Oak Knoll Storm Drain Improvements

Preliminary Engineering Report | City of Austin

1/15/2018

LAN Project No. 120-11884-001

Lockwood, Andrews & Newnam, Inc.
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Executive Summary

The Oak Knoll neighborhood has been subjected to significant structural flooding in recent flood events due to deficiencies with the local drainage infrastructure. The purpose of this report is to summarize the results of the analysis and provide the City recommendations regarding the feasibility of flood mitigation improvement projects in the area. The overall project includes detailed hydrologic, hydraulic, and alternatives analysis within the project area to reduce localized flooding in the region.

The City of Austin Watershed Protection Department has divided the project into three areas: The Oak Knoll Drive Storm Drain Improvements (SDI), Arabian Trail SDI, and Bell Avenue SDI are ranked #17, #95, and #38 respectively on the fiscal year 2018 Local Flood Hazard Mitigation storm drain improvement problem area priorities list. Hydrologic and hydraulic analysis of project improvements was performed utilizing InfoWorks® ICM "rain on mesh". Field survey of existing right-of-way was performed within each of the three study areas, as well as obtaining As-Built Elevation survey information for properties reporting structural flooding. A Phase 1 Environmental Site Assessment was conducted, which showed no Recognized Environmental Conditions were identified.

A total of nine (9) alternatives, three for each project area, were analyzed and evaluated. A goal of this study is to identify a solution for each study area that meets the Drainage Criteria Manual (DCM) requirements by providing pipe conveyance for the 25-year storm event in the gutter or below grade, while maintaining the 100-year storm within the right-of-way, removing all homes from the 100-year flood risk, and meeting minimum easement width requirements. In addition to meeting DCM requirements, other considerations included estimated construction costs, easement requirements, downstream impacts, traffic impacts, utility crossings, and constructability, among others. Life-cycle costs were estimated for each alternative, based on a 50-year service life expectancy.

The following storm drain improvements are recommended to address local flooding in each of the three study areas, as described below:

Oak Knoll Drive study area: Alternative 3 is the recommended solution for the Oak Knoll Drive study area, which includes construction of approximately 1,160 linear feet of new 4-ft x 3-ft reinforced concrete box culvert southeast along Woodcrest Drive and 300 linear feet of additional storm drain pipe northeast along Broad Oaks Drive (24-inch RCP), Oak Knoll Drive (30-inch RCP), and Three Oaks Trail (36-inch RCP), as well as approximately 380 linear feet of 5-ft x 3-ft reinforced concrete box culvert northwest connecting to 345 linear feet of upgraded storm drain system (6-ft x 3-ft box culvert) and new storm drain inlets across Columbia Oaks Court. The selected alternative removes 7 homes from the 100-yr floodplain and reduces flooding for 9 homes potentially at risk with an estimated cost of $2.3M. This alternative provides the same overall benefits as Alternative 2, in terms of addressing structural and yard flooding, but is less disruptive to residence. While Alternative 1 is the least expensive alternative, it does not remove as many structures from flooding as Alternative 3, which is one of the main objectives of the project.

In order to mitigate the downstream impacts across Jollyville Road and at Walnut Creek Tributary 7, Doucet + Chan designed a detention pond at the USPS plot of land downstream of the Oak Knoll outfall pipe. Calculations show that, this pond mitigated the impacts at Walnut Creek Tributary 7, but do not fully mitigate the increased flow over Jollyville Road. Although these

calculations indicate that the potential for impacts still exist for the Oak Knoll area with the designed detention pond, further analysis and optimization may mitigate these potential impacts.

The current design of the proposed storm drain system improvements is included in Appendix G of this PER. As this project progress to the Final Design phase and permitting, the final storm system design may change slightly from the results published in this PER.

Arabian Trail study area: Alternative 3 is the most cost effective solution for the Arabian Trail study area, which includes approximately 960 linear feet of 24-inch and 30-inch diameter RCP, and a 6-inch curb and gutter. This alternative provides similar benefits as Alternative 2, in terms of addressing structural and yard flooding. Alternative 3 removes 1 homes from the 100-yr floodplain and reduces flooding for 9 homes potentially at risk with an estimated cost of $500,000. Alternatives 1 and 2 both result in significant downstream impacts while alternative 3 results in only 1 cubic foot per second (cfs) increase in peak flow at Walnut Creek Tributary 7. Given that the area is fully developed, opportunities for mitigation are very limited.

Further modeling (and validation) was conducted in an attempt to duplicate the flood complaints for this area. However, these additional scenarios were also unable to produce flooding conditions consistent with the reported flooding from the October 2013 event. Given that there is good correlation throughout the rest of the study, the extent and severity of the problem is in question. Further analysis is required for this area in order to justify the cost of any improvements.

Bell Avenue study area: Alternative 1 is the recommended solution for the Bell Avenue study area, which includes approximately 2,370 linear feet of 6-ft x 3-ft concrete box culvert and 6-inch curb and gutter along Bell Avenue, from Jollyville Road to the US-183 frontage road, as well as a 24-inch RCP storm drain lateral along Secrest Drive. The selected alternative removes 8 homes from the 100-yr floodplain and reduces flooding for 4 homes potentially at risk with an estimated cost of $1.7M. This alternative can be fully constructed within existing right-of-way and would not warrant any permanent easements with private property owners. Each of the three alternatives has a local impact to the ponding depth within the US-183 Frontage Road and decrease the peak flow rate downstream at the outfall to Walnut Creek Tributary 7. LAN coordinated with the US-183 Project Team, which is currently studying improvements to US-183. However, at the time of this PER, no changes were proposed to the existing drainage system within the US-183 right-of-way. It is recommended that coordination with the Texas Department of Transportation (TxDOT) and the US-183 Project Team continue through the Final Design, Bidding and Construction Phases of the Oak Knoll Storm Drain Improvements project in order to address local impacts. Each of the three alternatives decrease the peak flow rate downstream at the outfall to Walnut Creek Tributary 7.

Table of Contents

1. Introduction

The City of Austin has identified the need to address existing flooding issues in the Oak Knoll area which is divided into three drainage systems located in the vicinity of Oak Knoll Drive, Arabian Trail and Bell Avenue. The project area is located in the Walnut Creek watershed in northwest Austin, Texas in the headwaters of Tributary Number 7. A location map is provided as Exhibit 1 of Appendix A.

Initial investigation of the overall storm drain drainage system quickly revealed the complex nature of flooding in the area. There are various storm sewer networks that drain multiple detention and retention ponds. The source of flooding is not evident at first glance; therefore, a detailed InfoWorks Integrated Catchment Modeling (ICM) 2-dimensional (2D) model is used to assess the performance of the existing drainage infrastructure and better understand the causes of the observed flooding. The following sections described the methods used in this analysis and the recommended solutions.

The primary data sources regarding the existing stormwater system in the study area were City provided GIS data, as-built construction plans provided by the City, field survey and site investigations. Other spatial GIS data was provided by the City and used in the study such as land cover, streets, building footprints, impervious cover, and contours. Capital Area Council of Governments (CAPCOG) 2012 LiDAR terrain data was obtained from the Texas Natural Resources Information System (TNRIS).

Figure 1: High water mark, Oak Knoll area, May 2015 flood

Historic flood photos and high water mark information (as shown in Figure 1) gathered during the April 2013, October 2013 and May 2015 flood events were also provided by the City. Flow and flood level measurements are not available. Observations are generally more qualitative in nature and model results are in general agreement with the observations.

1.1 Oak Knoll Drive Study Area

The Oak Knoll Drive study area is ranked #17 on the Local Flood Hazard Mitigation storm drain improvement (SDI) problem area priorities list for fiscal year (FY) 2018. The project is intended to alleviate the flooding where residents have reported 12 locations of house flooding and 8 locations of yard flooding. The Oak Knoll SDI project is generally bounded by Broad Oaks Drive along the west, Scrub Oak Ln. along the north, Columbia Oaks Drive along the east and Woodcrest Drive along the south. The existing storm drain infrastructure was constructed in the 1970s and 1980s and the project area is approximately 16.82-acres.

1.2 Arabian Trail Study Area

The Arabian Trail study area is ranked #95 on the Local Flood Hazard Mitigation SDI problem area priorities list for FY 2018. The project is intended to alleviate the flooding where residents have reported 6 locations of house flooding, 5 locations of yard flooding, and 1 location of street flooding. The Arabian Trail SDI is generally bounded by Arabian Trail along the west and north,

Secrest Drive along the east and Jollyville Road along the south. The existing storm drain infrastructure was constructed in the 1950s and the project area is approximately 32.5-acres.

1.3 Bell Avenue Study Area

The Bell Avenue study area is ranked #38 on the Local Flood Hazard Mitigation SDI problem area priorities list for FY 2018. The project is intended to alleviate the flooding where residents have reported 5 locations of house flooding and 3 locations of yard flooding. The Bell Avenue SDI is generally bounded by Arabian Trail to the north, US-183 to the east, Jollyville Road to the south and Secrest Drive to the west. The existing storm drain infrastructure was constructed in the 1950s and the project area is approximately 59-acres.

1.4 Purpose of this Report

The purpose of this study is to identify flood prone areas and make recommendations regarding the feasibility of flood mitigation projects in each area. This study also identifies specific drainage improvements necessary to address issues of conveyance, flooding, and maintenance at three separate locations, and develop preliminary recommendations and estimates of construction cost for the City's consideration. A hydrologic analysis is included to establish existing conditions and provide a basis for the proposed SDI in the hydraulic analysis. These projects are described in summary in the following section and comprehensively in the ensuing sections of this report.

2. Hydrologic and Hydraulic Analysis

The "rain on mesh" (ROM) method in Infoworks® Integrated Catchment Modeling (ICM) was used in this analysis and design to simulate the runoff and conveyance characteristics throughout the study area for the 2-, 5-, 10-, 25-, 50-, and 100-year (50%, 20%, 10%, 4%, 2%, 1% chance of occurrence) design storms. In this method, rainfall (or rainfall excess) is uniformly applied to a land surface model derived from the LiDAR terrain data. The following sections summarize the methods used and Appendix B includes the detailed 2D modeling guidelines. This study also includes computations using the City of Austin's standard methods (HEC-HMS and Rational Method) for comparison purposes. Back up information and computer models are included in Appendix C.

2.1 Precipitation

The design storms used in this analysis include the use of an NRCS Type III distribution with a 24-hour duration. The precipitation depths for each design storm presented in Table 1 are taken from the City of Austin Drainage Criteria Manual (DCM).

Table 1: Depth-Duration-Frequency Table for Austin and Travis County

Depth of Precipitation (in inches)									
Recurrence Interval (year)	**5 min***	**15 min**	**30 min**	**1-hr**	**2-hr**	**3-hr**	**6-hr**	**12-hr**	**24-hr**
2	0.48	0.98	1.32	1.72	2.16	2.32	2.67	3.06	3.44
5	0.62	1.26	1.71	2.28	2.89	3.13	3.56	4.07	4.99
10	0.71	1.47	1.98	2.68	3.42	3.71	4.21	4.81	6.1
25	0.84	1.76	2.36	3.28	4.2	4.55	5.14	5.90	7.64
50	0.94	2.01	2.68	3.79	4.88	5.28	5.94	6.86	8.87
100	1.05	2.29	3.04	4.37	5.66	6.11	6.85	7.96	10.2
* The 5-min rainfall depths were calculated using the 5-min rainfall intensity values from CoA DCM.									

2.2 Drainage Area

The "rain on mesh" methodology does not require the delineation of the watershed or subareas. However, for the purposes of computing runoff for HEC-HMS and the Rational Method for comparison, the subareas were delineated using the LIDAR, the City's GIS storm drain information, and field visit information. Exhibit 1 in Appendix A illustrates the subareas delineation and the study areas for the three (3) drainage systems.

2.3 Infiltration Losses (HEC-HMS)

The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service) has developed a rainfall runoff index, the runoff curve number (CN), which takes into account such factors as soil characteristics, land use/land conditions, and antecedent soil moisture to derive a generalized rainfall runoff relationship for a given area. A description of these components and the equation for calculating runoff depth from rainfall are provided below.

The NRCS classifies soils into four hydrologic soil groups: A, B, C, and D. These soil groups indicate the runoff potential of a soil, ranging from a low runoff potential (group A) to a high runoff

potential (group D). Using ArcMap 10.3 software and the delineations of the soil types found in the Soil Survey of Travis County (USDA), a composite curve number was calculated for each sub-area in the watershed.

The NRCS provides runoff curve numbers for three antecedent moisture conditions (AMC): I, II, and III. AMC I represents dry soil conditions and AMC III represents saturated soil conditions. AMC II, which represents average soil moisture conditions, is assumed for this analysis. Runoff curve numbers vary from 0 to 100, with the smaller values representing lower runoff potential and the larger values representing higher runoff potential. CN values between 81 and 84 were calculated for the soil types within the study area. HEC-HMS computes 100% runoff from impervious soil conditions, while runoff from less pervious soil conditions is estimated using the selected CN value and the following equations:

$$Q = (P - 0.2 \times S)^2 / (P + 0.8 \times S)$$

Equation 1

$$CN = 1000 / (10 + S)$$

Equation 2

Where:

Q = depth of runoff (in),
P = depth of precipitation (in),
S = potential maximum retention after runoff begins, and
CN = runoff curve number.

Computed curve numbers for each subarea are tabulated on Appendix C.

The hydrologic model utilizes weighted impervious cover values calculated for each watershed subarea. The weighted impervious cover used for the ultimate conditions model ranges between 49% and 90%. These values are derived from the City of Austin future land use information. The upper Walnut Creek Tributary No. 7 watershed is essentially fully developed. Impervious cover values for each subarea are tabulated in Appendix C.

2.4 Runoff Coefficient (Rational Method)

The runoff coefficient (C) is the rational method variable which takes into account the surface vegetation condition, soil type, imperviousness of the surface, land slope and ponding characteristics of the area. Impervious surfaces, such as asphalt pavements and roofs of buildings, will be subject to approximately 100 percent runoff (regardless of the slope). For the purposes of this analysis, the impervious cover values for each subarea were converted to C-values using the following equation:

$$C = IC/100 \times C_{IMPERV} + (1\text{-}IC)/100 \times C_{PERV}$$

Equation 3

Where:

C = computed runoff coefficient
IC = impervious cover (%)
C_{IMPERV} = impervious runoff coefficient from Table 2
C_{PERV} = pervious runoff coefficient from Table 2

Table 2: Rational Method Runoff Coefficients (City of Austin DCM)

25-yr	100-yr	Character of Surface
0.42	0.49	Pervious area - Fair condition, 2-7%
0.86	0.95	Impervious area - Asphaltic

Computed runoff coefficients for each subarea are tabulated on Appendix C.

2.5 Time of Concentration

For the Rational Method, the time of concentration (T_C) is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed (NRCS, 1985). For the NRCS unit hydrograph in HEC-HMS, the lag time (T_{LAG}) is assumed to be 60% of the watershed's time of concentration. It may be estimated by calculating and summing the travel time for each sub-reach defined by the flow type: sheet flow, shallow concentrated flow, roadway, storm sewers and channelized flow. The methods prescribed in the NRCS' Technical Release 55 (TR-55) were used to determine the time of concentration and lag time for each subarea. Appendix C shows the results of the calculations for this analysis utilizing each typical flow segment as presented below.

2.5.1 Sheet/Overland Flow (≤ 100ft)

Sheet flow is flow over plane surfaces. It usually occurs in the headwaters of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact, of drag over the plane surface and obstacles such as litter, crop ridges, and rocks, and of erosion and transportation of sediment. These n values are for very shallow flow depths of approximately 0.1 foot. Assuming sheet flow of less than or equal to 100 feet, travel time is computed as follows:

$$T_t = (0.007 \times (n \times L)^{0.8}) / (P_2^{0.5} \times s^{0.4})$$

Equation 4

Where:

T_t = travel time (hr),
L = Length of the reach in (ft),
n = Manning's roughness coefficient,
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (ft/ft).

2.5.2 Shallow Concentrated Flow

After a maximum of 100 feet, sheet flow usually becomes shallow concentrated flow. The flow is still considered shallow in depth and flows in a swale or gutter instead of a channel, which has greater depth. The average travel time can be determined from the following equations in which average velocity is a function of watercourse slope and type of channel (TR-55).

$$\text{Unpaved: } T_t = L / (16.1345 \times s^{0.5})$$

Equation 5

$$\text{Paved: } T_t = L / (20.3282 \times s^{0.5})$$
Equation 6

Where:

T_t = travel time (hr),
L = flow length (ft),
s = slope of hydraulic grade line (ft/ft).

2.5.3 Channel/Storm Drain Flow

The velocity in an open channel or a storm drain not flowing full can be determined by using Manning's Equation. Channel velocities can also be determined by using backwater profiles. For open channel flow, average flow velocity is usually determined by assuming a bank-full condition. Note that the channel flow component of the time of concentration may need to be divided into multiple segments in order to represent significant changes in channel characteristics or pipe flow. Manning's equation or water surface profile information can be used to estimate average flow velocity. Channel flow was calculated using Manning's Equation and dimensions (bottom width, side slopes) measured in the field.

Manning's equation is:

$$V = 1.49 \times R^{2/3} \times s^{0.5} / n$$
Equation 7

Where:

V = average velocity (ft/sec),
R = hydraulic radius (ft), equal to flow area divided by wetted perimeter,
s = slope of the hydraulic grade line (channel slope, ft/ft), and
n = Manning's roughness coefficient.

After computing the velocity, the following equation is used to compute travel time:

$$T_t = L / (3600 \times V)$$
Equation 8

Where:

T_t = total flow travel time (min),
L = channel length (ft), and
V = average velocity (ft/sec).

2.6 Runoff Routing

InfoWorks ICM is an integrated modeling platform that incorporates both urban and river catchments. With full integration of 1D and 2D hydrodynamic simulation techniques, both the above- and below-ground elements of catchments can be modeled to accurately represent all flow paths. InfoWorks ICM enables the hydraulics and hydrology of natural and man-made environments to be incorporated into a single model.

Storm sewer connectivity, sizes, and flowlines from the City were adjusted in order to match City provided as-built information. Where flowline or size information was not available from as-built information, it was supplemented with field measurements or assumed from surrounding similar pipes. In areas with no upstream or downstream information, pipe flowlines were assumed to be installed at grades sufficient to provide full flow velocities at three feet-per-second.

In the model, a triangular mesh is generated to perform the analysis of the surface flows using the built-in InfoWorks mesh creation process. Elevations at the vertices of the generated mesh elements are interpolated from the LiDAR provided by the City. Overland roughness zones were incorporated into the 2D mesh surface to account for variations in surface roughness such as the change from concrete areas to grassed areas.

Inlet capacity, within the study areas, was evaluated as part of this study. Inlets were modeled as a two part element consisting of an upstream modeling node interacting with the 2D mesh surface connected to a "capped" weir connected to a sealed node representing the connection to the downstream storm sewer system (lateral or trunk line depending on the location). The upstream modeling node was set to a "2D" flood type to interact with the 2D mesh without any restrictions. The "capped" weir consists of parameters describing the physical inlet such as throat elevation, throat width, and opening height. The "capped" weir represents both the weir regime of flow to the inlet and the orifice regime of inlet flow after the inlet opening height has been exceeded and is surcharged. Weir parameters were assigned based on the as-built and digital stormwater database to account for inlet type, width, and height. Inlet capacity simulated results were checked for appropriateness. Manning's Roughness parameters for conduits were established as 0.012 for precast concrete pipe and 0.024 for corrugated metal pipe where appropriate.

2.7 Comparison of Computed Peak Flow Rates

For benchmarking, this study includes a comparison of "rain on mesh" (ROM) with the NRCS Method and the Rational Method. All three methods include techniques to reflect the slope of the terrain and its roughness. While NRCS Method and Rational Method rely on a single representative sample of watershed length to compute the time response for an area, the ROM method uses a distributed rainfall runoff model that reflects the entire surface. Distributed rainfall modeling can reduce the variability of engineering judgement that's required in selecting the travel path (and in the computing the corresponding velocity computations) and provide a reliable repeatable method for conducting analyses. The following sections describe a comparison of these methods and draws conclusions with respect to conducting this study.

2.7.1 NRCS Method vs. Rational Method

Figures 2 and 3 present a comparison for 41 subareas between computed peak flow rates from NRCS Method and Rational Method for the 25-year and 100-year frequency storms, respectively. NRCS generally produced higher peak flow rates. Overall, the results compare to within approximately 15% for both events and 90% of the values lie within 1% to 14% for the 25-year and 1% to 10% for the 100-year. The average difference is 7% for the 25-year and 6% for the 100-year. The line represents a 1 to 1 correlation for reference and Table 3 includes a summary of the results.

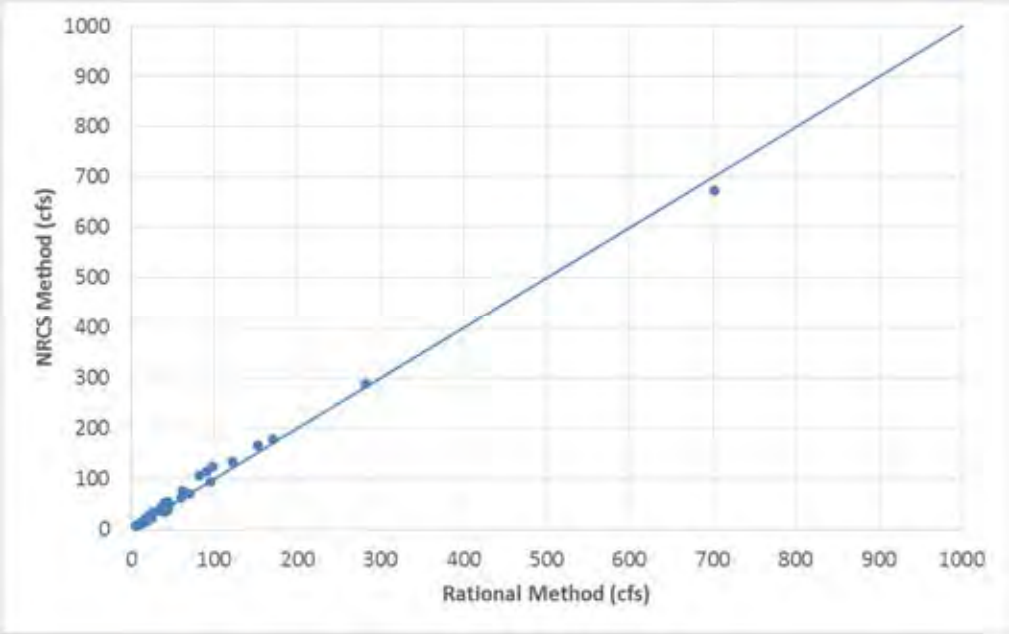


Figure 2 NRCS Method versus Rational Method (25 Year)

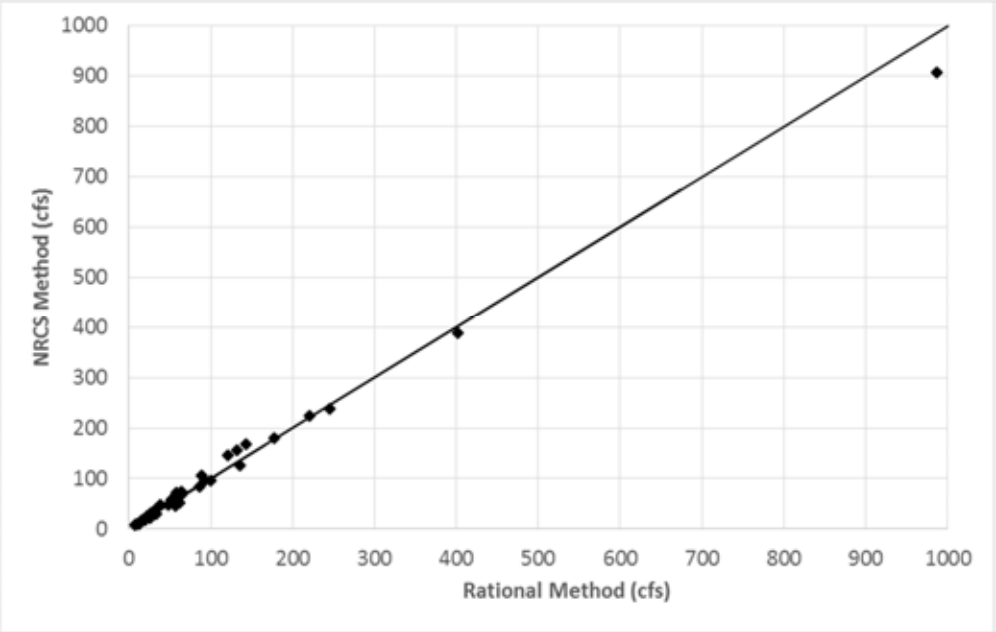


Figure 3 NRCS Method versus Rational Method (100 Year)

Table 3: Comparison of NRCS Method to the Rational Method

	Percent Difference	
	25-yr	**100-yr**
maximum	15%	11%
average	7%	6%
minimum	0%	0%

This comparison provides a point of reference to illustrate the consistency between these two widely used methods. Assuming that these calculations are acceptable and relatively accurate, a

subsequent comparison between NRCS Method and ROM can be used to support the use of InfoWorks ICM in this study.

2.7.2 NRCS Method vs. "Rain on Mesh"

For the purposes of this study, applied hydrology is rainfall derived from HEC-HMS (version 4.2) using the NRCS Method that is then applied to the mesh in ICM at a 2D point source for each drainage area (shown as "hydrograph applied" in Figure 4 below). "Rain on mesh" is the preferred method of analysis for this study area, because rainfall (or rainfall excess) can be distributed over the entire terrain, not just at the 2D point source, to better assess flood prone areas and the associated benefits of proposed solutions. Figure 4 illustrates the estimated floodplain limits for the distributed rainfall method (ROM) compared to applied hydrology applied to the terrain. Applied hydrology is not able to illustrate the full extent of inundation and over estimates flooding downstream of the 2D point source and is unable to quantify the extent (or risk) of flooding upstream. In addition, unlike NRCS Method which requires definitive subwatershed divides, ROM can account for runoff flows between subwatersheds to provide a more realistic expression of runoff characteristics.

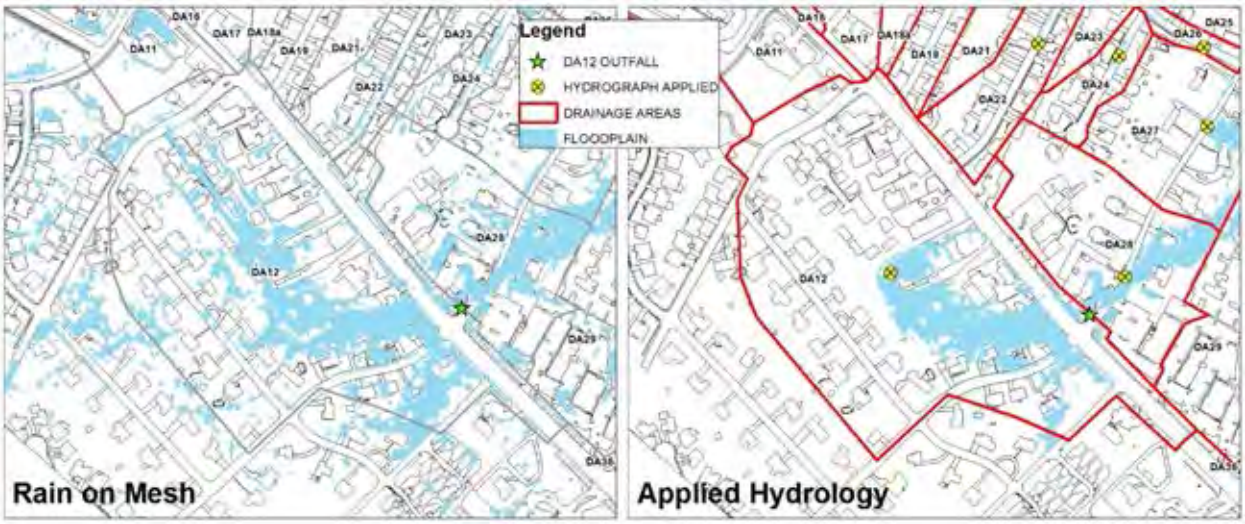


Figure 4: InfoWorks ICM Rain on Mesh versus Applied Hydrographs

In this study, there are two points of comparison available between the NRCS Method and ROM: an individual subarea and the total outflow from the study area. Only one subarea (DA12) was identified to have the least amount of overflow from other subwatersheds for a direct correlation. Both methods use the same rainfall totals and NRCS Type III distribution. However, the NRCS Method accounts for losses using the curve number and impervious cover while the initial ROM simulation utilizes total rainfall. Aside from depression storage in the surface, ROM does not explicitly account for soil infiltration. In the applied hydrology method, hydrographs are 'dropped' on (applied to) the InfoWorks ICM surface and routed to the outfall.

A comparison of the outflow hydrographs from DA12 and the total study area for the 25- and 100-year design storms events for the total rainfall (ROM), applied hydrology (NRCS Method), and excess precipitation (ROM) is summarized below. Table 4 and Table 5 show the peak flows and volumes for Drainage Area 12 and the total study area respectively.

Table 4: Peak Flows and Volumes for Drainage Area 12

Drainage Area 12				
	Peak Flow (cfs)		Volume (ac-ft)	
	25-Year	100-Year	25-Year	100-Year
Total Rainfall (ROM)	115	164	16	21
Applied Hydrology (NRCS)	115	156	17	23
difference	-	8	(1)	(2)
percent difference	0%	5%	-6%	-9%
Total Rainfall (ROM)	115	164	16	21
Excess Precipitation (ROM)	109	158	14	19
difference	6	6	2	2
percent difference	5%	4%	13%	10%

Table 5: Peak Flows and Volumes for Total Study Area

Total Study Area				
	Peak Flow (cfs)		Volume (ac-ft)	
	25-Year	100-Year	25-Year	100-Year
Total Rainfall (ROM)	1,904	2,604	326	446
Applied Hydrology (NRCS)	1,873	2,484	316	428
difference	31	120	10	18
percent difference	2%	5%	3%	4%
Total Rainfall (ROM)	1,904	2,604	326	446
Excess Precipitation (ROM)	1,816	2,517	293	410
difference	88	87	33	36
percent difference	5%	3%	11%	8%

When comparing the total rainfall (ROM) to the applied hydrographs method, computed peak flow rates are 2% to 5% higher with ROM for drainage area 12 and the total study area. The computed runoff volume is 6% to 9% lower from drainage area 12 and 3% to 4% higher from the total study area for ROM compared to NRCS.

When the excess precipitation (determined using NRCS infiltration losses) was applied to the mesh, for both events the peak flow was within 5% and the volume was within 13%. These results are expected due to the Type D soils (high curve number) in the area and the fact that that the drainage area is fully developed. Figures 5 and 6 show a comparison of the hydrographs.

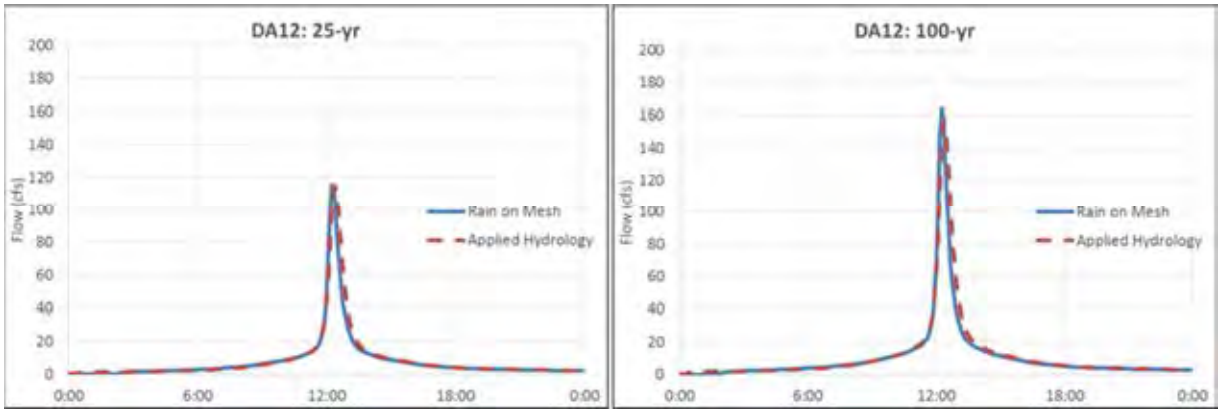


Figure 5: Hydrograph Comparison for Drainage Area 12 (DA12)

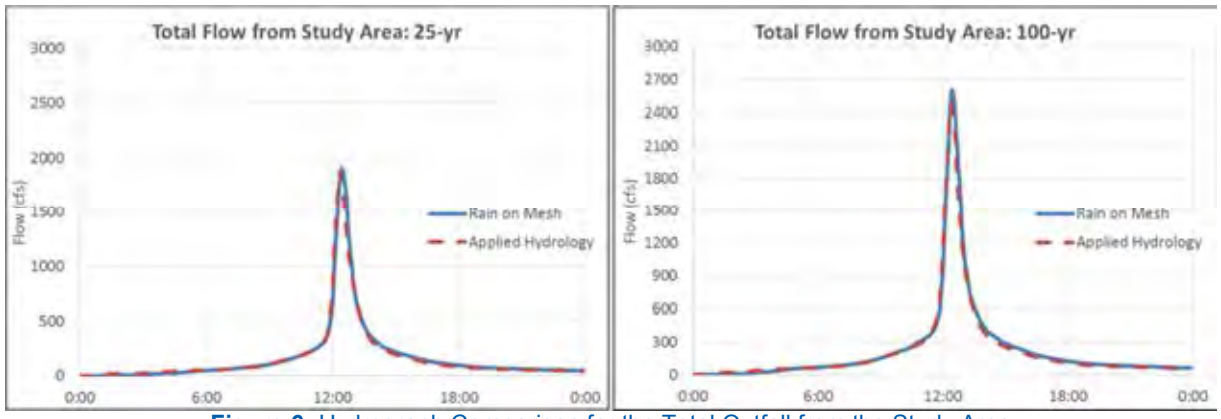


Figure 6: Hydrograph Comparison for the Total Outfall from the Study Area

From these results it can be concluded that InfoWorks ICM closely approximates the result of the Rational Method and NRCS Method for developed conditions for both the 25-year and 100-year design storms. Furthermore, given the variability of input parameters, the InfoWorks ICM ROM simulation provides a more comprehensive model of the watershed and a more descriptive simulation than the Rational Method or NRCS Method. Comparison between these methods is a good way to verify the results; however, it is expected that these computations result in slightly different answers. The total rainfall is used on the mesh in this study and surface storage is assumed to offset soil losses.

3. Utility Assessment

As part of the Preliminary Engineering phase, the project was submitted for review to the Austin Utility Location and Coordination Committee (AULCC) in order to collect existing utility information within the three project areas (Oak Knoll, Arabian Trail and Bell Avenue). LAN staff attended an AULCC coordination meeting on August 25, 2016. The AULCC members were provided with a map showing the conceptual project boundaries for this Pre-Design Phase. The project was assigned a Utility Coordination (UC) tracking number of UCC-160825-02-01 (ROW ID# 11577098). Information received from the AULCC is summarized in Appendix E.

In addition to the AULCC, LAN staff conducted a meeting with Austin Water (AW) staff on March 2, 2017 to discuss the project. The purpose of the meeting was to coordinate any potential water or wastewater Capital Improvement Project (CIP) improvements that may be planned within the project study limits, as well as understand AW requirements for addressing asbestos cement pipe, which is prevalent throughout the project limits. The majority of the water and wastewater utilities in this area were installed in the late 1970's and 1980's. Due to the age of the infrastructure, and the likelihood of multiple utility crossings and potential conflicts requiring adjustments or relocations, it is recommended that AW receive a copy of this final PER. AW will perform a clearance and adjustment review at completion of the 30% design stage.

Potential utility conflicts with existing utilities were identified based on the information received from the AULCC and AW meetings. The following assumptions were used to identify potential utility conflicts and quantify potential utility adjustments or relocations:

1) Proposed storm system is to be installed inside the existing right of way under pavement.

2) Proposed storm system could be designed to minimize adjustments at wastewater crossings.

3) Proposed storm system trench could be designed to meet the safe clearances recommended by AW, where proposed system parallels existing water lines. AW prefers a safe clearance of 5-feet between outer pipe diameters for parallel utilities at similar depths.

4) All asbestos cement (AC) water pipe must be removed and replaced with acceptable pipe at each proposed storm system crossing that exposes the AC pipe, per Utilities Criteria Manual, 2.9.2.B.18. It is assumed each AC pipe crossing will require removal and replacement. Pipe replacement was assumed to be between existing gate valves. If existing valves were not in the vicinity of the potential conflict, then a replacement of sixty (60) linear feet between two (2) new gate valves was assumed.

5) All cast iron water pipe crossings would require an adjustment, and would be replaced with sixty (60) linear feet of restrained ductile iron pipe.

6) All buried gas, electric, or telecommunication lines crossings could be in conflict with the proposed storm system.

In order to compare the alternatives, costs were estimated for relocating water lines at each proposed crossing, and crossings of buried, dry utilities (gas, electric, and telecommunications) were quantified. The results are summarized in Appendix E.

Based on the selected alternatives at completion of the PER phase, additional field survey is recommended for the final design phase to collect additional depth and flow line information for existing utilities along the selected alternatives corridors, including the elevation of the top of valves. In addition to field survey, due to the age of the existing water and wastewater infrastructure, Quality Level A (QL-A) Subsurface Utility Engineering (SUE) test holes are recommended to confirm pipe depths at potential crossings. AW recommended coordination with Mr. Wade Mullen, Public Works Department, for guidance on asbestos cement pipe removal procedures, specifications and requirements for inclusion in the final design and bidding documents.

4. Environmental Assessment

Baer Engineering and Environmental Consulting, Inc. prepared a Phase I Environmental Site Assessment (ESA), dated November 9, 2016, which is included as Appendix F. No Recognized Environmental Conditions (RECs) were identified within the project area; therefore, further environmental investigation should not be required in the Final Design phase. However, concurrence is required from the City of Austin.

Eight (8) RECs and one (1) Historic REC were identified off-site that may be a concern during construction. The Phase I ESA should be provided to the construction contractor so they are aware of potential contaminates in the area. If contamination is identified in the soil spoils, characterization and disposal of the soils/liquids needs to be conducted in accordance with all municipal, state, and federal regulations. Since there is no historical evidence of contamination, then the contractor would characterize only those soils displaying evidence of contamination.

5. Permitting

Baer Engineering and Environmental Consulting, Inc. (Baer) prepared a Permitting Analysis Report, dated December 27, 2016, which is included as Appendix F, and determined that the project is subject to the following local and state requirements for construction.

5.1 Local Requirements

The proposed construction project requires review and approval by several City of Austin (COA) departments. The following is a list of municipal requirements.

- The project areas are located within the COA full purpose jurisdiction. A Site Development Permit or General Permit is required per Land Development Code (LDC), 25-5-1.

- The project areas are within the Edwards Aquifer Recharge Zone. A COA Environmental Resource Inventory (ERI) report is required per LDC, 25-8-121. A budgetary cost for an ERI is estimated to be $11,000.

- The project is located over the COA-defined Edwards Aquifer Zone. A karst survey is required per Environmental Criteria Manual, Section 1.10.3.C. A budgetary cost for a karst survey that requires one (1) day of field work (the assumed time to survey each project location) is estimated to be $2,000.

- If trees larger than 19 inches in diameter or COA-defined heritage trees are planned for removal, permit approvals or variances will be required, per COA LDC 25-8-621 and 25-8-641.

- The Project lies within a fee zone of the Balcones Canyonlands Conservation Plan. As a stakeholder, the COA is required to participate in the HCP by providing the BCP Program with a habitat assessment application. The COA will internally deduct the area of the project limits from an established mitigation bank setup for COA infrastructure projects, as stipulated in the guidelines of the BCHCP.

Note that the Oak Knoll Drive study area is not located within the Edwards Aquifer Recharge Zone as delineated by the Texas Commission on Environmental Quality (TCEQ); however, all three study areas are within the Recharge Zone as delineated by the City of Austin.

5.2 State Requirements

The proposed construction project requires review and approval by multiple state agencies. The following is a list of state requirements.

- The Antiquities Code of Texas requires political subdivisions of the State to notify the Texas Historic Commission (THC) of ground-disturbing activity on public land. The THC will determine if further investigation is needed to survey the project limits for cultural resources prior to construction. Coordination with the THC is required.

- If the project design will result in the disturbance of greater than one acre of land during construction, the project owner must implement a storm water pollution prevention plan (SWPPP) as required by Section 402 of the Clean Water Act and Chapter 26 of the Texas Water Code.

- The Bell Avenue and Arabian Trail project area is within the Edwards Aquifer Recharge Zone. An approved Edwards Aquifer Protection Plan is required because the proposed improvements would not be considered an exempt regulated activity per TAC 30 Chapter 213.5(h)(1)(E)(ii). A budgetary cost to develop and process an EAPP is estimated to be $16,000. Based on TAC 30 Chapter 213.14 Fee Schedule, the estimated application fee would be $4,000. An approved EAPP must also be recorded in the Travis County deed records by the City, which a budgetary cost cannot be estimated for at this time.

5.3 Other Items of Interest

Baer also noted the following:

- Critical Environmental Features (CEF) were not identified on the COA GIS viewer within 150 feet of the project areas nor were CEFs observed during the preliminary field visit.

- A threatened and endangered species (TES) habitat assessment was conducted. No TES habitat was identified, so no further action is required.

6. Alternative Analysis and Results

Three (3) alternatives were identified and analyzed for each study area. One of the alternatives generally reflects the City's Drainage Criteria Manual (DCM). The project boundary for each of the three areas was defined based on complex analysis of the drainage area, recorded complaints and generally follows bordering lot lines.

The City provided documented complaint data for the 3 study areas. The data dated back to the 1990's and was verified using aerial imagery and LiDAR data. Homes with a registered flooding complaint, from the data provided by the City at the start of the project, were surveyed for finished floor elevations. To determine the existing ground elevation at each structure, the elevation from the current LiDAR (2012) at four points around the structure and the centroid were averaged. This data was used in accordance with the survey data to produce an average slab height of 0.8 feet for the area. The average slab height and existing ground elevations were then used to estimate a finished floor elevation for the other habitable structures in the study area in order to evaluate potential flood risk. The floodplain elevations calculated in the InfoWorks ICM model were then compared to these elevations to determine which structures experience flooding in each scenario. If the water surface elevation in the homes decreased, but was not removed, these structures were denoted as being "helped." For yards where residents reported flooding, the visual extent of the floodplain was evaluated for complete removal and yards with a decrease in water surface elevation were considered "helped." Some structures and yards experience localized flooding that is caused by the grading of the lot itself or the low slab elevation of the structure and cannot be improved with improvements in the City's right-of-way or with easements. Therefore, these structures and yards may not be removed from the floodplain or helped. For example, when the rain is dropped on the mesh, it collects in a pocket of the terrain and cannot leave due to the lot grading as shown in Figure 7.

Figure 7: Localized Flooding Example

The tables in each section also describe other "items to consider" such as:

- Hydrologic impacts – Proposed peak flow rate increases computed at the outfall to Walnut Creek Tributary 7 (WC Trib. 7) and immediately downstream of each study area (local). Any increase for the 2-, 10-, 25-, or 100-year storm events is considered to be an impact and is denoted with a 'Yes' or 'No' response. Calculations are shown in Appendix C.

- Traffic impacts – Impacts to traffic routes in the neighborhoods were considered, based on the extent and locations of improvements within the right-of-way.

- Easements – Where proposed storm drain solutions were located outside of existing right-of-way, the need for permanent drainage easements, as well as temporary construction easements, were considered.

- Dry Utility Crossings – An investigation of existing utilities within the three project areas was performed, which included AULCC coordination. Utility crossings impact construction costs and schedule. A summary of potential utility crossings is included in Appendix E.

- Meets DCM? – Proposed design conveys the 25-year storm within the pipe (or below grade) and the 100-year storm is approximately confined to within the right of way.

A detailed project cost estimate can be found in Appendix D (costs for detention will be added once alternative is selected). Life-cycle cost information for each alternative is included in Appendix G.

6.1 Oak Knoll Study Area

This project is intended to alleviate the flooding of buildings and yards through an upgraded storm drainage system. The existing system is approximately 980 linear feet, which extends from Oak Knoll Drive to Columbia Oaks Drive, consisting of 30-inch diameter Reinforced Concrete Pipe (RCP) with 2 18-inch RCP laterals extending into Oak Knoll Drive approximately 40 linear feet, and approximately 340 linear feet of a grass-lined channel extending from Woodcrest Drive to the 30-inch RCP. The 30-inch diameter storm sewer system is generally contained within an existing 10-foot easement outside of the right-of-way which meets the DCM requirement of a minimum 15-foot width for closed systems. The 2017 inspection videos of existing system were reviewed, and the pipes that are proposed to remain are in overall good condition and should not affect alternative selection.

6.1.1 Alternative 1

Alternative 1 is a proposed upgrade of the existing system. The existing 30-inch RCP would be removed, and a new 36-inch RCP will be constructed within the same trench. Laterals will be upgraded to 24-inch RCP. Exhibit 2.1 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events (e.g. 2-yr, 10-yr, 25-yr). This alternative does not meet the DCM criteria; however, it does provide an alternative that could reasonably be constructed within the existing 10-foot easement.

6.1.2 Alternative 2

Alternative 2 includes the extent of proposed improvements in Alternative 1 to remove and replace the existing system with a 5-ft x 3-ft reinforced concrete box culvert, as well as the construction of approximately 1,240 linear feet of new 4-ft x 3-ft concrete box culvert and new storm drain inlets along Oak Knoll Drive and northwest along Woodcrest Drive. A new 24-inch RCP lateral extends approximately 300 linear feet northeast along Broad Oaks Drive. Exhibit 2.2 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative meets the DCM criteria; however, installation of a new 5-ft x 3-ft box culvert would require additional permanent easement width, and bear increased risk to the City for construction due to the limited work space between homes and potential damage to the adjacent structures.

6.1.3 Alternative 3

Alternative 3 includes construction of approximately 1,160 linear feet of new 4-ft x 3-ft reinforced concrete box culvert southeast along Woodcrest Drive and 300 linear feet of additional storm drain pipe northeast along Broad Oaks Drive (24-inch RCP), Oak Knoll Drive (30-inch RCP), and Three Oaks Trail (36-inch RCP), as well as approximately 380 linear feet of 5-ft x 3-ft reinforced concrete box culvert northwest connecting to 345 linear feet of upgraded storm drain system (6-ft x 3-ft box culvert) and new storm drain inlets across Columbia Oaks Ct. Exhibit 2.3 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. The new 5-ft x 3-ft box culvert located outside the existing right-of-way is assumed to be installed within an existing 15-foot Drainage and Public Utility Easement.

6.1.4 Recommendation

Table 6 provides a comparison summary of the three (3) Oak Knoll alternatives.

Table 6: Oak Knoll Benefits, Costs, and Items to Consider

100-yr			Alt 1		Alt 2		Alt 3	
Benefits	**Reported Flooding**	**Flooding Identified in 2D Model**	**Removed**	**Helped**	**Removed**	**Helped**	**Removed**	**Helped**
Buildings***	12	6	2	10	10	5	6	9
Yard	8	-	0	6	0	6	0	6
Cost			$1,250,000		$2,170,000		$2,255,000	
Linear Feet of Pipe to be Installed			910		2,210		2,894	
Items to Consider								
Hydrologic Impacts (WC Trib. 7)			Yes		Yes		Yes	
Hydrologic Impacts (local)			No		No		No	
Traffic Impacts			Minimal		High		High	
Easements – Permanent			0*		0*		0*	
Easements – Temporary			7		7		3	
Dry Utility Crossings			6		17		17**	
Meets DCM?			No		Yes		Yes	

*The two existing 10-foot DE to be used for upgraded storm drain pipes are less than the minimum 15-foot width currently required for closed systems.
**Buried communication located in existing 15-foot DE/PUE in the rear of the lots along Columbia Oaks Drive may need to be removed and replaced in conduit to install proposed box culvert in existing easement.
***Reported flooding data was provided by the City of Austin. Flooding Identified in 2D Model is buildings with potential flooding in *addition* to those with reported flooding. Removed and Helped buildings are from the combined Reported Flooding and Flooding Identified in 2D Model.

Based on the comparison above, Alternative 3 is the recommended solution for the Oak Knoll Drive study area. This alternative provides the same overall benefits as Alternative 2, in terms of addressing structural and yard flooding. Alternative 2 is deemed not constructible given the project constraints and associated risks. While Alternative 1 is the least expensive alternative, it does not remove as many structures from flooding as Alternative 3, which is one of the main objectives of the project.

6.2 Arabian Trail Study Area

This project is intended to alleviate the flooding of buildings and yards through an upgraded storm drainage system. There is an existing gutter along Arabian Trail from Jollyville Road to Bell Avenue and ditches upstream of the western portion of Arabian Trail and northeast along Arabian Trail. The channel that runs parallel to US-183 is a v-notch channel with side slopes that very from 6:1 at the upstream end to 3:1 further downstream and generally contains somewhere between the 25-yr and 100-yr flows. The longitudinal slope is approximately 2%. The channel that extends perpendicular from US-183 is a v-notch channel with 3:1 side slopes and the longitudinal slope is approximately 1%.

6.2.1 Alternative 1

Alternative 1 includes the construction of approximately 2,300 linear feet of storm drain pipe along Arabian Trail, ranging in size from 24-inch RCP up to 5-ft x 3-ft reinforced concrete box culvert, a full 6-inch curb and gutter along the western portion of Arabian Trail, and ditch improvements to the upstream existing ditch. Exhibit 3.1 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative meets the DCM criteria; however, downstream impacts are high, and it is the most expensive alternative.

