City of St. Joseph, Missouri

Facilities Plan

Technical Memorandum No. TM-CSO-7

Green Solutions Opportunities Evaluation and Refinement

By

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Green Solutions Opportunities Evaluation and Refinement

1.0 Executive Summary

The green solutions model developed in Technical Memorandum (TM) TM-CSO-6 – Identification and Prioritization of Green Solutions Opportunities was evaluated and refined to provide the best green solutions opportunities for the City of St. Joseph Water Protection Program. A green solution is a vegetated, natural stormwater management practice that works in harmony with or mimics natural systems. Green solutions provide multiple benefits, including offsetting imperviousness, improving water quality, reducing wet weather flow, and providing floral, faunal, and aquatic habitat. Green solutions may also provide recreational opportunities and community amenities. Refinement of the opportunities identified in TM-CSO-6 was performed by creating a 1,000-foot buffer around the City's Parks, Open Space and Trails shapefile layers to identify City- and publicly-owned parcels for potential green solutions that could be integrated into the City's parks and trails system as amenities. The green solutions model identified various opportunities within the Brown's Branch, Whitehead, and Blacksnake Basins. The following four areas were identified as the best locations that could be retrofitted with multiple green solutions:

- Hyde Park
- Southwest Parkway
- Corby Parkway
- Parkway A

The green solutions refinement effort identified 23 potential green solutions with a total possible stormwater storage capacity of 9.4 million gallons (MG) at a probable project cost of $10.9 million. Green solutions opportunities were prioritized according to land ownership. The evaluation results presented herein focus on Tier 1 (City-owned) properties, although some Tier 2 (vacant parcels) and Tier 3 (boulevards and rights-of-way) opportunities are also presented. Identified green solutions consist of site scale, neighborhood scale, and watershed scale opportunities. Furthermore, where feasible, green solutions were specifically developed to help offset stormwater infrastructure proposed as part of the 1998 Comprehensive Stormwater Management Plan.

Green solutions opportunities in Hyde Park total 1.8 MG of potential wet weather runoff storage at a probable project cost of $1.1 million. Hyde Park opportunities include:

- Wetland channel
- Extended detention wetlands
- Neighborhood downspout disconnection and rain gardens

Green solutions opportunities for Southwest Parkway total 3.2 MG of potential wet weather runoff storage at a probable project cost of $3.9 million. Southwest Parkway opportunities include:

- Extended dry detention
- Stream stabilization
- Extended detention wetland
- Parking lot retrofit
- Neighborhood rain gardens and green streets with bioretention in the street right-of-way

Green solutions opportunities for Corby Parkway total 2.0 MG of potential wet weather runoff storage at a probable project cost of $2.3 million. Corby Parkway opportunities include:

- Wetland bench and sediment forebay for Corby Pond
- Extended detention wetland
- Neighborhood rain gardens and green streets with bioretention in the street right-of-way

Green solutions opportunities for the upper tributary area of Parkway A total 2.4 MG of potential wet weather runoff storage at a probable project cost of $3.6 million. Parkway A opportunities include:

- Extended dry detention on several vacant (Tier 2) parcels
- Neighborhood rain gardens and green streets with bioretention in the right-of-way

These green solutions opportunities are presented in detail within the body of the technical memorandum. Appendix A includes detailed figures of the green solution concepts and Appendix B provides the green solution hydrologic calculations.

It is recommended that the City review and prioritize the green solutions opportunities presented herein based on community priorities as well as the City's ability to pay for them. In addition, the City is encouraged to implement a green solutions demonstration project to showcase the concepts to the public and demonstrate the effectiveness of these stormwater management techniques.

In addition to the 23 opportunities presented in this TM, there are many vacant property and right-of-way (ROW) green solutions opportunities that could be explored in greater detail. Similar criteria and costing as presented herein could be used to evaluate these opportunities as part of a future evaluation.

2.0 Purpose of Technical Memorandum

The purpose of this technical memorandum is to:

- Identify green solutions opportunities that could be used as part of the Combined Sewer Overflow (CSO) Control Facilities Plan.
- Describe the potential green solutions and their potential wet weather benefits.
- Provide a preliminary cost opinion of the green solution concepts.
- Provide a summary map with the locations and general layout of the green solutions.
- Provide conceptual illustrations of three green solutions sites including small, medium, and large site solutions.

3.0 Green Solutions Application Criteria

Green solutions modeling and natural resources assessment from TM-CSO-6 – Identification and Prioritization of Green Solutions Opportunities were utilized as the basis for green solutions evaluations made within this TM. A green solution is a vegetated, natural stormwater management practice that works in harmony with or mimics natural systems to improve water quality, reduce wet weather flow, and provide floral, faunal, and aquatic habitat. Green solutions provide multiple benefit opportunities, including creating open space to link trails and parks and creating community amenities in residential and commercial areas. The evaluations described in this TM focused mainly on green solutions opportunities located on City-owned properties.

Results from the initial green solutions modeling (TM-CSO-6) were prioritized in tiers according to land ownership:

- Tier 1 – City-owned and semi-public
- Tier 2 – Vacant
- Tier 3 – Boulevards and ROWs

The opportunities presented in TM-CSO-6 were refined by creating a 1,000-foot buffer around the City's parks, open space, and trails to help identify properties (particularly publicly-owned) where potential green solutions could also provide recreational amenities.

Adjacent neighborhoods and streets were also evaluated to determine the potential for reducing stormwater volumes entering the City's combined sewer system. Selection criteria for "green street segments" include streets with:

- Less than a 5 percent slope
- Absence of mature trees
- Sufficient ROW space

Once sites were screened and prioritized, each site's catchment area was delineated and the amount of runoff from the catchment estimated. This helped determine how much of the catchment's runoff would be potentially captured by the selected green solution concept during a wet weather event. Each site's setting and topography was evaluated to identify feasible green solutions and estimate the available land area and potential runoff treatment and/or storage provided by the concept. Treatment and storage potential from the concept was compared to contributing runoff to estimate each green solution's effectiveness at capturing runoff from the water quality event. The water quality event (Design Event E) was defined as a 1.8 inch storm distributed over approximately 20 hours. This represents an approximate 3 month storm and is the same storm used as part of the larger City-wide program to determine if proposed CSO improvements meet Long Term Control Plan policies. Finally, the green solution costs were projected by applying cost factors developed from other similar scale projects in Missouri, Kansas, and Nebraska to the proposed green solution recommendations made herein.

3.1 Small Storm Hydrology

Frequent, smaller storms are responsible for most of the annual urban runoff and likewise are responsible for carrying most of the pollutant loading from an urban watershed to a receiving stream. These smaller events typically dictate the long term water quality health of a receiving stream. In contrast, larger, less frequent storms can contain significant pollutant loads. However, due to their infrequent nature, their pollutant contribution related to the long term average pollutant loading is generally less significant. Thus, the cumulative annual runoff volume and associated long term pollutant loading is the most important hydrologic function related to water health and quality. Therefore, water quality improvements are typically sized to capture and treat the smaller and more frequent wet weather events. In contrast, the peak runoff flow rate is the most important hydrologic characteristic used to design, evaluate, and retrofit drainage systems for mitigating flooding (Clayton and Schuler, 1996). Therefore, focusing on larger, less frequent stormwater events is typically the focus of flood control evaluations.

This technical memorandum and the green solutions evaluations made herein are focused to help support the ongoing CSO control plan. The CSO control plan is focused on improving water quality and is therefore targeting smaller, more frequent wet weather events. For this reason, the approach described in this memorandum focuses on capturing and treating the water quality volume (i.e., the runoff from smaller, more frequent storms) to achieve water quality improvements and reduce runoff from smaller events from entering the combined sewer system. Where possible and feasible, larger facilities that can also help offset peak flows from flood events were considered and are noted herein.

When designing effective green solutions or best management practices (BMPs), it is necessary to predict the amount of rainfall converted to runoff by upstream pervious and impervious surfaces. Impervious surfaces (i.e., concrete, asphalt, parking lots, roofs, etc.) convert most rainfall into runoff; however, there is some surface wetting (i.e., initial abstraction) losses as well as infiltration through cracks and seams that prevent all the rain from being converted to runoff. Runoff from impervious areas can be reduced if the surfaces are disconnected from the pipe and drainage system and allowed to drain through pervious areas such as permeable soils and vegetated swales (Natural Resources Conservation Service [NRCS] Hydrologic Soil Groups [HSG] B in St. Joseph; Pitt, 1994).

The amount of runoff generated by pervious surfaces is relative to the size of the pervious area, the spatial relationship to adjacent impervious surfaces, the permeability of the underlying soils, and the condition and type of vegetative cover. Several methods have been developed to predict rainfall-runoff, including the Rational Formula and NRCS Methods, particularly Technical Release (TR) 55, “Urban Hydrology for Small Watersheds (USDA, 1986);” TR-20, “Project Formulation Hydrology (USDA, 1982);” and Hydrologic Engineering Center (HEC) 1 (U.S. Army Corps of Engineers, 1982). While these methods are well suited for calculating volumetric runoff for the 2-, 10-, and 100-year rainfall events (i.e., flood events), they tend to under predict runoff volume for smaller rainfall events due to the use of the NRCS Curve Number (CN) procedure. The CN method is an empirical formula and is not suitable for predicting runoff from every conceivable wet weather event. For example, published CN values for pervious surfaces predict much lower runoff than observed runoff during smaller storms. Furthermore, if runoff is under predicted from pervious areas, more runoff is then associated with impervious areas and skews pollutant loading estimates and receiving stream water quality predictions.

To accurately estimate runoff from Design Storm E (1.8 inch rainfall event and target event for providing CSO control in St. Joseph), the Small Storm Hydrology Method (SSHM) developed by Dr. Pitt and others was applied. The SSHM uses volumetric runoff coefficients (Rv) based on the specific characteristics of the pervious and impervious surfaces of the drainage catchment (Pitt, 1994).

3.2 Green Solutions Best Management Practices

This section provides an overview of the green solutions BMP technologies applied within this TM. There are many BMP types and combinations, and more than one BMP or design variant may be appropriate for a given site. Therefore, the project team identified BMPs that appear to be most appropriate for specific sites based on each site's characteristics and potential benefits. Seven different BMPs (See Section 3.2.1 through Section 3.2.7 for descriptions) have been recommended for sites within St. Joseph. The descriptions of the selected BMPs are somewhat general in nature at this conceptual level of this study. Precise alignments, grading, and structures would be determined at the design stage when more detailed information becomes available. The conceptual BMPs' approximate size was determined based on surface runoff from their contributing catchment as described in the previous section, but some BMPs could be expanded if runoff from larger areas were directed to them (subject to space limitations). Finally, basic features could be changed; for example, detention basins could be dry or wet, and swales could be simply vegetated or could be designed as "bio-swales" that incorporate underdrains.

In Appendix A, three green solutions renderings are included that illustrate potential small, medium, and large scale applications that could apply at various locations around the City. The renderings include 1) a rain garden installed adjacent to a City-owned building that would fit on many residential sites (Figure 7); 2) a medium-scale extended detention basin with a wetland channel (Figure 5); and 3) a large detention basin retrofitted with a sediment basin and wetland edge treatment (Figure 17).

Following the seven selected BMPs are several other typical BMPs (see Section 3.2.8 through Section 3.2.12 for BMP descriptions) that could also be feasible throughout the City. These additional BMPs could be applied on both public and private property as voluntary retrofits or in response to future stormwater regulations. Potential green solution City-wide (i.e., programmatic) municipal codes and ordinances are addressed in the previously submitted Green/Sustainable City Code Examples Technical Memorandum.

3.2.1 Wetland Channel

A wetland channel is a variant of a vegetated swale (see Section 3.2.6) that is typically designed with a wet bottom and a meandering plan form (as opposed to a regular path). Wetland channels should be located in areas with continuous base flow or subsurface flow. Wetland channels typically store up to 1 foot of water; temporary storage may be added to a wetland channel by creating a floodplain bench, usually as a 1 to 3 foot deep terrace above the ordinary high water mark or wetland pool elevation that can convey runoff from larger rain events at relatively slow velocity.

Wetland channels are appropriate where small stream channels have become unstable or incised due to excessive flow from upper tributary areas, as in the case of increased upstream imperviousness, or where a channel has become disconnected with its floodplain. Vegetation in the wetland channel must tolerate frequent inundation. The vegetation selected for the floodplain bench should be able to tolerate both wet and dry conditions.

Wetland channel opportunities were identified based on site reconnaissance. The available area was estimated using geographic information systems (GIS) mapping and assuming 1 foot of storage in a typical, 8 foot wide channel to determine the percentage of contributing runoff that could be stored. It is assumed that additional runoff could be conveyed and treated in a broader floodplain bench, which would be determined during preliminary design.

3.2.2 Extended Detention Wetland

The extended detention wetland (EDW) is a stormwater wetland system that employs natural processes provided by wetland vegetation, soils, and natural microbes to remove pollutants from runoff. Stormwater wetlands are designed to detain the water quality design storm above the permanent wetland pool elevation. Generally, stormwater wetlands should be placed either in upland areas outside of waters of the United States, or in hydric soil areas where seepage of subsurface flow provides continuous base flow to keep vegetation alive.

EDW configurations are typically broad, shallow depressions that occupy a larger land area than wet detention ponds, but provide a greater contact area for pollutant removal as well as large areas for diverse native vegetation and wildlife habitat. EDW basins were proposed for areas where broad, shallow detention was most appropriate based on available land and existing topography. The basin footprint was identified using GIS mapping and assumed that the EDW would be designed to temporarily store the design storm at an average depth of 2 feet above a shallow, permanent wetland pool. If dictated by site constraints, EDW basins can be designed and appropriate vegetation selected to be dry seasonally.

3.2.3 Rain Gardens

Rain gardens typically are small depressions planted with native wetland or prairie vegetation, where overland runoff collects and infiltrates. Rain gardens are ideal for small sites such as residential yards and community common areas. Several areas were identified where rain gardens could be dispersed throughout residential areas. The maximum drainage area for each rain garden is assumed to be no greater than 1 acre, having no more than 6 to 12 inches of ponding, and infiltration characteristics to allow it to drain within 40 hours (prevents mosquito infestation and vegetation inundation). It was assumed that a typical residential rain garden would be 100 square feet and would store and infiltrate 50 cubic feet of runoff.

Rain gardens can take a variety of forms depending on available area, but should be placed at least 10 feet away from existing structures to avoid hydrostatic pressure or seepage into building foundations. Rain gardens are planted with a variety of native plants that are adapted to periodic wetness and dryness. Special soil is not required for rain gardens, but compaction from heavy equipment must be avoided during excavation and a 6 to 12 inch layer of organic topsoil will aid plant growth if the existing soil is heavy clay or a clay loam.

3.2.4 Green Streets

A green street can take many forms, but generally is any street that includes BMPs to capture runoff and reduce the volume entering the curb and gutter system. Typical green streets are designed with one or several BMPs in the ROW. Green streets can include vegetated swales, rain gardens, or bioswales (similar to vegetated swales except that they also incorporate engineered soils and an underdrain system), rain garden bump-outs mid-block or at intersections, pervious pavement, or any combination of the above strategies. The green street capacity should be designed to store the water quality design storm wherever possible.

Several areas where ROW areas exist to incorporate green streets were identified. Typically, ROW open space widths (space between the edge of pavement and ROW edge) should be 8 feet at minimum to allow swale or linear bioswales with 3-to-1 side slopes at 1 foot deep with a 2 foot wide bottom width. Nine inches of average storage were assumed or 6 cubic feet per linear foot of ROW. The roadway crown, the presence and proximity of existing curb and gutter or swales, the slope of existing drainage ways, and large, mature trees are design considerations that should be addressed during project design.

3.2.5 Extended Dry Detention

Extended dry detention (EDD) is a practice designed to capture the water quality volume in a vegetated basin and slowly bleed out or infiltrate the volume over 40 hours. Typically, EDD has an overflow structure that allows larger rainfalls to pass through the basin, while the water quality volume is either infiltrated or drained out slowly through a small orifice, perforated riser, or underdrain. EDD is also typically placed off-line (out of the stream channel), with maximum catchment areas up to 10 acres.

EDD basins may temporarily pond 2 to 4 feet of water and can be used in smaller sites than EDW basins. EDD basins were proposed where existing topography would allow detention, but standing water would be undesirable. Available footprint was estimated using GIS mapping and assuming an average of 2 feet of storage to be conservative. EDD basins are well suited for use as “pocket parks,” where the space can be used by the community as gardens, walks, or other open space between wet weather events.

3.2.6 Vegetated Swale

A vegetated swale is a broad channel with a dense stand of native vegetation covering the side slopes and channel bottom, which are designed to slowly convey runoff from the design storm. Vegetated swales are effective at trapping pollutants, promoting infiltration, and reducing flow velocities, and if designed with the proper plants, can be aesthetically pleasing. Vegetated swales are typically dry but could have some standing water on low slopes.

Vegetated swales were proposed where conveyance was more appropriate than storage to provide water quality treatment. Swales are most effective on 1 to 2 percent slopes with shallow flows of 4 to 6 inches and velocities about 1 foot per second (or somewhat more if non-native turf grasses are used). Check dams can be used to slow velocities. Native vegetation deep root systems slow and infiltrate runoff and reduce maintenance to periodic mowing or woody vegetation removal. Non-native turf grasses may be used, but regular maintenance will be difficult because of frequent wetness.

3.2.7 Wet Detention Basin with Sediment Forebay

A sediment forebay is a pretreatment basin used on the upstream end of EDW and EDD basins or wet ponds. The forebay decreases velocity and settles sediments, preventing their release into the receiving body. Forebays should be sized to contain at least 5 years of sediment from the contributing drainage area, should be 4 to 6 feet deep, and should be separated from the receiving body by gabions, rip-rap, gravel, earthen berm, or concrete weirs. The bottom should be reinforced with concrete, rip rap, geocellular confinement, or a similar surface that can be scooped out with a bucket.

Sediment forebays are optional, but typically recommended for all detention basins. However, one location (Corby Pond) was identified where a forebay would help reduce excessive sediment from being delivered to the pond from the upstream stream channel. A small wet detention basin downstream of the sediment forebay would improve sediment removal from the pond by settling out small colloidal clays and other water soluble pollutants. The wet detention basin could be designed as an amenity and to provide wildlife habitat and could incorporate a trailhead for the adjacent off-road trail.

3.2.8 Bioretention

Bioretention cells are similar to rain gardens but are typically applied to larger sites. Most bioretention facilities include a depressed area for storage of stormwater underlain by relatively permeable soils and a constructed underdrain to allow infiltration of the accumulated water. A bioretention cell is planted with water-tolerant plants that enhance the removal of pollutants. One of the difficulties with use of bioretention cells in St. Joseph is that the soils are typically clays of low permeability, and the underlying shale and limestone are similarly relatively impervious. However, bioretention facilities can be constructed with underdrain facilities that allow them to function in this region.

3.2.9 Stream Restoration

One of the application criteria for evaluating green solutions for St. Joseph was that the channels have less than five degrees of slope; the selected BMPs were therefore smaller wetland channels that would have a shallow, meandering form. However, larger-scale stream restoration may be appropriate in some locations. Stream restoration is frequently practiced on relatively steep drainage courses that have deeply incised erosion channels. Stream restoration usually involves construction of a series of grade control structures that allow water to pond behind them, thereby slowing the water velocity and allowing ponding. These ponds reduce pollutants by settlement of suspended solids. The ponds frequently are planted as wetlands to enhance pollutant removal and improve habitat. Banks may be regraded and revegetated for stabilization and to restore natural habitat.

