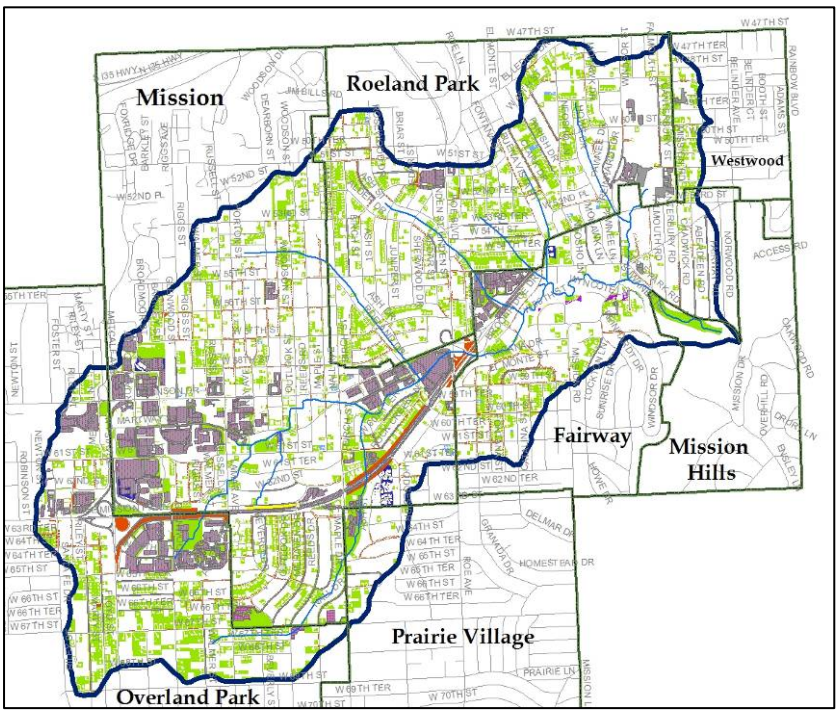
Rock Creek Watershed Planning
Final Feasibility Report



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Common Abbreviations

APWA	American Public Works Association
BMP	Best Management Practice
CCSM	Channel Condition Scoring Matrix
CWP	Center for Watershed Protection
EPA	Environmental Protection Agency
GIS	Geographical Information System
HEC-RAS	Hydrologic Engineering Center's River Analysis System
KCAPWA	Kansas City American Public Works Association
KDHE	Kansas Department of Health and Environment
MARC	Mid America Regional Council
NRCS	Natural Resources Conservation Service
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQV	Water Quality Volume
WRAPS	Watershed Restoration and Protection Strategy

Executive Summary

The Rock Creek Watershed extends through a highly urbanized portion of the northeastern corner of Johnson County, Kansas with area extending into the cities of Mission, Roeland Park, Fairway, Prairie Village, Mission Hills, Westwood, and Overland Park. Existing flood control infrastructure in the watershed is aging and experiencing degradation. Impervious space associated with existing development has negatively impacted water quality. Redevelopment opportunities necessitate the evaluation and implementation of projects with the goal of flood mitigation, reducing stormwater runoff and improving water quality through stream restoration and the emerging technologies of best management practices (BMPs). To address smaller flooding events and water quality issues, stream restoration projects and best management practices are separated into two components in this report. These practices should be integrated in stormwater management and future flood control projects. Both practices impact water quality, habitat, and recreation. Stream restoration projects and best management practices create amenities for communities in the watershed, connecting citizens to their environment.

This report includes the stream assessment methodology and results, recommended stream restoration projects, a presentation of BMP concepts, an implementation strategy for best management practices throughout the watershed and probable costs associated with these projects. The stream network was evaluated in two phases: initially, a geomorphologic stream assessment that determined channel stability and secondly, a habitat assessment to determine availability and quality. A BMP implementation strategy was developed using probable life cycle costs, evaluation of water quality benefit, and a methodology to locate BMPs in appropriate sites.

The stability of all streams in the Rock Creek watershed was evaluated using the Kansas City Metropolitan Chapter of American Public Works Association (KCAPWA) Channel Condition Scoring Matrix (CCSM). This matrix is located in

Appendix A-1. The CCSM rating ranged from 15.4 – 31.2, representing stream conditions between poor stability and significant system wide instability. In general, the CCSM rating reflected lack of sinuosity, pool-riffle structure, steep bank slopes and lack of vegetative protection. Most reaches scored poorly on these indicators. The habitat assessment was developed based on USDA stream types and the City of Lenexa Stream Assessment and Natural Resource Inventory Project methodology (Appendix A-2). The habitat availability and quality varied throughout the watershed. Generally, water quality and aquatic habitat were enhanced by pool-riffle structure, availability of consistent flow, vegetative cover, and a well-graded substrate.

A BMP locating methodology was applied to the Rock Creek watershed and identified many opportunities. Potential sites for dry ponds, infiltration, filtering practices, open swales and permeable paving were identified throughout the watershed. These sites were prioritized based on life cycle cost and water quality benefit in order to develop the recommended implementation strategy. Life cycle cost was calculated using a model published by the Water Environment Research Foundation. Water quality benefit was developed with data provided by the EPA and Center for Watershed Protection.

The recently published USGS report on the Blue River Basin addresses the water quality issues in the Rock Creek Watershed, a tributary of the Brush Creek and ultimately, the Blue River Basin. The USGS report summarizes water-quality data collected from 1998 to 2004, including measurements of stream discharge, physical properties, nutrients, organic wastewater and pharmaceutical compounds, and fecal-indicator bacteria (Wilkinson et al., 2006). Benthic macro-invertebrates were measured to assess the chemical, bacteriological, and biological conditions in the stream systems. The Rock Creek Watershed Study will provide additional water quality data to the current basin studies. It will also contribute to the development of predicting BMP efficiencies in an urban Midwestern watershed. The water quality monitoring plan is presented in this report.

This report and the accompanying geodatabase are intended for use by city planners and staff making key decisions about stormwater management. The report highlights opportunities for inter-jurisdictional projects and demonstrates the stream restoration and BMP projects that will have the largest benefit for associated cost. While the report provides a foundation for communities to begin the process of implementing sound concepts, the geodatabase may be an evolving tool, housed at Johnson County. The database can be updated as necessary when more specific sites are evaluated or as plans in the watershed change. As communities move forward toward educating city councils, commissions, and involving the public, we recommend continued communication between the municipalities within the watershed. Public demonstration projects with high visibility can represent the success of these stormwater management practices.

Introduction

The Rock Creek Watershed extends through a highly urbanized portion of the northeastern corner of Johnson County, Kansas with area extending into the Cities of Mission, Roeland Park, Fairway, Prairie Village, Mission Hills, Westwood, and Overland Park. This project exemplifies a watershed-based approach and cooperation of regional stakeholders. Existing flood control infrastructure in the watershed is aging and experiencing degradation. Impervious space associated with existing development has negatively impacted water quality. Simultaneously, the watershed is beginning to experience areas of redevelopment. These redevelopment opportunities necessitate the evaluation and implementation of projects with the goal of reducing stormwater runoff and improving water quality through stream restoration, policy change, and the emerging technologies of best management practices (BMPs). This approach includes structural and non-structural strategies which include alterations to stream structure, vegetative practices, land use, and public education regarding water resource management practices. The Rock Creek Watershed Feasibility Study provides the foundation for implementation of programs to improve water quality, reduce stormwater runoff, restore habitat, and restore stream stability. The study complements the Brush Creek Feasibility Study that is currently being completed.

This report presents the methodology, results, and an implementation strategy developed during the Feasibility Study. The study identified locations and methods to reduce flood damage, improve water quality, and enhance habitat through conceptual stream recommendations and best management practices (BMP). The Stream Assessment is comprised of geomorphic and habitat assessments of existing conditions. Results from these assessments were associated with restoration costs to develop a prioritized project list. The BMP Implementation strategy outlines appropriate BMP solutions for the Rock Creek watershed, identifies prime locations, provides a priority ranking with each solution, and highlights BMP solutions throughout the watershed. A Water

Quality Monitoring Plan, provided at the end of the report, outlines data collection, analysis, and reporting that will be completed by Kansas State University.

Stream Assessment

Current conditions of the Rock Creek stream network are indicative of the highly urbanized surroundings. Exposed sanitary sewer crossings, eroding stream banks, failing stream channel walls, and lack of habitat are the results of increased quantity and velocity, and compromised quality of surface runoff in the Rock Creek watershed. Assessment results, including both stream stability and habitat components, may assist the development of stormwater masterplans within the watershed. The proposed improvements are aimed to improve channel conditions, increase habitat availability, and to mitigate any future degradation of the stream network.

Evaluation and Conceptual Design Criteria

The conceptual design of recommended improvements, based on hydraulic and fluvial geomorphology principles, is an approach to improve channel stability, provide habitat, and enhance water quality. The proposed stream stabilization and water quality improvements were developed without alteration of the current floodplain bounds, based on flows from the Northeast Johnson County Watershed Study (2005). The floodplain constraints will be specific to each project and must be accounted for during final design of improvements. The final design should also incorporate pool, riffle, and run dimensions.

Channel Stability and Fluvial Geomorphology

The definition of a stable channel depends on whether the channel boundaries are considered rigid (static) or movable (dynamic). The stability of a rigid channel is achieved when the material forming the channel boundary effectively resists the erosive forces of flow. Stability of a dynamic channel is more difficult to define. In this case, a channel is considered stable if changes are within

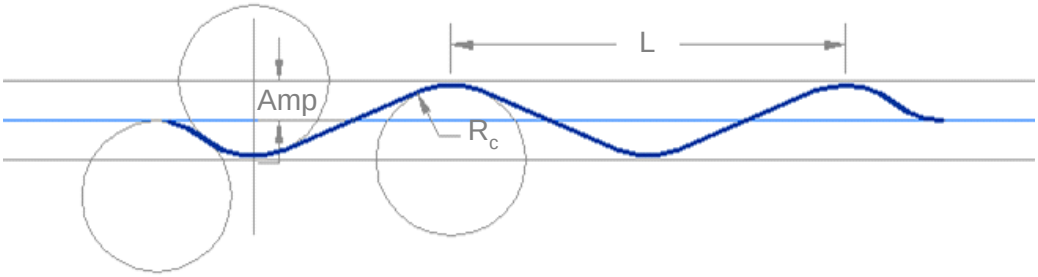
"acceptable" levels. In general, such stability is attained when the sediment supply rate equals the sediment transport rate.

In the urban/suburban context, the acceptable levels of change are constrained by rights-of-way and existing or proposed infrastructure. In many cases possible lateral migration and bank instability cannot be tolerated. Therefore, as stated by the Federal Highway Administration (Chen and Cotton, 1988), development of static equilibrium conditions is preferable in urban and suburban areas. Under static equilibrium conditions a stable channel will have a rigid boundary that effectively resists the erosive forces of flow while avoiding sedimentation of particles that are transported from an upstream source to the channel of interest.

Recent regulatory trends encourage land use changes and stream modifications that do not adversely impact downstream or upstream stability and environmental conditions. To mitigate the impact on the overall stream stability, it has been proposed that channel designs and stream modifications should mimic natural channels. Under this new paradigm, there is a preference for meandering channels that include pools and riffles instead of using constant-slope straight channels. In principle, this approach reduces flow velocities and shear stress in the designed or modified channel, increasing stability. Reduction of flow velocities and shear stress allows the use of flexible lining (riprap, vegetation, etc.) as opposed to rigid linings (concrete, soil cement, gabions, etc.). Flexible linings are generally less expensive, allow infiltration, provide habitat, and have an aesthetic value with their natural appearance.

Philip J. Soar and Colin R. Thorne (2001), provide a framework for designing stable channels for river restoration. The underlying assumptions behind this framework are that (1) the dimensions of stable natural channels are proportionally related to the discharge, and (2) the dimensions of the channel are inter-correlated. Based on extensive literature review and research, Soar and Thorne calculated average proportionality relations between discharge and channel dimensions for typical stable natural channels. These average

relationships provide a set of guidelines that serve as a basis for dimensioning a stable channel. The following is a summary of guidelines as suggested by Soar and Thorne:



a. Design of main channel is based on bank full discharge (Q_b).
b. Soar and Thorne (2001) indicate that the 2-year flood (Q_2) is an approximate upper boundary to bank full discharge. Preliminary studies in Kansas indicate that, for local urban areas, the 1-yr flood (Q_1) may be a better estimate of bank full discharge.
c. Channel width: $w = a Q_b^{0.5}$ where Q_b = bank full discharge in cfs and a = 2.03 (90% confidence: a = 1.12 to 3.69; lower values of "a" are associated with resistant banks as opposed to erodible banks). For the evaluation and conceptual design for Rock Creek and its tributaries, the lower end of the confidence interval was selected (a = 1.12) assuming stable banks and considering rights-of-way and existing infrastructure constraints. Larger widths, within the 90% confidence range, would also be acceptable.
d. Wave length: $L \cong 12w$ and/or pool-riffle spacing $L_{p-r} \cong 6w$
e. Radius of curvature: $R_c = c_{rc} w$ where $c_{rc} \cong 2.4$ (absolute minimum: $c_{rc} = 2$).
f. For the Rock Creek stream network, amplitude was set to obtain a sinuosity between 1.2 and 1.4. The amplitude may also be set based on sediment transport requirements and rights-of-way limitations.

Riparian Conditions and Water Quality

The stream restoration approach by Soar and Thorne (2001) mimics conditions typically present in natural channels. The meandering pattern, the pool-riffle sequence, wider stream channel and a flexible stream bed structure (rock and gravel) intrinsically have a positive impact on the habitat function of a healthy stream.

A riparian buffer zone is integral in stream restoration projects. This area incorporates appropriate native vegetation along the banks and would enhance the habitat function of the riparian corridor, improve bank stability and improve water quality. Riparian buffer zones help to reduce the amount of excess nutrients (i.e. nitrogen and phosphorus typically present in lawn fertilizer) and other pollutants. The Natural Resources Conservation Service (NRCS) recommends a total buffer zone width of 200 ft with a minimum of 25 ft for the streamside buffer zone. The implementation of these recommendations is unrealistic for the Rock Creek watershed due to rights-of-way and existing infrastructure limitations. The municipalities within the watershed, however, should encourage the creation of riparian buffer zones even if their size is smaller than optimal.

Geomorphologic Stream Assessment Methodology

The geomorphic stream assessment method utilized field and mapping data to assess stream conditions. High resolution aerial photographs and tight contours were used to determine the total meander, valley length and sinuosity of the flow path. The field assessment was integral to determine the current characteristics and structure of the stream.

Black & Veatch completed a geomorphologic stream assessment of the Rock Creek Watershed using the Channel Condition Scoring Matrix (CCSM) as defined in the 2005 Kansas City Metropolitan Area Chapter of APWA Standard Specification and Design Criteria Section 5605 guidelines (Table 5605-2, see Appendix A-1). The CCSM includes indices that evaluate the channel geometry, bank slope stability, streambed and bank material composition, and unstable conditions. Channel geometry indicators compare the stream plan and profile to ideal conditions of stable channels based on fluvial geomorphology theory. These indicators include evaluation of the sinuosity, ratio of curvature, and pool-riffle spacing. Streambed and bed material composition were evaluated based on soil texture, sediment composition, consolidation, armoring materials, and vegetative protection. Evidence of unstable conditions included bank cutting, mass wasting, bar development, scour and excessive sediment deposition in localized areas. The Rock Creek Watershed is situated in an urban, developed area; therefore, additional analysis on wall and armoring conditions was necessary.

The field data was collected using a customized form for ArcPad on a handheld PDA device. Geographic coordinates were obtained using a GPS unit connected to the PDA device. This form allowed the field entry of a set of parameters associated with each of the stability indicators. These parameters were used as an aid to rate each one of the indicators on the CCSM. However, in some cases the individual parameters were not measured or recorded and the score for an indicator was selected qualitatively based on observation and professional judgment. For each channel section, both the score of the indicator and the

weighted rating were stored in a GIS database. Reaches were defined based on points of confluence and the average results of sections within a reach were associated with the reach.

Geomorphologic Stream Assessment Observations

The Rock Creek stream network varies in condition and represents a fully developed watershed with a mix of natural streambank and manmade stabilization features. In general, there is very little floodplain or riparian corridor along most of the reaches. All stream reaches show evidence of degradation resulting from increased quantity and velocity of stormwater runoff.

The Cities of Overland Park and Mission have routed the majority of drainage tributaries through underground conveyance. Several stormwater projects are underway in the City of Roeland Park where infrastructure capacity is limited and existing natural channels show signs of degradation. Nearly all stream reaches in the City of Mission have been stabilized with various engineered structures. The Cities of Fairway and Mission Hills have completed fewer stabilization projects, preserving a more natural main channel with evidence of degradation. There are key problematic areas of sheer banks, mass wasting, and bar development along wide bends of the main channel. Degradation of existing infrastructure can be attributed to increased erosion and localized scour. The majority of the Rock Creek stream network lacks a riparian corridor however both the Cities of Roeland Park and Fairway have developed corridor parks.

The majority of stream channels are restricted and relatively straight compared to more natural, sinuous streams. In some areas, where the stream is transitioning between engineered and natural structure, the channel widens and meanders as it tries to achieve a stable form (stream bending). Steep bank slopes are consistent throughout the watershed and many have been armored with retaining walls of various construction, age and structural stability.

Some reaches of the main stem and all of the upper drainage ways are routed through pipes.

Natural occurrence of bedrock conditions and the extensive use of walls, engineered channels and bank stabilization methods have prevented excessive bank cutting and mass wasting conditions. One of the most stable sections of natural stream was found in Fairway where the stream had stabilized due to a limestone outcropping that is supporting the channel and banks. Grouted stone walls, keystone walls, and concrete channels were found to be in various conditions. These channels may become unstable over time as the materials are eroded by the abrasive action of high velocity flows. Reaches with manmade stabilization structures were not given a particularly high rating because they require maintenance and do not enhance water quality or habitat. Once the concrete lining begins to deteriorate, streambed degradation can progress at a rapid pace and wall foundations can be compromised. Without the concrete and walls, the stream will become extremely unstable. Channels with newer walls are in good condition. Some older stabilized channels show signs of periodic repair but most have not been maintained. There are locations where some walls have collapsed due to channel degradation or poor construction.

Generally, instabilities are the result of upstream development, points of channel transition, or pipe outlets that have not been stabilized. In areas where water is conveyed through existing or planned underground pipe infrastructure, the ability of the channel to function for habitat or water quality has disappeared. Efforts should be made to detain water in the upper reaches of the watershed before it enters the storm drainage system and also to dissipate energy at outlets of pipe conveyance in order to reduce the downstream impact. The absence of pristine, natural channels is a result of the urban stream corridor and existing land use throughout the watershed.

Geomorphologic Stream Assessment Results

The field assessment includes the main channel and tributaries within the watershed. The APWA CCSM rating ranged from 15.4 to 31.2, representing stream conditions varying between poor stability and significant system wide instability. With the CCSM system, a rating of 12 indicates a stream of moderate stability. A rating between 12 and 18 indicates that special measures may be necessary to address issues noted in the assessment. Streams with a rating greater than 18 should be studied in further detail to determine recommendations; they may exhibit significant system-wide instability. In general, the CCSM rating reflected lack of sinuosity, undefined pool-riffle structure, steep bank slopes and lack of vegetative protection. Most reaches scored poor on these indicators. The map in Appendix B-1 presents the CCSM rating for each reach.

Rapid Habitat Assessment Methodology

The second part of the stream assessment was completed using the 2001 City of Lenexa's Stream Assessment and Natural Resource Inventory Project methodology as a guide. This field assessment process was developed for the Kansas City region and applied by Patti Banks Associates to complete an evaluation of stream conditions for the downstream City of Mission Hills. The process, based on USDA scoring methods, includes characterization of stream banks and channel beds, characterization of erosion and sedimentation, stream flow rate, identification of overstory and understory vegetation, and identification and classification of aquatic invertebrates as water quality indicators. The different types of streams are defined as follows:

> **Type 1 -** Generally described as the highest quality naturally occurring stream with little negative impact. Erosion and sedimentation is low,

water quality indicators are positive and the surrounding riparian zone is a healthy, mature, succession woodland or other high-quality environment.

Type 2 - This type of high quality stream may have some down- or side-cutting, however, bank and bed composition (bedrock) assist in keeping the impact low. Water quality is generally good and the riparian zone is largely intact, although vegetation may be altered from that of a typical native plant association.

Type 3 - The riparian corridor is still restorable although deterioration is much more noticeable. While some remnant plant associations may be present, overall vegetative canopy cover is comprised of immature tree species. The potential for restoration exists although erosion and sedimentation can be greater than desirable.

Type 4 - Impacts are greater on this low quality stream type with significant indicators of bank erosion and sedimentation present. The adjoining riparian corridor may be intact but vegetation is not representative of a native plant association.

Type 5 - The channel in this type is the most changed and of the lowest quality. The riparian corridor is impaired to the point of providing little protection or benefit, and erosion and sedimentation indicators are significant. Water quality is questionable with noticeable phosphate and nitrate loading (large algae blooms).

In the Rock Creek watershed, this scoring system was adjusted to reflect existing conditions and properly assess habitat quality and availability. The Habitat Assessment Scoring Matrix, located in Appendix A-2, develops the USDA description with the addition of four specific categories: stability, aquatic habitat, terrestrial habitat and water quality. In the Rock Creek watershed where several stream sections have been routed underground or into concrete channels, additional assumptions were necessary. It should be noted that stability ratings

for concrete and underground channels were assumed to be Type 2 due to the temporary stability that these structures provide.

The stream geomorphologic assessment included a thorough characterization of bank and bed condition, erosion, and sedimentation patterns. These factors affect the physical stability of the stream network. Hydrology, vegetative habitat, and aquatic habitat all impact the availability of riparian habitat. Stream flow rates for the 2 and 100 year events were evaluated based on the Northeast Johnson County Hydrology study (2005).

The second stream reconnaissance included evaluation of the overstory and understory vegetation at representative locations, as well as kicknet sampling of benthic macroinvertebrates as indicators of water quality. The macroinvertebrate sampling was guided by the Missouri Stream Team methodology. These assessments of stability and habitat availability were combined to determine the overall health of the stream and future restoration opportunities within the watershed.

The stream evaluation factors described above were given numeric scores on a scale of one (1) to five (5), ranging from good to poor conditions. One fourth of the habitat score was developed using the CCSM scores to reflect channel and bank stability. The other three fourths were comprised of aquatic habitat, terrestrial habitat and water quality scores, all equally weighted to create the final score. The Habitat Assessment Scoring Matrix, Appendix A-2, provides detailed description for each category and its ranking based on the Kansas Wildlife & Parks Subjective Evaluation of Aquatic and Terrestrial Habitats (2004). The overall habitat score for each project was averaged with the stream geomorphogical assessment score to produce a final ranking. This score served as the "benefit" in a cost benefit ratio analysis to prioritize the list of projects.

Habitat Assessment Observations

Observations of bank and channel stability were taken during the stream geomorphic assessment. Aquatic habitat, terrestrial habitat, and water quality observations were taken in a second stream reconnaissance at representative points within the watershed.

Aquatic Habitat

Aquatic habitat was evaluated by characterizing the stream flow, channel substrate, macro-habitat types, and available in-stream fish cover. Aquatic habitat quality and type varied according to channel structure and substrate present. Concrete lined channels with little substrate variation do not provide habitat structure for fish or aquatic invertebrates. Channel areas that have variable structure in the form of boulders, cobble, gravel, or vegetation generally have a mix of pools, riffles, and runs that are critical to the habitat component of a healthy stream. The movement of large structural materials is indicative of high flow volumes and velocities. Frequent high flows greatly impact aquatic habitat by moving habitat structure. Aquatic habitat is also affected by the removal of natural debris for aesthetic or flood mitigation purposes.

Figure 1: City of Mission Reach 77 Looking Downstream

The highest quality aquatic habitat was found along the main channel of Rock Creek and in some tributaries. Example reaches include 4, 46, 95, and 117, represented in the Appendix B-2 map. This is likely due to the length of each reach, the relatively natural state, and the variety of macro-habitat types available including pools and riffle areas. The lowest aquatic scores are associated with concrete and grouted stone walls where habitat structure is virtually nonexistent. Reach 77, located along the Birch Creek tributary, is an example.

Terrestrial Habitat

Terrestrial habitat is rated based on its type, diversity, and condition. The overstory layer consists of a variety of tree species and the understory layer refers to shrubs, vines and/or herbaceous plants. The presence of invasive vegetation negatively impacts the overall health of the riparian corridor as these species compete with desirable native plants. There is a wide variety of terrestrial habitat adjacent to streams in the Rock Creek watershed. In most residential areas, a thin corridor of trees, shrubs and herbaceous material has been preserved. In other residential areas, this structural support has been replaced by turf grass.

Figure 2: City of Fairway Reach 32 Looking Upstream

Some commercial and business districts have constructed parking lots up to the banks of the stream network. Native plant species have not been able to compete with the introduction of winter creeper euonymus (*euonymus fortunei*), english ivy (*hedera helix*), and shrub honeysuckle (*lonicera tatarica*). These invasive plants, commonly used in residential landscaping, have spread to cover much of the bank and provide little erosion protection. The highest quality terrestrial habitat was found in reach 80 where the corridor widened with numerous trees and shrubs. Reach 32 along the main channel in Fairway provides an example of this wide corridor (Appendix B-3 map). The lowest quality was adjacent to reaches 140–147, an area representative of the proximate parking areas and the absence of stream corridor.

Water Quality

Sediment, runoff pollutants, and trash impact the type and diversity of aquatic life present within the stream. Groupings of benthic macroinvertebrates were used to determine water quality conditions. The presence of fish and amphibians also served to indicate moderate to good water quality. Excessive sediment deposition, trash, or the presence of oils and grease were noted during the field assessment. The presence of benthic macroinvertebrates was evaluated at representative locations for each reach in late April. Stream insects and crustaceans were separated by three groups that indicate water quality.