6.2.2 Alternative 2

Alternative 2 includes approximately 960 linear feet of 24-inch and 30-inch RCP, a full 6 inch curb and gutter, and ditch improvements to both existing ditches. Exhibit 3.2 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative meets the DCM criteria and provides the most benefits addressing structural, yard and street flooding; however, downstream impacts are high.

6.2.3 Alternative 3

Alternative 3 includes an identical storm drain system as Alternative 2; however, the existing ditches would not be improved with this alternative. Exhibit 3.3 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative does not meet the DCM criteria; however, it is the least cost alternative, and does not have adverse downstream impacts.

6.2.4 Recommendation

Table 7 shows a comparison of the three (3) Arabian Trail alternatives.

Table 7: Arabian Trail Benefits, Costs, and Items to Consider

100-yr			Alt 1		Alt 2		Alt 3	
Benefits	**Reported Flooding**	**Flooding Identified in 2D Model**	**Removed**	**Helped**	**Removed**	**Helped**	**Removed**	**Helped**
Buildings**	6	8	3	4	3	7	1	9
Yards	5	-	2	2	2	2	0	3
Street	1	-	0	1	0	1	0	0
Cost			$1,195,000		$635,000		$425,000	
Linear Feet of Pipe to be Installed			2,552		1,160		1,160	
Items to Consider								
Hydrologic Impacts (WC Trib. 7)			Yes		Yes		Yes	
Hydrologic Impacts (local)			Yes		Yes		No	
Traffic Impacts			High		Minimal		Minimal	
Easements - Permanent			0		0		0	
Easements - Temporary			0		0		0	
Dry Utility Crossings			1		1*		1	
Meets DCM?			Yes		Yes		No	

*Buried communication lines located in existing ditch may be in conflict with ditch improvements.
**Reported flooding data was provided by the City of Austin. Flooding Identified in 2D Model is buildings with potential flooding in *addition* to those with reported flooding. Removed and Helped buildings are from the combined Reported Flooding and Flooding Identified in 2D Model.

Based on the comparison above, Alternative 3 is the recommended solution for the Arabian Trail study area. This alternative provides similar benefits as Alternative 2, in terms of addressing structural and yard flooding. However, we also recommend that the City perform some maintenance of the existing drainage ditch west of Arabian Trail. Maintenance activities, including tree trimming, brush pickup, and removal of debris and other trash, would provide significant conveyance improvement. In addition, there are no downstream impacts to mitigate, and all work associated with the new storm drain system would be contained within the right-of-way. Alternatives 1 and 2 both result in high downstream impacts, with minimal to no area remaining within this developed neighborhood to allow for mitigation.

6.2.5 Additional Modeling of the Arabian Trail Area

Additional ICM modeling of the Arabian Trail study area was conducted to better determine the cause of the reported yard and structural flooding along Arabian Trail near Jollyville Road, which did not appear to see significant benefit with the proposed storm system alternatives in section 6.2 of this report. Table 8 shows the reported flooding in the Arabian trail study area.

Table 8: Flooding Reported Along Arabian Trail

Date	Address	Flood Code
2013-04-03	11808 ARABIAN TRL	Yard
2013-11-25	11801 ARABIAN TRL	Building
1996-10-22	11902 ARABIAN TRL	Standing water
2013-10-30	11800 ARABIAN TRL	Building
	11801 ARABIAN TRL	Building
	11804 ARABIAN TRL	Building
2013-10-30	11806 ARABIAN TRL	Building
2013-10-30	11808 ARABIAN TRL	Building
2013-10-30	11810 ARABIAN TRL	Building

As seen in Table 8, the majority of the reported flooding occurred during the October 2013 flood event. One of the 6 homes with reported building flooding was validated with the current existing conditions model (11801 Arabian Trail). For the purposes of this exercise, the 100-yr storm event was used to increase the likelihood of duplicating the rest of the reported flooding and the following scenarios were modeled:

1. **Blockage of the Channel due to the Existing Wrought Iron Fence:** It is understood that City maintenance staff cut and removed the bottom portion of the existing wrought-iron fence that traverses the City's drainage easement, at approximately 11900 Arabian Trail. Since this maintenance occurred after the October 2013 flood event, the channel was modeled with a portion blocked at the fence location with the assumption that debris could have built up on the fence, resulting in the reported flooding.

   Modeling Result: As shown in Figure 8, no flooding of the properties adjacent to the channel with reported flooding occurred.

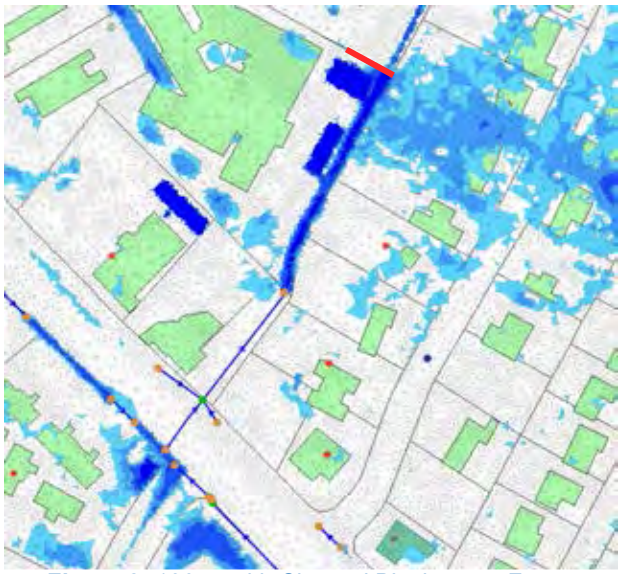


Figure 8: 100-yr with Channel Blockage at Fence

2. **Blockage of Upstream Culverts on Jollyville Road:** For this scenario, the culverts across Jollyville Road, upstream of the homes with reported flooding and the channel, were blocked.

   Modeling Result: As shown in Figure 9, for the 100-yr event, the water did not overtop Jollyville, and the homes with reported flooding received minor yard flooding, but no apparent structural flooding (based on the calculated average finished floor elevation of 0.9 feet from survey data).

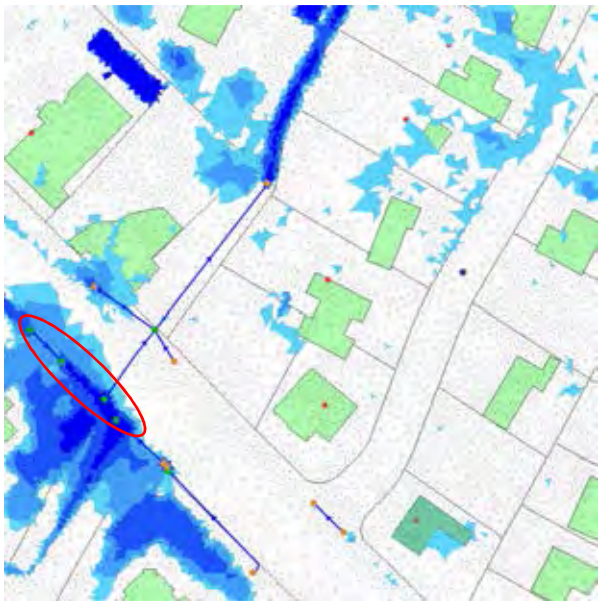


Figure 9: 100-yr Upstream Jollyville Inlets Blocked

3. **Blockage of Arabian Trail Cross-culvert:** Lastly, the cross-culvert under Arabian Trail at the Jollyville Road intersection was blocked.

Modeling Result: As shown in Figure 10, there was not a significant impact caused by this obstruction and no evidence of structural flooding for the properties with reported flooding.

Figure 8: 100-yr Blocking Arabian Trail Cross-Culvert

Existing conditions modeling results for this area do not correlate with reports of flooding as documented in the City's database for homes along Arabian Trail. These additional scenarios were also unable to produce flooding conditions consistent with the reported flooding from the October 2013 event. Given that there is good correlation throughout the rest of the study, the extent and severity of the problem is in question. There are two (2) basic possibilities in this immediate area: 1) the rainfall used in the model does not match actual site specific conditions produced from the event; and/or 2) we do not have enough information with respect to the reports of flooding to know the cause and extend of this flooding. Further analysis is required for this area in order to justify the cost of any improvements.

6.3 Bell Avenue Study Area

This project is intended to alleviate the flooding of buildings and yards through an upgraded storm drainage system. There is limited storm drain infrastructure within the City right-of-way, which was primarily installed in the 1950's. There is an existing 42-inch diameter RCP system within the Covert Car dealership property along the US 183 Frontage Road.

6.3.1 Alternative 1

Alternative 1 includes the construction of approximately 2,370 linear feet of 6-ft x 3-ft reinforced concrete box culvert and 6 inch curb and gutter along Bell Ave. from the US-183 southbound frontage road to Jollyville Road and a 24-inch RCP lateral northwest along Secrest Drive. Exhibit 4.1 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative meets the DCM criteria, and is fully contained within the existing right-of-way.

6.3.2 Alternative 2

Alternative 2 includes the construction of approximately 2,225 linear feet of 4-ft x 3-ft reinforced concrete box culvert and 6 inch curb and gutter along Bell Ave. from the US-183 southbound frontage road to Jollyville Road, a 24-inch RCP lateral northwest along Secrest Drive, as well as

1,050 linear feet of 4-ft x 3-ft reinforced concrete box culvert through the Stanwood Road right-of-way and the Covert car dealership property connecting to the US-183 southbound frontage road. Exhibit 4.2 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative provides similar benefits as Alternative 1, meets the DCM criteria, and has the highest estimated construction cost. It also would require an easement and construction access on the Covert property, which might require special considerations for construction.

6.3.3 Alternative 3

Alternative 3 includes the construction of approximately 2,225 linear feet of 42-inch diameter RCP storm drain pipe along Bell Avenue, a 6 inch curb and gutter along Bell Ave. from the US-183 southbound frontage road to Jollyville Road, and a 24-inch RCP lateral northwest along Secrest Drive. This alternative would result in two separate storm drain systems, with the southern portion of Bell Avenue tying into the existing storm drain system on the Covert property, and the northern portion of Bell Avenue tying into the US 183 Frontage Road. Exhibit 4.3 shows the proposed alignment and indicates structures removed from the 100-yr or less storm events. This alternative provides the least benefits in terms of addressing structural flooding and does not meet the DCM criteria.

6.3.4 Recommendation

Table 9 shows a comparison of the three (3) Bell Avenue alternatives.

Table 9: Bell Avenue Benefits, Costs, and Items to Consider

100-yr			**Alt 1**		**Alt 2**		**Alt 3**	
Benefits	**Reported Flooding**	**Flooding Identified in 2D Model**	**Removed**	**Helped**	**Removed**	**Helped**	**Removed**	**Helped**
Buildings*	5	9	8	4	8	4	3	8
Yard	3	-	0	2	0	2	0	2
Cost			$1,630,000		$1,905,000		$1,175,000	
Linear Feet of Pipe to be Installed			2,361		3,382		2,508	
Items to Consider								
Hydrologic Impacts (WC Trib. 7)			No		No		No	
Hydrologic Impacts (local)			Yes		Yes		Yes	
Traffic Impacts			High		High		High	
Easements-Permanent			0		1		1	
Easements- Temporary			0		1		1	
Dry Utility Crossings			3		6		4	
Meets DCM?			Yes		Yes		No	

*Reported flooding data was provided by the City of Austin. Flooding Identified in 2D Model is buildings with potential flooding in *addition* to those with reported flooding. Removed and Helped buildings are from the combined Reported Flooding and Flooding Identified in 2D Model.

Based on the comparison above, Alternative 1 is the recommended solution for the Bell Avenue study area. This alternative can be fully constructed within existing right-of-way and would not warrant any permanent easements with private property owners. Note that each of the three alternatives has a local impact to the ponding depth within the US 183 Frontage Road. LAN coordinated with the US 183 Project Team, which is currently studying improvements to US 183. However, at the time of this PER, no changes were proposed to the existing drainage system within the US 183 right-of-way. It is recommended that coordination with Texas Department of Transportation (TxDOT) and the US 183 Project Team continue through the Final Design, Bidding and Construction Phases of the Oak Knoll Storm Drain Improvements project.

6.4 30% Drawings

As part of this project, 30% drawings were developed by K Friese and Associates using StormCAD V8i. A comparison of this 1D analysis and the InfoWorks ICM 2D analysis along with the 30% drawings that were developed can be found in Appendix G.

7. Life-Cycle Cost

Life-cycle cost analysis is a tool that allows us to analyze multiple alternatives to determine the most cost-effective option to operate and maintain new infrastructure. In accordance with the Public Works Department's Quality Assurance Checklist for Complete Submittals, LAN has performed a Life-Cycle cost analysis for each alternative included herein. For basis of comparison, it was assumed that the life expectancy of all improvements is 50 years, although the U.S. Army Corps of Engineers recommends a design life of 70-100 years for precast concrete pipe. The unit costs and frequency of maintenance activities included in Table 10 below were based on input provided by the City, as well as best practices for maintenance for similar municipalities.

Table 10: Life-Cycle Unit Costs and Maintenance Frequency

Reinforced Concrete Pipe (RCP)		
Task	**Frequency**	**Cost**
Inspecting Manholes/Junctions	2 years	$70/Manhole
Inspecting Inlets	2 years	$70/Manhole
TV inspection	10 years	$2/linear ft.
Inspection of Outfalls	5 years	$70/Outfall
Flushing Manholes/Junctions	As needed	$2,100-5,250/Manhole
Flushing Inlets	As needed	$400/Inlet
Replacement - Pipe	At end of useful life	$500-1,000/linear ft.
Replacement – Manhole	At end of useful life	$10,000
Replacement – Inlet	At end of useful life	$8,000
Replacement – Outfalls	At end of useful life	$10,000
Swales		
Task	**Frequency**	**Cost**
Mowing	6-12 times per year	$0.0525/sq. ft.
Dredging	As needed	$30/linear ft.
Pond (New)		
Task	**Frequency**	**Cost**
Inspection	3-5 years	$250/Pond
Mowing	3-4 time/year	$750-1,000/Pond
O&M (Cleaning/General/311)	annually	$660/Pond

For purposes of comparison, maintenance of new ponds was not included in this analysis, as impacts are dependent on alternative selection. However, it is anticipated that the difference in life-cycle costs for pond maintenance would be negligible between the alternatives. Similarly, maintenance of existing swales in the Arabian Trail area were not included, since initial maintenance or channel grading costs are included in the construction cost estimates for each alternative. In addition, since these swales are existing, they are assumed to be already included in the Watershed Protection Department's maintenance program. Table 11 summarizes the life-cycle costs calculated for each alternative. Detailed life-cycle cost estimates are included in Appendix H.

Table 11: Life-Cycle Costs

Alternative	Life-Cycle Cost (50 Year Period)
Oak Knoll Alternative 1	$49,050
Oak Knoll Alternative 2	$96,300
Oak Knoll Alternative 3 **(Recommended)**	$135,200
Arabian Trail Alternative 1	$142,070
Arabian Trail Alternative 2	$93,200
Arabian Trail Alternative 3 **(Recommended)**	$93,200
Bell Avenue Alternative 1 **(Recommended)**	$145,110
Bell Avenue Alternative 2	$203,270
Bell Avenue Alternative 3	$193,830

8. Project Schedule

A proposed project schedule has been developed based on the recommended alternatives discussed herein. Based on available project funds and project prioritization, it is assumed that the Oak Knoll area storm drain improvements will proceed to final design, bid and construction as soon as possible, while the Bell Avenue and Arabian Trail improvements will proceed at a later time when sufficient funding is available. Thus, the schedule included herein assumes final design, bid and construction durations for the Oak Knoll area improvements only. The proposed schedule to complete the Oak Knoll Drive area storm drain improvements is as follows:

Preliminary Engineering Phase	June 2016 – July 2017
Final Design Phase	September 2017 – August 2018
Bid and Award Phase	September 2018 – February 2019
Construction Phase	March 2019 – January 2020

For planning purposes, approximately 12 months should be allowed for final design, 6 months for bid and award, and 9 months for construction of the Bell Avenue improvements and 6 months for construction of the Arabian Trail improvements, assuming they are constructed separately.

9. Mission Integration Practices

The mission of the City of Austin's Watershed Protection Department (WPD) "is to protect lives, property, and the environment of our community by reducing the impact of flooding, erosion, and water pollution." As part of the department's goal to integrate the three WPD divisions, staff explores ways that every project can integrate the different goals and objectives of the department through the Mission Integration Prioritization Team (MIPT) process. Source: City of Austin's Watershed Protection Master Plan (August 19, 2016).

All three of the Oak Knoll Storm Drain Improvement Projects are expected to meet 8 of the current (Fiscal Year 2015 – 2016) Watershed Protection Master Plan Goals and Objectives. Table 12 below identifies the objectives that will be met.

Table 12: WPD Master Plan Objectives Being Met

FM4	Provide mitigation for flood damage.
FM5	Prevent the creation of future flood hazards to human life and property.
FM6	Reduce the depth and frequency of localized flooding for buildings.
FM7	Reduce the depth and frequency of localized flooding for yards.
FM8	Reduce the danger of street flooding created by substandard storm drains.
FM9	Reduce standing water in public rights-of-way and drainage easements outside the 100-year floodplain.
CG5	Comply with Storm water NPDES permit requirements.
CG6	Minimize the risk to structures in the 100-year floodplain as required by the National Flood Insurance Program.

FM = Flood Mitigation CG = Common Goal

10. Adverse Impacts Analysis

Water surface elevations, peak flows, and velocities can be compared in InfoWorks ICM to assess the potential for adverse impact. The points of interest that were found are presented on the exhibits in Appendix I and discussed below. Potential for hydrologic impacts on Walnut Creek Tributary 7 were computed by modifying the hydrograph for the subarea (WALT7010) in the HEC-HMS model by adjusting the lagtime to match the percent change at the peak.

10.1 Oak Knoll Study Area

Within the Oak Knoll study area, the storm drain improvements tie into an existing 6 foot by 3 foot (6' x 3') RCP box that extends under the Austin Business Services property and outfalls across a commercial driveway and into a wooded area that is owned by the United States Postal Service (USPS) as shown in Figure 11. Without mitigation, the preferred improvements have potential adverse impacts (increased flow) downstream under Jollyville Road, over Jollyville Road, and on Walnut Creek Tributary 7 (Trib 7) as shown on Exhibit I-1 and I-2.

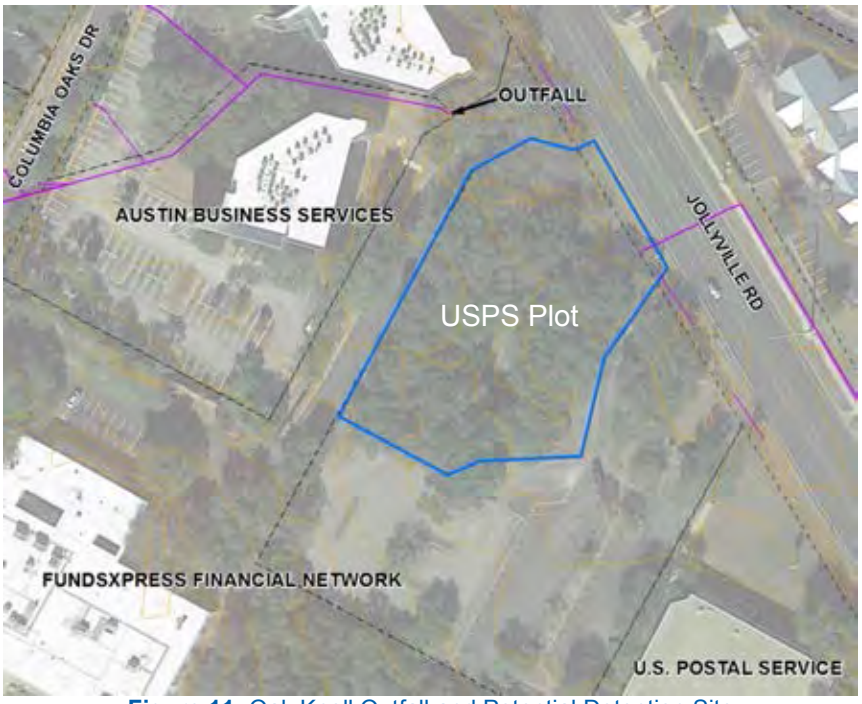


Figure 11: Oak Knoll Outfall and Potential Detention Site

In an attempt to mitigate potential impacts, three improvements were made to the Oak Knoll Drive study area: 1) Doucet + Chan designed a detention pond at the USPS property downstream of the Oak Knoll outfall pipe (detailed in the technical memo in Appendix I), 2) a relief pipe was added to prevent water from leaving the right-of-way at Columbia Oaks Drive, and 3) the pipe segment connecting the system to the upstream detention pond at Broad Oaks Drive and Woodcrest Drive was removed. This helped reduce the hydraulic grade lines (HGL) within the system and to prevent flooding between the improvements and the detention pond. In order to prevent the flooding of the commercial driveway and contain the storage volume in the pond site, a wall was modeled around the pond and the existing driveway was raised as shown in Figure 12.

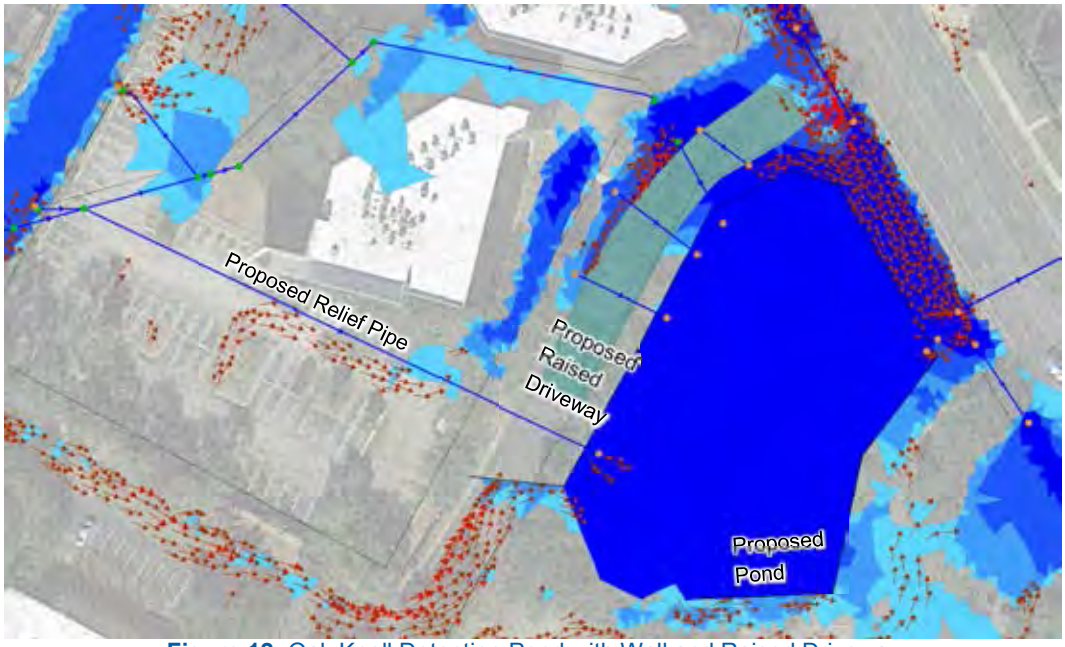


Figure 12: Oak Knoll Detention Pond with Wall and Raised Driveway

The results of this model show that this pond can mitigate the flow increase at Trib 7 and can eliminate the increased flow in the pipe under Jollyville Road. However it does not completely remove the increased flow over the roadway. The tables on Exhibit I-1 and I-2 shows the points of interest from this analysis. The detention pond was able to decrease the flow at Trib 7 by 37 cubic feet per second (cfs) and the flow in the pipes under Jollyville Road by 1.5 cfs. The estimated increase over Jollyville Road is 14 cfs. The estimated cost of the pond is approximately $2,000,000 (see the technical memo from Doucet + Chan in Appendix I for more detail). In final design, a water quality and/or stream stabilization component (extended detention, filtration in pond footprint, etc.) could be worked into the detention pond design. There is also potential for a water quality retrofit at Broad Oaks and Woodcrest Drive.

10.2 Arabian Trail Study Area

For the Arabian Trail study area, all three alternatives, resulted in similar impacts to the US-183 frontage road. Alternatives 1 and 2 both result in significant downstream impacts while alternative 3 results in only 1 cubic foot per second (cfs) increase in peak flow at Walnut Creek Tributary 7. Locally, there is no water surface elevation increase in the downstream ditch along Arabian Trail and there is less than an inch increases on the US-183 frontage road. The table on Exhibit I-3 shows the points of interest from this analysis. These improvements were not found to significantly benefit the homes with flood complaints and result in potential adverse impacts downstream. Given that the area is fully developed, opportunities for mitigation are very limited. The existing channel/swale in this area could be updated to include water quality components and improved for a more natural channel section (bioengineering swale, etc.), as well as bank stabilization.

Further modeling did not produce flooding conditions consistent with the reported flooding from the October 2013 event as discussed in section 6.2.5. One of the 6 homes with reported building flooding was validated with the existing conditions model (11801 Arabian Trail). We were unable to provide a benefit to this property with improvements within the existing right-of-way. In order to mitigate further flooding of this property, the estimated cost for buyout of this home is

approximately $430,000. Note however that property values are highly variable with market conditions and appraisals.

10.3 Bell Avenue Study Area

In the Bell Avenue study area, the storm drain improvements tie into one of three 6' x 3' boxes that run along the US-183 frontage road which outfall under US-183 to Walnut Creek Tributary 7 (Trib 7). All three storm drain improvements for this area result in changes to hydrograph timing at Trib 7 and decrease the computed peak flow rates. The improvements in alternative 2 and 3 split the increased flow between all three of the 6' x 3' while alternative 1 places the increased flow in one of the 6' x 3' boxes. All three alternative have an increased water surface elevation on the US-183 frontage road. Maintain and preserve existing roadside swales along Bell Avenue and use them as the collector system before the water enters the storm drain in order to address water auality and erosion in this area.

A scenario with the combined improvements of Bell Avenue alternative 1 and Oak Knoll Drive alternative 3 (without the detention pond) was also analyzed. This scenario did balance the increased flow at Trib 7 caused by the improvements at Oak Knoll Drive, but all of the other adverse impacts identified here and in section 10.1 are not mitigated here. A summary table of these impacts is shown on Exhibit I-4 and I-5.

10.4 Summary and Conclusion

Local impacts as well as impacts at Walnut Creek Tributary number 7 were evaluated as part of this study. Although impacts still exist for the Oak Knoll area with the designed detention pond in the PER, further analysis and optimization may mitigate these potential impacts and can be further reviewed and analyzed at 30% design (see Appendix G). For the Arabian trail area, estimated benefits do not warrant the cost of the improvements considered. The improvements at Bell Avenue reduce flooding but local impacts at the TxDOT right-of-way will require coordination with TxDOT and planned future improvements of US-183 in order to mitigate potential impacts.

Appendix A

Appendix A – Exhibits

DRAINAGE AREA MAP

LEGEND

- DRAINAGE AREAS
- STUDY AREA
- SITES FOR POTENTIAL MITIGATION
- WALNUT CREEK TRIBUTARY 7

DA01 DA02 DA03 DA04 DA05 DA06 DA07 DA08 DA09 DA10 DA11 DA12 DA13 DA14 DA15 DA16 DA17 DA18a DA18b DA19 DA21 DA22 DA23 DA24 DA25 DA26 DA27 DA28 DA29 DA30 DA31 DA32 DA33 DA35 DA36 DA37 DA38 DA39 DA40 DA41 DA42 DA43

OAK KNOLL AREA

ARABIAN TRAIL AREA

BELL AVENUE AREA

WAL CRK TRIB 7

US 183

JOLLYVILLE RD

OAK KNOLL DR

ARABIAN TRL

BELL AVE

DUVAL RD

0 350 700

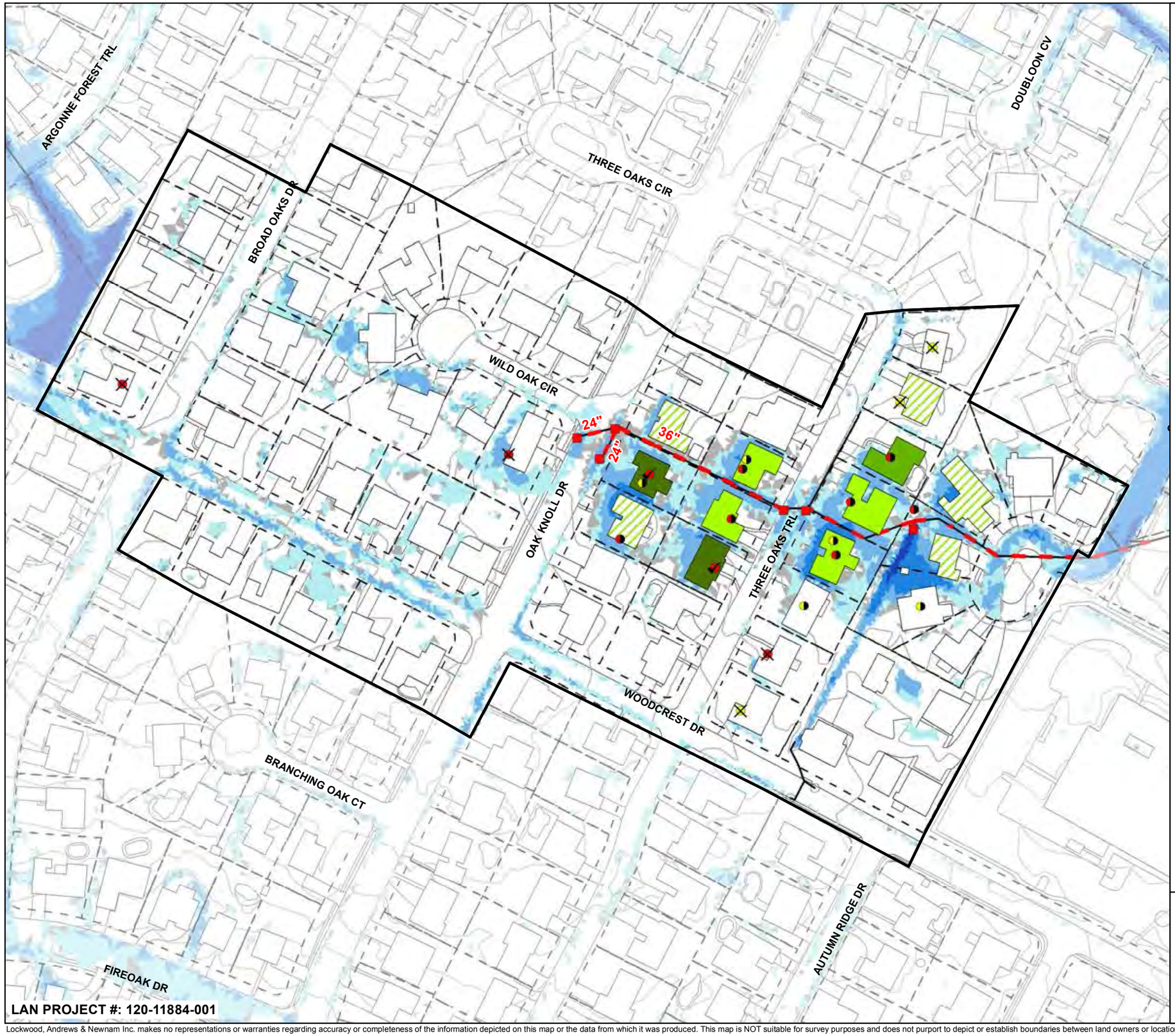
Feet

EXHIBIT 1

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

LAN PROJECT #: 120-11884-001

Updated 08/31/17



LAN PROJECT #: 120-11884-001

STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

N

0 50 100

Feet

OAK KNOLL AREA
100-YR INUNDATION ALTERNATIVE 1

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

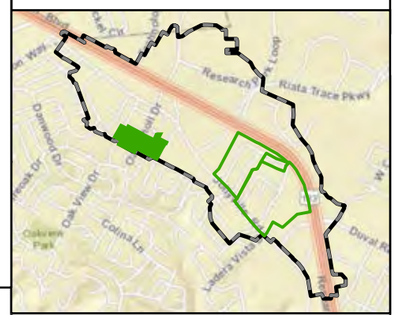
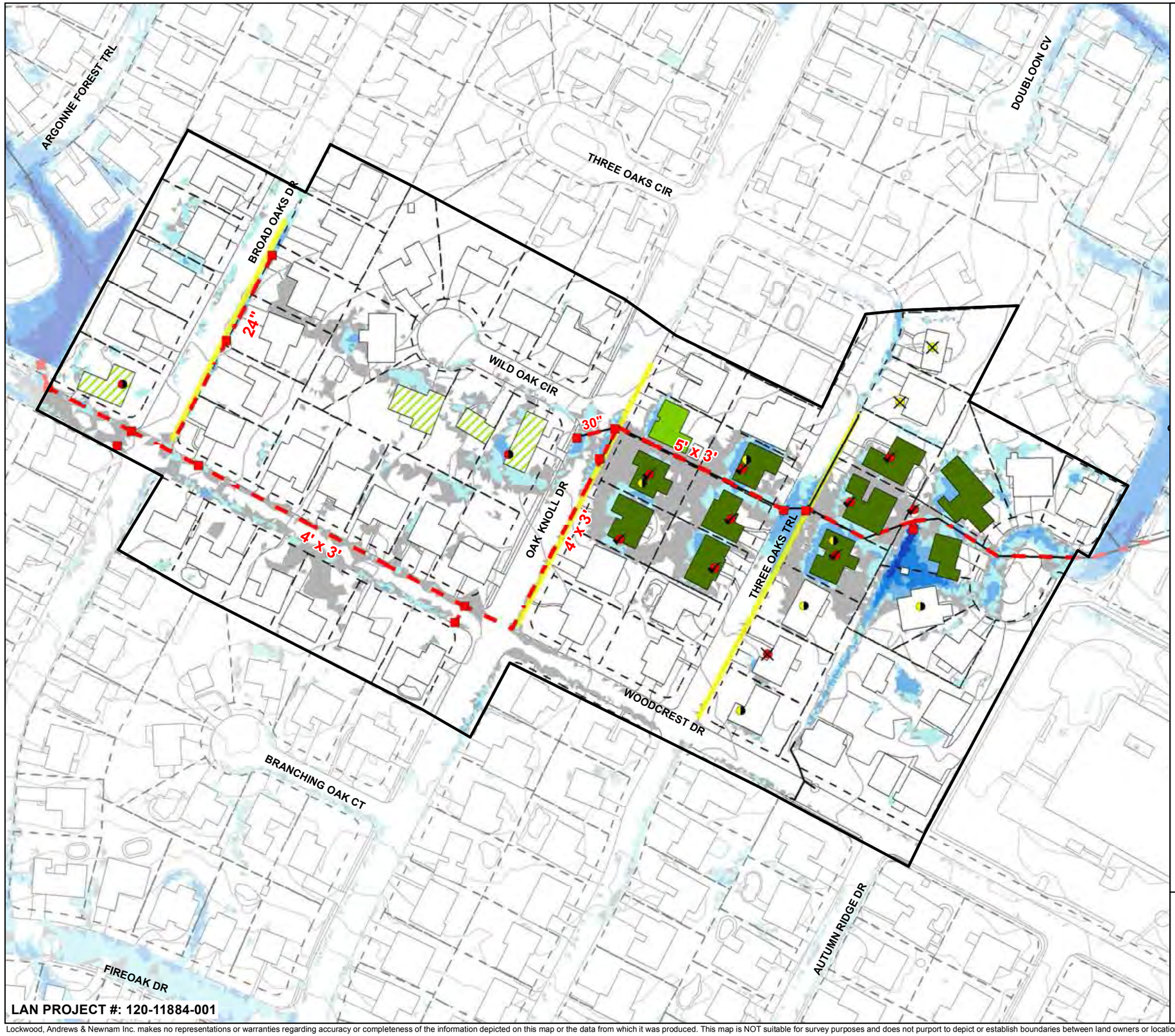


EXHIBIT 2.1

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 08/31/17



LAN PROJECT #: 120-11884-001

STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

PROPOSED FEATURES

- SURFACE IMPROVEMENTS (6" CURB AND GUTTER)

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

0 50 100

Feet

CITY OF AUSTIN FOUNDED 1839

OAK KNOLL AREA
100-YR INUNDATION
ALTERNATIVE 2 - DCM

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

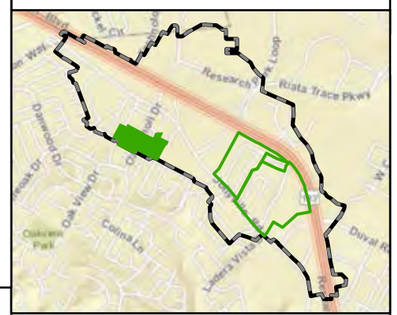
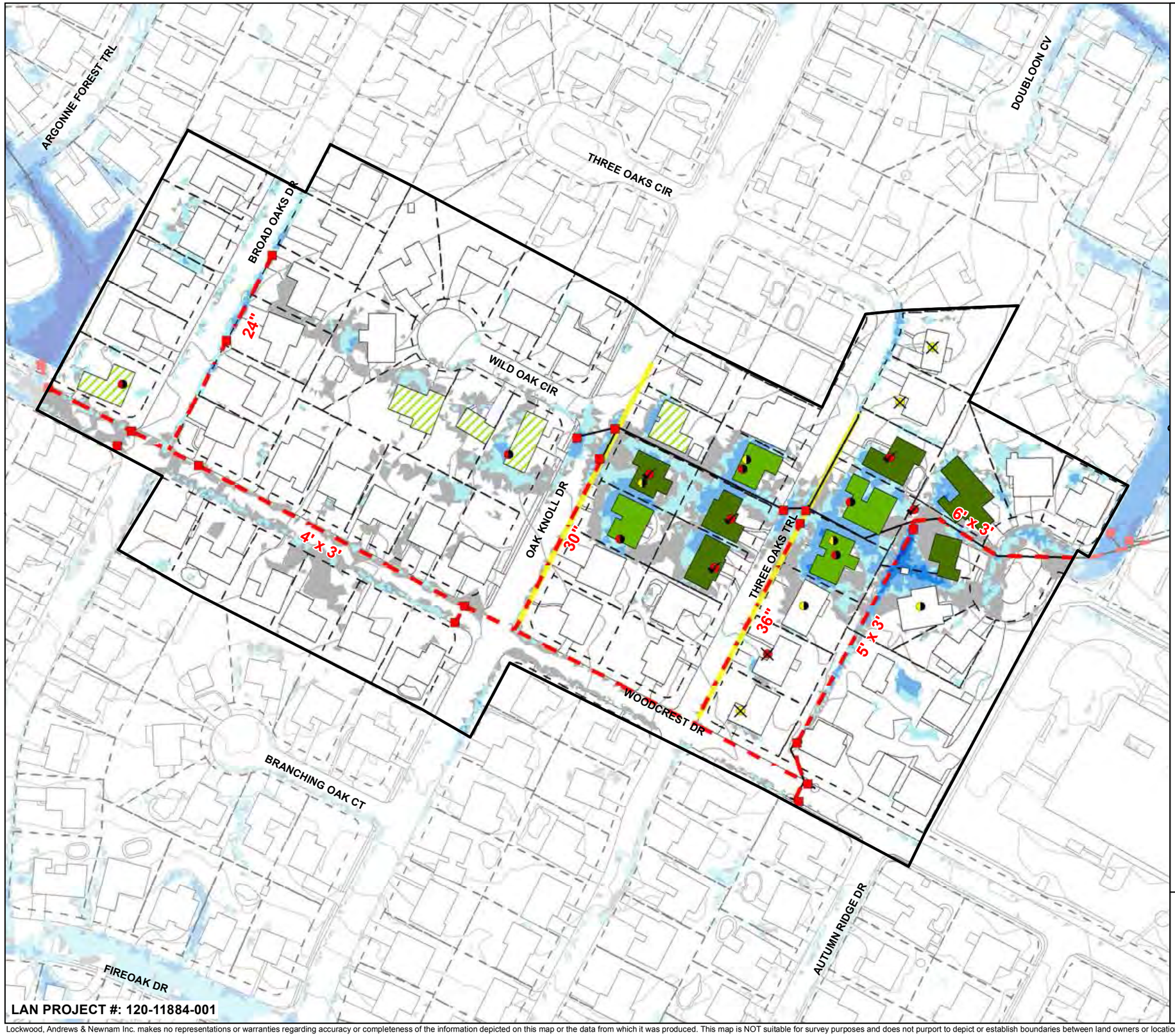


EXHIBIT 2.2

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 08/31/17



STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

PROPOSED FEATURES

- SURFACE IMPROVEMENTS (6" CURB AND GUTTER)

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

0 50 100
Feet

LAN PROJECT #: 120-11884-001

OAK KNOLL AREA
100-YR INUNDATION ALTERNATIVE 3

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELEPD
- ✕ NOT HELPED

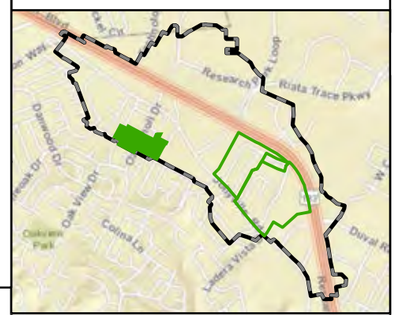
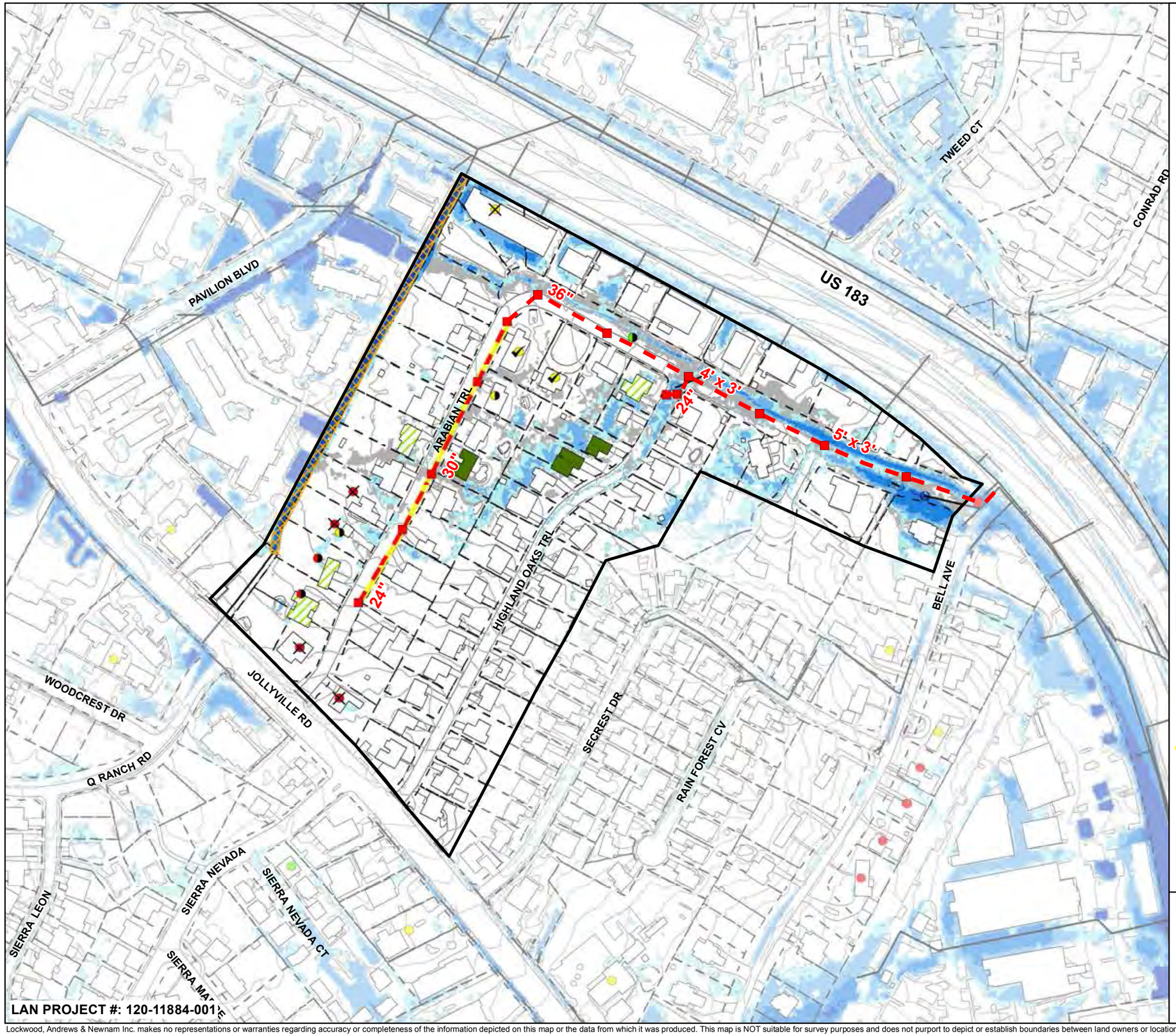


EXHIBIT 2.3

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 08/31/17



STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

PROPOSED FEATURES

- DITCH IMPROVEMENTS
- SURFACE IMPROVEMENTS (6" CURB AND GUTTER)

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

0 125 250
Feet

CITY OF AUSTIN FOUNDED 1839

ARABIAN TRAIL AREA
100-YR INUNDATION
ALTERNATIVE 1 - DCM

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

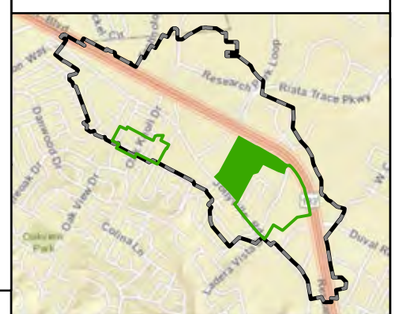
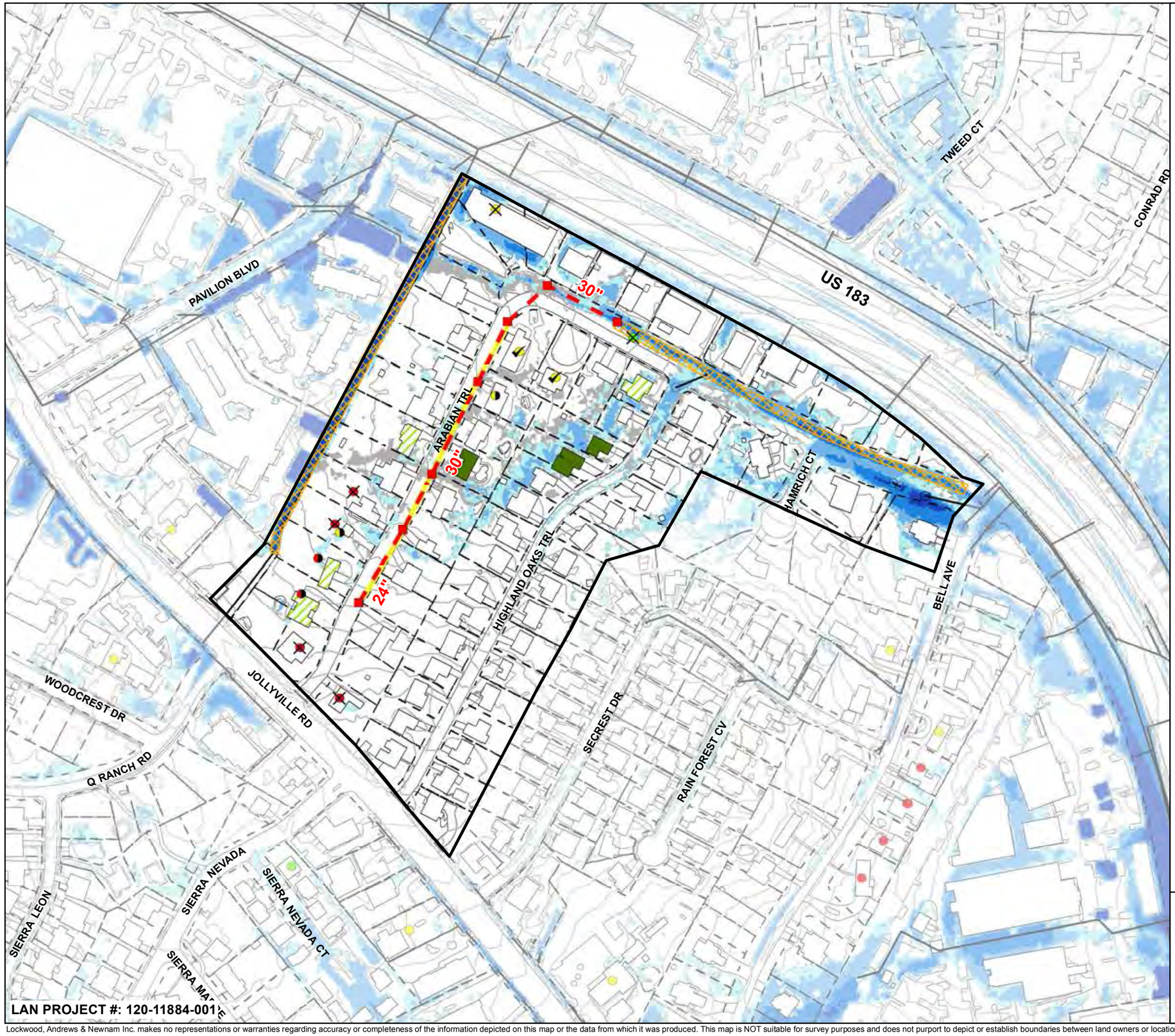