3.2.10 Rain Barrels

When placed at the end of residential downspouts, rain barrels can store the initial runoff from a roof and supply water to irrigate gardens. Even if a rain barrel is simply emptied to natural drainage following a rain event, they provide some storage to attenuate peak flows. A distinct advantage of rain barrels is that they involve individual homeowners in stormwater management, greatly improving the program's public outreach and education.

3.2.11 Green Roofs

Although more prevalent in areas that are more heavily urbanized such as Chicago and New York and often characterized by low intensity rainfall climates such as Portland or Seattle, green roofs are gaining widespread acceptance as an effective stormwater best management practice. These usually involve placement of 6 or 8 inches of pervious soils with appropriate vegetation on roofs with low slopes. Such roofs typically are on large commercial, industrial, or institutional facilities. The use of green roofs has several advantages, including visibility to improve public awareness, reduction in the heat island effects of urban areas, reduction of facility heating and cooling costs and energy usage, and involvement of the businesses, schools, or agencies directly in the stormwater management program.

3.2.12 Regional Stormwater Detention Facilities

Regional detention basins are typically larger than the extended dry detention and wet detention basin. Many regional detention facilities are large enough to be called lakes and support recreational activities such as fishing and non-motorized boating. If located in parks and maintained with a significant permanent pool, the detention facilities provide an amenity to the public and may generate widespread support for stormwater improvements and funding. The Whitehead and Blacksnake Basins have been considered for regional stormwater detention. The Whitehead Stormwater Detention Basin Facilities Assessment will provide further information on that basin.

3.3 Cost Opinions

Opinions of costs for potential BMPs were prepared using cost factors developed for previous projects while cross referencing national studies and local design projects. Unit costs per square foot of BMP area (and per cubic foot of storage) were also compared to the Center for Watershed Protection; the City of Omaha, Nebraska CSO program; the City of Kansas City, Missouri CSO program; a City of Lee's Summit, Missouri stormwater improvement project; and a Mission Hills, Kansas project, with its own opinions of probable cost for similar BMPs where available. Where necessary, unit costs were adjusted for inflation using the Engineering News Record construction cost index. The selected and cross-referenced cost factors include construction costs plus a design and engineering factor. The dollar per linear foot and dollar per cubic foot value presented herein includes those markups. Most BMPs are proposed for City- or publicly-owned sites or right-of-way and therefore do not include land acquisition costs. Estimated land costs are included where applicable. In addition, operation and maintenance costs as well as the 20-year present worth costs are included within the cost tables presented herein.

4.0 Green Solutions Evaluation

The model identified 23 green solutions opportunities, including within City- and publicly-owned properties. The 23 green solutions opportunities are located within four areas in the Brown's Branch, Whitehead, and Blacksnake Basins (see Figure 1 in Appendix A for overview). The following four areas were identified as the best locations that could be retrofitted with multiple green solutions:

- Hyde Park
- Southwest Parkway
- Corby Parkway
- Parkway A

The evaluation results presented herein focus on Tier 1 (City-owned) properties, although some Tier 2 (vacant parcels) and Tier 3 (boulevards and rights-of-way) opportunities are also presented. Identified green solutions consist of site, neighborhood, and watershed scale opportunities. Furthermore, where feasible, green solutions were specifically developed to help reduce stormwater infrastructure proposed as part of the 1998 Comprehensive Stormwater Management Plan.

The 23 green solutions opportunities could potentially provide up to a total of 9.4 MG of stormwater storage during wet weather events at a probable project cost of $10.9 million and a probable 20-year present worth of $16.0 million, or $1.16 per gallon stored (project cost basis) and $1.70 per gallon stored (present worth basis). Specific green solutions opportunities are presented in the following sections.

4.1 Hyde Park

Hyde Park is located in southern St. Joseph in the Brown's Branch Basin. Hyde Park is part of St. Joseph's historic parks and boulevards system and has several opportunities for BMP improvement. Stream channel improvements and extended detention wetlands could be installed in the park. In addition, an adjacent residential area was also identified as a good location for rain garden installations that could reduce overall stormwater flow (see Figure 2 in Appendix A for overview). Details of each of these three green solutions as well as associated costs are presented in the following sections.

4.1.1 Hyde Park Wetland Channel (HP1)

The first improvement identified is in the main stream channel that drains an adjacent pond and most of the recreational amenities of the park itself (see Figure 3 in Appendix A). The existing system is a flat-bottom stream channel with significant base flow from the upstream pond. The existing channel is lined with turf grass and mowed down to the stream edge. There is no existing riparian corridor. The existing grass lined open channel is shown in Photographs 1 through 4. The existing stream channel provides a retrofit opportunity to create a wetland channel with improvements such as natural vegetative flood benches and banks and check dams that can detain and clean runoff from the Hyde Park recreation facility; beautify the park by creating a park amenity (i.e., stream walk); and raise a low water crossing to impound more water within the stream channel.

Site and hydrologic characteristics of the proposed Hyde Park wetland channel green solution are shown in Table 1. The "Percentage of 1.8 inch Rainfall Captured" in Table 1 compares the amount of runoff generated from the 1.8 inch design event (Design Event E) to the estimated available green solution storage capacity. If the percentage is less than 100 percent, it implies that there is more runoff than storage volume available, and the runoff will not be completely contained by the green solution. If the percentage is greater than 100 percent, it implies that the green solution can completely contain the runoff from an event larger than Design Event E.

Photographs 1 and 2
Hyde Park: Looking South at Upstream End of Grassed Stream Channel

Photographs 3 and 4
Hyde Park: Grass Lined Stream Channel Upstream of Inlet Located at Central Roadway

Table 1 **Hyde Park Wetland Channel Site Characteristics**	
Identifier	CSO-HP1
Area	Hyde Park, St. Joseph
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	60 acres
Available Area for BMPs	2.3 acres / 1,092 linear feet
Slope of Site	Less than 5 percent
Vegetation	Turf grass
Soil per NRCS Survey	Kennebeck Mollisol
Infiltration Capacity	Moderately well drained
Drainage Area	380 acres
Pipe Capacity	7 ft x 7 ft box
Available Volume at 1 ft Depth	243,000 cu ft / 1.8 MG
Volume of Runoff from 1.8 inch Rainfall	731,000 cu ft
Percentage of 1.8 inch Rainfall Captured	33 percent

4.1.2 Hyde Park Extended Detention Wetlands (HP2)

The second improvement identified within Hyde Park is to provide a series of restored extended detention wetlands in the northern part of the park below the open channel stream (see Figure 4 in Appendix A for concept). This area appears to have been a historic dry detention basin with a former stream channel that has subsequently been piped after the detention basin dam washed out years ago. Photographs 5 through 8 show the existing wet soil vegetation (garlic mustard and other herbaceous plants), heavy shade by adjacent trees, and storm inlet structures. The Comprehensive Stormwater Management Plan recommends a parallel 7 foot by 7 foot box for conveyance. Therefore, the addition of a series of extended detention wetlands for low flows, piped to overflow into the existing 7 foot by 7 foot box, and selected tree removal would restore the lowland area that was most likely the original stream channel. The resulting park amenity (see Figure 5 in Appendix A for conceptual illustration) could include a raised walkway and vegetated wetland fringe and an improved seating area with wetland overlook.

Furthermore, an appropriately sized green solution at this location may help to reduce the proposed parallel 7 foot by 7 foot box if it were ever installed. However, the proposed extended detention wetlands recommended herein will provide minimal attenuation for the 25-year peak flow (the wetland is estimated to provide less than a 10 percent reduction in peak 25-year flows). Therefore, if flood control is to be provided by the proposed green solution, the current recommendation's storage volume would need to be increased significantly to attenuate flood events. This would also increase the facility's cost. For now, the facility is focused on controlling small, "CSO sized events" (i.e., Design Event E rather than larger flood events).

Hyde Park is currently used for festivals. Therefore, the proposed wetlands area could impact this use. If a green solution is pursued within Hyde Park, coordination with the parks department as well as park stakeholders will be important in selecting a green solution that enhances the current park uses rather than replacing them.

Table 2 presents the site and hydrologic characteristics of the proposed Hyde Park extended detention wetland green solution.

Photographs 5 and 6
Hyde Park: Eastern End of Remnant Stream Channel Looking West at Channel and Surge Basin

Photographs 7 and 8
Hyde Park: Storm Inlets Located within West End of Potential Extended Detention Wetlands

Table 2 Hyde Park Extended Detention Wetland Site Characteristics	
Identifier	CSO-HP2
Area	Hyde Park, St. Joseph
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	34 acres
Available Area for BMPs	1.3 acres
Slope of Site	Less than 2 percent
Vegetation	Turf grass / native trees
Soil per NRCS Survey	Kennebeck Mollisol
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	348 acres
Pipe Capacity	7 ft x 7 ft box
Available Volume at 2 ft Depth	113,256 cu ft / 844,889 gallons
Volume of Runoff from 1.8 inch Rainfall	426,000 cu ft
Percentage of 1.8 inch Rainfall Captured	27 percent

4.1.3 Hyde Park Neighborhood Disconnection/Rain Garden Program (HP3)

The third potential identified improvement is a residential area that drains to the Hyde Park valley (see Figure 6 in Appendix A for site overview). A roof downspout disconnection and/or rain garden/rain barrel program could help reduce overall wet weather flows into the Brown's Branch trunk line. Evidence from other communities (specifically Chicago, Illinois) has shown that disconnecting all downspouts within a residential area results in an approximate 20 percent reduction in peak flow within the collection system. Although this reduction would need further study to verify for St. Joseph, it is reasonable to assume that a reduction of this magnitude could be achievable.

In addition, there are several vacant wooded lots and wooded riparian corridors north of Thompson Street that could be preserved for stormwater filtration. Table 3 presents the site and hydrologic characteristics of the proposed Hyde Park neighborhood green solution. Photograph 9 shows open space within this area that could be retrofitted with rain gardens. Figure 7 (Appendix A) illustrates a typical residential scale rain garden.

Table 3
Hyde Park Neighborhood Site Characteristics

Identifier	CSO-HP3
Area	Hyde Park Neighborhood
Parcel Owner	Private
Parcel Size – i.e. Area of Neighborhood	66 acres
Available BMP Volume	50 cu ft per parcel
Number of Parcels	583 parcels
Slope of Site	Less than 5 percent
Vegetation	Turf grass / trees
Soil per NRCS Survey	Knox Alfisol Colo Mollisol (hydric)
Infiltration Capacity	Knox – Moderately well drained Colo – Poorly drained
Drainage Area	66 acres
Pipe Capacity	7 ft x 7 ft reinforced concrete box
Available Volume at 1 ft Depth	29,150 cu ft / 218,042 gallons
Volume of Runoff from 1.8 inch Rainfall	954,449 cu ft
Direct Tributary Area	275 acres
Percentage of 1.8 inch Rainfall Captured	3 percent

Photograph 9
Rain Garden Opportunity within Hyde Park Neighborhood

4.1.4 Green Solutions Cost Opinion for Hyde Park

Table 4 presents the opinion of probable project cost for the proposed improvements in Hyde Park, as described in Section 3.3.

Table 4
Hyde Park Green Solutions Opinion of Probable Project Cost

Description	Quantity	Units	Unit Cost	Land Acquisition ($1.33/sq ft)	Construction Cost	$ per Gallon	Annual Maintenance Cost (% of Capital)	Annual Maintenance Cost
Wetland Channel (HP1)	100,188	sq ft	$0.65	NA	$65,122	$0.09	5%	$3,256
Extended Detention Wetlands (HP2)	113,256	cu ft	$2.60	NA	$294,466	$0.35	5%	$14,723
Neighborhood Rain Gardens (HP3)	29,150	cu ft	$10.00	NA	$291,500	$1.34	7%	$20,405
Subtotal					*$651,088*			*$38,384*
General Requirements (12%)					$78,131			
Subtotal					*$729,218*			
Contingency (25%)					$182,305			
Opinion of Probable Construction Cost					**$911,523**			
Engineering, Legal, and Administration (20%)					$182,305			
Opinion of Total Project Cost					**$1,094,000**		**O&M PW**	**$478,354**
20 Year Present Worth [1]								**$1,572,000**
1. Assumes a 5% inflation rate for present worth calculation								

4.2 Southwest Parkway

Southwest Parkway is located in central St. Joseph within the Whitehead Basin (see Figure 8 in Appendix A for overview). The parkway is part of the historic parks and boulevards system. Several green solutions were identified for a stretch of Southwest Parkway from Commercial Street to US Highway 36. Concepts include dry extended detention, channel improvements, an extended detention wetland, a vegetated swale, and neighborhood rain gardens.

Considering the extent of pipe system improvements recommended by the Comprehensive Stormwater Management Plan for Southwest Parkway, a “multiple barrier approach to stormwater management” (Marsalek and Schreier, 2008) is recommended, where site, neighborhood, and watershed level BMPs are applied together to make a systematic and holistic impact on the quantity and quality of water entering the receiving stream and/or pipe system. The site level barrier includes rain gardens in each parcel where possible (Tier 2 sites); the neighborhood level barrier includes green streets or pocket parks with dry detention capacity; and the watershed level includes preservation of a wooded riparian corridor. Many of the basins in St. Joseph are well suited to this approach because most of the riparian corridors in the City are wooded ravines, where it is more beneficial to keep the existing stream system intact rather than create in-line detention (Patti Banks Associates and Black & Veatch, 2008).

4.2.1 US Highway 36 Right-of-Way Extended Dry Detention (SW1)

Located north of US Highway 36 is a small catchment area that is currently ponding water against the northern embankment of the highway at Merriott and Highway 36 (see Figure 9 in Appendix A for concept). This existing depression is an opportunity to add extended dry detention with native vegetation as a pretreatment before the water enters the pipe system which daylights a few blocks away. Table 5 presents the site and hydrologic characteristics of the proposed US Highway 36 off-ramp extended dry detention green solution.

Table 5
US Highway 36 Off-Ramp Extended Dry Detention Site Characteristics

Identifier	CSO-SW1
Area	Southwest Parkway, St. Joseph
Parcel Owner	Missouri Department of Transportation
Parcel Size	3.57 acres
Available Area for BMPs	0.84 acres
Slope of Site	Depression
Vegetation	Turf grass
Soil per NRCS Survey	Urban Complex
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	55 acres
Pipe Capacity	33 inch reinforced concrete pipe
Available Volume at 2 ft Depth	73,180 cu ft / 547, 392 gallons
Volume of Runoff from 1.8 inch Rainfall	149,000 cu ft
Direct Tributary Area	39.65 acres
Percentage of 1.8 inch Rainfall Captured	49 percent

4.2.2 Bryce Road Stream Stabilization (SW2)

An existing tributary located south of Bryce Road is unstable as evidenced by the existing incised channel (see Photograph 10). This instability is likely due to excessive flow passing into the tributary from site SW5 (see Figure 10 in Appendix A for concept). Potential recommendations include stream restoration and stabilization, a floodplain bench, and native riparian (stream) vegetation. Recreating a small floodplain bench will provide additional natural storage capacity and stabilize the stream from future development upstream of the parkway. Additional potential recommendations include a weir system to augment the storage capacity and an earthen amphitheatre integrated into the floodplain benching that would create a public amenity. Table 6 presents the site and hydrologic characteristics of the proposed Bryce Road stream stabilization green solution.

Photograph 10
Southwest Parkway: Incised Stream Channel

Table 6
Bryce Road Stream Stabilization Site Characteristics

Identifier	CSO-SW2
Area	Southwest Parkway, St. Joseph
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	12 acres
Available Area for BMPs	1.51 acres
Length of Stream Stabilization	1,000 linear feet
Slope of Site	2-5 percent
Vegetation	Turf grass / trees
Soil per NRCS Survey	Colo Mollisol
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	216 acres
Pipe Capacity	7 ft x 6 ft reinforced concrete box
Approximate Volume at 1 ft Depth	131,515 cu ft / 983,732 gallons
Volume of Runoff from 1.8 inch Rainfall	125,239 cu ft
Percentage of 1.8 inch Rainfall Captured	105 percent

4.2.3 Southwest Parkway Extended Detention Wetland (SW3)

The area located in-line within the stream channel at the northeastern corner of the intersection of Commercial Street and Southwest Parkway is well suited for an extended detention wetland (see Figure 11 in Appendix A for concept). This area receives constant base flow and if the channel is restored directly upstream of the area, the extended detention wetland improvement could likely be done under the same US Army Corps of Engineers Section 404 permit. The creation of a wetland with boardwalks linked to a trail system would increase the amenity value of Southwest

Parkway for residents. Additionally, the Missouri Department of Natural Resources (MDNR) would be more likely to approve the channel modification because the creation of a wetland will increase the habitat value of the existing natural resources. Table 7 presents the site and hydrologic characteristics of the proposed Southwest Parkway extended wetland green solution.

Table 7
Southwest Parkway Extended Detention Wetland Site Characteristics

Identifier	CSO-SW3
Area	Southwest Parkway, St. Joseph
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	12 acres
Available Area for BMPs	1.23 acres
Slope of Site	2-5 percent
Vegetation	Turf grass / trees
Soil per NRCS Survey	Colo Mollisol
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	215 acres
Pipe Capacity	7 ft x 6 ft reinforced concrete box
Available Volume at 2 ft Depth	107,151 cu ft / 801,538 gallons
Volume of Runoff from 1.8 inch Rainfall	146,701 cu ft
Percentage of 1.8 inch Rainfall Captured	73 percent

4.2.4 Southwest Parkway Mustang Field Extended Dry Detention Basin (SW4)

The area located at the southwestern corner of the intersection of Commercial Street and Southwest Parkway is well suited for extended dry detention (see Figure 12 in Appendix A for a site overview, see Photographs 11 and 12 for pictures of the site). Currently, this site is being used as either auxiliary parking or as an auxiliary practice field for the St. Joseph Mustangs baseball team. This area could be fed directly from the proposed CSO-SW3. The extended dry detention area would be designed to outlet slowly into the existing stream channel or possibly into the existing 4 foot by 4 foot box adjacent to the existing stream corridor. The basin could be designed as an amenity adjacent to the baseball stadium include seating, a loop extension of the current trail, native grasses and trees, a shade structure, or possibly a bullpen or warm up area. Table

8 presents the site and hydrologic characteristics of the proposed Mustang Field extended dry detention basin green solution.

Photographs 11 and 12
Southwest Parkway: Open Space Located East of Mustangs Baseball Facility

Table 8
Southwest Parkway Mustangs Field Extended Dry Detention Site Characteristics

Identifier	CSO-SW4
Area	Southwest Parkway, St. Joseph
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	17.1 acres
Available Area for BMPs	1.87 acres
Slope of Site	0-1 percent
Vegetation	Turf grass / street trees
Soil per NRCS Survey	Urban Complex
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	215 acres
Pipe Capacity	7 ft x 6 ft reinforced concrete box
Available Volume at 2 ft Depth	162,914 cu ft / 1,218,600 gallons
Volume of Runoff from 1.8 inch Rainfall	146,701 cu ft
Percentage of 1.8 inch Rainfall Captured	111 percent

4.2.5 Southwest Parkway Parking Lot Retrofit (SW5)

This site is a recently installed asphalt parking lot with a concrete flume directly discharging to a stream channel with an adjacent green space (see Figure 13 in Appendix A for site overview, see Photographs 13 and 14 for pictures of the site). Currently, the concrete flume is causing a stream channel scour area which is head-cutting up to the parking lot. Site improvements could include the addition of a vegetated swale adjacent to the parking lot and the removal and replacement of the concrete flume with a stepped terrace that will control water flow into the stream channel without creating an erosion problem. This is a water quality retrofit because it is a conveyance and not a storage green solution. Table 9 presents the site and hydrologic characteristics of the proposed Southwest Parkway parking lot retrofit green solution.