Figure 3: Benthic Macroinvertebrate Sampling

Group one taxa are pollution sensitive organisms found in good quality water including the stonefly, caddisfly, water penny, mayfly, and gilled snail. Group two taxa are somewhat pollution tolerant and can be found in water of good to fair quality. These include crayfish, sowbugs, scuds, damselfly, dragonfly and many larvae. Group three taxa are pollution tolerant and can be present in any quality of water. This group is comprised of worms, blackfly larva, leeches, and snails. The variety of substrate material influenced the habitat availability. Stream reaches lined with concrete were devoid of indicator organisms. The highest water quality was established in Reach 80 with the presence of mayfly. In areas with a higher percentage of silts and clays, crayfish were present. Sowbugs were prolific in areas with stream cover and algae blooms. Aquatic worms were present at most sites when sufficient water was available. In the downstream reaches of the main channel, damselfly nymphs were present. Overall, indicator organisms were present in the more natural reaches when sufficient, consistent flow was available.

Habitat Assessment Results

These observations and corresponding field data were scored within an Excel spreadsheet, yielding the following general trends. The cumulative score for each reach was then weighted and combined with the geomorphic assessment score to generate a final ranking. These scores are representative of existing conditions within the Rock Creek watershed. Appendix B-1 through B-4 maps represent habitat component scores. Appendix B-5 includes a complete stream asset inventory with the individual scores of each reach.

Summary of Habitat Assessment Results – General Trends

Reach Type	Stability	Aquatic Habitat	Terrestrial Habitat	Water Quality
Swale	3	4	3	1-4
Natural	3-4	2-3	2-3	1-3
Other/Restored	1-4	2-3	4	3
Gabion Baskets	2	3	3	3-4
Concrete/ Keystone	2	4	3-4	4
Underground	2	5	5	5

Stream Restoration and Proposed Improvements

There is an opportunity to restore all tributaries in the Rock Creek watershed, as well as sections of the main stem. Reaches were grouped into appropriate project sections. These restoration projects were ranked based on the APWA CCSM score, rapid habitat assessment score, project length and probable cost of the recommended restoration.

The Soar & Thorne 2001 guidelines were applied to design a conceptual bankfull stable cross section for each project. This method emphasizes the natural meander pattern of streams and uses the channel forming flow. Meanders are an important component of stream stability and habitat quality because they increase the travel time of flow through a stream, provide greater stream distance for the integration of pools, riffles and runs. Stabilization also decreases the stream's impact on an urban environment, securing vegetation that benefits habitat and water quality, and protecting the stream from higher events while maintaining the structure of the channel forming flow.

The conceptual recommendations, provided in Appendix C-2, were developed to provide conceptual designs and an opinion of probable cost for stream improvement projects. These designs represent the possibility of incorporating meanders, stream buffers, and habitat within the urban environment of the Rock Creek watershed. Given the constraints of a developed floodplain and increased flow due to development of the watershed, the Rock Creek stream network experiences high velocities during frequent storm events. Where possible, design plans should strive to reconnect the channel with its floodplain with the use of corridor parks and riparian corridors. Future design considerations should incorporate stabilization of the main channel that can resist shear stresses generated by storms up to the 100-year event. Vegetation may provide stabilization for smaller, select storm events but an underlying foundation of rock may be necessary to withstand velocities produced by larger storm events in the Rock Creek watershed.

A design approach that incorporates the methodologies and procedures by Rosgen (1996), Soar and Thorne (2001), Leopold (1994), U.S. Army Corps of Engineers (USACE, 1994) and the Federal Highway Administration (Chen and Cotton, 1988) is recommended. Rosgen provides guidelines for selecting a stream type that will be naturally stable with given site conditions. The literature review completed by Soar and Thorne in 2001 helps to define the ranges of relationships that describe geometry of natural streams. The conceptual improvements included in Appendix C-2 are developed using parameters that have large deviations from the mean in natural streams, producing a range of possible dimensions. These conceptual cross sections and meanders provide baseline geometry and a profile will need to be further developed to differentiate pools and riffles. Site specific topographic conditions should be combined with recommendations from the Rosgen (1996) classification analysis to provide further guidance on the baseline geometry and sinuosity. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) model can be used to obtain detailed stream hydraulic information that is essential to evaluate the stability of stream improvements at a variety of flow conditions.

Where high velocities contribute to erosion, low velocities allow possible sediment accumulation in the stream bed. Permissible velocity and shear stresses should be determined to reduce the erosive potential of flowing water. Chen and Cotton (1988) demonstrate that the shear stress method is preferable as it evaluates the expected channel shear stress to permissible shear stress of the lining material. Shear stresses should be evaluated for the channel bottom, banks as well as channel bends. Providing pools and riffles with appropriate spacing can reduce shear stresses and decrease the need for resistive materials. Basic hydraulic and sediment transport principles as well as geotechnical classification of soil and rock characteristics and vegetation recommendations should be incorporated into the final design.

Some general concepts should be taken into consideration with future construction work in or around any stream reaches in the watershed. While this report does not include recommendations for infrastructure, such as bridge or culvert sizing and conveyance, it is important to incorporate geomorphology principles in design. Such principles influence placement, structure, and level of hydraulic modeling applied to the project.

An opinion of probable cost was generated for both ideal and limited restorations of each stream project using the following unit costs. Ideal restorations included meanders, proper stabilization, walls when necessary and a dense planting of vegetation. Limited restorations included proper stabilization, walls when necessary and a less dense planting of vegetation.

Unit Costs

Item	Unit Cost	Unit
Regrade banks	$150	LF
Vegetation Ideal	$50	LF
Vegetation Limited	$10	LF
Cut	$10	CY
Riprap	$80	CY
Build wall (4')	$250	LF
Remove wall (4')	$50	LF
Remove channel	$100	CY

Land acquisition costs are provided for the ideal restoration projects as the additional meanders could extend into privately owned land. Land values were obtained from Johnson County. Dependent on the extent of stream construction, either a portion of the parcel or the entire parcel was accounted. The opinion of probable cost for ideal restoration is also provided without land costs. Other municipalities in the region have demonstrated implementation strategies that vary from purchase of a stream corridor to cost-share programs with the land owner. A complete list with projects described in detail is in Appendix C-2. These projects can be located on the Appendix C-1 map.

BMP Site Identification

Best management practices (BMP) are an emerging technology serving to decentralize some aspects of stormwater management while improving water quality and enhancing habitat. BMP solutions are a key component to watershed management because they can benefit water quality and potentially mitigate flooding damage. These practices include both structural and non-structural solutions, maintenance procedures, and other management practices. The nature of the Rock Creek watershed limits the size and type of applicable BMP and therefore may limit BMP flood damage mitigation to select, smaller events. The integration of BMPs into management of the Rock Creek watershed can substantially benefit water quality, habitat, and provide opportunities for public education regarding water resource issues. The following chapter presents selected BMP concepts, the site identification procedure, and an implementation strategy of recommended BMP solutions for the Rock Creek watershed.

Non Structural BMP Concepts

Non-structural BMPs prevent pollution through education, management, and planning procedures. They serve to limit the amount of pollutants available and typically lessen the need for more costly structural solutions. Ordinances and practices associated with land use and comprehensive site planning will be integral to the non structural options for the Rock Creek watershed.

Municipalities within the Rock Creek watershed have the opportunity to coordinate with several regional community education programs. The "10,000 Rain Garden" initiative was developed to address stakeholder concerns with a lack of green solutions to local flooding and runoff issues. This comprehensive public education endeavor is an example of actively engaging the Kansas City community. Another local program, "Grow Native!" is a joint endeavor of the Missouri Department of Conservation and the Missouri Department of Agriculture. This program aims to increase conservation awareness of native

plants and their effective use. These programs as well as local institutions, such as the Mid-America Regional Council (MARC), can serve as indispensable resources for future Rock Creek watershed education.

Minimal management and site planning recommendations are outlined within the Kansas City APWA/MARC Manual for Best Management Practices for Stormwater Quality (2003). Regional municipalities have adopted sediment and erosion control programs to preserve soil and its capacity for infiltration. The manual recommends that impervious surfaces be minimized, disturbance of a native soil profile be minimized, and vegetation be selected to maximize infiltration capacity. Downspouts and sump pumps that flow onto pavement or are piped into stormwater inlets should be redesigned to flow over pervious space or through a structural BMP. Land uses that contribute higher concentrations of pollutants should be required to adopt industry-specific BMPs.

Other management practices can be separated into three categories: upland cover, stream buffers, and floodplains. Each of these zones is integral to a healthy watershed. Undisturbed or restored uplands help reduce erosion both by covering soil and by slowing velocities of runoff. These areas reduce off-site runoff by allowing for infiltration. Sediments and other pollutants associated with stormwater are filtered. These areas typically have lower maintenance costs and may increase adjacent property values. Stream buffers create the natural corridor vegetation of a channel and generally consist of herbaceous and woody vegetation. APWA Section 5603.3 recommends stream buffers for all drainage areas greater than 40 acres, encouraging cities to adopt comprehensive stream preservation and buffer zone requirements as part of their master plan (KCAPWA, 2005). Bottomlands and floodplains are the third area to consider at the watershed scale. In the Rock Creek watershed, much of the floodplain has been developed. As these areas are redeveloped, it is important to consider the function and value of bottomlands as desirable habitat and recreational area.

Structural Treatment BMP Concepts

Structural BMP solutions for the Rock Creek watershed were selected using criteria established by the EPA (2002), Center for Watershed Protection (SMRC, 2007) and the KCAPWA Draft BMP Manual (2007). They include the following conceptual practices.

Dry Detention

Extended dry detention basins are designed to detain the stormwater runoff from a water quality design storm for 40 or more hours but do not maintain a permanent pool between storm events. A longer detention time allows for more particles and associated pollutants to settle. In some cases, dry detention basins develop wetland vegetation. This best management practice reduces the peak stormwater runoff rates and peak stages, thus potentially providing flood control benefits for select events.

Wet Extended Detention and Wetlands

Extended wet detention basins and wetlands collect stormwater runoff in a permanent pool. They facilitate settling as runoff collects in the pool as well as pollutant uptake through biological and chemical activity. Wet detention basins differ from wetlands primarily in having a greater average depth. This BMP option can be effective in enhancing water quality, flood and erosion protection, wildlife and aquatic habitats. It can also integrate community education, recreation and aesthetic benefits.

Bioretention and Infiltration

Filtering practices include many options at different scales using the same theory: runoff is filtered and infiltrated through the natural chemical, biological, and physical properties of plants, microbes, and soils. Bioretention basins are typically installed to infiltrate and treat surface water runoff from parking lots.

Pollutants are removed by natural processes including adsorption, filtration, volatilization, ion exchange and decomposition. An underdrain system can be installed to collect and discharge drainage to the storm sewer system or directly to receiving waters. Figure 4 demonstrates a bioretention area in nearby Lenexa, KS.

Figure 4. Bioretention (City of Lenexa, KS)

Open Swales

Open swales are broad, shallow, natural or constructed channels with a dense stand of native vegetation. A wetland can be incorporated as in Figure 5 but success is dependent on soil conditions. A swale is not designed to route a constant flow and mainly serves to reduce the flow velocities of stormwater runoff. The vegetation promotes infiltration, plant transpiration and enhances

Figure 5. Wetland Swale (Olsson Associates)

water quality as many particulate contaminants settle. These are a viable alternative to lined channels or typical curb-gutter systems where there is limited flow.

Filter Strips, Rain Gardens and Small Scale Solutions

A rain garden is a small depression planted with native wetland and prairie vegetation where sheet flow runoff collects and infiltrates. These gardens, usually placed in residential areas, act as small scale bioretention solutions and utilize the same natural processes to improve water quality. Filter strips are grassed areas often placed adjacent to an impervious surface such as a driveway, parking lot, sidewalk or roadway. These areas are used to treat shallow sheet flows and can be linked to another BMP such as a shallow ponding area where the water quality volume can be detained. Figure 6 provides an example of filter strips along a channel.

Figure 6. Filter Strips (Fort Collins, CO)

BMP Site Identification

A methodology that uses GIS data and analysis was developed to determine optimal locations for BMPs throughout the Rock Creek watershed. The factors taken into account in the selection of BMPs include drainage patterns and location as well as ownership and zoning, soil type and drainage characteristics, proximity to future trail systems, and vegetative patterns. The applied methodology accounts for these characteristics and links a site specific BMP to each parcel. The following data provided the basis for analysis in the GIS processing methodology.

Layer	Source	Description
Stream Network	DASC KansasGIS	National Hydrography Dataset; USGS with EPA
Soils	NRCS	U.S. General Soil Map developed by National Cooperative Soil Survey
Parks	JOCO AIMS Free Data	Existing and future parks
Vegetation	Johnson County	Individual and dense tree areas extracted from AIMS mapping
Paved Area & Transportation Network	Johnson County	
City Boundaries, Land Use Zoning	Johnson County	
Contours	Johnson County	Contours (2' interval)
FEMA Floodplain Mapping	JoCo AIMS Free Data	FEMA DFIRM Database
Watershed Boundary	JOCO AIMS Free Data	Hydrologic Unit Level 14 Code Boundaries produced by US Dept of Agriculture and the NRCS

The Rock Creek watershed was divided into permeable and impervious parcel areas. This first division of the watershed established the basis for two different characterization processes that follow.

Permeable BMP Characterization

Using GIS analysis capabilities and data provided by Johnson County and NRCS, each permeable parcel was associated with a land use and zoning category, soil type, and flood zone characteristics. These parcels were linked to a raster coverage that calculated a percentage of vegetated cover. Dense vegetation clusters were excluded because they are existing assets to the watershed and not

representative of future BMP locations. Another raster coverage was developed to calculate the contributing drainage area to each parcel. Connectivity to the stream network and inlet structures was evaluated by calculating downstream flow path. An average percent slope, based on a digital elevation model, was associated with each parcel as well.

Impervious BMP Characterization

Parking lots and buildings were highlighted and an area was calculated for each impervious parcel. A land use type and contributing drainage area was then linked to each parcel. Commercial or government zoned areas exceeding 0.5 acre were highlighted as possible locations for adjacent bioretention, green rooftops, or pervious paving installation.

Potential BMP Selection

Within Excel, parameters were defined for each type of BMP based on the KCAPWA BMP Manual. In the case of additional parameters, professional judgment determined appropriate ranges. These parameters are presented in Appendix A-3. The following BMP solutions were considered:

- Dry Pond (Quality Control Pond, Dry Extended Detention)
- Wet Pond (Wet Extended Detention, Multiple Pond System, Wet Pond)
- Wetlands (Shallow Marsh, Pond/Wetland, Submerged Gravel Wetland)
- Filtering Practice (Organic Filter, Perimeter Sand, Surface Sand, Vertical Sand, Bioretention, Rain Gardens)
- Infiltration Practice (Bioretention, Rain Gardens, Infiltration Trenches, Porous Pavements)
- Infiltration Basin
- Open Channel and Swale (Ditches, Grass Channel, Dry Swale, Wet Swale)
- Native Vegetation
- Filter Strips

BMP Identification Results

Best management practices are versatile and can have an impact on the health and integrity of a watershed. The identification methodology that was applied to the Rock Creek watershed generated thousands of results, pin-pointing the locations where BMPs should be installed based on specific site conditions and BMP characteristics.

The Rock Creek watershed is primarily residential with business districts and public lands located in central areas. In residential areas, structural BMP recommendations include filter strips and rain gardens with native vegetation that enhance habitat and promote stormwater infiltration of water on-site. There is the opportunity for communities to develop block bioretention facilities within their own neighborhoods to treat stormwater runoff when the individual sites are not well suited for rain gardens. Government owned land, including administration sites and parks, was selected as prime location for implementation of larger scale structural BMPs. Due to similarities between BMP types, most areas are associated with more than one solution. The resulting Appendix C-4 map demonstrates these results. While the locating methodology did not identify sites for successful dry pond detention or wetland installation, these BMP solutions can still be considered during the design phase. Filtering practices that allow infiltration, such as bio-retention and open grass swales, are recommended solutions for many areas in the watershed. Large parking areas and buildings are highlighted as opportunities for adjacent bioretention or filter strips, pervious paving or green roof installation. There are endless opportunities for planting of native vegetation and filter strips on a decentralized level. These solutions are provided in the GIS database; each recommendation is associated with the owner name, street address, property characteristics, and associated benefit and costs.

BMP Cost Analysis

Life cycle cost assessment provides a baseline to approximate relative costs. Whole life costs represent the total expenditure required over the lifetime of each BMP. This type of analysis allows different BMP solutions to be compared and can help determine when minimizing initial cost could possibly lead to greater overall costs. The whole life cost method identifies future costs and associates present day values using standard accounting techniques. It is most useful for the assessment of relative costs of different BMPs rather than exact costs as the implementation strategy will occur over a broad range of time and provided costs are based in 2007. In order to simplify the model for consideration of projects throughout the watershed, the following assumptions were made:

1. A somewhat conservative discount rate of 5.5%. This rate is used to convert all future costs and benefits to present value so that they can be compared. Utilities often use the average cost of borrowing as the discount rate for net present value calculations.
2. A design life of 50 years.
3. 75% of the permeable or impermeable parcel is available to be converted to the recommended BMP.
4. A medium level of maintenance.
5. A base facility cost per acre of drainage area.
6. A recommended factor (2.08) to adjust costs for smaller projects.
7. 25% of base cost is allocated for engineering and planning services.
8. Land acquisition costs are not accounted.
9. Land use is associated with the individual parcel where a BMP would be installed and includes residential, industrial, commercial, and right of way.

Dry ponds are considered extended detention facilities. A simple cost based on drainage area was calculated for each facility. Calculations include an assumed depth of two (2) feet. Routine maintenance includes inspection, reporting, information management and vegetation management. Corrective and infrequent

maintenance includes intermittent facility maintenance and sediment removal. The main pool volume of a dry detention is the water quality volume (WQV). Sediment is removed when the basin is 25% full.

Filtering practices, filter strips and open swales are grouped as swales due to similar construction methods. Routine maintenance includes inspection, reporting, information management and vegetation management with trash and minor debris removal. Corrective maintenance is included every four years to address larger or unexpected issues. An assumed depth of six inches was included in the calculations.

Retention BMPs include wetlands, wet detention ponds, and infiltration such as bioretention. An average depth of one (1) foot was included in the calculations. Structure volume exceeding the WQV was associated with flood detention and attenuation. This impact was not modeled to establish benefit. At this conceptual level, the retention cost does not include a forebay.

Permeable paving costs are based on the surface area of installation as well as the factors above. A high capital cost and medium level of maintenance were assumed. The model works for asphalt, porous concrete, grass/gravel pavers and interlocking concrete paving blocks. Assuming that best management practices are additional initial costs to projects, a capital cost of $4/sqft was associated with each permeable pavement installation. Routine maintenance includes inspection, reporting, information management, litter and debris removal, and permeable paving sweeping. The model assumes that high quality porous paving will need replacement after thirty five (35) years and includes a second large expenditure to replace the paving within the fifty (50) year design life. It was also assumed that the contributing drainage area was the area of the paved structure and the % impervious cover was assumed to be 100.

The technical recommendations are based on the treatment capacity of a proposed BMP. This capacity is evaluated using the detention volume of the

BMP and contaminant loading based on land use cover. A benefit cost ratio was developed using this capacity and the present value. Land use conditions are based on the Johnson County parcel classification (JOCO AIMS, 2007).

BMP Water Quality Benefits

Parcels with associated BMP solutions were evaluated considering main pollutants of concern: total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP). Performance information is based on the Brown and Schueler (1997) work included in an EPA report (EPA, 2002). It should be noted that percent removal is appropriate for a relative comparison but is a poor measure of performance in the case of BMPs. A wide range of influent water quality conditions prevent a BMP from uniform percent removal and, for many constituents, a minimum concentration is necessary to achieve any reduction. An estimation of the loading based on the parcel zoning was approximated using the Simple Method to Calculate Urban Stormwater Loads, published by the Center for Watershed Protection and made available by the Stormwater Manager's Resource Center (SMRC, 2007).

	Residential	Commercial	Roadway	Industrial
Total Suspended Solids *(mg/L)*	100	75	150	120
Total Nitrogen *(mg/L)*	2.2	2.0	3.0	2.5
Total Phosphorus *(mg/L)*	0.4	0.2	0.5	0.4

Table 1 Pollutant Concentrations by Land Use, Stormwater Manager's Resource Center (SMRC, 2007)

Removal efficiency of the contaminants associated with parcel land use was used to determine the benefit of any given BMP. It should be noted that BMPs acting in series can potentially have a more significant impact on water quality.

BMP Implementation Strategy

The integration of best management practices with management of the Rock Creek watershed may substantially benefit water quality, habitat, and provide opportunities for public education regarding water resource issues. Both structural and non-structural solutions can benefit water quality and mitigate flooding damage. Non-structural BMPs, hinging on education and management, can have substantial impact on the Rock Creek watershed as redevelopment opportunities continue. Each municipality should coordinate with their planning commission to develop an appropriate implementation plan. The development of agreements between municipalities, especially the coordination of BMPs and stream restoration projects that cross boundaries is highly recommended. The Watershed Restoration and Protection Strategy (WRAPS) programs provide an example of this kind of watershed approach. WRAPS is a planning and management framework serving to identify watershed restoration and protection needs, establish management goals, create cost effective action plans and implement those plans. WRAPS groups depend on citizen-stakeholders to design and accomplish these plans (WRAPS, 2007). Ordinances should be developed at the local level concerning sediment and erosion controls, native vegetation, limits to the percent impervious area, regulations controlling chemical application, and stream buffers. Existing educational programs and demonstration projects should also be encouraged and developed. The downstream City of Mission Hills may serve as a resource for these upstream endeavors.

Based on life cycle costs and water quality benefits, the following structural BMPs comprise the top priority public and commercial projects (see Appendix C-3 for example of GIS database listing). These BMP recommendations are listed as individual solutions but the success of a treatment train approach should be considered at each site. The Kansas City APWA BMP Manual 2007 provides guidance to assess the value of BMPs placed in series. Throughout the Rock Creek watershed, recommended BMPs are located adjacent to one another (Appendix C-4 map). Combining these individual projects into a larger scale

project that includes two or more BMPs along the same flowpath may result in higher removal of contaminants. A common approach is to place a filter strip upstream of a secondary BMP. Filter strips serve to slow stormwater velocities, allowing larger particles and sediments to settle before flowing into the retention area.

The following locations will provide the greatest water quality benefit for the associated cost. These public land BMP projects are highlighted as excellent public demonstration projects to integrate with future watershed redevelopment.

Public Land Recommendations

	Owner	*Address*	*BMP*	*2007 Total Cost (Including Maintenance)*	*Present Value Cost*
1.	City of Mission (993)	Martway and Dearborn Streets	Filtering Practice with Infiltration	$11,315	$3,851
2.	City of Mission (998)	Dearborn Street and W 59th Terrace	Filtering Practice with Infiltration	$27,690	$20,226
3.	City of Mission (945)	Martway and Beverly Avenue	Filtering Practice with Infiltration	$78,198	$26,993
4.	City of Overland Park (9151)	Johnson Drive and Metcalf Lane	Filtering Practice with Infiltration	$11,565	$4,101
5.	City of Mission (968)	Martway	Filtering Practice	$11,690	$4,226
6.	USPS (8731)	6029 Broadmoor Street	Filtering Practice	$78,198	$26,993
7.	City of Mission (8937)	Martway and Lamar Avenue	Filtering Practice	$11,190	$3,726

8.	City of Fairway (105547)	4330 Shawnee Mission Parkway	Permeable Paving	$174,067	$107,055
9.	USPS (8729)	6029 Broadmoor St.	Permeable Paving	$414,217	$259,594
10.	City of Roeland Park (5083)	Alhambra St. and Elledge Drive	Filtering Practice with Infiltration	$16,690	$9,226
11.	City of Mission (8707)	Broadmoor and Martway Streets	Filtering Practice with Infiltration	$14,440	$6,976
12.	City of Mission (7636)	6448 Nall Avenue	Filtering Practice with Infiltration	$78,198	$26,993
13.	City of Mission (1460)	6090 Woodson St.	Filtering Practice with Infiltration	$78,200	$26,993
14.	Unified School District #512	7401 Johnson Drive	Permeable Paving	$665,027	$418,900
15.	City of Mission (7714)	W 67th St. and Horton Drive	Filtering Practice with Infiltration	$79,198	$27,993

The above facilities may serve as demonstration projects as each municipality begins its watershed planning educational strategies. The second most important component of future planning is the incorporation of BMPs into redevelopment plans in commercial and industrial districts. The following list includes the top 15 locations for achieving a reduction in total suspended solids and nutrients at most efficient cost at commercial and industrial locations.

Private Facilities

(Commercial and Industrial Zoning)

	Owner (ID)	*Address*	*City*	*BMP*	*2007 Total Cost*	*Present Value Cost*
1.	FCB Real Estate Holdings (9132)	7508 Shawnee Mission Parkway	Overland Park	Filtering Practice with Native Vegetation	$45,837	$17,199
2.	Salvation Army (1000)	Johnson Drive and Lamar Avenue	Mission	Filtering Practice and On-site Bioretention	$47,837	$19,199
3.	Winchell's Donut House (9217)	6500 Johnson Drive	Mission	Bio-retention with Native Vegetation	$43,337	$14,699
4.	Park Place L.L.C. (133498)	7520 Shawnee Mission Parkway	Overland Park	Permeable Paving	$152,537	$93,397
5.	Fleming Corporation of Kansas (133313)	6501 Johnson Drive	Mission	Permeable Paving	$164,137	$100,765
6.	Keystone Real Estate (8746)	6819 Johnson Drive	Mission	Filtering Practice with Native Vegetation	$56,837	$28,199
7.	Herff Jones, Inc. (132597)	6015 Travis Lane	Mission	Permeable Paving	$178,608	$107,280
8.	Wendy's Restaurant (127306)	5101 Martway St.	Mission	Permeable Paving	$180,127	$110,914
9.	Sixty Three West Investors (132484)	5800 Foxridge Drive	Mission	Permeable Paving	$161,527	$99,086
10.	Great Plans Real Estate (127540)	6300 Nall Avenue	Mission	Permeable Paving	$194,967	$120,337
11.	Bear & Bear Associates (136415)	6800 W 64th Street	Mission	Permeable Paving	$206,357	$127,579
12.	CMT Partners (145772)	7000 Squibb Road	Mission	Permeable Paving	$144,018	$86,251
13.	QuikTrip Corporation (133426)	7400 Shawnee Mission Parkway	Overland Park	Permeable Paving with Adjacent Bioretention	$157,137	$96,304
14.	Frank Oddo Trustee (132618)	6800 Squibb Road	Mission	Permeable Paving	$181,218	$108,889

15.	Gourmet Systems of Kansas (132938)	6800 Johnson Drive	Mission	Permeable Paving	$245,967	$152,714

The accompanying GIS database provides a complete listing with over 4000 BMP locations, separated into permeable and impervious solutions. This resource may be utilized by the municipalities within the watershed as development projects come up for review. At the site planning level, more specific analysis will be necessary to determine the appropriate size and placement of a recommended BMP.