EXHIBIT 3.1

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 08/31/17



STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

PROPOSED FEATURES

- DITCH IMPROVEMENTS
- SURFACE IMPROVEMENTS (6" CURB AND GUTTER)

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

0 125 250
Feet

CITY OF AUSTIN FOUNDED 1839

ARABIAN TRAIL AREA
100-YR INUNDATION
ALTERNATIVE 2 - DCM

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REMOVED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

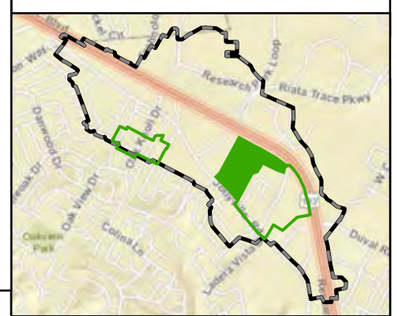
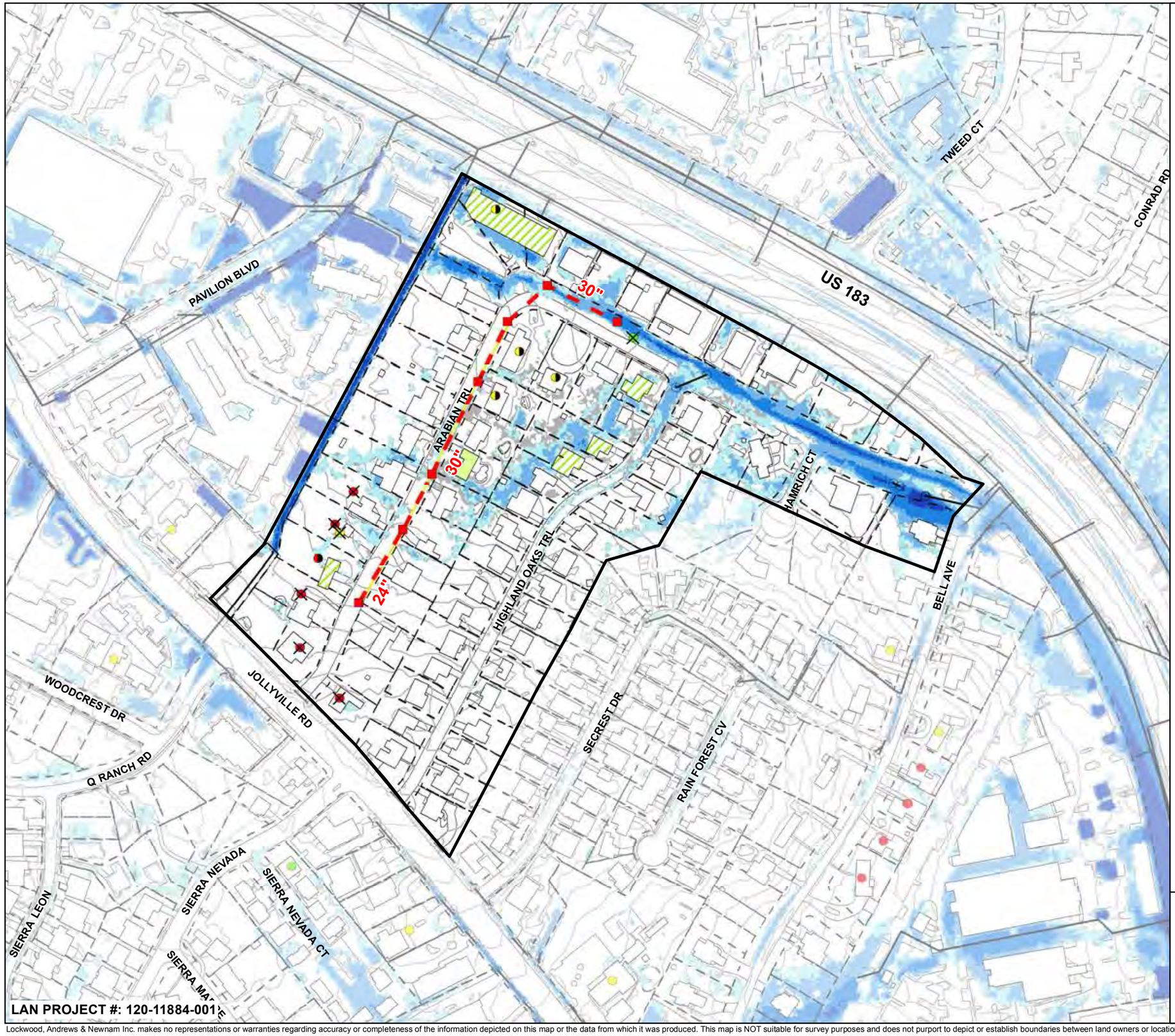


EXHIBIT 3.2

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 08/31/17



STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

PROPOSED FEATURES

- SURFACE IMPROVEMENTS (3" CURB AND GUTTER)

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

N

0 125 250

Feet

CITY OF AUSTIN FOUNDED 1839

ARABIAN TRAIL AREA
100-YR INUNDATION ALTERNATIVE 3

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

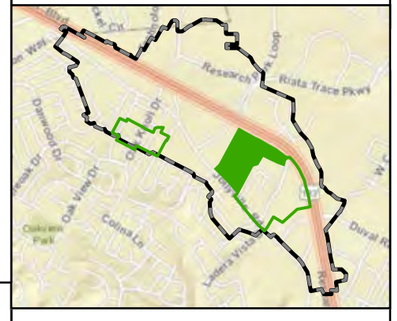
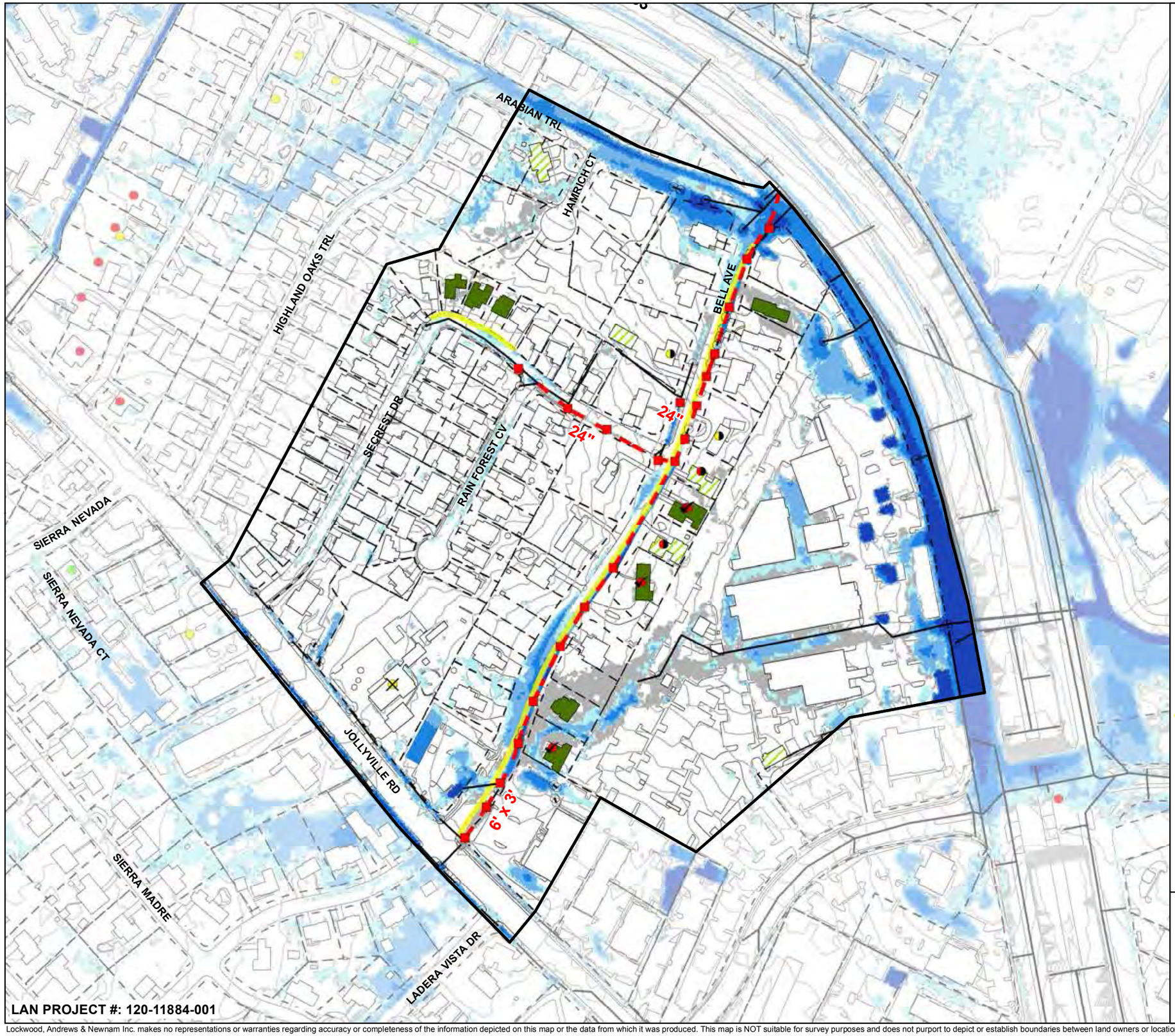


EXHIBIT 3.3

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 08/31/17



LAN PROJECT #: 120-11884-001

STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 2'
- > 2'

PROPOSED FEATURES

- SURFACE IMPROVEMENTS (6" CURB AND GUTTER)

Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft from survey data

N

0 125 250

Feet

CITY OF AUSTIN FOUNDED 1839

BELL AVENUE AREA
100-YR INUNDATION
ALTERNATIVE 1 - DCM

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

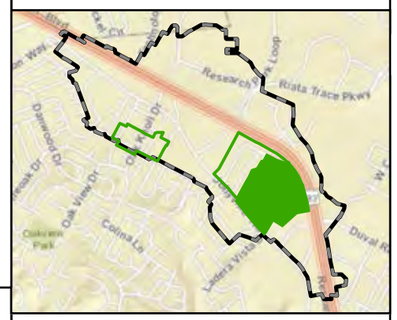
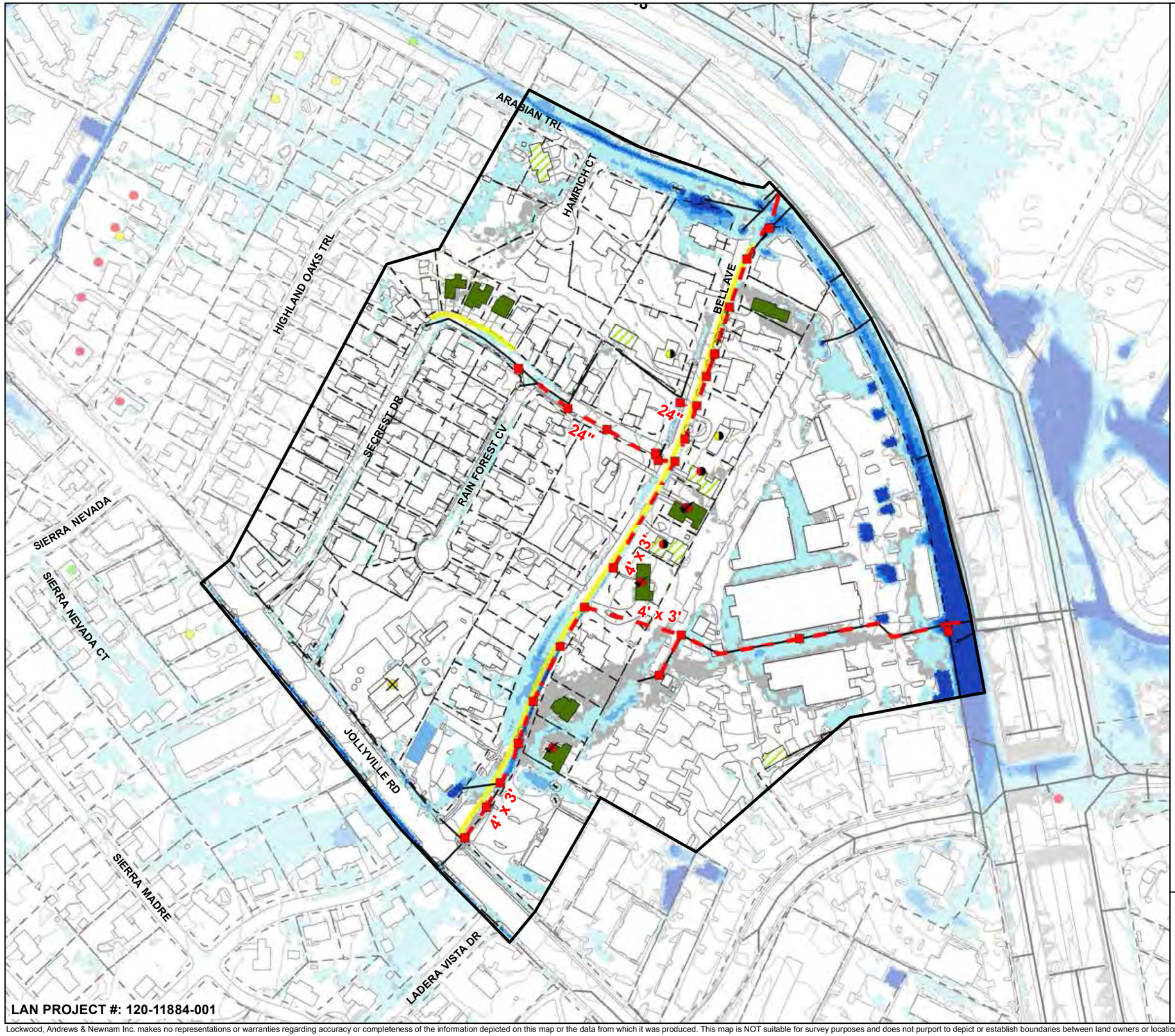


EXHIBIT 4.1

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Updated 05/30/17



STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 1.5'
- >1.5 - 2'
- > 2'

PROPOSED FEATURES

- SURFACE IMPROVEMENTS (6" CURB AND GUTTER)

*** Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft**

N

0 125 250

Feet

CITY OF AUSTIN FOUNDED 1839

BELL AVENUE AREA
100-YR INUNDATION
ALTERNATIVE 2 - DCM

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

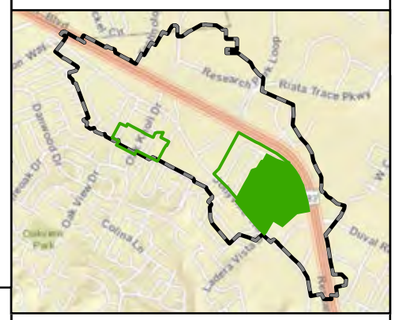
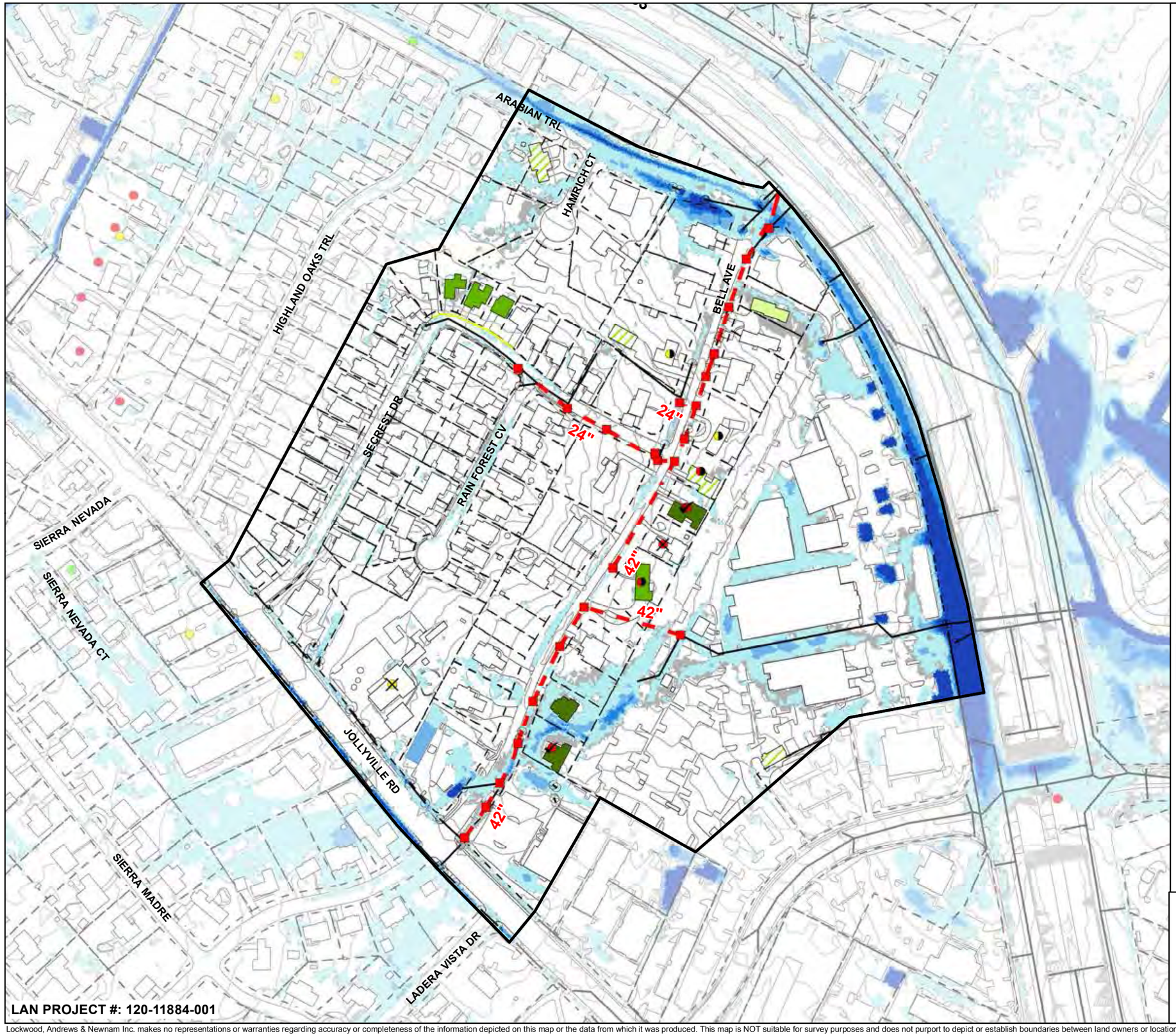


EXHIBIT 4.2

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

LAN PROJECT #: 120-11884-001

Updated 05/30/17



STRUCTURES

FLOODING REMOVED

- 100-YR
- 25-YR
- 10-YR
- 2-YR

FLOODING REDUCED

- W.S. ELEV DECREASED

PONDING/FLOODING

EXISTING

- ≥ 0.3'

PROPOSED

- 0.3' - 0.5'
- > 0.5' - 1'
- > 1' - 1.5'
- >1.5 - 2'
- > 2'

PROPOSED FEATURES

- SURFACE IMPROVEMENTS (3" CURB/ DRIVEWAY IMPROVEMENTS)

*** Flooding is based on a calculated average Finished Floor Elevation of 0.8 ft**

0 125 250

Feet

CITY OF AUSTIN FOUNDED 1839

BELL AVENUE AREA
100-YR INUNDATION ALTERNATIVE 3

LEGEND

- 2 FT CONTOURS
- LOT LINES
- AREA OF INFLUENCE
- EXISTING INLETS
- PROPOSED INLETS
- EXISTING STORM DRAIN
- PROPOSED STORM DRAIN

REPORTED FLOODING

- BUILDING
- STREET
- YARD

100-YR BENEFITS

- ✓ REMOVED
- ◑ HELPED
- ✕ NOT HELPED

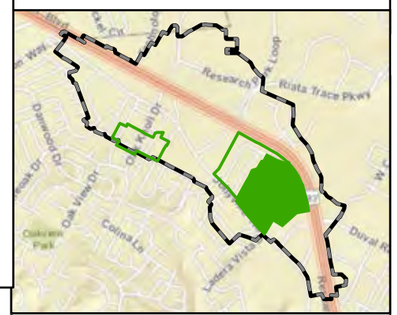


EXHIBIT 4.3

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

LAN PROJECT #: 120-11884-001

Appendix B

Appendix B – 2D Modeling Methods

Oak Knoll Storm Drain Improvements

Project Specific 2D Modeling Methods

Revised 3/22/17

LAN Project No. 120-11884-001

Table of Contents

1. Introduction

The purpose of this document is to supplement the City of Austin's Drainage Criteria Manual (DCM) by providing additional guidance on 2-dimensional (2D) hydraulic modeling. The DCM does not currently define specific methods or standards for 2D modeling. Various methods and approaches are available for inlet level analysis that can result in a wide range of modeling outcomes. This document will assist with defining best practices for consistency. As part of the Oak Knoll Drainage Improvements project, LAN will establish clear and agreed upon modeling methods that will be applied to the project as documented below.

1.1 Rain-on-Mesh vs Detailed Inlet Level Analyses

2D modeling can be conducted at varying levels of detail. "Rain on mesh" involves draping a rainfall hyetograph directly onto a 2D mesh. Hydrologic inputs are minimal as many of the traditional parameters are hydraulically calculated within the model such as Time of Concentration (Tc) and basin storage. Rain on mesh analysis can be conducted within a spectrum of analysis detail such as infiltration losses and sub-surface (storm drain) modeling. Depending on the level of detail developed for the rain-on-mesh simulation, analysis methods such as calibration/validation, inlet capacity, and creek flooding can be difficult to appropriately simulate.

Detailed "inlet-level" 2D modeling includes utilizing traditional hydrology by delineating a drainage area and developing a hydrograph to each inlet and other points of interest within the model. The modeler is given much more control on where flow enters the surface, inlet, or manhole which allows for more accurate modeling. As the sub-surface system is exceeded, overflow will spill onto the 2D mesh. Using more traditional hydrologic methods provides more parameters that are able to be adjusted during model validation. During detailed design, utilizing the detailed "inlet-level" 2D modeling analysis provides more accurate and appropriate flood mitigation solutions.

Analysis of the Oak Knoll Storm Drain improvements will begin with a high-level rain-on-mesh simulation and proceed to a detailed "inlet-level" 2D analysis as documented below.

2. Hydrologic Methods

In order to create the inlet level InfoWorks™ ICM model, a full hydrograph method is required for the dynamic analysis. Most storm drain systems that are designed in the City of Austin utilize the rational method, which is a steady state peak flow only method that does not provide a full hydrograph.

Section 2.3.0 of the City's Drainage Criteria Manual states:

> *"The National Resources Conservation Service (formerly the Soil Conservation Service) hydrologic methods (available in the NRCS TR-20, and the US Army Corps of Engineers' Hydrologic Engineering Center's HEC-HMS program) should be used for drainage areas larger than 100 acres but may also be used for drainage areas of any size."*

It is recommended that the NRCS hydrologic methods outlined in TR-55 be utilized to develop inlet level hydrographs. During the analysis and design, rational method peak flows will be compared to the NRCS peak flows. If warranted, the NRCS hydrographs will be modified to closely match the rational method peaks. This adjustment will be accomplished by modifying the peak rate factor.

2.1 Drainage Areas / Study Points

The appropriate number of study points will be selected for the ICM model to properly specify locations where inflow hydrographs will be placed inside the model based on discussion with City staff and overall project needs. A drainage basin will be delineated for each of the study points where it is determined that a drainage area with associated inflow hydrograph would be required. These locations could include areas such as inlets within the project corridor, likely direct offsite overflows, and significant ditches. Critical locations such as individual inlets may need additional study points to add more inflow definition, other less critical locations may be consolidated to reduce the total number of inflow points.

2.2 Rainfall

A NRCS Type III 24-hour storm will be utilized for hydrograph development. 24-hour rainfall depths per frequency event from Table 2-3 of the DCM will be used for the analysis.

2.3 Time of Concentration

The NRCS unit hydrographs are primarily a function of the lag time for each basin. Lag time is defined as 60% of the time of concentration. Time of Concentration (Tc) values will be calculated for each of the delineated basins using methods outlined in Section 2.5.3 of the DCM. Longest flowpaths will be delineated for each of the three flow regimes: sheet flow, shallow concentrated flow, and channel flow. The time of concentration values will be converted into lag times and input into the HMS model.

Section 2.4.2 of the DCM states that the minimum used Tc should be 5 minutes. While this may be appropriate for new storm sewer design, it may not be appropriate for a dynamic analysis for a flood mitigation project. It is recommended that the actual calculated Tc be utilized for the Oak Knoll Stormdrain Improvements project.

2.4 Losses

The Curve Number method will be utilized to estimate infiltration losses as outlined in Section 2.5.2 of the DCM. The NRCS soil data will be obtained to determine the hydrologic soil group classification for the region. A composite curve number will be created for each basin based on the land cover type in combination with the NRCS hydrologic soil group. Antecedent Moisture Conditions (AMC) II Curve Numbers values will be used for all areas unless otherwise directed.

2.5 Routing

Flood routing is directly simulated within the dynamic 2D model and is not necessary as part of the hydrologic analysis for this type of study.

2.6 Hydrograph Developments

Infoworks™ ICM is capable of computing hydrographs with the NRCS parameters, however it can be cumbersome to review. For the Oak Knoll Drainage Improvements project, the most up to date HEC-HMS version will be utilized to calculate inflow hydrographs. A hydrograph will be created for each specified study point required in the ICM model.

3. Hydraulic Methods

2-dimensional models are created in order to better understand the performance of a drainage system in a given study area. The models simulate the storm water runoff carried by both surface drainage features and the subsurface storm sewer infrastructure and its interactions with the ground surface.

3.1 1-D Network

3.1.1 Storm Sewer Modeling

Storm sewer connectivity, sizes and flowlines will be gathered from the provided GIS information in order to match City provided as-built information. Where flowline or size information is not available from GIS data or as-built information, it will be supplemented with field measurements or assumed from surrounding similar pipes. In areas with no upstream or downstream information, pipe flowlines will be assumed to be installed at grades sufficient to provide full flow velocities at three feet-per-second. The Manning's roughness parameters for conduits will be 0.012 for precast concrete pipes and 0.024 for corrugated metal pipes where appropriate.

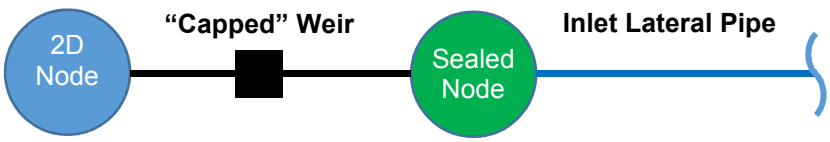
3.1.2 Node Types

Node types should be set according to what they physically represent. Inlets and points that are to interact with the 2D surface should be set to "2D Node" flood type. Sealed and connectivity manholes should be set to "sealed" flood type in order to not interact with the 2D surface. Storm sewer outfalls that will interact directly with 2D surfaces should be set to "2D outfall" type in order to place runoff back on to the surface at the storm sewer outfall. Traditional 1D outfalls should be set to "outfall" type. All nodes with the exception of "2D Nodes" should use the default parameters as specified per InfoWorks ICM. Parameters and values of "2D Nodes" should be set as shown below:

Ground elevation: assigned by LiDAR
Flooding Discharge Coefficient: 5, in order to not create an arbitrary restriction for the link between the 1D surface and 2D surface elements
Mesh Element Area Factor: 1, or as high as necessary to create a large enough mesh element for the subsurface system to interact with

3.1.3 Inlet Capacity Determination

Drainage inlet capacity will be evaluated to properly model the subsurface infrastructure flow. Inlets will be modeled as a three-part element consisting of two nodes and one link as illustrated below.



The first, upstream node is a 2D modeling node that interacts with the 2D mesh surface. The second node is a sealed node representing the connection to the downstream storm sewer system (lateral or trunk line depending on the location). The two nodes are connected via a "capped" weir to represent the losses and restrictions of an inlet. The inlet is represented as a

"capped" weir, limiting the amount of flow transferred from the mesh 2D node to the storm sewer system sealed node. The ICM default weir coefficients are inappropriate for DCM inlet equations due to the differences in weir equation implementation between the DCM and Infoworks ICM. Table 1 below illustrates the difference between DCM and ICM Equivalent coefficients. It is recommended that the ICM equivalent coefficients be used.

Table 1 ICM Equivalent Coefficients

Coefficient Type	DCM Coefficient	ICM Equivalent Coefficient
Weir	3.0	0.53
Weir	2.3	0.405
Orifice	0.67	0.95

Additional Weir parameters should be set as follows:

Length: actual length of inlet opening
Height: actual height of the inlet opening
Crest Elevation: elevation of the inlet throat set at the elevation of the LiDAR minus the height of the opening.
Primary discharge coefficient: 0.53 represents weir flow
Secondary discharge coefficient: 0.95 represents orifice flow when the inlet is overtopped.

Area inlets should be modeled like curb inlets with the weir lengths equal to the total length of sides for the area inlet. Grate inlets should also be modeled with the same approach where the weir length is equal to the total open length of the grates. Grate inlet capacity should be checked against typical DCM reported capacities and discharge coefficients within ICM modified to appropriately represent the overall inlet capacity. If desired, blockages can be represented with reductions in the effective length of the culvert or modifying the discharge coefficients to represent a reduced capacity condition.

3.1.4 Inlet Level Hydraulic Inputs

Hydrograph results will be exported from HEC-HMS using the HEC DSS-VUE program and imported to the InfoWorks™ ICM hydraulic model at the points of interest (manhole, inlet, surface, etc.). Each individual runoff hydrograph will be associated with the appropriate node within the model based upon the drainage area and node name. It is recommended that each subbasin be named according to the node that it will contribute to in the model. Additionally, it is recommended that each set of inflow records within the master database should be named according to the following protocol "ReturnPeriodDurationDevelopmentType" such as "100yr24hrExistingConditions" or "25yr3hrProposedConditions." This will enable clear documentation of the storm event of each flow record.

3.2 2D Network and Surface

3.2.1 LiDAR

Within ICM, a triangular mesh will be generated to perform the analysis of the surface flows using the built-in InfoWorks mesh creation process. LiDAR data will be provided by the City or acquired from survey data. This data will be imported into ICM as a high resolution ASCII ground model from which the mesh will be created. Elevations at the vertices of the generated mesh elements are interpolated from the LiDAR derived ground model. It is recommended that the raw LiDAR

(LAS files) be utilized in order to create a high resolution ASCII ground model. This ground model should be comprised of bare earth returns only and should be post processed into a grid of resolution sufficient to represent the area of interest. It is recommended that the grid resolution be of sub-5'x5' grids in order to appropriately represent the study area.

3.2.2 2D Simulation Area

The mesh minimum triangle size will be adjusted to provide adequate definition of the study area. The Terrain-sensitive meshing will be used and a six-inch max elevation difference set to ensure that curbs are visible in the 2D mesh zone. Recommend baseline parameters for the 2D simulation area are below:

Mesh ID: 1
Maximum Triangle Area: 1500 square feet
Minimum Triangle Area: 10 square feet, subject to change depending on underlying LiDAR resolution
Boundary Type: normal; to allow flow to leave the study area
Terrain Sensitive Meshing: enabled
Maximum Height Variation: 0.5-feet
Roughness: standard concrete values
Apply rainfall directly to mesh elements: enabled

Building footprints will not be placed as voids during development of the initial "rain-on-mesh" model due to the void area being removed from the mesh area artificially lowering the total volume of storm water calculated.

3.2.3 Roughness Zones

Overland roughness zones are incorporated into the 2D mesh surface to account for variations in surface roughness such as the change from concrete areas to grassed areas. The city land use data will be used to specify the correct roughness value assigned to different areas within the study area. Building footprint GIS data will be input as roughness areas with a high roughness coefficient to slow the flow through buildings.
Manning's Roughness tables are generally developed assuming channelized flow. These flows may not appropriately represent overland sheet flow that commonly occurs within a 2D model. LAN will work with the City to establish a project specific n-value table for the roughness zones within the 2D model that will be documented in this report. Preliminary recommended roughness values are below.

Table 2: Roughness Values for Flow less than 3.0 feet

Manning's "n"	Land Use
0.012	Streets, paved areas
0.085	Generic Residential
0.12	Dense Grass Areas (lawns)
0.14	Generic Undeveloped Area

Refer to the DCM for roughness values for any flow depths above 3.0 feet.

3.2.4 Break lines and Porous Walls/Polygons

Even with terrain sensitive meshing, it may be necessary to establish break lines in order to better represent critical topographic features such as roadway crowns, roadway curbs, and other distinct topographic transitions. Break lines should be drawn with the minimal number of vertices in order to describe the feature. Additional vertices can over complicate the mesh and create a high number of small triangles which can slow down the overall simulations. Break lines placed next to one another or directly adjacent (touching) should be drawn with snapping enabled and the end/start points of each break line exactly coincident.
Complicated overland flow regimes involving cross block flooding and fences may necessitate the need for porous walls. It is recommended that porous walls and polygons not be part of the initial simulation and only be added if the verification and validation events do not adequately represent known water surfaces or ponding extents. Porous walls and polygons have the ability to represent partially porous structures such as fences and building crawl spaces. Porous walls and polygons should be drawn with snapping enabled and with the minimal number of vertices necessary to represent the feature. Care should be taken with drawing porous walls and polygons to ensure that numerous small triangular features are not created within the mesh. If porous walls or polygons are necessary, the porosity of each feature should be estimated with field visits or other data.

3.2.5 Mesh Zones and Mesh Level Zones

Mesh zones should be utilized if a change in the prevailing mesh resolution of the 2D study area is necessary. This may be necessary when areas of higher resolution are needed while keeping the overall mesh counts as low as possible to assist with shorter run times.

Mesh Level and mesh zones should also be utilized when LiDAR elevations do not match known field conditions. Either option, can be utilized to provide surface adjustments. Mesh Level Zones can be utilized when a higher degree of control is required for surface adjustments.

Mesh Level Zones can be used in tandem with roughness zones to better define the overall finished floor elevation and structural footprint of structures. Mesh Level Zones can be used to set the mesh levels to the approximated finished floor of the structure and assist with preventing flow through that structure prior to inundation.

3.2.6 Infiltration Zones

Initial and infiltration losses are accounted for as part of the individual, inlet, level detailed HEC-HMS model and should not be “double counted” within the 2D surface.

3.3 Boundary Conditions

Storm sewer outfall locations should be evaluated in order to determine the influence of potential downstream conditions. Outfalls for storm sewer systems will be analyzed to ensure that tailwater conditions do not apply. If there is a natural or man-made drainage feature (i.e. drainage ditch, creek, river, pond, or lake) that the system outfalls into, the water surface elevation level (WSEL) of that feature will be determined. The resulting WSEL will be incorporated into the model as a Level Event that can be assigned to that outfall node or edge of the 2D mesh. If the travel time of the system being studied is significantly shorter than the system it outfalls into, a reasonably constant WSEL will be applied to the outfall node unless otherwise specified. If no detailed information can be found for the upstream or downstream drainage features, the 2D mesh zone

area will be extended a distance upstream and downstream. If outfalling to a drainage feature where offsite influences are expected, a 2D inflow point or inflow line, will be applied to the upstream edge of the 2D mesh and a known level or normal depth condition at the downstream edge of the mesh.

3.4 Simulation Run Parameters

Simulation parameters form the basis for how InfoWorks ICM runs are performed and stored. Recommended Defaults are as follows:

Name: "TypeReturnPeriodDuration;" example "ExistingConditions100yr24hr"
Run Parameters
Start: 00:00 01/01/2016 or to match inflow and tailwater start times
Timestep: 1s
Results Timestep Multiplier: 60
Gauge Timestep Multiplier: 60
Finish
Duration: 1440 minutes, assuming a 24-hour storm
Rain Event: Blank
Inflow: inflow for the specified return period and storm duration
Level: level for the specified return period and storm duration
Other Options:
Summary PRN Results: enabled
Exit if initialization fails: enabled
2D Parameters/ GPU: always enabled
Diagnostics/Timestep log: enabled

4. Calibration/Validation

Once the ICM model is built, runoff hydrographs for multiple historic flood events will be developed for each of the drainage areas based on rainfall depths or rain gages in the region. The hydrographs will be input to the 2D model and simulated to produce inundation depths for each event. The inundation results will be compared to the observed high water marks. Based on the results, the HEC-HMS and/or ICM model will be adjusted as appropriate to best simulate the historic events. Potential items to be adjusted include the following: overland roughness zones, structural block outs, porous walls, porous polygons, initial losses, infiltration parameters, inlet locations, inlet losses, tailwater conditions, mesh resolution, mesh adjustment zones, and break lines.

5. Design Methods

Design guidance and required hydraulic output outlined in the DCM is based upon 1D analysis only. It is not common for the City to develop construction documents based on a purely 2D hydraulic design, and therefore standard model output tables for the plans do not exist. LAN will create project specific runoff, inlet, and storm sewer calculation tables that effectively communicate modeling design parameters for reviewers that are not accustomed to 2D modeling analysis or design.

Specifics will be developed/discussed during the 30% design phase of the Oak Knoll Drainage Improvements project.

Appendix C

Appendix C – Hydrologic and Hydraulic Calculations

Weighted Curve Number Calculations/Impervious Cover

Time of Concentration/Lag Time

Comparison of Peak Flow Rates

Downstream Impacts

Weighted Curve Number Calculation

Project: Oak Knoll Drainage Study LAN Project No. 120-11884-001
Engineer: Olive MacGorman, EIT
Date: February 20, 2017

DA ID	Hyd Soil	Area (ac)	Land Use											
			CS	CS-1	CS-CO	GO	GO-CO	GR	GR-CO	GR-MU-CO	LI	LI-CO	LI-PDA	LI-PDA-CO	LO
DA01	D	1084900	0	0	0	0	0	0	0	0	0	0	0	0	0
DA02	D	573565	0	0	0	0	0	0	0	0	0	0	0	0	0
DA03	D	408550	0	0	0	0	0	0	0	0	0	0	0	0	0
DA04	D	126421	0	0	0	0	0	0	0	0	0	0	0	0	0
DA05	D	356772	0	0	0	2051	0	0	0	0	0	0	0	0	0
DA06	D	431986	0	0	0	0	0	0	0	0	0	0	0	0	0
DA07	D	135316	0	0	0	0	0	0	0	0	0	0	0	0	0
DA08	D	449168	0	0	0	406	0	0	0	0	0	0	0	7625	0
DA09	D	139966	0	0	0	119901	0	0	0	0	0	0	0	13478	0
DA10	D	266750	0	0	0	2684	75631	0	0	0	0	0	0	169061	0
DA11	D	357009	0	0	0	0	1605	0	0	0	166248	0	0	0	0
DA12	D	1256640	0	0	0	0	0	0	0	0	0	0	6928	0	118622
DA13	D	50052	0	0	0	0	0	0	0	0	0	0	0	0	8004
DA14	D	706768	0	0	5060	0	0	620522	0	0	0	0	0	0	724
DA15	D	469601	0	0	0	0	0	361856	364	396	0	0	0	0	79732
DA16	D	82425	0	0	0	0	0	249	0	35975	0	0	0	0	645
DA17	D	146450	0	0	0	0	0	0	0	132	0	0	0	0	0
DA18	D	739263	0	0	0	0	0	0	5692	0	0	0	0	0	4264
DA19	D	107199	0	0	0	0	0	0	0	0	0	0	0	0	0
DA21	D	382692	0	0	0	0	0	0	0	0	0	0	0	0	0
DA22	D	180796	0	0	0	0	0	0	0	0	0	0	0	0	0
DA23	D	66321	0	0	0	0	0	0	0	0	0	0	0	0	0
DA24	D	90446	0	0	0	0	0	0	0	0	0	0	0	0	0
DA25	D	159111	0	0	0	0	0	0	0	0	0	0	0	0	56
DA26	D	35826	0	0	0	0	0	0	0	0	0	0	0	0	0
DA27	D	429472	0	0	0	0	0	0	30431	0	0	0	0	0	290
DA28	D	391622	0	0	0	0	0	0	10641	0	0	0	72426	0	115783
DA29	D	1222980	0	0	0	0	0	26922	832634	139327	0	0	105839	0	60838
DA30	D	4648120	0	0	0	0	0	36836	0	0	4336358	41305	0	0	3207
DA31	D	2215000	0	7598	42031	0	0	500543	37677	0	0	0	0	0	438400
DA32	D	1470290	0	0	4972	0	0	6173	433	0	45050	285	0	0	10339
DA33	D	247124	0	0	0	0	0	1027	2455	0	0	0	0	0	2569
DA35	D	224802	0	0	0	0	0	0	4967	0	0	0	0	0	0
DA36	D	1528010	856	3109	0	0	0	324141	137185	6554	0	0	0	0	196784
DA37	D	1327610	5941	0	0	0	0	43330	0	0	0	0	0	0	208136
DA38	D	543585	0	0	225319	0	0	186626	0	0	0	0	0	0	20609
DA39	D	287088	0	0	0	0	194922	0	0	0	464	0	0	68338	0
DA40	D	106368	0	0	0	0	0	3895	84439	0	0	0	0	0	16812
DA41	A	65012	0	0	0	0	0	0	0	0	52527	0	0	0	11352
DA41	D	598702	0	0	0	0	0	23929	0	0	229455	149575	0	0	102472
DA42	D	162368	0	0	0	0	0	0	0	0	0	0	0	0	0
DA43	D	60776	0	0	0	0	0	0	0	0	0	0	0	0	0
Land Use IC%			0.95	0.95	0.95	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7

CN for all DA except 41 is 80

DA ID	Hyd Soil	Area (ac)	CN	Comp CN
DA41	A	65012	49	81
DA41	D	598702	84	

Source: City of Austin Drainage Criteria Manual

Weighted Curve Number Calculati

Project: Oak Knoll Drainage Study
Engineer: Olive MacGorman, EIT
Date: February 20, 2017

DA ID	Hyd Soil	Area (ac)	LO-CO	LO-MU-CO	LR	LR-CO	MF-2	PUD	SF-2	SF-3	SF-6	SF-6-CO	W/LO	ROW	IC%	Area (sqmi)
DA01	D	1084900	0	0	0	0	376736	80471	108362	441616	0	0	0	77715	52.69%	0.0389
DA02	D	573565	0	0	0	0	509	0	66028	350473	0	0	0	156556	57.30%	0.0206
DA03	D	408550	0	0	0	0	19340	3036	398	213287	0	0	0	172489	64.63%	0.0147
DA04	D	126421	0	0	0	0	0	0	18694	46317	0	0	0	61411	66.86%	0.0045
DA05	D	356772	0	0	0	0	0	0	0	194919	5174	0	0	154629	64.85%	0.0128
DA06	D	431986	0	0	0	0	0	0	320550	13413	0	0	0	98023	55.21%	0.0155
DA07	D	135316	0	0	0	0	0	0	106371	0	0	0	0	28945	54.63%	0.0049
DA08	D	449168	0	0	0	0	0	0	120369	161920	58210	52248	0	48390	52.93%	0.0161
DA09	D	139966	0	0	0	0	0	0	0	0	0	0	0	6587	80.47%	0.0050
DA10	D	266750	0	0	0	0	0	0	0	0	0	0	0	19374	80.73%	0.0096
DA11	D	357009	0	0	0	55180	0	0	35419	4285	0	0	0	94272	78.75%	0.0128
DA12	D	1256640	80407	3994	768	7682	0	0	633472	4895	0	0	72922	326949	62.63%	0.0451
DA13	D	50052	0	0	0	0	0	0	0	0	0	0	0	42048	86.80%	0.0018
DA14	D	706768	374	0	0	0	0	0	0	0	0	0	0	80089	90.00%	0.0254
DA15	D	469601	0	0	0	0	0	0	25277	0	0	0	0	1976	84.18%	0.0168
DA16	D	82425	0	0	0	0	0	0	508	0	0	0	0	45047	89.57%	0.0030
DA17	D	146450	0	0	0	0	0	0	108209	0	0	0	0	38109	56.75%	0.0053
DA18	D	739263	0	0	0	0	0	0	563854	71	0	0	0	165382	55.56%	0.0265
DA19	D	107199	0	0	0	0	0	0	76278	0	0	0	0	30921	57.98%	0.0038
DA21	D	382692	0	0	0	0	0	0	331839	16551	0	0	0	34302	49.03%	0.0137
DA22	D	180796	10951	0	0	0	0	0	126913	0	0	0	0	42932	57.20%	0.0065
DA23	D	66321	0	0	0	0	0	0	54629	0	0	0	0	11693	52.93%	0.0024
DA24	D	90446	0	0	0	0	0	0	60351	0	0	0	0	30095	59.97%	0.0032
DA25	D	159111	0	0	0	0	0	0	110616	10896	0	0	0	37543	55.63%	0.0057
DA26	D	35826	0	0	0	0	0	0	12173	0	0	0	0	23653	74.71%	0.0013
DA27	D	429472	0	0	0	0	0	0	192806	138392	0	0	0	67552	55.28%	0.0154
DA28	D	391622	4670	37764	0	0	0	0	20479	90816	0	0	0	39043	67.28%	0.0140
DA29	D	1222980	24513	0	0	28805	0	0	0	0	0	0	0	4102	87.50%	0.0439
DA30	D	4648120	3829	0	0	0	0	0	510	52488	0	0	0	173587	80.04%	0.1667
DA31	D	2215000	0	0	2997	3893	0	0	26415	4928	0	0	0	1150518	85.49%	0.0795
DA32	D	1470290	0	0	0	0	0	0	1149	1254	0	0	0	1400634	89.49%	0.0527
DA33	D	247124	0	0	0	0	0	0	0	278	0	0	0	240795	89.74%	0.0089
DA35	D	224802	0	0	0	0	0	0	0	0	0	0	0	219835	90.00%	0.0081
DA36	D	1528010	2964	0	2050	5970	0	0	0	0	0	0	0	848399	87.35%	0.0548
DA37	D	1327610	195519	0	0	0	0	0	641620	18765	0	0	0	214298	61.56%	0.0476
DA38	D	543585	70103	0	0	0	0	0	0	0	0	0	0	40929	88.73%	0.0195
DA39	D	287088	0	0	0	0	0	0	0	0	0	0	0	23363	80.81%	0.0103
DA40	D	106368	0	0	0	0	0	0	0	1068	0	0	0	153	86.39%	0.0038
DA41	A	65012	0	0	0	0	0	0	0	0	0	0	0	1134	79.81%	0.0238
DA41	D	598702	0	0	0	0	0	0	3315	460	0	0	0	89495		
DA42	D	162368	0	0	0	0	0	0	74057	54366	0	0	0	33945	54.41%	0.0058
DA43	D	60776	0	0	0	0	0	0	38797	0	0	0	0	21978	61.27%	0.0022
Land Use IC%			0.7	0.7	0.8	0.8	0.6	0.35	0.45	0.45	0.55	0.55	0.7	0.9	**Total Area (sqmi)**	0.8728

Table 2-7 lists the curve numbers for the four (4) soil groups under various land uses, land treatment and hydrologic conditions. Curve numbers for fully developed conditions should be based on maximum allowable impervious cover listed in Austin zoning and watershed ordinances. When calculating fully developed peak runoff rates it is recommended that the undeveloped curve number and the maximum allowable impervious cover be used as input parameters. In order to determine the soil classifications in the Austin area, the Natural Resource Conservation Service Soil Survey of Travis, Williamson or Hays County, Texas should be used. Digital versions of these soil datasets are available online at http://soildatamart.nrcs.usda.gov (accessed 12/18/2012).

