Lake Creek Flood Study

Prepared On Behalf Of:

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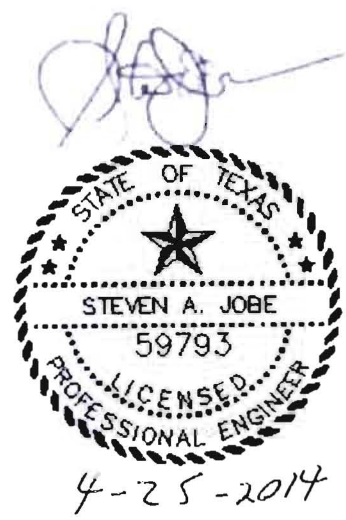

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I. INTRODUCTION

This flood study report is prepared on behalf of Tom Green County, San Angelo, Texas (client), by Chalk Mountain LLC dba Nationwide Floodplain Resources, a registered engineering company in the State of Texas TBPE Firm Number 11064. The intent of this report is to provide information required to prepare an application for a Letter of Map Revision, pertaining to the current floodplain for the East and West Forks of Lake Creek, as depicted on FEMA Flood Insurance Rate Panel Map number FM48451C0340E, dated June 12, 2012 and Panel Map number FM48451C0480E, also dated June 12, 2012.

This study is based upon newly acquired, detailed topographic information obtained from aerial ortho-photogrammetry as well as advanced two-dimensional hydrologic and hydraulic modeling techniques.

This report digresses on the hydrologic and hydraulic analysis of an area bounded downstream by Cauley Lane and upstream to a point approximately 3.35 miles north of the intersection of North Grape Creek Road and March Road for an area referred to as the East and West branches of Lake Creek.

A site location map of the subject area is shown below.

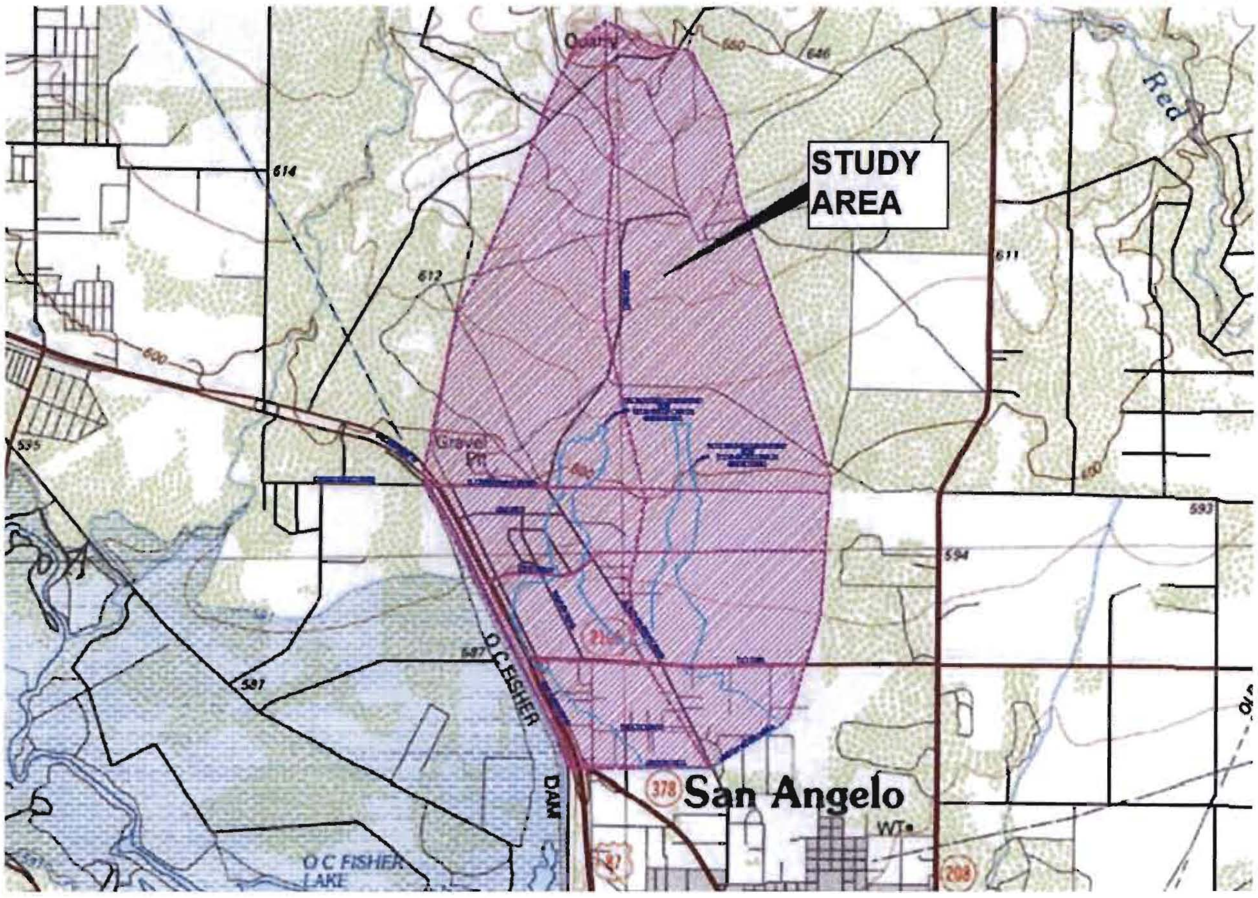


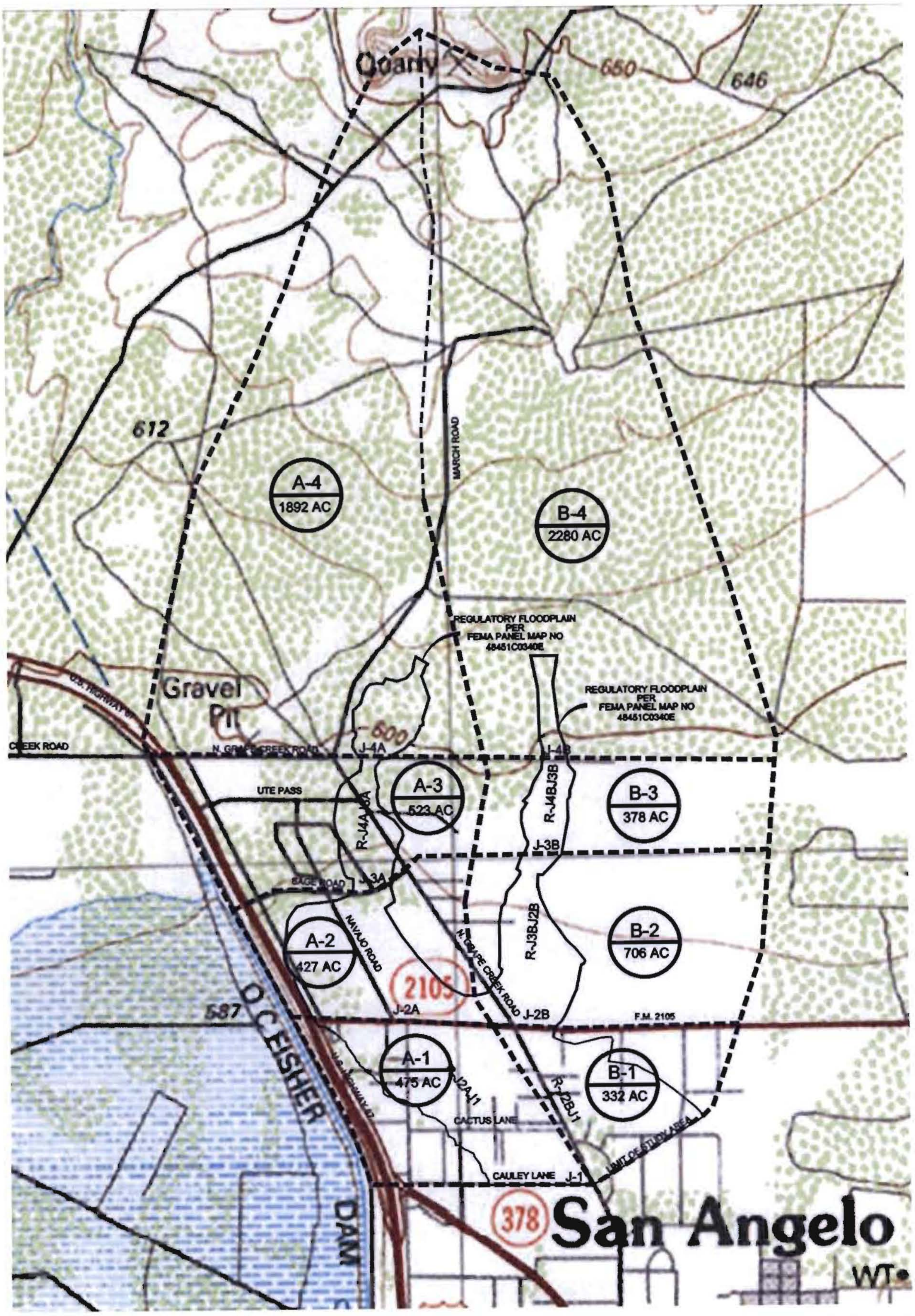
Figure 1

Sources of Geometric Data

A combination of geographic information has been utilized to develop this flood study. U.S.G.S. 7.5 minute quadrangles at a scale of 1"=2000' containing 10 foot contours were utilized for the hydrologic study.

