CITY OF CASTLE HILLS

MASTER DRAINAGE PLAN - PHASE I

WATERSHEDS II AND III

UPPER SAN ANTONIO RIVER WATERSHED

Prepared For

CASTLE HILLS, TEXAS

JULY 2015

Prepared By

klotz associates

Texas PE Firm Reg. #F-929

Project No. 1161.001.001

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Prepared For

CASTLE HILLS, TEXAS

Castle Hills, TX

LUIS A. CUELLAR
89656

, P.E.
07/27/15

JESUS DE LUNA NUNCIO
114240

07/27/15

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EXECUTIVE SUMMARY

The City of Castle Hills, Texas (the City) is located in Bexar County, Precinct 3, and is surrounded by the city of San Antonio. The City of Castle Hills is affected by periodic flooding throughout most of the city limits, with flooding extents ranging from localized nuisance flooding of roads and driveways, to larger scale watershed flooding that flood homes; soil erosion from rainfall events are also problems. The flooding is caused by a number of factors, yet the major causes can be reduced to:

- undersized (or non-existing) storm drains,
- excessive upstream runoff,
- backwater in storm sewers and cross culverts,
- near flat grade street profiles, and
- low conveyance in channels.

Large scale flooding has been reported to include inundated streets and homes, vehicles carried away by runoff and into outfalls, and damage of non-residential structures.

For runoff analysis purposes, the City has been partitioned into five (5) watersheds (refer to EXHIBIT B-1); this report will focus only on Watershed Areas II and III, specifically on key flood-prone areas as noted by the City and shown in EXHIBIT B-2. The identified problem areas are listed as follows:

Watershed II	Watershed III
1. Dogwood Ln. (Lockhill Selma Rd. / NW Military Hwy.)	1. Carolwood Dr. (Lockhill Selma Rd. / NW Military Hwy.)
2. Drainage ditch from N. Manton Ln. / Lockhill Selma Rd. to West Ave. near Krameria Dr., drainage crossing include: a. E. Castle Ln. b. Wisteria Dr. c. Mimosa Dr. d. Krameria Dr.	2. Banyan Dr. (Carolwood Dr. / Tamworth Dr.) 3. Outfall channel (Glentower Dr. / Tamworth Dr.)

This study included the development of hydrologic modeling using HEC-HMS v4.0 for routing/runoff calculations which determined the peak flows at specified points. Hydraulic modeling using HEC-RAS v4.1.0 used the peak discharges to determine water surface elevations and identify flooding extents based on the geometry of the existing road and/or channel within the project reach. The following observations were made:

Watershed II

The project area begins near the intersection of Lockhill Selma Dr. and Jandre Pl. (see EXHIBIT E, design point 2A) where a contributing upstream drainage area (DA 2A) of roughly 100 ac. from COSA discharges to design point 2A. The large amount of runoff is channelized through a series of residential lots, until merging into design point 2C at NW Military Hwy. The combined runoff is channelized through another series of residential lots and road crossing until reaching the project area's outfall at West Ave. consisting of three (3) 8 x 6 ft. box culverts (EXHIBIT E, design point 2H).

An immediate observation made when conducting a site visit was that the culvert crossing at NW Military Hwy. consists of three (3) 9x6 ft. and one (1) 8 x4 ft. concrete box culverts, yet some of the downstream crossings did not reflect similar underground conveyance capacities, for instance:

- E. Castle Ln. is a low-water crossing
- Mimosa Dr. only has three (3) 36 in. RCPs
- Krameria Dr. only has three (3) 36 in. RCPs

A reduction in culvert crossing size downstream will, in most cases, result in backwater buildup and overtopping, potentially flood the neighboring properties.

Through this study, it was determined that the outfall at West Ave. south of Krameria Dr. can convey the 10YR storm event (1,647 cfs). The proposed improvements should match the level of service of a 10YR storm event to maximize utilization of outfall capacity.

The proposed improvements should begin with ensuring all crossings are sized to manage the 10YR storm event, specifically the crossings at E. Castle Ln., Mimosa Dr. and Krameria Dr. Additionally, the existing channel running from E. Castle Ln. to West Ave. should also be upgraded in geometry and lining to allow for the conveyance of the 10YR storm event.

Watershed II: Summary of improvements		
Location/Peak Flow	**Existing Problems**	**Proposed Solutions**
Dogwood Ln./ 108.1 cfs.	Normal crown road with no storm drain system; no sags, varying road capacity of 11 - 30 cfs.	• 2 - 30 ft. and 2 -10 ft. curb inlets at Dogwood Ln. and Selma Dr., • 2 - 30 ft. and 2 -10 ft. curb inlets midway of Dogwood Ln., • 48 in. RCP to convey flow into exist stormdrain
E. Castle Ln./ 1274 cfs.	A low water crossing with no culvert; channel capacity of 215 cfs.	• 3 - 8 x 5 ft. SBCs with 1293 cfs capacity, • a rectangular concrete channel, 30 ft. wide by 2.6 ft. minimum depth up to mimosa, constant slope
Wisteria Dr./ 1454 cfs.	Channel downstream of wisteria outfall has a maximum capacity of 316.52 cfs.	• a rectangular concrete channel, 30 ft. wide by 2.84 ft. minimum depth up to Mimosa Dr., constant slope
Mimosa Dr./ 1478 cfs.	3 - 36 in. RCPs with maximum capacity of 341 cfs. Downstream channel capacity of 438 cfs.	• 3 - 8 x 5 ft. SBCs with 1529 cfs capacity, • a rectangular concrete channel, 28 ft. wide by 2.7 ft. minimum depth up to Krameria Dr., constant slope
Krameria Dr./ 1639 cfs.	3 - 36 in. RCPs with maximum capacity 219 cfs. Downstream channel capacity of 270 cfs.	• 3 - 8 x 6 ft. SBCs with 1667 cfs capacity, • a rectangular concrete channel, 35 ft. wide by 2.5 ft. minimum depth up to West Ave., constant slope

The associated costs would include channel excavation, concrete lined rectangular channel, replacing existing undersized cross culverts, headwalls, storm drain and curb inlets. The estimate cost for improving conveyance to provide the 10YR level of protection is approximately $3.5 million.

Watershed III

This study area begins at the intersection of Lockhill Selma Rd. and Carolwood Dr. (see EXHIBIT E, design point 3A). A large amount of runoff from upstream contributing areas in the COSA flows through a series of concrete energy dissipaters that sheet flow over Lockhill Selma Rd. and onto Carolwood Dr—this upstream COSA watershed is approximately 130 ac.

The roadway geometry of Carolwood Dr. is a normal crown for an initial 1,000 lf. and transitions to an inverted crown in an apparent effort to increase the street's conveyance capacity.

Runoff along Carolwood Dr. turns towards Banyan Dr. and merges with additional runoff from the local neighborhood, then discharges into a concrete trapezoidal channel between the residential lots of Glentower Dr. and Tamworth Dr., and finally under NW Military Hwy. via six (6) 6 x 3 ft. box culverts.

The immediate observations where that the stormwater flows are grossly exceeding the existing roadway capacity of Carolwood Dr. Consequently a hydraulic calculation was performed which revealed the upstream normal crown of Carolwood Dr. can convey approximately 10 cfs at the curb height, and about 124 cfs at its inverted crown section. However, the 5YR storm event runoff at this point is calculated at 327 cfs, which will overtop the curb height at either location.

Through this analysis, it was determined that the outfall at NW Military Hwy. can convey the 10YR storm event. The proposed improvements should provide for the conveyance of a 10YR storm to maximize utilization of outfall capacity.

The proposed improvements would intercept the runoff draining into and along Carolwood Dr. via curb inlets and grate inlets (for inverted crown sections), and convey the runoff through an underground storm drain to its respective outfall. The proposed culvert would discharge near the intersection of Glentower Dr. and NW Military Hwy., and intersect the existing concrete channel at its first bend.

Watershed III: Summary of improvements

Location/Peak Flow	Existing Problems	Proposed Solutions
Carolwood Dr./ 461 cfs.	Normal crown road with no sags that transitions into inverted crown road with no sags; no stormdrain; road cap= 9 - 93 cfs.	• 8 - 30 ft. and 2 - 20 ft. curb inlets at Carolwood Dr. and Selma Dr., • 8 x 4 ft. SBC from Carolwood Dr. to Banyan
Banyan Dr./ 574 cfs.	Inverted crown road with no sags; no stormdrain; max road cap=93 cfs.	• 2 - 3 x 10 ft. and 1 - 3 x 5 ft. grate inlets along road centerline, • 11 x 5 ft. from Banyan Dr. to Glentower Dr.
Glentower Dr./ 707 cfs.	Inverted crown road with no sags; no stormdrain; road cap=6 - 39 cfs.	• 3 - 3 x 10 ft. grate inlets along road centerline, • 12 x 5 ft. SBC from Glentower Dr. to NW Military Hwy.
Outfall channel	Runoff drains into concrete roadside channel on Banyan Dr. between Gardenview Dr. and Glentower Dr.; ex road cap=6 cfs.	• existing culvert at Glentower Dr. and NW Military Hwy. may need to be adjusted, • Construct 17.5 x 3 ft. concrete rectangular channel and match existing outfall

The associated costs would include installation of curb inlets and grate inlets (exact layout should follow geometry of the road paying close attention to type of crown), installation of concrete box culvert, outfall headwall, and channel excavation to match flow lines of box culvert to existing channel. The estimated cost for improving conditions to manage a 10YR storm event is approximately $3.4 million.

SECTION 1: INTRODUCTION

1.1 Background

The City of Castle Hills, Texas (City) is located in Bexar County (refer to EXHIBIT A) between IH-10 and US HWY 281, and intersected by Loop 410. The City's jurisdictional area is roughly 2.5mi^2, with roughly 2/3 of the city's area located on the north side of Loop 410. The City zoning is primarily residential, followed by commercial and institutional zoning (schools, churches).

The City of Castle Hills consists of five (5) watershed areas, and for the purpose of this Phase I report, efforts are focused on key problem areas in Watersheds II and III only (see EXHIBIT B-2).

- Watershed II conveys runoff into Olmos Creek, just east of the Loop 410/Jackson-Keller intersection,
- Watershed III conveys runoff to Tributary A of Airport Tributary to the east,
- The headwaters of both watersheds are located within the City of San Antonio (COSA), which conveys a significant amount of runoff through the City of Castle Hills,
- All five (5) of the watersheds within the City are part of the Upper San Antonio River watershed.

1.2 Purpose

The City has experienced repeated flooding of its roads and private property during light rainfall events. Therefore, the purpose of this study is to determine the causes of the flooding and propose solutions to minimize, or if possible, eliminate existing flooding problems in the City.

1.3 Authorization

This study was authorized by the City of Castle Hills as part of the Agreement issued on February 3, 2015 and approved by council on February 10, 2015.

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1.4 Overview of Approach

Pursuant to the project scope, the work phases have been performed during the development of this study and are briefly discussed below:

- Requested data regarding prior drainage related reports, repetitive loss data from FEMA, information on city drainage infrastructure, and community facilities which could impact existing drainage patterns. However, limited information was available at the time of this report.
- 2 ft. Contour information and aerial imagery was retrieved from the City of San Antonio's GIS website.
- 1 ft. LiDAR data was retrieved from the San Antonio River Authority's website.
- FEMA hydrologic and hydraulic (H&H) models were obtained for the downstream portions of Watersheds II and III.
- Identified current flooding and drainage problems areas and defined solutions to address the flooding problems through meetings with the City drainage committee and public works. Performed limited hydrologic and hydraulic modeling to identify channel capacities to convey storm runoff and determined areas where existing capacity limitations need to be addressed.
- Requested information about anticipated future development in the City which could significantly impact drainage and flooding conditions, however limited information was available at the time of this report.
- Developed geometry basics for channels following current guidelines for sizing and dimensioning drainage channels.

1.4.1 Historical Data

Past rainfall events were discussed with the Public Works Director of the City of Castle Hills, Rick Harada, on April 16, 2015 where he recalled damages to several properties along the main channels in Watershed II and Watershed III. A general list of recalled affected locations is follows:

- Approximately in 1995, the flowline of the ditch between Wisteria Dr. and Mimosa Dr. was excavated about 4 ft. in an effort to increase conveyance capacity.
- Flooding has reached 8 -10 ft. beyond existing drainage easement.
- Neighboring homes at E. Castle Ln. low-water crossing have been damaged by flooding
- Homes along Dogwood Ln. have been affected by flooding
- Vehicles have been dragged into outfall south of Banyan, breaking through wooden bollards
- Residential iron fence along Lockhill Selma Rd. by Jandre Pl. has been bent to the ground by runoff

A draft report was reviewed with the Castle Hills Drainage Committee on June 04, 2015, and additional meetings to discuss flooding issues with relevant governing entities are anticipated after approval of report by council. The purpose of the future meetings is to discuss possible funding assistance for the proposed improvements.

SECTION 2: DATA COLLECTION AND WATERSHED EVALUATION

2.1 Purpose

Data was collected for the purpose of identifying and characterizing flooding problems in the City. Data included best available hydrologic and hydraulic models, public domain information, site inspection, specific survey points and LiDAR data courtesy of the City of San Antonio and the San Antonio River Authority.

2.2 General Description of the Study Area

Watershed II and Watershed III are approximately 554 ac and 548 ac, respectively, of which 313 ac and 334 ac are within the Castle Hills city limits (see exhibits B-1 and C). The watersheds are primarily zoned residential with some lower density business/commercial, and parks.

The study areas contribute to the Upper San Antonio River watershed. Within each watershed, the City has identified several key locations that have significant flooding problems.

2.2.1 Topographic Data and Survey

1 ft. LiDAR contour data was used to (see Exhibit C) to develop the H&H models within each watershed. Detailed survey was also performed at specific locations that required data of higher precision, such as cross sections at hydraulic structures (i.e. roads, channels, culverts), channel confluences, and at drainage crossing structures.

The overall slope of the project area is from north to south, with elevations ranging from 860 feet in the northern portion to 760 feet in the southern areas. The total watershed (beyond the City of Castle Hills) can reach elevations in the 940 ft.

2.2.2 Soils

Hydrologic soil groups (HSGs) are used to estimate runoff from precipitation. Soils are assigned to one of four groups A, B, C, or D. They are grouped according to the infiltration of water assuming the soils are thoroughly wet and have received precipitation from long-duration storms. Well-draining soils (group A) generally allow water to move through the soil, reducing the amount of water that runs across the soil surface. This will typically result in reduced surface erosion in these well drained soils. Conversely, poorly drained soils (group D) provide a greater potential for high volume of storm water runoff.

The soils within Watersheds II and III are mainly composed of Type D (85%), Type C (14%) and Type B (less than 1%).

DRAINAGE AREA SOIL TYPES AND ACREAGE					
WATERSHED II			WATERSHED III		
AREA ID	AREA	CN	AREA ID	AREA	CN
2A	100.11	85.92	3A	130.07	84.01
2B	21.01	85.93	3B	35.71	85.78
2C	152.19	86.74	3C	43.78	84.78
2D	90.27	88.74	3D	12.83	84.35
2E	58.29	86.22			
2F	10.68	85.11			
2G	49.75	87.04			
2H	5.98	88.87			
2I	13.88	85.09			
2J	13.41	87.01			
2K	2.54	88.06			

Table 1 - CN Values for Watershed Drainage Areas

2.3 Regulatory Floodplains

The project area is located primarily within FEMA panel number 48029C0245G with an effective date of September 29, 2010 (see EXHIBIT D). The southern reach of Watershed III is designated with a FEMA Zone AE with established Base Flood Elevations (BFE). This limit of detailed study ends just south of Loop 410 within Watershed III. Watershed II does not have a regulated FEMA floodplain defined. The flooding problem areas identified and analyzed in this report are not in the vicinity of the regulated FEMA floodplains.

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2.4 Transportation Arteries and Drainage Structures

The primary artery through the project area is Loop 410, including frontage roads. Other collector / lateral roadways include West Ave., NW Military Hwy. and Lockhill-Selma Dr.

Hydraulic structures within Watershed II parallel Manton Ln, from Lockhill Selma Dr. to West Ave., and continue along West Ave. until reaching Loop 410. Drainage structures include pre-cast (PC) and cast-in-place (CIP) concrete box culverts, PC and CIP reinforced concrete pipes, and pedestrian bridges between residential lots. Channels characteristics vary between natural grassy swales, to concrete lined, to rock lined.

The hydraulic structures within Watershed III primarily consist of SBCs and MBCs, and begin at NW Military Hwy. south of Banyan Dr., continue through Loop 410, and reach Blanco Rd.

2.5 Hydrologic and Hydraulic Models

Hydrologic and hydraulic models are available from FEMA for portions of Olmos Creek and the Tributary A of Airport Tributary; however no hydraulic or hydrologic models for the length of reach considered by this study were identified.

New models were created using HEC-HMS and HEC-RAS to analyze the existing conditions of flooding throughout the key areas of watersheds II and III.

2.5.1 Hydrology

The determination of peak discharge is based upon U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS) software which incorporates rainfall values, soil type infiltration and imperviousness, drainage area, and channel routing. The runoff CN values were computed following the NRCS (Natural Resource Conservation Service) method, and soil maps were retrieved from the USDA (United States Department of Agriculture) website. The times of concentration for each drainage area were calculated using USDA's TR-55 method. SCS suggest that the UH lag times for the HEC-HMS model may be related as 60% of the time of concentration of each drainage area.

A summary of the hydrologic analysis and accompanying maps can be found in Exhibits E, F1, and I1.

The rainfall values were provided by the COSA UDC manual and are as follows:

Table 504-5 - Design Rainfall Values (inches)

USGS Adjusted Rainfall Values (pre-areal reduction)						
Frequency of Storm	5-year	10-year	25-year	50-year	100-year	500-year
Exceedance probability	0.2	0.1	0.04	0.02	0.01	0.002
Storm Duration						
Duration	Frequency					
	5-year	10-year	25-year	50-year	100-year	500-year
5 minute	0.68	0.78	0.93	1.04	1.13	1.52
15 minute	1.4	1.6	1.8	2.1	2.5	3.3
1 hour	1.85	2.76	3.32	3.85	4.35	5.8
2 hour	2.37	3.55	4.35	5.1	5.8	8.1
3 hour	3.26	3.95	4.9	5.7	6.6	9.4
6 hour	3.8	4.6	5.7	6.5	7.5	10.6
12 hour	4.4	5.4	6.4	7.5	8.8	12.4
24 hour	5	6	7.5	9	10	13.7

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WATERSHED RUNOFF SUMMARY									
WATERSHED II					WATERSHED II				
NODE ID	AREA (sq. mi.)	5YR (cfs)	10YR (cfs)	25YR (cfs)	NODE ID	AREA (sq. mi.)	5YR (cfs)	10YR (cfs)	25YR (cfs)
CULV W.Ave.	0.8091007	1141.5	1647	2051.7	CULV 410	0.34748	519.9	746.1	935.7
DA 2A	0.15636	236.1	336.4	418.9	DA 3A	0.20323	326.6	460.6	576.5
DA 2B	0.0328281	57.6	79.7	98.5	DA 3B	0.0557969	84.3	120.2	149.7
DA 2C	0.2378	350.3	501.3	622.9	DA 3C	0.0684062	111	156.3	194.7
DA 2D	0.14105	181	264.3	328.1	DA 3D	0.0200469	32.8	46.1	57.5
DA 2E	0.0910781	147	207	256.5	J@B	0.2590269	404.5	573.8	718.2
DA 2F	0.0166875	34	45.8	56.5	J@C	0.3274331	493.6	706.8	886.2
DA 2G	0.0773438	114.5	163.6	203.1	J@D	0.34748	519.9	746.1	935.7
DA 2H	0.0093438	19	25.5	30.9	R:A-J@B	0.20323	326.6	460.6	576.5
DA 2I	0.0216875	39.4	54.3	67.2	R: J@B-J@C	0.2590269	404.5	573.8	718.2
DA 2J	0.0209531	34.2	47.9	59.2	R: J@C-J@D	0.3274331	493.6	706.8	886.2
DA 2K	0.0039688	9.3	12.2	14.8					
J@C	0.4269881	636.9	909.4	1131.4					
J@D	0.6146475	888.4	1273.7	1584					
J@E	0.7057256	1011.3	1453.7	1809.4					
J@F	0.7224131	1024.9	1477.7	1840.2					
J@G	0.7997569	1132	1631.9	2032.3					
J@H	0.8091007	1141.5	1647	2051.7					
J@J	0.0426406	73.2	101.8	125.9					
J@K	0.0466094	77	108.1	133.9					
R:J@J-J@K	0.0426406	73.2	101.8	125.9					
R: A-J@C	0.15636	236.1	336.4	418.9					
R: B-J@C	0.0328281	57.6	79.7	98.5					
R: I-J@J	0.0216875	39.4	54.3	67.2					
R: J@C-J@D	0.4269881	636.9	909.4	1131.4					
R: J@D-J@E	0.6146475	888.4	1273.7	1584					
R: J@E-J@F	0.7057256	1011.3	1453.7	1809.4					
R: J@F-J@G	0.7224131	1024.9	1477.7	1840.2					
R: J@G-J@H	0.7997569	1132	1631.9	2032.3					
R: J@K-J@D	0.0466094	77	108.1	133.9					

Table 2 - Watershed Runoff Summary

2.5.2 Hydraulics

The hydraulic analysis for this study was modeled using HEC-RAS. The overall geometry of the existing drainage paths were extracted from 1 ft. LIDAR (March 2010 – November 2011) contours obtained from the SARA GIS website. The models included limited survey information which was gathered at specific crossings to determine culvert sizes and quantities, slopes, material, headwall and roadway elevations. Existing channel roughness values were estimated from a combination of aerial imagery and site investigation.

Additionally, the Federal Highway Administration's (FHWA) Hydraulic Toolbox 4.2 was used to determine the flow capacities of some existing street sections, existing channel sections, proposed curb/grate inlets, and proposed channel sections. The Chezy-Manning equation was used to size the proposed channels (steady uniform flow) as well as to estimate the sizing of the proposed underground storm mains.

A summary pf the hydraulic analysis and supporting documentation can be found in Exhibits F2 and I2.

DRAINAGE AREA Tc					
WATERSHED II			WATERSHED III		
AREA ID	Tc (mins)	LAG	AREA ID	Tc (mins)	LAG
2A	36.3	21.8	3A	30.8	18.5
2B	29.4	17.6	3B	36.1	21.7
2C	38.7	23.2	3C	31.4	18.8
2D	50.2	30.1	3D	30.5	18.3
2E	33.4	20.0			
2F	22.5	13.5			
2G	38.9	23.3			
2H	26.3	15.8			
2I	26.9	16.1			
2J	34.0	20.4			
2K	20.1	12.0			

Table 3 - Watershed Tc's and LAG times

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Reach	River Sta	Profile	E.G. US.	W.S. US.	El Weir Flow	Q Culv Group	Q Weir	Vel DS
			(ft)	(ft)	(ft)	(cfs)	(cfs)	(ft/s)
DAII_MAIN	7087.72 NW MIL	5YR	835.5	835.07	838.47	636.9		5.06
DAII_MAIN	7087.72 NW MIL	10YR	836.6	836.02	838.47	909.4		6.4
DAII_MAIN	7087.72 NW MIL	25YR	837.52	836.86	838.47	1131.4		7.38
DAII_MAIN	5583.83 WISTER	5YR	820.11	819.93	820.95	1011.3		5.06
DAII_MAIN	5583.83 WISTER	10YR	821.21	820.92	820.95	1399.21	54.49	7
DAII_MAIN	5583.83 WISTER	25YR	821.74	821.36	820.95	1505.41	303.99	7.53
DAII_MAIN	5140.695 MIMOSA	5YR	817.64	817.34	815.5	174.33	850.57	8.22
DAII_MAIN	5140.695 MIMOSA	10YR	818.11	817.79	815.5	179.13	1298.57	8.45
DAII_MAIN	5140.695 MIMOSA	25YR	818.43	818.09	815.5	181.3	1658.9	8.55
DAII_MAIN	4522.395 KRAMER	5YR	812.67	812.41	810.11	194.02	937.98	9.15
DAII_MAIN	4522.395 KRAMER	10YR	813.13	812.77	810.11	200.69	1431.21	9.46
DAII_MAIN	4522.395 KRAMER	25YR	813.47	813.1	810.11	205.08	1824.78	9.67

Table 4 - HECRAS Watershed II Culverts

SECTION 3: PROPOSED IMPROVEMENTS

3.1 Overview

Steep, narrow channels often allow for more development along channel banks, however, channels with these characteristics are also prone to erosion in and around confluences, and at channel bends due to high velocities. Flooding is also an issue for areas around these channels, especially upstream from inline drainage structures creating backwater.

Modifications to an existing channel may include widening the channel to increase conveyance capacity, or decreasing the bank slopes to help relieve erosion issues. However, existing developments along the channel limit the extents of modifications that can be constructed.

Methods of erosion control available to the City include, but are not limited to, channel modifications (e.g. widening, decreasing slope in steep areas), placement of rock rip-rap, gabion mattresses, concrete reinforcement in areas that are more susceptible to erosion problems, etc. These measures can slow the velocity of water and reduce the possibility of erosion, but could potentially increase the possibility of flooding.

Concrete lining is common method of channel protection; however the exclusive use of concrete to line a channel will increase the velocity of the water, potentially compounding the erosion problem downstream in unprotected sections of the channel. Energy dissipaters can be constructed in a concrete portion of the channel to reduce velocities before discharging into an unprotected section of the channel.

3.2 Level of Protection

The existing drainage infrastructures in Watersheds II and III have a conveyance capacity anywhere from less than a 1YR storm event to a 10YR storm event; Storm events greater than a 10YR storm will most likely result in the overtopping at the outfalls of each study area (see EXHIBIT E, design points 2H and 3D).

The proposed improvements are designed to handle a 10YR storm event, mainly because the outfall structures of each study areas can only handle a 10YR storm event.

The benefits from the proposed improvements will reduce the potential for flooding problems, reduce flooding water surface elevations, improve channel runoff conveyance, and reduce the risk of structural flooding and damage to roadways, utilities and property.

3.3 Elements of Cost Estimates

Approximate cost estimates for proposed improvements have been determined and are based on recent bid tabs, and recent public works projects as well as regional TxDOT projects. For items not included in these bid tabs, costs are based upon professional judgment and comparison to miscellaneous projects or project elements for which Klotz Associates has specific project knowledge and information or can be ascertained from information collected and reported by others.

All costs are estimates based on current economic conditions. Cost estimates are subject to significant change and costs may vary when bids are solicited. Actual bid estimates should be based upon detailed engineering designs with cost estimates completed shortly prior to bidding.

In developing these cost estimates, a conservative but realistic approach was taken because of the preliminary nature of the project and the fact that considerable time may pass before actual construction of proposed improvements. All costs were rounded up to the nearest $1,000.

The estimated costs assume all construction work will be performed by commercial contractors as opposed to City employees using City equipment.

Additionally, sanitary sewer manholes and exposed pipe were observed in the field, but no as-built drawing where provided to determine the exact layout configuration and extents of sewer system.

3.4 Estimated Project Costs

Costs associated with utility adjustments, land survey, geotechnical assessment, engineering design, and environmental assessment have been included as a percentage of the construction cost as listed in the estimate (refer to EXHIBIT G).

3.5 Watershed II

The project area begins near the intersection of Lockhill Selma Dr. and Jandre Pl. (see EXHIBIT E, design point 2A) where a contributing upstream drainage area (DA 2A) of roughly 100 ac. from COSA discharges to design point 2A. The large amount of runoff is channelized through a series of residential lots, until merging into design point 2C at NW Military Hwy. The combined runoff is channelized through another series of residential lots and road crossing until reaching the project area's outfall at West Ave. consisting of three (3) 8 x 6 ft. box culverts (EXHIBIT E, design point 2H).

The following observations made during the site visit:

- The culvert crossing at NW Military Hwy. consists of three (3) 9 x 6 ft. and one (1) 8 x 4 ft. concrete box culverts (194 sf. of conveyance area) but the culverts downstream are much smaller in size,
    1. E. Castle Dr. is a low-water-crossing with a geometrical hydraulic choking point,
    2. Mimosa Dr. has three (3) 36 in. RCPs (21 sf. of conveyance area),
    3. Krameria Dr. has three (3) 36 in. RCPs (21 sf. of conveyance area).

A downstream reduction in culvert area will, in most cases, cause backwater to build up and potentially flood upstream adjacent properties, as well as overtopping roadways.

Through this analysis, it was determined that the outfall at West Ave. can convey a 10YR storm event, therefore the proposed improvements were designed based on the outfall capacity constraints.

The proposed improvements include installing new culverts under E. Castle Dr. to protect adjacent properties and increasing the capacity of the crossings at Mimosa Dr. and Krameria Dr. to ensure all crossings are sized to convey the 10YR storm event. Additionally, the existing drainage channel between E. Castle and West Ave. must also be improved to match the conveyance capacity of the proposed culverts.

The following list describes locations reported to be problem areas and proposed solutions for each:

Dogwood Ln. Storm Sewer Improvements: Dogwood Ln. maintains a normal crown throughout its limits, making curb inlets a feasible option.

- The conveyance capacity within this street varies from 10.4 - 29.7 cfs.
- The total runoff amount through this road is 108.1 cfs (10YR). The runoff enters an existing grate inlet on NW Military that appears to outfall south of Sunflower Ln. (design point 2B),
- Based on the 1 ft. contours, two (2) inflow points were identified on this road (see EXHIBIT E):
    1. At design point 2I, located at the Lockhill Selma Dr. intersection where the 10YR runoff was computed at 54.3 cfs,
        - The roadway capacity at this point is only 11.3 cfs.
    2. At design point 2J, roughly 418 lf. downstream of design point 2I where the 10YR runoff amount was computed at 47.9 cfs
        - The roadway capacity at this point is only 29.7 cfs.

As shown in EXHIBIT H-1, the proposed conceptual improvements include:

- Install 2 - 30 ft. and 2 -10 ft. curb inlets at Dogwood and Selma (DP 3A)
- Install 2 - 30 ft. and 2 - 10 ft. curb inlets midway of Dogwood to intercept the second inflow point (DP 2J)
- Install a new 48 in. RCP to convey the runoff collected by the proposed curb inlets and connect to the existing stormdrain grate inlet at the NW Military intersection (DP 2I).

No information on the existing stormdrain along NW Military was made available during the creation of this report, and an underground stormdrain analysis was not part of this study. However, the existing underground drainage system should be able to handle the proposed improvements given that no additional flow is being added and the runoff outfalls to the same location. It is recommended that an analysis be performed in the design phase.

E. Castle Ln. Culvert Improvements: E. Castle Ln. is a low water crossing between Manton Ln. and Zornia Dr (see EXHIBIT E, DP 2D). The roadway conveyance capacity is 215.4 cfs and the 10YR storm event runoff is estimated at 1273.7 cfs.

As shown in EXHIBIT H-1, the proposed conceptual improvements include:

- Install 3 - 8 x 5 ft. Single Box Culverts (SBCs) to convey 1,293 cfs
- Construct a 30 ft. wide and 2.6 ft. minimum depth rectangular concrete channel up to Wisteria Dr.
    - The existing channel will have to be cut down roughly 6 ft. to make space for the SBCs under E. Castle Ln.

Wisteria Dr. Channel Improvements: The existing channel downstream of Wisteria Dr. (EXHIBIT E, DP 2E) has a conveyance capacity of 316.52 CFS, and the 10YR runoff at this location is 1,454 cfs.

As shown in EXHIBIT H-1, the proposed conceptual improvements include:

- o Construct a 30 ft. wide and 2.84 ft. minimum depth rectangular concrete channel up to Mimosa Dr.

Mimosa Dr. Culvert Improvements: Mimosa Dr. (EXHIBIT E, DP 2F) has an existing culvert crossing made up of 3 - 36 in. RCPs with a total conveyance of 340.8 cfs and the 10YR storm event runoff is 1477.7 cfs.

- When taking into account backwater effect, the culvert conveyance capacity is drastically reduced.
- The existing downstream channel capacity was calculated at 438.11 cfs.

As shown in EXHIBIT H-1, the proposed conceptual improvements include:

- o Install 3 – 8 x 5 ft. SBCs to convey 1,529 cfs.
- o Construct a rectangular concrete lined channel with a bottom width of 28 ft. and a minimum depth of 2.7 ft. up to Krameria Dr.

Krameria Dr. Culvert Improvements: Krameria Dr. (EXHIBIT E, design point 2G) has an existing culvert crossing of 3 - 36 in. RCPs with a total conveyance of 219.18 cfs and the 10YR storm event runoff is 1,639.1 cfs.

- The existing downstream channel capacity of 270.4 cfs

As shown in EXHIBIT H-1, the proposed conceptual improvements include:

- o Install 3 - 8 x 6 ft. SBCs to convey 1,667 cfs.
- o Construct a rectangular concrete channel with a bottom width of 35 ft. and a minimum depth of 2.5 ft. up to West Ave.

The associated costs for the improvements in Watershed II would include channel excavation, concrete lined rectangular channel, replacing existing undersized cross culverts, headwalls, storm drain and curb inlets.

The estimated cost for improving conditions to convey a 10YR is roughly $3.5 million.

No existing utility information was provided at the time of this report, and this amount does not include the cost of environmental permitting. Coordination efforts should be carried out in design phase to possibly include FEMA, U.S. Corps of Engineers (USACE), U.S. Fish and Wildlife, Environmental Protection Agency (EPA), and the Texas Commission on Environmental Quality (TCEQ) regarding the proposed improvements.

3.6 Watershed III

This project area begins at the intersection of Lockhill Selma Rd. and Carolwood Dr. (see EXHIBIT E, DP 3A). Carolwood Dr. received high amounts of runoff in the form of sheet flow through a series of concrete energy dissipaters. The area upstream, approximately 130 ac. located in the COSA, has 10YR storm event flow of 416 cfs.

The roadway geometry of Carolwood Dr. is a normal crown for an initial 1,000 lf. and transitions to an inverted crown in an apparent effort to increase the street's conveyance capacity.

Runoff along Carolwood Dr. turns towards Banyan Dr. and merges with additional runoff from the local neighborhood, then discharges into a concrete trapezoidal channel between the residential lots of Glentower Dr. and Tamworth Dr., and finally under NW Military Hwy. via six (6) 6 x 3 ft. box culverts (DP 3D).

