Gaines Tributary

Hydrologic and Hydraulic Analysis

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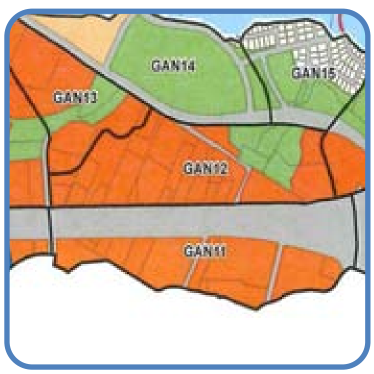

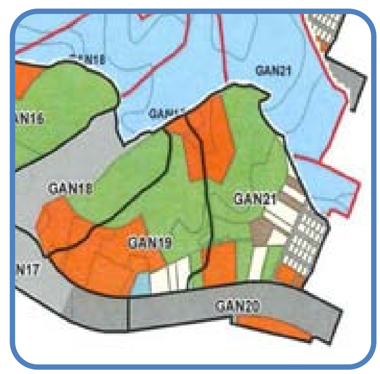



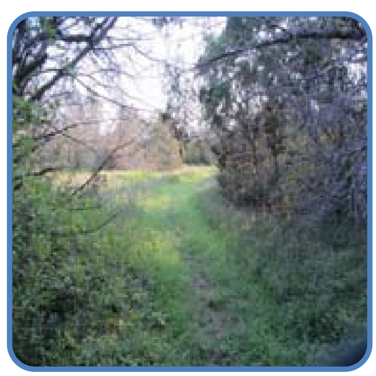

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1 Introduction

The Gaines Tributary Study is a comprehensive hydrologic and hydraulic analysis of the Gaines Watershed within Austin, Travis County, Texas. The purpose of this study is to create a GIS-based hydrologic and hydraulic analysis using best available data. This is a new study–not an update to previous models. The project is generally located downslope of William Cannon Dr. and outfalls into Barton Creek.

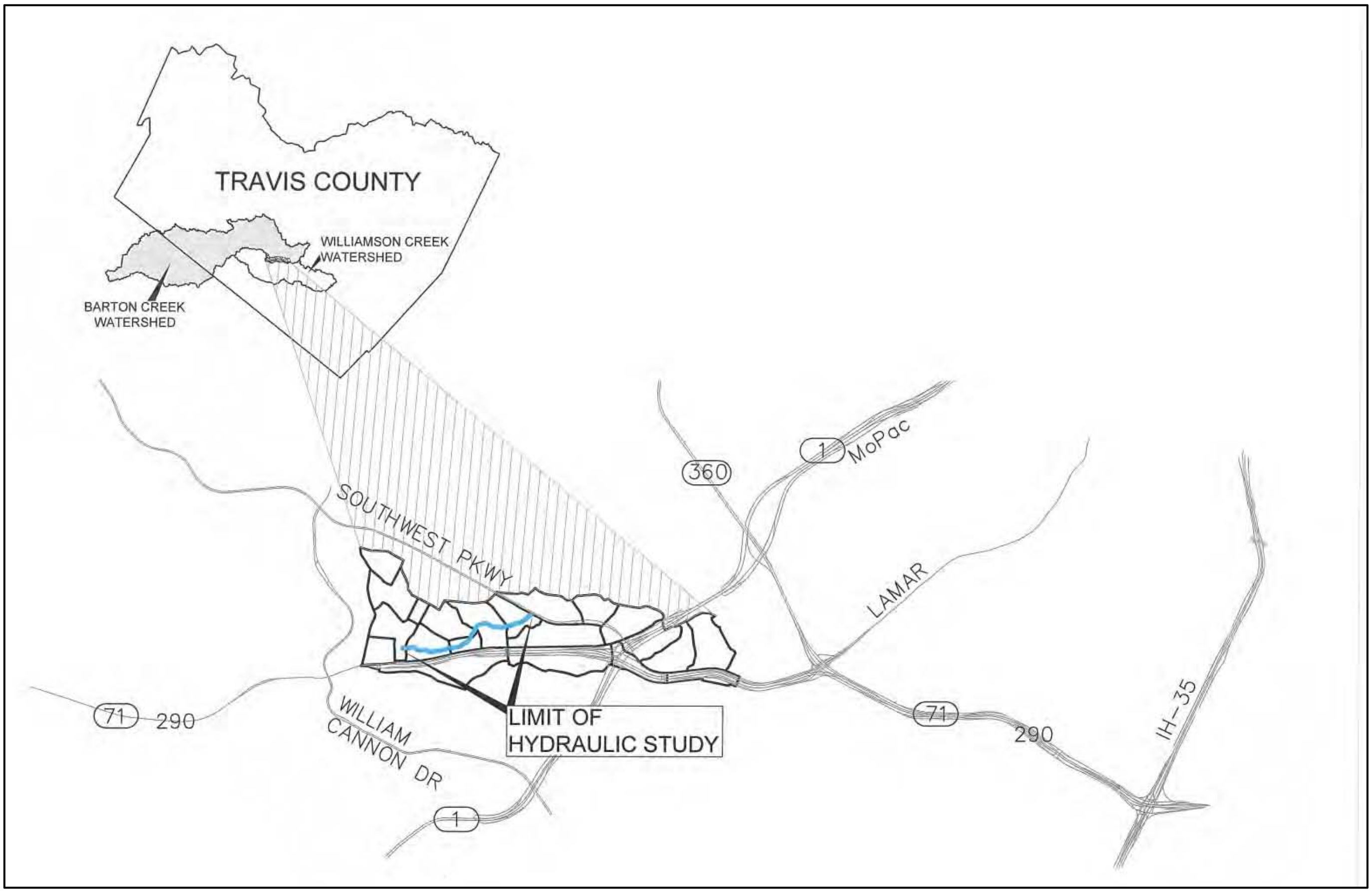


Figure 1. Gaines Tributary Watershed in Travis County

The primary objectives of the project are as follows:

1) Develop a new hydrologic model (HEC-HMS) for the Gaines Tributary watershed for existing and fully developed land use conditions for the selected return periods.
2) Develop a new, geo-referenced hydraulic model (HEC-RAS) for the Gaines Tributary for the reach upstream of Southwest Parkway and downstream of Vega Avenue for the existing and fully developed land use conditions for selected return periods.
3) Map floodplains for existing and fully developed land use conditions for selected return periods.

4) Utilize the new hydrologic and hydraulic models in assessing the drainage problems that have been reported in the general area downstream of Vega Avenue and upstream of Southwest Parkway.

2 Surveying

The City-provided 2003 LIDAR contour data has been used as the best available topographic data for the study area. For the 1.1 miles of stream scoped for detail study, the survey information collected is comprised of field surveys of the various public and private culvert crossings that exist throughout the study reach. The survey analysis includes identifying or establishing temporary bench marks and obtaining the physical dimensions of hydraulic and flood control structures as needed to complete the hydraulic analysis

2.1 Standards

Final horizontal coordinates are provided on the Texas Central (Zone 4203) State Plane Coordinate System on the North American Datum of 1983 (NAD83). Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88). The on-the-ground survey data accuracy ranges depending on terrain. For hardscape terrain such as concrete, on-the-ground data has a horizontal and vertical accuracy of approximately 0.01 feet. For variable terrain such as densely vegetated areas or loose soil areas, on-the-ground data has a horizontal and vertical accuracy of approximately 0.3 feet.

2.2 Deliverables

Survey schematics detailing each hydraulic structure are available in this document in Appendix D. The information provided has been used to develop the hydraulic model that is described later in this report.

2.3 Primary Control Points

Global Positioning System (GPS) Real Time Kinematic (RTK) surveying procedures are used to calculate the primary control points for this floodplain study. Ten (10) primary control points are set for this study. The coordinates of these points are processed in house using Leica Geo Office software. As part of the network adjustment, existing City of Austin benchmarks are used to determine our horizontal and vertical positions for the primary control.

2.4 Secondary Control Points

RTK GPS conventional surveying methods with total stations are utilized to set secondary control points from the primary control points. The secondary control points are located near the structures and cross section surveyed for this floodplain study. The positional data collected using the secondary control points are then used as control for the specific features needed for a hydraulic survey.

2.5 Elevation Reference Marks

Approximately 10 Elevation Reference Marks (ERMs) are set for the Gaines Tributary floodplain study. Most of the ERMs are set close to a structure that was included in the study.

2.6 Hydraulic Structures

Approximately 10 structures and 15 field cross sections are surveyed for this study. The survey data is collected following surveying standards set by FEMA under the 2011 *Guidelines and Specifications for Flood Hazard Mapping Partners,* Appendix M.

3 Hydrology

The HEC-HMS computer program, developed by The Army Corps of Engineers, is used in this analysis to estimate the existing and fully developed flows within the tributary. This analysis includes an evaluation of the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% annual chance (2-, 5-, 10-, 25-, 50-, 100-, and 500-year, respectively) storm events. This section describes the input parameters used in these studies and summarizes the results of the hydrologic analysis.

3.1 Drainage Area Delineation

The Gaines Tributary watershed is delineated and subdivided using the City of Austin 2003 two-foot LIDAR topography data. The boundaries are subsequently modified to reflect known drainage breaks as appropriate using available construction drawings from TXDOT and site/grading plan information for the various developments throughout the watershed (e.g., along streets, berms, drainage divides, etc.). The Drainage Area Map is included in Appendix A as Exhibit 1.

3.2 Precipitation

The precipitation depths are taken from the USGS's *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas* dated 2004. The 24-hour precipitation depths for each of the various storm events are shown in the table below. Each of these precipitation depths is distributed using an NRCS Type III distribution as per City of Austin criteria.

Table 1. Precipitation Depths for the City of Austin, Travis County, Texas

Percent Chance	Recurrence Interval (years)	Precipitation Depth (inches)
50%	2	3.44
20%	5	4.99
10%	10	6.10
4%	25	7.64
2%	50	8.87
1%	100	10.20
0.4%	250	12.00
0.2%	500	13.50

3.3 Runoff Losses

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

The NRCS classifies soils into four hydrologic soil groups: A, B, C, and D. These groups indicate the runoff potential of a soil, ranging from a low runoff potential (group A) to a high runoff potential (group D). The NRCS provides runoff curve numbers for three Antecedent Runoff Conditions (ARC): I, II and III. ARC I represents dry soil conditions and ARC III represents saturated soil conditions. ARC II is normally considered to be the average soil condition and is utilized for this analysis. Runoff curve numbers vary from 0 to 100, with the smaller values representing soils with lower runoff potential and the larger values representing soils with higher runoff potential.

For this analysis, curve numbers were evaluated independently of impervious cover (i.e., these curve numbers reflect fair condition open spaces). The majority of soils within the study area fall into NRCS Soil Group D, with limited Group A and Group C. ARC II is assumed for this analysis. A composite CN is computed based on area weighting of each hydrologic soil group within each subarea. Curve numbers for the various subareas range from 74 to 80. Impervious cover values are entered separately from CN values into the HEC-HMS model. A table listing the assumed CN values for this analysis is shown below.

HEC-HMS computes 100 percent runoff from impervious areas, while runoff from pervious areas is computed using the selected CN value and the following equations:

$$Q = (P - 0.2\times S)^2 / (P + 0.8\times S) \qquad \textit{Equation 1}$$

And

$$CN = 1000 / (10 + S) \qquad \textit{Equation 2}$$

Where:

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

Table 2. NRCS Curve Number Table

Hydrologic Soil Group	AMC II
A	49
B	69
C	79
D	84

The hydrologic model utilizes measured impervious cover percentages calculated for each watershed subarea. Existing conditions impervious cover for the watershed is quantified as a measured value using available City planimetric data supplemented with aerial photographs.

3.4 Unit Hydrograph Method

3.4.1 Background

A rainfall/runoff transformation is required to convert rainfall excess (total rainfall minus infiltration losses) into runoff from a particular subarea. The NRCS unit hydrograph is used in this analysis to generate runoff hydrographs for each defined subarea within the studied watersheds. The unit hydrograph method represents a hydrograph for one unit [inch] of direct runoff and is a nationally accepted standard engineering practice approach.

The dimensionless unit hydrograph developed by the NRCS (figure below) was developed by Victor Mockus and presented in *National Engineering Handbook, Section 4, Hydrology*. The dimensionless unit hydrograph has its ordinate values expressed in a dimensionless ratio, q/qp, and its abscissa values as t/Tp. This unit hydrograph has a point of inflection approximately 1.7 times the time to peak (Tp), and the time-to-peak 0.2 of the time-of-base (Tb) (NRCS 1985).

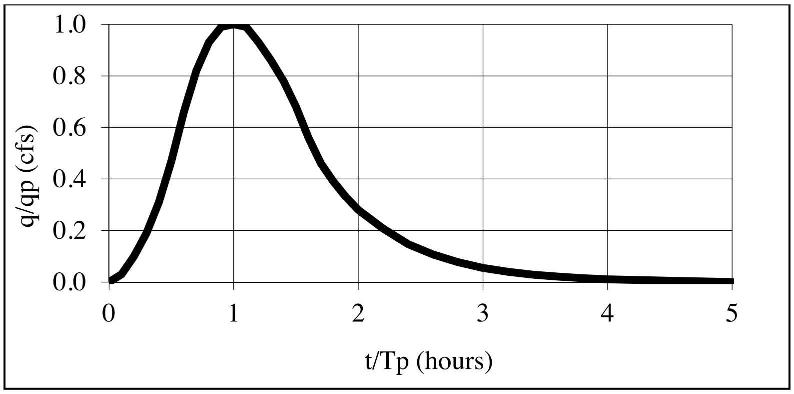


Figure 2. NRCS Unit Graph

In HEC-HMS, input data for this method consists of a single input parameter, T_{LAG}, which is equal to the time (hours) between the center of mass of rainfall excess and the peak of the unit hydrograph (NRCS 1985). In other words, there is a delay in time after a rain event begins before the runoff reaches it maximum peak. This delay is known as lag.

The time to peak is computed using the following equation:

$$T_{PEAK} = \Delta t/2 + T_{LAG} \qquad \textit{Equation 3}$$

Where:

T_{PEAK} = time to peak of the unit graph (hours),
Δt = computation interval or duration of unit excess (hours), and
T_{LAG} = watershed lag (hours).

The peak flow rate of the unit graph is computed using the following equation:

$$qp = 484A/T_{PEAK} \qquad \textit{Equation 4}$$

Where:

qp = peak flow rate of the unit graph (cubic feet per second [cfs] / inch) and
A = watershed area (square miles).
484 = peak rate factor (dimensionless)[1]

3.4.2 Time of Concentration

The NRCS method assumes that the lag time of a watershed is 60 percent of the watershed's time of concentration. The time of concentration 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). The time of concentration may be estimated by calculating and summing the travel time for each sub reach defined by the flow type: sheet flow, shallow concentrated flow, and channelized flow (including roadways, storm sewers, and natural/manmade channels). The methods prescribed in the NRCS' Technical Release 55 (TR-55) and the USDA's Hydrology Technical Note N4 are used to determine the times of concentration for each flow segment in

[1] The peak rate factor of 484 has been known to vary from 600 in steep terrain to 300 in very flat, swampy terrain. The 484 value is standard engineering practice and is utilized in this analysis.

this analysis. Appendix B contains the results of the calculations for this analysis utilizing each typical flow segment presented below.

Sheet Flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater 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:

$$Tt = (0.007 \times (n \times L)^{0.8}) / (P_2^{0.5} \times s^{0.4})$$ *Equation 5*

Where:

Tt = travel time (hr),
N = Manning's roughness coefficient,
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
S = slope of hydraulic grade line (land slope, ft/ft).

Shallow Concentrated Flow

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

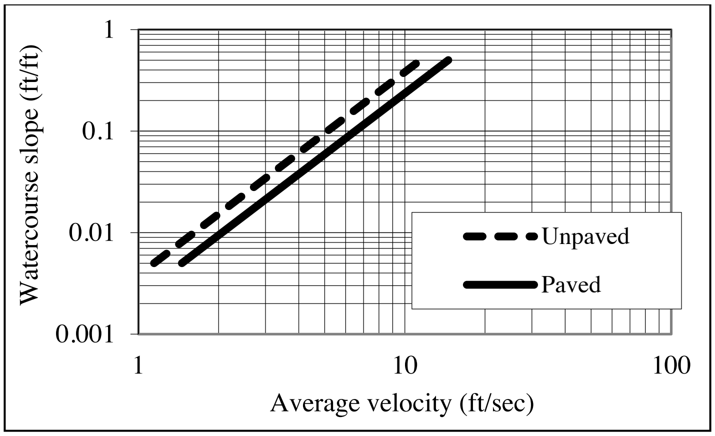


Figure 3. Avg. Velocities for Estimating Travel Time in Shallow Concentrated Flow Segments

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

$$Tt = L / (3600 \times V)$$ *Equation 6*

Where:

Tt = travel time (hr),
L = flow length (ft),
V = average velocity (ft/sec), and
3,600 = conversion factor from seconds to hours.

Channelized Flow

As the depth of concentrated flow increases, the shallow concentrated flow evolves into channelized flow. Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle maps. In the case of this analysis, channel flow either involves flow in man-made storm sewer infrastructure or flow in the natural channel. Manning's equation or water surface profile information (available from HEC-2 or HEC-RAS) can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevations. Both open channel and closed conduit systems can be included.

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.

3.4.3 Hydrograph Routing

Stream routing is used to modify hydrographs to reflect the effects of translation and attenuation within a channel reach. There are two stream routing techniques used in this analysis: 1) Muskingum-Cunge routing and 2) Modified Puls routing. Muskingum-Cunge routing is used downstream of Southwest Parkway and Modified Puls routing is used upstream of Southwest Parkway based on the development of a hydraulic model. Muskingum-Cunge does not account for riverine valley storage (overbank storage), whereas Modified Puls is a backwater routing technique that does account for valley storage.

The required input for Muskingum-Cunge routing includes: channel length, channel slope, Manning's roughness coefficients, and an estimate of the hydraulic grade line slope. If flow is primarily routed through a stormsewer, then pipe parameters are input. A trapezoidal channel shape is used to represent a typical channel section through each open channel routing reach. It is assumed that a composite Manning's n-value for a typical channel cross section in this study might range from 0.04 to 0.06.

Modified Puls routing is a considerably more detailed routing technique that allows the modeler to account for backwater effects within a reach. A storage-discharge relationship is developed for a range of flows for the various different reaches required for the hydrologic model. This storage-discharge relationship is extracted from the detailed hydraulic model generated as part of this hydraulic study. The range of flow rates is chosen to represent flows between and including the 50% and the 0.2% annual chance events. The storage-discharge relationship is divided into a specified number of subreaches in order to approximate the reach as a series of cascading reservoirs. Each reservoir is assumed to have a level pool, which implies a unique storage-discharge relationship. The number of subreaches is a function of the travel time (flood wave travel time) and the hydrologic model time interval. The number of subreaches may be computed as follows:

$$N = K / \Delta t$$ *Equation 8*

Where:

N = number of subreaches within a specific reach (dimensionless),
K = flood wave travel time within a specific reach (sec),
Δt = travel time for routing (sec).

Flood wave travel time may be computed as:

$$K = L / V_W$$ *Equation 9*

Where:

L = Channel reach length (feet)
V_W = Velocity of the flood wave (feet/sec)

The velocity of the flood wave is a direct ratio of the average velocity depending on the general channel shape. The ratio V_W / V is set to equal 1.67, 1.44, and 1.33 for wide rectangular, wide parabolic, and triangular channels, respectively. A ratio of 1.5 is standard engineering practice for natural channels and is assumed for this analysis. Single-subreach routing (N=1) implies that the downstream response is one time step from any change in the inflow hydrograph, which is indicative of a reservoir. As the number of subreaches increases, the attenuation effects of the reach begin to diminish.

3.5 Williamson Creek Overflow Hydrograph

A spillover hydrograph from Williamson Creek near the US State Hwy 290 crossing occurs between the Tributary 6 confluence and McCarty Lane. Based on the existing topography the overflow is estimated to enter into the Gaines Tributary watershed in and around the GAN05 subbasin.

In order to approximate the peak, size, and timing of this overflow hydrograph, the Williamson Creek HEC-RAS steady state hydraulic model has been truncated for this specific area of interest. The truncated model was converted into a HEC-RAS unsteady state model using the applicable hydrographs of Williamson Creek. After validating the peak flows were consistent between the steady state full and unsteady state truncated models, lateral weirs were introduced across the north bank of Williamson to mimic the overflow. Because two bridges exist across the overflow three lateral weirs were added between the Tributary 6 confluence and the US Hwy 290 ramp near cross section 738+62. Figure 4 depicts the approximate location of the modeled lateral weirs.

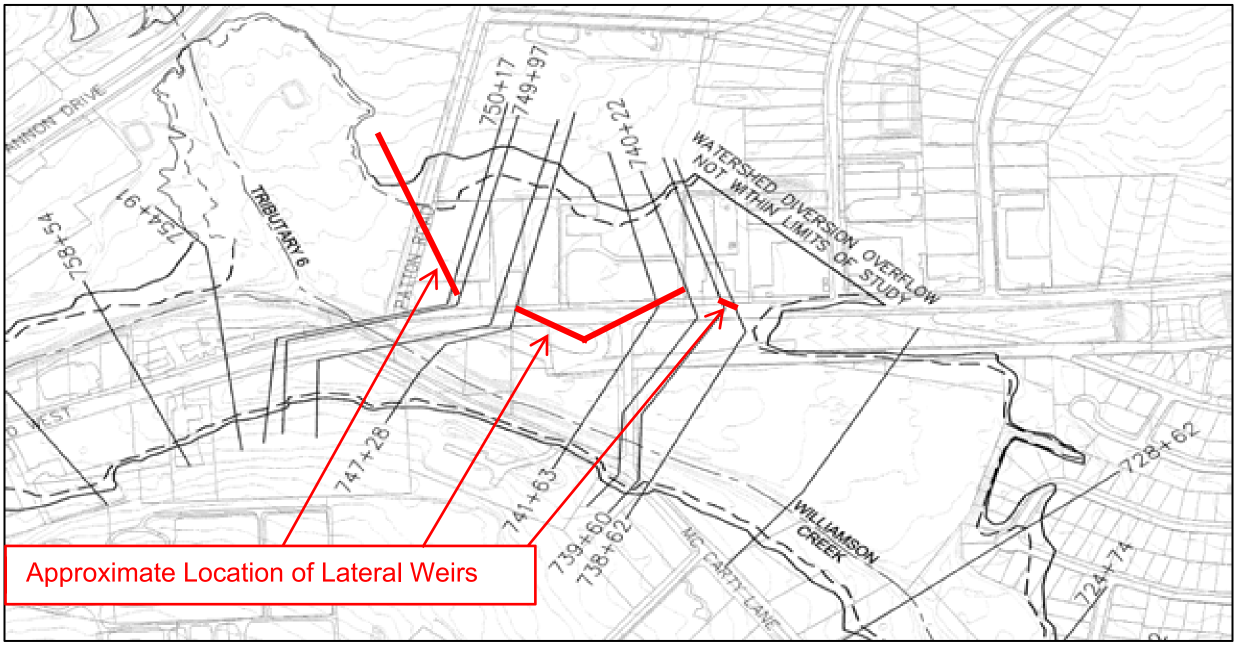


Figure 4. Williamson Creek Overflow Locations (Lateral Weirs)

After successful execution of the model the resulting hydrograph from the overflow was added into the HEC-HMS model as a source node to junction J_GAN05. The overflow hydrograph from Williamson is based on the Snyder unit hydrograph versus the NRCS that has been used for Gaines. Despite the differences in hydrograph methodologies the Williamson and Gaines both peak within 30 minutes of each other. Therefore; the results from the overflow from Williamson into Gaines represents a worst case scenario with the alignment of the peaks.

Numerous simulations have been performed by both RPS and staff from the City of Austin in an attempt to best quantify the overflow originating from Williamson. One of the simulations performed by staff resulted in higher peak flows and was therefore selected as the best representation of the overflow from Williamson Creek. The City provided hydrographs for the 4%, 1%, and 0.2% annual chance storm events to represent the overflow contribution from Williamson.

3.6 Hydrologic Analysis Results

The hydrologic results for the Gaines Tributary Watershed and also for the Williamson Creek overflow are presented in Appendix B. The digital data for the hydrologic analysis can be found in Appendix E of this report.

4 Hydraulics

4.1 Hydraulics Introduction

The reach of Gaines to be studied for the hydraulic scope of this study starts near the vicinity of Parkwood Dr. and ends just downstream of Southwest Parkway. There is a small portion of channel section that exists at the northern section of Parkwood Dr that drains an upstream portion originating from Vega Avenue through the Oak Park Subdivision that has also been analyzed in this study. The total length of stream studied is approximately 1.5 miles. The hydraulic analysis evaluates the existing conditions 50%, 20%, 10%, 4%, 2%, 1% and 0.2% annual chance storm events (2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events, respectively). The analysis also includes the evaluation of the fully developed conditions 50%, 20%, 10%, 4%, 2%, and 1% annual chance storm events. Gaines Tributary is completely contained within the City of Austin city limits, where the fully developed conditions 4% (25-year) floodplain serves as the regulatory floodway. The hydraulic model prepared as part of this analysis is geo-referenced for seamless integration into the City's GIS database.

The peak discharges developed with this study are used in the hydraulic models. The development of these peak discharges is described in detail in the Hydrology section of this study. The hydraulic analysis is used to establish flood elevations for the flooding sources in Gaines Tributary. The USACE HEC-RAS (HEC-RAS) software version 4.1.0 is used for the hydraulic analyses. The modeling is one-dimensional and steady state.

4.2 Hydraulic Methodology

The detail study methodology incorporates HEC-GeoRAS as a preprocessor to HEC-RAS. GeoRAS utilizes the geographically referenced data from the terrain model and miscellaneous shapefiles and with user input creates the input data file for HEC-RAS. HEC-RAS is then executed to determine the flood elevation at each cross section of the modeled stream. The resulting elevations are then imported back to GeoRas for creation of the flood boundaries.

4.2.1 Cross Sections

Model cross sections are placed along the study streams using the available contour data. Where roads or other structures are encountered, supplemental cross sections are entered to meet HEC-RAS data input needs. Survey data is collected for every detailed study structure. All data points collected for each structure are precisely captured and recorded. In addition to structures, natural channel cross sections are also captured. These cross sections are used to modify the channel portions of the cross sections derived from the terrain model.

4.2.2 Starting Water Surface Conditions

The downstream starting water surface elevation for Gaines is based on a normal depth calculation with a measured slope of 0.005 feet per foot. The model starts just downstream of the Southwest Parkway culvert crossing.

4.2.3 Ineffective Flow Areas

Ineffective flow areas are added to portions of various cross sections to accurately model any given section's ability to convey flow. Ineffective areas were modeled by 1) setting an ineffective flow area boundary in HEC-RAS with a test elevation that, if exceeded, would offer some level of conveyance, and 2) setting a permanent ineffective flow area boundary in HEC-RAS, which would permanently prevent that portion of the cross section from conveying flow. Examples of temporary ineffective flow areas include 1) minor swales parallel to the reach that eventually outfall into the reach or 2) crosses sections immediately upstream or downstream of an in-line structure. Examples of permanent ineffective flow area include 1) minor swales parallel to the reach, which do not outfall into the reach, or 2) off-line water quality / detention ponds. Streets are also evaluated on a case-by-case basis to determine whether or not that street offered flow conveyance to the system.

4.2.4 Parameter Estimation

The tables below show the various hydraulic parameters used to analyze the detailed reaches of the study. These tables are not reach specific, but rather, they apply to the project as a whole.

