected to mow them, count on some improvements to be well cared for while others may be ignored; have a plan as to how the ignored ones will be approached.
- Substantial landscape edges matter and they are worth the investment. Use highly visible, durable landscape edge treatments such as concrete ribbons or at minimum use commonly recognizable plants along the BMP edges so that residents or uninformed maintenance companies will not just mow them down. This is especially true in the spring months while the plants are still small and can be difficult for the untrained eye to distinguish them from weeds. Metal landscape edge is effective in the right context but is not generally visible enough to deter overzealous mowers.
- Utilities will have to be repaired from time to time. Pay attention to placing the BMPs away from utilities that may need frequent access, like water lines. Be prepared that some of the BMPs will be damaged by utility repairs and have a plan for how they can be quickly restored.
- Weeds will grow in the spaces between pavers in pervious paver areas. Include management of weeds in paver areas within the service agreement.
- Include two pruning and trimming visits (rather than one) in the service agreement to allow flexibility for reducing plant sizes. 2013 has been a rainy year and many of the plants are bigger and taller than typical. A pruning and trimming larger plants in early summer can help achieve a more compact appearance and is generally not harmful to plants. This will help prevent complaints that plants are too big and blocking visibility later in the summer.
- Check intersection sight lines carefully. As a general rule, keep plants to a maximum height of eighteen inches above top of curb when planted areas are within forty feet of intersections. This will help prevent complaints that plants are too big and blocking intersection visibility.
- Seek resident input on curb markers and plan for replacement needs. The curb markers can have a significant impact on the look of the project, which impacts residents. The curb markers will be hit by cars and they will need to be repaired or replaced. Off-the-shelf products are recommended for ease of replacement and potential for lower replacement cost.
- Many of the porous sidewalks installed adjacent to driveways were broken from vehicles using the driveways and had to be replaced. On future projects it is recommended that a short section of standard strength non-porous sidewalks be used on both sides of driveways.
FUTURE IMPLEMENTATION THROUGHOUT COMBINED SEWER SYSTEM
FUTURE IMPLEMENTATION THROUGHOUT COMBINED SEWER SYSTEM

Not unlike the approach for the remainder of the Middle Blue River Basin, Water Services will continue to look for additional opportunities for green infrastructure to meet requirements as outlined in the Consent Decree. Water Services will continue to stress the importance of applying the “lessons learned” as discussed in Section 3 along with social, environmental and financial impacts discovered throughout the pilot project to the planning and design of future green infrastructure projects. Water Services is currently looking at additional locations outside of the Middle Blue River Basin where green infrastructure may be cost effective in replacing grey infrastructure improvements.

It is possible that not all of the various types of BMPs used in the pilot project and Middle Blue River Basin will be used in future Overflow Control Program projects. After more data is gathered and studies are conducted, specific BMPs may be preferred over others based on performance, construction and maintenance costs, aesthetic appeal or other advantages. When evaluating scale and types of green infrastructure to be used, the individual watershed characteristics have to be considered on a case by case basis.
Calibration Rainfall Event 4/9/2013
Calibration Rainfall Event 5/29/2013
Calibration Rainfall Event 6/15/2013
Pre-existing and Post-BMP Calibration Flow – Pilot Area Outlet
Pre-existing and Post-BMP Calibration Flow – CSO 069