Appendix K3

TCEQ Edwards Aquifer Regulatory Evaluation and Hydrologic and Hydraulic Analysis Report

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1.1 BACKGROUND

1.1.1 Introduction

The US 281 Environmental Impact Statement (EIS) is being prepared for the Alamo Regional Mobility Authority (Alamo RMA) to evaluate improvements to the US 281 roadway from Loop 1604 to Borgfeld Drive. The project limits fall completely within Bexar County and include the floodplains of Mud Creek, two unnamed tributaries to Mud Creek, an unnamed tributary of Cibolo Creek, an unnamed tributary to West Elm Creek, Borgfeld Creek, and Cibolo Creek.

1.1.2 Purpose

This report outlines the procedure used to evaluate the compliance of the Preferred Expressway Alternative to meet the current regulatory requirements mandated by the Texas Commission on Environmental Quality (TCEQ), as well as the City of San Antonio requirement that proposed storm water runoff not increase from original conditions. One No-Build Alternative and two Build Alternatives (Expressway Alternative and Elevated Expressway Alternative) were evaluated in the US 281 Draft EIS; the Expressway Alternative was identified as the Preferred Alternative (Preferred Expressway Alternative) and is included in this report.

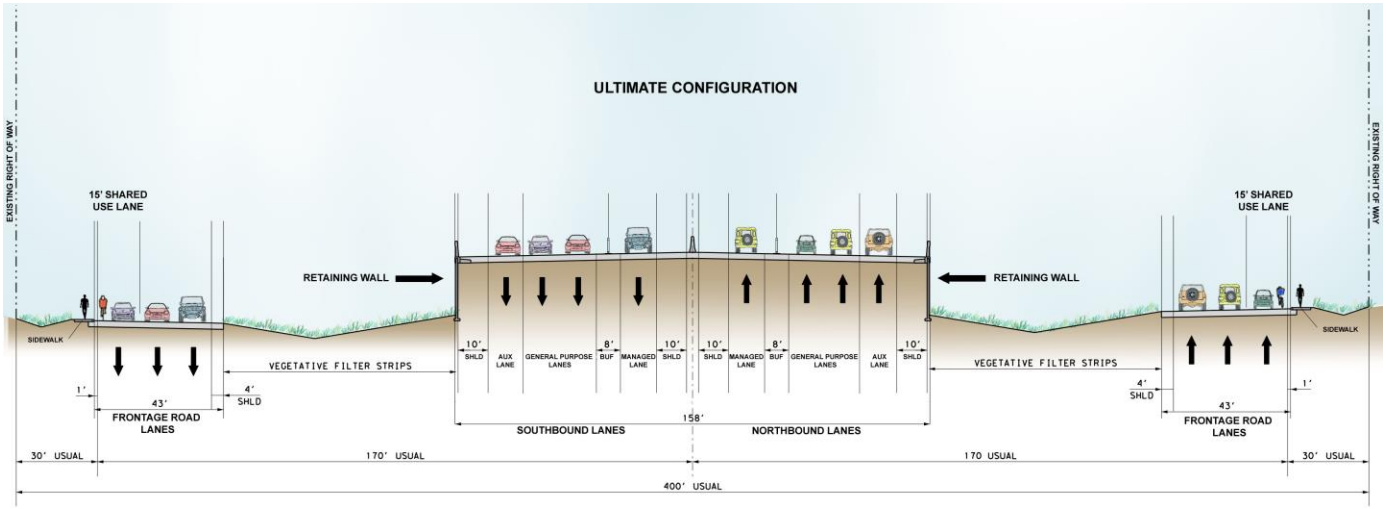
1.1.3 Proposed Alternative

Preferred Expressway Alternative

The Preferred Expressway Alternative extends approximately 7.3 miles from Loop 1604 to Borgfeld Drive. The typical proposed ROW would be 400 feet wide and would require approximately 79 acres of additional ROW. The Preferred Expressway Alternative would expand the US 281 to a six-lane expressway with partial access-controlled outer lanes. From Loop 1604 to Stone Oak Parkway, the expressway lanes would include two non-toll general purpose lanes with an auxiliary lane plus one managed lane in each direction. The expressway lanes would be situated between three partial access-controlled outer lanes in each direction, also known as frontage roads (**Figure K3-1**). From Stone Oak Parkway to Borgfeld Drive, the US 281 would ultimately be expanded to a six-lane expressway (three managed lanes in each direction) with two non-toll outer lanes in each direction. The expressway lanes would be managed and the outer lanes would function as US 281 (**Figure K3-2**). Grade separations would be provided at Sonterra Boulevard, Redland Road, Encino Rio, Evans Road, Stone Oak Parkway, Marshall Road, Wilderness Oaks, Overlook Parkway, Bulverde Road, and Borgfeld Drive to allow the expressway lanes to pass uninterrupted over the cross streets. No cross streets or driveways would access the expressway lanes directly. The outer lanes would be continuous for the length of the proposed project and serve local traffic by providing direct access to cross streets via signalized intersections and to adjacent businesses and neighborhoods. Four non-toll direct connector ramps would be provided at Loop 1604 to provide main lane to main lane connections for US 281 motorists travelling from westbound Loop 1604 to northbound US 281, from southbound US 281 to eastbound Loop 1604, from eastbound Loop 1604 to northbound US 281, and from southbound US 281 to westbound Loop 1604. From north of Evans Road to the south of Marshall Road, the managed lanes would split; the outer managed lane in each direction would remain at grade while the inner managed

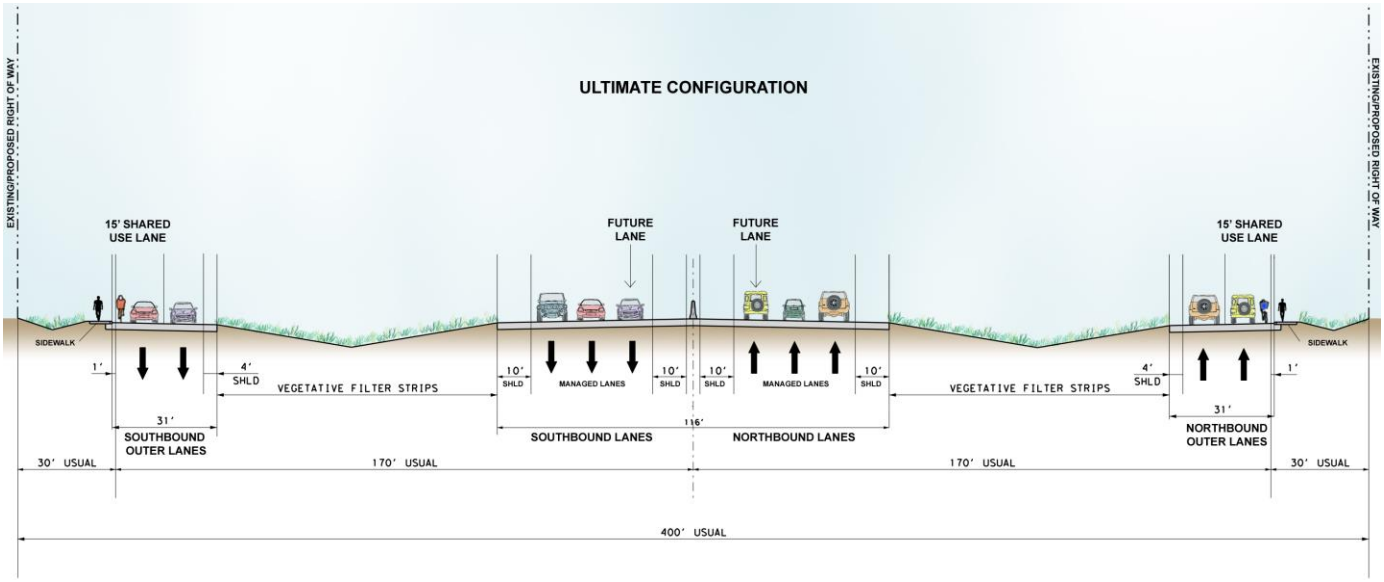
lane in each direction would transition into a ramp to provide access to the VIA Park and Ride Facility at Stone Oak Parkway. The proposed improvements would also include bicycle and pedestrian facilities along the length of the US 281 project corridor on both east and west sides of the US 281. A 15-foot wide outer lane would be provided to accommodate bicycles and a 6-foot wide sidewalk with crosswalks would be constructed.

Figure K3-1: Preferred Expressway Alternative typical section south of Stone Oak Parkway



Source: US 281 EIS Team, 2014.

Figure K3-2: Preferred Expressway Alternative typical section north of Stone Oak Parkway



Source: US 281 EIS Team, 2014.

1.1.4 Regulatory Requirements

The Preferred Expressway Alternative is located in the recharge zone of the Edwards Aquifer and is thus subject to Title 30 Chapter 213 of the Texas Administrative Code, which regulates any activity having the potential for polluting the Edwards Aquifer and hydrologically connected surface streams.

As previously noted, this alternative proposes the addition of impermeable surfaces, primarily in the form of expanded roadways, which prevent the natural infiltration of water into the soil and are therefore defined by TCEQ as impervious cover areas. Impervious cover increases the potential for surface water contamination with suspended solids, thus introducing an increased risk of groundwater degradation. To prevent contaminated storm water from reaching downstream receiving waters and groundwater, TCEQ regulates the total suspended solids (TSS) load permitted to leave the site by requiring a reduction in TSS load associated with development by at least 80 percent. This would be accomplished by implementing an Edwards Aquifer protection plan, which must be filed and approved in compliance with TCEQ regulations prior to commencement of construction. The rules and regulations for any regulated activity within the Edwards Aquifer recharge zone are available for reference in Texas Administrative Code Title 30 Chapter 213 Subchapter A.

Acceptable methods of solids removal are listed in the TCEQ Technical Guidance Manual (*Complying with the Edwards Aquifer Rules – Technical Guidance on Best Management Practices*, TCEQ, July 2005) which includes design criteria.

1.2 METHODOLOGY

The purpose of this study is to determine best management practices (BMPs) that comply with the TCEQ Edwards Aquifer Protection Program rules for the proposed alternative. Each BMP will be designed to meet the required TSS removal as required by TCEQ. TSS removal is achieved by directing the first flush of runoff, storm water containing this high initial pollutant load, to a BMP designed to hold the volume required by TCEQ calculations.

1.2.1 Treatment Method

The water quality loads were calculated for each drainage basin. After evaluating the slopes and available area it was determined that bioretention would be the primary BMP used, and vegetated filter strips would be used where space and slopes allowed.

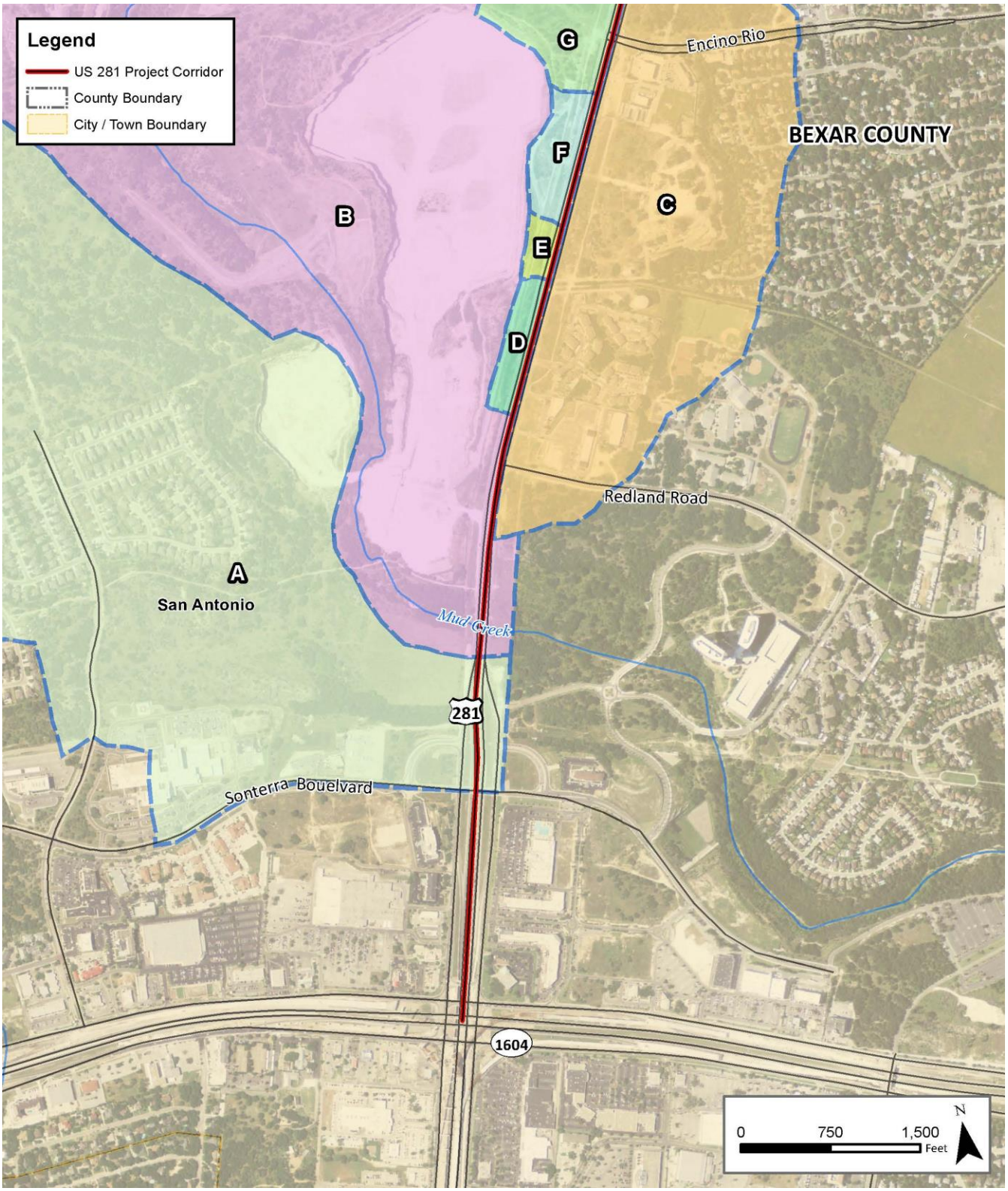
Bioretention - All bioretention areas will be designed to be 5 feet deep, filled with media for 4.5 feet, with 0.5 feet of room on top for ponding, and with a gravel underdrain below the media. A 5-10 foot strip of grass will be added to the approach boundary (on the sides where the water flows into the bioretention area) and the water will drain to grass-lined channels before entering the bioretention area.

Vegetated Filter Strip- These vegetated strips will be at least 15 feet wide next to the roadway, and essentially flat with low slopes (less than 20 percent). These strips will only be utilized when the pavement area draining to strip is less than 72 feet wide.

1.2.2 *Watersheds and Drainage Basins*

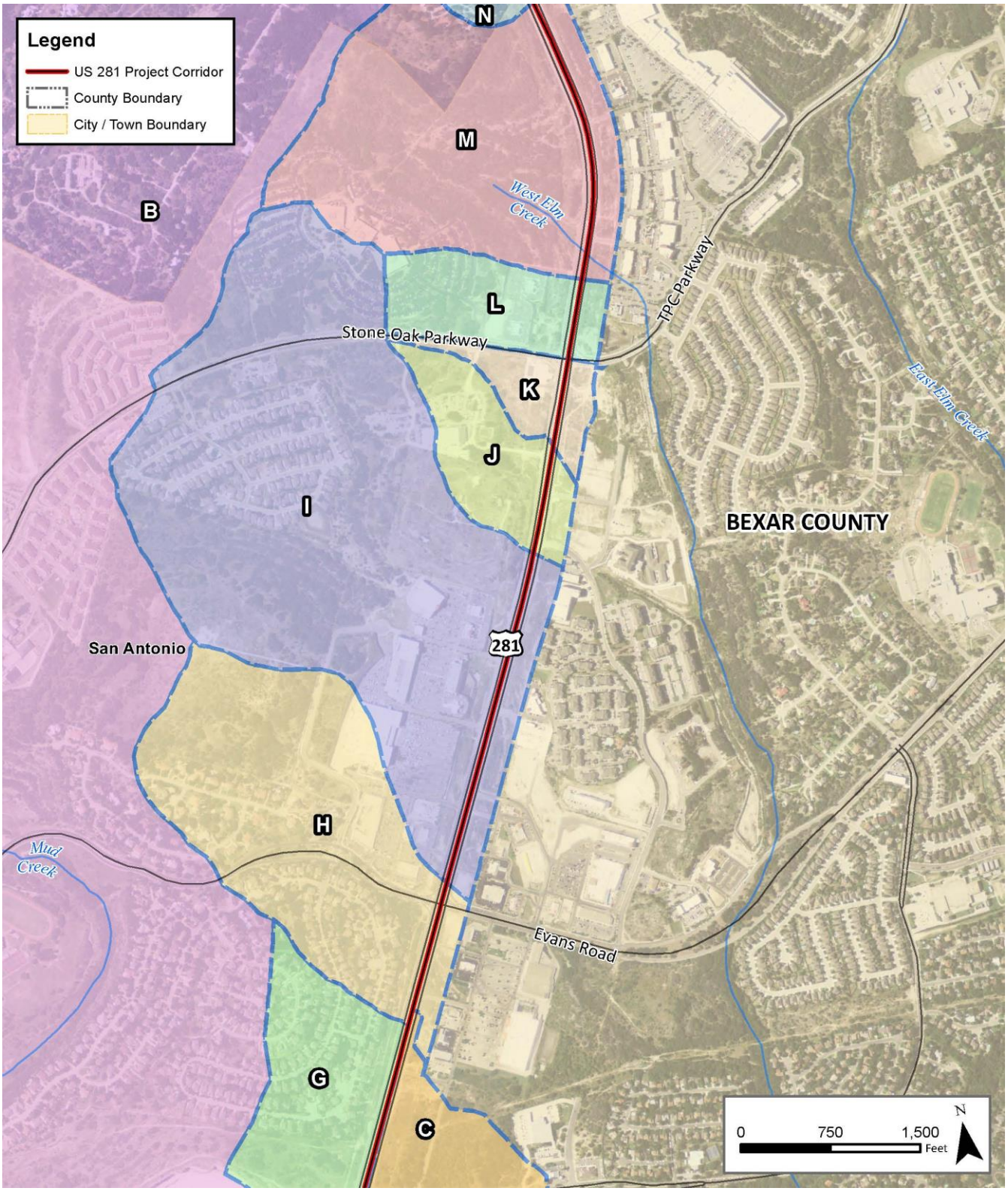
The US 281 Corridor Project is primarily located within the Salado Creek watershed, but also within the Cibolo Creek watershed on the northern most portion of the project. Within the Salado Creek watershed the project is within the Mud Creek, Elm Waterhole Creek, and West Elm Creek sub-watersheds. These watersheds were further subdivided into 23 drainage basins. These basins are determined based on site topography and the proposed improvements. The BMPs have been designed to treat the TSS increase within each individual drainage basin. The 23 drainage basins are shown and labeled "A" though "W" in **Figure K3-3a – e.**

Figure K3-3a: Drainage basins surrounding the Preferred Expressway Alternative



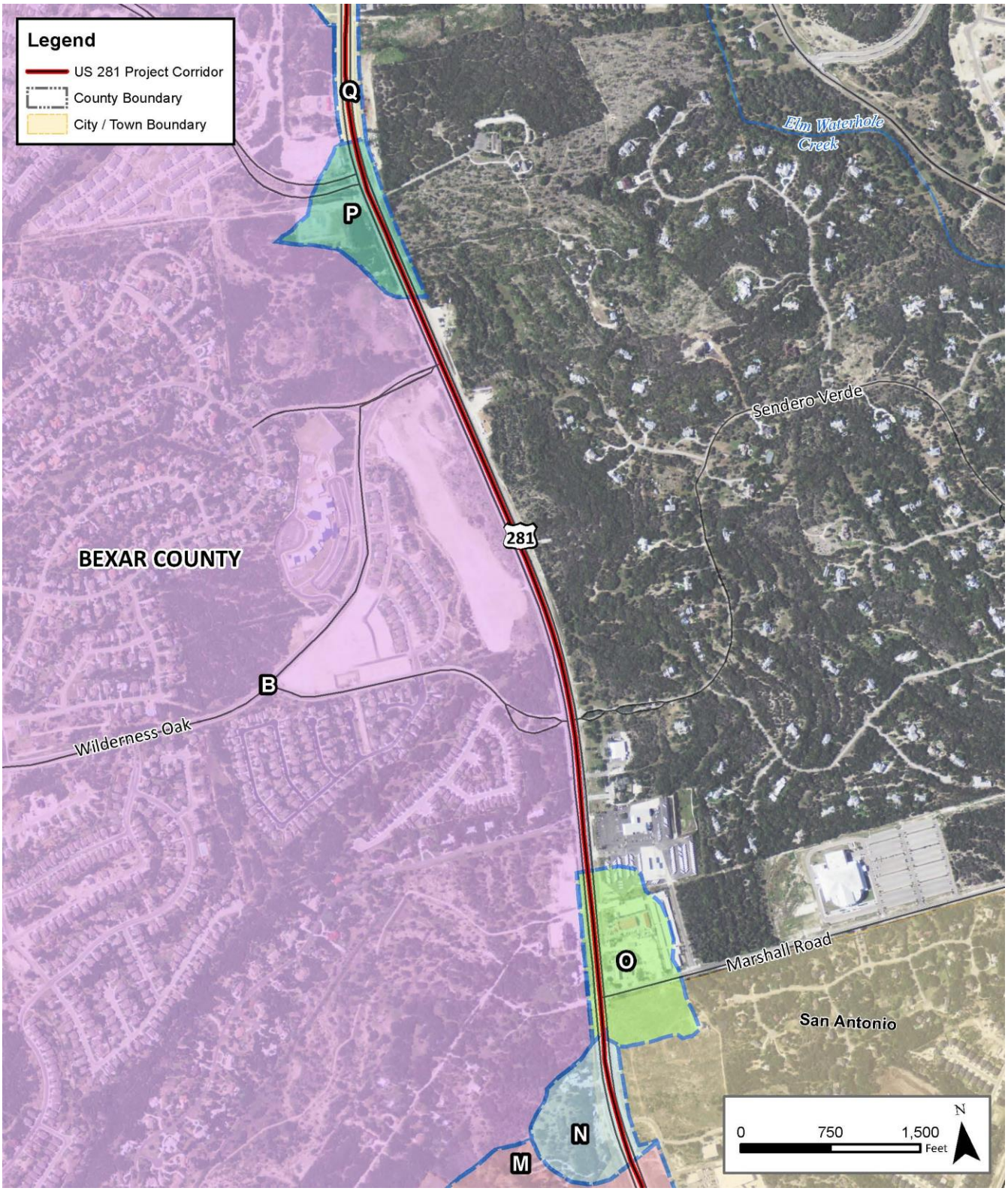
Source: US 281 EIS Team, 2014

Figure K3-3b: Drainage basins surrounding the Preferred Expressway Alternative



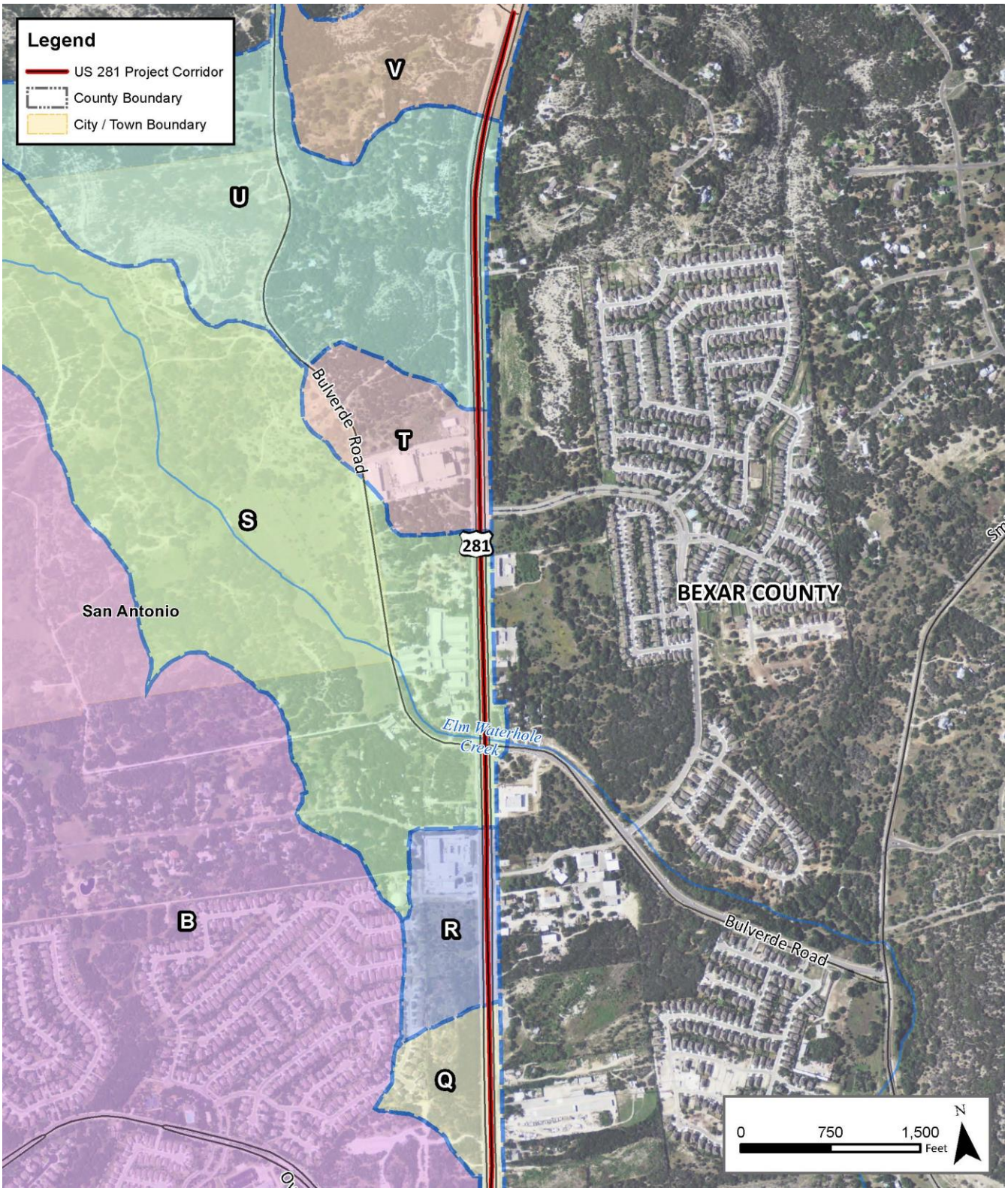
Source: US 281 EIS Team, 2014

Figure K3-3c: Drainage basins surrounding the Preferred Expressway Alternative



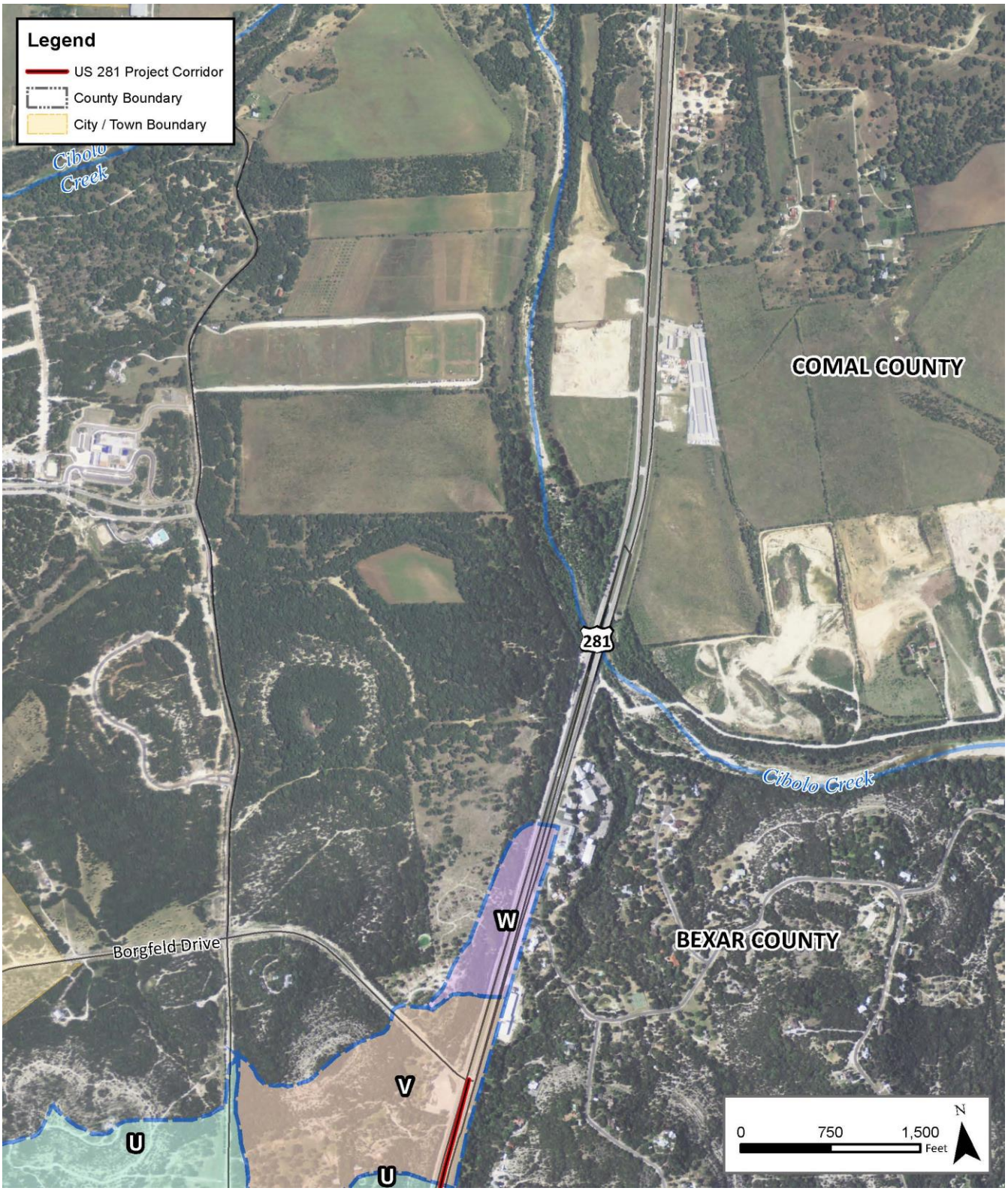
Source: US 281 EIS Team, 2014

Figure K3-3d: Drainage basins surrounding the Preferred Expressway Alternative



Source: US 281 EIS Team, 2014

Figure K3-3e: Drainage basins surrounding the Preferred Expressway Alternative



Source: US 281 EIS Team, 2014

Some larger watersheds were divided into multiple sections since bioretention is limited to 10-acre drainage areas. For Drainage Basin A, the proposed BMPs were increased by 20 percent to account for impervious areas under the direct connectors.

1.2.3 Calculations

Calculations have been performed using TCEQ's equations/spreadsheet for TSS generation and removal. Summary sheets from those calculations are included as **Appendix A**. BMP sizes required for appropriate TSS removal have also been calculated and are presented in the summary.

Inputs required for the TSS calculations included the total project area, the county in which the project resides (for rainfall determination) and the amount of existing and proposed impervious areas. As mandated by TCEQ, 80 percent is the required removal of the increase in TSS. All existing impervious cover is assumed to have been installed per regulatory rules (if any) at the time of their installation. In accordance with the Edwards Aquifer Rules, the proposed BMPs are sized to treat the additional TSS generated from the increase in impervious cover for the Preferred Expressway Alternative (30 TAC 213.5). The BMPs are designed to treat the runoff from a storm event of a specified duration and intensity or design storm.

1.2.4 Procedure

Electronic files of the proposed alternative were used to obtain all proposed impervious cover calculations. The procedure below has been used to evaluate the proposed alternative:

1. Generate impervious areas using CAD within the ROW for the alternative.
2. Combine existing and proposed areas in order to obtain the total post construction impervious cover.
3. Identify potential locations for water quality BMPs.
4. Calculate existing and proposed impervious cover within each watershed defined by locations of BMPs.
5. Use spreadsheet to determine the TSS removal goals for each watershed and estimate BMP volumes to achieve the required removal.
6. Examine the footprint of the BMPs required and develop proposed ROW needs.

1.2.5 Assumptions and Clarifications

The following assumption has been made in the development of this analysis:

- All existing impervious cover is assumed to have been installed per regulatory rules (if any) at the time of their installation and no treatment will be included in calculations for existing impervious cover. There are no requirements for treating existing impervious cover, only the increased impervious cover from the proposed project.

1.3 EVALUATION

1.3.1 Evaluation Criteria

The Preferred Expressway Alternative was evaluated using the following questions:

- Does this alternative meet the TSS removal requirements set by TCEQ?
- Can the TSS removal requirement be met utilizing the proposed ROW for the Preferred Expressway Alternative?

1.3.2 Evaluations Results

The following table presents a summary of the results. See the *Hydrologic and Hydraulic Analysis Report* that follows this summary for a detailed evaluation of the TSS generated at each outfall resulting from the incremental increase in impervious cover and the effectiveness of each proposed BMP.

Table K3-1: Summary of Results

Alternative	Total Number of Major Watersheds	Total Number of BMP Watersheds/ Basins	Total TSS Removal Required (lbs.)	TCEQ Requirements Met (Y/N)	Number of Basins Requiring Additional ROW
Preferred Expressway Alternative	23	23	48,633	Y	0

Source: US 281 EIS Team, 2012

1.3.3 Ability to Meet Required Treatment Threshold

As shown in **Table K3-1** above, the Preferred Expressway Alternative evaluated is capable of meeting the TCEQ requirements for TSS removal.

1.3.4 Additional Right of Way Requirements to Accommodate BMPs

The Preferred Expressway Alternative would not require additional ROW beyond the proposed ROW for the accommodation of BMPs.

1.4 CONCLUSIONS

The Preferred Expressway Alternative is able to meet the current regulatory requirements set forth by TCEQ for the entire project area. Therefore, a WPAP in accordance with current regulations will be prepared prior to construction.

As previously mentioned, bioretention and vegetated filter strips were identified as the preferred BMPs for the Preferred Expressway Alternative; however, there are several other options of permanent controls approved by TCEQ, including:

- Sand Filter Basins
- Retention/Irrigation
- Extended Detention Basins
- Grassy Swales
- Wet Basins
- Constructed Wetlands
- Permeable Concrete

Various innovative technologies have also been approved by TCEQ for use within the recharge zones of the Edwards Aquifer including:

- Contech StormFilter
- Stormceptor
- Vortechs

This list is subject to change by TCEQ and all methods should be verified with TCEQ's current approved list at the time of final design.

Appendix A - Impervious Cover Summary and Water Quality Summary

Impervious Cover and Water Quality Summary – Preferred Expressway Alternative

Basin Name	Area (ac)	Existing On-Site Impervious Area (ac)	Proposed On-Site Impervious Area (ac)	Proposed Increase in Impervious Area (ac)	Existing On-Site % Impervious	Proposed On-Site % Impervious	Required Water Quality Volume for Bioretention (cu ft)	Depth (ft)	Calculated Width (ft)	Calculated Length (ft)	Proposed Width (ft)	Proposed Length (ft)
A1	9.93	5.37	6.29	0.93	54.02%	63.34%	1,350	5	16.43	16.43	18	18
A2	9.93	5.37	6.29	0.93	54.02%	63.34%	1,350	5	16.43	16.43	18	18
A3	9.93	5.37	6.29	0.93	54.02%	63.34%	1,350	5	16.43	16.43	18	18
A4	9.93	5.37	6.29	0.93	54.02%	63.34%	1,350	5	16.43	16.43	18	18
B1	8.62	2.54	6.73	4.19	29.46%	78.07%	10,937	5	46.77	46.77	47	47
B2	8.62	2.54	6.73	4.19	29.46%	78.07%	10,937	5	46.77	46.77	47	47
C	10.14	2.36	6.41	4.05	23.27%	63.22%	9,567	5	43.74	43.74	44	44
D	7.55	1.71	5.27	3.56	22.62%	69.71%	9,264	5	43.04	43.04	43.5	43.5
E1	6.99	2.60	4.77	2.17	37.11%	68.19%	4,343	5	29.47	29.47	30	30
E2	6.99	2.60	4.77	2.17	37.11%	68.19%	4,343	5	29.47	29.47	30	30
F1	6.38	1.69	4.37	2.68	26.47%	68.37%	6,457	5	35.93	35.93	36	36
F2	6.38	1.69	4.37	2.68	26.47%	68.37%	6,457	5	35.93	35.93	36	36
G1	5.90	1.86	4.38	2.51	31.59%	74.21%	5,974	5	34.57	34.57	35	35
G2	5.90	1.86	4.38	2.51	31.59%	74.21%	5,974	5	34.57	34.57	20	62
H1	7.64	2.32	5.43	3.11	30.42%	71.08%	7,258	5	38.10	38.10	20	62
H2	7.64	2.32	5.43	3.11	30.42%	71.08%	7,258	5	38.10	38.10	20	62
H3	7.64	2.32	5.43	3.11	30.42%	71.08%	7,258	5	38.10	38.10	20	62
I1	7.66	2.00	4.90	2.90	26.12%	64.00%	6,743	5	36.72	36.72	37	37
I2	7.66	2.00	4.90	2.90	26.12%	64.00%	6,743	5	36.72	36.72	37	37
J	10.21	3.51	6.63	3.12	34.42%	64.95%	6,225	5	35.28	35.28	35.5	35.5
K	8.15	2.17	4.89	2.72	26.62%	59.98%	6,098	5	34.92	34.92	35	35
L1	10.97	2.20	5.88	3.68	20.04%	53.61%	8,799	5	41.95	41.95	42	42
L2	10.97	2.20	5.88	3.68	20.04%	53.61%	8,799	5	41.95	41.95	42	42
M1	9.32	2.36	5.31	2.96	25.30%	57.00%	6,637	5	36.43	36.43	37	37
M2	9.32	2.36	5.31	2.96	25.30%	57.00%	6,637	5	36.43	36.43	37	37
N	11.32	3.37	7.23	3.86	29.79%	63.91%	8,504	5	41.24	41.24	41.5	41.5
O1	10.33	2.51	6.25	3.73	24.33%	60.45%	8,542	5	41.33	41.33	20	88
O2	10.33	2.51	6.25	3.73	24.33%	60.45%	8,542	5	41.33	41.33	20	88
O3	10.33	2.51	6.25	3.73	24.33%	60.45%	8,542	5	41.33	41.33	20	88
O4	10.33	2.51	6.25	3.73	24.33%	60.45%	8,542	5	41.33	41.33	20	88
P1	7.81	2.05	4.10	2.06	26.20%	52.54%	4,351	5	29.50	29.50	30	30

Basin Name	Area (ac)	Existing On-Site Impervious Area (ac)	Proposed On-Site Impervious Area (ac)	Proposed Increase in Impervious Area (ac)	Existing On-Site % Impervious	Proposed On-Site % Impervious	Required Water Quality Volume for Bioretention (cu ft)	Depth (ft)	Calculated Width (ft)	Calculated Length (ft)	Proposed Width (ft)	Proposed Length (ft)
P2	7.81	2.05	4.10	2.06	26.20%	52.54%	4,351	5	29.50	29.50	30	30
Q1	7.47	1.66	4.22	2.56	22.18%	56.48%	5,942	5	34.47	34.47	35	35
Q2	7.47	1.66	4.22	2.56	22.18%	56.48%	5,942	5	34.47	34.47	35	35
Q3	7.47	1.66	4.22	2.56	22.18%	56.48%	5,942	5	34.47	34.47	35	35
R1	10.91	4.26	6.49	2.22	39.10%	59.48%	3,793	5	27.54	27.54	28	28
R2	10.91	4.26	6.49	2.22	39.10%	59.48%	3,793	5	27.54	27.54	28	28
S1	9.93	4.77	5.89	1.13	48.00%	59.33%	1,690	5	18.39	18.39	18.5	18.5
S2	9.93	4.77	5.89	1.13	48.00%	59.33%	1,690	5	18.39	18.39	18.5	18.5
T1	6.46	2.30	3.09	0.79	35.55%	47.84%	1,251	5	15.82	15.82	16	16
T2	6.46	2.30	3.09	0.79	35.55%	47.84%	1,251	5	15.82	15.82	16	16
U1	9.05	2.22	4.14	1.92	24.50%	45.76%	3,857	5	27.77	27.77	28	28
U2	9.05	2.22	4.14	1.92	24.50%	45.76%	3,857	5	27.77	27.77	28	28
V	10.58	4.20	5.15	0.95	39.69%	48.64%	1,420	5	16.85	16.85	17	17
W1	10.70	2.48	4.29	1.81	23.17%	40.06%	3,459	5	26.30	26.30	27	27
W2	10.70	2.48	4.29	1.81	23.17%	40.06%	3,459	5	26.30	26.30	27	27
W3	10.70	2.48	4.29	1.81	23.17%	40.06%	3,459	5	26.30	26.30	27	27

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ALAMO RMA

Texas Department of Transportation

HYDROLOGIC AND HYDRAULIC ANALYSIS

For

US 281 Schematic
Loop 1604 to Borgfeld Drive

CSJ: 0253-04-138

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List of Acronyms

AC-FT	Acre-feet
AEP	Annual Exceedance Probability
CFS	Cubic Feet Per Second
CN	Curve Number
DEM	Digital Elevation Model
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FM	Farm-to-Market
FPS	Feet Per Second
FT	Feet
GIS	Geographic Information System
HDM	TxDOT Hydraulic Design Manual
IN/HR	Inches Per Hour
LF	Linear Feet
LiDAR	Light Detection and Ranging
NAVD	North American Vertical Datum
NRCS	Natural Resources Conservation Service
PGL	Profile Grade Line
ROW	Right-Of-Way
TxDOT	Texas Department of Transportation
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WSE	Water Surface Elevation

EXECUTIVE SUMMARY

This report presents the drainage impact analysis/preliminary detention impact analysis of approximately 7.5 miles of US 281 roadway widening from Loop 1604 to Borgfeld Drive in Bexar County, Texas. The purpose of this study is to present the hydrologic analysis and mitigation recommendations to offset drainage impacts within the Salado Creek Watershed associated with the proposed improvements and widening of the US 281 alignment. The streams in this study include Mud Creek and an Unnamed Tributary to Mud Creek. This report is prepared for the Alamo Regional Mobility Authority (ARMA) and Texas Department of Transportation.

The Rational Method was used to estimate peak flows where the contributing drainage area was less than or equal to 200 acres. The peak flows for drainage areas greater than 200 acres were calculated using the Soil Conservation Service (SCS) Dimensionless Unit Hydrograph method.

Storm water detention is required to mitigate the increase in runoff rate due to the increase in impervious cover from the proposed roadway improvements. The estimated detention storage volume was quantified using the Modified Rational Method, based on the inflow hydrograph, along with the maximum allowable flow from the detention facility. The maximum allowable outflow is equal to the existing 1% peak flow, since detention is required to provide sufficient storage volume such that peak outflows are limited to a rate that is “equal to” or “less than” the existing peak flow. All of the proposed detention basins have been located within the ROW and areas under the bridges have been utilized where possible for the locations. In some locations where adequate land area is not available, the detention has been located under the proposed roadway and runoff will be detained in box culverts. It was determined that detention ponds are not necessary for all drainage basins. The Mud Creek crossing, specifically, does not require a detention pond. Mud Creek has a rather large drainage basin of 13.15 square miles. The peak flow for Mud Creek does not occur for hours after the storm peak. The Mud Creek crossing within the US 281 project is located towards the lower portion of Mud Creek. The development decreased the time of concentration for the local drainage basin. The peak flow from the local basin is therefore conveyed downstream well before Mud Creek peaks. At this location the proposed development actually decreases the peak flow within Mud Creek. This is typical for a small developed site located towards the lower reaches of a large drainage basin.

There are 23 existing bridge or culverts where channels cross the existing US 281 alignment. Cross-culverts were sized based on the hydraulic impact analyses for the 10%, 4%, 2%, and 1% AEPs using HY-8. The culvert sizing approach entailed adjusting the culvert size in the proposed HY-8 model until no adverse hydraulic impacts for the 1% AEP design peak flows across the alignment and no adverse hydraulic impact on the crossing channels at the 1% AEP were observed due to the proposed US 281 improvements. If the structure was determined to be insufficient or in conflict with proposed roadway widening elements, then a new, preliminary structure size or relocation was proposed.

Mud Creek intersects US 281 near the southern portion of the project near station 360+00. Currently there is a typical TX-DOT bridge spanning 140’ with 4 interior bents. This bridge was previously sized to accommodate the 100 year storm event. With the recent construction of a regional detention pond, constructed upstream of this crossing, the peak flow in Mud Creek has been greatly reduced. Therefore, to reduce the costs of bridge improvements, this study analyzed replacing the bridge with 2 – 10’ x 5’ RCB. These culverts have been sized to maintain and not increase the water surface elevations upstream of the TX-DOT Right-of-Way during the 100-year storm event. During the 500-year storm event US 281 remains un-inundated. Other than the modifications to the bridge at Mud Creek no other changes have been made to the Effective Model.
Preliminary sizes for storm sewer systems were determined using the TxDOT Hydraulic Design Manual design standards, 10-year design frequency with WinStorm v. 3.05 software. The proposed storm sewer

system consists of two trunk line systems along the northbound and southbound mainlanes. The trunk line varies from 24” to 36” RCP along the northbound and southbound mainlanes throughout the project.

This project is located within the Edwards Aquifer Recharge Zone. The Edwards Aquifer rules are an effective mechanism we can use to protect this valuable resource. TQEC publication RG-348, Complying with the Edwards Aquifer Rules, Technical Guidance on Best Management Practices (BMP) provides the necessary requirements to comply with the water quality requirements.

The proposed roadway improvements create an increase of impervious cover. This impervious cover creates an increase of total suspended solids (TSS) in the storm runoff. Based on the TCEQ rules the amount of TSS must be reduced to an acceptable level before getting released to the receiving surface waters. The US 281 Roadway expansion project has committed to using Low Impact Development (LID) to mitigate the increase of TSS created by the improvements. For this project specific LID Best Management Practices have been chosen to achieve this requirement.

The TCEQ spreadsheets for TSS Removal Calculations dated 4-20-2009 were used with each chosen permanent BMP. TSS removal is achieved by directing the first flush of runoff to a pond having the volume required as specified by TCEQ Guidance Manual.

Vegetative filter strips will be utilized in areas where slopes and roadway widths permit the use. Grassy swales are also used as an effective BMP.

Where vegetative filter strips and grassy swales cannot be used bioretention ponds will be used. Bioretention facilities are effectively sand filters that include additional organic material in the filtration media to support vegetation. This allows these facilities to be integrated into the site landscaping where they can provide unobtrusive treatment of stormwater runoff. Biofiltration basins are sized to capture a specific volume that will mitigate the increased TSS load. Bioretention facilities are a commonly used BMP for projects with a large increase in pavement areas with right-of-way constraints.

BMP calculations have been performed utilizing the TCEQ’s equations/spreadsheet for TSS generation and removal. All ponds are approximately 5-feet deep, filled with approximately 4.5-feet of filter media with 0.5-feet of available volume for ponding. There will be an underdrain below the media in gravel. Approximately 5 to 10-feet of grass filter strip around the boundary of the bioretention pond on the sides where water flows into the pond and bed by grass-line channels. The vegetative filter strip will be at least 15-feet wide next to the roadway, with flat slopes and used where the pavement draining to the strip is less than 72-feet wide. No additional right-of-way is needed outside of what is already planned for roadway expansion due to BMP evaluation.

1.0 INTRODUCTION

1.1 Project Description

This study includes hydrologic analyses for approximately 7.5 miles of proposed improvements and widening of US 281 in Bexar County, Texas from Loop 1604 to Borgfeld Drive. The purpose of this study is to present the hydrologic analysis and mitigation recommendations to offset drainage impacts within the Salado Creek Watershed associated with the proposed improvements and widening of the US 281 alignment. This report is prepared for the Alamo Regional Mobility Authority (ARMA) and Texas Department of Transportation. Study findings and recommendations are based on best available information and subject to change as additional data becomes available.

1.2 Project Location

The project is located in Bexar County from Loop 1604 to Borgfeld Drive. **Exhibit 1** shows the project location. The majority of the project reach is located within the Salado Creek Watershed. The streams in this study include Mud Creek and an Unnamed Tributary to Mud Creek. The general topography of the project area is very hilly with overland slopes consisting of heavily developed commercial and residential areas for the majority of the US 281 Corridor. As seen in **Exhibit 2**, the drainage area spans 16.53 square miles upstream of the proposed roadway.

1.3 Existing Structure Crossings

There are 23 existing structure crossings located along the project, see **Exhibit 3.** The existing culvert structures were analyzed using HY-8 to determine if they currently pass the 50-year storm event without overtopping the road. The existing bridge structure was analyzed in HEC-RAS v. 4.1.0 to determine if it currently passes the 50-year storm event without overtopping the road. Section 3.3 will discuss the proposed improvements to the crossings. **Table 1** lists the existing structure crossing, the existing size, the 50-year culvert discharge.

Table 1: Existing Structure Crossing

DA ID	STA	EXISTING	50 YR CULVERT DISCHARGE	DISCHARGE OVER ROAD
			CFS	CFS
A	352+17.94	4-10'X7' MCB	1185.6	0
B *	358+71.94	BRIDGE	166	0
C	371+54.91	10'x7' RCB	230.95	0
D	378+93.99	3'x3' RCB	35.9	0
E	390+02.10	3'x3' RCB	16.91	0
F	395+00.56	3'x3' RCB	52.07	0
G	411+61.13	6'x3' RCB	161.81	50.35
H	429+79.05	7'x7' & 7'X4' RCB	303.32	0
I	451+08.36	3-6'x3' RCB	468.5	0
J	470+36.10	3'x3' RCB	105.21	0.91
K	477+54.11	3'x3' RCB	75.09	0
L	483+43.48	4'x3' RCB	82.5	65.97
M	490+30.80	6'x5' RCB	258.31	0
N	513+20.14	3'x3' RCB	70.76	0
O	528+79.40	3'x3' RCB	128.91	0
P	588+46.24	30" RCP	35.12	37.87
Q	617+86.47	3'x3' RCB	106.73	17.88
R	637+33.22	3'x3' RCB	81.79	30.64
S	647+79.20	4-5'x5' MBC	519.1	0
T	674+93.09	4'x3' RCB	116.71	16.19
U	689+79.59	10'x7' & 10'x5' RCB	294.43	0
V	704+31.46	5'x5' RCB	166.96	0
W	729+91.75	30" RCP	27.04	36.13

* BRIDGE CROSSES ZONE A, FIRM PANEL 48029C0255G

1.4 FEMA Mapping

The drainage study area is located in the regulatory floodplain designated as Zone A and Zone X, as shown in **Exhibit 4**. The proposed roadway alignment crosses through FIRM Panels 48029C0255G, 48029C0130G, and 48029C0140G, (all dated September 29, 2010). **Table 2** indicates all FIRM panels that contain the watershed boundaries of Mud Creek and Unnamed Tributary to Mud Creek upstream of the project.

Table 2: FIRM Panels

FIRM Panel No.	Effective Date
48029C0255G	9/29/2010
48029C0130G	9/29/2010
48029C0140G	9/29/2010

Areas designated as Zone X areas with minimal flood hazard, usually above the 500-year flood level. Zone A indicates that the area was mapped using approximate methods and does not have Base Flood Elevations or an Effective hydrologic or hydraulic model. The models developed for this study serve as the basis for evaluating current hydrologic and hydraulic conditions at the existing bridge and culvert crossings located along the US 281 project. These models were not developed to become the new Effective Models for FEMA.

Floodplain Administrator will be notified and provide a copy of this report upon approval of this report.

1.5 Assumptions, Constraints, and Resources

A list of the assumptions and constraints used for this project are provided below.

- In Bexar County, the Digital Elevation Map (DEM) dataset was obtained from LiDAR data obtained from TNRIS based on data collected by FEMA in 2009.
- All DEM data was supplemented by USGS data and utilized for drainage area delineation.
- The DEM has a horizontal datum of NAD 83 and a vertical datum of NAVD 88.
- Aerials from 2011 were obtained from the City of San Antonio GIS Website.
- Soil classifications were determined from data from the United States Department of Agricultural Soil Survey Geographic Database.
- TxDOT guidelines were utilized in this study.

2.0 HYDROLOGY

2.1 Location and Topography

The project site is located north of San Antonio, Texas in Bexar County in the Salado Creek Watershed as indicated in **Exhibit 1**. Mud Creek flows southeast to ultimately discharge into the Salado Creek Watershed. The area upstream of the proposed roadway segment is primarily undeveloped, with a mixture of pasture and some wooded areas. The general topography of the project area is very hilly and overland slopes vary from steep to shallow from the northwest to southwest. The elevations in the area range from approximately 1,372 feet to 902 feet (NAVD 88).

2.2 Drainage Area

The LiDAR topographic data was used in conjunction with a geographic information system (GIS) to delineate subbasins and offsite drainage areas. The latest 2' contour (2011) from the City of San Antonio GIS Website, were used as a reference and the drainage boundaries were modified and further subdivided based on locations of interest. Field visits were conducted to confirm the drainage area boundaries/divides at specific locations. The acreage was then calculated for each delineated basin.

The drainage basins were delineated using a combination of ArcHydro 2.0 for ArcGIS 10.1 based on topographic data. Drainage areas were delineated based on land use including woods, pasture, residential and commercial utilizing current aerial imagery, the 2010 Zoning and Future Land Use shape files from the City of San Antonio, and the Bexar County Appraisal District property information codes.

2.3 SCS Method – Peak Flow Computation for Cross Structure Analysis

Per TxDOT criteria, the peak flows for drainage areas greater than 200 acres were calculated using the Soil Conservation Service (SCS) Dimensionless Unit Hydrograph method. The hydrologic soil groups within the project area were located from the United States Department of Agriculture Soil Survey Geographic database (**Exhibit 5**). The majority of soils in the area were classified under hydrologic soil Group D, which has a slow infiltration rate when saturated and consist primarily of clays. Precipitation amounts for the 10-year through 100-year storm events were taken from the *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*. **Table 3** presents interpolated rainfall depths by storm frequency.

Table 3: Rainfall Depths by Storm Frequency

DURATION	STORM FREQUENCY			
	10 YR	25 YR	50 YR	100 YR
	RAINFALL DEPTH (IN)			
15 MIN	1.6	2	2.3	2.6
1 HR	2.8	3.3	3.9	4.4
2 HR	3.6	4.4	5	5.8
3 HR	4	4.9	5.8	6.5
6 HR	4.6	5.5	6.5	7.5
12 HR	5.25	6.5	7.5	8.5
24 HR	6	7.5	9	10

The SCS method also uses a curve number that is based on the land use of the drainage area. The area upstream of the proposed project along Mud Creek is primarily undeveloped, with a mixture of pasture and some wooded areas. The SCS method uses a curve number to represent losses. The curve number was based on the antecedent moisture condition II and soil conditions for pasture with good hydrologic conditions. To account for any developed areas, an additional 10% impervious area was included in the calculations per available aerial maps. The time of concentration was calculated using the SCS methodology outlined in the TxDOT Hydraulic Design Manual, with lag time set to 60% of the time of concentration where t_p = 0.6 t_c (minimum 10 minutes). The flow paths were divided into sheet flow, shallow concentrated flow, and channel flow reaches for each drainage area.

The SCS method flows were calculated using the HEC-HMS v3.3. A HEC-HMS model was created; the SCS Curve Number Loss Method was used to account for precipitation loss, while the SCS Unit Hydrograph was selected for transforming the direct runoff response. Watershed-specific parameters, including drainage area, Curve Number, percent imperviousness, and lag time were inserted into the HEC-HMS models.

The existing flows calculated, along with the hydrologic parameters, per drainage crossing are listed in **Table 4.** All hydrologic calculations can be found in **Appendix A**. The HEC-HMS model output data can be found in **Appendix B**.

Table 4: SCS Method Existing Peak Flows for Storm Events

				Land Use		Curve Number Method Flows (CFS)			
Drainage ID	Area (mi^2)	t_c (min)	t_L (min)	CN	%IMP	Q_{10YR}	Q_{25YR}	Q_{50YR}	Q_{100YR}
A	1.11	195.91	117.55	77	22.61%	729.1	739	1185.6	1375.6
B	13.27	520.56	312.34	72	23.70%	3334.3	3382.3	5675.8	6621.4
I	0.37	154.55	92.73	77	24.46%	291.2	295.1	468.5	543.9
S	0.47	128.39	77.03	64	11.87%	278.1	283	519.1	618.1

The proposed watershed characteristics and unit hydrograph parameters are presented in **Table 5**.

Table 5: SCS Method Proposed Peak Flows for Storm Events

				Land Use		Curve Number Method Flows (CFS)			
Drainage ID	Area (mi^2)	t_c (min)	t_L (min)	CN	%IMP	Q_{10YR}	Q_{25YR}	Q_{50YR}	Q_{100YR}
A	1.11	195.91	117.55	77	22.78%	729.6	739.6	1186.1	1376
B	13.27	520.56	312.34	72	23.78%	3336.1	3384.1	5677.5	6623.2
I	0.37	154.55	92.73	78	29.52%	302.5	306.5	478.9	554.8
S	0.47	128.39	77.03	65	14.79%	295.8	300.8	538.4	638.7

The increase in flows from existing conditions is shown in **Table 6**.

Table 6: SCS Method Increase in Peak Flows for Storm Events

	PROPOSED-EXISTING Flows (CFS)			
Drainage ID	Q_{10YR}	Q_{25YR}	Q_{50YR}	Q_{100YR}
A	0.5	0.6	0.5	0.4
B	1.8	1.8	1.7	1.8
I	11.3	11.4	10.4	10.9
S	17.7	17.8	19.3	20.6

The Rational Method, discussed in the next section, was used to calculate peak flows for the remaining 19 subareas with less than 640 acres.

2.4 Rational Method – Peak Flow Computation for Cross Structure Analysis

The Rational Method was used to estimate peak flows for small drainage areas of up to about 200 acres. The utilization of the Rational Method follows the guidelines described in *Chapter 4, Section 12* of the *Texas Department of Transportation (TxDOT) Hydraulic Design Manual* (Revised May 2014). The Rational Method equation is expressed as

$$Q = CIA,$$

Where:

Q = maximum rate of runoff (cfs),

C = runoff coefficient,

I = average rainfall intensity (in/hr), and

A = drainage area (ac).

A runoff coefficient (*C*) was assigned to each land-use type in this study. A composite *C*-values was then calculated for each drainage area using weighted *C*-values of various land-uses within the drainage area. For the details on the determination of area-weighted Composite *C*-values, please refer to **Section 2.4.2, Land-Use.**

The rainfall intensity was determined using the equation

$$I = \frac{b}{(t_c+d)^e},$$

Where:

I = rainfall intensity (in/hr), and

t_c = time of concentration (min).

b, *d*, *e* = coefficients for specific frequencies listed by county in the rainfall Intensity-Duration-Frequency coefficients provided by Texas Department of Transportation.

The t_c is required in the Rational Method for estimating the design average rainfall intensity. The next section, 2.3.1 Time of Concentration will discuss the methodology discussed used for t_c to compute peak flows using the Rational Method for culvert sizing. For peak flows calculated using the Rational Method for right of way analysis, a minimum of 10 minutes was used as the time of concentration.

Table 7 presents the *b*, *d,* and *e* values used in this study for Bexar County provided by the Texas Department of Transportation.

Table 7: Rainfall Intensity-Duration-Frequency Coefficients for Bexar County

Year	b	d	e
2	56	8.7	0.798
5	70	8.7	0.784
10	79	8.7	0.779
25	88	8.7	0.769
50	94	8.7	0.756
100	107	8.7	0.762
250	150.1	14.892	0.7822
500	188	17.233	0.7959

Once runoff coefficient (*C*), average rainfall intensity (*I*) and drainage area acreage (*A*) were determined, they were substituted into the Rational Method equation to calculate peak flows.

2.4.1 Time of Concentration

For the peak flow calculation to size culverts, a travel-based t_c was computed for each drainage area. The t_c is the time at which the entire drainage area contributes to runoff and is calculated based on the time it takes for flow to travel from the most hydraulically remote point in the drainage area to the outfall of the drainage area.

In order to determine t_c, the runoff flow path that requires the longest travel time was identified in GIS based on LiDAR contour data and aerial photos. The flow path was then divided into segments for various flow types, including overland sheet flow, shallow concentrated flow, and open channel flow. Note that sheet flow was assumed to be applicable up to a flow length of no greater than 300 feet, and becomes shallow concentrated flow after that, per Technical Release 55 (TR-55) and TxDOT guidelines.

The travel time for sheet flow was calculated as:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_{2)}^{0.5} s^{0.4}}$$

Where:

T_t = travel time (hr.)

n = Manning's roughness coefficient

L= flow length (ft.), <300 ft.

P_2 = 2-year, 24-hour rainfall (in)

s = slope of hydraulic grade line (land slope, ft./ft.)

The travel time for shallow concentrated and channel flow was calculated as:

$$T_t = \frac{L}{3600V}$$

T_t = travel time (hr.)

L= flow length (ft.)

V= average velocity (ft./s)

3600 = conversion factor from seconds to hours

The average velocity for open channel flow was calculated using Manning's equation:

$$V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$$

Where:

V = average velocity (ft/s)

r = hydraulic radius (ft.) and is equal to a/p_w

a = cross sectional flow area (ft^2)

p_w = wetted perimeter (ft.)

s = slope of the hydraulic grade line (channel slope ft/ft)

n = Manning's roughness coefficient for open channel

For slopes less than 0.005 ft./ft., the following equations are used to calculate average velocities for shallow concentrated flow:

Unpaved: $V = 16.1345\ (s)^{0.5}$

Paved: $V = 20.3282\ (s)^{0.5}$

Travel time estimation requires flow velocity for various flow types. The flow path slope was determined using LiDAR contour data in GIS.

The total t_c for a drainage area was then determined as the sum of travel times for the runoff to flow through segments of all flow types along the entire flow path within the drainage area.

Within each drainage area, existing and proposed conditions flow paths were drawn and slopes along these flow paths were calculated using the LiDAR dataset. The slopes were used to estimate velocities, as described above, and the velocities were used to estimate time of concentration.

2.4.2 Land-Use

Peak flow estimations were calculated using a runoff coefficient (C) which is a function of land-use. Land-use was determined using a combination of aerial photography and the 2010 Zoning and Future Land Use shape files from the City of San Antonio and the Bexar County Appraisal District property information codes. **Table 8** presents C-values for various land-use types in the study.

The proposed land-use data incorporated additional paved and unpaved (grass-covered) areas within the ROW, usually 400 feet wide, for the proposed highway alignment.

Table 8: Runoff Coefficient (C) Values for Various Land Use Types

Land Use Type	C-Value*	Percent Impervious Cover
Grass-Covered ROW	0.4	0%
Pavement	0.9	100%
Commercial/ Residential	0.75	100%

*C-Values from the City of San Antonio Unified Development Code, conservative criteria

Using the following equation, an area weighted C-value was calculated for each drainage area for the existing and proposed conditions.

$$\bar{C} = \frac{\sum_{i=0}^{n} A_i C_i}{\sum_{i=0}^{n} A_i},$$

Where:

C_i = Land-use C-values for drainage area,

A_i = Area associated with land-use for drainage area, and

$\bar{C}$ = Area weighted C for the drainage area.

The area weighted C-values for each drainage area were used to calculate existing and proposed peak flow estimates for the Rational Method.

The Right of Way peak flows were used to calculate required detention pond volumes, size inlets, and size the preliminary storm sewer system.

Table 9 is the summary of existing hydrologic parameters and peak flows using the Rational Method.

The proposed flows with the hydrologic parameters for the remaining 19 subareas using the Rational Method are presented in **Table 10**.

Table 9: Rational Method Existing Peak Flows for Storm Events

			INTENSITY				C VALUE				FLOWS			
DA ID	AREA	Tc	I10	I25	I50	I100	PAVEMENT	BUSINESS / RESIDENTIAL	GRASSY	C WEIGHTED	Q10	Q25	Q50	Q100
	AC	MIN	IN/HR	IN/HR	IN/HR	IN/HR	0.9	0.75	0.4		CFS	CFS	CFS	CFS
C	167.18	91	2.19	2.56	2.90	3.21	7.40	26.06	133.73	0.48	175	204	231	256
D	6.62	10	8.07	9.26	10.27	11.49	1.37	0.47	4.79	0.53	28	32	36	40
E	3.21	10	8.07	9.26	10.27	11.49	0.56	0.24	2.41	0.51	13	15	17	19
F	9.72	10	8.07	9.26	10.27	11.49	1.97	0.56	7.19	0.52	41	47	52	58
G	51.33	24.65	5.14	5.93	6.63	7.39	2.76	28.87	19.70	0.62	165	190	212	237
H	105.91	38.58	3.92	4.54	5.09	5.67	3.96	43.43	58.52	0.56	233	270	303	337
J	29.62	22.35	5.44	6.27	7.00	7.81	2.56	5.80	21.26	0.51	82	95	106	118
K	15.77	14.74	6.77	7.78	8.66	9.67	2.77	2.80	10.20	0.55	59	67	75	84
L	29.07	16	6.50	7.47	8.32	9.29	2.44	14.28	12.35	0.61	116	133	149	166
M	115.11	42	3.71	4.30	4.83	5.37	5.48	13.34	96.28	0.46	198	230	258	287
N	16.77	15.65	6.57	7.56	8.41	9.39	2.36	1.51	12.91	0.50	55	64	71	79
O	25.48	17.85	6.14	7.07	7.88	8.80	1.77	15.09	8.62	0.64	100	116	129	144
P	15.83	16.38	6.42	7.39	8.23	9.19	3.33	2.51	9.99	0.56	57	66	73	82
Q	26.2	14.78	6.76	7.77	8.65	9.66	5.15	3.89	17.16	0.55	97	112	125	139
R	27.89	23.25	5.32	6.13	6.85	7.64	3.12	10.59	14.18	0.59	87	101	113	125
T	32.03	18.93	5.95	6.86	7.65	8.53	2.22	9.90	19.91	0.54	104	119	133	148
U	169.76	52.58	3.20	3.72	4.19	4.65	4.83	0.00	164.93	0.41	225	261	294	327
V	58.22	26.32	4.95	5.71	6.39	7.12	3.44	3.18	51.60	0.45	129	149	167	186
W	14.46	14.75	6.77	7.78	8.66	9.67	3.04	0.00	11.42	0.51	49	57	63	71

Table 10: Rational Method Proposed Peak Flows for Storm Events

			INTENSITY				C VALUE				FLOWS			
DA ID	AREA	Tc	I10	I25	I50	I100	PAVEMENT	BUSINESS / RESIDENTIAL	GRASSY	C WEIGHTED	Q10	Q25	Q50	Q100
	AC	MIN	IN/HR	IN/HR	IN/HR	IN/HR	0.9	0.75	0.4		CFS	CFS	CFS	CFS
C	167.18	91	2.19	2.56	2.90	3.21	20.05	25.77	121.36	0.51	188	220	249	276
D	6.62	10	8.07	9.26	10.27	11.49	3.39	0.47	2.76	0.68	36	42	46	52
E	3.21	10	8.07	9.26	10.27	11.49	1.39	0.24	1.58	0.64	17	19	21	24
F	9.72	10	8.07	9.26	10.27	11.49	3.29	0.56	5.87	0.59	46	53	59	66
G	51.33	24.65	5.14	5.93	6.63	7.39	5.88	28.86	16.58	0.65	173	199	223	248
H	105.91	38.58	3.92	4.54	5.09	5.67	8.95	43.40	53.56	0.59	243	281	316	351
J	29.62	22.35	5.44	6.27	7.00	7.81	6.48	5.52	17.62	0.57	93	107	119	133
K	15.77	14.74	6.77	7.78	8.66	9.67	6.12	2.02	7.63	0.64	68	78	87	97
L	29.07	16	6.50	7.47	8.32	9.29	5.15	14.25	9.68	0.66	125	143	160	178
M	115.11	42	3.71	4.30	4.83	5.37	14.30	13.34	87.46	0.50	215	249	280	311
N	16.77	15.65	6.57	7.56	8.41	9.39	5.30	0.49	10.98	0.57	63	72	80	90
O	25.48	17.85	6.14	7.07	7.88	8.80	1.84	15.02	8.63	0.64	101	116	129	144
P	15.83	16.38	6.42	7.39	8.23	9.19	5.42	2.35	8.06	0.62	63	73	81	91
Q	26.2	14.78	6.76	7.77	8.65	9.66	9.57	3.89	12.74	0.63	112	129	144	161
R	27.89	23.25	5.32	6.13	6.85	7.64	8.17	8.14	11.58	0.65	96	111	124	138
T	32.03	18.93	5.95	6.86	7.65	8.53	3.68	8.27	20.08	0.55	104	120	134	150
U	169.76	52.58	3.20	3.72	4.19	4.65	9.02	0.00	160.74	0.43	232	269	303	337
V	58.22	26.32	4.95	5.71	6.39	7.12	8.06	1.45	48.71	0.48	138	159	178	198
W	14.46	14.75	6.77	7.78	8.66	9.67	6.36	0.00	8.10	0.62	61	70	78	87

The increase in flows from existing conditions is shown in **Table 11**.

Table 11: Rational Method Increase in Peak Flows for Storm Events

	PROPOSED-EXISTING Flows (CFS)			
DA ID	Q_{10YR}	Q_{25YR}	Q_{50YR}	Q_{100YR}
C	14	16	18	20
D	8	9	10	12
E	3	4	4	5
F	5	6	7	8
G	8	9	10	12
H	10	11	13	14
J	10	12	13	15
K	9	11	12	14
L	9	10	11	12
M	16	19	21	24
N	7	8	9	10
O	0	0	0	0
P	6	7	8	9
Q	15	17	19	21
R	9	10	11	13
T	1	1	1	1
U	7	8	9	10
V	8	10	11	12
W	11	13	14	16

These flows were used to size the cross culvert structures using HY-8 which will be discussed in **Section 3.3** of this report.

2.5 Hydrology Method – Peak Flow Computation for Right of Way Analysis

The Rational Method was utilized to calculate the peak flows for the Right-of-Way Analysis and the Modified Rational Method was used to determine the detention volume required to mitigate the increased runoff from the proposed roadway improvements. The Rational Method discussion can be found in **Section 2.4** of this report. The Modified Rational Method is discussed in **Section 2.6** of this report.

2.6 Detention Volume Estimation

Storm water detention is required to mitigate the increase in runoff rate due to the increase in impervious cover from the proposed roadway improvements. The detention volume was quantified for each drainage area for the 400-foot right of way at each outfall. The difference between the existing and proposed 100-year storm event peak flow was used to estimate the required detention volume. The estimated detention storage volume was quantified using the Modified Rational Method, based on the inflow hydrograph. The maximum allowable flow from the detention facility was based on existing 100-year peak flows. The maximum allowable outflow is equal to the existing 1% peak flow, since detention is required to provide sufficient storage volume such that peak outflows are limited to a rate that is “equal to” or “less than” the existing peak flow.

Per the requirements of this project, peak flows downstream of the project cannot be increased. The additional impervious cover due to the roadway improvements creates increases to the peak runoff. To attenuate these flows mitigation will be required. All of the proposed detention basins have been located within the ROW and areas under the bridges have been utilized where possible for the locations. In some locations where adequate land area is not available, the detention has been located under the proposed roadway and runoff will be detained in reinforced concrete box culverts.

The proposed detention ponds have been sized using the Modified Rational Method. Runoff coefficients were weighted based on impervious cover land use percentages using the methodology discussed in the previous **Section 2.4.2 Land Use.**

The time of concentration used in the detention volume estimation was a minimum 10 minutes, as previously discussed in **Section 2.4.1 Time of Concentration**. Bexar County EBD coefficients have been used to calculate the storm intensity.

The Modified Rational Method calculates the required volume necessary to attenuate the peak flow by comparing the proposed inflow from the drainage basin to the required maximum outflow from the pond. This trial and error method produces the most conservative pond volume estimate. The equation used to calculate the inflow volume is:

$$\mathbf{V_i} = 60(1/2)(Q_P)[(t_d-t_c)+(t_d+t_c)]$$

Where: Q_P = peak inflow
t_d = critical storm duration, trial and error, See **Appendix C**
t_c = Time of concentration

The equation used to calculate the outflow volume is:

$$\mathbf{Vo} = 60(1/2)(Q_A)(t_d+t_c)$$

Where: Q_A = peak outflow
The required storage volume is then:

$$\mathbf{SD} = V_i - V_o$$

It was determined that detention ponds are not necessary for all drainage basins. The Mud Creek crossing, specifically, does not require a detention pond. Mud Creek has a rather large drainage basin of 13.15 square miles. The peak flow for Mud Creek does not occur for hours after the storm peak. The Mud Creek crossing within the US 281 project is located towards the lower portion of Mud Creek. Development has decreased the time of concentration for the local drainage basin. The peak flow from the local basin is therefore conveyed downstream well before Mud Creek peaks. At this location the

proposed development actually decreases the peak flow within Mud Creek. This is typical for a small developed site located towards the lower reaches of a large drainage basin.

A summary of the detention volume estimation is summarized in **Table 12**. The Modified Rational Method detention volume calculation can be found in **Appendix C**.

Table 12: Detention Volume Summary

POND	DETENTION POND VOLUME + 20%	UNDERGROUND DETENTION POND CULVERT SIZE	UNDERGROUND DETENTION POND TOTAL CULVERT LENGTH	UNDERGROUND DETENTION POND VOLUME + 20%
	AC-FT	RCB, W'xH'	LF	AC-FT
A	1.4			
B				
C1+C2		4x4	3,160	1.2
D		4x4	2,800	1.0
E		4x4	3,317	1.2
F	1.5			
G1+G2		5x5	2,480	1.4
H1+H2		5x5	4,680	2.7
I	1.6			
J	0.9			
K	0.8			
L	2.1			
M1+M2		3x3	8,261	1.7
N	1.1			
O1+O2		5x5	7,240	4.2
P	1.2			
Q1+Q2		4x4	5,820	2.1
R		4x4	4,157	1.5
S	1.0			
T		4x4	1,678	0.6
U		5x5	1,950	1.1
V	0.5			
W	1.6			

*Drainage Area B does not require a detention pond as discussed in Section 2.6

Further analysis during design phase can be done to determine if detention ponds adjacent to the roadway can be sized to over detain runoff to reduce the number of underground detention ponds listed in **Table 12**.

3.0 Hydraulics

3.1 Mud Creek HEC-RAS Model

Mud Creek is included in the Flood Insurance Study for Bexar County as a Flood Zone in the Salado Creek watershed. An Effective Model hydraulic model for Mud Creek was available from the San Antonio River Authority (SARA) through their Digital Data & Modeling Repository (D2MR) website. The portion of the Mud Creek hydraulic model that was used for this analysis was the Upper Mud Creek Reach.

Mud Creek intersects US 281 near the southern portion of the project near station 360+00. Currently there is a bridge spanning 140' with 4 interior bents. This bridge was previously sized to accommodate the 100 year storm event. With the recent construction of a regional detention pond, upstream of this crossing, the peak flow in Mud Creek has been greatly reduced. The Effective Mud Creek HEC-RAS model downloaded from the SARA website included the reduction of flow in the model, as discussed and concurred with by TxDOT and the ARMA. For the proposed conditions model the existing bridge was replaced with two 10' x 5' box culverts. These culverts have been sized to maintain and not increase the water surface elevations upstream of the TX-DOT Right-of-Way during the 100-year storm event as identified in the Effective Model. During the 500-year storm event US 281 is not inundated. Other than the modifications to the bridge at Mud Creek this analysis makes no other changes to the Effective Model.

3.1.1 Unnamed Ditch HEC-RAS Model

An unnamed Ditch intersects US 281 near the northern portion of the project near station 647+43. The existing bridge class culvert, 4-5'x5' MBC, sized to accommodate the 50 year storm event. For the proposed conditions model the existing bridge class culvert was relocated to station 647+79 and extended to the proposed roadway improvements.

3.2 Water Surface Elevations

The proposed US 281 improvements through Bexar County crosses Mud Creek and an Unnamed Tributary to Mud Creek. The Upper Mud Creek HEC-RAS model was downloaded from the San Antonio River Authority (SARA) website January 2014. The model is dated November 2005, created by PBS&J.

3.3 Cross Structure Sizing

There are 23 existing bridge or culverts where channels cross the existing US 281 alignment. Peak flows were estimated using the SCS and Rational Method, as described in **Section 2.3**. Cross-culverts were sized based on the hydraulic impact analyses for the 10%, 4%, 2%, and 1% AEPs using HY-8.

The culvert sizing approach entailed adjusting the culvert size in the proposed HY-8 model until no adverse hydraulic impacts (i.e. increases in WSE from existing condition) were observed due to the proposed US 281 improvements. Any increase in flow downstream due to the larger proposed culvert will be mitigated by the detention ponds. Culverts sized from this procedure provide sufficient conveyance for the 2% AEP design peak flows across the alignment and no adverse hydraulic impact on the crossing channels at the 2% AEP.

The HY-8 software requires tailwater data for culvert sizing. The required tailwater data are either the information of downstream channel (e.g., channel shape, size, Manning's n and invert elevation) or a constant elevation. A constant tailwater elevation was used and conservatively calculated as the soffit elevation of the culvert. The HY-8 culvert analysis output for existing and proposed conditions can be found in **Appendix D**.

If the structure was determined to be insufficient or in conflict with proposed roadway widening elements, then a new, preliminary structure size or relocation was proposed. **Table 13** lists the existing structure crossing, the existing size, the estimated current capacity, and proposed improvements, if necessary. **Exhibit 3** shows the locations of the proposed cross culvert structures.

Table 13: Proposed Cross Culvert Structures

DA ID	EXISTING STA	EXISTING	PROPOSED IMPROVEMENTS	PROPOSED STA	EXISTING 50 YR CULVERT DISCHARGE	PROPOSED 50 YR CULVERT DISCHARGE
					CFS	CFS
A	352+18.14	4-10'X7' MBC	NONE	352+18.14	1185.6	1186.1
B	358+74.26	BRIDGE	2-10'x5' MBC	358+71.94	166	166
C	369+30.37	10'x7' RCB	RELOCATE	371+54.91	230.95	249
D	378+65.80	3'x3' RCB	RELOCATE	378+93.99	35.9	46.3
E	389+84.24	3'x3' RCB	RELOCATE	390+02.10	16.91	21.19
F	394+97.42	3'x3' RCB	RELOCATE	395+00.56	52.07	58.84
G	411+33.43	6'x3' RCB	RELOCATE	411+61.13	161.81	222.69
H	429+61.99	7'x7' & 7'X4' RCB	9'x5' RCB	429+79.05	303.32	315.98
I	450+93.76	3-6'x3' RCB	RELOCATE	451+08.36	468.5	478.9
J	470+24.67	3'x3' RCB	4'x3' RCB	470+36.10	105.21	119.15
K	477+54.41	3'x3' RCB	RELOCATE	477+54.11	75.09	87.23
L	483+93.14	4'x3' RCB	RELOCATE	483+43.48	82.5	159.68
M	490+31.03	6'x5' RCB	RELOCATE	490+30.80	258.31	279.62
N	512+11.77	3'x3' RCB	RELOCATE	513+20.14	70.76	70.78
O	528+77.42	3'x3' RCB	4'x3' RCB	528+79.40	128.91	128.97
P	588+39.89	30" RCP	3'x3' RCB	588+46.24	35.12	81.15
Q	618+05.30	3'x3' RCB	4'x3' RCB	617+86.47	106.73	143.78
R	637+96.94	3'x3' RCB	4'x3' RCB	637+33.22	81.79	123.92
S	647+43.90	4-5'x5' MBC	RELOCATE	647+79.20	519.1	538.4
T	674+01.58	4'x3' RCB	RELOCATE	674+93.09	116.71	134.17
U	689+66.87	10'x7' & 10'x5' RCB	2-6'x5' MBC	689+79.59	294.43	303.2
V	704+19.78	5'x5' RCB	EXTEND	704+19.78	166.96	177.84
W	730+47.18	30" RCP	3'x3' RCB	729+91.75	27.04	77.58

3.3.1 Bridge to Box Culvert

Due to the Regional Detention Pond upstream of US 281, the existing US 281 bridge over Mud Creek is significantly higher than the Mud Creek water surface elevation shown in the Effective HEC-RAS Model. Therefore, to reduce the costs of bridge improvements, this study analyzed replacing the bridge with 2 – 10' x 5' RCB. The box culverts were modeled in the Upper Mud Creek HEC-RAS model to ensure that no increases in WSE were caused by the replacement of the bridge under proposed conditions for the 1% AEP storm event. A cost comparison determined that it was more cost effective to replace the US 281 bridge with two box culverts than to widen and improve the existing bridge. The replacement was discussed on February 26, 2014 with TxDOT and the ARMA with no objection from either parties.

Proposed changes (i.e. replacing the bridge with two 10'x5' RCB) were incorporated into the proposed geometry.

The existing FEMA flows were used in the proposed crossing plan since any increased runoff from the roadway project will be mitigated in onsite detention. **Table 14** compares the existing and the proposed US 281 Mud Creek cross structure 100-year WSEL.

Table 14: Proposed US 281 Cross Structure Summary

EXIST STA	EXIST 100 YR WSEL (FT)	PROP STA	PROP 100 YR WSEL (FT)	∆ PROP-EXIST 100 YR WSEL (FT)
39246	909.93	39246	909.93	0
38717	905.31	38717	905.33	0.02
38252	Bridge	38252	Culvert	Culvert
37713	901.16	37713	901.16	0

3.3.2 Bridge Class Box Culvert

The box culverts at station 647+43 were modeled in the Unnamed Ditch HEC-RAS model to ensure that no increases in WSE were caused by the relocation of the bridge class culverts under proposed conditions station 647+79, for the 2% AEP storm event. The proposed improvements to the roadway and culvert extension were incorporated into the proposed geometry.

Table 14.1 compares the existing and the proposed US 281 Unnamed Ditch cross structure 50-year WSEL.

Table 14.1: Proposed US 281 Cross Structure Summary

EXIST STA	EXIST 50 YR WSEL (FT)	PROP 50 YR WSEL (FT)	∆ PROP-EXIST 50 YR WSEL (FT)
548	1173.66	1173.66	0
518	1173.08	1173.08	0
498	1170.60	1172.31	1.71

The increase in the 50-year WSEL from existing to proposed condition at the upstream end of the proposed 4-5'x5' MBC is 1.71-ft. All flows are contained within the culvert and the bridge structure is not overtopped and can pass the 2% AEP. There are also no adverse impacts on any nearby structures. The increase attenuates 20-ft or less upstream of the bridge structure. The HEC-RAS output can be found in **Appendix E**.

3.4 Preliminary Drainage System including Storm Sewer System

Preliminary sizes for storm sewer systems were determined using the TxDOT Hydraulic Design Manual design standards, 10-year design frequency with WinStorm v. 3.05 software. The drainage areas were divided into smaller areas from the centerline of the roadway to the right of way plus 150-foot development strip at a c=0.65, where applicable. The smaller drainage areas were 400-feet long or less. The drainage systems are typically divided along the roadway centerline, with the two sides of the roadway having independent drainage systems to reduce the number of places where the storm sewer crosses beneath the mainlanes of the US 281.

Since this is a preliminary analysis to size the storm sewer pipes and determine the number of inlets required for the proposed roadway improvements, the minimum time of concentration used was 10 minutes, the runoff coefficient (*C*) for pavement (0.9) was used, and the smaller drainage areas were calculated as previously discussed.

The lower of the natural ground elevations or the edge of pavement elevations was used for the critical elevation. These elevations were used as part of the storm sewer sizing and depth of cover calculations. Edge of pavement for roadway crossings and ramp/frontage road crossings were also considered in determining cover requirements.

The proposed storm sewer system consists of two trunk line systems along the northbound and southbound mainlanes. The trunk line varies from 24” to 36” RCP along the northbound and southbound mainlanes throughout the project. The WinStorm outputs for the storm sewer systems are included in **Appendix F**.

4.0 Best Management Practices

This project is located within the Edwards Aquifer Recharge Zone. The Edwards Aquifer rules are an effective mechanism we can use to protect this valuable resource. These rules, found in Title 30 Texas Administrative Code Chapter 213, address activities that could pose a threat to water quality in the Edwards Aquifer, including wells and springs fed by the aquifer and water sources to the aquifer, including uplands areas draining directly to it and surface streams. TCEQ publication RG-348, Complying with the Edwards Aquifer Rules, Technical Guidance on Best Management Practices (BMP), Revised July 2005, provides the necessary requirements to comply with the water quality requirements.

The proposed roadway improvements create an increase of impervious cover. This impervious cover creates an increase of total suspended solids (TSS) in the storm runoff. Based on the TCEQ rules the amount of TSS must be reduced to an acceptable level before getting released to the receiving surface waters. The US 281 Roadway expansion project has committed to using Low Impact Development (LID) to mitigate the increase of TSS created by the improvements. For this project, the following LID Best Management Practices have been chosen to achieve this requirement:

- Vegetative filter strips
- Bioretention ponds

The following assumptions have been made in the development of this analysis:

- All existing impervious cover is assumed to have been in place per regulatory rules (if any) at the time of their installation and no treatment will be included in calculations for existing impervious cover. There are no requirements for treating existing impervious cover, only that increased impervious cover from the proposed project.
- All bioretention pond locations are approximate and exact locations will be identified during final design.
- A detailed drainage design will be required during the final design.
- This report has been provided to determine whether treatment goals can be met. Development of the water quality basins (bioretention ponds) during the final design will require the evaluation of best location and design configuration for the basins.

4.1 Regulatory Requirements

The proposed roadway improvement project consist of additional impermeable surfaces, primarily in the form of expanded roadways, which prevent the natural infiltration of water into the soil and are therefore defined by the TCEQ as impervious cover areas. Impervious cover increases the potential for surface water contamination with suspended solids, thus introducing an increased risk of groundwater degradation as a result. To prevent contaminated storm water from reaching downstream receiving waters and groundwater, the TCEQ regulates the total suspended solid (TSS) load permitted to leave the site by requiring an Edwards Aquifer protection plan that must reduce the increase in TSS load associated with development by at least 80%.

Prior to commencement of construction, an Edwards Aquifer protection plan must be filed and approved in compliance with TCEQ regulations. The rules and regulations for any regulated activity within the Edwards Aquifer recharge zone are available for reference in Texas Administrative Code Title 30 Chapter 213 Subchapter A.

Acceptable methods of solids removal are listed in the TCEQ Technical Guidance Manual (Complying with the Edwards Aquifer Rules – Technical Guidance on Best Management Practices, TCEQ, July 2005) and includes design criteria.

4.2 Methodology

The TCEQ spreadsheets for TSS Removal Calculations dated 4-20-2009 were used with each chosen permanent BMP. TSS removal is achieved by directing the first flush of runoff to a pond having the volume required as specified by TCEQ Guidance Manual.

4.2.1 Treatment Method

Vegetative filter strips will be utilized in areas where slopes and roadway widths permit the use. Vegetative filter strips can receive a flow from a maximum of 72-feet of roadway width and cannot be constructed on slopes greater than 20%. This criterion prevents vegetative filter strips from being used throughout the entire project.

Where vegetative filter strips cannot be used bioretention ponds will be used. Bioretention facilities are effectively sand filters that include additional organic material in the filtration media to support vegetation. This allows these facilities to be integrated into the site landscaping where they can provide unobtrusive treatment of stormwater runoff. Biofiltration basins are sized to capture a specific volume that will mitigate the increased TSS load. Bioretention facilities are a commonly used BMP for projects with a large increase in pavement areas with right-of-way constraints within the San Antonio area. The calculations for the bioretention pond sizes are in **Appendix G**.

Calculations are provided for all of the watersheds using the same treatment. By using the same treatment on all of the watersheds, the ability to obtain treatment within a watershed can be more easily judged.

4.2.2 Bioretention Pond Calculations/Sizing

The proposed project area has been divided into subareas in order to estimate the required and obtainable TSS removal. Each subarea has been evaluated for the amount of TSS increase, the removal required and the amount of removal obtained from the proposed BMP.

BMP calculations have been performed utilizing the TCEQ's equations/spreadsheet for TSS generation and removal. Summary sheets from the TSS generation, removal calculations, and basin sizes required for appropriate TSS removal are presented in **Appendix G**. **Exhibit 3** shows the approximate locations for the vegetative strips and bioretention ponds. **Table 15** shows the bioretention pond volume and sizing.

The inputs required for the TSS calculations included the total project area, the County in which the project resides (for rainfall determination), the amount of existing, and proposed impervious areas. As mandated by TCEQ, 80% removal of the increase in TSS is calculated as a required removal. All existing impervious cover is assumed to have been in place per regulatory rules (if any) at the time of their installation. There are no requirements for the treatment of the existing impervious cover.

The proposed roadway design files were used to obtain all proposed impervious cover calculations. The procedure below was used to evaluate the proposed improvements:

1. Delineate impervious areas within the right-of-way.

2. Calculate the total post construction impervious cover.
3. Use the TCEQ spreadsheet to determine the TSS removal goals for each drainage subarea and estimate basin volumes to achieve the required removal.
4. Identify locations for water quality ponds.

Table 15 is a summary of the water quality pond volumes and provides sizing suggestions. The acre-feet volume represents the entire excavated volume of the pond. All ponds are approximately 5-feet deep, filled with approximately 4.5-feet of filter media with 0.5-feet of available volume for ponding; please refer to the TCEQ RG-348 publication for filter media properties and water quality volume. There will be an underdrain, encased in gravel, below the media in gravel. Approximately 5 to 10-feet of grass filter strip around the boundary of the bioretention pond on the sides where water flows into the pond and bed from grass-line channels. The vegetative filter strip will be at least 15-feet wide next to the roadway, with flat slopes and used where the pavement draining to the strip is less than 72-feet wide.

Table 15. Bioretention Pond Volumes

DRAINAGE BASIN	TOTAL WATER QUALITY POND VOLUME	TOTAL WATER QUALITY POND VOLUME	SIZING COMMENTS
	CF	AC-FT	
A	5,401	0.12	4 bioretention ponds: 18x18 ft (approximate)
B	21,873	0.50	2 bioretention ponds: 47x47 ft (approximate)
C	9,567	0.22	1 bioretention pond: 44x44 ft (approximate)
D	9,264	0.21	1 bioretention pond: 44x44 ft (approximate)
E	8,686	0.20	2 bioretention ponds: 30x30 ft (approximate)
F	12,913	0.30	2 bioretention ponds: 36x36 ft (approximate)
G	11,948	0.27	2 bioretention ponds: 35x35 ft (approximate)
H	21,775	0.50	3 bioretention ponds: 35x35 ft (approximate)
I	13,486	0.31	2 bioretention ponds: 37x37 ft (approximate)
J	6,225	0.14	1 bioretention pond: 36x36 ft (approximate)
K	6,098	0.14	1 bioretention pond: 35x35 ft (approximate)
L	17,598	0.40	2 bioretention ponds: 42x42 ft (approximate)
M	13,275	0.30	2 bioretention ponds: 37x37 ft (approximate)
N	8,504	0.20	1 bioretention pond: 42x42 ft (approximate)
O	34,169	0.78	4 bioretention ponds: 42x42 ft (approximate)
P	8,703	0.20	2 bioretention ponds: 30x30 ft (approximate)
Q	17,825	0.41	3 bioretention ponds: 35x35 ft (approximate)
R	7,587	0.17	2 bioretention ponds: 28x28 ft (approximate)
S	3,380	0.08	2 bioretention ponds: 19x19 ft (approximate)
T	2,502	0.06	2 bioretention ponds: 16x16 ft (approximate)
U	7,714	0.18	2 bioretention ponds: 28x28 ft (approximate)
V	1,420	0.033	1 bioretention pond: 17x17 ft (approximate)
W	10,376	0.24	3 bioretention ponds: 27x27 ft (approximate)

5.0 Conclusions and Analysis

This report presents the drainage impact analysis/preliminary detention impact analysis of the US 281 roadway widening from Loop 1604 to Borgfeld Drive in Bexar County, Texas. Procedures presented in the TxDOT Hydraulic Design Manual (Revised May 2014) and the City of San Antonio Unified Development Code for Stormwater Management (January 1, 2006) were followed to perform hydrology and hydraulics for various structure crossings. The analysis identified cross culverts and a bridge crossing, sized and relocated culverts for the 2% AEP design peak flow. Conclusions and recommendations are summarized below based on the analysis in the report:

- There are 23 existing structure crossings located along the project shown on **Exhibit 3**. The existing culvert structures were analyzed using HY-8 and the existing bridge structure was analyzed in HEC-RAS v. 4.1.0 to determine if the structures currently pass the 50-year storm event without overtopping the road. **Table 1** lists the existing structure size and estimated current capacity.

- The Rational Method was utilized to calculate the peak flows for the Right-of-Way Analysis and the Modified Rational Method was used to determine the detention volume required to mitigate the increased runoff from the proposed roadway improvements. The Rational Method discussion can be found in **Section 2.4** of this report.

- Storm water detention is required to mitigate the increase in runoff rate due to the increase in impervious cover from the proposed roadway improvements. The detention volume was quantified for each drainage area for the 400-foot right of way. The 100-year storm event peak flow was used to estimate the required detention volume. The estimated detention storage volume was quantified using the Modified Rational Method, based on the inflow hydrograph, along with the maximum allowable flow from the detention facility. The maximum allowable outflow is equal to the existing 1% peak flow, since detention is required to provide sufficient storage volume such that peak outflows are limited to a rate that is “equal to” or “less than” the existing peak flow. This discussion can be found in **Section 2.5** of this report.

- All of the proposed detention basins have been located within the ROW and areas under the bridges have been utilized where possible for the locations. In some locations where adequate land area is not available, the detention has been located under the proposed roadway and runoff will be detained in reinforced concrete box culverts. Placement of the reinforced concrete box culverts can be alongside of the road, in most cases, to facilitate maintenance and repair. **Table 12** shows the summary of the detention volume estimation.

- All of the existing structures were sufficient to pass the 2% AEP, however, in the proposed condition, all but one structure will be upsized and relocated due to a structural conflict, and the bridge at Mud Creek will be replaced with 2 – 10’x5’ reinforced box culverts. These improvements are listed in **Table 13** of this report.

- An Effective Model hydraulic model for Mud Creek was available from the San Antonio River Authority (SARA) through their Digital Data & Modeling Repository (D2MR) website. Mud Creek intersects US 281 near the southern portion of the project near station 360+00. Currently there is a bridge spanning 140’ with 4 interior bents. This bridge was previously sized to accommodate the 50 year storm event. With the recent construction of a Regional Detention Pond, constructed upstream of this crossing, the peak flow in Mud Creek has been greatly reduced. For the proposed conditions model the existing bridge was replaced with 2 - 10’ x 5’ box culverts to reduce costs of bridge improvements. The existing FEMA flows were used in the proposed crossing plan since any increased runoff from the roadway project will be mitigated in onsite

detention. **Table 14** compares the existing and the proposed US 281 Mud Creek cross structure 100-year WSEL. These culverts have been sized to maintain and not increase the water surface elevations upstream of the TxDOT Right-of-Way during the 100-year storm event. During the 500-year storm event, US 281 is not inundated. Other than the modifications to the bridge at Mud Creek no other changes have been made to the Effective Model.

- Preliminary sizes for storm sewer systems were determined using the TxDOT Hydraulic Design Manual design standards, 10-year design frequency with WinStorm v. 3.05 software. The proposed storm sewer system consists of two trunk line systems along the northbound and southbound mainlanes. The trunk line varies from 24" to 36" RCP along the northbound and southbound mainlanes throughout the project. The WinStorm outputs for the storm sewer systems are included in **Appendix F**.

- The US 281 Project is to meet the current regulatory requirements for BMPs set forth by TCEQ for the entire project area. Several permanent controls approved by TCEQ include:

    - Retention/Irrigation
    - Extended Detention Basins
    - Grassy Swales
    - Vegetative Filter Strips
    - Bioretention
    - Wet Basins
    - Constructed Wetlands
    - Permeable Concrete

  The TCEQ spreadsheets for TSS Removal Calculations dated 4-20-2009 were used with each chosen permanent BMP. TSS removal is achieved by directing the first flush of runoff to a pond having the volume required as specified by TCEQ Guidance Manual. The calculations for the bioretention pond sizes are in **Appendix G**.

- Vegetative filter strips will be utilized in areas where slopes and roadway widths permit the use. Vegetative filter strips can receive a flow from a maximum of 72-feet of roadway width and cannot be constructed on slopes greater than 20%. The criteria prevent vegetative filter strips to be used throughout the entire project.

- Where vegetative filter strips cannot be used bioretention ponds will be used. Biofiltration basins are sized to capture a specific volume that will mitigate the increased TSS load. BMP calculations have been performed utilizing the TCEQ's equations/spreadsheet for TSS generation and removal. Summary sheets from the TSS generation, removal calculations, and basin sizes required for appropriate TSS removal are presented in **Appendix G**. **Exhibit 3** shows the approximate locations for the vegetative strips and bioretention ponds. **Table 15** is a summary of the water quality pond volumes and provides sizing suggestions. The acre-feet volume represents the entire excavated volume of the pond. All ponds are approximately 5-feet deep, filled with approximately 4.5-feet of media with 0.5-feet of available volume for ponding. There will be an underdrain below the media in gravel. Approximately 5 to 10-feet of grass filter strip around the boundary of the bioretention pond on the sides where water flows into the pond and bed by grass-line channels. The vegetative filter strip will be at least 15-feet wide next to the roadway, with flat slopes and used where the pavement draining to the strip is less than 72-feet wide.

- No additional right-of-way is needed outside of what is already planned for roadway expansion due to BMP evaluation.

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EXHIBITS

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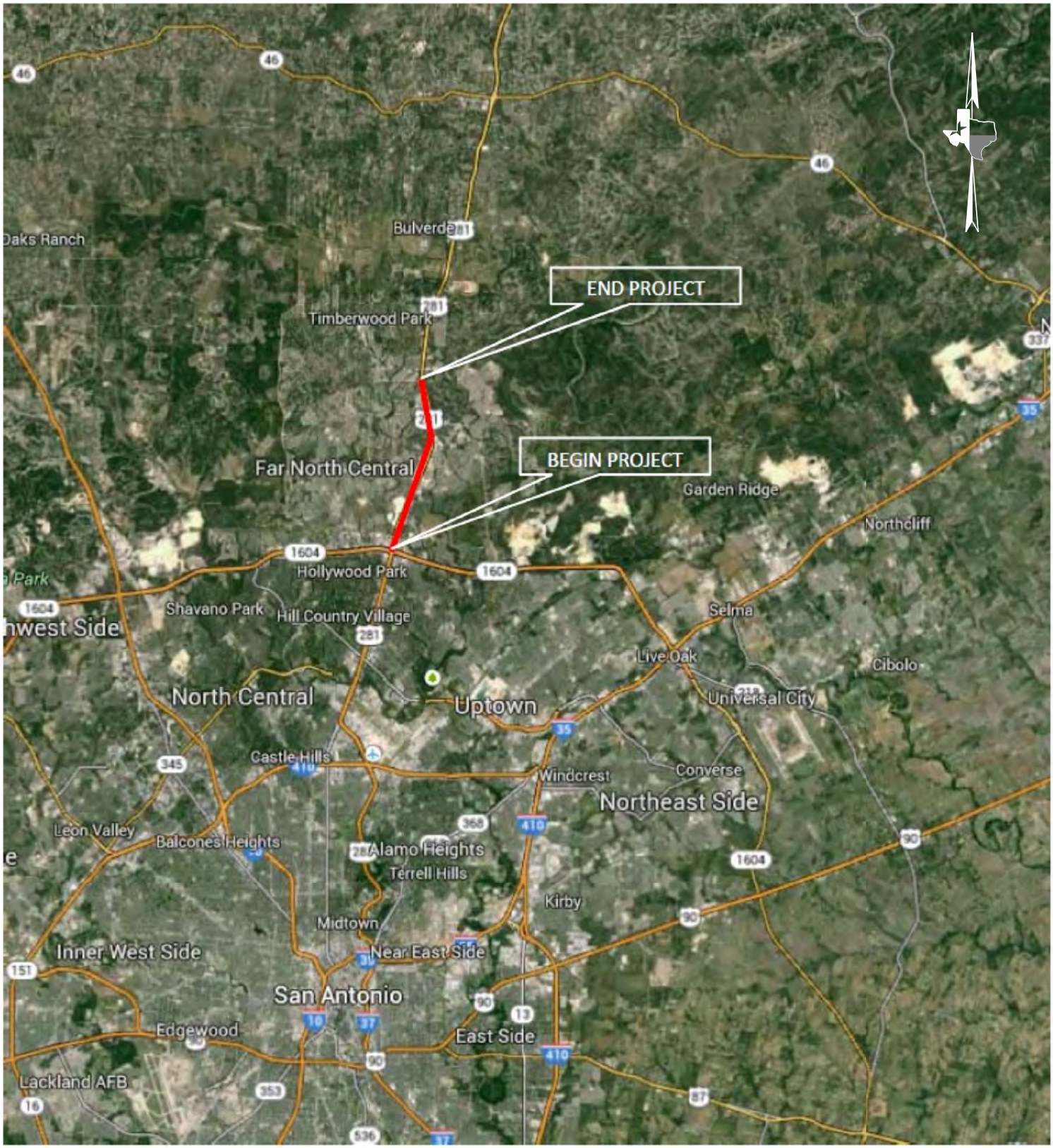

PROJECT LOCATION MAP

EXHIBIT 1

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DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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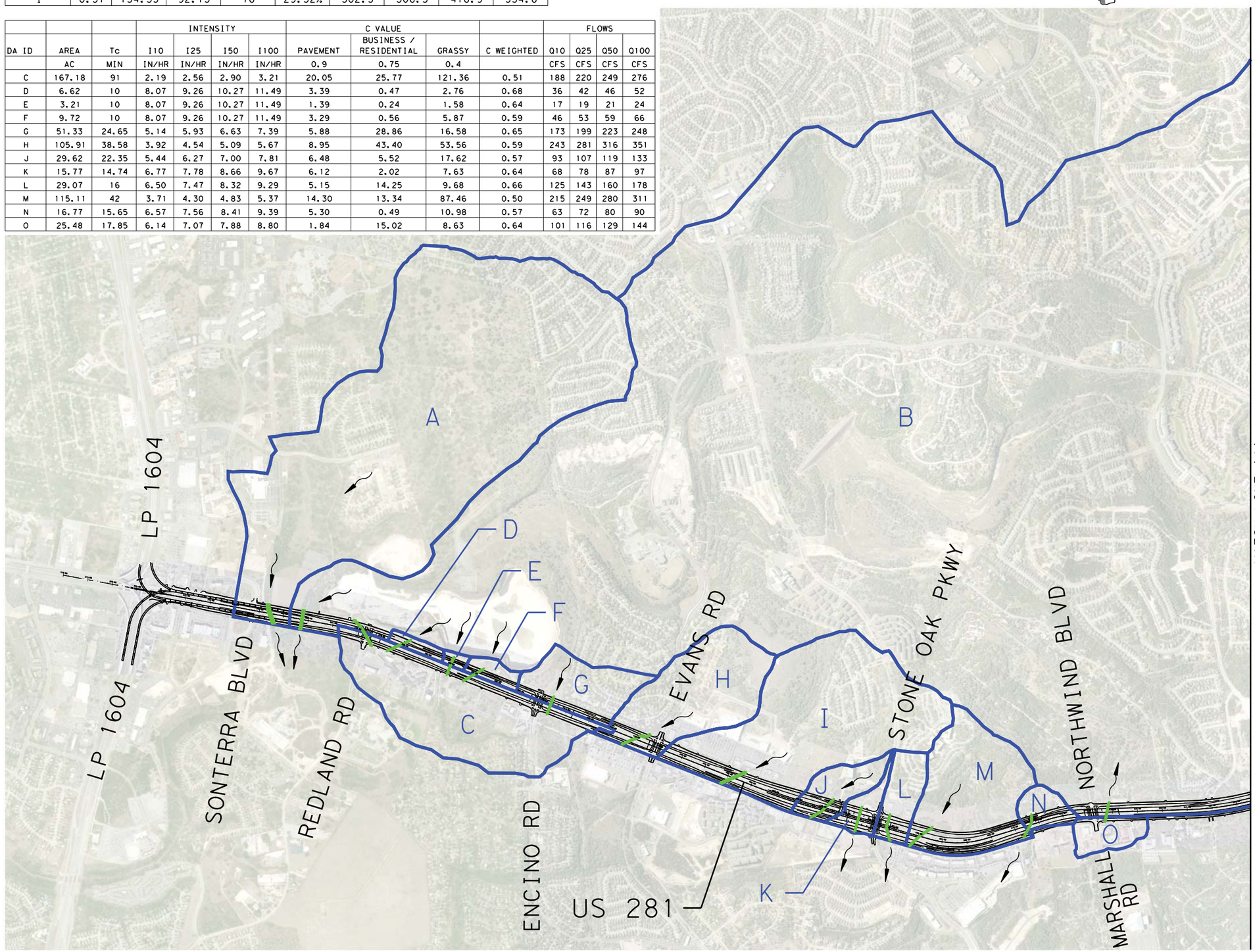
				LAND USE		CURVE NUMBER METHOD FLOWS (CFS)			
DRAINAGE ID	AREA (MI^2)	t_c (MIN)	t_L (MIN)	CN	% IMP	Q_{10YR}	Q_{25YR}	Q_{50YR}	Q_{100YR}
A	1.11	195.91	117.55	77	22.78%	729.6	739.6	1186.1	1376
B	13.27	520.56	312.34	72	23.78%	3336.1	3384.1	5677.5	6623.2
I	0.37	154.55	92.73	78	29.52%	302.5	306.5	478.9	554.8

			INTENSITY				C VALUE				FLOWS			
DA ID	AREA	Tc	I10	I25	I50	I100	PAVEMENT	BUSINESS / RESIDENTIAL	GRASSY	C WEIGHTED	Q10	Q25	Q50	Q100
	AC	MIN	IN/HR	IN/HR	IN/HR	IN/HR	0.9	0.75	0.4		CFS	CFS	CFS	CFS
C	167.18	91	2.19	2.56	2.90	3.21	20.05	25.77	121.36	0.51	188	220	249	276
D	6.62	10	8.07	9.26	10.27	11.49	3.39	0.47	2.76	0.68	36	42	46	52
E	3.21	10	8.07	9.26	10.27	11.49	1.39	0.24	1.58	0.64	17	19	21	24
F	9.72	10	8.07	9.26	10.27	11.49	3.29	0.56	5.87	0.59	46	53	59	66
G	51.33	24.65	5.14	5.93	6.63	7.39	5.88	28.86	16.58	0.65	173	199	223	248
H	105.91	38.58	3.92	4.54	5.09	5.67	8.95	43.40	53.56	0.59	243	281	316	351
J	29.62	22.35	5.44	6.27	7.00	7.81	6.48	5.52	17.62	0.57	93	107	119	133
K	15.77	14.74	6.77	7.78	8.66	9.67	6.12	2.02	7.63	0.64	68	78	87	97
L	29.07	16	6.50	7.47	8.32	9.29	5.15	14.25	9.68	0.66	125	143	160	178
M	115.11	42	3.71	4.30	4.83	5.37	14.30	13.34	87.46	0.50	215	249	280	311
N	16.77	15.65	6.57	7.56	8.41	9.39	5.30	0.49	10.98	0.57	63	72	80	90
O	25.48	17.85	6.14	7.07	7.88	8.80	1.84	15.02	8.63	0.64	101	116	129	144



LEGEND

- DRAINAGE AREA BOUNDARY
- A — DRAINAGE AREA ID
- FLOW DIRECTION
- DRAINAGE STRUCTURE

NOTE:

SEE "HYDROLOGIC AND HYDRAULIC ANALYSIS" REPORT TABLE 13 FOR CROSS CULVERT STRUCTURE INFORMATION.

0 1000 2000

SCALE: 1"=2000'

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DRAINAGE AREA MAP

EXHIBIT 2

SHEET 1 OF 2

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CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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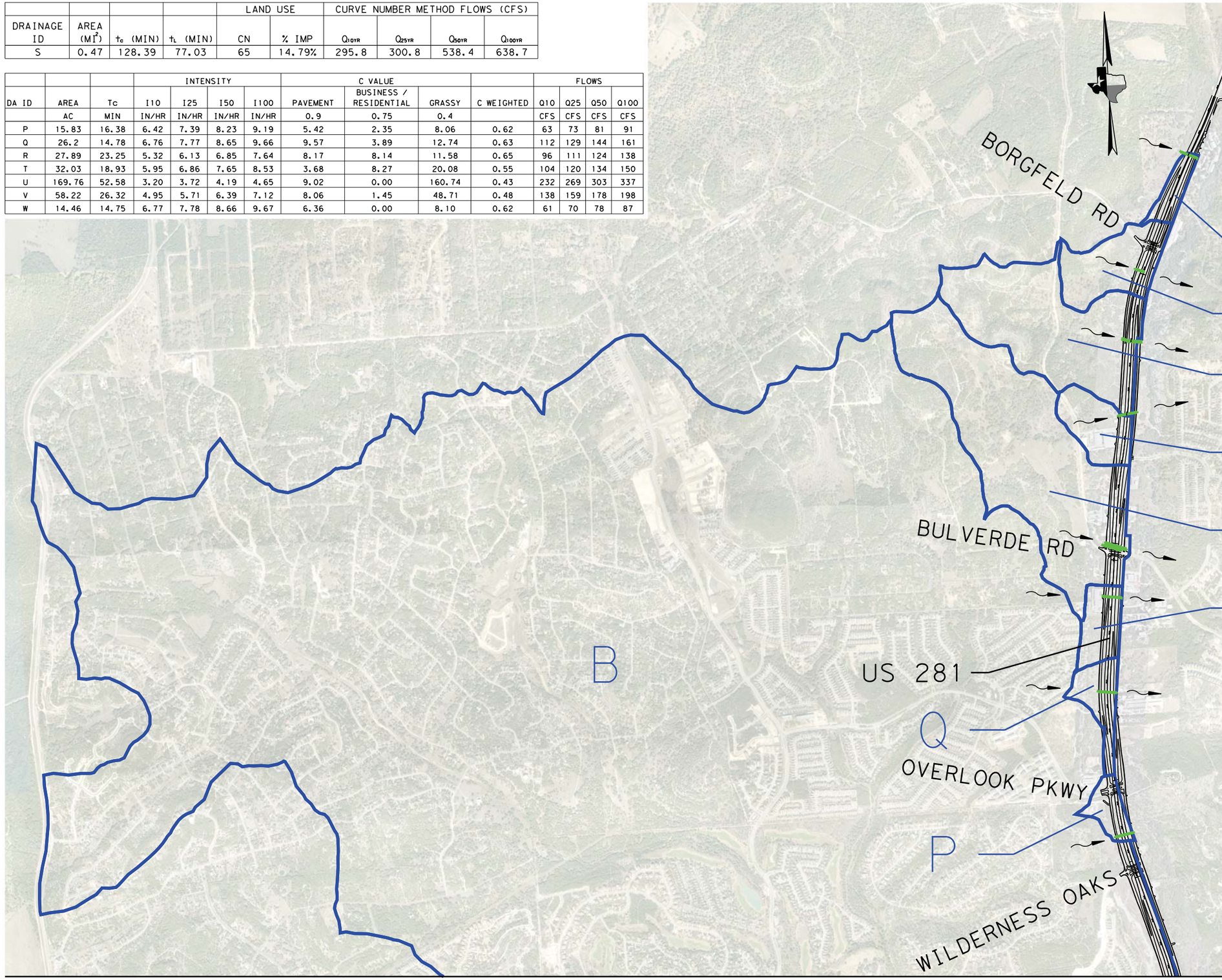
				LAND USE		CURVE NUMBER METHOD FLOWS (CFS)			
DRAINAGE ID	AREA (MI^2)	t_c (MIN)	t_L (MIN)	CN	% IMP	Q_{10YR}	Q_{25YR}	Q_{50YR}	Q_{100YR}
S	0.47	128.39	77.03	65	14.79%	295.8	300.8	538.4	638.7

			INTENSITY				C VALUE				FLOWS			
DA ID	AREA	Tc	I10	I25	I50	I100	PAVEMENT	BUSINESS / RESIDENTIAL	GRASSY	C WEIGHTED	Q10	Q25	Q50	Q100
	AC	MIN	IN/HR	IN/HR	IN/HR	IN/HR	0.9	0.75	0.4		CFS	CFS	CFS	CFS
P	15.83	16.38	6.42	7.39	8.23	9.19	5.42	2.35	8.06	0.62	63	73	81	91
Q	26.2	14.78	6.76	7.77	8.65	9.66	9.57	3.89	12.74	0.63	112	129	144	161
R	27.89	23.25	5.32	6.13	6.85	7.64	8.17	8.14	11.58	0.65	96	111	124	138
T	32.03	18.93	5.95	6.86	7.65	8.53	3.68	8.27	20.08	0.55	104	120	134	150
U	169.76	52.58	3.20	3.72	4.19	4.65	9.02	0.00	160.74	0.43	232	269	303	337
V	58.22	26.32	4.95	5.71	6.39	7.12	8.06	1.45	48.71	0.48	138	159	178	198
W	14.46	14.75	6.77	7.78	8.66	9.67	6.36	0.00	8.10	0.62	61	70	78	87



MATCH LINE 'A'

LEGEND

- DRAINAGE AREA BOUNDARY
- A — DRAINAGE AREA ID
- FLOW DIRECTION
- DRAINAGE STRUCTURE

NOTE:

SEE "HYDROLOGIC AND HYDRAULIC ANALYSIS" REPORT TABLE 13 FOR CROSS CULVERT STRUCTURE INFORMATION.

0 1000 2000

SCALE: 1"=2000'

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DRAINAGE AREA MAP

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CK:	SAT	BEXAR	0253	04	138	

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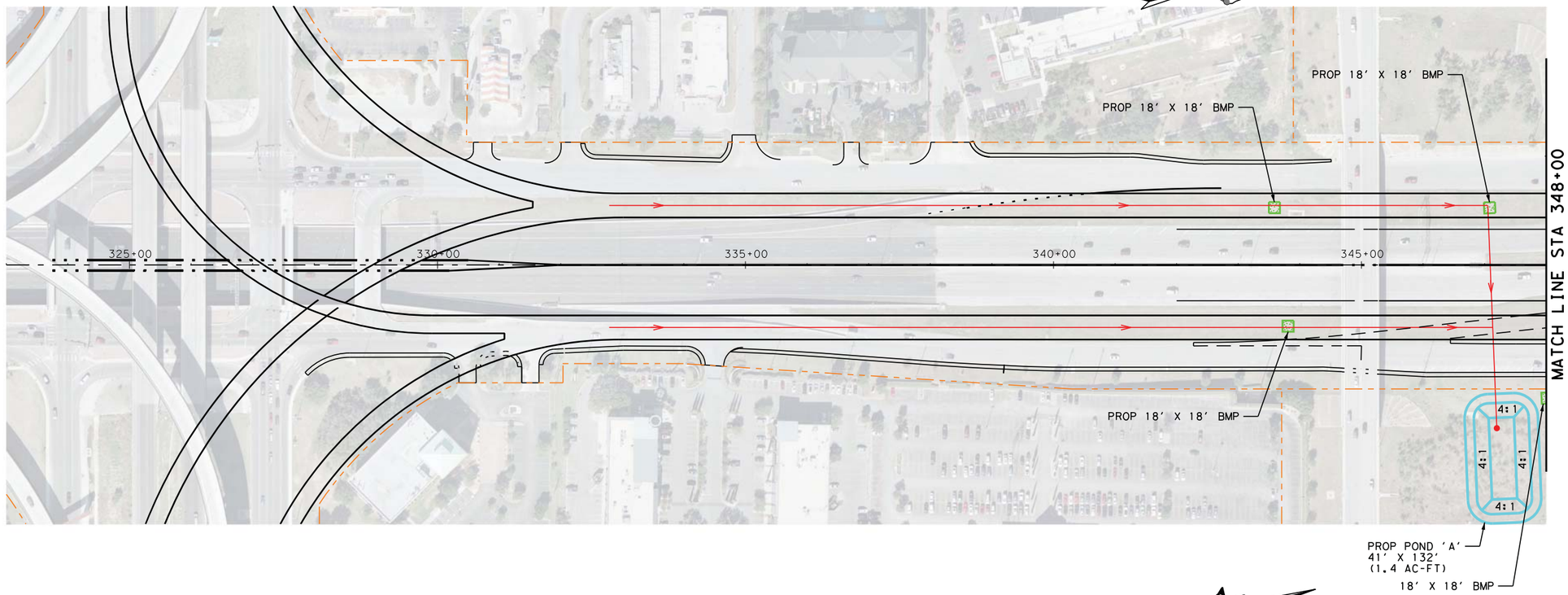
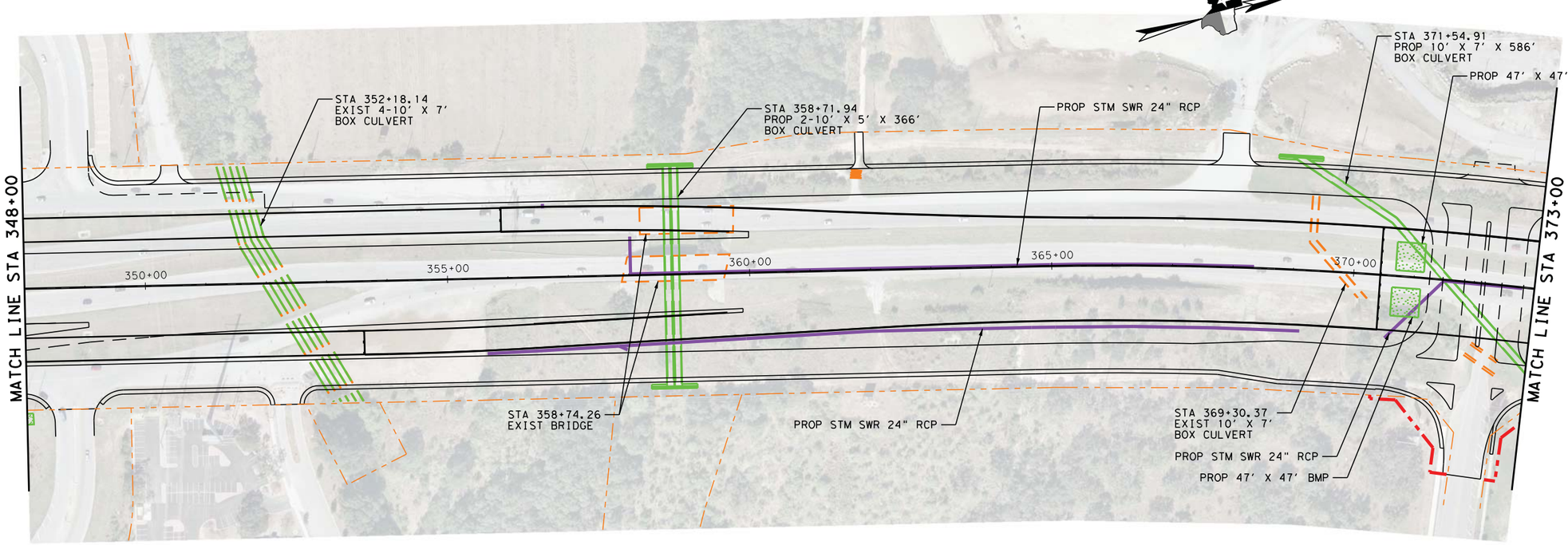


LEGEND

- PROP POND
- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
- PROPOSED RIGHT OF WAY
- EXISTING RIGHT OF WAY
- PROPOSED BMP
- PROPOSED VEGETATIVE STRIP
- PRELIMINARY DIRECTION PATH TO POND

NOTES:

1. LOCATION OF BMPs ARE SUBJECT TO CHANGE.
2. DETENTION POND DIMENSIONS (W' X L') ARE SUBJECT TO CHANGE.
3. UNDERGROUND DETENTION POND LENGTHS ARE SUBJECT TO CHANGE.