The technical nature of this Feasibility Study limited consideration to the water quality benefit of a specific BMP. Further planning and community participation is critical to determine the aesthetic, safety, and educational benefits of BMPs in the Rock Creek watershed. Green roof solutions were not evaluated for this reason but should be considered as the watershed develops – approximately 43% of all impervious space is accounted for in buildings. This type of BMP has measurable impact outside the scope of this study. While similar to a rain garden in water treatment capacity, green or living roof structures decrease energy use in a facility and provide an educational and aesthetic resource. This is a particularly appealing alternative because today's planning trends are focused on intense, concentrated urban environments.

Roadways cover approximately 11% of the Rock Creek watershed and account for 35.5% of total impervious area. Planning should consider the benefit of adjacent swales and filter strips and their capacity to treat right of way runoff. As parking lots require replacement or maintenance, the alternative of permeable paving should be considered. To generate a life cycle cost, this report accounts for a general additional cost of $4/sqft but design considerations can include porous asphalt or concrete, grass or gravel pavers, and interlocking concrete paving blocks.

As a sub-watershed within the larger Brush Creek watershed, Rock Creek has the opportunity to use local resources focused on watershed planning. The Brush Creek Coordinating Committee is a basin-wide coordination committee, involving public and private interests, formed to share information and discuss strategies for the Brush Creek Watershed. The committee meets regularly to discuss management plans for the Brush Creek Watershed and is comprised of representatives from the Kansas side – cities of Mission Hills, Mission, Mission Woods, Fairway and Prairie Village - and Missouri side – Kansas City - of the watershed. Through continued efforts led by MARC using KDHE funding, these stakeholders will develop a regional, multi-jurisdiction plan for Brush Creek that aligns watershed goals, provides a consensus of the priorities, and coordinates an action plan for activities along the Creek.

In order to develop the recommended projects and continue educating the community, funding should be sought from Federal, State and local sources. We recommend the formation of a local WRAPS group as well as an inter-local governing body that has some power to influence policy and carry out the implementation of projects. Mission Hills' projects are a good example of this concept implemented. Their project incorporates a 10 year modeling plan with two demonstration projects at Hiawasee and Peetwood Parks, limited to stream restoration. The SMAC program through Johnson County is a potential funding source – especially applicable because they are interested in acquiring performance data for the international stormwater database.

Water Quality Monitoring Plan

In coordination with stream restoration projects and best management practices, a water quality monitoring plan is an integral component to guide future planning and to address critical areas within the watershed. The plan outlined below includes real time and weekly monitoring of potential contaminants, completed by Kansas State University for the City of Mission.

Scope and Application

Severe flooding in the downstream reaches of the Rock Creek watershed is resulting in efforts to reduce runoff volume and time of concentration. While reduction of flooding is the primary concern, improvement of water quality is necessary to meet the National Pollution Discharge Elimination System (NPDES) permit. In accordance with the Kansas Department of Health and Environment, stormwater, in general, is subject to the following regulations from small municipalities (http://www.kdheks.gov/muni/download/PublicNotice.pdf):

> "The general permits require the permittee to develop, implement, and enforce a stormwater management plan (SMP) designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable, to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. The SMP covers the six minimum stormwater control measures and also requires implementation of Best Management Practices (BMP)for discharges of stormwater to designated high priority Total Maximum Daily Load (TMDL) streams and lakes in the immediate area downstream of the municipality. The SMP document must address the BMPs to be implemented by the permittee, provide measurable goals for each BMP, designate the municipality or municipalities responsible for implementing the control measures and provide a map illustrating the permitted area as defined by the requirements in the permit. The draft permits contain schedules of compliance requiring the submittal of the various documents to KDHE

and implementation of practices to control stormwater pollution from the MS4."

The purpose of this monitoring plan is to identify overall water quality in the Rock Creek watershed and document changes due to the implementation of stormwater best management practices. Data measurements will include stream discharge, physical properties, nutrients, and fecal coliform bacteria, which tie in with efforts of surrounding cities to quantify water quality. Sampling locations were selected to provide a comprehensive assessment of current water quality in the Rock Creek watershed. The selected locations also lend themselves to future monitoring efforts of stream restoration and BMP projects. Locations were based on accessibility, security, proximity to tributaries and future projects. These locations are highlighted on the map in Appendix C-5.

Summary of Methods

Teledyne ISCO Model 6712 samplers with a 730 bubbler module for flow measurement will be installed at each sampling location. These machines collect continuous flow data using the bubbler module. Real-time sediment data will be tested with an experimental sensor in a BMP on the corner of Lamar and Martway in Mission, KS as part of an ongoing study with the City of Mission. Samples will be collected weekly via grab sample at locations with continuous flow throughout the course of the study. During storm events, the ISCO samplers are activated by increased water level and take discrete samples in 340 mL glass bottles that will be collected within 24 hours for laboratory analysis. After collection, each sample will be placed in a cooler with ice for transportation to the analytical lab in Manhattan, Kansas. Samples will be stored at 4°C for no longer than one week before chemical analysis is preformed.

A field book will be kept to keep track of problems and general site concerns. The primary use of this will be as reference for future site visits. Stream level data will be downloaded from the ISCO to a Rapid Transfer Device (RTD) model 581 for temporary storage before downloaded to a database in Manhattan. The

experimental sensors will transmit Total Suspended Sediment data via a cellular phone card and be posted to a database in Manhattan. All data from sample analysis will be managed in an electronic database categorized by sample date, location, and type.

Summary of Analytical Methods

Both weekly grab samples and discrete samples from storm events will be monitored for contaminants of interest, following the methods outlined below. Analysis will be completed in the Kansas State University Agronomy Soil and Water Testing Laboratory.

Total Nitrogen and Phosphorus

1 to 10 ml sample is digested with Potassium Persulfate Reagent in an autoclave and then analyzed using a Technicon AutoAnalyzer II for phosphorus and an Alpkem RFA for nitrate nitrogen (cadmium reduction method).

Total Suspended Solids

50-100 ml of the samples is filtered thru 0.45 micron filters using a vacuum. The dry weight of the filter is measured before and after filtration. TSS is calculated based on mg/L.

Ammonia and Nitrate Nitrogen

Filtrate from the TSS procedure is measured for NH4-N and NO3-N using an Alpkem RFA autoanalyzer.

E-coli Bacteria

Procedure involves placing a membrane filter, with 25 ml the selected sample filtered through, onto a modified mTEC agar (USEPA, 2000). After a 24 to 26 hour incubation time, colony forming units are manually counted (Clesceri et al., 1998).

Electrical Conductivity (EC) using a conductivity meter

pH in accordance with EPA Standard Operating Procedure for Electrometric pH

Equipment and Supplies

Equipment required for the majority of these analyses include the ISCO Teledyne sampler, pipettes, pipette tips, a scale, a horizontal clean bench, an incubator, and reagents and laboratory materials described in the following section.

Reagents and Standards

(Laboratory Only)

Specific to each water quality analytical test, a list of necessary materials follows:

- Total Nitrogen (Total N) – mg/l
    - 1 to 10 ml sample is digested with Potassium Persulfate Reagent in an autoclave and then analyzed using a Technicon AutoAnalyzer II for phosphorus and an Alpkem RFA for nitrate nitrogen (cadmium reduction method).
    - Secondary samples will be analyzed for Total N using the HACH Total Nitrogen kit with catalog number 26722-45
- Total Phosphate (Total P) – mg/l
    - 1 to 10 ml sample is digested with Potassium Persulfate Reagent in an autoclave and then analyzed using a Technicon AutoAnalyzer II for phosphorus and an Alpkem RFA for nitrate nitrogen (cadmium reduction method).
    - Secondary samples will be analyzed for Total P using the HACH High Range Total Phosphate kit with catalog number 27672-45
- Total Suspended Solids (TSS) – mg/l
    - 50-100 ml of the sample is filtered thru 0.45 micron filters using a vacuum. The dry weight of the filter is measured before and after filtration. TSS is calculated based on mg/L.
- Electrical Conductivity (EC) – mS/cm

    - EC will be determined using a Hanna Instruments HI 9033 Multi-range Conductivity meter
- pH
    - Will be recorded using an electrometric pH meter, which will be calibrated before each use
    - Past monitoring shows consistent pH values generally between 7.5 and 9.0
- Bacteria – CFU
    - E-coli as an indicator bacteria measured by filtering 25 ml of the sample and plating onto a modified mTEC agar
- Nitrate – mg/l
    - Samples will be analyzed for Nitrate using the HACH NitraVer X Reagent kit catalog number 26053-45
- Ammonia – mg/l
    - Filtrate from the TSS procedure is measured for NH_4-N and NO_3-N using an Alpkem RFA autoanalyzer.
    - Samples will be analyzed for Ammonia using the HACH AmVer High Range Ammonia kit catalog number 26069-45

Quality Control

A standard solution will be run along with each set of samples to ensure continued accuracy. Random duplicates will also be run to ensure consistency along with periodic analysis from a separate lab. All samples will be collected and processed using protocols designed to prevent contamination.

Calibration and Standardization

Equipment will be calibrated before sample analysis to ensure accurate results in accordance with the equipment manual.

Data Analysis and Calculations

If values for Total N seem unusually high compared to other monitoring locations and past values, a more in-depth analysis can be preformed at a particular location to better understand nitrogen processes taking place.

In addition to grabbing samples for analysis, a real time sediment sensor will be implemented in order to track TSS levels and note any particular pattern to sediment delivery. The sensor location will be selected based off continuous flow as well as other specific site characteristics.

Results

Data will be presented in summarized tabular format along with selected graphical display for visualization. Background data will be stand alone and will be used as a comparison for future work. A field book will be kept for this project and hard copies of data will be kept on data sheets in the lab. Electronic copies will be used in data analysis. Annual reports will be submitted to the City of Mission. These results will initially establish a baseline evaluation of the watershed, demonstrate the overall success of the watershed program, and influence future efforts in the watershed.

Conclusions

The Rock Creek Watershed Feasibility Study provides the methodology, results and guidance for cities within the Rock Creek watershed to apply toward their watershed management and flood mitigation goals.

The stream assessment produced a scored system to determine restoration potential and guide future planning of the main channel and tributaries within the watershed. The APWA CCSM scores represent stream conditions that range between poor stability and system wide instability in the Rock Creek watershed. In general, the CCSM rating reflected lack of sinuosity, pool-riffle structure, steep bank slopes and lack of vegetative protection. The habitat availability and quality varied throughout the watershed. Generally, water quality and aquatic habitat were enhanced by pool-riffle structure, availability of consistent flow, vegetative cover, and a well-graded substrate. A consistent method was applied to determine the cost benefit ratio of stream restoration projects in both tributaries and the main channel.

Several areas in the watershed were identified for successful BMPs. Larger public areas with appropriate soil structure and sufficient contributing drainage areas were identified as potential sites for filtering practices, such as bio-retention, and open grass swales, allowing infiltration. Large parking areas and buildings are highlighted as opportunities for bioretention, filter strips, pervious paving or green roof installation.

Engaging the community in stormwater management should include educational and demonstration projects that can be taken to the residential level: small structural installations such as rain gardens and filter strips and plantings of native vegetation to increase infiltration capacity.

The opportunities in the Rock Creek watershed center on redevelopment of existing infrastructure with a more holistic vision of watershed planning. The

stream restoration and best management practice projects determined by this Feasibility Study create the foundation for planning commissions to take forward. There should also be a concerted effort by the Cities within the Rock Creek watershed to educate citizens and elected officials on the benefits of streams and stream corridors, the water quality benefits of best management practices, and the need to reduce impervious surfaces throughout the watershed.

References

Baker, Donald and Gonzalez-Quesada, Pablo, 2005. *Stream Design in Urban Areas*, EC 2005 Proceedings, International Erosion Control Association.

Center for Watershed Protection (CWP), 2000. *National Pollutant Removal Database for Stormwater Treatment Practices, 2nd Edition*, prepared by the Center for Watershed Protection, Ellicott City, MD, prepared for Tetra Tech, Inc., Fairfax, VA and the U.S. EPA Office of Science and Technology, Washington, D.C.

Chen, Y.H. and G.K. Cotton. 1988. "*Design of Roadside Channels with Flexible Linings*". U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 15.

Clesceri, L.S., G.E. Arnold, and D.E. Andrew. 1998. *Standard Methods for the Examination of Water and Wastewater*. Baltimore, MD: American Public Health Association and American Water Works Association and Water Environment Federation.

Environmental Protection Agency (EPA), 2002. *Considerations in the Design of Treatment BMPs to Improve Water Quality*. EPA/600/R-03/103, Washington, D.C.

Field, Richard, Tafuri, A.N., Muthukrishnan, S., Acquisto, B.A., Selvakumar, A, 2006. The Use of Best Management Practices (BMPs) in Urban Watersheds. DEStech Publications.

Kansas City Metropolitan Chapter, American Public Works Association (KCAPWA), 2005. *Construction and Material Specifications, Section 5600 Storm Drainage Systems and Facilities, Design Criteria.*

Kansas City Metropolitan Chapter, American Public Works Association (KCAPWA), 2007. *Draft BMP Manual.*

Kansas City Metropolitan Chapter, American Public Works Association (KCAPWA), 2003. *Manual for Best Management Practices for Stormwater Quality*, Mid-American Regional Council and American Public Works Association.

Lampe, L., Andrews, H., Barrett, M.E., Glass, C., Jefferies, C., Martin, P., Weinstein, N. Woods-Ballard, B. 2005. *Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems.* Water Environment Research Foundation 01-CTS-21, Alexandria, VA.

Leopold, L.B. 1994. *A View of the River*. Harvard University Press. 312 pp

Northeast Johnson County Watershed Study. May 2005. Johnson County, Kansas Public Works Department.

Riley, Ann L., 1998. *Restoring Streams in Cities: a guide for planners, policymakers, and citizens*. Island Press.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Fort Collins, Colorado.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Best Management Practices*, MWCOG. Washington, D.C.

Soar, Philip J. and Thorne, Colin R., 2001. "*Channel Restoration Design for Meandering Rivers*". Engineer Research and Development Center, US Army Corps of Engineers.

The Stormwater Manager's Resource Center, 2007. *The Simple Method to Calculate Urban Stormwater Loads*, Environmental Protection Agency, Office of Water, Office of Wastewater Management, Assistance Agreement #828077-0, http://www.stormwatercenter.net/, 2007. The SMRC site is managed and published by the Center for Watershed Protection, Inc., a 501(c)3 organization located in Ellicott City, Maryland.

U.S. Army Corps of Engineers (USACE). 1994. "Channel Stability Assessment for Flood Control Projects." Engineer Manual 1110-2-1418.

USEPA. 2000. Improved enumeration methods for the recreational water quality indicators—Enterococci and Escherichia coli. Office of Science and Technology, Washington, DC.

Wilkinson, D.H., Armstrong, D.J., Norman, R.D., Poulton, B.C., Furlong, E.T., and Zaugg, S.D., 2006, Water Quality in the Blue River Basin, Kansas City Metropolitan Area, Missouri and Kansas, July 1998 to October 2004: U.S. Geological Survey Scientific Investigations Report 2006-5147, 170.

Internet Resources

Automated Information Mapping System: Geographic Data & Service Provider for Johnson County, KS, http://aims.jocogov.org/, 2007.

International Stormwater BMP Database, 2007. http://www.bmpdatabase.org/ .

Kansas Department of Health and Environment. 2004. Kansas Surface Water Quality Standards. Available at: http://www.epa.gov/waterscience/standards/wqslibrary/ks/ks-tables-20041206.pdf

Kansas State University Soil Testing Laboratory. 2005. Research Soil Testing. Kansas State University Agronomy Soil Testing Laboratory. Available at: http://www.oznet.ksu.edu/Agronomy/SoilTesting/research.htm.

Kansas Watershed Restoration and Protection Strategy, The Kansas Department of Health and Environment, EPA Section 319, http://www.kswraps.org/faq/, 2007.

The Stormwater Manager's Resource Center, Environmental Protection Agency, Office of Water, Office of Wastewater Management, Assistance Agreement #828077-0, http://www.stormwatercenter.net/, 2007. The SMRC site is managed and published by the Center for Watershed Protection, Inc., a 501(c)3 organization located in Ellicott City, Maryland.

Appendices

Assessment Matrices

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Appendix C-5: Water Quality Sampling Location Map

Appendix A-1

APWA Channel Condition Scoring Matrix

Project: _____

Stream Name and Location: _____

Evaluated by: _____ Firm: _____ Date: _____

Table 5605-2
CHANNEL CONDITION SCORING MATRIX
(adapted from Johnson, et al 1999)

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Bank soil texture and coherence	cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)		0.6	
Average bank slope angle	slopes ≤ 2:1 on one or occasionally both banks	slopes up to1.7:1 (60°) common on one or both banks	bank slopes over 60° on one or both banks		0.6	
Average bank height	less than 6 feet	greater than 6 and less than 15 feet	greater than 15 feet		0.8	
Vegetative bank protection	wide to medium band of woody vegetation with 70-90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	narrow bank of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	thin or no band of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank		0.8	
Bank cutting	little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent		0.4	

Table 5605-2
CHANNEL CONDITION SCORING MATRIX
(adapted from Johnson, et al 1999)

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
Mass wasting	little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.		0.8	
Bar development	narrow relative to stream width at low flow, well-consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of bar	Bar widths wide relative to stream width with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the stream width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation		0.6	
Debris jam potential	slight – small amounts of debris in channel. Small jams could form	moderate – noticeable debris of all sizes present	significant – moderate to heavy accumulations of debris apparent		0.2	
Obstructions, flow deflectors (walls, bluffs) and sediment traps	negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	frequent and unstable causing continual shift of sediment and flow		0.2	
Channel bed material consolidation and armoring	massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of	shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm		0.8	

Table 5605-2
CHANNEL CONDITION SCORING MATRIX
(adapted from Johnson, et al 1999)

Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W= (R)
	particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm					
Sinuosity	1.2 ≤ Sinuosity ≤ 1.4	1.1<Sinuosity <1.2	Sinuosity <1.1		0.8	
Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3$, $5 < R_c/W_b < 7$	$2 < R_c/W_b$, $R_c/Wb > 7$		0.8	
Ratio of pool-riffle spacing to channel width at elevation of 2-year flow	$4 \leq$ Length/$W_b < 8$	$3 \leq$ Length/$W_b < 4$, $8 <$ Length/$W_b \leq 9$	$3 <$ Length/W_b, Length/Wb > 9, unless long pool or run because of geologic influence		0.8	
Percentage of channel constriction	< 25%	26-50%	> 50%		0.8	
Sediment movement	little to no loose sediment	scour and/or deposition, some loose sediment	near continuous scour and/or deposition and/or loose sediment		0.8	

TOTAL ____

Appendix A-2
Rapid Habitat Assessment Scoring Matrix

Appendix A-2: Habitat Assessment Scoring Matrix

	1	2	3	4	5
USDA Description: General guideline for City of Lenexa's Stream Assessment and Natural Resource Inventory Project	Generally described as the highest quality naturally occurring stream with little negative impact. Erosion and sedimentation is low, water quality indicators are positive and the surrounding riparian zone is a healthy, mature, succession woodland or other high-quality environment.	This type of high quality stream may have some down or side-cutting, however, bank and bed composition (bedrock) assist in keeping the impact low. Water quality is generally good and the riparian zone is largely intact, although vegetation may be altered from that of a typical native plant association.	The riparian corridor is still restorable although deterioration is much more noticeable. While some remnant plant associations may be present, overall vegetative canopy cover is comprised of immature tree species. The potential for restoration exists although erosion and sedimentation can be greater than desirable.	Impacts are greater on this low quality stream type with significant indicators of bank erosion and sedimentation present. The adjoining riparian corridor may be intact but vegetation is not representative of a native plant association.	A Type 5 channel is the most changed and of the lowest quality. The riparian corridor is impaired to the point of providing little protection or benefit, and erosion and sedimentation indicators are significant. Water quality is questionable with noticeable phosphate and nitrate loading (large algae blooms).
Black & Veatch Scoring for the Rock Creek Stream Network					
Stability: Based on results of stream geomorphologic assessment and utilized score developed in KCAPWA Channel Condition Scoring Matrix	CCSM Range: <12 indicating a channel of moderate stability OR a natural stream channel with cohesive materials such as rock, mild bank slopes, well developed vegetation, little bank cutting or mass wasting, consolidated channel bed.	CCSM Range: <12 indicating a channel of moderate stability, a stable engineered channel OR three of the following: cohesive materials, slightly steeper bank slopes, diverse vegetation that provides some stability, presence of unstable obstructions, bar development.	CCSM Range: 12<x<20 indicating stability issues within the channel OR three of the following observations: less cohesive materials, significant and frequent bank cutting, narrow bank of vegetation, steeper bank slopes and softer bed material.	CCSM Range: >20 indicating a channel of moderate stability, a degrading engineered channel OR three of the following: Steep bank slopes, significant and frequent bank cutting and mass wasting conditions, banks lack vegetation.	NA
Aquatic Habitat: Evaluated by stream flow, channel structure, channel substrate, macro habitat type, available in-stream fish cover.	Two of the following: Cobble substrate, low embeddedness, stable channel, little bank erosion, presence of riffles and deep pools, highly sinuous pattern.	Two of the following: gravel or small cobble substrate with good variation, moderate embeddedness, moderate sinuosity, presence of in-stream cover.	Two of the following: Sand, leaf litter, or mud/detritus/muck, embedded substrate, lacking in-stream cover, moderate bank erosion, low sinuosity.	Two of the following: Bedrock or Concrete, severe bank erosion, lacking in-stream cover, straightened channel	Underground.
Terrestrial Habitat: Based on type, diversity, condition of bank and riparian corridor.	High canopy density and three or more species	Medium canopy density with three or more species	Low canopy density with three or more species	Low density of monoculture canopy	Canopy not present.
Water Quality: Evaluated using indicator benthic macro invertebrate presence and diversity. Groups defined by the EPA.	Presence of group one taxa: pollution sensitive organisms found in good quality water.	Presence of group two taxa: somewhat pollution tolerant organisms found in water of good to fair quality.	Presence of group three taxa: pollution tolerant organisms available in any quality of water.	No invertebrates found during sampling and limited availability of channel substrate and nutrients.	Underground. No water quality benefit.