During the site visit, the immediate observations were:

- The storm water runoff from the upper watershed area (DA 3A) in COSA exceeds the roadway conveyance capacity of Carolwood Dr.
- The upstream normal crown section on Carolwood conveys 10 cfs. just at the curb height
- The inverted crown section conveys approximately124 cfs.
- The incoming runoff from a 5YR storm event at this location is 327 cfs., which overtops the curb height at both locations.

Through this analysis, it was determined that outfall at NW Military Hwy. can convey a 10YR storm event, so the proposed improvements were designed to meet this level of protection.

The following list describes locations reported to be problem areas and proposed conceptual solutions for each:

Carolwood Dr. Storm Sewer Improvements: Carolwood Dr. has a normal crown geometry that changes into an inverted crown as the road nears Banyan Dr. (see EXHIBIT H-2).

- Near Lockhill Selma Dr., the street has a conveyance 55.06 cfs
- The 10YR storm event runoff from the contributing upstream area is 460.6 cfs.

As shown in EXHIBIT H-2, the proposed conceptual improvements include:

- o Installing 8 - 30 ft. and 2 - 20 ft. curb inlets along Carolwood Dr. near Lockhill Selma Dr.

- Installing an 8 x 4 ft. SBC to convey the 10YR storm event runoff captured by the proposed inlets and convey the flow to a proposed junction box near Banyan Dr.

Special consideration should be made when installing the proposed curb inlets to avoid damaging the existing tree root systems along Carolwood Dr.

Banyan Dr. Storm Sewer Improvements: The road conveyance capacity at the inverted crown section is roughly 92.6 cfs to the top of curb (EXHIBIT E, design point 3B). The 10YR storm event runoff from the local neighborhood (DA 3B) at the Banyan/Carolwood intersection was computed to be 120.2 cfs.

As shown in EXHIBIT H-2, the proposed conceptual improvements include:

- Installing 2 - 3 x10 ft. and 1 - 3 x 5 ft. grate inlets along road centerline to capture flow in the inverted crown road section
- Installing an 11 x 5 ft. SBC to convey the total captured runoff (573.8 cfs) at Banyan Dr. and Carolwood Dr. to a proposed junction box downstream near Glentower Dr.

Glentower Dr. Storm Sewer Improvements: Banyan Dr. remains an inverted crown road through Glentower Dr. and has as roadway capacity of 39.2 cfs and an incoming local 10YR load from 156.3 cfs.

Currently, runoff is conveyed on the road and into a roadside concrete channel between Gardenview Dr. and Glentower Dr.

- The roadway capacity at the outfall location was estimated to be 6.54 cfs.
- The elevation difference between the road centerline and the existing concrete channel flow lines is less than 2 ft.

As shown in EXHIBIT H-2, the proposed conceptual improvements include:

- Installing 3 - 3 x 10 ft. grate inlets along road centerline of Banyan Dr. to intercept runoff
- Installing a 12 x 5 ft. SBC to carry the total 10YR runoff (706.8 cfs) down Glentower Dr. and into a roadside ditch along NW Military Hwy. - within TXDOT ROW.
- Widen the existing drainage channel along NW Military Hwy. to a 17.5 x 3 ft. concrete rectangular channel

The associated costs would include installation of curb inlets and grate inlets (layout in design phase should follow geometry of the existing road paying close attention to type of crown), installation of concrete box culverts, outfall headwall, channel excavation and lining to match flow lines of proposed box culvert to the existing channel. The estimate cost for improving conditions to manage a 10YR is roughly $3.4 million.

SECTION 4: CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Based on the results of the analysis performed for this report, significant improvements are required in both Watershed Areas II and III. Below is a recap of the existing problem areas and proposed improvements:

Watershed II

1. Dogwood Lane has no stormdrain system and insufficient roadway conveyance capacity. The proposed improvements include installing an underground stormdrain system.
2. Insufficient channel and culvert conveyance capacity through E. Castle, Wisteria, Mimosa, and Krameria. The proposed improvements include upgrading culvert conveyance capacities and building a wider drainage channel with concrete lining.

Watershed III

1. Insufficient drainage conveyance capacity along Carolwood Drive through Banyan Dr. The proposed improvements include installing an underground stormdrain system and rerouting the existing outfall towards Glentower Drive.

The estimated construction costs for these improvements are $3.5 million and $3.4 million, respectively.

It should be noted that the proposed improvements are based on a 10YR storm event based on the downstream limitations of the drainage system outfall.

4.2 Recommendations

It is recommended that the City develop a CIP and budget to address the proposed improvements for Watershed Areas II and III. Once CIP is developed, the projects can be phased to provide the best “bang for your buck.”

With the projects phased, we recommend the City initiate the design of the project. It is recommended that coordination efforts be carried out in design phase to include regulatory authorities such as FEMA, U.S. Corps of Engineers (USACE), U.S. Fish and Wildlife, Environmental Protection Agency (EPA), and the Texas Commission on Environmental Quality (TCEQ) regarding the proposed improvements. Local authorities such as SARA and TxDOT should also be contacted for possible joint alternative solutions.

EXHIBIT A –Location map

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klotz associates

7550 IH-10 WEST
NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN

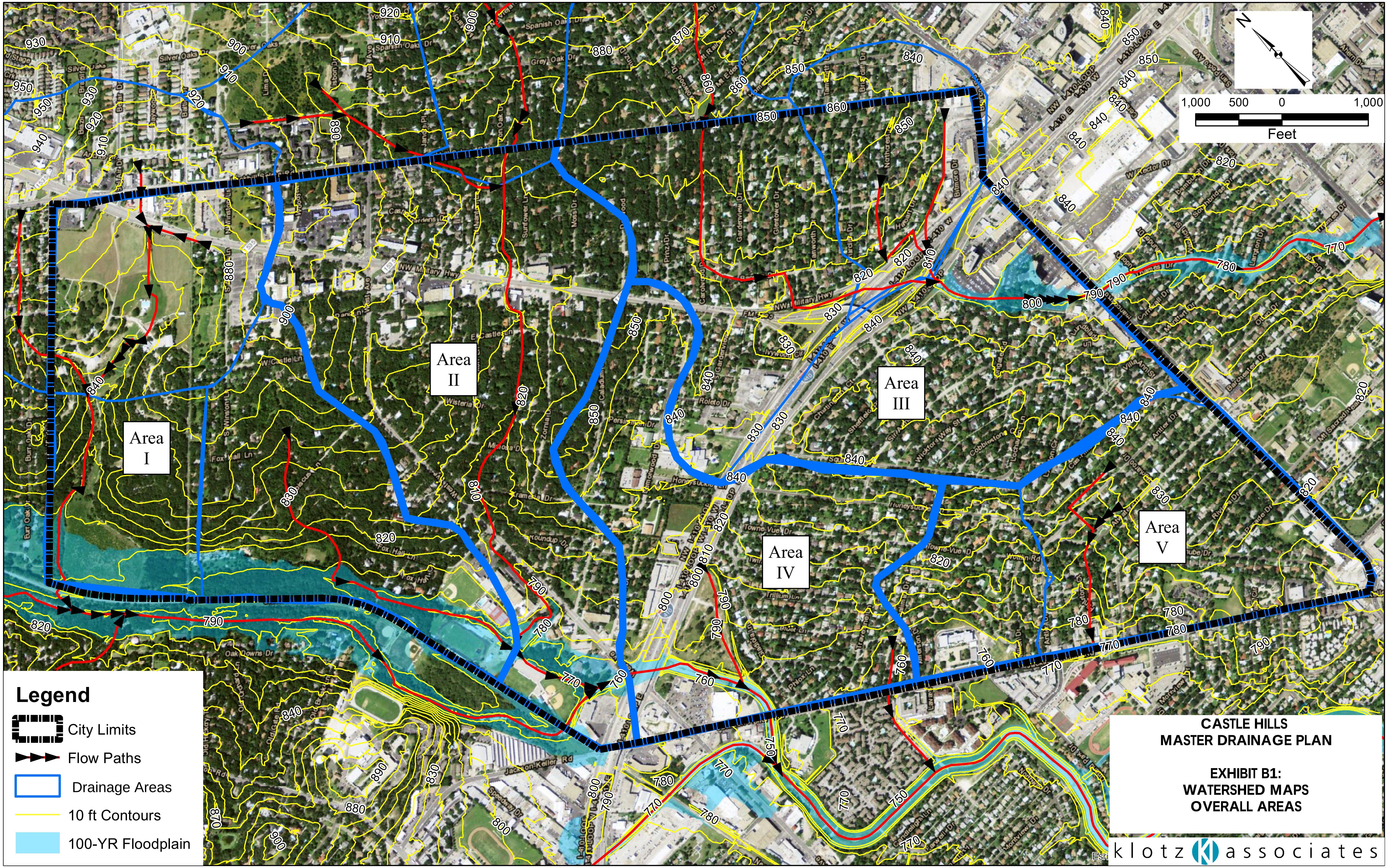
EXHIBIT A:
LOCATION MAP

SHEET 1 OF 1

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
	1161.001.001		
STATE	DIST.	COUNTY	
TEXAS	SA	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

EXHIBIT B – Watershed maps

EXHIBIT B -1

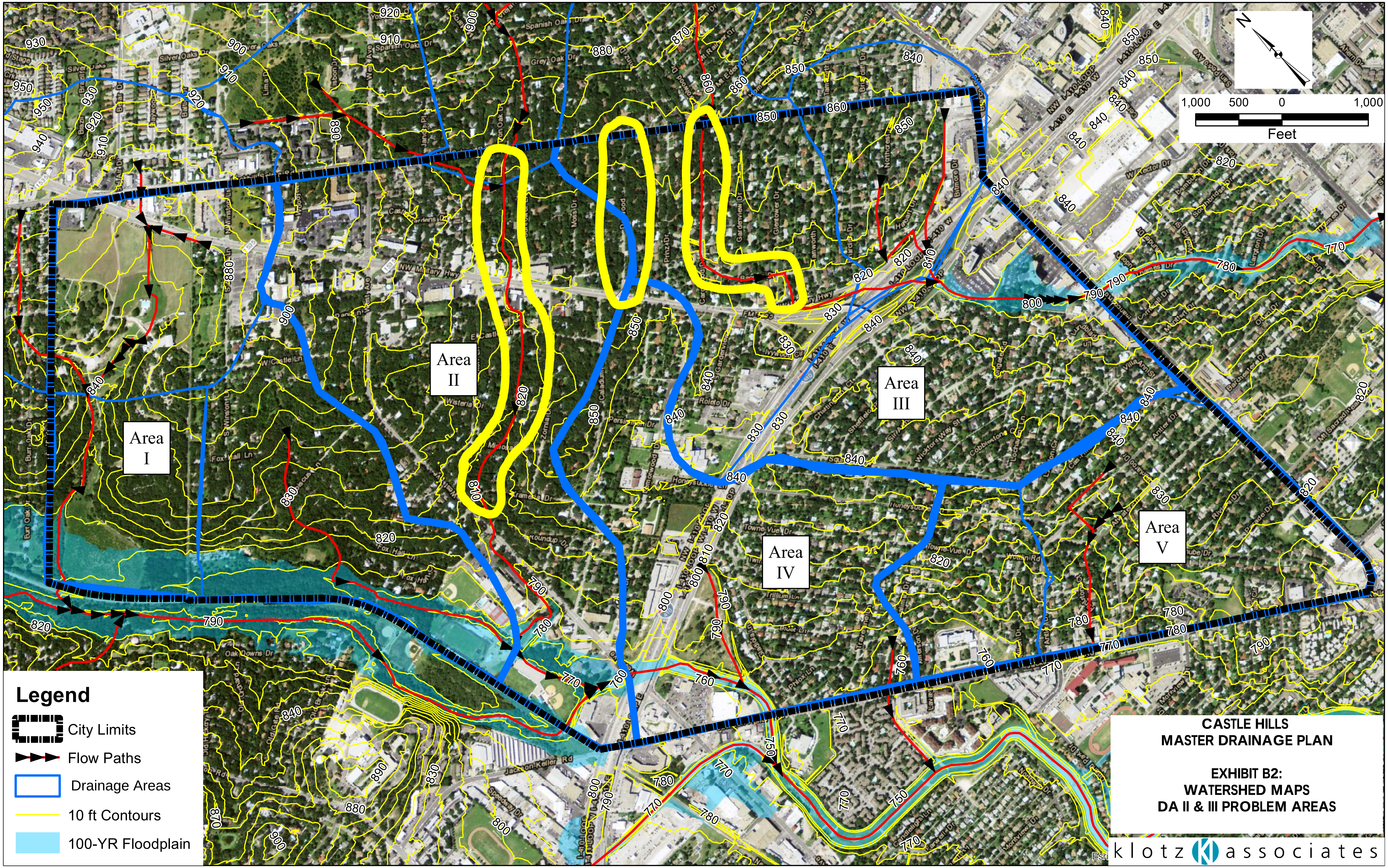


CASTLE HILLS
MASTER DRAINAGE PLAN

EXHIBIT B1:
WATERSHED MAPS
OVERALL AREAS

klotz associates

EXHIBIT B -2

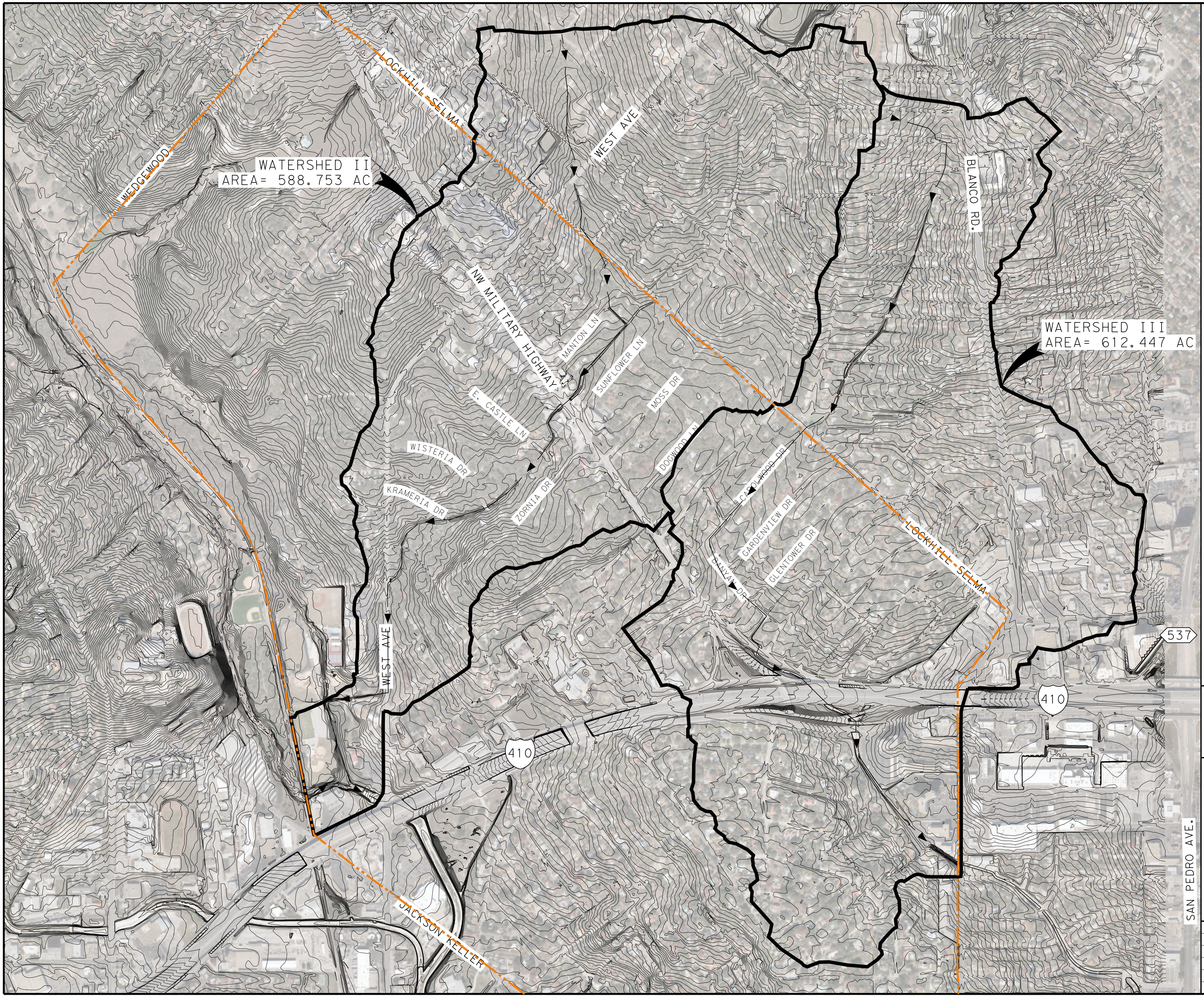


CASTLE HILLS
MASTER DRAINAGE PLAN

EXHIBIT B2:
WATERSHED MAPS
DA II & III PROBLEM AREAS

klotz associates

EXHIBIT C – Lidar topographic map



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SCALE: 1"=1000'

LEGEND

▬	WATERSHED BOUNDARY
—	2FT. CONTOURS
—▶ -	FLOW LINE
-·-	CITY LIMITS

SAN PEDRO AVE.

klotz associates
7550 IH-10 WEST
NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN

EXHIBIT C:
LIDAR TOPOGRAPHIC MAP

SHEET 1 OF 1

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
	1161.001.001		
STATE	DIST.	COUNTY	
TEXAS	SA	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

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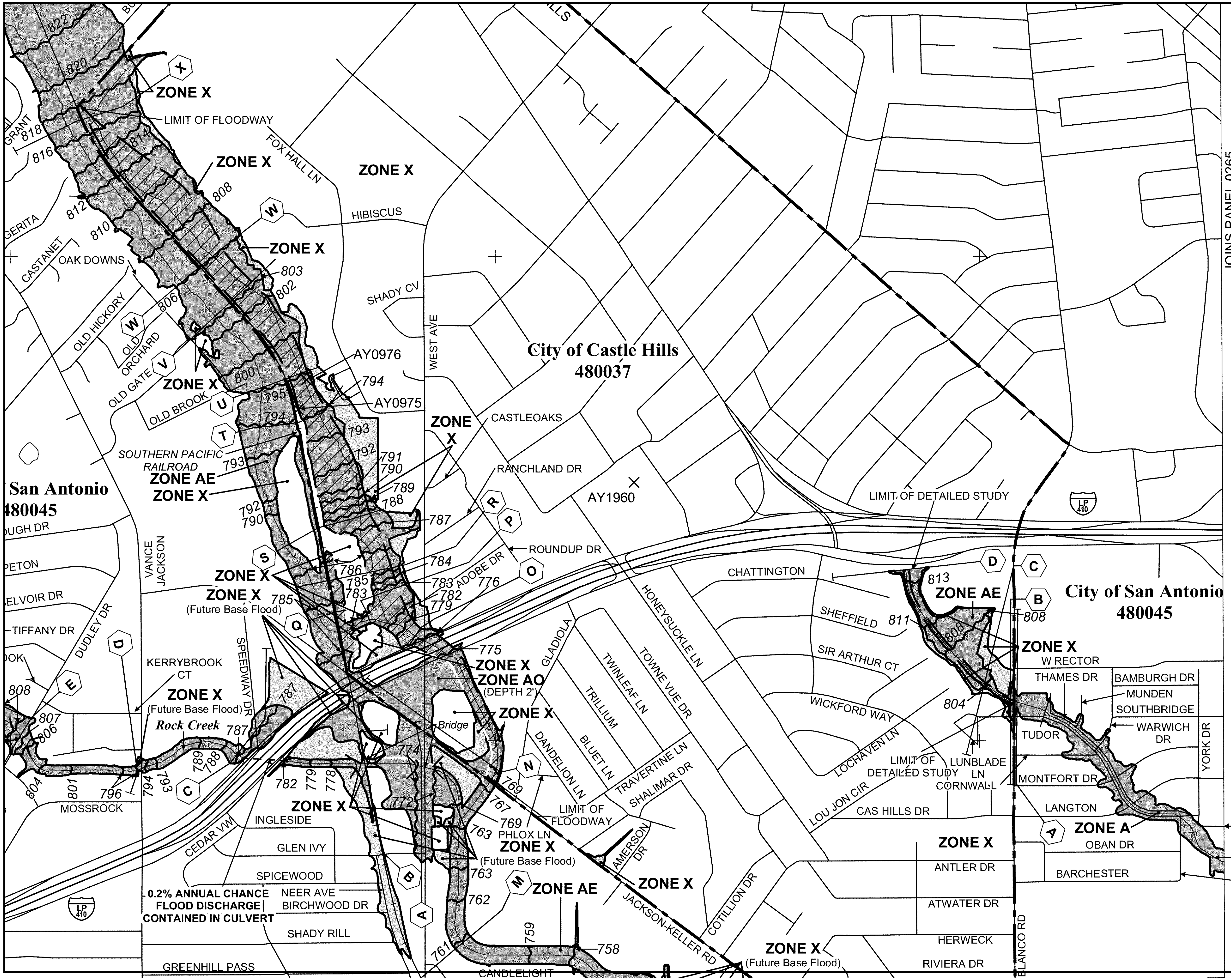
EXHIBIT D – FEMA 100YR floodplain map



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0245G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS

AND INCORPORATED AREAS

PANEL 245 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BALCONES HEIGHTS, CITY OF	481094	0245	G
CASTLE HILLS, CITY OF	480037	0245	G
SAN ANTONIO, CITY OF	480045	0245	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

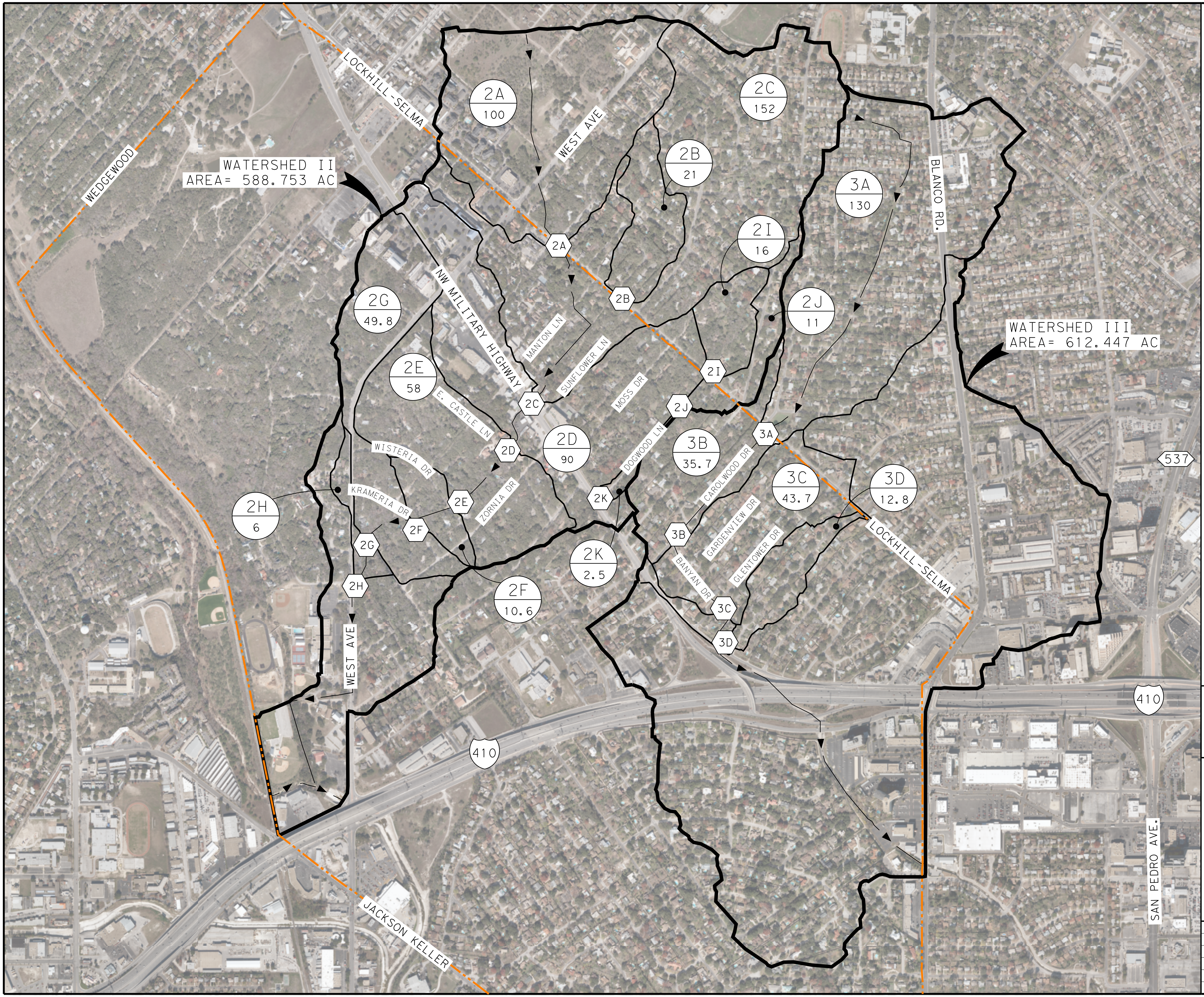
MAP NUMBER
48029C0245G

MAP REVISED
SEPTEMBER 29, 2010

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

EXHIBIT E – Drainage area map



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SCALE: 1"=1000'

LEGEND

━ WATERSHED BOUNDARY

― DRAINAGE AREA BOUNDARY

3A / 130 DRAINAGE AREA & ACREAGE

⬡ 3A DESIGN POINT

—▶— FLOW LINE

-·-·- CITY LIMITS

klotz associates

7550 IH-10 WEST
NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN

EXHIBIT E:
DRAINAGE AREA MAP

SHEET 1 OF 1

FED. RD. DIV. NO.	PROJECT NO.		SHEET NO.
	1161.001.001		
STATE	DIST.	COUNTY	
TEXAS	SA	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

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EXHIBIT F – HECRAS and HECHMS data

EXHIBIT F-1

Watershed II - 5YR Storm Event

Hydraulic Element	**Drainage Area (sq mi)**	**Peak Flow (cfs)**	**Time to Peak**	**Volume (ac-ft)**
CULV W.Ave.	0.8091007	1,141.50	04Jul2013, 12:31	3.34
DA 2A	0.15636	236.10	04Jul2013, 12:23	3.26
DA 2B	0.0328281	57.60	04Jul2013, 12:19	3.26
DA 2C	0.2378	350.30	04Jul2013, 12:25	3.33
DA 2D	0.14105	181.00	04Jul2013, 12:31	3.53
DA 2E	0.0910781	147.00	04Jul2013, 12:21	3.29
DA 2F	0.0166875	34.00	04Jul2013, 12:15	3.18
DA 2G	0.0773438	114.50	04Jul2013, 12:25	3.37
DA 2H	0.0093438	19.00	04Jul2013, 12:17	3.56
DA 2I	0.0216875	39.40	04Jul2013, 12:18	3.18
DA 2J	0.0209531	34.20	04Jul2013, 12:22	3.37
DA 2K	0.0039688	9.30	04Jul2013, 12:13	3.48
J@C	0.4269881	636.90	04Jul2013, 12:26	3.3
J@D	0.6146475	888.40	04Jul2013, 12:28	3.35
J@E	0.7057256	1,011.30	04Jul2013, 12:29	3.34
J@F	0.7224131	1,024.90	04Jul2013, 12:30	3.34
J@G	0.7997569	1,132.00	04Jul2013, 12:30	3.34
J@H	0.8091007	1,141.50	04Jul2013, 12:31	3.34
J@J	0.0426406	73.20	04Jul2013, 12:20	3.27
J@K	0.0466094	77.00	04Jul2013, 12:27	3.28
R:J@J-J@K	0.0426406	73.20	04Jul2013, 12:27	3.27
R: A-J@C	0.15636	236.10	04Jul2013, 12:28	3.25
R: B-J@C	0.0328281	57.60	04Jul2013, 12:23	3.26
R: I-J@J	0.0216875	39.40	04Jul2013, 12:20	3.18
R: J@C-J@D	0.4269881	636.90	04Jul2013, 12:27	3.3
R: J@D-J@E	0.6146475	888.40	04Jul2013, 12:30	3.35
R: J@E-J@F	0.7057256	1,011.30	04Jul2013, 12:30	3.34
R: J@F-J@G	0.7224131	1,024.90	04Jul2013, 12:31	3.34
R: J@G-J@H	0.7997569	1,132.00	04Jul2013, 12:31	3.34
R: J@K-J@D	0.0466094	77.00	04Jul2013, 12:30	3.28

Watershed II - 10YR Storm Event

Hydraulic Element	**Drainage Area (sq mi)**	**Peak Flow (cfs)**	**Time to Peak**	**Volume (ac-ft)**
CULV W.Ave.	0.80910	1,647.00	04Jul2013, 12:31	4.4
DA 2A	0.15636	336.40	04Jul2013, 12:24	4.3
DA 2B	0.03283	79.70	04Jul2013, 12:19	4.3
DA 2C	0.23780	501.30	04Jul2013, 12:25	4.4
DA 2D	0.14105	264.30	04Jul2013, 12:32	4.6
DA 2E	0.09108	207.00	04Jul2013, 12:22	4.4
DA 2F	0.01669	45.80	04Jul2013, 12:15	4.3
DA 2G	0.07734	163.60	04Jul2013, 12:25	4.5
DA 2H	0.00934	25.50	04Jul2013, 12:17	4.7
DA 2I	0.02169	54.30	04Jul2013, 12:18	4.2
DA 2J	0.02095	47.90	04Jul2013, 12:22	4.5
DA 2K	0.00397	12.20	04Jul2013, 12:13	4.6
J@C	0.42699	909.40	04Jul2013, 12:26	4.4
J@D	0.61465	1,273.70	04Jul2013, 12:28	4.4
J@E	0.70573	1,453.70	04Jul2013, 12:29	4.4
J@F	0.72241	1,477.70	04Jul2013, 12:30	4.4
J@G	0.79976	1,631.90	04Jul2013, 12:31	4.4
J@H	0.80910	1,647.00	04Jul2013, 12:31	4.4
J@J	0.04264	101.80	04Jul2013, 12:21	4.3
J@K	0.04661	108.10	04Jul2013, 12:27	4.4
R:J@J-J@K	0.04264	101.80	04Jul2013, 12:28	4.3
R: A-J@C	0.15636	336.40	04Jul2013, 12:29	4.3
R: B-J@C	0.03283	79.70	04Jul2013, 12:23	4.3
R: I-J@J	0.02169	54.30	04Jul2013, 12:20	4.2
R: J@C-J@D	0.42699	909.40	04Jul2013, 12:27	4.4
R: J@D-J@E	0.61465	1,273.70	04Jul2013, 12:30	4.4
R: J@E-J@F	0.70573	1,453.70	04Jul2013, 12:30	4.4
R: J@F-J@G	0.72241	1,477.70	04Jul2013, 12:31	4.4
R: J@G-J@H	0.79976	1,631.90	04Jul2013, 12:32	4.4
R: J@K-J@D	0.04661	108.10	04Jul2013, 12:30	4.4

Watershed II - 25YR Storm Event

Hydraulic Element	Drainage Area (sq mi)	Peak Flow (cfs)	Time to Peak	Volume (ac-ft)
CULV W.Ave.	0.80910	2,051.70	04Jul2013, 12:31	5.9
DA 2A	0.15636	418.90	04Jul2013, 12:24	5.8
DA 2B	0.03283	98.50	04Jul2013, 12:19	5.8
DA 2C	0.23780	622.90	04Jul2013, 12:25	5.9
DA 2D	0.14105	328.10	04Jul2013, 12:32	6.1
DA 2E	0.09108	256.50	04Jul2013, 12:22	5.8
DA 2F	0.01669	56.50	04Jul2013, 12:15	5.7
DA 2G	0.07734	203.10	04Jul2013, 12:25	5.9
DA 2H	0.00934	30.90	04Jul2013, 12:17	6.2
DA 2I	0.02169	67.20	04Jul2013, 12:18	5.7
DA 2J	0.02095	59.20	04Jul2013, 12:22	5.9
DA 2K	0.00397	14.80	04Jul2013, 12:13	6.1
J@C	0.42699	1,131.40	04Jul2013, 12:26	5.9
J@D	0.61465	1,584.00	04Jul2013, 12:28	5.9
J@E	0.70573	1,809.40	04Jul2013, 12:29	5.9
J@F	0.72241	1,840.20	04Jul2013, 12:30	5.9
J@G	0.79976	2,032.30	04Jul2013, 12:30	5.9
J@H	0.80910	2,051.70	04Jul2013, 12:31	5.9
J@J	0.04264	125.90	04Jul2013, 12:21	5.8
J@K	0.04661	133.90	04Jul2013, 12:27	5.8
R:J@J-J@K	0.04264	125.90	04Jul2013, 12:28	5.8
R: A-J@C	0.15636	418.90	04Jul2013, 12:29	5.8
R: B-J@C	0.03283	98.50	04Jul2013, 12:23	5.8
R: I-J@J	0.02169	67.20	04Jul2013, 12:20	5.7
R: J@C-J@D	0.42699	1,131.40	04Jul2013, 12:27	5.9
R: J@D-J@E	0.61465	1,584.00	04Jul2013, 12:30	5.9
R: J@E-J@F	0.70573	1,809.40	04Jul2013, 12:30	5.9
R: J@F-J@G	0.72241	1,840.20	04Jul2013, 12:31	5.9
R: J@G-J@H	0.79976	2,032.30	04Jul2013, 12:31	5.9
R: J@K-J@D	0.04661	133.90	04Jul2013, 12:30	5.8