0 50 100 200

SCALE: 1"=200'

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EXHIBIT 3

SHEET 1 OF 9

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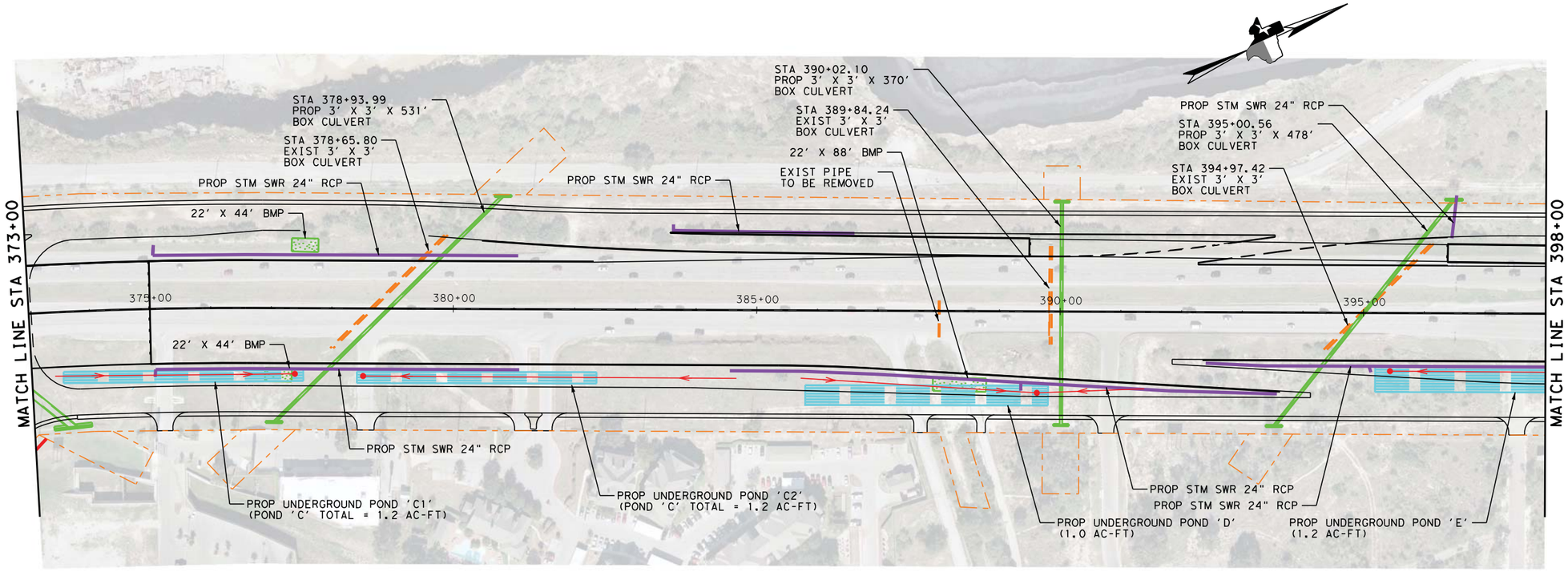

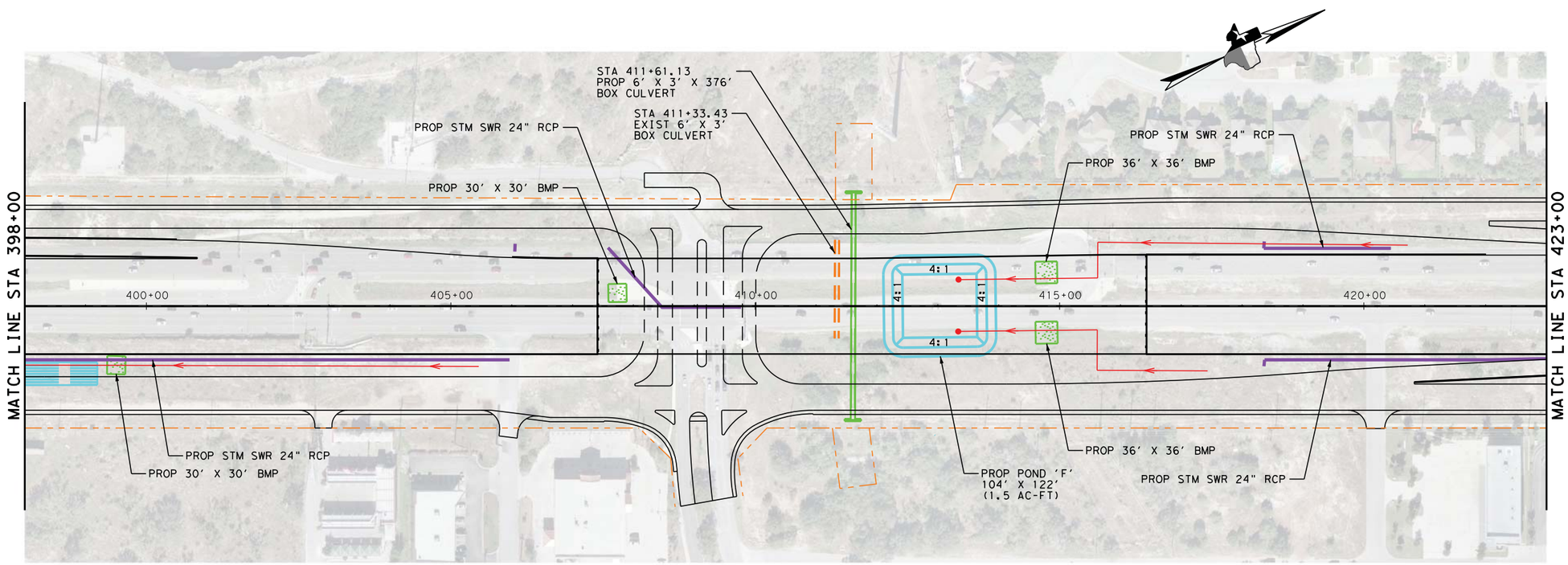

LEGEND

- PROP POND
- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
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0 50 100 200

SCALE: 1"=200'

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EXHIBIT 3

SHEET 2 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
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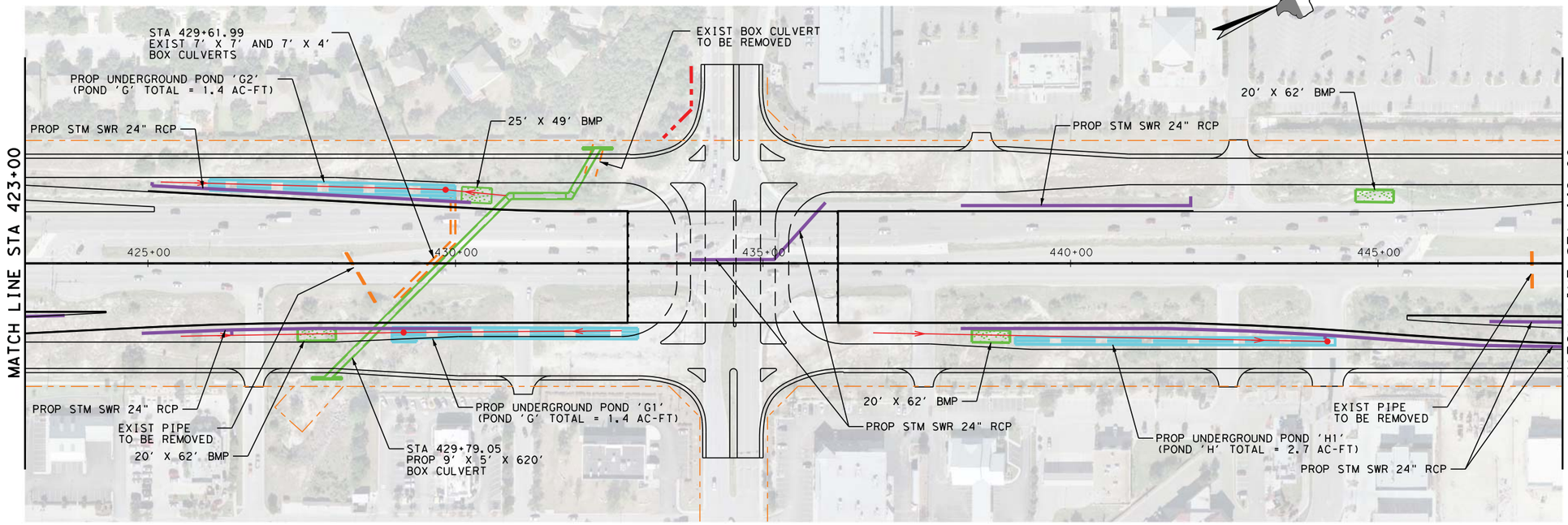

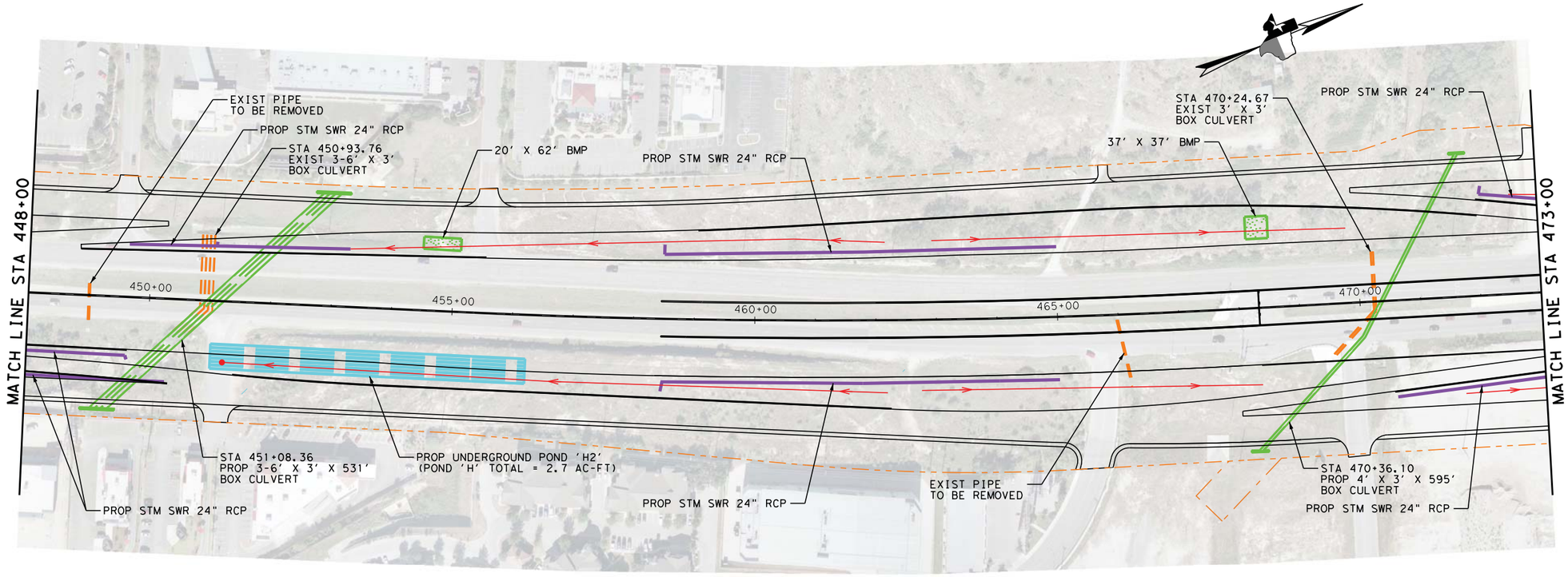

LEGEND

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- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
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SCALE: 1"=200'

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EXHIBIT 3

SHEET 3 OF 9

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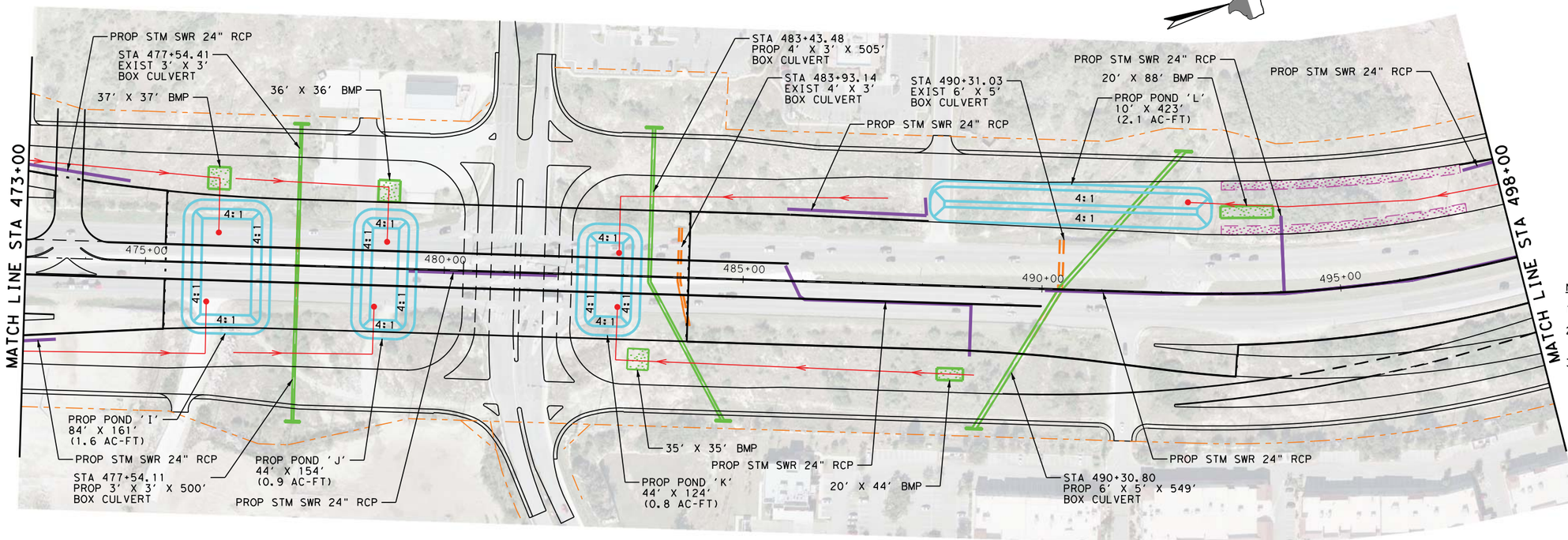

LEGEND

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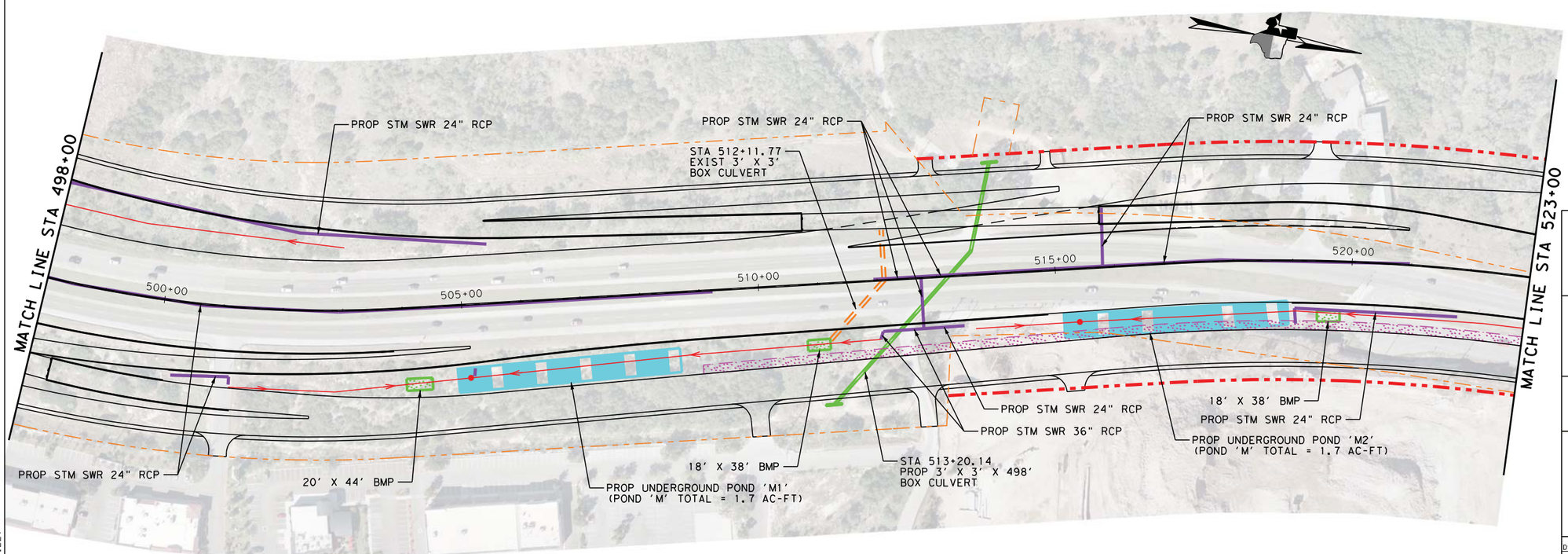

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EXHIBIT 3

SHEET 4 OF 9

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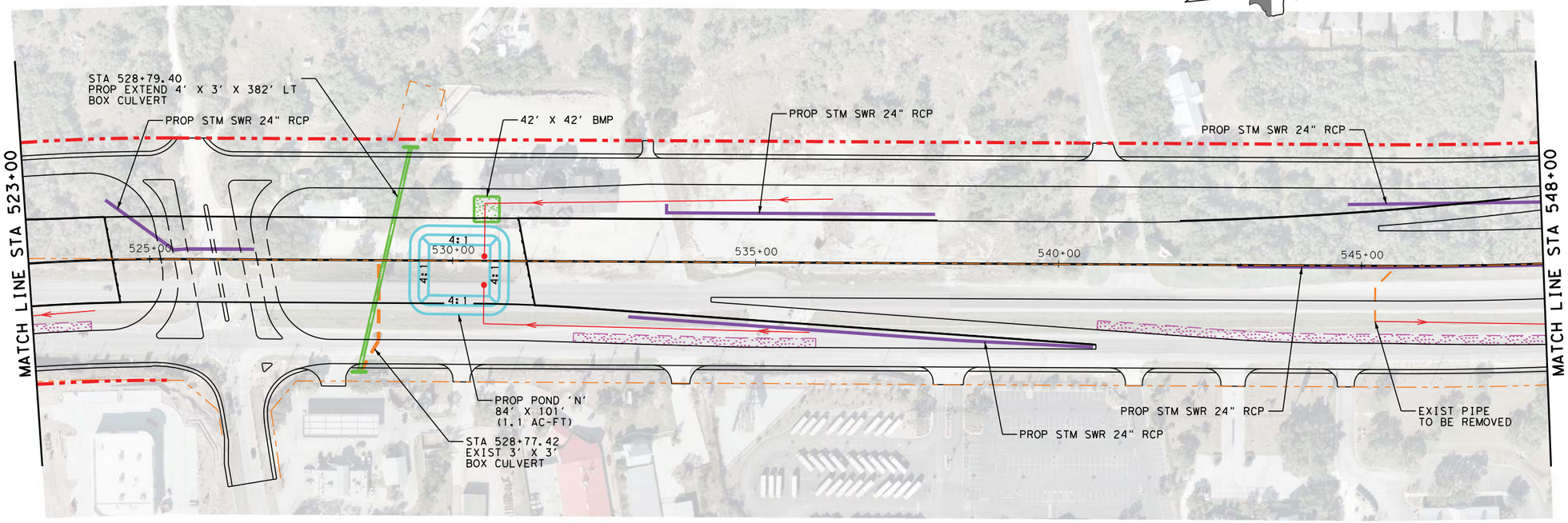

LEGEND

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- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
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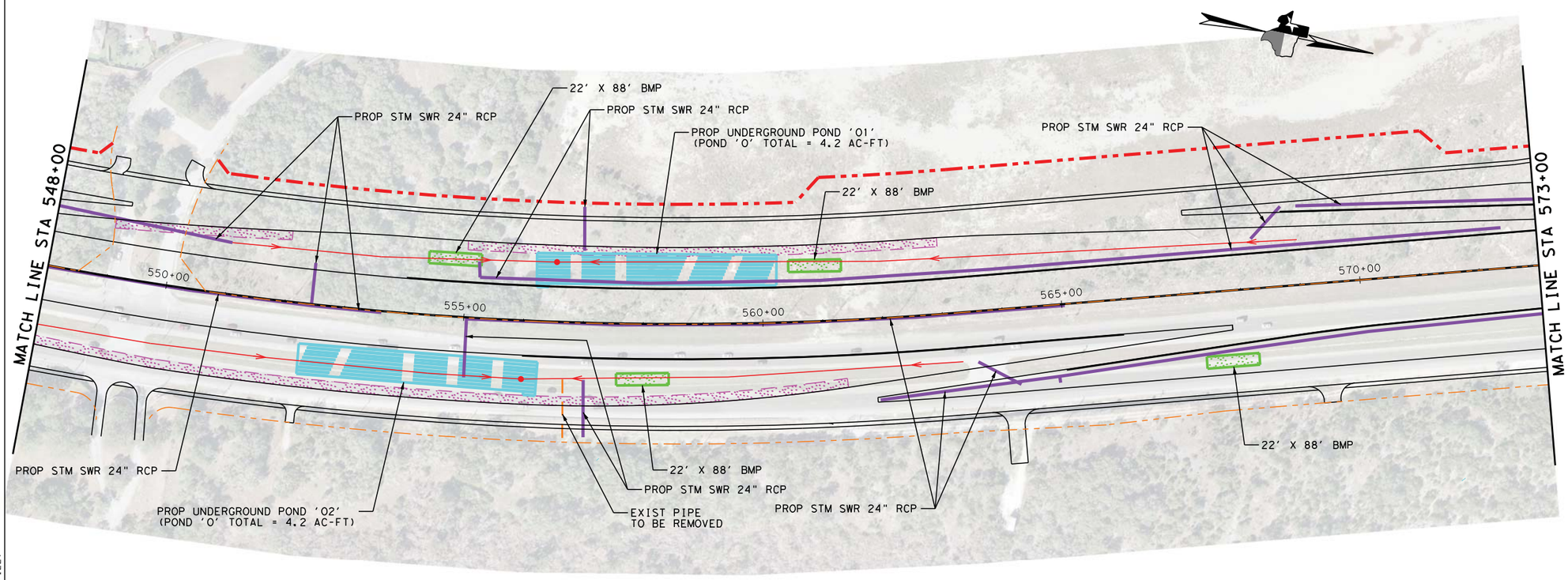

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SCALE: 1"=200'

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EXHIBIT 3

SHEET 5 OF 9

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CK:	SAT	BEXAR	0253	04	138	

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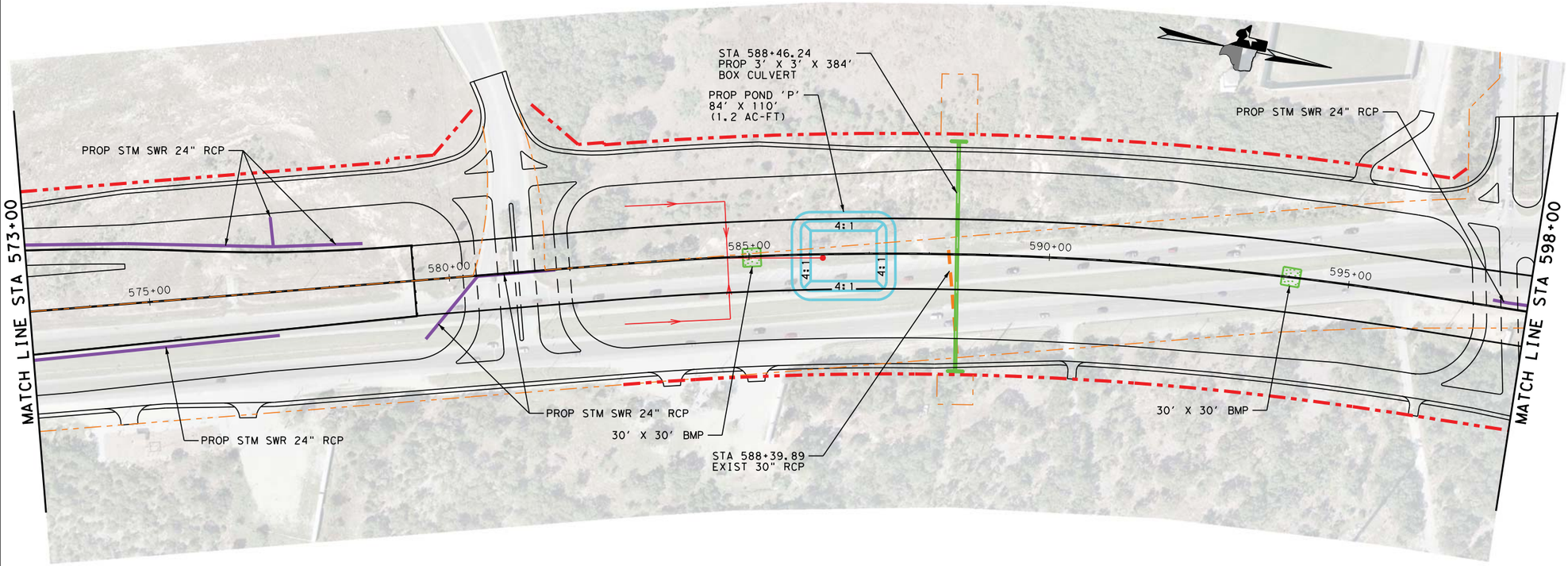

LEGEND

- PROP POND
- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
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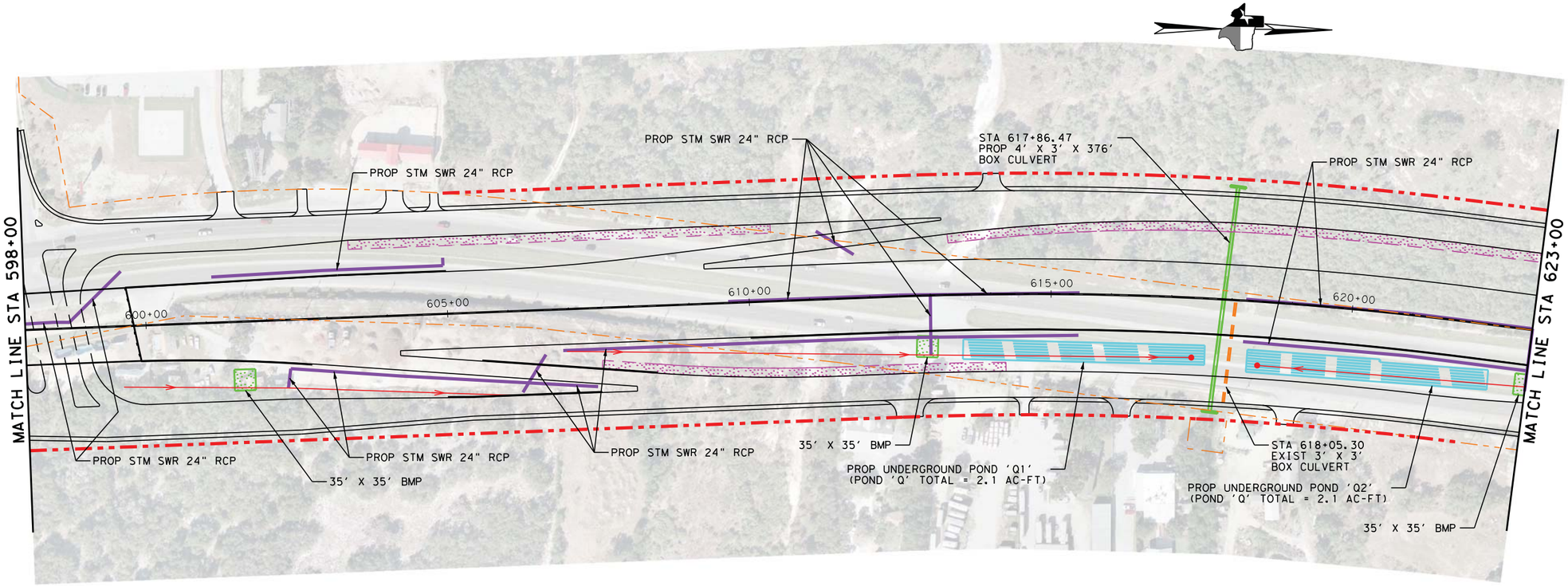

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EXISTING AND PROPOSED STRUCTURE CROSSINGS / PROPOSED VEGETATIVE STRIPS AND BIORETENTION POND LOCATIONS

EXHIBIT 3

SHEET 6 OF 9

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CK:	SAT	BEXAR	0253	04	138	

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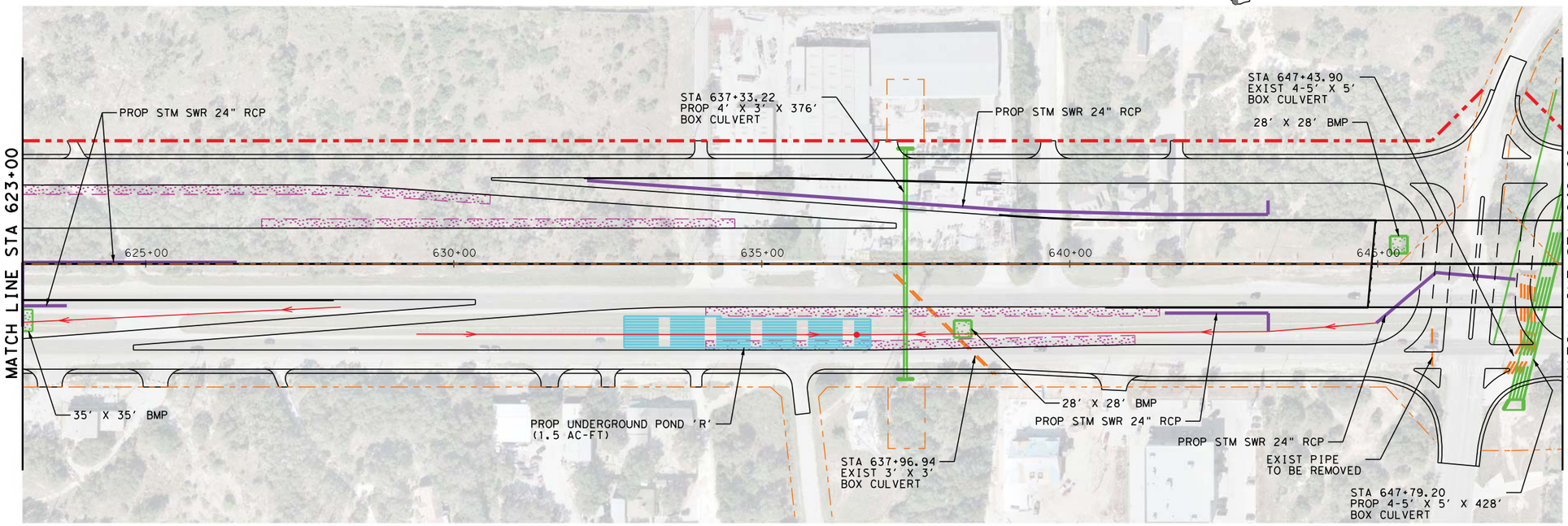

LEGEND

- PROP POND
- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
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- EXISTING RIGHT OF WAY
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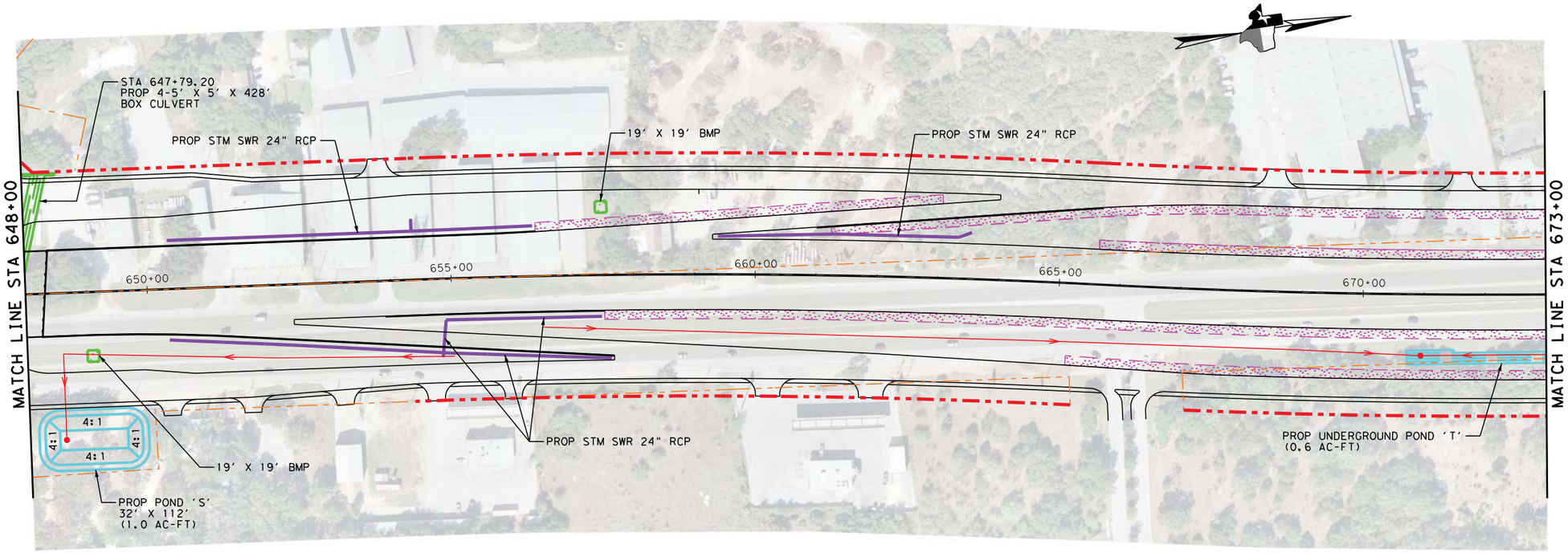

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SCALE: 1"=200'

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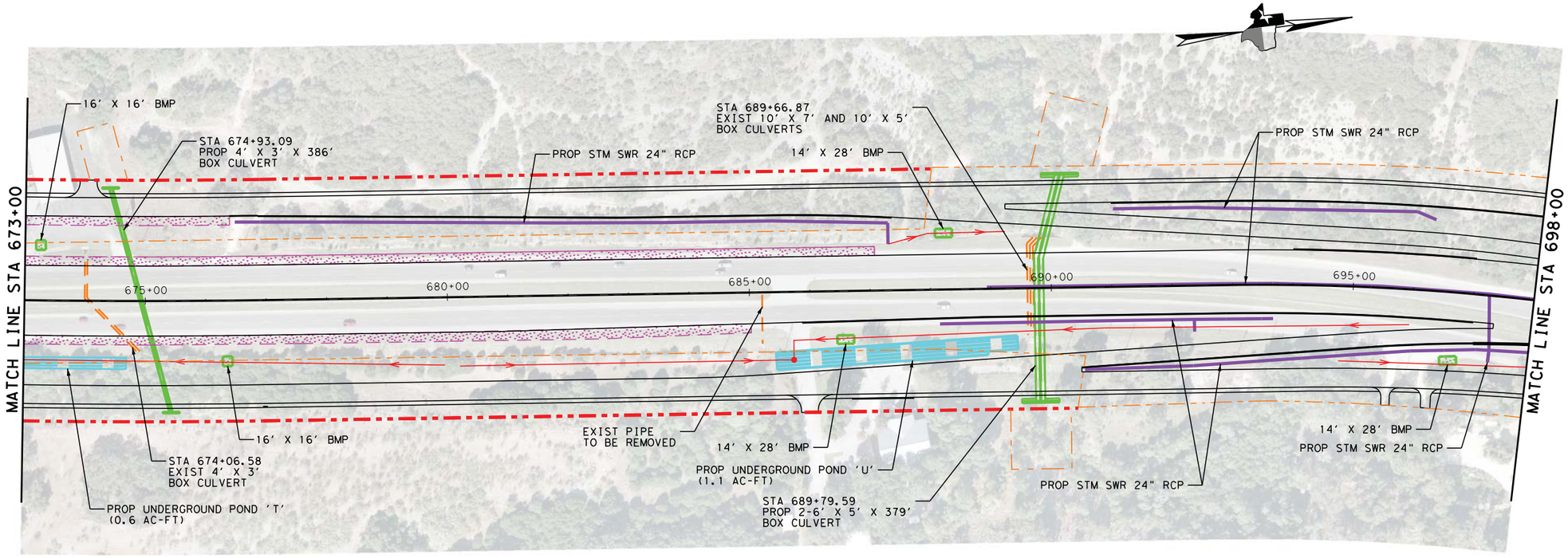
EXISTING AND PROPOSED STRUCTURE CROSSINGS / PROPOSED VEGETATIVE STRIPS AND BIORETENTION POND LOCATIONS

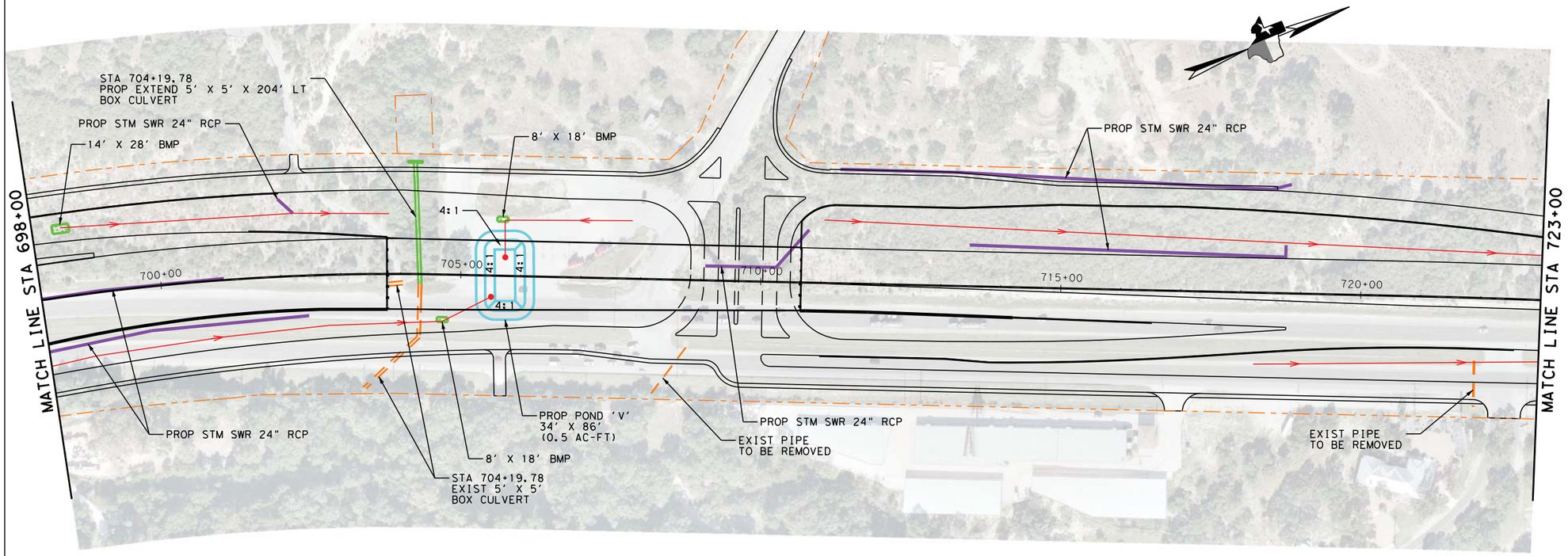
EXHIBIT 3

SHEET 7 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

$TIME$
$DATE$
$FILE$
$FILES$





LEGEND

- PROP POND
- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
- PROPOSED RIGHT OF WAY
- EXISTING RIGHT OF WAY
- PROPOSED BMP
- PROPOSED VEGETATIVE STRIP
- PRELIMINARY DIRECTION PATH TO POND

NOTES:

1. LOCATION OF BMPs ARE SUBJECT TO CHANGE.
2. DETENTION POND DIMENSIONS (W' X L') ARE SUBJECT TO CHANGE.
3. UNDERGROUND DETENTION POND LENGTHS ARE SUBJECT TO CHANGE.

0 50 100 200

SCALE: 1"=200'

ALAMO RMA — Alamo Regional Mobility Authority "Moving people faster"

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5995 Rogerdale Road
Houston, Texas 77072-3495
(832)351-6000 www.jacobs.com
Jacobs Engineering Group Inc. F-2966

Texas Department of Transportation

US 281 EIS

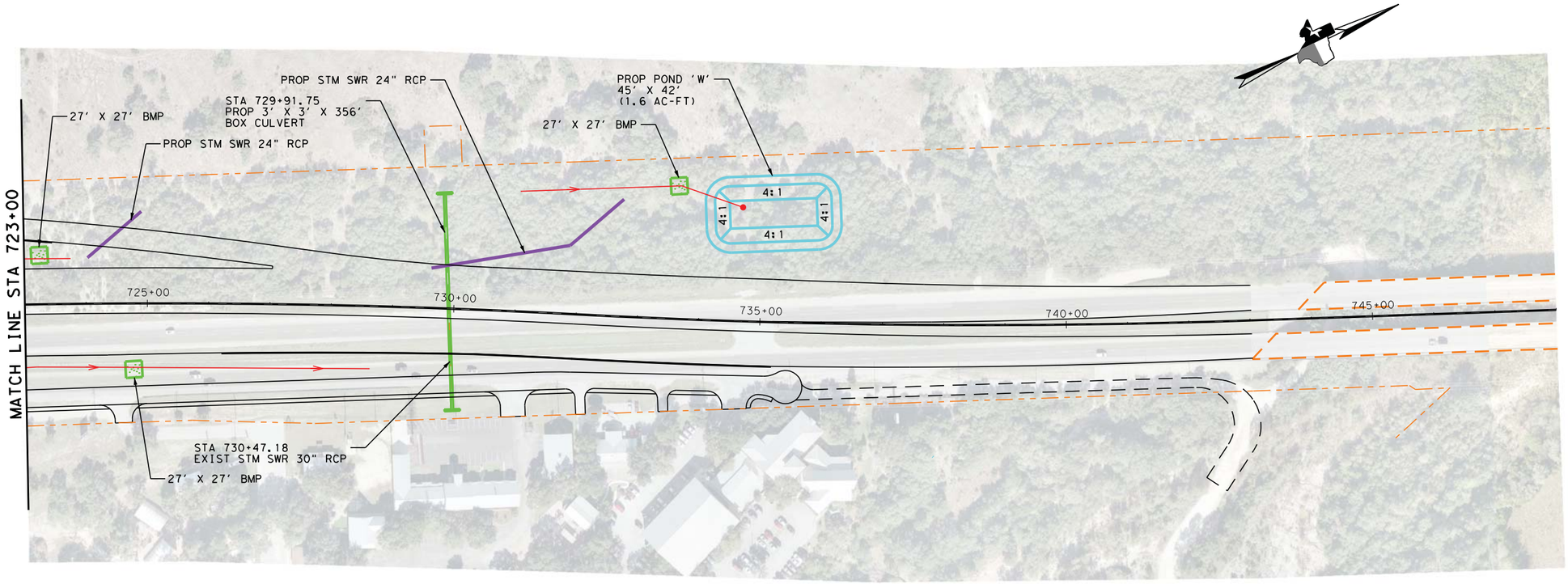
EXISTING AND PROPOSED STRUCTURE CROSSINGS / PROPOSED VEGETATIVE STRIPS AND BIORETENTION POND LOCATIONS

EXHIBIT 3

SHEET 8 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

$TIME$
$DATE$
$FILE$
$FILES$



LEGEND

- PROP POND
- PROPOSED DRAINAGE STRUCTURE
- EXISTING STRUCTURE
- PROPOSED STORM SEWER PIPE
- PROPOSED RIGHT OF WAY
- EXISTING RIGHT OF WAY
- PROPOSED BMP
- PROPOSED VEGETATIVE STRIP
- PRELIMINARY DIRECTION PATH TO POND

NOTES:

1. LOCATION OF BMPs ARE SUBJECT TO CHANGE.
2. DETENTION POND DIMENSIONS (W' X L') ARE SUBJECT TO CHANGE.
3. UNDERGROUND DETENTION POND LENGTHS ARE SUBJECT TO CHANGE.

0 50 100 200

SCALE: 1"=200'

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US 281 EIS

EXISTING AND PROPOSED STRUCTURE CROSSINGS / PROPOSED VEGETATIVE STRIPS AND BIORETENTION POND LOCATIONS

EXHIBIT 3

SHEET 9 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

$TIME$
$DATE$
$FILE$
$FILE$

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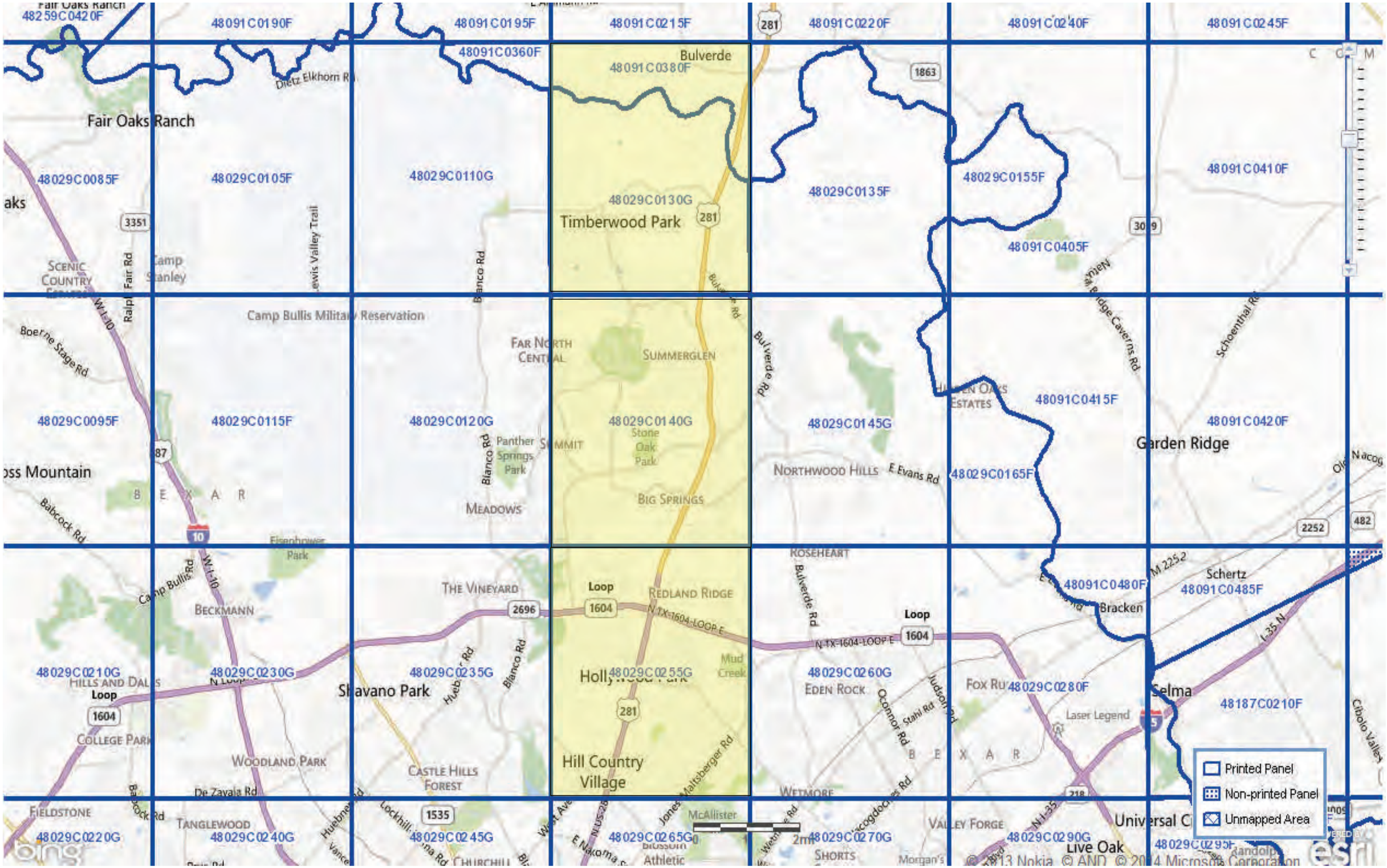
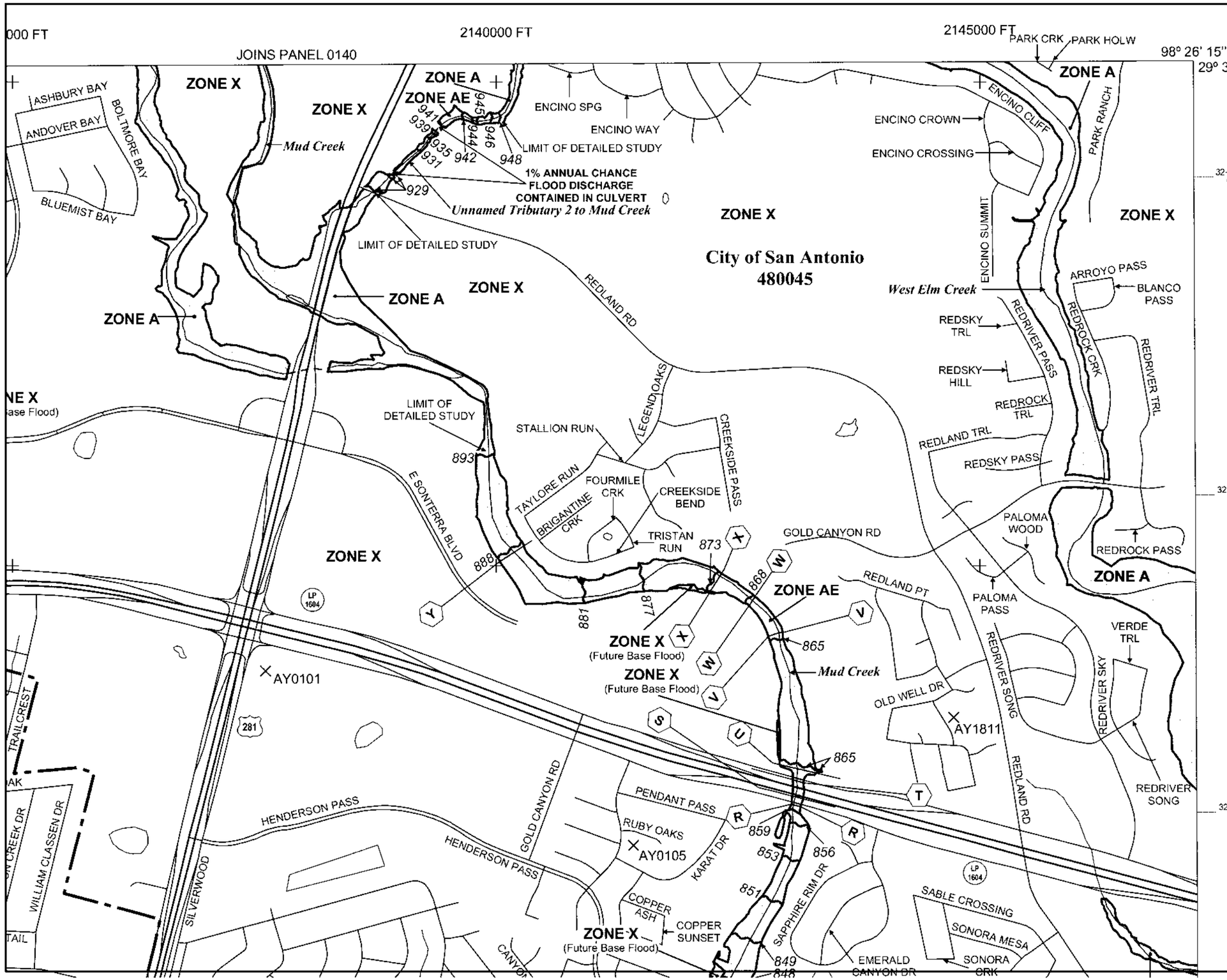


EXHIBIT 4 - FEMA FLOOD INSURANCE RATE MAP (FIRM) MAP INDEX PAGE 1 OF 7



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0255G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS

AND INCORPORATED AREAS

PANEL 255 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BEXAR COUNTY	480035	0255	G
HILL COUNTRY VILLAGE, CITY OF	481106	0255	G
HOLLYWOOD PARK, TOWN OF	480040	0255	G
SAN ANTONIO, CITY OF	480045	0255	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.

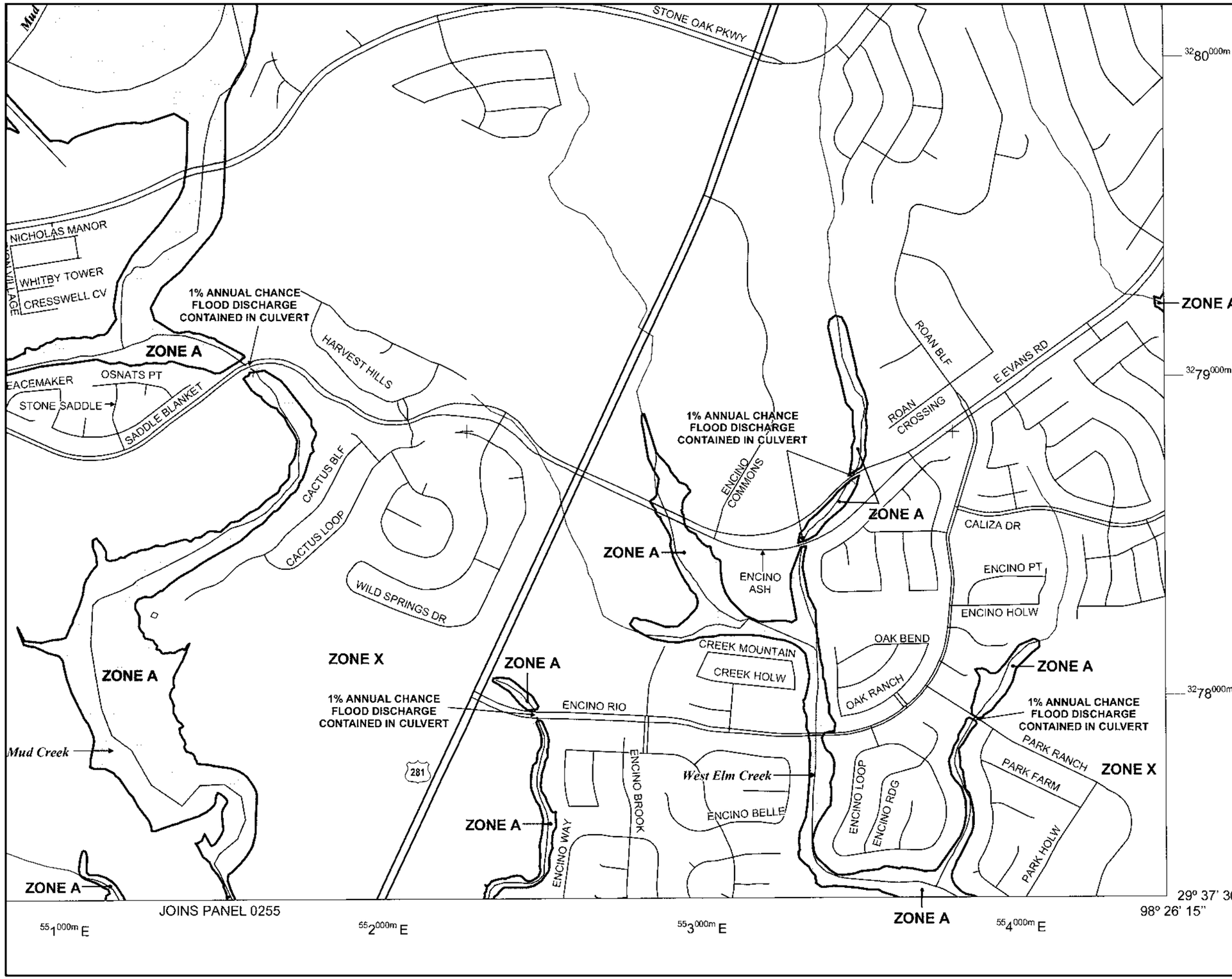
MAP NUMBER
48029C0255G

MAP REVISED
SEPTEMBER 29, 2010

Federal Emergency Management Agency

Exhibit 4A

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



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0140G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS
AND INCORPORATED AREAS

PANEL 140 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BEXAR COUNTY	480035	0140	G
SAN ANTONIO, CITY OF	480045	0140	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.

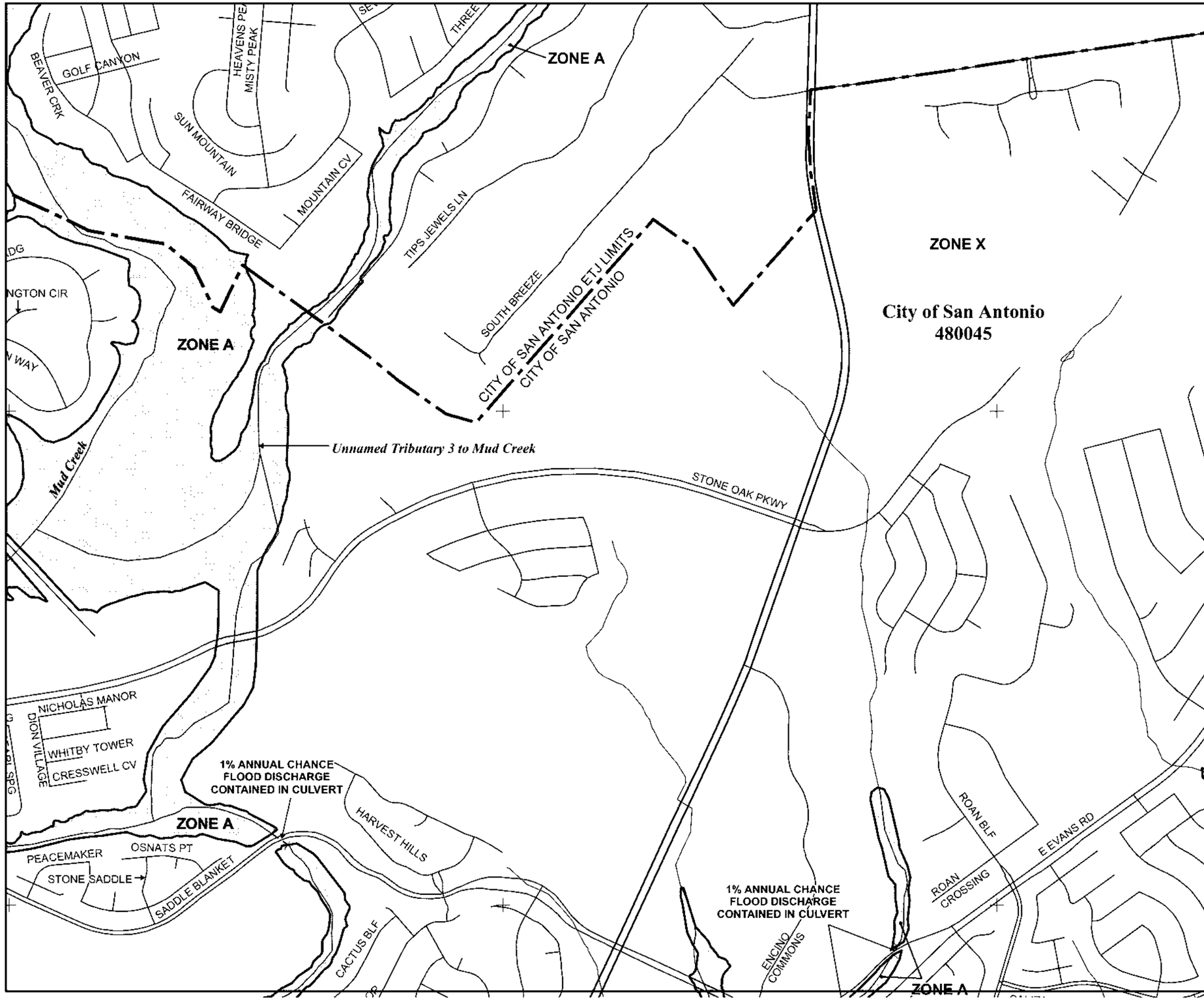
MAP NUMBER
48029C0140G

MAP REVISED
SEPTEMBER 29, 2010

Federal Emergency Management Agency

Exhibit 4B

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



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0140G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS
AND INCORPORATED AREAS

PANEL 140 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BEXAR COUNTY	480035	0140	G
SAN ANTONIO, CITY OF	480045	0140	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.

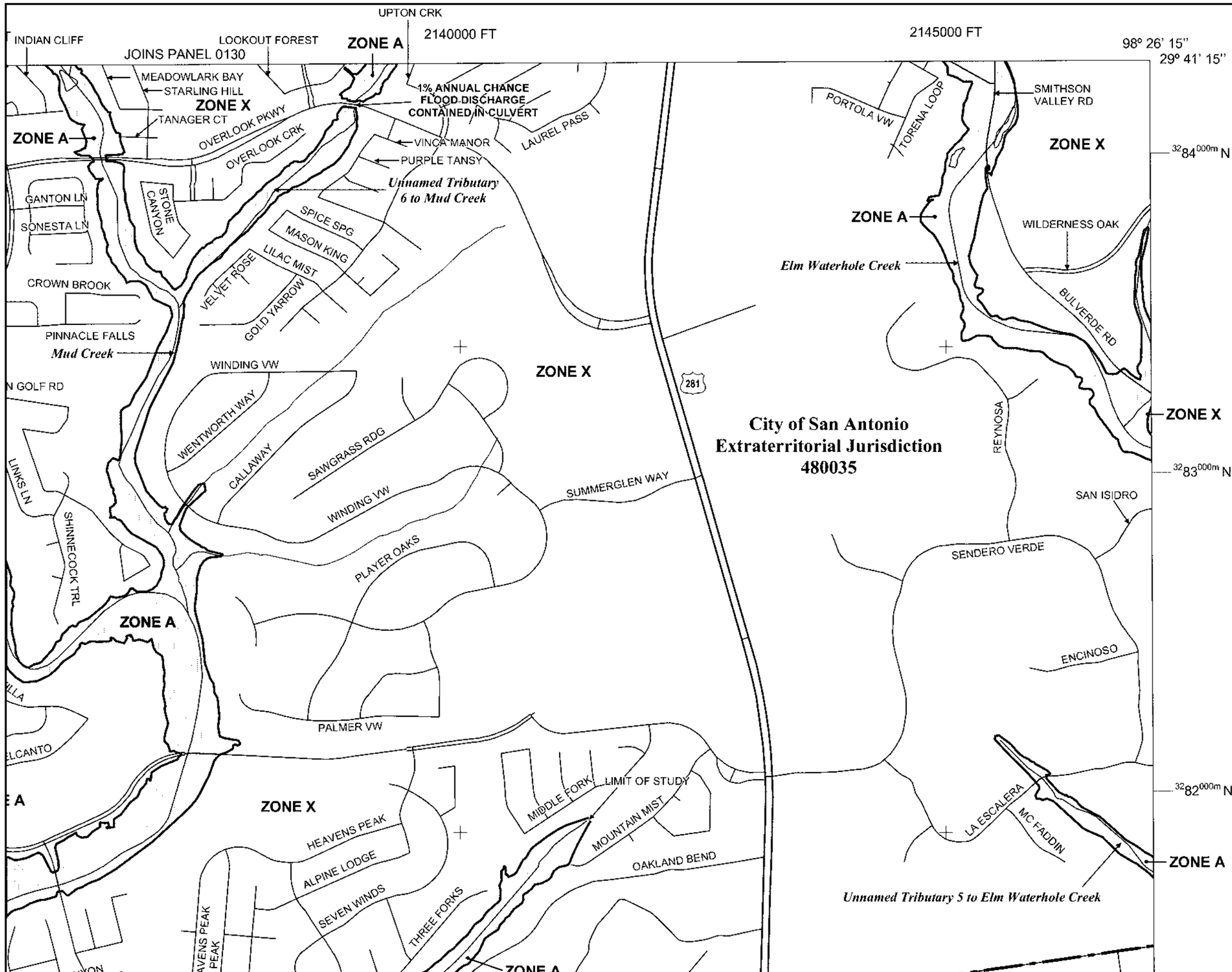
MAP NUMBER
48029C0140G

MAP REVISED
SEPTEMBER 29, 2010

Federal Emergency Management Agency

Exhibit 4C

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



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0140G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS
AND INCORPORATED AREAS

PANEL 140 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BEXAR COUNTY	480035	0140	G
SAN ANTONIO, CITY OF	480045	0140	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.

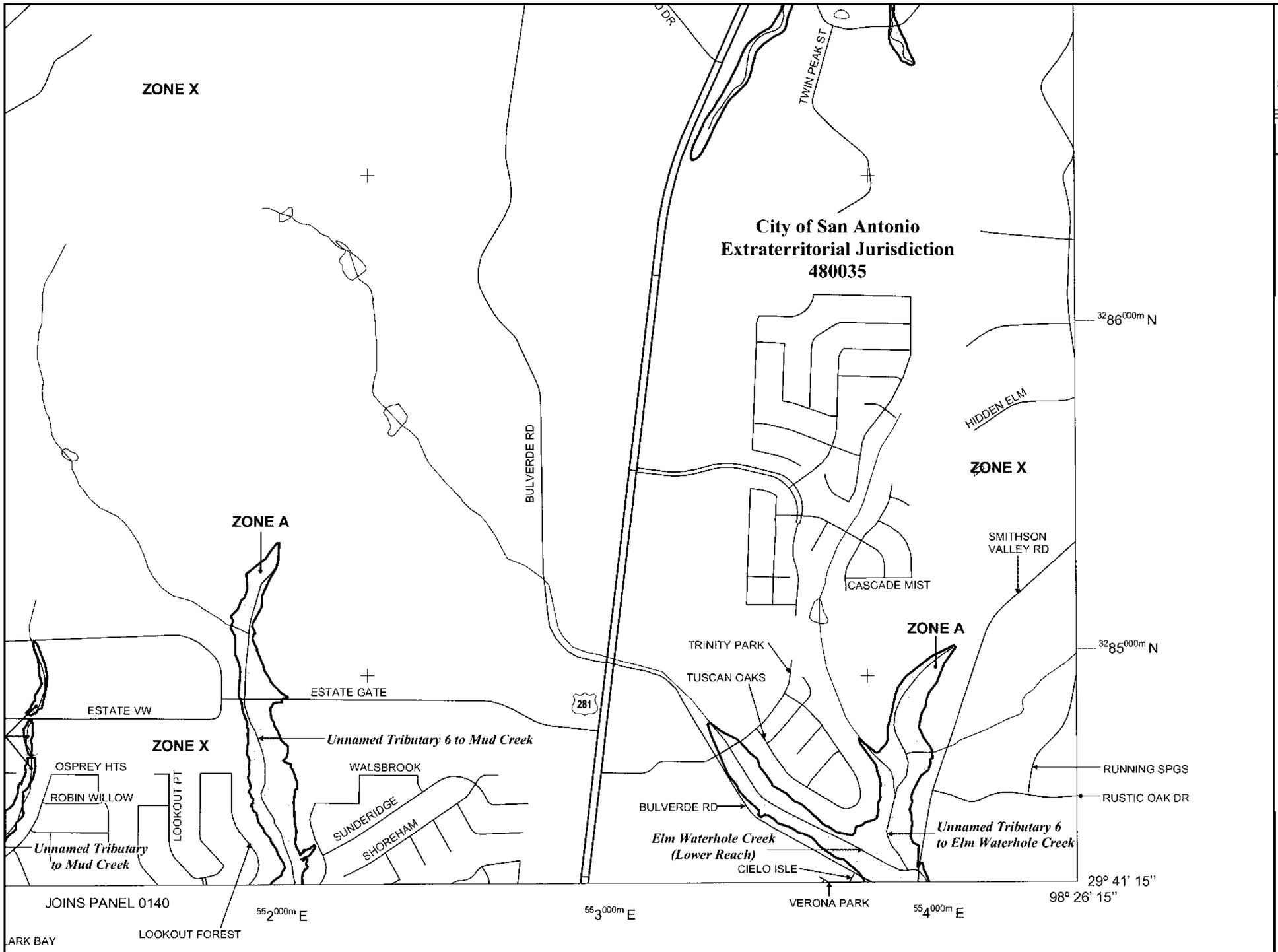
MAP NUMBER
48029C0140G

MAP REVISED
SEPTEMBER 29, 2010

Federal Emergency Management Agency

Exhibit 4D

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



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0130G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS
AND INCORPORATED AREAS

PANEL 130 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BEXAR COUNTY	480035	0130	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.

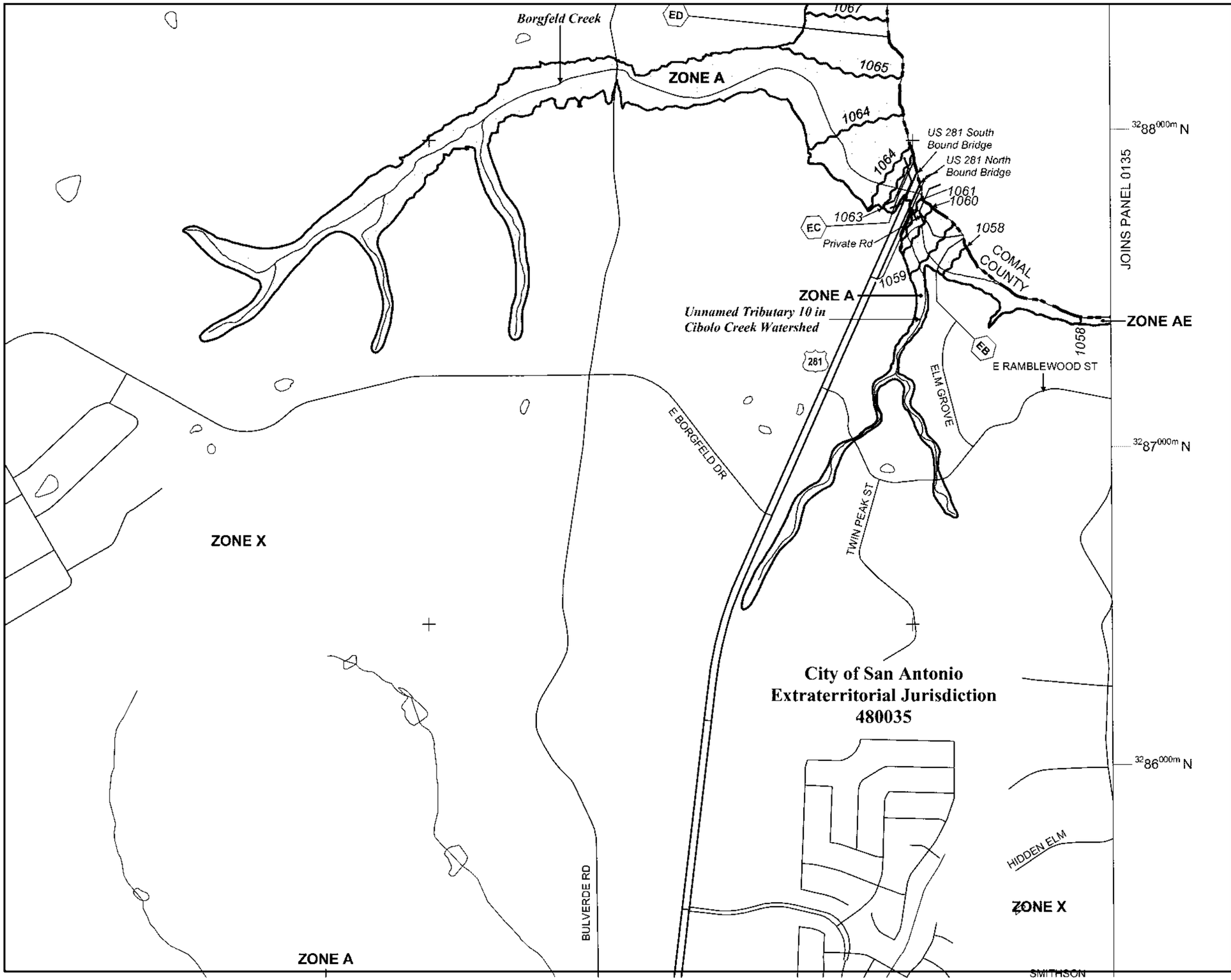
MAP NUMBER
48029C0130G

MAP REVISED
SEPTEMBER 29, 2010

Federal Emergency Management Agency

Exhibit 4E

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



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0130G

FIRM

FLOOD INSURANCE RATE MAP

BEXAR COUNTY, TEXAS
AND INCORPORATED AREAS

PANEL 130 OF 785

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BEXAR COUNTY	480035	0130	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
48029C0130G

MAP REVISED
SEPTEMBER 29, 2010

Federal Emergency Management Agency

Exhibit 4F

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

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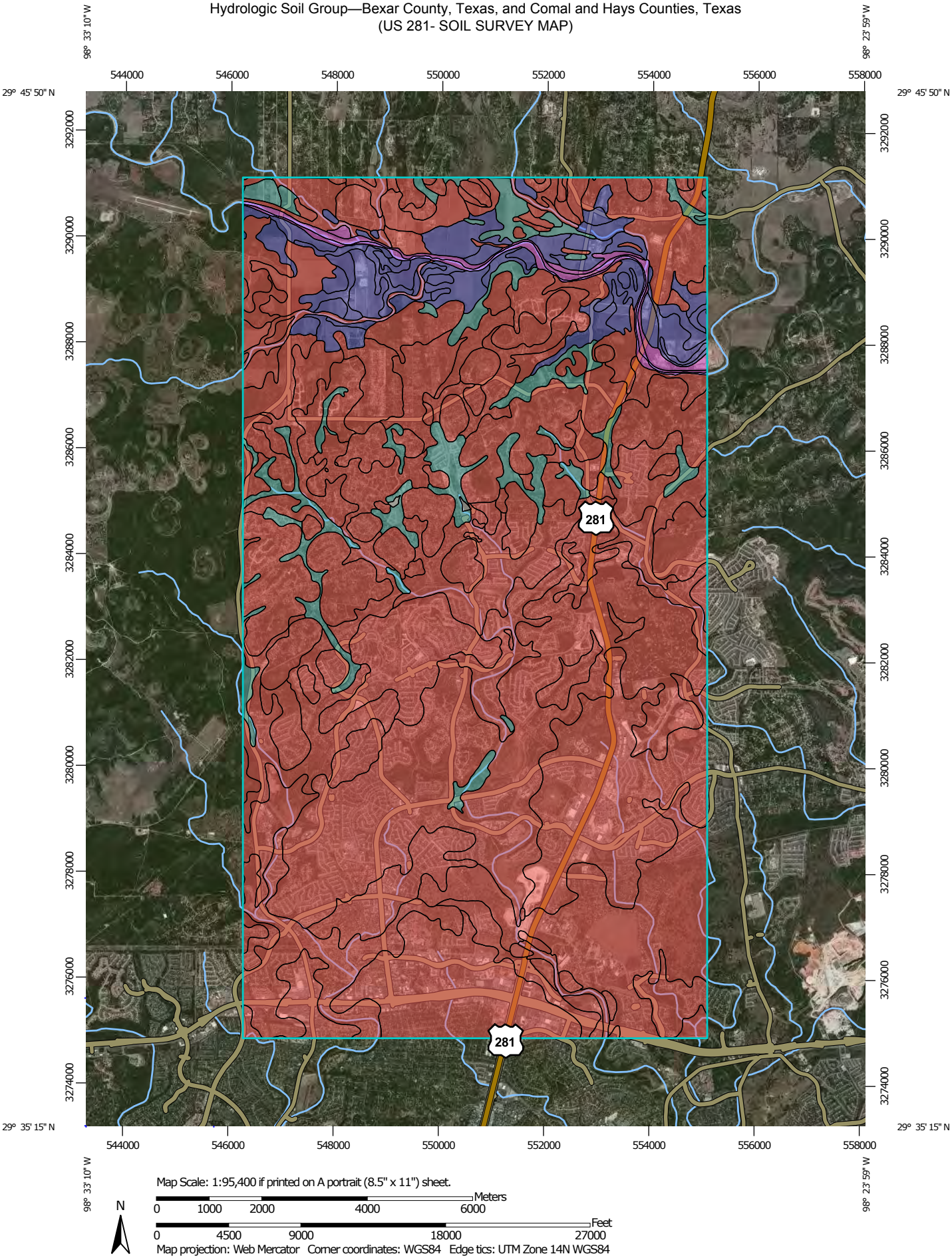
EXHIBIT 5

Hydrologic Soil Group—Bexar County, Texas, and Comal and Hays Counties, Texas
(US 281- SOIL SURVEY MAP)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bexar County, Texas
Survey Area Data: Version 15, Dec 12, 2013

Soil Survey Area: Comal and Hays Counties, Texas
Survey Area Data: Version 9, Dec 12, 2013

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 6, 2011—Feb 12, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

EXHIBIT 5

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bexar County, Texas (TX029)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BrD	Brackett gravelly clay loam, 3 to 12 percent slopes	D	785.9	2.2%
BrE	Brackett gravelly clay loam, 12 to 20 percent slopes	D	1,358.3	3.8%
BtE	Brackett-Eckrant association, 20 to 60 percent slopes	D	2,161.5	6.1%
Ca	Anhalt clay, 0 to 1 percent slopes	D	1,105.3	3.1%
Cb	Crawford and Bexar stony soils	D	5,668.6	15.9%
Kr	Krum clay, 1 to 5 percent slopes	C	1,409.7	4.0%
LvA	Lewisville silty clay, 0 to 1 percent slopes	B	518.1	1.5%
LvB	Lewisville silty clay, 1 to 3 percent slopes	B	440.5	1.2%
Or	Orif soils, 0 to 1 percent slopes, frequently flooded	A	146.7	0.4%
PaB	Patrick soils, 1 to 3 percent slopes, rarely flooded	B	275.3	0.8%
Pt	Pits and Quarries, 1 to 90 percent slopes	D	6.2	0.0%
TaB	Eckrant cobbly clay, 1 to 5 percent slopes	D	5,267.0	14.8%
TaC	Eckrant cobbly clay, 5 to 15 percent slopes	D	6,273.7	17.6%
TaD	Eckrant-Rock outcrop complex, 15 to 60 percent slopes	D	5,633.6	15.8%
TbB	Tarpley clay, 1 to 3 percent slopes	D	398.0	1.1%
Tc	Tinn clay, 0 to 1 percent slopes, occasionally flooded	D	119.9	0.3%
Tf	Tinn and Frio soils, 0 to 1 percent slopes, frequently flooded	D	84.3	0.2%
VaB	Sunev loam, 1 to 3 percent slopes	B	119.5	0.3%

Hydrologic Soil Group— Summary by Map Unit — Bexar County, Texas (TX029)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
VcB	Sunev clay loam, 1 to 3 percent slopes	B	82.4	0.2%
W	Water		11.5	0.0%
Subtotals for Soil Survey Area			**31,865.8**	**89.6%**
Totals for Area of Interest			**35,556.8**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — Comal and Hays Counties, Texas (TX604)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
AnA	Anhalt clay, 0 to 1 percent slopes	D	49.6	0.1%
AnB	Anhalt clay, 1 to 3 percent slopes	D	201.4	0.6%
BoB	Boerne fine sandy loam, 1 to 3 percent slopes, rarely flooded	A	131.7	0.4%
BrB	Bolar clay loam, 1 to 3 percent slopes	C	72.6	0.2%
BtD	Brackett-Rock outcrop-Comfort complex, 1 to 8 percent slopes	D	281.5	0.8%
BtG	Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes	D	43.8	0.1%
CrD	Comfort-Rock outcrop complex, 1 to 8 percent slopes	D	295.5	0.8%
DeB	Denton silty clay, 1 to 3 percent slopes	D	245.6	0.7%
DeC3	Denton silty clay, 1 to 5 percent slopes, eroded	D	27.6	0.1%
GrC	Gruene clay, 1 to 5 percent slopes	D	26.9	0.1%
KrA	Krum clay, 0 to 1 percent slopes	C	184.4	0.5%
KrB	Krum clay, 1 to 3 percent slopes	C	95.0	0.3%
LeA	Lewisville silty clay, 0 to 1 percent slopes	B	271.7	0.8%
LeB	Lewisville silty clay, 1 to 3 percent slopes	B	345.0	1.0%
Oa	Oakalla silty clay loam, 0 to 1 percent slopes, rarely flooded	B	59.5	0.2%
Or	Orif soils, 0 to 1 percent slopes, frequently flooded	A	179.1	0.5%

Hydrologic Soil Group— Summary by Map Unit — Comal and Hays Counties, Texas (TX604)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
PuC	Purves clay, 1 to 5 percent slopes	D	130.8	0.4%
RcD	Real-Comfort-Doss complex, 1 to 8 percent slopes	D	703.0	2.0%
RUD	Rumple-Comfort association, 1 to 8 percent slopes	C	31.3	0.1%
SuA	Sunev silty clay loam, 0 to 1 percent slopes	B	184.0	0.5%
SuB	Sunev clay loam, 1 to 3 percent slopes	B	96.5	0.3%
TaB	Tarpley clay, 1 to 3 percent slopes	D	34.3	0.1%
Subtotals for Soil Survey Area			**3,690.9**	**10.4%**
Totals for Area of Interest			**35,556.8**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

EXHIBIT 5

APPENDIX A – HYDROLOGIC CALCULATIONS – EXISTING AND PROPOSED

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C=Cr+Ci+Cv+Cs= (0.1+0.08+0.06+0.06) = 0.3	**0.4**	**Grassy**
(TXDOT HYDRAULIC MANUAL)	**0.75**	**Business/Residential**
(TXDOT HYDRAULIC MANUAL)	**0.9**	**Pavement**

EXISTING CONDITIONS - OFFSITE

BASIN INFORMATION		TIME OF CONCENTRATION	INTENSITY						C VALUE				FLOWS					
DRAINAGE BASIN	AREA (ACRES)	Tc (minutes)	I2	I5	I10	I25	I50	I100	PAVEMENT (acres)	BUSINESS / RESIDENTIAL (acres)	GRASSY (acres)	C WEIGHTED	Q2	Q5	Q10	Q25	Q50	Q100
A	712.34														788	1000.8	1158.3	1321.7
B	8490.30														3741	4787.5	5562.7	6383.3
C	167.18	91	1.42	1.90	2.19	2.56	2.90	3.21	7.40	26.06	133.73	0.48	113.41	151.19	174.60	203.66	230.95	255.73
D	6.62	10	5.41	7.05	8.07	9.26	10.27	11.49	1.37	0.47	4.79	0.53	18.91	24.63	28.20	32.35	35.90	40.15
E	3.21	10	5.41	7.05	8.07	9.26	10.27	11.49	0.56	0.24	2.41	0.51	8.91	11.60	13.29	15.24	16.91	18.92
F	9.72	10	5.41	7.05	8.07	9.26	10.27	11.49	1.97	0.56	7.19	0.52	27.43	35.72	40.91	46.93	52.07	58.24
G	51.33	25	3.41	4.48	5.14	5.93	6.63	7.39	2.76	28.87	19.70	0.62	109.17	143.33	164.62	189.92	212.33	236.66
H	105.91	39	2.58	3.41	3.92	4.54	5.09	5.67	3.96	43.43	58.52	0.56	153.68	202.76	233.28	270.07	303.32	337.37
I	237.62														311.7	395.2	457.2	521.6
J	29.62	22	3.61	4.74	5.44	6.27	7.00	7.81	2.56	5.80	21.26	0.51	54.73	71.78	82.41	95.01	106.12	118.33
K	15.77	15	4.52	5.90	6.77	7.78	8.66	9.67	2.77	2.80	10.20	0.55	39.18	51.19	58.69	67.47	75.09	83.87
L	29.07	16	4.33	5.67	6.50	7.47	8.32	9.29	2.44	14.28	12.35	0.61	77.33	101.10	115.94	133.36	148.51	165.83
M	115.11	42	2.44	3.22	3.71	4.30	4.83	5.37	5.48	13.34	96.28	0.46	130.49	172.33	198.35	229.79	258.31	287.19
N	16.77	16	4.38	5.73	6.57	7.56	8.41	9.39	2.36	1.51	12.91	0.50	36.88	48.20	55.27	63.57	70.78	79.04
O	25.48	18	4.09	5.35	6.14	7.07	7.88	8.80	1.77	15.09	8.62	0.64	66.92	87.58	100.47	115.65	128.91	143.88
P	15.83	16	4.28	5.60	6.42	7.39	8.23	9.19	3.33	2.51	9.99	0.56	38.00	49.69	56.99	65.56	73.03	81.54
Q	26.20	15	4.51	5.89	6.76	7.77	8.65	9.66	5.15	3.89	17.16	0.55	65.06	84.99	97.45	112.03	124.68	139.26
R	27.89	23	3.53	4.63	5.32	6.13	6.85	7.64	3.12	10.59	14.18	0.59	57.95	76.03	87.31	100.68	112.50	125.42
S	300.69														308.8	417.2	502.2	594.7
T	32.03	19	3.96	5.19	5.95	6.86	7.65	8.53	2.22	9.90	19.91	0.54	68.90	90.22	103.52	119.20	132.94	148.35
U	169.76	53	2.10	2.78	3.20	3.72	4.19	4.65	4.83	0.00	164.93	0.41	147.56	195.39	225.10	261.28	294.43	326.98
V	58.22	26	3.28	4.31	4.95	5.71	6.39	7.12	3.44	3.18	51.60	0.45	85.67	112.55	129.30	149.24	166.96	186.04
W	14.46	15	4.52	5.90	6.77	7.78	8.66	9.67	3.04	0.00	11.42	0.51	32.99	43.10	49.41	56.81	63.22	70.61

PROPOSED CONDITIONS - OFFSITE

BASIN INFORMATION		TIME OF CONCENTRATION	INTENSITY						C VALUE				FLOWS					
DRAINAGE BASIN	AREA (ACRES)	Tc (minutes)	I2	I5	I10	I25	I50	I100	PAVEMENT (acres)	BUSINESS / RESIDENTIAL (acres)	GRASSY (acres)	C WEIGHTED	Q2	Q5	Q10	Q25	Q50	Q100
A	712.34														788.5	1001.3	1158.7	1322.1
B	8490.30														3742.8	4789.3	5564.5	6384.9
C	167.18	91	1.42	1.90	2.19	2.56	2.90	3.21	20.05	25.77	121.36	0.51	122.27	163.01	188.25	219.57	249.00	275.71
D	6.62	10	5.41	7.05	8.07	9.26	10.27	11.49	3.39	0.47	2.76	0.68	24.39	31.77	36.38	41.73	46.30	51.79
E	3.21	10	5.41	7.05	8.07	9.26	10.27	11.49	1.39	0.24	1.58	0.64	11.16	14.54	16.65	19.10	21.19	23.70
F	9.72	10	5.41	7.05	8.07	9.26	10.27	11.49	3.29	0.56	5.87	0.59	31.00	40.37	46.23	53.03	58.84	65.81
G	51.33	25	3.41	4.48	5.14	5.93	6.63	7.39	5.88	28.86	16.58	0.65	114.49	150.32	172.65	199.18	222.69	248.20
H	105.91	39	2.58	3.41	3.92	4.54	5.09	5.67	8.95	43.40	53.56	0.59	160.10	211.22	243.02	281.35	315.98	351.45
I	237.62														322.4	406	467.8	531.6
J	29.62	22	3.61	4.74	5.44	6.27	7.00	7.81	6.48	5.52	17.62	0.57	61.45	80.59	92.53	106.67	119.15	132.86
K	15.77	15	4.52	5.90	6.77	7.78	8.66	9.67	6.12	2.02	7.63	0.64	45.52	59.46	68.18	78.38	87.23	97.43
L	29.07	16	4.33	5.67	6.50	7.47	8.32	9.29	5.15	14.25	9.68	0.66	83.14	108.70	124.66	143.39	159.68	178.30
M	115.11	42	2.44	3.22	3.71	4.30	4.83	5.37	14.30	13.34	87.46	0.50	141.26	186.55	214.71	248.75	279.62	310.88
N	16.77	16	4.38	5.73	6.57	7.56	8.41	9.39	5.30	0.49	10.98	0.57	41.76	54.59	62.60	71.99	80.16	89.51
O	25.48	18	4.09	5.35	6.14	7.07	7.88	8.80	1.84	15.02	8.63	0.64	66.95	87.62	100.52	115.70	128.97	143.95
P	15.83	16	4.28	5.60	6.42	7.39	8.23	9.19	5.42	2.35	8.06	0.62	42.22	55.22	63.33	72.85	81.15	90.60
Q	26.20	15	4.51	5.89	6.76	7.77	8.65	9.66	9.57	3.89	12.74	0.63	75.02	98.02	112.38	129.19	143.78	160.60
R	27.89	23	3.53	4.63	5.32	6.13	6.85	7.64	8.17	8.14	11.58	0.65	63.83	83.75	96.17	110.91	123.92	138.16
S	300.69														326.1	435.9	521.4	613.9
T	32.03	19	3.96	5.19	5.95	6.86	7.65	8.53	3.68	8.27	20.08	0.55	69.53	91.04	104.47	120.30	134.17	149.71
U	169.76	53	2.10	2.78	3.20	3.72	4.19	4.65	9.02	0.00	160.74	0.43	151.96	201.21	231.80	269.06	303.20	336.72
V	58.22	26	3.28	4.31	4.95	5.71	6.39	7.12	8.06	1.45	48.71	0.48	91.25	119.89	137.73	158.97	177.84	198.17
W	14.46	15	4.52	5.90	6.77	7.78	8.66	9.67	6.36	0.00	8.10	0.62	40.48	52.89	60.63	69.71	77.58	86.65

Highlighted areas will be calculated via HEC-HMS (areas A, I, S) and HEC-RAS (area B)

Row Labels	Sum of AC*CN	Sum of AC*%IMP	Sum of AC
A	54850.02	16108.05061	712.3379221
B	610216.0658	201256.6815	8490.298921
C	12890.70415	6191.0316	167.4117422
D	497.4946815	154.2127816	6.46096989
E	247.8148596	169.6806706	3.2183748
F	750.785641	593.0330823	9.75046287
G	3964.490768	2382.356883	51.48689309
H	8170.210179	3059.470892	106.1066257
I	18296.47336	5813.031508	237.6165372
J	2280.43968	1113.918393	29.61609974
K	1192.568661	754.6282532	15.48790469
L	2233.738481	1173.214611	29.00959067
M	8876.554637	1836.217382	115.2799304
N	1295.072296	524.4085121	16.81912073
O	1963.241578	964.0724607	25.49664387
P	1208.80308	813.3167337	15.6987413
Q	2010.001748	1135.3088	26.1039188
R	2145.699538	1532.12425	27.86622776
S	19385.90927	3568.986927	300.6848177
Grand Total	**752476.0884**	**249143.7459**	**10386.75144**

Existing Condition

DA ID	SCS CN	%IMP	AREA AC
A	77	22.61	712.34
B	72	23.70	8490.30
C	77	36.98	167.41
D	77	23.87	6.46
E	77	52.72	3.22
F	77	60.82	9.75
G	77	46.27	51.49
H	77	28.83	106.11
I	77	24.46	237.62
J	77	37.61	29.62
K	77	48.72	15.49
L	77	40.44	29.01
M	77	15.93	115.28
N	77	31.18	16.82
O	77	37.81	25.50
P	77	51.81	15.70
Q	77	43.49	26.10
R	77	54.98	27.87
S	64	11.87	300.68

Row Labels	Sum of AC*CN	Sum of AC*%IMP	Sum of AC
A	54915.12091	16223.6907	712.3379221
B	610346.1169	201862.2277	8490.298921
C	12890.70415	6191.0316	167.4117422
D	497.4946815	154.2127816	6.46096989
E	247.8148596	169.6806706	3.2183748
F	750.785641	593.0330823	9.75046287
G	3964.490768	2382.356883	51.48689309
H	8170.210179	3059.470892	106.1066257
I	18548.6505	7013.875023	237.6165372
J	2280.43968	1113.918393	29.61609974
K	1192.568661	754.6282532	15.48790469
L	2233.738481	1173.214611	29.00959067
M	8876.554637	1836.217382	115.2799304
N	1295.072296	524.4085121	16.81912073
O	1963.241578	964.0724607	25.49664387
P	1208.80308	813.3167337	15.6987413
Q	2010.001748	1135.3088	26.1039188
R	2145.699538	1532.12425	27.86622776
S	19648.95214	4446.304604	300.6848177
Grand Total	**753186.4604**	**251943.0933**	**10386.75144**

Proposed Condition

DA ID	SCS CN	%IMP	AREA AC
A	77	22.78	712.34
B	72	23.78	8490.30
C	77	36.98	167.41
D	77	23.87	6.46
E	77	52.72	3.22
F	77	60.82	9.75
G	77	46.27	51.49
H	77	28.83	106.11
I	78	29.52	237.62
J	77	37.61	29.62
K	77	48.72	15.49
L	77	40.44	29.01
M	77	15.93	115.28
N	77	31.18	16.82
O	77	37.81	25.50
P	77	51.81	15.70
Q	77	43.49	26.10
R	77	54.98	27.87
S	65	14.79	300.68

Watershed	Flow Type	Length (ft)	Top Elevation	Low Elevation	Slope (ft/ft)	n_{OF}	Paved?	Manning's n	Avg V (ft/s)	T_C (hr)	TC (MIN)	T_L (hr)	T_L (MIN)
DA A	Sheet Flow	300	1136	1126	0.0333	0.15				1.412		0.847	
DA A	Shallow Concentrated	4962	1126	968	0.0318		N 16.1345		2.900	0.475		0.285	
DA A	Channel	6630	968	914	0.0081			0.075	1.336	1.378		0.827	
Total		11892.000								3.265	195.915	**1.959**	117.5487856

	AC	mi^2
Existing Area	712.338	1.1130
Proposed Area	712.338	1.1130

2-yr 24-hr rainfall (in)	0.165

Unpaved	N	16.1345	FIGURE 3-1 TR-55
Paved	Y	20.3282	2.9 FT/S

Cross sectional area (ft^2)	6
Wetted perimeter (ft)	9.325

CN	Existing	77
	Proposed	77

%IMP	Existing	22.61
	Proposed	22.78

Irrigation Channel

Distance	Elevation
0	1
3	0
6	0
9	1

Watershed	Flow Type	Length (ft)	Top Elevation	Low Elevation	Slope (ft/ft)	n_{OF}	Paved?	Manning's n	Avg V (ft/s)	T_C (hr)	TC (MIN)	T_L (hr)	T_L (MIN)
DA B	Sheet Flow	300	1388	1284	0.3467	0.15				0.553		0.332	
DA B	Shallow Concentrated	2572	1176	1154	0.0086		N 16.1345		1.600	0.447		0.268	
DA B	Channel	43393	1284	902	0.0088			0.075	1.389	8.676		5.206	
Total		46265.000								9.676	520.562	5.806	348.3313

	AC	mi^2
Existing Area	8490.299	13.2661
Proposed Area	8490.299	13.2661

2-yr 24-hr rainfall (in)	0.165

Unpaved	N	16.1345	FIGURE 3-1 TR-55
Paved	Y	20.3282	1.6 FT/S

Cross sectional area (ft^2)	6
Wetted perimeter (ft)	9.325

CN	Existing	72
	Proposed	72

%IMP	Existing	23.70
	Proposed	23.78

Irrigation Channel

Distance	Elevation
0	1
3	0
6	0
9	1

Watershed	Flow Type	Length (ft)	Top Elevation	Low Elevation	Slope (ft/ft)	n_{OF}	Paved?	Manning's n	Avg V (ft/s)	T_C (hr)	TC (MIN)	T_L (hr)	T_L (MIN)
DA I	Sheet Flow	300	1226	1222	0.0133	0.15				2.037		1.222	
DA I	Shallow Concentrated	2168	1222	1098	0.0572		N 16.1345		3.950	0.152		0.091	
DA I	Channel	3211	1098	1020	0.0243			0.075	2.308	0.386		0.232	
Total		5679.000								2.576	154.546	**1.545**	92.7273752

	AC	mi^2
Existing Area	237.617	0.3713
Proposed Area	237.617	0.3713

2-yr 24-hr rainfall (in)	0.165

Unpaved	N	16.1345	FIGURE 3-1 TR-55
Paved	Y	20.3282	3.95 FT/S

Cross sectional area (ft^2)	6
Wetted perimeter (ft)	9.325

CN	Existing	77
	Proposed	78

%IMP	Existing	24.46
	Proposed	29.52

Irrigation Channel

Distance	Elevation
0	1
3	0
6	0
9	1

Hydrologic Calculations Tc
DA I
>640 AC

Watershed	Flow Type	Length (ft)	Top Elevation	Low Elevation	Slope (ft/ft)	n_{OF}	Paved?	Manning's n	Avg V (ft/s)	T_C (hr)	TC (MIN)	T_L (hr)	T_L (MIN)
DA S	Sheet Flow	300	1390	1364	0.0867	0.15				0.963		0.578	
DA S	Shallow Concentrated	1246	1364	1280	0.0674		N 16.1345		4.200	0.082		0.049	
DA S	Channel	7734	1280	1144	0.0176			0.075	1.964	1.094		0.656	
Total		9280.000								2.140	128.392	**1.284**	77.03527753

	AC	mi^2
Existing Area	300.685	0.4698
Proposed Area	300.685	0.4698

2-yr 24-hr rainfall (in)	0.165

Unpaved	N	16.1345	FIGURE 3-1 TR-55
Paved	Y	20.3282	4.2 FT/S

Cross sectional area (ft^2)	6
Wetted perimeter (ft)	9.325

CN	Existing	64
	Proposed	65

%IMP	Existing	11.87
	Proposed	14.79

Irrigation Channel

Distance	Elevation
0	1
3	0
6	0
9	1

FLOWS

	EXISTING				PROPOSED				PROP-EXIST			
DA ID	**10 YR**	**25 YR**	**50 YR**	**100 YR**	**10 YR**	**25 YR**	**50 YR**	**100 YR**	**10 YR**	**25 YR**	**50 YR**	**100 YR**
	CFS	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**	**CFS**
A	788	1000.8	1158.3	1321.7	788.5	1001.3	1158.7	1322.1	0.5	0.5	0.4	0.4
B	3741	4787.5	5562.7	6383.3	3742.8	4789.3	5564.5	6384.9	1.8	1.8	1.8	1.6
I	311.7	395.2	457.2	521.6	322.4	406	467.8	531.6	10.7	10.8	10.6	10
S	308.8	417.2	502.2	594.7	326.1	435.9	521.4	613.9	17.3	18.7	19.2	19.2

APPENDIX B – HEC-HMS OUTPUT DATA – EXISTING AND PROPOSED

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EXISTING CONDITION

Global Summary Results for Run "EX_10%_10YR"

Project: US 281 Simulation Run: EX_10%_10YR

Start of Run: 01Jan2000, 00:00 Basin Model: EXIST_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 10%
Compute Time: 04Feb2014, 10:46:40 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA A	1.1130	788.0	01Jan2000, 18:11	252.6
DA B	13.2661	3741.0	01Jan2000, 22:19	1672.2
DA I	0.3713	311.7	01Jan2000, 17:44	86.4
DA S	0.4698	308.8	01Jan2000, 17:31	74.0

Global Summary Results for Run "EX_4%_25YR"

Project: US 281 Simulation Run: EX_4%_25YR

Start of Run: 01Jan2000, 00:00 Basin Model: EXIST_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 4%
Compute Time: 04Feb2014, 10:47:18 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	1000.8	01Jan2000, 18:10	5.39
DA B	13.2661	4787.5	01Jan2000, 22:16	3.04
DA I	0.3713	395.2	01Jan2000, 17:44	5.52
DA S	0.4698	417.2	01Jan2000, 17:30	3.95

Global Summary Results for Run "EX_2%_50YR"

Project: US 281 Simulation Run: EX_2%_50YR

Start of Run: 01Jan2000, 00:00 Basin Model: EXIST_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 2%
Compute Time: 04Feb2014, 10:46:58 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	1158.3	01Jan2000, 18:09	6.27
DA B	13.2661	5562.7	01Jan2000, 22:13	3.59
DA I	0.3713	457.2	01Jan2000, 17:43	6.41
DA S	0.4698	502.2	01Jan2000, 17:30	4.74

Global Summary Results for Run "EX_1%_100YR"

Project: US 281 Simulation Run: EX_1%_100YR

Start of Run: 01Jan2000, 00:00 Basin Model: EXIST_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 1%
Compute Time: 04Feb2014, 10:46:19 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	1321.7	01Jan2000, 18:09	7.27
DA B	13.2661	6383.3	01Jan2000, 22:10	4.24
DA I	0.3713	521.6	01Jan2000, 17:43	7.42
DA S	0.4698	594.7	01Jan2000, 17:29	5.65

PROPOSED CONDITION

Global Summary Results for Run "PR_10%_10YR"

Project: US 281 Simulation Run: PR_10%_10YR

Start of Run: 01Jan2000, 00:00 Basin Model: PROP_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 10%
Compute Time: 04Feb2014, 11:45:28 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	788.5	01Jan2000, 18:11	4.26
DA B	13.2661	3742.8	01Jan2000, 22:19	2.37
DA I	0.3713	322.4	01Jan2000, 17:44	4.57
DA S	0.4698	326.1	01Jan2000, 17:30	3.15

Global Summary Results for Run "PR_4%_25YR"

Project: US 281 Simulation Run: PR_4%_25YR

Start of Run: 01Jan2000, 00:00 Basin Model: PROP_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 4%
Compute Time: 04Feb2014, 11:46:09 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	1001.3	01Jan2000, 18:10	5.40
DA B	13.2661	4789.3	01Jan2000, 22:16	3.05
DA I	0.3713	406.0	01Jan2000, 17:43	5.74
DA S	0.4698	435.9	01Jan2000, 17:30	4.16

Global Summary Results for Run "PR_2%_50YR"

Project: US 281 Simulation Run: PR_2%_50YR

Start of Run: 01Jan2000, 00:00 Basin Model: PROP_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 2%
Compute Time: 04Feb2014, 11:45:47 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	1158.7	01Jan2000, 18:09	6.28
DA B	13.2661	5564.5	01Jan2000, 22:13	3.60
DA I	0.3713	467.8	01Jan2000, 17:43	6.64
DA S	0.4698	521.4	01Jan2000, 17:29	4.97

Global Summary Results for Run "PR_1%_100YR"

Project: US 281 Simulation Run: PR_1%_100YR

Start of Run: 01Jan2000, 00:00 Basin Model: PROP_US281
End of Run: 02Jan2000, 00:00 Meteorologic Model: Met 1%
Compute Time: 04Feb2014, 11:45:04 Control Specifications: Control 1

Volume Units: IN AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
DA A	1.1130	1322.1	01Jan2000, 18:09	7.27
DA B	13.2661	6384.9	01Jan2000, 22:10	4.24
DA I	0.3713	531.6	01Jan2000, 17:43	7.66
DA S	0.4698	613.9	01Jan2000, 17:29	5.89

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APPENDIX C – MODIFIED RATIONAL METHOD – DETENTION VOLUME CALCULATIONS

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Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: A
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.71
b =	107
d =	8.7
e =	0.762
t_d =	13.63
A_p =	39.7 ac
Q_A =	303.4 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**265,479 ft3**
Qp =	$C_p i_D A_p$ =	324.6 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**215,050 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**50,429 ft3**
		1.4 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 130' **Width =** 65'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.1863	**0.1863**	**1.00**	**13.63**

Directions for use - A (manual)

1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)

1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)

1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: B
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.79
b =	107
d =	8.7
e =	0.762
t_d =	19.48
A_p =	17.2 ac
Q_A =	108.4 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**182,975 ft3**
Qp =	$C_p i_D A_p$ =	156.5 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**95,874 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**87,101 ft3**
		2.4 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 170' **Width =** 85'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2514	**0.2514**	**1.00**	**19.48**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: C
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.72
b =	107
d =	8.7
e =	0.762
t_d =	18.59
A_p =	10.1 ac
Q_A =	60.1 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**93,030 ft3**
Qp =	$C_p i_D A_p$ =	83.4 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**51,581 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**41,449 ft3**

1.1 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 118' **Width =** 59'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2414	**0.2414**	**1.00**	**18.59**

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: D
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.75
b =	107
d =	8.7
e =	0.762
t_d =	19.71
A_p =	7.6 ac
Q_A =	44.5 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**76,813 ft3**
Qp =	$C_p i_D A_p$ =	65.0 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**39,683 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**37,130 ft3**

1.0 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 111' **Width =** 56'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2540	**0.2540**	**1.00**	**19.71**

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: E
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.74
b =	107
d =	8.7
e =	0.762
t_d =	16.70
A_p =	14.0 ac
Q_A =	94.1 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**119,321 ft3**
Qp =	$C_p i_D A_p$ =	119.1 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**75,377 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**43,945 ft3**

1.2 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 121' **Width =** 61'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2203	**0.2203**	**1.00**	**16.70**

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: F
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.74
b =	107
d =	8.7
e =	0.762
t_d =	18.68
A_p =	12.8 ac
Q_A =	78.1 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**121,973 ft3**
Qp =	$C_p i_D A_p$ =	108.8 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**67,192 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**54,781 ft3**
		1.5 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 135' **Width =** 68'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2424	**0.2426**	**1.00**	**18.69**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: G
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.77
b =	107
d =	8.7
e =	0.762
t_{d} =	18.52
A_{p} =	11.8 ac
Q_{A} =	75.6 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**116,148 ft3**
Qp =	$C_p i_D A_p$ =	104.5 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**64,713 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**51,435 ft3**
		1.4 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 131' **Width =** 65'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2406	**0.2406**	**1.00**	**18.52**

Modified Rational Method
Detention Volume Calc
DA G

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: H
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.76
b =	107
d =	8.7
e =	0.762
t_d =	18.30
A_p =	22.9 ac
Q_A =	145.4 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**218,447 ft3**
Qp =	$C_p i_D A_p$ =	198.9 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**123,442 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**95,005 ft3**
		2.6 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 178' **Width =** 89'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2382	**0.2382**	**1.00**	**18.30**

Directions for use - A (manual)

1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)

1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)

1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: I
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.72
b =	107
d =	8.7
e =	0.762
t_{d} =	18.12
A_{p} =	15.3 ac
Q_{A} =	93.4 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**137,739 ft3**
Qp =	$C_p i_D A_p$ =	126.7 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**78,766 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**58,973 ft3**
		1.6 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 140' **Width =** 70'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2362	**0.2362**	**1.00**	**18.13**

Directions for use - A (manual)

1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)

1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)

1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: J
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.72
b =	107
d =	8.7
e =	0.762
t_{d} =	17.11
A_{p} =	10.2 ac
Q_{A} =	65.8 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**87,233 ft3**
Qp =	$C_p i_D A_p$ =	85.0 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**53,508 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**33,725 ft3**
		0.9 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 106' **Width =** 53'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2249	**0.2249**	**1.00**	**17.11**

Detention Volume Calculator
Modified Rational Method
281 EIS
Basin: K
Date: 2/10/2014

user entry

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.70
b =	107
d =	8.7
e =	0.762
t_{d} =	17.50
A_{p} =	8.1 ac
Q_{A} =	49.7 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**68,767 ft3**
Qp =	$C_p i_D A_p$ =	65.5 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**41,030 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**27,736 ft3**
		0.8 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 96' **Width =** 48'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2292	**0.2293**	**1.00**	**17.50**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: L
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.67
b =	107
d =	8.7
e =	0.762
t_d =	17.79
A_p =	21.9 ac
Q_A =	126.0 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**179,663 ft3**
Qp =	$C_p i_D A_p$ =	168.3 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**105,064 ft3**

Calculated Storage Volume		
SD =	$V_i - V_o$ =	**74,600 ft3**
		2.1 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 158' **Width =** 79'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2325	**0.2325**	**1.00**	**17.80**

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: M
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.69
b =	107
d =	8.7
e =	0.762
t_d =	17.42
A_p =	18.6 ac
Q_A =	111.9 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**153,366 ft3**
Qp =	$C_p i_D A_p$ =	146.7 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**92,028 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**61,339 ft3**
		1.7 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 143' **Width =** 71'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2283	**0.2283**	**1.00**	**17.42**

Directions for use - A (manual)

1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)

1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)

1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: N
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.72
b =	107
d =	8.7
e =	0.762
t_{d} =	17.40
A_{p} =	11.3 ac
Q_{A} =	71.4 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**97,654 ft3**
Qp =	$C_p i_D A_p$ =	93.5 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**58,656 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**38,998 ft3**
		1.1 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 114' **Width =** 57'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2281	**0.2282**	**1.00**	**17.41**

Directions for use - A (manual)

1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)

1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)

1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: O
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.70
b =	107
d =	8.7
e =	0.762
t_{d} =	17.90
A_{p} =	41.3 ac
Q_{A} =	247.7 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**358,119 ft3**
Qp =	$C_p i_D A_p$ =	333.4 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**207,307 ft3**

Calculated Storage Volume		
SD =	$V_i - V_o$ =	**150,813 ft3**
		4.2 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 224' **Width =** 112'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2337	**0.2344**	**1.00**	**17.95**

Directions for use - A (manual)

1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)

1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)

1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: P
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.66
b =	107
d =	8.7
e =	0.762
t_{d} =	16.40
A_{p} =	15.6 ac
Q_{A} =	95.3 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**116,989 ft3**
Qp =	$C_p i_D A_p$ =	118.9 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**75,451 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**41,537 ft3**
		1.1 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 118' **Width =** 59'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2170	**0.2173**	**1.00**	**16.42**

Detention Volume Calculator
Modified Rational Method
281 EIS
Basin: Q
Date: 2/10/2014

user entry

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.68
b =	107
d =	8.7
e =	0.762
t_d =	17.76
A_p =	22.4 ac
Q_A =	131.5 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**187,168 ft3**
Qp =	$C_p i_D A_p$ =	175.6 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**109,519 ft3**

Calculated Storage Volume		
SD =	$V_i - V_o$ =	**77,650 ft3**
		2.1 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 161' **Width =** 80'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2321	**0.2325**	**1.00**	**17.79**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: R
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.70
b =	107
d =	8.7
e =	0.762
t_{d} =	15.93
A_{p} =	21.8 ac
Q_{A} =	143.6 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**167,034 ft3**
Qp =	$C_p i_D A_p$ =	174.8 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**111,732 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**55,302 ft3**
		1.5 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 136' **Width =** 68'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2117	**0.2118**	**1.00**	**15.94**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: S
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_{p} =	0.70
b =	107
d =	8.7
e =	0.762
t_{d} =	14.82
A_{p} =	19.9 ac
Q_{A} =	138.8 cfs
t_{c} =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**141,376 ft3**
Qp =	$C_p i_D A_p$ =	159.0 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**103,331 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**38,045 ft3**
		1.0 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 113' **Width =** 56'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.1994	**0.1995**	**1.00**	**14.82**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: T
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.64
b =	107
d =	8.7
e =	0.762
t_d =	14.75
A_p =	12.9 ac
Q_A =	83.1 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**83,928 ft3**
Qp =	$C_p i_D A_p$ =	94.8 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**61,712 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**22,216 ft3**
		0.6 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 86' **Width =** 43'

Calcuate t_d

a	b	a/b	New t_d
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.1986	**0.1986**	**1.00**	**14.75**

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: U
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.63
b =	107
d =	8.7
e =	0.762
t_d =	15.85
A_p =	18.1 ac
Q_A =	107.9 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**124,315 ft3**
Qp =	$C_p i_D A_p$ =	130.7 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**83,700 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**40,615 ft3**
		1.1 AC-FT

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 116' **Width =** 58'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2108	**0.2109**	**1.00**	**15.85**

Detention Volume Calculator
Modified Rational Method
281 EIS
Basin: V
Date: 2/10/2014

user entry

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.64
b =	107
d =	8.7
e =	0.762
t_d =	14.47
A_p =	10.6 ac
Q_A =	69.5 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**67,872 ft3**
Qp =	$C_p i_D A_p$ =	78.2 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**51,056 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**16,816 ft3**
		0.5 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio
Length = 75' **Width =** 37'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.1956	**0.1957**	**1.00**	**14.48**

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

Detention Volume Calculator
Modified Rational Method
281 EIS

user entry

Basin: W
Date: 2/10/2014

Hydrologic Data Entry	
Storm Event	100-yr
C_p =	0.60
b =	107
d =	8.7
e =	0.762
t_d =	15.10
A_p =	32.1 ac
Q_A =	190.2 cfs
t_c =	10 min
i	11.49

Inflow Hydrograph Volume		
V_i =	$60(1/2)(Q_P)[(t_D-t_c)+(t_d+t_c)]$ =	**200,490 ft3**
Qp =	$C_p i_D A_p$ =	221.3 cfs

Outflow Hydrograph Volume		
Vo =	$60(1/2)(Q_A)(t_D+t_c)$ =	**143,188 ft3**

Calculated Storage Volume		
SD =	V_i - V_o =	**57,301 ft3**

1.6 AC-FT

Calculated Basin Dimensions Assume 6' Depth, 2:1 L/W Ratio

Length = 138' **Width =** 69'

Calcuate t_d			
a	**b**	**a/b**	**New t_d**
$[(t_d+d)^{(e+1)}]/[b(t_d+d-e*t_d)]$	(2*Cp*Ap)/Qa		(a/b) * t_d
0.2025	**0.2026**	**1.00**	**15.11**

Directions for use - A (manual)
1. Enter values for all cells that are orange
2. enter "30" into cell B13
3. If E30 = 1 then your answer is in cell C27
4. If E30 ≠ 1 then enter the value of cell G30 into cell B13
5. repeat step 4 until until E30 = 1
6. answer is in cell C27

Directions for use - B (with use of Goal Seek Function)
1. Enter values for all cells that are orange
2. enter "30" into cell B7
3. Use command "Goal Seek" under Tools pulldown menu
4. Within Goal Seek:
   set cell :E32, To vaule: "1", By Changing: B13
5. Answer is in C27

Directions for use - C (with use of a macro)
1. Enter values for all cells that are orange
2. Press crtl+r
3. Answer is in C27

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APPENDIX D – HY-8 CULVERT ANALYSIS REPORT

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HY-8 Culvert Analysis Report

Project Notes

Project Title: US 281 Existing Condition

Designer:

Project Date: Monday, January 20, 2014

Notes:

Project Units: U.S. Customary Units

Outlet Control Option: Profiles

Exit Loss Option: Standard Method

Crossing Notes: Crossing 352+18.14

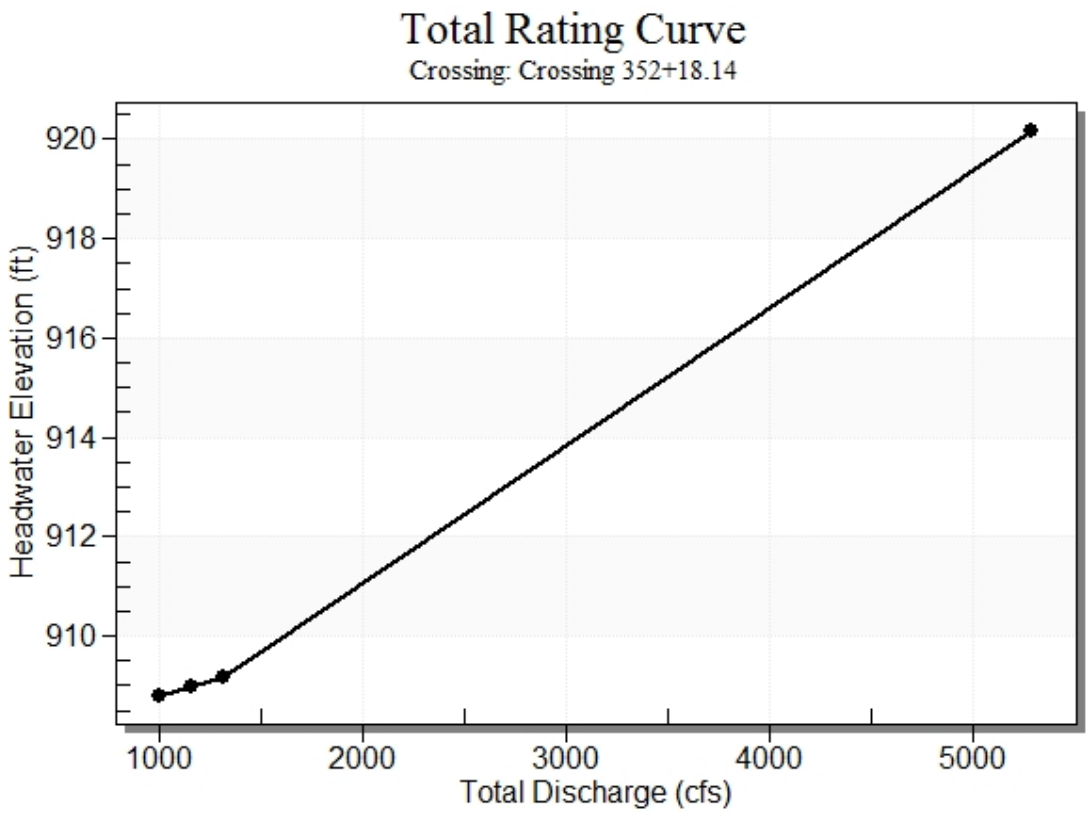
Crossing Discharge Data

Discharge Selection Method: Recurrence

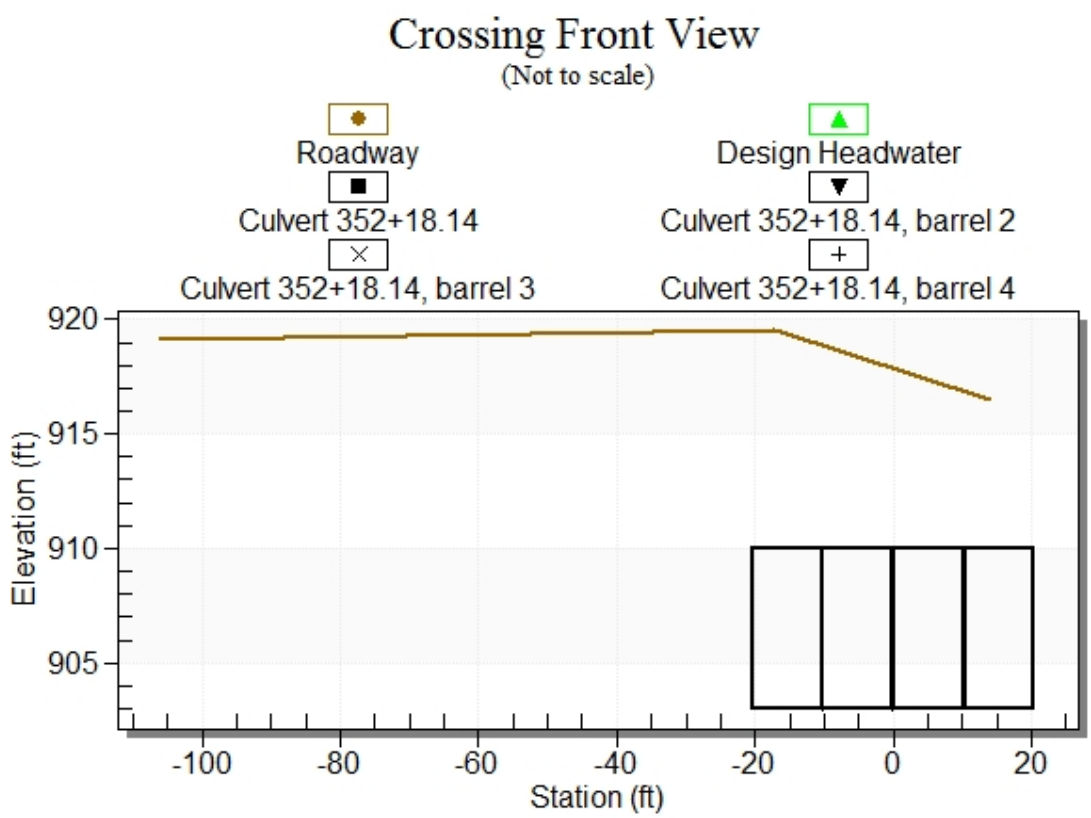
Table 1 - Summary of Culvert Flows at Crossing: Crossing 352+18.14

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 352+18.14 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
908.81	25 year	1000.80	1000.80	0.00	1
908.97	50 year	1158.30	1158.30	0.00	1
909.16	100 year	1321.70	1321.70	0.00	1
916.52	Overtopping	3973.49	3973.49	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 352+18.14



Crossing Front View (Roadway Profile): Crossing 352+18.14



Culvert Notes: Culvert 352+18.14

Table 2 - Culvert Summary Table: Culvert 352+18.14

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	1000.80	1000.80	908.81	4.558	5.837	1-S1t	2.166	2.689	6.890	7.000	3.631	0.000
50 year	1158.30	1158.30	908.97	5.013	5.997	1-S1t	2.401	2.964	6.890	7.000	4.203	0.000
100 year	1321.70	1321.70	909.16	5.464	6.190	1-S1t	2.626	3.237	6.890	7.000	4.796	0.000

****

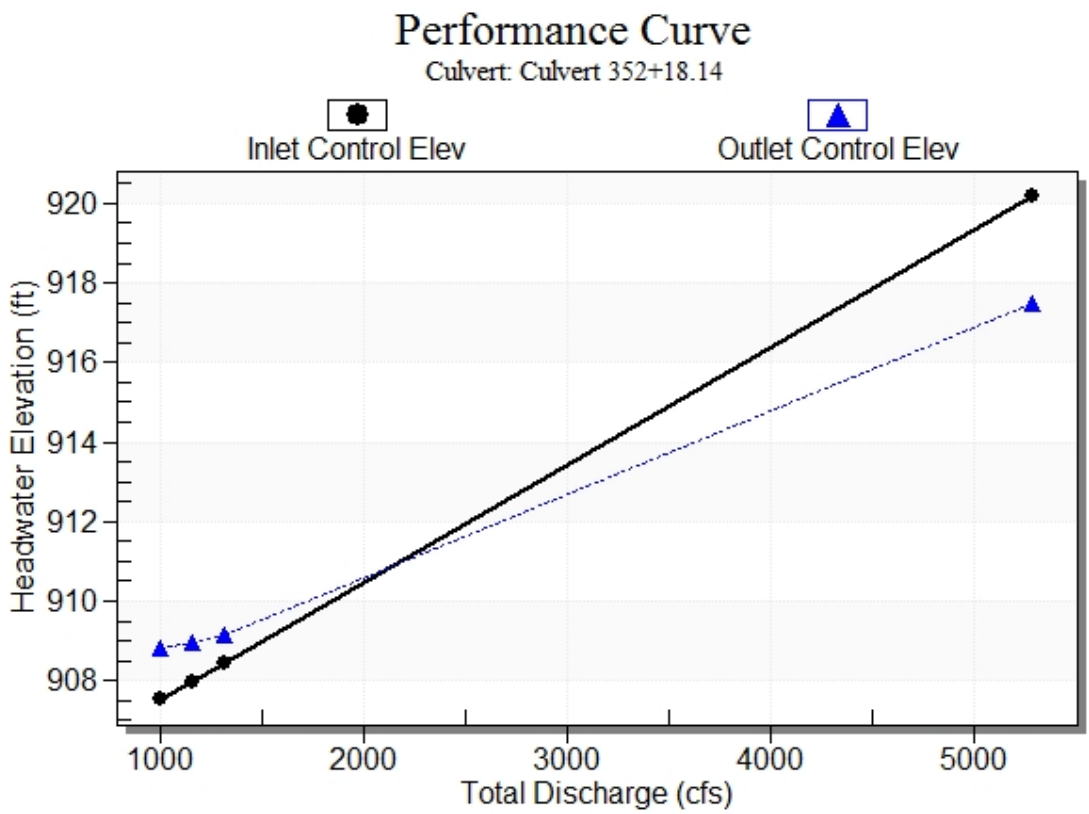
Straight Culvert

Inlet Elevation (invert): 902.97 ft, Outlet Elevation (invert): 901.45 ft

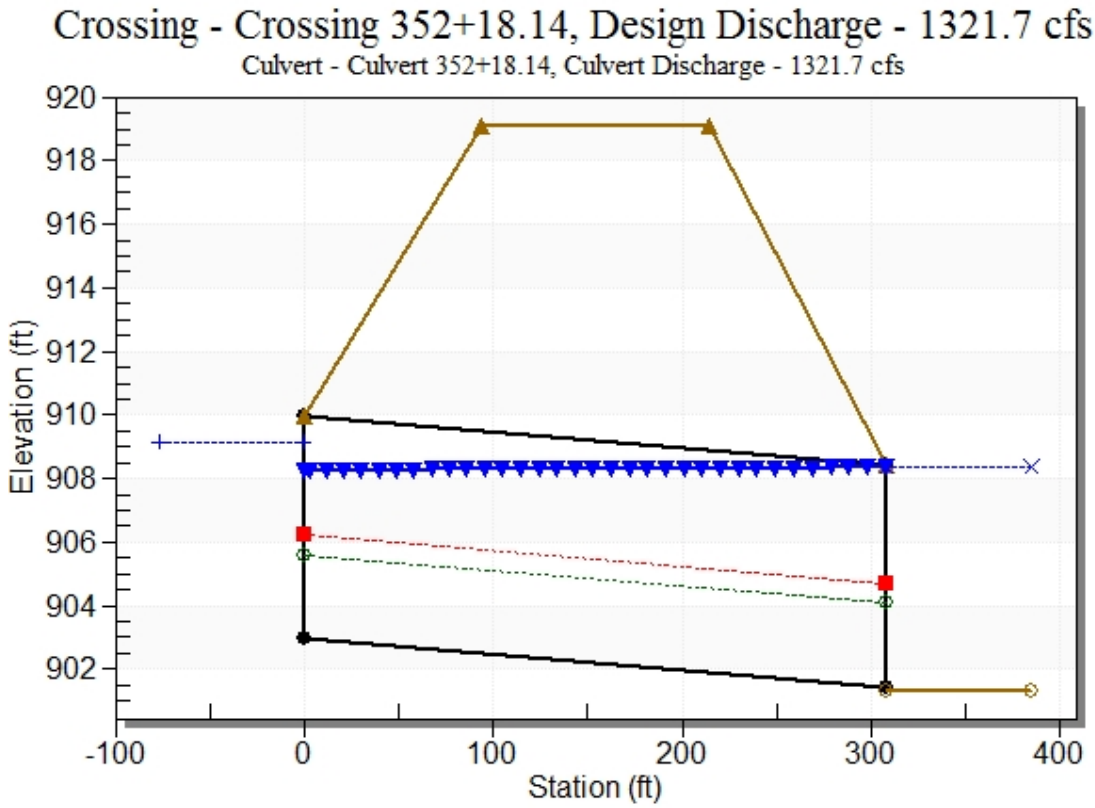
Culvert Length: 308.00 ft, Culvert Slope: 0.0049

****

Culvert Performance Curve Plot: Culvert 352+18.14



Water Surface Profile Plot for Culvert: Culvert 352+18.14



Site Data - Culvert 352+18.14

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 902.97 ft

Outlet Station: 308.00 ft

Outlet Elevation: 901.45 ft

Number of Barrels: 4

Culvert Data Summary - Culvert 352+18.14

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 352+18.14)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1000.80	908.34	7.00
1158.30	908.34	7.00
1321.70	908.34	7.00

Tailwater Channel Data - Crossing 352+18.14

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 908.34 ft

Roadway Data for Crossing: Crossing 352+18.14

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-106.00	919.12
1	-17.00	919.57
2	14.00	916.52

Roadway Surface: Paved

Roadway Top Width: 120.00 ft

Crossing Notes: Crossing 369+30.37

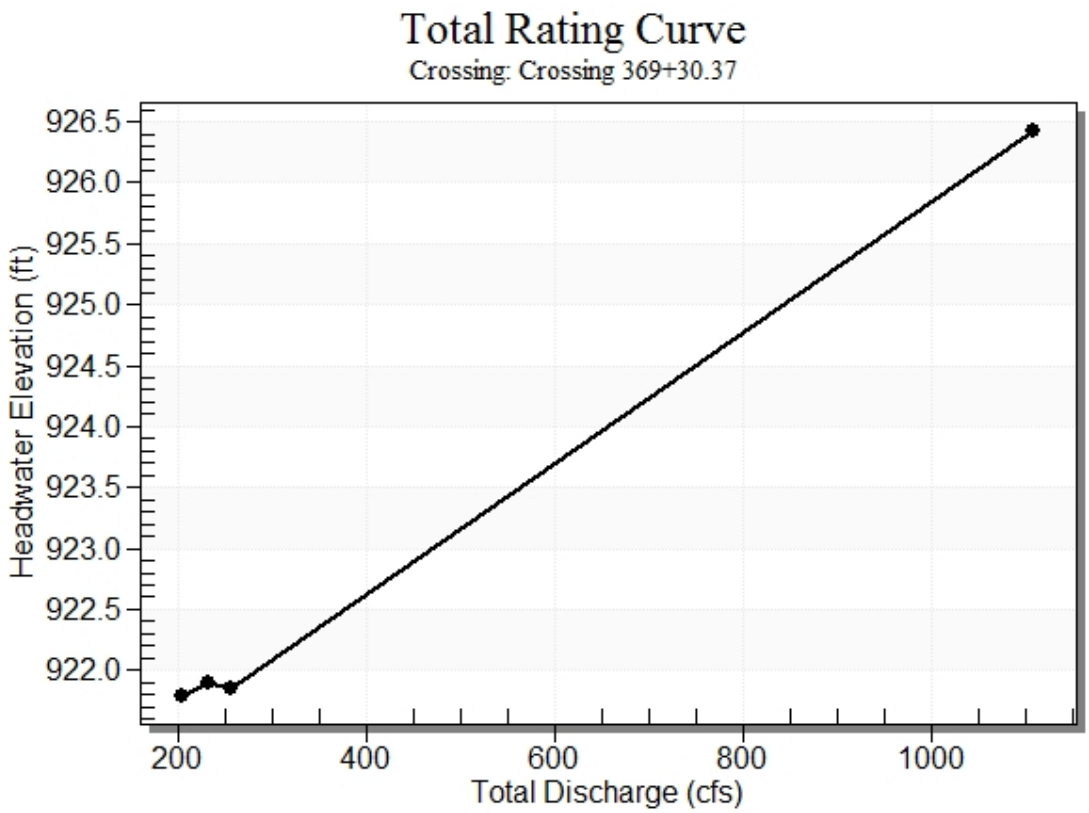
Crossing Discharge Data

Discharge Selection Method: Recurrence

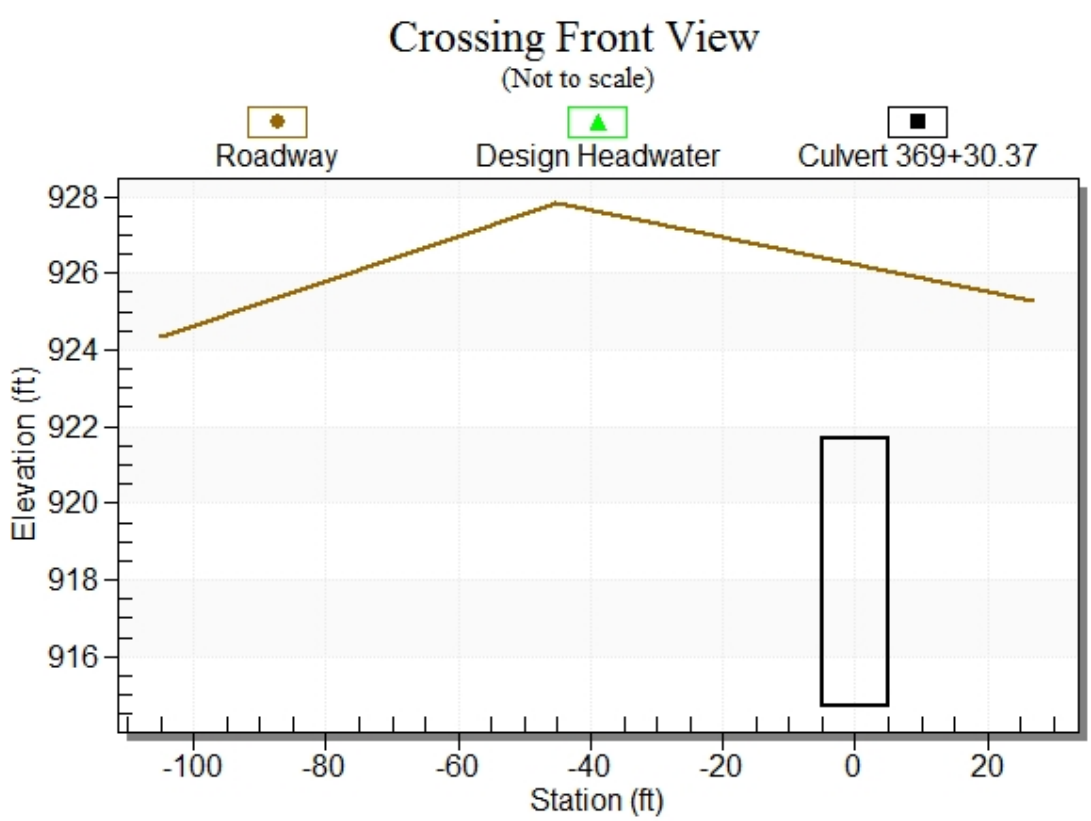
Table 4 - Summary of Culvert Flows at Crossing: Crossing 369+30.37

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 369+30.37 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
921.80	25 year	203.66	203.66	0.00	1
921.89	50 year	230.95	230.95	0.00	1
921.86	100 year	255.73	255.73	0.00	1
927.84	Overtopping	1042.29	1042.29	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 369+30.37



Crossing Front View (Roadway Profile): Crossing 369+30.37



Culvert Notes: Culvert 369+30.37

Table 5 - Culvert Summary Table: Culvert 369+30.37

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	203.66	203.66	921.80	3.604	7.096	3-M1f	3.278	2.344	7.000	7.000	2.909	0.000
50 year	230.95	230.95	921.89	3.928	7.194	3-M1f	3.586	2.549	7.000	7.000	3.299	0.000
100 year	255.73	255.73	921.86	4.209	7.156	4-FFf	3.866	2.728	7.000	7.000	3.653	0.000

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Straight Culvert

Inlet Elevation (invert): 914.70 ft, Outlet Elevation (invert): 914.50 ft

Culvert Length: 199.00 ft, Culvert Slope: 0.0010

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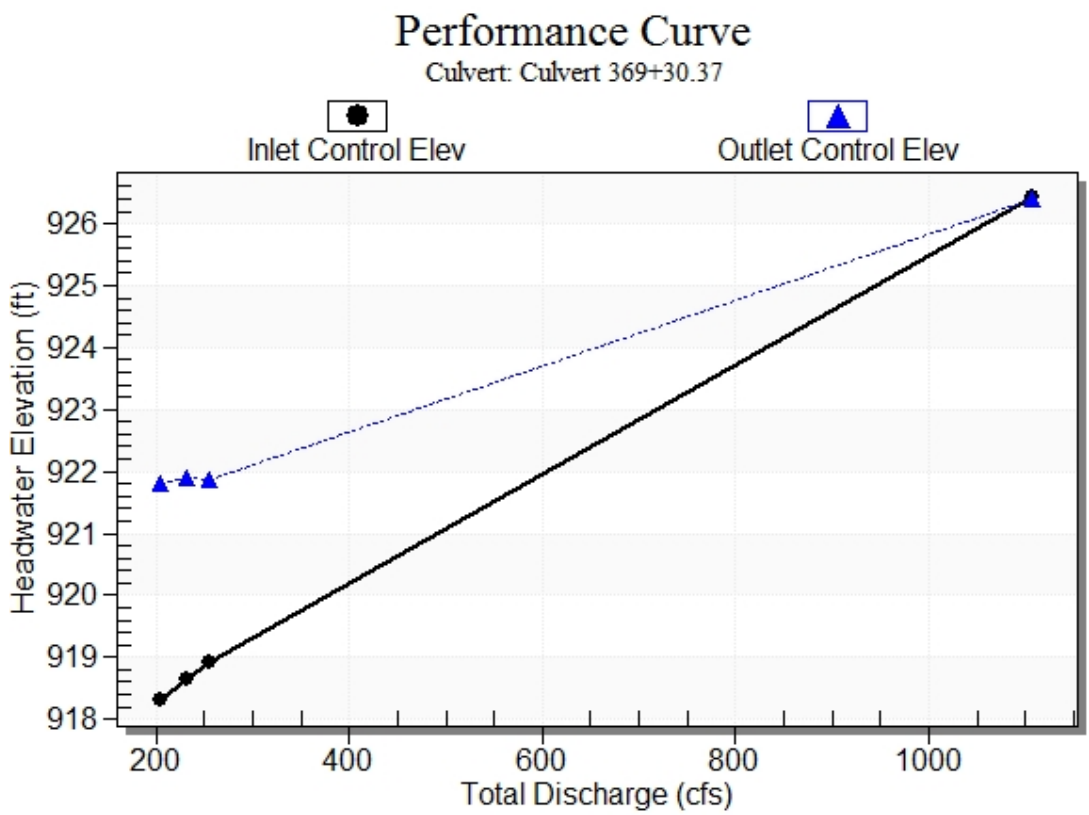
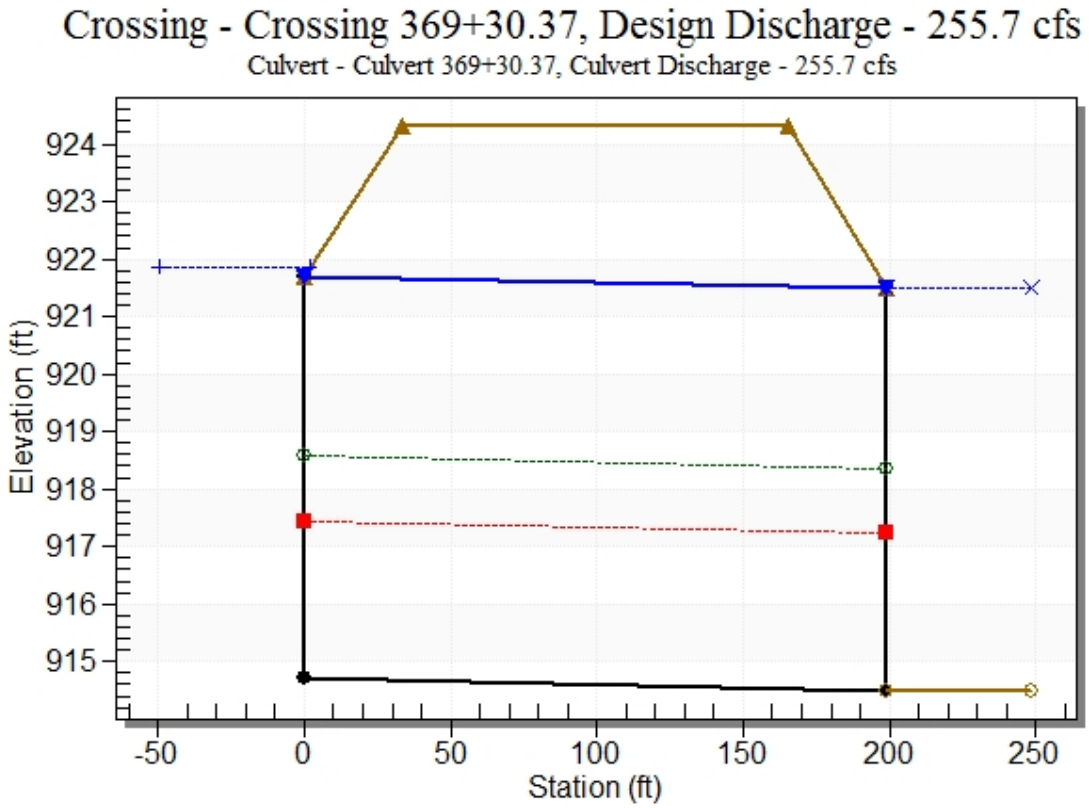
Culvert Performance Curve Plot: Culvert 369+30.37



Water Surface Profile Plot for Culvert: Culvert 369+30.37



Site Data - Culvert 369+30.37

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 914.70 ft

Outlet Station: 199.00 ft

Outlet Elevation: 914.50 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 369+30.37

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Crossing 369+30.37)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
203.66	921.50	7.00
230.95	921.50	7.00
255.73	921.50	7.00

Tailwater Channel Data - Crossing 369+30.37

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 921.50 ft

Roadway Data for Crossing: Crossing 369+30.37

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-105.00	924.33
1	-45.00	927.84
2	27.00	925.30

Roadway Surface: Paved

Roadway Top Width: 132.00 ft

Crossing Notes: Crossing 378+65.80

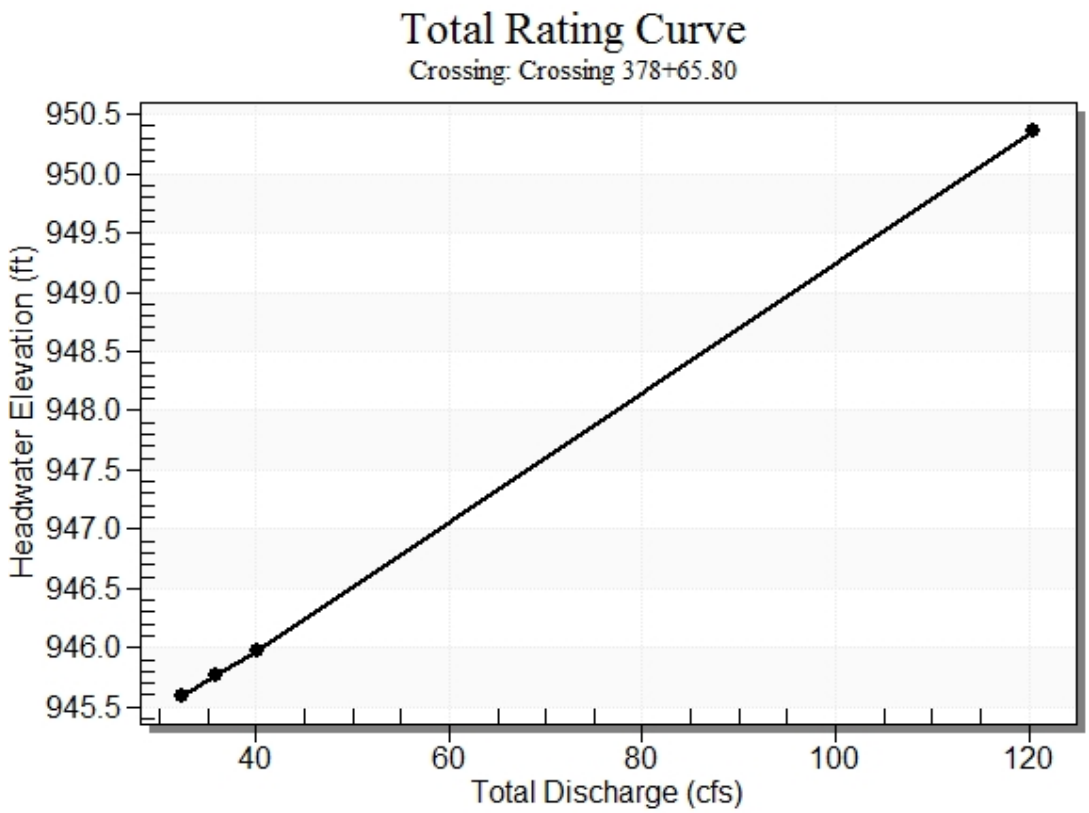
Crossing Discharge Data

Discharge Selection Method: Recurrence

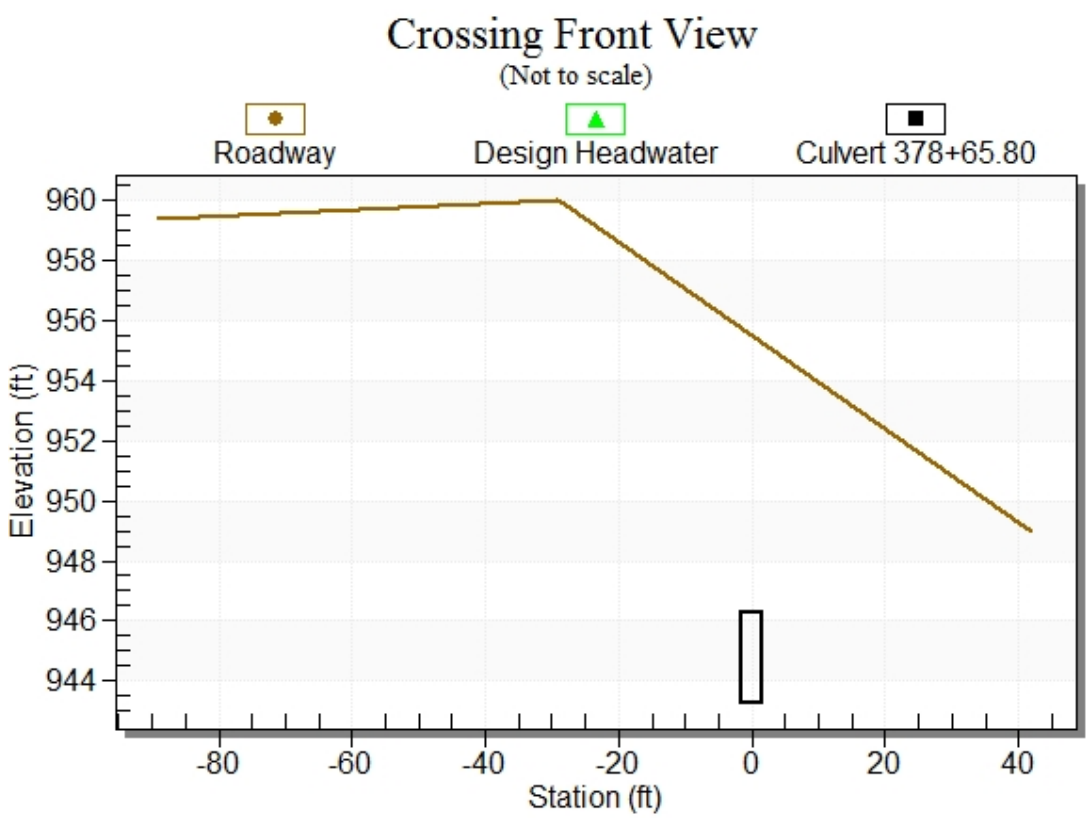
Table 7 - Summary of Culvert Flows at Crossing: Crossing 378+65.80

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 378+65.80 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
945.60	25 year	32.35	32.35	0.00	1
945.77	50 year	35.90	35.90	0.00	1
945.98	100 year	40.15	40.15	0.00	1
948.98	Overtopping	89.21	89.21	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 378+65.80



Crossing Front View (Roadway Profile): Crossing 378+65.80



Culvert Notes: Culvert 378+65.80

Table 8 - Culvert Summary Table: Culvert 378+65.80

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	32.35	32.35	945.60	2.339	0.0*	1-JS1f	0.856	1.534	3.000	3.000	3.594	0.000
50 year	35.90	35.90	945.77	2.512	0.0*	1-JS1f	0.924	1.644	3.000	3.000	3.989	0.000
100 year	40.15	40.15	945.98	2.716	0.0*	1-S2n	1.004	1.772	1.004	3.000	13.331	0.000

* Full Flow Headwater elevation is below inlet invert.

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Straight Culvert

Inlet Elevation (invert): 943.26 ft, Outlet Elevation (invert): 937.26 ft

Culvert Length: 264.07 ft, Culvert Slope: 0.0227

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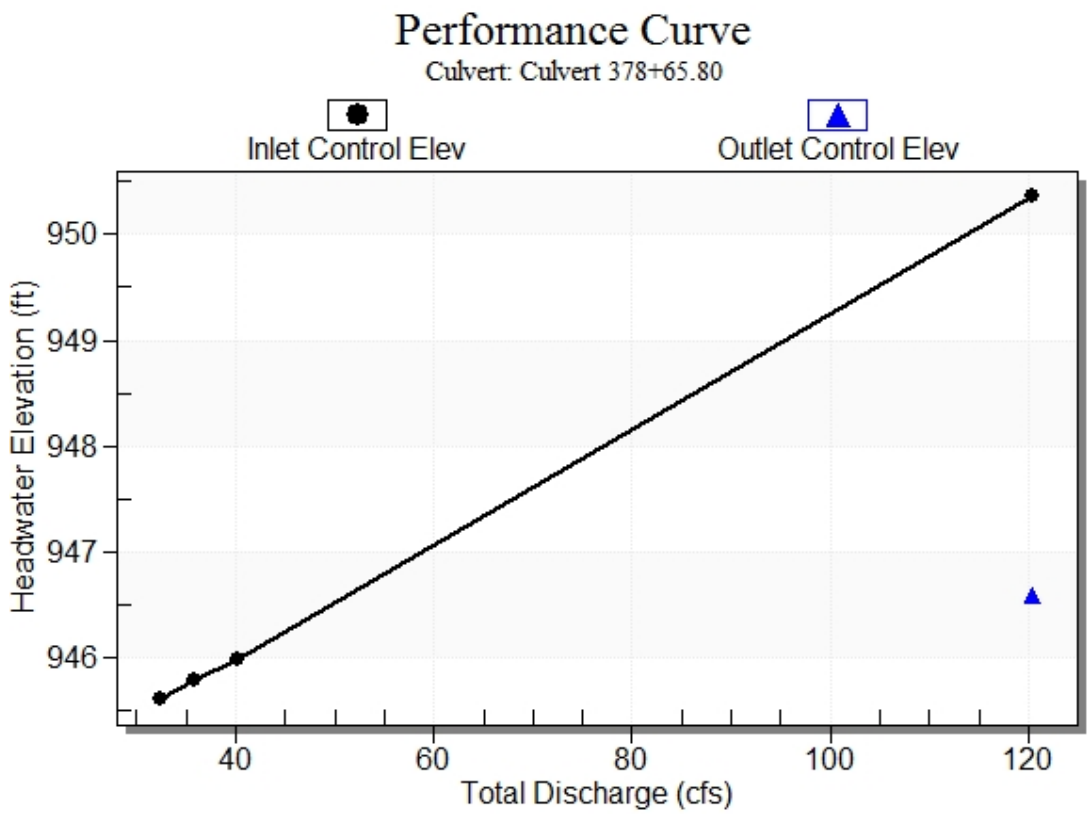
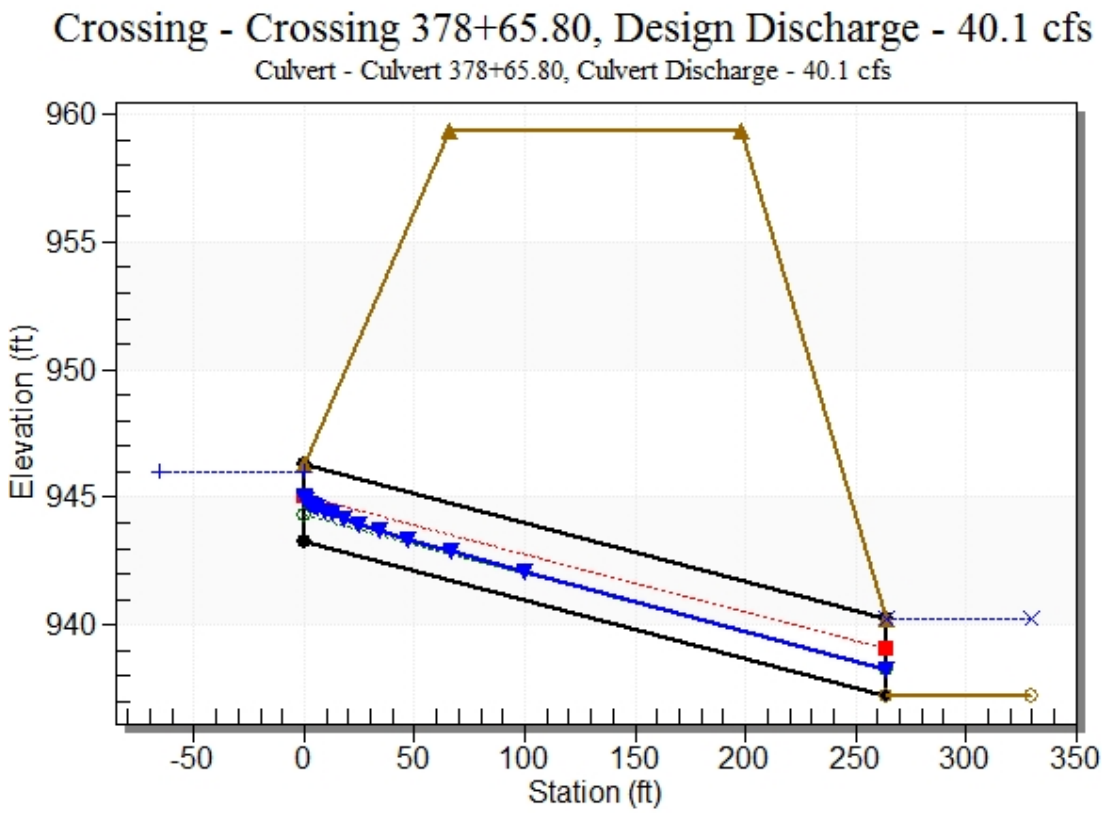
Culvert Performance Curve Plot: Culvert 378+65.80



Water Surface Profile Plot for Culvert: Culvert 378+65.80



Site Data - Culvert 378+65.80

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 943.26 ft

Outlet Station: 264.00 ft

Outlet Elevation: 937.26 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 378+65.80

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Crossing 378+65.80)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
32.35	940.26	3.00
35.90	940.26	3.00
40.15	940.26	3.00

Tailwater Channel Data - Crossing 378+65.80

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 940.26 ft

Roadway Data for Crossing: Crossing 378+65.80

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-89.00	959.37
1	-29.00	960.01
2	42.00	948.98

Roadway Surface: Paved

Roadway Top Width: 132.00 ft

Crossing Notes: Crossing 389+84.24

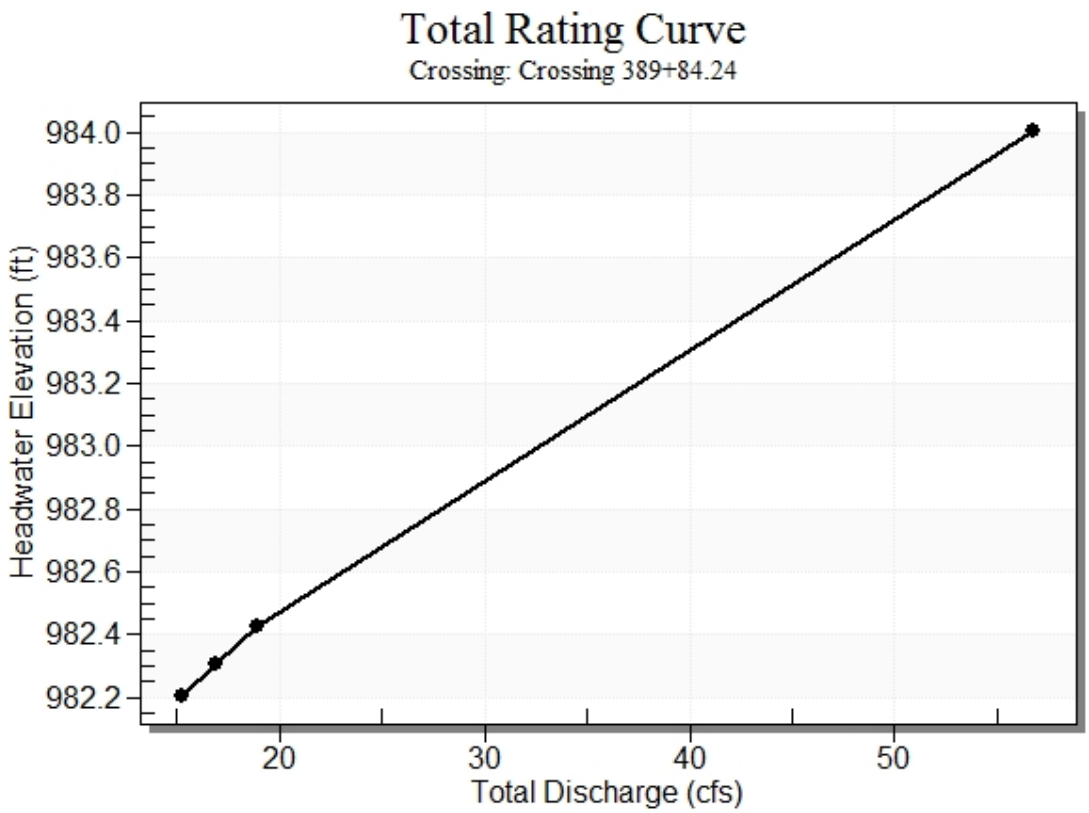
Crossing Discharge Data

Discharge Selection Method: Recurrence

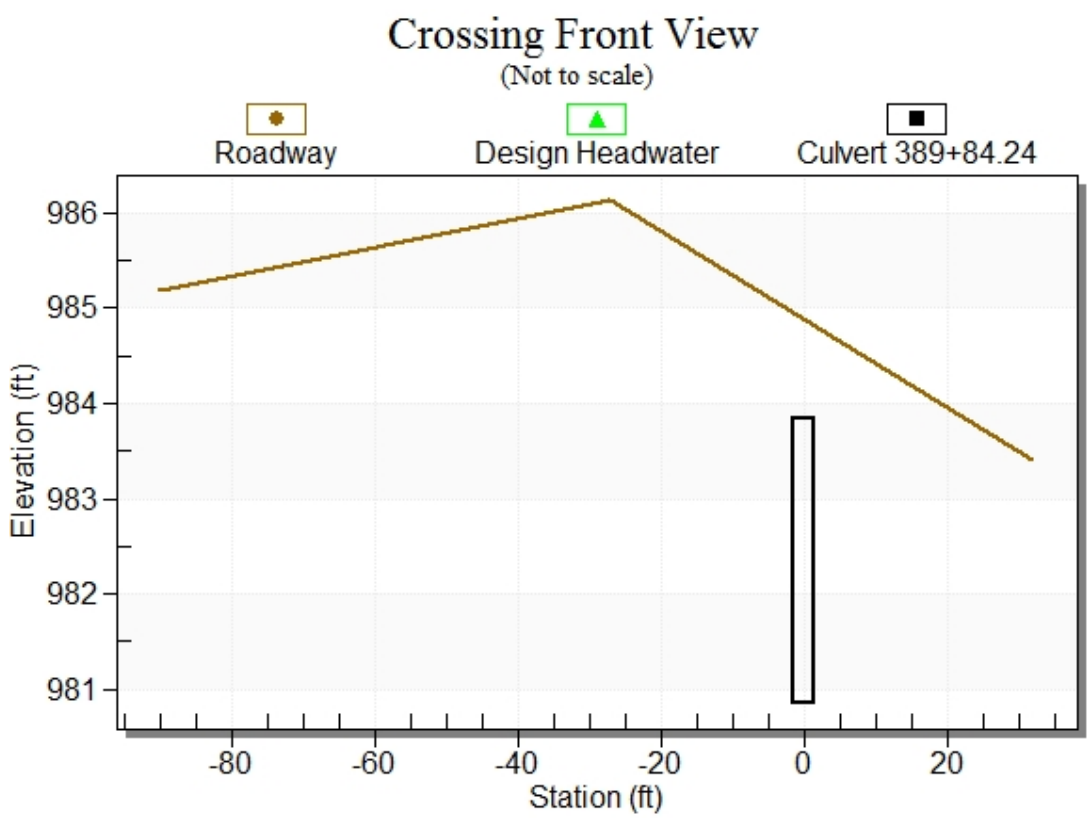
Table 10 - Summary of Culvert Flows at Crossing: Crossing 389+84.24

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 389+84.24 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
982.21	25 year	15.24	15.24	0.00	1
982.30	50 year	16.91	16.91	0.00	1
982.42	100 year	18.92	18.92	0.00	1
983.40	Overtopping	37.69	37.69	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 389+84.24



Crossing Front View (Roadway Profile): Crossing 389+84.24



Culvert Notes: Culvert 389+84.24

Table 11 - Culvert Summary Table: Culvert 389+84.24

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	15.24	15.24	982.21	1.356	0.0*	1-JS1f	0.379	0.929	3.000	3.000	1.693	0.000
50 year	16.91	16.91	982.30	1.453	0.0*	1-JS1f	0.403	0.996	3.000	3.000	1.879	0.000
100 year	18.92	18.92	982.42	1.572	0.0*	1-JS1f	0.433	1.073	3.000	3.000	2.102	0.000

* Full Flow Headwater elevation is below inlet invert.