Photographs 13 and 14
Green Space Adjacent to Parking Lot and
Concrete Drainage Flume Leading to Stream

Table 9
Southwest Parkway Parking Lot Retrofit Site Characteristics

Identifier	CSO-SW5
Area	Southwest Parkway, St. Joseph
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	1.3 acres
Available Area for BMPs	0.23 acres
Slope of Site	2-15 percent
Vegetation	Turf grass / trees
Soil per NRCS Survey	Urban Complex
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	1.3 acres
Pipe Capacity	Not applicable
Available Volume at 0.83 ft Depth	8,409 cu ft / 62,903 gallons
Volume of Runoff from 1.8 inch Rainfall	8,409 cu ft
Percentage of 1.8 inch Rainfall Captured	100 percent

4.2.6 Southwest Parkway Neighborhood Rain Gardens (SW6)

The neighborhoods surrounding Southwest Parkway are well suited for rain garden/rain barrel installations (see Figure 14 in Appendix A for a site overview). Rain gardens and/or rain barrels in this neighborhood would decrease nutrient inflow to the stream within Southwest Parkway and decrease intensity of wet weather events in the Whitehead Basin combined sewer. Table 10 presents the site and hydrologic characteristics of the proposed Southwest Parkway neighborhood rain gardens green solution.

Table 10
Southwest Parkway Neighborhood Site Characteristics

Identifier	CSO-SW6
Area	Southwest Parkway Tributary Parcels
Parcel Owner	Varies, Private
Parcel Size – Combined	176 acres
Available BMP Volume	50 cu ft per parcel
Number of Parcels	717 parcels
Slope of Site	1-15 percent
Vegetation	Turf grass / trees
Soil per NRCS Survey	Marshall Mollisol – well drained Knox Alfisol – well drained
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	176 acres
Pipe Capacity	Varies – 54 inch reinforced concrete pipe to 7 ft x 6 ft reinforced concrete box
Available Volume at 1 ft Depth	35,850 cu ft / 268,158 gallons
Volume of Runoff from 1.8 inch Rainfall	610,297 cu ft
Percentage of 1.8 inch Rainfall Captured	6 percent

4.2.7 Southwest Parkway Neighborhood Green Streets (SW7)

Several streets in the Southwest Parkway neighborhood are well suited for installation of green street strategies, including ROW swales and rain gardens or vegetated bump-outs (see Figure 14 in Appendix A for a site overview). The green street segment is proposed for streets that are: 1) less than 5 percent slope, 2) absent of mature trees, and 3) have sufficient ROW space. Table 11 presents the site and hydrologic characteristics of the proposed Southwest Parkway neighborhood green streets green solution.

Table 11 Southwest Parkway Neighborhood Green Streets Site Characteristics	
Identifier	CSO-SW7
Area	Southwest Parkway Streets
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	Varies
Available BMP Volume	6 cu ft per linear foot
Number of Linear Feet	6,572 linear feet
Slope of Site	0-5 percent
Vegetation	Turf grass / sparse trees
Soil per NRCS Survey	Marshall Mollisol – well drained Knox Alfisol – well drained
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	176 acres
Pipe Capacity	Varies – 54 inch reinforced concrete pipe to 7 ft x 6 ft reinforced concrete box
Available Volume	39,432 cu ft / 294, 951 gallons
Volume of Runoff from 1.8 inch Rainfall	326,117 cu ft
Percentage of 1.8 inch Rainfall Captured	12 percent

4.2.8 Green Solutions Cost Opinion for Southwest Parkway

Table 12 presents the opinion of probable project cost for the proposed Southwest Parkway improvements, as described in Section 3.3.

Table 12
Southwest Parkway Green Solutions Opinion of Probable Project Cost

Description	Quantity	Units	Unit Cost	Land Acquisition ($1.33/sq ft)	Construction Cost	$ per Gallon	Annual Maintenance Cost (% of Capital)	Annual Maintenance Cost
US 36 ROW Extended Dry Detention (SW1)	73,180	cu ft	$2.50	NA	$182,950	$0.33	5%	$9,148
Bryce Road Stream Stabilization and Floodplain Bench (SW2)	1,000	lin ft	$500.00	NA	$500,000	NA	7%	$35,000
Extended Detention Wetland (SW3)	107,151	cu ft	$2.60	NA	$278,593	$0.35	7%	$19,501
Mustang Field Extended Dry Detention (SW4)	162,914	cu ft	$2.60	NA	$423,576	$0.35	5%	$21,179
Parking Lot Retrofit (SW5)	8,324	cu ft	$12.00	NA	$99,888	$1.60	7%	$6,992
Neighborhood Rain Gardens (SW6)	35,850	cu ft	$10.00	NA	$358,500	$1.34	7%	$25,095

Table 12
Southwest Parkway Green Solutions Opinion of Probable Project Cost

Description	Quantity	Units	Unit Cost	Land Acquisition ($1.33/sq ft)	Construction Cost	$ per Gallon	Annual Maintenance Cost (% of Capital)	Annual Maintenance Cost
Neighborhood Green Streets (SW7)	39,432	cu ft	$12.00	NA	$473,184	$1.60	7%	$33,123
			Subtotal		*$2,316,691*			*$150,038*
			General Requirements (12%)		$278,003			
			Subtotal		*$2,594,694*			
			Contingency (25%)		$648,673			
			Opinion of Probable Construction Cost		**$3,243,367**			
			Engineering, Legal, and Administration (20%)		$648,673			
			Opinion of Total Project Cost		**$3,892,000**		**O&M PW**	**$1,869,803**
			20 Year Present Worth [1]					**$5,762,000**

1. Assumes a 5% inflation rate for present worth calculation

4.3 Corby Parkway

Corby Parkway is located in the Blacksnake Basin. The Comprehensive Stormwater Management Plan proposes several pipe improvements along Corby Parkway, including a parallel 30 inch and 36 inch reinforced concrete pipe (RCP) and a 3 foot by 4 foot parallel reinforced concrete box (RCB). Therefore, green solutions in this area may help to offset the proposed stormwater improvements. Green solution improvements identified include stabilizing the existing Corby Pond bank, a sediment forebay for the pond itself, an extended detention wetland for the area northeast of the existing pond, rain garden retrofits for every parcel within the tributary area of Corby Park, and several green streets where right-of-way width allows linear BMPs to be installed (see Figure 15 in Appendix A for overview). The adjacent bike/trail system could also be improved during construction of the proposed BMPs by extending the trail to the existing ball fields increasing the trail system's convenience.

The extent of pipe system improvements proposed for Corby Parkway makes this area suitable for the multiple barrier approach to stormwater management (Marsalek and Schreier, 2008). Similar to Southwest Parkway, site, neighborhood, and watershed level BMPs would be applied together to make a systematic impact on the quantity and quality of water entering the receiving stream and/or pipe system. The site level barrier includes rain gardens in each parcel where possible (Tier 2 sites); the neighborhood level barrier includes green streets or pocket parks with extended dry detention capacity; and the watershed level includes preservation of a wooded riparian corridor. As stated previously, many of the basins in St. Joseph are well suited to this approach because most of the riparian corridors in the City are wooded ravines, where it is more beneficial to keep the existing stream system intact rather than create in-line detention.

4.3.1 Corby Parkway Pond Wetland Bench (CP1)

The existing Corby Pond is experiencing stream bank erosion and fishing path damage on the northwestern and eastern side of the pond (see Figure 16 in Appendix A for site overview and Photographs 15 and 16 for pictures of the site). The erosion is primarily caused by wind. Additionally, the pond has a brown murky color from suspended sediment and insufficient vegetative filtration. The installation of a wetland bench (littoral shelf) is proposed on the eroding side of the pond, planted with native grasses capable of withstanding inundation (see Figure 17 and Figure 18 for conceptual illustrations of the site and the wetland bench). The vegetation will inhibit erosion and improve water quality. The bench will also act as a public safety and waterfowl barrier. Table 13 presents the site and hydrologic characteristics of the proposed Corby Pond wetland bench green solution.

Photographs 15 and 16
Corby Parkway: Bank Erosion and Sediment Affecting Water Quality

Table 13
Corby Parkway Pond Wetland Bench Site Characteristics

Identifier	CSO-CP1
Area	Corby Pond
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	66 acres
Available Area for BMPs	1 acre
Number of Linear Feet	1,200 linear feet
Slope of Site	2-15 percent
Vegetation	Turf grass / dirt
Soil per NRCS Survey	Colo Mollisol – hydric
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	476 acres
Pipe Capacity	4 ft x 3 ft reinforced concrete box
Available Volume	Not applicable

4.3.2 Corby Parkway Pond Wet Detention Basin with Sediment Forebay (CP2)

In addition to the pond bank stabilization, a pretreatment BMP with a sediment forebay on the eastern side of the pond is recommended. A small tributary running adjacent to Northwest Parkway empties into the eastern end of the pond. A properly sized wet detention basin with its own sediment forebay would provide pretreatment and sediment removal for Corby Pond. The wet detention basin should be designed with a permanent pool of at least 6 feet deep. A pond at this location could be a pleasing aesthetic amenity that improves water quality, creates habitat, and incorporates a trailhead for the adjacent off-road trail. It would also help stabilize and restore the existing under-managed ravine (see Figures 16, 17, and 18 in Appendix A for concepts). Table 14 presents the site and hydrologic characteristics of the proposed green solution.

An existing combined sewer passes approximately 10 feet below this site. Therefore, before a wet detention basin is constructed, this sewer would need to be inspected to determine if a wet detention basin would be feasible without providing sewer rehabilitation and repair. Costs for improving the sewer have not been included herein.

Table 14
Corby Parkway Pond Wet Detention Basin Site Characteristics

Identifier	CSO-CP2
Area	Corby Pond
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	66 acres
Available Area for BMPs	0.5 acres
Slope of Site	0-5 percent
Vegetation	Overgrown brush / trees
Soil per NRCS Survey	Marshall Mollisol – well drained
Infiltration Capacity	Moderate (0.6 in/hr)
Drainage Area	67.69 acres
Pipes Capacity	4 ft x 3 ft reinforced concrete box
Available Volume at 3 ft Depth	61,918 cu ft / 325,828 gallons
Volume of Runoff from 1.8 inch Rainfall	70,763 cu ft
Percentage of 1.8 inch Rainfall Captured	89 percent

4.3.3 Corby Parkway Extended Detention Wetland (CP3)

Directly north of Corby Pond, across Northwest Parkway, an existing valley of overgrown vines and groundcover indicates the presence of hydric soils. An extended detention wetland is recommended in this area. Installation of the wetland in the valley would improve the vegetative quality (currently less desirable groundcover), provide detention for stormwater flows, and integrate adjacent trails with a wetland boardwalk to make the space publicly accessible (see Figure 19 in Appendix A for site overview, see Photograph 17 for a picture of the site). Table 15 presents the site and hydrologic characteristics of the proposed Corby Pond extended detention wetland green solution.

Photograph 17
Corby Parkway: Remnant Stream Channel with Vegetation

Table 15 Corby Parkway Extended Detention Wetland Site Characteristics	
Identifier	CSO-CP3
Area	Corby Park
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	71 acres
Available Area for BMPs	1.5 acres
Slope of Site	0-2 percent
Vegetation	Overgrown brush / trees
Soil per NRCS Survey	Colo Mollisol – hydric
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	180 acres
Pipe Capacity	4 ft x 3 ft reinforced concrete box
Available Volume at 2 ft Depth	130,680 cu ft / 977,486 gallons
Volume of Runoff from 1.8 inch Rainfall	214,633 cu ft
Percentage of 1.8 inch Rainfall Captured	61 percent

4.3.4 Corby Parkway Neighborhood Rain Gardens (CP4)

The neighborhoods draining to Corby Pond were also identified as good areas for rain garden/rain barrel installation. If all the downspouts in this neighborhood were disconnected from the combined sewer system, it would increase the tributary base flow and increase the viability of the proposed extended wet detention (see Figure 20 in Appendix A for a site overview). Table 16 presents the site and hydrologic characteristics of the proposed Corby Parkway neighborhood rain garden green solution.

Table 16 Corby Parkway Neighborhood Rain Garden Site Characteristics	
Identifier	CSO-CP4
Area	Corby Park Neighborhood
Parcel Owner	Varies, Private
Parcel Size	Varies
Available BMP Volume	50 cu ft per parcel
Number of Parcels	608
Slope of Site	0-10 percent
Vegetation	Turf Grass / Sparse Trees
Soil per NRCS Survey	Marshall Mollisol – Well Drained Knox Alfisol – Well Drained
Infiltration Capacity	Well Drained
Drainage Area (all parcels)	233 acres
Pipe Capacity	Varies – 18 inch reinforced concrete pipe to 4 ft x 3 ft reinforced concrete box
Available Volume at 1 ft Depth	30,400 cu ft / 227,696 gallons
Volume of Runoff from 1.8 inch Rainfall	811,711 cu ft
Percentage of 1.8 inch Rainfall Captured	3.7 percent

4.3.5 Corby Parkway Neighborhood Green Streets (CP5)

Several streets in the Corby Parkway neighborhood are well suited for installation of green street strategies, including ROW swales and rain gardens or vegetated bump-outs (see Figure 20 in Appendix A for a site overview). Green streets are proposed for streets that are: 1) less than 5 percent slope, 2) absent of mature trees, and 3) have sufficient ROW space. Table 17 presents the site and hydrologic characteristics of the proposed Corby Parkway neighborhood green streets green solution.

Table 17 Corby Parkway Neighborhood Green Streets Site Characteristics	
Identifier	CSO-CP5
Area	Corby Park ROW
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	Varies
Available BMP Volume	6 cu ft per linear foot
Number of Linear Feet	7,096 linear feet
Slope of Site	0-5 percent
Vegetation	Turf grass / sparse trees
Soil per NRCS Survey	Marshall Mollisol – well drained Knox Alfisol – well drained
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	91.17 acres

Table 17 **Corby Parkway Neighborhood Green Streets Site Characteristics**	
Pipe Capacity	Varies – 18 inch reinforced concrete pipe to 4 ft x 3 ft reinforced concrete box
Available Volume	42,576 cu ft / 318,468 gallons
Volume of Runoff from 1.8 inch Rainfall	214,682 cu ft
Percentage of 1.8 inch Rainfall Captured	20 percent

4.3.6 Green Solutions Cost Opinion for Corby Parkway

Table 18 presents the opinion of probable project cost for the proposed Southwest Parkway improvements, as described in Section 3.3.

Table 18
Corby Parkway Green Solutions Opinion of Probable Project Cost

Description	Quantity	Units	Unit Cost	Land Acquisition ($1.33/sq ft)	Construction Cost	$ per Gallon	Annual Maintenance Cost (% of Capital)	Annual Maintenance Cost
Wetland Bench (CP1)	1,200	lin ft	$28.95	NA	$34,740	NA	7%	$2,432
Extended Wet Detention (CP2)	61,918	cu ft	$2.60	NA	$160,987	$0.35	5%	$8,049
Extended Detention Wetland (CP3)	130,680	cu ft	$2.60	NA	$339,768	$0.35	5%	$16,988
Neighborhood Rain Gardens (CP4)	30,400	cu ft	$10.00	NA	$304,000	$1.34	7%	$21,280
Neighborhood Green Streets (CP5)	42,576	cu ft	$12.00	NA	$510,912	$1.60	7%	$35,764
Subtotal					*$1,350,407*			*$84,513*
General Requirements (12%)					$162,049			
Subtotal					*$1,512,456*			
Contingency (25%)					$378,114			
Opinion of Probable Construction Cost					**$1,890,570**			
Engineering, Legal, and Administration (20%)					$378,114			
Opinion of Total Project Cost					**$2,269,000**		**O&M PW**	**$1,053,224**
20 Year Present Worth [1]								**$3,322,000**

1. Assumes a 5% inflation rate for present worth calculation

4.4 Parkway A

Parkway A was identified through the modeling process because it has a City-owned open space in a valley that is not wooded (see Figure 21 in Appendix A for overview). Upon field investigation, it was found that this segment of stream was earth filled to create open space for a school owned parking lot and recreational fields. When the floodplain was filled, the stream was buried and conveyed through a pipe. The existing large surface parking lots could therefore have BMPs constructed to help control the runoff generated from the site. Furthermore, a demonstration rain garden at one of the two school buildings could help to generate public support for other recommendations within this drainage area.

Parkway A area is a good candidate for the multiple barrier approach to stormwater management (Marsalek and Schreier, 2008). Site-level barriers would include rain gardens in each parcel where possible (Tier 2 sites); neighborhood-level barriers would include green streets or pocket parks with extended dry detention basins; and watershed-level barriers would include preservation of a wooded riparian corridor.

4.4.1 Parkway A Tier 2 Vacant Sites (PWA1)

Six vacant sites were identified in the modeling process. Each of the sites are adjacent to or intersect a stream or surface flow line and are well suited to detain flows before they drop down into the valley or enter the pipe system (see Figure 22 in Appendix A for a site overview). These sites can be designed as dry detention or rain gardens depending on the tributary area and should be designed to also serve as a neighborhood pocket park or other amenity. Table 19 presents the site and hydrologic characteristics of the proposed Parkway A vacant site green solution opportunities.

Table 19
Parkway A Tier 2 Vacant Sites Site Characteristics

Identifier	CSO-PWA1
Area	Tier 2 Vacant Sites
Parcel Owner	Varies, Private
Parcel Size	Site 1: 0.93 acre Site 4: 0.91 acre Site 2: 0.14 acre Site 5: 0.1 acre Site 3: 1 acre Site 6: 0.14 acre Subtotal: 3.22 acres
Available Area for BMPs	Site 1: 0.61 acre Site 4: 0.6 acre Site 2: 0.1 acre Site 5: 0.06 acre Site 3: 0.66 acre Site 6: 0.1 acre Subtotal: 2.67 acres
Slope of Site	0-10 percent
Vegetation	Open / overgrown brush / trees
Soil per NRCS Survey	Colo Mollisol – hydric Marshall Mollisol – not hydric

Table 19
Parkway A Tier 2 Vacant Sites Site Characteristics

Infiltration Capacity	Marshall – Moderate (0.6 in/hr) Colo – Low (0.2 in/hr)
Drainage Area	Site 1: 14.6 acres Site 4: 7.9 acres Site 2: 3.12 acres Site 5: 3.6 acres Site 3: 37.9 acres Site 6: 3.5 acres Subtotal: 70.62 acres
Pipe Capacity	4 ft x 3 ft reinforced concrete box
Available Volume at 2 ft Depth	Site 1: 53,142 cu ft / 397,502 gallons Site 2: 8,712 cu ft / 65,165 gallons Site 3: 57,498 cu ft / 430,085 gallons Site 4: 52,272 cu ft / 390,994 gallons Site 5: 5,226 cu ft / 39,090 gallons Site 6: 8,712 cu ft / 65,165 gallons Subtotal: 185,562 cu ft / 1,388,001 gallons
Volume of Runoff from 1.8 inch Rainfall	Site 1: 94,439 cu ft Site 4: 41,293 cu ft Site 2: 16,308 cu ft Site 5: 18,817 cu ft Site 3: 85,095 cu ft Site 6: 18,294 cu ft Subtotal: 274,246 cu ft
Percentage of 1.8 inch Rainfall Captured	Site 1: 56 percent Site 4: 127 percent Site 2: 53 percent Site 5: 28 percent Site 3: 66 percent Site 6: 48 percent Overall Average: 68 percent

4.4.2 Parkway A Neighborhood Rain Gardens (PWA2)

The neighborhoods draining to Parkway A were also identified as good areas for rain garden/rain barrel installation. If all the parcels in this tributary installed a small rain garden or rain barrel, it would decrease a small percentage of all wet weather flows (see Figure 23 in Appendix A for a site overview). Table 20 presents the site and hydrologic characteristics of the proposed Parkway A neighborhood rain garden green solution opportunity.

