Hydraulics & Hydrology

HYDRAULICS & HYDROLOGY

Hydraulics & Hydrology Site Map

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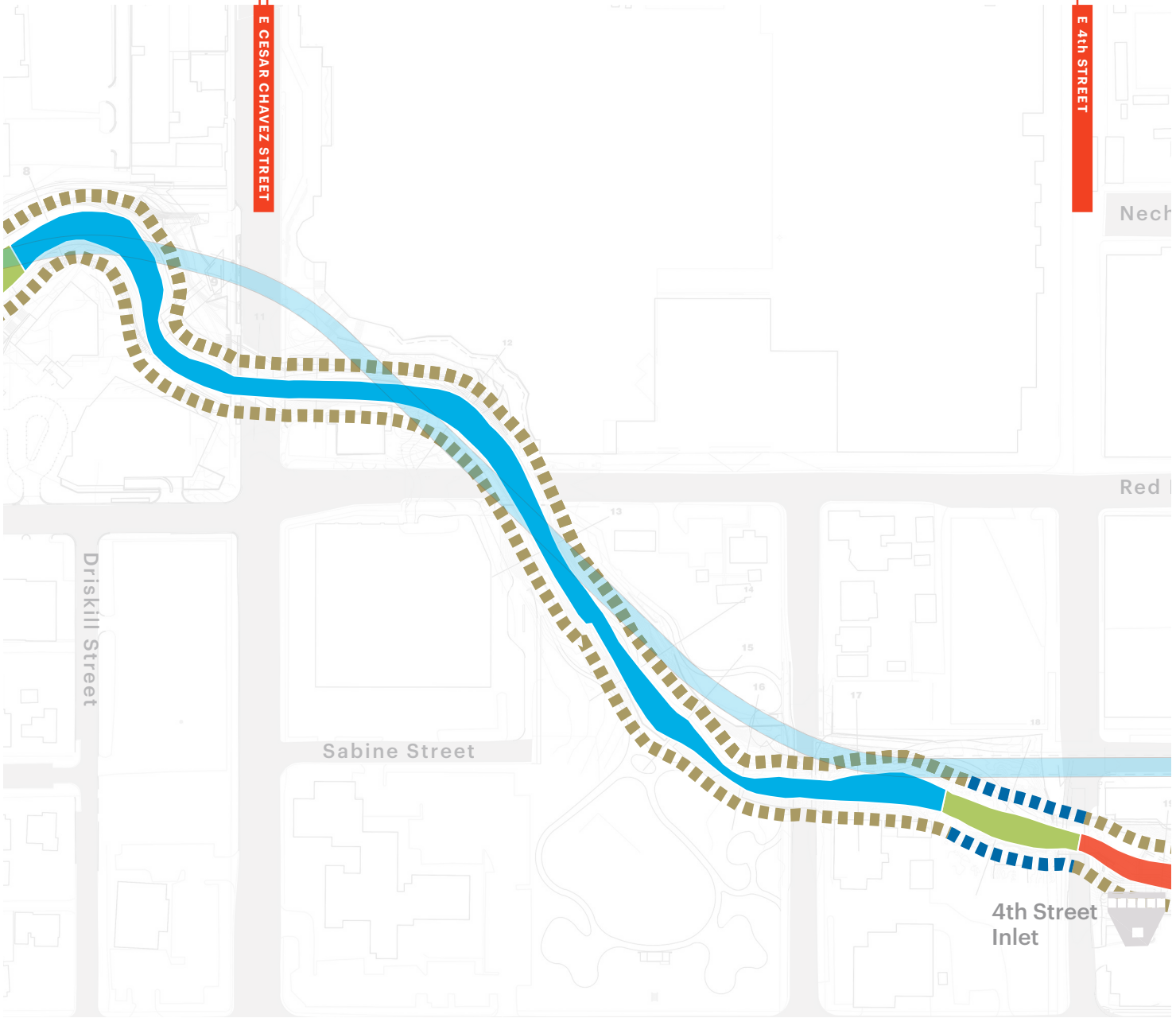
II


E CESAR CHAVEZ STREET
E 4th STREET
Driskill Street
Sabine Street
4th Street
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HYDRAULICS & HYDROLOGY

Hydraulics & Hydrology Site Map (cont.)
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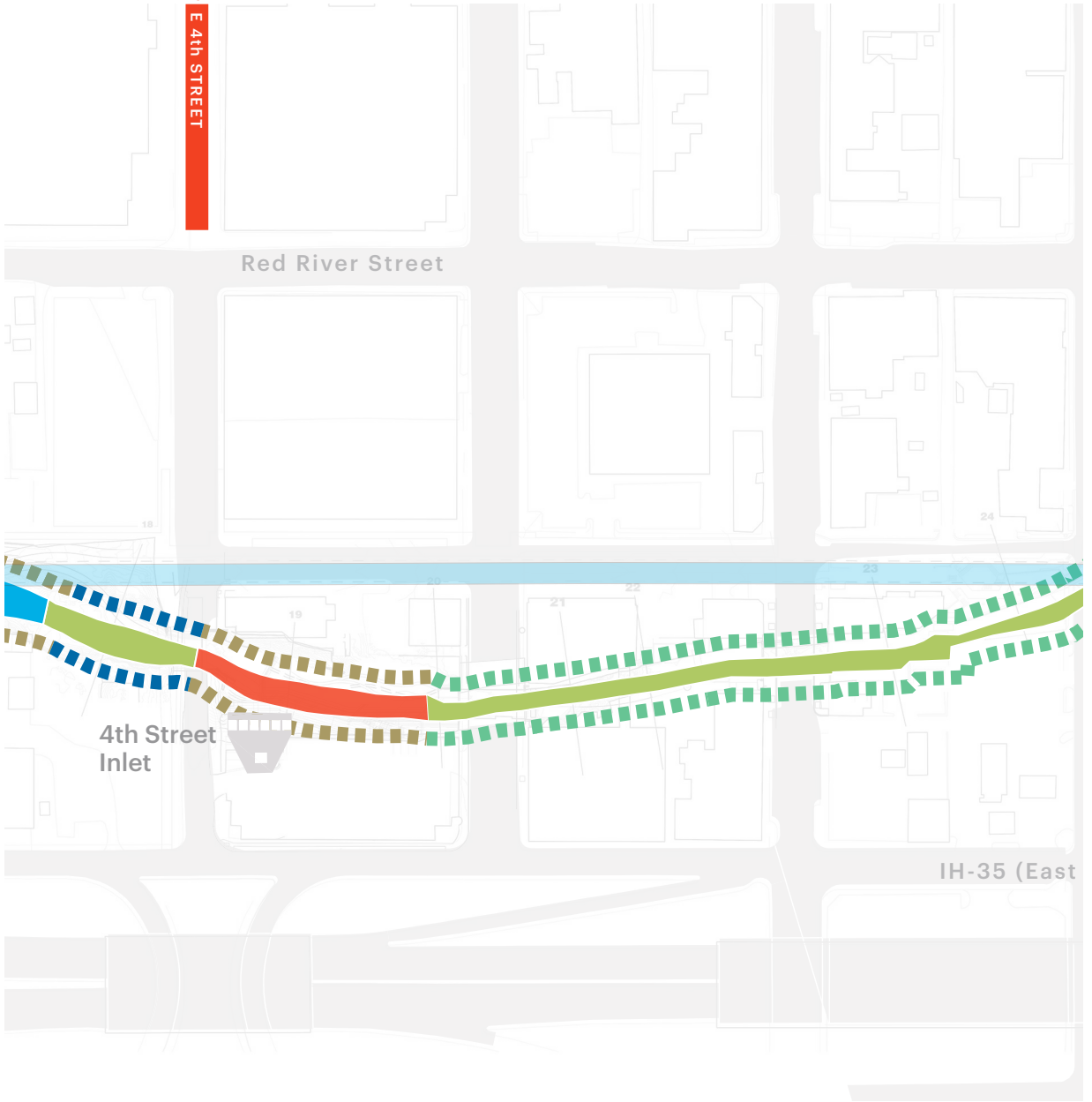


POTENTIAL PROJECT TYPE

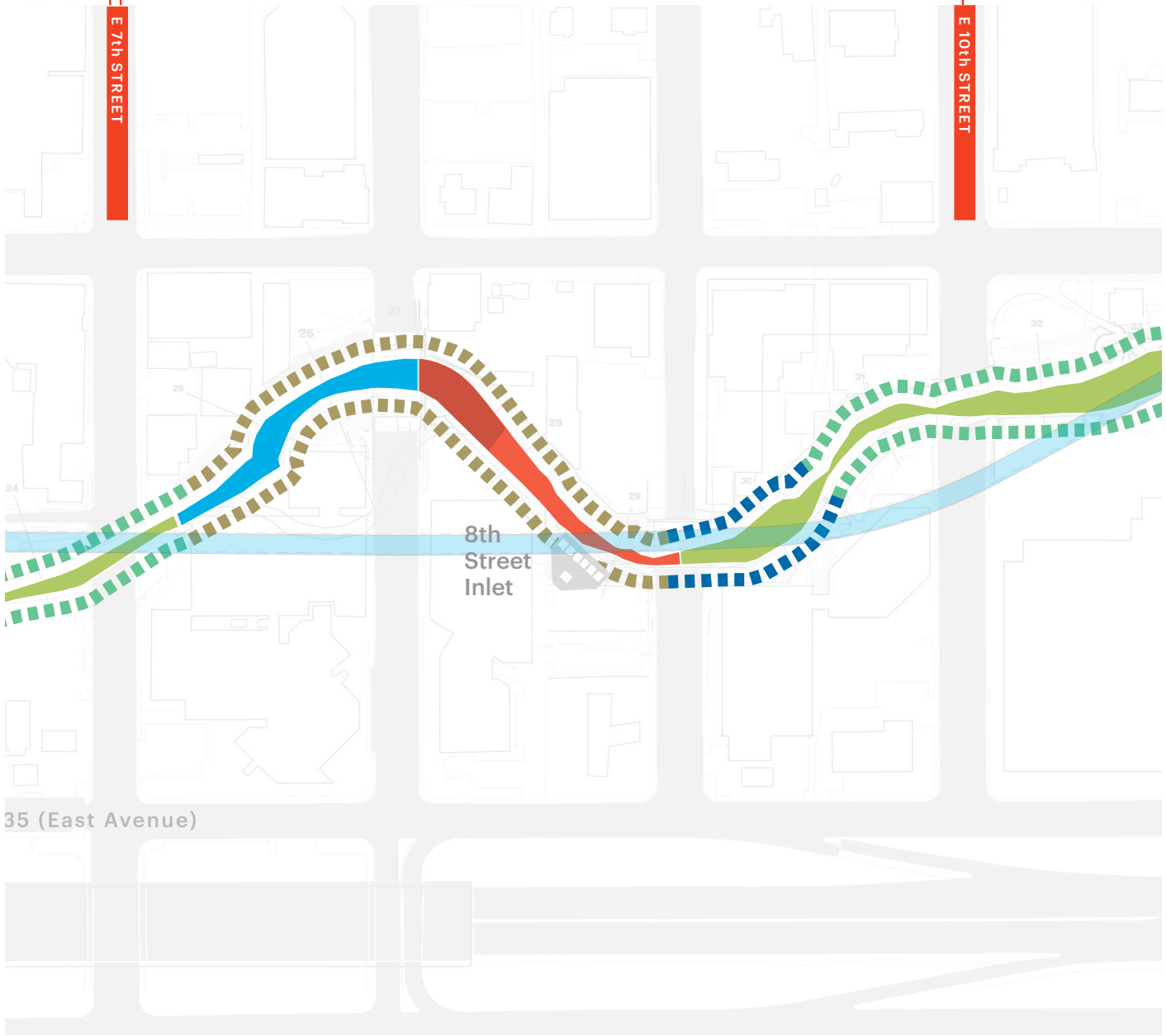
- Tunnel Project
- Habitat Improvements Only
- Restored Channel Form
  (With Pool & Riffle Sequences)

HYDRAULICS & GEOMORPHOLOGY

- Sand, Gravel, Cobble Bed
- Deep Pool
- Rock Bed
- Concrete Bed
- Waller Tunnel

0′ 100′ 200′

IV



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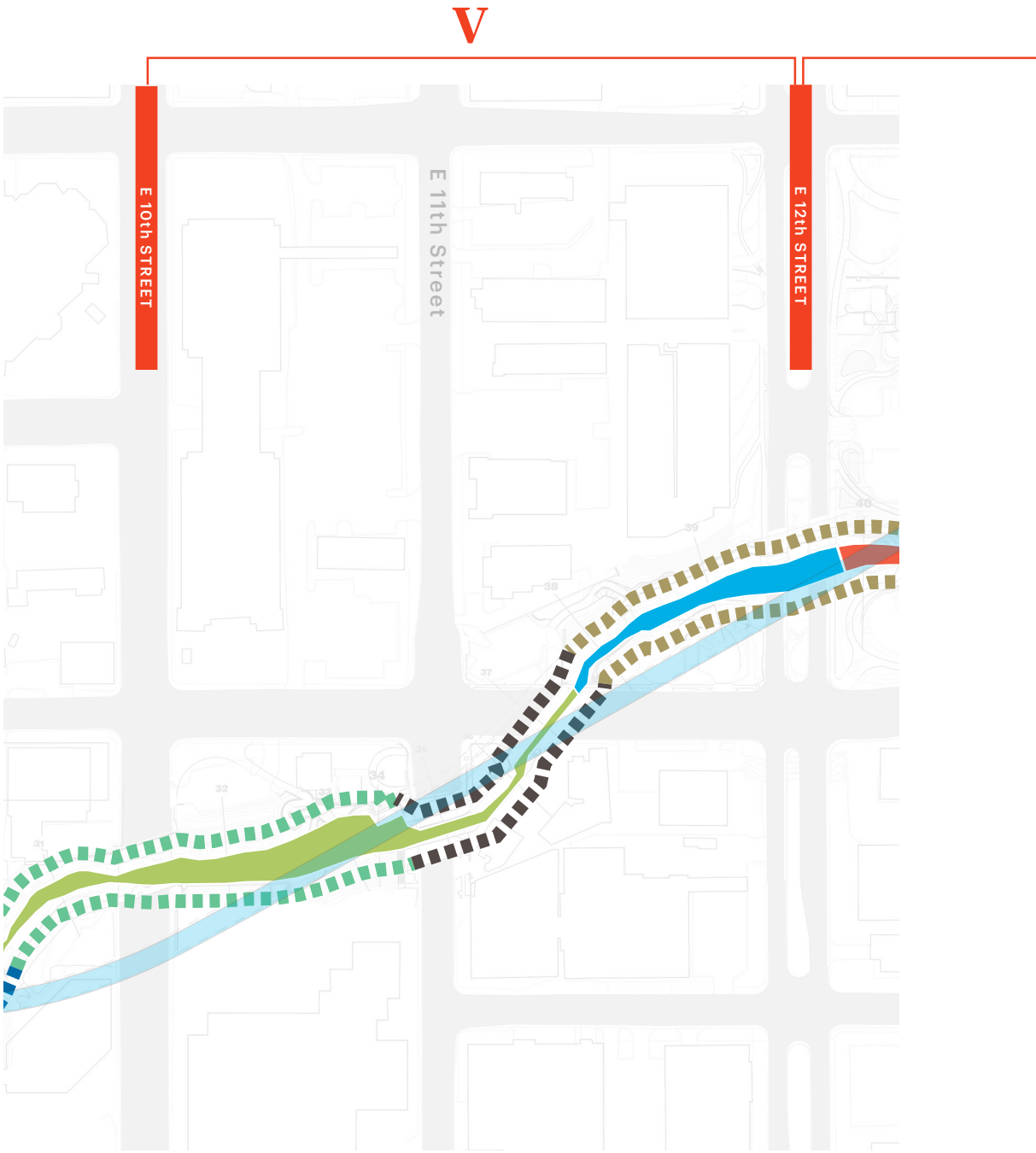

POTENTIAL PROJECT TYPE

- Tunnel Project
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HYDRAULICS & GEOMORPHOLOGY

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- Deep Pool
- Rock Bed
- Concrete Bed
- Waller Tunnel

0′ 100′ 200′

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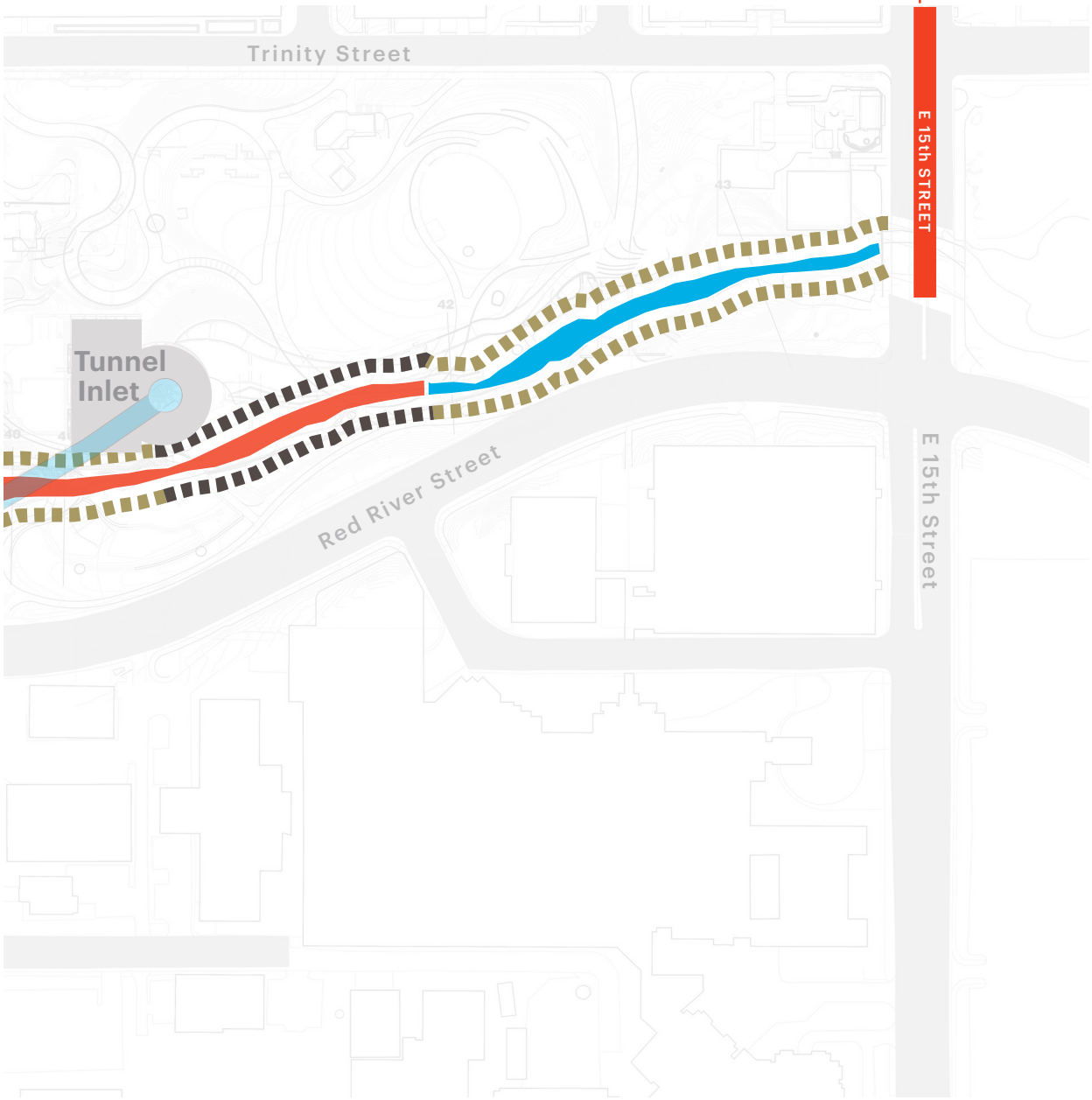
Trinity Street
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Tunnel
Inlet
Red River Street
E 15th Street