Table 2-7
NRCS Runoff Curve Numbers for Urban Areas and Agricultural Lands (assuming ARC-II condition)

Cover Description		Curve Numbers for Hydrologic Soil Group			
Cover type and Hydrologic Condition	Average % Impervious Area [1]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)					
Poor condition (grass cover 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover 75%)		39	61	74	80

Source: City of Austin Drainage Criteria Manual

Rational Method Calculations

Project: Oak Knoll Drainage Study
Engineer: Olive MacGorman, EIT
Date: March 1, 2017

Rainfall Intensity (i)			
	a	**b**	**c**
25-yr	82.936	10.746	0.7634
100-yr	118.3	13.185	0.7736

C-Value (C)		
25-yr	**100-yr**	
0.42	0.49	Pervious area C - Fair condition, 2-7% (C_{PERV})
0.86	0.95	Impervious area C (C_{IMPERV})

DA ID	T_c min	IC%*	Area acres	C_{25yr}**	C_{100yr}**	i_{25yr} in/hr	i_{100yr} in/hr	Q_{25yr} cfs	Q_{100yr} cfs
DA01	28.50	52.69	24.91	0.65	0.73	5.04	6.60	81.7	120.4
DA02	35.00	57.30	13.17	0.67	0.75	4.48	5.90	39.6	58.6
DA03	25.00	64.81	9.30	0.71	0.79	5.41	7.07	35.4	51.8
DA04	28.17	59.86	6.63	0.68	0.77	5.07	6.64	23.0	33.7
DA05	17.17	64.85	8.19	0.71	0.79	6.53	8.44	37.7	54.5
DA06	19.67	55.21	9.92	0.66	0.74	6.12	7.94	40.2	58.6
DA07	18.67	56.77	4.52	0.67	0.75	6.28	8.13	19.0	27.6
DA08	16.83	52.93	10.31	0.65	0.73	6.59	8.51	44.4	64.4
DA09	5.50	80.47	3.21	0.77	0.86	9.87	12.28	24.6	34.0
DA10	7.50	80.73	6.12	0.78	0.86	9.04	11.36	42.9	59.9
DA11	16.67	78.75	8.20	0.77	0.85	6.62	8.55	41.6	59.7
DA12	35.00	62.63	28.85	0.70	0.78	4.48	5.90	89.9	132.5
DA13	6.67	86.80	1.15	0.80	0.89	9.36	11.72	8.6	12.0
DA14	13.83	90.00	16.23	0.82	0.90	7.20	9.24	95.3	135.5
DA15	14.33	84.18	10.78	0.79	0.88	7.09	9.11	60.4	86.1
DA16	6.50	89.57	1.89	0.81	0.90	9.43	11.80	14.5	20.1
DA17	15.17	56.75	3.36	0.67	0.75	6.91	8.90	15.6	22.5
DA18	25.17	55.56	16.97	0.66	0.75	5.39	7.04	60.8	89.1
DA19	16.83	57.98	2.46	0.68	0.76	6.59	8.51	11.0	15.9
DA21	33.33	49.03	8.79	0.64	0.72	4.61	6.07	25.7	38.1
DA22	18.00	57.20	4.15	0.67	0.75	6.39	8.27	17.8	25.8
DA23	21.33	52.94	1.52	0.65	0.73	5.87	7.64	5.8	8.5
DA24	17.83	59.97	2.08	0.68	0.77	6.41	8.30	9.1	13.2
DA25	12.00	55.63	3.65	0.66	0.75	7.64	9.75	18.5	26.6
DA26	6.67	74.73	0.82	0.75	0.83	9.36	11.72	5.8	8.0
DA27	19.67	55.28	9.86	0.66	0.74	6.12	7.94	40.0	58.3
DA28	14.83	67.28	9.00	0.72	0.80	6.98	8.98	45.0	64.6
DA29	25.00	87.50	28.08	0.81	0.89	5.41	7.07	122.2	177.1
DA30	9.00	80.03	106.94	0.77	0.86	8.51	10.76	702.4	987.1
DA31	15.33	85.53	51.41	0.80	0.88	6.88	8.86	281.6	402.3
DA32	18.50	89.64	33.34	0.81	0.90	6.30	8.16	171.2	245.6
DA33	5.83	89.74	5.67	0.81	0.90	9.72	12.12	44.9	62.1
DA35	5.83	90.00	5.16	0.82	0.90	9.72	12.12	40.9	56.5
DA36	25.00	87.35	35.08	0.80	0.89	5.41	7.07	152.6	221.1
DA37	33.33	61.58	30.55	0.69	0.77	4.61	6.07	97.3	143.3
DA38	15.00	88.73	12.48	0.81	0.90	6.95	8.94	70.3	100.2
DA39	16.67	80.81	6.59	0.78	0.86	6.62	8.55	33.9	48.6
DA40	5.83	86.39	2.44	0.80	0.89	9.72	12.12	19.0	26.3
DA41	25	79.81	15.24	0.77	0.86	5.41	7.07	63.5	92.3

*Impervious Cover (IC)

**$C = IC/100 \times C_{IMPERV} + (1-IC)/100 \times C_{PERV}$

Time of Concentration

SCS Method (TR_55)
Project: Oak Knoll Drainage Study
Location: ok 120-11884-001
Engineer: Alex Chan
Date: October 18, 2016
Updated: Olive MacGorman - Feb 20, 2017

DA ID	Time of Concentration (min)	Lag Time (min)
DA01	28.44	17.06
DA02	34.95	20.97
DA03	27.61	16.56
DA04	23.34	14.00
DA05	17.15	10.29
DA06	19.71	11.83
DA07	18.63	11.18
DA08	16.77	10.06
DA09	5.55	3.33
DA10	7.56	4.54
DA11	17.71	10.62
DA12	35.06	21.03
DA13	6.16	3.69
DA14	13.86	8.31
DA15	14.37	8.62
DA16	6.54	3.92
DA17	15.15	9.09
DA18a	25.20	15.12
DA18b	19.58	11.75
DA19	16.84	10.10
DA21	33.29	19.97
DA22	18.04	10.82
DA23	21.31	12.79
DA24	17.75	10.65
DA25	12.06	7.23
DA26	6.66	4.00
DA27	19.75	11.85
DA28	14.86	8.91
DA29	24.35	14.61
DA30	17.98	10.79
DA31	13.26	7.96
DA32	18.58	11.15
DA33	7.34	4.40
DA35	6.47	3.88
DA36	10.86	6.52
DA37	22.39	13.44
DA38	5.08	3.05
DA39	16.02	9.61
DA40	2.12	1.27
DA41	23.34	14.00
DA42	17.62	10.57
DA43	12.17	7.30

See the attached data disk for calculations.

	Peak Flow (cfs)						
	25-yr				100-yr		
	HMS	Rational	% dif		HMS	Rational	% dif
DA01	106.9	81.7	13%		146.0	120.4	10%
DA02	52.0	39.6	13%		70.9	58.6	10%
DA03	42.9	35.4	10%		58.2	51.8	6%
DA04	28.9	23.0	11%		39.4	33.7	8%
DA05	43.3	37.7	7%		58.8	54.5	4%
DA06	49.4	40.2	10%		67.4	58.6	7%
DA07	23.0	19.0	10%		31.3	27.6	6%
DA08	53.9	44.4	10%		73.7	64.4	7%
DA09	21.5	24.6	7%		29.0	34.0	8%
DA10	39.7	42.9	4%		53.5	59.9	6%
DA11	44.6	41.6	3%		60.1	59.7	0%
DA12	114.8	89.9	12%		156.1	132.5	8%
DA13	7.6	8.6	6%		10.2	12.0	8%
DA14	94.5	95.3	0%		126.8	135.5	3%
DA15	61.8	60.4	1%		83.1	86.1	2%
DA16	12.6	14.5	7%		17.0	20.1	8%
DA17	18.3	15.6	8%		24.9	22.5	5%
DA18	77.0	60.8	12%		105.1	89.1	8%
DA19	13.0	11.0	9%		17.7	15.9	6%
DA21	35.0	25.7	15%		48.0	38.1	11%
DA22	21.4	17.8	9%		29.1	25.8	6%
DA23	7.3	5.8	11%		10.0	8.5	8%
DA24	10.8	9.1	8%		14.7	13.2	5%
DA25	21.0	18.5	6%		28.7	26.6	4%
DA26	5.4	5.8	3%		7.3	8.0	5%
DA27	49.1	40.0	10%		67.0	58.3	7%
DA28	49.9	45.0	5%		67.7	64.6	2%
DA29	133.6	122.2	4%		179.5	177.1	1%
DA30	673.8	702.4	2%		907.7	987.1	4%
DA31	289.4	281.6	1%		389.0	402.3	2%
DA32	178.0	171.2	2%		238.8	245.6	1%
DA33	38.2	44.9	8%		51.3	62.1	9%
DA35	34.8	40.9	8%		46.7	56.5	10%
DA36	166.9	152.6	4%		224.2	221.1	1%
DA37	124.0	97.3	12%		168.7	143.3	8%
DA38	71.0	70.3	1%		95.3	100.2	2%
DA39	36.0	33.9	3%		48.5	48.6	0%
DA40	16.4	19.0	7%		22.0	26.3	9%
DA41	71.8	63.5	6%		96.7	92.3	2%

Total Outflow Downstream Impacts												WC Trib No. 7
	2-Year			10-Year			25-Year			100-Year		
	Peak (cfs)	Δ	%	Peak (cfs)	Δ	%	Peak (cfs)	Δ	%	Peak (cfs)	Δ	%
Existing	748			1,494			1,906			2,592		
Oak Knoll												
OK1	749	1	0.2%	1,500	6	0.4%	1,917	11	0.6%	2,608	15	0.6%
OK2	766	18	2.4%	1,555	61	4.1%	1,968	62	3.3%	2,650	58	2.2%
OK3	756	8	1.0%	1,529	35	2.3%	1,929	23	1.2%	2,613	21	0.8%
Arabian Trial												
AT1	730	-17	-2.3%	1,512	18	1.2%	1,945	39	2.1%	2,638	46	1.8%
AT2	737	-10	-1.4%	1,518	24	1.6%	1,941	36	1.9%	2,643	50	1.9%
AT3	740	-8	-1.0%	1,496	2	0.1%	1,903	-3	-0.1%	2,593	1	0.0%
Bell Avenue												
BA1	717	-31	-4.1%	1,455	-39	-2.6%	1,852	-54	-2.8%	2,515	-78	-3.0%
BA2	740	-8	-1.1%	1,484	-10	-0.7%	1,862	-44	-2.3%	2,555	-38	-1.5%
BA3	738	-10	-1.3%	1,480	-14	-1.0%	1,869	-37	-1.9%	2,559	-34	-1.3%

negative 'deltas' indicate a reduction in computed peak flow rates, and positive 'deltas' indicate an increase in computed peak flow rates

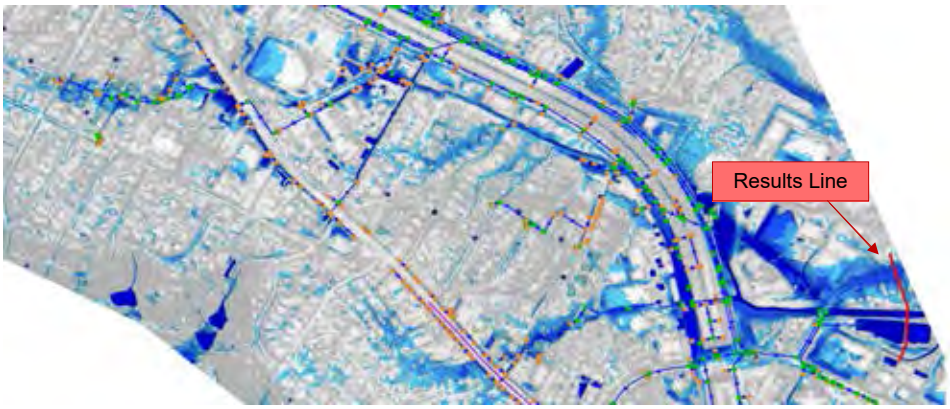


Figure 1: Total Outfall Results Line

Directly Downstream of Oak Knoll Drive Improvements

	2-Year			10-Year			25-Year			100-Year		
	Peak (cfs)	Δ	%	Peak (cfs)	Δ	%	Peak (cfs)	Δ	%	Peak (cfs)	Δ	%
Existing	88	-	-	144	-	-	177	-	-	246	-	-
OK1	90	3	3.1%	158	13	9.3%	189	12	6.8%	254	8	3.3%
OK2	115	27	31.0%	188	44	30.3%	226	49	27.6%	303	58	23.4%
OK3	114	26	29.7%	184	40	27.9%	226	49	27.6%	305	60	24.3%

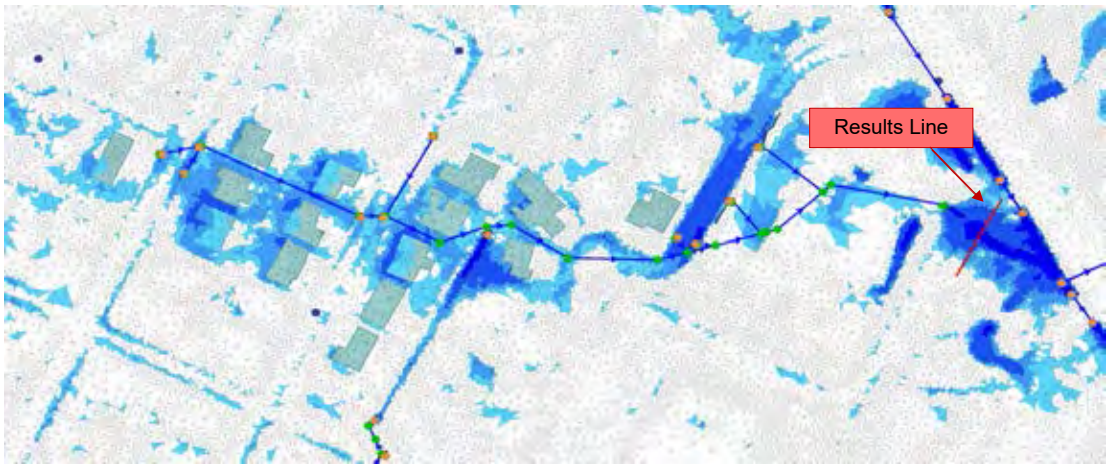


Figure 2: Oak Knoll Results Line

Appendix D

Appendix D – Construction Cost Estimates

Oak Knoll Alternatives 1 - 3

Arabian Trail Alternatives 1 - 3

Bell Avenue Alternatives 1 - 3

OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					OAK KNOLL ALT 1
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 60 IN DIA.	EA	$7,200	3	$18,960
2	JUNCTION BOX (7FT. X 4FT)	EA	$6,500	1	$6,500
3	INLET, STANDARD 10 FT	EA	$5,000	7	$35,000
4	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	1110	$5,550
5	PIPE, 24 IN. DIA., CLASS III RCP (ALL DEPTHS)	LF	$90	120	$10,800
6	PIPE, 36 IN. DIA., CLASS III RCP (ALL DEPTHS)	LF	$155	790	$122,450
7	EROSION CONTROLS	LS	$5,000	1	$5,000
8	TRAFFIC CONTROLS	LS	$10,000	1	$10,000
9	REVEGETATION	SY	$10	1100	$11,000
10	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	790	$7,900
11	SPECIAL SHORING	LF	$1,000	490	$490,000
12	STRUCTURAL MONITORING	EA	$2,500	8	$20,000
13	WATER LINE ADJUSTMENTS	LS	$56,000	1	$56,000
14	ASBESTOS PIPE REMOVAL	LS	$54,000	1	$54,000
15	PAVEMENT REPAIRS	LS	$14,000	1	$14,000
16	REMOVE AND REPLACE P.C. CONCRETE CURB AND GUTTER	LF	$40	190	$7,600
17	REMOVE AND REPLACE P.C. CONCRETE SIDEWALK, 4-FT WIDE	LF	$30	30	$900
18	REMOVE AND REPLACE P.C. CONCRETE DRIVEWAY	SF	$25	175	$4,375
				SUBTOTAL	$880,035
				MOBILIZATION 5%	$44,010
				CONTINGENCY 35%	$323,420
				TOTAL COST	$1,247,465
				ESTIMATED CONSTRUCTION COST	**$1,250,000**

ASSUMPTIONS

1. At storm drain crossings, water asbestos cement pipe is to be replaced with 60 linear feet of PVC C-900 pipe between 2 new gate valves, if valves were not in the vicinity.
2. For proposed storm drain improvements along Three Oaks Trail, water asbestos cement pipe to be replaced 20 feet passed the proposed storm drain limits with PVC C-900 pipe with gate valves at each end. Outside clearance between pipes appears to be less than 5-feet per best available information.
3. Pavement repair to be per COA STD 510S-3.
4. Existing wastewater crossings do not need to be adjusted.

Not to be used for construction, bidding, permitting or regulatory approval purposes. This document is released on May 5, 2017 for the purpose of interim review under the authority of Travis Michel, Texas PE NO. 95805, Lockwood, Andrews & Newnam, Inc., Texas Registered Engineering Firm - 2614

OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					OAK KNOLL ALT 2
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	7	$44,200
2	INLET, STANDARD 10 FT	EA	$5,000	15	$75,000
3	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	2545	$12,725
4	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	360	$32,400
5	PRECAST CONCRETE BOX CULVERTS (4 FT. X 3 FT.)	LF	$250	1060	$265,000
6	PRECAST CONCRETE BOX CULVERTS (5 FT. X 3 FT.)	LF	$275	790	$217,250
7	EROSION CONTROLS	LS	$5,000	1	$5,000
8	TRAFFIC CONTROLS	LS	$30,000	1	$30,000
9	REVEGETATION	SY	$10	1100	$11,000
10	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	2210	$22,100
11	SPECIAL SHORING	LF	$1,000	490	$490,000
12	STRUCTURAL MONITORING	EA	$2,500	8	$20,000
13	WATER LINE ADJUSTMENTS	LS	$58,000	1	$58,000
14	ASBESTOS PIPE REMOVAL	LS	$90,000	1	$90,000
15	PAVEMENT REPAIRS	LS	$70,000	1	$70,000
16	REMOVE AND REPLACE P.C. CONCRETE CURB AND GUTTER	LF	$40	870	$34,800
17	REMOVE AND REPLACE P.C. CONCRETE SIDEWALK, 4-FT WIDE	LF	$30	30	$900
18	REMOVE AND REPLACE P.C. CONCRETE DRIVEWAY	SF	$25	175	$4,375
19	REMOVE, REGRADE AND REPLACE P.C. CONCRETE CURB, GUTTER AND DRIVEWAY TO CONTAIN RUNOFF ALONG NEGATIVE DRAINING SIDE OF ROAD	LF	$50	950	$47,500
				SUBTOTAL	$1,530,250
				MOBILIZATION 5%	$76,520
				CONTINGENCY 35%	$562,370
				TOTAL ESTIMATED CONSTRUCTION COST	$2,169,140
				ESTIMATED CONSTRUCTION COST	**$2,170,000**

ASSUMPTIONS

1. At storm drain crossings, water asbestos cement pipe is to be replaced with 60 linear feet of PVC C-900 pipe between 2 new gate valves, if valves were not in the vicinity.
2. For proposed storm drain improvements along Three Oaks Trail, water asbestos cement pipe to be replaced 20 feet passed the proposed storm drain limits with PVC C-900 pipe with gate valves at each end. Outside clearance between pipes appears to be less than 5-feet per best available information.
3. Pavement repair to be per COA STD 510S-3.
4. Existing wastewater crossings do not need to be adjusted.
5. Assumes ABANDONED Wastewater AC Pipe on Oak Knoll does not need to be removed.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					OAK KNOLL ALT 3
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	10	$57,880
2	INLET, STANDARD 10 FT	EA	$5,000	20	$100,000
3	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	3454	$17,270
4	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	300	$27,000
5	PIPE, 30" DIA RCP CLASS III STORM SEWER PIPE	LF	$125	260	$32,500
6	PIPE, 36" DIA RCP CLASS III STORM SEWER PIPE	LF	$155	330	$51,150
7	PRECAST CONCRETE BOX CULVERTS (4 FT. X 3 FT.)	LF	$250	1162	$290,500
8	PRECAST CONCRETE BOX CULVERTS (5 FT. X 3 FT.)	LF	$275	381	$104,775
9	PRECAST CONCRETE BOX CULVERTS (6 FT. X 3 FT.)	LF	$340	461	$156,740
10	EROSION CONTROLS	LS	$5,000	1	$5,000
11	TRAFFIC CONTROLS	LS	$30,000	1	$30,000
12	REVEGETATION	SY	$10	1200	$12,000
13	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	2894	$28,940
14	SPECIAL SHORING	LF	$1,000	200	$200,000
15	STRUCTURAL MONITORING	EA	$2,500	3	$7,500
16	WATER LINE ADJUSTMENTS	LS	$86,000	1	$86,000
17	ASBESTOS PIPE REMOVAL	LS	$162,000	1	$162,000
18	PAVEMENT REPAIRS	LS	$92,000	1	$92,000
19	REMOVE AND REPLACE P.C. CONCRETE CURB AND GUTTER	LF	$40	1305	$52,200
20	REMOVE AND REPLACE P.C. CONCRETE SIDEWALK, 4-FT WIDE	LF	$30	30	$900
21	REMOVE AND REPLACE P.C. CONCRETE DRIVEWAY	SF	$25	350	$8,750
22	REMOVE, REGRADE AND REPLACE P.C. CONCRETE CURB, GUTTER AND DRIVEWAY TO CONTAIN RUNOFF ALONG NEGATIVE DRAINING SIDE OF ROAD	LF	$50	1330	$66,500
				SUBTOTAL	$1,589,605
				MOBILIZATION 5%	$79,490
				CONTINGENCY 35%	$584,190
				TOTAL COST	$2,253,285
				ESTIMATED CONSTRUCTION COST	**$2,255,000**

ASSUMPTIONS

1. At storm drain crossings, water asbestos cement pipe is to be replaced with 60 linear feet of PVC C-900 pipe between 2 new gate valves, if valves were not in the vicinity.
2. Pavement repair to be per COA STD 510S-3.
3. Existing wastewater crossings do not need to be adjusted.
4. Assumes ABANDONED Wastewater AC Pipe on Oak Knoll does not need to be removed.

NOTES

1. Buried communication located in existing 15-foot DE/PUE in the rear of the lots along Columbia Oaks Dr, may need to be removed and replaced in conduit to install proposed box culvert in existing easement.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					ARABIAN TRAIL ALT 1
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	9	$51,040
2	INLET, STANDARD 10 FT	EA	$5,000	8	$40,000
3	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	2732	$13,660
4	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	311	$27,990
5	PIPE, 30" DIA RCP CLASS III STORM SEWER PIPE	LF	$125	365	$45,625
6	PIPE, 36" DIA RCP CLASS III STORM SEWER PIPE	LF	$140	745	$104,300
7	PRECAST CONCRETE BOX CULVERTS (4 FT. X 3 FT.)	LF	$250	615	$153,750
8	PRECAST CONCRETE BOX CULVERTS (5 FT. X 3 FT.)	LF	$275	516	$141,900
9	CLEANING AND RESHAPING DITCHES	LF	$30	1000	$30,000
10	EROSION CONTROLS	LS	$5,000	1	$5,000
11	TRAFFIC CONTROLS	LS	$20,000	1	$20,000
12	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	2552	$25,520
13	WATER LINE ADJUSTMENTS	LS	$45,000	1	$45,000
14	PAVEMENT REPAIRS	LS	$95,000	1	$95,000
15	REMOVE P.C. LAYDOWN CURB	LF	$10	1225	$12,250
16	P.C. CONCRETE CURB AND GUTTER (CATCH)	LF	$25	1225	$30,625
				SUBTOTAL	$841,660
				MOBILIZATION 5%	$42,090
				CONTINGENCY 35%	$309,320
				TOTAL COST	$1,193,070
				ESTIMATED CONSTRUCTION COST	**$1,195,000**

ASSUMPTIONS

1. Water cast iron pipe to be replaced with 60 linear feet of DI CL350 pipe in order to provide adequate pipe restraint.
2. Pavement repair to be per COA STD 510S-3.
3. Existing wastewater crossings do not need to be adjusted.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					ARABIAN TRAIL ALT 2
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	4	$23,200
2	INLET, STANDARD 10 FT	EA	$5,000	8	$40,000
3	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	1220	$6,100
4	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	380	$34,200
5	PIPE, 30" DIA RCP CLASS III STORM SEWER PIPE	LF	$125	780	$97,500
6	CLEANING AND RESHAPING DITCHES	LF	$30	2000	$60,000
7	EROSION CONTROLS	LS	$5,000	1	$5,000
8	TRAFFIC CONTROLS	LS	$10,000	1	$10,000
9	REVEGETATION	SY	$10	4500	$45,000
10	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	1160	$11,600
11	WATER LINE ADJUSTMENTS	LS	$32,000	1	$32,000
12	PAVEMENT REPAIRS	LS	$38,000	1	$38,000
13	REMOVE P.C. LAYDOWN CURB	LF	$10	1225	$12,250
14	P.C. CONCRETE CURB AND GUTTER (CATCH)	LF	$25	1225	$30,625
15	REMOVE AND REPLACE P.C. CONCRETE CURB AND GUTTER (CURB CUT)	LF	$40	15	$600
				SUBTOTAL	$446,075
				MOBILIZATION	5%	$22,310
				CONTINGENCY	35%	$163,940
				TOTAL COST	$632,325
				ESTIMATED CONSTRUCTION COST	**$635,000**

ASSUMPTIONS

1. Water cast iron pipe to be replaced with 60 linear feet of DI CL350 pipe in order to provide adequate pipe restraint.
2. Pavement repair to be per COA STD 510S-3.
3. Existing wastewater crossings do not need to be adjusted.

NOTES

1. Buried communication located in existing ditch that is to be cleaned and regraded on Arabian Trail.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					ARABIAN TRAIL ALT 3
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	4	$23,200
2	INLET, STANDARD 10 FT	EA	$5,000	8	$40,000
3	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	1220	$6,100
4	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	380	$34,200
5	PIPE, 30" DIA RCP CLASS III STORM SEWER PIPE	LF	$125	780	$97,500
6	EROSION CONTROLS	LS	$5,000	1	$5,000
7	TRAFFIC CONTROLS	LS	$10,000	1	$10,000
8	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	1160	$11,600
9	WATER LINE ADJUSTMENTS	LS	$32,000	1	$32,000
10	PAVEMENT REPAIRS	LS	$38,000	1	$38,000
11	REMOVE AND REPLACE P.C. CONCRETE CURB AND GUTTER (CURB CUT)	LF	$40	15	$600
				SUBTOTAL	$298,200
			MOBILIZATION	5%	$14,910
			CONTINGENCY	35%	$109,590
				TOTAL COST	$422,700
			ESTIMATED CONSTRUCTION COST		**$425,000**

ASSUMPTIONS

1. Water cast iron pipe to be replaced with 60 linear feet of DI CL350 pipe in order to provide adequate pipe restraint.
2. Pavement repair to be per COA STD 510S-3.
3. Existing wastewater crossings do not need to be adjusted.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					BELL AVENUE ALT 1
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	8	$47,220
2	INLET, STANDARD 10 FT	EA	$5,000	10	$50,000
3	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	3261	$16,305
4	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	513	$46,170
5	PRECAST CONCRETE BOX CULVERTS (6 FT. X 3 FT.)	LF	$340	1848	$628,320
6	EROSION CONTROLS	LS	$5,000	1	$5,000
7	TRAFFIC CONTROLS	LS	$20,000	1	$20,000
8	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	2361	$23,610
9	WATER LINE ADJUSTMENTS	LS	$96,000	1	$96,000
10	ASBESTOS PIPE REMOVAL	LS	$54,000	1	$54,000
11	PAVEMENT REPAIRS	LS	$111,000	1	$111,000
12	P.C. CONCRETE CURB AND GUTTER (CATCH)	LF	$25	2000	$50,000
				SUBTOTAL	$1,147,625
				MOBILIZATION	5%	$57,390
				CONTINGENCY	35%	$421,760
				TOTAL COST	$1,626,775
				ESTIMATED CONSTRUCTION COST	**$1,630,000**

ASSUMPTIONS

1. Water cast iron pipe to be replaced with 60 linear feet of DI CL350 pipe in order to provide adequate pipe restraint.
2. For proposed storm drain improvements along Secrest Dr., water asbestos cement pipe to be replaced between existing gate valves located near the proposed strom drain limits with PVC C-900 pipe. Outside clearance between pipes appears to be less than 5-feet per best available information.
3. Pavement repair to be per COA STD 510S-3.
4. Existing wastewater crossings do not need to be adjusted.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					BELL AVENUE ALT 2
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	11	$67,640
2	INLET, STANDARD 10 FT	EA	$5,000	4	$20,000
3	INLET, GRATED 4-FT X 4-FT	EA	$4,200	10	$42,000
4	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	4342	$21,710
5	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	513	$46,170
6	PRECAST CONCRETE BOX CULVERTS (4 FT. X 3 FT.)	LF	$250	2869	$717,250
7	EROSION CONTROLS	LS	$5,000	1	$5,000
8	TRAFFIC CONTROLS	LS	$20,000	1	$20,000
9	REVEGETATION	SY	$40	200	$8,000
10	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	3382	$33,820
11	WATER LINE ADJUSTMENTS	LS	$103,000	1	$103,000
12	ASBESTOS PIPE REMOVAL	LS	$54,000	1	$54,000
13	PAVEMENT REPAIRS	LS	$150,000	1	$150,000
14	P.C. CONCRETE CURB AND GUTTER	LF	$25	2000	$50,000
15	REMOVE AND REPLACE P.C. CONCRETE CURB AND GUTTER (CURB CUT)	LF	$40	100	$4,000
				SUBTOTAL	$1,342,590
			MOBILIZATION	5%	$67,130
			CONTINGENCY	35%	$493,410
				TOTAL COST	$1,903,130
			ESTIMATED CONSTRUCTION COST		**$1,905,000**

ASSUMPTIONS

1. Water cast iron pipe to be replaced with 60 linear feet of DI CL350 pipe in order to provide adequate pipe restraint.
2. For proposed storm drain improvements along Secrest Dr., water asbestos cement pipe to be replaced between existing gate valves located near the proposed storm drain limits with PVC C-900 pipe. Outside clearance between pipes appears to be less than 5-feet per best available information.
3. Pavement repair to be per COA STD 510S-3.
4. Existing wastewater crossings do not need to be adjusted.
5. Undeveloped Stanwood Road to be open cut while maintaining a temporary driveway in existing right-of-way.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
OPINION OF PROBABLE CONSTRUCTION COST					BELL AVENUE ALT 3
PRELIMINARY ENGINEERING REPORT					
5/11/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	STANDARD PRE-CAST MANHOLE W/ PRECAST BASE, 48 IN DIA.	EA	$6,000	8	$50,160
2	INLET, STANDARD 10 FT	EA	$5,000	4	$20,000
3	INLET, GRATED 4-FT X 4-FT	EA	$4,200	13	$54,600
4	TRENCH EXCAVATION SAFETY PROTECTIVE SYSTEM (ALL DEPTHS)	LF	$5	3468	$17,340
5	PIPE, 24" DIA RCP CLASS III STORM SEWER PIPE	LF	$90	513	$46,170
6	PIPE, 42" DIA RCP CLASS III STORM SEWER PIPE	LF	$165	1995	$329,175
7	EROSION CONTROLS	LS	$5,000	1	$5,000
8	TRAFFIC CONTROLS	LS	$20,000	1	$20,000
9	REVEGETATION	SY	$40	200	$8,000
10	VIDEO INSPECTION OF NEWLY INSTALLED BOX CULVERTS AND STORM DRAIN PIPE	LF	$10	2508	$25,080
11	WATER LINE ADJUSTMENTS	LS	$103,000	1	$103,000
12	ASBESTOS PIPE REMOVAL	LS	$54,000	1	$54,000
13	PAVEMENT REPAIRS	LS	$96,000	1	$96,000
				SUBTOTAL	$828,525
				MOBILIZATION	5%	$41,430
				CONTINGENCY	35%	$304,490
				TOTAL COST	$1,174,445
				ESTIMATED CONSTRUCTION COST	**$1,175,000**

ASSUMPTIONS

1. Water cast iron pipe to be replaced with 60 linear feet of DI CL350 pipe in order to provide adequate pipe restraint.
2. For proposed storm drain improvements along Secrest Dr., water asbestos cement pipe to be replaced between existing gate valves located near the proposed storm drain limits with PVC C-900 pipe. Outside clearance between pipes appears to be less than 5-feet per best available information.
3. Pavement repair to be per COA STD 510S-3.
4. Existing wastewater crossings do not need to be adjusted.
5. Undeveloped Stanwood Road to be open cut while maintaining a temporary driveway in existing right-of-way.

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Appendix E

Appendix E - Utilities

AULCC Workbook

Utility Exhibit

Utility Crossing Summary Table

AULCC Project Transmittal

Project Name: WPD-Oak Knoll Drainage Improvements
UC Tracking #: UCC-160825-02-01
CIP ID#: 5789.102
Project Sponsor: WPD
Mapsco #: 464.000
License Agreement #:
Grid #: H35, H36, J34, J35
ROW ID# 11577098

Meeting Date: August 25, 2016 **Meeting Starts:** 2:00 PM

Meeting Location: **10th Floor Conference Room, One Texas Center, 505 Barton Springs Road

Project Description: The goal of the Oak Knoll Drainage Improvements project is to support the City of Austin in their efforts to improve the Oak Knoll Region by developing a plan to address existing flooding issues. The City of Austin Watershed Protection Department has divided the project into three main areas: Oak Knoll Drive Storm Drain Improvements (SDI), Arabian Trail SDI, and Bell Avenue SDI. The project will include alternative drainage improvements within the project area shown in Figure 1, attached with the cover letter. Improvements such as storm sewer/inlet improvements, open roadway conveyance improvements, and detention will be considered during the Pre-Design Phase. These improvements could require land grading, open trenches more than 5-feet in depth, and/or utility relocations. In order for us to evaluate the alternative drainage improvements, we request that the facility owners within the project area provide maps and records of their existing facilities and plans for any proposed facilities.

Address Range	*Street*	*Cross Street 1*	*Cross Street 2*
	US 183	Spicewood Springs Road	Floral Park Drive
	Charing Cross Road		
	Chelsea Moor		
	Sierra Madre		
	Jollyville Road	Ladera Vista Drive	Taylor Draper Lane

Instructions: Review the plans and provide written comments, record information, system maps, and any other written documentation to indicate horizontal and vertical locations of facilities in possible conflict with the proposed facilities. Also, provide information as to other projects planned by the utility or agency in the area, including schedule and proposed horizontal or vertical locations. Please e-mail the data review sheet (see tab at bottom) as an attachment to the primary project contact and copy the utility coordinator. Use the "additional comments" tab to provide any comments for which their is not space on the data sheet.

Notes: Utility location information for City of Austin projects not received in a timely manner may be obtained from a third party, using potholing or other methods, and billed to the facility owner pursuant to City Code. Delay costs caused by the failure of the facility owner to provide the information or for failure to relocate/adjust the facility prior to construction will also be billed to the facility owner. Comments not received for private party projects & license agreements by the meeting date will interpreted as a "yes" and approval of the project or license agreement may result.

Project Contact (Primary): Eric Nelson 512-396-4040
Project Manager (Owner's): Thuan Nguyen 512-974-3513
Project Engineer: Travis Michel 512-338-2722
Project Contact Email: elnelson@lan-inc.com tmmichel@lan-inc.com

Est. Bid Dates: 10/1/2017 to 12/31/2017 **Plan Dist. Date:** August 4, 2016
Est. Construction Dates: 1/1/2018 to 12/31/2018 **C.D. Plans** **Email Plans**

Designer: Lockwood, Andrews & Newnam, Inc. **Design Stage:** 30%

Right-of-way Management Division, Austin Transportation Department
3701 Lake Austin Blvd, (512) 974-7180, fax 974-5617

AULCC: Gregory Pepper, *AULCC@austintexas.gov* **Division Manager:** Jason Redfern, Jason.Redfern@austintexas.gov

Project Name:	**WPD-Oak Knoll Drainage Improvements**	Date:	**August 25, 2016**
UC Tracking #:	**UCC-160825-02-01**	CIP ID #:	**5789.102**
Type of Review:	**0%**	ROWID #:	**11577098**
Project Manager:	**0**		
Engineer:	**Eric Nelson 512-396-4040**		
Project Contact:	**0**		
Others? (See attendance sheet)			

Project Notes:

Utility	**Austin Energy**		
Rep.	Mora Asadi (North)	Sedrick James (South)	Other_____
E-mail?			
Data Sh?			
Clear?			
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict_____		

Utility	**Austin Energy -CW (Chilled Water)**	
Rep.	Carol Stewart	James Matlock
E-mail?	**Y**	Clear.
Data Sh?	**N**	
Clear?	**Y**	
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict_____	

Utility	**Austin Water Utility**	
Rep.	Eric Sermeno	Angela Baez
E-mail?	**Y**	For additional information please visit Maps and Records at 625 East 10th street, 2nd floor or request for Web address access E-mail tracy.busby@caustintexas.gov and for question call Tracy Busby 972-0116. If you have technical questions contact Steve Hutton at 972-0195. Caution with water and wastewater services, for existing service information please contact Taps office 972-0022, 2nd floor at Waller Creek. Please maintain the required clearance from OD to OD established by TCEQ for existing/proposed AWU infrastructure. See additional comments 1
Data Sh?	**Y**	
Clear?	**N**	
Docs?	System Maps ____ As-built Plans ____ Marked-up Plans ____ Other _____ No Apparent Conflict_____	

Utility	**Watershed Engineering Division**	
Rep.	Reyes Camacho	Sergio Mendoza
E-mail?	**Y**	No conflicts.
Data Sh?	**Y**	
Clear?	**Y**	
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflicts_____	

Utility	**PWD-Street & Bridge Division**	
Rep.	Daren Duncan	David Boswell
E-mail?	**Y**	See additional comments 2.
Data Sh?	**Y**	
Clear?	**TBD**	
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____	

Utility	**ATD-Signals**	
Rep.	Chris Dixon	Benjamin W. Henson
E-mail?	**N**	Underground behind curbs southside of Jollyville.
Data Sh?	**N**	
Clear?	**TBD**	
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____	

Utility	**ATD-Traffic Control**		
Rep.	Eva Moore	Daniel Hunter	Other_____
E-mail?			
Data Sh?			
Clear?			
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflicts _____		

Utility	**Austin Center for Events (ACE)**	
Rep.	Betty Torres	Other_____
E-mail?	**Y**	No conflicts.
Data Sh?	**N**	
Clear?	**Y**	

Project Name:	**WPD-Oak Knoll Drainage Improvements**	Date:	**August 25, 2016**

Utility	**Austin Park & Recreation**		
Rep.	Gregory Montes	Marilyn Shashoua	Other_____
E-mail?			
Data Sh?			
Clear?			

Utility	**Texas Gas Service**		
Rep.	Chelseigh Simmons	Larissa Prince	Other_____
E-mail?	**Y**	See additional comments 3.	
Data Sh?	**Y**		
Clear?	**N**		
Docs?	System Maps ___x____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflicts _____		

Utility	**GAATN (Greater Austin Area Telecommunication Network)**		
Rep.	Chris Gonzales	Carlo DeMatos	
E-mail?	**Y**	Please use caution as there is underground facilities in the area. Call for locates and pot hole where necessary.	
Data Sh?	**Y**		
Clear?	**N**		
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____		

Utility	**AT&T Texas (SWBT)**		
Rep.	Michael Dill		
E-mail?	**Y**	AT&T has aerial and underground facilities in the areas. Conflicts do exist. Call for locates and pothole depths as	
Data Sh?	**Y**	needed. For relocates call 866-200-4926.	
Clear?	**N**		
Docs?	System Maps ___x_____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____		

Utility	**Teleport Communications of America (AT&T Metro)**		
Rep.	Chris Walker	Nick Edwards	Roger Allen
E-mail?			
Data Sh?			
Clear?			
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____		

Utility	**AT&T Corp - Legacy T**		
Rep.	Steve Walker	Ike Butler	
E-mail?			
Data Sh?			
Clear?			
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____		

Utility	**Grande Communications**		
Rep.	Luis Mata	Daniel Pina	
E-mail?			
Data Sh?			
Clear?			
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____		

Utility	**Time Warner Cable (TWC)**		
Rep.	Joseph Boyle	Other_____	
E-mail?	**Y**	Please use caution around aerial and underground facilities. Please coordinate relocation or removal with Pete	
Data Sh?	**Y**	Navejas. If new service is needed please contact joseph.boyle@charter.com	
Clear?	**N**		
Docs?	System Maps ___x____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflicts _____		

Utility	**Google Fiber Texas (GFT)**		
Rep.	Scott Cunningham	Other_____	
E-mail?	**Y**	This was a record request only. Actual plans will require review before clearing.	
Data Sh?	**Y**		
Clear?	**TBD**		
Docs?	System Maps __x_____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflicts _____		

Utility	**Verizon Business (MCI)**		
Rep.	Dean Boyers	Doug Kougl	
E-mail?	**Y**	Aerial fiber on Austin Energy poles. No conflicts are expected.	
Data Sh?	**N**		
Clear?	**TBD**		
Docs?	System Maps _____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflicts _____		

Project Name:	**WPD-Oak Knoll Drainage Improvements**	Date:	**August 25, 2016**

Utility	**Level 3**	
Rep.	D.W. Shirley	John Boedeker
E-mail?	**Y**	Underground facilities in project area. Reference file number 64128 TX.
Data Sh?	**N**	
Clear?	**TBD**	
Docs?	System Maps ____x____ As-built Plans _____ Marked-up Plans _____ No Apparent Conflict _____	

Utility	**Cap Metro Bus**	
Rep.	Laurie Shaw	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**Cap Metro RxR**	
Rep.	Vincent Sandoval	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**COA-Office of Real Estate Services**	
Rep.	Andy Halm	
E-mail?		No comment.
Data Sh?		
Clear?		
Docs?		

Utility	**TxDOT**	
Rep.		
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**Alpheus**	
Rep.	Morris Bankhead	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**CenturyLink**	
Rep.	Greg Willis	Martin Ruble
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**FIBERLIGHT**	
Rep.	Jonathan Meshell	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**FIBERNET**	
Rep.	Noel Rice	
E-mail?	Y	No conflict.
Data Sh?	N	
Clear?	Y	
Docs?	N	

Utility	**Tel Pacific Network Services**	
Rep.	Robert Cuevas	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**XO Communications**	
Rep.	Chistopher Jones	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**Zayo**	
Rep.	Freddie Kight	
E-mail?	Y	Clear.
Data Sh?	N	
Clear?	Y	
Docs?	N	

Utility	**ZNET**	
Rep.	Chad Hambacher	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**Crown Castle**	
Rep.	Marty Brown	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**APOGEE - UT Area Fiber**	
Rep.	Sean Eaton	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**Atmos Gas**	
Rep.	Brad Crosswhite	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Utility	**Chevron Pipeline**	
Rep.	Peter Hicks	
E-mail?		
Data Sh?		
Clear?		
Docs?		

Project Name:	**WPD-Oak Knoll Drainage Improvements**	Date:	**August 25, 2016**

Utility	**CITGO Pipeline**		Utility	**Enterprise Pipeline**	
Rep.	Tiffany Rogers		Rep.	Charlie Rogers	
E-mail?			E-mail?		
Data Sh?			Data Sh?		
Clear?			Clear?		
Docs?			Docs?		

Utility	**Kinder Morgan Pipeline**		Utility	**Koch Pipeline**	
Rep.	Jim Ephraim		Rep.	Jeremy Martin	
E-mail?			E-mail?		
Data Sh?			Data Sh?		
Clear?			Clear?		
Docs?			Docs?		

Utility	**LCRA**		Utility	**PEC**	
Rep.	Bob Beckmann		Rep.	Kay Jeanes	
E-mail?			E-mail?		
Data Sh?			Data Sh?		
Clear?			Clear?		
Docs?			Docs?		

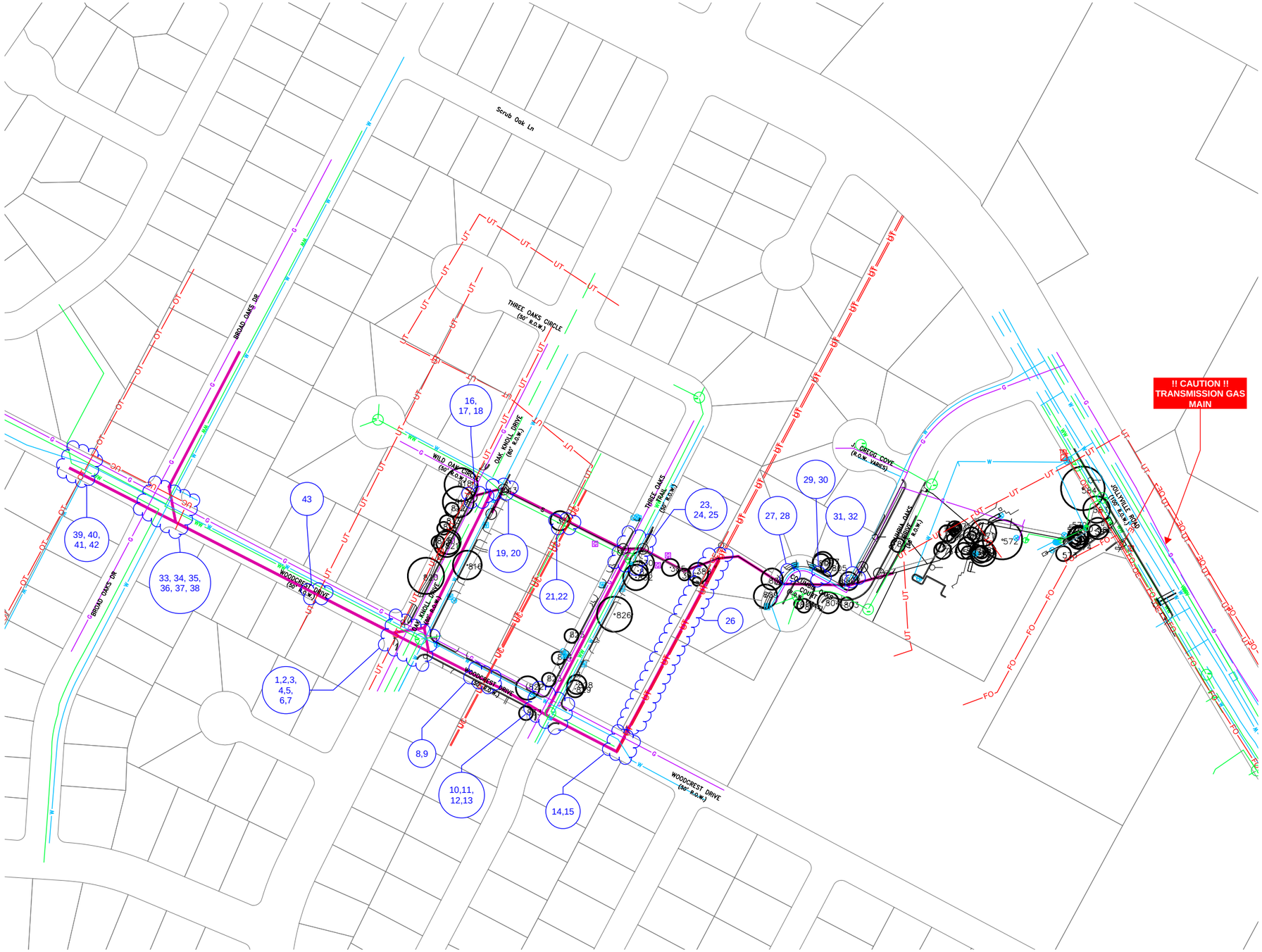
Utility	**Bluebonnet Elec.**		Utility	**ONCOR Elec. Delivery**	
Rep.	Melissa Wickel		Rep.		
E-mail?	Y	No conflict.	E-mail?		
Data Sh?	Y		Data Sh?		
Clear?	Y		Clear?		
Docs?	N		Docs?		

Conflict Notes:

ADDITIONAL COMMENTS

Project Name:	**WPD-Oak Knoll Drainage Improvements**		
UC Tracking #:	**UCC-160825-02-01**	Project CIP ID #:	**5789.102**
License Agreement #:	0	Other ID #:	
Meeting Date:	**August 25, 2016**	Design Stage:	**4258600%**

Comments #1	**1) This project is within Grid H 35-36, there are multiple existing Water & Wastewater infrastructures in the proposed area of improvements; 2) For information about AW infrastructures, As-built copies can be obtained at Records at 625 East 10th Street, Suite 215, Austin, Texas 78701, 512-972-0271 or via FTP website: ftp://ftp.austintexas.gov/GIS-Data/WWW/; 3) For next review show all AW infrastructures in plan & profile view; 4) For relocation of AW infrastructures need to see AW Plan Reviewer fro appointment call at 512-972-0154; 5) Need to see this project again;**
Comments #2	**For trench repair in streets constructed of flexible base with an asphalt surface, use detail 1100S-2. Use detail 1100S-3 for concrete or asphalt overlaid concrete streets and use detail 1100S-5 for full depth asphalt streets. In all cases, we recommend using CLSM for backfill. If detail 1100S-8A or B or 1100S-6B or D is used, we recommend substituting CLSM in the detail where Class J PC concrete is shown.** **Note that Jollyville Road protected. When lines to be placed are in the DAPCZ, are over 300 feet in length, or include protected street segments, a paving plan showing an enhanced pavement restoration strategy is required. This requires, in addition to the trench repair, the removal and replacement of the existing asphaltic concrete surface. Surface asphalt removal may be by sawing, edge milling or milling to the minimum thickness required by the street classification. The areas requiring replacement will be at least the full traffic lane width up to the full street width for the total length of the cut. Use detail 1100S-7 for guidance regarding the required limits of surface restoration and show these areas on the plans.**
Comments #3	**Provided system maps** **Show exist. Gas system in future project limits and provide revised plan set for review.** **We're throughout this area; particularly a high pressure distribution (HPD) line along Jollyville and Oak Knoll. Any conflicts requiring a relocation of this line will be timely. Please see Comment #2, below, for additional details for this line.** **Contact ONE call for locates; Keep 2 ft vertical and 2 ft horizontal clearance from all distribution gas lines.** **Please add the following as a note on every sheet where you'll be digging within 10' of a transmission or high pressure distribution line.** **"When digging within 10' of a transmission or HPD line, please make contact with Anthony Garcia (P: 512-401-1507; C: 915-525-0210; Email: agarcia@txgas.com) at least 48 hours in advance so that a TGS representative can be scheduled to be present during all excavation activities. Please maintain at least 5' (OD to OD) from the transmission or HPD line as well."**



Page 1 of 3

LEGEND

- ASSUMED STORM ALIGNMENT
- PL — PROPERTY LINES
- UT — UNDERGROUND COMMUNICATION
- OT — OVERHEAD COMMUNICATION
- UC — UNDERGROUND CABLE
- WW — WASTEWATER LINE
- WASTEWATER LINE (ABANDONED)
- G — GAS LINE
- W — WATER LINE
- WATER LINE (ABANDONED)
- EASEMENT LINE
- S — STORMWATER LINE
- RIGHT OF WAY
- OE — ELECTRIC LINE (OVERHEAD)
- FO — FIBER OPTIC (BURIED)
- BUILDING
- SIGN
- MAILBOX
- W — WATER METER
- WATER VALVE
- FH — FIRE HYDRANT
- WWCO — WASTEWATER CLEAN OUT
- STMH — STORMWATER SEWER MANHOLE
- WWMH — WASTEWATER MANHOLE
- G — GAS MARKER
- TEL — TELEPHONE RISER
- IRON ROD FOUND
- E — ELECTRIC METER
- E — JUNCTION BOX
- LIGHT POLE
- C — CABLE TV MARKER
- BOLLARD/POST

N

Oak Knoll Drainage Improvements

Location - Oak Knoll Dr Austin, Texas

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

8911 N. Capital of Texas Hwy
Building 2, Suite 2300
Austin, TX 78759
Tel 512-338-4212
www.lan-inc.com

Preliminary Engineering Report

KEY PLAN

REVISIONS

NO.	DESCRIPTION	DATE

FILE LOG

ACTIVITY	
Manager	TMM
Design	
Draw	
Check	

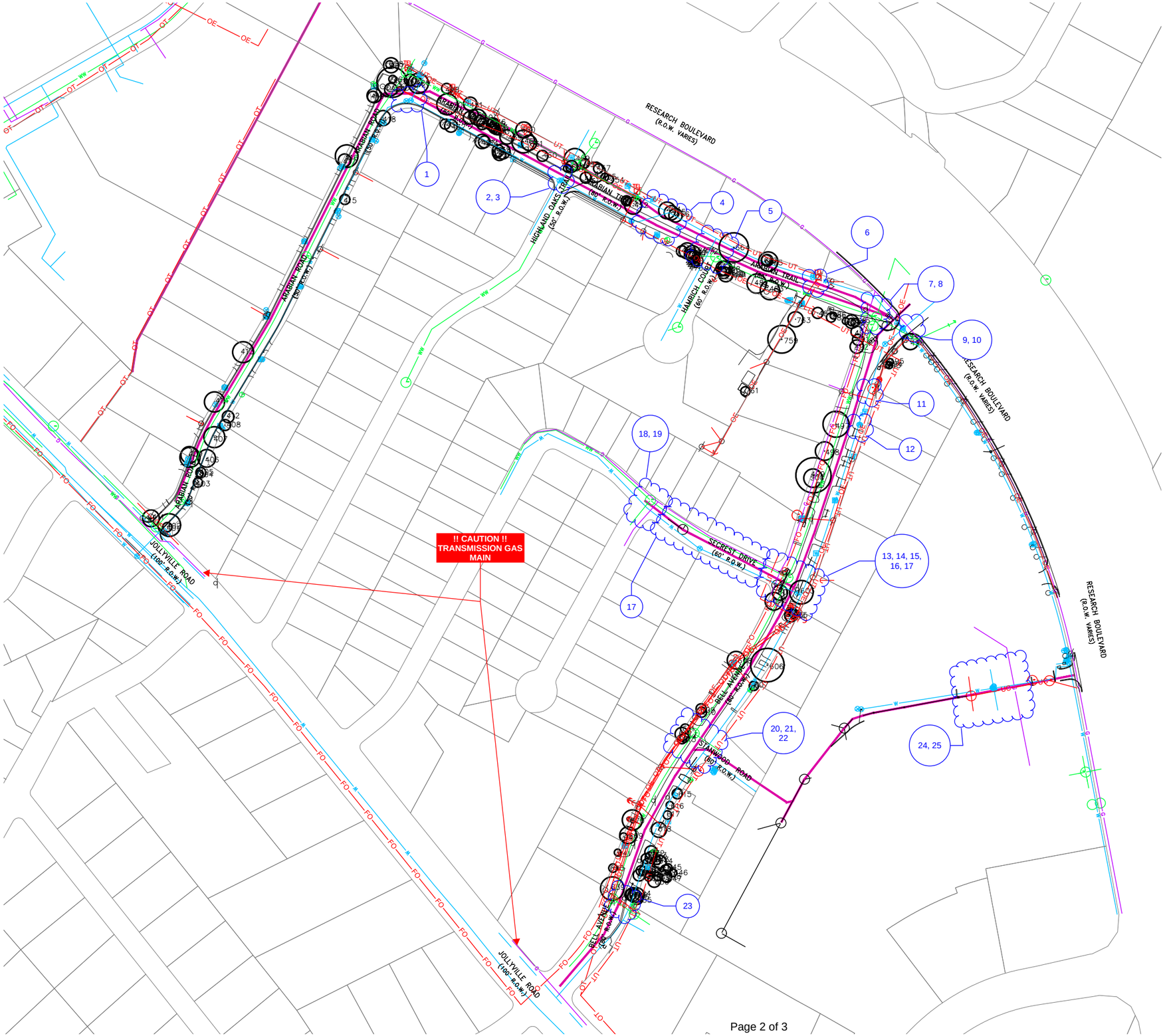
STAMP

0 100 200

SCALE: 1"=100'

Project No. 120-11884-001
Date: MAY 2017

Exhibit 1



LEGEND

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- E — JUNCTION BOX
- LIGHT POLE
- C — CABLE TV MARKER
- BOLLARD/POST

N

Oak Knoll Drainage Improvements

Location - Bell Avenue and Arabian Trails Austin, Texas

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

8911 N. Capital of Texas Hwy
Building 2, Suite 2300
Austin, TX 78759
Tel 512-338-4212
www.lan-inc.com

Preliminary Engineering Report

KEY PLAN

REVISIONS

NO.	DESCRIPTION	DATE

FILE LOG

ACTIVITY	
Manager	TMM
Design	
Draw	
Check	

STAMP

0 120 240

SCALE: 1"=120'

Project No. 120-11884-001
Date: MAY 2017

Exhibit 2

CLIENT	CITY OF AUSTIN
PROJECT NAME	OAK KNOLL DRAINAGE IMPROVEMENTS
PROJECT NO.	120-11884-001
DATE	5/18/2017
SUBJECT	IDENTIFICATION OF UNDERGROUND UTILITY CROSSINGS
STATUS	PRELIMINARY ENGINEERING REPORT

MATERIAL ABBREVIATIONS
CS = Coated Steel, AC = Asbestos Cement
VC = Vitrified Clay, CONC = Concrete
DI = Ductile Iron, CI = Cast Iron
PVC = Poly-vinyl chloride

LOCATION	ID	UTILITY	SIZE	MATERIAL	OWNER	STREET	TERSECTIOI	AS BUILT #	STATUS
Oak Knoll 2 / 3	1	Telephone	-	-	ATT	Woodcrest	-	-	-
Oak Knoll 2 / 3	2	Gas	4 in.	CS	One Gas	Woodcrest	-	-	-
Oak Knoll 2 / 3	3	Wastewater	8 in.	AC	Austin Water	Woodcrest	-	S-1984-1027	Abandoned
Oak Knoll 2 / 3	4	Wastewater	8 in.	VC	Austin Water	Woodcrest	-	S-1972-0079	In Service
Oak Knoll 3	5	Wastewater	8 in.	CONC	Austin Water	Woodcrest	-	S-1985-0812	In Service
Oak Knoll 3	6	Water	12 in.	AC	Austin Water	Woodcrest	8847	W-1972-0095	In Service
Oak Knoll 2 / 3	7	Water	6 in.	AC	Austin Water	Oak Knoll	8847	W-1972-0095	In Service
Oak Knoll 3	8	Telephone	-	-	ATT	Woodcrest	-	-	-
Oak Knoll 3	9	Cable	-	-	Charter	Woodcrest	-	-	-
Oak Knoll 3	10	Gas	2 in.	CS	One Gas	Woodcrest	-	-	-
Oak Knoll 3	11	Wastewater	8 in.	DI	Austin Water	Woodcrest	-	S-1972-0079	In Service
Oak Knoll 3	12	Water	6 in.	AC	Austin Water	Three Oaks	8848	W-1972-0095	In Service
Oak Knoll 3	13	Water	12 in.	AC	Austin Water	Woodcrest	8848	W-1972-0095	In Service
Oak Knoll 3	14	Gas	2 in.	CS	One Gas	Woodcrest	-	-	-
Oak Knoll 3	15	Water	12 in.	AC	Austin Water	Woodcrest	8848	W-1982-0547	In Service
Oak Knoll 1 / 2	16	Telephone	-	-	ATT	Wild Oak	-	-	-
Oak Knoll 1 / 2	17	Gas	4 in.	CS	One Gas	Wild Oak	-	-	-
Oak Knoll 1 / 2	18	Wastewater	8 in.	AC	Austin Water	Wild Oak	-	S-1984-1027	Abandoned
Oak Knoll 1 / 2 / 3	19	Water	12 in.	AC	Austin Water	Wild Oak	8849	W-1972-0095	In Service
Oak Knoll 1 / 2 / 3	20	Wastewater	8 in.	VC	Austin Water	Wild Oak	-	S-1972-0079	In Service
Oak Knoll 1 / 2	21	Telephone	-	-	ATT	Wild Oak	-	-	-
Oak Knoll 1 / 2	22	Wastewater	8 in.	VC	Austin Water	Wild Oak	-	S-1972-0079	In Service
Oak Knoll 1 / 2	23	Gas	2 in.	CS	One Gas	Wild Oak	-	-	-
Oak Knoll 1 / 2 / 3	24	Wastewater	8 in.	CONC	Austin Water	Wild Oak	-	S-1972-0079	In Service
Oak Knoll 1 / 2 / 3	25	Water	6 in.	AC	Austin Water	Wild Oak	8848	W-1972-0095	In Service
Oak Knoll 1 / 2 / 3	26	Telephone	-	-	ATT	Woodcrest/Wild Oak	-	-	-
Oak Knoll 1 / 2 / 3	27	Water	6 in.	AC	Austin Water	Woodcrest/Wild Oak	14129	W-1981-0681	In Service
Oak Knoll 1 / 2 / 3	28	Gas	2 in.	CS	One Gas	Woodcrest/Wild Oak	-	-	-
Oak Knoll 1 / 2 / 3	29	Water	6 in.	AC	Austin Water	Woodcrest/Wild Oak	14129	W-1981-0681	In Service
Oak Knoll 1 / 2 / 3	30	Gas	2 in.	CS	One Gas	Woodcrest/Wild Oak	-	-	-
Oak Knoll 1 / 2 / 3	31	Water	6 in.	AC	Austin Water	Woodcrest/Wild Oak	14129	W-1981-0681	In Service
Oak Knoll 1 / 2 / 3	32	Gas	2 in.	CS	One Gas	Woodcrest/Wild Oak	-	-	-
Oak Knoll 2 / 3	33	Water	8 in.	AC	Austin Water	Woodcrest/Broad Oak	8846	W-1972-0095	In Service
Oak Knoll 2 / 3	34	Water	6 in.	AC	Austin Water	Broad Oak	8846	W-1972-0095	In Service
Oak Knoll 2 / 3	35	Wastewater	8 in.	VC	Austin Water	Broad Oak	-	S-1972-0079	In Service
Oak Knoll 2 / 3	36	Wastewater	8 in.	PVC	Austin Water	Woodcrest	-	S-1985-0812	In Service
Oak Knoll 2 / 3	37	Gas	2 in.	CS	One Gas	Woodcrest/Wild Oak	-	-	-
Oak Knoll 2 / 3	38	Cable	-	-	Charter	Woodcrest/Broad Oak	-	-	-
Oak Knoll 2 / 3	39	Water	6 in.	DI	Austin Water	Woodcrest/Broad Oak	71692	No Avail Info	In Service
Oak Knoll 2 / 3	40	Water	6 in.	AC	Austin Water	Woodcrest/Broad Oak	71692	W-1972-0095	In Service
Oak Knoll 2 / 3	41	Wastewater	8 in.	VC	Austin Water	Woodcrest/Broad Oak	-	S-1972-0079	In Service
Oak Knoll 2 / 3	42	Wastewater	8 in.	PVC	Austin Water	Woodcrest/Broad Oak	-	S-1985-0812	In Service
Oak Knoll 2 / 3	43	Telephone	-	-	ATT	Woodcrest	-	-	-
Arabian Trails 1 / 2 / 3	1	Water	6 in.	CI	Austin Water	Arabian Rd	-	No Avail Info	In Service
Arabian Trails 1	2	Water	6 in.	CI	Austin Water	Arabian Rd	7785	W-1970-0810	In Service
Arabian Trails 1	3	Wastewater	8 in.	CONC	Austin Water	Arabian Rd	-	S-1970-0810	In Service
Arabian Trails 1	4	Water	6 in.	CI	Austin Water	Arabian Tr - North	30214	W-1986-0861	In Service
Arabian Trails 1	5	Water	2 in.	PVC	Austin Water	Arabian Tr - North	-	No Avail Info	In Service
Arabian Trails 1	6	Telephone	-	-	ATT	Arabian Tr - North	-	-	-
Arabian Trails 1	7	Gas	2 in.	CS	One Gas	Arabian Tr - North	-	-	-
Arabian Trails 1	8	Wastewater	8 in.	PVC	Austin Water	Arabian Tr - North	-	No Avail Info	Abandoned
Bell Avenue 1 / 2 / 3	9	Water	12 in.	DI	Austin Water	Bell Avenue	18970	W-1993-0009	In Service
Bell Avenue 1 / 2 / 3	10	Wastewater	8 in.	PVC	Austin Water	Bell Avenue	-	S-1993-009	In Service
Bell Avenue 1 / 2 / 3	11	Telephone	-	-	ATT	Bell Avenue	-	-	-
Bell Avenue 1 / 2 / 3	12	Water	6 in.	CI	Austin Water	Bell Avenue	26090	No Avail Info	In Service
Bell Avenue 1 / 2 / 3	13	Wastewater	8 in.	PVC	Austin Water	Bell Avenue	-	S-1977-0116	In Service
Bell Avenue 1 / 2 / 3	14	Fiber Optic	-	-	Level 3	Secrest Dr	-	-	-
Bell Avenue 1 / 2 / 3	15	Gas	2 in.	CS	One Gas	Secrest Dr	-	-	-
Bell Avenue 1 / 2 / 3	16	Telephone	-	-	ATT	Bell Avenue/ Secrest Dr	-	-	-
Bell Avenue 1 / 2 / 3	17	Water	8 in.	AC	Austin Water	Secrest Dr	14400	W-1982-0558	In Service
Bell Avenue 1 / 2 / 3	18	Wastewater	8 in.	PVC	Austin Water	Secrest Dr	-	S-1982-0558	In Service
Bell Avenue 1 / 2 / 3	19	Gas	2 in.	CS	One Gas	Secrest Dr	-	-	-
Bell Avenue 1	20	Wastewater	8 in.	PVC	Austin Water	Bell Avenue	-	S-1977-0116	In Service
Bell Avenue 2 / 3	21	Water	6 in.	CI	Austin Water	Bell Avenue	17748	No Avail Info	In Service
Bell Avenue 2 / 3	22	Telephone	-	-	ATT	Bell Avenue/ Stanwood	-	-	-
Bell Avenue 1 / 2 / 3	23	Wastewater	8 in.	PVC	Austin Water	Bell Avenue	-	S-1977-0116	In Service
Bell Avenue 2	24	Gas	2 in.	CI	One Gas	Private Driveway	-	-	-
Bell Avenue 2	25	Cable	-	-	Charter	Private Driveway	-	-	-

Appendix F

Appendix F – Environmental Assessment and Permitting Report

Phase I Environmental Site Assessment, Baer Engineering and Environmental Consulting, Inc., November 9, 2016

Permitting Analysis Report, Baer Engineering and Environmental Consulting, Inc., December 27, 2016

PHASE I ENVIRONMENTAL SITE ASSESSMENT

City of Austin

OAK KNOLL DRAINAGE IMPROVEMENTS

AUSTIN, TEXAS 78757

Prepared for: Lockwood, Andrews & Newnam, Inc.
8911 North Capital of Texas Highway
Building 2, Suite 2300
Austin, Texas 78759

November 9, 2016

Baer Engineering and Environmental Consulting, Inc.
7756 Northcross Drive, Suite 211, Austin, Texas 78757
Phone: 512/453-3733; Fax: 512/453-3316

Baer Engineering Document No. 162014-8I.010

TABLE OF CONTENTS

1.0 SUMMARY

This Phase I Environmental Site Assessment (ESA) was performed in accordance with the All Appropriate Inquiries (AAI) Rule specified in the Federal Register Part III EPA 40 CFR Part 312 (U.S. Environmental Protection Agency [US EPA], 2005) and the American Society for Testing and Materials (ASTM) Standard E 1527-13 entitled *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process* (ASTM, 2014). The ASTM standard is based on three major lines of inquiry: regulatory records review and historical documentation, site reconnaissance, and interviews with people familiar with the site.

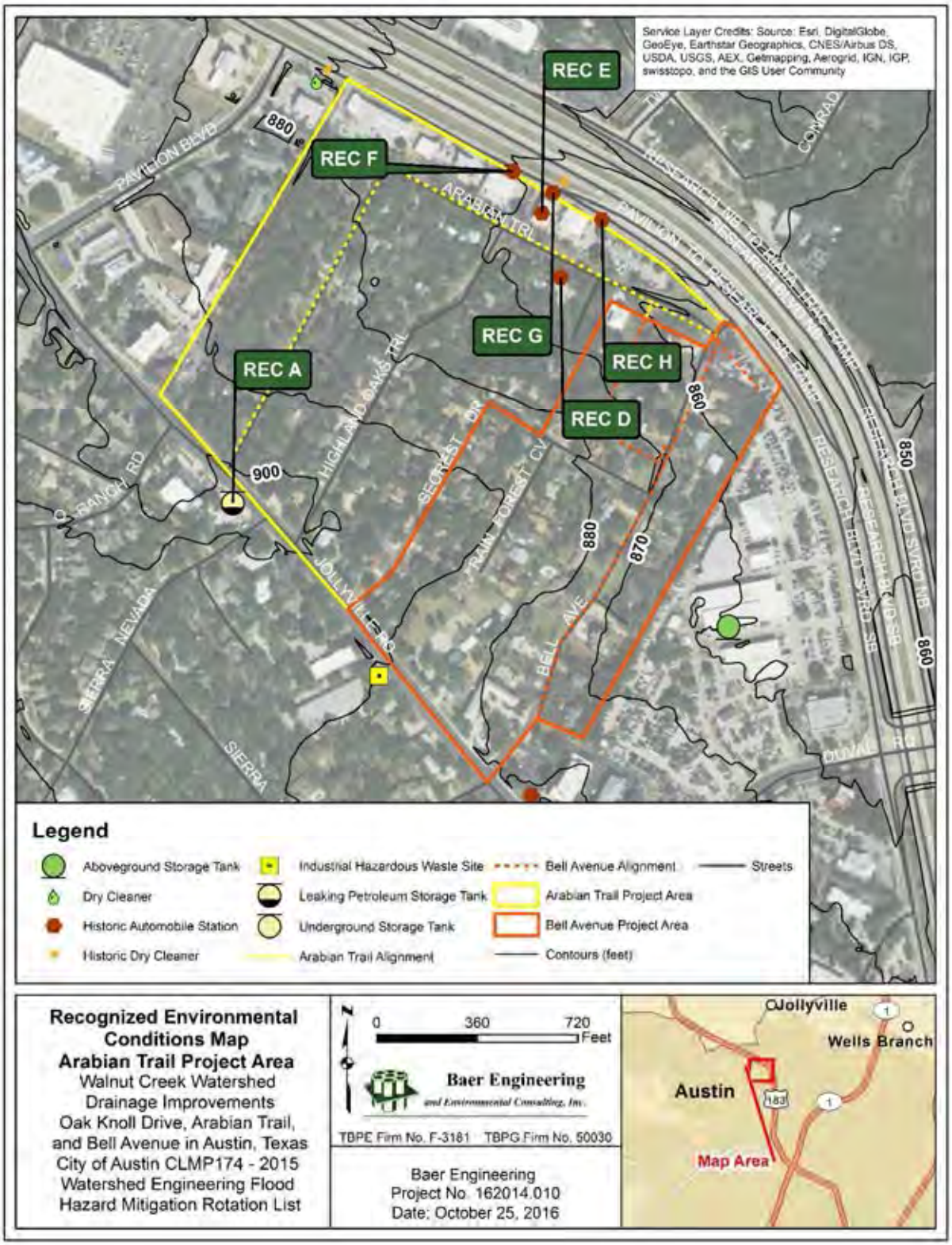
The subject site consists of 107 acres, comprising three project areas. The project consists of 7,440 linear feet of storm drain conduit alignment located within the project areas near Jollyville Road, Austin, Texas (Site). The project area transects multiple residential and commercial properties. A map depicting the storm drain conduit alignment and project areas is featured on pages 3 and 4.

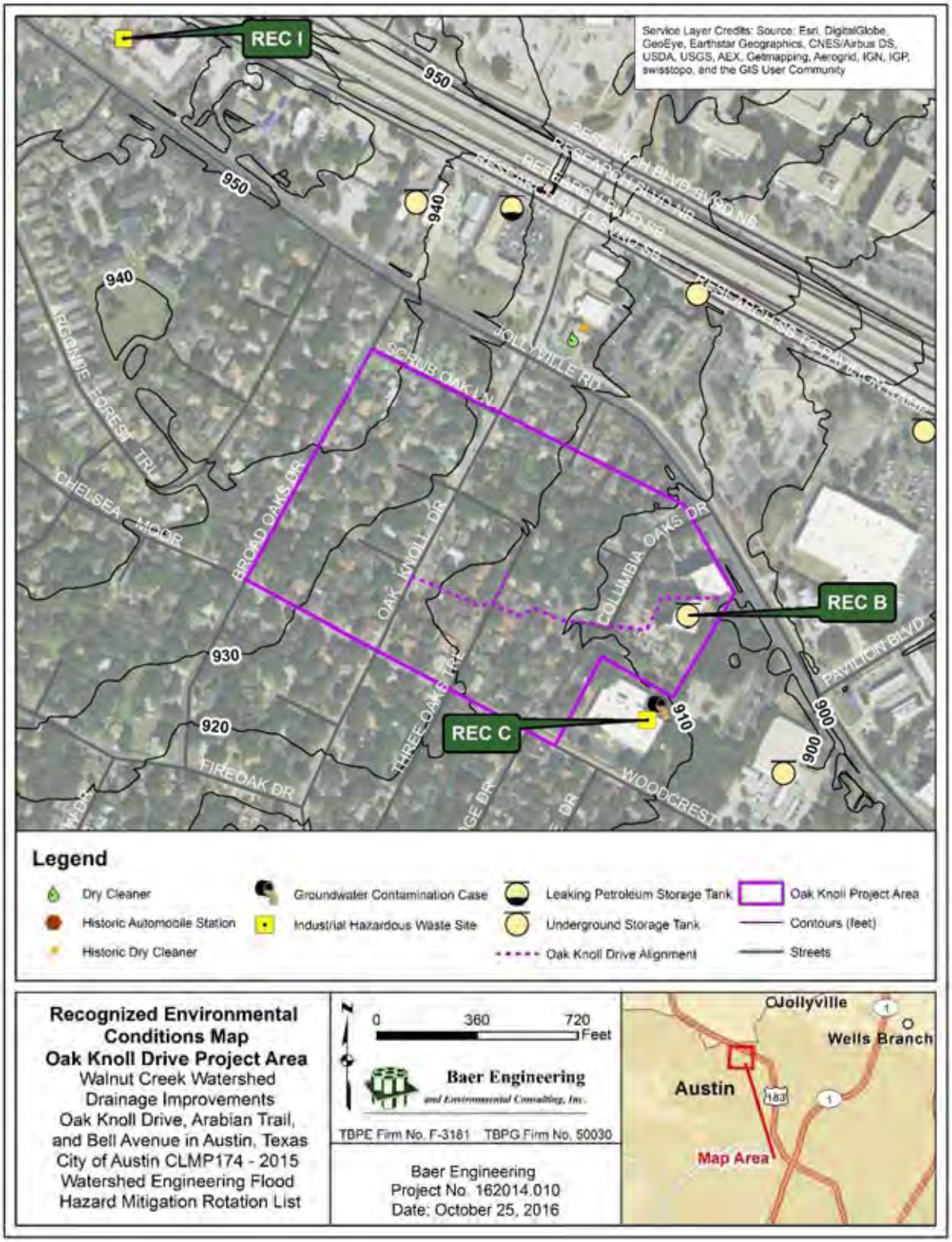
The Phase I ESA performed for this Site identified eight (8) Recognized Environmental Conditions (RECs) and one (1) Historical Recognized Environmental Condition (HREC) in connection with the property. A table discussing these RECs and HREC is featured on the next page.

FINDING #	SITE NAME	ADDRESS	TYPE	DISCUSSION	REC	REC ID
1	Jollyville Food Mart	11794 Jollyville Road	LPST[1]	Likely up-gradient. Adjacent to LOC[5].	Yes	A
2	Covert Buick	11750 Research Boulevard	PST[2]	Likely down-gradient from LOC. Facility has not reported a release. Contaminants would be hydrocarbons.	No	NONE
3	Synergy Center	11940 Jollyville Road	PST	Immediately adjacent to alignment. Likely down-gradient from LOC. Facility has not reported a release. Contaminants would be hydrocarbons.	Yes	B
4	Columbia Scientific Industries	11950 Jollyville Road	VCP[3]	Likely cross-gradient from LOC. Facility is in VCP to clean up a solvent release reported in 1999.	Yes	C
5	Auto Clinic	11929 Arabian Trail	HASS[4]	Likely up-gradient. Immediately adjacent to LOC. Contaminants would be hydrocarbons.	Yes	D
6	Midas Auto Systems Experts	11928 Research Boulevard	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	Yes	E
7	Brake Check	12032 Research Boulevard	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	Yes	F
8	• DDS Paintless Dent Repair • B Garnett Lewis Cleaners	12006 Research Boulevard	HASS	Likely down-gradient from alignment. Because of the presence of a potential dry-cleaning facility, Baer Engineering considers this to be a REC.	Yes	G
9	Carters Transmissions	11980 Research Boulevard	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	Yes	H
10	Lambs Tire and Automotive Centers	11675 Jollyville Road	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	No	NONE
H-1	American Drycleaning	12636 Research Boulevard, Suite 101	VCP Dry Cleaners	Likely up-gradient. Perchloroethylene has the potential to travel long distances.	Yes	I

1: LPST: Leaking Petroleum Storage Tank
2: PST: Petroleum Storage Tank
3: VCP: Voluntary Cleanup Program
4: HASS: Historic Automobile Service Station
5: LOC: Limits of Construction

The locations of the RECs are shown on the maps below:




REC I
REC B
REC C
950
940
930
920
910
900
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
JOLLYVILLE RD
SCRUB OAK LN
BROAD OAKS DR
OAK KNOLL DR
COLUMBIA OAKS DR
THREE OAKS TRL
FIREOAK DR
WOODCREST
PAVILION BLVD
CHELSEA MOOR
Legend
Dry Cleaner
Historic Automobile Station
Historic Dry Cleaner
Groundwater Contamination Case
Industrial Hazardous Waste Site
Leaking Petroleum Storage Tank
Underground Storage Tank
Oak Knoll Drive Alignment
Oak Knoll Project Area
Contours (feet)
Streets
Recognized Environmental Conditions Map
Oak Knoll Drive Project Area
Walnut Creek Watershed Drainage Improvements
Oak Knoll Drive, Arabian Trail, and Bell Avenue in Austin, Texas
City of Austin CLMP174 - 2015 Watershed Engineering Flood Hazard Mitigation Rotation List
0 360 720 Feet
Baer Engineering and Environmental Consulting, Inc.
TBPE Firm No. F-3181 TBPG Firm No. 50030
Baer Engineering
Project No. 162014.010
Date: October 25, 2016
Jollyville
Wells Branch
Austin
183
Map Area

2.0 INTRODUCTION

This Phase I ESA was performed in accordance with the US EPA AAI and ASTM 1527-13 Phase I ESA Standard. This report includes a review of specified records, description of the Site reconnaissance, and interviews.

2.1 Location and Legal Description

This report presents the results of a Phase I ESA conducted on the following property: three project areas totaling 107 acres and 7,440 linear feet of storm drain conduit alignment within the project areas near Jollyville Road, Austin, Texas. The Site is in the north section of Austin. A detailed Site map is presented in **Appendix A**. In general, the Site is bounded on all sides by residential and commercial properties.

A vicinity map is presented in **Appendix B**, and Site photographs are presented in **Appendix C**.

2.2 Purpose

The purpose of a Phase I ESA is to identify, to the extent feasible, RECs in connection with the Site. RECs are defined as the presence or likely presence of hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release on the property or into the ground, ground vapors, groundwater, or surface water of the property. The term REC is not intended to include *de minimis* conditions that generally do not present a threat to human health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of the Texas Commission on Environmental Quality (TCEQ) or other appropriate governmental agencies.

2.3 Detailed Scope of Services

Baer Engineering proposed to provide the following scope of services for a Phase I ESA at the Site:

This Phase I ESA is completed in compliance with AAI Regulation as specified in the Federal Register Part III EPA 40 CFR Part 312 and the ASTM *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process* (E 1527-13). It will identify and record existing, potential, or suspect conditions that may impose an environmental liability on, or restrict the use of, the subject property. The purpose of a Phase I ESA is to satisfy one of the requirements to qualify for the innocent landowner, contiguous property owner, or *bona fide* prospective purchaser limitations on Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) liability. The Phase I ESA will constitute AAI into the previous ownership and uses of the property consistent with good commercial or customary practice.

The Phase I ESA is designed to identify potential RECs as the term is defined by ASTM. These conditions could result in regulatory liability and response costs for the past, present, or future owners of the Site or could adversely affect the value of the Site. ASTM defines REC as:

> *"The presence or likely presence of any hazardous substances or petroleum products in, on, or at a property: 1) due to any release to the environment; 2) under conditions indicative of a release to the environment; or 3) under*

conditions that pose a material threat of a future release to the environment. De minimis are not recognized environmental conditions."

The Phase I ESA will include the Environmental Professional's opinions of the impact on the Site for conditions identified in the findings section. The logic and reasoning used by the Environmental Professional in evaluating information collected during the course of the investigation related to such conditions will be discussed. Frequently, an item initially suspected to be a REC is subsequently determined, upon further evaluation, not to be considered a REC. The opinion will specifically include the Environmental Professional's rationale for concluding that a condition is or is not currently a REC. Existing conditions identified by the Environmental Professional as RECs will be listed in the conclusions section of the report.

The following outline is Baer Engineering's standard scope of services for completing a Phase I ESA. All of these activities are limited to ready and safe access, cooperative contacts, and reasonable availability.

a. On-Site Investigation

Baer Engineering will perform an on-site reconnaissance to identify indicators of hazardous substances or petroleum products regulated by the TCEQ and other governmental agencies. Surveys to determine the presence of radon, lead in drinking water, wetlands, regulatory compliance, cultural and historical resources, industrial hygiene, health and safety, ecological resources, endangered species, indoor air quality, biological agents, asbestos, lead-containing paint, and mold are intentionally and by mutual agreement excluded from the scope of service for the Phase I ESA.

A visual on-site investigation of the subject property and adjoining properties from the nearest vantage point will be completed. If an on-site investigation cannot be performed because of unusual circumstances (e.g., physical limitations, remote/inaccessible location, etc.), then Baer Engineering will:

- Visually investigation the property via an alternative method (e.g., aerial photo, fence line observation, etc.);
- Document efforts taken to obtain access and why efforts were unsuccessful;
- Document other sources of information that were consulted to assess releases or threatened releases; and
- Comment on the significance of the failure to conduct a visual on-site investigation.

Evaluation of site conditions includes observation of the following:

- Periphery of the property;
- Each side of wet and dry drainage pathways (if present);
- Periphery of on-site water bodies (if present);
- Public and maintenance areas;
- Improvements and structures on the property; and
- The remaining area not included above, including wooded or overgrown areas, where accessible.

The Phase I ESA report will describe evidence of the following, if observed at the site:

- Odors of chemical gases, petroleum products, or other odors;
- Landfilling, dumping, disturbed soils, or direct burial activity;
- Surface impoundment, oil/water separators, or holding ponds;
- Air emissions or wastewater discharges;
- Industrial or manufacturing activities;
- Monitoring wells or remediation equipment;
- Stained or discolored soil;
- Leachate or seeps;
- Areas of distressed, discolored, or stained vegetation;
- Chemical spills or releases;
- Groundwater or surface water contamination;
- Oil or gas well exploration, extraction, or refinery activities;
- Prolonged use or misapplication of pesticides, germicides, soil conditioners, or fertilizers;
- Farm waste; and
- Other known or observed environmentally-sensitive or suspect conditions on-site from an off-site source onto the subject property.

b. Assess Adjacent Properties

Baer Engineering will evaluate adjacent properties and properties in the vicinity from public thoroughfares to determine if there are facilities or structures that are likely to use, store, generate, or dispose of hazardous substances or petroleum products.

c. Review Regulatory Records

Baer Engineering will review the following sources to obtain information about the potential for hazardous substances or petroleum products to exist at the site or at properties in the vicinity of the site:

- US EPA;
- TCEQ; and
- Local Fire Department.

AAI requires a review of federal, state, and local government records (or databases containing government records) for the subject property and nearby and adjoining properties. Additional regulation requires search for environmental cleanup liens against the subject property that are filed and recorded under federal, tribal, state, and local law.

d. Review Historical Information.

Baer Engineering will research and review reasonably ascertainable sources of historical information about the property. The purpose is to create a comprehensive review of the potential for releases of hazardous substances at the property. The records that may be reviewed include, but are not limited to:

- Aerial Photographs;
- Groundwater Information;
- Topographic Maps;
- Environmental Lien Search;

- Sanborn Maps;
- Previous Reports provided by the client;
- Building Department Records;
- Property Tax Records; and
- Zoning and Land Use Records.

e. Conduct Interviews

Baer Engineering will conduct interviews with readily available past and present owners, operators, and occupants of the Site, as required by ASTM E 1527-13. These interviews are intended to collect information on the past uses and ownerships of the property and to identify potential conditions that may indicate the presence of releases or threatened releases of hazardous substances or petroleum products at the subject property. Baer Engineering will interview readily available owners and occupants of neighboring and nearby properties, in cases where the site is recently abandoned.

Interviews will be conducted to meet the objectives and performance factors of the AAI (40 CFR 312.20 (e) – (f)). Where possible, interviews will be conducted with, but not limited to, the following:

- Key Site Managers;
- Current/Past Facility Managers; and
- Governmental Officials.

f. Photographic Documentation

Photographs of the site reconnaissance documenting existing site conditions and adjoining properties will be included in the report.

g. Data Gaps

The report will identify and comment on significant data gaps that affect the ability of the Environmental Professional to identify RECs, and the sources of information that were consulted to address the data gaps.

The results of the Phase I ESA will be documented in a written report. The report will include:

- The Environmental Professional's opinion as to whether RECs exist;
- Identification of data gaps;
- Qualifications of the Environmental Professional(s) in **Appendix E**; and
- The signature(s) of the Environmental Professional(s) who prepared the report.

The report format will follow the recommended format included in ASTM E 1527-13, and will include the following:

- Summary
- User-Provided Information
- Interviews
- Additional Investigations
- Deviations
- Appendices
- Introduction
- Records Review
- Findings
- Conclusions
- Additional Services
- Site Description
- Site Reconnaissance
- Opinion of RECs
- Evidence of RECs
- References

2.4 Phase I ESA Limitations

The performance of a Phase I ESA is intended to reduce, but not eliminate, the uncertainty regarding the presence of RECs at the site. This Phase I ESA will be limited to information that is "reasonably ascertainable" and "practically reviewable," according to ASTM standards, considering the time and cost associated with the assessment. Baer Engineering does not guarantee the completeness or accuracy of the regulatory agency files and site listings. No sampling or laboratory analysis to assess the potential presence of environmental conditions in or near the Site is performed under normal Phase I ESA activities and, therefore, was not included in the scope of work for this Phase I ESA.

2.4.1 Significant Assumptions

Each potential REC was evaluated to determine its potential to affect the Site. The evaluations relied on Baer Engineering's experience with similar sites, and on assumptions about the behavior of contaminants in the subsurface. Baer Engineering believes the assumptions used are reasonable, and the conclusions based on the assumptions will, in most cases, be accurate. However, actual conditions at the Site and the surrounding area may be different from those used in the assumptions. Collection of subsurface samples can help to define the actual conditions, but such additional data collection is beyond the scope of the ASTM E 1527-13 standard.

Hazardous substances and petroleum products from off-site properties can potentially affect down-gradient properties, if the contaminants are transported by surface runoff. Surface releases of liquid flow downhill, so it is assumed surface releases from off-site properties at a lower elevation than the Site will not affect the Site. Roads are usually designed to drain water to the edges of the roads, so they typically act to divert surface flow or prevent flow from crossing the road. A general view of topography, and thus surface flow, can be obtained from topographic maps of appropriate scale. Small scale features that affect surface flow, including roads and berms, can be observed during a site visit.

If contaminants move downward through soil and encounter groundwater, the contaminants may migrate in the same manner as the groundwater. The flow direction of groundwater beneath the surface is not as easily determined as the flow of water over the surface. Typically the direction of groundwater flow is similar to that of surface flow. In urban environments the natural areas of recharge to the groundwater may be altered, and, consequently, there may be local perturbations of the gradient. In evaluating the potential for contaminant plumes in groundwater from off-site properties to affect the Site, it was assumed the groundwater flow direction is the same as the general surface flow direction, and groundwater contaminant plumes from off-site properties that are not up-gradient from the Site are not likely to affect the Site. The direction of groundwater flow may mimic the direction of surface flow.

Contaminants that migrate through unsaturated soil are typically limited in their areal extent. A release of a liquid at the surface will tend to migrate primarily downward in soil unless it encounters a relatively impermeable layer such as pavement, clay, or bedrock. Typically, the extent of soil contamination is limited to an area around the release that is on the order of tens of feet. In the case of leaking petroleum storage tank (LPST) sites, contaminated soil usually does not extend beyond the property with the release (BEG, 1997). Consequently, it is expected that nearby sites with only soil contamination from a petroleum release will not likely affect the subject Site, if they are more than about 100

feet from the Site. It is assumed that contaminants other than petroleum will also behave in a similar way.

Contaminants that reach groundwater can spread laterally on top of the water or by becoming dissolved in the water and subsequently migrating, mostly in the down-gradient direction, by advection. The areal extents of contaminant plumes depend on many factors, such as the volume of the contaminant released, and the rate of volatilization, degradation, and dilution. For example, the length of dissolved benzene plumes from LPST sites in Texas usually does not exceed 200 feet, and most of the groundwater plumes are confined to the property where the release occurred. Over ninety percent of benzene plumes in Texas are estimated to be less than 400 feet long (BEG, 1997). Among organic compounds, benzene moves relatively quickly after becoming dissolved in groundwater, so these observations should provide conservative estimates for plumes of other organic compounds. It is expected that nearby sites with contamination from dissolved organic compounds, including petroleum products, will not likely affect the subject Site, if they are more than about 400 feet from the Site. This distance can be considerably reduced for properties that are down-gradient from the Site.

Migration of contaminants through unsaturated soil as vapor is dependent on the method of biodegradation associated with the type of chemical. Petroleum hydrocarbons, low in ethanol content, generally biodegrade rapidly in aerobic conditions. Complete degradation produces water and carbon dioxide. Incomplete degradation can produce intermediate products, typically of a less toxic nature than the original chemical. Some petroleum hydrocarbons, typically high in ethanol content, can biodegrade under anaerobic conditions and produce methane as a byproduct. Alternately, chlorinated solvents, such as those used in dry cleaning facilities, biodegrade under anaerobic conditions. This process is typically much slower, and the chlorinated solvents may produce intermediate chemicals of a higher toxicity level than the parent compounds (US EPA, 2015). These conditions promote vapor plumes that remain near the source of contamination and are limited in their potential for subsurface migration in the case of petroleum hydrocarbons. Chlorinated solvents plumes are more likely to travel further than petroleum hydrocarbon plumes (US EPA, 2011).

These assumptions are based on the most likely interpretation of a limited amount of data. There is always the possibility that conditions are outside the statistical average. Consequently, it is not possible to predict with certainty the effect of off-site contamination on the subject Site.

2.4.2 Limitations and Exceptions

The findings and opinions conveyed via this Phase I ESA report are based on practically reviewable and publicly available information obtained from a variety of sources, enumerated in this report, which Baer Engineering believes are reliable. Baer Engineering has exercised due diligence and performed appropriate inquiry within the limits of the scope of this specific project. Nonetheless, Baer Engineering cannot and does not guarantee the authenticity or reliability of the information it has relied upon. This report is not a comprehensive site characterization and should not be construed as such. The opinions presented in this report are based on findings derived from a site reconnaissance, a review of specified regulatory records and historical sources, and comments made by interviewees. The consultant cannot under any circumstances warrant or guarantee that not finding indicators of hazardous substances or petroleum

products means that hazardous substances or petroleum products do not exist on the Site. Certain indicators of the presence of hazardous substances or petroleum products may have been latent at the time of the site visit and may subsequently become observable. Certain hazardous substances or petroleum products may not provide easily recognizable indicators. Additional research, including invasive testing, can reduce client risk, but no techniques now commonly employed can eliminate these risks altogether.

2.4.3 Deviations

Baer Engineering performed this Phase I ESA in conformance with the scope and limitations of the US EPA AAI and ASTM E 1527-13 Standard. The exception:

- An environmental lien search for properties was not included in this research and report. This omission was agreed upon by LAN, the City of Austin, and Baer Engineering. Documentation of the agreement can be found in **Appendix G**.

2.4.4 Special Terms and Conditions

Baer Engineering advises each client of the risks associated with a Phase I ESA. In essence, a Phase I ESA is a service whose basic elements are determined by the standard of care prevailing at the time the service was rendered in the area where it was rendered. Because standards of care can be identified only through retrospective inquiry, Baer Engineering has assumed that the standard of care is articulated by US EPA AAI and ASTM E 1527-13 Standard.

The guidelines used to define “hazardous materials” were obtained from Title 30 Texas Administrative Code (TAC) §335. For the purposes of this report, the “vicinity” of the Site is defined as properties located near the Site as specified by the approximate minimum search distances defined in US EPA AAI and ASTM E 1527-13 Standard.

2.4.5 User Reliance

City of Austin (COA) and its agents are the only intended beneficiaries of this report. They are the only parties to whom Baer Engineering has explained the risks involved in the shaping of the scope of services needed to satisfactorily manage those risks from the client’s point of view. Baer Engineering’s findings and opinions related in this report may not be relied upon by any parties except those listed above. With the consent of City of Austin, Baer Engineering is available to contract with other parties to develop findings and opinions related specifically to such other parties’ unique risk management concerns.

The ASTM Standard states that Phase I ESAs completed more than 180 days prior to the time of reliance are no longer considered to be valid. Between 180 days and one year, the Phase I ESA can be updated by conducting the following tasks:

- Interviews with owners, operators, and occupants;
- Searches for recorded environmental cleanup liens;
- Reviews of federal, tribal, state, and local government records;
- Visual investigation of the property and of adjoining properties; and
- Declaration by the environmental professional responsible for the assessment or update.

After one year, Phase I ESAs are no longer valid or eligible for updating. The assessment must be repeated in its entirety.

3.0 USER PROVIDED INFORMATION

3.1 Title Records
A title search was not part of the scope of work for this Phase I ESA.

3.2 Environmental Liens or Activity and Use Limitations
The entire Site lies within public ROW. No Environmental Liens or Activity and Use Limitations (AULs) were requested for the Site.

3.3 Specialized Knowledge
Baer Engineering does not have specialized knowledge of the Site and no such information was provided by the COA.

3.4 Commonly Known or Reasonably Ascertainable Information
Baer Engineering is not aware of information regarding commonly known or reasonably ascertainable information about the Site.

3.5 Valuation Reduction for Environmental Issues
No information was reported to Baer Engineering concerning the valuation of the property.

3.6 Owner, Property Manager, and Occupant Information
The roadway portion of the Site is owned by the City of Austin (COA). The residential portions of the Site are individually owned.

4.0 RECORDS REVIEW

4.1 Standard Environmental Record Sources

EDR conducted a search of environmental regulatory databases to identify potential environmental concerns associated with the Site. The US EPA AAI and ASTM E1527-13 Standard define the minimum search distances for some databases. The following table lists sites located within the minimum search distance. A copy of the database search is presented in **Appendix F**.

Database*	Search Distance (miles)	Target Property (Site)	Total Sites Listed**
Federal ASTM Standard Environmental Record Sources			
NPL	1.00	No	0
Delisted NPL	0.50	No	0
CERCLIS	0.50	No	0
CERCLIS-NFRAP	0.50	No	0
RCRA CORRACTS	1.00	No	0
RCRA-TSDF	0.50	No	0
RCRA Generators	Site and Adjoining	No	0
Federal Institutional/Eng Control	Site	No	0
ERNS	Site	No	0
State ASTM Standard Environmental Record Source			
State Equivalent NPL	1.00	No	0
State Equivalent CERCLIS	0.50	No	0
State Landfill	0.50	No	0
LPST	**0.50**	**No**	**3**
USTs and ASTs	**Site and Adjoining**	**No**	**7 (3 inactive)**
State Institutional/Eng Control	Site	No	0
TX VCP	**0.50**	**No**	**3**
Brownfields	0.50	No	0
Additional Environmental Record Sources			
Dry Cleaners	**0.25**	**No**	**4**
RCRA NonGen / NLR	**0.25**	**No**	**3**
TX Ind. Haz Waste	**0.25**	**No**	**3**
TX Ind. Haz Waste Corr Action	**0.25**	**No**	**1**
Non-ASTM Database			
EDR MGP	1.00	No	0
EDR US Hist UST	Site and Adjoining	No	0
EDR US Hist Auto Station	**0.125**	**No**	**9**
EDR US Hist Cleaners	**0.125**	**No**	**3**

* See **Appendix F** for abbreviation listings.
** Sites may be listed in more than one database.

National Priorities List (NPL)
No NPL sites are listed at the Site or within 1.0 mile of the Site.

Delisted Sites
No delisted sites are listed at the Site or within 0.5 miles of the Site.

CERCLIS
No CERCLIS sites are listed within 0.5 miles of the Site.

CERCLIS-NFRAP Sites
No CERCLIS-NFRAP sites are listed within 0.5 miles of the Site.

RCRA CORRACTS
No RCRA-CORRACTS sites are listed at the Site or within 1.0 mile of the Site.

RCRA-TSDF
No RCRA-TSDF sites are listed within 0.5 miles of the Site.

RCRA Generator Sites
No RCRA Generator sites are listed at or adjoining the Site.

Federal Institutional Control Sites
No Federal Institutional Control sites are listed within 0.5 miles of the Site.

ERNS Sites
No ERNS sites are listed for the Site.

State Equivalent NPL / CERCLIS
No State Equivalent NPL / CERCLIS sites are listed within 1.0 mile of the Site.

State Landfill Sites
No State Landfill sites are listed within 0.5 miles of the Site.

TCEQ LPST Sites
Three (3) Leaking Petroleum Storage Tank (LPST) sites were identified within 0.5 miles of the Site, as per the EDR report. LPST sites are those with documented releases from petroleum storage tanks, either from underground storage tanks (USTs) or aboveground storage tanks (ASTs). The sites are tabulated below.

SITE NAME	ADDRESS	DIRECTION / DISTANCE (FEET)		STATUS
Jollyville Food Mart	11794 Jollyville Road	Southeast	98	Final concurrence issued, case closed. Soil contamination only, requires full site assessment & rap.
The Convenient Store	12518 Research Blvd Suite N	Northwest	415	Final concurrence issued, case closed. The vertical extent of contamination has been defined and the assessment results document that groundwater is not affected.
TX DOT DS 549	11646 Research Boulevard	Southeast	1,569	Final concurrence issued, case closed. The Edwards aquifer, recharge zone or transition zone is affected.

Jollyville Food Mart is located at 11794 Jollyville Road, 98 feet southeast of the Arabian Trail Stormwater Conduit Alignment, and adjacent to the Site. This location is likely up-gradient of the Site. Records state the case start date was July 30, 1990 and the UST was removed from the ground. Final concurrence was issued October 19, 1990. The new UST, 8000-gallon gasoline storage tank, is double walled and is equipped with release detection systems on the tank and piping. The affected medium is reported to be soil. Based on this information, Baer Engineering considers this location to be a REC.

The remaining LPSTs are outside the assumed distance of influence discussed in **section 2.4.1** above.

Underground Storage Tank (UST) and Aboveground Storage Tank (AST) Sites
Most petroleum storage tanks (PSTs) that store fuel, either USTs or ASTs, are required to be registered with the TCEQ. One (1) UST locations and one (1) AST location are listed as being located adjacent to the Site.

SITE NAME	ADDRESS	DIRECTION / DISTANCE (feet)		Type of Tank	STATUS
Jollyville Food Mart	11794 Jollyville Road	Southeast	Adjacent	UST	Active
Covert Buick	11750 Research Boulevard	East	Adjacent	AST	Active
Synergy Center	11940 Jollyville Road	North	Adjacent	UST	Unknown
Northtown Hills Center	10820 North US Highway 183	East	Mislocated on map	UST	Inactive
Balcones Sta	11900 Jollyville Road	East/West	320/452	UST	Inactive

Jollyville Food Mart is located at 11794 Jollyville Road, 98 feet southeast of the Arabian Trail Stormwater Conduit Alignment and adjacent to the Project Site Area. This property is discussed in the LPST section above.

Covert Buick is located at 11750 Research Boulevard, 145 feet east of the Arabian Trail Stormwater Conduit Alignment and adjacent to the Site. The tank is listed as a 12,000-gallon gasoline storage tank that was installed in 1999. This property is located down gradient of the Site. Based on the gradient direction, Baer Engineering does not consider this location to be a REC.