Table 20
Parkway A Neighborhood Rain Garden Site Characteristics

Identifier	CSO-PWA2
Area	Parkway A Upper Watershed
Parcel Owner	Varies, Private
Parcel Size	0.1 acre to 1.0 acre
Available BMP Volume	50 cu ft per parcel
Number of Parcels	1,211
Slope of Site	0-15 percent
Vegetation	Turf / overgrown brush / trees

Table 20 **Parkway A Neighborhood Rain Garden Site Characteristics**	
Soil per NRCS Survey	Colo Mollisol – hydric Marshall Mollisol – not hydric
Infiltration Capacity	Marshall – Moderate (0.6 in/hr) Colo – Low (0.2 in/hr)
Drainage Area	223 acres
Pipe Capacity	4 ft x 3 ft reinforced concrete box
Available Volume at 1 ft Depth	60,550 cu ft / 452,914 gallons
Volume of Runoff from 1.8 inch Rainfall	773,451 cu ft
Percentage of 1.8 inch Rainfall Captured	7.8 percent

4.4.3 Parkway A Tier 3 Green Streets (PWA3)

Several streets in the Parkway A neighborhood are well suited for installation of green street strategies, including ROW swales, rain gardens, or vegetated bump-outs along the straighter side streets (see Figure 23 in Appendix A). Green streets are proposed for streets that are: 1) less than 5 percent slope, 2) absent of mature trees, and 3) have sufficient ROW space. Table 21 presents the site and hydrologic characteristics of the proposed Parkway A green streets green solution opportunity.

Table 21 **Parkway A Tier 3 Green Streets Site Characteristics**	
Identifier	CSO-PWA3
Area	Parkway A
Parcel Owner	City of St. Joseph, Missouri
Parcel Size	Varies
Available BMP Volume	6 cu ft per linear foot
Number of Linear Feet	11,558 linear feet
Slope of Site	1-5 percent
Vegetation	Turf grass / sparse trees
Soil per NRCS Survey	Colo Mollisol – hydric Marshall Mollisol – not hydric
Infiltration Capacity	Low (0.2 in/hr)
Drainage Area	156.71 acres
Pipe Capacity	8 ft x 7 ft reinforced concrete box
Available Volume	69,348 cu ft / 518,723 gallons
Volume of Runoff from 1.8 inch Rainfall	543,833 cu ft
Percentage of 1.8 inch Rainfall Captured	12.7 percent

4.4.4 Green Solutions Cost Opinion for Parkway A

Table 22 presents the opinion of probable project cost for the proposed Parkway A proposed green solution improvements, as described in Section 3.3.

Table 22
Parkway A Green Solutions Opinion of Probable Project Cost

Description	Quantity	Units	Unit Cost	Land Acquisition ($1.33/sq ft)	Construction Cost	$ per Gallon	Annual Maintenance Cost (% of Capital)	Annual Maintenance Cost
Extended Dry Detention (PWA1)	53,142	cu ft	$2.50	$70,678.86	$203,534	$0.51	5%	$10,177
Extended Dry Detention (PWA1)	8,712	cu ft	$2.50	$11,586.96	$33,367	$0.51	5%	$1,668
Extended Dry Detention (PWA1)	57,498	cu ft	$2.50	$76,472.34	$220,217	$0.51	5%	$11,011
Extended Dry Detention (PWA1)	52,272	cu ft	$2.50	$69,521.76	$200,202	$0.51	5%	$10,010
Extended Dry Detention (PWA1)	5,226	cu ft	$2.50	$6,950.58	$20,016	$0.51	5%	$1,001
Extended Dry Detention (PWA1)	8,712	cu ft	$2.50	$11,586.96	$33,367	$0.51	5%	$1,668
Rain Gardens (PWA2)	60,550	cu ft	$10.00	NA	$605,500	$1.34	7%	$42,385
Green Streets (PWA3)	69,348	cu ft	$12.00	NA	$832,176	$1.60	7%	$58,252
Subtotal					*$2,148,378*			*$136,172*
General Requirements (12%)					$257,805			
Subtotal					*$2,406,184*			
Contingency (25%)					$601,546			
Opinion of Probable Construction Cost					**$3,007,730**			
Engineering, Legal, and Administration (20%)					$601,546			
Opinion of Total Project Cost					**$3,609,000**		**O&M PW**	**$1,697,010**
20 Year Present Worth [1]								**$5,306,000**

1. Assumes a 5% inflation rate for present worth calculation

5.0 Summary and Conclusions

Site, neighborhood, and watershed scale green solutions were proposed in each of the areas containing larger City-owned opportunities. Furthermore, green solutions that can help alleviate needed stormwater improvements were proposed where feasible. These solutions were specifically identified to create an overlap between the green solutions opportunities and the stormwater infrastructure recommendations as identified in the 1998 Comprehensive Stormwater Management Plan in order to help offset the use of traditional flood protection. There are many vacant and right-of-way green solutions opportunities beyond the 23 sites identified in this TM that could be explored in greater detail in the future by applying the same cost projection methodology discussed herein. Green solutions opportunities range from larger facilities such as detention basins to smaller neighborhood scale rain gardens and green streets.

Opportunities in Hyde Park (within the Brown's Branch Basin) total 1.8 MG of potential storage at an opinion of probable project cost of $1.1 million. Hyde Park opportunities include:

- Wetland channel
- Extended detention wetlands
- Neighborhood downspout disconnection and rain gardens

Green solutions opportunities in Southwest Parkway (within the Whitehead Basin) total 3.2 MG of potential storage at an opinion of probable project cost of $3.9 million. Southwest Parkway opportunities include:

- Extended dry detention
- Stream stabilization
- Extended detention wetland
- Parking lot retrofit
- Neighborhood rain gardens and green streets with bioretention in the street right-of-way

Green solutions opportunities in Corby Park (within the Blacksnake Basin) total 2.0 MG of potential storage at an opinion of probable project cost of $2.3 million. Corby Park opportunities include:

- Extended detention wetland
- Wetland bench and sediment forebay for Corby Pond
- Neighborhood rain gardens and green streets with bioretention in the street right-of-way

Green solutions opportunities within the upper tributary area of Parkway A total 2.4 MG of potential storage at an opinion of probable project cost of $3.6 million. Parkway A opportunities include:

- Extended dry detention in vacant parcels (Tier 2)
- Neighborhood rain gardens and green streets with bioretention in the right-of-way

It is recommended that the City review and prioritize the green solutions opportunities provided in this TM based on community priorities as well as the City's ability to pay for potential green solutions improvements. It is recommended that the City implement a green solutions demonstration project to showcase the concept to the public and demonstrate the effectiveness of stormwater volume reduction for the CSO control program.

6.0 References

1. Claytor, Richard A. and Schueler, Thomas R. 1996. "Design of Stormwater Filtering Systems." Center for Watershed Protection. Silver Spring, Maryland.
2. Marsalek and Schreier. 2008. "A Multiple Barrier Approach to Stormwater Management." Presented at the Americana 2009 International Trade Show, Montreal, Canada. March 17.
3. Pitt, R. 1994. Small Storm Hydrology. University of Alabama – Birmingham. Unpublished manuscript presented at Design of Stormwater Quality Management Practices. Madison, Wisconsin. May 17-19.
4. Schulte, Scott A.; Henson, Jeffrey; and Elbert-Noll, Patricia A. 2008. "Riparian Buffer Benefits and Kansas City, Missouri's Stream Setback Ordinance." September 21.
5. United States Army Corps of Engineers. 1982. HEC-2, Water Surface Profiles. Hydrologic Engineering Center. Computer Program.

6. United States Department of Agriculture. 1982. Project Formulation – Hydrology. Soil Conservation Service, Engineering Division. Technical Release 20 (TR-20).
7. United States Department of Agriculture. 1986. Urban Hydrology for Small Watersheds. Soil Conservation Service, Engineering Division. Technical Release 55 (TR-55).

Appendix A

Figures

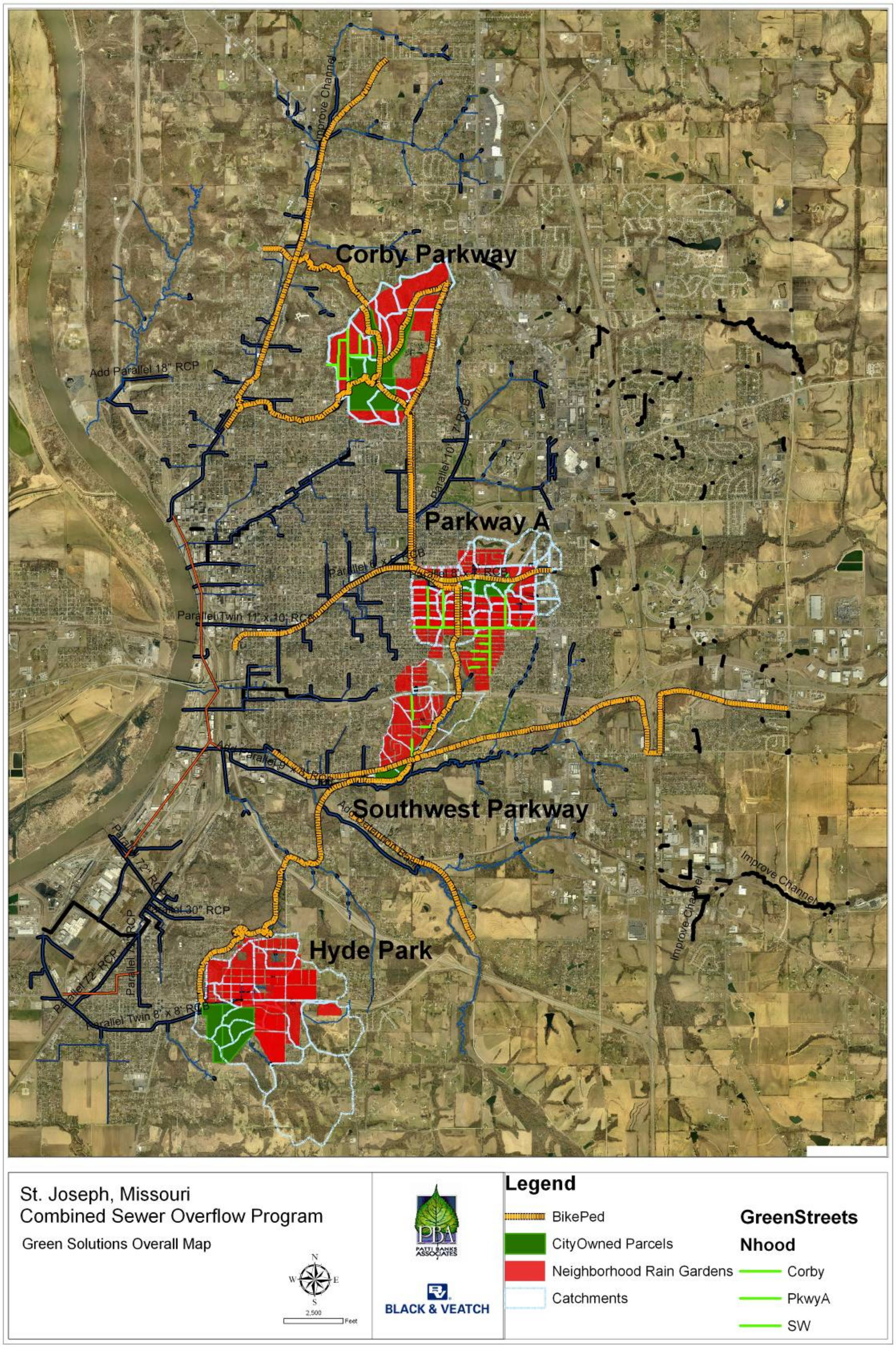

Figure 1 – Overview of Potential City-Owned Green Solutions

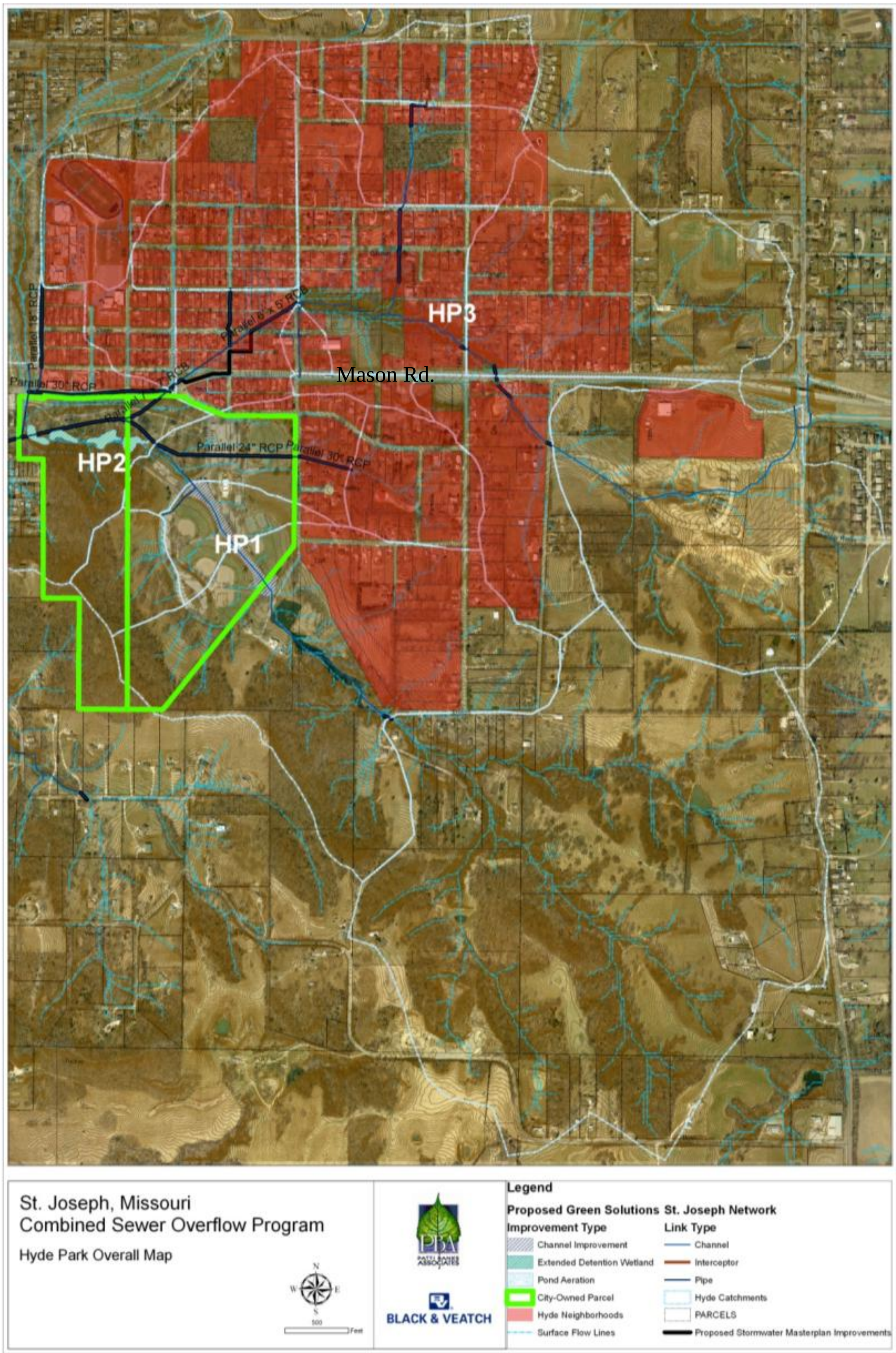

Figure 2 – Overview of Hyde Park Opportunities

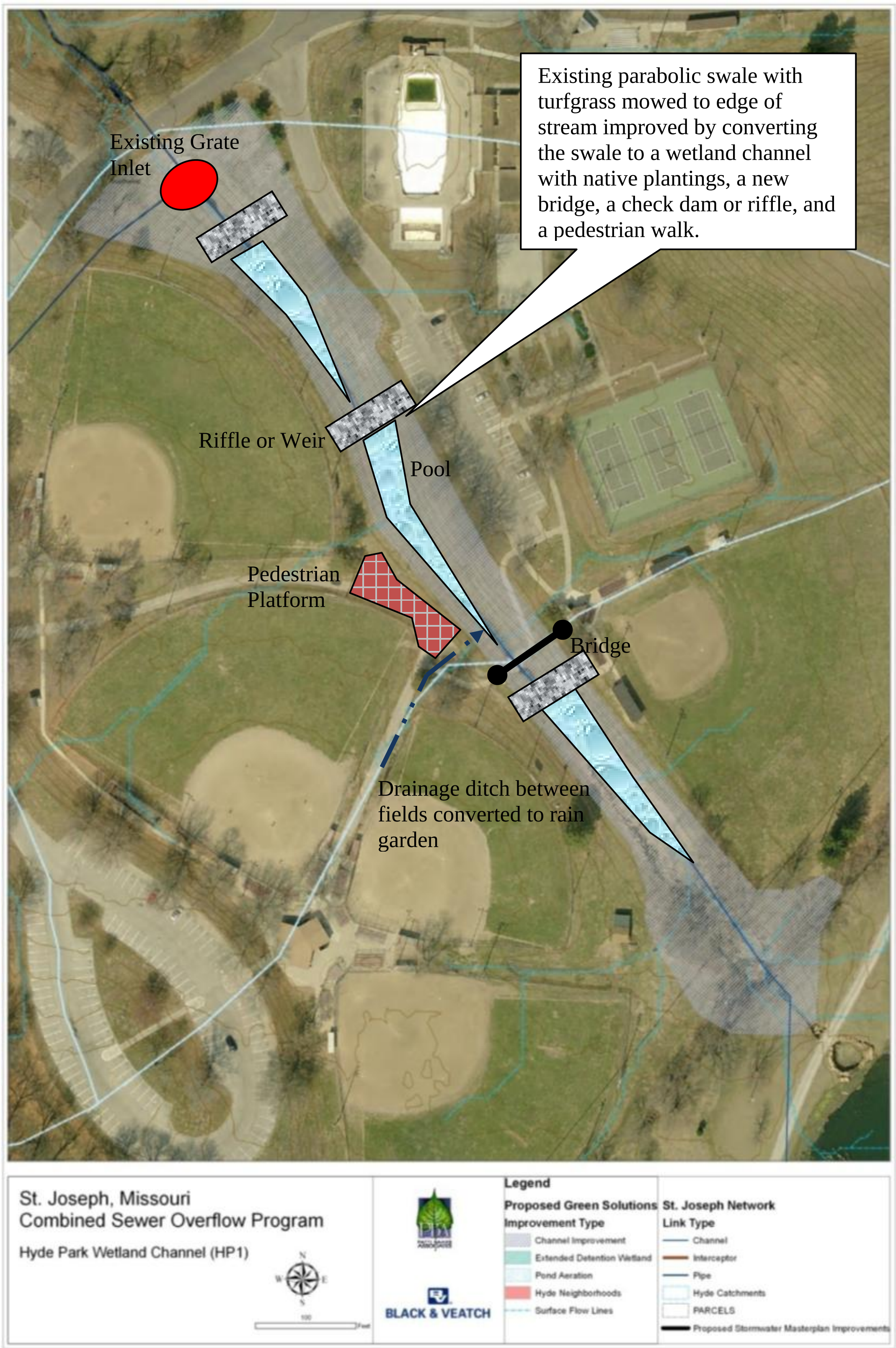

Figure 3 – Hyde Park Wetland Channel Concept (HP1)