Appendix A-3
BMP Selection Criteria Matrix

Appendix A-3: BMP Selection Criteria

	Polygon Area (acres)	Permeability	Zoning	Hydric Category	Hydrologic Soil Group	Contributing Drainage Area (acres)	Slope (%)	Dispersed Vegetation	Aesthetics	Habitat	Maintenance	Safety
Dry Pond (Quality Control Pond, Dry Extended Detention)	>0.5	Permeable	Residential, Commercial, Gov/Pub	Other	B, C	>10, for underground dry detention <5	<5	<10	M	W	B	B
Wet Pond (Wet Extended Detention, Multiple Pond System, Wet Pond)	>0.01	Permeable	Sometimes Residential, Commercial, Gov/Pub	Partially hydric, Hydric	B, C, D	>5	<5	<5	B	B	B	W
Wetlands (Shallow Marsh, Pond/Wetland System, Submerged Gravel Wetland)	>0.05	Permeable	Sometimes Residential, Commercial, Gov/Pub	Partially hydric, Hydric	B, C, D	>10	<5	<5	B	B	M	B
Filtering Practice (Organic Filter, Perimeter Sand, Surface Sand, Vertical Sand, Bioretention, Rain Gardens)	>0.01	Permeable	Residential, Gov/Pub, Commerical, Right of Way	Hydric, Partially Hydric, Other	B,C,D	<5	<5	<10	M	W	W	B
Infiltration Practice (Infiltration Trenches, Porous Pavements)	>0.01	Permeable	Residential, Gov/Pub, Commerical, Right of Way	Hydric, Partially Hydric, Other	B,C	<5	<5	<15	B	M	W	B
Open Channel and Swale (Ditches, Grass Channel, Dry Swale, Wet Swale)	>0.01	Permeable	Residential, Gov/Pub, Commerical, Right of Way	Other	B, C	<5	<10	<5	M	W	B	B
Native Vegetation	NA	Permeable	Residential, Commerical, Gov/Pub, Right of Way	Hydric, Partially Hydric, Other	B,C,D	NA	NA	<10	M	B	M	B
Filter Strips (adjacent to parking lots)	>0.01	Permeable	Residential, Gov/Pub, Sometimes Commerical	Hydric, Partially Hydric, Other	B,C,D	<2	<5	<10	M	M	W	B
Parking Lot Detention	>0.5	Impervious	Gov/Pub, Sometimes Commercial	NA	NA	NA	NA	NA	M	W	M	B

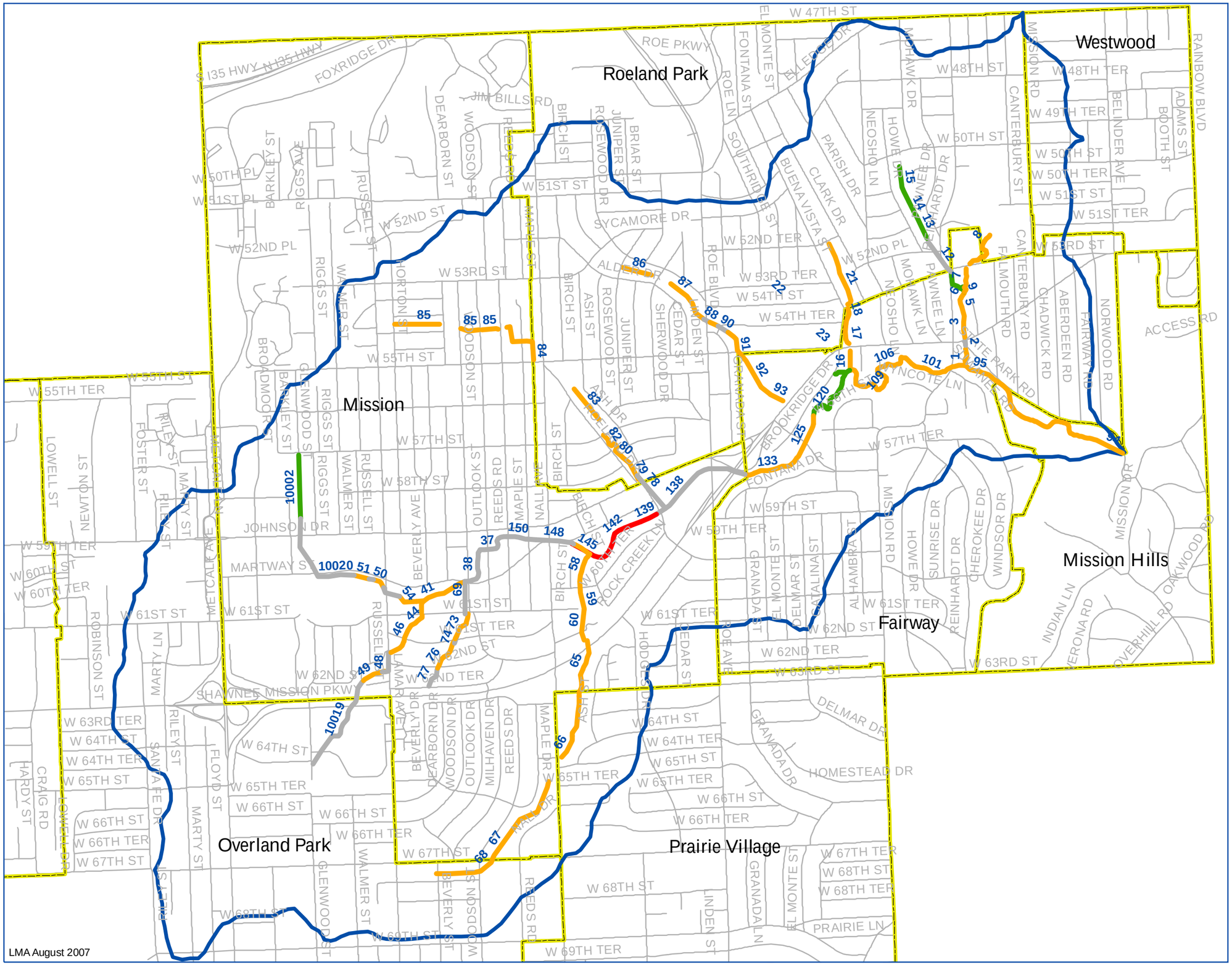
Based on the KS APWA and MARC BMP Manual 2003 and EPA 600/R-03/103

Appendix B-1

APWA Stream Assessment Results Map

Rock Creek Watershed Feasibility Study

Appendix B-1
APWA CCSM Assessment Results



LEGEND

- Underground
- Stable
- Moderate Stability
- Significant Instability
- System Wide Instability
- RockCreekWatershed
- City Boundary

0 1,500 Feet

1 inch equals 1,500 feet

Please refer to Appendix A-1 APWA Channel Condition Scoring Matrix and pages 6-9 of the Feasibility Study for additional detail.

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Appendix B-2
Aquatic Habitat Assessment Results Map

Rock Creek Watershed Feasibility Study

Appendix B-2 Aquatic Habitat Assessment Results

Roeland Park
Westwood
Mission
Mission Hills
Fairway
Overland Park
Prairie Village

LMA August 2007

LEGEND

Aquatic Habitat

- High Quality (1)
- General Quality (2)
- Moderate Quality (3)
- Low Quality (4)
- Underground (5)
- RockCreekWatershed
- City Boundary

0 1,500 Feet

1 inch equals 1,500 feet

Please refer to Appendix A-2 Rapid Habitat Assessment Scoring Matrix and page 12 of the Feasibility Study for additional detail.

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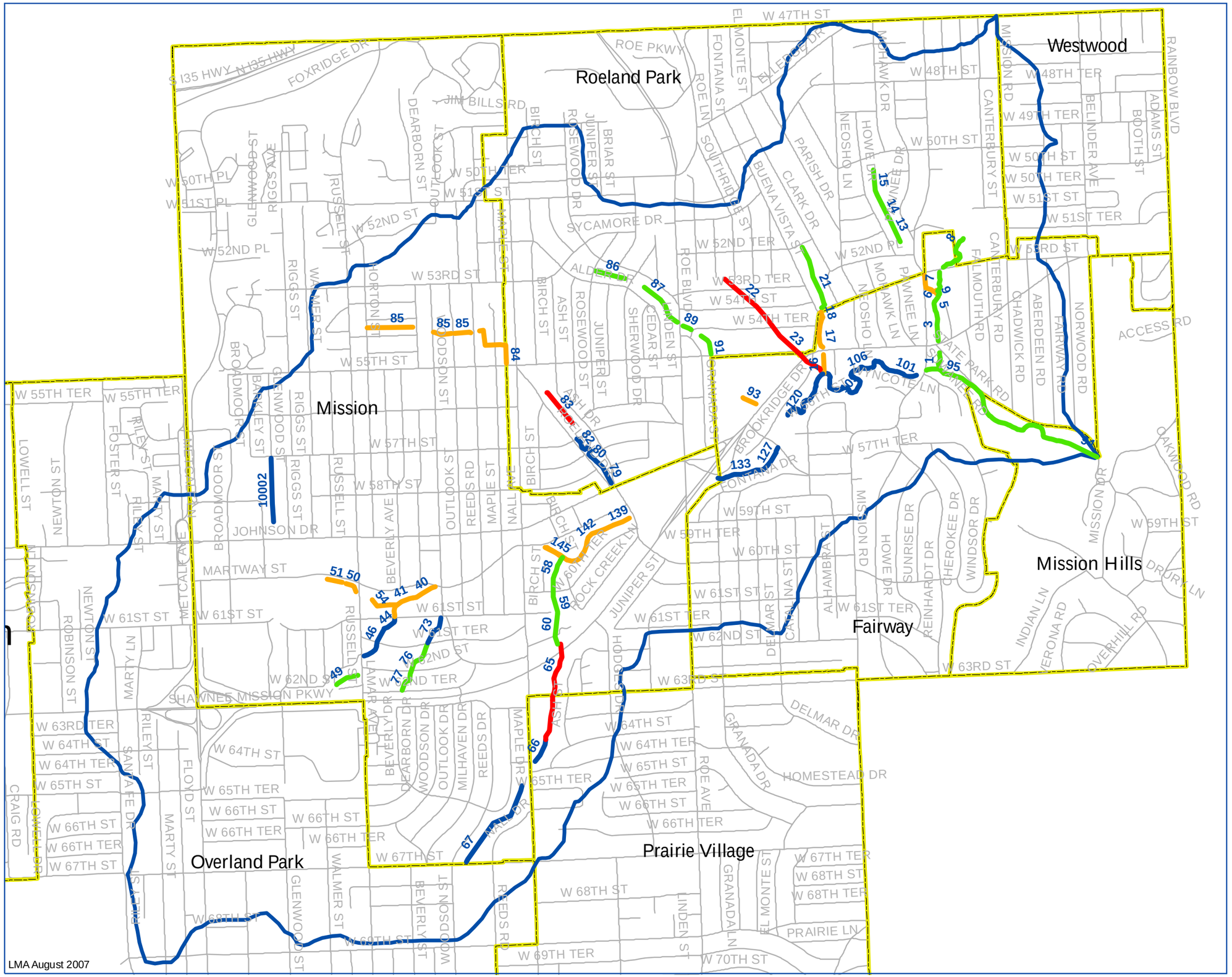
Appendix B-3
Terrestrial Habitat Assessment Results Map

Rock Creek Watershed Feasibility Study

Appendix B-3 Terrestrial Habitat Assessment Results



Please refer to Appendix A-2 Rapid Habitat Assessment Scoring Matrix and pages 13-14 of the Feasibility Study for additional detail.

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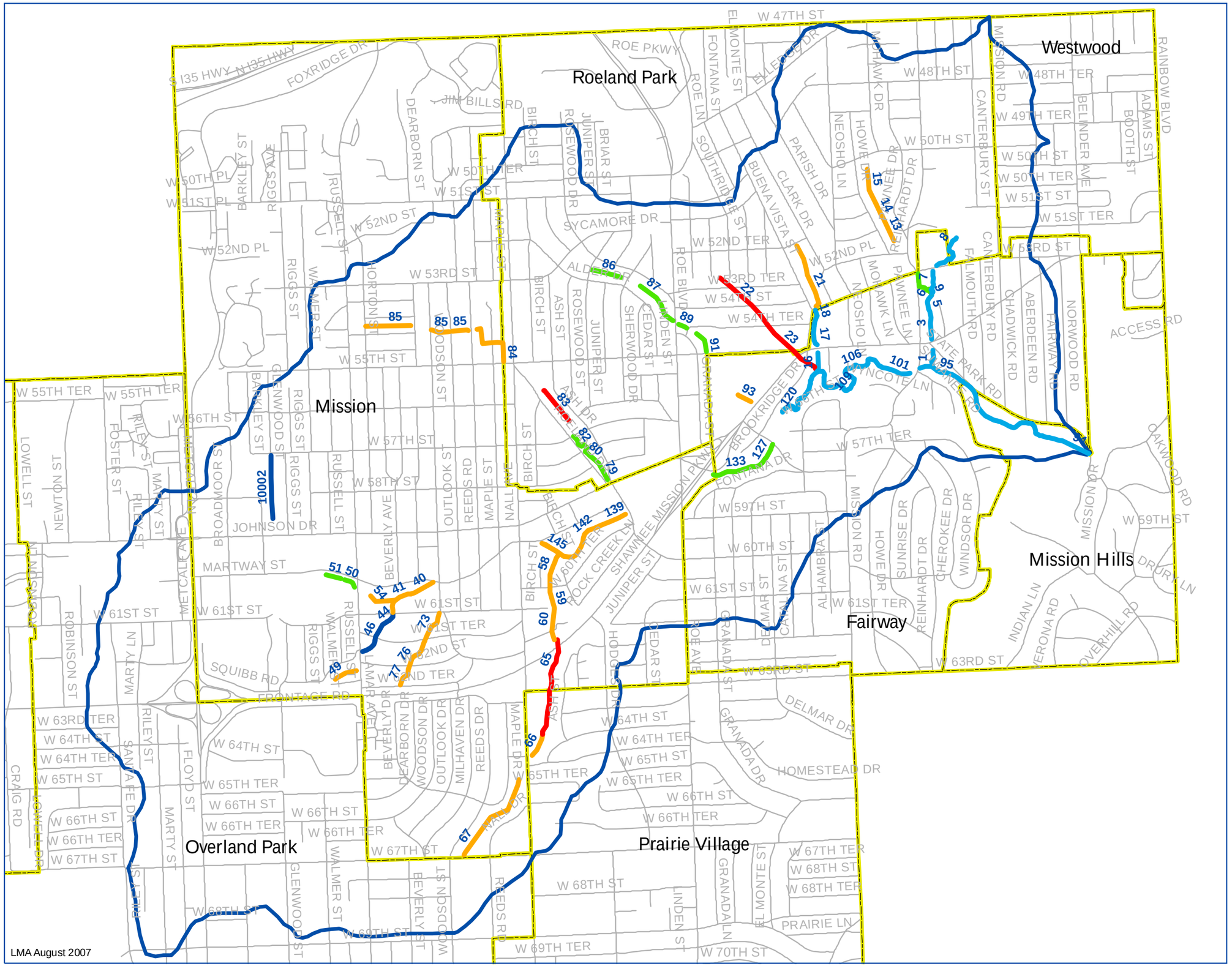
Appendix B-4
Water Quality Assessment Results Map

Rock Creek Watershed Feasibility Study

Appendix B-4 Water Quality Assessment Results



LEGEND

Water Quality

- High Quality (1)
- General Quality (2)
- Moderate Quality (3)
- Poor Quality (4)
- Underground (5)
- RockCreekWatershed
- City Boundary

0 1,500 Feet

1 inch equals 1,500 feet

Please refer to Appendix A-2 Rapid Habitat Assessment Scoring Matrix and pages 14-15 of the Feasibility Study for additional detail.

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Appendix B-5
Stream Asset Inventory Summary

Appendix B-5: Rock Creek Watershed Study Stream Asset Inventory Summary

Reach ID	Project ID	Stability Total Score	Aquatic Total Score	Terrestrial Total Score	Water Quality Total Score	Total Score	Weighted Score	B&V APWA CCSM Stream Assessment	Weighted Geomorphic Assessment	Combined (Equal Ranking)	
83	16	2	5	5	5	17.00	10.00	20.00	9.26	9.63	Higest Benefit
65	12	2	5	5	5	17.00	10.00	18.20	8.43	9.21	
65	12	2	5	5	5	17.00	10.00	18.20	8.43	9.21	
65	12	2	5	5	5	17.00	10.00	18.20	8.43	9.21	
65	12	2	5	5	5	17.00	10.00	18.20	8.43	9.21	
139	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
140	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
141	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
142	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
143	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
144	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
145	10	4	2	4	4	14.00	8.24	21.60	10.00	9.12	
146	32	4	2	4	4	14.00	8.24	21.00	9.72	8.98	
147	32	4	2	4	4	14.00	8.24	21.00	9.72	8.98	
40	7	2	4	4	4	14.00	8.24	20.80	9.63	8.93	
41	7	2	4	4	4	14.00	8.24	20.80	9.63	8.93	
73	8	4	4	2	4	14.00	8.24	20.20	9.35	8.79	
55	3	2	4	4	4	14.00	8.24	20.20	9.35	8.79	
54	3	2	4	4	4	14.00	8.24	20.20	9.35	8.79	
85	17	2	4	4	4	14.00	8.24	20.00	9.26	8.75	
84	17	2	4	4	4	14.00	8.24	20.00	9.26	8.75	
93	18	2	4	4	4	14.00	8.24	19.60	9.07	8.65	
16	23	4	3	4	2	13.00	7.65	21.40	9.91	8.78	
18	24	4	3	4	2	13.00	7.65	21.40	9.91	8.78	
17	24	4	3	4	2	13.00	7.65	21.40	9.91	8.78	
10008	25	2	4	3	4	13.00	7.65	21.40	9.91	8.78	
21	25	2	4	3	4	13.00	7.65	21.40	9.91	8.78	
20	25	2	4	3	4	13.00	7.65	21.40	9.91	8.78	
42	4	2	4	4	4	14.00	8.24	18.60	8.61	8.42	
77	9	2	4	3	4	13.00	7.65	20.20	9.35	8.50	
76	9	2	4	3	4	13.00	7.65	20.20	9.35	8.50	
75	9	2	4	3	4	13.00	7.65	20.20	9.35	8.50	
77	9	2	4	3	4	13.00	7.65	20.20	9.35	8.50	
50	2	2	3	4	3	12.00	7.06	20.20	9.35	8.21	
51	2	2	3	4	3	12.00	7.06	20.20	9.35	8.21	
13	31	3	4	3	4	14.00	8.24	16.40	7.59	7.91	
14	31	3	4	3	4	14.00	8.24	16.40	7.59	7.91	
10010	31	3	4	3	4	14.00	8.24	16.40	7.59	7.91	
15	31	3	4	3	4	14.00	8.24	16.40	7.59	7.91	
9	36	3	4	4	3	14.00	8.24	16.4	7.59	7.91	
11	36	3	4	4	3	14.00	8.24	16.4	7.59	7.91	

Reach ID	Project ID	Stability Total Score	Aquatic Total Score	Terrestrial Total Score	Water Quality Total Score	Total Score	Weighted Score	B&V Stream Assessment	Weighted Geomorphic Assessment	Combined (Equal Ranking)
60	11	2	4	3	4	13.00	7.65	18.20	8.43	8.04
59	11	2	4	3	4	13.00	7.65	18.20	8.43	8.04
58	11	2	4	3	4	13.00	7.65	18.20	8.43	8.04
57	11	2	4	3	4	13.00	7.65	18.20	8.43	8.04
56	11	2	4	3	4	13.00	7.65	18.20	8.43	8.04
91	19	3	3	3	3	12.00	7.06	19.60	9.07	8.07
10006	21	3	3	3	3	12.00	7.06	19.60	9.07	8.07
86	21	3	3	3	3	12.00	7.06	19.60	9.07	8.07
87	21	3	3	3	3	12.00	7.06	19.60	9.07	8.07
89	20	3	3	3	3	12.00	7.06	19.60	9.07	8.07
98	27	4	2	3	2	11.00	6.47	21.20	9.81	8.14
131	33	3	4	2	3	12.00	7.06	18.60	8.61	7.83
49	6	2	3	3	4	12.00	7.06	18.60	8.61	7.83
66	13	2	4	2	4	12.00	7.06	18.20	8.43	7.74
67	14	2	4	2	4	12.00	7.06	18.20	8.43	7.74
82	15	3	3	2	3	11.00	6.47	20.00	9.26	7.86
82	15	3	3	2	3	11.00	6.47	20.00	9.26	7.86
80	15	3	3	2	3	11.00	6.47	20.00	9.26	7.86
79	15	3	3	2	3	11.00	6.47	20.00	9.26	7.86
106	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
107	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
108	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
109	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
110	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
111	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
112	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
113	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
115	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
101	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
102	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
103	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
104	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
100	26	4	2	2	2	10.00	5.88	21.20	9.81	7.85
126	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
127	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
128	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
129	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
130	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
132	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
133	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
134	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
135	33	3	3	2	3	11.00	6.47	18.60	8.61	7.54
136	34	3	3	2	3	11.00	6.47	18.60	8.61	7.54
94	27	3	2	3	2	10.00	5.88	20.00	9.26	7.57

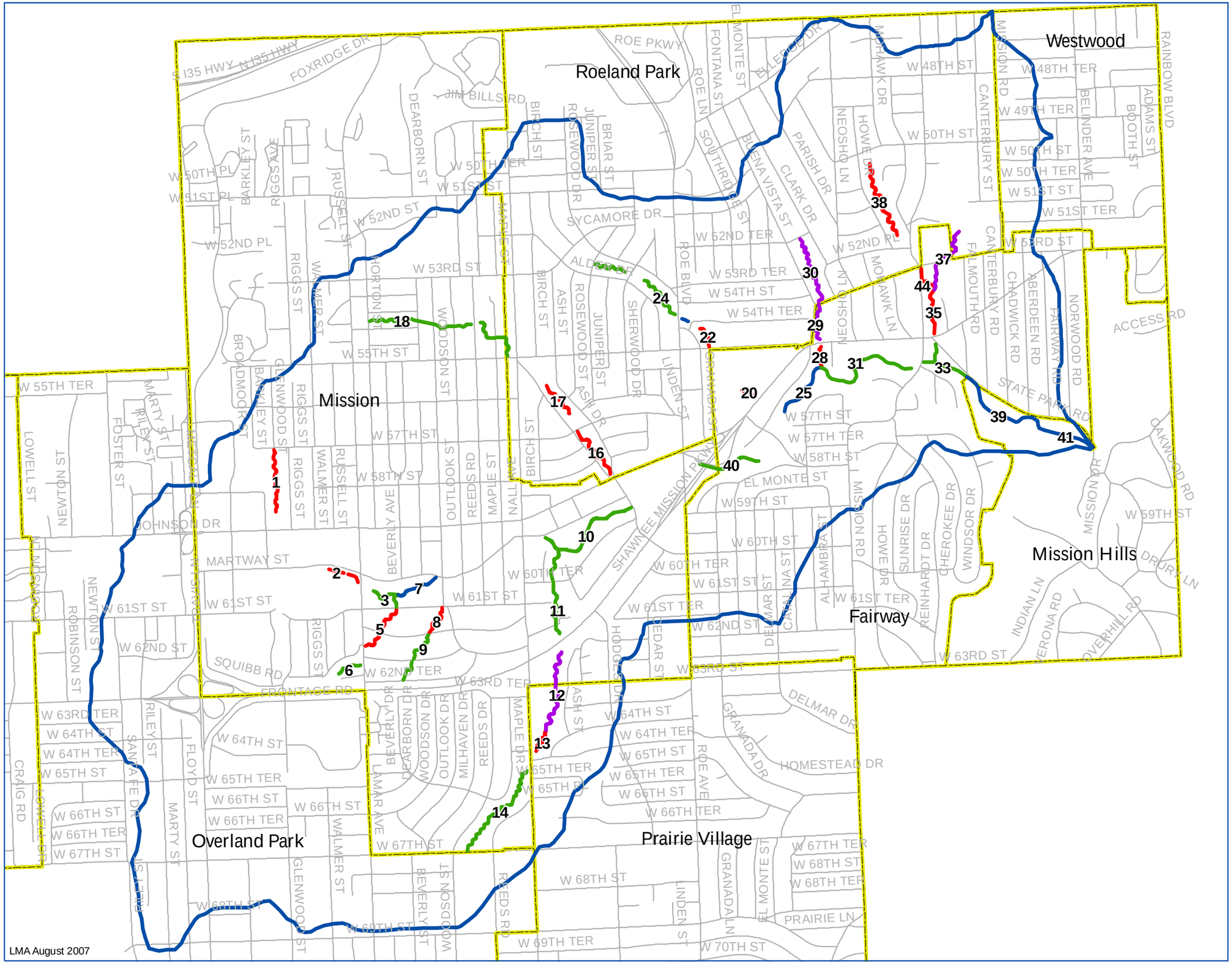
Reach ID	Project ID	Stability Total Score	Aquatic Total Score	Terrestrial Total Score	Water Quality Total Score	Total Score	Weighted Score	B&V Stream Assessment	Weighted Geomorphic Assessment	Combined (Equal Ranking)
95	27	3	2	3	2	10.00	5.88	20.00	9.26	7.57
97	27	3	2	3	2	10.00	5.88	20.00	9.26	7.57
97	27	3	2	3	2	10.00	5.88	20.00	9.26	7.57
0	28	3	2	3	2	10.00	5.88	19.80	9.17	7.52
1	28	3	2	3	2	10.00	5.88	19.80	9.17	7.52
3	29	3	2	3	2	10.00	5.88	19.80	9.17	7.52
5	29	3	2	3	2	10.00	5.88	19.80	9.17	7.52
6	29	3	2	3	2	10.00	5.88	19.80	9.17	7.52
8	30	3	2	3	2	10.00	5.88	19.80	9.17	7.52
7	30	3	2	3	2	10.00	5.88	19.80	9.17	7.52
121	22	2	2	2	2	8.00	4.71	15.40	7.13	5.92
120	22	2	2	2	2	8.00	4.71	15.40	7.13	5.92
119	22	2	2	2	2	8.00	4.71	15.40	7.13	5.92
118	22	2	2	2	2	8.00	4.71	15.40	7.13	5.92
117	22	2	2	2	2	8.00	4.71	15.40	7.13	5.92
116	22	2	2	2	2	8.00	4.71	15.40	7.13	5.92
47	5	1	2	2	1	6.00	3.53	18.60	8.61	6.07
46	5	1	2	2	1	6.00	3.53	18.60	8.61	6.07
45	5	1	2	2	1	6.00	3.53	18.60	8.61	6.07
44	5	1	2	2	1	6.00	3.53	18.60	8.61	6.07
43	5	1	2	2	1	6.00	3.53	18.60	8.61	6.07
10002	1	1	2	2	1	6.00	3.53	15.60	7.22	5.38

Lowest Benefit

Appendix C-1
Prioritized Stream Restoration Map

Rock Creek Watershed Feasibility Study

Appendix C-1 Proposed Stream Restoration Projects



LEGEND

- High Priority
- Moderate Priority
- Lower Priority
- Interjuridictional Projects
- RockCreekWatershed
- City Boundary

0 1,500 Feet

1 inch equals 1,500 feet

BLACK & VEATCH building a world of difference™

ENERGY WATER INFORMATION GOVERNMENT

Appendix C-2
Proposed Stream Improvement Projects

Conceptual Proposed Improvements Project List

1. Improvement Project 1

PRIORITY 12

The existing length of this reach (Reach ID 10002) is 1019 feet, and its 2-year flow was not determined by the NE Johnson County study. The following parameters were determined based on Soar and Thorne criteria for an approximate flow of 198 cfs, taken from a downstream reach:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	16
Wave Length (L)	177
Pool-riffle Spacing	89
Radius of Curvature (Rc)	38
Range*	32-79
Amplitude (Amp)	28

* Absolute minimum – APWA maximum

Issues:

- Some signs of erosion and instability.
- Channelized flow path.
- Existing swale is planted with turf grass, limited infiltration capacity.
- Degrading pipe and inlet infrastructure for downstream half of channel.

Project 1

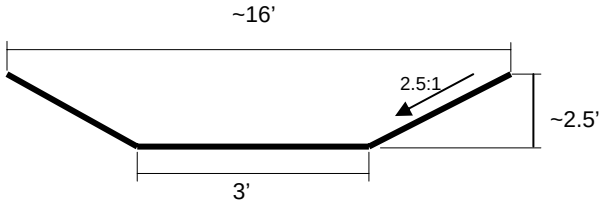
Optimal Restoration:

- Upstream section: Add meandering pattern, vegetate banks and create buffer zone with native vegetation
- Downstream section: Add meandering pattern to channel for low flow conveyance. Match proposed cross-section below.