HYDRAULICS & HYDROLOGY

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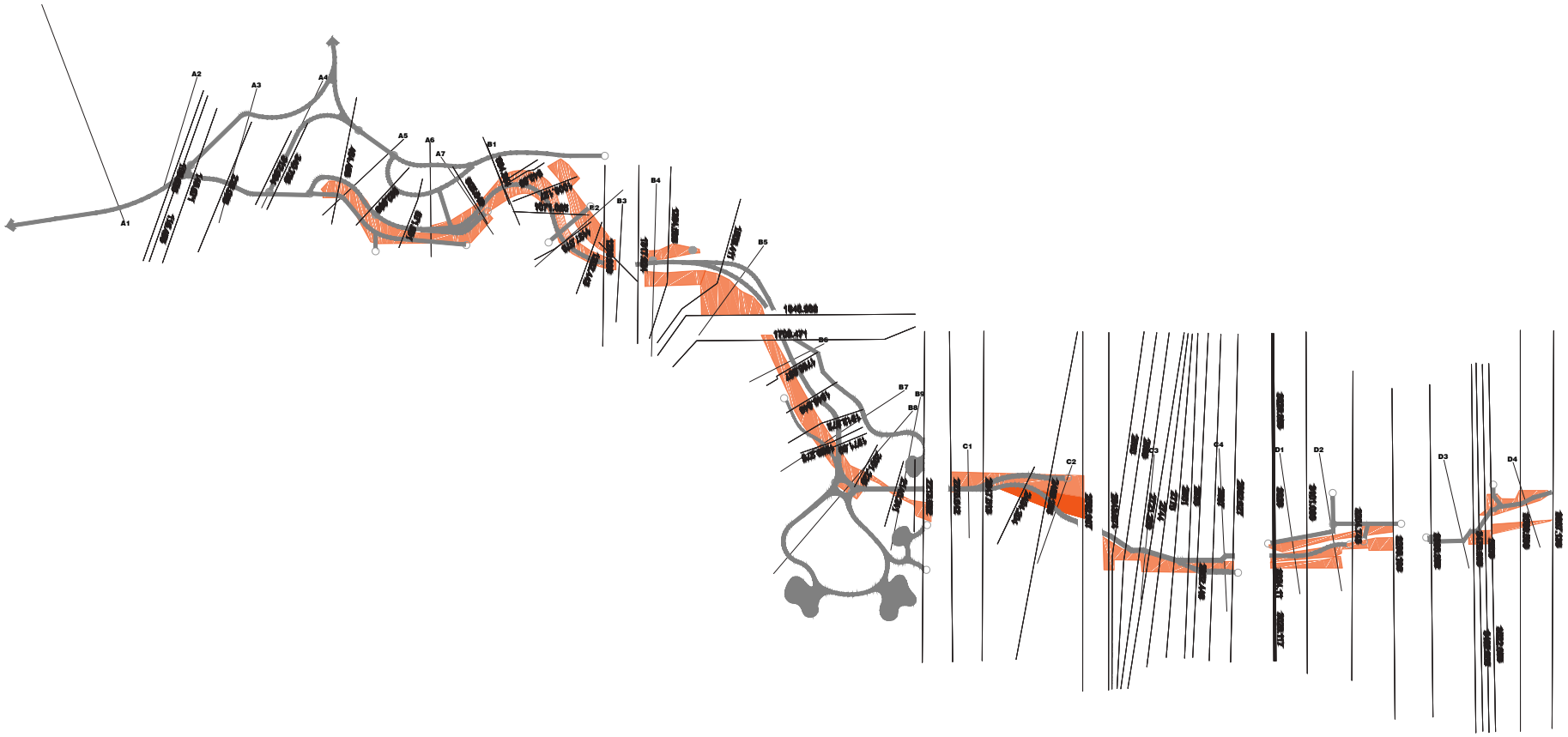

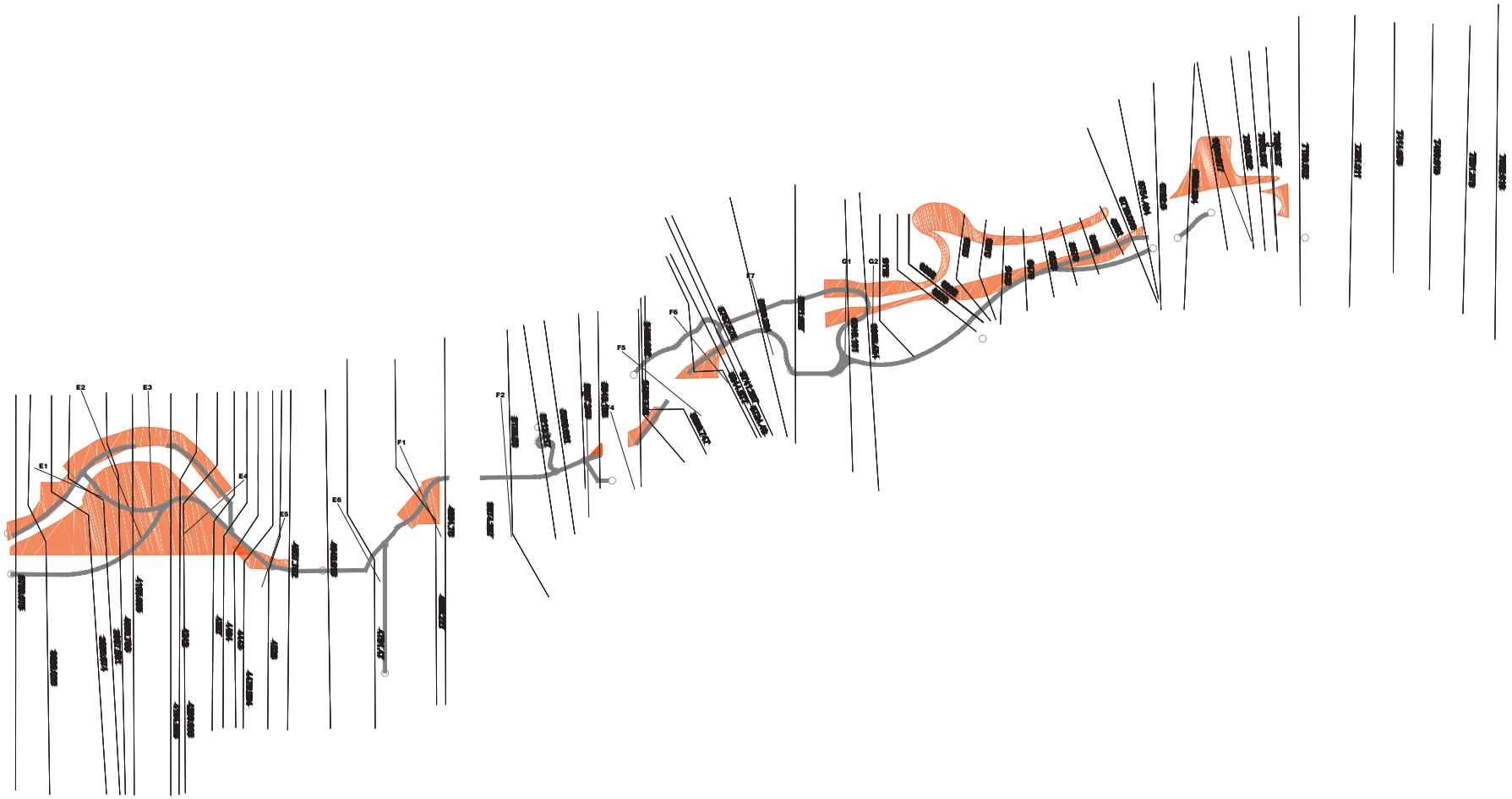
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LimnoTech
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Memorandum

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

Date: December 11, 2014
Project: Waller Creek Framework Plan

To: Danielle Choi, MVVA
Gullivar Shepard, MVVA

CC: Susan Benz, BRG
Waller Creek Conservancy
City of Austin, Watershed Protection Department

SUBJECT: **Summary of Program Verification and Discovery Tasks**

This memorandum provides a summary of tasks completed by LimnoTech for the Program Verification and Discovery phases (Tasks 2 and 3) of the Waller Creek Corridor Framework Plan (CCF) conducted over the period from June 2014 through May 2015.

During the Program Verification phase of the Waller Creek Corridor Framework Plan (CCF), LimnoTech evaluated the hydrology and hydraulics of Waller Creek. Through review of existing studies and technical documents developed by the City of Austin's Watershed Protection Department (WPD), preliminary review of H&H models, and field visits to Waller Creek, LimnoTech and the larger team developed an understanding of existing conditions and verified assumptions made during the competition phase.

The Discovery phase of the CCF involved a detailed evaluation of the existing HEC-RAS and HEC-HMS models that were provided to LimnoTech upon initiation of the project. The objectives of this phase of the project were to identify changes to the system since the models were developed, identify areas needing refinement in the models, and incorporation of proposed development changes to stormwater inputs and/or other model elements that could affect the hydrology and hydraulics in Waller Creek.

A more detailed summary of activities conducted under the two project phases is provided below.

Program Verification

Existing Conditions and Critical Areas for Design Considerations

One of the goals of the Program Verification phase of the project was to identify areas within the design corridor in which distinct conditions exist that will either constrain restoration design or that will create unique opportunities for design enhancement or preservation of elements of the existing system. Areas requiring special consideration may include:

- Stream segments with a need for preservation or protection of existing features, such as the pool and riffle formations in the Creek Mouth area,

- Stream areas where the presence of exposed bedrock, concrete walls, weirs, or other heavy infrastructure presents a constraint on modification,
- Stream areas undergoing physical change, including zones of significant bank erosion, slope failure, or creek migration due to excessive sedimentation or erosion, or
- Stream areas in which hydraulics present a significant constraint, either under current conditions or conditions anticipated after completion of the diversion tunnel and drop shafts.

Under the present condition in Waller Creek, there are several areas from the Creek Mouth to 12th Street that will require additional consideration in the development of restoration strategies. These areas have been identified either by visual observation, or detected in the HEC-RAS model. Figures 1-6 contain plan view sketches that summarize critical hydrologic, hydraulic, or stream bank areas that may need special consideration in the design phases of this project. In general, a number of design constraints were identified. The most prevalent design constraints are related to existing or potential scour sites, protecting existing or proposed infrastructure, risk of trail inundation, and bedrock outcrops.

The exposed retaining wall toe in Figure 1 is a key design consideration in the Creek Mouth area. The exposed toe has been identified as a desirable habitat feature (e.g., fish refugia) so preservation of this feature will need to consider restoration strategies that prevent sediment infilling of the toe openings without further destabilization of the wall footing. Additionally, the riffle/pool formations in this area may serve as template for restoration strategies further upstream.

In Figure 2, a pipe is exposed downstream of 4th Street due to a near vertical bank scour, which presents a unique design challenge. There are two conflicting design alternatives: 1) build the bank back out to cover the existing pipe as is, which may increase flood risk or 2) lay the bank back which will require pipe reconstruction and property acquisition.

The weirs near 5th and 7th streets (Figures 3 - 4) are likely acting as barriers to fish passage. The design challenge in this case is to modify or remove the weirs to improve fish passage without causing new erosion issues. In multiple locations along the creek channel, the presence of bedrock substrate and concrete walls are common (Figures 3 - 5). In these areas, the design challenge is to improve habitat without modifying the banks.

The diversion tunnel under the 11th Street and Red River Street intersection (Figure 6) is also a critical design area with respect to the trail connection and flood reduction goals. The current schematic design calls for all creek flows to be routed through this diversion tunnel in order to make more space for trail design. It will need to be confirmed that the diversion tunnel has adequate conveyance to safely pass all flood flows under the new flow regime.

Discovery

Hydrologic and Hydraulic Models Overview

The existing HEC-RAS and HEC-HMS models developed for the Waller Creek Tunnel project were created to address a different set of objectives than the model needed for the CCF. One significant difference is that the Waller Creek Tunnel model was developed with a focus on flooding due to larger storm events, whereas the model simulations developed for the CCF consider a much broader range of events: baseflow conditions, a moderate high flow event (i.e., 2-year recurrence), as well as the 100-year event condition. The HEC-RAS model designed for the Waller Creek Tunnel project also focused on the impacts of the tunnel inlets on creek flows in the immediate vicinity of the inlets, requiring greater resolution in areas near the inlets than in reaches between the inlets. A hydraulic model intended to represent baseflow conditions requires greater detail and more highly resolved stream cross-sections than a model intended to simulate high flows during large storm events. Therefore, this memo highlights features of the Waller Creek Tunnel model that provide a basis for further development of the CCF model, to better represent the behavior of the Creek under the full range of flow conditions.

The HEC-HMS model developed for the Waller Creek Tunnel project includes both existing land-use (FEMA standard) and fully-developed land-use conditions and both pre- and post-tunnel conditions as defined in the "Waller Creek Tunnel Project: Proposed Conditions Hydrologic and Hydraulic Report" (November 2010). The fully-developed condition HEC-HMS model increases the impervious cover by 40 to 95% over the existing-conditions model. HEC-RAS models were developed for the Waller Creek Tunnel project based on the results of the HEC-HMS models for both the existing and fully-developed conditions. In the Waller Creek Corridor Framework project, LimnoTech will refine and apply the HEC-HMS and HEC-RAS models to understand hydrology and hydraulics under post-tunnel, fully-developed conditions.

The modeling process includes the same three steps for both the Waller Creek Tunnel project and for the Waller Creek Corridor Framework project.

1) Two local (5 city blocks) HEC-RAS models were developed for the reaches immediately around the 4th St and 8th St inlets. In these models, the inlets are fully functioning. The local HEC-RAS models were used to develop stream discharge vs tunnel discharge rating curves for the 4th St and 8th St inlets.

2) A HEC-HMS model was developed for the entire Waller Creek watershed. The rating curves developed in the local HEC-RAS models were used to model the discharge into the 4th St and 8th St inlet features in the HEC-HMS model. The discharge through the morning glory spillway in Waterloo Park was modeled directly in HEC-HMS using existing HEC-HMS pond hydraulics capabilities. The HEC-HMS model was then used to predict discharges throughout Waller Creek.

3) A third HEC-RAS model (from here forward called the Tunnel Model) was developed for Waller Creek from 16th Street to the Creek discharge at Lady Bird Lake. The peak discharge results from the HEC-HMS model were used to establish discharges in the HEC-RAS model. In the Tunnel Model the physical geometry of the 4th St and 8th St inlet structures was modeled but the inlet function as a source of flow to the system were not. Modeling the 4th St and 8th St inlet functions was not necessary, because the influence of the inlets on the discharge was already accounted for in the HEC-HMS model.

The local HEC-RAS models (step 1) and the HEC-HMS model (step 2) are appropriate for the Plan's near-baseflow modeling objectives of the CCF; however, there are a number of features in the Tunnel Model, described in greater detail below, which will need to be reviewed/refined in order to develop it into a model that will sufficiently meet the objectives of the Waller Creek Framework Plan. The third HEC-RAS model (step 3) developed for the CCF will be called the Framework Model, and will be used to inform the planning process moving forward. In general, low flows (which are the focus of the CCF) are more sensitive to small changes in topography than high flows; consequently, low flow models tend to require greater resolution than models that focus on high flows. The cross-sections reflect the model resolution in two ways: 1) a single cross-section's ability to represent the actual channel is a reflection of the lateral resolution and 2) the cross-section spacing is a reflection of the longitudinal resolution.

At low flows, the lateral resolution will significantly influence the water surface elevation because small scale channel geometry features have a greater impact on the distribution of water in a cross-section at low flows than at high flows.

Longitudinal spacing of the cross-sections influence the water surface profile estimates. Smaller cross-section spacing is required at low flows to ensure that discharge controlling in-stream features are not missed. This information is necessary for the determination of critical shear stress near small scale features in the creek. For example, the presence of a pool may not control flow and water surface elevation at high flows, but that same pool may control discharge and water surface elevation during smaller events.

While the Tunnel Model's longitudinal cross-section spacing is sufficiently resolved to model flood events, the low-flow events (1-30 cfs) require additional longitudinal resolution. Figure 7 illustrates how a pool resolved longitudinally in the Tunnel Model cross-sections (spaced approximately 65 feet) impacts the water surface elevation profiles during low flow events. If these more tightly spaced cross-sections were omitted, as they are in other areas of the Tunnel Model, the impact of the pool feature on the low flow water surface would be unknown.

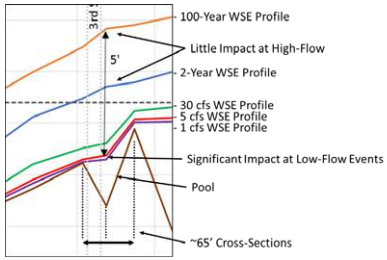

Figure 7. Illustration of the impacts of cross-section resolution near 3rd Street.

Basis for Model Refinement

Cross-Section Data

The existing model has relatively high cross-section resolution (both longitudinal and lateral) near the tunnel inlets and near the confluence, but is less resolved in other areas. In the less resolved areas, the model may be misrepresenting existing hydraulic features that influence flow and water surface elevations; consequently, the cross-sections will need additional refinement. Two potential issues have been identified with model resolution in the Program Verification phase. First, several cross-sections are based on water surface elevations that are sourced through LiDAR data collected in 2003. LiDAR tends to be unreliable in areas below the water surface and, in those areas it is inadequate for the increased lateral resolution requirements of the Framework model. Secondly, there are large spatial gaps between some existing cross-sections (100—300 ft), which creates uncertainty in the hydraulic conditions due to the lower longitudinal resolution. The spatial resolution and source of elevation data for each cross-section is also shown in Figures 1-6. The HEC-RAS cross-sections that are based on LiDAR data appear primarily downstream of 3rd Street. The resolution of the model is higher upstream of 3rd Street. In addition, the cross-sections based on LiDAR data in the upstream reaches are supplemented by cross-sections based on survey data resulting in model cross-sections that more accurately describe the existing condition. In the Creek Mouth area, we field identified key pool-riffle sequences that are not represented in the existing model. Given that many of the cross-sections downstream of 3rd Street are based on LiDAR data, and are accompanied by large spatial gaps, a more refined model in this downstream reach is necessary to accurately predict pre- and post-tunnel hydraulic conditions in Waller Creek. Detailed information regarding the need and locations for additional surveys that will be used to refine the HEC-RAS model can be found in the Survey Request Memo attached in Appendix A.