The hydraulic study utilized two-foot contour data obtained from ortho-rectified aerial data as acquired and prepared by United Geo Technologies LLC.

The Hydrologic Work Map (Figure 2) shown on the following page illustrates the drainage basin which defines the study area utilized for the hydrologic analysis. For a more detailed view, reference sheet C1.PDF.


Quarry
660
646
612
MARCH ROAD
A-4
1892 AC
B-4
2280 AC
REGULATORY FLOODPLAIN
PER
FEMA PANEL MAP NO
48451C0340E
REGULATORY FLOODPLAIN
PER
FEMA PANEL MAP NO
48451C0340E
Gravel
Pit
600
CREEK ROAD
J-4A
J-4B
UTE PASS
A-3
523 AC
R-J4BJ3B
B-3
378 AC
J-3B
SAGE ROAD
J-3A
A-2
427 AC
NAVAJO ROAD
R-J3BJ2B
B-2
706 AC
2105
587
J-2A
J-2B
F.M. 2105
O C FISHER
A-1
475 AC
B-1
332 AC
CACTUS LANE
CAULEY LANE
J-1
LIMIT OF STUDY AREA
DAM
378
San Angelo
WT

II. HYDROLOGIC ANALYSIS

A hydrologic model of was prepared which represents existing conditions experienced during the 100-year storm event. The hydrology for the watershed was analyzed using the US Army Corps of Engineers (USCOE) HEC-HMS Watershed modeling Program Version 3.4. The HEC-HMS program arranges the incremental rainfall amounts in a critical pattern and generates runoff which, when applied to the unit hydrograph, produces a discharge associated with each sub-area. The discharge for the uppermost sub-area is routed through the next downstream sub-area and combined with the runoff from that sub-area. This continues sequentially to the mouth of the basin at the property line.

HEC-HMS Order of Operations

The following figure illustrates the order of operations used to define the HEC-HMS computer model.

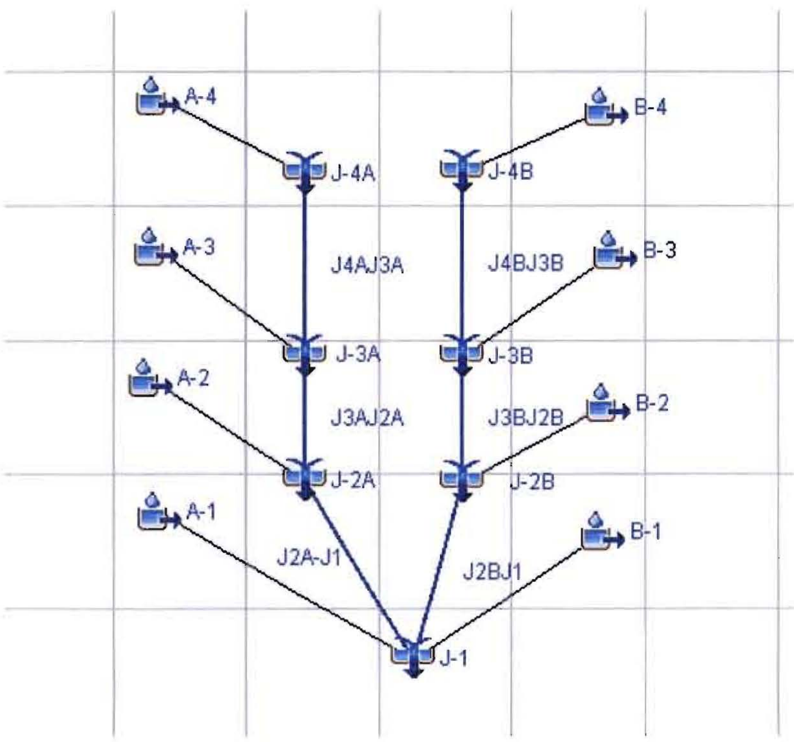


FIGURE 3
HEC-HMS Order of Operations

HYDROLOGIC PARAMETERS

Drainage Area Boundaries

For the purposes of this study, eight sub-basins A-1 thru A-4 and B-1 thru B-4 were delineated within the overall drainage basin, representing a total drainage area of approximately 6,284 acres (9.81 square miles).

Precipitation

A 24-hour design storm was developed using the Soil Conservation Service (SCS) Type II rainfall distribution and a computational interval of 5 minutes for the 100-year return periods. Point rainfall depths are based upon the National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum HYDRO-35 (5 – 60 minutes) and the National Weather Service Technical Paper No. 40 (1 – 24 hours). The design storm point rainfall values were based on historical depths and storm characteristics and obtained for Tom Green County, Texas.

Duration	(inches)	
5 Minute	0.85	**
15 Minute	1.81	**
1 Hour	3.75	*
2 Hour	4.5	*
3 Hour	4.9	*
6 Hour	6	*
12 Hour	7.1	*
1 Day	8.4	*

* from USWB TP40, Rainfall Frequency Atlas of the U.S.
** from NOAA Technical Memorandum NWS Hydro-35

Table 1 – Rainfall

Hydrologic Routing

The SCS Unit Hydrograph runoff calculation method was selected due to the size of the watershed. The contributing watershed was divided into eight sub-basins, used to represent the movement of water over the land surface and in stream channels. The input to this component is a precipitation hyetograph. Precipitation excess is computed by subtracting infiltration and detention losses based on a soil water infiltration rate function. The rainfall and infiltration were assumed to be uniform over the sub basin. The resulting rainfall excesses were then routed by the SCS Unit Hydrograph method to the outlet of the sub basin, producing a runoff hydrograph. The SCS Unit Hydrograph method produces a runoff hydrograph at the most downstream point in the sub basin. Flows resulting from upstream sub-basins were routed through downstream sub-basins using the reach method. The lag time used for each reach was estimated to be 60% of the time of concentration for the sub-basin which the reach crosses.

Unit Hydrograph - Time of Concentration

The SCS Dimensionless Unit Hydrograph was used to transform rainfall excess into sub-basin flows. The time of concentration was estimated using TR-55 SCS methodology. This methodology incorporates three types of flow: sheet flow, shallow concentrated flow and channel flow. The resulting time of concentration is the sum of sheet flow, shallow concentrated flow and open channel flow segments.

Sheet Flow

Sheet flow was estimated to occur for the first 300 feet, with channelized flow occurring thereafter. Normally, sheet flow is calculated using this equation:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} S^{0.4}}$$

where:

n = Manning's roughness coefficients for sheet flow;
L = the length, in feet, of the overland flow path;
P2 = the 2-year, 24-hour rainfall, in inches;
S = the land slope in feet per foot; and,
Tt = the sheet flow travel time in minutes.

Each parameter for sheet flow was derived from the Hydrology work map. The selected roughness coefficient for overland flow is 0.011. A rainfall amount for P2 of 3.3 inches was utilized (per TP-40).

Shallow Concentrated Flow

The second component of the existing time of concentration is the shallow concentrated flow time, which is determined by the equation:

Tt = L / 3600 * V

where:
L = Length in feet;
V = Velocity in feet per second; Assumption, V= 2 fps
Tsc = the shallow concentrated flow time in hours.

Channelized Flow

A detailed field inspection, combined with inspection of aerial photography and detailed 2-foot contour interval topographic maps revealed no channelized flow areas. Therefore, the channel flow component was not included as part of the calculation of total travel time.