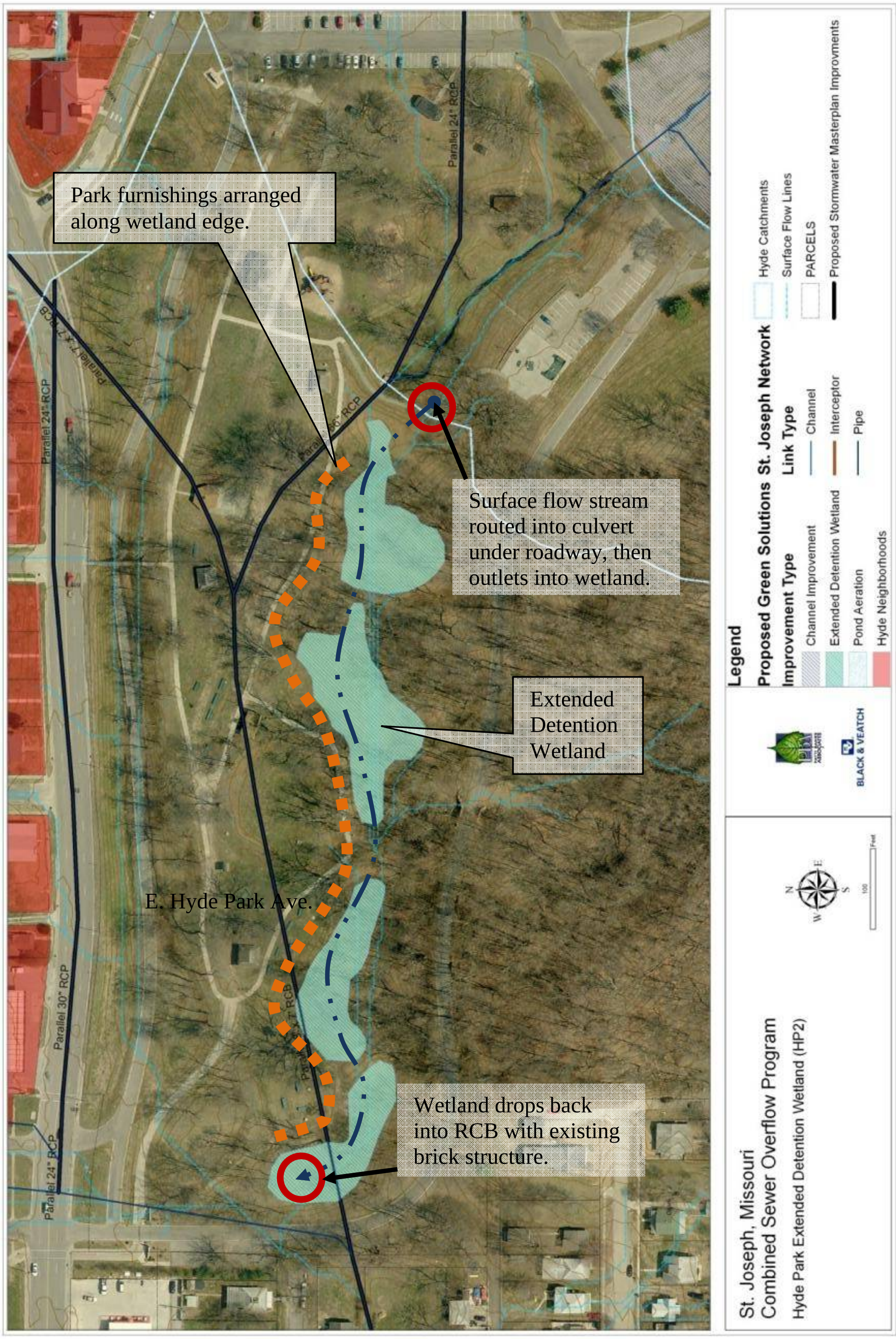

Figure 4 – Hyde Park Extended Detention Wetlands Concept (HP2)

Figure 5 – Hyde Park Extended Detention Wetlands Concept (HP2)

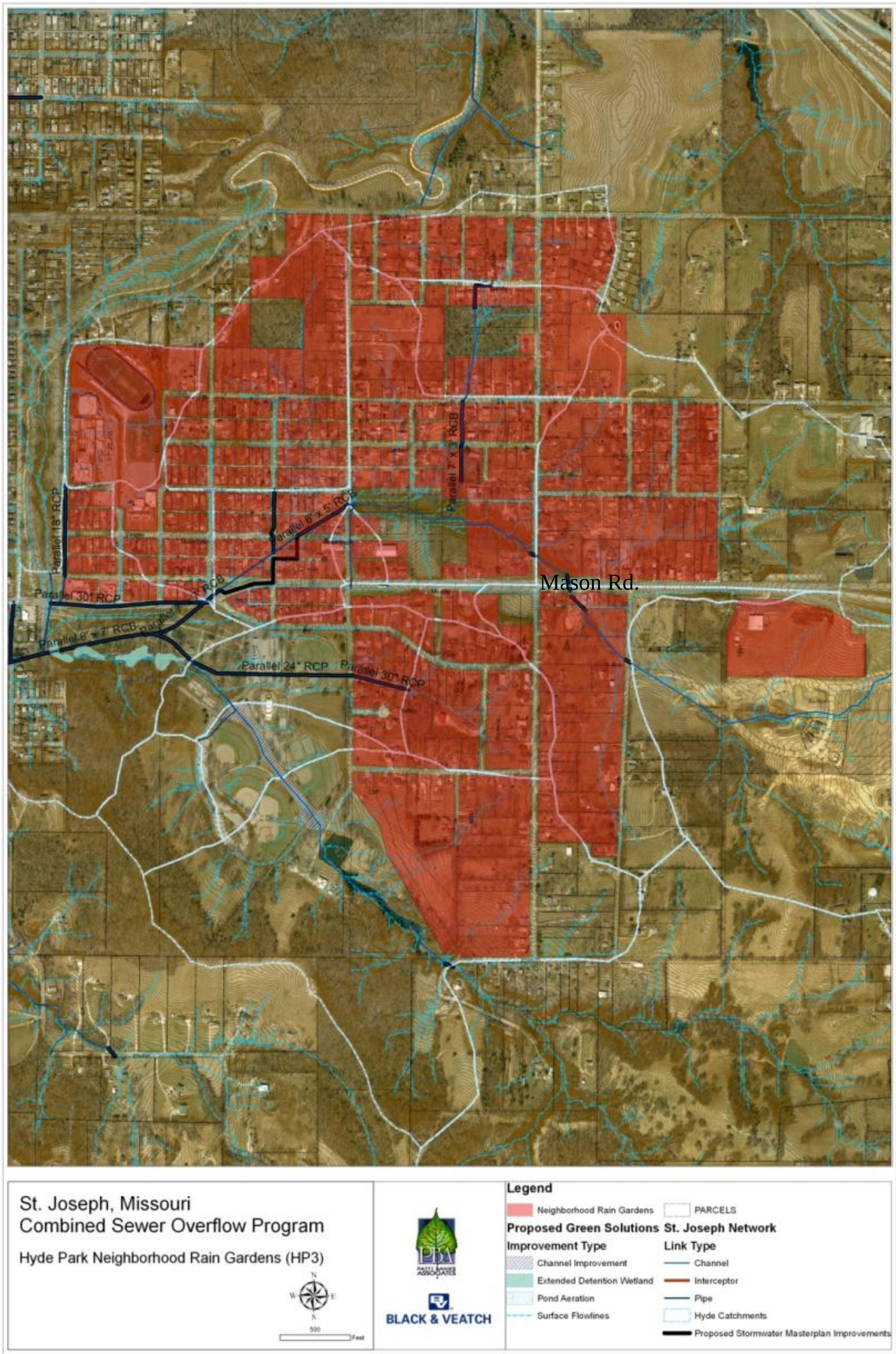

Figure 6 – Hyde Park Neighborhood
Downspout Disconnection/Rain Garden Program (HP3)

Figure 7 – Small Scale Rain Garden Conceptual Illustration

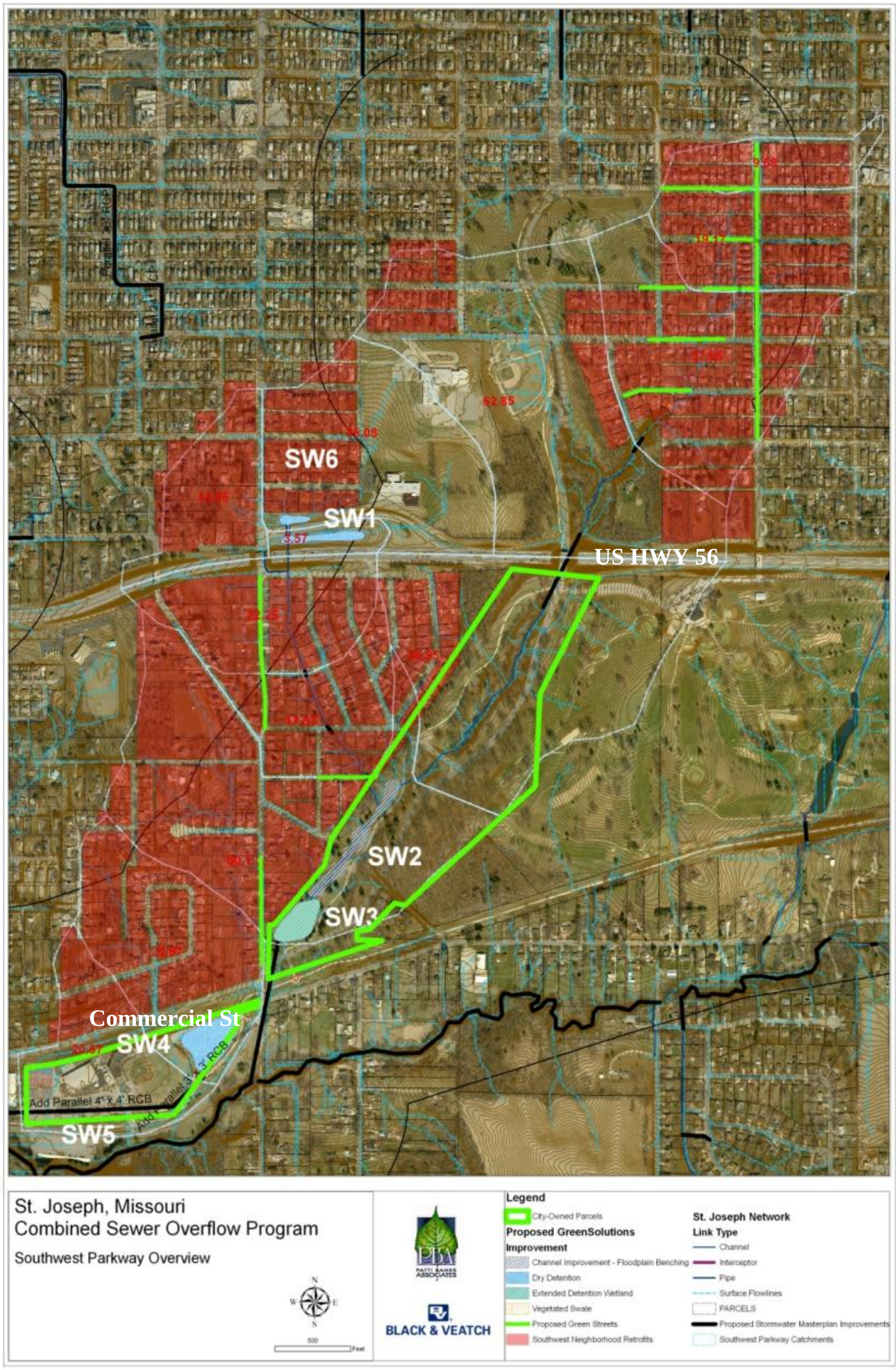

Figure 8 – Overview of Southwest Parkway, Drainage Basins, and Adjacent Neighborhood

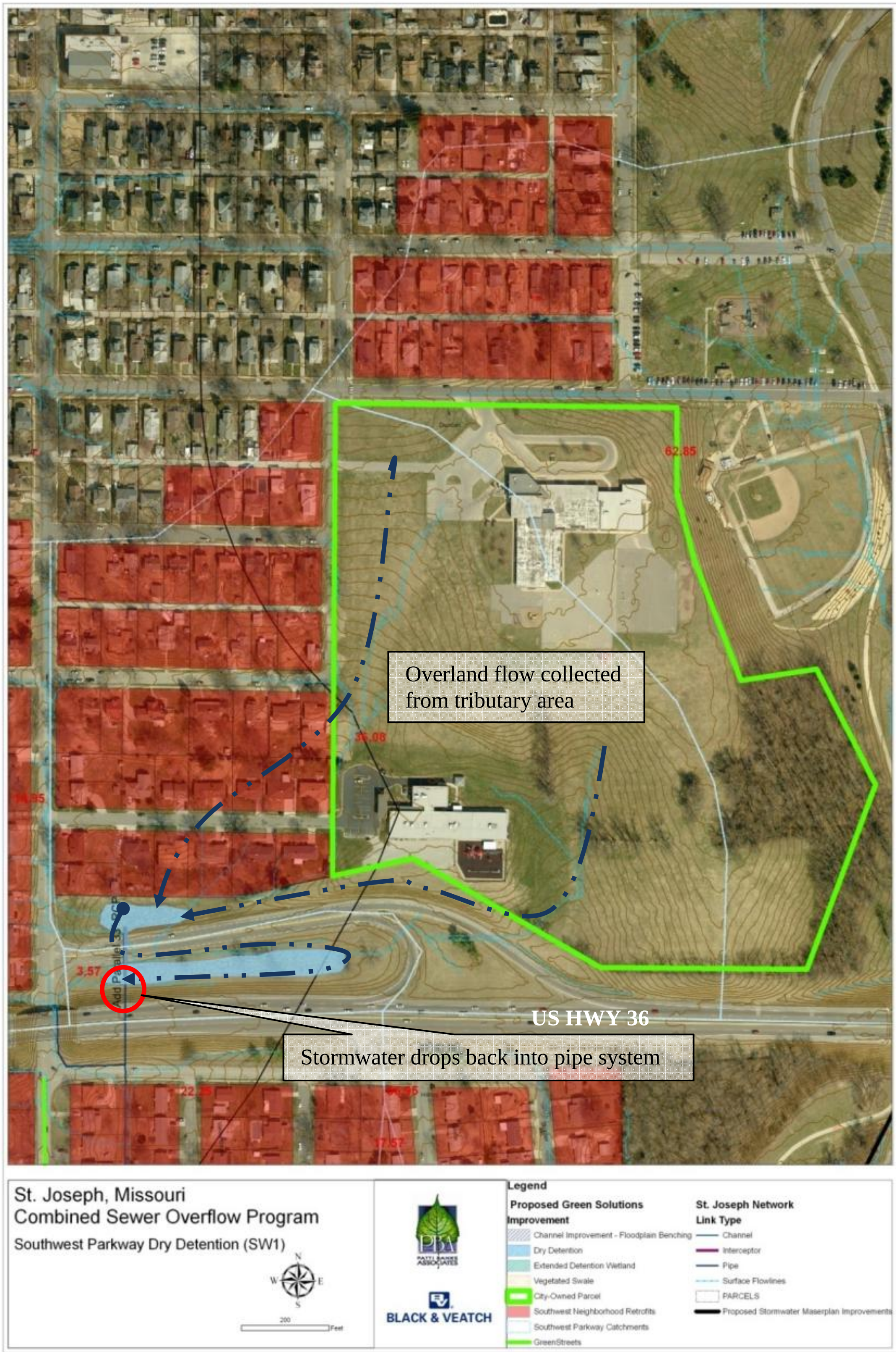

Figure 9 – Southwest Parkway Extended Dry Detention Concept (SW1)

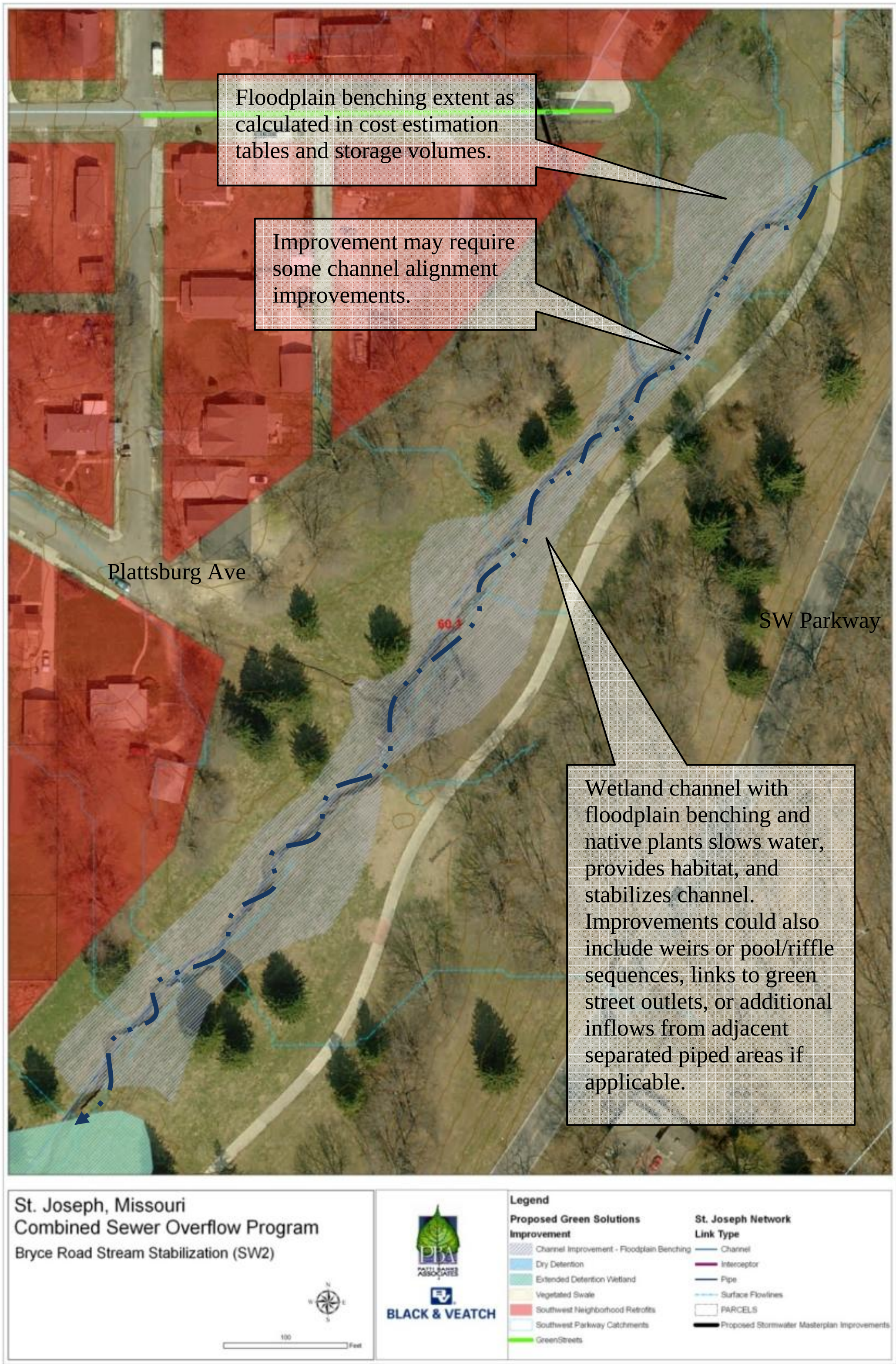

Figure 10 – Southwest Parkway Stream Stabilization at Bryce Road (SW2)