Hydraulic Structures

Several hydraulic structures were previously identified as underrepresented in the Tunnel Model. These structures are described below along with identified refinements necessary for the Framework Model.

Cesar Chavez Street Weir

The existing walkway crossing the stream under Cesar Chavez Street acts as broad-crested weir and is not represented in the Tunnel Model (Figure 8). The absence of the weir in the Tunnel Model causes significant under prediction of water depths during low-flow events as the weir creates backwater effects upstream of Cesar Chavez Street. The weir structure will be added to the Framework Model upon receipt of additional survey data.

Program Verification and Discovery *December 11, 2014*

Figure 8. Weir created by trail under Cesar Chavez St.

Palm Park Stormwater Outfall

There is a surface stormwater outfall on the east bank of Waller Creek near Palm Park (Figure 9) that is not represented in the Tunnel Model cross-sections. The restriction caused by the structure may result in water surface elevations greater than those predicted by the HEC-RAS models. The topographical survey information requested (Appendix A) includes two cross-section locations that capture the transition areas of the stormwater outfall. This structure will be added to the Framework Model when new survey data has been collected.

Figure 9. Stormwater outfall creates a restriction on the east bank of Waller Creek near Palm Park.

Palm Park Grade Control Structure

There is a scour protection gabion along the toe of the east bank Palm Park retaining wall that is acting as a grade control structure (Figure 10) and is not captured in the existing model. This gabion prevents further incision of the channel in this location and creates a one-foot step at its downstream edge. The retaining wall and gabion are slated for removal under the current version of the Framework Plan. This location is a critical area in the Framework Model to ensure that the creek does not further degrade after the gabion is removed from the bed.

Figure 10. Grade control gabion near Palm Park.

7th Street Weir

There is a low weir at the downstream end of the 7th Street Bridge (Figure 11) that is not represented in the Tunnel Model. The weir creates a pool under 7th Street during low flows and its absence in the model results in the under prediction of water depth upstream of 7th Street during low flows. This weir will need to be surveyed and incorporated into future modeling efforts prior to design of the 8th Street redevelopment area; however, it is considered an acceptable omission for the scope of the Framework Model.

Figure 11. 7th Street Weir

Model Hydraulics

There are two additional features of the Tunnel Model that will require modification to improve the ability of the Framework Model to support the CCF.

HEC-HMS output

The peak discharge results from the HEC-HMS model are slightly different from the steady flow input data represented in the Tunnel Model. No explanation has been found for the difference; however, the differences were small enough to not significantly impact the Tunnel Model results. The Framework Model steady flow input data has been updated to use the HEC-HMS peak discharge results rounded to the nearest 1 cfs.

11th St Diversion Tunnel

There is a diversion tunnel under the 11th Street/Red River Street intersection that allows a portion of the high flow discharge to bypass the main channel of Waller Creek from upstream of Red River Street to downstream of 11th Street. This diversion tunnel is included as a separate reach in the Tunnel Model as River – WLR1-DIV, Reach: Reach-01. The diversion tunnel runs parallel to the main channel between 11th Street and Red River Street – River: WLR, Reach: Reach-02.

The diversion tunnel and the main channel share upstream and downstream cross-sections. The flows from each reach are separated in the Tunnel Model through the use of ineffective flow areas placed in the upstream and downstream cross-sections. The locations of the ineffective flow areas cause an over prediction of the water depth in the main channel reach just downstream of the 11th St Bridge at low flows. For the 5 cfs discharge, the two reaches differ in water surface elevation by 1 foot.

Currently, the CCF anticipates the removal of the main channel in this location and redirection of all of the flow through the diversion tunnel. Consequently, this discrepancy will only impact the existing conditions model. Refining the ineffective flow areas to remove this discrepancy could be an unnecessarily expensive effort; hence, the discrepancy will be accepted for the existing conditions Framework Model with acknowledgement that it will be addressed in the proposed conditions Framework Model.

Stormwater Inputs and Outfall Ranking

Stormwater inputs to the HEC-RAS model are generated using the HEC-HMS model and are introduced into the HEC-RAS model at a limited number of locations that effectively lump multiple stormwater sources into aggregated inputs. Despite this aggregation of sources, a review of the HEC-HMS output found that the stormwater inputs into the HEC-RAS model are sufficiently resolved to predict water surface elevations for the CCF.

A relatively coarse disaggregation of the stormwater outfalls was conducted for the purpose of ranking the storm sewer outfalls based on their volumetric stormwater outputs. For this analysis only public outfalls were included in the ranking.

For each sub-watershed, the runoff volume from a 1-inch, 24-hour storm was modeled using the HEC-HMS model developed for the post-tunnel, fully-developed condition. A percentage of the total runoff volume for a given sub-watershed allocated to each outfall was based on the cross-sectional area of that outfall. The outfalls were then ranked based on their associated runoff volumes. For instances where two outfalls had the same associated runoff volumes, each outfall was further ranked by the ratio of its runoff volume to the total runoff volume of the creek upstream of that point.

Figure 12 shows a map of the outfall locations and their rankings by approximate 1-inch, 24-hour storm volume. Appendix B includes a table of the outfall drainage IDs, dimensions, and ranking. This information will be used for futures tasks of identifying and prioritizing potential retrofit scenarios. These retrofit scenarios could be applied in the stream corridor, within the storm sewer network, or as upland systems.

Proposed Land Developments

There have been no new developments constructed in the area since the creation of the Tunnel Model. There are, however, several proposed developments in the vicinity of Waller Creek, which include Waller Park Place, the Freemont, and Sabine Street. Of these sites, the Waller Park Place construction is the only one that will have significant impacts on the creek hydraulics. These impacts are not known at this point; however, an assessment of the effects will be included in the modeling efforts for the pending site development project. The stormwater discharges from the proposed sites had not been made available at the time this memo was developed.

Available Models

There have been a number of models discussed throughout this document. Appendix C provides a list of all of the currently available HEC-RAS and HEC-HMS models associated with the Waller Creek Framework Plan.

Summary

The Program Verification and Discovery phases of the CCF were largely completed in November, 2014. The one outstanding element still pending for the Discovery phase involves increasing the resolution of the HEC-RAS model through incorporation of additional cross-sections and/or modification and refinement of existing cross-sections. Execution of this effort requires additional topographical surveys in critical areas, which were requested in a technical memorandum on September 15, 2014 (Appendix A). Once LimnoTech receives the topographical survey data, we will update and refine the HEC-RAS model to better understand the knowledge gaps with respect to the hydraulic influences in critical sub-reaches as described in the Survey Request Memo. This new information, along with the verification of baseline conditions in Waller Creek, will be used to iteratively update the hydrology and hydraulic models to evaluate design concepts and provide recommendations to avoid associated risk factors. The information gained through this next steps will be presented in the final Waller Creek Corridor Framework Plan.

References

Reis, B., French, D., Moody, K., and Hughes, G. (November 2010) “Waller Creek Tunnel Project: Proposed Conditions Hydrologic and Hydraulic Report” Prepared by: Kellogg Brown & Root Services, Inc. and Espey Consultants, Inc. Prepared for: City of Austin, TX

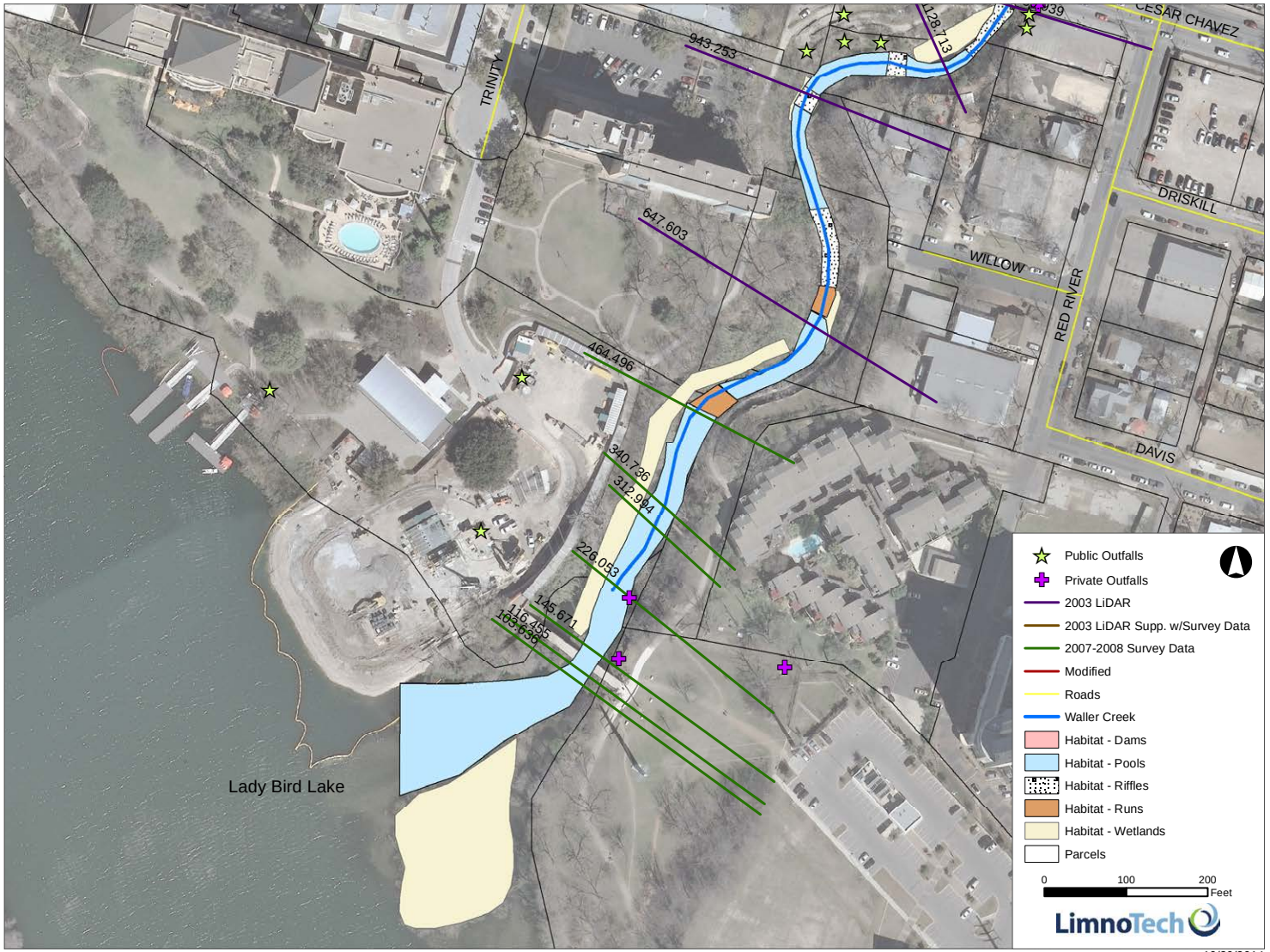

Figure 1. Critical areas in the Creek Mouth

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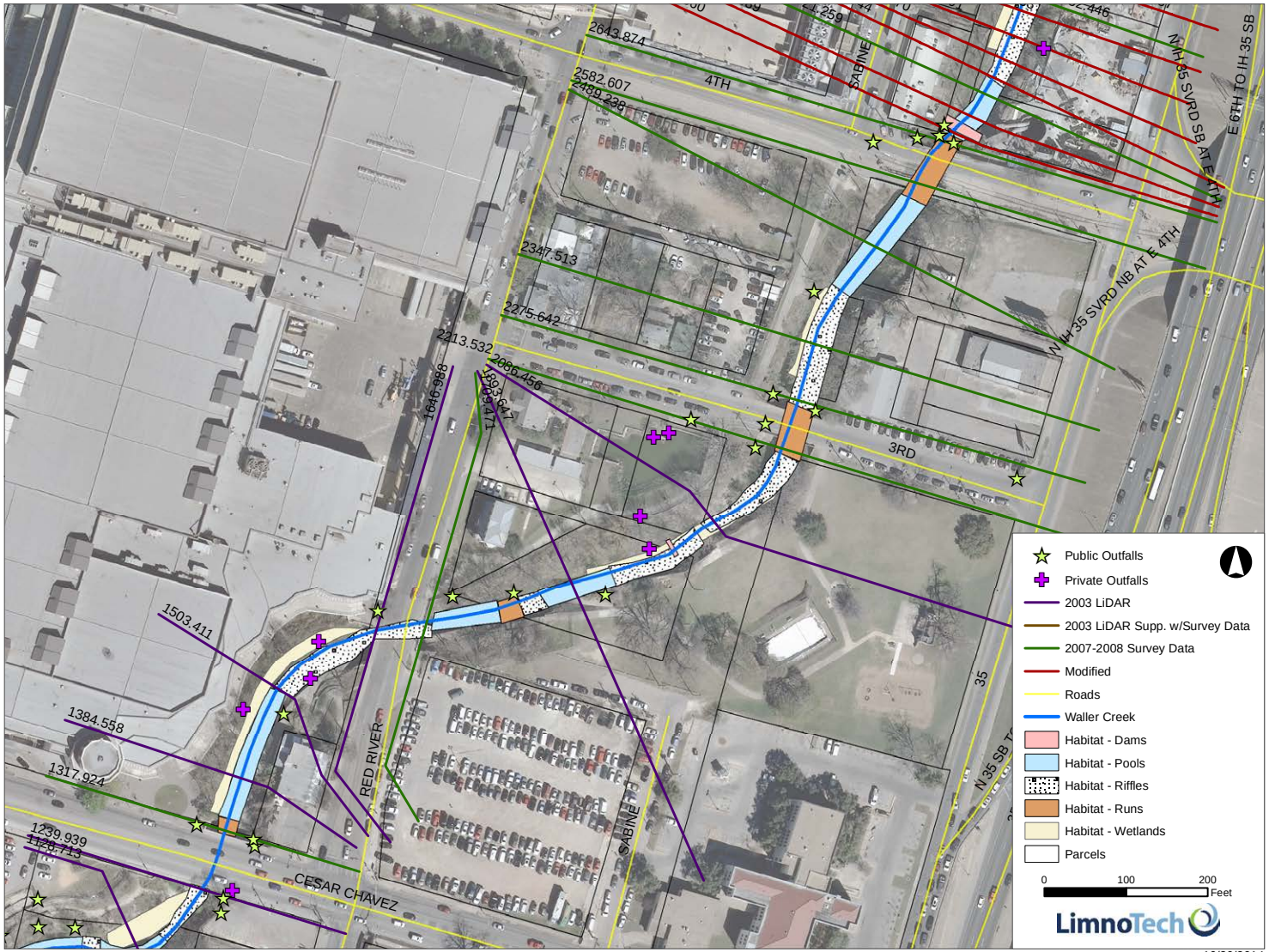