Table 2 - Time of Concentration/Lag Time Calculations

DRAINAGE CALCULATION SUMMARY
SUB-BASIN - LAG TIME

		TOTAL	SHEET FLOW					CONCENTRATED FLOW					
DRAIN AREA NO	AREA (acres)	REACH LENGTH (Lc/Lc) (feet)	REACH LENGTH (Lc/Lc) (feet)	SLOPE So/Sc (ft/ft)	MANNING (n)	P2 (inches)	Tc (hrs)	REACH LENGTH (Lc/Lc) (feet)	SLOPE So/Sc (ft/ft)	MANNING (n)	Tc (hrs)	Tc Total (hrs)	Lag Total (min)
A-1	475.0	8490	300	0.0006	0.018	3.30	0.2909	8190	0.0006	0.200	18.749	19.04	685
A-2	427.0	5127	300	0.0004	0.018	3.30	0.3430	4827	0.0004	0.200	13.578	13.92	501
A-3	523.0	6444	300	0.0017	0.018	3.30	0.1900	6144	0.0017	0.200	8.262	8.45	304
A-4	1892.0	17627	300	0.0023	0.018	3.30	0.1696	17327	0.0023	0.200	20.207	20.38	734
B-1	332.0	5282	301	0.0060	0.018	3.30	0.1151	4981	0.0060	1.200	21.392	21.51	774
B-2	706.0	7492	302	0.0015	0.018	3.30	0.2029	7190	0.0015	2.200	114.670	114.87	4135
B-3	378.0	6200	303	0.0018	0.018	3.30	0.1886	5897	0.0018	3.200	124.445	124.63	4487
B-4	2280.0	17930	304	0.0022	0.018	3.30	0.1726	17626	0.0022	4.200	435.372	435.54	15680

Infiltration and Soil Losses

The SCS Curve Number methodology, as detailed in NRCS Technical Release 55 – Urban Hydrology for Small Watersheds, was used to estimate infiltration and soil losses.

The SCS method uses curve numbers (CN). The curve number is the parameter used by the HEC-HMS model to estimate the amount of excess rainfall that will result in direct runoff. Curve numbers values are related to the different land cover, hydrologic soil group, and land management practices.

The Soil Conservation Service (SCS), U.S. Department of Agriculture, has instituted a soil classification system for use in soil survey maps across the country. Based on experimentation and experience, the agency has been able to relate the drainage characteristics of soil groups to a curve number, CN (SCS, 1972 and 1975). The SCS provided information on relating soil group type to the curve number as a function of soil cover, land use type and antecedent moisture conditions. "A" soils are those which have high infiltration capacity and subsequently low runoff rates. "D" soils are those with very low infiltration capacity and very high runoff rates. The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Runoff Curve Numbers

Cover description	Curve numbers for hydrologic soil group			
	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.)				
Poor condition (grass cover <50%)	68	79	86	89
Poor condition (grass cover 50 to 75%)	49	69	79	84
Poor condition (grass cover >75%)	39	61	74	80
Impervious areas:				
Paved parking lots, roofs, driveways, etc. (excluding right of way)	98	98	98	98
Streets and roads:				
Paved; curbs and storm sewers (excluding right-of-way)	98	98	98	98
Paved; open ditches (including right-of-way)	83	89	92	93
Gravel (including right of way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Western desert urban areas:				
Natural desert landscaping (pervious area only)	63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)	96	96	96	96
Urban districts:				
Commercial and business (85% imp.)	89	92	94	95
Industrial (72% imp.)	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses) (65% imp.)/small>	77	85	90	92
1/4 acre (38% imp.)	61	75	83	87
1/3 acre (30% imp.)	57	72	81	86
1/2 acre (25% imp.)	54	70	80	85
1 acre (20% imp.)	51	68	79	84
2 acres (12% imp.)	46	65	77	82

Developing urban areas				
Cover description	Curve numbers for hydrologic soil group			
	A	B	C	D
Newly graded areas (pervious areas only, no vegetation)	77	86	91	94

Cultivated agricultural lands						
Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment[A]	Hydrologic	A	B	C	D
Fallow	Bare soil	--	77	86	91	94
	Crop residue cover	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + R	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + R	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

Other agricultural lands					
Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrolog ic	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.A	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	---	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.B	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30C	48	65	73
Woods—grass combination (orchard or tree farm).D	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.E	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	---	59	74	82	86

Soil Types within the Watershed

The different land cover and soil groups found within the sub basins were taken from the Natural Resources Conservation Service (NRCS) Soil Survey of Tom Green County, Texas. Within each sub basin, more than one land cover type and soil group exist. In order to find a representative curve number, a weighted curve number was determined using the areas of the different land cover and soil types in each sub basin.

The average soil type found within the watershed are hydrologic soil group type A. A soils map including soil types found and their hydrologic soil group rating follows on the next page.

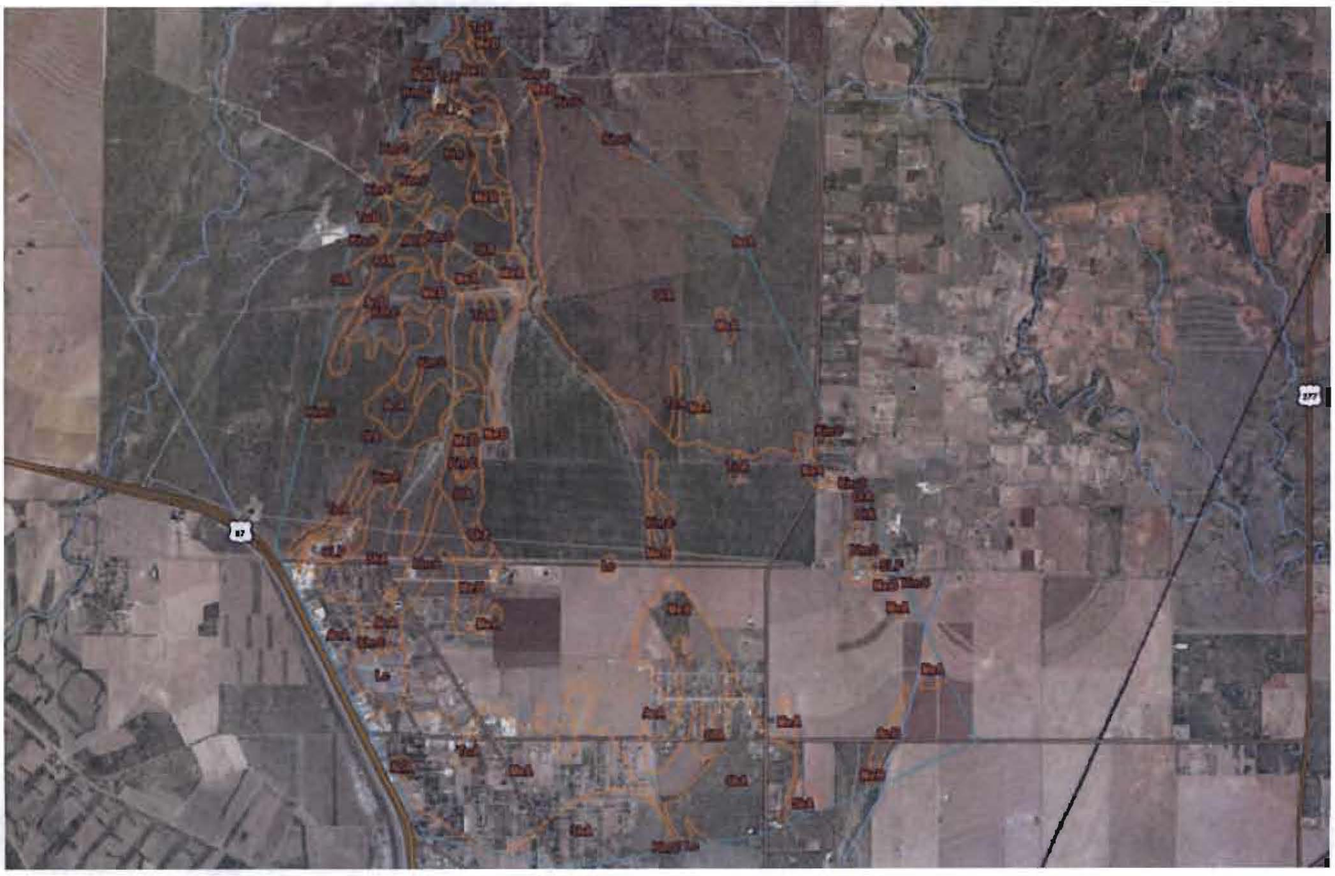


FIGURE 4
Soils Map

Table 4 – Hydrologic Soil Types Found within Region

Tom Green County, Texas (TX451)

