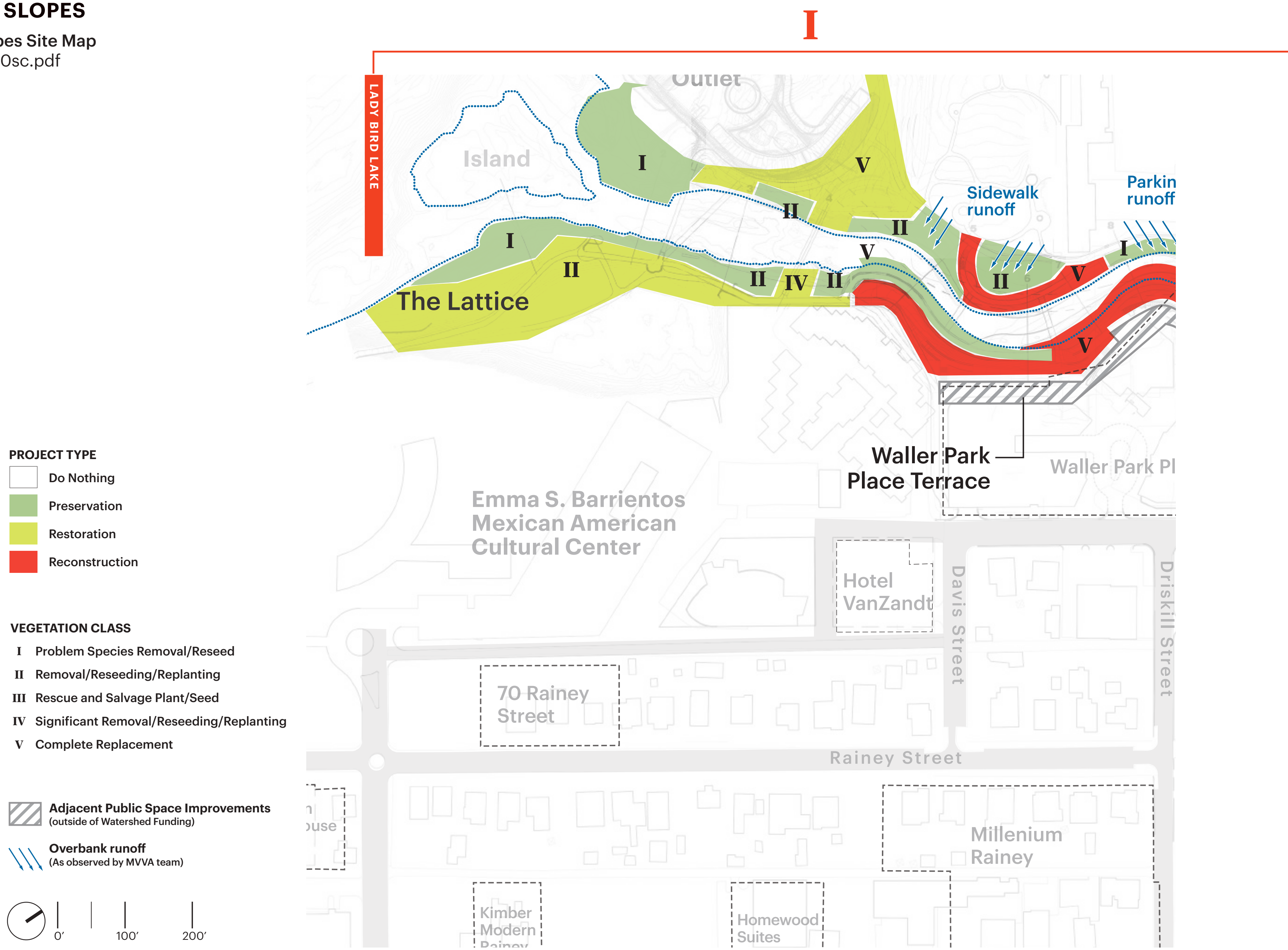
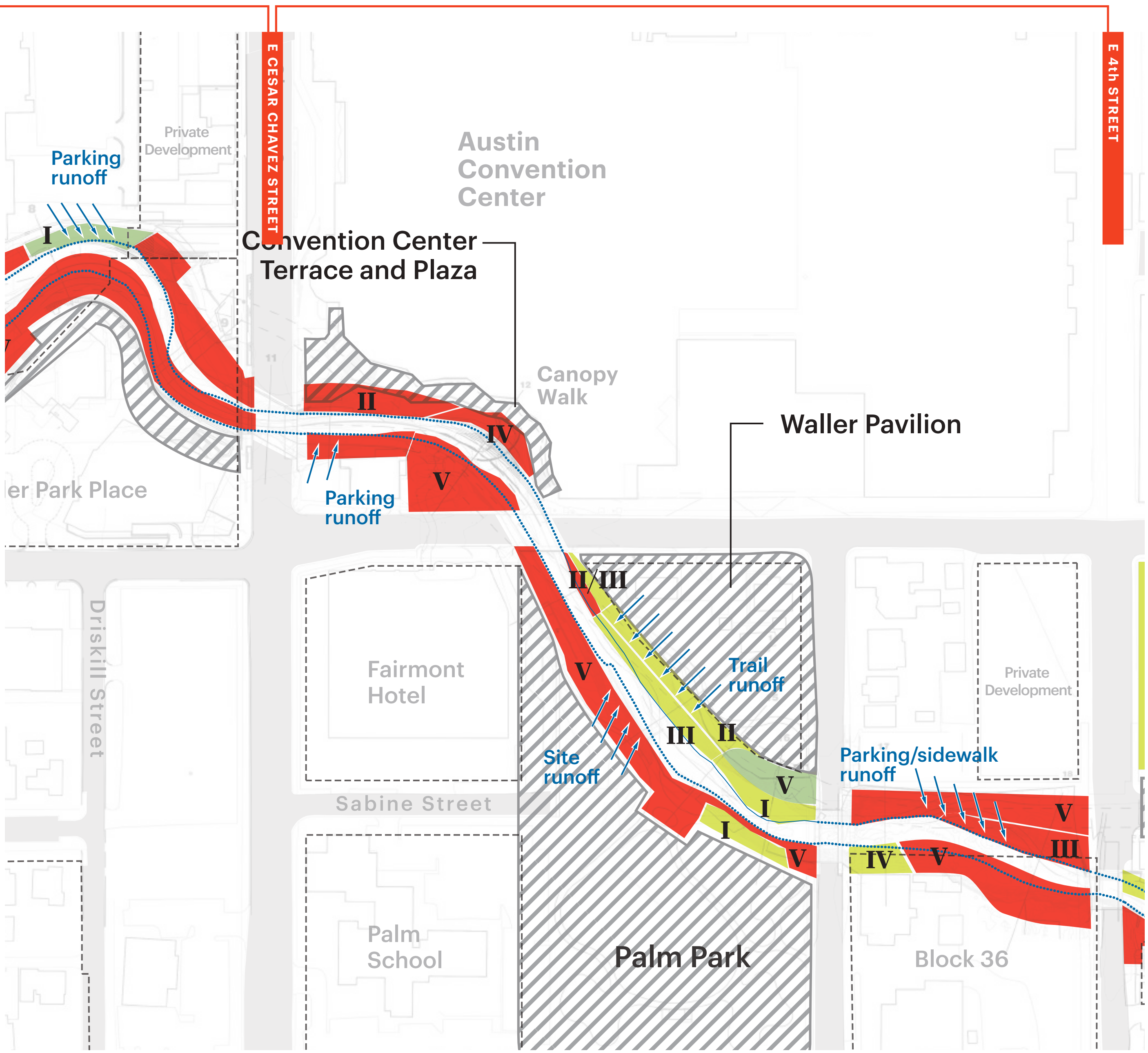
Riparian Slopes

RIPARIAN SLOPES

Riparian Slopes Site Map
RIPARIAN_300sc.pdf

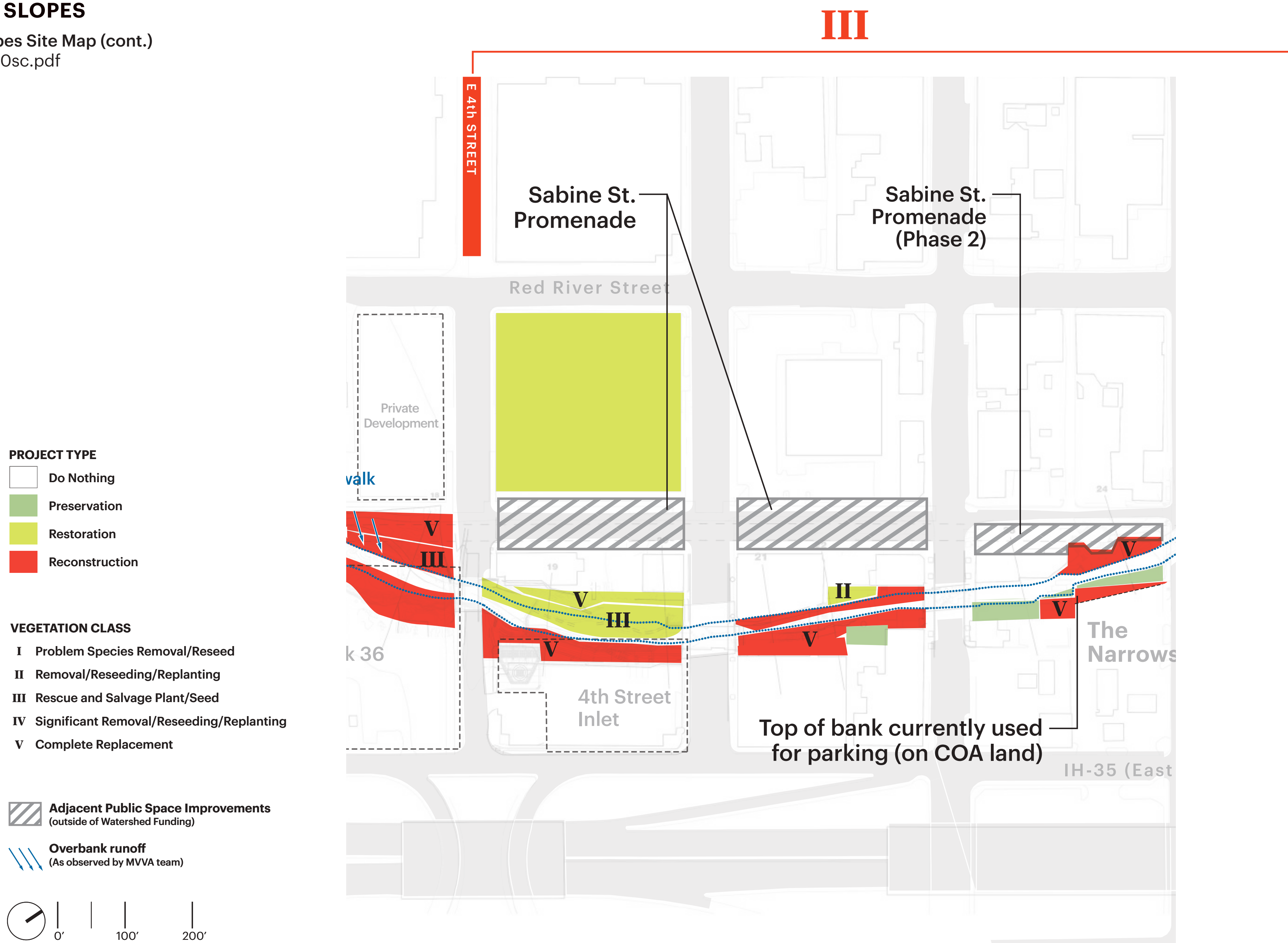


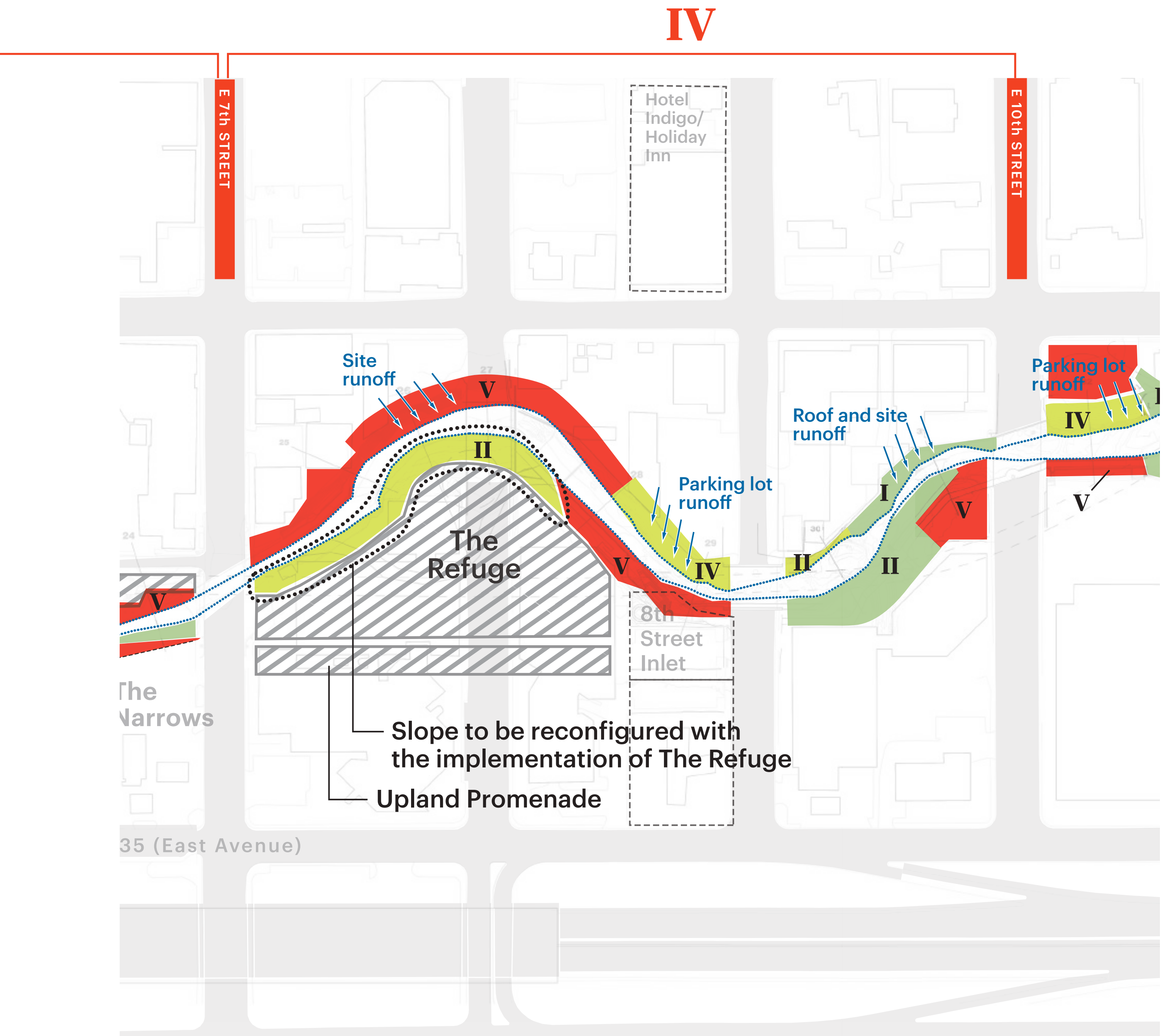
II


E CESAR CHAVEZ STREET
E 4th STREET
Austin Convention Center
Private Development
Parking runoff
Convention Center Terrace and Plaza
Canopy Walk
Waller Pavilion
er Park Place
Parking runoff
Fairmont Hotel
Driskill Street
Sabine Street
Site runoff
Trail runoff
Private Development
Parking/sidewalk runoff
Palm School
Palm Park
Block 36
I
II
IV
V
II/III
V
III
II
V
I
I
V
V
III
IV
V

RIPARIAN SLOPES

Riparian Slopes Site Map (cont.)
RIPARIAN_300sc.pdf




IV
E 7th STREET
E 10th STREET
Hotel Indigo/ Holiday Inn
Site runoff
Roof and site runoff
Parking lot runoff
Parking lot runoff
The Refuge
8th Street Inlet
The Narrows
35 (East Avenue)
V
II
IV
I
Slope to be reconfigured with the implementation of The Refuge
Upland Promenade

RIPARIAN SLOPES

Riparian Slopes Site Map (cont.)
RIPARIAN_300sc.pdf

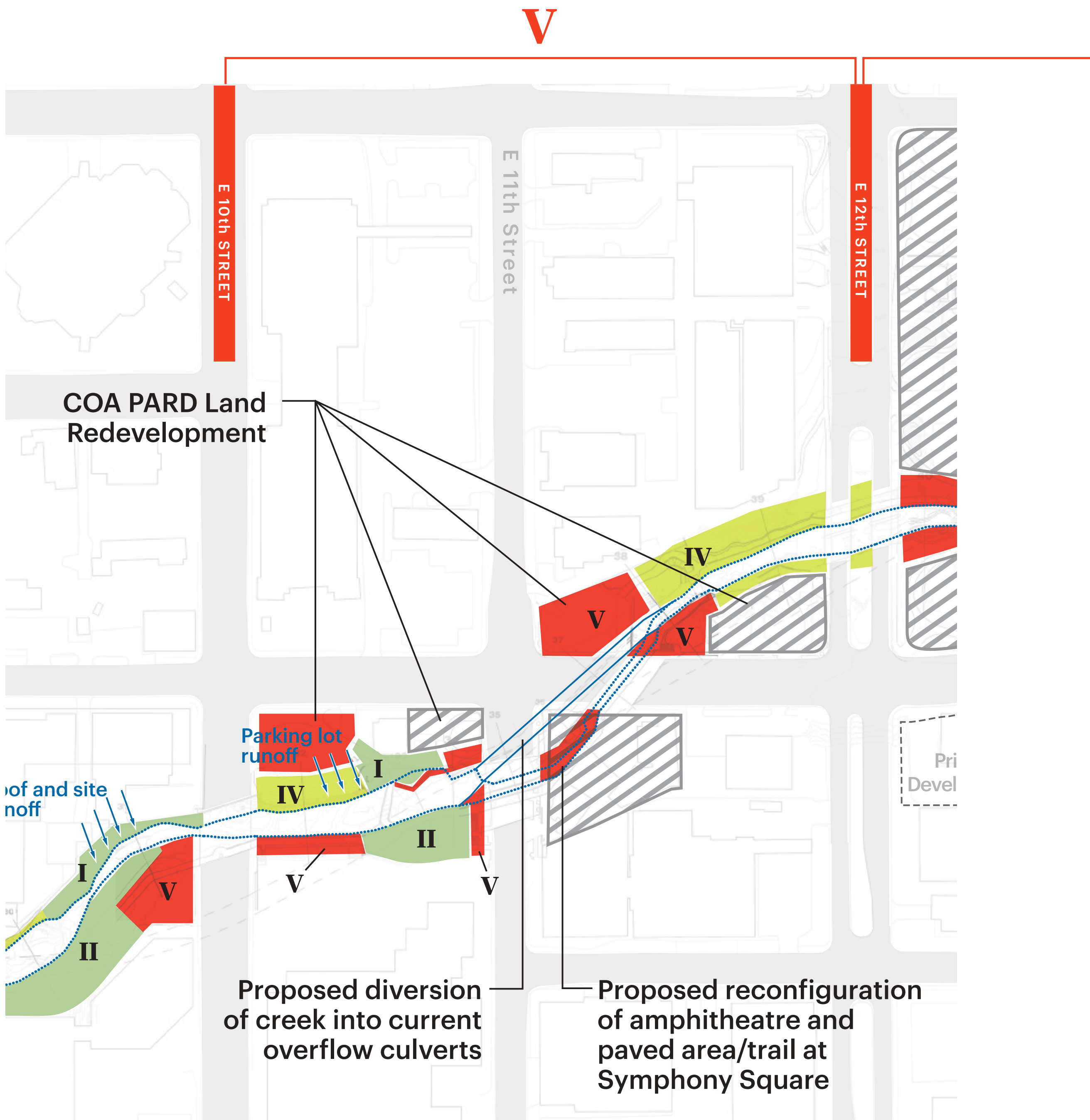
PROJECT TYPE
- Do Nothing
- Preservation
- Restoration
- Reconstruction

VEGETATION CLASS
- I Problem Species Removal/Reseed
- II Removal/Reseeding/Replanting
- III Rescue and Salvage Plant/Seed
- IV Significant Removal/Reseeding/Replanting
- V Complete Replacement

Adjacent Public Space Improvements
(outside of Watershed Funding)

Overbank runoff
(As observed by MVVA team)

0' 100' 200'



VI


Trinity Street
E 15th STREET
Waterloo Park
V
II
Red River Street
E 15th Street
UT
Medical
University Medical
Center Brackenridge
Private
Development

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APPLIED ECOLOGICAL SERVICES

WALLER CREEK FRAMEWORK PLAN

APPENDIX

RIPARIAN & AQUATIC HABITAT RESTORATION GOALS & STRATEGIES

Introduction

There are many opportunities - as well as constraints - for restoring the riparian and aquatic habitats of Waller Creek. Understanding the larger Waller Creek watershed, past work by the City of Austin Watershed Protection Department, and the accomplishments of the Waller Creek Framework Plan provide a foundation for advancing restoration in and along Waller Creek as park/trail projects and development proceed along the corridor.