Table 3. Channel Manning's n Table

Type	Value
Concrete	0.015
Asphalt (street and parking lot)	0.02
Channel at bridges/culverts or uniform cross section with no vegetation	0.035
Channel, uniform cross section, straight, light vegetation	0.04
Channel, uniform cross section, straight, heavier vegetation	0.045
Channel, irregular cross section, meandering, brush	0.055
Channel, irregular cross section, meandering, heavier brush	0.06
Channel, irregular cross section, meandering, heavier brush with medium trees	0.07

Table 4. Overbank Manning's n Table

Type	Value
Asphalt (street and parking lot)	0.02
Asphalt (parking lot with obstacles)	0.03
Improved area, uniform cross section, straight, light vegetation	0.04
Improved area uniform cross section and straight	0.045
Natural area, uniform cross section, light/medium brush	0.05
Natural area, irregular cross section, medium brush	0.055
Natural area, irregular cross section, meandering, heavier brush	0.06
Natural area, irregular cross section, meandering, heavier brush, light trees	0.065
Natural channel, irregular cross section, meandering, heavier brush with medium trees	0.07
Light tree coverage, scattered tree clusters (10% - 25%)	0.08
Medium tree coverage (50%)	0.09
Heavy tree cover (>75%), commercial and residential areas (privacy fences not typical)	0.1
Residential areas with privacy fences typical	0.15

Table 5. Miscellaneous Hydraulic Coefficients Table

Coefficient Type	Value or Range
Expansion coefficients for bridges / culverts / in-line structures	0.3 to 0.5
Expansion coefficients for channels	0.3
Contraction coefficients for bridges / culverts / in-line structures	0.1 to 0.3
Contraction coefficients for channels	0.1
Weir coefficients (road deck)	2.6
Culvert entrance loss coefficient	0.5
Culvert exit loss coefficient	1
Lateral weir coefficient (split flow)	1.0 to 2.0

4.2.5 Hydraulic Floodplain Delineation

The hydraulic floodplain for each flood event, corresponding to each studied stream, is delineated on an ARCMAP generated terrain model. The City of Austin processed LIDAR point and line files are used to create triangular nodes, which in turn, form the surface of the terrain. It is on this surface that cross section stations and elevations are plotted to constitute the delineation of the floodplain for Gaines Tributary.

All floodplains were delineated on the three-dimensional surface of the terrain. It should be noted that this surface does not exactly match the two-dimensional surface of the contours. When discrepancies arose between the terrain and the contours, the width of the floodplain calculated in the model results is first satisfied, while delineating the exact water surface elevation on the contours is second priority. This methodology produces the most accurate delineation of the hydraulic floodplain.

Floodway delineation in the Gaines Tributary watershed conforms to the City of Austin regulations which establish the 4% (25-year) annual chance fully developed conditions floodplain as a conservative regulatory floodway rather than the traditional one-foot-rise floodway as defined by the National Flood Insurance Program.

Work map exhibits delineating the existing and fully developed floodplains (with proposed improvements) are included in Appendix A. Each work map contains contour information, cross section locations, and boundaries representing the delineated floodplain. A table summarizing the base flood elevations (BFE's) for each stream is included in Appendix C.

4.3 Results Conclusions

Results of the hydraulic analysis are summarized in the hydraulic summary tables in Appendix C and floodplain delineation plots for the various storm events, including the Williamson Creek overflow scenario can be found in Exhibits 5, 6, and 7 in Appendix A.

4.3.1 Gaines Tributary

Gaines Tributary drains approximately 1.9 square miles of land into Barton Creek. The total reach length for the portion of Gaines that has been studied is 7,920 feet. There are 32 cross sections and 7 culvert crossings in the hydraulic model. Results of the hydraulic analysis reveal that every structure except for the Southwest Parkway crossing are overtopped during the 1-percent-annual-chance flood. Most of Gaines is unimproved with mostly a rock bottom, grass and/or dense vegetation side slopes, and partially developed overbanks. The downstream starting water surface elevation for this reach is based on a normal depth calculation with a measured slope of 0.005 feet per foot. Appendix C contains a table summary of the existing conditions and fully developed conditions computed water surface elevations.

4.3.2 Oak Park North Tributary Reach

A small unnamed tributary crosses Parkwood Drive and Oakclaire Drive just north of Oakclaire Lane. This reach drains approximately 117 acres of land through a small culvert and ditch system crossing the northern portion of the Oak Park Subdivision. The type of flow entering the subdivision is shallow concentrated due to the absence of a defined channel section just upstream of Parkwood Dr. The flow concentrates into a small channel section as it enters the subdivision just upstream of Parkwood Dr. After draining across Parkwood Dr. and then crossing Oakclaire Dr., the flow transitions back to shallow concentrated flow through the undeveloped tract of land just east of the subdivision. This channel has little carrying capacity with overflows traveling down both Parkwood Drive and Oakclaire Drive before eventually making it down to Gaines. The stream section never really becomes defined across the undeveloped tract as it stays in a shallow concentrated condition until it outfalls into Gaines tributary. Visual observation of numerous shallow fingers along with a field survey of the centerline of the flow paths confirm that the path of flow from this area does generally drain south towards Gaines Tributary. Because this stream section is only defined through the short channel section crossing the Oak Park Subdivision, a separate hydraulic model has been created using a normal depth starting condition of 0.017. Appendix C contains a table summary of the existing conditions and fully developed conditions computed water surface elevations.

4.4 Conclusions

The contributing drainage area to Gaines Tributary and the overflow from Williamson Creek are both significant contributors to the riverine flooding that has been experienced. The flooding that occurs from the contributing drainage area of Gaines alone, without the contributions of the overflows from Williamson, makes up a majority of the source flooding that both the Oak Park and Oak Acres Subdivisions are experiencing. The overflow from Williamson compounds the flooding further. The following summary provides an approximate quantity on the area and number of structures (within or touched by the inundation limits of the floodplain) that are being impacted by the existing conditions 1% storm event in Gaines Tributary.

	1% Gaines Only	**1% Williamson Overflow**
Inundation Area (AC)	52	59
Homes within Floodplain	18	25

The area of the floodplain and the number of homes within the floodplain are approximate and reflective of riverine flooding from Vega Avenue to Southwest Parkway. Additionally, there are approximately 19 homes that are being impacted from the Oak Park tributary near Parkwood Drive and Oakclaire Drive.

5 Floodplain Mitigation Improvements

The scope of this project includes identifying flood control improvements within Gaines Tributary to reduce floodplain inundation limits by way of reducing base flood elevations and/or conveyance improvements. Structural flood controls such as detention ponds, flood diversion improvements, conveyance improvements, etc., are potential construction projects that could be built in an effort to alter the flood condition of a watershed. These projects have a high variability in complexity and cost. *Regional detention ponds* are large impoundments of floodwater that reduces peak flow rates downstream. *Flood diversion improvements* consist of improvements that redirect floodwaters away from the main source of flooding. *Conveyance improvements* include structural improvements that increase the flood carrying capacity of the stream, such as bridge/culvert upgrades and channel improvements.

Because of the unavailability of suitable land from the Williamson overflow to the main stem of Gaines the use of a regional detention pond is not a viable option and therefore not considered. A flood diversion structure had been initially considered as a potential alternative for preventing Williamson Creek from overflowing into Gaines. However, with the contributing drainage area of Gaines being a huge source of flooding by itself, the addition of a flood diversion structure would not solve the current flooding problems in Gaines. Therefore, channel improvements to the creek and culvert upgrades at each of the existing road crossings will be necessary to reduce base flood elevations and bring the floodplain into the banks of Gaines Tributary.

5.1 Conveyance Improvements

The structural improvements needed to reduce base flood elevations and contain the floodplain within the banks of the creek have been sized for the 1% storm event in accordance with the City of Austin's Drainage Criteria Manual (DCM). Structural improvements have been identified for Gaines Tributary and the Oak Park tributary within the northern part of the Oak Park Subdivision.

5.1.1 Gaines Only Structural Improvements

The improvements needed consist of a combination of channel widening improvements as well as culvert upgrades at each of the three road crossings within the Oak Park and Oak Acres Subdivisions. The improvements that have been chosen reflect existing constraints that include roadway elevations, channel slopes, and culvert depths. Exhibit 8 in Appendix A provides a graphical representation of the channel widening improvements and culvert upgrades. These improvements are summarized below.

Channel Improvements:

Station 113+29 to 97+14, Bottom Width = 100’
Station 124+94 to 113+29, Bottom Width = 75’
Station 138+49 to 130+46, Bottom Width = 20’
Station 140+37 to 139+36, Bottom Width = 20’

Culvert Upgrades:

Oak Boulevard………..10 – 6’x 3’ Box Culverts
Oakclaire Dr…………..2 – 7’x 4’ Box Culverts
Parkwood Dr………….2 – 7’x 4’ Box Culverts

Table 6: Cost Estimate for Gaines Only

Item	Description	Quantity	Unit	Unit Price	Amount
	Engineers Opinion of Probable Cost Channel Improvements and Culvert Upgrades Gaines Only				
120S	Channel Excavation	14500	CY	$ 30.00	$ 435,000.00
102S	Misc. Demolition	1	LS	$ 100,000.00	$ 100,000.00
559S	50' - 6'x3' RCB (including misc. concrete works)	10	EA	$ 15,000.00	$ 150,000.00
559S	50' - 7'x3' RCB (including misc. concrete works)	2	EA	$ 20,000.00	$ 40,000.00
559S	50' - 7'x3' RCB (including misc. concrete works)	2	EA	$ 20,000.00	$ 40,000.00
200S	Phased Road Reconstruction at Crossings	900	LF	$ 700.00	$ 630,000.00
600S	Misc. Erosion & Sedimentation Controls	1	LS	$ 100,000.00	$ 100,000.00
608S	Planting & Revegetation	1	LS	$ 100,000.00	$ 100,000.00
	Subtotal				$ 1,595,000.00
	Engineering and Permitting (Federal, State & Local)	30%			$ 478,500.00
	Construction Contingency	35%			$ 558,250.00
	Total Project Construction Cost				$ 2,631,750.00
	Property Buyout and Acquisition Cost (including closing and other miscellaneous soft cost)	6	Homes	$ 405,000.00	$ 2,430,000.00
	Easement Acquisition Cost	427800	SF	$ 1.00	$ 427,800.00

The approximate costs for channel excavation reflect the widening improvements as well as necessary stream bank and channel stabilization measures. These improvements would warrant the removal of approximately six homes. The buyout of the properties includes the property values listed on the Travis County Appraisal District (TCAD) tax roll with an added percentage (50% increase to TCAD property value) to cover miscellaneous soft cost (appraisal, closing costs, inspections, asbestos testing/abatement, demolition, and relocation benefits ,etc).

5.1.2 Williamson Creek Overflow Structural Improvements

For the Williamson overflow condition, the structural improvements have been increased to account for the additional flows. There is additional channel widening that will be needed in the headwaters where the overflow enters into Gaines but along with increased culvert capacity at each of the road crossings. Exhibit 9 in Appendix A provides a graphical representation of the channel widening improvements and culvert upgrades needed for this scenario. These improvements are summarized below.

Channel Improvements:
Station 113+29 to 97+14, Bottom Width = 100’
Station 124+94 to 113+29, Bottom Width = 75’
Station 138+49 to 130+46, Bottom Width = 50’
Station 140+37 to 139+36, Bottom Width = 40’

Culvert Upgrades:
Oak Boulevard………..12 – 6’x 4’ Box Culverts
Oakclaire Dr…………..8 – 7’x 4’ Box Culverts
Parkwood Dr………….7 – 7’x 4’ Box Culverts

Table 7: Cost Estimate for Williamson Overflow

Engineers Opinion of Probable Cost Channel Improvements and Culvert Upgrades Gaines with Williamson Overflow					
Item	Description	Quantity	Unit	Unit Price	Amount
120S	Channel Excavation	16000	CY	$ 30.00	$ 480,000.00
102S	Misc. Demolition	1	LS	$ 100,000.00	$ 100,000.00
559S	50' - 6'x3' RCB (including misc. concrete works)	12	EA	$ 15,000.00	$ 180,000.00
559S	50' - 7'x3' RCB (including misc. concrete works)	8	EA	$ 20,000.00	$ 160,000.00
559S	50' - 7'x3' RCB (including misc. concrete works)	7	EA	$ 20,000.00	$ 140,000.00
200S	Phased Road Reconstruction at Crossings	900	LF	$ 700.00	$ 630,000.00
600S	Misc. Erosion & Sedimentation Controls	1	LS	$ 100,000.00	$ 100,000.00
608S	Planting & Revegetation	1	LS	$ 100,000.00	$ 100,000.00
	Subtotal				$ 1,890,000.00
	Engineering and Permitting (Federal, State & Local)	30%			$ 567,000.00
	Construction Contingency	35%			$ 661,500.00
	Total Project Construction Cost				**$ 3,118,500.00**
	Property Buyout and Acquisition Cost (including closing and other miscellaneous soft cost)	6	Homes	$ 405,000.00	$ 2,430,000.00
	Easement Acquisition Cost	448800	SF	$ 1.00	$ 448,800.00

The approximate costs for channel excavation reflect the widening improvements as well as necessary stream bank and channel stabilization measures. These improvements would warrant the removal of approximately six homes. The buyout of the properties includes the property values listed on the Travis County Appraisal District (TCAD) tax roll with an added percentage to cover miscellaneous soft cost (appraisal, closing costs, inspections, asbestos testing/abatement, demolition, and relocation benefits,etc).

5.1.3 Oak Park North Tributary Structural Improvements

The structural improvements needed to reduce base flood elevations and contain the floodplain within the small unnamed tributary that crosses Parkwood Drive and Oakclaire Drive just north of Oakclaire Lane are summarized on Exhibit 9 in Appendix A. These improvements include:

Channel Improvements:
Station 10+20 to 2+05, Bottom Width = 16’

Culvert Upgrades:
Parkwood Dr…………..2 – 8’x 3’ Box Culverts

Oakclaire Dr…………..2 – 8’x 3’ Box Culverts

Table 8: Cost Estimate for Oak Park Tributary

Item	Description	Quantity	Unit	Unit Price	Amount
	Engineers Opinion of Probable Construction Cost Channel Improvements and Culvert Upgrades Oak Park Tributary				
Item	Description	Quantity	Unit	Unit Price	Amount
120S	Channel Excavation	2100	CY	$ 30.00	$ 63,000.00
102S	Misc. Demolition	1	LS	$ 10,000.00	$ 10,000.00
559S	50' - 7'x4' RCB (including misc. concrete works)	4	EA	$ 20,000.00	$ 80,000.00
559S	50' - 6'x4' RCB (including misc. concrete works)	5	EA	$ 18,000.00	$ 90,000.00
200S	Phased Road Reconstruction at Crossings	200	LF	$ 700.00	$ 140,000.00
600S	Misc. Erosion & Sedimentation Controls	1	LS	$ 10,000.00	$ 10,000.00
608S	Planting & Revegetation	1	LS	$ 10,000.00	$ 10,000.00
	Subtotal				$ 403,000.00
	Engineering and Survey	15%			$ 60,450.00
	Construction Contingency	35%			$ 141,050.00
	Total Project Construction Cost				**$ 604,500.00**
	Property Buyout and Acquisition Cost (including closing and other miscellaneous soft cost)	8	Homes	$ 405,000.00	$ 3,240,000.00

The approximate costs for channel excavation reflect the widening improvements as well as necessary stream bank and channel stabilization measures. These improvements would warrant the removal of approximately eight homes. The buyout of the properties includes the property values listed on the Travis County Appraisal District (TCAD) tax roll with an added percentage to cover miscellaneous soft cost (appraisal, closing costs, inspections, asbestos testing/abatement, demolition, and relocation benefits,etc).

5.2 Summary of Improvements

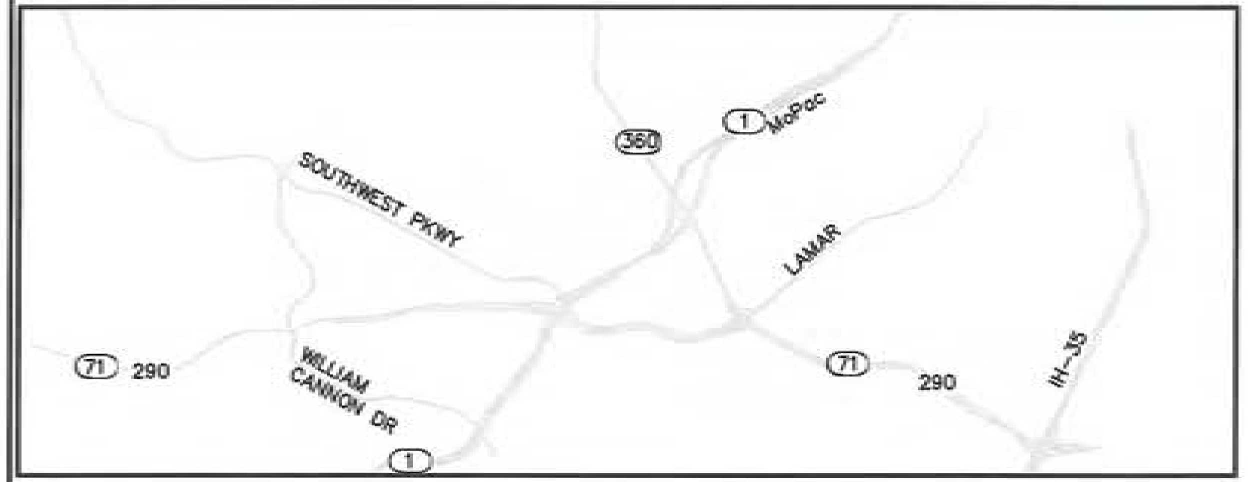
The channel improvements and the upgrade of culverts at Oak Boulevard, Oakclaire Drive, and Parkwood Drive are needed to bring the floodplain back into the banks of Gaines Tributary for the Gaines only and the Williamson Overflow scenarios. The improvements needed for the Gaines only scenario are less than the improvements needed for the Williamson Overflow scenario but accounts for roughly 85% of the total cost.

Unless the overflows from Williamson can be prevented from discharging into Gaines the Williamson Overflow scenario represents the actual 1% floodplain delineation. The Gaines only scenario is for reference purposes and is not a representation of actual flooding conditions when Williamson Creek overtops.

The benefits associated with the improvements proposed is that the floodplain will be contained within the banks of Gaines and remove the homes quantified in Section 4.4 from the floodplain. Additionally Oak Boulevard, Oakclaire Drive, and Parkwood Drive will be passable during a 1% storm event. The exception to the homes benefitting from the improvements are the four to five homes that will likely need to be removed due to their proximity to where the channel widening improvements will need to occur.

Appendix A – Exhibits

Exhibit 1 – Site Location/Drainage Area Map



LEGEND

DRAINAGE AREA BOUNDARY

MAJOR CONTOUR

MINOR CONTOUR

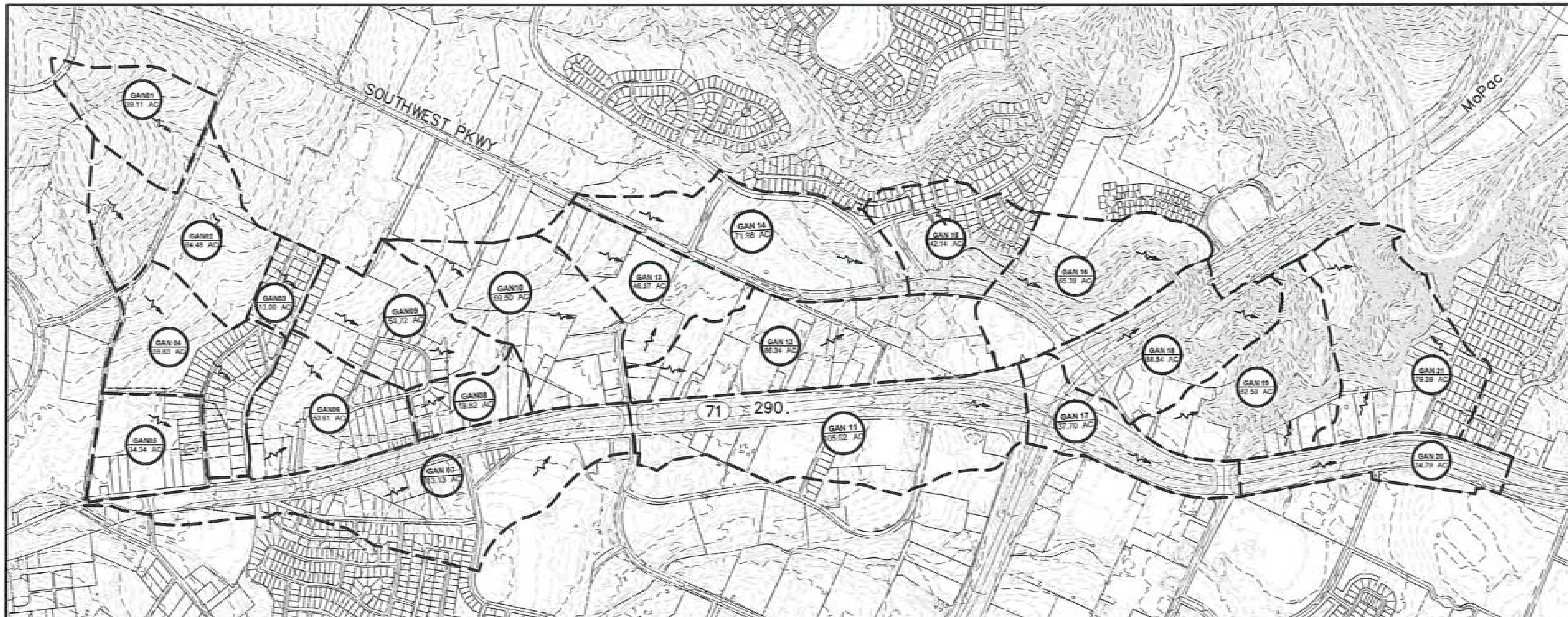
DRAINAGE AREA NAME

DRAINAGE AREA ACRES

N

0 1,200' 2,400'

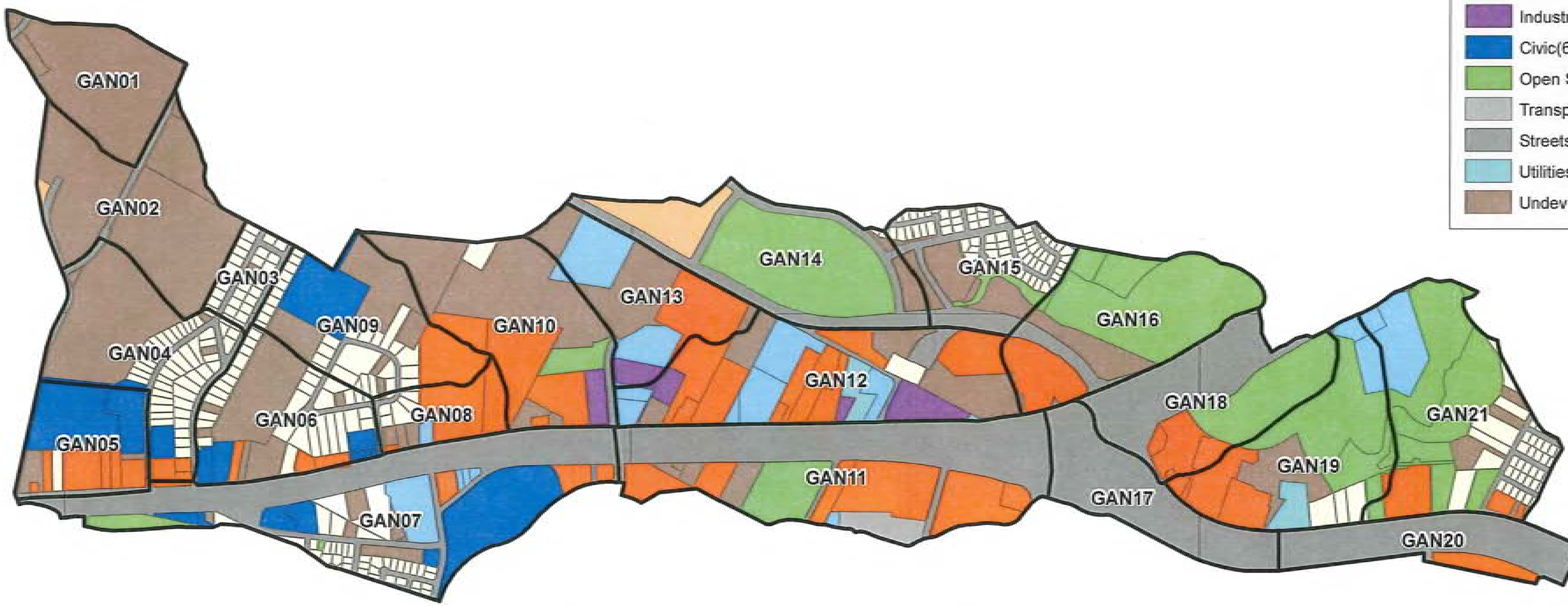
SCALE IN FEET



RPS — 4801 Southwest Parkway, Parkway 2, Suite 150 Austin, Texas 78735 (512) 326-5659 TBPE #F-293	**EXHIBIT 1** SITE LOCATION/DRAINAGE AREA MAP GAINES TRIBUTARY AUSTIN, TRAVIS CO, TX NOV 2013 — 11005.20

P:\Active\11005.20_Gaines_Tributary\CADD-11005.20\FINAL DWG FOR REPORT\11005.20sxh DAM 11 2013 10/29/2013 2:46 PM

Exhibit 2 – Existing Conditions Land Use Map



Legend

Existing Land Use

- Single Family (100) or Duplex (150)
- Multi-family (200)
- Commercial and Mixed-Use(300)
- Office (400)
- Industrial (500)
- Civic(600)
- Open Space (700)
- Transportation (800)
- Streets and Roads (860)
- Utilities (870)
- Undeveloped (900)

N

1,200 600 0 1,200 2,400 Feet

Existing Land Use Map

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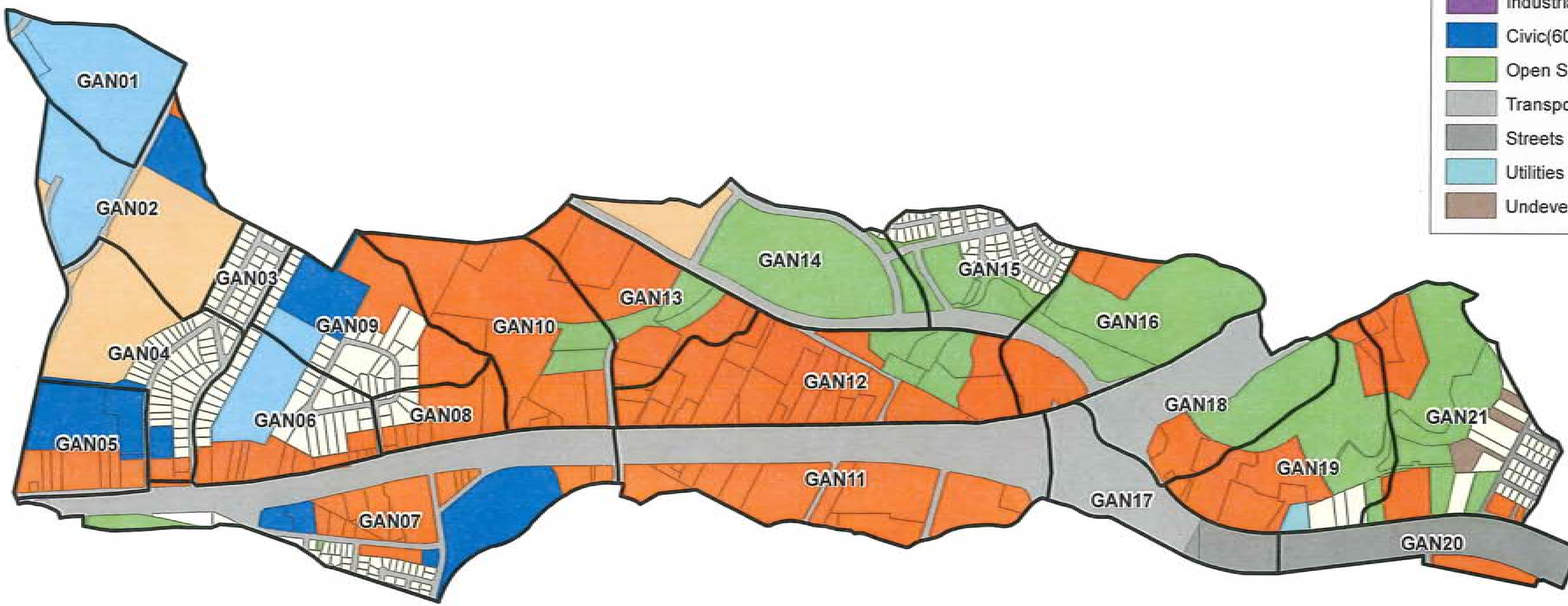
Exhibit 3 – Future Land Use Map



Legend

Future Land Use

- Single Family (100) or Duplex (150)
- Multi-family (200)
- Commercial and Mixed-Use (300)
- Office (400)
- Industrial (500)
- Civic(600)
- Open Space (700)
- Transportation (800)
- Streets and Roads (860)
- Utilities (870)
- Undeveloped (900)

N

1,200 600 0 1,200 2,400 Feet

Future Land Use Map

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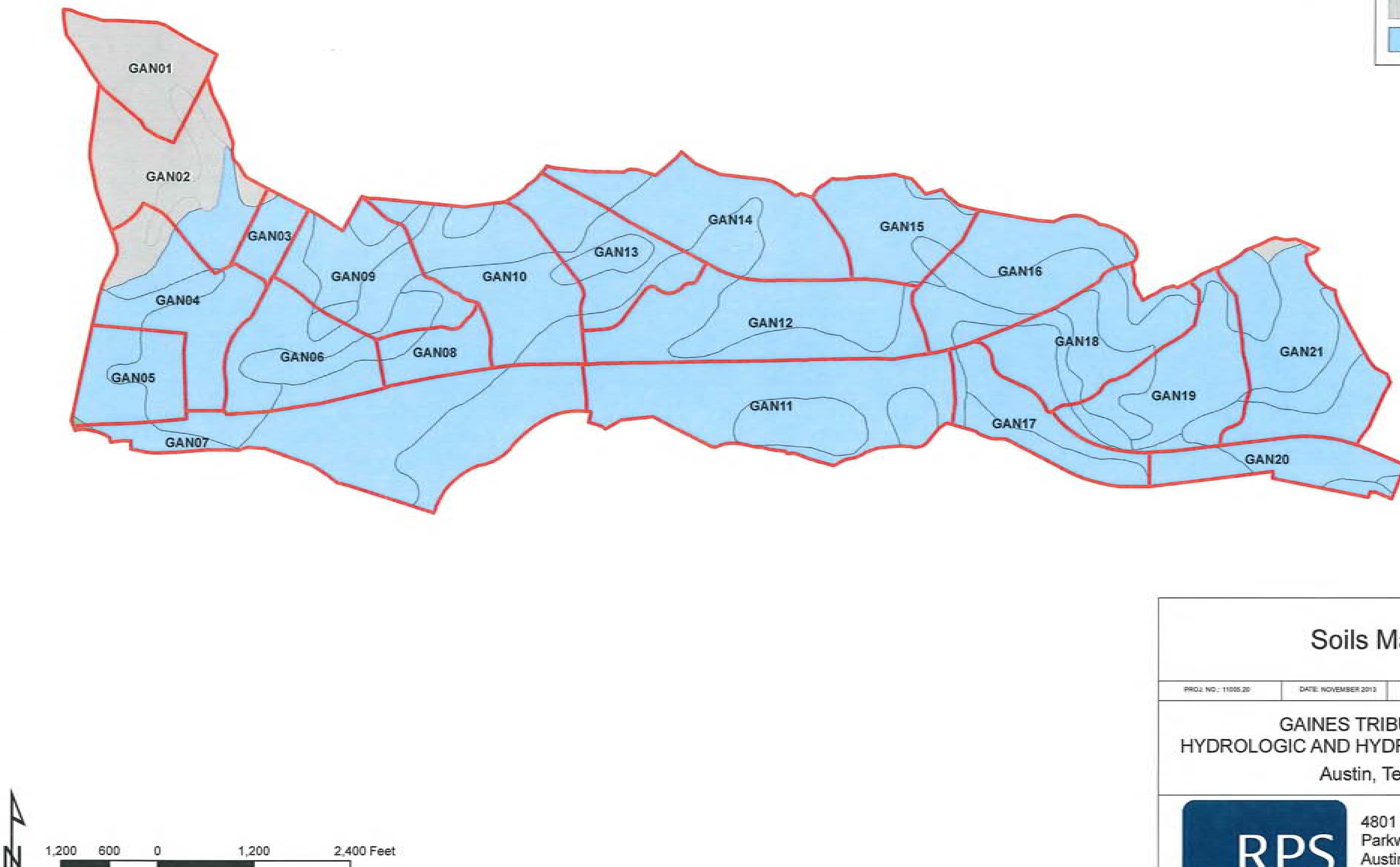
Exhibit 4 – Hydrologic Soils Group Map



Legend

Soils Hydro Group

- A
- C
- D

Soils Map

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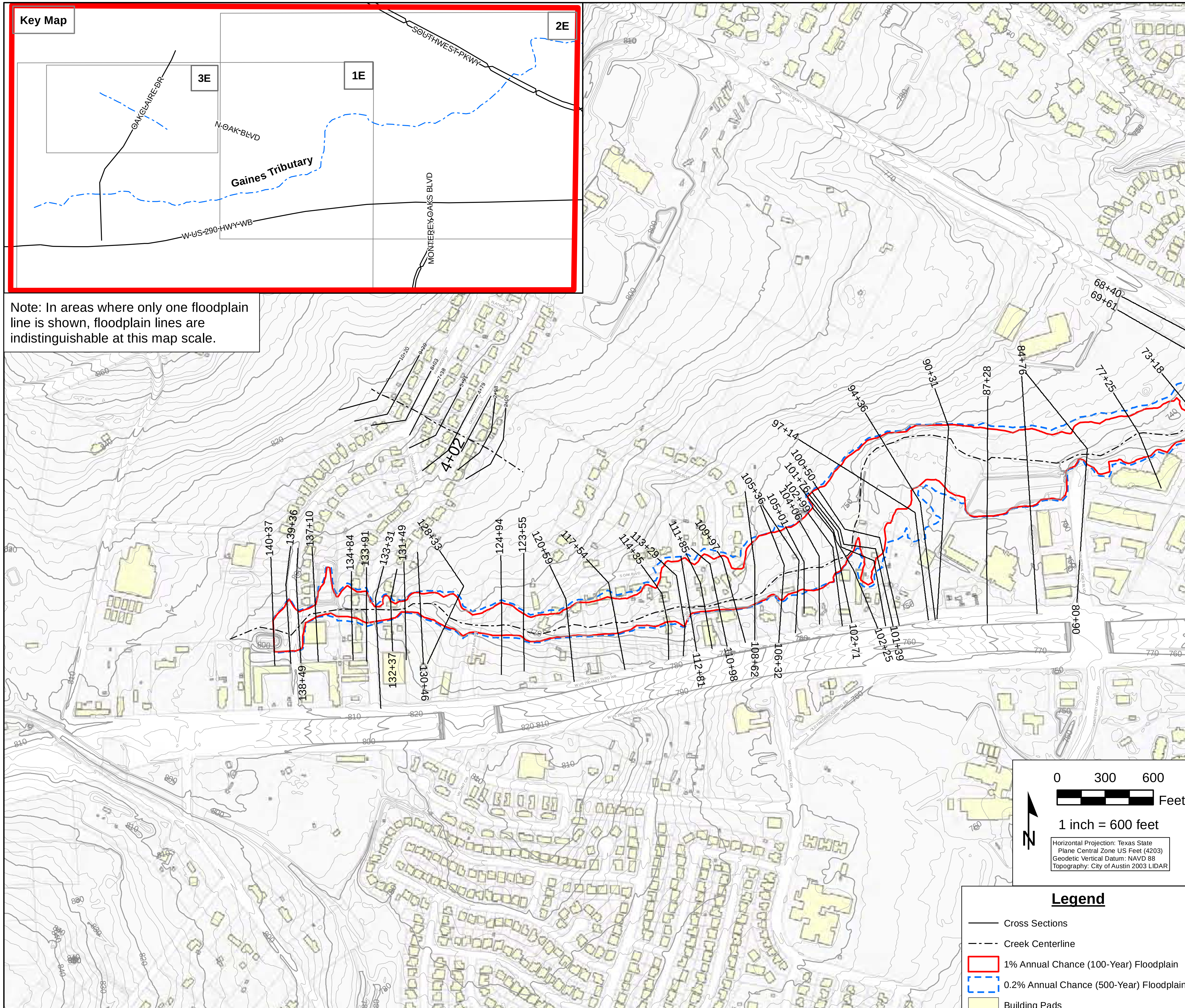
Exhibit 5 – Existing Conditions Floodplains



Legend

- Cross Sections
- Creek Centerline
- 1% Annual Chance (100-Year) Floodplain
- 0.2% Annual Chance (500-Year) Floodplain
- Building Pads

Exhibit 5 Key Map
Existing Conditions Floodplains

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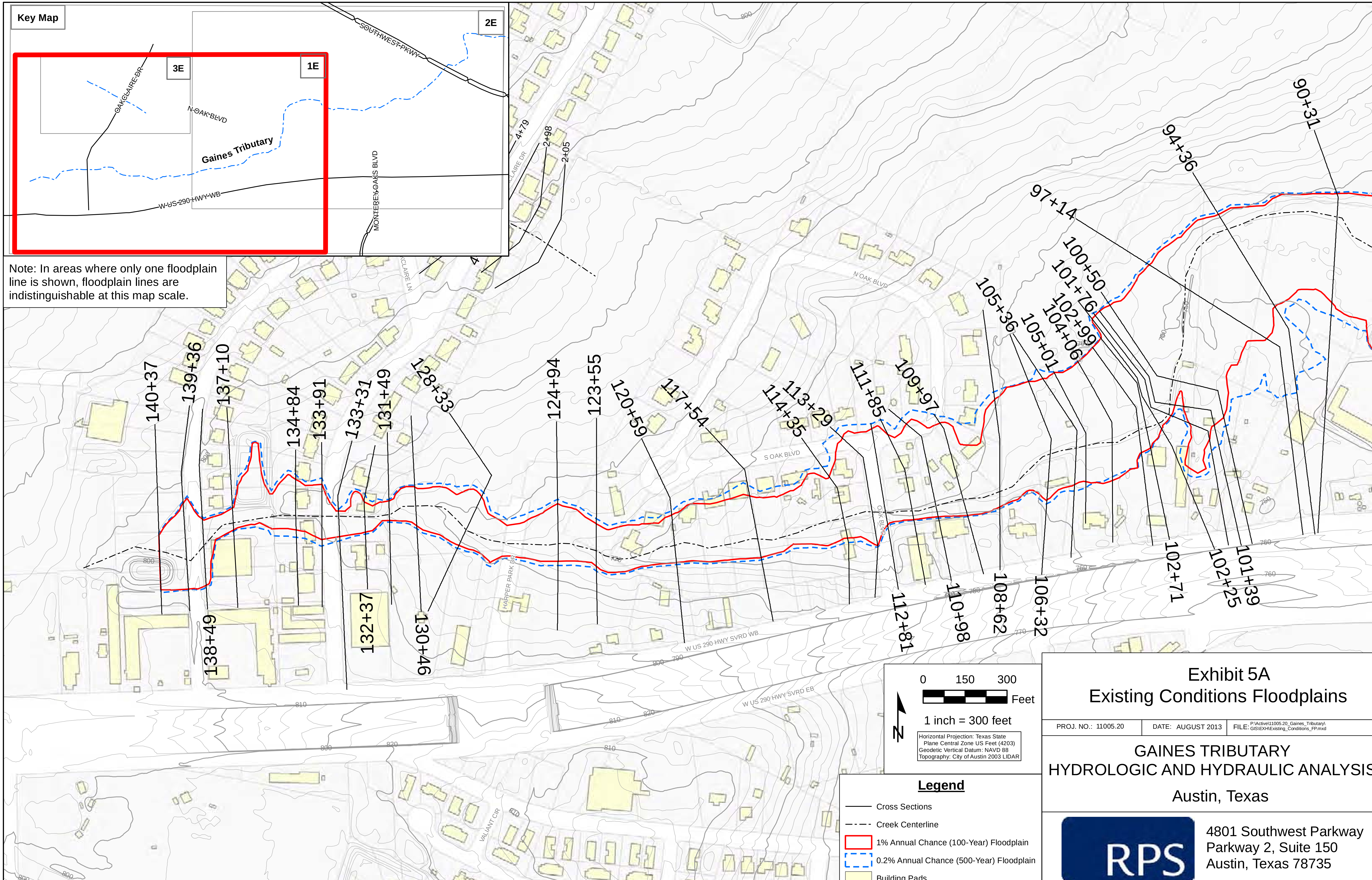

Exhibit 5A
Existing Conditions Floodplains

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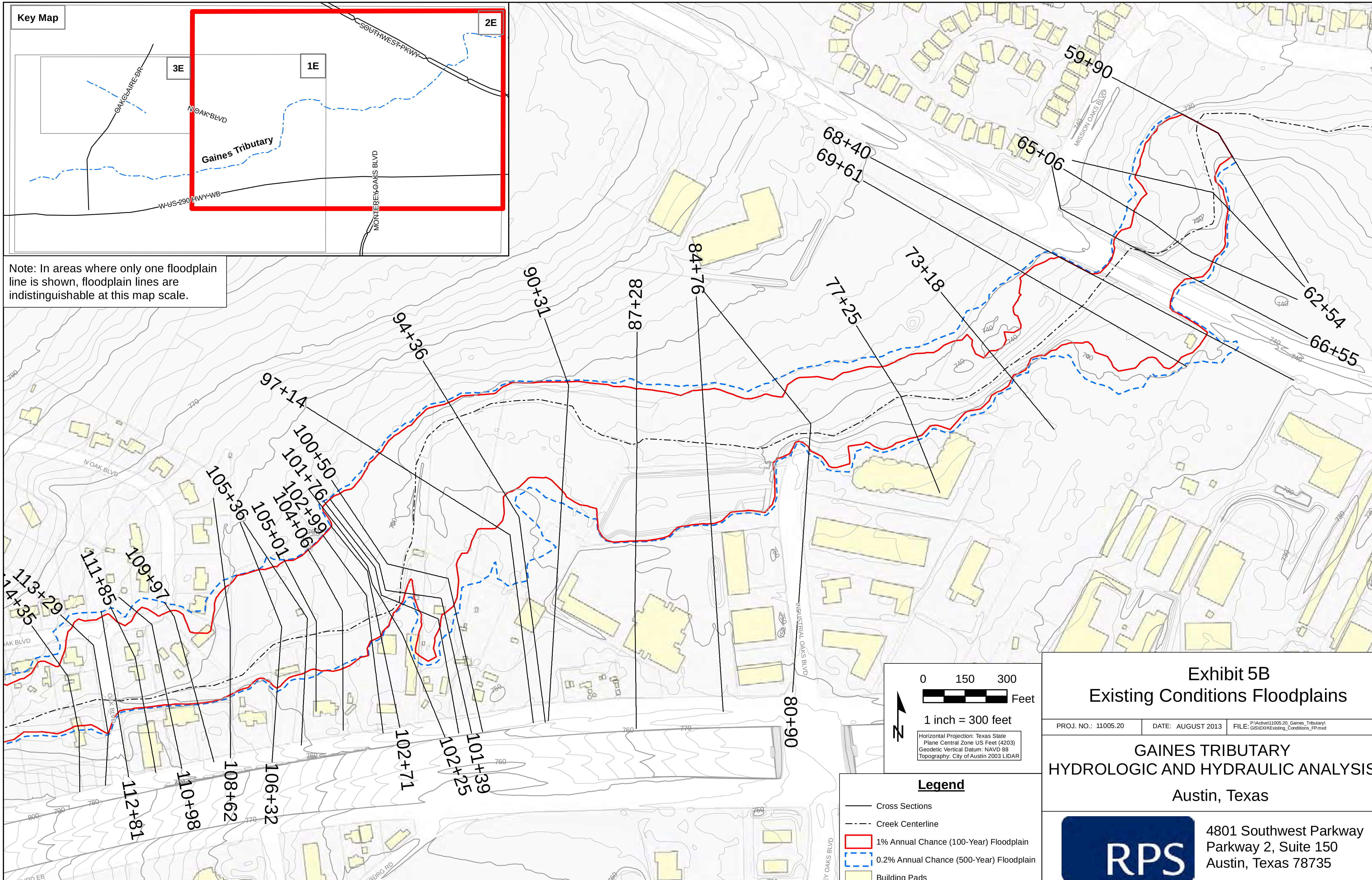
Key Map
3E
1E
2E
SOUTHWEST PKWY
OAKCLAIRE DR
N OAK BLVD
Gaines Tributary
W US 290 HWY WB
MONTEREY OAKS BLVD
Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.
59+90
62+54
65+06
66+55
68+40
69+61
73+18
77+25
80+90
84+76
87+28
90+31
94+36
97+14
100+50
101+39
101+76
102+25
102+71
102+99
104+06
105+01
105+36
106+32
108+62
109+97
110+98
111+85
112+81
113+29
114+35
MISSION OAKS BLVD
INDUSTRIAL OAKS BLVD
N OAK BLVD
0 150 300 Feet
1 inch = 300 feet
N
Horizontal Projection: Texas State Plane Central Zone US Feet (4203)
Geodetic Vertical Datum: NAVD 88
Topography: City of Austin 2003 LIDAR
Legend
Cross Sections
Creek Centerline
1% Annual Chance (100-Year) Floodplain
0.2% Annual Chance (500-Year) Floodplain
Building Pads
Exhibit 5B
Existing Conditions Floodplains
PROJ. NO.: 11005.20
DATE: AUGUST 2013
FILE: P:\Active\11005.20_Gaines_Tributary\GIS\EXH\Existing_Conditions_FP.mxd
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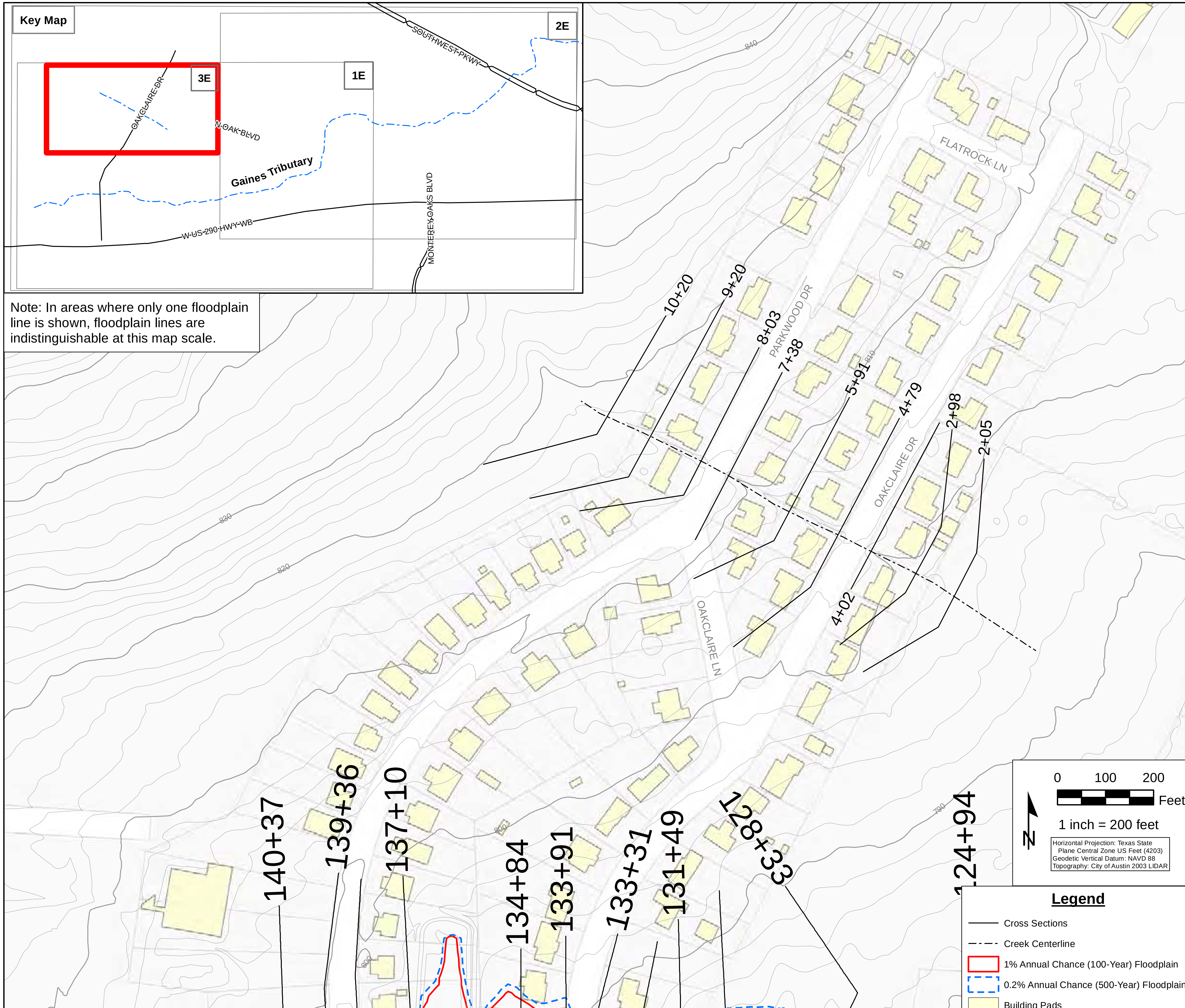

Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.

0 100 200 Feet

1 inch = 200 feet

N

Horizontal Projection: Texas State Plane Central Zone US Feet (4203)
Geodetic Vertical Datum: NAVD 88
Topography: City of Austin 2003 LIDAR

Legend

- Cross Sections
- Creek Centerline
- 1% Annual Chance (100-Year) Floodplain
- 0.2% Annual Chance (500-Year) Floodplain
- Building Pads

Exhibit 5C
Existing Conditions Floodplains

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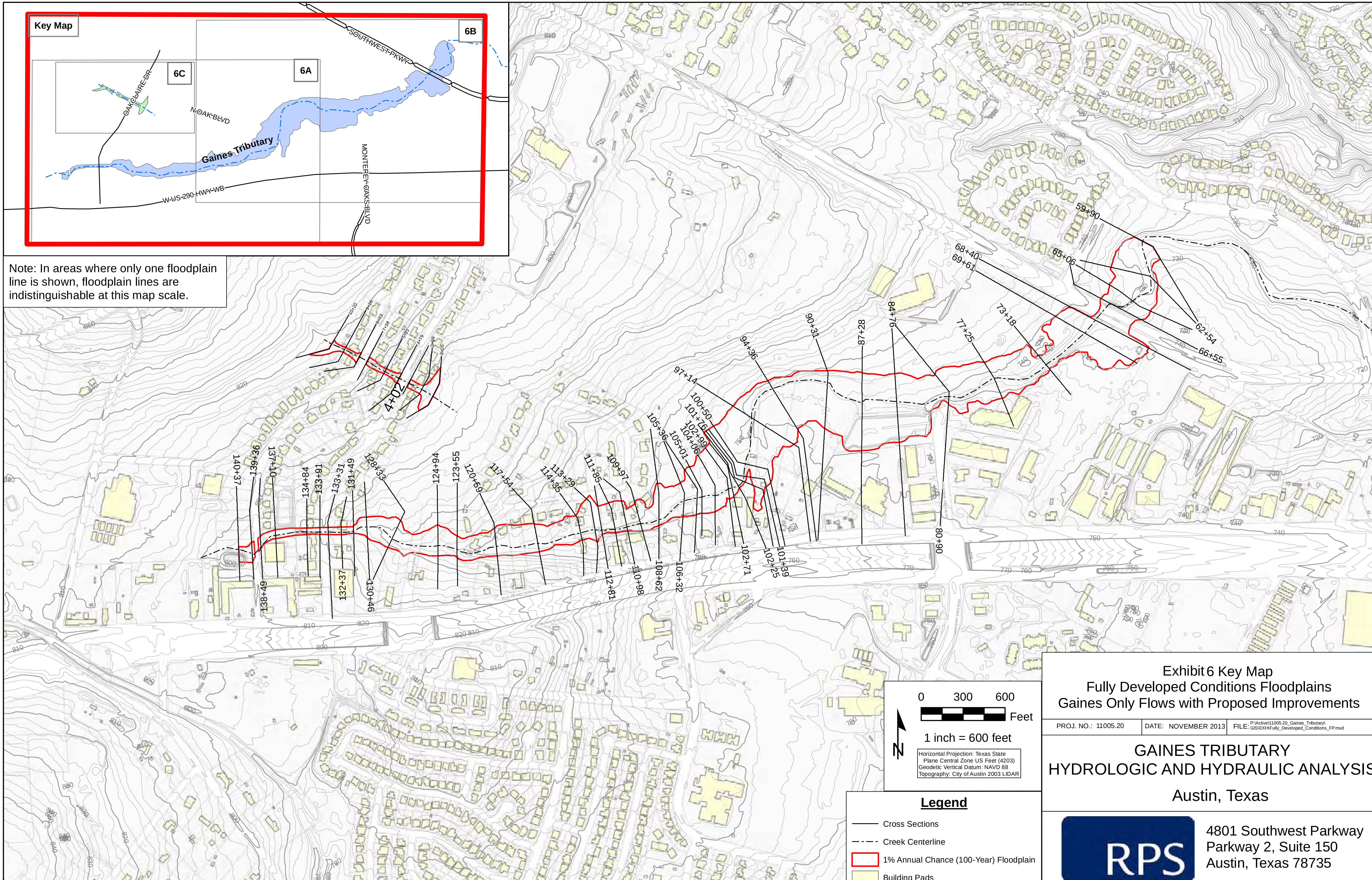
Exhibit 6 – Fully Developed Conditions Floodplains (Gaines Only Flows with Proposed Improvements)



Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.

0 300 600 Feet

1 inch = 600 feet

N

Horizontal Projection: Texas State Plane Central Zone US Feet (4203)
Geodetic Vertical Datum: NAVD 88
Topography: City of Austin 2003 LIDAR

Legend

- Cross Sections
- Creek Centerline
- 1% Annual Chance (100-Year) Floodplain
- Building Pads

Exhibit 6 Key Map
Fully Developed Conditions Floodplains
Gaines Only Flows with Proposed Improvements

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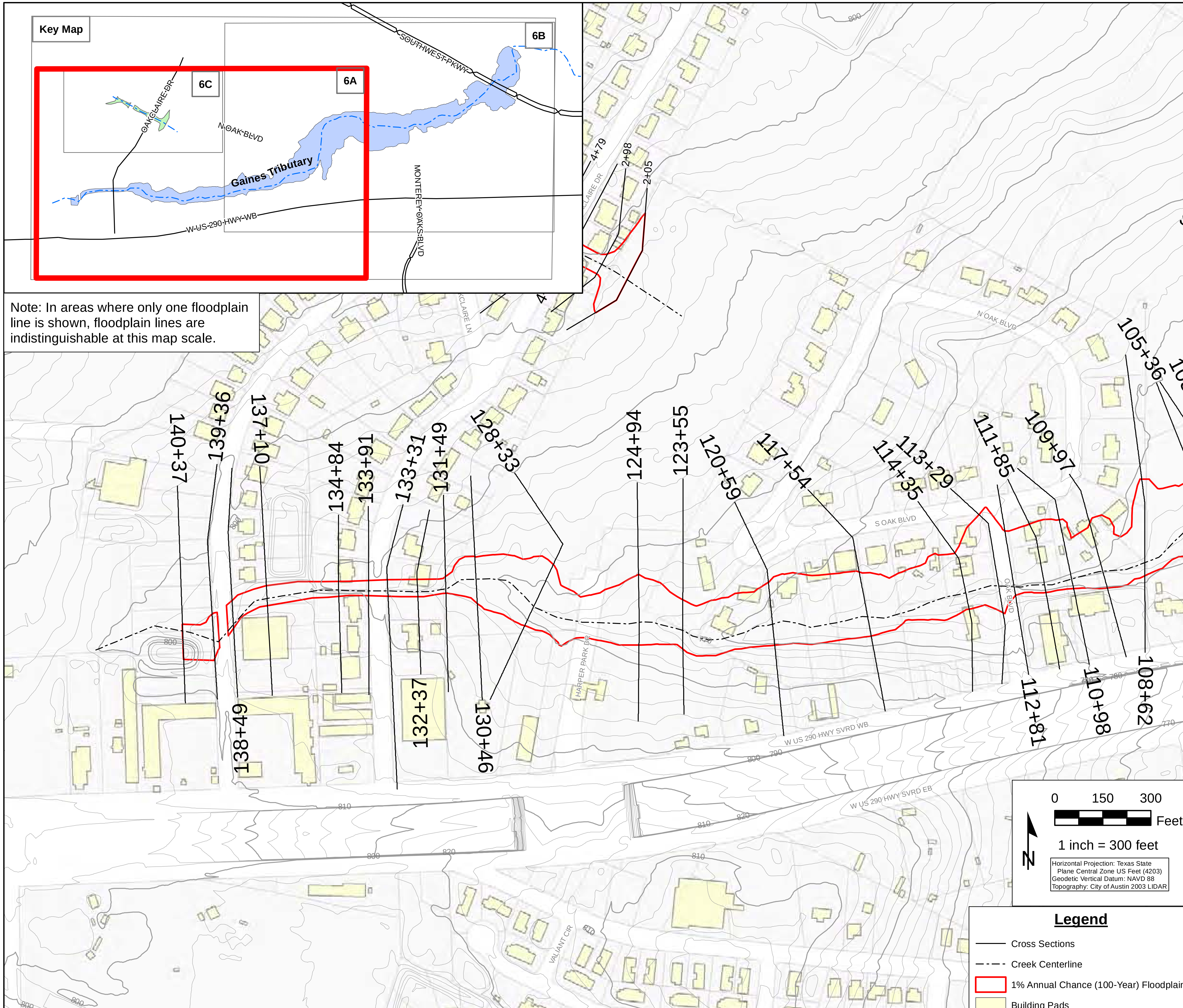

Exhibit 6A
Fully Developed Conditions Floodplains
Gaines Only Flows with Proposed Improvements

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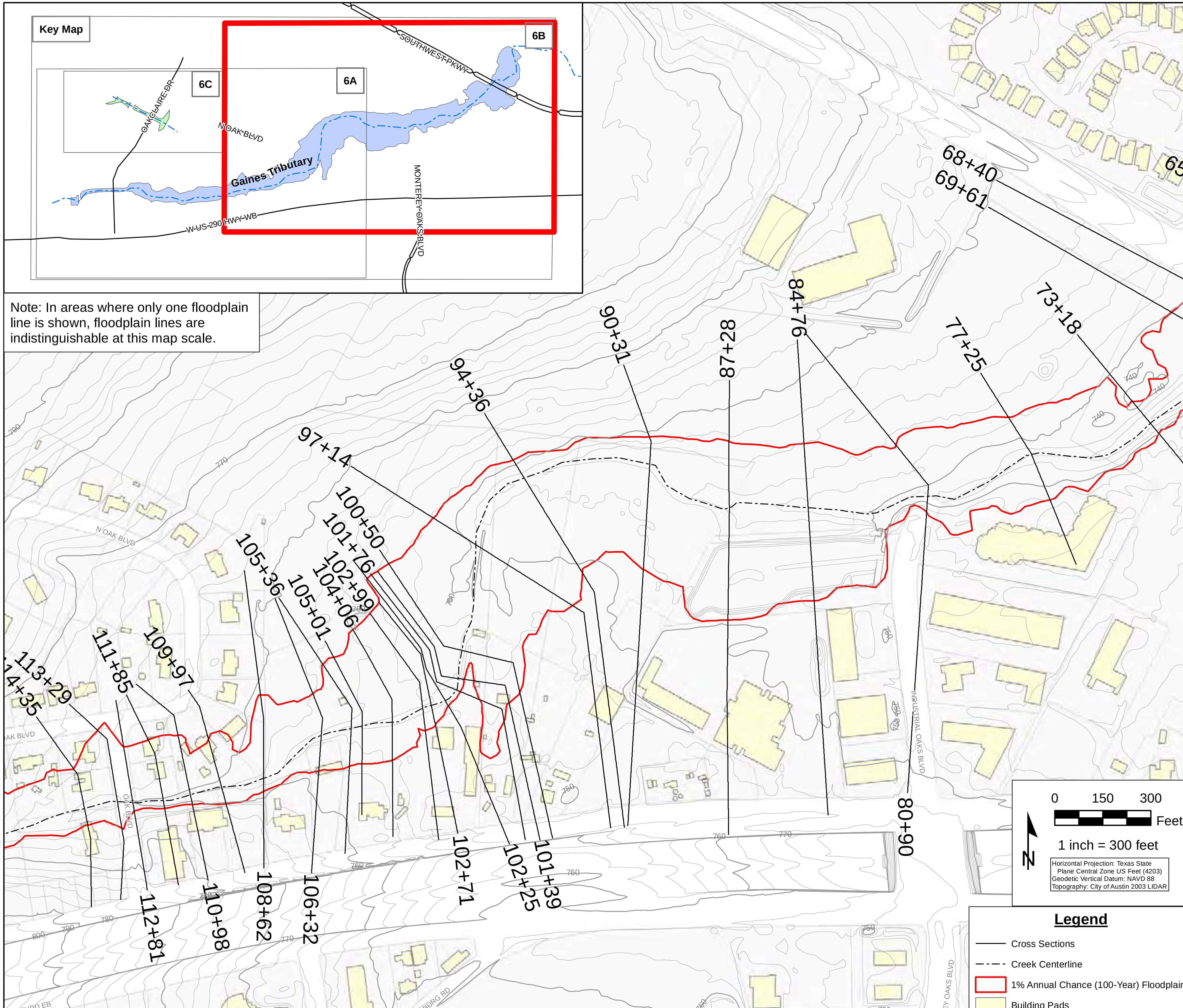

Exhibit 6B
Fully Developed Conditions Floodplains
Gaines Only Flows with Proposed Improvements

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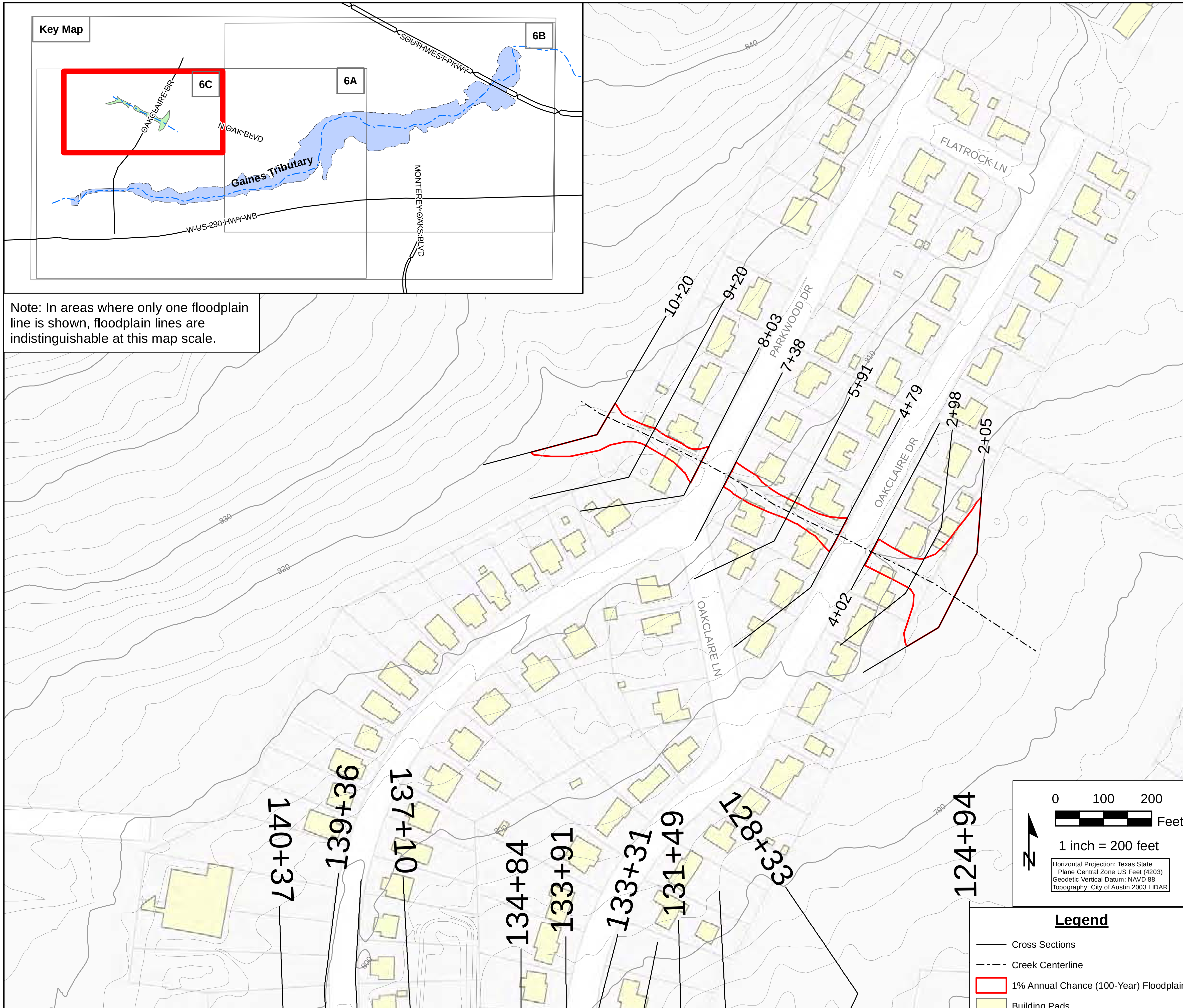

Exhibit 6C

Fully Developed Conditions Floodplains

Gaines Only Flows with Proposed Improvements

PROJ. NO.: 11005.20 | DATE: NOVEMBER 2013 | FILE: P:\Active\11005.20_Gaines_Tributary\GIS\EXH\Fully_Developed_Conditions_FP.mxd

GAINES TRIBUTARY

HYDROLOGIC AND HYDRAULIC ANALYSIS

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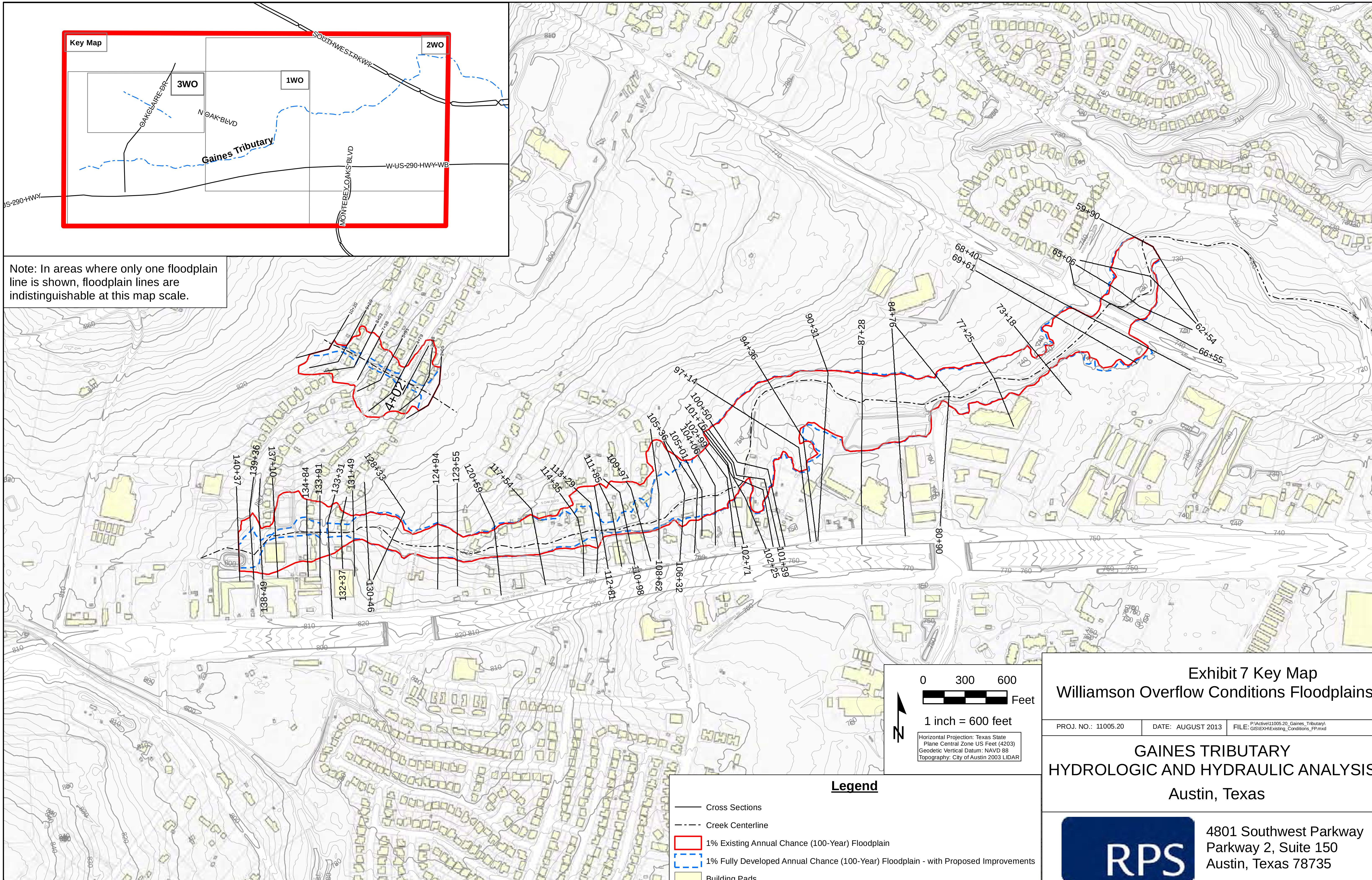
Exhibit 7 – Williamson Overflow Floodplains


Key Map
3WO
1WO
2WO
SOUTHWEST PKWY
OAKCLAIRE DR
N OAK BLVD
Gaines Tributary
W US 290 HWY WB
MONTEREY OAKS BLVD
US 290 HWY
Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.
0 300 600 Feet
1 inch = 600 feet
N
Horizontal Projection: Texas State Plane Central Zone US Feet (4203)
Geodetic Vertical Datum: NAVD 88
Topography: City of Austin 2003 LIDAR
Legend
Cross Sections
Creek Centerline
1% Existing Annual Chance (100-Year) Floodplain
1% Fully Developed Annual Chance (100-Year) Floodplain - with Proposed Improvements
Building Pads
Exhibit 7 Key Map
Williamson Overflow Conditions Floodplains
PROJ. NO.: 11005.20
DATE: AUGUST 2013
FILE: P:\Active\11005.20_Gaines_Tributary\GIS\EXH\Existing_Conditions_FP.mxd
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RPS
4801 Southwest Parkway
Parkway 2, Suite 150
Austin, Texas 78735
59+90
62+54
65+06
66+55
68+40
69+61
73+18
77+25
80+98
84+76
87+28
90+31
94+36
97+14
100+50
101+39
101+76
102+25
102+71
102+99
104+06
105+01
105+36
106+32
108+62
109+97
110+98
111+85
112+81
113+29
114+85
117+54
120+59
123+55
124+94
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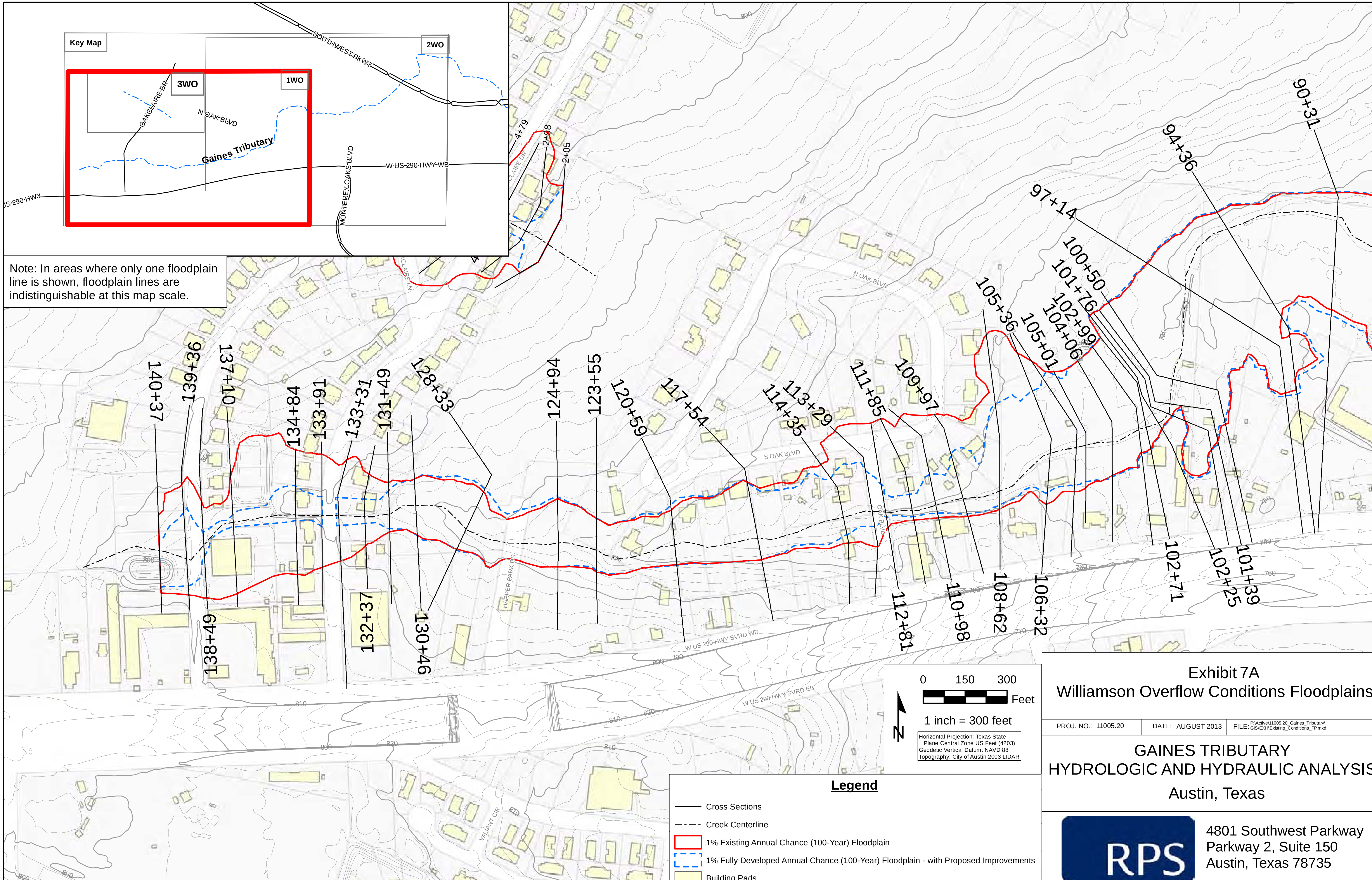
138+49
139+36
140+37
4+02



Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.

Legend

- Cross Sections
- Creek Centerline
- 1% Existing Annual Chance (100-Year) Floodplain
- 1% Fully Developed Annual Chance (100-Year) Floodplain - with Proposed Improvements
- Building Pads

Exhibit 7A
Williamson Overflow Conditions Floodplains

PROJ. NO.: 11005.20 | DATE: AUGUST 2013 | FILE: P:\Active\11005.20_Gaines_Tributary\GIS\EXH\Existing_Conditions_FP.mxd

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HYDROLOGIC AND HYDRAULIC ANALYSIS
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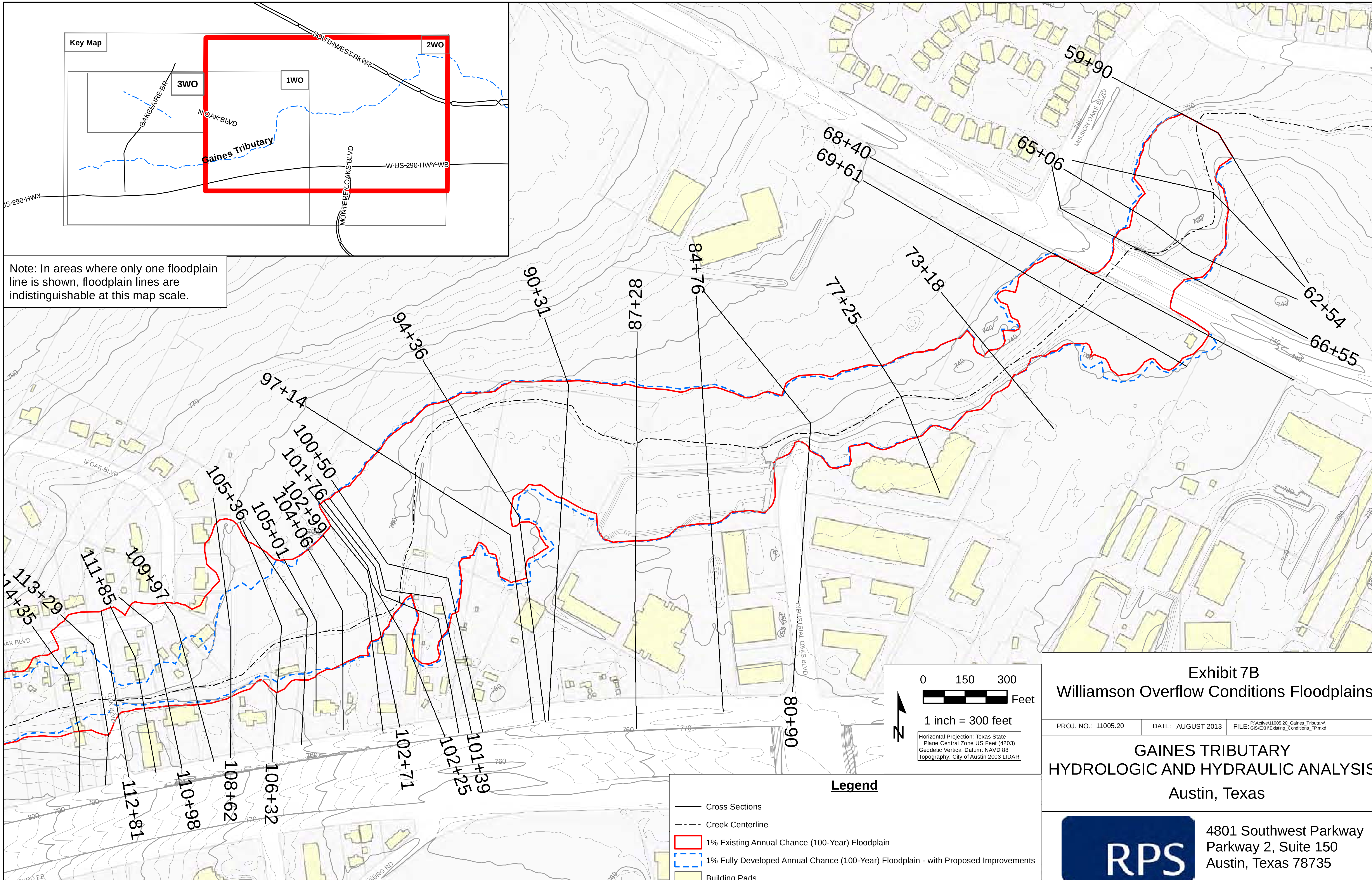

Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.

Legend

- Cross Sections
- Creek Centerline
- 1% Existing Annual Chance (100-Year) Floodplain
- 1% Fully Developed Annual Chance (100-Year) Floodplain - with Proposed Improvements
- Building Pads

Exhibit 7B
Williamson Overflow Conditions Floodplains

PROJ. NO.: 11005.20 | DATE: AUGUST 2013 | FILE: P:\Active\11005.20_Gaines_Tributary\GIS\EXH\Existing_Conditions_FP.mxd

GAINES TRIBUTARY HYDROLOGIC AND HYDRAULIC ANALYSIS

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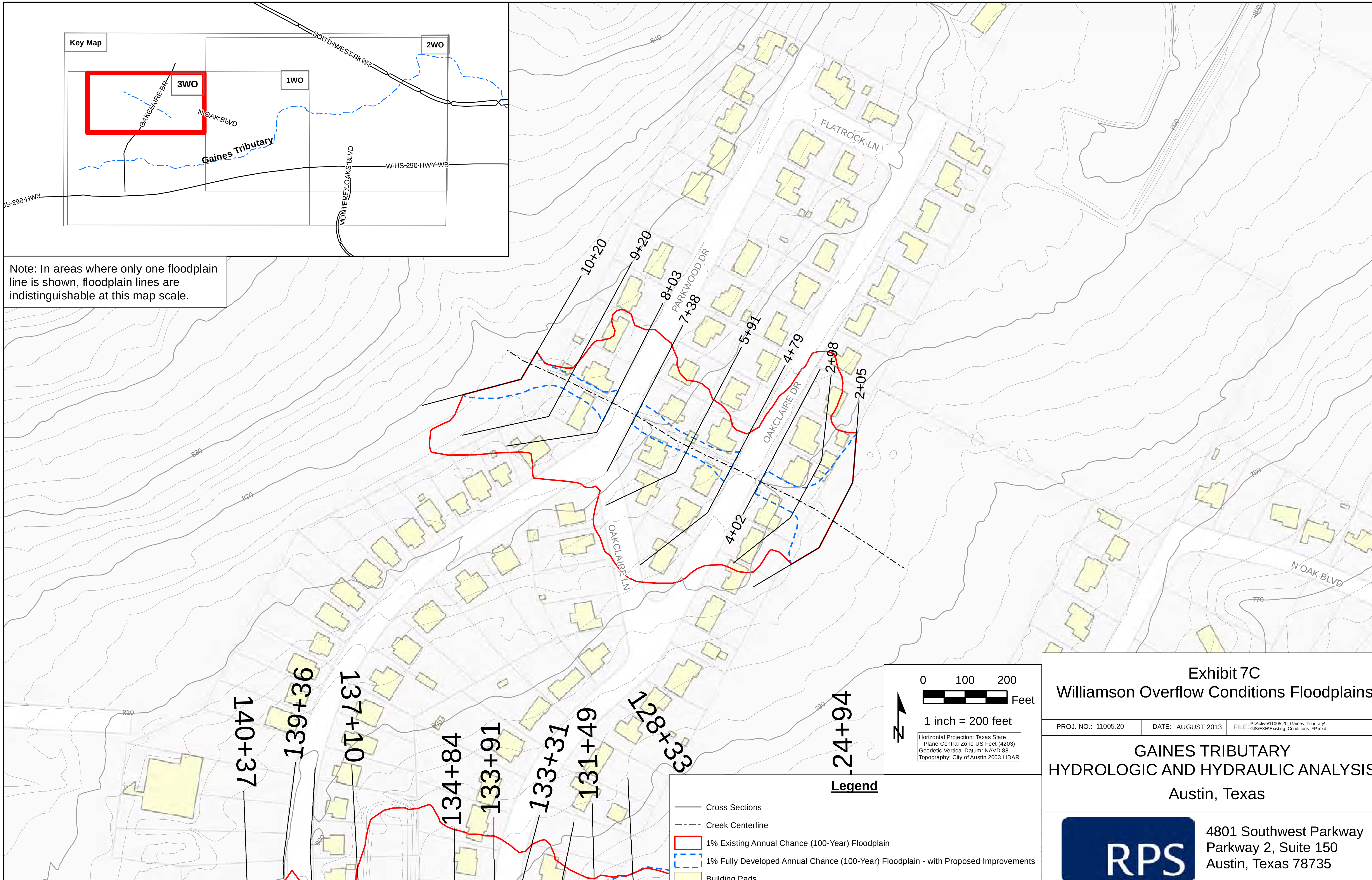
Parkway 2, Suite 150
Austin, Texas 78735



Note: In areas where only one floodplain line is shown, floodplain lines are indistinguishable at this map scale.

0 100 200 Feet

1 inch = 200 feet

Horizontal Projection: Texas State Plane Central Zone US Feet (4203)
Geodetic Vertical Datum: NAVD 88
Topography: City of Austin 2003 LIDAR

Legend

- Cross Sections
- Creek Centerline
- 1% Existing Annual Chance (100-Year) Floodplain
- 1% Fully Developed Annual Chance (100-Year) Floodplain - with Proposed Improvements
- Building Pads

Exhibit 7C
Williamson Overflow Conditions Floodplains

PROJ. NO.: 11005.20 | DATE: AUGUST 2013 | FILE: P:\Active\11005.20_Gaines_Tributary\GIS\EXH\Existing_Conditions_FP.mxd

GAINES TRIBUTARY
HYDROLOGIC AND HYDRAULIC ANALYSIS
Austin, Texas

RPS
4801 Southwest Parkway
Parkway 2, Suite 150
Austin, Texas 78735

Exhibit 8 – Proposed Gaines Conveyance Improvements (Gaines Flows)

RPS

4801 Southwest Parkway,
Parkway 2, Suite 150
Austin, Texas 78735
(512) 326-5659
TBPE #F-293

EXHIBIT 8

PROPOSED GAINES CONVEYANCE IMPROVEMENTS (GAINES FLOWS)

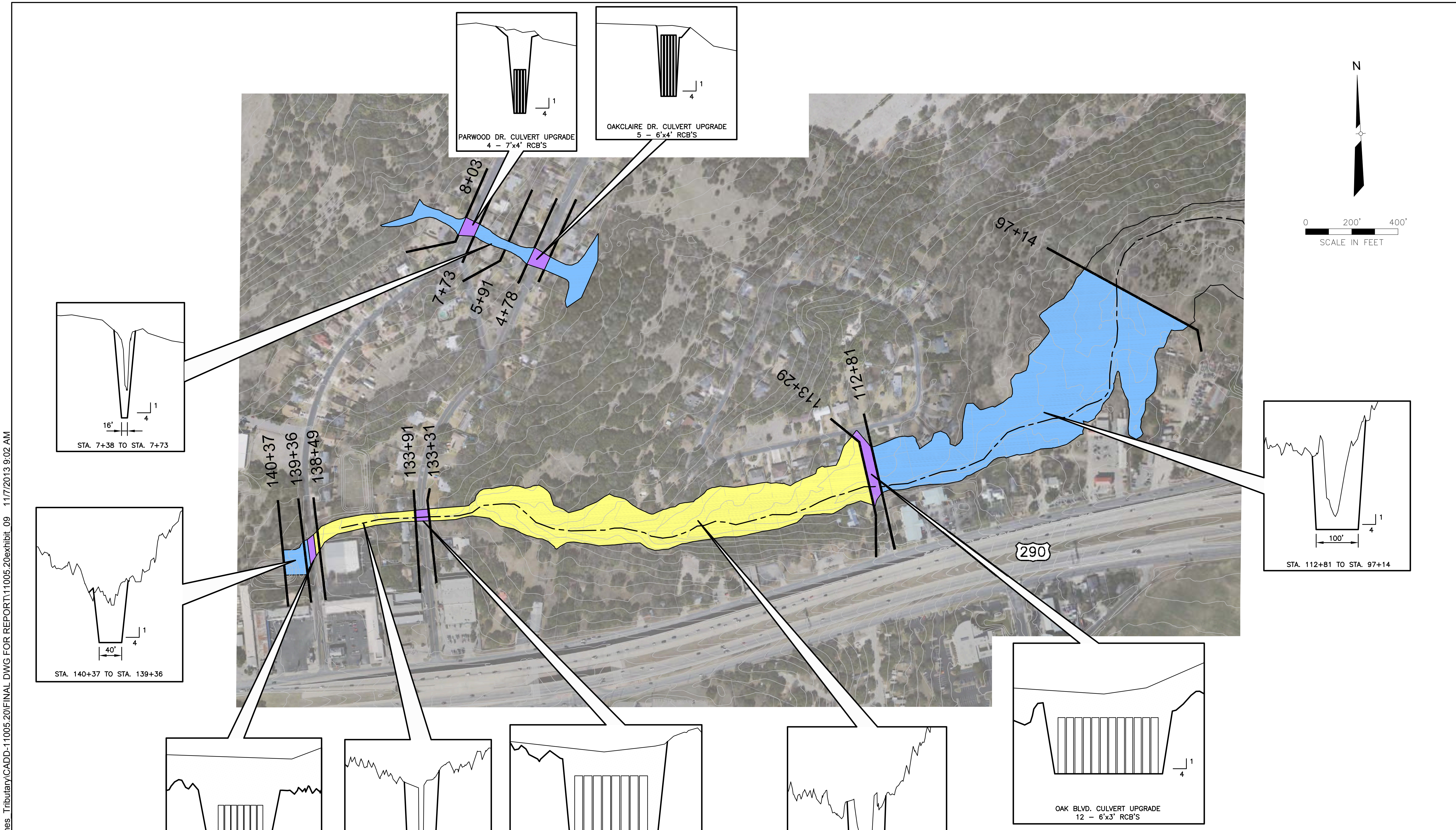
GAINES TRIBUTARY
AUSTIN, TRAVIS CO, TX

NOV 2013

11005.20

P:\Active\11005.20 Gaines Tributary\CADD-11005.20\FINAL DWG FOR REPORT\11005.20exhibit 08 11/7/2013 9:05 AM

Exhibit 9 – Proposed Gaines Conveyance Improvements (Williamson Overflows)



RPS
4801 Southwest Parkway,
Parkway 2, Suite 150
Austin, Texas 78735
(512) 326-5659
TBPE #F-293

EXHIBIT 9
PROPOSED GAINES CONVEYANCE IMPROVEMENTS (WILLIAMSON OVERFLOWS)

GAINES TRIBUTARY
AUSTIN, TRAVIS CO, TX

NOV 2013 11005.20

Appendix B – Hydrologic Calculations / Summary Tables

Existing Conditions Impervious Cover Calculation Table
Fully Developed Conditions Impervious Cover Calculation Table
Weighted Curve Number Calculation Table
Existing Conditions Time of Concentration Calculation Table
Fully Developed Conditions Time of Concentration Calculation Table
Existing Conditions Hydrologic Flow Summary
Fully Developed Conditions Hydrologic Flow Summary

Existing Conditions Impervious Cover Calculation Table

GAINES TRIBUTARY
Existing Conditions

EXISTING CONDITONS IMPERVIOUS COVER CALCULATION

Drainage Basin	Area by Land Use Type (Acres)												Impervious Cover Area (Acres)	Total Area (Acres)	Impervious Cover Percent
	100	113	200	300	400	500	600	700	800	860	870	900			
GAN01										0.85		38.26	2.68	39.11	7%
GAN02	0.00		0.59				0.01			4.12		59.76	7.05	64.48	11%
GAN03	9.47						0.013			3.198		0.312	7.16	13.00	55%
GAN04	17.76			2.37			3.29	0.00		6.90		29.50	18.71	59.83	31%
GAN05	1.1			9.2			18.4			3.2		2.5	17.73	34.34	52%
GAN06	18.83			3.16			5.66	0.04		2.33		20.59	16.20	50.61	32%
GAN07	10.37	4.44		5.44	7.65		24.97	3.49		51.47		5.31	73.00	113.13	65%
GAN08	3.17			12.76	0.82					0.86		2.21	11.14	19.82	56%
GAN09	15.76			7.83			11.98			1.51		17.64	19.81	54.72	36%
GAN10	1.64			20.56	0.64	2.89	0.01	3.96		1.80		37.99	19.92	69.50	29%
GAN11			0.00	32.67	0.47	0.00		10.21	4.84	52.09	0.01	4.72	73.51	105.02	70%
GAN12	1.84			33.19	16.71	8.69				4.97	3.55	17.39	47.80	86.34	55%
GAN13				11.43	14.34	2.74				0.22		17.63	19.61	46.37	42%
GAN14	0.35		10.90	0.02	0.00			37.96		19.56		3.19	24.47	71.98	34%
GAN15	16.33			0.00				2.54		11.60		11.68	18.37	42.14	44%
GAN16	0.09			10.12				42.60		4.70		7.88	11.24	65.39	17%
GAN17				0.01						37.69	0.00	0.00	33.93	37.70	90%
GAN18				8.95				19.42		30.16		0.02	32.96	58.54	56%
GAN19	4.84			12.86	4.74			27.20		0.00	3.90	8.96	17.97	62.50	29%
GAN20	0.00			3.99	0.00	0.00	0.01	0.00		30.79	0.00	0.00	30.31	34.79	87%
GAN21	14.91			7.10	10.82			38.57		3.34		4.64	21.60	79.39	27%
												Totals:	525.18	1,208.70	**43%**

Land Use Code	Land use Description	Average Percent
100	Single Family (100) or Duplex (150)	45%
113	Mobile Homes (113)	45%
200	Multi-family (200)	60%
300	Commercial (300)	65%
400	Office (400)	65%
500	Industrial (500)	65%
600	Civic(600)	45%
700	Open Space (700)	0%
800	Transportation (800)	100%
860	Streets and Roads (860)	90%
870	Utilities (870)	100%
900	Undeveloped (900)	5%

Fully Developed Conditions Impervious Cover Calculation Table

GAINES TRIBUTARY
Fully Developed Conditions

FULLY DEVELOPED CONDITONS IMPERVIOUS COVER CALCULATION

Drainage Basin	Area by Land Use Type (Acres)											Impervious Cover Area (Acres)	Total Area (Acres)	Impervious Cover Percent
	100	200	300	400	500	600	700	800	860	870	900			
GAN01				38.21				0.90				27.65	39.11	71%
GAN02	0.00	30.48	0.43	21.54		7.90		4.12				42.89	64.48	67%
GAN03	9.79	0.00				0.01		3.19				8.09	13.00	62%
GAN04	18.35	28.92	2.37			3.29	0.00	6.90				38.13	59.83	64%
GAN05			12.43			18.71		3.20				20.95	34.34	61%
GAN06	19.10		14.05	15.09			0.04	2.33				32.98	50.61	65%
GAN07	7.99		25.32	1.53		23.66	3.43	51.20				85.90	113.13	76%
GAN08	3.27		15.70					0.85				14.26	19.82	72%
GAN09	18.59		18.21	4.43		11.98		1.51				32.96	54.72	60%
GAN10	0.02		60.41			0.01	7.36	1.70				47.02	69.50	68%
GAN11			52.96					52.06				91.78	105.02	87%
GAN12			69.75				14.26	2.32				54.64	86.34	63%
GAN13			37.49				8.65	0.22				28.34	46.37	61%
GAN14	0.35	10.90	0.02				41.19	19.52				26.80	71.98	37%
GAN15	16.33		0.00				14.15	11.66				19.83	42.14	47%
GAN16	0.09		17.17				43.43	4.70				17.62	65.39	27%
GAN17			0.01					28.25	9.44	0.00	0.00	36.76	37.70	97%
GAN18			8.97				19.43	30.15				36.87	58.54	63%
GAN19	4.84		28.58				27.20	0.00	0.00	1.80	0.08	25.66	62.50	41%
GAN20	0.00		3.99	0.00	0.00	0.01	0.00		30.79	0.00	0.00	30.71	34.79	88%
GAN21	14.91		17.92				38.57	0.18	3.16		4.64	24.16	79.39	30%
											Totals:	743.99	1,208.71	**62%**

Land Use Code	Land use Description	Average Percent
100	Single Family (100) or Duplex (150)	50%
113	Mobile Homes (113)	50%
200	Multi-family (200)	65%
300	Commercial (300)	75%
400	Office (400)	70%
500	Industrial (500)	75%
600	Civic(600)	45%
700	Open Space (700)	0%
800	Transportation (800)	100%
860	Streets and Roads (860)	90%
870	Utilities (870)	100%
900	Undeveloped (900)	5%

Weighted Curve Number Calculation Table

GAINES TRIBUTARY
Weighted Curve Number

WEIGHTED CURVE NUMBER CALCULATION TABLE

	Area of NRCS Group (Acres)				Total Area	Percent of Soil Type				Weighted Curve Number
Drainage Basin	A	B	C	D	(Acres)	%A	%B	%C	%D	AMC II
GAN01			39.11		39.11	0%	0%	100%	0%	79
GAN02			49.62	14.86	64.48	0%	0%	77%	23%	80
GAN03			0.43	12.56	13.00	0%	0%	3%	97%	84
GAN04			11.92	47.92	59.83	0%	0%	20%	80%	83
GAN05	0.30			34.04	34.34	1%	0%	0%	99%	84
GAN06				50.61	50.61	0%	0%	0%	100%	84
GAN07	1.57			113.38	114.95	1%	0%	0%	99%	84
GAN08				19.82	19.82	0%	0%	0%	100%	84
GAN09				54.72	54.72	0%	0%	0%	100%	84
GAN10				69.50	69.50	0%	0%	0%	100%	84
GAN11				105.02	105.02	0%	0%	0%	100%	84
GAN12				86.34	86.34	0%	0%	0%	100%	84
GAN13				46.37	46.37	0%	0%	0%	100%	84
GAN14				71.98	71.98	0%	0%	0%	100%	84
GAN15				42.14	42.14	0%	0%	0%	100%	84
GAN16				65.39	65.39	0%	0%	0%	100%	84
GAN17				37.70	37.70	0%	0%	0%	100%	84
GAN18				58.54	58.54	0%	0%	0%	100%	84
GAN19				62.50	62.50	0%	0%	0%	100%	84
GAN20				34.79	34.79	0%	0%	0%	100%	84
GAN21			2.29	77.10	79.39	0%	0%	3%	97%	84
Total	2	0	103	1105	1210.52	0%	0%	9%	91%	

Hydrologic Soil Group	AMC II
A	49
B	69
C	79
D	84

Existing Conditions Time of Concentration Calculation Table

GAINES TRIBUTARY

Time of Concentration Calculations

TR-55 Method of Computing the Time of Concentration
EXISTING CONDITIONS

			GAN01	GAN02	GAN03	GAN04	GAN05	GAN06	GAN07	GAN08	GAN09	GAN10	GAN11	GAN12	GAN13	GAN14	GAN15
Sheet Flow	variable	units															
Manning's roughness coef.	n	n/a	0.2	0.2	0.3	0.2	0.02	0.3	0.02	0.3	0.2	0.1	0.02	0.02	0.2	0.02	0.3
Flow Length	L	feet	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2-year, 24-hour rainfall	P2	inches	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44
Slope	s	ft/ft	0.015	0.020	0.020	0.020	0.020	0.020	0.020	0.015	0.015	0.015	0.010	0.010	0.015	0.020	0.015
Travel time	Tt	hours	0.22	0.20	0.27	0.20	0.03	0.27	0.03	0.31	0.22	0.13	0.04	0.04	0.22	0.03	0.31
Shallow Concentrated Flow		min.	13.3	11.9	16.5	11.9	1.9	16.5	1.9	18.5	13.3	7.7	2.5	2.5	13.3	1.9	18.5
Flow Length	L	feet	196	1,353	967	1,398	929	1,373	180	349	1,450	1,925	373	722	553	1,297	306
Slope	s	ft/ft	0.020	0.030	0.020	0.020	0.020	0.020	0.020	0.020	0.015	0.015	0.010	0.010	0.015	0.020	0.020
Surface (1=paved or 2=unpaved)		n/a	2	2	1	1	2	2	1	1	2	2	1	2	2	2	2
Velocity	V	ft/sec	2.29	2.81	2.91	2.91	2.29	2.29	2.91	2.91	1.98	1.98	2.06	1.62	1.98	2.29	2.29
Travel time	Tt	hours	0.02	0.13	0.09	0.13	0.11	0.17	0.02	0.03	0.20	0.27	0.05	0.12	0.08	0.16	0.04
Manning's Equation		min.	1.4	8.0	5.5	8.0	6.8	10.0	1.0	2.0	12.2	16.2	3.0	7.4	4.6	9.4	2.2
Flow Type (n/a, open, box, circular)			open	open	open	circular	open	open	circular	open	open	open	circular	open	open	open	circular
Flow Length	L	feet	1846	1560	371	828	315	581	5677	1239	1159	1215	3264	3057	2041	3300	1888
Slope	S	ft/ft	0.050	0.035	0.020	0.020	0.020	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
roughness	n	n/a	0.050	0.050	0.050	0.013	0.050	0.050	0.015	0.050	0.050	0.050	0.015	0.050	0.050	0.050	0.050
Open Channel																	
Bottom Width	BW	feet	2	2	2		2	2		2	2	2		2	2	2	
Side Slopes (H:1)	H	feet	4	4	4		4	4		4	4	4		4	4	4	
Depth	d	feet	2	2	2		2	2		2	2	2		2	2	2	
...or Closed Conduit																	
Rise (box) or Diameter (circular)	R or D	feet				2			3				3				2
Span (0 if circular)	S	feet															
Cross-Sectional Area	X-A	feet^2	20.00	20.00	20.00	3.14	20.00	20.00	7.07	20.00	20.00	20.00	7.07	20.00	20.00	20.00	3.14
Flow Rate	Q	cfs	140.42	117.48	88.81	32.08	88.81	62.80	57.96	62.80	62.80	62.80	57.96	62.80	62.80	62.80	5.90
Velocity	V	ft/sec	7.02	5.87	4.44	10.21	4.44	3.14	8.20	3.14	3.14	3.14	8.20	3.14	3.14	3.14	1.88
Travel time	Tt	hours	0.07	0.07	0.02	0.02	0.02	0.05	0.19	0.11	0.10	0.11	0.11	0.27	0.18	0.29	0.28
Flow Type (n/a, open, box, circular)			n/a	n/a	n/a	open	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	open
Flow Length	L	feet				217											259
Slope	S	ft/ft				0.020											0.020
roughness	n	n/a				0.050											0.050
Open Channel																	
Bottom Width	BW	feet				2											2
Side Slopes (H:1)	H	feet				4											4
Depth	d	feet				2											2
...or Closed Conduit																	
Rise (box) or Diameter (circular)	R or D	feet															
Span (0 if circular)	S	feet															
Cross-Sectional Area	X-A	feet^2	n/a	n/a	n/a	20.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20.00
Flow Rate	Q	cfs	n/a	n/a	n/a	88.81	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	88.81
Velocity	V	ft/sec	0.00	0.00	0.00	4.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44
Travel time	Tt	hours	-	-	-	0.014	-	-	-	-	-	-	-	-	-	-	0.016
Total Travel Time	TC	hours	0.32	0.41	0.39	0.37	0.16	0.49	0.24	0.45	0.53	0.50	0.20	0.44	0.48	0.48	0.64
	TC	min.	19.2	24.4	23.4	22.1	9.8	29.5	14.5	27.0	31.7	30.3	12.1	26.1	28.8	28.8	38.4
Lag Time	TL	hours	0.19	0.24	0.23	0.22	0.10	0.30	0.14	0.27	0.32	0.30	0.12	0.26	0.29	0.29	0.38
	TL	min.	11.49	14.61	14.03	13.23	5.89	17.71	8.67	16.22	19.01	18.17	7.28	15.69	17.30	17.30	23.05

GAINES TRIBUTARY

Time of Concentration Calculations

TR-55 Method of Computing the Time of Concentration EXISTING CONDITIONS			GAN16	GAN17	GAN18	GAN19	GAN20	GAN21
Sheet Flow	variable	units						
Manning's roughness coef.	n	n/a	0.2	0.02	0.02	0.02	0.02	0.3
Flow Length	L	feet	100	100	100	100	100	100
2-year, 24-hour rainfall	P2	inches	3.44	3.44	3.44	3.44	3.44	3.44
Slope	s	ft/ft	0.010	0.010	0.015	0.015	0.010	0.010
Travel time	Tt	hours	0.26	0.04	0.04	0.04	0.04	0.36
Shallow Concentrated Flow		min.	15.7	2.5	2.1	2.1	2.5	21.7
Flow Length	L	feet	605	426	1,013	898	376	596
Slope	s	ft/ft	0.020	0.020	0.020	0.020	0.020	0.020
Surface (1=paved or 2=unpaved)		n/a	2	1	2	2	1	2
Velocity	V	ft/sec	2.29	2.91	2.29	2.29	2.91	2.29
Travel time	Tt	hours	0.07	0.04	0.12	0.11	0.04	0.07
Manning's Equation		min.	4.4	2.4	7.4	6.5	2.2	4.3
Flow Type (n/a, open, box, circular)			open	circular	open	open	circular	open
Flow Length	L	feet	2181	2241	1609	2061	1486	3140
Slope	S	ft/ft	0.010	0.010	0.010	0.010	0.010	0.010
roughness	n	n/a	0.050	0.015	0.050	0.050	0.015	0.050
Open Channel								
Bottom Width	BW	feet	2		2	2		2
Side Slopes (H:1)	H	feet	4		4	4		4
Depth	d	feet	2		2	2		2
...or Closed Conduit								
Rise (box) or Diameter (circular)	R or D	feet		3			3	
Span (0 if circular)	S	feet						
Cross-Sectional Area	X-A	feet^2	20.00	7.07	20.00	20.00	7.07	20.00
Flow Rate	Q	cfs	62.80	57.96	62.80	62.80	57.96	62.80
Velocity	V	ft/sec	3.14	8.20	3.14	3.14	8.20	3.14
Travel time	Tt	hours	0.19	0.08	0.14	0.18	0.05	0.28
Flow Type (n/a, open, box, circular)			n/a	n/a	n/a	n/a	n/a	n/a
Flow Length	L	feet						
Slope	S	ft/ft						
roughness	n	n/a						
Open Channel								
Bottom Width	BW	feet						
Side Slopes (H:1)	H	feet						
Depth	d	feet						
...or Closed Conduit								
Rise (box) or Diameter (circular)	R or D	feet						
Span (0 if circular)	S	feet						
Cross-Sectional Area	X-A	feet^2	n/a	n/a	n/a	n/a	n/a	n/a
Flow Rate	Q	cfs	n/a	n/a	n/a	n/a	n/a	n/a
Velocity	V	ft/sec	0.00	0.00	0.00	0.00	0.00	0.00
Travel time	Tt	hours	-	-	-	-	-	-
Total Travel Time	TC	hours	0.53	0.16	0.30	0.33	0.13	0.71
	TC	min.	31.7	9.5	18.0	19.6	7.7	42.7
Lag Time	TL	hours	0.32	0.09	0.18	0.20	0.08	0.43
	TL	min.	19.00	5.69	10.82	11.75	4.60	25.63

Fully Developed Time of Concentration Calculation Table

GAINES TRIBUTARY

Time of Concentration Calculations

TR-55 Method of Computing the Time of Concentration
FULLY DEVELOPED CONDITIONS

			GAN01	GAN02	GAN03	GAN04	GAN05	GAN06	GAN07	GAN08	GAN09	GAN10	GAN11	GAN12	GAN13	GAN14	GAN15	GAN16
Sheet Flow	variable	units																
Manning's roughness coef.	n	n/a	0.02	0.02	0.3	0.2	0.02	0.2	0.02	0.3	0.2	0.02	0.02	0.02	0.02	0.02	0.3	0.2
Flow Length	L	feet	50	50	100	50	50	100	100	100	50	50	100	100	100	50	100	100
2-year, 24-hour rainfall	P2	inches	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44
Slope	s	ft/ft	0.015	0.020	0.020	0.020	0.020	0.020	0.020	0.015	0.015	0.015	0.010	0.010	0.015	0.020	0.015	0.010
Travel time	Tt	hours	0.02	0.02	0.27	0.11	0.02	0.20	0.03	0.31	0.13	0.02	0.04	0.04	0.04	0.02	0.31	0.26
Shallow Concentrated Flow		min.	1.2	1.1	16.5	6.8	1.1	11.9	1.9	18.5	7.7	1.2	2.5	2.5	2.1	1.1	18.5	15.7
Flow Length	L	feet	246	1,403	967	1,250	1,035	1,153	180	349	1,254	1,770	373	722	553	1,347	306	605
Slope	s	ft/ft	0.020	0.030	0.020	0.020	0.020	0.020	0.020	0.020	0.015	0.015	0.010	0.010	0.015	0.020	0.020	0.020
Surface (1=paved or 2=unpaved)		n/a	2	2	1	1	2	2	1	1	2	2	1	2	2	2	2	2
Velocity	V	ft/sec	2.29	2.81	2.91	2.91	2.29	2.29	2.91	2.91	1.98	1.98	2.06	1.62	1.98	2.29	2.29	2.29
Travel time	Tt	hours	0.03	0.14	0.09	0.12	0.13	0.14	0.02	0.03	0.18	0.25	0.05	0.12	0.08	0.16	0.04	0.07
Manning's Equation		min.	1.8	8.3	5.5	7.2	7.5	8.4	1.0	2.0	10.5	14.9	3.0	7.4	4.6	9.8	2.2	4.4
Flow Type (n/a, open, box, circular)			open	open	open	circular	open	open	circular	open	open	open	circular	open	open	open	circular	open
Flow Length	L	feet	1846	1560	371	1014	315	1127	5677	1239	1468	1215	3264	3057	2041	3300	1715	2181
Slope	S	ft/ft	0.050	0.035	0.020	0.020	0.020	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
roughness	n	n/a	0.050	0.050	0.050	0.013	0.050	0.050	0.015	0.050	0.050	0.050	0.015	0.050	0.050	0.050	0.050	0.050
Open Channel																		
Bottom Width	BW	feet	2	2	2		2	2		2	2	2		2	2	2		2
Side Slopes (H:1)	H	feet	4	4	4		4	4		4	4	4		4	4	4		4
Depth	d	feet	2	2	2		2	2		2	2	2		2	2	2		2
...or Closed Conduit																		
Rise (box) or Diameter (circular)	R or D	feet				2			3				3				2	
Span (0 if circular)	S	feet																
Cross-Sectional Area	X-A	feet^2	20.00	20.00	20.00	3.14	20.00	20.00	7.07	20.00	20.00	20.00	7.07	20.00	20.00	20.00	3.14	20.00
Flow Rate	Q	cfs	140.42	117.48	88.81	32.08	88.81	62.80	57.96	62.80	62.80	62.80	57.96	62.80	62.80	62.80	5.90	62.80
Velocity	V	ft/sec	7.02	5.87	4.44	10.21	4.44	3.14	8.20	3.14	3.14	3.14	8.20	3.14	3.14	3.14	1.88	3.14
Travel time	Tt	hours	0.07	0.07	0.02	0.03	0.02	0.10	0.19	0.11	0.13	0.11	0.11	0.27	0.18	0.29	0.25	0.19
Flow Type (n/a, open, box, circular)			n/a	n/a	n/a	open	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	open	n/a
Flow Length	L	feet				217											259	
Slope	S	ft/ft				0.020											0.020	
roughness	n	n/a				0.050											0.050	
Open Channel																		
Bottom Width	BW	feet				2											2	
Side Slopes (H:1)	H	feet				4											4	
Depth	d	feet				2											2	
...or Closed Conduit																		
Rise (box) or Diameter (circular)	R or D	feet																
Span (0 if circular)	S	feet																
Cross-Sectional Area	X-A	feet^2	n/a	n/a	n/a	20.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20.00	n/a
Flow Rate	Q	cfs	n/a	n/a	n/a	88.81	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	88.81	n/a
Velocity	V	ft/sec	0.00	0.00	0.00	4.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44	0.00
Travel time	Tt	hours	-	-	-	0.014	-	-	-	-	-	-	-	-	-	-	0.016	-
Total Travel Time	TC	hours	0.12	0.23	0.39	0.27	0.16	0.44	0.24	0.45	0.43	0.38	0.20	0.44	0.29	0.47	0.61	0.53
	TC	min.	7.4	13.8	23.4	16.5	9.8	26.3	14.5	27.0	26.0	22.5	12.1	26.1	17.6	28.4	36.9	31.7
Lag Time	TL	hours	0.07	0.14	0.23	0.16	0.10	0.26	0.14	0.27	0.26	0.23	0.12	0.26	0.18	0.28	0.37	0.32
	TL	min.	4.43	8.31	14.03	9.87	5.88	15.76	8.67	16.22	15.59	13.52	7.28	15.69	10.56	17.04	22.13	19.00

GAINES TRIBUTARY

Time of Concentration Calculations

TR-55 Method of Computing the Time of Concentration
FULLY DEVELOPED CONDITIONS

	variable	units	GAN17	GAN18	GAN19	GAN20	GAN21
Sheet Flow	variable	units					
Manning's roughness coef.	n	n/a	0.02	0.02	0.02	0.02	0.3
Flow Length	L	feet	100	100	100	100	100
2-year, 24-hour rainfall	P2	inches	3.44	3.44	3.44	3.44	3.44
Slope	s	ft/ft	0.010	0.015	0.015	0.010	0.010
Travel time	Tt	hours	0.04	0.04	0.04	0.04	0.36
Shallow Concentrated Flow		min.	2.5	2.1	2.1	2.5	21.7
Flow Length	L	feet	426	1,013	898	376	596
Slope	s	ft/ft	0.020	0.020	0.020	0.020	0.020
Surface (1=paved or 2=unpaved)		n/a	1	2	2	1	2
Velocity	V	ft/sec	2.91	2.29	2.29	2.91	2.29
Travel time	Tt	hours	0.04	0.12	0.11	0.04	0.07
Manning's Equation		min.	2.4	7.4	6.5	2.2	4.3
Flow Type (n/a, open, box, circular)			circular	open	open	circular	open
Flow Length	L	feet	2241	1609	2061	1486	3140
Slope	S	ft/ft	0.010	0.010	0.010	0.010	0.010
roughness	n	n/a	0.015	0.050	0.050	0.015	0.050
Open Channel							
Bottom Width	BW	feet		2	2		2
Side Slopes (H:1)	H	feet		4	4		4
Depth	d	feet		2	2		2
...or Closed Conduit							
Rise (box) or Diameter (circular)	R or D	feet	3			3	
Span (0 if circular)	S	feet					
Cross-Sectional Area	X-A	feet^2	7.07	20.00	20.00	7.07	20.00
Flow Rate	Q	cfs	57.96	62.80	62.80	57.96	62.80
Velocity	V	ft/sec	8.20	3.14	3.14	8.20	3.14
Travel time	Tt	hours	0.08	0.14	0.18	0.05	0.28
Flow Type (n/a, open, box, circular)			n/a	n/a	n/a	n/a	n/a
Flow Length	L	feet					
Slope	S	ft/ft					
roughness	n	n/a					
Open Channel							
Bottom Width	BW	feet					
Side Slopes (H:1)	H	feet					
Depth	d	feet					
...or Closed Conduit							
Rise (box) or Diameter (circular)	R or D	feet					
Span (0 if circular)	S	feet					
Cross-Sectional Area	X-A	feet^2	n/a	n/a	n/a	n/a	n/a
Flow Rate	Q	cfs	n/a	n/a	n/a	n/a	n/a
Velocity	V	ft/sec	0.00	0.00	0.00	0.00	0.00
Travel time	Tt	hours	-	-	-	-	-
Total Travel Time	TC	hours	0.16	0.30	0.33	0.13	0.71
	TC	min.	9.5	18.0	19.6	7.7	42.7
Lag Time	TL	hours	0.09	0.18	0.20	0.08	0.43
	TL	min.	5.69	10.82	11.75	4.60	25.63

Existing Conditions Hydrologic Flow Summary

GAINES TRIBUTARY EXISTING CONDITIONS HYDROLOGIC FLOW SUMMARY

	Computed Peak Flow Rate (cfs)									
HEC-HMS Node	50%	20%	10%	4%	2%	1%	0.20%	2%(WO)	1%(WO)	0.2%(WO)
GAN02	66.7	125.1	170	234.2	286.2	342.8	483.4	286.2	342.8	483.4
GAN01	40.2	78.3	107.7	149.7	183.9	221	314.1	183.9	221	314.1
R_GAN02	39.8	77.8	106.8	149.1	183.2	220.5	311.9	183.2	220.5	311.9
J_GAN02	105.4	202	276.3	382	467.5	560.6	794.9	467.5	560.6	794.9
R_GAN03	104.9	201	274.4	380.7	466.9	560.5	792.4	466.9	560.5	792.4
GAN03	22.6	35.5	44.9	57.9	68.4	79.7	107.7	68.4	79.7	107.7
J_GAN03	126.2	234.4	318.3	437.5	533.9	638.5	897.8	533.9	638.5	897.8
R_GAN06_U	125.4	233.7	316.8	433.9	530.9	635.1	892.8	530.9	635.1	892.8
GAN04	89	148.7	193.1	255.3	305.3	359.3	493.1	305.3	359.3	493.1
GAN05	75.5	118.9	150.5	194.7	230	268.1	362.5	230	268.1	362.5
Williamson Overflow								880	1462.9	2907.9
J_GAN05	75.5	118.9	150.5	194.7	230	268.1	362.5	908.9	1497.7	2958.2
J_GAN06_U	229.9	413.9	554.8	754.9	915.6	1091.1	1532.4	1204.8	1862.7	3549
R_GAN06_L	208.4	377.7	507.2	698.2	851.5	1017.3	1442.7	1166.6	1826.9	3470.5
GAN06	69.4	115	148.5	195.4	233	273.6	374.1	233	273.6	374.1
J_GAN06_L	270.4	483.6	644.8	883.9	1075.2	1279.6	1809	1247.6	1930.9	3633.5
R_GAN08	228.9	433.4	588.5	820.1	995.1	1185.6	1671.6	1214.7	1880.5	3557.9
GAN09	74.9	122.6	157.7	206.8	246.3	289	394.5	246.3	289	394.5
GAN08	32.8	51.3	64.8	83.6	98.7	115	155.4	98.7	115	155.4
J_GAN09	302.7	568.1	769.6	1067.9	1292.3	1535.3	2158.7	1324.4	2015.7	3764.9
R_GAN10	225.7	478.1	669.6	938.9	1164.9	1397.6	1968.8	1304.9	1957.4	3682.3
GAN07	242.2	373.1	468.3	601.2	707.5	822.5	1107.3	707.5	822.5	1107.3
J_GAN07	242.2	373.1	468.3	601.2	707.5	822.5	1107.3	707.5	822.5	1107.3
R_GAN08_TXDOT	238.5	365.2	457.1	584.5	685.9	795.6	1066.9	685.9	795.6	1066.9
GAN10	92.3	154.2	199.8	263.8	315	370.3	507.2	315	370.3	507.2
J_GAN10	397.5	669.7	947.5	1341.9	1660.7	2005.2	2827.6	1664.4	2170.6	4000.3
R_GAN13	374.6	661.3	931	1314.8	1584	1895.4	2755.2	1598.5	2148	3974.2
GAN13	68.5	110.6	141.5	184.6	219.1	256.6	349.2	219.1	256.6	349.2
J_GAN13	442.6	733.3	1026.8	1447.5	1730.3	2067.4	3015.9	1734.3	2208.2	4069.4
R_GAN12	435.6	731.3	1022.2	1438.9	1723.1	2057.2	2999.7	1729.3	2205.3	4061.5
GAN11	243.6	371.1	463.5	592.1	694.9	806.1	1081.5	694.9	806.1	1081.5

GAINES TRIBUTARY EXISTING CONDITIONS HYDROLOGIC FLOW SUMMARY

	Computed Peak Flow Rate (cfs)									
HEC-HMS Node	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.20%**	**2%(WO)**	**1%(WO)**	**0.2%(WO)**
J_GAN11	243.6	371.1	463.5	592.1	694.9	806.1	1081.5	694.9	806.1	1081.5
R_GAN12_TXDOT	239.9	363.6	452.6	575.8	673.7	779	1037.9	673.7	779	1037.9
GAN12	143.7	225.4	284.9	368	434.5	506.3	684.1	434.5	506.3	684.1
GAN14	101.1	166.4	214.4	281.6	335.4	393.6	538	335.4	393.6	538
J_GAN14	822.2	1324.3	1696.6	2254.3	2713.8	3156.5	4412.2	2713.8	3156.5	4520.7
R_GAN15	819.5	1320.4	1692.1	2250.8	2709.2	3153.6	4405.4	2709.2	3153.6	4519.7
GAN15	55.6	89.4	114.1	148.7	176.4	206.4	280.5	176.4	206.4	280.5
J_GAN15	873.9	1405.8	1803.3	2397.9	2883	3357.1	4685.9	2883.1	3357.1	4740.8
R_GAN16	869	1401.3	1798.4	2392.8	2875.1	3350.2	4672	2875.2	3350.3	4737.8
GAN16	78.3	135.4	177.6	236.8	284.2	335.6	462.9	284.2	335.6	462.9
J_GAN16	945.2	1532	1969.2	2618.9	3147.3	3671	5093.6	3147.3	3671	5128
R_GAN18	940.7	1525.2	1962.6	2611.5	3137.3	3664.4	5080	3137.4	3664.4	5122.6
GAN18	112.6	176.2	222.6	287.3	339.1	395	533.5	339.1	395	533.5
J_GAN18	999.5	1623.8	2087.9	2767.9	3326.3	3886	5350	3326.3	3886	5375.9
R_GAN19	995	1617.6	2082.5	2761	3318	3877	5343.2	3318	3877.1	5370
GAN19	98.6	164.3	212.7	280.5	334.7	393.3	538.2	334.7	393.3	538.2
GAN17	101.5	149.4	183.9	231.8	270.1	311.5	414.1	270.1	311.5	414.1
J_GAN17	101.5	149.4	183.9	231.8	270.1	311.5	414.1	270.1	311.5	414.1
R_GAN19_TXDOT	101.1	148.5	182.6	229.7	267.3	308.2	408.5	267.3	308.2	408.5
J_GAN19	1076.1	1758.6	2264.5	2996.1	3604.1	4223.7	5782.6	3604.1	4223.7	5791.5
R_GAN21	1069.1	1750.1	2253.6	2985.5	3590.7	4207.6	5769.1	3590.8	4207.7	5781.6
GAN21	89	149.4	194	256.7	306.8	361.1	495.2	306.8	361.1	495.2
GAN20	96.1	142.2	175.3	221.3	258.1	297.9	396.5	258.1	297.9	396.5
J_GAN20	96.1	142.2	175.3	221.3	258.1	297.9	396.5	258.1	297.9	396.5
R_GAN21_TXDOT	94.4	139.6	172	216.9	252.7	291.4	386.9	252.7	291.4	386.9
J_GAN21	1171.3	1924.4	2485.2	3290.2	3952.8	4645.2	6360.4	3952.9	4645.2	6367.5

Fully Developed Conditions Hydrologic Flow Summary

FULLY DEVELOPED CONDITIONS HYDROLOGIC FLOW SUMMARY

	Computed Peak Flow Rate (cfs)							
HEC-HMS Node	50%	20%	10%	4%	2%	1%	4%(WO)	1%(WO)
GAN02	135.7	209.7	264	340	401	467.1	340	467.1
GAN01	95.3	146	183.2	235.2	277	322.3	235.2	322.3
R_GAN02	93.7	143.4	180.7	232.4	273.5	318.6	232.4	318.6
J_GAN02	228.3	353.1	444.7	572.4	674.4	785.7	572.4	785.7
R_GAN03	226.9	349.3	438.6	565.3	667.6	779	565.3	779
GAN03	23.6	36.4	45.8	58.8	69.2	80.5	58.8	80.5
J_GAN03	249.4	384.1	482.5	619.2	729.9	851.6	619.2	851.6
R_GAN06_U	246.1	380.5	479.1	615.5	722.1	843.1	615.5	843.1
GAN04	122.2	188.6	236.9	304.3	358.2	416.5	304.3	416.5
GAN05	79.4	122.8	154.3	198.3	233.4	271.4	198.3	271.4
Williamson Overflow							480.2	1694.4
J_GAN05	79.4	122.8	154.3	198.3	233.4	271.4	506.9	1732.1
J_GAN06_U	404.5	637.7	807.9	1045.8	1234.4	1446.3	1045.9	2059.5
R_GAN06_L	346	548.4	704	918.8	1093.3	1289	918.8	2036
GAN06	89	136.8	171.5	219.9	258.6	300.4	219.9	300.4
J_GAN06_L	431	682.8	872.3	1138.7	1351.9	1589.4	1138.7	2163.3
R_GAN08	364.8	599.3	781.9	1019.3	1206.5	1419.3	1019.3	2123.5
GAN09	93.9	145.8	183.5	236.1	278.2	323.8	236.1	323.8
GAN08	35.8	54.4	67.8	86.5	101.4	117.6	86.5	117.6
J_GAN09	465.1	766.7	1001.1	1307.2	1547.9	1818.4	1307.2	2285.9
R_GAN10	366.9	645.9	850.8	1146.4	1375.1	1616.8	1151.5	2236.8
GAN07	257.7	388.8	483.7	615.8	721.5	835.8	615.8	835.8
J_GAN07	257.7	388.8	483.7	615.8	721.5	835.8	615.8	835.8
R_GAN08_TXDOT	253.5	380.2	471.6	598.3	699.5	808.7	598.3	808.7
GAN10	131.7	201.4	252	322.5	378.9	439.8	322.5	439.8
J_GAN10	512.5	902.8	1205.7	1626.7	1965.9	2325.4	1626.8	2493
R_GAN13	490.1	885.7	1180	1547.3	1846.9	2198.1	1548.5	2479.2
GAN13	92.5	143.3	180.2	231.7	272.9	317.4	231.7	317.4
J_GAN13	560.7	948.6	1265.8	1651.3	1970.3	2343.6	1651.4	2542.1
R_GAN12	551.5	944.4	1257.9	1644.2	1960.1	2329.2	1644.7	2540.6
GAN11	265.9	393.3	485	612.5	714.4	824.6	612.5	824.6

FULLY DEVELOPED CONDITIONS HYDROLOGIC FLOW SUMMARY

	Computed Peak Flow Rate (cfs)							
HEC-HMS Node	50%	20%	10%	4%	2%	1%	4%(WO)	1%(WO)
J_GAN11	265.9	393.3	485	612.5	714.4	824.6	612.5	824.6
R_GAN12_TXDOT	261.3	384.8	473.1	595	691.9	796.1	595	796.1
GAN12	150.4	232.1	291.4	374.2	440.4	511.9	374.2	511.9
GAN14	103.6	169.3	217.6	285.4	339.7	398.4	285.4	398.4
J_GAN14	977.2	1522.5	1947.4	2562.8	2992.8	3464.7	2562.8	3465.5
R_GAN15	975.8	1519.9	1945.5	2554.8	2988.1	3461.7	2554.8	3462.9
GAN15	57.7	92.1	117.3	152.6	180.8	211.3	152.6	211.3
J_GAN15	1031.4	1609	2061.8	2705.2	3163.7	3671.5	2705.2	3672.7
R_GAN16	1025.6	1602.9	2056.4	2696.8	3156.1	3665.3	2696.8	3667.3
GAN16	84.2	141.2	183.3	242.2	289.5	340.7	242.2	340.7
J_GAN16	1107.1	1741	2232.4	2931	3441	3992.5	2931	3993.2
R_GAN18	1102.2	1735.1	2225.7	2924.7	3431.6	3986.8	2924.8	3988.5
GAN18	117.1	180.8	227	291.5	343.1	398.8	291.5	398.8
J_GAN18	1168	1836.7	2352.8	3087.2	3632.2	4216.3	3087.2	4216.9
R_GAN19	1162.4	1831.7	2346.2	3079.7	3623	4207.1	3079.8	4207.9
GAN19	106.6	172.3	220.5	287.8	341.7	399.9	287.8	399.9
GAN17	104.9	152.9	187.3	235	273.1	314.3	235	314.3
J_GAN17	104.9	152.9	187.3	235	273.1	314.3	235	314.3
R_GAN19_TXDOT	104.4	151.9	185.8	232.8	270.2	311	232.8	311
J_GAN19	1254.6	1979	2532.5	3329.4	3925.9	4565.6	3329.4	4565.9
R_GAN21	1245.7	1970.4	2521.4	3315.7	3910.2	4553.1	3315.7	4553.6
GAN21	90.9	151.3	195.9	258.4	308.5	362.7	258.4	362.7
GAN20	96.6	142.6	175.8	221.8	258.5	298.3	221.8	298.3
J_GAN20	96.6	142.6	175.8	221.8	258.5	298.3	221.8	298.3
R_GAN21_TXDOT	94.9	140.1	172.4	217.4	253.1	291.8	217.4	291.8
J_GAN21	1352.6	2150.3	2756	3622	4286.8	4994	3622	4994.5

Appendix C – Hydraulic Summary Tables

Existing Conditions Computed WSEL Summary Table

Fully Developed Conditions Computed WSEL Summary Table

Existing Conditions Computed WSEL Summary Table

Gaines Tributary
Computed Water Surface Elevation Summary Table
Existing Conditions

OAK PARK TRIBUTARY										
River	CWSEL (ft)									
Station	50%	20%	10%	4%	2%	1%	0.2%	2% (WO)	1% (WO)	0.2% (WO)	Description
10+20	817.88	818.03	818.27	818.39	818.45	818.53	818.73	818.45	818.53	818.73	
9+20	816.67	816.86	816.82	816.94	817.06	817.18	817.36	817.06	817.18	817.36	
8+03	814.70	814.30	815.20	815.33	815.41	815.49	815.71	815.41	815.49	815.71	
7+73											PARKWOOD DRIVE
7+38	811.93	812.65	813.10	813.67	813.80	813.89	814.12	813.80	813.89	814.12	
5+91	807.52	807.73	807.86	808.05	808.12	808.20	808.36	808.12	808.20	808.36	
4+68	805.05	805.16	805.20	805.22	805.32	805.38	805.54	805.32	805.38	805.54	
4+43											OAKCLAIRE DRIVE
4+10	803.24	803.65	803.79	803.92	804.00	804.11	804.26	804.00	804.11	804.26	
2+98	799.95	800.17	800.24	800.37	800.45	800.52	800.70	800.45	800.52	800.70	
2+05	797.02	797.26	797.40	797.58	797.71	797.83	798.08	797.71	797.83	798.08	

GAINES TRIBUTARY											
River	CWSEL (ft)										
Station	50%	20%	10%	4%	2%	1%	0.2%	2% (WO)	1% (WO)	0.2% (WO)	Description
140+37	797.38	797.50	797.54	797.58	797.60	797.62	797.75	798.43	799.00	800.00	
139+36	797.40	797.55	797.61	797.69	797.75	797.80	797.92	798.42	798.79	799.45	
138+95											PARKWOOD DRIVE
138+49	794.81	795.09	795.25	795.51	795.69	795.83	796.04	796.68	797.13	798.28	
137+10	792.43	792.45	792.52	792.63	792.71	792.75	792.97	793.70	794.41	795.50	
134+84	788.80	789.46	789.89	790.30	790.45	790.60	790.86	791.81	792.25	793.10	
133+91	788.39	789.15	789.57	790.05	790.19	790.30	790.40	791.12	791.61	792.21	
133+61											OAKCLAIRE DRIVE
133+31	787.47	787.86	787.96	788.17	788.30	788.47	788.71	790.39	790.80	791.39	
132+37	786.43	786.74	787.05	787.20	787.31	787.36	787.57	788.18	788.61	789.40	
131+49	782.88	783.16	783.35	783.62	783.77	783.88	784.17	785.09	785.78	787.29	
130+46	781.95	782.18	782.39	782.59	782.80	783.00	783.38	783.54	784.15	785.29	
128+33	779.56	780.01	780.19	780.50	780.70	780.84	781.24	780.96	781.46	782.45	
124+94	775.87	776.23	776.55	776.82	777.06	777.31	777.71	777.41	778.01	779.28	
123+55	773.51	774.35	774.56	774.98	775.12	775.24	775.70	775.37	775.94	776.66	
120+59	769.03	769.53	769.76	770.06	770.32	770.55	771.12	770.52	771.24	772.54	
117+54	766.10	766.67	767.16	767.78	768.09	768.36	768.99	768.32	769.10	770.40	
114+35	763.56	764.16	764.29	764.37	764.57	764.83	765.36	764.77	765.49	766.74	

Gaines Tributary
Computed Water Surface Elevation Summary Table
Existing Conditions

GAINES TRIBUTARY											
River	CWSEL (ft)										
Station	50%	20%	10%	4%	2%	1%	0.2%	2% (WO)	1% (WO)	0.2% (WO)	Description
113+29	763.59	764.24	764.43	764.65	764.85	764.99	765.30	764.96	765.39	766.12	
113+07											OAK BOULEVARD
112+81	761.72	762.45	762.84	763.31	763.61	763.89	764.49	763.85	764.60	765.75	
111+85	761.20	761.85	762.12	762.44	762.65	762.85	763.33	762.82	763.41	764.59	
110+98	760.52	761.08	761.42	761.84	762.14	762.42	763.01	762.38	763.09	764.29	
109+97	760.04	760.41	760.60	760.86	761.04	761.17	761.54	761.15	761.72	762.71	
108+62	758.72	759.17	759.43	759.76	759.94	760.15	760.54	760.12	760.64	761.46	
106+32	757.37	757.86	758.10	758.39	758.65	758.81	759.25	758.78	759.26	760.10	
105+36	756.55	756.93	757.19	757.46	757.50	757.74	757.94	757.71	758.17	758.85	
105+18											PRIVATE ROAD
105+01	756.25	756.50	756.73	757.00	757.17	757.35	757.74	757.19	757.66	758.67	
104+06	755.20	755.61	755.84	756.12	756.31	756.43	756.79	756.34	756.72	756.99	
102+99	754.19	754.45	754.58	754.75	754.87	755.06	755.28	754.87	755.23	755.86	
102+85											PRIVATE ROAD
102+71	753.83	754.16	754.36	754.61	754.77	754.91	755.21	754.79	755.14	755.83	
102+25	753.54	753.84	754.05	754.30	754.47	754.61	754.82	754.50	754.77	755.31	
101+76	752.94	753.26	753.42	753.51	753.57	753.77	754.19	753.59	754.13	754.63	
101+60											PRIVATE ROAD
101+39	753.00	753.32	753.49	753.70	753.84	753.97	754.28	753.86	754.22	754.66	
100+50	752.23	752.55	752.76	752.96	753.08	753.19	753.47	753.09	753.41	754.04	
97+14	750.02	750.46	750.71	750.98	751.14	751.30	751.66	751.16	751.58	752.39	
94+36	748.57	749.14	749.38	749.76	749.95	750.12	750.58	750.02	750.50	751.46	
90+31	746.32	746.86	747.18	747.56	747.81	748.28	748.64	747.85	748.45	749.24	
87+28	744.95	745.41	745.80	746.22	746.52	746.91	747.37	746.52	747.01	747.91	
84+76	743.32	743.83	744.30	744.82	745.09	745.40	745.95	745.10	745.51	746.53	
80+90	741.05	741.61	742.04	742.58	742.93	743.29	744.03	742.94	743.43	744.98	
77+25	739.48	740.24	740.82	741.49	741.90	742.33	743.24	741.90	742.50	744.17	
73+18	737.67	738.25	738.56	738.95	739.36	739.50	740.40	739.36	739.63	741.20	
69+61	734.30	735.11	736.08	737.30	738.17	739.35	740.15	738.19	739.53	740.52	
68+40	733.96	735.03	735.97	737.18	738.05	739.31	740.12	738.07	739.51	740.47	
67+55											SOUTHWEST PARKWAY
66+55	733.06	733.54	733.91	734.34	734.59	734.78	735.43	734.60	734.89	736.03	
65+06	732.31	732.82	733.18	733.56	733.83	734.03	734.57	733.83	734.12	735.08	

Gaines Tributary
Computed Water Surface Elevation Summary Table
Existing Conditions

GAINES TRIBUTARY											
River	CWSEL (ft)										
Station	50%	20%	10%	4%	2%	1%	0.2%	2% (WO)	1% (WO)	0.2% (WO)	Description
62+54	729.73	730.17	730.54	731.07	731.26	731.62	732.25	731.26	731.71	732.92	
59+90	727.94	728.41	728.79	729.28	729.58	729.87	730.61	729.58	729.98	731.30	

Fully Developed Conditions Computed WSEL Summary Table

Gaines Tributary
Computed Water Surface Elevation Summary Table
Fully Developed Conditions

OAK PARK TRIBUTARY									
River	CWSEL (ft)								
Station	50%	20%	10%	4%	2%	1%	4% (WO)	1% (WO)	Description
10+20	818.04	818.35	818.42	818.52	818.61	818.7	818.52	818.7	
9+20	816.9	816.87	817	817.15	817.23	817.33	817.15	817.33	
8+03	814.42	815.27	815.37	815.48	815.59	815.68	815.48	815.68	
7+73									PARKWOOD DRIVE
7+38	812.73	813.42	813.8	813.88	813.98	814.1	813.88	814.1	
5+91	807.74	807.92	808.08	808.18	808.26	808.33	808.18	808.33	
4+68	805.15	805.21	805.27	805.36	805.44	805.52	805.36	805.52	
4+43									OAKCLAIRE DRIVE
4+10	803.68	803.87	803.96	804.09	804.16	804.24	804.09	804.24	
2+98	800.18	800.32	800.4	800.5	800.58	800.67	800.5	800.67	
2+05	797.03	797.19	797.29	797.42	797.51	797.6	797.42	797.6	

GAINES TRIBUTARY									
River	CWSEL (ft)								
Station	50%	20%	10%	4%	2%	1%	4% (WO)	1% (WO)	Description
140+37	797.43	797.5	797.54	797.58	797.6	797.62	797.98	799.4	
139+36	797.46	797.55	797.62	797.69	797.75	797.81	798.08	798.92	
138+95									PARKWOOD DRIVE
138+49	794.83	795.09	795.26	795.51	795.78	795.83	796.25	797.36	
137+10	792.45	792.47	792.53	792.63	792.7	792.75	793.2	794.7	
134+84	788.84	789.48	789.95	790.33	790.48	790.6	791.24	792.41	
133+91	788.46	789.15	789.62	790.1	790.23	790.27	790.54	791.77	
133+61									OAKCLAIRE DRIVE
133+31	787.51	787.89	787.98	788.19	788.32	788.48	789.9	790.91	
132+37	786.46	786.76	787.07	787.2	787.32	787.36	787.75	788.75	
131+49	782.91	783.19	783.38	783.64	783.78	783.89	784.46	786.08	
130+46	782.1	782.43	782.58	782.89	783.08	783.26	783.16	784.29	
128+33	779.99	780.31	780.57	780.81	780.99	781.17	780.81	781.62	
124+94	776.21	776.69	776.89	777.26	777.45	777.63	777.26	778.17	
123+55	774.33	774.72	775.05	775.2	775.42	775.64	775.2	776.08	
120+59	769.43	769.81	770.04	770.4	770.63	770.88	770.4	771.45	
117+54	766.51	767.26	767.76	768.17	768.44	768.73	768.17	769.3	
114+35	764.07	764.31	764.36	764.66	764.91	765.14	764.66	765.73	
113+29	764.13	764.48	764.64	764.88	765.03	765.15	764.88	765.48	

Gaines Tributary
Computed Water Surface Elevation Summary Table
Fully Developed Conditions

GAINES TRIBUTARY									
River Station	CWSEL (ft)								Description
	50%	20%	10%	4%	2%	1%	4% (WO)	1% (WO)	
113+07									OAK BOULEVARD
112+81	762.3	762.92	763.29	763.7	763.99	764.27	763.7	764.8	
111+85	761.7	762.18	762.43	762.71	762.92	763.13	762.71	763.6	
110+98	760.96	761.49	761.82	762.23	762.52	762.78	762.23	763.3	
109+97	760.32	760.65	760.85	761.08	761.21	761.41	761.08	761.85	
108+62	759.08	759.47	759.74	760.02	760.21	760.38	760.02	760.79	
106+32	757.73	758.18	758.38	758.66	758.85	759.04	758.66	759.43	
105+36	756.9	757.17	757.46	757.68	757.83	757.94	757.68	758.2	
105+18									PRIVATE ROAD
105+01	756.4	756.72	756.95	757.18	757.36	757.53	757.18	757.81	
104+06	755.47	755.84	756.05	756.32	756.44	756.6	756.32	756.87	
102+99	754.36	754.58	754.75	754.87	755.07	755.16	754.87	755.3	
102+85									PRIVATE ROAD
102+71	754.03	754.36	754.57	754.78	754.91	755.06	754.78	755.26	
102+25	753.72	754.06	754.29	754.48	754.59	754.71	754.48	754.87	
101+76	753.19	753.39	753.36	753.6	753.85	753.98	753.6	754.24	
101+60									PRIVATE ROAD
101+39	753.22	753.49	753.66	753.85	753.98	754.13	753.85	754.34	
100+50	752.45	752.76	752.92	753.08	753.2	753.34	753.08	753.52	
97+14	750.33	750.7	750.92	751.16	751.31	751.47	751.16	751.71	
94+36	748.97	749.38	749.67	749.98	750.14	750.33	749.98	750.68	
90+31	746.64	747.16	747.44	747.8	748.27	748.43	747.8	748.6	
87+28	745.18	745.74	746.1	746.49	746.89	747.1	746.49	747.18	
84+76	743.55	744.22	744.7	745.07	745.38	745.61	745.07	745.74	
80+90	741.3	741.98	742.42	742.9	743.24	743.56	742.9	743.73	
77+25	739.82	740.69	741.24	741.82	742.23	742.65	741.82	742.86	
73+18	737.95	738.47	738.76	739.16	739.42	739.7	739.16	739.79	
69+61	734.62	735.83	736.79	737.85	739.18	739.67	737.85	739.83	
68+40	734.42	735.73	736.68	737.72	739	739.65	737.72	739.81	
67+55									SOUTHWEST PARKWAY
66+55	733.27	733.82	734.17	734.53	734.72	734.99	734.53	735.13	
65+06	732.54	733.09	733.4	733.78	734.03	734.22	733.78	734.34	
62+54	729.93	730.47	730.88	731.17	731.46	731.77	731.17	731.89	

Gaines Tributary
Computed Water Surface Elevation Summary Table
Fully Developed Conditions

GAINES TRIBUTARY									
River Station	CWSEL (ft)								Description
	50%	20%	10%	4%	2%	1%	4% (WO)	1% (WO)	
59+90	728.14	728.7	729.08	729.49	729.79	730.09	729.49	730.24	

Appendix D - Flood Crossing Data Sheets

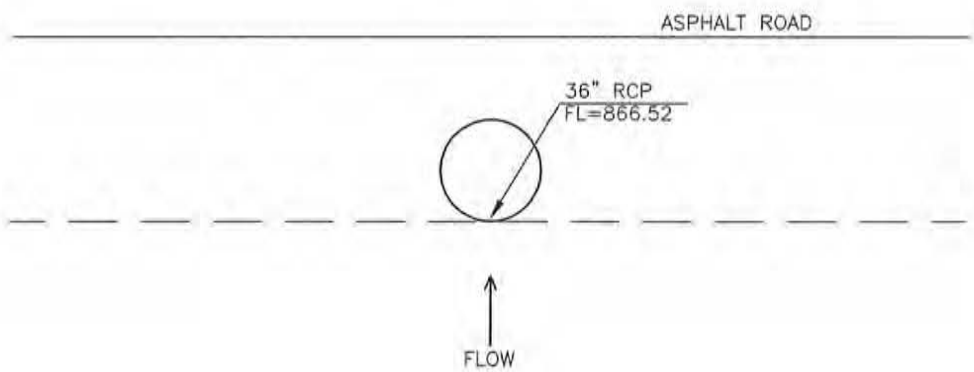
Ground Survey of Road Crossing Structures

Ground Survey of Road Crossing Structures

FLOOD CROSSING DATA SHEET

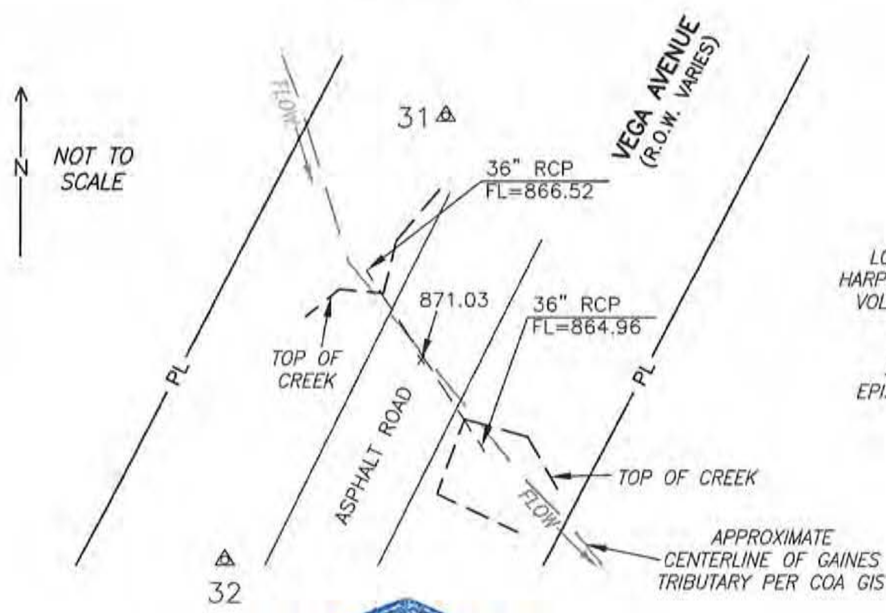
PROJECT GAINES TRIBUTARY MAPPING
STRUCTURE NAME X1-VEGA
STREAM NAME GAINES TRIBUTARY
DATE 8/2/12
LOCATION VEGA AVENUE
CREW DAN MARTINEZ
TYPE BR ( ) CUL ( ) DAM ( ) XS ( )
TBM ELEV 870.28 TBM ID CP 31
BRIDGE RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____
CULVERT NUM# ____ SHAPE ____ LENGTH ____ SIZE: H ____ W ____ SKEW ____
CULVERT I/O TYPE 36" MATERIAL RCP WINGWALL US ____ DS ____
DAM TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____
TBM DESCRIPTION 60D NAIL

PROFILE VIEW



PLAN VIEW

NOTE: PROPERTY LINES SHOWN ARE FOR REFERENCE ONLY AND NOT THE RESULT OF A BOUNDARY SURVEY



STATE OF TEXAS · REGISTERED · STEVEN M. DUARTE · 5940 · PROFESSIONAL LAND SURVEYOR

DATE: 08-27-12
DRAWN BY: smd

MAI JOB NO.: 512-03-12
REFERENCE: 613/9

8/27/12

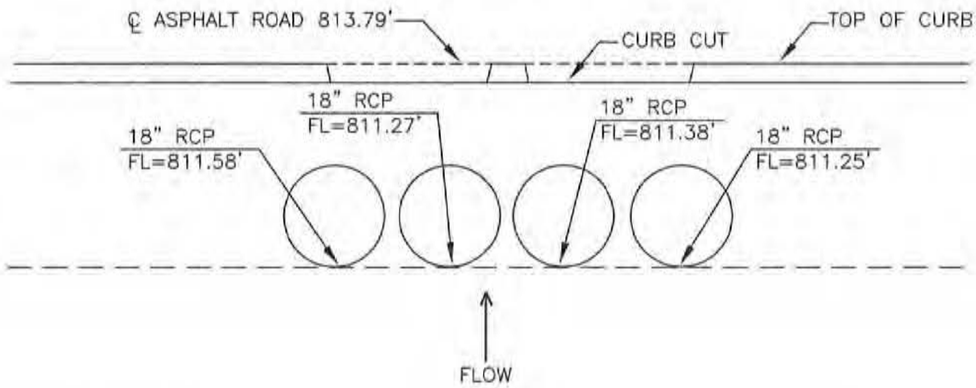
Steven M. Duarte Date:
Registered Professional Land Surveyor
No. 5940 – State of Texas

MACIAS & ASSOCIATES, L.P.
LAND SURVEYORS
5410 SOUTH 1ST STREET
AUSTIN, TEXAS 78745 PH. (512)442-7875
FAX (512)442-7876 EMAIL: WWW.MACIASWORLD.COM

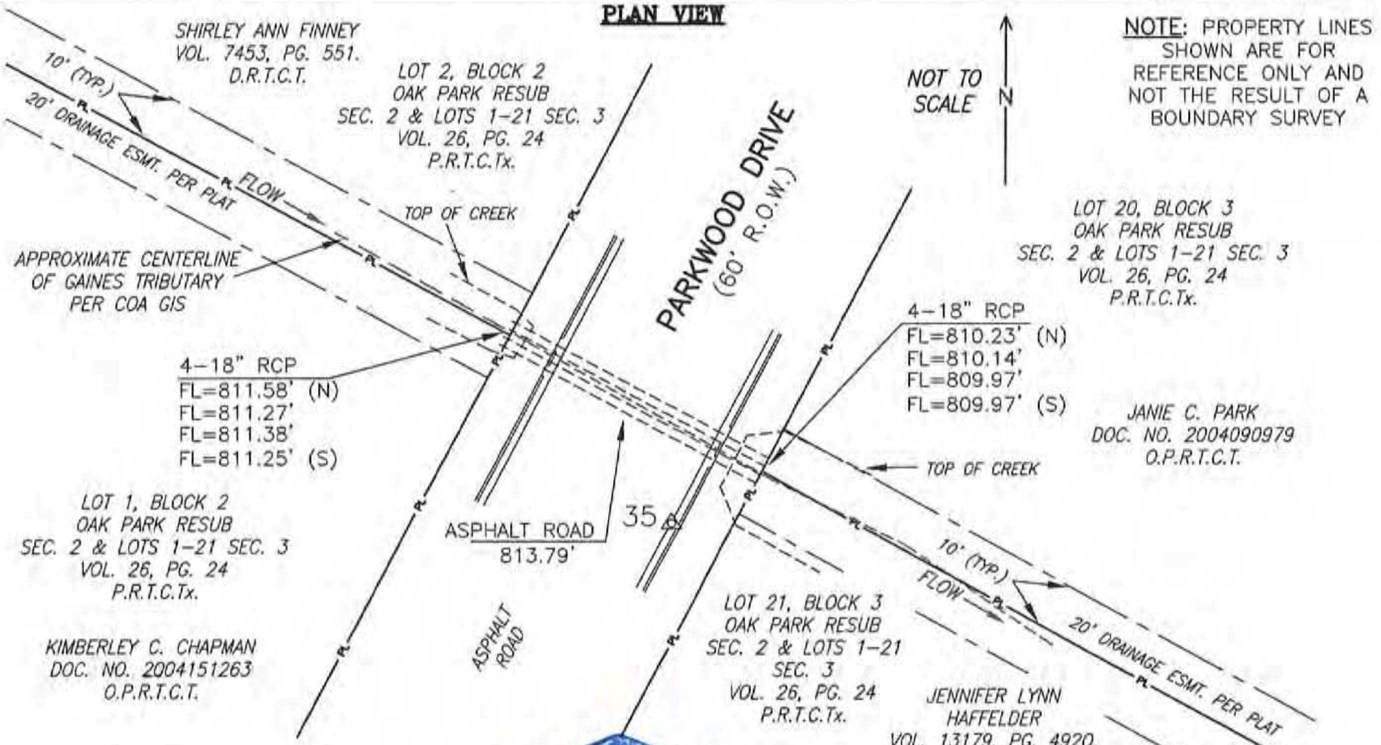
FLOOD CROSSING DATA SHEET

PROJECT: GAINES TRIBUTARY MAPPING
STRUCTURE NAME: X2–PARKWOOD DRIVE
STREAM NAME: GAINES TRIBUTARY
DATE: 8/2/12
LOCATION: PARKWOOD DRIVE
CREW: STEVEN DUARTE
TYPE: BR ( ) CUL ( ) DAM ( ) XS ( )
TBM ELEV: 813.15' TBM ID: CP 35
BRIDGE: RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____
CULVERT: NUM# 4 SHAPE ROUND LENGTH ____ SIZE: H ____ W ____ SKEW ____
CULVERT: I/O TYPE 18" MATERIAL CONC. WINGWALL US ____ DS ____
DAM: TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____
TBM DESCRIPTION: MAG NAIL

PROFILE VIEW



PLAN VIEW



NOTE: PROPERTY LINES SHOWN ARE FOR REFERENCE ONLY AND NOT THE RESULT OF A BOUNDARY SURVEY

STATE OF TEXAS REGISTERED STEVEN M. DUARTE 5940 PROFESSIONAL LAND SURVEYOR

8/27/12

Steven M. Duarte Date:
Registered Professional Land Surveyor
No. 5940 – State of Texas

DATE: 08–27–12
DRAWN BY: smd
MAI JOB NO.: 512–03–12
REFERENCE: 613/9

MACIAS & ASSOCIATES, L.P.
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FLOOD CROSSING DATA SHEET

PROJECT: GAINES TRIBUTARY MAPPING — STRUCTURE NAME: X3-OAKCLAIRE-NORTH

STREAM NAME: GAINES TRIBUTARY — DATE: 8/6/12

LOCATION: OAKCLAIRE DRIVE — CREW: STEVEN DUARTE

TYPE: BR ( ) CUL ( ) DAM ( ) XS ( ) — TBM ELEV: 804.07' — TBM ID: CP 33

BRIDGE: RAIL ___ DECK ___ WIDTH ___ PIER(s) ___ @ ___ PIER SHAPE ___

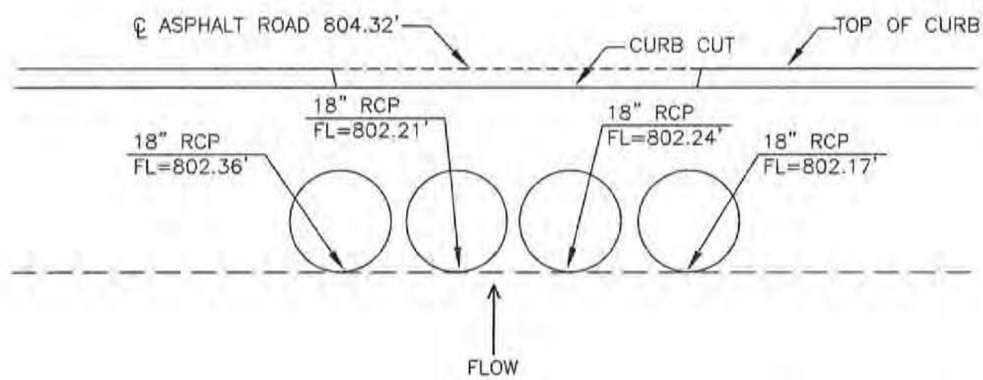
CULVERT: NUM# 4 — SHAPE ROUND — LENGTH ___ — SIZE: H ___ W ___ — SKEW ___

CULVERT: I/O TYPE 18" — MATERIAL CONC. — WINGWALL US ___ DS ___

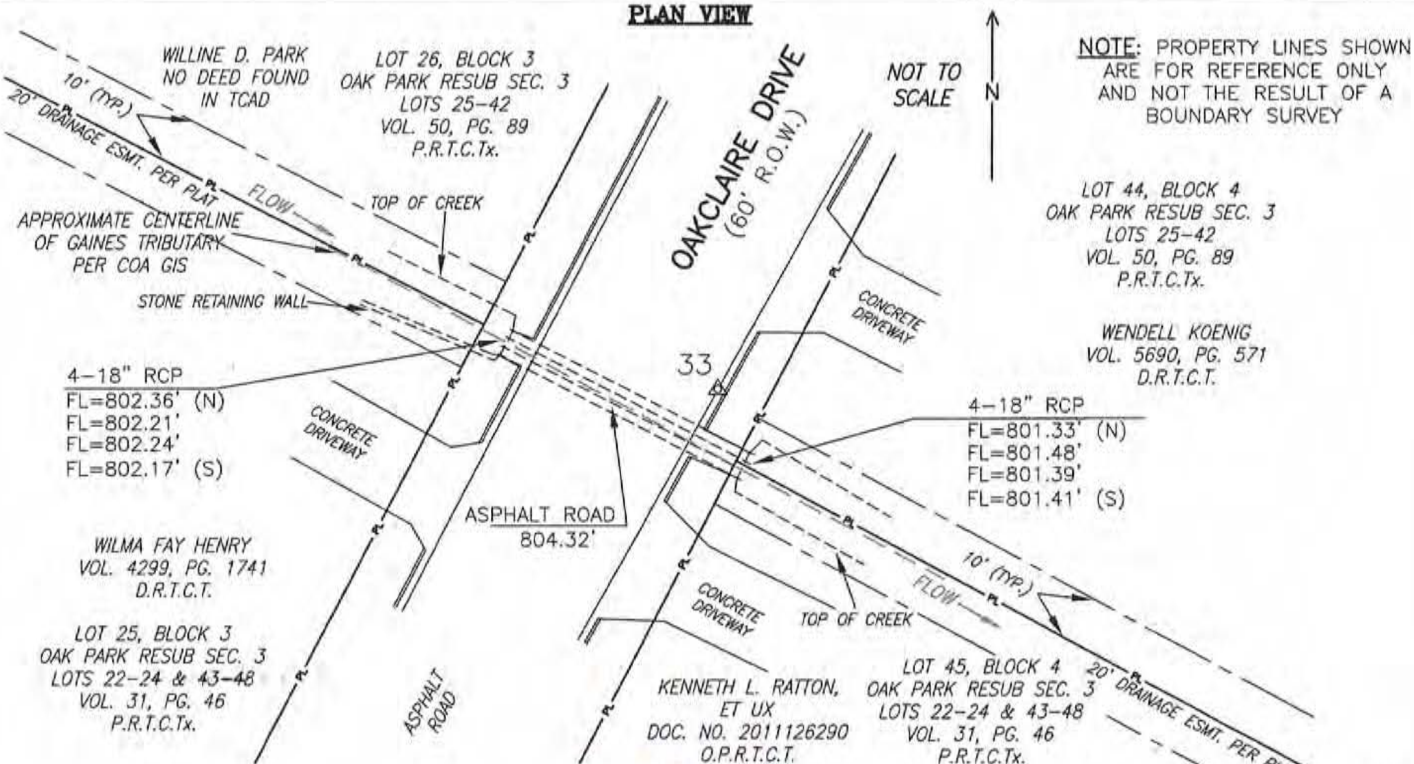
DAM: TOP WIDTH ___ SIDE SLOPE US ___ DS ___ RISER ___ X ___ SPY: ___

TBM DESCRIPTION: MAG NAIL

PROFILE VIEW



PLAN VIEW



DATE: 08-27-12
DRAWN BY: smd

MAI JOB NO.: 512-03-12
REFERENCE: 613/9

8/27/12
Date:

Steven M. Duarte
Registered Professional Land Surveyor
No. 5940 – State of Texas

STATE OF TEXAS — REGISTERED — STEVEN M. DUARTE — 5940 — PROFESSIONAL LAND SURVEYOR

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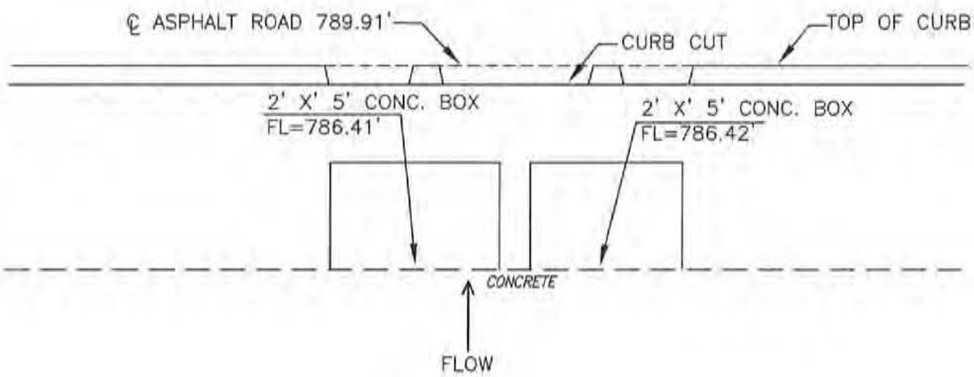
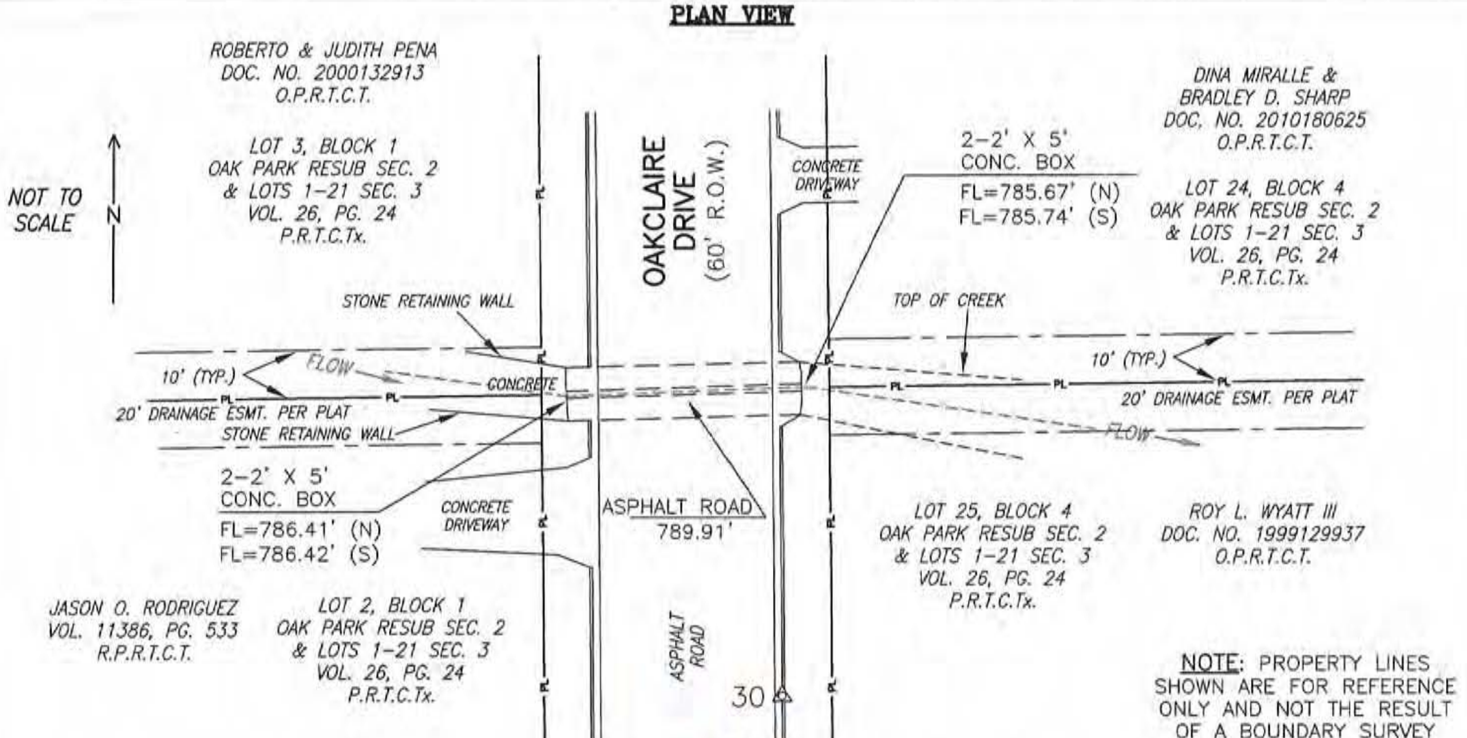
FLOOD CROSSING DATA SHEET

PROJECT: GAINES TRIBUTARY MAPPING
STRUCTURE NAME: X4-OAKCLAIRE-SOUTH
STREAM NAME: GAINES TRIBUTARY
DATE: 8/6/12
LOCATION: OAKCLAIRE DRIVE
CREW: STEVEN DUARTE
TYPE: BR ( ) CUL ( ) DAM ( ) XS ( )
TBM ELEV: 789.56' TBM ID: CP 30
BRIDGE: RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____
CULVERT: NUM# 2 SHAPE RECT. LENGTH ____ SIZE: H 2' W 5' SKEW ____
CULVERT: I/O TYPE ____ MATERIAL CONC. WINGWALL US ____ DS ____
DAM: TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____
TBM DESCRIPTION: MAG NAIL

PROFILE VIEW



PLAN VIEW



NOTE: PROPERTY LINES SHOWN ARE FOR REFERENCE ONLY AND NOT THE RESULT OF A BOUNDARY SURVEY

STATE OF TEXAS — REGISTERED — STEVEN M. DUARTE — 5940 — PROFESSIONAL LAND SURVEYOR

8/27/12

Steven M. Duarte
Registered Professional Land Surveyor
No. 5940 - State of Texas
Date:

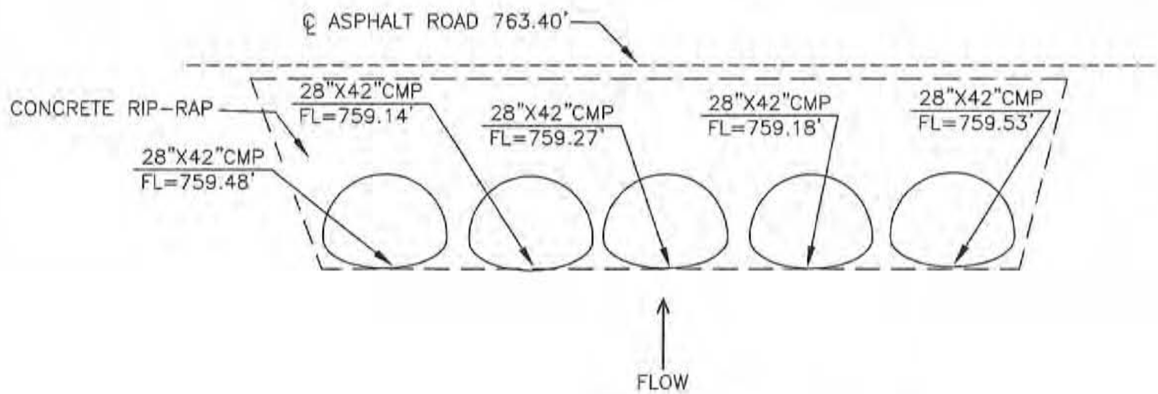
DATE: 08-27-12
DRAWN BY: smd
MAI JOB NO.: 512-03-12
REFERENCE: 613/9

MACIAS & ASSOCIATES, L.P.
LAND SURVEYORS
5410 SOUTH 1ST STREET
AUSTIN, TEXAS 78745 PH. (512)442-7875
FAX (512)442-7876 EMAIL: WWW.MACIASWORLD.COM

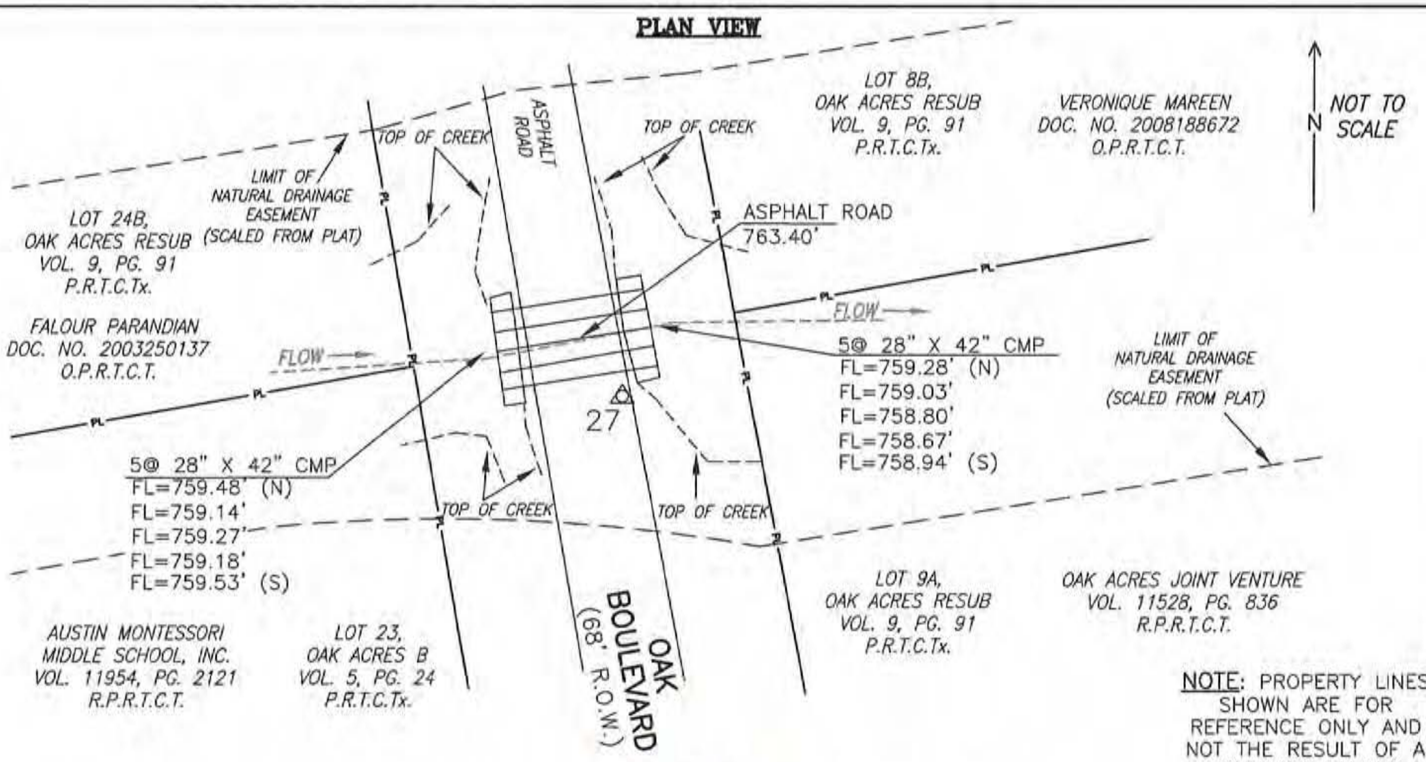
FLOOD CROSSING DATA SHEET

PROJECT: GAINES TRIBUTARY MAPPING
STRUCTURE NAME: X5–OAK BOULEVARD
STREAM NAME: GAINES TRIBUTARY
DATE: 8/6/12
LOCATION: OAK BOULEVARD
CREW: STEVEN DUARTE
TYPE: BR ( ) CUL ( ) DAM ( ) XS ( )
TBM ELEV: 763.28'
TBM ID: CP 27
BRIDGE: RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____
CULVERT: NUM# 5 SHAPE PIPE–ARCH LENGTH ____ SIZE: H 28" W 42" SKEW ____
CULVERT: I/O TYPE ____ MATERIAL CMP WINGWALL US ____ DS ____
DAM: TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____
TBM DESCRIPTION: MAG NAIL

PROFILE VIEW



PLAN VIEW



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DRAWN BY: smd
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STATE OF TEXAS REGISTERED STEVEN M. DUARTE 5940 PROFESSIONAL LAND SURVEYOR

8/27/12
Steven M. Duarte
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FLOOD CROSSING DATA SHEET

PROJECT GAINES TRIBUTARY MAPPING — **STRUCTURE NAME** X6-COLEMAN WEST

STREAM NAME GAINES TRIBUTARY — **DATE** 8/2/12

LOCATION COLEMAN/14.69 ACRES — **CREW** JACK CROW

TYPE BR ( ) CUL ( ) DAM ( ) XS ( ) — **TBM ELEV** 756.35 **TBM ID** CP 26

BRIDGE RAIL ____ DECK ____ WIDTH ____ PIER(s) ____@____ PIER SHAPE ____

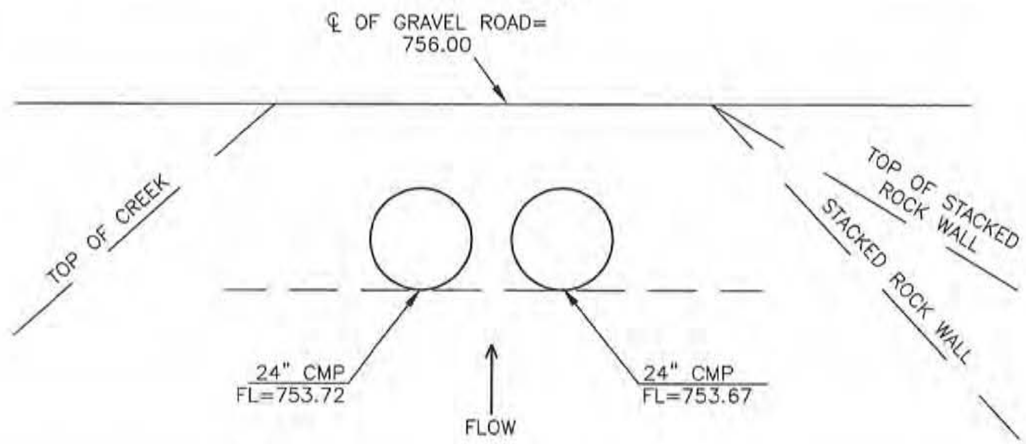
CULVERT NUM#____ SHAPE____ LENGTH ____ SIZE: H____ W____ SKEW ____

CULVERT I/O TYPE 24" MATERIAL CMP WINGWALL US____ DS____

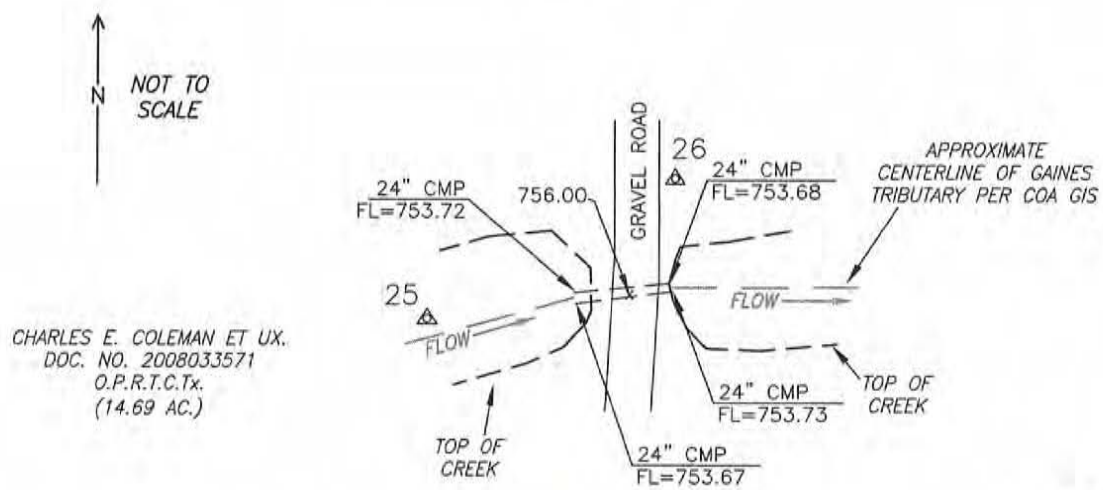
DAM TOP WIDTH____ SIDE SLOPE US____ DS____ RISER ____X____ SPY:____

TBM DESCRIPTION 60D NAIL

PROFILE VIEW



PLAN VIEW



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STATE OF TEXAS — REGISTERED — STEVEN M. DUARTE — 5940 — PROFESSIONAL LAND SURVEYOR

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Steven M. Duarte — Date:
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FLOOD CROSSING DATA SHEET

PROJECT GAINES TRIBUTARY MAPPING **STRUCTURE NAME** X7-COLEMAN MIDDLE

STREAM NAME GAINES TRIBUTARY **DATE** 8/2/12

LOCATION COLEMAN/14.69 ACRES **CREW** JACK CROW

TYPE BR ( ) CUL ( ) DAM ( ) XS ( ) **TBM ELEV** 755.21 **TBM ID** CP 24

BRIDGE RAIL ______ DECK ______ WIDTH ______ PIER(s) ______ @ ______ PIER SHAPE ______

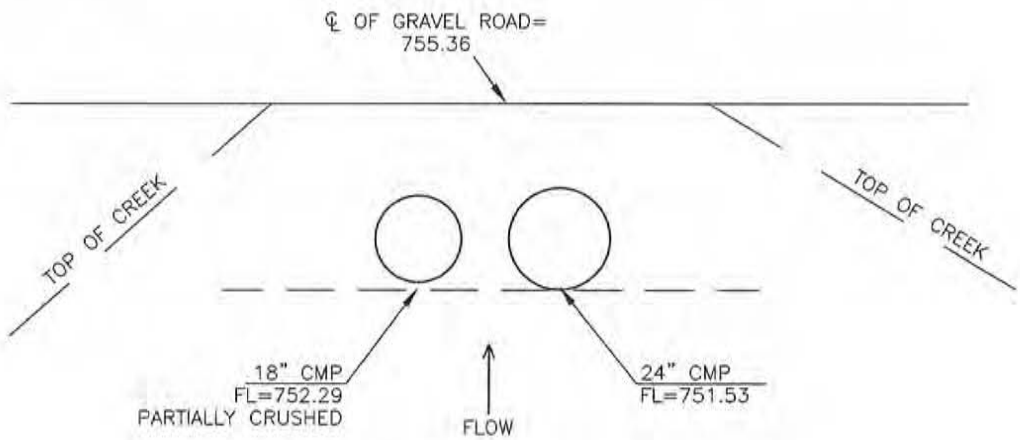
CULVERT NUM# ______ SHAPE ______ LENGTH ______ SIZE: H ______ W ______ SKEW ______

CULVERT I/O TYPE 18"/24" MATERIAL CMP WINGWALL US ______ DS ______

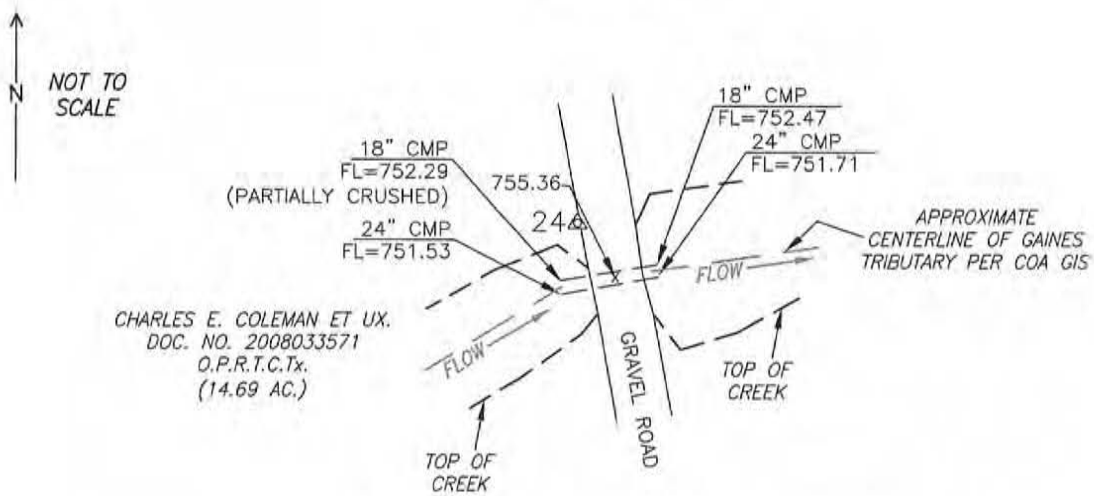
DAM TOP WIDTH ______ SIDE SLOPE US ______ DS ______ RISER ______ X ______ SPY: ______

TBM DESCRIPTION 60D NAIL

PROFILE VIEW



PLAN VIEW



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STATE OF TEXAS REGISTERED STEVEN M. DUARTE 5940 PROFESSIONAL LAND SURVEYOR

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FLOOD CROSSING DATA SHEET

PROJECT GAINES TRIBUTARY MAPPING — STRUCTURE NAME X8-COLEMAN EAST

STREAM NAME GAINES TRIBUTARY — DATE 8/6/12

LOCATION COLEMAN/14.69 ACRES — CREW JACK CROW

TYPE BR ( ) CUL ( ) DAM ( ) XS ( ) — TBM ELEV 754.29 TBM ID CP 22

BRIDGE RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____

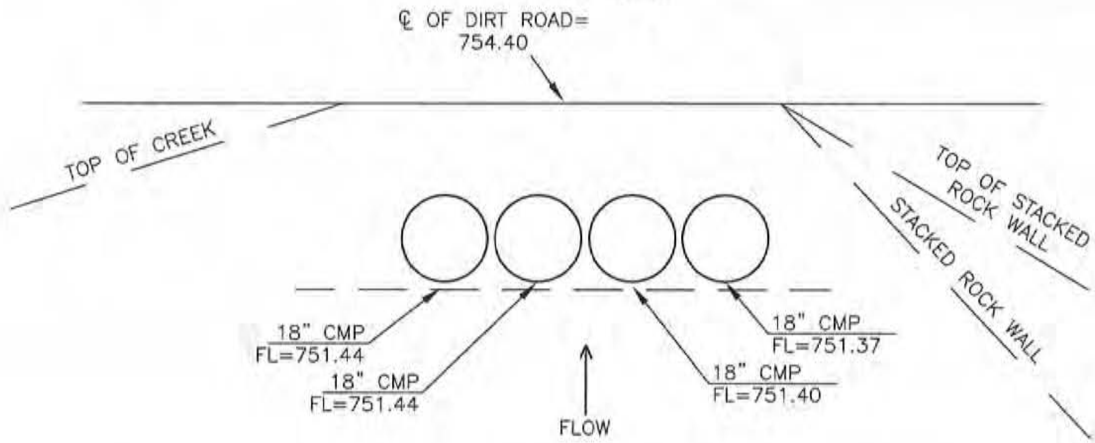
CULVERT NUM# ____ SHAPE ____ LENGTH ____ SIZE: H ____ W ____ SKEW ____

CULVERT I/O TYPE 18" MATERIAL CMP WINGWALL US ____ DS ____

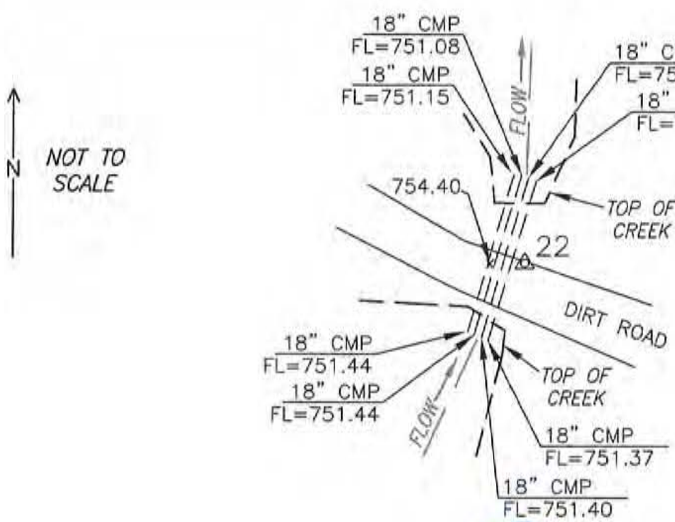
DAM TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____

TBM DESCRIPTION 60D NAIL

PROFILE VIEW



PLAN VIEW



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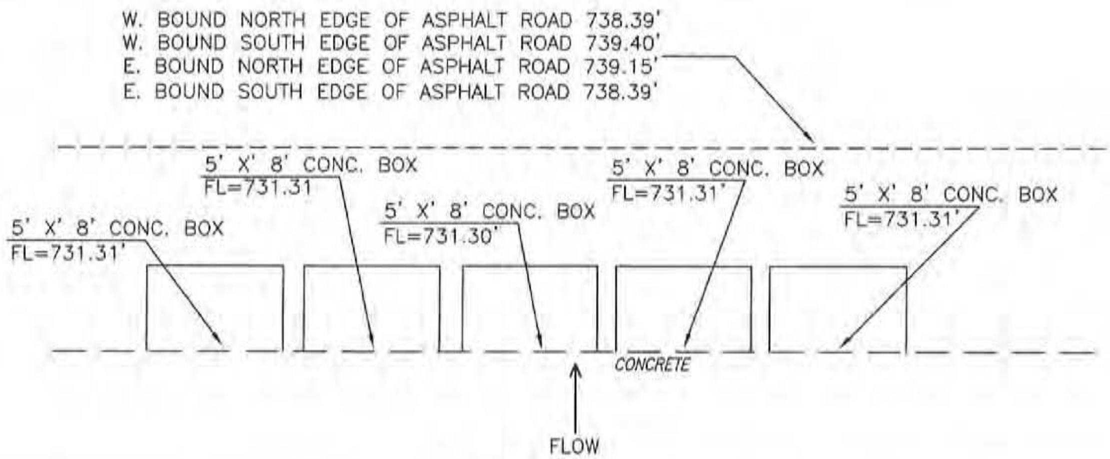
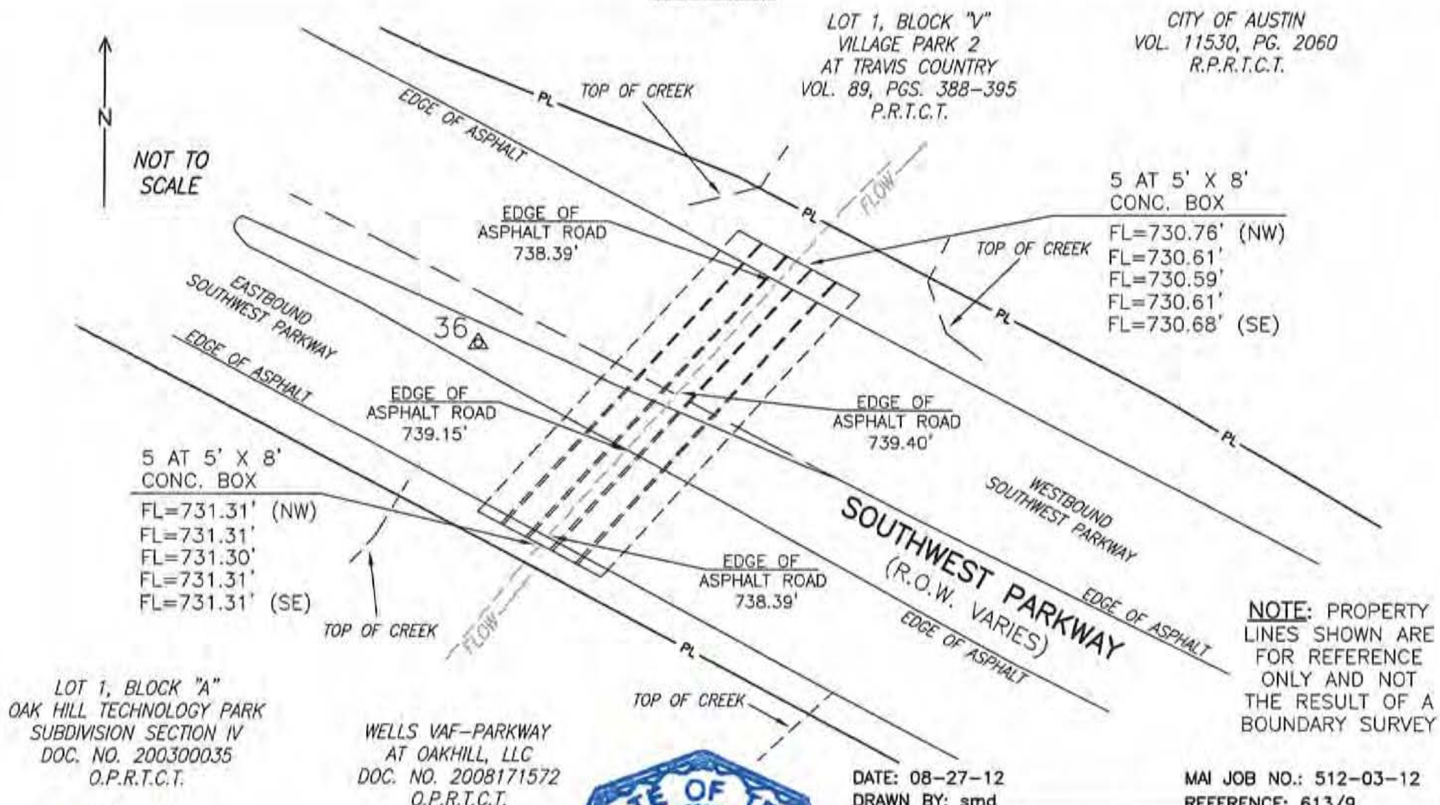
FLOOD CROSSING DATA SHEET

PROJECT: GAINES TRIBUTARY MAPPING
STRUCTURE NAME: X9-SOUTHWEST PARKWAY
STREAM NAME: GAINES TRIBUTARY
DATE: 8/6/12
LOCATION: SOUTHWEST PARKWAY
CREW: STEVEN DUARTE
TYPE: BR ( ) CUL ( ) DAM ( ) XS ( )
TBM ELEV: 738.80' TBM ID: CP 36
BRIDGE: RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____
CULVERT: NUM# 5 SHAPE RECT. LENGTH ____ SIZE: H 5' W 8' SKEW ____
CULVERT: I/O TYPE ____ MATERIAL CONC. WINGWALL US ____ DS ____
DAM: TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____
TBM DESCRIPTION: 1/2" REBAR

PROFILE VIEW



PLAN VIEW



LOT 1, BLOCK "A"
OAK HILL TECHNOLOGY PARK
SUBDIVISION SECTION IV
DOC. NO. 200300035
O.P.R.T.C.T.

WELLS VAF-PARKWAY
AT OAKHILL, LLC
DOC. NO. 2008171572
O.P.R.T.C.T.

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FLOOD CROSSING DATA SHEET

PROJECT: GAINES TRIBUTARY MAPPING
STRUCTURE NAME: X10-PARKWOOD SOUTH

STREAM NAME: GAINES TRIBUTARY
DATE: 9/19/12

LOCATION: PARKWOOD DRIVE
CREW: STEVEN DUARTE

TYPE: BR ( ) CUL ( ) DAM ( ) XS ( )
TBM ELEV: 797.08' TBM ID: CP 45

BRIDGE: RAIL ____ DECK ____ WIDTH ____ PIER(s) ____ @ ____ PIER SHAPE ____

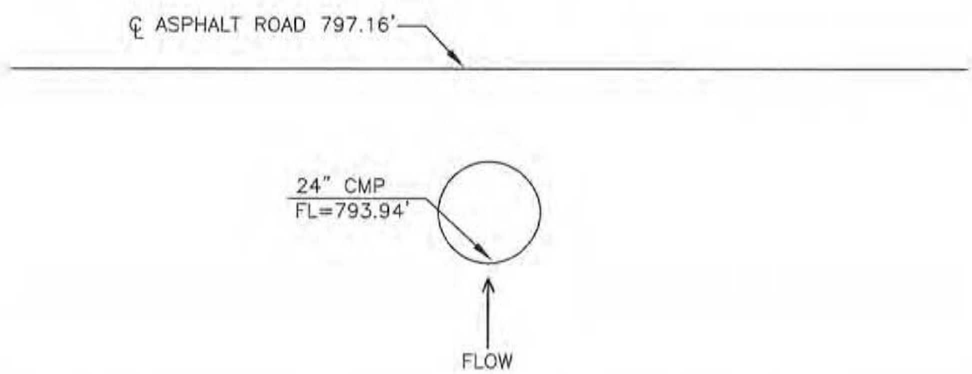
CULVERT: NUM# 1 SHAPE ROUND LENGTH ____ SIZE: H ____ W ____ SKEW ____

CULVERT: I/O TYPE 24" MATERIAL CMP WINGWALL US ____ DS ____

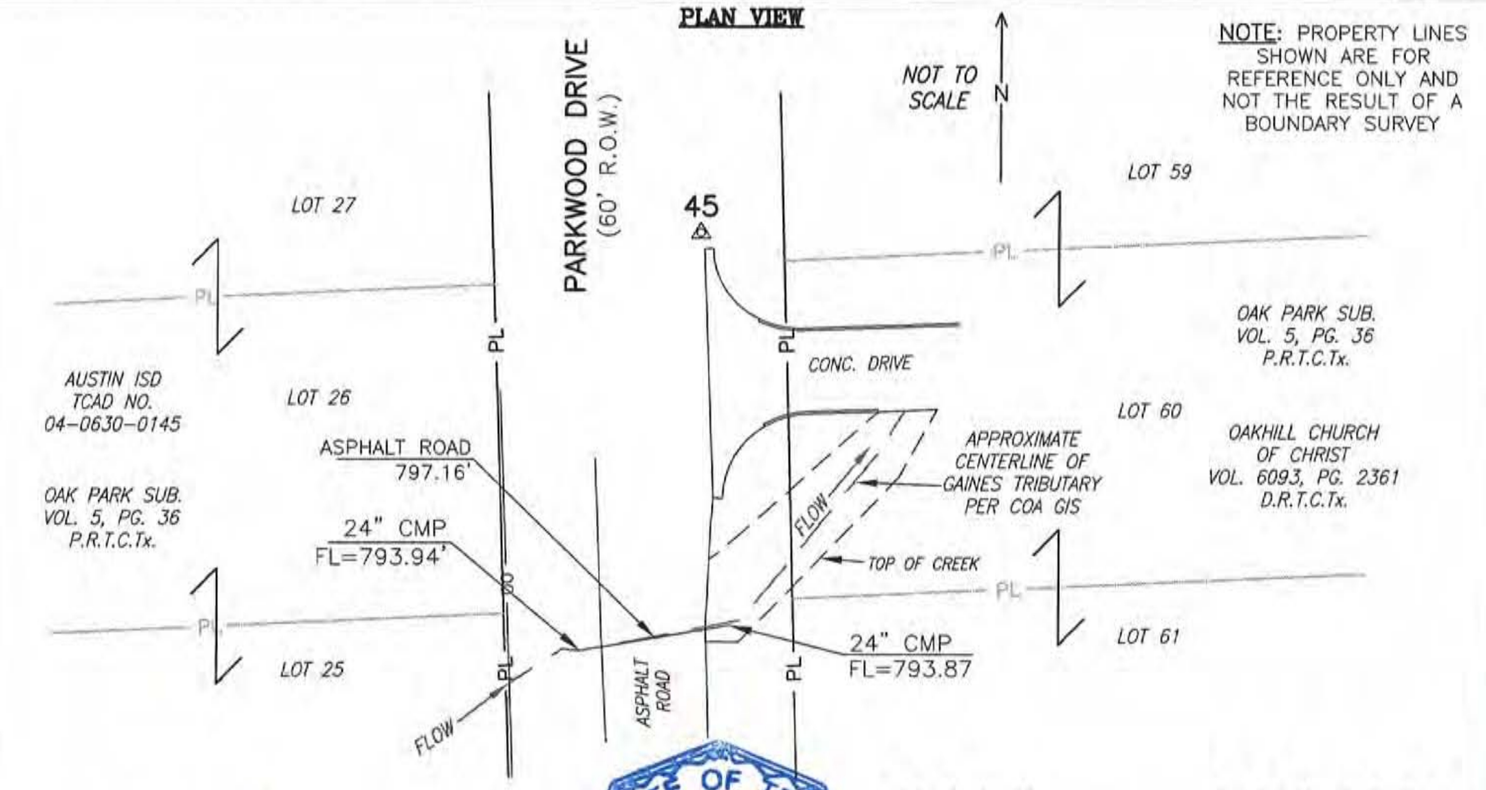
DAM: TOP WIDTH ____ SIDE SLOPE US ____ DS ____ RISER ____ X ____ SPY: ____

TBM DESCRIPTION: MAG NAIL

PROFILE VIEW



PLAN VIEW



STATE OF TEXAS — REGISTERED — STEVEN M. DUARTE — 5940 — PROFESSIONAL LAND SURVEYOR

DATE: 09-20-12
DRAWN BY: smd

MAI JOB NO.: 512-03-12
REFERENCE: 615/22

Steven M. Duarte — Date: 9/20/12
Registered Professional Land Surveyor
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Appendix E – Digital Data Disk