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Straight Culvert

Inlet Elevation (invert): 980.85 ft, Outlet Elevation (invert): 972.00 ft

Culvert Length: 162.24 ft, Culvert Slope: 0.0546

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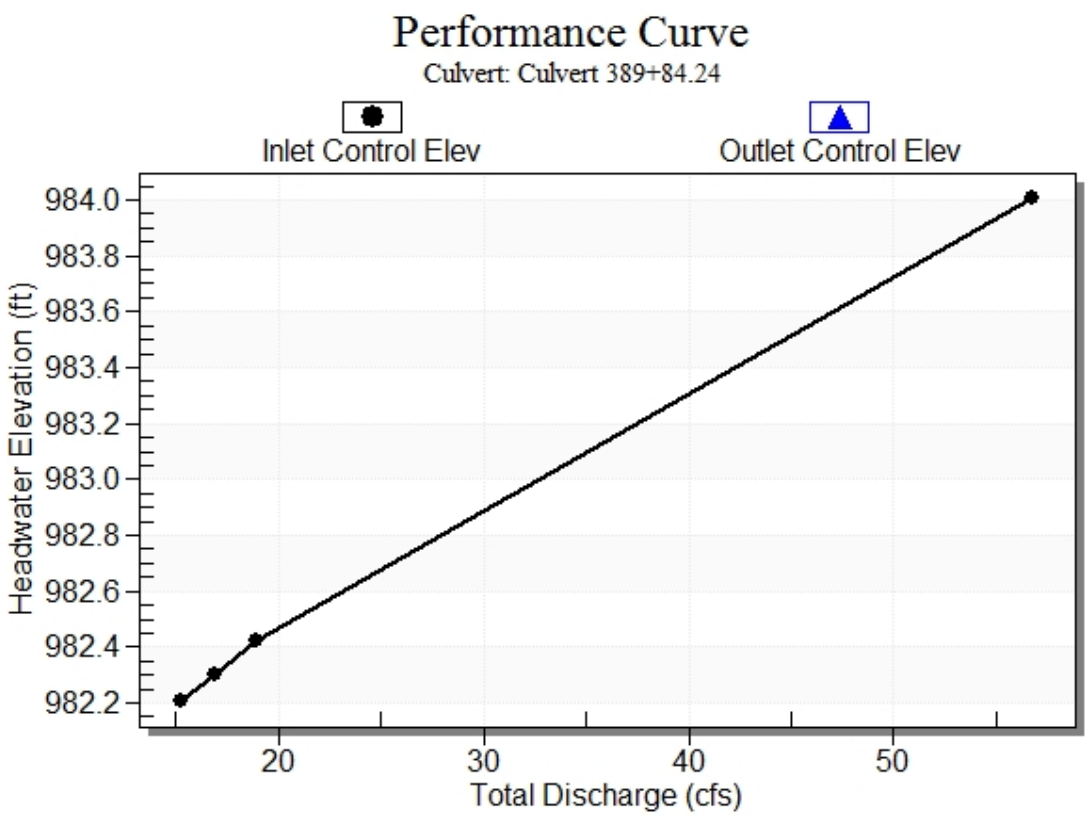
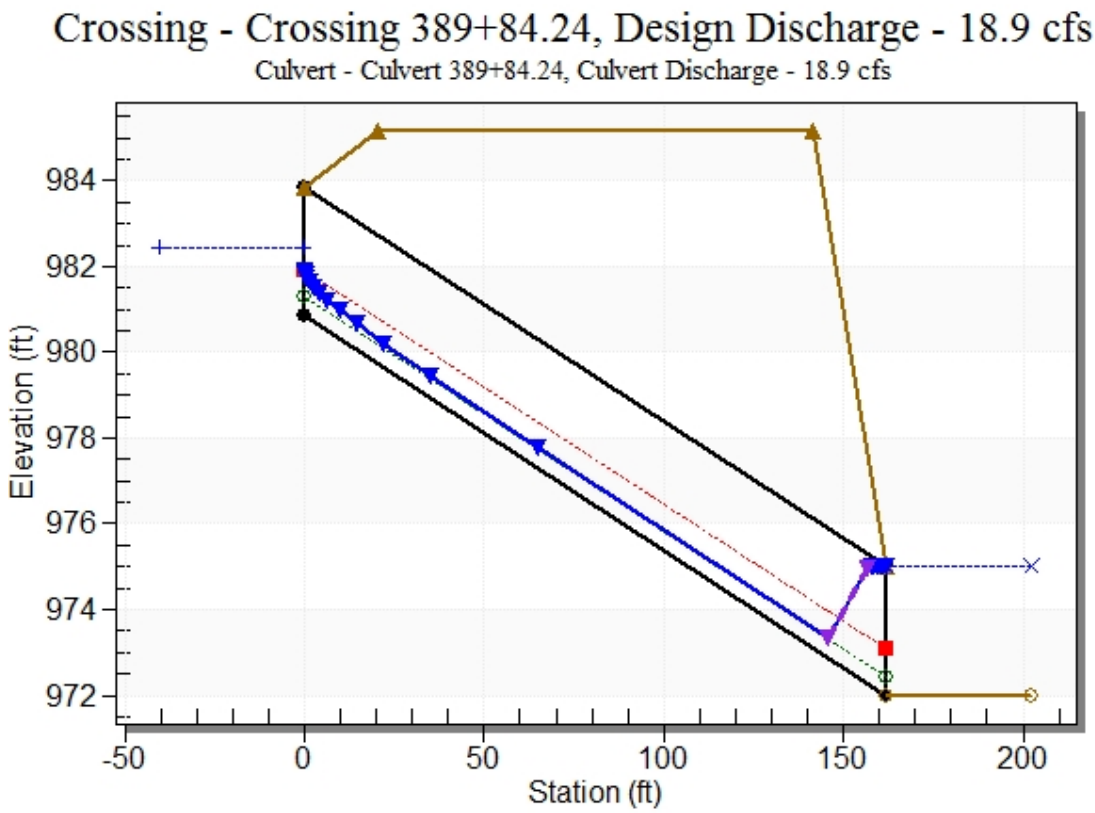
Culvert Performance Curve Plot: Culvert 389+84.24



Water Surface Profile Plot for Culvert: Culvert 389+84.24



Site Data - Culvert 389+84.24

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 980.85 ft

Outlet Station: 162.00 ft

Outlet Elevation: 972.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 389+84.24

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 12 - Downstream Channel Rating Curve (Crossing: Crossing 389+84.24)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
15.24	975.00	3.00
16.91	975.00	3.00
18.92	975.00	3.00

Tailwater Channel Data - Crossing 389+84.24

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 975.00 ft

Roadway Data for Crossing: Crossing 389+84.24

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-90.00	985.18
1	-27.00	986.14
2	32.00	983.40

Roadway Surface: Paved

Roadway Top Width: 121.00 ft

Crossing Notes: Crossing 394+97.42

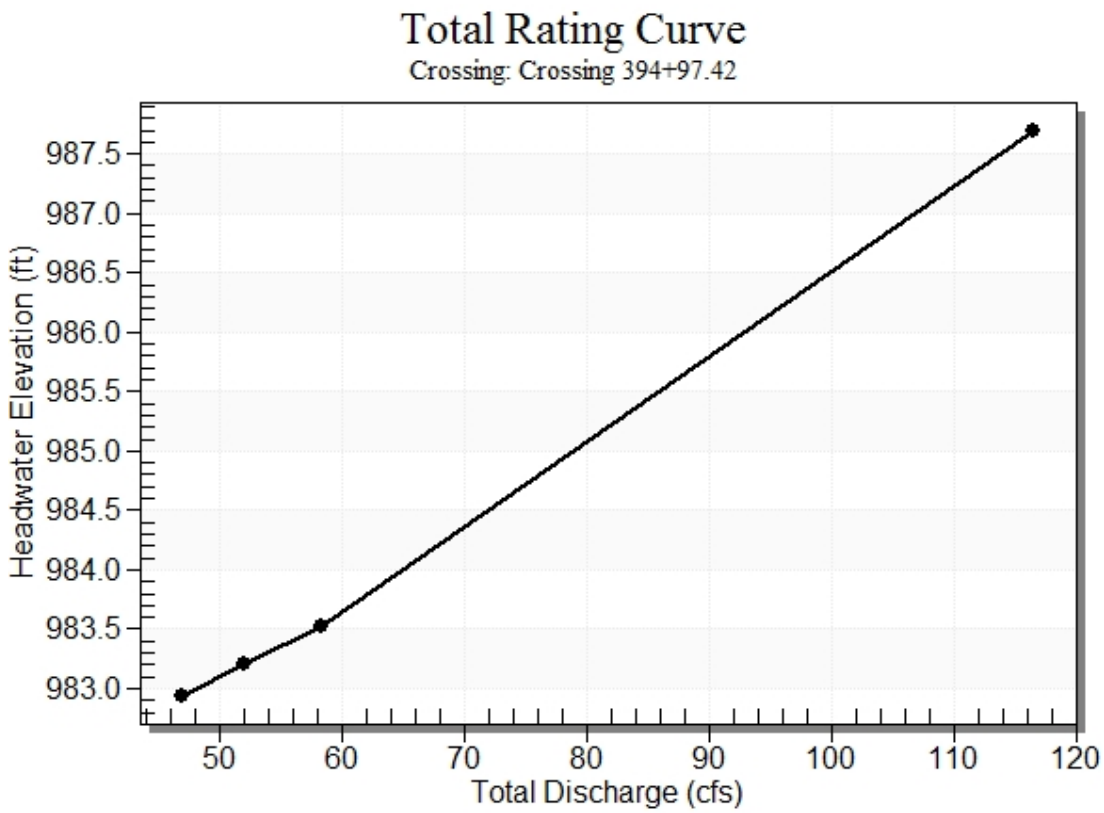
Crossing Discharge Data

Discharge Selection Method: Recurrence

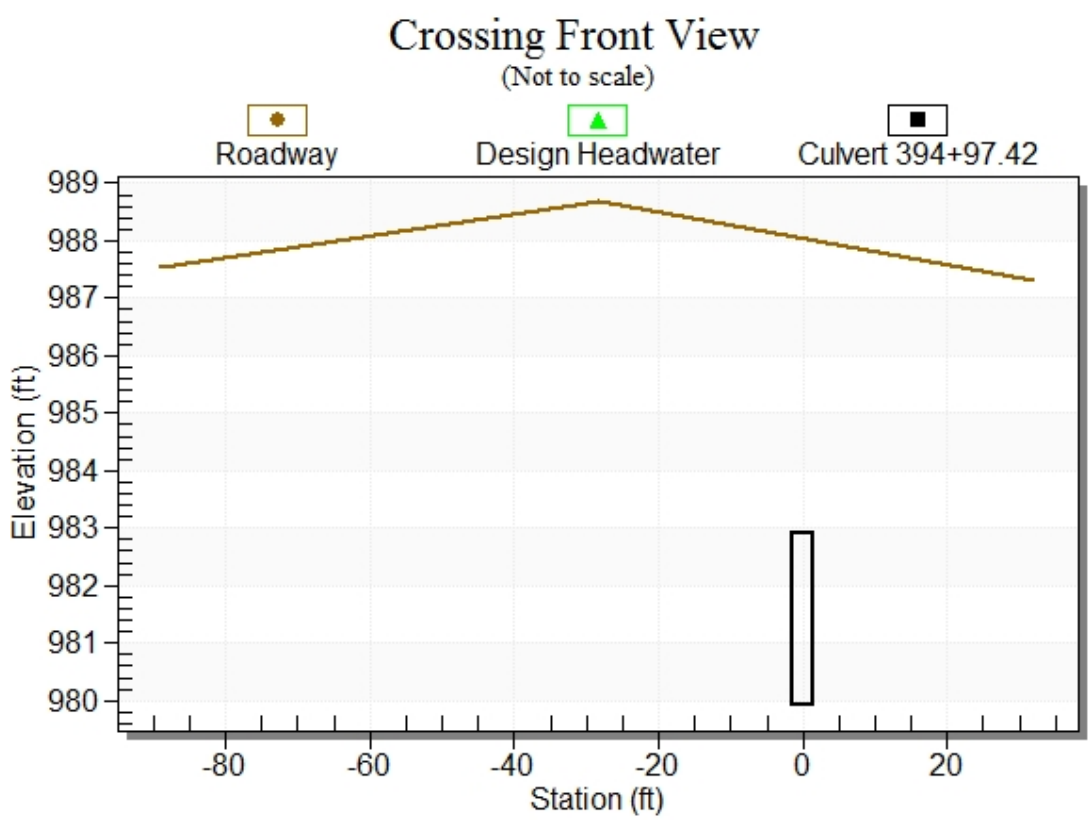
Table 13 - Summary of Culvert Flows at Crossing: Crossing 394+97.42

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 394+97.42 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
982.95	25 year	46.93	46.93	0.00	1
983.20	50 year	52.07	52.07	0.00	1
983.53	100 year	58.24	58.24	0.00	1
987.31	Overtopping	107.61	107.61	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 394+97.42



Crossing Front View (Roadway Profile): Crossing 394+97.42



Culvert Notes: Culvert 394+97.42

Table 14 - Culvert Summary Table: Culvert 394+97.42

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	46.93	46.93	982.95	3.025	0.0*	5-S2n	0.950	1.966	0.950	3.000	16.460	0.000
50 year	52.07	52.07	983.20	3.283	0.0*	5-S2n	1.025	2.107	1.054	3.000	16.460	0.000
100 year	58.24	58.24	983.53	3.609	0.0*	5-S2n	1.110	2.270	1.135	3.000	17.098	0.000

* Full Flow Headwater elevation is below inlet invert.

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Straight Culvert

Inlet Elevation (invert): 979.92 ft, Outlet Elevation (invert): 971.00 ft

Culvert Length: 248.16 ft, Culvert Slope: 0.0360

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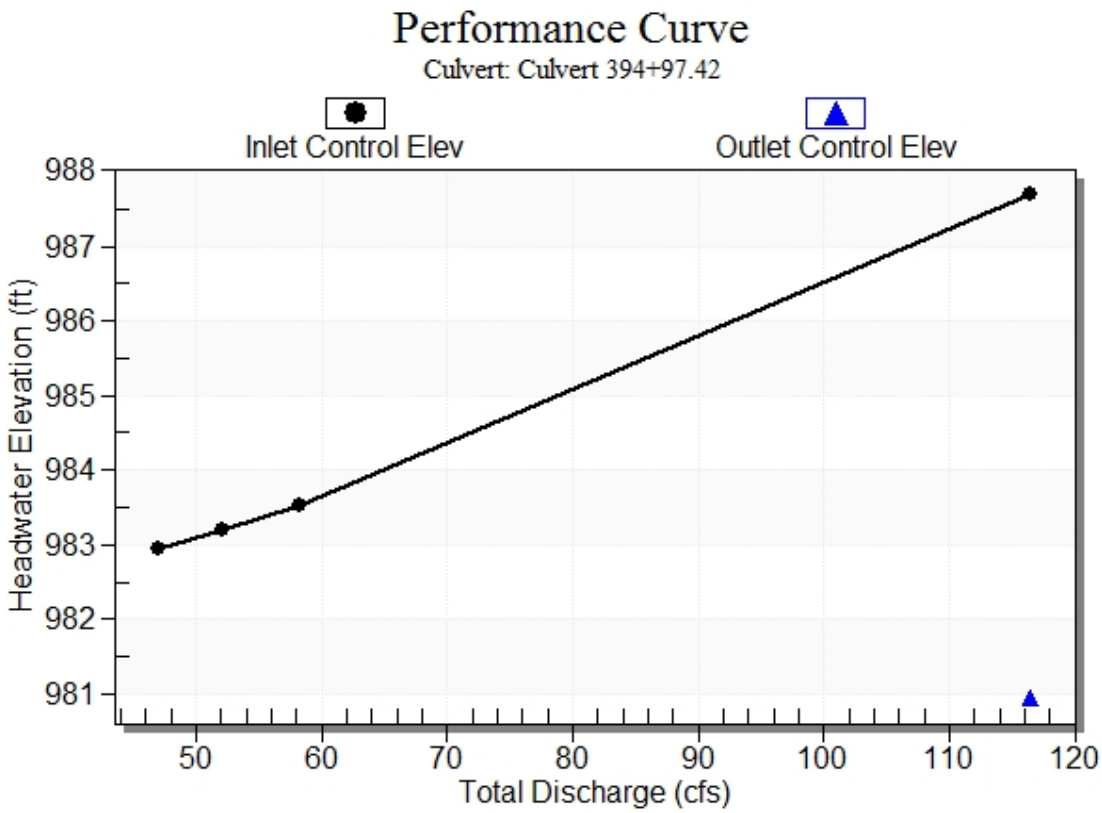
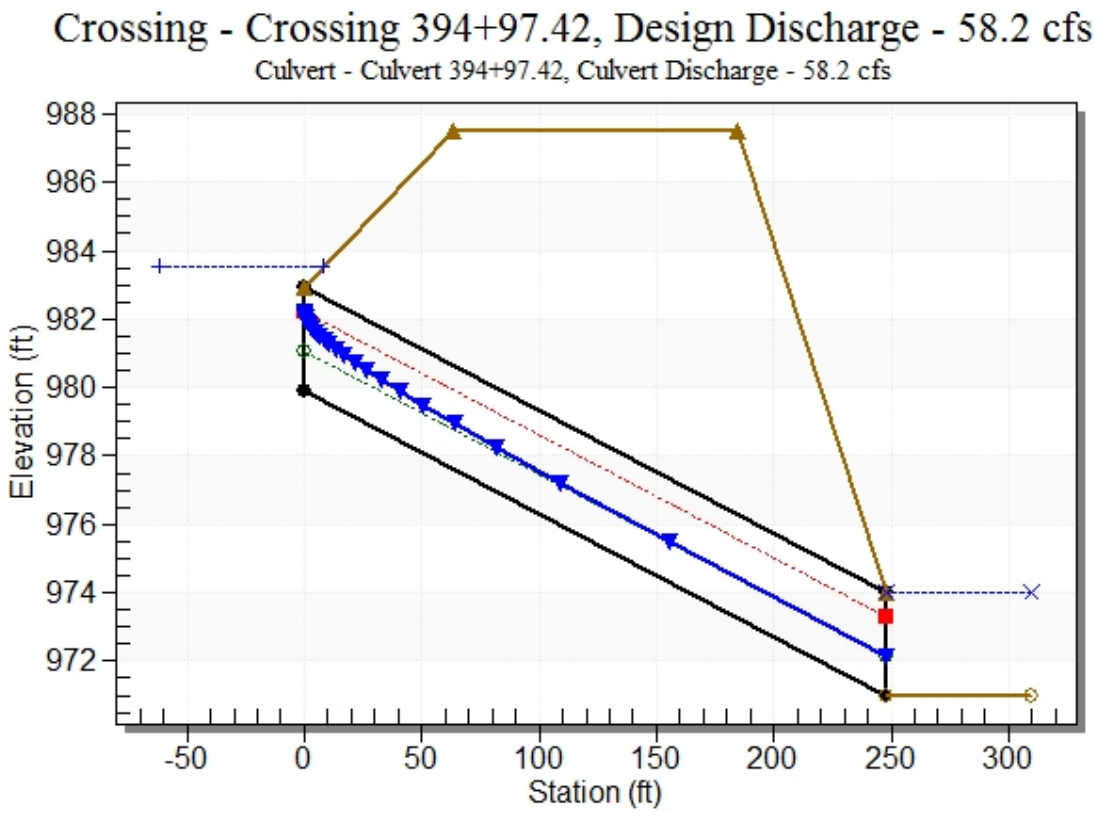
Culvert Performance Curve Plot: Culvert 394+97.42



Water Surface Profile Plot for Culvert: Culvert 394+97.42



Site Data - Culvert 394+97.42

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 979.92 ft

Outlet Station: 248.00 ft

Outlet Elevation: 971.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 394+97.42

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 15 - Downstream Channel Rating Curve (Crossing: Crossing 394+97.42)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
46.93	974.00	3.00
52.07	974.00	3.00
58.24	974.00	3.00

Tailwater Channel Data - Crossing 394+97.42

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 974.00 ft

Roadway Data for Crossing: Crossing 394+97.42

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-89.00	987.53
1	-28.00	988.69
2	32.00	987.31

Roadway Surface: Paved

Roadway Top Width: 121.00 ft

Crossing Notes: Crossing 411+33.43

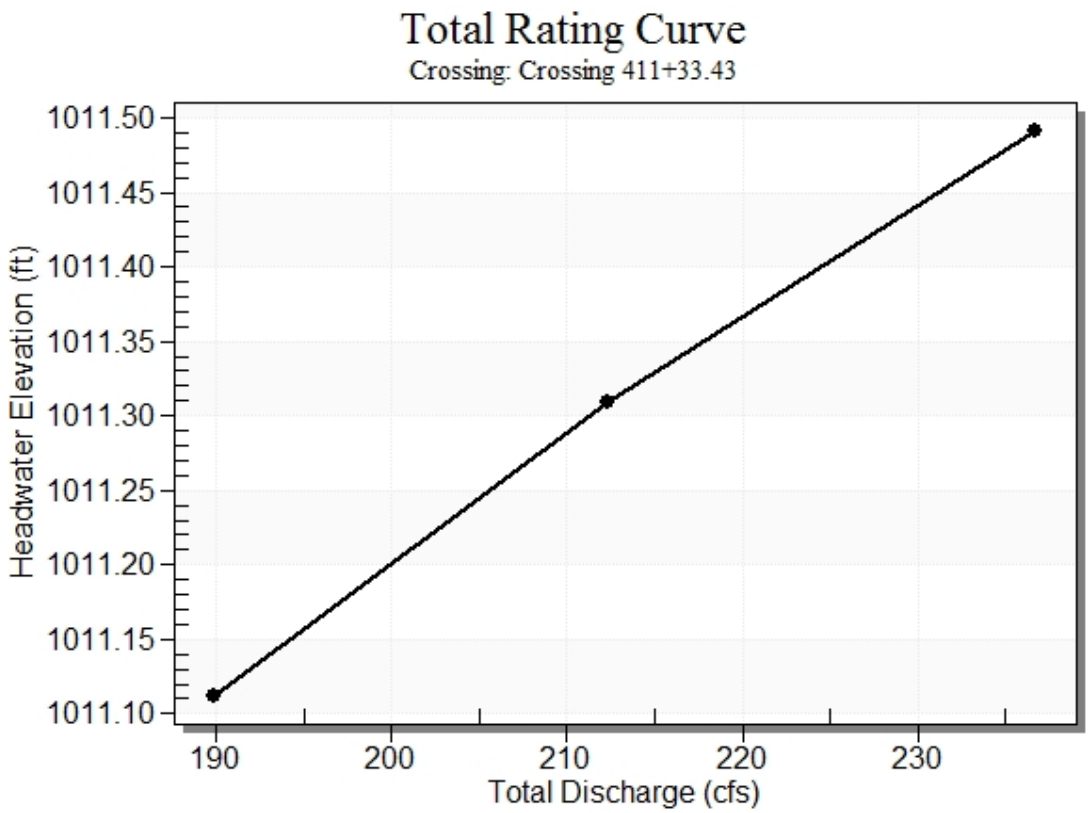
Crossing Discharge Data

Discharge Selection Method: Recurrence

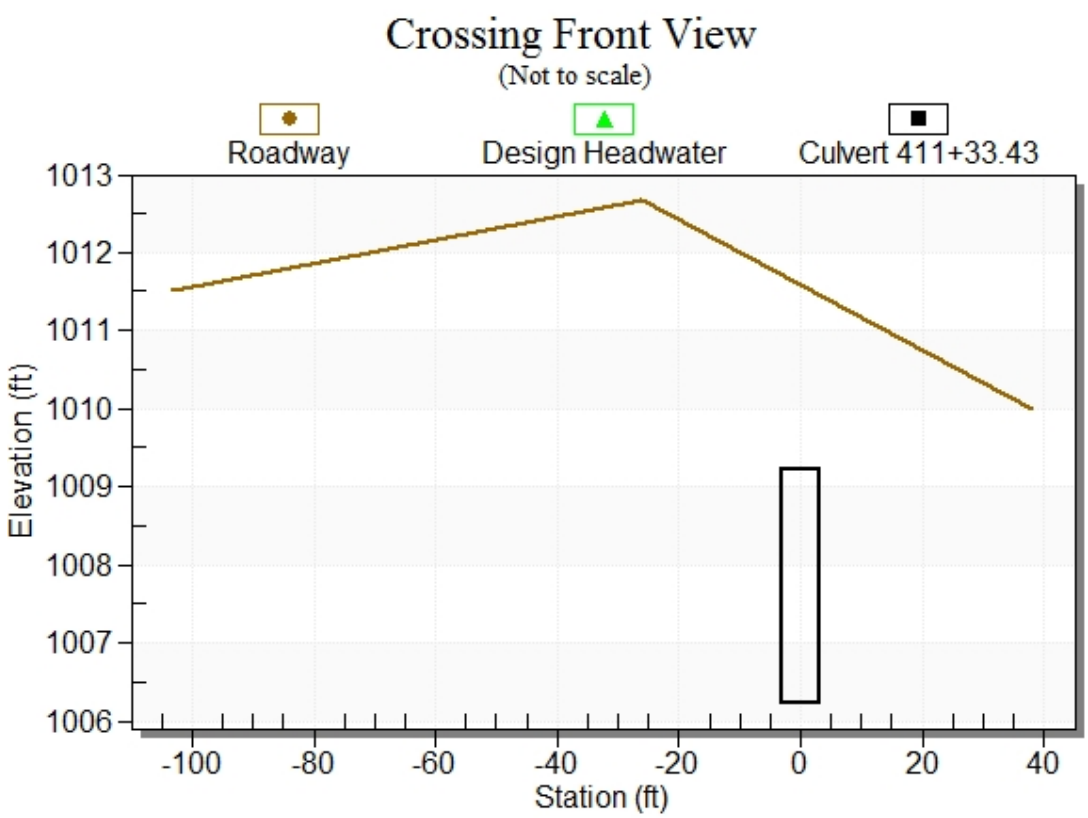
Table 16 - Summary of Culvert Flows at Crossing: Crossing 411+33.43

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 411+33.43 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1011.11	25 year	189.92	156.40	33.50	8
1011.31	50 year	212.33	161.81	50.35	6
1011.49	100 year	236.66	166.69	69.87	7
1010.00	Overtopping	121.30	121.30	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 411+33.43



Crossing Front View (Roadway Profile): Crossing 411+33.43



Culvert Notes: Culvert 411+33.43

Table 17 - Culvert Summary Table: Culvert 411+33.43

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	189.92	156.40	1011.11	4.882	2.466	5-S2n	1.550	2.763	1.702	2.411	15.311	3.064
50 year	212.33	161.81	1011.31	5.079	2.669	5-S2n	1.588	2.827	1.748	2.514	15.431	3.151
100 year	236.66	166.69	1011.49	5.262	2.856	5-S2n	1.622	2.883	1.786	2.619	15.555	3.238

****

Straight Culvert

Inlet Elevation (invert): 1006.23 ft, Outlet Elevation (invert): 1003.39 ft

Culvert Length: 160.03 ft, Culvert Slope: 0.0178

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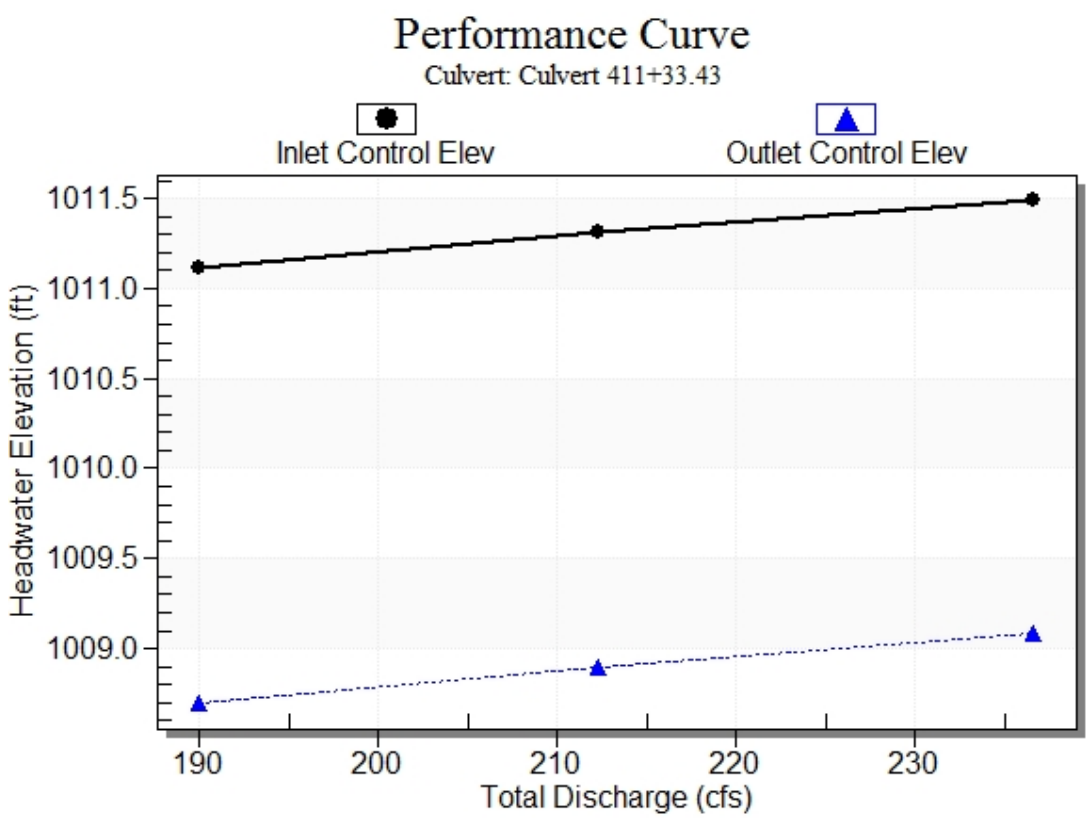
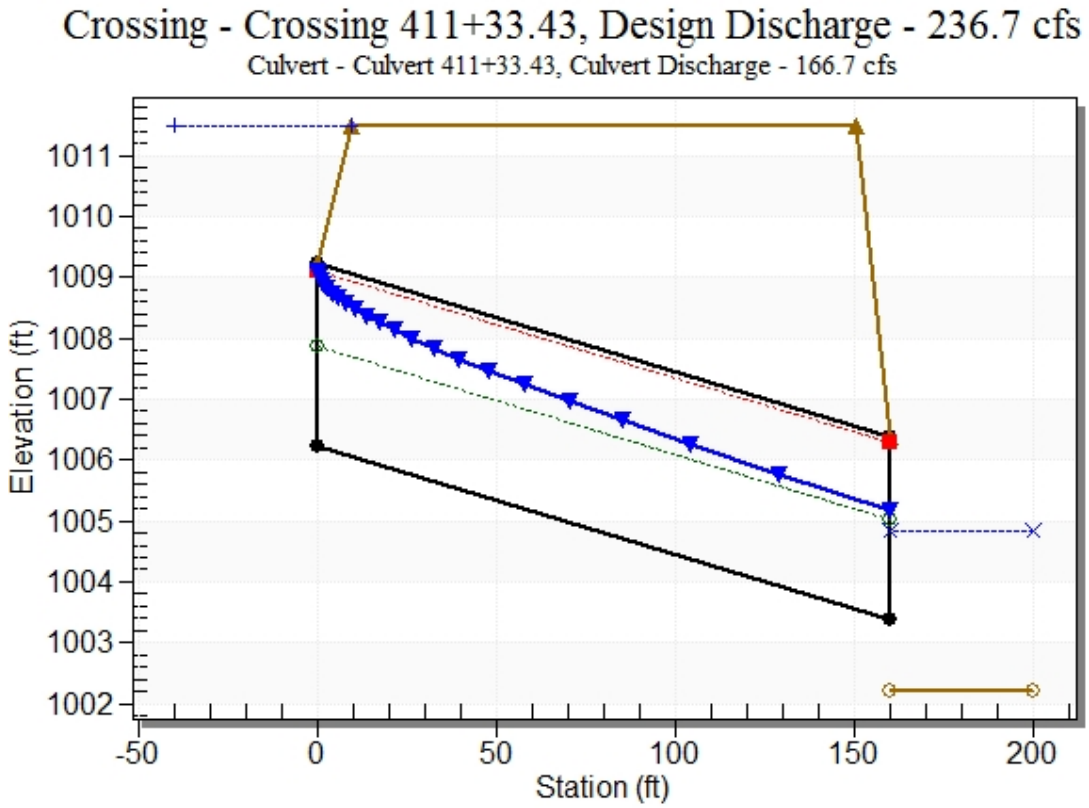
Culvert Performance Curve Plot: Culvert 411+33.43



Water Surface Profile Plot for Culvert: Culvert 411+33.43



Site Data - Culvert 411+33.43

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1006.23 ft

Outlet Station: 160.00 ft

Outlet Elevation: 1003.39 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 411+33.43

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 18 - Downstream Channel Rating Curve (Crossing: Crossing 411+33.43)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
189.92	1004.63	2.41	3.06	0.45	0.49
212.33	1004.73	2.51	3.15	0.47	0.50
236.66	1004.84	2.62	3.24	0.49	0.50

Tailwater Channel Data - Crossing 411+33.43

Tailwater Channel Option: Triangular Channel

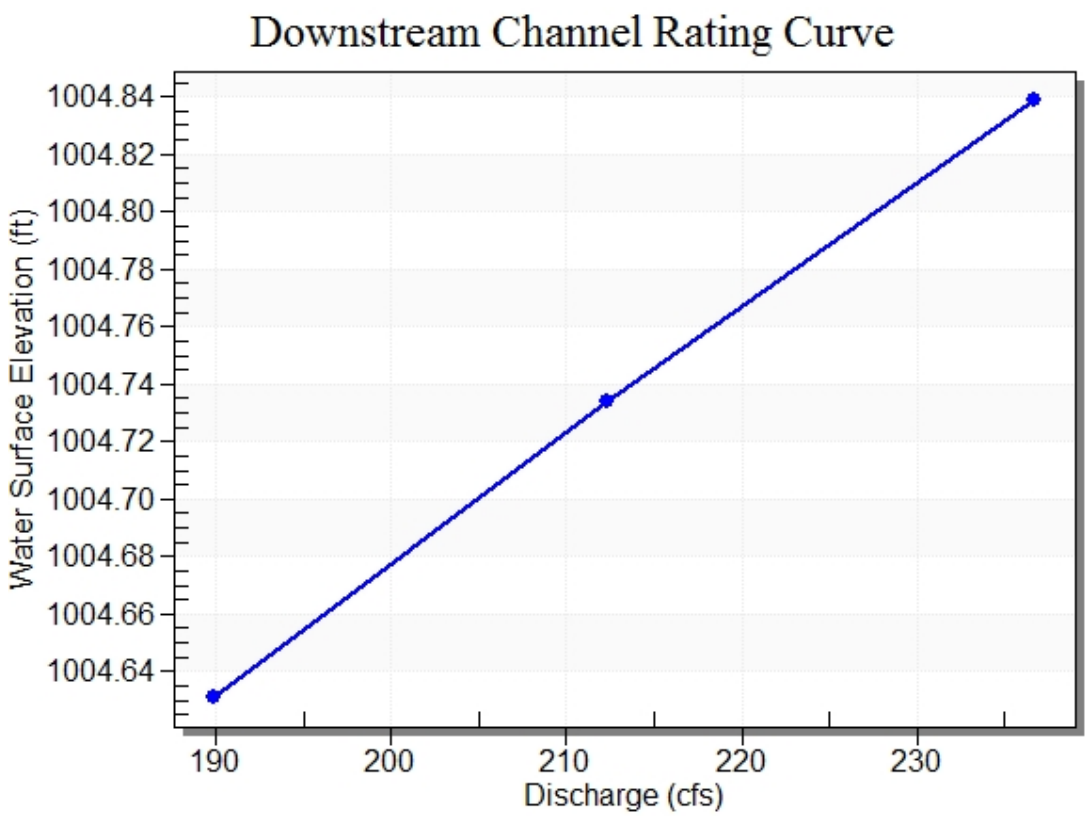
Side Slope (H:V): 10.66 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0300

Channel Invert Elevation: 1002.22 ft

Tailwater Rating Curve Plot for Crossing: Crossing 411+33.43



Roadway Data for Crossing: Crossing 411+33.43

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-103.00	1011.50
1	-26.00	1012.67
2	38.00	1010.00

Roadway Surface: Paved

Roadway Top Width: 141.00 ft

Crossing Notes: Crossing 429+61.99

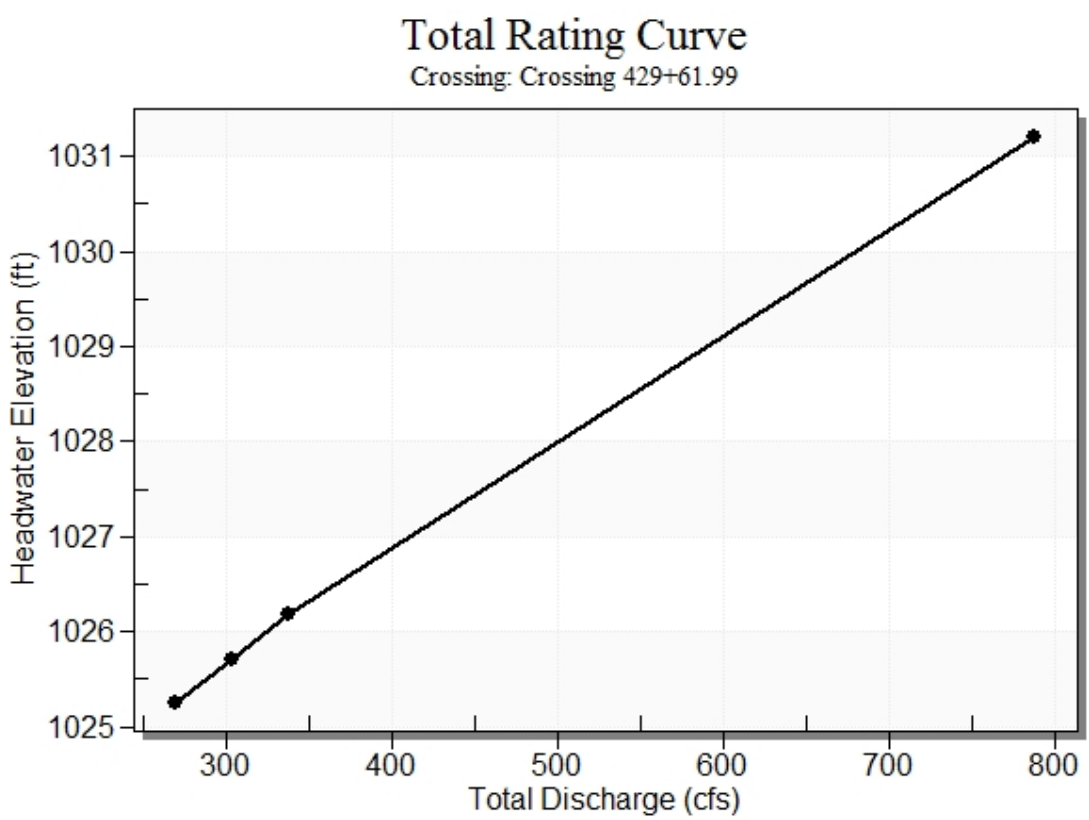
Crossing Discharge Data

Discharge Selection Method: Recurrence

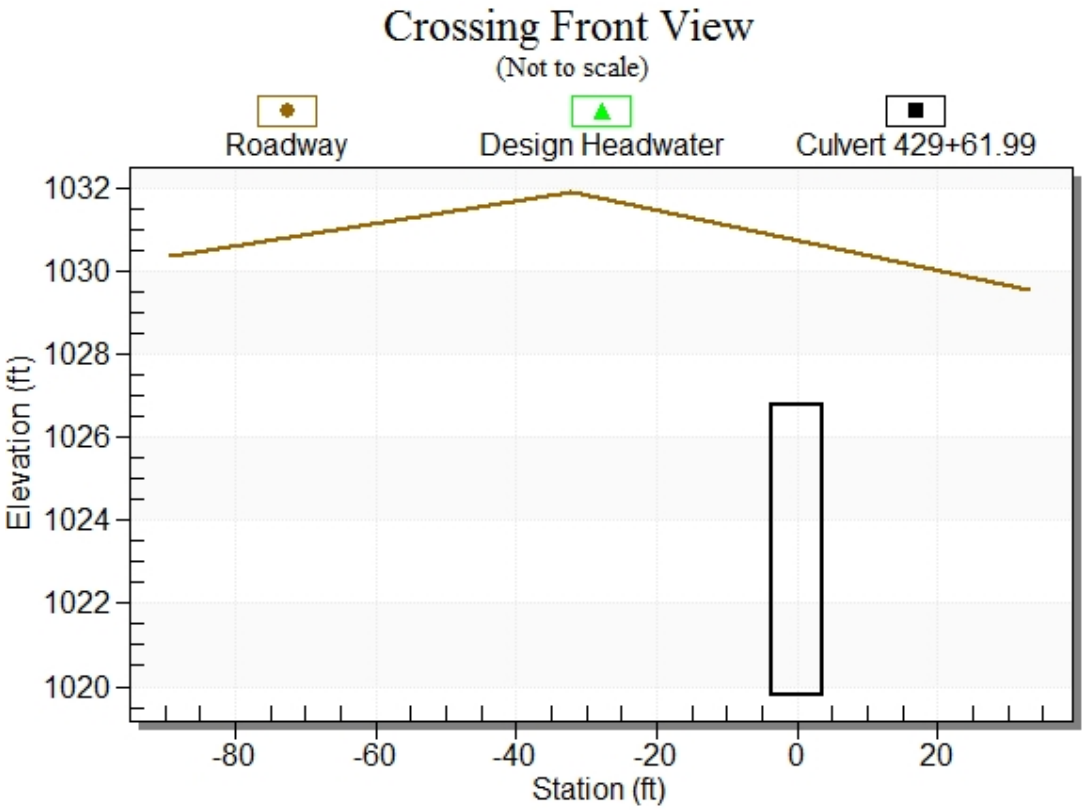
Table 19 - Summary of Culvert Flows at Crossing: Crossing 429+61.99

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 429+61.99 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1025.26	25 year	270.07	270.07	0.00	1
1025.72	50 year	303.32	303.32	0.00	1
1026.17	100 year	337.37	337.37	0.00	1
1029.53	Overtopping	562.55	562.55	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 429+61.99



Crossing Front View (Roadway Profile): Crossing 429+61.99



Culvert Notes: Culvert 429+61.99

Table 20 - Culvert Summary Table: Culvert 429+61.99

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	270.07	270.07	1025.26	5.471	3.306	1-JS1f	1.815	3.589	7.000	7.000	5.512	0.000
50 year	303.32	303.32	1025.72	5.925	3.528	1-JS1f	1.969	3.878	7.000	7.000	6.190	0.000
100 year	337.37	337.37	1026.17	6.385	3.781	1-S2n	2.126	4.163	2.437	7.000	19.778	0.000

****

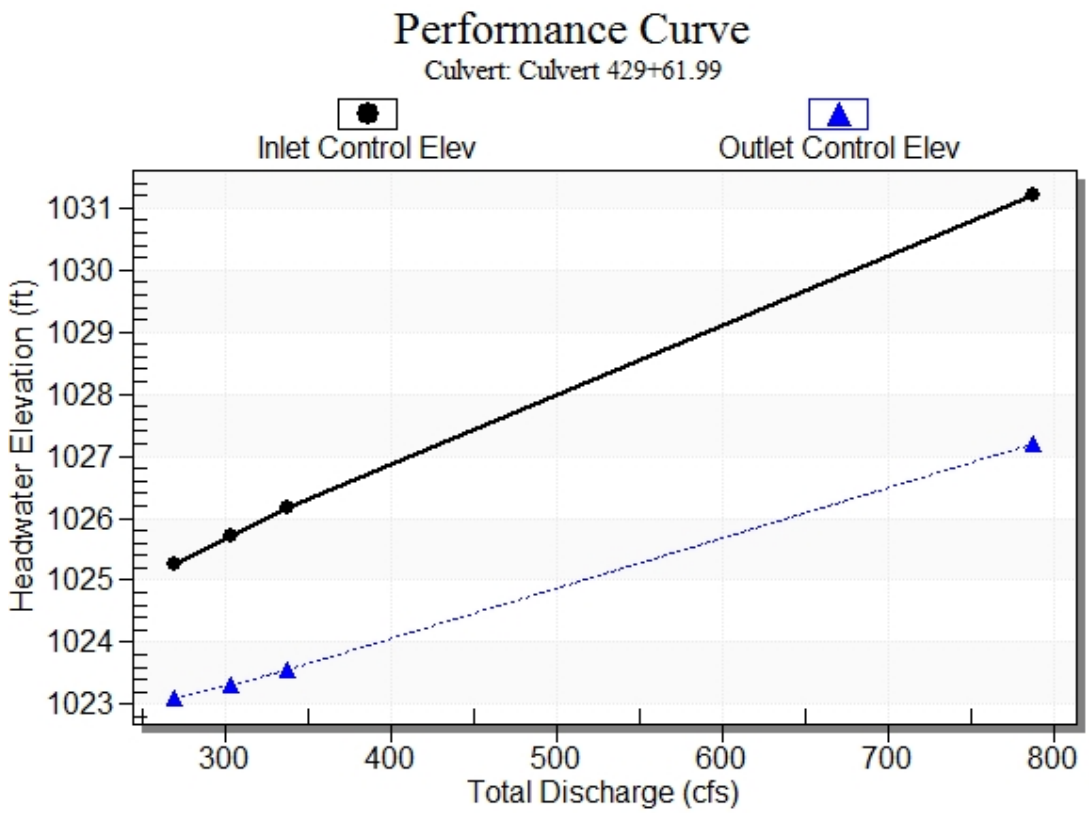
Straight Culvert

Inlet Elevation (invert): 1019.79 ft, Outlet Elevation (invert): 1015.25 ft

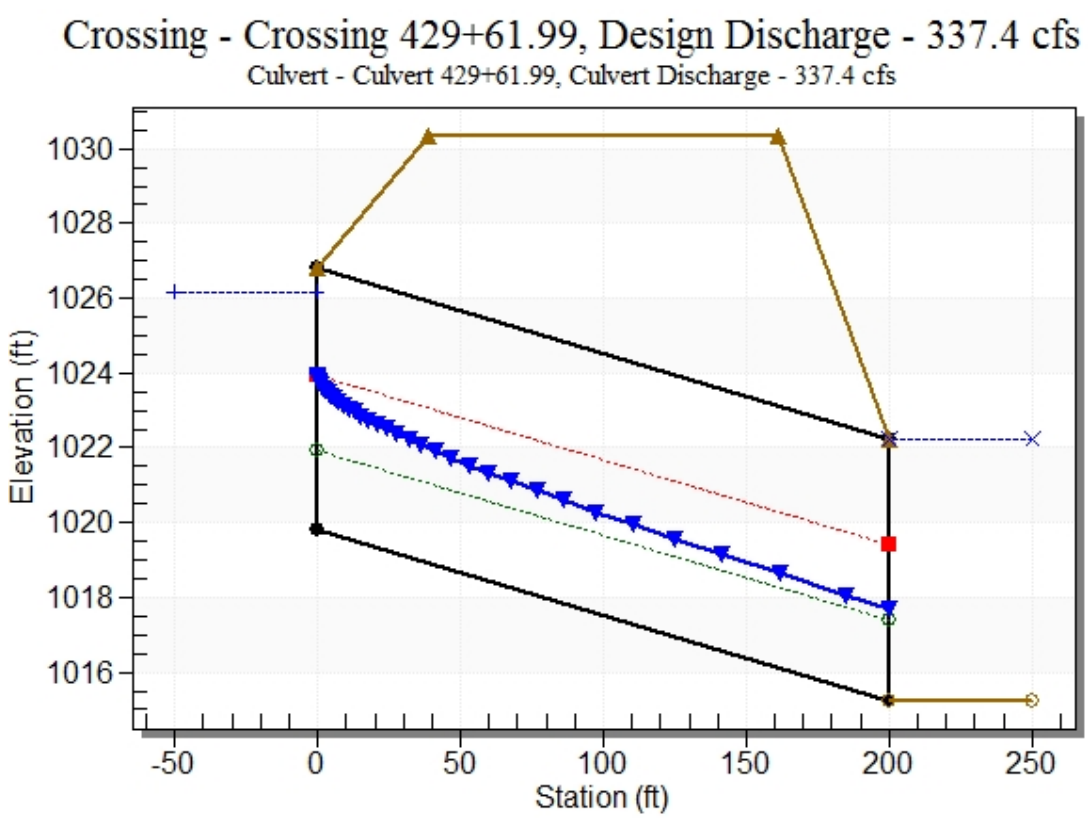
Culvert Length: 200.05 ft, Culvert Slope: 0.0227

****

Culvert Performance Curve Plot: Culvert 429+61.99



Water Surface Profile Plot for Culvert: Culvert 429+61.99



Site Data - Culvert 429+61.99

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1019.79 ft

Outlet Station: 200.00 ft

Outlet Elevation: 1015.25 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 429+61.99

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 21 - Downstream Channel Rating Curve (Crossing: Crossing 429+61.99)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
270.07	1022.25	7.00
303.32	1022.25	7.00
337.37	1022.25	7.00

Tailwater Channel Data - Crossing 429+61.99

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1022.25 ft

Roadway Data for Crossing: Crossing 429+61.99

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-89.00	1030.36
1	-32.00	1031.91
2	33.00	1029.53

Roadway Surface: Paved

Roadway Top Width: 122.00 ft

Crossing Notes: Crossing 450+93.76

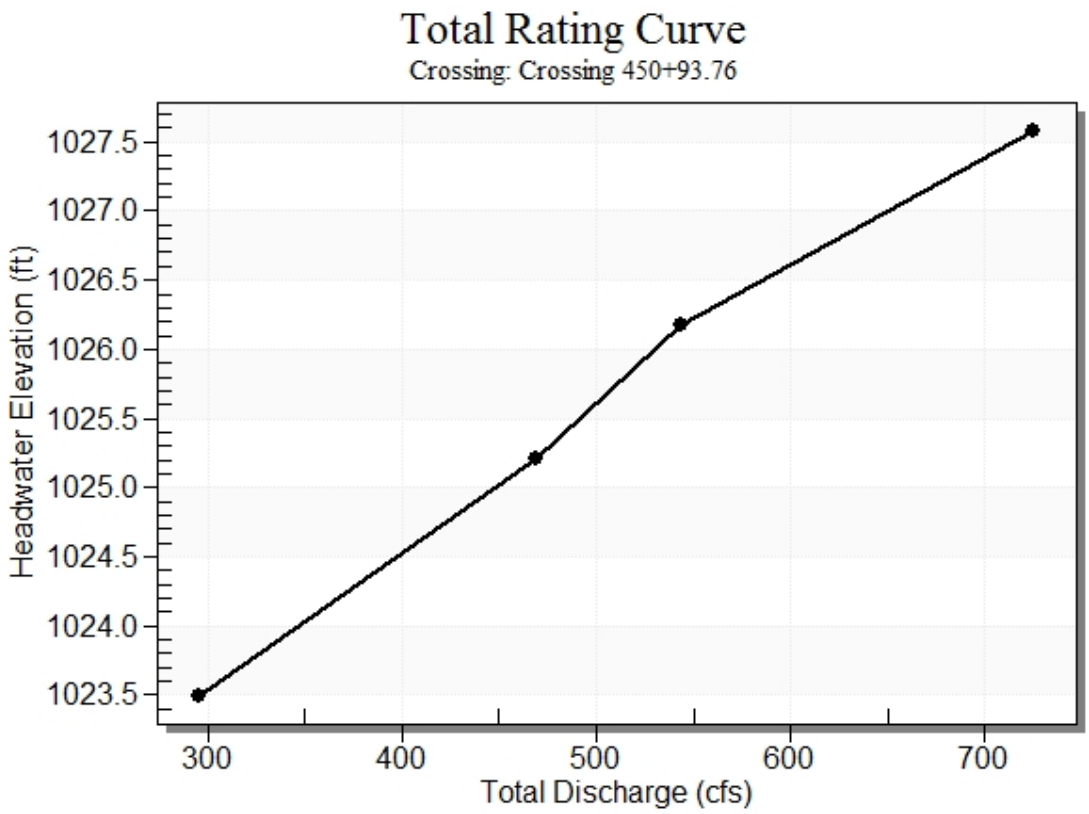
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 22 - Summary of Culvert Flows at Crossing: Crossing 450+93.76

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 450+93.76 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1023.50	25 year	295.10	295.10	0.00	1
1025.21	50 year	468.50	468.50	0.00	1
1026.18	100 year	543.90	543.90	0.00	1
1027.60	Overtopping	636.57	636.57	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 450+93.76



Culvert Notes: Culvert 450+93.76

Table 23 - Culvert Summary Table: Culvert 450+93.76

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	295.10	295.10	1023.50	3.159	0.215	5-S2n	1.064	2.029	1.124	3.000	14.580	0.000
50 year	468.50	468.50	1025.21	4.869	1.729	5-S2n	1.458	2.761	1.591	3.000	16.359	0.000
100 year	543.90	543.90	1026.18	5.842	2.602	5-S2n	1.619	3.000	1.784	3.000	16.940	0.000

****

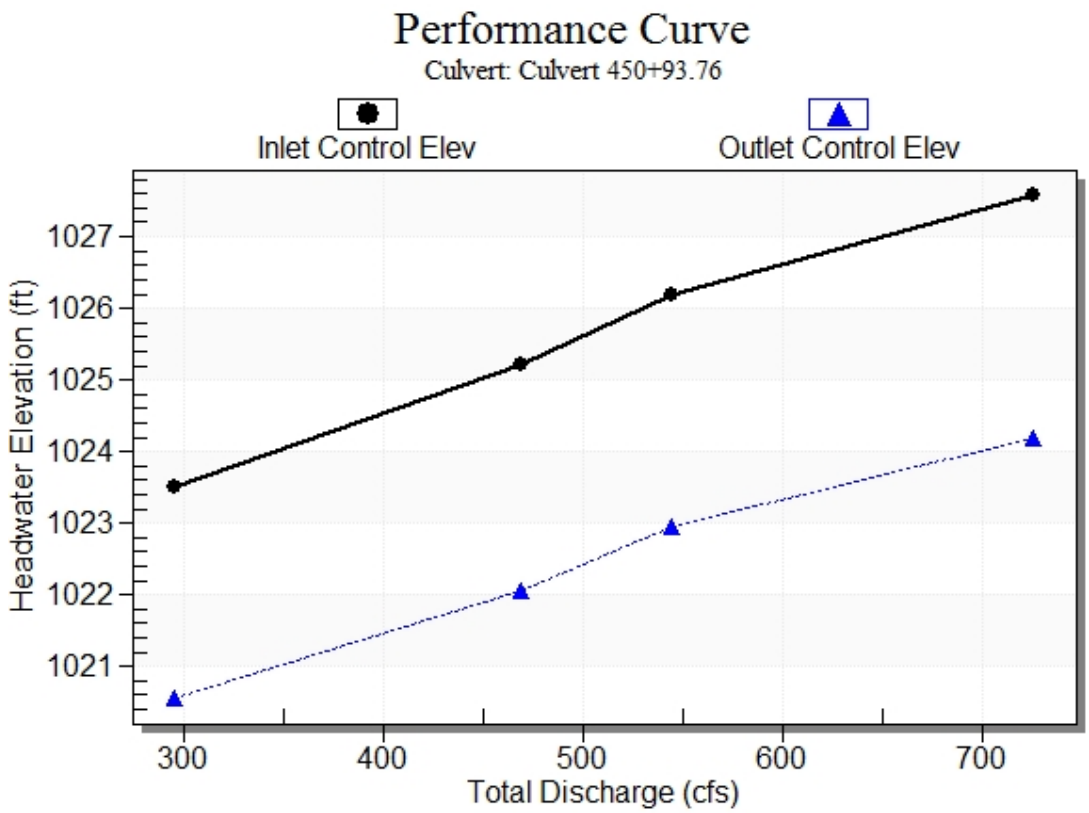
Straight Culvert

Inlet Elevation (invert): 1020.34 ft, Outlet Elevation (invert): 1016.56 ft

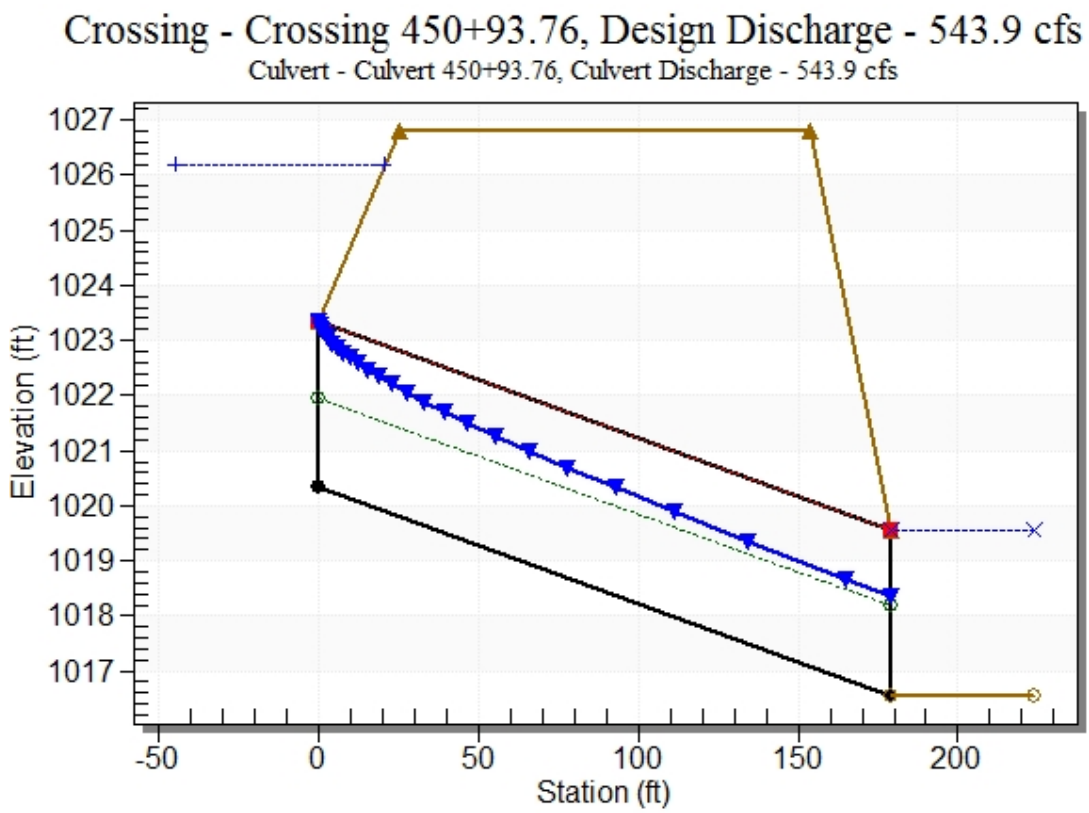
Culvert Length: 179.04 ft, Culvert Slope: 0.0211

****

Culvert Performance Curve Plot: Culvert 450+93.76



Water Surface Profile Plot for Culvert: Culvert 450+93.76



Site Data - Culvert 450+93.76

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1020.34 ft

Outlet Station: 179.00 ft

Outlet Elevation: 1016.56 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 450+93.76

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 24 - Downstream Channel Rating Curve (Crossing: Crossing 450+93.76)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
295.10	1019.56	3.00
468.50	1019.56	3.00
543.90	1019.56	3.00

Tailwater Channel Data - Crossing 450+93.76

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1019.56 ft

Roadway Data for Crossing: Crossing 450+93.76

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-97.00	1026.82
1	-28.00	1027.60
2	32.00	1026.83

Roadway Surface: Paved

Roadway Top Width: 129.00 ft

Crossing Notes: Crossing 470+24.67

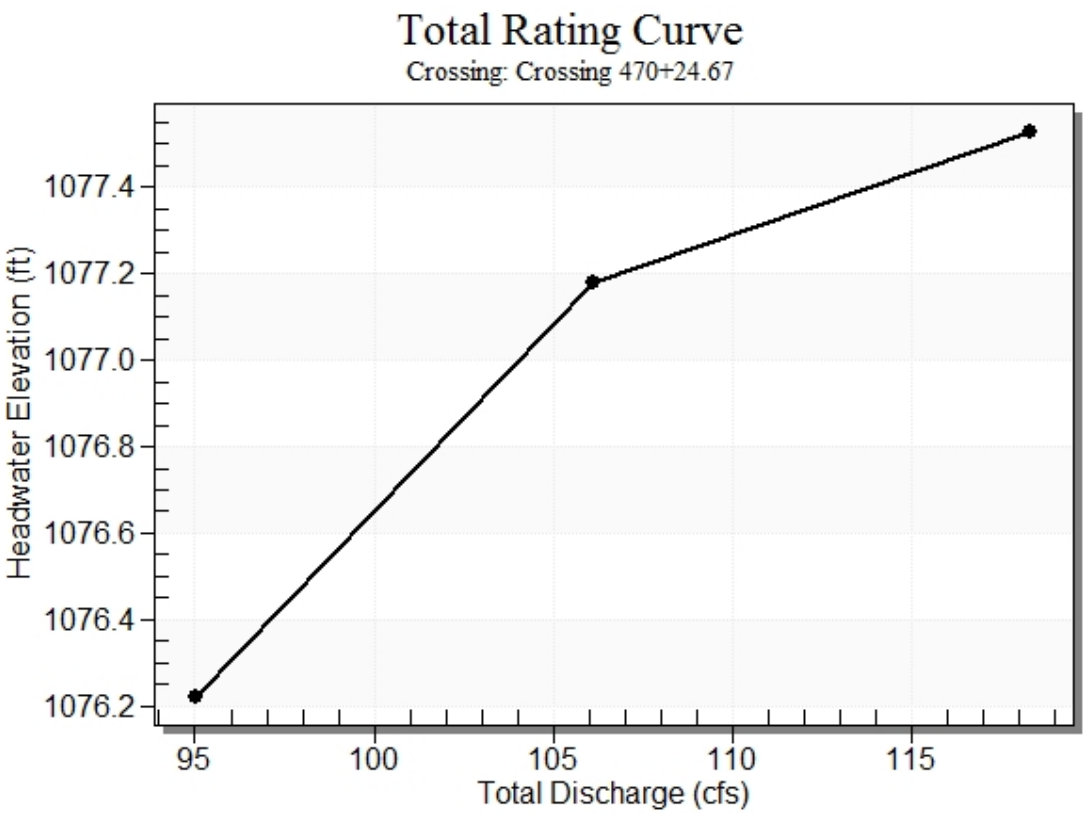
Crossing Discharge Data

Discharge Selection Method: Recurrence

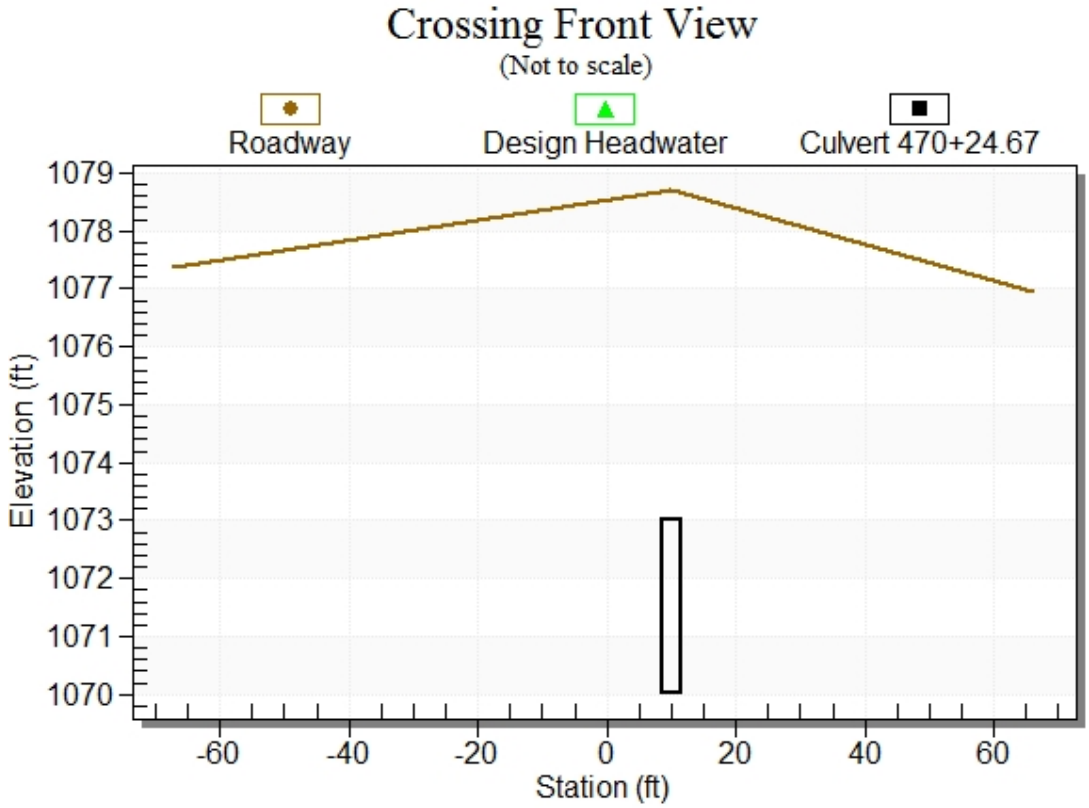
Table 25 - Summary of Culvert Flows at Crossing: Crossing 470+24.67

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 470+24.67 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1076.22	25 year	95.01	95.01	0.00	1
1077.18	50 year	106.12	105.21	0.91	4
1077.53	100 year	118.33	108.71	9.54	12
1076.94	Overtopping	102.77	102.77	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 470+24.67



Crossing Front View (Roadway Profile): Crossing 470+24.67



Culvert Notes: Culvert 470+24.67

Table 26 - Culvert Summary Table: Culvert 470+24.67

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	95.01	95.01	1076.22	6.203	1.455	5-S2n	1.701	3.000	1.788	1.350	17.713	2.704
50 year	106.12	105.21	1077.18	7.158	2.483	5-S2n	1.838	3.000	1.937	1.430	18.101	2.792
100 year	118.33	108.71	1077.53	7.509	2.859	5-S2n	1.885	3.000	1.988	1.514	18.231	2.881

****

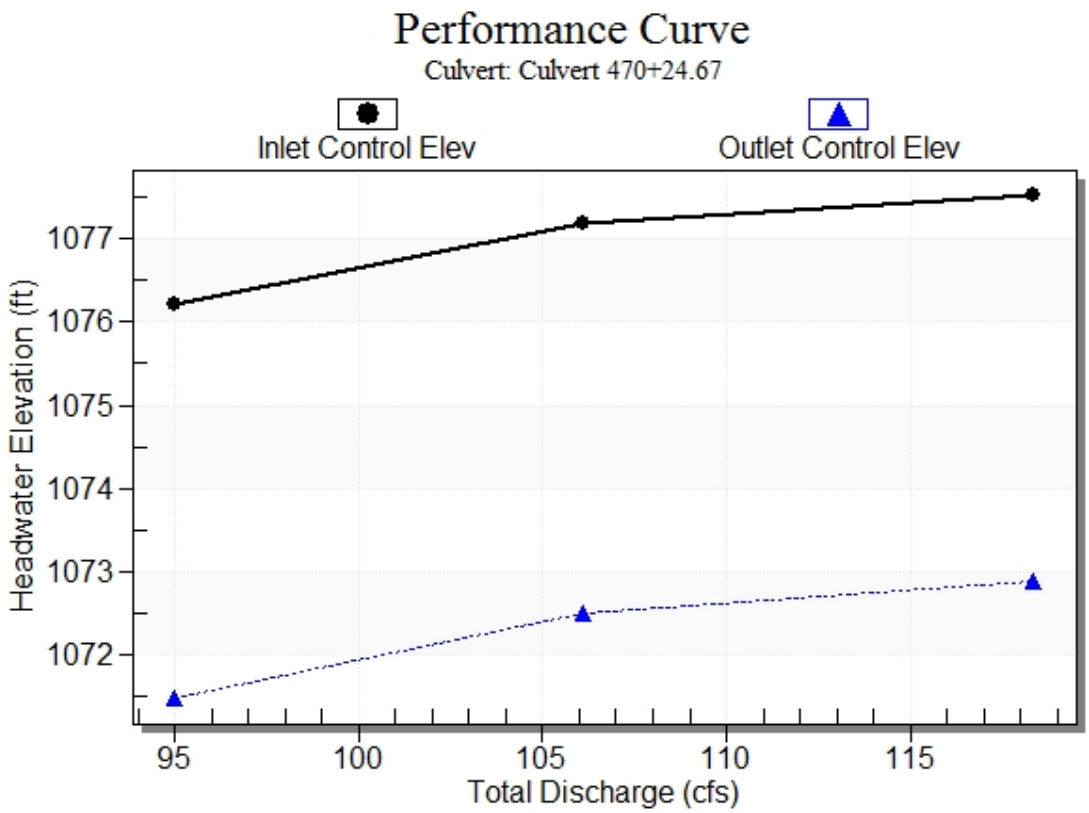
Straight Culvert

Inlet Elevation (invert): 1070.02 ft, Outlet Elevation (invert): 1063.93 ft

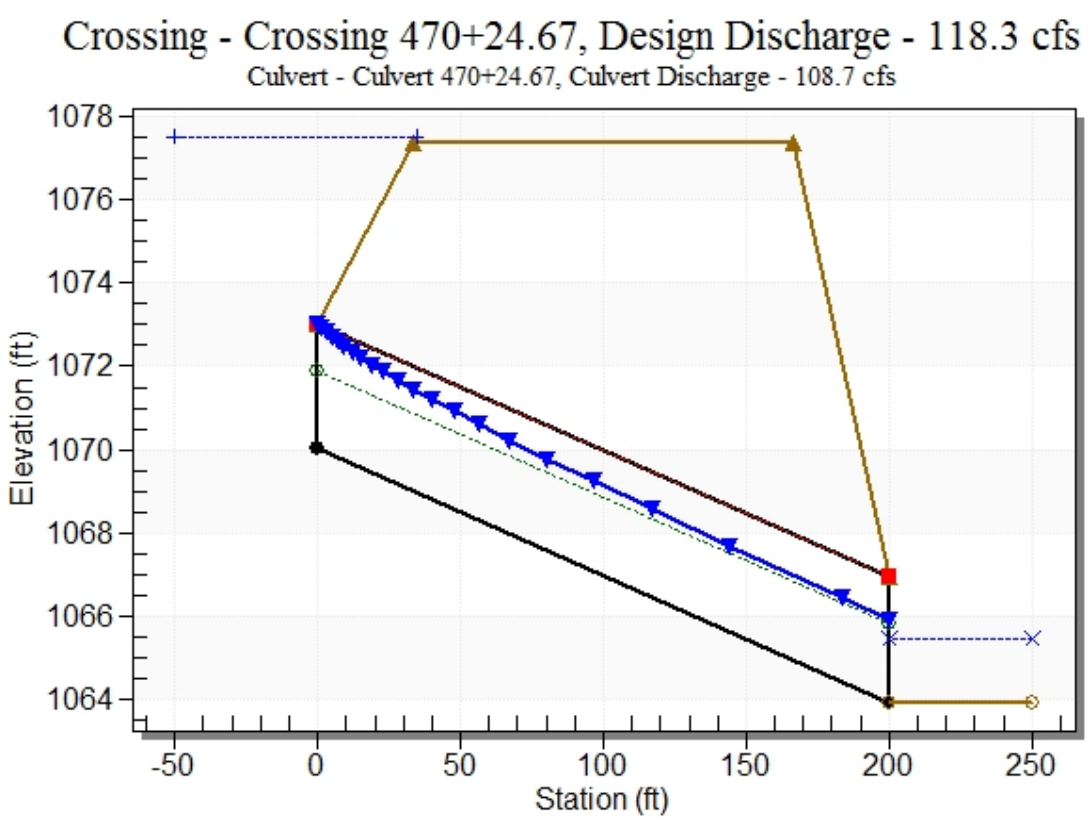
Culvert Length: 200.09 ft, Culvert Slope: 0.0304

****

Culvert Performance Curve Plot: Culvert 470+24.67



Water Surface Profile Plot for Culvert: Culvert 470+24.67



Site Data - Culvert 470+24.67

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1070.02 ft

Outlet Station: 200.00 ft

Outlet Elevation: 1063.93 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 470+24.67

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 27 - Downstream Channel Rating Curve (Crossing: Crossing 470+24.67)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
95.01	1065.28	1.35	2.70	0.25	0.48
106.12	1065.36	1.43	2.79	0.27	0.48
118.33	1065.44	1.51	2.88	0.28	0.48

Tailwater Channel Data - Crossing 470+24.67

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 16.96 ft

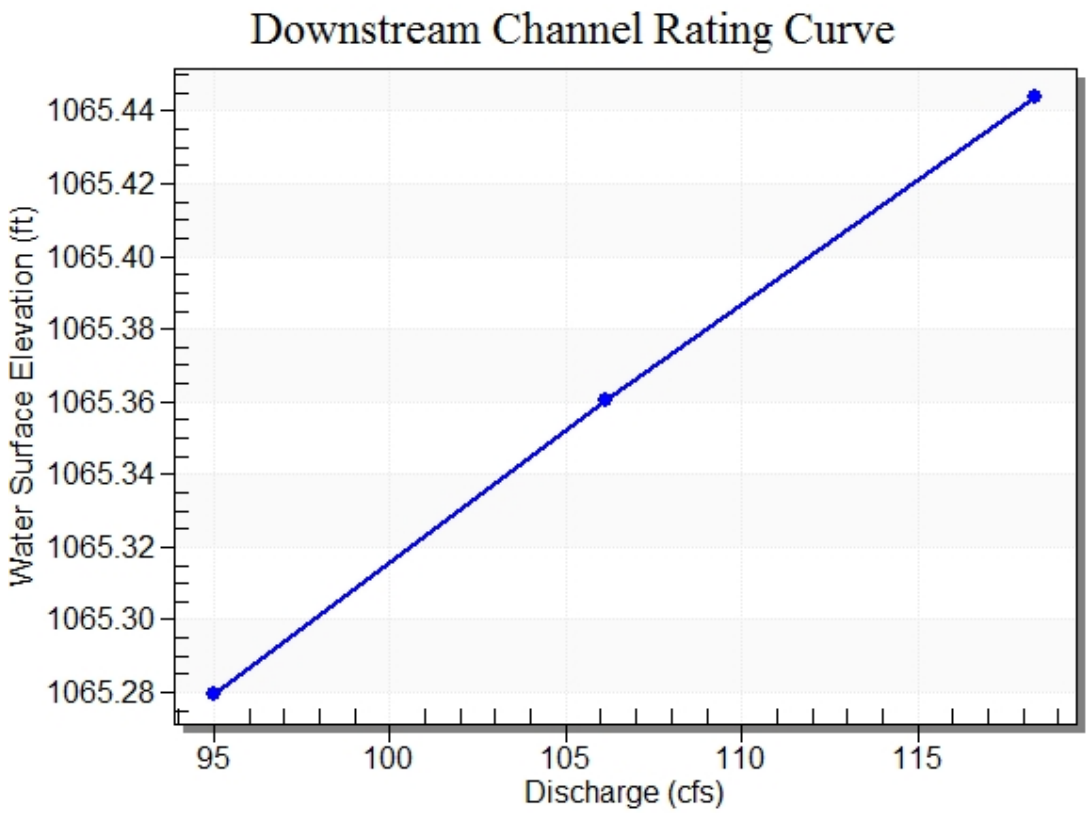
Side Slope (H:V): 6.72 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0300

Channel Invert Elevation: 1063.93 ft

Tailwater Rating Curve Plot for Crossing: Crossing 470+24.67



Roadway Data for Crossing: Crossing 470+24.67

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-67.00	1077.37
1	10.00	1078.71
2	66.00	1076.94

Roadway Surface: Paved

Roadway Top Width: 133.00 ft

Crossing Notes: Crossing 477+54.41

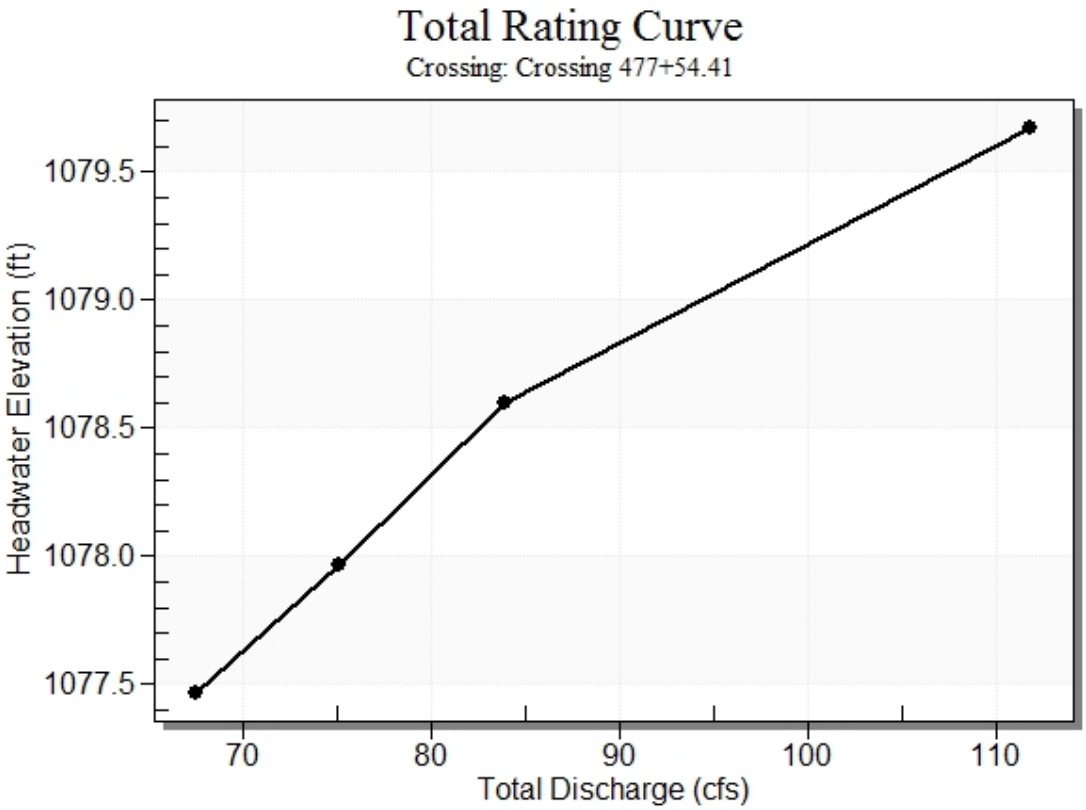
Crossing Discharge Data

Discharge Selection Method: Recurrence

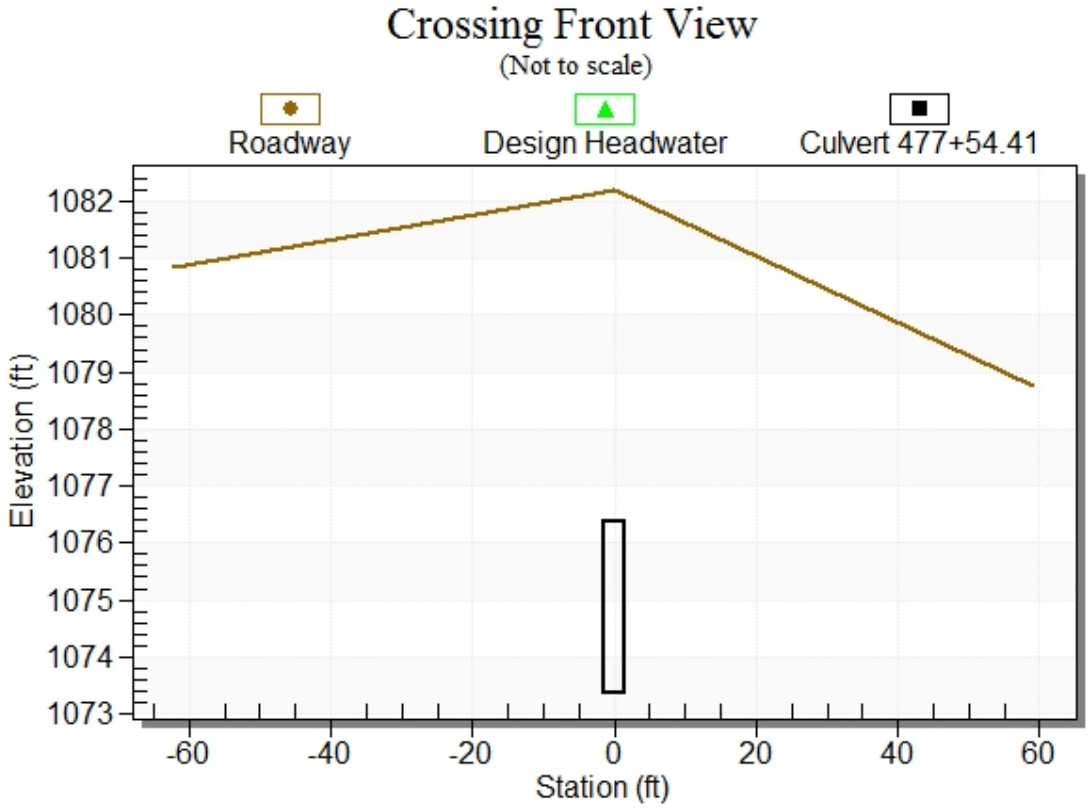
Table 28 - Summary of Culvert Flows at Crossing: Crossing 477+54.41

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 477+54.41 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1077.47	25 year	67.47	67.47	0.00	1
1077.96	50 year	75.09	75.09	0.00	1
1078.60	100 year	83.87	83.87	0.00	1
1078.75	Overtopping	85.77	85.77	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 477+54.41



Crossing Front View (Roadway Profile): Crossing 477+54.41



Culvert Notes: Culvert 477+54.41

Table 29 - Culvert Summary Table: Culvert 477+54.41

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	67.47	67.47	1077.47	4.110	0.0*	5-S2n	1.039	2.504	1.099	3.000	20.455	0.000
50 year	75.09	75.09	1077.96	4.605	0.0*	5-S2n	1.121	2.690	1.193	3.000	20.972	0.000
100 year	83.87	83.87	1078.60	5.242	0.0*	5-S2n	1.216	2.895	1.304	3.000	21.436	0.000

* Full Flow Headwater elevation is below inlet invert.

****

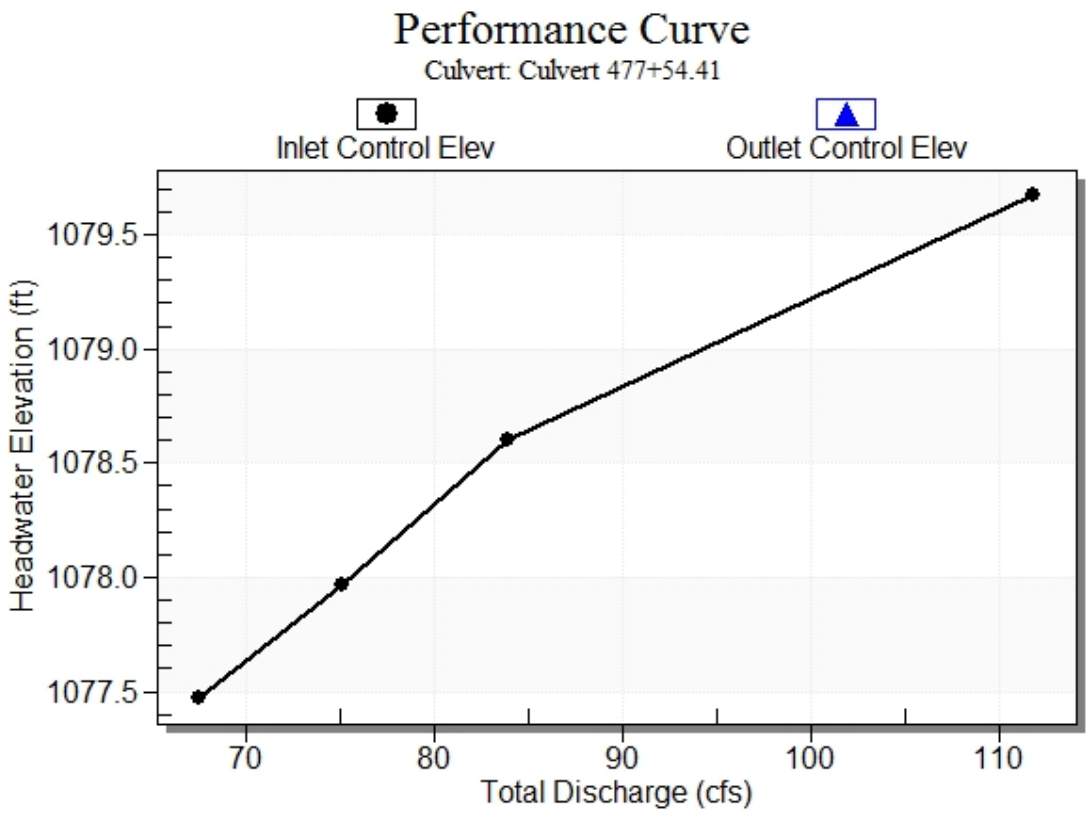
Straight Culvert

Inlet Elevation (invert): 1073.36 ft, Outlet Elevation (invert): 1063.55 ft

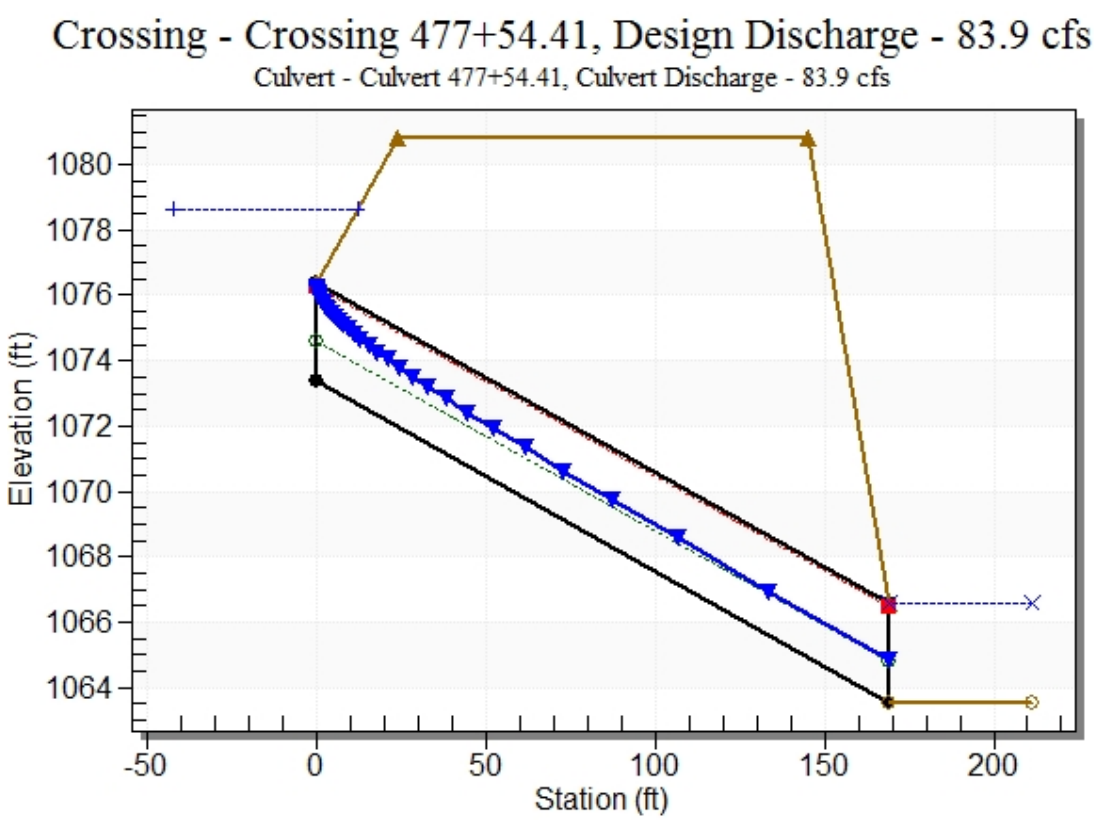
Culvert Length: 169.28 ft, Culvert Slope: 0.0580

****

Culvert Performance Curve Plot: Culvert 477+54.41



Water Surface Profile Plot for Culvert: Culvert 477+54.41



Site Data - Culvert 477+54.41

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1073.36 ft

Outlet Station: 169.00 ft

Outlet Elevation: 1063.55 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 477+54.41

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 30 - Downstream Channel Rating Curve (Crossing: Crossing 477+54.41)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
67.47	1066.55	3.00
75.09	1066.55	3.00
83.87	1066.55	3.00

Tailwater Channel Data - Crossing 477+54.41

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1066.55 ft

Roadway Data for Crossing: Crossing 477+54.41

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-62.00	1080.84
1	0.00	1082.20
2	59.00	1078.75

Roadway Surface: Paved

Roadway Top Width: 121.00 ft

Crossing Notes: Crossing 483+93.14

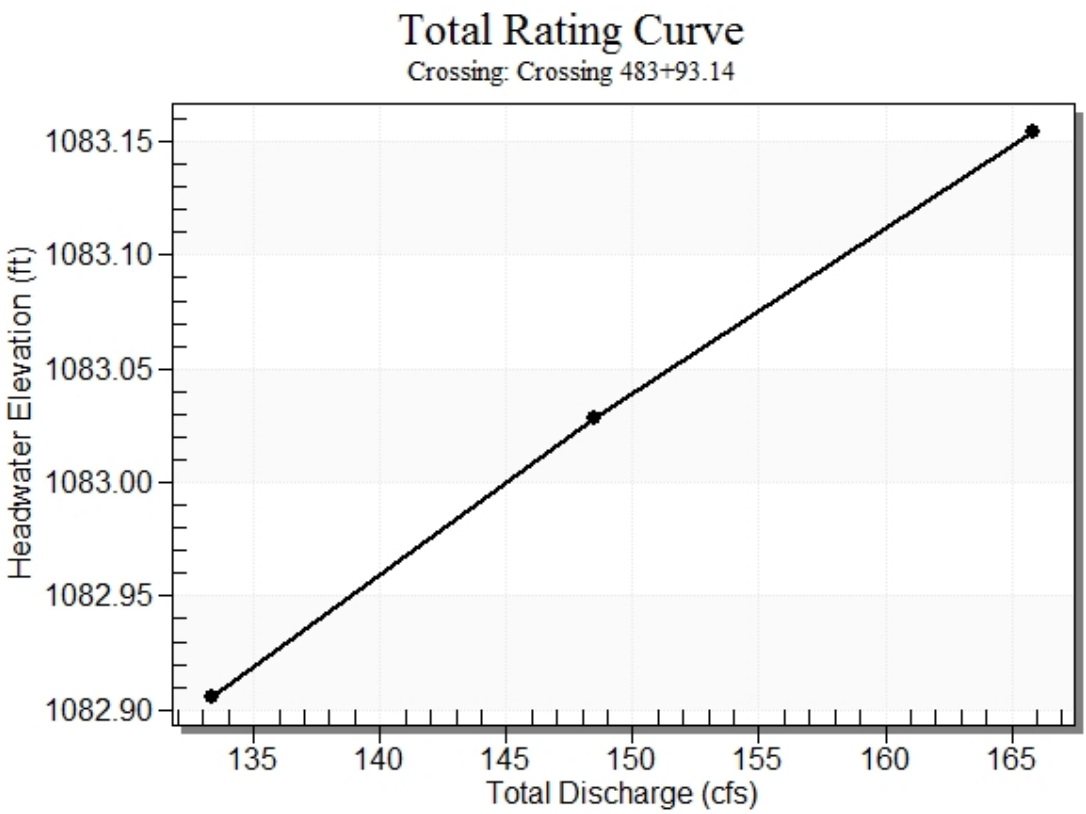
Crossing Discharge Data

Discharge Selection Method: Recurrence

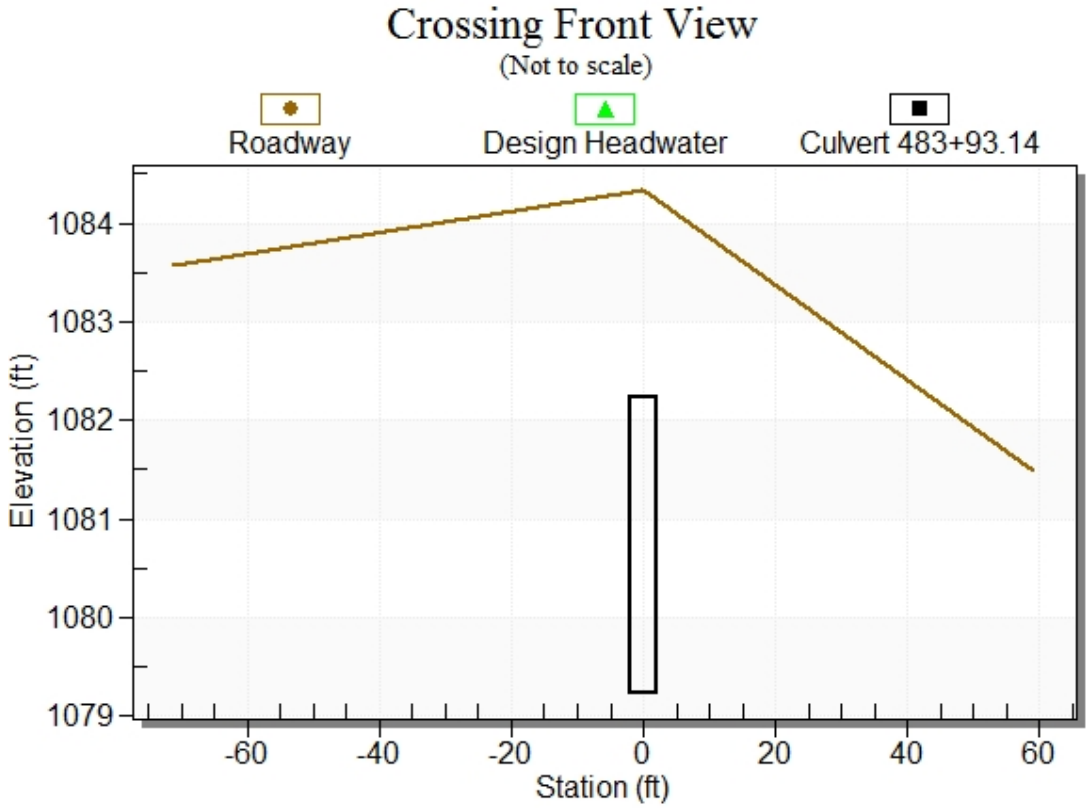
Table 31 - Summary of Culvert Flows at Crossing: Crossing 483+93.14

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 483+93.14 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1082.91	25 year	133.36	79.61	53.73	8
1083.03	50 year	148.51	82.50	65.97	5
1083.15	100 year	165.83	85.41	80.31	4
1081.48	Overtopping	41.68	41.68	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 483+93.14



Crossing Front View (Roadway Profile): Crossing 483+93.14



Culvert Notes: Culvert 483+93.14

Table 32 - Culvert Summary Table: Culvert 483+93.14

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	133.36	79.61	1082.91	3.675	0.0*	5-S2n	0.989	2.308	1.053	3.000	18.895	0.000
50 year	148.51	82.50	1083.03	3.797	0.0*	5-S2n	1.013	2.364	1.084	3.000	19.034	0.000
100 year	165.83	85.41	1083.15	3.924	0.0*	5-S2n	1.037	2.419	1.112	3.000	19.200	0.000

* Full Flow Headwater elevation is below inlet invert.

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Straight Culvert

Inlet Elevation (invert): 1079.23 ft, Outlet Elevation (invert): 1071.71 ft

Culvert Length: 165.17 ft, Culvert Slope: 0.0456

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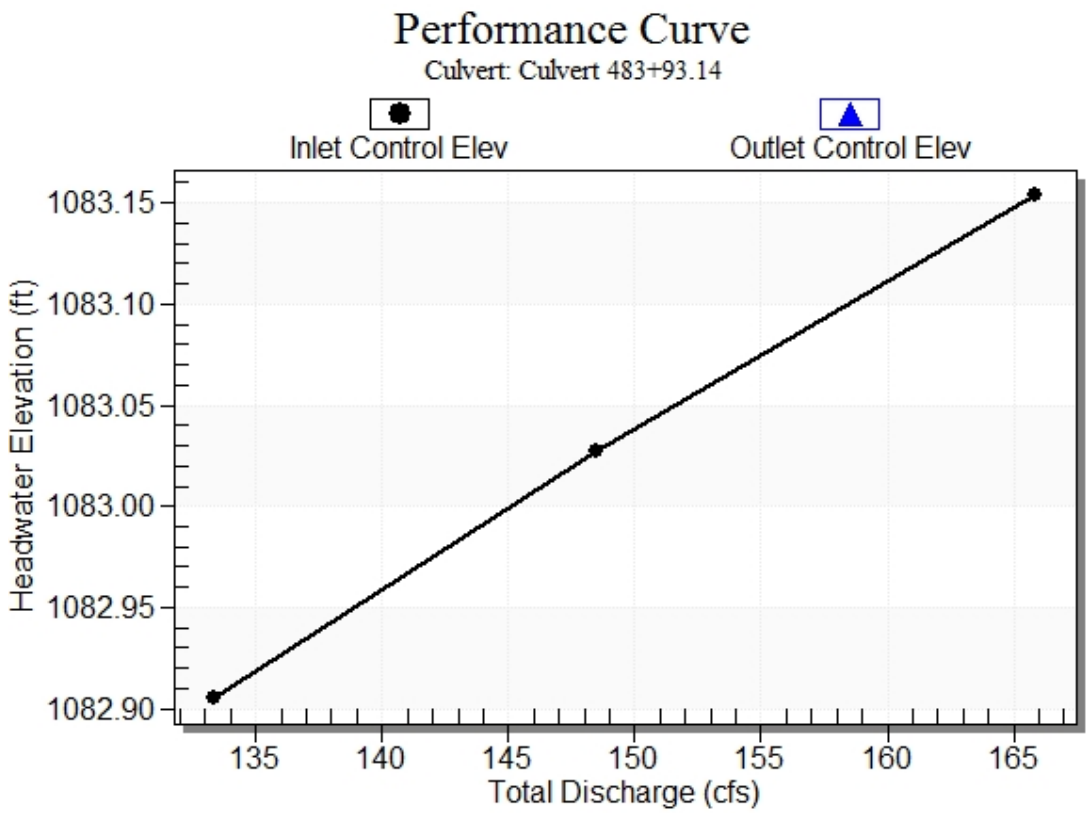
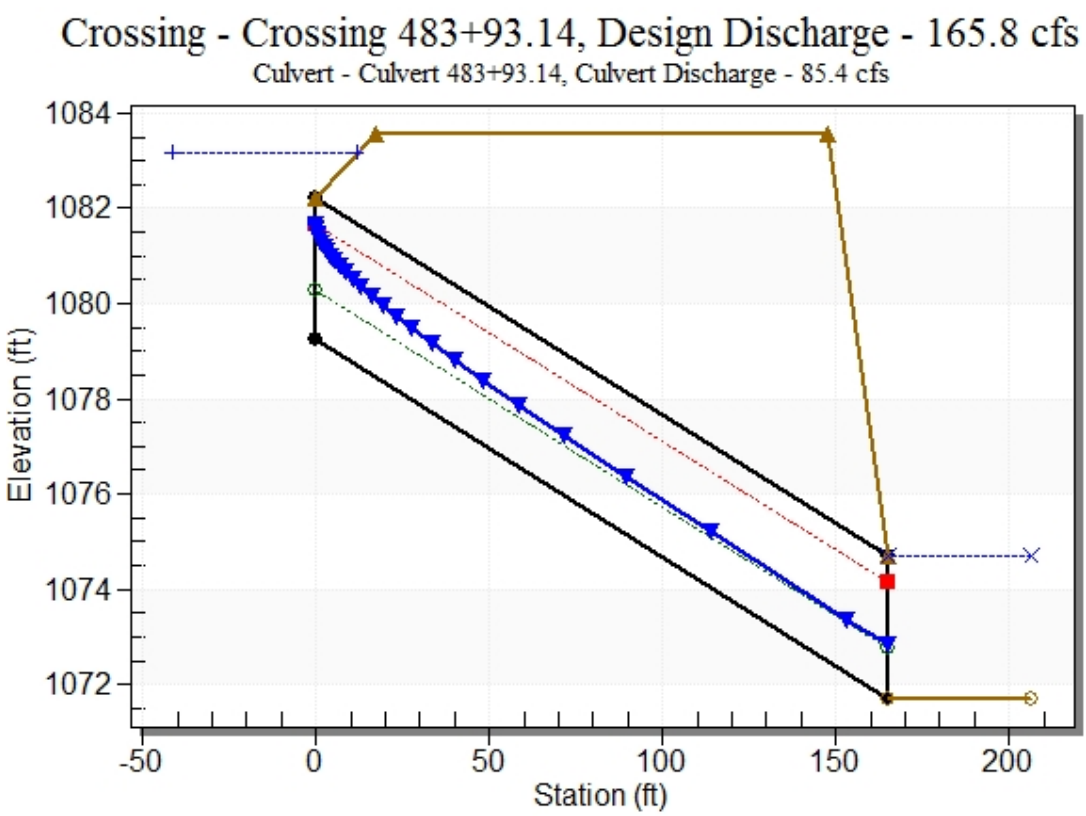
Culvert Performance Curve Plot: Culvert 483+93.14



Water Surface Profile Plot for Culvert: Culvert 483+93.14



Site Data - Culvert 483+93.14

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1079.23 ft

Outlet Station: 165.00 ft

Outlet Elevation: 1071.71 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 483+93.14

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 33 - Downstream Channel Rating Curve (Crossing: Crossing 483+93.14)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
133.36	1074.71	3.00
148.51	1074.71	3.00
165.83	1074.71	3.00

Tailwater Channel Data - Crossing 483+93.14

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1074.71 ft

Roadway Data for Crossing: Crossing 483+93.14

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-71.00	1083.58
1	0.00	1084.34
2	59.00	1081.48

Roadway Surface: Paved

Roadway Top Width: 130.00 ft

Crossing Notes: Crossing 490+31.03

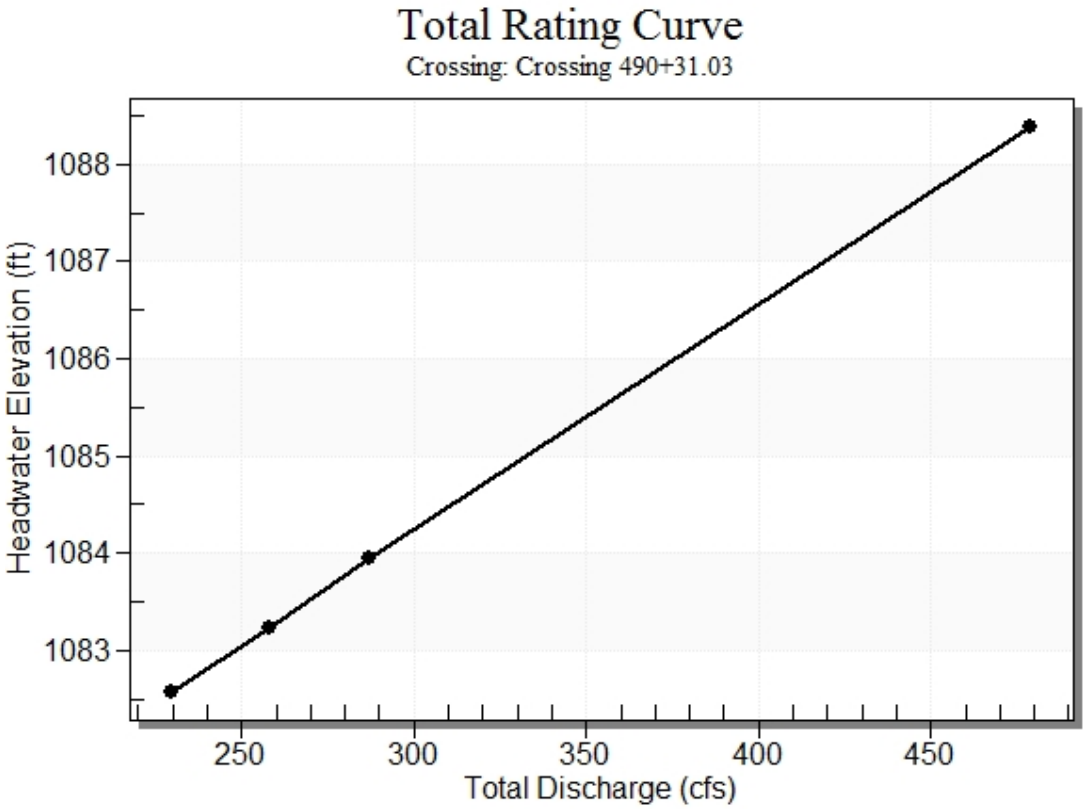
Crossing Discharge Data

Discharge Selection Method: Recurrence

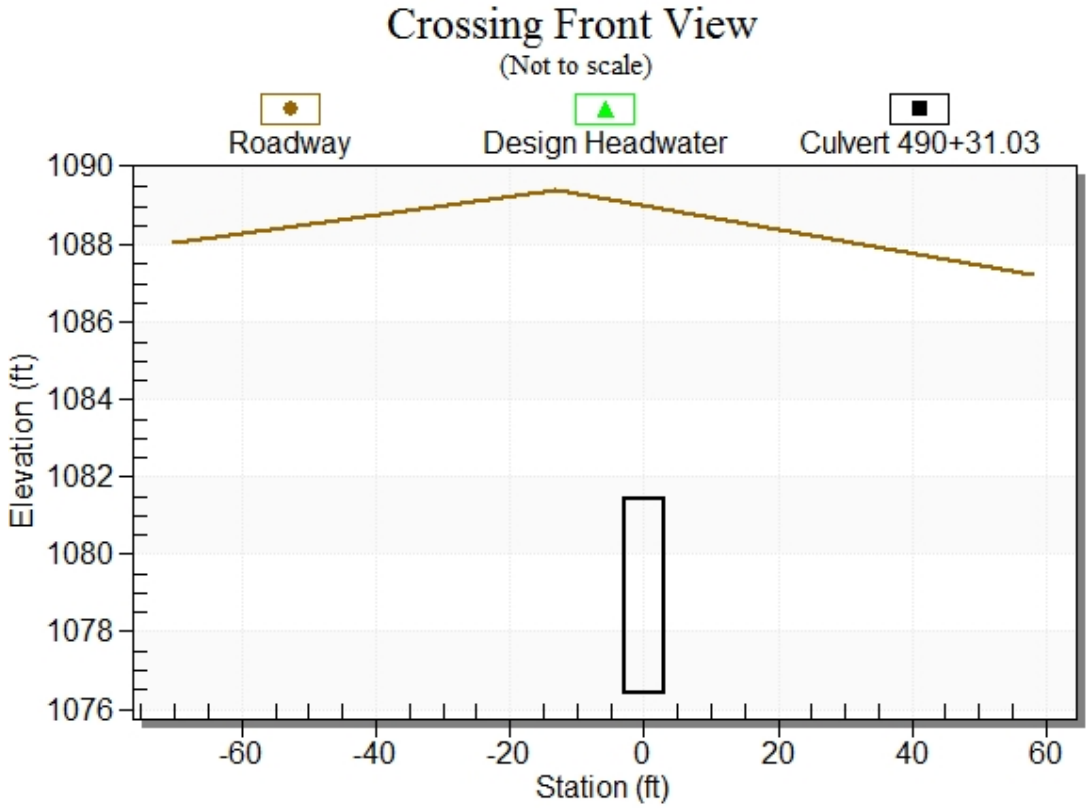
Table 34 - Summary of Culvert Flows at Crossing: Crossing 490+31.03

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 490+31.03 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1082.58	25 year	229.79	229.79	0.00	1
1083.23	50 year	258.31	258.31	0.00	1
1083.95	100 year	287.19	287.19	0.00	1
1087.23	Overtopping	394.34	394.34	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 490+31.03



Crossing Front View (Roadway Profile): Crossing 490+31.03



Culvert Notes: Culvert 490+31.03

Table 35 - Culvert Summary Table: Culvert 490+31.03

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	229.79	229.79	1082.58	6.170	3.689	5-S2n	2.033	3.571	2.264	5.000	16.913	0.000
50 year	258.31	258.31	1083.23	6.825	4.166	5-S2n	2.216	3.861	2.481	5.000	17.354	0.000
100 year	287.19	287.19	1083.95	7.541	4.706	5-S2n	2.391	4.144	2.694	5.000	17.770	0.000

****

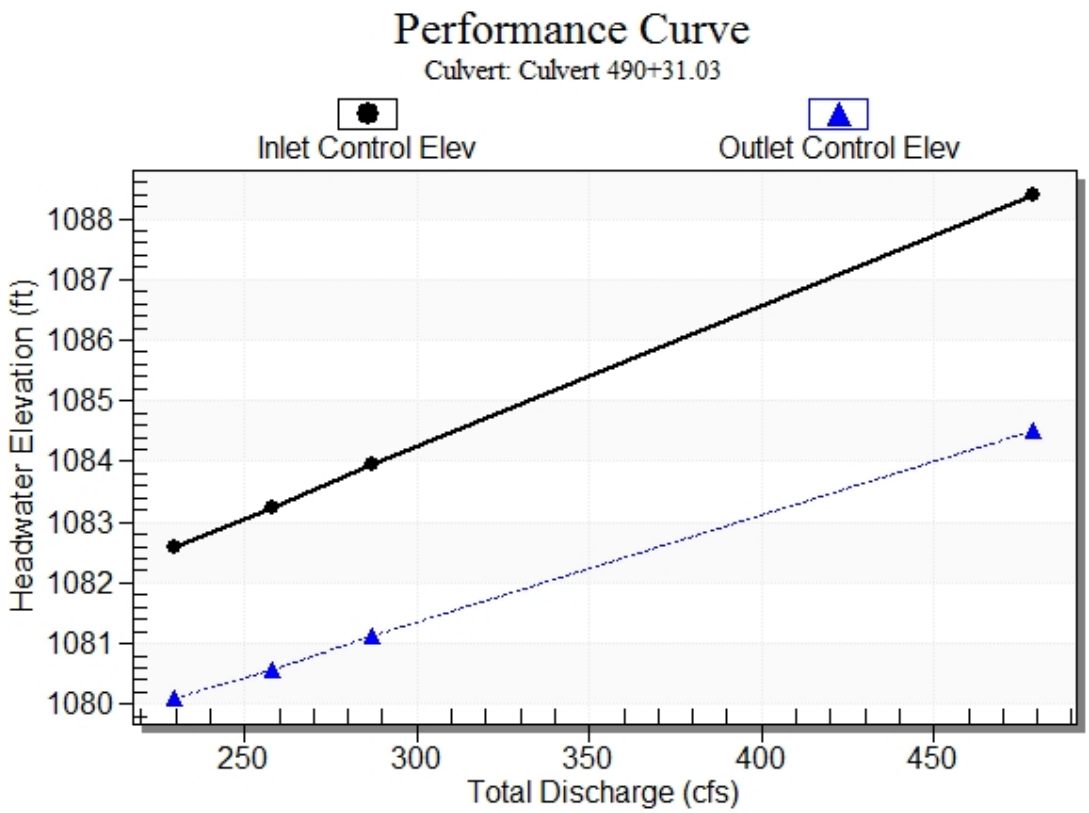
Straight Culvert

Inlet Elevation (invert): 1076.41 ft, Outlet Elevation (invert): 1073.29 ft

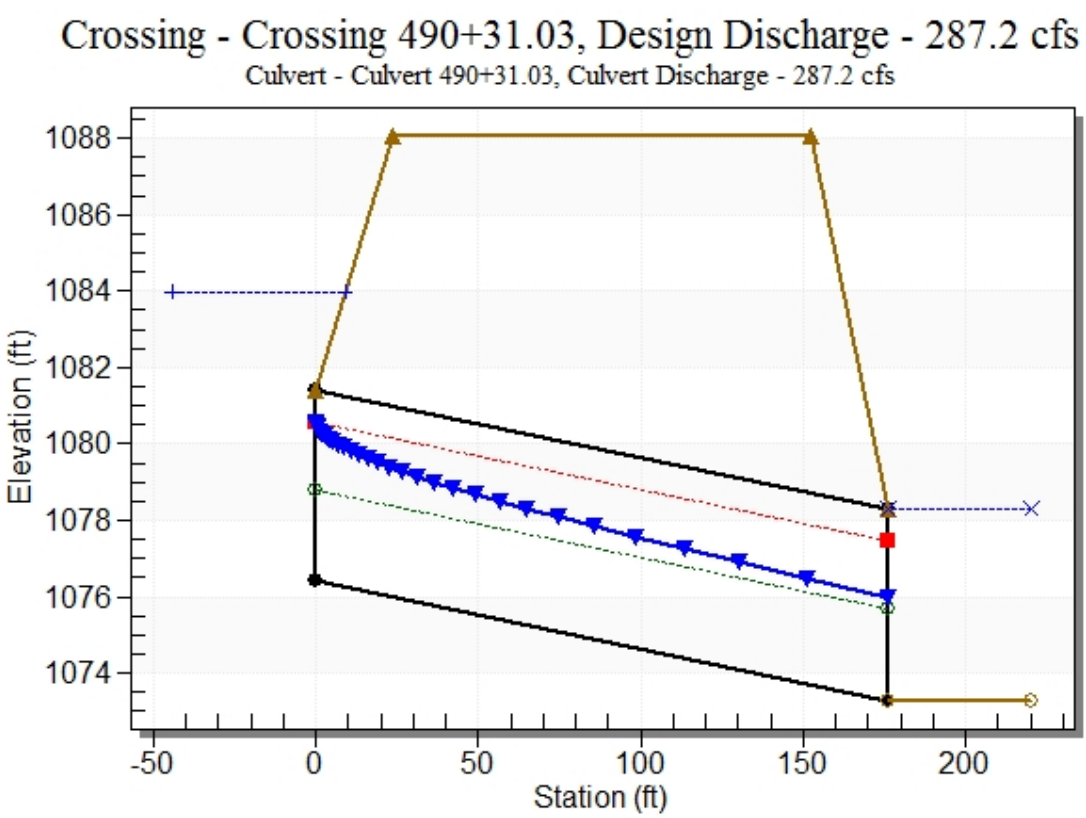
Culvert Length: 176.03 ft, Culvert Slope: 0.0177

****

Culvert Performance Curve Plot: Culvert 490+31.03



Water Surface Profile Plot for Culvert: Culvert 490+31.03



Site Data - Culvert 490+31.03

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1076.41 ft

Outlet Station: 176.00 ft

Outlet Elevation: 1073.29 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 490+31.03

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 36 - Downstream Channel Rating Curve (Crossing: Crossing 490+31.03)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
229.79	1078.29	5.00
258.31	1078.29	5.00
287.19	1078.29	5.00

Tailwater Channel Data - Crossing 490+31.03

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1078.29 ft

Roadway Data for Crossing: Crossing 490+31.03

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-70.00	1088.08
1	-13.00	1089.43
2	58.00	1087.23

Roadway Surface: Paved

Roadway Top Width: 129.00 ft

Crossing Notes: Crossing 512+11.77

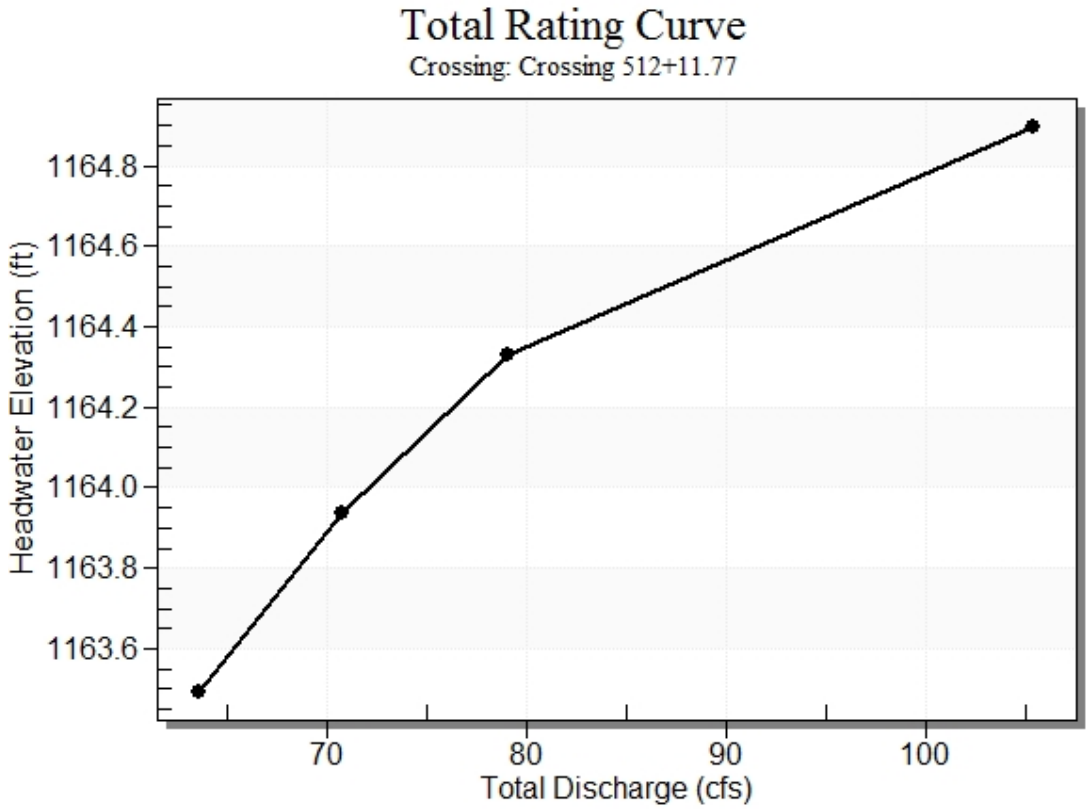
Crossing Discharge Data

Discharge Selection Method: Recurrence

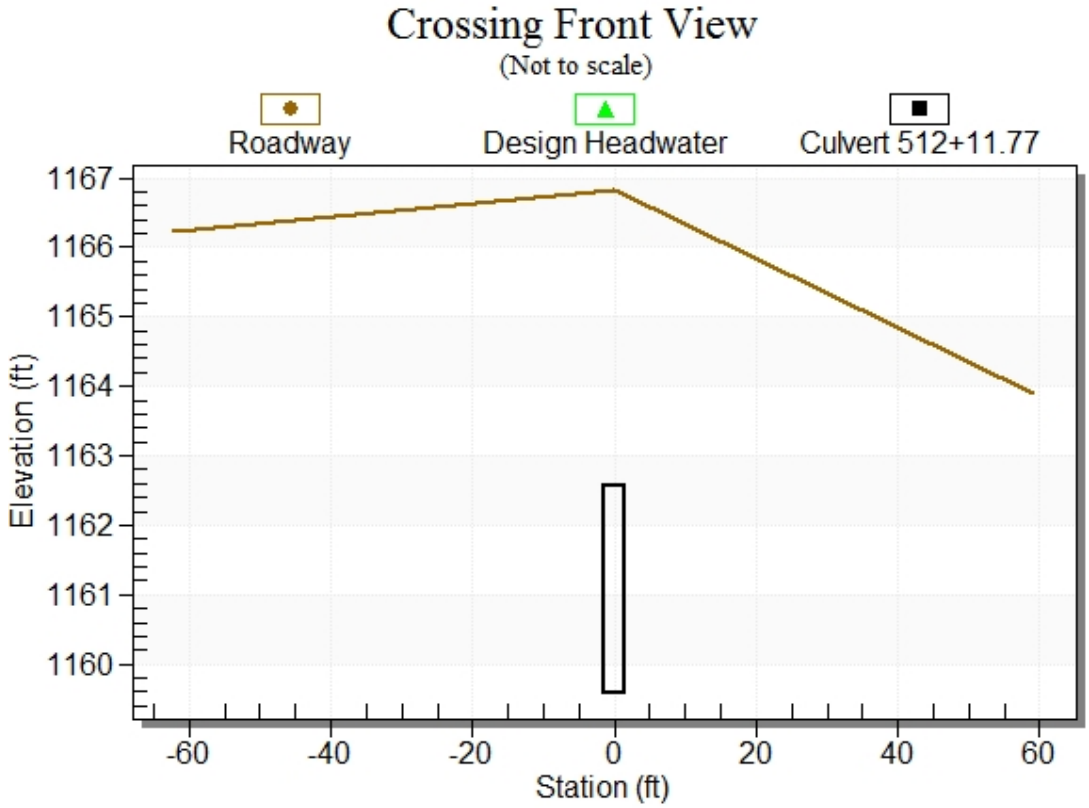
Table 37 - Summary of Culvert Flows at Crossing: Crossing 512+11.77

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 512+11.77 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1163.49	25 year	63.57	63.57	0.00	1
1163.94	50 year	70.78	70.76	0.00	6
1164.33	100 year	79.04	76.62	2.40	8
1163.91	Overtopping	70.37	70.37	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 512+11.77



Crossing Front View (Roadway Profile): Crossing 512+11.77



Culvert Notes: Culvert 512+11.77

Table 38 - Culvert Summary Table: Culvert 512+11.77

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	63.57	63.57	1163.49	3.914	0.0*	5-S2n	1.223	2.407	1.271	3.000	16.677	0.000
50 year	70.78	70.76	1163.94	4.355	0.0*	5-S2n	1.326	2.585	1.380	3.000	17.086	0.000
100 year	79.04	76.62	1164.33	4.748	0.0*	5-S2n	1.405	2.726	1.469	3.000	17.382	0.000

* Full Flow Headwater elevation is below inlet invert.