Synergy Center is located at 11940 Jollyville Road, north of the Oak Knoll Stormwater Conduit Alignment and within the Site boundary. This property is listed in the City of Austin Underground Storage Tank Interactive Map (USTIM). Additional records were not available for the UST at this location. Based on this information, Baer Engineering considers this location to be a REC.

Northtown Hills Center is located at 10820 North US Highway 183. This location appears to be adjacent to the Site on the USTIM, however Travis County Appraisal District (TCAD) places the address listed by the City of Austin approximately 1.56 miles south-southeast of this location. The TCAD parcel the COA USTIM places this record on is the Covert Buick parcel discussed above.

Balcones Sta is located at 11900 Jollyville Road. This location is 320 feet east and downgradient of the Oak Knoll project area. This location is 452 feet west and up-gradient of the Arabian Trail project area. This location is listed as a United States Postal Service station. The tank status for this location is listed as inactive. Gasoline for fleet refueling is listed as the contents of the USTs at this location. EDR records show the location of this tank on Oak Knoll Drive, however TCAD lists the location of this address

on Jollyville Road between the Oak Knoll project area and the Arabian Trail project area. Because of its relative position, Baer Engineering does not consider his location to be a REC.

State Institutional Control Sites
No State Institutional Control sites are listed within 0.5 miles of the Site.

Texas Voluntary Cleanup Program (VCP) Sites
Three (3) VCP sites are listed within 0.5 miles of the Site.

Columbia Scientific Industries is located at 11950 Jollyville Road, south and adjacent to the Site and the Oak Knoll Stormwater Conduit Alignment. This property is located at equal elevation to the Site and the conduit alignment. Groundwater is the affected medium listed for the property. The contaminants listed are VOCs. The site entered the VCP on March 22, 1999. It is still listed as an active VCP site. The responsible party listed is United Technologies Corporation.. An active class V underground injection control permit with the TCEQ is listed for this location. The injected fluid listed is “GW TREATED TO MCLS”, records state the injection project began in March 2010. The contaminants listed are TPH and Metals. This location is listed as an inactive industrial hazardous waste site. The waste description is “Mixed lab packs of used & unused chemicals resulting from closure of facility/ac”. Due to the proximity to the Site and status of the VCP program, Baer Engineering considers this listing to be a REC.

American Drycleaning was located at 12636 Research Boulevard, Suite 101, 1,138 feet northwest of the Site and 1,892 feet northwest of the Oak Knoll Stormwater Conduit Alignment. This property is located up-gradient of the Site and the conduit alignment. Records list the VCP start date as June 28, 2001, and the site is listed as inactive and completed as of January 18, 2002. Groundwater is the medium affected and the contaminants listed for the property are chlorinated solvents. An inactive industrial hazardous waste corrective action solid waste registration is listed for the site, with the individual chemicals requiring a remedy listed as tetrachloroethylene (PERC). This chemical is a dense non-aqueous phase liquid (DNAPL) used by dry-cleaning facilities. There is some evidence of an association between perc and increased risk of certain cancers in dry cleaning workers exposed for many years. The National Institute for Occupational Safety and Health (NIOSH) has designated perc as a "potential occupational carcinogen". The National Toxicology Program has designated it as "reasonably anticipated to be a human carcinogen". The International Agency for Research on Cancer (IARC) has designated perc as a "probable human carcinogen". It is known to impact human health in other ways. PERC is difficult to remediate because of its dense nature, having a density greater than water. Due to the up-gradient location and nature of the contaminants, Baer Engineering considers this location to be an HREC.

McNeal 3 & 4 LTD Ceramics, this property is also listed as Luminex Austin Campus (Luminex) with the TCEQ, is located at 12212 and 12112 Technology Boulevard, Suite A, 1,613 feet north-northwest of the Site and 2,355 feet from the Oak Knoll Stormwater Conduit Alignment. This property is located at equal elevation to conduit alignment. The contaminants listed for this location are TPH. The VCP status is listed as inactive and completed under the Texas Risk Reduction Program (TRRP) as of July 24, 2002. This property is listed as an industrial hazardous waste solid waste registration location with the TCEQ. Waste listed for the property are:

- Mixed Acid Solution. Manufacture of ceramic components for the computer industry, August 1995;
- Aluminum Oxide, primarily a Solid with a liquid phase. Manufacturing of ceramic components for the electronic industry, August 1995;
- Plant Trash. Routine manufacturing processes, August 1995;
- Aluminum Nitride solid. Aluminum nitride powder is mixed to make ceramics parts for the semi-conductor industry. Parts ate machined to exact specification and residuals are collected as wastes, July 1999.

Additional records listing waste details for Luminex can be found in **Appendix F**. Due to the proximity to the Site and assumed direction of groundwater flow, Baer Engineering does not consider this location to be a REC.

Brownfields Sites
No Brownfields sites are listed within 0.5 miles of the Site.

Dry Cleaner Sites
Four (4) Dry Cleaner sites are listed within 0.25 miles of the Site.

Elegant Alterations & Cleaners is located at 12200 Research Boulevard, Suite 300, northwest and adjacent of the Site and 269 feet northwest of the Arabian Trail Stormwater Conduit Alignment. This property is upgradient of the Site and conduit alignment. TCEQ records show that this facility is a drop station. Based on this information, Baer Engineering does not consider this location to be a REC.

Super Care Cleaners is located at 11917 Oak Knoll Drive, Suite E, 297 feet from the Site and 934 feet north of the Oak Knoll Stormwater Conduit Alignment. This property is located at equal elevation to the Site and conduit alignment. TCEQ records show that this facility is a drop station. Based on this information, Baer Engineering does not consider this location to be a REC.

Best Cleaners 2 is located at 12518 Research Boulevard, Suite M, 415 feet north of the Site and 1,040 feet from the Oak Knoll Stormwater Conduit Alignment. This property is located at equal elevation to the Site and the conduit alignment. This location is also listed in the LPST section above as The Convenient Store. This address is part of a shopping complex named Oak Knoll Village. The facility is listed as a drop station with the TCEQ. Based on this information, Baer Engineering does not consider this location to be a REC.

Go Go Cleaners, also listed as Q Cleaners by the TCEQ, is located at 11602 Jollyville Road, 980 feet southeast of the Site and Bell Avenue Stormwater Conduit Alignment. This property is located down gradient of the Site and conduit alignment. The facility is registered as a drop station with the TCEQ. Based on this information, Baer Engineering does not consider this location to be a REC.

RCRA Non-Gen/NLR Sites
Three (3) RCRA NonGen/NLR sites are listed in the EDR records within 0.25 miles of the Site.

Flashcards Incorporated is located at 11740 Jollyville Road. This property is discussed below in the Industrial hazardous Waste section.

Columbia Scientific Industries is located at 11950 Jollyville Road and is discussed in the VCP section above.

FST Service Corp is located at 11652 Jollyville Road, 434 feet southeast of the Site and Bell Avenue Stormwater Conduit Alignment. This property is located down gradient of the Site and the conduit alignment. The facility is listed as a handler and transporter of used oil. Based on this information, Baer Engineering does not consider this location to be a REC.

Industrial Hazardous Waste (IHW) Sites
Three (3) IHW sites are listed in the EDR records within 0.25 miles of the Site.

Flashcards Incorporated is located at 11740 Jollyville Road, west and adjacent to the Site and 420 feet northwest of the Bell Avenue Stormwater Conduit Alignment. This property is located up-gradient of the Site and the conduit alignment. This property is listed as an inactive IHW conditionally exempt small quantity generator site. Waste listed under the IHW registration includes:

- Waste petroleum Naphtha/ Circulating parts cleanaz/ 3-6-93; and
- Inic Toner Roller Wash/Press clean up/ 12-22-92.

The RCRA Non-Gen records for this property list wastes for the property are:

- ignitable waste;
- lead;
- benzene; and
- tetrachloroethylene.

No violations are listed in the EDR records for this property. Based on this information, Baer Engineering does not consider this location to be a REC.

Columbia Scientific Industries is located at 11950 Jollyville Road and is discussed in the VCP section above.

3M Company is located at 11705 Research Boulevard and is discussed in the Industrial Hazardous Waste Corrective Action Sites section below.

Industrial Hazardous Waste Corrective Action sites
One (1) Industrial Hazardous Waste Corrective Action site was found within 0.25 miles of the Site.

3M Company is located at 11705 Research Boulevard, 805 feet east-southeast of the Site and 965 feet east-southeast of the Bell Avenue Stormwater Conduit Alignment. This property is located downgradient of the Site and the conduit alignment. This property is listed as an active IHW corrective action cleanup site. Solid wastes listed for the site are numerous and relate to the fabrication of printed circuitry, the specific wastes listed are provided in **Appendix F**. Based on its location, Baer Engineering does not consider this location to be a REC.

4.2 Additional Records Sources

4.2.1 Additional EDR Historical Records

EDR searches records beyond those required by the ASTM 1527-13 Standard for Phase I ESAs. Some of these include exclusive EDR records compiled based on collections of business directories and other listings regarding historical land use in the area, such as UST sites, automobile service stations, and dry cleaners. EDR identified eighteen (18) former automobile service stations at seven (7) locations, and five (5) former dry cleaners at three (3) locations within 0.25 miles of the subject Site. These historical sites are as follows:

SITE NAME	YEAR (S) OF LISTING	ADDRESS	DIRECTION / DISTANCE (feet)	
Historic auto service station sites				
Auto Clinic	2001	11929 Arabian Trail	South	Adjacent
Midas Auto Systems Experts	1999	11928 Research Boulevard	North	Adjacent
Midas Auto Service Experts	2001, 2003, 2009, 2011			
Midas Muffler Shops	2004			
Midas Auto SVC Experts	2010			
Brake Check	1984, 1999, 2000, 2001, 2003-2012	12032 Research Boulevard	North	Adjacent
Brake Check NO	1990			
DDS Paintless Dent Repair	2004	12006 Research Boulevard	North	Adjacent
Carters Transmissions	1999, 2000, 2005-2007	11980 Research Boulevard	North	Adjacent
Carters Transmissions Inc.	2008, 2009			
Lambs Tire and Automotive Centers	2012	11675 Jollyville Road	Southeast	Adjacent
Fast Lube Auto Repair	1980, 1984	12538 Research Boulevard	North	319
B All Auto & Truck Repair	1984			
Lube Fast	1999, 2000, 2004, 2005, 2007-2009			
Just Brakes	2002, 2003, 2006			
Ben White Automotive	2010-2012			
B B & M Transmission Center Auto Service	1990			
A fast Lube Auto Repair	1990			
Historic Drycleaners				
B Garnett Lewis Cleaners	1984	12006 Research Boulevard	North	Adjacent
Alterations & Cleaner By Elegant	2003	12200 Research Boulevard	Northwest	Adjacent
Alterations and Cleaners by Elegant	2005			
E Super Care Cleaners	1990	11917 Oak Knoll Drive	North	295
Super Care Cleaners	2002, 2005-2007, 2010-2012			

Former Automobile Service Stations

Auto Clinic is located at 11929 Arabian Trail, south and adjacent of the Arabian Trail Stormwater Conduit Alignment and within the Site boundary. Additional records were not located for this property. Baer Engineering considers this property to be a REC, due to the proximity to the Site and lack of additional records.

Midas Auto Systems Experts is located at 11928 Research Boulevard, north of the Arabian Trail Stormwater Conduit Alignment and within the Site boundary. The only additional records located for this property was an Edwards Aquifer Permit. Baer Engineering considers this property to be a REC, due to the proximity to the Site and lack of additional records.

Brake Check is located at 12032 Research Boulevard, north and adjacent of the Arabian Trail Stormwater Conduit Alignment and within the Site boundary. TCEQ records list a Non-Permitted Municipal Solid Waste investigation in 2015. A complaint is registered with the TCEQ from March 3, 2015, the description reads "An automotive shop is dumping brake fluid, transmission fluid, power steering fluid, antifreeze, and engine oil onto the ground." Based on this information, Baer Engineering considers this location to be a REC.

DDS Paintless Dent Repair is located at 12006 Research Boulevard, north and adjacent of the Arabian Trail Stormwater Conduit Alignment and within the Site boundary. This property is listed as a historic drycleaners. Additional records were not located for this property. Baer Engineering considers this property to be a REC, due to the proximity to the Site and lack of additional records.

Carters Transmissions is located at 11980 Research Boulevard, north and adjacent of the Arabian Trail Stormwater Conduit Alignment and within the Site boundary. Additional records were not located for this property. Baer Engineering considers this property to be a REC, due to the proximity to the Site and lack of additional records.

Lambs Tire and Automotive Centers is located at 11675 Jollyville Road, south and adjacent of the Bell Avenue Stormwater Conduit Alignment and the Site. Additional records were not located for this property. Baer Engineering considers this property to be a REC, due to the proximity to the Site and lack of additional records.

Fast Lube Auto Repair is located at 12538 Research Boulevard, 337 feet north of the project area and 1,077 feet from the Oak Knoll Stormwater Conduit Alignment. This property is cross gradient of the Site and the conduit alignment. This property is the location of a UST. Records list a diesel storage tank was removed from the ground in 1998. This property is listed as Valvoline Express Care NW in TCEQ records at 12538A Research Boulevard, with an active used oil registration as a collection center. Based on this information, Baer Engineering does not consider this location to be a REC.

Former Cleaners

B Garnett Cleaners is located at 12006 Research Boulevard; this property is discussed in the Former Automobile Service Stations section above.

Elegant Alterations & Cleaners is located at 12200 Research Boulevard; this property is discussed in the Drycleaners section above.

E Super Care Cleaners is located at 11917 Oak Knoll Drive; this location is discussed in the Drycleaners section above.

4.2.2 Previous Environmental Reports

No previous environmental investigations were provided by the client for our review.

4.2.3 Vapor Encroachment Screening

Baer Engineering completed an analysis of the likelihood of vapor migration onto the property using EDR records, soil reports, and the previously stated assumption that groundwater gradients may be represented by surface water flows. This analysis was completed to identify Vapor Encroachment Conditions (VECs), which are defined in the

ASTM Standard E 2600 as "the presence or likely presence of vapors in the sub-surface of the target property caused by the release of vapors from contaminated soil or groundwater either on or near the target property." No vapor is likely going to impact the project. A copy of this analysis is presented in **Appendix F**.

4.3 Physical Setting Sources

4.3.1 Review of Topographic Maps

Baer Engineering reviewed the 2013 USGS 7.5-minute *Jollyville and Pflugerville East Quadrangle* topographic map for information about the topography of the Site. A portion of the map is presented in **Appendix G**. The map shows the Site is at an approximate elevation of 860 to 940 feet above mean sea level. Topography of the immediate area generally slopes to the east.

4.3.2 Flood Map

The Federal Emergency Management Agency (FEMA) website was searched for Flood Insurance Rate Maps (FIRMs) for the Site (FEMA, 2016). Review of the flood map for this area (Map Item ID 48453C0245J & 48453C0265K) indicates the Site is not within the 100-year flood zone (FEMA, 2016). A map of the FEMA flood hazard areas, in relation to the Site, can be found in **Appendix F**.

4.3.3 Site Soils

According to the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), the Site lies within the Tarrant and Speck soils (map unit symbol TcA) land complex with 0 to 6 percent slopes, the San Saba clay (map unit symbol SaB) land complex with 1 to 2 percent slopes, and the Speck stony clay loam (map unit symbol SsC) land complex with 1 to 5 percent slopes (USDA, 2016). The soil units within the project area are listed as a Class D soil group, with very slow infiltration rates, clayey soils, a high water table, or have an impervious layer not far beneath the surface. A map of the Site soils is provided in **Appendix F**.

4.3.4 Site Geology and Hydrogeology

According to the Bureau of Economic Geology's (BEG) Geologic Atlas of Texas *Austin Sheet,* the Site is located on the Fredricksburg Group. The Fredricksburg Group is an early Cretaceous formation consisting primarily of limestone, dolomite, marl, and chert. The Site overlies the Edwards aquifer, a state-designated major aquifer. Portions of the Site are located within the Edwards Aquifer Recharge Zone, an environmentally sensitive area in which construction activities are regulated by the City of Austin and the State of Texas. The following water well information was reviewed:

Tracking No.	Well Name	Depth (feet)	Drill Date	Information	Status
77778	T3 B2	32	3/4/2006	• Monitoring well, United Technologies • 11950 Jollyville Road, Austin, TX • Formation: no data reported	Unknown
77776	T3 B1	30.5	3/4/2006	• Monitoring well, United Technologies • 11950 Jollyville Road, Austin, TX • Formation: no data reported	Unknown
77777	T3 B3	35	3/4/2006	• Monitoring well, United Technologies • 11950 Jollyville Road, Austin, TX • Formation: no data reported	Unknown

TRACKING NO.	WELL NAME	DEPTH (FEET)	DRILL DATE	INFORMATION	STATUS
36925	PO-1	30	3/27/2004	• Monitoring well, Harris Labney, Ltd. • 11905 Jollyville Road, Austin, TX • Formation: Edwards	Unknown
36926	MW-17	100	3/26/2004	• Monitoring well, Forney Corporation • 11900 Jollyville Road, Austin, TX • Formation: no data reported	Plugged #24993
36923	JR-1	30	3/25/2004	• Monitoring well, Forney Corporation • 11900 Jollyville Road, Austin, TX • Formation: no data reported	Unknown
5834607	D-17	250	1939	• Domestic Water Well, L.E. Taungate • Approximately 11851 Jollyville Road, Austin, TX • Formation: Glen Rose	Unknown
154715	SB# 1, 2, 4, 6, 7, 8	21	9/26/2008	• Environmental Soil Boring, United Technologies • 11950 Jollyville Road, Austin, TX • Formation: no data reported	Plugged
154718	PO- 6, 7	21	9/26/2008	• Environmental Soil Boring, United Technologies • 11950 Jollyville Road, Austin, TX • Formation: no data reported	Unknown
154716	SB# 9. 10	21	9/26/2008	• Environmental Soil Boring, United Technologies • 11950 Jollyville Road, Austin, TX • Formation: no data reported	Plugged
5834608	D-18	181	Unknown	• Domestic Water Well, S.W. Seiders • Approximately 5841 Secrest Drive, Austin, TX • Formation: Glen Rose	Unknown
318427	1	440	3/28/2013	• Irrigation, Culvert Buick, Inc. • 11750 Research Blvd. Austin, TX 78759 • Formation: no data reported	Unknown
5834606	-	330	10/1963	• Domestic Water Well, Walter Krizov • Approximately 11672 Jollyville Road, Austin, TX • Formation: Glen Rose	Unknown

4.4 Historical Use Information

The Site has been used as a residential area since 1967. Records do not indicate the land use of the Site prior to 1896. The 1896 to 1910 topographic maps do not depict structures within the Site area. The project area appears to have experienced major development between 1980 and 1988. The surrounding areas appear to have experienced major development between 1973 and 1980.

4.4.1 Sanborn Fire Insurance Maps

Sanborn Fire Insurance Maps were requested from EDR. Sanborn maps covering the Site were not found, indicating the area was not developed until after 1961. After WWII, production of new maps and revisions by Sanborn decreased drastically and ceased in 1961. After 1961 no new maps were produced and only the revision service continued. There were a few revisions up to 1990 (Georgia State University Research Library).

Sanborn maps for the Site area were not available. The Sanborn map report is available in **Appendix G**.

4.4.2 Historical Aerial Photographs

Baer Engineering reviewed a suite of aerial photographs obtained from EDR for information about the history of the Site. Reproductions of these photographs are included in **Appendix G**. The scale of each photograph is approximately 1 inch equals 500 feet. The following aerial photographs from the EDR collection were reviewed: 1940, 1953, 1967, 1973, 1980, 1988, 1995, 2005, 2008, 2010, and 2012.

The 1940 and 1953 aerial photographs show rural areas on and adjacent to the Site. The surrounding properties are vegetated. Jollyville Road appears as a developed roadway.

The 1967 aerial photograph depicts development along Arabian Trail and Bell Avenue. Roadway development has occurred in the surrounding areas. Moderate vegetation coverage remains on the lots surrounding the project area. The properties to the south are developed with several new structures visible in the photograph.

The 1973 aerial photograph depicts increased urban home development and the addition of Highland Oaks Trail. The adjacent properties to the southwest have several new structures visible in the photograph. Oak Knoll Drive and Broad Oaks Drive are visible roadways.

The 1980 aerial photograph Columbia Oaks Drive is seen. The properties along Oak Knoll Drive and Broad Oaks Drive appear developed. Three Oaks Trail, Doubloon Cove, and the adjacent properties are also developed. Major urban development to the north and south of the Site is visible.

The 1988 aerial photograph shows the addition of Seacrest Drive and development of properties adjacent to it. Significant development is seen along Columbia Oaks and on properties adjacent to the north and south of the Site.

The 1995 to 2012 aerial photo graphs show little change on the Site and surrounding properties. Commercial properties were developed to the east of the Site in the 1995 photograph. Residential properties to the south and adjacent of the Site are visible in the 1995 photographs.

4.4.3 Historical Topographic Maps

Baer Engineering reviewed historical topographic maps obtained from EDR for additional information about the history of development at the Site. Historical topographic maps were available for 1896, 1897, 1910, 1955/1959, 1968, 1973, 1987 and 2013. Reproductions of portions of the historical topographic maps are presented in **Appendix G**.

1896 to 1910 – Austin

This map depicts Jollyville Road and the Jollyville area. The Site is appears to be mostly undeveloped. Two creeks are depicted south and southwest of the Site.

1955/1959 – 1959-Lake Travis, 1955- Austin Southeast
Structures can be seen on and adjacent to the Site. The Williamson County line can be seen to the north of the Site. Arabian Trail appears developed in this map. Jollyville Road is labeled as Highway 183.

1968 – Jollyville, Pflugerville East
Bell Avenue appears developed on this map. Structures are depicted adjacent to Arabian Trail and Bell Avenue. Highway 183 appears separate from Jollyville Road.

1973 – Jollyville, Pflugerville East
Highland Oaks Trail, Oak Knoll Drive, Three Oaks Trail, and Broad oaks Drive are depicted on this map. Several structures are depicted adjacent to Highland Oaks Trail and Arabian Trail. The surrounding areas appear to have experienced major development.

1987 – Jollyville, Pflugerville East
Columbia Oaks Drive, Seaforest Drive, and Rainforest Cove are depicted on this map. Structures are depicted adjacent to Seaforest Drive and Rainforest Cove. The surrounding areas appear to have had extensive roadway development.

2013 – Jollyville, Pflugerville East
This map depicts roadways and topography, no structures are represented on the 2013 map. J Gregg Cove and Hamrich Court appear on this map.

4.4.4 Historical Tenant Search
Baer Engineering requested City Directory listings from EDR. They are provided in **Appendix G**. Records dating back to 1896 were provided by EDR. Listings from 1896 through 2013 identified the nearby properties as mixed-use properties, including residential and commercial uses.

4.4.5 Building Permit Search
Baer Engineering requested a building permit search from EDR. Permits for the Site include activities such as remodeling, sign displays, gas meter installations, electrical installations, HVAC system replacement, and certificates of occupancy. A copy of the EDR results is provided in **Appendix G**.

A review of the building permit search documents did not reveal additional RECs for the Site.

5.0 SITE RECONNAISSANCE

5.1 Methodology and Limiting Conditions

Information derived from the Site reconnaissance is presented in this section. A Site Map is provided in **Appendix A**. Photographs taken during the Site reconnaissance are presented in **Appendix C**.

The Site reconnaissance was conducted by Mr. Mark Sloop and Ms. Leilani Williams, of Baer Engineering, on September 28, 2016. The reconnaissance included an on-site visual observation of the Site and of surrounding properties from publicly-accessible areas and parcels where Right-of-Entry had been granted. Findings of the Site reconnaissance are presented on the map in **Appendix D**.

5.2 General Site Setting

The Site and the surrounding properties are in an area of predominantly mixed commercial and residential land use. This includes single-family homes and businesses. A Site Map is included in **Appendix A**.

5.3 Current Uses of the Property

The Site consists of paved roadway and fenced residential areas.

5.4 Description of Structures, Roads, and Other Improvements to the Site

Baer Engineering made the following field observations:

- 12 utility poles with transformers are present on the Site. Eight of these transformers did not have PCB markings on them. Four of these transformers are marked “No PCBs”.

5.5 Current Uses of Adjoining Properties

The properties immediately adjoining the Site have the following uses:

- North – Highway 183/Research Boulevard, P. Terry’s Burger Stand, Learning Factory Preschool Academy, Dunkin Donuts, and associated parking lots.
- South – Jollyville Road, and residential areas.
- East – Covert Cadillac, Clinical Pathology Laboratories, Covert Buick GMS Austin, Walgreens, parking lots for these businesses, and residential areas.
- West – Jollyville Pediatrics, Academy Sports and Outdoors, Chase Bank, associated parking lots, and residential areas.

Baer Engineering conducted a reconnaissance of the properties adjacent to the Site. The Food Mart on Jollyville is closed and for sale. No employees were available to interview. The tanks appeared to still be present on this site.

6.0 INTERVIEWS

6.1 Interview with Owner

The stormwater conduit alignments are primarily within the Right-of-Way of the City of Austin. No interviews were conducted with owners.

6.2 Interview with Site Manager

The stormwater conduit alignments are primarily within the right of way of the City of Austin. No interviews were conducted with roadway managers.

6.3 Interviews with Local Government Officials

Public records were requested from various local government officials. Documentation of these requests is provided on **Appendix H**, as available. Summaries of the information received are as follows:

6.3.1 Travis County

An Open Records request was submitted to the Travis County Clerk on August 23, 2016, for information pertaining to hazardous materials storage or incidents, chemical spills or cleanups, landfills or dumping, and previous environmental site assessments at the Site and immediate vicinity. On August 23, 2016, Tiffany Taylor, a Travis County employee informed Baer Engineering that there is no information on record in association with this property. A copy of this correspondence is available in **Appendix H**. The information pertaining to this location is framed in a red box.

6.3.2 City of Austin

An Open Records request was submitted to the COA in August 23, 2016, for information pertaining to hazardous materials storage or incidents, chemical spills or cleanups, landfills or dumping, and previous environmental site assessments at the Site and immediate vicinity. Records for the COA Petroleum Storage Tank program were received on August 29, 2016, from Carla Johnson. Review of the COA records provided did not reveal additional RECs for the Site. A copy of provided records is available in **Appendix H.**

6.4 Interviews with Others

Ms. Marilu Nunez is the store manager at The Convenient Store (Shell), located as 12518 Research Boulevard. Mr. Mark Sloop interviewed her on September 28, 2016. She had no environmental concerns to report.

7.0 EVALUATION

7.1 Findings

The findings and opinions presented are relative to the dates of our Site work and the opinions included in this ESA are based on information obtained during the survey and on our experience. If additional information becomes available that might affect our environmental findings, we request the opportunity to review the information, reassess the potential concerns, and modify our opinions, if warranted. This assessment includes a review of documents prepared by others. Baer Engineering did not conduct a separate review to verify the accuracy of the information in those documents.

Although Baer Engineering has attempted to identify the potential for environmental impacts to the subject Site, potential sources of contamination may have escaped detection because of the limited scope of this assessment, the possible inaccuracy of public records, or the possibility of undetected or unreported environmental incidents. It was not the purpose of this study to determine the actual presence, degree, or extent of contamination, if any, at the Site. This would require additional exploratory work, including sampling and laboratory analysis.

On-site –

- The Site consists of roadways and residential properties.

Off-site –

- Adjacent properties consist of commercial and residential land use. The dominant land use is residential.
- One LPST site was adjacent to the Site;
- One PST is located adjacent to the Site;
- One VCP with a reported solvent release reported in 1999 near the Site;
- Six historical auto service stations adjacent to the Site; and
- One VCP and Dry Cleaner business possibly affecting the site due to the usage of tetrachloroethylene (PERC) at the business.
- Review of historical aerial photographs and topographic maps did not reveal indications of RECs.

7.2 Environmental Professional's Opinion of Impact on the Property

On-site – Baer Engineering did not identify any RECs on Site.

Off-site – Baer Engineering identified eight (8) RECs and one (1) HREC off-Site, listed as follows:

SITE NAME	ADDRESS	TYPE	DISCUSSION	REC ID
Jollyville Food Mart	11794 Jollyville Road	LPST[1]	Likely up-gradient. Adjacent to LOC[5].	**A**
Synergy Center	11940 Jollyville Road	PST	Immediately adjacent to alignment. Likely down-gradient from LOC. Facility has not reported a release. Contaminants would be hydrocarbons.	**B**

SITE NAME	ADDRESS	TYPE	DISCUSSION	REC ID
Columbia Scientific Industries	11950 Jollyville Road	VCP[3]	Likely cross-gradient from LOC. Facility is in VCP to clean up a solvent release reported in 1999.	C
Auto Clinic	11929 Arabian Trail	HASS[4]	Likely up-gradient. Immediately adjacent to LOC. Contaminants would be hydrocarbons.	D
Midas Auto Systems Experts	11928 Research Boulevard	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	E
Brake Check	12032 Research Boulevard	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	F
• DDS Paintless Dent Repair • B Garnett Lewis Cleaners	12006 Research Boulevard	HASS	Likely down-gradient from alignment. Because of the presence of a potential dry-cleaning facility, Baer Engineering considers this to be a REC.	G
Carters Transmissions	11980 Research Boulevard	HASS	Likely down-gradient from alignment. Facility has not reported a release. Contaminants would be hydrocarbons.	H
American Drycleaning	12636 Research Boulevard, Suite 101	VCP Dry Cleaners	Likely up-gradient. Perchloroethylene has the potential to travel long distances.	I

1: LPST: Leaking Petroleum Storage Tank
2: PST: Petroleum Storage Tank
3: VCP: Voluntary Cleanup Program
4: HASS: Historic Automobile Service Station
5: LOC: Limits of Construction

7.3 Conclusions

Baer Engineering and Environmental Consulting, Inc. has performed a Phase I ESA in conformance with the scope and limitations of the EPA AAI and ASTM 1527-13 Standard (excluding environmental lien search, as discussed above), for the Oak Knoll Stormwater Drain Improvements project in Austin, Texas.

7.4 Additional Investigations

No additional investigations were performed during the preparation of this report.

7.5 Data Gaps

No significant data gaps were encountered during this Phase I ESA.

7.6 Deletions

There were no deletions identified during the preparation of this report.

7.7 References

ASTM, 2014. ASTM International, *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*, Designation: E 1527-13, 2014.

ASTM, 2014. ASTM International, *Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions*, Designation: E 2600-10, 2010.

BEG, 1963. Bureau of Economic Geology, Geologic Atlas of Texas, *Austin Sheet* (rev. 1963).

BEG, 1997. Bureau of Economic Geology, Geological Circular 97-1, *Extent, Mass, and Duration of Hydrocarbon Plumes from Leaking Petroleum Storage Tank Sites in Texas*, the University of Texas at Austin, 1997.

FEMA, 2016. Federal Emergency Management Agency, Online Map Service Center, Travis County and Incorporated Areas, January, 2016, Flood Insurance Rate Map No. 48453C0465J, https://msc.fema.gov/portal, last accessed October 1, 2016.

GSU, 2016. Library Research Guides at Georgia State University, Guide to Sanborn Fire Insurance Maps, http://research.library.gsu.edu/c.php?g=115461&p=755495.

TCAD, 2016. Travis County Appraisal District, http://propaccess.traviscad.org/clientdb/Property.aspx?prop_id=100851, http://propaccess.traviscad.org/clientdb/Property.aspx?prop_id=100852, last accessed October 1, 2016.

TCEQ, 2016. Texas Commission on Environmental Quality, Central Registry Webpage, http://www15.tceq.texas.gov/crpub/index.cfm?fuseaction=cust.CustSearch, last accessed October 1, 2016.

TSHA, 2016. Texas State Historical Association, *The Handbook of Texas Online*, Austin, TX, http://www.tshaonline.org/handbook/, last accessed October 1, 2016.

TWDB, 2016. Texas Water Development Board Water Information Integration & Dissemination (WIID), http://www.twdb.texas.gov/groundwater/aquifer/GAT/index.asp, last accessed October 1, 2016.

USDA, 2016. United States Department of Agriculture, Natural Resource Conservation Service, Web Soil Survey webpage, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm, last accessed October 1, 2016..

US EPA, 1975. Office of Toxic Substances, *Environmental Aspects of Chemical Use in Printing Operations*. US EPA, 1975.

US EPA, 2011. Office of Underground Storage Tanks, *Petroleum Hydrocarbons and chlorinated Hydrocarbons Differ in their Potential for Vapor Intrusion.* US EPA, 2011.

US EPA, 2012. Federal Register Part III EPA 40 CFR Part 312.

US EPA, 2015. Office of Underground Storage Tanks, *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites.* US EPA, 2015.

USGS, 2013. United States Geological Survey, 7.5-Minute Topographic Quadrangle Map, *Austin Quadrangle*, 2013.

7.8 Statement and Signatures of Environmental Professionals

The preparers represent that to the best of their knowledge the information and facts contained in this report are true and correct. No material facts have been suppressed or misstated.

We declare that, to the best of our professional knowledge and belief, we meet the definition of Environmental professional, as defined in §312.10 of 40 CFR §312. We have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property. We have developed and performed the all appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

Signature	Signature
Mark Sloop	Rosemary Wyman
Date: November 9, 2016	Date: November 9, 2016
Title: Staff Geologist, G.I.T	Title: Principal Geologist, CHMM, CPESC

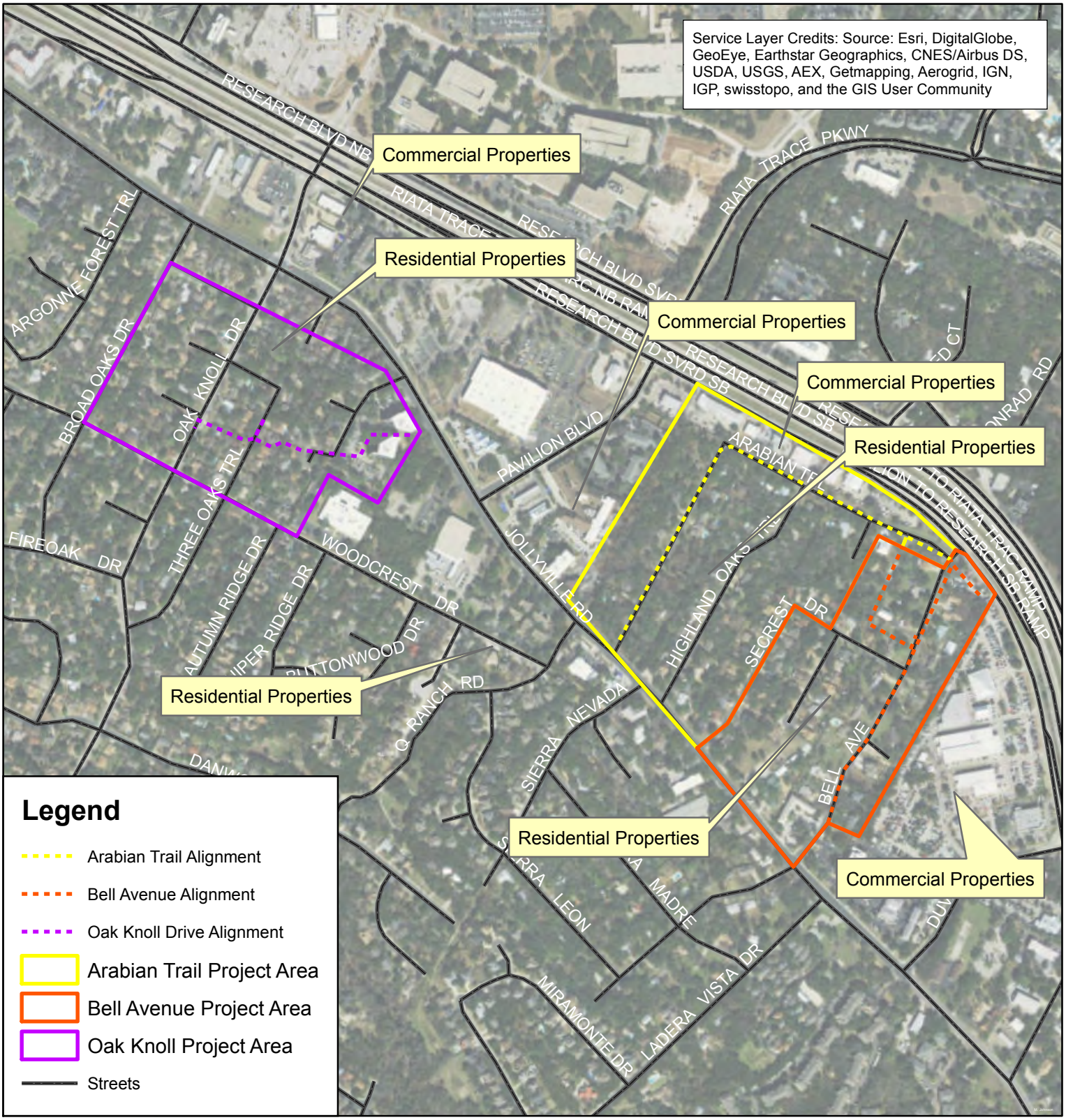
8.0 NON-SCOPE SERVICES

No additional services beyond those specified by the ASTM E 1527-13 Standard and listed in the contract between Baer Engineering and COA were completed for the Phase I ESA.

9.0 APPENDICES

Supporting documentation and qualifications of the Environmental Professionals are provided below.

A. SITE MAP



Appendix A: Site Map

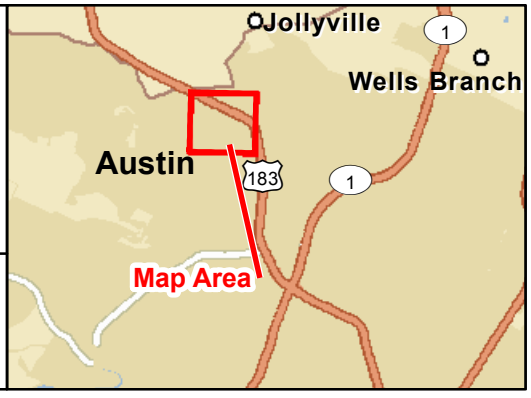
Walnut Creek Watershed
Drainage Improvements
Oak Knoll Drive, Arabian Trail,
and Bell Avenue in Austin, Texas
City of Austin CLMP174 - 2015
Watershed Engineering Flood
Hazard Mitigation Rotation List

0 500 1,000 Feet

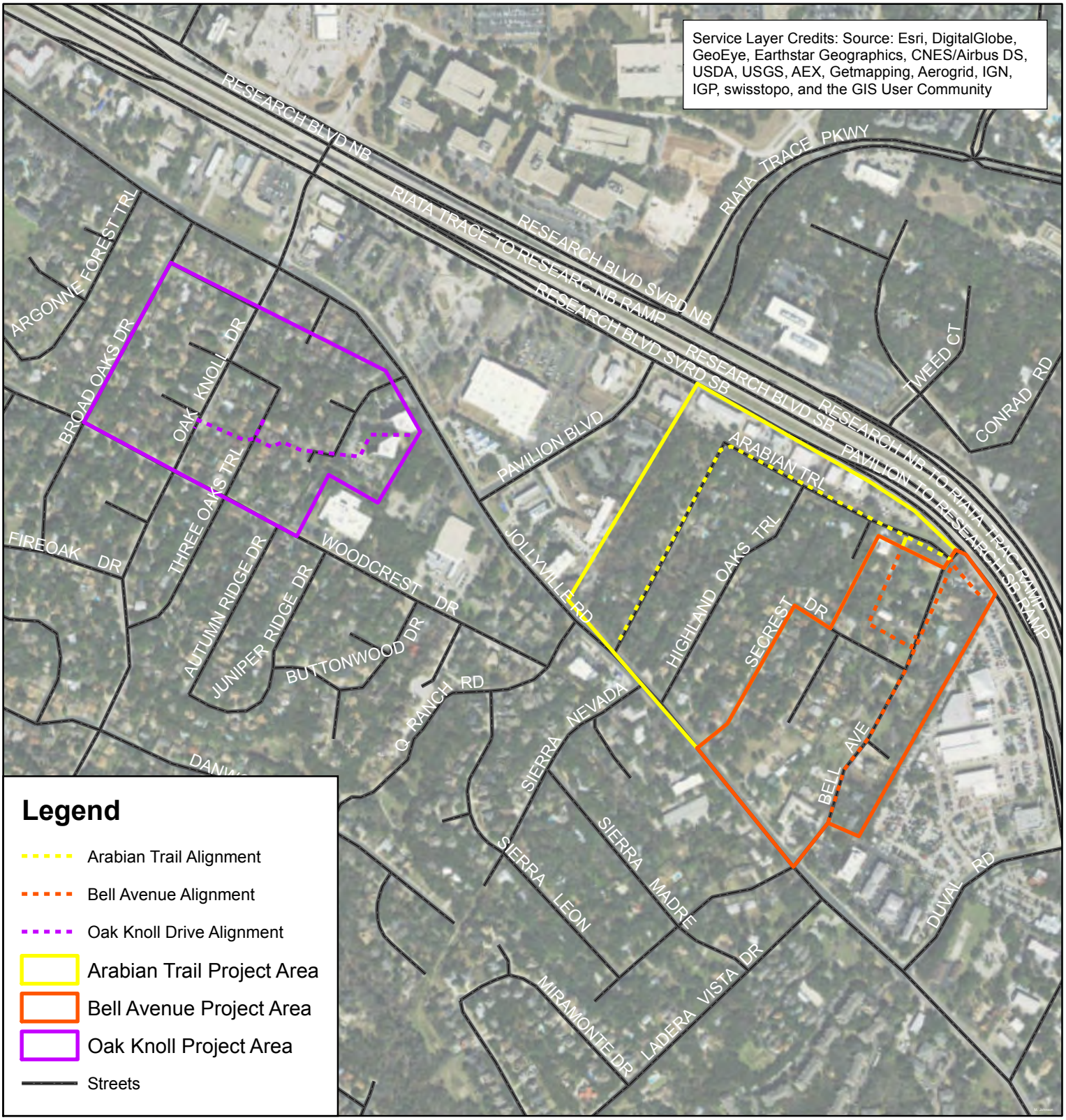
Baer Engineering
and Environmental Consulting, Inc.

TBPE Firm No. F-3181 TBPG Firm No. 50030

Baer Engineering
Project No. 162014.011
Date: October 14, 2016



B. VICINITY MAP



Appendix B: Site Vicinity Map

Walnut Creek Watershed
Drainage Improvements
Oak Knoll Drive, Arabian Trail,
and Bell Avenue in Austin, Texas
City of Austin CLMP174 - 2015
Watershed Engineering Flood
Hazard Mitigation Rotation List

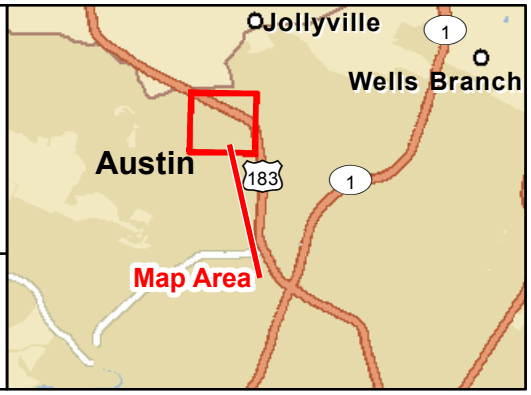
N

0 600 1,200 Feet

Baer Engineering
and Environmental Consulting, Inc.

TBPE Firm No. F-3181 TBPG Firm No. 50030

Baer Engineering
Project No. 162014.011
Date: October 14, 2016



C. SITE PHOTOGRAPHS

PHOTOGRAPH 1- North Arabian Trail facing west.

PHOTOGRAPH 2- Food Mart 11794 Jollyville Road. This is REC ID A.

PHOTOGRAPH 3- The west side of Synergy plaza. This is REC ID B.

PHOTOGRAPH 4- Midas Auto Service. This is REC ID E.

PHOTOGRAPH 5 - 55 gallon drums of synthetic motor oil and used tires at Midas Auto Service Experts. This is REC ID E.

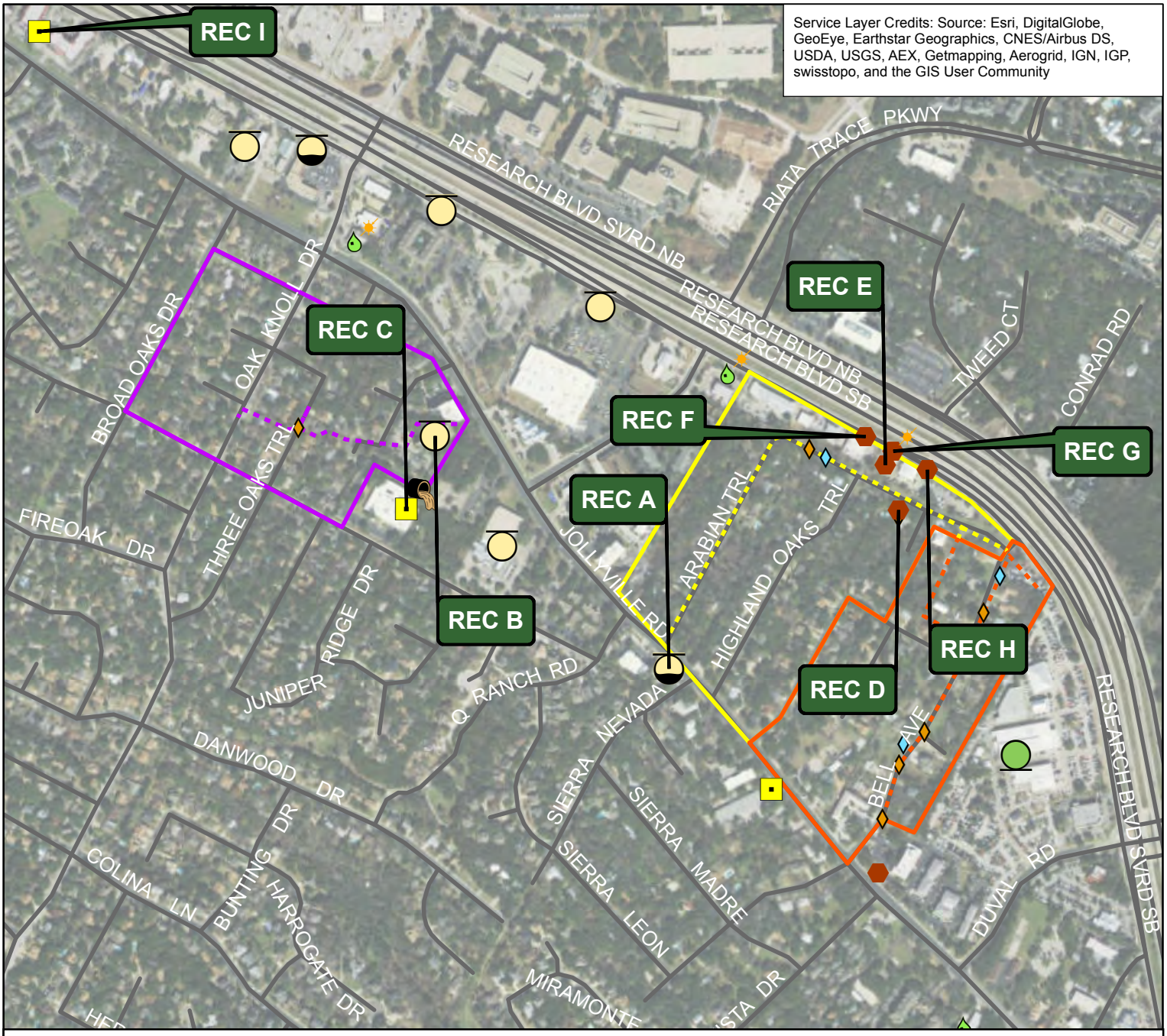
PHOTOGRAPH 6 - 55 gallon drums of synthetic motor oil and used tires at Midas Auto Service Experts. This is REC ID E.

PHOTOGRAPH 7 – Brake Check. This is REC ID F.

PHOTOGRAPH 8 – The location of the former DDS Paintless Dent Repair and B Garnett Lewis Cleaners business. Current businesses at this location are Top Cash Pawn and The Paint Guy. This is REC ID G.

PHOTOGRAPHS 9 – Eight (8) pole mounted transformers, possibly with PCBs.

D. SITE INVESTIGATION FINDINGS MAP



Legend

- Aboveground Storage Tank
- Dry Cleaner
- Historic Automobile Station
- Historic Dry Cleaner
- Groundwater Contamination Case
- Industrial Hazardous Waste Site
- Leaking Petroleum Storage Tank
- Underground Storage Tank
- **Transformer**
  - Marked "No PCBs"
  - No Markings
- Arabian Trail Alignment
- Bell Avenue Alignment
- Oak Knoll Drive Alignment
- Arabian Trail Project Area
- Bell Avenue Project Area
- Oak Knoll Project Area
- Streets

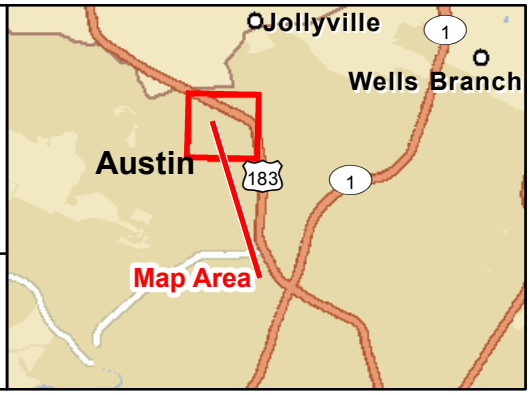
Appendix D: Site Investigation Findings Map

Walnut Creek Watershed
Drainage Improvements
Oak Knoll Drive, Arabian Trail,
and Bell Avenue in Austin, Texas
City of Austin CLMP174 - 2015
Watershed Engineering Flood
Hazard Mitigation Rotation List

0 650 1,300 Feet

Baer Engineering
and Environmental Consulting, Inc.
TBPE Firm No. F-3181 TBPG Firm No. 50030

Baer Engineering
Project No. 162014.010
Date: October 25, 2016



PHASE I ENVIRONMENTAL SITE ASSESSMENT
OAK KNOLL DRAINAGE IMPROVEMENTS
November 9, 2016

PDF PAGES 47-1419 (Appendices E - I) NOT INCLUDED IN PRINTOUT

(SEE PDF)

Baer Engineering and Environmental Consulting, Inc.