Figure 2. Critical areas from Cesar Chavez to 4th Street

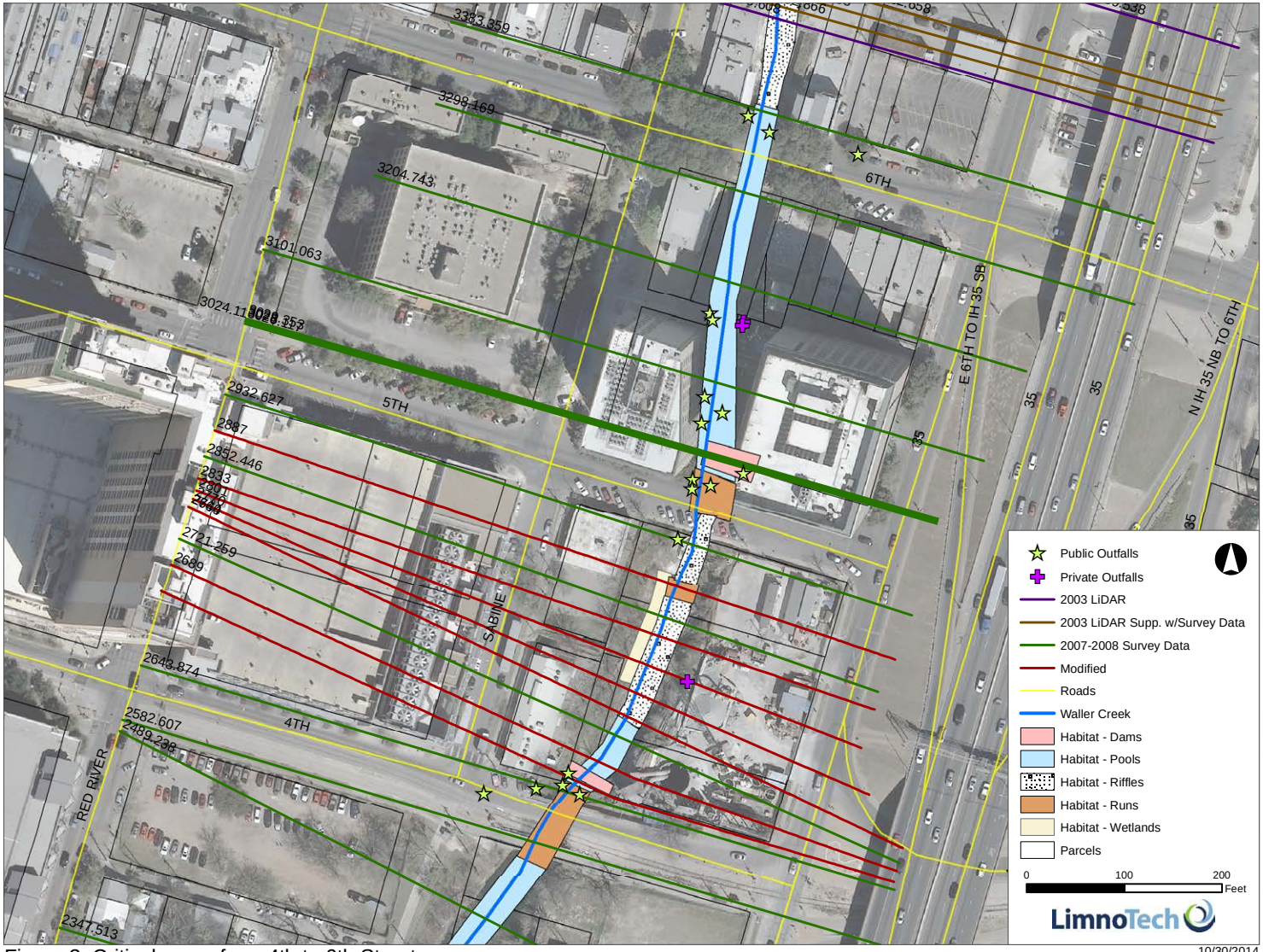

Figure 3. Critical areas from 4th to 6th Streets

HYDRAULICS & HYDROLOGY

Limnotech Program Verification Memo (14-15)
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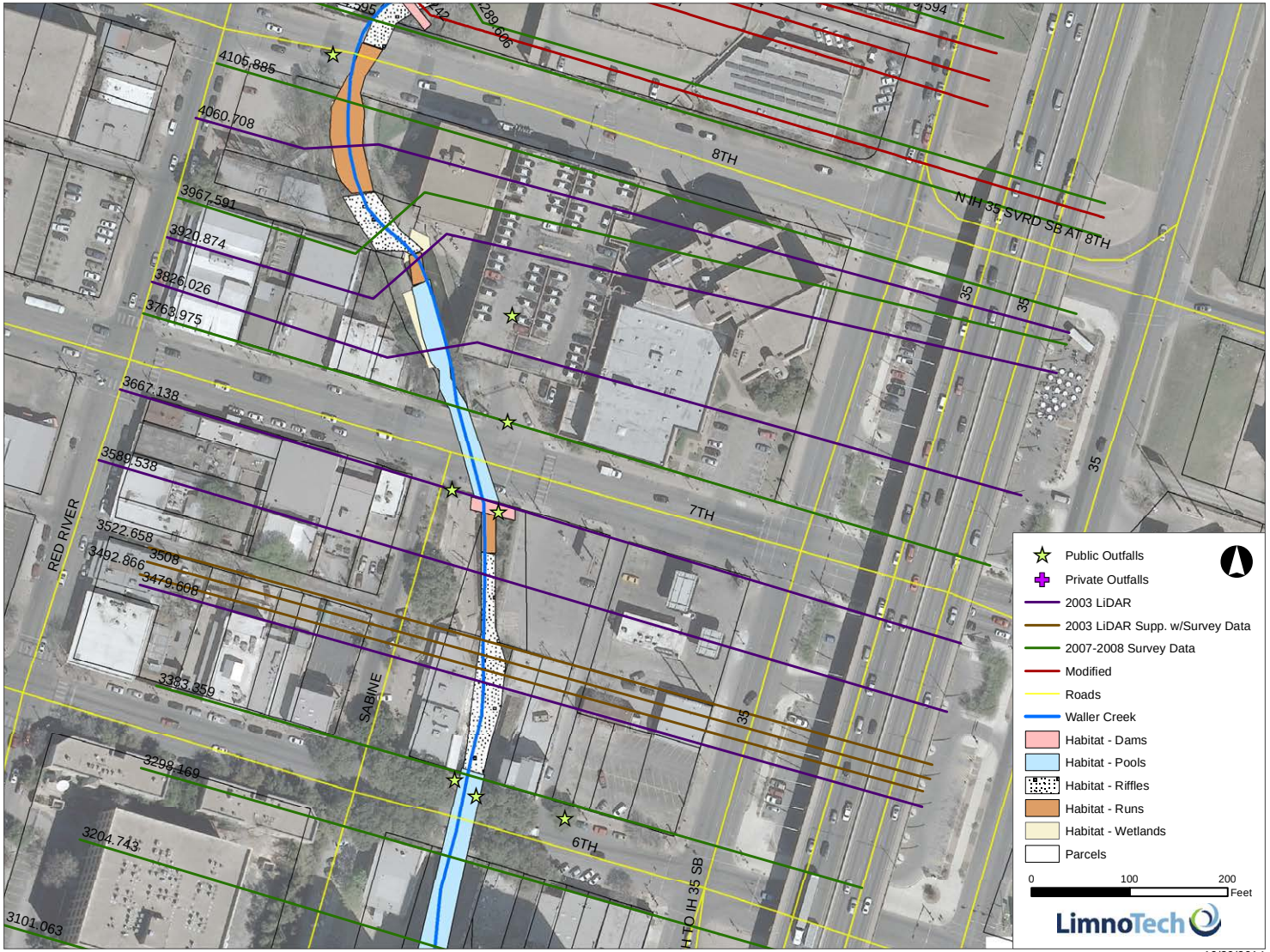

Figure 4. Critical areas from 6th to 8th Streets

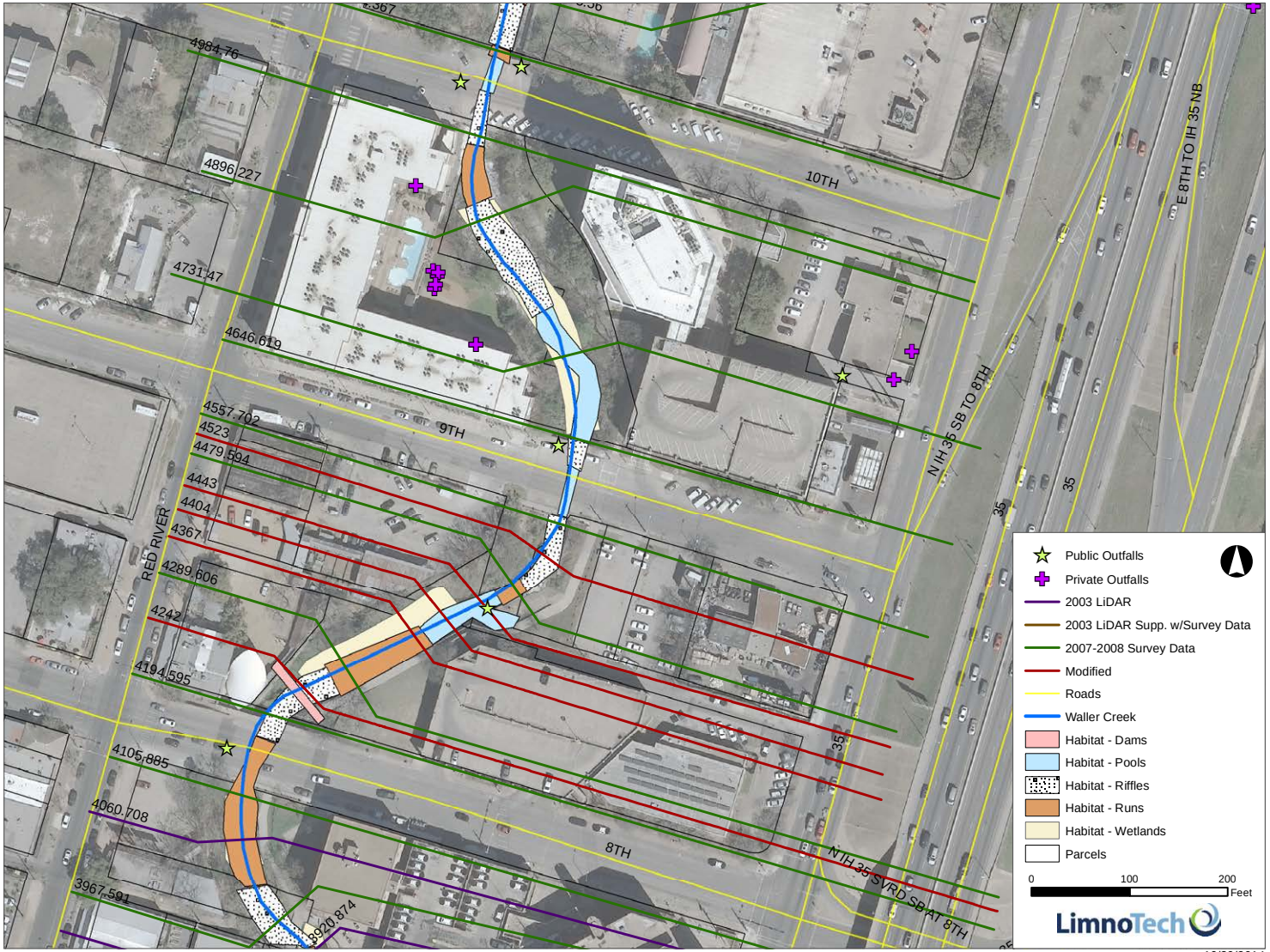

Figure 5. Critical areas from 8th to 10th Streets

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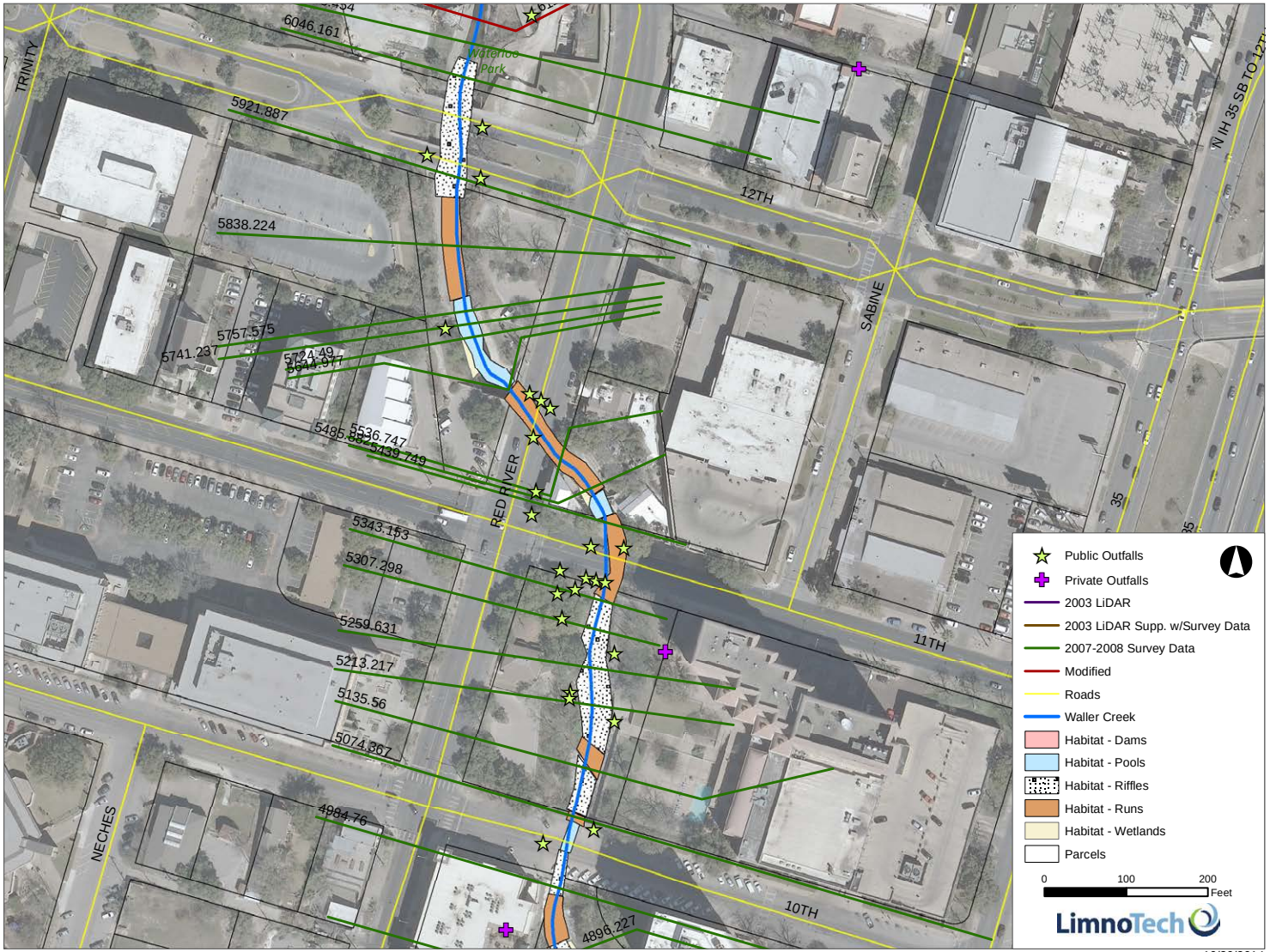

Figure 6. Critical areas from 10th to 12th Streets

Appendix A
Survey Request Memo

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Memorandum

From: Dendy Lofton, PhD
Craig Taylor
Tim Dekker, PE, PhD

Date: 15 September 2014
Project: Waller Creek

To: Danielle Choi, MVVA
Gullivar Shepard, MVVA

CC: Susan Benz, BRG
Waller Creek Conservancy
City of Austin, Watershed Protection Department

SUBJECT: **Topographical survey request**

Topographical Survey Request

As part of the Waller Creek Corridor Framework, LimnoTech has identified areas where resolution in the HEC-RAS model is necessary. Increased resolution of the HEC-RAS model in these areas is critically important to inform proposed design elements in the restoration of Waller Creek. In order to refine the model with additional cross-sections, topographical survey data is needed in these locations.

Basis for Additional Surveys

In some areas of Waller Creek, the distance between cross-sections approximates 300 feet, which results in large gaps in understanding with regard to the hydraulic influences in these sub-reaches. The existing HEC-RAS cross-sections are derived from field survey data (2007-2008) and LiDar data (2003). Field verification of these cross-sections indicated that some HEC-RAS cross-sections generated from Lidar data are underrepresenting actual conditions in Waller Creek. Cumulatively, these issues underline the need for additional cross-sections to improve the resolution in these sub-reaches.

The basis for additional HEC-RAS cross-sections in particular areas are described below:

Preservation Zones: These sections are needed to resolve the pool-riffle sequences in the HEC-RAS model. The improved resolution will be used to verify that this sub-reach designated as an area of preservation will continue to function in a similar manner under post-tunnel and post-restoration conditions.

Restoration and Reconstruction Zones: These sections are needed to refine the HEC-RAS model in areas where the stream bed will be reconstructed. The HEC-RAS model will also need to be updated with proposed reconstruction cross-sections. Without existing condition cross-sections in the same locations, it will be difficult to determine if any post-construction changes in water surface elevation are due to the channel reconstruction or due to the current model resolution. This distinction could have important implications for the future floodplain mapping efforts.

Limnotech Program Verification Memo (19-20)

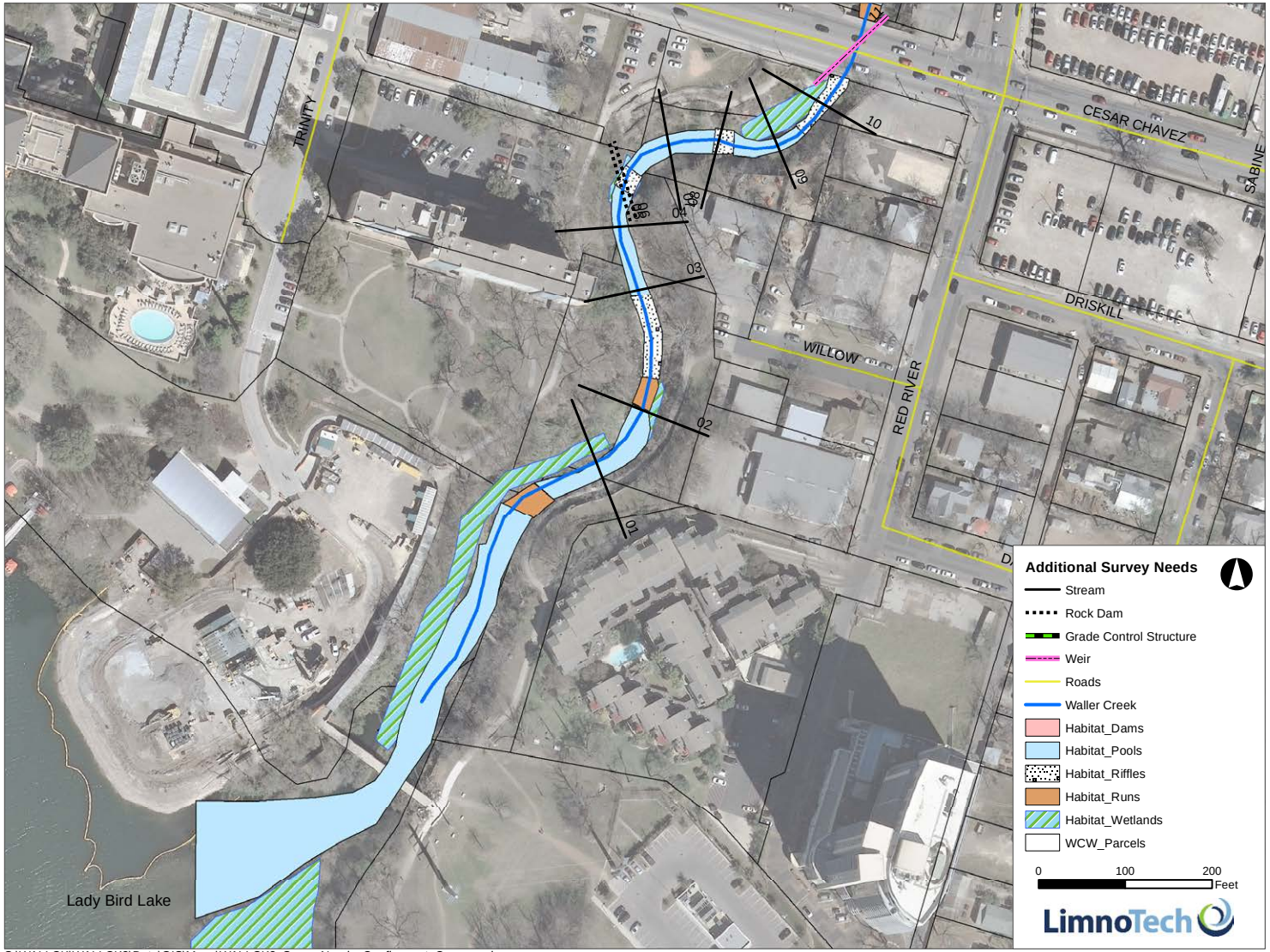
2014 12 11_LimnoTech_Program_Verification_Discovery_Memo-1.pdf

At the rock dam: These sections are needed to evaluate the rock dam and its impacts on the exposed footing of the adjacent retaining wall. The rock dam is believed to cause the habitat development in the exposed footing, but it also appears to be causing the undermining of the wall footing.

Location of Additional Survey Needs

The area of interest in Waller Creek for this data request extends from the confluence with Lady Bird Lake upstream to 4th Street (Figures 1 and 2). The coordinates of the locations where additional survey information is needed are shown in Table 1, which also includes a description of the type of survey that is needed. For example, stream surveys can be captured perpendicular to the stream channel. In contrast, surveys where rock dams or other structures exist, additional descriptions regarding the desired orientation accompany the survey ID number.