Limited Restoration:

- Native vegetation of upstream swale.

Project 1



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 143, 127, Priority 12
- Optimal Restoration with Land Acquisition = $450,968
- Limited Restoration = $ 102,612

2. Improvement Project 2

PRIORITY 11

The existing length of this reach (Reach ID 50 and 51) is 467 feet, and its 2-year flow is approximately 499 cfs. The following parameters were determined based on Soar and Thorne criteria for a 499 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	25
Wave Length (L)	282
Pool-riffle Spacing	141
Radius of Curvature (Rc)	60
Range*	50-125
Amplitude (Amp)	45

* Absolute minimum – APWA maximum

Issues:

- Some signs of erosion and instability on left and right banks.
- Lack of flood benches.
- Lack of vegetative material and bank structure.

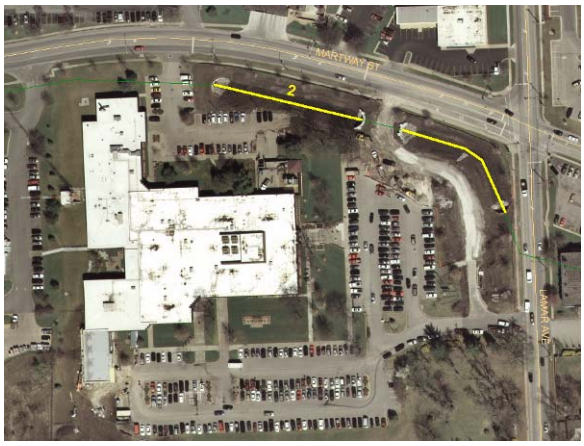
Project 2

Optimal Restoration:

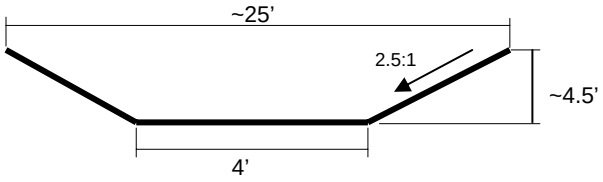
- Vegetate banks and create buffer zone
- Define low flow channel and stabilize areas with riprap.
- Incorporate pool-riffle run sequence.

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 2



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 94,072; Priority 11
- Optimal Restoration with Land Acquisition = $397,472
- Limited Restoration = $ 77,148

3. Improvement Project 3

PRIORITY 28

The existing length of this concrete trapezoidal reach (Reach ID 55 and 54) is 439 feet, and its 2-year flow is 499 cfs. The following parameters were determined based on Soar and Thorne criteria for a 499 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	25
Wave Length (L)	282
Pool-riffle Spacing	141
Radius of Curvature (Rc)	60
Range*	50-125
Amplitude (Amp)	45

* Absolute minimum – APWA maximum

Issues:

- Right and left bank wall requires repair
- Concrete structure provides little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.

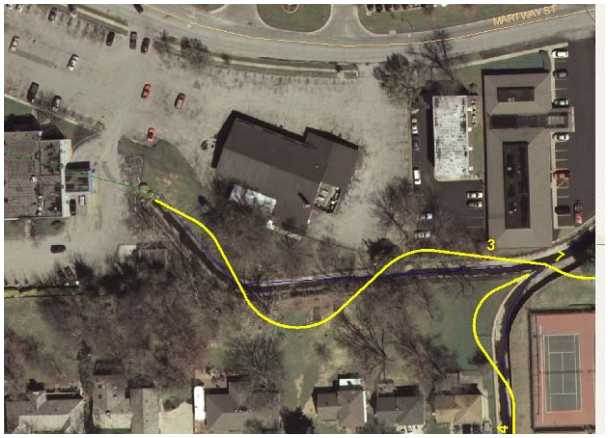
Project 3

Optimal Restoration:

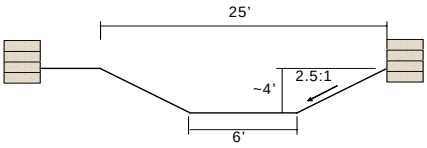
- Add meandering pattern to channel
- Replace wall on right and left banks as needed to develop floodplain benching.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Remove concrete channel
- Replace walls on right and left banks as necessary.
- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 3



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 271,484; Priority 28
- Optimal Restoration with Land Acquisition = $468,428
- Limited Restoration = $ 241,081

4. Improvement Project 4

PRIORITY 26

The existing length of this keystone wall reach (Reach ID 42) is 195 feet, and its 2-year flow is 222 cfs. The following parameters were determined based on Soar and Thorne criteria for a 222 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	17
Wave Length (L)	188
Pool-riffle Spacing	94
Radius of Curvature (Rc)	40
Range*	33-83
Amplitude (Amp)	30

* Absolute minimum – APWA maximum

Issues:

- Concrete and keystone structure provides little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.

Project 4

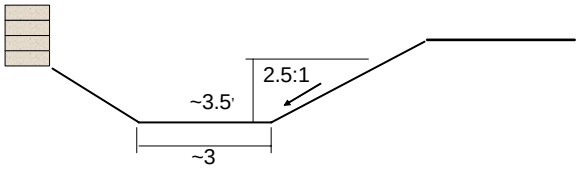
Optimal Restoration:

- Add meandering pattern to channel
- Use existing wall as protection of left bank. Incorporate flood bench, extending into park area.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel as necessary.

Limited Restoration:

- Remove concrete and restore floodplain on right side.
- Limited vegetation of banks.
- Provide rip rap/bank protection of channel as necessary.

Project 4



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 114,899; Priority 26
- Optimal Restoration with Land Acquisition = $127,084
- Limited Restoration = $ 101,886

5. Improvement Project 5

PRIORITY 14

The existing length of this reach (Reach ID 47, 46, 45, 44, 43) flows southwest from W 61st Street toward Lamar Avenue. Its length is 824 feet and its 2-year flow is 222 cfs. It should be noted this stream is one of the most stable in the watershed with excellent habitat availability and very stable bank and bed structure. In this case, a limited approach to restoration is appropriate and a better alternative to disruption of the existing stream. To provide consistent approach, this project was evaluated using the same methodology as other reaches. The following parameters were determined based on Soar and Thorne criteria for a 222 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	17
Wave Length (L)	188
Pool-riffle Spacing	94
Radius of Curvature (Rc)	40
Range*	33-83
Amplitude (Amp)	30

* Absolute minimum – APWA maximum

Issues:

- Limited signs of erosion and instability on left and right banks
- Lack of native understory vegetation.

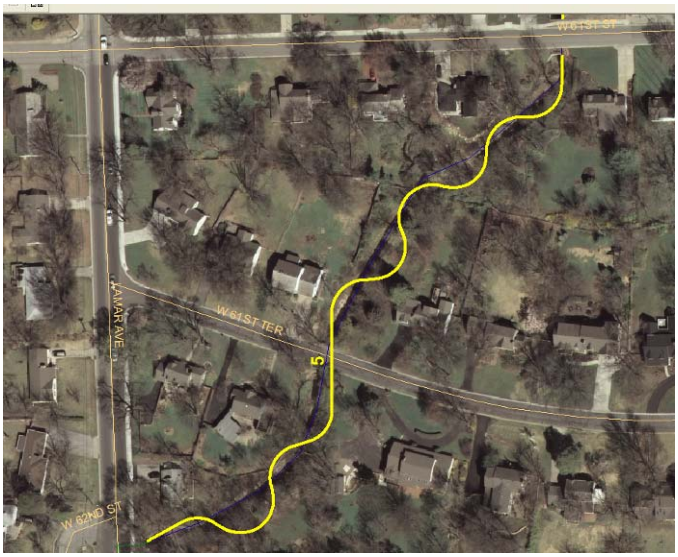
Project 5

Optimal Restoration:

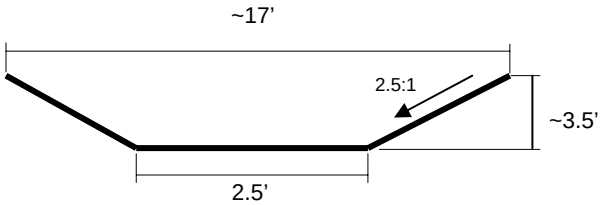
- Add meandering pattern to channel
- Vegetate banks with native plants
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel as necessary.



Project 5



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 153,319; Priority 14
- Optimal Restoration with Land Acquisition = $233,505
- Limited Restoration = $ 108,580

6. Improvement Project 6

PRIORITY 18

The existing length of this reach (Reach ID 49) is 377 feet, and its 2-year flow is 222 cfs. The following parameters were determined based on Soar and Thorne criteria for a 222 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	17
Wave Length (L)	188
Pool-riffle Spacing	94
Radius of Curvature (Rc)	40
Range*	33-83
Amplitude (Amp)	30

* Absolute minimum – APWA maximum

Issues:

- Lack of stream buffer and corridor
- Gabion basket walls provide little benefit to vegetation, habitat, and water quality.

Project 6

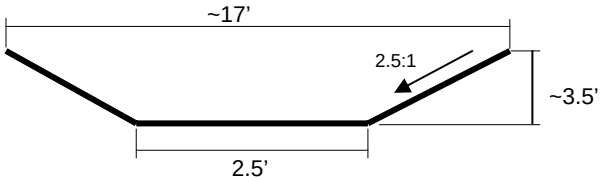
Optimal Restoration:

- Add meandering pattern to channel
- Replace gabion basket walls on right and left bank with recommended cross-section below.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel as necessary

Limited Restoration:

- Replace gabion basket walls on right and left bank with recommended cross-section below.
- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 6



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 109,998; Priority 18
- Optimal Restoration with Land Acquisition = $139,080
- Limited Restoration = $ 91,412

7. Improvement Project 7

PRIORITY 33

The existing length of this concrete trapezoidal reach (Reach ID 40, 41) is 702 feet, and its 2-year flow is 634 cfs. This reach is located directly downstream of the confluence of Projects 3 and 4; it extends to Martway Street. The following parameters were determined based on Soar and Thorne criteria for a 634 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	28
Wave Length (L)	318
Pool-riffle Spacing	159
Radius of Curvature (Rc)	68
Range*	56-141
Amplitude (Amp)	51

* Absolute minimum – APWA maximum

Issues:

- Existing concrete channel is degrading.
- A stream buffer corridor is not present.
- Concrete structure provides little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.

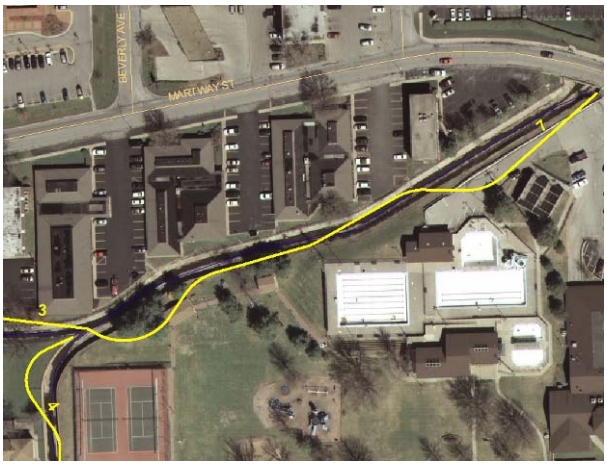
Project 7

Optimal Restoration:

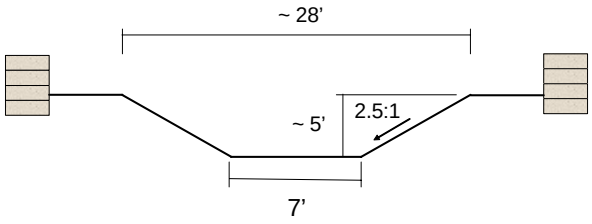
- Add meandering pattern to channel
- Replace wall on right and left bank, allowing an appropriate width to integrate flood benches.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace wall on right and left bank, allowing an appropriate width to integrate flood benches.
- Provide rip rap/bank protection of channel



Project 7



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 603,059; Priority 33
- Optimal Restoration with Land Acquisition = $887,681
- Limited Restoration = $ 556,554

8. Improvement Project 8

PRIORITY 4

The existing length of this Countryside reach (Reach ID 73) is 476 feet, and its 2-year flow is 120 cfs. The following parameters were determined based on Soar and Thorne criteria for a 120 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	12
Wave Length (L)	138
Pool-riffle Spacing	69
Radius of Curvature (Rc)	29
Range*	25-61
Amplitude (Amp)	22

* Absolute minimum – APWA maximum

Issues:

- Significant erosion and instability on left and right banks
- Excessive sedimentation in channel.
- Lack of native vegetation.
- Absence of low flow channel.

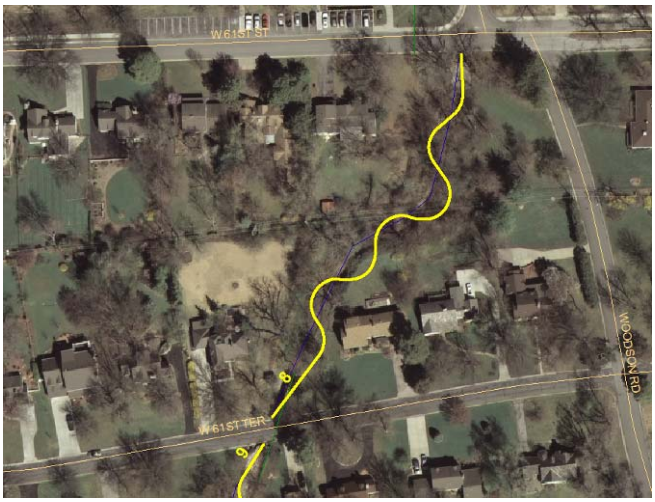
Project 8

Optimal Restoration:

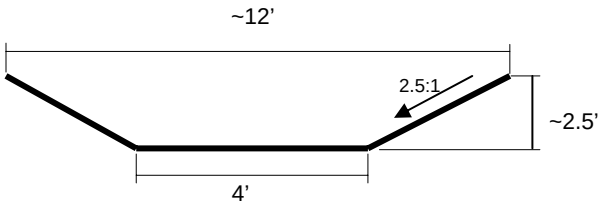
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel
- Development of riffle and pool sections.

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 8



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 76,285; Priority 4
- Optimal Restoration with Land Acquisition = $104,782
- Limited Restoration = $ 50,992

9. Improvement Project 9

PRIORITY 22

The existing length of this reach (Reach ID 77, 76, 75) is 882 feet, and its 2-year flow is approximately 120 cfs. The following parameters were determined based on Soar and Thorne criteria for a 120 cfs flow:

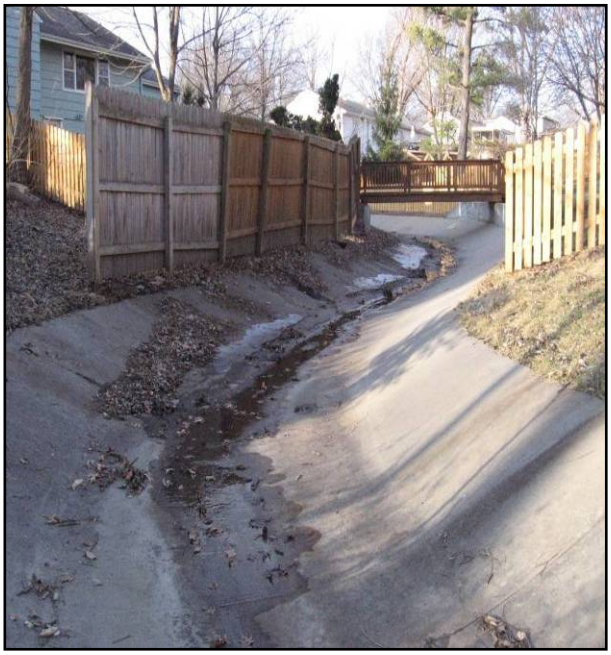
Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	12
Wave Length (L)	138
Pool-riffle Spacing	69
Radius of Curvature (Rc)	29
Range*	25-61
Amplitude (Amp)	22

* Absolute minimum – APWA maximum

Issues:

- Concrete and grouted rock channels are in various conditions.
- Concrete structure provides little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.
- Lack of native vegetation and stream corridor
- Lack of public education about stream.



Project 9

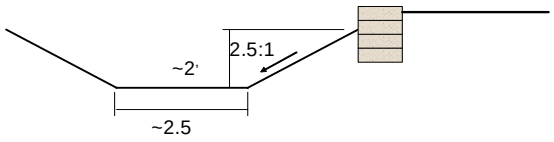
Optimal Restoration:

- Add meandering pattern to channel
- Replace concrete and grouted rock channels with natural slopes and flood benches.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel as necessary

Limited Restoration:

- Replace concrete and grouted rock channels with natural slopes and flood benches.
- Limited vegetation to create corridor
- Provide rip rap/bank protection of channel as necessary

Project 9



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 617,322; Priority 22
- Optimal Restoration with Land Acquisition = $672,671
- Limited Restoration = $ 556,970

10. Improvement Project 10

PRIORITY 30

This project consists of two segments. The first segment (Reach ID 140, 141, 142, 143, 144, and 145) is upstream of the stormwater outfall structure and the confluence with Birch Creek tributary. This segment has an existing length of 1460 feet, and its 2-year flow is 1207 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1207 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	39
Wave Length (L)	438
Pool-riffle Spacing	219
Radius of Curvature (Rc)	93
Range*	78-195
Amplitude (Amp)	70

* Absolute minimum – APWA maximum

The second segment (Reach ID 139) which is downstream of the tributary confluence has an existing length of 274 feet, and its 2-year flow is 1581 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1581 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	45
Wave Length (L)	501
Pool-riffle Spacing	251
Radius of Curvature (Rc)	107
Range*	89-223
Amplitude (Amp)	80

* Absolute minimum – APWA maximum

Improvement Segment #1 of Project 10

Reach ID 139

Project 10 – Segment 1

Issues:

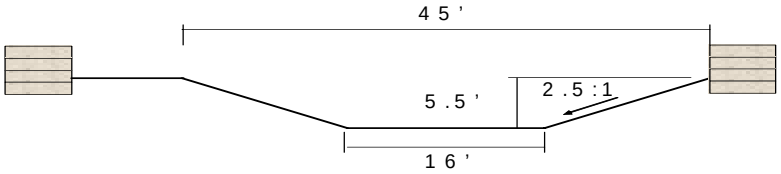
- Significant erosion and instability on left and right banks threaten existing parking lot and building infrastructure.
- Lack of native vegetation and stream corridor.

Optimal Restoration:

- Add meandering pattern to channel
- Develop wall structures allowing appropriate width to develop low flow channel and flood benching.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Recommended Cross Section

Improvement Segment #2 of Project 10

Reach ID 140, 141, 142

Issues:

- Signs of instability and erosion.
- Lack of native vegetation and stream buffer

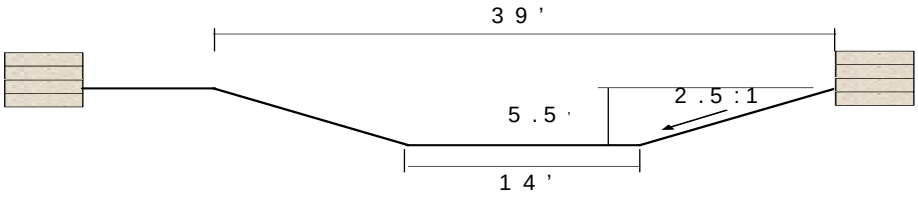
Project 10 – Segment 2

Optimal Restoration:

- Incorporate meander pattern where space allows.
- Add walls to allow width for stable cross section.
- Vegetate both banks and create buffer zone
- Provide rip rap/bank protection of channel as necessary

Limited Restoration:

- Add wall on right bank.
- Limited vegetation of both banks
- Provide rip rap/bank protection of channel



Recommended Cross Section

Improvement Segment #3 of Project 10

Reach ID 143 and 144

Issues:

- Newer gabion basket walls on both banks provide little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.

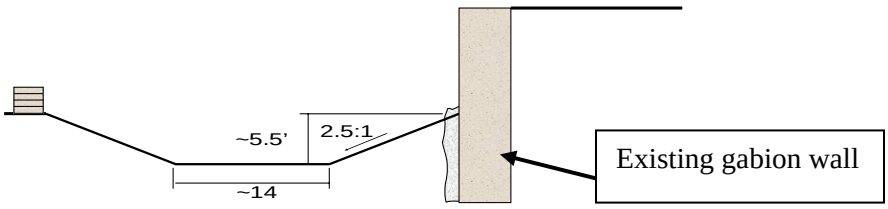
Project 10 – Segment 3

Optimal Restoration:

- Incorporate additional vegetate on both banks and create more substantial buffer zone
- Develop conceptual cross section between existing bank structures.
- Provide rip rap/bank protection of channel and develop flood benching as necessary.

Limited Restoration:

- Limited vegetation of both banks.
- Develop conceptual cross section between existing bank structures.
- Provide rip rap/bank protection of channel



Recommended Cross Section

Improvement Segment #4 of Project 10

Reach ID 145

Project 10 – Segment 4

Issues:

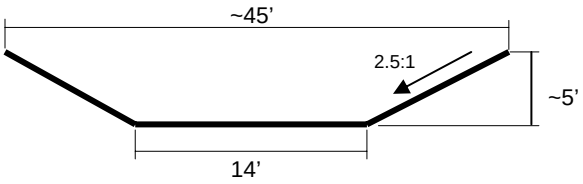
- Overwidening of cross section and lack of flood benching allows for excessive sediment deposition.
- Newer gabion basket walls on both banks provide little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.

Optimal Restoration:

- Add meandering pattern to channel.
- Vegetate banks and create buffer zone
- Develop a stable cross section based on Soar & Thorne methodology within existing gabion walls.
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Develop a stable cross section based on Soar & Thorne methodology within existing gabion walls.
- Provide rip rap/bank protection of channel as necessary.



Project 10 **Recommended Cross Section**

Estimated Improvement Cost for Project 10:

- Optimal Restoration = $ 1,218,892; Priority 30
- Optimal Restoration with Land Acquisition = $2,099,762
- Limited Restoration = $ 1,051,844

11. Improvement Project 11

PRIORITY 29

This downstream section of the Birch Creek tributary extends from Shawnee Mission Parkway to its confluence with Rock Creek. The existing length of this reach (Reach ID 60, 59, 58, 57, 56) is 1440 feet, and its 2-year flow is 394 cfs. The following parameters were determined based on Soar and Thorne criteria for a 394 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	22
Wave Length (L)	250
Pool-riffle Spacing	125
Radius of Curvature (Rc)	53
Range*	44-111
Amplitude (Amp)	40

* Absolute minimum – APWA maximum

Issues:

- Right and left bank wall are aging.
- Absence of a stream corridor and native vegetation.
- Concrete channels provide little habitat or water quality value, increases flow velocities and possibly contributes to downstream flooding concerns.

Project 11

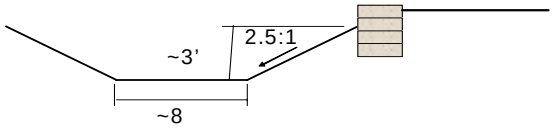
Optimal Restoration:

- Add meandering pattern to channel
- Replace concrete channel with stable cross section.
- Incorporate native vegetation and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace wall on right/left(?) bank
- Replace concrete channel with stable cross section.
- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 11



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 817,281; Priority 29
- Optimal Restoration with Land Acquisition = $1,023,886
- Limited Restoration = $ 735,960

12. Improvement Project 12

PRIORITY 13

This reach (Reach ID 65) is currently underground. Its existing length is 1593 feet, and its 2-year flow is 207 cfs. The following parameters were determined based on Soar and Thorne criteria for a 207 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	16
Wave Length (L)	181
Pool-riffle Spacing	91
Radius of Curvature (Rc)	39
Range*	32-81
Amplitude (Amp)	29

* Absolute minimum – APWA maximum

Issues:

- Underground structure is aging.
- Piped streams provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.

Project 12

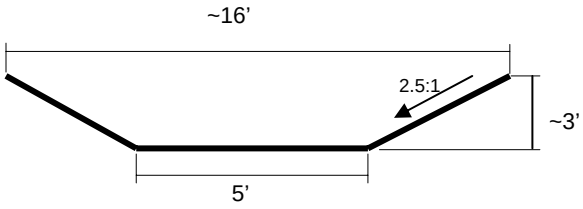
Optimal Restoration:

- Replace underground structure with open channel such as the stable cross section determined by Soar & Thorne's method.
- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel as necessary.