Map Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AnA	Angelo clay loam, 0 to 1 percent slopes	5,356.2	42.7%
AnB	Angelo clay loam, 1 to 3 percent slopes	310.7	2.5%
BeD	Berda loam, 3 to 8 percent slopes	66.9	0.5%
CLP	Pits, caliche	50.2	0.4%
KmC	Cho association, undulating	846.8	6.7%
Lc	Lipan clay	90.4	0.7%
MeA	Mereta clay loam, dry, 0 to 1 percent slopes	1,286.7	10.3%
MeB	Mereta clay loam, dry, 1 to 3 percent slopes	292.1	2.3%
OlA	Sagerton clay loam, 0 to 1 percent slopes	2,847.4	22.7%
RtA	Rotan clay loam, 0 to 1 percent slopes	127.1	1.0%
SkA	Slaughter-Cho complex, 0 to 1 percent slopes	998.4	8.0%
SLF	Sanitary landfill	1.9	0.0%
TaE	Tarrant association, hilly	138.8	1.1%
ToA	Tobosa clay, 0 to 1 percent slopes	130.7	1.0%
TuB	Tulia loam, 1 to 3 percent slopes	8.1	0.1%

Weighted Curve Number

For the purposes of this study, curve numbers were based upon both undeveloped as well as developed conditions. Developed conditions assumed two acre home sites as the average land usage. Based upon this assumption of land future usage as well as hydrologic soil types encountered within the drainage basin, a weighted curve number of 46 was utilized for undeveloped basins and a curve number of 49 was utilized for developed sub-basins.

Table 5 - Summary of Hydrologic Results

The results of the hydrologic analysis are presented in the table below:

Global Summary Results for Run "Pre-Dev 100-Year"

Project: Project 2   Simulation Run: Pre-Dev 100-Year

Start of Run: 01Jan2002, 00:00   Basin Model: Existing Development
End of Run: 04Jan2002, 02:45   Meteorologic Model: 100-Year
Compute Time: 28Apr2014, 12:20:03   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: IN (•) AC-FT   Sorting: Hydrologic

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
B-4	3.56	1109.9	01Jan2002, 18:45	451.9
J-4B	3.56	1109.9	01Jan2002, 18:45	451.9
J4BJ3B	3.56	1103.1	01Jan2002, 18:45	451.9
B-3	0.59	287.4	01Jan2002, 17:15	64.6
J-3B	4.15	1210.6	01Jan2002, 18:45	516.4
J3BJ2B	4.15	1209.7	01Jan2002, 19:00	516.4
B-2	1.10	452.3	01Jan2002, 17:30	120.4
J-2B	5.25	1442.0	01Jan2002, 18:45	636.8
J2BJ1	5.25	1441.0	01Jan2002, 19:00	636.8
A-4	2.96	940.0	01Jan2002, 18:45	375.7
J-4A	2.96	940.0	01Jan2002, 18:45	375.7
J4AJ3A	2.96	938.9	01Jan2002, 18:45	375.7
A-3	0.82	388.9	01Jan2002, 17:15	89.8
J-3A	3.78	1094.5	01Jan2002, 18:45	465.5
J3AJ2A	3.78	1093.4	01Jan2002, 18:45	465.5
A-2	0.67	223.9	01Jan2002, 18:00	73.3
J-2A	4.45	1278.1	01Jan2002, 18:30	538.8
J2A-J1	4.45	1278.1	01Jan2002, 18:45	538.8
A-1	0.74	203.3	01Jan2002, 18:30	81.0
B-1	0.52	375.1	01Jan2002, 16:45	56.9
J-1	10.96	2981.6	01Jan2002, 18:45	1313.6

Conclusions of Hydrologic Analysis

Results from the hydrologic analysis are utilized within the hydraulic analysis of this project.

III. TWO-DIMENSIONAL ANALYSIS

A two-dimensional hydrologic and hydraulic model was prepared which represents existing conditions experienced during the 100-year storm event. The model was prepared using the FLO-2D V2009 software by FLO-2D Software, Inc. The FLO-2D software utilizes a comprehensive flood routing model that provides a variety of analyses including simulates channel flow, unconfined overland flow and street flow over complex topography. The software provides a comprehensive simulation of storm events by considering localized rainfall data, infiltration, sediment transport, buildings, levees, embankments, walls (wall collapse), dam breach, mudflows, storm drain, culverts, bridges, hydraulic structures and groundwater. Rainfall, infiltration and most features can be spatially and temporally variable with historical rainfall events replicated with NEXRAD data. FLO-2D is the most comprehensive hydrologic and hydraulic modeling software in the world.

FLO-2D Input

The FLO-2D model utilizes the following components:

- Inflow Hydrographs - as prepared using HEC-HMS
- Rainfall Data - as stated in Table 1 above
- Runoff Curve Numbers - as stated in Table 2 above
- Mannings Roughness Coefficients - which describe roughness of the terrain
- Terrain Points - extracted from three-dimensional terrain models derived from the newly developed ortho-photography for the area. Terrain Points were sampled on a 10-foot grid
- Gridded Mesh – a gridded mesh (100'x100' grid cell) was developed from the Terrain Points

FLO-2D Operations

Solution Algorithm

The FLO-2D model uses the full dynamic wave momentum equation and a central finite difference routing scheme with eight potential flow directions to predict the progression of a floodwave over a system of square grid elements.

The Grid System

FLO-2D requires two sets of data: topography and hydrology. Topography was sampled from the digital terrain maps obtained from the newly acquired digital ortho-photography, based upon a sampling interval of 10'. The sampling resulted in the generation of 961,148 terrain points, which were utilized to represent the digital terrain model.

A processor program called the Grid Developer System (GDS) generates the grid system and assigns the elevations. For the purposes of this study, a grid element size of 100 feet was utilized, resulting in xxxx grid cells utilized in the calculation of the floodplain.

Each grid cell was assigned an elevation, based upon averaging of the terrain points which fall within each grid cell.

Backgound Images

The Aerial imagery developed for this project was imported and utilized as the background to assist graphical editing of the surface model.

Volume Conservation, Routing Algorithm Stability and Timesteps

The key to accurate flood routing is volume conservation. FLO-2D tracks and reports on volume conservation. For the purposes of our analysis, a computational time step of 15 minutes was utilized. Additionally, the Froude Number was limited to 0.8 to insure numerical stability.

Inflow Hydrographs or Rainfall

Both inflow hydrographs and rainfall runoff information was utilized for the FLO-2D model. Outflow hydrographs obtained from the results of the HEC-HMS analysis were assigned as Inflow hydrographs to floodplain nodes. Additionally, the rainfall data identified in Table 1 was utilized within FLO-2D as the rainfall runoff model.

For this particular project, the outflow hydrographs for sub-basins A-4 and B-4 were utilized as the initial inflow hydrographs for areas downstream of these particular sub-basins. The hydrograph at Junction A-4A was applied to the West Branch of Lake Creek at grid cell number **xxx.** The hydrograph at Junction A-4B was to the upstream end of the East Branch of Lake Creek at grid cell number **xxx**. See **Figure 6** for the locations at which these two inflow hydrographs were applied.