Waller Creek - Confluence to Cesar Chavez



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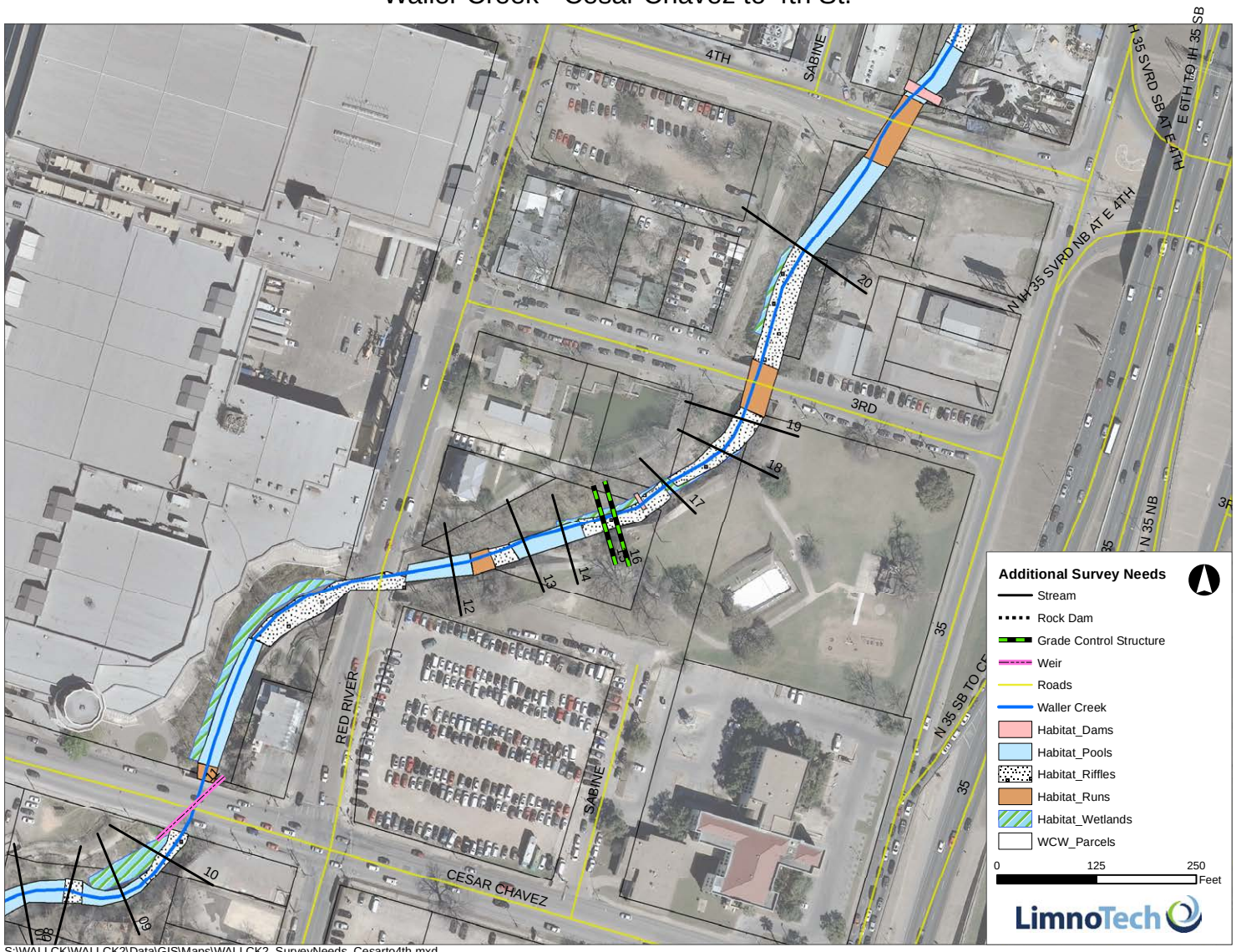
3

Figure 1: Waller Creek - Confluence to Cesar Chavez

Waller Creek - Cesar Chavez to 4th St.



S:\WALLCK\WALLCK2\Data\GIS\Maps\WALLCK2_SurveyNeeds_Cesarto4th.mxd
10/7/2014 **Figure 2: Waller Creek - Cesar Chavez to 4th St.**

4

Table 1. Coordinates and corresponding description of stream or structure location where additional surveys are needed to refine the HEC-RAS model.

IDNo	Type	Description	Basis	XCoord	YCoord	SHAPE Length
1	Stream	Pool - Cross-Section	Data gap - area underrepresented	3115162	10068076	171.10
2	Stream	Downstream riffle - Cross-Section	Existing lidar - transition area underrepresented	3115215	10068135	160.47
3	Stream	Upstream riffle - Cross-Section	Existing cross-section gap - transition underrepresented	3115211	10068274	139.92
4	Stream	Pool - Cross-Section	Data gap - Large distance between existing cross-sections	3115189	10068347	152.58
5	Rock Dam	Rock dam - Downstream Structure Survey	Poorly represented structure data	3115192	10068389	92.73
6	Rock Dam	Rock dam - Upstream Structure Survey	Poorly represented structure data	3115196	10068401	95.53
7	Stream	Pool - Cross-Section	Data gap - Large distance between existing cross-sections	3115246	10068442	140.47
8	Stream	Riffle - Cross-Section	No existing riffle data	3115304	10068446	138.49
9	Stream	Pool - Cross-Section	Existing lidar - under represents conditions	3115372	10068441	136.58
10	Stream	20' downstream of weir - Cross-Section	No bridge transition data	3115425	10068488	150.13
11	Weir	Weir - Structure Survey (along U/S & D/S Crests and Toes)	No structure data	3115464	10068558	116.14
12	Stream	Pool - Cross-Section	Existing cross-section gap	3115785	10068856	117.83
13	Stream	Upstream riffle - Cross-Section	Existing lidar - under represents conditions	3115875	10068885	124.31
14	Stream	Sediment bar - Cross-Section	Existing lidar - under represents conditions	3115923	10068900	116.28
15	Grade Control Structure	Gabian grade control structure - Structure Survey	No structure data	3115974	10068916	103.31
16	Grade Control Structure	Gabian grade control structure - Cross-Section	Data gap - area underrepresented	3115989	10068919	111.22
17	Stream	Pool - Cross-Section	Existing lidar - under represents conditions	3116053	10068957	98.52
18	Stream	Downstream riffle - Cross-Section	Existing lidar - under represents conditions	3116123	10068999	139.18
19	Stream	Upstream riffle - Cross-Section	Transition zone needs better representation in the model	3116148	10069039	148.67
20	Stream	Upstream riffle - Cross-Section	Critical transition needs better representation in the model	3116227	10069250	189.09

Appendix B
Drainage Outfall Table

DRAINAGE_ID	WIDTH	HEIGHT	Overall Ranking	Initial Retrofit Scenario
627753	24	24	17	A
94974	30	30	22	A
373296	18	18	25	A
602378	21	21	27	A
60663	15	15	41	A
61494	18	18	45	A
364357	18	18	46	A
58822	24	24	52	A
58823	24	24	53	A
58599	18	18	56	A
58665	18	18	63	A
372277	12	12	65	A
377456	12	12	83	A
63740	30	30	11	B
220629	30	30	12	B
641157	30	30	14	B
60605	24	24	18	B
225134	24	24	20	B
602539	24	24	23	B
367642	24	24	24	B
60664	18	18	28	B
226998	18	18	29	B
225169	18	18	31	B
94845	18	18	34	B
377434	24	24	35	B
61495	24	24	36	B
95799	48	48	37	B
61557	18	18	43	B
60842	42	48	1	CD
459895	160	116	2	CD
459894	160	116	3	CD
370054	66	66	4	CD
225202	36	48	5	CD
406442	60	60	6	CD
370053	60	60	7	CD
546933	36	36	8	CD
364899	36	36	9	CD
364912	36	36	10	CD
226993	18	18	32	CD
61327	36	36	67	CD
380780	36	36	68	CD
95258	24	24	70	CD
225156	12	12	47	D
467195	27	27	49	D
92645	24	24	50	D
58927	21	21	54	D
95064	18	18	55	D
226721	18	18	57	D
225869	18	18	58	D
226707	18	18	60	D
475568	18	18	61	D
476265	15	15	64	D
372270	12	12	66	D
61486	18	18	73	D
225697	12	12	84	D
607103	30	30	15	U
377521	30	30	16	U
367691	24	24	21	U
378006	18	18	26	U
225148	18	18	33	U
202775	18	18	38	U
202782	18	18	39	U
602227	21	21	40	U
225140	15	15	42	U
377637	18	18	44	U

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 (eg. Roof drain or connected to another outfall)

DRAINAGE_ID	WIDTH	HEIGHT	Overall Ranking	Initial Retrofit Scenario
61459	12	12	48	U
226963	30	30	69	U
227290	18	18	71	U
61518	18	18	72	U
380310	18	18	74	U
225194	30	30	13	D
363559	24	24	19	B
225185	18	18	30	D
58652	24	24	51	D
459774	18	18	59	D
459813	18	18	62	D
378164	10	10	75	n/a
378135	10	10	76	n/a
378129	10	10	77	n/a
378148	10	10	78	n/a
378159	10	10	79	n/a
378152	10	10	80	n/a
378163	10	10	81	n/a
378030	8	8	82	n/a
372044	12	12	85	n/a

Appendix C
Model Version Logs

HEC-HMS *Note: Version A.B.C: A = Major Revision, B = Basin Revision, C = Meteorologic Revision

Version 1.0.0
This version is the November 2010 Waller Creek Tunnel HEC-HMS model developed by Espey Consultants.

HEC-HMS File Name: Waller_Creek_Tunnel.hms

Basin Models

Title	Description	Modifications
Existing Conditions	Waller Creek pre-tunnel w/2010 watershed	none
Fully Developed Conditions	Waller Creek pre-tunnel w/fully-developed watershed	none
Proposed Tunnel Project_EX	Waller Creek post-tunnel w/2010 watershed	none
Proposed Tunnel Project_FD	Waller Creek post-tunnel w/fully-developed watershed	none

Meteorologic Models

Title	Description	Modifications
24H_01%	24-hour, 100-year SCS Type 3 Storm	none
24H_02%	24-hour, 50-year SCS Type 3 Storm	none
24H_04%	24-hour, 25-year SCS Type 3 Storm	none
24H_0.2%	24-hour, 500-year SCS Type 3 Storm	none
24H_0.4%	24-hour, 250-year SCS Type 3 Storm	none
24H_10%	24-hour, 10-year SCS Type 3 Storm	none
24H_20%	24-hour, 5-year SCS Type 3 Storm	none
24H_50%	24-hour, 2-year SCS Type 3 Storm	none

Version 2.0.0
This version contains all of the files from version 1.0.
Only the files that have been added or updated are included in this list.

HEC-HMS File Name: Waller_Creek_Tunnel.hms

Basin Models

Title	Description	Modifications
Proposed_FD_No_8th	"Proposed Tunnel Project_FD" with the 8th Street Inlet Removed	Removed 8th St inlet and pond

Meteorologic Models

Title	Description	Modifications
24H_1Inch	24-hour, 1-Inch SCS Type 3 Storm	Added a 1-inch storm model

Version 3.0.0
The Version 2.0.0 model was packaged and sent to WDP.

HEC-RAS *Note: Version A.B.C: A = Major Revision, B = Geometry Revision, C = Flow Revision

Version 1.0.0
This version was received at the beginning of the Framework Project

Project Files (These Project use the same Geometry and Flow files)

Title	File Name	File Type	Description
WLR_Proposed_WCT	WLR_Proposed_WCT.prj	Project	Waller Creek Corridor with final tunnel design
WLR_Proposed_WCT_4thStreetWeirMove	WLR_Proposed_WCT_4t.prj	Project	Waller Creek with relocated 4th Street Weir Alt 1
WLR_Proposed_WCT_4thStreetWeirMove	WLR_Proposed_WCT_4th_4b.prj	Project	Waller Creek with relocated 4th Street Weir Alt 2
WLR_Prop_WCT_no8thStreet	WLR_Prop_WCT_no5th5.prj	Project	Waller Creek without the 4th St Weir
WLR_Prop_WCT_no8th	WLR_Prop_WCT_no8th.prj	Project	Waller Creek without the 8th St Weir
WLR_Prop_WCT_nowirs	WLR_Prop_WCT_nowar.prj	Project	Waller Creek without the 4th or 8th St Weir

Geometry Files

Title	File Extension	File Type	Description
WLR_Existing	xxx.g02	Geometry	Waller Creek pre-tunnel
WLR_Rev_Existing	xxx.go1	Geometry	Waller Creek pre-tunnel with updated cross-sections
WLR_Proposed	xxx.go3	Geometry	Waller Creek post-tunnel, pre-restoration

Flow Files

Title	File Extension	File Type	Description
WLR_Fully Developed	xxx.f02	Flow	Waller Creek pre-tunnel w/fully-developed watershed
WLR_Existing Conditions	xxx.f45	Flow	Waller Creek pre-tunnel w/2010 watershed
WLR_Proposed_EX	xxx.f06	Flow	Waller Creek post-tunnel w/2010 watershed
WLR_Proposed_FD	xxx.f04	Flow	Waller Creek post-tunnel w/fully-developed watershed

Sub-Folder

Title	File Name	File Type	Description
WLR_RC_4th	WLR_RC_4th.prj	Project	Rating Curve Model for the 4th Street Inlet
WLR_RC_4th	WLR_RC_4th.g01	Geometry	Waller Creek near 4th St Inlet
RC_4th	WLR_RC_4th.f01	Flow	Incremental increases in flow
WLR_RC_8th	WLR_RC_8th.prj	Project	Rating Curve Model for the 8th Street Inlet
WLR_RC_8th	WLR_RC_8th.g01	Geometry	Waller Creek near 8th St Inlet
RC_8th	WLR_RC_8th.f01	Flow	Incremental increases in flow

Version 2.0.0
This version contains all of the files from version 1.0.
Only the files that have been added or updated are included in this list.

Title	File Name	File Type	Description	Modifications
WLR_Proposed_WCT	WLR_Proposed_WCT.prj	Project	Waller Creek Corridor with final tunnel design	Changed flow regime to mixed Subcritical & Supercritical
WLR_Proposed_FD	WLR_Proposed_WCT.f04	Flow	Waller Creek post-tunnel w/fully-developed watershed	Updated flows to reflect the HEC-HMS model output and increased baseflow to 5 cfs
WLR_Proposed_FD_Baseflow	WLR_Proposed_WCT.f01	Flow	Waller Creek with baseflow discharges of 1, 5, & 30 cfs	Added three baseflow scenarios
WLR_Proposed_Creek Restoration	WLR_Proposed_Creek_.prj	Project	Waller Creek w/ tunnel design and proposed creek restorations	Updated geometry to reflect potential restoration efforts (Divert all flow to 11th St tunnel)
WLR_Proposed_Restored	WLR_Proposed_Creek_.g04	Geometry	Waller Creek w/ tunnel design and proposed creek restorations	Removed main creek reach between Red River St and 11th St
WLR_Proposed_FD_Restored	WLR_Proposed_Creek_.f03	Flow	Waller Creek post-tunnel w/fully-developed watershed	Same flows as: WLR_Proposed_WCT.f04
WLR_Prop_WCT_no8th	WLR_Prop_WCT_no8th.prj	Project	Waller Creek without the 8th St Weir	The flow files were updated to reflect the correct location of the 72 in outfall between 9th & 10th Street.

Version 2.0.1

Project Name	File Name	Type	Description	Modifications
WLR_Proposed_WCT	WLR_Proposed_WCT.f04	Flow	Waller Creek post-tunnel w/fully-developed watershed	Added a flow profile for the 500-year event
WLR_Proposed_Creek Restoration	WLR_Proposed_Creek_.f03	Flow	Waller Creek post-tunnel w/fully-developed watershed	Added a flow profile for the 500-year event
WLR_Proposed_WCT	WLR_Proposed_WCT.f02	Flow	Waller Creek pre-tunnel w/fully-developed watershed	Added a flow profile for the 500-year event

Version 3.0.0
The Version 2.0.1 model was packaged and sent to WDP.

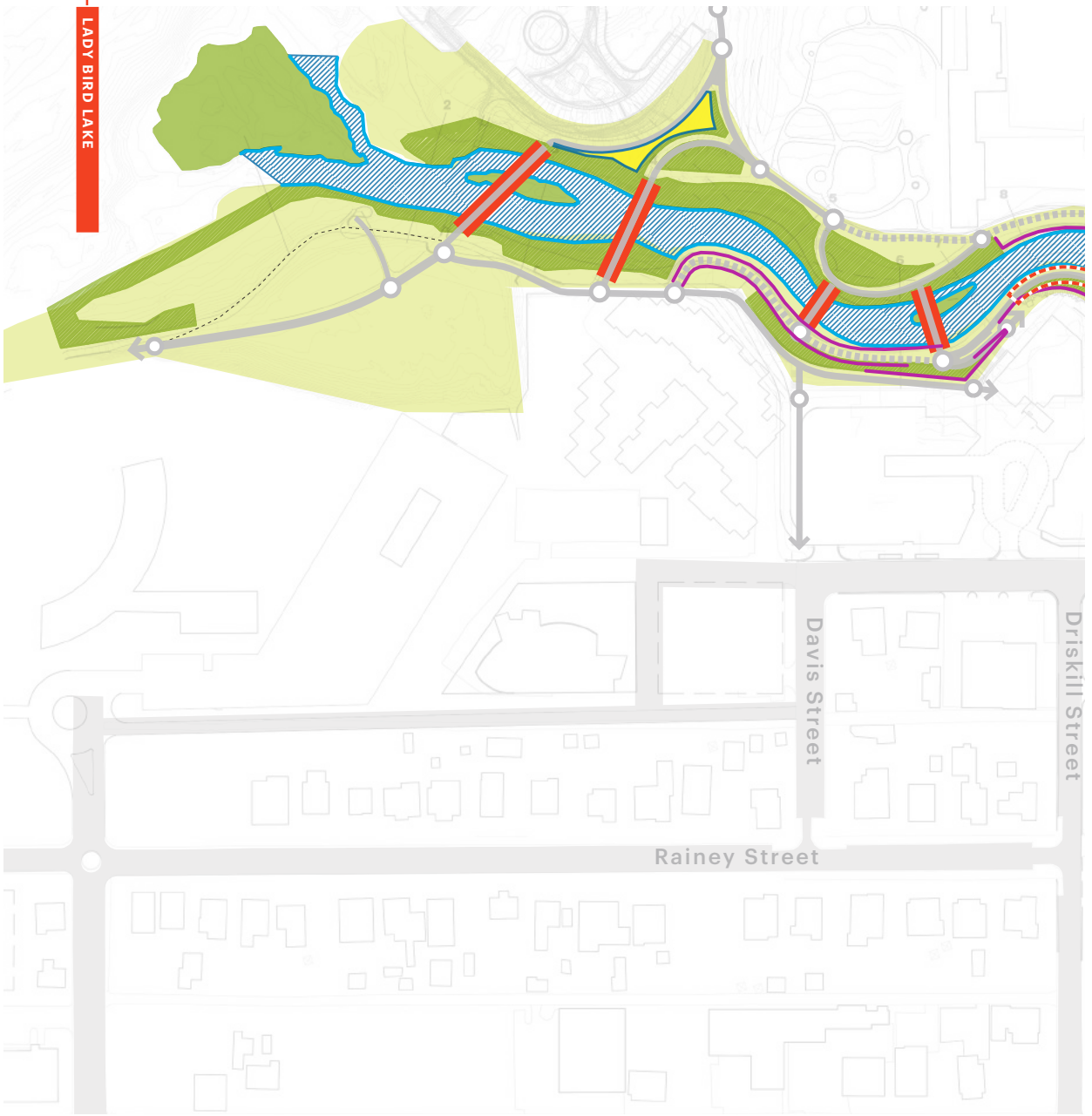
Maintenance & Operations

MAINTENANCE & OPERATIONS

Maintenance & Operations Site Map

MAINTENANCE_OPERATIONS_300sc.pdf

I



LANDSCAPE TYPE

- Riparian Slope
- Parkland
- Stormwater Management
- Creek Channel
- Vertical Slope
- Creek Edge
- Upland Corridor Edge