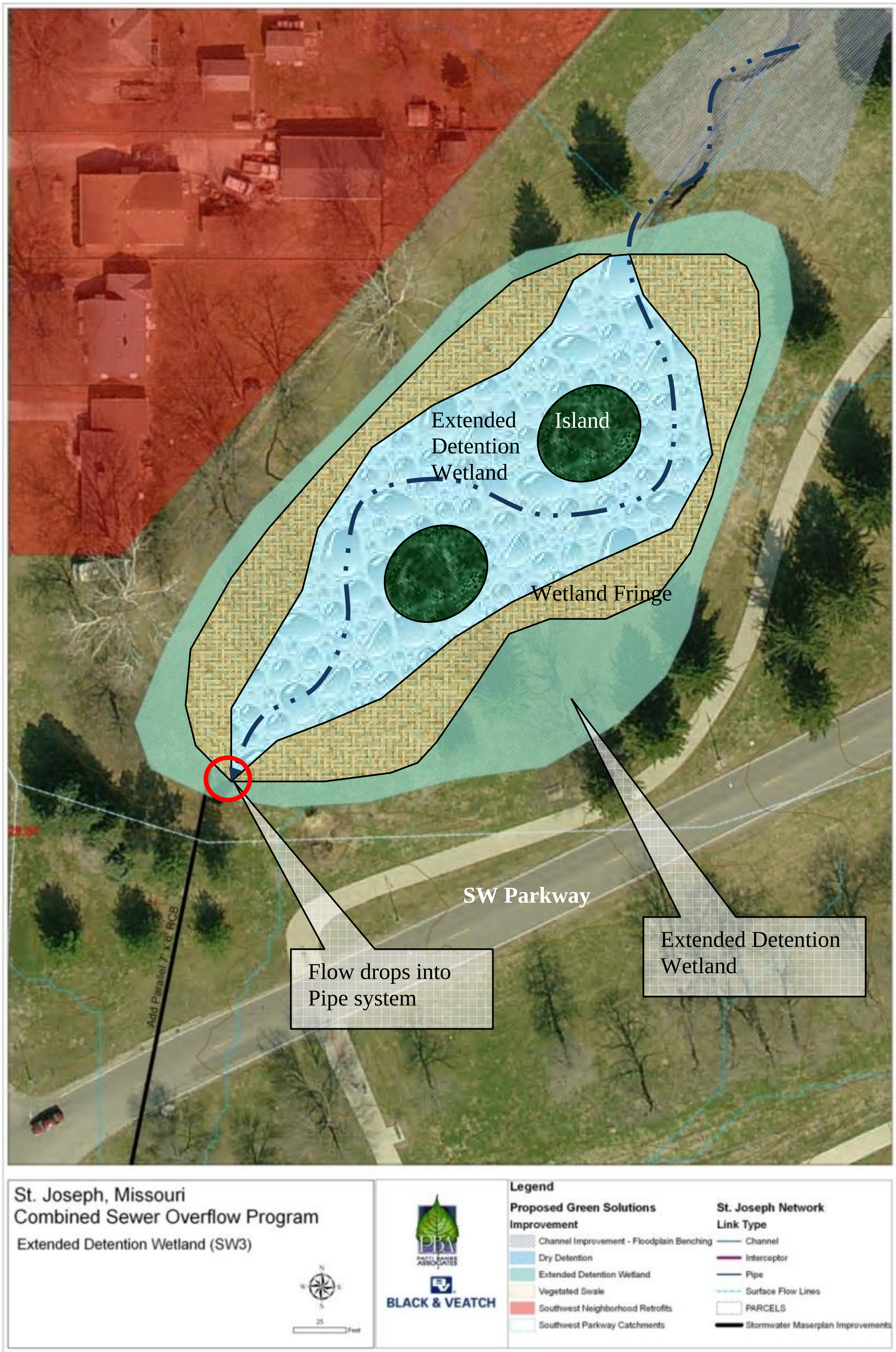

Figure 11 – Southwest Parkway Extended Detention Wetland (SW3)

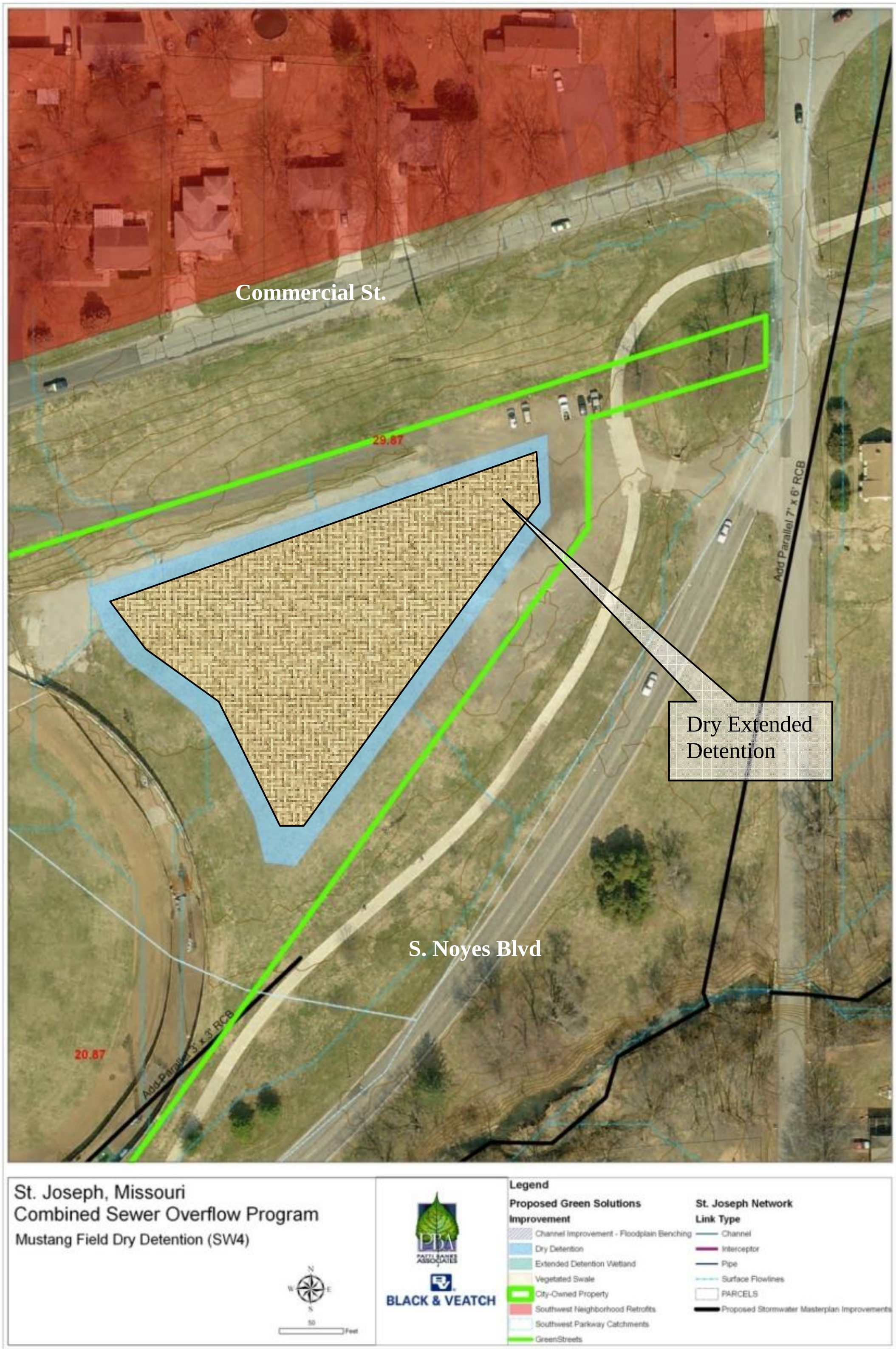

Figure 12 – Southwest Parkway Mustang Field Extended Dry Detention Concept (SW4)

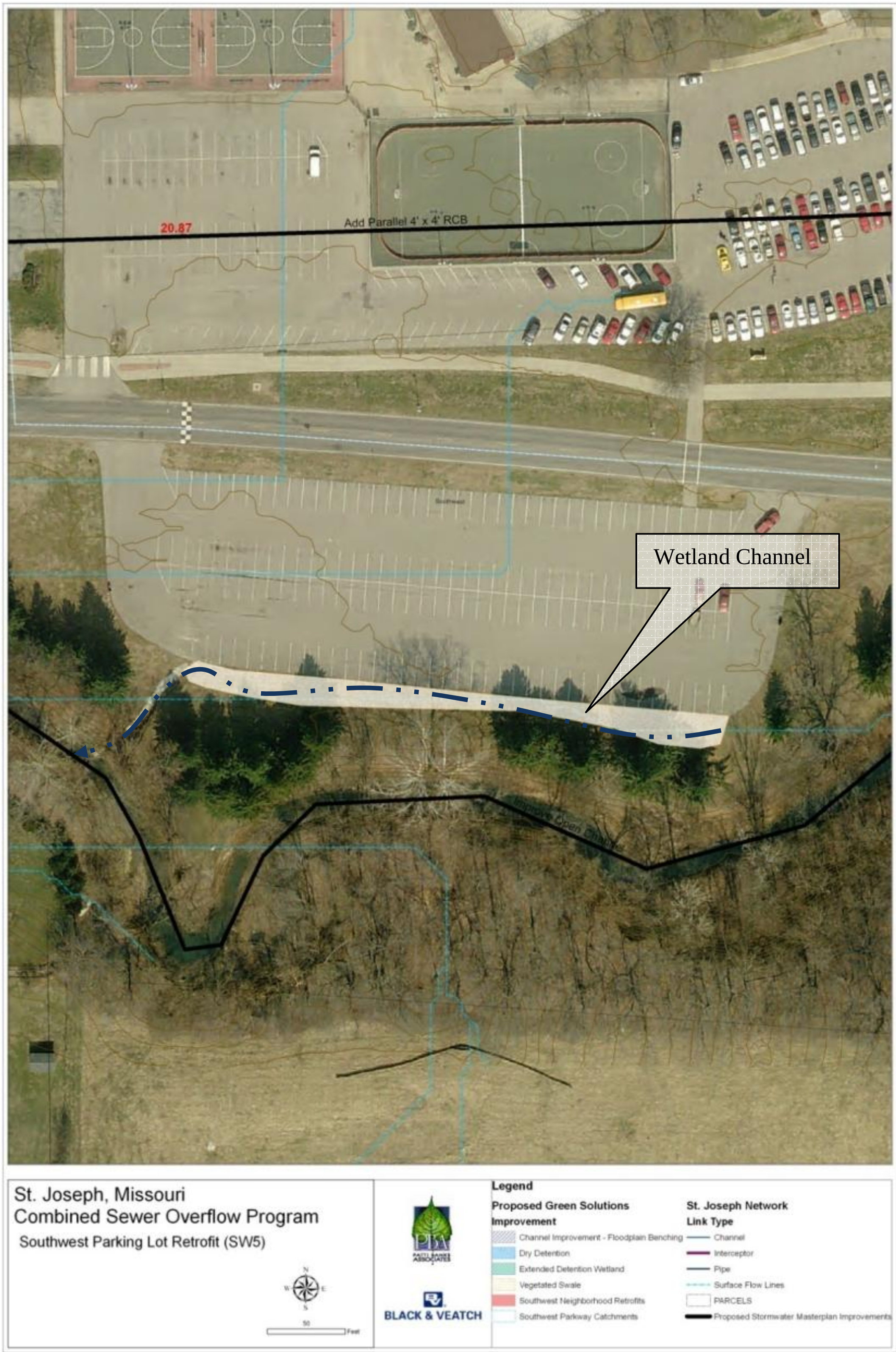

Figure 13 – Southwest Parkway Parking Lot Retrofit Concept (SW5)

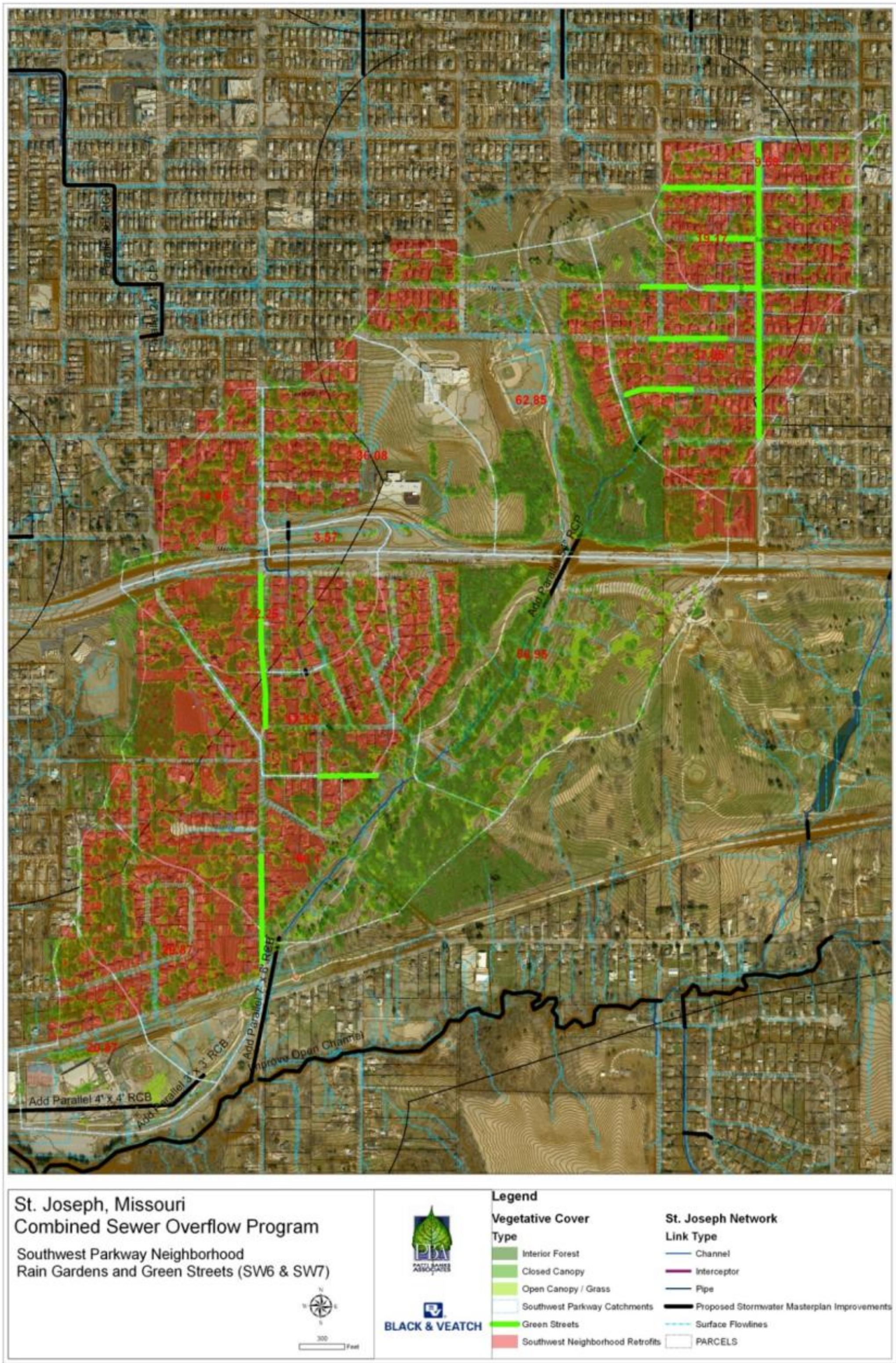

Figure 14 – Southwest Parkway Neighborhood Concept (SW6 and SW7)

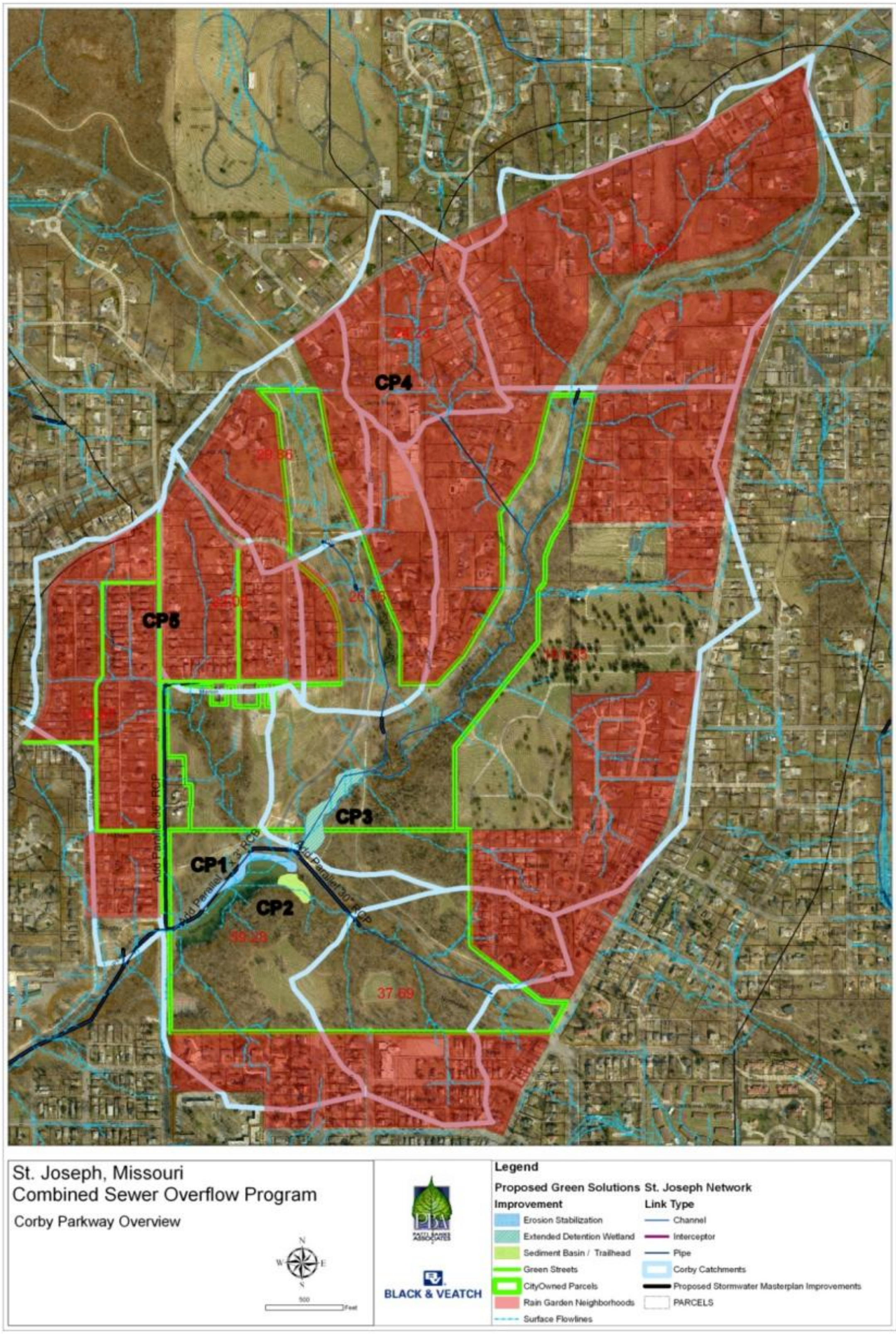

Figure 15 – Overview of Corby Parkway, Drainage Basins, and Adjacent Neighborhood