Limited Restoration:

- Replace underground structure with open, stable cross section.
- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 12



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 1,652,519; Priority 13
- Optimal Restoration with Land Acquisition = $1,922,209
- Limited Restoration = $ 1,450,128

13. Improvement Project 13

PRIORITY 16

The existing length of this reach (Reach ID 66) is 392 feet, and its 2-year flow is approximately 127 cfs. The following parameters were determined based on Soar and Thorne criteria for a 127 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	13
Wave Length (L)	142
Pool-riffle Spacing	71
Radius of Curvature (Rc)	30
Range*	25-63
Amplitude (Amp)	23

* Absolute minimum – APWA maximum

Issues:

- Concrete channels provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.
- Lack of stream corridor buffer

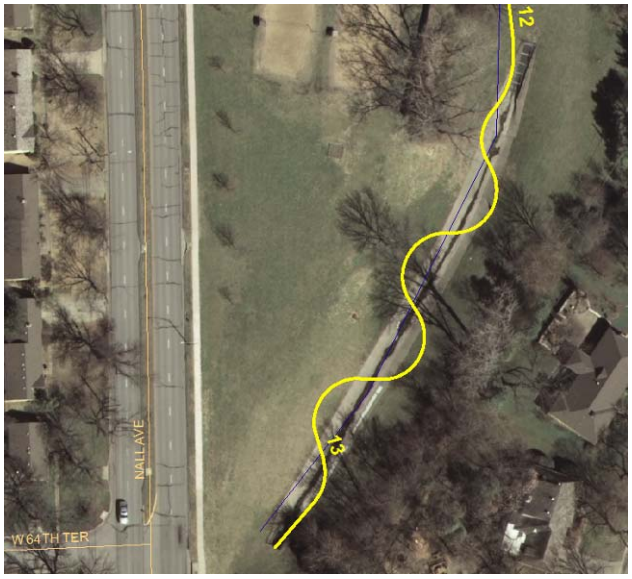
Project 13

Optimal Restoration:

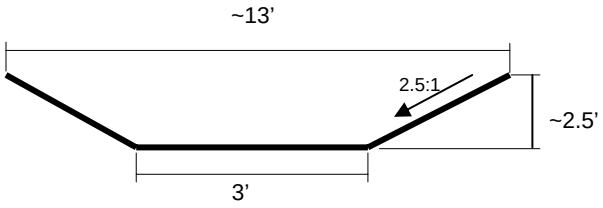
- Add meandering pattern to channel
- Replace concrete channel with stable cross section
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace concrete channel with stable cross section
- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 13



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 100,994; Priority 16
- Optimal Restoration with Land Acquisition = $144,253
- Limited Restoration = $ 84,194

14. Improvement Project 14

PRIORITY 27

The existing length of this reach (Reach ID 67) is 1579 feet, and its 2-year flow is approximately 100 cfs. The following parameters were determined based on Soar and Thorne criteria for a 100 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	11
Wave Length (L)	126
Pool-riffle Spacing	63
Radius of Curvature (Rc)	27
Range*	22-56
Amplitude (Amp)	20

* Absolute minimum – APWA maximum

Issues:

- Concrete channels provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.
- Lack of stream corridor buffer

Project 14

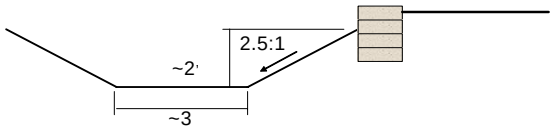
Optimal Restoration:

- Add meandering pattern to channel
- Replace concrete structure with stable cross section.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace concrete structure with stable cross section.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Project 14



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 912,945; Priority 27
- Optimal Restoration with Land Acquisition = $1,102,624
- Limited Restoration = $ 806,853

15. Improvement Project 15

PRIORITY 10

The existing length of this reach (Reach ID 82, 80, 79) is 1003 feet, and its 2-year flow is 268 cfs. The following parameters were determined based on Soar and Thorne criteria for a 268 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	18
Wave Length (L)	206
Pool-riffle Spacing	103
Radius of Curvature (Rc)	44
Range*	37-92
Amplitude (Amp)	33

* Absolute minimum – APWA maximum

Issues:

- Observed instability and erosion on left and right banks
- Substrate is not well graded, consisting of mostly silts.

Project 16

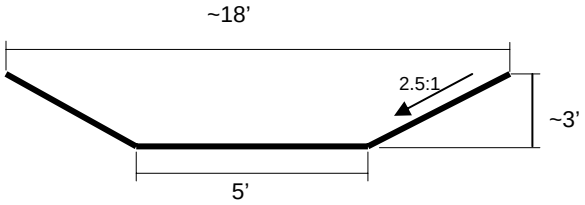
Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Develop stable cross section as drawn
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Develop stable cross section
- Provide rip rap/bank protection of channel

Project 15



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 253,154; Priority 10
- Optimal Restoration with Land Acquisition = $307,746
- Limited Restoration = $ 200,741

16. Improvement Project 16

PRIORITY 15

The existing length of this underground reach (Reach ID 83) is 637 feet, and its 2-year flow is 268 cfs. The following parameters were determined based on Soar and Thorne criteria for a 268 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	18
Wave Length (L)	206
Pool-riffle Spacing	103
Radius of Curvature (Rc)	44
Range*	37-92
Amplitude (Amp)	33

* Absolute minimum – APWA maximum

Issues:

- Piped streams provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.

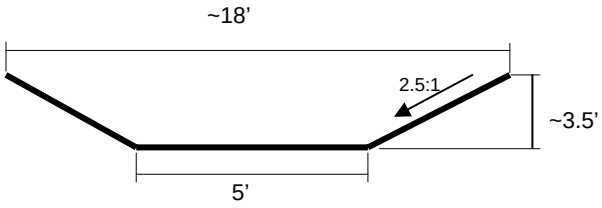
Optimal Restoration:

- Add meandering pattern to channel
- Develop stable cross section.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Develop stable cross section
- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 16



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 184,641; Priority 15
- Optimal Restoration with Land Acquisition = $251,060
- Limited Restoration = $ 159,331

17. Improvement Project 17

PRIORITY 24

This concrete channel (Reach ID 85, 84) extends 2206 feet, and its 2-year flow is 268 cfs. The following parameters were determined based on Soar and Thorne criteria for a 268 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	18
Wave Length (L)	206
Pool-riffle Spacing	103
Radius of Curvature (Rc)	44
Range*	37-92
Amplitude (Amp)	33

* Absolute minimum – APWA maximum

Issues:

- Concrete channel is aging.
- Lack of vegetated stream corridor.
- Lack of community awareness of watersheds, water quality, and stream corridors.

Project 17

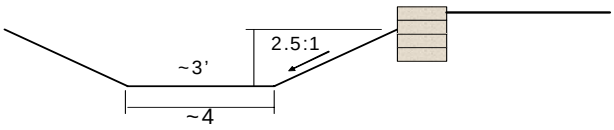
Optimal Restoration:

- Add meandering pattern to channel
- Replace concrete with stable cross section.
- Vegetate right/left banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace concrete with stable cross section.
- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 17



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 1,155,041; Priority 24
- Optimal Restoration with Land Acquisition = $1,324,185
- Limited Restoration = $ 1,048,936

18. Improvement Project 33

PRIORITY 23

This project consists of two segments. The first segment (Reach ID 136) has an existing length of 164 feet, and its 2-year flow is 1581 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1581 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	45
Wave Length (L)	501
Pool-riffle Spacing	251
Radius of Curvature (Rc)	107
Range*	89-223
Amplitude (Amp)	80

* Absolute minimum – APWA maximum

The second segment (Reach ID 126, 127, 128, 129, 130, 131, 132, 133, 134, 135) is 1018 feet, and its 2-year flow is 1700 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1700 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	46
Wave Length (L)	520
Pool-riffle Spacing	260
Radius of Curvature (Rc)	111
Range*	92-231
Amplitude (Amp)	83

* Absolute minimum – APWA maximum

Improvement Segment #1 of Project 33

Reach ID 136

Issues:

- Limited infrastructure is degrading
- Some signs of erosion on both banks
- Concrete channels provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.

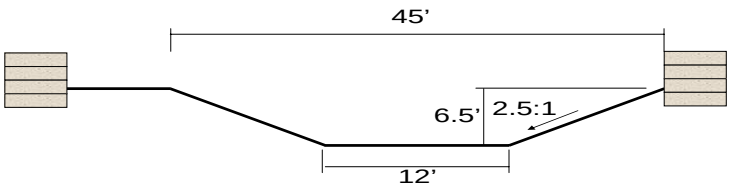
Project 33 – Segment 1

Optimal Restoration:

- Add meandering pattern to channel
- Replace left and right channel wall with sufficient width to develop low flow channel and flood benches.
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace left and right channel wall with sufficient width to develop low flow channel and flood benches.
- Provide rip rap/bank protection of channel



Recommended Cross Section

Improvement Segment #2 of Project 33

Reach ID 126-135

Issues:

- Some signs of instability and erosion on both banks
- Lack of community education of water quality and stream corridors.

Project 33 – Segment 2

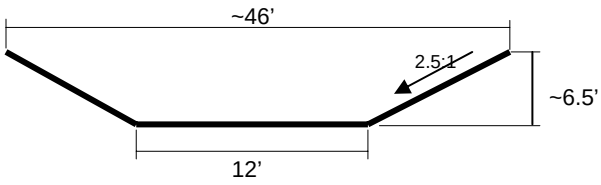
Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Develop stable cross section, providing bank protection
- Limited vegetation of banks

Project 33



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $513,360; Priority 23
- Optimal Restoration with Land Acquisition = $533,490
- Limited Restoration = $440,950

19. Improvement Project 18

PRIORITY 8

This short reach (Reach ID 93) extends only 236 feet, and its 2-year flow is 156 cfs. The following parameters were determined based on Soar and Thorne criteria for a 156 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	14
Wave Length (L)	158
Pool-riffle Spacing	79
Radius of Curvature (Rc)	34
Range*	28-70
Amplitude (Amp)	25

* Absolute minimum – APWA maximum

Issues:

- Existing channel experiencing degradation.
- Concrete channels provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.

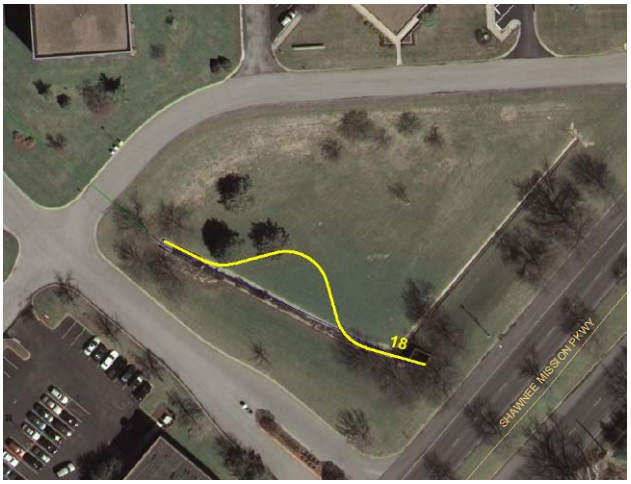
Project 18

Optimal Restoration:

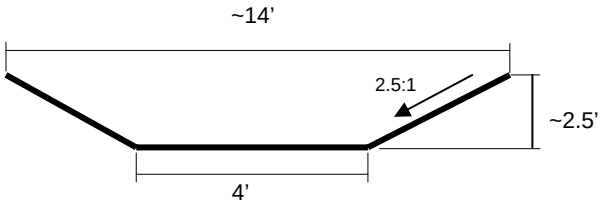
- Add meandering pattern to channel
- Replace concrete channel with stable cross section.
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace concrete channel with stable cross section
- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 18



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 48,481; Priority 8
- Optimal Restoration with Land Acquisition = $48,481 (Public Land)
- Limited Restoration = $ 38,127

20. Improvement Project 19

PRIORITY 6

The existing length of this reach (Reach ID 91) is 354 feet, and its 2-year flow is 174 cfs. The following parameters were determined based on Soar and Thorne criteria for a 174 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	15
Wave Length (L)	166
Pool-riffle Spacing	83
Radius of Curvature (Rc)	35
Range*	30-74
Amplitude (Amp)	27

* Absolute minimum – APWA maximum

Issues:

- Some signs of instability and erosion on both banks

Project 19

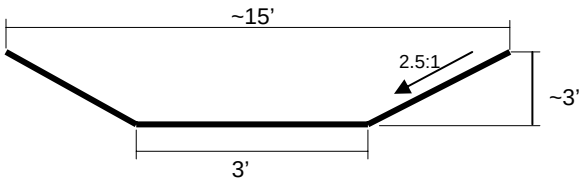
Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 19



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 54,849; Priority 6
- Optimal Restoration with Land Acquisition = $84,670
- Limited Restoration = $ 40,389

21. Improvement Project 20

PRIORITY 32

The existing length of this reach (Reach ID 89) is 143 feet, and its 2-year flow is 174 cfs. The following parameters were determined based on Soar and Thorne criteria for a 174 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	15
Wave Length (L)	166
Pool-riffle Spacing	83
Radius of Curvature (Rc)	35
Range*	30-74
Amplitude (Amp)	27

* Absolute minimum – APWA maximum

Issues:

- At upstream end, right bank should be stabilized.
- At downstream end, both right and left bank stabilization is deteriorating.
- Overwidened upstream section allows excessive sediment deposition.

Project 20

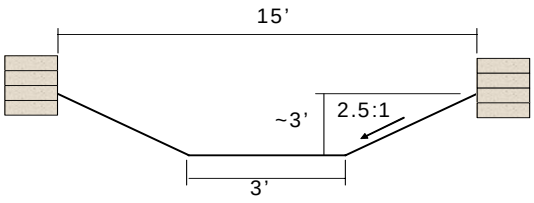
Optimal Restoration:

- Develop wall on right bank to allow for a floodplain bench.
- Incorporate vegetation and stream buffer.
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace right bank wall as necessary.
- Incorporate vegetation and stream buffer.
- Provide rip rap/bank protection of channel

Project 20



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 106,660; Priority 32
- Optimal Restoration with Land Acquisition = $115,455
- Limited Restoration = $ 100,508

22. Improvement Project 21

PRIORITY 20

The existing length of this reach (Reach ID 86, 87) is 1280 feet, and its 2-year flow is 174 cfs. The following parameters were determined based on Soar and Thorne criteria for a 174 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	15
Wave Length (L)	166
Pool-riffle Spacing	83
Radius of Curvature (Rc)	35
Range*	30-74
Amplitude (Amp)	27

* Absolute minimum – APWA maximum

<u>Improvement Segment #1 of Reach 21</u>

Reach ID 86

Project 21 – Segment 1

Issues:

- Some signs of erosion and instability
- Lack of public access to stream

Optimal Restoration:

- Add meandering pattern to channel
- Replace channel structures with stable cross section
- Vegetate both banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace channel structures with stable cross section
- Vegetate both banks and create buffer zone
- Provide rip rap/bank protection of channel

<u>Improvement Segment #2 of Project 21</u>

Reach ID 87

Project 21 – Segment 2

Issues:

- Some signs of instability and erosion on banks
- Lack of native vegetation and stream corridor

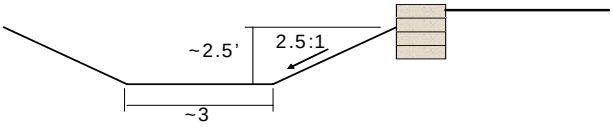
Optimal Restoration:

- Add meandering pattern to channel
- Replace channel structures with stable cross section
- Vegetate both banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace channel structures with stable cross section
- Vegetate both banks and create buffer zone
- Provide rip rap/bank protection of channel

Project 21



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 611,992; Priority 20
- Optimal Restoration with Land Acquisition = $714,470
- Limited Restoration = $ 537,735

23. Improvement Project 22

PRIORITY 31

The existing length of this reach (Reach ID 121, 120, 119, 118, 117, 116) is 1067 feet, and its 2-year flow is 1868 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1868 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	48
Wave Length (L)	545
Pool-riffle Spacing	273
Radius of Curvature (Rc)	116
Range*	97-242
Amplitude (Amp)	87

* Absolute minimum – APWA maximum

Issues:

- Significant erosion and instability on both banks

Project 22

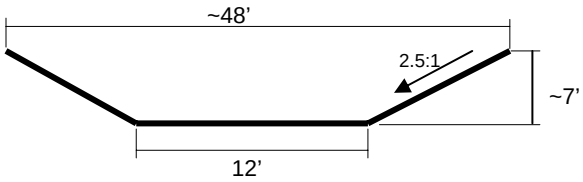
Optimal Restoration:

- Add meandering pattern to channel
- Integrate recommended stable cross section
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Integrate recommended stable cross section
- Limited vegetation of banks
- Provide rip rap/bank protection of channel as necessary

Project 22



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 510,715; Priority 31
- Optimal Restoration with Land Acquisition = $621,451
- Limited Restoration = $ 445,145

24. Improvement Project 26

PRIORITY 19

The existing length of this reach (Reach ID 99, 100, 101, 102, 103, 104, 106, 107, 108, 109, 110, 111, 112, 113, 115) is 2622 feet, and its 2-year flow is 1854 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1854 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	48
Wave Length (L)	543
Pool-riffle Spacing	272
Radius of Curvature (Rc)	116
Range*	96-241
Amplitude (Amp)	87

* Absolute minimum – APWA maximum

Issues:

- Instability and erosion in key areas along project length as stream is naturally attempting to transition into a stable form.
- Lack of consistent stream buffer between creek and neighborhood lawns.

Project 26

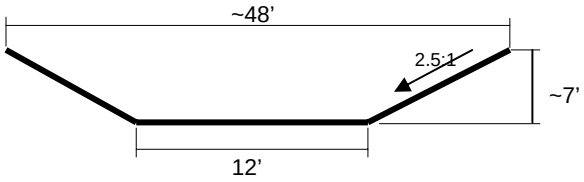
Optimal Restoration:

- Add meandering pattern to channel where applicable
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel where necessary

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 26



Recommended Cross Section

Estimated Improvement Project Cost:

- Optimal Restoration = $ 610,596; Priority 19
- Optimal Restoration with Land Acquisition = $1,000,668
- Limited Restoration = $ 511,405

25. Improvement Project 23

PRIORITY 1

The existing length of this reach (Reach ID 16) is 308 feet, and its 2-year flow is 100 cfs. The low cost of restoring this reach produced a high priority rank. However, restoration potential and influence are limited by completion of this project alone. The following parameters were determined based on Soar and Thorne criteria for a 100 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	11
Wave Length (L)	126
Pool-riffle Spacing	63
Radius of Curvature (Rc)	27
Range*	22-56
Amplitude (Amp)	20

* Absolute minimum – APWA maximum

Issues:

- Some signs of instability and erosion on both banks.
- Significant sediment deposition of silts, limiting soil gradation.

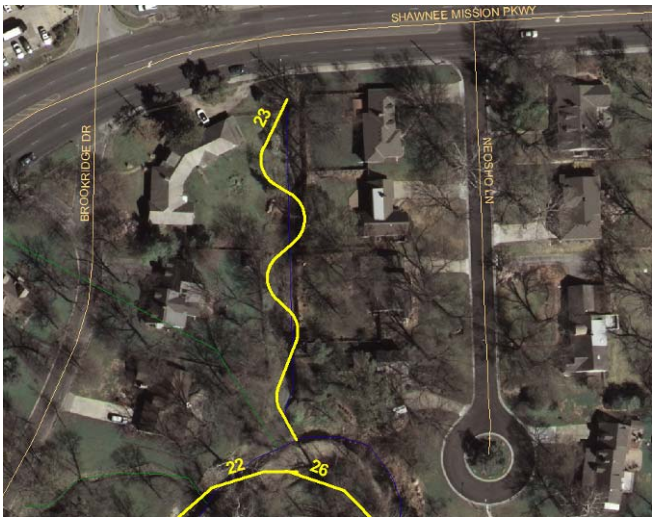
Project 23

Optimal Restoration:

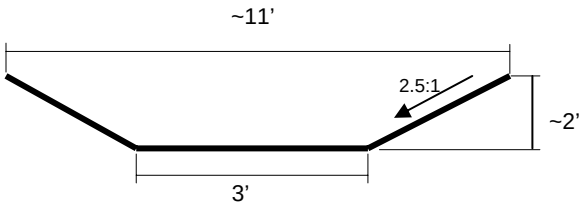
- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 23



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 43,214; Priority 1
- Optimal Restoration with Land Acquisition = $149,356
- Limited Restoration = $ 27,675

26. Improvement Project 24

PRIORITY 2

The existing length of this reach (Reach ID 18, 17) is 593 feet, and its 2-year flow is approximately 100 cfs. The following parameters were determined based on Soar and Thorne criteria for a 100 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	11
Wave Length (L)	126
Pool-riffle Spacing	63
Radius of Curvature (Rc)	27
Range*	22-56
Amplitude (Amp)	20

* Absolute minimum – APWA maximum

Issues:

- Significant down-cutting, instability and erosion
- Lack of native vegetation and stream corridor.

Project 24

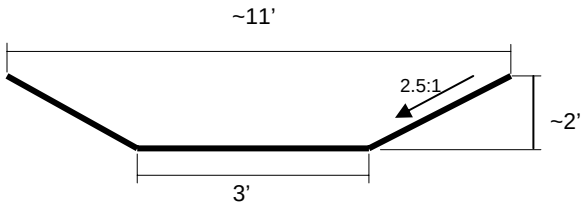
Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel as necessary

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel as necessary

Project 24



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 78,011; Priority 2
- Optimal Restoration with Land Acquisition = $154,281
- Limited Restoration = $ 52,709

27. Improvement Project 25

PRIORITY 3

The existing length of this intermittent reach (Reach ID 20, 21) is 1064 feet, and its 2-year flow is approximately 100 cfs. The following parameters were determined based on Soar and Thorne criteria for a 100 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	11
Wave Length (L)	126
Pool-riffle Spacing	63
Radius of Curvature (Rc)	27
Range*	22-56
Amplitude (Amp)	20

* Absolute minimum – APWA maximum

Issues:

- Some signs of erosion and instability.
- Channelized flow path.
- Existing swale is planted with turf grass, limited infiltration capacity.

Project 25

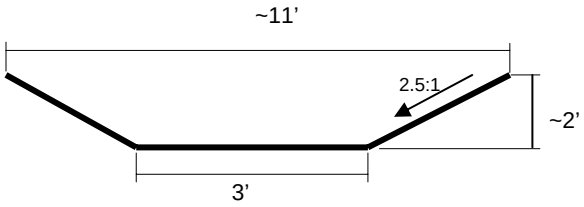
Optimal Restoration:

- Add meandering pattern to a conveyance swale to slow flows during storm events
- Vegetate swale and create buffer zone
- Provide rip rap/bank protection if necessary

Limited Restoration:

- Limited vegetation of swale
- Provide rip rap/bank protection if necessary

Project 25



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 153,262; Priority 3
- Optimal Restoration with Land Acquisition = $380,328
- Limited Restoration = $ 98,694

28. Improvement Project 28

PRIORITY 25

The existing length of this reach (Reach ID 0, 1) is 271 feet, and its 2-year flow is 347 cfs. The following parameters were determined based on Soar and Thorne criteria for a 347 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	21
Wave Length (L)	235
Pool-riffle Spacing	117
Radius of Curvature (Rc)	50
Range*	42-104
Amplitude (Amp)	38

* Absolute minimum – APWA maximum

Issues:

- Some signs of instability and erosion on both banks
- Lack of native vegetation

Project 28

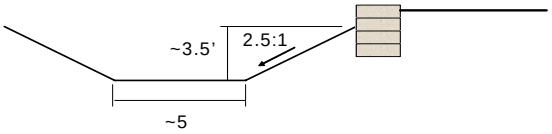
Optimal Restoration:

- Add channel wall on left and right banks
- Incorporate vegetation and stable cross section
- Provide rip rap/bank protection of channel

Limited Restoration:

- Add channel wall on left bank
- Limited vegetation of both banks
- Provide rip rap/bank protection of channel as necessary

Project 28



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 124,328; Priority 25
- Optimal Restoration with Land Acquisition = $162,991
- Limited Restoration = $ 109,000

29. Improvement Project 29

PRIORITY 17

The existing length of this reach (Reach ID 3, 5, 6) is 767 feet, and its 2-year flow is 347 cfs. The following parameters were determined based on Soar and Thorne criteria for a 347 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	21
Wave Length (L)	235
Pool-riffle Spacing	117
Radius of Curvature (Rc)	50
Range*	42-104
Amplitude (Amp)	38

* Absolute minimum – APWA maximum

<u>Improvement Segment #1 of Project 29</u>

Reach ID 3

Issues:

- Channel infrastructure degrading
- Lack of stream buffer between lawns and tributary

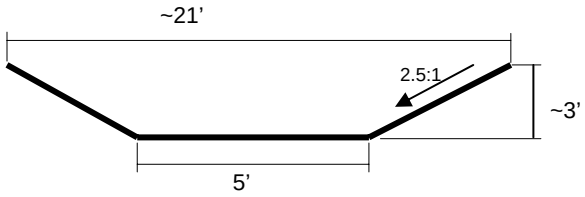
Project 29 – Segment 1

Optimal Restoration:

- Add meandering pattern to channel
- Develop stable cross section
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Recommended Cross Section

<u>Improvement Segment #2 of Project 29</u>

Reach ID 5, 6

Issues:

- Observed instability and erosion on both banks

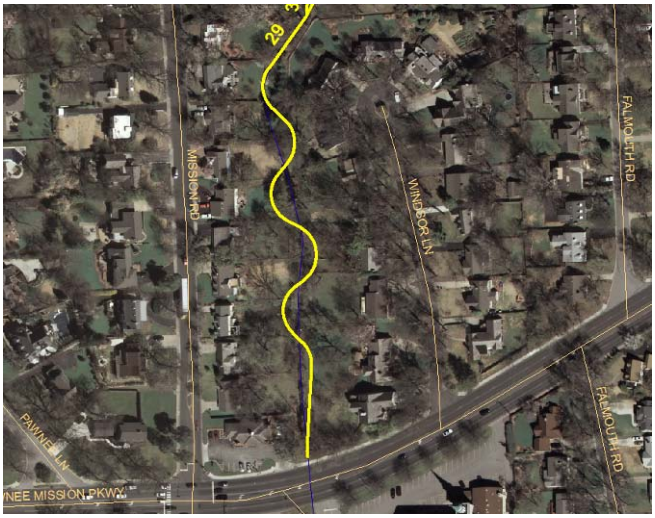
Project 29 – Segment 2

Optimal Restoration:

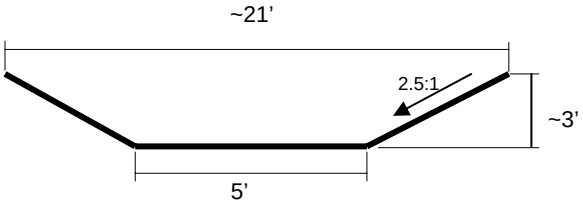
- Add meandering pattern to channel
- Develop stable cross section
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Develop stable cross section
- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 29



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 209,423; Priority 17
- Optimal Restoration with Land Acquisition = $403,931
- Limited Restoration = $ 146,937