PERMITTING ANALYSIS REPORT

Oak Knoll Drainage Improvements
Austin, Texas

PREPARED FOR:

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Austin, Texas 78759

City of Austin
Watershed Protection Department
505 Barton Springs Road
Austin, Texas 78704

Baer Engineering Document No. 162014-8i.013
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APPENDICES

1.0 INTRODUCTION

The residents around Oak Knoll Drive, Arabian Trail, and Bell Avenue in Austin have experienced flooding issues caused by inadequate stormwater drainage. The City of Austin (COA) engaged Lockwood, Andrews & Newnam, Inc. (LAN) to evaluate storm drain improvement options and prepare a Preliminary Engineering Report (PER) to evaluate options and make recommendations to alleviate the flooding in these three areas.

The proposed project sites are located in northwest Austin between the following roadways:

- Jollyville Road and Woodcrest Drive for the Oak Knoll Drive site; and
- Research Boulevard and Jollyville Road for the Arabian Trail and Bell Avenue sites

The project sites are shown on an aerial figure, located in **APPENDIX A**.

Baer Engineering and Environmental Consulting Inc. (Baer Engineering), sub-consultant to LAN, evaluated permitting requirements for the project areas and identified applicable local, state, and federal regulatory programs that may apply to this project. This report includes a summary of requisite agency coordination, clearances, and permit approvals that must be obtained prior to construction. We have based this analysis report on information provided by LAN, desktop research, and on our site reconnaissance.

The project is required to coordinate within the following agencies and departments:

1. COA Development Services Department (DSD)
2. Balcones Canyonlands Preserve (BCP) Program, Part of Austin Water Utility
3. Texas Historical Commission (THC)
4. Texas Commission on Environmental Quality (TCEQ)

2.0 REGULATORY AGENCY REQUIREMENTS

The following table provides a summary of the applicable regulatory programs for the proposed project. An explanation of the coordination process for each program is provided in the sub-sections following the table.

TABLE 1: SUMMARY OF REGULATORY AGENCY REQUIREMENTS

AGENCY	CITATION	COMMENT
MUNCIPAL		
COA DSD	COA Land Development Code (LDC), 25-5-1	The project areas are located within the COA full purpose jurisdiction. A Site Development Permit or General Permit is required.
COA DSD	COA LDC, 25-8-121	The project areas are within the Edwards Aquifer Recharge Zone. A COA Environmental Resources Inventory (ERI) report may be required.
COA DSD	COA LDC Section 25-8-281	CEFs were not identified on the COA GIS viewer within 150 feet of the project areas nor were CEFs observed during the preliminary field visit.
COA DSD	COA ECM, Section 1.10.3.C	The project is located over the COA-defined Edwards Aquifer Zone. Karst Survey is required.
COA DSD	COA LDC 25-8-621 and 25-8-641	If trees larger than 19 inches in diameter or COA-defined heritage trees are planned for removal, permit approvals or variances will be required.
BCP Program	Balcones Canyonlands Habitat Conservation Plan (BCHCP)	Project lies within a fee zone of the BCHCP. The Project owner, COA, will need to participate in the BCHCP.
STATE		
TPWD	Texas Parks and Wildlife Department (TPWD) Code Chapter 12	A threatened and endangered (TES) habitat assessment was conducted. No TES habitat was identified; no further action is required.
THC	Antiquities Code of Texas	The project has the potential to disturb protected cultural resources. Agency coordination is required.
TCEQ	Texas Water Code Section 26.040	If the project will disturb greater than one acre of land, a Storm Water Pollution Prevention Plan (SWPPP) is required.
TCEQ	Edwards Aquifer Protection Program	A portion of the project lies within the boundaries of the TCEQ-defined recharge zone of the Edwards Aquifer. An Edwards Aquifer Protection Plan is required.
FEDERAL		
USFWS	Endangered Species Act 1973	A TES habitat assessment was conducted. No TES habitat was identified; no further action is required.

2.1 Municipal Coordination

The proposed project sites are within the COA full purpose jurisdiction. As such, the project must comply with the regulations set forth by the COA LDC. The following subsections provide a summary of applicable requirements associated with the proposed activities, as defined in the COA LDC, Title 25.

2.1.1 COA Development Services Department (DSD)

The project areas are located within COA full purpose jurisdiction.

2.1.1.1 COA Site Development Permit

COA LDC, Chapter 25-5, requires site plan review and approval by DSD prior to development of property within the City's jurisdiction. The site plan approval may be obtained through either the Site Development Permit Process or the General Permit Program. To determine if the project is eligible to participate in the General Permit Program, the Preliminary Engineering Report or preliminary design plans will need to be reviewed by the General Permit Program Coordinator.

2.1.1.2 Environmental Resources Inventory Report

The project will require a COA ERI Report. The COA LDC, Section 25-8-121 (A) states the following:

> *An applicant shall file an environmental resources inventory report with the Site Development Permit Application for proposed development located:*
>
> ***1. Over a karst aquifer;***
> ***2. Within an area draining to a karst aquifer or reservoir;***
> *3. In a water quality transition zone;*
> *4. In a critical water quality zone;*
> *5. In a flood plain; or*
> *6. On a tract with a gradient of more than 15 percent.*

The proposed project sites meet criteria 1 and 2, above.

The COA LDC, Section 25-8-121 (B) and (C) states the following:

> *An environmental resources inventory must:*
>
> *(1) identify critical environmental features and propose protection measures for the features;*
> *(2) provide an environmental justification for spoil disposal locations or roadway alignments;*
> *(3) propose methods to achieve overland flow;*
> *(4) describe proposed industrial uses and the pollution abatement program; and*
> *(5) be completed as prescribed by the Environmental Criteria Manual.*
> *(6) a hydrogeologic report in accordance with Section 25-8-122 (Hydrogeologic Report);*
> *(7) a vegetation report in accordance with Section 25-8-123 (Vegetation Report); and*
> *(8) a wastewater report in accordance with Section 25-8-124 (Wastewater Report).*

The proposed project must satisfy the above requirements, or obtain a waiver from the ERI requirements, before the COA DSD will approve a Site Development Permit or General Permit.

2.1.1.3 Critical Environmental Features (CEFs)

The COA ECM, Section 1.10.3 defines CEFs as features that are of vital importance to the protection of natural resources. CEFs include bluffs, canyon rimrock, point recharge features, springs, seeps, and wetlands. In ECM 1.10.4, Determining Size of CEF Protective Buffers, a standard 150-foot protective buffer is established around CEFs, with a maximum 300-foot buffer for point recharge features. Buffers are also three-dimensional, extending across the land as well as above and below the land surface.

A CEF survey was conducted on September 28, 2016. CEFs, as defined by the COA, were not observed.

2.1.1.4 Tree Removal

The COA LDC, Section 25-8-602 (3), defines a protected tree as "*a tree with a diameter of 19 inches or more, measured four and one-half feet above natural grade.*"

The COA LDC, Section 25-8-621, states that "*except as otherwise provided in this section, a person may not remove a protected tree unless the Planning and Development Review Department (Development Services Department) has issued a permit for the removal under this division.*" The COA has an approval process that may involve a site visit by a COA arborist as well as certain approval criteria noted below from LDC, Section 25-8-624, Sub-sections A and D:

(A) The Planning and Development Review Department (Development Services Department) may approve an application to remove a protected tree only after determining that the tree:
- *(1) prevents reasonable access to the property;*
- *(2) prevents a reasonable use of the property;*
- *(3) is an imminent hazard to life or property, and the hazard cannot reasonably be mitigated without removing the tree;*
- *(4) is dead;*
- *(5) is diseased, and:*
  - *(a) restoration to sound condition is not practicable; or*
  - *(b) the disease may be transmitted to other trees and endanger their health; or*
- *(6) for a tree located on public property or a public street or easement:*
  - *(a) prevents the opening of necessary vehicular traffic lanes in a street or alley; or*
  - *(b) prevents the construction of utility or drainage facilities that may not feasibly be rerouted.*

(D) The Planning and Development Review Department (Development Services Department) shall require mitigation as a condition of application approval. A removal permit may not be issued until the applicant satisfies the condition or posts fiscal security to ensure performance of the condition within one year.

The COA LDC, Section 25-8-602 (1), defines a *"heritage tree as a tree that has a diameter of 24 inches or more, measured four and one-half feet above natural grade, and is one of the following species:*

(a) Ash, Texas
(b) Cypress, Bald

(c) Elm, American
(d) Elm, Cedar
(e) Madrone, Texas
(f) Maple, Bigtooth
(g) All Oaks
(h) Pecan
(i) Walnut, Arizona
(j) Walnut, Eastern Black"

The COA LDC, Section 25-8-641, addresses the removal of a heritage tree:

> *(A) Removal of a heritage tree is prohibited unless the Planning and Development Review Department (Development Services Department) has issued a permit for the removal under this division.*
>
> *(B) A permit to remove a heritage tree may be issued only if a variance is approved under Section 25-8-642 (Administrative Variance) or 25-8-643 (Land Use Commission Variance).*

2.1.1.5 Critical Water Quality Zone Development

The project areas are located in the Walnut Creek watershed as defined by the COA. Walnut Creek listed as a suburban watershed by the COA. Depending on the size of the waterway, the Critical Water Quality Zone (CWQZ) is between 100 and 300 feet from the centerline of the waterway. No portion of the project is within the CWQZ of Walnut Creek or its tributaries. The project sites are depicted in relation to the COA CWQZ on the City of Austin Environmental Constraints figure, located in **APPENDIX A**.

2.1.2 Balcones Canyonlands Conservation Plan (BCCP)

The project is located within the boundaries of the BCHCP fee zone, which contains potential threatened and endangered species habitat. According to the BCPP map, the project lies within Golden-cheeked Warbler (GCWA) – Zone 3 (Not known to be habitat) and Endangered Cave Species Habitat Karst Zones 1 and 2. For this specific project, participation in the BCHCP allows for incidental "take" of Karst Zones 1 & 2 stemming from construction. No mitigation is required for construction within GCWA Zone 3. As a stakeholder, the COA is required to participate in the HCP by providing the BCP Program with habitat assessment application. The COA will internally deduct the area of the project limits from an established mitigation bank setup for COA infrastructure projects, as stipulated in the guidelines of the BCHCP.

The project sites are shown in relation to the Balcones Canyonlands Conservation Plan Fee Zone on the BCCP Fee Zone Map, located in **APPENDIX A**.

2.2 State Coordination

The proposed project will be subject to state regulations and requisite coordination prior to construction with following agencies:

2.2.1 Texas Parks and Wildlife Department (TPWD)

TPWD is charged with the protection of state biological resources, such as rare, threatened, and endangered plant and animal species. A list of threatened and endangered species (TES) for Travis County is provided in **APPENDIX B**. Potential habitat for TES within and near the project area was evaluated on September 28, 2016. Results of the habitat evaluation are presented in **APPENDIX B**.

2.2.2 Texas Historical Commission (THC)

Construction projects sponsored by federal or state agencies are required to comply with the National Historic Preservation Act. The THC enforces this code. Appropriate project coordination must be submitted to the THC prior to construction. The THC will review the project details to determine if the project has potential to impact significant archeological or historical resources. The THC will either provide a formal response that clears the project from further investigations or request additional investigations.

2.2.3 Texas Commission on Environmental Quality (TCEQ)

The TCEQ is the environmental agency for the state of Texas. The TCEQ strives to protect the state's public health and natural resources consistent with sustainable economic development. The goal of TCEQ is clean air, clean water, and safe management of waste.

2.2.3.1 Storm Water Pollution Prevention Plan (SWPPP)

If the project design will result in the disturbance of greater than one acre of land during construction, the project owner must implement a SWPPP to satisfy Section 402 of the Clean Water Act and Chapter 26 of the Texas Water Code, which establishes the requirements for the Texas Pollution Discharge Elimination System (TPDES). If the project disturbs more than five acres of unpaved surface, then a Notice of Intent (NOI) and a Notice of Termination (NOT) are required.

2.2.3.2 Edwards Aquifer Protection Program

According to the TCEQ Chapter 213 – Edwards Aquifer Subchapter A, the Arabian Trail and Bell Avenue projects are within the Edwards Aquifer Recharge Zone. An Edwards Aquifer Protection Plan is required for any regulated activity proposed on the Edwards Aquifer recharge zone. This includes construction-related activity, such as:

- The construction of buildings, utility stations, roads, highways, railroads;
- Clearing, excavation, or any other activities that alter or disturb the topographic, geologic, or existing recharge characteristics of a site; or
- Any other activities which may pose a potential for contaminating the Edwards Aquifer and hydrologically connected surface streams.

The project sites are depicted in relation to the TCEQ Edwards Aquifer Recharge Zone on the City of Austin Environmental Constraints figure, located in **APPENDIX A**.

2.3 Federal Coordination

The proposed project will be subject to various federal regulations and requisite coordination with associated federal agencies. Coordination with the following regulatory entity must be conducted prior to construction:

2.3.1 United States Fish and Wildlife Department (USFWS)

USFWS is charged with the protection of federal-listed threatened and endangered species. A list of threatened, endangered, and rare species for Travis County is provided in **APPENDIX B**. The project is not likely to impact federal-listed threatened and endangered species. No coordination with USFWS is required or expected.

3.0 CONCLUSIONS

Baer Engineering has reviewed project information provided by LAN to analyze potential regulatory requirements associated with the Walnut Creek watershed drainage improvements in Austin, Texas. Upon review of the provided information and preliminary site reconnaissance, we have determined the project is subject to several local, state, and federal requirements.

3.1 Local Coordination Summary

The proposed construction project requires review and approval by several COA departments. The following is a list of municipal requirements.

1. A COA Site Development Permit or General Permit is required per LDC, 25-5-1.

2. A COA ERI report is required per LDC, 25-8-121.

3. A karst survey is required per ECM, Section 1.10.3.C.

4. If trees larger than 19 inches in diameter or COA-defined heritage trees are planned for removal, permit approvals or variances will be required, per COA LDC 25-8-621 and 25-8-641.

5. Project lies within a fee zone of the BCCP. The Project owner, COA, is required to participate in the BCHCP.

3.2 State Coordination Summary

The proposed maintenance project requires review and approval by several state agencies. The following is a list of state requirements.

1. The project must be reviewed by the THC for cultural resources protection. Coordination with THC is required.

2. If the project design will result in the disturbance of greater than one acre of land during construction, the project owner must implement a SWPPP as required by Section 402 of the Clean Water Act and Chapter 26 of the Texas Water Code.

3. The Bell Avenue and Arabian Trail proposed alignments of the project is within the Edwards Aquifer Recharge Zone. An approved Edwards Aquifer Protection Plan is required.

3.3 Federal Summary

The proposed maintenance project does not require environmental approval by federal agencies.

4.0 VEGETATION ASSESSMENT

The following table lists the dominant plant species observed within the proposed project areas for the project. Plants are separated into three community types: herbaceous, shrubs and vines, and canopy.

HERBACEOUS LAYER	
Bermudagrass (*Cynodon dactylon*)	Johnsongrass (*Sorghum halepense*)
Common Sunflower (*Helianthus annuus*)	Turk's Cap (*Malvaviscus drummondii*)
SHRUB AND VINE LAYER	
Texas Mountain Laurel (*Sophora secundiflora*)	
CANOPY LAYER	
Arizona Ash (*Fraxinus velutina*)	Chinese Elm (*Ulmus parvifolia*)
Chinaberry (*Melia azedarach*)	Live Oak (*Quercus fusiformis*)

5.0 LIMITATIONS

This information is being provided to LAN to assist with the design of the Oak Knoll Drainage Improvements Project. We have relied upon information provided by LAN to perform this analysis. Changes to the project design could result in significant changes to regulatory permitting requirements. Site reconnaissance was performed on September 28, 2016. Conditions observed during those days may not reflect site conditions on any other date. In addition, certain elements may have been hidden by vegetation or other site features during the field visits. These elements may be observable during a different time of year. Baer Engineering has exercised due diligence and performed appropriate inquiry within the limits of the scope of this specific project. Nonetheless, Baer Engineering cannot and does not guarantee the authenticity or reliability of the information upon which it has relied.

Thank you for the opportunity to work on this project.

Leilani Williams, M.S.
Staff Biologist

Mark Sloop, GIT
Staff Geologist

David Sperry, M.S.
Wildlife Conservation Biologist

6.0 DATA SOURCES

City of Austin Environmental Criteria Manual, Supplement 5, Online content updated on May 31, 2016. https://www.municode.com/library/tx/austin/codes/environmental_criteria_manual

City of Austin Land Development Code, Supplement 115, Online content updated on September 28, 2016. https://www.municode.com/library/tx/austin/codes/land_development_code

City of Austin Open Data Portal https://data.austintexas.gov/
City of Austin GIS Data for Springs and Seeps, Updated August 24, 2016.
City of Austin GIS Data for Rock Outcrops, Updated August 24, 2016.
City of Austin GIS Data Wetlands, Updated August 24, 2016.
City of Austin GIS Data Biological Resource Buffers, Updated August 24, 2016.
City of Austin GIS Data for Austin Fully Developed Floodplain, Updated August 24, 2016.
City of Austin GIS Data for Edwards Aquifer Contributing Zone, Updated August 24, 2016.
City of Austin GIS Data for Recharge Zone, Updated August 24, 2016.
City of Austin GIS Data for Creek Buffers, Updated August 27, 2016.

City of Austin and Travis County, 1996. Habitat Conservation Plan and Final Environmental Impact Statement. https://www.traviscountytx.gov/tnr/bccp

Texas Administrative Code, Title 13. Cultural Resources, Part 2. Texas Historical Commission. Chapter 25 State Archeological Program. Effective May 20, 2013.
http://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=3&ti=13&pt=2

Texas Commission on Environmental Quality, Chapter 213 – Edwards Aquifer Subchapter A: Edwards Aquifer in Median, Bexar, Comal, Kinney, Uvalde, Hays, Travis, and Williamson Counties. Effective April 24, 2008.
https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/213a.pdf

Texas Commission on Environmental Quality, Chapter 213 – Edwards Aquifer Subchapter B: Contributing Zone to the Edwards Aquifer in Median, Bexar, Comal, Kinney, Uvalde, Hays, Travis, and Williamson Counties. Effective April 24, 2008.
https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/213b.pdf

Texas Government Code, Title 4. Executive Branch, Subtitle D. History, Culture, and Education, Chapter 442. Texas Historical Commission. Most Recently Amended 2013, effective September 1, 2013. http://www.statutes.legis.state.tx.us/Docs/GV/htm/GV.442.htm

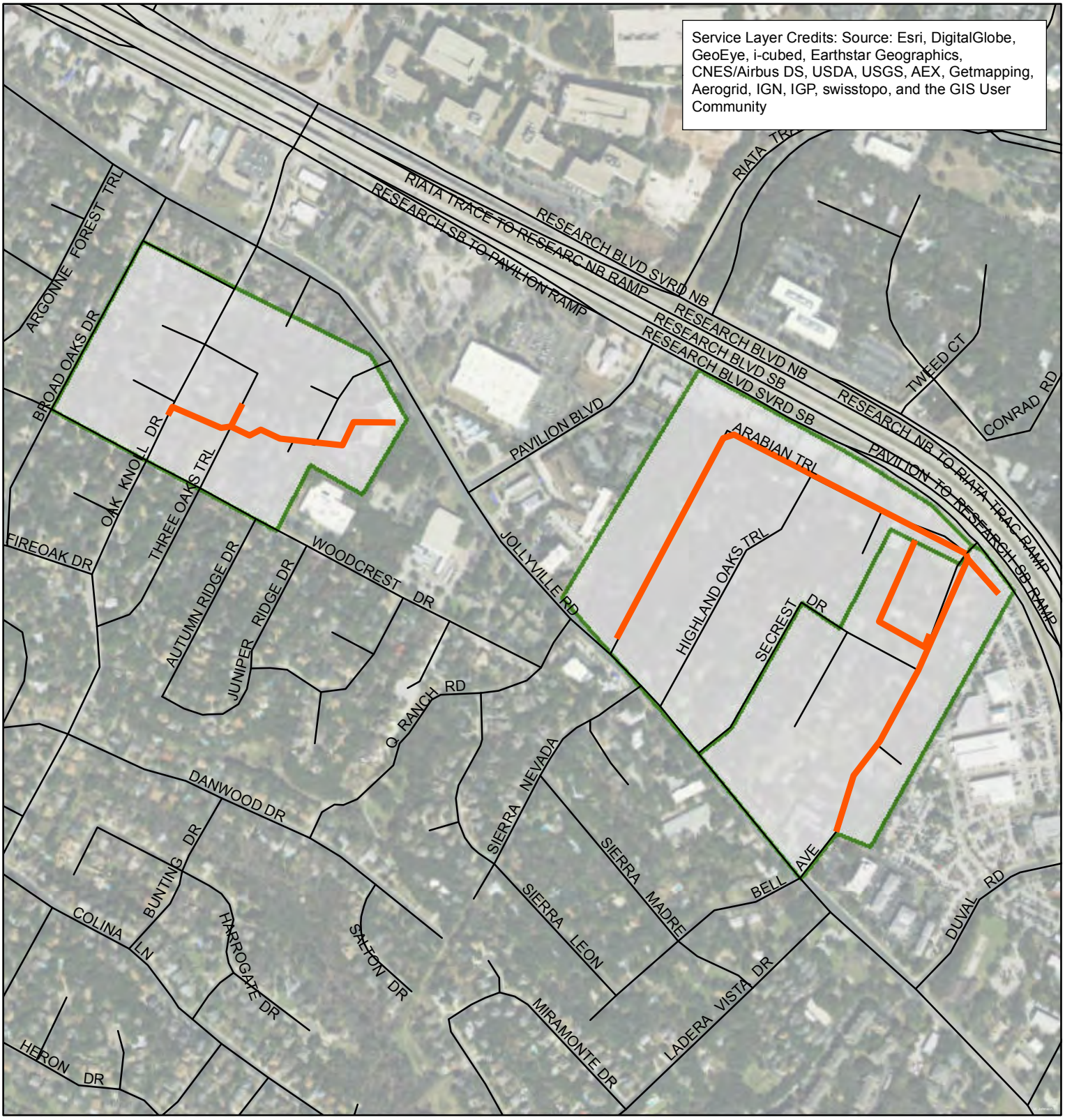
Texas Parks and Wildlife Department, Parks and Wildlife Code, Title 2. Parks and Wildlife Department, Chapter 12. Powers and Duties Concerning Wildlife, Subchapter A. General Powers and Duties. Effective September 1, 2011.
http://www.statutes.legis.state.tx.us/Docs/PW/htm/PW.12.htm#A

Texas Parks and Wildlife Department, Wildlife Division, Diversity and Habitat Assessment Programs. County Lists of Texas' Special Species. Travis County, revised 5/16/2016. Please refer to the following website for the most updated version of this list http://tpwd.texas.gov/gis/rtest/

Texas Water Code, Title 2. Water Administration. Subtitle D. Water Quality Control, Chapter 26. Water Quality Control, Section 26.040. General Permits. Effective September 1, 2011. http://www.statutes.legis.state.tx.us/Docs/WA/htm/WA.26.htm

U.S. Fish and Wildlife Service, Endangered Species Act of 1973, 16 U.S.C. Sections 1531-1544. Approved December 28, 1973, Most Recently Amended January 24, 2002. http://www.epw.senate.gov/esa73.pdf?

APPENDIX A - Site Figures



Aerial Map

Oak Knoll Drainage Improvements
Austin, Texas
City of Austin CLMP174 - 2015
Watershed Engineering Flood
Hazard Mitigation Rotation List

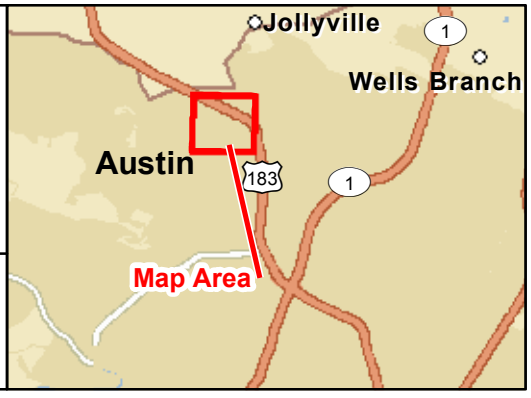
0 500 1,000 Feet

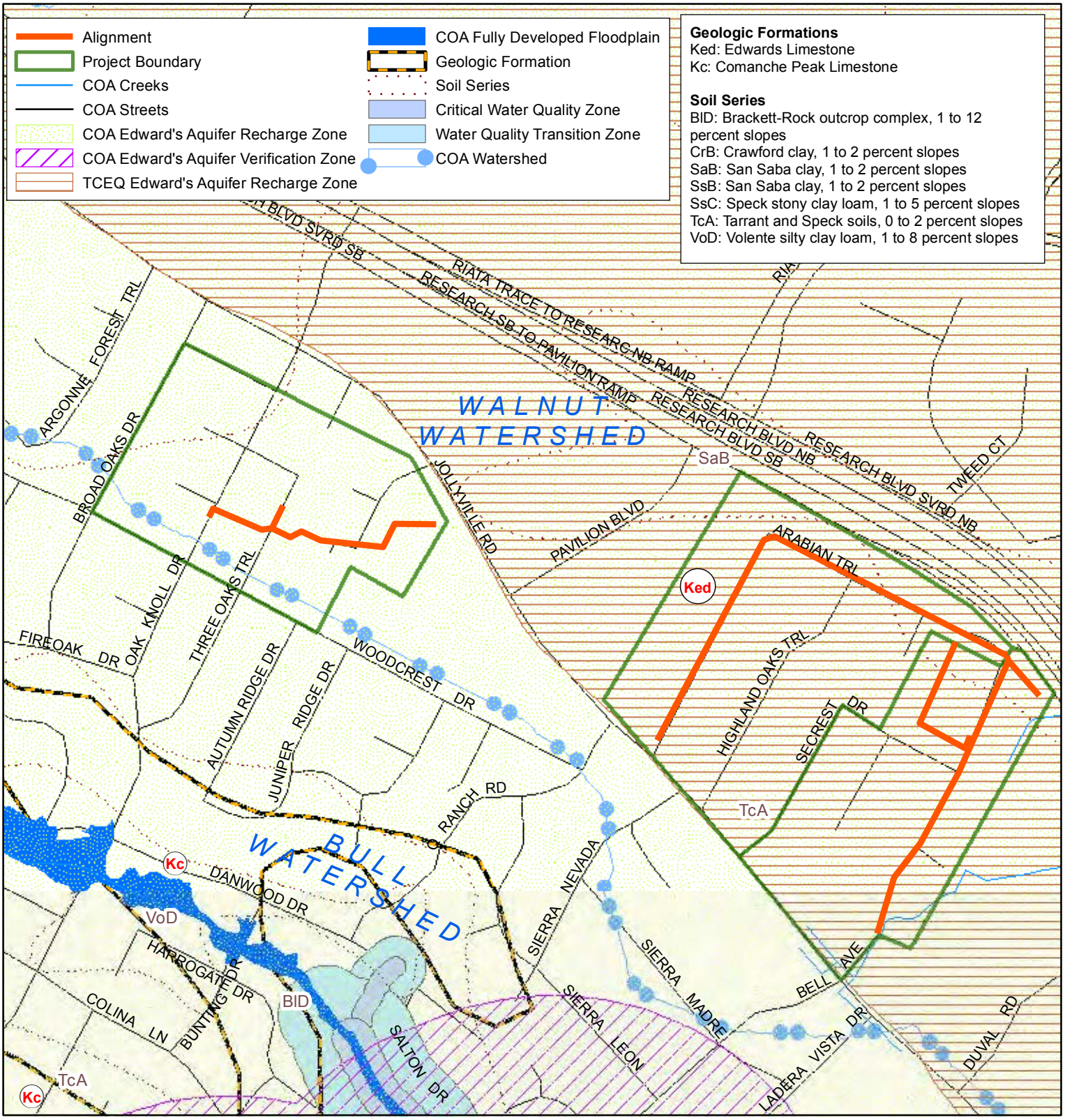
Baer Engineering
and Environmental Consulting, Inc.

TBPE Firm No. F-3181 TBPG Firm No. 50030

Alignment
Project Boundary

Baer Engineering
Project No. 162014.010
Date: August 26, 2016



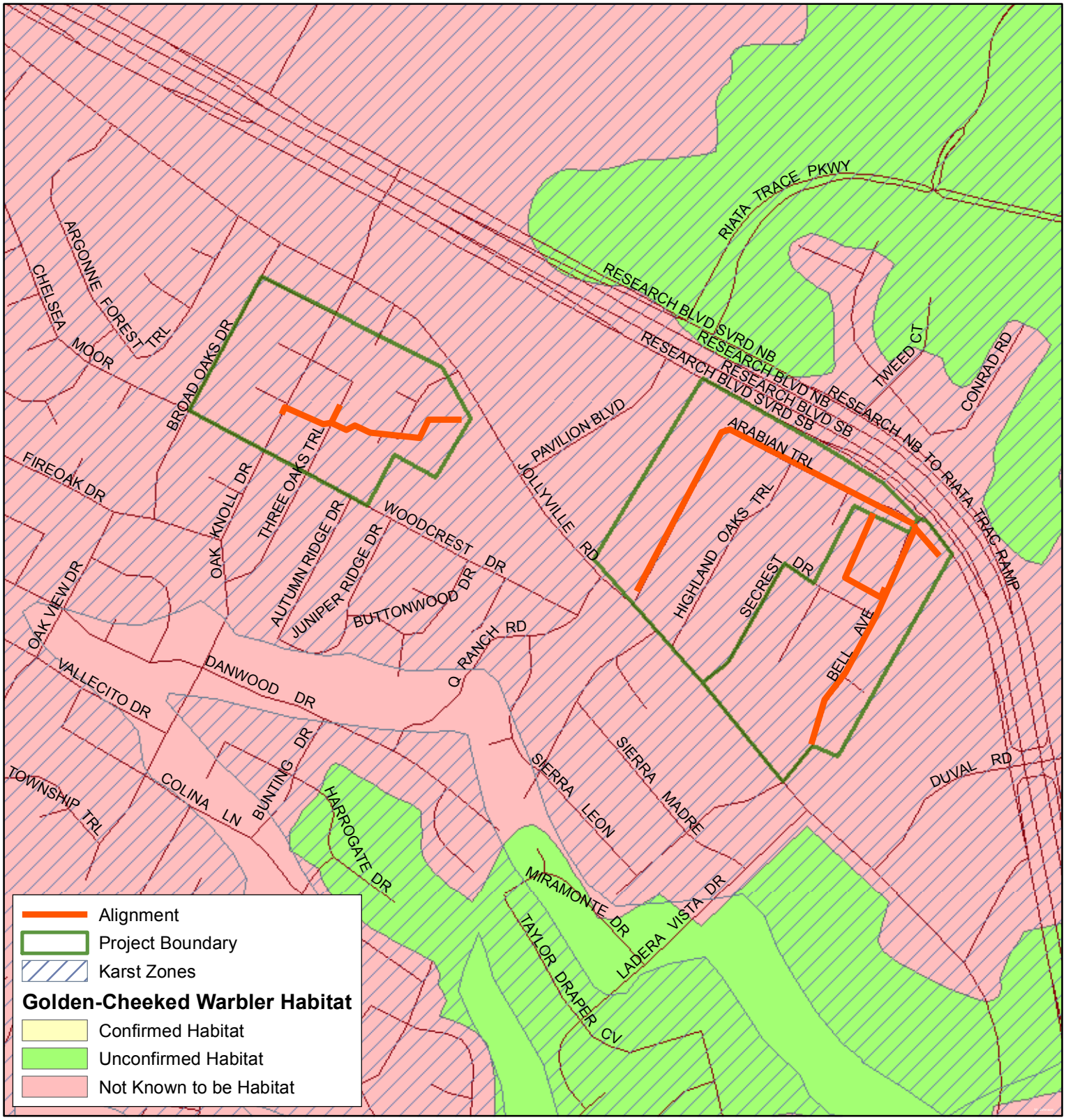


City of Austin Environmental Constraints

Oak Knoll Drainage Improvements
Austin, Texas
City of Austin CLMP174 - 2015
Watershed Engineering Flood
Hazard Mitigation Rotation List

TBPE Firm No. F-3181 TBPG Firm No. 50030

Baer Engineering
Project No. 162014.010
Date: October 31, 2016



Balcones Canyonlands Conservation Plan Fee Zone Map

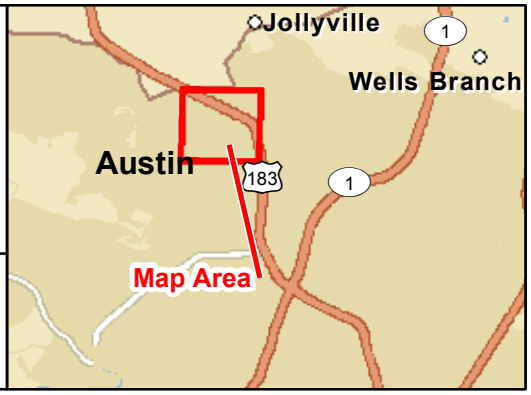
Oak Knoll Drainage Improvements
Austin, Texas
City of Austin CLMP174 - 2015
Watershed Engineering Flood
Hazard Mitigation Rotation List

Data Source: Balcones Canyonlands
Habitat Conservation Plan

0 500 1,000 Feet

Baer Engineering
and Environmental Consulting, Inc.
TBPE Firm No. F-3181 TBPG Firm No. 50030

Baer Engineering
Project No. 162014.010
Date: October 31, 2016



APPENDIX B - State and Federal List of Threatened and Endangered Species Habitat Assessment Results

Federal and State-listed species and status for Travis County, Texas.

SPECIES	*SCIENTIFIC NAME*	FEDERAL LISTING	STATE LISTING
Austin Blind Salamander	*Eurycea waterlooensis*	Endangered	none
Barton Springs Salamander	*Eurycea sosorum*	Endangered	Endangered
Jollyville Plateau Salamander	*Eurycea tonkawae*	Threatened	none
Bone Cave Harvestman	*Texella reyesi*	Endangered	none
Bee Creek Cave Harvestman	*Texella reddelli*	Endangered	none
Tooth Cave Pseudoscorpion	*Tartarocreagris texana*	Endangered	none
Tooth Cave Spider	*Tayshaneta myopica*	Endangered	none
Kretschmarr Cave Mold Beetle	*Texamaurops reddelli*	Endangered	none
Tooth Cave Ground Beetle	*Rhadine persephone*	Endangered	none
Bald Eagle	*Haliaeetus leucocephalus*	Delisted	Threatened
Black-Capped Vireo	*Vireo atricapilla*	Endangered	Endangered
Golden-Cheeked Warbler	*Setophaga chrysoparia*	Endangered	Endangered
Interior Least Tern	*Sterna antillarum athalassos*	Endangered	Endangered
Peregrine Falcon	*Falco peregrinus* ssp.	Delisted	Threatened
Red Knot	*Calidris canutus rufa*	Threatened	none
Whooping Crane	*Grus americana*	Endangered	Endangered
Smalleye Shiner	*Notropis buccula*	Endangered	none
Red Wolf	*Canis rufus*	Endangered	Endangered
False Spike Mussel	*Quadrula mitchelli*	none	Threatened
Smooth Pimpleback	*Quadrula houstonensis*	Candidate	Threatened
Texas Fatmucket	*Lampsilis bracteata*	Candidate	Threatened
Texas Pimpleback	*Quadrula petrina*	Candidate	Threatened
Texas Horned Lizard	*Phrynosoma cornutum*	none	Threatened
Bracted Twistflower	*Streptanthus bracteatus*	Candidate	none

Source: Texas Parks and Wildlife Department, Wildlife Division, Diversity and Habitat Assessment Programs. County Lists of Texas' Special Species. Travis County, revised 5/16/2016. Please refer to the following website for the most updated version of this list http://tpwd.texas.gov/gis/rtest/

Baer Engineering reviewed the USFWS website and online database for proposed and designated critical habitat for TES. This review for Travis County was conducted on November 1, 2016. Critical habitat for the Jollyville Salamander (*Eurycea tonkawae*) and Austin Blind Salamander (*E. waterlooensis*) currently exists in Travis County (USFWS 2016).

We reviewed the Travis County karst maps (Veni 1992, 1994, 2002). The karst maps were prepared for the USFWS and are the recognized authorities regarding the areas likely or known to contain endemic karst invertebrate species within Travis County, Texas.

Baer Engineering conducted a TES habitat assessment of the project limits on September 28, 2016. The project limits were evaluated on foot. Potential wildlife habitat was evaluated based on factors such as vegetation and resource availability.

FINDINGS

Amphibians

Three amphibians are listed and known to occur in Travis County. The Barton Springs salamander (*Eurycea sosorum*) is listed by USFWS and TPWD as endangered. This species inhabits the Barton and Eliza Springs outlets of the Edwards Aquifer. These springs are located in Zilker Park in Austin, Texas. Barton Springs contribute to Barton Springs Pool, while the Eliza Springs outflow into a small pool, protected from park patrons.

The Austin blind salamander (*E. waterlooensis*) is listed as an endangered species by USFWS. This species prefers the subterranean cavities of the Edwards Aquifer instead of the surface where springs emerge (Hillis et al. 2001). This species shares the same segment of the Edwards Aquifer the Barton Springs Salamander prefers, but is encountered far less frequently. Observations for this species have been recorded at the outlets of Old Mill Spring, Eliza Spring, and the Main Spring. USFWS designated one critical habitat unit for this species around the Old Mill Spring, Eliza Spring, and the Main Spring totaling 120 acres (Code of Federal Regulations, 2013).

The Jollyville Plateau salamander (*E. tonkawae*), is listed as a threatened species by USFWS. This species occurs in the Jollyville Plateau and Brushy Creek areas of the Edwards Plateau in Travis and Williamson Counties, Texas. USFWS designated 32 critical habitat units for this species totaling 4,331 acres. The critical habitat units are located throughout the two counties around springs where this species has been observed.

The project area is approximately 10.8 aerial miles northwest from the springs where *E. sosorum* and *E. waterlooensis* are known to occur. Known occurrence locations and the closest critical habitat unit for *E. tonkawae* are 1,700 feet south from the project area. The proposed project areas are within the Walnut Creek Watershed and the *E. tonkawae* critical habitat and known occurrences are in the Bull Creek Watershed. Stormwater runoff in the project areas will flow north away from the critical habitat and known occurrences, therefore this project should not affect listed amphibians or their habitat.

Karst Invertebrates (Arachnids and Insects)

There are six karst invertebrates listed as endangered and one species that is listed as a candidate species by USFWS in Travis County. These species inhabit caves associated with the Edwards Limestone region of Travis County. George Veni prepared maps for the USFWS regarding the areas likely or known to contain endemic karst invertebrate species within Travis County (Veni 1992, 1994, 2002). These maps are divided into four zones, each with varying degrees of probability to contain endangered karst invertebrate species. This project lies within

Zone 1, which is defined as areas that are known to contain endangered karst invertebrate species (Veni 1992, 1994, 2002). According to the Balcones Canyonlands Conservation Plan (BCCP) map, the project lies within Endangered Cave Species Habitat Karst Zones 1 and 2. For this specific project, participation in the Balcones Canyonlands Habitat Conservation Plan (BCHCP) will allow for incidental "take" of habitat for the six federal-listed endangered karst invertebrates in Karst Zones 1 & 2 stemming from construction.

Birds

Eight bird species listed by the TPWD and USFWS are known to occur in Travis County. The following paragraphs provide information regarding each of the seven species, their habitat, and their potential relation to the project.

The Peregrine Falcon (*Falco peregrinus*) and the Bald Eagle (*Haliaeetus leucocephalus*), have been delisted by the USFWS and are listed as threatened by TPWD. These species are migratory and could pass over the project area. A few migrants of these species are spotted in the Austin area each year. The project area does not support suitable habitat for these species and it is unlikely the proposed project will adversely affect these birds.

The Black-capped vireo (*Vireo atricapilla*) and Golden-cheeked warbler (*Setophaga chrysoparia*) are listed as endangered by USFWS and TPWD. These migratory songbirds nest in Central Texas and require specific breeding habitats. The vireo prefers to breed in thickets with dense scrubby foliage, from the ground to about six feet. The warbler relies on large old-growth Ashe juniper (*Juniper ashei*) and oak (*Quercus* spp.) woodlands for nesting. Due to a lack of preferred nesting habitat in the project area, the project will not affect these species.

The Interior Least Tern (*Sterna antillarum athalassos*) is listed as endangered by USFWS and TPWD. This migratory species nests along sand and gravel bars within braided streams and rivers. These birds have been documented nesting on man-made structures such as inland beaches, wastewater treatment plants, and gravel mines. These birds prefer open areas with wide beaches, as they tend to avoid areas with thick vegetation and little open space along the water's edge. These birds are rare in the Austin area and the project area does not provide preferred nesting habitat for this species.

The Whooping Crane (*Grus americana*) is listed as endangered by USFWS and TPWD. This bird breeds in Canada and winters on the Texas coast. During migration, the crane typically stops to rest and feed in open bottomlands of large rivers, marshes, and agricultural areas. There are very few sightings of this bird recorded for the Austin area. The project area does not contain the typical stopover habitat and it is unlikely the proposed project will adversely affect this species.

Red Knot (*Calidris canutus rufa*) is listed as a threatened species by USFWS. This species migrates long distances in flocks northward through the contiguous United States mainly April-June, southward July-October. This bird is a small, plump-bodied, short-necked shorebird that in breeding plumage, typically held from May through August, is a distinctive and unique pottery orange. Surveys of wintering birds along the coasts of southern Chile and Argentina and during spring migration in Delaware Bay on the U.S. coast indicate that a serious population decline occurred in the 2000s (USFWS 2013). This population decline was caused primarily by reduced food availability from increased harvests of horseshoe crabs (USFWS 2013). Horseshoe crab harvests are now managed with the goal to stabilize and recover this species population (USFWS 2013). The population has stabilized in the past few years, but remains at low levels relative to earlier decades (USFWS 2013). The project area does not contain the typical stopover habitat and it is unlikely that work associated with the proposed project will adversely affect this species.

Mammals
The Red wolf (*Canis rufus*) is listed as endangered by USFWS and TPWD. In 1970's this species was known to inhabit the brushy and forested area and coastal prairies of eastern Texas. During the 1980's the last remaining individuals were captured to start a captive breeding program. Reintroductions have occurred in North Carolina, South Carolina, and Florida. Currently, no individuals of this species are believed to exist in Texas. The proposed project will have no impact on this species.

Mollusks and Fish
Freshwater mussels burrow into the substrate to maintain position on the stream bottom. Some mussel species require free-flowing streams, while other species prefer, or are tolerant of, lentic habitat. Freshwater mussels are filter-feeders, collecting algae, detritus, and bacteria from the water as it passes across the gills. Excessive amounts of suspended sediments can interfere with a mussel's ability to filter feed. Four mollusk species are listed as threatened by TPWD and listed as candidate species for USFWS. These species are: the False Spike Mussel (*Quincuncina mitchelli*), the Smooth Pimpleback (*Quadrula houstonensis*), the Texas Fatmucket (*Lampsilis bracteata*), and the Texas Pimpleback (*Quadrula petrina*). The Smalleye Shiner (*Notropis buccula*) is listed as a candidate species by USFWS. This species is endemic to the upper Brazos River system and its tributaries. TPWD reports this species was apparently introduced into the adjacent Colorado River drainage. Typical habitat for this species is described as medium to large prairie streams with sandy substrate and turbid to clear warm water.

The project area does not support potential habitat for freshwater mussels or fish.

Reptiles
The Texas Horned Lizard (*Phrynosoma cornutum*), a state-listed threatened species, is thought to exist within several regions of the state. This reptile is known to occur in open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees. Preferred soils may vary in texture from sandy to rocky. Most importantly, this species relies on an indigenous species of ant, whose populations have been reduced by the introduction of the imported red fire ant. Due to the absence of the preferred habitat for this species near the project area the species is not expected to be affected by the proposed project.

Plants
Bracted Twistflower (*Streptanthus bracteatus*) is listed as a candidate species by USFWS. The typical habitat for this species is described as shallow, well-drained gravelly clays and clay loams over limestone, in oak-juniper woodlands and associated openings, on steep to moderate slopes and in canyon bottoms (Poole et al. 2007). No habitat for this plant was observed within the project area and no individuals were observed during field reconnaissance. Because of the lack of habitat for this plant species in the project area, the Bracted Twistflower is not expected to be affected by the proposed project.

Literature Cited

Code of Federal Regulations. 2013. Endangered and Threatened Wildlife and Plants; Endangered Status for Four Central Texas Salamanders and Designation of Critical Habitat. Department of Interior, 50 CFR Part 17.

Poole J.M., W.R. Carr, D.M. Price, and J.R. Singhurst. 2007. Rare plants of Texas. Texas A&M University Press, College Station, TX.

Texas Parks and Wildlife Department. 2016. Wildlife Diversity Program. Natural Diversity Database. Travis County, Texas, revised May 16, 2016. Web accessed on November 4, 2016. http://tpwd.texas.gov/gis/ris/es/ES_Reports.aspx?county=Travis

United States Fish and Wildlife Service. 2016. Travis County Karst Zones and Salamander Critical Habitat Mapper, Online Viewer. Accessed November 4, 2016. http://www.fws.gov/southwest/es/austintexas/Maps_Data.html

Veni, G. 1992. Geological controls on cave development and the distribution of cave fauna in the Austin, Texas, region. Report prepared for U.S. Fish and Wildlife Service, Austin, Texas.

Veni, G. 1994. Geological controls on cave development and the distribution of endemic cave fauna in the San Antonio, Texas, region. Report prepared for Texas Parks and Wildlife Department, Austin, Texas, and U.S. Fish and Wildlife Service, Austin, Texas.

Veni, G. 2002. Delineation of hydrogeologic areas and zones for the management and recovery of endangered karst invertebrate species in Bexar County, Texas. Report prepared for the U.S. Fish and Wildlife Service, Austin, Texas.

Appendix G

Appendix G – 1D/2D Comparison and 30% Drawings

Bound Under Separate Cover

Appendix H

Appendix H – Life-Cycle Cost Estimates

Oak Knoll Alternatives 1 - 3

Arabian Trail Alternatives 1 - 3

Bell Avenue Alternatives 1 - 3

OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - OAK KNOLL ALT 1					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	275	$19,250
2	INSPECTING OUTFALLS	EA	$70	10	$700
3	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	8	$20,000
4	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	4550	$9,100
				TOTAL LIFE-CYCLE COST	**$49,050**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

Not to be used for construction, bidding, permitting or regulatory approval purposes. This document is released on May 31, 2017 for the purpose of interim review under the authority of Travis Michel, Texas PE NO. 95805, Lockwood, Andrews & Newnam, Inc., Texas Registered Engineering Firm - 2614

OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - OAK KNOLL ALT 2					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	550	$38,500
2	INSPECTING OUTFALLS	EA	$70	10	$700
3	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	14	$35,000
4	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	11050	$22,100
				TOTAL LIFE-CYCLE COST	**$96,300**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - OAK KNOLL ALT 3					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	750	$52,500
2	INSPECTING OUTFALLS	EA	$70	10	$700
3	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	20	$50,000
4	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	16000	$32,000
				TOTAL LIFE-CYCLE COST	**$135,200**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - ARABIAN TRAIL ALT 1					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	425	$29,750
2	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	34	$85,000
3	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	13660	$27,320
				TOTAL LIFE-CYCLE COST	**$142,070**

CONSTRAINTS	UNIT	QUANTITY

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - ARABIAN TRAIL ALT 2					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	300	$21,000
2	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	24	$60,000
3	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	6100	$12,200
				TOTAL LIFE-CYCLE COST	**$93,200**

CONSTRAINTS	UNIT	QUANTITY

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - ARABIAN TRAIL ALT 3					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	300	$21,000
2	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	24	$60,000
3	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	6100	$12,200
				TOTAL LIFE-CYCLE COST	**$93,200**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - BELL AVENUE ALT 1					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	450	$31,500
2	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	36	$90,000
3	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	11805	$23,610
				TOTAL LIFE-CYCLE COST	**$145,110**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - BELL AVENUE ALT 2					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	EA	$70	625	$43,750
2	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	50	$125,000
3	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	16910	$33,820
4	INSPECTING OUTFALLS	EA	$70	10	$700
				TOTAL LIFE-CYCLE COST	**$203,270**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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OAK KNOLL DRAINAGE IMPROVEMENTS PROJECT					
LIFE-CYCLE COST ANALYSIS - BELL AVENUE ALT 3					
PRELIMINARY ENGINEERING REPORT					
5/31/2017					
ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**UNIT COST**	**QUANTITY**	**ITEM COST**
1	INSPECTING MANHOLES/JUNCTION BOXES/INLETS	p	$70	625	$43,750
2	FLUSHING MANHOLES/JUNCTION BOXES	EA	$2,500	50	$125,000
3	TV INSPECTION OF STORM DRAINS/BOX CULVERTS	LF	$2	12540	$25,080
				TOTAL LIFE-CYCLE COST	**$193,830**

ASSUMPTIONS

1. Flushing of manholes and inlets was assumed to occur once every 25 years.
2. Mowing of swales was assumed to be 6 times per year. Mowing of ponds was assumed to be 3 times per year.
3. Life cycle costs are based on 50-year life expectancy.

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Appendix I

Appendix I – Downstream Impacts for Preferred Alternatives

Exhibit I-1 Oak Knoll Alternative 3 with and without Detention Impacts

Exhibit I-2 Oak Knoll with Detention HMS Flow Impacts

Exhibit I-3 Arabian Trail Alternative 3 Impacts

Exhibit I-4 Bell Avenue Alternative 1 and Combined Bell Ave and Oak Knoll Impacts

Exhibit I-5 Bell Avenue HMS Flow Impacts

Oak Knoll Drainage Improvements Preliminary Design Assessment, Doucet + Chan, October 31, 2017

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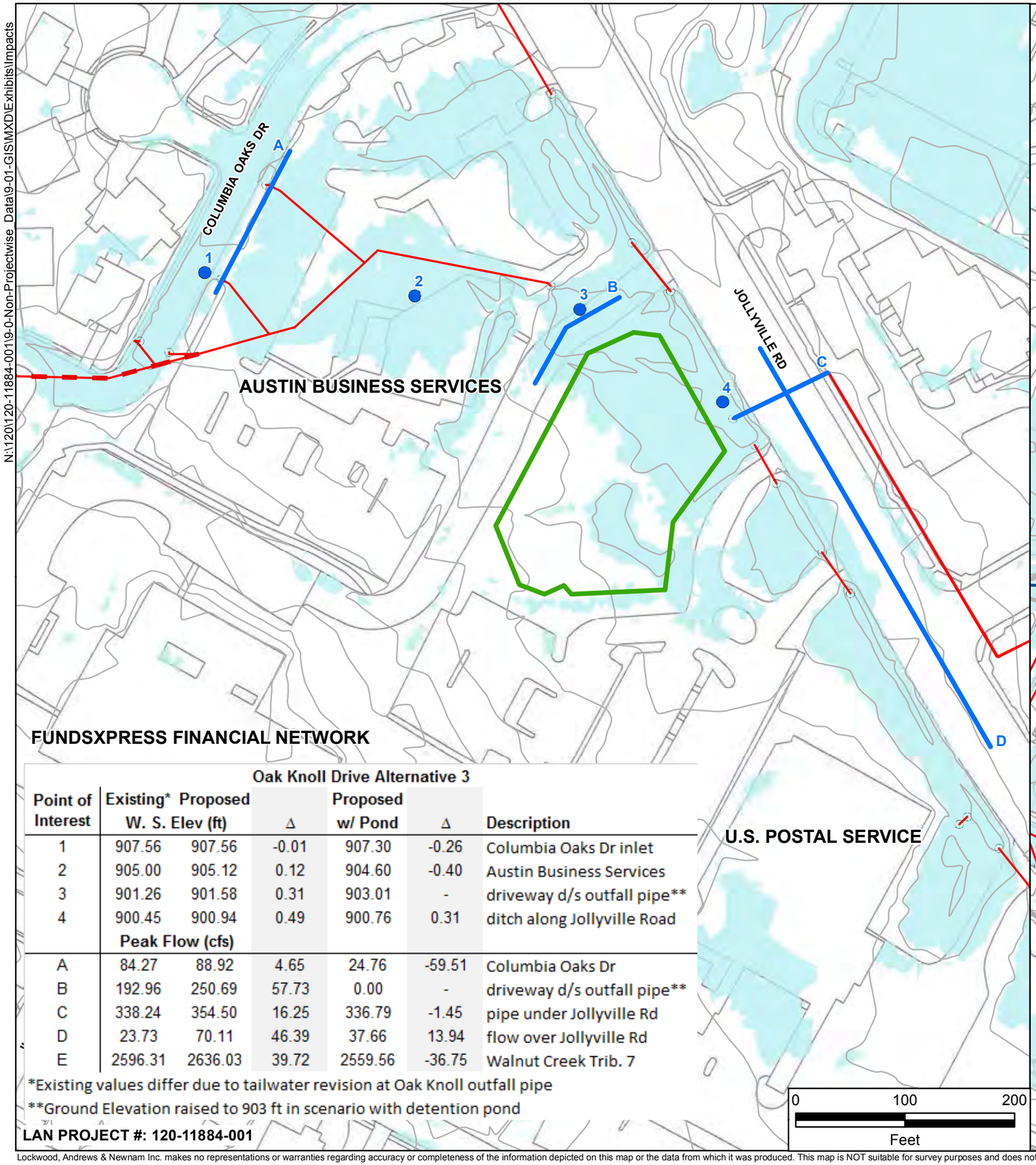

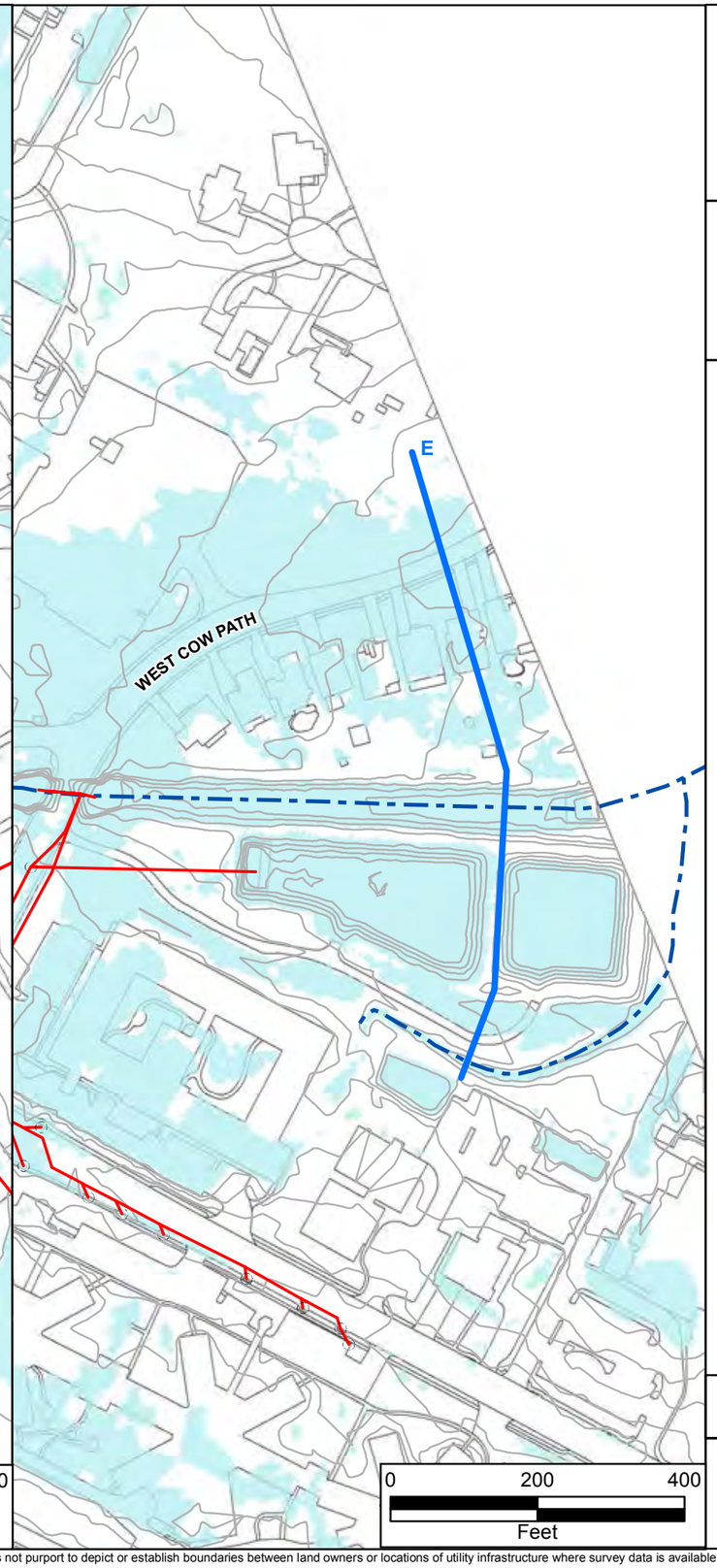

Oak Knoll Drive Alternative 3

Point of Interest	Existing* W. S. Elev (ft)	Proposed	Δ	Proposed w/ Pond	Δ	Description
1	907.56	907.56	-0.01	907.30	-0.26	Columbia Oaks Dr inlet
2	905.00	905.12	0.12	904.60	-0.40	Austin Business Services
3	901.26	901.58	0.31	903.01	-	driveway d/s outfall pipe**
4	900.45	900.94	0.49	900.76	0.31	ditch along Jollyville Road
	Peak Flow (cfs)					
A	84.27	88.92	4.65	24.76	-59.51	Columbia Oaks Dr
B	192.96	250.69	57.73	0.00	-	driveway d/s outfall pipe**
C	338.24	354.50	16.25	336.79	-1.45	pipe under Jollyville Rd
D	23.73	70.11	46.39	37.66	13.94	flow over Jollyville Rd
E	2596.31	2636.03	39.72	2559.56	-36.75	Walnut Creek Trib. 7

*Existing values differ due to tailwater revision at Oak Knoll outfall pipe

**Ground Elevation raised to 903 ft in scenario with detention pond

LAN PROJECT #: 120-11884-001

OAK KNOLL AREA
ALTERNATIVE 3 WITH DETENTION 100-YR IMPACTS

LEGEND

- EXISTING INUNDATION
- 2 FT CONTOURS
- WALNUT CREEK TRIBUTARY 7
- PROPOSED STORM DRAIN
- EXISTING STORM DRAIN PIPES
- EXISTING INLETS
- RESULTS LINE (POI)
- POINTS OF INTEREST
- DETENTION POND

EXHIBIT I-1

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

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OAK KNOLL DRIVE W/ DETENTION DOWNSTREAM IMPACTS

100-YR INUNDATION

ALTERNATIVE 3 - DCM

OAK KNOLL AREA

YETT BRANCH CREEK

WALNUT TRIB. 7

JWALT7020

JWALT7030

JWALT7040

JWALT7050

JWALT70100

JWALT70105, JWALNC110

WALNUT CREEK

KRAMER CREEK

LEGEND

- STUDY AREA
- WALNUT CREEK TRIB. 7 SUBBASIN
- WALNUT CREEK SUBBASINS
- PROPOSED FLOODPLAIN
- STREAM CENTERLINE
- POINTS OF INTEREST

0 800 1,600

Feet

EXHIBIT I-2

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Oak Knoll Alt 3 w/ Detention		100-YR			
Point of Interest	HEC-HMS ID	EXISTING (cfs)	PROPOSED (cfs)	Δ (cfs)	Percent Difference
ICM Results Line	-	2596.31	2559.56	-36.75	-1.42%
WC Trib 7 (Project Location)	JWALT7020	1796.55	1771.09	-25.46	-1.42%
Mustang Chase Crossing	JWALT7030	2319.25	2274.03	-45.22	-1.95%
Union Pacific/Dorsett Rd Crossing	JWALT7040	3506.98	3477.50	-29.48	-0.84%
Duval Rd Crossing 1	JWALT7050	2847.45	2778.02	-69.43	-2.44%
Duval Rd Crossing 2	JWALT70100	2978.47	2971.47	-7.00	-0.24%
WC Trib 7 just U/S of WC	JWALT70105	3015.20	3008.12	-7.08	-0.23%
WC Trib 7 confluence w/ WC	JWALNC110	15861.94	15861.14	-0.80	-0.01%

LAN PROJECT #: 120-11884-001

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ARABIAN TRL

HIGHLAND OAKS TRL

HAMRICH CT

SECREST DR

RAIN FOREST CV

JOLLYVILLE RD

WEST COW PATH

ANGUS RD

1

2

A

Arabian Trail Alternative 3

Point of Interest	Existing W. S. Elev (ft)	Proposed W. S. Elev (ft)	Δ	Description
1	864.44	864.44	0.00	ditch along Arabian Trl
2	859.73	859.79	0.06	u/s US-183 frontage rd
	Peak Flow (cfs)			
A	2592.46	2593.43	0.96	Walnut Creek Trib. 7

LAN PROJECT #: 120-11884-001

ARABIAN TRAIL AREA
ALTERNATIVE 3
100-YR IMPACTS

LEGEND

- EXISTING INUNDATION
- 2 FT CONTOURS
- WALNUT CREEK TRIBUTARY 7
- EXISTING STORM DRAIN PIPES
- EXISTING INLETS
- RESULTS LINE (POI)
- POINTS OF INTEREST

N

0 200 400
Feet

EXHIBIT I-3

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

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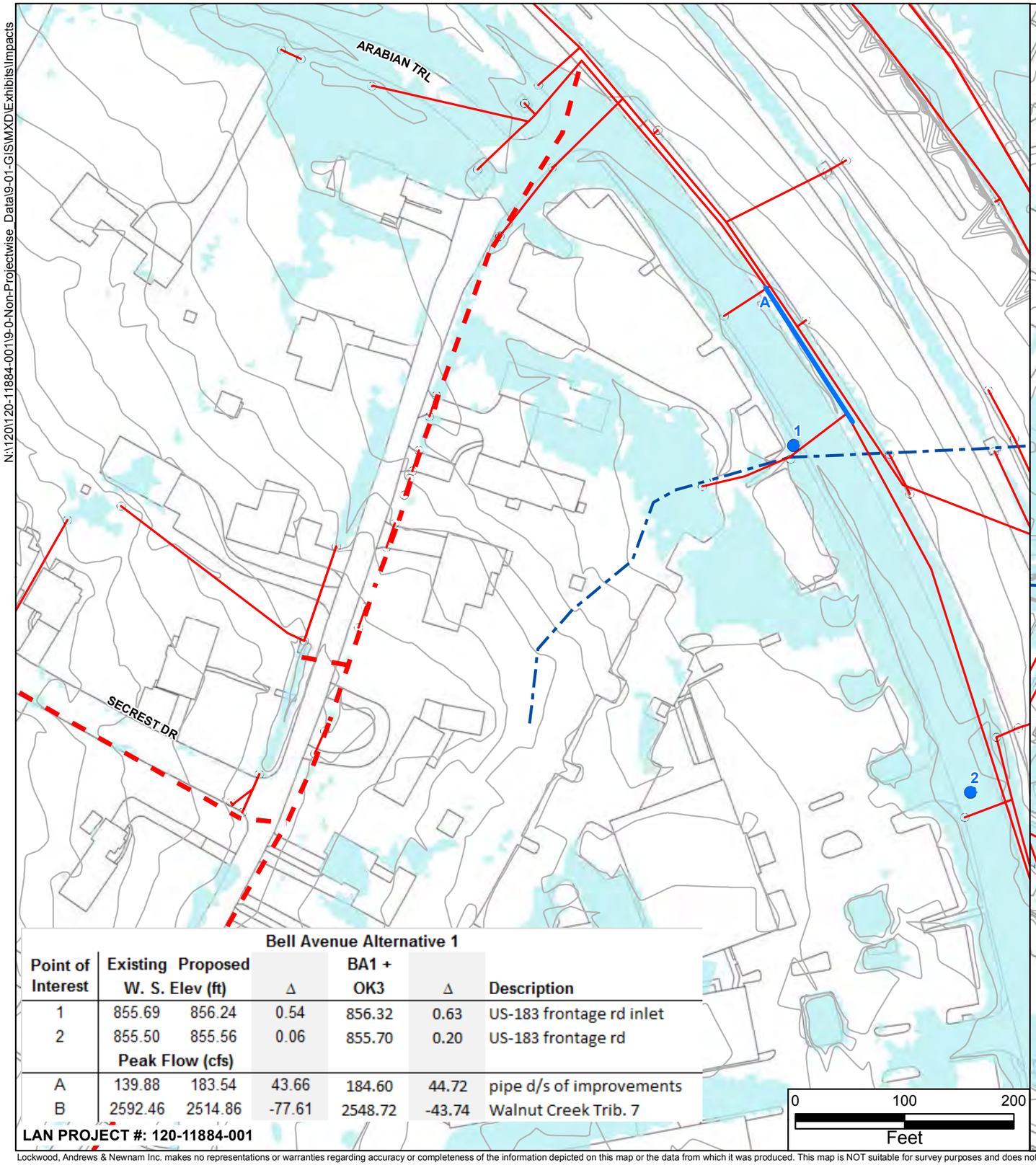

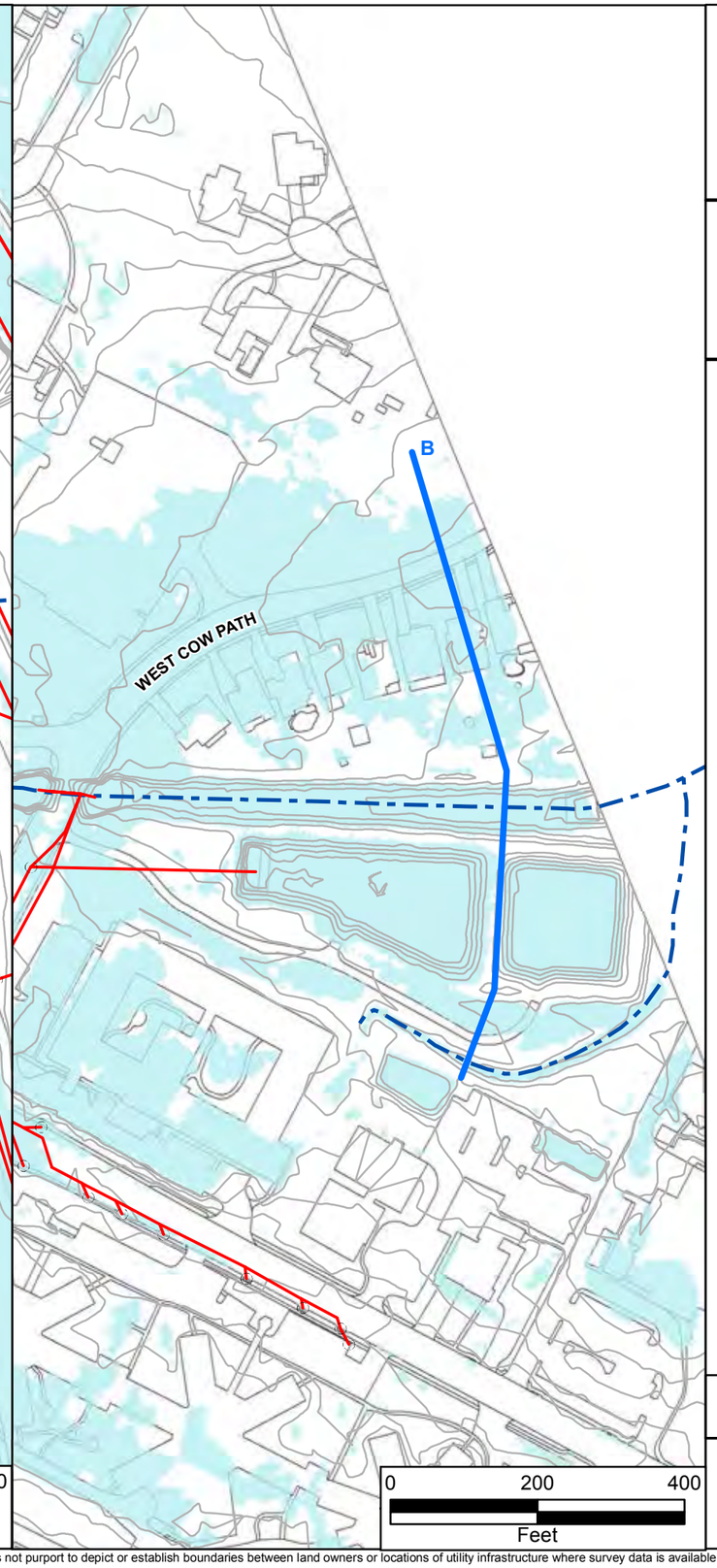

Bell Avenue Alternative 1

Point of Interest	Existing W. S. Elev (ft)	Proposed W. S. Elev (ft)	Δ	BA1 + OK3	Δ	Description
1	855.69	856.24	0.54	856.32	0.63	US-183 frontage rd inlet
2	855.50	855.56	0.06	855.70	0.20	US-183 frontage rd
	Peak Flow (cfs)					
A	139.88	183.54	43.66	184.60	44.72	pipe d/s of improvements
B	2592.46	2514.86	-77.61	2548.72	-43.74	Walnut Creek Trib. 7

LAN PROJECT #: 120-11884-001

BELL AVENUE AREA

ALTERNATIVE 1 +
OAK KNOLL ALT 3
100-YR IMPACTS

LEGEND

- EXISTING INUNDATION
- 2 FT CONTOURS
- WALNUT CREEK TRIBUTARY 7
- EXISTING STORM DRAIN PIPES
- EXISTING INLETS
- RESULTS LINE (POI)
- POINTS OF INTEREST

EXHIBIT I-4

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

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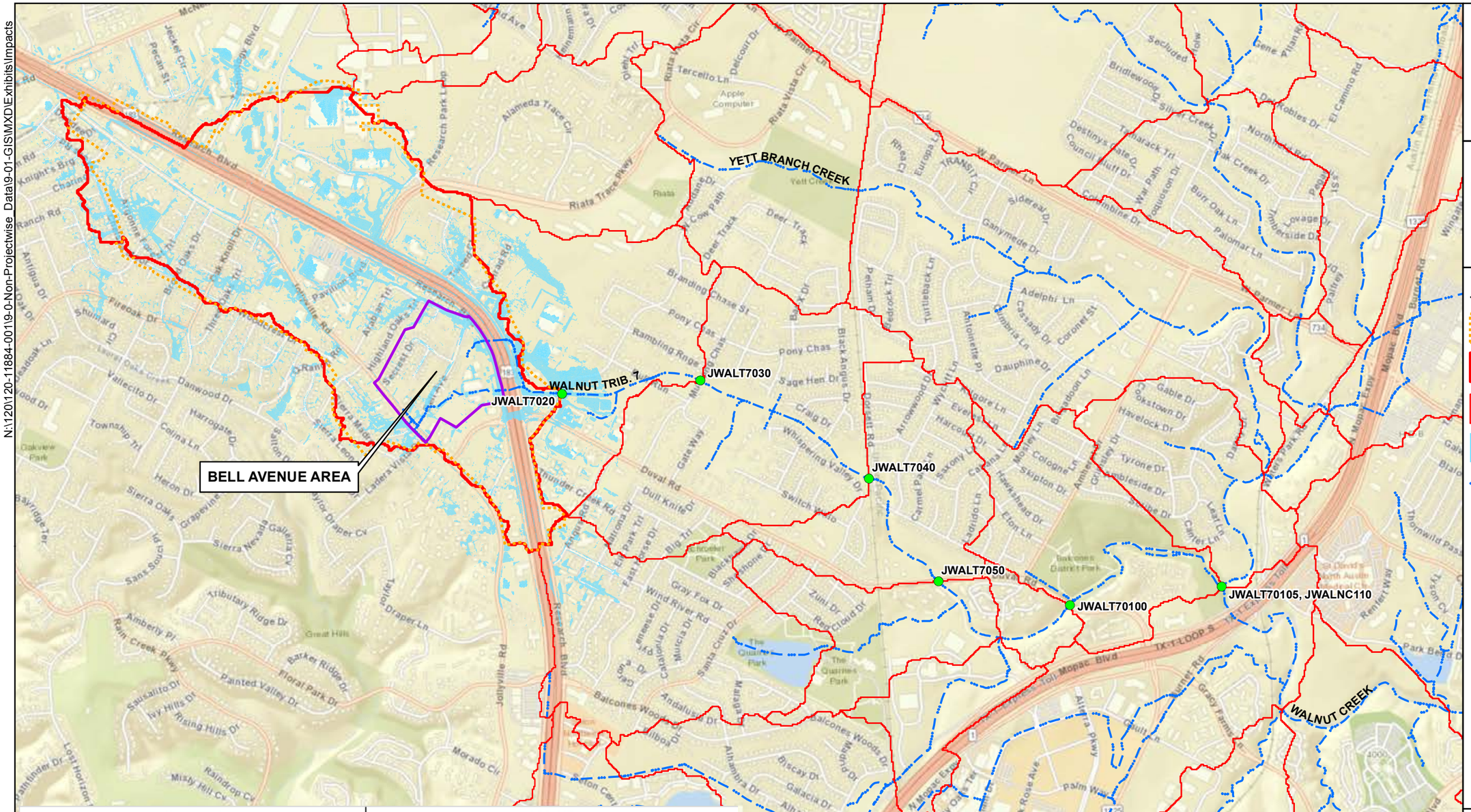

Bell Ave Alt 1		100-YR			
Point of Interest	HEC-HMS ID	EXISTING (cfs)	PROPOSED (cfs)	Δ (cfs)	Percent Difference
ICM Results Line	-	2592.46	2514.86	-77.61	-2.99%
WC Trib 7 (Project Location)	JWALT7020	1796.55	1742.83	-53.72	-2.99%
Mustang Chase Crossing	JWALT7030	2319.25	2224.55	-94.70	-4.08%
Union Pacific/Dorsett Rd Crossing	JWALT7040	3506.98	3443.75	-63.23	-1.80%
Duval Rd Crossing 1	JWALT7050	2847.45	2696.52	-150.93	-5.30%
Duval Rd Crossing 2	JWALT70100	2978.47	2963.57	-14.90	-0.50%
WC Trib 7 just U/S of WC	JWALT70105	3015.20	3000.12	-15.08	-0.50%
WC Trib 7 confluence w/ WC	JWALNC110	15861.94	15860.32	-1.62	-0.01%

LAN PROJECT #: 120-11884-001

BELL AVENUE DRIVE DOWNSTREAM IMPACTS
100-YR INUNDATION
ALTERNATIVE 1 - DCM

LEGEND

- STUDY AREA
- WALNUT CREEK TRIB. 7 SUBBASIN
- WALNUT CREEK SUBBASINS
- PROPOSED FLOODPLAIN
- STREAM CENTERLINE
- POINTS OF INTEREST

0 800 1,600
Feet

EXHIBIT I-5

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Oak Knoll Drainage Improvements Preliminary Design Assessment

STORM WATER DETENTION POND AT 11900 JOLLYVILLE ROAD

(U.S. POSTAL SERVICE BALCONES POST OFFICE SITE)

John R. King, P.E.
DOUCET + CHAN
A DIVISION OF DOUCET & ASSOCIATES, INC.
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Table of Contents

1. INTRODUCTION

Lockwood, Andrews & Newnam, Inc. (LAN) is assessing storm water improvements for the Oak Knoll Drainage Improvements for the City of Austin (COA). The study area consists of three (3) project areas: Oak Knoll Drive Storm Drain Improvements (SDI) project area, Arabian Trail SDI project area, and Bell Avenue SDI project area. The three SDI project areas are within the Walnut Creek Watershed, which the COA has classified as a Suburban Watershed in the COA Land Development Code (LDC 25-8-2). The primary purpose of the study is to prepare preliminary engineering assessments of storm drain improvement strategies to alleviate flooding of buildings, yards, and roadways within the three SDI project areas.

LAN requested that Doucet + Chan (D+C), a division of Doucet & Associates, Inc., prepare a preliminary design geometric assessment, identify site constraints and prepare engineer's preliminary opinion of probable construction cost for a proposed storm water detention pond (Pond) adjacent to the Jollyville Road Right-of-Way (ROW). Exhibit 1 shows the general location of the Pond site.

2. SITE CONSTRAINTS

2.1 Location

The proposed Pond site is currently a heavily wooded, un-developed section of the U.S. Postal Service Balcones Post Office at 11900 Jollyville Road. It is located north of the Post Office Building and south of the Synergy Plaza Building at 11940 Jollyville Road. The Pond site is immediately bound by the Jollyville Road Right-of-Way (ROW), a private driveway that provides the Fundsxpress Financial Network Building and its parking lot access to Jollyville Road, a private driveway that provides the Post Office building and its parking lot access to Jollyville Road, and a Post Office parking lot. Exhibit 1 shows the general location of the Pond site.

2.2 Land Use and Zoning

The proposed Pond site is a part of the same tract of land upon which the U.S. Postal Service Post Office Building is located. This tract of land is zoned by the COA as "GO-CO". The tracts of land on either side of the proposed Pond site are zoned as "GO", "LI-PDA-CO", and "LI". The tracts of land across Jollyville Road to the northeast of the Pond site are zoned as "LO-CO, "GR" and "LO". The tracts of land across Woodcrest Drive to the southwest of the Pond site are zoned as "SF-2".

Since the Pond site is on a tract with "GO-CO" zoning, the site is subject to the following primary land use and zoning constraints in accordance with the COA Land Development Code:

1. "GO", General Office District, allows office or commercial use that serves the community and city-wide needs (LDC 25-2-95).

2. "CO", Conditional Overlay Combining District, modifies "GO" use and site development regulations to address specific circumstances presented by the site (LDC 25-2-164).

3. The City Zoning Use Summary Table (LDC 25-2-491) is not clear if storm water detention is an allowable use in "GO" zoning (unless the "CO" specifically allows it use). Otherwise, new zoning or amended "CO" might be required to allow construction of the Pond on "GO" zoned property.

4. "GO" zoning criteria includes:

   Front yard setback = 15'
   Street side yard setback = 15'
   Interior side yard setback = 5'
   Rear yard setback = 5'
   Maximum impervious cover = 80%

The Pond use is about 505 feet from property zoned as "SF-2" along Woodcrest Drive, so the site is subject to the following compatibility land development constraints in accordance with the COA Land Development Code (Article 10 of LDC 25-2):

1. Any use within 540 feet or less from property in SF-5 or more restrictive zoning district (e.g. existing SF-2 zoned property along Woodcrest Drive) is subject to Compatibility Standards.

2. The proposed maximum height of the Pond retaining wall of about 8 feet nest to the Jollyville Road ROW is well within the most restrictive 30-ft maximum allowable height of the Compatibility Standards.

3. Scale/clustering standards of the Compatibility Standards do not apply to the Pond.

4. Screening of the off-street parking (i.e. staging area) is required.

5. The driveway around the Pond must be aligned to be no closer than 25 feet from property in SF-5 or more restrictive zoning district. The proposed staging area and maintenance access strip is at least 505 feet away from the SF-2 zoned property along Woodcrest Drive.

2.3 Environmental and Watershed

The site is subject to the following primary environmental and watershed development constraints in accordance with the COA Land Development Code:

1. The Pond site is within the Walnut Creek Watershed. Walnut Creek has a Critical Water Quality Zone (CWQZ) (LDC 25-8-92), but the Pond site is not within the CWQZ.

2. Impervious cover associated with commercial use cannot exceed 80% within a Suburban Watershed (LDC 25-8-392(C)).

3. Impervious cover calculations exclude detention basins, but include roads, driveways and parking surfaces (e.g. the Pond staging area) (LDC 25-8-63).

4. Water quality controls are not required of new + redeveloped impervious cover does not exceed 8,000 square feet. The proposed Pond staging area surface is about 1,012 square feet.

2.4 Drainage and Environmental Criteria Manual Criteria for Storm Water Detention Ponds

The layout of the proposed Pond is subject to the following COA Drainage (DCM) and Environmental Criteria Manual (ECM) criteria:

Drainage Criteria Manual (DCM 1.2.4)

1. A barrier fence must be constructed around the pond with a 12-ft wide access gate.

2. Landscape screening of the pond must be provided per the Environmental Criteria Manual (see ECM criteria below).

3. A 12-ft wide maintenance access strip must be provided around the perimeter of the toe of slope or top of cut.

4. The pond can be no closer than 50 feet to a residential structure.

5. A permanent access ramp must be constructed into the pond with a 4H:1V maximum slope and a 12-ft wide minimum width.

6. An access drive from a public ROW to the pond must be constructed with a 12-ft minimum width and an equipment turn-around if the access drive is more than 200 feet from a paved public roadway.

7. A Pond maintenance equipment staging area must be provided that is at least 800 square feet in area and with 20-ft minimum dimensions.

8. The steepest allowable side slopes in the Pond are 3H:1V.

9. The Pond bottom slopes must be no flatter than 2% if grassed bottom. Bottom slopes to the trickle channel (pilot channel) must be 2%, but the trickle channel slope can be no flatter than 0.5%.

Environmental Criteria Manual (ECM 2.9.1)

Pond screening can be one of the following two types:

1. Hedge-like vegetative screen.

2. Existing vegetation of at least 10 feet in width.

2.5 Existing Utilities

There are no know utilities on the Pond site; however, a site survey has not been conducted and AULCC coordination has not been performed for this site. According to available information (including Austin Water GIS information and approved site plans), the following utilities are near the Pond site:

Drainage: The general direction of overland flow on the Pond site is to the northeast, toward the Jollyville Road shoulder ditch. There is an existing double-culvert under Jollyville Road with its inlet within the roadway shoulder ditch immediately north of the one-way-in driveway into the Post Office site. This double culvert receives flows within the shoulder ditch on the south side of the road and discharges into a roadway storm drain system along the north side of the road. The proposed Pond will discharge into the south shoulder ditch and then to the existing culvert under the roadway to the north side of the road.

The 1981 Columbia Oaks sub-division drainage improvement plans, which includes this site, shows a drainage easement covering the north corner of this site where the original drainage from the adjacent tract to the north flows across the northern portion of this site via open channel to the Jollyville Road culvert. It is not known if this

drainage easement is in existence, because the 1981 drainage system was later modified to its current configuration on the adjacent Synergy Plaza Building site.

Water: According to Austin Water GIS mapping, there are existing 24" and 16" water lines within the Jollyville Road ROW. There do not appear to be any water lines on the pond site.
Wastewater: According to Austin Water GIS mapping, there are existing 10" and 24" wastewater lines aligned close to the south Jollyville Road ROW line, but aligned within the ROW. There do not appear to be any wastewater lines on the pond site.

Power: Overhead power line and poles along the south shoulder of Jollyville Road.
Telecommunications: 1981 utility improvement drawings along Jollyville Road indicate telecommunications conduits along the north shoulder of Jollyville Road. AULCC coordination is needed to confirm the type(s) and alignments of telecommunication conduits.

Natural Gas: The 1981 utility improvement drawings along Jollyville Road indicate a natural gas line along the north side of the Jollyville Road ROW. AULCC coordination is needed to confirm the size and alignment of the natural gas line.

3. DETENTION POND LAYOUT

LAN selected the proposed Pond site and requested that D+C prepare a storm water detention pond layout that maximizes the available detention storage volume, subject to the site constraints (see Section 2 of this report). Initially, D+C prepared rough layouts of two alternative pond configurations: sloped embankment configuration and vertical retaining wall configuration. LAN determined that vertical pond retaining walls would provide the greatest detention storage volume and requested that all further preliminary design assessments of the Pond to be based upon vertical retaining wall configuration. The preliminary design layout of the Pond has the following components (see Exhibit 1):

1. Primary horizontal geometric constraint is to provide a 12-ft wide maintenance access strip around the perimeter of the pond plus a 7-ft side vegetative screening zone, resulting in a pond retaining wall setback of at least 19 feet from the property lines.

2. Construction of a vertical inside face reinforced concrete retaining wall to maximize storm water detention storage. Set the top of wall at elevation 904 to provide approximately 6 inches of freeboard above the peak Q100 water surface elevation in the pond, per LAN modeling results.

3. Set the pond floor lowest elevation at approximately 896.15 to provide positive pond outfall flow to the existing drainage culvert under Jollyville Road.

4. Provide a concrete trickle channel at 0.5% slope to the pond outfall structure and slope the grassed channel floor grades to the trickle channel at 2.0% grade.

5. Provide a 12-ft wide access ramp into the pond to facilitate maintenance.

6. Provide approximately 3'x3' outfall structure/energy dissipater within the Jollyville Road shoulder drainage ditch that discharges to the existing Jollyville Road culvert.

7. Provide a 45' x 45' triangular staging area.

8. Provide an 8-ft high security fence around the site.

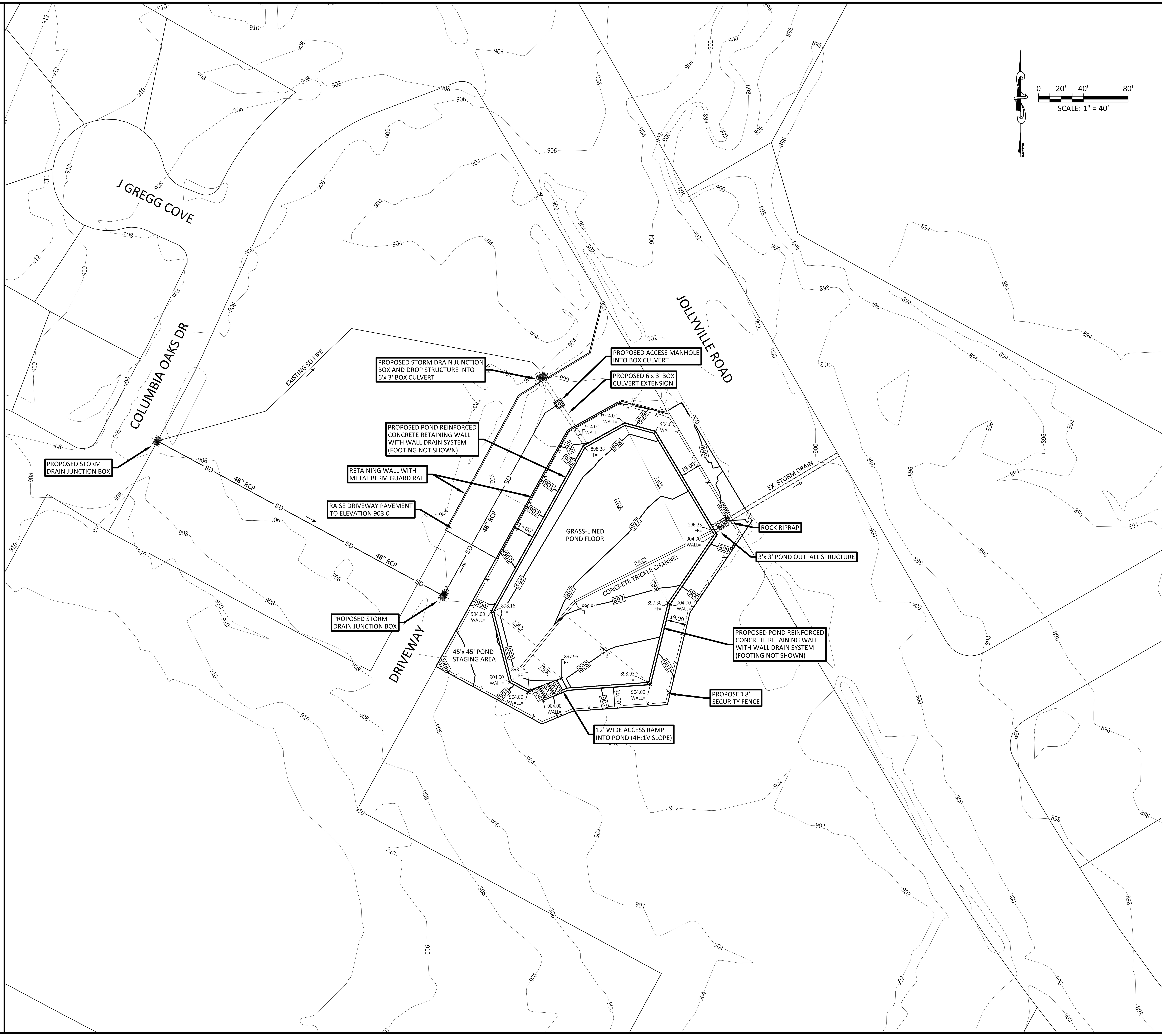
9. Extend an 6'x3' box culvert northwest from the pond under the Fundsxpress Financial Network building driveway to receive site drainage discharges from the Synergy Plaza Building site.

10. Construct a 48" storm drain pipe across the Synergy Plaza Building parking lot to bypass excess storm drain flows to the pond. Connect the 48" storm drain pipe to the proposed 6'x3' box culvert extension.

11. Raise the Fundsxpress Financial Network Building driveway at the pond to a finished grade of at least elevation 903 to prevent the Pond's Q100 water surface elevation from flooding the driveway.

4. PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST

D+C prepared an engineer's preliminary opinion of probable construction cost for the Pond, raising the private access driveway next to the Pond, construction of 6'x3' box culvert extension to the Pond, and construction of a 48" storm drain pipe to the Pond. Local, updated construction unit prices were used for the cost assessment, resulting in an estimated construction cost of **$2,028,038** (see Table 1 for detailed breakdown of the construction cost opinion).



CONTRACTOR NOTES:

EXISTING UNDERGROUND & OVERHEAD UTILITIES IN VICINITY. CONTRACTOR TO CONTACT UTILITY COMPANIES PRIOR TO CONSTRUCTION. CONTRACTOR TO CALL 811 FOR UTILITY LOCATES PRIOR TO EXCAVATION. CONTRACTOR TO FIELD VERIFY EXISTING UTILITY LOCATIONS & DEPTH PRIOR TO BEGINNING CONSTRUCTION.

CONTRACTOR SHALL CONSIDER PROPOSED UTILITY IMPROVEMENTS AND PROVIDE ADEQUATE HORIZONTAL AND VERTICAL CLEARANCE DURING INSTALLATION OF ALL UTILITY INFRASTRUCTURE.

DOUCET+CHAN
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Austin, Texas 78735, Phone: (512)-583-2600
www.doucetengineers.com
Firm Registration Number: 3937

EXHIBIT 1

OAK KNOLL DRAINAGE IMPROVEMENTS

STORM WATER DETENTION POND AT 11900 JOLLYVILLE ROAD

STATE OF TEXAS
JOHN R. KING
58429
LICENSED PROFESSIONAL ENGINEER
10/31/2017

Designed: JK
Drawn: ZD
Reviewed:
Date: 10/31/2017

EXHIBIT 1

Project No.: 1141-004

TABLE 1
Oak Knoll Drainage Improvements
Storm Water Detention Pond
Opinion of Probable Construction Cost

Item No.	Quantity	Unit	Item Description	Unit Price	Amount	Notes
102S-A	1.2	AC	Clearing and Grubbing	$ 5,000.00	$ 6,000.00	clear and grub the site
104S-A	522	LF	Remove P.C. Concrete Curb	$ 11.00	$ 5,742.00	remove curb along private driveway to raise grade at at box culvert crossing
110S-B	210	CY	Street Excavation, Plan Quantity	$ 35.00	$ 7,350.00	Remove 6" depth of existing driveway pavement to reconstruct at box culvert crossing + roadway retaining wall footing excavation
120S-B	9,760	CY	Channel Excavation, Plan Quantity	$ 35.00	$ 341,600.00	pond excavation
130S-T	890	CY	Class C (Topsoil), Plan Quantity, 6-In. Depth	$ 48.00	$ 42,720.00	driveway shoulders where reconstructed, top of pond wall, pond floor, disturbed areas within Jollyville Road ditch
132S-A	1,600	CY	Embankment	$ 32.00	$ 51,200.00	pond wall backfill
210S-A	152	CY	Flexible Base	$ 85.00	$ 12,920.00	parking lot pavement reconstruction along 48" SD pipe to pond
210S-A	270	CY	Flexible Base	$ 85.00	$ 22,950.00	private driveway reconstruction at box culvert crossing and pond staging area
340S-B-C2	260	SY	Hot Mix Asphaltic Concrete Pavement, 2 Inches, Type C	$ 30.00	$ 7,800.00	2" thickness: parking lot pavement reconstruction along 48" SD pipe to pond
340S-B-C3	930	SY	Hot Mix Asphaltic Concrete Pavement, 3 Inches, Type C	$ 40.00	$ 37,200.00	3" thickness: private driveway at box culvert crossing
SP401S-I	1	LS	Cofferdams and Dewatering	$ 8,000.00	$ 8,000.00	prevent Jollyville Road ditch flooding into pond excavation
403S-LF	195	LF	Trickle Channel, Reinforced Concrete	$ 25.00	$ 4,875.00	pond floor trickle channel
414S-C	400	CY	Cast-in-Place Portland Cement Concrete Retaining Wall, Including Reinforcement (Pond)	$ 650.00	$ 260,000.00	Pond retaining wall
414S-C	80	CY	Cast-in-Place Portland Cement Concrete Retaining Wall, Including Reinforcement (Driveway)	$ 650.00	$ 52,000.00	Private drive retaining wall at box culvert crossing
430S-A	522	LF	P.C. Concrete Curb and Gutter	$ 30.00	$ 15,660.00	new curb and gutter along private driveway at box culvert crossing
506S-CNSW	1	EA	Connection to Existing 6 Ft. x 3 Ft. Box Culvert	$ 3,000.00	$ 3,000.00	connect to ex. box culvert in parking lot for new 48" SD pipe
506S-JSW7x7	1	EA	Junction Box, 7 Ft. x 7 Ft.	$ 12,500.00	$ 12,500.00	junction box/manhole for 48" SD pipe across parking lot
506S-JSW9x9	1	EA	Junction Box, 9 Ft. x 9 Ft.	$ 17,500.00	$ 17,500.00	junction box/manhole for /6'x3' box/48" SD pipe connection in parking lot
506S-SSW48Dia.	1	EA	Special Manhole, 48 in. Dia.	$ 3,000.00	$ 3,000.00	48" access manhole into 6'x3' box culvert at connection to 48" SD pipe from parking lot
508S-E3x3	1	EA	Energy Dissipator, 3 Ft. x 3 Ft. Pond Outfall	$ 17,000.00	$ 17,000.00	outfall energy dissipator at Jollyville Road ditch
508S-IG5x4	1	EA	Inlet, Grated, 5 Ft. x 4 Ft.	$ 3,000.00	$ 3,000.00	drop inlet at connection of local storm drain system to 6'x3' box culvert extension
509S-1	578	LF	Trench Excavation Safety Protective Systems (all depths)	$ 4.00	$ 2,312.00	along box culvert extension and 48" SD pipe
510-ASD48Dia.	500	LF	Pipe, 48 Inch Dia. RCP, Class III (all depths), including Excavation and Backfill	$ 350.00	$ 175,000.00	new 48" SD pipe across parking lot to pond
551	700	LF	Pipe Underdrains, 6 In. (for pond retaining wall)	$ 84.00	$ 58,800.00	along pond retaining wall
559S6x3	78	LF	Precast Concrete Box Culverts, 6 Ft x 3 Ft	$ 540.00	$ 42,120.00	extend existing box culvert into pond

TABLE 1
Oak Knoll Drainage Improvements
Storm Water Detention Pond
Opinion of Probable Construction Cost

Item No.	Quantity	Unit	Item Description	Unit Price	Amount	Notes
604S-A	5,400	SY	Non-Native Seeding for Erosion Control Method, _ Mulch	$ 3.00	$ 16,200.00	seed all disturbed areas
605S-A	5,400	SY	Soil Retention Blanket Class 2, Type D	$ 10.00	$ 54,000.00	all grassed areas
608S-1LO	216	EA	Planting Type Live Oak, 1.5" Caliper Size	$ 700.00	$ 151,200.00	tree mitigation (324 caliper inches)
SP608S	12	MO	Extended Plantings Maintenance	$ 1,500.00	$ 18,000.00	maintain new grassing and new trees
609S-F	5,400	SY	Watering	$ 3.00	$ 16,200.00	water new grassing and new trees
610S-A	770	LF	Tree Protective Fencing Type A Chain Link Fence	$ 7.00	$ 5,390.00	protect existing trees along the 2 private driveways
610S-R	36	EA	Removal of Existing Trees	$ 560.00	$ 20,160.00	remove all trees on site + 2 trees for 48" SD pipe construction
SP610S-E	10	EA	Tree Trimming	$ 300.00	$ 3,000.00	trees along 2 private driveways coming off Jollyville Road
628S-B	160	LF	Sediment Containment Dikes	$ 14.00	$ 2,240.00	triangular sediment control dikes across private driveway at box culvert crossing + along trench for 48" SD pipe within parking lot
639S	80	LF	Rock Berm	$ 41.00	$ 3,280.00	within Jollyville Road ditch and ata pond outfall structure until grassing established
641S	1	EA	Stabilized Construction Entrance	$ 1,800.00	$ 1,800.00	
642S	900	LF	Silt Fence	$ 3.10	$ 2,790.00	around perimeter of site
700S-TM	1	LS	Total Mobilization Payment	$ 78,000.00	$ 78,000.00	5% of all costs excluding Mob cost
701S-H	900	LF	Security Fence, 8 Foot High, Type Steel	$ 14.00	$ 12,600.00	security fence around perimeter of pond site
704	264	LF	Metal Beam Guard Railing	$ 52.00	$ 13,728.00	along retaining wall for private driveway reconstruction at box culvert crossing
704-T	4	EA	Metal Beam Guard Railing, Terminal Anchor Sections	$ 1,200.00	$ 4,800.00	at each end of guard rail along private driveway reconstruction at box culvert crossing
SP721S-A	1	EA	Staff Gauge	$ 900.00	$ 900.00	pond depth gage attached to face of pond retaining wall
802S-B C.I.P.	1	EA	C.I.P. Project Sign	$ 900.00	$ 900.00	
803S-CD	20	CD	Barricades, Signs, and Traffic Handling.	$ 300.00	$ 6,000.00	traffic control for construction of box culvert and reconstruction of private driveway at box culvert crossing
824S	2	EA	Traffic Signs	$ 400.00	$ 800.00	
			SUBTOTAL		$ 1,622,430.20	
			25% CONTENGENCIES		$ 405,607.55	
			CONSTRUCTION COST TOTAL		**$2,028,037.75**	

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