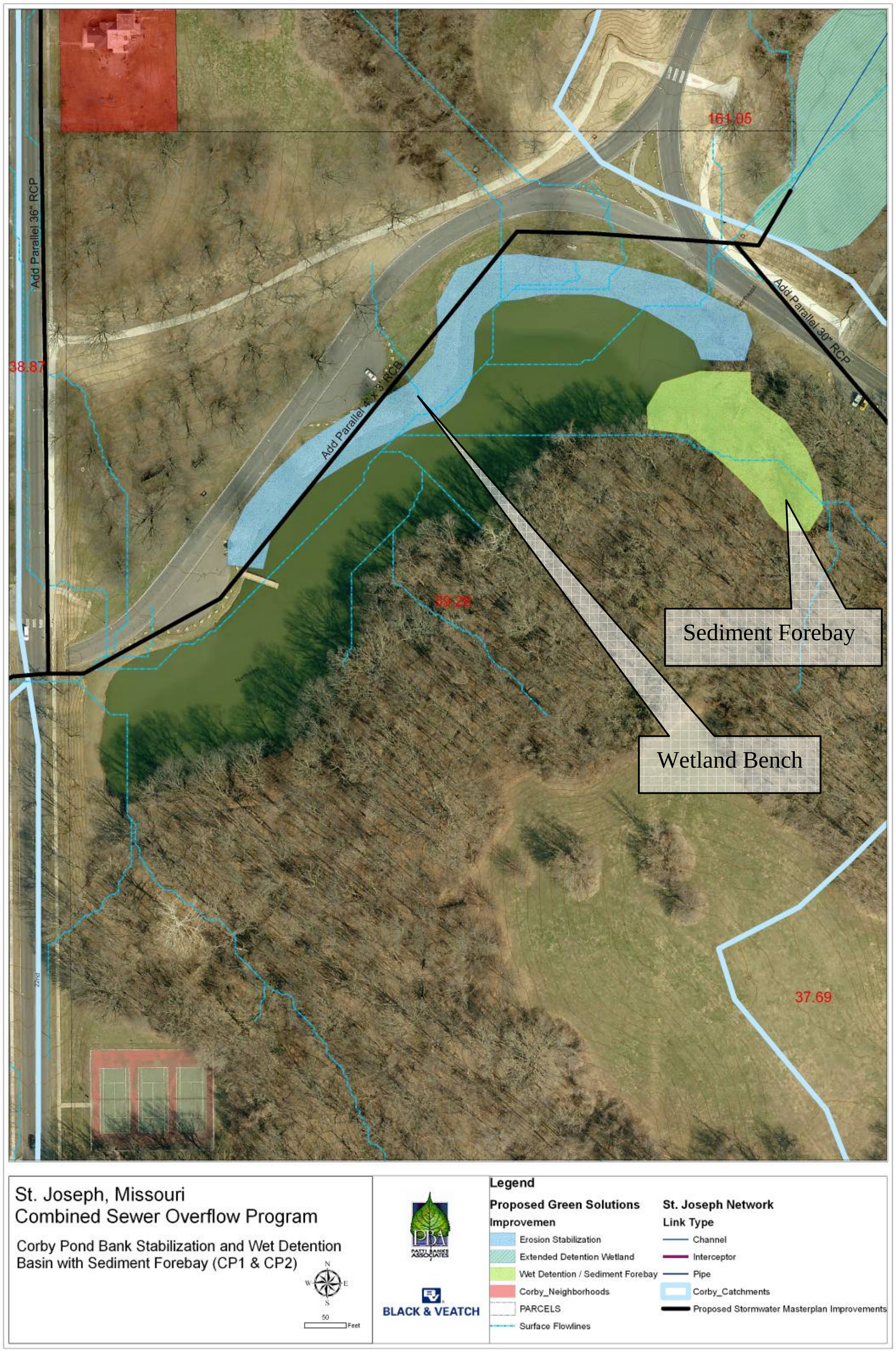

Figure 16 – Corby Pond Bank Stabilization and Wet Detention Basin with Sediment Forebay (CP1 and CP2)

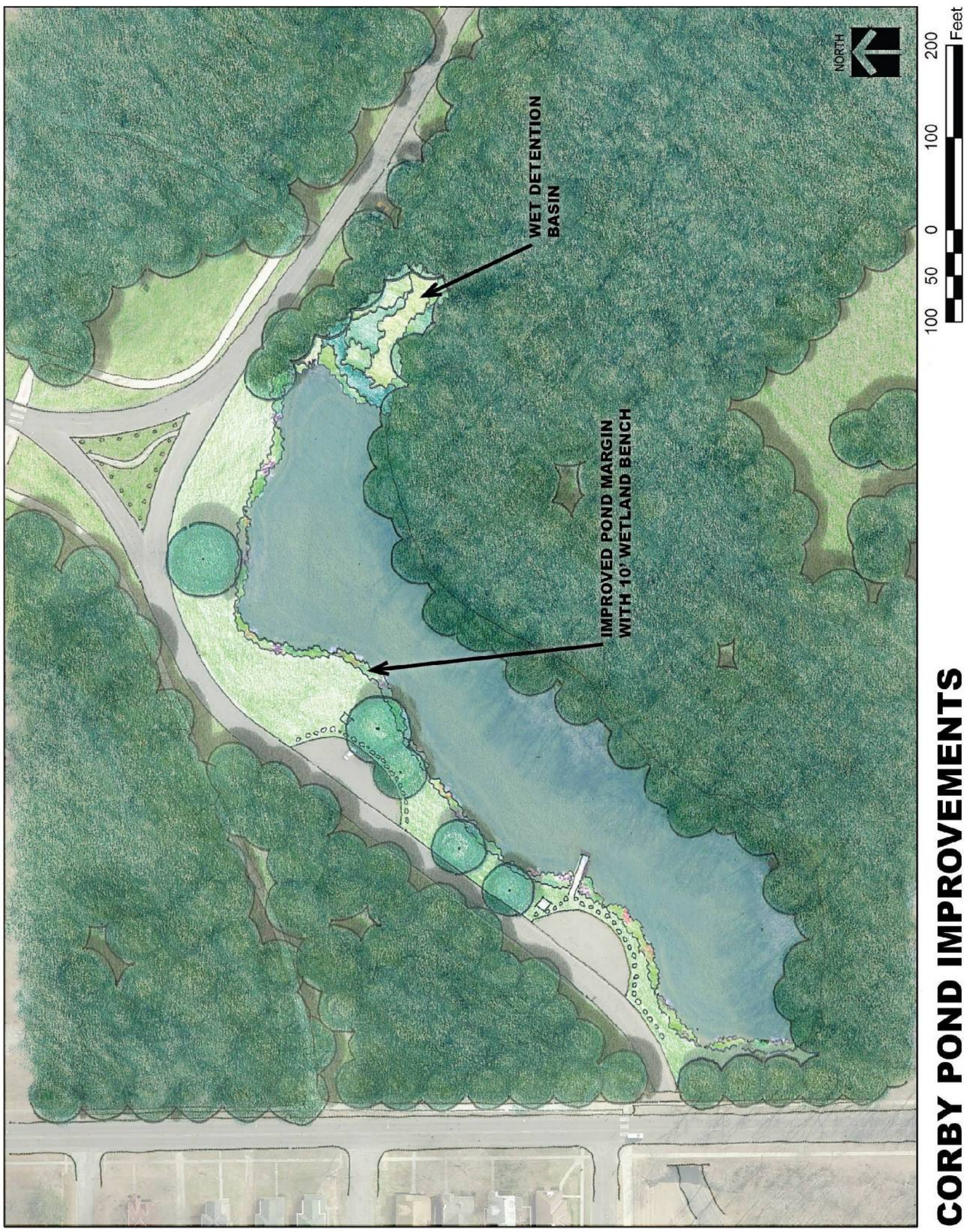

Figure 17 – Corby Pond Bank Stabilization and Wet Detention Basin Concept (CP1 and CP2)

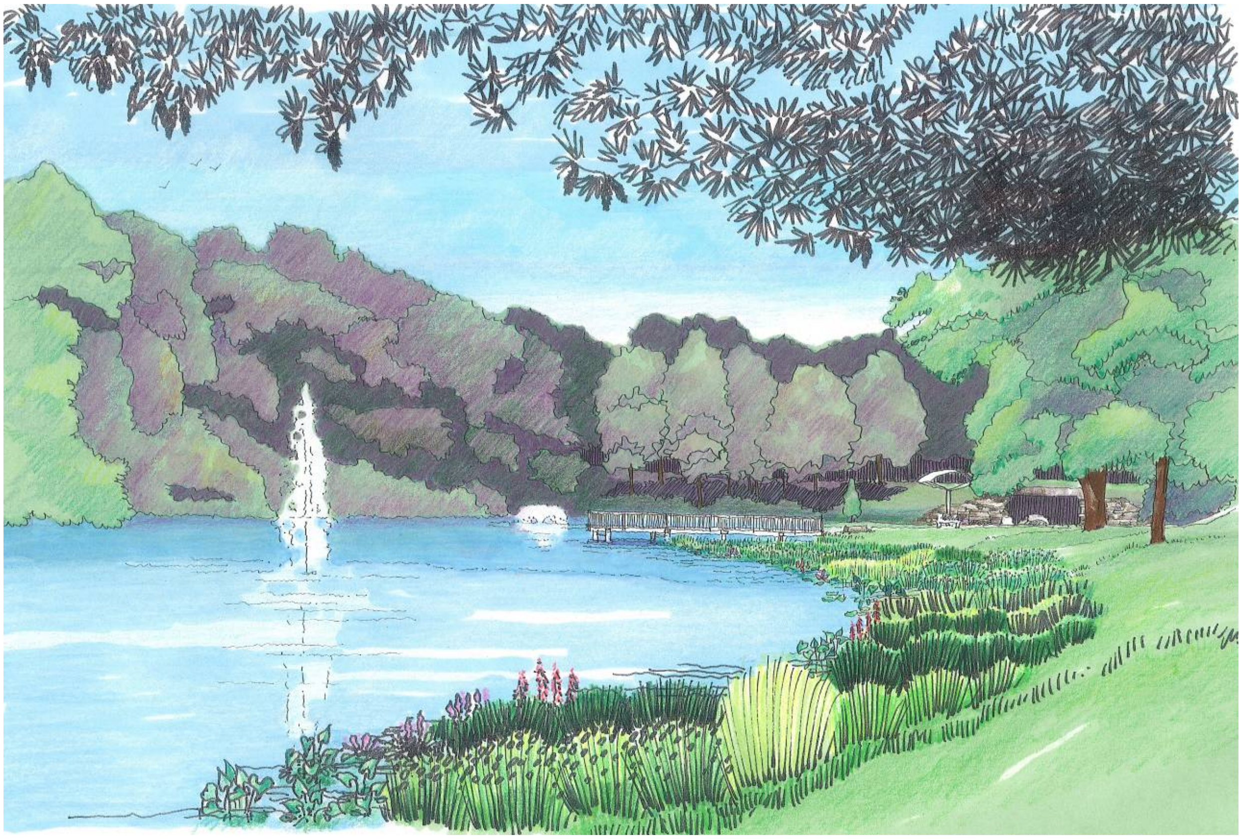

Figure 18 – Corby Pond Wetland Bench Conceptual Illustration (CP1 and CP2)

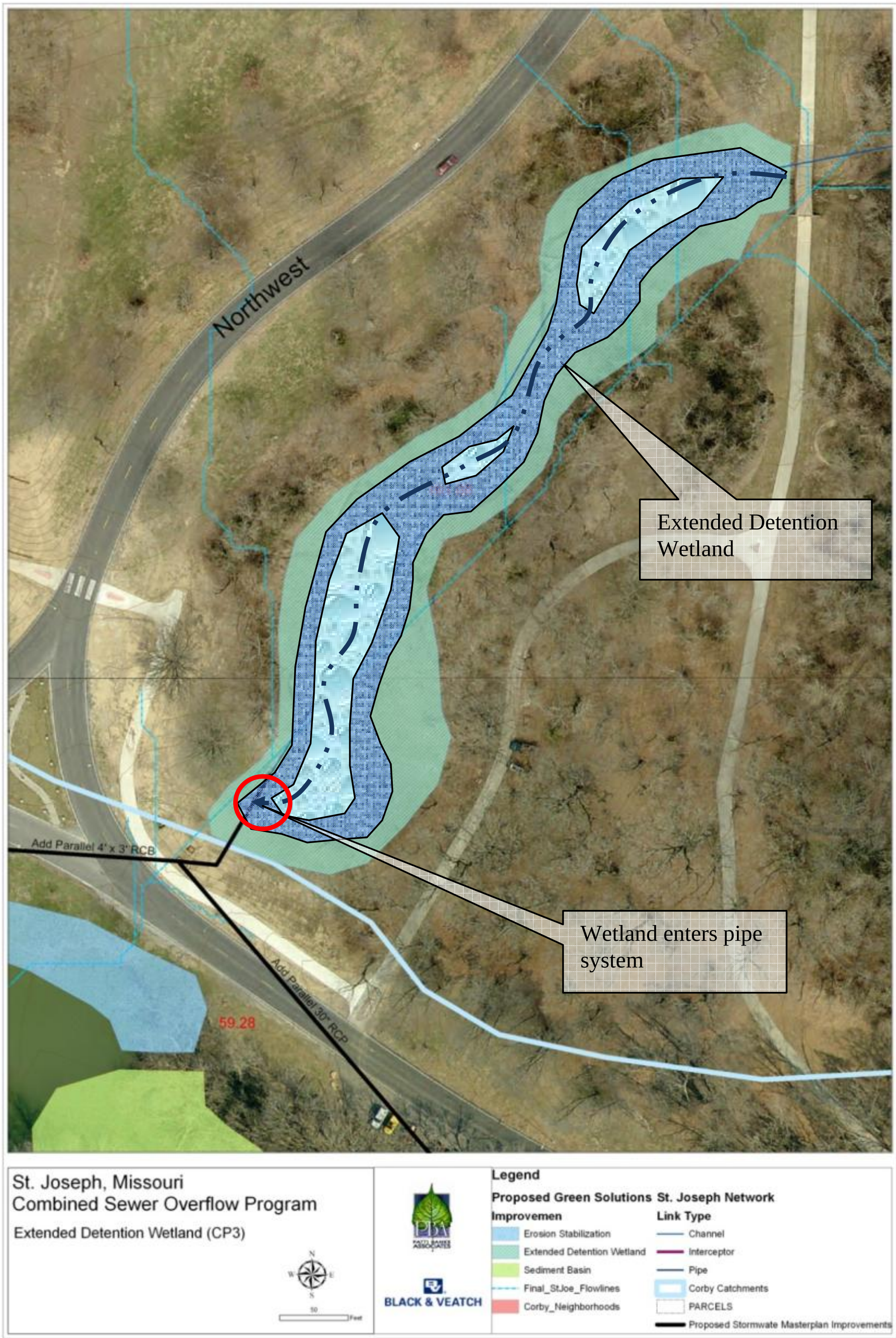

Figure 19 – Corby Parkway Extended Detention Wetland Concept (CP3)

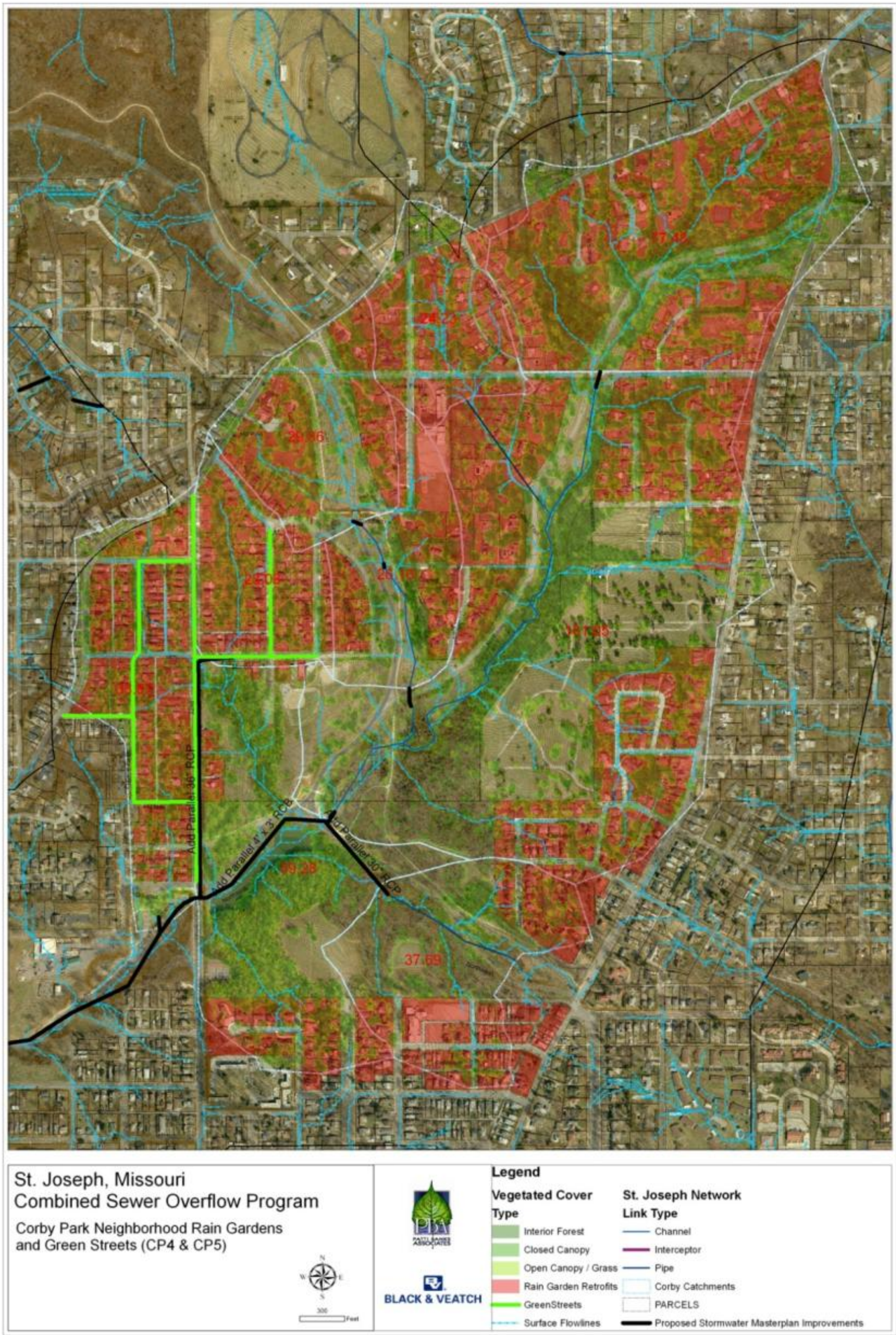

Figure 20 – Corby Parkway Neighborhood and Green Streets (CP4 and CP5)