TRAIL TYPE

- Trail
- Trail on Structure
- Bridge

0′ 100′ 200′

II

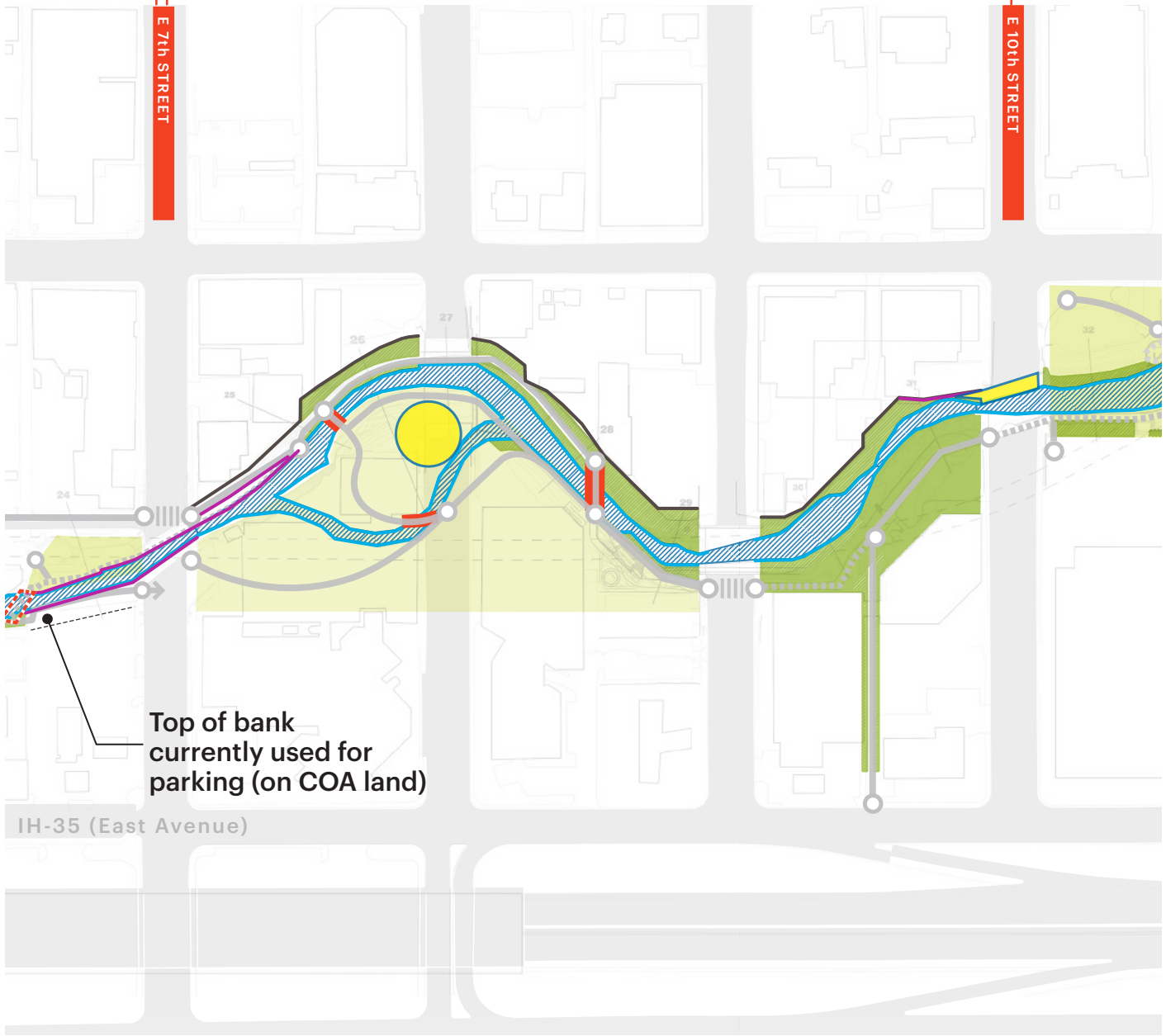

E CESAR CHAVEZ STREET
E 4th STREET
Driskill Street
Sabine Street
Red

MAINTENANCE & OPERATIONS

Maintenance & Operations Site Map (cont.)

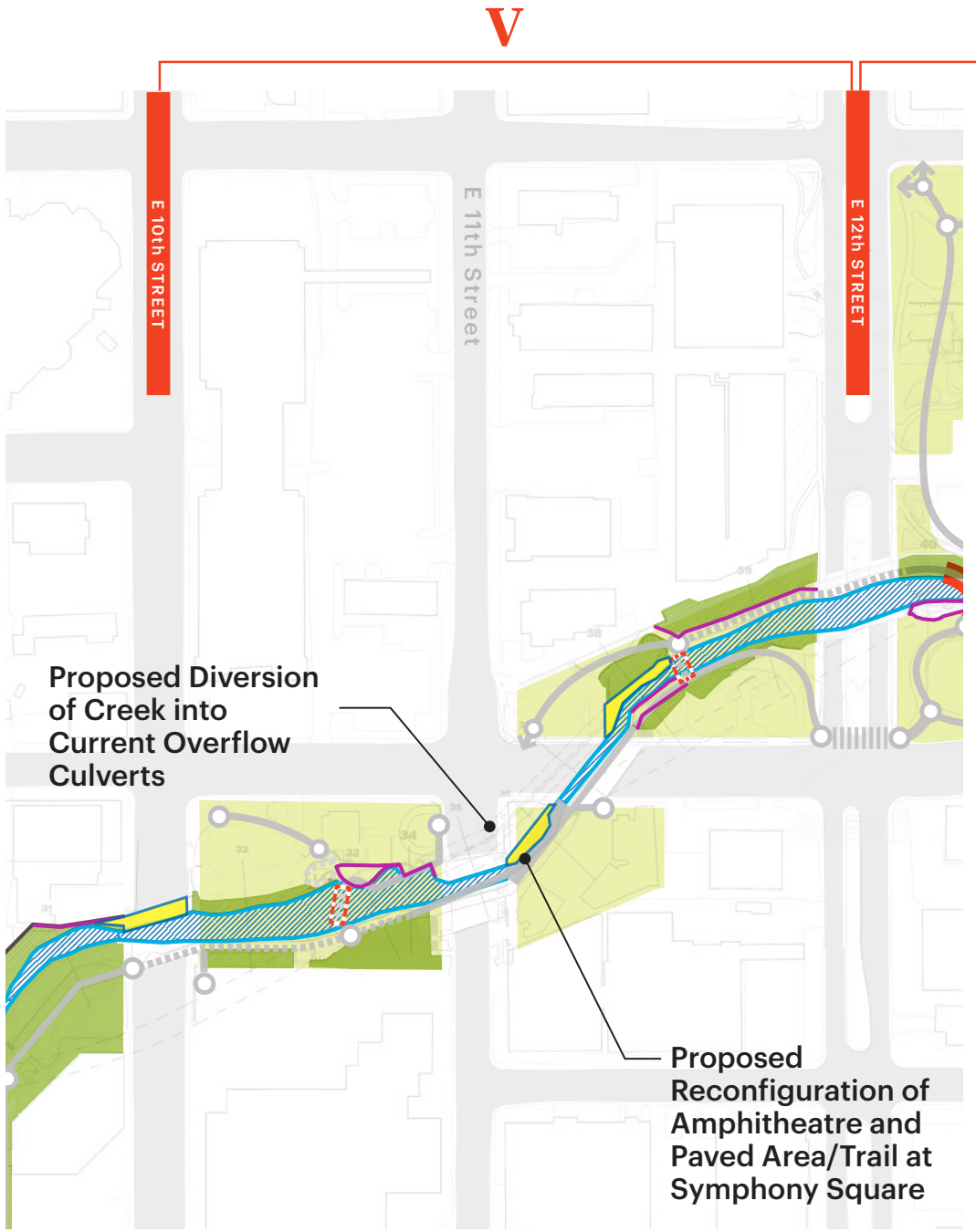
MAINTENANCE_OPERATIONS_300sc.pdf

IV


E 7th STREET
E 10th STREET
Top of bank
currently used for
parking (on COA land)
IH-35 (East Avenue)

MAINTENANCE & OPERATIONS

Maintenance & Operations Site Map (cont.)
MAINTENANCE_OPERATIONS_300sc.pdf



LANDSCAPE TYPE
- Riparian Slope
- Parkland
- Stormwater Management
- Creek Channel
- Vertical Slope
- Creek Edge
- Upland Corridor Edge

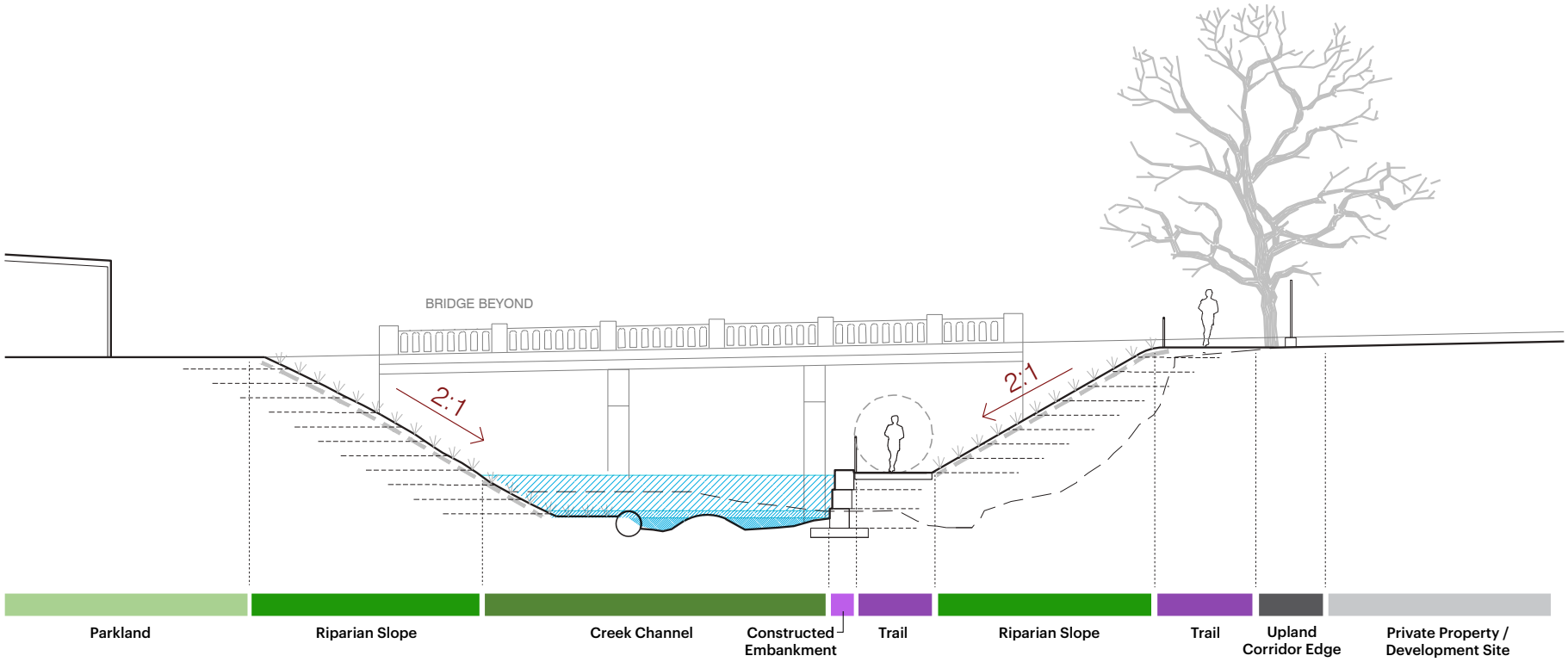
TRAIL TYPE
- Trail
- Trail on Structure
- Bridge

0′ 100′ 200′

VI

MAINTENANCE & OPERATIONS

Maintenance Zones Section
2015.04.24_Maintenance Zones_UPDATE.pdf



MAINTENANCE & OPERATIONS

Maintenance and Operations Report
20150701_Final Framework_M&O Report.pdf

WALLER CREEK FRAMEWORK PLAN

AUSTIN, TEXAS

MAINTENANCE AND OPERATIONS REPORT

Prepared By:
ETM Associates, L.L.C
1202 Raritan Avenue
Highland Park, NJ 08904

Prepared For:
MVVA
16 Court Street, 11th Floor
Brooklyn, NY 11241

JULY 2015

GENERAL ASSUMPTIONS

The Waller Creek Corridor landscape types are based on the Waller Creek Framework Plan developed by Michael Van Valkenburgh Associates (MVVA). Currently, Waller Creek Framework Plan (Framework Plan) is composed of seven (7) landscape types. ETM has developed descriptions, tasks and estimated hours needed for maintenance of each landscape type, which have in turn been reviewed and commented on by MVVA, Lady Bird Johnson Wildflower Center (LBJWC), and all City of Austin departments that may have some level of responsibility for Waller Creek. Due to the conceptual stage of the Framework Plan, ETM has made some assumptions to arrive at tasks and estimated hours.

In addition to the seven (7) landscape types, there are three (3) additional landscape types and features that are outside of the Framework Plan. An estimate had been provided for these landscape types and features due to their proximity and relationships to the Framework Plan.

This report only focuses on the maintenance of the Framework Plan, detailed assessment of individual projects (such as Waterloo Park) will be done for each phased plan.

STANDARDS OF CARE

The recommended standards of care for Waller Creek have been developed in consultation with LBJWC, as they provide recommendations for tasks and task frequencies for care of all plantings in order to meet high-standards of maintenance. While frequencies and demands might seem high at first during the plant establishment period, work is expected to lessen once the plant communities mature. The maturity period will vary among planting types. The Austin Parks and Recreation Department (APARD) maintenance standards were referenced by ETM and adjusted to meet the needs of Waller Creek for all other tasks that reflect landscape design, location and anticipated usage. Actual maintenance will ultimately be based on usage, weather, standards of care and resources available for maintenance. Actual work may be done more or less frequently. For instance, litter removal may need to be done more frequently during heavily used months and less frequently during the winter. The frequencies represent an average to be performed over the course of the year.

The maintenance tasks and frequencies included in the spreadsheets aim to achieve the standards needed in order to provide a healthy, well-maintained public landscape, to ensure public safety, and to identify the resources needed in order to protect capital investments long-term. APARD level 1 maintenance care is used where it is applicable, such as tasks that are typical park work, but not necessarily for natural planting areas, as the level 1 practice may not be appropriate. The natural planting areas are not intended for frequent use and they are function-driven. The landscape debris (leaves, fallen trees, broken branches) that gets left behind is intentional, but the practice does not reflect the level 1 maintenance care.

MAINTENANCE ASSUMPTIONS

Seasonality:
Austin's climate generally ranges from very hot summer days to mild winter days, with the exception of some extreme weather condition where it may freeze during winter. Therefore, it is assumed that drinking fountains, irrigation, and restrooms will remain operable year round due to the mild winter, and will not be shut down. However, a thorough seasonal maintenance will be required to ensure they operate properly throughout the year.

Due to Austin's climate, plantings will grow throughout the year, with some seasonal reduction of growth during winter months. Monitoring and weeding of invasive species will occur more frequently (once every week to every two weeks) during summer growing season, and less frequently (once every two weeks to monthly) during the winter when plant growth has slowed.

Ecological maintenance tasks and frequencies have been estimated for both the initial establishment and the post-establishment periods. Inputs are higher during the establishment period during which new plantings increase root volume and soil cover, and then decrease as plant communities mature.

Staffing:
Maintenance tasks have been divided into four (4) categories: semi-skilled maintenance, skilled maintenance (including trades), semi-skilled ecological landscape maintenance and skilled ecological landscape management.

Semi-skilled labor includes maintenance tasks that can be done with limited training, or can be done under supervision. It is assumed that basic cleaning and grounds work will be done by semi-skilled staff, and some maintenance work will be done with 75% semi-skilled and 25% skilled staff.

Semi-skilled tasks include:
- Litter removal: grounds, water's edge, and fence
- Debris removal
- Emptying trash and recycle bins
- Cleaning paths
- Powerwashing
- Cleaning/maintenance of furnishings
- Cleaning catchbasin inlets
- Cleaning catchbasin sumps
- Maintenance of drinking fountains
- Some light repair
- Some graffiti removal
- Some pest control (rodent, birds, ants, etc.)
- Some signage maintenance
- Some railing maintenance
- Some fence maintenance
- Fence graphic panel and component maintenance
- Some irrigation inspection and maintenance (50%)
- Some cleanout of stormwater features
- Some annual furnishing maintenance
- Restroom cleaning
- Spot watering
- Installation and maintenance of temporary fence for planting
- Seasonal restroom maintenance

Skilled maintenance tasks include:
- Some light repair
- Some graffiti removal
- Some pest control (rodent, birds, ants, etc.)
- Some signage maintenance/minor repair
- Some railing maintenance/minor repair
- Some irrigation inspection and maintenance/repair (50%)
- Some fence maintenance/minor repair
- Hardscape maintenance/minor repair
- Structure inspection and maintenance/minor repair
- Some cleanout of stormwater features/minor repair
- Clearing of storm drain system
- Annual maintenance/minor repair of site furnishings

- Restroom repair

It is assumed that 75% of ecological landscape management will be done by semi-skilled ecological landscape management staff, and 25% with skilled staff. For instance, regular monitoring, soil sampling and testing, and developing work tasks will need to be done by skilled staff who can then direct and oversee semi-skilled staff. Skilled staff will do quarterly inspections and preparation of reports and work plans.

Skilled ecological landscape management tasks include:
- Monitoring (plants, disease, and invasive species)
- Invasive species control (flora)
- Over-seeding/replanting
- Determining soil amendments
- Erosion control measures
- Landscape management in restoration areas
- Vegetation protection
- Woody plant thinning and removal
- Replanting
- Tree maintenance
- Shrub bed maintenance

EXPLANATION OF THE MAINTENANCE TASKS AND HOURS SHEET IS AS FOLLOWS:

TASK – Maintenance task
QTY – Total quantity of a task that needs to be done
UNIT – Unit of measurement
UNIT (MIN) – Time standard to complete one unit of the task in minutes
ONCE (MIN) – Task quantity x time standard
ONCE (HOURS) – Time in minutes converted to hours
ANNUAL FREQUENCY – Number of times task is done annually
TOTAL HOURS- Annual frequency x time in hours for performing a task once

msf = 1,000 square feet
clf = 100 linear feet

METHODOLOGY

The estimated annual hours (TOTAL HOURS) for maintenance of a specific task (TASK) is calculated by multiplying the task quantity (QTY) by the time standard to complete one unit of the task (UNIT MIN). This number is then divided by 60 in order to convert minutes to hours. Hours are then multiplied by the total number of times the task is estimated to be done annually (FREQ) to arrive at the estimated number of hours needed annually to complete the task.

The landscape type quantities are provided by MVVA, as of May 19, 2015. The number of restrooms is only an estimate. It is important to note that the quantities shown in the summary for Trails, Trails on Structures, Bridges, Creek Channel, Stormwater Management, and Upland Corridor Edge reflect the number of units, and not the quantity in acreage.

A detailed breakdown of the estimated hours for each unit of landscape type can be found at the end of the report.

MAINTENANCE & OPERATIONS

Maintenance and Operations Report (cont.)