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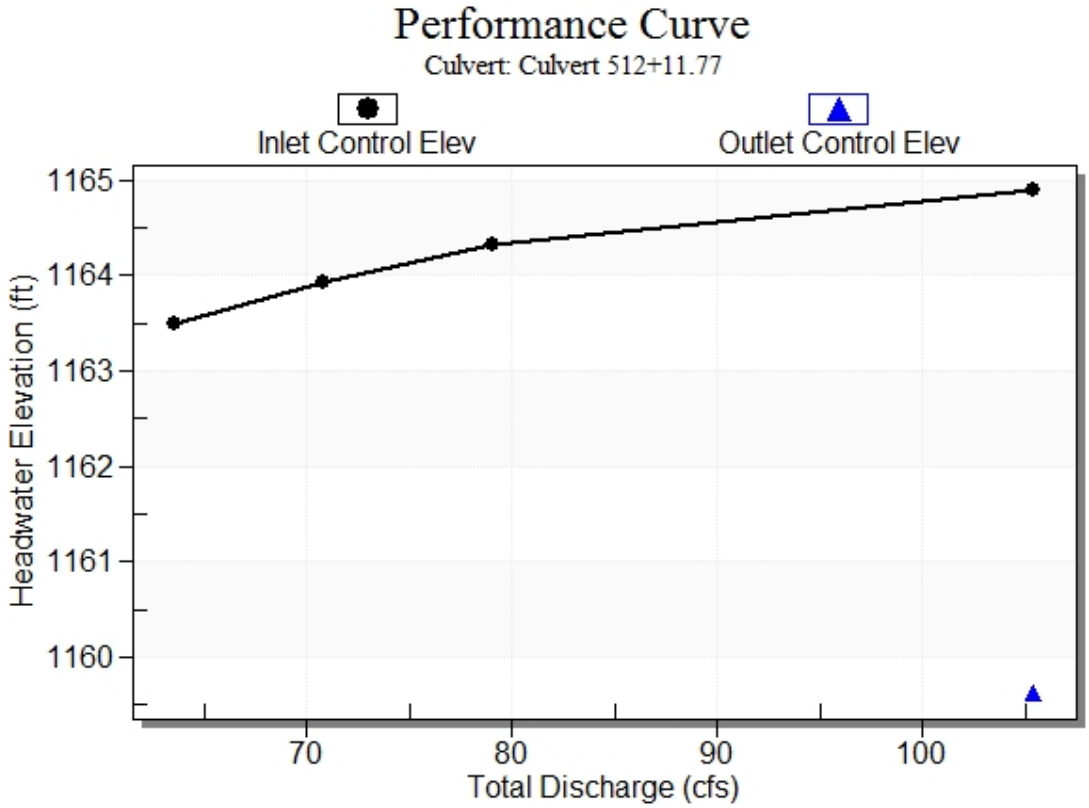
Straight Culvert

Inlet Elevation (invert): 1159.58 ft, Outlet Elevation (invert): 1153.05 ft

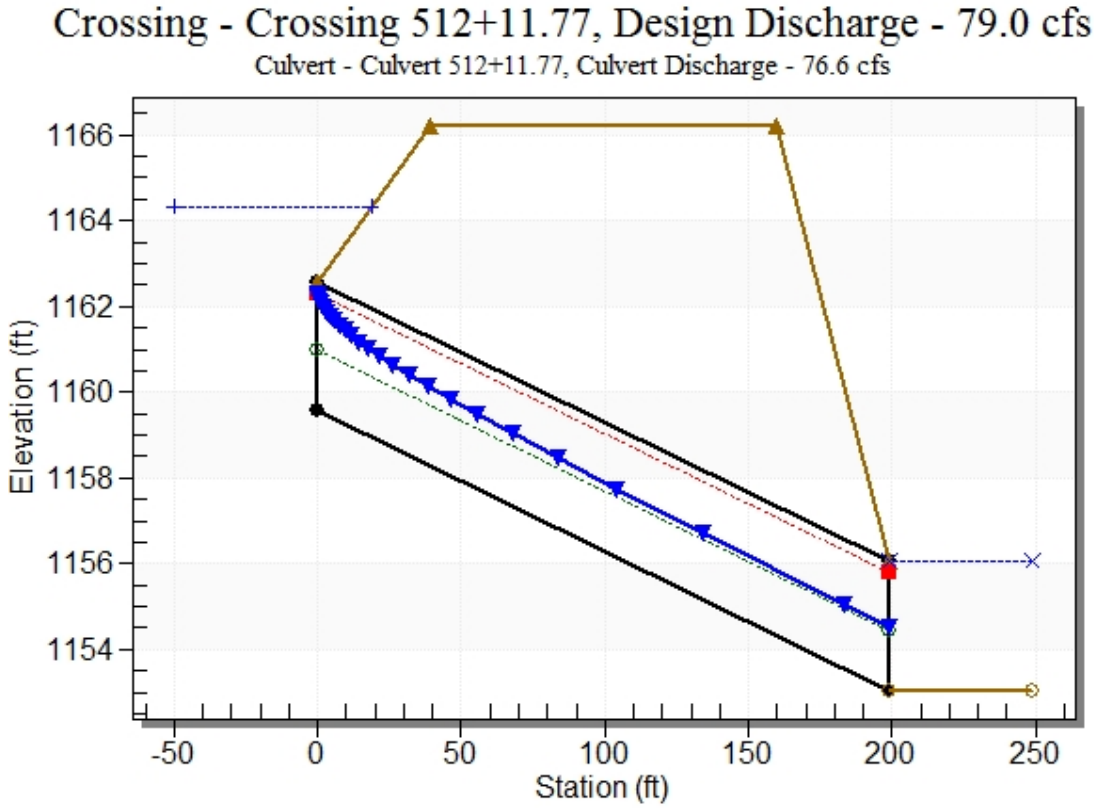
Culvert Length: 199.11 ft, Culvert Slope: 0.0328

****

Culvert Performance Curve Plot: Culvert 512+11.77



Water Surface Profile Plot for Culvert: Culvert 512+11.77



Site Data - Culvert 512+11.77

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1159.58 ft

Outlet Station: 199.00 ft

Outlet Elevation: 1153.05 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 512+11.77

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 39 - Downstream Channel Rating Curve (Crossing: Crossing 512+11.77)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
63.57	1156.05	3.00
70.78	1156.05	3.00
79.04	1156.05	3.00

Tailwater Channel Data - Crossing 512+11.77

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1156.05 ft

Roadway Data for Crossing: Crossing 512+11.77

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-62.00	1166.23
1	0.00	1166.83
2	59.00	1163.91

Roadway Surface: Paved

Roadway Top Width: 120.00 ft

Crossing Notes: Crossing 528+77.42

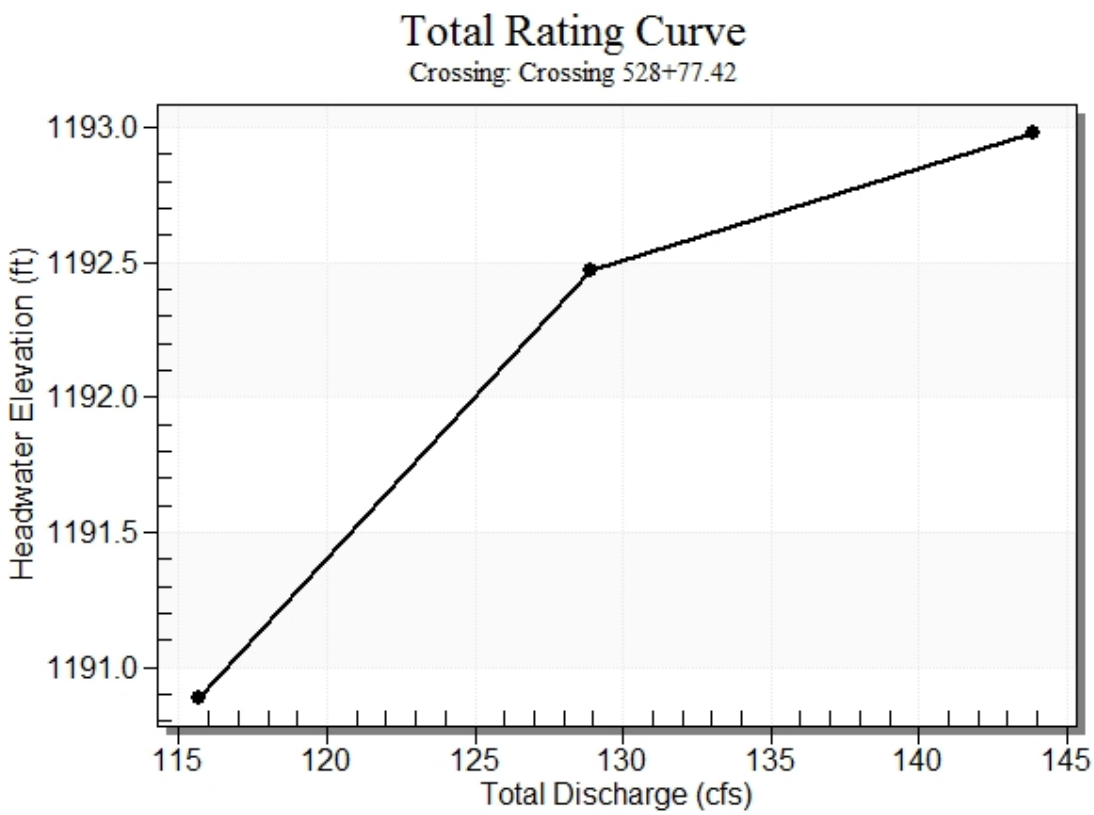
Crossing Discharge Data

Discharge Selection Method: Recurrence

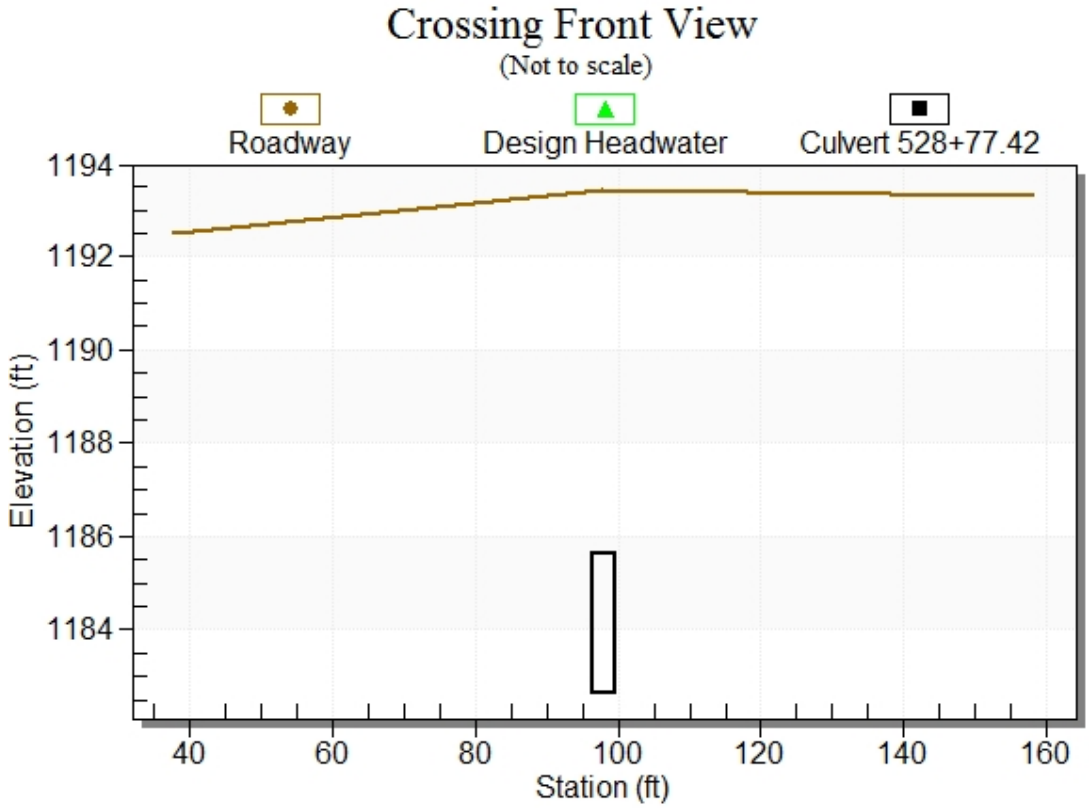
Table 40 - Summary of Culvert Flows at Crossing: Crossing 528+77.42

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 528+77.42 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1190.89	25 year	115.65	115.65	0.00	1
1192.47	50 year	128.91	128.91	0.00	1
1192.98	100 year	143.88	132.79	10.97	10
1193.43	Overtopping	136.11	136.11	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 528+77.42



Crossing Front View (Roadway Profile): Crossing 528+77.42



Culvert Notes: Culvert 528+77.42

Table 41 - Culvert Summary Table: Culvert 528+77.42

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	115.65	115.65	1190.89	8.250	4.679	5-S2n	2.094	3.000	2.212	3.875	17.426	4.136
50 year	128.91	128.91	1192.47	9.832	6.345	5-S2n	2.281	3.000	2.399	4.202	17.914	4.246
100 year	143.88	132.79	1192.98	10.342	7.195	5-S2n	2.335	3.000	2.452	4.564	18.056	4.356

****

Straight Culvert

Inlet Elevation (invert): 1182.64 ft, Outlet Elevation (invert): 1177.90 ft

Culvert Length: 180.06 ft, Culvert Slope: 0.0263

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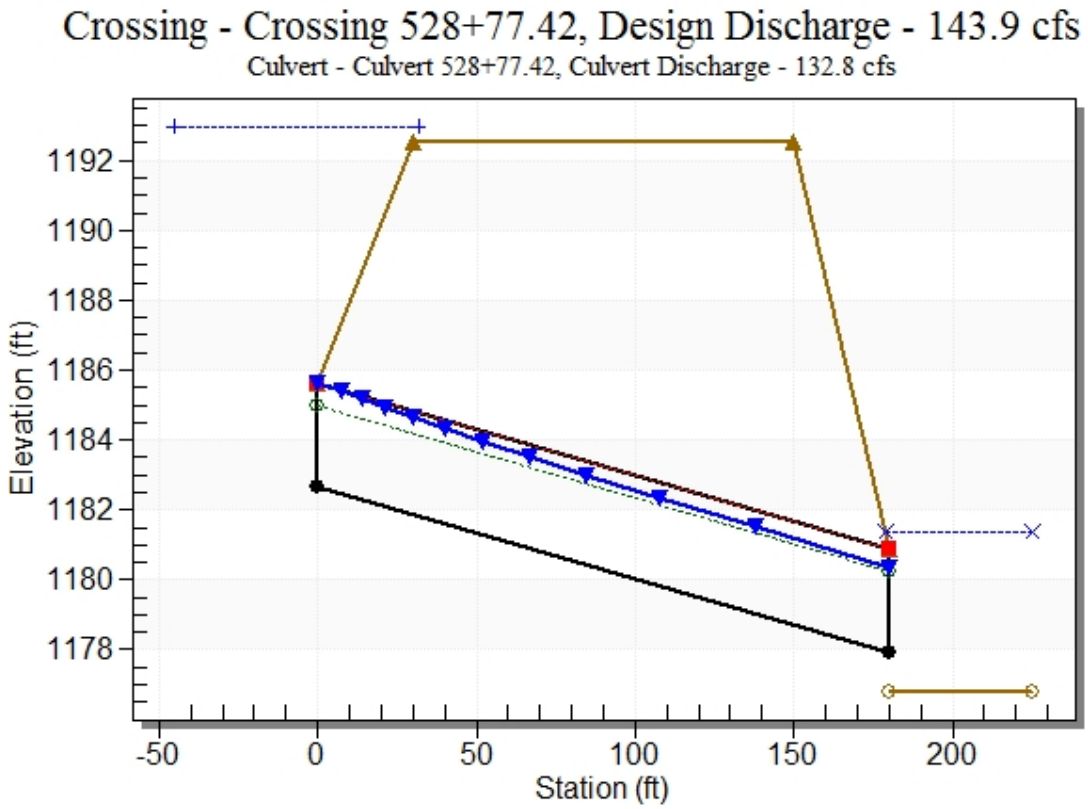
Culvert Performance Curve Plot: Culvert 528+77.42

Water Surface Profile Plot for Culvert: Culvert 528+77.42



Site Data - Culvert 528+77.42

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1182.64 ft

Outlet Station: 180.00 ft

Outlet Elevation: 1177.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 528+77.42

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 42 - Downstream Channel Rating Curve (Crossing: Crossing 528+77.42)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
115.65	1180.68	3.87	4.14	0.73	0.37
128.91	1181.01	4.20	4.25	0.79	0.37
143.88	1181.37	4.56	4.36	0.85	0.36

Tailwater Channel Data - Crossing 528+77.42

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 7.10 ft

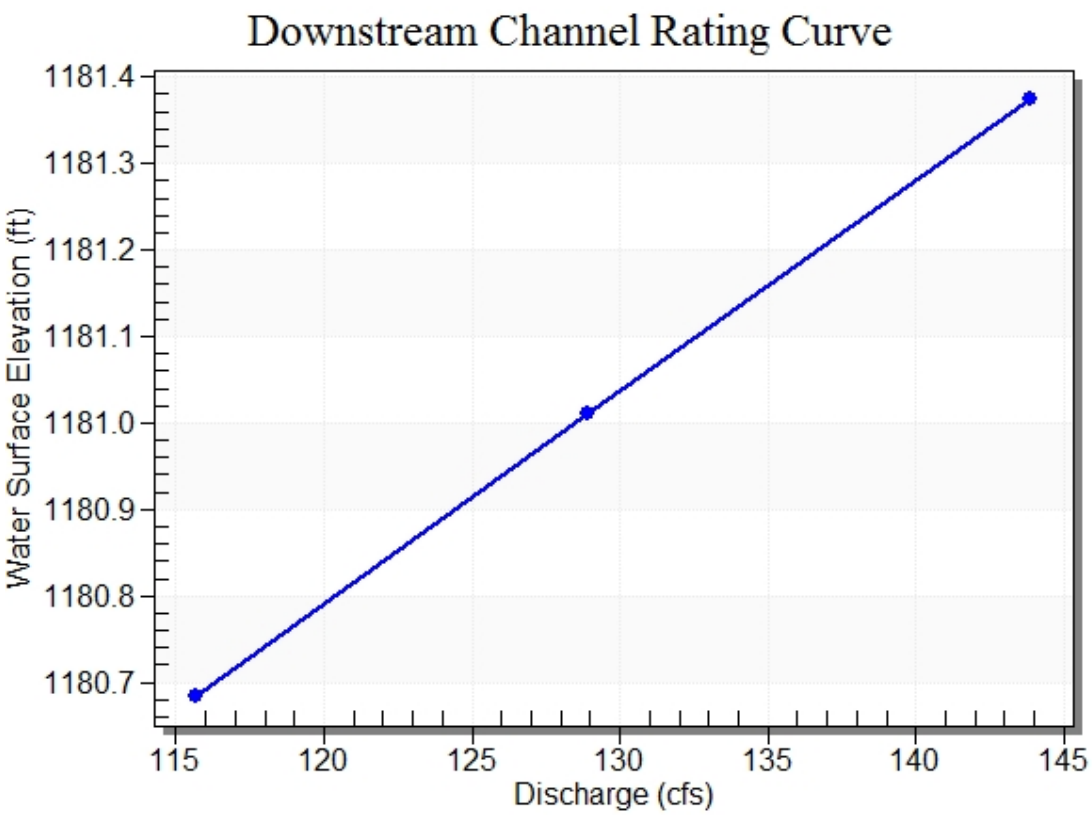
Side Slope (H:V): 0.03 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0300

Channel Invert Elevation: 1176.81 ft

Tailwater Rating Curve Plot for Crossing: Crossing 528+77.42



Roadway Data for Crossing: Crossing 528+77.42

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	38.00	1192.50
1	98.00	1193.43
2	158.00	1193.30

Roadway Surface: Paved

Roadway Top Width: 120.00 ft

Crossing Notes: Crossing 588+39.89

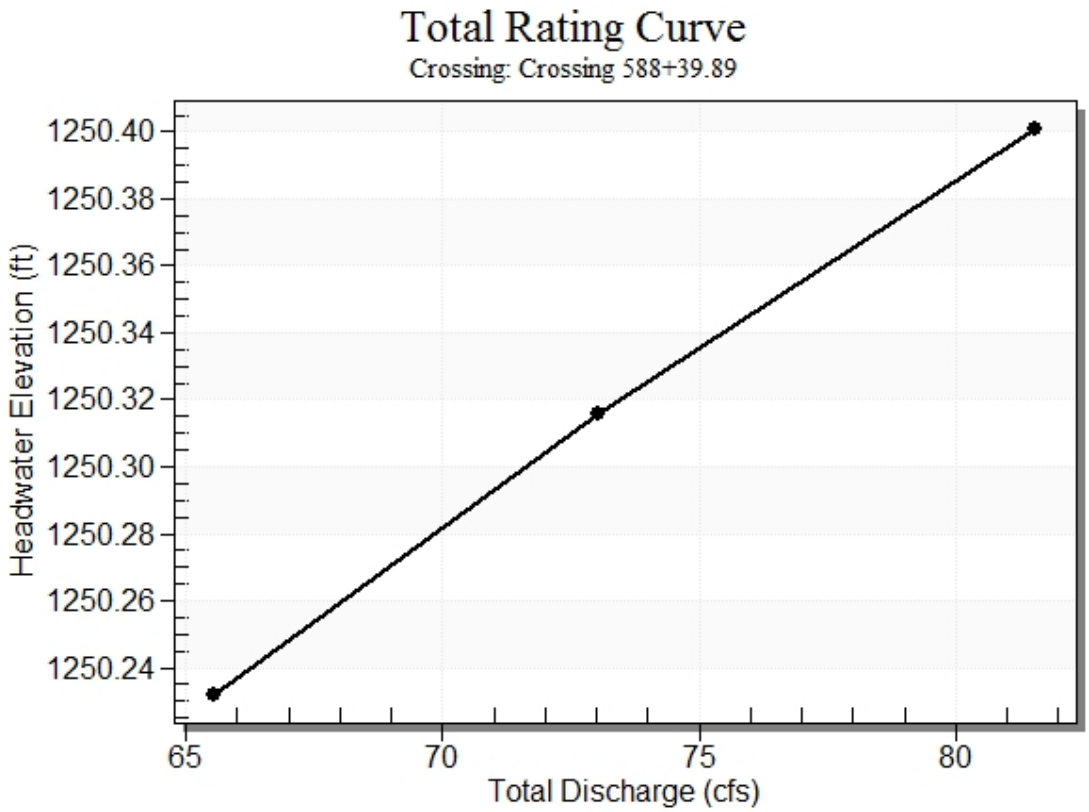
Crossing Discharge Data

Discharge Selection Method: Recurrence

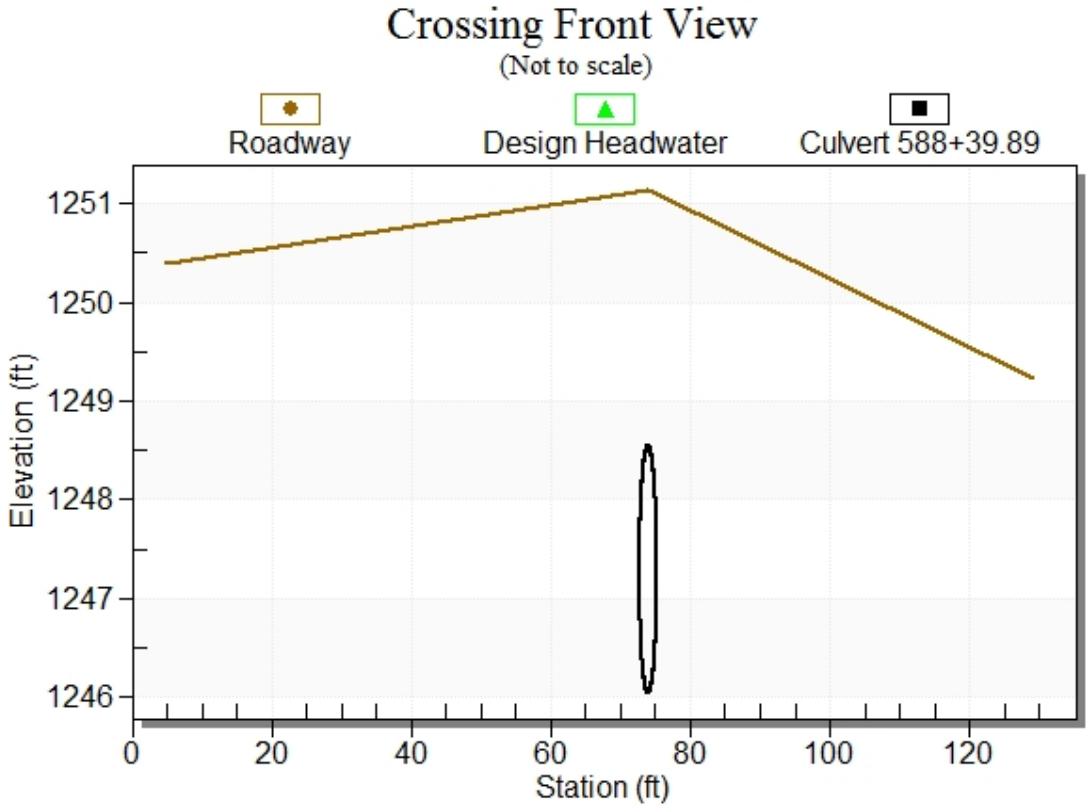
Table 43 - Summary of Culvert Flows at Crossing: Crossing 588+39.89

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 588+39.89 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1250.23	25 year	65.56	34.56	30.96	10
1250.32	50 year	73.03	35.12	37.87	5
1250.40	100 year	81.54	35.67	45.76	4
1249.23	Overtopping	26.97	26.97	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 588+39.89



Crossing Front View (Roadway Profile): Crossing 588+39.89



Culvert Notes: Culvert 588+39.89

Table 44 - Culvert Summary Table: Culvert 588+39.89

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	65.56	34.56	1250.23	4.192	1.367	5-S2n	1.806	1.995	1.806	1.597	9.128	4.137
50 year	73.03	35.12	1250.32	4.276	1.651	5-S2n	1.829	2.010	1.829	1.682	9.148	4.257
100 year	81.54	35.67	1250.40	4.361	1.938	5-S2n	1.852	2.025	1.852	1.774	9.169	4.384

****

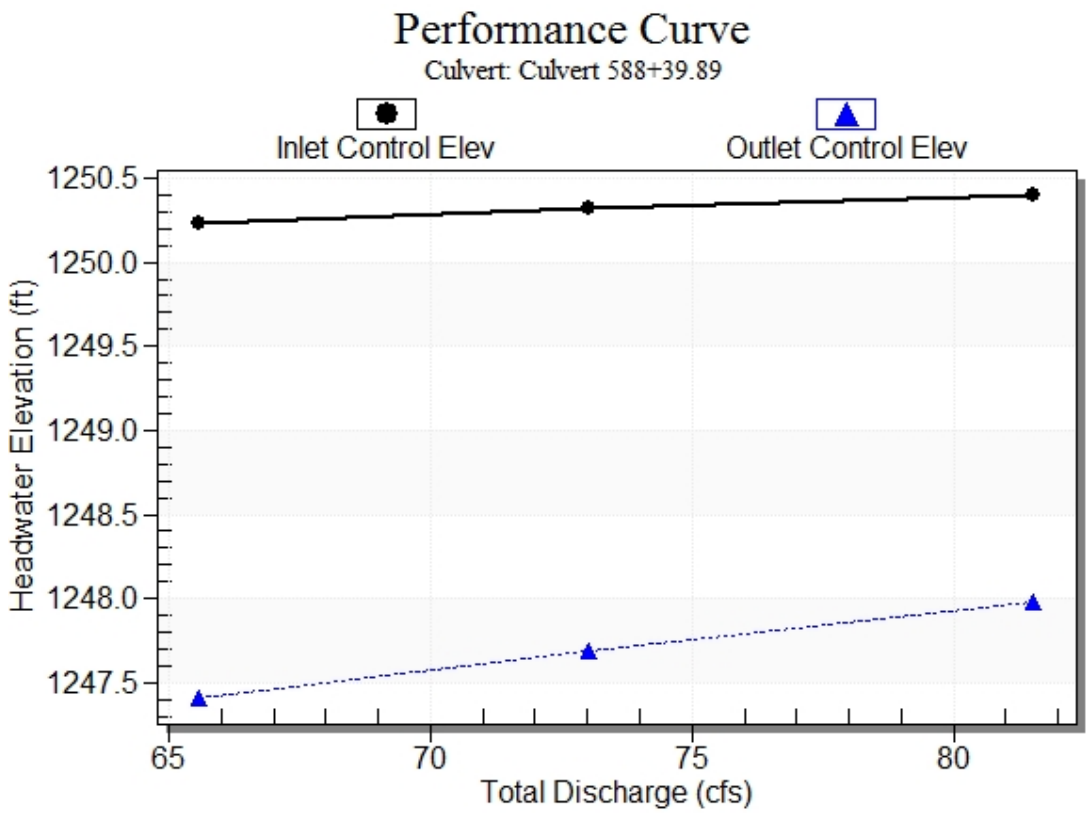
Straight Culvert

Inlet Elevation (invert): 1246.04 ft, Outlet Elevation (invert): 1236.62 ft

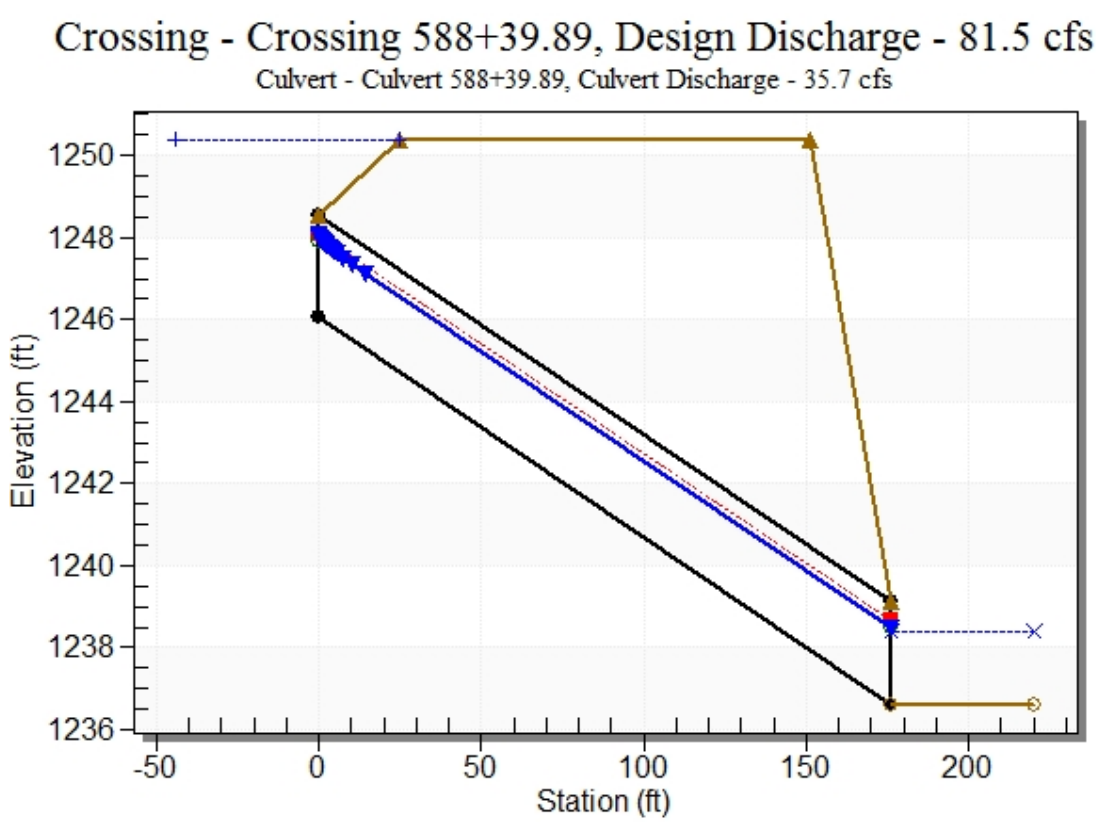
Culvert Length: 176.25 ft, Culvert Slope: 0.0535

****

Culvert Performance Curve Plot: Culvert 588+39.89



Water Surface Profile Plot for Culvert: Culvert 588+39.89



Site Data - Culvert 588+39.89

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1246.04 ft

Outlet Station: 176.00 ft

Outlet Elevation: 1236.62 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 588+39.89

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Aluminum

Embedment: 0.00 in

Barrel Manning's n: 0.0310

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Table 45 - Downstream Channel Rating Curve (Crossing: Crossing 588+39.89)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
65.56	1238.22	1.60	4.14	0.30	0.71
73.03	1238.30	1.68	4.26	0.31	0.71
81.54	1238.39	1.77	4.38	0.33	0.72

Tailwater Channel Data - Crossing 588+39.89

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 4.88 ft

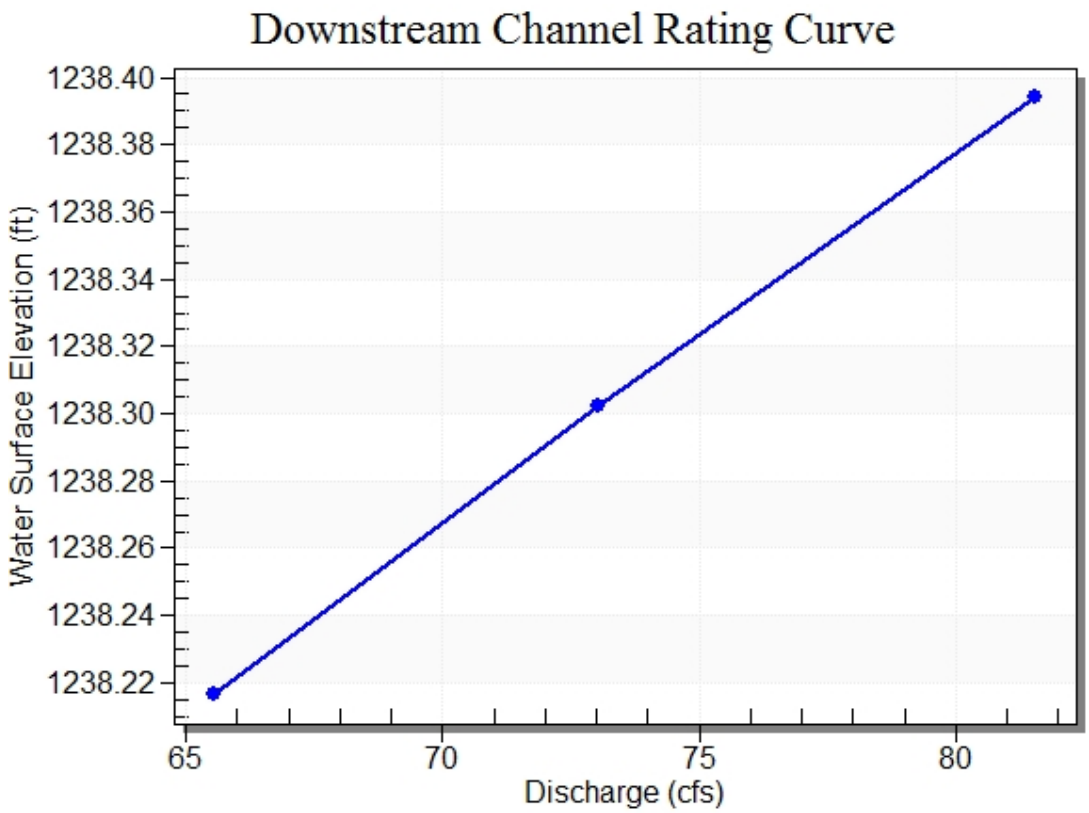
Side Slope (H:V): 3.16 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0200

Channel Invert Elevation: 1236.62 ft

Tailwater Rating Curve Plot for Crossing: Crossing 588+39.89



Roadway Data for Crossing: Crossing 588+39.89

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	5.00	1250.40
1	74.00	1251.14
2	129.00	1249.23

Roadway Surface: Paved

Roadway Top Width: 126.00 ft

Crossing Notes: Crossing 618+05.30

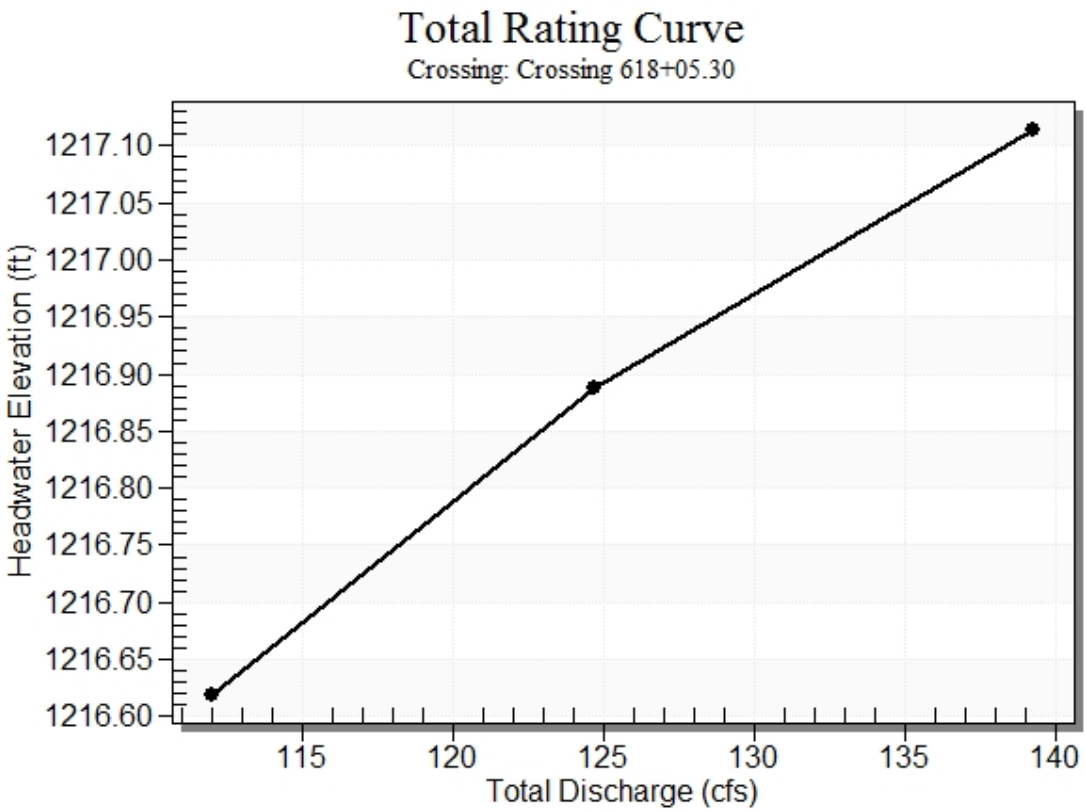
Crossing Discharge Data

Discharge Selection Method: Recurrence

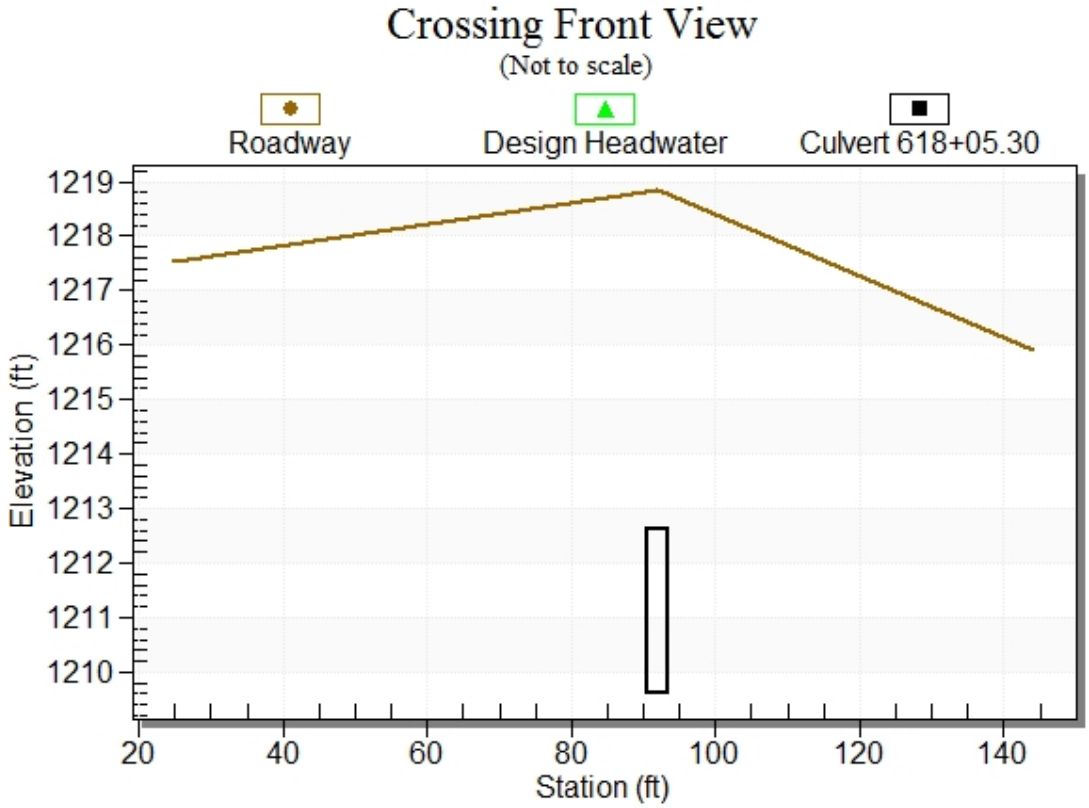
Table 46 - Summary of Culvert Flows at Crossing: Crossing 618+05.30

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 618+05.30 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1216.62	25 year	112.03	104.01	7.97	11
1216.89	50 year	124.68	106.73	17.88	6
1217.11	100 year	139.26	108.97	30.21	6
1215.91	Overtopping	96.45	96.45	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 618+05.30



Crossing Front View (Roadway Profile): Crossing 618+05.30



Culvert Notes: Culvert 618+05.30

Table 47 - Culvert Summary Table: Culvert 618+05.30

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	112.03	104.01	1216.62	7.009	0.0*	5-S2n	1.494	3.000	1.625	3.000	21.332	0.000
50 year	124.68	106.73	1216.89	7.277	0.0*	5-S2n	1.524	3.000	1.657	3.000	21.464	0.000
100 year	139.26	108.97	1217.11	7.505	0.0*	5-S2n	1.548	3.000	1.686	3.000	21.540	0.000

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

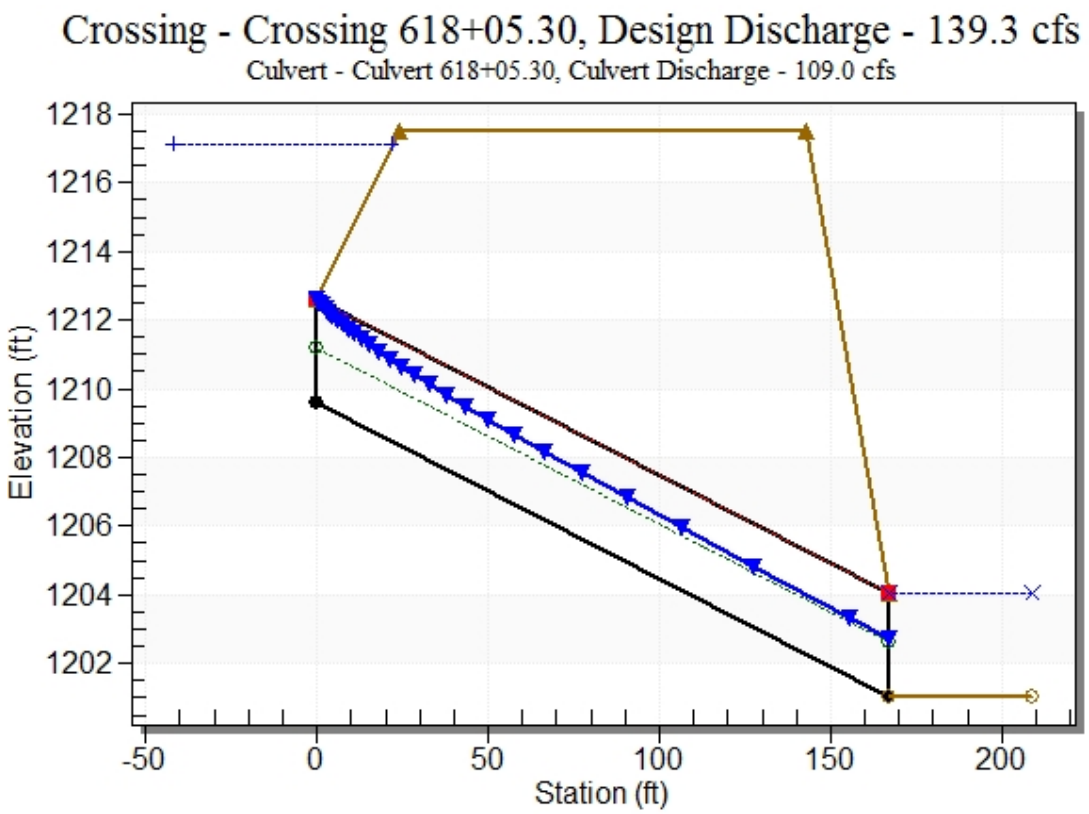
Inlet Elevation (invert): 1209.61 ft, Outlet Elevation (invert): 1201.05 ft

Culvert Length: 167.22 ft, Culvert Slope: 0.0513

****

Culvert Performance Curve Plot: Culvert 618+05.30

Water Surface Profile Plot for Culvert: Culvert 618+05.30



Site Data - Culvert 618+05.30

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1209.61 ft

Outlet Station: 167.00 ft

Outlet Elevation: 1201.05 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 618+05.30

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 48 - Downstream Channel Rating Curve (Crossing: Crossing 618+05.30)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
112.03	1204.05	3.00
124.68	1204.05	3.00
139.26	1204.05	3.00

Tailwater Channel Data - Crossing 618+05.30

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1204.05 ft

Roadway Data for Crossing: Crossing 618+05.30

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	25.00	1217.53
1	92.00	1218.85
2	144.00	1215.91

Roadway Surface: Paved

Roadway Top Width: 119.00 ft

Crossing Notes: Crossing 637+96.94

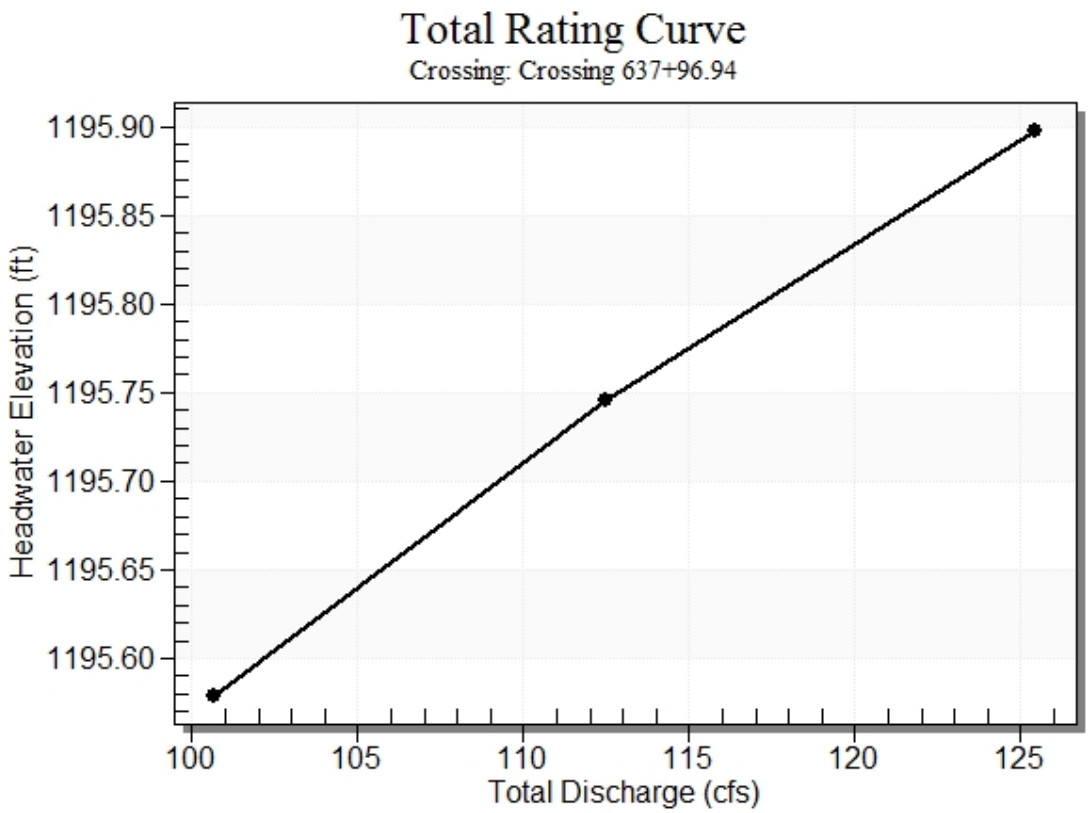
Crossing Discharge Data

Discharge Selection Method: Recurrence

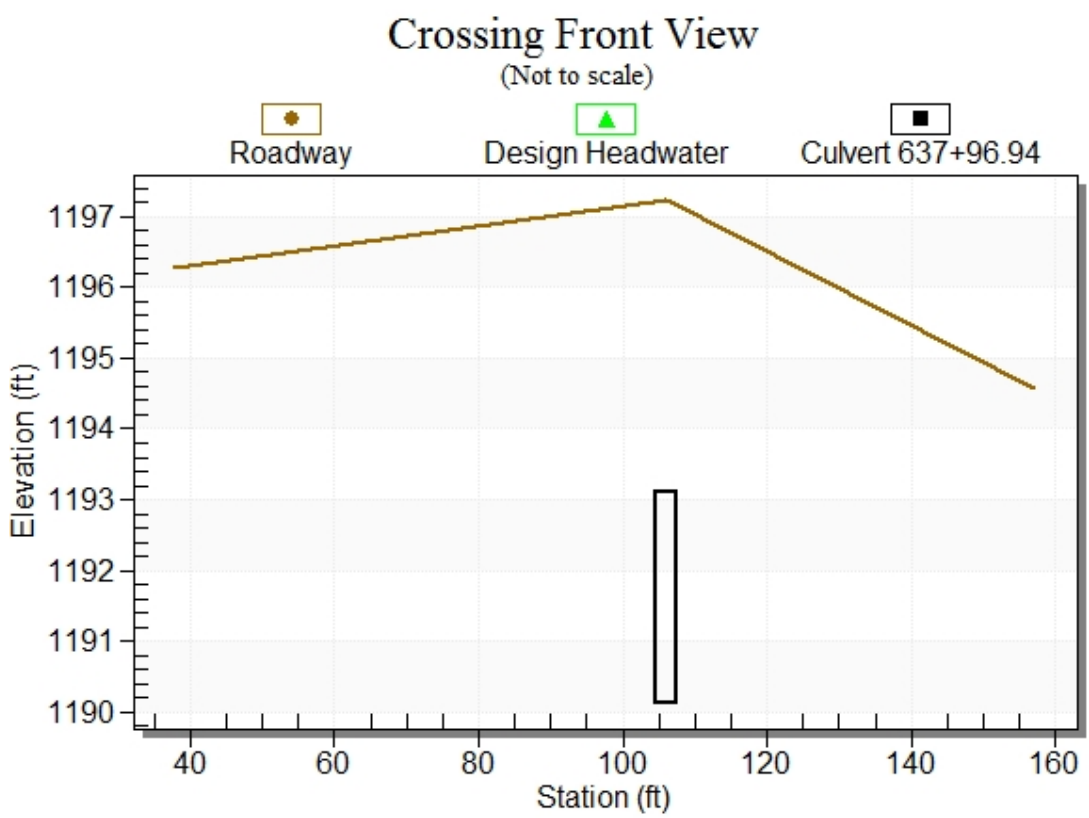
Table 49 - Summary of Culvert Flows at Crossing: Crossing 637+96.94

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 637+96.94 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1195.58	25 year	100.68	79.72	20.92	11
1195.75	50 year	112.50	81.79	30.64	6
1195.90	100 year	125.42	83.65	41.65	5
1194.57	Overtopping	65.80	65.80	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 637+96.94



Crossing Front View (Roadway Profile): Crossing 637+96.94



Culvert Notes: Culvert 637+96.94

Table 50 - Culvert Summary Table: Culvert 637+96.94

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	100.68	79.72	1195.58	5.458	0.423	5-S2n	1.570	2.799	1.624	1.777	16.363	3.334
50 year	112.50	81.79	1195.75	5.624	0.632	5-S2n	1.601	2.847	1.652	1.889	16.500	3.448
100 year	125.42	83.65	1195.90	5.778	0.824	5-S2n	1.629	2.890	1.685	2.004	16.552	3.562

****

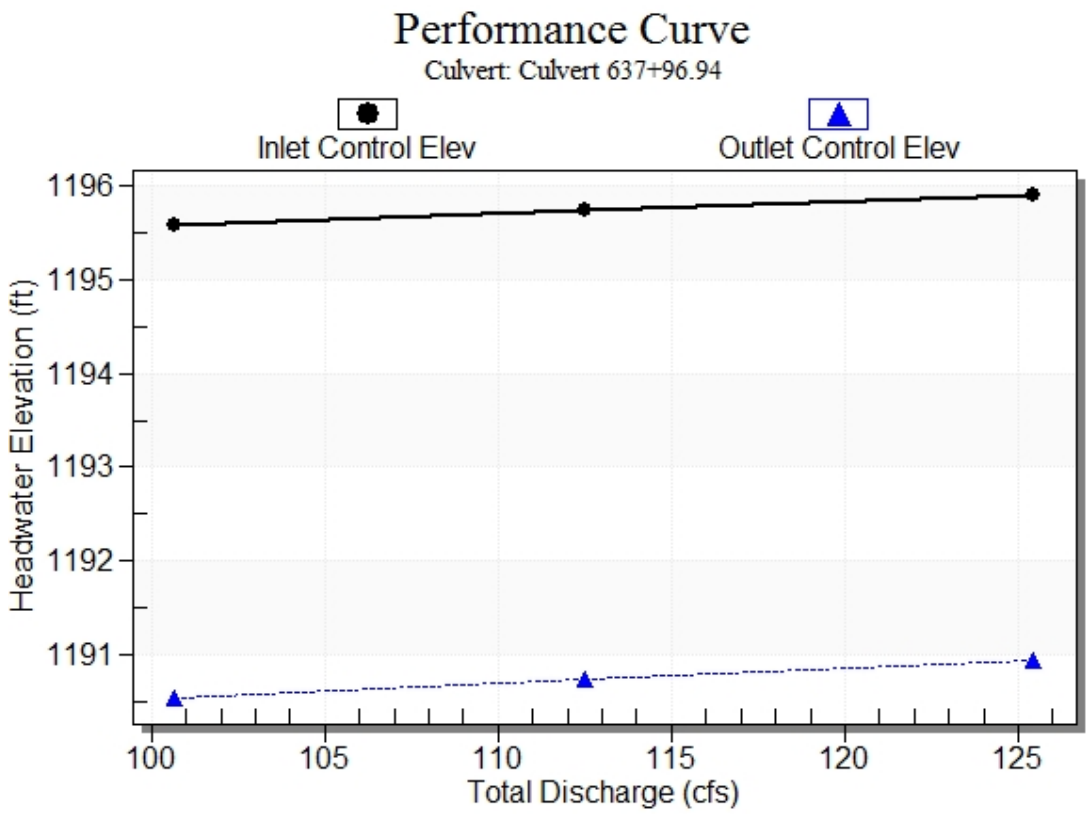
Straight Culvert

Inlet Elevation (invert): 1190.12 ft, Outlet Elevation (invert): 1184.12 ft

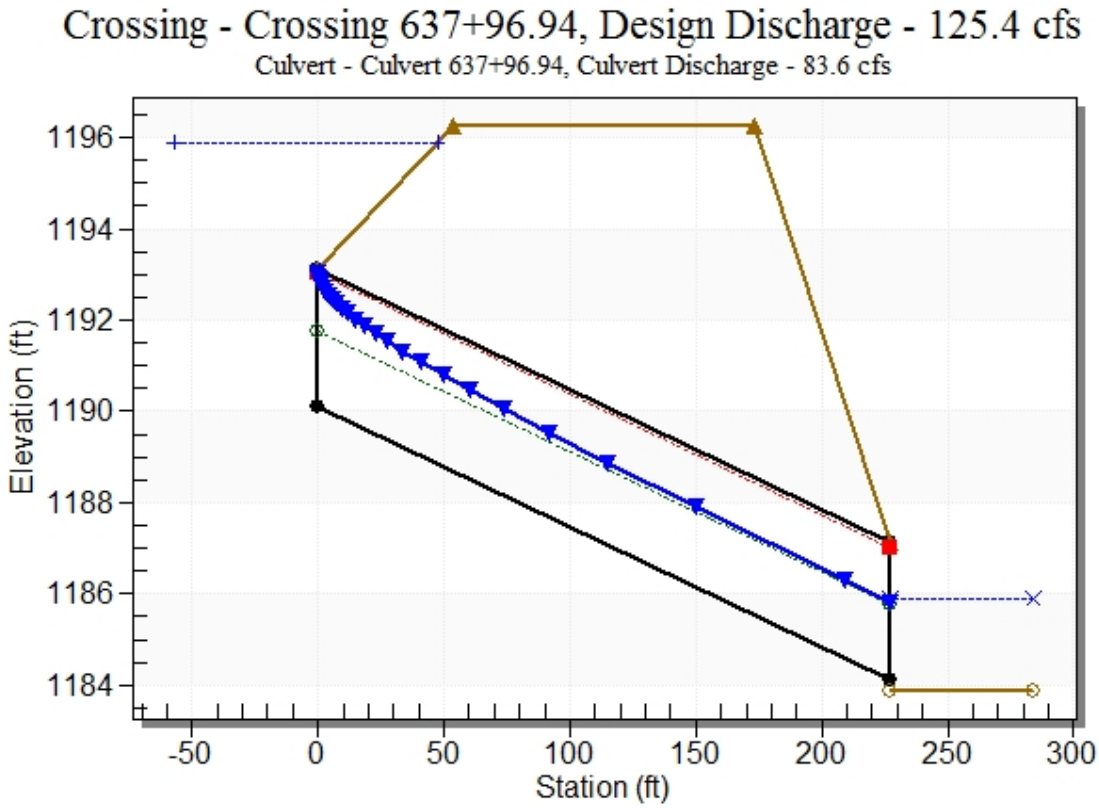
Culvert Length: 227.08 ft, Culvert Slope: 0.0264

****

Culvert Performance Curve Plot: Culvert 637+96.94



Water Surface Profile Plot for Culvert: Culvert 637+96.94



Site Data - Culvert 637+96.94

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1190.12 ft

Outlet Station: 227.00 ft

Outlet Elevation: 1184.12 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 637+96.94

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 51 - Downstream Channel Rating Curve (Crossing: Crossing 637+96.94)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
100.68	1185.67	1.78	3.33	0.33	0.50
112.50	1185.78	1.89	3.45	0.35	0.50
125.42	1185.89	2.00	3.56	0.38	0.50

Tailwater Channel Data - Crossing 637+96.94

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 12.50 ft

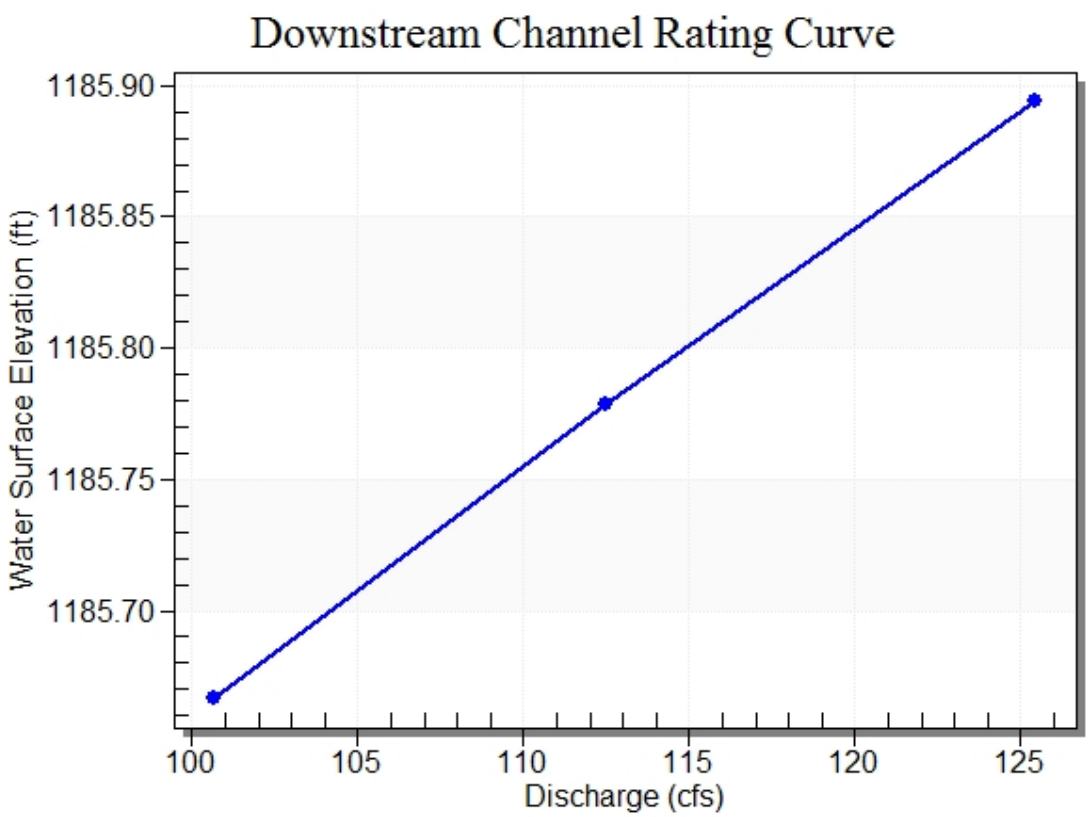
Side Slope (H:V): 2.53 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0300

Channel Invert Elevation: 1183.89 ft

Tailwater Rating Curve Plot for Crossing: Crossing 637+96.94



Roadway Data for Crossing: Crossing 637+96.94

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	38.00	1196.27
1	106.00	1197.24
2	157.00	1194.57

Roadway Surface: Paved

Roadway Top Width: 119.00 ft

Crossing Notes: Crossing 674+01.58

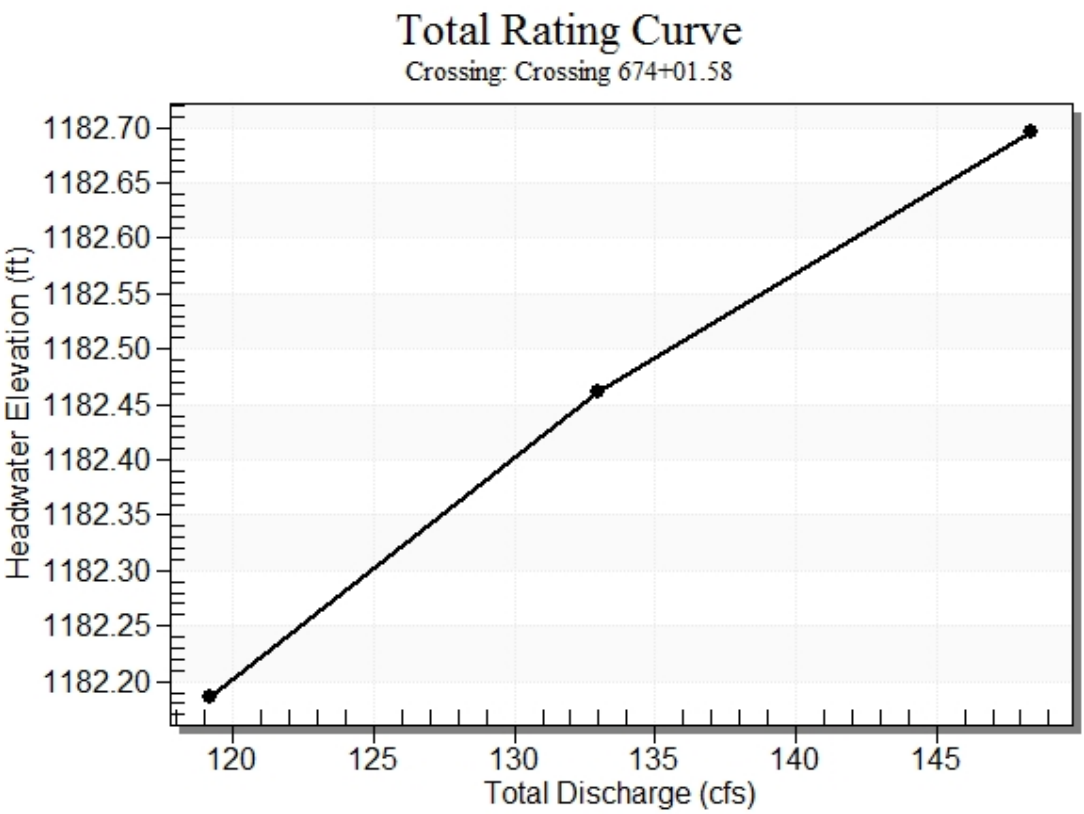
Crossing Discharge Data

Discharge Selection Method: Recurrence

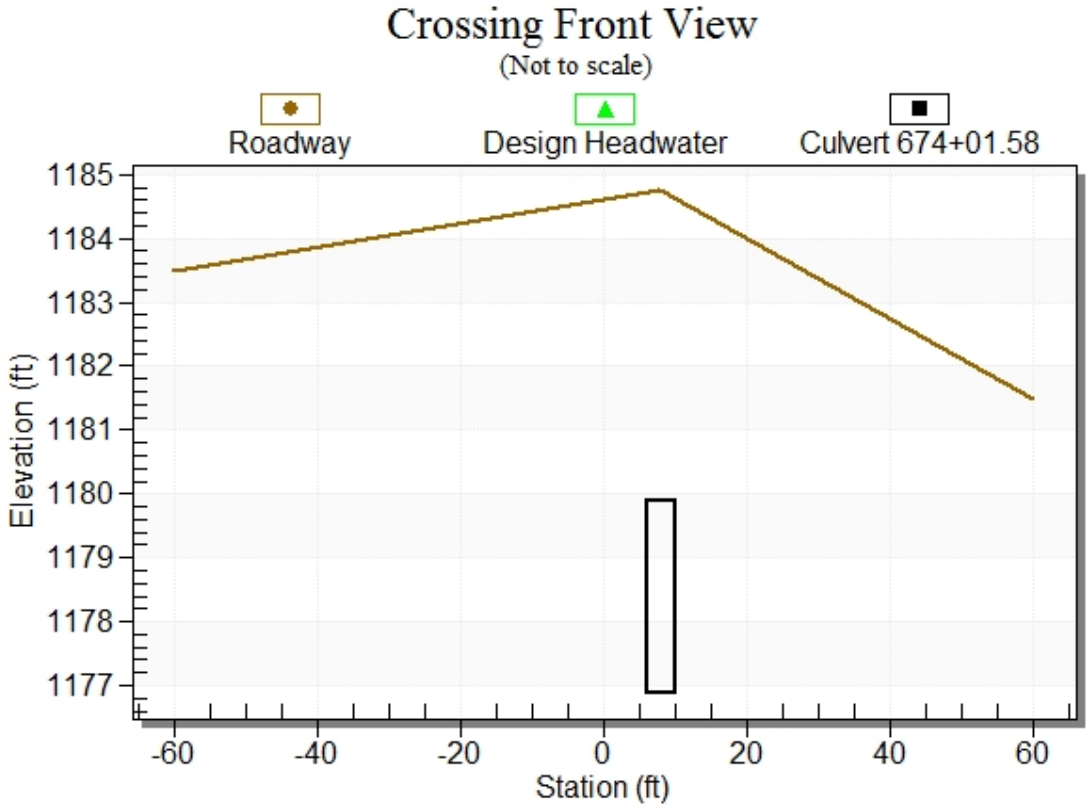
Table 55 - Summary of Culvert Flows at Crossing: Crossing 674+01.58

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 674+01.58 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1182.19	25 year	119.20	112.07	7.07	11
1182.46	50 year	132.94	116.71	16.19	6
1182.70	100 year	148.35	120.54	27.78	6
1181.48	Overtopping	99.03	99.03	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 674+01.58



Crossing Front View (Roadway Profile): Crossing 674+01.58



Culvert Notes: Culvert 674+01.58

Table 56 - Culvert Summary Table: Culvert 674+01.58

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	119.20	112.07	1182.19	5.306	1.448	5-S2n	1.575	2.900	1.672	3.000	16.761	0.000
50 year	132.94	116.71	1182.46	5.581	1.725	5-S2n	1.623	2.979	1.724	3.000	16.928	0.000
100 year	148.35	120.54	1182.70	5.817	1.962	5-S2n	1.663	3.000	1.769	3.000	17.038	0.000

****

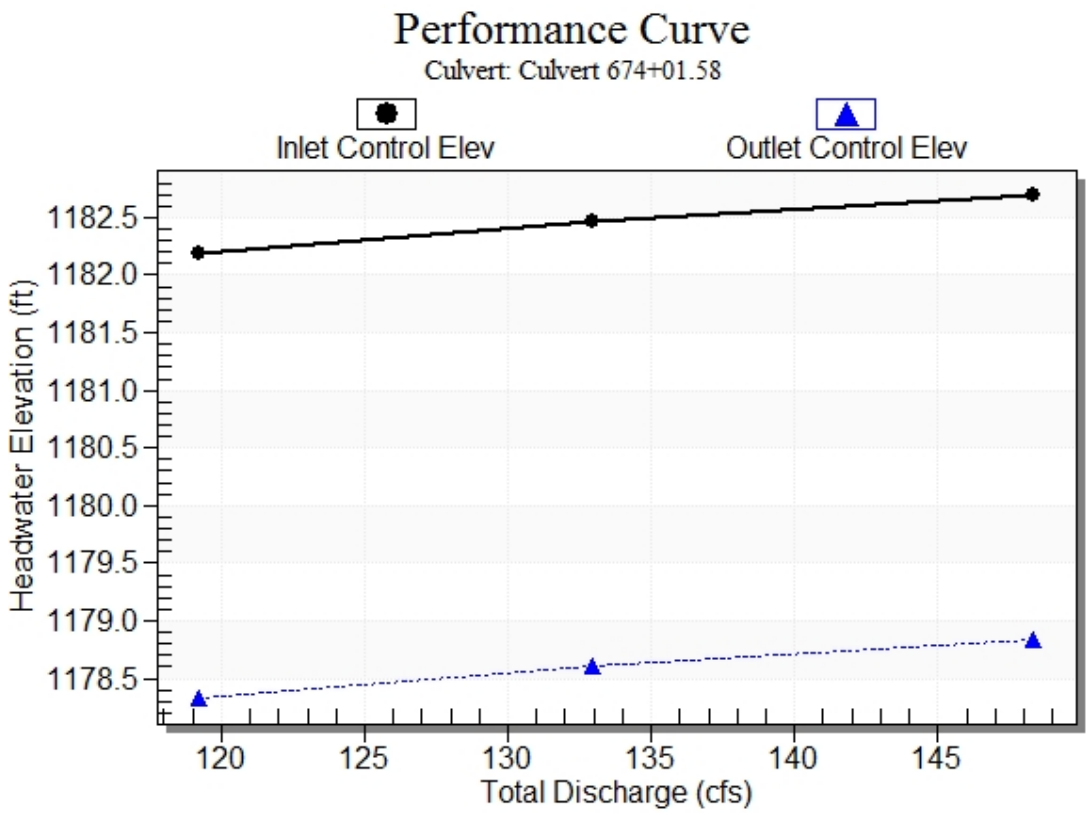
Straight Culvert

Inlet Elevation (invert): 1176.88 ft, Outlet Elevation (invert): 1172.05 ft

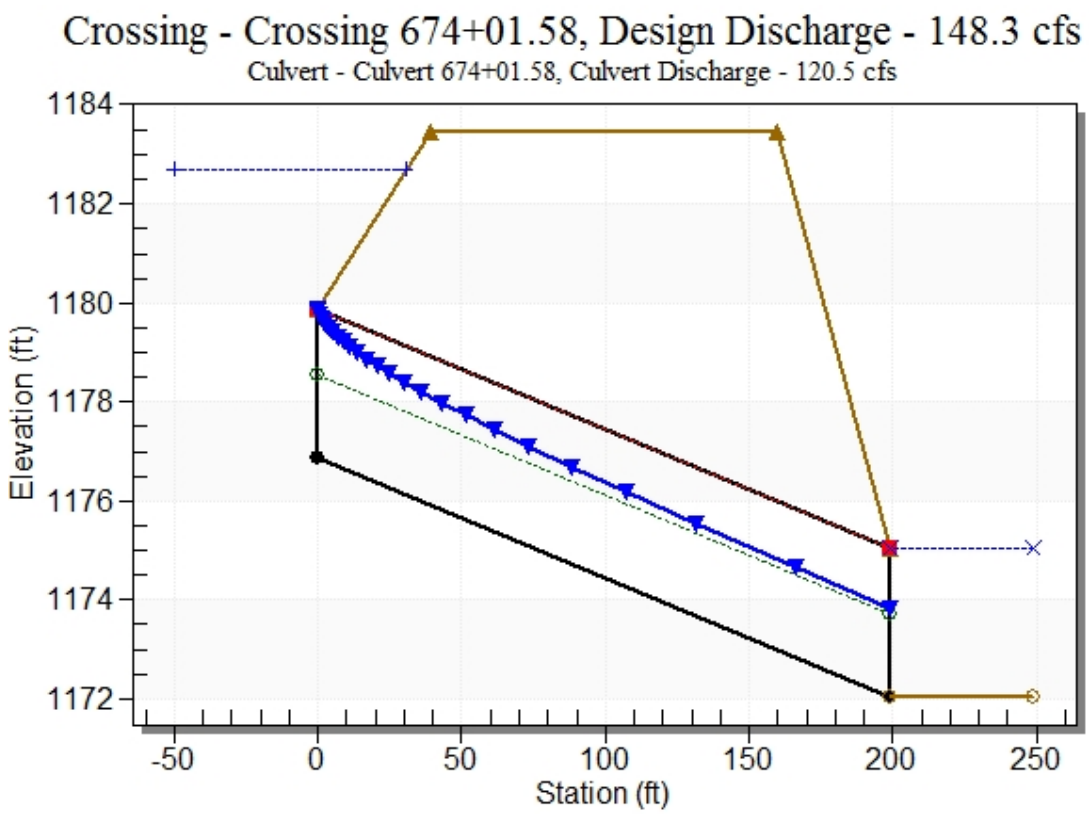
Culvert Length: 199.06 ft, Culvert Slope: 0.0243

****

Culvert Performance Curve Plot: Culvert 674+01.58



Water Surface Profile Plot for Culvert: Culvert 674+01.58



Site Data - Culvert 674+01.58

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1176.88 ft

Outlet Station: 199.00 ft

Outlet Elevation: 1172.05 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 674+01.58

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 57 - Downstream Channel Rating Curve (Crossing: Crossing 674+01.58)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
119.20	1175.05	3.00
132.94	1175.05	3.00
148.35	1175.05	3.00

Tailwater Channel Data - Crossing 674+01.58

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1175.05 ft

Roadway Data for Crossing: Crossing 674+01.58

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-60.00	1183.48
1	8.00	1184.76
2	60.00	1181.48

Roadway Surface: Paved

Roadway Top Width: 120.00 ft

Crossing Notes: Crossing 689+66.87

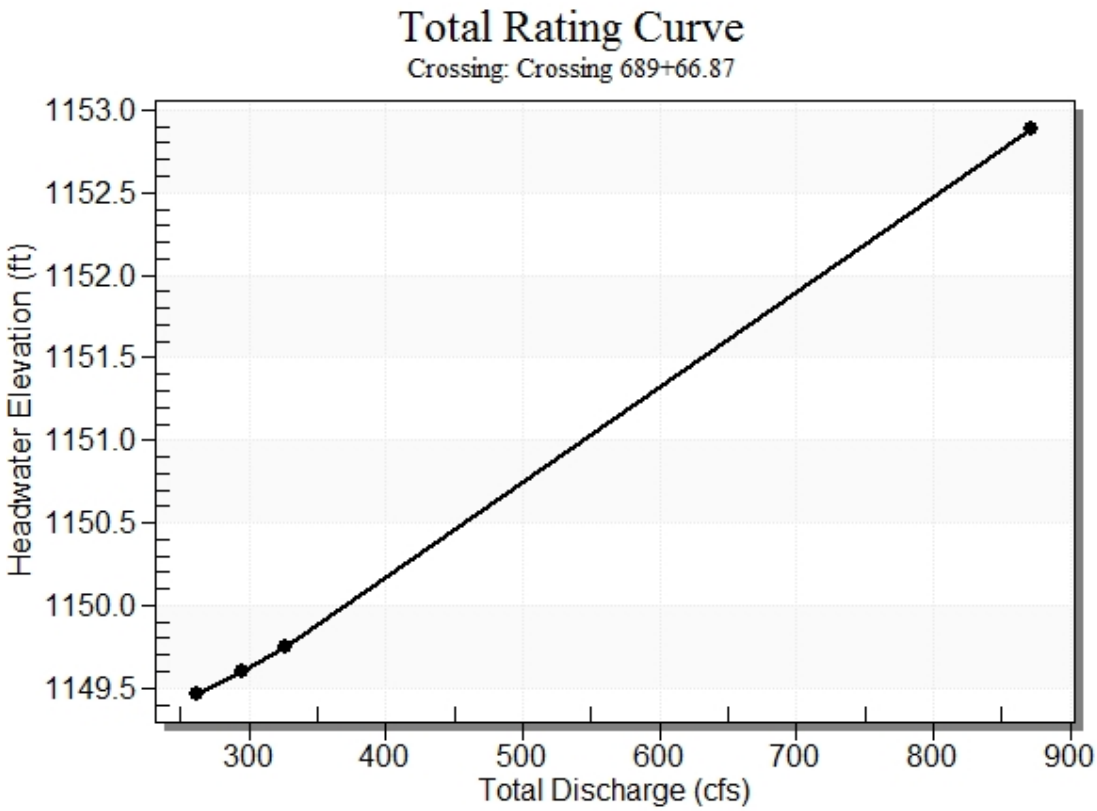
Crossing Discharge Data

Discharge Selection Method: Recurrence

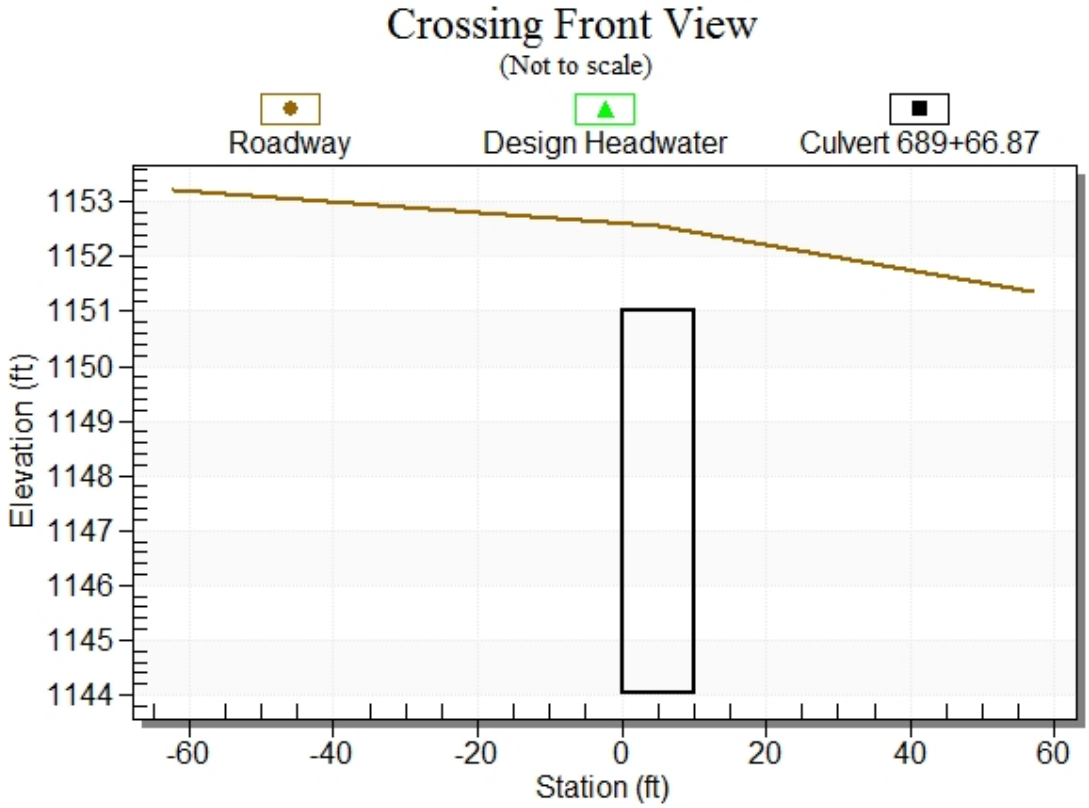
Table 58 - Summary of Culvert Flows at Crossing: Crossing 689+66.87

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 689+66.87 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1149.47	25 year	261.28	261.28	0.00	1
1149.60	50 year	294.43	294.43	0.00	1
1149.75	100 year	326.98	326.98	0.00	1
1151.37	Overtopping	578.07	578.07	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 689+66.87



Crossing Front View (Roadway Profile): Crossing 689+66.87



Culvert Notes: Culvert 689+66.87

Table 59 - Culvert Summary Table: Culvert 689+66.87

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	261.28	261.28	1149.47	4.231	5.439	1-S1f	1.629	2.768	7.000	7.000	3.733	0.000
50 year	294.43	294.43	1149.60	4.588	5.570	1-S1f	1.759	2.997	7.000	7.000	4.206	0.000
100 year	326.98	326.98	1149.75	4.925	5.721	1-S1f	1.885	3.214	7.000	7.000	4.671	0.000

****

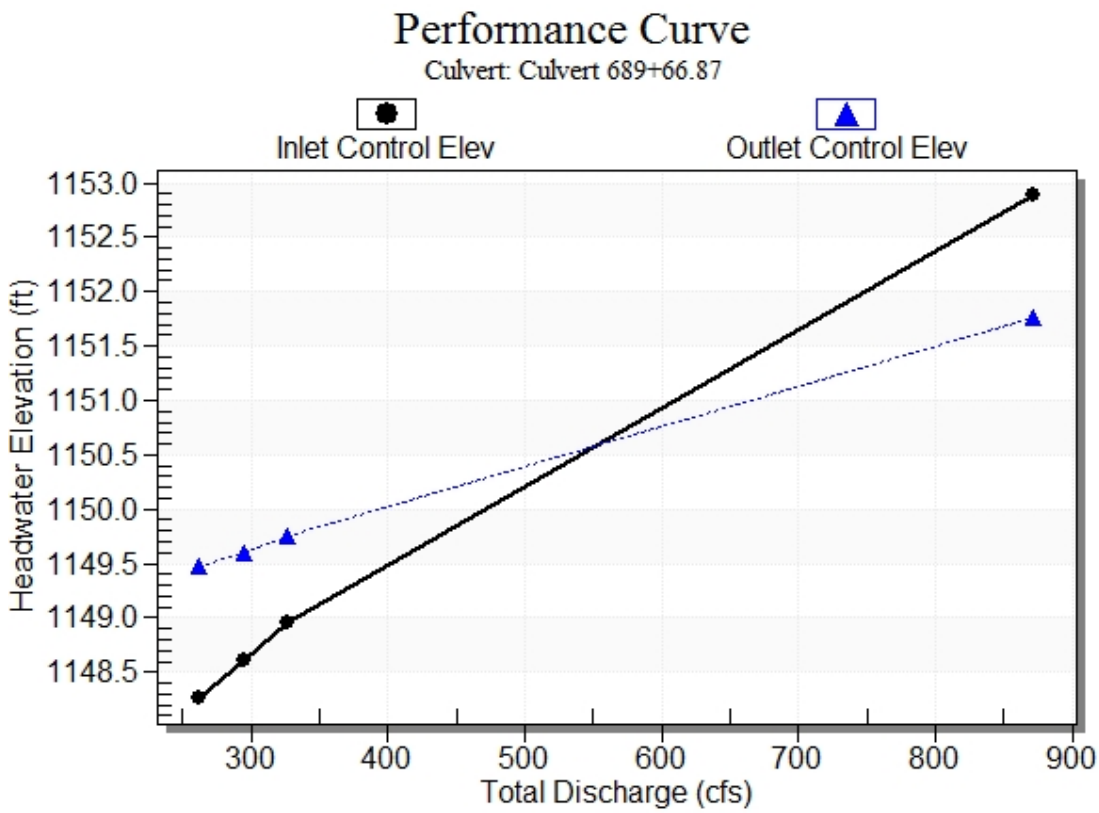
Straight Culvert

Inlet Elevation (invert): 1144.03 ft, Outlet Elevation (invert): 1142.01 ft

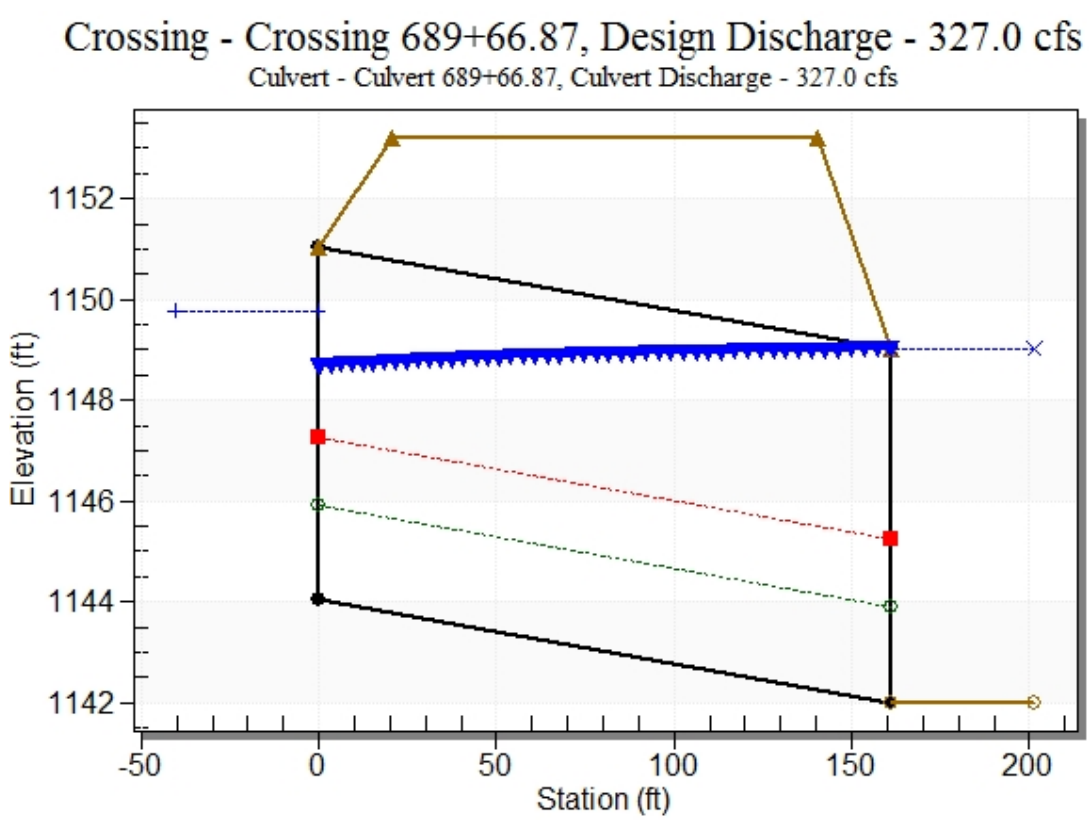
Culvert Length: 161.01 ft, Culvert Slope: 0.0125

****

Culvert Performance Curve Plot: Culvert 689+66.87



Water Surface Profile Plot for Culvert: Culvert 689+66.87



Site Data - Culvert 689+66.87

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1144.03 ft

Outlet Station: 161.00 ft

Outlet Elevation: 1142.01 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 689+66.87

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 60 - Downstream Channel Rating Curve (Crossing: Crossing 689+66.87)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
261.28	1149.01	7.00
294.43	1149.01	7.00
326.98	1149.01	7.00

Tailwater Channel Data - Crossing 689+66.87

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1149.01 ft

Roadway Data for Crossing: Crossing 689+66.87

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-62.00	1153.22
1	5.00	1152.56
2	57.00	1151.37

Roadway Surface: Paved

Roadway Top Width: 120.00 ft

Crossing Notes: Crossing 704+19.78

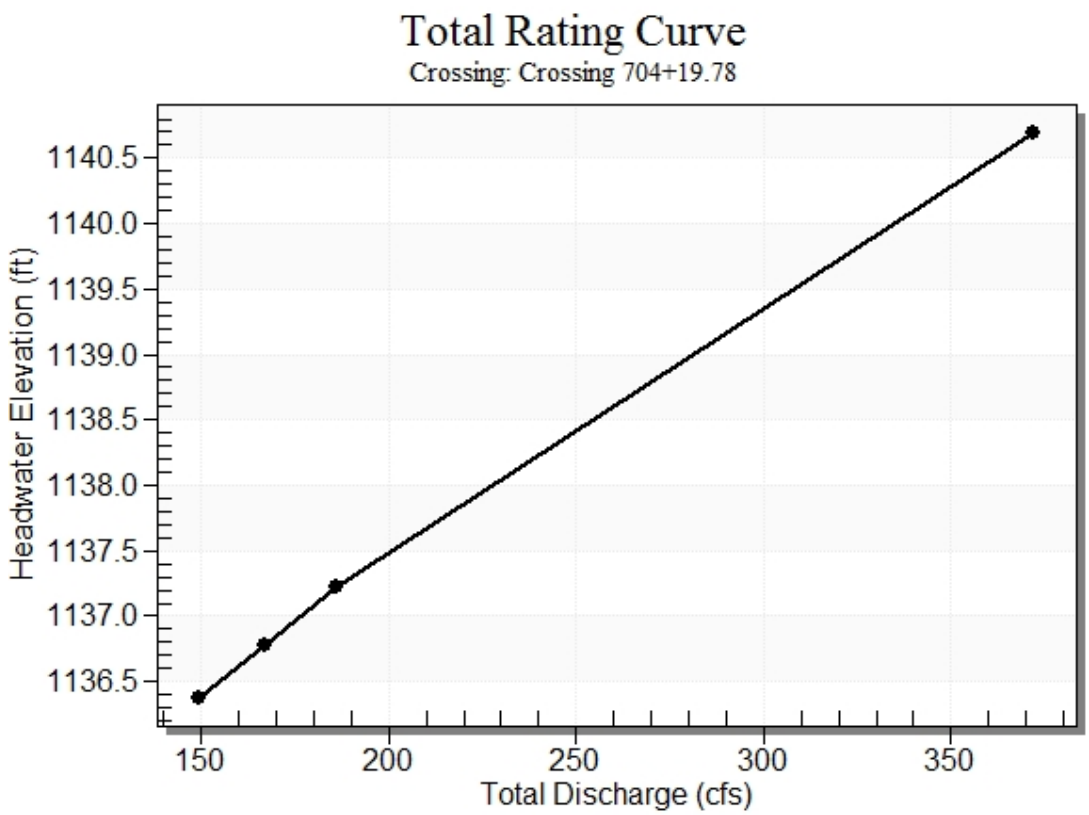
Crossing Discharge Data

Discharge Selection Method: Recurrence

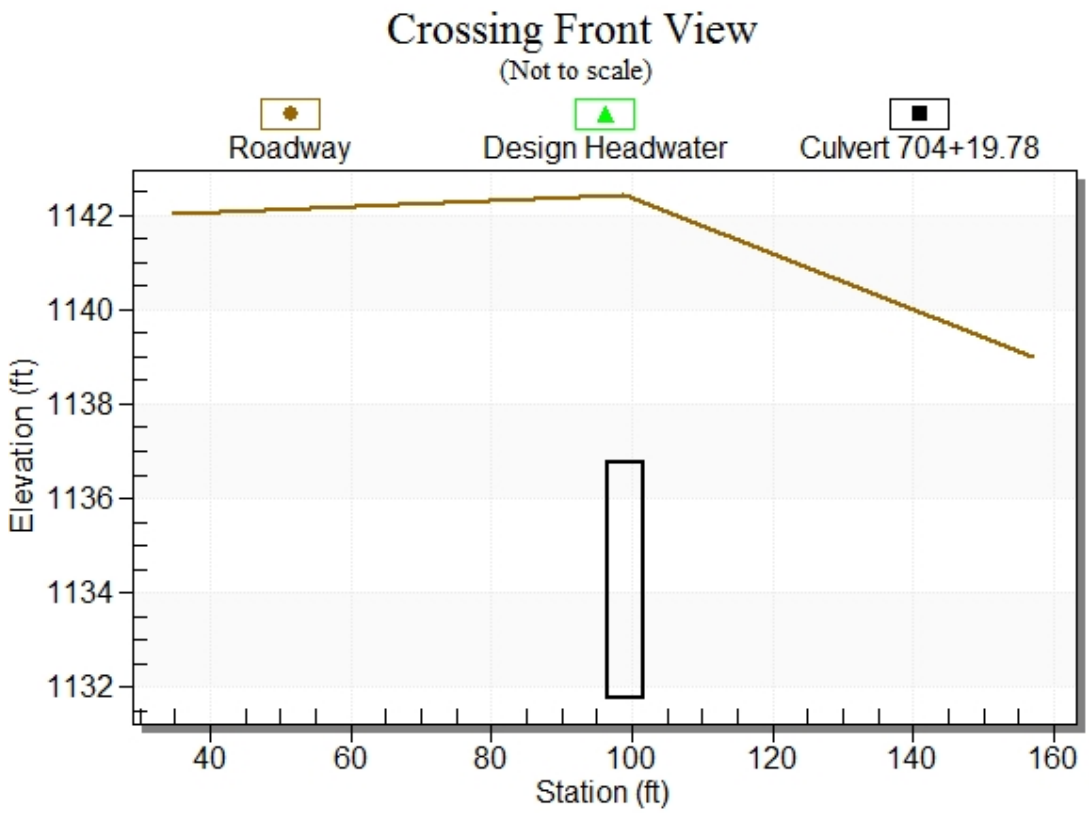
Table 61 - Summary of Culvert Flows at Crossing: Crossing 704+19.78

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 704+19.78 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1136.38	25 year	149.24	149.24	0.00	1
1136.78	50 year	166.96	166.96	0.00	1
1137.22	100 year	186.04	186.04	0.00	1
1139.01	Overtopping	253.42	253.42	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 704+19.78



Crossing Front View (Roadway Profile): Crossing 704+19.78



Culvert Notes: Culvert 704+19.78

Table 62 - Culvert Summary Table: Culvert 704+19.78

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	149.24	149.24	1136.38	4.620	0.0*	1-S2n	1.413	3.025	1.527	5.000	19.546	0.000
50 year	166.96	166.96	1136.78	5.020	0.0*	5-S2n	1.533	3.259	1.668	5.000	20.024	0.000
100 year	186.04	186.04	1137.22	5.463	0.0*	5-S2n	1.661	3.503	1.816	5.000	20.488	0.000

* Full Flow Headwater elevation is below inlet invert.

****

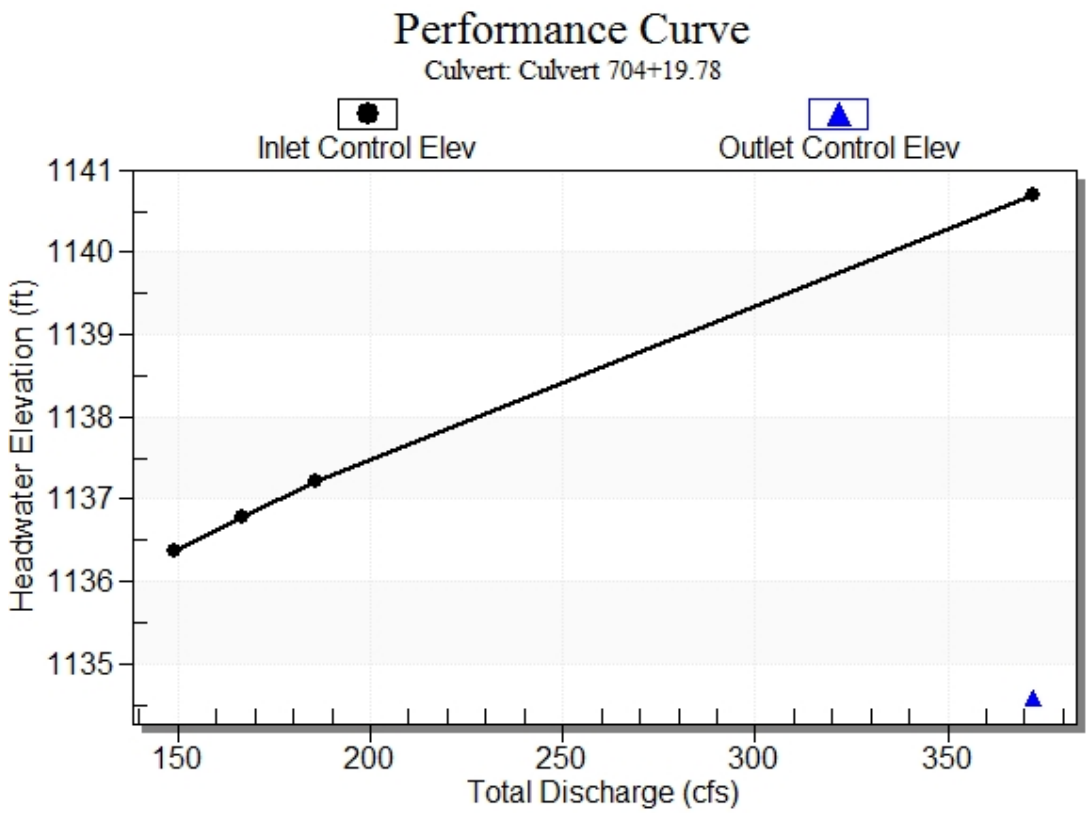
Straight Culvert

Inlet Elevation (invert): 1131.76 ft, Outlet Elevation (invert): 1124.84 ft

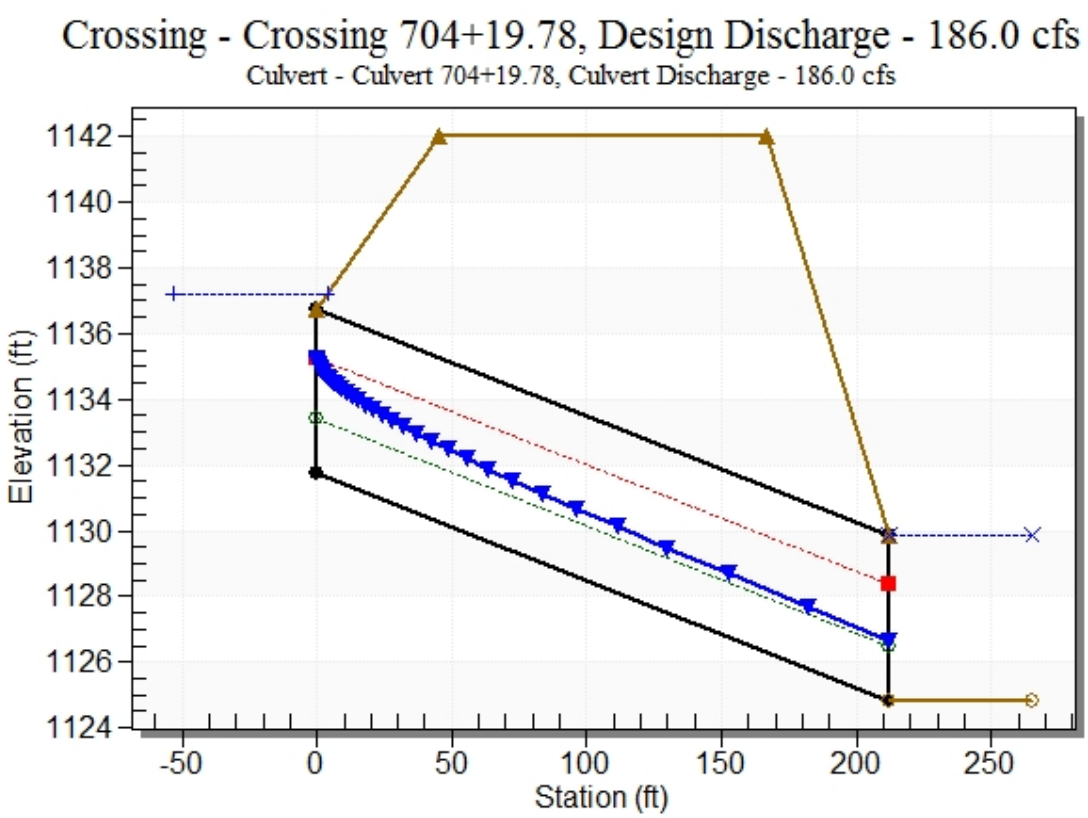
Culvert Length: 212.11 ft, Culvert Slope: 0.0326

****

Culvert Performance Curve Plot: Culvert 704+19.78



Water Surface Profile Plot for Culvert: Culvert 704+19.78



Site Data - Culvert 704+19.78

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1131.76 ft

Outlet Station: 212.00 ft

Outlet Elevation: 1124.84 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 704+19.78

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 63 - Downstream Channel Rating Curve (Crossing: Crossing 704+19.78)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
149.24	1129.84	5.00
166.96	1129.84	5.00
186.04	1129.84	5.00

Tailwater Channel Data - Crossing 704+19.78

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1129.84 ft

Roadway Data for Crossing: Crossing 704+19.78

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	35.00	1142.04
1	99.00	1142.44
2	157.00	1139.01

Roadway Surface: Paved

Roadway Top Width: 122.00 ft

Crossing Notes: Crossing 730+47.18

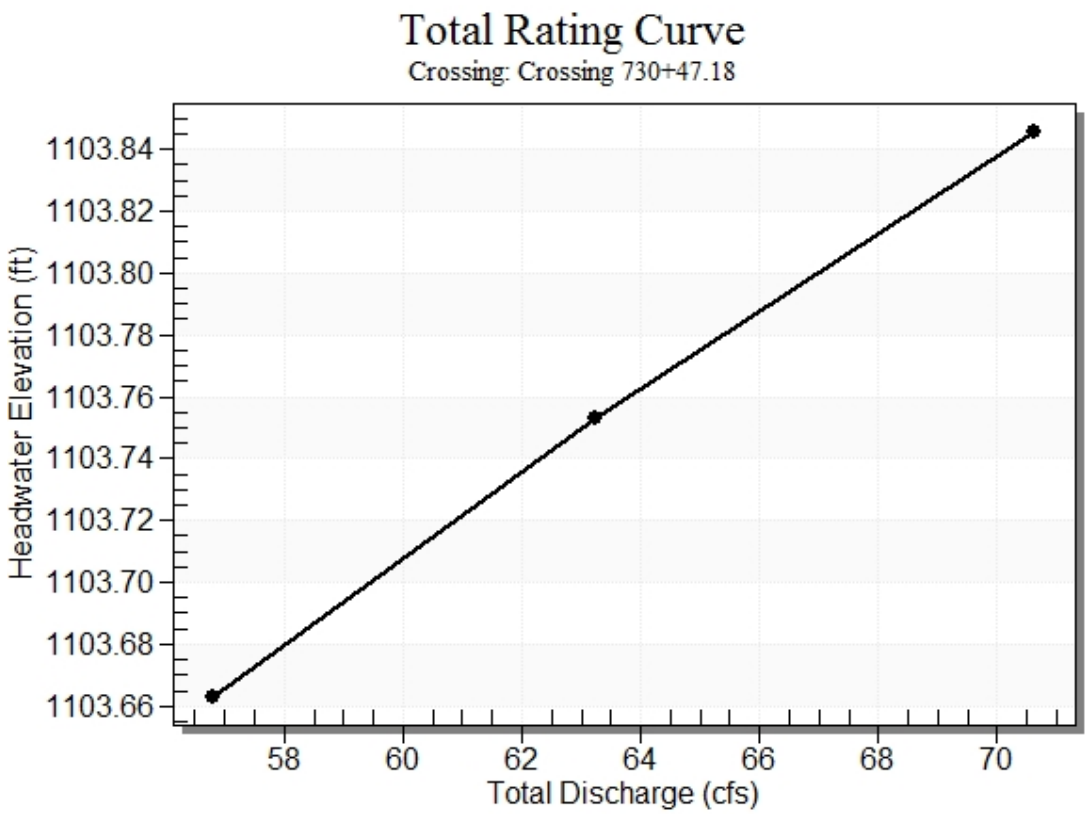
Crossing Discharge Data

Discharge Selection Method: Recurrence

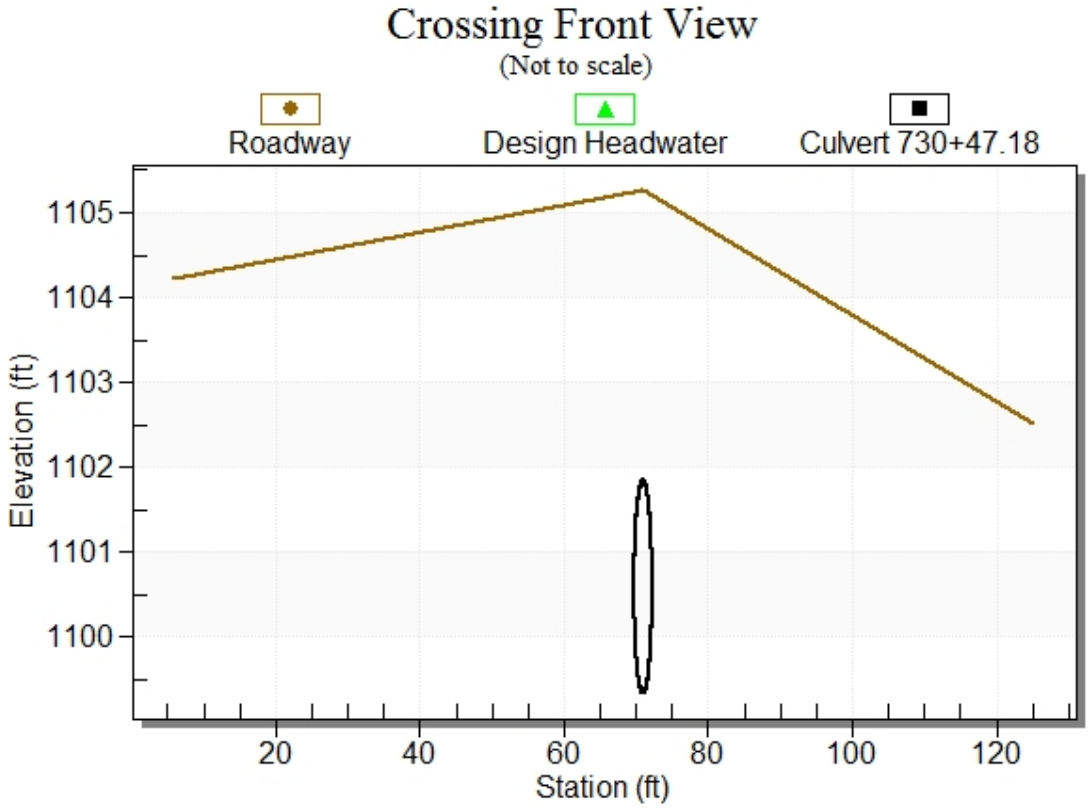
Table 64 - Summary of Culvert Flows at Crossing: Crossing 730+47.18

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 730+47.18 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1103.66	25 year	56.81	26.79	29.93	9
1103.75	50 year	63.22	27.04	36.13	4
1103.85	100 year	70.61	27.30	43.29	4
1102.51	Overtopping	23.37	23.37	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 730+47.18



Crossing Front View (Roadway Profile): Crossing 730+47.18



Culvert Notes: Culvert 730+47.18

Table 65 - Culvert Summary Table: Culvert 730+47.18

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	56.81	26.79	1103.66	3.213	4.322	4-FFf	2.500	1.763	2.500	2.500	5.459	0.000
50 year	63.22	27.04	1103.75	3.242	4.412	4-FFf	2.500	1.771	2.500	2.500	5.509	0.000
100 year	70.61	27.30	1103.85	3.271	4.505	4-FFf	2.500	1.779	2.500	2.500	5.561	0.000

****

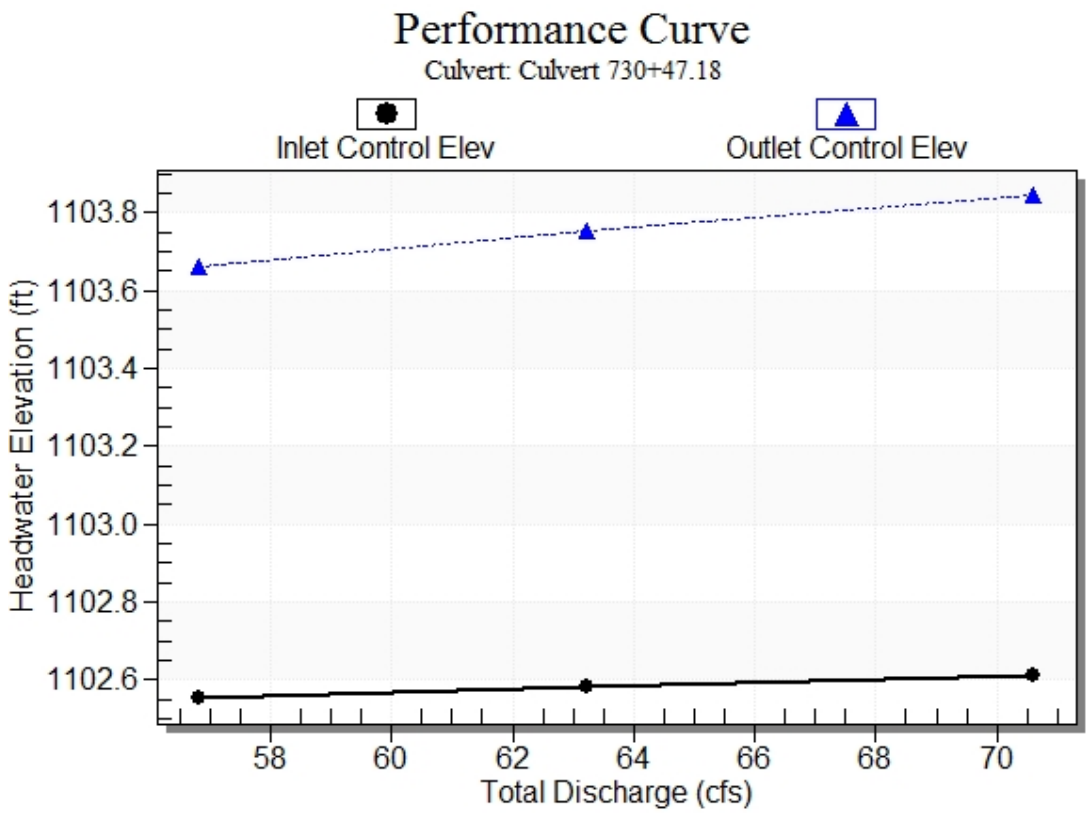
Straight Culvert

Inlet Elevation (invert): 1099.34 ft, Outlet Elevation (invert): 1096.35 ft

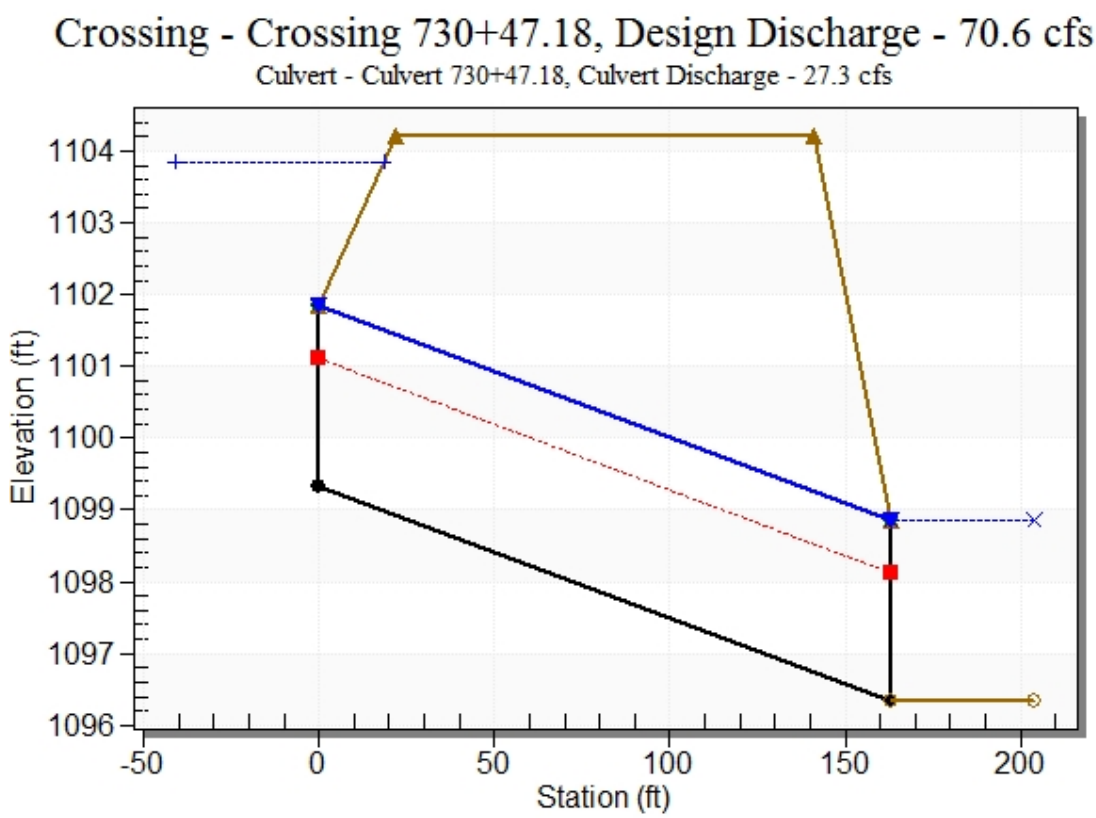
Culvert Length: 163.03 ft, Culvert Slope: 0.0183

****

Culvert Performance Curve Plot: Culvert 730+47.18



Water Surface Profile Plot for Culvert: Culvert 730+47.18



Site Data - Culvert 730+47.18

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1099.34 ft

Outlet Station: 163.00 ft

Outlet Elevation: 1096.35 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 730+47.18

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Aluminum

Embedment: 0.00 in

Barrel Manning's n: 0.0310

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Table 66 - Downstream Channel Rating Curve (Crossing: Crossing 730+47.18)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
56.81	1098.85	2.50
63.22	1098.85	2.50
70.61	1098.85	2.50

Tailwater Channel Data - Crossing 730+47.18

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1098.85 ft

Roadway Data for Crossing: Crossing 730+47.18

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	6.00	1104.22
1	71.00	1105.27
2	125.00	1102.51

Roadway Surface: Paved

Roadway Top Width: 119.00 ft

HY-8 Culvert Analysis Report

Project Notes

Project Title: US 281 Proposed Condition

Designer:

Project Date: Thursday, February 27, 2014

Notes:

Project Units: U.S. Customary Units

Outlet Control Option: Profiles

Exit Loss Option: Standard Method

Crossing Notes: Crossing 371+54.91

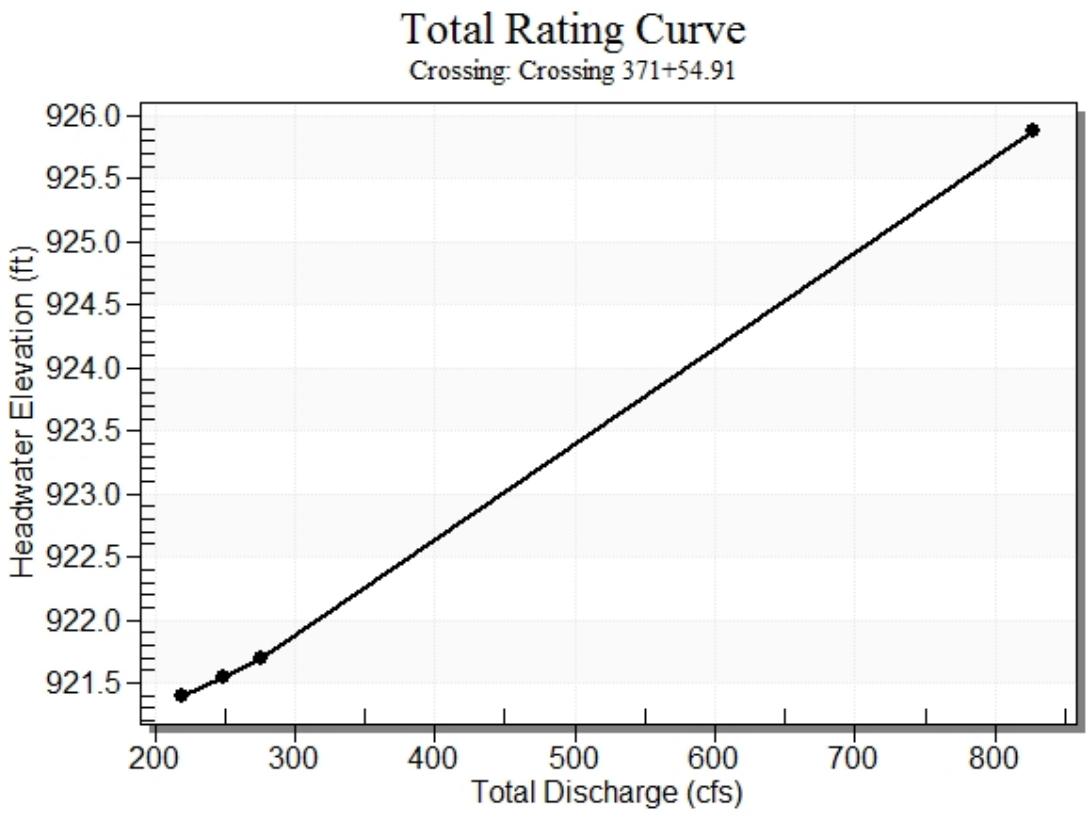
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: Crossing 371+54.91

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 371+54.91 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
921.40	25 year	219.57	219.57	0.00	1
921.55	50 year	249.00	249.00	0.00	1
921.70	100 year	275.71	275.71	0.00	1
925.81	Overtopping	786.61	786.61	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 371+54.91



Crossing Front View (Roadway Profile): Crossing 371+54.91

Culvert Notes: Culvert 371+54.91

Table 2 - Culvert Summary Table: Culvert 371+54.91

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	219.57	219.57	921.40	4.197	6.124	3-M1f	2.570	2.465	7.000	7.000	3.137	0.000
50 year	249.00	249.00	921.55	4.553	6.271	3-M1f	2.806	2.680	7.000	7.000	3.557	0.000
100 year	275.71	275.71	921.70	4.864	6.418	3-M1f	3.020	2.869	7.000	7.000	3.939	0.000

****

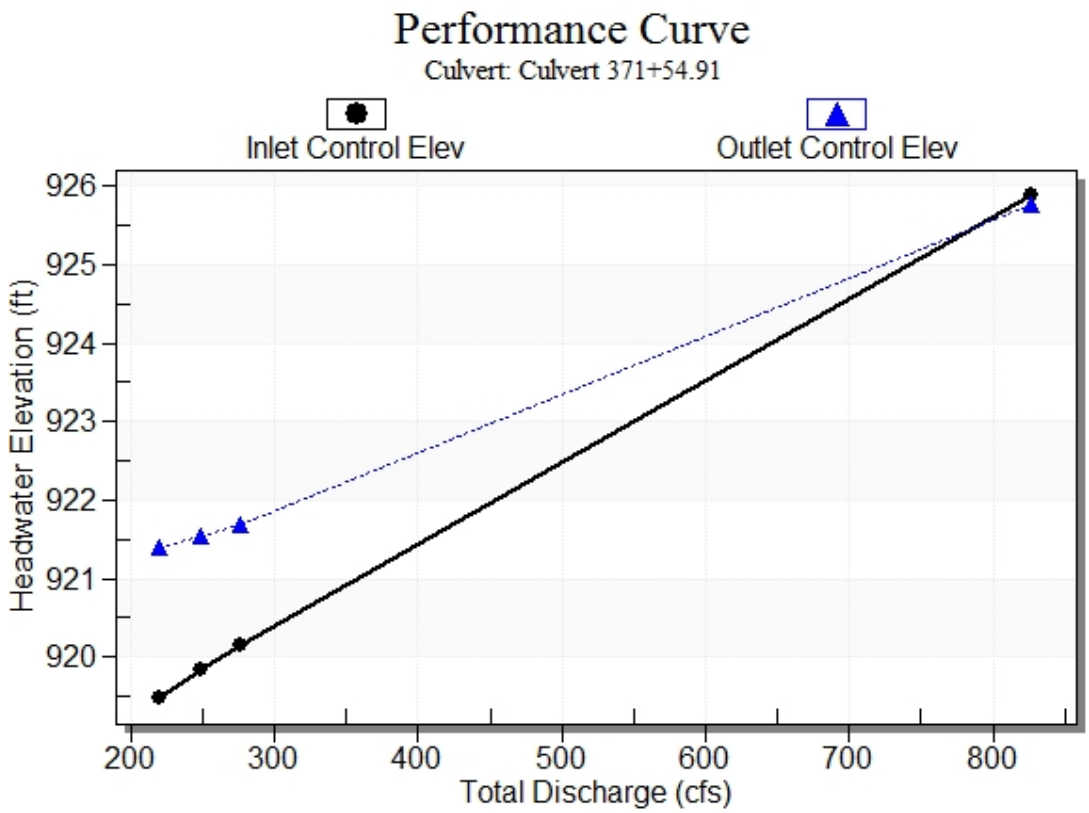
Straight Culvert

Inlet Elevation (invert): 915.28 ft, Outlet Elevation (invert): 913.92 ft

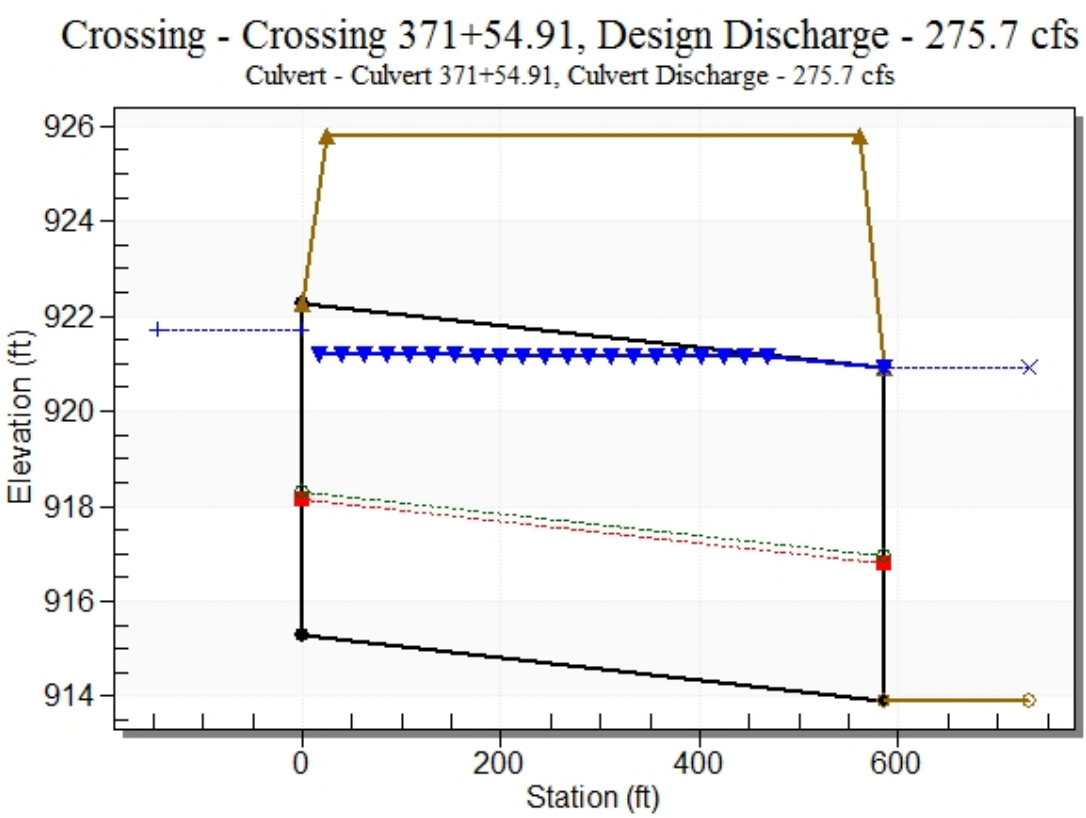
Culvert Length: 586.00 ft, Culvert Slope: 0.0023

****

Culvert Performance Curve Plot: Culvert 371+54.91



Water Surface Profile Plot for Culvert: Culvert 371+54.91



Site Data - Culvert 371+54.91

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 915.28 ft

Outlet Station: 586.00 ft

Outlet Elevation: 913.92 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 371+54.91

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 371+54.91)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
219.57	920.92	7.00
249.00	920.92	7.00
275.71	920.92	7.00

Tailwater Channel Data - Crossing 371+54.91

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 920.92 ft

Roadway Data for Crossing: Crossing 371+54.91

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-286.62	925.81
1	0.00	925.81
2	250.62	925.81

Roadway Surface: Paved

Roadway Top Width: 537.24 ft

Crossing Notes: Crossing 378+93.99

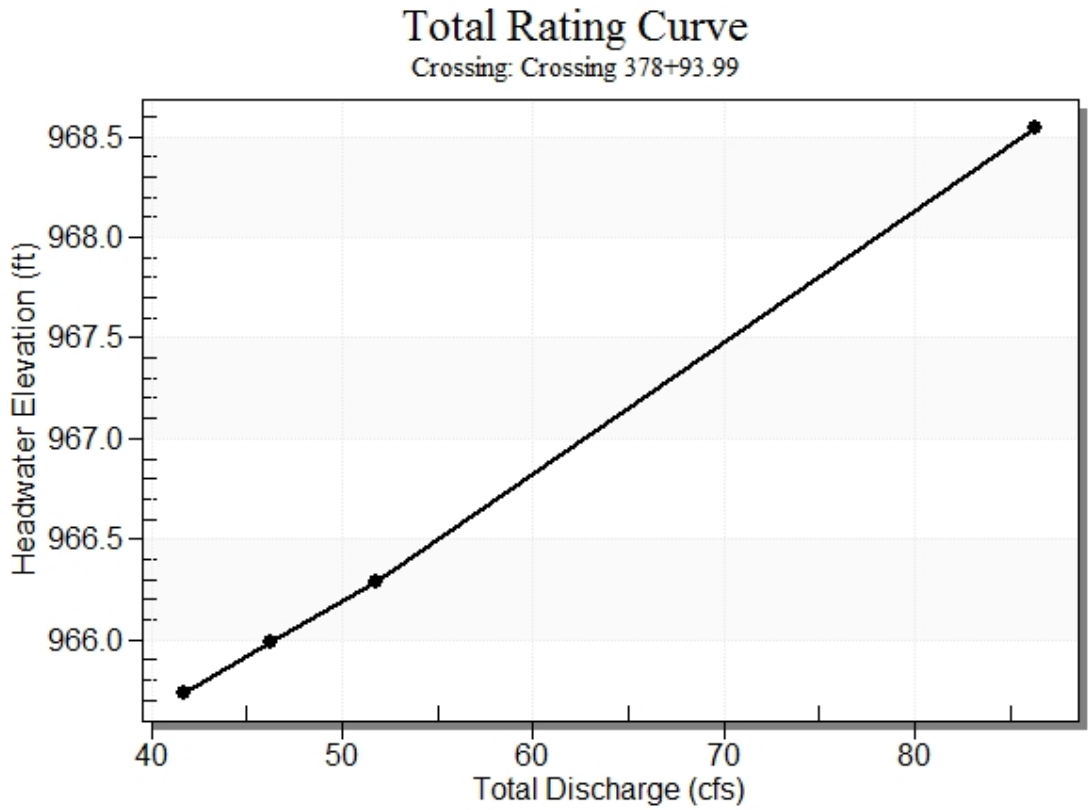
Crossing Discharge Data

Discharge Selection Method: Recurrence

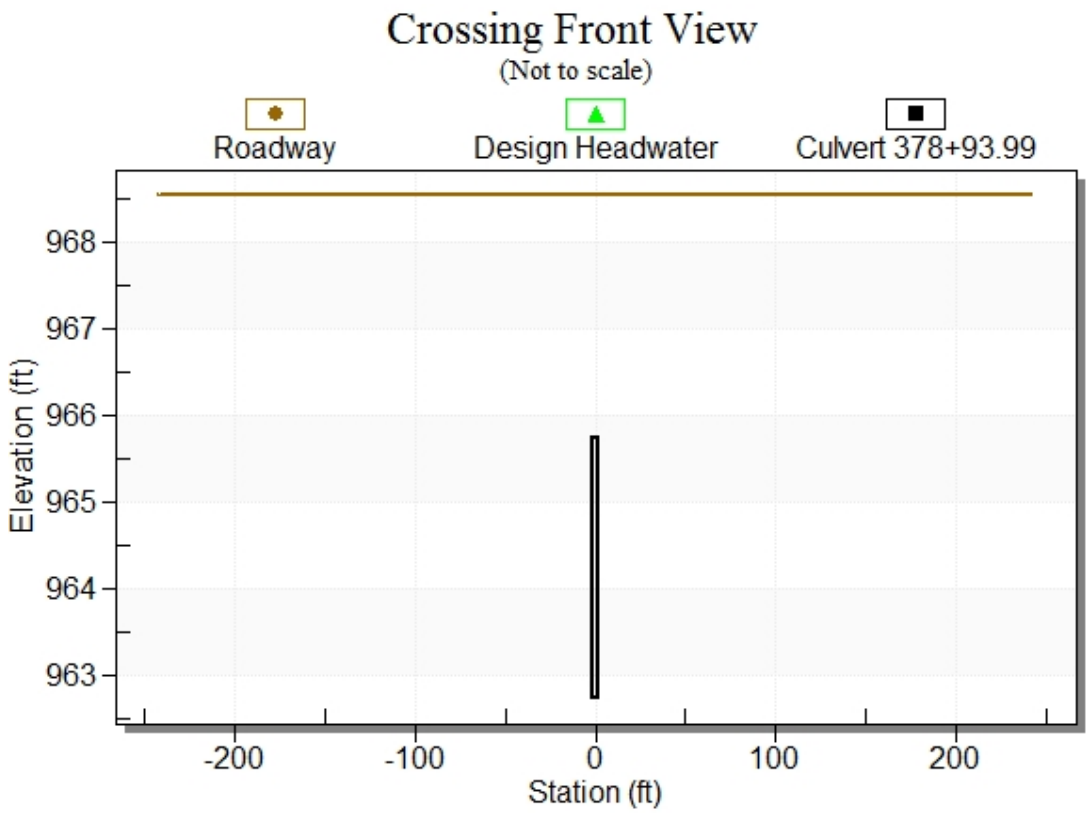
Table 4 - Summary of Culvert Flows at Crossing: Crossing 378+93.99

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 378+93.99 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
965.74	25 year	41.73	41.73	0.00	1
965.98	50 year	46.30	46.30	0.00	1
966.28	100 year	51.79	51.79	0.00	1
968.54	Overtopping	84.54	84.54	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 378+93.99



Crossing Front View (Roadway Profile): Crossing 378+93.99



Culvert Notes: Culvert 378+93.99

Table 5 - Culvert Summary Table: Culvert 378+93.99

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	41.73	41.73	965.74	3.008	0.0*	5-S2n	0.750	1.818	0.750	3.000	18.548	0.000
50 year	46.30	46.30	965.98	3.252	0.0*	5-S2n	0.805	1.948	0.805	3.000	19.160	0.000
100 year	51.79	51.79	966.28	3.554	0.0*	5-S2n	0.872	2.100	0.872	3.000	19.793	0.000

* Full Flow Headwater elevation is below inlet invert.

****

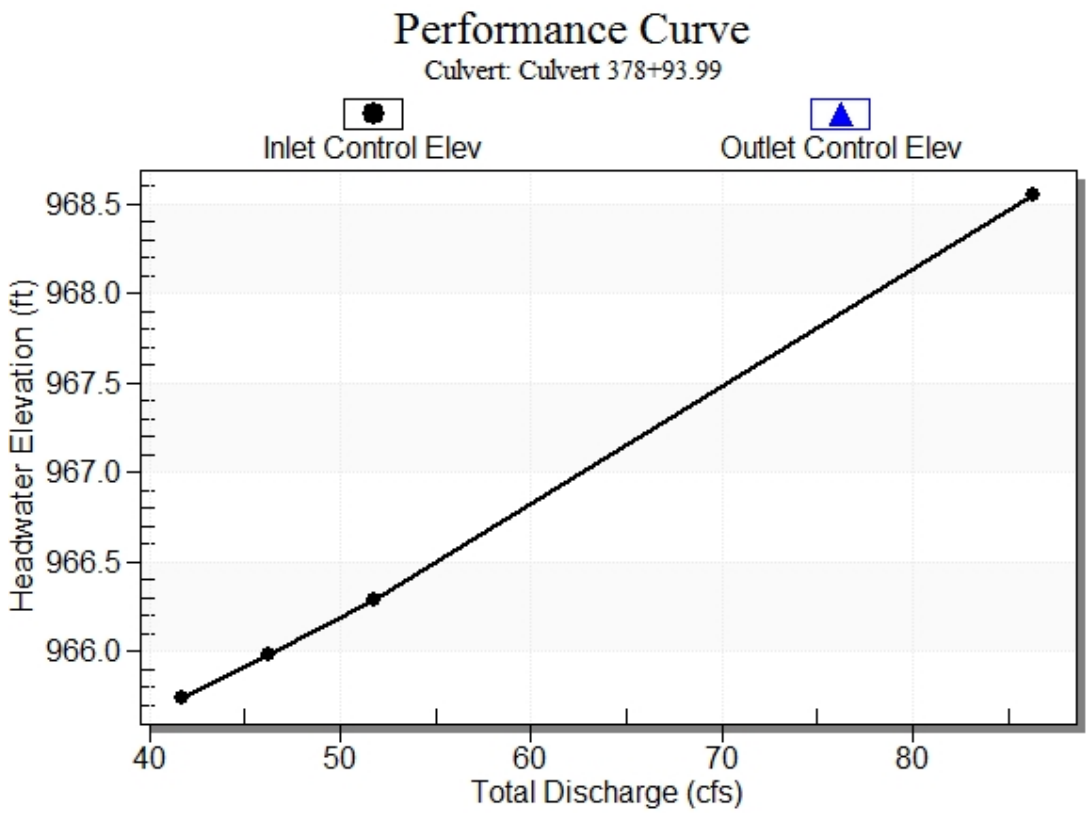
Straight Culvert

Inlet Elevation (invert): 962.73 ft, Outlet Elevation (invert): 933.33 ft

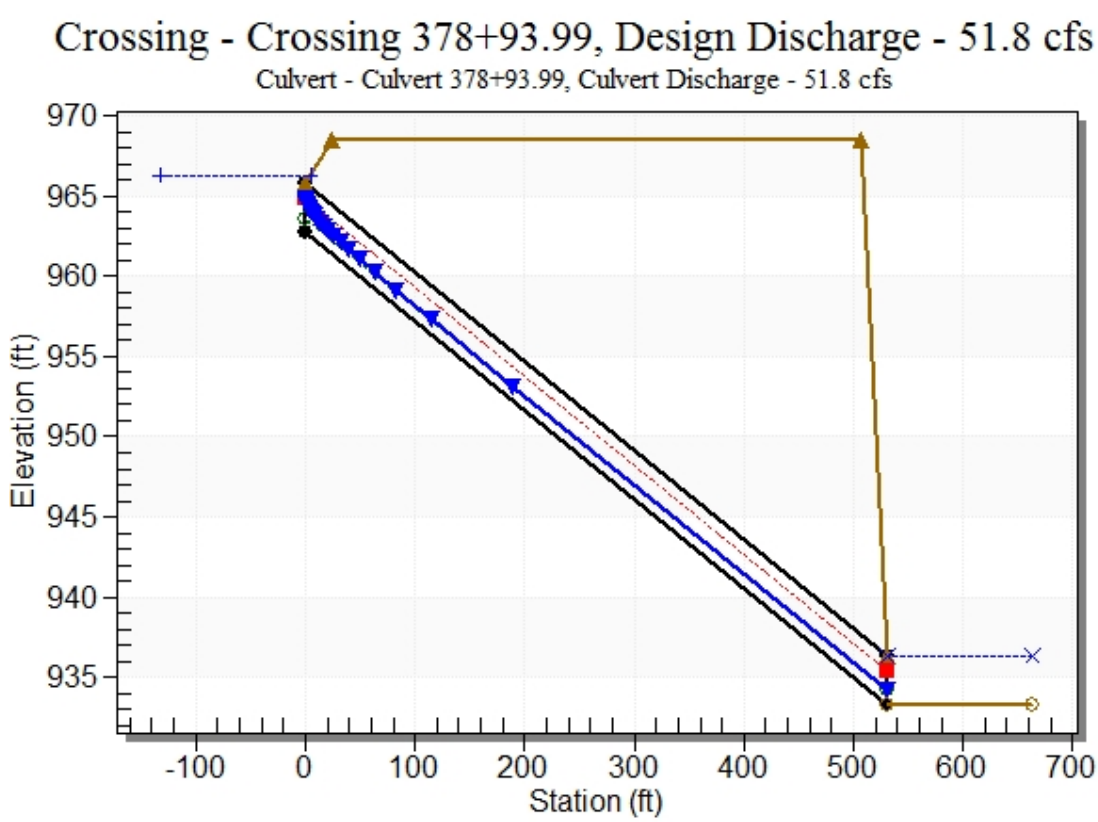
Culvert Length: 531.81 ft, Culvert Slope: 0.0554

****

Culvert Performance Curve Plot: Culvert 378+93.99



Water Surface Profile Plot for Culvert: Culvert 378+93.99



Site Data - Culvert 378+93.99

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 962.73 ft

Outlet Station: 531.00 ft

Outlet Elevation: 933.33 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 378+93.99

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Crossing 378+93.99)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
41.73	936.33	3.00
46.30	936.33	3.00
51.79	936.33	3.00

Tailwater Channel Data - Crossing 378+93.99

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 936.33 ft

Roadway Data for Crossing: Crossing 378+93.99

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-241.92	968.54
1	0.00	968.54
2	241.92	968.54

Roadway Surface: Paved

Roadway Top Width: 483.84 ft

Crossing Notes: Crossing 390+02.10

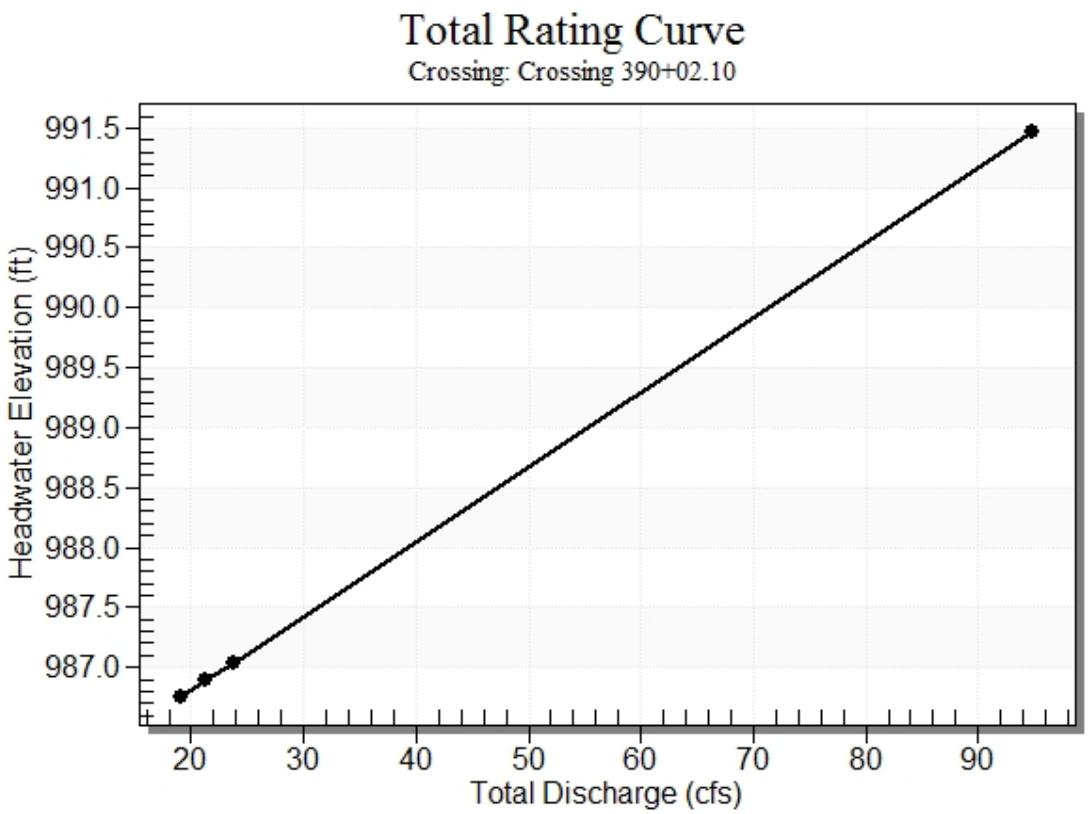
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 7 - Summary of Culvert Flows at Crossing: Crossing 390+02.10

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 390+02.10 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
986.76	25 year	19.10	19.10	0.00	1
986.89	50 year	21.19	21.19	0.00	1
987.03	100 year	23.70	23.70	0.00	1
991.46	Overtopping	91.90	91.90	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 390+02.10



Crossing Front View (Roadway Profile): Crossing 390+02.10

Culvert Notes: Culvert 390+02.10

Table 8 - Culvert Summary Table: Culvert 390+02.10

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	19.10	19.10	986.76	1.759	0.0*	1-JS1f	0.435	1.080	3.000	3.050	2.122	0.000
50 year	21.19	21.19	986.89	1.886	0.0*	1-JS1f	0.466	1.157	3.000	3.050	2.354	0.000
100 year	23.70	23.70	987.03	2.035	0.0*	1-S2n	0.503	1.247	0.519	3.050	15.212	0.000

* Full Flow Headwater elevation is below inlet invert.