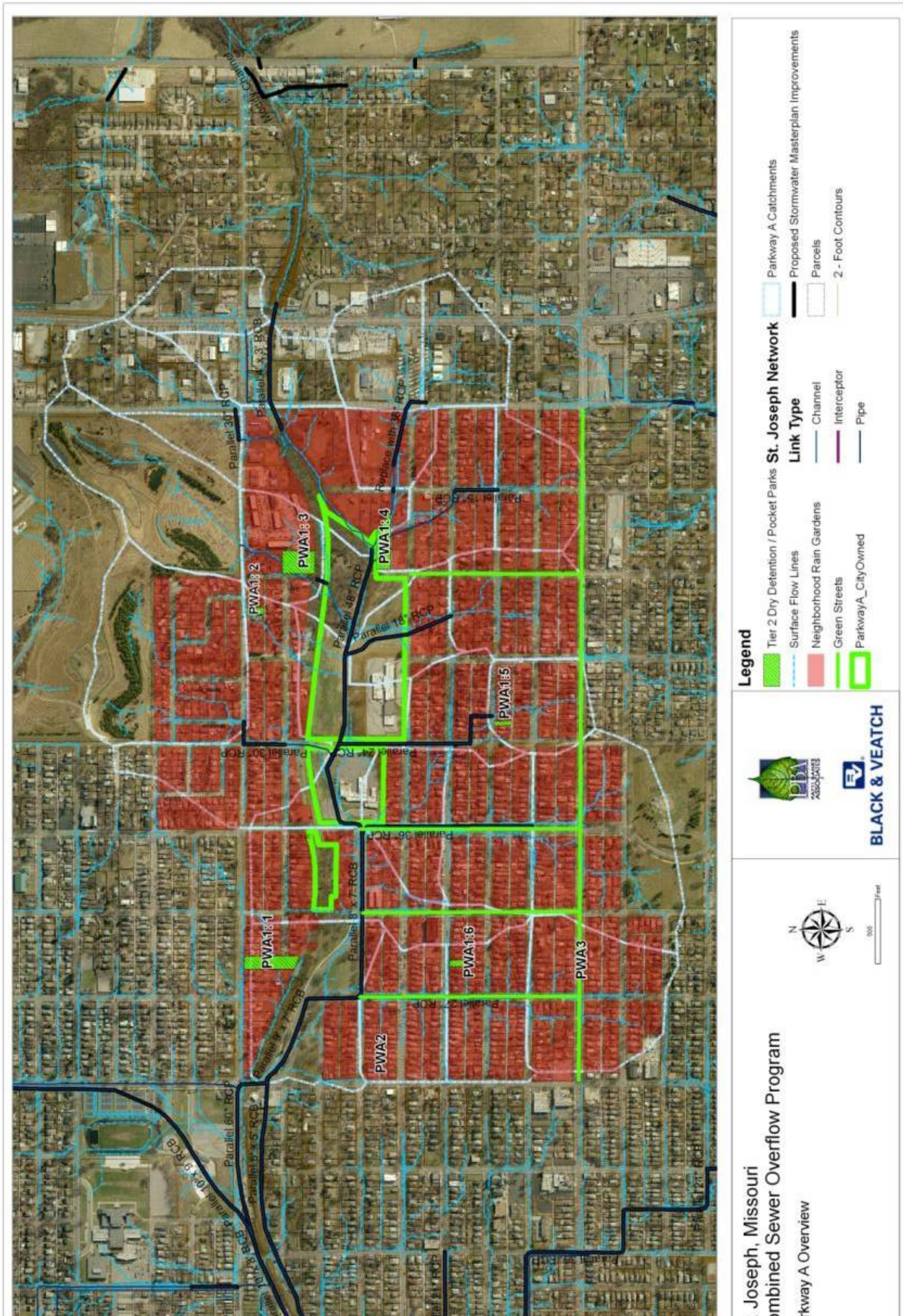

Figure 21 – Overview of Parkway A, Drainage Basins, and Adjacent Neighborhood

Figure 22 – Parkway A Tier 2 Vacant Sites (PWA1)

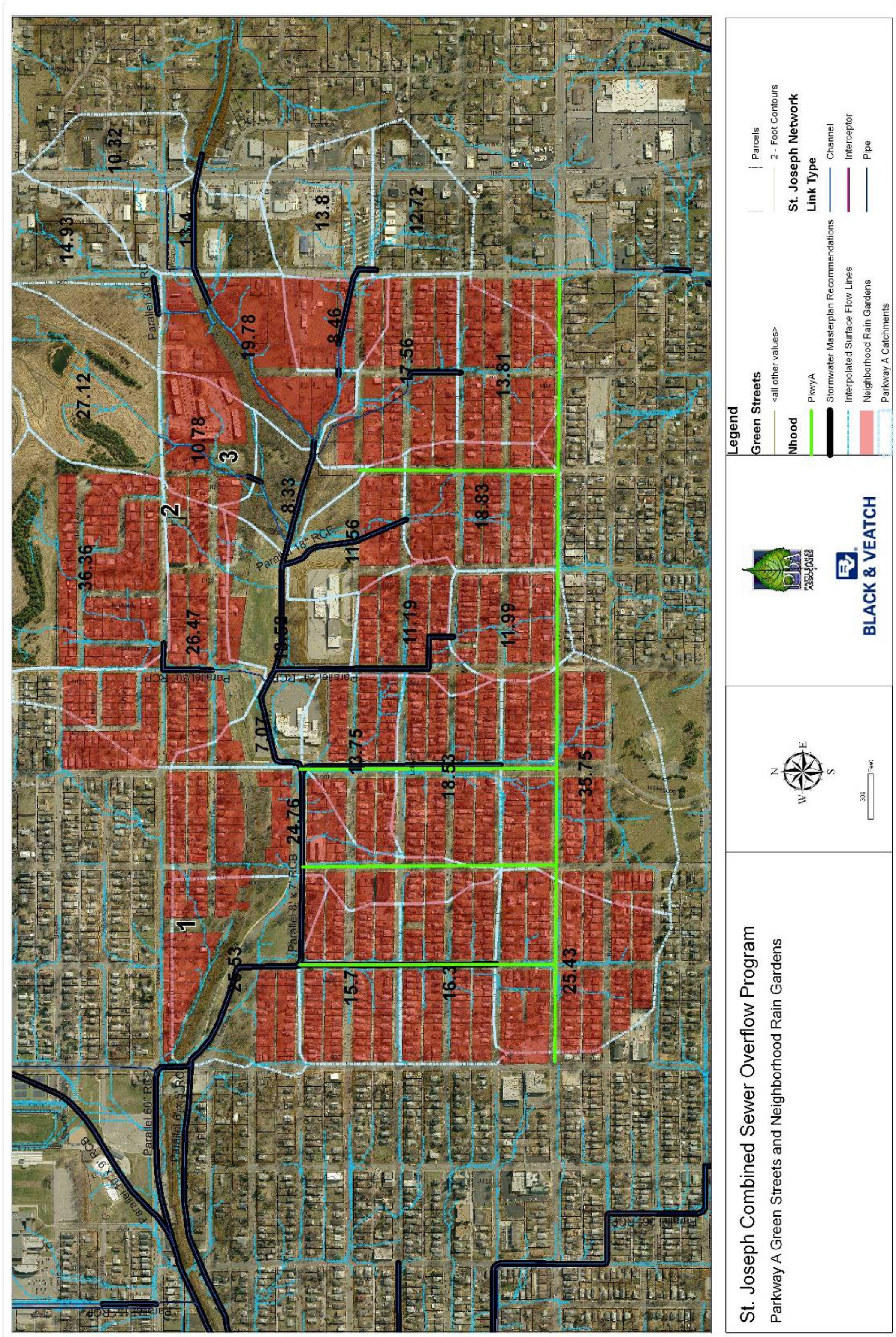

Figure 23 – Parkway A Green Streets and Neighborhood Rain Gardens (PWA2 and PWA3)

Appendix B

Hydrology Calculations

Water Quality Volume Calculations

Small Storms Hydrology Method: WQv = (P) * (Weighted Rv)

Project: City of St. Joseph CSO Program

By: BTL *Checked By: SAS*

Date: 9/10/09 *Date: 9/10/09*

1. Area: Hyde Park Wetland Channel (HP1)

Design Storm (P)	1.8	Inches		
Total Area	380.00	Acres		
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0.00	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	79.8	0.8	63.84
Vegetation (soils HSG B)	300	0.16	48.00
Vegetation (soils HSG C-D)	0.00	0.25	0.00
Sum			111.84
WRv = Σ (Rv/ac)			0.29
WRv * P =	0.53	Inches	
WQv = (WRv * P * ac / 12)	16.78	Acre-Feet	
WQv =	**730,733**	Cubic Feet	

2. Area: Hyde Park Extended Detention Wetland (HP2)

Design Storm (P)	1.8	Inches	
Total Area	348	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	348.22	0.16	55.72
Vegetation (soils HSG C-D)	38	0.25	9.50
Sum			65.22
WRv = Σ (Rv/ac)			0.19
WRv * P =	0.34	Inches	
WQv = (WRv * P * ac / 12)	9.78	Acre-Feet	
WQv =	**426,099**	Cubic Feet	

3. Area: Hyde Park Neighborhood Rain Gardens (HP3)

Design Storm (P)	1.8	Inches	
Total Area	275	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	104.5	0.99	103.46

Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	170.5	0.25	42.63
Sum			146.08
WRv = Σ (Rv/ac)			0.53
WRv * P =	0.96	Inches	
WQv = (WRv * P * ac / 12)	21.91	Acre-Feet	
WQv =	**954,449**	Cubic Feet	

4. Area: US Hwy 36 ROW Dry Detention (SW1)

Design Storm (P)	1.8	Inches	
Total Area	39.65	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	19.8	0.99	19.60
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	19.8	0.16	3.17
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			22.77
WRv = Σ (Rv/ac)			0.57
WRv * P =	1.03	Inches	
WQv = (WRv * P * ac / 12)	3.42	Acre-Feet	
WQv =	**148,773**	Cubic Feet	

5. Area: Southwest Parkway Bryce Road Wetland Channel (SW2)

Design Storm (P)	1.8	Inches	
Total Area	215.53	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	119.8	0.16	19.17
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			19.17
WRv = Σ (Rv/ac)			0.09
WRv * P =	0.16	Inches	
WQv = (WRv * P * ac / 12)	2.88	Acre-Feet	
WQv =	**125,239**	Cubic Feet	

6. Area: Southwest Parkway Extended Detention Wetland (SW3)

Design Storm (P)	1.8	Inches
Total Area	215.53	Acres

WRv =	Acres	Runoff Coef.	Product
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas		0.99	0.00
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	140.33	0.16	22.45
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			22.45
WRv = Σ (Rv/ac)			0.10
WRv * P =	0.19	Inches	
WQv = (WRv * P * ac / 12)	3.37	Acre-Feet	
WQv =	**146,701**	Cubic Feet	

7. Area: Southwest Parkway Mustang Field Dry Extended Detention (SW4)

Design Storm (P)	1.8	Inches	
Total Area	215.53	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	140.33	0.16	22.45
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			22.45
WRv = Σ (Rv/ac)			0.10
WRv * P =	0.19	Inches	
WQv = (WRv * P * ac / 12)	3.37	Acre-Feet	
WQv =	**146,701**	Cubic Feet	

8. Area: Southwest Parkway Parking Lot Vegetated Swale Retrofit (SW5)

Design Storm (P)	1.8	Inches	
Total Area	1.3	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	1.3	0.99	1.29
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			1.29
WRv = Σ (Rv/ac)			0.99
WRv * P =	1.78	Inches	
WQv = (WRv * P * ac / 12)	0.19	Acre-Feet	
WQv =	**8,409**	Cubic Feet	

9. Area: Southwest Parkway Neighborhood Rain Gardens (SW6)

Design Storm (P)	1.8	Inches	
Total Area	176.03	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	66.8	0.99	66.13
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	109.1	0.25	27.28
Sum			93.41
WRv = Σ (Rv/ac)			0.53
WRv * P =	0.96	Inches	
WQv = (WRv * P * ac / 12)	14.01	Acre-Feet	
WQv =	**610,297**	Cubic Feet	

10. Area: Southwest Parkway Neighborhood Green Streets (SW7)

Design Storm (P)	1.8	Inches	
Total Area	91.17	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	35.72	0.99	35.36
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	58.2	0.25	14.55
Sum			49.91
WRv = Σ (Rv/ac)			0.55
WRv * P =	0.99	Inches	
WQv = (WRv * P * ac / 12)	7.49	Acre-Feet	
WQv =	**326,117**	Cubic Feet	

11. Area: Corby Parkway Sediment Forebay (CP2)

Design Storm (P)	1.8	Inches	
Total Area	67.69	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	67.69	0.16	10.83
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			10.83
WRv = Σ (Rv/ac)			0.16
WRv * P =	0.29	Inches	
WQv = (WRv * P * ac / 12)	1.62	Acre-Feet	

WQv =	**70,763**	Cubic Feet	

12. Area: Corby Parkway Extended Detention Wetland (CP3)

Design Storm (P)	1.8	Inches	
Total Area	180	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	135	0.16	21.60
Vegetation (soils HSG C-D)	45	0.25	11.25
Sum			32.85
WRv = Σ (Rv/ac)			0.18
WRv * P =	0.33	Inches	
WQv = (WRv * P * ac / 12)	4.93	Acre-Feet	
WQv =	**214,633**	Cubic Feet	

13. Area: Corby Parkway Neighborhoods (CP4)

Design Storm (P)	1.8	Inches	
Total Area	233.89	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	88.87	0.99	87.98
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	145.01	0.25	36.25
Sum			124.23
WRv = Σ (Rv/ac)			0.53
WRv * P =	0.96	Inches	
WQv = (WRv * P * ac / 12)	18.63	Acre-Feet	
WQv =	**811,711**	Cubic Feet	

14. Area: Corby Parkway Green Streets (CP5)

Design Storm (P)	1.8	Inches	
Total Area	61.9	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	23.5	0.99	23.27
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	38.37	0.25	9.59
Sum			32.86

WRv = Σ (Rv/ac)			0.53
WRv * P =	0.96	Inches	
WQv = (WRv * P * ac / 12)	4.93	Acre-Feet	
WQv =	**214,682**	Cubic Feet	

15. Area: Parkway A Site 1 (PWA1)

Design Storm (P)	1.8	Inches	
Total Area	14.6	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	14.6	0.99	14.45
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			14.45
WRv = Σ (Rv/ac)			0.99
WRv * P =	1.78	Inches	
WQv = (WRv * P * ac / 12)	2.17	Acre-Feet	
WQv =	**94,439**	Cubic Feet	

16. Area: Parkway A Site 2 (PWA1)

Design Storm (P)	1.8	Inches	
Total Area	3.12	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	3.12	0.8	2.50
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			2.50
WRv = Σ (Rv/ac)			0.80
WRv * P =	1.44	Inches	
WQv = (WRv * P * ac / 12)	0.37	Acre-Feet	
WQv =	**16,308**	Cubic Feet	

17. Area: Parkway A Site 3 (PWA1)

Design Storm (P)	1.8	Inches	
Total Area	37.9	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	10.9	0.8	8.72

Vegetation (soils HSG B)	26.9	0.16	4.30
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			13.02
WRv = Σ (Rv/ac)			0.34
WRv * P =	0.62	Inches	
WQv = (WRv * P * ac / 12)	1.95	Acre-Feet	
WQv =	**85,095**	Cubic Feet	

18. Area: Parkway A Site 4 (PWA1)

Design Storm (P)	1.8	Inches	
Total Area	7.9	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	7.9	0.8	6.32
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			6.32
WRv = Σ (Rv/ac)			0.80
WRv * P =	1.44	Inches	
WQv = (WRv * P * ac / 12)	0.95	Acre-Feet	
WQv =	**41,293**	Cubic Feet	

19. Area: Parkway A Site 5 (PWA1)

Design Storm (P)	1.8	Inches	
Total Area	3.6	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	3.6	0.8	2.88
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			2.88
WRv = Σ (Rv/ac)			0.80
WRv * P =	1.44	Inches	
WQv = (WRv * P * ac / 12)	0.43	Acre-Feet	
WQv =	**18,817**	Cubic Feet	

20. Area: Parkway A Site 6 (PWA1)

Design Storm (P)	1.8	Inches	
Total Area	3.5	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**

Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	0	0.99	0.00
Small impervious areas/narrow streets	3.5	0.8	2.80
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	0	0.25	0.00
Sum			2.80
WRv = Σ (Rv/ac)			0.80
WRv * P =	1.44	Inches	
WQv = (WRv * P * ac / 12)	0.42	Acre-Feet	
WQv =	**18,294**	Cubic Feet	

<u>21. Area:</u> <u>Parkway A Neighborhoods (PWA2)</u>

Design Storm (P)	1.8	Inches	
Total Area	222.9	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	84.7	0.99	83.85
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	138.1	0.25	34.53
Sum			118.38
WRv = Σ (Rv/ac)			0.53
WRv * P =	0.96	Inches	
WQv = (WRv * P * ac / 12)	17.76	Acre-Feet	
WQv =	**773,451**	Cubic Feet	

<u>22. Area:</u> <u>Parkway A Green Streets (PWA3)</u>

Design Storm (P)	1.8	Inches	
Total Area	156.71	Acres	
WRv =	**Acres**	**Runoff Coef.**	**Product**
Flat Roof/large unpaved parking	0	0.9	0.00
Pitched roof/large impervious areas	59.54	0.99	58.94
Small impervious areas/narrow streets	0	0.8	0.00
Vegetation (soils HSG B)	0	0.16	0.00
Vegetation (soils HSG C-D)	97.16	0.25	24.29
Sum			83.23
WRv = Σ (Rv/ac)			0.53
WRv * P =	0.96	Inches	
WQv = (WRv * P * ac / 12)	12.48	Acre-Feet	
WQv =	**543,833**	Cubic Feet	