20150701_Final Framework_M&O Report.pdf

Landscape Type			Segment 1		Segment 2	
	Typ Hour/ Unit	Unit	Qty	Hours	Qty	Hours
Constructed Embankments*	448	1 Acre	0.20	87	0.11	51
Trails	177	0.23 Acre	3.49	618	2.79	494
Trails on Structures	139	0.23 Acre	0.30	42	0.50	70
Bridges	142	0.32 Acre	0.60	85	0.10	14
Restoration Areas	493	1 Acre	2.00	985	1.16	570
Creek Channel	244	0.34 Acre	4.17	1,018	2.23	544
Stormwater Management	125	0.11 Acre	0.48	60		
Upland Corridor Edge**	153	0.28 Acre			0.30	45
Parkland	503	1 Acre	5.91	2,973	3.51	1,768
Restroom	420	Each	1.00	420	1.00	420
TOTAL HOURS				6,288		3,977

* Assumed to be 5' wide on average
** Assumed to be 12' wide on average
Trails are assumed to be 10' wide on average
Bridges are assumed to be 14' wide on average

Landscape Type			Segment 3		Segment 4	
	Typ Hour/ Unit	Unit	Qty	Hours	Qty	Hours
Constructed Embankments*	448	1 Acre	0.18	82	0.07	31
Trails	177	0.23 Acre	0.70	124	2.40	424
Trails on Structures	139	0.23 Acre	0.70	97		
Bridges	142	0.32 Acre	0.10	14	0.20	28
Restoration Areas	493	1 Acre	0.47	231	1.13	557
Creek Channel	244	0.34 Acre	1.63	397	2.48	605
Stormwater Management	125	0.11 Acre			1.06	133
Upland Corridor Edge**	153	0.28 Acre	0.42	65	1.08	166
Parkland	503	1 Acre	0.17	88	1.48	745
Restroom	420	Each	1.00	420	1.00	420
TOTAL HOURS				1,518		3,108

Landscape Type			Segment 5		Segment 6		Total	
	Typ Hour/ Unit	Unit	Qty	Hours	Qty	Hours		Hours
Constructed Embankments*	448	1 Acre	0.06	26	0.05	21		298
Trails	177	0.23 Acre	1.70	300	3.49	618		2,576
Trails on Structures	139	0.23 Acre	0.10	14	0.40	56		278
Bridges	142	0.32 Acre			0.30	43		185
Restoration Areas	493	1 Acre	0.43	213	0.09	43		2,599
Creek Channel	244	0.34 Acre	1.58	386	1.82	445		3,394
Stormwater Management	125	0.11 Acre						193
Upland Corridor Edge**	153	0.28 Acre						276
Parkland	503	1 Acre	2.41	1,210	10.57	5,317		12,102
Restroom	420	Each						
TOTAL HOURS				2,148		6,542		21,902

Summary of maintenance hours during Establishment Period

Landscape Type			Segment 1		Segment 2	
	Typ Hour/ Unit	Unit	Qty	Hours	Qty	Hours
Constructed Embankments*	224	1 Acre	0.20	44	0.11	26
Trails	177	0.23 Acre	3.49	618	2.79	494
Trails on Structures	139	0.23 Acre	0.30	42	0.50	70
Bridges	142	0.32 Acre	0.60	85	0.10	14
Restoration Areas	249	1 Acre	2.00	497	1.16	288
Creek Channel	208	0.34 Acre	4.17	868	2.23	463
Stormwater Management	104	0.11 Acre	0.48	50		
Upland Corridor Edge**	94	0.28 Acre			0.30	28
Parkland	503	1 Acre	5.91	2,973	3.51	1,768
Restroom	420	Each	1.00	420	1.00	420
TOTAL HOURS				5,596		3,571

* Assumed to be 5' wide on average
** Assumed to be 12' wide on average
Trails are assumed to be 10' wide on average
Bridges are assumed to be 14' wide on average

Landscape Type			Segment 3		Segment 4	
	Typ Hour/ Unit	Unit	Qty	Hours	Qty	Hours
Constructed Embankments*	224	1 Acre	0.18	41	0.07	15
Trails	177	0.23 Acre	0.70	124	2.40	424
Trails on Structures	139	0.23 Acre	0.70	97		
Bridges	142	0.32 Acre	0.10	14	0.20	28
Restoration Areas	249	1 Acre	0.47	116	1.13	281
Creek Channel	208	0.34 Acre	1.63	338	2.48	515
Stormwater Management	104	0.11 Acre			1.06	110
Upland Corridor Edge**	94	0.28 Acre	0.42	40	1.08	102
Parkland	503	1 Acre	0.17	88	1.48	745
Restroom	420	Each	1.00	420	1.00	420
TOTAL HOURS				1,279		2,640

Landscape Type			Segment 5		Segment 6		Total	
	Typ Hour/ Unit	Unit	Qty	Hours	Qty	Hours		Hours
Constructed Embankments*	224	1 Acre	0.06	13	0.05	10		149
Trails	177	0.23 Acre	1.70	300	3.49	618		2,576
Trails on Structures	139	0.23 Acre	0.10	14	0.40	56		278
Bridges	142	0.32 Acre			0.30	43		185
Restoration Areas	249	1 Acre	0.43	107	0.09	22		1,311
Creek Channel	208	0.34 Acre	1.58	329	1.82	379		2,893
Stormwater Management	104	0.11 Acre						160
Upland Corridor Edge**	94	0.28 Acre						169
Parkland	503	1 Acre	2.41	1,210	10.57	5,317		12,102
Restroom	420	Each						
TOTAL HOURS				1,973		6,445		19,823

Summary of maintenance hours during Post-Establishment Period

MAINTENANCE STRATEGY

Maintenance and management of Waller Creek may be done by various public and private entities, including the following:

- Austin Parks and Recreation
- Watershed Protection
- Public Works- Roads and Bridges
- Waller Creek Conservancy (WCC)
- Volunteers

At this time, definitive roles and responsibilities have not been determined. The intent of this report has been to develop an order of magnitude regarding the number of hours that may be needed annually to maintain the landscapes within the Framework Plan, as well as a list of tasks required to maintain the project.

While much of the maintenance work is routine - such as de-littering, debris removal from the water and graffiti removal - access to the site, steep slopes and the nature of the landscape plantings will present challenges, influence equipment choices and maintenance practices, and determine staff skill levels and knowledge. The design goal for the plantings will not be that of a manicured landscape, but rather a well-maintained "natural landscape". Management of the landscape areas will be an ongoing process and plantings will take up to five years to become established and reach the design intent. Therefore, management will be a "process" rather than a "project". Management should consider allocating some funds for plant replacement or material replacement, even during the establishment period, as some items may not be covered under warranty, or the warranty period has expired. This is not a capital replacement cost, but should be considered as part of the maintenance cost. Plants may get damaged from vandalism, overuse, hot summer days; soil may get eroded away, etc. These costs will need to be considered and build into the annual maintenance budget.

As roles and responsibilities are developed, it will be important that each entity understands the standards by which Waller Creek is to be maintained. It will also be necessary to understand who has the capacity and expertise required to assume those responsibilities and what tasks can and cannot be covered by partners. One possible role for the WCC is to focus on those areas that currently lack expertise within the public sector.

Volunteers and Texas Conservation Corps (TCC) should be considered to help supplement maintenance, not only would they help engage the public, but also create a site presence. Many semi-skilled tasks can be done by volunteers with little to no training, some supervision by a skilled staff or a volunteer coordinator may be necessary on certain tasks. TCC should be utilized in assisting some of the ecological landscape management tasks, their assistance will particularly be important after a flood event.

Ultimately, any maintenance strategy should include the various city agencies along with clearly defined roles, responsibilities and standards for the WCC. We assume the actual work will be done with in-house city staff supplemented with contracted services for both semi-skilled work and work that requires specialized equipment and/or skills that are not available to WCC and city departments.

Even with a well planned maintenance strategy, all entities involved should be aware that there may be certain inefficiencies in the delivery of maintenance due project phasing over time.

Waller Creek will also need to abide by the city's water restriction, when one is in place.

Another important role that the maintenance staff will play is to help change the perception of the creek corridor. There's a current perception that Waller Creek is unsafe and occupied by homeless individuals, and the only time that it gets used is when an event takes place where there is presence of other people. The consistent presence of uniformed maintenance staff will help established the image that Waller Creek is being taken cared of and that it's a safe place to be at.

MAINTENANCE FACILITIES

ETM recommends planning for a series of maintenance facilities along the Waller Creek for operational efficiency. The total length of the Waller Creek project is approximately 1.5 miles. While Waterloo Park may be the ideal site for a central maintenance facility, other secondary and tertiary sites should be considered along Waller Creek. These sites could be at street level and may be an actual facility or simply a "lay-down" area for the temporary storage of materials. Containers are one option for accommodating facility needs, provided that the area can be secured. Ideally, at-grade maintenance areas should align with access points to Waller Creek.

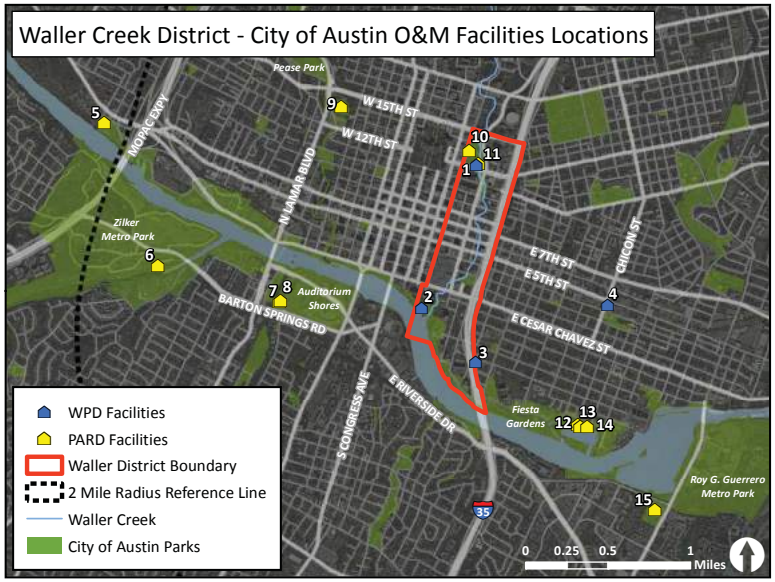
Currently, there are a number of city maintenance facilities/areas that exist, some of which could be used for Waller Creek maintenance needs.

There are several existing WPD and PARD facilities located within the site boundary, and it would be ideal if these spaces could be shared with Waller Creek. Additional facilities will still need to be established in order to ensure an efficient operation, but building upon or sharing an existing facility will help reduce costs and the time it takes to do the work for the parties involved.

MAINTENANCE & OPERATIONS

Maintenance and Operations Report (cont.)

20150701_Final Framework_M&O Report.pdf



#	Facility Name	Address
Watershed Protection Department Facilities - contact John Beachy 512-974-3516		
1	Waterloo Inlet	500 E 12th St
2	Bay 0	74 Trinity St
3	Nursery	1007 Lambie St
4	411 Chicon	411 Chicon St
Parks and Recreation Department Facilities - contact Joe Diaz 512-391-0402		
5	Eilers (Deep Eddy) Neighborhood Park Parking Lot Dumpster	401 Deep Eddy Ave
6	Zilker Metro Park Maintenance Building Hub	2105 Andrew Zilker Rd
7	Butler Metro Park Parking Lot Dumpster	421 Dawson Rd
8	Butler Metro Park Parking Lot Easy Go	421 Dawson Rd
9	Austin Recreation Center Dumpster	1301 Shoal Creek Blvd
10	Waterloo Neighborhood Park Restroom Easy Go	1305 Trinity St
11	Waterloo Neighborhood Park Parking Lot Dumpster	500 E 12th St
12	Fiesta Gardens Maintenance Facility Dumpsters	2101 Jesse E Segovia St
13	Fiesta Gardens Maintenance Easy Go	2101 Jesse E Segovia St
14	Fiesta Gardens Maintenance Facility Hub	2101 Jesse E Segovia St
15	Central Maintenance Complex at Town Lake Metro Park Hub	2525 S Lakeshore Blvd

Information provided by the City of Austin Parks & Recreation Department (PARD) and the Watershed Protection Department (WPD).

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BUDGET

This report does not provide a detailed, estimated maintenance budget, and only work within the Waller Creek Framework Plan project limit line will be considered in developing an estimated budget.

The following personnel rates, which include indirect costs, reflect those provided by the Austin Parks Department:

- Semi-skilled maintenance staff $24/hr
- Skilled maintenance staff $38/hr
- Skilled ecological landscape management staff $47/hr
- Contracted services $75/hr

At this time, it has not been determined what tasks will be done with in-house staff versus contracted services. Who is responsible for what work will need to be determined before a final budget can be developed. ETM has not accounted for any costs associated with administration, security, or park programming.

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CONSTRUCTED EMBANKMENTS (NEARLY VERTICAL)

These areas are typically slopes exceeding 2:1 in steepness. This category includes: nearly vertical retaining walls (proposed and existing), mechanically stabilized earth embankments, and slopes reinforced by geosynthetics. These areas do not have trails and are not intended for frequent use or public access. Vegetation, when present, is expected to include native vines, grasses, and forbs; erosion control will be critical. Depending on the species mix, these areas may require limited clearing or annual mowing, though removal of vegetation will typically be limited to conditions that may eventually compromise the structural stability of a wall or embankment. Litter is expected to be minimal. Maintenance in these areas will be more time consuming as access is more difficult than in other areas.

Unit = 1 Acre

Constructed Embankments	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Litter removal	4	msf	20	80	1.3	26	35	26	35	10% of an acre
Monitoring	7	msf	30	210	3.5	12	42	2	7	Regular monitoring of vegetation and site conditions: site photos, take soil samples [if needed] inspection and action report
Invasive species control (flora)	4	msf	40	520	8.7	12	104	4	35	Weeding, herbicide treatment, cut and paint etc. 10% of an acre
Pest control	4	msf	15	60	1.0	4	4	4	4	10% of an acre
Over-seeding/replanting	7	msf	45	315	5.3	2	11	2	11	15% of an acre
Erosion control	9	msf	120	1,080	18.0	6	108	3	54	20% of an acre; landscapes and slopes repair from erosion: install erosion blanket, coir logs, compost and revegetate as needed
Landscape management	11	msf	180	1,980	33.0	4	132	2	66	25% of an acre; includes grass cutback (if necessary), seasonal removal/cleanup, prune back, removal of thatch, leaves etc., maintain log of actions taken
Graffiti removal		allow					8		8	Done on vertical walls
Structure inspection and maintenance		allow					5		5	Regular inspection of retaining structures
Riparian Areas - Constructed Embankments							**448**		**224**	**Annual Hours/1 Acre**

TRAILS

Description: Trails are the primary means of moving through the corridor. Trails will typically be concrete, and vary in width from 8'-14'; with 10' being the average width. The trails will likely have railings on the creekside edge; lighting and seating will be located along the trail. Other site furnishings, such as signage and small trashcans, will be affixed to railings. When cleaning, staff should take care to not wash or push the debris down into the creek level. Debris should be pushed towards the inner edge and then collected. In situations where cleaning agent is required, choose one that would be the least harmful to the planting and water quality.

Unit = 0.23 Acre
10,000 SF (assumes 1,000 LF and 10' wide)

Trails	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Empty trash/recycling cans	2	each	5	10	0.2	312	52	2/1,000 LF, 6x/week for 52 weeks
Remove litter/debris	1.5	msf	4	6	0.1	52	5	15% of unit , weekly
Clean paths	1	msf	10	10	0.2	12	2	10% of unit, weekly; with hand sweeper, broom, or backpack blower to limit debris getting into the creek
Powerwash	5	msf	15	75	1.3	52	65	50% of unit, done monthly to remove stains
Pest control	1	msf	8	8	0.1	12	2	10% of unit
Clean/maintain furnishings	4	each	40	160	2.7	6	16	4/unit, done monthly; includes lighting, trashcans, bike racks, etc.
Railing maintenance	2.5	clf	20	50	0.8	12	10	25% of railing; done monthly, cleaning wiping down with mild detergent, connections are to be inspected and tightened as necessary
Maintain drinking fountains	1	each	15	15	0.3	12	3	1/trailhead; routine cleaning/maintenance
Repair lights		allow					6	Repair damage/bulbs for site lighting; assumes 3 occurances
Graffiti removal		allow					8	
Hardscape maintenance		allow					5	Includes patching or any necessary repair work on concrete and concrete edges (erosion)
Signage		allow					3	Repair and cleaning of park and interpretive signs
Trails							**177**	**Annual Hours/0.23 Acre**

CONSTRUCTED EMBANKMENTS (NEARLY VERTICAL)

These areas are typically slopes exceeding 2:1 in steepness. This category includes: nearly vertical retaining walls (proposed and existing), mechanically stabilized earth embankments, and slopes reinforced by geosynthetics. These areas do not have trails and are not intended for frequent use or public access. Vegetation, when present, is expected to include native vines, grasses, and forbs; erosion control will be critical. Depending on the species mix, these areas may require limited clearing or annual mowing, though removal of vegetation will typically be limited to conditions that may eventually compromise the structural stability of a wall or embankment. Litter is expected to be minimal. Maintenance in these areas will be more time consuming as access is more difficult than in other areas.

Unit = 1 Acre

Constructed Embankments	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Litter removal	4	msf	20	80	1.3	26	35	26	35	10% of an acre
Monitoring	7	msf	30	210	3.5	12	42	2	7	Regular monitoring of vegetation and site conditions: site photos, take soil samples [if needed] inspection and action report
Invasive species control (flora)	4	msf	40	520	8.7	12	104	4	35	Weeding, herbicide treatment, cut and paint etc. 10% of an acre
Pest control	4	msf	15	60	1.0	4	4	4	4	10% of an acre
Over-seeding/replanting	7	msf	45	315	5.3	2	11	2	11	15% of an acre
Erosion control	9	msf	120	1,080	18.0	6	108	3	54	20% of an acre; landscapes and slopes repair from erosion: install erosion blanket, coir logs, compost and revegetate as needed
Landscape management	11	msf	180	1,980	33.0	4	132	2	66	25% of an acre; includes grass cutback (if necessary), seasonal removal/cleanup, prune back, removal of thatch, leaves etc., maintain log of actions taken
Graffiti removal		allow					8		8	Done on vertical walls
Structure inspection and maintenance		allow					5		5	Regular inspection of retaining structures
Riparian Areas - Constructed Embankments							**448**		**224**	**Annual Hours/1 Acre**

TRAILS

Description: Trails are the primary means of moving through the corridor. Trails will typically be concrete, and vary in width from 8'-14'; with 10' being the average width. The trails will likely have railings on the creekside edge; lighting and seating will be located along the trail. Other site furnishings, such as signage and small trashcans, will be affixed to railings. When cleaning, staff should take care to not wash or push the debris down into the creek level. Debris should be pushed towards the inner edge and then collected. In situations where cleaning agent is required, choose one that would be the least harmful to the planting and water quality.