****

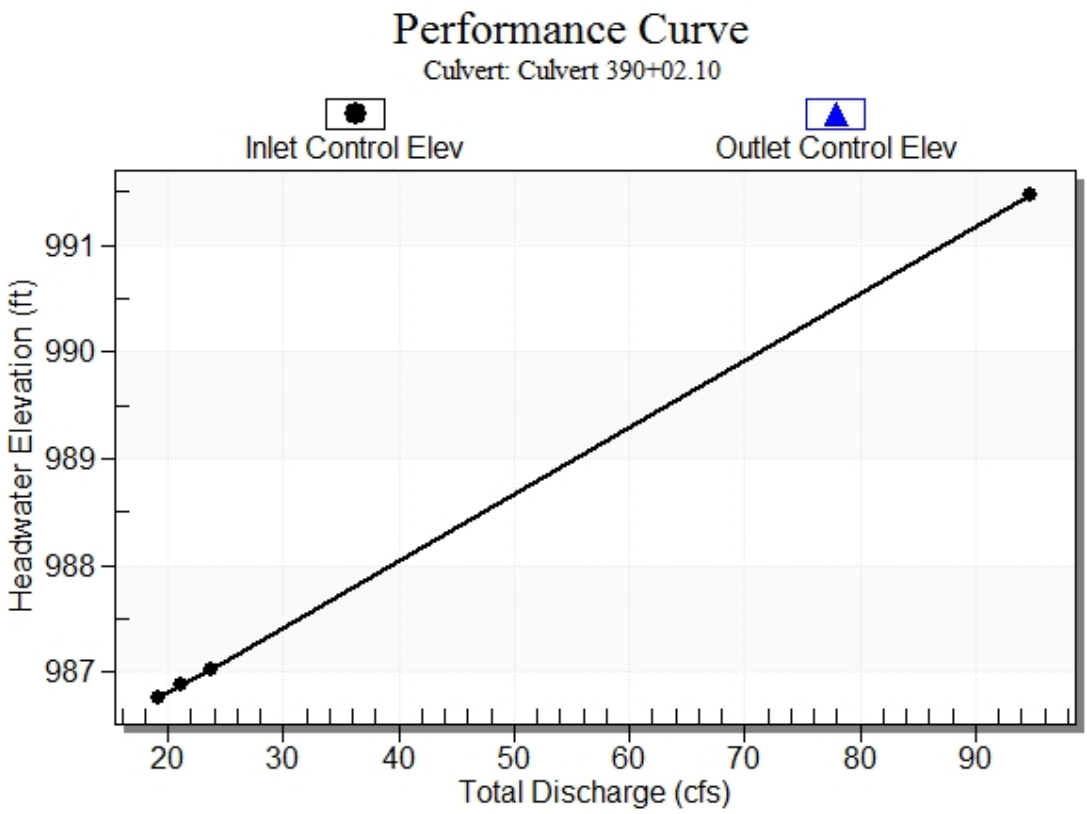
Straight Culvert

Inlet Elevation (invert): 985.00 ft, Outlet Elevation (invert): 964.68 ft

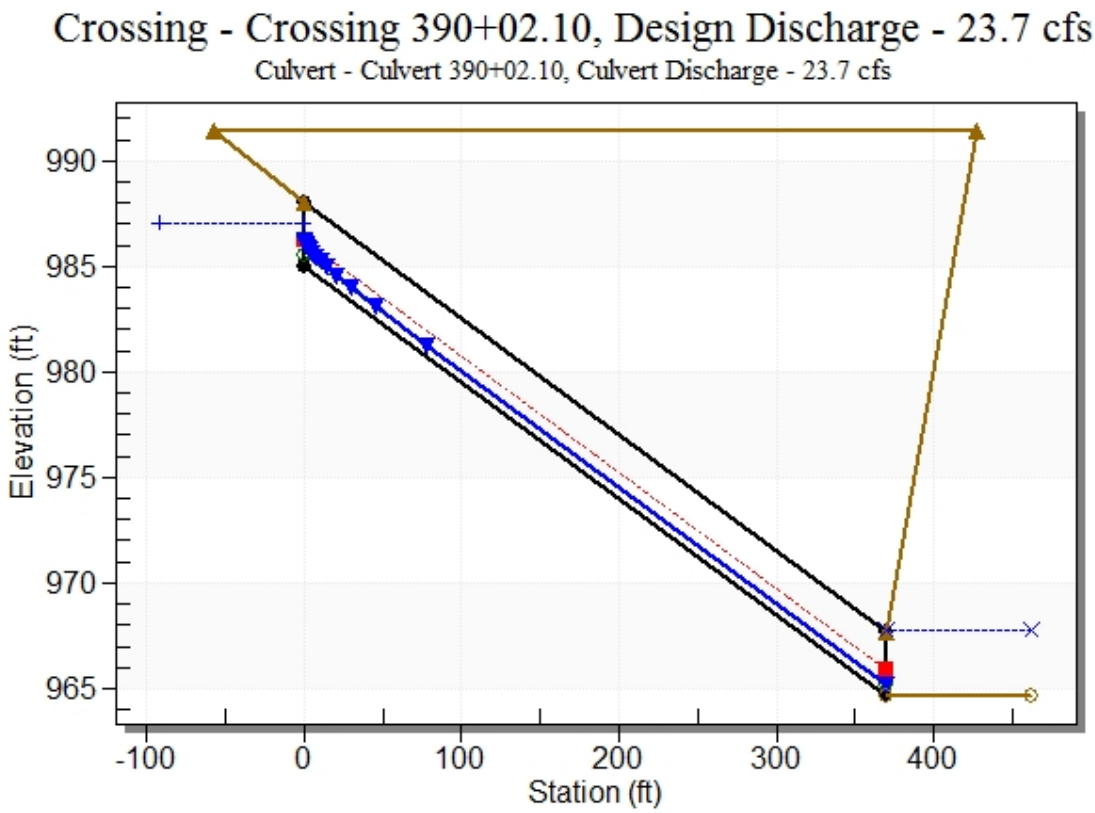
Culvert Length: 370.56 ft, Culvert Slope: 0.0549

****

Culvert Performance Curve Plot: Culvert 390+02.10



Water Surface Profile Plot for Culvert: Culvert 390+02.10



Site Data - Culvert 390+02.10

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 985.00 ft

Outlet Station: 370.00 ft

Outlet Elevation: 964.68 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 390+02.10

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Crossing 390+02.10)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
19.10	967.73	3.05
21.19	967.73	3.05
23.70	967.73	3.05

Tailwater Channel Data - Crossing 390+02.10

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 967.73 ft

Roadway Data for Crossing: Crossing 390+02.10

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-241.92	991.46
1	0.00	991.46
2	241.92	991.46

Roadway Surface: Paved

Roadway Top Width: 483.84 ft

Crossing Notes: Crossing 395+00.56

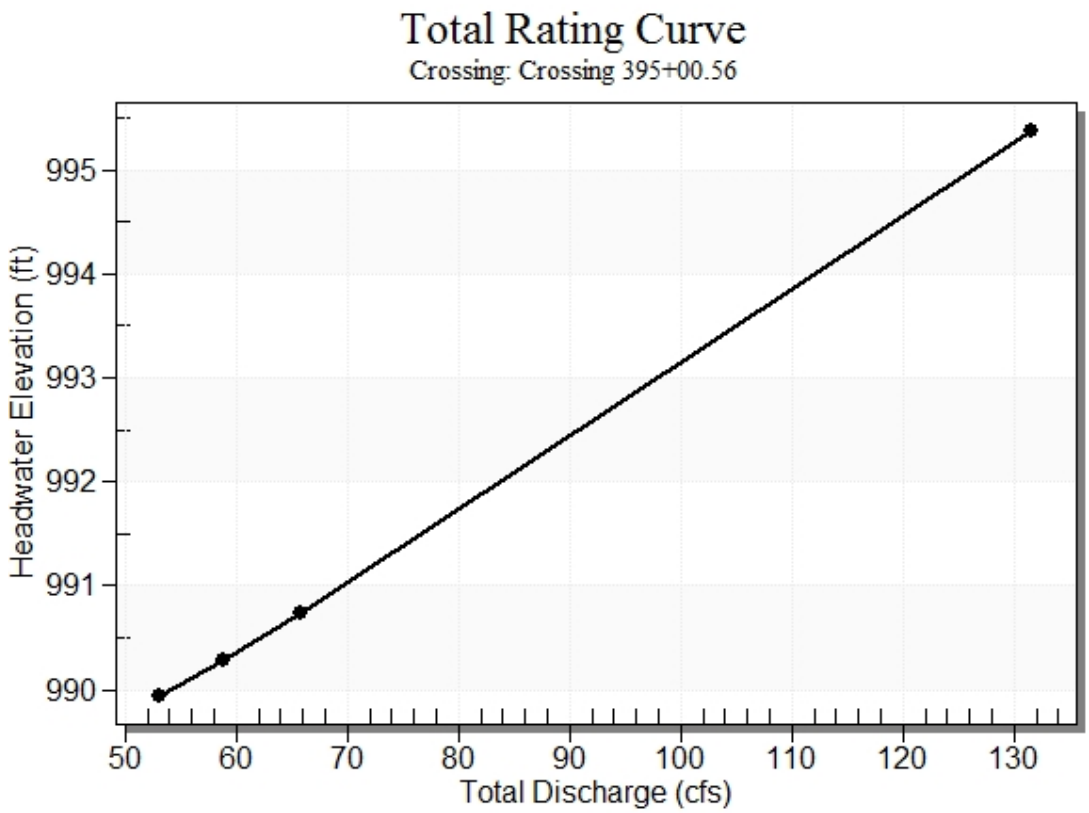
Crossing Discharge Data

Discharge Selection Method: Recurrence

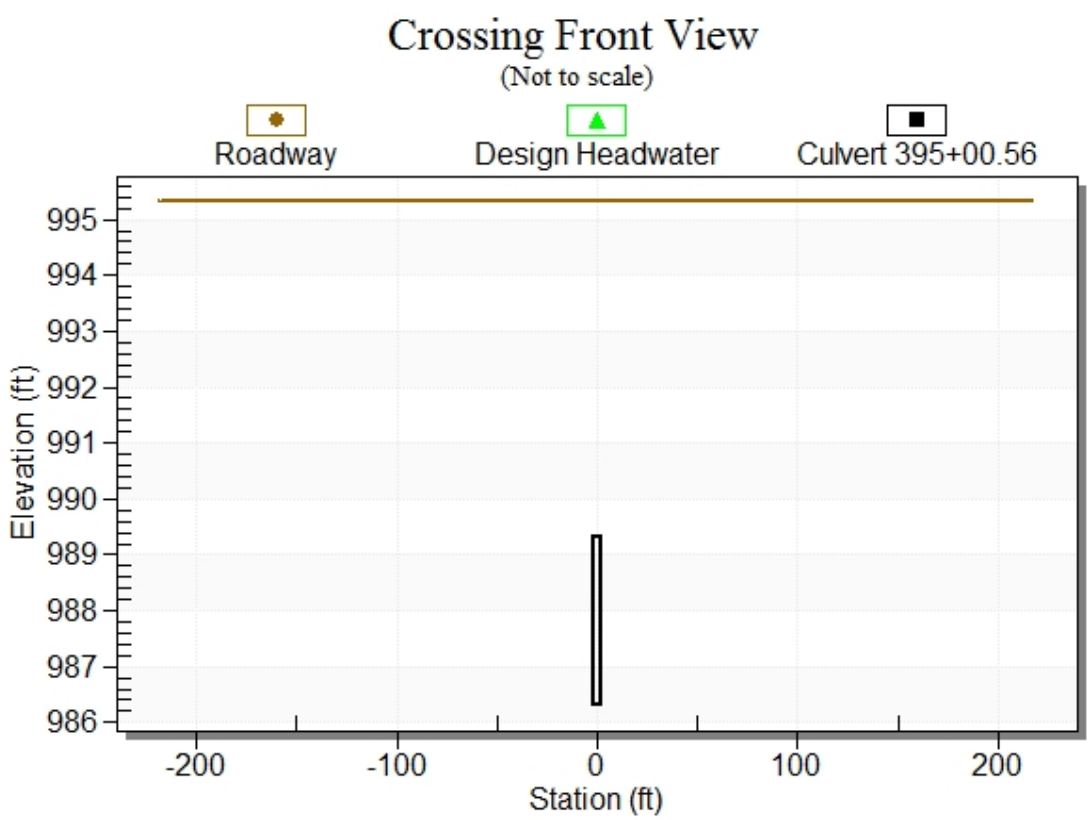
Table 10 - Summary of Culvert Flows at Crossing: Crossing 395+00.56

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 395+00.56 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
989.95	25 year	53.03	53.03	0.00	1
990.29	50 year	58.84	58.84	0.00	1
990.73	100 year	65.81	65.81	0.00	1
995.33	Overtopping	115.96	115.96	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 395+00.56



Crossing Front View (Roadway Profile): Crossing 395+00.56



Culvert Notes: Culvert 395+00.56

Table 11 - Culvert Summary Table: Culvert 395+00.56

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	53.03	53.03	989.95	3.639	0.0*	5-S2n	0.953	2.133	0.981	3.000	18.011	0.000
50 year	58.84	58.84	990.29	3.980	0.0*	5-S2n	1.027	2.286	1.027	3.000	19.090	0.000
100 year	65.81	65.81	990.73	4.421	0.0*	5-S2n	1.112	2.463	1.112	3.000	19.728	0.000

* Full Flow Headwater elevation is below inlet invert.

****

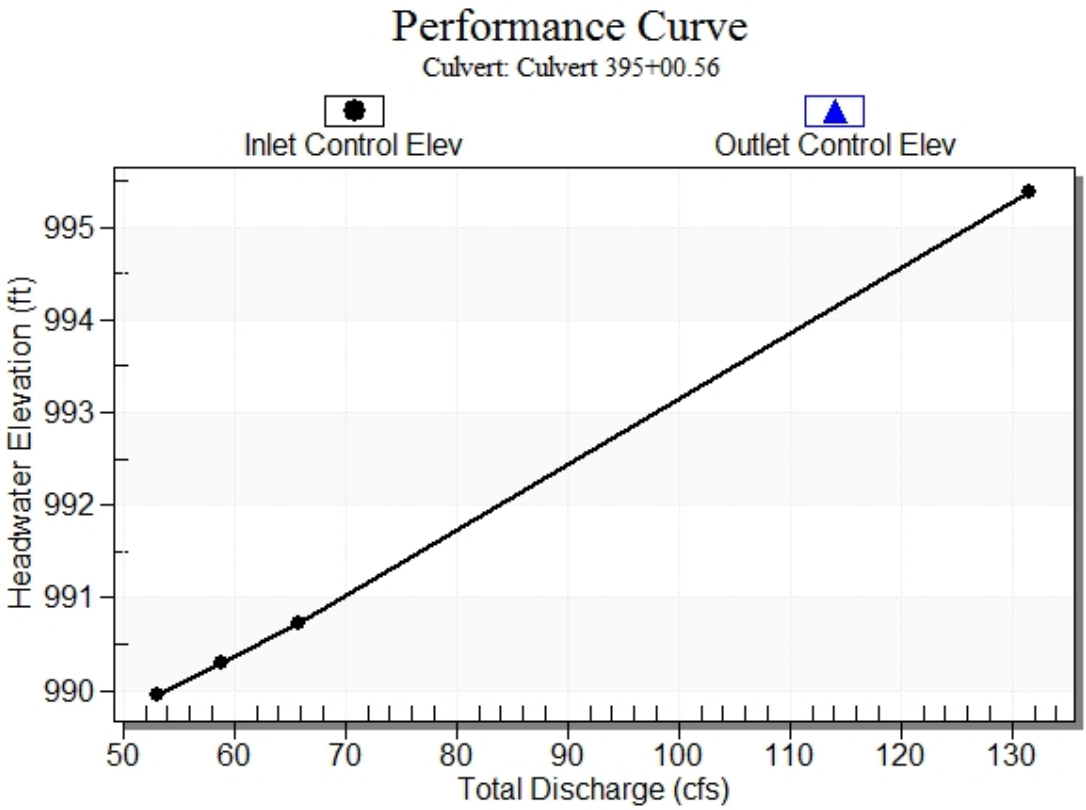
Straight Culvert

Inlet Elevation (invert): 986.31 ft, Outlet Elevation (invert): 964.49 ft

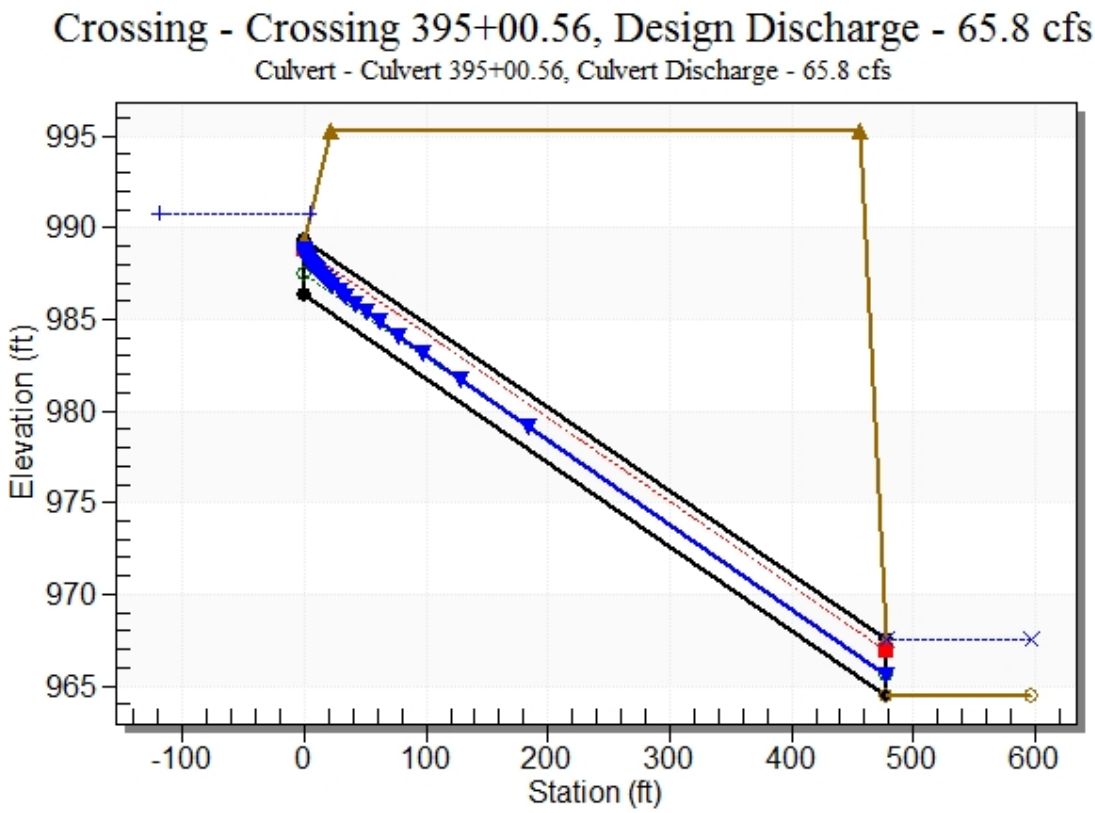
Culvert Length: 478.50 ft, Culvert Slope: 0.0456

****

Culvert Performance Curve Plot: Culvert 395+00.56



Water Surface Profile Plot for Culvert: Culvert 395+00.56



Site Data - Culvert 395+00.56

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 986.31 ft

Outlet Station: 478.00 ft

Outlet Elevation: 964.49 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 395+00.56

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 12 - Downstream Channel Rating Curve (Crossing: Crossing 395+00.56)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
53.03	967.49	3.00
58.84	967.49	3.00
65.81	967.49	3.00

Tailwater Channel Data - Crossing 395+00.56

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 967.49 ft

Roadway Data for Crossing: Crossing 395+00.56

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-218.30	995.33
1	0.00	995.33
2	217.40	995.33

Roadway Surface: Paved

Roadway Top Width: 435.70 ft

Crossing Notes: Crossing 411+61.13

Crossing Discharge Data

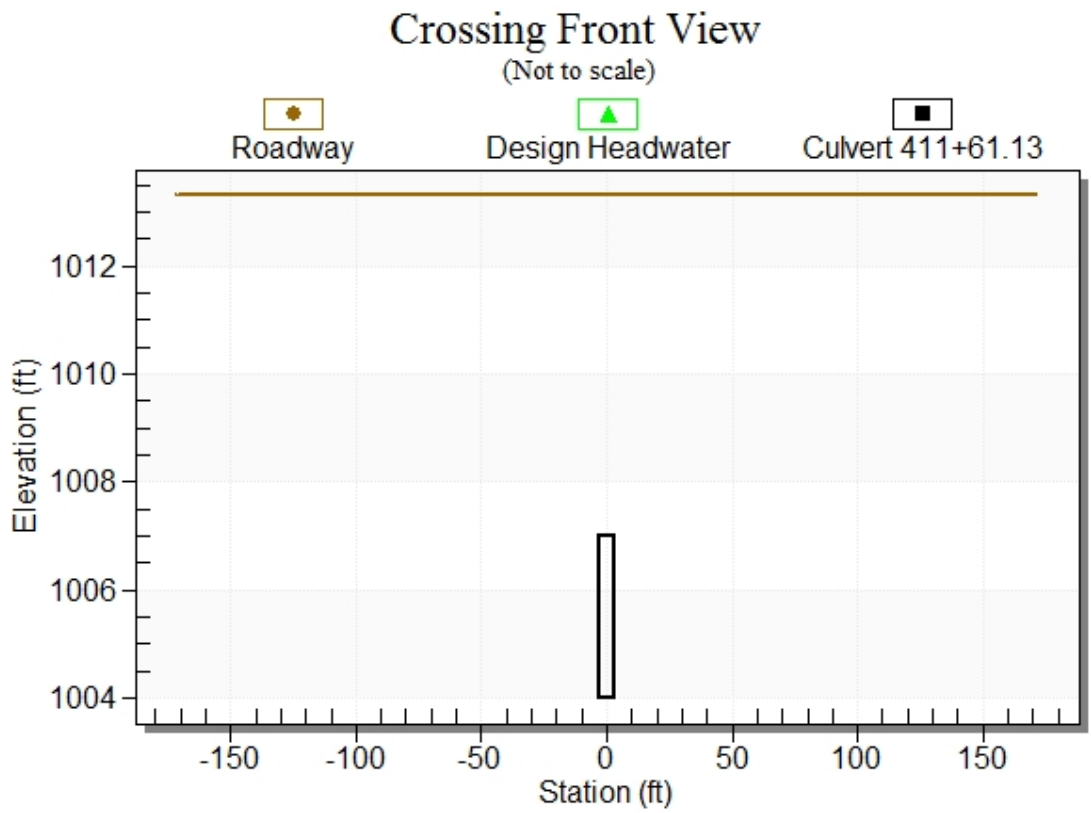
Discharge Selection Method: Recurrence

Table 13 - Summary of Culvert Flows at Crossing: Crossing 411+61.13

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 411+61.13 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1011.26	25 year	199.18	199.18	0.00	1
1012.52	50 year	222.69	222.69	0.00	1
1013.37	100 year	248.20	236.52	11.36	14
1013.32	Overtopping	235.76	235.76	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 411+61.13

Crossing Front View (Roadway Profile): Crossing 411+61.13



Culvert Notes: Culvert 411+61.13

Table 14 - Culvert Summary Table: Culvert 411+61.13

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	199.18	199.18	1011.26	7.261	2.717	5-S2n	1.895	3.000	1.948	3.000	17.045	0.000
50 year	222.69	222.69	1012.52	8.524	4.177	5-S2n	2.053	3.000	2.115	3.000	17.546	0.000
100 year	248.20	236.52	1013.37	9.371	5.111	5-S2n	2.143	3.000	2.209	3.000	17.845	0.000

****

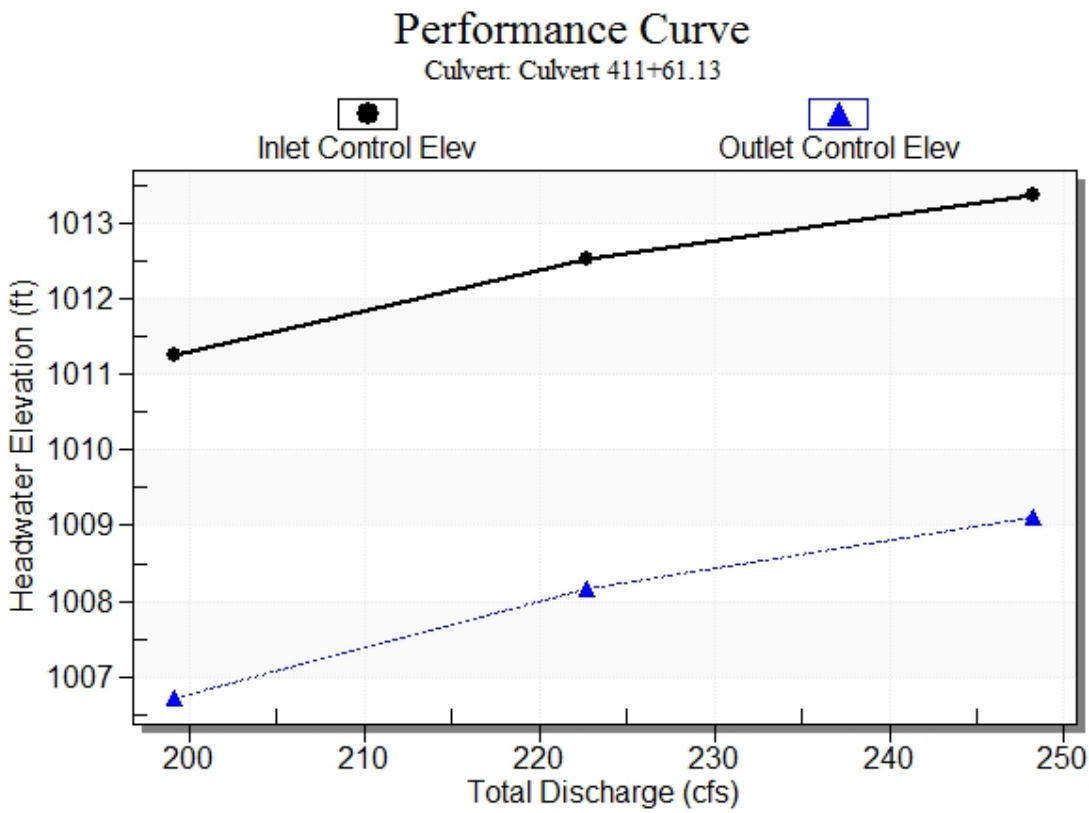
Straight Culvert

Inlet Elevation (invert): 1004.00 ft, Outlet Elevation (invert): 997.88 ft

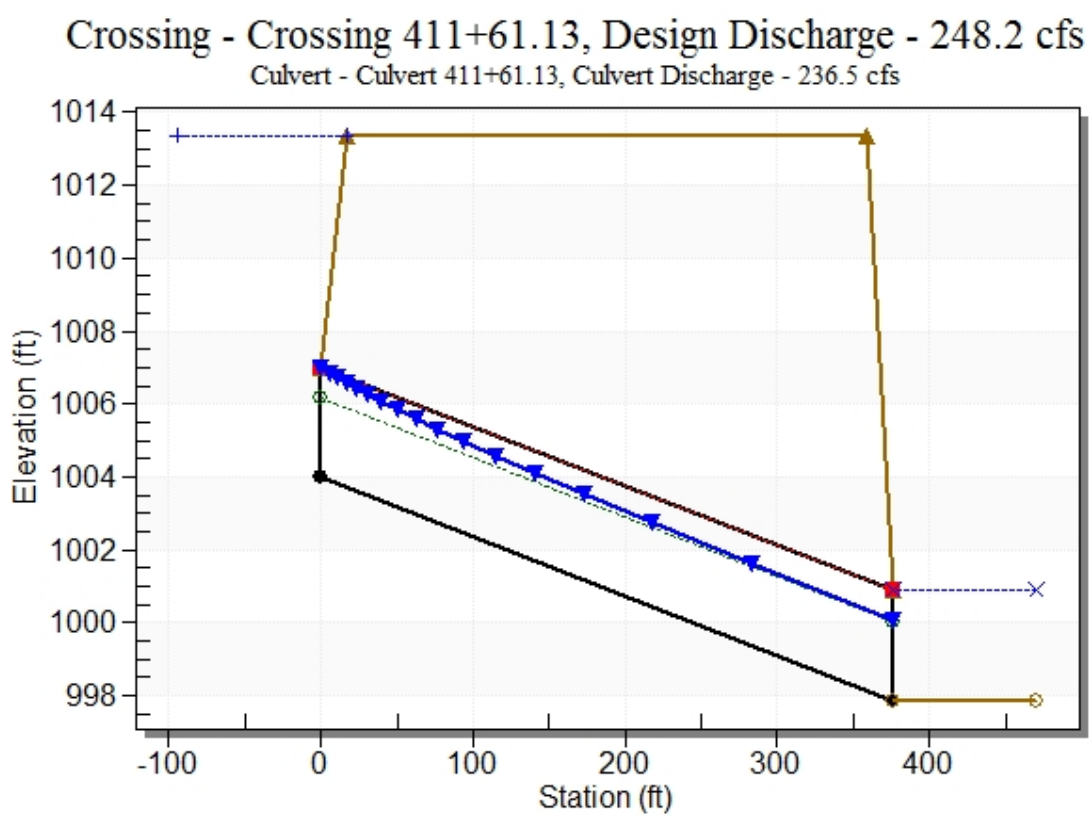
Culvert Length: 376.05 ft, Culvert Slope: 0.0163

****

Culvert Performance Curve Plot: Culvert 411+61.13



Water Surface Profile Plot for Culvert: Culvert 411+61.13



Site Data - Culvert 411+61.13

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1004.00 ft

Outlet Station: 376.00 ft

Outlet Elevation: 997.88 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 411+61.13

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 15 - Downstream Channel Rating Curve (Crossing: Crossing 411+61.13)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
199.18	1000.88	3.00
222.69	1000.88	3.00
248.20	1000.88	3.00

Tailwater Channel Data - Crossing 411+61.13

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1000.88 ft

Roadway Data for Crossing: Crossing 411+61.13

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-171.00	1013.32
1	0.00	1013.32
2	171.00	1013.32

Roadway Surface: Paved

Roadway Top Width: 342.00 ft

Crossing Notes: Crossing 429+79.05

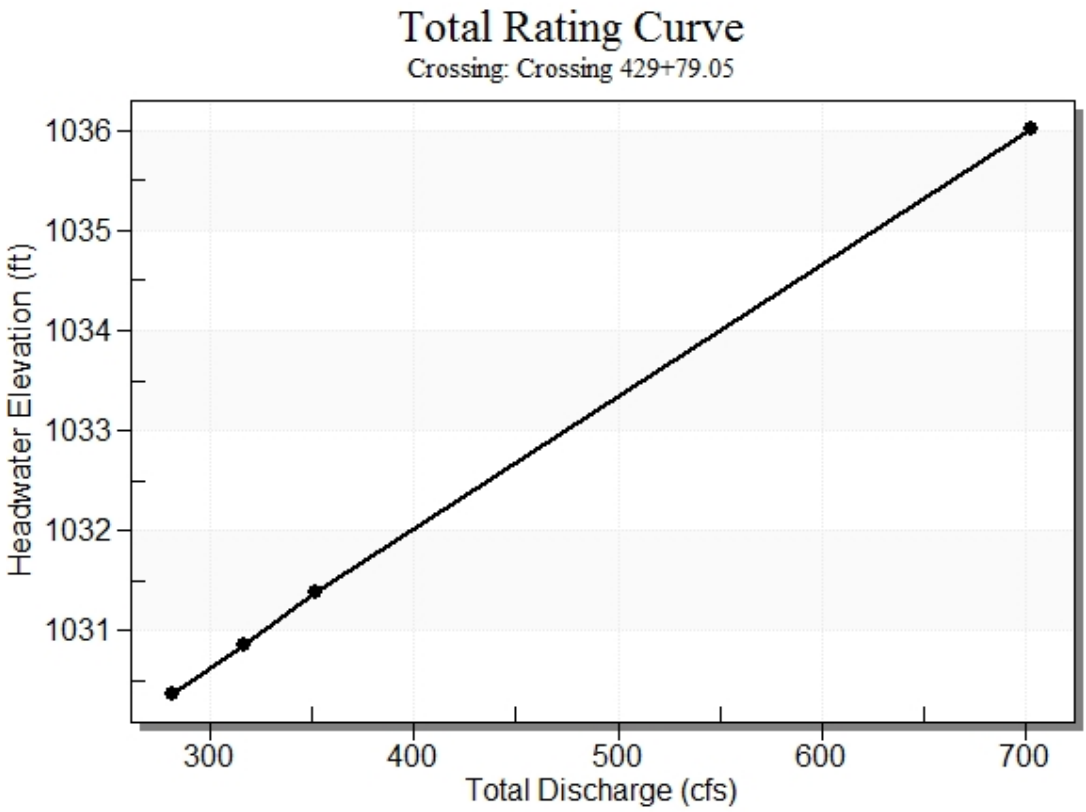
Crossing Discharge Data

Discharge Selection Method: Recurrence

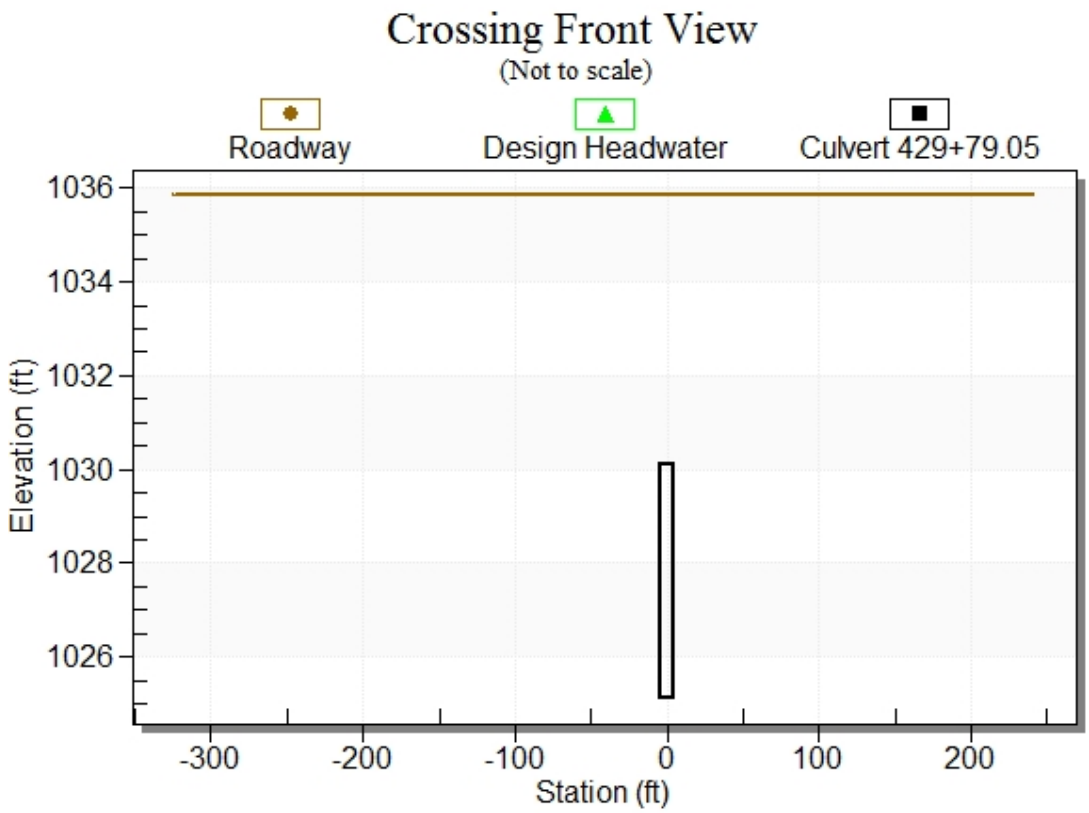
Table 16 - Summary of Culvert Flows at Crossing: Crossing 429+79.05

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 429+79.05 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1030.38	25 year	281.35	281.35	0.00	1
1030.86	50 year	315.98	315.98	0.00	1
1031.38	100 year	351.45	351.45	0.00	1
1035.86	Overtopping	588.65	588.65	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 429+79.05



Crossing Front View (Roadway Profile): Crossing 429+79.05



Culvert Notes: Culvert 429+79.05

Table 17 - Culvert Summary Table: Culvert 429+79.05

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	281.35	281.35	1030.38	5.259	0.0*	5-JS1f	1.521	3.119	5.000	7.000	6.252	0.000
50 year	315.98	315.98	1030.86	5.742	0.0*	5-JS1f	1.653	3.370	5.000	7.000	7.022	0.000
100 year	351.45	351.45	1031.38	6.258	0.0*	5-JS1f	1.772	3.618	5.000	7.000	7.810	0.000

* Full Flow Headwater elevation is below inlet invert.

****

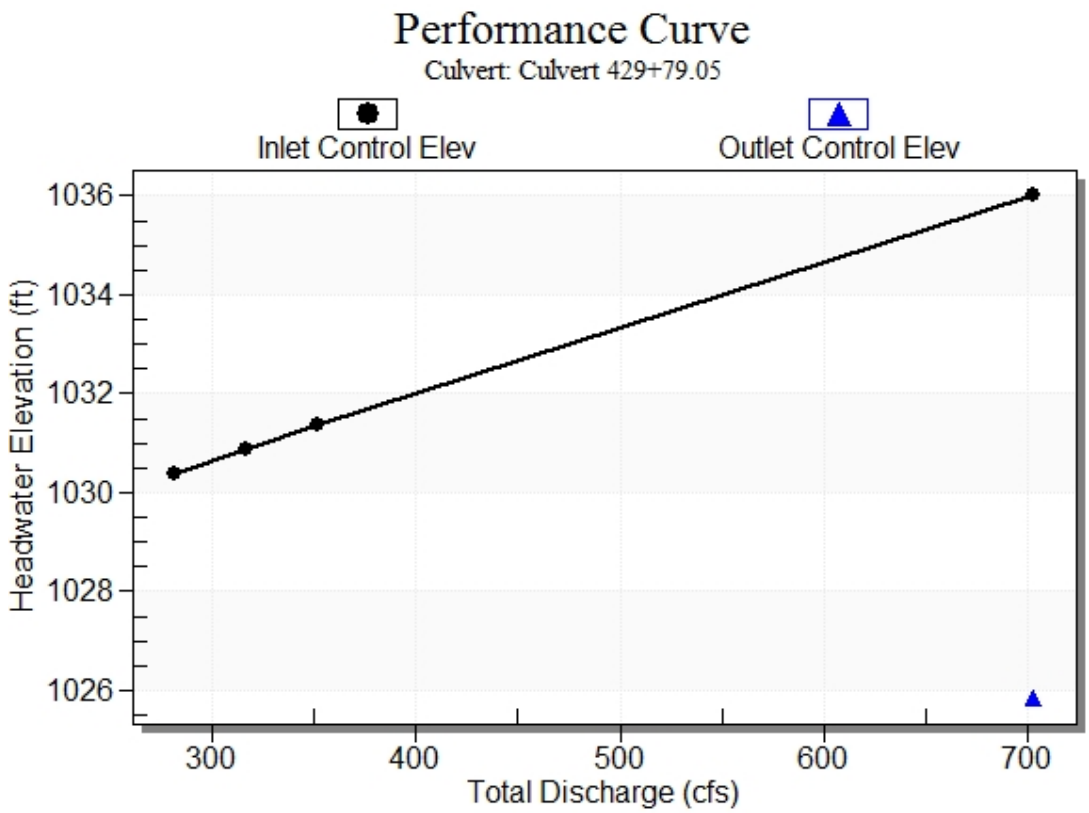
Straight Culvert

Inlet Elevation (invert): 1025.12 ft, Outlet Elevation (invert): 1011.03 ft

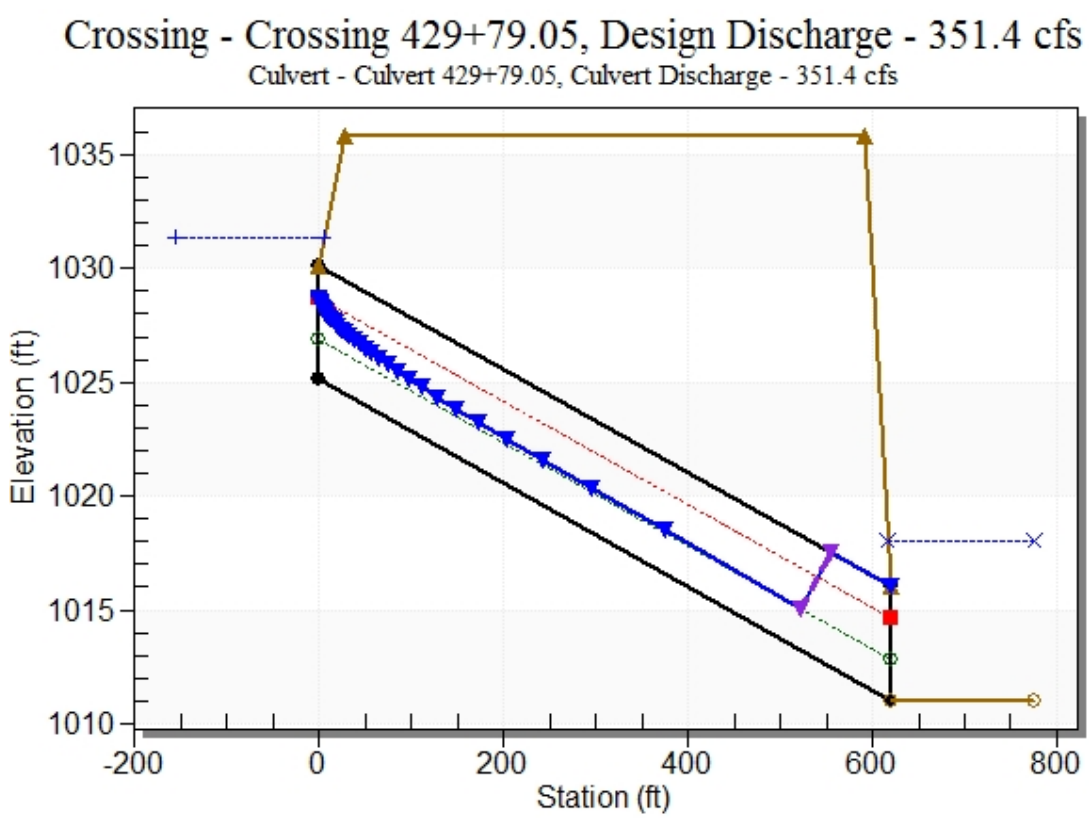
Culvert Length: 620.16 ft, Culvert Slope: 0.0227

****

Culvert Performance Curve Plot: Culvert 429+79.05



Water Surface Profile Plot for Culvert: Culvert 429+79.05



Site Data - Culvert 429+79.05

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1025.12 ft

Outlet Station: 620.00 ft

Outlet Elevation: 1011.03 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 429+79.05

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 18 - Downstream Channel Rating Curve (Crossing: Crossing 429+79.05)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
281.35	1018.03	7.00
315.98	1018.03	7.00
351.45	1018.03	7.00

Tailwater Channel Data - Crossing 429+79.05

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1018.03 ft

Roadway Data for Crossing: Crossing 429+79.05

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-323.83	1035.86
1	0.00	1035.86
2	240.67	1035.86

Roadway Surface: Paved

Roadway Top Width: 564.50 ft

Crossing Notes: Crossing 451+08.36

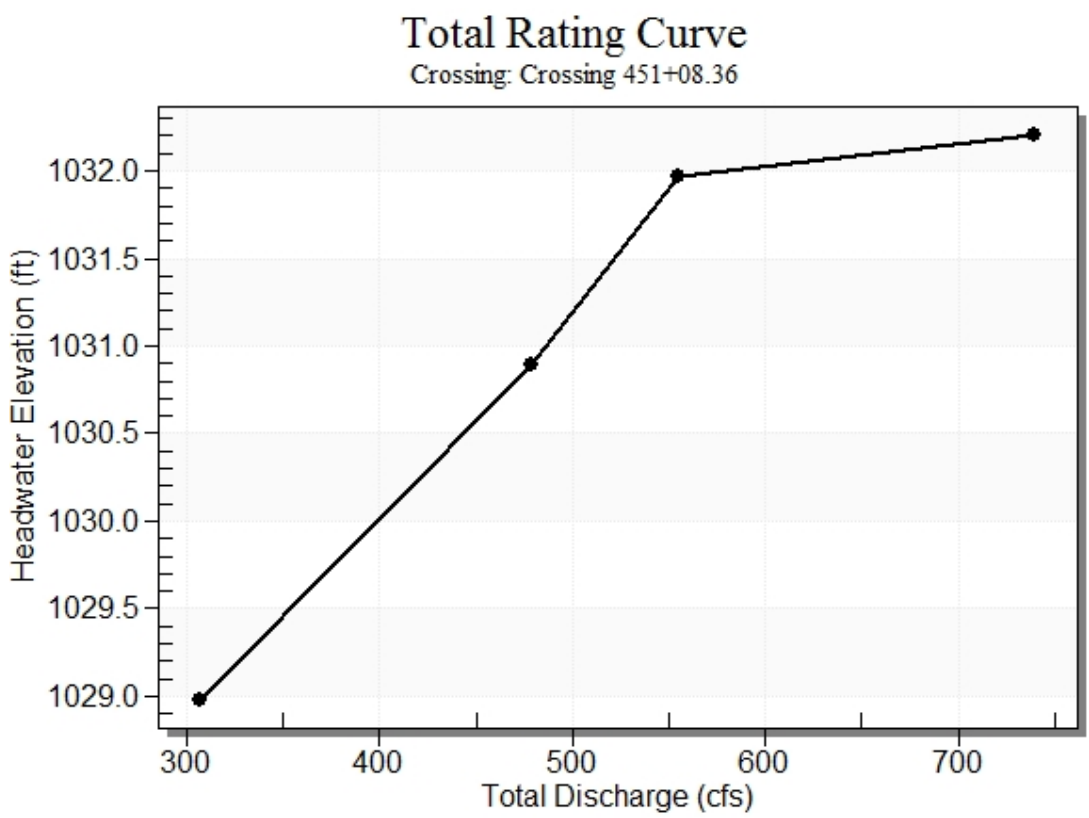
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: Crossing 451+08.36

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 451+08.36 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1028.98	25 year	306.50	306.50	0.00	1
1030.89	50 year	478.90	478.90	0.00	1
1031.96	100 year	554.80	553.75	0.00	29
1031.97	Overtopping	554.09	554.09	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 451+08.36



Culvert Notes: Culvert 451+08.36

Table 2 - Culvert Summary Table: Culvert 451+08.36

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	306.50	306.50	1028.98	3.573	0.0*	5-S2n	1.181	2.080	1.181	3.000	14.424	0.000
50 year	478.90	478.90	1030.89	5.481	0.0*	5-S2n	1.608	2.801	1.632	3.000	16.299	0.000
100 year	554.80	553.75	1031.96	6.554	0.219	5-S2n	1.781	3.000	1.781	3.000	17.278	0.000

* Full Flow Headwater elevation is below inlet invert.

****

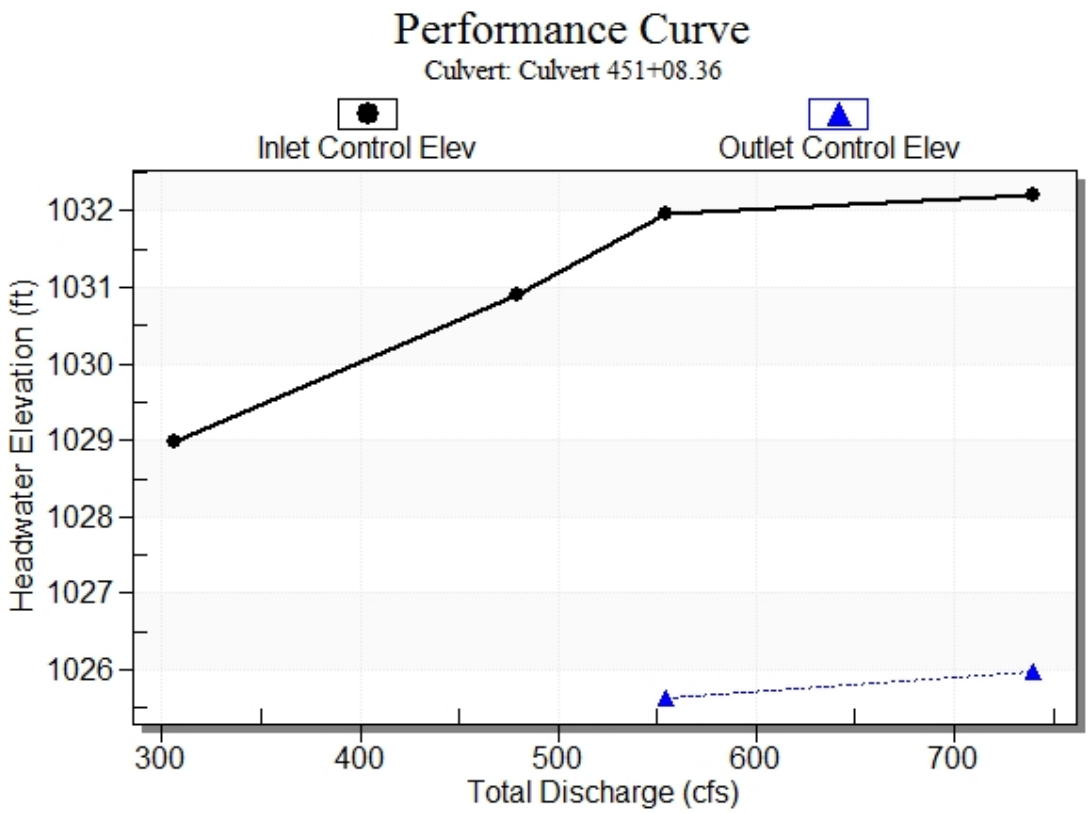
Straight Culvert

Inlet Elevation (invert): 1025.41 ft, Outlet Elevation (invert): 1016.56 ft

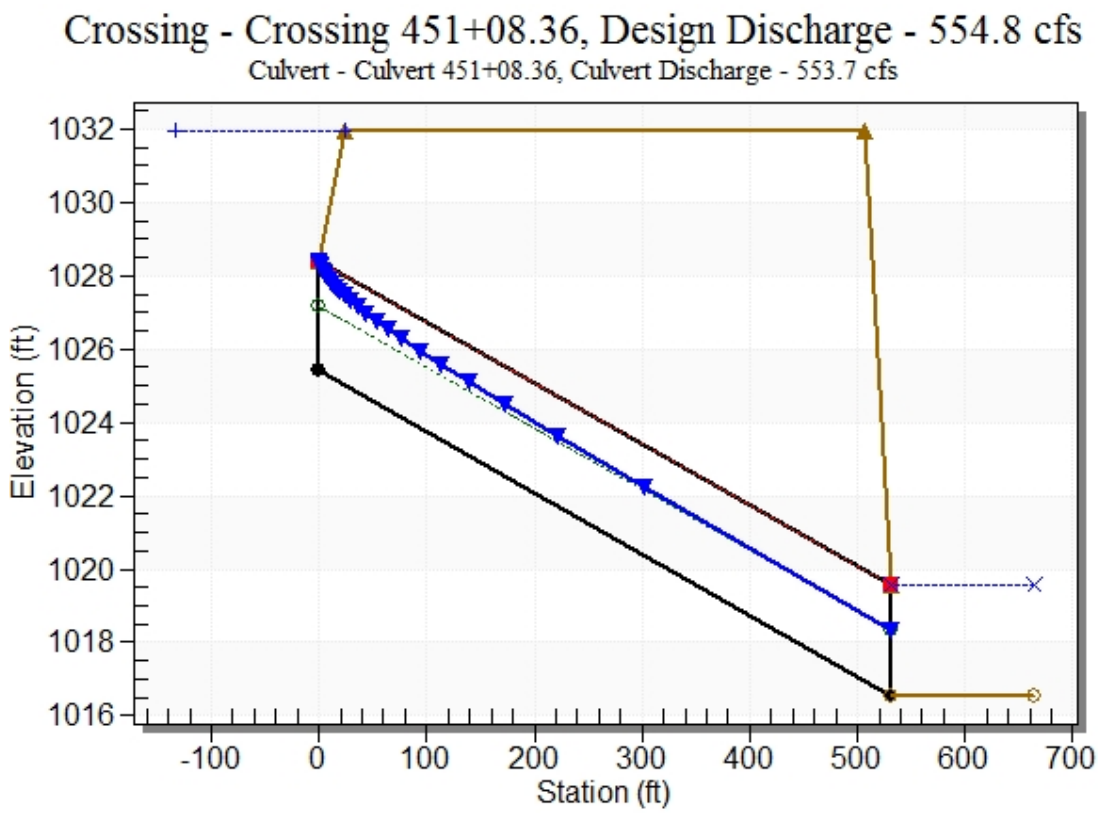
Culvert Length: 531.07 ft, Culvert Slope: 0.0167

****

Culvert Performance Curve Plot: Culvert 451+08.36



Water Surface Profile Plot for Culvert: Culvert 451+08.36



Site Data - Culvert 451+08.36

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1025.41 ft

Outlet Station: 531.00 ft

Outlet Elevation: 1016.56 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 451+08.36

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 451+08.36)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
306.50	1019.56	3.00
478.90	1019.56	3.00
554.80	1019.56	3.00

Tailwater Channel Data - Crossing 451+08.36

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1019.56 ft

Roadway Data for Crossing: Crossing 451+08.36

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-242.04	1031.97
1	0.00	1031.97
2	240.62	1031.97

Roadway Surface: Paved

Roadway Top Width: 482.66 ft

Crossing Notes: Crossing 470+36.10

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 22 - Summary of Culvert Flows at Crossing: Crossing 470+36.10

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 470+36.10 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1086.00	25 year	106.67	106.67	0.00	1
1086.79	50 year	119.15	119.15	0.00	1
1087.14	100 year	132.86	124.18	7.92	17
1087.11	Overtopping	123.76	123.76	0.00	Overtopping

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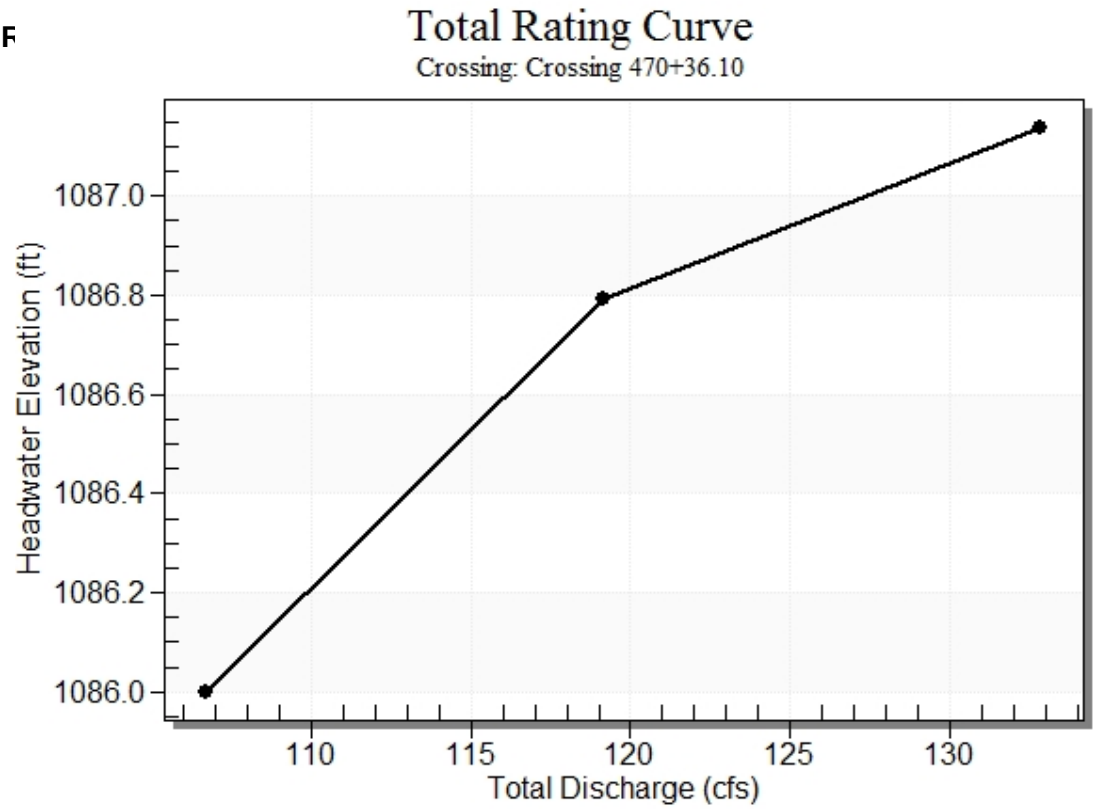
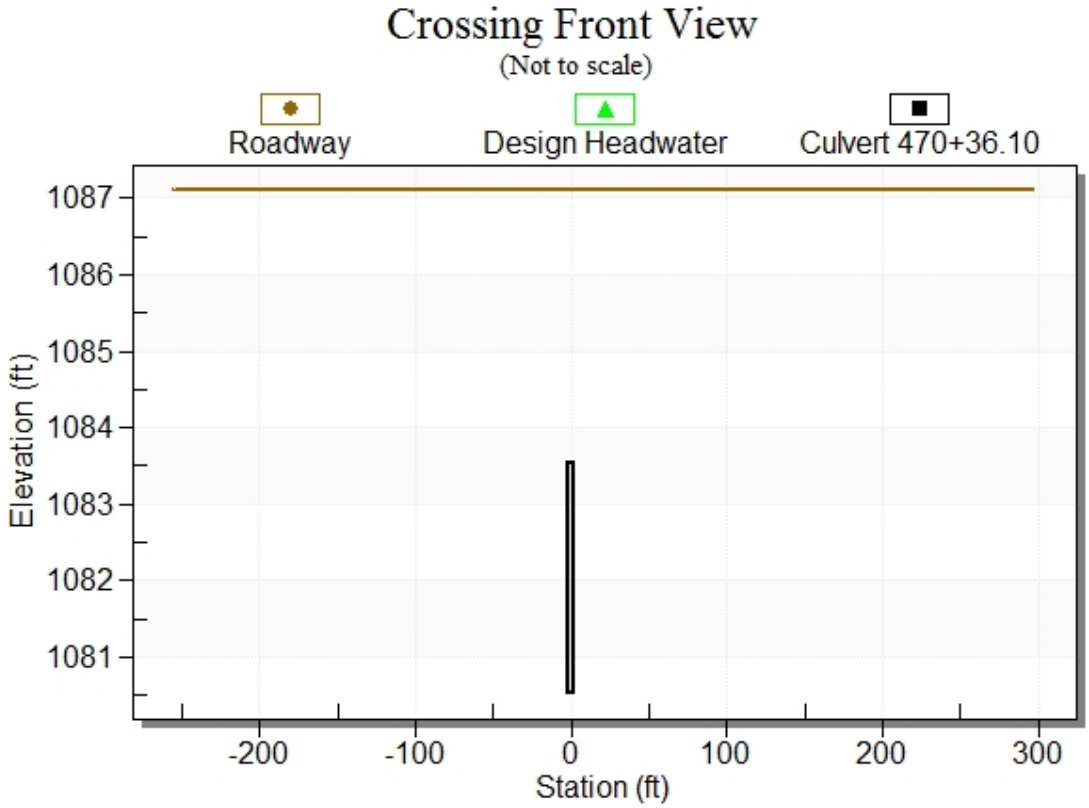


Crossing Front View (Roadway Profile): Crossing 470+36.10



Culvert Notes: Culvert 470+36.10

Table 23 - Culvert Summary Table: Culvert 470+36.10

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	106.67	106.67	1086.00	5.471	0.0*	5-S2n	1.366	2.806	1.375	3.000	19.394	0.000
50 year	119.15	119.15	1086.79	6.263	0.0*	5-S2n	1.478	3.000	1.478	3.000	20.158	0.000
100 year	132.86	124.18	1087.14	6.609	0.0*	5-S2n	1.523	3.000	1.523	3.000	20.387	0.000

* Full Flow Headwater elevation is below inlet invert.

****

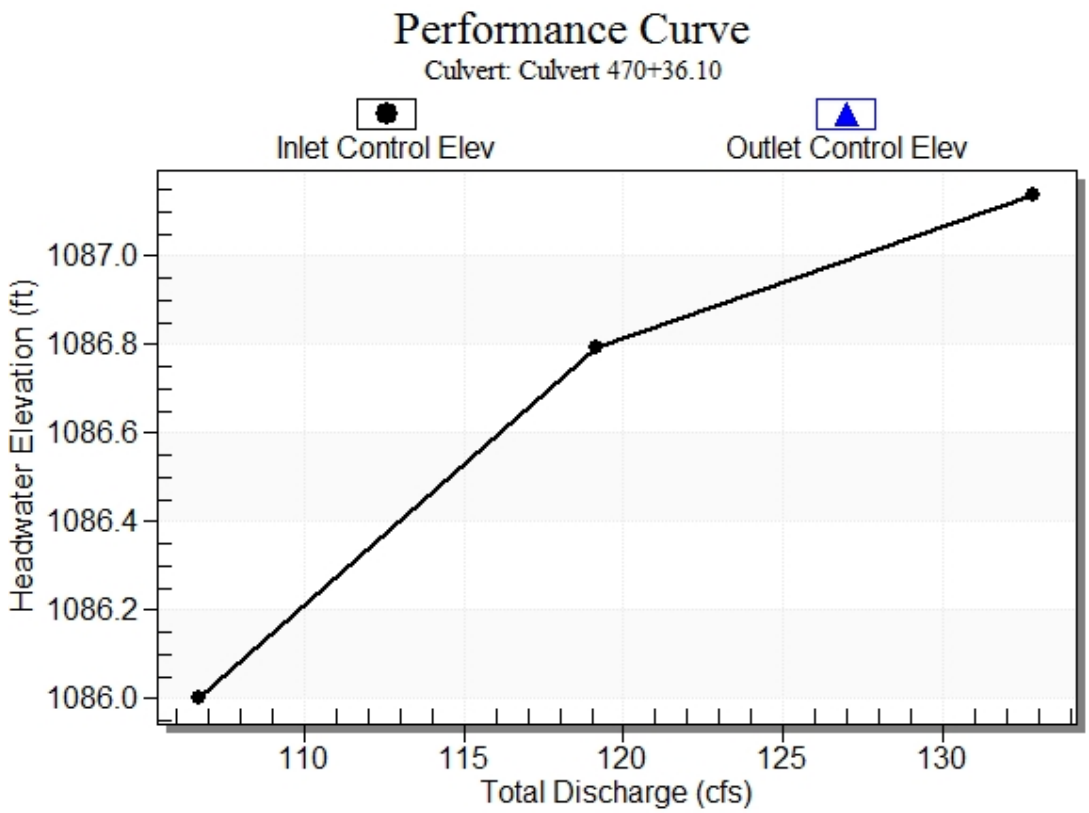
Straight Culvert

Inlet Elevation (invert): 1080.53 ft, Outlet Elevation (invert): 1061.11 ft

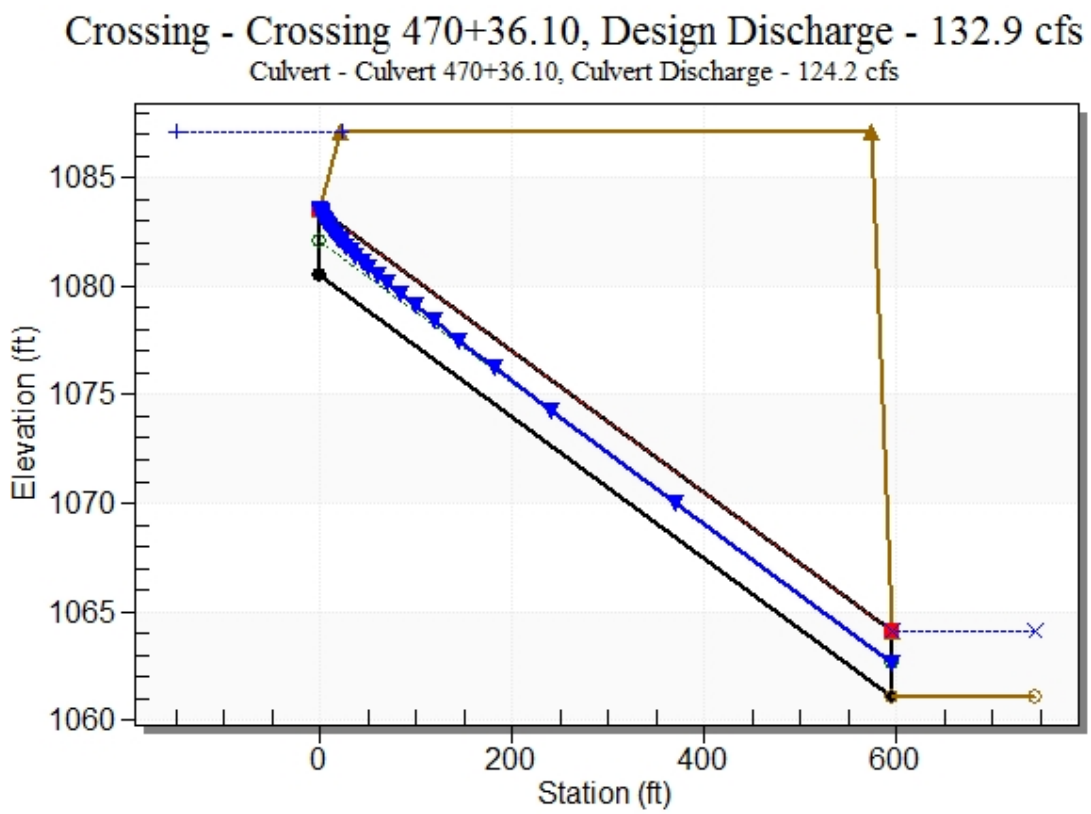
Culvert Length: 595.32 ft, Culvert Slope: 0.0326

****

Culvert Performance Curve Plot: Culvert 470+36.10



Water Surface Profile Plot for Culvert: Culvert 470+36.10



Site Data - Culvert 470+36.10

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1080.53 ft

Outlet Station: 595.00 ft

Outlet Elevation: 1061.11 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 470+36.10

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 24 - Downstream Channel Rating Curve (Crossing: Crossing 470+36.10)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
106.67	1064.11	3.00
119.15	1064.11	3.00
132.86	1064.11	3.00

Tailwater Channel Data - Crossing 470+36.10

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1064.11 ft

Roadway Data for Crossing: Crossing 470+36.10

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-254.52	1087.11
1	0.00	1087.11
2	296.29	1087.11

Roadway Surface: Paved

Roadway Top Width: 550.81 ft

Crossing Notes: Crossing 477+54.11

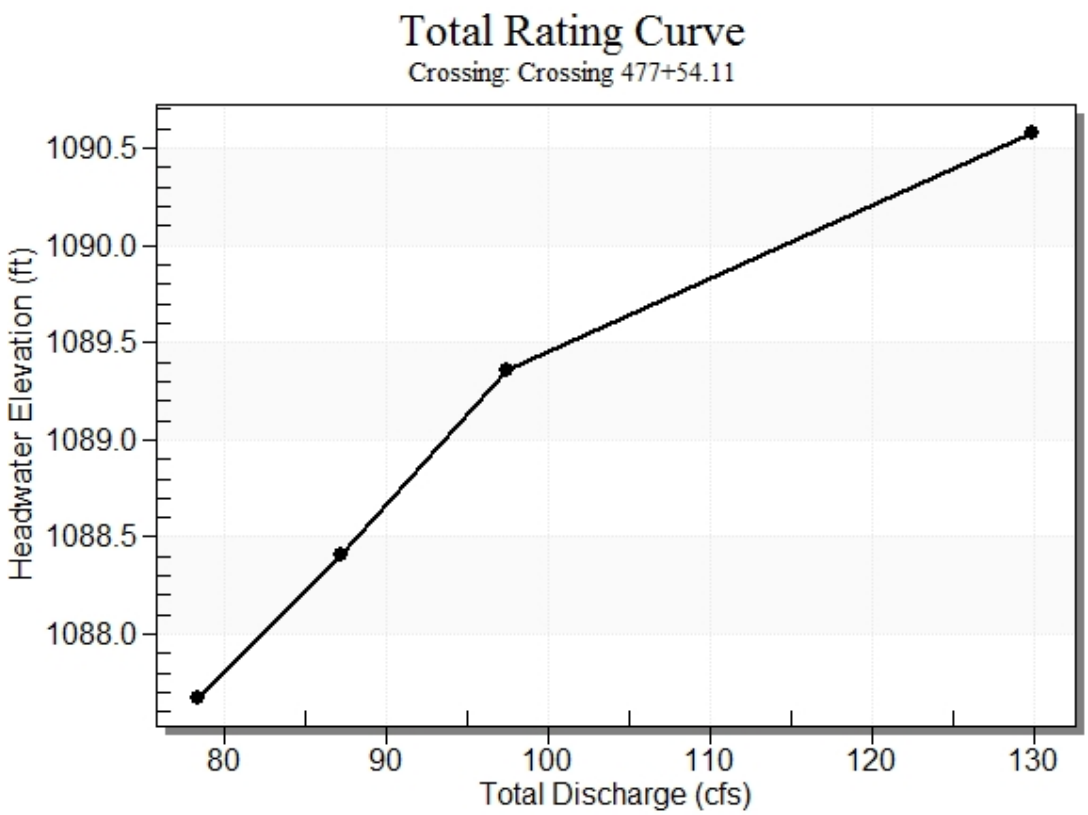
Crossing Discharge Data

Discharge Selection Method: Recurrence

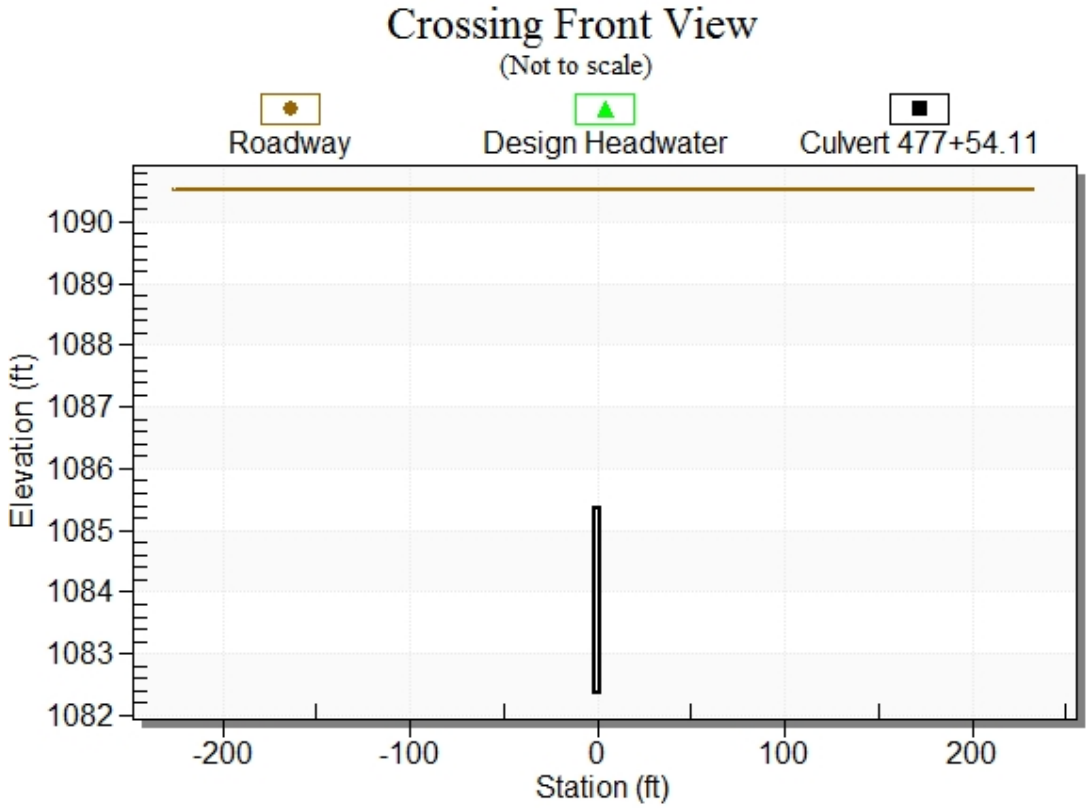
Table 25 - Summary of Culvert Flows at Crossing: Crossing 477+54.11

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 477+54.11 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1087.68	25 year	78.38	78.38	0.00	1
1088.41	50 year	87.23	87.23	0.00	1
1089.35	100 year	97.43	97.43	0.00	1
1090.52	Overtopping	108.56	108.56	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 477+54.11



Crossing Front View (Roadway Profile): Crossing 477+54.11



Culvert Notes: Culvert 477+54.11

Table 26 - Culvert Summary Table: Culvert 477+54.11

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	78.38	78.38	1087.68	5.317	0.0*	5-S2n	1.217	2.768	1.217	3.000	21.468	0.000
50 year	87.23	87.23	1088.41	6.047	0.0*	5-S2n	1.319	2.972	1.319	3.000	22.045	0.000
100 year	97.43	97.43	1089.35	6.995	0.0*	5-S2n	1.431	3.000	1.431	3.000	22.702	0.000

* Full Flow Headwater elevation is below inlet invert.

****

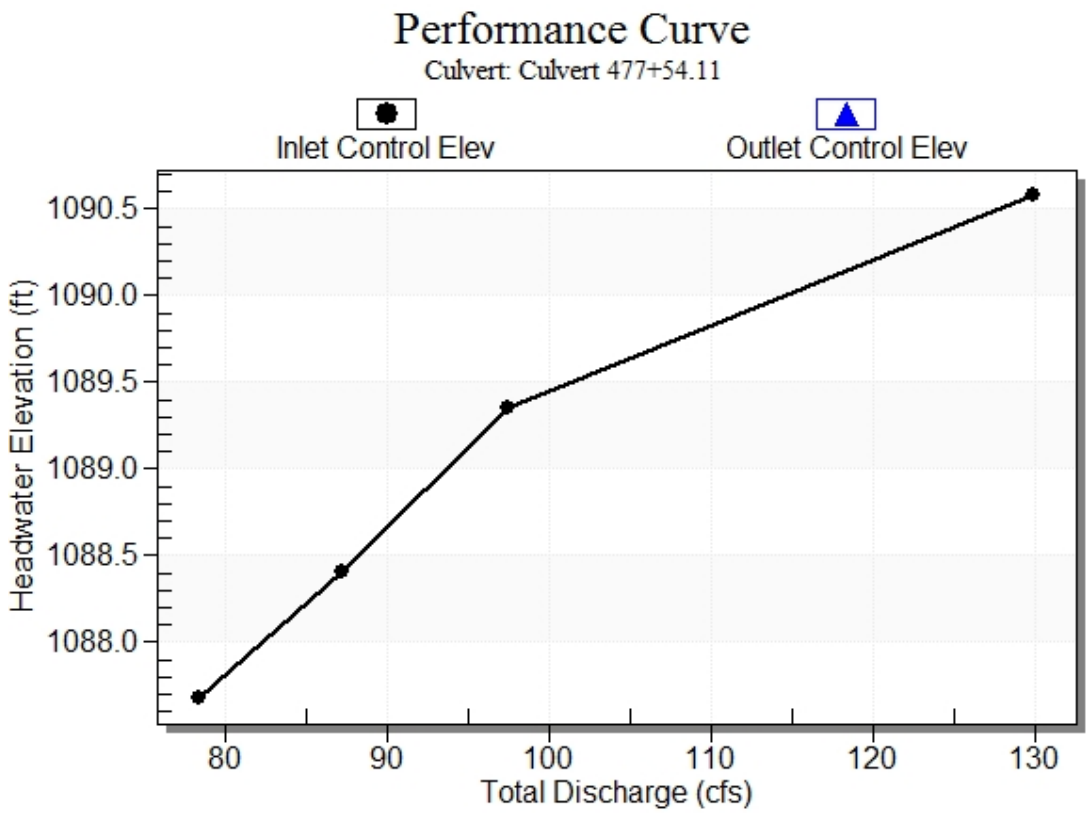
Straight Culvert

Inlet Elevation (invert): 1082.36 ft, Outlet Elevation (invert): 1057.08 ft

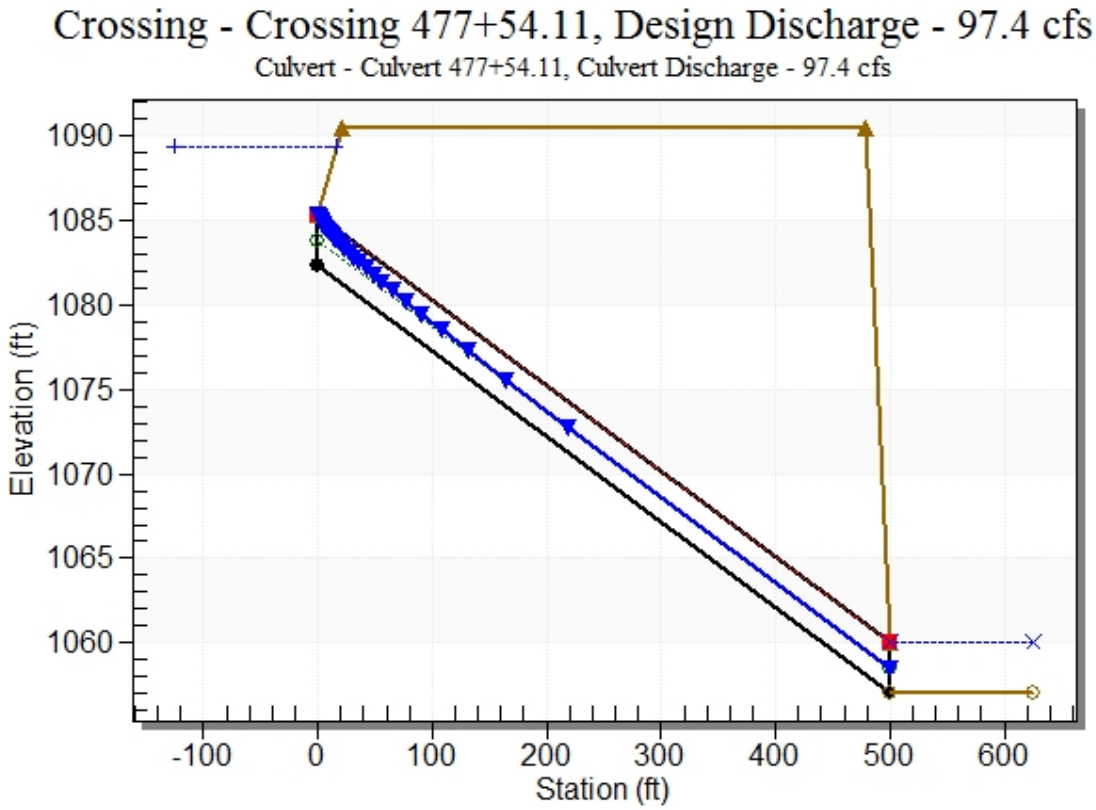
Culvert Length: 500.64 ft, Culvert Slope: 0.0506

****

Culvert Performance Curve Plot: Culvert 477+54.11



Water Surface Profile Plot for Culvert: Culvert 477+54.11



Site Data - Culvert 477+54.11

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1082.36 ft

Outlet Station: 500.00 ft

Outlet Elevation: 1057.08 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 477+54.11

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 27 - Downstream Channel Rating Curve (Crossing: Crossing 477+54.11)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
78.38	1060.08	3.00
87.23	1060.08	3.00
97.43	1060.08	3.00

Tailwater Channel Data - Crossing 477+54.11

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1060.08 ft

Roadway Data for Crossing: Crossing 477+54.11

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-225.56	1090.52
1	0.00	1090.52
2	232.26	1090.52

Roadway Surface: Paved

Roadway Top Width: 457.82 ft

Crossing Notes: Crossing 483+43.48

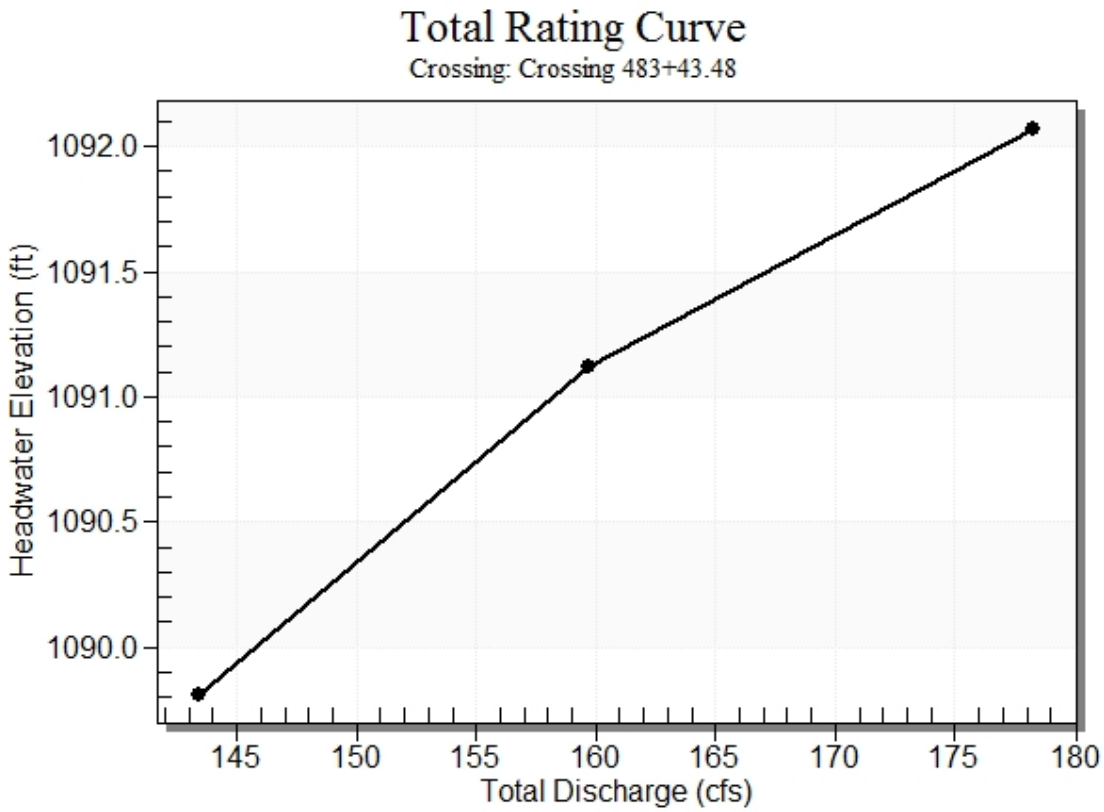
Crossing Discharge Data

Discharge Selection Method: Recurrence

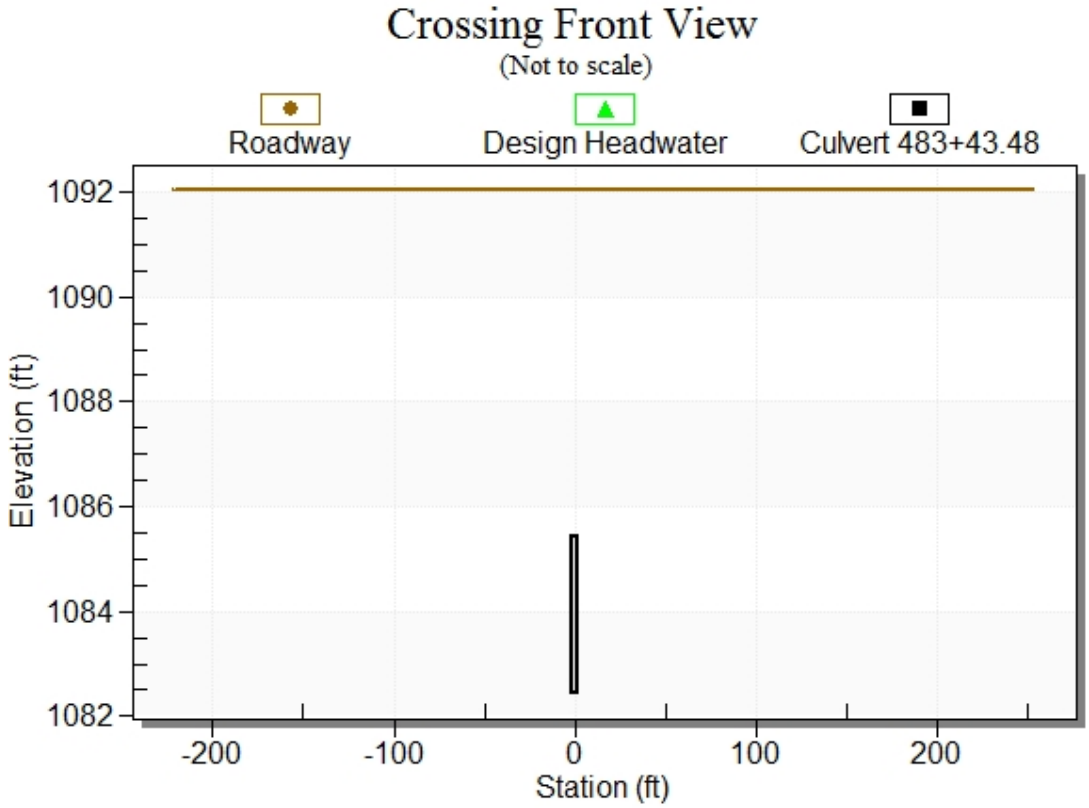
Table 28 - Summary of Culvert Flows at Crossing: Crossing 483+43.48

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 483+43.48 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1089.81	25 year	143.39	143.39	0.00	1
1091.12	50 year	159.68	159.68	0.00	1
1092.07	100 year	178.30	170.09	8.05	11
1092.04	Overtopping	169.75	169.75	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 483+43.48



Crossing Front View (Roadway Profile): Crossing 483+43.48



Culvert Notes: Culvert 483+43.48

Table 29 - Culvert Summary Table: Culvert 483+43.48

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	143.39	143.39	1089.81	7.373	0.0*	5-S2n	1.536	3.000	1.536	2.230	23.337	0.000
50 year	159.68	159.68	1091.12	8.683	0.0*	5-S2n	1.664	3.000	1.693	2.230	23.578	0.000
100 year	178.30	170.09	1092.07	9.632	0.0*	5-S2n	1.742	3.000	1.766	2.230	24.080	0.000

* Full Flow Headwater elevation is below inlet invert.

****

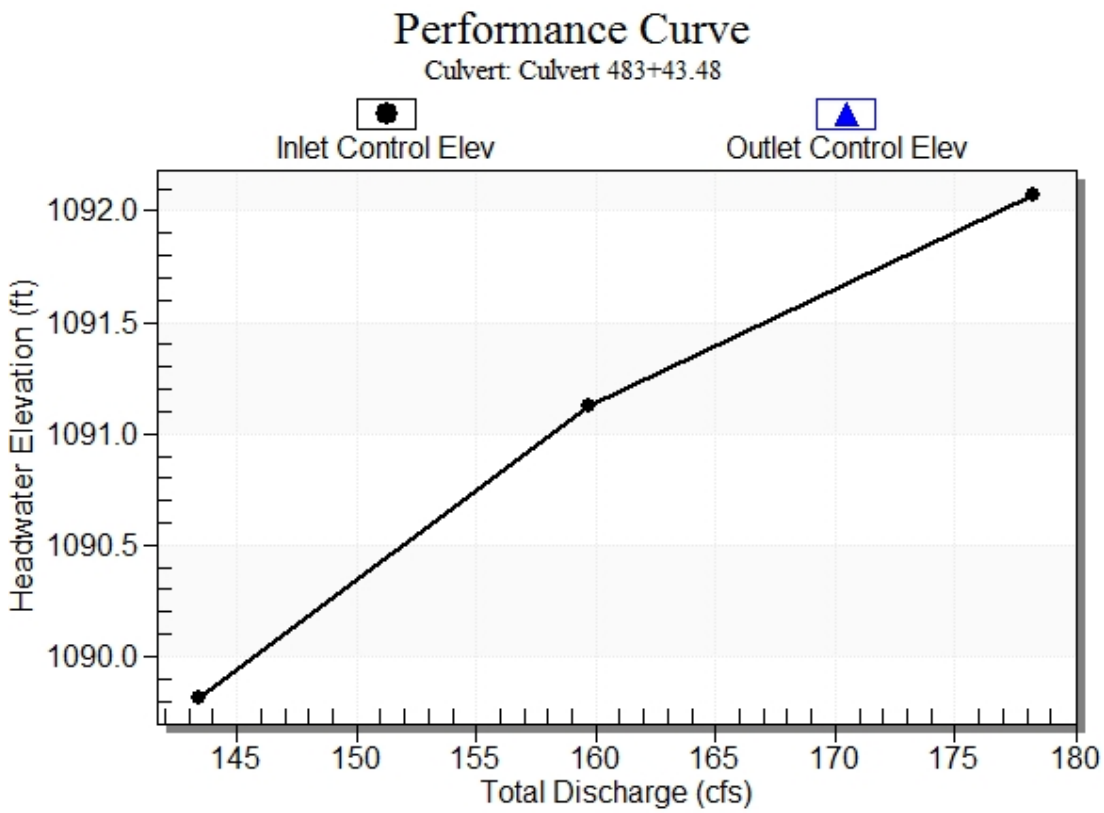
Straight Culvert

Inlet Elevation (invert): 1082.44 ft, Outlet Elevation (invert): 1060.98 ft

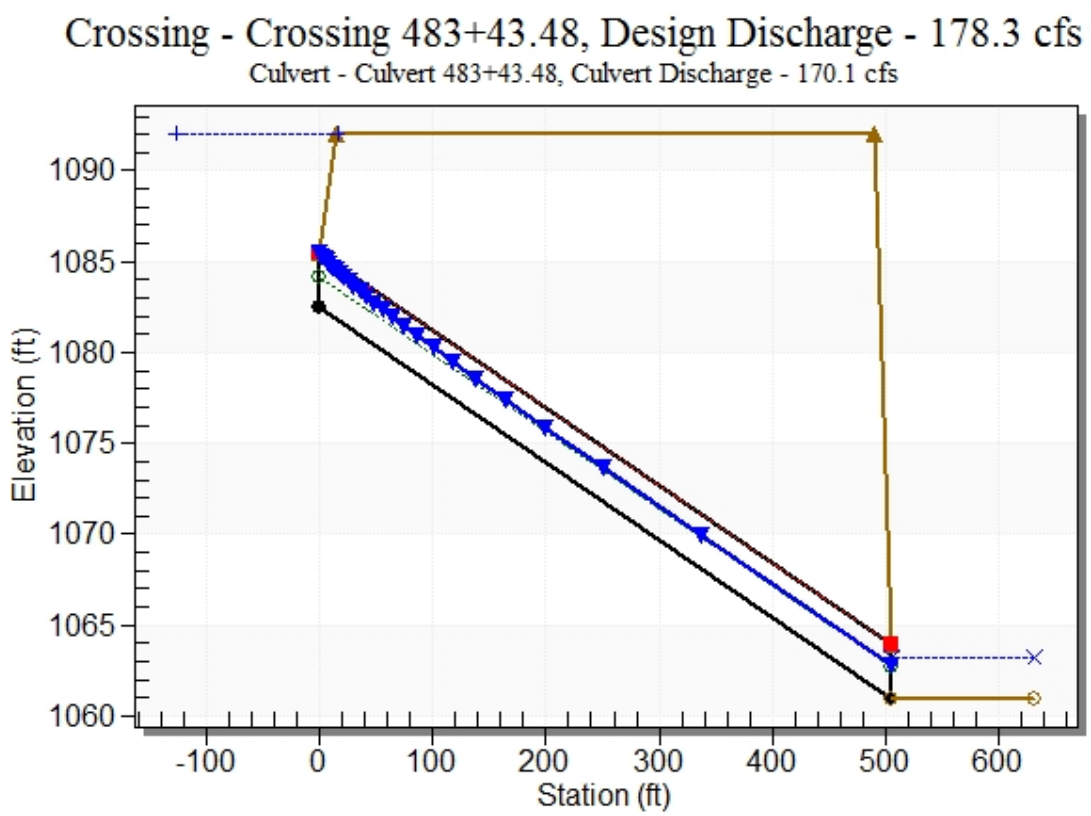
Culvert Length: 505.46 ft, Culvert Slope: 0.0425

****

Culvert Performance Curve Plot: Culvert 483+43.48



Water Surface Profile Plot for Culvert: Culvert 483+43.48



Site Data - Culvert 483+43.48

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1082.44 ft

Outlet Station: 505.00 ft

Outlet Elevation: 1060.98 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 483+43.48

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (30-75º flare) Wingwall

Inlet Depression: NONE

Table 30 - Downstream Channel Rating Curve (Crossing: Crossing 483+43.48)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
143.39	1063.21	2.23
159.68	1063.21	2.23
178.30	1063.21	2.23

Tailwater Channel Data - Crossing 483+43.48

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1063.21 ft

Roadway Data for Crossing: Crossing 483+43.48

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-221.00	1092.04
1	0.00	1092.04
2	253.14	1092.04

Roadway Surface: Paved

Roadway Top Width: 474.14 ft

Crossing Notes: Crossing 490+30.80

Crossing Discharge Data

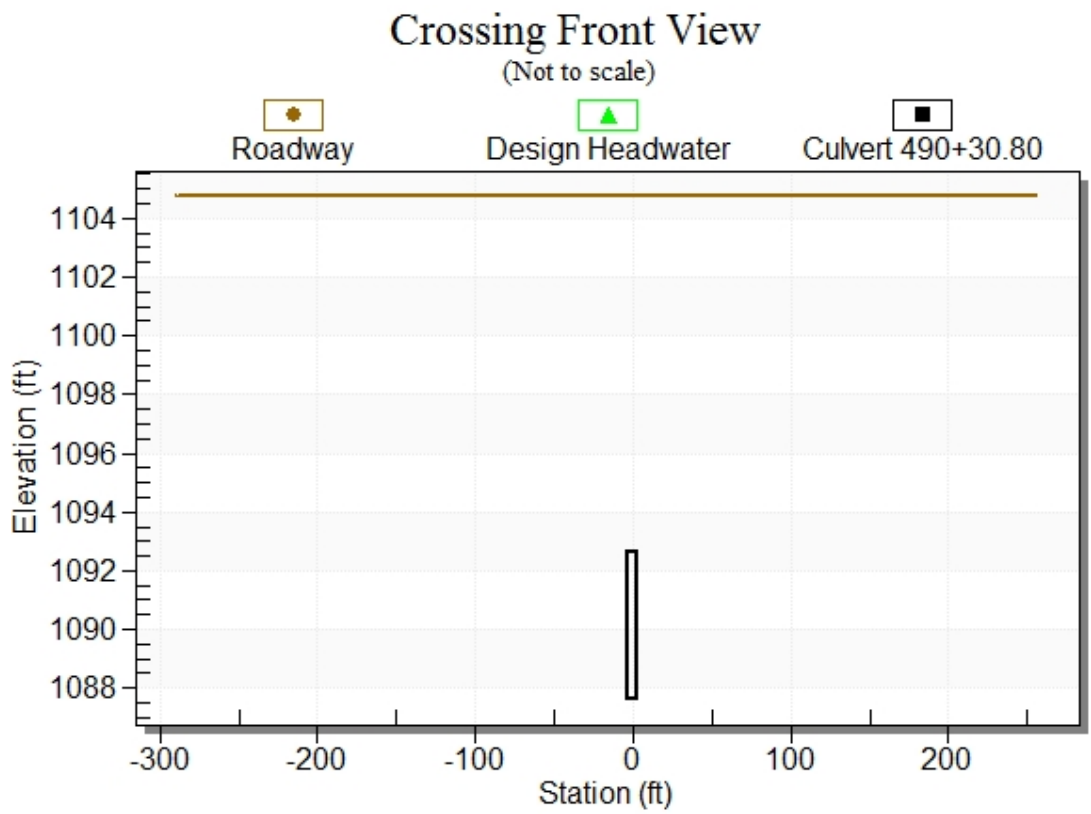
Discharge Selection Method: Recurrence

Table 31 - Summary of Culvert Flows at Crossing: Crossing 490+30.80

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 490+30.80 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1094.18	25 year	248.75	248.75	0.00	1
1094.93	50 year	279.62	279.62	0.00	1
1095.76	100 year	310.88	310.88	0.00	1
1104.77	Overtopping	538.75	538.75	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 490+30.80

Crossing Front View (Roadway Profile): Crossing 490+30.80



Culvert Notes: Culvert 490+30.80

Table 32 - Culvert Summary Table: Culvert 490+30.80

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	248.75	248.75	1094.18	6.564	0.0*	5-S2n	1.741	3.765	1.771	5.000	23.414	0.000
50 year	279.62	279.62	1094.93	7.311	0.0*	5-S2n	1.889	4.071	1.933	5.000	24.112	0.000
100 year	310.88	310.88	1095.76	8.141	0.0*	5-S2n	2.038	4.369	2.095	5.000	24.738	0.000

* Full Flow Headwater elevation is below inlet invert.

****

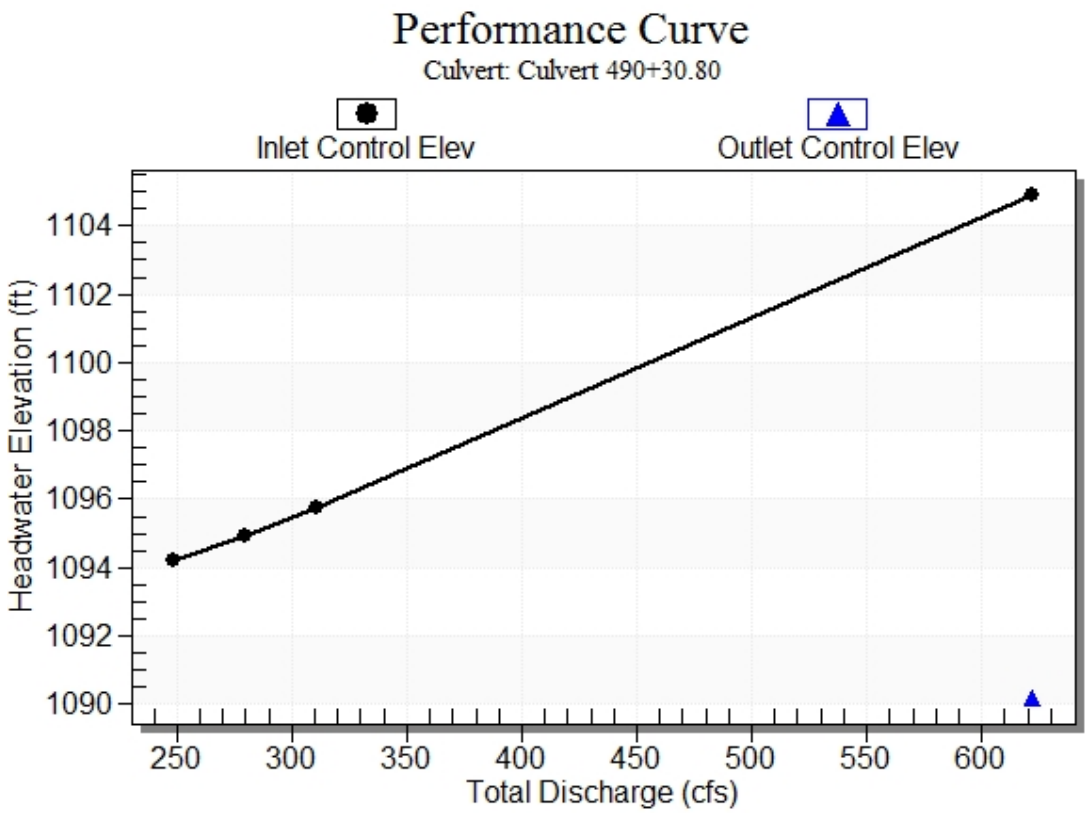
Straight Culvert

Inlet Elevation (invert): 1087.62 ft, Outlet Elevation (invert): 1069.94 ft

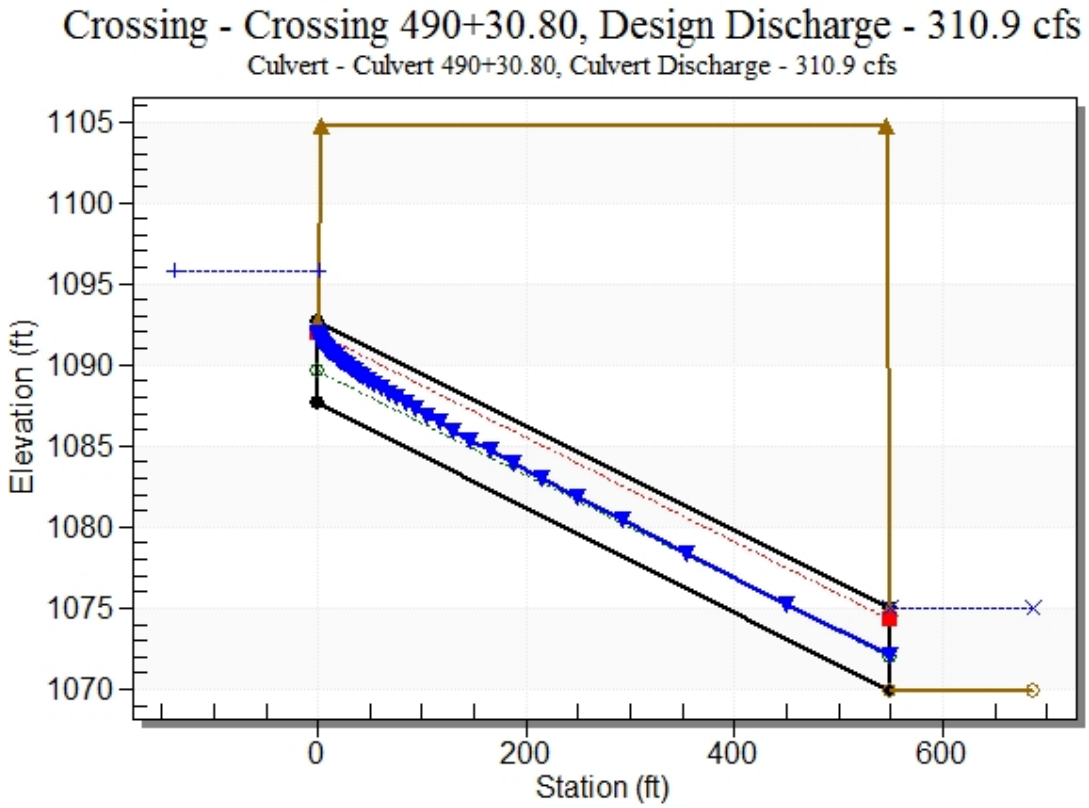
Culvert Length: 549.28 ft, Culvert Slope: 0.0322

****

Culvert Performance Curve Plot: Culvert 490+30.80



Water Surface Profile Plot for Culvert: Culvert 490+30.80



Site Data - Culvert 490+30.80

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1087.62 ft

Outlet Station: 549.00 ft

Outlet Elevation: 1069.94 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 490+30.80

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 33 - Downstream Channel Rating Curve (Crossing: Crossing 490+30.80)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
248.75	1074.94	5.00
279.62	1074.94	5.00
310.88	1074.94	5.00

Tailwater Channel Data - Crossing 490+30.80

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1074.94 ft

Roadway Data for Crossing: Crossing 490+30.80

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-288.47	1104.77
1	0.00	1104.77
2	255.19	1104.77

Roadway Surface: Paved

Roadway Top Width: 543.66 ft

Crossing Notes: Crossing 513+20.14

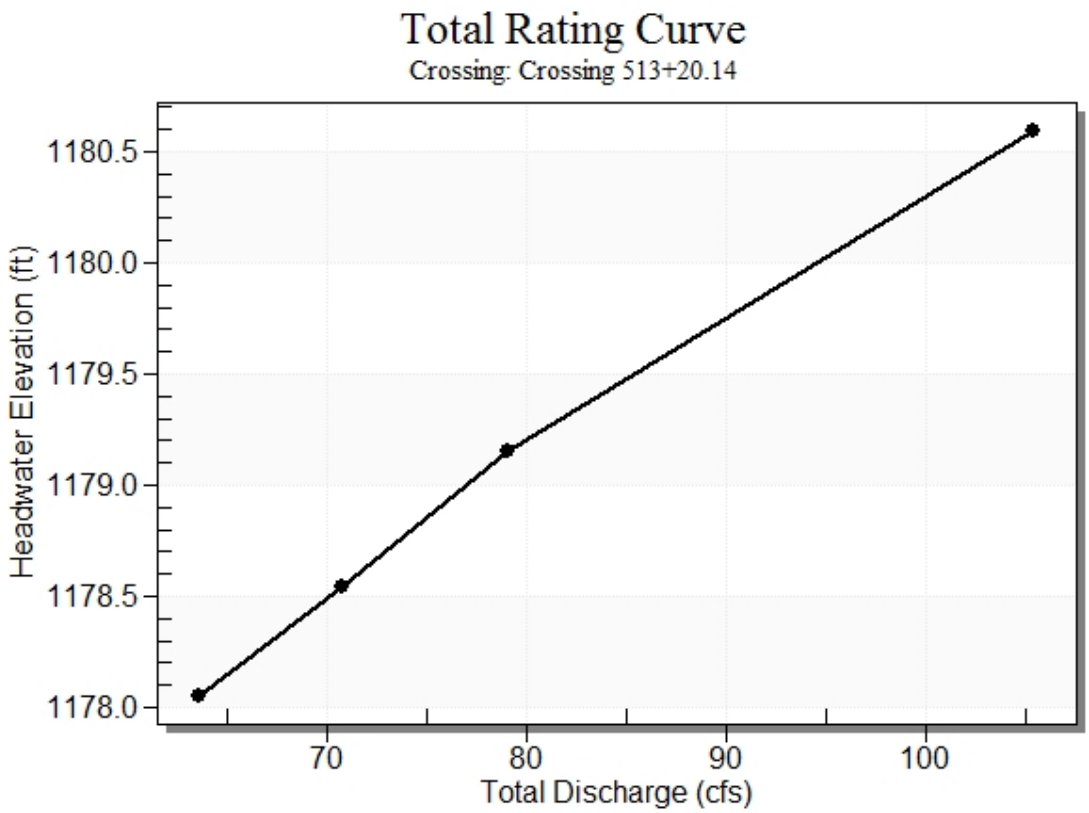
Crossing Discharge Data

Discharge Selection Method: Recurrence

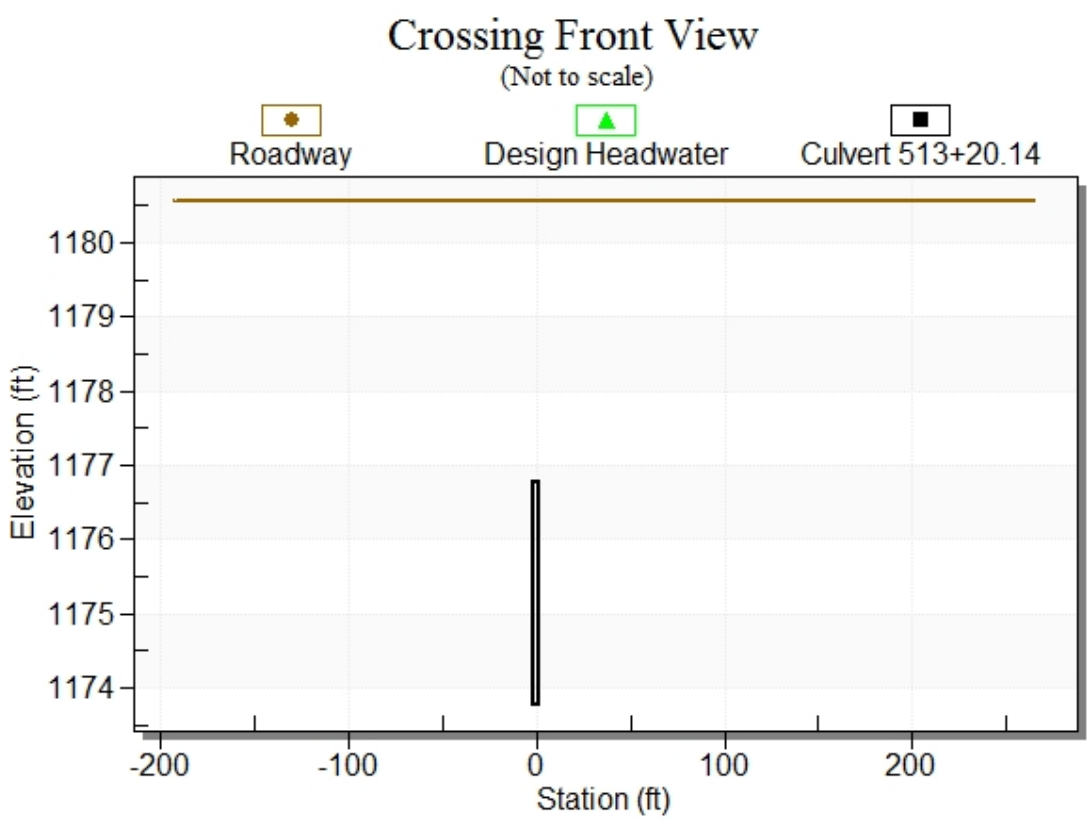
Table 34 - Summary of Culvert Flows at Crossing: Crossing 513+20.14

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 513+20.14 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1178.05	25 year	63.57	63.57	0.00	1
1178.54	50 year	70.78	70.78	0.00	1
1179.15	100 year	79.04	79.04	0.00	1
1180.56	Overtopping	95.15	95.15	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 513+20.14



Crossing Front View (Roadway Profile): Crossing 513+20.14



Culvert Notes: Culvert 513+20.14

Table 35 - Culvert Summary Table: Culvert 513+20.14

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	63.57	63.57	1178.05	4.285	0.0*	5-S2n	1.142	2.407	1.142	3.000	18.559	0.000
50 year	70.78	70.78	1178.54	4.770	0.0*	5-S2n	1.236	2.586	1.236	3.000	19.094	0.000
100 year	79.04	79.04	1179.15	5.385	0.0*	5-S2n	1.343	2.783	1.350	3.000	19.516	0.000

* Full Flow Headwater elevation is below inlet invert.

****

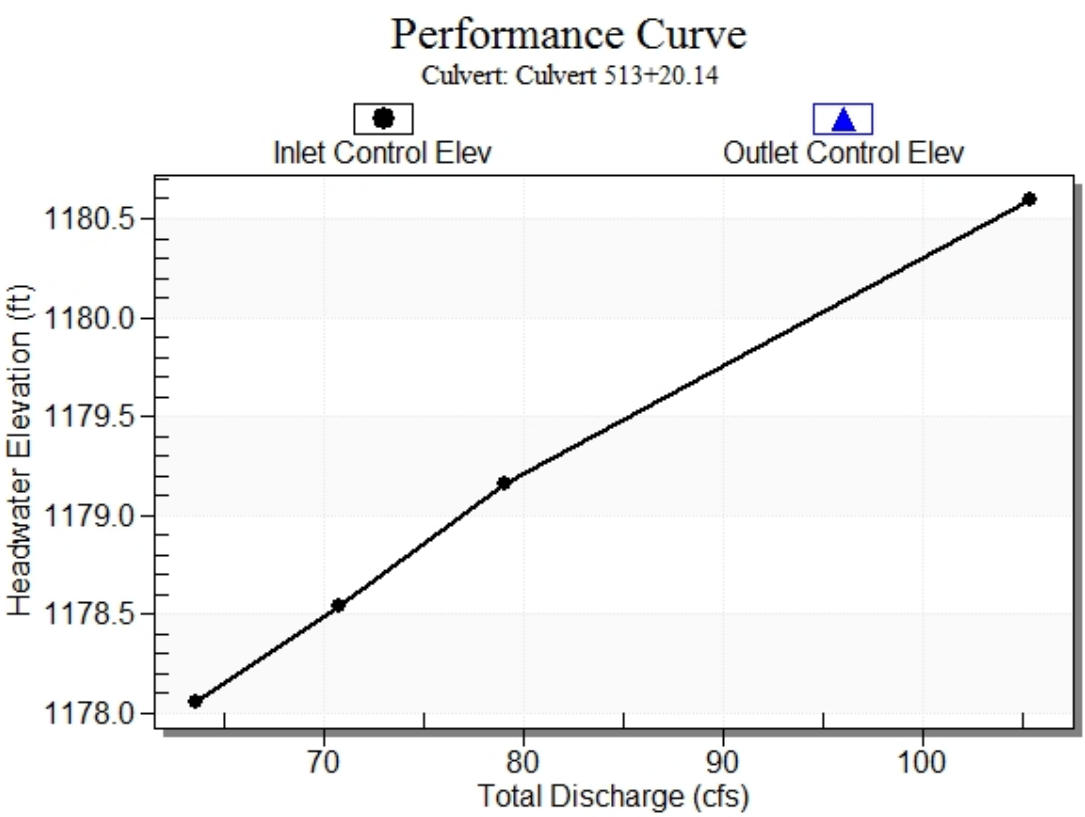
Straight Culvert

Inlet Elevation (invert): 1173.77 ft, Outlet Elevation (invert): 1154.06 ft

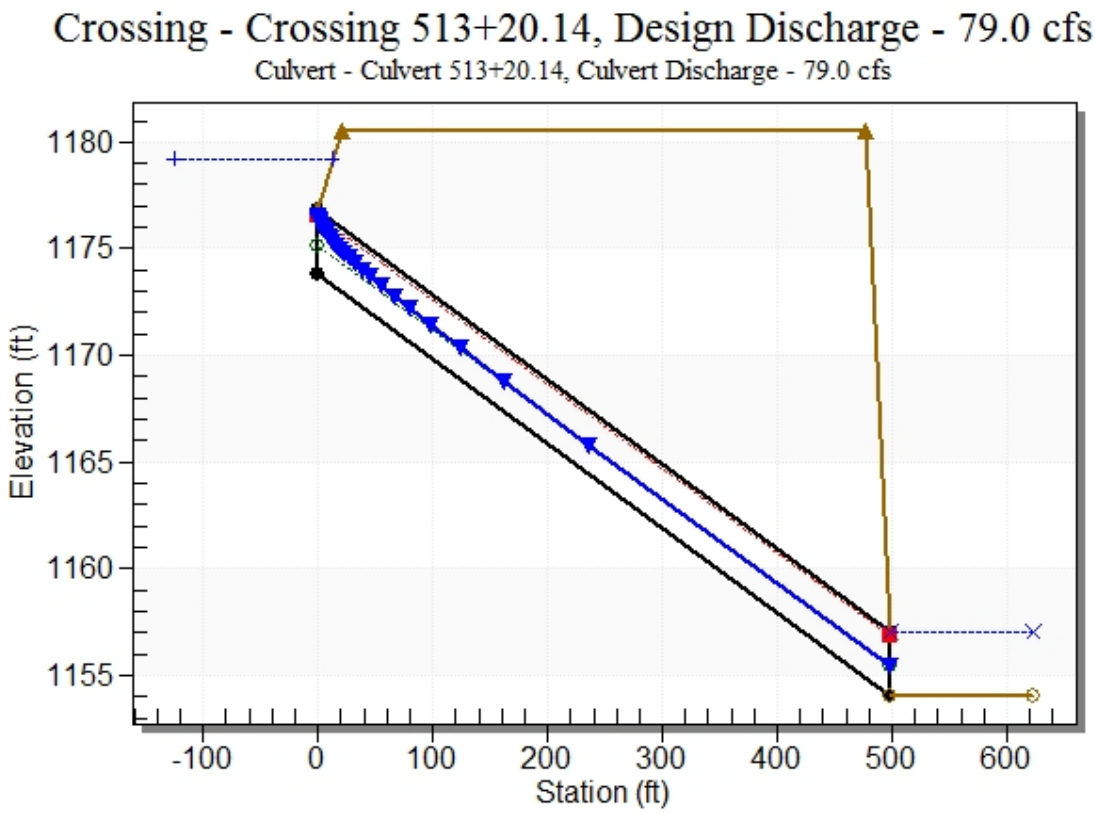
Culvert Length: 498.39 ft, Culvert Slope: 0.0396

****

Culvert Performance Curve Plot: Culvert 513+20.14



Water Surface Profile Plot for Culvert: Culvert 513+20.14



Site Data - Culvert 513+20.14

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1173.77 ft

Outlet Station: 498.00 ft

Outlet Elevation: 1154.06 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 513+20.14

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 36 - Downstream Channel Rating Curve (Crossing: Crossing 513+20.14)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
63.57	1157.06	3.00
70.78	1157.06	3.00
79.04	1157.06	3.00

Tailwater Channel Data - Crossing 513+20.14

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1157.06 ft

Roadway Data for Crossing: Crossing 513+20.14

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-192.11	1180.56
1	0.00	1180.56
2	264.53	1180.56

Roadway Surface: Paved

Roadway Top Width: 456.64 ft

Crossing Notes: Crossing 528+79.40

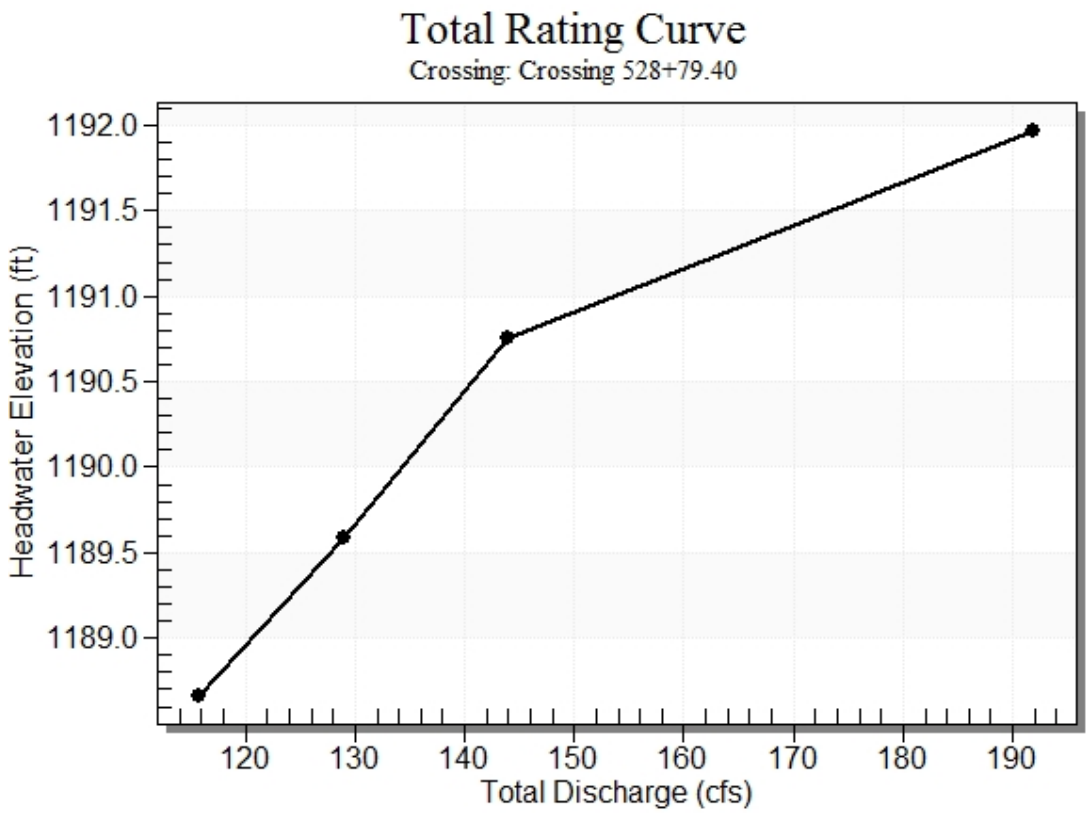
Crossing Discharge Data

Discharge Selection Method: Recurrence

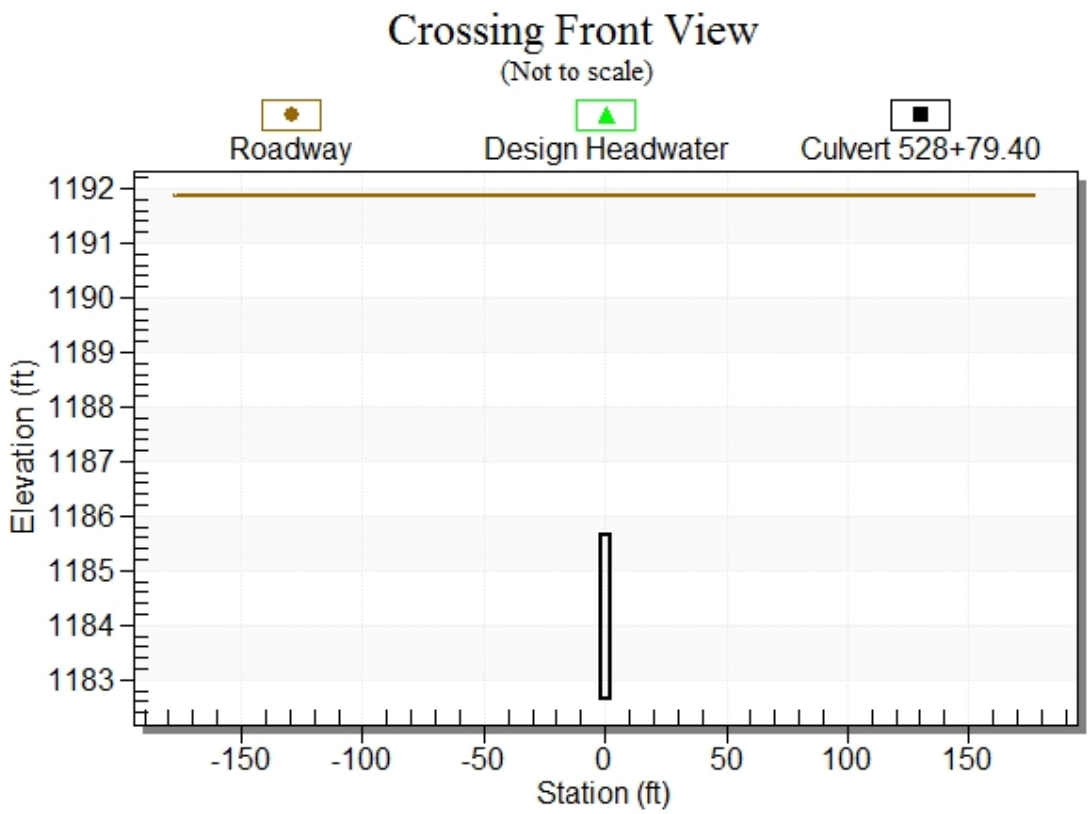
Table 37 - Summary of Culvert Flows at Crossing: Crossing 528+79.40

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 528+79.40 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1188.67	25 year	115.70	115.70	0.00	1
1189.58	50 year	128.97	128.97	0.00	1
1190.75	100 year	143.95	143.95	0.00	1
1191.87	Overtopping	156.63	156.63	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 528+79.40



Crossing Front View (Roadway Profile): Crossing 528+79.40



Culvert Notes: Culvert 528+79.40

Table 38 - Culvert Summary Table: Culvert 528+79.40

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	115.70	115.70	1188.67	6.027	0.0*	5-S2n	1.374	2.962	1.404	3.000	20.595	0.000
50 year	128.97	128.97	1189.58	6.945	0.0*	5-S2n	1.484	3.000	1.513	3.000	21.310	0.000
100 year	143.95	143.95	1190.75	8.113	0.0*	5-S2n	1.609	3.000	1.646	3.000	21.861	0.000

* Full Flow Headwater elevation is below inlet invert.

****

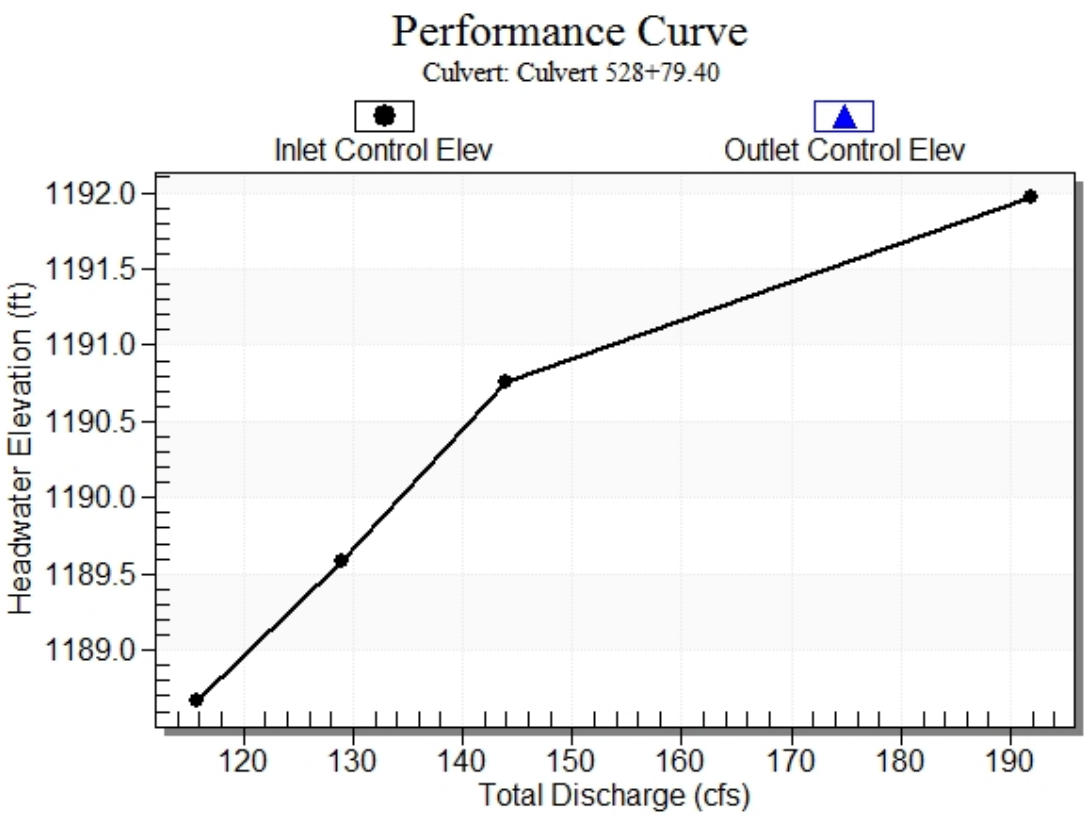
Straight Culvert

Inlet Elevation (invert): 1182.64 ft, Outlet Elevation (invert): 1167.90 ft

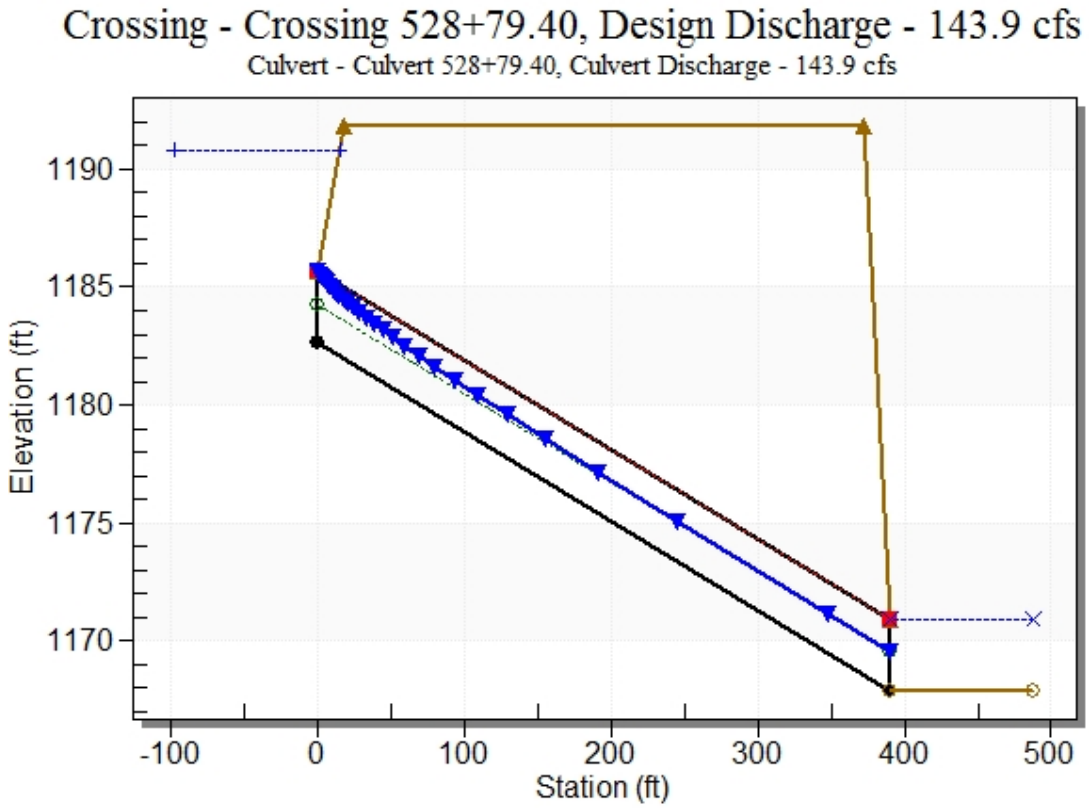
Culvert Length: 390.28 ft, Culvert Slope: 0.0378

****

Culvert Performance Curve Plot: Culvert 528+79.40



Water Surface Profile Plot for Culvert: Culvert 528+79.40



Site Data - Culvert 528+79.40

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1182.64 ft

Outlet Station: 390.00 ft

Outlet Elevation: 1167.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 528+79.40

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 39 - Downstream Channel Rating Curve (Crossing: Crossing 528+79.40)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
115.70	1170.90	3.00
128.97	1170.90	3.00
143.95	1170.90	3.00

Tailwater Channel Data - Crossing 528+79.40

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1170.90 ft

Roadway Data for Crossing: Crossing 528+79.40

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-177.03	1191.87
1	0.00	1191.87
2	176.81	1191.87

Roadway Surface: Paved

Roadway Top Width: 353.84 ft

Crossing Notes: Crossing 588+46.24

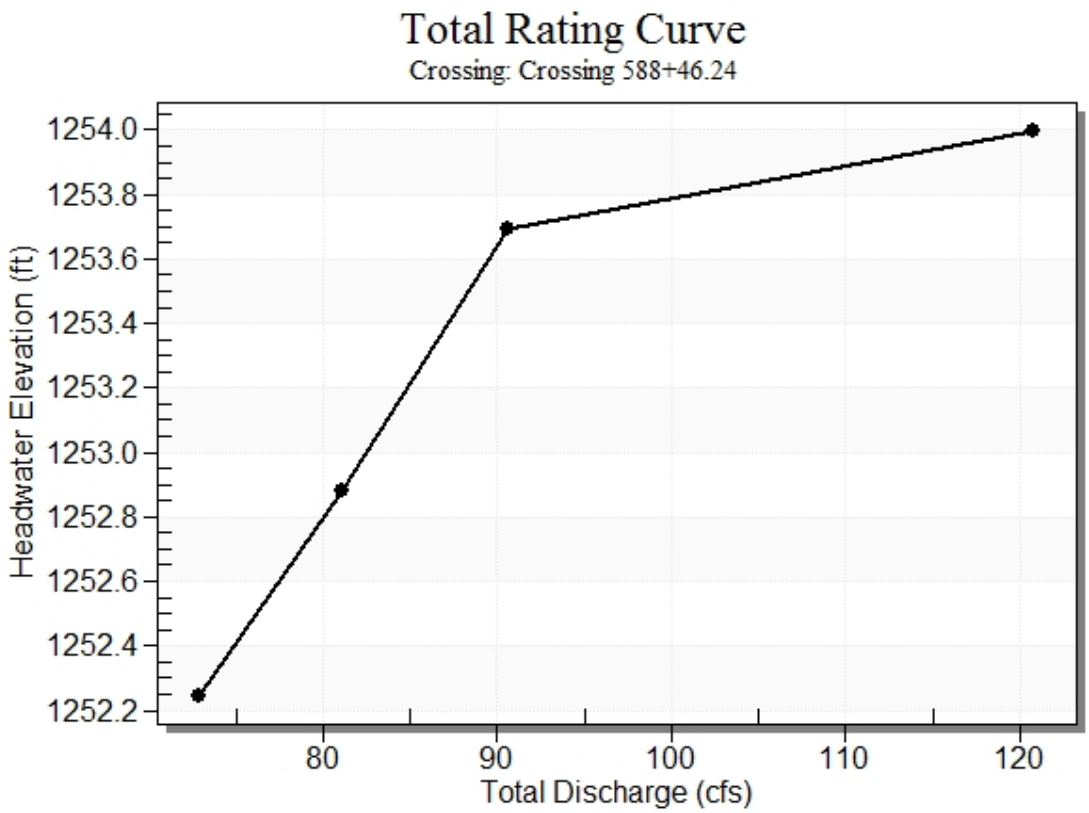
Crossing Discharge Data

Discharge Selection Method: Recurrence

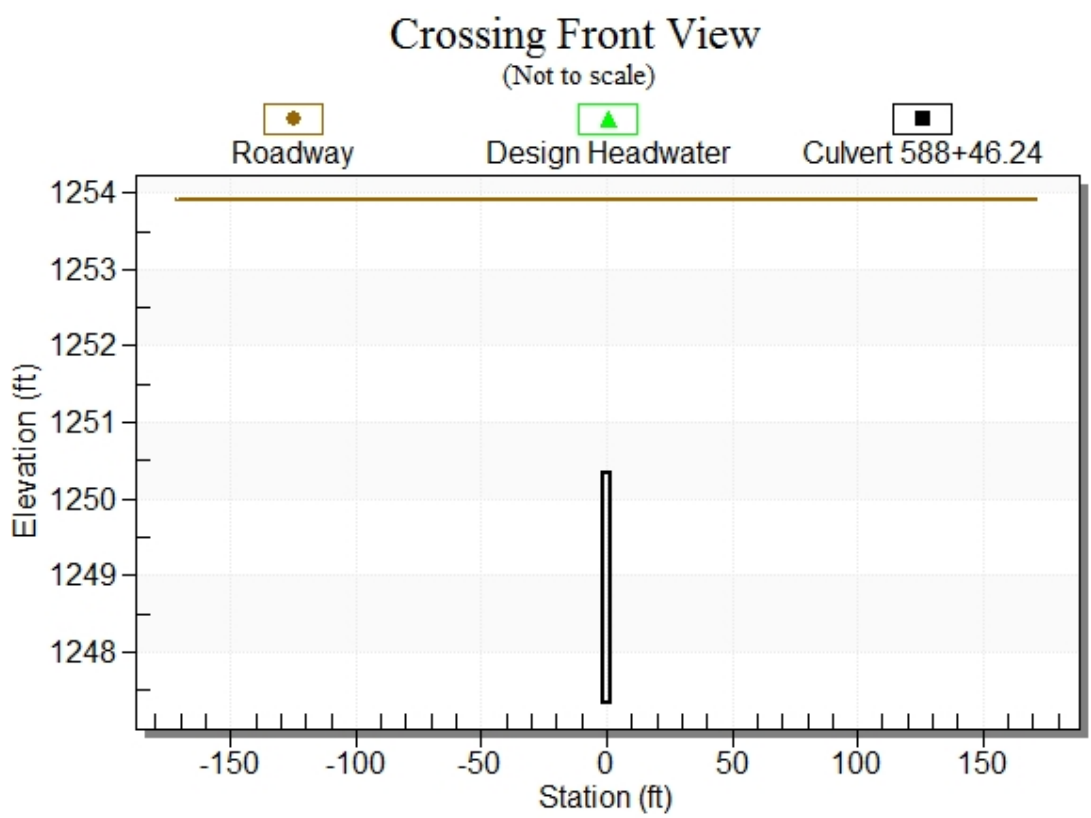
Table 40 - Summary of Culvert Flows at Crossing: Crossing 588+46.24

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 588+46.24 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1252.25	25 year	72.85	72.85	0.00	1
1252.88	50 year	81.15	81.15	0.00	1
1253.69	100 year	90.60	90.60	0.00	1
1253.91	Overtopping	92.94	92.94	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 588+46.24



Crossing Front View (Roadway Profile): Crossing 588+46.24



Culvert Notes: Culvert 588+46.24

Table 41 - Culvert Summary Table: Culvert 588+46.24

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	72.85	72.85	1252.25	4.917	0.0*	5-S2n	1.257	2.636	1.257	3.000	19.314	0.000
50 year	81.15	81.15	1252.88	5.552	0.0*	5-S2n	1.363	2.832	1.363	3.000	19.846	0.000
100 year	90.60	90.60	1253.69	6.363	0.0*	5-S2n	1.478	3.000	1.478	3.000	20.428	0.000

* Full Flow Headwater elevation is below inlet invert.