Waller Creek's Watershed Context

Stream ecosystems – including their aquatic habitats, bank slopes, and riparian buffers - must not be considered in isolation from the larger landscape in which they occur. It is the runoff water from tributary watersheds (and the various land uses represented in the catchment) that strongly influence the health of a given stream ecosystem. Land and vegetation conversion for agricultural practices, large areas of runoff from impervious surfaces such as roofs and parking lots, and anaerobic storm sewer discharges create and extend deteriorating conditions from the upper watershed to downstream environments and receiving water bodies. Due to this interconnected relationship, it is essential to understand the entire watershed in order to understand stream conditions, establish realistic restoration goals, and implement sustainable strategies. Another way to consider the influence of watershed context is to realize that restoration in a downstream reach of a larger watershed may do little to ultimately improve the stream ecosystem, especially the aquatic plant and animal communities. Because of this longitudinal relationship from headwaters to the outlet of a stream, context remains a critical element when restoring and managing stream ecosystems.

The Waller Creek Tunnel (WCT) presents both an opportunity and a constraint to restoration of the Waller Creek Corridor. The WCT is discussed in greater detail in this Framework Plan, but in brief, once on-line, the WCT will "shave off" Waller Creek's peak flows by providing a bypass route (from Waterloo Park to Lady Bird Lake) that will significantly reduce flows in previously-flood prone downtown Austin. Recirculation pumping (from the Lake and WCT) will provide a relatively steady baseflow to Waller Creek, as well as intermittent "flushing" sequences of higher flows. These fundamental changes in the creek's hydrology will reduce the frequency and magnitude of

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erosive/damaging flood flows and provide different baseflow conditions. These hydrologic changes have been considered throughout the Framework Plan and inform the feasibility and design of recommended riparian and aquatic restoration projects.

Functional Assessment & Goals

Prior to development of the Waller Creek Framework Plan, the City of Austin's Watershed Protection Department (WPD) developed a Functional Assessment of Floodplain Health method, tailored to the region's riparian systems. WPD performed a Functional Assessment for Lower Waller Creek in 2014, and scores are noted in the "Block-by-Block Enlargements" section of the Framework Plan (e.g. the "blue book"). The following sections were adapted from information provided by WPD.

Overview

The Functional Assessment was developed by a cross-disciplinary team of ecologists, engineers, statisticians, and policymakers. The intent was to provide a simple, accurate, and locally-derived tool to assess specific functional characteristics of three discrete units: the floodplain outside of the Critical Water Quality Zone (CWQZ), the Critical Water Quality Zone, and the active channel. This assessment tool provides riparian measures to apply on the banks and overbank riparian areas, to assess the condition and geomorphic characteristics such as channel stability and in-stream aquatic habitat. Some measures follow from Pfankuch (1975), Barbour et al. (1999), and Harman et al. (2012), developed by the U.S. Forest Service and USEPA for conducting Riparian Functional Assessments.

Riparian Slopes

Riparian zones are transitional, extending from the edge of water bodies to the edges of upland communities. This ecosystem includes all of the biotic (e.g., plants, animals, bacteria, fungi) and abiotic (e.g., soil, water, nutrients) components that intersect in this diverse and highly productive transitional landscape position. The preservation, rehabilitation and restoration of healthy riparian slopes often relies on buffer areas as a critical component that offer protection of the water quality, erosion prevention and ecological services provided in this zone. The benefits provided by a buffer are proportional to the size and land management practices of these buffers, with more services provided by larger buffers (>300 ft wide) and buffers consisting of a healthy, native plant community with intact canopy, understory, and ground cover vegetation.

All waterways should be buffered from development, and the structure, composition, and function of degraded riparian ecosystems should be restored to the highest levels achievable. Managed succession is the guiding principle for the WPD riparian restoration approach. The goal is to facilitate the establishment of a low maintenance, resilient native plant community that requires minimal management inputs (e.g., irrigation, mowing, herbicide/fertilizers) and promotes establishment and recruitment of diverse native flora and fauna. However, it must be recognized that *low* maintenance does not mean *no*maintenance. A healthy riparian slope will require maintenance, especially in urban landscapes where disturbance and invasion pressures by non-native plants are often greatest.

Aquatic Habitat

The in-stream biological community and habitat potential are influenced by the quality of water entering the system, flow regimes, and the physical habitat that forms the template within which biological communities develop. Waller Creek's water quality and flow characteristics have been influenced largely by upstream land use and the WCT (both discussed above). The WCT project includes an aeration system to improve the quality of water recirculated from the tunnel into Waller Creek at Waterloo Park. The Framework Plan also addresses these issues of water quality and flow to the extent possible within the geographic constraints of the project. The Framework Plan includes elements such as in-line storm sewer sediment/floatable traps and end-of-pipe stormwater treatment systems (e.g., infiltration areas and treatment wetlands) to improve water quality.

With regard to physical aquatic habitat, in general, the more complex and diverse the available substrate types and plant cover in a stream, the better the habitat for a variety of aquatic organisms. This includes both structural cover (e.g., bedrock, cobbles, gravel, sand, large woody debris) and geomorphic and fluvial cover (e.g., eddies, riffles, runs, bank overhangs, falls and drops, pools, backwaters). These physical characteristics of aquatic habitat are influenced by geomorphic/geologic factors, watershed characteristics, flow regimes, as well as the characteristic of the riparian zone (e.g., slopes, vegetation). Structural, geomorphic, and fluvial cover can be defined by their size, redundancy, and distribution at micro-, meso-, and macro-scales. Micro-scale is focused on substrate composition (e.g., size class, distribution, embeddedness), meso-scale includes habitat units (e.g., riffles, pools, bars), and macro-scale brings in reach scale effects (stream plan-view form such as sinuosity, riparian shade, and food/nutrient sources). All of these factors contribute to a stream's organismal occupation and dynamics.

Framework Plan Accomplishments

Overview
A major accomplishment of the Framework Plan was the consideration of the creek's ecology beyond the perspective of functional assessment at a sub-section scale or focusing on individual development sites. Rather, Waller Creek was viewed holistically as a longitudinal study from Waterloo Park to Lady Bird Lake. What happens on individual restoration/development sites can now be evaluated in the context of the 1.5-mile study area, not just considering local conditions.

Field Assessments
During development of the Framework Plan, the project team (including technical staff from WPD, Applied Ecological Services, Inc. (AES) ecologists, and LimnoTech engineers and ecologists) conducted additional assessment of the project area's existing riparian and aquatic conditions. Early in the Framework Plan process, the WPD completed their Functional Assessment on four sections of the project area. This assessment characterized baseline conditions of Waller Creek prior to construction and operation of the WCT, and provides an important reference for future assessments and monitoring.

In 2012, AES ecologists Steven I. Apfelbaum and Doug Mensing conducted a field assessment of the project area's riparian slopes, focusing on stream bank stability and restoration strategies. Both banks of the project area were observed and mapped with regard to their height, slope, and relative stability. Also considered was existing infrastructure (e.g., buildings, roads, trails) that might limit slope re-grading and necessitate alternative stabilization strategies. This assessment, in conjunction

with planned development along the creek, informed the Framework Plan's strategies for addressing unstable banks and related restoration needs.

In 2014, AES ecologists and WPD Environmental Scientist Mateo Scoggins conducted a field inventory and assessment of existing aquatic and riparian habitat. The entire creek was walked for the project area, and existing bed, bank, and aquatic habitat features were mapped. These included bed substrate types, bank erosion and stability, vegetation dominance, and in-stream features such as pools, riffles, gravel bars, and exposed bedrock reaches. Natural materials (e.g., gravel deposits) in locations slated for development were also mapped as salvage opportunities. These materials can be removed prior to development activities, and replaced following construction or used for stream restoration/enhancement in other sections of the creek. These field inventories (summarized in the Framework Plan) created the vernacular and mapping for recommended: 1) protection and preservation strategies for existing aquatic habitat features, and 2) aquatic habitat restoration and enhancement priorities in Waller Creek.

Inter-disciplinary Design
Throughout the Framework Plan, the inter-disciplinary design team worked collaboratively to assess the interaction between existing and proposed trails and public space improvements, bank stabilization needs, habitat enhancement opportunities, opportunities for improved stormwater management, and the integration of future land re-development along the corridor. Through multiple field surveys, discussions, and plan revisions, the team considered trail and public space requirements (e.g., location, elevation, slope, access), existing bank conditions, adjacent aquatic habitats, and stormwater outfalls and surface runoff. Considering all of these elements in the context of balancing project goals led to the recommendations presented in the Framework Plan.

Riparian & Aquatic Restoration Strategies & Techniques
Based on Waller Creek's geology, geomorphology, flow regime, and riparian character, restoration strategies were developed to provide functional lift to the Waller Creek riparian corridor. The restoration strategies and specific techniques that follow were identified for their applicability to Waller Creek. As development and restoration projects proceed along the creek, appropriate techniques will be selected and customized for individual locations to help achieve the social, environmental, and financial goals of the Framework Plan.

Riparian Slope Stabilization (focused on lower slope and toe of slope)

Pull Back Slope. Waller Creek has become entrenched due to channel downcutting, in many locations to the underlying bedrock. This form of channel development has resulted in generally steep banks, some of which have continued to erode and fail, threatening infrastructure and degrading stream conditions. Grading back banks to a more stable angle and stabilizing these slopes with appropriate native vegetation is a proven stream restoration technique. However, this approach is not feasible in many locations along Waller Creek due to the dense urban development, often extending up to the edge of bank slopes. Where feasible, re-grading the slope to a minimum angle of 2.5:1 (horizontal to vertical) or flatter is preferred in order to eliminate the need for more aggressive and engineered stabilization techniques. These moderate slopes can typically be stabilized with erosion control blanket, seeded, and planted with appropriate native vegetation (including groundcover, understory and upper story vegetation. Appropriate soils (e.g., re-spreading salvaged topsoil when possible), available sunlight, moisture regime, and appropriate species selection must be considered when designing effective bioengineered solutions. Pulling back slopes provides

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functional lift by stabilizing slopes, preventing mass wasting, and widening the riparian zone. Where horizontal space available for re-grading is limited, steeper slopes can be stabilized with more aggressive bioengineering techniques, some of which are discussed below.

Hydromulching/Seeding. Steep slopes and other difficult to access areas can be stabilized using hydromulch containing seed. This slurry, sometimes accompanied by a tackifier to enhance adhesion, is sprayed onto prepared soil to facilitate revegetation. Hydromulch/seed is typically applied above the creek's baseflow elevation and uses a combination of fast-growing, annual cover crops and deep-rooted perennial native species for rapid and effective soil stabilization. Hydromulching/seeding provides functional lift by stabilizing slopes, preventing mass wasting, and accelerating the revegetation of restored/enhanced riparian zones.

Live Plant Plugs. Some desirable native plant species exhibit poor or slow seed germination rates. Additionally, certain environmental conditions (e.g., emergent wetland plantings installed into standing water) do not lend themselves to effective seeding. Establishment of these species and plants in these situations may be best accomplished through the installation of live plant plugs. The size of plug, installation spacing, and other variables depend on the species of plant and restoration goals. Live plant plugs are often installed directly into coir logs. Installing live plant plugs provides functional lift by stabilizing slopes, preventing mass wasting, and accelerating the revegetation of restored/enhanced riparian zones.

Soil Lifts. This bioengineering technique can be used to establish and stabilize steeper slopes (e.g., steeper than 2.5:1). A non-degradable geotextile is used to wrap native soils, which have been seeded with an appropriate, aggressive, native seed mix. Each soil lift is usually 6" to 12" high, and they are typically staggered in a stairstep-like fashion; individual lift height and staggering/spacing is determined by the overall slope height warranting stabilization and the horizontal space available. Flatter slopes are preferred as they typically result in improved vegetation growth. Soil lifts provide functional lift by stabilizing steeper slopes, preventing mass wasting, and widening the riparian zone. Live fascines (discussed below) can be used in conjunction with soil lifts.

Coir Log. Coir is a natural fiber derived from coconut husks. This material is commonly used in bioengineering applications (e.g., coir logs, coir blankets) because it is slow to degrade. Coir products are used to provide temporary erosion control and facilitate the establishment of permanently-stabilizing vegetation. Coir logs can be installed at the bottom of slopes for toe protection, and they can also be installed in shallow water to create protected aquatic zones (for establishment of vegetation and aquatic wildlife refugia. Coir logs vary in size (8" to 20" diameter), they are secured with stakes/anchors and rope/cables, and can be vegetated with live stakes (discussed below) or native plant plugs. Coir logs provide functional lift by stabilizing slopes, preventing mass wasting, and providing riparian and stream-edge habitat for plants and animals.

Live Stakes. Live stakes are a cost-effective bioengineering technique to establish stabilizing woody vegetation and structural habitat. Live stakes are typically 0.5"-3" diameter, 1.5'-5' long, locally harvested, 2-5 yr old branches installed so tip extends into very moist or wet soil. Live stakes should be installed such that at least ¾ of the stake is covered by soil. Installation orientation of live stakes is also important because of plant geotropism growth behavior; in other words, live stakes should be installed with the top of the plant oriented up. Self-rooting species must be used for live

staking; local live stake research conducted by Duncan and Klingshirn (2012) recommends the following species: false willow, roughleaf dogwood, buttonbush, American sycamore, Eastern cottonwood, and black willow. Live stakes can be installed in conjunction with many other bioengineering techniques (e.g., as joint plantings in rip rap, or directly into coir logs). Live stakes provide functional lift by stabilizing slopes, preventing mass wasting, accelerating revegetation of woody species (providing stream shading/cooling), and providing riparian and stream-edge habitat for plants and animals.

Rip Rap Toe. Toe protection at the bottom of bank slopes is a critical location for providing long-term bank stability. Based on Waller Creek's flow regime, natural or salvaged angular rock (to prevent rolling/shifting), 18"-24" in size, with a specific gravity of ≥2.4 is recommended. Use of rip rap toe provides functional lift by stabilizing slopes, preventing mass wasting, and providing riparian and stream-edge habitat for plants and animals. Live stakes (discussed above) can be installed as "joint plantings" in a rip rap toe.

<u>Flood bench/riparian restoration and habitats</u>

Flood Bench Wetland. These wetlands are located on the flood bench, and are intermittently flooded during periods of high channel flow, typically 1-3 times annually in a healthy watershed. Flood bench wetlands along Waller Creek will be designed to flood several times per year and will be typically composed of re-worked native soils. Flood bench wetlands provide functional lift by widening the riparian corridor, improving floodplain connectivity, reducing the erosive force of flood flows, and providing important wetland habitat and refugia for plants and animals.

Stormwater Wetland. Stormwater wetlands are similar to flood bench wetlands, however they receive flow from stormwater outlet pipes rather than creek flows. For this reason, stormwater wetlands are typically constructed 2-3 feet above the baseflow elevation, and they may be constructed with native or engineered soils to facilitate infiltration and runoff treatment. These treatment wetlands are designed to capture sediment and nutrients and mitigate flood pulses to the extent feasible given the wetland's area and volume. Stormwater wetlands provide functional lift by widening the riparian corridor, reducing the erosive force of flood flows, and providing important wetland habitat and refugia for plants and animals.

Flood Bench Channel. Similar to flood bench wetlands, these constructed channels are located on the flood bench, and function as intermittent flow paths during periods of high flow. Flood bench wetlands are designed to flow many times per year and are typically composed of re-worked native soils. Flood bench channels provide functional lift by widening the riparian corridor, improving floodplain connectivity, reducing the erosive force of flood flows, and providing important habitat and refugia for plants and animals.

Flood Bench Boulder Cluster. Flood bench boulder clusters typically consist of a grouping of 3-5 boulders partially embedded into the flood bench substrate, perhaps by up to 1/3 of their diameter. Salvaged boulders or other local stone should be used when feasible. The size of the boulders is determined on a site-by-site basis considering anticipated shear stress; the intent is that flood flows will not move installed boulders. Flood bench boulder clusters provide functional lift by providing riparian and stream-edge habitat for plants and animals.

Flood Bench Log. Flood bench logs typically consist of a grouping of 2-5 logs anchored into the flood bench and spanning the normal water line. Logs should be salvaged or locally harvested when feasible, and the boles should have a minimum diameter of 12". Flood bench logs provide functional lift by providing riparian and stream-edge habitat for plants and animals.

Vertical Planting. The banks of Waller Creek consist of vertical walls in several locations. While these areas are constructed of large stone blocks or concrete, they still provide a substrate on which vegetation can be grown. Seed and other propagules can be sprayed onto vertical walls with seams and/or small ledges, and herbaceous plants can be installed in larger seams/gaps. Moss propagules can be sprayed directly onto certain surfaces to expedite colonization of such species. Vines can be planted below or above these walls such that their tendrils and leaves "green and screen" the underlying engineered walls. Vertical planting techniques provide functional lift by accelerating the revegetation of these walls and creating a more natural aesthetic.

Terrace Planting. Some of Waller Creek's banks consist of terraced walls with narrow shelves or steps available for revegetation. Native seed and/or live plants can be installed on these terraces. The use of woody plants should be used sparingly due to the potentially destructive force of their woody root systems. Terrace plantings provide functional lift by enhancing the vegetation along creek walls, providing stream shading, and creating a more natural aesthetic.

<u>In-channel restoration and habitats</u>

Deep Pool. Deep pools are aquatic habitat areas that are a minimum of 3 feet deep and are self-scouring. Several deep pools exist along Waller Creek, and others have been designed at strategic locations. Deep pools provide functional lift by creating important aquatic habitat diversity and providing refugia for certain aquatic species.

Cooling Pool. Cooling pools are essentially deep pools (≥3 feet deep, self-scouring) and constructed in a shaded area (such as under a bridge or dense canopy cover). The water depth and shading of cooling pools create refugia for thermally-sensitive aquatic wildlife. These cooler habitats are critical for some species, especially during hot and dry weather. As with deep pools, cooling pools provide functional lift by creating important aquatic habitat diversity and providing refugia for certain aquatic species (especially those sensitive to warmer waters).

Rock Weir. A rock weir is a grade-control structure that spans the channel and is keyed into both banks. Similar to a low-head dam, a rock weir helps maintain a minimum water level on its upstream side. Rock weirs provide functional lift by stabilizing upstream flows, reducing channel downcutting, creating aquatic habitat diversity (e.g., areas of low flow and scour), and providing an opportunity for aeration of creek waters.

Cross Vane. Cross vanes are a common stream restoration technique used to direct channel flow and stabilize banks. Cross vanes can be constructed of rocks or logs installed into both stream banks and angled upstream into the channel flow. If logs are used, salvaged/local, rot-resistant species are preferred, and boles should be ≥12" diameter. Cross vanes provide functional lift by stabilizing banks and streams (through influencing the stream's geomorphology), creating aquatic habitat diversity (e.g., areas of low flow and scour), and providing an opportunity for aeration of creek waters.

Bank Vane. A bank vane is similar to one-side of a cross vane, again designed to direct channel flow and stabilize banks. Bank vanes consist of rocks or logs that are keyed into the bank and extend into the stream at an upstream angle. If logs are used, salvaged/local, rot-resistant species are preferred, and boles should be ≥12" diameter. Bank vanes provide functional lift by stabilizing banks and streams (through influencing the stream's geomorphology), creating aquatic habitat diversity (e.g., areas of low flow and scour), and providing an opportunity for aeration of creek waters.

Riffle. Riffles are shallow, turbulent sections of a creek where waters flow over rocky substrates (e.g., gravel, cobbles, stone) and around exposed boulders. Several riffles exist along Waller Creek, and others have been designed at strategic locations. Riffles provide functional lift by creating critically important aquatic habitats for aquatic wildlife that require these fast, aerated waters for completing their life cycle.

In-Channel Boulder Cluster. Similar to the flood bench boulder clusters, these in-channel boulder clusters typically consist of a grouping of 3-5 boulders installed in the channel. Salvaged boulders or other local stone should be used when feasible. The size of the boulders is determined on a site-by-site basis considering anticipated shear stress; the intent is that channel flows will not move installed boulders. In-channel boulder clusters provide functional lift by providing in-channel habitat/substrates and refugia for aquatic plants and animals.

Rock Lunker/Undercut Structure. Lunkers are aquatic habitat structures built into stream bank. Installed just below the low water level, these structures typically consist of a 24" rock slab installed on top of support rocks, creating underwater voids beneath the bank. Rock lunkers provide functional lift by creating relatively dark, cool, calm refugia for fish and other aquatic wildlife.

Permanent Island. Islands in streams create important habitat diversity, both above and below the water line. Permanent islands exist along Waller Creek, and construction of additional islands (using salvaged and/or local stone and plant materials) would provide functional lift by further diversifying the channel and riparian zone in terms of water depths, flow regimes, and vegetative cover.

Submerged Log. Submerged logs are anchored below the water surface. Salvaged/local, rot-resistant logs are preferred, and boles should be ≥10" diameter. Submerged logs provide functional lift by providing in-channel large woody debris, and habitat/substrates for aquatic plants and animals.

Emergent Log. Emergent logs are anchored and installed to span the normal water line. Salvaged/local, rot-resistant logs are preferred, and boles should be ≥12" diameter. Submerged logs provide functional lift by providing in-channel large woody debris, and habitat/substrates for riparian and aquatic plants and animals.

<u>Salvage</u>

Salvage river rock for bed, bank, and bar reconstruction. Development projects proposed along Waller Creek will affect the channel in a variety of ways, from moderate modifications of uplands and upper banks to complete replacement of stream banks with engineered walls to wholesale realignment of the creek channel itself. Prior to direct disturbance/reconstruction of the creek and its banks, opportunities should be sought to salvage available rock, cobble, or gravel. These valuable

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native materials can be re-used in the vicinity of the disturbance/reconstruction project or used elsewhere along the creek for channel and habitat restoration/enhancement. Salvage and replacement of these materials will provide functional lift through maintenance of desired geomorphology and retention or establishment of various channel substrates, providing a diversity of stable habitats.