Unit = 0.23 Acre
10,000 SF (assumes 1,000 LF and 10' wide)

Trails	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Empty trash/recycling cans	2	each	5	10	0.2	312	52	2/1,000 LF, 6x/week for 52 weeks
Remove litter/debris	1.5	msf	4	6	0.1	52	5	15% of unit , weekly
Clean paths	1	msf	10	10	0.2	12	2	10% of unit, weekly; with hand sweeper, broom, or backpack blower to limit debris getting into the creek
Powerwash	5	msf	15	75	1.3	52	65	50% of unit, done monthly to remove stains
Pest control	1	msf	8	8	0.1	12	2	10% of unit
Clean/maintain furnishings	4	each	40	160	2.7	6	16	4/unit, done monthly; includes lighting, trashcans, bike racks, etc.
Railing maintenance	2.5	clf	20	50	0.8	12	10	25% of railing; done monthly, cleaning wiping down with mild detergent, connections are to be inspected and tightened as necessary
Maintain drinking fountains	1	each	15	15	0.3	12	3	1/trailhead; routine cleaning/maintenance
Repair lights		allow					6	Repair damage/bulbs for site lighting; assumes 3 occurances
Graffiti removal		allow					8	
Hardscape maintenance		allow					5	Includes patching or any necessary repair work on concrete and concrete edges (erosion)
Signage		allow					3	Repair and cleaning of park and interpretive signs
Trails							**177**	**Annual Hours/0.23 Acre**

CONSTRUCTED EMBANKMENTS (NEARLY VERTICAL)

These areas are typically slopes exceeding 2:1 in steepness. This category includes: nearly vertical retaining walls (proposed and existing), mechanically stabilized earth embankments, and slopes reinforced by geosynthetics. These areas do not have trails and are not intended for frequent use or public access. Vegetation, when present, is expected to include native vines, grasses, and forbs; erosion control will be critical. Depending on the species mix, these areas may require limited clearing or annual mowing, though removal of vegetation will typically be limited to conditions that may eventually compromise the structural stability of a wall or embankment. Litter is expected to be minimal. Maintenance in these areas will be more time consuming as access is more difficult than in other areas.

Unit = 1 Acre

Constructed Embankments	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Litter removal	4	msf	20	80	1.3	26	35	26	35	10% of an acre
Monitoring	7	msf	30	210	3.5	12	42	2	7	Regular monitoring of vegetation and site conditions: site photos, take soil samples [if needed] inspection and action report
Invasive species control (flora)	4	msf	40	520	8.7	12	104	4	35	Weeding, herbicide treatment, cut and paint etc. 10% of an acre
Pest control	4	msf	15	60	1.0	4	4	4	4	10% of an acre
Over-seeding/replanting	7	msf	45	315	5.3	2	11	2	11	15% of an acre
Erosion control	9	msf	120	1,080	18.0	6	108	3	54	20% of an acre; landscapes and slopes repair from erosion: install erosion blanket, coir logs, compost and revegetate as needed
Landscape management	11	msf	180	1,980	33.0	4	132	2	66	25% of an acre; includes grass cutback (if necessary), seasonal removal/cleanup, prune back, removal of thatch, leaves etc., maintain log of actions taken
Graffiti removal		allow					8		8	Done on vertical walls
Structure inspection and maintenance		allow					5		5	Regular inspection of retaining structures
Riparian Areas - Constructed Embankments							**448**		**224**	**Annual Hours/1 Acre**

TRAILS

Description: Trails are the primary means of moving through the corridor. Trails will typically be concrete, and vary in width from 8'-14'; with 10' being the average width. The trails will likely have railings on the creekside edge; lighting and seating will be located along the trail. Other site furnishings, such as signage and small trashcans, will be affixed to railings. When cleaning, staff should take care to not wash or push the debris down into the creek level. Debris should be pushed towards the inner edge and then collected. In situations where cleaning agent is required, choose one that would be the least harmful to the planting and water quality.

Unit = 0.23 Acre
10,000 SF (assumes 1,000 LF and 10' wide)

Trails	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Empty trash/recycling cans	2	each	5	10	0.2	312	52	2/1,000 LF, 6x/week for 52 weeks
Remove litter/debris	1.5	msf	4	6	0.1	52	5	15% of unit , weekly
Clean paths	1	msf	10	10	0.2	12	2	10% of unit, weekly; with hand sweeper, broom, or backpack blower to limit debris getting into the creek
Powerwash	5	msf	15	75	1.3	52	65	50% of unit, done monthly to remove stains
Pest control	1	msf	8	8	0.1	12	2	10% of unit
Clean/maintain furnishings	4	each	40	160	2.7	6	16	4/unit, done monthly; includes lighting, trashcans, bike racks, etc.
Railing maintenance	2.5	clf	20	50	0.8	12	10	25% of railing; done monthly, cleaning wiping down with mild detergent, connections are to be inspected and tightened as necessary
Maintain drinking fountains	1	each	15	15	0.3	12	3	1/trailhead; routine cleaning/maintenance
Repair lights		allow					6	Repair damage/bulbs for site lighting; assumes 3 occurances
Graffiti removal		allow					8	
Hardscape maintenance		allow					5	Includes patching or any necessary repair work on concrete and concrete edges (erosion)
Signage		allow					3	Repair and cleaning of park and interpretive signs
Trails							**177**	**Annual Hours/0.23 Acre**

TRAILS ON STRUCTURES

Description: Trails on structure are supported by piers, pilings, or footings; in some cases, these trails are integrated into larger structures, such as the Waller Creek Tunnel side-flow inlets. Trails on structure also include small foot bridges at creek level and the areas under these bridges. Trails on structure will have the same kind of amenities as normal trails, but in some cases, railing may be required on both sides. Site furnishing will be bolted onto these rails to conserve space. Some trailheads may also be trails on structure. It is also assumed that trails on structure average 10' width.

Unit = 0.23 Acre
10,000 SF (assumes 1,000 LF and 10' wide)

Trails on Structures	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Empty trash/recycling station	2	each	5	10	0.2	312	52	2/1,000 LF, 6x/week for 52 weeks
Remove litter/debris	1.5	msf	4	6	0.1	52	5	15% of unit , weekly, includes underside of structure
Clean catchbasin inlets	4	each	10	40	0.7	12	8	4/unit, monthly
Blow paths with backpack blower	5	msf	5	25	0.4	52	22	50% of unit, weekly; with backpack blower
Powerwash	2	msf	8	12	0.2	12	2	50% of unit, done monthly to remove stains
Pest control	1	msf	30	30	0.5	6	3	10% of unit
Clean/maintain furnishings	4	each	10	40	0.7	12	8	4/unit, done monthly; includes lighting, trashcans, bike racks, etc.
Railing maintenance	2.5	clf	20	50	0.8	12	10	25% of rail; done monthly
Repair lights		allow					6	Repair damage/bulbs for site lighting; assumes 3 occurances
Graffiti removal		allow					8	
Hardscape maintenance		allow					5	Includes patching or any necessary repair work on concrete or concrete edges (erosion)
Structure maintenance		allow					5	Task applies to general inspection and minor maintenance or structure elements. Does not include any major repair work.
Signage		allow					5	Repair/cleaning of park and interpretive signage
Trails on Structures							**139**	**Annual Hours/0.23 Acre**

BRIDGES

Description: Bridges are integrated with the circulation network, but differ from trails on structure in that they span greater distances. In many cases, bridges will connect trails well above creek level. Bridges will need regular safety and structural inspections, and repairs done immediately. Additionally, bridges will need to be inspected for graffiti and debris that should be removed. Bridges may consist of different materials such as cable, composite decking, concrete, or steel. Bridges are assumed to be an average of 14' wide.

Unit = 0.32 Acre
14,000 SF (assumes 1,000 LF and 14' wide)

Bridges	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Empty trash/recycling cans	2	each	5	10	0.2	312	52	2/1,000 LF, 6x/week for 52 weeks
Remove litter/debris	1.5	msf	4	6	0.1	52	5	15% of unit , weekly
Blow with backpack blower	7	msf	5	35	0.6	52	30	50% of unit, weekly; with backpack blower
Powerwash	7	msf	8	56	0.9	12	11	50% of unit, done monthly to remove stains
Pest control	1	msf	30	30	0.5	6	3	10% of unit
Clean/Maintain furnishings	4	each	10	40	0.7	12	8	4/unit, done monthly; includes lighting, trashcans, signage, bike racks, etc.
Railing maintenance	2.5	clf	20	50	0.8	12	10	25% of railings; done monthly
Repair lights		allow					6	Repair damage/bulbs for site lighting; assumes 3 occurances
Graffiti removal		allow					8	
Hardscape maintenance		allow					3	Includes patching or any necessary repair work on concrete
Structure maintenance		allow					5	Task applies to general inspection and minor bridge maintenance. Does not include any major repair work.
Bridges							**142**	**Annual Hours/0.32 Acre**

RESTORATION AREAS - SLOPES

These areas are the slopes abutting the creek channel, from top-of-bank to the water's edge. Slopes are typically 2:1 to 4:1. Vegetation on riparian slopes are characterized by native trees, shrubs, groundcover, and grasses. These areas do not have trails and are not intended for frequent use. However, these areas will be impacted by park users, adjacent development and upland urban land uses. Management of these areas will be function-driven and depend on regular monitoring. Depending on the species mix, these areas may require semi-annual management actions, including invasive species and pest control, overseeding, and soil amendments. During establishment, additional actions may include irrigation inspection and maintenance. Regular monitoring for erosion and related repairs, and for public safety hazards, such as debris on trails and low-hanging branches, will need to occur regularly. Litter and debris removal will happen on an as-needed basis, with sensitivity to organic debris,such as fallen leaves, that may be beneficial to the habitat. Access for all maintenance and monitoring activities may take additional time due to steepness of slopes and limited access from top-of-bank when adjacent to buildings and private development sites.

Unit = 1 Acre

Restoration Areas - Slopes	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Litter removal	4	msf	15	60	1.0	12	12	12	12	20% of an acre
Debris removal		allow					5		5	Debris removal, such as tree stumps or other floatables
Monitoring	7	msf	60	420	7.0	12	84	2	14	15% of an acre; regular monitoring of vegetation and site conditions: site photos, take soil samples [if needed] inspection and action report
Invasive species control (flora)	7	msf	40	280	4.7	12	56	4	19	15% of an acre; weeding, herbicide treatment, cut and paint etc., done on an as needed basis based on monitoring
Pest control	4	msf	15	60	1.0	4	4	4	4	10% of an acre; done on an as needed basis based on monitoring
Over-seeding/replanting	7	msf	30	210	3.5	2	7	2	7	15% of an acre; done on an as needed basis based on monitoring
Irrigation inspection + maintenance	4	msf	45	180	3.0	12	36			Temporary irrigation, system will only be used during establishment period and will be turned off after establishment
Soil amendments (OM, fertilizer, mulch)	17	msf	60	1,020	17.0	2	34	1	17	40% of an acre; done on an as needed basis based on monitoring
Erosion control	9	msf	120	1,080	18.0	4	72	2	36	20% of an acre; landscapes and slopes repair from erosion: install erosion blanket, coir logs, compost and revegetate as needed
Spot-watering	9	msf	20	180	3.0	6	18	12	36	15% of an acre; hand watering to help plants established during the establishement period. Some time is allocated for post-establishment period during time of
Landscape management	11	msf	180	1,980	33.0	4	132	2	66	25% of an acre; includes grass cutback (if necessary), seasonal removal/cleanup, prune back, removal of thatch, leaves etc., maintain log of actions taken
Vegetation protection	11	msf	45	495	8.3	4	33	4	33	25% of an acre; protect areas that have been repaired or overused; install temporary fence, tree protection, tree/shrub staking, flagging, signage
Restoration Areas - Slopes							**493**		**249**	**Annual Hours/1 Acre**

CREEK CHANNEL

The creek channel is primarily the area within the corridor within the 100-year floodplain. It includes riffles, pools, and other aquatic features, floodplain benches, and wetland benches, both existing and proposed. These areas will get no public use, and maintenance will be minimal. After storm events debris may accumulate which will need to be removed.

Unit = 0.34 Acre
15,000 SF (assumes 1,000 LF and 15' wide)

Creek Channel	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Remove litter - landside	2	clf	60	90	1.5	52	78	52	78	20% of entire length, weekly
Remove litter and debris - waterside	2	clf	240	360	6.0	12	72	12	72	Done monthly, after a large flood event, or routine maintenance. To be done with a small boat. Task only applicable from Lady Bird Lake to Cesar Chavez
Landscape maintenance	3	msf	180	540	9.0	4	36	2	18	20% unit, revegetation/planting/seeding/plant removal, includes time for woody plant removal
Erosion control	3	msf	180	540	9.0	4	36	2	18	20% of unit, as needed (raking/material infill/stabilization)
Monitoring and inspection		allow					12		12	Quarterly
Structure maintenance		allow					10		10	Routine maintenance on built structures
Creek Channel							**244**		**208**	**Annual Hours/0.34 Acre**

STORMWATER MANAGEMENT

Stormwater management will include rain gardens, outfalls, overbank and other features to help manage stormwater runoff. These areas will get little or no public use. Maintenance will be minimal but rain gardens will require some regular horticultural maintenance. Most stormwater management features will require regular inspections before and after storms or rain event.

Unit = 0.11 Acre
5,000 SF

Stormwater Management	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Remove litter	11	msf	20	220	3.7	12	44	12	44	Done on a monthly basis
Remove large debris		allow					15		15	Removal of large debris from storms or rain event
Remove invasive species		allow					15		10	
Landscape maintenance	1.3	msf	180	225	3.8	4	15	2	8	25% of unit; only applicable to rain gardens
Erosion control	1	msf	180	180	3.0	4	12	2	6	15% of unit; As needed (raking/material infill/stabilization), replanting
Monitoring and inspection		allow					8		5	Monthly
Cleanout		allow					16		16	Done once a year
Stormwater Management							**125**		**104**	**Annual Hours/0.11 Acre**

UPLAND CORRIDOR EDGE

The upland corridor edge is the boundary between the creek corridor/publicly-accessible trail system and adjacent properties. The edge itself will get limited use, but a fence or other boundary structure will be needed to separate the creek corridor from adjacent properties and/or recreational/ecological areas when these uses are incompatible. The fence may be planted with vines or other screen plantings; vegetation will need regular upkeep. Litter that gets caught in the fences will also need to be removed. Fences may also have graphic information that will need to be maintained and periodically updated. Invasive species will need to be removed from the ground plane as necessary, some reseeding/replanting may be needed. There is potential for erosion and erosion control may be needed and coordinated with adjacent property owners.

Unit = 0.28 Acre
12,000 SF (assumes 1,000 LF and 12' wide)

Upland Corridor Edge	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Estab. Freq (Annual)	Estab. Total Hours	Post-Estab. Freq (Annual)	Post-Estab Total Hours	Comments
Remove litter	2	df	30	72	1.2	26	31	26	31	20% of entire length (30' wide), bi-weekly
Remove litter - fence	2	df	30	45	0.8	12	9	12	9	15% of length of fence, focus primarily on the bottom and the face of the face, done monthly
Invasive species control (flora)	2	msf	60	120	2.0	12	24	4	8	Weeding, herbicide treatment, cut and paint etc. 15% of unit
Landscape maintenance	6	msf	120	720	12.0	4	48	2	24	50% of unit, includes cutback, pruning/trimming, replanting, etc.
Monitoring and inspection	2	msf	30	60	1.0	12	12	2	2	15% of an acre; regular monitoring of vegetation and site conditions: site photos, take soil samples [if needed] inspection and action report
Erosion control	2	msf	120	288	4.8	4	19	2	10	20% of an acre; landscapes and slopes repair from erosion: install erosion blanket, coir logs, compost and revegetate as needed
Fence (structure) maintenance		allow					5		5	
Fence graphic panel and component maintenance		allow					5		5	Check for attachment connections, any tear in the panels, etc. Replace as needed.
Upland Corridor Edge							**153**		**94**	**Annual Hours/0.28 Acre**

PARKLAND

Description: Parkland includes areas that will receive regular use by the general public. Both passive activities and heavily programmed public events will occur in parkland. In some cases, trailheads and other more intensely planted or used areas within the creek corridor are considered to be parkland. Parkland will require regular trash pick-up, horticultural maintenance, and site furnishing maintenance.

Unit = 1 Acre

Parkland	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Empty trash/recycling station	4	each	5	20	0.3	516	172	4/acre, 5x/week for 36 weeks (8 months), 3x/day for 16 weeks (4 months)
Remove litter/debris	11	msf	5	55	0.9	52	48	25% of an acre , weekly
Blow paths with backpack blower	4	msf	5	20	0.3	52	17	10% of acre, weekly; with backpack blower
Mow turf (open areas)	31	msf	3	93	1.6	52	81	60% of an acre; Toro Groundmaster or equal
Trim w/string trimmer	10	clf	3	30	0.5	52	26	1,000 lf/acre
Seasonal turf renovation	9	msf	80	720	12.0	3	36	20% of an acre, thatch, aerate, seed, monitor
Tree maintenance	10	each	25	250	4.2	5	21	assume 10 trees/acre; includes fertilizing, pruning and replacement
Shrub bed maintenance	9	msf	35	315	5.3	6	32	20% of an acre ; bi-monthly. pruning, plant replacement
Spot watering		allow					12	
Pest control	4	msf	15	60	1.0	6	6	10% of an acre
Temporary fence	2.5	clf	10	25	0.4	10	4	Install/maintain temporary fencing, assume 250 lf/acre
Clean catchbasin inlets	4	each	4	16	0.3	12	3	4/acre, monthly
Clean catchbasin sumps	4	each	30	120	2.0	2	4	4/acre, 2x/year
Clear storm drain system		allow					5	
Clean/maintain furnishings	4	each	6	24	0.4	12	5	4/acre, done monthly; includes lighting, trashcans, signage, bike racks, etc.
Annual furnishing maintenance	4	each	40	160	2.7	1	3	Once annually, includes repainting, recoating, thorough inspection and maintenance, etc.
Maintain drinking fountains	1	each	10	10	0.2	12	2	1/acre; routine cleaning/maintenance
Irrigation inspection and repair		allow					20	replace damaged sprayheads and damaged line
Replace lights		allow					4	Assumes 2 occurances
Hardscape maintenance	4	msf	25	100	1.7	2	3	10%; includes patching or any necessary repair work on concrete
Parkland							**503**	**Annual Hours/1 Acre**

RESTROOMS

Public access restroom facility with separate mens/womens rooms. The restrooms will be accessible by the public year-round. While winterization is not needed, it is recommended that seaonsal maintenance should be preformed to ensure the facilities are running efficiently. Facilities will require regular cleaning and restocking, periodic replacement and repairs, graffiti should be removed as soon as possible. It is also assumed a drinking fountain is attached to each of these facilities.

Unit = Each

Restrooms	QTY	Unit	Unit (mins)	Once (mins)	Once (hours)	Annual Freq	Total Hours	Comments
Clean	2	each	15	30	1	726	363	(Mens/Womens); Includes cleaning and disinfecting of sinks, counters, urinals, toilets, walls and floors, Daily for 4 months, 2x a day for 4 months, and 3x a day for 4 months
Remove Graffiti		allow					20	Includes both gum and graffiti removal
Repairs		allow					20	Includes material replacement, facility repair, utility maintenance, etc.
Seasonal maintenance		allow					4	Startup and shutdown
Maintain drinking fountains	1	each	15	15	0.3	52	13	1/restroom; routine cleaning/maintenance
Restrooms							**420**	**Annual Hours/Each Restroom**