Watershed III - 5YR Storm Event

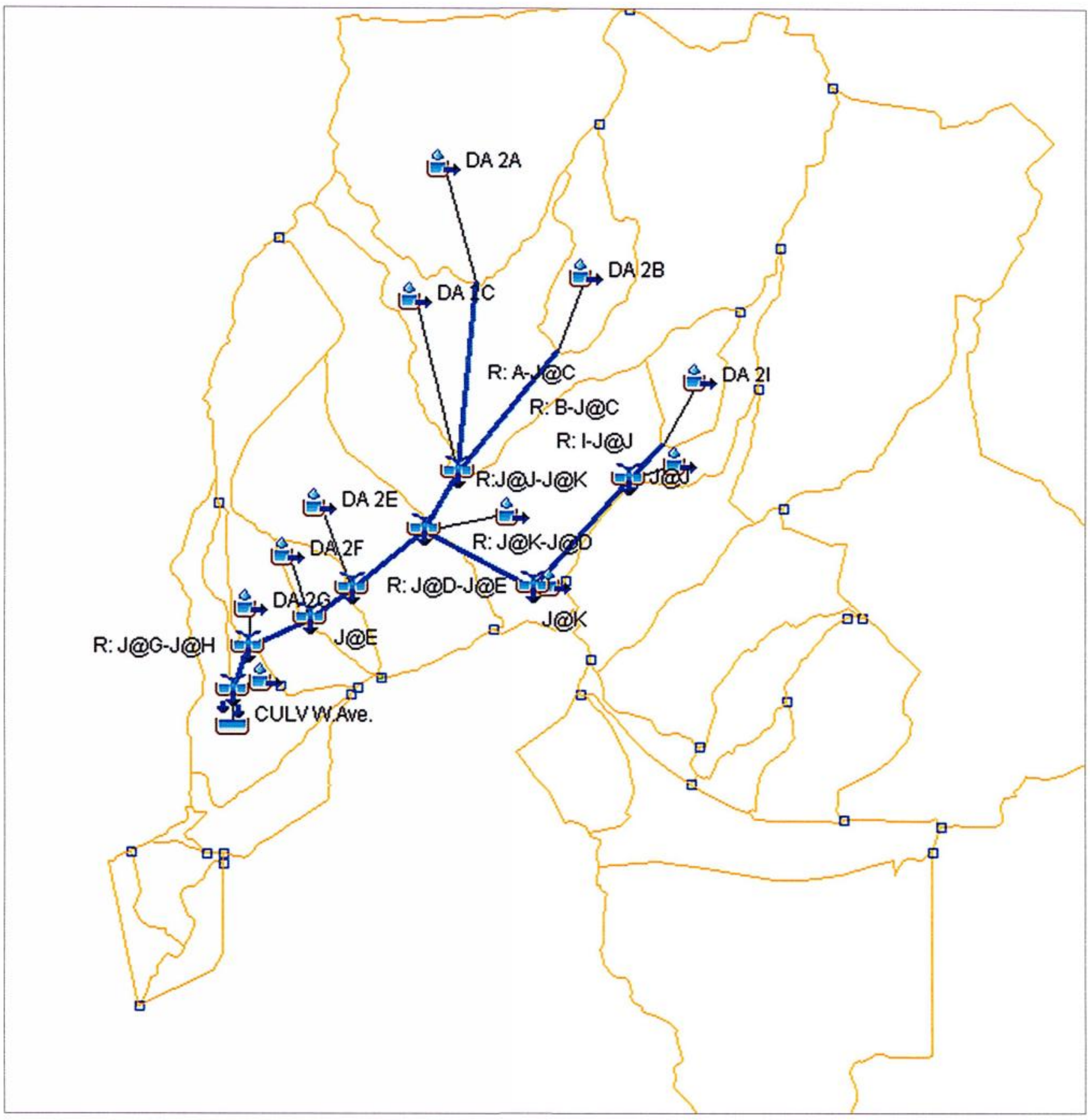
Hydraulic Element	**Drainage Area (sq mi)**	**Peak Flow (cfs)**	**Time to Peak**	**Volume (ac-ft)**
CULV 410	0.34748	519.90	04Jul2013, 12:27	3.1
DA 3A	0.20323	326.60	04Jul2013, 12:20	3.1
DA 3B	0.05580	84.30	04Jul2013, 12:23	3.2
DA 3C	0.06841	111.00	04Jul2013, 12:20	3.2
DA 3D	0.02005	32.80	04Jul2013, 12:20	3.1
J@B	0.25903	404.50	04Jul2013, 12:28	3.1
J@C	0.32743	493.60	04Jul2013, 12:28	3.1
J@D	0.34748	519.90	04Jul2013, 12:27	3.1
R:A-J@B	0.20323	326.60	04Jul2013, 12:29	3.1
R: J@B-J@C	0.25903	404.50	04Jul2013, 12:29	3.1
R: J@C-J@D	0.32743	493.60	04Jul2013, 12:28	3.1

Watershed III - 10YR Storm Event

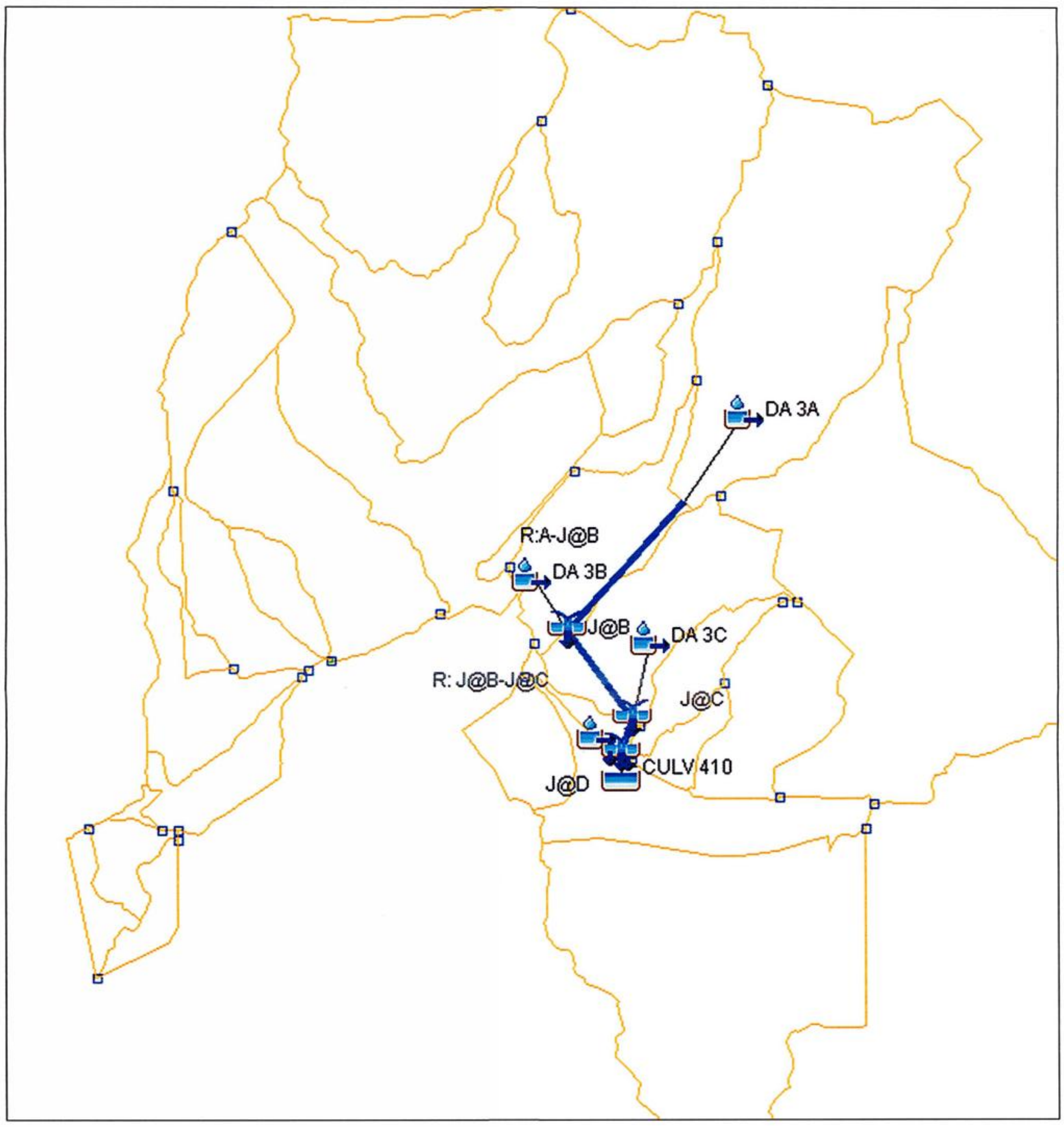
Hydraulic Element	**Drainage Area (sq mi)**	**Peak Flow (cfs)**	**Time to Peak**	**Volume (ac-ft)**
CULV 410	0.34748	746.10	04Jul2013, 12:28	4.2
DA 3A	0.20323	460.60	04Jul2013, 12:20	4.1
DA 3B	0.05580	120.20	04Jul2013, 12:24	4.3
DA 3C	0.06841	156.30	04Jul2013, 12:21	4.2
DA 3D	0.02005	46.10	04Jul2013, 12:20	4.2
J@B	0.25903	573.80	04Jul2013, 12:29	4.2
J@C	0.32743	706.80	04Jul2013, 12:28	4.2
J@D	0.34748	746.10	04Jul2013, 12:28	4.2
R:A-J@B	0.20323	460.60	04Jul2013, 12:29	4.1
R: J@B-J@C	0.25903	573.80	04Jul2013, 12:30	4.2
R: J@C-J@D	0.32743	706.80	04Jul2013, 12:28	4.2

Watershed III - 25YR Storm Event

Hydraulic Element	Drainage Area (sq mi)	Peak Flow (cfs)	Time to Peak	Volume (ac-ft)
CULV 410	0.34748	935.70	04Jul2013, 12:28	5.6
DA 3A	0.20323	576.50	04Jul2013, 12:20	5.6
DA 3B	0.05580	149.70	04Jul2013, 12:23	5.8
DA 3C	0.06841	194.70	04Jul2013, 12:21	5.7
DA 3D	0.02005	57.50	04Jul2013, 12:20	5.6
J@B	0.25903	718.20	04Jul2013, 12:28	5.6
J@C	0.32743	886.20	04Jul2013, 12:28	5.6
J@D	0.34748	935.70	04Jul2013, 12:28	5.6
R:A-J@B	0.20323	576.50	04Jul2013, 12:29	5.6
R: J@B-J@C	0.25903	718.20	04Jul2013, 12:29	5.6
R: J@C-J@D	0.32743	886.20	04Jul2013, 12:28	5.6

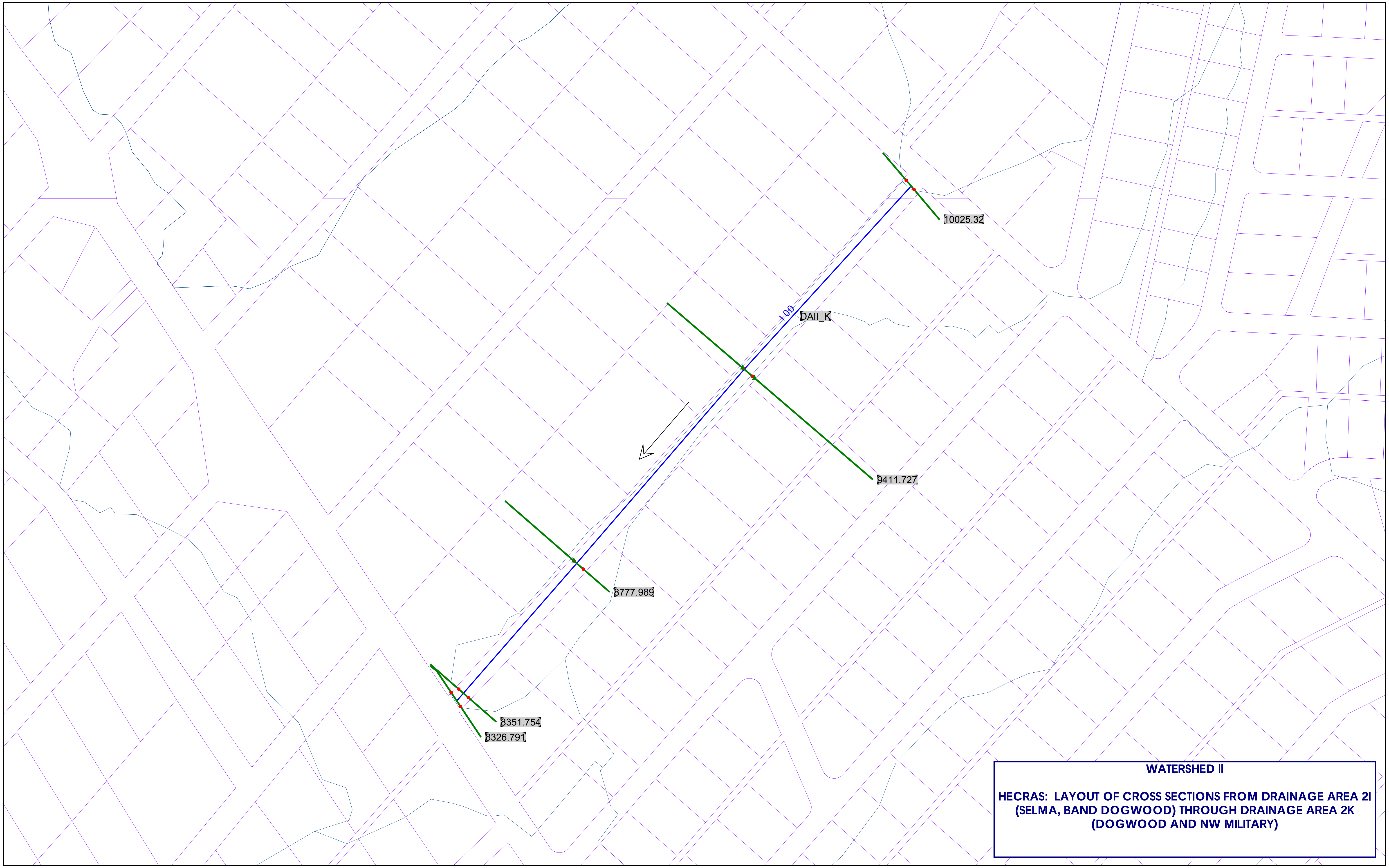


WATERSHED II: HECHMS ROUTING MAP



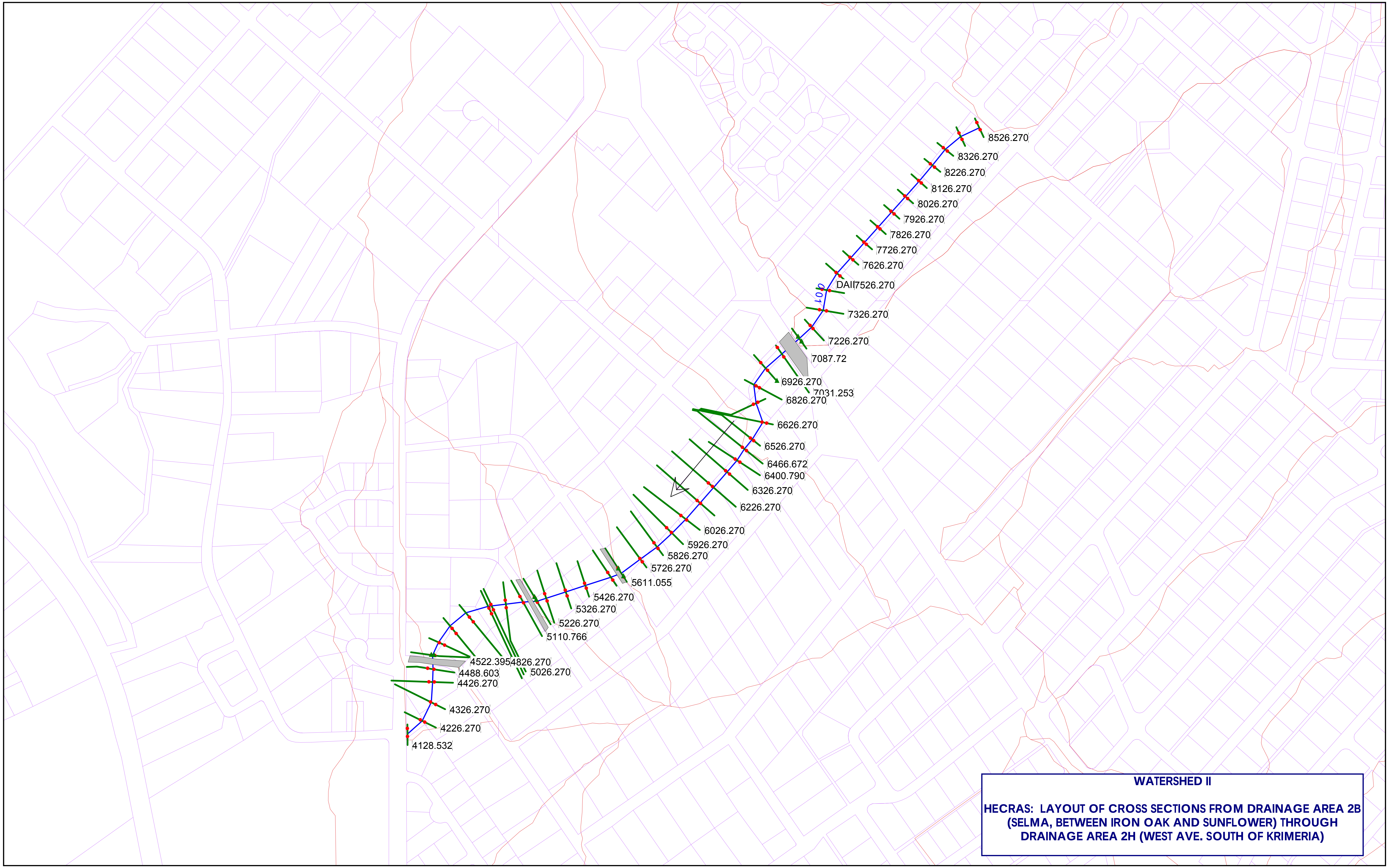
WATERSHED III: HECHMS ROUTING MAP

EXHIBIT F-2



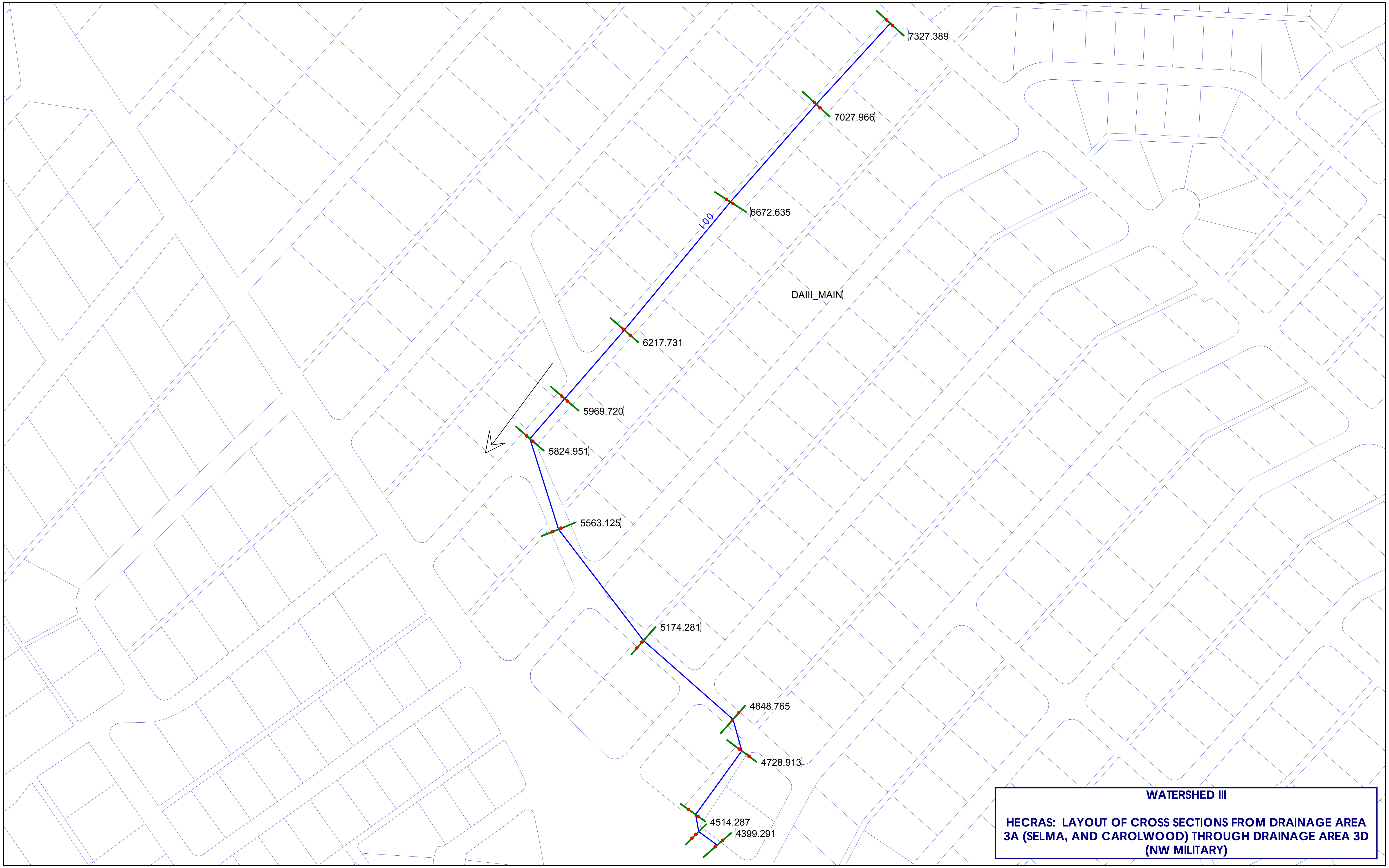
WATERSHED II

HECRAS: LAYOUT OF CROSS SECTIONS FROM DRAINAGE AREA 2I
(SELMA, BAND DOGWOOD) THROUGH DRAINAGE AREA 2K
(DOGWOOD AND NW MILITARY)



WATERSHED II

HECRAS: LAYOUT OF CROSS SECTIONS FROM DRAINAGE AREA 2B (SELMA, BETWEEN IRON OAK AND SUNFLOWER) THROUGH DRAINAGE AREA 2H (WEST AVE. SOUTH OF KRIMERIA)



WATERSHED III

HECRAS: LAYOUT OF CROSS SECTIONS FROM DRAINAGE AREA 3A (SELMA, AND CAROLWOOD) THROUGH DRAINAGE AREA 3D (NW MILITARY)

Profile Output Table - Standard Table 1
HEC-RAS Plan: EX_SURV River: 001 Reach: DAII_K

Rivers = 1
Hydraulic Reaches = 1
River Stations = 5
Plans = 1
Profiles = 3

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
DAII_K	10025.32	5YR		39.4	850.8	851.69	851.69	851.95	0.004776	4.1	9.76	19.71	1.01
DAII_K	10025.32	10YR		54.3	850.8	851.83	851.83	852.13	0.004389	4.42	12.57	21.43	0.99
DAII_K	10025.32	25YR		67.2	850.8	851.93	851.93	852.26	0.004252	4.67	14.79	22.74	1
DAII_K	9411.727	5YR		73.2	845.67	847.07	847.07	847.18	0.001497	2.84	54.25	495.52	0.59
DAII_K	9411.727	10YR		101.8	845.67	847.15	847.14	847.23	0.001307	2.83	91.77	510.04	0.56
DAII_K	9411.727	25YR		125.9	845.67	847.21	847.16	847.28	0.001061	2.69	124.91	516.27	0.51
DAII_K	8777.989	5YR		73.2	845.39	846	846	846.03	0.001457	1.98	73.54	255.93	0.54
DAII_K	8777.989	10YR		101.8	845.39	846	846	846.05	0.002822	2.75	73.51	255.93	0.75
DAII_K	8777.989	25YR		125.9	845.39	846	846	846.08	0.004316	3.4	73.51	255.93	0.93
DAII_K	8351.754	5YR		77	842.62	843.28	843.28	843.58	0.004516	4.4	17.51	29.1	1
DAII_K	8351.754	10YR		108.1	842.62	843.43	843.43	843.81	0.004253	4.92	21.99	29.43	1
DAII_K	8351.754	25YR		133.9	842.62	843.54	843.54	843.98	0.004118	5.28	25.36	29.68	1.01
DAII_K	8326.791	5YR		77	842.49	843.03	843.03	843.28	0.004741	3.98	19.36	39.24	1
DAII_K	8326.791	10YR		108.1	842.49	843.16	843.16	843.47	0.004494	4.45	24.31	40.01	1.01
DAII_K	8326.791	25YR		133.9	842.49	843.26	843.26	843.61	0.004298	4.75	28.19	40.62	1

Profile Output Table - Standard Table 1
HEC-RAS Plan: EX   River: 001   Reach: DAII_MAIN

WATERSHED II: MAIN CHANNEL

Rivers   = 1
Hydraulic Reaches = 1
River Stations   = 53
Plans   = 1
Profiles   = 3

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
DAII_MAIN	8526.27	5YR		57.6	851	852.28		852.39	0.008744	2.77	20.77	28.97	0.58
DAII_MAIN	8526.27	10YR		79.7	851	852.44		852.59	0.009377	3.09	25.83	32.37	0.61
DAII_MAIN	8526.27	25YR		98.5	851	852.56		852.73	0.009859	3.31	29.73	34.76	0.63
DAII_MAIN	8426.27	5YR		57.6	850	850.92		851.12	0.020307	3.55	16.24	29.54	0.84
DAII_MAIN	8426.27	10YR		79.7	850	851.08		851.3	0.018843	3.75	21.28	33.92	0.83
DAII_MAIN	8426.27	25YR		98.5	850	851.18	851.08	851.42	0.017825	4.01	24.7	36.73	0.83
DAII_MAIN	8326.27	5YR		57.6	848.07	849.23		849.42	0.01451	3.42	16.85	26.27	0.74
DAII_MAIN	8326.27	10YR		79.7	848.07	849.36		849.6	0.015292	3.95	20.43	29.14	0.78
DAII_MAIN	8326.27	25YR		98.5	848.07	849.46	849.36	849.75	0.015793	4.33	23.3	31.32	0.81
DAII_MAIN	8226.27	5YR		57.6	846.11	847.18	847.18	847.49	0.026208	4.49	12.99	21.85	0.98
DAII_MAIN	8226.27	10YR		79.7	846.11	847.34	847.34	847.7	0.023833	4.84	16.8	24.24	0.97
DAII_MAIN	8226.27	25YR		98.5	846.11	847.47	847.47	847.86	0.022668	5.09	19.84	25.98	0.96
DAII_MAIN	8126.27	5YR		57.6	843.91	845.1	844.94	845.31	0.012603	3.71	15.9	22.28	0.71
DAII_MAIN	8126.27	10YR		79.7	843.91	845.26	845.12	845.53	0.012919	4.22	19.62	24.15	0.74
DAII_MAIN	8126.27	25YR		98.5	843.91	845.39		845.69	0.012667	4.53	22.81	25.65	0.75
DAII_MAIN	8026.27	5YR		57.6	843	843.84		844.03	0.012809	3.62	16.53	24.92	0.71
DAII_MAIN	8026.27	10YR		79.7	843	843.99		844.23	0.012899	4.08	20.47	26.82	0.74
DAII_MAIN	8026.27	25YR		98.5	843	844.09	843.97	844.38	0.013446	4.47	23.39	29.07	0.76
DAII_MAIN	7926.27	5YR		57.6	841	841.9	841.9	842.22	0.027323	4.56	12.64	19.64	1
DAII_MAIN	7926.27	10YR		79.7	841	842.06	842.06	842.45	0.026014	4.99	15.98	21.46	1.01
DAII_MAIN	7926.27	25YR		98.5	841	842.19	842.19	842.62	0.023753	5.28	18.78	22.79	0.99
DAII_MAIN	7826.27	5YR		57.6	839.14	840.59		840.75	0.007471	3.33	18.03	20.92	0.57
DAII_MAIN	7826.27	10YR		79.7	839.14	840.75		840.97	0.008538	3.9	21.46	22.35	0.62
DAII_MAIN	7826.27	25YR		98.5	839.14	840.88		841.15	0.008677	4.23	24.66	23.61	0.64
DAII_MAIN	7726.27	5YR		57.6	838.67	839.62		839.82	0.011874	3.72	16.22	22.8	0.7
DAII_MAIN	7726.27	10YR		79.7	838.67	839.84		840.06	0.009691	3.91	21.54	24.98	0.65
DAII_MAIN	7726.27	25YR		98.5	838.67	839.96		840.22	0.009882	4.23	24.68	26.18	0.67
DAII_MAIN	7626.27	5YR		57.6	837.03	838.18	838.08	838.42	0.016663	3.94	14.79	21.91	0.8
DAII_MAIN	7626.27	10YR		79.7	837.03	838.26	838.25	838.63	0.022649	4.91	16.53	22.76	0.95
DAII_MAIN	7626.27	25YR		98.5	837.03	838.38	838.38	838.8	0.021701	5.25	19.27	24.05	0.95
DAII_MAIN	7526.27	5YR		57.6	835.73	836.65		836.84	0.01465	3.49	16.49	23.94	0.74
DAII_MAIN	7526.27	10YR		79.7	835.73	836.9		837.09	0.010601	3.52	22.7	26.61	0.66
DAII_MAIN	7526.27	25YR		98.5	835.73	837.64		837.72	0.001922	2.25	45.68	35.15	0.31
DAII_MAIN	7426.27	5YR		57.6	834.76	836.01		836.08	0.004284	2.23	25.87	29.34	0.42
DAII_MAIN	7426.27	10YR		79.7	834.76	836.74		836.78	0.001147	1.56	51.52	40.11	0.23
DAII_MAIN	7426.27	25YR		98.5	834.76	837.62		837.64	0.000293	1.09	99.89	79	0.13
DAII_MAIN	7326.27	5YR		57.6	834	835.81		835.85	0.001388	1.59	36.31	29.22	0.25
DAII_MAIN	7326.27	10YR		79.7	834	836.68		836.71	0.000478	1.22	65.53	37.51	0.16
DAII_MAIN	7326.27	25YR		98.5	834	837.6		837.61	0.00018	0.98	105.19	50.11	0.1
DAII_MAIN	7226.27	5YR		57.6	834.1	835.27	835.27	835.62	0.00291	4.76	12.09	17.61	1.01
DAII_MAIN	7226.27	10YR		79.7	834.1	836.62		836.68	0.000132	1.99	42.5	27.37	0.26
DAII_MAIN	7226.27	25YR		98.5	834.1	837.57		837.6	0.000049	1.6	71.81	34.77	0.17
DAII_MAIN	7144.194	5YR		636.9	830.84	835.07	833.36	835.5	0.000316	5.26	121.1	29.75	0.45
DAII_MAIN	7144.194	10YR		909.4	830.84	836.02	834.01	836.6	0.000323	6.1	148.98	29.89	0.48
DAII_MAIN	7144.194	25YR		1131.4	830.84	836.86	834.5	837.52	0.000302	6.53	173.26	30.02	0.47
DAII_MAIN	7087.72			Culvert									
DAII_MAIN	7031.253	5YR		636.9	829.93	834.63		834.78	0.000127	3.16	201.44	51.46	0.28
DAII_MAIN	7031.253	10YR		909.4	829.93	835.23		835.47	0.000167	3.9	233.27	59.7	0.33
DAII_MAIN	7031.253	25YR		1131.4	829.93	835.65		835.94	0.000193	4.4	274.31	145.36	0.36
DAII_MAIN	6926.27	5YR		636.9	831	833.8	833.8	834.68	0.002123	7.5	84.96	52	1.01
DAII_MAIN	6926.27	10YR		909.4	831	834.32	834.32	835.35	0.001773	8.17	116.81	70.8	0.96
DAII_MAIN	6926.27	25YR		1131.4	831	834.68	834.68	835.81	0.00163	8.65	144.45	84.79	0.95
DAII_MAIN	6826.27	5YR		636.9	830	833.06	833.06	833.67	0.000984	7.08	164.09	190.07	0.75
DAII_MAIN	6826.27	10YR		909.4	830	833.54	833.54	834.01	0.000754	6.89	279.81	262.52	0.67
DAII_MAIN	6826.27	25YR		1131.4	830	833.7	833.7	834.22	0.000838	7.5	321.82	266.74	0.71
DAII_MAIN	6726.27	5YR		636.9	829	830.62	830.62	830.99	0.002382	7.24	219.86	261.14	1.05
DAII_MAIN	6726.27	10YR		909.4	829	830.82	830.82	831.27	0.00262	8.26	272.59	267.43	1.12
DAII_MAIN	6726.27	25YR		1131.4	829	830.98	830.98	831.48	0.002673	8.85	314.58	272.47	1.15
DAII_MAIN	6626.27	5YR		636.9	828	830.35	830.35	830.71	0.001684	6.9	247.45	292.94	0.91
DAII_MAIN	6626.27	10YR		909.4	828	830.57	830.57	830.98	0.001859	7.81	310.56	303.14	0.97
DAII_MAIN	6626.27	25YR		1131.4	828	830.8		831.19	0.001603	7.82	383.55	315.53	0.92

DAII_MAIN	6526.27	5YR		636.9	827	829.8	829.8	830.43	0.001388	7.9	195.54	218.01	0.87
DAII_MAIN	6526.27	10YR		909.4	827	830.3	830.3	830.81	0.001048	7.74	328.47	279.13	0.78
DAII_MAIN	6526.27	25YR		1131.4	827	830.48	830.48	831.04	0.001141	8.4	379.13	284.85	0.82
DAII_MAIN	6466.672	5YR		888.4	826.24	829.11	829.11	829.58	0.001244	7.22	232.73	235.45	0.82
DAII_MAIN	6466.672	10YR		1273.7	826.24	829.4	829.4	829.92	0.001325	8.04	303.12	257.43	0.86
DAII_MAIN	6466.672	25YR		1584	826.24	829.58	829.58	830.16	0.001419	8.68	350.11	270.38	0.9
DAII_MAIN	6400.79	5YR		888.4	824.86	828.03		828.32	0.00333	5.65	287.49	259.45	0.6
DAII_MAIN	6400.79	10YR		1273.7	824.86	828.3		828.65	0.003906	6.5	358.48	265.52	0.66
DAII_MAIN	6400.79	25YR		1584	824.86	828.43		828.87	0.004758	7.38	392.43	268.79	0.73
DAII_MAIN	6326.27	5YR		888.4	824	827.54	827.54	827.98	0.005945	6.36	206.29	240.34	0.61
DAII_MAIN	6326.27	10YR		1273.7	824	827.88	827.88	828.3	0.005669	6.62	304.44	336.08	0.61
DAII_MAIN	6326.27	25YR		1584	824	828.06	828.06	828.48	0.005662	6.83	366.02	352.78	0.61
DAII_MAIN	6226.27	5YR		888.4	825.33	826.64	826.64	827.03	0.005965	1.81	211.32	276.29	0.45
DAII_MAIN	6226.27	10YR		1273.7	825.33	826.88	826.88	827.31	0.006854	2.52	281.66	298.32	0.52
DAII_MAIN	6226.27	25YR		1584	825.33	827.02	827.02	827.49	0.007607	2.97	322.59	305.47	0.56
DAII_MAIN	6126.27	5YR		888.4	822	825.08	825.08	825.49	0.007935	6.52	196.62	205.23	0.69
DAII_MAIN	6126.27	10YR		1273.7	822	825.31	825.31	825.81	0.008869	7.28	245.85	217.32	0.74
DAII_MAIN	6126.27	25YR		1584	822	825.45	825.45	826.04	0.010002	7.96	275.82	225.35	0.79
DAII_MAIN	6026.27	5YR		888.4	821.71	824.42		824.58	0.003641	3.86	285.04	258.48	0.45
DAII_MAIN	6026.27	10YR		1273.7	821.71	824.71		824.91	0.003784	4.26	362.29	279.91	0.47
DAII_MAIN	6026.27	25YR		1584	821.71	824.87		825.11	0.004176	4.66	407.92	291.75	0.5
DAII_MAIN	5926.27	5YR		888.4	820.99	823.59	823.59	824.01	0.009218	6.23	192.31	216.15	0.72
DAII_MAIN	5926.27	10YR		1273.7	820.99	823.86	823.83	824.32	0.009096	6.67	254.18	237.93	0.73
DAII_MAIN	5926.27	25YR		1584	820.99	824.18		824.57	0.006823	6.23	332.27	262.99	0.64
DAII_MAIN	5826.27	5YR		888.4	820	823.11		823.3	0.003508	4.01	263.69	207.75	0.45
DAII_MAIN	5826.27	10YR		1273.7	820	823.58		823.78	0.002822	4.04	369.09	237.41	0.41
DAII_MAIN	5826.27	25YR		1584	820	823.94		824.13	0.002375	4	457.76	255.18	0.39
DAII_MAIN	5726.27	5YR		888.4	819.63	822.42	822.42	823.04	0.001491	8.53	258.65	198.53	0.92
DAII_MAIN	5726.27	10YR		1273.7	819.63	822.8	822.8	823.52	0.001595	9.63	337.41	217.97	0.97
DAII_MAIN	5726.27	25YR		1584	819.63	822.96	822.96	823.85	0.001899	10.89	374.55	226.15	1.07
DAII_MAIN	5611.055	5YR		1011.3	813.5	819.93	815.98	820.11	0.000079	3.46	292.5	78.47	0.24
DAII_MAIN	5611.055	10YR		1453.7	813.5	820.92	816.66	821.21	0.000101	4.3	337.8	172.68	0.28
DAII_MAIN	5611.055	25YR		1809.4	813.5	821.36	817.15	821.74	0.000152	4.96	416.32	185.19	0.33
DAII_MAIN	5583.83			Culvert									
DAII_MAIN	5556.611	5YR		1011.3	813.53	819.47		819.69	0.00131	3.8	271.56	70.98	0.28
DAII_MAIN	5556.611	10YR		1453.7	813.53	819.98		820.35	0.001969	4.92	317.64	122.41	0.34
DAII_MAIN	5556.611	25YR		1809.4	813.53	820.32		820.78	0.002405	5.63	362.12	142.58	0.38
DAII_MAIN	5426.27	5YR		1011.3	815	818.55	818.55	819.28	0.009042	7.85	162.69	110.21	0.76
DAII_MAIN	5426.27	10YR		1453.7	815	819.03	819.03	819.83	0.008811	8.47	219.79	130.24	0.76
DAII_MAIN	5426.27	25YR		1809.4	815	819.32	819.32	820.2	0.008939	8.96	259.6	142.57	0.78
DAII_MAIN	5326.27	5YR		1011.3	814.47	817.96		818.32	0.005015	5.51	215.39	130.36	0.56
DAII_MAIN	5326.27	10YR		1453.7	814.47	818.43		818.87	0.005117	6.13	283.19	153.77	0.58
DAII_MAIN	5326.27	25YR		1809.4	814.47	818.77		819.25	0.005018	6.46	338.04	170.83	0.58
DAII_MAIN	5226.27	5YR		1011.3	814	817.5		817.85	0.004369	5.39	224.79	132.71	0.53
DAII_MAIN	5226.27	10YR		1453.7	814	817.89		818.36	0.005069	6.27	281.03	150.71	0.58
DAII_MAIN	5226.27	25YR		1809.4	814	818.16		818.71	0.005623	6.91	322.42	167.78	0.62
DAII_MAIN	5178.442	5YR		1024.9	812.01	817.34	817.01	817.63	0.004088	5.28	257.48	186.91	0.5
DAII_MAIN	5178.442	10YR		1477.7	812.01	817.79	817.31	818.11	0.003815	5.53	346.2	207.22	0.49
DAII_MAIN	5178.442	25YR		1840.2	812.01	818.09	817.53	818.43	0.003705	5.72	410.04	219.89	0.49
DAII_MAIN	5140.695			Culvert									
DAII_MAIN	5110.766	5YR		1024.9	810.17	815.94	815.13	816.55	0.005482	6.58	185.2	122.81	0.59
DAII_MAIN	5110.766	10YR		1477.7	810.17	816.32	816.32	817.12	0.006892	7.84	237.16	151.46	0.67
DAII_MAIN	5110.766	25YR		1840.2	810.17	816.59	816.59	817.48	0.007393	8.47	281.96	172.5	0.7
DAII_MAIN	5026.27	5YR		1024.9	810.81	815.92		816.15	0.002201	4.45	319.5	249.77	0.38
DAII_MAIN	5026.27	10YR		1477.7	810.81	816.32		816.57	0.002317	4.85	423.35	266.79	0.4
DAII_MAIN	5026.27	25YR		1840.2	810.81	816.58		816.85	0.002415	5.13	492.11	274.73	0.41
DAII_MAIN	4956.567	5YR		1024.9	810.81	815.33	815.33	815.88	0.006469	6.79	207.76	186.76	0.63
DAII_MAIN	4956.567	10YR		1477.7	810.81	815.68	815.68	816.28	0.006846	7.44	279.03	216.27	0.66
DAII_MAIN	4956.567	25YR		1840.2	810.81	815.91	815.91	816.54	0.007061	7.84	329.31	231.79	0.68
DAII_MAIN	4939.574	5YR		1024.9	810.81	815.19	815.19	815.71	0.006581	6.68	211.92	190.81	0.64
DAII_MAIN	4939.574	10YR		1477.7	810.81	815.49	815.49	816.1	0.007505	7.54	272.26	211.17	0.69
DAII_MAIN	4939.574	25YR		1840.2	810.81	815.73	815.73	816.37	0.007563	7.89	323.92	228.27	0.7
DAII_MAIN	4826.27	5YR		1024.9	810	813.77	813.77	814.42	0.009323	7.42	175.71	135.26	0.75
DAII_MAIN	4826.27	10YR		1477.7	810	814.2	814.2	814.92	0.009179	8.05	240.31	168.05	0.76
DAII_MAIN	4826.27	25YR		1840.2	810	814.47	814.47	815.24	0.009198	8.48	290.19	195.11	0.78
DAII_MAIN	4726.27	5YR		1024.9	809.21	813.4		813.72	0.00359	5.22	254.69	174.94	0.48
DAII_MAIN	4726.27	10YR		1477.7	809.21	813.84	812.99	814.2	0.003765	5.77	343.69	221.77	0.51
DAII_MAIN	4726.27	25YR		1840.2	809.21	814.12	813.69	814.51	0.003816	6.07	407.62	240.38	0.51

DAII_MAIN	4626.27	5YR		1024.9	809	812.4	812.4	813.13	0.009139	7.69	168.01	129.33	0.76
DAII_MAIN	4626.27	10YR		1477.7	809	812.89	812.89	813.63	0.008326	8.07	241.01	167.31	0.74
DAII_MAIN	4626.27	25YR		1840.2	809	813.26	813.26	813.96	0.007325	8.07	312.81	214.94	0.71
DAII_MAIN	4557.326	5YR		1132	805.68	812.41	811.67	812.67	0.00224	5.27	321.65	192.49	0.39
DAII_MAIN	4557.326	10YR		1631.9	805.68	812.77	812.14	813.13	0.003043	6.41	398.88	241.57	0.47
DAII_MAIN	4557.326	25YR		2032.3	805.68	813.1	812.41	813.46	0.002977	6.58	486.45	274.54	0.46
DAII_MAIN	4522.395			Culvert									
DAII_MAIN	4488.603	5YR		1132	805.5	810.57		810.92	0.00301	5.33	258.56	132.96	0.44
DAII_MAIN	4488.603	10YR		1631.9	805.5	810.87		811.42	0.00433	6.68	302.3	150.48	0.54
DAII_MAIN	4488.603	25YR		2032.3	805.5	811.11		811.78	0.005148	7.52	340.08	165.66	0.59
DAII_MAIN	4426.27	5YR		1132	806.97	809.84	809.84	810.56	0.011155	7.26	171.45	130.5	0.81
DAII_MAIN	4426.27	10YR		1631.9	806.97	810.54	810.42	811.08	0.007037	6.79	296.21	202.59	0.67
DAII_MAIN	4426.27	25YR		2032.3	806.97	810.65	810.65	811.36	0.009046	7.87	318.83	208.65	0.76
DAII_MAIN	4326.27	5YR		1132	805	808.46	808.46	809.37	0.010695	8.44	157.17	86.84	0.82
DAII_MAIN	4326.27	10YR		1631.9	805	808.94	808.94	810.11	0.012185	9.85	202.81	110.58	0.9
DAII_MAIN	4326.27	25YR		2032.3	805	809.59	809.59	810.43	0.007918	8.84	309.55	180.09	0.74
DAII_MAIN	4226.27	5YR		1132	803	806.41	806.41	807.22	0.010538	8.21	164.59	97.5	0.81
DAII_MAIN	4226.27	10YR		1631.9	803	806.89	806.89	807.87	0.010717	9.09	213.62	109.08	0.84
DAII_MAIN	4226.27	25YR		2032.3	803	807.28	807.28	808.31	0.009928	9.36	259.32	120.9	0.82
DAII_MAIN	4128.532	5YR		1141.5	794	796.79	796.79	798.2	0.002077	9.52	119.95	43.01	1
DAII_MAIN	4128.532	10YR		1647	794	797.56	797.56	799.36	0.001997	10.75	153.14	43.01	1
DAII_MAIN	4128.532	25YR		2051.7	794	798.12	798.12	800.2	0.001963	11.58	177.17	43.01	1.01

Profile Output Table - Culvert Only
HEC-RAS Plan: EX River: 001 Reach: DAII_MAIN

WATERSHED II: CULVERTS ALONG MAIN CHANNEL

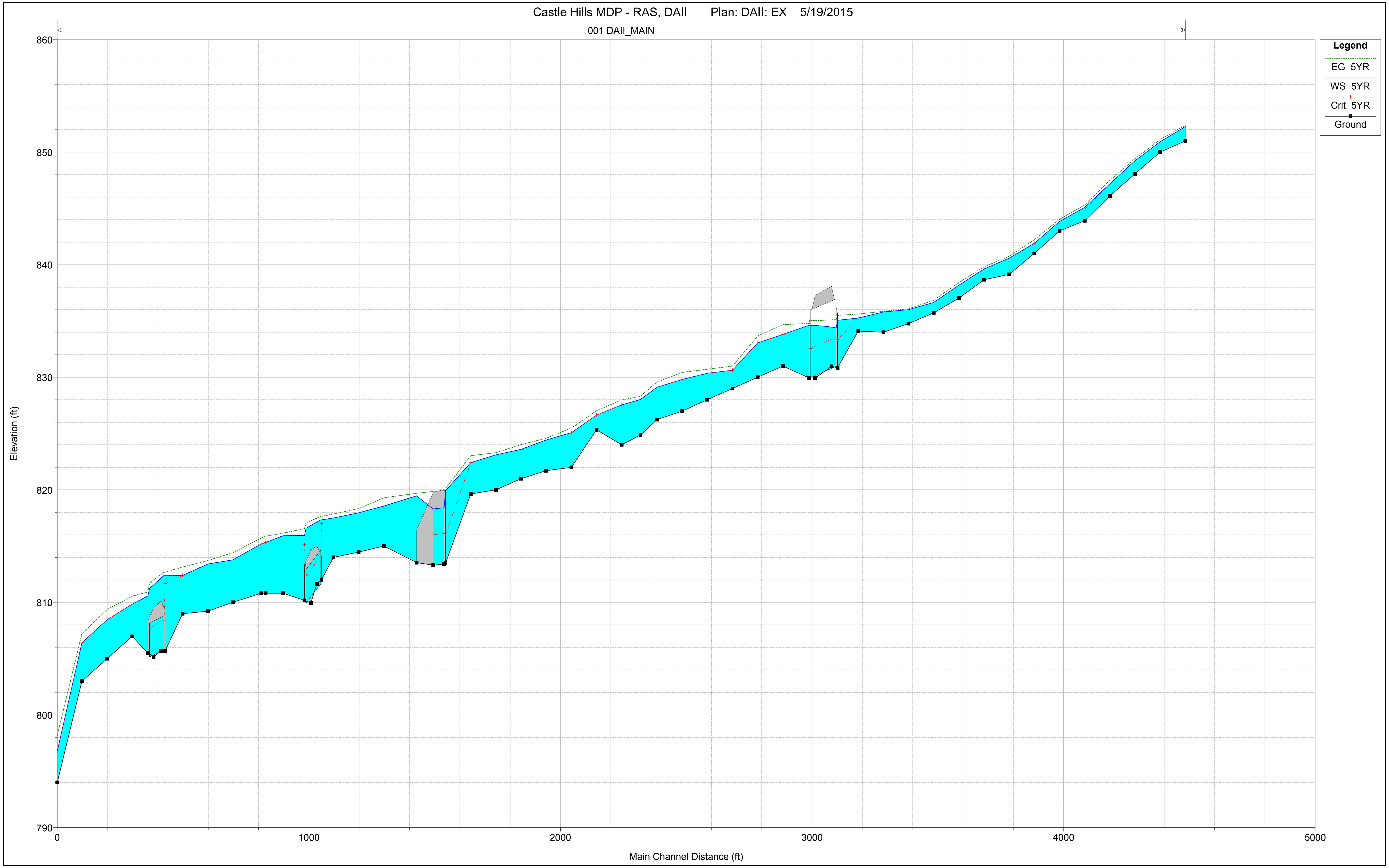
Rivers = 1
Hydraulic Reaches = 1
River Stations = 4
Plans = 1
Profiles = 3

Reach	River Sta	Profile	Plan	E.G. US. (ft)	W.S. US. (ft)	E.G. IC (ft)	E.G. OC Min (ft)	El Weir Flow (ft)	Q Culv Group (cfs)	Q Weir (cfs)	Delta WS Culv (ft)	Vel US Culv (ft/s)	Vel DS (ft/s)
DAII_MAIN	7087.72 NW MIL	5YR		835.5	835.07	835.34	835.5	838.47	636.9		0.44	6.91	5.06
DAII_MAIN	7087.72 NW MIL	10YR		836.6	836.02	836.54	836.6	838.47	909.4		0.79	8.72	6.4
DAII_MAIN	7087.72 NW MIL	25YR		837.52	836.86	837.43	837.52	838.47	1131.4		1.21	10.43	7.38
DAII_MAIN	5583.83 WISTER	5YR		820.11	819.93	818.03	820.11	820.95	1011.3		0.46	5.06	5.06
DAII_MAIN	5583.83 WISTER	10YR		821.21	820.92	819.32	821.21	820.95	1399.21	54.49	0.94	7	7
DAII_MAIN	5583.83 WISTER	25YR		821.74	821.36	820.68	821.74	820.95	1505.41	303.99	1.05	7.53	7.53
DAII_MAIN	5140.695 MIMOSA	5YR		817.64	817.34	817.59	817.64	815.5	174.33	850.57	1.4	8.22	8.22
DAII_MAIN	5140.695 MIMOSA	10YR		818.11	817.79	818.02	818.11	815.5	179.13	1298.57	1.47	8.45	8.45
DAII_MAIN	5140.695 MIMOSA	25YR		818.43	818.09	818.36	818.43	815.5	181.3	1658.9	1.49	8.55	8.55
DAII_MAIN	4522.395 KRAMER	5YR		812.67	812.41	812.59	812.67	810.11	194.02	937.98	1.84	9.15	9.15
DAII_MAIN	4522.395 KRAMER	10YR		813.13	812.77	813.1	813.13	810.11	200.69	1431.21	1.89	9.46	9.46
DAII_MAIN	4522.395 KRAMER	25YR		813.47	813.1	813.41	813.47	810.11	205.08	1824.78	1.99	9.67	9.67

Profile Output Table - Standard Table 1
HEC-RAS Plan: DAIII_EXSURV River: 001 Reach: DAIII_MAIN

Rivers = 1
Hydraulic Reaches = 1
River Stations = 13
Plans = 1
Profiles = 3

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
DAIII_MAIN	7327.389	5YR		326.6	855.23	857.04	857.04	857.51	0.002564	5.95	80.56	105.54	0.87
DAIII_MAIN	7327.389	10YR		460.6	855.23	857.32	857.32	857.84	0.002417	6.51	113.41	127.74	0.87
DAIII_MAIN	7327.389	25YR		576.5	855.23	857.53	857.53	858.08	0.002272	6.82	142.3	141.57	0.86
DAIII_MAIN	7027.966	5YR		326.6	851.08	852.94	852.94	853.46	0.002895	6.27	74.89	96.99	0.93
DAIII_MAIN	7027.966	10YR		460.6	851.08	853.29	853.29	853.82	0.002355	6.54	115.05	132.79	0.87
DAIII_MAIN	7027.966	25YR		576.5	851.08	853.51	853.51	854.04	0.00217	6.79	145.59	144.36	0.85
DAIII_MAIN	6672.635	5YR		326.6	846.61	848.29	848.29	848.79	0.002943	6.16	71.11	85.11	0.93
DAIII_MAIN	6672.635	10YR		460.6	846.61	848.66	848.66	849.13	0.002177	6.22	109.57	120.28	0.83
DAIII_MAIN	6672.635	25YR		576.5	846.61	848.84	848.84	849.34	0.002155	6.6	131.54	129.4	0.84
DAIII_MAIN	6217.731	5YR		326.6	841.53	843.37	843.37	844.05	0.002978	6.71	53.53	46.13	0.95
DAIII_MAIN	6217.731	10YR		460.6	841.53	843.74	843.74	844.56	0.00274	7.44	71.93	53.13	0.95
DAIII_MAIN	6217.731	25YR		576.5	841.53	844.05	844.05	844.95	0.002522	7.88	90.5	71.77	0.93
DAIII_MAIN	5969.72	5YR		326.6	837.41	839.23	839.23	839.86	0.002805	6.53	57.92	54.22	0.93
DAIII_MAIN	5969.72	10YR		460.6	837.41	839.61	839.61	840.35	0.002521	7.17	82.22	77.8	0.91
DAIII_MAIN	5969.72	25YR		576.5	837.41	839.93	839.93	840.68	0.002148	7.34	111.71	104.12	0.86
DAIII_MAIN	5824.951	5YR		404.5	836.68	838.63	838.63	839.3	0.002591	6.71	72.16	73.93	0.91
DAIII_MAIN	5824.951	10YR		573.8	836.68	839.02	839.02	839.78	0.002344	7.32	106.29	100.49	0.89
DAIII_MAIN	5824.951	25YR		718.2	836.68	839.38	839.38	840.09	0.00192	7.35	146.26	123.1	0.83
DAIII_MAIN	5563.125	5YR		404.5	835.25	837.15	837.15	837.87	0.002752	7.01	69.2	59.91	0.94
DAIII_MAIN	5563.125	10YR		573.8	835.25	837.62	837.62	838.41	0.002284	7.49	103.66	89.54	0.89
DAIII_MAIN	5563.125	25YR		718.2	835.25	837.99	837.99	838.76	0.001906	7.59	141.89	115.79	0.83
DAIII_MAIN	5174.281	5YR		404.5	832.22	834.15	834.15	834.76	0.002453	6.64	82.95	84.63	0.89
DAIII_MAIN	5174.281	10YR		573.8	832.22	834.41	834.41	835.22	0.002815	7.81	106.9	97.92	0.97
DAIII_MAIN	5174.281	25YR		718.2	832.22	834.82	834.82	835.52	0.002048	7.53	152.95	122.89	0.86
DAIII_MAIN	4848.765	5YR		404.5	827.67	829.32	829.32	829.89	0.002738	6.49	88.42	100.81	0.92
DAIII_MAIN	4848.765	10YR		573.8	827.67	829.68	829.68	830.26	0.00232	6.85	126.86	110.84	0.88
DAIII_MAIN	4848.765	25YR		718.2	827.67	830.48		830.78	0.00084	5.21	218.55	118.62	0.56
DAIII_MAIN	4728.913	5YR		493.6	824.99	827.89	827.89	829.02	0.002042	8.52	57.94	26.25	1
DAIII_MAIN	4728.913	10YR		706.8	824.99	828.55	828.55	829.9	0.001763	9.35	78.73	36.72	0.97
DAIII_MAIN	4728.913	25YR		886.2	824.99	829.05	829.05	830.54	0.001585	9.86	99.14	45.01	0.95
DAIII_MAIN	4514.287	5YR		493.6	822.81	827.82		828.07	0.000211	4.07	132.52	48.04	0.35
DAIII_MAIN	4514.287	10YR		706.8	822.81	828.57		828.92	0.000235	4.81	179.88	73.16	0.39
DAIII_MAIN	4514.287	25YR		886.2	822.81	829.15		829.55	0.000238	5.22	222.09	73.16	0.39
DAIII_MAIN	4461.84	5YR		519.9	822.31	826.89	826.89	827.96	0.00131	8.77	85.2	51.2	0.84
DAIII_MAIN	4461.84	10YR		746.1	822.31	827.51	827.51	828.79	0.001333	9.9	119.28	57.89	0.87
DAIII_MAIN	4461.84	25YR		935.7	822.31	828.04	828.04	829.42	0.001264	10.47	153.31	71.63	0.87
DAIII_MAIN	4399.291	5YR		519.9	821.48	825.91	825.91	827.28	0.001603	9.55	64.4	32.67	0.91
DAIII_MAIN	4399.291	10YR		746.1	821.48	826.78	826.78	828.32	0.001389	10.36	97.72	44.36	0.88
DAIII_MAIN	4399.291	25YR		935.7	821.48	827.47	827.47	829.02	0.001206	10.67	132.21	55.94	0.84


Castle Hills MDP - RAS, DAII Plan: DAII: EX 5/19/2015
001 DAII_MAIN
Legend
EG 5YR
WS 5YR
Crit 5YR
Ground
Elevation (ft)
860
850
840
830
820
810
800
790
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

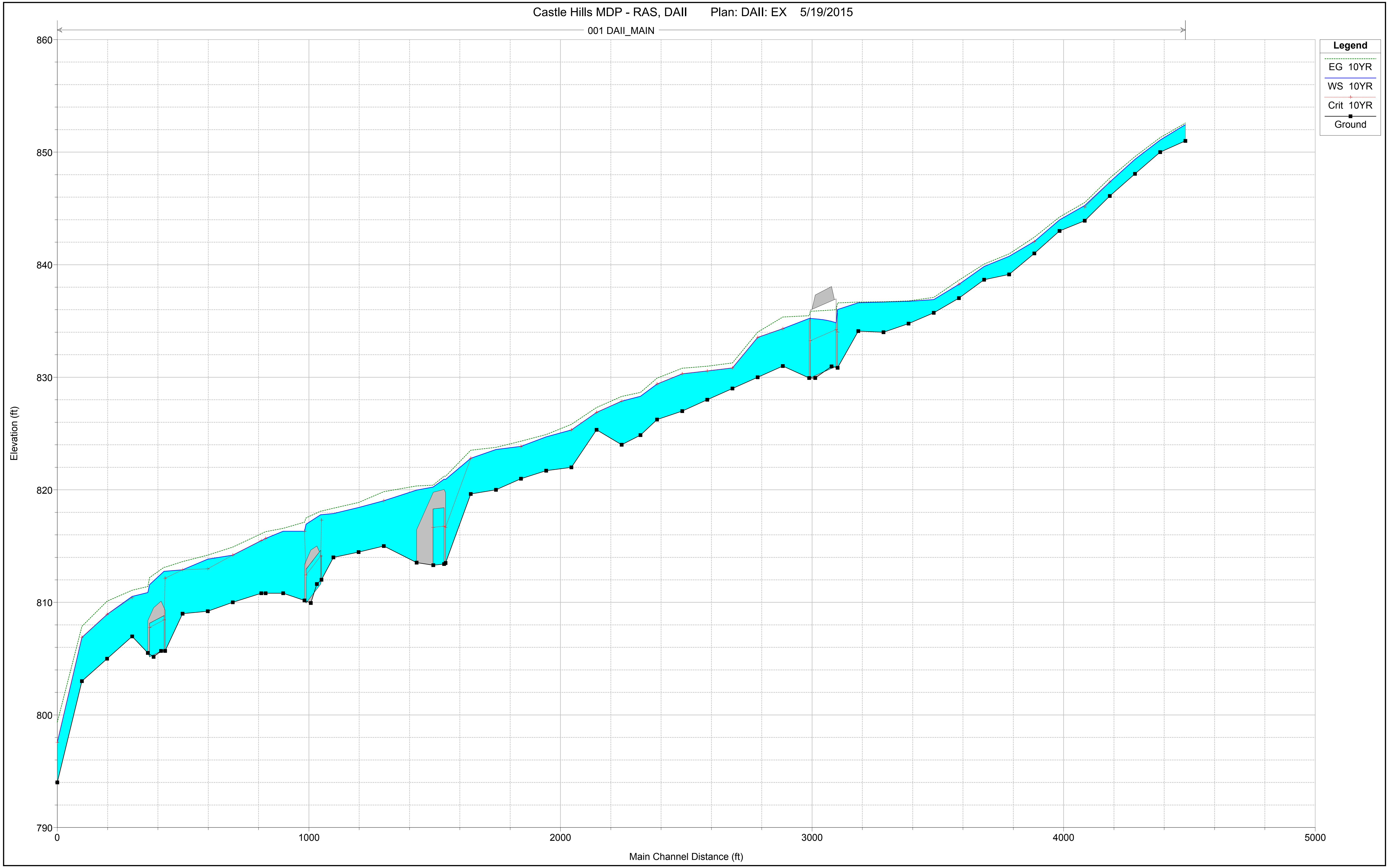

Castle Hills MDP - RAS, DAII Plan: DAII: EX 5/19/2015
001 DAII_MAIN
Legend
EG 10YR
WS 10YR
Crit 10YR
Ground
Elevation (ft)
Main Channel Distance (ft)
860
850
840
830
820
810
800
790
0
1000
2000
3000
4000
5000

EXHIBIT G – Cost estimate

klotz associates

FOR REVIEW ONLY

DO NOT USE FOR PERMITTING, BIDDING, OR CONSTRUCTION.

JESUS DE LUNA NUNCIO, PE# 114240
TEXAS SERIAL NO.
06/22/2015
DATE

CITY OF CASTLE HILLS
MASTER DRAINAGE PLAN, PHASE 01
WATERSHED II: LOCKHILL SELMA TO WEST AVENUE
PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST
KLOTZ JOB NO.: 1161.001.001

6/22/2015

ITEM NO.	DESC. CODE	DESCRIPTION	ENGLISH UNIT	ESTIMATED QUANTITY	PRICE PER UNIT	AMOUNT
DOGWOOD DR						
465	2054	INLET (COMPL)(CURB)(TY 2)(10')	EA	4	$5,862.00	$23,448.00
-	-	INLET (COMPL)(CURB)(TY 2)(30')	EA	4	$12,000.00	$48,000.00
464	2005	RC PIPE (CL III)(24 IN)	LF	56	$56.00	$3,136.00
464	2011	RC PIPE (CL III)(48 IN)	LF	1,700	$146.00	$248,200.00
402	2001	TRENCH EXCAVATION PROTECTION	LF	1,700	$3.00	$5,100.00
-	-	JUNCTION BOX 5'X5'X5'	EA	2	$4,500.00	$9,000.00
-	-	SPECIAL JUNCTION BOXES (COMPLETE)	EA	1	$10,000.00	$10,000.00
					Subtotal	**$346,884**
E. CASTLE LN						
462	2020	CONC BOX CULV (8 FT X 5 FT)	LF	201	$434.00	$87,234.00
402	2001	TRENCH EXCAVATION PROTECTION	LF	67	$3.00	$201.00
432	2001	RIPRAP (CONC)(4 IN)	CY	342	$1,000.00	$341,852.00
110	2002	EXCAVATION (CHANNEL)	CY	2,383	$9.00	$21,450.00
466	2050	WINGWALL (PW)(HW=6 FT)	EA	2	$12,350.00	$24,700.00
					Subtotal	**$475,437**
WISTERIA						
432	2001	RIPRAP (CONC)(4 IN)	CY	175	$1,000.00	$175,309.00
110	2002	EXCAVATION (CHANNEL)	CY	556	$9.00	$5,000.00
					Subtotal	**$180,309**
MIMOSA DRIVE						
462	2020	CONC BOX CULV (8 FT X 5 FT)	LF	174	$434.00	$75,516.00
402	2001	TRENCH EXCAVATION PROTECTION	LF	58	$3.00	$174.00
432	2001	RIPRAP (CONC)(4 IN)	CY	236	$1,000.00	$235,741.00
110	2002	EXCAVATION (CHANNEL)	CY	1,626	$9.00	$14,630.00
466	2050	WINGWALL (PW)(HW=6 FT)	EA	2	$12,350.00	$24,700.00
					Subtotal	**$350,761**
KRIMERIA DRIVE						
462	2021	CONC BOX CULV (8 FT X 6 FT)	LF	174	$397.00	$69,078.00
402	2001	TRENCH EXCAVATION PROTECTION	LF	58	$3.00	$174.00
432	2001	RIPRAP (CONC)(4 IN)	CY	178	$1,000.00	$177,778.00
110	2002	EXCAVATION (CHANNEL)	CY	1,167	$9.00	$10,500.00
466	2051	WINGWALL (PW)(HW=7 FT)	EA	2	$16,347.00	$32,694.00
					Subtotal	**$290,224**
					Construction Sub-Total	**$1,643,615**
2336	2001	MOBILIZATION - 10% OF SUBTOTAL	LS	$164,361.50	1	$164,362.00
		UTILITY ADJUSTMENTS - 25% OF SUBTOTAL	LS	$410,903.75	1	$410,904.00
		CONTINGENCIES - 25% OF SUBTOTAL	LS	$410,903.75	1	$410,904.00
		PREP ROW - 5% OF SUBTOTAL	LS	$82,180.75	1	$82,181.00
		TRAFFIC CONTROL - 3% OF SUBTOTAL	LS	$49,308.45	1	$49,308.00
					Construction Cost Total	**$2,761,274**
		ENGINEERING AND SURVEY - 15% OF CONSTRUCTION COST	LS	$414,191.10	1	$414,191.00
		SURVEYING - 5% OF CONSTRUCTION COST	LS	$138,063.70	1	$138,064.00
		ENVIRONMENTAL, GEOTECHNICAL, STRUCTURAL - 7% OF CONST. COST	LS	$193,289.18	1	$193,289.00
		EASEMENT ACQUISITION	LS	$35,000.00	1	$35,000.00
					PROJECT TOTAL	**$3,506,818**

k l o t z associates

CITY OF CASTLE HILLS
MASTER DRAINAGE PLAN, PHASE 01
WATERSHED III: LOCKHILL SELMA TO NW. MILITARY
PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST
KLOTZ JOB NO.: 1161.001.001

FOR REVIEW ONLY

DO NOT USE FOR PERMITTING, BIDDING, OR CONSTRUCTION.

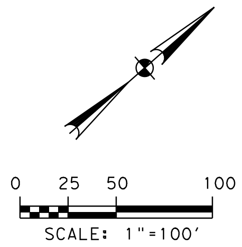
JESUS DE LUNA NUNCIO, PE# 114240
TEXAS SERIAL NO.
06/22/2015
DATE

6/22/2015

ITEM NO.	DESC. CODE	DESCRIPTION	ENGLISH UNIT	ESTIMATED QUANTITY	PRICE PER UNIT	AMOUNT
CAROLWOOD/SELMA						
465	2056	INLET (COMPL)(CURB)(TY 2)(20')	EA	2	$8,874.00	$17,748.00
-	-	INLET (COMPL)(CURB)(TY 2)(30')	EA	8	$12,000.00	$96,000.00
464	2005	RC PIPE (CL III)(24 IN)	LF	252	$56.00	$14,112.00
462	2019	CONC BOX CULV (8 FT X 4 FT)	LF	1,300	$375.00	$487,500.00
					Subtotal	**$615,360**
BANYAN/CAROLWOOD						
-	-	INLET (COMPL)(TRAFFIC)(TY X-2)	EA	2	$12,000.00	$24,000.00
465	2143	INLET (COMPL)(TRAFFIC)(TY X-1)	EA	1	$5,642.00	$5,642.00
-	-	PRECAST REINFORCED CONCRETE CULVERT (11' x 5')	L.F.	1,067	$580.00	$618,860.00
					Subtotal	**$648,502**
GLENTOWER/NW MILITARY						
-	-	PRECAST REINFORCED CONCRETE CULVERT (12' x 5')	L.F.	352	$620.00	$218,240.00
-	-	INLET (COMPL)(TRAFFIC)(TY X-2)	EA	3	$12,000.00	$36,000.00
110	2002	EXCAVATION (CHANNEL)	CY	389	$9.00	$3,500.00
432	2001	RIPRAP (CONC)(4 IN)	CY	58	$1,000.00	$58,025.00
466	2050	WINGWALL (PW)(HW=6 FT)	EA	1	$12,350.00	$12,350.00
					Subtotal	**$328,115**
					Construction Sub-Total	**$1,591,977**
2336	2001	MOBILIZATION - 10% OF ALL ITEMS	LS	$159,197.70	1	$159,198.00
		UTILITY ADJUSTMENTS - 25% OF SUBTOTAL	LS	$397,994.25	1	$397,994.00
		CONTINGENCIES- 25% OF SUBTOTAL	LS	$397,994.25	1	$397,994.00
		PREP ROW - 5% OF SUBTOTAL	LS	$79,598.85	1	$79,599.00
		TRAFFIC CONTROL - 3% OF SUBTOTAL	LS	$47,759.31	1	$47,759.00
					CONSTRUCTION COST TOTAL	**$2,674,521**
		ENGINEERING AND SURVEY - 15% OF CONSTRUCTION COST	LS	$401,178.15	1	$401,178.00
		SURVEYING - 5% OF CONSTRUCTION COST	LS	$133,726.05	1	$133,726.00
		ENVIRONMENTAL, GEOTECHNICAL, STRUCTURAL - 7% OF CONST. COST	LS	$187,216.47	1	$187,216.00
		EASEMENT ACQUISITION	LS	$5,000.00	1	$5,000.00
					PROJECT TOTAL	**$3,401,641**

EXHIBIT H – Proposed improvement layouts

EXHIBIT H -1



LEGEND

━━	WATERSHED BOUNDARY
— — —	1FT CONTOURS
──	LOT LINES
━━	STORM SEWER IMPROVEMENTS

klotz associates

7550 IH-10 WEST
NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN
EXHIBIT H1:
WATERSHED II
STORM SEWER IMPROVEMENTS
DOGWOOD LN

SHEET 1 OF 1

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
	1161.001.001		
STATE	DIST.	COUNTY	
TEXAS	SA	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

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0 100 200

SCALE: 1"=200'

LEGEND

━━ WATERSHED BOUNDARY

── DRAINAGE AREA BOUNDARY

── LOT LINES

- - - 1FT CONTOURS

─ ▶ ─ FLOW LINE

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NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN
EXHIBIT H1:
WATERSHED II
CHANNEL IMPROVEMENTS

SHEET 1 OF 1

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
	1161.001.001		
STATE	DIST.	COUNTY	
TEXAS	SA	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

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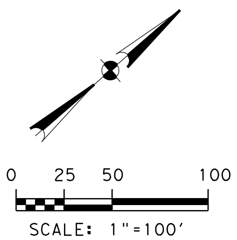
EXHIBIT H -2



LEGEND

▬	WATERSHED BOUNDARY
— - —	1FT CONTOURS
—	LOT LINES
▬	STORM SEWER IMPROVEMENTS

klotz associates

7550 IH-10 WEST
NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN
EXHIBIT H2:
WATERSHED III
STORM SEWER IMPROVEMENTS
CAROLWOOD DR

SHEET 1 OF 2

FED. RD. DIV. NO.	PROJECT NO.		SHEET NO.
	1161.001.001		
STATE	DIST.	COUNTY	
TEXAS	SA	BEXAR	
CONT.	SECT.	JOB	HIGHWAY NO.

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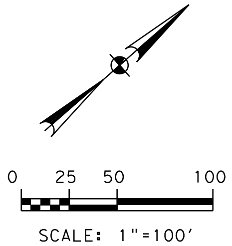

LEGEND

━━	WATERSHED BOUNDARY
──	STORM SEWER IMPROVEMENTS
─	LOT LINES
– – –	1FT CONTOURS

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7550 IH-10 WEST
NORTHWEST CENTER, SUITE 300
SAN ANTONIO, TX 78229
Phone: (210) 736-0425 Fax: (210) 736-0405
Texas PE Firm Reg. #F-929

CASTLE HILLS
MASTER DRAINAGE PLAN
EXHIBIT H2:
WATERSHED III
BANYAN DR
STORM SEWER IMPROVEMENTS

SHEET 2 OF 2

FED.RD. DIV.NO.	PROJECT NO.			SHEET NO.
	1161.001.001			
STATE	DIST.	COUNTY		
TEXAS	SA	BEXAR		
CONT.	SECT.	JOB	HIGHWAY NO.	

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EXHIBIT I – Supporting documentation

EXHIBIT I – 1

Time of Concentration for path: 2A

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	897.00	ft
elevation, min	894.75	ft
Δelevation	**2.25**	ft
land slope, s	**0.0075**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	2038.00	ft
elevation, max	894.75	ft
elevation, min	860.75	ft
Δelevation	**34.00**	ft
watercourse slope, s	**0.0167**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.272**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)**=**	**36.30**	**minutes**

Time of Concentration for path: 2B

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	921.00	ft
elevation, min	911.50	ft
Δelevation	**9.50**	ft
land slope, s	**0.0317**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	92.00	ft
elevation, max	911.50	ft
elevation, min	908.00	ft
Δelevation	**3.50**	ft
watercourse slope, s	**0.0380**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.008**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	1280.70	ft
elevation, max	908.00	ft
elevation, min	873.50	ft
Δelevation	**34.50**	ft
watercourse slope, s	**0.0269**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.107**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	889.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600*V)$	**0.04**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)**=**	**29.36**	**minutes**

Time of Concentration for path: 2C

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	933.00	ft
elevation, min	926.50	ft
Δelevation	**6.50**	ft
land slope, s	**0.0217**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	108.00	ft
elevation, max	926.50	ft
elevation, min	921.00	ft
Δelevation	**5.50**	ft
watercourse slope, s	**0.0509**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.008**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	2513.00	ft
elevation, max	921.00	ft
elevation, min	854.50	ft
Δelevation	**66.50**	ft
watercourse slope, s	**0.0265**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.211**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	562.00	ft
elevation, max	854.50	ft
elevation, min	843.00	ft
Δelevation	**11.50**	ft
watercourse slope, s	**0.0205**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	ft/s
$T_t = L/(3600KS^{0.5})$	**0.068**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	872.50	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**10.00**	ft/s
$T_t = L/(3600*V)$	**0.02**	hr

watershed T_C (10mins min)**=**	**38.68**	**minutes**

Time of Concentration for path: 2D

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	873.00	ft
elevation, min	862.00	ft
Δelevation	**11.00**	ft
land slope, s	**0.0367**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	1652.00	ft
elevation, max	862.00	ft
elevation, min	841.75	ft
Δelevation	**20.25**	ft
watercourse slope, s	**0.0123**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.257**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	994.55	ft
elevation, max	841.75	ft
elevation, min	838.00	ft
Δelevation	**3.75**	ft
watercourse slope, s	**0.0038**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.221**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	726.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**8.00**	ft/s
$T_t = L/(3600*V)$	**0.03**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)**=**	**50.21**	**minutes**

Time of Concentration for path: 2E

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	874.00	ft
elevation, min	864.75	ft
Δelevation	**9.25**	ft
land slope, s	**0.0308**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	1503.00	ft
elevation, max	864.75	ft
elevation, min	834.00	ft
Δelevation	**30.75**	ft
watercourse slope, s	**0.0205**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.181**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	918.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600*V)$	**0.04**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)**=**	**33.41**	**minutes**

Time of Concentration for path: 2F

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	846.00	ft
elevation, min	834.00	ft
Δelevation	**12.00**	ft
land slope, s	**0.0400**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	452.00	ft
elevation, max	834.00	ft
elevation, min	814.00	ft
Δelevation	**20.00**	ft
watercourse slope, s	**0.0442**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.037**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	139.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**8.00**	ft/s
$T_t = L/(3600*V)$	**0.00**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)**=**	**22.51**	**minutes**

Time of Concentration for path: 2G

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	903.00	ft
elevation, min	889.00	ft
Δelevation	**14.00**	ft
land slope, s	**0.0467**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	627.00	ft
elevation, max	889.00	ft
elevation, min	868.00	ft
Δelevation	**21.00**	ft
watercourse slope, s	**0.0335**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.059**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	2191.00	ft
elevation, max	868.00	ft
elevation, min	828.50	ft
Δelevation	**39.50**	ft
watercourse slope, s	**0.0180**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.223**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	378.50	ft
elevation, max	828.50	ft
elevation, min	813.00	ft
Δelevation	**15.50**	ft
watercourse slope, s	**0.0410**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.026**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	218.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**8.00**	ft/s
$T_t = L/(3600{*}V)$	**0.01**	hr

watershed T_C (10mins min)**=**	**38.91**	**minutes**

Time of Concentration for path: 2H

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	856.00	ft
elevation, min	847.00	ft
Δelevation	**9.00**	ft
land slope, s	**0.0300**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	156.00	ft
elevation, max	847.00	ft
elevation, min	842.00	ft
Δelevation	**5.00**	ft
watercourse slope, s	**0.0321**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.015**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	1016.50	ft
elevation, max	842.00	ft
elevation, min	809.00	ft
Δelevation	**33.00**	ft
watercourse slope, s	**0.0325**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	
$T_t = L/(3600KS^{0.5})$	**0.077**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	380.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**8.00**	ft/s
$T_t = L/(3600{*}V)$	**0.01**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

watershed T_C (10mins min)**=**	**26.32**	**minutes**

Time of Concentration for path: 2I

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	890.00	ft
elevation, min	881.50	ft
Δelevation	**8.50**	ft
land slope, s	**0.0283**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	1094.00	ft
elevation, max	881.50	ft
elevation, min	852.00	ft
Δelevation	**29.50**	ft
watercourse slope, s	**0.0270**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.115**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

watershed T_C (10mins min)**=**	**26.88**	**minutes**

Time of Concentration for path: 2J

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	907.00	ft
elevation, min	896.50	ft
Δelevation	**10.50**	ft
land slope, s	**0.0350**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	1713.00	ft
elevation, max	896.50	ft
elevation, min	854.25	ft
Δelevation	**42.25**	ft
watercourse slope, s	**0.0247**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	
$T_t = L/(3600KS^{0.5})$	**0.149**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	529.00	ft
elevation, max	854.25	ft
elevation, min	848.00	ft
Δelevation	**6.25**	ft
watercourse slope, s	**0.0118**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	ft/s
$T_t = L/(3600KS^{0.5})$	**0.084**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

watershed T_C (10mins min)**=**	**33.98**	**minutes**

Time of Concentration for path: 2K

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	282.00	ft
elevation, max	847.25	ft
elevation, min	846.00	ft
Δelevation	**1.25**	ft
land slope, s	**0.0044**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	29.00	ft
elevation, max	846.00	ft
elevation, min	843.00	ft
Δelevation	**3.00**	ft
watercourse slope, s	**0.1034**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	
$T_t = L/(3600KS^{0.5})$	**0.001**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

watershed T_C (10mins min)**=**	**20.07**	**minutes**

Time of Concentration for path: X

Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr

watershed T_C (10mins min)**=**	**#DIV/0!**	**minutes**

Time of Concentration for path:	**A-J@C**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	1967.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600{*}V)$	**0.09**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**B-J@C**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	1432.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600{*}V)$	**0.07**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@C-J@D**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	666.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**8.00**	ft/s
$T_t = L/(3600{*}V)$	**0.02**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**I-J@J**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	428.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**3.00**	ft/s
$T_t = L/(3600{*}V)$	**0.04**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@J-J@K**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	1285.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**3.00**	ft/s
$T_t = L/(3600{*}V)$	**0.12**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@K-J@D**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	1854.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**8.00**	ft/s
$T_t = L/(3600{*}V)$	**0.06**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@D-J@E**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
∆elevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	858.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600{*}V)$	**0.04**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@E-J@F**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
∆elevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	456.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600{*}V)$	**0.02**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@F-J@G**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
∆elevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	622.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600{*}V)$	**0.03**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@G-J@H**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
∆elevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	405.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
$T_t = L/(3600{*}V)$	**0.02**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**X**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
∆elevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**X**	
Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
∆elevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr
Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
∆elevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600{*}V)$	**X**	hr
watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path: 3A

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	932.00	ft
elevation, min	924.00	ft
Δelevation	**8.00**	ft
land slope, s	**0.0267**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	314.00	ft
elevation, max	924.00	ft
elevation, min	911.00	ft
Δelevation	**13.00**	ft
watercourse slope, s	**0.0414**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.027**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	128.00	ft
elevation, max	911.00	ft
elevation, min	908.00	ft
Δelevation	**3.00**	ft
watercourse slope, s	**0.0234**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.011**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	309.60	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
T_t = L/(3600*V)	**0.01**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	2750.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**6.00**	ft/s
T_t = L/(3600*V)	**0.13**	hr

watershed T_C (10mins min)=	**30.78**	**minutes**

Time of Concentration for path: 3B

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	850.00	ft
elevation, min	847.00	ft
Δelevation	**3.00**	ft
land slope, s	**0.0100**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	697.00	ft
elevation, max	847.00	ft
elevation, min	842.50	ft
Δelevation	**4.50**	ft
watercourse slope, s	**0.0065**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.149**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	778.50	ft
elevation, max	842.50	ft
elevation, min	836.25	ft
Δelevation	**6.25**	ft
watercourse slope, s	**0.0080**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.119**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

watershed T_C (10mins min)=	**36.09**	**minutes**

Time of Concentration for path: 3C

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	858.00	ft
elevation, min	854.00	ft
Δelevation	**4.00**	ft
land slope, s	**0.0133**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	1307.00	ft
elevation, max	854.00	ft
elevation, min	835.50	ft
Δelevation	**18.50**	ft
watercourse slope, s	**0.0142**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.189**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

watershed T_C (10mins min)=	**31.35**	**minutes**

Time of Concentration for path: 3D

Sheet Flow:		-
surface description	grass	-
overland flow roughness coefficient, n	0.41	-
flow length, L (300ft max)	300.00	ft
elevation, max	857.00	ft
elevation, min	855.50	ft
Δelevation	**1.50**	ft
land slope, s	**0.0050**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**0.33**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	U	-
flow length, L	1158.50	ft
elevation, max	855.50	ft
elevation, min	832.00	ft
Δelevation	**23.50**	ft
watercourse slope, s	**0.0203**	ft/ft
k (16.13 unpaved, 20.32 paved)	16.13	
$T_t = L/(3600KS^{0.5})$	**0.140**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)	P	-
flow length, L	587.00	ft
elevation, max	855.50	ft
elevation, min	825.00	ft
Δelevation	**30.50**	ft
watercourse slope, s	**0.0520**	ft/ft
k (16.13 unpaved, 20.32 paved)	20.32	ft/s
$T_t = L/(3600KS^{0.5})$	**0.035**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

watershed T_C (10mins min)=	**30.52**	**minutes**

Time of Concentration for path: X

Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
T_t = L/(3600*V)	**X**	hr

watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**A-J@B**

Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	1577.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**3.00**	ft/s
$T_t = L/(3600*V)$	**0.15**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@B-J@C**

Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	1020.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**12.00**	ft/s
$T_t = L/(3600*V)$	**0.02**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**J@C-J@D**

Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	390.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**0.0000**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**12.00**	ft/s
$T_t = L/(3600*V)$	**0.01**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

Time of Concentration for path:	**X**

Sheet Flow:		-
surface description		-
overland flow roughness coefficient, n		-
flow length, L (300ft max)	0.00	ft
elevation, max		ft
elevation, min		ft
Δelevation	**0.00**	ft
land slope, s	**0.0000**	ft/ft
2yr 24hr rainfall, P_2	3.60	in
$T_t = [0.007(nL)^{0.8}]/[(P_2^{0.5})(s^{0.4})]$	**#DIV/0!**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	
$T_t = L/(3600KS^{0.5})$	**X**	hr

Shallow Concentrated Flow:		-
surface description (paved/unpaved)		-
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
watercourse slope, s	**X**	ft/ft
k (16.13 unpaved, 20.32 paved)	-	ft/s
$T_t = L/(3600KS^{0.5})$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

Channel Flow:		-
cross sectional flow area, a	0.00	ft2
wetted perimeter, pw	0.00	ft
hydraulic radius, r = a/pw	**X**	ft
flow length, L	0.00	ft
elevation, max	0.00	ft
elevation, min	0.00	ft
Δelevation	**0.00**	ft
channel slope, s	**X**	ft/ft
manning's roughness coefficient, n	0.00	-
$V = [1.49(r^{2/3})(s^{1/2})]/n$	**X**	ft/s
or V_{manual}=	**???**	ft/s
$T_t = L/(3600*V)$	**X**	hr

watershed T_C (10mins min)=	**#DIV/0!**	**minutes**

EXHIBIT I – 2

Hydraulic Analysis Report

WS II = DA 2I

Project Data

Project Title: Dogwood

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Channel Analysis, Dogwood @ Selma

Notes:

Input Parameters

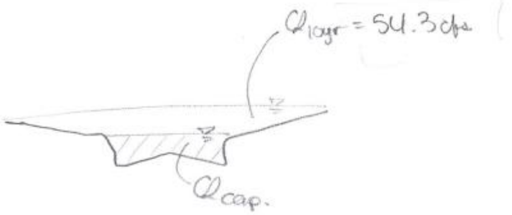
Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
15.65	852.32	0.0160
16.58	851.77	0.0160
16.58	851.77	0.0160
31.68	852.41	0.0160
31.84	852.41	0.0160
44.83	853.80	0.0160
44.97	853.79	0.0160
44.98	853.80	0.0160
44.99	853.80	0.0160
45.90	854.15	-----

Longitudinal Slope: 0.0100 ft/ft

Depth: 0.4950 ft



Result Parameters

Flow: 11.2592 cfs — ex street capacity

Area of Flow: 3.0986 ft^2

Wetted Perimeter: 12.6620 ft

Hydraulic Radius: 0.2447 ft

Average Velocity: 3.6336 ft/s

Top Width: 12.5167 ft

Froude Number: 1.2870

Critical Depth: 0.5476 ft

Critical Velocity: 2.9695 ft/s

Critical Slope: 0.0058 ft/ft

Critical Top Width: 13.85 ft

Calculated Max Shear Stress: 0.3089 lb/ft^2

Calculated Avg Shear Stress: 0.1527 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160

Curb and Gutter Analysis: 2I:Curb on each side, set 1

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0100 ft/ft

Cross-Slope of Pavement: 0.0200 ft/ft

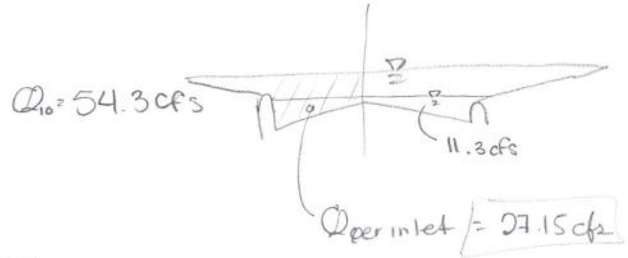
Uniform Gutter Geometry

Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 24.8596 ft

Gutter Result Parameters



Design Flow: 27.1500 cfs

Gutter Depression: 0.0000 in

Area of Flow: 6.1800 ft^2

Eo (Gutter Flow to Total Flow): 0.2006

Gutter Depth at Curb: 5.9663 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 30.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 22.1958 cfs — capacity per inlet on each side

Bypass Flow: 4.9542 cfs

Efficiency: 0.8175

54.30 − 22.19 × 2 = 9.92 cfs as C.Q

by-pass from each side ∴ Q_{bT} = (0 × 2 = 9.92 cfs

Curb and Gutter Analysis: 2I:Curb on each side, set 2

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0100 ft/ft

Cross-Slope of Pavement: 0.0200 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 13.1313 ft

Gutter Result Parameters

Design Flow: 4.9500 cfs — from previous C.O. on each side

Gutter Depression: 0.0000 in

Area of Flow: 1.7243 ft^2

Eo (Gutter Flow to Total Flow): 0.3567

Gutter Depth at Curb: 3.1515 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 10.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 3.5749 cfs

Bypass Flow: 1.3751 cfs — Q_T in street = 1.38×2 = 2.76 cfs

Efficiency: 0.7222

Channel Analysis: Channel Analysis, Dogwood J@J

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
28.02	847.91	0.0160
28.06	847.89	0.0160
29.06	847.52	0.0160
29.73	847.55	0.0160
44.47	847.87	0.0160
45.04	847.93	0.0160
57.22	846.97	0.0160
57.86	847.72	0.0160
58.82	848.24	0.0160
58.86	848.26	-----

Longitudinal Slope: 0.0100 ft/ft

Depth: 0.8800 ft

Result Parameters

Flow: 29.7340 cfs — capacity > Q_{co} = 2.76 cfs from inlets US.

Area of Flow: 7.5956 ft^2

Wetted Perimeter: 27.7568 ft

Hydraulic Radius: 0.2736 ft

Average Velocity: 3.9146 ft/s

Top Width: 27.2807 ft

Froude Number: 1.3074

Critical Depth: 0.9408 ft

Critical Velocity: 3.1824 ft/s

Critical Slope: 0.0056 ft/ft

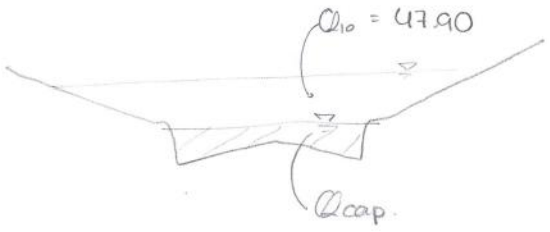
Critical Top Width: 29.71 ft

Calculated Max Shear Stress: 0.5491 lb/ft^2

Calculated Avg Shear Stress: 0.1708 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160



Curb and Gutter Analysis: 2J: Curb on each side, set 1

Notes:

$Q = 47.9/2 = 23.95$cfs

Gutter Input Parameters

Longitudinal Slope of Road: 0.0100 ft/ft

Cross-Slope of Pavement: 0.0200 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0150

Gutter Width: 2.0000 ft

Width of Spread: 23.1505 ft

Gutter Result Parameters

Design Flow: 23.9500 cfs

Q on each side ;
Inflow from J@J = Q_{10yr} = 47.90 cfs

Gutter Depression: 0.0000 in

Area of Flow: 5.3594 ft^2

Eo (Gutter Flow to Total Flow): 0.2143

Gutter Depth at Curb: 5.5561 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 30.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 20.0050 cfs

Bypass Flow: 3.9450 cfs

Efficiency: 0.8353

Curb and Gutter Analysis: 2J: Curb on each side, set 2

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0100 ft/ft

Cross-Slope of Pavement: 0.0200 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0150

Gutter Width: 2.0000 ft

Width of Spread: 11.7772 ft

Gutter Result Parameters

Design Flow: 3.9500 cfs

Gutter Depression: 0.0000 in

Area of Flow: 1.3870 ft^2

Eo (Gutter Flow to Total Flow): 0.3916

Gutter Depth at Curb: 2.8265 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 10.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 3.0443 cfs

Bypass Flow: 0.9057 cfs

Efficiency: 0.7707

Channel Analysis: Channel Analysis, 0.005ft/ft US from outfall

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
10.44	846.44	0.0160
10.44	846.44	0.0160
11.19	845.93	0.0160
11.19	845.93	0.0160
11.99	846.16	0.0160
12.00	846.16	0.0160
25.97	846.23	0.0160
36.86	845.95	0.0160
37.75	845.95	0.0160
40.29	845.89	0.0160
40.30	845.89	0.0160
40.80	846.13	0.0160
41.18	846.32	-----

Longitudinal Slope: 0.0050 ft/ft

Depth: 0.4000 ft

Result Parameters

Flow: 10.3988 cfs — capacity of street @ flat spot

Area of Flow: 5.1829 ft^2

Wetted Perimeter: 30.6929 ft

Hydraulic Radius: 0.1689 ft

Q from U.S. CO = 0.91 cfs × 2 = 1.82 cfs < Q_{cap} ∴ ok!

Average Velocity: 2.0064 ft/s

Top Width: 30.4533 ft

Froude Number: 0.8571

Critical Depth: 0.3833 ft

Critical Velocity: 2.2251 ft/s

Critical Slope: 0.0070 ft/ft

Critical Top Width: 30.39 ft

Calculated Max Shear Stress: 0.1248 lb/ft^2

Calculated Avg Shear Stress: 0.0527 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160

2 PIPE DISCHARGE

DATE: **4/29/2015**
TIME: **11:07 AM**
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FORTY SIX HYDROLOGIC / CIVIL COMPUTER PROGRAMS

MANNINGS FORMULA FOR PIPES FLOWING FULL SOLVING FOR DISCHARGE

PROJECT : Dogwood lane, from Selma to NW Military

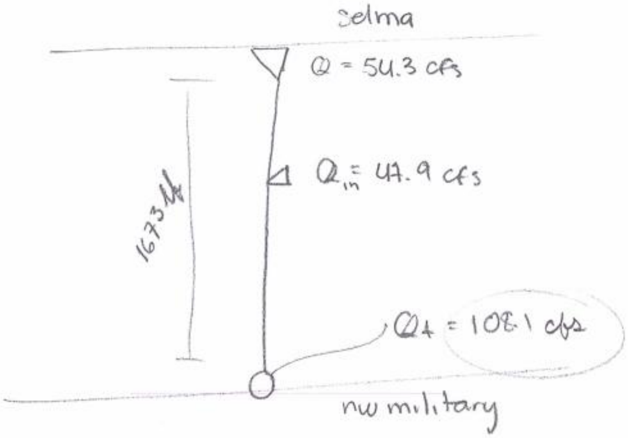
INSTRUCTIONS

ENTER PIPE SLOPE IN FT/FT	***S=***	***0.006***	FL SLOPE IN FT/FT
ENTER PIPE DIAMETER IN FEET	***D=***	***4***	DIAMETER OF PIPE IN FT.
ENTER MANNINGS N-VALUE	***N=***	***0.013***	MANNINGS N-VALUE

RESULTS

Qfull= 111.266 CFS > 108.1 cfs ∴ ok!

Q= 111.265514 DISCHARGE IN CFS
A= 12.56636 AREA IN SQ. FT.
V= 8.85423577 VELOCITY IN FPS
Hv= 1.21735235 VELOCITY HEAD IN FT.
Pw= 12.56636 WETTED PERIMETER IN FT.
R= 1 HYDRAULIC RADIUS IN FT.
R(2/3)= 1 HYDRAULIC RADIUS TO (2/3)
AR(2/3)= 12.56636 AREA * HYDRA. RAD. TO (2/3)
K= 1436.43161 CONVEYANCE



7 BOX CAPACITY

DATE: 4/28/2015
TIME: 10:41 AM
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FORTY SIX HYDROLOGIC / CIVIL
COMPUTER PROGRAMS

MANNINGS FORMULA FOR BOX CULVERTS FLOWING FULL SOLVING FOR CAPACITY

PROJECT: PROPOSED CULVERTS AT E. CASTLE

INSTRUCTIONS

ENTER BOX FRICTIONAL SLOPE IN FT/FT *Sf=* ***0.005*** FRICTIONAL SLOPE IN FT/FT
ENTER BOX SPAN IN FEET *S=* ***8*** BOX SPAN IN FEET
ENTER BOX HEIGHT IN FEET *H=* ***5*** BOX HEIGHT IN FEET
ENTER MANNING'S N-VALUE *N=* ***0.013*** MANNINGS N-VALUE

RESULTS

Qcal.= 430.87 CFS

Dc= 4.48282 CRITICAL DEPTH, FT.

Qcal.= 430.8686 DISCHARGE IN CFS
A= 40 AREA IN SQ. FT.
V= 10.77172 VELOCITY IN FPS
Hv= 1.801706 VELOCITY HEAD IN FT.
Pw= 26 WETTED PERIMETER IN FT.
R= 1.538462 HYDRAULIC RADIUS IN FT.
R(2/3)= 1.332676 HYDRAULIC RADIUS TO (2/3)
AR(2/3)= 53.30702 AREA * HYDRA. RAD. TO (2/3)
K= 6093.403 CONVEYANCE

3 culvs @ 430.87 = 1292.61 > Q_{100yr} = 1273.70cfs ∴ ok!

3~ 8'x 5' SBCs

- low water xing will need to drop by 5' or 6' and direct drive culverts.

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: E. CASTLE - DS, EX

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	826.31	0.0400
3.61	826.00	0.0400
7.96	825.28	0.0400
9.52	825.00	0.0400
10.60	824.78	0.0400
10.93	824.74	0.0400
12.46	824.48	0.0400
13.61	824.28	0.0400
15.32	824.00	0.0400
17.41	824.00	0.0400
24.55	824.00	0.0400
25.38	824.00	0.0400
26.41	824.21	0.0400
30.29	825.00	0.0400
33.09	825.57	0.0400
35.37	826.00	0.0400
39.01	826.28	-----

Longitudinal Slope: 0.0100 ft/ft

Depth: 2.2000 ft

Result Parameters

Flow: 215.3960 cfs — ex. cap. of channel

Area of Flow: 48.4982 ft^2

Wetted Perimeter: 37.1019 ft

Hydraulic Radius: 1.3072 ft

Average Velocity: 4.4413 ft/s

Top Width: 36.7170 ft

Froude Number: 0.6810

Critical Depth: 1.7748 ft

Critical Velocity: 6.1925 ft/s — ex. vel.

Critical Slope: 0.0223 ft/ft

Critical Top Width: 29.21 ft

Calculated Max Shear Stress: 1.3728 lb/ft^2

Calculated Avg Shear Stress: 0.8157 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0400 — rock lined & weeds

Channel Analysis: E. CASTLE - DS, PR

Notes:

Input Parameters

Channel Type: Rectangular

Channel Width: 30.0000 ft

Longitudinal Slope: 0.0070 ft/ft

Manning's n: 0.0130

Flow: 1273.7000 cfs = Q_{10yr}

Result Parameters

Depth: 2.6077 ft — min. channel depth req. (0.5ft freeboard only for 25yr)

Area of Flow: 78.2314 ft^2

Wetted Perimeter: 35.2154 ft

Hydraulic Radius: 2.2215 ft

Average Velocity: 16.2812 ft/s — vel. pr.

Top Width: 30.0000 ft

Froude Number: 1.7768

Critical Depth: 3.8254 ft

Critical Velocity: 11.0986 ft/s

Critical Slope: 0.0021 ft/ft

Critical Top Width: 30.00 ft

Calculated Max Shear Stress: 1.1390 lb/ft^2

Calculated Avg Shear Stress: 0.9704 lb/ft^2

7 BOX CAPACITY

DATE: 4/28/2015
TIME: 11:17 AM
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FORTY SIX HYDROLOGIC / CIVIL COMPUTER PROGRAMS

MANNINGS FORMULA FOR BOX CULVERTS FLOWING FULL SOLVING FOR CAPACITY

PROJECT: PROPOSED CULVERTS AT MIMOSA

INSTRUCTIONS

ENTER BOX FRICTIONAL SLOPE IN FT/FT	*Sf=*	*0.007*	FRICTIONAL SLOPE IN FT/FT
ENTER BOX SPAN IN FEET	*S=*	*8*	BOX SPAN IN FEET
ENTER BOX HEIGHT IN FEET	*H=*	*5*	BOX HEIGHT IN FEET
ENTER MANNING'S N-VALUE	*N=*	*0.013*	MANNINGS N-VALUE

RESULTS

Qcal.= 509.81 CFS

Dc= 5.0148812 CRITICAL DEPTH, FT.

Qcal.=	509.8106	DISCHARGE IN CFS
A=	40	AREA IN SQ. FT.
V=	12.74527	VELOCITY IN FPS
Hv=	2.522388	VELOCITY HEAD IN FT.
Pw=	26	WETTED PERIMETER IN FT.
R=	1.538462	HYDRAULIC RADIUS IN FT.
R(2/3)=	1.332676	HYDRAULIC RADIUS TO (2/3)
AR(2/3)=	53.30702	AREA * HYDRA. RAD. TO (2/3)
K=	6093.403	CONVEYANCE

3 culverts × Q_{cal} = 1529.43 cfs > Q_{10yr} = 1477.70 cfs ∴ ok!

Use 3~8'×5' SBCs

- mimosa ℄ to drop by ± 2 ft, channel exc. req'd

Hydraulic Analysis Report

Project Data

Project Title:
Designer:
Project Date: Friday, April 24, 2015
Project Units: U.S. Customary Units
Notes:

Channel Analysis: MIMOSA - DS, EX

Notes:

Input Parameters

Channel Type: Trapezoidal
Side Slope 1 (Z1): 2.0000 ft/ft
Side Slope 2 (Z2): 2.0000 ft/ft
Channel Width: 14.0000 ft
Longitudinal Slope: 0.0100 ft/ft
Manning's n: 0.0400 — rocks
Depth: 3.2600 ft

Result Parameters

Flow: 438.1109 cfs — capacity of ex. ch.
Area of Flow: 66.8952 ft^2
Wetted Perimeter: 28.5792 ft
Hydraulic Radius: 2.3407 ft
Average Velocity: 6.5492 ft/s — vel. ex.
Top Width: 27.0400 ft
Froude Number: 0.7338
Critical Depth: 2.7234 ft
Critical Velocity: 8.2722 ft/s
Critical Slope: 0.0194 ft/ft
Critical Top Width: 24.89 ft
Calculated Max Shear Stress: 2.0342 lb/ft^2
Calculated Avg Shear Stress: 1.4606 lb/ft^2

Channel Analysis: MIMOSA - DS, PR

Notes:

Input Parameters

Channel Type: Rectangular

Channel Width: 28.0000 ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0130

Flow: 1477.7000 cfs — cap. = Q_{10yr} ∴ ok!

Result Parameters

Depth: 2.6862 ft — min. ch. depth

Area of Flow: 75.2149 ft^2

Wetted Perimeter: 33.3725 ft

Hydraulic Radius: 2.2538 ft

Average Velocity: 19.6464 ft/s

Top Width: 28.0000 ft

Froude Number: 2.1124

Critical Depth: 4.4225 ft

Critical Velocity: 11.9333 ft/s

Critical Slope: 0.0022 ft/ft

Critical Top Width: 28.00 ft

Calculated Max Shear Stress: 1.6762 lb/ft^2

Calculated Avg Shear Stress: 1.4064 lb/ft^2

7 BOX CAPACITY

DATE: **4/28/2015**
TIME: **11:09 AM**
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FORTY SIX HYDROLOGIC / CIVIL COMPUTER PROGRAMS

MANNINGS FORMULA FOR BOX CULVERTS FLOWING FULL SOLVING FOR CAPACITY

PROJECT: PROPOSED CULVERTS AT KRAMERIA

INSTRUCTIONS

ENTER BOX FRICTIONAL SLOPE IN FT/FT *Sf=* *0.005* FRICTIONAL SLOPE IN FT/FT
ENTER BOX SPAN IN FEET *S=* *8* BOX SPAN IN FEET
ENTER BOX HEIGHT IN FEET *H=* *6* BOX HEIGHT IN FEET
ENTER MANNING'S N-VALUE *N=* *0.013* MANNINGS N-VALUE

RESULTS

Qcal.= 555.72 CFS

Dc= 5.3116098 CRITICAL DEPTH, FT.

Qcal.= 555.7215 DISCHARGE IN CFS
A= 48 AREA IN SQ. FT.
V= 11.57753 VELOCITY IN FPS
Hv= 2.081354 VELOCITY HEAD IN FT.
Pw= 28 WETTED PERIMETER IN FT.
R= 1.714286 HYDRAULIC RADIUS IN FT.
R(2/3)= 1.432371 HYDRAULIC RADIUS TO (2/3)
AR(2/3)= 68.7538 AREA * HYDRA. RAD. TO (2/3)
K= 7859.088 CONVEYANCE

3 culverts @ 555.72 = 1667.16 cfs > Q_{10yr} = 1639.10 cfs ∴ ok !

3 ~ 8'×6' SBCs

- Krameria will need to drop by 3 ft ∴ channel exc req'd

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: KRIMERIA - DS, EX

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	806.55	0.0400
0.14	806.53	0.0400
4.24	806.00	0.0400
6.56	805.63	0.0400
10.50	805.00	0.0400
26.56	805.00	0.0400
27.83	805.00	0.0400
27.95	805.02	0.0400
33.33	806.00	0.0400
36.14	806.61	-----

Longitudinal Slope: 0.0300 ft/ft
Depth: 1.5000 ft

Result Parameters

Flow: 270.3480 cfs exist. Ch. cap.
Area of Flow: 39.2900 ft^2
Wetted Perimeter: 35.5304 ft
Hydraulic Radius: 1.1058 ft
Average Velocity: 6.8808 ft/s
Top Width: 35.2752 ft
Froude Number: 1.1490
Critical Depth: 1.6161 ft
Critical Velocity: 6.2221 ft/s
Critical Slope: 0.0222 ft/ft
Critical Top Width: 36.14 ft
Calculated Max Shear Stress: 2.8080 lb/ft^2
Calculated Avg Shear Stress: 2.0701 lb/ft^2
Composite Manning's n Equation: Lotter method
Manning's n: 0.0400 rock & weeds

Channel Analysis: KRIMERIA - DS, PR

Notes:

Input Parameters

Channel Type: Rectangular

Channel Width: 35.0000 ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0130

Flow: 1639.1000 cfs

Result Parameters

Depth: 2.4563 ft — min. ch. depth req'd for Q_{10yr}

Area of Flow: 85.9694 ft^2

Wetted Perimeter: 39.9125 ft

Hydraulic Radius: 2.1539 ft

Average Velocity: 19.0661 ft/s

Top Width: 35.0000 ft

Froude Number: 2.1439

Critical Depth: 4.0839 ft

Critical Velocity: 11.4674 ft/s

Critical Slope: 0.0020 ft/ft

Critical Top Width: 35.00 ft

Calculated Max Shear Stress: 1.5327 lb/ft^2

Calculated Avg Shear Stress: 1.3441 lb/ft^2

WS III = DA 3A

Hydraulic Analysis Report

Project Data

Project Title: Carolwood

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: 3A - Channel Analysis - Carolwood @ Selma

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
14.46	856.09	0.0160
15.33	855.57	0.0160
15.34	855.56	0.0160
17.36	855.60	0.0160
29.96	855.73	0.0160
41.99	855.30	0.0160
44.53	855.20	0.0160
45.29	856.03	0.0160
45.30	856.04	-----

Longitudinal Slope: 0.0100 ft/ft

Depth: 0.7400 ft

Result Parameters

Flow: 55.0629 cfs roadex. capacity

Area of Flow: 11.4802 ft^2

Wetted Perimeter: 30.9336 ft

Hydraulic Radius: 0.3711 ft

Average Velocity: 4.7963 ft/s

Top Width: 30.4902 ft

Froude Number: 1.3775

Critical Depth: 0.8305 ft

Critical Velocity: 3.8645 ft/s

Critical Slope: 0.0049 ft/ft

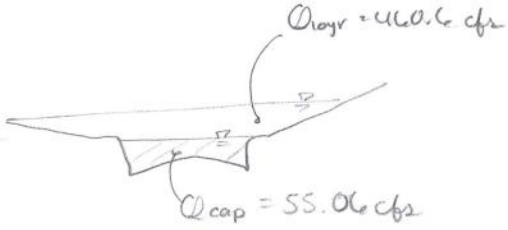
Critical Top Width: 30.72 ft

Calculated Max Shear Stress: 0.4618 lb/ft^2

Calculated Avg Shear Stress: 0.2316 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160



Curb and Gutter Analysis: 3A - Curb on each side, set 01

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0130 ft/ft

Cross-Slope of Pavement: 0.0250 ft/ft

Uniform Gutter Geometry

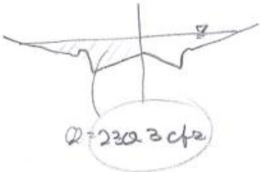
Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 45.8942 ft

Gutter Result Parameters

Design Flow: 230.3000 cfs — 460.6 cfs (Q_{10} total) on road total



Gutter Depression: 0.0000 in

Area of Flow: 26.3285 ft^2

Eo (Gutter Flow to Total Flow): 0.1122

Gutter Depth at Curb: 13.7683 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 30.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 81.5704 cfs

Bypass Flow: 148.7296 cfs

Efficiency: 0.3542

Curb and Gutter Analysis: 3A - Curb on each side, set 02

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0130 ft/ft

Cross-Slope of Pavement: 0.0250 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 38.9536 ft

Gutter Result Parameters

Design Flow: 148.7300 cfs

Gutter Depression: 0.0000 in

Area of Flow: 18.9672 ft^2

Eo (Gutter Flow to Total Flow): 0.1313

Gutter Depth at Curb: 11.6861 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 30.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 63.7996 cfs

Bypass Flow: 84.9304 cfs

Efficiency: 0.4290

Curb and Gutter Analysis: 3A - Curb on each side, set 03

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0130 ft/ft

Cross-Slope of Pavement: 0.0250 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 31.5715 ft

Gutter Result Parameters

Design Flow: 84.9300 cfs

Gutter Depression: 0.0000 in

Area of Flow: 12.4595 ft^2

Eo (Gutter Flow to Total Flow): 0.1603

Gutter Depth at Curb: 9.4715 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 30.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 46.2622 cfs

Bypass Flow: 38.6678 cfs

Efficiency: 0.5447

Curb and Gutter Analysis: 3A - Curb on each side, set 04

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0130 ft/ft

Cross-Slope of Pavement: 0.0250 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 23.5047 ft

Gutter Result Parameters

Design Flow: 38.6680 cfs

Gutter Depression: 0.0000 in

Area of Flow: 6.9059 ft^2

Eo (Gutter Flow to Total Flow): 0.2114

Gutter Depth at Curb: 7.0514 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 30.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 28.7174 cfs

Bypass Flow: 9.9506 cfs

Efficiency: 0.7427

Curb and Gutter Analysis: 3A - Curb on each side, set 05

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0130 ft/ft

Cross-Slope of Pavement: 0.0250 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0160

Gutter Width: 2.0000 ft

Width of Spread: 14.1286 ft

Gutter Result Parameters

Design Flow: 9.9510 cfs

Gutter Depression: 0.0000 in

Area of Flow: 2.4952 ft^2

Eo (Gutter Flow to Total Flow): 0.3347

Gutter Depth at Curb: 4.2386 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 20.0000 ft

Local Depression: 2.5000 in

Inlet Result Parameters

Intercepted Flow: 8.9558 cfs

Bypass Flow: 0.9952 cfs each inlet $\therefore Q_{co\,total} = 1 \times 2 = 2$ cfs

Efficiency: 0.9000

Channel Analysis: 3A - Channel Analysis - Carolwood @ Selma, 300' DS

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
15.28	851.63	0.0160
15.28	851.63	0.0160
16.17	851.10	0.0160
16.20	851.10	0.0160
31.24	851.73	0.0160
45.07	851.61	0.0160
45.16	851.60	0.0160
45.17	851.61	0.0160
46.23	852.19	-----

Longitudinal Slope: 0.0130 ft/ft

Depth: 0.4300 ft

Result Parameters

Flow: 8.8532 cfs > 2cfs ∴ ok!

Area of Flow: 2.3480 ft^2

Wetted Perimeter: 11.0506 ft

Hydraulic Radius: 0.2125 ft

Average Velocity: 3.7706 ft/s

Top Width: 10.9235 ft

Froude Number: 1.4332

Critical Depth: 0.4966 ft

Critical Velocity: 2.8272 ft/s

Critical Slope: 0.0060 ft/ft

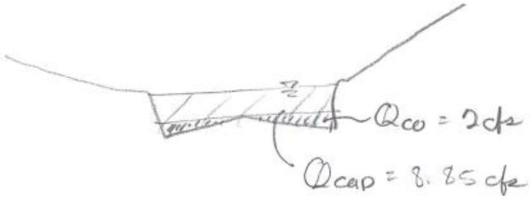
Critical Top Width: 12.62 ft

Calculated Max Shear Stress: 0.3488 lb/ft^2

Calculated Avg Shear Stress: 0.1724 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160



3B

Hydraulic Analysis Report

Project Data

Project Title: Carolwood

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: 3B - Channel Analysis - Carolwood @ Banyan, CP

Notes:

Input Parameters

Channel Type: Custom Cross Section

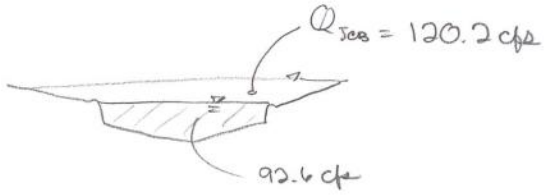
Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
31.28	840.88	0.0160
31.63	840.64	0.0160
32.20	840.36	0.0160
40.52	840.05	0.0160
46.94	839.83	0.0160
55.65	840.17	0.0160
61.16	840.36	0.0160
61.73	840.65	0.0160
62.11	840.82	-----

Longitudinal Slope: 0.0100 ft/ft

Depth: 0.8000 ft

Result Parameters



Flow: 92.5931 cfs capacity ex. of road

Area of Flow: 15.5281 ft^2

Wetted Perimeter: 30.1838 ft

Hydraulic Radius: 0.5145 ft

Average Velocity: 5.9629 ft/s

Top Width: 30.0370 ft

Froude Number: 1.4615

Critical Depth: 0.9515 ft

Critical Velocity: 4.6017 ft/s

Critical Slope: 0.0043 ft/ft

Critical Top Width: 30.60 ft

Calculated Max Shear Stress: 0.4992 lb/ft^2

Calculated Avg Shear Stress: 0.3210 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160

Hydraulic Analysis Report

Project Data

Project Title: Carolwood

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: 3B - Channel - C@B Simple, 1

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 34.0000 ft/ft

Side Slope 2 (Z2): 34.0000 ft/ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0160

Flow: 120.2000 cfs

Result Parameters

Depth: 0.9429 ft

Area of Flow: 30.2252 ft^2

Wetted Perimeter: 64.1419 ft

Hydraulic Radius: 0.4712 ft

Average Velocity: 3.9768 ft/s

Top Width: 64.1142 ft

Froude Number: 1.0207

Critical Depth: 0.9506 ft

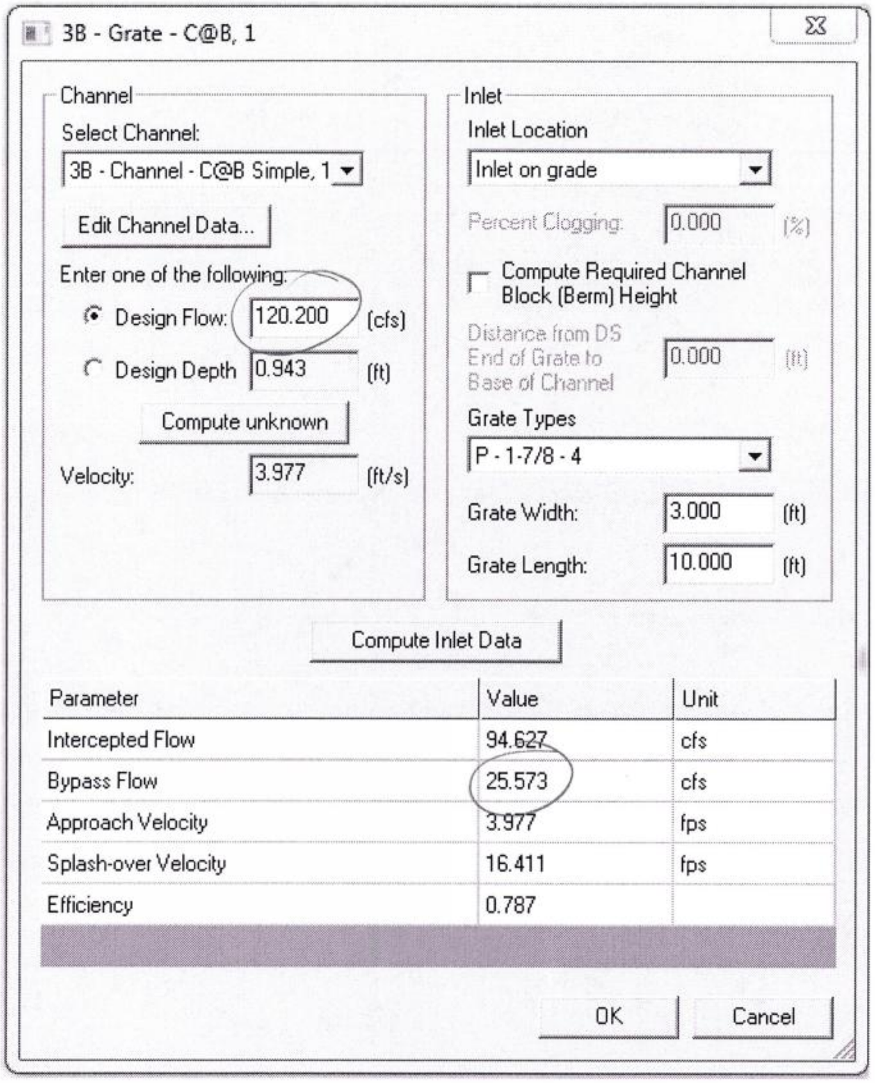
Critical Velocity: 3.9121 ft/s

Critical Slope: 0.0048 ft/ft

Critical Top Width: 64.64 ft

Calculated Max Shear Stress: 0.2942 lb/ft^2

Calculated Avg Shear Stress: 0.1470 lb/ft^2



3B - Grate - C@B, 1

Channel

Select Channel: 3B - Channel - C@B Simple, 1

Enter one of the following:

● Design Flow: 120.200 (cfs)

○ Design Depth 0.943 (ft)

Velocity: 3.977 (ft/s)

Inlet

Inlet Location: Inlet on grade

Percent Clogging: 0.000 (%)

☐ Compute Required Channel Block (Berm) Height

Distance from DS End of Grate to Base of Channel: 0.000 (ft)

Grate Types: P - 1-7/8 - 4

Grate Width: 3.000 (ft)

Grate Length: 10.000 (ft)

Parameter	Value	Unit
Intercepted Flow	94.627	cfs
Bypass Flow	25.573	cfs
Approach Velocity	3.977	fps
Splash-over Velocity	16.411	fps
Efficiency	0.787	

Channel Analysis: 3B - Channel - C@B Simple, 2

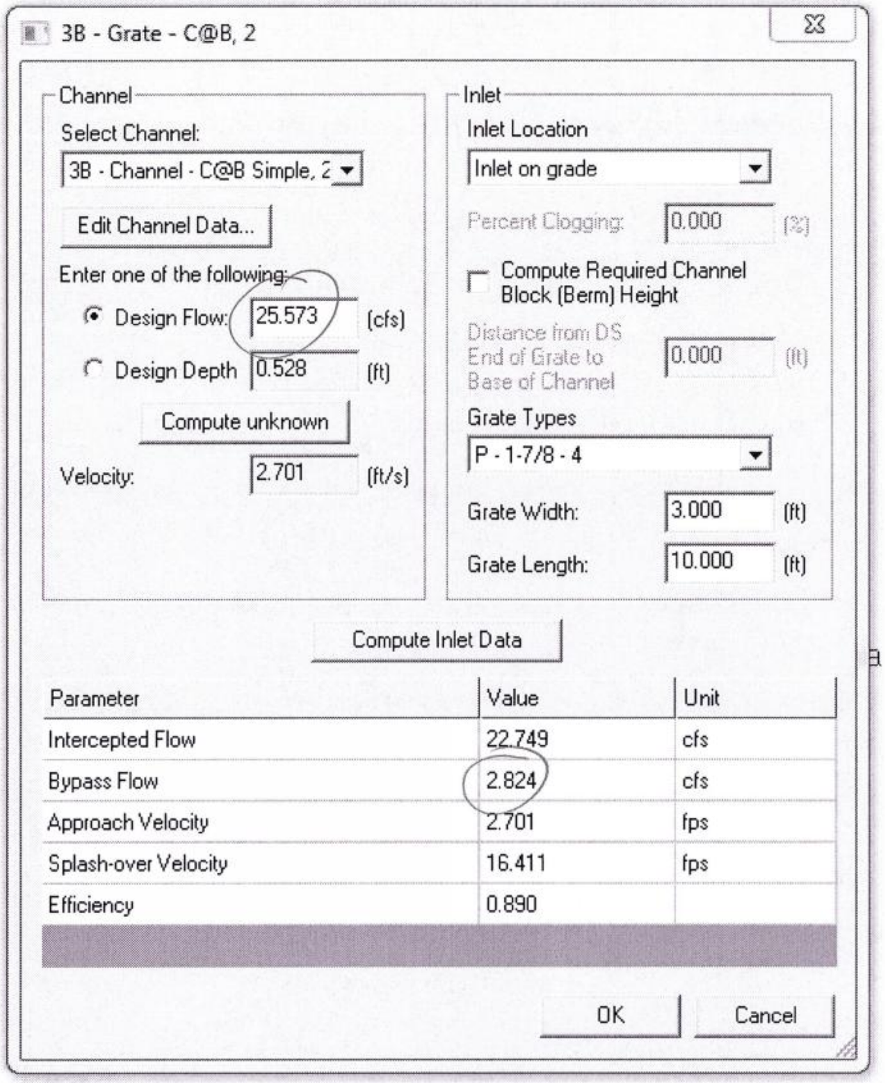
Notes:

Input Parameters

Channel Type: Triangular
Side Slope 1 (Z1): 34.0000 ft/ft
Side Slope 2 (Z2): 34.0000 ft/ft
Longitudinal Slope: 0.0050 ft/ft
Manning's n: 0.0160
Flow: 25.5730 cfs

Result Parameters

Depth: 0.5277 ft
Area of Flow: 9.4684 ft^2
Wetted Perimeter: 35.9001 ft
Hydraulic Radius: 0.2637 ft
Average Velocity: 2.7009 ft/s
Top Width: 35.8846 ft
Froude Number: 0.9266
Critical Depth: 0.5119 ft
Critical Velocity: 2.8707 ft/s
Critical Slope: 0.0059 ft/ft
Critical Top Width: 34.81 ft
Calculated Max Shear Stress: 0.1646 lb/ft^2
Calculated Avg Shear Stress: 0.0823 lb/ft^2



3B - Grate - C@B, 2

Channel

Select Channel: 3B - Channel - C@B Simple, 2

Enter one of the following:

● Design Flow: 25.573 (cfs)

○ Design Depth 0.528 (ft)

Velocity: 2.701 (ft/s)

Inlet

Inlet Location: Inlet on grade

Percent Clogging: 0.000 (%)

☐ Compute Required Channel Block (Berm) Height

Distance from DS End of Grate to Base of Channel: 0.000 (ft)

Grate Types: P - 1-7/8 - 4

Grate Width: 3.000 (ft)

Grate Length: 10.000 (ft)

Parameter	Value	Unit
Intercepted Flow	22.749	cfs
Bypass Flow	2.824	cfs
Approach Velocity	2.701	fps
Splash-over Velocity	16.411	fps
Efficiency	0.890	

if 2.824 cfs is not allowable, add one 3'x5' to reduce CO to less than all cfs

3C

Hydraulic Analysis Report

Project Data

Project Title: Carolwood

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: 3C - Channel Analysis - Banyan pre-Glentower, CP

Notes:

Input Parameters

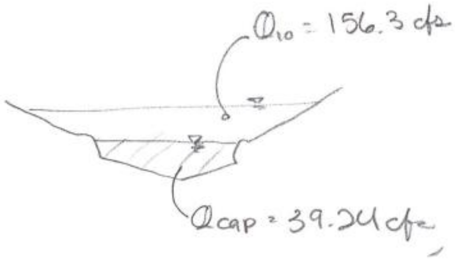
Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
21.63	831.46	0.0160
22.01	831.35	0.0160
22.16	831.30	0.0160
26.61	831.21	0.0160
35.95	830.91	0.0160
47.43	831.09	0.0160
52.25	831.24	0.0160
52.39	831.30	0.0160
52.78	831.47	-----

Longitudinal Slope: 0.0130 ft/ft

Depth: 0.4600 ft



Result Parameters

Flow: 39.2434 cfs — ex road cap.

Area of Flow: 8.6268 ft^2

Wetted Perimeter: 30.6395 ft

Hydraulic Radius: 0.2816 ft

Average Velocity: 4.5490 ft/s

Top Width: 30.5928 ft

Froude Number: 1.5096

Critical Depth: 0.5504 ft

Critical Velocity: 3.4382 ft/s

Critical Slope: 0.0052 ft/ft

Critical Top Width: 31.09 ft

Calculated Max Shear Stress: 0.3732 lb/ft^2

Calculated Avg Shear Stress: 0.2284 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160

Hydraulic Analysis Report

Project Data

Project Title: Carolwood

Designer:

Project Date: Friday, April 24, 2015

Project Units: U.S. Customary Units

Notes:

Channel Analysis: 3C - Channel - B@pG Simple, 1

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 34.8000 ft/ft

Side Slope 2 (Z2): 49.2400 ft/ft

Longitudinal Slope: 0.0130 ft/ft

Manning's n: 0.0160

Flow: 156.3000 cfs

Result Parameters

Depth: 0.8033 ft

Area of Flow: 27.1181 ft^2

Wetted Perimeter: 67.5327 ft

Hydraulic Radius: 0.4016 ft

Average Velocity: 5.7637 ft/s

Top Width: 67.5130 ft

Froude Number: 1.6026

Critical Depth: 0.9760 ft

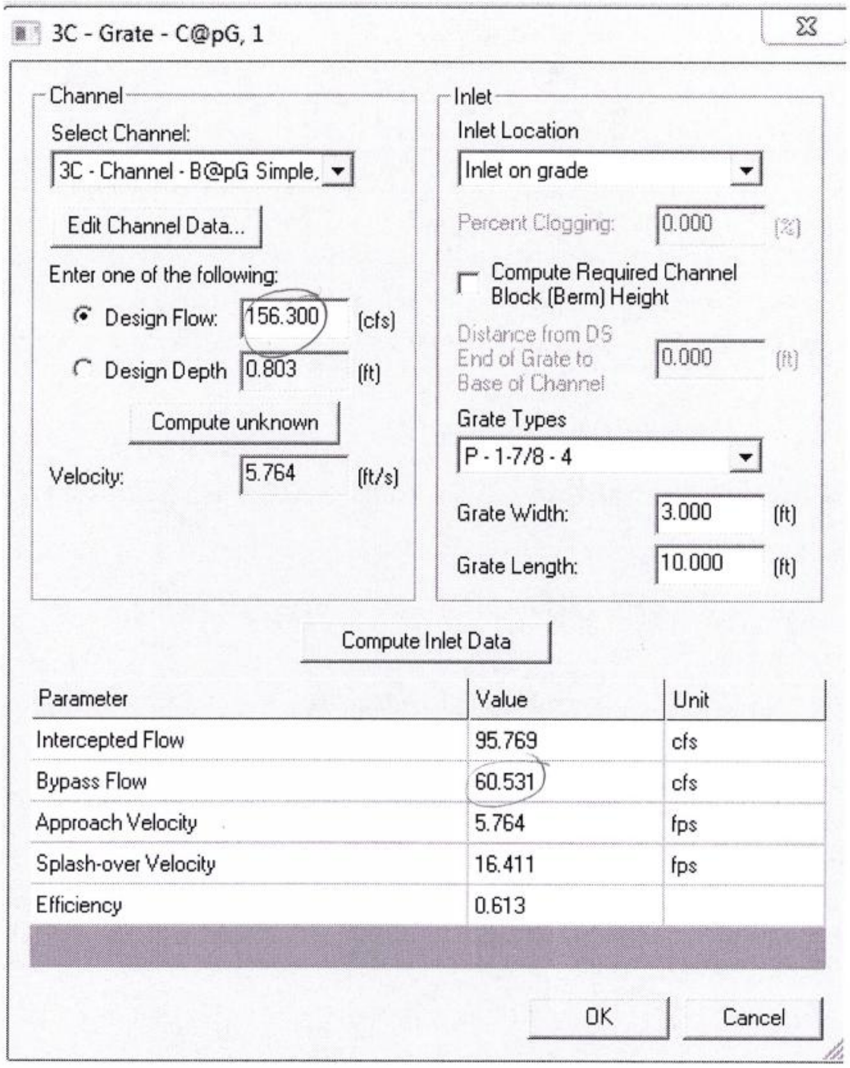
Critical Velocity: 3.9050 ft/s

Critical Slope: 0.0046 ft/ft

Critical Top Width: 84.52 ft

Calculated Max Shear Stress: 0.6517 lb/ft^2

Calculated Avg Shear Stress: 0.3257 lb/ft^2



3C - Grate - C@pG, 1

Channel

Select Channel: 3C - Channel - B@pG Simple,

Enter one of the following:

● Design Flow: 156.300 (cfs)

○ Design Depth 0.803 (ft)

Velocity: 5.764 (ft/s)

Inlet

Inlet Location: Inlet on grade

Percent Clogging: 0.000 (%)

☐ Compute Required Channel Block (Berm) Height

Distance from DS End of Grate to Base of Channel 0.000 (ft)

Grate Types: P - 1-7/8 - 4

Grate Width: 3.000 (ft)

Grate Length: 10.000 (ft)

Parameter	Value	Unit
Intercepted Flow	95.769	cfs
Bypass Flow	60.531	cfs
Approach Velocity	5.764	fps
Splash-over Velocity	16.411	fps
Efficiency	0.613	

Channel Analysis: 3C - Channel - B@pG Simple, 2

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 34.8000 ft/ft

Side Slope 2 (Z2): 49.2400 ft/ft

Longitudinal Slope: 0.0130 ft/ft

Manning's n: 0.0160

Flow: 60.5310 cfs

Result Parameters

Depth: 0.5629 ft

Area of Flow: 13.3129 ft^2

Wetted Perimeter: 47.3174 ft

Hydraulic Radius: 0.2814 ft

Average Velocity: 4.5468 ft/s

Top Width: 47.3036 ft

Froude Number: 1.5104

Critical Depth: 0.6678 ft

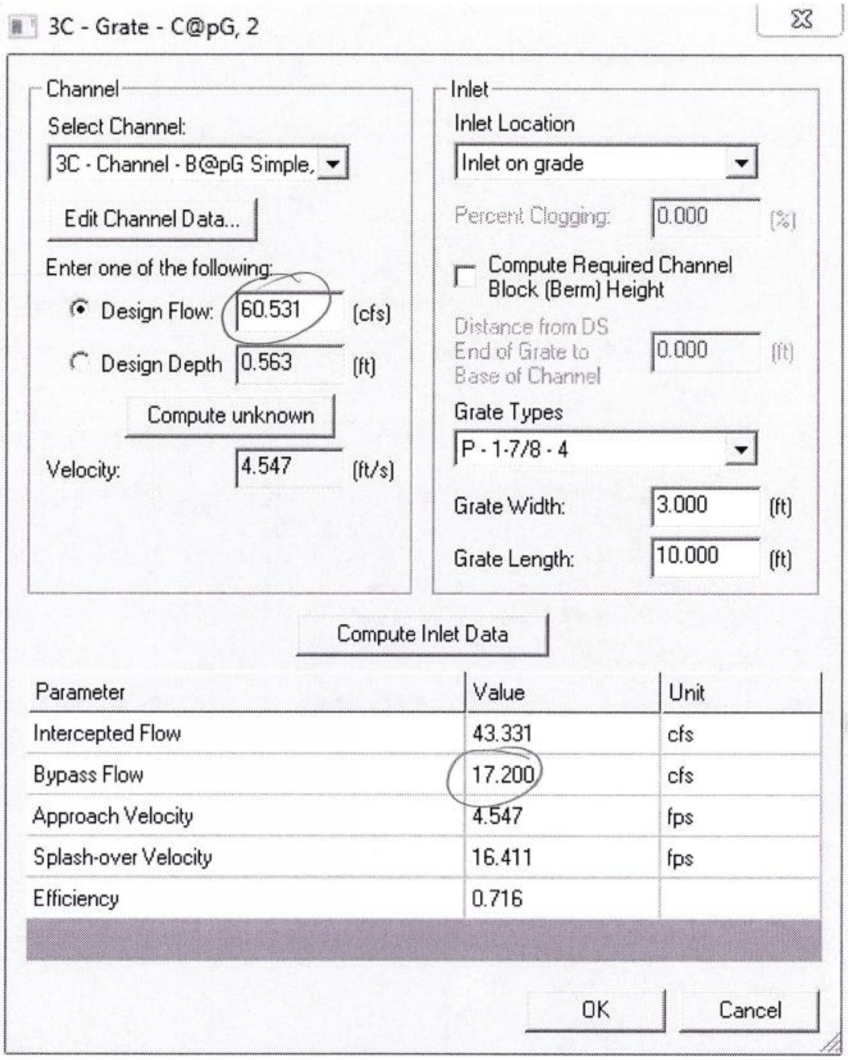
Critical Velocity: 3.2302 ft/s

Critical Slope: 0.0052 ft/ft

Critical Top Width: 57.83 ft

Calculated Max Shear Stress: 0.4566 lb/ft^2

Calculated Avg Shear Stress: 0.2282 lb/ft^2



Channel

Select Channel: 3C - Channel - B@pG Simple,

Enter one of the following:

● Design Flow: 60.531 (cfs)

○ Design Depth 0.563 (ft)

Velocity: 4.547 (ft/s)

Inlet

Inlet Location: Inlet on grade

Percent Clogging: 0.000 [%]

☐ Compute Required Channel Block (Berm) Height

Distance from DS End of Grate to Base of Channel 0.000 (ft)

Grate Types: P - 1-7/8 - 4

Grate Width: 3.000 (ft)

Grate Length: 10.000 (ft)

Parameter	Value	Unit
Intercepted Flow	43.331	cfs
Bypass Flow	17.200	cfs
Approach Velocity	4.547	fps
Splash-over Velocity	16.411	fps
Efficiency	0.716	

another 3'x10' will red. co to 2.95 cfs <
6.54 cfs road cap. post glentower

Channel Analysis: 3C - Channel Analysis - Banyan ~~@~~ post Glentower

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
33.46	827.98	0.0160
33.98	827.82	0.0160
49.17	827.67	0.0160
49.17	827.67	0.0160
49.17	827.67	0.0160
49.17	827.67	0.0160
49.17	827.67	0.0160
49.20	827.67	0.0160
64.14	827.86	0.0160
64.52	827.86	0.0160
64.63	827.88	0.0160
64.64	827.88	-----

Longitudinal Slope: 0.0130 ft/ft

Depth: 0.1800 ft

Result Parameters

Flow: 6.5411 cfs

Area of Flow: 2.9114 ft^2

Wetted Perimeter: 29.7919 ft

Hydraulic Radius: 0.0977 ft

Average Velocity: 2.2467 ft/s

Top Width: 29.7854 ft

Froude Number: 1.2664

Critical Depth: 0.1975 ft

Critical Velocity: 1.8990 ft/s

Critical Slope: 0.0077 ft/ft

Critical Top Width: 30.76 ft

Calculated Max Shear Stress: 0.1460 lb/ft^2

Calculated Avg Shear Stress: 0.0793 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0160

7 BOX CAPACITY

DATE: 4/28/2015
TIME: 8:24 PM
INDEX

FORTY SIX HYDROLOGIC / CIVIL COMPUTER PROGRAMS

MANNINGS FORMULA FOR BOX CULVERTS FLOWING FULL SOLVING FOR CAPACITY

PROJECT Main trunk line under Banyan/Gardenview; flattest allowable

INSTRUCTIONS

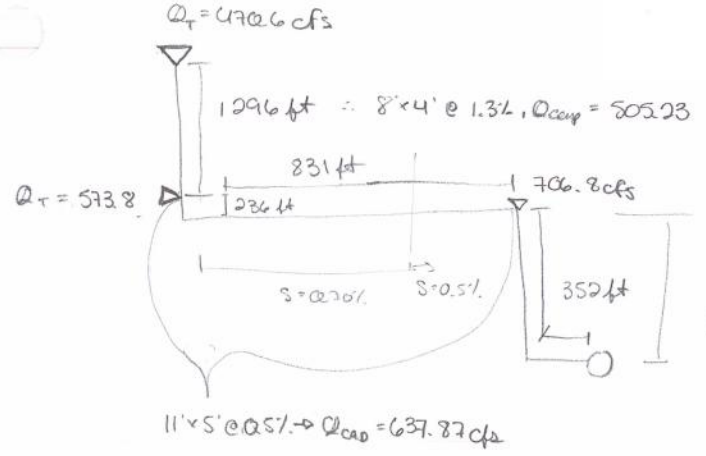
ENTER BOX FRICTIONAL SLOPE IN FT/FT	***Sf=***	***0.005***	FRICTIONAL SLOPE IN FT/FT
ENTER BOX SPAN IN FEET	***S=***	***12***	BOX SPAN IN FEET
ENTER BOX HEIGHT IN FEET	***H=***	***5***	BOX HEIGHT IN FEET
ENTER MANNING'S N-VALUE	***N=***	***0.013***	MANNINGS N-VALUE

RESULTS

Qcal.= 708.21 CFS

Dc= 4.764681 CRITICAL DEPTH, FT.

Qcal.=	708.2065	DISCHARGE IN CFS
A=	60	AREA IN SQ. FT.
V=	11.80344	VELOCITY IN FPS
Hv=	2.163373	VELOCITY HEAD IN FT.
Pw=	34	WETTED PERIMETER IN FT.
R=	1.764706	HYDRAULIC RADIUS IN FT.
R(2/3)=	1.460321	HYDRAULIC RADIUS TO (2/3)
AR(2/3)=	87.61924	AREA * HYDRA. RAD. TO (2/3)
K=	10015.55	CONVEYANCE



255.5 @ S = 1%
571.43 @ S = 1.5%
355.58 @ S = 1%
192.53 @ S = 2%
1325.11 @ S = 0.5%

12'×5' @ S = 0.5%, Q_{cap} = 708.21

DATE: 4/29/2015
TIME: 6:12 PM
INDEX

FORTY SIX HYDROLOGIC / CIVIL
COMPUTER PROGRAMS

MANNINGS FORMULA FOR
TRAPIZODIAL CHANNELS
SOLVING FOR CAPACITY

PROJECT Proposed outfall at Glentower and NW Military, from 12x5 SBC

INSTRUCTIONS

ENTER DEPTH OF FLOW IN FEET	*D=*	*3*	DEPTH OF FLOW IN FEET
ENTER BOTTOM WIDTH IN FEET	*BW=*	*17.5*	BOTTOM WIDTH IN FEET
ENTER LEFT SIDE SLOPE	*L S.S=*	*0.001*	LEFT SIDE SLOPE
ENTER RIGHT SIDE SLOPE	*R S.S.=*	*0.001*	RIGHT SIDE SLOPE
ENTER FLOW LINE SLOPE IN FT/FT	*SFL=*	*0.005*	FL SLOPE IN FT/FT
ENTER MANNINGS N-VALUE	*N=*	*0.013*	MANNING'S N-VALUE
ENTER "V" DEPTH IN BOTTOM, IN FT.	*Vd=*	*0*	V-DEPTH IN CEN. SEC. IN. FT.

RESULTS

Qcal=	**725.39**	**DISCHARGE, CFS**
Dn=	**3**	**FEET**
(NOTE: Dn MEASURED FROM TOE OF SLOPE.)		
A=	**52.51**	**SQ. FT.**
V=	**13.81**	**FPS**
Hv=	**2.961**	**FT.**
FN=	**1.405**	**FROUDE NO.**

Qcal=	725.3898	CAL. FLOW IN CFS
A=	52.509	AREA IN SQ. FT.
Pw=	23.5	WETTED PERIMETER IN FT.
R=	2.234425	HYDRAULIC RADIUS IN FT.
R(2/3)=	1.709138	HYDRAULIC RADIUS TO (2/3)
AR(2/3)=	89.74515	AREA*HYDRA. RAD. TO (2/3)
K=	10258.56	CONVEYANCE
TW=	17.506	TOP WIDTH AT FLOW DEPTH
Va=	0	V-AREA IN SQ. FT.
PwBOTT=	17.5	WET. PERIMETER BOTTOM,FT

> Q_{load} = 708.21 cfs ∴ ok!!

7 BOX CAPACITY

DATE: 7/6/2015
TIME: 11:28 AM
INDEX

FORTY SIX HYDROLOGIC / CIVIL COMPUTER PROGRAMS

MANNINGS FORMULA FOR BOX CULVERTS FLOWING FULL SOLVING FOR CAPACITY

PROJECT Existing outfall for WS III under NW. Military, South of Banyan

INSTRUCTIONS

ENTER BOX FRICTIONAL SLOPE IN FT/FT	*Sf=*	***0.005***	FRICTIONAL SLOPE IN FT/FT
ENTER BOX SPAN IN FEET	*S=*	***6***	BOX SPAN IN FEET
ENTER BOX HEIGHT IN FEET	*H=*	***3***	BOX HEIGHT IN FEET
ENTER MANNING'S N-VALUE	*N=*	***0.013***	MANNINGS N-VALUE

RESULTS

Qcal.= 145.49 CFS

Dc= 2.6333132 CRITICAL DEPTH, FT.

Qcal.=	145.4899	DISCHARGE IN CFS
A=	18	AREA IN SQ. FT.
V=	8.082774	VELOCITY IN FPS
Hv=	1.01446	VELOCITY HEAD IN FT.
Pw=	18	WETTED PERIMETER IN FT.
R=	1	HYDRAULIC RADIUS IN FT.
R(2/3)=	1	HYDRAULIC RADIUS TO (2/3)
AR(2/3)=	18	AREA * HYDRA. RAD. TO (2/3)
K=	2057.538	CONVEYANCE

6~6'x3' SBC's

Q_{group} = 145.49 x 6 = $\boxed{872.94 \text{ cfs}}$ > Q_{10yr} = 746.1 cfs = ok!

DATE: 7/2/2015
TIME: 3:13 PM
INDEX

FORTY SIX HYDROLOGIC / CIVIL
COMPUTER PROGRAMS

MANNINGS FORMULA FOR BOX CULVERTS FLOWING FULL SOLVING FOR CAPACITY

PROJECT Existing culvert under West Ave. @ Foxhall

W.S. II outfall

INSTRUCTIONS

ENTER BOX FRICTIONAL SLOPE IN FT/FT	*Sf=*	*0.005* FRICTIONAL SLOPE IN FT/FT
ENTER BOX SPAN IN FEET	*S=*	*6* BOX SPAN IN FEET
ENTER BOX HEIGHT IN FEET	*H=*	*8* BOX HEIGHT IN FEET
ENTER MANNING'S N-VALUE	*N=*	*0.013* MANNINGS N-VALUE

RESULTS

Qcal.= 555.72 CFS

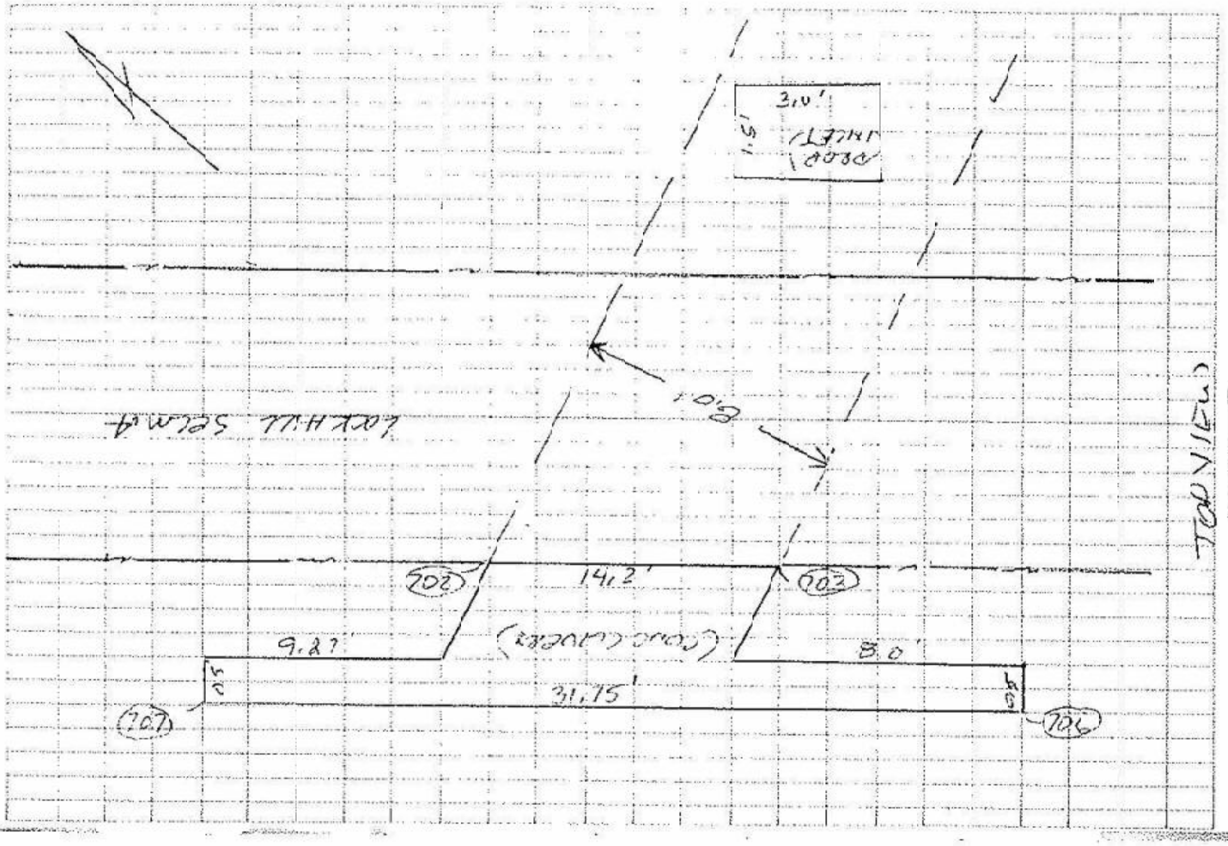
Dc= 6.434557 CRITICAL DEPTH, FT.

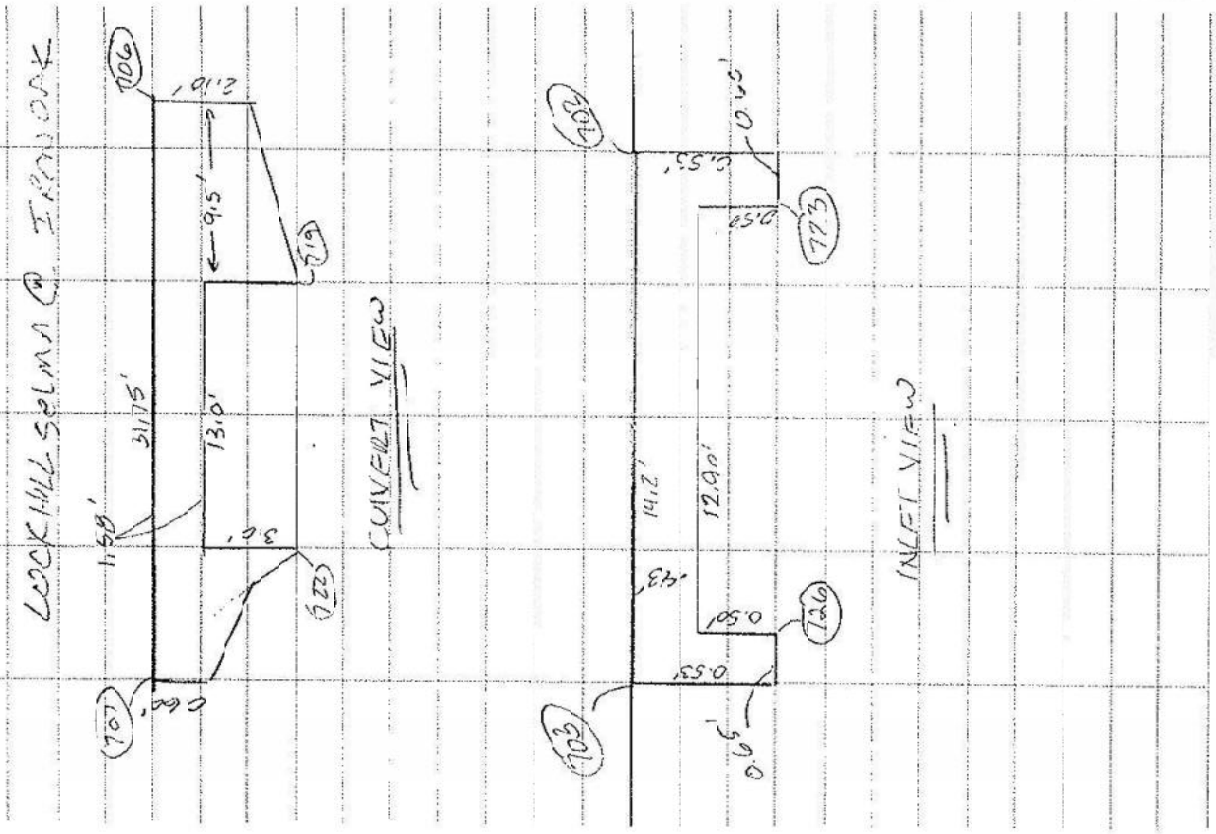
Qcal.= 555.7215 DISCHARGE IN CFS
A= 48 AREA IN SQ. FT.
V= 11.57753 VELOCITY IN FPS
Hv= 2.081354 VELOCITY HEAD IN FT.
Pw= 28 WETTED PERIMETER IN FT.
R= 1.714286 HYDRAULIC RADIUS IN FT.
R(2/3)= 1.432371 HYDRAULIC RADIUS TO (2/3)
AR(2/3)= 68.7538 AREA * HYDRA. RAD. TO (2/3)
K= 7859.088 CONVEYANCE

3 ~ 8'×6' SBCs

$Q_{group} = 555.72 \times 3 = \boxed{1{,}667.16 \text{ cfs}} > Q_{10yr} = 1647 \text{ cfs} \therefore \text{ok!}$

EXHIBIT I – 3

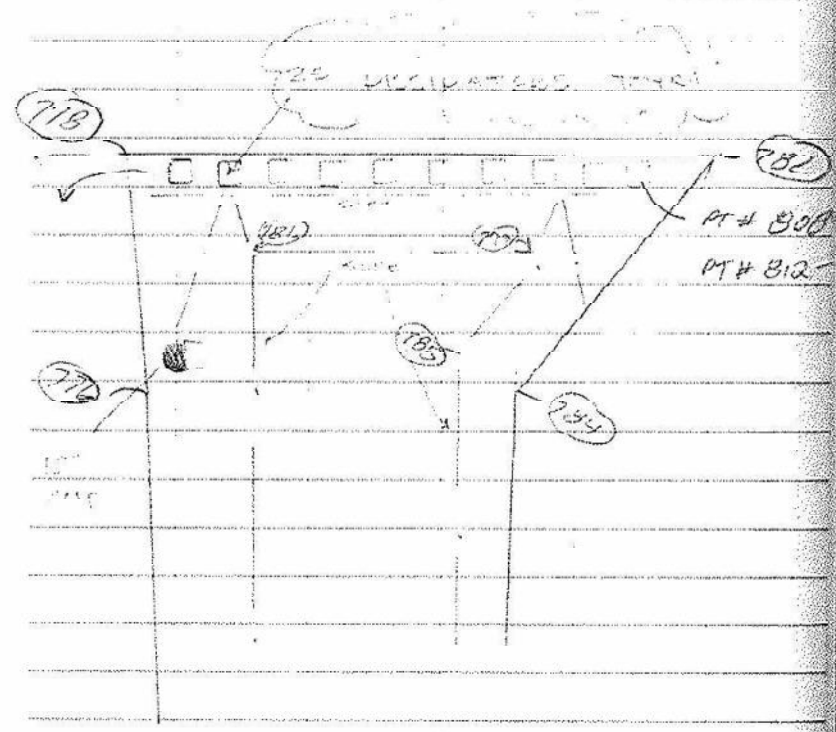

LOCKHILL SELMA
DROP INLET
3.0'
1.5'
8.0'
TOP VIEW
702
14.2'
703
(CONC CULVERT)
9.27'
8.0'
0.5
31.75'
0.5
707
706

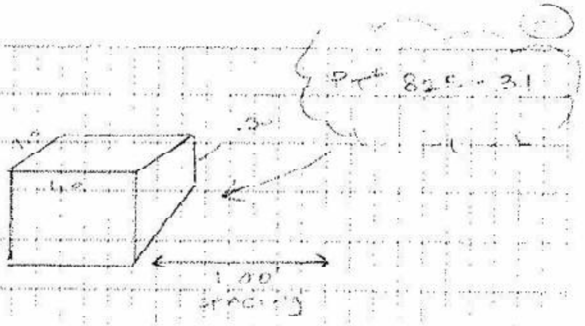

LOCKHILL SELMA @ IRON OAK
706
2.16'
9.5'
719
31.75'
13.0'
1.58'
3.6'
722
707
0.62'
CULVERT VIEW
702
0.53'
0.66'
0.50'
773
14.2'
12.00'
.43'
0.50'
726
0.53'
703
0.66'
INLET VIEW

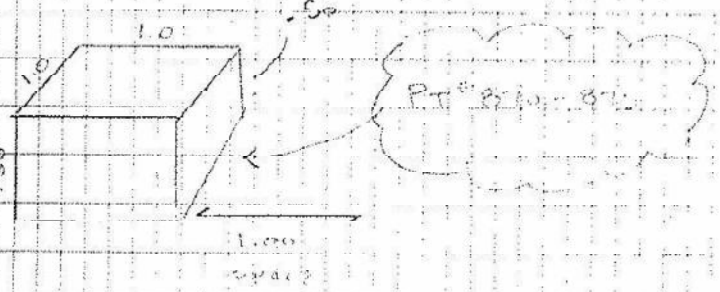
LOCKHILL SELMA @ MANTON

(DOWNSTREAM CHANNEL)

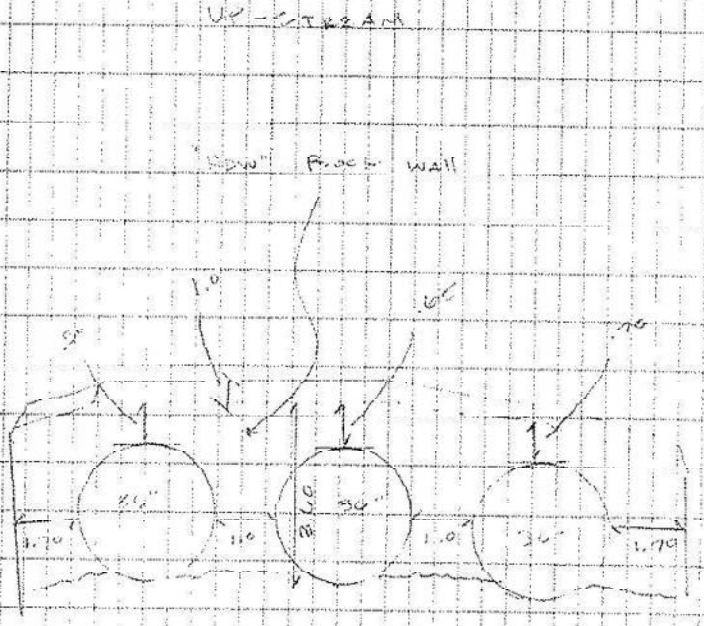
MANTON





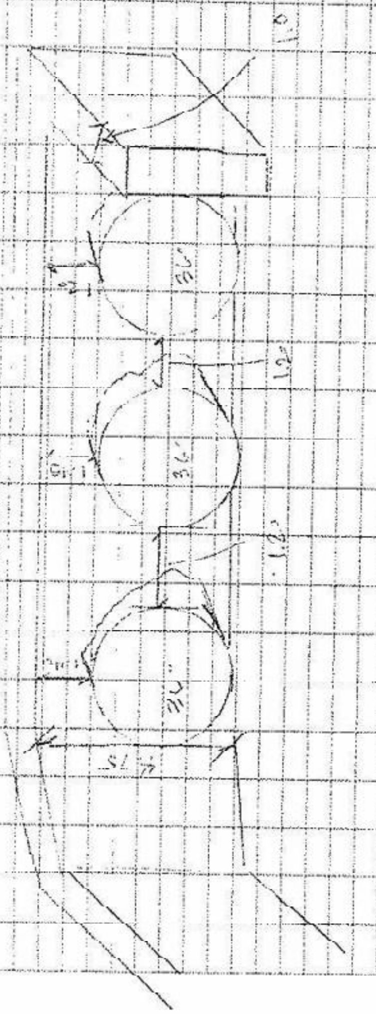


MANTON MIMOSA

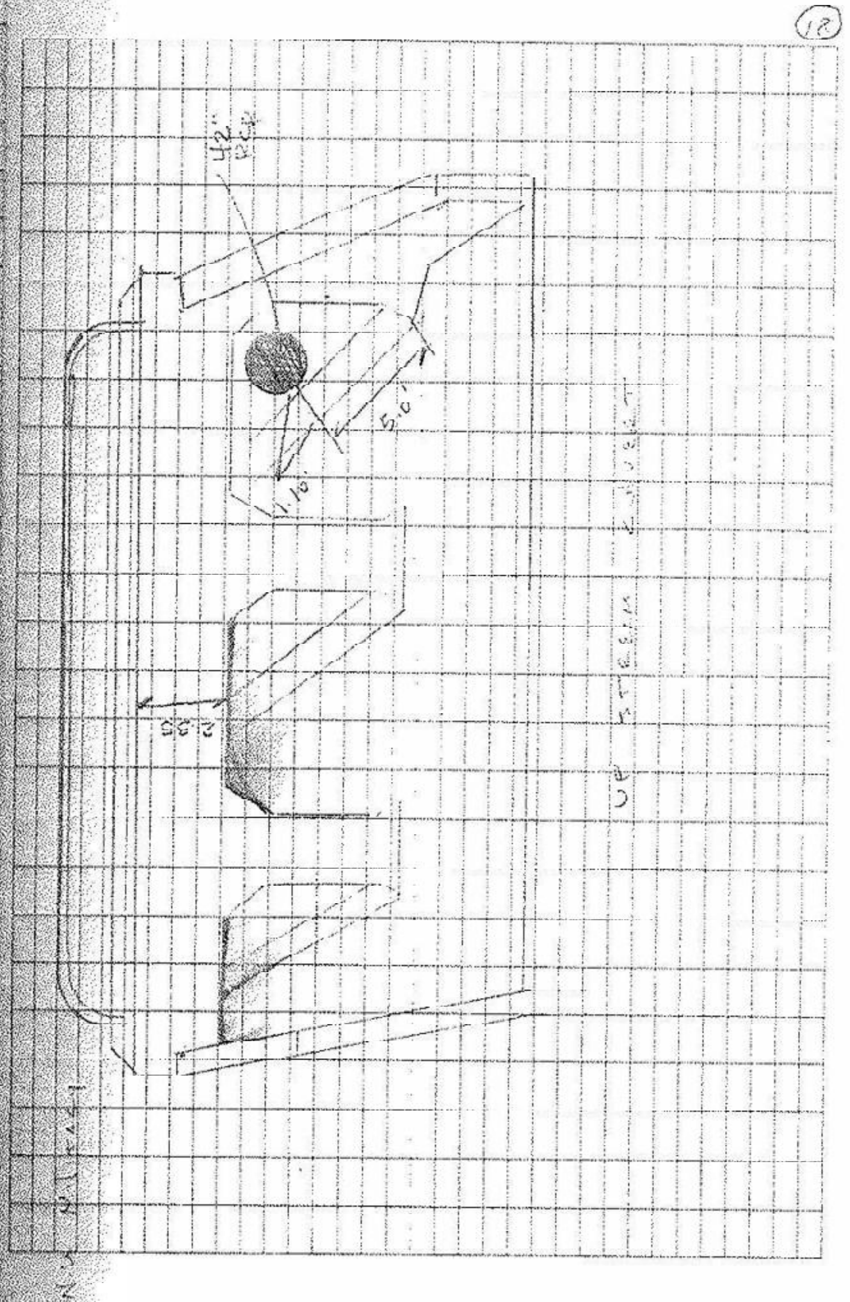


Pg

MANTON MIMOSA

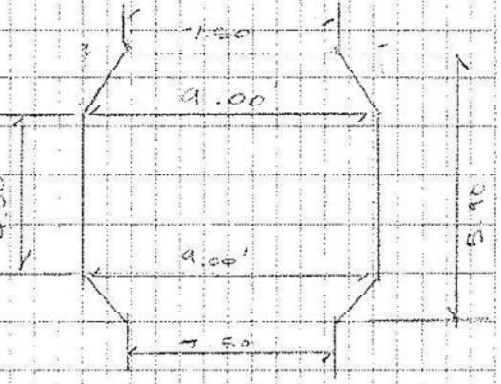


MANTON SUNFLOWER

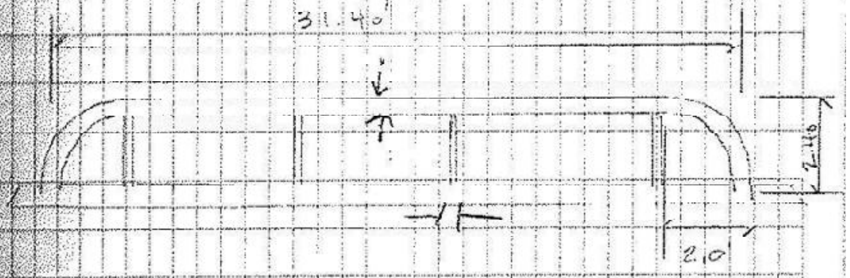


MANTON SUNFLOWER

BOX CULVERT DETAIL



HAND RAIL DETAIL



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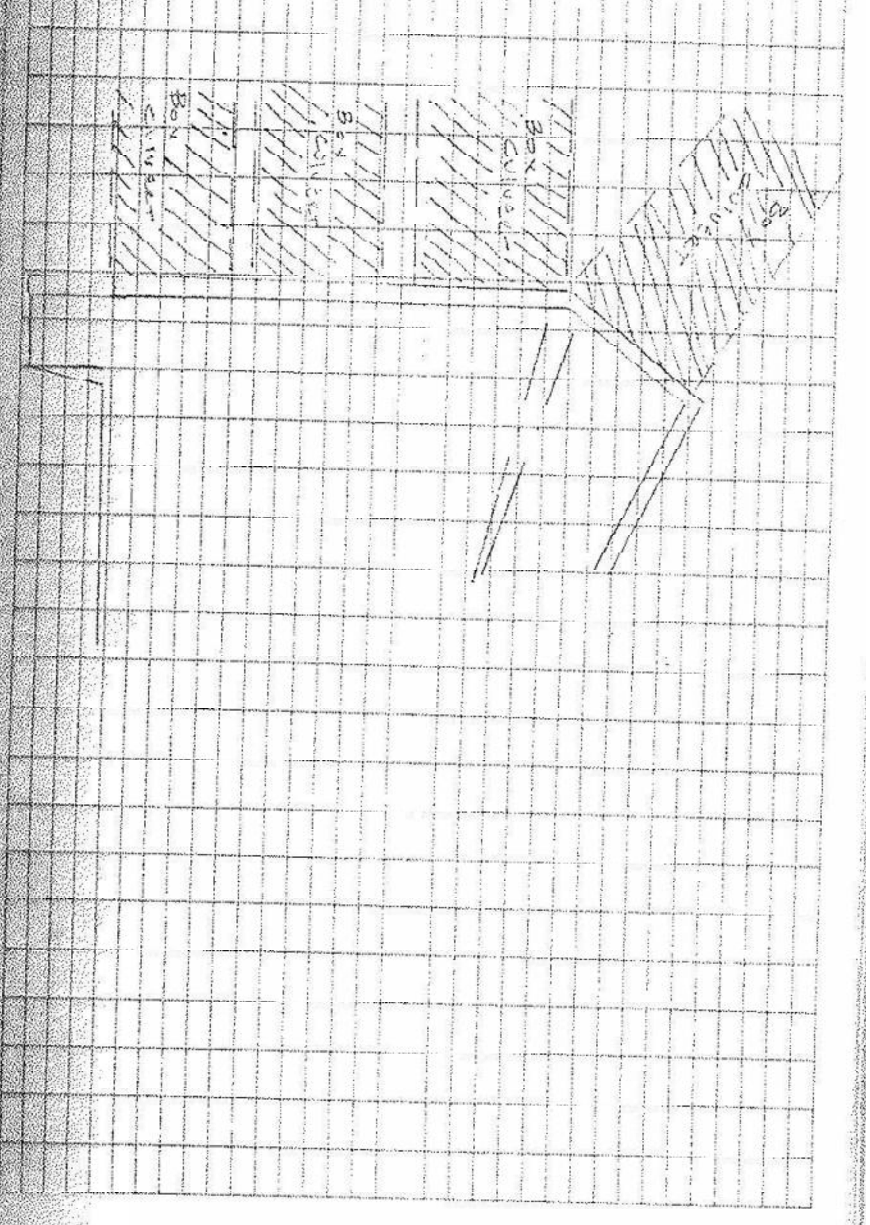

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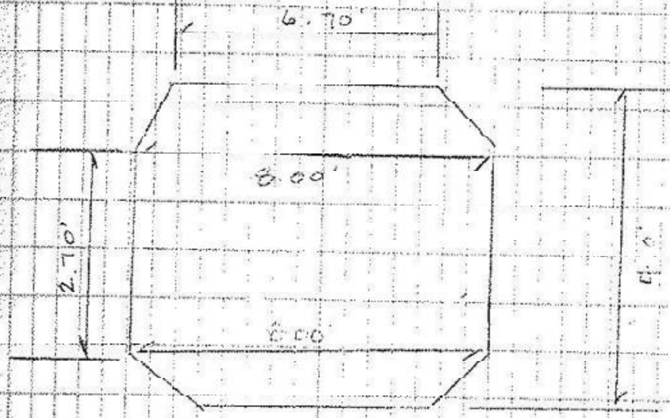
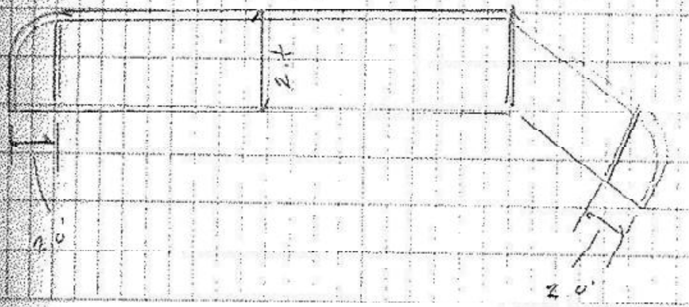
MANTON SUNFLOWER

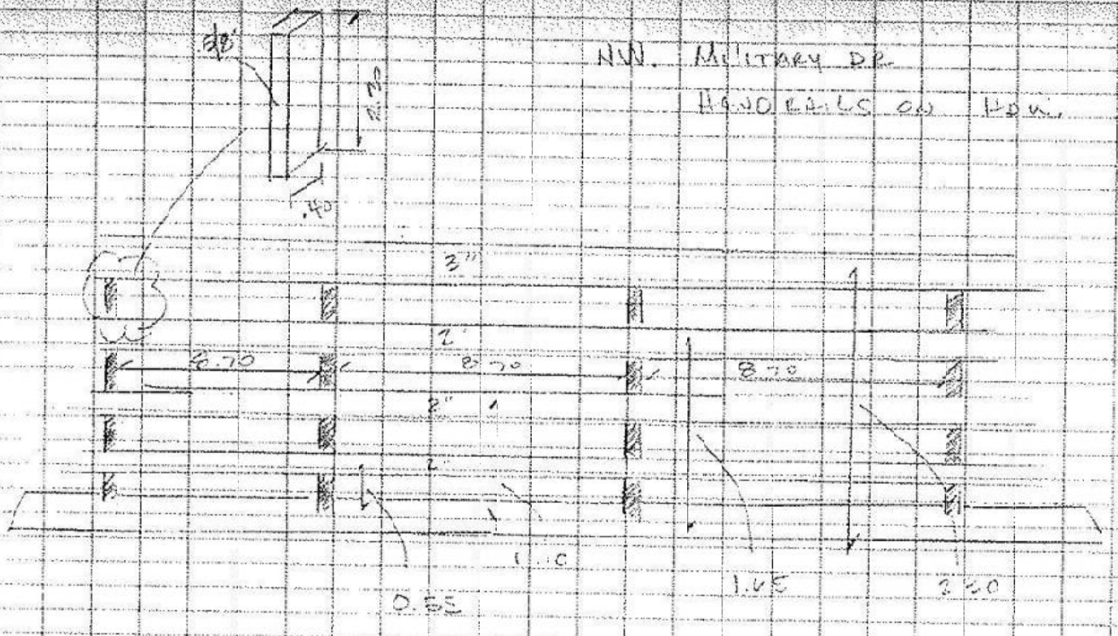
BOX CULVERT # 51
DETAIL



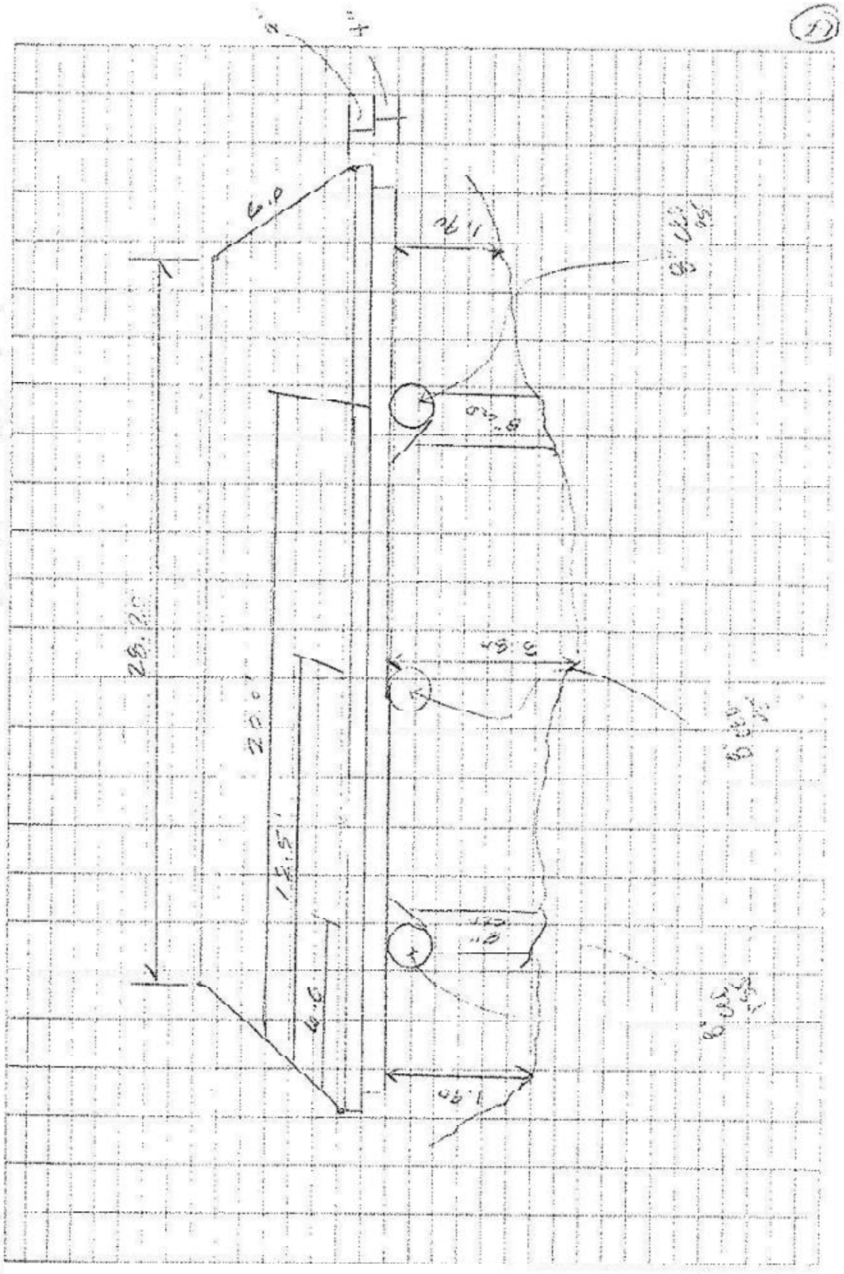
HW # 45



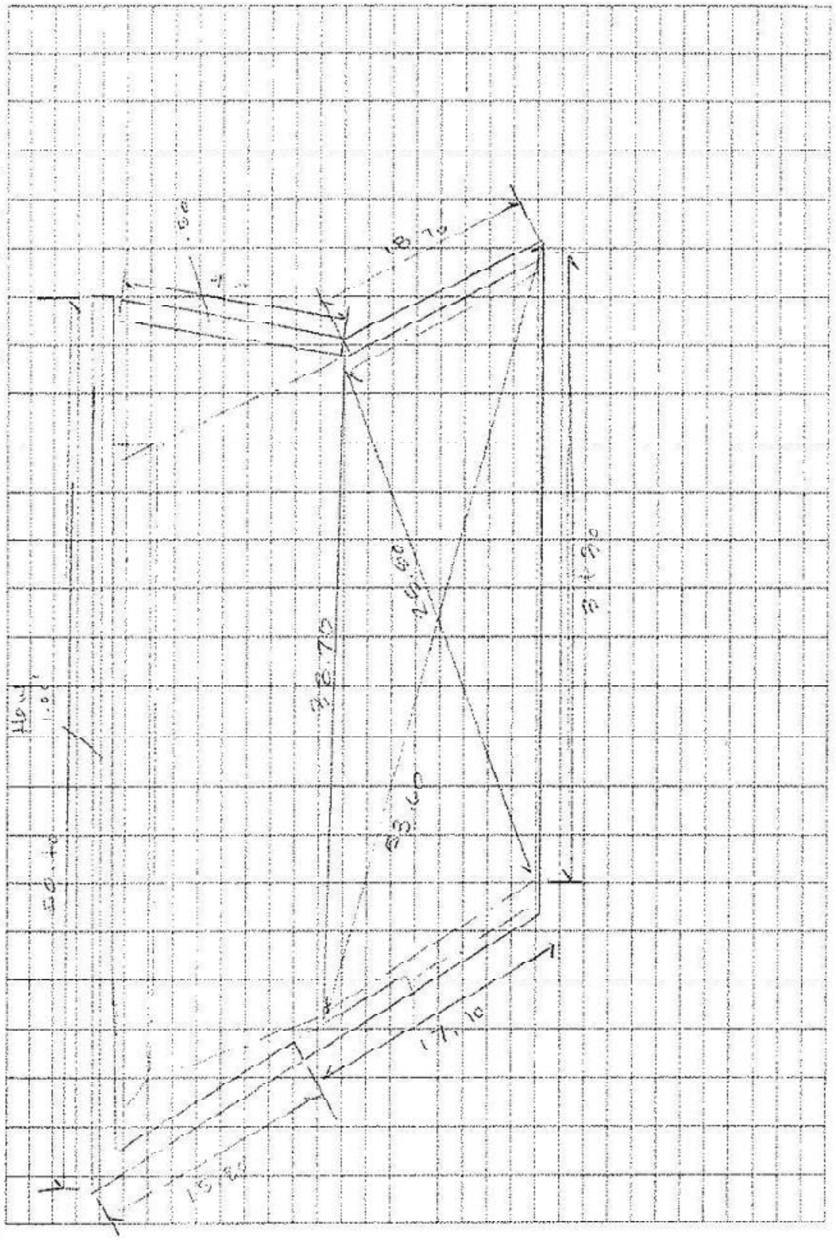
MANTON SUNFLOWER



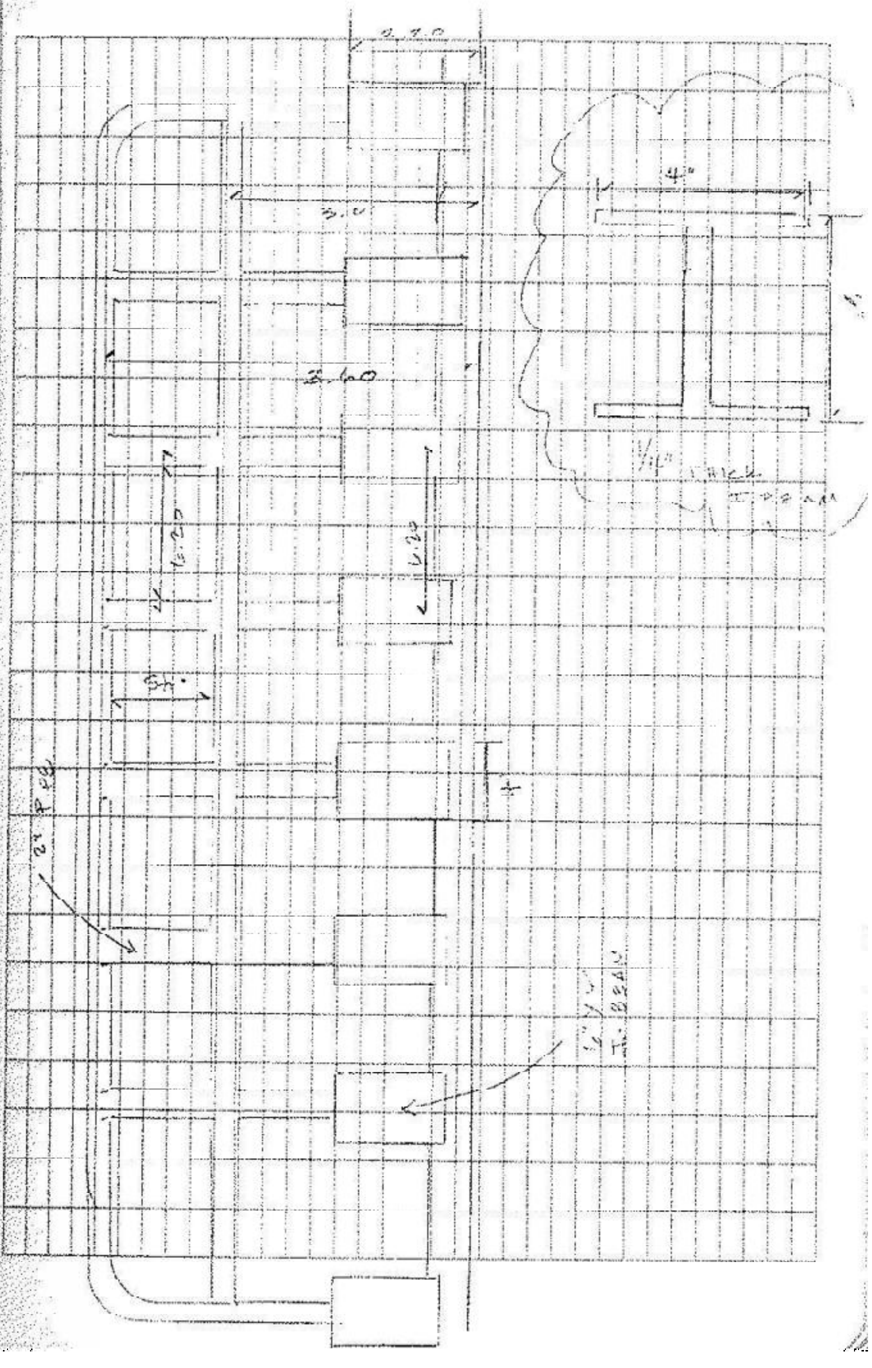
PEDESTRIAN BRIDGE



WESTAVE @ FOX HALL



WEST AVE_ FOXHALL



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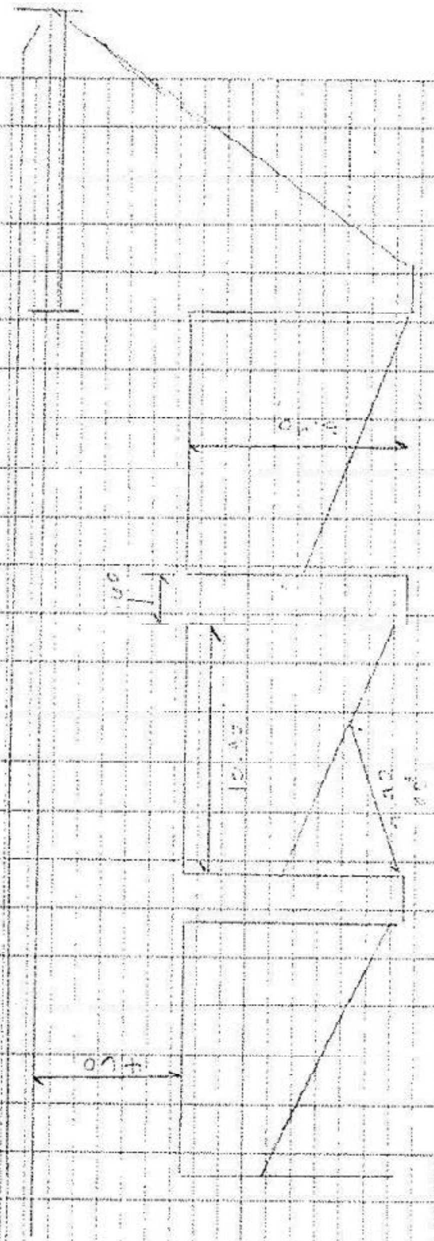

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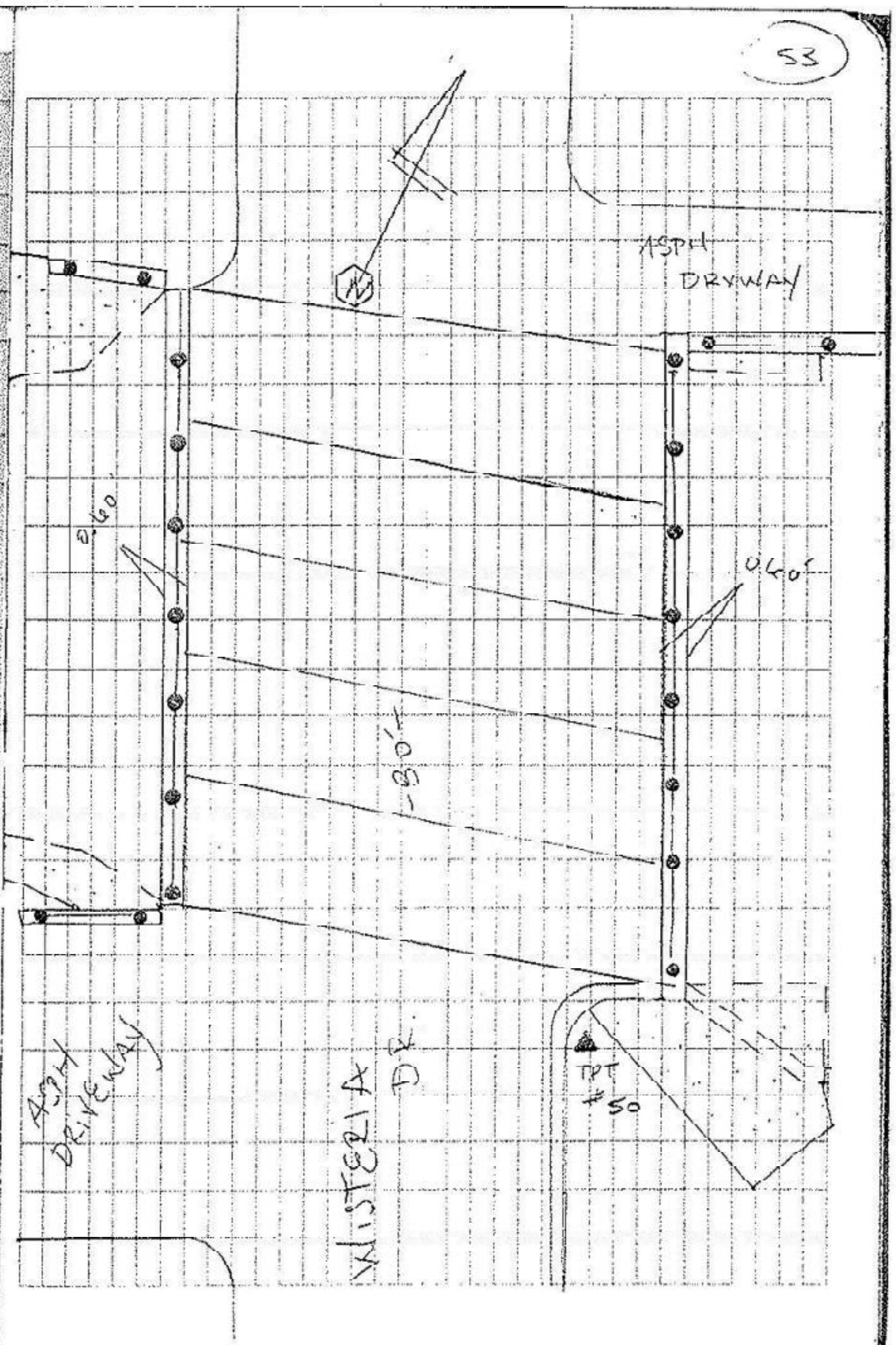
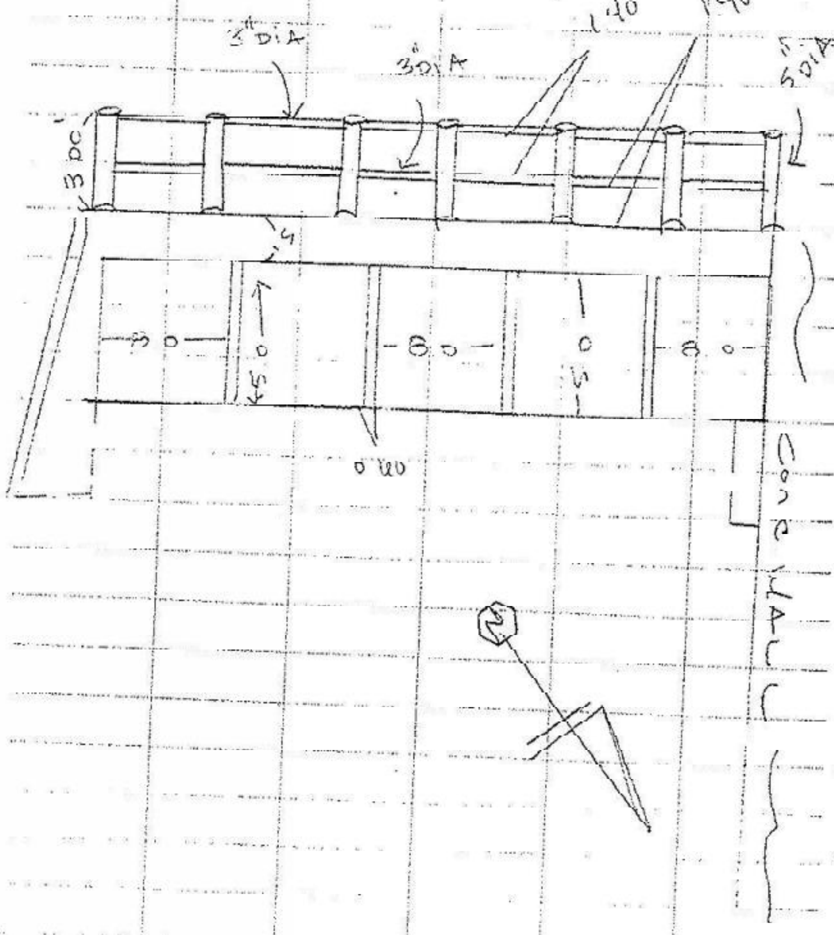
WISTERIA MANTON_ZORNIA



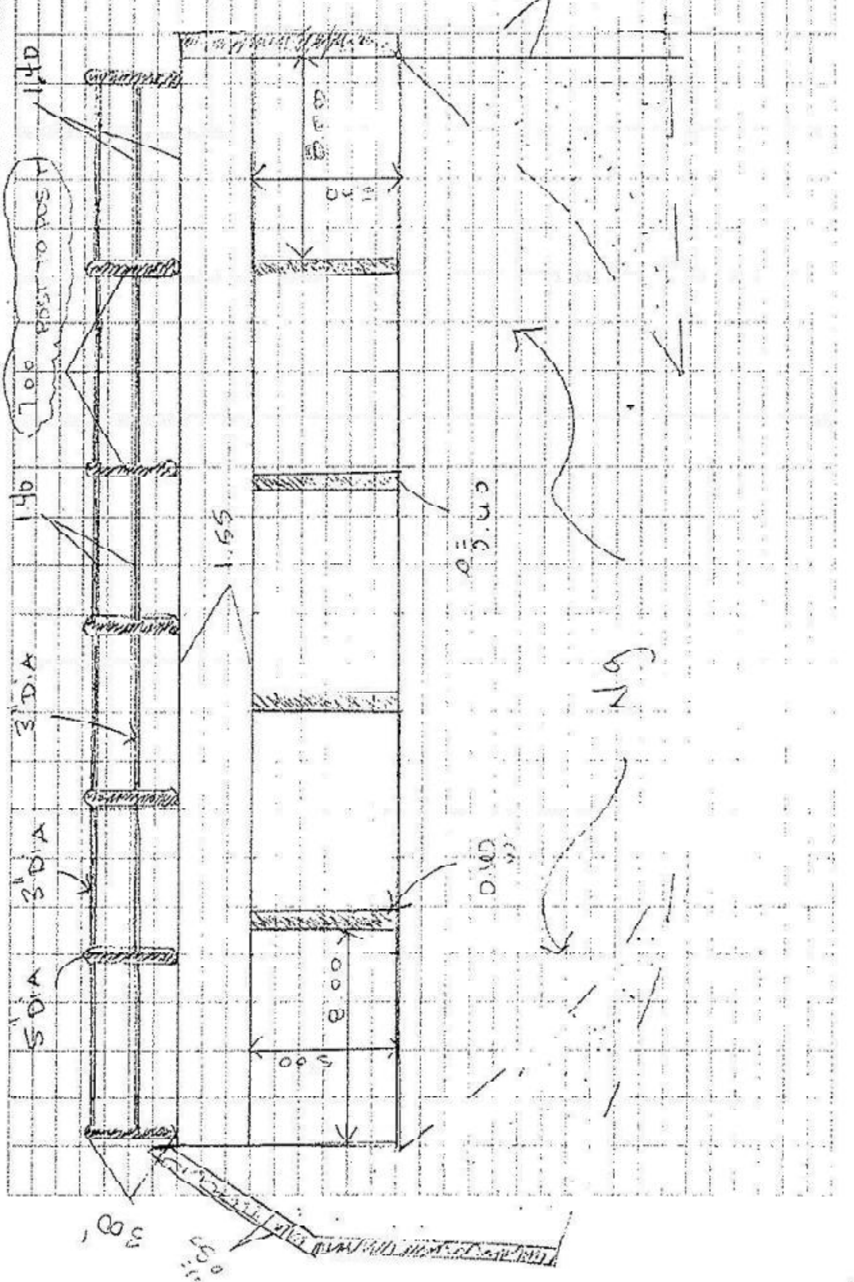
WISTERIA MANTON_ZORNIA

NORTH SIDE OF CULVERT
FACING SOUTH

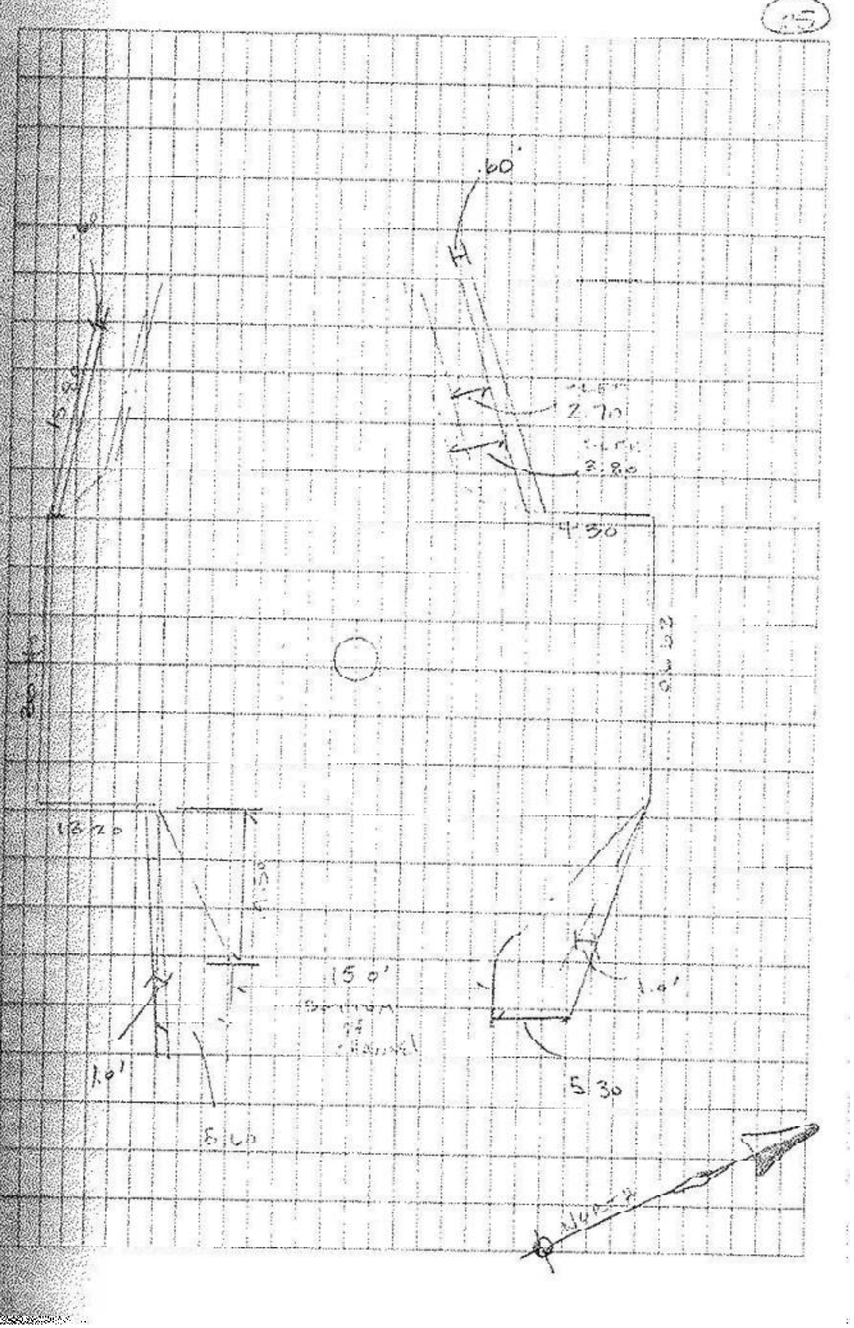


FACING NORTH

S. SIDE OF CULVERT



E CASTLE MANTON _ ZORNIA



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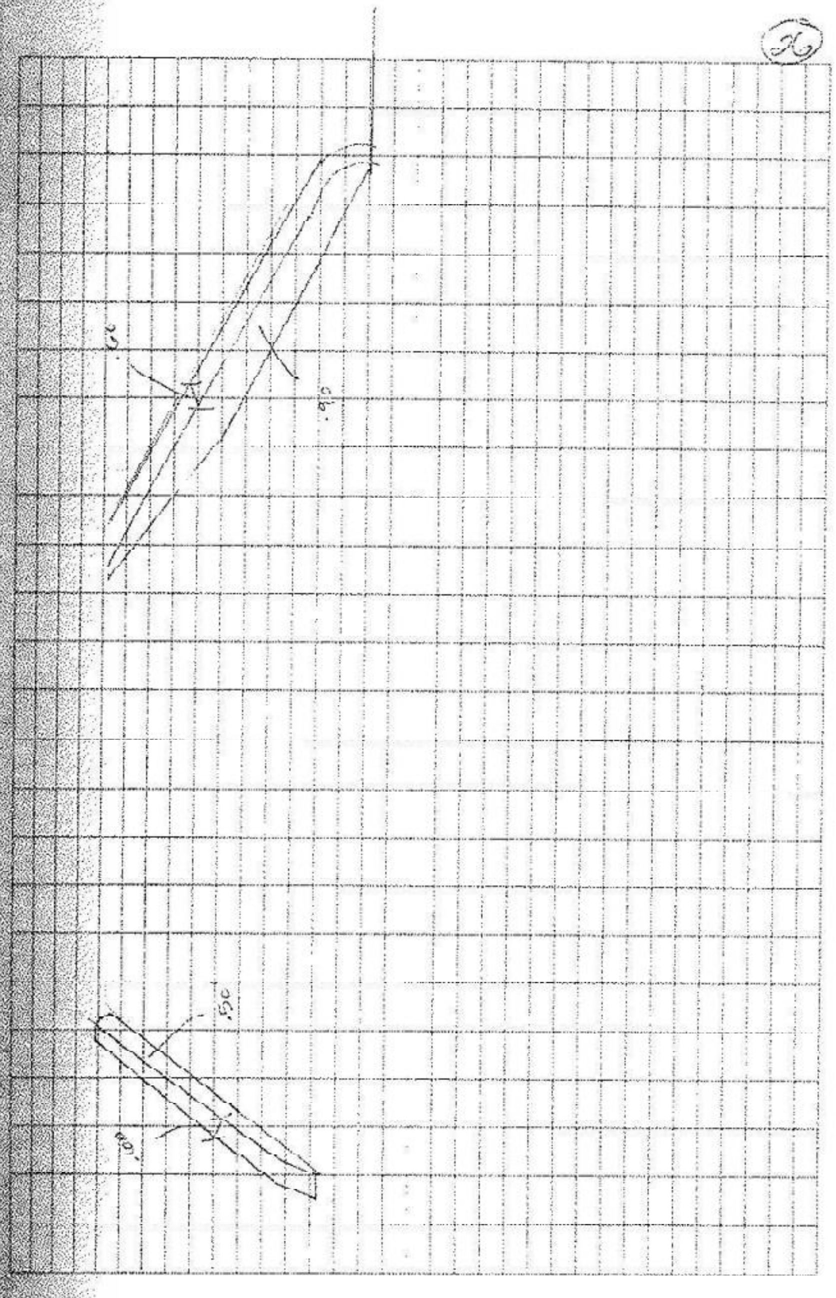

KRAMERIA WEST AVE _ ZORNIA

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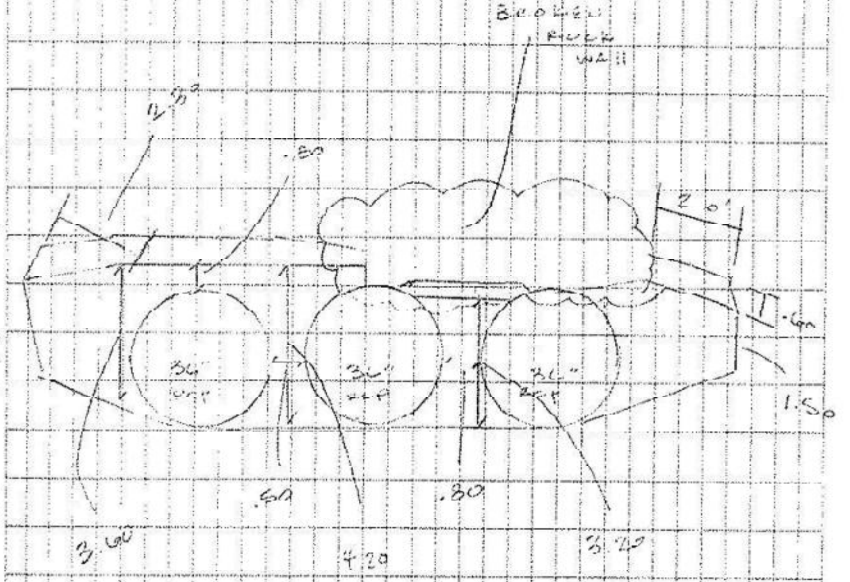
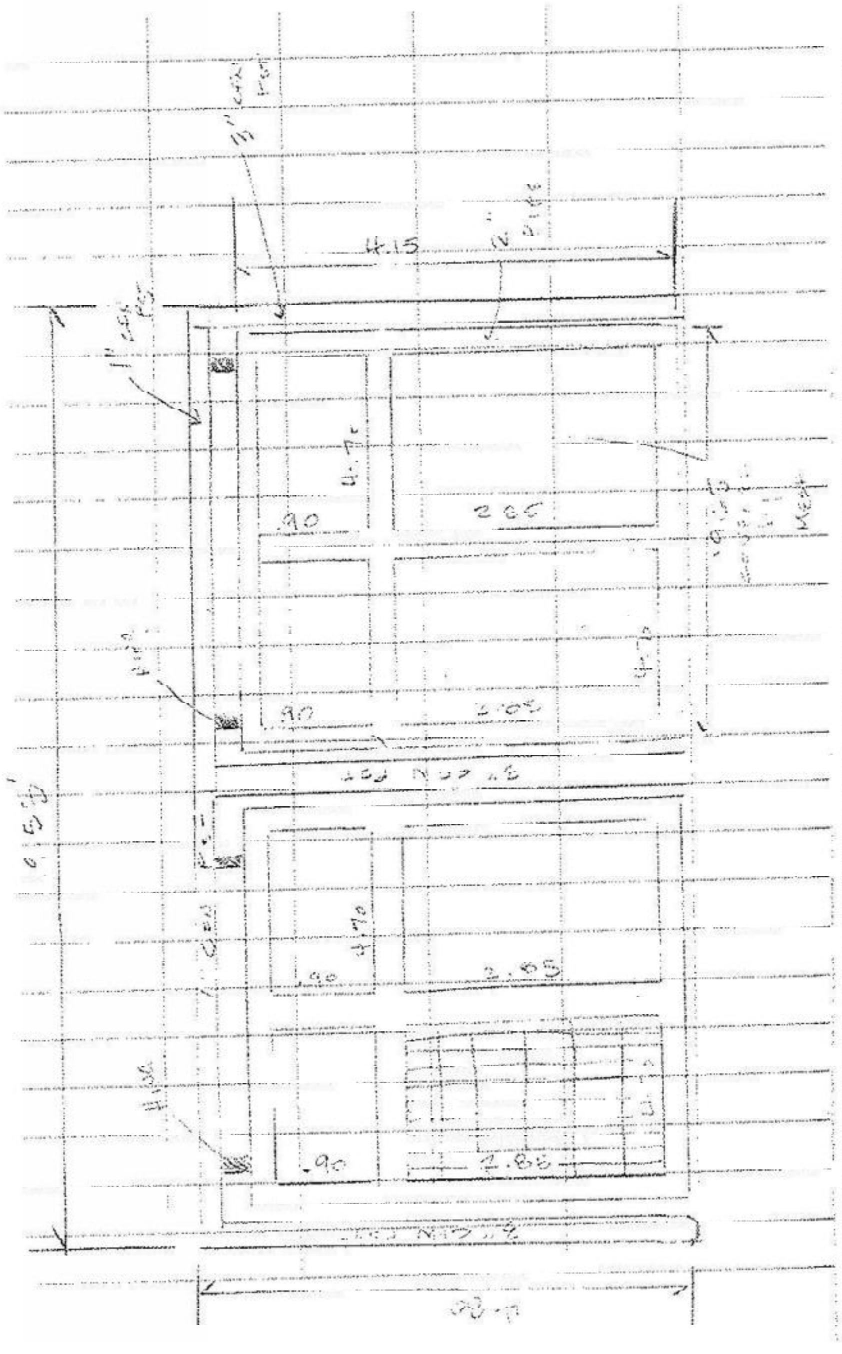
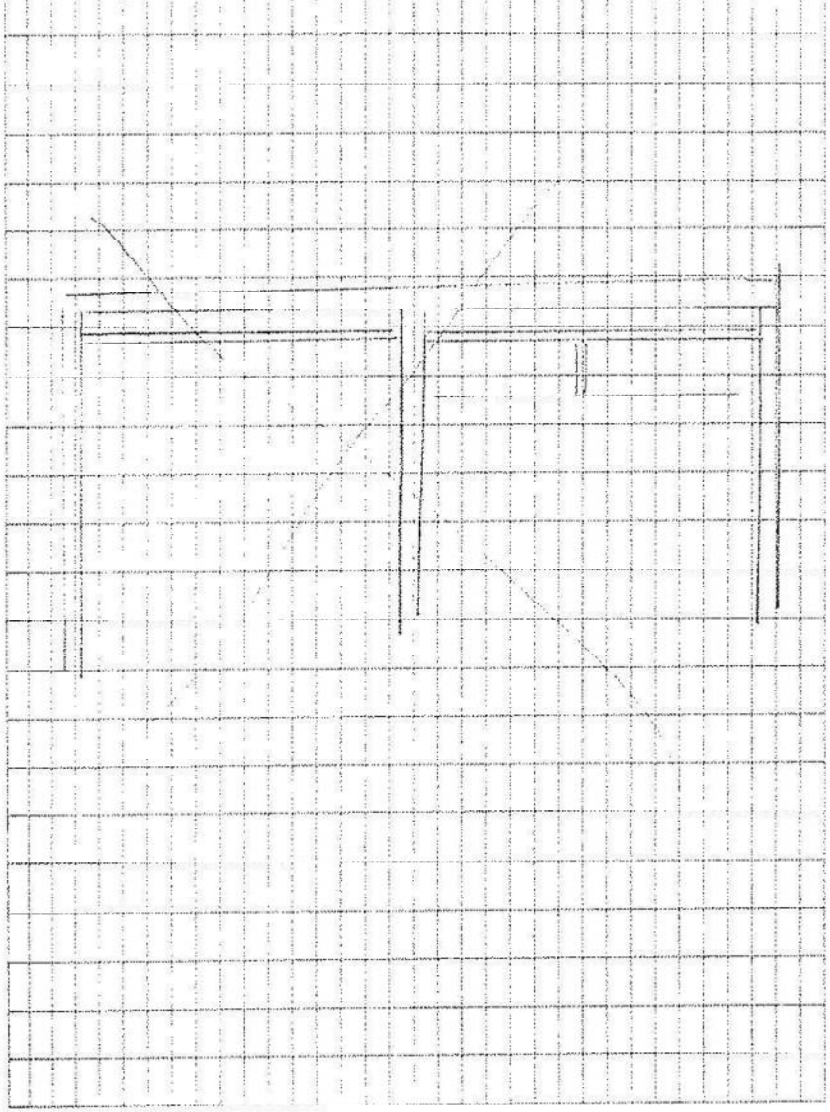


KRAMERIA WEST AVE _ ZORNIA





LOCKHILL SELMA @ CAROLWOOD

DISSIPATOR DETAIL