Future Recommendations for Implementation of Framework Plan Goals

Waller Creek restoration and enhancement projects will be implemented largely in conjunction with new creek-side development projects. Early engagement with stakeholders is critical to sharing goals and developing a proactive, holistic approach to the development. This approach will enable adverse impacts to Waller Creek to be minimized (e.g., channel/bank disturbance, stormwater management techniques) as well as enable the benefits of creek-side development to be maximized. Early partnerships between development and creek interests will provide the opportunity for demonstration projects that will engage and inculcate stream restoration philosophy more broadly in the entire watershed.

The following step-by-step process will aid future developers and land managers to design with Waller Creek, embracing the unique opportunities it presents for development, while maximizing conservation values and sustainability principles.

1. Use Framework Plan data/findings
2. Update/refine assessments for project local area
3. Design with the creek's ecology

a. Consider specific key restoration/enhancement goals for different sections of Waller Creek

b. Work with WPD, WCC and others to preserve desirable elements/areas (where feasible) and select appropriate restoration and enhancement techniques for particular areas

4. Implement improvements (using qualified contractors/oversight); integrate improvements into City development review process
5. Monitor results (during and after construction); WPD provide regulatory oversight on public land; other mechanisms for corridor-wide functionality across fragmented ownership conditions
6. Maintain elements for high function (specify methods, frequency, responsible party, funding sources, etc.); while there may be a high investment for construction and monitoring during establishment, there will likely be lower requirements for long-term maintenance after establishment

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Identification and assessment of potential sources for soil import for the Waller Creek project was initiated on May 14-15, 2015 by Ted Hartsig of Olsson Associates. The purpose of the assessment was to locate suitable sources of soil, sand, and compost that can be used by contractors in implementation of the landscape design plans for Waller Creek restoration projects.

During interviews with vendors as well as City personnel, it became apparent that there are two primary types of soil used for landscaping projects in the Austin area: decomposed granite and "loam," or "City of Austin loam." Decomposed granite is granitic rock that has weathered to the point that it readily fractures into smaller pieces of weak rock, and mixtures of gravel, sand, and silt-sized particles with some clay. What is considered loam in the Austin area (even sandy loam) is dominantly silt or silty clay. The silty soil may have some very fine sand component and some clay, but when wet it is very plastic and sticky, and when dry it is very hard. Locally it is called "red death." The City of Austin loam is the silt soil blended with compost (80 percent soil to 20 percent compost by volume) to provide better structure.

The decomposed granite is from a source northwest of Austin that sells to vendors, including all of those interviewed on May 14 and 15. The "loam" soils are obtained from pits on the east side of the city, in an oxbow of the Colorado River.

Potential soil and compost vendors were initially identified through internet search and interviews with Waller Creek design team members in Austin. (pending testing of soil texture). Some vendors could not be visited on May 14 or 15 due to rain and closing of their operations, or because of time delays due to traffic. Below are summary notes of each vendor visited.

Geo Growers, Inc.
12002 Highway 290 West
Austin, Texas 78737 512.892.2722

GeoGrowers provides soil and compost for residential and commercial applications. Their primary soil product is decomposed granite which is purchased by GeoGrowers for redistribution. Their operation consists primarily of about a 3-acre lot on which soil mixes and compost are formulated and shipped. Soil blends (typically varying screenings of decomposed granite and compost) are bucket mixed with a front-end loader. The owner, Mr. George Altgelt reports that he can provide up to 3,000 cubic yards of material per week.

Two samples were provided:

1. "Wonder Dirt" or decomposed granite fines and sands
2. "Tree Soil" or screened decomposed granite

GeoGrowers

Organics by Gosh
13602 FM 969
Austin, TX 76724 512-276-1211

Organics by Gosh focuses on providing soil and compost mixtures. Their primary source of soil is nearby their facility where they have a 400 acre soil pit. The pit is in an oxbow of the Colorado River, and comprised primarily of fine silt loam or silty clay loam. The silty clay loam is very plastic and sticky when wet, with little to no sand content. At his operation, Mr. Gosh blends soil with compost to create the "City of Austin" or COA loam. Mr. Gosh indicated that he is capable of producing up to 3,000 cubic yards of soil and soil blends per day.

Organics by Gosh also has a large composting operation. Currently they compost primarily vegetative materials (woody debris, leaves, grasses) and manure.

No prices were discussed, but likely to work on volume discount basis compared to their retail lists.
Mr. Gosh provided several samples of representative soils:

1. Screened Sandy soil (appears to be fine sand, red in color)
2. Unscreened sandy soil
3. Clay loam soil
4. A soil from a contracted location (appears to be clay loam/loam)
5. 2:1 "loam-compost" blend with gypsum added
6. "F&G" base loam – appears to be a 1:1 loam-compost blend

Organics by Gosh

The Natural Gardener
8648 Old Bee Caves Road
Austin, Texas 78735

Intended to visit with the owner of the Natural Gardener, but weather and time (primarily due to traffic between locations) did not enable me to visit with them. By information obtained, the Natural Gardener is primarily oriented to home landscapers, but their information says that they have worked with municipal agencies. The size and capacity of the operation are unknown at this time.

Whittlesey Landscape Supplies
3219 S. IH35
Round Rock, TX, 78664

Whittlesy is perhaps the largest supplier of landscape supplies in the Austin region. They own at least 4 facilities/yards in the region, and at least two soil pits ("loam" pits). They obtain decomposed granite from a supplier northwest of Austin. In addition, Whittlesey has at least two compost operations where they have compost of different blends, including plant material and manure (50/50 mix). We discussed developing specific compost, which they can do. Whittlesey provided several soil samples (and their own analyses) of the City of Austin loam as well as decomposed granite, and mixes of the loam or granite with compost (to provide the COA loam).

During the visit, the different soils were compared and discussed. The "loam" soil is very fine and is more a silt loam or silty clay (see introductory paragraph). The decomposed granite is very coarse sand with some fines. We mixed the two together (2 parts granite to 1 part loam) and seemed to come up with a viable soil blend. More investigation into this should be completed.

Whittlesey owns numerous pieces of equipment to handle large operations. They own 4 large vibrating screens and will screen soils, composts, and blends down to ¼" size fractions. They are capable of producing more than 5,000 cubic yards of material per day.

No photos – it was raining too hard during the visit

Austin Landscape Supplies
5317 S Interstate 35, Georgetown, TX 78626
(512) 930-2311

Met with Austin Landscape Supplies sales personnel in July. Austin Landscape Supplies sells bulk soils, including topsoils and amended "growing soils," compost, rock, and other landscaping supplies. The sales group was not able to provide a tour of their facilities, but indicated that they get their soil from nearby soil pits, including the standard Colorado River sources, and nearby decomposed granite sources. They stated that their compost is typically a mix of brush debris and manure, and that they sell the local "dillo dirt" derived from municipal sludge compost. The owner was not available the day of the vendor visit, but an email was later received that he would be very interested in bidding on the Waller Creek project, and had the capacity to meet the soil volume requirements.

Stormwater Retrofit

STORMWATER RETROFIT

Storm Sewer Outfalls Priorities Table 2015-01-16.pdf

Retrofit Scenario Selection Criteria

A	Adequate Space & Peak Discharge < ~1.5 cfs
B	Not A, Ranked higher than 40, and Peak Discharge < 3-3.5 cfs
CD	Not A or B, Ranked higher than 40 and Peak Discharge > 3.0-3.5 cfs
D	Not A and Ranked lower than 40
U	Unknown at the time this memo was developed - No picture or pipe not found
n/a	Not applicable - Does not flow at 2-year storm

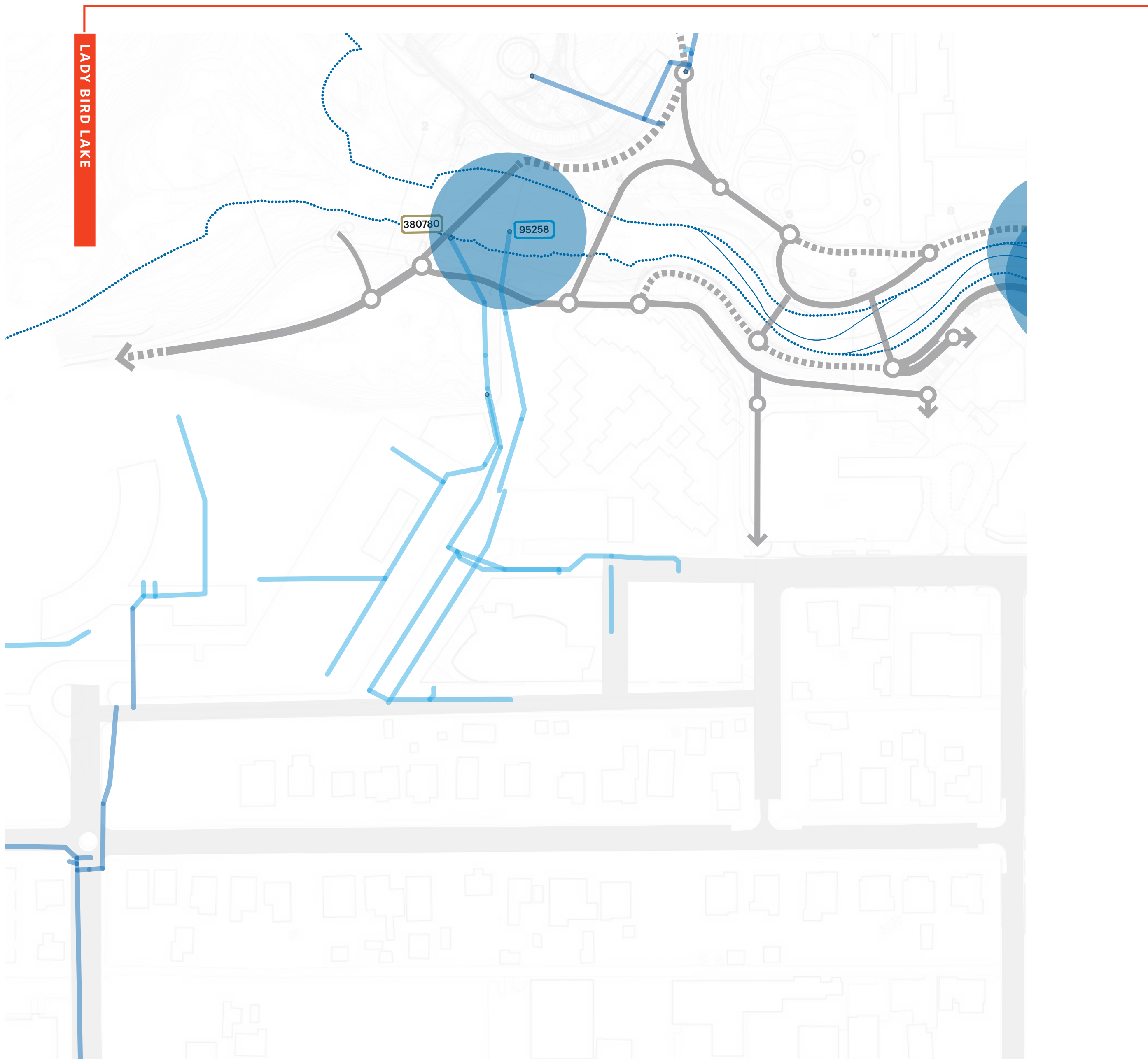
DRAINAGE_ID	WIDTH	HEIGHT	Overall Ranking	Initial Retrofit Scenario
364357	18	18	19	A
602378	21	21	27	A
61557	18	18	30	A
61495	24	24	31	A
225134	24	24	33	A
372277	12	12	37	A
61494	18	18	38	A
377456	12	12	44	A
370053	60	60	8	B
377434	24	24	11	B
467195	27	27	13	B
58599	18	18	14	B
641157	30	30	18	B
367642	24	24	23	B
602539	24	24	24	B
95258	24	24	25	B
226993	18	18	26	B
225194	30	30	28	B
406442	60	60	1	CD
60842	42	48	2	CD
94974	30	30	3	CD
364912	36	36	4	CD
92645	24	24	5	CD
63740	30	30	6	CD
60605	24	24	7	CD
220629	30	30	9	CD
627753	24	24	10	CD
380780	36	36	12	CD
546933	36	36	21	CD
364899	36	36	22	CD
58652	24	24	29	CD
58927	21	21	32	CD
459774	18	18	34	CD
475568	18	18	35	CD
459813	18	18	36	CD
61486	18	18	39	CD
476265	15	15	40	D
225169	18	18	41	D
94845	18	18	42	D
95064	18	18	43	D
225697	12	12	45	D
372270	12	12	47	D
58665	18	18	n/a	D
58822	24	24	n/a	D
58823	24	24	n/a	D
60663	15	15	n/a	D
60664	18	18	n/a	D
61327	36	36	n/a	D
225156	12	12	n/a	D
225185	18	18	n/a	D
225202	36	48	n/a	D
225869	18	18	n/a	D
226721	18	18	n/a	D
226998	18	18	n/a	D
363559	24	24	n/a	D
370054	66	66	n/a	D
373296	18	18	n/a	D
367691	24	24	15	U
377521	30	30	16	U
607103	30	30	17	U
226963	30	30	20	U
61459	12	12	46	U

LimnoTech & Michael Van Valkenburgh Associates (January 2015)

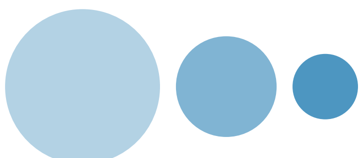
STORMWATER RETROFIT

Stormwater Retrofit: Inline Treatment Assessment
STORMWATER-INLINE_300sc.pdf

I



LEVEL OF CONTRIBUTION



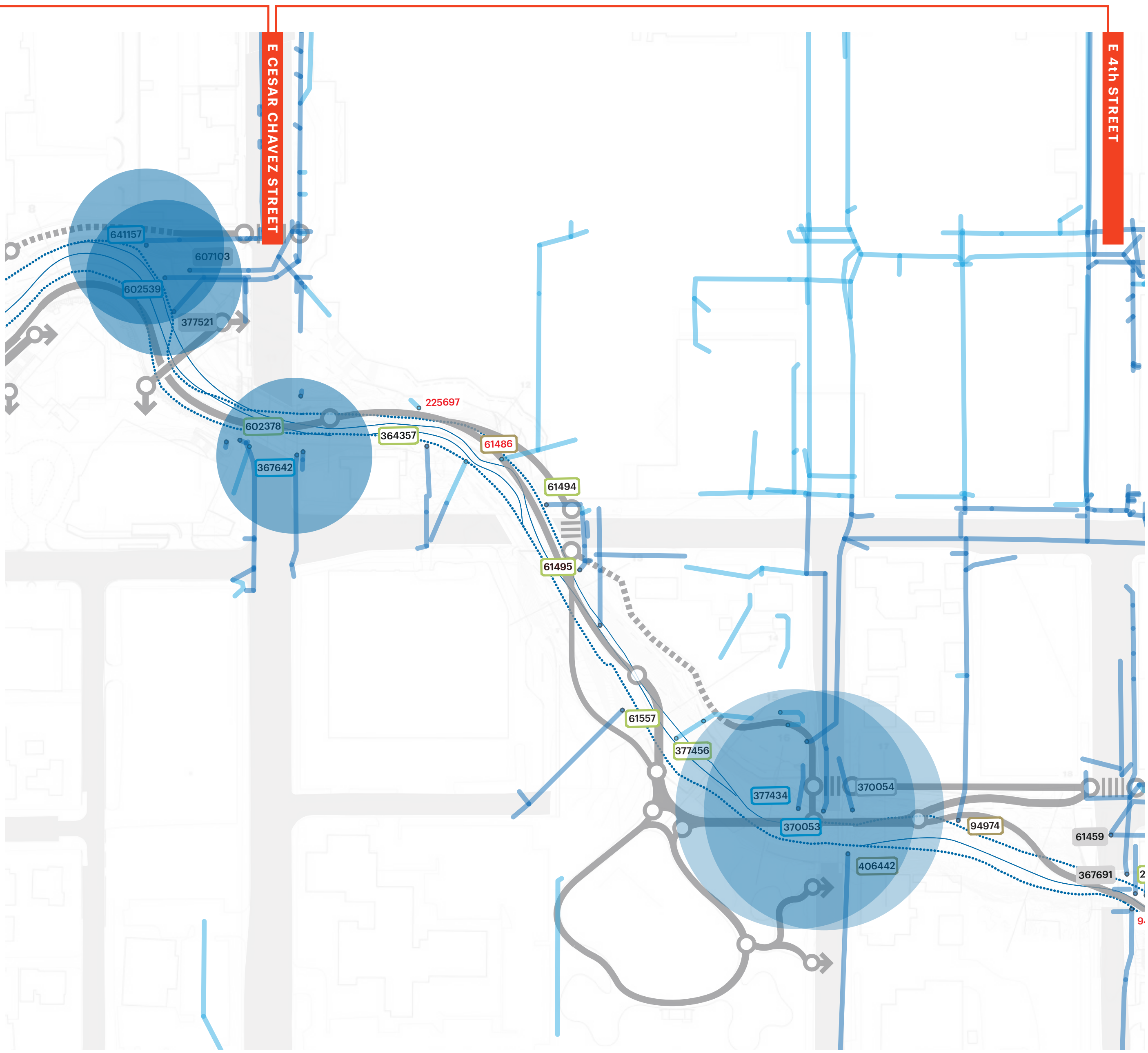
High Medium Low

KEY

- 12345 Landscape Treatment - “A”
- 12345 Inline Treatment - “B”
- 12345 Sewershed/Do Nothing - “C/D”
- 12345 Do Nothing “D”
- 12345 Trail Conflict - Convey - “E”
- 12345 Unknown

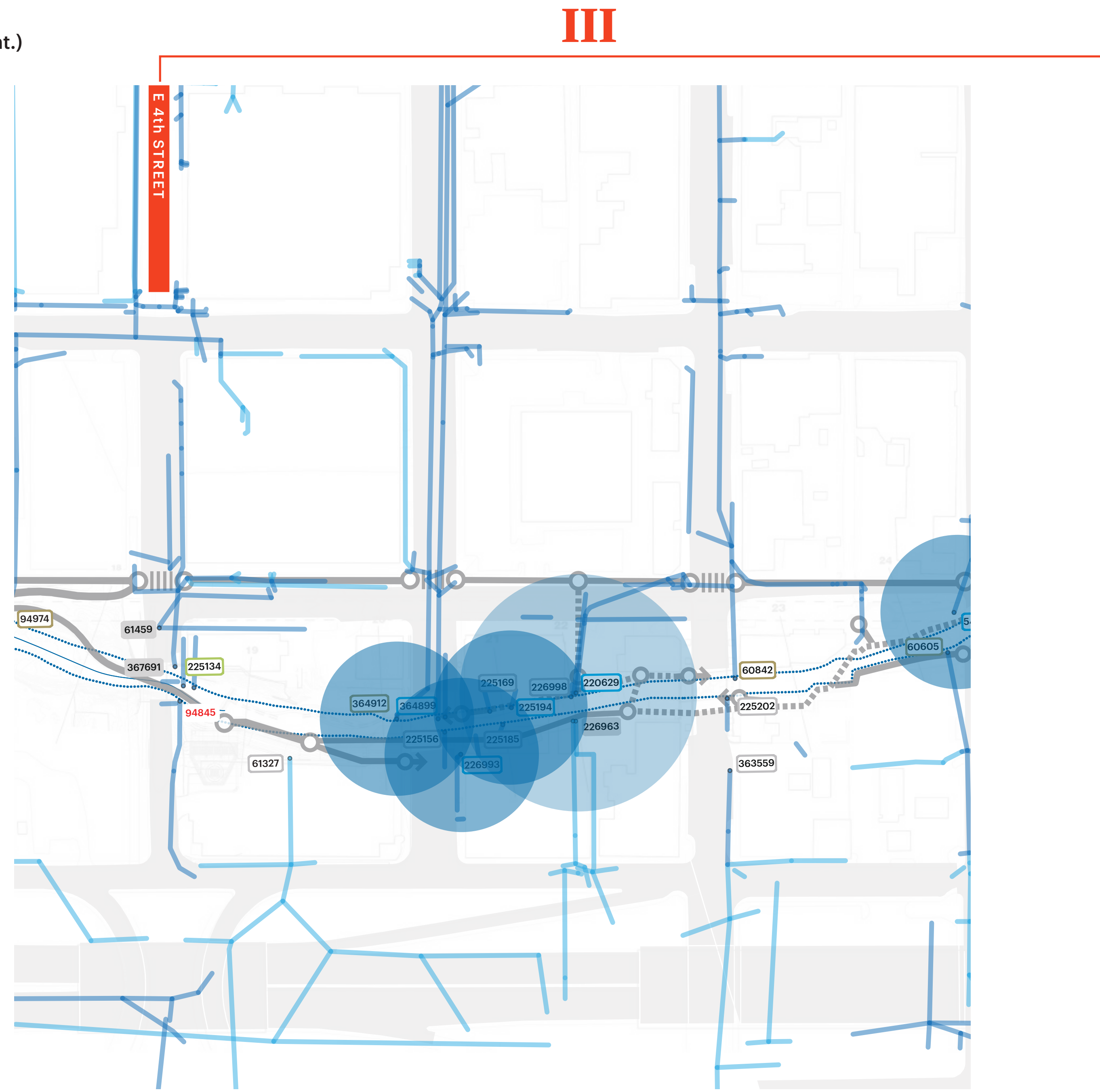
0′ 100′ 200′

II


E CESAR CHAVEZ STREET
E 4th STREET
641157
607103
602539
377521
225697
602378
364357
61486
367642
61494
61495
61557
377456
377434
370054
370053
94974
61459
406442
367691