Table 6 - Inflow Hydrograph at Upstream Point of West Branch of Lake Creek

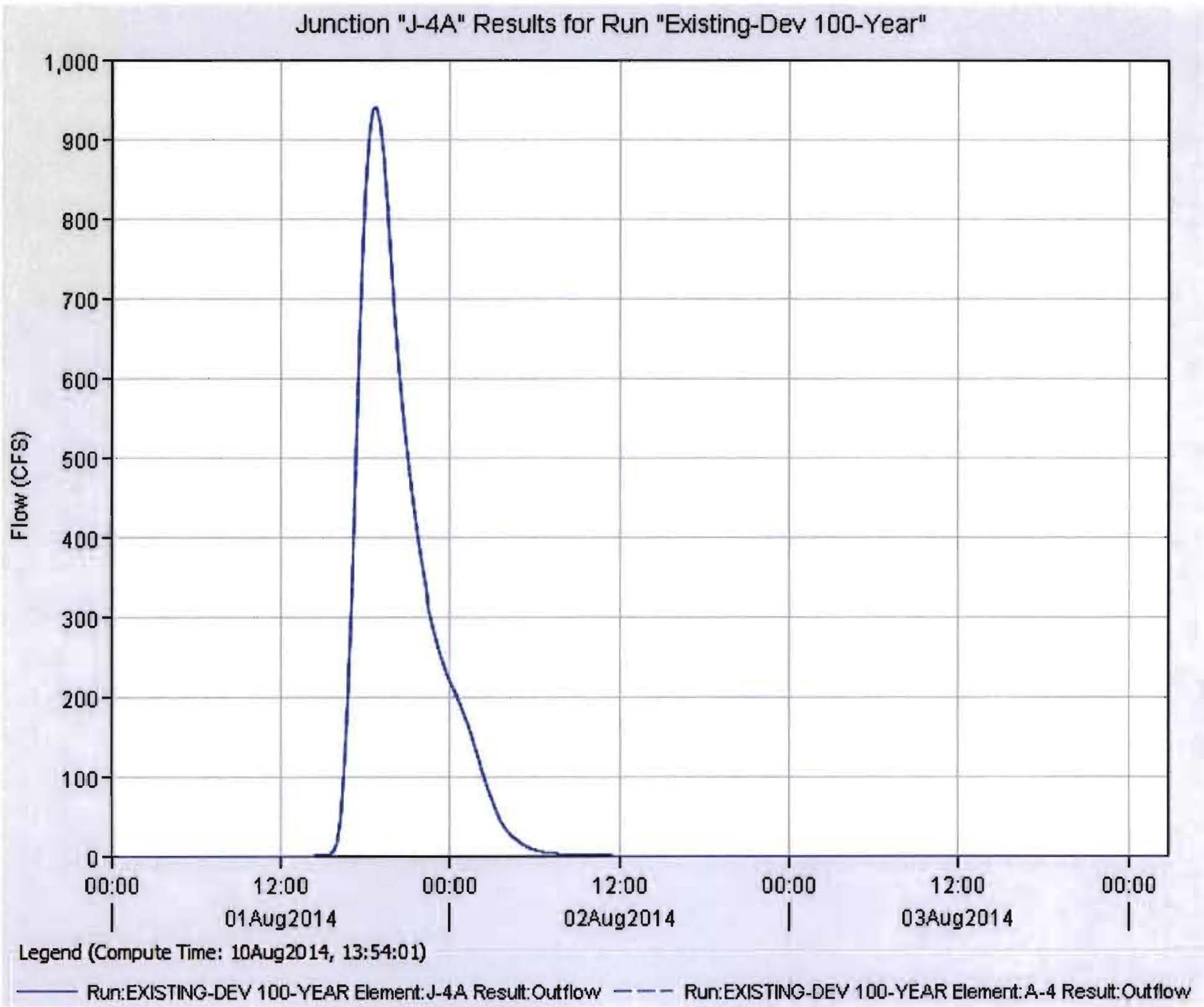


Table 7 – Tabular Hydrograph at Upstream of West Branch of Lake Creek

Date	Time	Inflow (cfs)	Outflow (cfs)
1-Aug-14	:00	0.2	0.2
1-Aug-14	15:15	0.7	0.7
1-Aug-14	15:30	1.8	1.8
1-Aug-14	15:45	5.1	5.1
1-Aug-14	16:00	15.2	15.2
1-Aug-14	16:15	47.3	47.3
1-Aug-14	16:30	108.1	108.1
1-Aug-14	16:45	194.8	194.8
1-Aug-14	17:00	311.1	311.1
1-Aug-14	17:15	455	455
1-Aug-14	17:30	607.2	607.2
1-Aug-14	17:45	740.6	740.6
1-Aug-14	18:00	841.4	841.4
1-Aug-14	18:15	905.9	905.9
1-Aug-14	18:30	938.6	938.6
1-Aug-14	18:45	940	940
1-Aug-14	19:00	918.4	918.4
1-Aug-14	19:15	879.6	879.6
1-Aug-14	19:30	822.2	822.2
1-Aug-14	19:45	750.5	750.5
1-Aug-14	20:00	682.7	682.7
1-Aug-14	20:15	625.7	625.7
1-Aug-14	20:30	575.2	575.2
1-Aug-14	20:45	530.7	530.7
1-Aug-14	21:00	491.2	491.2
1-Aug-14	21:15	453.7	453.7
1-Aug-14	21:30	418.7	418.7
1-Aug-14	21:45	387.2	387.2
1-Aug-14	22:00	359.1	359.1
1-Aug-14	22:15	334	334
1-Aug-14	22:30	311.3	311.3
1-Aug-14	22:45	291.4	291.4
1-Aug-14	23:00	273.5	273.5
1-Aug-14	23:15	257.9	257.9
1-Aug-14	23:30	243.8	243.8
1-Aug-14	23:45	231.3	231.3
2-Aug-14	0:00	219.9	219.9
2-Aug-14	0:15	209.4	209.4
2-Aug-14	0:30	198.9	198.9

2-Aug-14	0:45	188.2	188.2
2-Aug-14	1:00	176.9	176.9
2-Aug-14	1:15	164.5	164.5
2-Aug-14	1:30	150.8	150.8
2-Aug-14	1:45	136.2	136.2
2-Aug-14	2:00	121.1	121.1
2-Aug-14	2:15	106.2	106.2
2-Aug-14	2:30	91.8	91.8
2-Aug-14	2:45	78.3	78.3
2-Aug-14	3:00	66	66
2-Aug-14	3:15	54.9	54.9
2-Aug-14	3:30	45.3	45.3
2-Aug-14	3:45	37.4	37.4
2-Aug-14	4:00	31.3	31.3
2-Aug-14	4:15	26.2	26.2
2-Aug-14	4:30	22	22
2-Aug-14	4:45	18.4	18.4
2-Aug-14	5:00	15.4	15.4
2-Aug-14	5:15	12.8	12.8
2-Aug-14	5:30	10.7	10.7
2-Aug-14	5:45	8.9	8.9
2-Aug-14	6:00	7.4	7.4
2-Aug-14	6:15	6.2	6.2
2-Aug-14	6:30	5.1	5.1
2-Aug-14	6:45	4.3	4.3
2-Aug-14	7:00	3.5	3.5
2-Aug-14	7:15	2.9	2.9
2-Aug-14	7:30	2.4	2.4
2-Aug-14	7:45	2	2
2-Aug-14	8:00	1.6	1.6
2-Aug-14	8:15	1.3	1.3
2-Aug-14	8:30	1.1	1.1