30. Improvement Project 30

PRIORITY: 7

The existing length of this reach (Reach ID 7, 8) is 1109 feet, and its 2-year flow is approximately 150 cfs. The following parameters were determined based on Soar and Thorne criteria for a 150 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	14
Wave Length (L)	154
Pool-riffle Spacing	77
Radius of Curvature (Rc)	33
Range*	27-69
Amplitude (Amp)	25

* Absolute minimum – APWA maximum

Issues:

- Some signs of instability and erosion on both banks
- Lack of vegetated stream corridor

Project 30

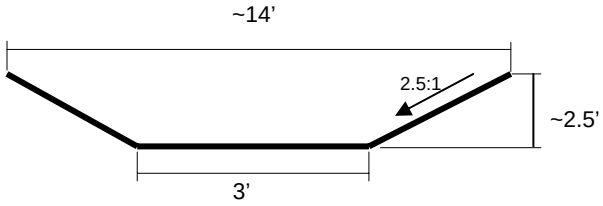
Optimal Restoration:

- Develop stable cross section
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 30



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 113,883; Priority 7
- Optimal Restoration with Land Acquisition = $209,993
- Limited Restoration = $ 76,997

31. Improvement Project 36

PRIORITY 5

The existing length of this reach (Reach ID 9, 11) is 481 feet, and its 2-year flow is 175 cfs. The following parameters were determined based on Soar and Thorne criteria for a 175 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	15
Wave Length (L)	167
Pool-riffle Spacing	83
Radius of Curvature (Rc)	36
Range*	30-74
Amplitude (Amp)	27

* Absolute minimum – APWA maximum

Issues:

- Some signs of instability and erosion on both banks

Project 36

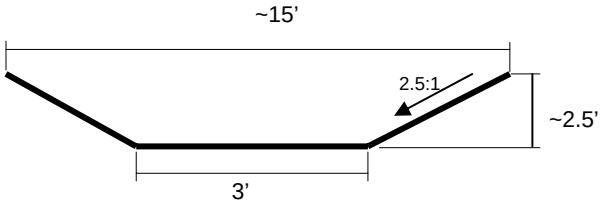
Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 36



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 63,516; Priority 5
- Optimal Restoration with Land Acquisition = $63,516 (Public Land)
- Limited Restoration = $ 50,973

32. Improvement Project 31

PRIORITY 9

The existing length of this reach (Reach ID 13, 14, 15) is 1247 feet, and its 2-year flow is 175 cfs. The following parameters were determined based on Soar and Thorne criteria for a 175 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	15
Wave Length (L)	167
Pool-riffle Spacing	83
Radius of Curvature (Rc)	36
Range*	30-74
Amplitude (Amp)	27

* Absolute minimum – APWA maximum

<u>Improvement Segment #1 of Reach 31</u>

Reach ID 13

Issues:

- Some signs of instability and erosion on both banks
- Channelized section lacking meander pattern

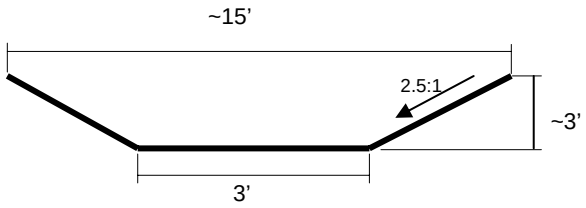
Project 31 – Segment 1

Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel
- Develop stream corridor buffer

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel
- Develop stream corridor buffer



Recommended Cross Section

<u>Improvement Segment #2 of Project 31</u>

Reach ID 14

Issues:

- Large scour hole at end of concrete channel.
- Observed erosion and lack of stream buffer

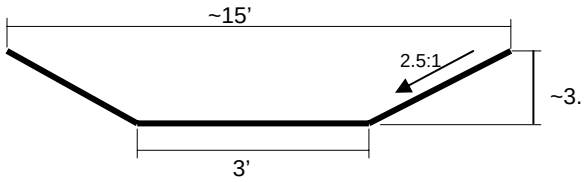
Project 31 – Segment 2

Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Recommended Cross Section

<u>Improvement Segment #3 of Project 31</u>

Reach ID 15

Issues:

- Concrete channels provide little habitat or water quality value, increase flow velocities and possibly contribute to downstream flooding concerns.
- Lack of stream corridor buffer and native vegetation

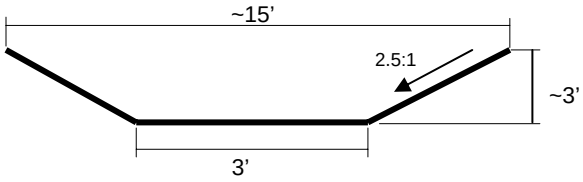
Optimal Restoration:

- Add meandering pattern to channel
- Replace concrete with stable cross section
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

Limited Restoration:

- Replace concrete with stable cross section
- Limited vegetation of banks
- Provide rip rap/bank protection of channel

Project 31



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 247,283; Priority 9
- Optimal Restoration with Land Acquisition = $525,132
- Limited Restoration = $ 166,137

33. Improvement Project 27

PRIORITY 21

This project consists of two segments, divided by a tributary (Reach ID 34). The first segment (Reach ID 98) has an existing length of 183 feet, and its 2-year flow is 1854 cfs. The following parameters were determined based on Soar and Thorne criteria for a flow of 1854 cfs:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	48
Wave Length (L)	543
Pool-riffle Spacing	272
Radius of Curvature (Rc)	116
Range*	96-241
Amplitude (Amp)	87

* Absolute minimum – APWA maximum

The second segment (Reach ID 94, 95, 97) is 2746 feet, and its 2-year flow is 1999 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1999 cfs flow:

Recommended Channel Shape

Parameter	Value (ft)
Main Channel Width (w)	50
Wave Length (L)	564
Pool-riffle Spacing	282
Radius of Curvature (Rc)	120
Range*	100-250
Amplitude (Amp)	90

* Absolute minimum – APWA maximum

Improvement Segment #1 of Project 27

This project consists of two segments, divided by a tributary (Reach ID 34). The first segment (Reach ID 98) has an existing length of 183 feet, and its 2-year flow is 1854 cfs. The following parameters were determined based on Soar and Thorne criteria for a flow of 1854 cfs:

Reach ID 98

Project 27 – Segment 1

Issues:

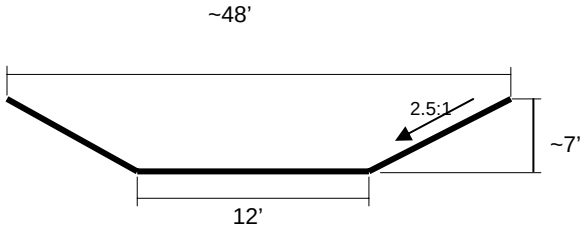
- Evidence of erosion and instability
- Lack of native vegetation and stream buffer

Optimal Restoration:

- Add meandering pattern to channel
- Develop stable cross section with natural slopes and benching
- Provide rip rap/bank protection of channel

Limited Restoration:

- Develop stable cross section with natural slopes and benching
- Provide rip rap/bank protection of channel



Recommended Cross Section

Improvement Segment #2 of Project 27

Issues:

- Some signs of instability and erosion on both banks
- Lack of stream buffer between lawns, parking lots and creek

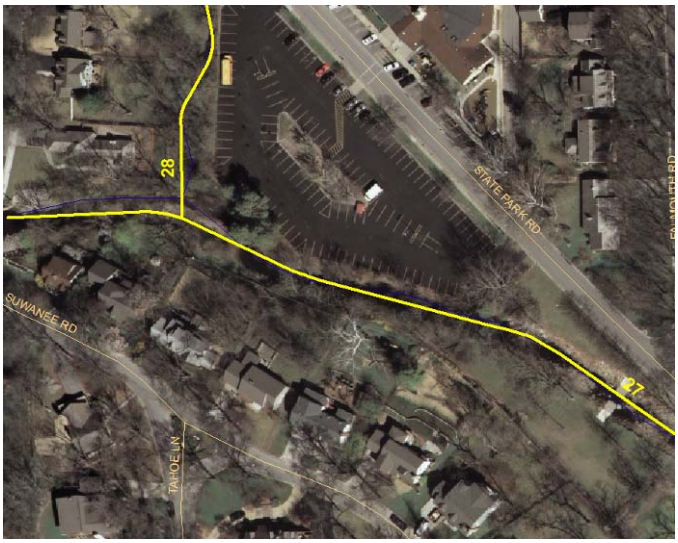
Optimal Restoration:

- Add meandering pattern to channel
- Vegetate banks and create buffer zone
- Provide rip rap/bank protection of channel

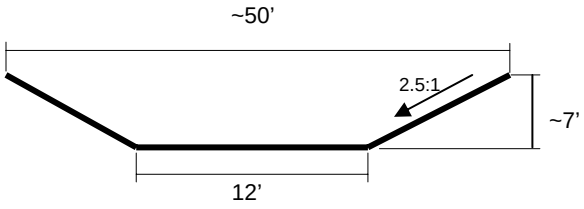
Project 27 – Segment 2

Limited Restoration:

- Limited vegetation of banks
- Provide rip rap/bank protection of channel



Project 27



Recommended Cross Section

Estimated Improvement Cost:

- Optimal Restoration = $ 1,170,783; Priority 21
- Optimal Restoration with Land Acquisition = $1,280,339
- Limited Restoration = $ 985,504

34. Improvement Project 32

Priority 23

The 1-yr flow for this reach is estimated to be 1520 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1520 cfs flow:

Parameter	Value
Main channel width (w)	44 ft
Wave length (L)	492 ft
Pool-riffle spacing	246 ft
Radius of curvature (Rc)	105 ft
Range *	87-218 ft
Amplitude (Amp)	79 ft

- Absolute minimum – APWA max

<u>Improvement Segment #1 of Project 32</u>

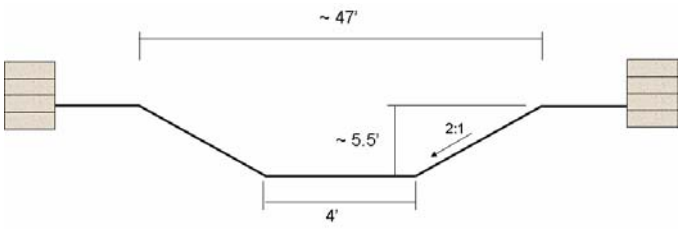
Length: 1620 ft

Optimal restoration:

- Remove walls.
- Relocate the stream following a meandering pattern.
- Stabilize banks using a 2:1 slope. Create flood benches and add walls as necessary (see sketch below).
- Replace two pedestrian bridges to accommodate new proposed geometry.
- Vegetate banks and flood benches and create buffer zone.

Limited restoration:

- Repair walls as needed.
- Stabilize banks using a 2:1 slope.



Improvement Segment #2 of Project 32

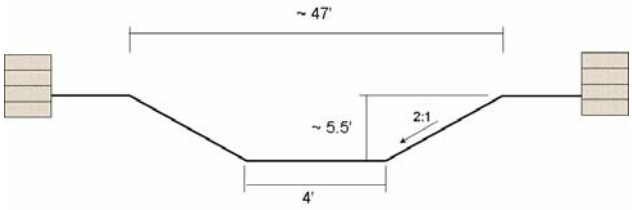
Length: 90 ft

Optimal restoration:

- Remove walls.
- Relocate the stream following a meandering pattern.
- Stabilize banks using a 2:1 slope. Create flood benches and add walls as necessary (see sketch below).
- Move concrete weir upstream. The new weir should be placed in between meanders. This will significantly reduce the impact that the existing weir is having on the right bank located immediately downstream from the weir.
- Vegetate banks and flood benches and create buffer zone.

Limited restoration:

- Repair walls
- Stabilize banks using a 2:1 slope.
- Move concrete weir upstream. The new weir should be placed in between meanders. This will significantly reduce the impact that the existing weir is having on the right bank located immediately downstream from the weir.



Estimated Improvement Cost:

- Optimal Restoration = $1,397,342; Priority 23
- Optimal Restoration with Land Acquisition = $1,650,742
- Limited Restoration = $901,694

35. Improvement Project 34

Priority 34

The 1-yr flow for this reach is estimated to be 1520 cfs. The following parameters were determined based on Soar and Thorne criteria for a 1520 cfs flow:

Parameter	Value
Main channel width (w)	44 ft
Wave length (L)	492 ft
Pool-riffle spacing	246 ft
Radius of curvature (Rc)	105 ft
Range *	87-218 ft
Amplitude (Amp)	79 ft

- Absolute minimum – APWA max

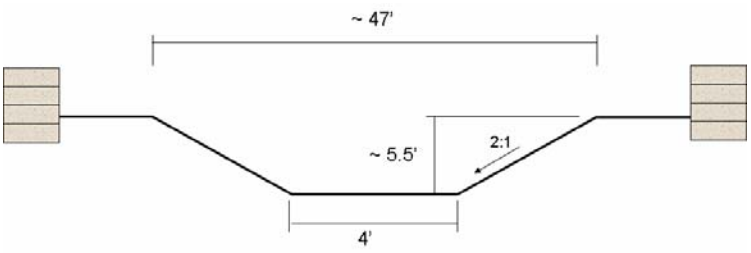
Length: 920 ft

Optimal restoration:

- Relocate the stream following a meandering pattern.
- Stabilize banks using a 2:1 slope. Create flood benches and add walls as necessary (see sketch below).
- Replace pedestrian bridge to accommodate new proposed geometry.
- Remove walls (210 ft, downstream end).
- Vegetate banks and flood benches and create buffer zone.
- Remove low water crossing or rebuild to accommodate new proposed geometry
- Replace sanitary sewer crossing to accommodate new proposed geometry

Limited restoration:

- Stabilize banks using a 2:1 slope.
- Repair sanitary sewer encasement.



Estimated Improvement Cost:

- Optimal Restoration = $1,011,042; Priority 34
- Optimal Restoration with Land Acquisition = $1,264,442
- Limited Restoration = $552,417

Estimated Improvement Cost:

- Optimal Restoration = $1,011,042; Priority 34
- Optimal Restoration with Land Acquisition = $1,264,442
- Limited Restoration = $552,417

Appendix C-3
Recommended Best Management Practices

Appendix C-3 Recommended BMP Locations

City Owned Properties ~ Top 100 BMP Locations

ID	OWNER	Street Address	City	BMP RECOMMENDATION	Area (ac)	Total Costs	PV of Costs	Cost-Benefit Ratio
993	CITY OF MISSION	Martway and Dearborn Streets	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.05	$11,315	$3,851	16.35
998	CITY OF MISSION	Dearborn Street and W 59th Terrace	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$27,690	$20,226	27.65
945	CITY OF MISSION	Martway and Beverly Avenue	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.10	$78,198	$26,993	47.16
9151	CITY OF OVERLAND PARK	Johnson Drive and Metcalf Lane	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$11,565	$4,101	54.53
968	CITY OF MISSION	Martway	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,690	$4,226	63.60
8731	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$78,198	$26,993	69.76
8937	CITY OF MISSION	Martway and Lamar Avenue	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$11,190	$3,726	74.49
105547	CITY OF FAIRWAY	4330 SHAWNEE MISSION PKWY	Fairway	Permeable Pavement	0.53	$174,067	$107,055	81.10
132628	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	Permeable Pavement	1.33	$414,217	$259,594	85.99
5083	CITY OF ROELAND PARK	Alhambra Street and Elledge Drive	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$16,690	$9,226	92.15
8707	CITY OF MISSION	Broadmoor and Martway Streets	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$14,440	$6,976	93.87
7636	CITY OF MISSION	6448 NALL AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.39	$78,198	$26,993	94.55
1460	CITY OF MISSION	6090 WOODSON ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	3.83	$78,200	$26,993	96.98
133885	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	Permeable Pavement	2.15	$665,027	$418,900	108.23
7714	CITY OF MISSION	6649 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$79,198	$27,993	111.40
8728	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$78,198	$26,993	112.71
8938	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,815	$4,351	112.85
33	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$16,690	$9,226	117.38
971	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$11,315	$3,851	120.22
3669	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.06	$12,315	$4,851	130.02
9528	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$79,573	$28,368	139.40
30	CITY OF MISSION	6090 WOODSON ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	3.83	$78,201	$26,994	146.55
10392	CITY OF OVERLAND PARK	0 NS NT	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$11,315	$3,851	150.67
8280	CITY OF PRAIRIE VILLAGE	0 NS NT	Prairie Village	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,690	$4,226	155.29
7305	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,315	$3,851	158.90
132623	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	Permeable Pavement	0.96	$302,817	$188,825	161.06
9523	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.07	$79,573	$28,368	163.02
3643	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$14,065	$6,601	180.56
7058	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$15,190	$7,726	180.71
9524	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$83,198	$31,993	190.66
10390	CITY OF OVERLAND PARK	6510 WALMER ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$45,462	$16,824	193.43
372	CITY OF MISSION	5904 MAPLE ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$43,212	$14,574	193.69
3671	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.09	$11,565	$4,101	198.09
8649	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$14,190	$6,726	198.43
8281	CITY OF PRAIRIE VILLAGE	0 NS NT	Prairie Village	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,315	$3,851	199.62
8732	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.18	$78,698	$27,493	201.64
9530	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$78,323	$27,118	202.54
3673	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$13,190	$5,726	204.54
9488	STATE OF KANSAS	0 NS NT	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$15,815	$8,351	207.28
554	CITY OF MISSION	5924 OUTLOOK ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.05	$47,837	$19,199	208.11
10359	STATE OF KANSAS	6900 W 67TH ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$43,212	$14,574	221.97
4223	CITY OF WESTWOOD	0 NS NT	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$15,940	$8,476	222.13
10389	CITY OF OVERLAND PARK	6400 GLENWOOD ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$44,837	$16,199	224.40
8867	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$11,815	$4,351	229.99
7283	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$12,065	$4,601	230.86
9520	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$78,573	$27,368	235.51
10681	STATE OF KANSAS	6741 METCALF AVE	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$56,337	$27,699	240.66
7480	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,440	$3,976	249.43
1005	CITY OF MISSION	5959 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$78,948	$27,743	249.91
9487	STATE OF KANSAS	0 NS NT	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$13,190	$5,726	251.62
3665	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,940	$4,476	251.65
7284	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.36	$12,565	$5,101	253.00
7482	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,315	$3,851	255.44

325	CITY OF MISSION	5521 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.07	$43,212	$14,574	264.38
7173	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.54	$78,949	$27,743	264.47
10621	STATE OF KANSAS	6727 FLOYD ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$49,087	$20,449	267.52
7486	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,315	$3,851	272.65
7519	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,440	$3,976	281.29
7511	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$11,315	$3,851	282.40
7306	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$13,565	$6,101	283.27
7484	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$11,315	$3,851	288.93
4229	CITY OF WESTWOOD	0 NS NT	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$30,940	$23,476	294.61
10391	CITY OF OVERLAND PARK	0 NS NT	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.55	$12,815	$5,351	297.78
8855	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$12,190	$4,726	299.56
8854	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$18,315	$10,851	300.32
7523	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$11,440	$3,976	303.16
8648	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.06	$11,440	$3,976	303.44
8900	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$11,440	$3,976	317.68
27	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.07	$11,315	$3,851	321.02
9529	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$78,198	$26,993	321.36
3641	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$14,565	$7,101	325.74
7307	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$59,108	$21,079	326.65
7524	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$11,315	$3,851	327.16
566	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$13,565	$6,101	330.15
10608	STATE OF KANSAS	6700 METCALF AVE	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$43,212	$14,574	332.22
5082	CITY OF ROELAND PARK	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$25,065	$17,601	334.68
461	CITY OF MISSION	5703 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.05	$43,087	$14,449	337.70
890	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	4.54	$43,337	$14,699	339.46
10630	STATE OF KANSAS	6803 FLOYD ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$43,337	$14,699	340.48
112246	CITY OF ROELAND PARK	0 NS NT	Roeland Park	Permeable Pavement	0.46	$143,178	$85,775	348.76
103130	CITY OF MISSION	0 NS NT	Mission	Permeable Pavement	0.49	$153,838	$92,248	350.52
132799	CITY OF MISSION	0 NS NT	Mission	Permeable Pavement	1.06	$327,108	$197,532	362.99
132815	CITY OF MISSION	0 NS NT	Mission	Permeable Pavement	1.32	$406,008	$245,488	365.33
132773	CITY OF MISSION	0 NS NT	Mission	Permeable Pavement	0.45	$141,088	$84,504	368.64
32	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.05	$11,315	$3,851	378.47
7506	CITY OF MISSION	0 NS NT	Mission	0,0,0,0,Infiltration,0,0,0	0.00	$11,315	$3,851	381.79
10987	CITY OF FAIRWAY	4109 BROOKRIDGE DR	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$113,073	$61,868	385.58
10675	STATE OF KANSAS	7001 W 67TH ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$43,462	$14,824	386.34
7075	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$12,315	$4,851	395.04
8677	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.06	$13,315	$5,851	400.59
9932	STATE OF KANSAS	6426 METCALF AVE	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$43,587	$14,949	407.49
7520	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$14,565	$7,101	411.04
8673	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$11,315	$3,851	415.63
7515	CITY OF MISSION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.05	$11,440	$3,976	419.97

Commercial Owned Properties ~ Top 100 Locations

ID	OWNER	Street Address	City	BMP RECOMMENDATION	Area (ac)	Total Costs	PV of Costs	Cost-Benefit Ratio
9132	FCB REAL ESTATE HOLDINGS LLC	7508 SHAWNEE MISSION PKWY	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0008	$45,837	$17,199	14.42
1000	SALVATION ARMY	Johnson Drive and Lamar Avenue	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0278	$47,837	$19,199	16.64
9217	WINCHELLS DONUT HOUSES	6500 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0870	$43,337	$14,699	22.16
133498	PARK PLACE, L.L.C.	7520 SHAWNEE MISSION PKWY	Overland Park	Permeable Pavement	0.4625	$152,537	$93,397	22.44
133313	FLEMING CORPORATION OF KANSAS	6501 JOHNSON DR	Mission	Permeable Pavement	0.5009	$164,137	$100,765	23.96
8746	KEYSTONE REAL ESTATE	6819 JOHNSON DR APT A	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0107	$56,837	$28,199	25.12
132597	HERFF JONES, INC.	6015 TRAVIS LN	Mission	Permeable Pavement	0.5730	$178,608	$107,280	25.36
127306	WENDYS OLD FASHIONED	5101 MARTWAY ST	Mission	Permeable Pavement	0.5537	$180,127	$110,914	26.24
132484	SIXTY THREE WEST INVESTORS	5800 FOXRIDGE DR	Mission	Permeable Pavement	0.4923	$161,527	$99,086	27.72
127540	GREAT PLAINS REAL ESTATE	6300 NALL AVE	Mission	Permeable Pavement	0.6023	$194,967	$120,337	27.99
136415	BEAR & BEAR ASSOCIATES	6800 W 64TH ST	Overland Park	Permeable Pavement	0.6401	$206,357	$127,579	29.93
145772	CMT PARTNERS	7000 SQUIBB RD APT A	Mission	Permeable Pavement	0.4585	$144,018	$86,251	32.24
133426	QUIKTRIP CORPORATION	7400 SHAWNEE MISSION PKWY	Overland Park	Permeable Pavement	0.4780	$157,137	$96,304	33.98
132618	ODDO, FRANK L. TRUSTEE	6800 SQUIBB RD	Mission	Permeable Pavement	0.5812	$181,218	$108,889	35.49
132938	GOURMET SYSTEMS OF KANSAS,	6800 JOHNSON DR	Mission	Permeable Pavement	0.7713	$245,967	$152,714	37.18
132517	HOYT, JOHN C.	5800 BROADMOOR ST	Mission	Permeable Pavement	0.6255	$201,867	$124,697	38.41
130518	NAZARENE CHURCH	6301 NALL AVE	Prairie Village	Permeable Pavement	0.4889	$160,377	$98,359	38.72
8741	WHITE FAMILY, LLC	5959 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.1335	$49,212	$20,574	39.11
2123	ROELAND PARK UNITED	4910 W 51ST TER	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0659	$79,323	$28,118	39.92
145771	ENTERCOM KANSAS CITY, LLC	7000 SQUIBB RD	Mission	Permeable Pavement	0.4585	$151,287	$92,571	40.61
131150			Mission	Permeable Pavement	0.8807	$279,197	$173,840	41.74
127574	2004 PROPERTY E, LLC	6299 NALL AVE	Mission	Permeable Pavement	0.8737	$277,107	$172,511	43.11
117627	ROMAN CATHOLIC ARCHBISHOP	5041 REINHARDT DR	Roeland Park	Permeable Pavement	0.9677	$305,637	$190,630	43.62
137180	DIXON LUMBER COMPANY,	6330 LAMAR AVE	Overland Park	Permeable Pavement	0.6084	$196,847	$121,540	43.77
1225	MIKE & CONNIE, LLC	6350 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0646	$43,212	$14,574	43.92
121032	OLD MISSION METHODIST CHURCH	5519 STATE PARK RD	Fairway	Permeable Pavement	0.6564	$211,167	$130,611	45.94
8275	CEMETERY	0 NS NT	Prairie Village	0,0,0,Filtering Practice,Infiltration,0,0,0	0.3655	$78,198	$26,993	46.13
945	CITY OF MISSION	6200 MARTWAY ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0969	$78,198	$26,993	47.16
132541	MISSION TOWERS PROPERTIES I,	0 NS NT	Mission	Permeable Pavement	0.7123	$228,097	$141,362	50.53
8756	SCHOOL DISTRICT 110	5900 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0020	$78,198	$26,993	52.81
8785	JO CO BD OF COMMISSIONERS	6000 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0096	$78,448	$27,243	53.61
132714	BLOCK PROPERTIES COMPANY XXV,	6500 MARTWAY ST	Mission	Permeable Pavement	0.8171	$259,867	$161,535	55.11
138490			Overland Park	Permeable Pavement	0.6609	$212,627	$131,564	55.11
111965	GATEWAY DEVELOPERS, LLC (THE)	4913 JOHNSON DR	Mission	Permeable Pavement	1.2280	$384,537	$240,749	56.04
132619	KEYSTONE REAL ESTATE	6819 JOHNSON DR	Mission	Permeable Pavement	0.7607	$242,937	$150,785	56.71
8757	SCHOOL DISTRICT 110	5900 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.2713	$88,699	$37,493	57.45
132642	TARGET CORPORATION	6100 BROADMOOR ST	Mission	Permeable Pavement	0.8123	$258,507	$160,683	57.97
132621	KEYSTONE REAL ESTATE	6819 JOHNSON DR	Mission	Permeable Pavement	1.0318	$325,077	$202,959	59.21
131404			Mission	Permeable Pavement	0.8693	$275,957	$171,785	61.85
132515	HRG ASSOCIATES	5665 FOXRIDGE DR	Mission	Permeable Pavement	0.7610	$242,937	$150,785	63.04
113538			Mission	Permeable Pavement	0.4930	$161,737	$99,211	63.11
132876	CREDIT UNION OF JOHNSON COUNTY	6219 MARTWAY ST	Mission	Permeable Pavement	0.9952	$313,997	$195,942	63.78
132571	WELLS, JOAN M. BARKLEY CO-TTEE	0 NS NT	Mission	Permeable Pavement	0.8050	$249,148	$150,152	64.15
138006			Overland Park	Permeable Pavement	1.0117	$319,117	$199,200	66.40
127276	MISSION BANK BUILDING, L.L.C.	5201 JOHNSON DR	Mission	Permeable Pavement	1.0489	$330,197	$206,217	67.54
9240	MIKE & CONNIE, LLC	6350 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0646	$43,212	$14,574	67.67
125991	TMM ROELAND PARK CENTER, LLC	5150 ROE AVE	Roeland Park	Permeable Pavement	0.8813	$279,407	$173,965	68.00
137173	WR COMPANY, LLC	6300 LAMAR AVE	Overland Park	Permeable Pavement	1.5672	$487,477	$306,106	69.42
8731	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0070	$78,198	$26,993	69.76
131672			Prairie Village	Permeable Pavement	0.4864	$159,647	$97,883	69.82
9235	BELL EQUITY, LLC	6400 JOHNSON DR	Mission	0,0,0,0,Infiltration,0,0,0	0.0305	$43,212	$14,574	70.75
9012	BROADMOOR SQUARE, L.C.	6840 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0028	$43,587	$14,949	73.26
132645	KEYSTONE REAL ESTATE	6819 JOHNSON DR APT A	Mission	Permeable Pavement	0.9870	$311,387	$194,264	74.03
4898	WATER DISTRICT #1 OF JOHNSON	0 NS NT	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.6538	$43,212	$14,574	76.37
132715	BLOCK PROPERTIES COMPANY XXV,	6500 MARTWAY ST	Mission	Permeable Pavement	1.1957	$374,717	$234,485	79.23

137844			Mission	Permeable Pavement	0.8835	$280,137	$174,441	80.16
105547	CITY OF FAIRWAY	4330 SHAWNEE MISSION PKWY	Fairway	Permeable Pavement	0.5336	$174,067	$107,055	81.10
132929	BROADMOOR SQUARE, L.C.	6840 JOHNSON DR	Mission	Permeable Pavement	0.6493	$209,077	$129,283	81.49
5749	OLD MISSION METHODIST CHURCH	5522 STATE PARK RD	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0103	$78,323	$27,118	83.61
8729	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0096	$78,198	$26,993	84.36
956	REAL ESTATE CORPORATION, INC.	5945 BEVERLY AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0013	$43,587	$14,949	84.51
8702	HERFF JONES, INC.	6015 TRAVIS LN	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.1422	$54,712	$26,074	85.61
132628	UNITED STATES POSTAL SERVICE	0 NS NT	Mission	Permeable Pavement	1.3255	$414,217	$259,594	85.99
8689	WELLS, JOAN M. B. CO-TRUSTEE	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0058	$43,337	$14,699	87.50
137427			Overland Park	Permeable Pavement	0.8215	$261,327	$162,487	88.24
9243	LITTLE LAMBS MONTESSORI	5837 RIGGS ST	Mission	0,0,0,0,Infiltration,0,0,0	0.0006	$78,573	$27,368	91.47
8761	POLLINA, JOHN	5940 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0063	$43,337	$14,699	91.70
137185	WR GLENWOOD, L.L.C.	6301 GLENWOOD AVE	Overland Park	Permeable Pavement	0.6555	$210,957	$130,486	92.45
3456	D & G BUILDING PARTNERSHIP	4818 JOHNSON DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0015	$54,212	$25,574	92.59
8752	UNITED STATES POSTAL SERVICE	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.1829	$78,198	$26,993	94.45
7636	CITY OF MISSION	6448 NALL AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.3907	$78,198	$26,993	94.55
132617	ODDO, FRANK L. TRUSTEE	6800 SQUIBB RD	Mission	Permeable Pavement	0.9558	$294,818	$177,893	96.08
1460	CITY OF MISSION	6090 WOODSON ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	3.8266	$78,200	$26,993	96.98
8790	JO CO BD OF COMMISSIONERS	6000 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0143	$78,448	$27,243	98.35
8956	SALVATION ARMY	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0278	$47,837	$19,199	102.48
8775	MCDONALDS CORPORATION	6767 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0259	$46,087	$17,449	103.10
8797	MCDONALDS CORPORATION	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0203	$43,212	$14,574	104.56
5400	STATE OF KANSAS	0 NS NT	Fairway	0,0,0,0,Infiltration,0,0,0	0.0123	$78,198	$26,993	106.03
133885	UNIFIED SCHOOL DIST #512	7401 JOHNSON DR	Overland Park	Permeable Pavement	2.1530	$665,027	$418,900	108.23
8734	UNITED STATES POSTAL SERVICE	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0148	$78,198	$26,993	109.73
7714	CITY OF MISSION	6649 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.1093	$79,198	$27,993	111.40
8728	UNITED STATES POSTAL SERVICE	6029 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0409	$78,198	$26,993	112.71
8698	DISCOUNT SALES OUTLET, INC.	5930 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0165	$43,212	$14,574	113.99
8701	ERICKSON, RUSSELL	5915 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0207	$43,462	$14,824	114.99
8773	MCDONALDS CORPORATION	6767 JOHNSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0114	$57,087	$28,449	116.12
8743	TARGET CORPORATION	6100 BROADMOOR ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.1093	$43,212	$14,574	117.14
138766			Overland Park	Permeable Pavement	0.6750	$217,017	$134,345	117.56
8789	JO CO BD OF COMMISSIONERS	6000 LAMAR AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.2288	$78,198	$26,993	118.14
8829	JOHNSON-NEFF PARTNERSHIP	0 NS NT	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.0087	$44,587	$15,949	119.52

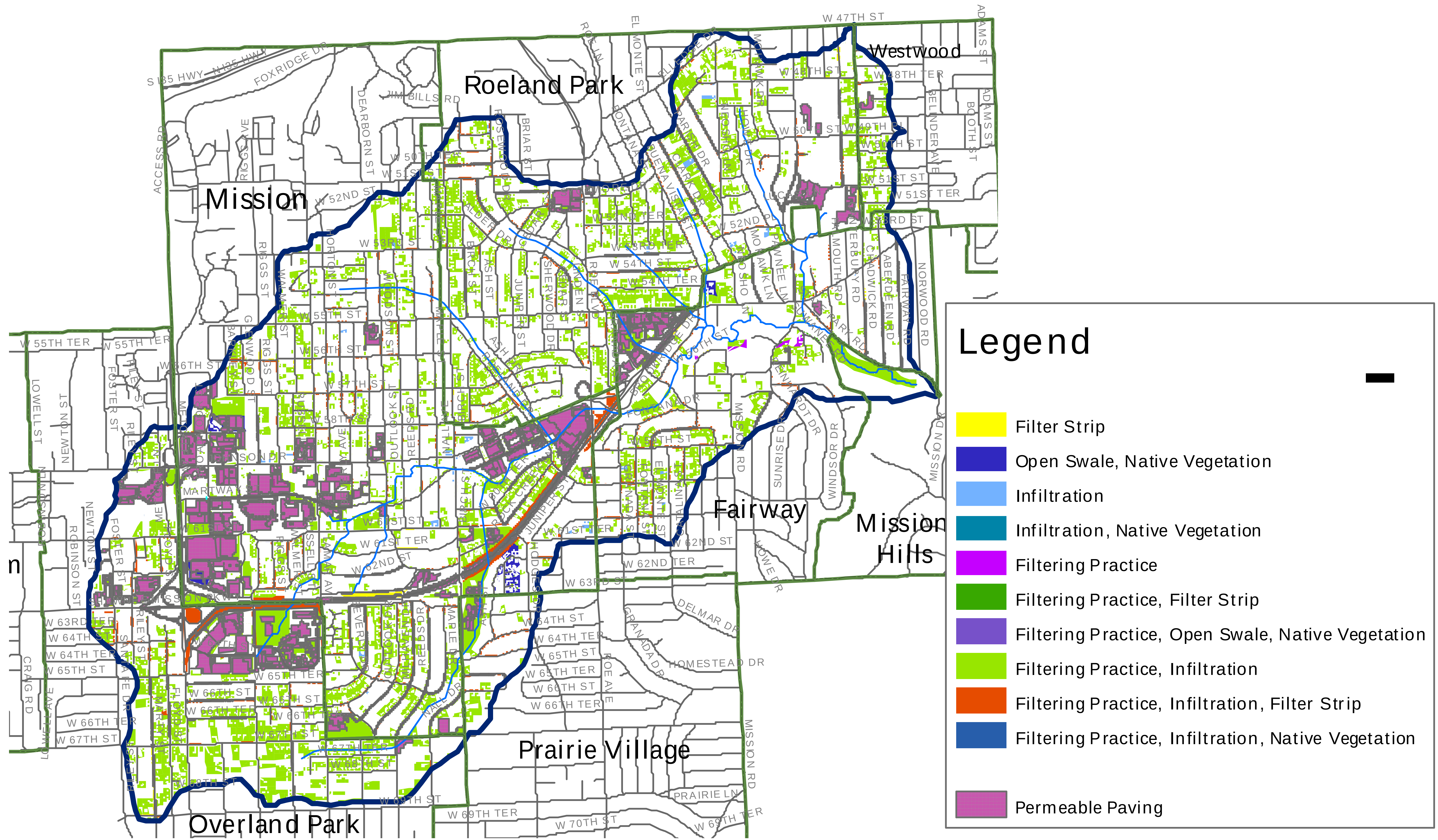
Residential Properties ~ Top 100 BMP Locations

ID	OWNER	Street Address	City	BMP RECOMMENDATION	Area (ac)	Total Costs	PV of Costs	Cost-Benefit Ratio
2101	BOUSE, ELLEN D.	5101 W 51ST ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$43,462	$14,824	1.91
5324	SULLIVAN, WILLIAM F.	5408 MOHAWK LN	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.31	$43,462	$14,824	3.77
4941	STEWART, MARK F.	5000 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.39	$46,962	$18,324	4.03
1248	HAAS, SIME	5508 WALMER ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.22	$43,212	$14,574	5.76
7815	BILLINGSLEY, ANDREW MARK	6632 WOODSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.22	$47,087	$18,449	9.08
4954	RUNIONS, WINIFRED D.	5120 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.40	$43,337	$14,699	10.12
4942	EBERT, JOANN TRUSTEE	5008 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.04	$43,962	$15,324	11.48
9189	OSWALD, ROBERT D.	6411 MARTY ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.26	$43,837	$15,199	11.67
4237	STORM, LEO F.	3004 W 50TH ST	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$43,212	$14,574	11.83
6597	LANGLEY, STEVEN M.	5239 CATALINA ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.21	$43,712	$15,074	11.87
2000	HIGGINBOTHAM, GEORGE R.	5120 BIRCH ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.17	$53,337	$24,699	12.53
5301	DODD, MARILYN R.	5400 PAWNEE LN	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.34	$44,462	$15,824	12.83
4234	MCWARD, JAMES A.	4945 FAIRWAY RD	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.12	$49,712	$21,074	12.83
7779	DDM PROPERTY SOLUTIONS, LLC	6515 WOODSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$47,462	$18,824	12.99
5076	DEJONG, ROBERT C.	3703 W 47TH PL	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$43,712	$15,074	15.52
4947	BALL, STEVEN R.	5040 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.40	$78,448	$27,243	20.05
4295	MCSWEENEY, ARTHUR J.	5131 MISSION RD	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.18	$43,337	$14,699	20.88
1908	LLOYD, SCOTT G.	5401 W 50TH ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$43,462	$14,824	21.28
6600	MILLER, SHERRIE LYNN	5223 CATALINA ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.09	$48,212	$19,574	22.08
7721	DILLON, BRUCE E.	6636 MILHAVEN DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.24	$46,212	$17,574	22.72
8146	SUNUKJIAN, JASON	6212 W 68TH ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$45,462	$16,824	23.13
9673			Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.04	$70,733	$32,704	26.02
2996	SMITH, CELIA L.	5929 CATALINA ST	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.13	$47,712	$19,074	28.23
8528			Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.45	$58,108	$20,079	28.59
127293	MISSION MART SHOPPING CENTER	0 NS NT	Mission	Permeable Pavement	0.62	$201,027	$124,196	28.61
4940	ARNOLD, WILLIAM G.	4954 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.02	$48,212	$19,574	29.90
8176	REINHARDT, GEORGE E. JR	6510 W 69TH ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.25	$52,962	$24,324	30.00
1973	MILLER, ROBERT P.	5418 SYCAMORE DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.10	$43,962	$15,324	30.27
127290	MISSION MART SHOPPING CENTER	0 NS NT	Mission	Permeable Pavement	0.60	$194,027	$119,735	30.45
4500			Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.33	$57,983	$19,954	30.83
127285	MISSION MART SHOPPING CENTER	5399 MARTWAY ST	Mission	Permeable Pavement	0.52	$170,407	$104,750	31.20
11844	PIHL, ROBERT W.	5001 W 57TH ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.15	$43,712	$15,074	31.28
5635	LITTLE, DONALD D.	5500 CANTERBURY RD	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$52,712	$24,074	32.15
8960	MADRIGAL, KIMBERLY S.	5644 GLENWOOD ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.28	$43,587	$14,949	32.47
7784	HERREN, PETER H.	6433 WOODSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.19	$62,212	$33,574	33.20
2172	WADE, ROBERT M.	5234 JUNIPER ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.15	$53,712	$25,074	33.21
2122	FILIPCZUK, SHERRI	4916 W 51ST TER	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.13	$47,337	$18,699	33.43
10894			Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.01	$58,108	$20,079	34.19
4269	ROSS, MICHAEL S.	4925 MISSION RD	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.45	$44,087	$15,449	34.55
8138	BUCHANAN, SHARON A.	6101 W 67TH TER	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$45,087	$16,449	35.02
8168	MILLER, MICHAEL L. TRUSTEE	6809 GLENWOOD ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.49	$49,712	$21,074	35.03
234	HANSEN, JAMES V.	5723 BEVERLY AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$61,712	$33,074	35.68
1743	NORNEY, CAROL	5235 MAPLE ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$43,212	$14,574	35.70
10907			Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.27	$58,233	$20,204	36.05
8559			Mission	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.04	$70,358	$32,329	36.30
5348	BEUSCHER, WILLIAM B.	5244 MOHAWK DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.27	$53,462	$24,824	36.87
10433	PETERS, JAMES D.	7404 W 69TH ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.06	$60,212	$31,574	36.94
7781	OHALLORAN, TIMOTHY M. TRUSTEE	6503 WOODSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.17	$52,837	$24,199	37.10
2323	BETTISON-ESTRADA, GISELA P.	5420 ROE AVE	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$43,712	$15,074	38.11
11515	FAUST, GEORGE M.	6027 W 53RD TER	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.10	$47,337	$18,699	38.72
4293	SUTERA, AGNES E.	2905 W 51ST TER	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.19	$43,212	$14,574	39.62
11520	LOGAN, SHERRI LYNN	6126 W 53RD PL	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.10	$43,462	$14,824	40.16
9255	WHITEMAN, FLOYD E.	5731 RIGGS ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.29	$46,587	$17,949	40.96
9655			Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.31	$62,233	$24,204	41.27
2042	RUMA, LUCILLE R. TRUSTEE	5136 ASH ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.27	$45,712	$17,074	43.30

9100	GOLDEN, BRADLEY A.	7415 W 61ST ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.28	$43,462	$14,824	44.56
4052	MUEHLBERGER, CAROL A.	4813 CANTERBURY ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.15	$43,962	$15,324	45.26
4051	MORRIS, TIM	4819 CANTERBURY ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$45,462	$16,824	46.11
11464	CROSSLEY, KYLE S.	5460 HORTON ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.09	$43,712	$15,074	46.87
5264	SIEGRIST, ROGER H.	5423 MISSION RD	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.20	$63,837	$35,199	47.47
7958	FORAL, KRISTINE R.	5201 W 60TH TER	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.23	$43,212	$14,574	47.51
1182	WISDOM, SANDRA JEAN	5701 WALMER ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$43,212	$14,574	47.55
11521	SANCHEZ, PAZ F.	6122 W 53RD PL	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$43,337	$14,699	48.35
2131	KAMPHAUS, L. FRANCES TRUSTEE	5101 W 51ST TER	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.17	$54,212	$25,574	48.38
12513			Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.01	$58,108	$20,079	48.73
7763	GILL, GERALD G.	6347 OUTLOOK DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.19	$46,337	$17,699	49.25
1033	MILLER, SHANNON	5609 BARKLEY ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.17	$43,337	$14,699	49.52
7762	INGERSOLL, KELLY	6403 OUTLOOK DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.19	$48,587	$19,949	50.09
2960	SPRINKLE, TINA	5909 ALHAMBRA ST	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.00	$43,962	$15,324	50.29
3008	DECICCO, ROBERT J. TRUSTEE	5924 CATALINA ST	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$43,962	$15,324	52.68
12514			Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,Filter Strip	0.01	$58,108	$20,079	53.32
4979	CUMMINGS, ED	5033 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.37	$59,837	$31,199	53.32
5476	BARTLETT, DAVID J.	5543 ABERDEEN RD	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.13	$63,712	$35,074	54.32
4266	MONROE, MEGAN	3009 W 49TH PL	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$43,962	$15,324	54.70
6530	LONG, CAROLYN S.	4126 W 53RD TER	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.13	$43,337	$14,699	54.85
1754	PARKER, SAMUEL	5127 MAPLE ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$49,962	$21,324	55.13
5354	SEATON, WILLIAM G.	3900 W 53RD ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.23	$43,962	$15,324	55.78
8946	PARKS, ROBERT A.	6170 W 61ST ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.27	$43,587	$14,949	56.06
4054	KELLERMAN, RYAN S.	4801 CANTERBURY ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.21	$43,337	$14,699	56.73
5867			Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.26	$86,233	$48,204	56.78
4268	DEATHERAGE, CARL L.	5003 MISSION RD	Westwood	0,0,0,Filtering Practice,Infiltration,0,0,0	0.32	$43,212	$14,574	58.65
1192	HALE, LAVONNE J.	6400 W 58TH ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$43,337	$14,699	59.68
4943	EBERT, JOANN TRUSTEE	5008 PARISH DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.31	$79,823	$28,618	60.02
8161	BAYLESS, LINTON T. JR	6601 W 67TH ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.88	$43,212	$14,574	61.38
7713	DRUMMOND, WILBERT N. JR TTEE	6601 MILHAVEN DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.27	$43,337	$14,699	61.91
237	THORPE, PAULINE E.	5739 BEVERLY AVE	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.13	$45,962	$17,324	62.32
7756	ENGLER, JUDITH K.	6501 OUTLOOK DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.21	$44,212	$15,574	62.34
8303	LOVING, STEVEN B.	5316 W 65TH PL	Prairie Village	0,0,0,Filtering Practice,Infiltration,0,0,0	0.24	$58,712	$30,074	62.72
1714	WOOD, CHAD T.	5107 OUTLOOK ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.01	$48,212	$19,574	63.78
9549	OPPENHEIMER, OLLIE T.	6430 RILEY ST	Overland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.03	$47,337	$18,699	66.40
7816	GRAVES, WILDA JEAN TRUSTEE	6644 WOODSON DR	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.24	$43,337	$14,699	67.26
11590	MASSEY, J. WARREN JR	6121 W 54TH TER	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$48,837	$20,199	67.28
6523	WIGGLESWORTH, KENNETH A.	4100 W 55TH ST	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.29	$43,712	$15,074	68.28
2148	HAGER, MICHAEL	5008 SYCAMORE DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.16	$44,212	$15,574	68.71
4761	GRANT, DAVID N. TRUSTEE	5101 NEOSHO LN	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.22	$44,337	$15,699	69.62
2872	MOSCHELL, ALEXANDRA M.	3912 W 57TH TER	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.31	$44,087	$15,449	71.63
1993	PRICE, JUANITA L.	5121 NALL AVE	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.17	$51,712	$23,074	73.43
60	VEATCH, LISA A.	5512 HORTON ST	Mission	0,0,0,Filtering Practice,Infiltration,0,0,0	0.11	$49,587	$20,949	74.30
4032	KIECKER, CHRISTINA	4916 MISSION RD	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.14	$48,087	$19,449	75.12
2317	GRANT, DANIEL N.	5332 ROSEWOOD DR	Roeland Park	0,0,0,Filtering Practice,Infiltration,0,0,0	0.13	$44,587	$15,949	75.88
3076	BISHOP-PRICE, TERI	5943 GRANADA ST	Fairway	0,0,0,Filtering Practice,Infiltration,0,0,0	0.22	$43,462	$14,824	76.26
3362	HILT, MERRITT M. JR	4707 W 61ST ST	Mission	0,0,0,0,Infiltration,0,0,0	0.16	$47,462	$18,824	76.50

Appendix C-4
Recommended BMP Location Map

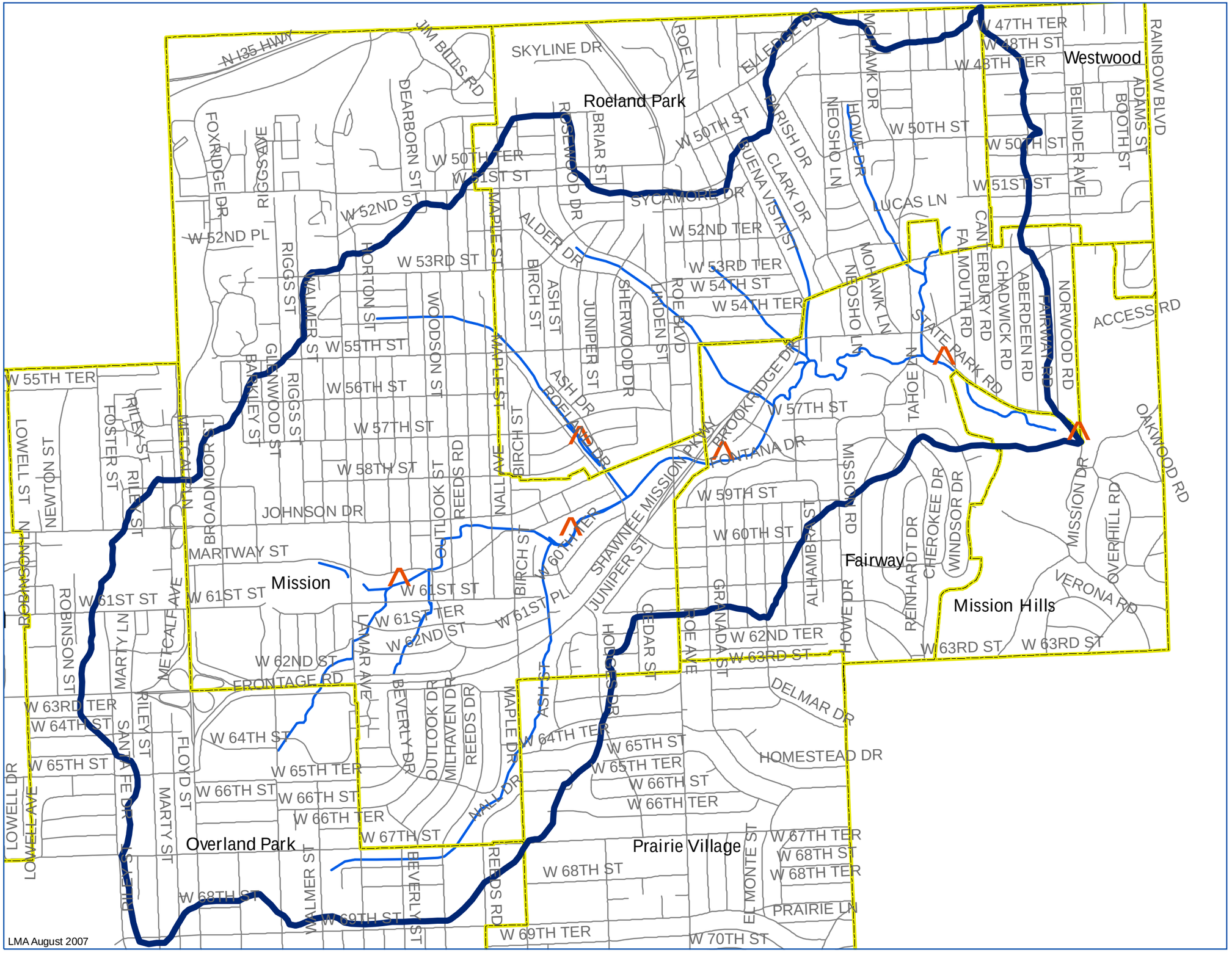
Appendix C-4 BMP Recommendations



Appendix C-5
Water Quality Sampling Location Map

Rock Creek Watershed Feasibility Study

Appendix C-5 Water Quality Sampling Locations



LEGEND

- SamplingLocations
- City Boundary
- Existing Reach
- RockCreekWatershed

0 1,500 Feet

1 inch equals 1,500 feet

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ENERGY WATER INFORMATION GOVERNMENT