****

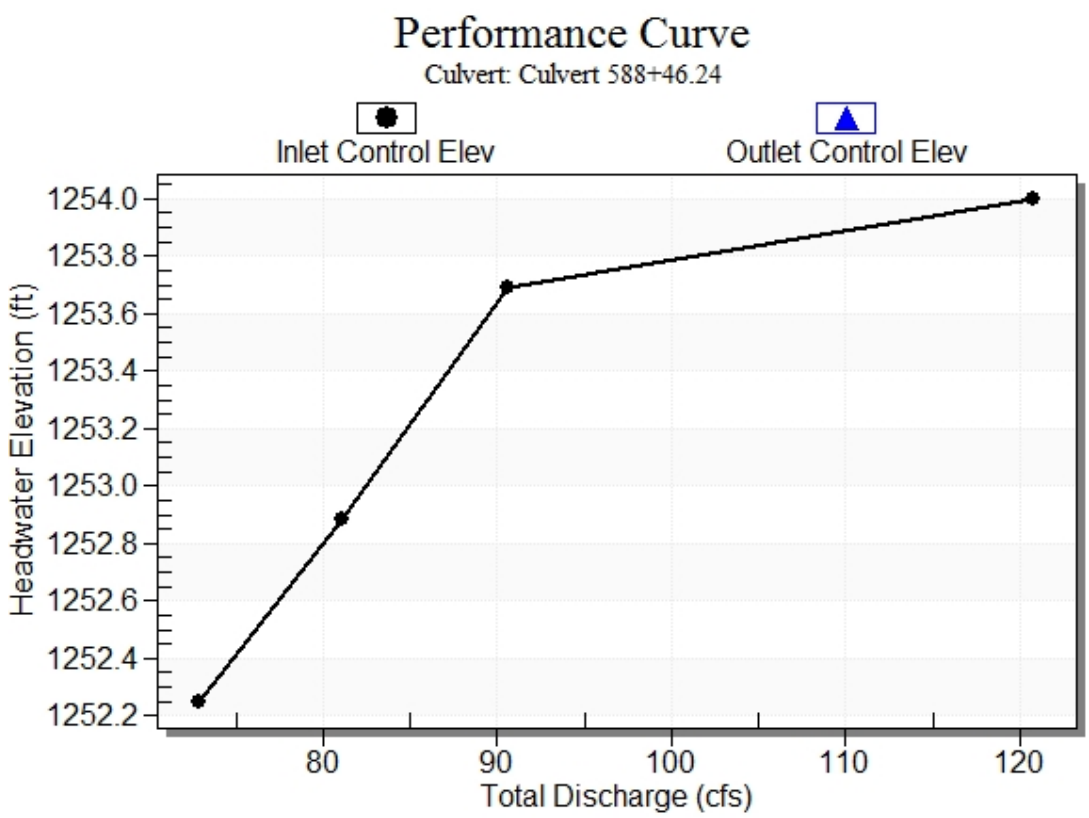
Straight Culvert

Inlet Elevation (invert): 1247.33 ft, Outlet Elevation (invert): 1231.96 ft

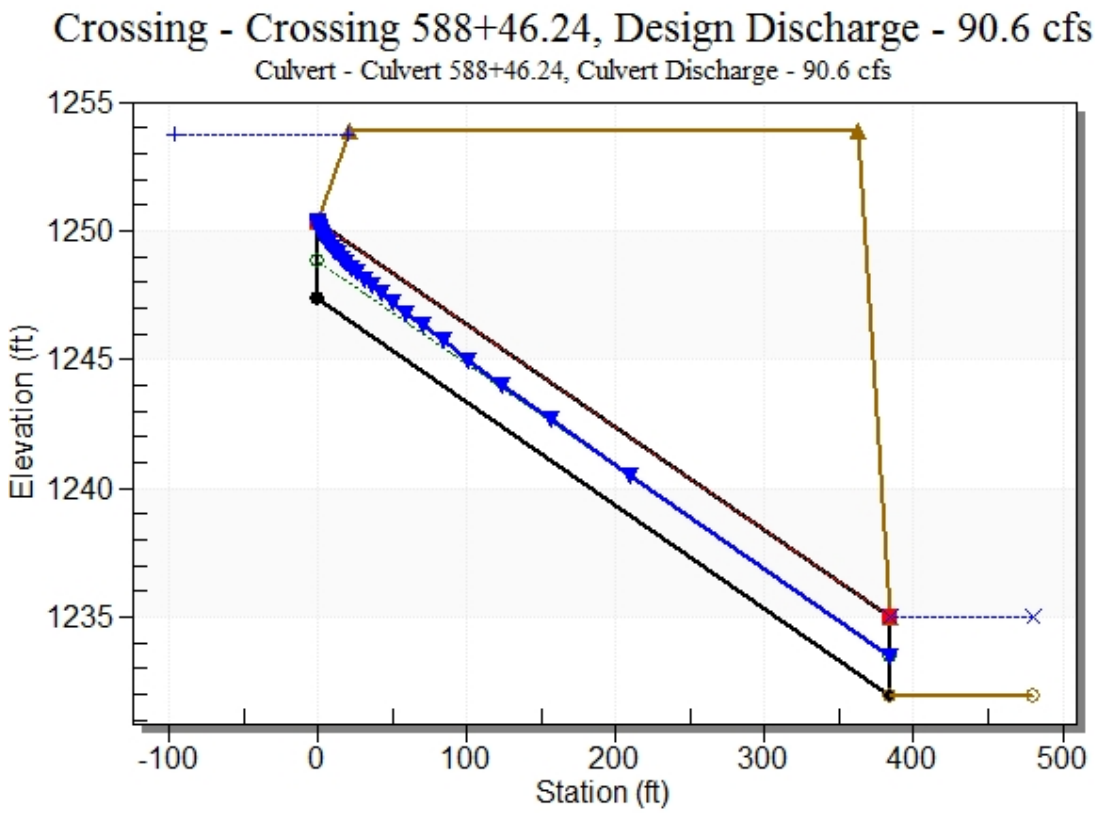
Culvert Length: 384.31 ft, Culvert Slope: 0.0400

****

Culvert Performance Curve Plot: Culvert 588+46.24



Water Surface Profile Plot for Culvert: Culvert 588+46.24



Site Data - Culvert 588+46.24

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1247.33 ft

Outlet Station: 384.00 ft

Outlet Elevation: 1231.96 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 588+46.24

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 42 - Downstream Channel Rating Curve (Crossing: Crossing 588+46.24)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
72.85	1234.96	3.00
81.15	1234.96	3.00
90.60	1234.96	3.00

Tailwater Channel Data - Crossing 588+46.24

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1234.96 ft

Roadway Data for Crossing: Crossing 588+46.24

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-171.00	1253.91
1	0.00	1253.91
2	171.00	1253.91

Roadway Surface: Paved

Roadway Top Width: 342.00 ft

Crossing Notes: Crossing 617+86.47

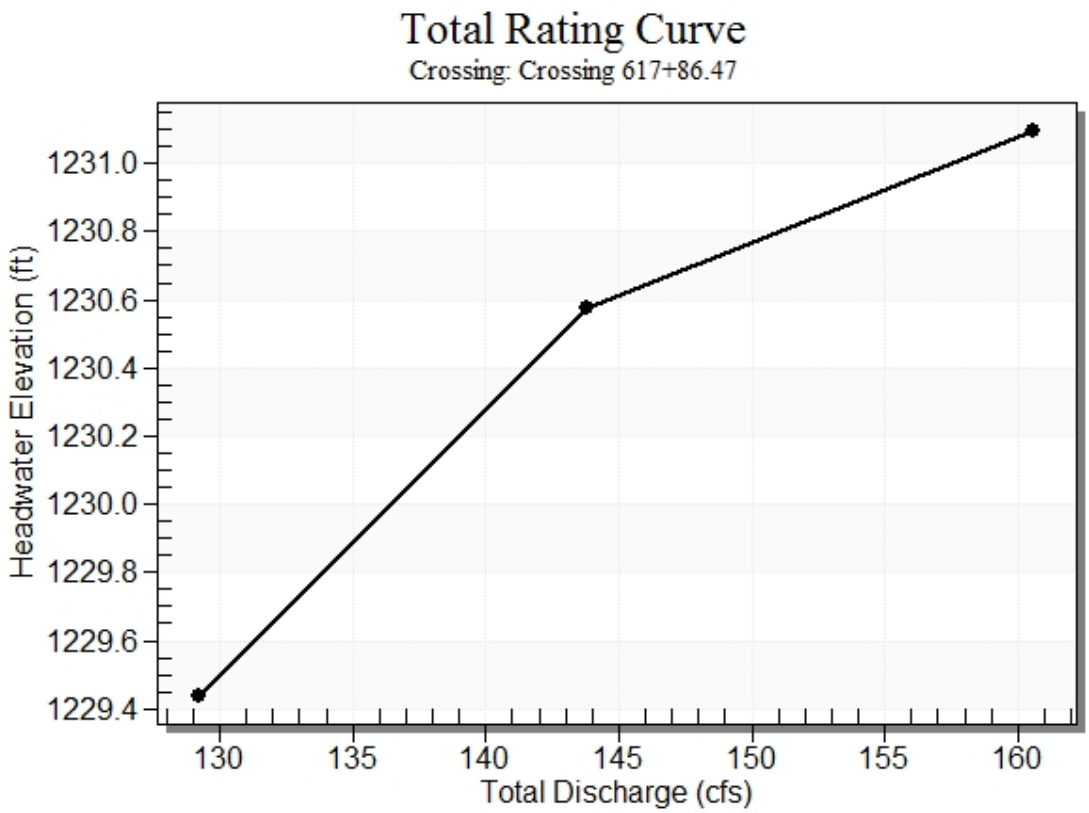
Crossing Discharge Data

Discharge Selection Method: Recurrence

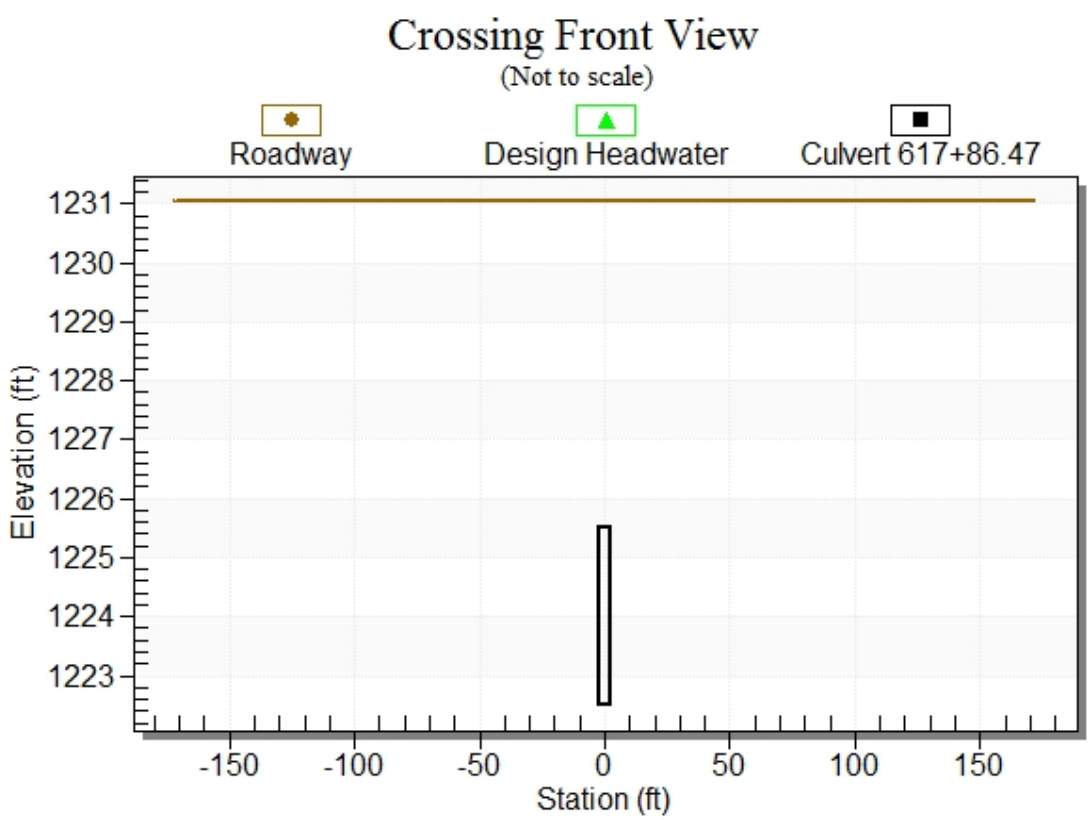
Table 43 - Summary of Culvert Flows at Crossing: Crossing 617+86.47

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 617+86.47 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.44	25 year	129.19	129.19	0.00	1
1230.58	50 year	143.78	143.78	0.00	1
1231.10	100 year	160.60	149.94	10.36	18
1231.05	Overtopping	149.38	149.38	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 617+86.47



Crossing Front View (Roadway Profile): Crossing 617+86.47



Culvert Notes: Culvert 617+86.47

Table 44 - Culvert Summary Table: Culvert 617+86.47

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	129.19	129.19	1229.44	6.940	0.0*	5-S2n	1.328	3.000	1.328	3.000	24.323	0.000
50 year	143.78	143.78	1230.58	8.078	0.0*	5-S2n	1.432	3.000	1.466	3.000	24.514	0.000
100 year	160.60	149.94	1231.10	8.597	0.0*	5-S2n	1.476	3.000	1.512	3.000	24.798	0.000

* Full Flow Headwater elevation is below inlet invert.

****

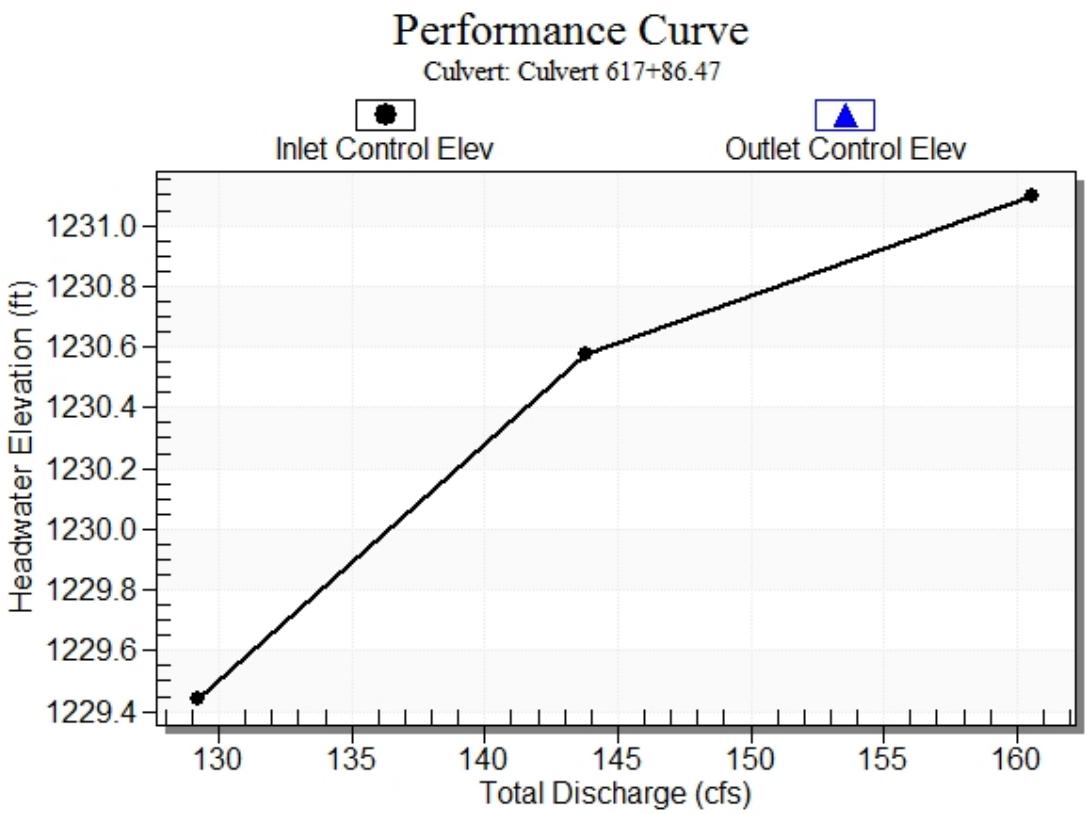
Straight Culvert

Inlet Elevation (invert): 1222.50 ft, Outlet Elevation (invert): 1202.99 ft

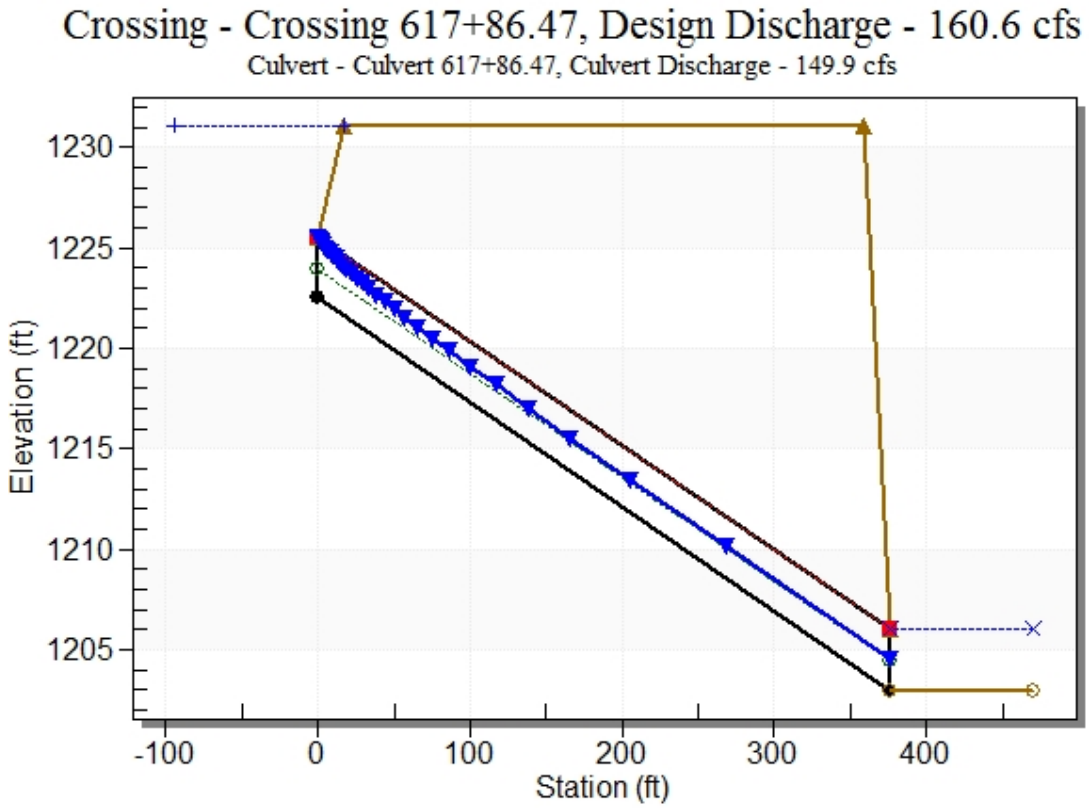
Culvert Length: 376.51 ft, Culvert Slope: 0.0519

****

Culvert Performance Curve Plot: Culvert 617+86.47



Water Surface Profile Plot for Culvert: Culvert 617+86.47



Site Data - Culvert 617+86.47

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1222.50 ft

Outlet Station: 376.00 ft

Outlet Elevation: 1202.99 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 617+86.47

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 45 - Downstream Channel Rating Curve (Crossing: Crossing 617+86.47)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
129.19	1205.99	3.00
143.78	1205.99	3.00
160.60	1205.99	3.00

Tailwater Channel Data - Crossing 617+86.47

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1205.99 ft

Roadway Data for Crossing: Crossing 617+86.47

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-171.43	1231.05
1	0.00	1231.05
2	171.46	1231.05

Roadway Surface: Paved

Roadway Top Width: 342.89 ft

Crossing Notes: Crossing 637+33.22

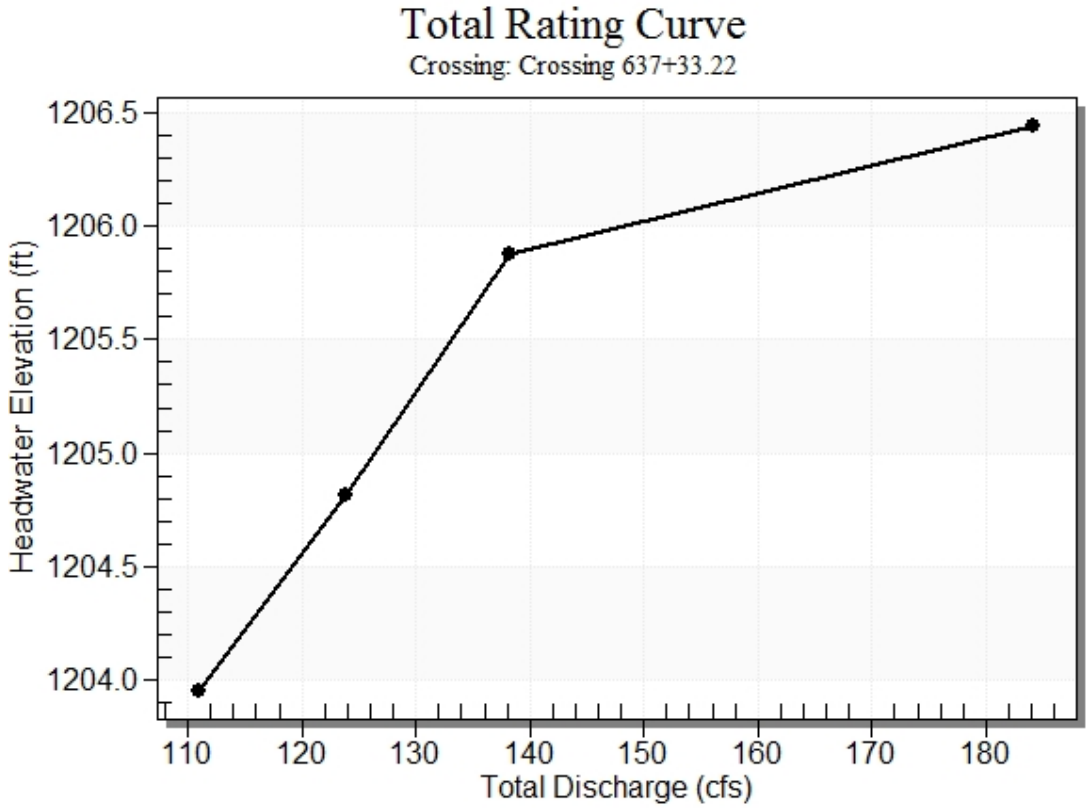
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 46 - Summary of Culvert Flows at Crossing: Crossing 637+33.22

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 637+33.22 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1203.96	25 year	110.91	110.91	0.00	1
1204.82	50 year	123.92	123.92	0.00	1
1205.88	100 year	138.16	138.16	0.00	1
1206.33	Overtopping	143.74	143.74	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 637+33.22



Crossing Front View (Roadway Profile): Crossing 637+33.22

Culvert Notes: Culvert 637+33.22

Table 47 - Culvert Summary Table: Culvert 637+33.22

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	110.91	110.91	1203.96	5.706	0.0*	5-S2n	1.217	2.880	1.234	3.000	22.465	0.000
50 year	123.92	123.92	1204.82	6.567	0.0*	5-S2n	1.320	3.000	1.349	3.000	22.963	0.000
100 year	138.16	138.16	1205.88	7.629	0.0*	5-S2n	1.425	3.000	1.454	3.000	23.763	0.000

* Full Flow Headwater elevation is below inlet invert.

****

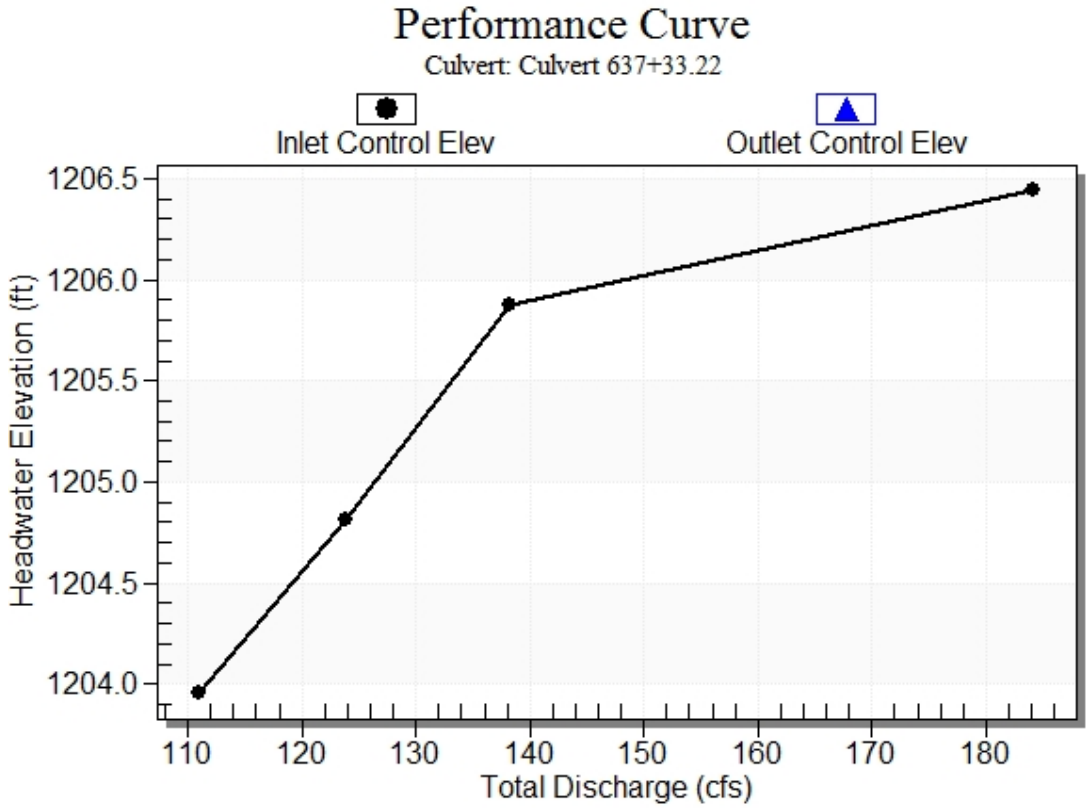
Straight Culvert

Inlet Elevation (invert): 1198.25 ft, Outlet Elevation (invert): 1180.00 ft

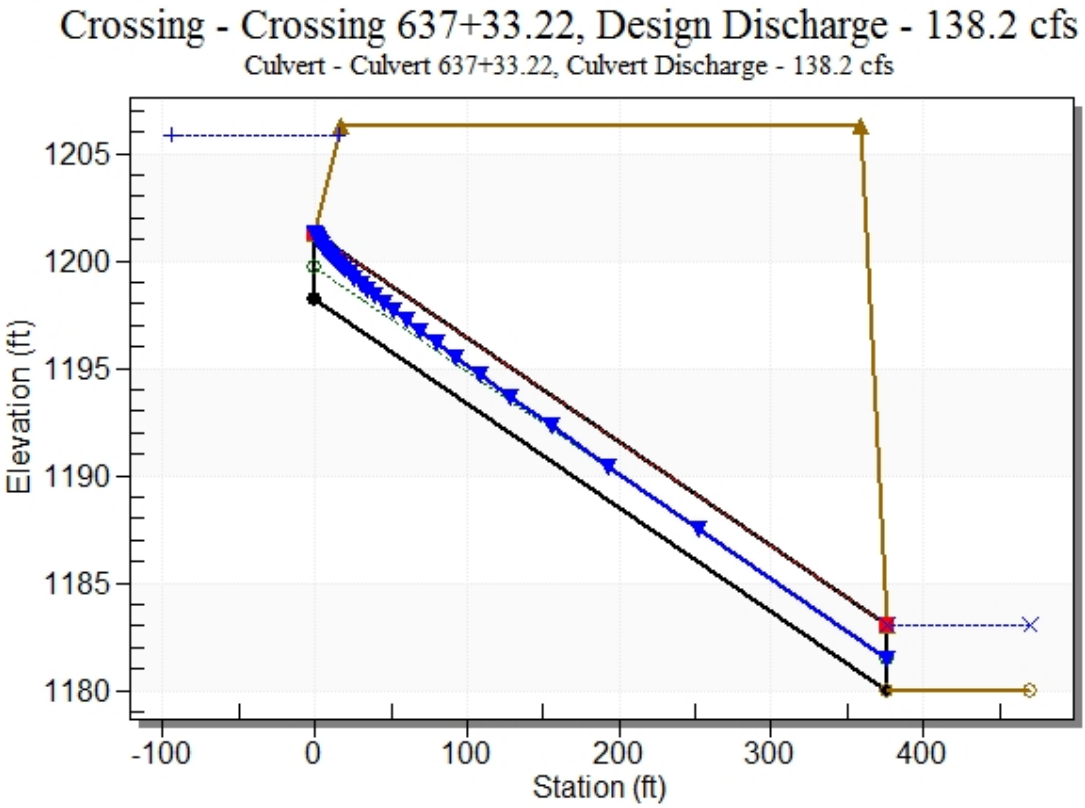
Culvert Length: 376.44 ft, Culvert Slope: 0.0485

****

Culvert Performance Curve Plot: Culvert 637+33.22



Water Surface Profile Plot for Culvert: Culvert 637+33.22



Site Data - Culvert 637+33.22

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1198.25 ft

Outlet Station: 376.00 ft

Outlet Elevation: 1180.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 637+33.22

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 48 - Downstream Channel Rating Curve (Crossing: Crossing 637+33.22)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
110.91	1183.00	3.00
123.92	1183.00	3.00
138.16	1183.00	3.00

Tailwater Channel Data - Crossing 637+33.22

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1183.00 ft

Roadway Data for Crossing: Crossing 637+33.22

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-171.00	1206.33
1	0.00	1206.33
2	171.00	1206.33

Roadway Surface: Paved

Roadway Top Width: 342.00 ft

Crossing Notes: Crossing 674+93.09

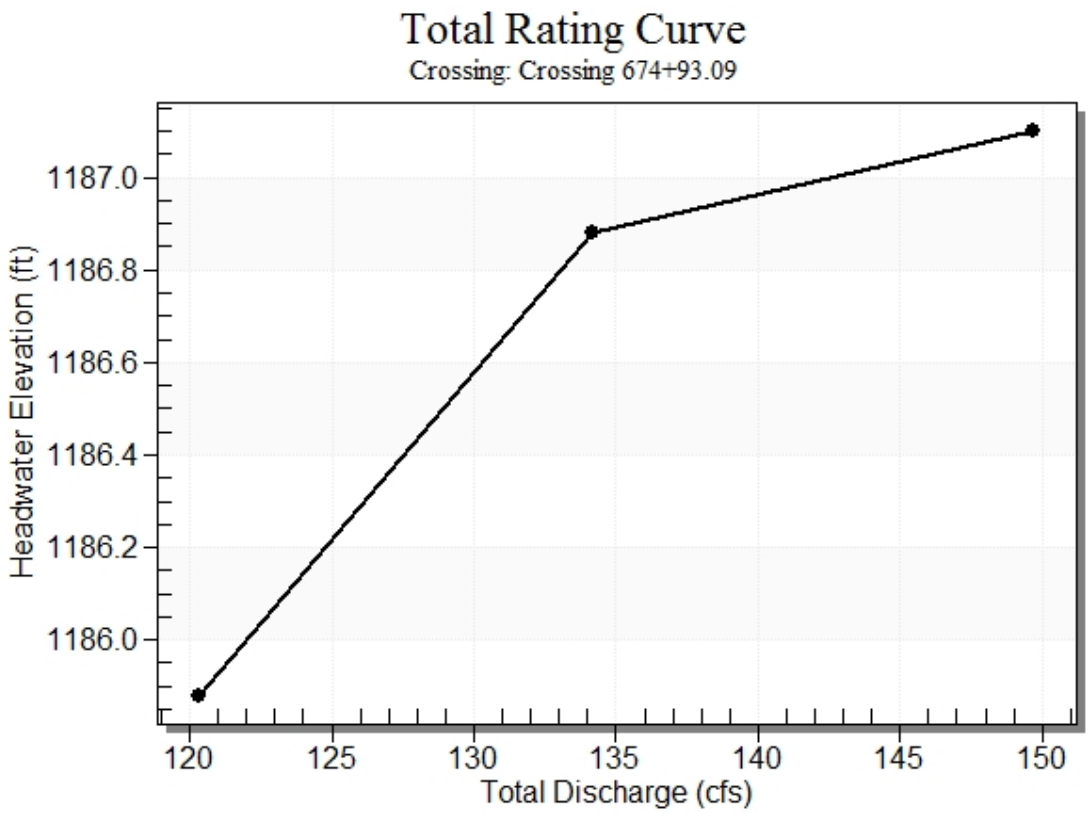
Crossing Discharge Data

Discharge Selection Method: Recurrence

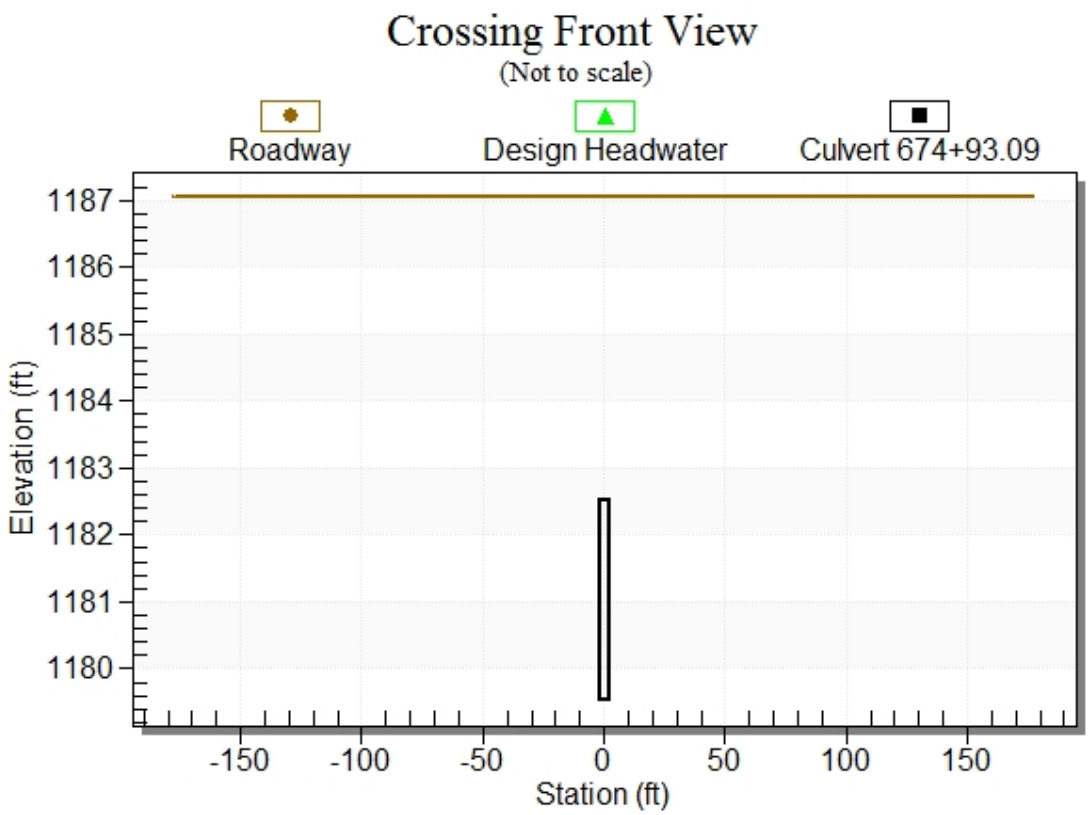
Table 52 - Summary of Culvert Flows at Crossing: Crossing 674+93.09

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 674+93.09 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1185.88	25 year	120.30	120.30	0.00	1
1186.88	50 year	134.17	134.17	0.00	1
1187.10	100 year	149.71	137.01	12.34	11
1187.05	Overtopping	136.34	136.34	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 674+93.09



Crossing Front View (Roadway Profile): Crossing 674+93.09



Culvert Notes: Culvert 674+93.09

Table 53 - Culvert Summary Table: Culvert 674+93.09

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	120.30	120.30	1185.88	6.351	0.0*	5-S2n	1.618	3.000	1.649	3.000	18.237	0.000
50 year	134.17	134.17	1186.88	7.352	0.0*	5-S2n	1.753	3.000	1.792	3.000	18.720	0.000
100 year	149.71	137.01	1187.10	7.572	0.011	5-S2n	1.780	3.000	1.817	3.000	18.855	0.000

* Full Flow Headwater elevation is below inlet invert.

****

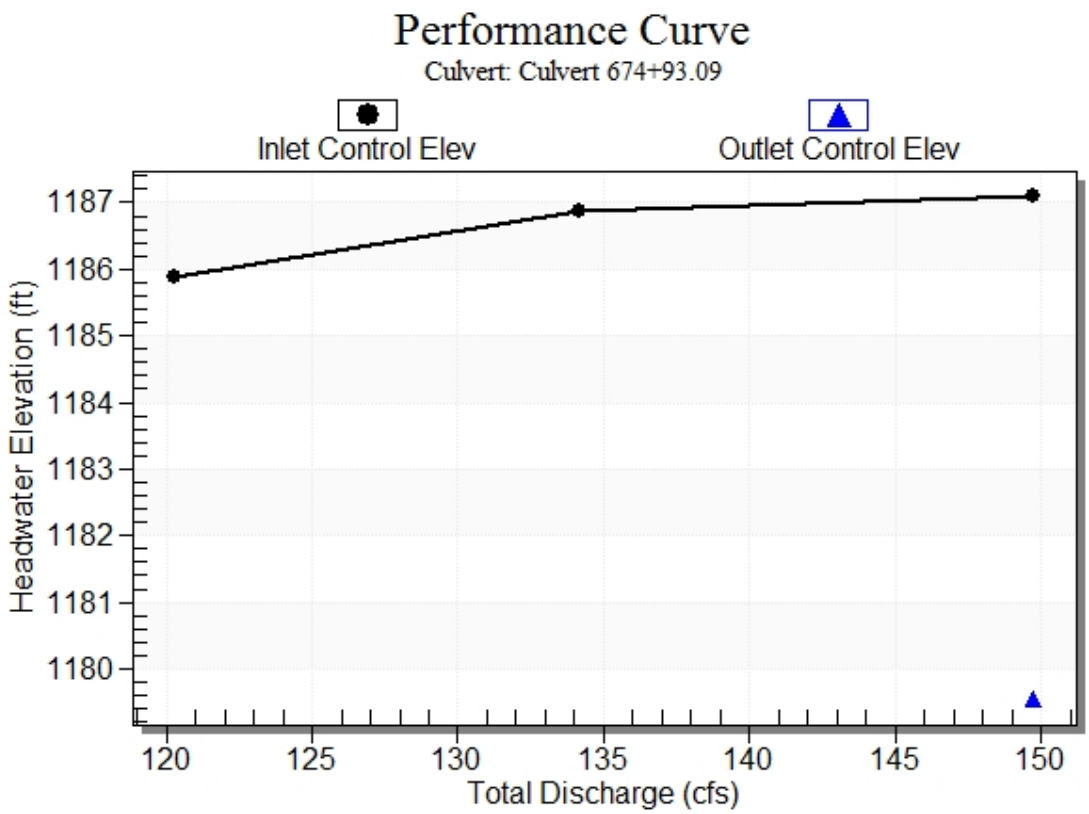
Straight Culvert

Inlet Elevation (invert): 1179.53 ft, Outlet Elevation (invert): 1169.50 ft

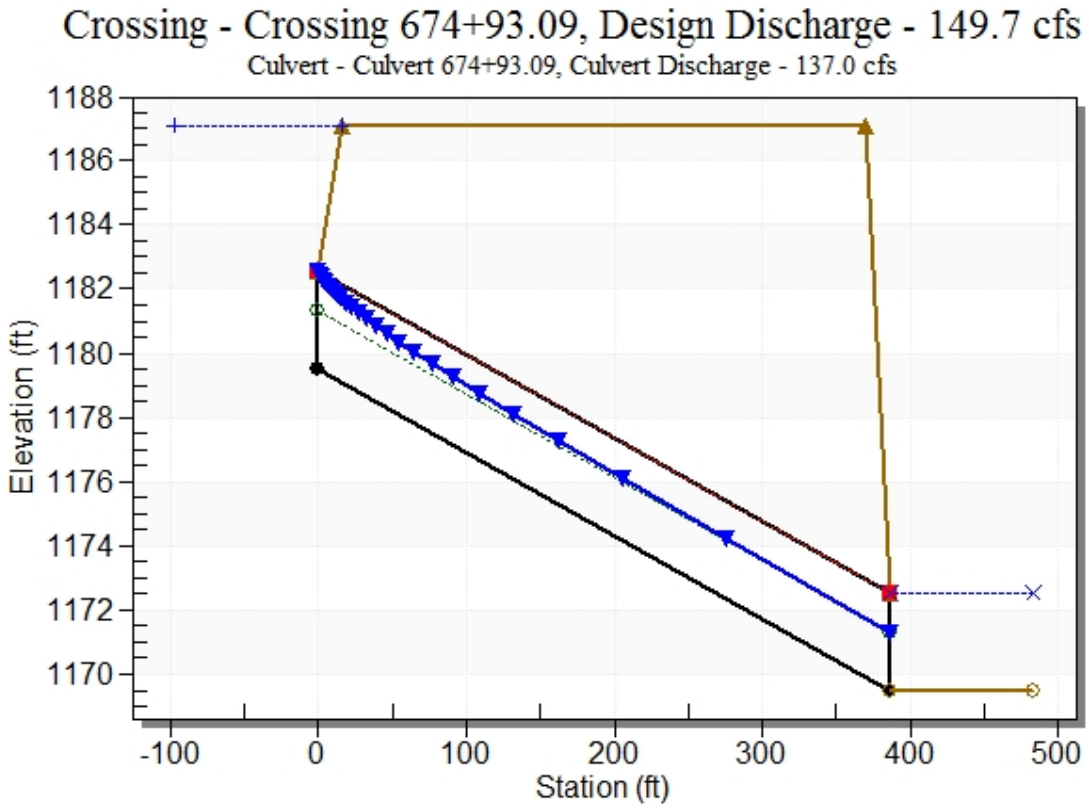
Culvert Length: 386.13 ft, Culvert Slope: 0.0260

****

Culvert Performance Curve Plot: Culvert 674+93.09



Water Surface Profile Plot for Culvert: Culvert 674+93.09



Site Data - Culvert 674+93.09

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1179.53 ft

Outlet Station: 386.00 ft

Outlet Elevation: 1169.50 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 674+93.09

Barrel Shape: Concrete Box

Barrel Span: 4.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 54 - Downstream Channel Rating Curve (Crossing: Crossing 674+93.09)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
120.30	1172.50	3.00
134.17	1172.50	3.00
149.71	1172.50	3.00

Tailwater Channel Data - Crossing 674+93.09

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1172.50 ft

Roadway Data for Crossing: Crossing 674+93.09

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-177.15	1187.05
1	0.00	1187.05
2	176.97	1187.05

Roadway Surface: Paved

Roadway Top Width: 354.12 ft

Crossing Notes: Crossing 689+79.59

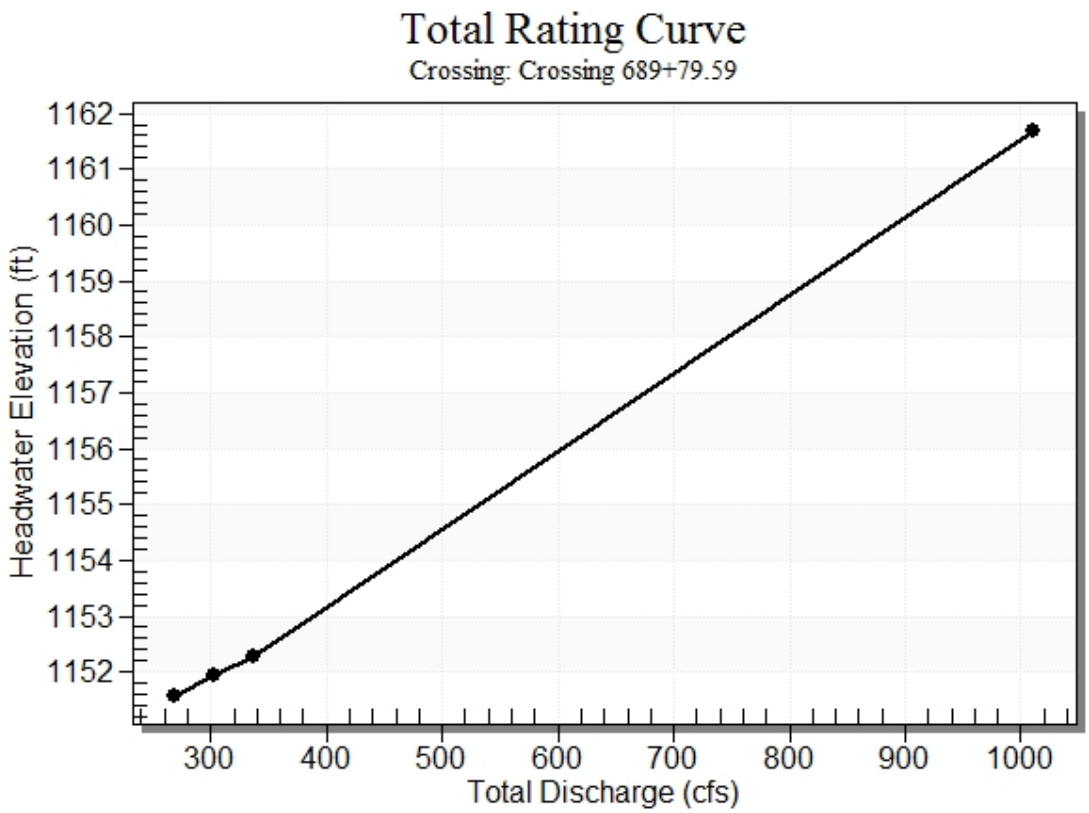
Crossing Discharge Data

Discharge Selection Method: Recurrence

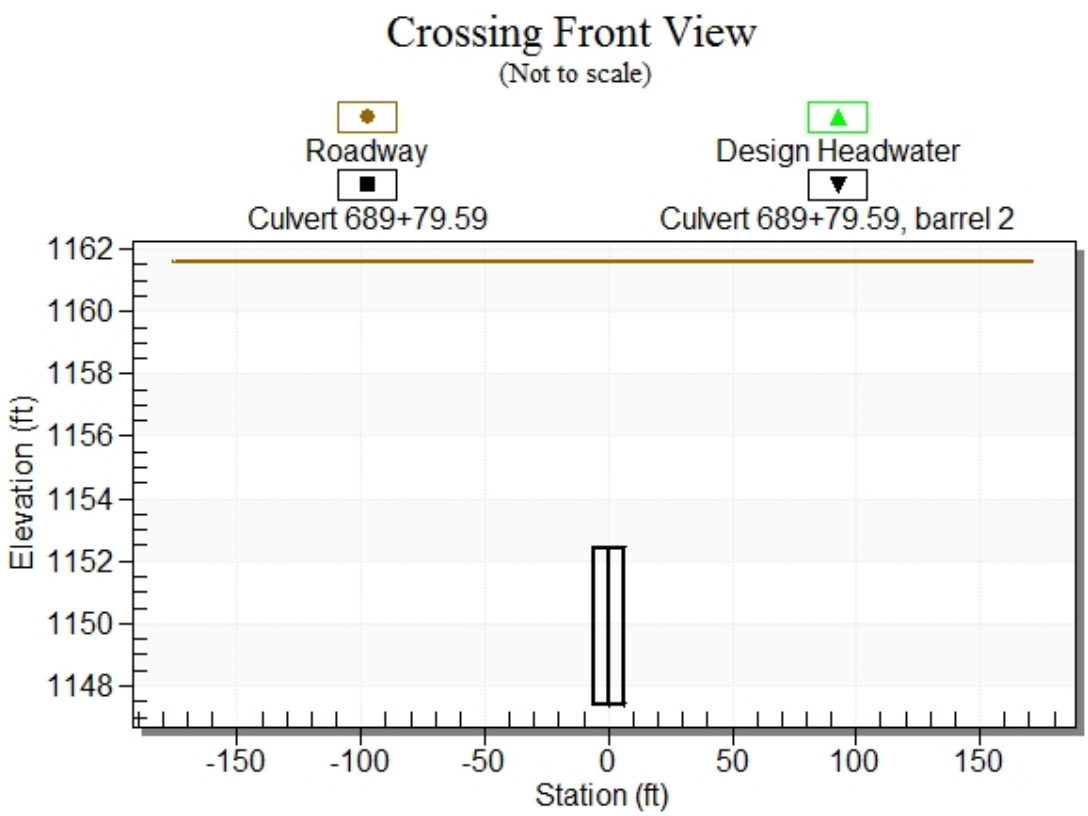
Table 55 - Summary of Culvert Flows at Crossing: Crossing 689+79.59

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 689+79.59 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1151.58	25 year	269.06	269.06	0.00	1
1151.94	50 year	303.20	303.20	0.00	1
1152.28	100 year	336.72	336.72	0.00	1
1161.57	Overtopping	956.81	956.81	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 689+79.59



Crossing Front View (Roadway Profile): Crossing 689+79.59



Culvert Notes: Culvert 689+79.59

Table 56 - Culvert Summary Table: Culvert 689+79.59

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	269.06	269.06	1151.58	4.174	0.0*	1-JS1f	1.295	2.499	5.000	5.000	4.484	0.000
50 year	303.20	303.20	1151.94	4.526	0.0*	1-S2n	1.406	2.707	1.450	5.000	17.426	0.000
100 year	336.72	336.72	1152.28	4.868	0.0*	1-S2n	1.515	2.903	1.554	5.000	18.055	0.000

* Full Flow Headwater elevation is below inlet invert.

****

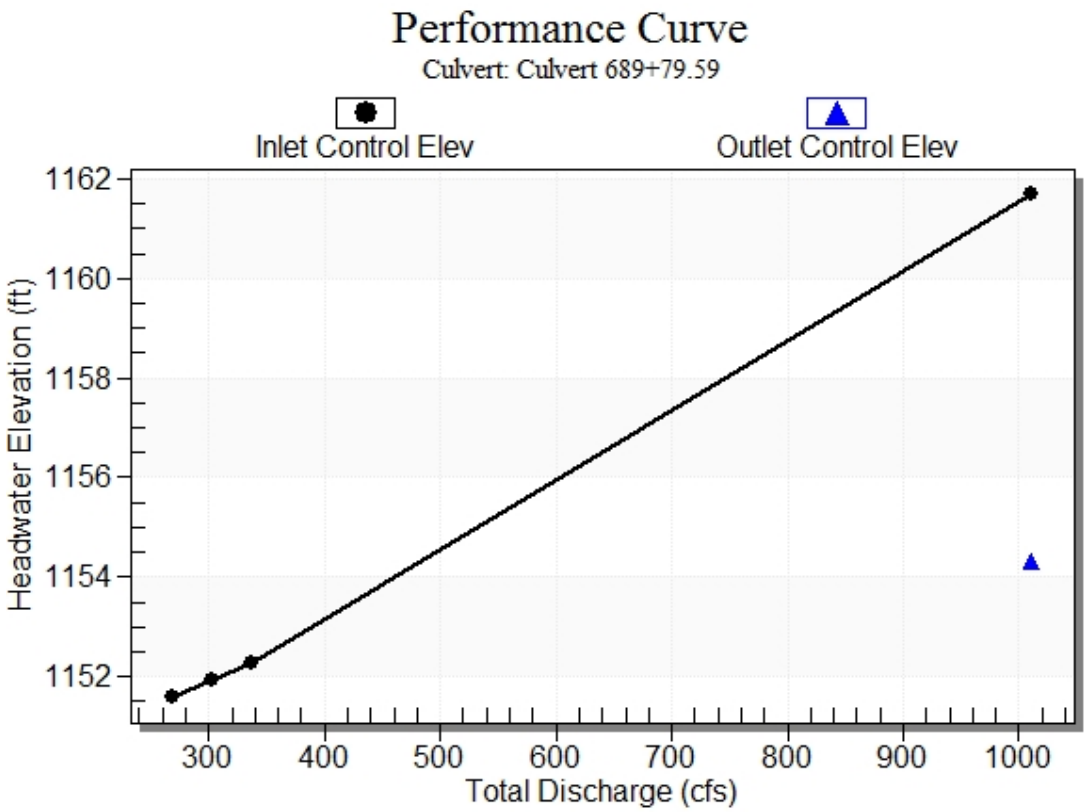
Straight Culvert

Inlet Elevation (invert): 1147.41 ft, Outlet Elevation (invert): 1139.15 ft

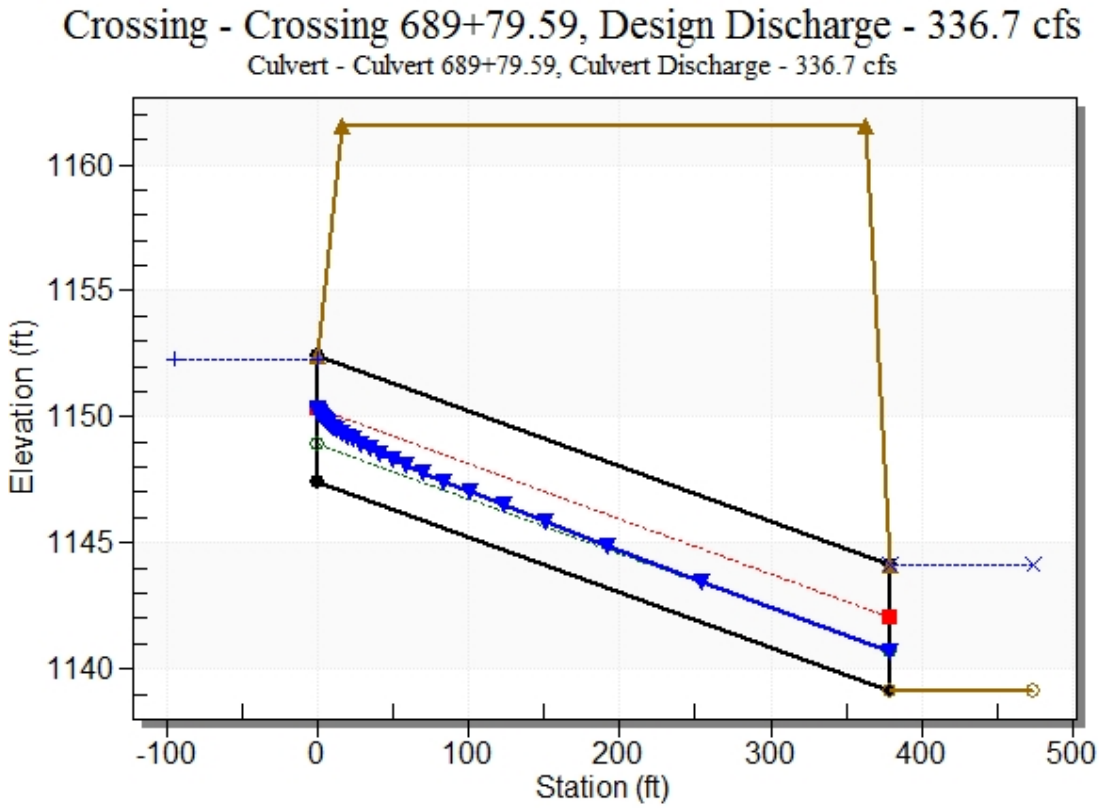
Culvert Length: 379.09 ft, Culvert Slope: 0.0218

****

Culvert Performance Curve Plot: Culvert 689+79.59



Water Surface Profile Plot for Culvert: Culvert 689+79.59



Site Data - Culvert 689+79.59

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1147.41 ft

Outlet Station: 379.00 ft

Outlet Elevation: 1139.15 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 689+79.59

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 57 - Downstream Channel Rating Curve (Crossing: Crossing 689+79.59)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
269.06	1144.15	5.00
303.20	1144.15	5.00
336.72	1144.15	5.00

Tailwater Channel Data - Crossing 689+79.59

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1144.15 ft

Roadway Data for Crossing: Crossing 689+79.59

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-175.25	1161.57
1	0.00	1161.57
2	171.00	1161.57

Roadway Surface: Paved

Roadway Top Width: 346.25 ft

Crossing Notes: Crossing 704+31.46

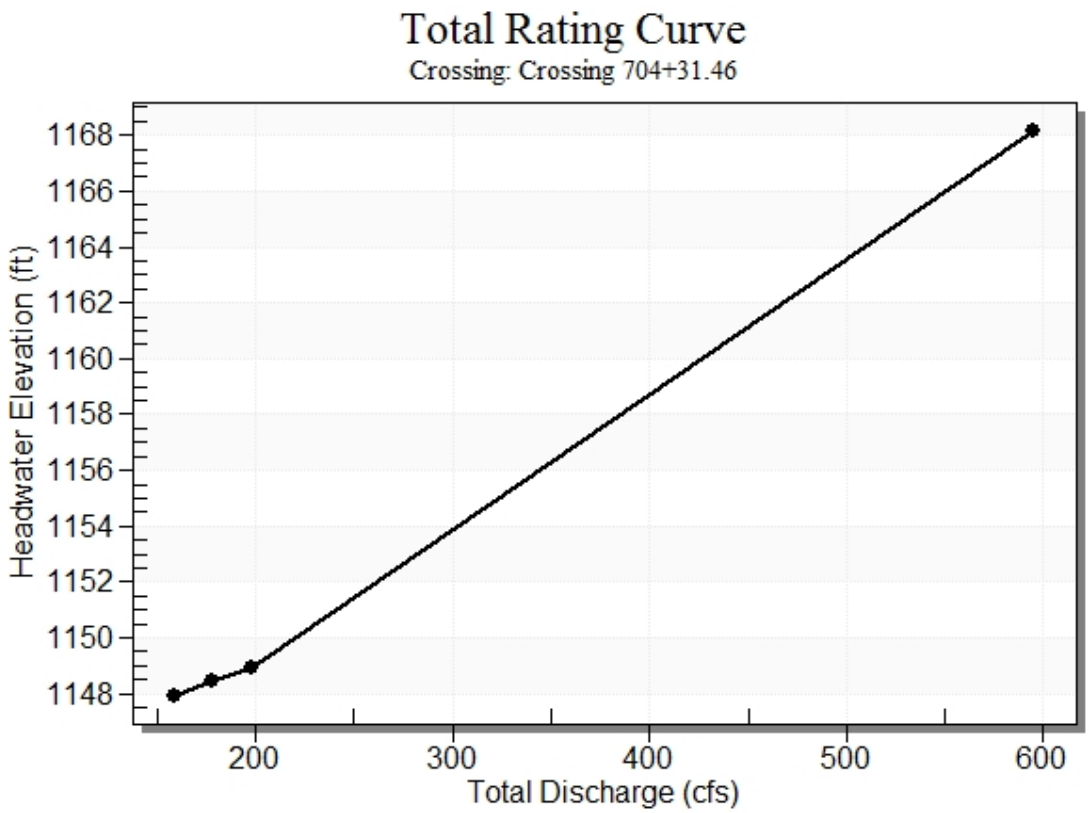
Crossing Discharge Data

Discharge Selection Method: Recurrence

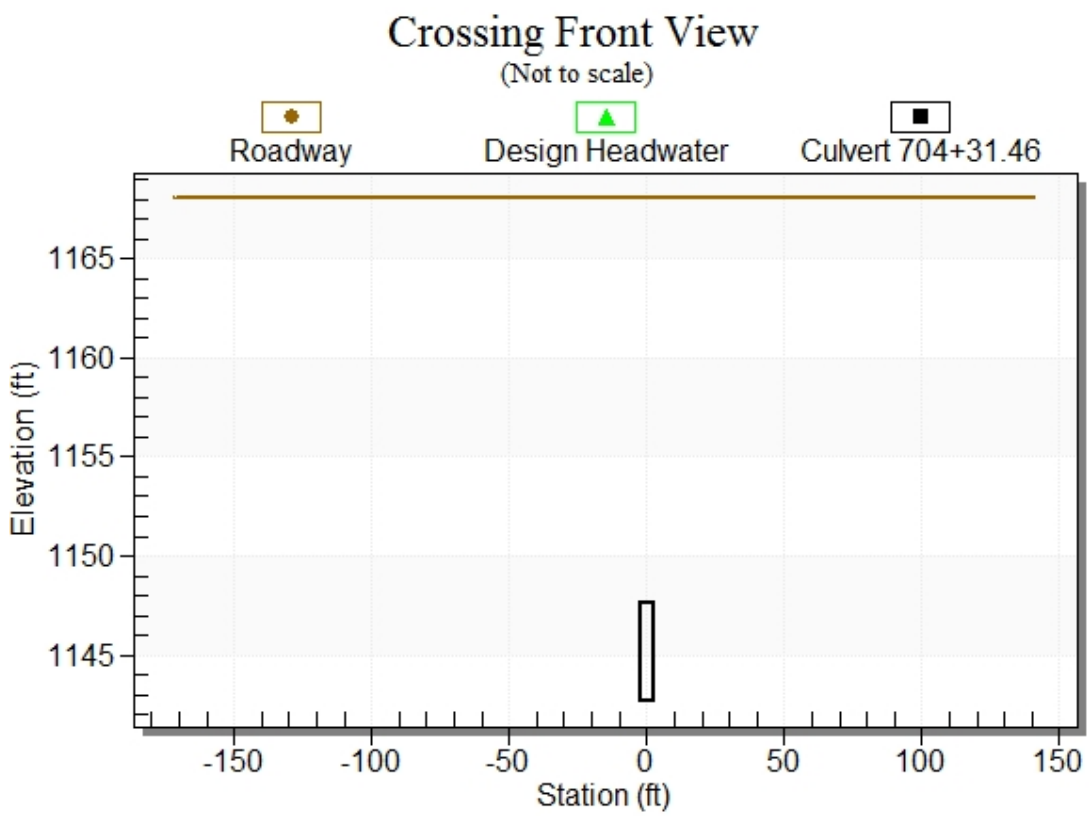
Table 58 - Summary of Culvert Flows at Crossing: Crossing 704+31.46

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 704+31.46 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1147.95	25 year	158.97	158.97	0.00	1
1148.42	50 year	177.84	177.84	0.00	1
1148.96	100 year	198.17	198.17	0.00	1
1168.08	Overtopping	562.09	562.09	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 704+31.46



Crossing Front View (Roadway Profile): Crossing 704+31.46



Culvert Notes: Culvert 704+31.46

Table 59 - Culvert Summary Table: Culvert 704+31.46

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	158.97	158.97	1147.95	5.275	0.0*	5-S2n	1.343	3.155	1.381	5.000	23.021	0.000
50 year	177.84	177.84	1148.42	5.751	0.0*	5-S2n	1.454	3.400	1.497	5.000	23.761	0.000
100 year	198.17	198.17	1148.96	6.287	0.0*	5-S2n	1.574	3.654	1.620	5.000	24.460	0.000

* Full Flow Headwater elevation is below inlet invert.

****

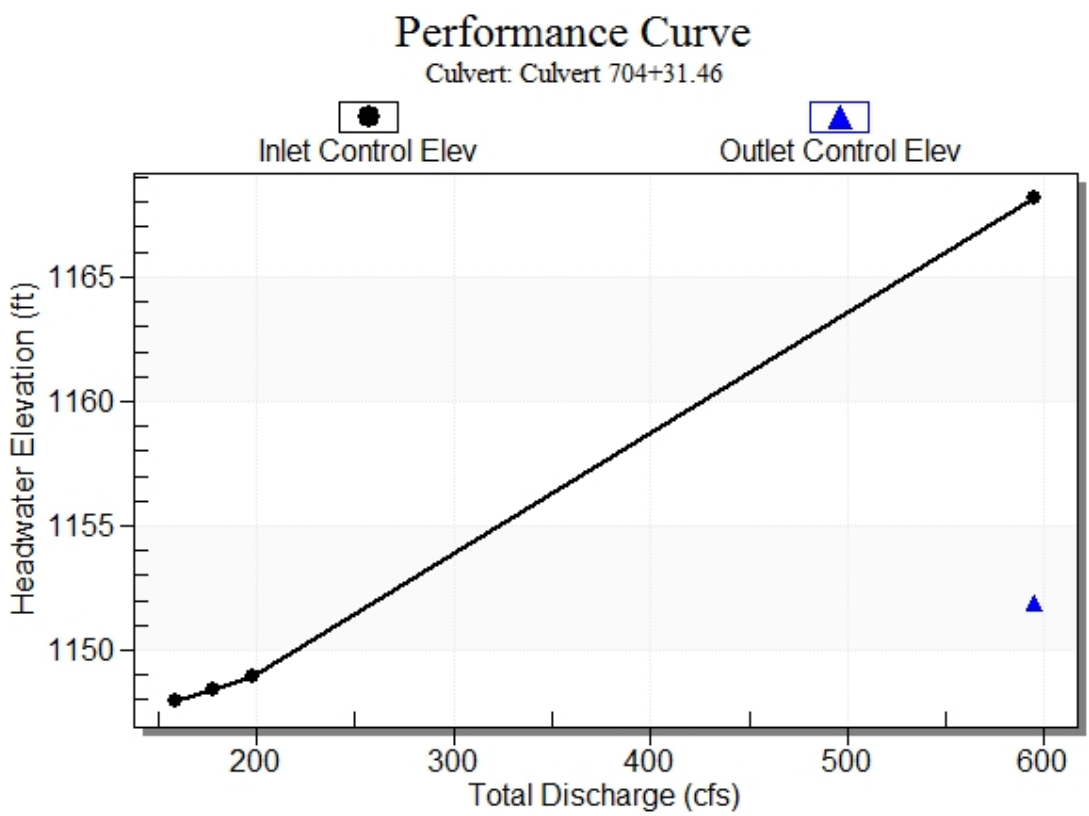
Straight Culvert

Inlet Elevation (invert): 1142.67 ft, Outlet Elevation (invert): 1124.84 ft

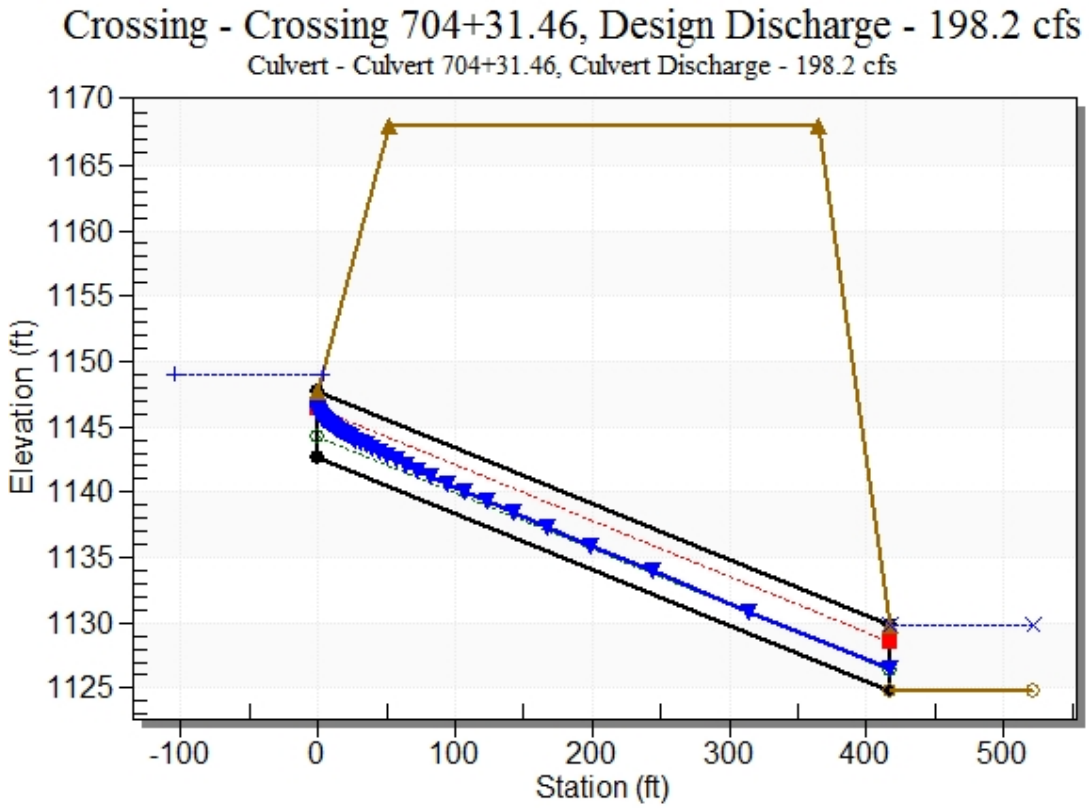
Culvert Length: 417.38 ft, Culvert Slope: 0.0428

****

Culvert Performance Curve Plot: Culvert 704+31.46



Water Surface Profile Plot for Culvert: Culvert 704+31.46



Site Data - Culvert 704+31.46

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1142.67 ft

Outlet Station: 417.00 ft

Outlet Elevation: 1124.84 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 704+31.46

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 60 - Downstream Channel Rating Curve (Crossing: Crossing 704+31.46)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
158.97	1129.84	5.00
177.84	1129.84	5.00
198.17	1129.84	5.00

Tailwater Channel Data - Crossing 704+31.46

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1129.84 ft

Roadway Data for Crossing: Crossing 704+31.46

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-171.19	1168.08
1	0.00	1168.08
2	140.66	1168.08

Roadway Surface: Paved

Roadway Top Width: 311.85 ft

Crossing Notes: Crossing 729+91.75

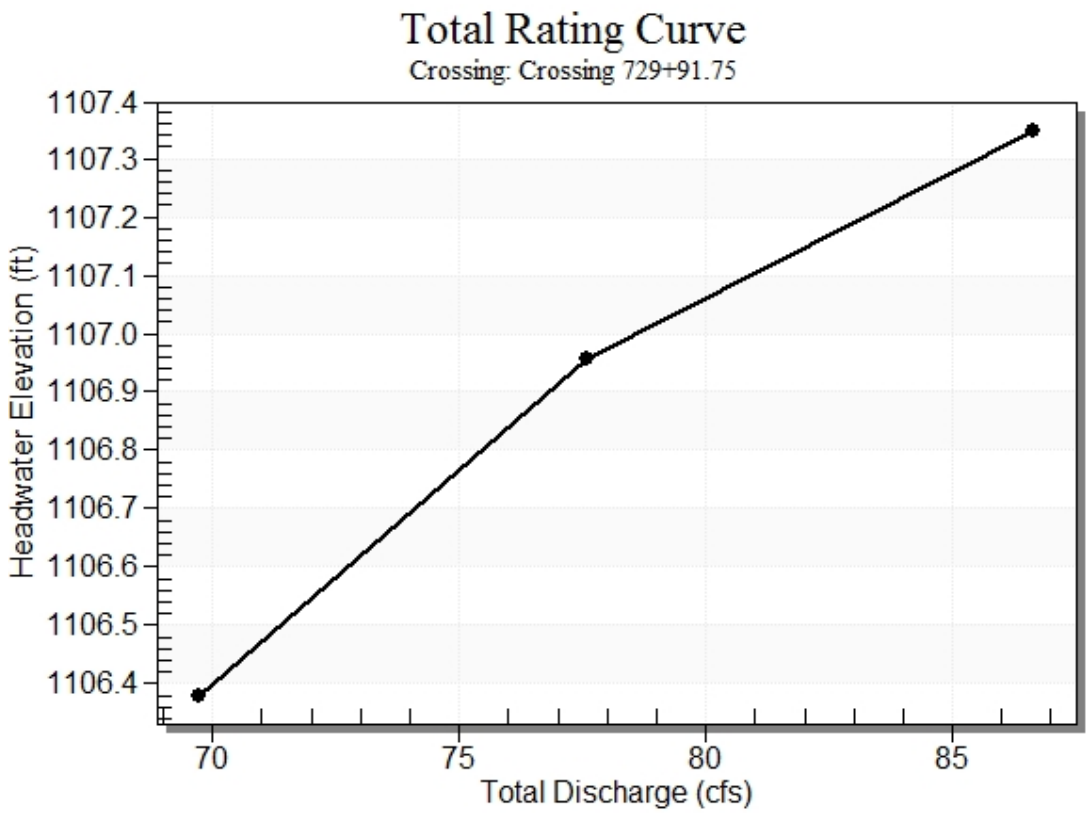
Crossing Discharge Data

Discharge Selection Method: Recurrence

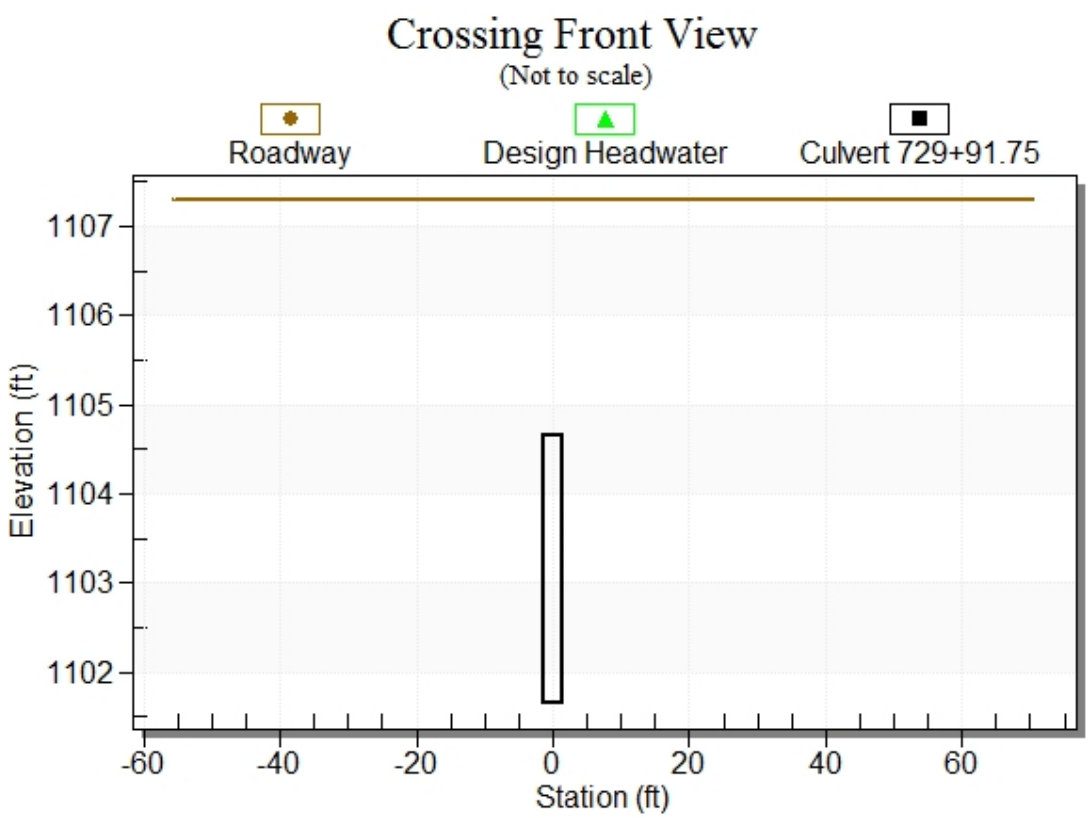
Table 61 - Summary of Culvert Flows at Crossing: Crossing 729+91.75

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 729+91.75 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1106.38	25 year	69.71	69.71	0.00	1
1106.96	50 year	77.58	77.58	0.00	1
1107.35	100 year	86.65	82.50	3.91	15
1107.30	Overtopping	81.90	81.90	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 729+91.75



Crossing Front View (Roadway Profile): Crossing 729+91.75



Culvert Notes: Culvert 729+91.75

Table 62 - Culvert Summary Table: Culvert 729+91.75

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25 year	69.71	69.71	1106.38	4.730	0.799	5-S2n	1.724	2.560	1.749	3.000	13.287	0.000
50 year	77.58	77.58	1106.96	5.307	1.618	5-S2n	1.871	2.749	1.871	3.000	13.821	0.000
100 year	86.65	82.50	1107.35	5.698	2.173	5-S2n	1.963	2.864	1.977	3.000	13.907	0.000

****

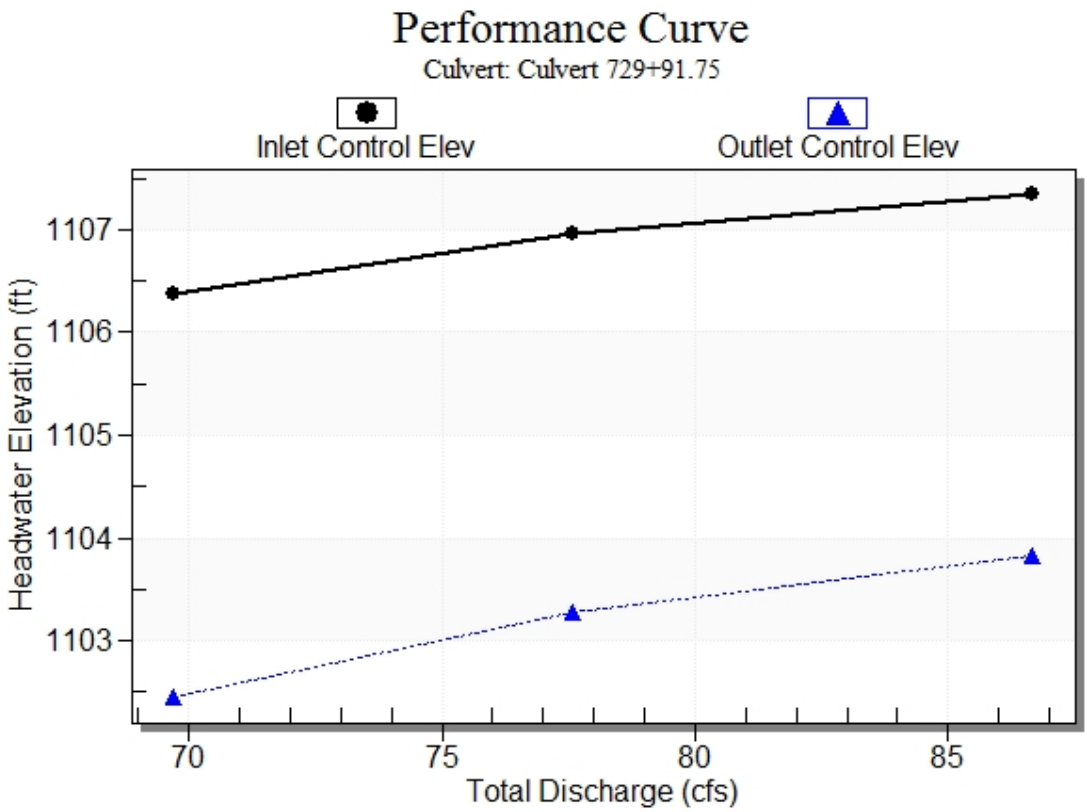
Straight Culvert

Inlet Elevation (invert): 1101.65 ft, Outlet Elevation (invert): 1096.02 ft

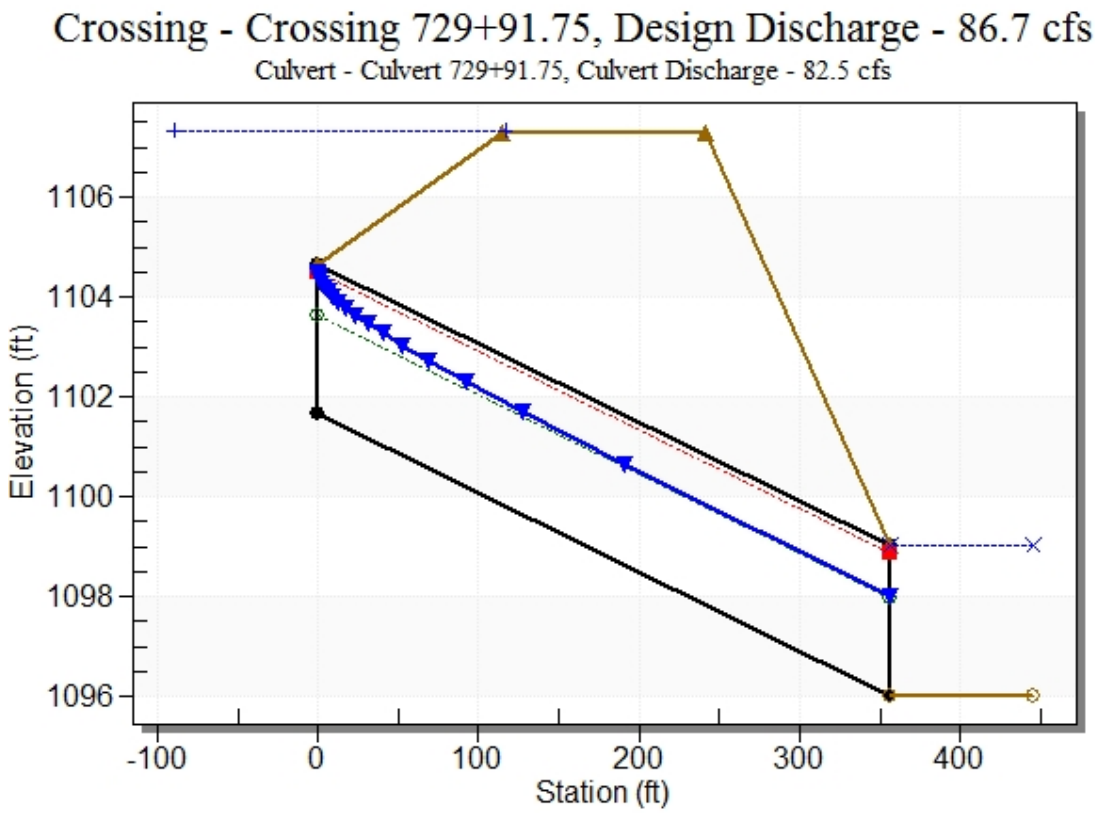
Culvert Length: 356.04 ft, Culvert Slope: 0.0158

****

Culvert Performance Curve Plot: Culvert 729+91.75



Water Surface Profile Plot for Culvert: Culvert 729+91.75



Site Data - Culvert 729+91.75

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1101.65 ft

Outlet Station: 356.00 ft

Outlet Elevation: 1096.02 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 729+91.75

Barrel Shape: Concrete Box

Barrel Span: 3.00 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 63 - Downstream Channel Rating Curve (Crossing: Crossing 729+91.75)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
69.71	1099.02	3.00
77.58	1099.02	3.00
86.65	1099.02	3.00

Tailwater Channel Data - Crossing 729+91.75

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1099.02 ft

Roadway Data for Crossing: Crossing 729+91.75

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	-55.41	1107.30
1	0.00	1107.30
2	70.34	1107.30

Roadway Surface: Paved

Roadway Top Width: 125.75 ft

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APPENDIX E – HEC-RAS PLANS – MUD CREEK AND UNNAMED DITCH

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MUD CREEK HEC-RAS MODEL

EXISTING			PROPOSED			PROPOSED - EXISTING
River Sta	100 YR W.S. Elev		River Sta	100 YR W.S. Elev		100 YR W.S. Elev
	(ft)			(ft)		(ft)
81352	1234.63		81352	1234.64		0.01
80858	1228.39		80858	1228.39		0
80230	1221.36		80230	1221.36		0
79509	1213.58		79509	1213.58		0
78928	1207.15		78928	1207.15		0
78276	1202.17		78276	1202.17		0
77723	1194.03		77723	1194.03		0
77223	1194.31		77223	1194.31		0
76723	1194.28		76723	1194.28		0
76413	1194.27		76413	1194.27		0
76372	Inl Struct		76372			Inl Struct
76331	1181.62		76331	1181.62		0
75753	1175.89		75753	1175.93		0.04
75733	Culvert		75733			Culvert
75694	1174.44		75694	1174.44		0
75223	1166.73		75223	1166.73		0
74723	1161.85		74723	1161.85		0
74223	1157.83		74223	1157.83		0
73723	1152.58		73723	1152.58		0
73223	1149.31		73223	1149.31		0
72549	1145.6		72549	1145.6		0
72502	Culvert		72502			Culvert
72437	1142.53		72437	1142.53		0
72213	1139.77		72213	1139.77		0
71713	1134.02		71713	1134.02		0
71213	1127.66		71213	1127.66		0
70713	1120.78		70713	1120.78		0
70213	1118.05		70213	1118.05		0
69713	1115.48		69713	1115.48		0
69213	1108.76		69213	1108.78		0.02
68713	1105.54		68713	1105.52		-0.02
68213	1098.5		68213	1098.52		0.02
67713	1097.6		67713	1097.6		0
67213	1095.76		67213	1095.76		0
66713	1092.99		66713	1092.99		0
66213	1090.61		66213	1090.6		-0.01
65798	1088.97		65798	1088.91		-0.06
65769	Culvert		65769			Culvert
65697	1086.64		65697	1086.64		0
65213	1084.31		65213	1084.31		0
64713	1081.09		64713	1081.09		0
64213	1076.83		64213	1076.83		0
63788	1075.78		63788	1075.78		0
63702	Culvert		63702			Culvert
63644	1074.78		63644	1074.78		0
63213	1072.3		63213	1072.3		0
62713	1070.44		62713	1070.44		0
62213	1067.4		62213	1067.4		0
61713	1064.76		61713	1064.76		0
61213	1063.47		61213	1063.47		0
60713	1062.66		60713	1062.66		0
60213	1062.56		60213	1062.56		0
59713	1062.56		59713	1062.56		0
59213	1062.51		59213	1062.51		0
58713	1062.52		58713	1062.52		0
58213	1062.52		58213	1062.52		0
57713	1062.51		57713	1062.51		0
57213	1062.5		57213	1062.5		0
56713	1062.5		56713	1062.5		0

MUD CREEK HEC-RAS MODEL

EXISTING			PROPOSED			PROPOSED - EXISTING
River Sta	100 YR W.S. Elev		River Sta	100 YR W.S. Elev		100 YR W.S. Elev
	(ft)			(ft)		(ft)
56213	1062.5		56213	1062.5		0
55713	1062.5		55713	1062.5		0
55213	1019.37		55213	1019.37		0
54713	1019.34		54713	1019.34		0
54213	1019.3		54213	1019.3		0
53628	1013.45		53628	1013.45		0
53506	Culvert		53506			Culvert
53404	1012.09		53404	1012.09		0
53213	1010.55		53213	1010.55		0
52713	1007.78		52713	1007.78		0
52213	1004.11		52213	1004.11		0
51713	1000.33		51713	1000.33		0
51213	995.01		51213	995.01		0
50713	993.55		50713	993.55		0
50213	989.91		50213	989.91		0
49713	988.17		49713	988.17		0
49213	987.83		49213	987.83		0
48948	987.56		48948	987.56		0
48799	Culvert		48799			Culvert
48611	979.95		48611	979.95		0
48213	976.83		48213	976.83		0
47713	973.41		47713	973.41		0
47213	966.74		47213	966.74		0
46713	962.79		46713	962.79		0
46213	961.84		46213	961.84		0
45713	961.5		45713	961.5		0
45213	961.47		45213	961.47		0
44713	961.45		44713	961.45		0
44213	961.46		44213	961.46		0
43713	961.45		43713	961.45		0
43213	961.45		43213	961.45		0
42713	961.45		42713	961.45		0
42346	961.45		42346	961.45		0
41964	929.93		41964	929.93		0
41712	929.84		41712	929.84		0
41212	921.54		41212	921.54		0
40712	920.81		40712	920.81		0
40212	920.78		40212	920.78		0
39712	920.46		39712	920.46		0
39246	909.92		39246	909.93		0.01
38717	905.31		38717	905.33		0.02
38366	**904.85**		**38478**	**905.3**		**0.45**
38252	**Bridge**		**38252**			**Culvert**
38127	**902.96**		**37941**	**902.36**		**-0.6**
37713	901.16		37713	901.16		0
37213	898.21		37213	898.21		0
36713	892.36		36713	892.36		0
36213	889.74		36213	889.74		0
35682	886.58		35682	886.58		0

Replaced Mud Creek Bridge in existing model with 2 - 10'x5' RCB, shifted station location slightly to adjust for the proposed improvements to US 281.

HEC-RAS PLAN: MUDU EXISTING FEMA RIVER SAL MUD CK U REACH: HR1010320A

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HR1010320A	81352	100-yr	975	1232	1234.64	1234.08	1234.87	0.006463	4.81	298.3	213.65	0.54
HR1010320A	80858	100-yr	975	1227.44	1228.39	1228.39	1228.74	0.032754	5.73	226.36	329.06	1.04
HR1010320A	80230	100-yr	975	1219.9	1221.36		1221.45	0.005508	2.63	423.48	410.63	0.4
HR1010320A	79509	100-yr	975	1212.3	1213.58	1213.58	1213.97	0.026584	5.99	221.78	287.68	0.97
HR1010320A	78928	100-yr	975	1202	1207.15		1207.32	0.001811	3.4	312.31	148.63	0.31
HR1010320A	78276	100-yr	2628	1198.89	1202.17	1202.17	1202.85	0.015847	6.94	439.33	329.84	0.91
HR1010320A	77723	100-yr	2628	1188	1194.03		1195.03	0.009348	8.04	327.06	100.32	0.76
HR1010320A	77223	100-yr	2628	1188	1194.31		1194.37	0.000251	2.3	1588.23	414.85	0.16
HR1010320A	76723	100-yr	2628	1188	1194.28		1194.3	0.000076	1.26	2711.21	583.38	0.09
HR1010320A	76413	100-yr	2628	1188	1194.27	1188.94	1194.28	0.000028	0.76	3919.43	784.52	0.05
HR1010320A	76372		Inl Struct									
HR1010320A	76331	100-yr	2628	1178.16	1181.62	1181.62	1182.65	0.01907	8.97	385.76	246.19	1.04
HR1010320A	75753	100-yr	2628	1172	1175.93	1175.04	1176.23	0.003748	4.95	750.23	408.87	0.49
HR1010320A	75733		Culvert									
HR1010320A	75694	100-yr	2628	1171.44	1174.44	1174.44	1174.98	0.040218	6.98	534.58	486.52	0.85
HR1010320A	75223	100-yr	2628	1162	1166.73		1166.96	0.005412	3.82	687.38	177.95	0.34
HR1010320A	74723	100-yr	2628	1157.12	1161.85	1160.99	1162.5	0.016879	7.32	451.88	230.97	0.62
HR1010320A	74223	100-yr	2628	1152	1157.83		1158.12	0.005158	4.6	688.98	211.24	0.35
HR1010320A	73723	100-yr	4136	1148	1152.58		1153.28	0.016289	6.92	673.18	249.81	0.6
HR1010320A	73223	100-yr	4136	1144	1149.31		1149.5	0.004083	3.53	1265.02	375.95	0.3
HR1010320A	72549	100-yr	4136	1138	1145.6	1142.41	1146.04	0.006271	5.48	858.82	246.84	0.39
HR1010320A	72502		Culvert									
HR1010320A	72437	100-yr	4136	1136	1142.53	1139.97	1143.26	0.008581	6.86	602.67	324.13	0.47
HR1010320A	72213	100-yr	4136	1134	1139.77		1140.31	0.020814	5.92	706.2	293.07	0.64
HR1010320A	71713	100-yr	4136	1128	1134.02		1134.4	0.007523	5.48	989.46	307.45	0.43
HR1010320A	71213	100-yr	4136	1120	1127.66		1128.7	0.018581	8.37	554.69	173.8	0.66
HR1010320A	70713	100-yr	4136	1112	1120.78		1121.62	0.010983	7.38	560.25	115.03	0.59
HR1010320A	70213	100-yr	4136	1112	1118.05		1118.39	0.003937	4.7	912.76	202.72	0.36
HR1010320A	69713	100-yr	4136	1110	1115.48		1115.94	0.006214	5.97	844.81	205.52	0.45
HR1010320A	69213	100-yr	4136	1104	1108.78	1108.56	1110.09	0.028486	9.2	453.28	148.45	0.9
HR1010320A	68713	100-yr	4136	1098.19	1105.52	1103.09	1105.81	0.003644	4.71	1129.92	313.64	0.35
HR1010320A	68213	100-yr	8547	1094	1098.52	1098.52	1099.86	0.03028	10.9	1070.9	389.98	0.96
HR1010320A	67713	100-yr	8547	1086	1097.6		1097.65	0.000621	2.57	5608.09	1260.57	0.15
HR1010320A	67213	100-yr	17184	1082	1095.76		1096.66	0.004532	9.02	3064.99	534.91	0.45
HR1010320A	66713	100-yr	17184	1079.7	1092.99		1093.84	0.007223	7.4	2322.75	397.92	0.54
HR1010320A	66213	100-yr	17184	1078	1090.6		1091.15	0.003898	7.4	3281.99	558.35	0.4
HR1010320A	65798	100-yr	17184	1078	1088.91	1085.98	1089.5	0.003967	7.4	3543.9	688.68	0.41
HR1010320A	65769		Culvert									
HR1010320A	65697	100-yr	17184	1078	1086.64	1086.36	1088.99	0.009129	12.87	1664.24	346.07	0.86
HR1010320A	65213	100-yr	17184	1072	1084.31		1085	0.004822	8.12	3140.52	510.85	0.44
HR1010320A	64713	100-yr	17184	1068	1081.09	1078.55	1082.12	0.007058	10.67	2561.6	420.86	0.54
HR1010320A	64213	100-yr	17184	1064	1076.83		1078.19	0.008602	11.98	2494.15	474.44	0.61
HR1010320A	63788	100-yr	17184	1064	1075.78	1070.89	1076.46	0.001719	7.24	3213.55	527.09	0.38
HR1010320A	63702		Culvert									
HR1010320A	63644	100-yr	17184	1064	1074.78	1070.5	1075.49	0.002951	9.84	2872.19	466.58	0.53
HR1010320A	63213	100-yr	17184	1060	1072.3		1073.39	0.008486	10.43	2696.29	528.56	0.56
HR1010320A	62713	100-yr	18812	1054.66	1070.44		1070.97	0.002817	8.47	4011.58	636.51	0.39
HR1010320A	62213	100-yr	18812	1054	1067.4		1068.88	0.005887	11.18	2621.75	510.83	0.56
HR1010320A	61713	100-yr	18812	1054	1064.76		1065.81	0.005931	9.99	2695.63	399.9	0.54
HR1010320A	61213	100-yr	18812	1052	1063.47		1063.84	0.002357	6.62	4235.53	488.55	0.35
HR1010320A	60713	100-yr	18812	1046	1062.66		1062.97	0.001287	5.92	5311.71	671.61	0.27
HR1010320A	60213	100-yr	18812	1036	1062.56		1062.71	0.000204	4.15	8402.67	800.37	0.15
HR1010320A	59713	100-yr	18812	1036	1062.56		1062.62	0.000086	2.8	11043.53	770.53	0.1
HR1010320A	59213	100-yr	18812	1034	1062.51		1062.58	0.000091	3.2	11008.7	744.04	0.11
HR1010320A	58713	100-yr	18812	1036	1062.52		1062.54	0.000027	1.71	20045.29	1042.19	0.06
HR1010320A	58213	100-yr	18812	1032	1062.52		1062.53	0.000012	1.2	23961.55	1177.79	0.04
HR1010320A	57713	100-yr	18812	1024.96	1062.51		1062.52	0.000014	1.55	23279.41	1103.31	0.05
HR1010320A	57213	100-yr	18812	1024	1062.5		1062.52	0.00001	1.28	24363.86	1230.82	0.04
HR1010320A	56713	100-yr	18812	1022	1062.5		1062.51	0.000009	0.98	30299.73	1663.12	0.03
HR1010320A	56213	100-yr	18812	1020	1062.5	1027.17	1062.51	0.000002	0.65	48128.39	1718.43	0.02
HR1010320A	55713	100-yr	18812	1020	1062.5		1062.51	0.000003	0.76	40867.98	1415.71	0.02
HR1010320A	55213	100-yr	151	1016	1019.37		1019.37	0.000063	0.46	327.57	172.27	0.06
HR1010320A	54713	100-yr	151	1016	1019.34		1019.35	0.00004	0.34	473.48	223.55	0.04
HR1010320A	54213	100-yr	151	1016	1019.3		1019.3	0.000284	0.69	282.45	299	0.1
HR1010320A	53628	100-yr	2114	1010.44	1013.45	1013.45	1014.52	0.015375	8.6	276.02	210.66	0.95

HR1010320A	53506		Culvert									
HR1010320A	53404	100-yr	2114	1008	1012.09	1011.3	1012.8	0.007573	6.79	311.58	108.68	0.69
HR1010320A	53213	100-yr	2114	1006	1010.55		1011.29	0.008259	6.87	308.22	112.63	0.71
HR1010320A	52713	100-yr	2114	1004	1007.78		1008.19	0.004534	5.65	555.58	274.31	0.54
HR1010320A	52213	100-yr	2114	998	1004.11	1003.16	1005.28	0.007315	8.7	279.49	368.99	0.71
HR1010320A	51713	100-yr	2114	996	1000.33		1001.3	0.008363	9.02	351.53	120.15	0.76
HR1010320A	51213	100-yr	2114	990	995.01		995.59	0.01572	7.56	446.96	226.8	0.68
HR1010320A	50713	100-yr	2114	988	993.55		993.66	0.00156	3.07	941.75	256.58	0.23
HR1010320A	50213	100-yr	4227	986	989.91		990.72	0.01985	8.66	703.58	288.49	0.77
HR1010320A	49713	100-yr	4227	974.23	988.17		988.41	0.001815	5.05	1525.51	353.5	0.27
HR1010320A	49213	100-yr	4227	974	987.83		987.92	0.000529	3.06	2419.88	435.64	0.15
HR1010320A	48948	100-yr	4227	976.01	987.56	980.63	987.72	0.000892	3.7	1401.92	375.58	0.19
HR1010320A	48799		Culvert									
HR1010320A	48611	100-yr	4227	974	979.95	977.35	980.44	0.002698	6.19	831.24	302.55	0.45
HR1010320A	48213	100-yr	4227	974	976.83	976.77	978.08	0.015926	9.37	509.15	202.73	0.98
HR1010320A	47713	100-yr	4227	968	973.41		973.98	0.004599	6.09	693.76	183.89	0.55
HR1010320A	47213	100-yr	4227	960	966.74	966.74	968.65	0.042206	11.14	384.41	106.44	0.97
HR1010320A	46713	100-yr	4227	956	962.79		963.43	0.003411	6.44	678.8	157.08	0.5
HR1010320A	46213	100-yr	4227	956	961.84		962.17	0.001714	4.73	1004.02	243.06	0.36
HR1010320A	45713	100-yr	4227	955.22	961.5		961.61	0.000633	3.06	1843.84	426.93	0.22
HR1010320A	45213	100-yr	4227	948	961.47		961.5	0.000082	2.09	4368.3	573.73	0.1
HR1010320A	44713	100-yr	4227	944	961.45		961.47	0.000025	1.22	4856.65	688.22	0.05
HR1010320A	44213	100-yr	4227	942	961.46		961.46	0.000009	0.87	9085.37	984.63	0.04
HR1010320A	43713	100-yr	4227	934	961.45		961.46	0.000005	0.77	11020.06	1225.72	0.03
HR1010320A	43213	100-yr	4227	934	961.45		961.46	0.000003	0.62	13033.76	928.67	0.02
HR1010320A	42713	100-yr	4227	930.06	961.45		961.46	0.000003	0.64	13340.41	798.79	0.02
HR1010320A	42346	100-yr	4227	932	961.45		961.45	0.000003	0.55	11469.35	786.63	0.02
HR1010320A	41964	100-yr	171	922.84	929.93		929.93	0.000056	0.7	243.72	58.47	0.06
HR1010320A	41712	100-yr	171	928.69	929.84		929.88	0.007184	1.62	105.52	155.52	0.35
HR1010320A	41212	100-yr	171	920.48	921.54	921.54	921.87	0.061793	4.6	37.2	57.59	1.01
HR1010320A	40712	100-yr	171	916	920.81	917.67	920.82	0.000357	0.79	216.36	1131.19	0.09
HR1010320A	40212	100-yr	171	914	920.78	915.05	920.78	0.000038	0.32	529.61	838.3	0.03
HR1010320A	39712	100-yr	171	920	920.46	920.46	920.69	0.007702	3.83	44.64	152.89	1.01
HR1010320A	39246	100-yr	171	908.67	909.93	909.93	910.26	0.050116	4.62	37.04	55.31	0.99
HR1010320A	38717	100-yr	171	902	905.31	903.56	905.33	0.001127	1.27	134.49	80.67	0.17
HR1010320A	**38366**	**100-yr**	**171**	**903.76**	**904.85**	**904.33**	**904.88**	**0.001518**	**1.28**	**133.61**	**160.56**	**0.25**
HR1010320A	**38252**		**Bridge**									
HR1010320A	**38127**	**100-yr**	**171**	**902**	**902.96**	**902.52**	**903.02**	**0.003881**	**2.12**	**80.84**	**92.4**	**0.4**
HR1010320A	37713	100-yr	171	900	901.16	900.69	901.27	0.004564	2.61	65.41	98.27	0.45
HR1010320A	37213	100-yr	171	896.2	898.21	897.73	898.27	0.008104	1.99	85.9	186.81	0.52
HR1010320A	36713	100-yr	171	890	892.36	891.71	892.55	0.005609	3.48	49.07	34.58	0.52
HR1010320A	36213	100-yr	171	888	889.74		889.85	0.005111	2.62	65.19	66.3	0.47
HR1010320A	35682	100-yr	171	885.04	886.58	885.95	886.64	0.007204	2.03	84.05	78.17	0.35

HEC-RAS PLAN: PROP RIVER SAL MUD CK U REACH: HR1010320A

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HR1010320A	81352	100-yr	975	1232	1234.64	1234.08	1234.87	0.006463	4.81	298.3	213.65	0.54
HR1010320A	80858	100-yr	975	1227.44	1228.39	1228.39	1228.74	0.032754	5.73	226.36	329.06	1.04
HR1010320A	80230	100-yr	975	1219.9	1221.36		1221.45	0.005508	2.63	423.48	410.63	0.4
HR1010320A	79509	100-yr	975	1212.3	1213.58	1213.58	1213.97	0.026584	5.99	221.78	287.68	0.97
HR1010320A	78928	100-yr	975	1202	1207.15		1207.32	0.001811	3.4	312.31	148.63	0.31
HR1010320A	78276	100-yr	2628	1198.89	1202.17	1202.17	1202.85	0.015847	6.94	439.33	329.84	0.91
HR1010320A	77723	100-yr	2628	1188	1194.03		1195.03	0.009348	8.04	327.06	100.32	0.76
HR1010320A	77223	100-yr	2628	1188	1194.31		1194.37	0.000251	2.3	1588.23	414.85	0.16
HR1010320A	76723	100-yr	2628	1188	1194.28		1194.3	0.000076	1.26	2711.21	583.38	0.09
HR1010320A	76413	100-yr	2628	1188	1194.27	1188.94	1194.28	0.000028	0.76	3919.43	784.52	0.05
HR1010320A	76372		Inl Struct									
HR1010320A	76331	100-yr	2628	1178.16	1181.62	1181.62	1182.65	0.01907	8.97	385.76	246.19	1.04
HR1010320A	75753	100-yr	2628	1172	1175.93	1175.04	1176.23	0.003748	4.95	750.23	408.87	0.49
HR1010320A	75733		Culvert									
HR1010320A	75694	100-yr	2628	1171.44	1174.44	1174.44	1174.98	0.040218	6.98	534.58	486.52	0.85
HR1010320A	75223	100-yr	2628	1162	1166.73		1166.96	0.005412	3.82	687.38	177.95	0.34
HR1010320A	74723	100-yr	2628	1157.12	1161.85	1160.99	1162.5	0.016879	7.32	451.88	230.97	0.62
HR1010320A	74223	100-yr	2628	1152	1157.83		1158.12	0.005158	4.6	688.98	211.24	0.35
HR1010320A	73723	100-yr	4136	1148	1152.58		1153.28	0.016289	6.92	673.18	249.81	0.6
HR1010320A	73223	100-yr	4136	1144	1149.31		1149.5	0.004083	3.53	1265.02	375.95	0.3
HR1010320A	72549	100-yr	4136	1138	1145.6	1142.41	1146.04	0.006271	5.48	858.82	246.84	0.39

HR1010320A	72502		Culvert									
HR1010320A	72437	100-yr	4136	1136	1142.53	1139.97	1143.26	0.008581	6.86	602.67	324.13	0.47
HR1010320A	72213	100-yr	4136	1134	1139.77		1140.31	0.020814	5.92	706.2	293.07	0.64
HR1010320A	71713	100-yr	4136	1128	1134.02		1134.4	0.007523	5.48	989.46	307.45	0.43
HR1010320A	71213	100-yr	4136	1120	1127.66		1128.7	0.018581	8.37	554.69	173.8	0.66
HR1010320A	70713	100-yr	4136	1112	1120.78		1121.62	0.010983	7.38	560.25	115.03	0.59
HR1010320A	70213	100-yr	4136	1112	1118.05		1118.39	0.003937	4.7	912.76	202.72	0.36
HR1010320A	69713	100-yr	4136	1110	1115.48		1115.94	0.006214	5.97	844.81	205.52	0.45
HR1010320A	69213	100-yr	4136	1104	1108.78	1108.56	1110.09	0.028486	9.2	453.28	148.45	0.9
HR1010320A	68713	100-yr	4136	1098.19	1105.52	1103.09	1105.81	0.003644	4.71	1129.92	313.64	0.35
HR1010320A	68213	100-yr	8547	1094	1098.52	1098.52	1099.86	0.03028	10.9	1070.9	389.98	0.96
HR1010320A	67713	100-yr	8547	1086	1097.6		1097.65	0.000621	2.57	5608.09	1260.57	0.15
HR1010320A	67213	100-yr	17184	1082	1095.76		1096.66	0.004532	9.02	3064.99	534.91	0.45
HR1010320A	66713	100-yr	17184	1079.7	1092.99		1093.84	0.007223	7.4	2322.75	397.92	0.54
HR1010320A	66213	100-yr	17184	1078	1090.6		1091.15	0.003898	7.4	3281.99	558.35	0.4
HR1010320A	65798	100-yr	17184	1078	1088.91	1085.98	1089.5	0.003967	7.4	3543.9	688.68	0.41
HR1010320A	65769		Culvert									
HR1010320A	65697	100-yr	17184	1078	1086.64	1086.36	1088.99	0.009129	12.87	1664.24	346.07	0.86
HR1010320A	65213	100-yr	17184	1072	1084.31		1085	0.004822	8.12	3140.52	510.85	0.44
HR1010320A	64713	100-yr	17184	1068	1081.09	1078.55	1082.12	0.007058	10.67	2561.6	420.86	0.54
HR1010320A	64213	100-yr	17184	1064	1076.83		1078.19	0.008602	11.98	2494.15	474.44	0.61
HR1010320A	63788	100-yr	17184	1064	1075.78	1070.89	1076.46	0.001719	7.24	3213.55	527.09	0.38
HR1010320A	63702		Culvert									
HR1010320A	63644	100-yr	17184	1064	1074.78	1070.5	1075.49	0.002951	9.84	2872.19	466.58	0.53
HR1010320A	63213	100-yr	17184	1060	1072.3		1073.39	0.008486	10.43	2696.29	528.56	0.56
HR1010320A	62713	100-yr	18812	1054.66	1070.44		1070.97	0.002817	8.47	4011.58	636.51	0.39
HR1010320A	62213	100-yr	18812	1054	1067.4		1068.88	0.005887	11.18	2621.75	510.83	0.56
HR1010320A	61713	100-yr	18812	1054	1064.76		1065.81	0.005931	9.99	2695.63	399.9	0.54
HR1010320A	61213	100-yr	18812	1052	1063.47		1063.84	0.002357	6.62	4235.53	488.55	0.35
HR1010320A	60713	100-yr	18812	1046	1062.66		1062.97	0.001287	5.92	5311.71	671.61	0.27
HR1010320A	60213	100-yr	18812	1036	1062.56		1062.71	0.000204	4.15	8402.67	800.37	0.15
HR1010320A	59713	100-yr	18812	1036	1062.56		1062.62	0.000086	2.8	11043.53	770.53	0.1
HR1010320A	59213	100-yr	18812	1034	1062.51		1062.58	0.000091	3.2	11008.7	744.04	0.11
HR1010320A	58713	100-yr	18812	1036	1062.52		1062.54	0.000027	1.71	20045.29	1042.19	0.06
HR1010320A	58213	100-yr	18812	1032	1062.52		1062.53	0.000012	1.2	23961.55	1177.79	0.04
HR1010320A	57713	100-yr	18812	1024.96	1062.51		1062.52	0.000014	1.55	23279.41	1103.31	0.05
HR1010320A	57213	100-yr	18812	1024	1062.5		1062.52	0.00001	1.28	24363.86	1230.82	0.04
HR1010320A	56713	100-yr	18812	1022	1062.5		1062.51	0.000009	0.98	30299.73	1663.12	0.03
HR1010320A	56213	100-yr	18812	1020	1062.5	1027.17	1062.51	0.000002	0.65	48128.39	1718.43	0.02
HR1010320A	55713	100-yr	18812	1020	1062.5		1062.51	0.000003	0.76	40867.98	1415.71	0.02
HR1010320A	55213	100-yr	151	1016	1019.37		1019.37	0.000063	0.46	327.57	172.27	0.06
HR1010320A	54713	100-yr	151	1016	1019.34		1019.35	0.00004	0.34	473.48	223.55	0.04
HR1010320A	54213	100-yr	151	1016	1019.3		1019.3	0.000284	0.69	282.45	299	0.1
HR1010320A	53628	100-yr	2114	1010.44	1013.45	1013.45	1014.52	0.015375	8.6	276.02	210.66	0.95
HR1010320A	53506		Culvert									
HR1010320A	53404	100-yr	2114	1008	1012.09	1011.3	1012.8	0.007573	6.79	311.58	108.68	0.69
HR1010320A	53213	100-yr	2114	1006	1010.55		1011.29	0.008259	6.87	308.22	112.63	0.71
HR1010320A	52713	100-yr	2114	1004	1007.78		1008.19	0.004534	5.65	555.58	274.31	0.54
HR1010320A	52213	100-yr	2114	998	1004.11	1003.16	1005.28	0.007315	8.7	279.49	368.99	0.71
HR1010320A	51713	100-yr	2114	996	1000.33		1001.3	0.008363	9.02	351.53	120.15	0.76
HR1010320A	51213	100-yr	2114	990	995.01		995.59	0.01572	7.56	446.96	226.8	0.68
HR1010320A	50713	100-yr	2114	988	993.55		993.66	0.00156	3.07	941.75	256.58	0.23
HR1010320A	50213	100-yr	4227	986	989.91		990.72	0.01985	8.66	703.58	288.49	0.77
HR1010320A	49713	100-yr	4227	974.23	988.17		988.41	0.001815	5.05	1525.51	353.5	0.27
HR1010320A	49213	100-yr	4227	974	987.83		987.92	0.000529	3.06	2419.88	435.64	0.15
HR1010320A	48948	100-yr	4227	976.01	987.56	980.63	987.72	0.000892	3.7	1401.92	375.58	0.19
HR1010320A	48799		Culvert									
HR1010320A	48611	100-yr	4227	974	979.95	977.35	980.44	0.002698	6.19	831.24	302.55	0.45
HR1010320A	48213	100-yr	4227	974	976.83	976.77	978.08	0.015926	9.37	509.15	202.73	0.98
HR1010320A	47713	100-yr	4227	968	973.41		973.98	0.004599	6.09	693.76	183.89	0.55
HR1010320A	47213	100-yr	4227	960	966.74	966.74	968.65	0.042206	11.14	384.41	106.44	0.97
HR1010320A	46713	100-yr	4227	956	962.79		963.43	0.003411	6.44	678.8	157.08	0.5
HR1010320A	46213	100-yr	4227	956	961.84		962.17	0.001714	4.73	1004.02	243.06	0.36
HR1010320A	45713	100-yr	4227	955.22	961.5		961.61	0.000633	3.06	1843.84	426.93	0.22
HR1010320A	45213	100-yr	4227	948	961.47		961.5	0.000082	2.09	4368.3	573.73	0.1
HR1010320A	44713	100-yr	4227	944	961.45		961.47	0.000025	1.22	4856.65	688.22	0.05
HR1010320A	44213	100-yr	4227	942	961.46		961.46	0.000009	0.87	9085.37	984.63	0.04
HR1010320A	43713	100-yr	4227	934	961.45		961.46	0.000005	0.77	11020.06	1225.72	0.03

HR1010320A	43213	100-yr	4227	934	961.45		961.46	0.000003	0.62	13033.76	928.67	0.02
HR1010320A	42713	100-yr	4227	930.06	961.45		961.46	0.000003	0.64	13340.41	798.79	0.02
HR1010320A	42346	100-yr	4227	932	961.45		961.45	0.000003	0.55	11469.35	786.63	0.02
HR1010320A	41964	100-yr	171	922.84	929.93		929.93	0.000056	0.7	243.72	58.47	0.06
HR1010320A	41712	100-yr	171	928.69	929.84		929.88	0.007184	1.62	105.52	155.52	0.35
HR1010320A	41212	100-yr	171	920.48	921.54	921.54	921.87	0.061793	4.6	37.2	57.59	1.01
HR1010320A	40712	100-yr	171	916	920.81	917.67	920.82	0.000357	0.79	216.36	1131.19	0.09
HR1010320A	40212	100-yr	171	914	920.78	915.05	920.78	0.000038	0.32	529.61	838.3	0.03
HR1010320A	39712	100-yr	171	920	920.46	920.46	920.69	0.007702	3.83	44.64	152.89	1.01
HR1010320A	39246	100-yr	171	908.67	909.93	909.93	910.26	0.050116	4.62	37.04	55.31	0.99
HR1010320A	38717	100-yr	171	902	905.33	903.56	905.35	0.001093	1.26	136.06	81.18	0.17
HR1010320A	**38478**	**100-yr**	**171**	**903**	**905.3**	**903.37**	**905.3**	**0.000068**	**0.5**	**344.75**	**167.5**	**0.06**
HR1010320A	**38252**		**Culvert**									
HR1010320A	**37941**	**100-yr**	**171**	**901.5**	**902.36**	**902.03**	**902.46**	**0.005941**	**2.5**	**68.45**	**83.64**	**0.49**
HR1010320A	37713	100-yr	171	900	901.16	900.69	901.27	0.004564	2.61	65.41	98.27	0.45
HR1010320A	37213	100-yr	171	896.2	898.21	897.73	898.27	0.008104	1.99	85.9	186.81	0.52
HR1010320A	36713	100-yr	171	890	892.36	891.71	892.55	0.005609	3.48	49.07	34.58	0.52
HR1010320A	36213	100-yr	171	888	889.74		889.85	0.005111	2.62	65.19	66.3	0.47
HR1010320A	35682	100-yr	171	885.04	886.58	885.95	886.64	0.007204	2.03	84.05	78.17	0.35

EXISTING CONDITION UNNAMED DITCH

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	548	10 yr	278.1	1171.94	1173.24		1173.35	0.005216	3.18	118.79	143.73	0.49
1	548	25 yr	283	1171.94	1173.25		1173.37	0.005234	3.2	120.23	144.6	0.49
1	548	50 yr	519.1	1171.94	1173.66		1173.82	0.005496	3.94	185.04	170.29	0.53
1	548	100 yr	618.1	1171.94	1173.8		1173.98	0.005568	4.17	209.37	178.45	0.54
1	518	10 yr	278.1	1171.76	1172.72	1172.72	1173.05	0.022372	5.22	69	110.87	0.96
1	518	25 yr	283	1171.76	1172.73	1172.73	1173.06	0.02225	5.25	70.04	111.6	0.96
1	518	50 yr	519.1	1171.76	1173.08	1173.08	1173.51	0.020183	6.21	114.6	139.11	0.97
1	518	100 yr	618.1	1171.76	1173.2	1173.2	1173.67	0.019832	6.53	131.71	148.32	0.97
1	498	10 yr	278.1	1166.44	1169.19	1168.18	1169.53	0.004188	4.71	59.01	102.17	0.5
1	498	25 yr	283	1166.44	1169.22	1168.2	1169.57	0.004172	4.74	59.7	102.88	0.5
1	498	50 yr	519.1	1166.44	1170.6	1169.08	1171.12	0.003646	5.8	89.46	133.76	0.5
1	498	100 yr	618.1	1166.44	1171.11	1169.39	1171.7	0.003507	6.15	100.5	145.2	0.5
1	404		Culvert									
1	310	10 yr	278.1	1164.89	1167.74	1166.62	1168.06	0.003716	4.55	61.16	45	0.48
1	310	25 yr	283	1164.89	1167.76	1166.65	1168.09	0.003743	4.59	61.68	45.1	0.48
1	310	50 yr	519.1	1164.89	1168.82	1167.51	1169.41	0.004416	6.15	84.46	49.71	0.55
1	310	100 yr	618.1	1164.89	1169.02	1167.83	1169.77	0.005291	6.96	88.84	50.6	0.6
1	290	10 yr	278.1	1165.02	1167.83		1167.9	0.000886	2.19	146.93	70.71	0.23
1	290	25 yr	283	1165.02	1167.86		1167.92	0.000886	2.21	148.81	71.07	0.23
1	290	50 yr	519.1	1165.02	1169.03		1169.13	0.000884	2.78	263.09	192.99	0.25
1	290	100 yr	618.1	1165.02	1169.31		1169.42	0.000891	2.92	320.61	227.85	0.25
1	260	10 yr	278.1	1165.02	1167.8	1166.18	1167.87	0.000921	2.22	144.92	70.31	0.24
1	260	25 yr	283	1165.02	1167.83	1166.19	1167.9	0.000921	2.23	146.75	70.67	0.24
1	260	50 yr	519.1	1165.02	1168.99	1166.75	1169.1	0.000922	2.82	256.99	191.24	0.25
1	260	100 yr	618.1	1165.02	1169.28	1166.95	1169.39	0.000922	2.95	313.72	220.61	0.25

PROPOSED CONDITION UNNAMED DITCH

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	548	10 yr	326.1	1171.94	1173.34		1173.46	0.005328	3.37	133.01	151.39	0.5
1	548	25 yr	435.9	1171.94	1173.53		1173.68	0.005414	3.71	163.65	162.79	0.52
1	548	50 yr	521.4	1171.94	1173.66		1173.83	0.005497	3.94	185.62	170.49	0.53
1	548	100 yr	613.9	1171.94	1173.79		1173.98	0.005563	4.16	208.39	178.13	0.54
1	518	10 yr	326.1	1171.76	1172.8	1172.8	1173.15	0.021799	5.46	78.45	117.29	0.97
1	518	25 yr	435.9	1171.76	1172.97	1172.97	1173.37	0.020879	5.93	99.15	130.23	0.97
1	518	50 yr	521.4	1171.76	1173.08	1173.08	1173.52	0.02018	6.22	114.99	139.33	0.97
1	518	100 yr	613.9	1171.76	1173.2	1173.2	1173.66	0.019856	6.52	130.96	147.93	0.97
1	498	10 yr	326.1	1166.44	1171.15	1168.36	1171.31	0.00095	3.22	101.31	146.05	0.26
1	498	25 yr	435.9	1166.44	1171.82	1168.79	1172.04	0.001089	3.77	115.76	161.04	0.29
1	498	50 yr	521.4	1166.44	1172.31	1169.08	1172.57	0.001171	4.13	126.12	171.78	0.3
1	498	100 yr	613.9	1166.44	1172.8	1169.38	1173.11	0.001242	4.49	136.66	182.71	0.31
1	284		Culvert									
1	50	10 yr	326.1	1162.91	1165.37	1164.87	1165.98	0.008773	6.34	52.54	48.05	0.71
1	50	25 yr	435.9	1162.91	1165.54	1165.28	1166.49	0.012501	7.92	56.24	49.23	0.86
1	50	50 yr	521.4	1162.91	1165.63	1165.59	1166.9	0.016085	9.17	58.06	49.81	0.98
1	50	100 yr	613.9	1162.91	1165.89	1165.89	1167.36	0.016339	9.84	63.75	51.63	1
1	30	10 yr	326.1	1163.71	1165.15	1165.15	1165.69	0.020554	6.68	61.14	56.96	0.99
1	30	25 yr	435.9	1163.71	1165.39	1165.39	1166.02	0.020151	7.33	74.86	59.34	1.01
1	30	50 yr	521.4	1163.71	1165.56	1165.56	1166.26	0.019629	7.74	85.26	61.08	1.01
1	30	100 yr	613.9	1163.71	1165.72	1165.72	1166.5	0.019538	8.18	95.41	62.74	1.03
1	0	10 yr	326.1	1161	1162.7	1162.7	1163.42	0.018413	7.19	51.56	37.41	0.97
1	0	25 yr	435.9	1161	1163.03	1163.03	1163.88	0.017434	7.86	64.24	40.15	0.97
1	0	50 yr	521.4	1161	1163.27	1163.27	1164.19	0.01667	8.27	73.97	42.12	0.97
1	0	100 yr	613.9	1161	1163.5	1163.5	1164.51	0.016114	8.68	84.02	44.07	0.97

APPENDIX F – SUB-DRAINAGE AREA MAPS & WINSTORM

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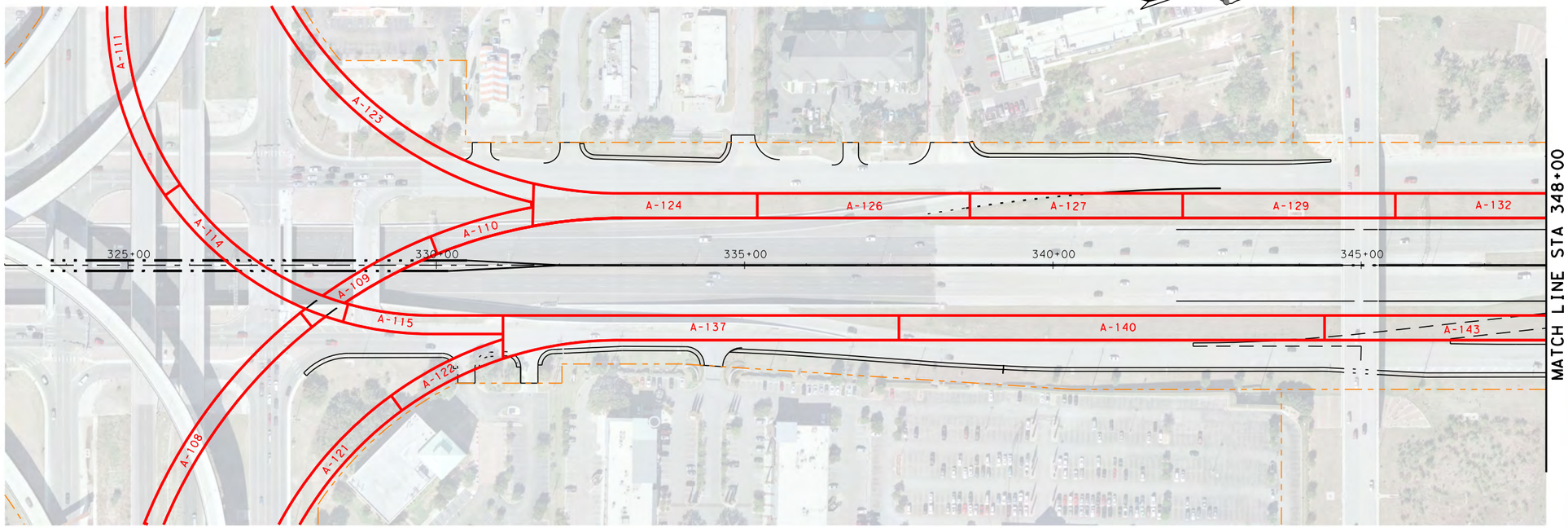

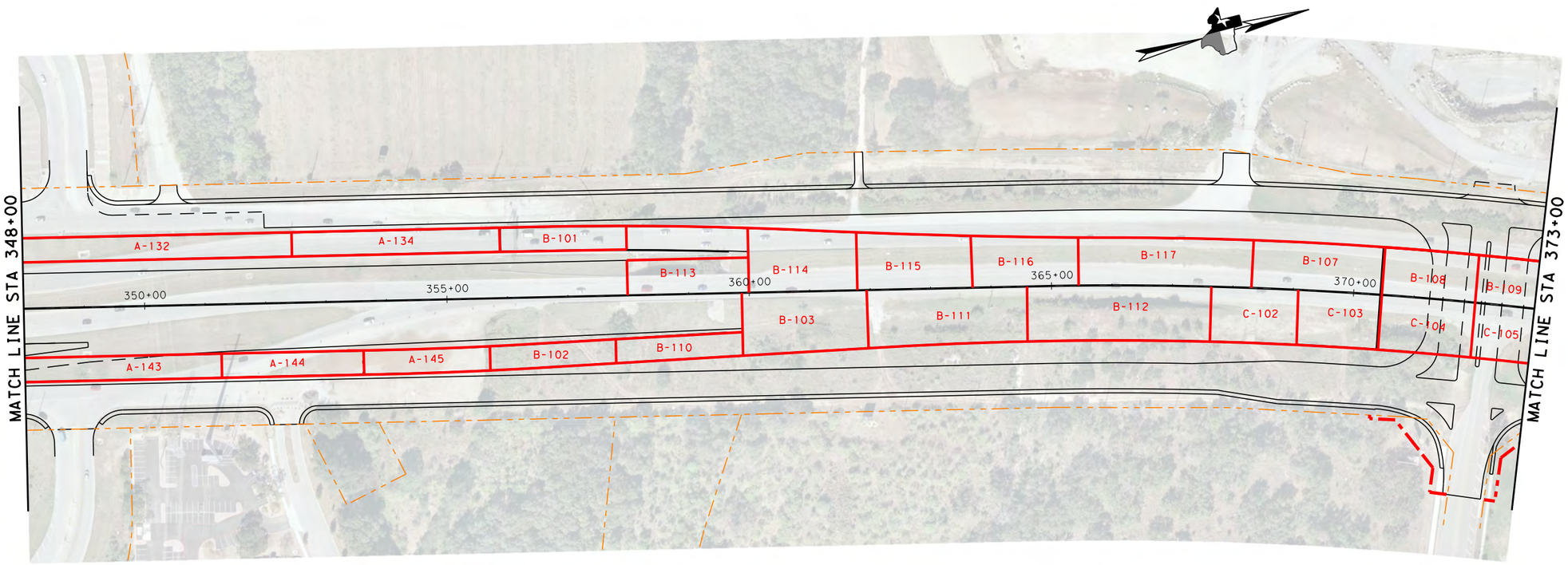

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 1 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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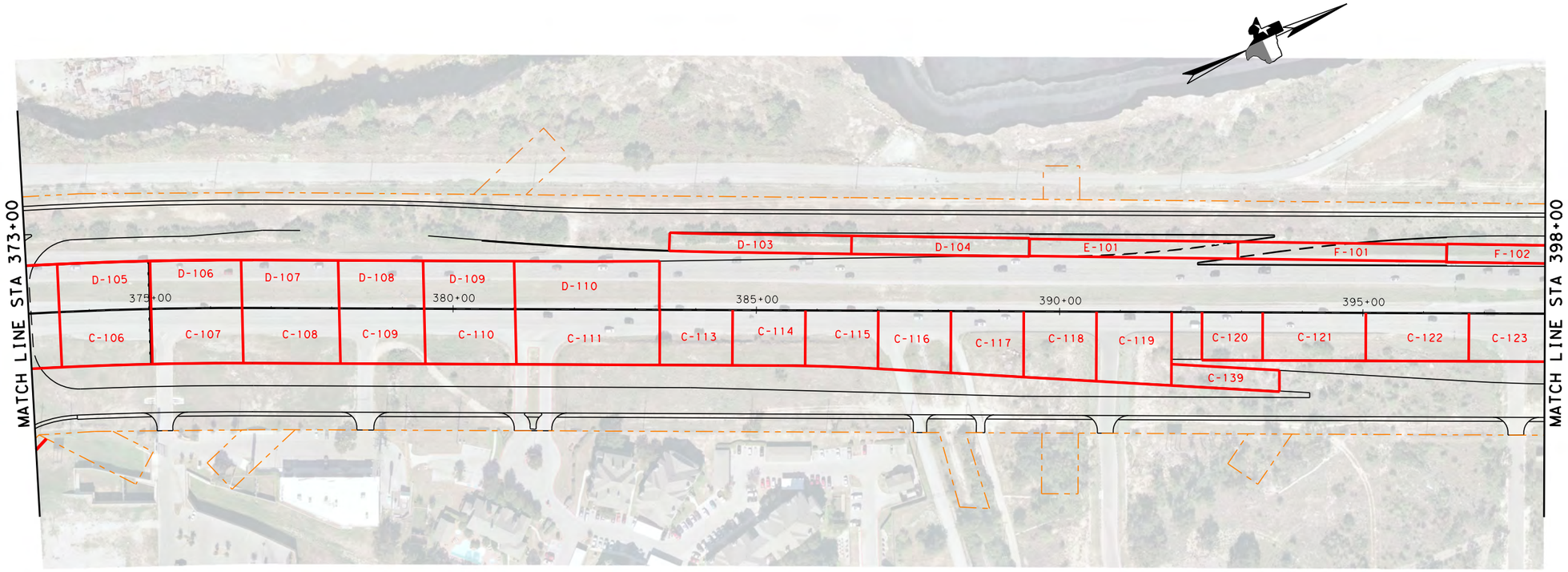

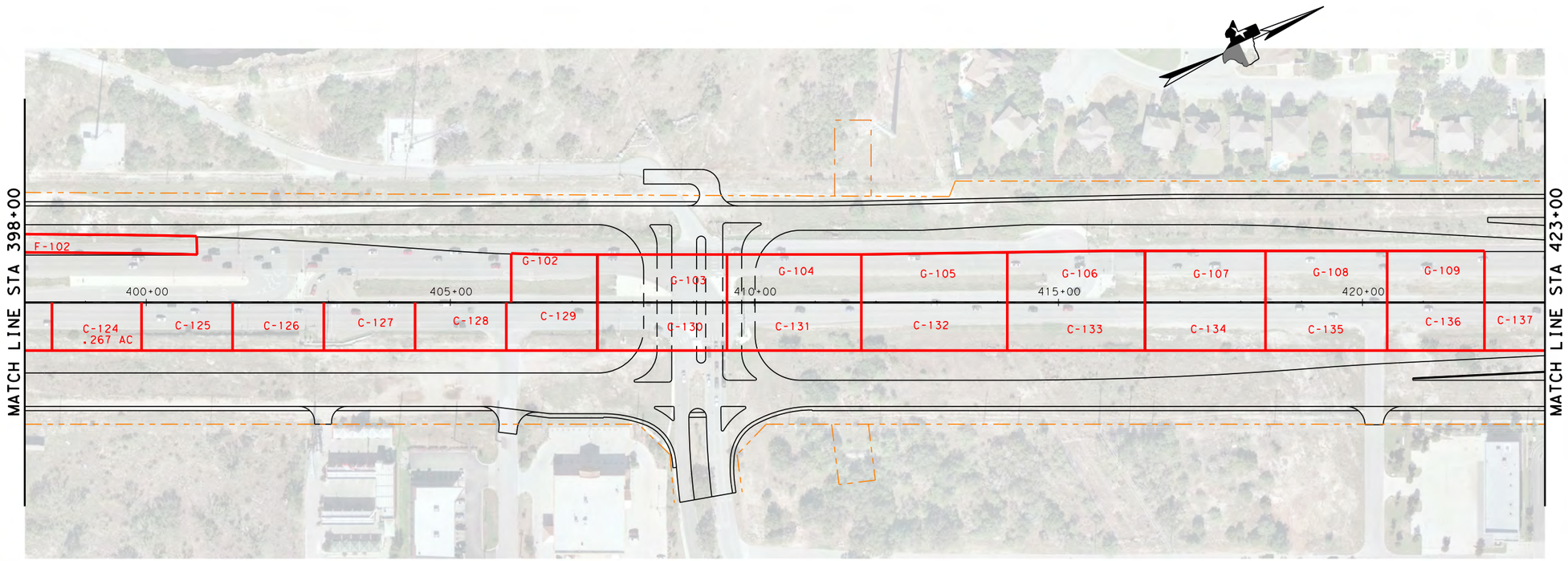

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 2 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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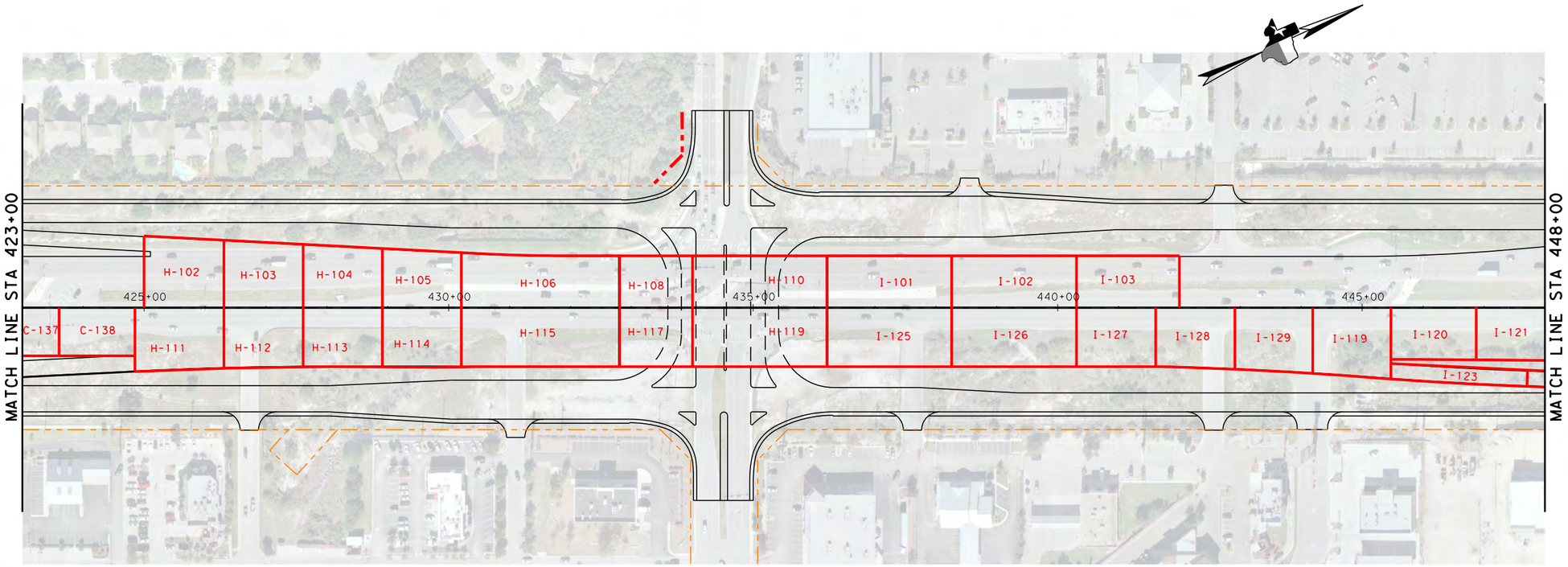

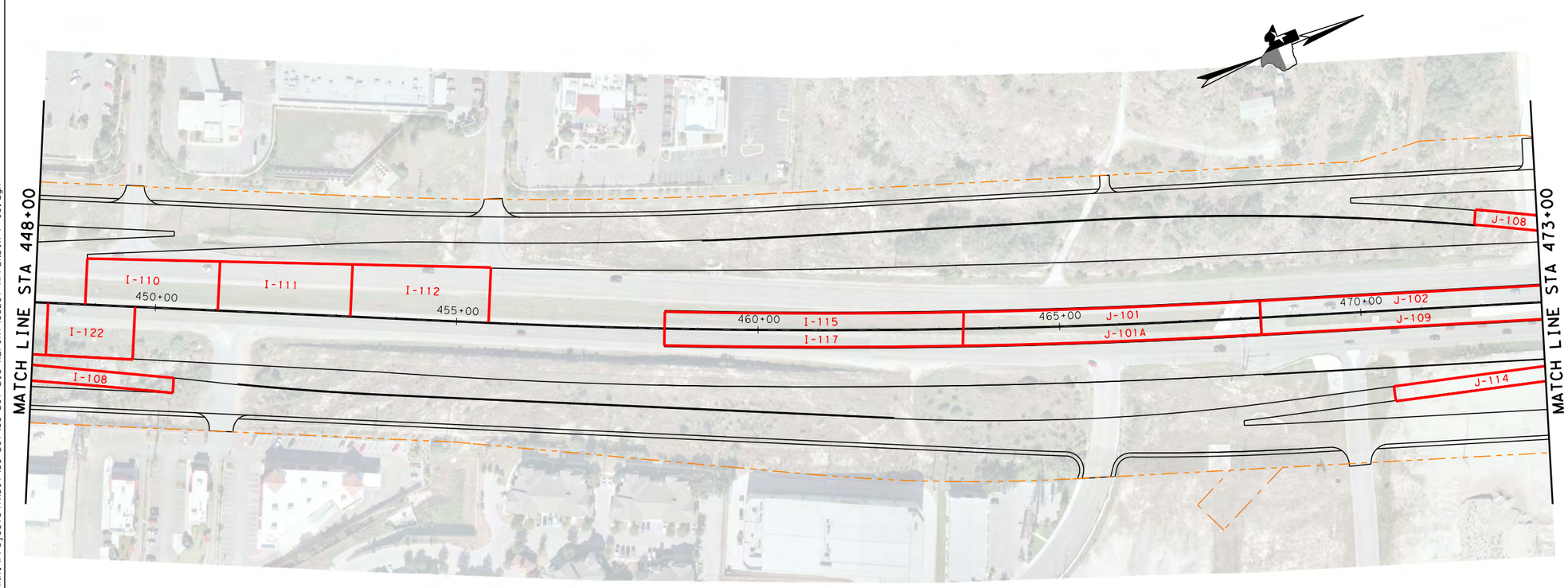

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 3 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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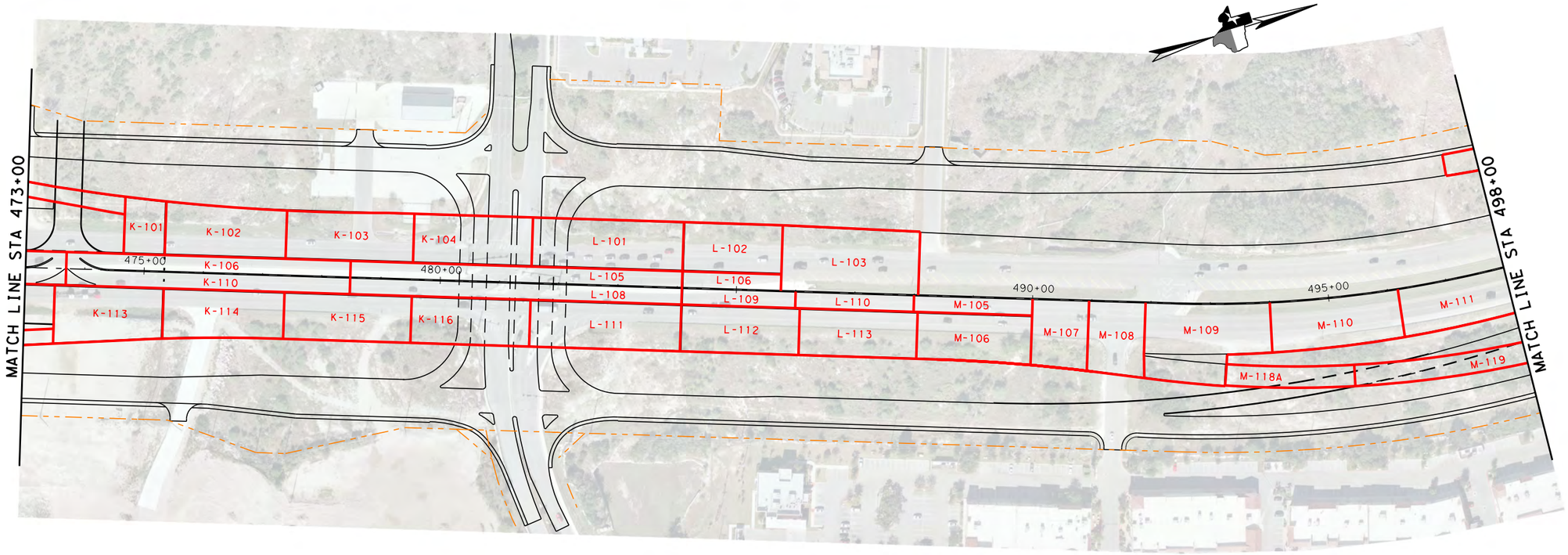

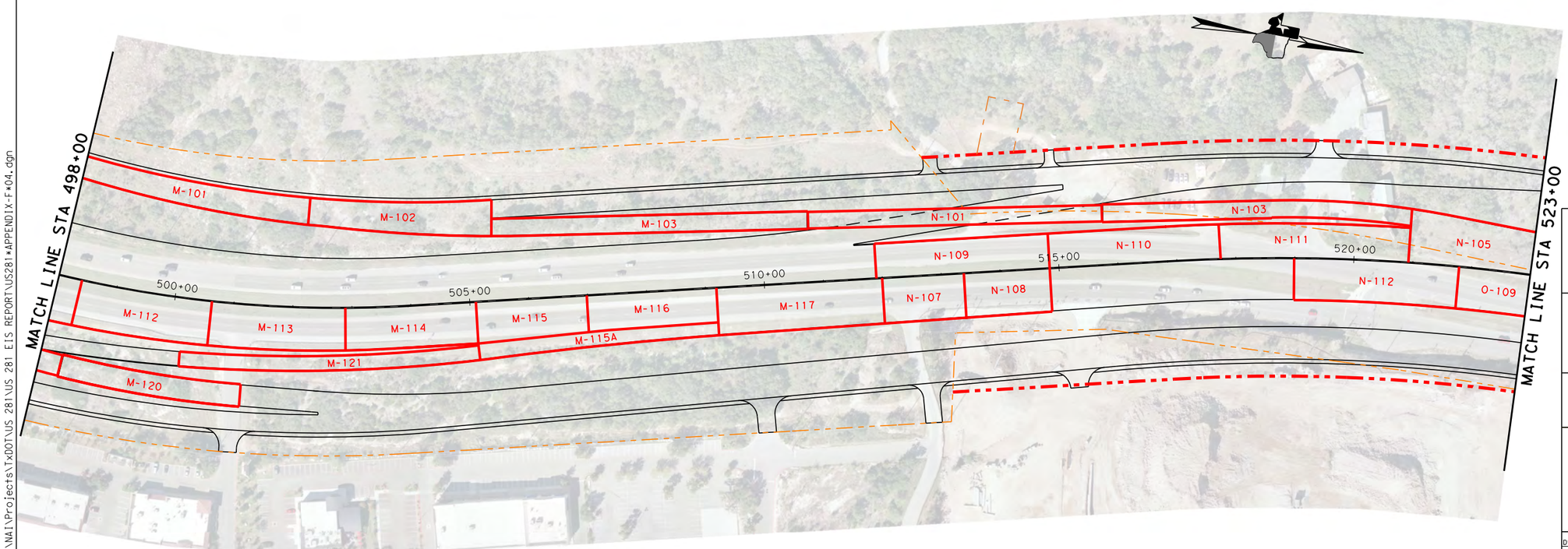

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

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SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 4 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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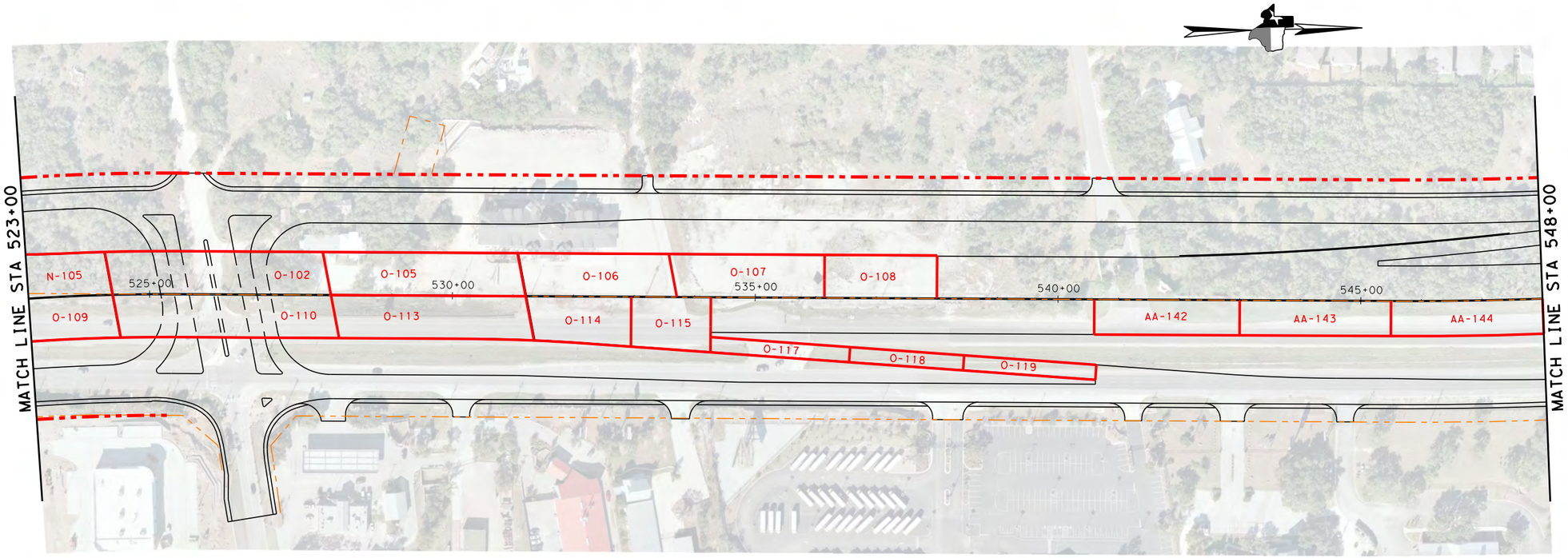

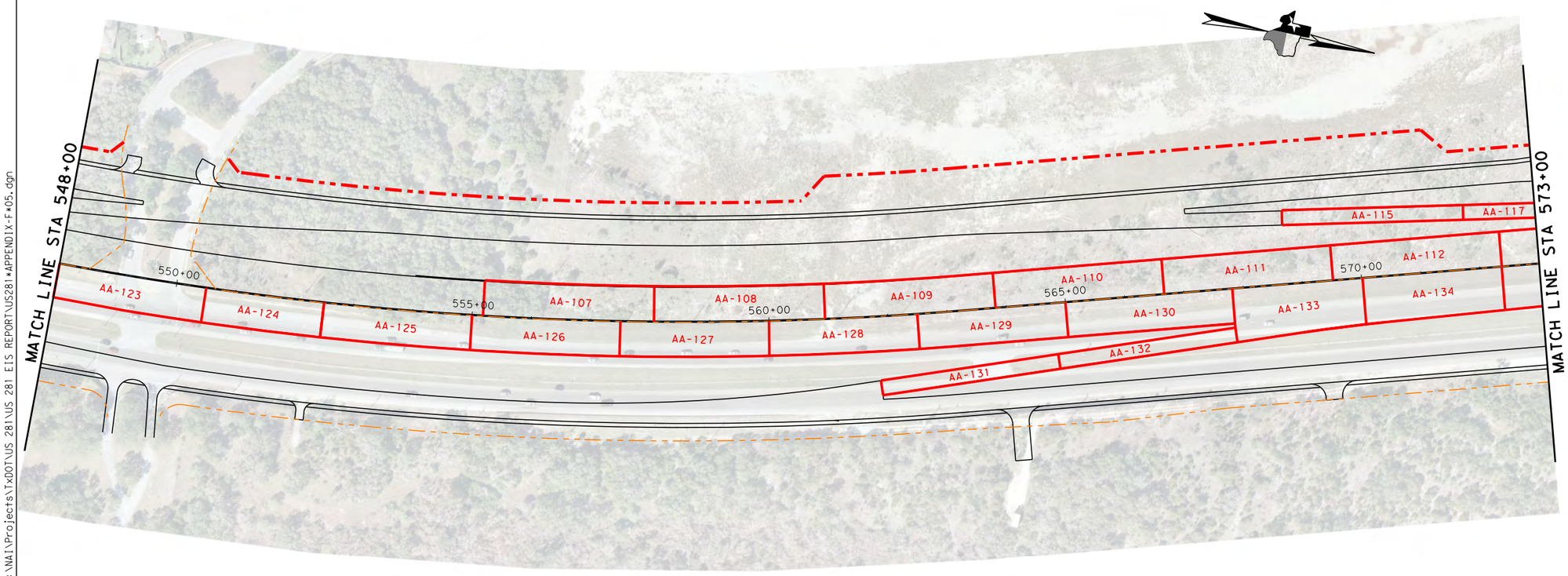

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 5 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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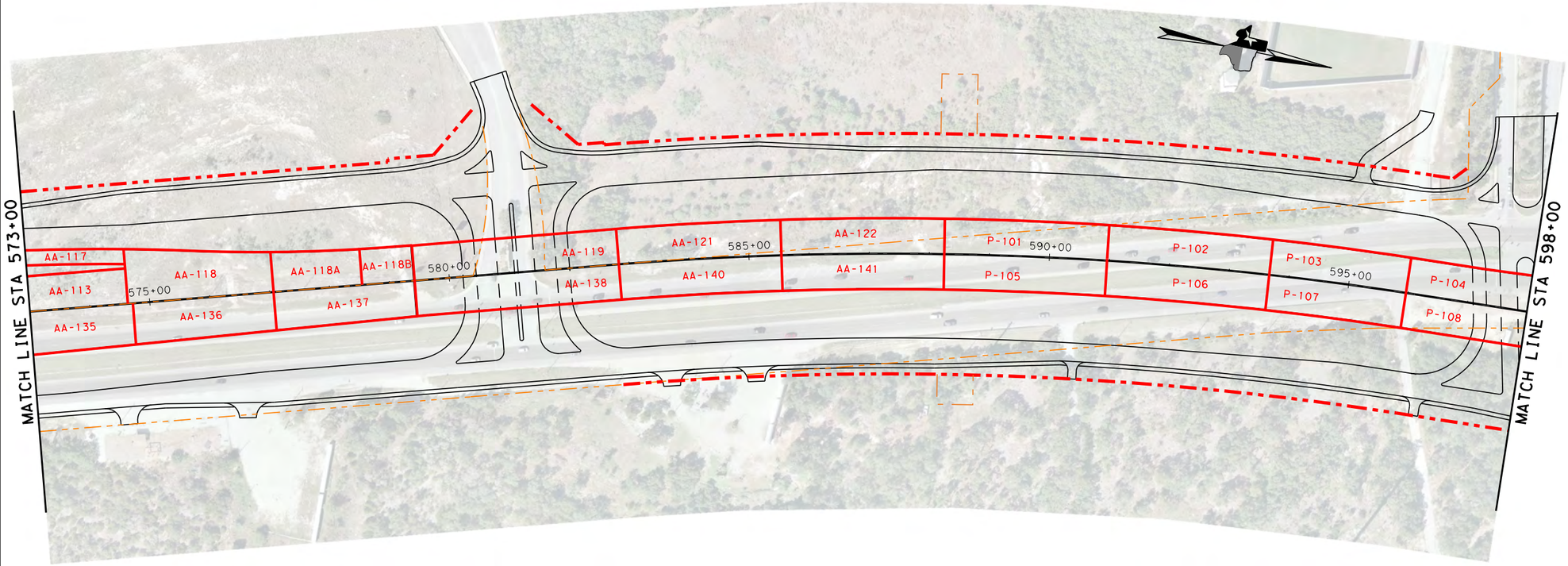

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 6 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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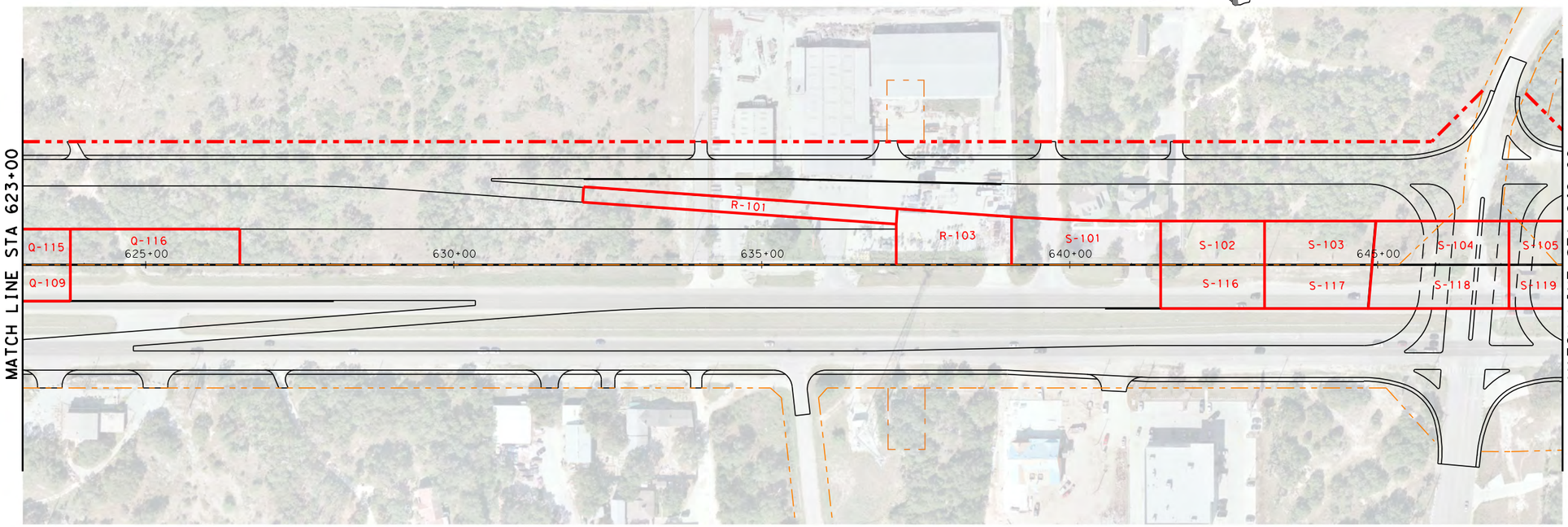

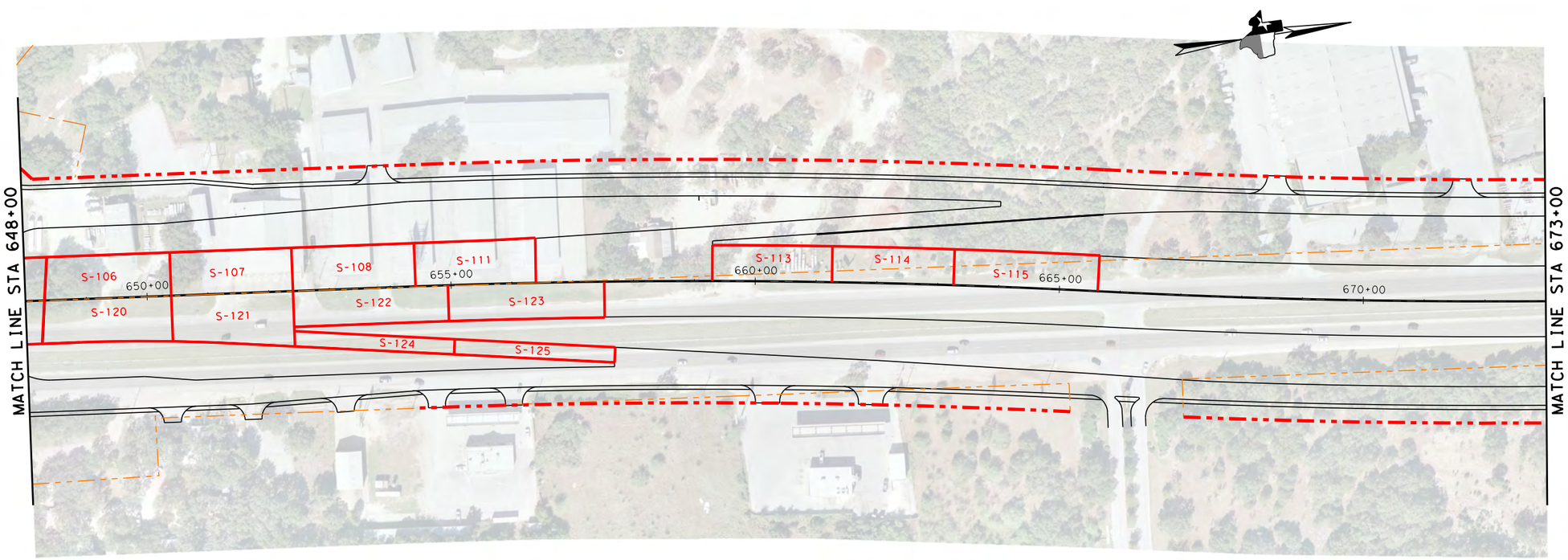

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 7 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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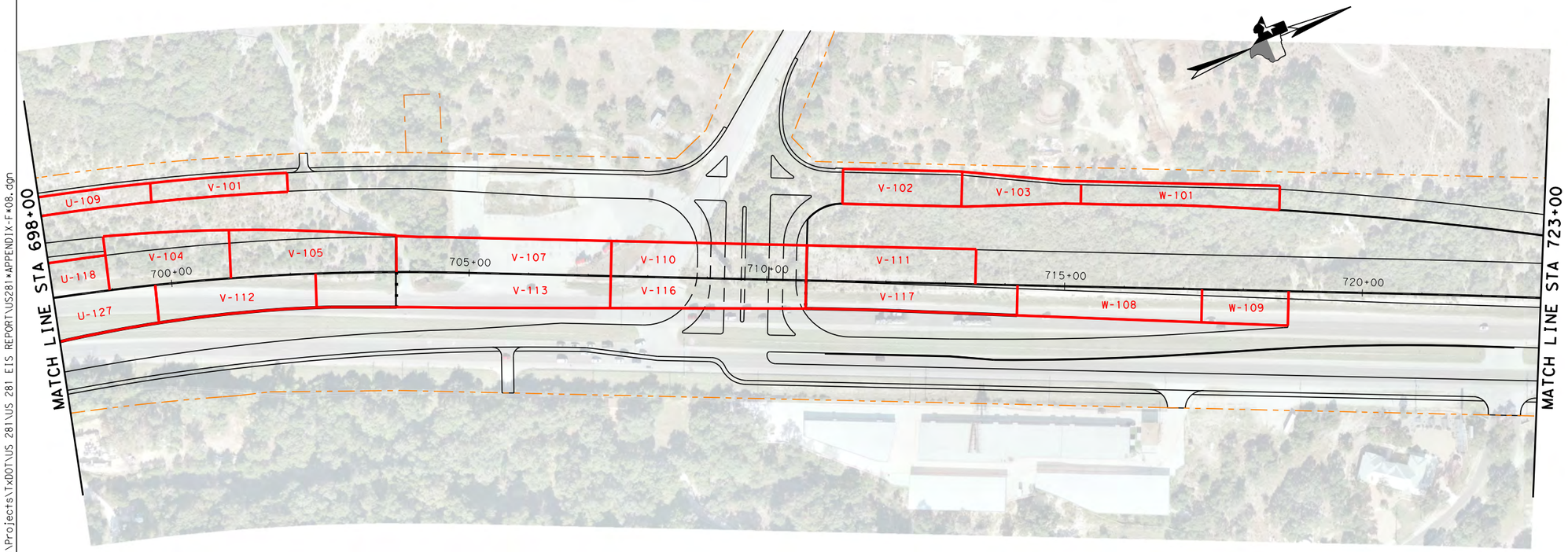

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

0 50 100 200

SCALE: 1"=200'

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 8 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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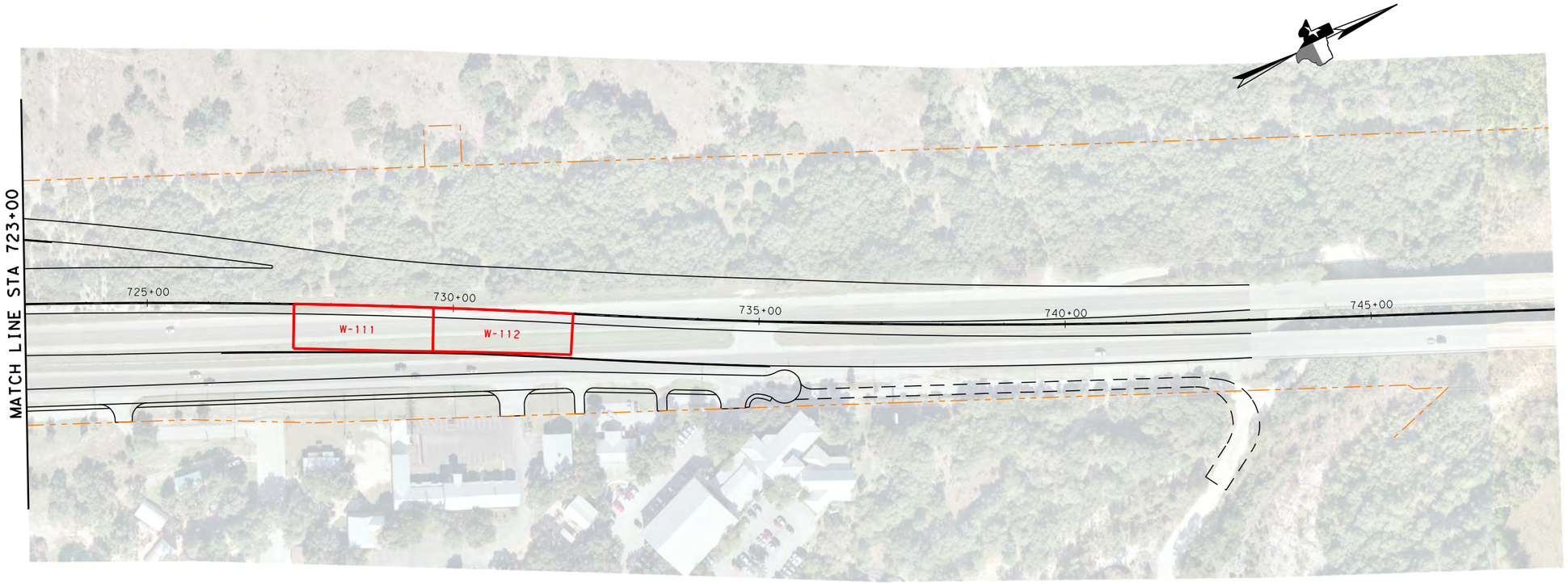

LEGEND

SUB-DRAINAGE AREA BOUNDARY

A SUB-DRAINAGE AREA ID

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SUB-DRAINAGE AREAS

APPENDIX F

SHEET 9 OF 9

DSN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CK:	6	TEXAS				US 281
DRN:	STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	SHEET NO.
CK:	SAT	BEXAR	0253	04	138	

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WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:58:44 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-142	0.9	0.32	10.00	10.00	8.07	0.000	2.321
	0.9	0.32	Pavement				
AA-143	0.9	0.33	10.00	10.00	8.07	0.000	2.418
	0.9	0.33	Pavement				
AA-144	0.9	0.33	10.00	10.00	8.07	0.000	2.425
	0.9	0.33	Pavement				
AA-123	0.9	0.34	10.00	10.00	8.07	0.000	2.455
	0.9	0.34	Pavement				
AA-124	0.9	0.27	10.00	10.00	8.07	0.000	1.978
	0.9	0.27	Pavement				
AA-125	0.9	0.34	10.00	10.00	8.07	0.000	2.474
	0.9	0.34	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-142	CircMh	0.900	0.32	10.00	8.07	0.000	0.00	2.321
AA-143	CircMh	0.900	0.65	11.38	7.64	0.000	0.00	4.484
AA-144	CircMh	0.900	0.99	12.51	7.31	0.000	0.00	6.494
AA-123	CircMh	0.900	1.32	13.56	7.05	0.000	0.00	8.398
AA-124	CircMh	0.900	1.94	14.35	6.86	0.000	0.00	11.956
AA-125	CircMh	0.900	0.34	10.00	8.07	0.000	0.00	2.474
OUT	Outlt	0.900	1.94	14.35	6.86	0.000	0.00	11.956

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-142	AA-143	1172.72	1171.97	Circ 1	0.00	2.00	250.00	0.30	0.013
2	AA-143	AA-144	1171.97	1171.22	Circ 1	0.00	2.00	249.00	0.30	0.013
3	AA-144	AA-123	1171.22	1170.48	Circ 1	0.00	2.00	249.00	0.30	0.013
4	AA-123	AA-124	1170.48	1169.87	Circ 1	0.00	2.00	202.00	0.30	0.013
5	AA-125	AA-124	1170.22	1169.87	Circ 1	0.00	2.00	117.00	0.30	0.013
6	AA-124	OUT	1169.87	1169.32	Circ 1	0.00	2.00	109.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1173.31	1172.80	0.011	0.59	0.83	3.03	1.88	2.32	12.39	0.000
2	1172.80	1172.25	0.039	0.83	1.03	3.65	2.74	4.48	12.42	0.000
3	1172.25	1171.69	0.082	1.03	1.21	3.98	3.28	6.49	12.33	0.000
4	1171.69	1171.15	0.138	1.20	1.28	4.25	3.95	8.40	12.43	0.000
5	1171.17	1171.15	0.012	0.61	1.28	3.06	1.16	2.47	12.37	0.000
6	1171.15	1170.60	0.279	1.28	1.28	5.62	5.62	11.96	16.07	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-142	0.9	0.32	10.00	10.00	11.49	0.000	3.304
	0.9	0.32	Pavement				
AA-143	0.9	0.33	10.00	10.00	11.49	0.000	3.442
	0.9	0.33	Pavement				
AA-144	0.9	0.33	10.00	10.00	11.49	0.000	3.452
	0.9	0.33	Pavement				
AA-123	0.9	0.34	10.00	10.00	11.49	0.000	3.495
	0.9	0.34	Pavement				
AA-124	0.9	0.27	10.00	10.00	11.49	0.000	2.815
	0.9	0.27	Pavement				
AA-125	0.9	0.34	10.00	10.00	11.49	0.000	3.523
	0.9	0.34	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-142	CircMh	0.900	0.32	10.00	11.49	0.000	0.00	3.304
AA-143	CircMh	0.900	0.65	11.24	10.94	0.000	0.00	6.423
AA-144	CircMh	0.900	0.99	12.28	10.52	0.000	0.00	9.343
AA-123	CircMh	0.900	1.32	13.25	10.17	0.000	0.00	12.120
AA-124	CircMh	0.900	1.94	13.99	9.91	0.000	0.00	17.284
AA-125	CircMh	0.900	0.34	10.00	11.49	0.000	0.00	3.523
OUT	Outlt	0.900	1.94	13.99	9.91	0.000	0.00	17.284

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-142	AA-143	1172.72	1171.97	Circ 1	0.00	2.00	250.00	0.30	0.013
2	AA-143	AA-144	1171.97	1171.22	Circ 1	0.00	2.00	249.00	0.30	0.013
3	AA-144	AA-123	1171.22	1170.48	Circ 1	0.00	2.00	249.00	0.30	0.013
4	AA-123	AA-124	1170.48	1169.87	Circ 1	0.00	2.00	202.00	0.30	0.013
5	AA-125	AA-124	1170.22	1169.87	Circ 1	0.00	2.00	117.00	0.30	0.013
6	AA-124	OUT	1169.87	1169.32	Circ 1	0.00	2.00	109.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1173.43	1173.01	0.021	0.70	1.04	3.35	2.01	3.30	12.39	0.000
2	1173.01	1172.63	0.081	1.02	1.40	4.01	2.72	6.42	12.42	0.000
3	1172.63	1172.23	0.171	1.31	1.75	4.28	3.21	9.34	12.33	0.000
4	1172.23	1171.75	0.287	1.59	1.88	4.52	3.96	12.12	12.43	0.000
5	1171.77	1171.75	0.024	0.73	1.88	3.37	1.15	3.52	12.37	0.000
6	1171.75	1171.20	0.584	1.88	1.88	5.65	5.65	17.28	16.07	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1170.60(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-125
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-144
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-143
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-142

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1171.20(ft)
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-125
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-144
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-143
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-142

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:00:21 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-107	0.9	0.39	10.00	10.00	8.07	0.000	2.819
	0.9	0.39	Pavement				
AA-108	0.9	0.39	10.00	10.00	8.07	0.000	2.819
	0.9	0.39	Pavement				
AA-109	0.9	0.39	10.00	10.00	8.07	0.000	2.817
	0.9	0.39	Pavement				
AA-110	0.9	0.39	10.00	10.00	8.07	0.000	2.803
	0.9	0.39	Pavement				
AA-111	0.9	0.39	10.00	10.00	8.07	0.000	2.803
	0.9	0.39	Pavement				
AA-112	0.9	0.39	10.00	10.00	8.07	0.000	2.803
	0.9	0.39	Pavement				
AA-113	0.9	0.31	10.00	10.00	8.07	0.000	2.228
	0.9	0.31	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-107	CircMh	0.900	2.63	17.23	6.26	0.000	0.00	14.800
AA-108	CircMh	0.900	2.24	16.26	6.45	0.000	0.00	12.998
AA-109	CircMh	0.900	1.85	15.18	6.67	0.000	0.00	11.121
AA-110	CircMh	0.900	1.46	14.07	6.92	0.000	0.00	9.124
AA-111	CircMh	0.900	1.08	12.90	7.21	0.000	0.00	7.002
AA-112	CircMh	0.900	0.69	11.60	7.57	0.000	0.00	4.720
AA-113	CircMh	0.900	0.31	10.00	8.07	0.000	0.00	2.228
OUT	Outlt	0.900	2.63	17.23	6.26	0.000	0.00	14.800

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-113	AA-112	1167.24	1166.39	Circ 1	0.00	2.00	284.00	0.30	0.013
2	AA-112	AA-111	1166.39	1165.53	Circ 1	0.00	2.00	286.00	0.30	0.013
3	AA-111	AA-110	1165.53	1164.68	Circ 1	0.00	2.00	285.00	0.30	0.013
4	AA-110	AA-109	1164.68	1163.82	Circ 1	0.00	2.00	285.00	0.30	0.013
5	AA-109	AA-108	1163.82	1162.97	Circ 1	0.00	2.00	284.00	0.30	0.013
6	AA-108	AA-107	1162.97	1161.98	Circ 1	0.00	2.00	284.00	0.35	0.013
7	AA-107	OUT	1161.98	1161.85	Circ 1	0.00	2.00	25.00	0.52	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1167.82	1167.25	0.010	0.58	0.86	2.96	1.73	2.23	12.38	0.000
2	1167.25	1166.61	0.044	0.86	1.08	3.66	2.73	4.72	12.41	0.000
3	1166.61	1165.96	0.096	1.08	1.28	4.05	3.29	7.00	12.36	0.000
4	1165.96	1165.32	0.163	1.28	1.50	4.29	3.61	9.12	12.43	0.000
5	1165.32	1164.56	0.242	1.50	1.59	4.40	4.14	11.12	12.38	0.000
6	1164.56	1163.48	0.330	1.59	1.59	4.84	4.84	13.00	13.36	0.000
7	1163.48	1163.35	0.428	1.50	1.50	5.86	5.86	14.80	16.32	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-107	0.9	0.39	10.00	10.00	11.49	0.000	4.014
	0.9	0.39	Pavement				
AA-108	0.9	0.39	10.00	10.00	11.49	0.000	4.014
	0.9	0.39	Pavement				
AA-109	0.9	0.39	10.00	10.00	11.49	0.000	4.010
	0.9	0.39	Pavement				
AA-110	0.9	0.39	10.00	10.00	11.49	0.000	3.991
	0.9	0.39	Pavement				
AA-111	0.9	0.39	10.00	10.00	11.49	0.000	3.991
	0.9	0.39	Pavement				
AA-112	0.9	0.39	10.00	10.00	11.49	0.000	3.991
	0.9	0.39	Pavement				
AA-113	0.9	0.31	10.00	10.00	11.49	0.000	3.172
	0.9	0.31	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-107	CircMh	0.900	2.63	16.46	9.16	0.000	0.00	21.680
AA-108	CircMh	0.900	2.24	15.68	9.39	0.000	0.00	18.931
AA-109	CircMh	0.900	1.85	14.75	9.67	0.000	0.00	16.118
AA-110	CircMh	0.900	1.46	13.70	10.01	0.000	0.00	13.196
AA-111	CircMh	0.900	1.08	12.62	10.40	0.000	0.00	10.093
AA-112	CircMh	0.900	0.69	11.43	10.86	0.000	0.00	6.773
AA-113	CircMh	0.900	0.31	10.00	11.49	0.000	0.00	3.172
OUT	Outlt	0.900	2.63	16.46	9.16	0.000	0.00	21.680

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-113	AA-112	1167.24	1166.39	Circ 1	0.00	2.00	284.00	0.30	0.013
2	AA-112	AA-111	1166.39	1165.53	Circ 1	0.00	2.00	286.00	0.30	0.013
3	AA-111	AA-110	1165.53	1164.68	Circ 1	0.00	2.00	285.00	0.30	0.013
4	AA-110	AA-109	1164.68	1163.82	Circ 1	0.00	2.00	285.00	0.30	0.013
5	AA-109	AA-108	1163.82	1162.97	Circ 1	0.00	2.00	284.00	0.30	0.013
6	AA-108	AA-107	1162.97	1161.98	Circ 1	0.00	2.00	284.00	0.35	0.013
7	AA-107	OUT	1161.98	1161.85	Circ 1	0.00	2.00	25.00	0.52	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1169.36	1169.30	0.020	0.69	2.00	3.32	1.01	3.17	12.38	0.000
2	1169.30	1169.05	0.090	1.06	2.00	3.99	2.16	6.77	12.41	0.000
3	1169.05	1168.48	0.199	1.38	2.00	4.38	3.21	10.09	12.36	0.000
4	1168.48	1167.51	0.340	1.75	2.00	4.53	4.20	13.20	12.43	0.000
5	1167.51	1166.07	0.507	2.00	2.00	5.13	5.13	16.12	12.38	0.000
6	1166.07	1164.08	0.700	2.00	2.00	6.03	6.03	18.93	13.36	0.000
7	1164.08	1163.85	0.918	2.00	2.00	6.90	6.90	21.68	16.32	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1163.35(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-113

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        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1163.85(ft)
Run# 7  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-107
Run# 6  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-108
Run# 5  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-109
Run# 4  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-113
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WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:01:24 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-126	0.9	0.34	10.00	10.00	8.07	0.000	2.469
	0.9	0.34	Pavement				
AA-127	0.9	0.34	10.00	10.00	8.07	0.000	2.471
	0.9	0.34	Pavement				
AA-128	0.9	0.34	10.00	10.00	8.07	0.000	2.476
	0.9	0.34	Pavement				
AA-129	0.9	0.34	10.00	10.00	8.07	0.000	2.463
	0.9	0.34	Pavement				
AA-130	0.9	0.38	10.00	10.00	8.07	0.000	2.771
	0.9	0.38	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-126	CircMh	0.900	1.74	14.41	6.84	0.000	0.00	10.726
AA-127	CircMh	0.900	1.40	13.44	7.07	0.000	0.00	8.925
AA-128	CircMh	0.900	1.06	12.42	7.34	0.000	0.00	7.013
AA-129	CircMh	0.900	0.72	11.30	7.66	0.000	0.00	4.966
AA-130	CircMh	0.900	0.38	10.00	8.07	0.000	0.00	2.771
OUT	Outlt	0.900	1.74	14.41	6.84	0.000	0.00	10.726

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-130	AA-129	1173.74	1172.99	Circ 1	0.00	2.00	250.00	0.30	0.013
2	AA-129	AA-128	1172.99	1172.23	Circ 1	0.00	2.00	251.00	0.30	0.013
3	AA-128	AA-127	1172.23	1171.48	Circ 1	0.00	2.00	250.00	0.30	0.013
4	AA-127	AA-126	1171.48	1170.73	Circ 1	0.00	2.00	251.00	0.30	0.013
5	AA-126	OUT	1170.73	1170.26	Circ 1	0.00	2.00	94.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1174.38	1173.87	0.015	0.64	0.88	3.19	2.09	2.77	12.39	0.000
2	1173.87	1173.31	0.048	0.88	1.08	3.76	2.87	4.97	12.45	0.000
3	1173.31	1172.73	0.096	1.08	1.25	4.06	3.40	7.01	12.39	0.000
4	1172.73	1171.93	0.156	1.25	1.25	4.32	4.32	8.92	12.37	0.000
5	1171.93	1171.46	0.225	1.20	1.20	5.43	5.43	10.73	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-126	0.9	0.34	10.00	10.00	11.49	0.000	3.515
	0.9	0.34	Pavement				
AA-127	0.9	0.34	10.00	10.00	11.49	0.000	3.517
	0.9	0.34	Pavement				
AA-128	0.9	0.34	10.00	10.00	11.49	0.000	3.525
	0.9	0.34	Pavement				
AA-129	0.9	0.34	10.00	10.00	11.49	0.000	3.506
	0.9	0.34	Pavement				
AA-130	0.9	0.38	10.00	10.00	11.49	0.000	3.945
	0.9	0.38	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-126	CircMh	0.900	1.74	14.14	9.87	0.000	0.00	15.465
AA-127	CircMh	0.900	1.40	13.19	10.19	0.000	0.00	12.855
AA-128	CircMh	0.900	1.06	12.24	10.54	0.000	0.00	10.071
AA-129	CircMh	0.900	0.72	11.20	10.96	0.000	0.00	7.106
AA-130	CircMh	0.900	0.38	10.00	11.49	0.000	0.00	3.945
OUT	Outlt	0.900	1.74	14.14	9.87	0.000	0.00	15.465

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-130	AA-129	1173.74	1172.99	Circ 1	0.00	2.00	250.00	0.30	0.013
2	AA-129	AA-128	1172.99	1172.23	Circ 1	0.00	2.00	251.00	0.30	0.013
3	AA-128	AA-127	1172.23	1171.48	Circ 1	0.00	2.00	250.00	0.30	0.013
4	AA-127	AA-126	1171.48	1170.73	Circ 1	0.00	2.00	251.00	0.30	0.013
5	AA-126	OUT	1170.73	1170.26	Circ 1	0.00	2.00	94.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1174.52	1174.09	0.030	0.78	1.10	3.47	2.22	3.95	12.39	0.000
2	1174.09	1173.69	0.099	1.09	1.46	4.04	2.89	7.11	12.45	0.000
3	1173.69	1173.23	0.198	1.38	1.75	4.37	3.45	10.07	12.39	0.000
4	1173.23	1172.32	0.323	1.75	1.75	4.41	4.41	12.85	12.37	0.000
5	1172.32	1171.85	0.467	1.59	1.59	5.76	5.76	15.46	16.00	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1171.46(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-129
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-130

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1171.85(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-126
Run# 4 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-129
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-130

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:02:16 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-131	0.9	0.17	10.00	10.00	8.07	0.000	1.257
	0.9	0.17	Pavement				
AA-132	0.9	0.17	10.00	10.00	8.07	0.000	1.257
	0.9	0.17	Pavement				
AA-133	0.9	0.42	10.00	10.00	8.07	0.000	3.078
	0.9	0.42	Pavement				
AA-134	0.9	0.41	10.00	10.00	8.07	0.000	2.969
	0.9	0.41	Pavement				
AA-135	0.9	0.38	10.00	10.00	8.07	0.000	2.785
	0.9	0.38	Pavement				
AA-136	0.9	0.36	10.00	10.00	8.07	0.000	2.601
	0.9	0.36	Pavement				
AA-137	0.9	0.33	10.00	10.00	8.07	0.000	2.419
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-131	CircMh	0.900	0.17	10.00	8.07	0.000	0.00	1.257
AA-132	CircMh	0.900	2.25	15.28	6.65	0.000	0.00	13.486
AA-133	CircMh	0.900	1.91	14.15	6.90	0.000	0.00	11.849
AA-134	CircMh	0.900	1.48	13.32	7.11	0.000	0.00	9.488
AA-135	CircMh	0.900	1.07	12.35	7.36	0.000	0.00	7.117
AA-136	CircMh	0.900	0.69	11.29	7.66	0.000	0.00	4.766
AA-137	CircMh	0.900	0.33	10.00	8.07	0.000	0.00	2.419
OUT	Outlt	0.900	2.25	15.28	6.65	0.000	0.00	13.486

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-131	AA-132	1181.68	1180.77	Circ 1	0.00	2.00	302.00	0.30	0.013
2	AA-137	AA-136	1184.45	1183.75	Circ 1	0.00	2.00	235.00	0.30	0.013
3	AA-136	AA-135	1183.75	1183.04	Circ 1	0.00	2.00	236.00	0.30	0.013
4	AA-135	AA-134	1183.04	1182.34	Circ 1	0.00	2.00	234.00	0.30	0.013
5	AA-134	AA-133	1182.34	1181.68	Circ 1	0.00	2.00	218.00	0.30	0.013
6	AA-133	AA-132	1181.68	1180.77	Circ 1	0.00	2.00	303.00	0.30	0.013
7	AA-132	OUT	1180.77	1180.66	Circ 1	0.00	2.00	22.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1182.21	1182.18	0.003	0.43	1.41	2.54	0.53	1.26	12.42	0.000
2	1185.05	1184.61	0.011	0.60	0.86	3.04	1.87	2.42	12.35	0.000
3	1184.61	1184.14	0.044	0.86	1.10	3.69	2.70	4.77	12.41	0.000
4	1184.14	1183.69	0.099	1.09	1.35	4.05	3.16	7.12	12.37	0.000
5	1183.69	1183.24	0.176	1.31	1.56	4.34	3.60	9.49	12.45	0.000
6	1183.24	1182.18	0.274	1.56	1.56	4.50	4.50	11.85	12.40	0.000
7	1182.18	1182.07	0.355	1.41	1.41	5.71	5.71	13.49	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years
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Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
AA-131	0.9	0.17	10.00	10.00	11.49	0.000	1.790
	0.9	0.17	Pavement				
AA-132	0.9	0.17	10.00	10.00	11.49	0.000	1.790
	0.9	0.17	Pavement				
AA-133	0.9	0.42	10.00	10.00	11.49	0.000	4.382
	0.9	0.42	Pavement				
AA-134	0.9	0.41	10.00	10.00	11.49	0.000	4.227
	0.9	0.41	Pavement				
AA-135	0.9	0.38	10.00	10.00	11.49	0.000	3.965
	0.9	0.38	Pavement				
AA-136	0.9	0.36	10.00	10.00	11.49	0.000	3.702
	0.9	0.36	Pavement				
AA-137	0.9	0.33	10.00	10.00	11.49	0.000	3.444
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
AA-131	CircMh	0.900	0.17	10.00	11.49	0.000	0.00	1.790
AA-132	CircMh	0.900	2.25	14.77	9.66	0.000	0.00	19.595
AA-133	CircMh	0.900	1.91	13.84	9.96	0.000	0.00	17.102
AA-134	CircMh	0.900	1.48	13.01	10.25	0.000	0.00	13.689
AA-135	CircMh	0.900	1.07	12.13	10.58	0.000	0.00	10.234
AA-136	CircMh	0.900	0.69	11.16	10.97	0.000	0.00	6.827
AA-137	CircMh	0.900	0.33	10.00	11.49	0.000	0.00	3.444
OUT	Outlt	0.900	2.25	14.77	9.66	0.000	0.00	19.595

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	AA-131	AA-132	1181.68	1180.77	Circ 1	0.00	2.00	302.00	0.30	0.013
2	AA-137	AA-136	1184.45	1183.75	Circ 1	0.00	2.00	235.00	0.30	0.013
3	AA-136	AA-135	1183.75	1183.04	Circ 1	0.00	2.00	236.00	0.30	0.013
4	AA-135	AA-134	1183.04	1182.34	Circ 1	0.00	2.00	234.00	0.30	0.013
5	AA-134	AA-133	1182.34	1181.68	Circ 1	0.00	2.00	218.00	0.30	0.013
6	AA-133	AA-132	1181.68	1180.77	Circ 1	0.00	2.00	303.00	0.30	0.013
7	AA-132	OUT	1180.77	1180.66	Circ 1	0.00	2.00	22.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1182.84	1182.83	0.006	0.52	2.00	2.79	0.57	1.79	12.42	0.000
2	1186.09	1186.05	0.023	0.72	2.00	3.39	1.10	3.44	12.35	0.000
3	1186.05	1185.83	0.091	1.06	2.00	4.03	2.17	6.83	12.41	0.000
4	1185.83	1185.35	0.205	1.38	2.00	4.44	3.26	10.23	12.37	0.000
5	1185.35	1184.56	0.366	2.00	2.00	4.36	4.36	13.69	12.45	0.000
6	1184.56	1182.83	0.571	2.00	2.00	5.44	5.44	17.10	12.40	0.000
7	1182.83	1182.66	0.750	2.00	2.00	6.24	6.24	19.59	16.00	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1182.07(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-132
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-131
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-133
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-134
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-135
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-136
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-137

```
        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1182.66(ft)
Run# 7  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-132
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-131
Run# 6  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-133
Run# 5  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-134
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-135
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-136
Upstream hydraulic gradeline exceeds critical elevation at node Id= AA-137
```

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:36:01 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-106	0.9	0.11	10.00	10.00	8.07	0.000	0.779
	0.9	0.11	Pavement				
L-109	0.9	0.12	10.00	10.00	8.07	0.000	0.896
	0.9	0.12	Pavement				
L-112	0.9	0.36	10.00	10.00	8.07	0.000	2.634
	0.9	0.36	Pavement				
L-110	0.9	0.13	10.00	10.00	8.07	0.000	0.934
	0.9	0.13	Pavement				
L-113	0.9	0.36	10.00	10.00	8.07	0.000	2.619
	0.9	0.36	Pavement				
M-105	0.9	0.13	10.00	10.00	8.07	0.000	0.934
	0.9	0.13	Pavement				
M-106	0.9	0.36	10.00	10.00	8.07	0.000	2.583
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-106	CircMh	0.900	0.11	10.00	8.07	0.000	0.00	0.779
L-109	CircMh	0.900	0.23	10.43	7.93	0.000	0.00	1.646
L-112	CircMh	0.900	0.59	10.46	7.92	0.000	0.00	4.229
L-110	CircMh	0.900	0.72	11.39	7.63	0.000	0.00	4.958
L-113	CircMh	0.900	1.08	11.41	7.62	0.000	0.00	7.429
M-105	CircMh	0.900	1.21	11.74	7.53	0.000	0.00	8.209
M-106	CircMh	0.900	1.57	11.75	7.53	0.000	0.00	10.612
OUT	Outlt	0.900	1.57	11.75	7.53	0.000	0.00	10.612

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-106	L-109	1072.46	1072.29	Circ 1	0.00	2.00	57.00	0.30	0.013
2	L-109	L-112	1072.29	1072.27	Circ 1	0.00	2.00	5.00	0.40	0.013
3	L-112	L-110	1072.27	1071.68	Circ 1	0.00	2.00	198.00	0.30	0.013
4	L-110	L-113	1071.68	1071.66	Circ 1	0.00	2.00	5.00	0.40	0.013
5	L-113	M-105	1071.66	1071.43	Circ 1	0.00	2.00	79.00	0.29	0.013
6	M-105	M-106	1071.43	1071.41	Circ 1	0.00	2.00	5.00	0.40	0.013
7	M-106	OUT	1071.41	1070.77	Circ 1	0.00	2.00	128.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1073.09	1073.08	0.001	0.34	0.79	2.20	0.67	0.78	12.36	0.000
2	1073.08	1073.08	0.005	0.46	0.81	3.01	1.37	1.65	14.31	0.000
3	1073.08	1072.80	0.035	0.81	1.12	3.53	2.33	4.23	12.35	0.000
4	1072.80	1072.80	0.048	0.81	1.14	4.14	2.68	4.96	14.31	0.000
5	1072.80	1072.61	0.108	1.13	1.18	4.08	3.87	7.43	12.21	0.000
6	1072.61	1072.60	0.132	1.09	1.19	4.67	4.22	8.21	14.31	0.000
7	1072.60	1071.96	0.220	1.19	1.19	5.46	5.46	10.61	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-106	0.9	0.11	10.00	10.00	11.49	0.000	1.109
	0.9	0.11	Pavement				
L-109	0.9	0.12	10.00	10.00	11.49	0.000	1.276
	0.9	0.12	Pavement				
L-112	0.9	0.36	10.00	10.00	11.49	0.000	3.750
	0.9	0.36	Pavement				
L-110	0.9	0.13	10.00	10.00	11.49	0.000	1.330
	0.9	0.13	Pavement				
L-113	0.9	0.36	10.00	10.00	11.49	0.000	3.728
	0.9	0.36	Pavement				
M-105	0.9	0.13	10.00	10.00	11.49	0.000	1.330
	0.9	0.13	Pavement				
M-106	0.9	0.36	10.00	10.00	11.49	0.000	3.678
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-106	CircMh	0.900	0.11	10.00	11.49	0.000	0.00	1.109
L-109	CircMh	0.900	0.23	10.39	11.31	0.000	0.00	2.348
L-112	CircMh	0.900	0.59	10.42	11.30	0.000	0.00	6.033
L-110	CircMh	0.900	0.72	11.26	10.93	0.000	0.00	7.103
L-113	CircMh	0.900	1.08	11.28	10.92	0.000	0.00	10.644
M-105	CircMh	0.900	1.21	11.58	10.80	0.000	0.00	11.774
M-106	CircMh	0.900	1.57	11.59	10.79	0.000	0.00	15.222
OUT	Outlt	0.900	1.57	11.59	10.79	0.000	0.00	15.222

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-106	L-109	1072.46	1072.29	Circ 1	0.00	2.00	57.00	0.30	0.013
2	L-109	L-112	1072.29	1072.27	Circ 1	0.00	2.00	5.00	0.40	0.013
3	L-112	L-110	1072.27	1071.68	Circ 1	0.00	2.00	198.00	0.30	0.013
4	L-110	L-113	1071.68	1071.66	Circ 1	0.00	2.00	5.00	0.40	0.013
5	L-113	M-105	1071.66	1071.43	Circ 1	0.00	2.00	79.00	0.29	0.013
6	M-105	M-106	1071.43	1071.41	Circ 1	0.00	2.00	5.00	0.40	0.013
7	M-106	OUT	1071.41	1070.77	Circ 1	0.00	2.00	128.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic US Elev (ft)	Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1073.36	1073.35	0.002	0.41	1.06	2.43	0.65	1.11	12.36	0.000
2	1073.35	1073.35	0.011	0.55	1.08	3.37	1.35	2.35	14.31	0.000
3	1073.35	1073.17	0.071	0.98	1.49	3.92	2.40	6.03	12.35	0.000
4	1073.17	1073.17	0.099	1.00	1.51	4.52	2.79	7.10	14.31	0.000
5	1073.17	1072.98	0.221	1.44	1.55	4.40	4.07	10.64	12.21	0.000
6	1072.98	1072.97	0.271	1.38	1.56	5.11	4.47	11.77	14.31	0.000
7	1072.97	1072.33	0.453	1.56	1.56	5.78	5.78	15.22	16.00	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1071.96(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-106

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        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1072.33(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-106
```

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 12:57:00 PM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-110	0.9	0.19	10.00	10.00	8.07	0.000	1.379
	0.9	0.19	Pavement				
A-145	0.9	0.19	10.00	10.00	8.07	0.000	1.394
	0.9	0.19	Pavement				
B-111	0.9	0.56	10.00	10.00	8.07	0.000	4.088
	0.9	0.56	Pavement				
B-112	0.9	0.63	10.00	10.00	8.07	0.000	4.600
	0.9	0.63	Pavement				
C-102	0.9	0.30	10.00	10.00	8.07	0.000	2.180
	0.9	0.30	Pavement				
C-103	0.9	0.29	10.00	10.00	8.07	0.000	2.074
	0.9	0.29	Pavement				
B-102	0.9	0.19	10.00	10.00	8.07	0.000	1.389
	0.9	0.19	Pavement				
B-103	0.9	0.48	10.00	10.00	8.07	0.000	3.461
	0.9	0.48	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-110	CircMh	0.900	2.83	14.79	6.76	0.000	0.00	17.219
A-145	CircMh	0.900	0.19	10.00	8.07	0.000	0.00	1.394
B-111	CircMh	0.900	1.78	13.30	7.11	0.000	0.00	11.404
B-112	CircMh	0.900	1.22	12.24	7.39	0.000	0.00	8.107
B-102	CircMh	0.900	0.38	10.62	7.87	0.000	0.00	2.713
B-103	CircMh	0.900	2.26	14.06	6.92	0.000	0.00	14.072
C-102	CircMh	0.900	0.59	10.82	7.81	0.000	0.00	4.114
C-103	CircMh	0.900	0.29	10.00	8.07	0.000	0.00	2.074
OUT	Outlt	0.900	2.83	14.79	6.76	0.000	0.00	17.219

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-145	B-102	909.57	909.28	Circ 1	0.00	2.00	97.00	0.30	0.013
2	B-102	B-110	909.28	908.91	Circ 1	0.00	2.00	122.00	0.30	0.013
3	C-103	C-102	912.29	911.86	Circ 1	0.00	2.00	143.20	0.30	0.013
4	C-102	B-112	911.86	910.96	Circ 1	0.00	2.00	300.00	0.30	0.013
6	B-112	B-111	910.96	910.16	Circ 1	0.00	2.00	265.00	0.30	0.013
7	B-111	B-103	910.16	909.54	Circ 1	0.00	2.00	208.00	0.30	0.013
8	B-103	B-110	909.54	908.91	Circ 1	0.00	3.00	210.00	0.30	0.013
9	B-110	OUT	908.91	908.83	Circ 1	0.00	3.00	15.00	0.53	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	910.19	910.17	0.004	0.45	0.89	2.61	1.03	1.39	12.37	0.000
2	910.17	910.14	0.014	0.63	1.23	3.18	1.34	2.71	12.46	0.000
3	912.84	912.66	0.008	0.55	0.80	2.92	1.78	2.07	12.40	0.000
4	912.66	912.16	0.033	0.80	1.20	3.52	2.10	4.11	12.39	0.000
6	912.16	911.66	0.128	1.19	1.50	4.17	3.21	8.11	12.43	0.000
7	911.66	910.83	0.254	1.50	1.50	4.51	4.51	11.40	12.35	0.000
8	910.83	910.14	0.045	1.29	1.29	4.85	4.85	14.07	36.54	0.000
9*	910.14	910.06	0.067	1.23	1.23	6.31	6.31	17.22	48.72	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-110	0.9	0.19	10.00	10.00	11.49	0.000	1.963
	0.9	0.19	Pavement				
A-145	0.9	0.19	10.00	10.00	11.49	0.000	1.985
	0.9	0.19	Pavement				
B-111	0.9	0.56	10.00	10.00	11.49	0.000	5.820
	0.9	0.56	Pavement				
B-112	0.9	0.63	10.00	10.00	11.49	0.000	6.548
	0.9	0.63	Pavement				
C-102	0.9	0.30	10.00	10.00	11.49	0.000	3.103
	0.9	0.30	Pavement				
C-103	0.9	0.29	10.00	10.00	11.49	0.000	2.952
	0.9	0.29	Pavement				
B-102	0.9	0.19	10.00	10.00	11.49	0.000	1.977
	0.9	0.19	Pavement				
B-103	0.9	0.48	10.00	10.00	11.49	0.000	4.927
	0.9	0.48	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-110	CircMh	0.900	2.83	14.32	9.81	0.000	0.00	24.990
A-145	CircMh	0.900	0.19	10.00	11.49	0.000	0.00	1.985
B-111	CircMh	0.900	1.78	13.00	10.26	0.000	0.00	16.449
B-112	CircMh	0.900	1.22	12.02	10.62	0.000	0.00	11.655
B-102	CircMh	0.900	0.38	10.56	11.23	0.000	0.00	3.874
B-103	CircMh	0.900	2.26	13.66	10.02	0.000	0.00	20.375
C-102	CircMh	0.900	0.59	10.74	11.15	0.000	0.00	5.879
C-103	CircMh	0.900	0.29	10.00	11.49	0.000	0.00	2.952
OUT	Outlt	0.900	2.83	14.32	9.81	0.000	0.00	24.990

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-145	B-102	909.57	909.28	Circ 1	0.00	2.00	97.00	0.30	0.013
2	B-102	B-110	909.28	908.91	Circ 1	0.00	2.00	122.00	0.30	0.013
3	C-103	C-102	912.29	911.86	Circ 1	0.00	2.00	143.20	0.30	0.013
4	C-102	B-112	911.86	910.96	Circ 1	0.00	2.00	300.00	0.30	0.013
6	B-112	B-111	910.96	910.16	Circ 1	0.00	2.00	265.00	0.30	0.013
7	B-111	B-103	910.16	909.54	Circ 1	0.00	2.00	208.00	0.30	0.013
8	B-103	B-110	909.54	908.91	Circ 1	0.00	3.00	210.00	0.30	0.013
9	B-110	OUT	908.91	908.83	Circ 1	0.00	3.00	15.00	0.53	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	910.48	910.47	0.008	0.54	1.19	2.91	1.02	1.99	12.37	0.000
2	910.47	910.43	0.029	0.77	1.52	3.50	1.51	3.87	12.46	0.000
3	913.42	913.39	0.017	0.66	1.53	3.24	1.14	2.95	12.40	0.000
4	913.39	913.23	0.068	0.97	2.00	3.90	1.87	5.88	12.39	0.000
6	913.23	912.52	0.265	1.53	2.00	4.52	3.71	11.65	12.43	0.000
7	912.52	911.13	0.529	2.00	2.00	5.24	5.24	16.45	12.35	0.000
8	911.13	910.43	0.093	1.59	1.59	5.34	5.34	20.38	36.54	0.000
9*	910.43	910.35	0.140	1.52	1.52	6.93	6.93	24.99	48.72	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

```
        Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 910.06(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= A-145
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-103

        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 910.35(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= A-145
Run# 7  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-103
```

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:45:49 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-113	0.96	0.27	10.00	10.00	8.07	0.000	2.070
	0.96	0.27	Pavement				
B-114	0.96	0.42	10.00	10.00	8.07	0.000	3.238
	0.96	0.42	Pavement				
B-115	0.96	0.39	10.00	10.00	8.07	0.000	3.059
	0.96	0.39	Pavement				
B-116	0.96	0.33	10.00	10.00	8.07	0.000	2.586
	0.96	0.33	Pavement				
B-117	0.96	0.52	10.00	10.00	8.07	0.000	4.049
	0.96	0.52	Pavement				
B-107	0.96	0.39	10.00	10.00	8.07	0.000	3.048
	0.96	0.39	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-113	CircMh	0.960	2.33	14.20	6.89	0.000	0.00	15.414
B-114	CircMh	0.960	2.06	13.57	7.04	0.000	0.00	13.949
B-115	CircMh	0.960	1.64	12.91	7.21	0.000	0.00	11.385
B-116	CircMh	0.960	1.25	12.17	7.41	0.000	0.00	8.890
B-117	CircMh	0.960	0.92	11.44	7.62	0.000	0.00	6.698
B-107	CircMh	0.960	0.39	10.00	8.07	0.000	0.00	3.048
OUT	Outlt	0.960	2.33	14.20	6.89	0.000	0.00	15.414

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-107	B-117	912.09	911.24	Circ 1	0.00	2.00	285.00	0.30	0.013
3	B-117	B-116	911.24	910.71	Circ 1	0.00	2.00	175.00	0.30	0.013
4	B-116	B-115	910.71	910.14	Circ 1	0.00	2.00	191.00	0.30	0.013
5	B-115	B-114	910.14	909.61	Circ 1	0.00	2.00	178.00	0.30	0.013
6	B-114	B-113	909.61	908.75	Circ 1	0.00	2.00	202.00	0.43	0.013
7	B-113	OUT	908.75	908.44	Circ 1	0.00	2.00	62.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	912.77	912.31	0.018	0.67	1.07	3.29	1.79	3.05	12.36	0.000
3	912.31	912.02	0.088	1.05	1.31	4.02	3.08	6.70	12.45	0.000
4	912.02	911.67	0.154	1.25	1.53	4.30	3.45	8.89	12.36	0.000
5	911.67	911.17	0.253	1.50	1.56	4.50	4.32	11.39	12.35	0.000
6	911.17	910.31	0.380	1.56	1.56	5.30	5.30	13.95	14.76	0.000
7	910.31	910.00	0.464	1.56	1.56	5.85	5.85	15.41	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
B-113	0.96	0.27	10.00	10.00	11.49	0.000	2.947
	0.96	0.27	Pavement				
B-114	0.96	0.42	10.00	10.00	11.49	0.000	4.610
	0.96	0.42	Pavement				
B-115	0.96	0.39	10.00	10.00	11.49	0.000	4.355
	0.96	0.39	Pavement				
B-116	0.96	0.33	10.00	10.00	11.49	0.000	3.681
	0.96	0.33	Pavement				
B-117	0.96	0.52	10.00	10.00	11.49	0.000	5.763
	0.96	0.52	Pavement				
B-107	0.96	0.39	10.00	10.00	11.49	0.000	4.340
	0.96	0.39	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
B-113	CircMh	0.960	2.33	13.80	9.98	0.000	0.00	22.319
B-114	CircMh	0.960	2.06	13.27	10.16	0.000	0.00	20.119
B-115	CircMh	0.960	1.64	12.70	10.37	0.000	0.00	16.367
B-116	CircMh	0.960	1.25	11.98	10.64	0.000	0.00	12.769
B-117	CircMh	0.960	0.92	11.31	10.91	0.000	0.00	9.595
B-107	CircMh	0.960	0.39	10.00	11.49	0.000	0.00	4.340
OUT	Outlt	0.960	2.33	13.80	9.98	0.000	0.00	22.319

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	B-107	B-117	912.09	911.24	Circ 1	0.00	2.00	285.00	0.30	0.013
3	B-117	B-116	911.24	910.71	Circ 1	0.00	2.00	175.00	0.30	0.013
4	B-116	B-115	910.71	910.14	Circ 1	0.00	2.00	191.00	0.30	0.013
5	B-115	B-114	910.14	909.61	Circ 1	0.00	2.00	178.00	0.30	0.013
6	B-114	B-113	909.61	908.75	Circ 1	0.00	2.00	202.00	0.43	0.013
7	B-113	OUT	908.75	908.44	Circ 1	0.00	2.00	62.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	914.60	914.49	0.037	0.81	2.00	3.62	1.38	4.34	12.36	0.000
3	914.49	914.18	0.180	1.31	2.00	4.39	3.05	9.59	12.45	0.000
4	914.18	913.57	0.318	1.75	2.00	4.38	4.06	12.77	12.36	0.000
5	913.57	912.64	0.523	2.00	2.00	5.21	5.21	16.37	12.35	0.000
6	912.64	911.04	0.791	2.00	2.00	6.40	6.40	20.12	14.76	0.000
7	911.04	910.44	0.973	2.00	2.00	7.10	7.10	22.32	16.00	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 910.00(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-107

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 910.44(ft)
Run# 7 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-113
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-114
Run# 5 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-115
Run# 4 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= B-107

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:49:22 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-107	0.9	0.31	10.00	10.00	8.07	0.000	2.283
	0.9	0.31	Pavement				
C-108	0.9	0.33	10.00	10.00	8.07	0.000	2.429
	0.9	0.33	Pavement				
C-109	0.9	0.29	10.00	10.00	8.07	0.000	2.125
	0.9	0.29	Pavement				
C-110	0.9	0.31	10.00	10.00	8.07	0.000	2.277
	0.9	0.31	Pavement				
C-111	0.9	0.50	10.00	10.00	8.07	0.000	3.601
	0.9	0.50	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-107	CircMh	0.900	1.75	12.54	7.31	0.000	0.00	11.515
C-108	CircMh	0.900	1.44	11.97	7.46	0.000	0.00	9.647
C-109	CircMh	0.900	1.10	11.33	7.65	0.000	0.00	7.586
C-110	CircMh	0.900	0.81	10.73	7.83	0.000	0.00	5.706
C-111	CircMh	0.900	0.50	10.00	8.07	0.000	0.00	3.601
OUT	Outlt	0.900	1.75	12.54	7.31	0.000	0.00	11.515

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	C-111	C-110	935.14	934.69	Circ 1	0.00	2.00	150.00	0.30	0.013
3	C-110	C-109	934.69	934.27	Circ 1	0.00	2.00	140.00	0.30	0.013
4	C-109	C-108	934.27	933.79	Circ 1	0.00	2.00	161.00	0.30	0.013
5	C-108	C-107	933.79	933.34	Circ 1	0.00	2.00	149.00	0.30	0.013
6	C-107	OUT	933.34	933.28	Circ 1	0.00	2.00	12.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	935.88	935.66	0.025	0.73	0.97	3.44	2.38	3.60	12.39	0.000
3	935.66	935.42	0.064	0.95	1.15	3.86	3.04	5.71	12.39	0.000
4	935.42	935.10	0.112	1.13	1.31	4.17	3.47	7.59	12.35	0.000
5	935.10	934.59	0.182	1.31	1.31	4.41	4.41	9.65	12.43	0.000
6	934.59	934.53	0.259	1.25	1.25	5.57	5.57	11.51	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-107	0.9	0.31	10.00	10.00	11.49	0.000	3.250
	0.9	0.31	Pavement				
C-108	0.9	0.33	10.00	10.00	11.49	0.000	3.457
	0.9	0.33	Pavement				
C-109	0.9	0.29	10.00	10.00	11.49	0.000	3.025
	0.9	0.29	Pavement				
C-110	0.9	0.31	10.00	10.00	11.49	0.000	3.241
	0.9	0.31	Pavement				
C-111	0.9	0.50	10.00	10.00	11.49	0.000	5.126
	0.9	0.50	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-107	CircMh	0.900	1.75	12.38	10.49	0.000	0.00	16.522
C-108	CircMh	0.900	1.44	11.81	10.71	0.000	0.00	13.839
C-109	CircMh	0.900	1.10	11.22	10.95	0.000	0.00	10.859
C-110	CircMh	0.900	0.81	10.66	11.19	0.000	0.00	8.149
C-111	CircMh	0.900	0.50	10.00	11.49	0.000	0.00	5.126
OUT	Outlt	0.900	1.75	12.38	10.49	0.000	0.00	16.522

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	C-111	C-110	935.14	934.69	Circ 1	0.00	2.00	150.00	0.30	0.013
3	C-110	C-109	934.69	934.27	Circ 1	0.00	2.00	140.00	0.30	0.013
4	C-109	C-108	934.27	933.79	Circ 1	0.00	2.00	161.00	0.30	0.013
5	C-108	C-107	933.79	933.34	Circ 1	0.00	2.00	149.00	0.30	0.013
6	C-107	OUT	933.34	933.28	Circ 1	0.00	2.00	12.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	936.31	936.24	0.051	0.89	1.55	3.79	1.96	5.13	12.39	0.000
3	936.24	936.10	0.130	1.19	1.83	4.19	2.70	8.15	12.39	0.000
4	936.10	935.79	0.230	1.44	2.00	4.49	3.46	10.86	12.35	0.000
5	935.79	935.03	0.374	2.00	2.00	4.41	4.41	13.84	12.43	0.000
6	935.03	934.97	0.533	1.69	1.69	5.84	5.84	16.52	16.00	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 934.53(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-111

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 934.97(ft)
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-107
Run# 5 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-111

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:51:33 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-113	0.9	0.25	10.00	10.00	8.07	0.000	1.821
	0.9	0.25	Pavement				
C-114	0.9	0.25	10.00	10.00	8.07	0.000	1.822
	0.9	0.25	Pavement				
C-115	0.9	0.26	10.00	10.00	8.07	0.000	1.863
	0.9	0.26	Pavement				
C-116	0.9	0.27	10.00	10.00	8.07	0.000	1.978
	0.9	0.27	Pavement				
C-117	0.9	0.29	10.00	10.00	8.07	0.000	2.103
	0.9	0.29	Pavement				
C-118	0.9	0.31	10.00	10.00	8.07	0.000	2.229
	0.9	0.31	Pavement				
C-119	0.9	0.34	10.00	10.00	8.07	0.000	2.434
	0.9	0.34	Pavement				
C-139	0.9	0.14	10.00	10.00	8.07	0.000	1.040
	0.9	0.14	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-113	CircMh	0.900	0.25	10.00	8.07	0.000	0.00	1.821
C-114	CircMh	0.900	0.50	10.71	7.84	0.000	0.00	3.538
C-115	CircMh	0.900	0.76	11.29	7.66	0.000	0.00	5.226
C-116	CircMh	0.900	1.03	11.83	7.50	0.000	0.00	6.959
C-117	CircMh	0.900	2.11	12.37	7.35	0.000	0.00	13.929
C-118	CircMh	0.900	0.79	11.85	7.50	0.000	0.00	5.298
C-119	CircMh	0.900	0.48	11.24	7.68	0.000	0.00	3.305
C-139	CircMh	0.900	0.14	10.00	8.07	0.000	0.00	1.040
OUT	Outlt	0.900	2.11	12.37	7.35	0.000	0.00	13.929

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-113	C-114	963.70	963.34	Circ 1	0.00	2.00	120.60	0.30	0.013
2	C-114	C-115	963.34	962.98	Circ 1	0.00	2.00	118.50	0.30	0.013
3	C-115	C-116	962.98	962.62	Circ 1	0.00	2.00	121.40	0.30	0.013
4	C-116	C-117	962.62	962.26	Circ 1	0.00	2.00	119.50	0.30	0.013
5	C-139	C-119	963.53	962.99	Circ 1	0.00	2.00	178.27	0.30	0.013
6	C-119	C-118	962.99	962.62	Circ 1	0.00	2.00	124.20	0.30	0.013
7	C-118	C-117	962.62	962.26	Circ 1	0.00	2.00	120.00	0.30	0.013
8	C-117	OUT	962.26	961.80	Circ 1	0.00	2.00	101.00	0.46	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	964.23	964.10	0.006	0.52	0.76	2.84	1.65	1.82	12.36	0.000
2	964.10	963.99	0.024	0.73	1.01	3.38	2.23	3.54	12.47	0.000
3	963.99	963.88	0.053	0.91	1.26	3.78	2.52	5.23	12.32	0.000
4	963.88	963.76	0.095	1.06	1.50	4.10	2.75	6.96	12.42	0.000
5	963.94	963.87	0.002	0.39	0.88	2.41	0.78	1.04	12.45	0.000
6	963.87	963.82	0.021	0.70	1.20	3.35	1.67	3.30	12.35	0.000
7	963.82	963.76	0.055	0.91	1.50	3.83	2.09	5.30	12.39	0.000
8	963.76	963.30	0.379	1.50	1.50	5.51	5.51	13.93	15.27	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-113	0.9	0.25	10.00	10.00	11.49	0.000	2.592
	0.9	0.25	Pavement				
C-114	0.9	0.25	10.00	10.00	11.49	0.000	2.593
	0.9	0.25	Pavement				
C-115	0.9	0.26	10.00	10.00	11.49	0.000	2.652
	0.9	0.26	Pavement				
C-116	0.9	0.27	10.00	10.00	11.49	0.000	2.815
	0.9	0.27	Pavement				
C-117	0.9	0.29	10.00	10.00	11.49	0.000	2.994
	0.9	0.29	Pavement				
C-118	0.9	0.31	10.00	10.00	11.49	0.000	3.173
	0.9	0.31	Pavement				
C-119	0.9	0.34	10.00	10.00	11.49	0.000	3.465
	0.9	0.34	Pavement				
C-139	0.9	0.14	10.00	10.00	11.49	0.000	1.481
	0.9	0.14	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-113	CircMh	0.900	0.25	10.00	11.49	0.000	0.00	2.592
C-114	CircMh	0.900	0.50	10.65	11.19	0.000	0.00	5.052
C-115	CircMh	0.900	0.76	11.18	10.96	0.000	0.00	7.480
C-116	CircMh	0.900	1.03	11.67	10.76	0.000	0.00	9.980
C-117	CircMh	0.900	2.11	12.17	10.57	0.000	0.00	20.019
C-118	CircMh	0.900	0.79	11.69	10.75	0.000	0.00	7.600
C-119	CircMh	0.900	0.48	11.13	10.99	0.000	0.00	4.730
C-139	CircMh	0.900	0.14	10.00	11.49	0.000	0.00	1.481
OUT	Outlt	0.900	2.11	12.17	10.57	0.000	0.00	20.019

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-113	C-114	963.70	963.34	Circ 1	0.00	2.00	120.60	0.30	0.013
2	C-114	C-115	963.34	962.98	Circ 1	0.00	2.00	118.50	0.30	0.013
3	C-115	C-116	962.98	962.62	Circ 1	0.00	2.00	121.40	0.30	0.013
4	C-116	C-117	962.62	962.26	Circ 1	0.00	2.00	119.50	0.30	0.013
5	C-139	C-119	963.53	962.99	Circ 1	0.00	2.00	178.27	0.30	0.013
6	C-119	C-118	962.99	962.62	Circ 1	0.00	2.00	124.20	0.30	0.013
7	C-118	C-117	962.62	962.26	Circ 1	0.00	2.00	120.00	0.30	0.013
8	C-117	OUT	962.26	961.80	Circ 1	0.00	2.00	101.00	0.46	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	965.01	965.00	0.013	0.63	1.66	3.09	0.93	2.59	12.36	0.000
2	965.00	964.95	0.050	0.89	1.97	3.74	1.61	5.05	12.47	0.000
3	964.95	964.82	0.109	1.13	2.00	4.11	2.38	7.48	12.32	0.000
4	964.82	964.59	0.195	1.34	2.00	4.45	3.18	9.98	12.42	0.000
5	964.78	964.77	0.004	0.47	1.78	2.64	0.50	1.48	12.45	0.000
6	964.77	964.73	0.044	0.86	2.00	3.67	1.51	4.73	12.35	0.000
7	964.73	964.59	0.113	1.13	2.00	4.18	2.42	7.60	12.39	0.000
8	964.59	963.80	0.783	2.00	2.00	6.37	6.37	20.02	15.27	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years

```
Tailwater set to uniform depth elevation = 963.30(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-118
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-119
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-139
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-113

        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 963.80(ft)
Run# 8  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-118
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-119
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-139
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-113
```

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:51:58 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-120	0.9	0.18	10.00	10.00	8.07	0.000	1.317
	0.9	0.18	Pavement				
C-121	0.9	0.31	10.00	10.00	8.07	0.000	2.239
	0.9	0.31	Pavement				
C-122	0.9	0.31	10.00	10.00	8.07	0.000	2.239
	0.9	0.31	Pavement				
C-123	0.9	0.31	10.00	10.00	8.07	0.000	2.239
	0.9	0.31	Pavement				
C-124	0.9	0.27	10.00	10.00	8.07	0.000	1.939
	0.9	0.27	Pavement				
C-125	0.9	0.27	10.00	10.00	8.07	0.000	1.975
	0.9	0.27	Pavement				
C-126	0.9	0.27	10.00	10.00	8.07	0.000	1.975
	0.9	0.27	Pavement				
C-127	0.9	0.27	10.00	10.00	8.07	0.000	1.975
	0.9	0.27	Pavement				
C-128	0.9	0.27	10.00	10.00	8.07	0.000	1.975
	0.9	0.27	Pavement				
C-129	0.9	0.27	10.00	10.00	8.07	0.000	1.975
	0.9	0.27	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-120	CircMh	0.900	0.18	10.00	8.07	0.000	0.00	1.317
C-121	CircMh	0.900	0.49	10.64	7.86	0.000	0.00	3.465
C-122	CircMh	0.900	2.73	14.70	6.78	0.000	0.00	16.670
C-123	CircMh	0.900	1.94	14.07	6.92	0.000	0.00	12.057
C-124	CircMh	0.900	1.63	13.42	7.08	0.000	0.00	10.366
C-125	CircMh	0.900	1.36	12.85	7.23	0.000	0.00	8.843
C-126	CircMh	0.900	1.09	12.24	7.39	0.000	0.00	7.234
C-127	CircMh	0.900	0.82	11.59	7.57	0.000	0.00	5.561
C-128	CircMh	0.900	0.54	10.87	7.79	0.000	0.00	3.814
C-129	CircMh	0.900	0.27	10.00	8.07	0.000	0.00	1.975
OUT	Outlt	0.900	2.73	14.70	6.78	0.000	0.00	16.670

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-120	C-121	972.28	971.98	Circ 1	0.00	2.00	99.00	0.30	0.013
2	C-121	C-122	971.98	971.47	Circ 1	0.00	2.00	170.00	0.30	0.013
3	C-129	C-128	974.73	974.28	Circ 1	0.00	2.00	151.00	0.30	0.013
4	C-128	C-127	974.28	973.83	Circ 1	0.00	2.00	149.00	0.30	0.013
5	C-127	C-126	973.83	973.38	Circ 1	0.00	2.00	151.00	0.30	0.013
6	C-126	C-125	973.38	972.93	Circ 1	0.00	2.00	150.00	0.30	0.013
7	C-125	C-124	972.93	972.49	Circ 1	0.00	2.00	147.00	0.30	0.013
8	C-124	C-123	972.49	971.98	Circ 1	0.00	2.00	170.00	0.30	0.013
9	C-123	C-122	971.98	971.47	Circ 1	0.00	2.00	170.00	0.30	0.013
10	C-122	OUT	971.47	971.45	Circ 1	0.00	3.00	5.00	0.40	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	972.87	972.85	0.003	0.44	0.87	2.59	1.01	1.32	12.45	0.000
2	972.85	972.78	0.023	0.72	1.31	3.41	1.59	3.47	12.39	0.000
3	975.27	975.05	0.008	0.54	0.77	2.89	1.79	1.98	12.35	0.000
4	975.05	974.78	0.028	0.77	0.95	3.45	2.59	3.81	12.43	0.000
5	974.78	974.51	0.060	0.94	1.13	3.85	3.05	5.56	12.35	0.000
6	974.51	974.23	0.102	1.09	1.30	4.11	3.34	7.23	12.39	0.000
7	974.23	973.95	0.153	1.25	1.46	4.28	3.60	8.84	12.38	0.000
8	973.95	973.57	0.210	1.41	1.59	4.39	3.86	10.37	12.39	0.000
9	973.57	972.78	0.284	1.59	1.59	4.49	4.49	12.06	12.39	0.000
10	972.78	972.76	0.062	1.31	1.31	5.61	5.61	16.67	42.19	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
C-120	0.9	0.18	10.00	10.00	11.49	0.000	1.876
	0.9	0.18	Pavement				
C-121	0.9	0.31	10.00	10.00	11.49	0.000	3.188
	0.9	0.31	Pavement				
C-122	0.9	0.31	10.00	10.00	11.49	0.000	3.188
	0.9	0.31	Pavement				
C-123	0.9	0.31	10.00	10.00	11.49	0.000	3.188
	0.9	0.31	Pavement				
C-124	0.9	0.27	10.00	10.00	11.49	0.000	2.761
	0.9	0.27	Pavement				
C-125	0.9	0.27	10.00	10.00	11.49	0.000	2.812
	0.9	0.27	Pavement				
C-126	0.9	0.27	10.00	10.00	11.49	0.000	2.812
	0.9	0.27	Pavement				
C-127	0.9	0.27	10.00	10.00	11.49	0.000	2.812
	0.9	0.27	Pavement				
C-128	0.9	0.27	10.00	10.00	11.49	0.000	2.812
	0.9	0.27	Pavement				
C-129	0.9	0.27	10.00	10.00	11.49	0.000	2.812
	0.9	0.27	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
C-120	CircMh	0.900	0.18	10.00	11.49	0.000	0.00	1.876
C-121	CircMh	0.900	0.49	10.58	11.23	0.000	0.00	4.947
C-122	CircMh	0.900	2.73	14.26	9.83	0.000	0.00	24.171
C-123	CircMh	0.900	1.94	13.75	10.00	0.000	0.00	17.411
C-124	CircMh	0.900	1.63	13.15	10.20	0.000	0.00	14.940
C-125	CircMh	0.900	1.36	12.61	10.40	0.000	0.00	12.731
C-126	CircMh	0.900	1.09	12.04	10.62	0.000	0.00	10.396
C-127	CircMh	0.900	0.82	11.43	10.86	0.000	0.00	7.975
C-128	CircMh	0.900	0.54	10.79	11.13	0.000	0.00	5.450
C-129	CircMh	0.900	0.27	10.00	11.49	0.000	0.00	2.812
OUT	Outlt	0.900	2.73	14.26	9.83	0.000	0.00	24.171

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	C-120	C-121	972.28	971.98	Circ 1	0.00	2.00	99.00	0.30	0.013
2	C-121	C-122	971.98	971.47	Circ 1	0.00	2.00	170.00	0.30	0.013
3	C-129	C-128	974.73	974.28	Circ 1	0.00	2.00	151.00	0.30	0.013
4	C-128	C-127	974.28	973.83	Circ 1	0.00	2.00	149.00	0.30	0.013
5	C-127	C-126	973.83	973.38	Circ 1	0.00	2.00	151.00	0.30	0.013
6	C-126	C-125	973.38	972.93	Circ 1	0.00	2.00	150.00	0.30	0.013
7	C-125	C-124	972.93	972.49	Circ 1	0.00	2.00	147.00	0.30	0.013
8	C-124	C-123	972.49	971.98	Circ 1	0.00	2.00	170.00	0.30	0.013
9	C-123	C-122	971.98	971.47	Circ 1	0.00	2.00	170.00	0.30	0.013
10	C-122	OUT	971.47	971.45	Circ 1	0.00	3.00	5.00	0.40	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	973.17	973.16	0.007	0.52	1.18	2.86	0.97	1.88	12.45	0.000
2	973.16	973.09	0.048	0.88	1.62	3.74	1.82	4.95	12.39	0.000
3	976.22	976.21	0.015	0.65	1.93	3.19	0.91	2.81	12.35	0.000
4	976.21	976.12	0.058	0.92	2.00	3.85	1.73	5.45	12.43	0.000
5	976.12	975.94	0.124	1.17	2.00	4.17	2.54	7.97	12.35	0.000
6	975.94	975.62	0.211	1.41	2.00	4.40	3.31	10.40	12.39	0.000
7	975.62	975.16	0.317	1.69	2.00	4.50	4.05	12.73	12.38	0.000
8	975.16	974.41	0.436	2.00	2.00	4.76	4.76	14.94	12.39	0.000
9	974.41	973.09	0.592	2.00	2.00	5.54	5.54	17.41	12.39	0.000
10	973.09	973.07	0.131	1.62	1.62	6.22	6.22	24.17	42.19	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 972.76(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-122
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-121
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-120
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-125
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-129

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 973.07(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-122
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-121
Run# 9 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-120
Run# 8 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-124
Run# 7 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-125
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= C-129

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:52:27 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-106	0.9	0.27	10.00	10.00	8.07	0.000	1.976
	0.9	0.27	Pavement				
D-107	0.9	0.29	10.00	10.00	8.07	0.000	2.108
	0.9	0.29	Pavement				
D-108	0.9	0.25	10.00	10.00	8.07	0.000	1.845
	0.9	0.25	Pavement				
D-109	0.9	0.27	10.00	10.00	8.07	0.000	1.976
	0.9	0.27	Pavement				
D-110	0.9	0.43	10.00	10.00	8.07	0.000	3.155
	0.9	0.43	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-106	CircMh	0.900	1.52	12.64	7.28	0.000	0.00	9.981
D-107	CircMh	0.900	1.25	12.04	7.45	0.000	0.00	8.381
D-108	CircMh	0.900	0.96	11.38	7.63	0.000	0.00	6.599
D-109	CircMh	0.900	0.71	10.76	7.82	0.000	0.00	4.975
D-110	CircMh	0.900	0.43	10.00	8.07	0.000	0.00	3.155
OUT	Outlt	0.900	1.52	12.64	7.28	0.000	0.00	9.981

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	D-110	D-109	940.13	939.68	Circ 1	0.00	2.00	150.00	0.30	0.013
3	D-109	D-108	939.68	939.26	Circ 1	0.00	2.00	140.70	0.30	0.013
4	D-108	D-107	939.26	938.78	Circ 1	0.00	2.00	159.37	0.30	0.013
5	D-107	D-106	938.78	938.32	Circ 1	0.00	2.00	152.30	0.30	0.013
6	D-106	OUT	938.32	938.25	Circ 1	0.00	2.00	17.00	0.41	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	940.82	940.57	0.019	0.69	0.89	3.30	2.34	3.15	12.39	0.000
3	940.57	940.31	0.048	0.88	1.05	3.76	2.99	4.97	12.36	0.000
4	940.31	939.98	0.085	1.03	1.20	4.04	3.34	6.60	12.42	0.000
5	939.98	939.54	0.137	1.20	1.22	4.25	4.18	8.38	12.43	0.000
6	939.54	939.47	0.195	1.22	1.22	4.98	4.98	9.98	14.52	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-106	0.9	0.27	10.00	10.00	11.49	0.000	2.813
	0.9	0.27	Pavement				
D-107	0.9	0.29	10.00	10.00	11.49	0.000	3.001
	0.9	0.29	Pavement				
D-108	0.9	0.25	10.00	10.00	11.49	0.000	2.626
	0.9	0.25	Pavement				
D-109	0.9	0.27	10.00	10.00	11.49	0.000	2.813
	0.9	0.27	Pavement				
D-110	0.9	0.43	10.00	10.00	11.49	0.000	4.491
	0.9	0.43	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-106	CircMh	0.900	1.52	12.43	10.47	0.000	0.00	14.344
D-107	CircMh	0.900	1.25	11.88	10.68	0.000	0.00	12.022
D-108	CircMh	0.900	0.96	11.26	10.93	0.000	0.00	9.448
D-109	CircMh	0.900	0.71	10.68	11.18	0.000	0.00	7.107
D-110	CircMh	0.900	0.43	10.00	11.49	0.000	0.00	4.491
OUT	Outlt	0.900	1.52	12.43	10.47	0.000	0.00	14.344

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	D-110	D-109	940.13	939.68	Circ 1	0.00	2.00	150.00	0.30	0.013
3	D-109	D-108	939.68	939.26	Circ 1	0.00	2.00	140.70	0.30	0.013
4	D-108	D-107	939.26	938.78	Circ 1	0.00	2.00	159.37	0.30	0.013
5	D-107	D-106	938.78	938.32	Circ 1	0.00	2.00	152.30	0.30	0.013
6	D-106	OUT	938.32	938.25	Circ 1	0.00	2.00	17.00	0.41	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	941.00	940.85	0.039	0.83	1.17	3.66	2.35	4.49	12.39	0.000
3	940.85	940.66	0.099	1.09	1.40	4.04	3.02	7.11	12.36	0.000
4	940.66	940.38	0.174	1.31	1.60	4.32	3.51	9.45	12.42	0.000
5	940.38	939.95	0.282	1.56	1.63	4.57	4.40	12.02	12.43	0.000
6	939.95	939.88	0.402	1.63	1.63	5.25	5.25	14.34	14.52	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 939.47(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-110

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 939.88(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-110

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:53:47 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-103	0.9	0.21	10.00	10.00	8.07	0.000	1.501
	0.9	0.21	Pavement				
D-104	0.9	0.20	10.00	10.00	8.07	0.000	1.469
	0.9	0.20	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-103	CircMh	0.900	0.41	11.90	7.48	0.000	0.00	2.755
D-104	CircMh	0.900	0.20	10.00	8.07	0.000	0.00	1.469
OUT	Outlt	0.900	0.41	11.90	7.48	0.000	0.00	2.755

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	D-104	D-103	971.97	971.08	Circ 1	0.00	2.00	298.00	0.30	0.013
2	D-103	OUT	971.08	971.03	Circ 1	0.00	2.00	10.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	972.44	971.64	0.004	0.47	0.56	2.62	2.03	1.47	12.36	0.000
2*	971.64	971.59	0.015	0.56	0.56	3.80	3.80	2.75	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
D-103	0.9	0.21	10.00	10.00	11.49	0.000	2.137
	0.9	0.21	Pavement				
D-104	0.9	0.20	10.00	10.00	11.49	0.000	2.091
	0.9	0.20	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
D-103	CircMh	0.900	0.41	11.69	10.76	0.000	0.00	3.958
D-104	CircMh	0.900	0.20	10.00	11.49	0.000	0.00	2.091
OUT	Outlt	0.900	0.41	11.69	10.76	0.000	0.00	3.958

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	D-104	D-103	971.97	971.08	Circ 1	0.00	2.00	298.00	0.30	0.013
2	D-103	OUT	971.08	971.03	Circ 1	0.00	2.00	10.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	972.52	971.76	0.009	0.55	0.68	2.94	2.22	2.09	12.36	0.000
2*	971.76	971.71	0.031	0.68	0.68	4.21	4.21	3.96	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 971.59(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-104

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 971.71(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= D-104

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:54:15 AM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-102	0.9	0.31	10.00	10.00	8.07	0.000	2.230
	0.9	0.31	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-102	CircMh	0.900	0.31	10.00	8.07	0.000	0.00	2.230
OUT	Outlt	0.900	0.31	10.00	8.07	0.000	0.00	2.230

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
7	F-102	OUT	987.72	987.37	Circ 1	0.00	2.00	71.00	0.49	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
7*	988.23	987.88	0.010	0.51	0.51	3.55	3.55	2.23	15.89	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
F-102	0.9	0.31	10.00	10.00	11.49	0.000	3.174
	0.9	0.31	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
F-102	CircMh	0.900	0.31	10.00	11.49	0.000	0.00	3.174
OUT	Outlt	0.900	0.31	10.00	11.49	0.000	0.00	3.174

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
7	F-102	OUT	987.72	987.37	Circ 1	0.00	2.00	71.00	0.49	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
7*	988.33	987.98	0.020	0.61	0.61	3.92	3.92	3.17	15.89	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 987.88(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= F-102

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 987.98(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= F-102

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:54:31 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-107	0.9	0.39	10.00	10.00	8.07	0.000	2.814
	0.9	0.39	Pavement				
G-108	0.9	0.39	10.00	10.00	8.07	0.000	2.835
	0.9	0.39	Pavement				
G-109	0.9	0.31	10.00	10.00	8.07	0.000	2.267
	0.9	0.31	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-107	CircMh	0.900	1.09	11.04	7.74	0.000	0.00	7.589
G-108	CircMh	0.900	0.70	10.58	7.88	0.000	0.00	4.983
G-109	CircMh	0.900	0.31	10.00	8.07	0.000	0.00	2.267
OUT	Outlt	0.900	1.09	11.04	7.74	0.000	0.00	7.589

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-109	G-108	1018.78	1018.47	Circ 1	0.00	2.00	104.00	0.30	0.013
2	G-108	G-107	1018.47	1018.15	Circ 1	0.00	2.00	105.10	0.30	0.013
3	G-107	OUT	1018.15	1018.12	Circ 1	0.00	2.00	10.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1019.45	1019.40	0.010	0.58	0.93	3.01	1.58	2.27	12.35	0.000
2	1019.40	1019.28	0.049	0.88	1.13	3.77	2.74	4.98	12.48	0.000
3	1019.28	1019.25	0.113	1.13	1.13	4.17	4.17	7.59	12.39	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-107	0.9	0.39	10.00	10.00	11.49	0.000	4.005
	0.9	0.39	Pavement				
G-108	0.9	0.39	10.00	10.00	11.49	0.000	4.035
	0.9	0.39	Pavement				
G-109	0.9	0.31	10.00	10.00	11.49	0.000	3.228
	0.9	0.31	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-107	CircMh	0.900	1.09	10.95	11.06	0.000	0.00	10.849
G-108	CircMh	0.900	0.70	10.53	11.25	0.000	0.00	7.110
G-109	CircMh	0.900	0.31	10.00	11.49	0.000	0.00	3.228
OUT	Outlt	0.900	1.09	10.95	11.06	0.000	0.00	10.849

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-109	G-108	1018.78	1018.47	Circ 1	0.00	2.00	104.00	0.30	0.013
2	G-108	G-107	1018.47	1018.15	Circ 1	0.00	2.00	105.10	0.30	0.013
3	G-107	OUT	1018.15	1018.12	Circ 1	0.00	2.00	10.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1019.73	1019.70	0.020	0.70	1.23	3.27	1.59	3.23	12.35	0.000
2	1019.70	1019.59	0.099	1.08	1.44	4.12	2.94	7.11	12.48	0.000
3	1019.59	1019.56	0.230	1.44	1.44	4.49	4.49	10.85	12.39	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1019.25(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-109

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1019.56(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-109

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 2:24:22 PM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-102	0.9	0.26	10.00	10.00	8.07	0.000	1.877
	0.9	0.26	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-102	CircMh	0.900	0.26	10.00	8.07	0.000	0.00	1.877
OUT	Outlt	0.900	0.26	10.00	8.07	0.000	0.00	1.877

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-102	OUT	1013.19	1013.15	Circ 1	0.00	2.00	13.00	0.31	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1013.71	1013.67	0.007	0.52	0.52	2.87	2.87	1.88	12.55	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
G-102	0.9	0.26	10.00	10.00	11.49	0.000	2.673
	0.9	0.26	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
G-102	CircMh	0.900	0.26	10.00	11.49	0.000	0.00	2.673
OUT	Outlt	0.900	0.26	10.00	11.49	0.000	0.00	2.673

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	G-102	OUT	1013.19	1013.15	Circ 1	0.00	2.00	13.00	0.31	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1013.82	1013.78	0.014	0.63	0.63	3.19	3.19	2.67	12.55	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1013.67(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-102

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1013.78(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= G-102

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:55:46 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-102	0.9	0.34	10.00	10.00	8.07	0.000	2.493
	0.9	0.34	Pavement				
H-103	0.9	0.32	10.00	10.00	8.07	0.000	2.326
	0.9	0.32	Pavement				
H-104	0.9	0.30	10.00	10.00	8.07	0.000	2.178
	0.9	0.30	Pavement				
H-105	0.9	0.28	10.00	10.00	8.07	0.000	2.031
	0.9	0.28	Pavement				
H-106	0.9	0.51	10.00	10.00	8.07	0.000	3.737
	0.9	0.51	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-102	CircMh	0.900	1.76	12.16	7.41	0.000	0.00	11.724
H-103	CircMh	0.900	1.41	11.70	7.54	0.000	0.00	9.598
H-104	CircMh	0.900	1.09	11.18	7.69	0.000	0.00	7.576
H-105	CircMh	0.900	0.79	10.62	7.87	0.000	0.00	5.623
H-106	CircMh	0.900	0.51	10.00	8.07	0.000	0.00	3.737
OUT	Outlt	0.900	1.76	12.16	7.41	0.000	0.00	11.724

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	H-106	H-105	1034.93	1034.54	Circ 1	0.00	2.00	130.00	0.30	0.013
3	H-105	H-104	1034.54	1034.15	Circ 1	0.00	2.00	130.00	0.30	0.013
4	H-104	H-103	1034.15	1033.76	Circ 1	0.00	2.00	130.60	0.30	0.013
5	H-103	H-102	1033.76	1033.40	Circ 1	0.00	2.00	120.00	0.30	0.013
6	H-102	OUT	1033.40	1033.38	Circ 1	0.00	2.00	6.00	0.33	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	1035.70	1035.52	0.027	0.75	0.98	3.47	2.43	3.74	12.39	0.000
3	1035.52	1035.34	0.062	0.94	1.19	3.89	2.88	5.62	12.39	0.000
4	1035.34	1035.13	0.112	1.13	1.37	4.16	3.30	7.58	12.36	0.000
5	1035.13	1034.87	0.180	1.31	1.47	4.39	3.88	9.60	12.39	0.000
6	1034.87	1034.85	0.269	1.47	1.47	4.74	4.74	11.72	13.06	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-102	0.9	0.34	10.00	10.00	11.49	0.000	3.549
	0.9	0.34	Pavement				
H-103	0.9	0.32	10.00	10.00	11.49	0.000	3.312
	0.9	0.32	Pavement				
H-104	0.9	0.30	10.00	10.00	11.49	0.000	3.101
	0.9	0.30	Pavement				
H-105	0.9	0.28	10.00	10.00	11.49	0.000	2.891
	0.9	0.28	Pavement				
H-106	0.9	0.51	10.00	10.00	11.49	0.000	5.321
	0.9	0.51	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-102	CircMh	0.900	1.76	12.04	10.62	0.000	0.00	16.797
H-103	CircMh	0.900	1.41	11.58	10.80	0.000	0.00	13.748
H-104	CircMh	0.900	1.09	11.09	11.00	0.000	0.00	10.833
H-105	CircMh	0.900	0.79	10.58	11.23	0.000	0.00	8.024
H-106	CircMh	0.900	0.51	10.00	11.49	0.000	0.00	5.321
OUT	Outlt	0.900	1.76	12.04	10.62	0.000	0.00	16.797

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	H-106	H-105	1034.93	1034.54	Circ 1	0.00	2.00	130.00	0.30	0.013
3	H-105	H-104	1034.54	1034.15	Circ 1	0.00	2.00	130.00	0.30	0.013
4	H-104	H-103	1034.15	1033.76	Circ 1	0.00	2.00	130.60	0.30	0.013
5	H-103	H-102	1033.76	1033.40	Circ 1	0.00	2.00	120.00	0.30	0.013
6	H-102	OUT	1033.40	1033.38	Circ 1	0.00	2.00	6.00	0.33	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	1036.34	1036.28	0.055	0.92	1.74	3.76	1.83	5.32	12.39	0.000
3	1036.28	1036.16	0.126	1.17	2.00	4.19	2.55	8.02	12.39	0.000
4	1036.16	1035.86	0.229	1.44	2.00	4.48	3.45	10.83	12.36	0.000
5	1035.86	1035.41	0.369	2.00	2.00	4.38	4.38	13.75	12.39	0.000
6	1035.41	1035.38	0.551	2.00	2.00	5.35	5.35	16.80	13.06	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1034.85(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-104
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-106

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1035.38(ft)
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-102
Run# 5 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-104
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-106

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:56:18 AM

PROJECT NAME : US281
JOB NUMBER :
PROJECT DESCRIPTION : SAN ANTONIO
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-111	0.9	0.34	10.00	10.00	8.07	0.000	2.490
	0.9	0.34	Pavement				
H-112	0.9	0.29	10.00	10.00	8.07	0.000	2.132
	0.9	0.29	Pavement				
H-113	0.9	0.29	10.00	10.00	8.07	0.000	2.108
	0.9	0.29	Pavement				
H-114	0.9	0.29	10.00	10.00	8.07	0.000	2.118
	0.9	0.29	Pavement				
H-115	0.9	0.58	10.00	10.00	8.07	0.000	4.205
	0.9	0.58	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-111	CircMh	0.900	0.34	10.00	8.07	0.000	0.00	2.490
H-112	CircMh	0.900	1.80	11.67	7.55	0.000	0.00	12.212
H-113	CircMh	0.900	1.16	11.14	7.70	0.000	0.00	8.050
H-114	CircMh	0.900	0.87	10.60	7.87	0.000	0.00	6.170
H-115	CircMh	0.900	0.58	10.00	8.07	0.000	0.00	4.205
OUT	Outlt	0.900	1.80	11.67	7.55	0.000	0.00	12.212

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-111	H-112	1019.54	1019.10	Circ 1	0.00	2.00	146.00	0.30	0.013
3	H-115	H-114	1020.27	1019.88	Circ 1	0.00	2.00	129.00	0.30	0.013
4	H-114	H-113	1019.88	1019.49	Circ 1	0.00	2.00	129.00	0.30	0.013
5	H-113	H-112	1019.49	1019.10	Circ 1	0.00	2.00	131.00	0.30	0.013
6	H-112	OUT	1019.10	1019.07	Circ 1	0.00	2.00	6.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1020.44	1020.41	0.012	0.61	1.31	3.07	1.14	2.49	12.42	0.000
3	1021.09	1020.90	0.035	0.80	1.02	3.60	2.60	4.21	12.44	0.000
4	1020.90	1020.69	0.074	1.00	1.20	3.93	3.13	6.17	12.44	0.000
5	1020.69	1020.41	0.127	1.19	1.31	4.14	3.68	8.05	12.35	0.000
6	1020.41	1020.38	0.291	1.31	1.31	5.59	5.59	12.21	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
H-111	0.9	0.34	10.00	10.00	11.49	0.000	3.545
	0.9	0.34	Pavement				
H-112	0.9	0.29	10.00	10.00	11.49	0.000	3.036
	0.9	0.29	Pavement				
H-113	0.9	0.29	10.00	10.00	11.49	0.000	3.001
	0.9	0.29	Pavement				
H-114	0.9	0.29	10.00	10.00	11.49	0.000	3.015
	0.9	0.29	Pavement				
H-115	0.9	0.58	10.00	10.00	11.49	0.000	5.986
	0.9	0.58	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
H-111	CircMh	0.900	0.34	10.00	11.49	0.000	0.00	3.545
H-112	CircMh	0.900	1.80	11.54	10.82	0.000	0.00	17.499
H-113	CircMh	0.900	1.16	11.05	11.02	0.000	0.00	11.515
H-114	CircMh	0.900	0.87	10.54	11.24	0.000	0.00	8.807
H-115	CircMh	0.900	0.58	10.00	11.49	0.000	0.00	5.986
OUT	Outlt	0.900	1.80	11.54	10.82	0.000	0.00	17.499

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	H-111	H-112	1019.54	1019.10	Circ 1	0.00	2.00	146.00	0.30	0.013
3	H-115	H-114	1020.27	1019.88	Circ 1	0.00	2.00	129.00	0.30	0.013
4	H-114	H-113	1019.88	1019.49	Circ 1	0.00	2.00	129.00	0.30	0.013
5	H-113	H-112	1019.49	1019.10	Circ 1	0.00	2.00	131.00	0.30	0.013
6	H-112	OUT	1019.10	1019.07	Circ 1	0.00	2.00	6.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1021.13	1021.11	0.025	0.73	2.00	3.39	1.13	3.55	12.42	0.000
3	1021.63	1021.56	0.070	0.97	1.68	3.97	2.13	5.99	12.44	0.000
4	1021.56	1021.41	0.152	1.25	1.92	4.26	2.84	8.81	12.44	0.000
5	1021.41	1021.11	0.259	1.53	2.00	4.46	3.67	11.52	12.35	0.000
6	1021.11	1021.07	0.598	2.00	2.00	5.57	5.57	17.50	16.00	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1020.38(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-115

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1021.07(ft)
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= H-115

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 2:13:15 PM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-120	0.9	0.27	10.00	10.00	8.07	0.000	1.960
	0.9	0.27	Pavement				
M-121	0.9	0.29	10.00	10.00	8.07	0.000	2.125
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-120	CircMh	0.900	0.56	10.59	7.88	0.000	0.00	3.987
M-121	CircMh	0.900	0.29	10.00	8.07	0.000	0.00	2.125
OUT	Outlt	0.900	0.56	10.59	7.88	0.000	0.00	3.987

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	M-121	M-120	1138.12	1137.87	Circ 1	0.00	2.00	98.00	0.26	0.013
2	M-120	OUT	1137.87	1137.77	Circ 1	0.00	2.00	20.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1138.71	1138.55	0.009	0.59	0.68	2.77	2.26	2.13	11.43	0.000
2*	1138.55	1138.45	0.031	0.68	0.68	4.24	4.24	3.99	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-120	0.9	0.27	10.00	10.00	11.49	0.000	2.789
	0.9	0.27	Pavement				
M-121	0.9	0.29	10.00	10.00	11.49	0.000	3.025
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-120	CircMh	0.900	0.56	10.53	11.24	0.000	0.00	5.692
M-121	CircMh	0.900	0.29	10.00	11.49	0.000	0.00	3.025
OUT	Outlt	0.900	0.56	10.53	11.24	0.000	0.00	5.692

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	M-121	M-120	1138.12	1137.87	Circ 1	0.00	2.00	98.00	0.26	0.013
2	M-120	OUT	1137.87	1137.77	Circ 1	0.00	2.00	20.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1138.84	1138.70	0.018	0.70	0.83	3.07	2.46	3.03	11.43	0.000
2*	1138.70	1138.60	0.063	0.83	0.83	4.63	4.63	5.69	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1138.45(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-120
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-121

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1138.60(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-120
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-121

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 2:14:53 PM

PROJECT NAME : San Antonio
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-115A	0.9	0.23	10.00	10.00	8.07	0.000	1.665
	0.9	0.23	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-115A	CircMh	0.900	0.23	10.00	8.07	0.000	0.00	1.665
OUT	Outlt	0.900	0.23	10.00	8.07	0.000	0.00	1.665

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	M-115A	OUT	1136.58	1136.48	Circ 1	0.00	2.00	20.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1*	1137.02	1136.92	0.005	0.44	0.44	3.28	3.28	1.67	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-115A	0.9	0.23	10.00	10.00	11.49	0.000	2.371
	0.9	0.23	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-115A	CircMh	0.900	0.23	10.00	11.49	0.000	0.00	2.371
OUT	Outlt	0.900	0.23	10.00	11.49	0.000	0.00	2.371

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	M-115A	OUT	1136.58	1136.48	Circ 1	0.00	2.00	20.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1*	1137.10	1137.00	0.011	0.52	0.52	3.66	3.66	2.37	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1136.92(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-115A

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1137.00(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-115A

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:56:52 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-101	0.9	0.40	10.00	10.00	8.07	0.000	2.905
	0.9	0.40	Pavement				
I-102	0.9	0.40	10.00	10.00	8.07	0.000	2.905
	0.9	0.40	Pavement				
I-103	0.9	0.33	10.00	10.00	8.07	0.000	2.395
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-101	CircMh	0.900	0.40	10.00	8.07	0.000	0.00	2.905
I-102	CircMh	0.900	0.80	11.06	7.73	0.000	0.00	5.566
I-103	CircMh	0.900	1.13	11.79	7.52	0.000	0.00	7.642
OUT	Outlt	0.900	1.13	11.79	7.52	0.000	0.00	7.642

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-101	I-102	1033.32	1032.70	Circ 1	0.00	2.00	206.00	0.30	0.013
2	I-102	I-103	1032.70	1032.20	Circ 1	0.00	2.00	168.00	0.30	0.013
3	I-103	OUT	1032.20	1032.12	Circ 1	0.00	2.00	15.00	0.53	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1033.98	1033.64	0.016	0.66	0.94	3.24	2.00	2.91	12.41	0.000
2	1033.64	1033.15	0.061	0.94	0.95	3.85	3.77	5.57	12.34	0.000
3*	1033.15	1033.07	0.114	0.95	0.95	5.17	5.17	7.64	16.52	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-101	0.9	0.40	10.00	10.00	11.49	0.000	4.136
	0.9	0.40	Pavement				
I-102	0.9	0.40	10.00	10.00	11.49	0.000	4.136
	0.9	0.40	Pavement				
I-103	0.9	0.33	10.00	10.00	11.49	0.000	3.410
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-101	CircMh	0.900	0.40	10.00	11.49	0.000	0.00	4.136
I-102	CircMh	0.900	0.80	10.97	11.05	0.000	0.00	7.959
I-103	CircMh	0.900	1.13	11.64	10.77	0.000	0.00	10.955
OUT	Outlt	0.900	1.13	11.64	10.77	0.000	0.00	10.955

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-101	I-102	1033.32	1032.70	Circ 1	0.00	2.00	206.00	0.30	0.013
2	I-102	I-103	1032.70	1032.20	Circ 1	0.00	2.00	168.00	0.30	0.013
3	I-103	OUT	1032.20	1032.12	Circ 1	0.00	2.00	15.00	0.53	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1034.12	1033.87	0.033	0.80	1.17	3.54	2.16	4.14	12.41	0.000
2	1033.87	1033.39	0.124	1.17	1.19	4.16	4.09	7.96	12.34	0.000
3	1033.39	1033.31	0.234	1.19	1.19	5.64	5.64	10.96	16.52	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1033.07(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1033.31(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:22:12 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-126	0.9	0.46	10.00	10.00	8.07	0.000	3.315
	0.9	0.46	Pavement				
I-127	0.9	0.29	10.00	10.00	8.07	0.000	2.103
	0.9	0.29	Pavement				
I-128	0.9	0.29	10.00	10.00	8.07	0.000	2.140
	0.9	0.29	Pavement				
I-129	0.9	0.31	10.00	10.00	8.07	0.000	2.223
	0.9	0.31	Pavement				
I-123	0.9	0.14	10.00	10.00	8.07	0.000	0.989
	0.9	0.14	Pavement				
I-125	0.9	0.46	10.00	10.00	8.07	0.000	3.315
	0.9	0.46	Pavement				
I-108	0.9	0.15	10.00	10.00	8.07	0.000	1.116
	0.9	0.15	Pavement				
I-119	0.9	0.33	10.00	10.00	8.07	0.000	2.405
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-126	CircMh	0.900	0.91	11.01	7.75	0.000	0.00	6.364
I-127	CircMh	0.900	1.20	11.56	7.58	0.000	0.00	8.206
I-128	CircMh	0.900	1.50	12.07	7.44	0.000	0.00	10.019
I-129	CircMh	0.900	2.42	13.81	6.98	0.000	0.00	15.236
I-123	CircMh	0.900	0.29	11.58	7.58	0.000	0.00	1.976
I-125	CircMh	0.900	0.46	10.00	8.07	0.000	0.00	3.315
I-108	CircMh	0.900	0.15	10.00	8.07	0.000	0.00	1.116
I-119	CircMh	0.900	0.62	13.20	7.13	0.000	0.00	3.987
OUT	Outlt	0.900	2.42	13.81	6.98	0.000	0.00	15.236

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-125	I-126	1019.48	1018.86	Circ 1	0.00	2.00	204.00	0.30	0.013
2	I-126	I-127	1018.86	1018.47	Circ 1	0.00	2.00	130.00	0.30	0.013
3	I-127	I-128	1018.47	1018.08	Circ 1	0.00	2.00	130.00	0.30	0.013
4	I-128	I-129	1018.08	1017.70	Circ 1	0.00	2.00	128.00	0.30	0.013
5	I-108	I-123	1019.55	1018.46	Circ 1	0.00	2.00	259.00	0.42	0.013
7	I-123	I-119	1018.46	1018.08	Circ 1	0.00	2.00	230.00	0.17	0.013
8	I-119	I-129	1018.08	1017.70	Circ 1	0.00	2.00	128.00	0.30	0.013
9	I-129	OUT	1017.70	1017.66	Circ 1	0.00	2.00	7.00	0.57	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1020.19	1019.92	0.021	0.70	1.06	3.36	1.97	3.32	12.47	0.000
2	1019.92	1019.71	0.079	1.02	1.24	3.97	3.10	6.36	12.39	0.000
3	1019.71	1019.48	0.132	1.19	1.40	4.22	3.49	8.21	12.39	0.000
4	1019.48	1019.17	0.196	1.38	1.47	4.35	4.05	10.02	12.33	0.000
5	1019.93	1019.27	0.002	0.38	0.81	2.74	0.94	1.12	14.68	0.000
7	1019.27	1019.21	0.008	0.63	1.13	2.36	1.08	1.98	9.20	0.000
8	1019.21	1019.17	0.031	0.78	1.47	3.51	1.61	3.99	12.33	0.000
9	1019.17	1019.13	0.453	1.47	1.47	6.16	6.16	15.24	17.10	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-126	0.9	0.46	10.00	10.00	11.49	0.000	4.720
	0.9	0.46	Pavement				
I-127	0.9	0.29	10.00	10.00	11.49	0.000	2.993
	0.9	0.29	Pavement				
I-128	0.9	0.29	10.00	10.00	11.49	0.000	3.046
	0.9	0.29	Pavement				
I-129	0.9	0.31	10.00	10.00	11.49	0.000	3.165
	0.9	0.31	Pavement				
I-123	0.9	0.14	10.00	10.00	11.49	0.000	1.408
	0.9	0.14	Pavement				
I-125	0.9	0.46	10.00	10.00	11.49	0.000	4.720
	0.9	0.46	Pavement				
I-108	0.9	0.15	10.00	10.00	11.49	0.000	1.588
	0.9	0.15	Pavement				
I-119	0.9	0.33	10.00	10.00	11.49	0.000	3.423
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-126	CircMh	0.900	0.91	10.93	11.07	0.000	0.00	9.097
I-127	CircMh	0.900	1.20	11.44	10.86	0.000	0.00	11.751
I-128	CircMh	0.900	1.50	11.92	10.66	0.000	0.00	14.367
I-129	CircMh	0.900	2.42	13.47	10.09	0.000	0.00	22.012
I-123	CircMh	0.900	0.29	11.42	10.87	0.000	0.00	2.834
I-125	CircMh	0.900	0.46	10.00	11.49	0.000	0.00	4.720
I-108	CircMh	0.900	0.15	10.00	11.49	0.000	0.00	1.588
I-119	CircMh	0.900	0.62	12.91	10.29	0.000	0.00	5.749
OUT	Outlt	0.900	2.42	13.47	10.09	0.000	0.00	22.012

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-125	I-126	1019.48	1018.86	Circ 1	0.00	2.00	204.00	0.30	0.013
2	I-126	I-127	1018.86	1018.47	Circ 1	0.00	2.00	130.00	0.30	0.013
3	I-127	I-128	1018.47	1018.08	Circ 1	0.00	2.00	130.00	0.30	0.013
4	I-128	I-129	1018.08	1017.70	Circ 1	0.00	2.00	128.00	0.30	0.013
5	I-108	I-123	1019.55	1018.46	Circ 1	0.00	2.00	259.00	0.42	0.013
7	I-123	I-119	1018.46	1018.08	Circ 1	0.00	2.00	230.00	0.17	0.013
8	I-119	I-129	1018.08	1017.70	Circ 1	0.00	2.00	128.00	0.30	0.013
9	I-129	OUT	1017.70	1017.66	Circ 1	0.00	2.00	7.00	0.57	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1020.86	1020.79	0.044	0.86	1.93	3.66	1.52	4.72	12.47	0.000
2	1020.79	1020.59	0.162	1.28	2.00	4.28	2.90	9.10	12.39	0.000
3	1020.59	1020.24	0.270	1.56	2.00	4.46	3.74	11.75	12.39	0.000
4	1020.24	1019.73	0.403	2.00	2.00	4.57	4.57	14.37	12.33	0.000
5	1020.00	1019.82	0.005	0.45	1.36	3.05	0.70	1.59	14.68	0.000
7	1019.82	1019.79	0.016	0.77	1.71	2.56	0.99	2.83	9.20	0.000
8	1019.79	1019.73	0.065	0.97	2.00	3.81	1.83	5.75	12.33	0.000
9	1019.73	1019.66	0.947	2.00	2.00	7.01	7.01	22.01	17.10	0.000

END

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 NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

        Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1019.13(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-129
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-119
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-125

        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1019.66(ft)
Run# 9  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-129
Run# 4  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-119
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-125
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WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:23:40 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-120	0.9	0.27	10.00	10.00	8.07	0.000	1.989
	0.9	0.27	Pavement				
I-121	0.9	0.27	10.00	10.00	8.07	0.000	1.936
	0.9	0.27	Pavement				
I-122	0.9	0.29	10.00	10.00	8.07	0.000	2.097
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-120	CircMh	0.900	0.27	10.00	8.07	0.000	0.00	1.989
I-121	CircMh	0.900	0.54	10.78	7.82	0.000	0.00	3.802
I-122	CircMh	0.900	0.83	11.49	7.60	0.000	0.00	5.673
OUT	Outlt	0.900	0.83	11.49	7.60	0.000	0.00	5.673

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-120	I-121	1011.90	1011.49	Circ 1	0.00	2.00	136.00	0.30	0.013
2	I-121	I-122	1011.49	1011.05	Circ 1	0.00	2.00	146.00	0.30	0.013
3	I-122	OUT	1011.05	1011.02	Circ 1	0.00	2.00	7.00	0.43	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic US Elev (ft)	Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1012.44	1012.26	0.008	0.54	0.77	2.91	1.80	1.99	12.42	0.000
2	1012.26	1011.91	0.028	0.77	0.86	3.44	2.95	3.80	12.42	0.000
3	1011.91	1011.88	0.063	0.86	0.86	4.40	4.40	5.67	14.81	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-120	0.9	0.27	10.00	10.00	11.49	0.000	2.832
	0.9	0.27	Pavement				
I-121	0.9	0.27	10.00	10.00	11.49	0.000	2.755
	0.9	0.27	Pavement				
I-122	0.9	0.29	10.00	10.00	11.49	0.000	2.985
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-120	CircMh	0.900	0.27	10.00	11.49	0.000	0.00	2.832
I-121	CircMh	0.900	0.54	10.71	11.17	0.000	0.00	5.432
I-122	CircMh	0.900	0.83	11.34	10.90	0.000	0.00	8.132
OUT	Outlt	0.900	0.83	11.34	10.90	0.000	0.00	8.132

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-120	I-121	1011.90	1011.49	Circ 1	0.00	2.00	136.00	0.30	0.013
2	I-121	I-122	1011.49	1011.05	Circ 1	0.00	2.00	146.00	0.30	0.013
3	I-122	OUT	1011.05	1011.02	Circ 1	0.00	2.00	7.00	0.43	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1012.56	1012.42	0.016	0.65	0.93	3.21	1.98	2.83	12.42	0.000
2	1012.42	1012.11	0.058	0.92	1.06	3.84	3.20	5.43	12.42	0.000
3	1012.11	1012.08	0.129	1.06	1.06	4.80	4.80	8.13	14.81	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1011.88(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-122
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-121
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-120

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1012.08(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-122
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-121
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-120

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:24:42 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-110	0.9	0.40	10.00	10.00	8.07	0.000	2.898
	0.9	0.40	Pavement				
I-111	0.9	0.42	10.00	10.00	8.07	0.000	3.085
	0.9	0.42	Pavement				
I-112	0.9	0.47	10.00	10.00	8.07	0.000	3.415
	0.9	0.47	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-110	CircMh	0.900	0.40	10.00	8.07	0.000	0.00	2.898
I-111	CircMh	0.900	1.29	11.09	7.72	0.000	0.00	8.992
I-112	CircMh	0.900	0.47	10.00	8.07	0.000	0.00	3.415
OUT	Outlt	0.900	1.29	11.09	7.72	0.000	0.00	8.992

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-110	I-111	1022.31	1021.87	Circ 1	0.00	2.00	145.00	0.30	0.013
2	I-112	I-111	1022.53	1021.87	Circ 1	0.00	2.00	220.00	0.30	0.013
3	I-111	OUT	1021.87	1021.84	Circ 1	0.00	2.00	7.00	0.43	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1023.06	1023.00	0.016	0.66	1.13	3.23	1.59	2.90	12.46	0.000
2	1023.25	1023.00	0.023	0.72	1.13	3.36	1.87	3.41	12.39	0.000
3	1023.00	1022.97	0.158	1.13	1.13	4.94	4.94	8.99	14.81	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-110	0.9	0.40	10.00	10.00	11.49	0.000	4.125
	0.9	0.40	Pavement				
I-111	0.9	0.42	10.00	10.00	11.49	0.000	4.392
	0.9	0.42	Pavement				
I-112	0.9	0.47	10.00	10.00	11.49	0.000	4.861
	0.9	0.47	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-110	CircMh	0.900	0.40	10.00	11.49	0.000	0.00	4.125
I-111	CircMh	0.900	1.29	11.00	11.04	0.000	0.00	12.860
I-112	CircMh	0.900	0.47	10.00	11.49	0.000	0.00	4.861
OUT	Outlt	0.900	1.29	11.00	11.04	0.000	0.00	12.860

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	I-110	I-111	1022.31	1021.87	Circ 1	0.00	2.00	145.00	0.30	0.013
2	I-112	I-111	1022.53	1021.87	Circ 1	0.00	2.00	220.00	0.30	0.013
3	I-111	OUT	1021.87	1021.84	Circ 1	0.00	2.00	7.00	0.43	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1023.36	1023.31	0.033	0.80	1.44	3.53	1.71	4.13	12.46	0.000
2	1023.47	1023.31	0.046	0.88	1.44	3.68	2.01	4.86	12.39	0.000
3	1023.31	1023.28	0.323	1.44	1.44	5.32	5.32	12.86	14.81	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1022.97(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-112

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1023.28(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-112

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:28:24 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-115	0.9	0.32	10.00	10.00	8.07	0.000	2.312
	0.9	0.32	Pavement				
J-101	0.9	0.32	10.00	10.00	8.07	0.000	2.300
	0.9	0.32	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-115	CircMh	0.900	0.64	12.44	7.33	0.000	0.00	4.193
J-101	CircMh	0.900	0.32	10.00	8.07	0.000	0.00	2.300
OUT	Outlt	0.900	0.64	12.44	7.33	0.000	0.00	4.193

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-101	I-115	1050.57	1048.63	Circ 1	0.00	2.00	488.00	0.40	0.013
3	I-115	OUT	1048.63	1048.55	Circ 1	0.00	2.00	16.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1051.11	1049.33	0.010	0.54	0.70	3.34	2.37	2.30	14.27	0.000
3*	1049.33	1049.25	0.034	0.70	0.70	4.32	4.32	4.19	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-115	0.9	0.32	10.00	10.00	11.49	0.000	3.292
	0.9	0.32	Pavement				
J-101	0.9	0.32	10.00	10.00	11.49	0.000	3.274
	0.9	0.32	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-115	CircMh	0.900	0.64	12.19	10.56	0.000	0.00	6.035
J-101	CircMh	0.900	0.32	10.00	11.49	0.000	0.00	3.274
OUT	Outlt	0.900	0.64	12.19	10.56	0.000	0.00	6.035

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-101	I-115	1050.57	1048.63	Circ 1	0.00	2.00	488.00	0.40	0.013
3	I-115	OUT	1048.63	1048.55	Circ 1	0.00	2.00	16.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1051.22	1049.48	0.021	0.65	0.85	3.71	2.57	3.27	14.27	0.000
3*	1049.48	1049.40	0.071	0.85	0.85	4.73	4.73	6.03	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1049.25(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1049.40(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:30:38 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-117	0.9	0.32	10.00	10.00	8.07	0.000	2.312
	0.9	0.32	Pavement				
J-101A	0.9	0.32	10.00	10.00	8.07	0.000	2.310
	0.9	0.32	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-117	CircMh	0.900	0.64	12.49	7.32	0.000	0.00	4.193
J-101A	CircMh	0.900	0.32	10.00	8.07	0.000	0.00	2.310
OUT	Outlt	0.900	0.64	12.49	7.32	0.000	0.00	4.193

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-101A	I-117	1050.57	1048.63	Circ 1	0.00	2.00	495.00	0.39	0.013
3	I-117	OUT	1048.63	1048.55	Circ 1	0.00	2.00	16.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1051.12	1049.33	0.010	0.55	0.70	3.32	2.38	2.31	14.16	0.000
3*	1049.33	1049.25	0.034	0.70	0.70	4.32	4.32	4.19	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
I-117	0.9	0.32	10.00	10.00	11.49	0.000	3.292
	0.9	0.32	Pavement				
J-101A	0.9	0.32	10.00	10.00	11.49	0.000	3.288
	0.9	0.32	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
I-117	CircMh	0.900	0.64	12.25	10.53	0.000	0.00	6.034
J-101A	CircMh	0.900	0.32	10.00	11.49	0.000	0.00	3.288
OUT	Outlt	0.900	0.64	12.25	10.53	0.000	0.00	6.034

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	J-101A	I-117	1050.57	1048.63	Circ 1	0.00	2.00	495.00	0.39	0.013
3	I-117	OUT	1048.63	1048.55	Circ 1	0.00	2.00	16.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1051.23	1049.48	0.021	0.66	0.85	3.67	2.58	3.29	14.16	0.000
3*	1049.48	1049.40	0.071	0.85	0.85	4.73	4.73	6.03	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1049.25(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-101A

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1049.40(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= I-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-101A

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:33:00 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-114	0.9	0.17	10.00	10.00	8.07	0.000	1.259
	0.9	0.17	Pavement				
K-113	0.9	0.39	10.00	10.00	8.07	0.000	2.817
	0.9	0.39	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-114	CircMh	0.900	0.56	11.57	7.58	0.000	0.00	3.827
K-113	CircMh	0.900	0.39	10.00	8.07	0.000	0.00	2.817
OUT	Outlt	0.900	0.56	11.57	7.58	0.000	0.00	3.827

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	K-113	J-114	1071.54	1070.64	Circ 1	0.00	2.00	301.00	0.30	0.013
2	J-114	OUT	1070.64	1070.60	Circ 1	0.00	2.00	9.00	0.44	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1072.19	1071.33	0.015	0.65	0.69	3.19	2.95	2.82	12.37	0.000
2	1071.33	1071.29	0.029	0.69	0.69	4.00	4.00	3.83	15.08	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-114	0.9	0.17	10.00	10.00	11.49	0.000	1.792
	0.9	0.17	Pavement				
K-113	0.9	0.39	10.00	10.00	11.49	0.000	4.010
	0.9	0.39	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-114	CircMh	0.900	0.56	11.42	10.86	0.000	0.00	5.486
K-113	CircMh	0.900	0.39	10.00	11.49	0.000	0.00	4.010
OUT	Outlt	0.900	0.56	11.42	10.86	0.000	0.00	5.486

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	K-113	J-114	1071.54	1070.64	Circ 1	0.00	2.00	301.00	0.30	0.013
2	J-114	OUT	1070.64	1070.60	Circ 1	0.00	2.00	9.00	0.44	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1072.32	1071.48	0.031	0.78	0.84	3.53	3.22	4.01	12.37	0.000
2	1071.48	1071.44	0.059	0.84	0.84	4.41	4.41	5.49	15.08	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1071.29(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= K-113

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1071.44(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= K-113

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:34:16 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-108	0.9	0.16	10.00	10.00	8.07	0.000	1.169
	0.9	0.16	Pavement				
K-101	0.9	0.15	10.00	10.00	8.07	0.000	1.078
	0.9	0.15	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-108	CircMh	0.900	0.31	11.85	7.50	0.000	0.00	2.088
K-101	CircMh	0.900	0.15	10.00	8.07	0.000	0.00	1.078
OUT	Outlt	0.900	0.31	11.85	7.50	0.000	0.00	2.088

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	K-101	J-108	1076.30	1075.49	Circ 1	0.00	2.00	269.00	0.30	0.013
2	J-108	OUT	1075.49	1075.42	Circ 1	0.00	2.00	14.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1076.70	1075.98	0.002	0.40	0.49	2.42	1.81	1.08	12.42	0.000
2*	1075.98	1075.91	0.009	0.49	0.49	3.52	3.52	2.09	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
J-108	0.9	0.16	10.00	10.00	11.49	0.000	1.665
	0.9	0.16	Pavement				
K-101	0.9	0.15	10.00	10.00	11.49	0.000	1.534
	0.9	0.15	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
J-108	CircMh	0.900	0.31	11.68	10.76	0.000	0.00	2.996
K-101	CircMh	0.900	0.15	10.00	11.49	0.000	0.00	1.534
OUT	Outlt	0.900	0.31	11.68	10.76	0.000	0.00	2.996

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	K-101	J-108	1076.30	1075.49	Circ 1	0.00	2.00	269.00	0.30	0.013
2	J-108	OUT	1075.49	1075.42	Circ 1	0.00	2.00	14.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1076.78	1076.08	0.005	0.48	0.59	2.67	2.00	1.53	12.42	0.000
2*	1076.08	1076.01	0.018	0.59	0.59	3.91	3.91	3.00	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1075.91(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= K-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1076.01(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= J-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= K-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:36:01 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-106	0.9	0.11	10.00	10.00	8.07	0.000	0.779
	0.9	0.11	Pavement				
L-109	0.9	0.12	10.00	10.00	8.07	0.000	0.896
	0.9	0.12	Pavement				
L-112	0.9	0.36	10.00	10.00	8.07	0.000	2.634
	0.9	0.36	Pavement				
L-110	0.9	0.13	10.00	10.00	8.07	0.000	0.934
	0.9	0.13	Pavement				
L-113	0.9	0.36	10.00	10.00	8.07	0.000	2.619
	0.9	0.36	Pavement				
M-105	0.9	0.13	10.00	10.00	8.07	0.000	0.934
	0.9	0.13	Pavement				
M-106	0.9	0.36	10.00	10.00	8.07	0.000	2.583
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-106	CircMh	0.900	0.11	10.00	8.07	0.000	0.00	0.779
L-109	CircMh	0.900	0.23	10.43	7.93	0.000	0.00	1.646
L-112	CircMh	0.900	0.59	10.46	7.92	0.000	0.00	4.229
L-110	CircMh	0.900	0.72	11.39	7.63	0.000	0.00	4.958
L-113	CircMh	0.900	1.08	11.41	7.62	0.000	0.00	7.429
M-105	CircMh	0.900	1.21	11.74	7.53	0.000	0.00	8.209
M-106	CircMh	0.900	1.57	11.75	7.53	0.000	0.00	10.612
OUT	Outlt	0.900	1.57	11.75	7.53	0.000	0.00	10.612

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-106	L-109	1072.46	1072.29	Circ 1	0.00	2.00	57.00	0.30	0.013
2	L-109	L-112	1072.29	1072.27	Circ 1	0.00	2.00	5.00	0.40	0.013
3	L-112	L-110	1072.27	1071.68	Circ 1	0.00	2.00	198.00	0.30	0.013
4	L-110	L-113	1071.68	1071.66	Circ 1	0.00	2.00	5.00	0.40	0.013
5	L-113	M-105	1071.66	1071.43	Circ 1	0.00	2.00	79.00	0.29	0.013
6	M-105	M-106	1071.43	1071.41	Circ 1	0.00	2.00	5.00	0.40	0.013
7	M-106	OUT	1071.41	1070.77	Circ 1	0.00	2.00	128.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1073.09	1073.08	0.001	0.34	0.79	2.20	0.67	0.78	12.36	0.000
2	1073.08	1073.08	0.005	0.46	0.81	3.01	1.37	1.65	14.31	0.000
3	1073.08	1072.80	0.035	0.81	1.12	3.53	2.33	4.23	12.35	0.000
4	1072.80	1072.80	0.048	0.81	1.14	4.14	2.68	4.96	14.31	0.000
5	1072.80	1072.61	0.108	1.13	1.18	4.08	3.87	7.43	12.21	0.000
6	1072.61	1072.60	0.132	1.09	1.19	4.67	4.22	8.21	14.31	0.000
7	1072.60	1071.96	0.220	1.19	1.19	5.46	5.46	10.61	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-106	0.9	0.11	10.00	10.00	11.49	0.000	1.109
	0.9	0.11	Pavement				
L-109	0.9	0.12	10.00	10.00	11.49	0.000	1.276
	0.9	0.12	Pavement				
L-112	0.9	0.36	10.00	10.00	11.49	0.000	3.750
	0.9	0.36	Pavement				
L-110	0.9	0.13	10.00	10.00	11.49	0.000	1.330
	0.9	0.13	Pavement				
L-113	0.9	0.36	10.00	10.00	11.49	0.000	3.728
	0.9	0.36	Pavement				
M-105	0.9	0.13	10.00	10.00	11.49	0.000	1.330
	0.9	0.13	Pavement				
M-106	0.9	0.36	10.00	10.00	11.49	0.000	3.678
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-106	CircMh	0.900	0.11	10.00	11.49	0.000	0.00	1.109
L-109	CircMh	0.900	0.23	10.39	11.31	0.000	0.00	2.348
L-112	CircMh	0.900	0.59	10.42	11.30	0.000	0.00	6.033
L-110	CircMh	0.900	0.72	11.26	10.93	0.000	0.00	7.103
L-113	CircMh	0.900	1.08	11.28	10.92	0.000	0.00	10.644
M-105	CircMh	0.900	1.21	11.58	10.80	0.000	0.00	11.774
M-106	CircMh	0.900	1.57	11.59	10.79	0.000	0.00	15.222
OUT	Outlt	0.900	1.57	11.59	10.79	0.000	0.00	15.222

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-106	L-109	1072.46	1072.29	Circ 1	0.00	2.00	57.00	0.30	0.013
2	L-109	L-112	1072.29	1072.27	Circ 1	0.00	2.00	5.00	0.40	0.013
3	L-112	L-110	1072.27	1071.68	Circ 1	0.00	2.00	198.00	0.30	0.013
4	L-110	L-113	1071.68	1071.66	Circ 1	0.00	2.00	5.00	0.40	0.013
5	L-113	M-105	1071.66	1071.43	Circ 1	0.00	2.00	79.00	0.29	0.013
6	M-105	M-106	1071.43	1071.41	Circ 1	0.00	2.00	5.00	0.40	0.013
7	M-106	OUT	1071.41	1070.77	Circ 1	0.00	2.00	128.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1073.36	1073.35	0.002	0.41	1.06	2.43	0.65	1.11	12.36	0.000
2	1073.35	1073.35	0.011	0.55	1.08	3.37	1.35	2.35	14.31	0.000
3	1073.35	1073.17	0.071	0.98	1.49	3.92	2.40	6.03	12.35	0.000
4	1073.17	1073.17	0.099	1.00	1.51	4.52	2.79	7.10	14.31	0.000
5	1073.17	1072.98	0.221	1.44	1.55	4.40	4.07	10.64	12.21	0.000
6	1072.98	1072.97	0.271	1.38	1.56	5.11	4.47	11.77	14.31	0.000
7	1072.97	1072.33	0.453	1.56	1.56	5.78	5.78	15.22	16.00	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1071.96(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-106

```
        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1072.33(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-106
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WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:37:15 AM

PROJECT NAME : US 281
JOB NUMBER :
PROJECT DESCRIPTION :
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-102	0.9	0.32	10.00	10.00	8.07	0.000	2.311
	0.9	0.32	Pavement				
L-103	0.9	0.58	10.00	10.00	8.07	0.000	4.222
	0.9	0.58	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-102	CircMh	0.900	0.32	10.00	8.07	0.000	0.00	2.311
L-103	CircMh	0.900	0.90	11.29	7.66	0.000	0.00	6.202
OUT	Outlt	0.900	0.90	11.29	7.66	0.000	0.00	6.202

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-102	L-103	1080.26	1079.56	Circ 1	0.00	2.00	233.00	0.30	0.013
2	L-103	OUT	1079.56	1079.41	Circ 1	0.00	2.00	30.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1080.85	1080.43	0.010	0.59	0.87	3.01	1.77	2.31	12.40	0.000
2*	1080.43	1080.28	0.075	0.87	0.87	4.75	4.75	6.20	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-102	0.9	0.32	10.00	10.00	11.49	0.000	3.290
	0.9	0.32	Pavement				
L-103	0.9	0.58	10.00	10.00	11.49	0.000	6.010
	0.9	0.58	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-102	CircMh	0.900	0.32	10.00	11.49	0.000	0.00	3.290
L-103	CircMh	0.900	0.90	11.16	10.97	0.000	0.00	8.882
OUT	Outlt	0.900	0.90	11.16	10.97	0.000	0.00	8.882

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-102	L-103	1080.26	1079.56	Circ 1	0.00	2.00	233.00	0.30	0.013
2	L-103	OUT	1079.56	1079.41	Circ 1	0.00	2.00	30.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1080.96	1080.62	0.021	0.70	1.06	3.34	1.94	3.29	12.40	0.000
2	1080.62	1080.47	0.154	1.06	1.06	5.24	5.24	8.88	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1080.28(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-102

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1080.47(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-102

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:39:17 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-107	0.9	0.25	10.00	10.00	8.07	0.000	1.822
	0.9	0.25	Pavement				
M-108	0.9	0.27	10.00	10.00	8.07	0.000	1.957
	0.9	0.27	Pavement				
M-109	0.9	0.57	10.00	10.00	8.07	0.000	4.138
	0.9	0.57	Pavement				
M-110	0.9	0.42	10.00	10.00	8.07	0.000	3.067
	0.9	0.42	Pavement				
M-111	0.9	0.42	10.00	10.00	8.07	0.000	3.021
	0.9	0.42	Pavement				
M-112	0.9	0.40	10.00	10.00	8.07	0.000	2.926
	0.9	0.40	Pavement				
M-113	0.9	0.39	10.00	10.00	8.07	0.000	2.838
	0.9	0.39	Pavement				
M-114	0.9	0.37	10.00	10.00	8.07	0.000	2.654
	0.9	0.37	Pavement				
M-115	0.9	0.29	10.00	10.00	8.07	0.000	2.091
	0.9	0.29	Pavement				
M-116	0.9	0.30	10.00	10.00	8.07	0.000	2.209
	0.9	0.30	Pavement				
M-117	0.9	0.40	10.00	10.00	8.07	0.000	2.903
	0.9	0.40	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-107	CircMh	0.900	0.25	10.00	8.07	0.000	0.00	1.822
M-108	CircMh	0.900	0.52	10.55	7.89	0.000	0.00	3.695
M-109	CircMh	0.900	1.09	11.02	7.74	0.000	0.00	7.598
M-110	CircMh	0.900	4.08	16.12	6.47	0.000	0.00	23.764
M-111	CircMh	0.900	2.57	15.38	6.63	0.000	0.00	15.308
M-112	CircMh	0.900	2.15	14.61	6.80	0.000	0.00	13.155
M-113	CircMh	0.900	1.75	13.78	6.99	0.000	0.00	10.999
M-114	CircMh	0.900	1.36	12.90	7.21	0.000	0.00	8.810
M-115	CircMh	0.900	0.99	11.98	7.46	0.000	0.00	6.660
M-116	CircMh	0.900	0.70	11.13	7.71	0.000	0.00	4.883
M-117	CircMh	0.900	0.40	10.00	8.07	0.000	0.00	2.903
OUT	Outlt	0.900	4.08	16.12	6.47	0.000	0.00	23.764

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	M-107	M-108	1094.56	1094.28	Circ 1	0.00	2.00	94.20	0.30	0.013
2	M-108	M-109	1094.28	1093.99	Circ 1	0.00	2.00	95.60	0.30	0.013
3	M-109	M-110	1093.99	1093.36	Circ 1	0.00	2.00	210.50	0.30	0.013
4	M-116	M-115	1097.25	1096.68	Circ 1	0.00	2.00	187.00	0.30	0.013
5	M-115	M-114	1096.68	1096.02	Circ 1	0.00	2.00	221.00	0.30	0.013
6	M-114	M-113	1096.02	1095.35	Circ 1	0.00	2.00	225.00	0.30	0.013
7	M-113	M-112	1095.35	1094.68	Circ 1	0.00	2.00	223.00	0.30	0.013
8	M-112	M-111	1094.68	1093.91	Circ 1	0.00	2.00	222.00	0.35	0.013
9	M-111	M-110	1093.91	1093.26	Circ 1	0.00	3.00	217.20	0.30	0.013
10	M-110	OUT	1093.26	1092.70	Circ 1	0.00	3.00	114.00	0.49	0.013
12	M-117	M-116	1097.91	1097.25	Circ 1	0.00	2.00	220.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1095.22	1095.20	0.006	0.52	0.92	2.84	1.30	1.82	12.34	0.000
2	1095.20	1095.15	0.027	0.75	1.16	3.43	1.96	3.69	12.46	0.000
3	1095.15	1094.78	0.113	1.13	1.42	4.17	3.18	7.60	12.38	0.000
4	1098.13	1097.73	0.047	0.88	1.05	3.69	2.92	4.88	12.49	0.000
5	1097.73	1097.30	0.087	1.05	1.28	4.00	3.14	6.66	12.36	0.000
6	1097.30	1096.85	0.152	1.25	1.50	4.27	3.48	8.81	12.35	0.000
7	1096.85	1096.31	0.236	1.47	1.63	4.45	4.02	11.00	12.40	0.000
8	1096.31	1095.27	0.338	1.63	1.63	4.81	4.81	13.16	13.32	0.000
9	1095.27	1094.78	0.053	1.36	1.52	4.92	4.25	15.31	36.49	0.000
10*	1094.78	1094.22	0.127	1.52	1.52	6.59	6.59	23.76	46.75	0.000
12	1098.57	1098.13	0.016	0.66	0.88	3.24	2.20	2.90	12.39	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-107	0.9	0.25	10.00	10.00	11.49	0.000	2.594
	0.9	0.25	Pavement				
M-108	0.9	0.27	10.00	10.00	11.49	0.000	2.786
	0.9	0.27	Pavement				
M-109	0.9	0.57	10.00	10.00	11.49	0.000	5.891
	0.9	0.57	Pavement				
M-110	0.9	0.42	10.00	10.00	11.49	0.000	4.366
	0.9	0.42	Pavement				
M-111	0.9	0.42	10.00	10.00	11.49	0.000	4.300
	0.9	0.42	Pavement				
M-112	0.9	0.40	10.00	10.00	11.49	0.000	4.166
	0.9	0.40	Pavement				
M-113	0.9	0.39	10.00	10.00	11.49	0.000	4.039
	0.9	0.39	Pavement				
M-114	0.9	0.37	10.00	10.00	11.49	0.000	3.778
	0.9	0.37	Pavement				
M-115	0.9	0.29	10.00	10.00	11.49	0.000	2.977
	0.9	0.29	Pavement				
M-116	0.9	0.30	10.00	10.00	11.49	0.000	3.144
	0.9	0.30	Pavement				
M-117	0.9	0.40	10.00	10.00	11.49	0.000	4.133
	0.9	0.40	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-107	CircMh	0.900	0.25	10.00	11.49	0.000	0.00	2.594
M-108	CircMh	0.900	0.52	10.51	11.26	0.000	0.00	5.272
M-109	CircMh	0.900	1.09	10.93	11.07	0.000	0.00	10.864
M-110	CircMh	0.900	4.08	15.48	9.44	0.000	0.00	34.672
M-111	CircMh	0.900	2.57	14.82	9.65	0.000	0.00	22.285
M-112	CircMh	0.900	2.15	14.21	9.84	0.000	0.00	19.052
M-113	CircMh	0.900	1.75	13.47	10.09	0.000	0.00	15.872
M-114	CircMh	0.900	1.36	12.63	10.39	0.000	0.00	12.691
M-115	CircMh	0.900	0.99	11.79	10.71	0.000	0.00	9.562
M-116	CircMh	0.900	0.70	11.04	11.03	0.000	0.00	6.984
M-117	CircMh	0.900	0.40	10.00	11.49	0.000	0.00	4.133
OUT	Outlt	0.900	4.08	15.48	9.44	0.000	0.00	34.672

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	M-107	M-108	1094.56	1094.28	Circ 1	0.00	2.00	94.20	0.30	0.013
2	M-108	M-109	1094.28	1093.99	Circ 1	0.00	2.00	95.60	0.30	0.013
3	M-109	M-110	1093.99	1093.36	Circ 1	0.00	2.00	210.50	0.30	0.013
4	M-116	M-115	1097.25	1096.68	Circ 1	0.00	2.00	187.00	0.30	0.013
5	M-115	M-114	1096.68	1096.02	Circ 1	0.00	2.00	221.00	0.30	0.013
6	M-114	M-113	1096.02	1095.35	Circ 1	0.00	2.00	225.00	0.30	0.013
7	M-113	M-112	1095.35	1094.68	Circ 1	0.00	2.00	223.00	0.30	0.013
8	M-112	M-111	1094.68	1093.91	Circ 1	0.00	2.00	222.00	0.35	0.013
9	M-111	M-110	1093.91	1093.26	Circ 1	0.00	3.00	217.20	0.30	0.013
10	M-110	OUT	1093.26	1092.70	Circ 1	0.00	3.00	114.00	0.49	0.013
12	M-117	M-116	1097.91	1097.25	Circ 1	0.00	2.00	220.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1095.64	1095.63	0.013	0.63	1.35	3.09	1.15	2.59	12.34	0.000
2	1095.63	1095.59	0.054	0.91	1.60	3.81	1.95	5.27	12.46	0.000
3	1095.59	1095.18	0.231	1.44	1.82	4.49	3.62	10.86	12.38	0.000
4	1100.20	1100.02	0.095	1.06	2.00	4.12	2.22	6.98	12.49	0.000
5	1100.02	1099.63	0.179	1.31	2.00	4.38	3.04	9.56	12.36	0.000
6	1099.63	1098.92	0.315	1.69	2.00	4.49	4.04	12.69	12.35	0.000
7	1098.92	1097.82	0.492	2.00	2.00	5.05	5.05	15.87	12.40	0.000
8	1097.82	1095.62	0.709	2.00	2.00	6.06	6.06	19.05	13.32	0.000
9	1095.62	1095.18	0.112	1.69	1.92	5.44	4.66	22.28	36.49	0.000
10	1095.18	1094.62	0.270	1.92	1.92	7.25	7.25	34.67	46.75	0.000
12	1100.27	1100.20	0.033	0.80	2.00	3.54	1.32	4.13	12.39	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1094.22(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-117

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1094.62(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-108
Run# 8 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-107
Run# 7 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-113
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-117

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:44:52 AM

PROJECT NAME : US 281
JOB NUMBER :
PROJECT DESCRIPTION : SAN ANTONIO
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-101	0.9	0.42	10.00	10.00	8.07	0.000	3.034
	0.9	0.42	Pavement				
M-102	0.9	0.37	10.00	10.00	8.07	0.000	2.710
	0.9	0.37	Pavement				
M-103	0.9	0.37	10.00	10.00	8.07	0.000	2.681
	0.9	0.37	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-101	CircMh	0.900	1.16	13.66	7.02	0.000	0.00	7.329
M-102	CircMh	0.900	0.74	11.66	7.55	0.000	0.00	5.045
M-103	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.681
OUT	Outlt	0.900	1.16	13.66	7.02	0.000	0.00	7.329

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	M-103	M-102	1112.08	1111.14	Circ 1	0.00	2.00	313.00	0.30	0.013
3	M-102	M-101	1111.14	1109.80	Circ 1	0.00	2.00	448.00	0.30	0.013
4	M-101	OUT	1109.80	1109.38	Circ 1	0.00	2.00	84.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	1112.71	1112.03	0.014	0.63	0.89	3.14	1.98	2.68	12.40	0.000
3	1112.03	1110.75	0.050	0.89	0.95	3.73	3.42	5.05	12.37	0.000
4*	1110.75	1110.33	0.105	0.95	0.95	4.96	4.96	7.33	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
M-101	0.9	0.42	10.00	10.00	11.49	0.000	4.319
	0.9	0.42	Pavement				
M-102	0.9	0.37	10.00	10.00	11.49	0.000	3.859
	0.9	0.37	Pavement				
M-103	0.9	0.37	10.00	10.00	11.49	0.000	3.816
	0.9	0.37	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
M-101	CircMh	0.900	1.16	13.33	10.14	0.000	0.00	10.586
M-102	CircMh	0.900	0.74	11.51	10.83	0.000	0.00	7.233
M-103	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.816
OUT	Outlt	0.900	1.16	13.33	10.14	0.000	0.00	10.586

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	M-103	M-102	1112.08	1111.14	Circ 1	0.00	2.00	313.00	0.30	0.013
3	M-102	M-101	1111.14	1109.80	Circ 1	0.00	2.00	448.00	0.30	0.013
4	M-101	OUT	1109.80	1109.38	Circ 1	0.00	2.00	84.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	1112.85	1112.24	0.028	0.77	1.10	3.45	2.16	3.82	12.40	0.000
3	1112.24	1110.99	0.102	1.09	1.19	4.11	3.72	7.23	12.37	0.000
4	1110.99	1110.57	0.219	1.19	1.19	5.45	5.45	10.59	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1110.33(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-101
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-103

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1110.57(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-101
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-103

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:53:04 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
N-109	0.9	0.40	10.00	10.00	8.07	0.000	2.894
	0.9	0.40	Pavement				
N-110	0.9	0.39	10.00	10.00	8.07	0.000	2.853
	0.9	0.39	Pavement				
N-111	0.9	0.44	10.00	10.00	8.07	0.000	3.168
	0.9	0.44	Pavement				
N-105	0.9	0.61	10.00	10.00	8.07	0.000	4.462
	0.9	0.61	Pavement				
N-107	0.9	0.24	10.00	10.00	8.07	0.000	1.758
	0.9	0.24	Pavement				
N-108	0.9	0.25	10.00	10.00	8.07	0.000	1.807
	0.9	0.25	Pavement				
N-103	0.9	0.36	10.00	10.00	8.07	0.000	2.588
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
N-109	CircMh	0.900	0.40	10.00	8.07	0.000	0.00	2.894
N-110	CircMh	0.900	1.80	12.62	7.29	0.000	0.00	11.803
N-111	CircMh	0.900	1.05	11.46	7.61	0.000	0.00	7.195
N-105	CircMh	0.900	0.61	10.00	8.07	0.000	0.00	4.462
N-107	CircMh	0.900	2.69	13.93	6.96	0.000	0.00	16.837
N-108	CircMh	0.900	0.25	10.00	8.07	0.000	0.00	1.807
N-103	CircMh	0.900	0.36	10.00	8.07	0.000	0.00	2.588
N-104	CircMh	0.000	0.00	0.00	0.00	0.000	0.00	0.000
MH-1	CircMh	0.900	2.45	13.70	7.01	0.000	0.00	15.443
MH-2	CircMh	0.900	2.20	13.41	7.08	0.000	0.00	14.010
MH-3	CircMh	0.900	1.41	12.27	7.38	0.000	0.00	9.346
OUT	Outlt	0.900	2.69	13.93	6.96	0.000	0.00	16.837

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	N-105	N-111	1160.36	1159.40	Circ 1	0.00	2.00	319.00	0.30	0.013
5	N-111	MH-3	1159.40	1158.81	Circ 1	0.00	2.00	198.00	0.30	0.013
6	N-103	MH-3	1159.00	1158.81	Circ 1	0.00	2.00	64.00	0.30	0.013
7	MH-3	N-110	1158.81	1158.53	Circ 1	0.00	2.00	92.00	0.30	0.013
8	N-110	MH-2	1158.53	1157.89	Circ 1	0.00	2.00	214.00	0.30	0.013
9	N-109	MH-2	1158.13	1157.89	Circ 1	0.00	2.00	80.00	0.30	0.013
10	MH-2	MH-1	1157.89	1157.57	Circ 1	0.00	3.00	88.00	0.36	0.013
11	N-108	MH-1	1157.79	1157.57	Circ 1	0.00	2.00	68.00	0.32	0.013
12	MH-1	N-107	1157.57	1157.36	Circ 1	0.00	3.00	68.00	0.31	0.013
13	N-107	OUT	1157.36	1157.30	Circ 1	0.00	3.00	14.00	0.43	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	1161.19	1160.54	0.039	0.83	1.14	3.63	2.41	4.46	12.41	0.000
5	1160.54	1160.25	0.101	1.09	1.44	4.09	2.98	7.20	12.35	0.000
6	1160.25	1160.25	0.013	0.63	1.44	3.09	1.07	2.59	12.33	0.000
7	1160.25	1160.09	0.171	1.28	1.56	4.40	3.55	9.35	12.48	0.000
8	1160.09	1159.12	0.272	1.56	1.56	4.48	4.48	11.80	12.37	0.000
9	1159.13	1159.11	0.016	0.66	1.22	3.23	1.44	2.89	12.39	0.000
10	1159.11	1158.93	0.044	1.22	1.36	5.20	4.50	14.01	40.23	0.000
11	1158.93	1158.93	0.006	0.51	1.36	2.88	0.79	1.81	12.87	0.000
12	1158.93	1158.65	0.054	1.36	1.36	4.96	4.96	15.44	37.07	0.000
13*	1158.65	1158.59	0.064	1.29	1.29	5.80	5.80	16.84	43.67	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
N-109	0.9	0.40	10.00	10.00	11.49	0.000	4.120
	0.9	0.40	Pavement				
N-110	0.9	0.39	10.00	10.00	11.49	0.000	4.061
	0.9	0.39	Pavement				
N-111	0.9	0.44	10.00	10.00	11.49	0.000	4.510
	0.9	0.44	Pavement				
N-105	0.9	0.61	10.00	10.00	11.49	0.000	6.352
	0.9	0.61	Pavement				
N-107	0.9	0.24	10.00	10.00	11.49	0.000	2.503
	0.9	0.24	Pavement				
N-108	0.9	0.25	10.00	10.00	11.49	0.000	2.572
	0.9	0.25	Pavement				
N-103	0.9	0.36	10.00	10.00	11.49	0.000	3.685
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
N-109	CircMh	0.900	0.40	10.00	11.49	0.000	0.00	4.120
N-110	CircMh	0.900	1.80	12.45	10.46	0.000	0.00	16.944
N-111	CircMh	0.900	1.05	11.34	10.90	0.000	0.00	10.304
N-105	CircMh	0.900	0.61	10.00	11.49	0.000	0.00	6.352
N-107	CircMh	0.900	2.69	13.57	10.06	0.000	0.00	24.336
N-108	CircMh	0.900	0.25	10.00	11.49	0.000	0.00	2.572
N-103	CircMh	0.900	0.36	10.00	11.49	0.000	0.00	3.685
N-104	CircMh	0.000	0.00	0.00	0.00	0.000	0.00	0.000
MH-1	CircMh	0.900	2.45	13.36	10.13	0.000	0.00	22.304
MH-2	CircMh	0.900	2.20	13.11	10.22	0.000	0.00	20.216
MH-3	CircMh	0.900	1.41	12.10	10.59	0.000	0.00	13.416
OUT	Outlt	0.900	2.69	13.57	10.06	0.000	0.00	24.336

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
2	N-105	N-111	1160.36	1159.40	Circ 1	0.00	2.00	319.00	0.30	0.013
5	N-111	MH-3	1159.40	1158.81	Circ 1	0.00	2.00	198.00	0.30	0.013
6	N-103	MH-3	1159.00	1158.81	Circ 1	0.00	2.00	64.00	0.30	0.013
7	MH-3	N-110	1158.81	1158.53	Circ 1	0.00	2.00	92.00	0.30	0.013
8	N-110	MH-2	1158.53	1157.89	Circ 1	0.00	2.00	214.00	0.30	0.013
9	N-109	MH-2	1158.13	1157.89	Circ 1	0.00	2.00	80.00	0.30	0.013
10	MH-2	MH-1	1157.89	1157.57	Circ 1	0.00	3.00	88.00	0.36	0.013
11	N-108	MH-1	1157.79	1157.57	Circ 1	0.00	2.00	68.00	0.32	0.013
12	MH-1	N-107	1157.57	1157.36	Circ 1	0.00	3.00	68.00	0.31	0.013
13	N-107	OUT	1157.36	1157.30	Circ 1	0.00	3.00	14.00	0.43	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
2	1162.01	1161.79	0.079	1.02	2.00	3.97	2.02	6.35	12.41	0.000
5	1161.79	1161.38	0.207	1.41	2.00	4.37	3.28	10.30	12.35	0.000
6	1161.40	1161.38	0.027	0.75	2.00	3.42	1.17	3.68	12.33	0.000
7	1161.38	1161.06	0.352	1.88	2.00	4.38	4.27	13.42	12.48	0.000
8	1161.06	1159.41	0.561	2.00	2.00	5.39	5.39	16.94	12.37	0.000
9	1159.43	1159.41	0.033	0.80	1.52	3.53	1.60	4.12	12.39	0.000
10	1159.41	1159.26	0.092	1.50	1.69	5.72	4.94	20.22	40.23	0.000
11	1159.26	1159.26	0.013	0.61	1.69	3.18	0.91	2.57	12.87	0.000
12	1159.26	1158.95	0.112	1.69	1.69	5.45	5.45	22.30	37.07	0.000
13	1158.95	1158.89	0.133	1.59	1.59	6.38	6.38	24.34	43.67	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1158.59(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-1
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-2
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-3
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-105

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1158.89(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-1
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-2
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-108
Run# 8 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-109
Run# 7 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-3
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-105

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:54:08 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
N-112	0.9	0.45	10.00	10.00	8.07	0.000	3.282
	0.9	0.45	Pavement				
O-109	0.9	0.43	10.00	10.00	8.07	0.000	3.115
	0.9	0.43	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
N-112	CircMh	0.900	0.88	11.40	7.63	0.000	0.00	6.047
O-109	CircMh	0.900	0.43	10.00	8.07	0.000	0.00	3.115
OUT	Outlt	0.900	0.88	11.40	7.63	0.000	0.00	6.047

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	O-109	N-112	1187.23	1186.41	Circ 1	0.00	2.00	274.00	0.30	0.013
2	N-112	OUT	1186.41	1186.29	Circ 1	0.00	2.00	26.00	0.46	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1187.92	1187.29	0.019	0.69	0.88	3.26	2.36	3.12	12.38	0.000
2	1187.29	1187.17	0.071	0.88	0.88	4.58	4.58	6.05	15.37	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
N-112	0.9	0.45	10.00	10.00	11.49	0.000	4.672
	0.9	0.45	Pavement				
O-109	0.9	0.43	10.00	10.00	11.49	0.000	4.434
	0.9	0.43	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
N-112	CircMh	0.900	0.88	11.27	10.93	0.000	0.00	8.663
O-109	CircMh	0.900	0.43	10.00	11.49	0.000	0.00	4.434
OUT	Outlt	0.900	0.88	11.27	10.93	0.000	0.00	8.663

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	O-109	N-112	1187.23	1186.41	Circ 1	0.00	2.00	274.00	0.30	0.013
2	N-112	OUT	1186.41	1186.29	Circ 1	0.00	2.00	26.00	0.46	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1188.06	1187.49	0.038	0.83	1.08	3.61	2.57	4.43	12.38	0.000
2	1187.49	1187.37	0.147	1.08	1.08	5.02	5.02	8.66	15.37	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1187.17(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-109

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1187.37(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= N-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-109

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:55:42 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
O-106	0.9	0.41	10.00	10.00	8.07	0.000	2.955
	0.9	0.41	Pavement				
O-107	0.9	0.41	10.00	10.00	8.07	0.000	2.966
	0.9	0.41	Pavement				
O-108	0.9	0.30	10.00	10.00	8.07	0.000	2.199
	0.9	0.30	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
O-106	CircMh	0.900	1.12	12.19	7.40	0.000	0.00	7.448
O-107	CircMh	0.900	0.71	11.05	7.73	0.000	0.00	4.950
O-108	CircMh	0.900	0.30	10.00	8.07	0.000	0.00	2.199
OUT	Outlt	0.900	1.12	12.19	7.40	0.000	0.00	7.448

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	O-108	O-107	1189.83	1189.27	Circ 1	0.00	2.00	188.00	0.30	0.013
2	O-107	O-106	1189.27	1188.50	Circ 1	0.00	2.00	256.00	0.30	0.013
3	O-106	OUT	1188.50	1188.36	Circ 1	0.00	2.00	27.00	0.52	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1190.40	1190.15	0.009	0.57	0.88	2.98	1.66	2.20	12.35	0.000
2	1190.15	1189.45	0.048	0.88	0.95	3.75	3.35	4.95	12.41	0.000
3*	1189.45	1189.31	0.108	0.95	0.95	5.04	5.04	7.45	16.29	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
O-106	0.9	0.41	10.00	10.00	11.49	0.000	4.206
	0.9	0.41	Pavement				
O-107	0.9	0.41	10.00	10.00	11.49	0.000	4.222
	0.9	0.41	Pavement				
O-108	0.9	0.30	10.00	10.00	11.49	0.000	3.131
	0.9	0.30	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
O-106	CircMh	0.900	1.12	12.00	10.63	0.000	0.00	10.699
O-107	CircMh	0.900	0.71	10.96	11.06	0.000	0.00	7.079
O-108	CircMh	0.900	0.30	10.00	11.49	0.000	0.00	3.131
OUT	Outlt	0.900	1.12	12.00	10.63	0.000	0.00	10.699

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	O-108	O-107	1189.83	1189.27	Circ 1	0.00	2.00	188.00	0.30	0.013
2	O-107	O-106	1189.27	1188.50	Circ 1	0.00	2.00	256.00	0.30	0.013
3	O-106	OUT	1188.50	1188.36	Circ 1	0.00	2.00	27.00	0.52	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1190.53	1190.35	0.019	0.69	1.08	3.27	1.80	3.13	12.35	0.000
2	1190.35	1189.69	0.098	1.08	1.19	4.10	3.64	7.08	12.41	0.000
3	1189.69	1189.55	0.224	1.19	1.19	5.50	5.50	10.70	16.29	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1189.31(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-108

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1189.55(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-108

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:57:15 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
O-114	0.9	0.30	10.00	10.00	8.07	0.000	2.150
	0.9	0.30	Pavement				
O-115	0.9	0.26	10.00	10.00	8.07	0.000	1.901
	0.9	0.26	Pavement				
O-117	0.9	0.13	10.00	10.00	8.07	0.000	0.959
	0.9	0.13	Pavement				
O-118	0.9	0.11	10.00	10.00	8.07	0.000	0.787
	0.9	0.11	Pavement				
O-119	0.9	0.13	10.00	10.00	8.07	0.000	0.912
	0.9	0.13	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
O-114	CircMh	0.900	0.30	10.00	8.07	0.000	0.00	2.150
O-115	CircMh	0.900	0.56	10.74	7.83	0.000	0.00	3.930
O-117	CircMh	0.900	0.69	11.83	7.50	0.000	0.00	4.659
O-118	CircMh	0.900	0.92	12.68	7.27	0.000	0.00	6.045
O-119	CircMh	0.900	0.13	10.00	8.07	0.000	0.00	0.912
OUT	Outlt	0.900	0.92	12.68	7.27	0.000	0.00	6.045

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	O-114	O-115	1191.40	1191.00	Circ 1	0.00	2.00	132.00	0.30	0.013
2	O-115	O-117	1191.00	1190.31	Circ 1	0.00	2.00	229.00	0.30	0.013
3	O-117	O-118	1190.31	1189.75	Circ 1	0.00	2.00	188.00	0.30	0.013
4	O-119	O-118	1190.41	1189.75	Circ 1	0.00	2.00	220.00	0.30	0.013
5	O-118	OUT	1189.75	1189.68	Circ 1	0.00	2.00	15.00	0.47	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1191.96	1191.77	0.009	0.56	0.77	2.97	1.92	2.15	12.45	0.000
2	1191.77	1191.16	0.030	0.77	0.85	3.50	3.08	3.93	12.42	0.000
3	1191.16	1190.62	0.042	0.84	0.87	3.70	3.57	4.66	12.35	0.000
4	1190.78	1190.62	0.002	0.37	0.87	2.31	0.70	0.91	12.39	0.000
5*	1190.62	1190.55	0.071	0.87	0.87	4.63	4.63	6.05	15.46	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
O-114	0.9	0.30	10.00	10.00	11.49	0.000	3.060
	0.9	0.30	Pavement				
O-115	0.9	0.26	10.00	10.00	11.49	0.000	2.707
	0.9	0.26	Pavement				
O-117	0.9	0.13	10.00	10.00	11.49	0.000	1.366
	0.9	0.13	Pavement				
O-118	0.9	0.11	10.00	10.00	11.49	0.000	1.120
	0.9	0.11	Pavement				
O-119	0.9	0.13	10.00	10.00	11.49	0.000	1.299
	0.9	0.13	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
O-114	CircMh	0.900	0.30	10.00	11.49	0.000	0.00	3.060
O-115	CircMh	0.900	0.56	10.67	11.19	0.000	0.00	5.615
O-117	CircMh	0.900	0.69	11.65	10.77	0.000	0.00	6.688
O-118	CircMh	0.900	0.92	12.43	10.47	0.000	0.00	8.703
O-119	CircMh	0.900	0.13	10.00	11.49	0.000	0.00	1.299
OUT	Outlt	0.900	0.92	12.43	10.47	0.000	0.00	8.703

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	O-114	O-115	1191.40	1191.00	Circ 1	0.00	2.00	132.00	0.30	0.013
2	O-115	O-117	1191.00	1190.31	Circ 1	0.00	2.00	229.00	0.30	0.013
3	O-117	O-118	1190.31	1189.75	Circ 1	0.00	2.00	188.00	0.30	0.013
4	O-119	O-118	1190.41	1189.75	Circ 1	0.00	2.00	220.00	0.30	0.013
5	O-118	OUT	1189.75	1189.68	Circ 1	0.00	2.00	15.00	0.47	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1192.09	1191.94	0.018	0.67	0.94	3.30	2.10	3.06	12.45	0.000
2	1191.94	1191.36	0.062	0.94	1.05	3.88	3.36	5.62	12.42	0.000
3	1191.36	1190.83	0.087	1.05	1.08	4.02	3.87	6.69	12.35	0.000
4	1190.89	1190.83	0.003	0.44	1.08	2.55	0.75	1.30	12.39	0.000
5	1190.83	1190.76	0.148	1.08	1.08	5.04	5.04	8.70	15.46	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1190.55(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-118
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-119
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-114

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1190.76(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-118
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-119
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= O-114

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:05:53 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
P-109	0.9	0.38	10.00	10.00	8.07	0.000	2.731
	0.9	0.38	Pavement				
P-110	0.9	0.33	10.00	10.00	8.07	0.000	2.425
	0.9	0.33	Pavement				
P-111	0.9	0.19	10.00	10.00	8.07	0.000	1.389
	0.9	0.19	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
P-109	CircMh	0.900	0.90	13.00	7.19	0.000	0.00	5.829
P-110	CircMh	0.900	0.53	12.12	7.42	0.000	0.00	3.508
P-111	CircMh	0.900	0.19	10.00	8.07	0.000	0.00	1.389
OUT	Outlt	0.900	0.90	13.00	7.19	0.000	0.00	5.829

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	P-111	P-110	1264.32	1263.33	Circ 1	0.00	2.00	331.30	0.30	0.013
2	P-110	P-109	1263.33	1262.79	Circ 1	0.00	2.00	178.50	0.30	0.013
3	P-109	OUT	1262.79	1262.56	Circ 1	0.00	2.00	33.00	0.70	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1264.77	1264.06	0.004	0.45	0.73	2.60	1.35	1.39	12.37	0.000
2	1264.06	1263.56	0.024	0.73	0.77	3.40	3.17	3.51	12.44	0.000
3*	1263.56	1263.33	0.066	0.77	0.77	5.27	5.27	5.83	18.89	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
P-109	0.9	0.38	10.00	10.00	11.49	0.000	3.888
	0.9	0.38	Pavement				
P-110	0.9	0.33	10.00	10.00	11.49	0.000	3.452
	0.9	0.33	Pavement				
P-111	0.9	0.19	10.00	10.00	11.49	0.000	1.978
	0.9	0.19	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
P-109	CircMh	0.900	0.90	12.70	10.36	0.000	0.00	8.406
P-110	CircMh	0.900	0.53	11.91	10.67	0.000	0.00	5.043
P-111	CircMh	0.900	0.19	10.00	11.49	0.000	0.00	1.978
OUT	Outlt	0.900	0.90	12.70	10.36	0.000	0.00	8.406

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	P-111	P-110	1264.32	1263.33	Circ 1	0.00	2.00	331.30	0.30	0.013
2	P-110	P-109	1263.33	1262.79	Circ 1	0.00	2.00	178.50	0.30	0.013
3	P-109	OUT	1262.79	1262.56	Circ 1	0.00	2.00	33.00	0.70	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1264.86	1264.22	0.008	0.54	0.89	2.90	1.46	1.98	12.37	0.000
2	1264.22	1263.73	0.050	0.89	0.94	3.73	3.49	5.04	12.44	0.000
3*	1263.73	1263.50	0.138	0.94	0.94	5.81	5.81	8.41	18.89	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1263.33(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= P-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= P-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= P-111

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1263.50(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= P-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= P-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= P-111

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:06:51 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
Q-101	0.9	0.21	10.00	10.00	8.07	0.000	1.541
	0.9	0.21	Pavement				
Q-101A	0.9	0.29	10.00	10.00	8.07	0.000	2.126
	0.9	0.29	Pavement				
Q-102	0.9	0.33	10.00	10.00	8.07	0.000	2.367
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
Q-101	CircMh	0.900	0.21	10.00	8.07	0.000	0.00	1.541
Q-101A	CircMh	0.900	0.50	11.14	7.71	0.000	0.00	3.502
Q-102	CircMh	0.900	0.83	12.12	7.42	0.000	0.00	5.549
OUT	Outlt	0.900	0.83	12.12	7.42	0.000	0.00	5.549

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	Q-101	Q-101A	1256.47	1255.92	Circ 1	0.00	2.00	184.00	0.30	0.013
2	Q-101A	Q-102	1255.92	1255.32	Circ 1	0.00	2.00	200.00	0.30	0.013
3	Q-102	OUT	1255.32	1255.26	Circ 1	0.00	2.00	13.30	0.45	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1256.95	1256.65	0.005	0.48	0.73	2.69	1.49	1.54	12.37	0.000
2	1256.65	1256.16	0.024	0.73	0.84	3.40	2.81	3.50	12.39	0.000
3	1256.16	1256.10	0.060	0.84	0.84	4.46	4.46	5.55	15.20	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
Q-101	0.9	0.21	10.00	10.00	11.49	0.000	2.194
	0.9	0.21	Pavement				
Q-101A	0.9	0.29	10.00	10.00	11.49	0.000	3.026
	0.9	0.29	Pavement				
Q-102	0.9	0.33	10.00	10.00	11.49	0.000	3.370
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
Q-101	CircMh	0.900	0.21	10.00	11.49	0.000	0.00	2.194
Q-101A	CircMh	0.900	0.50	11.03	11.03	0.000	0.00	5.011
Q-102	CircMh	0.900	0.83	11.93	10.66	0.000	0.00	7.970
OUT	Outlt	0.900	0.83	11.93	10.66	0.000	0.00	7.970

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	Q-101	Q-101A	1256.47	1255.92	Circ 1	0.00	2.00	184.00	0.30	0.013
2	Q-101A	Q-102	1255.92	1255.32	Circ 1	0.00	2.00	200.00	0.30	0.013
3	Q-102	OUT	1255.32	1255.26	Circ 1	0.00	2.00	13.30	0.45	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1257.04	1256.81	0.009	0.57	0.89	2.97	1.62	2.19	12.37	0.000
2	1256.81	1256.35	0.049	0.89	1.03	3.70	3.07	5.01	12.39	0.000
3	1256.35	1256.29	0.124	1.03	1.03	4.88	4.88	7.97	15.20	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1256.10(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-101A
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1256.29(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-101A
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 9:36:01 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-106	0.9	0.11	10.00	10.00	8.07	0.000	0.779
	0.9	0.11	Pavement				
L-109	0.9	0.12	10.00	10.00	8.07	0.000	0.896
	0.9	0.12	Pavement				
L-112	0.9	0.36	10.00	10.00	8.07	0.000	2.634
	0.9	0.36	Pavement				
L-110	0.9	0.13	10.00	10.00	8.07	0.000	0.934
	0.9	0.13	Pavement				
L-113	0.9	0.36	10.00	10.00	8.07	0.000	2.619
	0.9	0.36	Pavement				
M-105	0.9	0.13	10.00	10.00	8.07	0.000	0.934
	0.9	0.13	Pavement				
M-106	0.9	0.36	10.00	10.00	8.07	0.000	2.583
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-106	CircMh	0.900	0.11	10.00	8.07	0.000	0.00	0.779
L-109	CircMh	0.900	0.23	10.43	7.93	0.000	0.00	1.646
L-112	CircMh	0.900	0.59	10.46	7.92	0.000	0.00	4.229
L-110	CircMh	0.900	0.72	11.39	7.63	0.000	0.00	4.958
L-113	CircMh	0.900	1.08	11.41	7.62	0.000	0.00	7.429
M-105	CircMh	0.900	1.21	11.74	7.53	0.000	0.00	8.209
M-106	CircMh	0.900	1.57	11.75	7.53	0.000	0.00	10.612
OUT	Outlt	0.900	1.57	11.75	7.53	0.000	0.00	10.612

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-106	L-109	1072.46	1072.29	Circ 1	0.00	2.00	57.00	0.30	0.013
2	L-109	L-112	1072.29	1072.27	Circ 1	0.00	2.00	5.00	0.40	0.013
3	L-112	L-110	1072.27	1071.68	Circ 1	0.00	2.00	198.00	0.30	0.013
4	L-110	L-113	1071.68	1071.66	Circ 1	0.00	2.00	5.00	0.40	0.013
5	L-113	M-105	1071.66	1071.43	Circ 1	0.00	2.00	79.00	0.29	0.013
6	M-105	M-106	1071.43	1071.41	Circ 1	0.00	2.00	5.00	0.40	0.013
7	M-106	OUT	1071.41	1070.77	Circ 1	0.00	2.00	128.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1073.09	1073.08	0.001	0.34	0.79	2.20	0.67	0.78	12.36	0.000
2	1073.08	1073.08	0.005	0.46	0.81	3.01	1.37	1.65	14.31	0.000
3	1073.08	1072.80	0.035	0.81	1.12	3.53	2.33	4.23	12.35	0.000
4	1072.80	1072.80	0.048	0.81	1.14	4.14	2.68	4.96	14.31	0.000
5	1072.80	1072.61	0.108	1.13	1.18	4.08	3.87	7.43	12.21	0.000
6	1072.61	1072.60	0.132	1.09	1.19	4.67	4.22	8.21	14.31	0.000
7	1072.60	1071.96	0.220	1.19	1.19	5.46	5.46	10.61	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
L-106	0.9	0.11	10.00	10.00	11.49	0.000	1.109
	0.9	0.11	Pavement				
L-109	0.9	0.12	10.00	10.00	11.49	0.000	1.276
	0.9	0.12	Pavement				
L-112	0.9	0.36	10.00	10.00	11.49	0.000	3.750
	0.9	0.36	Pavement				
L-110	0.9	0.13	10.00	10.00	11.49	0.000	1.330
	0.9	0.13	Pavement				
L-113	0.9	0.36	10.00	10.00	11.49	0.000	3.728
	0.9	0.36	Pavement				
M-105	0.9	0.13	10.00	10.00	11.49	0.000	1.330
	0.9	0.13	Pavement				
M-106	0.9	0.36	10.00	10.00	11.49	0.000	3.678
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
L-106	CircMh	0.900	0.11	10.00	11.49	0.000	0.00	1.109
L-109	CircMh	0.900	0.23	10.39	11.31	0.000	0.00	2.348
L-112	CircMh	0.900	0.59	10.42	11.30	0.000	0.00	6.033
L-110	CircMh	0.900	0.72	11.26	10.93	0.000	0.00	7.103
L-113	CircMh	0.900	1.08	11.28	10.92	0.000	0.00	10.644
M-105	CircMh	0.900	1.21	11.58	10.80	0.000	0.00	11.774
M-106	CircMh	0.900	1.57	11.59	10.79	0.000	0.00	15.222
OUT	Outlt	0.900	1.57	11.59	10.79	0.000	0.00	15.222

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	L-106	L-109	1072.46	1072.29	Circ 1	0.00	2.00	57.00	0.30	0.013
2	L-109	L-112	1072.29	1072.27	Circ 1	0.00	2.00	5.00	0.40	0.013
3	L-112	L-110	1072.27	1071.68	Circ 1	0.00	2.00	198.00	0.30	0.013
4	L-110	L-113	1071.68	1071.66	Circ 1	0.00	2.00	5.00	0.40	0.013
5	L-113	M-105	1071.66	1071.43	Circ 1	0.00	2.00	79.00	0.29	0.013
6	M-105	M-106	1071.43	1071.41	Circ 1	0.00	2.00	5.00	0.40	0.013
7	M-106	OUT	1071.41	1070.77	Circ 1	0.00	2.00	128.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic US Elev (ft)	Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1073.36	1073.35	0.002	0.41	1.06	2.43	0.65	1.11	12.36	0.000
2	1073.35	1073.35	0.011	0.55	1.08	3.37	1.35	2.35	14.31	0.000
3	1073.35	1073.17	0.071	0.98	1.49	3.92	2.40	6.03	12.35	0.000
4	1073.17	1073.17	0.099	1.00	1.51	4.52	2.79	7.10	14.31	0.000
5	1073.17	1072.98	0.221	1.44	1.55	4.40	4.07	10.64	12.21	0.000
6	1072.98	1072.97	0.271	1.38	1.56	5.11	4.47	11.77	14.31	0.000
7	1072.97	1072.33	0.453	1.56	1.56	5.78	5.78	15.22	16.00	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1071.96(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-106

```
        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1072.33(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= M-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-110
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= L-106
```

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:10:18 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
Q-113	0.9	0.37	10.00	10.00	8.07	0.000	2.684
	0.9	0.37	Pavement				
Q-114	0.9	0.37	10.00	10.00	8.07	0.000	2.676
	0.9	0.37	Pavement				
Q-115	0.9	0.37	10.00	10.00	8.07	0.000	2.664
	0.9	0.37	Pavement				
Q-116	0.9	0.37	10.00	10.00	8.07	0.000	2.660
	0.9	0.37	Pavement				
Q-107	0.9	0.37	10.00	10.00	8.07	0.000	2.702
	0.9	0.37	Pavement				
Q-108	0.9	0.37	10.00	10.00	8.07	0.000	2.694
	0.9	0.37	Pavement				
Q-109	0.9	0.37	10.00	10.00	8.07	0.000	2.700
	0.9	0.37	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
Q-113	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.684
Q-114	CircMh	0.900	0.74	11.46	7.61	0.000	0.00	5.054
Q-115	CircMh	0.900	0.73	11.45	7.61	0.000	0.00	5.023
Q-116	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.660
Q-107	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.702
Q-108	CircMh	0.900	0.74	11.43	7.62	0.000	0.00	5.095
Q-109	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.700
MH-1	CircMh	0.900	1.47	12.36	7.36	0.000	0.00	9.739
MH-2	CircMh	0.900	2.59	12.63	7.28	0.000	0.00	16.949
OUT	Outlt	0.900	2.59	12.63	7.28	0.000	0.00	16.949

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	Q-113	Q-114	1214.61	1213.79	Circ 1	0.00	2.00	276.00	0.30	0.013
2	Q-114	MH-1	1213.79	1213.18	Circ 1	0.00	2.00	201.00	0.30	0.013
3	Q-116	Q-115	1214.23	1213.40	Circ 1	0.00	2.00	276.00	0.30	0.013
4	Q-115	MH-1	1213.40	1213.18	Circ 1	0.00	2.00	72.00	0.31	0.013
5	MH-1	MH-2	1213.18	1212.97	Circ 1	0.00	2.00	71.00	0.30	0.013
6	Q-107	Q-108	1214.39	1213.57	Circ 1	0.00	2.00	272.00	0.30	0.013
7	Q-108	MH-2	1213.57	1212.97	Circ 1	0.00	2.00	200.00	0.30	0.013
8	Q-109	MH-2	1213.19	1212.97	Circ 1	0.00	2.00	72.00	0.31	0.013
9	MH-2	OUT	1212.97	1212.75	Circ 1	0.00	2.00	34.00	0.65	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1215.24	1214.78	0.014	0.63	0.99	3.15	1.74	2.68	12.33	0.000
2	1214.78	1214.64	0.050	0.89	1.46	3.74	2.06	5.05	12.46	0.000
3	1214.87	1214.67	0.014	0.63	1.27	3.17	1.27	2.66	12.41	0.000
4	1214.67	1214.64	0.049	0.88	1.46	3.80	2.05	5.02	12.51	0.000
5	1214.64	1214.50	0.185	1.34	1.53	4.34	3.77	9.74	12.30	0.000
6	1215.02	1214.62	0.014	0.63	1.05	3.17	1.62	2.70	12.42	0.000
7	1214.62	1214.50	0.051	0.89	1.53	3.77	1.97	5.09	12.39	0.000
8	1214.51	1214.50	0.014	0.63	1.53	3.16	1.05	2.70	12.51	0.000
9	1214.50	1214.28	0.561	1.53	1.53	6.57	6.57	16.95	18.20	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
Q-113	0.9	0.37	10.00	10.00	11.49	0.000	3.820
	0.9	0.37	Pavement				
Q-114	0.9	0.37	10.00	10.00	11.49	0.000	3.809
	0.9	0.37	Pavement				
Q-115	0.9	0.37	10.00	10.00	11.49	0.000	3.792
	0.9	0.37	Pavement				
Q-116	0.9	0.37	10.00	10.00	11.49	0.000	3.786
	0.9	0.37	Pavement				
Q-107	0.9	0.37	10.00	10.00	11.49	0.000	3.847
	0.9	0.37	Pavement				
Q-108	0.9	0.37	10.00	10.00	11.49	0.000	3.835
	0.9	0.37	Pavement				
Q-109	0.9	0.37	10.00	10.00	11.49	0.000	3.844
	0.9	0.37	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
Q-113	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.820
Q-114	CircMh	0.900	0.74	11.33	10.90	0.000	0.00	7.239
Q-115	CircMh	0.900	0.73	11.33	10.90	0.000	0.00	7.193
Q-116	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.786
Q-107	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.847
Q-108	CircMh	0.900	0.74	11.30	10.91	0.000	0.00	7.297
Q-109	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.844
MH-1	CircMh	0.900	1.47	12.15	10.58	0.000	0.00	14.000
MH-2	CircMh	0.900	2.59	12.41	10.47	0.000	0.00	24.374
OUT	Outlt	0.900	2.59	12.41	10.47	0.000	0.00	24.374

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	Q-113	Q-114	1214.61	1213.79	Circ 1	0.00	2.00	276.00	0.30	0.013
2	Q-114	MH-1	1213.79	1213.18	Circ 1	0.00	2.00	201.00	0.30	0.013
3	Q-116	Q-115	1214.23	1213.40	Circ 1	0.00	2.00	276.00	0.30	0.013
4	Q-115	MH-1	1213.40	1213.18	Circ 1	0.00	2.00	72.00	0.31	0.013
5	MH-1	MH-2	1213.18	1212.97	Circ 1	0.00	2.00	71.00	0.30	0.013
6	Q-107	Q-108	1214.39	1213.57	Circ 1	0.00	2.00	272.00	0.30	0.013
7	Q-108	MH-2	1213.57	1212.97	Circ 1	0.00	2.00	200.00	0.30	0.013
8	Q-109	MH-2	1213.19	1212.97	Circ 1	0.00	2.00	72.00	0.31	0.013
9	MH-2	OUT	1212.97	1212.75	Circ 1	0.00	2.00	34.00	0.65	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1215.67	1215.60	0.029	0.77	1.81	3.45	1.28	3.82	12.33	0.000
2	1215.60	1215.42	0.102	1.09	2.00	4.12	2.30	7.24	12.46	0.000
3	1215.55	1215.49	0.028	0.76	2.00	3.47	1.21	3.79	12.41	0.000
4	1215.49	1215.42	0.101	1.09	2.00	4.09	2.29	7.19	12.51	0.000
5	1215.42	1215.14	0.383	2.00	2.00	4.46	4.46	14.00	12.30	0.000
6	1215.40	1215.33	0.029	0.77	1.76	3.48	1.32	3.85	12.42	0.000
7	1215.33	1215.14	0.104	1.09	2.00	4.15	2.32	7.30	12.39	0.000
8	1215.16	1215.14	0.029	0.77	2.00	3.47	1.22	3.84	12.51	0.000
9	1215.14	1214.75	1.161	2.00	2.00	7.76	7.76	24.37	18.20	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1214.28(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-2
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-1
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-116

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1214.75(ft)
Run# 9 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-2
Run# 5 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH-1
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= Q-116

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:12:30 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
R-101	0.9	0.29	10.00	10.00	8.07	0.000	2.127
	0.9	0.29	Pavement				
R-103	0.9	0.36	10.00	10.00	8.07	0.000	2.637
	0.9	0.36	Pavement				
S-101	0.9	0.41	10.00	10.00	8.07	0.000	2.941
	0.9	0.41	Pavement				
S-102	0.9	0.27	10.00	10.00	8.07	0.000	1.996
	0.9	0.27	Pavement				
S-103	0.9	0.29	10.00	10.00	8.07	0.000	2.106
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
R-101	CircMh	0.900	0.29	10.00	8.07	0.000	0.00	2.127
R-103	CircMh	0.900	0.66	13.39	7.09	0.000	0.00	4.185
S-101	CircMh	0.900	1.06	13.85	6.97	0.000	0.00	6.660
S-102	CircMh	0.900	1.34	14.86	6.74	0.000	0.00	8.103
S-103	CircMh	0.900	1.63	15.53	6.59	0.000	0.00	9.649
OUT	Outlt	0.900	1.63	15.53	6.59	0.000	0.00	9.649

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	R-101	R-103	1185.70	1183.91	Circ 1	0.00	2.00	597.00	0.30	0.013
3	R-103	S-101	1183.91	1183.61	Circ 1	0.00	2.00	99.00	0.30	0.013
4	S-101	S-102	1183.61	1182.88	Circ 1	0.00	2.00	243.00	0.30	0.013
5	S-102	S-103	1182.88	1182.38	Circ 1	0.00	2.00	168.00	0.30	0.013
6	S-103	OUT	1182.38	1182.31	Circ 1	0.00	2.00	23.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1186.26	1184.76	0.009	0.56	0.85	2.94	1.67	2.13	12.39	0.000
3	1184.76	1184.66	0.034	0.80	1.05	3.58	2.51	4.18	12.45	0.000
4	1184.66	1184.08	0.087	1.05	1.20	4.00	3.40	6.66	12.40	0.000
5	1184.08	1183.69	0.128	1.19	1.31	4.17	3.71	8.10	12.34	0.000
6	1183.69	1183.62	0.182	1.31	1.31	4.42	4.42	9.65	12.48	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
R-101	0.9	0.29	10.00	10.00	11.49	0.000	3.028
	0.9	0.29	Pavement				
R-103	0.9	0.36	10.00	10.00	11.49	0.000	3.754
	0.9	0.36	Pavement				
S-101	0.9	0.41	10.00	10.00	11.49	0.000	4.187
	0.9	0.41	Pavement				
S-102	0.9	0.27	10.00	10.00	11.49	0.000	2.841
	0.9	0.27	Pavement				
S-103	0.9	0.29	10.00	10.00	11.49	0.000	2.998
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
R-101	CircMh	0.900	0.29	10.00	11.49	0.000	0.00	3.028
R-103	CircMh	0.900	0.66	13.04	10.24	0.000	0.00	6.046
S-101	CircMh	0.900	1.06	13.46	10.09	0.000	0.00	9.637
S-102	CircMh	0.900	1.34	14.38	9.78	0.000	0.00	11.764
S-103	CircMh	0.900	1.63	15.01	9.59	0.000	0.00	14.028
OUT	Outlt	0.900	1.63	15.01	9.59	0.000	0.00	14.028

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	R-101	R-103	1185.70	1183.91	Circ 1	0.00	2.00	597.00	0.30	0.013
3	R-103	S-101	1183.91	1183.61	Circ 1	0.00	2.00	99.00	0.30	0.013
4	S-101	S-102	1183.61	1182.88	Circ 1	0.00	2.00	243.00	0.30	0.013
5	S-102	S-103	1182.88	1182.38	Circ 1	0.00	2.00	168.00	0.30	0.013
6	S-103	OUT	1182.38	1182.31	Circ 1	0.00	2.00	23.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic US Elev (ft)	Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1186.37	1185.24	0.018	0.67	1.33	3.27	1.37	3.03	12.39	0.000
3	1185.24	1185.18	0.071	0.98	1.57	3.93	2.28	6.05	12.45	0.000
4	1185.18	1184.83	0.181	1.31	1.95	4.41	3.09	9.64	12.40	0.000
5	1184.83	1184.40	0.270	1.56	2.00	4.47	3.74	11.76	12.34	0.000
6	1184.40	1184.31	0.384	2.00	2.00	4.47	4.47	14.03	12.48	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1183.62(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-101
Upstream hydraulic gradeline exceeds critical elevation at node Id= R-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= R-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1184.31(ft)
Run# 6 Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-101
Upstream hydraulic gradeline exceeds critical elevation at node Id= R-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= R-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:16:38 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-116	0.9	0.27	10.00	10.00	8.07	0.000	1.996
	0.9	0.27	Pavement				
S-117	0.9	0.28	10.00	10.00	8.07	0.000	2.032
	0.9	0.28	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-116	CircMh	0.900	0.27	10.00	8.07	0.000	0.00	1.996
S-117	CircMh	0.900	0.55	10.98	7.76	0.000	0.00	3.871
OUT	Outlt	0.900	0.55	10.98	7.76	0.000	0.00	3.871

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-116	S-117	1179.58	1179.08	Circ 1	0.00	2.00	168.00	0.30	0.013
2	S-117	OUT	1179.08	1178.94	Circ 1	0.00	2.00	28.90	0.48	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1180.13	1179.76	0.008	0.55	0.68	2.87	2.14	2.00	12.34	0.000
2*	1179.76	1179.62	0.029	0.68	0.68	4.15	4.15	3.87	15.75	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-116	0.9	0.27	10.00	10.00	11.49	0.000	2.841
	0.9	0.27	Pavement				
S-117	0.9	0.28	10.00	10.00	11.49	0.000	2.893
	0.9	0.28	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-116	CircMh	0.900	0.27	10.00	11.49	0.000	0.00	2.841
S-117	CircMh	0.900	0.55	10.88	11.09	0.000	0.00	5.536
OUT	Outlt	0.900	0.55	10.88	11.09	0.000	0.00	5.536

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-116	S-117	1179.58	1179.08	Circ 1	0.00	2.00	168.00	0.30	0.013
2	S-117	OUT	1179.08	1178.94	Circ 1	0.00	2.00	28.90	0.48	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1180.24	1179.90	0.016	0.66	0.82	3.17	2.34	2.84	12.34	0.000
2*	1179.90	1179.76	0.060	0.82	0.82	4.56	4.56	5.54	15.75	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1179.62(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-116

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1179.76(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-116

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:17:38 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-106	0.9	0.34	10.00	10.00	8.07	0.000	2.436
	0.9	0.34	Pavement				
S-107	0.9	0.33	10.00	10.00	8.07	0.000	2.368
	0.9	0.33	Pavement				
S-108	0.9	0.33	10.00	10.00	8.07	0.000	2.387
	0.9	0.33	Pavement				
S-111	0.9	0.33	10.00	10.00	8.07	0.000	2.380
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-106	CircMh	0.900	0.34	10.00	8.07	0.000	0.00	2.436
S-107	CircMh	0.900	0.66	11.07	7.73	0.000	0.00	4.600
S-108	CircMh	0.900	1.32	11.99	7.46	0.000	0.00	8.846
S-111	CircMh	0.900	0.33	10.00	8.07	0.000	0.00	2.380
OUT	Outlt	0.900	1.32	11.99	7.46	0.000	0.00	8.846

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-106	S-107	1178.01	1177.40	Circ 1	0.00	2.00	200.00	0.31	0.013
2	S-107	S-108	1177.40	1176.80	Circ 1	0.00	2.00	202.00	0.30	0.013
3	S-108	OUT	1176.80	1176.74	Circ 1	0.00	2.00	11.00	0.55	0.013
4	S-111	S-108	1177.40	1176.80	Circ 1	0.00	2.00	199.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1178.61	1178.25	0.012	0.59	0.85	3.12	1.93	2.44	12.50	0.000
2	1178.25	1177.83	0.041	0.84	1.03	3.65	2.82	4.60	12.33	0.000
3*	1177.83	1177.77	0.153	1.03	1.03	5.42	5.42	8.85	16.71	0.000
4	1178.00	1177.83	0.011	0.59	1.03	3.05	1.46	2.38	12.42	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-106	0.9	0.34	10.00	10.00	11.49	0.000	3.468
	0.9	0.34	Pavement				
S-107	0.9	0.33	10.00	10.00	11.49	0.000	3.371
	0.9	0.33	Pavement				
S-108	0.9	0.33	10.00	10.00	11.49	0.000	3.398
	0.9	0.33	Pavement				
S-111	0.9	0.33	10.00	10.00	11.49	0.000	3.388
	0.9	0.33	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-106	CircMh	0.900	0.34	10.00	11.49	0.000	0.00	3.468
S-107	CircMh	0.900	0.66	10.98	11.05	0.000	0.00	6.578
S-108	CircMh	0.900	1.32	11.81	10.71	0.000	0.00	12.698
S-111	CircMh	0.900	0.33	10.00	11.49	0.000	0.00	3.388
OUT	Outlt	0.900	1.32	11.81	10.71	0.000	0.00	12.698

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-106	S-107	1178.01	1177.40	Circ 1	0.00	2.00	200.00	0.31	0.013
2	S-107	S-108	1177.40	1176.80	Circ 1	0.00	2.00	202.00	0.30	0.013
3	S-108	OUT	1176.80	1176.74	Circ 1	0.00	2.00	11.00	0.55	0.013
4	S-111	S-108	1177.40	1176.80	Circ 1	0.00	2.00	199.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1178.73	1178.46	0.023	0.72	1.06	3.41	2.06	3.47	12.50	0.000
2	1178.46	1178.11	0.085	1.03	1.31	4.03	3.01	6.58	12.33	0.000
3	1178.11	1178.05	0.315	1.31	1.31	5.81	5.81	12.70	16.71	0.000
4	1178.20	1178.11	0.022	0.72	1.31	3.34	1.55	3.39	12.42	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1177.77(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-106

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1178.05(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-111
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-107
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-106

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:18:34 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-120	0.9	0.35	10.00	10.00	8.07	0.000	2.545
	0.9	0.35	Pavement				
S-121	0.9	0.38	10.00	10.00	8.07	0.000	2.753
	0.9	0.38	Pavement				
S-124	0.9	0.15	10.00	10.00	8.07	0.000	1.096
	0.9	0.15	Pavement				
S-125	0.9	0.15	10.00	10.00	8.07	0.000	1.100
	0.9	0.15	Pavement				
S-122	0.9	0.35	10.00	10.00	8.07	0.000	2.506
	0.9	0.35	Pavement				
S-123	0.9	0.35	10.00	10.00	8.07	0.000	2.523
	0.9	0.35	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-120	CircMh	0.900	0.35	10.00	8.07	0.000	0.00	2.545
S-121	CircMh	0.900	0.73	11.09	7.72	0.000	0.00	5.070
S-124	CircMh	0.900	0.30	11.82	7.51	0.000	0.00	2.043
S-125	CircMh	0.900	0.15	10.00	8.07	0.000	0.00	1.100
S-122	CircMh	0.900	0.69	11.37	7.64	0.000	0.00	4.760
S-123	CircMh	0.900	0.35	10.00	8.07	0.000	0.00	2.523
MH	CircMh	0.900	1.72	12.20	7.40	0.000	0.00	11.485
OUT	Outlt	0.900	1.72	12.20	7.40	0.000	0.00	11.485

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-123	S-122	1175.82	1175.05	Circ 1	0.00	2.00	256.00	0.30	0.013
2	S-122	MH	1175.05	1174.89	Circ 1	0.00	2.00	54.00	0.30	0.013
3	S-120	S-121	1176.24	1175.64	Circ 1	0.00	2.00	201.00	0.30	0.013
4	S-121	MH	1175.64	1174.89	Circ 1	0.00	2.00	250.00	0.30	0.013
5	S-125	S-124	1175.72	1174.92	Circ 1	0.00	2.00	266.00	0.30	0.013
6	S-124	MH	1174.92	1174.89	Circ 1	0.00	2.00	11.00	0.31	0.013
7	MH	OUT	1174.89	1174.85	Circ 1	0.00	2.00	8.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1176.43	1176.17	0.012	0.61	1.12	3.12	1.39	2.52	12.41	0.000
2	1176.17	1176.14	0.044	0.86	1.25	3.69	2.30	4.76	12.32	0.000
3	1176.86	1176.53	0.013	0.62	0.89	3.09	1.87	2.54	12.36	0.000
4	1176.53	1176.14	0.050	0.89	1.25	3.75	2.45	5.07	12.39	0.000
5	1176.18	1176.14	0.002	0.40	1.22	2.44	0.55	1.10	12.41	0.000
6	1176.14	1176.14	0.008	0.55	1.25	2.93	0.99	2.04	12.58	0.000
7	1176.14	1176.10	0.258	1.25	1.25	5.56	5.56	11.49	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-120	0.9	0.35	10.00	10.00	11.49	0.000	3.623
	0.9	0.35	Pavement				
S-121	0.9	0.38	10.00	10.00	11.49	0.000	3.919
	0.9	0.38	Pavement				
S-124	0.9	0.15	10.00	10.00	11.49	0.000	1.560
	0.9	0.15	Pavement				
S-125	0.9	0.15	10.00	10.00	11.49	0.000	1.566
	0.9	0.15	Pavement				
S-122	0.9	0.35	10.00	10.00	11.49	0.000	3.568
	0.9	0.35	Pavement				
S-123	0.9	0.35	10.00	10.00	11.49	0.000	3.592
	0.9	0.35	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-120	CircMh	0.900	0.35	10.00	11.49	0.000	0.00	3.623
S-121	CircMh	0.900	0.73	10.98	11.05	0.000	0.00	7.253
S-124	CircMh	0.900	0.30	11.62	10.78	0.000	0.00	2.934
S-125	CircMh	0.900	0.15	10.00	11.49	0.000	0.00	1.566
S-122	CircMh	0.900	0.69	11.24	10.94	0.000	0.00	6.817
S-123	CircMh	0.900	0.35	10.00	11.49	0.000	0.00	3.592
MH	CircMh	0.900	1.72	11.99	10.64	0.000	0.00	16.505
OUT	Outlt	0.900	1.72	11.99	10.64	0.000	0.00	16.505

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-123	S-122	1175.82	1175.05	Circ 1	0.00	2.00	256.00	0.30	0.013
2	S-122	MH	1175.05	1174.89	Circ 1	0.00	2.00	54.00	0.30	0.013
3	S-120	S-121	1176.24	1175.64	Circ 1	0.00	2.00	201.00	0.30	0.013
4	S-121	MH	1175.64	1174.89	Circ 1	0.00	2.00	250.00	0.30	0.013
5	S-125	S-124	1175.72	1174.92	Circ 1	0.00	2.00	266.00	0.30	0.013
6	S-124	MH	1174.92	1174.89	Circ 1	0.00	2.00	11.00	0.31	0.013
7	MH	OUT	1174.89	1174.85	Circ 1	0.00	2.00	8.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1176.70	1176.61	0.025	0.73	1.56	3.43	1.36	3.59	12.41	0.000
2	1176.61	1176.58	0.091	1.06	1.69	4.02	2.41	6.82	12.32	0.000
3	1177.01	1176.84	0.026	0.74	1.20	3.41	1.84	3.62	12.36	0.000
4	1176.84	1176.58	0.103	1.09	1.69	4.13	2.56	7.25	12.39	0.000
5	1176.59	1176.58	0.005	0.48	1.66	2.73	0.56	1.57	12.41	0.000
6	1176.58	1176.58	0.017	0.66	1.69	3.27	1.04	2.93	12.58	0.000
7	1176.58	1176.54	0.532	1.69	1.69	5.84	5.84	16.50	16.00	0.000

END

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1176.10(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-122
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-121
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-120
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-125

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        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1176.54(ft)
Run# 7  Insufficient capacity.
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-122
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-121
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-123
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-120
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-125
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WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:19:50 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-113	0.9	0.27	10.00	10.00	8.07	0.000	1.938
	0.9	0.27	Pavement				
S-114	0.9	0.27	10.00	10.00	8.07	0.000	1.973
	0.9	0.27	Pavement				
S-115	0.9	0.32	10.00	10.00	8.07	0.000	2.337
	0.9	0.32	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-113	CircMh	0.900	0.27	10.00	8.07	0.000	0.00	1.938
S-114	CircMh	0.900	0.54	11.11	7.72	0.000	0.00	3.738
S-115	CircMh	0.900	0.86	12.08	7.43	0.000	0.00	5.754
OUT	Outlt	0.900	0.86	12.08	7.43	0.000	0.00	5.754

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-113	S-114	1185.60	1185.02	Circ 1	0.00	2.00	193.00	0.30	0.013
2	S-114	S-115	1185.02	1184.41	Circ 1	0.00	2.00	203.00	0.30	0.013
3	S-115	OUT	1184.41	1184.30	Circ 1	0.00	2.00	23.00	0.48	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1186.13	1185.77	0.007	0.53	0.75	2.90	1.79	1.94	12.40	0.000
2	1185.77	1185.25	0.027	0.75	0.84	3.47	2.97	3.74	12.40	0.000
3*	1185.25	1185.14	0.065	0.84	0.84	4.57	4.57	5.75	15.65	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
S-113	0.9	0.27	10.00	10.00	11.49	0.000	2.758
	0.9	0.27	Pavement				
S-114	0.9	0.27	10.00	10.00	11.49	0.000	2.808
	0.9	0.27	Pavement				
S-115	0.9	0.32	10.00	10.00	11.49	0.000	3.327
	0.9	0.32	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
S-113	CircMh	0.900	0.27	10.00	11.49	0.000	0.00	2.758
S-114	CircMh	0.900	0.54	11.01	11.04	0.000	0.00	5.347
S-115	CircMh	0.900	0.86	11.91	10.67	0.000	0.00	8.259
OUT	Outlt	0.900	0.86	11.91	10.67	0.000	0.00	8.259

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	S-113	S-114	1185.60	1185.02	Circ 1	0.00	2.00	193.00	0.30	0.013
2	S-114	S-115	1185.02	1184.41	Circ 1	0.00	2.00	203.00	0.30	0.013
3	S-115	OUT	1184.41	1184.30	Circ 1	0.00	2.00	23.00	0.48	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1186.24	1185.94	0.015	0.64	0.92	3.18	1.95	2.76	12.40	0.000
2	1185.94	1185.44	0.056	0.92	1.03	3.78	3.27	5.35	12.40	0.000
3	1185.44	1185.33	0.133	1.03	1.03	5.06	5.06	8.26	15.65	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1185.14(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-113

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1185.33(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= S-113

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:22:02 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-101	0.9	0.14	10.00	10.00	8.07	0.000	0.990
	0.9	0.14	Pavement				
U-102	0.9	0.15	10.00	10.00	8.07	0.000	1.111
	0.9	0.15	Pavement				
U-103	0.9	0.17	10.00	10.00	8.07	0.000	1.204
	0.9	0.17	Pavement				
U-104	0.9	0.18	10.00	10.00	8.07	0.000	1.306
	0.9	0.18	Pavement				
U-105	0.9	0.18	10.00	10.00	8.07	0.000	1.320
	0.9	0.18	Pavement				
U-106	0.9	0.21	10.00	10.00	8.07	0.000	1.493
	0.9	0.21	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-101	CircMh	0.900	0.14	10.00	8.07	0.000	0.00	0.990
U-102	CircMh	0.900	0.29	11.24	7.67	0.000	0.00	1.998
U-103	CircMh	0.900	0.46	13.30	7.11	0.000	0.00	2.913
U-104	CircMh	0.900	0.63	14.22	6.89	0.000	0.00	3.935
U-105	CircMh	0.900	0.82	15.08	6.69	0.000	0.00	4.918
U-106	CircMh	0.900	1.02	15.95	6.51	0.000	0.00	5.987
OUT	Outlt	0.900	1.02	15.95	6.51	0.000	0.00	5.987

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-101	U-102	1161.17	1160.64	Circ 1	0.00	2.00	176.00	0.30	0.013
2	U-102	U-103	1160.64	1159.58	Circ 1	0.00	2.00	353.30	0.30	0.013
3	U-103	U-104	1159.58	1159.04	Circ 1	0.00	2.00	180.10	0.30	0.013
4	U-104	U-105	1159.04	1158.51	Circ 1	0.00	2.00	179.20	0.30	0.013
5	U-105	U-106	1158.51	1157.93	Circ 1	0.00	2.00	192.20	0.30	0.013
6	U-106	OUT	1157.93	1157.76	Circ 1	0.00	2.00	34.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1161.55	1161.19	0.002	0.38	0.55	2.36	1.42	0.99	12.42	0.000
2	1161.19	1160.24	0.008	0.55	0.66	2.87	2.21	2.00	12.39	0.000
3	1160.24	1159.82	0.017	0.66	0.78	3.25	2.56	2.91	12.39	0.000
4	1159.82	1159.39	0.030	0.78	0.88	3.46	2.98	3.93	12.30	0.000
5	1159.39	1158.77	0.047	0.88	0.88	3.72	3.72	4.92	12.43	0.000
6*	1158.77	1158.60	0.070	0.84	0.84	4.75	4.75	5.99	16.00	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-101	0.9	0.14	10.00	10.00	11.49	0.000	1.409
	0.9	0.14	Pavement				
U-102	0.9	0.15	10.00	10.00	11.49	0.000	1.582
	0.9	0.15	Pavement				
U-103	0.9	0.17	10.00	10.00	11.49	0.000	1.714
	0.9	0.17	Pavement				
U-104	0.9	0.18	10.00	10.00	11.49	0.000	1.859
	0.9	0.18	Pavement				
U-105	0.9	0.18	10.00	10.00	11.49	0.000	1.880
	0.9	0.18	Pavement				
U-106	0.9	0.21	10.00	10.00	11.49	0.000	2.125
	0.9	0.21	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-101	CircMh	0.900	0.14	10.00	11.49	0.000	0.00	1.409
U-102	CircMh	0.900	0.29	11.11	10.99	0.000	0.00	2.862
U-103	CircMh	0.900	0.46	12.96	10.27	0.000	0.00	4.207
U-104	CircMh	0.900	0.63	13.79	9.98	0.000	0.00	5.703
U-105	CircMh	0.900	0.82	14.56	9.73	0.000	0.00	7.149
U-106	CircMh	0.900	1.02	15.35	9.48	0.000	0.00	8.724
OUT	Outlt	0.900	1.02	15.35	9.48	0.000	0.00	8.724

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-101	U-102	1161.17	1160.64	Circ 1	0.00	2.00	176.00	0.30	0.013
2	U-102	U-103	1160.64	1159.58	Circ 1	0.00	2.00	353.30	0.30	0.013
3	U-103	U-104	1159.58	1159.04	Circ 1	0.00	2.00	180.10	0.30	0.013
4	U-104	U-105	1159.04	1158.51	Circ 1	0.00	2.00	179.20	0.30	0.013
5	U-105	U-106	1158.51	1157.93	Circ 1	0.00	2.00	192.20	0.30	0.013
6	U-106	OUT	1157.93	1157.76	Circ 1	0.00	2.00	34.00	0.50	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1161.62	1161.30	0.004	0.45	0.66	2.64	1.57	1.41	12.42	0.000
2	1161.30	1160.38	0.016	0.66	0.80	3.19	2.42	2.86	12.39	0.000
3	1160.38	1160.00	0.035	0.80	0.96	3.60	2.82	4.21	12.39	0.000
4	1160.00	1159.60	0.064	0.95	1.09	3.86	3.24	5.70	12.30	0.000
5	1159.60	1158.98	0.100	1.09	1.09	4.07	4.07	7.15	12.43	0.000
6*	1158.98	1158.81	0.149	1.05	1.05	5.19	5.19	8.72	16.00	0.000

==========END==========

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1158.60(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-104
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1158.81(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-106
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-104
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-102
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:24:09 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-123	0.9	0.37	10.00	10.00	8.07	0.000	2.674
	0.9	0.37	Pavement				
U-124	0.9	0.31	10.00	10.00	8.07	0.000	2.282
	0.9	0.31	Pavement				
U-125	0.9	0.27	10.00	10.00	8.07	0.000	1.959
	0.9	0.27	Pavement				
U-126	0.9	0.37	10.00	10.00	8.07	0.000	2.660
	0.9	0.37	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-123	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.674
U-124	CircMh	0.900	0.68	11.55	7.59	0.000	0.00	4.659
U-125	CircMh	0.900	1.32	12.13	7.42	0.000	0.00	8.802
U-126	CircMh	0.900	0.37	10.00	8.07	0.000	0.00	2.660
OUT	Outlt	0.900	1.32	12.13	7.42	0.000	0.00	8.802

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-123	U-124	1143.84	1142.97	Circ 1	0.00	2.00	290.70	0.30	0.013
2	U-124	U-125	1142.97	1142.58	Circ 1	0.00	2.00	130.50	0.30	0.013
3	U-126	U-125	1142.97	1142.58	Circ 1	0.00	2.00	130.30	0.30	0.013
4	U-125	OUT	1142.58	1142.47	Circ 1	0.00	2.00	20.00	0.55	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1144.47	1143.83	0.014	0.63	0.86	3.13	2.07	2.67	12.38	0.000
2	1143.83	1143.61	0.042	0.84	1.03	3.70	2.85	4.66	12.37	0.000
3	1143.68	1143.61	0.014	0.63	1.03	3.17	1.63	2.66	12.38	0.000
4*	1143.61	1143.50	0.151	1.03	1.03	5.39	5.39	8.80	16.78	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-123	0.9	0.37	10.00	10.00	11.49	0.000	3.807
	0.9	0.37	Pavement				
U-124	0.9	0.31	10.00	10.00	11.49	0.000	3.249
	0.9	0.31	Pavement				
U-125	0.9	0.27	10.00	10.00	11.49	0.000	2.788
	0.9	0.27	Pavement				
U-126	0.9	0.37	10.00	10.00	11.49	0.000	3.787
	0.9	0.37	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-123	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.807
U-124	CircMh	0.900	0.68	11.41	10.87	0.000	0.00	6.676
U-125	CircMh	0.900	1.32	11.95	10.65	0.000	0.00	12.639
U-126	CircMh	0.900	0.37	10.00	11.49	0.000	0.00	3.787
OUT	Outlt	0.900	1.32	11.95	10.65	0.000	0.00	12.639

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-123	U-124	1143.84	1142.97	Circ 1	0.00	2.00	290.70	0.30	0.013
2	U-124	U-125	1142.97	1142.58	Circ 1	0.00	2.00	130.50	0.30	0.013
3	U-126	U-125	1142.97	1142.58	Circ 1	0.00	2.00	130.30	0.30	0.013
4	U-125	OUT	1142.58	1142.47	Circ 1	0.00	2.00	20.00	0.55	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1144.61	1144.07	0.028	0.77	1.10	3.44	2.15	3.81	12.38	0.000
2	1144.07	1143.88	0.087	1.05	1.30	4.01	3.10	6.68	12.37	0.000
3	1143.93	1143.88	0.028	0.77	1.30	3.42	1.76	3.79	12.38	0.000
4	1143.88	1143.77	0.312	1.30	1.30	5.86	5.86	12.64	16.78	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1143.50(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-125
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-123

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1143.77(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-125
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-124
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-126
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-123

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:30:26 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-113	0.9	0.26	10.00	10.00	8.07	0.000	1.889
	0.9	0.26	Pavement				
U-114	0.9	0.29	10.00	10.00	8.07	0.000	2.076
	0.9	0.29	Pavement				
U-115	0.9	0.34	10.00	10.00	8.07	0.000	2.465
	0.9	0.34	Pavement				
U-116	0.9	0.25	10.00	10.00	8.07	0.000	1.784
	0.9	0.25	Pavement				
U-117	0.9	0.25	10.00	10.00	8.07	0.000	1.788
	0.9	0.25	Pavement				
V-104	0.9	0.42	10.00	10.00	8.07	0.000	3.062
	0.9	0.42	Pavement				
V-105	0.9	0.46	10.00	10.00	8.07	0.000	3.339
	0.9	0.46	Pavement				
U-118	0.9	0.24	10.00	10.00	8.07	0.000	1.722
	0.9	0.24	Pavement				
U-128	0.9	0.10	10.00	10.00	8.07	0.000	0.750
	0.9	0.10	Pavement				
U-129	0.9	0.10	10.00	10.00	8.07	0.000	0.750
	0.9	0.10	Pavement				
U-130	0.9	0.10	10.00	10.00	8.07	0.000	0.750
	0.9	0.10	Pavement				
U-131	0.9	0.06	10.00	10.00	8.07	0.000	0.458
	0.9	0.06	Pavement				
U-127	0.9	0.44	10.00	10.00	8.07	0.000	3.191
	0.9	0.44	Pavement				
V-112	0.9	0.37	10.00	10.00	8.07	0.000	2.657
	0.9	0.37	Pavement				
V-113	0.9	0.65	10.00	10.00	8.07	0.000	4.727
	0.9	0.65	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-113	CircMh	0.900	0.26	10.00	8.07	0.000	0.00	1.889
U-114	CircMh	0.900	0.55	11.26	7.67	0.000	0.00	3.769
U-115	CircMh	0.900	0.89	11.89	7.49	0.000	0.00	5.965
U-116	CircMh	0.900	1.13	12.45	7.33	0.000	0.00	7.463
U-117	CircMh	0.900	1.38	13.17	7.14	0.000	0.00	8.853
V-104	CircMh	0.900	0.88	11.01	7.75	0.000	0.00	6.144
V-105	CircMh	0.900	0.46	10.00	8.07	0.000	0.00	3.339
U-118	CircMh	0.900	2.50	13.72	7.01	0.000	0.00	15.734
U-128	CircMh	0.900	0.10	10.00	8.07	0.000	0.00	0.750
U-129	CircMh	0.900	0.21	11.39	7.63	0.000	0.00	1.419
U-130	CircMh	0.900	0.31	12.54	7.31	0.000	0.00	2.039
U-131	CircMh	0.900	0.37	13.56	7.05	0.000	0.00	2.364
U-127	CircMh	0.900	0.81	14.16	6.90	0.000	0.00	5.046
V-112	CircMh	0.900	1.02	11.23	7.68	0.000	0.00	7.027
V-113	CircMh	0.900	0.65	10.00	8.07	0.000	0.00	4.727
MH	CircMh	0.900	4.32	14.26	6.88	0.000	0.00	26.772
OUT	Outlt	0.900	4.32	14.26	6.88	0.000	0.00	26.772

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-113	U-114	1150.00	1149.36	Circ 1	0.00	2.00	213.00	0.30	0.013
2	U-114	U-115	1149.36	1148.97	Circ 1	0.00	2.00	131.00	0.30	0.013
3	U-115	U-116	1148.97	1148.57	Circ 1	0.00	2.00	133.00	0.30	0.013
4	U-116	U-117	1148.57	1148.04	Circ 1	0.00	2.00	178.00	0.30	0.013
5	U-117	U-118	1148.04	1147.05	Circ 1	0.00	2.00	179.00	0.55	0.013
6	V-105	V-104	1148.67	1148.02	Circ 1	0.00	2.00	205.00	0.32	0.013
7	V-104	U-118	1148.02	1147.50	Circ 1	0.00	2.00	175.00	0.30	0.013
8	U-118	MH	1147.50	1147.22	Circ 1	0.00	3.00	94.00	0.30	0.013
9	U-128	U-129	1149.23	1148.69	Circ 1	0.00	2.00	180.00	0.30	0.013
10	U-129	U-130	1148.69	1148.15	Circ 1	0.00	2.00	180.00	0.30	0.013
11	U-130	U-131	1148.15	1147.61	Circ 1	0.00	2.00	180.00	0.30	0.013
12	U-131	U-127	1147.61	1147.28	Circ 1	0.00	2.00	108.00	0.31	0.013
13	U-127	MH	1147.28	1147.22	Circ 1	0.00	2.00	22.00	0.27	0.013
14	V-113	V-112	1148.73	1147.97	Circ 1	0.00	2.00	264.00	0.29	0.013
15	V-112	MH	1147.93	1147.22	Circ 1	0.00	2.00	239.00	0.30	0.013
16	MH	OUT	1147.22	1145.84	Circ 1	0.00	3.00	20.00	6.92	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1150.53	1150.13	0.007	0.53	0.77	2.82	1.69	1.89	12.40	0.000
2	1150.13	1149.96	0.028	0.76	0.99	3.45	2.43	3.77	12.35	0.000
3	1149.96	1149.70	0.070	0.97	1.13	3.96	3.28	5.97	12.41	0.000
4	1149.70	1149.07	0.109	1.13	1.13	4.10	4.10	7.46	12.35	0.000
5*	1149.07	1148.88	0.153	1.03	1.83	5.42	2.94	8.85	16.83	0.000
6	1149.37	1149.08	0.022	0.70	1.06	3.39	1.97	3.34	12.74	0.000
7	1149.08	1148.88	0.074	1.00	1.38	3.91	2.65	6.14	12.33	0.000
8	1148.88	1148.49	0.056	1.38	1.38	4.94	4.94	15.73	36.41	0.000
9	1149.57	1149.15	0.001	0.34	0.46	2.16	1.39	0.75	12.39	0.000
10	1149.15	1148.70	0.004	0.46	0.55	2.62	2.03	1.42	12.39	0.000
11	1148.70	1148.25	0.008	0.55	0.64	2.93	2.35	2.04	12.39	0.000
12	1148.25	1148.19	0.011	0.59	0.91	3.03	1.71	2.36	12.51	0.000
13	1148.19	1148.01	0.050	0.91	0.91	3.65	3.65	5.05	11.82	0.000
14	1149.61	1149.01	0.044	0.88	1.04	3.58	2.87	4.73	12.14	0.000
15	1149.01	1148.16	0.096	1.08	1.08	4.07	4.07	7.03	12.33	0.000
16*	1148.01	1146.63	0.161	0.79	0.79	17.95	17.95	26.77	175.44	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-113	0.9	0.26	10.00	10.00	11.49	0.000	2.689
	0.9	0.26	Pavement				
U-114	0.9	0.29	10.00	10.00	11.49	0.000	2.955
	0.9	0.29	Pavement				
U-115	0.9	0.34	10.00	10.00	11.49	0.000	3.509
	0.9	0.34	Pavement				
U-116	0.9	0.25	10.00	10.00	11.49	0.000	2.540
	0.9	0.25	Pavement				
U-117	0.9	0.25	10.00	10.00	11.49	0.000	2.545
	0.9	0.25	Pavement				
V-104	0.9	0.42	10.00	10.00	11.49	0.000	4.359
	0.9	0.42	Pavement				
V-105	0.9	0.46	10.00	10.00	11.49	0.000	4.753
	0.9	0.46	Pavement				
U-118	0.9	0.24	10.00	10.00	11.49	0.000	2.451
	0.9	0.24	Pavement				
U-128	0.9	0.10	10.00	10.00	11.49	0.000	1.068
	0.9	0.10	Pavement				
U-129	0.9	0.10	10.00	10.00	11.49	0.000	1.068
	0.9	0.10	Pavement				
U-130	0.9	0.10	10.00	10.00	11.49	0.000	1.068
	0.9	0.10	Pavement				
U-131	0.9	0.06	10.00	10.00	11.49	0.000	0.651
	0.9	0.06	Pavement				
U-127	0.9	0.44	10.00	10.00	11.49	0.000	4.543
	0.9	0.44	Pavement				
V-112	0.9	0.37	10.00	10.00	11.49	0.000	3.783
	0.9	0.37	Pavement				

V-113	0.9	0.65	10.00	10.00	11.49	0.000	6.729
	0.9	0.65	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-113	CircMh	0.900	0.26	10.00	11.49	0.000	0.00	2.689
U-114	CircMh	0.900	0.55	11.13	10.99	0.000	0.00	5.398
U-115	CircMh	0.900	0.89	11.70	10.75	0.000	0.00	8.566
U-116	CircMh	0.900	1.13	12.22	10.55	0.000	0.00	10.736
U-117	CircMh	0.900	1.38	12.89	10.30	0.000	0.00	12.764
V-104	CircMh	0.900	0.88	10.91	11.08	0.000	0.00	8.789
V-105	CircMh	0.900	0.46	10.00	11.49	0.000	0.00	4.753
U-118	CircMh	0.900	2.50	13.39	10.12	0.000	0.00	22.727
U-128	CircMh	0.900	0.10	10.00	11.49	0.000	0.00	1.068
U-129	CircMh	0.900	0.21	11.25	10.94	0.000	0.00	2.033
U-130	CircMh	0.900	0.31	12.28	10.52	0.000	0.00	2.935
U-131	CircMh	0.900	0.37	13.21	10.18	0.000	0.00	3.417
U-127	CircMh	0.900	0.81	13.74	10.00	0.000	0.00	7.308
V-112	CircMh	0.900	1.02	11.11	10.99	0.000	0.00	10.060
V-113	CircMh	0.900	0.65	10.00	11.49	0.000	0.00	6.729
MH	CircMh	0.900	4.32	13.84	9.97	0.000	0.00	38.785
OUT	Outlt	0.900	4.32	13.84	9.97	0.000	0.00	38.785

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-113	U-114	1150.00	1149.36	Circ 1	0.00	2.00	213.00	0.30	0.013
2	U-114	U-115	1149.36	1148.97	Circ 1	0.00	2.00	131.00	0.30	0.013
3	U-115	U-116	1148.97	1148.57	Circ 1	0.00	2.00	133.00	0.30	0.013
4	U-116	U-117	1148.57	1148.04	Circ 1	0.00	2.00	178.00	0.30	0.013
5	U-117	U-118	1148.04	1147.05	Circ 1	0.00	2.00	179.00	0.55	0.013
6	V-105	V-104	1148.67	1148.02	Circ 1	0.00	2.00	205.00	0.32	0.013
7	V-104	U-118	1148.02	1147.50	Circ 1	0.00	2.00	175.00	0.30	0.013
8	U-118	MH	1147.50	1147.22	Circ 1	0.00	3.00	94.00	0.30	0.013
9	U-128	U-129	1149.23	1148.69	Circ 1	0.00	2.00	180.00	0.30	0.013
10	U-129	U-130	1148.69	1148.15	Circ 1	0.00	2.00	180.00	0.30	0.013
11	U-130	U-131	1148.15	1147.61	Circ 1	0.00	2.00	180.00	0.30	0.013
12	U-131	U-127	1147.61	1147.28	Circ 1	0.00	2.00	108.00	0.31	0.013
13	U-127	MH	1147.28	1147.22	Circ 1	0.00	2.00	22.00	0.27	0.013
14	V-113	V-112	1148.73	1147.97	Circ 1	0.00	2.00	264.00	0.29	0.013
15	V-112	MH	1147.93	1147.22	Circ 1	0.00	2.00	239.00	0.30	0.013
16	MH	OUT	1147.22	1145.84	Circ 1	0.00	3.00	20.00	6.92	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1150.64	1150.41	0.014	0.63	1.05	3.15	1.62	2.69	12.40	0.000
2	1150.41	1150.30	0.057	0.92	1.33	3.82	2.44	5.40	12.35	0.000
3	1150.30	1150.09	0.143	1.22	1.52	4.27	3.35	8.57	12.41	0.000
4	1150.09	1149.70	0.225	1.44	1.66	4.44	3.84	10.74	12.35	0.000
5	1149.70	1149.23	0.318	1.30	2.00	5.92	4.06	12.76	16.83	0.000
6	1149.60	1149.46	0.044	0.84	1.44	3.77	1.96	4.75	12.74	0.000
7	1149.46	1149.23	0.151	1.25	1.73	4.26	3.04	8.79	12.33	0.000
8	1149.23	1148.75	0.116	1.73	1.73	5.37	5.37	22.73	36.41	0.000
9	1149.63	1149.24	0.002	0.40	0.55	2.40	1.53	1.07	12.39	0.000
10	1149.24	1148.81	0.008	0.55	0.66	2.92	2.23	2.03	12.39	0.000
11	1148.81	1148.47	0.017	0.66	0.86	3.22	2.27	2.94	12.39	0.000
12	1148.47	1148.42	0.023	0.72	1.14	3.36	1.85	3.42	12.51	0.000
13	1148.42	1148.18	0.104	1.14	1.14	3.95	3.95	7.31	11.82	0.000
14	1149.80	1149.31	0.088	1.06	1.34	3.97	3.02	6.73	12.14	0.000
15	1149.31	1148.36	0.198	1.38	1.38	4.37	4.37	10.06	12.33	0.000
16*	1148.18	1146.80	0.338	0.96	0.96	19.93	19.93	38.79	175.44	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

```
        Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1146.63(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-118
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-104
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-131
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-130
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-129
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-113

        Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1146.80(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= MH
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-118
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-127
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-104
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-131
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-113
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-116
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-105
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-130
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-115
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-129
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-114
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-128
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-113
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WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:34:56 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-107	0.9	0.23	10.00	10.00	8.07	0.000	1.659
	0.9	0.23	Pavement				
U-108	0.9	0.27	10.00	10.00	8.07	0.000	1.969
	0.9	0.27	Pavement				
U-109	0.9	0.30	10.00	10.00	8.07	0.000	2.150
	0.9	0.30	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-107	CircMh	0.900	0.23	10.00	8.07	0.000	0.00	1.659
U-108	CircMh	0.900	0.50	10.83	7.80	0.000	0.00	3.507
U-109	CircMh	0.900	0.80	12.66	7.28	0.000	0.00	5.209
OUT	Outlt	0.900	0.80	12.66	7.28	0.000	0.00	5.209

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-107	U-108	1151.92	1151.50	Circ 1	0.00	2.00	138.00	0.30	0.013
2	U-108	U-109	1151.50	1150.40	Circ 1	0.00	2.00	367.00	0.30	0.013
3	U-109	OUT	1150.40	1150.29	Circ 1	0.00	2.00	35.00	0.31	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1152.41	1152.23	0.005	0.49	0.73	2.76	1.59	1.66	12.48	0.000
2	1152.23	1151.29	0.024	0.73	0.89	3.35	2.59	3.51	12.39	0.000
3	1151.29	1151.18	0.053	0.89	0.89	3.85	3.85	5.21	12.68	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
U-107	0.9	0.23	10.00	10.00	11.49	0.000	2.361
	0.9	0.23	Pavement				
U-108	0.9	0.27	10.00	10.00	11.49	0.000	2.803
	0.9	0.27	Pavement				
U-109	0.9	0.30	10.00	10.00	11.49	0.000	3.060
	0.9	0.30	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
U-107	CircMh	0.900	0.23	10.00	11.49	0.000	0.00	2.361
U-108	CircMh	0.900	0.50	10.76	11.14	0.000	0.00	5.010
U-109	CircMh	0.900	0.80	12.41	10.47	0.000	0.00	7.498
OUT	Outlt	0.900	0.80	12.41	10.47	0.000	0.00	7.498

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	U-107	U-108	1151.92	1151.50	Circ 1	0.00	2.00	138.00	0.30	0.013
2	U-108	U-109	1151.50	1150.40	Circ 1	0.00	2.00	367.00	0.30	0.013
3	U-109	OUT	1150.40	1150.29	Circ 1	0.00	2.00	35.00	0.31	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1152.52	1152.39	0.011	0.59	0.89	3.02	1.75	2.36	12.48	0.000
2	1152.39	1151.51	0.049	0.89	1.11	3.70	2.80	5.01	12.39	0.000
3	1151.51	1151.40	0.110	1.11	1.11	4.19	4.19	7.50	12.68	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1151.18(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-107

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1151.40(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= U-107

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:35:45 AM

PROJECT NAME : SAN ANTONIO
JOB NUMBER :
PROJECT DESCRIPTION : US 281
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
V-101	0.9	0.17	10.00	10.00	8.07	0.000	1.227
	0.9	0.17	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
V-101	CircMh	0.900	0.17	10.00	8.07	0.000	0.00	1.227
OUT	Outlt	0.900	0.17	10.00	8.07	0.000	0.00	1.227

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	V-101	OUT	1167.55	1167.33	Circ 1	0.00	2.00	35.00	0.63	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1*	1167.91	1167.69	0.003	0.36	0.36	3.25	3.25	1.23	17.94	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
V-101	0.9	0.17	10.00	10.00	11.49	0.000	1.747
	0.9	0.17	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
V-101	CircMh	0.900	0.17	10.00	11.49	0.000	0.00	1.747
OUT	Outlt	0.900	0.17	10.00	11.49	0.000	0.00	1.747

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	V-101	OUT	1167.55	1167.33	Circ 1	0.00	2.00	35.00	0.63	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1*	1167.97	1167.75	0.006	0.42	0.42	3.62	3.62	1.75	17.94	0.000

END

* Super critical flow.

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1167.69(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-101

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1167.75(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-101

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:36:21 AM

PROJECT NAME : US 281
JOB NUMBER :
PROJECT DESCRIPTION : Storm Calculations
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
V-102	0.9	0.27	10.00	10.00	8.07	0.000	1.959
	0.9	0.27	Pavement				
V-103	0.9	0.21	10.00	10.00	8.07	0.000	1.556
	0.9	0.21	Pavement				
W-101	0.9	0.29	10.00	10.00	8.07	0.000	2.103
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
V-102	CircMh	0.900	0.27	10.00	8.07	0.000	0.00	1.959
V-103	CircMh	0.900	0.48	11.17	7.70	0.000	0.00	3.353
W-101	CircMh	0.900	0.77	13.79	6.99	0.000	0.00	4.864
OUT	Outlt	0.900	0.77	13.79	6.99	0.000	0.00	4.864

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	V-102	V-103	1172.05	1171.45	Circ 1	0.00	2.00	201.00	0.30	0.013
2	V-103	W-101	1171.45	1170.00	Circ 1	0.00	2.00	520.00	0.28	0.013
3	W-101	OUT	1170.00	1169.89	Circ 1	0.00	2.00	35.00	0.31	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1172.59	1172.17	0.007	0.54	0.72	2.87	1.93	1.96	12.36	0.000
2	1172.17	1170.86	0.022	0.72	0.86	3.30	2.59	3.35	11.95	0.000
3	1170.86	1170.75	0.046	0.86	0.86	3.77	3.77	4.86	12.68	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
V-102	0.9	0.27	10.00	10.00	11.49	0.000	2.788
	0.9	0.27	Pavement				
V-103	0.9	0.21	10.00	10.00	11.49	0.000	2.215
	0.9	0.21	Pavement				
W-101	0.9	0.29	10.00	10.00	11.49	0.000	2.993
	0.9	0.29	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
V-102	CircMh	0.900	0.27	10.00	11.49	0.000	0.00	2.788
V-103	CircMh	0.900	0.48	11.04	11.02	0.000	0.00	4.800
W-101	CircMh	0.900	0.77	13.43	10.10	0.000	0.00	7.034
OUT	Outlt	0.900	0.77	13.43	10.10	0.000	0.00	7.034

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	V-102	V-103	1172.05	1171.45	Circ 1	0.00	2.00	201.00	0.30	0.013
2	V-103	W-101	1171.45	1170.00	Circ 1	0.00	2.00	520.00	0.28	0.013
3	W-101	OUT	1170.00	1169.89	Circ 1	0.00	2.00	35.00	0.31	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1172.70	1172.33	0.015	0.64	0.88	3.21	2.09	2.79	12.36	0.000
2	1172.33	1171.06	0.045	0.88	1.06	3.63	2.83	4.80	11.95	0.000
3	1171.06	1170.95	0.097	1.06	1.06	4.15	4.15	7.03	12.68	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1170.75(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-101
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-102

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1170.95(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-101
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-103
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-102

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:40:21 AM

PROJECT NAME : US 281
JOB NUMBER :
PROJECT DESCRIPTION : Storm Calculations
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
V-111	0.9	0.39	10.00	10.00	8.07	0.000	2.797
	0.9	0.39	Pavement				
V-117	0.9	0.40	10.00	10.00	8.07	0.000	2.893
	0.9	0.40	Pavement				
W-108	0.9	0.38	10.00	10.00	8.07	0.000	2.744
	0.9	0.38	Pavement				
W-109	0.9	0.19	10.00	10.00	8.07	0.000	1.371
	0.9	0.19	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
V-111	CircMh	0.900	0.39	10.00	8.07	0.000	0.00	2.797
V-117	CircMh	0.900	0.78	10.38	7.95	0.000	0.00	5.602
W-108	CircMh	0.900	1.16	11.71	7.54	0.000	0.00	7.878
W-109	CircMh	0.900	1.35	12.29	7.37	0.000	0.00	8.960
OUT	Outlt	0.900	1.35	12.29	7.37	0.000	0.00	8.960

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	V-111	V-117	1142.66	1142.44	Circ 1	0.00	2.00	73.00	0.30	0.013
2	V-117	W-108	1142.44	1141.51	Circ 1	0.00	2.00	310.00	0.30	0.013
3	W-109	OUT	1141.07	1140.97	Circ 1	0.00	2.00	21.00	0.48	0.013
4	W-108	W-109	1141.51	1141.07	Circ 1	0.00	2.00	146.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1143.42	1143.38	0.015	0.64	0.94	3.22	1.92	2.80	12.42	0.000
2	1143.38	1142.67	0.061	0.94	1.16	3.87	2.98	5.60	12.39	0.000
3	1142.16	1142.06	0.157	1.09	1.09	5.14	5.14	8.96	15.61	0.000
4	1142.67	1142.16	0.121	1.16	1.16	4.19	4.19	7.88	12.42	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
V-111	0.9	0.39	10.00	10.00	11.49	0.000	3.982
	0.9	0.39	Pavement				
V-117	0.9	0.40	10.00	10.00	11.49	0.000	4.118
	0.9	0.40	Pavement				
W-108	0.9	0.38	10.00	10.00	11.49	0.000	3.906
	0.9	0.38	Pavement				
W-109	0.9	0.19	10.00	10.00	11.49	0.000	1.952
	0.9	0.19	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
V-111	CircMh	0.900	0.39	10.00	11.49	0.000	0.00	3.982
V-117	CircMh	0.900	0.78	10.35	11.33	0.000	0.00	7.987
W-108	CircMh	0.900	1.16	11.56	10.81	0.000	0.00	11.293
W-109	CircMh	0.900	1.35	12.11	10.59	0.000	0.00	12.866
OUT	Outlt	0.900	1.35	12.11	10.59	0.000	0.00	12.866

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	V-111	V-117	1142.66	1142.44	Circ 1	0.00	2.00	73.00	0.30	0.013
2	V-117	W-108	1142.44	1141.51	Circ 1	0.00	2.00	310.00	0.30	0.013
3	W-109	OUT	1141.07	1140.97	Circ 1	0.00	2.00	21.00	0.48	0.013
4	W-108	W-109	1141.51	1141.07	Circ 1	0.00	2.00	146.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 0.000 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1143.65	1143.62	0.031	0.78	1.18	3.50	2.07	3.98	12.42	0.000
2	1143.62	1143.01	0.125	1.16	1.50	4.24	3.16	7.99	12.39	0.000
3	1142.45	1142.35	0.323	1.38	1.38	5.59	5.59	12.87	15.61	0.000
4	1143.01	1142.45	0.249	1.50	1.50	4.47	4.47	11.29	12.42	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Tailwater set to uniform depth elevation = 1142.06(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-111

Runoff Frequency of: 100 Years
Tailwater set to uniform depth elevation = 1142.35(ft)
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-109
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-108
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-117
Upstream hydraulic gradeline exceeds critical elevation at node Id= V-111

WinStorm (STORM DRAIN DESIGN) Version 3.05, Jan. 25, 2002
Run @ 5/14/2014 10:41:15 AM

PROJECT NAME : US 281
JOB NUMBER :
PROJECT DESCRIPTION : Storm Calculations
DESIGN FREQUENCY : 10 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
W-111	0.9	0.38	10.00	10.00	8.07	0.000	2.766
	0.9	0.38	Pavement				
W-112	0.9	0.36	10.00	10.00	8.07	0.000	2.629
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
W-111	CircMh	0.900	0.38	10.00	8.07	0.000	0.00	2.766
W-112	CircMh	0.900	0.74	11.20	7.69	0.000	0.00	5.139
OUT	Outlt	0.900	0.74	11.20	7.69	0.000	0.00	5.139

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	W-111	W-112	1096.85	1096.16	Circ 1	0.00	2.00	230.00	0.30	0.013
2	W-112	OUT	1096.16	1095.81	Circ 1	0.00	2.00	116.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 1097.810 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1097.89	1097.85	0.015	0.64	1.69	3.19	0.97	2.77	12.39	0.000
2	1097.85	1097.81	0.052	0.89	2.00	3.80	1.64	5.14	12.43	0.000

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
W-111	0.9	0.38	10.00	10.00	11.49	0.000	3.937
	0.9	0.38	Pavement				
W-112	0.9	0.36	10.00	10.00	11.49	0.000	3.743
	0.9	0.36	Pavement				

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
W-111	CircMh	0.900	0.38	10.00	11.49	0.000	0.00	3.937
W-112	CircMh	0.900	0.74	11.11	11.00	0.000	0.00	7.351
OUT	Outlt	0.900	0.74	11.11	11.00	0.000	0.00	7.351

Conveyance Configuration Data

Run#	Node I.D. US	Node I.D. DS	Flowline Elev. US (ft)	Flowline Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	W-111	W-112	1096.85	1096.16	Circ 1	0.00	2.00	230.00	0.30	0.013
2	W-112	OUT	1096.16	1095.81	Circ 1	0.00	2.00	116.00	0.30	0.013

Conveyance Hydraulic Computations. Tailwater = 1097.810 (ft)

Run#	Hydraulic Gradeline US Elev (ft)	Hydraulic Gradeline DS Elev (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	1097.96	1097.90	0.030	0.78	1.74	3.46	1.35	3.94	12.39	0.000
2	1097.90	1097.81	0.106	1.11	2.00	4.11	2.34	7.35	12.43	0.000

==========END==========

NORMAL TERMINATION OF WINSTORM.

Warning Messages for current project:

Runoff Frequency of: 10 Years
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-111

Runoff Frequency of: 100 Years
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-112
Upstream hydraulic gradeline exceeds critical elevation at node Id= W-111

APPENDIX G – TSS CALCULATIONS FOR PROPOSED BIORENTION PONDS

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Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Bexar**		
Total project area included in plan * =	**9.93**	acres	0.25
Predevelopment impervious area within the limits of the plan * =	**5.37**	acres	0.25
Total post-development impervious area within the limits of the plan * =	**6.29**	acres	0.25
Total post-development impervious cover fraction * =	**0.63**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**755**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **A**

Total drainage basin/outfall area =	**9.93**	acres
Predevelopment impervious area within drainage basin/outfall area =	**5.37**	acres
Post-development impervious area within drainage basin/outfall area =	**6.29**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.63**	
$L_{M\ THIS\ BASIN}$ =	**755**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**9.93**	acres
A_I =	**6.29**	acres
A_P =	**3.64**	acres
L_R =	**5865**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **755** lbs.

F = **0.13**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.07**	inches
Post Development Runoff Coefficient =	**0.45**	
On-site Water Quality Volume =	**1125**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**225**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**1350**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**1350**	cubic feet	5 ft deep
	16.43	ft square	4 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	9.93	acres
Impervious Cover in Drainage Area =	6.29	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.59	

A_{CS} = cross-sectional area of flow in Swale =	25.51	sf
P_W = Wetted Perimeter =	77.71	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 75.60 feet

Q = CiA = 6.44 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.78 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.44 cfs

Manning's Equation Q =	0.53	cfs	Error 1 =	5.91
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.78	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	5.91
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

The resulting "Swale
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Click on solve.

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The value in the "Se
The value in the "By
Click on solve.

The resulting "Desig
If the resulting "Desi

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.46		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.50	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.50	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	91.83	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	85.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	6050.68	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	8.62	acres	0.5
Predevelopment impervious area within the limits of the plan * =	2.54	acres	0.5
Total post-development impervious area within the limits of the plan * =	6.73	acres	0.5
Total post-development impervious cover fraction * =	**0.78**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**3420**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **B**

Total drainage basin/outfall area =	8.62	acres
Predevelopment impervious area within drainage basin/outfall area =	2.54	acres
Post-development impervious area within drainage basin/outfall area =	6.73	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.78**	
$L_{M\ THIS\ BASIN}$ =	**3420**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	8.62	acres
A_I =	6.73	acres
A_P =	**1.89**	acres
L_R =	**6245**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **3420** lbs.

F = **0.55**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.49**	inches
Post Development Runoff Coefficient =	**0.60**	
On-site Water Quality Volume =	**9114**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1823**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**10937**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**10937**	cubic feet	5 ft deep
	46.77	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	8.62	acres
Impervious Cover in Drainage Area =	6.73	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.65	

A_{CS} = cross-sectional area of flow in Swale =	24.39	sf
P_W = Wetted Perimeter =	74.28	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 72.17 feet

Q = CiA = 6.16 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.16 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	5.63
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	5.63
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

The resulting "Swale
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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and
the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or
across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.62		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.68	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.68	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	6060.88	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =		**Bexar**	
Total project area included in plan	* =	**10.14**	acres
Predevelopment impervious area within the limits of the plan	* =	**2.36**	acres
Total post-development impervious area within the limits of the plan	* =	**6.41**	acres
Total post-development impervious cover fraction	* =	**0.63**	
P =		**30**	inches
$L_{M\ TOTAL\ PROJECT}$ =		**3305**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **C**

Total drainage basin/outfall area =	**10.14**	acres
Predevelopment impervious area within drainage basin/outfall area =	**2.36**	acres
Post-development impervious area within drainage basin/outfall area =	**6.41**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.63**	
$L_{M\ THIS\ BASIN}$ =	**3305**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**10.14**	acres
A_I =	**6.41**	acres
A_P =	**3.73**	acres
L_R =	**5975**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **3305** lbs.

F = **0.55**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.49**	inches
Post Development Runoff Coefficient =	**0.44**	
On-site Water Quality Volume =	**7973**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1595**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**9567**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**9567**	cubic feet	5 ft deep
	43.74	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales — Designed as Required in RG-348 — Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.14	acres
Impervious Cover in Drainage Area =	6.41	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.59	

A_{CS} = cross-sectional area of flow in Swale =	26.00	sf
P_W = Wetted Perimeter =	79.10	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 76.99 feet

Q = CiA = 6.57 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.57 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	6.04
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	6.04
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

The resulting "Swale
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Click on solve.

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16. Vegetated Filter Strips — Designed as Required in RG-348 — Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults — Designed as Required in RG-348 — Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.46		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.50	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.50	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	5798.68	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar	
Total project area included in plan * =	7.55	acres
Predevelopment impervious area within the limits of the plan * =	1.71	acres
Total post-development impervious area within the limits of the plan * =	5.27	acres
Total post-development impervious cover fraction * =	**0.70**	
P =	**30**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**2902**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **D**

Total drainage basin/outfall area =	7.55	acres
Predevelopment impervious area within drainage basin/outfall area =	1.71	acres
Post-development impervious area within drainage basin/outfall area =	5.27	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.70**	
$L_{M\ THIS\ BASIN}$ =	**2902**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP =	Bioretention	
Removal efficiency =	**89**	percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	7.55	acres
A_I =	5.27	acres
A_P =	**2.29**	acres
L_R =	**4897**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ =	2902	lbs.
F =	**0.59**	

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.56**	inches
Post Development Runoff Coefficient =	**0.50**	
On-site Water Quality Volume =	**7720**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1544**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**9264**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**9264**	cubic feet	5 ft deep
	43.04	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	7.55	acres
Impervious Cover in Drainage Area =	5.27	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.62	

A_{CS} = cross-sectional area of flow in Swale =	20.24	sf
P_W = Wetted Perimeter =	61.84	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 59.73 feet

Q = CiA = 5.12 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 5.12 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.58
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.58
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

The resulting "Swale
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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.52	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.58 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.58	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	4752.83	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	6.99	acres	0.5
Predevelopment impervious area within the limits of the plan * =	2.60	acres	0.5
Total post-development impervious area within the limits of the plan * =	4.77	acres	0.5
Total post-development impervious cover fraction * =	**0.68**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**1774**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **E**

Total drainage basin/outfall area =	6.99	acres
Predevelopment impervious area within drainage basin/outfall area =	2.60	acres
Post-development impervious area within drainage basin/outfall area =	4.77	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.68**	
$L_{M\ THIS\ BASIN}$ =	**1774**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	6.99	acres
A_I =	4.77	acres
A_P =	**2.22**	acres
L_R =	**4439**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **1774** lbs.

F = **0.40**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.29**	inches
Post Development Runoff Coefficient =	**0.49**	
On-site Water Quality Volume =	**3619**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**724**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**4343**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**4343**	cubic feet	5	ft deep
	29.47	ft square	2	ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	6.99	acres
Impervious Cover in Drainage Area =	4.77	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.61	

A_{CS} = cross-sectional area of flow in Swale =	18.56	sf
P_W = Wetted Perimeter =	56.78	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 54.67 feet

Q = CiA = 4.69 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 4.69 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.15
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.15
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
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Click on solve.

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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.51		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.56	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.56	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	4307.83	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	6.38	acres	0.5
Predevelopment impervious area within the limits of the plan * =	1.69	acres	0.5
Total post-development impervious area within the limits of the plan * =	4.37	acres	0.5
Total post-development impervious cover fraction * =	**0.68**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**2183**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **F**

Total drainage basin/outfall area =	6.38	acres
Predevelopment impervious area within drainage basin/outfall area =	1.69	acres
Post-development impervious area within drainage basin/outfall area =	4.37	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.68**	
$L_{M\ THIS\ BASIN}$ =	**2183**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	6.38	acres
A_I =	4.37	acres
A_P =	**2.02**	acres
L_R =	**4062**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2183** lbs.

F = **0.54**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.47**	inches
Post Development Runoff Coefficient =	**0.49**	
On-site Water Quality Volume =	**5380**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1076**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**6457**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**6457**	cubic feet	5 ft deep
	35.93	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	6.38	acres
Impervious Cover in Drainage Area =	4.37	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.61	

A_{CS} = cross-sectional area of flow in Swale =	16.96	sf
P_W = Wetted Perimeter =	51.98	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 49.88 feet

Q = CiA = 4.29 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 4.29 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	3.75
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	3.75
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and
the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or
across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.51		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.56	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.56	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	3941.98	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	5.90	acres	0.5
Predevelopment impervious area within the limits of the plan * =	1.86	acres	0.5
Total post-development impervious area within the limits of the plan * =	4.38	acres	0.5
Total post-development impervious cover fraction * =	**0.74**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**2052**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **G**

Total drainage basin/outfall area =	5.90	acres
Predevelopment impervious area within drainage basin/outfall area =	1.86	acres
Post-development impervious area within drainage basin/outfall area =	4.38	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.74**	
$L_{M\ THIS\ BASIN}$ =	**2052**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	5.90	acres
A_I =	4.38	acres
A_P =	**1.52**	acres
L_R =	**4067**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2052** lbs.

F = **0.50**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.42**	inches
Post Development Runoff Coefficient =	**0.55**	
On-site Water Quality Volume =	**4978**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**996**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**5974**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**5974**	cubic feet	5 ft deep
	34.57	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	5.90	acres
Impervious Cover in Drainage Area =	4.38	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.63	

A_{CS} = cross-sectional area of flow in Swale =	16.29	sf
P_W = Wetted Perimeter =	49.97	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 47.86 feet

Q = CiA = 4.12 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 4.12 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	3.58
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	3.58
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.57	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.63 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.63	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	3946.94	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Bexar**	
Total project area included in plan * =	**22.93**	acres
Predevelopment impervious area within the limits of the plan * =	**6.97**	acres
Total post-development impervious area within the limits of the plan * =	**16.30**	acres
Total post-development impervious cover fraction * =	**0.71**	
P =	**30**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**7608**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **H**

Total drainage basin/outfall area =	**22.93**	acres
Predevelopment impervious area within drainage basin/outfall area =	**6.97**	acres
Post-development impervious area within drainage basin/outfall area =	**16.30**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.71**	
$L_{M\ THIS\ BASIN}$ =	**7608**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Aqualogic Cartridge Filter**
Removal efficiency = **95** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**22.93**	acres
A_I =	**16.30**	acres
A_P =	**6.63**	acres
L_R =	**16172**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **7608** lbs.

F = **0.47**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.38**	inches
Post Development Runoff Coefficient =	**0.52**	
On-site Water Quality Volume =	**16469**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**3294**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**19762**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**NA**	cubic feet	5 ft deep
	#VALUE!	ft square	3 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**19762**	cubic feet
Filter canisters (FCs) to treat WQV =	**45.48**	cartridges
Filter basin area (RIA_F) =	**90.96**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	22.93	acres
Impervious Cover in Drainage Area =	16.30	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.62	

A_{CS} = cross-sectional area of flow in Swale =	62.00	sf
P_W = Wetted Perimeter =	187.11	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 185.00 feet

Q = CiA = 15.67 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 15.67 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	15.14
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	15.14
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
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The required "Swale

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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.54	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.59 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.59	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	14703.48	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	7.66	acres	0.5
Predevelopment impervious area within the limits of the plan * =	2.00	acres	0.5
Total post-development impervious area within the limits of the plan * =	4.90	acres	0.5
Total post-development impervious cover fraction * =	**0.64**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**2367**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **I**

Total drainage basin/outfall area =	7.66	acres
Predevelopment impervious area within drainage basin/outfall area =	2.00	acres
Post-development impervious area within drainage basin/outfall area =	4.90	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.64**	
$L_{M\ THIS\ BASIN}$ =	**2367**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	7.66	acres
A_I =	4.90	acres
A_P =	**2.76**	acres
L_R =	**4568**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2367** lbs.

F = **0.52**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.45**	inches
Post Development Runoff Coefficient =	**0.45**	
On-site Water Quality Volume =	**5619**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1124**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**6743**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**6743**	cubic feet	5	ft deep
	36.72	ft square	2	ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	7.66	acres
Impervious Cover in Drainage Area =	4.90	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.59	

A_{CS} = cross-sectional area of flow in Swale =	19.74	sf
P_W = Wetted Perimeter =	60.34	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 58.23 feet

Q = CiA = 4.99 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 4.99 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.45
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.45
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
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Click on solve.

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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.46		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.51	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.51	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	4433.00	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar	
Total project area included in plan * =	10.21	acres
Predevelopment impervious area within the limits of the plan * =	3.51	acres
Total post-development impervious area within the limits of the plan * =	6.63	acres
Total post-development impervious cover fraction * =	0.65	
P =	30	inches
$L_{M\ TOTAL\ PROJECT}$ =	2542	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 1

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = J

Total drainage basin/outfall area =	10.21	acres
Predevelopment impervious area within drainage basin/outfall area =	3.51	acres
Post-development impervious area within drainage basin/outfall area =	6.63	acres
Post-development impervious fraction within drainage basin/outfall area =	0.65	
$L_{M\ THIS\ BASIN}$ =	2542	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = 89 percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	10.21	acres
A_I =	6.63	acres
A_P =	3.58	acres
L_R =	6175	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 2542 lbs.

F = 0.41

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.31**	inches
Post Development Runoff Coefficient =	**0.46**	
On-site Water Quality Volume =	**5188**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1038**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**6225**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**6225**	cubic feet	5 ft deep
	35.28	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.21	acres
Impervious Cover in Drainage Area =	6.63	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.60	

A_{CS} = cross-sectional area of flow in Swale =	26.48	sf
P_W = Wetted Perimeter =	80.56	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 78.45 feet

Q = CiA = 6.69 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.69 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	6.16
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	6.16
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.47		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.52	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.52	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	5993.08	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar	
Total project area included in plan * =	8.15	acres
Predevelopment impervious area within the limits of the plan * =	2.17	acres
Total post-development impervious area within the limits of the plan * =	4.89	acres
Total post-development impervious cover fraction * =	0.60	
P =	30	inches
$L_{M\ TOTAL\ PROJECT}$ =	2218	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 1

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = K

Total drainage basin/outfall area =	8.15	acres
Predevelopment impervious area within drainage basin/outfall area =	2.17	acres
Post-development impervious area within drainage basin/outfall area =	4.89	acres
Post-development impervious fraction within drainage basin/outfall area =	0.60	
$L_{M\ THIS\ BASIN}$ =	2218	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = 89 percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	8.15	acres
A_I =	4.89	acres
A_P =	3.26	acres
L_R =	4561	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 2218 lbs.

F = 0.49

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.41**	inches
Post Development Runoff Coefficient =	**0.42**	
On-site Water Quality Volume =	**5081**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1016**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**6098**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**6098**	cubic feet	5 ft deep
	34.92	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	8.15	acres
Impervious Cover in Drainage Area =	4.89	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.58	

A_{CS} = cross-sectional area of flow in Swale =	20.42	sf
P_W = Wetted Perimeter =	62.35	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 60.25 feet

Q = CiA = 5.16 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 5.16 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.62
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.62
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
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Click on solve.

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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.42	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.47 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.47	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	4426.08	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Bexar**		
Total project area included in plan * =	**10.97**	acres	0.5
Predevelopment impervious area within the limits of the plan * =	**2.20**	acres	0.5
Total post-development impervious area within the limits of the plan * =	**5.88**	acres	0.5
Total post-development impervious cover fraction * =	**0.54**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**3004**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **L**

Total drainage basin/outfall area =	**10.97**	acres
Predevelopment impervious area within drainage basin/outfall area =	**2.20**	acres
Post-development impervious area within drainage basin/outfall area =	**5.88**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.54**	
$L_{M\ THIS\ BASIN}$ =	**3004**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**10.97**	acres
A_I =	**5.88**	acres
A_P =	**5.09**	acres
L_R =	**5504**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **3004** lbs.

F = **0.55**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.49**	inches
Post Development Runoff Coefficient =	**0.38**	
On-site Water Quality Volume =	**7332**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1466**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**8799**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**8799**	cubic feet	5 ft deep
	41.95	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.97	acres
Impervious Cover in Drainage Area =	5.88	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.55	

A_{CS} = cross-sectional area of flow in Swale =	26.24	sf
P_W = Wetted Perimeter =	79.82	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 77.72 feet

Q = CiA = 6.63 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.63 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	6.10
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	6.10
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
The value in the "Se
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Click on solve.

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The value in the "Se
The value in the "By
Click on solve.

The resulting "Desig
If the resulting "Desi

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and
the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or
across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.36		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.40	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.40	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	5342.13	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	9.32	acres	0.5
Predevelopment impervious area within the limits of the plan * =	2.36	acres	0.5
Total post-development impervious area within the limits of the plan * =	5.31	acres	0.5
Total post-development impervious cover fraction * =	**0.57**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**2412**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **M**

Total drainage basin/outfall area =	9.32	acres
Predevelopment impervious area within drainage basin/outfall area =	2.36	acres
Post-development impervious area within drainage basin/outfall area =	5.31	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.57**	
$L_{M\ THIS\ BASIN}$ =	**2412**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	9.32	acres
A_I =	5.31	acres
A_P =	**4.01**	acres
L_R =	**4967**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2412** lbs.

F = **0.49**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.41**	inches
Post Development Runoff Coefficient =	**0.40**	
On-site Water Quality Volume =	**5531**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1106**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**6637**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**6637**	cubic feet	5	ft deep
	36.43	ft square	2	ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	9.32	acres
Impervious Cover in Drainage Area =	5.31	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.56	

A_{CS} = cross-sectional area of flow in Swale =	22.87	sf
P_W = Wetted Perimeter =	69.72	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 67.62 feet

Q = CiA = 5.78 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 5.78 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	5.25
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	5.25
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
The value in the "Se
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Click on solve.

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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and
the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or
across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.39	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.43 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.43	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	4820.79	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar	
Total project area included in plan * =	11.32	acres
Predevelopment impervious area within the limits of the plan * =	3.37	acres
Total post-development impervious area within the limits of the plan * =	7.23	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**30**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**3151**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **N**

Total drainage basin/outfall area =	11.32	acres
Predevelopment impervious area within drainage basin/outfall area =	3.37	acres
Post-development impervious area within drainage basin/outfall area =	7.23	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.64**	
$L_{M\ THIS\ BASIN}$ =	**3151**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP =	Bioretention	
Removal efficiency =	**89**	percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	11.32	acres
A_I =	7.23	acres
A_P =	**4.08**	acres
L_R =	**6740**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ =	3151	lbs.
F =	**0.47**	

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.38**	inches
Post Development Runoff Coefficient =	**0.45**	
On-site Water Quality Volume =	**7086**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1417**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**8504**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**8504**	cubic feet	5 ft deep
	41.24	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	11.32	acres
Impervious Cover in Drainage Area =	7.23	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.59	

A_{CS} = cross-sectional area of flow in Swale =	29.16	sf
P_W = Wetted Perimeter =	88.57	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 86.47 feet

Q = CiA = 7.37 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 7.37 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	6.83
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	6.83
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
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Click on solve.

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Click on solve.

The resulting "Desig
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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.46	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.51 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.51	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	6541.16	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Bexar**		
Total project area included in plan * =	**10.33**	acres	0.25
Predevelopment impervious area within the limits of the plan * =	**2.51**	acres	0.25
Total post-development impervious area within the limits of the plan * =	**6.25**	acres	0.25
Total post-development impervious cover fraction * =	**0.60**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**3046**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **O**

Total drainage basin/outfall area =	**10.33**	acres
Predevelopment impervious area within drainage basin/outfall area =	**2.51**	acres
Post-development impervious area within drainage basin/outfall area =	**6.25**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.60**	
$L_{M\ THIS\ BASIN}$ =	**3046**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**10.33**	acres
A_I =	**6.25**	acres
A_P =	**4.09**	acres
L_R =	**5830**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **3046** lbs.

F = **0.52**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.45**	inches
Post Development Runoff Coefficient =	**0.42**	
On-site Water Quality Volume =	**7119**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**1424**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**8542**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**8542**	cubic feet	5 ft deep
	41.33	ft square	4 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales — Designed as Required in RG-348 — Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.33	acres
Impervious Cover in Drainage Area =	6.25	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.58	

A_{CS} = cross-sectional area of flow in Swale =	25.99	sf
P_W = Wetted Perimeter =	79.06	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 76.96 feet

Q = CiA = 6.57 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.57 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	6.03
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	6.03
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
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Click on solve.

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Click on solve.

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16. Vegetated Filter Strips — Designed as Required in RG-348 — Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults — Designed as Required in RG-348 — Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.43		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.47	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.47	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	5657.73	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	7.81	acres	0.5
Predevelopment impervious area within the limits of the plan * =	2.05	acres	0.5
Total post-development impervious area within the limits of the plan * =	4.10	acres	0.5
Total post-development impervious cover fraction * =	0.53		
P =	30	inches	
$L_{M\ TOTAL\ PROJECT}$ =	1678	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **P**

Total drainage basin/outfall area =	7.81	acres
Predevelopment impervious area within drainage basin/outfall area =	2.05	acres
Post-development impervious area within drainage basin/outfall area =	4.10	acres
Post-development impervious fraction within drainage basin/outfall area =	0.53	
$L_{M\ THIS\ BASIN}$ =	1678	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	7.81	acres
A_I =	4.10	acres
A_P =	3.71	acres
L_R =	3843	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **1678** lbs.

F = **0.44**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.34**	inches
Post Development Runoff Coefficient =	**0.37**	
On-site Water Quality Volume =	**3626**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**725**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**4351**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**4351**	cubic feet	5 ft deep
	29.50	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	7.81	acres
Impervious Cover in Drainage Area =	4.10	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.55	

A_{CS} = cross-sectional area of flow in Swale =	18.53	sf
P_W = Wetted Perimeter =	56.71	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 54.60 feet

Q = CiA = 4.68 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 4.68 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.15
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.15
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

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Click on solve.

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The value in the "Se
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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.35	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.39 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.39	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	3730.04	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	7.47	acres	0.33
Predevelopment impervious area within the limits of the plan * =	1.66	acres	0.33
Total post-development impervious area within the limits of the plan * =	4.22	acres	0.33
Total post-development impervious cover fraction * =	**0.56**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**2090**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Q**

Total drainage basin/outfall area =	7.47	acres
Predevelopment impervious area within drainage basin/outfall area =	1.66	acres
Post-development impervious area within drainage basin/outfall area =	4.22	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.56**	
$L_{M\ THIS\ BASIN}$ =	**2090**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	7.47	acres
A_I =	4.22	acres
A_P =	**3.25**	acres
L_R =	**3944**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2090** lbs.

F = **0.53**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.46**	inches
Post Development Runoff Coefficient =	**0.40**	
On-site Water Quality Volume =	**4951**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**990**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**5942**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**5942**	cubic feet	5	ft deep
	34.47	ft square	3	ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	7.47	acres
Impervious Cover in Drainage Area =	4.22	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.56	

A_{CS} = cross-sectional area of flow in Swale =	18.25	sf
P_W = Wetted Perimeter =	55.87	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 53.76 feet

Q = CiA = 4.61 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 4.61 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.08
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.08
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.39	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.43 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.43	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	3827.49	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	10.91	acres	0.5
Predevelopment impervious area within the limits of the plan * =	4.26	acres	0.5
Total post-development impervious area within the limits of the plan * =	6.49	acres	0.5
Total post-development impervious cover fraction * =	0.59		
P =	30	inches	
$L_{M\ TOTAL\ PROJECT}$ =	1814	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 1

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = R

Total drainage basin/outfall area =	10.91	acres
Predevelopment impervious area within drainage basin/outfall area =	4.26	acres
Post-development impervious area within drainage basin/outfall area =	6.49	acres
Post-development impervious fraction within drainage basin/outfall area =	0.59	
$L_{M\ THIS\ BASIN}$ =	1814	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = 89 percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	10.91	acres
A_I =	6.49	acres
A_P =	4.42	acres
L_R =	6057	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 1814 lbs.

F = 0.30

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.19**	inches
Post Development Runoff Coefficient =	**0.42**	
On-site Water Quality Volume =	**3161**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**632**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**3793**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**3793**	cubic feet	5	ft deep
	27.54	ft square	2	ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.91	acres
Impervious Cover in Drainage Area =	6.49	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.57	

A_{CS} = cross-sectional area of flow in Swale =	27.24	sf
P_W = Wetted Perimeter =	82.82	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 80.72 feet

Q = CiA = 6.88 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.88 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	6.35
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	6.35
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

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Then click on "Tools
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Click on solve.

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The value in the "Se
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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.42		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.46	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.46	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	5878.17	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	9.93	acres	0.5
Predevelopment impervious area within the limits of the plan * =	4.77	acres	0.5
Total post-development impervious area within the limits of the plan * =	5.89	acres	0.5
Total post-development impervious cover fraction * =	0.59		
P =	30	inches	
$L_{M\ TOTAL\ PROJECT}$ =	918	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 1

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = S

Total drainage basin/outfall area =	9.93	acres
Predevelopment impervious area within drainage basin/outfall area =	4.77	acres
Post-development impervious area within drainage basin/outfall area =	5.89	acres
Post-development impervious fraction within drainage basin/outfall area =	0.59	
$L_{M\ THIS\ BASIN}$ =	918	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = 89 percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	9.93	acres
A_I =	5.89	acres
A_P =	4.04	acres
L_R =	5503	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 918 lbs.

F = 0.17

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.09**	inches
Post Development Runoff Coefficient =	**0.42**	
On-site Water Quality Volume =	**1408**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**282**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**1690**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**1690**	cubic feet	5 ft deep
	18.39	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales — Designed as Required in RG-348 — Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	9.93	acres
Impervious Cover in Drainage Area =	5.89	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.57	

A_{CS} = cross-sectional area of flow in Swale =	24.78	sf
P_W = Wetted Perimeter =	75.45	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 73.34 feet

Q = CiA = 6.26 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.26 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	5.73
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	5.73
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
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Click on solve.

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16. Vegetated Filter Strips — Designed as Required in RG-348 — Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults — Designed as Required in RG-348 — Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.42		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.46	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.46	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	5340.39	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Bexar**		
Total project area included in plan * =	**6.46**	acres	0.5
Predevelopment impervious area within the limits of the plan * =	**2.30**	acres	0.5
Total post-development impervious area within the limits of the plan * =	**3.09**	acres	0.5
Total post-development impervious cover fraction * =	**0.48**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**648**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **T**

Total drainage basin/outfall area =	**6.46**	acres
Predevelopment impervious area within drainage basin/outfall area =	**2.30**	acres
Post-development impervious area within drainage basin/outfall area =	**3.09**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.48**	
$L_{M\ THIS\ BASIN}$ =	**648**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Vegetated Filter Strips**
Removal efficiency = **85** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**6.46**	acres
A_I =	**3.09**	acres
A_P =	**3.37**	acres
L_R =	**2772**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **648** lbs.

F = **0.23**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.14**	inches
Post Development Runoff Coefficient =	**0.35**	
On-site Water Quality Volume =	**1100**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**220**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**1320**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**NA**	cubic feet	5 ft deep
	#VALUE!	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales — Designed as Required in RG-348 — Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	6.46	acres
Impervious Cover in Drainage Area =	3.09	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.53	

A_{CS} = cross-sectional area of flow in Swale =	14.79	sf
P_W = Wetted Perimeter =	45.47	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 43.36 feet

Q = CiA = 3.74 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 3.74 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	3.20
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	3.20
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
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The required "Swale

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Then click on "Tools
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Click on solve.

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Click on solve.

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16. Vegetated Filter Strips — Designed as Required in RG-348 — Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults — Designed as Required in RG-348 — Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.31		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.34	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.34	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	2816.91	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar		
Total project area included in plan * =	9.05	acres	0.5
Predevelopment impervious area within the limits of the plan * =	2.22	acres	0.5
Total post-development impervious area within the limits of the plan * =	4.14	acres	0.5
Total post-development impervious cover fraction * =	**0.46**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**1570**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **U**

Total drainage basin/outfall area =	9.05	acres
Predevelopment impervious area within drainage basin/outfall area =	2.22	acres
Post-development impervious area within drainage basin/outfall area =	4.14	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.46**	
$L_{M\ THIS\ BASIN}$ =	**1570**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	9.05	acres
A_I =	4.14	acres
A_P =	**4.91**	acres
L_R =	**3896**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **1570** lbs.

F = **0.40**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.29**	inches
Post Development Runoff Coefficient =	**0.34**	
On-site Water Quality Volume =	**3214**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**643**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**3857**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**3857**	cubic feet	5 ft deep
	27.77	ft square	2 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	9.05	acres
Impervious Cover in Drainage Area =	4.14	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.52	

A_{CS} = cross-sectional area of flow in Swale =	20.38	sf
P_W = Wetted Perimeter =	62.25	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 60.15 feet

Q = CiA = 5.15 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 5.15 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	4.62
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	4.62
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
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Click on solve.

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16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.29		**C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03**
i = design rainfall intensity =	1.1	in/hour	
A = drainage area in acres =	1	acres	
Q = flow rate in cubic feet per second =	0.32	cubic feet/sec	

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.32	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	3780.97	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	Bexar	
Total project area included in plan * =	10.58	acres
Predevelopment impervious area within the limits of the plan * =	4.20	acres
Total post-development impervious area within the limits of the plan * =	5.15	acres
Total post-development impervious cover fraction * =	0.49	
P =	30	inches
$L_{M\ TOTAL\ PROJECT}$ =	772	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 1

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = V

Total drainage basin/outfall area =	10.58	acres
Predevelopment impervious area within drainage basin/outfall area =	4.20	acres
Post-development impervious area within drainage basin/outfall area =	5.15	acres
Post-development impervious fraction within drainage basin/outfall area =	0.49	
$L_{M\ THIS\ BASIN}$ =	772	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = 89 percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	10.58	acres
A_I =	5.15	acres
A_P =	5.43	acres
L_R =	4832	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 772 lbs.

F = 0.16

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.09**	inches
Post Development Runoff Coefficient =	**0.35**	
On-site Water Quality Volume =	**1183**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**237**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**1420**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**1420**	cubic feet	5 ft deep
	16.85	ft square	

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales — Designed as Required in RG-348 — Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.58	acres
Impervious Cover in Drainage Area =	5.15	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.53	
A_{CS} = cross-sectional area of flow in Swale =	24.38	sf
P_W = Wetted Perimeter =	74.24	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 72.13 feet

Q = CiA = 6.16 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 6.16 cfs

Manning's Equation Q = 0.54 cfs — Error 1 = 5.63
Swale Width= 6.00 ft

Instructions are provided to the right (green comments).

Flow Velocity 0.25 ft/s
Minimum Length = 75.83 ft

Instructions are provided to the right (blue comments).

Design Width = 6 ft
Design Discharge = 0.54 cfs — Error 2 = 5.63
Design Depth = 0.33 ft
Flow Velocity = 0.23 cfs
Minimum Length = 68.93 ft

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

The resulting "Swale
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Then proceed as ins

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The value in the "Se
The value in the "By
Click on solve.

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First set the desired
Highlight Cell F232.
Click on "Tools" and
The value in the "Se
The value in the "By
Click on solve.

The resulting "Desig
If the resulting "Desi

16. Vegetated Filter Strips — Designed as Required in RG-348 — Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults — Designed as Required in RG-348 — Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.32	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres
Q = flow rate in cubic feet per second =	0.35	cubic feet/sec

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.35	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	4689.71	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **281 EIS**
Date Prepared: **5/12/2014**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Bexar**		
Total project area included in plan * =	**10.70**	acres	0.33
Predevelopment impervious area within the limits of the plan * =	**2.48**	acres	0.33
Total post-development impervious area within the limits of the plan * =	**4.29**	acres	0.33
Total post-development impervious cover fraction * =	**0.40**		
P =	**30**	inches	
$L_{M\ TOTAL\ PROJECT}$ =	**1474**	lbs.	

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **W**

Total drainage basin/outfall area =	**10.70**	acres
Predevelopment impervious area within drainage basin/outfall area =	**2.48**	acres
Post-development impervious area within drainage basin/outfall area =	**4.29**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.40**	
$L_{M\ THIS\ BASIN}$ =	**1474**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Vegetated Filter Strips**
Removal efficiency = **85** percent

Aqualogic Cartridge Filter
Bioretention
Contech StormFilter
Constructed Wetland
Extended Detention
Grassy Swale
Retention / Irrigation
Sand Filter
Stormceptor
Vegetated Filter Strips
Vortechs
Wet Basin
Wet Vault

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**10.70**	acres
A_I =	**4.29**	acres
A_P =	**6.41**	acres
L_R =	**3869**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **1474** lbs.

F = **0.38**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348 Pages 3-34 to 3-36

Rainfall Depth =	**0.27**	inches
Post Development Runoff Coefficient =	**0.31**	
On-site Water Quality Volume =	**3173**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**635**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**3807**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

7. Retention/Irrigation System Designed as Required in RG-348 Pages 3-42 to 3-46

Required Water Quality Volume for retention basin =	**NA**	cubic feet

Irrigation Area Calculations:

Soil infiltration/permeability rate =	**0.1**	in/hr	**Enter determined permeability rate or assumed value of 0.1**
Irrigation area =	**NA**	square feet	
	NA	acres	

8. Extended Detention Basin System Designed as Required in RG-348 Pages 3-46 to 3-51

Required Water Quality Volume for extended detention basin =	**NA**	cubic feet

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins =	**NA**	cubic feet	
Minimum filter basin area =	**NA**	square feet	
Maximum sedimentation basin area =	**NA**	square feet	**For minimum water depth of 2 feet**
Minimum sedimentation basin area =	**NA**	square feet	**For maximum water depth of 8 feet**

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin =	**NA**	cubic feet	5 ft deep
	#VALUE!	ft square	3 ponds

11. Wet Basins Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**NA**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**NA**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

12. Constructed Wetlands Designed as Required in RG-348 Pages 3-71 to 3-73

Required Water Quality Volume for Constructed Wetlands =	**NA**	cubic feet

13. AquaLogic™ Cartridge System Designed as Required in RG-348 Pages 3-74 to 3-78

**** 2005 Technical Guidance Manual (RG-348) does not exempt the required 20% increase with maintenance contract with AquaLogic™.**

Required Sedimentation chamber capacity =	**NA**	cubic feet
Filter canisters (FCs) to treat WQV =	**NA**	cartridges
Filter basin area (RIA_F) =	**NA**	square feet

14. Stormwater Management StormFilter® by CONTECH

Required Water Quality Volume for Contech StormFilter System =	**NA**	cubic feet

THE SIZING REQUIREMENTS FOR THE FOLLOWING BMPs / LOAD REMOVALS ARE BASED UPON FLOW RATES - NOT CALCULATED WATER QUALITY VOLUME

15. Grassy Swales Designed as Required in RG-348 Pages 3-51 to 3-54

Design parameters for the swale:

Drainage Area to be Treated by the Swale = A =	10.70	acres
Impervious Cover in Drainage Area =	4.29	acres
Rainfall intensity = i =	1.1	in/hr
Swale Slope =	0.005	ft/ft
Side Slope (z) =	3	
Design Water Depth = y =	0.33	ft
Weighted Runoff Coefficient = C =	0.49	

A_{CS} = cross-sectional area of flow in Swale =	23.01	sf
P_W = Wetted Perimeter =	70.13	feet
R_H = hydraulic radius of flow cross-section = A_{CS}/P_W =	0.33	feet
n = Manning's roughness coefficient =	0.2	

15A. Using the Method Described in the RG-348

Manning's Equation: $Q = \frac{1.49}{n} A_{CS} R_H^{2/3} S^{0.5}$

$b = \frac{0.134 \times Q}{y^{1.67} S^{0.5}} - zy$ = 68.02 feet

Q = CiA = 5.82 cfs

To calculate the flow velocity in the swale:

V (Velocity of Flow in the swale) = Q/A_{CS} = 0.25 ft/sec

To calculate the resulting swale length:

L = Minimum Swale Length = V (ft/sec) * 300 (sec) = 75.83 feet

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters must be modified and the solver rerun.

15B. Alternative Method using Excel Solver

Design Q = CiA = 5.82 cfs

Manning's Equation Q =	0.54	cfs	Error 1 =	5.28
Swale Width=	6.00	ft		

Instructions are provided to the right (green comments).

Flow Velocity	0.25	ft/s
Minimum Length =	75.83	ft

Instructions are provided to the right (blue comments).

Design Width =	6	ft		
Design Discharge =	0.54	cfs	Error 2 =	5.28
Design Depth =	0.33	ft		
Flow Velocity =	0.23	cfs		
Minimum Length =	68.93	ft		

If any of the resulting values do not meet the design requirement set forth in RG-348, the design parameters may be modified and the solver rerun.
If any of the resulting values still do not meet the design requirement set forth in RG-348, widening the swale bottom value may not be possible.

To solve for bottom
Excel can simultane
The required "Swale

First, highlight Cell F
Then click on "Tools
The value in the "Se
The value in the "By
Click on solve.

The resulting "Swale
If the resulting "Swa

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Click on "Tools" and
Then proceed as ins

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The required "Desig

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Highlight Cell F232.

Click on "Tools" and
The value in the "Se
The value in the "By
Click on solve.

The resulting "Desig
If the resulting "Desi
First set the desired
Highlight Cell F232.
Click on "Tools" and
The value in the "Se
The value in the "By
Click on solve.

The resulting "Desig
If the resulting "Desi

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

17. Wet Vaults Designed as Required in RG-348 Pages 3-30 to 3-32 & 3-79

Required Load Removal Based upon Equation 3.3 = **NA** lbs

First calculate the load removal at 1.1 in/hour

RG-348 Page 3-30 Equation 3.4: Q = CiA

C = runoff coefficient for the drainage area =	0.25	
i = design rainfall intensity =	1.1	in/hour
A = drainage area in acres =	1	acres

C = Runoff Coefficient = 0.546 $(IC)^2$ + 0.328 (IC) + 0.03

Q = flow rate in cubic feet per second = 0.27 cubic feet/sec

RG-348 Page 3-31 Equation 3.5: $V_{OR} = Q/A$

Q = Runoff rate calculated above =	0.27	cubic feet/sec
A = Water surface area in the wet vault =	150	square feet

V_{OR} = Overflow Rate =	0.00	feet/sec
Percent TSS Removal from Figure 3-1 (RG-348 Page 3-31) =	53	percent
Load removed by Wet Vault =	#VALUE!	lbs

If a bypass occurs at a rainfall intensity of less than 1.1 in/hours
Calculate the efficiency reduction for the actual rainfall intensity rate

Actual Rainfall Intensity at which Wet Vault bypass Occurs =	0.5	in/hour
Fraction of rainfall treated from Figure 3-2 RG-348 Page 3-32 =	0.75	percent
Efficiency Reduction for Actual Rainfall Intensity =	0.83	percent
Resultant TSS Load removed by Wet Vault =	#VALUE!	lbs

18. Permeable Concrete Designed as Required in RG-348 Pages 3-79 to 3-83

PERMEABLE CONCRETE MAY ONLY BE USED ON THE CONTRIBUTING ZONE

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =	86.38	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	75.00	percent	
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	70.00	percent	
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =	3931.75	lbs

20. Stormceptor

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if multiple values provided in Calculated Model Size or if you are choosing a larger model size) =	0	Model Size
Surface Area =	#N/A	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	

21. Vortech

Required TSS Removal in BMP Drainage Area=	**NA**	lbs
Impervious Cover Overtreatment=	0.0000	ac
TSS Removal for Uncaptured Area =	0.00	lbs
BMP Sizing		
Effective Area =	NA	EA
Calculated Model Size(s) =	#N/A	
Actual Model Size (if choosing larger model size) =	Vx1000	Pick Model Size
Surface Area =	7.10	ft^2
Overflow Rate =	#VALUE!	V_{or}
Rounded Overflow Rate =	#VALUE!	V_{or}
BMP Efficiency % =	#VALUE!	%
L_R Value =	#VALUE!	lbs
TSS Load Credit =	#VALUE!	lbs
Is Sufficient Treatment Available? (TSS Credit $\geq$ TSS Uncapt.)	#VALUE!	
TSS Treatment by BMP (LM + TSS Uncapt.) =	#VALUE!	