STORMWATER RETROFIT

Stormwater Retrofit: Inline Treatment Assessment (cont.)
STORMWATER-INLINE_300sc.pdf



LEVEL OF CONTRIBUTION

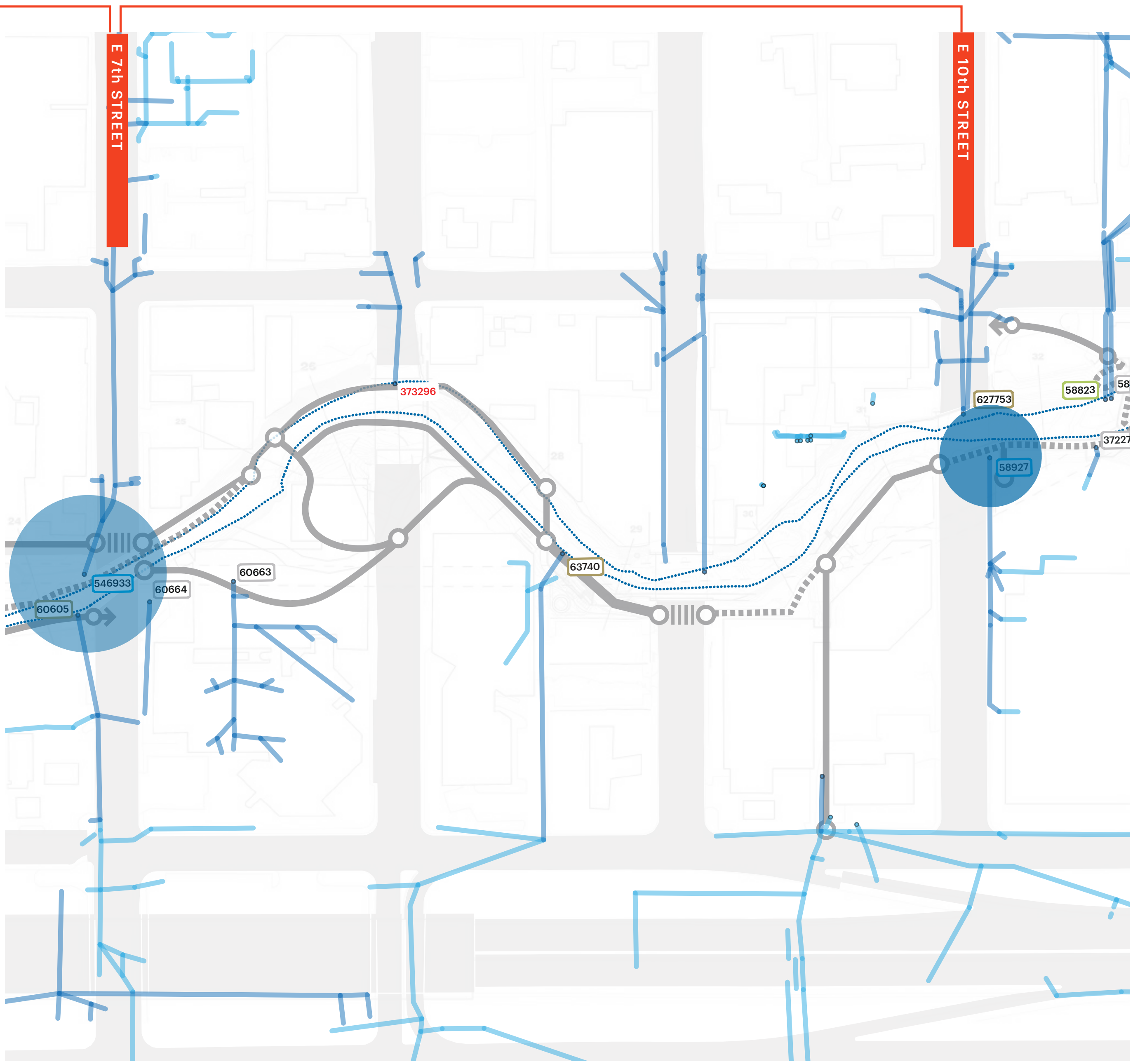
High | Medium | Low

KEY

- 12345 — Landscape Treatment - "A"
- 12345 — Inline Treatment - "B"
- 12345 — Sewershed/Do Nothing - "C/D"
- 12345 — Do Nothing "D"
- 12345 — Trail Conflict - Convey - "E"
- 12345 — Unknown

0' 100' 200'

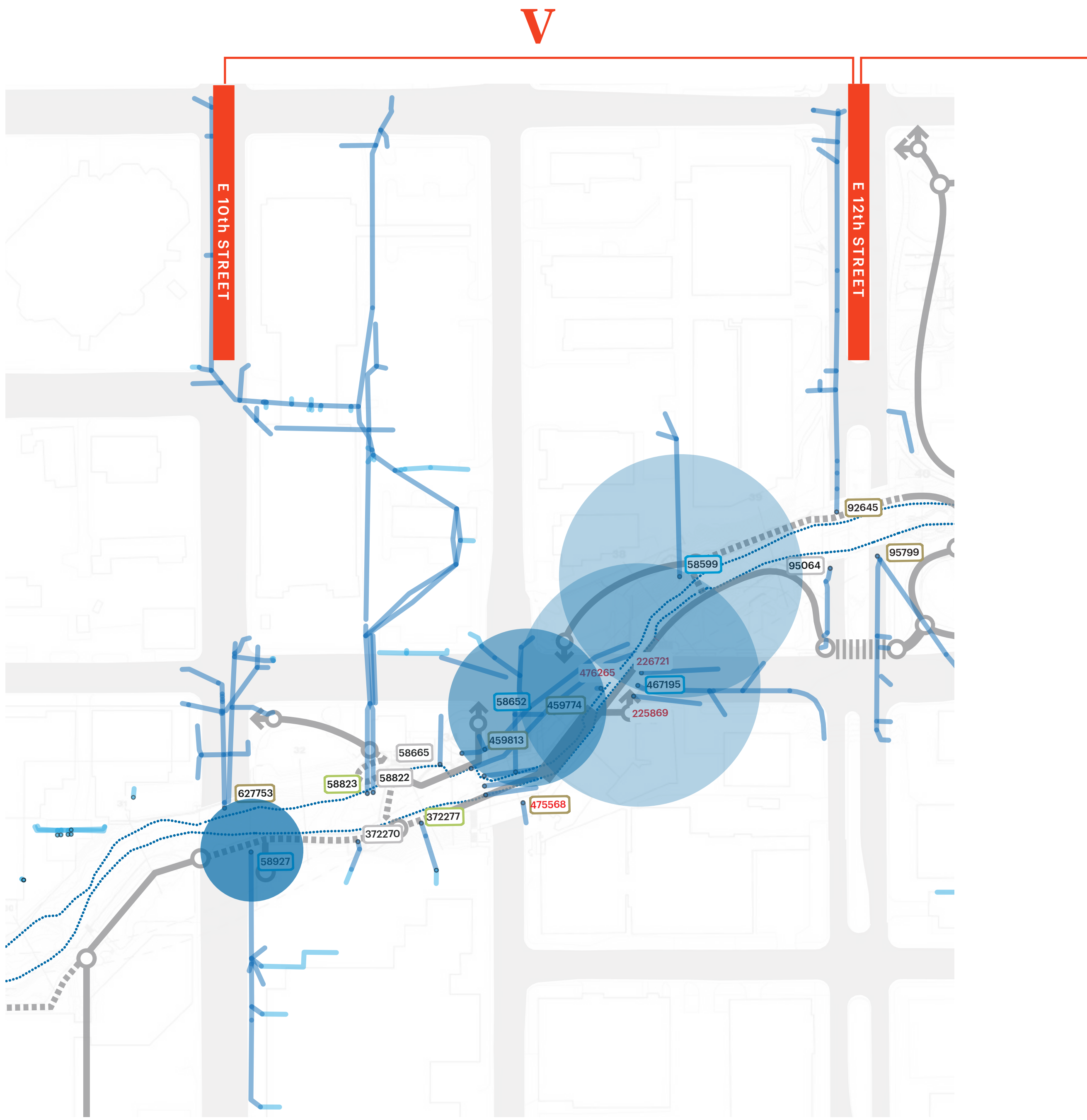
IV



E 7th STREET
E 10th STREET
373296
627753
58823
58
37227
58927
546933
60605
60663
60664
63740

STORMWATER RETROFIT

Stormwater Retrofit: Inline Treatment Assessment (cont.)
STORMWATER-INLINE_300sc.pdf



LEVEL OF CONTRIBUTION

High Medium Low

KEY

12345	Landscape Treatment - "A"
12345	Inline Treatment - "B"
12345	Sewershed/Do Nothing - "C/D"
12345	Do Nothing "D"
12345	Trail Conflict - Convey - "E"
12345	Unknown

0′ 100′ 200′

VI

Inline Storm Drain Treatment Location Assessment (1-4)

250 003 - Waller Creek Storm Drain Treatment- 2015.03.31_reduced.pdf

BIG RED DOG
ENGINEERING | CONSULTING

250.003

Date: March 31, 2015

From: Ernie Amacher, P.E.; Diana Wang, P.E.

To: Mike Kelly, P.E. – WPD
Janna Renfro, P.E. – WPD

CC: Danielle Choi, Gullivar Shepard - MVVA
Susan Benz, BRG
Waller Creek Conservancy

Project: Waller Creek Corridor Framework

Re: Inline Storm Drain Treatment Location Assessment

Summary:

This assessment is intended to describe potential conflicts and considerations for the utilization of inline storm water treatment devices in conjunction with improvements at the Waller Creek Watershed. The scope of this report is in reference to the use of SAFL Baffle and SNOUT storm water treatment devices proposed by Limnotech and does not address alternate solutions for storm water treatment, such as the use of vegetated strips. It was assumed that two manholes would be required where inline treatment is desired; an 8' storm drain manhole incorporating SAFL Baffle treatment devices, and a 4' manhole for SNOUT treatment devices. Where required, 12' wide access easements have been proposed to provide right of use for maintenance vehicles. Additionally, 20'x30' temporary construction easements have been shown for installation purposes.

Criteria for Placement:

1. Access and Proximity to the Creek - The preferred location for inline treatment device placement is within public R.O.W., closest to the downstream outfall. Where R.O.W. placement is not feasible, the treatment devices have been placed on-site at locations minimizing the length of access routes.
2. Existing Storm Infrastructure - In scenarios where an existing manhole is present, and within the vicinity of the outfall, the location of inline treatment devices have been shifted to repurpose existing manholes.
3. Utility Conflicts - GIS data was utilized to compare the location of the proposed treatment devices with known existing utility lines in order to avoid conflicts during the construction process. Due to the approximate nature of this data, utility field locates and a formal survey will be required at a later date to ensure constructability.
4. Other Conflicts - Aerial imagery and data collected from an in-field site visit was utilized to place on-site treatment devices at locations minimizing interference with above surface objects such as trees and retaining walls.

Data Scope:

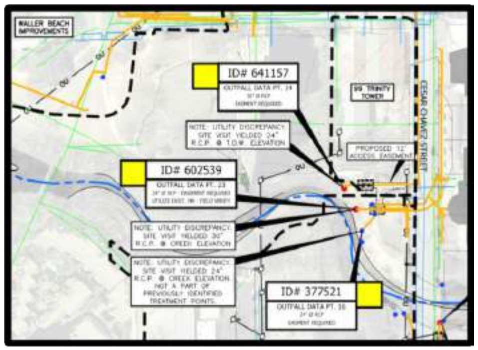
GIS data was provided to Big Red Dog Engineering by LimnoTech on March 11, 2015 which proposed thirteen different outfalls identified as potential locations for inline treatment. After site investigation, two additional outfalls were identified as potential locations for inline treatment. One point of the original thirteen was considered unsuitable due to maintenance restrictions, and four points of the cumulative fifteen presented potential constraints which will require further research and enhanced engineering design as plans progress. The information on the following pages details the causes for either discounting or raising concern at the outfalls in question.

ID #	DATA POINT	DIA.(MATERIAL) PER GIS	EASEMENT REQ.	SUITABILITY FOR INLINE TREATMENT	FIELD NOTES
602539	23	24" (RCP)	YES	MODERATE	30" DIA. @ T.O.W. LEVEL
641157	14	30" (RCP)	YES	MODERATE	24" DIA. @ CREEK LEVEL
377521	16	24" (CONC.)	YES	MODERATE	30" DIA. @ CREEK LEVEL
367642	24	24" (CONC.)	PROBABLE	HIGH	MAY REQUIRE EASMENT
377434	35	24" (RCP)	PROBABLE	HIGH	MAY REQUIRE EASMENT
370053	7	60" (RCP)	NO	HIGH	USE EXIST. MANHOLE
364899	9	36" (UNK.)	NO	HIGH	
225194	13	30" (UNK.)	YES	LOW	RESTRICTED ACCESS
226998	29	18" (UNK.)	YES	HIGH	COMBINE W' 220629
220629	12	30" (UNK.)	YES	HIGH	COMBINE W' 226998
546933	8	36" (CONC.)	NO	HIGH	USE EXIST. MANHOLE
58927	54	21" (RCP)	NO	HIGH	
58652	51	24" (CONC.)	NO	HIGH	
467195	49	27" (RCP)	NO	HIGH	
58599	56	18" (UNK.)	YES	MODERATE	CONFLICT W' MH, TREES

Table 1: Inline Treatment Data Set (From South to North)

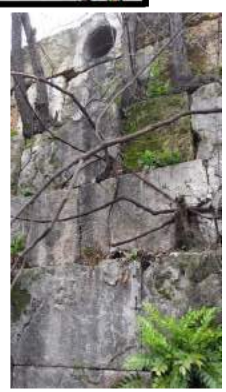
<u>Outfall ID#641157(Data Pt. 14), ID#602539(Data Pt. 13), & ID#377521(Data Pt. 16)</u>

Three large diameter outfalls have been identified as potential locations for inline treatment south of Cesar Chavez Street, and adjacent to the future 99 Trinity Tower Project. Coordination with development plans for 99 Trinity Tower will need to be performed to ensure whether re-routing of the existing storm drain lines will be required as a part of the re-development process, and to access compatibility with the future site plan.



Suspected Data Pt. 16

Suspected Data Pt. 23

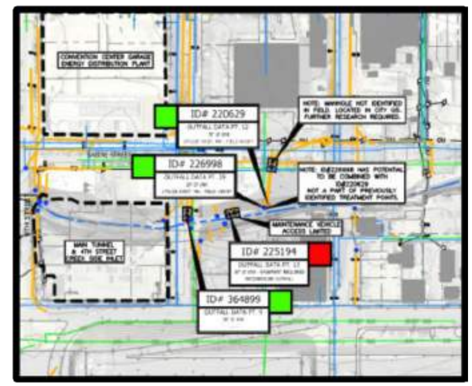


Suspected Data Pt. 14

BIG RED DOG Engineering and Consulting | 512.669.5560 | www.BIGREDDOG.com

<u>Outfall ID#225194(Data Pt. 13), ID#226998(Data Pt. 29), & ID#220629(Data Pt. 12)</u>

Three large diameter outfalls have been identified as potential locations for inline treatment within the vicinity of the courtyard plaza near the existing Hilton Garden Inn. It is suspected that outfall data point 13 is not a viable option due to maintenance access constraints. Due to the close proximity of data points 12 & 29, it is believed that the two outfalls can be combined into a single system utilizing combined storm treatment manholes serving both points. Further research pending access to as-built documents will be required to determine the suitability of a combined outfall system.



<u>Data Pts. 13, 12, 29 – Facing West</u>

STORMWATER RETROFIT

Inline Storm Drain Treatment Location Assessment (5-7)

250 003 - Waller Creek Storm Drain Treatment- 2015.03.31_reduced.pdf

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Outfall ID#58599(Data Pt. 56)

Data point 56 is located to the west of Waller Creek near the Public Employees Association Building and conveys, at minimum, stormwater runoff for parking facilities associated with St. Elias Orthodox Church. While it is believed that space will be adequate to locate in-line treatment, the close proximity of existing wastewater infrastructure and existing heritage trees will inhibit the placement of inline treatment devices at this location. Coordination with adjacent property owners may be required to determine the potential to locate storm water treatment infrastructure off-site within upstream parcels.

Manhole Near Pt. 56

HeritageTree "A" Near Pt. 56

HeritageTree "B" Near Pt. 56

250.003 – Waller Creek Conservancy | Storm Inline Treatment| March 31, 2015 | Page 5 of 6

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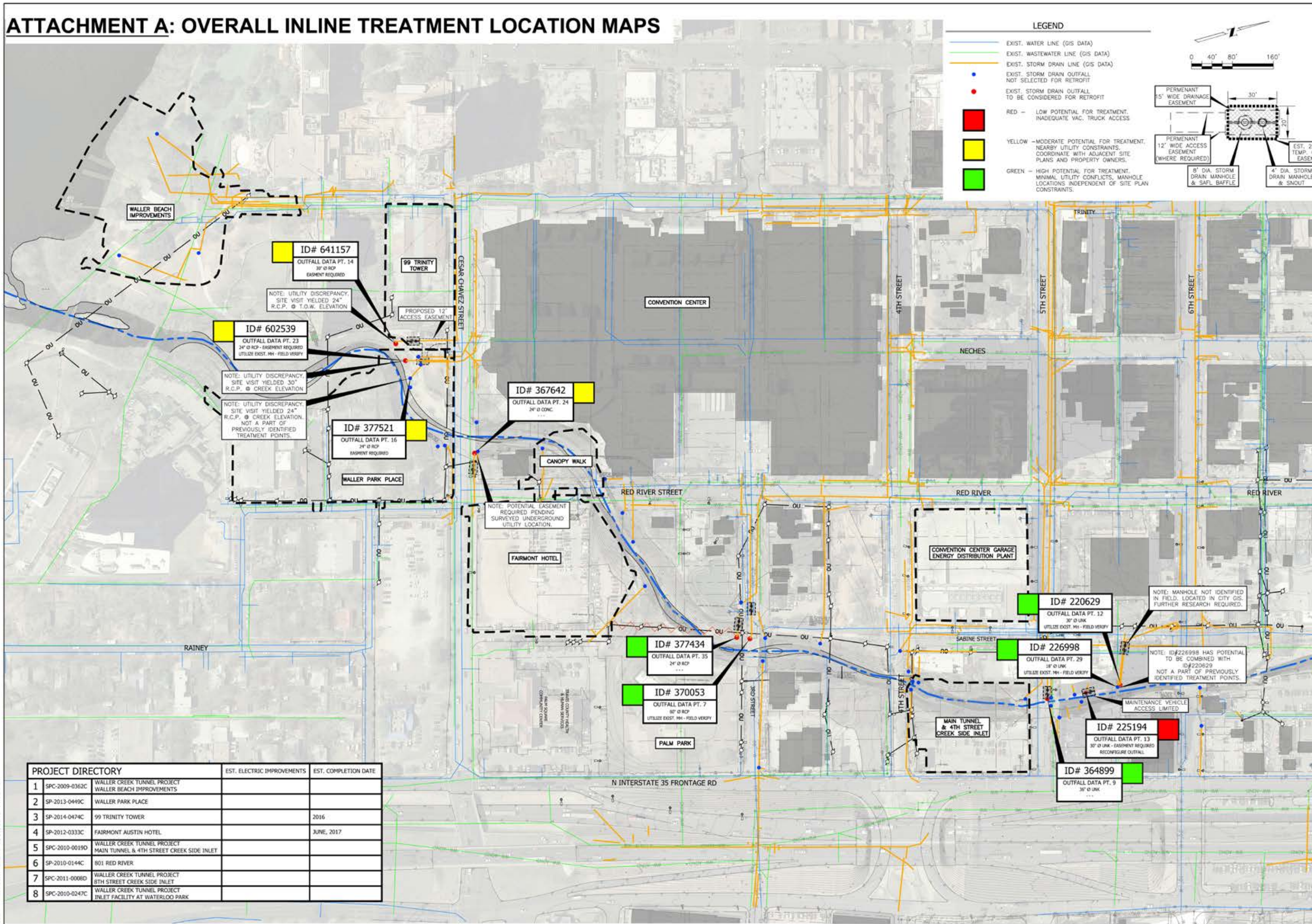
Attachments

Attachment A – Overall Inline Treatment Location Maps

250.003 – Waller Creek Conservancy | Storm Inline Treatment| March 31, 2015 | Page 6 of 6

ATTACHMENT A: OVERALL INLINE TREATMENT LOCATION MAPS



PROJECT DIRECTORY			EST. ELECTRIC IMPROVEMENTS	EST. COMPLETION DATE
1	SPC-2009-0362C	WALLER CREEK TUNNEL PROJECT WALLER BEACH IMPROVEMENTS		
2	SP-2013-0449C	WALLER PARK PLACE		
3	SP-2014-0474C	99 TRINITY TOWER		2016
4	SP-2012-0333C	FAIRMONT AUSTIN HOTEL		JUNE, 2017
5	SPC-2010-0019D	WALLER CREEK TUNNEL PROJECT MAIN TUNNEL & 4TH STREET CREEK SIDE INLET		
6	SP-2010-0144C	801 RED RIVER		
7	SPC-2011-0008D	WALLER CREEK TUNNEL PROJECT 8TH STREET CREEK SIDE INLET		
8	SPC-2010-0247C	WALLER CREEK TUNNEL PROJECT INLET FACILITY AT WATERLOO PARK		