Table 8 - Inflow Hydrograph at Upstream Point of East Branch of Lake Creek

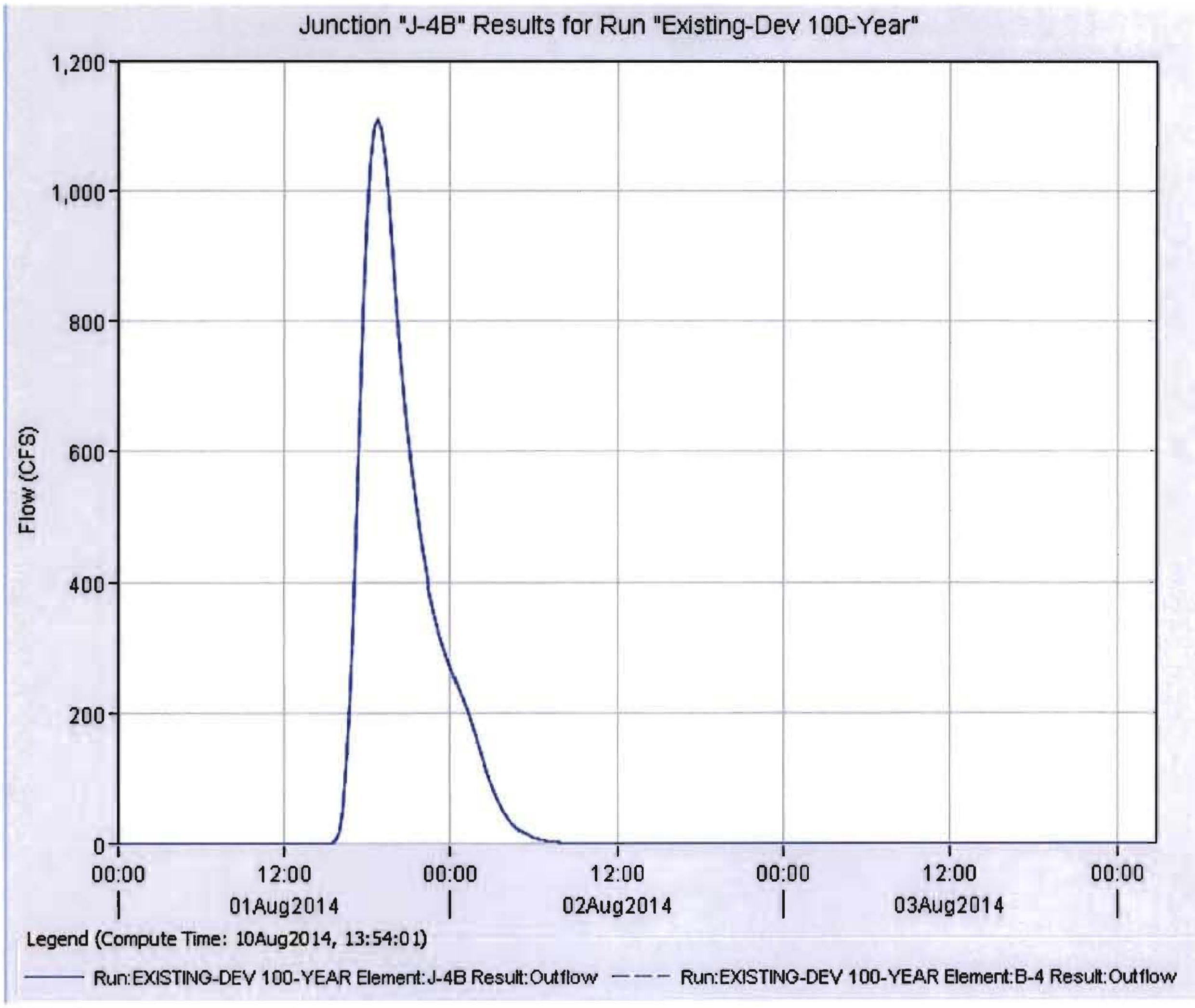


Table 9 – Tabular Hydrograph at Upstream Point of East Branch of Lake Creek

Date	Time	Inflow (cfs)	Outflow (cfs)
1-Aug-14	15:15	0.8	0.8
1-Aug-14	15:30	2.1	2.1
1-Aug-14	15:45	5.6	5.6
1-Aug-14	16:00	16.8	16.8
1-Aug-14	16:15	52.5	52.5
1-Aug-14	16:30	120.2	120.2
1-Aug-14	16:45	216.6	216.6
1-Aug-14	17:00	345.8	345.8
1-Aug-14	17:15	507.7	507.7
1-Aug-14	17:30	684.1	684.1
1-Aug-14	17:45	843.2	843.2
1-Aug-14	18:00	967.3	967.3
1-Aug-14	18:15	1051	1051
1-Aug-14	18:30	1097.1	1097.1
1-Aug-14	18:45	1109.9	1109.9
1-Aug-14	19:00	1092.6	1092.6
1-Aug-14	19:15	1054.9	1054.9
1-Aug-14	19:30	997.3	997.3
1-Aug-14	19:45	921.2	921.2
1-Aug-14	20:00	840.7	840.7
1-Aug-14	20:15	769.4	769.4
1-Aug-14	20:30	707.4	707.4
1-Aug-14	20:45	652.4	652.4
1-Aug-14	21:00	604.4	604.4
1-Aug-14	21:15	559.6	559.6
1-Aug-14	21:30	517.8	517.8
1-Aug-14	21:45	478.5	478.5
1-Aug-14	22:00	444.2	444.2
1-Aug-14	22:15	413	413
1-Aug-14	22:30	385.4	385.4
1-Aug-14	22:45	360.3	360.3
1-Aug-14	23:00	338.3	338.3
1-Aug-14	23:15	318.3	318.3
1-Aug-14	23:30	300.9	300.9
1-Aug-14	23:45	285.1	285.1
2-Aug-14	0:00	271	271
2-Aug-14	0:15	257.8	257.8
2-Aug-14	0:30	244.9	244.9
2-Aug-14	0:45	231.8	231.8

2-Aug-14	1:00	218.1	218.1
2-Aug-14	1:15	203.1	203.1
2-Aug-14	1:30	186.8	186.8
2-Aug-14	1:45	169.5	169.5
2-Aug-14	2:00	151.7	151.7
2-Aug-14	2:15	134	134
2-Aug-14	2:30	116.9	116.9
2-Aug-14	2:45	100.6	100.6
2-Aug-14	3:00	85.6	85.6
2-Aug-14	3:15	72.1	72.1
2-Aug-14	3:30	60.1	60.1
2-Aug-14	3:45	49.8	49.8
2-Aug-14	4:00	41.4	41.4
2-Aug-14	4:15	34.7	34.7
2-Aug-14	4:30	29.2	29.2
2-Aug-14	4:45	24.5	24.5
2-Aug-14	5:00	20.6	20.6
2-Aug-14	5:15	17.3	17.3
2-Aug-14	5:30	14.5	14.5
2-Aug-14	5:45	12.1	12.1
2-Aug-14	6:00	10.2	10.2
2-Aug-14	6:15	8.5	8.5
2-Aug-14	6:30	7.1	7.1
2-Aug-14	6:45	5.9	5.9
2-Aug-14	7:00	5	5
2-Aug-14	7:15	4.1	4.1
2-Aug-14	7:30	3.4	3.4
2-Aug-14	7:45	2.9	2.9
2-Aug-14	8:00	2.4	2.4
2-Aug-14	8:15	2	2
2-Aug-14	8:30	1.6	1.6
2-Aug-14	8:45	1.3	1.3

Infiltration and Evaporation Losses

Spatially variable infiltration for the floodplain was computed using the Soil Conservation Service (SCS) method. For the purposes of this project, based upon hydraulic soil types and land usage encountered within the project area, it was found that a Curve Number of 49 best represents the watershed.

Exchange of Channel and Floodplain Discharge

One-dimensional channel flow is simulated with rectangular, trapezoidal or surveyed cross sections. Unconfined floodplain flow is simulated in eight directions (4 compass directions and 4 diagonal directions). Overbank flow or return flow to the channel is simulated for each timestep.

For this particular project, channel flow was not considered due to the non-existence of any discernable channels, based in part upon our engineering staff's own field reconnaissance, the field reconnaissance performed by our land surveying team, as well as inspection of the newly acquired aerial ortho-photography and digital terrain maps.

Street Flow

Streets are simulated as shallow rectangular channels with a curb. Streets can intersect and exchange flow with the floodplain.

For this particular project, the streets were not modeled, since there are no streets with curbs, ditches or raised roads which would act at impediments to flow. Essentially, the ground adjacent to the paved surfaces is at the same elevation as the paved surfaces.

Hydraulic Structures

Hydraulic structures can represent bridges, culverts, weirs or other hydraulic control features. Hydraulic structures are simulated by user specified discharge rating curves or tables assigned to either channel or floodplain elements. Culvert flow can occur between grid elements that are not contiguous.

For this particular project, there are no significant hydraulic structures, ditches or channels which would need to be modeled.

Levees and Levee Breach Failure

Levees, road embankments and dams can be simulated by specifying crest elevations on a grid element boundary. There a several levee failure options including a comprehensive breach erosion model. Levee breaches can be initiated with fragility curves.

Buildings and Flow Obstructions

Floodplain storage loss due to buildings or features can be modeled. A portion or the entire element can be removed from potential inundation. Grid element flow exchange can be partially or entirely obstructed in all of the eight flow directions. For this particular project, the sparseness and density of land usage indicated that the flow obstruction due to the existence of structures was negligible and modeling of the structures was not necessary.

Model Output, Results and Mapping

The Post-processor FLO-2D 2009 MAPPER program was utilized to create output maps which are shown on the next pages below.

Figure 5 - Aerial Photography Map

The following map illustrates the extent of the aerial mapping for this particular project.

Figure 6 - Terrain Point Map

The following map illustrated a total of 961,148 terrain points, with the color variation denoting the elevation differential amongst the set of terrain points. Storm water runoff flows from north to south. The top portion of the basin reflects the highest elevations within the project area, with each point denoted as a various hue of red and yellow. The bottom portion of the basin reflects the lowest elevations within the project area, with each point denoted as a variation of a blue hue.

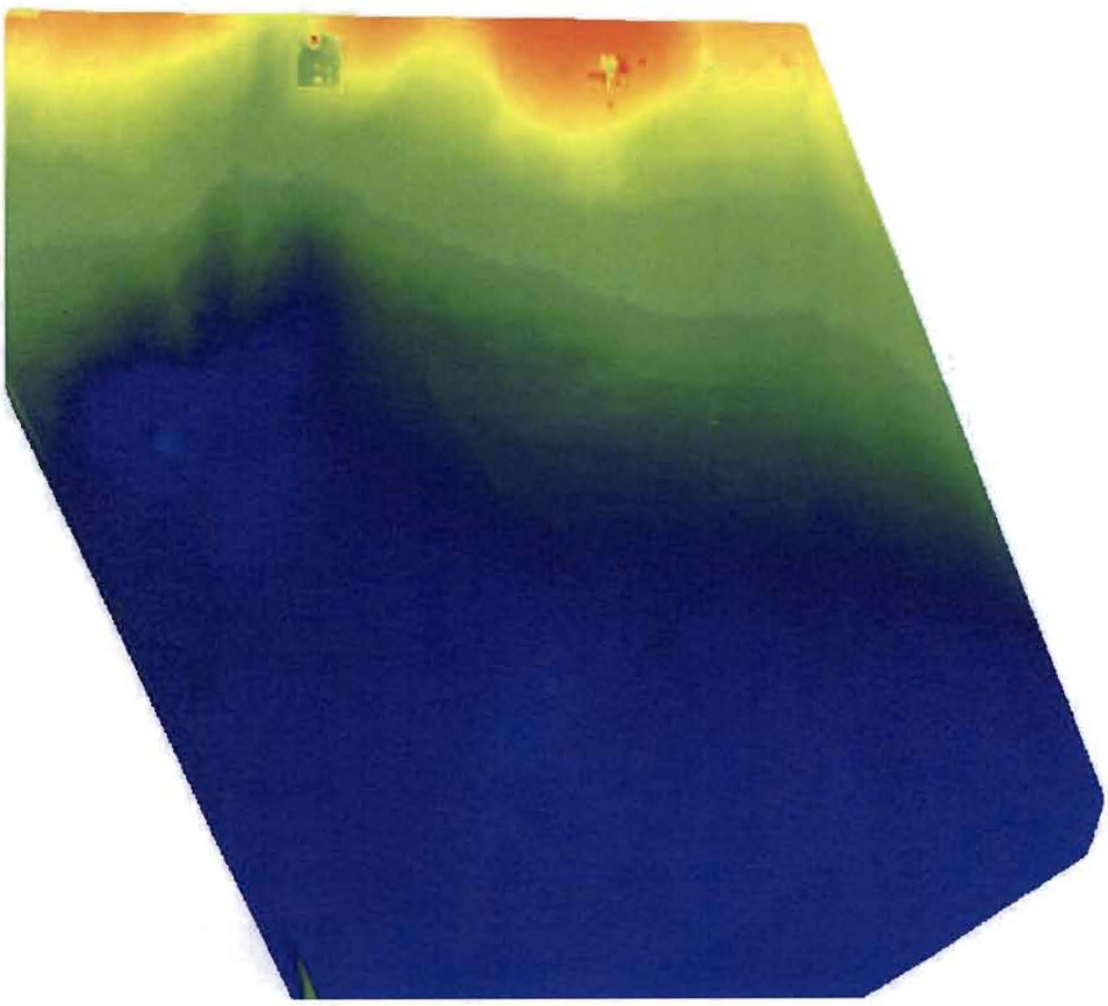


Figure 7 - Gridded Element Ground Surface Elevation Map

The following map illustrates the gridded surface with elevations assigned to each grid cell.

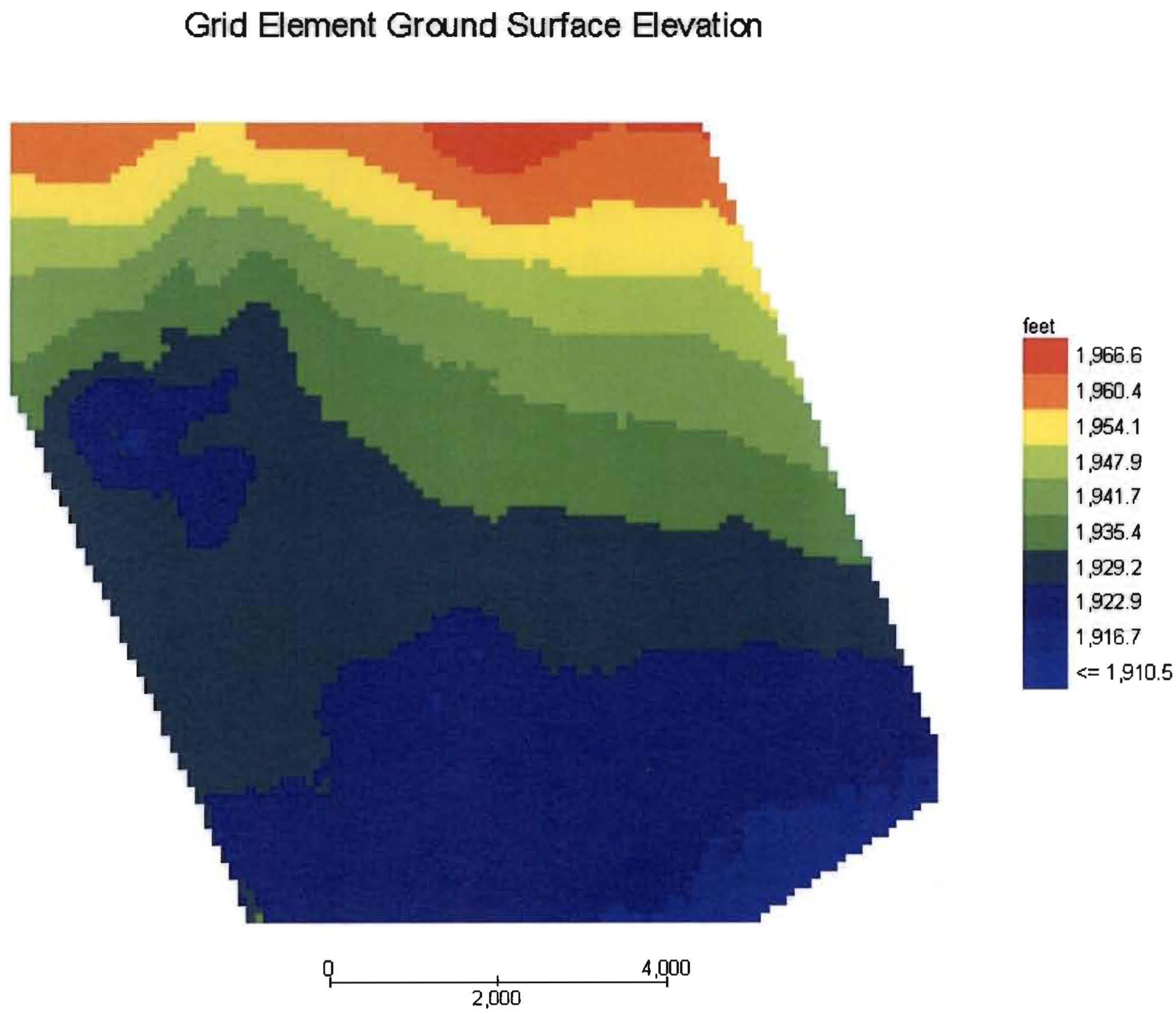


Figure 8 - Gridded Terrain Map

The following map represents the gridded terrain map, superimposed onto a background of the ortho-photographic aerial maps.