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WWW.BIGREDDOG.COM
BIG RED DOG
ENGINEERING | CONSULTING

PRELIMINARY
NOT FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.
PREPARED UNDER THE SUPERVISION OF MICHAEL V. REYES, P.E. #111664 ON February 17, 2015

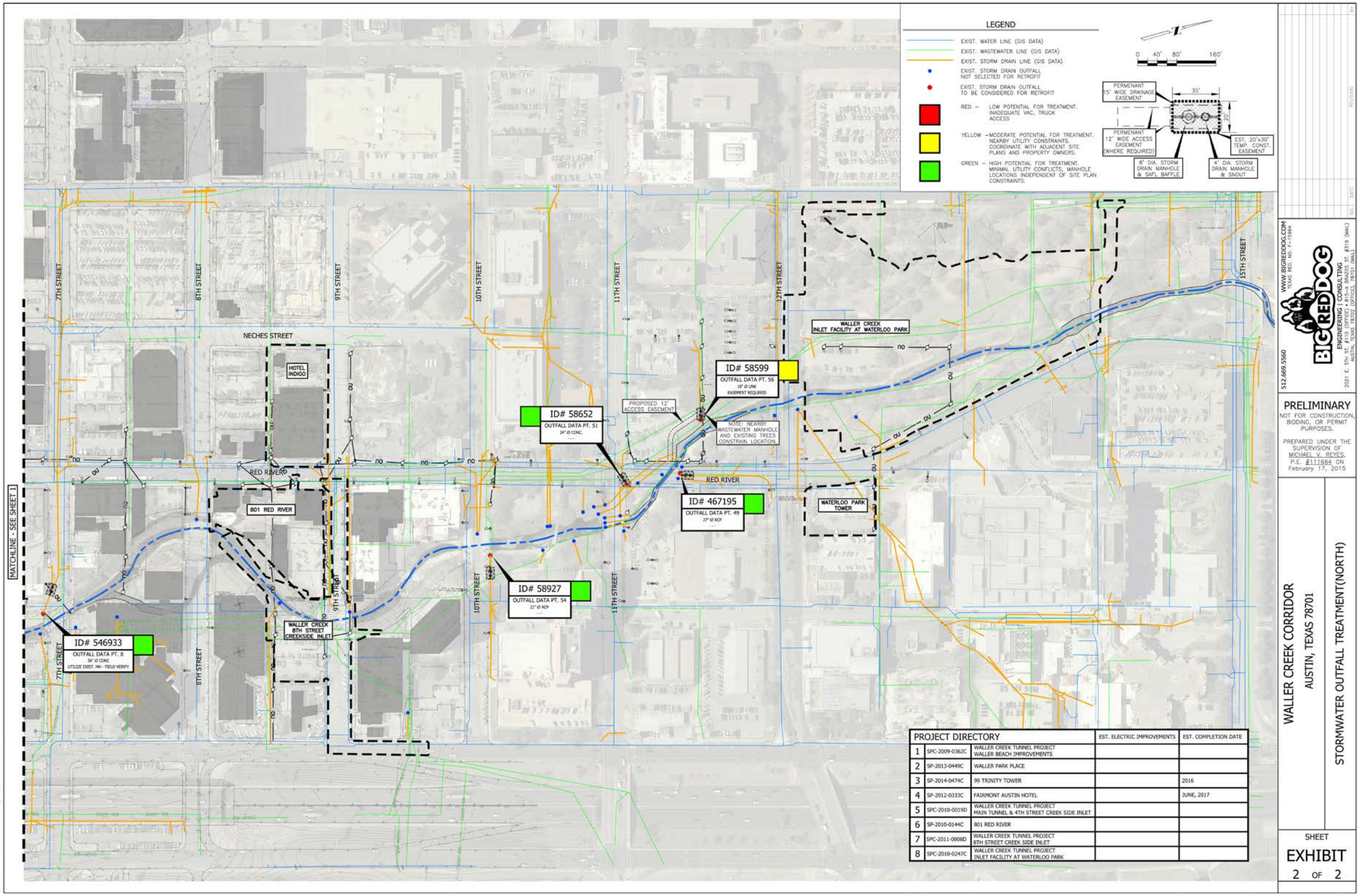
WALLER CREEK CORRIDOR
AUSTIN, TEXAS 78701
STORMWATER OUTFALL TREATMENT(SOUTH)

SHEET
EXHIBIT
1 OF 2

STORMWATER RETROFIT

Inline Storm Drain Treatment Location Assessment (8)

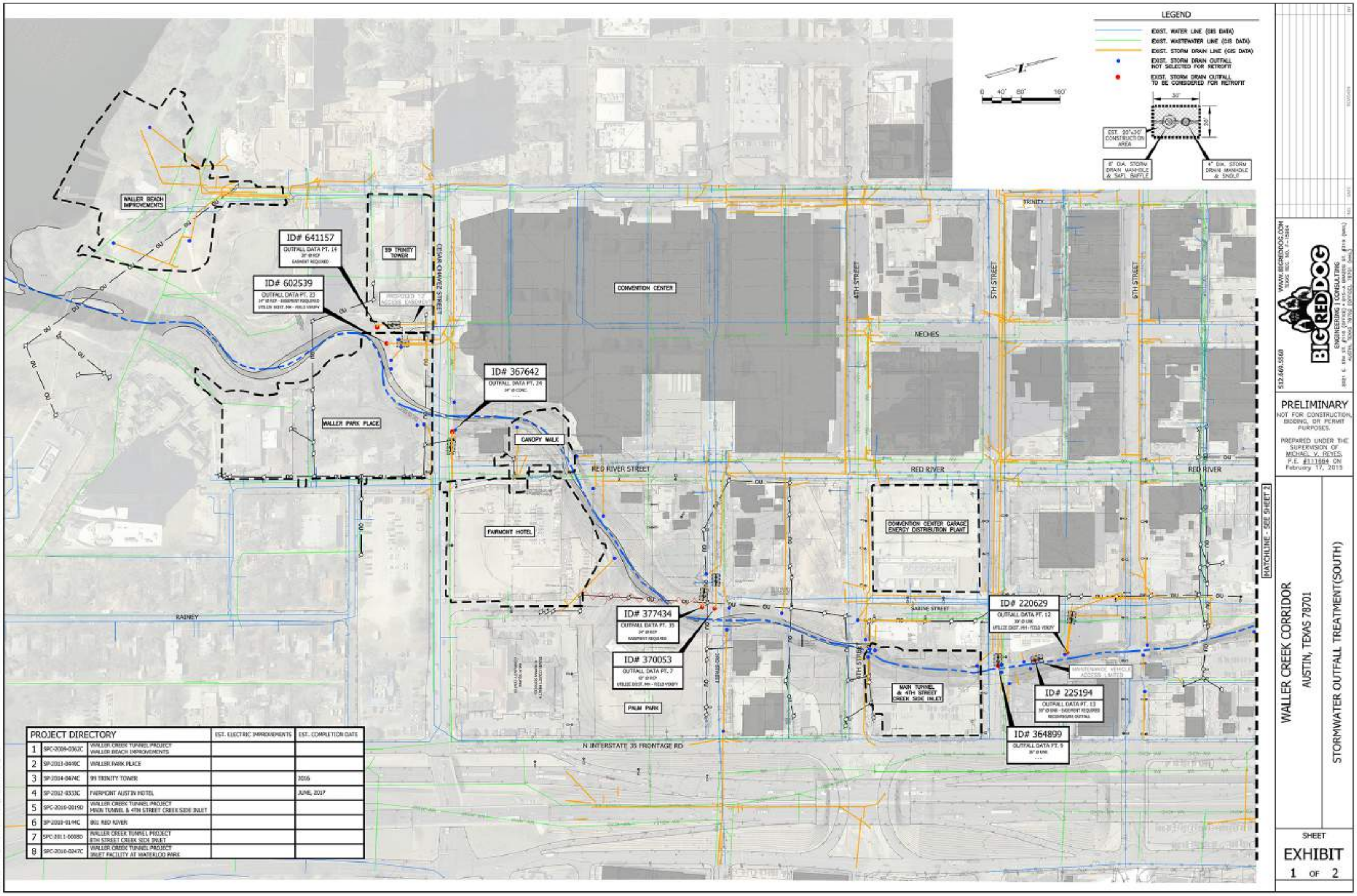
250 003 - Waller Creek Storm Drain Treatment- 2015.03.31_reduced.pdf



STORMWATER RETROFIT

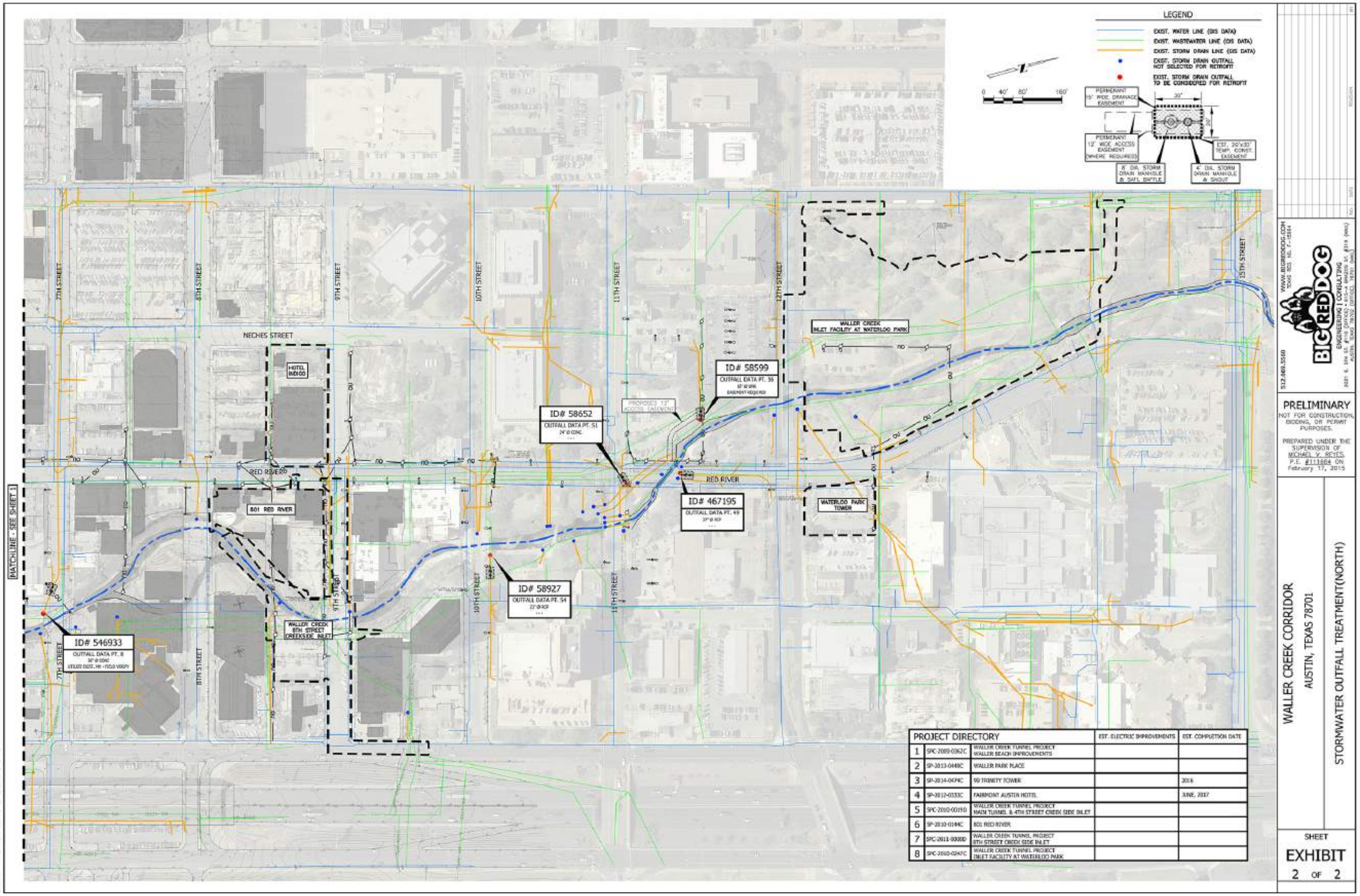
Stormwater Outfall Treatment (South) (1)

250.003 -SHT 1-TREATMENT LOCATE-2015.03.19.pdf



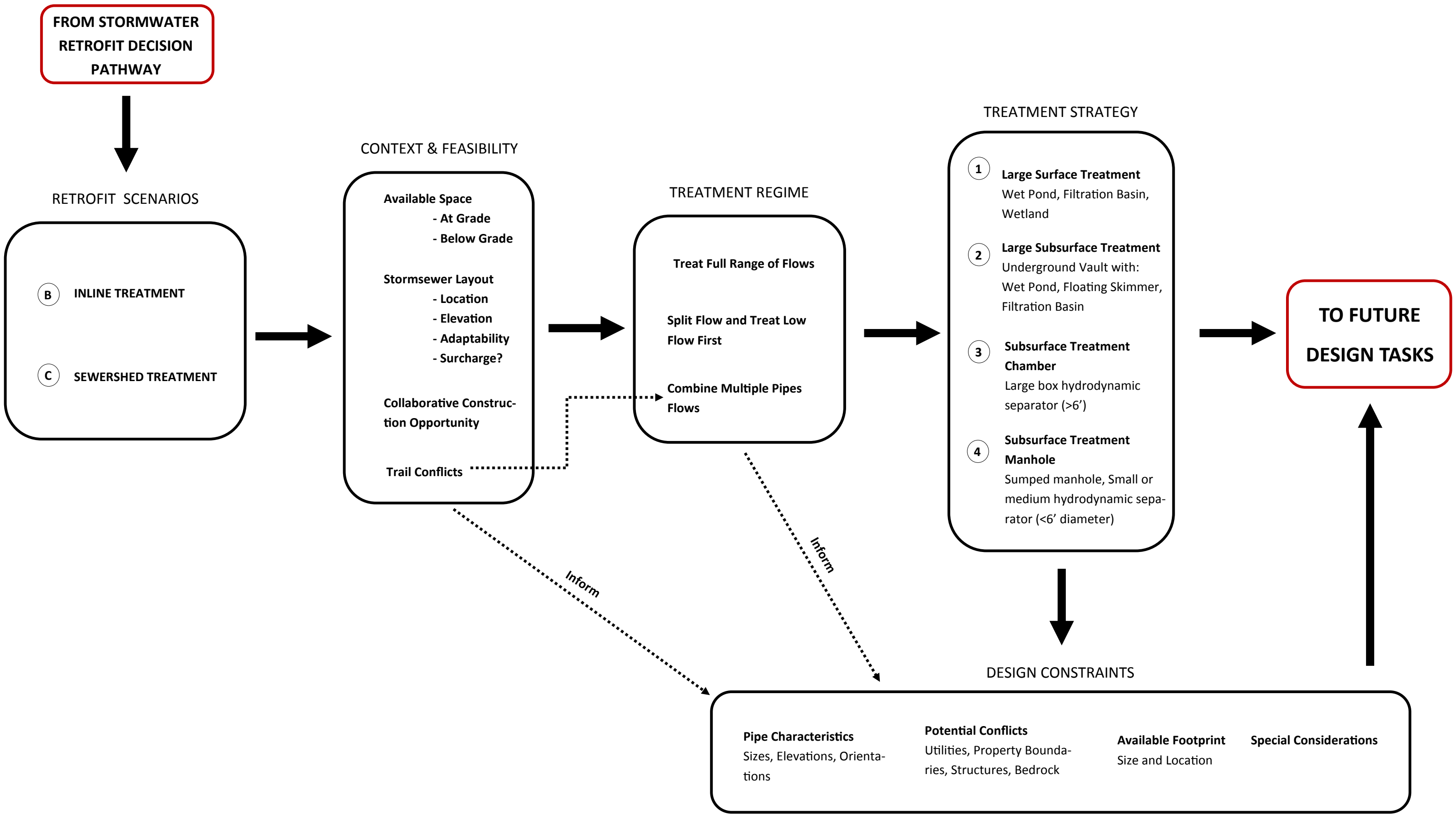
STORMWATER RETROFIT

Stormwater Outfall Treatment (North) (2)
250.003 -SHT 1-TREATMENT LOCATE-2015.03.19.pdf



Limnotech Inline Treatment Flowchart

2014.12.01_Inline Treatment Flow Chart.pdf



INLINE STORMWATER TREATMENT DECISION PATHWAY

2014.11.26

LimnoTech
Water Environment | Scientists Engineers

7300 Hudson Blvd.
Suite 295
Oakdale, MN 55128
651.330.6038
www.limno.com

Memorandum

From: Craig Taylor
Dendy D. Lofton, PhD
Tim Dekker, PhD
Jeremy Walgrave, PE

Date: February 23, 2015
Project: Waller Creek Framework Plan

To: Mike Kelly, PE, WPD
Janna Renfro, WPD

CC: MVVA Team
Susan Benz, BRG
Waller Creek Conservancy

SUBJECT: Summary of Inline Treatment Strategy and the Design Path Forward

Overview

There are several constraints that should be considered when selecting stormwater treatment devices. These constraints inform the decision-making process in determination of the devices most appropriate for Austin, TX. Firstly, the target sediments have rather fine particle size distributions (PSD) compared to the operating range of most stormwater treatment systems. Secondly, the treatment device needs to be able to trap floatable trash such as cups and plates, but not be susceptible to fouling (i.e., clogging). Finally, an overarching goal is to reduce the total sediment and trash load to Waller Creek rather than to obtain specific reduction targets. This final goal means that the best treatment system or combination of treatment systems is the one that yields the lowest construction and annual maintenance cost per pound of total suspended sediment (TSS) reduction.

The constraints of stormwater treatment in Austin could be addressed by either inlet or inline treatment. Inlet treatment devices have the advantage of higher TSS removal efficiency. The disadvantage of inlet treatment devices is that it is typically cost prohibitive to install devices in every inlet. Consequently, some inlets are treated to a high degree and some are not treated at all. Inline treatment devices are typically less efficient at removing TSS than inlet treatment; however, they are capable of treating runoff from several inlets. With fewer devices required, inline treatment has the advantage of lower maintenance requirements. This maintenance advantage is the basis for the motivation to default to inline treatment whenever possible.

Inline Treatment Devices

There are a few proprietary stormwater treatment systems (e.g., hydrodynamic separators) that should be considered for inline treatment in the Waller Creek watershed. These devices were selected for two reasons: 1) scour prevention features and 2) trash/debris management features. Within sump scour prevention is of utmost importance because the flashy nature of the hydrology in this region results in resuspension of previously captured sediment. Trash and debris have also been identified as a concern for Waller Creek. The trash and debris found within the Waller Creek watershed is unique in that it contains a significant amount of fabric (e.g., clothing and blankets)

in addition to the typical municipal trash (e.g., cups, bottles, and plastic bags). Not only is it important for inline treatment systems to capture trash, it is equally important that they are not prone to fouling. Of the many inline treatment systems on the market, the field was narrowed down to a short list of three systems based on the following criteria:

1) the system must have been tested for removal efficiency and washout using a mass balance method
2) normalized removal efficiency and washout curves must be available for the system; and
3) the system must be free of internal restrictions, screens, and abrupt transitions which may be prone to debris fouling.

Three systems have been identified that meet these requirements:

- Upstream Technologies' SAFL Baffle used in series with a Best Management Practices Incorporated's Snout
- Environment 21's V2B1
- Hydro-International's Downstream Defender

The first system identified is the SAFL Baffle paired in series with a Snout device. The SAFL Baffle is a system that can be installed in any sumped manhole. The baffle is intended to diffuse the water jet entering a manhole and prevent the accumulated sediment in the sump from washing out. Diffusing the water jet also slows the velocities down allowing for slightly higher removal efficiencies. The majority of the testing conducted on the SAFL Baffle has been for a configuration with the inlet and outlet pipes located directly across from each other; however, there has been some research to suggest that the system has higher sediment retention when the pipes are located at 90° angles to each other. The Snout device can be retrofitted into almost any manhole with an existing sump. The Snout is effectively a skimmer to prevent floatables from passing through the manhole. The Snout manhole may be placed either upstream or downstream of the SAFL Baffle manhole. There are merits to either configuration. It is important to note that a SAFL Baffle and a Snout are sometimes placed in the same manhole; however, this configuration has not been tested and the Snout may work against the scour protection offered by the SAFL Baffle.

The strengths of the SAFL Baffle are that it is relatively inexpensive compared to typical hydrodynamic separators and it is not prone to reduced performance due to leaf fouling. The weakness of the SAFL Baffle is that it was designed to remove sediment at the upper end of the Austin PSD. For stormsewer networks with high outfall discharges, it may be necessary to 1) split the flow into two treatment manholes or 2) move the treatment manholes upstream in the watershed.

The next two hydrodynamic separators identified are Environment 21's V2B1 and the Hydro International's Downstream Defender. The strengths of both of these systems are that they target smaller particle sizes within the range of the Austin PSD and they have internal floatables traps. The primary drawback of both of these systems are that they tend to be more expensive. The floatables trap in the V2B1 is nearly as large as that of the snout, while the floatables trap on the Downstream Defender is smaller relative to the other two systems. The greatest strength of the Downstream Defender is that is the only system that will only require one new manhole. This savings would likely offset most of the additional cost of the device itself.

Since each of these three hydrodynamic separators target a different range of flows and PSD, it is likely that each one could be considered the best alternative at different sites within the Waller Creek watershed. The best way to determine the appropriate alternative for a given site is to estimate the removal efficiency and cost for each device as well as the site-specific operations and maintenance constraints.

Head loss

An additional consideration when selecting a treatment device to retrofit into an existing stormsewer network is hydraulic loss. All inline treatment devices create additional head losses. The selected inline treatment device needs to be incorporated into the sewershed model to confirm that the additional head loss created by the device does not cause unacceptable consequences such as premature surcharging of the upstream inlets.

Howard et al. (2011) measured head loss for a 4 ft x 4 ft SAFL Baffle over a range of discharges (Figure 1). The head losses ranged from 0.2 ft at 1.8 cfs to 0.4 ft at 5.5 cfs.

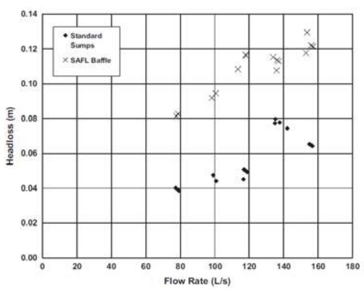


Figure 1: Head loss vs flow rate in a 4 x 4 ft sump with and without the SAFL Baffle (from Howard et al. 2011).

Head loss has also been estimated for the Downstream Defender. Guidance for head loss provided by Hydro-International indicates a head loss coefficient of k = 3 (Eqn 1).

$$H_l = k\frac{V^2}{2g} \qquad (1)$$

Where: H_l = Head loss
k = Head loss coefficient
V = Inlet velocity
g = Acceleration due to gravity

Guidance for V2B1 head loss estimates was not available at the time this memo was drafted.

Maintenance

All three of the hydrodynamic separators discussed above can be cleaned using a vactor truck. They all recommend a minimum of one cleaning per year. Additional cleanings may be required if large volumes of sediment or trash are accumulated. The Sizing Hydrodynamic Separators and Manholes (SHSAM) model (discussed in more detail below) estimates the sediment volume collected to determine how many additional cleanings would be required each year. None of the manufactures are able to estimate how often their devices will need to be cleaned for trash because the loading rates from the watershed are unknown. It is recommended that the devices be monitored regularly to adaptively manage cleaning frequency.

Some basic information about SAFL Baffle maintenance can be found at these websites:

- http://www.dnr.state.mn.us/water_access/bmp/sump_manhole_with_safl_baffle_bmp.html

- http://stormwater.safl.umn.edu/updates-december-2011
- http://upstreamtechnologies.us/safl-baffle/

The V2B1 maintenance documents can be found that the following websites:

- http://www.env21.com/media/docs/v2b1/drawings/V2B1%20System%20Maintenance%20130305.pdf
- http://www.env21.com/v2b1.html

The Downstream Defender maintenance documents can be found at the follow websites:

- http://www.hydro-int.com/UserFiles/downloads/DD-Operation%20And%20Maintenance%20Manual_0.pdf
- http://www.hydro-int.com/us/products/downstream-defender

Trash Capture & Fouling Risk

The three devices discussed were selected in part because they have features that have been observed to be resistant to trash fouling in other non-treatment stormwater devices. The Downstream Defender and the V2B1 have floatables skimmers. The SAFL Baffle should capture floatables larger than its 5-inch holes, and placing a snout in an adjacent manhole will increase the efficiency of capturing smaller floatables. None of these systems are intended to capture neutrally buoyant trash.

McIntire (2012) found that a SAFL Baffle with a deep sump (sump depth > diameter) continues to perform at a similar efficiency even when the baffle is partially fouled. Tests with plastic bags found that many of the bags will become trapped in the baffle. Leaves, soda cans, and 24 oz. bottles tend to pass through. The greatest risk of fouling is most likely if many plastic bags (several hundred) were to completely blind the baffle, but it is unlikely that such a high volume of plastic bags will enter the chamber during a single storm event.

The internal plumbing of the V2B1 tested at the St. Anthony Falls Laboratory (SAFL) had a diameter equal to the diameter of the influent pipes. This decreases the risk of large debris, which would not fit through the internal plumbing, working its way into the treatment chamber. The swirling nature of the flow in the chamber will also act to reduce the risk of debris being drawn into the central orifice. The central orifice of the V2B1 is not confined by a weir, which allows more time for material to accumulate before it will need maintenance cleaning. In the event that the central orifice were to clog, the bypass plumbing would activate and the treatment efficiency of the system would be closer to that of a standard sump. The greatest risk of fouling is if the floatables debris mat is allowed to get too large and they overwhelm the central orifice. This scenario could be caused by a lack of maintenance to remove trash.

The Downstream Defender has a cylindrical baffle which acts as a robust floatables skimmer. This feature has been found to be very efficient at capturing trash in other stormwater devices tested. In this system, the inlet pipe enters the manhole tangentially and flow must pass under an apron in order to reach the outlet pipe, which is set at a higher elevation than the inlet. The depth of the cylindrical baffle and the large internal conveyance area make it unlikely to foul with debris. However, if it were to foul with some large object, such as a blanket, it could be difficult to clear the clog.

Given the types of debris observed in Waller Creek, the most likely cause of any one of these systems to fail is large pieces of fabric such as cloths and blankets.

Typical Manhole Sizing and Bypass Considerations

For all three of the devices discussed, the typical manhole sizes are expected to be on the order of 6-8 feet in diameter. Both the V2B1 and the SAFL Baffle placed inline with a Snout will require two manholes to be replaced or retrofitted. The V2B1 will require that the two manholes be relatively close to one another. The SAFL Baffle and Snout manholes can be as far apart as is convenient. This means that the V2B1 system would most likely remove one existing manhole and replace it with 2 new manholes. The SAFL Baffle and Snout system will likely remove two existing manholes and replace it with two new manholes in the same locations. The Downstream Defender only requires 1 manhole. This means that the system would typically remove one existing manhole and replace it with 1 new manhole. The challenge in this case is that the upstream piping will need to be reconfigured in order to accommodate the lower elevation, tangential inlet. There is an alternate configuration for the Downstream Defender that places a new manhole next to an existing manhole and then modifies the existing manhole to send and receive discharge to and from the Downstream Defender (see Figure 2). The drawback of this configuration is that it takes up more space and increases the risk of utility conflicts.

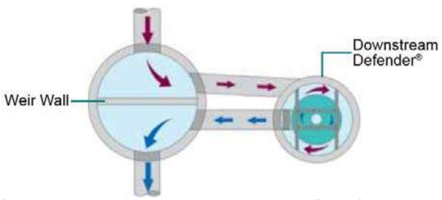


Figure 2: Downstream Defender alternate configuration (from O&M Manual linked above)

In general, all three of the systems will perform at a higher efficiency if discharges greater than the design treatment discharge are externally bypassed around the device. External bypassing typically requires 2 or 3 additional manholes. The additional construction cost typically makes external bypasses cost prohibitive. One of the merits of the Downstream Defender is that it can be externally bypassed using an existing large manhole as shown in Figure 2.

SHSAM Modeling

For a single site with a single device, the most streamlined method for sizing a device and estimating its treatment efficiency is the use of the SHSAM model. The SHSAM model is free software which can be found at http://upstreamtechnologies.us/design-guide/ along with a working example. SHSAM contains TSS treatment curves for nine hydrodynamic separators. All of the devices included in the SHSAM have been tested using a mass balance method developed at SAFL. All of the devices have been tested for removal efficiency and about half of them have been tested for washout prevention. The SAFL Baffle, V2B1, and Downstream Defender have been tested for both removal efficiency and washout prevention.

For a single watershed, SHASM uses a seasonal runoff model and the treatment curves to predict the removal efficiency for each selected device. SHSAM also predicts the number of additional cleanings the device will require beyond the annual maintenance cleaning. There are several inputs required for the SHSAM model:

1) 15-minute rainfall data

2) PSD
3) Watershed data,
4) Temperature (optional)
5) Influent TSS concentration.

The user can select predefined rainfall and temperature data for Dallas, TX or can supply data for Austin, TX. The model also has five predefined PSDs, or user specified input can be supplied.

The SHSAM model will output a table detailing the removal efficiency and removal load for each simulation year and the average removal efficiency for all years simulated. The output table will also include the average number of additional cleanings required beyond the annual maintenance cleaning. The removal efficiency results provided in the output tables need to be read with caution. These results cannot be fairly compared to efficiency claims made by any device not modeled in SHSAM, any device modeled in SHSAM but with a different washout setting, or any device measured as part of separate study. The removal efficiency predicted by SHSAM is typically markedly lower than the removal efficiency measured during physical testing. This difference is due to the method by which removal efficiency is calculated. Most physical testing and removal efficiency claims are based on the treatment efficiency during a single discharge event. In this case, the efficiency claims are limited to a specific range of flows. The SHSAM model considers all ranges of flows through out the simulation period. In SHSAM, the TSS in large event flows that are bypassed around the treatment device count against the devices reported removal efficiency. For example, if a given device removes 80% of the TSS that passes through it and half of the flows are bypassed around the device, then the removal efficiency is actually only 40%.

Alternate Modeling

The SHSAM model is a unique tool with a range of applications, but has a number of limitations. These limitations include single watershed modeling, no pipe routing, constant influent TSS concentrations, single treatment device selection, and no discharge input option. In situations where these limitations are too restrictive, as they may be in Austin, the removal efficiency calculations can be made directly from the device testing reports. This section will discuss TSS treatment curves developed for the hydrodynamic separators and the procedures for estimating the removal efficiency and washout concentration.

The removal efficiency and washout concentration of most hydrodynamic separators can be normalized by the Péclet Number (Eqn 2) and the jet Froude Number (Eqn 3).

$$Pe = \frac{U_s * h * D}{Q} \qquad (2)$$

$$Fr_j^2 = \frac{U_j^2}{gD} \qquad (3)$$

Where: Pe = Péclet number
U_s = Particle settling velocity
h = Height from inlet to bottom of chamber
D = Manhole diameter
Q = Discharge
Fr_j = Jet Froude number
U_j = Inlet velocity
g = Acceleration due to gravity

The particle settling velocity in the equations presented below is calculated according to Cheng (1997) (Eqn 4).

$$U_s = \frac{\nu}{d}\left[\sqrt{25 + 1.2\left[d\left(\frac{g\left(\frac{\rho_p}{\rho_w}-1\right)}{\nu^2}\right)^{\frac{1}{3}}\right]^2} - 5\right]^{1.5} \quad (4)$$

Where: ν = Water kinematic viscosity
d = Particle diameter
ρ_p = Particle density (~2.55 x 10^6 g/m^3)
ρ_w = Water density

SAFL Baffle Efficiency and Washout Concentration Curves

Howard (2010) developed empirical removal efficiency (Eqn 5) and washout concentration (Eqn 6) curves for the SAFL Baffle. Sample calculations for the removal efficiency equations are included in Attachment D "SAFL Baffle Calcs.xlsx."

$$\eta = 100\left[1 + \left(0.0208\frac{Pe}{Fr_j^2}\right)^{-2.1216}\right]^{-0.4713} \quad (5)$$

$$\frac{C(SG-1)}{SG\cdot\rho_w} = \frac{A_w}{Pe/Fr_j^2} + B_w \cdot exp\left(C_w \cdot \left(Pe/Fr_j^2\right)\right) \quad (6)$$

Where: $A_w = 8.3\text{x}10^{-6}$
$B_w = 4.7\text{x}10^{-4}$
$C_w = -3.18$

V2B1 Efficiency and Washout Concentration Curves

Wilson et al (2009) developed empirical removal efficiency (Eqn 7) and washout concentration (Eqn 8) curves the V2B1.

$$\eta = \left(\frac{1}{0.99^{1.85}} + \frac{1}{(2.2Pe)^{1.85}}\right)^{-\left(\frac{1}{1.85}\right)} \quad (7)$$

C = 32.673 $Q^{2.55}$ -> For a d50 = 110 microns (8a)
C = 0.095 $Q^{6.04}$ -> For a d50 = 200 microns (8b)

Downstream Defender Efficiency and Washout Concentrations Curves

Taylor et al (2011) developed empirical removal efficiency (Eqn 9) and washout concentration (Eqn 10) curves for the Downstream Defender.

$$\eta = \left(\frac{1}{1.0^{3.77}} + \frac{1}{(0.56Pe)^{3.77}}\right)^{-\left(\frac{1}{3.77}\right)} \quad (9)$$

$$\frac{C(SG-1)}{SG\cdot\rho_w} = \frac{A_w}{Pe/Fr_j^2} + B_w \cdot exp\left(C_w \cdot \left(Pe/Fr_j^2\right)\right) \quad (10)$$

Where: $A_w = 4.14\text{x}10^{-5}$
$B_w = 3.13\text{x}10^{-4}$
$C_w = -3.87$

Overall Removal Efficiency

Equations 1 through 10 can be applied for any given discharge and for each particle size in the PSD. The removal efficiency for each particle size can be aggregated into an overall removal efficiency based on the weighting of each PSD bin. The removal efficiency and washout concentration for a series of storms can be modeled by considering each time step of the hydrographs as a single constant discharge. For each time step, the total sediment captured is equal to the sum of the influent concentration times the removal efficiency minus the washout concentration times the effluent volume. Care needs to be taken when performing this type of running time series, mass balance calculation to ensure that the material washed out never exceeds the material available in the sump and the sump cleanings are properly accounted for.

Hydrodynamic Separator Selection

Cost estimates can be prepared based on the device costs, number of manholes required, and typical construction and annual maintenance cost for the City of Austin. Knowing the TSS load reduction and installation and annual maintenance cost, the most cost effective hydrodynamic separator can be determined by dividing the life cycle cost by the TSS load reduction.

References

Cheng, N (1997) "A Simplified Settling Velocity Formula for Sediment Particle" *Journal of Hydraulic Engineering* Vol. 123, Iss. 2, pg 149-152.

Howard, A (2010) "Use of Standard Sumps for Suspended Sediment Removal from Stormwater" Master's Thesis – University of Minnesota, Advisors: Heinz Stefan and Omid Mohseni

Howard, A., Mohseni, O., Gulliver, J., and Stefan, H. (2011) "SAFL Baffle retrofit for suspended sediment removal in storm sewer sumps" *Journal of Water Research*. Vol. 45, pg 5895-5904

LimnoTech (2014). Summary of Program Verification and Discovery Tasks. Technical Memorandum. December 11, 2014.

McIntire, K.D. (2012) "Stormwater Treatment with the SAFL Baffle: Debris and Non-standard Sump Testing" Master's Thesis – University of Minnesota, Advisors: Omid Mohseni and John Gulliver

Taylor, C., Howard, A., Marr, J, and Mohseni, O. (2011) "Assessment of the Removal Efficiency and Washout Characteristics of a 6' Diameter Hydro International Downstream Defender®" SAFL Project Report No. 553, University of Minnesota

Wilson, W.A, Mohseni, O., Gulliver, J.S., Hozalski, R.M, and Stefan, H.G. (2009) "Assessment of Hydrodynamic Separators for Storm-Water Treatment." *Journal of Hydraulic Engineering* Vol. 135, Iss. 5, pg 383-392

STORMWATER RETROFIT

Stormwater Retrofit: Landscape Treatment Assessment
STORMWATER-LAND_300sc.pdf

LEVEL OF CONTRIBUTION

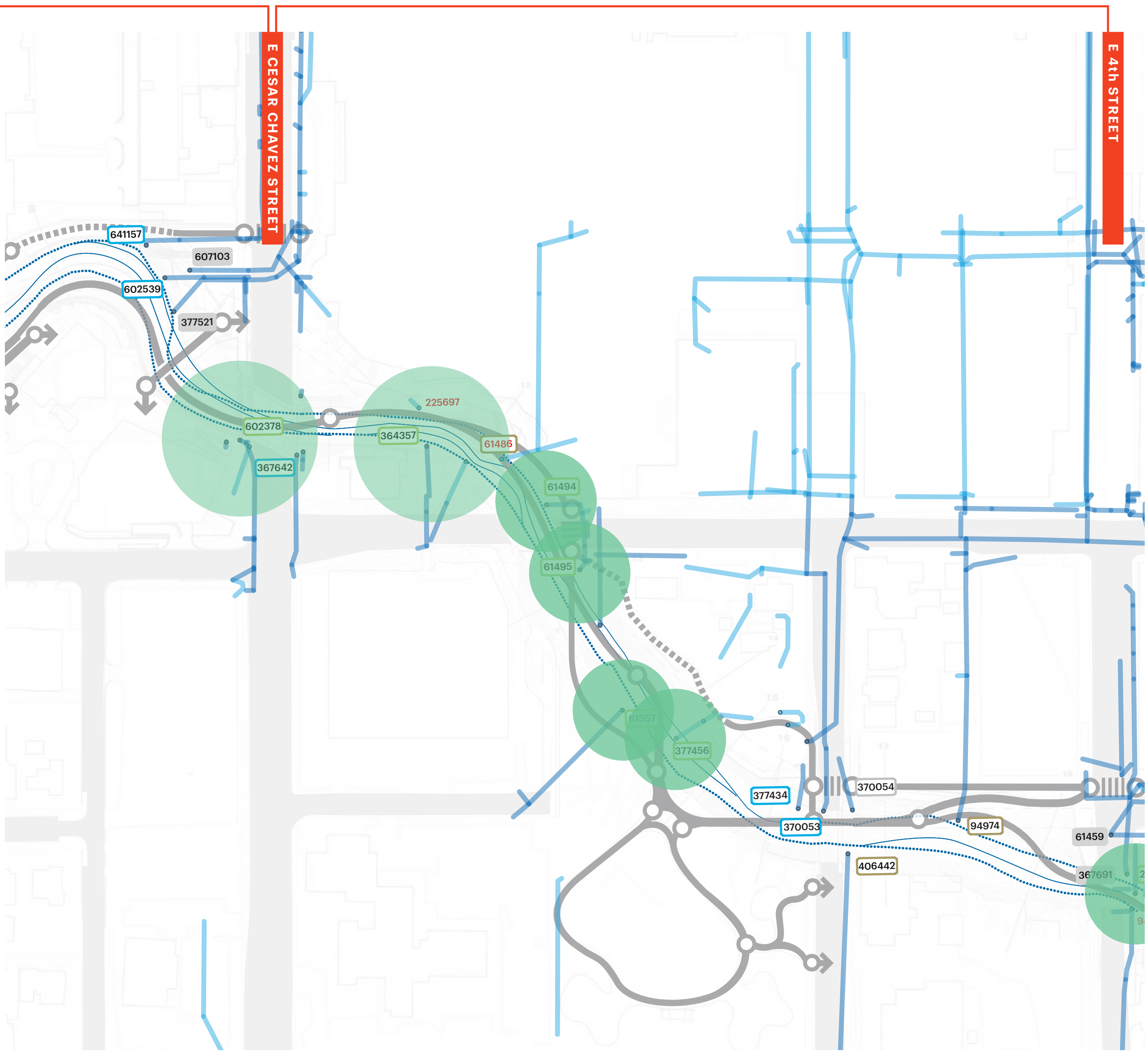
High (N/A) Medium Low

KEY

12345	Landscape Treatment - "A"
12345	Inline Treatment - "B"
12345	Sewershed/Do Nothing - "C/D"
12345	Do Nothing "D"
12345	Trail Conflict - Convey - "E"
12345	Unknown

0' 100' 200'

II



E CESAR CHAVEZ STREET
E 4th STREET
641157
607103
602539
377521
225697
602378
364357
61486
367642
61494
61495
61557
377456
377434
370054
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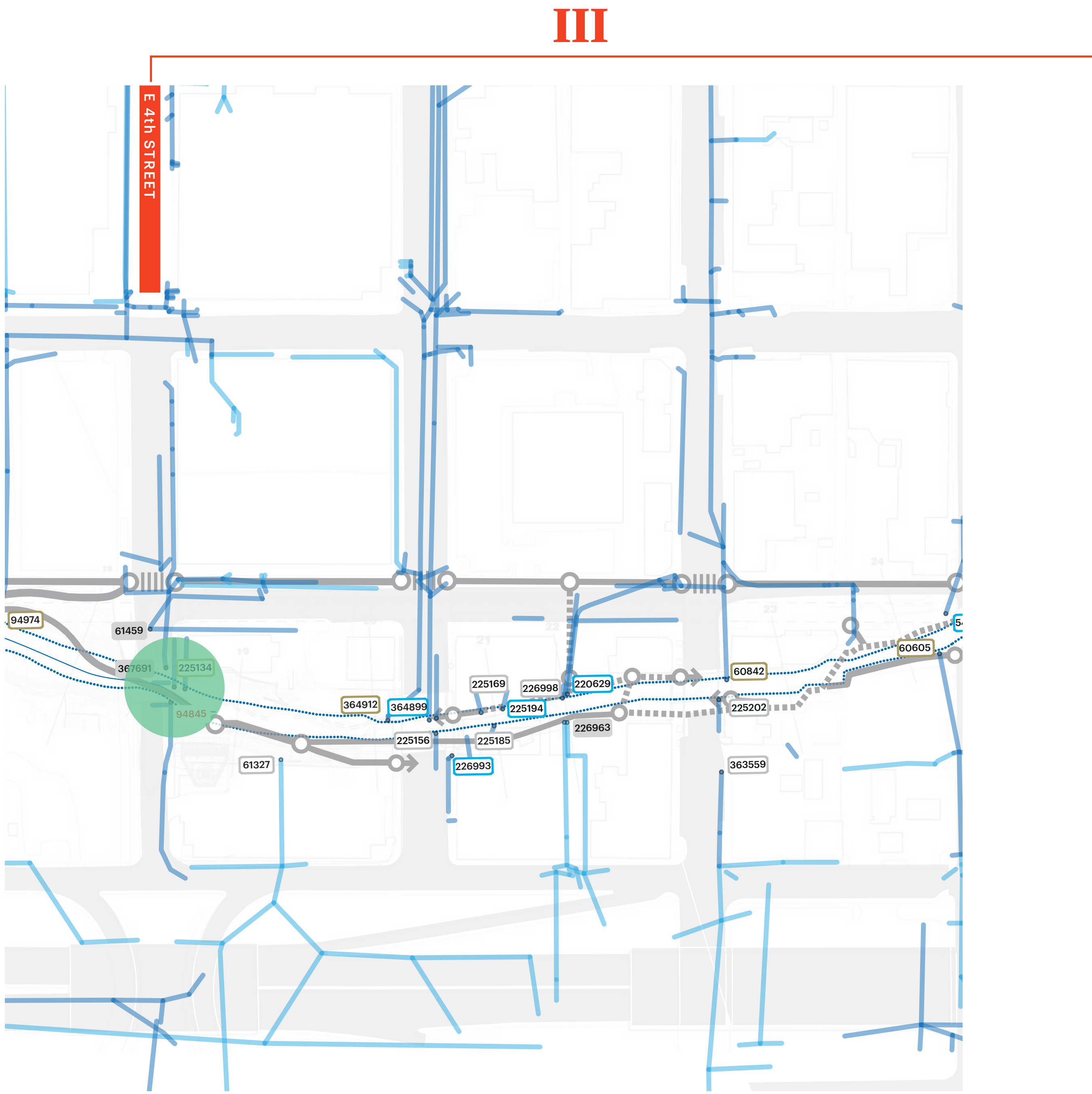
STORMWATER RETROFIT

Stormwater Retrofit: Landscape Treatment Assessment
STORMWATER-LAND_300sc.pdf



LEVEL OF CONTRIBUTION

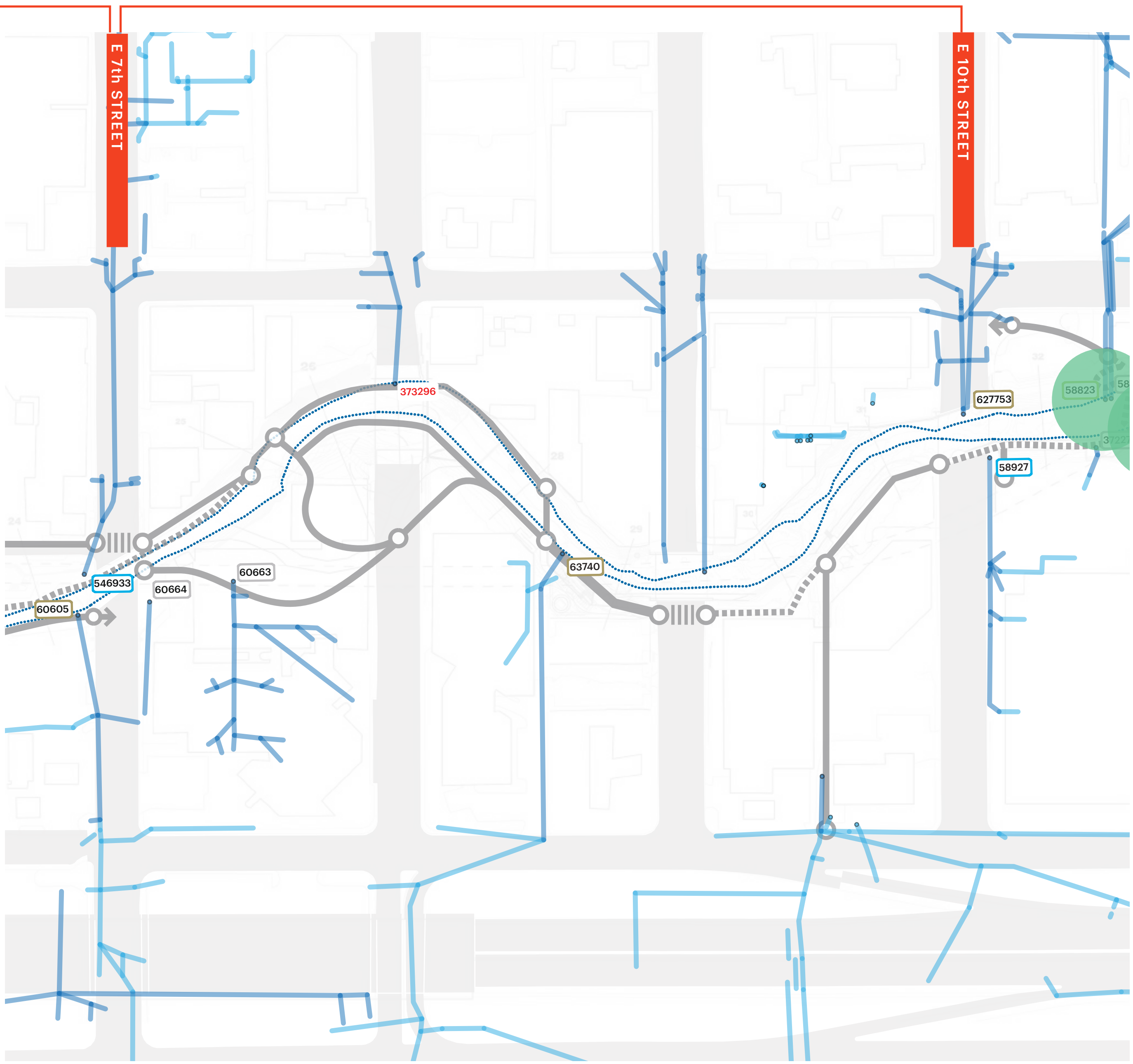
High (N/A) | Medium | Low

KEY

12345	Landscape Treatment - “A”
12345	Inline Treatment - “B”
12345	Sewershed/Do Nothing - “C/D”
12345	Do Nothing “D”
12345	Trail Conflict - Convey - “E”
12345	Unknown

0′ 100′ 200′

IV


E 7th STREET
E 10th STREET
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627753
58823
58927
546933
60605
60664
60663
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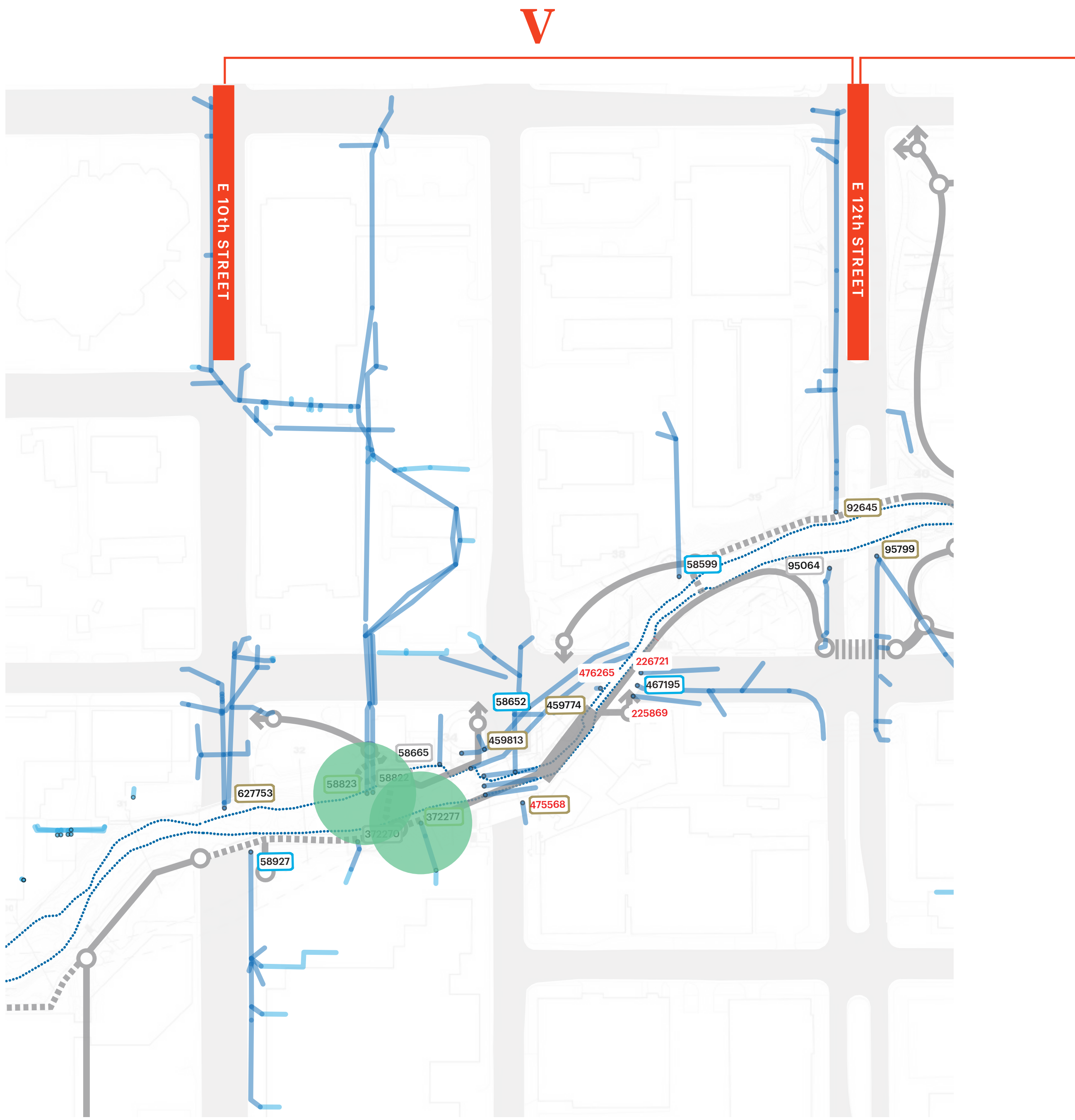
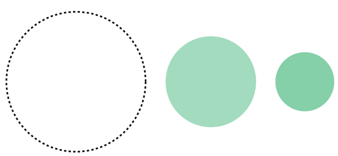
STORMWATER RETROFIT

Stormwater Retrofit: Landscape Treatment Assessment
STORMWATER-LAND_300sc.pdf



LEVEL OF CONTRIBUTION



High (N/A) Medium Low

KEY

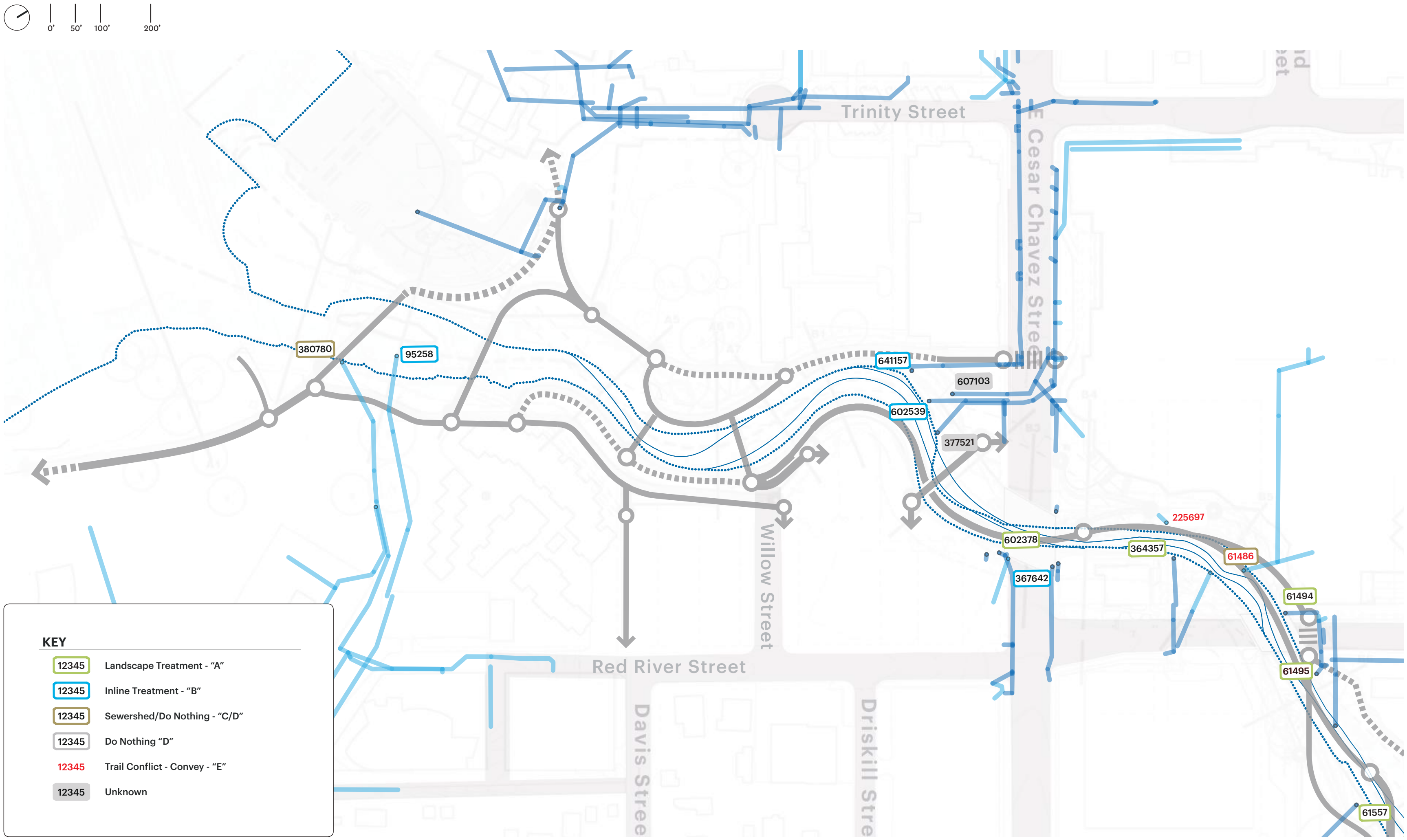
- 12345 Landscape Treatment - "A"
- 12345 Inline Treatment - "B"
- 12345 Sewershed/Do Nothing - "C/D"
- 12345 Do Nothing "D"
- 12345 Trail Conflict - Convey - "E"
- 12345 Unknown

VI

Stormwater Atlas (1-2)
2015.02.06_Stormwater 11X17_with pics.pdf

WALLER CREEK STORMWATER OUTFALLS

Lady Bird Lake to E. 2nd Street



36” CONC. (#60)

Active?: Y
Inv. Elevation:
Year Built: 2008

Retrofit Category: Sewershed
Comments: Maintenance/ Ownership labeled as “Other”

24” CONC. (#62)

Active?: Y
Inv. Elevation:
Year Built: 1955

Retrofit Category: Inline
Comments: Tree roots compromised/affecting outfall

30” RCP (#14)

Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category: Inline
Comments:

30” CONC. (#15)

Active?: Y
Inv. Elevation: 437.96
Year Built:

Retrofit Category: Unknown
Comments: Could not locate in field - believed to be reconstructed with retaining walls in 1987 and re-routed to 602539

24” RCP (#23)

Active?: N
Inv. Elevation: 435.28
Year Built: 1973

Retrofit Category: Inline
Comments:

30” RCP (#16)

Active?: Y
Inv. Elevation: 432.75
Year Built: 1973

Retrofit Category: Unknown
Comments: Located 12/1/2014 in photos. Believed year built to be 1987 (date of block retaining walls and trail)

Lady Bird Lake to E. 2nd Street

STORMWATER RETROFIT

Stormwater Atlas (3-4)
2015.02.06_Stormwater 11X17_with pics.pdf

21" CONC. (#26)
Active?: Y
Inv. Elevation: 443.41
Year Built: 1973
Retrofit Category: Landscape
Comments: Cesar Chavez Bridge

24" CONC. (#24)
Active?: Y
Inv. Elevation:
Year Built:
Retrofit Category: Inline
Comments: Connectivity Assumed based on TV inspection

12" CONC. (#65, PRIVATE
Active?: Y
Inv. Elevation:
Year Built: 1973
Retrofit Category: Trail Conflict
Comments: Maintenance/ Ownership labeled as "Other"

18" RCP (#39)
Active?: Y
Inv. Elevation:
Year Built: 1973
Retrofit Category: Landscape
Comments: Bank restoration/trail removal planned

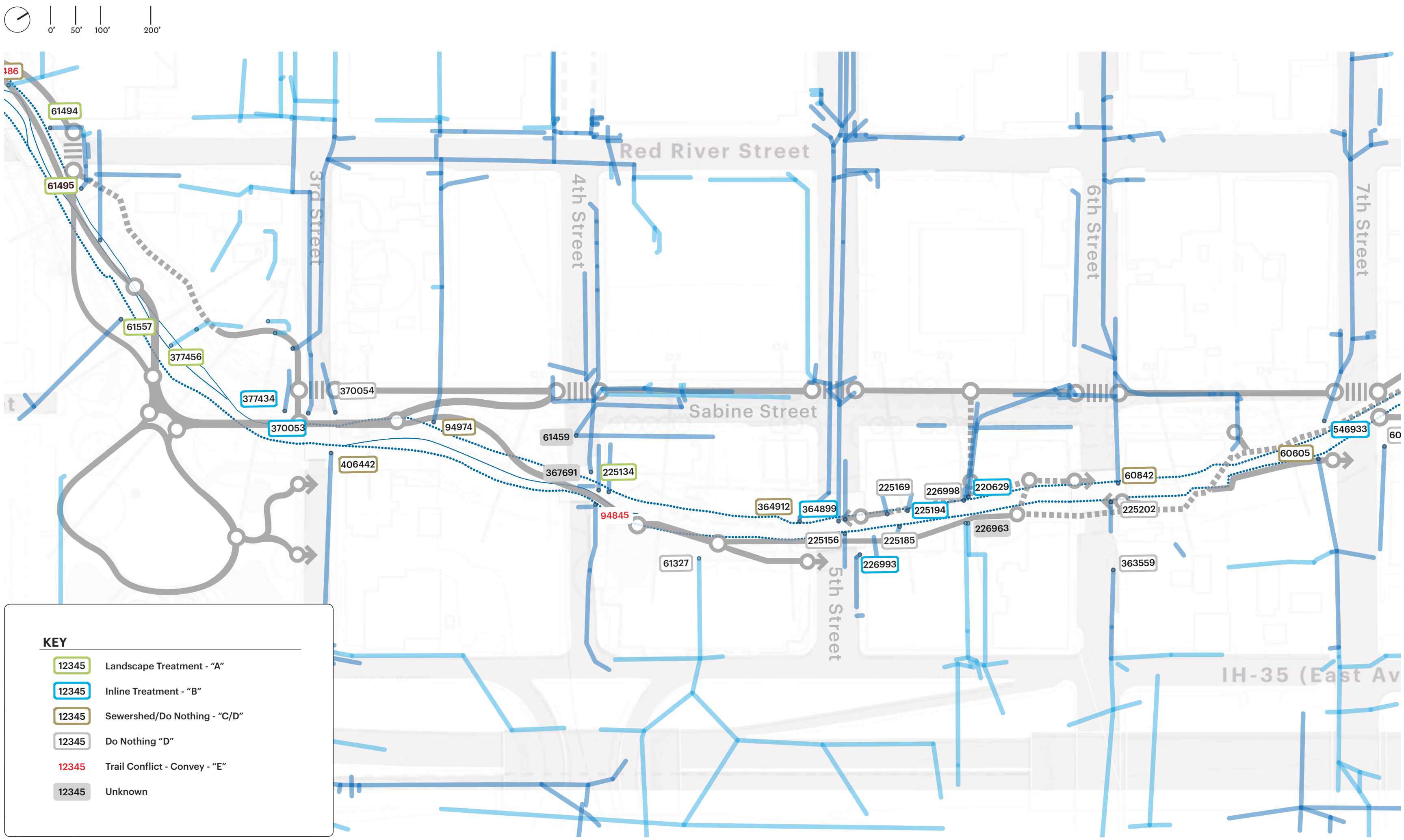
18" CONC. (#74, PRIVATE
Confirmed inactive by COA 12/2014

18" CONC. (#63, PRIVATE)
Active?: Y
Inv. Elevation:
Year Built: 1931
Retrofit Category: Sewershed
Comments: Maintenance/ Ownership labeled as "Other". Dimension Conflict

Lady Bird Lake to E. 2nd Street

WALLER CREEK STORMWATER OUTFALLS

E. 2nd Street to E. 7th Street



STORMWATER RETROFIT

Stormwater Atlas (5-6)
2015.02.06_Stormwater 11X17_with pics.pdf

18" CONC. (#38)
Active?: Y
Inv. Elevation:
Year Built: 1931
Retrofit Category: Landscape
Comments: Red River Bridge Abutment, downstream side.

24" RCP (#34)
Active?: N
Inv. Elevation: 452.5
Year Built:
Retrofit Category: Landscape
Comments: Red River Bridge Abutment, upstream side. Unsure of connectivity.

18" CONCRETE (#44
Confirmed inactive by COA 12/2014

18" RCP (#37)
Active?: Y
Inv. Elevation:
Year Built:
Retrofit Category: Landscape
Comments:

12" NO DATA (#64)
Active?: Y
Inv. Elevation:
Year Built: 1973
Retrofit Category: Landscape
Comments:

24" RCP (#33)
Active?: Y
Inv. Elevation:
Year Built: 1990
Retrofit Category: Inline
Comments:

E. 2nd Street to E. 7th Street

60" RCP (#7)

Active?: Y
Inv. Elevation: 440.25
Year Built: 2002

Retrofit Category: Inline
Comments: West side abutment of 3rd St. bridge. Dimension discrepency

60" RCP (#6)

Active?: Y
Inv. Elevation: 440.93
Year Built: 1931

Retrofit Category: Sewershed
Comments: Conflict in Inv. Elevation Values

NO DATA

Active?: Unknown
Inv. Elevation:
Year Built:

Retrofit Category:
Comments:

66"(#4)

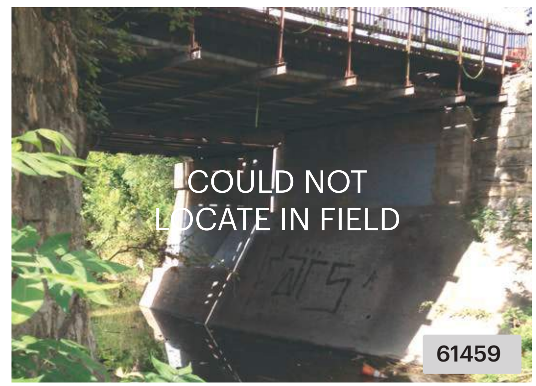
Active?: N
Inv. Elevation:
Year Built:

Retrofit Category: Do Nothing
Comments: Sometimes called out as WW line. Has been removed.

30" RCP (#22)

Active?: Y
Inv. Elevation:
Year Built: 1915

Retrofit Category: Sewershed
Comments: Dimension Discrepancy; below existing undercut trail



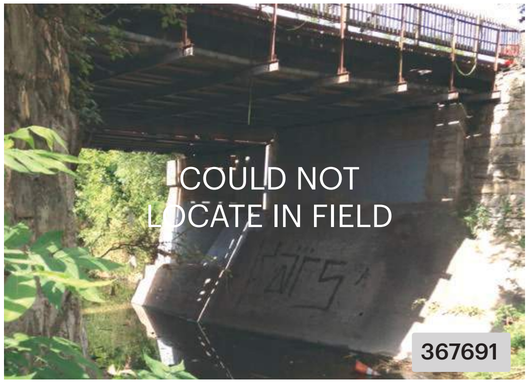
12" (#41)

Active?: Unknown
Inv. Elevation:
Year Built:

Retrofit Category: Unknown
Comments: Shown in bridge abutment - covered by recent concrete work on abutments?

E. 2nd Street to E. 7th Street

Stormwater Atlas (7-8)
2015.02.06_Stormwater 11X17_with pics.pdf



24" RCP (#21)

Active?: Y
Inv. Elevation: 453.7
Year Built: 2003

Retrofit Category: Unknown
Comments: Rebuild not shown in Tunnel drawings; Elev. indicates mid-bank - 4th Street Bridge Deck = 464)

18" CONC (#32)

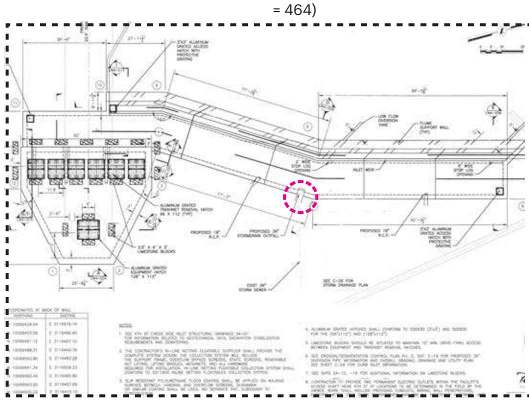
Active?: N
Inv. Elevation: 454.3
Year Built: 1931

Retrofit Category: Trail Conflict
Comments: Trail passes below outfall

24" NO DATA (#20)

Active?: N
Inv. Elevation: 452.5
Year Built:

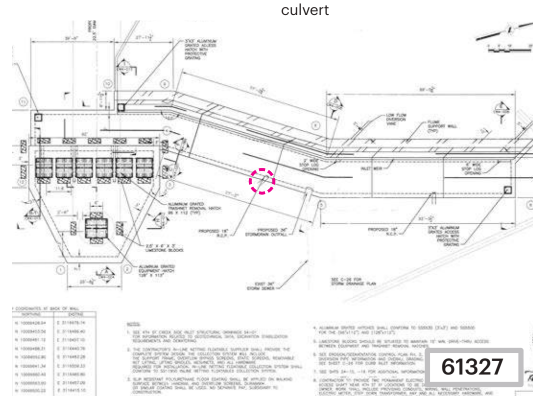
Retrofit Category: Landscape
Comments: Need field confirmation / access to 4th Street Inlet Site; photo is of partially collapsed brick culvert



36" 4TH ST INLET

Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category:
Comments: Need field revision from PWD to confirm



15" NO DATA (#59)

Active?:
Inv. Elevation:
Year Built: Completion 2015 with Side Inlet

Retrofit Category: Do Nothing
Comments: Directed into 4th street side inlet

E. 2nd Street to E. 7th Street

36″ RCP (#10)

Active?: Y
Inv. Elevation: 452.9
Year Built: 1992

Retrofit Category: Sewershed
Comments: Elevation seems incorrect; creek bed here is +/- 443, future avg. water level is 445.

36″ (#9)

Active?: Y
Inv. Elevation: 453.5
Year Built:

Retrofit Category: Inline
Comments: 5th St. bridge deck elevation is at 465.5

12″ (#40)

Active?: Y
Inv. Elevation: 460.5
Year Built: 1960

Retrofit Category: Do Nothing
Comments: Need field confirmation / access to 4th street inlet site

18″ (#31)

Active?: Y
Inv. Elevation: 460.26
Year Built:

Retrofit Category: Inline
Comments:

18″ (#30)

Active?: Y
Inv. Elevation: 455.5
Year Built: 1960

Retrofit Category: Do Nothing
Comments:

17″ (#29)

Active?: Y
Inv. Elevation: 453
Year Built: 1960

Retrofit Category: Do Nothing
Comments:

E. 2nd Street to E. 7th Street

STORMWATER RETROFIT

Stormwater Atlas (9-10)
2015.02.06_Stormwater 11X17_with pics.pdf

30" (#13)

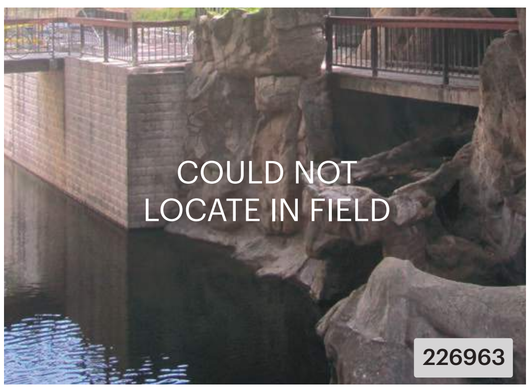
Active?: Y
Inv. Elevation: 455.3
Year Built: 1960
Retrofit Category: Inline
Comments:

18" RCP (#28)

Active?: Y
Inv. Elevation: 459.8
Year Built: 1983
Retrofit Category: Do Nothing
Comments:

30" (#12)

Active?: Y
Inv. Elevation: 461.9
Year Built: 1915
Retrofit Category: Inline
Comments:



30" PRIVATE (#61)

Active?: Y
Inv. Elevation:
Year Built: 1955
Retrofit Category: Unknown
Comments:

36"X48" STONE (#5)

Active?: Y
Inv. Elevation:
Year Built: 1960
Retrofit Category: Unknown
Comments: In 6th St Bridge Abutment (East)

42"X48" STONE (#1)

Active?: Y
Inv. Elevation:
Year Built: 1931
Retrofit Category: Sewershed
Comments: 6th St Bridge Abutment (West)

E. 2nd Street to E. 7th Street

24” (#18)

Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category: Sewershed
Comments:

36” CONC. (#8)

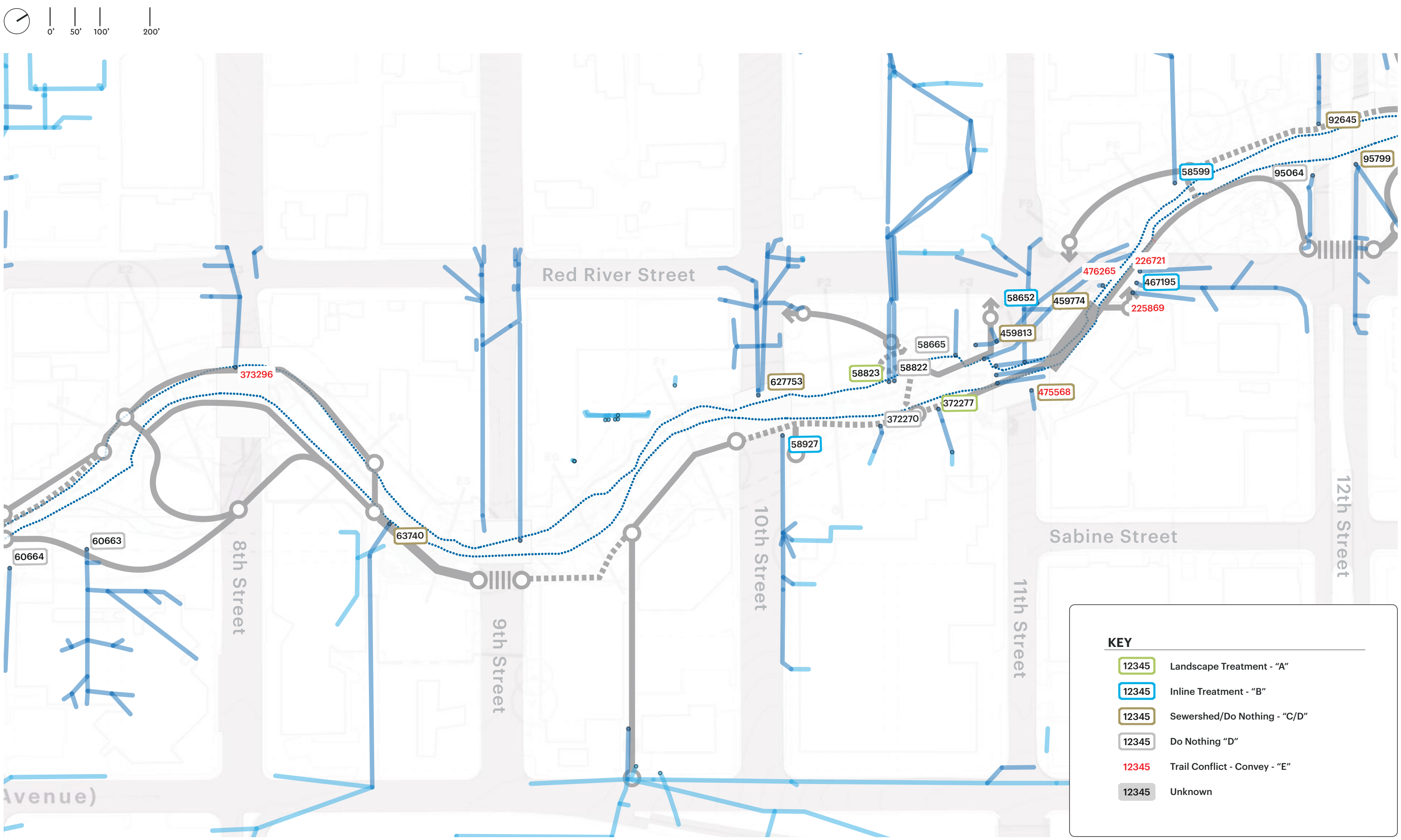
Active?: Y
Inv. Elevation:
Year Built: 1929

Retrofit Category: Inline
Comments: Shown as circular 36” in GIS data

E. 2nd Street to E. 7th Street

WALLER CREEK STORMWATER OUTFALLS

E. 7th Street to E. 12th Street



18" CONC. (#27)

Active?:
Inv. Elevation:
Year Built:

Retrofit Category: Do Nothing
Comments: In 7th St Bridge Abutment (East)

15" CONC. (#36)

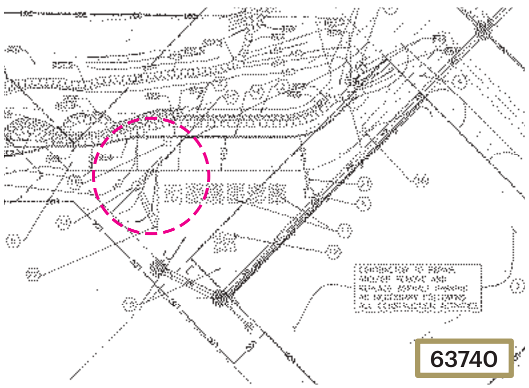
Active?:
Inv. Elevation:
Year Built:

Retrofit Category: Do Nothing
Comments: Drains Austin Police Dept. Site

18" CONC. (#25)

Active?:
Inv. Elevation:
Year Built:

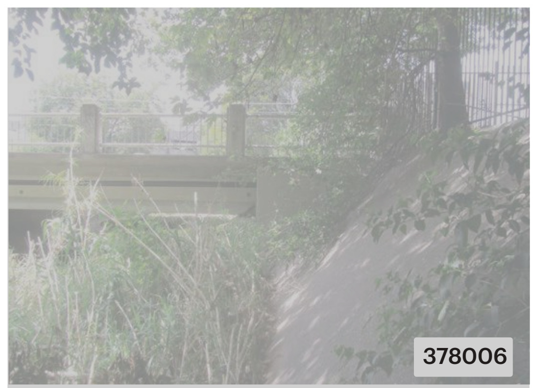
Retrofit Category: Trail Conflict
Comments: In 8th St Bridge abutment (west)



30" (#11)

Active?: Y
Inv. Elevation:
Year Built: 1959

Retrofit Category: Sewershed
Comments: Redirected into 8th street inlet? Drawing indicates bypass?



18" (#26)

Confirmed inactive by COA 12/2014

24" CONC. (#17)

Active?: Y
Inv. Elevation: Approx 465
Year Built:

Retrofit Category: Sewershed
Comments:

STORMWATER RETROFIT

Stormwater Atlas (13-14)
2015.02.06_Stormwater 11X17_with pics.pdf

72"
Active?: Y
Inv. Elevation: 464.7
Year Built: 1959

Retrofit Category:
Comments: Redirected into 8th St. side inlet- completely offline after WCT completion?

21" RCP (#47)
Active?: Y
Inv. Elevation: 465.72
Year Built:

Retrofit Category: Inline
Comments: Dimension Discrepency

12" RCP (#58)
Active?: Y
Inv. Elevation: 462.37
Year Built: 1985

Retrofit Category: Do Nothing
Comments:

24" (#46)
Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category: Landscape
Comments:

18" CONC. (#45)
Active?:Y
Inv. Elevation:
Year Built:

Retrofit Category: Do Nothing
Comments: GIS plans show split at Red River; possibly combined with 58823?

24" CONC. (#55)
Active?: Y
Inv. Elevation: Approx 465
Year Built:

Retrofit Category: Do Nothing
Comments:

E. 7th Street to E. 12th Street

12″ RCP (#57)

Active?: Y
Inv. Elevation: 466.46
Year Built: 1985
Retrofit Category: Landscape
Comments:

160″ RCP (#3)

Active?: Y
Inv. Elevation:
Year Built:
Retrofit Category:
Comments: Recieves runoff from 459183 (#62) & 58652 (#51)

160″ RCP (#2)

Active?: Y
Inv. Elevation:
Year Built:
Retrofit Category:
Comments: Recieves runoff from 459774 (#59)

18″ (#53)

Active?: Y
Inv. Elevation:
Year Built:
Retrofit Category: Sewershed
Comments: Directly above trail under 11th St Bridge

18″ (#60)

Active?: N
Inv. Elevation:
Year Built:
Retrofit Category:
Comments: West bank of 11th Street Bridge abutment (right side of image)

15″ (#56)

Active?: N
Inv. Elevation:
Year Built:
Retrofit Category: Trail Conflict
Comments: Plugged w/ Debris

E. 7th Street to E. 12th Street

STORMWATER RETROFIT

Stormwater Atlas (15-16)
2015.02.06_Stormwater 11X17_with pics.pdf

18" (#51)
Active?: N
Inv. Elevation:
Year Built:
Retrofit Category: Trail Conflict
Comments: Not located in TV inspection- plugged downstream end

27"RCP (#42)
Active?: Y
Inv. Elevation: 471.55
Year Built: 1975
Retrofit Category: Inline
Comments:

18" (#50)
Active?: N
Inv. Elevation: N
Year Built:
Retrofit Category: Trail Conflict
Comments: Not located in TV inspection- plugged downstream end

18" CONC. (#49)
Active?: Y
Inv. Elevation:
Year Built:
Retrofit Category: Inline
Comments:

24" CONC. (#43)
Active?: Y
Inv. Elevation: 469.5
Year Built: 1930
Retrofit Category: Sewershed
Comments:

48" RCP (#35)
Active?: Y
Inv. Elevation: 568.85
Year Built: 1931
Retrofit Category:
Comments: Material Discrepency

E. 7th Street to E. 12th Street

18" (#48)

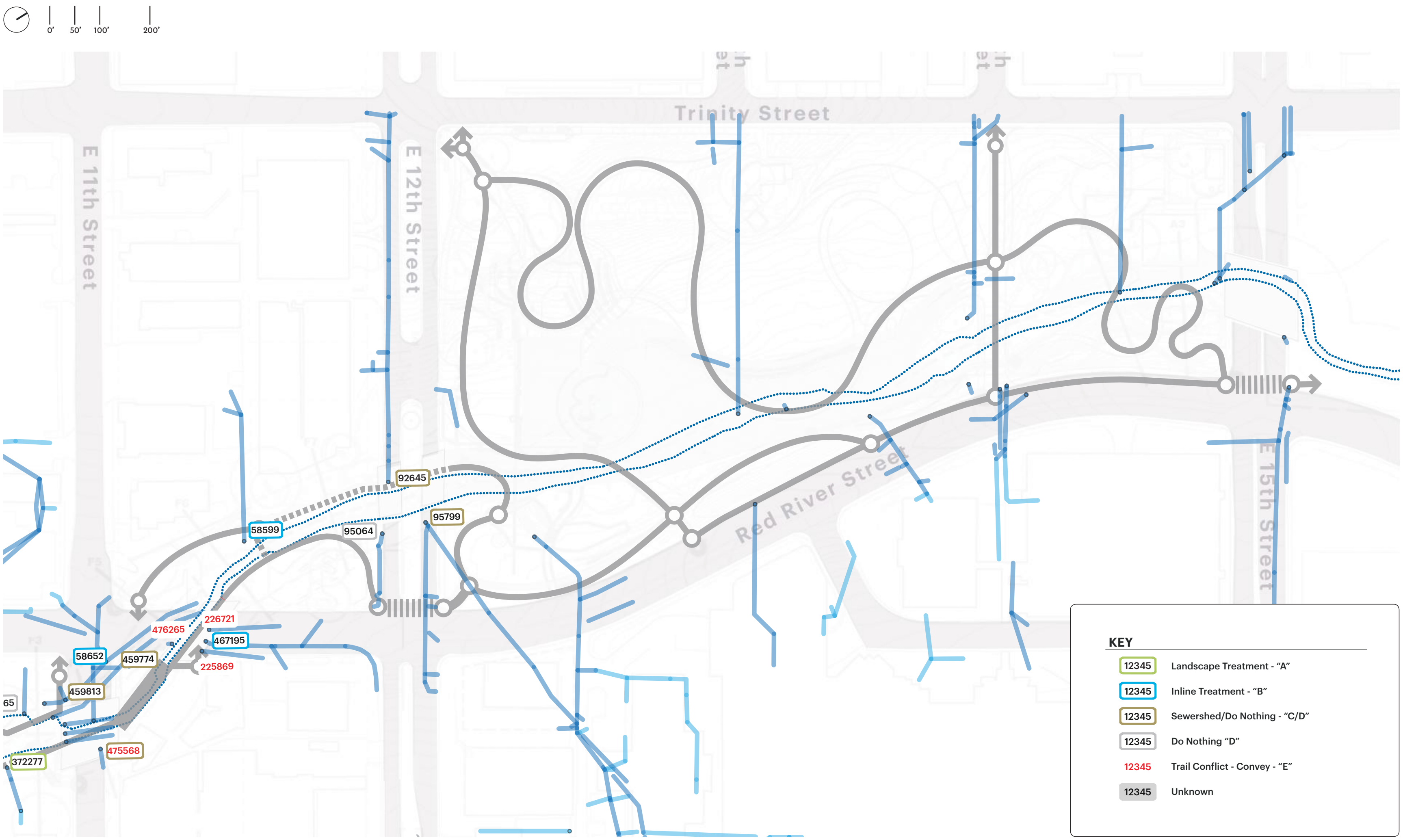
Active?: Y
Inv. Elevation:
Year Built: 1931

Retrofit Category: Do Nothing
Comments: Utility through main prevents inspection of pipe

E. 7th Street to E. 12th Street

WALLER CREEK STORMWATER OUTFALLS

E. 12th Street to E. 15th Street



30”

Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category:
Comments: Waterloo Park - WCT Inlet

18” CONC.

Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category:
Comments: TV inspection shows that a 3’ stub of the original 18” pipe was left connecting to the header. Waterloo Park - WCT Inlet

18” CONC.

Active?: Y
Inv. Elevation:
Year Built:

Retrofit Category:
Comments: Waterloo Park - WCT Inlet

36”

Active?: Y
Inv. Elevation:
Year Built: 1931

Retrofit Category:
Comments: Waterloo Park - WCT Inlet