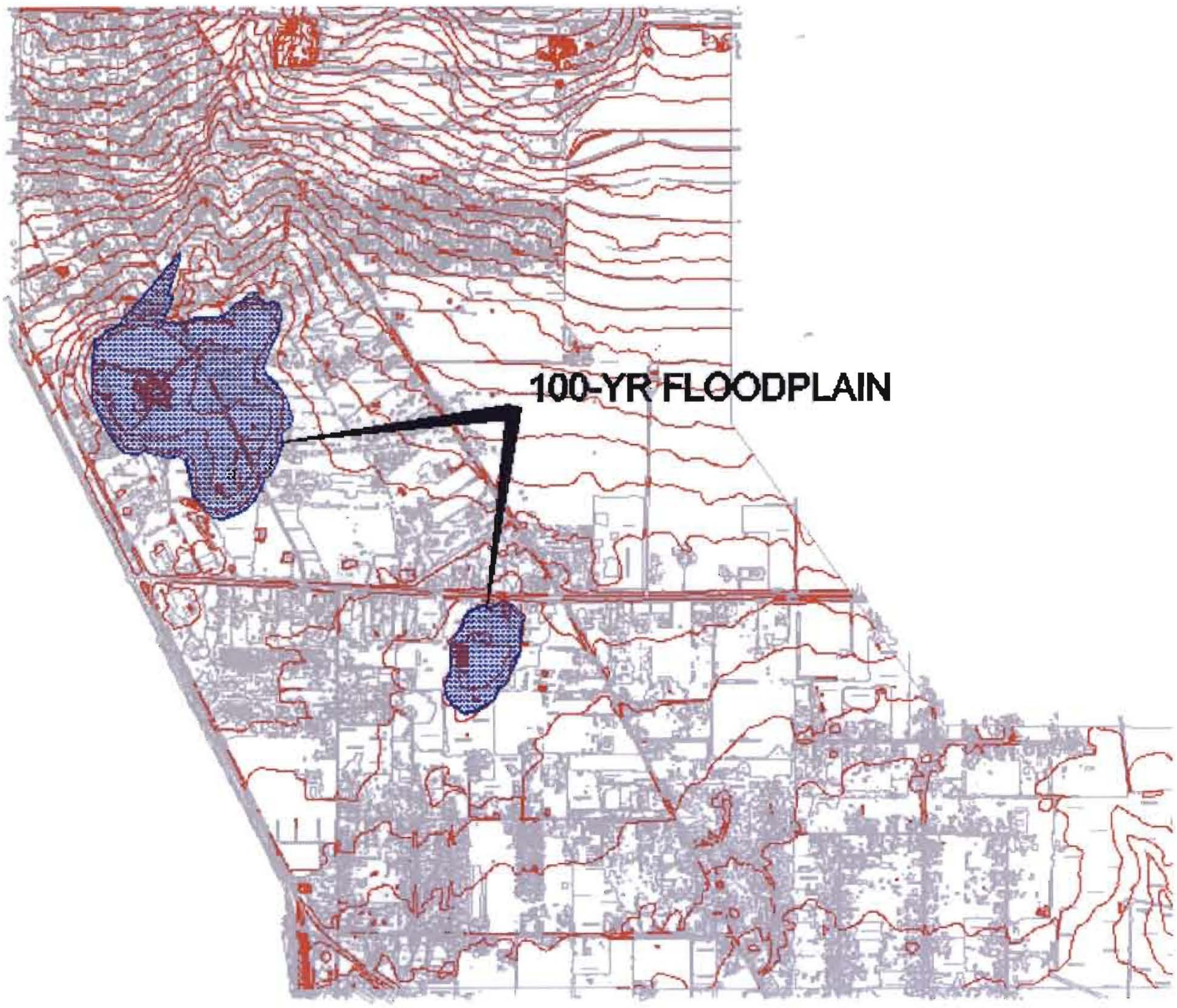
Figure 9 - Gridded Element Final Flow Depth Map

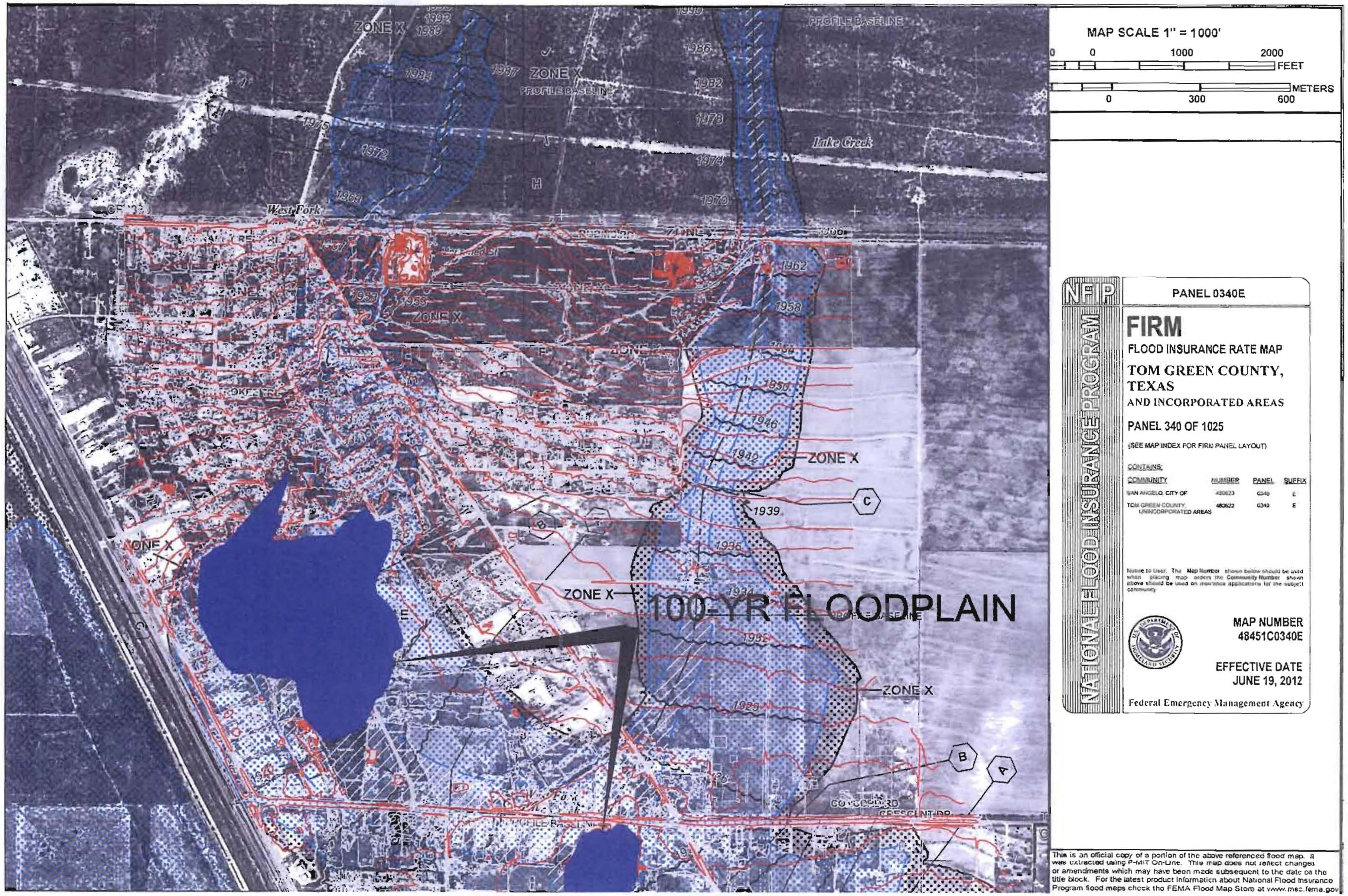
The following map represents the maximum calculated depths of water during the 100-year storm event.

GRID ELEMENT MAXIMUM FLOW DEPTH

Figure 10 – Calculated Floodplain Map

The following map represents the revised Zone AE Special Flood Hazard Zone, labeled as 100-YR Floodplain.





MAP SCALE 1" = 1000'
0 1000 2000 FEET
0 300 600 METERS
ZONE X
PROFILE BASELINE
Lake Creek
West Fork
100-YR FLOODPLAIN
NFIP
NATIONAL FLOOD INSURANCE PROGRAM
PANEL 0340E
FIRM
FLOOD INSURANCE RATE MAP
TOM GREEN COUNTY, TEXAS
AND INCORPORATED AREAS
PANEL 340 OF 1025
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
TOM GREEN COUNTY, UNINCORPORATED AREAS 480622 0340 E
MAP NUMBER 48451C0340E
EFFECTIVE DATE JUNE 19, 2012
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov