Final Drainage Report
Cottonwood Creek Stormwater Detention Basin
and
Tutt Boulevard Extension
Capital Improvement Project

Colorado Springs, Colorado

Prepared for:
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October 22, 2019

Capital Project Drainage Report

Signature Page

Cottonwood Creek Stormwater Detention Basin and Tutt Boulevard Extension

Engineer's Statement

This report and plan for the drainage design of the Cottonwood Creek Stormwater Detention Basin and Tutt Boulevard Extension Project was prepared by me (or under my direct supervision) and is correct to the best of my knowledge and belief. Said report and plan has been prepared in accordance with the City of Colorado Springs Drainage Criteria Manual and is in conformity with the master plan of the drainage basin. I understand that the City of Colorado Springs does not and will not assume liability for drainage facilities designed by others. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

SIGNATURE ________ 10/22/19 Date

Colorado P.E. No 19310

City Project Manager's Statement

I hereby certify that the drainage for the Cottonwood Creek Stormwater Detention Basin and Tutt Boulevard Extension Project will be constructed according to the design presented in this report. I further understand that field changes must be reviewed by the City Review Engineer to ensure conformance with the original design intent. I am employed by and perform engineering services solely for the City of Colorado Springs, and therefore am exempt from Colorado Revised Statute Title 12, Article 25, Part 1 according to § 12-25-103(1), C.R.S.

Name of City Project Manager JEFF DUNN

Authorized Signature ________ Date 11/19/19

City of Colorado Springs Statement:

Filed in accordance with Section 7.7.906 of the Code of the City of Colorado Springs, 2001, as amended.

________ 2/21/2020

For City Engineer **Date**

Conditions:

I. General Location and Description of Project

The Cottonwood Creek Stormwater Detention Basin and Tutt Boulevard Extension project has been proposed by the City of Colorado Spring Water Resources Engineering Division (WRED). The purpose of the project is to provide 100-year flood detention storage for Cottonwood Creek and to provide the and water quality treatment for the portion of Tutt Boulevard subject to extension. For Cottonwood Creek the project will involve the installation of a 14-foot by 8-foot box culvert to carry runoff under Tutt Boulevard, two drop structures upstream of the embankment, a pedestrian underpass and attendant grading and revegetation. The extension of Tutt Boulevard will involve the construction of two traffic lanes that will begin at the present intersection of Tutt Boulevard and "new" Cowpoke Road, north to "old" Cowpoke Road. A water quality BMP will be constructed to detain and treat runoff from the roadway before discharging to the Cottonwood Creek drainageway upstream of Tutt Boulevard. The improvements to the roadway and drainageway will all be constructed on present or future City owned land and right-of-way. Because the flood storage is created by a publicly operated and maintained roadway, the embankment is exempted from review by the Office of the State Engineer, Dam Safety Branch as described in the *Rules and Regulations for Dam Safety and Dam Construction*.

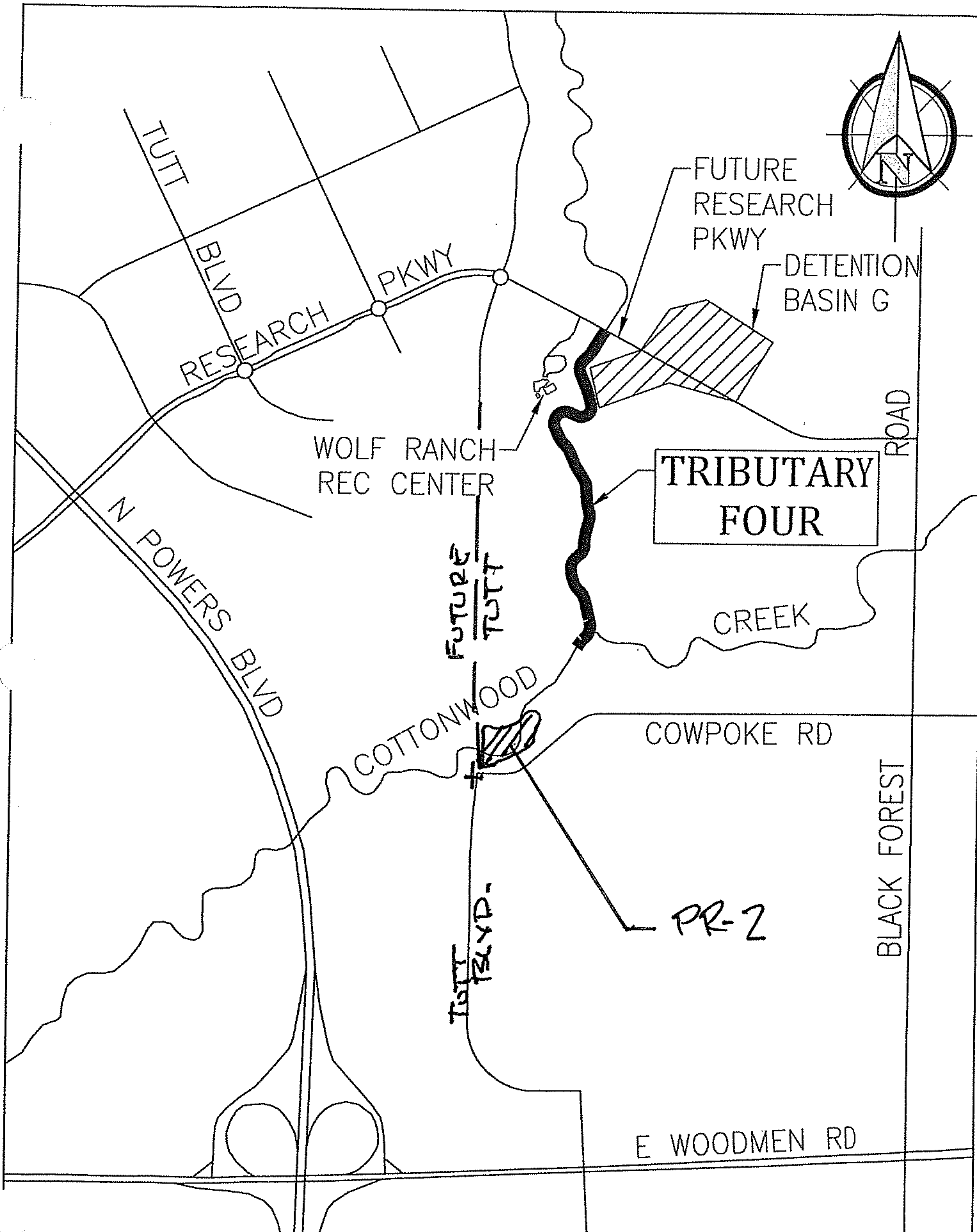
The location of the site is presented on Figure 1. Photographs that show the condition of the drainageway in October 2017 are contained within Appendix A.

The Cottonwood Creek Stormwater Detention is one of several identified in the inter-governmental agreement (IGA) between the City of Colorado Springs and Pueblo County. The facility is to provide detention of stormwater only. The facility will not provide water quality storage, nor will it be designed to operate as a full spectrum detention (FSD), basin. The site has been selected to take advantage of the proposed roadway embankment that must be constructed to extend Tutt Boulevard from its present terminus just south of Cottonwood Creek, north into Wolf Ranch. The land needed for the embankment as well as the storage area currently lies within the City of Colorado Springs and El Paso County.

II. Criteria and References

The following references were reviewed as part of conducting the hydrologic analysis and in the layout of the detention basin storage area and appurtenances.

1. NRCS Soil Survey for El Paso County, Colorado.
2. City of Colorado Springs Drainage Criteria Manual, Volumes 1 and 2, prepared by City of Colorado Springs, dated April 2014, with most current clarifications.
3. Rules and Regulations for Dam Safety and Dam Construction, State of Colorado Department of Natural Resources Division of Water Resources Office of the State Engineer Dam Safety Branch dated January 1, 2007.



VICINITY MAP

SCALE: NTS

FIG.1

5. HEC-1 Flood Hydrograph Package User's Manual prepared by US Army Corps of Engineers Hydrologic Engineering Center dated June 1998.
6. Cottonwood Creek Drainage Basin Planning Study prepared by Matrix Design Group, March 2019.
7. Cottonwood Creek Drainage Basin Planning Study Evaluation of PR-2 (Tutt Pond) IGA Detention Facility, prepared by Matrix Design Group, August 2017.
8. Colorado Springs Department of Utilities FIMS topographic mapping and utility maps.
9. Cottonwood Creek PR2 and Tutt Boulevard Extension Conditional Letter of Map Revision, Case no. 18-08-1091P, May 2019.

III. Existing Watershed Conditions

The portion of the Cottonwood Creek watershed tributary to the facility covers 6.06 square miles. The predominant present and future land use is single-family. Land within Wolf Ranch that will outfall to the facility is proposed as residential on lots ranging in size from 6,000 to 8,000 square feet. Upstream of Black Forest Road the land use is rural residential with lots ranging in size from 2.5 to 5-acres. In the uppermost portion of the watershed 5-acre and 10-acre rural residential lots are located. At this time the watershed is approximately 85 percent developed.

IV. Major Drainageway Hydrology

The hydrology used in the design of the Cottonwood Creek PR-2 detention basin was obtained from Reference 5. Peak discharges for the existing and future development conditions were determined using Reference 4. The hydrograph model was compiled using the curve number loss method. The following hydrologic parameters were developed in Reference 5 to assess the required inflow and outflow discharges to guide the design.

1. The land use within the watershed when fully developed will result in a percent imperviousness value of 16 percent. This value has been applied in the development of the curve numbers that were input to the HEC-1 routing model.
2. An antecedent moisture condition of II (saturated), was assumed when evaluating the NRCS curve number.
3. Due to the size of the watershed, the "dominant" storm was assumed to be the 24-hour duration storm and was applied in Reference 2.
4. The rainfall depth used for input to the HEC-1 model was obtained from NOAA Atlas 3. The 24-hour rainfall depth for the 100-year recurrence interval is 4.4 inches.
5. The Type II rainfall distribution applied was obtained from Reference 2. The 24-hour design storm temporal distribution input to the HEC-1 model.

Provided within Appendix A are the tabular hydrographs for the Cottonwood Creek watershed at Tutt Boulevard as determined in Reference 5 and 6 for the 10-, 50- 100- and 500-year recurrence intervals. The hydrographs for the above recurrence interval was input to HEC-1 to develop a model that could be used to rout a hydrograph through PR-2 for the purposes of design. A match between the results listed in Reference 6 and this design effort was obtained. The input and output for the HEC-1 model to be used in the design of PR-2 is contained within Appendix A. The watershed map from Reference 5 is contained within Appendix B.

The design discharges for the project are as follows:

	10yr	50yr	100yr	500yr
		(cubic feet per second)		
Inflow	971	1945	2379	3576
Outflow	959	1808	2079	2600

Based upon the results above, a 13 percent reduction in the 100-year peak discharge will be affected due to the incidental flood storage that is created by the Tutt Boulevard embankment.

V. Major Drainageway Hydraulics

The hydraulic calculations focused on determining the outlet culvert through the embankment and the design of the Cottonwood Creek drainageway upstream of the detention basin's storage pool.

Outlet culvert: Contained in Appendix D are the hydraulic calculations for the outlet culvert proposed for the project. During the alternative analysis various sizes of principal outlet structures were hydraulically analyzed. The Urban Drainage and Flood Control District (UDFCD) Culvert Rating spreadsheet was used to develop discharge curves for each alternative structure for input to the HEC-1 hydrology model.

6-foot (rise) by 12-foot (span) CBC
6-foot (rise) by 14-foot (span) CBC
8-foot (rise) by 14-foot (span) CBC
11-foot diameter RCP
2- 8-foot diameter RCPs

As a result of the alternate analysis the 8-foot high by 14-foot wide concrete box culvert was selected. The Federal Highways Administration (FHWA) HY-8 culvert analysis program was used to rate the selected culvert. The HY-8 input and output are contained within Appendix D. The results from the HEC-RAS model for the proposed condition as presented in the CLOMR (Reference 9) for this project was used to determine the hydraulic grade line and velocities for the purpose of design. The CBC will operate in an inlet control condition and therefore the hydraulic grade line at the entrance to the CBC is determined by the size of the opening and the headwater depth.

The geometry of the box culvert was chosen to meet the Colorado Department of Transportation M-standards for a single box culvert. The M-standard details for a single-bay box culvert have been included within Appendix D. The selected box culvert can be either cast-in-place or precast. Based upon the analysis, the 8-foot by 14-foot CBC can maintain the 100-year HGL 1.5 feet below the trail elevation at the entrance to the proposed pedestrian underpass.

Cottonwood Creek Drainageway: Contained in Appendix D are the hydraulic calculations for the drainageway measure to be completed as part of the detention basin and roadway extension. Two hydraulic conditions were analyzed: (1) storage pool empty with 100-year discharge coming into the facility; and (2) storage pool. For case 1, normal depth calculations were carried out using UDFCD channel design spreadsheets. From these calculations the riprap bank lining material and the drop crest geometry were determined. The drops were designed to contain the 100-year design inflow within the crest of the drop. The design slope of the drainageway upstream of the box culvert was set at 0.5%. Using this the design slope and average velocities for the 100-year recurrence interval ranged from 9.1 to 12.9 feet per second. Using the methods outlined in the UDFCD DCM Chapter 8, Type L (D50=9-inches), soil riprap is required.

For case 2 a HEC-RAS model was developed to determine the 100-year hydraulic grade line assuming the storage area was full. Contained within Appendix D is the HEC-RAS flood profile summary. Also contained in Appendix D is the CLOMR work map for the proposed condition. For case 2 the backwater from the storage pool at full depth would cause the drops to become submerged.

Under normal flow conditions (storage pool is empty), the inflow channel has 100-year velocities that range from 6 feet per second between and upstream of the proposed drops, to 12 feet per second at the crest of the drops. The CBC 100-year outlet velocity is estimated at 16.4 feet per second using the HEC-RAS model results. Velocity at the terminus of the project is estimated at 3.4 feet per second

VI. Floodplains

According to the Federal Emergency Management Agency (FEMA), the site does lie within a designated floodplain. The Floodplain Insurance Rate Map (FIRM) for the City of Colorado Springs panel 529G effective December 7, 2018 was reviewed to determine any potential floodplain delineation. Provided on Figure 2 is the firmette for the project area. Since the work as proposed will occur within a regulatory floodway, a CLOMR was required. Work maps and HEC-RAS hydraulic summary provided to FEMA for review as part of the CLOMR are included within Appendix D. The CLOMR was approved in May 2019 and the determination letter has been included within Appendix D. A Letter of Map Revision (LOMR), is required and will be provided to FEMA once the as-built condition of the project is surveyed and the floodplains determined.

VII. Tutt Boulevard Drainage

Contained within Appendix E is the roadway drainage report prepared for the Tutt Boulevard Extension. The roadway drainage report was used to determine the sizes of the proposed curb inlets required at the intersection with "new" Cowpoke Road. The roadway drainage report was used in the design of the proposed water quality basin located at the northeast corner of New Cowpoke Road and future Tutt Boulevard that will store and treat runoff from generated by the public roadway. Runoff from the roadway will be picked up by inlets located at the south end of proposed Tutt Boulevard. Runoff collected by the inlets will be conveyed via a storm sewer to a forebay. The forebay will discharge to a concrete trickle channel that will convey low flow to the proposed outlet structure. The outlet structure will be fitted with a trash rack and a perforated plate that will control the discharge of the stored runoff at the prescribed release rates. The flow emerging from the perforated plate side of the outlet structure will discharge to the proposed 54-inch RCP. The 54-inch RCP will then discharge to the flood storage pool at the location shown on the design plans. The water quality basin lies above and outside the 100-year base flood elevation at this point along Cottonwood Creek.

VIII. Four Step Process

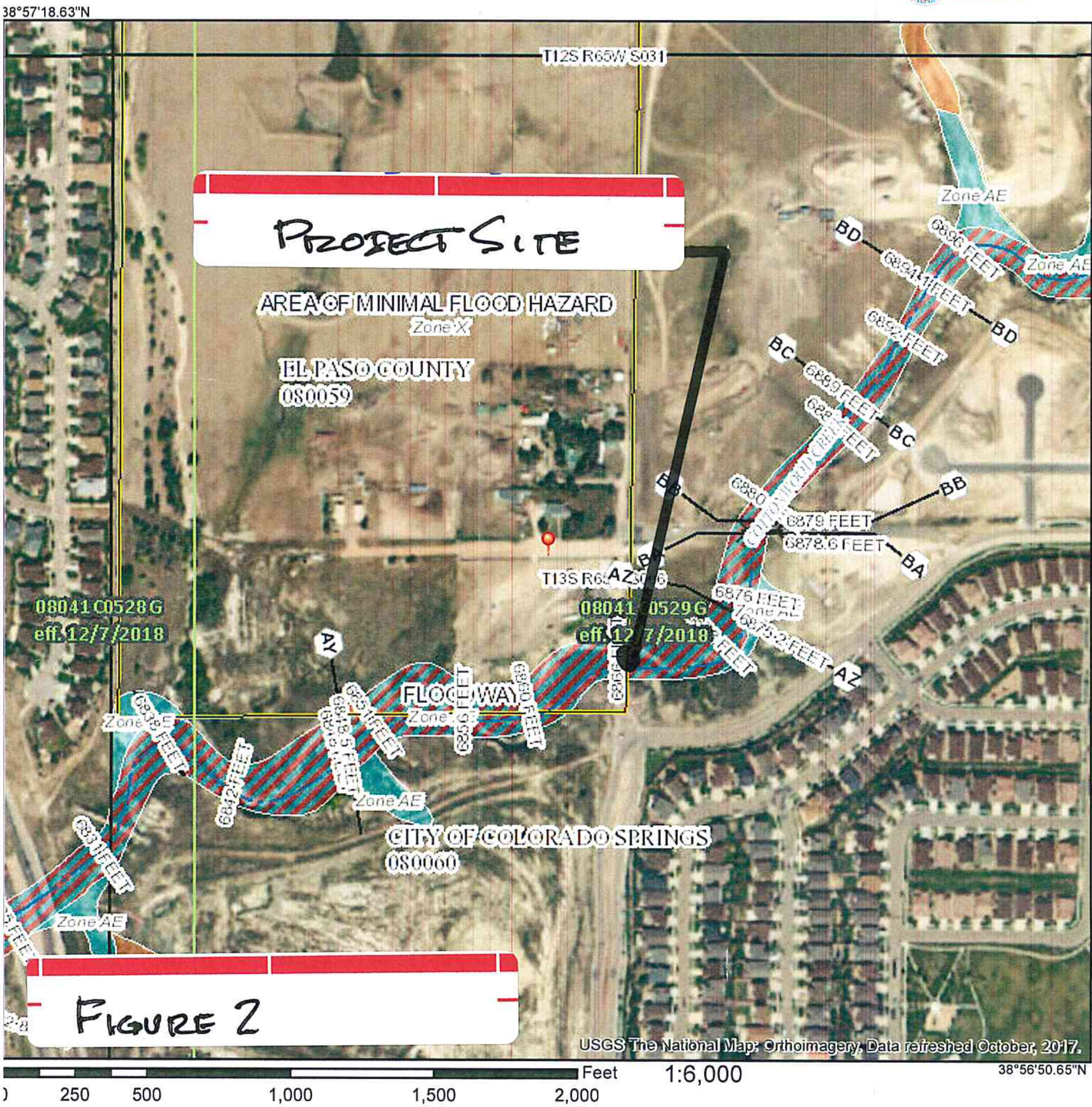
The construction of the detention basin outlet and storage area, and the drainageway improvements for Cottonwood Creek will disturb approximately 10.6 acres within an overall project site of 13.5 acres. Area of the drainageway improvements measured to the top of the proposed banks is estimated at 4.5 acres. All disturbed areas outside of the drainageway will be stabilized with native grasses.

Because of the extent of the disturbance the Four Step process was followed. The Four Step Process is a requirement of the City of Colorado Springs for any construction activity that has disturbance of more than one acre.

Step One-Runoff Reduction: The existing condition of the drainageway is one of steep eroded banks and an invert that flows on native bedrock. The proposed drainageway improvements will raise the invert well above the bedrock. The invert will be restored using

National Flood Hazard Layer FIRMette

FEMA



Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 4/23/2019 at 2:32:58 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

native sand and cobbles that will allow for some of the runoff in the drainageway, particularly for low flows, to percolate into the subgrade. The steep eroded banks will be replaced by soil riprap bank linings that will be revegetated with native grasses. Overall the effective imperviousness of the corridor will be reduced upon completion of the project.

Step Two- Water Quality Storage: Since there is no increase in the imperviousness of the drainageway corridor over present day conditions, storage of the water capture volume is not required. However, the construction of the outlet culvert and storage area will act to reduce the 100-year peak runoff from approximately 2,400 cubic feet per second to 1,900 cubic feet per second. The portion of the 100-year volume that is stored will be released over a longer time period as compared to the present-day conditions. The reduction in peak discharges for the 100-year recurrence interval will benefit the drainageway facilities that lie downstream of the project.

The project includes the extension of Tutt Boulevard from its present terminus at New Cowpoke Road, north to the boundary with Wolf Ranch. This segment of Tutt Boulevard was the subject of the final drainage report prepared by Rockwell Consulting that is included in the Appendix E of this report. The runoff from sub-basin that covers the Tutt Boulevard extension work will be conveyed within the street section. Runoff in the street will move south and will outfall to curb inlets at New Cowpoke Road. The runoff collected by the curb inlets will discharge to a storm sewer that will then carry runoff into a proposed water quality basin. The water quality basin will store the water quality capture volume (WQCV) and release it to Cottonwood Creek upstream of the proposed box culvert. The WQCV was estimated at .165 acre-feet. The WQCV will be released over a 40-hour period. The water quality basin has been designed to be in conformance with Reference 2. The water quality basin has an outlet control structure fitted with a trash rack and perforated plate, a micro-pool, a concrete trickle channel and a forebay.

Step Three-Drainageway Stabilization: As discussed above in Step Two, the existing drainageway is typified by steep eroded banks and an invert that has incised itself into the native bedrock. These conditions will continue to occur until the channel is stabilized both vertically and horizontally. The proposed channel linings in combination with the sloping drop structures will result in a longitudinal stream slope of 0.5 percent. The 0.5 percent stream slope will allow for normal flow conditions to occur for all recurrence intervals and eliminate the high velocity and critical depth conditions that exist now and that cause bank and invert erosion.

Step Four-Source Controls: The construction of the drainageway stabilization measures will not increase the imperviousness of the project areas and therefore source control are not required.

The proposed drainageway improvements have been designed to meet the requirements of the Four Step Process. The creation of 100-year flood storage made possible by this project will not adversely impact downstream reaches of Cottonwood Creek.

IX. Full Spectrum Detention

Using the methodology described in Volume II of the Urban Drainage and Flood Control District (UDFCD) Storm Drainage Criteria Manual the water quality capture volume (WQCV), and excess urban runoff volume (EURV) was determined for the watershed that is tributary to the Cottonwood Creek PR-2 water quality basin. The required storage detention of the 100-year recurrence interval has not been provided for within the storage pool of the water quality basin. The 100-year storage is being provided within the storage pool of the Cottonwood Creek PR-2 facility.

The following design parameters were input to the FSD analysis:

Basin area:	6.14 acres
Percent imperviousness	79.1 %
Hydrologic soils:	
HSG B	100 %
MDCIA assumption	0
Storage requirement	WQCV and EURV
Drain time:	
WCQV	40 hours
EURV-100-year	< 72 hours
100-year Inflow	50.5 cubic feet per second

Based upon the above hydrologic assumptions, the following volumes were determined:

WQCV	.165 acre-feet
EURV	.538 acre-feet

Approximately .538 acre-feet of water quality storage will be provided within the storage pool. The supporting calculations for extended detention basin are provided in Appendix F.

Using the volumes stated above the following FSD basin design parameters were established. The parameters are based upon the guidelines for the design of extended detention basin (EDB's), that are summarized in Reference 6.

Forebay release rate:	1.01 cfs
Minimum forebay volume:	.005 AF
Maximum forebay depth:	1.5 inches
Trickle channel capacity:	2 cfs
Micro-pool area:	> 10 square feet
Initial surcharge depth:	> 4 inches
Initial surcharge volume:	.01 AF

An emergency spillway has been provided capable of passing the un-detained 100-year inflow should the principal outlet become plugged. The top grate of the outlet structure has been sized to be able to convey the un-detained 100-year inflow as well, so it is unlikely that the emergency spillway will come into service. The 100-year inflow will pass though the outlet structure via the top grate and into the 54-inch RCP that passes beneath the storage pool.

X. Drainage and Bridge Fees

The construction as proposed required that a subdivision plat be created for the portion of the project that that lies west of future Tutt Boulevard. This parcel covers 2.147 acres. The parcel lies within the Cottonwood Creek drainage basin therefore drainage, bridge and basin surcharge fees are due prior to plat recordation as follows:

Type of Fee	Acres	Fee / Acre (2020)	Fee
Drainage Fee	2.147	$14,356	$30,822.33
Bridge Fee	2.147	$1,175	$2,522.73
Surcharge	2.147	$752	$1,614.54
Total Fees			**$34,959.60**

XI. Conclusions

The following conclusions can be summarized based upon the final drainage report and associated analyses:

1. Peak discharges for the 100-year for Cottonwood Creek will be attenuated by storage created upstream of the Tutt Boulevard roadway embankment. Approximately a 13 percent reduction in the 100-year peak flow rate will be affected.
2. The storage and release of the WQCV over a 40-hour period as generated by the roadway itself will cause suspended sediment and debris to fall out within the storage area of the

water quality basin., thereby reducing the amount of sediment and debris available to be transported to the downstream drainageway.

3. The construction of the major drainageway that includes the channel linings and drop structures will slow the velocity of the runoff as it approaches the flood storage pool. The construction of the drainageway facilities will raise the invert of the Creek and eliminate the incised section of Cottonwood Creek through the City's property. Thereby greatly reducing the sediment load to downstream reaches that now result from invert degradation and channel bank sloughing.
4. The implementation of an operations and maintenance manual for this facility will allow for the routine inspection and cleaning of the storage area and outlet works. Presently, yard wastes from surrounding lots are dumped with the storage area and along the inflow channel. Routine clearing of such waste will ensure that the outlet works perform as designed.

APPENDIX B

MAJOR DRAINAGEWAY HYDROLOGY INFORMATION
COTTONWOOD CREEK DBPS MARCH 2019 SELECTED EXCERPTS

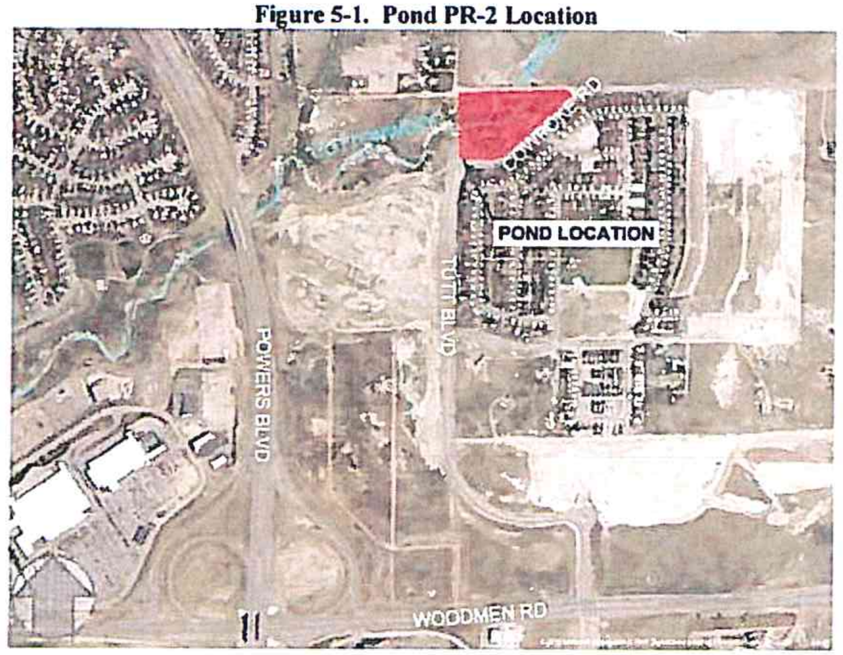
REFERENCE 5
Cottonwood Creek DBPS
MATRIX DESIGN GROUP
MARCH 2019

A more detailed analysis of the site conditions may require adjustment to the performance results and opinions of probable construction costs. A summary of the conditions and evaluation results at each potential pond location is provided in the following subsections.

5.4.1. Pond PR-2 (Tutt Pond)

The City owns the parcel on which this potential facility is located (Schedule #5306201001). The location of Pond PR-2 is shown on Figure 5-1. This detention facility is planned for construction upstream of the proposed extension of Tutt Boulevard over Cottonwood Creek, and is also referred to as the "Tutt Pond". The proposed roadway embankment will impound flood flows and the culvert crossing under the proposed Tutt Boulevard will provide the outlet structure of the pond.

Figure 5-1. Pond PR-2 Location



The drainage basin area upstream of this site is approximately 6 square miles with a percent imperviousness of 16% and much of the basin is within El Paso County. Two cases for the pond configuration were evaluated.

Case 1 - This case was created to consider the cost and performance of the pond using only the proposed Tutt Boulevard extension embankment to create the detention storage volume. No excavation of the side slopes adjacent to Cottonwood Creek is proposed to increase the available storage volume. The outlet culvert will extend under the proposed Tutt Boulevard extension that will serve as the emergency spillway for the pond. The storage available for this case accounts for the proposed Cumbre Vista water quality treatment facility to be located in the easterly portion of the site. A schematic of the Case 1 configuration is provided as Figure 5-8 at the end of this section.

Case 2 - This case was created to consider the cost and performance of the pond by increasing the storage volume upstream of the proposed Tutt Boulevard extension embankment with the excavation of slopes adjacent to Cottonwood Creek. The same type of outlet culvert as proposed in Case 1 is proposed in Case 2. The storage available for this case also accounts for the proposed Cumbre Vista water quality treatment facility to be located in the easterly portion of the site. A schematic of the Case 2 configuration is provided as Figure 5-9 at the end of this section.

The results of the performance evaluations for Case 1 and Case 2 are summarized in the following table.

Table 5-1. Pond PR-2 Performance Summary

Configuration	Peak Inflow (cfs)	Peak Outflow (cfs)	Reduction in Peak Inflow	Max. Elevation (ft)	Max. Storage Volume (ac-ft)
	Runoff Event: 2-Year, 24-Hour				
Case 1	327	327	0%	6,874	10 5
Case 2	327	325	1%	6,869	20 0
	Runoff Event: 100-Year, 24-Hour				
Case 1	1,949	1,709	12%	6,877	17 3
Case 2	1,949	1,667	15%	6,874	31 9

The opinion of probable construction costs for Case 1 and Case 2 is summarized in the following table.

Table 5-2. Pond PR-2 Opinion of Probable Construction Costs

Item	Case 1 (without exc.)	Case 2 (with exc.)
Construction Subtotal	$2,078,000	$3,243,000
Construction Contingency (25%)	$520,000	$487,000
Engineering (15%)	$312,000	$811,000
Total	$2,910,000	$4,541,000

1-4

Table 3-20. Peak Flows at Select Design Points

Location	HEC-HMS Element	Area (sq mi)	Existing Flows (cfs)				Future Flows (cfs)				Future Flows Increase (%)			
			2-year	5-year	10-year	100-year	2-year	5-year	10-year	100-year	2-year	5-year	10-year	100-year
Cottonwood Creek														
Black Forest Road	JUC190	3.46	93	210	340	1,100	93	210	340	1,100	0%	0%	0%	0%
Future Research Parkway (Wolf Ranch)	JWR164	1.97	470	630	740	1,200	460	610	750	1,500	-2%	-3%	1%	25%
Cowpoke Road	JMC052	6.06	560	750	890	2,400	480	710	970	2,400	-14%	-5%	9%	0%
Cottonwood Creek Main Stem Upstream of Rangewood Drive	JMC246	10.85	890	1,200	1,400	3,400	1,000	1,400	1,700	3,600	12%	17%	21%	6%
Rangewood Tributary Upstream of Rangewood Drive	JRT166	3.41	990	1,300	1,500	2,200	990	1,300	1,500	2,200	0%	0%	0%	0%
Rangewood Drive	JLC032	14.26	1,700	2,300	2,700	5,100	1,900	2,400	3,000	5,300	12%	4%	11%	4%
At Confluence with Monument Creek	CC_Outlet	19.17	2,200	3,100	3,600	6,800	2,400	3,200	3,900	7,100	9%	3%	8%	4%
South Pine Creek														
At Confluence with Pine Creek	JSPC200	3.69	950	1,300	1,500	2,100	950	1,300	1,500	2,100	0%	0%	0%	0%

Table 3-21. Flow Volumes at Select Design Points

Location	HEC-HMS Element	Area (sq mi)	Existing Flow Volume (ac-ft)				Future Flow Volume (ac-ft)				Future Flow Volume Increase (%)			
			2-year	5-year	10-year	100-year	2-year	5-year	10-year	100-year	2-year	5-year	10-year	100-year
Cottonwood Creek														
Black Forest Road	JUC190	3.46	15	43	69	210	15	43	70	220	0%	0%	1%	5%
Future Research Parkway (Wolf Ranch)	JWR164	1.97	8	26	42	130	22	46	66	170	3%	2%	57%	31%
Cowpoke Road	JMC052 ✓	6.06	26	77	130	390	47	110	160	440	81%	43%	23%	13%
Cottonwood Creek Main Stem Upstream of Rangewood Drive	JMC246	10.85	98	220	320	570	150	300	420	1,000	53%	36%	31%	75%
Rangewood Tributary Upstream of Rangewood Drive	JRT166	3.41	68	130	170	380	76	140	180	400	12%	8%	6%	5%
Rangewood Drive	JLC032	14.26	170	350	490	1,200	230	440	600	1,400	35%	26%	22	17%
At Confluence with Monument Creek	CC_Outlet	19.17	300	580	790	1,900	370	670	910	2,000	23%	16%	15%	5%
South Pine Creek														
At Confluence with Pine Creek	JSPC200	3.69	120	200	260	470	120	200	260	470	0%	0%	0%	0%

2-4

Table 3-22. Summary of Existing Hydrologic Results at Key Design Points

Hydrologic Element	Drainage Area (sq mi)	Hydrologic Results			
		2-Year		100-Year	
		Peak Discharge (cfs)	Volume (ac-ft)	Peak Discharge (cfs)	Volume (ac-ft)
CC OUTLET	19 17	2200	560	6800	1800
Fairfax	1 44	180	33	250	76
JLC032	14 26	1700	330	5100	1200
JLC034	14 53	1800	340	5200	1300
JLC036	15 13	1900	370	5300	1300
JLC082	15 5	2000	390	5600	1400
JLC084	16 22	2100	410	5900	1500
JLC100	16 37	2100	420	6000	1500
JLC122	16 54	2100	420	6000	1500
JLC124	16 69	2100	430	6100	1500
JLC126	16 95	2200	440	6200	1500
JLC150	17 37	2200	460	6400	1600
JLC212	18.48	2400	520	6900	1700
JLC214	18.83	2400	540	7100	1800
* JMC052	6 06	560	53	2400	470
JMC053	6 06	560	53	2400	470
JMC054	6 4	570	59	2400	490
JMC056	6.61	630	64	2500	520
JMC058	7 27	690	70	2700	560
JMC172	8 71	810	99	3000	670
JMC174	8 85	820	100	3000	690
JMC176	9 18	890	110	3100	730
JMC178	9 46	910	120	3200	760
JMC242	10 41	790	180	3300	840
JMC244	10 47	820	190	3300	850
JMC246	10 85	890	200	3400	880
JRT106	2 12	580	47	1300	210
JRT162	2 61	740	62	1600	270
JRT164	3 27	950	79	2100	350
JRT166	3 41	990	83	2200	370
JSPC154	2 93	560	92	1200	390
JSPC156	3 19	760	100	1600	230
JSPC162	2 03	150	62	230	260
JSPC164	2 03	150	62	230	260
JSPC166	2 32	250	71	480	300
JSPC200	3 69	950	120	2100	260
JUC104	2 24	37	13	700	130
JUC122	2 24	37	13	700	130
JUC124	2 34	39	14	750	140
JUC126	2.63	48	18	820	170
JUC130	2 82	59	22	930	190
JUC140	3 05	76	27	1100	210
JUC150	3 14	77	28	1100	220
JUC160	3 24	78	29	1100	230
JUC190	3 46	93	34	1100	250
JUC192	3 79	160	20	1300	280
JUC194	3 93	210	24	1300	290
JWR166	2 05	480	35	1200	170
JWR170	2 13	500	37	1300	180
RSPC200	3 69	950	1200	1500	270

Table 3-23. Summary of Future Hydrologic Results at Key Design Points

Hydrologic Element	Drainage Area (sq mi)	Hydrologic Results			
		2-Year		100-Year	
		Peak Discharge (cfs)	Volume (ac-ft)	Peak Discharge (cfs)	Volume (ac-ft)
CC OUTLET	19 17	2400	640	7100	2000
Fairfax	1 44	180	29	260	160
JLC032	14 26	1900	410	5300	1400
JLC034	14 53	1900	420	5500	1400
JLC036	15 13	2000	450	5700	1500
JLC082	15 5	2100	470	6000	1500
JLC084	16 22	2200	490	6300	1600
JLC100	16 37	2200	500	6400	1600
JLC122	16 54	2200	500	6400	1600
JLC124	16.69	2300	510	6500	1600
JLC126	16 95	2300	520	6600	1700
JLC150	17 37	2300	540	6800	1700
JLC212	18 48	2500	600	7300	1900
JLC214	18 83	2500	620	7500	1900
* JMC052	6.06	480	120	2400	560
JMC053	6.06	480	120	2400	560
JMC054	6 4	490	130	2500	590
JMC056	6 61	530	140	2600	610
JMC058	7 27	590	150	2800	660
JMC172	8 71	680	210	3100	810
JMC174	8 85	690	220	3100	830
JMC176	9 18	740	230	3200	870
JMC178	9 46	750	240	3300	900
JMC242	10 41	920	270	3500	980
JMC244	10 47	950	270	3500	990
JMC246	10 85	1000	280	3600	1000
JRT106	2 12	580	47	1300	210
JRT162	2 61	740	62	1600	270
JRT164	3 27	950	79	2100	350
JRT166	3 41	990	83	2200	370
JSPC154	2 93	560	92	1200	390
JSPC156	3 19	760	100	1600	230
JSPC162	2 03	150	62	230	260
JSPC164	2 03	150	62	230	260
JSPC166	2 32	250	71	480	300
JSPC200	3 69	950	120	2100	260
JUC104	2 24	37	13	700	130
JUC122	2 24	37	13	700	130
JUC124	2 34	39	14	750	140
JUC126	2 63	48	18	820	170
JUC130	2 82	59	22	930	190
JUC140	3 05	76	27	1100	210
JUC150	3 14	77	28	1100	220
JUC160	3 24	78	29	1100	230
JUC190	3 46	93	34	1100	250
JUC192	3 79	130	51	1300	300
JUC194	3 93	150	57	1300	320
JWR166	2 05	360	64	1400	230
JWR170	2 13	360	66	1400	240
RSPC200	3 69	950	1200	15000	270

* JMC Ø52 = COWPOKE & COTTONWOOD CREEK

Cottonwood Creek Drainage Basin Planning Study

Future Model Results

Hydrologic Element	Drainage Area (sq mi)	Results 2-Year Peak Discharge (cfs)	5-Year Peak Discharge (cfs)	10-Year Peak Discharge (cfs)	25-Year Peak Discharge (cfs)	50-Year Peak Discharge (cfs)	100-Year Peak Discharge (cfs)
CC_OUTLET	19 17	2400	3200	3900	5400	6200	7100
CHDP1_Lower	0.42	77	90	100	110	120	130
CHDP1_Upper	0.42	280	390	460	520	600	660
CHDP2	1.61	80	90	96	110	110	120
DP3	0.14	12	32	45	64	73	75
EX_4	0.98	27	41	64	130	150	170
EX_5/6	0.19	14	15	35	75	96	110
EX_8	0.67	52	100	130	140	150	150
EX_9	0.18	3.2	13	21	44	59	74
Fairfax	1.44	180	210	220	240	250	260
JLC010	0.27	100	140	160	180	200	230
JLC032	14.26	1900	2400	3000	4000	4600	5300
JLC034	14.53	1900	2500	3100	4100	4800	5500
JLC036	15.13	2000	2600	3200	4300	5000	5700
JLC050	0 07	36	47	55	61	70	78
JLC070	0.2	54	71	83	93	110	120
JLC072	0.44	150	200	230	260	300	330
JLC082	15.5	2100	2800	3300	4500	5200	6000
JLC084	16 22	2200	2900	3500	4800	5500	6300
JLC100	16.37	2200	3000	3600	4800	5600	6400
JLC110	0.17	29	38	45	50	57	63
JLC122	16.54	2200	3000	3600	4900	5600	6400
JLC124	16.69	2300	3000	3600	4900	5700	6500
JLC126	16.95	2300	3100	3700	5000	5800	6600
JLC130	0.05	34	44	52	58	66	73
JLC140	0.15	81	110	120	140	160	180
JLC150	17.37	2300	3100	3800	5100	5900	6800
JLC170	0.4	250	330	390	430	500	550
JLC180	0.68	400	530	620	690	790	870
JLC190	0.88	540	710	830	930	1100	1200
JLC200	1.11	610	800	940	1100	1200	1300
JLC212	18.48	2500	3400	4000	5500	6400	7300
JLC214	18.83	2500	3400	4100	5700	6500	7500
JLC220	0.17	120	160	180	210	240	260

Hydrologic Element	Drainage Area (sq mi)	Results 2-Year Peak Discharge (cfs)	5-Year Peak Discharge (cfs)	10-Year Peak Discharge (cfs)	25-Year Peak Discharge (cfs)	50-Year Peak Discharge (cfs)	100-Year Peak Discharge (cfs)
JMC010	0.09	62	82	96	110	120	140
JMC022	0.19	14	15	35	75	96	110
JMC024	0	0	0	0	0	0	0
JMC032	0.19	14	15	35	75	96	110
JMC034	0.34	14	15	36	80	110	130
JMC040	0.21	92	120	140	160	180	200
✓ JMC052	6.06	480	710	970	1600	2000	2400
JMC053	6.06	480	700	970	1600	2000	2400
JMC054	6.4	490	720	1000	1700	2100	2500
JMC056	6.61	530	760	1000	1700	2100	2600
JMC058	7.27	590	830	1100	1800	2200	2800
JMC060	0.18	85	110	130	150	170	190
JMC070	0.36	86	110	130	170	200	230
JMC080	0.67	220	300	350	390	450	500
JMC090	0.98	27	41	64	130	150	170
JMC100	0.11	45	59	69	77	88	97
JMC110	1.17	150	190	230	250	290	320
JMC130	0.14	110	140	160	180	210	230
JMC140	0.07	60	79	93	100	120	130
JMC150	0.07	16	21	25	28	32	35
JMC162	0.14	74	97	110	130	150	160
JMC164	0.33	120	160	180	200	230	260
JMC172	8.71	680	1000	1200	2000	2500	3100
JMC174	8.85	690	1000	1200	2100	2500	3100
JMC176	9.18	740	1100	1300	2100	2600	3200
JMC178	9.46	750	1100	1300	2200	2600	3300
JMC180	0.21	130	170	200	220	250	280
JMC190	0.38	190	250	300	330	380	420
JMC200	0.15	67	88	100	120	130	150
JMC210	0.09	51	68	79	88	100	110
JMC222	0.53	260	340	400	450	510	560
JMC224	0.62	310	410	480	530	610	670
JMC225	0.06	56	74	86	97	110	120
JMC226	0.95	450	590	690	770	880	970
JMC242	10.41	920	1300	1600	2300	2700	3500
JMC244	10.47	950	1300	1600	2300	2700	3500
JMC246	10.85	1000	1400	1700	2300	2800	3600

4-4

REFERENCE 6

Matrix DESIGN GROUP
AN EMPLOYEE-OWNED COMPANY

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Phone: 719.575.0100
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MEMORANDUM

Date: August 3, 2017

To: Adam Copper, P.E., City of Colorado Springs, Project Manager

From: Dan Bare, P.E., Drake Ludwig, E.I., Thomas Donahue, E.I., Matrix Design Group

RE: Cottonwood Creek DBPS – Evaluation of PR-2 (Tutt Pond) IGA Detention Facility DRAFT

Introduction

As a component of the Cottonwood Creek Drainage Basin Planning Study (DBPS) the City of Colorado Springs (City) requested that Matrix Design Group (Matrix) evaluate several Inter-Governmental Agreement (IGA) Detention Projects within the Cottonwood Creek basin. The IGA detention projects were evaluated for their cost and performance. This memorandum summarizes the process and results of said evaluation for the PR-2 (Tutt Pond) IGA Detention Facility (Facility) located on the main stem of Cottonwood Creek, east of Powers Boulevard, at the proposed extension of Tutt Boulevard across Cottonwood Creek as shown in Figure 1.

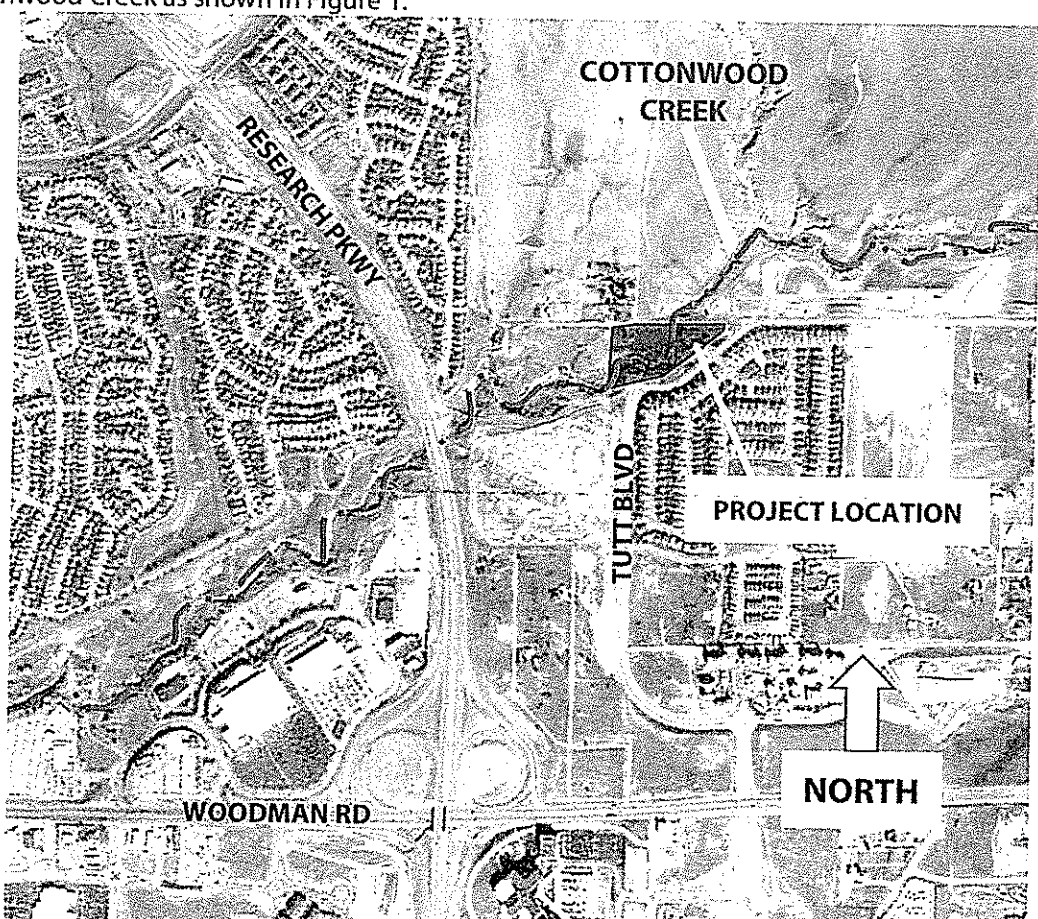


Figure 1. Project Location

The Facility was evaluated using the detailed hydrologic model representing the greater Cottonwood Creek basin, developed for the DBPS currently in progress. The site was evaluated for two possible cases. The first case is based on the storage created upstream of the proposed Tutt Boulevard extension without increasing the storage volume by excavation. The roadway profile for the proposed extension provided by the City was used to set the maximum storage available. The second case is based on the additional storage that could be created by excavating the sides of the proposed detention facility. Both cases considered the proposed water quality facility that is planned to treat runoff from the Cumbre Vista development, southeast of the site. Due to the procedures recently formulated by the State Engineer's office, design criteria for the embankment and emergency spillway may need approval by that office. The project will need to be submitted to the State Engineer to determine jurisdiction, which will be based on the size and hazard rating of the facility. Should the facility be determined to be under the jurisdiction of the State Engineer, the overtopping design flow (Inflow Design Flood) requirement will likely be the criteria that will most affect the design of the facility and its cost. For the purposes of this evaluation it was assumed that the facility would be designed to comply with City criteria which requires that the emergency spillway be designed to safely pass the 100-year peak inflow.

The following sections summarize the evaluation process and the results of the evaluation.

Hydrology

Using the US Army Corps of Engineers (USACE) Hydrologic Engineering Center – Hydrologic Modeling System 4.2.1 (HEC-HMS), a hydrologic model for the Cottonwood Creek basin was created for the DBPS. As outlined in the City's Drainage Criteria Manual (DCM), the Natural Resources Conservation Service (NRCS) Curve Number Loss and Dimensionless Unit Hydrograph Method was used to estimate design flows and volumes. Some of the input parameters used in the model are based upon datasets that have been updated since the publication of the DCM in 2014, such as the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 data. A detailed discussion of the procedures used in the development of the DBPS hydrologic model can be found in Section 3 of the DRAFT Cottonwood Creek DBPS report (June 2017) under review by the City and provided separately.

The Facility was evaluated using future, full build-out, hydrologic conditions to develop flood hydrographs for the 2-year and 100-year storm events. The watershed area for the contributing basin is approximately 6.0 square miles, about 16% of which is impervious. Evaluation of the facility assumed that upstream detention would be implemented with future development in the Wolf Ranch development project, but did not include detention in the future El Paso County developments. The hydrologic analysis completed as part of the DBPS indicated that the 24-hour event storm event was dominant (produced the greatest peak flows) and thus was used for the evaluation of the Facility.

Site Conditions and Design

The City currently owns the parcel on which the Facility is to be located. The conceptual layout of the Facility was located just upstream of the proposed extension of Tutt Boulevard crossing to use the roadway embankment as an emergency spillway.

The size of the upstream drainage basin, the expected sediment load, and no need for water quality treatment precluded the use of a full-spectrum pond configuration. Therefore, a conventional outlet culvert was used in the evaluations. Two cases for the pond configuration were evaluated.

Case 1

This case was created to consider the cost and performance of the pond using only the proposed Tutt Boulevard extension embankment to create the detention storage volume. No excavation of the side slopes adjacent to Cottonwood Creek is proposed to increase the available storage volume. The 9'x7' outlet culvert will extend under the proposed Tutt Boulevard extension and the emergency spillway will discharge over the proposed Tutt Boulevard roadway embankment. The storage available for this case accounts for the proposed Cumbre Vista water quality treatment facility to be located in the easterly portion of the site. Figure 2 shows a schematic of the Case 1 facility.

Case 2

This case was created to consider the cost and performance of the pond by increasing the storage upstream of the proposed Tutt Boulevard extension embankment with the excavation of slopes adjacent to Cottonwood Creek. The same type of outlet culvert as proposed in Case 1 is proposed in Case 2. The storage available for this case accounts for the proposed Cumbre Vista water quality treatment facility to be located in the easterly portion of the site. Figure 3 shows a schematic of the Case 2 facility.

Cost Analysis

A conceptual cost analysis was completed for the two Facility configurations described above. The costs estimated are based upon unit costs collected during the completion of the Monument Creek Restoration Master Plan project and will also be used for cost estimates included in the Cottonwood Creek DBPS. Table 1 summarizes the estimated project costs for the Facility for Cases 1 and 2. No land acquisition costs are anticipated since the parcel is owned by the City.

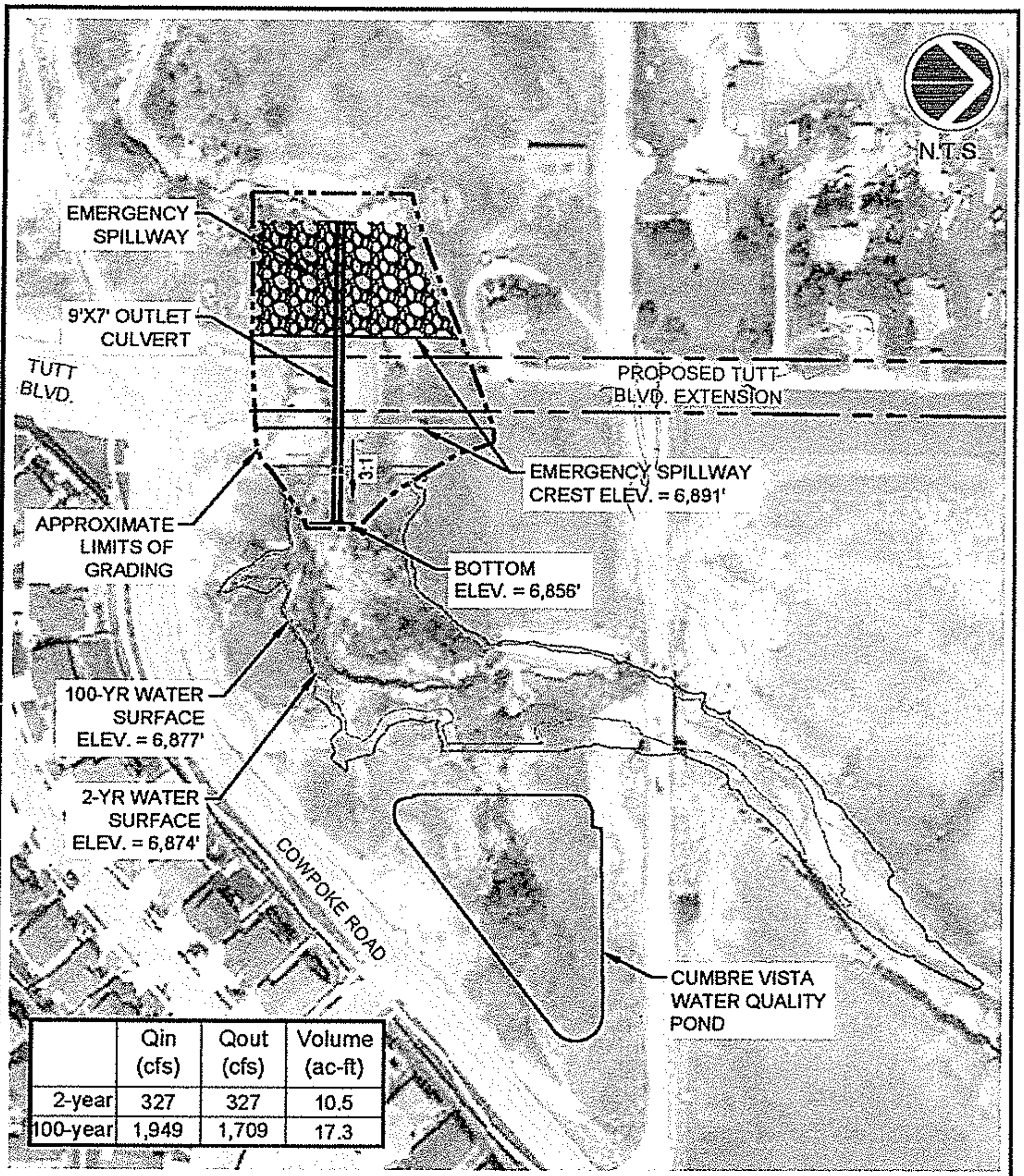
Table 1. PR-2 Detention Facility Cost Estimates

Item	**Case 1 (without exc.)**	**Case 2 (with exc.)**
Construction Subtotal	$2,078,000	$3,243,000
Construction Contingency (25%)	$520,000	$487,000
Engineering (15%)	$312,000	$811,000
Total	**$2,910,000**	**$4,541,000**

Construction costs include:

- Mobilization/demobilization
- Dewatering
- Excavation/embankment/haul
- Channel stabilization
- Outlet structure
- Emergency spillway
- Access road
- Sediment and erosion control
- Top soil and revegetation

Roadway associated improvements and utilities required to complete the Tutt Boulevard extension were not included in the cost estimates. Additionally, if the Facility is required to be reviewed and approved by the State Engineer, the estimated costs can be expected to increase.

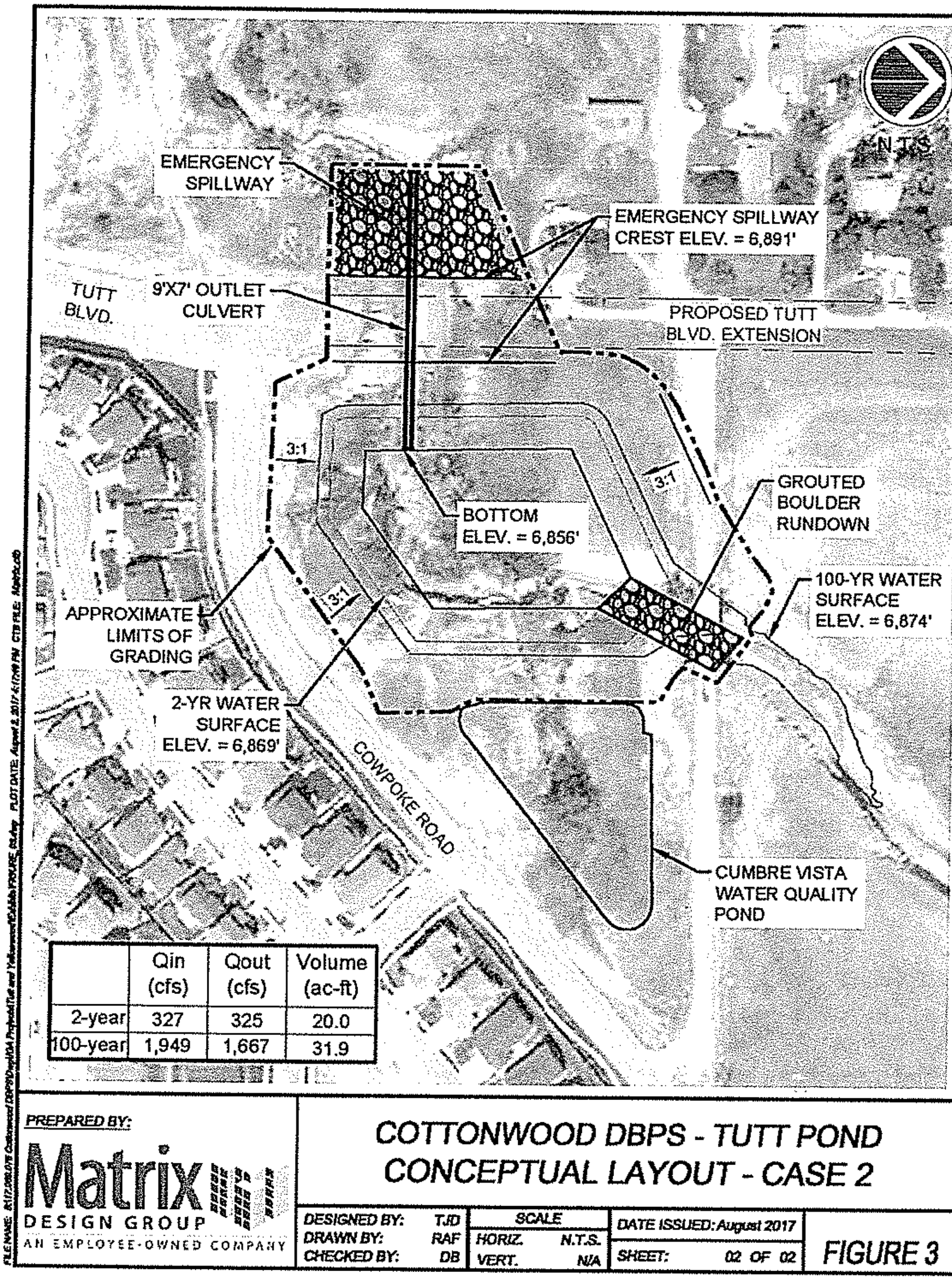


	Qin (cfs)	Qout (cfs)	Volume (ac-ft)
2-year	327	327	10.5
100-year	1,949	1,709	17.3

PREPARED BY: Matrix DESIGN GROUP, AN EMPLOYEE-OWNED COMPANY

COTTONWOOD DBPS - TUTT EMBANKMENT CONCEPTUAL LAYOUT - CASE 1

DESIGNED BY: TJD	SCALE		DATE ISSUED: August 2017		FIGURE 2
DRAWN BY: RAF	HORIZ.	N.T.S.	SHEET:	01 OF 02	
CHECKED BY: DB	VERT.	N/A			



	Qin (cfs)	Qout (cfs)	Volume (ac-ft)
2-year	327	325	20.0
100-year	1,949	1,667	31.9

Performance Evaluation

The performance of the Facility was evaluated by integrating the two conceptual layouts into the aforementioned hydrologic model and routing the input hydrographs through the Facility. The peak flows downstream of the Facility were then compared to the peak inflows for both a high- (2-Year) and low-frequency (100-Year) runoff event to determine the effectiveness of each case. Table 2 summarizes the results of the evaluation.

Table 2. PR-2 Detention Facility Performance Summary

Configuration	Peak Inflow (cfs)	Peak Outflow (cfs)	Reduction in Peak Inflow (%)	Max. Elevation (ft)	Max. Storage (ac-ft)
	Runoff Event: 2-Year, 24-Hour				
Case 1	327	327	0%	6,861.7	0.5
Case 2	327	325	1%	6,861.7	7.5
	Runoff Event: 100-Year, 24-Hour				
Case 1	1949	1709	12%	6,887.5	55.8
Case 2	1949	1667	15%	6,886.3	85.6

With the embankment height and storage volume available the outlet structure required is a 9' x 7' box culvert for each case.

Due to the limited reduction achieved by the two cases evaluated a third case could be considered. By reducing the size of the outlet culvert and providing an overflow structure to pass most of the 100-year inflow a more significant reduction in the 2-year flood event could be achieved. However, since the inflow to the 2-year flood event is only 327 cfs even a 50% reduction would result in a limited overall lowering of downstream flood flows. This option could be considered further during the final design phase of the project.

Summary

The proposed detention facility (PR-2) was evaluated considering two cases for providing flood control storage. Each case was evaluated for cost and performance. Case 1 considered a facility based on the storage created by the embankment of the proposed Tutt Boulevard extension only and Case 2 considered a facility based on the additional storage created by excavation of the upstream slopes adjacent to Cottonwood Creek. For purposes of these evaluations it was assumed that the facilities would be designed based on City criteria and not to comply with State Engineer criteria.

At a cost of about $2.91 million Case 1 will provide a peak flood flow reduction of about 0% for the 24-hour, 2-year storm event and about 12% for the 24-hour, 100-year storm event. At a total cost of about $4.54 million Case 2 will provide a peak flood flow reduction of about 1% for the 24-hour, 2-year storm event and about 15% for the 24-hour, 100-year storm event.

The analyses summarized in this memorandum are based on limited site information and conceptual designs. A more detailed analysis of the site conditions may require adjustment to the estimated costs and performance results.

APPENDIX C

SUPPORTING HYDROLOGIC CALCULATIONS

REF. 6

Cottonwood Creek DBPS - Future Condtions - NOAA Atlas 2 - Type II Design Storm - 0.2 Ia

(Future conditions includes planned detention ponds in Wolf Ranch)

24-Hour Inflow Hydrographs to PR-2 Pond [cfs]								
Date	Time	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
1-Jan-00	0:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Jan-00	0:15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Jan-00	0:30	0.3	0.4	0.5	0.6	0.8	0.9	1.1
1-Jan-00	0:45	1.5	2.0	2.3	3.0	3.4	3.8	4.8
1-Jan-00	1:00	2.2	2.9	3.5	4.6	5.1	5.6	6.9
1-Jan-00	1:15	2.7	3.6	4.3	5.5	6.2	7.0	8.9
1-Jan-00	1:30	3.2	4.3	5.0	6.8	7.7	8.8	11.1
1-Jan-00	1:45	3.7	4.9	5.9	8.2	9.3	10.4	12.9
1-Jan-00	2:00	4.2	5.7	7.0	9.4	10.5	11.7	14.4
1-Jan-00	2:15	4.7	6.5	7.8	10.3	11.5	12.7	15.6
1-Jan-00	2:30	5.2	7.2	8.5	11.1	12.3	13.5	16.4
1-Jan-00	2:45	5.7	7.7	9.1	11.7	12.9	14.1	17.3
1-Jan-00	3:00	6.2	8.2	9.6	12.2	13.4	14.6	18.2
1-Jan-00	3:15	6.5	8.6	10.0	12.5	13.8	15.2	18.9
1-Jan-00	3:30	6.8	8.9	10.3	12.9	14.3	15.8	19.5
1-Jan-00	3:45	7.1	9.2	10.6	13.2	14.8	16.3	20.1
1-Jan-00	4:00	7.4	9.6	11.0	13.9	15.5	17.1	21.0
1-Jan-00	4:15	8.0	10.3	11.8	15.1	16.8	18.5	22.7
1-Jan-00	4:30	8.4	10.8	12.3	15.9	17.7	19.4	23.9
1-Jan-00	4:45	8.7	11.1	12.8	16.6	18.4	20.3	25.0
1-Jan-00	5:00	8.6	10.9	12.7	16.4	18.2	20.1	24.8
1-Jan-00	5:15	8.1	10.3	12.3	16.0	17.9	19.8	24.6
1-Jan-00	5:30	10.0	13.0	15.3	19.8	22.1	24.4	30.0
1-Jan-00	5:45	10.0	13.1	15.4	19.7	21.9	24.0	29.4
1-Jan-00	6:00	9.9	13.2	15.4	19.6	21.9	24.2	29.7
1-Jan-00	6:15	10.2	13.6	15.8	20.5	22.9	25.2	31.0
1-Jan-00	6:30	10.8	14.4	16.9	21.8	24.3	26.9	33.2
1-Jan-00	6:45	11.2	15.2	17.7	22.9	25.6	28.1	34.5
1-Jan-00	7:00	11.7	15.7	18.3	23.7	26.3	29.0	35.8
1-Jan-00	7:15	12.3	16.1	19.0	24.4	27.1	29.8	37.2
1-Jan-00	7:30	12.6	16.6	19.5	25.1	27.9	30.7	38.4
1-Jan-00	7:45	12.8	17.2	20.0	25.8	28.7	31.6	39.3
1-Jan-00	8:00	13.2	17.6	20.6	26.5	29.4	32.3	40.2
1-Jan-00	8:15	13.7	18.1	21.2	27.3	30.3	33.3	41.3
1-Jan-00	8:30	14.5	19.2	22.5	28.8	31.9	35.1	43.5
1-Jan-00	8:45	15.4	20.4	23.8	30.5	33.8	37.4	46.3
1-Jan-00	9:00	16.0	21.3	24.8	31.7	35.2	39.4	48.5
1-Jan-00	9:15	16.7	22.1	25.8	33.1	37.2	41.4	51.1
1-Jan-00	9:30	17.6	23.3	27.2	35.1	39.7	44.1	77.5
1-Jan-00	9:45	18.4	24.5	28.6	37.4	42.2	46.7	96.1
1-Jan-00	10:00	19.5	26.0	30.4	40.1	44.9	49.6	104.2
1-Jan-00	10:15	20.5	27.3	32.0	42.4	47.4	52.3	110.7

REFERENCE 5

HYDROGRAPH @
100 TOTT- 'PR2'

1-Jan-00	10:30	21.9	29.2	34.2	45.5	50.8	75.3	118.4
1-Jan-00	10:45	24.0	32.0	37.9	50.1	55.9	103.0	132.2
1-Jan-00	11:00	26.8	35.8	43.0	56.3	96.1	121.7	156.3
1-Jan-00	11:15	30.3	41.0	49.0	66.2	128.7	144.6	191.6
1-Jan-00	11:30	34.3	47.3	56.1	131.1	155.0	173.5	238.8
1-Jan-00	11:45	47.4	65.4	77.6	184.4	211.3	243.3	349.3
1-Jan-00	12:00	102.4	140.1	234.8	404.2	482.8	575.7	840.8
1-Jan-00	12:15	181.0	500.3	662.4	944.0	1107.9	1296.5	1958.1
1-Jan-00	12:30	475.3	689.4	850.8	1391.9	1743.3	2379.2	3576.1
1-Jan-00	12:45	440.1	687.8	970.7	1580.5	1944.7	2246.9	3263.0
1-Jan-00	13:00	342.9	629.9	850.9	1455.3	1799.9	2105.9	2800.7
1-Jan-00	13:15	273.4	476.4	688.7	1192.5	1464.7	1708.2	2304.0
1-Jan-00	13:30	223.2	386.7	544.9	952.0	1169.9	1370.0	1852.4
1-Jan-00	13:45	186.8	323.2	451.6	753.3	934.9	1108.1	1508.8
1-Jan-00	14:00	157.4	277.0	384.5	623.9	751.8	896.6	1247.9
1-Jan-00	14:15	135.0	240.6	330.9	526.4	628.9	741.1	1045.7
1-Jan-00	14:30	118.1	211.6	288.5	452.7	538.3	631.1	886.0
1-Jan-00	14:45	104.9	188.1	254.5	394.8	467.5	546.1	768.8
1-Jan-00	15:00	93.8	168.4	226.2	347.5	410.4	478.0	680.5
1-Jan-00	15:15	84.6	152.2	202.9	310.0	365.5	424.8	612.2
1-Jan-00	15:30	77.7	139.4	185.0	281.6	331.7	385.0	553.7
1-Jan-00	15:45	72.2	128.9	170.5	258.8	304.7	353.3	502.1
1-Jan-00	16:00	67.5	120.0	158.4	239.8	282.4	327.1	459.9
1-Jan-00	16:15	63.7	112.8	148.6	225.2	265.4	307.4	428.4
1-Jan-00	16:30	61.0	107.6	141.7	214.9	253.2	293.1	405.1
1-Jan-00	16:45	59.0	103.7	136.6	206.9	243.8	282.2	387.8
1-Jan-00	17:00	56.8	99.8	131.2	198.9	234.6	271.6	371.3
1-Jan-00	17:15	54.7	95.8	125.8	191.0	225.2	260.5	354.2
1-Jan-00	17:30	52.6	92.3	121.2	183.8	216.7	250.6	339.5
1-Jan-00	17:45	51.3	89.8	117.7	178.4	210.1	242.7	327.3
1-Jan-00	18:00	50.3	87.7	114.8	173.4	204.1	235.6	317.0
1-Jan-00	18:15	48.8	84.9	110.9	167.2	196.8	227.3	305.1
1-Jan-00	18:30	47.0	81.5	106.3	160.3	188.6	217.6	291.1
1-Jan-00	18:45	45.2	78.3	102.2	153.7	180.8	208.5	278.4
1-Jan-00	19:00	44.0	75.9	99.0	148.6	174.5	201.0	267.6
1-Jan-00	19:15	43.2	74.1	96.5	144.1	169.2	194.8	259.1
1-Jan-00	19:30	42.4	72.5	94.2	140.6	165.2	190.4	253.4
1-Jan-00	19:45	41.9	71.2	92.4	138.3	162.5	187.5	249.9
1-Jan-00	20:00	41.3	69.8	90.9	136.3	160.3	185.0	246.8
1-Jan-00	20:15	40.1	67.8	88.4	132.6	156.0	180.1	240.0
1-Jan-00	20:30	38.5	65.2	85.1	127.5	149.9	172.8	229.5
1-Jan-00	20:45	37.1	62.7	81.8	122.2	143.5	165.2	219.1
1-Jan-00	21:00	36.8	60.8	79.1	117.8	138.0	158.7	209.6
1-Jan-00	21:15	36.3	59.2	76.8	113.9	133.0	152.7	201.6
1-Jan-00	21:30	35.7	58.0	74.7	110.4	128.9	148.2	196.0
1-Jan-00	21:45	35.2	56.8	72.8	107.9	126.2	145.2	192.3
1-Jan-00	22:00	34.7	55.8	71.4	106.2	124.3	143.1	190.0

1-Jan-00	22:15	34.3	55.0	70.5	105.0	123.1	141.9	188.7
1-Jan-00	22:30	33.9	54.5	69.9	104.4	122.5	141.2	188.0
1-Jan-00	22:45	33.6	54.2	69.5	104.0	122.1	140.9	187.7
1-Jan-00	23:00	33.4	54.0	69.2	103.8	122.0	140.7	187.5
1-Jan-00	23:15	33.2	53.8	69.2	103.8	122.0	140.7	187.5
1-Jan-00	23:30	33.2	53.8	69.2	103.8	122.0	140.7	187.5
1-Jan-00	23:45	33.1	53.8	69.2	103.9	122.1	140.8	187.6
2-Jan-00	0:00	32.7	53.2	68.4	102.6	120.4	138.8	184.7

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN   1998               *
*            VERSION 4.1                *
*                                       *
*  RUN DATE   06AUG18  TIME  14:42:39   *
*                                       *
*****************************************
```

```
***************************************
*                                     *
*   U.S. ARMY CORPS OF ENGINEERS      *
*   HYDROLOGIC ENGINEERING CENTER     *
*         609 SECOND STREET           *
*      DAVIS, CALIFORNIA 95616        *
*          (916) 756-1104             *
*                                     *
***************************************
```

```
X     X  XXXXXXX  XXXXX        X
X     X  X        X     X     XX
X     X  X        X            X
XXXXXXX  XXXX     X          XXXXX  X
X     X  X        X            X
X     X  X        X     X      X
X     X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

8x14 'CBe
10-4t

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                  HEC-1 INPUT                                             PAGE  1

 LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   1          ID           COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT5.DAT
   2          ID           PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
   3          ID           INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
   4          ID           10  YEAR    24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
   5          ID           8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED
              *DIAGRAM
   6          IT      15       0       0     144
   7          IO       5       0

   8          KK   DPPR2
   9          KM         DESIGN POINT PR 2 INFLOW TO DET BASIN PR2
  10          BA     6.1
  11          QI       0       0      .5     2.3     3.5     4.3     6.0     5.9       7     7.8
  12          QI     8.5     9.1     9.6      10    10.3    10.6      11    11.8    12.3    12.8
```

```
13          QI   12.7   12.3   15.3   15.4   15.4   15.8   16.9   17.7   18.3     19
14          QI   19.5     20   20.6   21.2   22.5   23.8   24.8   25.8   24.8   25.8
15          QI   27.2   28.6   30.4     32   34.2   37.9     43     49   56.1   77.6
16          QI    235    662    851    971    851    689    545    452    385    331
17          QI    289    255    226    203    185    171    158    149    142    137
18          QI    131    126    121    118    115    111    106    102     99   96.5
19          QI   94.2   92.4   90.9   88.4   85.1   81.8   79.1   76.8   74.7   72.8
20          QI   72.4   70.5   69.9   69.5   69.2   69.2   69.2   69.2   68.4     65

21          KK  DBPR2
22          KM         ROUTE INFLOW HYDROGRAPH THROUGH DETETNION BASIN PR2
23          KM         THIS IS OUTFLOW FROM DETENTION BASIN PR2
24          KM         8' X 14 CBC OUTLET PIPE
25          RS      1   ELEV     58
26          SV      0    .11     .4   1.01      2   2.57   6.78   8.75   12.5   17.2
27          SV     23   30.2   38.2   47.3   57.3   68.5   79.6   92.1
28          SE     58     60     62     64     66     68     70     72     74     76
29          SE     78     80     82     84     86     88     90     92
30          SQ      0    120    300    550    850   1160   1400   1600   1740   1910
31          SQ   2060   2210   2330   2480   2580   2670   2760   2880
32          ZZ
1
        SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING         (--->) DIVERSION OR PUMP FLOW
```

```
NO.       (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  8       DPPR2
              V
              V
 21       DBPR2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
*                                        *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*              JUN   1998                *
*            VERSION 4.1                 *
*                                        *
* RUN DATE   06AUG18  TIME  14:42:39     *
*                                        *
******************************************

******************************************
*                                        *
*    U.S. ARMY CORPS OF ENGINEERS        *
*    HYDROLOGIC ENGINEERING CENTER       *
*          609 SECOND STREET             *
*       DAVIS, CALIFORNIA 95616          *
*           (916) 756-1104               *
*                                        *
******************************************

COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT5.DAT
PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
10  YEAR     24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
```

```
                    8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED

7 IO       OUTPUT CONTROL VARIABLES
                IPRNT           5  PRINT CONTROL
                IPLOT           0  PLOT CONTROL
                QSCAL          0.  HYDROGRAPH PLOT SCALE

  IT       HYDROGRAPH TIME DATA
                 NMIN          15  MINUTES IN COMPUTATION INTERVAL
                IDATE      1    0  STARTING DATE
                ITIME        0000  STARTING TIME
                   NQ         144  NUMBER OF HYDROGRAPH ORDINATES
               NDDATE      2    0  ENDING DATE
               NDTIME        1145  ENDING TIME
                ICENT          19  CENTURY MARK

          COMPUTATION INTERVAL     .25 HOURS
               TOTAL TIME BASE   35.75 HOURS

      ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
```

TEMPERATURE DEGREES FAHRENHEIT

1

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+					6-HOUR	24-HOUR	72-HOUR			
	HYDROGRAPH AT									
+		DPPR2	971.	13.25	348.	141.	100.	6.10		
	ROUTED TO									
+		DBPR2	959.	13.25	348.	141.	100.	6.10		
+									66.70	13.25

*** NORMAL END OF HEC-1 ***

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JUN   1998               *
*           VERSION 4.1                 *
*                                       *
*  RUN DATE   06AUG18  TIME  14:43:41   *
*                                       *
*****************************************
```


```
*****************************************
*                                       *
*   U.S. ARMY CORPS OF ENGINEERS        *
*   HYDROLOGIC ENGINEERING CENTER       *
*         609 SECOND STREET             *
*      DAVIS, CALIFORNIA 95616          *
*          (916) 756-1104               *
*                                       *
*****************************************
```


```
X     X  XXXXXXX   XXXXX         X
X     X  X         X     X      XX
X     X  X         X             X
XXXXXXX  XXXX      X      XXXXX  X
X     X  X         X             X
X     X  X         X     X       X
X     X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

8'x14' CBC
50-year

```
THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


1                                  HEC-1 INPUT                                          PAGE  1

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1          ID             COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT5.DAT
  2          ID             PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
  3          ID             INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
  4          ID             50  YEAR    24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
  5          ID             8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED
             *DIAGRAM
  6          IT      15       0       0     144
  7          IO       5       0

  8          KK   DPPR2
  9          KM            DESIGN POINT PR 2 INFLOW TO DET BASIN PR2
 10          BA     6.1
 11          QI       0       0      .8     3.4     5.1     6.2     7.7     9.3    10.5    11.5
 12          QI    12.3    12.9    13.4    13.8    14.3    14.8    15.5    16.8    17.7    18.4
```

```
13        QI    18.2   17.9   22.1   21.9   22.9   24.3   25.6   26.3   27.1   27.9
14        QI    28.7   29.7   30.3   31.9   32.3   35.2   37.2   39.7   42.2   44.9
15        QI    47.4   50.8   55.9   96.1    129    155    211    483   1108   1743
16        QI    1945   1800   1465   1170    935    752    629    538    468    410
17        QI     366    332    305    282    265    253    244    235    225    217
18        QI     210    204    197    189    181    175    169    165    160    156
19        QI     150    144    138    133    129    126    124    123    123    122
20        QI     122    122    122    122    122    120

21        KK   DBPR2
22        KM          ROUTE INFLOW HYDROGRAPH THROUGH DETETNION BASIN PR2
23        KM          THIS IS OUTFLOW FROM DETENTION BASIN PR2
24        KM          8' X 14 CBC OUTLET PIPE
25        RS       1   ELEV     58
26        SV       0    .11     .4   1.01      2   3.57   6.78   8.75   12.5   17.5
27        SV      23   30.2   38.2   47.3   57.3   68.5   79.6   90.1
28        SE      58     60     62     64     66     68     70     72     74     76
29        SE      78     80     82     84     86     88     90     92
30        SQ       0    120    300    550    850   1160   1400   1600   1740   1910
31        SQ    2060   2210   2330   2480   2580   2670   2760   2880
32        ZZ
1
          SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING        (--->) DIVERSION OR PUMP FLOW
```

```
NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  8       DPPR2
              V
              V
 21       DBPR2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                            ****************************************
 *                                       *                            *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                            *   U.S. ARMY CORPS OF ENGINEERS       *
 *              JUN   1998               *                            *   HYDROLOGIC ENGINEERING CENTER      *
 *            VERSION 4.1                *                            *         609 SECOND STREET            *
 *                                       *                            *      DAVIS, CALIFORNIA 95616         *
 *  RUN DATE   06AUG18  TIME  14:43:41   *                            *          (916) 756-1104              *
 *                                       *                            *                                      *
*****************************************                             ****************************************
```

```
COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT5.DAT
PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
50  YEAR    24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
```

```
                         8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED

  7 IO        OUTPUT CONTROL VARIABLES
                    IPRNT           5  PRINT CONTROL
                    IPLOT           0  PLOT CONTROL
                    QSCAL          0.  HYDROGRAPH PLOT SCALE

    IT        HYDROGRAPH TIME DATA
                     NMIN          15  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1    0  STARTING DATE
                    ITIME        0000  STARTING TIME
                       NQ         144  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      2    0  ENDING DATE
                   NDTIME        1145  ENDING TIME
                    ICENT          19  CENTURY MARK

                COMPUTATION INTERVAL     .25 HOURS
                     TOTAL TIME BASE   35.75 HOURS

       ENGLISH UNITS
            DRAINAGE AREA          SQUARE MILES
            PRECIPITATION DEPTH    INCHES
            LENGTH, ELEVATION      FEET
            FLOW                   CUBIC FEET PER SECOND
            STORAGE VOLUME         ACRE-FEET
            SURFACE AREA           ACRES
```

TEMPERATURE   DEGREES FAHRENHEIT

1

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
	HYDROGRAPH AT									
+		DPPR2	1945.	12.50	683.	269.	191.	6.10		
	ROUTED TO									
+		DBPR2	1808.	12.75	683.	269.	191.	6.10		
+									74.80	12.75

*** NORMAL END OF HEC-1 ***

8'x14' 100-year

```
1*****************************************                    ***************************************
 *                                       *                    *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *   U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998               *                    *   HYDROLOGIC ENGINEERING CENTER     *
 *             VERSION 4.1               *                    *         609 SECOND STREET           *
 *                                       *                    *      DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   06AUG18  TIME  14:43:13   *                    *           (916) 756-1104            *
 *                                       *                    *                                     *
 *****************************************                    ***************************************


                            X     X  XXXXXXX   XXXXX        X
                            X     X  X        X     X      XX
                            X     X  X        X             X
                            XXXXXXX  XXXX     X       XXXXX X
                            X     X  X        X             X
                            X     X  X        X     X       X
                            X     X  XXXXXXX   XXXXX       XXX


            THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.
```

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID            COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT100.DAT
  2           ID            PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
  3           ID            INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
  4           ID            100 Year, 24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
  5           ID            8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED
              *DIAGRAM
  6           IT      15       0       0     144
  7           IO       5       0

  8           KK   DPPR2
  9           KM           DESIGN POINT PR 2 INFLOW TO DET BASIN PR2
 10           BA     6.1
 11           QI       0       0      .9     3.8     5.6       7     8.8    10.4    11.7    12.7
 12           QI    13.5    14.4    14.6    15.2    15.8    16.3   17.01    18.5    19.4    20.3
```

```
 13        QI     20     20     20     34     24     24     25     27     28     29
 14        QI     30     31     32   32.5     33     35     37     39     41     44
 15        QI     47     50     52     75    103    122    145    174    243    575
 16        QI   1297   2379   2247   2106   1708   1370   1108    897    741    631
 17        QI    546    478    385    353    327    307    293    282    272    261
 18        QI    251    243    236    227    218    209    201    195    190    188
 19        QI    185    180    173    165    159    153    148    145    143    142
 20        QI    141  140.5    140    139

 21        KK  DBPR2
 22        KM         ROUTE INFLOW HYDROGRAPH THROUGH DETETNION BASIN PR2
 23        KM         THIS IS OUTFLOW FROM DETENTION BASIN PR2
 24        KM         8' X 14 CBC OUTLET PIPE
 25        RS      1   ELEV     58
 26        SV      0    .11     .4   1.01    2.0   3.57   6.78   8.75   12.5   17.2
 27        SV   23.0   30.2   38.2   47.3   57.3   68.5   79.6   92.1
 28        SE     58     60     62     64     66     68     70     72     74     76
 29        SE     78     80     82     84     86     88     90     92
 30        SQ      0    120    300    550    850   1160   1400   1600   1740   1910
 31        SQ   2060   2210   2330   2480   2580   2670   2760   2880
 32        ZZ
1

         SCHEMATIC DIAGRAM OF STREAM NETWORK

 INPUT
  LINE      (V) ROUTING         (--->) DIVERSION OR PUMP FLOW
```

```
NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  8       DPPR2
              V
              V
 21       DBPR2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
*                                         *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)     *
*              JUN   1998                 *
*            VERSION 4.1                  *
*                                         *
*  RUN DATE   06AUG18  TIME  14:43:13     *
*                                         *
*****************************************

*****************************************
*                                         *
*    U.S. ARMY CORPS OF ENGINEERS         *
*    HYDROLOGIC ENGINEERING CENTER        *
*          609 SECOND STREET              *
*       DAVIS, CALIFORNIA 95616           *
*           (916) 756-1104                *
*                                         *
*****************************************

COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT100.DAT
PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
100 Year, 24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
```

```
                     8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED

7 IO       OUTPUT CONTROL VARIABLES
                 IPRNT          5  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT       HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME       0000  STARTING TIME
                    NQ        144  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     2    0  ENDING DATE
                NDTIME       1145  ENDING TIME
                ICENT          19  CENTURY MARK

            COMPUTATION INTERVAL    .25 HOURS
                 TOTAL TIME BASE  35.75 HOURS

     ENGLISH UNITS
          DRAINAGE AREA          SQUARE MILES
          PRECIPITATION DEPTH    INCHES
          LENGTH, ELEVATION      FEET
          FLOW                   CUBIC FEET PER SECOND
          STORAGE VOLUME         ACRE-FEET
          SURFACE AREA           ACRES
```

TEMPERATURE DEGREES FAHRENHEIT

1

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD			BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+					6-HOUR	24-HOUR	72-HOUR			
	HYDROGRAPH AT									
+		DPPR2	2379.	12.75	804.	314.	221.	6.10		
	ROUTED TO									
+		DBPR2	2079.	13.25	804.	314.	221.	6.10		
+									78.25	13.25

*** NORMAL END OF HEC-1 ***

8'x14' CBC
500-year

```
1*****************************************                ***************************************
 *                                       *                *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                *   U.S. ARMY CORPS OF ENGINEERS      *
 *              JUN   1998               *                *   HYDROLOGIC ENGINEERING CENTER     *
 *            VERSION 4.1                *                *         609 SECOND STREET           *
 *                                       *                *      DAVIS, CALIFORNIA 95616        *
 *  RUN DATE   06AUG18  TIME  14:41:35   *                *          (916) 756-1104             *
 *                                       *                *                                     *
 *****************************************                ***************************************


                    X     X  XXXXXXX   XXXXX          X
                    X     X  X         X     X       XX
                    X     X  X         X              X
                    XXXXXXX  XXXX      X       XXXXX  X
                    X     X  X         X              X
                    X     X  X         X     X        X
                    X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.
```

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1       ID        COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT5.DAT
  2       ID        PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
  3       ID        INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
  4       ID        500 YEAR    24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
  5       ID        8' X 14' CBC  OLD COWPOKE ROAD BRIDGE REMOVED
          *DIAGRAM
  6       IT      15       0       0     144
  7       IO       5       0

  8       KK   DPPR2
  9       KM       DESIGN POINT PR 2 INFLOW TO DET BASIN PR2
 10       BA     6.1
 11       QI       0       0     1.1     4.8     6.9     8.9    11.1    12.9    14.4    15.6
 12       QI    16.4    17.3    18.2    18.9    19.5    20.1      21    22.7    23.9      25
```

```
13          QI   24.8   24.6     30   29.4   29.7     31   33.2   34.5   35.8   37.2
14          QI   38.4   39.3   40.2   41.3   43.5   46.3   48.5     51     78     96
15          QI    104    111    118    132    156    192    239    349    841   1958
16          QI   3576   3263   2801   2304   1852   1509   1248   1046    885    769
17          QI    681    612    554    502    460    428    405    388    372    354
18          QI    340    327    317    305    291    278    268    259    253    250
19          QI    247    240    230    219    210    202    196    193    190    189
20          QI    188    188    188    188    188    188    185

21          KK  DBPR2
22          KM         ROUTE INFLOW HYDROGRAPH THROUGH DETETNION BASIN PR2
23          KM         THIS IS OUTFLOW FROM DETENTION BASIN PR2
24          KM         8' X 14 CBC OUTLET PIPE
25          RS      1   ELEV     58
26          SV      0    .11     .4   1.01      2   3.57   6.78   8.75   12.5   17.3
27          SV     23   30.2   38.2   47.3   57.3   68.5   79.6   92.1
28          SE     58     60     62     64     66     68     70     72     74     76
29          SE     78     80     82     84     86     88     90
30          SQ      0    120    300    550    850   1160   1400   1600   1740   1910
31          SQ   2060   2210   2330   2480   2580   2670   2760   2880
32          ZZ
1

        SCHEMATIC DIAGRAM OF STREAM NETWORK

INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
```

```
NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  8       DPPR2
              V
              V
 21       DBPR2

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                    ****************************************
*                                       *                    *                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *    U.S. ARMY CORPS OF ENGINEERS      *
*              JUN   1998               *                    *    HYDROLOGIC ENGINEERING CENTER     *
*           VERSION 4.1                 *                    *          609 SECOND STREET           *
*                                       *                    *       DAVIS, CALIFORNIA 95616        *
*  RUN DATE   06AUG18  TIME  14:41:35   *                    *           (916) 756-1104             *
*                                       *                    *                                      *
****************************************                     ****************************************

                         COTTONWOOD CREEK DETENTION BASIN AT TUTT BOULEVARD FN:COT5.DAT
                         PRELIMINARY HYDROLOGY  DEVELOPED BASIN CONDITION     PN 17043
                         INFLOW HYDROGRAPH PER MATRIX COTTONWOOD DBPS
                         500 YEAR    24HR RAINFALL NOAA ATLAS 2 PER DCM TYPE II DISTRIBUTION
```

8' X 14' CBC OLD COWPOKE ROAD BRIDGE REMOVED

```
7 IO      OUTPUT CONTROL VARIABLES
               IPRNT          5  PRINT CONTROL
               IPLOT          0  PLOT CONTROL
               QSCAL          0. HYDROGRAPH PLOT SCALE

  IT      HYDROGRAPH TIME DATA
                NMIN         15  MINUTES IN COMPUTATION INTERVAL
               IDATE      1   0  STARTING DATE
               ITIME       0000  STARTING TIME
                  NQ        144  NUMBER OF HYDROGRAPH ORDINATES
              NDDATE      2   0  ENDING DATE
              NDTIME       1145  ENDING TIME
               ICENT         19  CENTURY MARK

            COMPUTATION INTERVAL    .25 HOURS
                 TOTAL TIME BASE  35.75 HOURS

     ENGLISH UNITS
          DRAINAGE AREA         SQUARE MILES
          PRECIPITATION DEPTH   INCHES
          LENGTH, ELEVATION     FEET
          FLOW                  CUBIC FEET PER SECOND
          STORAGE VOLUME        ACRE-FEET
          SURFACE AREA          ACRES
```

TEMPERATURE DEGREES FAHRENHEIT

1

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+										
	HYDROGRAPH AT									
+		DPPR2	3576.	12.50	1145.	438.	309.	6.10		
	ROUTED TO									
+		DBPR2	2600.	13.00	1145.	438.	309.	6.10		
+									86.43	13.00

*** NORMAL END OF HEC-1 ***

APPENDIX D

MAJOR DRAINAGEWAY HYDRAULIC CALCULATIONS
CONDITIONAL LETTER OF MAP REVISION CASE NO. 18-18-1091P

12043

TWAFRZ

HY-8 Culvert Analysis Report

8' x 14' CBC

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 1950 cfs

Maximum Flow: 2500 cfs

Table 1 - Summary of Culvert Flows at Crossing: Crossing 1

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6858.00	0.00	0.00	0.00	1
6861.55	250.00	250.00	0.00	1
6863.63	500.00	500.00	0.00	1
6865.41	750.00	750.00	0.00	1
6867.16	1000.00	1000.00	0.00	1
6869.08	1250.00	1250.00	0.00	1
6871.30	1500.00	1500.00	0.00	1
6873.92	1750.00	1750.00	0.00	1
6876.32	1950.00	1950.00	0.00	1
6880.45	2250.00	2250.00	0.00	1
6884.60	2500.00	2500.00	0.00	1
6892.00	2880.34	2880.34	0.00	Overtopping

Rating Curve Plot for Crossing: Crossing 1

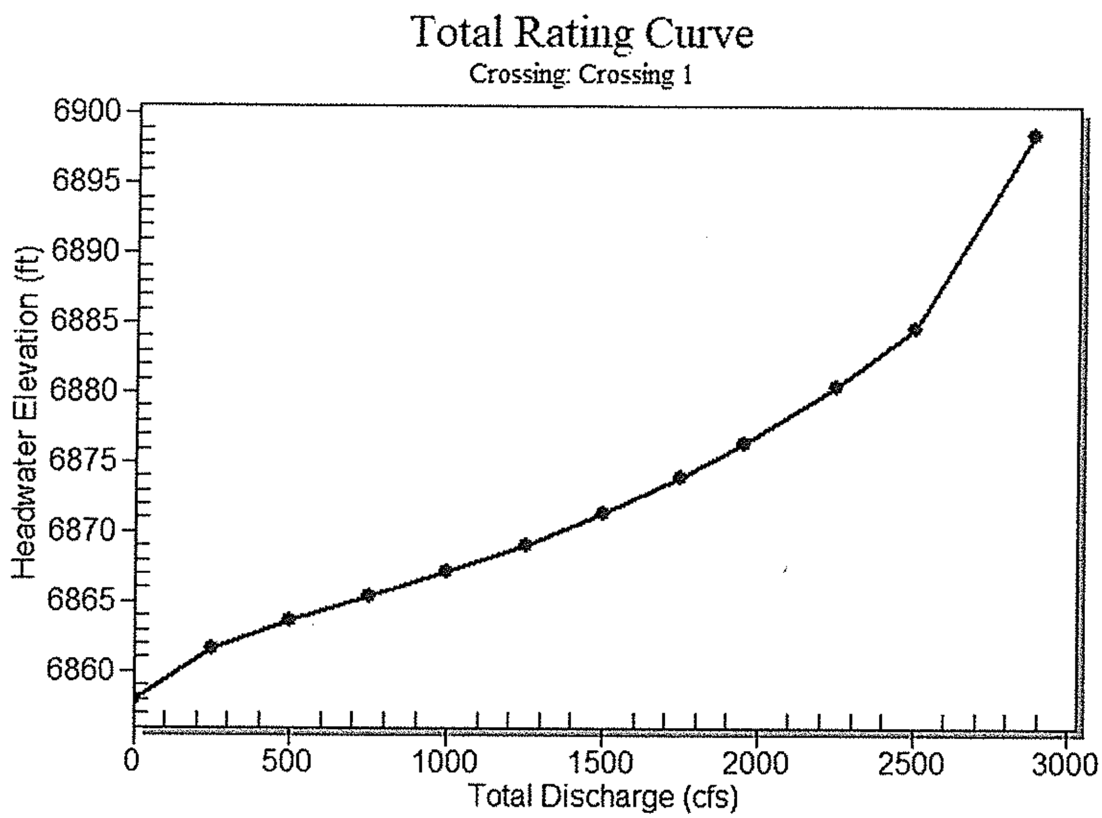


Table 2 - Culvert Summary Table: Culvert 1

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)
0.00	0.00	6858.00	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
250.00	250.00	6861.55	3.545	0.0*	1-S2n	0.844	2.147	0.896	1.573	19.940	6.047
500.00	500.00	6863.63	5.629	0.0*	1-S2n	1.311	3.409	1.422	2.295	25.113	7.466
750.00	750.00	6865.41	7.410	0.0*	1-S2n	1.705	4.467	1.924	2.845	27.846	8.402
1000.00	1000.00	6867.16	9.161	0.0*	5-S2n	2.061	5.411	2.406	3.302	29.682	9.118
1250.00	1250.00	6869.08	11.081	0.0*	5-S2n	2.390	6.279	2.874	3.701	31.064	9.705
1500.00	1500.00	6871.30	13.304	0.0*	5-S2n	2.703	7.091	3.330	4.057	32.173	10.206
1750.00	1750.00	6873.92	15.916	1.261	5-S2n	3.001	7.858	3.776	4.381	33.106	10.645
* 1950.00	1950.00	6876.32	18.316	3.104	5-S2n	3.233	8.000	4.123	4.622	33.782	10.962
* 2250.00	2250.00	6880.45	22.451	6.120	5-S2n	3.569	8.000	4.615	4.958	34.821	11.394
2500.00	2500.00	6884.60	26.600	8.964	5-S2n	3.842	8.000	4.996	5.219	35.740	11.720

* FOR HGL, HEC-RAS MODEL USED FOR UPSTREAM WATER SURFACE ELEVATION.

* Full Flow Headwater elevation is below inlet invert.

****

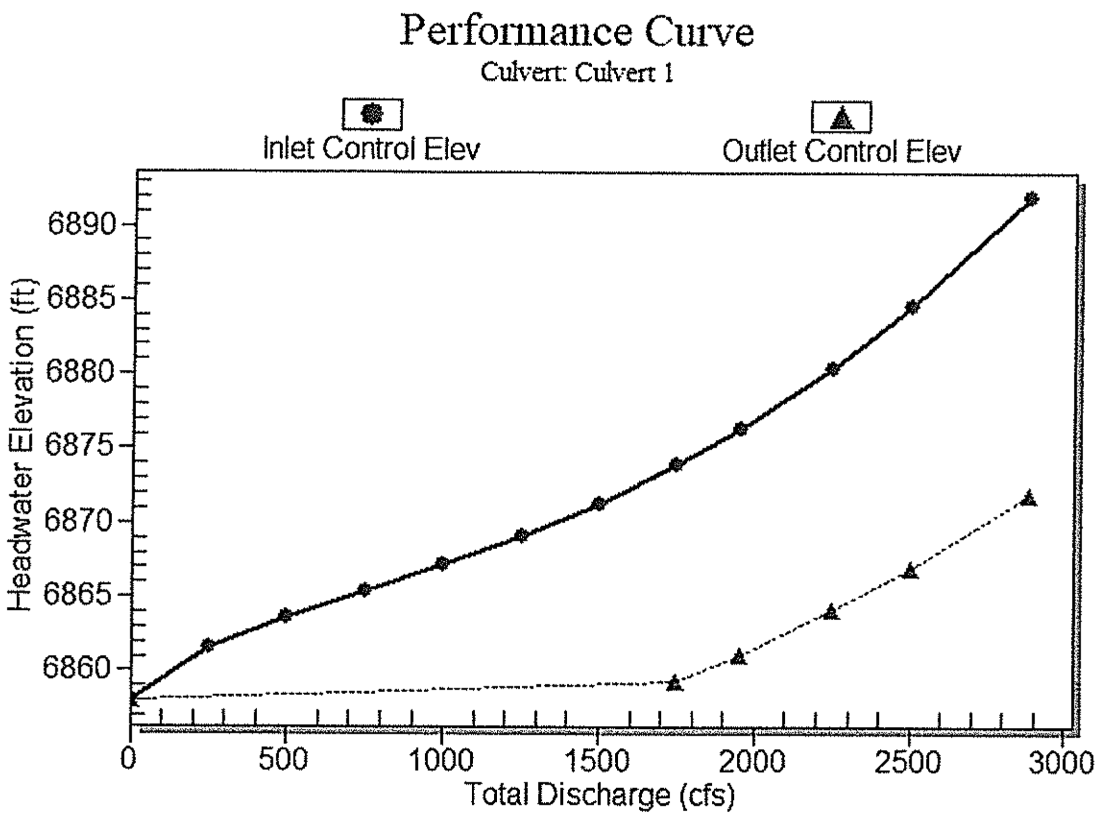
Straight Culvert

Inlet Elevation (invert): 6858.00 ft,   Outlet Elevation (invert): 6844.00 ft

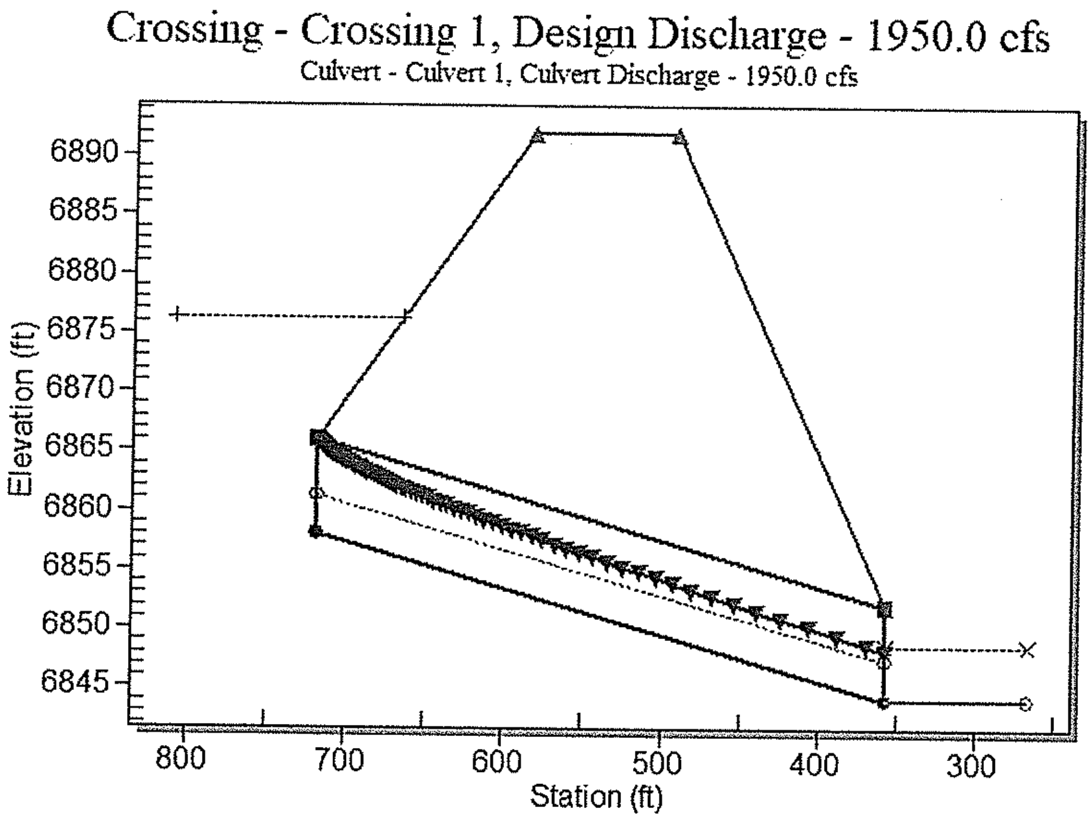
Culvert Length: 361.27 ft,   Culvert Slope: 0.0388

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 718.00 ft

Inlet Elevation: 6858.00 ft

Outlet Station: 357.00 ft

Outlet Elevation: 6844.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 14.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Crossing 1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	6844.00	0.00	0.00	0.00	0.00
250.00	6845.57	1.57	6.05	1.47	0.95
500.00	6846.30	2.30	7.47	2.15	1.00
750.00	6846.84	2.84	8.40	2.66	1.02
1000.00	6847.30	3.30	9.12	3.09	1.05
1250.00	6847.70	3.70	9.70	3.46	1.06
1500.00	6848.06	4.06	10.21	3.80	1.07
1750.00	6848.38	4.38	10.64	4.10	1.09
1950.00	6848.62	4.62	10.96	4.33	1.09
2250.00	6848.96	4.96	11.39	4.64	1.10
2500.00	6849.22	5.22	11.72	4.88	1.11

Tailwater Channel Data - Crossing 1

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 20.00 ft

Side Slope (H:V): 4.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0350

Channel Invert Elevation: 6844.00 ft

Roadway Data for Crossing: Crossing 1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 200.00 ft

Crest Elevation: 6892.00 ft

Roadway Surface: Paved

Roadway Top Width: 90.00 ft

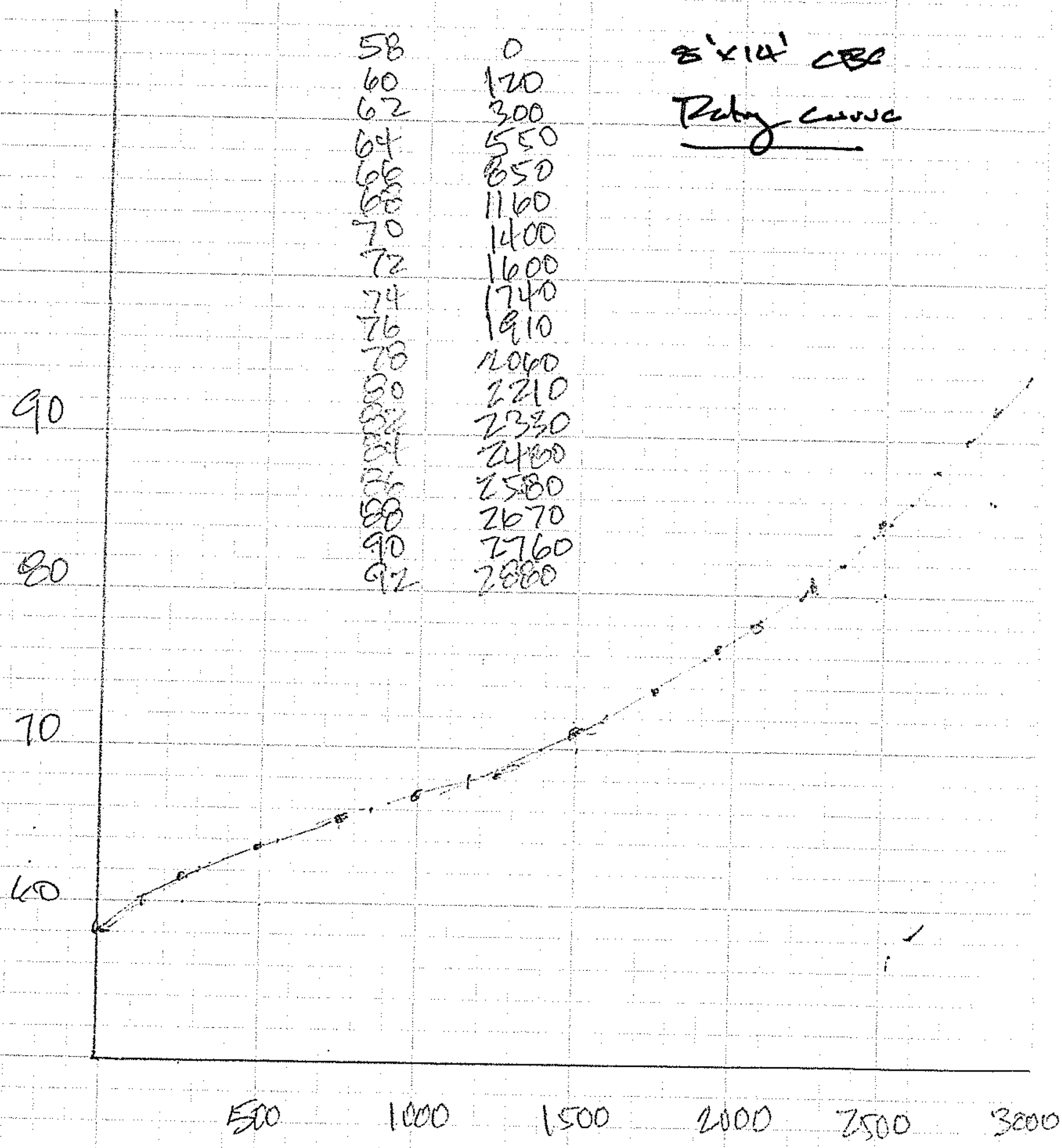
Kiowa Engineering Corporation

CLIENT: City of CS
JOB NO. 17043
PAGE:
PROJECT:
DATE CHECKED:
DATE:
DETAIL: Outlet Culvert Hydraulics
CHECKED BY: RJW
COMPUTED BY: RJW

8'x14' CBC

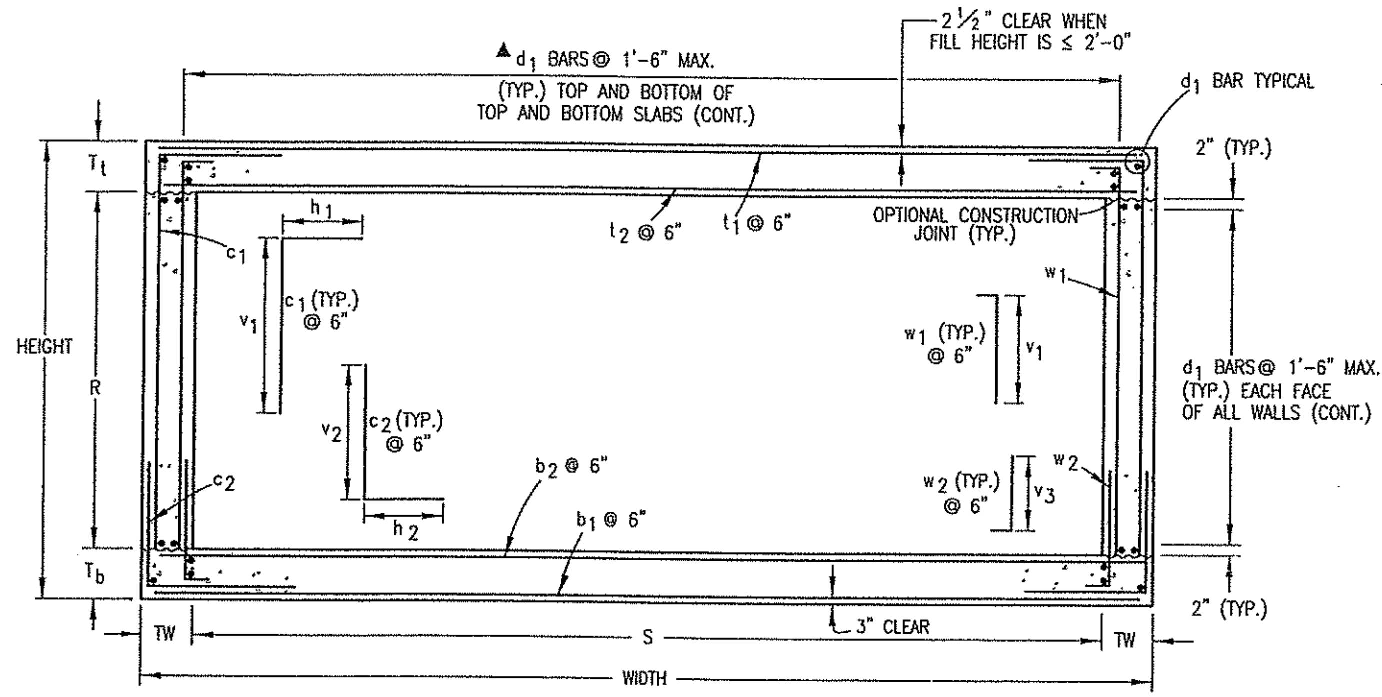
Rating curve

58	0
60	120
62	300
64	550
66	850
68	1160
70	1400
72	1600
74	1740
76	1910
78	2060
80	2210
82	2330
84	2480
86	2580
88	2670
90	2760
92	2860

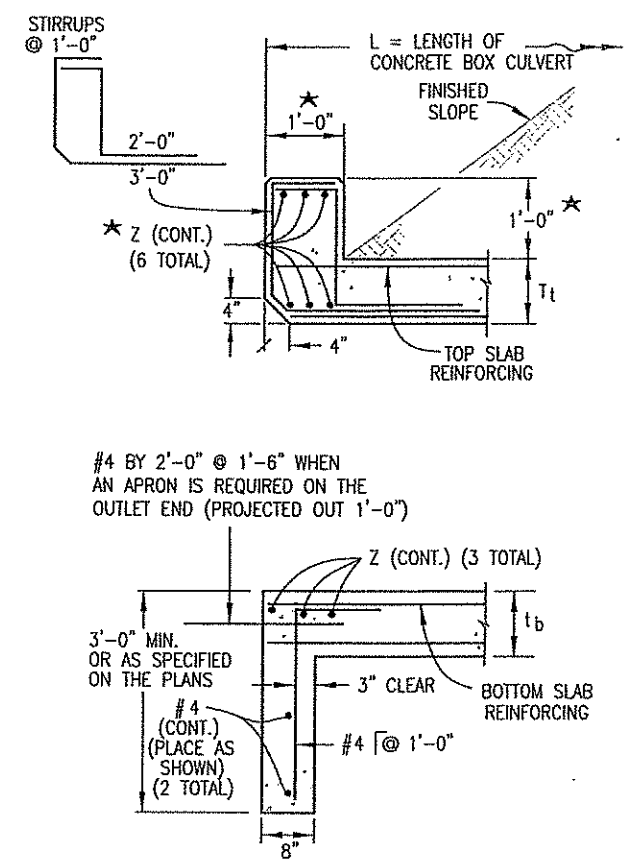


City of Colorado Springs
Cottonwoood Creek PR 2 Stormwater Detention Basin Final Design
Volume Calculation

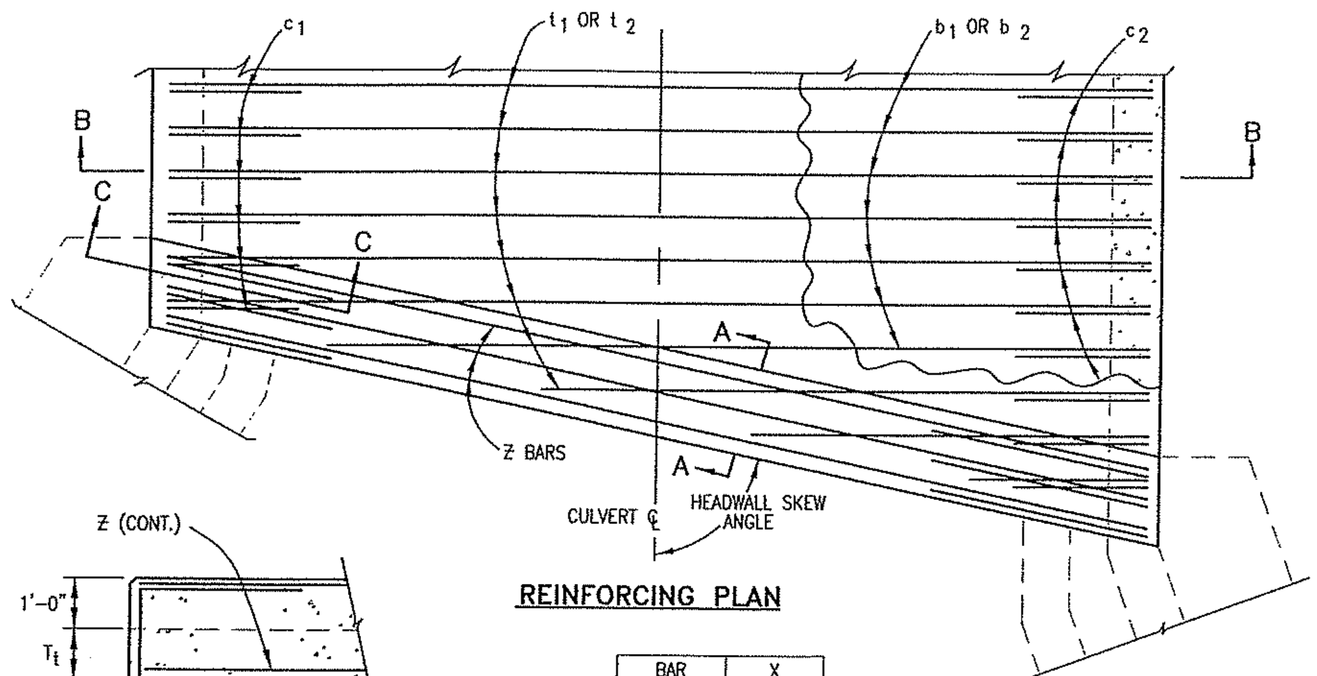
Stage	Elevation	Area sq. ft.	Area Acres	Avg. Area	Increment	Incremental Volume	Cumulative Volume
0	58	0	0.00				
				0.05	2	0.11	0.11
2	60	4,582	0.11				
				0.15	2	0.30	0.40
4	62	8,300	0.19				
				0.31	2	0.61	1.01
6	64	18,444	0.42				
				0.49	2	0.99	2.00
8	66	24519	0.56				
				0.76	2	1.52	3.53
10	68	41871	0.96				
				1.13	2	2.26	5.78
12	70	56530	1.30				
				1.48	2	2.97	8.75
14	72	72788	1.67				
				1.89	2	3.78	12.54
16	74	92028	2.11				
				2.33	2	4.66	17.20
18	76	111103	2.55				
				2.91	2	5.83	23.03
20	78	142697	3.28				
				3.56	2	7.12	30.15
22	80	167435	3.84				
				4.03	2	8.06	38.20
24	82	183599	4.21				
				4.53	2	9.06	47.26
26	84	210893	4.84				
				5.01	2	10.02	57.28
28	86	225683	5.18				
				5.37	2	10.73	68.01
28	88	241734	5.55				
				5.79	2	11.58	79.59
28	90	262644	6.03				
				6.28	2	12.55	92.14
28	92	284060	6.52				



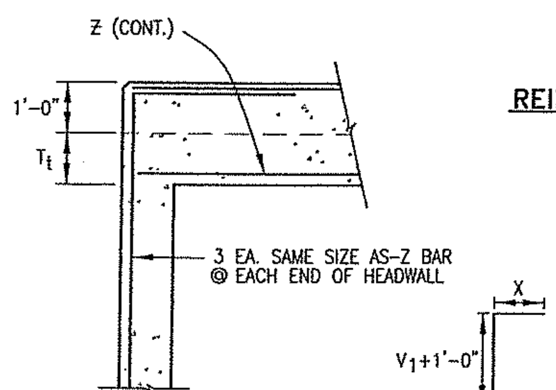
SECTION B–B



SECTION A–A



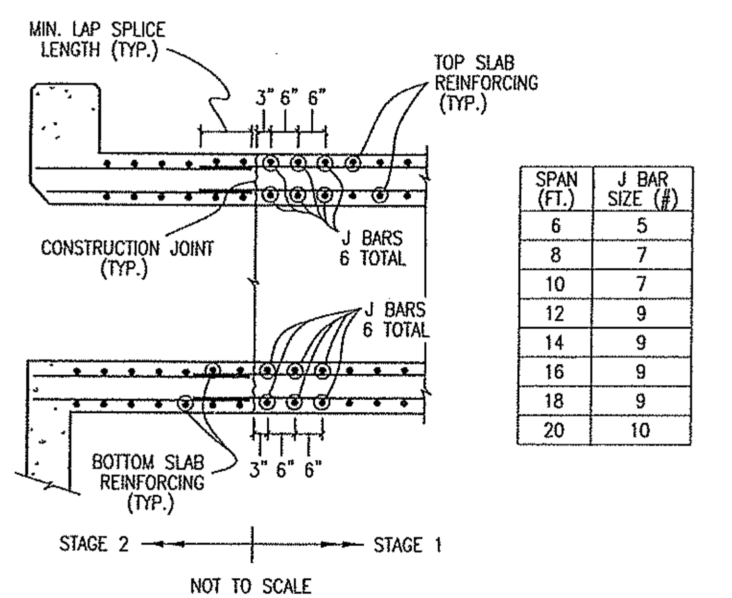
REINFORCING PLAN



SECTION C–C

HEADWALL CORNER REINFORCING DETAIL

BAR SIZE (#)	X (FT.–IN.)
4	1–9
5	2–2
6	2–7
7	3–1
8	4–0
9	5–1
10	6–5
11	7–11



SPAN (FT.)	J BAR SIZE (#)
6	5
8	7
10	7
12	9
14	9
16	9
18	9
20	10

CONSTRUCTION JOINT DETAIL FOR STAGED CONSTRUCTION

NOTE: THIS DETAIL IS FOR CONSTRUCTION JOINTS PERPENDICULAR TO THE ℄ OF THE BOX ONLY.

GENERAL NOTES

1. ALL CONCRETE SHALL BE CLASS D (BOX CULVERT).
2. ALL CONSTRUCTION JOINTS SHALL BE THOROUGHLY CLEANED BEFORE FRESH CONCRETE IS PLACED.
3. CONSTRUCTION JOINTS NOT SHOWN ON THE PLANS MAY BE CONSTRUCTED ONLY IF APPROVED BY THE ENGINEER.
4. THE CONTRACTOR SHALL MAINTAIN THE STABILITY OF THE STRUCTURE DURING CONSTRUCTION.
5. STRUCTURE EXCAVATION AND BACKFILL SHALL BE IN ACCORDANCE WITH STANDARD PLAN M-206-1.
6. FOR ANY CULVERT SPAN 20 FT. OR GREATER, A FOUNDATION INVESTIGATION AND REPORT ARE REQUIRED.
7. BACKFILL SHALL NOT BEGIN UNTIL TOP SLAB HAS REACHED DESIGN STRENGTH, f'_c.
8. SPLICE QUANTITIES FOR LONGITUDINAL AND TRANSVERSE BARS ARE NOT INCLUDED.
9. REINFORCING STEEL SHALL BE GRADE 60.
10. THE MINIMUM LAP SPLICE LENGTH FOR EPOXY COATED REINFORCING BARS SHALL BE:

BAR SIZE:	#4	#5	#6	#7	#8	#9	#10	#11
SPLICE LENGTH:	1'-3"	1'-6"	1'-10"	2'-2"	3'-8"	4'-8"	5'-11"	7'-3"

THE MINIMUM LAP SPLICE LENGTH FOR BLACK REINFORCING BARS SHALL BE:

BAR SIZE:	#4	#5	#6	#7	#8	#9	#10	#11
SPLICE LENGTH:	1'-0"	1'-4"	1'-7"	1'-10"	2'-5"	3'-1"	3'-11"	4'-10"

11. ALL DIMENSIONS ARE PERPENDICULAR TO THE CENTERLINE OF THE BOX.
12. WINGWALLS SHALL BE TIED TO CONCRETE BOX CULVERT IN ACCORDANCE WITH STANDARD PLAN M-601-20.
13. ALL TRANSVERSE REINFORCING SHALL BE NORMAL TO THE CENTERLINE OF THE BOX.
14. FILL HEIGHT IS THE DISTANCE MEASURED FROM TOP OF TOP SLAB TO TOP OF PAVEMENT.
15. ALL EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ IN.

▲ WHEN THE FILL HEIGHT IS LESS THAN OR EQUAL TO 2 FT., THE SPACING OF THE d_1 BARS IN THE BOTTOM OF THE TOP SLAB SHALL BE 6 IN. OR LESS. USE THE FOLLOWING EQUATION TO CALCULATE THE ADDITIONAL REINFORCING QUANTITY. WHERE S IS IN FEET:

ADDED REINFORCING, LBS./LIN FT. $= \left(\frac{S}{0.5} - \frac{S}{1.5}\right) \times 0.668 = 0.891\ S$

DESIGN DATA: 16TH EDITION OF THE AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES

SERVICE LOAD DESIGN METHOD

UNIT STRESSES: f_s = 24,000 psi., f_y = 60,000 psi., f_c = 1,800 psi., f'_c = 4,500 psi., n = 8

LOADING DATA:

LIVE LOAD = AASHTO, HS 20-44 AND ALTERNATE MILITARY LOADING

DEAD LOAD CASE 1: VERTICAL EARTH LOAD = 120 LBS./CU. FT. HORIZONTAL EARTH LOAD = 30 LBS./CU.FT.

DEAD LOAD CASE 2: VERTICAL EARTH LOAD = 120 LBS./CU. FT. HORIZONTAL EARTH LOAD = 60 LBS./CU. FT.

FUTURE HMA OVERLAY = 48 LBS./SQ. FT. BASED ON 4 IN. THICKNESS

LIVE LOAD SURCHARGE ON EXTERIOR WALLS = 2 FT. OF EARTH

★ IF HEADWALL MOUNT GUARDRAIL IS USED (SEE STANDARD PLAN M-606-1, SHEET 16):

- ALL REINFORCING STEEL SHALL BE ACCORDING TO THIS BOX CULVERT PLAN.
- ANY ADDITIONAL STIRRUP LENGTH WILL NOT BE MEASURED AND PAID FOR SEPARATELY BUT SHALL BE INCLUDED IN THE WORK.
- HEADWALL DIMENSION AND CONCRETE QUANTITY SHALL BE ACCORDING TO STANDARD PLAN M-606-1, SHEET 16.
- POST ANCHORS SHALL BE PROVIDED ACCORDING TO STANDARD PLAN M-606-1, SHEET 16.
- POST ANCHORS AND CONCRETE FOR HEADWALL MOUNT OF GUARDRAIL WILL NOT BE MEASURED AND PAID FOR SEPARATELY BUT SHALL BE INCLUDED IN THE WORK.
- POST ANCHORS WHEN REQUIRED AND ENCASED IN HEADWALL CONCRETE, SHALL CONFORM TO ASTM A 36 OR AASHTO M 169 STEEL.

Computer File Information	
Creation Date: 07/04/06	Initials: SJR
Last Modification Date: 07/04/06	Initials: LTA
Full Path: www.dot.state.co.us/DesignSupport/	
Drawing File Name: 601010102.dwg	
CAD Ver.: MicroStation V8 Scale: Not to Scale	Units: English

(R-X) (R-X) (R-X) (R-X)

Sheet Revisions	
Date:	Comments

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Project Development Branch SRJ/LTA

SINGLE CONCRETE BOX CULVERT

Issued By: Project Development Branch on July 04, 2006

STANDARD PLAN NO.
M-601-1
Sheet No. 1 of 2

SINGLE CONCRETE BOX CULVERT DIMENSIONS & QUANTITIES (EXCLUDING HEADWALLS & TOEWALLS)

BOX SIZE S	BOX SIZE R	HT.	WIDTH	FILL HEIGHT ALLOWED	SLAB & WALL THICKNESS (INCHES) T_t	T_b	TW	BAR SIZES t_1* & b_1	t_2	b_2	w_1* & w_2	c_1*	c_2	d_1▲	DIMENSIONS h_1	h_2	v_1	v_2	v_3	QUANTITIES CONCRETE	REBAR STL.
FT.	FT.	FT.-IN.	FT.-IN.	FT.-FT.				#	#	#	#	#	#	NO.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	CU.YDS./LIN.FT.	LBS./LIN.FT.
6	7	8-5	7-8	0 TO 10	8	9	10	4	5	5	4	4	4	48	2-7	2-11	7-6	2-3	2-3	0.834	153
		8-7	7-8	>10 TO 15	8.5	10.5	10	4	5	5	4	4	4		2-7	3-1	7-6	2-4	2-4	0.882	154
		8-10	7-8	>15 TO 20	10	12.0	10	4	5	5	4	4	4		2-7	3-3	7-9	2-6	2-6	0.953	156
8	6	7-7.5	9-8	0 TO 10	9	10.5	10	4	6	6	4	4	4	52	3-4	2-10	6-7	2-4	2-4	0.952	184
		7-11	9-8	>10 TO 15	10.5	12.5	10	4	6	6	4	4	4		3-0	2-10	6-8	2-6	2-6	1.057	184
		8-3	9-8	>15 TO 20	12.5	14.5	10	4	7	7	4	4	4		3-2	2-11	6-10	2-8	2-8	1.176	207
	8	9-7.5	9-8	0 TO 10	9.0	10.5	10	4	6	6	4	5	4	60	4-5	3-5	8-7	2-4	2-4	1.076	224
		9-11	9-8	>10 TO 15	10.5	12.5	10	4	6	6	4	5	4		2-9	3-7	8-8	2-6	2-6	1.180	218
		10-3	9-8	>15 TO 20	12.5	14.5	10	4	6	6	4	5	4		2-9	3-9	8-10	2-8	2-8	1.299	221
	10	11-8	9-8	0 TO 10	9	11	10	4	6	5	5	5	5	64	2-9	2-9	10-7	2-10	2-10	1.214	253
		11-11	9-8	>10 TO 15	10.5	12.5	10	4	6	6	5	5	5		2-9	2-9	10-8	2-11	2-11	1.303	267
		12-3	9-11	>15 TO 20	12.5	14.5	11.5	4	6	6	5	5	5		2-11	5-1	10-10	3-1	3-1	1.536	282
10	6	7-10.5	11-8	0 TO 10	10.5	12.0	10	4	6	7	4	5	5	56	3-4	3-0	6-8	2-11	2-6	1.181	243
		8-3	11-8	>10 TO 15	12.5	14.5	10	4	7	7	4	5	4		3-4	2-11	6-10	3-1	2-8	1.343	248
		8-10	11-8	>15 TO 20	15.5	18.5	10	4	7	7	4	4	5		3-1	2-9	7-1	3-5	3-0	1.395	244
	8	9-10.5	11-8	0 TO 10	10.5	12.0	10	4	6	7	4	5	5	64	3-11	3-5	8-8	2-11	2-6	1.304	266
		10-3.5	11-8	>10 TO 15	13	14.5	10	4	7	7	4	5	5		4-1	3-6	8-11	3-1	2-8	1.484	282
		10-9	11-8	>15 TO 20	15.5	17.5	10	4	7	7	4	5	5		3-6	2-11	9-1	3-4	2-11	1.682	280
	10	11-11	11-8	0 TO 10	10.5	12.5	10	4	6	6	4	5	5	68	2-11	4-6	10-8	2-11	2-6	1.445	270
		12-3.5	11-8	>10 TO 15	12.5	15.0	10	4	7	7	5	6	5		3-4	4-10	10-10	3-7	3-2	1.608	354
		12-8	11-11	>15 TO 20	15.0	17.5	11.5	4	7	7	5	5	5		3-8	3-4	11-1	3-4	3-4	1.905	328
12	6	7-11	13-8	0 TO 8	10.5	12.5	10	4	7	7	4	6	5	60	3-11	3-8	6-8	3-4	2-6	1.341	306
		8-4	13-8	>8 TO 12	13	15	10	4	8	8	4	5	5		2-10	2-9	6-11	3-2	2-9	1.551	313
		8-9.5	13-8	>12 TO 16	15.5	18	10	4	8	8	4	5	5		3-6	2-9	7-1	3-5	3-0	1.783	319
		9-3.5	13-8	>16 TO 20	19.0	20.5	10	4	8	9	4	5	5		3-6	2-9	7-5	3-7	3-2	2.037	341
	8	9-11	13-8	0 TO 8	10.5	12.5	10	4	7	7	5	6	5	68	4-1	3-9	8-8	3-4	2-11	1.464	351
		10-4	13-8	>8 TO 12	13	15	10	4	8	8	4	6	5		3-4	2-9	8-11	3-6	2-9	1.675	358
		10-9.5	13-8	>12 TO 16	15.5	18	10	4	8	8	4	5	5		3-6	2-10	9-1	3-5	3-0	1.907	338
		11-3.5	13-8	>16 TO 20	18.5	21	10	4	8	8	4	5	5		3-6	3-0	9-4	3-8	3-3	2.160	342
	10	12-0	13-8	0 TO 8	11	13	10	4	7	7	4	6	5	72	5-3	4-4	10-8	3-5	2-7	1.630	360
		12-4.5	13-8	>8 TO 12	13	15.5	10	4	8	8	4	6	6		3-4	3-4	10-11	3-7	2-9	1.819	393
		12-9.5	13-9	>12 TO 16	15.5	18	10.5	4	8	8	4	6	5		4-3	3-2	11-1	3-10	3-0	2.070	390
		13-2	13-11	>16 TO 20	18	20	11.5	4	8	8	4	6	5		4-4	3-5	11-4	4-0	3-2	2.342	396
14	6	7-11.5	15-8	0 TO 6	11	12.5	10	4	8	8	5	6	6	68	4-3	4-0	6-9	3-4	2-11	1.507	408
		8-2	15-8	>6 TO 8	12	14	10	4	8	8	4	6	6		4-1	3-4	6-10	3-6	2-8	1.628	386
		8-5	15-8	>8 TO 10	13.5	15.5	10	4	8	8	4	6	5		3-4	2-9	6-11	3-7	2-9	1.773	368
		8-9	15-8	>10 TO 12	15.5	17.5	10	4	9	9	4	6	5		4-3	2-10	7-1	3-9	2-11	1.966	421
		9-4.5	15-8	>12 TO 16	19.5	21	10	4	9	9	4	5	5		3-6	2-10	7-5	3-8	3-3	2.329	400
		9-7.5	15-8	>16 TO 18	21	22.5	10	4	9	9	4	5	5		3-6	2-11	7-7	3-9	3-4	2.474	402
	8	10-0	15-8	0 TO 6	11	13	10	4	8	8	5	6	6	76	4-4	4-1	8-9	3-5	3-0	1.654	435
		10-2	15-8	>6 TO 8	12	14	10	4	8	8	4	6	6		4-2	3-7	8-10	3-6	2-8	1.751	410
		10-5.5	15-8	>8 TO 10	13.5	16	10	4	8	8	4	6	5		3-4	2-11	8-11	3-8	2-10	1.920	394
		10-10	15-8	>10 TO 12	15.5	18.5	10	4	9	9	4	6	5		4-3	2-11	9-1	3-10	3-0	2.138	444
		11-3.5	15-9	>12 TO 16	18.5	21	10.5	4	9	9	4	5	5		3-7	3-1	9-4	3-8	3-3	2.439	421
		11-6.5	15-8	>16 TO 18	20	22.5	10	4	9	9	4	5	5		3-6	3-1	9-6	3-9	3-4	2.549	419
	10	12-0	15-8	0 TO 6	11	13	10	4	8	8	5	6	6	80	4-10	4-4	10-9	3-5	3-0	1.778	455
		12-2.5	15-8	>6 TO 8	12	14.5	10	4	8	8	4	6	6		4-10	4-3	10-10	3-6	2-8	1.899	439
		12-5.5	15-9	>8 TO 10	13.5	16	10.5	4	8	8	4	6	6		3-4	3-5	10-11	3-8	2-10	2.082	426
		12-9.5	15-9	>10 TO 12	15.5	18	10.5	4	8	8	4	6	6		4-3	3-4	11-1	3-10	3-0	2.277	436
		13-4	15-10	>12 TO 16	18.5	21.5	11	4	9	9	4	6	5		4-4	3-5	11-4	4-1	3-3	2.634	443
		13-6.5	15-11	>16 TO 18	20	22.5	11.5	4	9	9	4	6	5		4-4	3-6	11-6	4-2	3-4	2.798	477
16	6	8-2.5	17-9	0 TO 6	12.5	14	10.5	4	8	8	4	7	6	72	4-7	3-11	6-10	3-6	2-8	1.841	452
		8-5.5	17-11	>6 TO 8	13.5	16	11.5	4	8	8	5	7	6		3-10	3-5	6-11	3-8	3-3	2.057	463
		8-9	17-10	>8 TO 10	15.5	17.5	11	4	9	9	5	7	6		4-10	3-5	7-1	3-9	3-4	2.242	524
	8	10-3.5	17-9	0 TO 6	12.5	15	10.5	4	8	8	5	7	6	80	4-7	3-10	8-10	3-7	3-2	2.025	497
		10-6.5	17-10	>6 TO 8	14.0	16.5	11.0	4	9	9	4	7	6		3-8	3-4	9-0	4-2	2-10	2.189	522
		10-11	17-9	>8 TO 10	16.5	18.5	10.5	4	9	9	4	6	5		4-3	3-2	9-2	3-10	3-0	2.436	484
	10	12-4.5	17-8	0 TO 6	13.5	15	10	4	8	9	5	7	6	84	4-9	4-3	10-11	3-7	3-2	2.171	554
		12-8	17-9	>6 TO 8	15	17	10.5	4	9	9	4	6	6		4-3	3-4	11-1	3-9	2-11	2.401	515
		12-11	17-9	>8 TO 10	16.5	18.5	10.5	4	9	9	4	6	6		4-3	3-4	11-2	3-10	3-0	2.566	516
18	8	10-5	19-11	0 TO 5	13.5	15.5	11.5	4	8	9	5	7	7	84	5-2	4-5	8-11	4-1	3-2	2.351	588
		10-9	19-10	>5 TO 7	15.5	17.7	11	4	9	9	4	7	6		4-10	3-11	9-1	3-9	2-11	2.563	565
	10	12-6	19-10	0 TO 5	14	16	11	4	9	9	4	7	6	88	5-1	4-6	11-0	3-8	2-10	2.515	598
		12-9	19-11	>5 TO 7	15.5	17.5	11.5	4	9	9	4	7	6		5-0	4-5	11-1	3-10	2-11	2.738	597
20	8	10-3.5	22-0	0 TO 3	13.5	15	12	5	9	9	5	7	8	92	5-9	5-2	8-11	4-1	3-2	2.528	700
		10-9.5	22-2	>3 TO 6	16	17.5	13	4	9	9	4	7	7		5-5	4-9	9-2	4-3	2-11	2.934	646
		11-0.5	22-3	>6 TO 8	17	19.5	13.5	4	9	10	4	8	7		5-8	4-7	9-3	4-5	3-1	3.173	727
		11-5.5	22-2	>8 TO 10	19.5	22	13	4	10	10	4	7	6		5-0	4-4	9-4	4-2	3-4	3.481	702
	10	12-5.5	21-11	0 TO 3	15	15.5	11.5	4	9	9	5	7	7	96	5-4	4-11	11-1	4-1	3-2	2.773	692
		12-9	22-1	>3 TO 6	15	18	12.5	4	9	10	4	8	7		5-8	4-9	11-1	4-4	3-0	3.021	751
		13-0.5	22-1	>6 TO 8	17	19.5	12.5	4	10	10	4	8	7		5-7	4-7	11-3	4-5	3-1	3.259	792
		13-5.5	22-2	>8 TO 10	19.5	22	13	4	10	10	4	7	6		5-1	4-7	11-5	4-2	3-4	3.642	728

HEADWALL AND TOEWALL QUANTITIES

HEADWALL SKEW ANGLE	90° TO 75 °			74° TO 60 °			59° TO 45 °		
SPAN - S	Z	STIRRUPS	REBAR QUANT.	Z	STIRRUPS	REBAR QUANT.	Z	STIRRUPS	REBAR QUANT.
	#	#	LBS./LIN.FT.	#	#	LBS./LIN.FT.	#	#	LBS./LIN.FT.
6	4	4	22.1	4	4	21.9	4	4	21.3
8	4	4	22.5	4	4	22.3	5	4	28.0
10	5	4	28.2	5	4	27.9	7	4	43.2
12	5	4	27.6	6	4	34.5	8	5	56.4
14	6	4	34.0	7	4	41.9	10	5	81.5
16	6	4	32.3	8	5	53.3	☆	☆	☆
18	7	4	39.0	9	5	62.6	☆	☆	☆
20	7	4	38.6	11	6	96.9	☆	☆	☆
CONCRETE QUANTITY = 0.085 CU.YDS./LIN.FT.									

NOTES

1. QUANTITIES ARE PER LINEAR FOOT (OF HEADWALL) FOR ONE HEADWALL AND TOEWALL AND INCLUDE ALL HEADWALL AND TOEWALL REINFORCING STEEL. QUANTITY INCLUDED WAS CALCULATED PER 1 FT. STRIP. SKEW ANGLE MAY VARY. QUANTITIES SHALL BE PAID FOR AS SHOWN ON THE PLANS.

☆ 2. A SKEWED HEADWALL IS NOT RECOMMENDED FOR THESE SPANS. A SPECIAL DESIGN IS REQUIRED.

3. FOR HEADWALL AND TOEWALL DETAILS SEE SHEET 1.

4. WHEN THE FILL HEIGHT IS LESS THAN OR EQUAL TO 2 FT.-0 IN., ALL REINFORCING BARS IN THE HEADWALL, ALL REINFORCING BARS DESIGNATED BY AN ASTERISK (*), AND THE d_1 IN THE BARS IN THE TOP MAT OF THE TOP SLAB SHALL BE EPOXY COATED.

5. REINFORCING QUANTITIES INCLUDE BOTH EPOXY-COATED AND UNCOATED BARS.

6. WHEN AN R (RISE) OF LESS THAN 6 FT. IS REQUIRED, USE THE BAR SIZES AND THE SLAB AND WALL THICKNESSES FOR THE 6 FT. RISE (IF AVAILABLE ON THE TABLE).

▲ 7. THE SIZE OF d_1 BARS IS #4. THE NUMBER OF BARS REQUIRED IS LISTED.

Computer File Information	
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Drawing File Name: 601010202.dwg	
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English	

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(R-X)

Sheet Revisions	
Date:	Comments

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SINGLE CONCRETE BOX CULVERT

Issued By: Project Development Branch on July 04, 2006

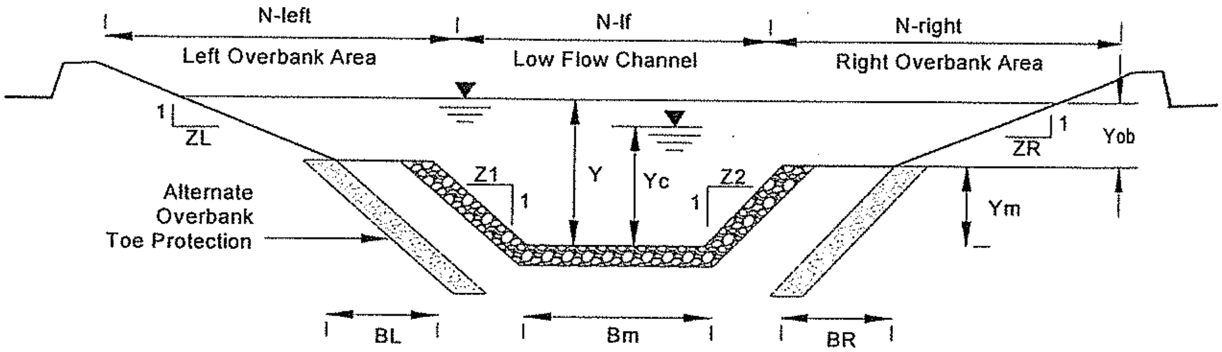
STANDARD PLAN NO.
M-601-1

Sheet No. 2 of 2

Capacity Analysis of Composite Channel

Project: 17043 Cottonwood Detention Basin PR2

nnel ID: Channel design station 9+00 Q100 2380 cfs



Design Information (Input)

Channel Invert Slope	So = 0.00500 ft/ft	Left Overbank Bottom Width	BL = 2.00 ft
		Left Overbank Side Slope	ZL = 4.00 ft/ft
Low Flow Channel Bottom Width	Bm = 50.00 ft	Left Overbank Manning's n	n-left = 0.0350
Low Flow Channel Left Side Slope	Z1 = 7.20 ft/ft	Right Overbank Bottom Width	BR = 2.00 ft
Low Flow Channel Right Side Slope	Z2 = 7.20 ft/ft	Right Overbank Side Slope	ZR = 4.00 ft/ft
Low Flow Channel Manning's Nn for Qd	n-lf = 0.0250	Right Overbank Manning's n	n-right = 0.0350
Low Flow Channel Manning's Nn for Q100 (See USDCM Vol. II, n vs. Depth Graph)	n-m-Q100 = 0.0220		
Low Flow Channel Bank-full depth	Ym = 3.35 ft	Overbank Flow Depth Yob (Y - Ym)	Yob = 0.10 ft

Low Flow Channel Condition for Qd		Low Flow Channel Flow Condition for Q100	
Top width	Tlf = 98.2 ft	Top width	Tm = 98.2 ft
Flow area	Alf = 248.3 sq ft	Flow area	Am = 258.1 sq ft
Wetted perimeter	Plf = 98.7 ft	Wetted perimeter	Pm = 98.7 ft
Discharge (Calculated)	Qlf = 1,935.6 cfs	Discharge	Qm = 2,346.5 cfs
Velocity	Vlf= 7.8 fps	Velocity	Vm = 9.1 fps
Froude number	Fr-lf = 0.86	Froude number	Frm = 0.99
Qd Critical Velocity	Vlfc = 8.71 fps	100-Yr. Critical Velocity	Vmc = 9.2 fps
Qd Critical Depth	Ylfc = 3.08 ft	100-Yr. Critical Depth	Ymc = 3.4 ft

Left Overbank Flow Condition for Q100		Right Overbank Flow Condition for Q100	
Top width	TL = 2.4 ft	Top width	TR = 2.4 ft
Flow area	AL = 0.2200 sq ft	Flow area	AR = 0.2200 sq ft
Wetted perimeter	PL = 2.4100 ft	Wetted perimeter	PR = 2.4100 ft
Discharge	QL = 0.1 cfs	Discharge	QR = 0.1 cfs
Velocity	VL = 0.6 fps	Velocity	VR = 0.6 fps
Froude number	FrL = 0.36	Froude number	FrR = 0.36
100-Yr. Critical Velocity	VLc = 1.3 fps	100-Yr. Critical Velocity	VRc = 1.3 fps
100-Yr. Critical Depth in Overbanks	YLc = 0.1 ft	100-Yr. Critical Depth in Overbanks	YRc = 0.1 ft

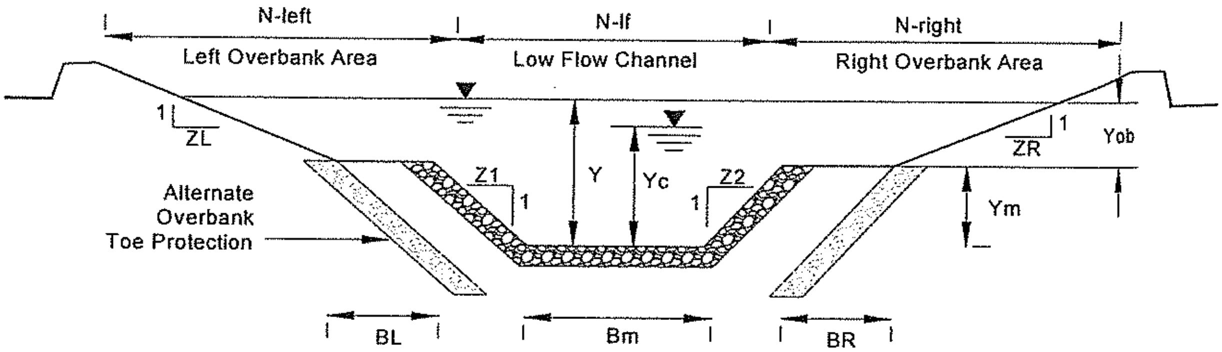
Composite Cross-Section Flow Condition for Q100

Top width	T = 103.0 ft	Discharge	Q = 2,346.7 cfs
Channel Depth Y	Y = 3.45 ft	Velocity	V = 9.1 fps
Flow area	A = 258.6 sq ft	Froude number	Fr = 1.01
Wetted perimeter	P = 103.5 ft	100-Yr. Critical Velocity	Vc = 9.0 fps
Cross-Sectional Manning's n (Calculated)	n = 0.0214	100-Yr. Critical Depth in Overbanks	Yc = 0.12 ft

Capacity Analysis of Composite Channel

Project: 17043 Cottonwood Detention Basin PR2

nnel ID: Channel design stations 11+25 and 14+25 Q100=2380 cfs



Design Information (Input)				
Channel Invert Slope	So = 0.00500 ft/ft	Left Overbank Bottom Width	BL = 16.00 ft	
		Left Overbank Side Slope	ZL = 7.20 ft/ft	
Low Flow Channel Bottom Width	Bm = 14.00 ft	Left Overbank Manning's n	n-left = 0.0350	
Low Flow Channel Left Side Slope	Z1 = 3.00 ft/ft	Right Overbank Bottom Width	BR = 16.00 ft	
Low Flow Channel Right Side Slope	Z2 = 3.00 ft/ft	Right Overbank Side Slope	ZR = 7.20 ft/ft	
Low Flow Channel Manning's Nn for Qd	n-lf = 0.0250	Right Overbank Manning's n	n-right = 0.0350	
Low Flow Channel Manning's Nn for Q100 (See USDCM Vol. II, n vs. Depth Graph)	n-m-Q100 = 0.0220			
Low Flow Channel Bank-full depth	Ym = 2.00 ft	Overbank Flow Depth Yob (Y - Ym)	Yob = 3.05 ft	

Low Flow Channel Condition for Qd		**Low Flow Channel Flow Condition for Q100**	
Top width	Tlf = 26.0 ft	Top width	Tm = 26.0 ft
Flow area	Alf = 40.0 sq ft	Flow area	Am = 119.3 sq ft
Wetted perimeter	Plf = 26.7 ft	Wetted perimeter	Pm = 26.7 ft
Discharge (Calculated)	Qlf = 221.0 cfs	Discharge	Qm = 1,551.9 cfs
Velocity	Vlf= 5.5 fps	Velocity	Vm = 13.0 fps
Froude number	Fr-lf = 0.79	Froude number	Frm = 1.07
Qd Critical Velocity	Vlfc = 6.63 fps	100-Yr. Critical Velocity	Vmc = 5.5 fps
Qd Critical Depth	Ylfc = 1.73 ft	100-Yr. Critical Depth	Ymc = 5.1 ft
Left Overbank Flow Condition for Q100		**Right Overbank Flow Condition for Q100**	
Top width	TL = 38.0 ft	Top width	TR = 38.0 ft
Flow area	AL = 82.2900 sq ft	Flow area	AR = 82.2900 sq ft
Wetted perimeter	PL = 38.1700 ft	Wetted perimeter	PR = 38.1700 ft
Discharge	QL = 413.4 cfs	Discharge	QR = 413.4 cfs
Velocity	VL = 5.0 fps	Velocity	VR = 5.0 fps
Froude number	FrL = 0.60	Froude number	FrR = 0.60
100-Yr. Critical Velocity	VLc = 7.4 fps	100-Yr. Critical Velocity	VRc = 7.4 fps
100-Yr. Critical Depth in Overbanks	YLc = 2.3 ft	100-Yr. Critical Depth in Overbanks	YRc = 2.3 ft

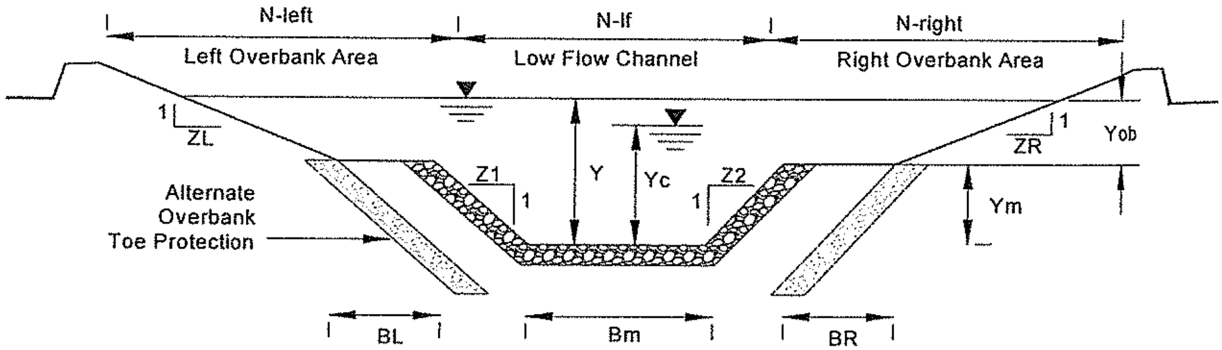
Composite Cross-Section Flow Condition for Q100

Top width	T = 101.9 ft	Discharge	Q = 2,378.7 cfs
Channel Depth Y	Y = 5.05 ft	Velocity	V = 8.4 fps
Flow area	A = 283.9 sq ft	Froude number	Fr = 0.88
Wetted perimeter	P = 103.0 ft	100-Yr. Critical Velocity	Vc = 9.5 fps
Cross-Sectional Manning's n (Calculated)	n = 0.0247	100-Yr. Critical Depth in Overbanks	Yc = 2.09 ft

Capacity Analysis of Composite Channel

Project: 17043 Cottonwood Detention Bsibn PR2

nnel ID: Channel design station 12+00 Q100=2380 cfs



Design Information (Input)

Channel Invert Slope	So = 0.00500 ft/ft	Left Overbank Bottom Width	BL = 2.00 ft
		Left Overbank Side Slope	ZL = 4.00 ft/ft
Low Flow Channel Bottom Width	Bm = 14.00 ft	Left Overbank Manning's n	n-left = 0.0350
Low Flow Channel Left Side Slope	Z1 = 3.00 ft/ft	Right Overbank Bottom Width	BR = 2.00 ft
Low Flow Channel Right Side Slope	Z2 = 3.00 ft/ft	Right Overbank Side Slope	ZR = 4.00 ft/ft
Low Flow Channel Manning's Nn for Qd	n-lf = 0.0250	Right Overbank Manning's n	n-right = 0.0350
Low Flow Channel Manning's Nn for Q100	n-m-Q100 = 0.0220		
(See USDCM Vol. II, n vs. Depth Graph)			
Low Flow Channel Bank-full depth	Ym = 2.00 ft	Overbank Flow Depth Yob (Y - Ym)	Yob = 3.80 ft

Low Flow Channel Condition for Qd		Low Flow Channel Flow Condition for Q100	
Top width	Tlf = 26.0 ft	Top width	Tm = 26.0 ft
Flow area	Alf = 40.0 sq ft	Flow area	Am = 138.8 sq ft
Wetted perimeter	Plf = 26.7 ft	Wetted perimeter	Pm = 26.7 ft
Discharge (Calculated)	Qlf = 221.0 cfs	Discharge	Qm = 1,997.3 cfs
Velocity	Vlf= 5.5 fps	Velocity	Vm = 14.4 fps
Froude number	Fr-lf = 0.79	Froude number	Frm = 1.10
Qd Critical Velocity	Vlfc = 6.63 fps	100-Yr. Critical Velocity	Vmc = 5.4 fps
Qd Critical Depth	Ylfc = 1.73 ft	100-Yr. Critical Depth	Ymc = 5.8 ft

Left Overbank Flow Condition for Q100		Right Overbank Flow Condition for Q100	
Top width	TL = 17.2 ft	Top width	TR = 17.2 ft
Flow area	AL = 36.4800 sq ft	Flow area	AR = 36.4800 sq ft
Wetted perimeter	PL = 17.6700 ft	Wetted perimeter	PR = 17.6700 ft
Discharge	QL = 178.1 cfs	Discharge	QR = 178.1 cfs
Velocity	VL = 4.9 fps	Velocity	VR = 4.9 fps
Froude number	FrL = 0.59	Froude number	FrR = 0.59
100-Yr. Critical Velocity	VLc = 7.4 fps	100-Yr. Critical Velocity	VRc = 7.4 fps
100-Yr. Critical Depth in Overbanks	YLc = 3.0 ft	100-Yr. Critical Depth in Overbanks	YRc = 3.0 ft

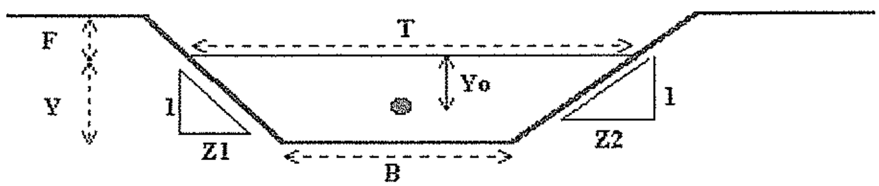
Composite Cross-Section Flow Condition for Q100

Top width	T = 60.4 ft	Discharge	Q = 2,353.4 cfs
Channel Depth Y	Y = 5.80 ft	Velocity	V = 11.1 fps
Flow area	A = 211.8 sq ft	Froude number	Fr = 1.05
Wetted perimeter	P = 62.0 ft	100-Yr. Critical Velocity	Vc = 7.3 fps
Cross-Sectional Manning's n (Calculated)	n = 0.0215	100-Yr. Critical Depth in Overbanks	Yc = 3.80 ft

Normal Flow Analysis - Trapezoidal Channel

Project: 1\7043 Cottonwood Creek Detention Basin PR2

Channel ID: Q100=1940 cfs

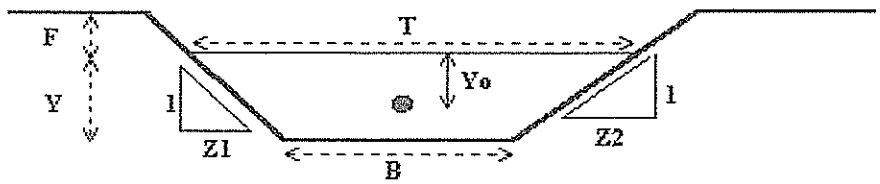


Design Information (Input)			
Channel Invert Slope	So =	0.0050	ft/ft
Manning's n	n =	0.025	
Bottom Width	B =	40.00	ft
Left Side Slope	Z1 =	3.00	ft/ft
Right Side Slope	Z2 =	3.00	ft/ft
Freeboard Height	F =	1.00	ft
Design Water Depth	Y =	**4.00**	ft

Normal Flow Condtion (Calculated)			
Discharge	Q =	**1,897.74**	cfs
Froude Number	Fr =	**0.89**	
Flow Velocity	V =	**9.12**	fps
Flow Area	A =	208.00	sq ft
Top Width	T =	64.00	ft
Wetted Perimeter	P =	65.30	ft
Hydraulic Radius	R =	3.19	ft
Hydraulic Depth	D =	3.25	ft
Specific Energy	Es =	5.29	ft
Centroid of Flow Area	Yo =	1.84	ft
Specific Force	Fs =	57.51	kip

Critical Flow Analysis - Trapezoidal Channel

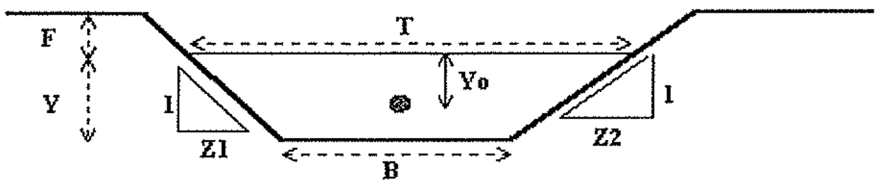
Project: 1\7043 Cottonwood Creek Detention Basin PR2
Channel ID: Flow Spreader Q100=1940 cfs



Design Information (Input)			
Bottom Width	B =	80.00	ft
Left Side Slope	Z1 =	6.00	ft/ft
Right Side Slope	Z2 =	6.00	ft/ft
Design Discharge	Q =	**1,940.00**	cfs
Critical Flow Condition (Calculated)			
Critical Flow Depth	Y =	**2.46**	ft
Critical Flow Area	A =	233.66	sq ft
Critical Top Width	T =	109.58	ft
Critical Hydraulic Depth	D =	2.13	ft
Critical Flow Velocity	V =	8.30	fps
Froude Number	Fr =	**1.00**	
Critical Wetted Perimeter	P =	109.99	ft
Critical Hydraulic Radius	R =	2.12	ft
Critical (min) Specific Energy	Esc =	3.54	ft
Centroid on the Critical Flow Area	Yoc =	1.10	ft
Critical (min) Specific Force	Fsc =	47.35	kip

Critical Flow Analysis - Trapezoidal Channel

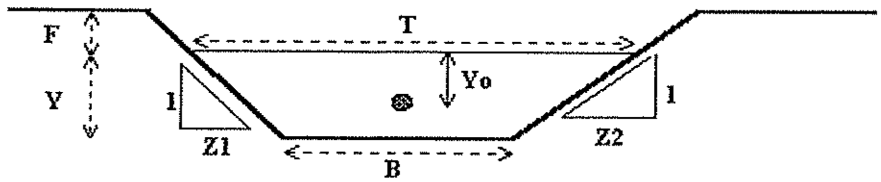
Project: 17043 Cottonwood Detention Basin PR-2
Channel ID: Flow spreader design 5-year Q=500 cfs



Design Information (Input)			
Bottom Width	B =	50.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Slope	Z2 =	4.00	ft/ft
Design Discharge	Q =	**700.00**	cfs
Critical Flow Condition (Calculated)			
Critical Flow Depth	**Y =**	**1.73**	ft
Critical Flow Area	A =	98.79	sq ft
Critical Top Width	T =	63.88	ft
Critical Hydraulic Depth	D =	1.55	ft
Critical Flow Velocity	V =	7.09	fps
Froude Number	**Fr =**	**1.00**	
Critical Wetted Perimeter	P =	64.31	ft
Critical Hydraulic Radius	R =	1.54	ft
Critical (min) Specific Energy	Esc =	2.51	ft
Centroid on the Critical Flow Area	Yoc =	0.80	ft
Critical (min) Specific Force	Fsc =	14.54	kip

Normal Flow Analysis - Trapezoidal Channel

Project: 17043 Cottonwood Detention Basin PR-2
Channel ID: Flow spreader design 5-year Q=500 cfs



Design Information (Input)			
Channel Invert Slope	So =	0.0050	ft/ft
Manning's n	n =	0.025	
Bottom Width	B =	50.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Slope	Z2 =	4.00	ft/ft
Freeboard Height	F =	1.00	ft
Design Water Depth	Y =	**2.00**	ft

Normal Flow Condtion (Calculated)			
Discharge	Q =	**708.46**	cfs
Froude Number	Fr =	**0.81**	
Flow Velocity	V =	**6.11**	fps
Flow Area	A =	116.00	sq ft
Top Width	T =	66.00	ft
Wetted Perimeter	P =	66.49	ft
Hydraulic Radius	R =	1.74	ft
Hydraulic Depth	D =	1.76	ft
Specific Energy	Es =	2.58	ft
Centroid of Flow Area	Yo =	0.95	ft
Specific Force	Fs =	15.29	kip

8.1 Riprap Sizing

Procedures for sizing rock to be used in soil riprap, void-filled riprap, and riprap over bedding are the same.

8.1.1 Mild Slope Conditions

When subcritical flow conditions occur and/or slopes are mild (less than 2 percent), UDFCD recommends the following equation (Hughes, et al, 1983):

$$d_{50} \geq \left[\frac{VS^{0.17}}{4.5(G_s - 1)^{0.66}}\right]^2$$ Equation 8-11

Where:

V = mean channel velocity (ft/sec)

S = longitudinal channel slope (ft/ft)

d_{50} = mean rock size (ft)

Gs = specific gravity of stone (minimum = 2.50, typically 2.5 to 2.7), Note: In this equation (Gs -1) considers the buoyancy of the water, in that the specific gravity of water is subtracted from the specific gravity of the rock.

Note that Equation 8-11 is applicable for sizing riprap for channel lining with a longitudinal slope of no more than 2%. This equation is not intended for use in sizing riprap for steep slopes (typically in excess of 2 percent), rundowns, or protection downstream of culverts. Information on rundowns is provided in Section 7.0 of the *Hydraulic Structures* chapter of the USDCM, and protection downstream of culverts is discussed in the *Culverts and Bridges* chapter. For channel slopes greater than 2% use one of the methods presented in 8.1.2.

Rock size does not need to be increased for steeper channel side slopes, provided the side slopes are no steeper than 2.5H:1V (UDFCD 1982). Channel side slopes steeper than 2.5H:1V are not recommended because of stability, safety, and maintenance considerations. See Figure 8-34 for riprap placement specifications. At the upstream and downstream termination of a riprap lining, the thickness should be increased 50% for at least 3 feet to prevent undercutting.

8.1.2 Steep Slope Conditions

Steep slope rock sizing equations are used for applications where the slope is greater than 2 percent and/or flows are in the supercritical flow regime. The following rock sizing equations may be referred to for riprap design analysis on steep slopes:

- CSU Equation, *Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase II* (prepared by S.R. Abt, et al, Colorado State University, 1988). This method was developed for steep slopes from 2 to 20 percent.
- USDA- Agricultural Research Service Equations, *Design of Rock Chutes* (by K.M. Robinson, et al, USDA- ARS, 1998 Transactions of ASAE) and *An Excel Program to Design Rock Chutes for Grade*

KIOWA ENGINEERING CORPORATION

JOB Cottonwood DTS PR-2

SHEET NO. Proj 17043 OF 11/6

CALCULATED BY ______ DATE 3/30/18

CHECKED BY ______ DATE ______

SCALE Channel Design

Riprap Sizing: Per Vol 1 UDFCD

Eq. 8-11 for channels with S ≤ 2%

$$d_{50} \geq \left[\frac{VS^{.17}}{4.5(G_s-1)^{.66}}\right]^2$$

for $G_s = 2.6$ $\quad d_{50} = \left(\frac{VS^{.17}}{6.14}\right)^2$

For S = .5 %

$$d_{50} = \left(\frac{.406V}{6.14}\right)^2 = (.066V)^2$$

Max Velocity in section (use composite Q)

Sta	V (fps)	d_{50} (ft)	d_{50} inches	Type
9+00	9.1	.36	4.3"	VL
11+25	8.4	.31	3.7"	VL
12+00	11.1	.54	6.4"	L
13+40	12.9	.72	8.7	L

Type VL = 6"
Type L = 9"
Type M D_{50} = 12"

Use 'L', 18" Thick, SRR Throughout

Cottonwood Creek PRZ
10-, 50; 100-year & 500year
PROPOSED CONDITIONS
CLOMR

HEC-RAS Plan: Proposed Multi-Prof River: Cottonwood Creek Reach: Main Stem

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)	
Main Stem	4872	10 yr	1500.00	6897.60	6900.30	6900.30	6901.51	0.017351	8.83	169.93	70.96	1.01
Main Stem	4872	50 yr	3563.00	6897.60	6902.25	6902.25	6904.18	0.016567	11.12	320.45	83.99	1.00
Main Stem	4872	100 yr	4876.00	6897.60	6903.23	6903.23	6905.47	0.016606	11.99	406.54	91.98	1.01
Main Stem	4872	500 yr	9876.00	6897.60	6906.08	6906.08	6909.16	0.016397	14.08	701.66	115.22	1.01
Main Stem	4235	10 yr	971.00	6883.98	6887.40	6887.40	6888.52	0.014478	8.51	114.06	51.23	1.01
Main Stem	4235	50 yr	1945.00	6883.98	6888.79	6888.79	6890.31	0.013753	9.89	196.63	64.80	1.00
Main Stem	4235	100 yr	2379.00	6883.98	6889.26	6889.26	6890.96	0.013877	10.45	227.57	67.90	1.01
Main Stem	4235	500 yr	3576.00	6883.98	6890.38	6890.38	6892.48	0.013784	11.61	307.98	74.54	1.01
Main Stem	3996	10 yr	971.00	6880.56	6884.69	6883.52	6884.98	0.003138	4.30	225.78	88.37	0.47
Main Stem	3996	50 yr	1945.00	6880.56	6886.10	6884.58	6886.56	0.003164	5.42	358.66	98.52	0.50
Main Stem	3996	100 yr	2379.00	6880.56	6886.61	6884.97	6887.14	0.003162	5.81	409.58	101.07	0.51
Main Stem	3996	500 yr	3576.00	6880.56	6887.82	6885.88	6888.51	0.003206	6.69	534.75	107.08	0.53
Main Stem	3981	10 yr	971.00	6880.50	6884.31	6883.90	6884.90	0.002578	6.17	157.25	74.06	0.75
Main Stem	3981	50 yr	1945.00	6880.50	6885.62	6885.01	6886.48	0.002283	7.44	261.45	84.83	0.75
Main Stem	3981	100 yr	2379.00	6880.50	6886.10	6885.40	6887.06	0.002229	7.86	302.74	88.83	0.75
Main Stem	3981	500 yr	3576.00	6880.50	6887.24	6886.39	6888.43	0.002101	8.72	409.87	98.20	0.75
Main Stem	3971	10 yr	971.00	6880.50	6883.90	6883.90	6884.84	0.004972	7.78	124.88	68.11	1.01
Main Stem	3971	50 yr	1945.00	6880.50	6885.03	6885.03	6886.40	0.004364	9.38	207.30	77.19	1.01
Main Stem	3971	100 yr	2379.00	6880.50	6885.46	6885.46	6886.97	0.004193	9.87	240.97	80.64	1.01
Main Stem	3971	500 yr	3576.00	6880.50	6886.47	6886.47	6888.33	0.003929	10.97	326.12	88.68	1.01
Main Stem	3932	10 yr	971.00	6874.00	6881.40	6878.88	6881.77	0.000712	4.88	199.05	46.62	0.43
Main Stem	3932	50 yr	1945.00	6874.00	6883.06	6880.86	6883.76	0.001081	6.71	289.89	60.22	0.54
Main Stem	3932	100 yr	2379.00	6874.00	6883.62	6881.51	6884.46	0.001207	7.33	324.63	64.27	0.57
Main Stem	3932	500 yr	3576.00	6874.00	6886.69	6883.00	6887.33	0.000771	6.39	559.49	89.73	0.45
Main Stem	3907	10 yr	971.00	6873.90	6881.38	6878.81	6881.75	0.000694	4.85	200.28	48.36	0.42
Main Stem	3907	50 yr	1945.00	6873.90	6883.03	6880.79	6883.73	0.001069	6.73	288.86	59.05	0.54
Main Stem	3907	100 yr	2379.00	6873.90	6883.58	6881.45	6884.42	0.001200	7.39	322.08	62.53	0.57
Main Stem	3907	500 yr	3576.00	6873.90	6886.63	6882.95	6887.30	0.000776	6.58	543.70	83.92	0.46
Main Stem	3905	10 yr	971.00	6875.00	6881.29	6879.32	6881.74	0.000932	5.35	181.50	47.64	0.48
Main Stem	3905	50 yr	1945.00	6875.00	6882.89	6881.17	6883.72	0.001363	7.32	265.76	58.02	0.60
Main Stem	3905	100 yr	2379.00	6875.00	6883.41	6881.81	6884.41	0.001517	8.01	296.91	61.34	0.64
Main Stem	3905	500 yr	3576.00	6875.00	6886.57	6883.24	6887.30	0.000851	6.83	523.25	82.80	0.48
Main Stem	3897	10 yr	971.00	6875.00	6881.28	6879.34	6881.73	0.000935	5.35	181.41	47.71	0.48
Main Stem	3897	50 yr	1945.00	6875.00	6882.87	6881.16	6883.71	0.001369	7.33	265.45	58.05	0.60
Main Stem	3897	100 yr	2379.00	6875.00	6883.39	6881.80	6884.39	0.001525	8.02	296.47	61.35	0.64
Main Stem	3897	500 yr	3576.00	6875.00	6886.56	6883.23	6887.29	0.000963	6.82	524.43	87.07	0.49
Main Stem	3814	10 yr	971.00	6875.00	6881.08	6879.62	6881.58	0.003816	5.71	170.11	50.59	0.55
Main Stem	3814	50 yr	1945.00	6875.00	6882.61	6881.34	6883.50	0.005075	7.57	257.08	62.04	0.66
Main Stem	3814	100 yr	2379.00	6875.00	6883.12	6881.92	6884.17	0.005479	8.23	289.17	65.16	0.69
Main Stem	3814	500 yr	3576.00	6875.00	6886.47	6883.23	6887.16	0.002158	6.68	534.98	81.19	0.46
Main Stem	3616	10 yr	971.00	6875.47	6880.50	6879.10	6880.87	0.003039	4.87	199.30	65.30	0.49
Main Stem	3616	50 yr	1945.00	6875.47	6881.91	6880.46	6882.57	0.003830	6.52	298.31	74.83	0.58
Main Stem	3616	100 yr	2379.00	6875.47	6882.35	6880.96	6883.15	0.004195	7.16	332.34	77.50	0.61
Main Stem	3616	500 yr	3576.00	6875.47	6886.35	6882.08	6886.77	0.001205	5.18	689.74	101.58	0.35
Main Stem	3503	10 yr	971.00	6875.50	6879.07	6879.07	6880.09	0.020930	8.09	119.97	59.60	1.01
Main Stem	3503	50 yr	1945.00	6875.50	6880.35	6880.35	6881.68	0.019012	9.25	210.22	80.72	1.01
Main Stem	3503	100 yr	2379.00	6875.50	6880.79	6880.79	6882.23	0.017857	9.62	247.38	86.93	1.01
Main Stem	3503	500 yr	3576.00	6875.50	6886.33	6881.78	6886.60	0.000957	4.13	865.89	128.34	0.28
Main Stem	3328	10 yr	971.00	6874.50	6878.32	6877.94	6878.88	0.002702	5.99	162.05	83.00	0.76
Main Stem	3328	50 yr	1945.00	6874.50	6879.55	6878.99	6880.33	0.002411	7.08	274.86	100.72	0.76
Main Stem	3328	100 yr	2379.00	6874.50	6880.01	6879.38	6880.84	0.002715	7.34	324.31	123.28	0.80
Main Stem	3328	500 yr	3576.00	6874.50	6886.40	6880.46	6886.51	0.000115	2.63	1361.21	180.44	0.17
Main Stem	3318	10 yr	971.00	6874.49	6877.95	6877.95	6878.82	0.004945	7.47	130.06	75.32	1.00
Main Stem	3318	50 yr	1945.00	6874.49	6879.01	6879.01	6880.25	0.004508	8.92	217.97	90.15	1.01
Main Stem	3318	100 yr	2379.00	6874.49	6879.40	6879.40	6880.76	0.004358	9.36	254.05	95.28	1.01
Main Stem	3318	500 yr	3576.00	6874.49	6886.39	6880.49	6886.51	0.000139	2.71	1321.38	178.11	0.18
Main Stem	3279	10 yr	971.00	6868.40	6874.74	6873.32	6875.32	0.001474	6.11	159.02	48.40	0.59
Main Stem	3279	50 yr	1945.00	6868.40	6876.80	6875.21	6877.56	0.001398	6.99	278.12	66.80	0.60
Main Stem	3279	100 yr	2379.00	6868.40	6878.19	6875.80	6878.81	0.000909	6.27	379.17	77.70	0.50
Main Stem	3279	500 yr	3576.00	6868.40	6886.40	6877.13	6886.50	0.000098	2.49	1435.25	161.23	0.15

HEC-RAS Plan: Proposed Multi-Prof River: Cottonwood Creek Reach: Main Stem (Continued)

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)	
Main Stem	3254	10 yr	971.00	6868.30	6874.65	6873.24	6875.27	0.001486	6.33	153.45	44.19	0.60
Main Stem	3254	50 yr	1945.00	6868.30	6876.59	6875.16	6877.50	0.001634	7.68	253.10	58.79	0.65
Main Stem	3254	100 yr	2379.00	6868.30	6878.03	6875.80	6878.77	0.001076	6.87	346.16	69.68	0.54
Main Stem	3254	500 yr	3576.00	6868.30	6886.38	6877.21	6886.49	0.000109	2.63	1359.00	152.34	0.16
Main Stem	3252	10 yr	971.00	6869.40	6874.17	6873.74	6875.23	0.003045	8.26	117.56	39.23	0.84
Main Stem	3252	50 yr	1945.00	6869.40	6876.06	6875.55	6877.45	0.002869	9.48	205.14	53.41	0.85
Main Stem	3252	100 yr	2379.00	6869.40	6877.85	6876.17	6878.75	0.001410	7.60	313.22	66.89	0.62
Main Stem	3252	500 yr	3576.00	6869.40	6886.38	6877.57	6886.49	0.000115	2.68	1332.96	151.64	0.16
Main Stem	3244	10 yr	971.00	6869.40	6873.74	6873.74	6875.16	0.004441	9.57	101.51	36.04	1.00
Main Stem	3244	50 yr	1945.00	6869.40	6875.55	6875.55	6877.38	0.004085	10.85	179.25	49.65	1.01
Main Stem	3244	100 yr	2379.00	6869.40	6877.84	6876.16	6878.74	0.001423	7.62	312.11	66.76	0.62
Main Stem	3244	500 yr	3576.00	6869.40	6886.38	6877.57	6886.49	0.000115	2.70	1322.94	149.98	0.16
Main Stem	3144	10 yr	971.00	6868.87	6872.99	6872.99	6874.12	0.020618	8.51	114.14	51.43	1.01
Main Stem	3144	50 yr	1945.00	6868.87	6874.43	6874.43	6875.87	0.018597	9.64	201.72	69.92	1.00
Main Stem	3144	100 yr	2379.00	6868.87	6878.09	6874.89	6878.40	0.001853	4.49	530.11	106.55	0.35
Main Stem	3144	500 yr	3576.00	6868.87	6886.39	6876.02	6886.47	0.000158	2.16	1652.26	164.91	0.12
Main Stem	3028	10 yr	971.00	6868.25	6872.06	6871.67	6872.61	0.002663	5.95	163.23	83.59	0.75
Main Stem	3028	50 yr	1945.00	6868.25	6874.69	6872.71	6874.95	0.000921	4.14	470.36	166.21	0.43
Main Stem	3028	100 yr	2379.00	6868.25	6878.22	6873.11	6878.29	0.000121	2.10	1132.49	202.35	0.16
Main Stem	3028	500 yr	3576.00	6868.25	6886.42	6874.20	6886.44	0.000020	1.16	3094.19	285.60	0.06
Main Stem	3018	10 yr	971.00	6868.24	6871.67	6871.67	6872.55	0.005065	7.52	129.18	75.41	1.01
Main Stem	3018	50 yr	1945.00	6868.24	6874.65	6872.76	6874.94	0.000749	4.37	445.44	159.00	0.46
Main Stem	3018	100 yr	2379.00	6868.24	6878.22	6873.15	6878.29	0.000084	2.14	1110.05	202.44	0.16
Main Stem	3018	500 yr	3576.00	6868.24	6886.42	6874.27	6886.44	0.000011	1.16	3093.39	290.16	0.06
Main Stem	2979	10 yr	971.00	6862.00	6868.46	6867.08	6869.21	0.001935	6.94	139.84	42.02	0.67
Main Stem	2979	50 yr	1945.00	6862.00	6874.74	6869.35	6874.88	0.000199	3.05	638.03	155.32	0.27
Main Stem	2979	100 yr	2379.00	6862.00	6878.23	6870.00	6878.28	0.000050	1.89	1259.92	193.49	0.13
Main Stem	2979	500 yr	3576.00	6862.00	6886.42	6871.33	6886.44	0.000010	1.10	3248.10	291.96	0.06
Main Stem	2954	10 yr	971.00	6862.00	6868.52	6867.02	6869.12	0.001421	6.24	155.64	44.09	0.59
Main Stem	2954	50 yr	1945.00	6862.00	6874.74	6868.98	6874.88	0.000190	2.97	654.81	167.90	0.27
Main Stem	2954	100 yr	2379.00	6862.00	6878.23	6869.61	6878.28	0.000048	1.80	1318.43	203.67	0.13
Main Stem	2954	500 yr	3576.00	6862.00	6886.43	6871.04	6886.44	0.000009	1.00	3585.70	319.81	0.05
Main Stem	2952	10 yr	971.00	6863.25	6868.02	6867.58	6869.07	0.003040	8.25	117.76	39.36	0.84
Main Stem	2952	50 yr	1945.00	6863.25	6874.73	6869.40	6874.87	0.000213	3.07	633.99	169.06	0.28
Main Stem	2952	100 yr	2379.00	6863.25	6878.23	6870.01	6878.28	0.000050	1.82	1304.11	205.27	0.13
Main Stem	2952	500 yr	3576.00	6863.25	6886.43	6871.41	6886.44	0.000009	0.99	3596.31	322.75	0.05
Main Stem	2944	10 yr	971.00	6863.25	6867.58	6867.58	6869.01	0.004465	9.56	101.39	36.07	1.01
Main Stem	2944	50 yr	1945.00	6863.25	6874.73	6869.40	6874.87	0.000210	3.01	647.10	175.31	0.28
Main Stem	2944	100 yr	2379.00	6863.25	6878.23	6870.01	6878.28	0.000049	1.78	1337.87	214.54	0.13
Main Stem	2944	500 yr	3576.00	6863.25	6886.43	6871.41	6886.44	0.000009	0.96	3721.35	332.47	0.05
Main Stem	2784	10 yr	971.00	6862.35	6866.50	6865.84	6866.91	0.008598	5.16	188.26	103.27	0.67
Main Stem	2784	50 yr	1945.00	6862.35	6874.80	6866.98	6874.82	0.000050	1.06	1827.47	249.69	0.07
Main Stem	2784	100 yr	2379.00	6862.35	6878.25	6867.34	6878.26	0.000025	0.85	2806.93	325.27	0.05
Main Stem	2784	500 yr	3576.00	6862.35	6886.43	6868.09	6886.44	0.000007	0.63	5705.63	399.06	0.03
Main Stem	2774	10 yr	971.00	6862.30	6866.48	6865.71	6866.87	0.001672	5.05	192.46	89.02	0.60
Main Stem	2774	50 yr	1945.00	6862.30	6874.80	6866.92	6874.82	0.000029	1.06	1840.67	247.26	0.07
Main Stem	2774	100 yr	2379.00	6862.30	6878.25	6867.27	6878.26	0.000016	0.85	2814.43	317.50	0.05
Main Stem	2774	500 yr	3576.00	6862.30	6886.43	6868.01	6886.44	0.000005	0.63	5666.11	397.57	0.03
Main Stem	2763	10 yr	971.00	6862.30	6866.60	6865.46	6866.80	0.001103	3.53	275.44	140.05	0.44
Main Stem	2763	50 yr	1945.00	6862.30	6874.80	6866.42	6874.82	0.000023	1.01	1930.37	245.00	0.06
Main Stem	2763	100 yr	2379.00	6862.30	6878.25	6866.73	6878.28	0.000014	0.82	2891.43	307.76	0.05
Main Stem	2763	500 yr	3576.00	6862.30	6886.43	6867.43	6886.44	0.000005	0.62	5731.01	407.68	0.03
Main Stem	2747	10 yr	971.00	6858.90	6866.71	6861.69	6866.75	0.000044	1.56	621.70	128.06	0.12
Main Stem	2747	50 yr	1945.00	6858.90	6874.80	6862.67	6874.81	0.000007	0.88	2211.82	237.41	0.05
Main Stem	2747	100 yr	2379.00	6858.90	6878.25	6863.03	6878.26	0.000005	0.76	3150.39	295.81	0.04
Main Stem	2747	500 yr	3576.00	6858.90	6886.43	6863.94	6886.44	0.000002	0.61	5907.83	401.50	0.03
Main Stem	2668	10 yr	971.00	6858.50	6866.70	6861.56	6866.74	0.000052	1.66	585.39	123.82	0.13
Main Stem	2668	50 yr	1945.00	6858.50	6874.80	6862.71	6874.81	0.000008	0.94	2062.19	213.65	0.05
Main Stem	2668	100 yr	2379.00	6858.50	6878.25	6863.15	6878.26	0.000005	0.83	2870.44	261.48	0.04
Main Stem	2668	500 yr	3576.00	6858.50	6886.43	6864.13	6886.44	0.000003	0.67	5346.82	367.78	0.03

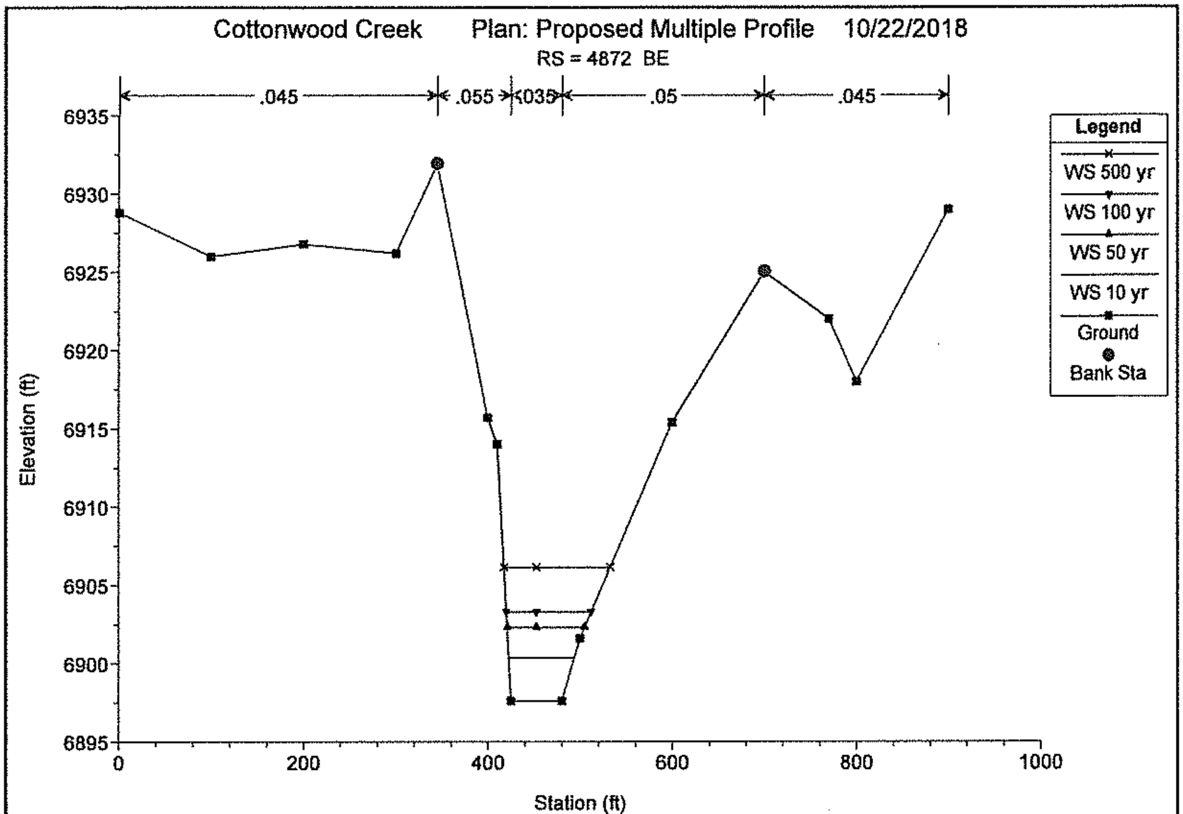
HEC-RAS Plan: Proposed Multi-Prof River: Cottonwood Creek Reach: Main Stem (Continued)

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)	
Main Stem	2665	10 yr	971.00	6860.50	6866.70	6863.54	6866.77	0.000131	2.19	443.83	123.45	0.20
Main Stem	2665	50 yr	1945.00	6860.50	6874.80	6864.50	6874.82	0.000011	1.02	1908.26	211.45	0.06
Main Stem	2665	100 yr	2379.00	6860.50	6878.25	6864.86	6878.26	0.000007	0.88	2707.04	258.95	0.05
Main Stem	2665	500 yr	3576.00	6860.50	6886.43	6865.75	6886.44	0.000003	0.69	5155.09	363.17	0.03
Main Stem	2643	10 yr	971.00	6860.50	6866.70	6863.67	6866.80	0.000173	2.49	389.94	106.39	0.23
Main Stem	2643	50 yr	1945.00	6850.50	6874.80	6864.76	6874.82	0.000014	1.15	1684.18	189.07	0.07
Main Stem	2643	100 yr	2379.00	6860.50	6878.25	6865.17	6878.27	0.000009	0.99	2398.01	234.33	0.05
Main Stem	2643	500 yr	3576.00	6860.50	6886.43	6866.15	6886.44	0.000004	0.76	4684.06	332.97	0.04
Main Stem	2642	10 yr	971.00	6858.50	6866.70	6860.65	6866.75	0.000059	1.76	552.61	105.59	0.14
Main Stem	2642	50 yr	1945.00	6858.50	6874.80	6861.90	6874.82	0.000018	1.06	1834.16	187.67	0.06
Main Stem	2642	100 yr	2379.00	6858.50	6878.25	6862.38	6878.26	0.000014	0.94	2541.28	231.80	0.05
Main Stem	2642	500 yr	3576.00	6858.50	6886.43	6863.88	6886.44	0.000007	0.74	4819.24	332.23	0.03
Main Stem	2631	10 yr	971.00	6858.24	6866.70		6867.75	0.000298	8.20	118.44	78.49	0.50
Main Stem	2631	50 yr	1945.00	6858.24	6874.80		6875.89	0.000128	8.39	231.83	170.27	0.36
Main Stem	2631	100 yr	2379.00	6858.24	6878.25		6879.37	0.000102	8.49	280.14	202.11	0.33
Main Stem	2631	500 yr	3576.00	6858.24	6886.43		6887.71	0.000073	9.06	394.66	324.08	0.30
Main Stem	2440		Culvert									
Main Stem	2250	10 yr	959.00	6841.69	6846.93	6846.93	6849.59	0.014961	13.06	73.42	37.21	1.01
Main Stem	2250	50 yr	1808.00	6841.69	6849.71	6849.71	6853.74	0.012904	16.10	112.28	38.10	1.00
Main Stem	2250	100 yr	2079.00	6841.69	6850.48	6850.48	6854.92	0.012556	16.89	123.10	38.34	1.00
Main Stem	2250	500 yr	2600.00	6841.69	6851.90	6851.90	6857.04	0.011953	18.20	142.87	40.48	1.00
Main Stem	2221	10 yr	959.00	6838.00	6846.18	6841.72	6846.36	0.001057	3.39	283.28	51.94	0.26
Main Stem	2221	50 yr	1808.00	6838.00	6848.54	6843.41	6848.83	0.001331	4.31	419.43	64.14	0.30
Main Stem	2221	100 yr	2079.00	6838.00	6849.58	6843.86	6849.86	0.001164	4.25	488.80	70.22	0.26
Main Stem	2221	500 yr	2600.00	6838.00	6852.56	6844.66	6852.76	0.000651	3.58	726.89	93.19	0.23
Main Stem	2177	10 yr	959.00	6838.01	6846.16	6841.82	6846.30	0.000799	2.78	344.49	73.26	0.23
Main Stem	2177	50 yr	1808.00	6838.01	6846.58	6843.32	6848.75	0.000815	3.32	544.29	95.18	0.24
Main Stem	2177	100 yr	2079.00	6838.01	6849.62	6843.72	6849.78	0.000676	3.20	649.73	106.67	0.23
Main Stem	2177	500 yr	2600.00	6838.01	6852.62	6844.38	6852.70	0.000332	2.35	1106.16	183.25	0.17
Main Stem	1459	10 yr	1976.00	6840.80	6842.60	6842.60	6843.47	0.021684	7.47	264.68	155.04	1.01
Main Stem	1459	50 yr	4693.00	6840.80	6843.97	6843.97	6845.42	0.018930	9.67	485.37	167.24	1.00
Main Stem	1459	100 yr	6422.00	6840.80	6844.66	6844.66	6846.42	0.018409	10.64	603.46	173.26	1.01
Main Stem	1459	500 yr	13009.00	6840.80	6846.83	6846.83	6849.49	0.016694	13.08	994.30	187.38	1.00

TUTT →

CBC → OUTLET

@ END → OF PLUNGE POOL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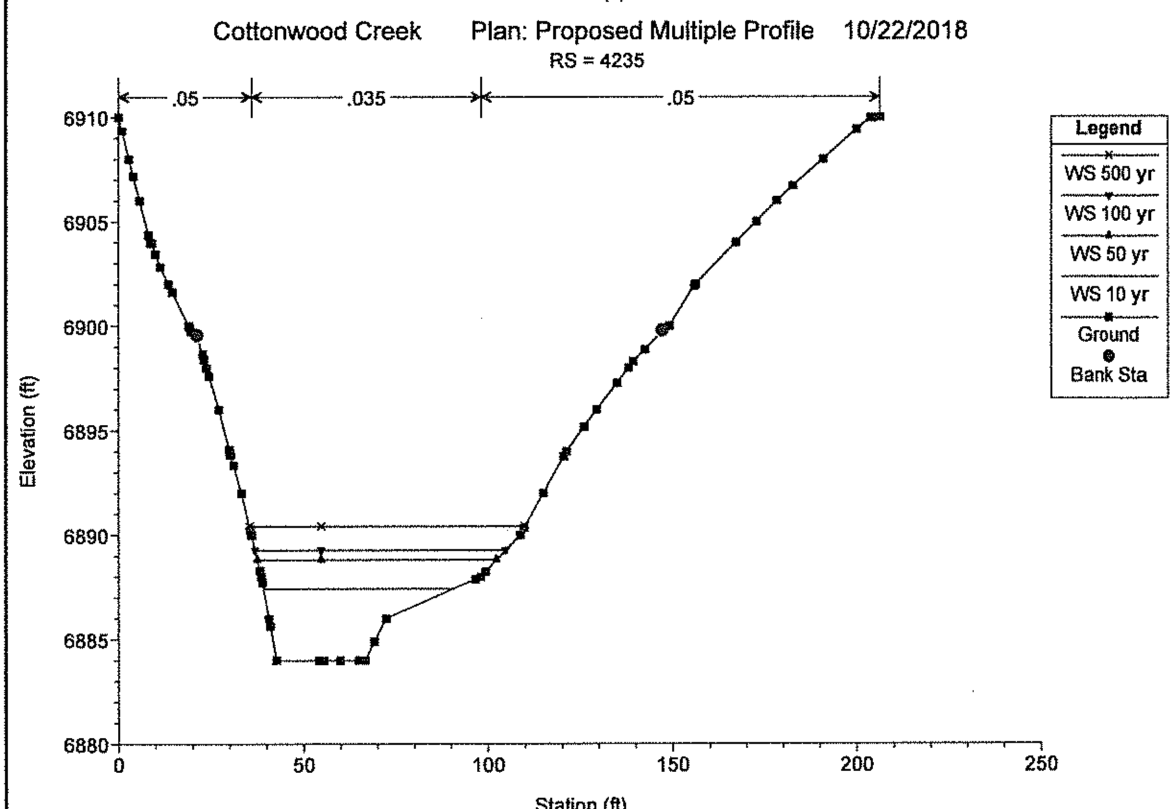
RS = 4872 BE
.045
.055
.035
.05
.045
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta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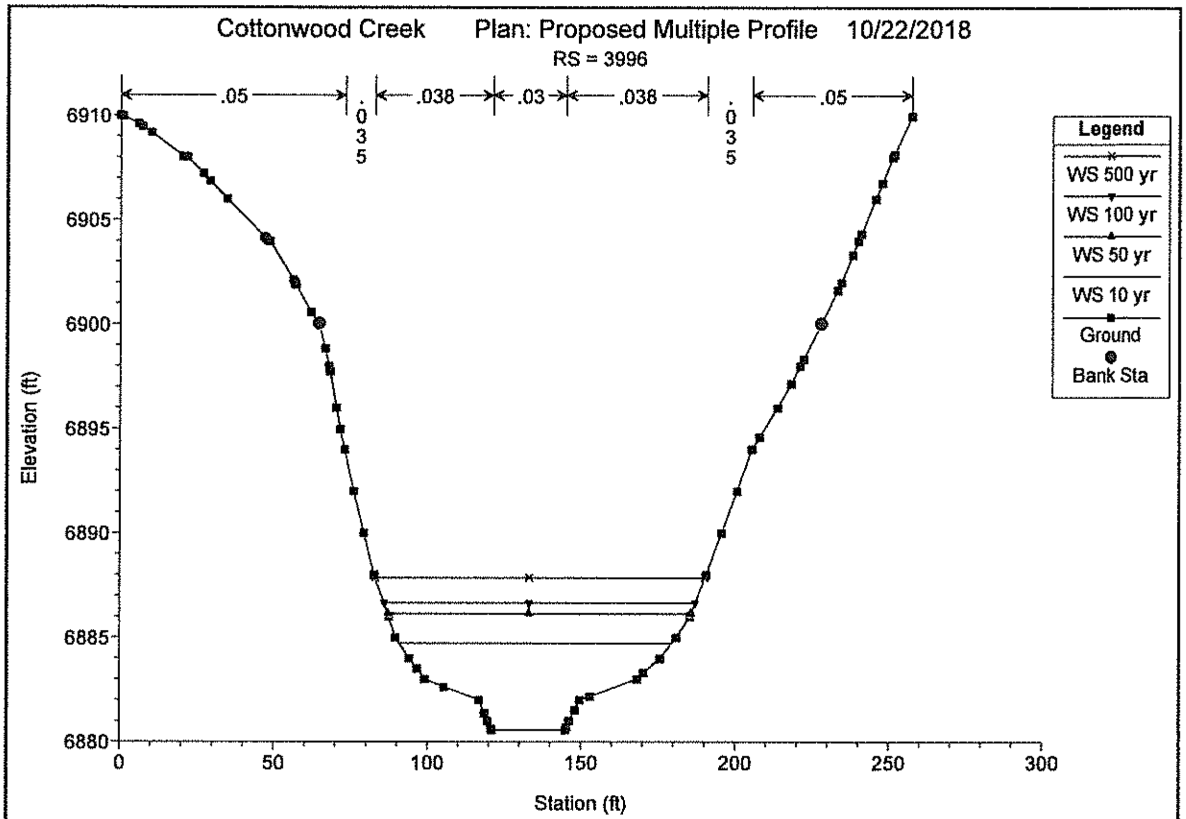
.035
.05
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
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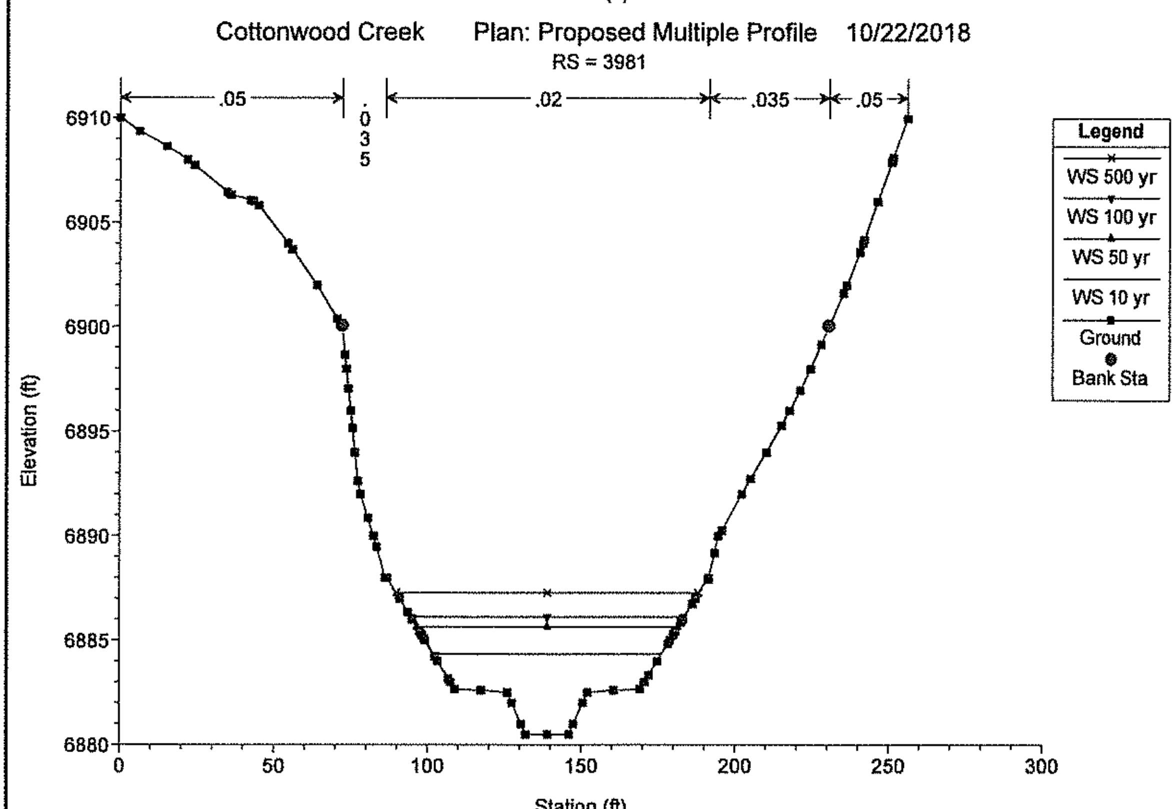
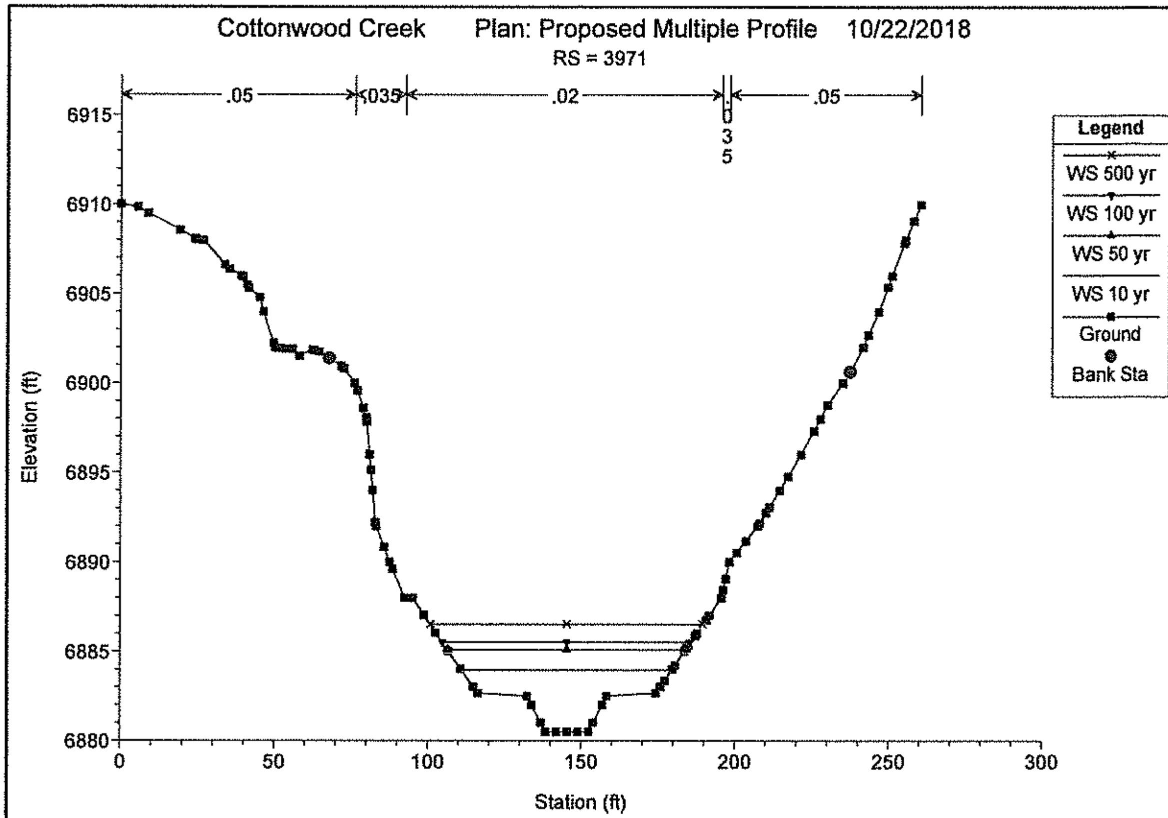
.05
.035
.038
.03
.038
.035
.05
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6910
6905
6900
6895
6890
6885
6880
0
50
100
150
200
250
300
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3981
.05
.035
.02
.035
.05
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6910
6905
6900
6895
6890
6885
6880
0
50
100
150
200
250
300
Station (ft)



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
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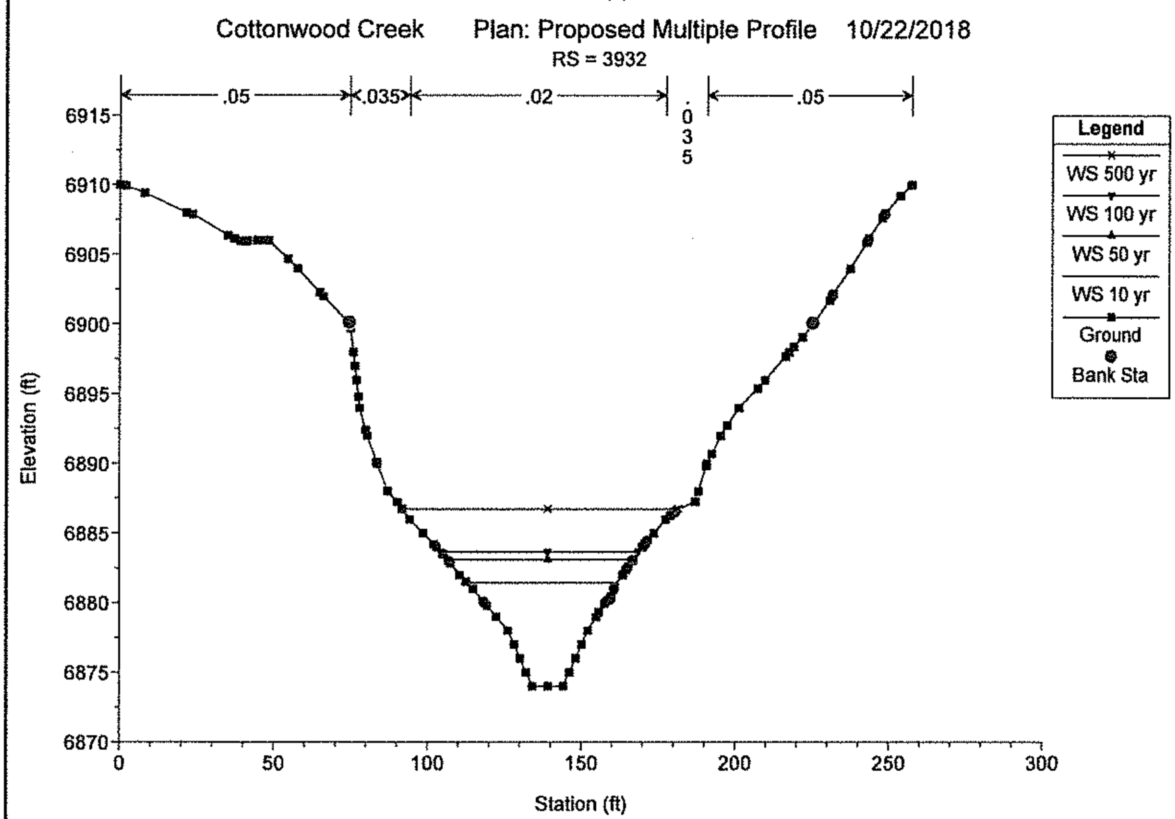
.05
.035
.02
.035
.05
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
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.05
.035
.02
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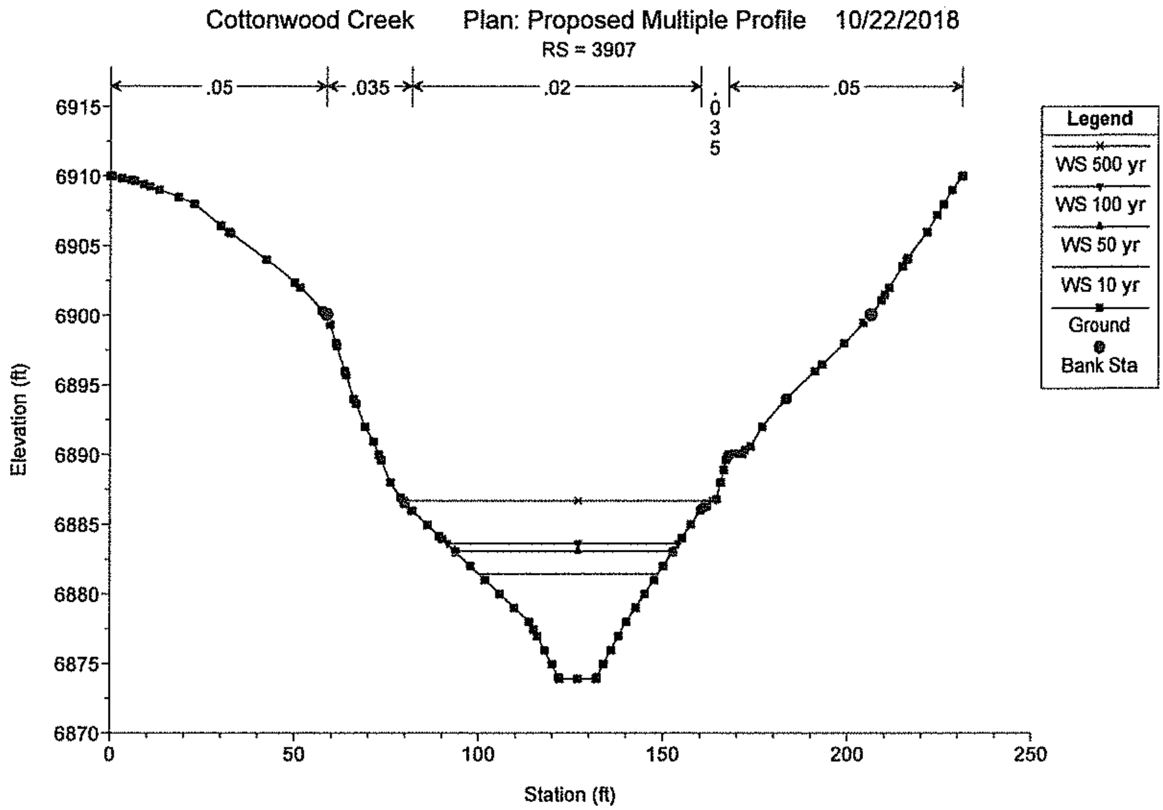
.05
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
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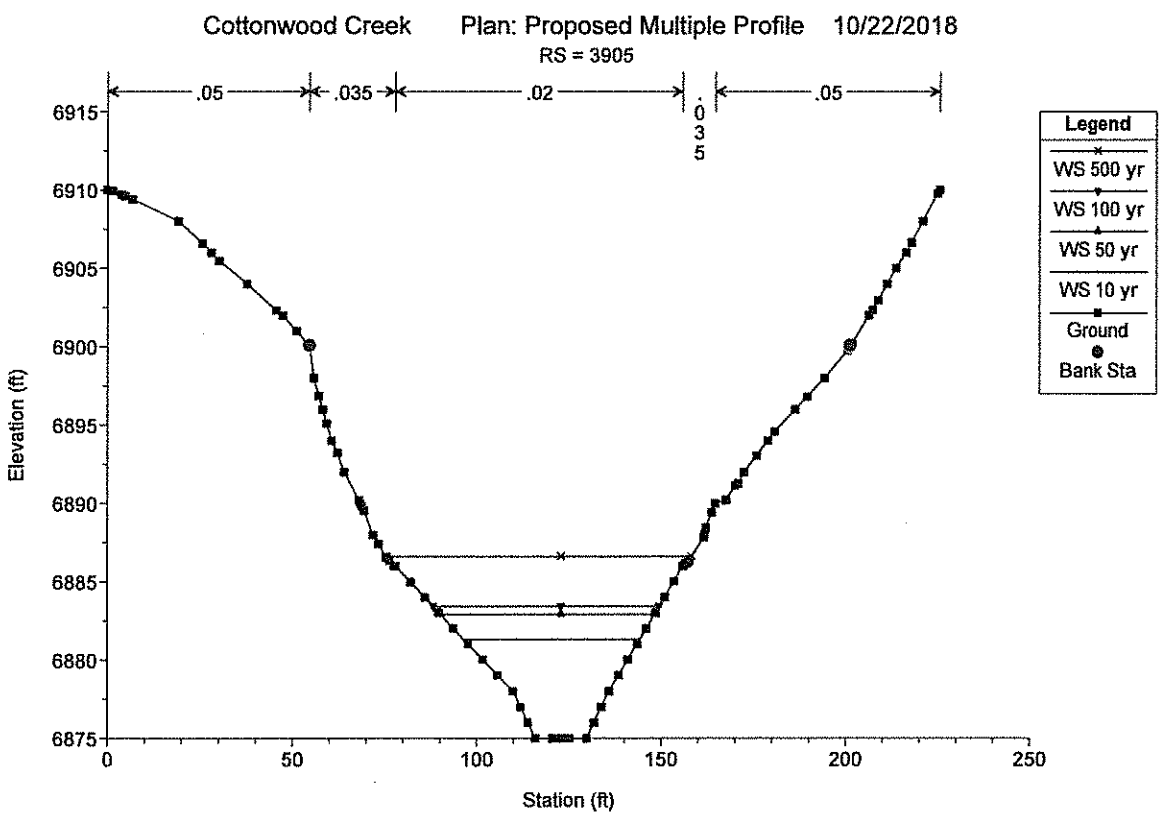
.05
.035
.02
.035
.05
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
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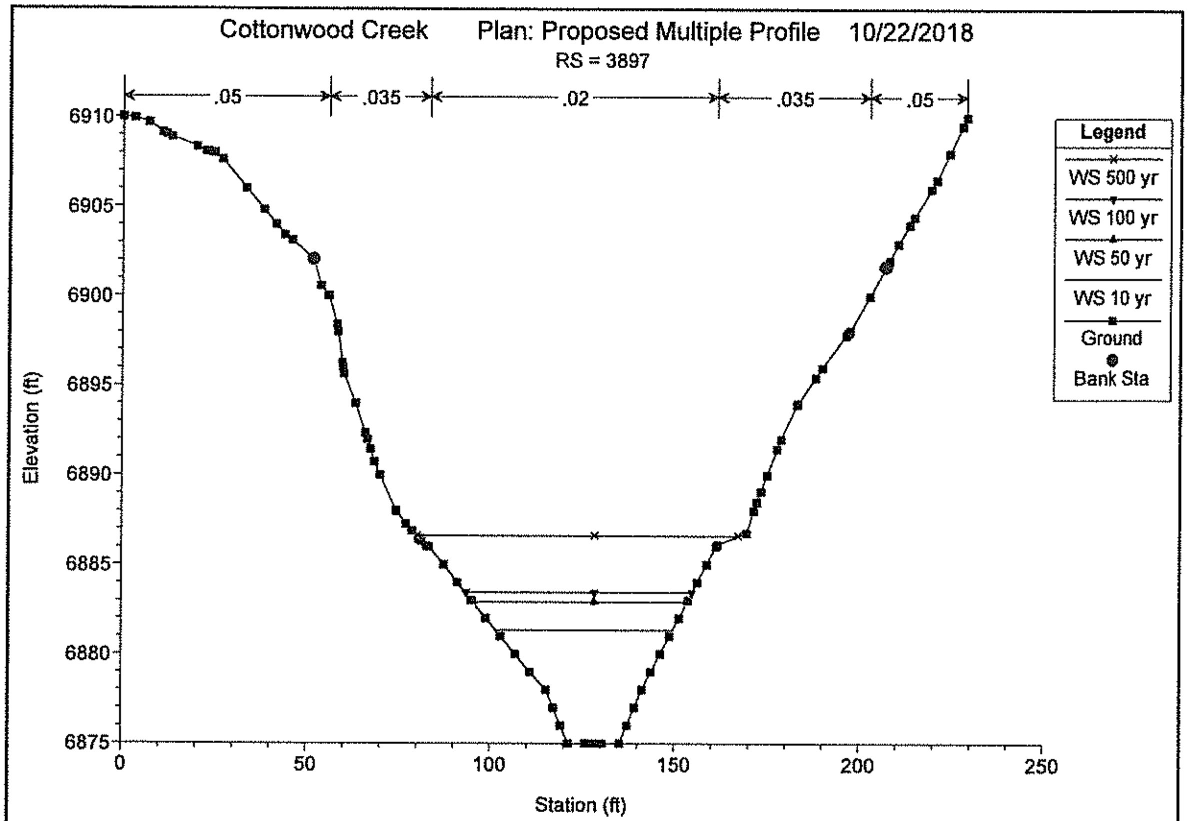
.05
.035
.02
.035
.05
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
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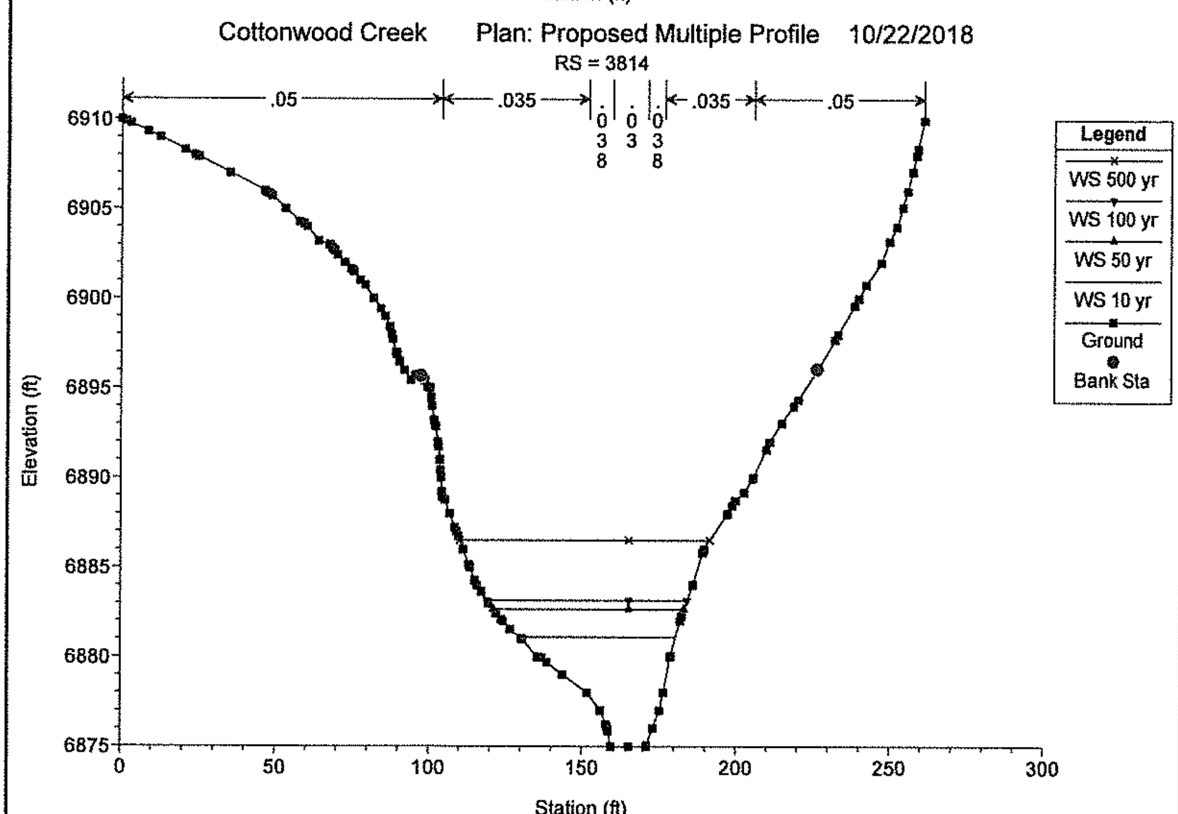
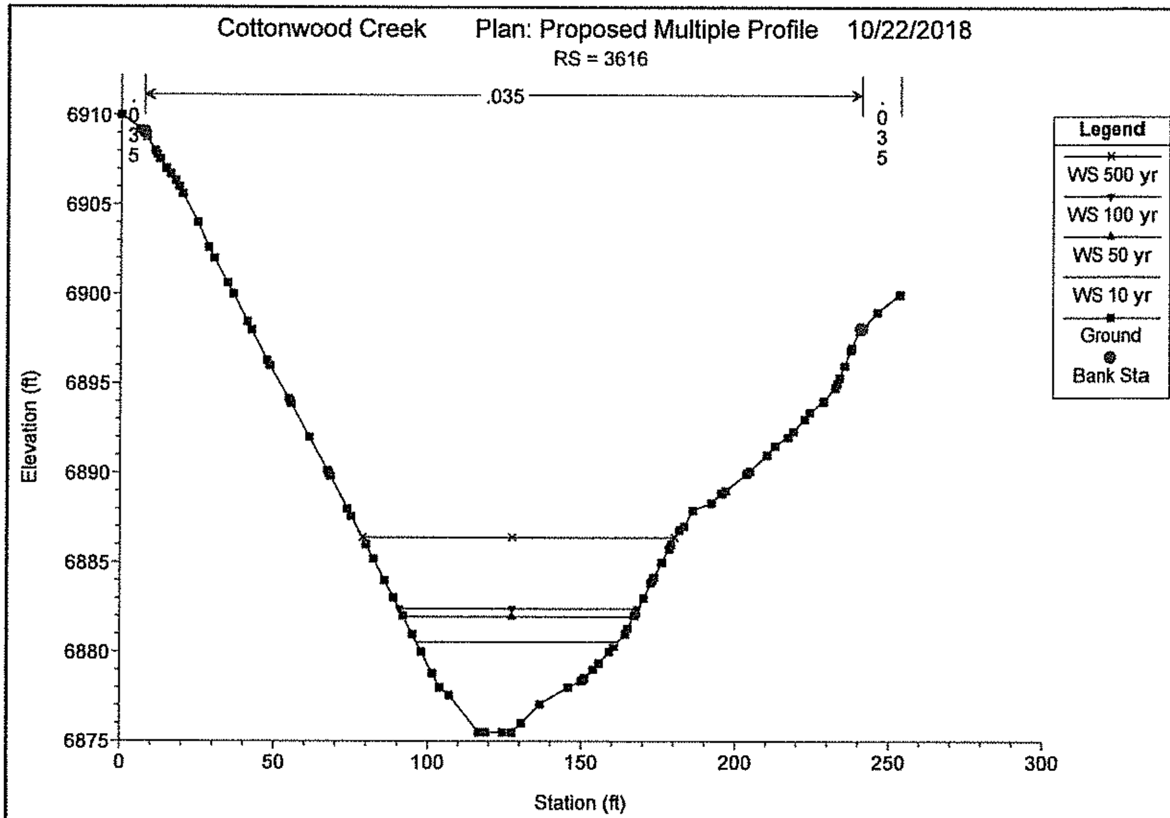
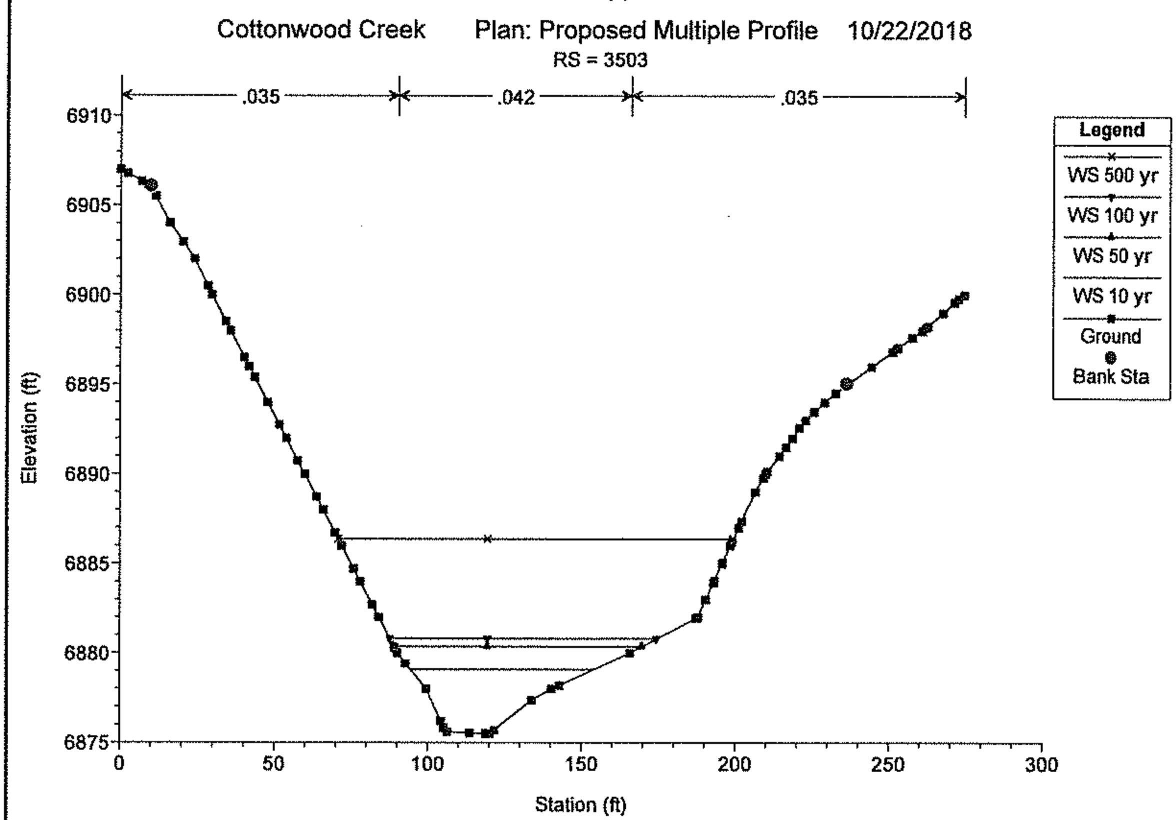
.05
.035
.02
.035
.05
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6910
6905
6900
6895
6890
6885
6880
6875
0
50
100
150
200
250
Station (ft)

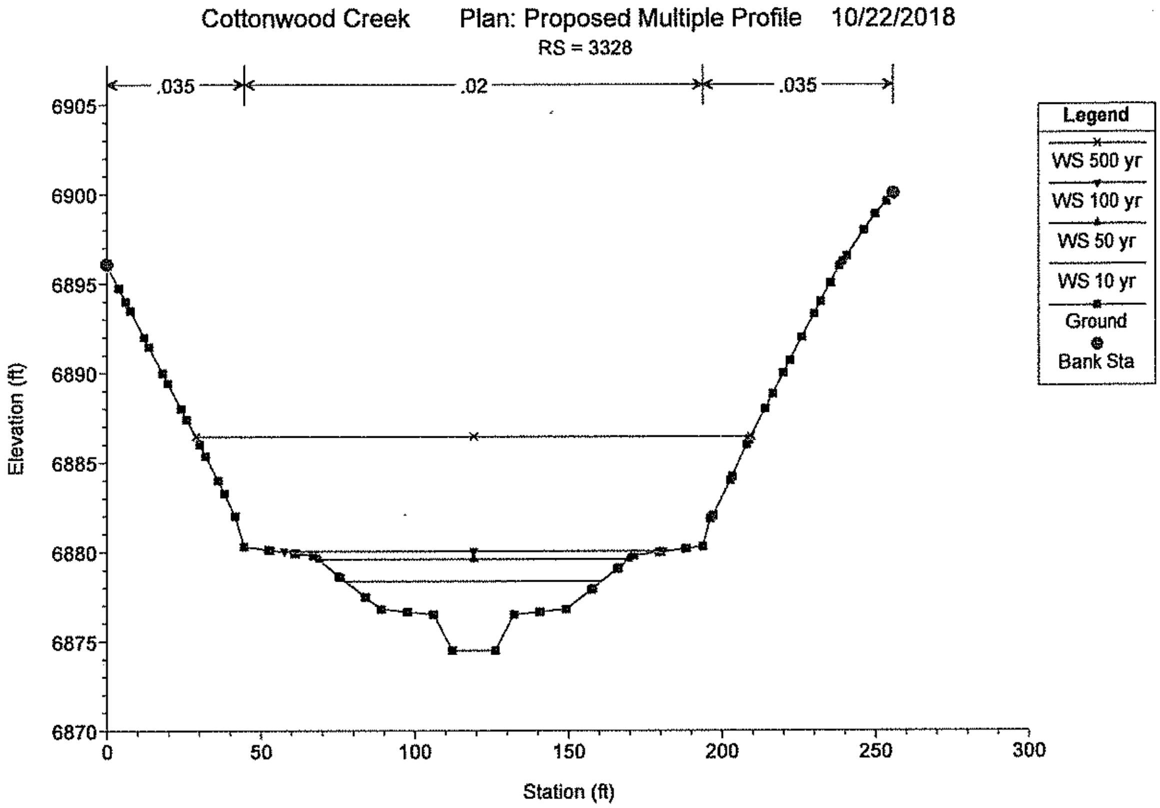

Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3814
.05
.035
.038
.03
.038
.035
.05
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6910
6905
6900
6895
6890
6885
6880
6875
0
50
100
150
200
250
300
Station (ft)

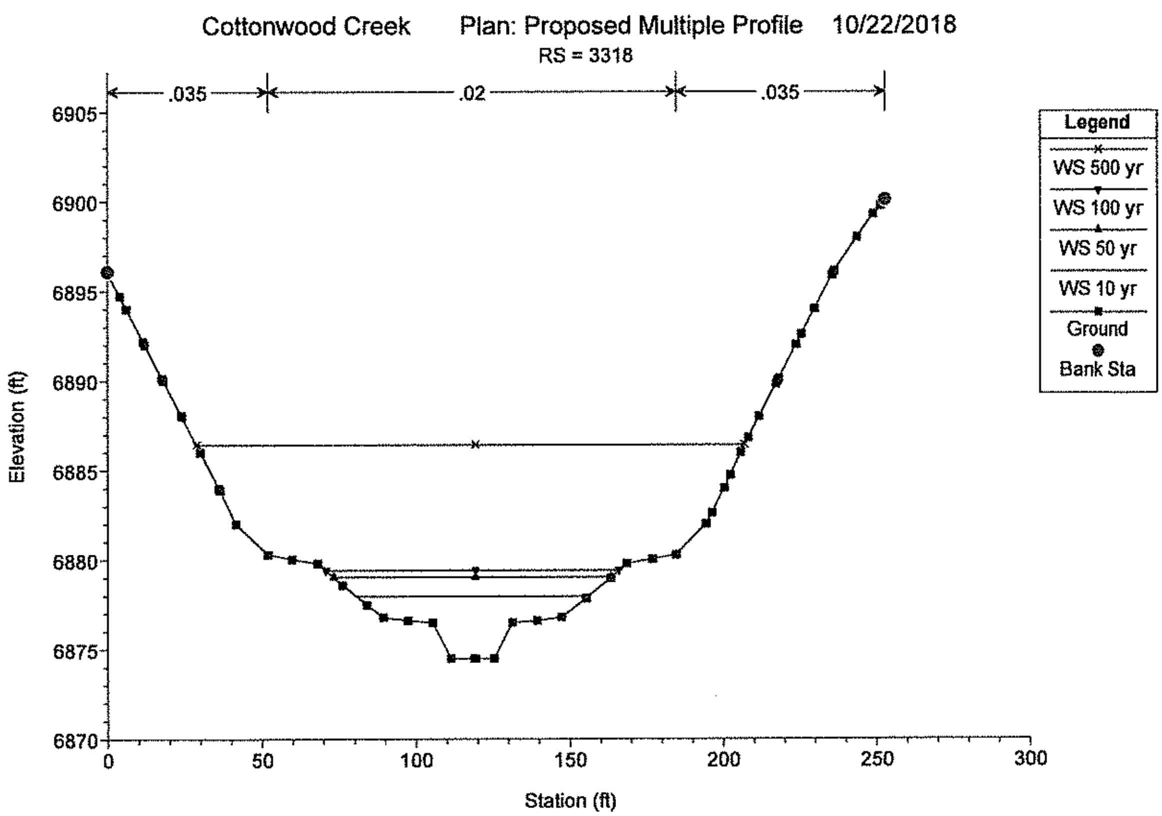


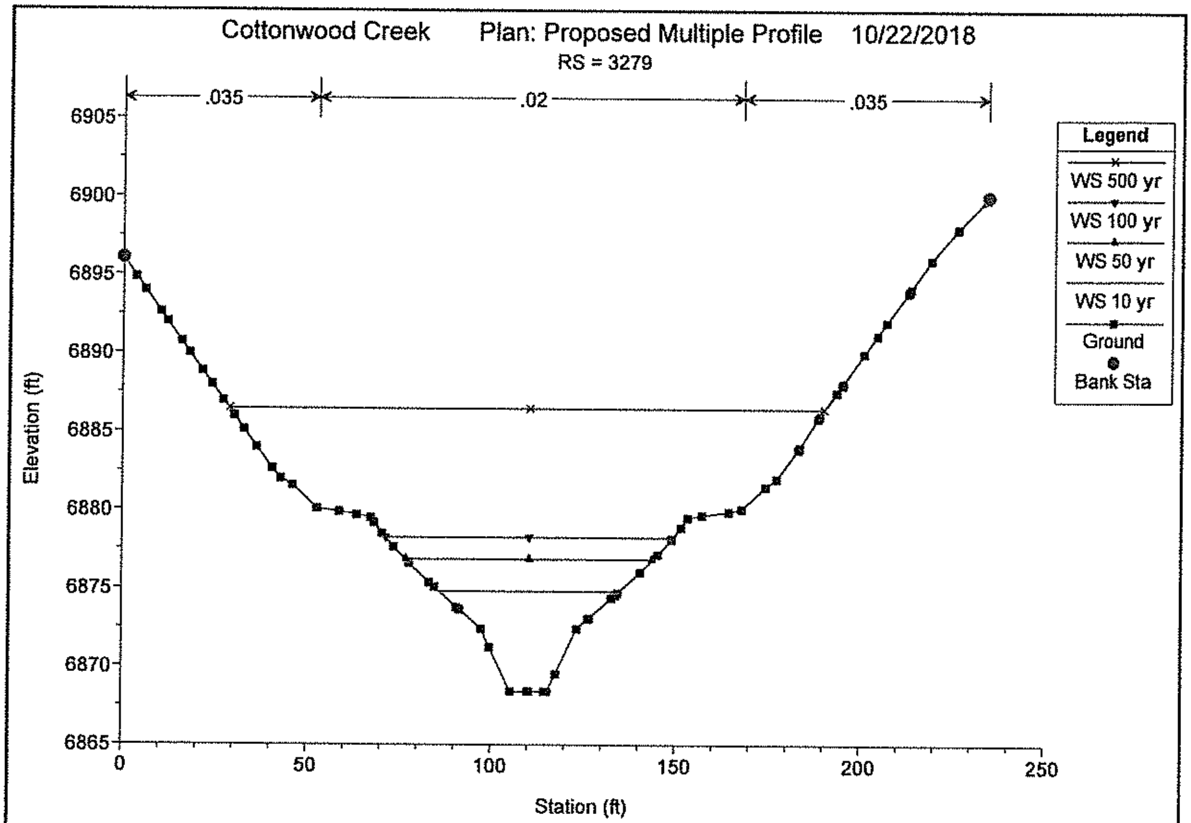
Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3616
.035
.035
.035
Elevation (ft)
Station (ft)
6910
6905
6900
6895
6890
6885
6880
6875
0
50
100
150
200
250
300
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3503
.035
.042
.035
Elevation (ft)
Station (ft)
6910
6905
6900
6895
6890
6885
6880
6875
0
50
100
150
200
250
300
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3328
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6905
6900
6895
6890
6885
6880
6875
6870
0
50
100
150
200
250
300
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3318
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6905
6900
6895
6890
6885
6880
6875
6870
0
50
100
150
200
250
300
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3279
.035
.02
.035
Elevation (ft)
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6900
6895
6890
6885
6880
6875
6870
6865
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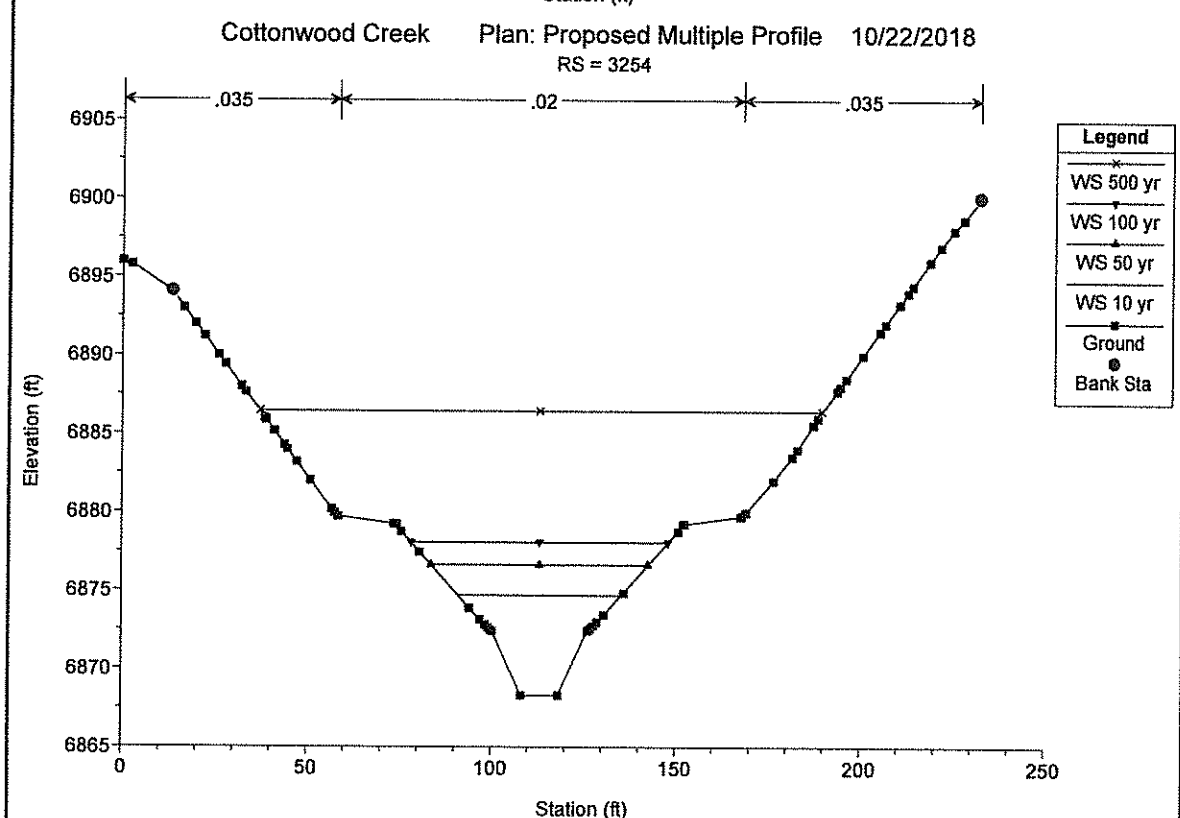
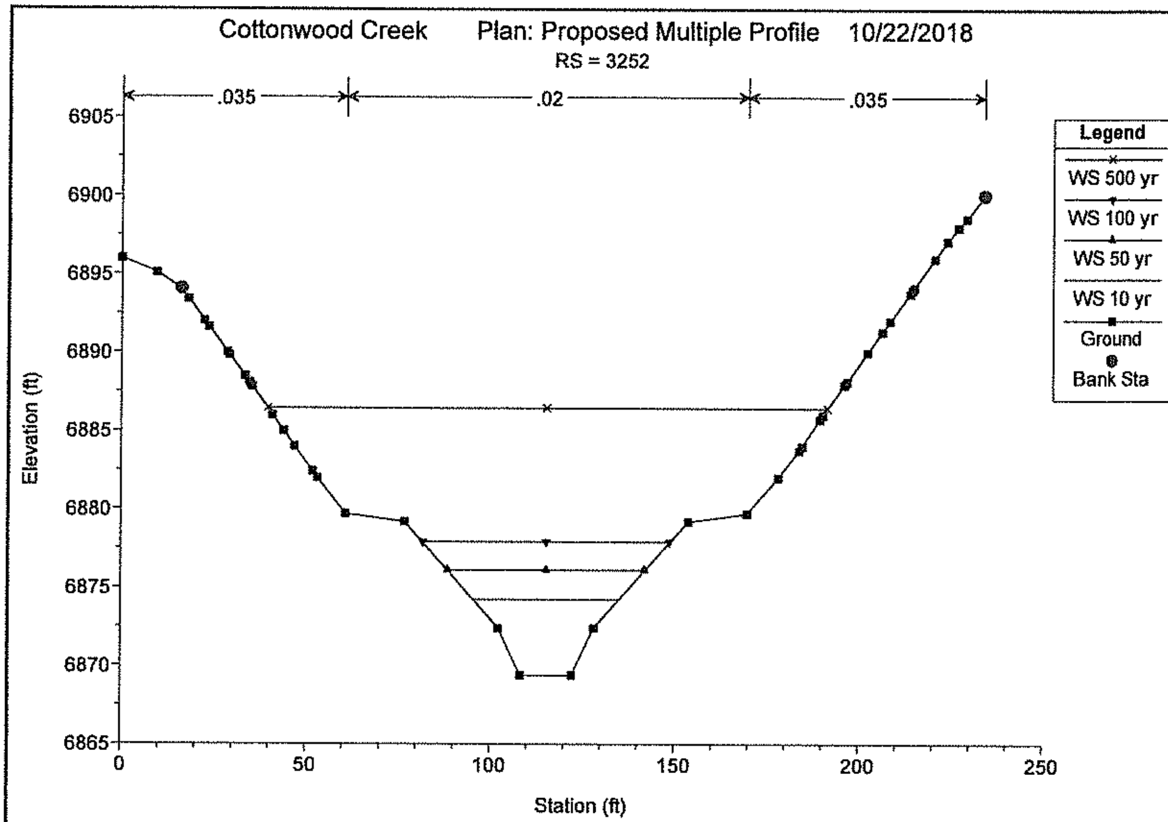
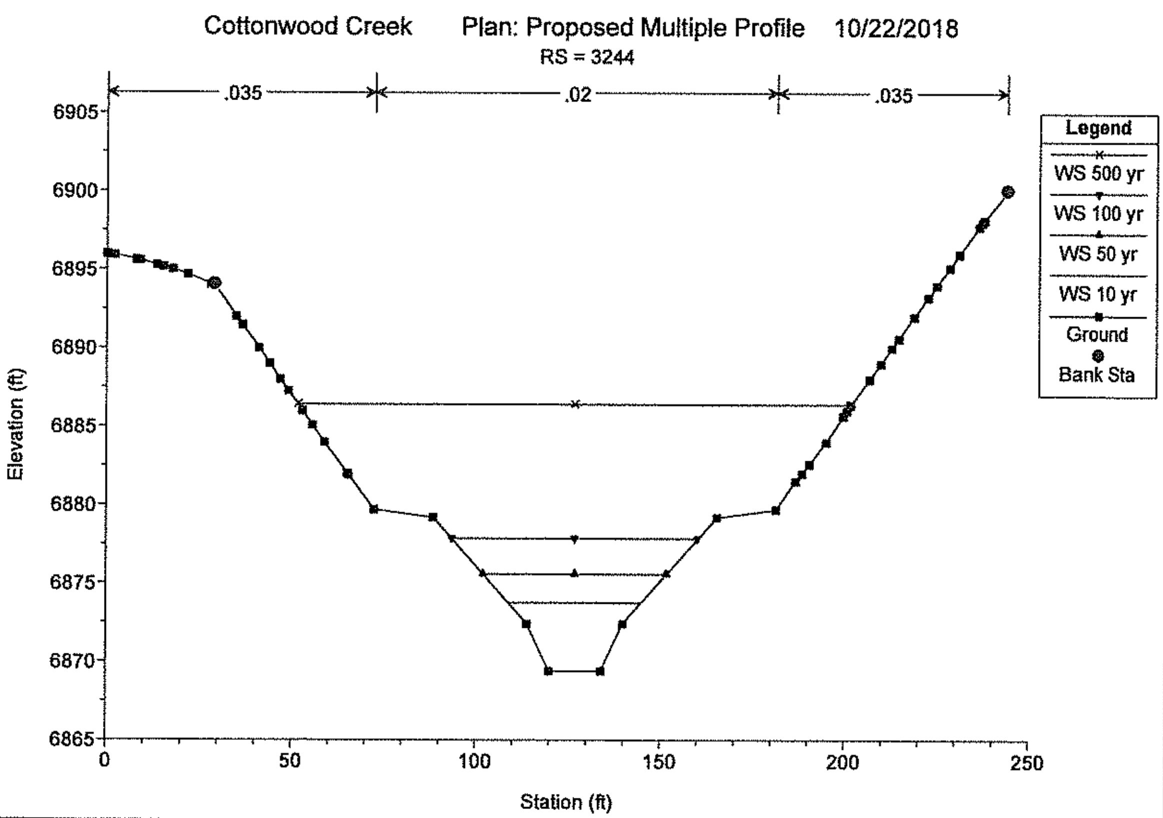
100
150
200
250
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3254
.035
.02
.035
Elevation (ft)
6905
6900
6895
6890
6885
6880
6875
6870
6865
0
50
100
150
200
250
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3252
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6865
6870
6875
6880
6885
6890
6895
6900
6905
Station (ft)
0
50
100
150
200
250



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3244
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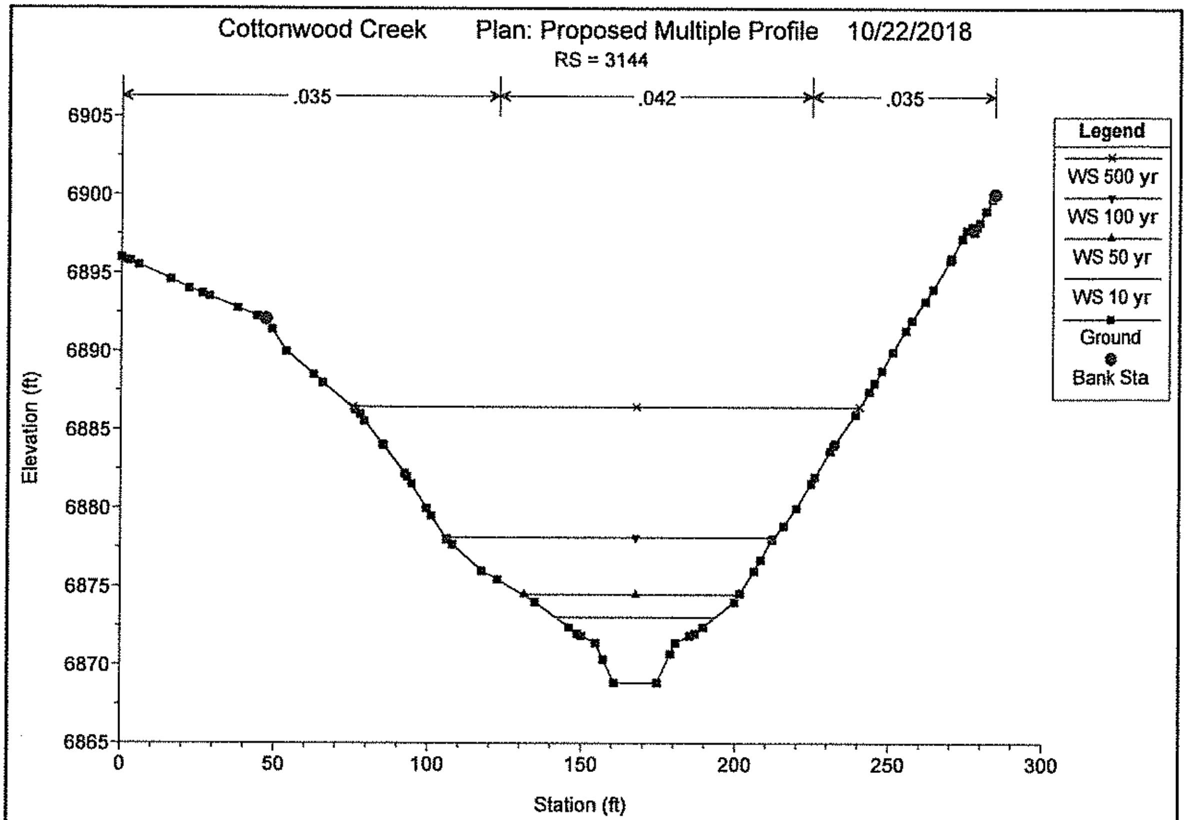
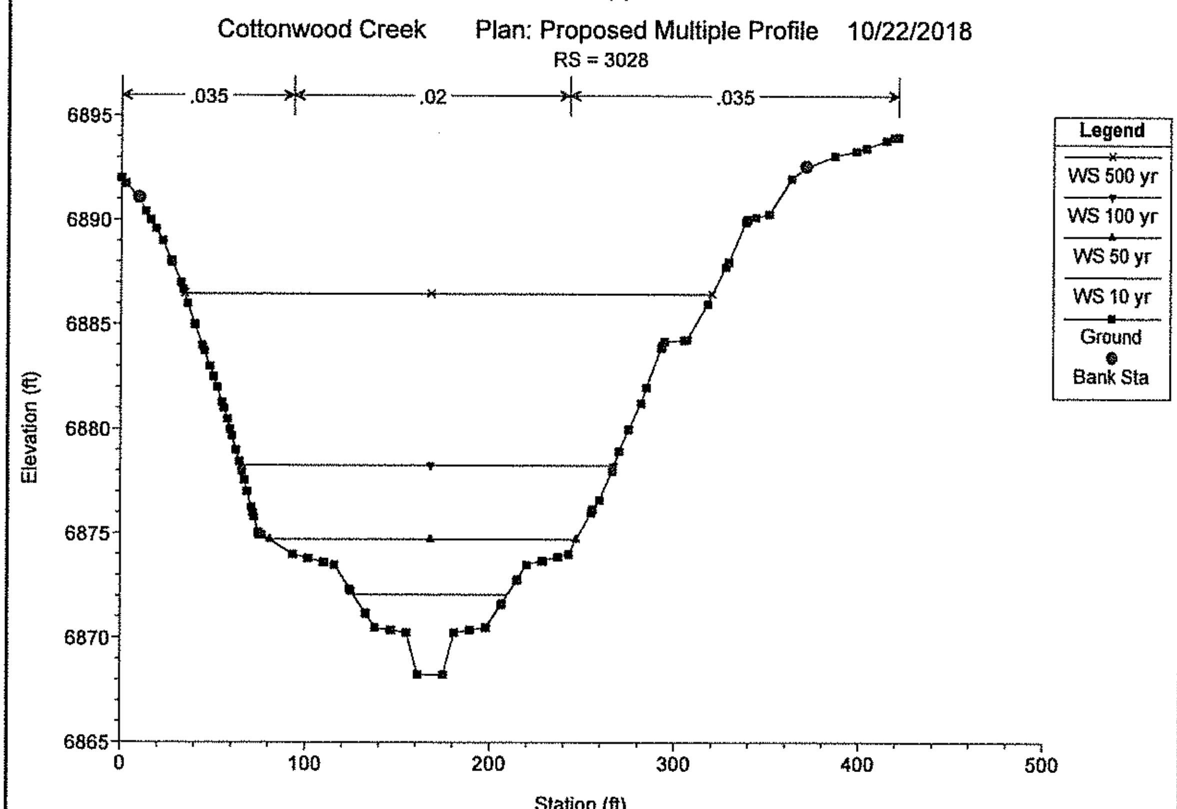
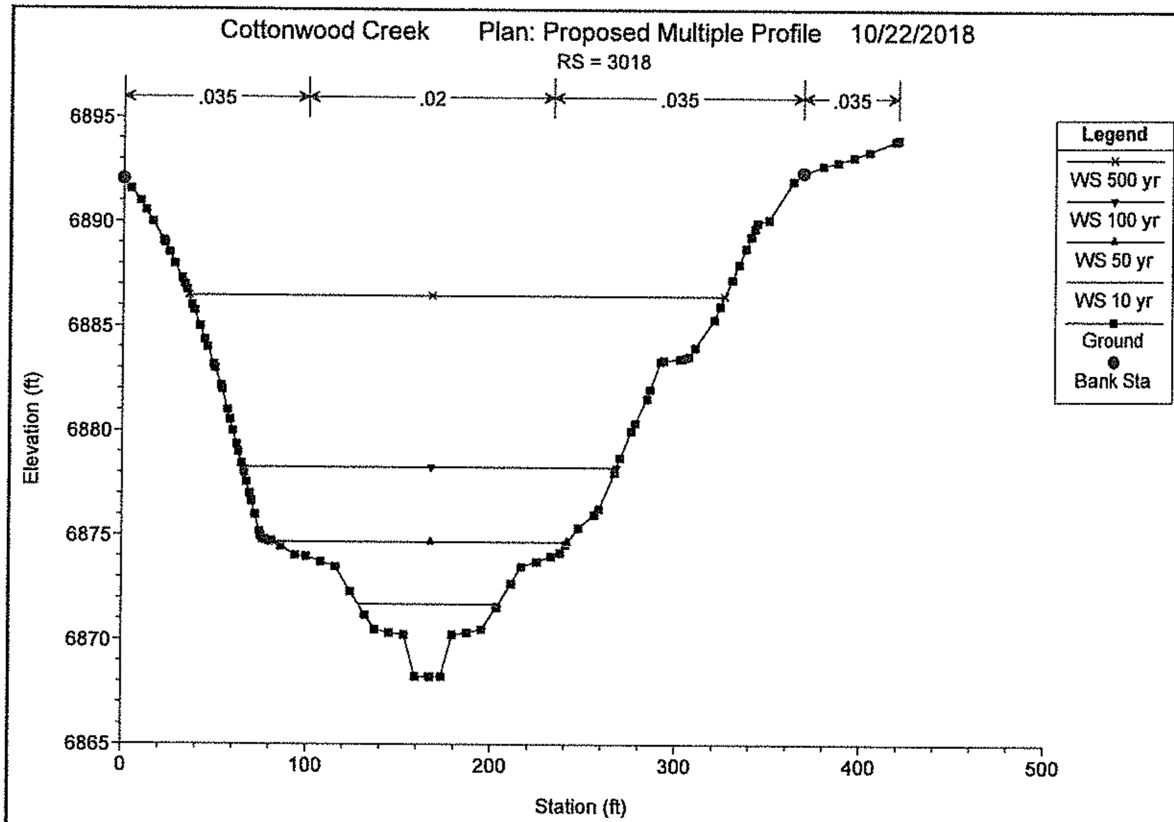
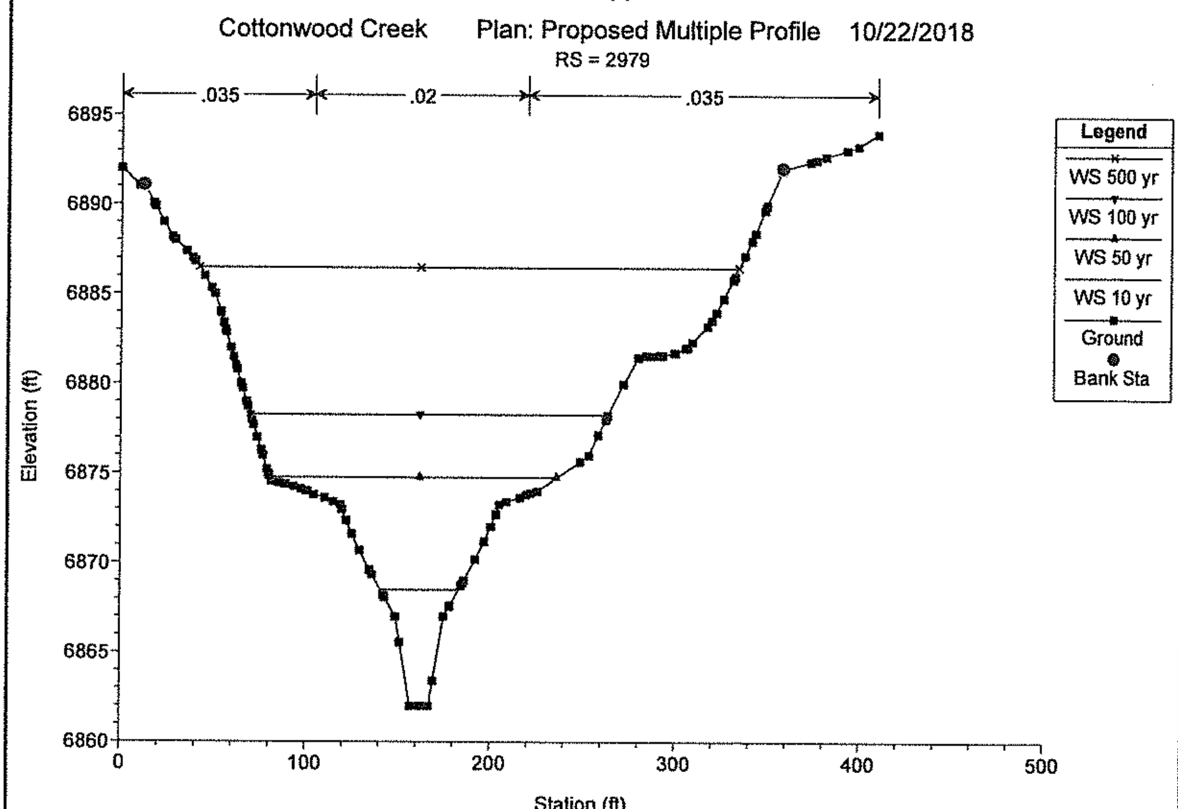
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6865
6870
6875
6880
6885
6890
6895
6900
6905
Station (ft)
0
50
100
150
200
250


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3144
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6905
6900
6895
6890
6885
6880
6875
6870
6865
0
50
100
150
200
250
300
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3028
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
0
100
200
300
400
500
Station (ft)



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 3018
.035
.02
.035
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
0
100
200
300
400
500
Station (ft)



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2979
.035
.02
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Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
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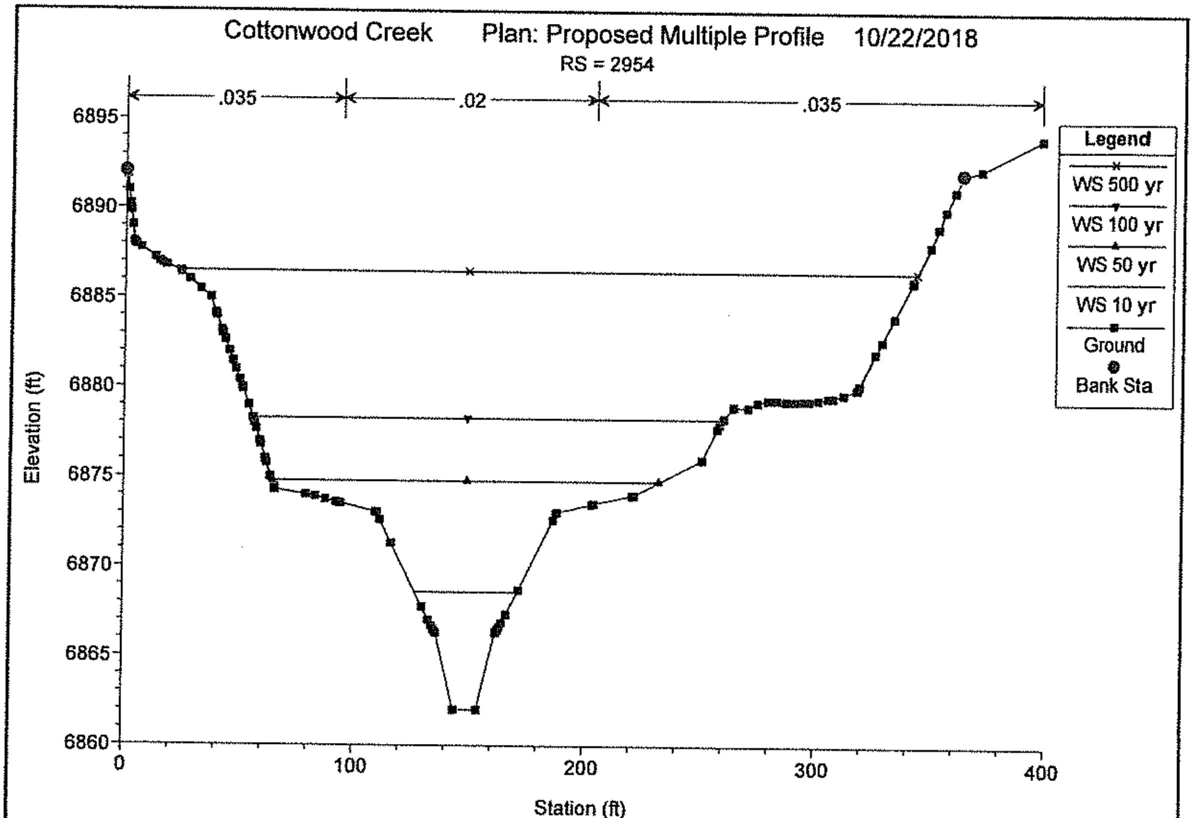
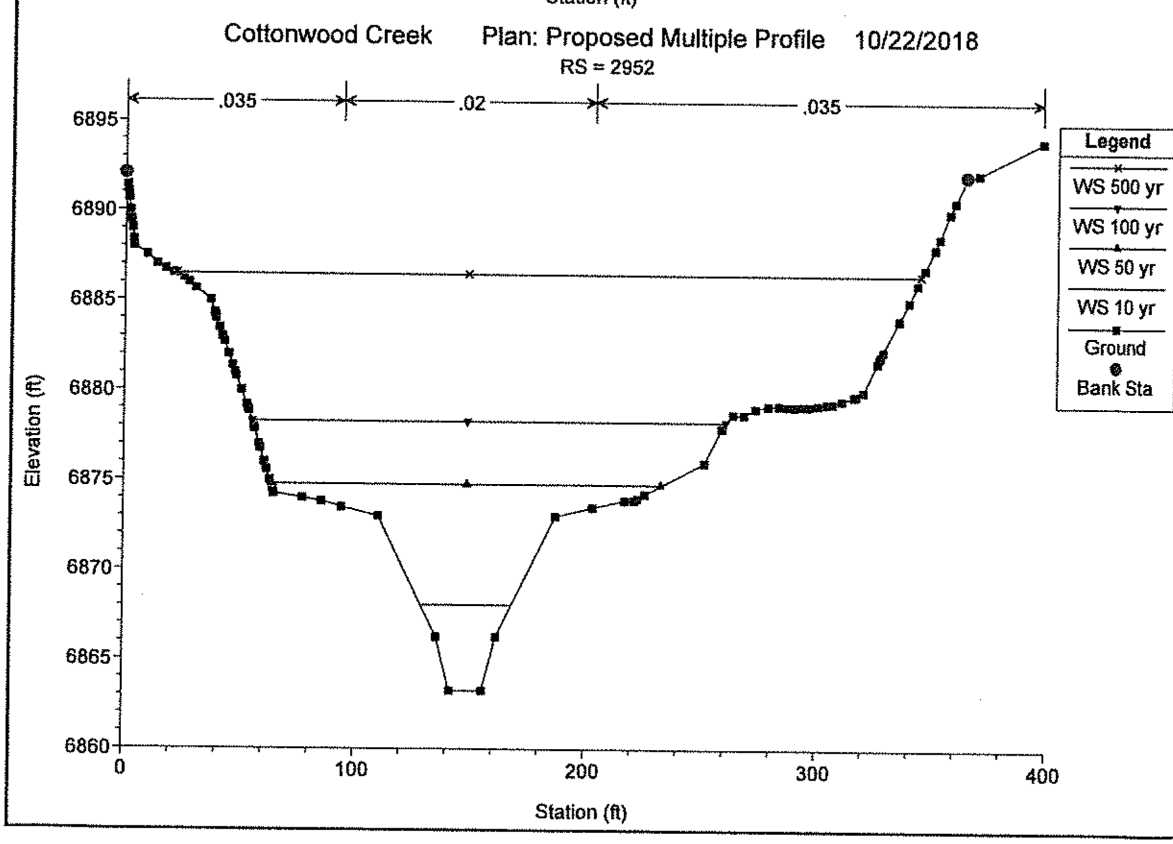
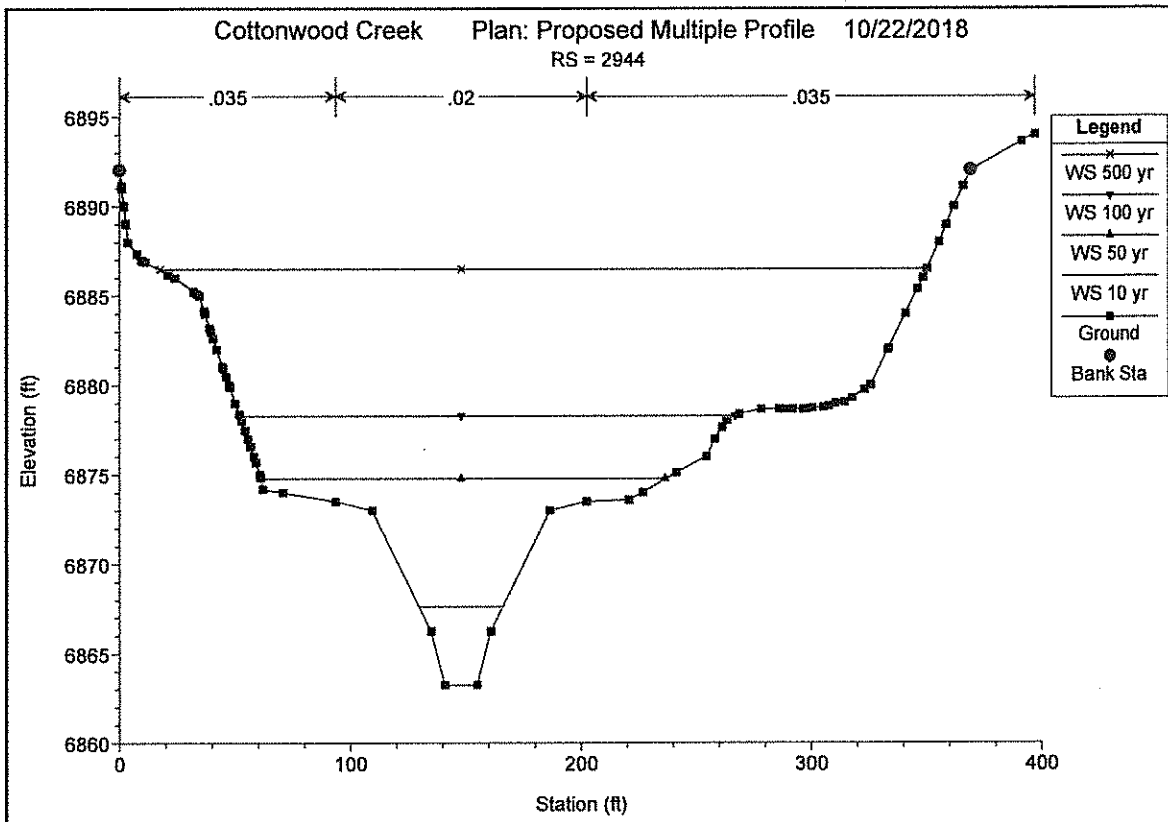
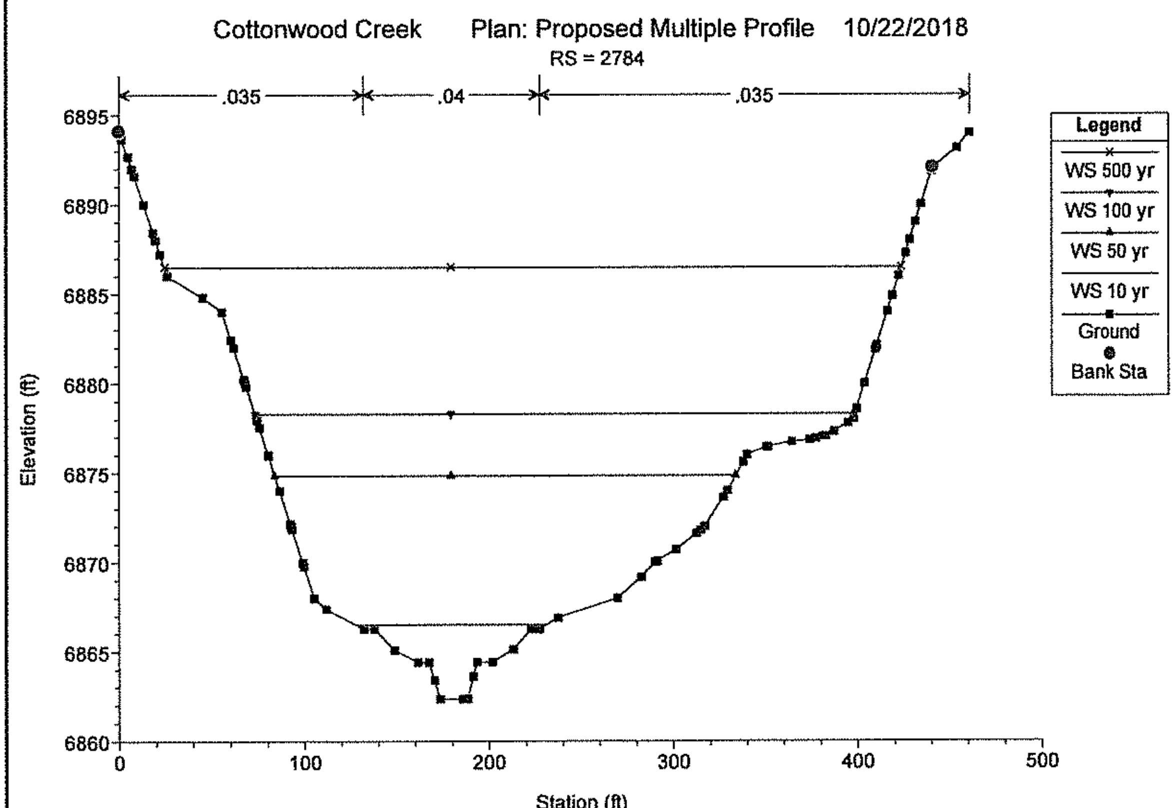
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
500
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2954
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2952
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2944
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6895
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2784
.035
.04
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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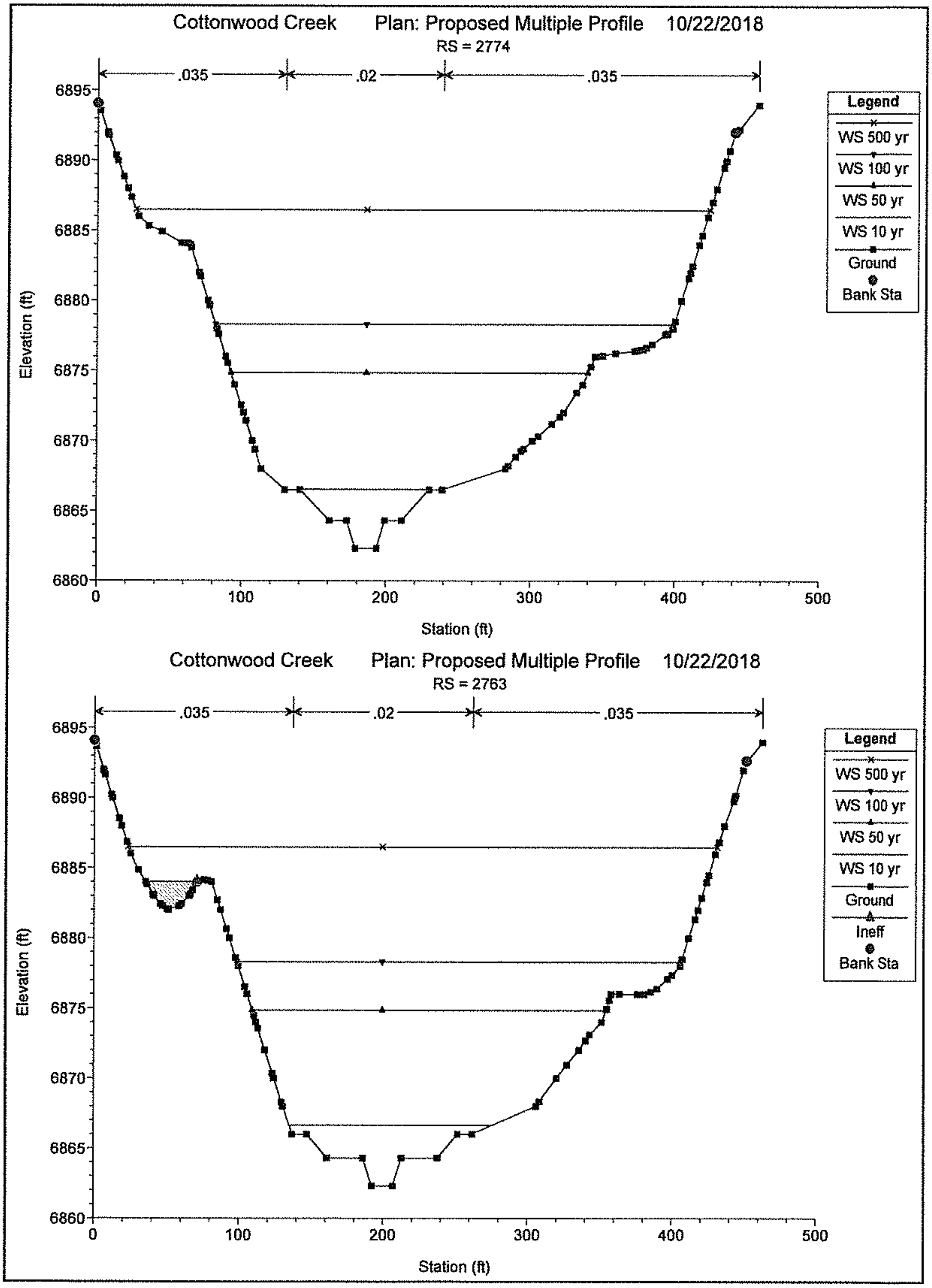
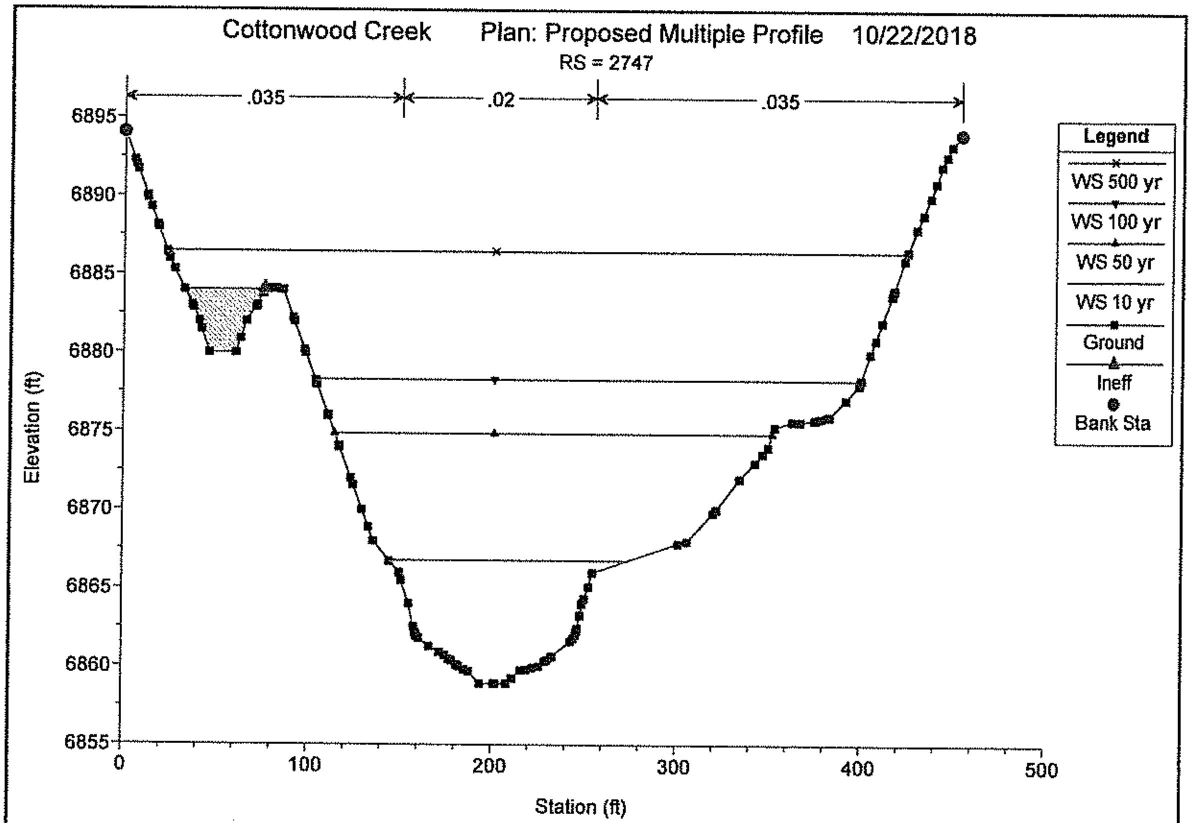
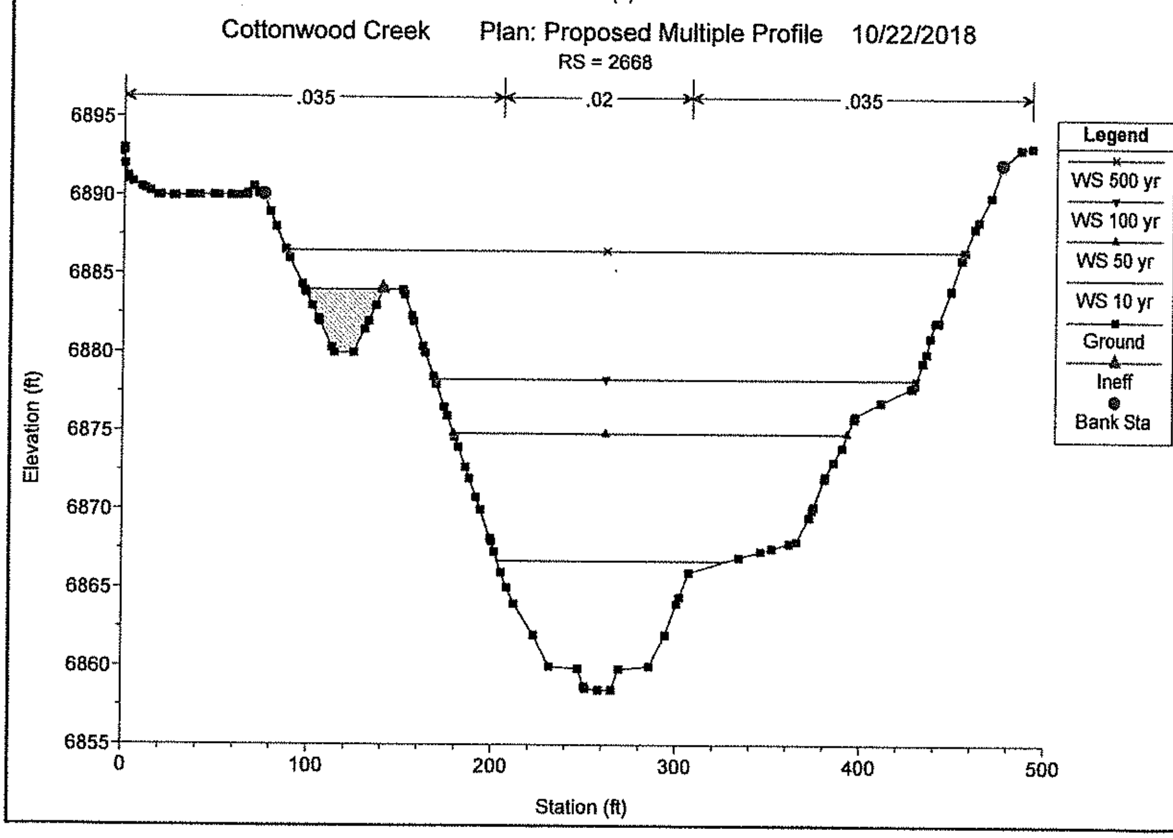
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
500



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2774
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6895
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
500
Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2763
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
6895
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
500


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2747
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
6860
6855
0
100
200
300
400
500
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2668
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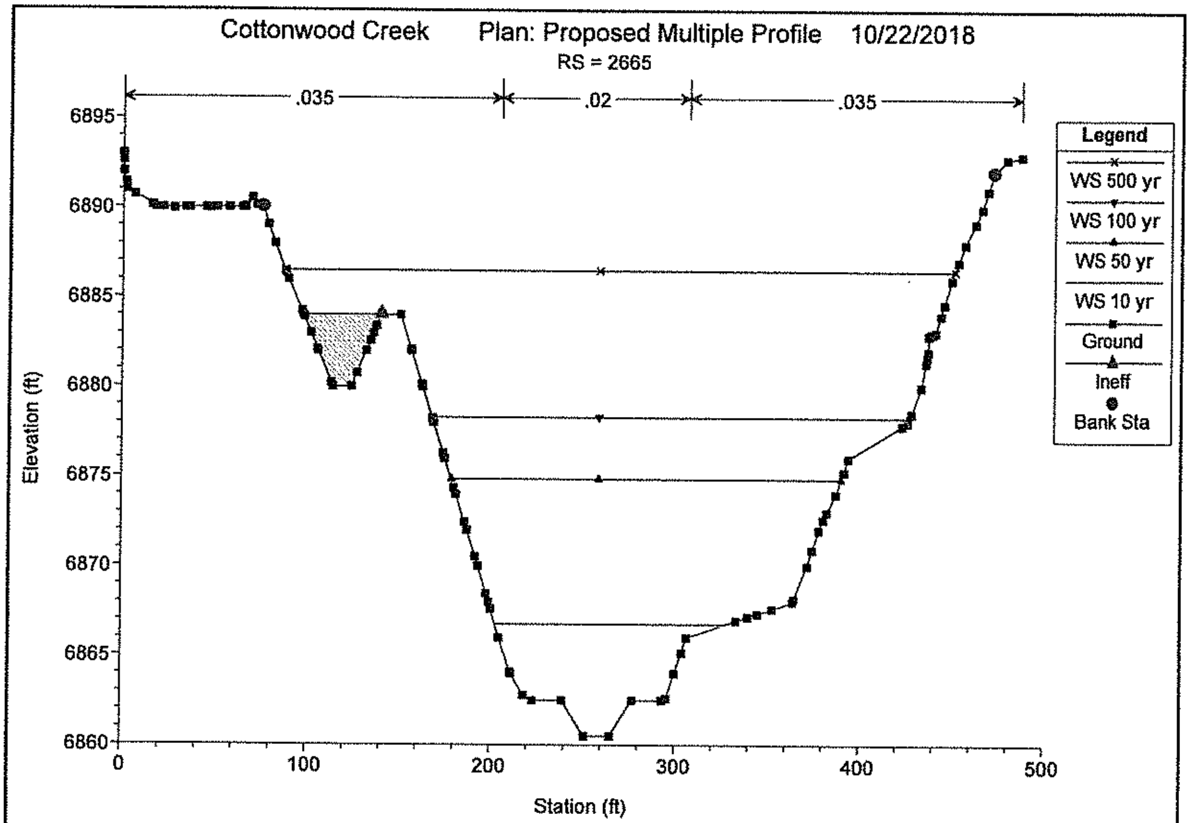
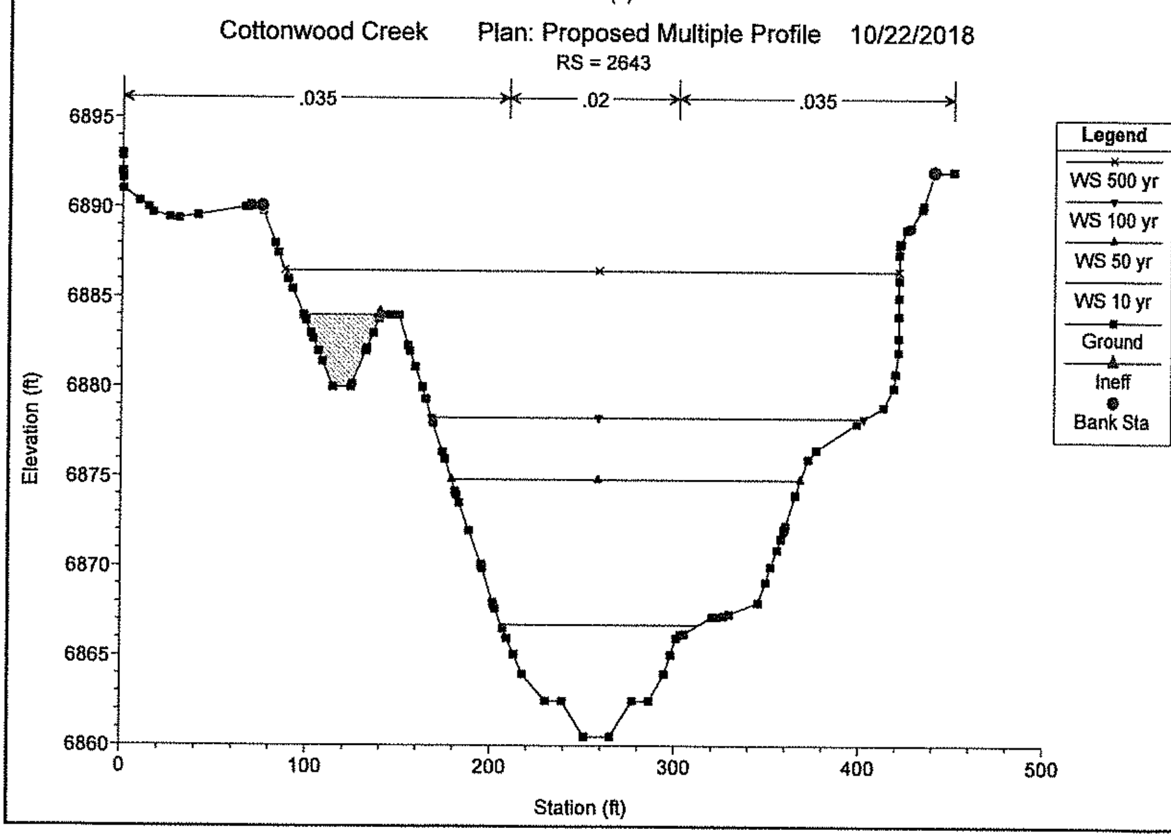
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
6860
6855
0
100
200
300
400
500
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2665
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
6895
6890
6885
6880
6875
6870
6865
6860
0
100
200
300
400
500
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2643
.035
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
6895
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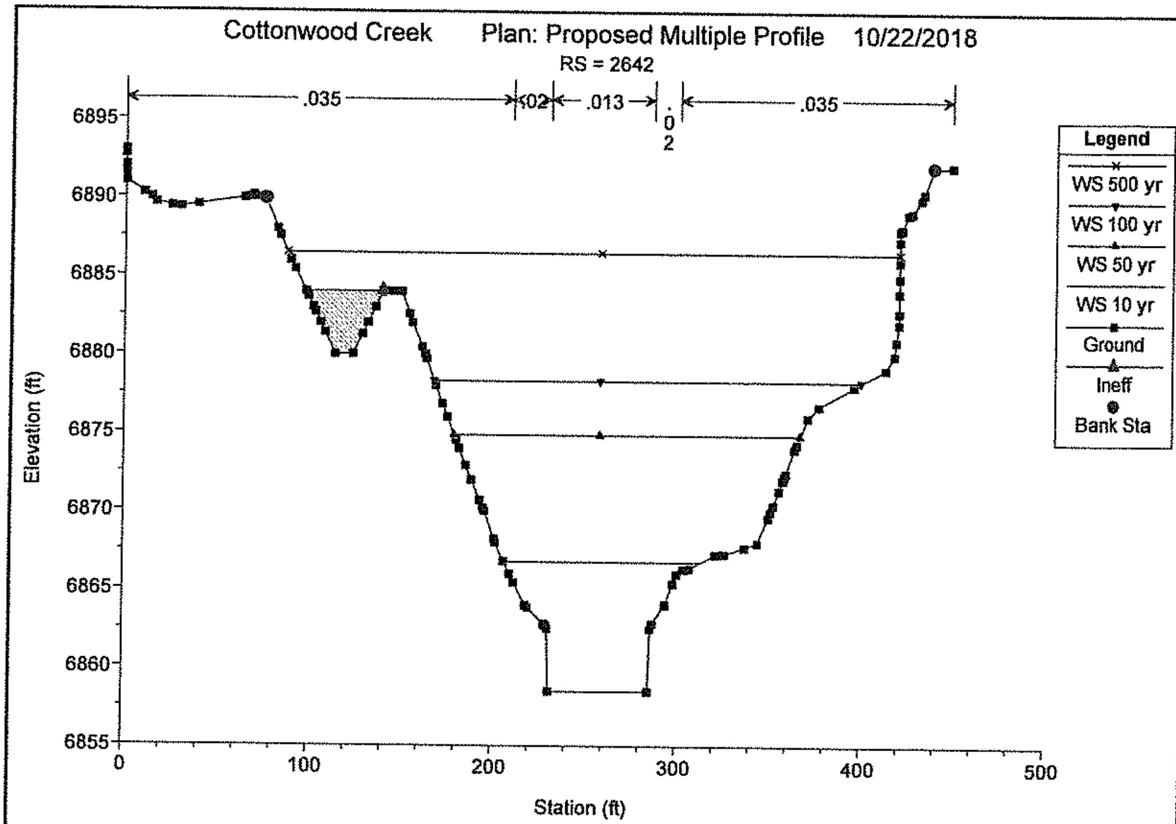
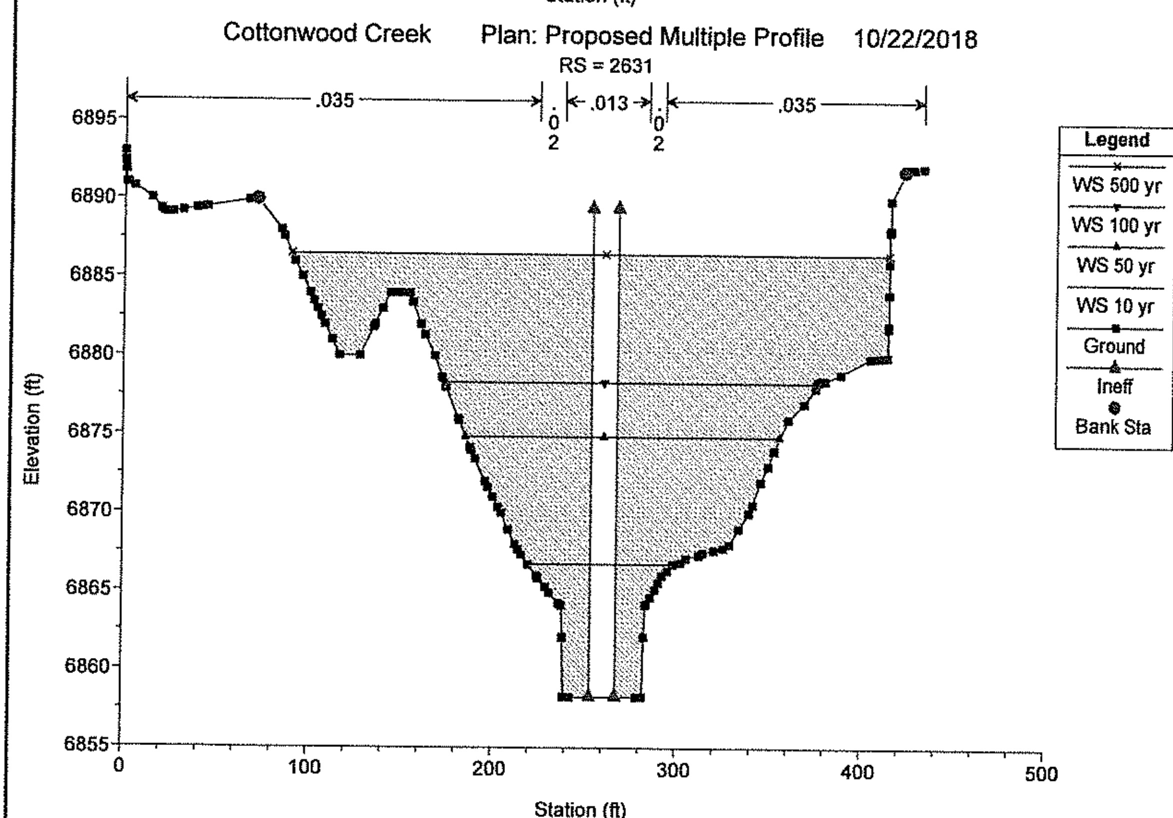
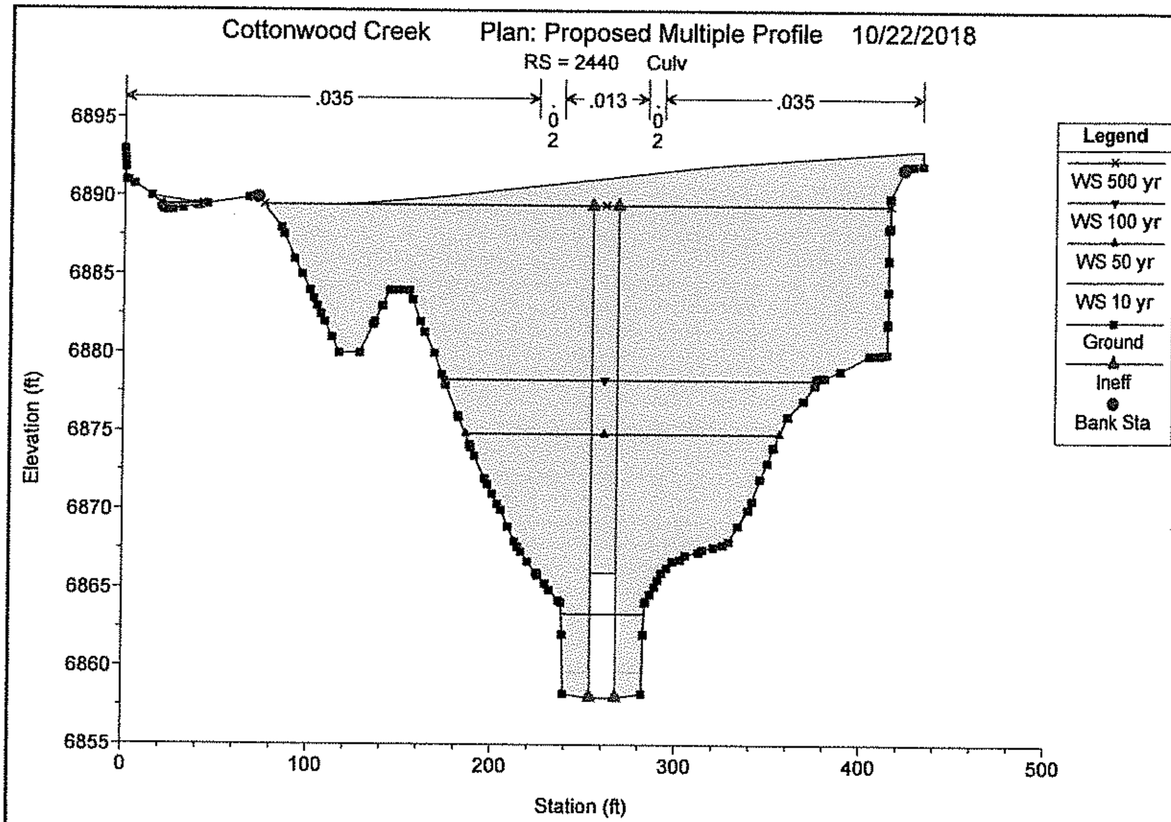
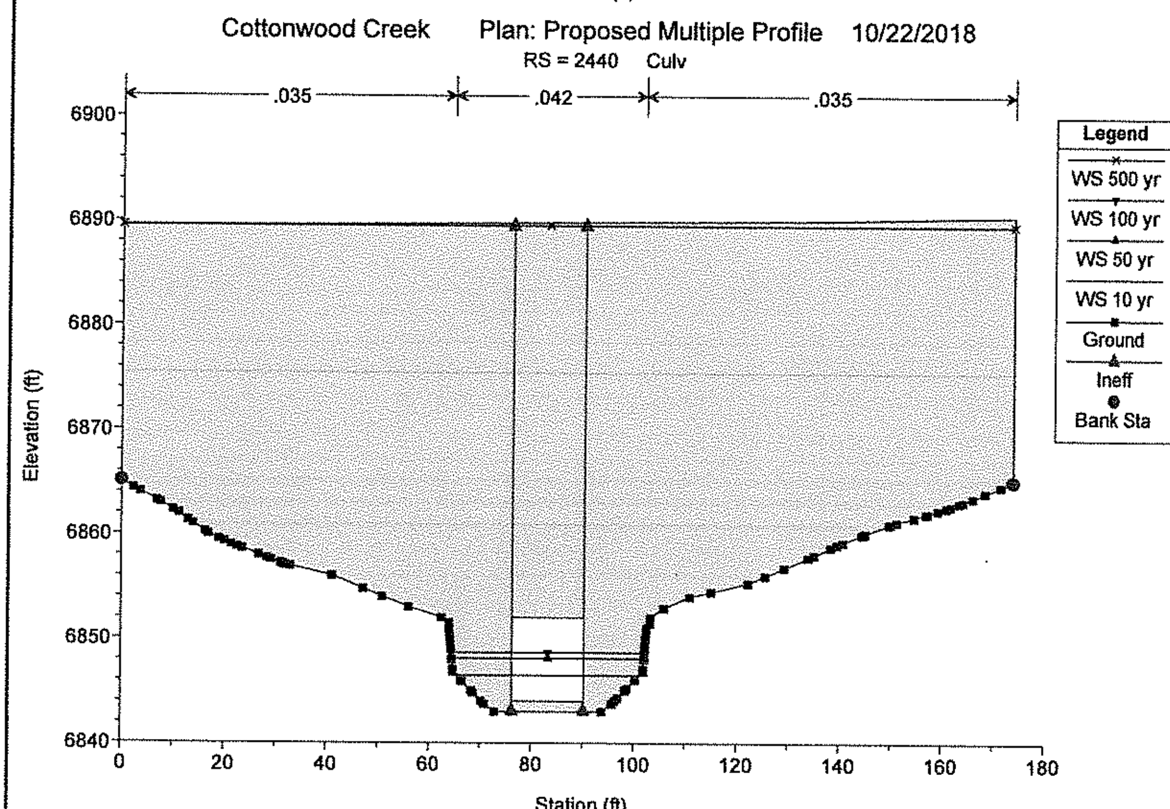
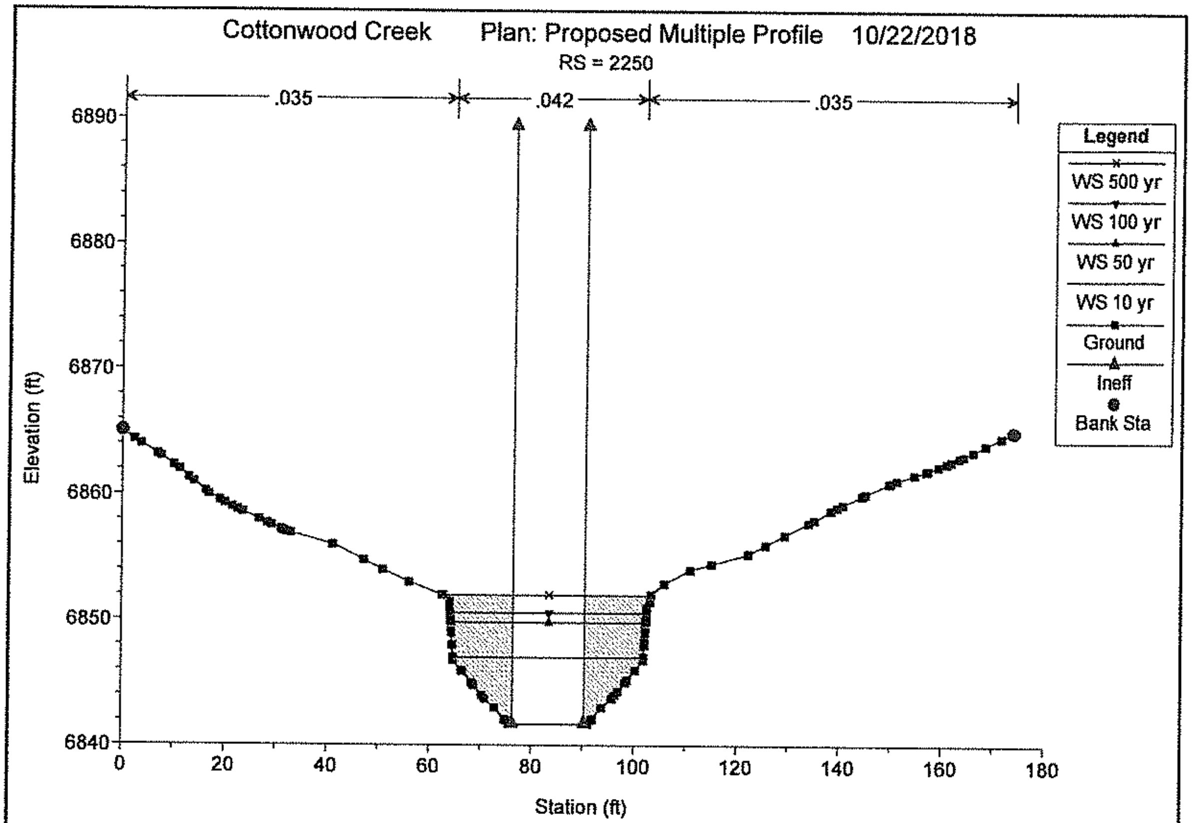
6885
6880
6875
6870
6865
6860
0
100
200
300
400
500
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2642
.035
.02
.013
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

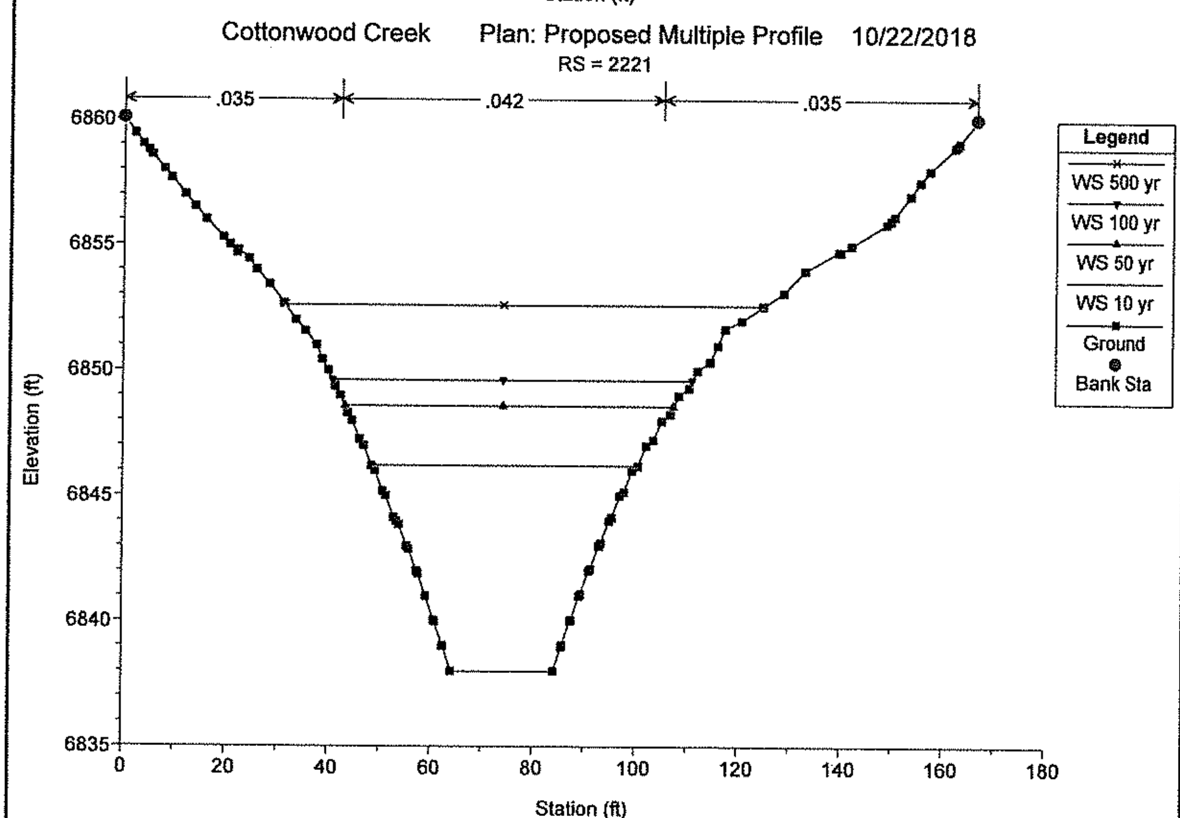

Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2631
.035
.02
.013
.02
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2440 Culv
.035
.013
.035
.02
.02
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta

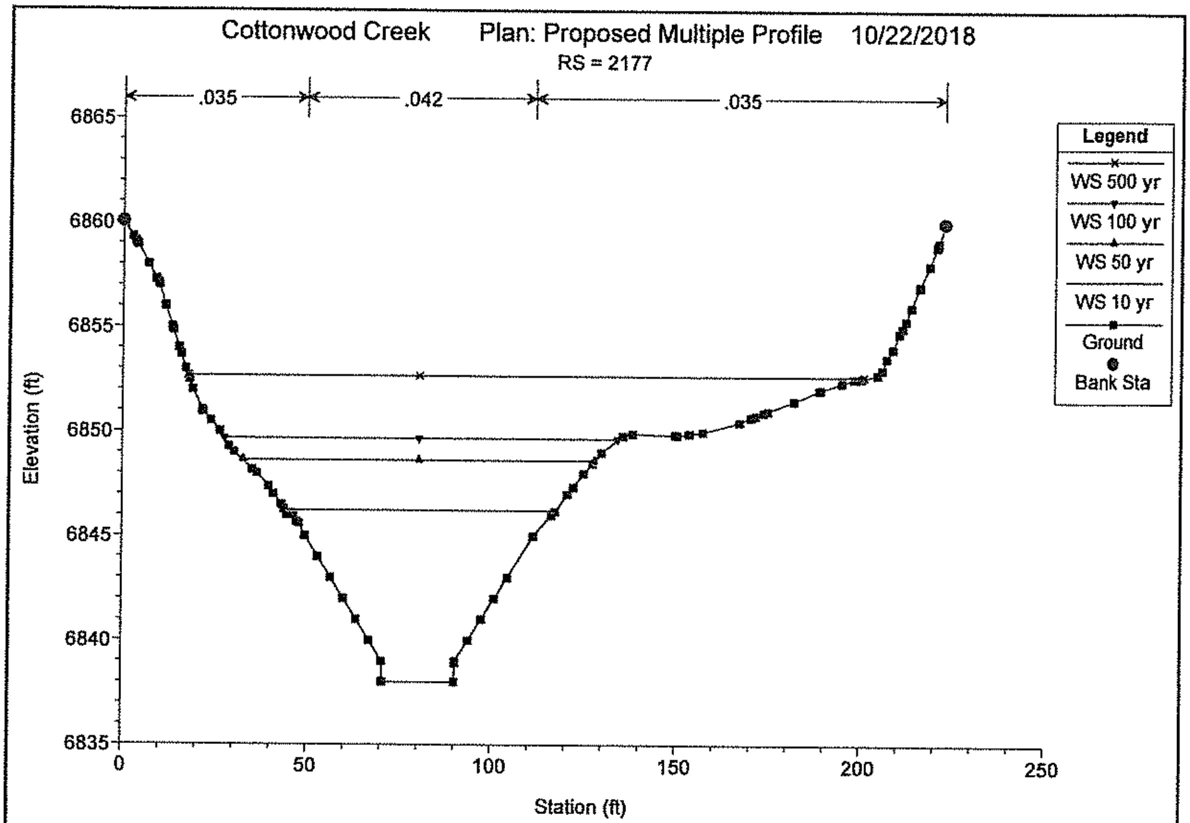

Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2440 Culv
.035
.042
.035
Elevation (ft)
Station (ft)
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta

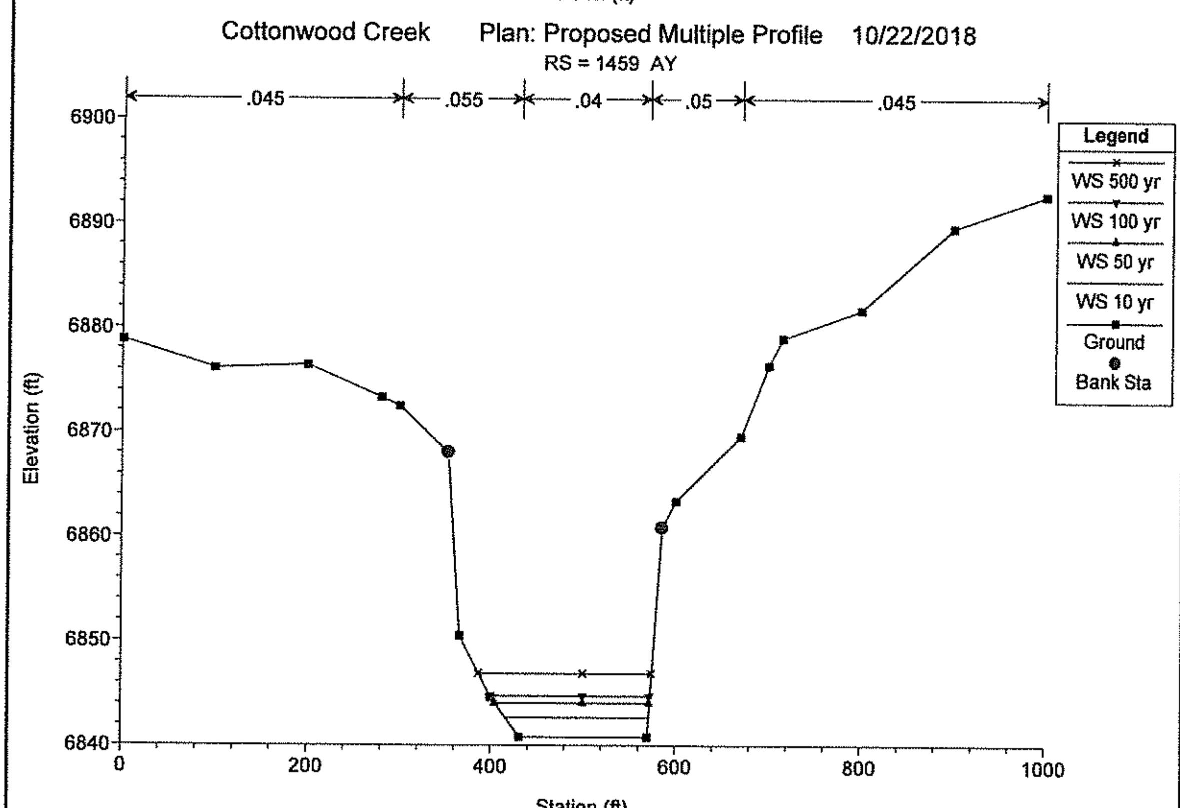


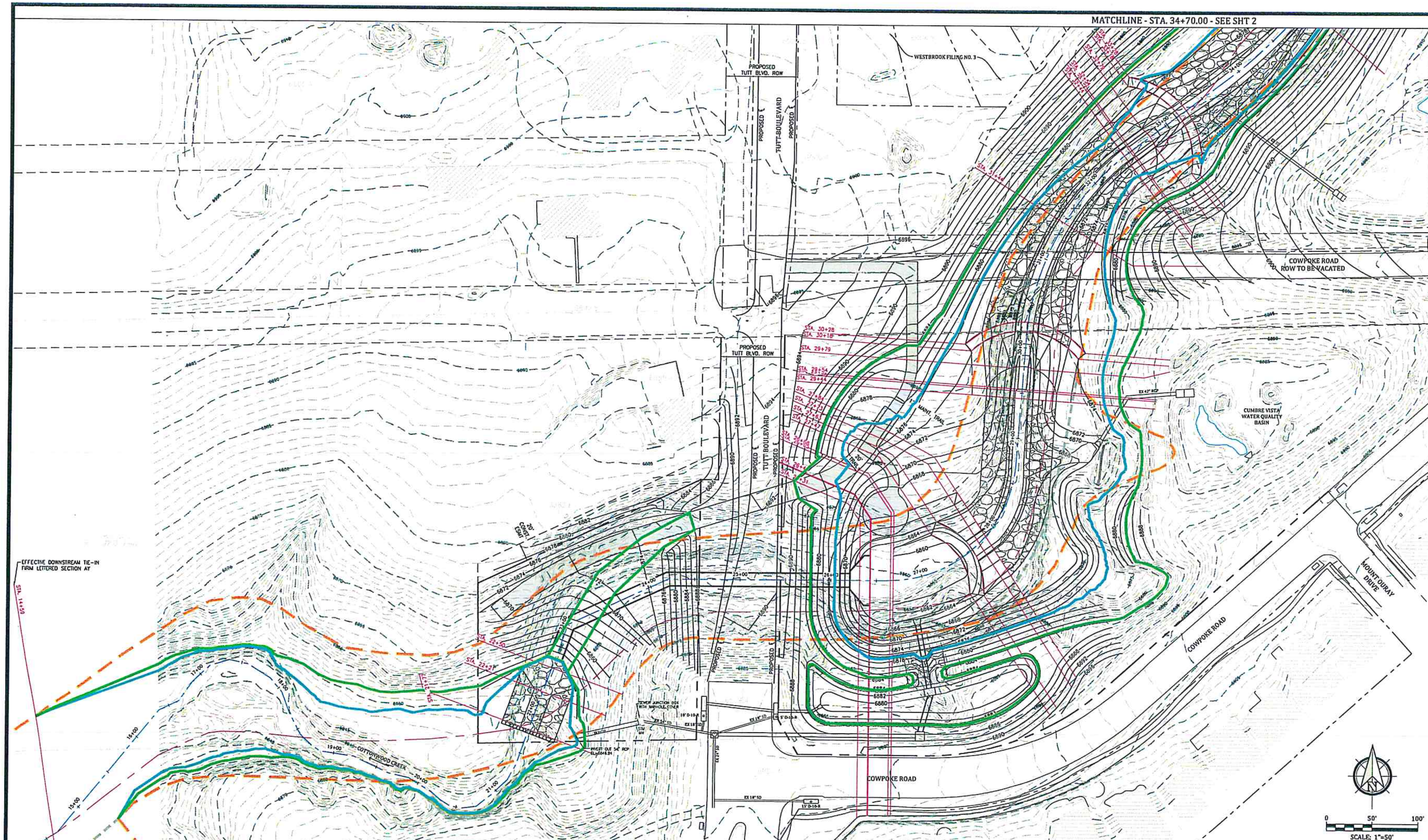
Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2250
.035
.042
.035
Elevation (ft)
Station (ft)
6890
6880
6870
6860
6850
6840
0
20
40
60
80
100
120
140
160
180
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Ineff
Bank Sta



Cottonwood Creek Plan: Proposed Multiple Profile 10/22/2018
RS = 2221
.035
.042
.035
Elevation (ft)
Station (ft)
6860
6855
6850
6845
6840
6835
0
20
40
60
80
100
120
140
160
180
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta


Cottonwood Creek
Plan: Proposed Multiple Profile
10/22/2018
RS = 2177
.035
.042
.035
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6835
6840
6845
6850
6855
6860
6865
0
50
100
150
200
250


Cottonwood Creek
Plan: Proposed Multiple Profile
10/22/2018
RS = 1459 AY
.045
.055
.04
.05
.045
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
6840
6850
6860
6870
6880
6890
6900
0
200
400
600
800
1000



TOPOGRAPHIC MAPPING WAS PROVIDED BY LANDMARK MAPPING, LTD. AND ROCKWELL CONSULTING, INC. IN 2017 AND BASED ON NORTH AMERICAN DATUM 1983 COLORADO STATE PLANE COORDINATES, CENTRAL ZONE AND NATIONAL GEODETIC VERTICAL DATUM 1929.

THE TOPOGRAPHY WAS COMPILED IN ACCORDANCE WITH NATIONAL MAPPING STANDARDS FOR 1"=200' & 2' CONTOUR INTERVAL DETAIL.

SITE BENCHMARK: FIMS MONUMENT NUMBER 69

ERIC L. STREAM — DATED
COLORADO LIC. 53471

LEGEND

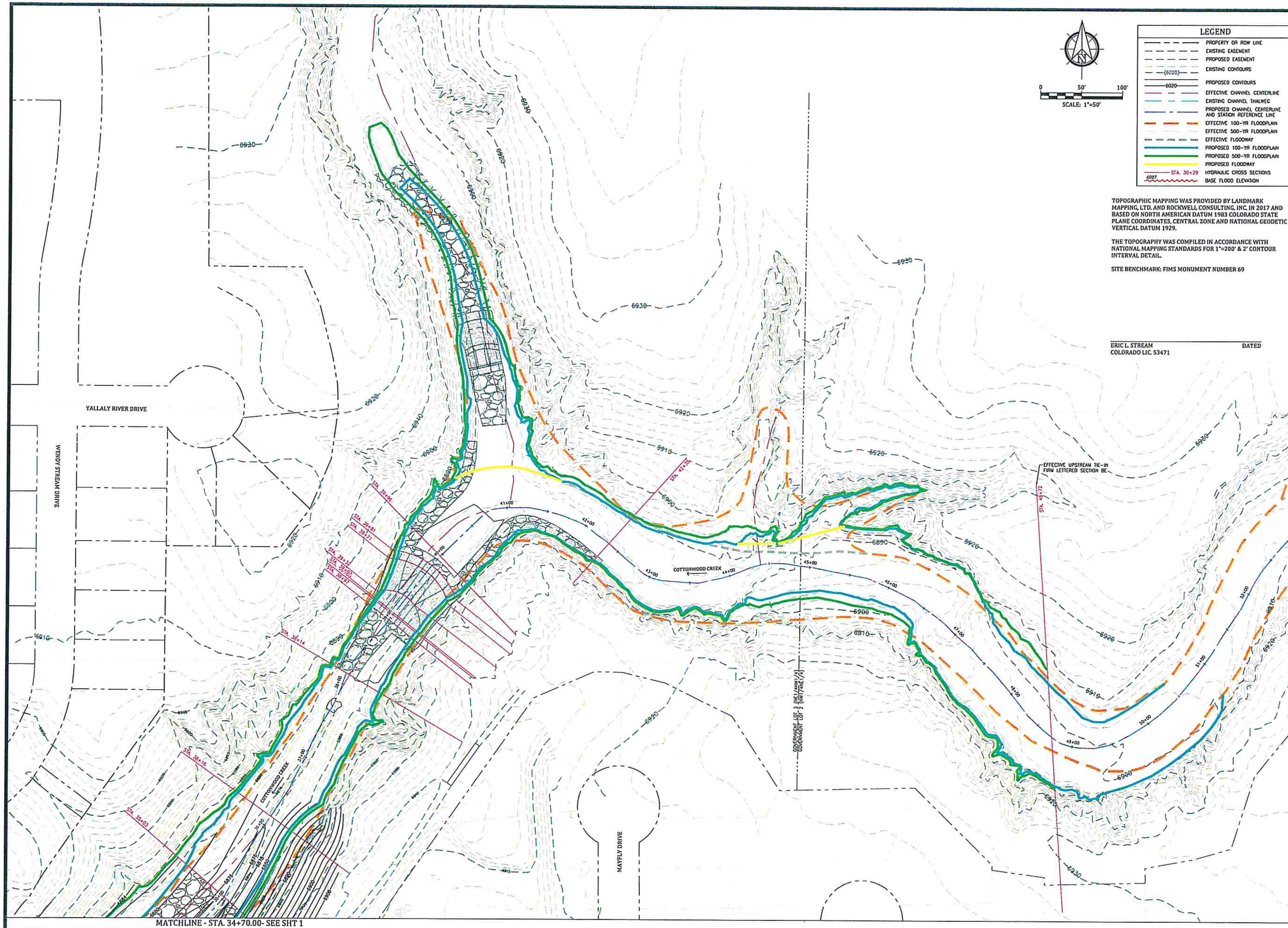
- PROPERTY OR ROW LINE
- EXISTING EASEMENT
- PROPOSED EASEMENT
- (6020) EXISTING CONTOURS
- 6020 PROPOSED CONTOURS
- EFFECTIVE CHANNEL CENTERLINE
- EXISTING CHANNEL THALWEG
- PROPOSED CHANNEL CENTERLINE AND STATION REFERENCE LINE
- EFFECTIVE 100-YR FLOODPLAIN
- EFFECTIVE 500-YR FLOODPLAIN
- EFFECTIVE FLOODWAY
- PROPOSED 100-YR FLOODPLAIN
- PROPOSED 500-YR FLOODPLAIN
- PROPOSED FLOODWAY
- STA. 30+29 HYDRAULIC CROSS SECTIONS
- 6007 BASE FLOOD ELEVATION

Kiowa Engineering Corporation
Celebrating 30 years
7175 West Jefferson Avenue, Suite 2200
Lakewood, Colorado 80235
(303) 692-0369

COTTONWOOD CREEK STORMWATER DETENTION BASIN PR-2
TUTT BOULEVARD AND COWPOKE ROAD CLOMR
PROPOSED CONDITIONS FLOODPLAIN WORKMAP
COLORADO SPRINGS, COLORADO

Project No.:	17043
Date:	August 6, 2018
Design:	RNW
Drawn:	ELS
Check:	RNW
Revisions:	

SHEET 1 OF 2 SHEETS



LEGEND

— — —	PROPERTY OR ROW LINE
— — —	EXISTING EASEMENT
— — —	PROPOSED EASEMENT
—(6020)—	EXISTING CONTOURS
—6020—	PROPOSED CONTOURS
— — —	EFFECTIVE CHANNEL CENTERLINE
— — —	EXISTING CHANNEL THALWEG
— — —	PROPOSED CHANNEL CENTERLINE AND STATION REFERENCE LINE
— — —	EFFECTIVE 100-YR FLOODPLAIN
— — —	EFFECTIVE 500-YR FLOODPLAIN
— — —	EFFECTIVE FLOODWAY
——	PROPOSED 100-YR FLOODPLAIN
——	PROPOSED 500-YR FLOODPLAIN
——	PROPOSED FLOODWAY
—— STA. 30+29	HYDRAULIC CROSS SECTIONS
6007	BASE FLOOD ELEVATION

TOPOGRAPHIC MAPPING WAS PROVIDED BY LANDMARK MAPPING, LTD. AND ROCKWELL CONSULTING, INC. IN 2017 AND BASED ON NORTH AMERICAN DATUM 1983 COLORADO STATE PLANE COORDINATES, CENTRAL ZONE AND NATIONAL GEODETIC VERTICAL DATUM 1929.

THE TOPOGRAPHY WAS COMPILED IN ACCORDANCE WITH NATIONAL MAPPING STANDARDS FOR 1"=200' & 2' CONTOUR INTERVAL DETAIL.

SITE BENCHMARK: FIMS MONUMENT NUMBER 69

ERIC L. STREAM
COLORADO LIC. 53471

DATED

Kiowa Engineering Corporation
Celebrating 30 years
7175 West Jefferson Avenue, Suite 2200
Lakewood, Colorado 80235
(303) 692-0369

COTTONWOOD CREEK STORMWATER DETENTION BASIN PR-2
TUTT BOULEVARD AND COWPOKE ROAD CLOMR
PROPOSED CONDITIONS FLOODPLAIN WORKMAP
COLORADO SPRINGS, COLORADO

Project No.:	17043
Date:	August 6, 2018
Design:	RNW
Drawn:	ELS
Check:	RNW
Revisions:	

Federal Emergency Management Agency
Washington, D.C. 20472

May 6, 2019

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

IN REPLY REFER TO:
Case No.: 18-08-1091R

The Honorable John Suthers
Mayor, City of Colorado Springs
30 South Nevada Avenue
Colorado Springs, CO 80903

Community Name: City of Colorado Springs, CO
Community No.: 080060

104

Dear Mr. Suthers:

We are providing our comments with the enclosed Conditional Letter of Map Revision (CLOMR) on a proposed project within your community that, if constructed as proposed, could revise the effective Flood Insurance Study (FIS) report and Flood Insurance Rate Map (FIRM) for your community.

If you have any questions regarding the floodplain management regulations for your community, the National Flood Insurance Program (NFIP) in general, or technical questions regarding this CLOMR, please contact the Director, Mitigation Division of the Federal Emergency Management Agency (FEMA) Regional Office in Denver, at (303) 235-4830, or the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP). Additional information about the NFIP is available on our website at https://www.fema.gov/national-flood-insurance-program.

Sincerely,

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

Enclosure:
Conditional Letter of Map Revision Comment Document

cc: The Honorable Amy Folsom
County Administrator, El Paso County

Mr. Keith Curtis, P.E., CFM
Floodplain Administrator
City of Colorado Springs

Mr. Eric Stream, P.E., CFM
Civil Engineer
Kiowa Engineering Corporation

Federal Emergency Management Agency
Washington, D.C. 20472

CONDITIONAL LETTER OF MAP REVISION
COMMENT DOCUMENT

	COMMUNITY INFORMATION	PROPOSED PROJECT DESCRIPTION	BASIS OF CONDITIONAL REQUEST
COMMUNITY	City of Colorado Springs El Paso County Colorado COMMUNITY NO.: 080060	CULVERT DETENTION BASIN	BASE MAP CHANGES FLOODWAY HYDRAULIC ANALYSIS HYDROLOGIC ANALYSIS UPDATED TOPOGRAPHIC DATA
IDENTIFIER	Tutt Boulevard and Cowpoke Road CLOMR	APPROXIMATE LATITUDE & LONGITUDE: 38.950, -104.716 SOURCE: USGS QUADRANGLE DATUM: NAD 83	

AFFECTED MAP PANELS

TYPE: FIRM* NO.: 08041C0529G DATE: December 7, 2018

* FIRM - Flood Insurance Rate Map

FLOODING SOURCE AND REACH DESCRIPTION

Cottonwood Creek – From approximately 6,700 feet downstream of Black Forest Road to approximately 3,260 feet downstream of Black Forest Road.

PROPOSED PROJECT DESCRIPTION

Flooding Source	Proposed Project	Location of Proposed Project
Cottonwood Creek	New Culvert	At Tutt Boulevard.
	New Detention Basin	At Tutt Boulevard.
	Removal of Structure	At Cowpoke Road.

SUMMARY OF IMPACTS TO FLOOD HAZARD DATA

Flooding Source	Effective Flooding	Proposed Flooding	Increases	Decreases
Cottonwood Creek	Zone AE	Zone AE	Yes	Yes
	Floodway	Floodway	Yes	Yes
	BFEs*	BFEs	Yes	Yes
	Zone X (shaded)	Zone X (shaded)	Yes	Yes

* BFEs - Base (1-percent-annual-chance) Flood Elevations

COMMENT

This document provides the Federal Emergency Management Agency's (FEMA's) comment regarding a request for a CLOMR for the project described above. This document is not a final determination; it only provides our comment on the proposed project in relation to the flood hazard information shown on the effective National Flood Insurance Program (NFIP) map. We reviewed the submitted data and the data used to prepare the effective flood hazard information for your community and determined that the proposed project meets the minimum floodplain management criteria of the NFIP. Your community is responsible for approving all floodplain development and for ensuring that all permits required by Federal or State/Commonwealth law have been received. State/Commonwealth, county, and community officials, based on their knowledge of local conditions and in the interest of safety, may set higher standards for construction in the Special Flood Hazard Area (SFHA), the area subject to inundation by the base flood). If the State/Commonwealth, county, or community has adopted more restrictive or comprehensive floodplain management criteria, these criteria take precedence over the minimum NFIP criteria.

This comment is based on the flood data presently available. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional Information about the NFIP is available on the FEMA website at https://www.fema.gov/national-flood-insurance-program.

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

Federal Emergency Management Agency

Washington, D.C. 20472

CONDITIONAL LETTER OF MAP REVISION COMMENT DOCUMENT (CONTINUED)

OTHER COMMUNITIES AFFECTED BY THIS CONDITIONAL REQUEST

CID Number: 080059 **Name:** El Paso County, Colorado

AFFECTED MAP PANELS

TYPE: FIRM NO.: 08041C0529G DATE: December 7, 2018

This comment is based on the flood data presently available. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional Information about the NFIP is available on the FEMA website at https://www.fema.gov/national-flood-insurance-program.

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Engineering Services Branch
Federal Insurance and Mitigation Administration

Federal Emergency Management Agency
Washington, D.C. 20472

CONDITIONAL LETTER OF MAP REVISION COMMENT DOCUMENT (CONTINUED)

COMMUNITY INFORMATION

To determine the changes in flood hazards that will be caused by the proposed project, we compared the hydraulic modeling reflecting the proposed project (referred to as the proposed conditions model) to the hydraulic modeling used to prepare the Flood Insurance Study (FIS) (referred to as the effective model). If the effective model does not provide enough detail to evaluate the effects of the proposed project, an existing conditions model must be developed to provide this detail. This existing conditions model is then compared to the effective model and the proposed conditions model to differentiate the increases or decreases in flood hazards caused by more detailed modeling from the increases or decreases in flood hazards that will be caused by the proposed project.

The table below shows the changes in the BFEs:

BFE Comparison Table

Flooding Source: Cottonwood Creek		BFE Change (feet)	Location of maximum change
Existing vs. Effective	Maximum increase	None	NA
	Maximum decrease	7.0	Approximately 4,230 feet downstream of Black Forest Road
Proposed vs. Existing	Maximum increase	0.9	Approximately 4,350 feet downstream of Black Forest Road
	Maximum decrease	3.4	Approximately 4,170 feet downstream of Black Forest Road
Proposed vs. Effective	Maximum increase	14.0	Approximately 5,540 feet downstream of Black Forest Road
	Maximum decrease	6.7	Approximately 4,230 feet downstream of Black Forest Road

Increases due to the proposed project that exceed those permitted under Paragraphs (c)(10) or (d)(3) of Section 60.3 of the NFIP regulations must adhere to Section 65.12 of the NFIP regulations. With this request, your community has complied with all requirements of Paragraph 65.12(a) of the NFIP regulations. Compliance with Paragraph 65.12(b) also is necessary before FEMA can issue a Letter of Map Revision when a community proposes to permit encroachments into the effective floodplain/regulatory floodway that will cause BFE increases in excess of those permitted under Paragraph 60.3(d)(3)/60.3(c)(10).

NFIP regulations Subparagraph 60.3(b)(7) requires communities to ensure that the flood-carrying capacity within the altered or relocated portion of any watercourse is maintained. This provision is incorporated into your community's existing floodplain management ordinances; therefore, responsibility for maintenance of the altered or relocated watercourse, including any related appurtenances such as bridges, culverts, and other drainage structures, rests with your community. We may request that your community submit a description and schedule of maintenance activities necessary to ensure this requirement.

This comment is based on the flood data presently available. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional information about the NFIP is available on the FEMA website at https://www.fema.gov/national-flood-insurance-program.

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Washington, D.C. 20472

CONDITIONAL LETTER OF MAP REVISION
COMMENT DOCUMENT (CONTINUED)

COMMUNITY INFORMATION (CONTINUED)

DATA REQUIRED FOR FOLLOW-UP LOMR

Upon completion of the project, your community must submit the data listed below and request that we make a final determination on revising the effective FIRM and FIS report. If the project is built as proposed and the data below are received, a revision to the FIRM and FIS report would be warranted.

• Detailed application and certification forms must be used for requesting final revisions to the maps. Therefore, when the map revision request for the area covered by this letter is submitted, Form 1, entitled "Overview and Concurrence Form," must be included. A copy of this form may be accessed at https://www.fema.gov/media-library/assets/documents/1343.

• The detailed application and certification forms listed below may be required if as-built conditions differ from the proposed plans. If required, please submit new forms, which may be accessed at https://www.fema.gov/media-library/assets/documents/1343, or annotated copies of the previously submitted forms showing the revised information.

Form 2, entitled "Riverine Hydrology and Hydraulics Form." Hydraulic analyses for as-built conditions of the base flood the 10-percent, 2-percent, and 0.2-percent-annual-chance floods, and the regulatory floodway, must be submitted with Form 2.

Form 3, entitled "Riverine Structures Form."

• A certified topographic work map showing the revised and effective base and 0.2-percent-annual-chance floodplain and floodway boundaries. Please ensure that the revised information ties in with the current effective information at the downstream and upstream ends of the revised reach.

• An annotated copy of the FIRM, at the scale of the effective FIRM, that shows the revised base and 0.2-percent-annual-chance floodplain and floodway boundary delineations shown on the submitted work map and how they tie-in to the base and 0.2-percent-annual-chance floodplain and floodway boundary delineations shown on the current effective FIRM at the downstream and upstream ends of the revised reach.

• As-built plans, certified by a registered Professional Engineer, of all proposed project elements.

• A copy of the public notice distributed by your community stating its intent to revise the regulatory floodway, or a signed statement by your community that it has notified all affected property owners and affected adjacent jurisdictions.

• Documentation of the individual legal notices sent to property owners who will be affected by any widening or shifting of the base floodplain and/or any BFE increases or BFE establishment along Cottonwood Creek.

This comment is based on the flood data presently available. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional information about the NFIP is available on the FEMA website at https://www.fema.gov/national-flood-insurance-program.

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Engineering Services Branch
Federal Insurance and Mitigation Administration

Federal Emergency Management Agency

Washington, D.C. 20472

CONDITIONAL LETTER OF MAP REVISION COMMENT DOCUMENT (CONTINUED)

COMMUNITY INFORMATION (CONTINUED)

DATA REQUIRED FOR FOLLOW-UP LOMR (continued)

• An officially adopted maintenance and operation plan for the proposed Tutt Boulveard Culvert and Detention Basin . This plan, which may be in the form of a written statement from the community Chief Executive Officer, an ordinance, or other legislation, must describe the nature of the maintenance activities, the frequency with which they will be performed, and the title of the local community official who will be responsible for ensuring that the maintenance activities are accomplished.

• FEMA's fee schedule for reviewing and processing requests for conditional and final modifications to published flood information and maps may be accessed at https://www.fema.gov/forms-documents-and-software/flood-map-related-fees. The fee at the time of the map revision submittal must be received before we can begin processing the request. Payment of this fee can be made through a check or money order, made payable in U.S. funds to the National Flood Insurance Program, or by credit card (Visa or MasterCard only). Please either forward the payment, along with the revision application, to the following address:

LOMC Clearinghouse
Attention: LOMR Manager
3601 Eisenhower Avenue, Suite 500
Alexandria, Virginia 22304-6426

or submit the LOMR using the Online LOMC portal at: https://hazards.fema.gov/femaportal/onlinelomc/signin

After receiving appropriate documentation to show that the project has been completed, FEMA will initiate a revision to the FIRM and FIS report. Because the flood hazard information (i.e., base flood elevations, base flood depths, SFHAs, zone designations, and/or regulatory floodways) will change as a result of the project, a 90-day appeal period will be initiated for the revision, during which community officials and interested persons may appeal the revised flood hazard information based on scientific or technical data.

This comment is based on the flood data presently available. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional information about the NFIP is available on the FEMA website at https://www.fema.gov/national-flood-insurance-program.

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Engineering Services Branch
Federal Insurance and Mitigation Administration

Federal Emergency Management Agency

Washington, D.C. 20472

CONDITIONAL LETTER OF MAP REVISION
COMMENT DOCUMENT (CONTINUED)

COMMUNITY INFORMATION (CONTINUED)

COMMUNITY REMINDERS

We have designated a Consultation Coordination Officer (CCO) to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Ms. Jeanine P. Petterson
Director, Mitigation Division
Federal Emergency Management Agency, Region VIII
Denver Federal Center, Building 710
P.O. Box 25267
Denver, CO 80225-0267
(303) 235-4830

This comment is based on the flood data presently available. If you have any questions about this document, please contact the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional information about the NFIP is available on the FEMA website at https://www.fema.gov/national-flood-insurance-program.

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

APPENDIX E

TUTT BOULEVARD ROAD EXTENSION NORTH OF COWPOKE ROAD
FINAL DRAINAGE REPORT

FINAL DRAINAGE REPORT
for
TUTT BOULEVARD ROAD EXTENSION NORTH OF COWPOKE ROAD
May 2018

Prepared for:

City of Colorado Springs, Colorado
30 South Nevada, Suite 405
Colorado Springs, CO 80903

Prepared by:

Rockwell Consulting, Inc.
1955 N. Union Boulevard, Suite 200
Colorado Springs, CO 80909
(719) 475-2575

Project# 17-023

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FINAL DRAINAGE REPORT
for
TUTT BOULEVARD ROAD EXTENSION NORTH OF COWPOKE ROAD
May 2018

DRAINAGE PLAN STATEMENTS

ENGINEER'S STATEMENT

The attached drainage plan and report for Tutt Boulevard Expansion were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the City of Colorado Springs Drainage Design and Technical Criteria and isi conformity with the master plan for the drainage basin. I understand that the City of Colorado Springs does not and will not assume liability for drainage facilities designed by others.

____
Kent D. Rockwell, P.E.

CERTIFICATION STATEMENT

The City of Colorado Springs hereby certifies that the drainage facilities for Tutt Boulevard Expansion shall be constructed according to the design presented in this report. I, as the developer, understand that the City of Colorado Springs does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the City of Colorado Springs reviews drainage plans pursuant to Colorado Revised Statutes, Title 30, Article 28; but cannot, on behalf of Tutt Boulevard Expansion, guarantee that final drainage design review will absolve The City of Colorado Springs of future liability for improper design. I further understand that approval of the final plat does not imply approval of my engineer's drainage design.

The City of Colorado Springs

BY: ____________________________ ________________
AUTHORIZED SIGNATURE DATE

TITLE:

ADDRESS:

CITY OF COLORADO SPRINGS

Filed in accordance with Section 7-7-906 of the code of the City of Colorado Springs, 2001, as amended.

______________________________________ ____________
FOR THE CITY ENGINEER DATE

FINAL DRAINAGE REPORT
TUTT BOULEVARD ROAD EXTENSION NORTH OF COWPOKE ROAD
May 2018

PURPOSE

The purpose of this report is to identify the existing and proposed runoff patterns and drainage facilities required for the Tutt Boulevard Road Extension north of Cowpoke Road. The proposed roadway extension consists of a 600 linear feet extension of Tutt Boulevard north of the existing Cowpoke Road and Tutt Boulevard extension. Associated with the road extension, a regional detention pond is proposed along the east side of Tutt Boulevard.

SUMMARY OF DATA

The sources of information used in the development of this study are listed below:

1. City of Colorado Springs Drainage Criteria Manual, May, 2014.
2. Soil Survey for El Paso County, Colorado, U.S. Department of Agriculture, Soil Conservation Service, June 1980.
3. "Flood Insurance Studies for Colorado Springs and El Paso County, Colorado", prepared by the Federal Emergency Management Agency (FEMA), 1985.
4. "Cottonwood Creek Drainage Basin Planning Study" by URS Consultants, Inc., August 1995.
5. "Cottonwood Creek Prudent Line Study" by Ayres & Associates, 1996.
6. "Preliminary/Final Drainage Report for Power Boulevard (Research Parkway to Woodmen Road" by JR Engineering, July, 2000.
7. "Preliminary/Final Drainage Report for Research Parkway (Scarborough Drive to Powers Blvd.) including Research Parkway Subdivision Filing No. 6, by JR Engineering, April, 2000.
8. "Master Development Drainage Plan for Wolf Ranch, Colorado Springs, Colorado," prepared by Kiowa Engineering, 2013.
9. "Westcreek at Wolf Ranch Subdivision Master Development Drainage Report & Final Drainage Report for Westcreek at Wolf Ranch Subdivision Filings 1, 2, 3, 4 and 5" prepared by Rockwell Minchow Consultants, Inc., dated July, 2004.
10. Master Development Drainage Plan for Westcreek at Wolf Ranch Phase 3 and Final Drainage Report for Westcreek at Wolf Ranch Subdivision Filings 13 and 14, prepared by Rockwell Consulting, Inc, dated December 18, 2017.
11. Preliminary/Final Drainage Report for Tutt Boulevard Filing No. 4, Woodmen Road to Cowpoke Road, prepared by Matrix Design Group, Inc., dated April, 2005.

12. Amendment No. 1 to the Final Drainage Report for Cumber Vista Filing No. 1 and Preliminary/Final Drainage Report for Cumbre Vista Filing No. 2, 3, 4, and 5, prepared by JR Engineering, dated January, 2007.

GENERAL LOCATION AND DESCRIPTION

The Tutt Boulevard Road Extension project is located north of the existing Cowpoke Road and Tutt Boulevard intersection. (see Vicinity Map - Figure 1). The existing Cowpoke Road and Tutt Boulevard intersection is currently a two way intersection with existing Tutt Boulevard to the south and existing Cowpoke Road to the east. It is anticipated that this intersection will only be a 3 way intersection with no extension of Cowpoke Road to the west in the future.

The site is within a portion of the Northwest Quarter of Section 6, Township 1 South, Range 65 West of the 6th P.M., City of Colorado Springs, El Paso County, Colorado. The site is bound on the west by large 5 acre tracts within El Paso County, on the north by future residential development within the Wolf Ranch Development, on the south by existing Tutt Boulevard and on the east by Cottonwood Creek and an existing detention pond. The site improvement span existing Cottonwood Creek.

Well-established native grasses exist throughout the proposed development. The topography north of the proposed improvements generally slopes from north to south. Cottonwood Creek flows from northeast to southwest.

SOILS

According to the Soil Survey of El Paso County Area, Colorado, prepared by the U.S. Department of Agriculture Soil Conservation Service, the soils underlying the Recreation Center fall under the Stapleton/Bernal Series (Soil 85). These soils are classified as Hydrologic Group "B" and "D" soils. Since bedrock is known to exist just below the surface Hydrologic Group "D" soils were used to determine runoff coefficients.

CLIMATE

This area of El Paso County can be described as the foothills, with total precipitation amounts typical of a semi-arid region. Winters are generally cold and dry, and summers relatively warm and dry. Precipitation ranges from 12 to 14 inches per year, with the majority of this moisture occurring in the spring and summer in the form of rainfall. Thunderstorms are common during the summer months.

FLOODPLAIN STATEMENT

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) #08041C0529 F dated March 17, 1997, the Tutt Boulevard Road Extension cross a 100 year floodplain as depicted in Exhibit 3. A Letter of Map Revision (LOMR) will be prepared by Kiowa Engineering and submitted to FEMA for their review.

DRAINAGE CRITERIA

The current City of Colorado Springs Drainage Criteria was utilized in this report. Peak runoff quantities were determined using the Rational Method for both the 5 year and 100 year storms, as required for drainage basins less than 130 acres. Urban Drainage and Flood Control criteria, including water quality and full spectrum detention pond spreadsheets, was also used in the preparation of this report.

FOUR STEP PROCESS TO MINIMIZE ADVERSE IMPACTS OF URBANIZATION

Step 1: The Tutt Boulevard Roadway Expansion project basically consists of just roadway improvements so there is limited opportunities for low impact development. Instead an Extended Detention Basin (EDB) will be constructed as part of the roadway improvements.

Step 2: The runoff collected from the street improvement area including some offsite areas, will be captured and conveyed to a proposed Extended Detention Basin (EDB). The EDB will be utilized to provide water quality capture volume for the proposed street improvements.

Step 3: The EDB will discharge directly into the proposed detention pond located just upstream of Tutt Boulevard which drains to Cottonwood Creek. Grade control structures have recently been constructed along Tributary #4 to stabilize the channel. Additional grade control structures are being planned as part of these improvements.

Step 4: Site specific BMP's will be utilized during construction and up to stabilization of the site to minimize off-site contaminants and to protect the downstream receiving waters.

HISTORIC DRAINAGE BASIN DESCRIPTIONS

A brief description of the historic drainage for the site is provided in this section of the report. A summary of peak historic runoff for the historic basin(s) is depicted on the Historic Drainage Plan (Exhibit 1) provided in the appendix. The historic drainage area affecting this site is defined by four historic drainage basins.

The majority of the tributary area to the proposed Tutt Boulevard Roadway Improvement Project consists of existing Cottonwood Creek. An area just north of Cottonwood Creek also drains toward Cottonwood Creek and basically runoff from this area sheet flows into Cottonwood Creek. This area is defined as Basin A on the Historic Drainage Map. The 14.47 acre Basin A generates runoff rates of 6.9 cubic feet per second (cfs) during the 5 year storm and 36.1 cfs during the 100 year storm.

Existing Cowpoke Road and existing Tutt Boulevard south of Cowpoke drain toward the southerly end of the proposed improvements. An existing 10' sump inlet is located along the west side of Tutt Boulevard just north of Cowpoke Road and an existing 5' sump inlet is located along the east side of Tutt Boulevard north of Cowpoke Road. The Cowpoke Road and Tutt Boulevard Road tributary area is defined as Basins OS-1, OS-2 and OS-3. With the proposed Tutt Boulevard Roadway Improvements, Basins OS-1, OS-2 and OS-3 will remain the same with the exception that the existing 5' sump inlet located along the east side of Tutt Boulevard north of Cowpoke will be replaced.

Basin OS-1 is located along the west side of existing Tutt Boulevard. According to the Tutt Boulevard Filing No. 4 Drainage Report (Ref #11), flow rates of 3.3 cfs during the 5 year storm and 8.0 cfs during the 100 year storm, bypass upstream inlets reaching the existing 10' sump inlet along the west side of Tutt Boulevard.

Basin OS-2 consists of 2.26 acres along the north side of Cowpoke Road extending approximately 2,600 feet. Runoff rates of 4.6 cubic feet per second (cfs) during the 5 year storm and 9.6 cfs during the 100 year storm are generated from this basin. These flows reach an existing 10' on-grade inlet at the intersection of Cowpoke Road and Mount Ouray Road. This inlet collects runoff rates of 4.6 cfs during the 5 year storm and 7.6 cfs during the 100 year storm. The remaining flows enter Basin OS-3 as street flows.

Basin OS-3 comprise an additional 0.53 acres along the north side of Cowpoke Road. Runoff rates of $Q_5 =$ 1.7 cfs and $Q_{100} =$ 3.2 cfs are generated from this basin during the 5 and 100 year storms, respectively. These flows along with the bypass flows from Basin OS-2 turn northerly into Tutt Boulevard. An existing 5' inlet is located along the east side of Tutt Boulevard just north of Cowpoke Road.

DEVELOPED DRAINAGE BASIN

A brief description of each developed drainage basin for the site is provided in this section of the report. A summary of peak-developed runoff for the basins is depicted on the Developed Drainage Plan (Exhibit 2) provided in the appendix. All proposed drainage facilities are approximate in size and may vary with actual layout and design.

Basin 1 consists of 1.92 acres along the west side of the future Tutt Boulevard expansion north of Cowpoke Road. Runoff rates of 4.5 cfs and 11.5 cfs are generated from this basin during the 5 and 100 year storms respectively. These flows enter Basin 2 as street flows.

Basin 2 is also located along the west side of future Tutt Boulevard and comprises 0.57 acres. This basin generates runoff rates of 1.8 cfs during the 5 year storm and 3.5 cfs during the 100 year storm. The combined flows from Basins 1 and 2 of 6.3 cfs and 15.0 cfs reach a proposed 14' on-grade inlet located approximately 50 feet north of the Tutt Boulevard and Cowpoke Road intersection.

This proposed 14' inlet will be installed just north of the existing 10' sump inlet located approximately 50' north of Cowpoke Road. The new 14' inlet will collect runoff rates of 6.3 cfs during the 5 year storm and 12.3 cfs during the 100 year storm. Flow rates of $Q_5 =$ 0.0 cfs and $Q_{100} =$ 2.7 cfs will bypass this inlet and continue to the existing 10' sump inlet.

Basin OS-1 is located along the west side of existing Tutt Boulevard. According to the Tutt Boulevard Filing No. 4 Drainage Report (Ref #11), flow rates of 3.3 cfs during the 5 year storm and 8.0 cfs during the 100 year storm, bypass upstream inlets reaching the existing 10' sump inlet along the west side of Tutt Boulevard. The existing 10' sump inlet will collect a total of 3.3 cfs during the 5 year storm and 10.7 cfs during the 100 year storm.

The total flows rates of $Q_5 =$ 9.6 cfs and $Q_{100} =$ 23.0 cfs collected from Basins 1, 2 and OS-1 by the proposed 14' on-grade inlet and the existing 10' sump inlet will be piped across Tutt Boulevard within a proposed 24" RCP to the proposed 16' sump inlet on the east side of Tutt Boulevard.

Basin OS-2 consists of 2.26 acres along the north side of Cowpoke Road extending approximately 2,600 feet. Runoff rates of 4.6 cubic feet per second (cfs) during the 5 year storm and 9.6 cfs during the 100 year storm are generated from this basin. These flows reach an existing 10' on-grade inlet at the intersection of Cowpoke Road and Mount Ouray Road. This inlet collects runoff rates of 4.6 cfs during the 5 year storm and 7.6 cfs during the 100 year storm. The remaining flows enter Basin OS-3 as street flows.

Basin OS-3 comprise an additional 0.53 acres along the north side of Cowpoke Road. Runoff rates of $Q_5 =$ 1.7 cfs and $Q_{100} =$ 3.2 cfs are generated from this basin during the 5 and 100 year storms, respectively. These flows along with the bypass flows from Basin OS-2 turn northerly into Tutt Boulevard. An existing 5' inlet is located along the east side of Tutt Boulevard just north of Cowpoke Road. This existing inlet will be replaced with a proposed 16' sump inlet. The new 16' sump inlet will collect flow rates of 5.1 cfs during the 5 year storm and 12.6 cfs during the 100 year storm.

Basin 3 consists of 1.51 acres along the east side of Tutt Boulevard. Runoff rates of 3.4 cfs and 7.4 cfs are generated from this basin during the 5 and 100 year storms, respectively. The runoff generated from this basin flow southerly along the east side of Tutt to a proposed 16' sump inlet that replaces the existing 5' sump inlet at the south end of Basin 3.

Total flow rates of 14.7 cfs during the 5 year storm and 35.6 cfs will be piped to the proposed Extended Detention Basin to be constructed at the northeast corner of Tutt Boulevard and Cowpoke Road. ???...

Basin 4 consists of approximately 5.12 acres just east of future Tutt Boulevard. This is the general area of the proposed detention pond. Runoff rates of 3.2 cfs during the 5 year storm and 17.7 cfs during the 100 year storm reach Cottonwood Creek and continue as stream flows within Cottonwood Creek.

Basin 5 comprises the existing detention pond constructed as part of the Cumbre Vista Development. This 1.96 acre basin generates runoff rates of 1.3 cfs and 7.3 cfs during the 5 and 100 year storms, respectively. This pond will remain as is.

WATER QUALITY

A private Extended Detention Basin (EDB) will be utilized to provide Water Quality Capture volume for the Tutt Boulevard Roadway Improvement project. The pond will be constructed at the northeast corner of Tutt Boulevard and Cowpoke Road. The EDB will discharge directly into the proposed detention pond to be constructed just upstream of Tutt Boulevard. Kiowa Engineering will provide a more detailed drainage memo describing the sizing of the EDB.

EROSION CONTROL

Erosion control measures will be installed per the approved grading/erosion control plans.

DRAINAGE, BRIDGE AND POND FEES

Tutt Boulevard Road Extension Filing No. 1 is within the Cottonwood Creek Drainage Basin. The 2018 Drainage, Bridge and Pond Fees per acre are listed below. At this time, the exact acreage of Filing NO. 1 is unknown.

($12,692/Acre Total)

	$/Acre
Capital Improvements Portion	$ 10,172.00
Land Portion	$ 3,069.00
Cash Portion	$ 678.00
BRIDGE FEES	$ 1,059.00

DRAINAGE FACILTIES (Public Non Reimbursable)

The following drainage facilities will be required for the Tutt Boulevard Roadway Improvements.

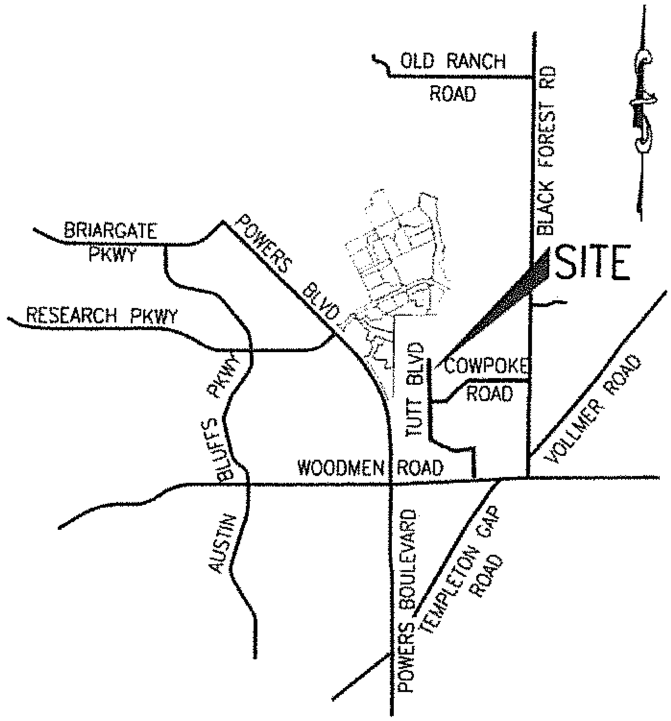
Tutt Boulevard Filing No. 1 (Public/Non-Reimbursable)

ITEM	QUANTITY		UNIT PRICE	EXTENDED COST
24" RCP	77	L.F.	$ 90.00	$ 6,930.00
30" RCP	55	L.F.	$ 120.00	$ 6,600.00
14' D-10-R Inlets	1	Ea.	$ 9,100.00	$ 9,100.00
16' D-10-R Inlets	1	Ea.	$ 9,900.00	$ 9,900.00
Demolition	1	L.S.	$15,000.00	$ 15,000.00
			Sub-Total	$ 47,530.00
10% Eng. and Contingency				$ 4,753.00
			Grand Total	$ 52,183.00

CONCLUSION

Runoff generated from Tutt Boulevard Roadway Improvement Project will be collected within streets, inlets and drainage pipes and conveyed to a proposed water quality pond which will then discharge to a proposed detention pond, The conveyance of these flows to the various detention/water quality basins will not adversely affect downstream facilities if all facilities are properly maintained.

APPENDIX



Vicinity Map

NOT TO SCALE

FIGURE 1

FILE: 17023DEV.DWG
DATE: 6/24/18

JOB NO. 17-023

ROCKWELL CONSULTING, Inc.
ENGINEERING • SURVEYING
1955 N. UNION BLVD., SUITE 200
COLORADO SPRINGS, CO 80909
(719) 475-2575 • FAX (719) 475-9223

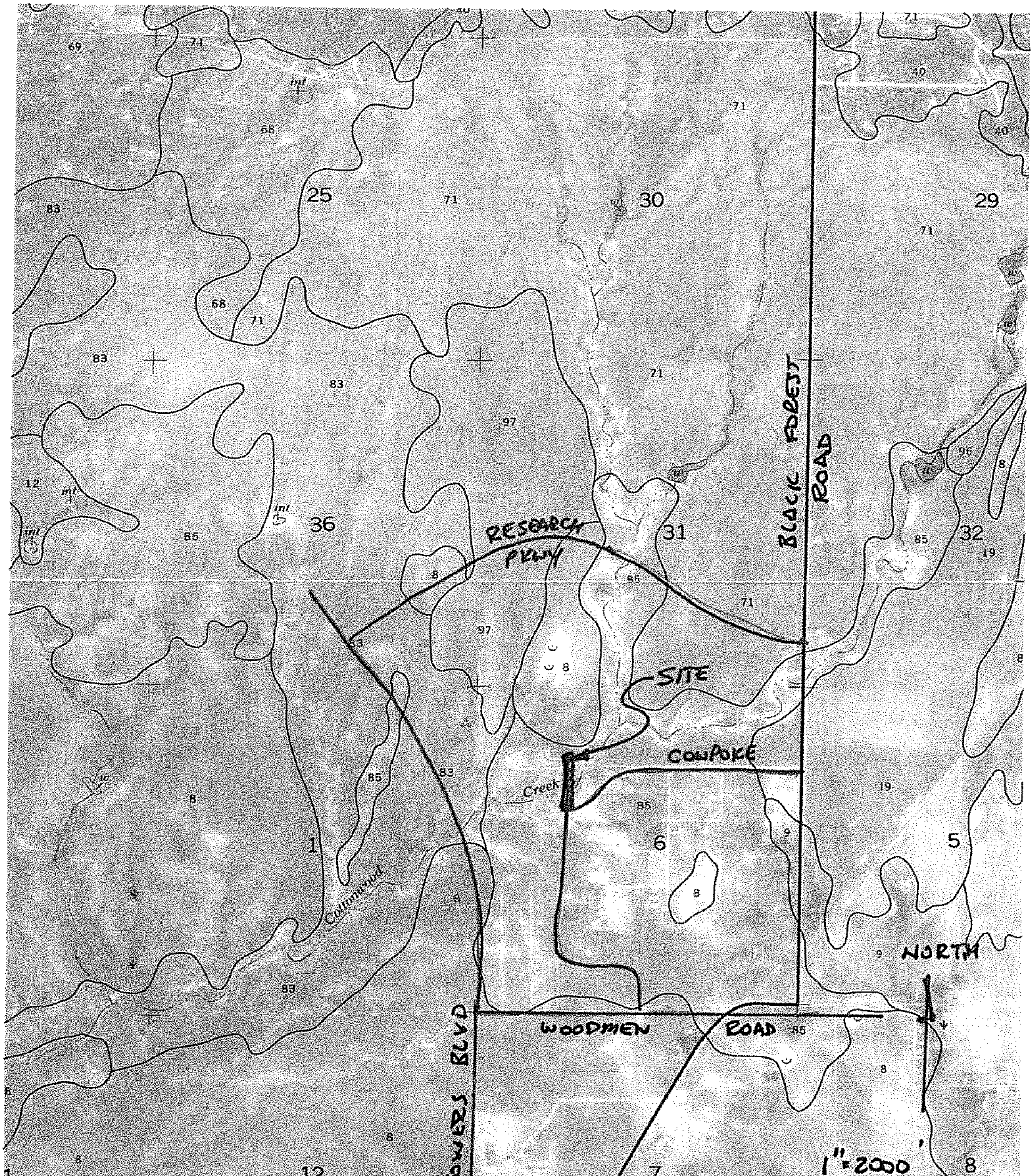
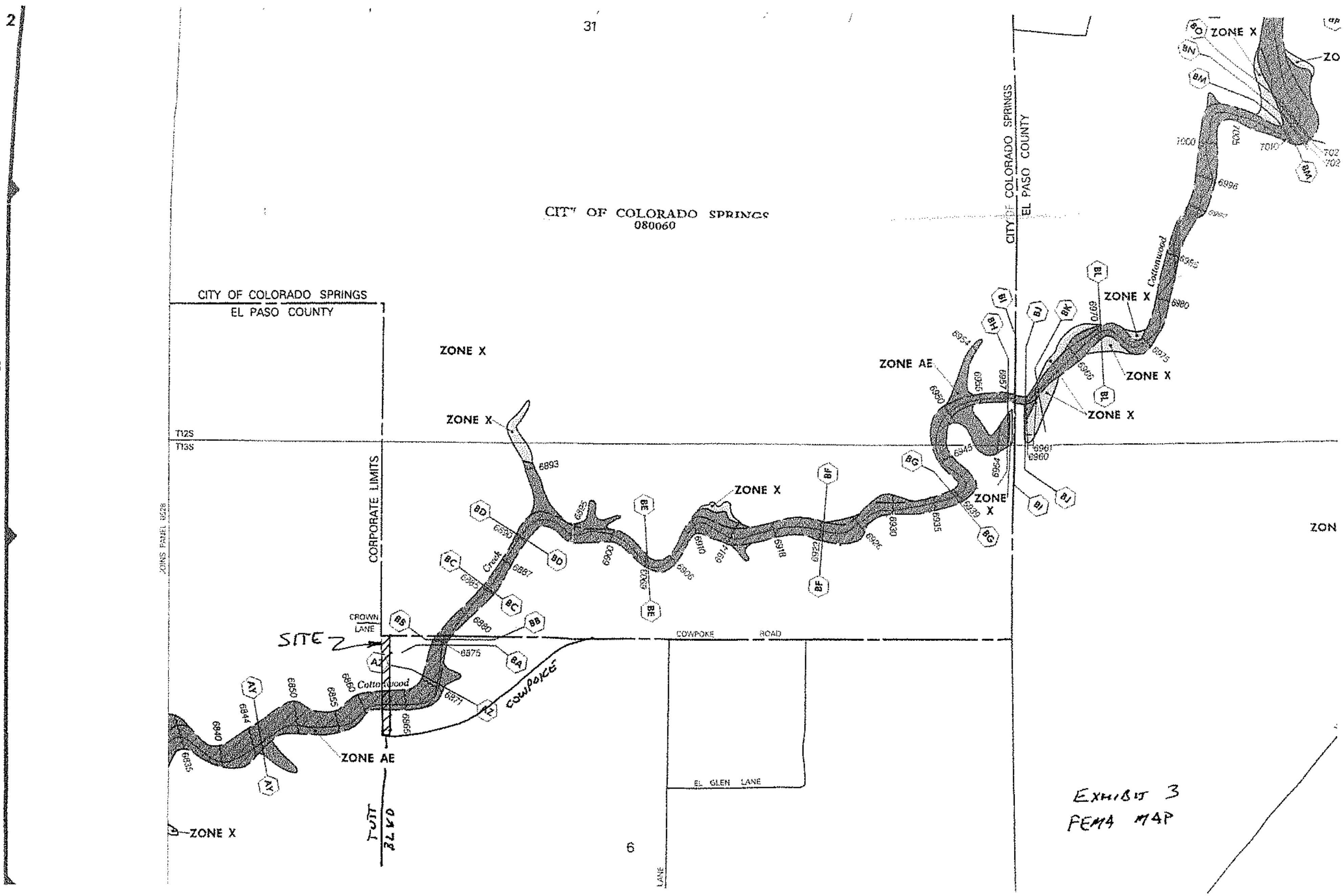


FIGURE 2
SOILS MAP



CITY OF COLORADO SPRINGS
080060
CITY OF COLORADO SPRINGS
EL PASO COUNTY
ZONE X
ZONE AE
CORPORATE LIMITS
CROWN LANE
COWPOKE ROAD
EL GLEN LANE
Cottonwood
Creek
SITE
TUTT BLVD
COWPOKE
T12S
T13S
31
6
EXHIBIT 3
FEMA MAP

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Garden of the Gods Residential

BASIN: A
AREA: 14.47
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets	0.25	0.90	0.95	1.73%
Open Space	14.22	0.15	0.50	98.27%
Res. Bldgs	0	0.90	0.95	0.00%
	0	0.00	0.00	0.00%
	14.47			100%

COMPOSITE: C5= 0.16 C100= 0.51

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	300	4.0%		18.80
Swale	900	8.0%	4.2	3.54
Tc Total:				22.34

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
2.9 in/hr	4.9 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
6.9 cfs	36.1 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: 1
AREA: 1.92
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets/Bldgs	0.78	0.90	0.96	40.63%
Open Space	1.14	0.15	0.50	59.38%
	0	0.90	0.95	0.00%
	0	0.00	0.00	0.00%
	1.92			100%

COMPOSITE: C5= 0.45 C100= 0.69

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	30	3.0%		1.38
Street	800	4.0%	4.0	3.33
Tc Total:				4.71

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
5.2 in/hr	8.7 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
4.5 cfs	11.5 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: 2
AREA: 1.51
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets/Bldgs	0.92	0.90	0.96	60.93%
Open Space	0.59	0.15	0.50	39.07%
	0	0.90	0.95	0.00%
	0	0.00	0.00	0.00%
	1.51			100%

COMPOSITE: C5= 0.61 C100= 0.78

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	30	2.0%		7.47
Street	800	1.5%	2.4	5.44
Tc Total:				12.92

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
3.7 in/hr	6.3 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
3.4 cfs	7.4 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: 3
AREA: 0.57
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets/Bldgs	0.48	0.90	0.96	84.21%
Open Space	0.09	0.15	0.50	15.79%
	0	0.90	0.95	0.00%
	0	0.00	0.00	0.00%
	0.57			100%

COMPOSITE: C5= 0.78 C100= 0.89

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	30	3.0%		6.54
Street	550	1.5%	2.4	3.74
Tc Total:				10.28

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
4.1 in/hr	6.9 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
1.8 cfs	3.5 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: 4
AREA: 5.12
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets/Bldgs	0.00	0.90	0.95	0.00%
Open Space	5.12	0.15	0.50	100.00%
	0	0.90	0.95	0.00%
	0	0.00	0.00	0.00%
	5.12			100%

COMPOSITE: C5= 0.15 C100= 0.50

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	100	5.0%		10.08
Street	0	1.5%	2.4	0.00
Tc Total:				10.08

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
4.1 in/hr	6.9 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
3.2 cfs	17.7 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: 5
AREA: 1.96
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5		C100	% AREA
Streets/Bldgs	0.00	0.90		0.95	0.00%
Open Space	1.96	0.15		0.50	100.00%
	0	0.90		0.95	0.00%
	0	0.00		0.00	0.00%
	1.96				100%
COMPOSITE:	C5=	0.15	C100=	0.50	

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	100	10.0%		8.02
Street	0	2.0%	2.8	0.00
Tc Total:				8.02

Intensity, I (inches/hr) from Fig 6-5

I5	I100
4.5 in/hr	7.5 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	Q100
1.3 cfs	7.3 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: Basin OS-2
AREA: 2.26
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets/Bldgs	1.23	0.90	0.96	54.42%
Open Space	0.58	0.15	0.50	25.66%
Lots	0.45	0.49	0.65	19.91%
	0	0.00	0.00	0.00%
	2.26			100%

COMPOSITE: C5= 0.63 C100= 0.78

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	30	3.0%		6.54
Street	2150	2.5%	3.2	11.33
Tc Total:				17.87

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
3.3 in/hr	5.5 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
4.6 cfs	9.6 cfs

HYDROLOGY

RATIONAL METHODOLOGY

PROJECT: Tutt Blvd Expansion

BASIN: Basin OS-3
AREA: 0.53
SOIL TYPE: D

RUNOFF COEFFICIENT, C

ZONE/DEVELOPMENT TYPE	AREA	C5	C100	% AREA
Streets/Bldgs	0.42	0.90	0.96	79.25%
Open Space	0.11	0.15	0.50	20.75%
Lots	0	0.49	0.65	0.00%
	0	0.00	0.00	0.00%
	0.53			100%

COMPOSITE: C5= 0.74 C100= 0.86

TIME OF CONCENTRATION: Tc In Minutes:

Travel Type	L	s %	v5 (fps)	Tc (5 year)
Overland	20	3.0%		5.34
Street	800	2.5%	3.2	4.22
Tc Total:				9.55

Intensity, I (inches/hr) from Fig 6-5

I5	**I100**
4.2 in/hr	7.0 in/hr

PEAK FLOW: Q-CIA in cfs

Q5	**Q100**
1.7 cfs	3.2 cfs

The 3.48 acres site will be drained by a proposed 24" storm sewer extended to the site. Peak stormwater flows will be Q(5)=8.7 cfs and Q(100)=17.8 cfs. The 24" storm sewer will also provide an overflow relief for the site. The 24" storm sewer will ensure that the system will not become surcharged when the maximum overflow rates are discharged. Runoff from this area will be directed to Design Point 11.

Design Point 11 has been used to size the storm sewer within Tutt Boulevard. Runoff from upstream sub-basins D23 and D22 will combine within a proposed 30" RCP storm sewer. Peak runoff rates have been calculated as Q(5)=23.3 cfs and Q(100)=47.4 cfs.

Design Point 12 will combine flows from Design Point 11 and sub-basin D21. The trunk storm sewer at this point will remain as a 30" RCP conveying peak flows of Q(5)=25.8 cfs and Q(100)=52.4 cfs.

Design Point 13 will combine peak stormwater runoff rates from Design Point 12 and sub-basin D20 and D24. The runoff rates for the minor and major storm events have been calculated as Q(5)=92.6 cfs and Q(100)=194.1 cfs. A proposed 54" RCP storm sewer will convey flows to the north to Design Point 14.

Design Point 14 will combine flows from Design Points 12 and 13 and sub-basins D30 and D31. The routed peak runoff rates within the proposed 54" RCP storm sewer at this point are Q(5)=120.6 cfs and Q(100)=249.8 cfs.

Sub-basin D23 will be comprised of 6.27 acres of future commercial development. Peak runoff rates for this area are Q(5)=15.4 cfs and Q(100)=31.4 cfs. Flows will be directed to a proposed 30" RCP stub-out at Tutt Boulevard. Flows will travel downstream to Design Point 11.

Sub-basin D24 is comprised of 17.94 acres of future commercial development. Peak runoff rates for this area are Q(5)=37.8 cfs and Q(100)=76.9 cfs. Runoff from this area will have to be directed to the north to Sorpressa Lane. The elevation changes across the site in relationship to Tutt Boulevard makes discharging storm water to the storm system in Tutt prohibitive. This area will have to extend the stormwater infrastructure to the site utilizing existing or proposed utility corridors.

Sub-basin D30 is 2.55 acres of Tutt Boulevard. Peak runoff rates for this area will be Q(5)=5.9 cfs and Q(100)=11.9 cfs. Flows will be conveyed to a proposed 10' City standard D10R sump inlet at the intersection of Tutt Boulevard and Sorpressa Lane.

Sub-basin D31 consists of 3.81 acres of proposed roadway. Peak flows of Q(5)=8.8 cfs and Q(100)=17.8 cfs will be directed to a 10' City standard D10R flow-by inlet. The inlet will capture Q(5)=5.5 cfs and Q(100)=9.8 cfs of flow. The remaining flows will travel to a proposed 10' inlet at Design Point 15.

Sub-basin D32 is 1.72 acres of Tutt Boulevard. Runoff from this area will travel to a proposed 15' City Standard D10R sump inlet at Cowpoke road. The inlet will capture the peak flows of

Q(5)=4.3 cfs and Q(100)=8.8 cfs from sub-basin D32 as well as flows from sub-basin D40 at Design Point 16.

Sub-basin D33 is 1.61 acres of proposed roadway generating flows of Q(5)=4.0 cfs and Q(100)=8.2 cfs. Runoff will be directed to the north via curb and gutter to a proposed 15' City Standard D10R inlet. Flows from sub-basin D31 will enter the sump inlet at Design Point 15.

At Design Point 15, runoff from sub-basin D31, D33, and D35 will be combined for a total routed flow of Q(5)=7.5 cfs and Q(100)=16.6 cfs. The sub-basin area is comprised of the western half of Tutt Boulevard. Runoff will be collected by a proposed 10' D10R sump inlet.

Sub-basin D34 will capture the future flows north of Cowpoke Road along Tutt Boulevard. A preliminary design has been completed north of Cottonwood Creek, including an alignment for a proposed bridge to span the creek. Runoff from the 1.27 acre sub-basin will flow to a proposed 5' D10R sump inlet and be conveyed downstream to the proposed 54" RCP trunk sewer. Peak runoff rates for this area are Q(5)=3.5 cfs and Q(100)=7.1 cfs.

Sub-basin D35 will also capture the future flows from Tutt Boulevard north of Cowpoke Road. Runoff rates of Q(5)=2.1 cfs and Q(100)=4.3 cfs will be generated by the 0.78 acre basin. Stormwater will combine with flows from the south from sub-basins D31 and D33. A proposed 10' D10R sump inlet will capture the flows.

Sub-basin D40 comprises 5.38 acres of residential development adjacent to the proposed Powerwood development. Runoff from this area of Q(5)=11.6 cfs and Q(100)=24.1 cfs will sheet flow across lawns and landscaping prior to entering the roadway. Stormwater from sub-basin D32 and D40 will combine at Design Point 16 and enter a proposed 15' City Standard D10R sump inlet.

At Design Point 16, surface flows at the proposed 15' inlet have been calculated as Q(5)=15.7 cfs and Q(100)=32.3 cfs. Runoff will be conveyed to Design Point 17 and combine with the upstream storm sewer flows.

Design Point 17 will have routed flows of Q(5)=132.1 cfs and Q(100)=274.4 cfs will be conveyed to Cottonwood Creek via a proposed 54" RCP. At the outfall point, a headwall and proposed large diameter riprap will protect the existing channel banks and provide energy dissipation.

STREET AND INLET HYDRAULICS

Version 4.05 Released March 2017
Urban Drainage and Flood Control District
Denver, Colorado

Purpose: **This workbook can be used to size a variety of inlets based on allowable spread and depth in a street or swale.**

Content: **The workbook consists of the following worksheets:**

Q-Peak The *Q-Peak* sheet calculates the peak discharge for the inlet tributary area based on the Rational Method for the minor and major storm events. Alternatively, the user can enter a known flow. Information from this sheet is then exported to the *Inlet Management* sheet.

Inlet Management The *Inlet Management* sheet imports information from the *Q-Peak* sheet and *Inlet [#]* sheets and can be used to connect inlets in series so that bypass flow from an upstream inlet is added to flow calculated for the next downstream inlet. This sheet can also be used to modify design information from the Q-peak sheet.

Inlet [#] *Inlet [#]* sheets are created each time the user exports information from the *Q-Peak* sheet to the *Inlet Management* sheet. The *Inlet [#]* sheets calculate allowable half-street capacity based on allowable depth and allowable spread for the minor and major storm events. This is also where the user selects an inlet type and calculates the capacity of that inlet.

Inlet Pictures The Inlet Pictures sheet contains a library of photographs of the various types of inlets contained in UD-Inlet and referenced in the USDCM.

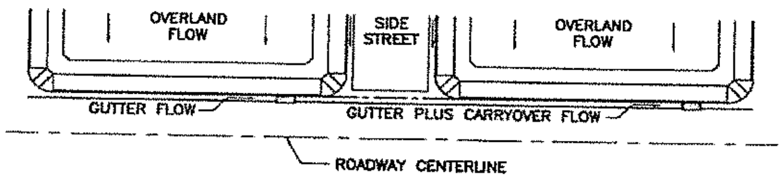
Acknowledgements: ***Spreadsheet Development Team:***
Dr. James C.Y. Guo, P.E.
Professor, Department of Civil Engineering, University of Colorado at Denver
Ken A. MacKenzie, P.E., Chris Carandang
Urban Drainage and Flood Control District
Derek N. Rapp, P.E.
Peak Stormwater Engineering, LLC

Comments? Direct all comments regarding this spreadsheet workbook to: UDFCD email
Revisions? Check for revised versions of this or any other workbook at: Downloads

Version 4.05 Released March 2017

DESIGN PEAK FLOW FOR SWALE OR ONE-HALF OF STREET BY THE RATIONAL METHOD

Project: Tutt Boulevared Extension



Show Details

Design Flow: ONLY if already determined through other methods:
(local peak flow for 1/2 of street OR grass-lined channel):

	Minor Storm	Major Storm	
$^*Q_{Known}$ =	3.4	7.4	cfs

* If you enter flows in Row 14, select "Street Inlet" or "Area Inlet" button and then skip the rest of this sheet and click "Add New Inlet" at bottom of sheet.

<-- FILL IN THIS SECTION OR...

FILL IN THE SECTIONS BELOW <--

Geographic Information: (Enter data in the blue cells):

Subcatchment Area =		Acres
Percent Imperviousness =		%
NRCS Soil Type =		A, B, C, or D

Site Type:
- (•) Site is Urban
- ( ) Site is Rural

Flows Developed For:
- (•) Street Inlet
- ( ) Area Inlet in a Swale

	Slope (ft/ft)	Length (ft)
Overland Flow =		
Gutter Flow =		

Rainfall Information: Intensity I (inch/hr) = $C_1 * P_1 / (C_2 + T_c) ^ C_3$

	Minor Storm	Major Storm	
Design Storm Return Period, T_r =			years
Return Period One-Hour Precipitation, P_1 =			inches
C_1 =			
C_2 =			
C_3 =			
User-Defined Storm Runoff Coefficient (leave this blank to accept a calculated value), C =			
User-Defined 5-yr. Runoff Coefficient (leave this blank to accept a calculated value), C_5 =			
Bypass (Carry-Over) Flow from upstream Subcatchments, Q_b =	1.7	5.2	cfs
Total Design Peak Flow, Q =	5.1	12.6	cfs

Version 4.05 Released March 2017

INLET MANAGEMENT

INLET NAME	Inlet 1-2	Existing West Inlet (10)	Inlet OS-2	Proposed 16' (East Side)
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	On Grade		On Grade	
Inlet Type	Colorado Springs D-10-R		Colorado Springs D-10-R	

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	6.3	3.3	4.6	3.4
Major Q_{Known} (cfs)	15.0	8.0	9.6	7.4

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	User-Defined
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	1.7
Major Bypass Flow Received, Q_b (cfs)	0.0	2.7	0.0	5.2

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

Overland Slope (ft/ft)				
Overland Length (ft)				
Channel Slope (ft/ft)				
Channel Length (ft)				

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	6.3	3.3	4.6	5.1
Major Total Design Peak Flow, Q (cfs)	15.0	10.7	9.6	12.6
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0		0.0	
Major Flow Bypassed Downstream, Q_b (cfs)	2.7		2.0	

Minor Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A

Major Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A

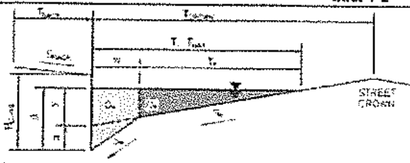
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Tutt Boulevared Extension

Inlet ID: Inlet 1-2



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	5.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	18.0	ft
Gutter Width	W =	3.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.015	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	12.0	18.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Allow Flow Depth at Street Crown (leave blank for no)				check = yes

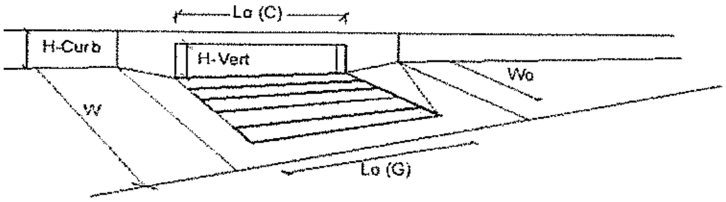
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	7.1	17.0	cfs

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (Colorado Springs D-10-R)	Type =	Colorado Springs D-10-R		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	4.0	4.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	14.00	14.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	6.3	12.3	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	2.7	cfs
Capture Percentage = Q_a/Q_o =	C% =	100	82	%

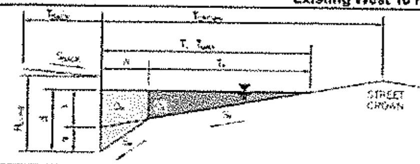
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Tutt Boulevared Extension

Inlet ID: Existing West 10 Foot



Gutter Geometry (Enter data in the blue cells)

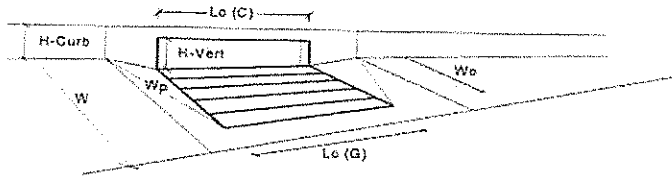
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	5.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	8.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	18.0	ft
Gutter Width	W =	3.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	12.0	18.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches
Check boxes are not applicable in SUMP conditions				

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	SUMP	SUMP	cfs

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	Colorado Springs D-10-R		MINOR	MAJOR	
Type of Inlet		Type =	Colorado Springs D-10-R		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	4.00	[illegible]	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	[illegible]	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	5.1	7.2	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	[illegible]	feet
Width of a Unit Grate		W_o =	N/A	[illegible]	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	[illegible]	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	[illegible]	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	[illegible]	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	10.00	[illegible]	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	8.00	[illegible]	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	8.00	[illegible]	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	81.00	[illegible]	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	3.00	[illegible]	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	[illegible]	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	[illegible]	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.18	0.35	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.46	0.68	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.86	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	3.3	10.7	cfs
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	3.3	10.7	cfs

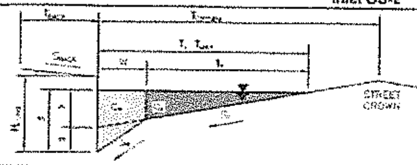
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Tuft Boulevared Extension

Inlet ID: Inlet OS-2



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	5.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	18.0	ft
Gutter Width	W =	3.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.020	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	12.0	18.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)				check = yes

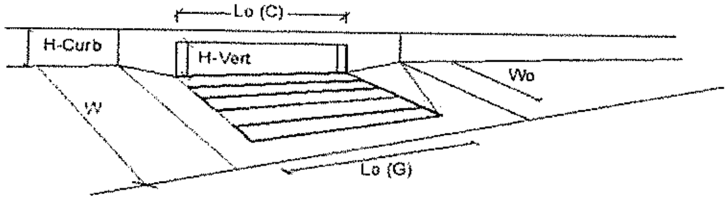
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	8.2	19.6	cfs

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (Colorado Springs D-10-R)	Type =	Colorado Springs D-10-R		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	4.0	[illegible]	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	[illegible]	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	[illegible]	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	[illegible]	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	Q =	4.6	7.6	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)	Q_b =	0.0	2.0	cfs
Capture Percentage = Q_a/Q_o =	C% =	99	79	%

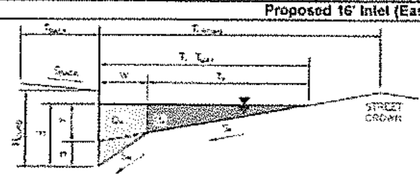
Version 4.05 Released March 2017

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: Tutt Boulevared Extension

Inlet ID: Proposed 16' Inlet (East Side)



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	5.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.0	ft
Gutter Width	W =	3.00	ft
Street Transverse Slope	S_X =	0.020	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.000	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

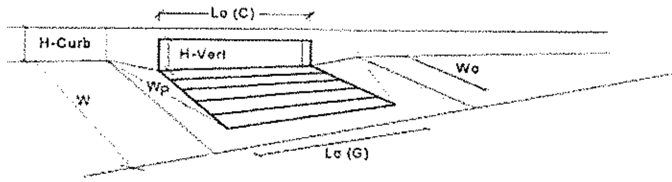
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	12.0	16.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	8.0	inches

Check boxes are not applicable in SUMP conditions

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	SUMP	SUMP	cfs

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	Colorado Springs D-10-R		MINOR	MAJOR	
Type of Inlet		Type =	Colorado Springs D-10-R		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	4.00	[illegible]	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	[illegible]	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	5.4	7.1	inches
Grate Information			MINOR	MAJOR	☑ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	16.00	[illegible]	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	8.00	[illegible]	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	[illegible]	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	81.00	[illegible]	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	3.00	[illegible]	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	[illegible]	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	[illegible]	

Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.20	0.34	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.51	0.67	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.75	0.85	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	

		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	Q_a =	**5.1**	**12.6**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	5.1	12.6	cfs

Tutt Blvd Extension 5 Year Stm

Project File: 5 YEAR TUTT OUTFALL.stm	Number of lines: 2	Date: 7/1/2018

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	55.00	0.00	Curb	5.10	0.00	0.00	0.0	80.00	2.00	81.10	30	Cir	0.013	0.50	89.50	1+00 - 1+55
2	1	77.06	0.00	Curb	9.60	0.00	0.00	0.0	81.60	1.51	82.76	24	Cir	0.013	1.00	88.90	1+55-236.06

Tutt Blvd Extension 5 Year Stm | Number of lines: 2 | Date: 7/1/2018

Structure Report

Struct No.	Structure ID	Junction Type	Rim Elev (ft)	Structure			Line Out			Line In		
				Shape	Length (ft)	Width (ft)	Size (in)	Shape	Invert (ft)	Size (in)	Shape	Invert (ft)
1		Curb-Horiz	89.50	Cir	4.00	4.00	30	Cir	81.10	24	Cir	81.60
2		Curb-Horiz	88.90	Cir	4.00	4.00	24	Cir	82.76			

Tutt Blvd Extension 5 Year Stm | Number of Structures: 2 | Run Date: 7/1/2018

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	1+00 - 1+55	14.70	30	Cir	55.00	80.00	81.10	2.000	82.02	82.39	n/a	83.08 i	End	Curb-Horiz
2	1+55-236.06	9.60	24	Cir	77.06	81.60	82.76	1.505	83.08	83.87	n/a	84.49 i	1	Curb-Horiz

Tutt Blvd Extension 5 Year Stm

Number of lines: 2

Run Date: 7/1/2018

NOTES: Return period = 2 Yrs. ; i - Inlet control.

RCI

Line No.	Line No.	Line No.	Line ID	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	n-val Pipe	Known Q (cfs)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Cover Dn (ft)	Cover Up (ft)	Defl Ang (Deg)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)
1	1	1	1+00 - 1+55	30	55.00	80.00	81.10	2.00	0.013	5.10	0.00	89.50	n/a	5.90	0.00	82.02	82.39 j	83.08 i
2	2	2	1+55-236.06	24	77.06	81.60	82.76	1.51	0.013	9.60	89.50	88.90	5.90	4.14	0.00	83.08	83.87 j	84.49 i

Tutt Blvd Extension 5 Year Stm | Number of lines: 2 | Date: 7/1/2018

NOTES: i Inlet control; ** Critical depth

Hydraulic Grade Line Computations

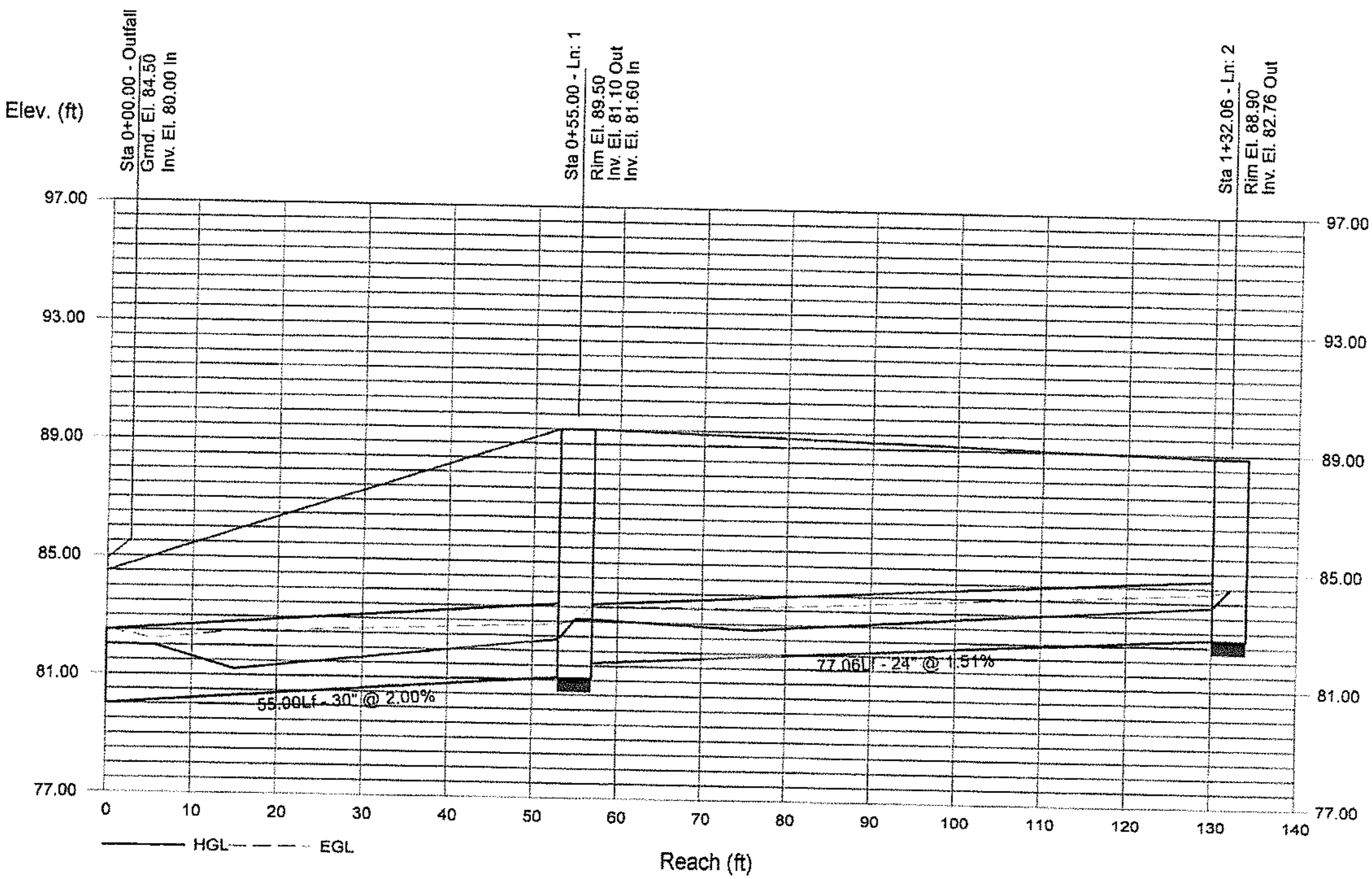
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
	(in)	(cfs)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(%)	(ft)	(K)	(ft)
1	30	14.70	80.00	82.02	2.02	2.56	3.46	0.51	82.53	n/a	55.00	81.10	82.39 j	1.29**	2.56	5.75	0.51	82.90i	n/a	n/a	n/a	0.50	n/a
2	24	9.60	81.60	83.08	1.48	1.78	3.84	0.45	83.53	n/a	77.06	82.76	83.87 j	1.11**	1.78	5.38	0.45	84.32i	n/a	n/a	n/a	1.00	n/a

Tutt Blvd Extension 5 Year Stm | Number of lines: 2 | Run Date: 7/1/2018

Notes: ; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

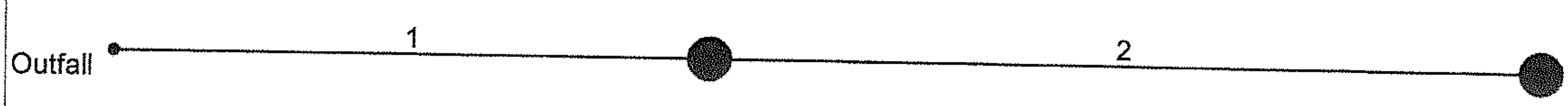
Storm Sewer Profile

Proj. file: 5 YEAR TUTT OUTFALL.stm



Storm Sewers

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: 100 YEAR TUTT OUTFALL.stm	Number of lines: 2	Date: 7/1/2018

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	55.00	0.00	Curb	12.60	0.00	0.00	0.0	80.00	2.00	81.10	30	Cir	0.013	0.50	89.50	1+00 - 1+55
2	1	77.06	0.00	Curb	23.00	0.00	0.00	0.0	81.60	1.51	82.76	24	Cir	0.013	1.00	88.90	1+55-236.06

Project File: 100 YEAR TUTT OUTFALL.stm | Number of lines: 2 | Date: 7/1/2018

Structure Report

Struct No.	Structure ID	Junction Type	Rim Elev (ft)	Structure			Line Out			Line In		
				Shape	Length (ft)	Width (ft)	Size (in)	Shape	Invert (ft)	Size (in)	Shape	Invert (ft)
1		Curb-Horiz	89.50	Cir	4.00	4.00	30	Cir	81.10	24	Cir	81.60
2		Curb-Horiz	88.90	Cir	4.00	4.00	24	Cir	82.76			

Project File: 100 YEAR TUTT OUTFALL.stm | Number of Structures: 2 | Run Date: 7/1/2018

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	1+00 - 1+55	35.60	30	Cir	55.00	80.00	81.10	2.000	82.02	83.12	n/a	84.94 i	End	Curb-Horiz
2	1+55-236.06	23.00	24	Cir	77.06	81.60	82.76	1.505	84.94*	85.74*	0.83	86.57	1	Curb-Horiz

Project File: 100 YEAR TUTT OUTFALL.stm | Number of lines: 2 | Run Date: 7/1/2018

NOTES: Return period = 2 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

RCI

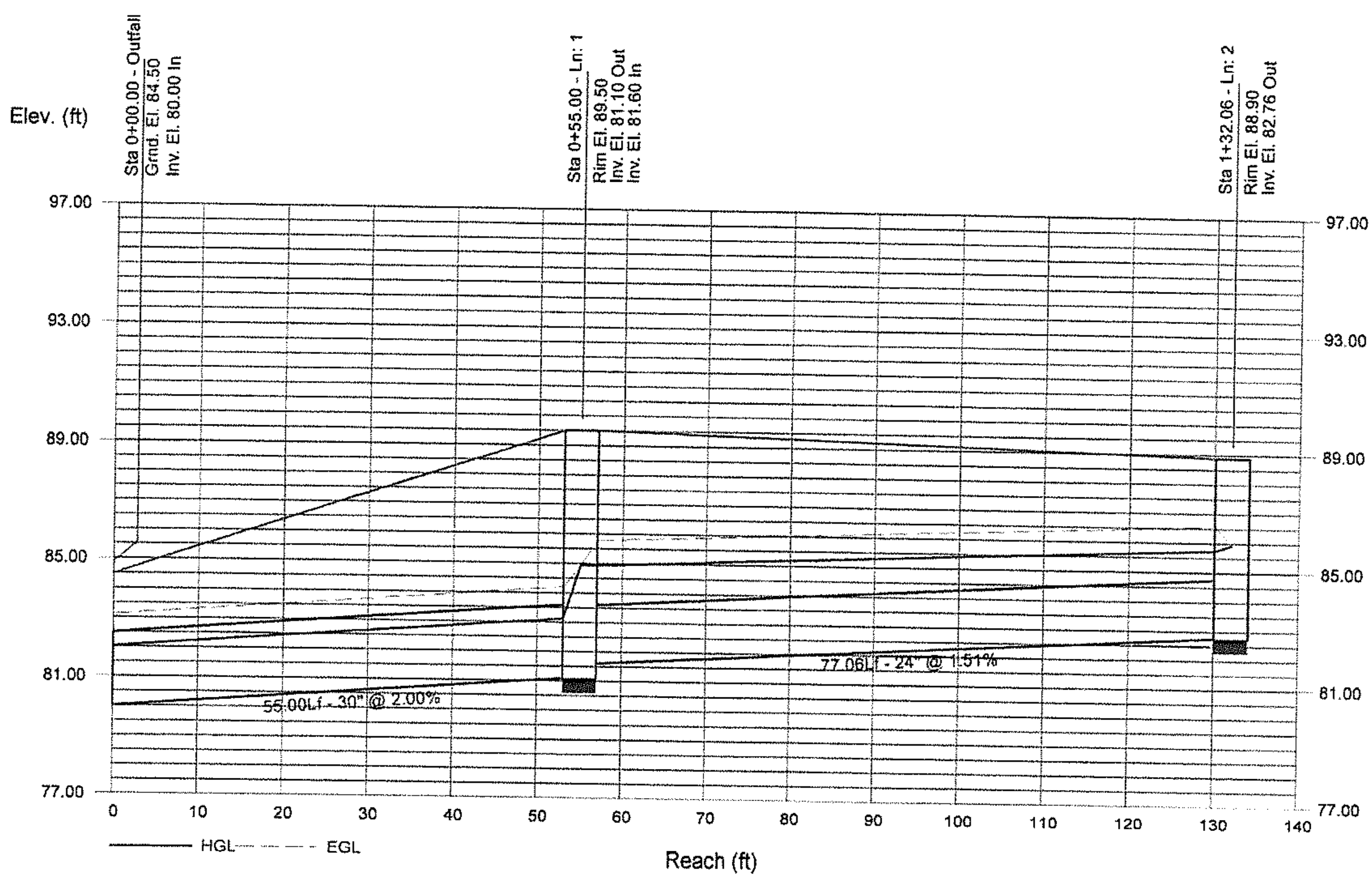
Line No.	Line No.	Line No.	Line ID	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	n-val Pipe	Known Q (cfs)	Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Cover Dn (ft)	Cover Up (ft)	Defl Ang (Deg)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)
1	1	1	1+00 - 1+55	30	55.00	80.00	81.10	2.00	0.013	12.60	0.00	89.50	n/a	5.90	0.00	82.02	83.12	84.94 i
2	2	2	1+55-236.06	24	77.06	81.60	82.76	1.51	0.013	23.00	89.50	88.90	5.90	4.14	0.00	84.94	85.74	86.57

Project File: 100 YEAR TUTT OUTFALL.stm | Number of lines: 2 | Date: 7/1/2018

NOTES: i Inlet control; ** Critical depth

Storm Sewer Profile

Proj. file: 100 YEAR TUTT OUTFALL.stm



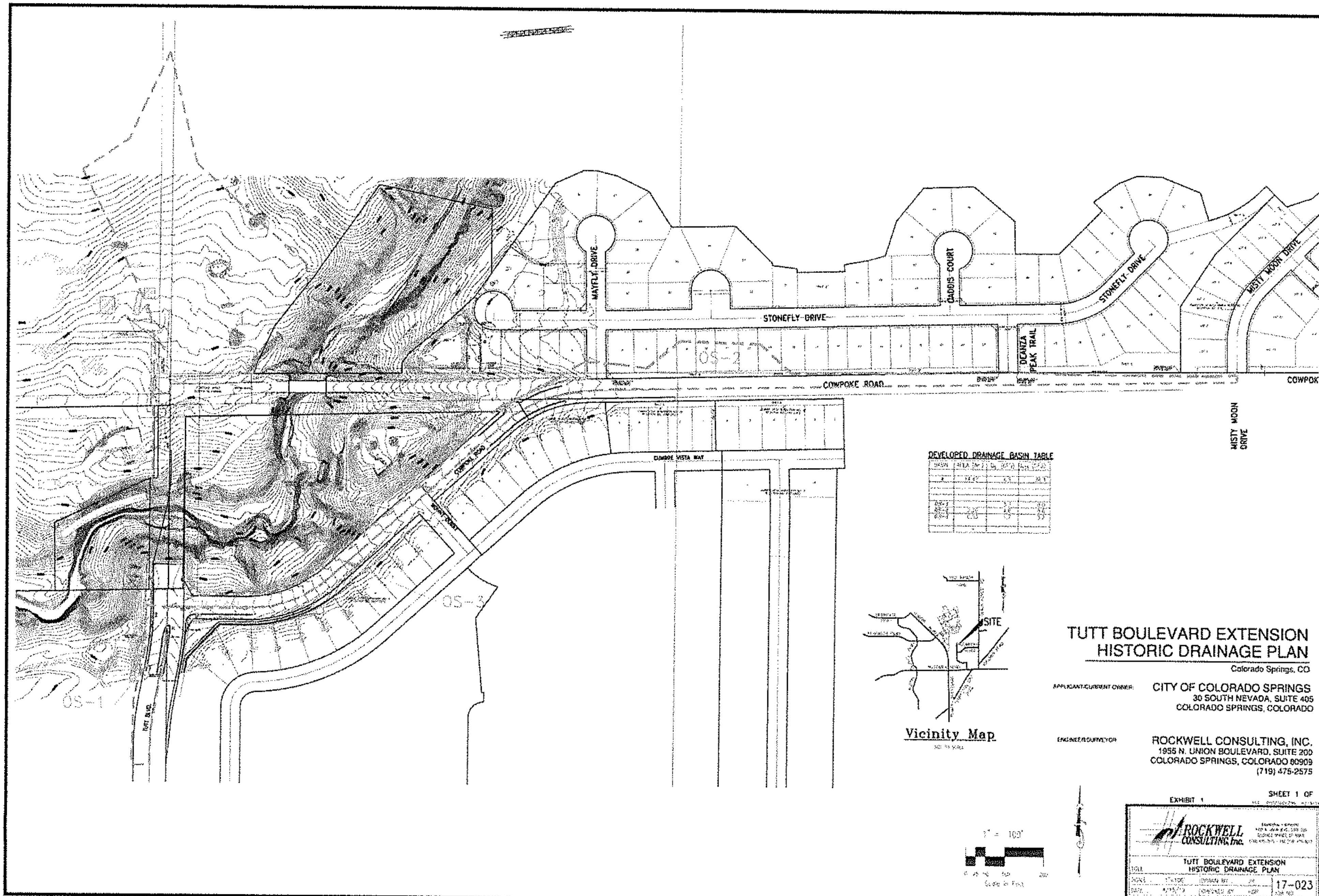
Storm Sewers

Hydraulic Grade Line Computations

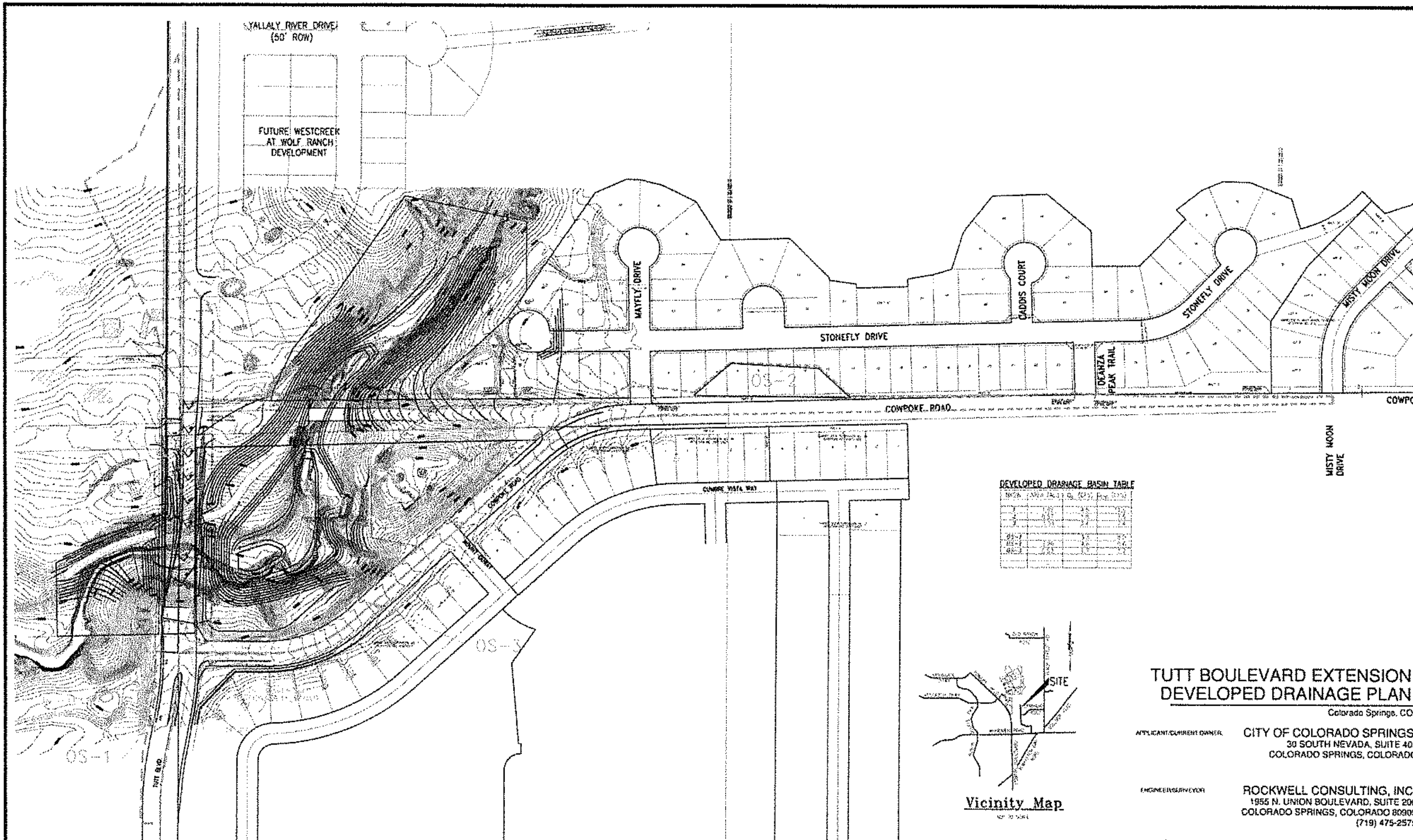
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	30	35.60	80.00	82.02	2.02	4.25	8.38	1.09	83.11	n/a	55.00	81.10	83.12	2.02**	4.26	8.37	1.09	84.21i	n/a	n/a	n/a	0.50	n/a
2	24	23.00	81.60	84.94	2.00	3.14	7.32	0.83	85.78	1.035	77.06	82.76	85.74	2.00	3.14	7.32	0.83	86.57	1.034	1.034	0.797	1.00	0.83

Project File: 100 YEAR TUTT OUTFALL.stm | Number of lines: 2 | Run Date: 7/1/2018

Notes: ; ** Critical depth. ; c = cir e = ellip b = box



STONEFLY DRIVE
MAYFLY DRIVE
CADDIS COURT
DEANZA PEAK TRAIL
MISTY MOON DRIVE
COWPOKE ROAD
CUMBRE VISTA WAY
TUTT BLVD.
OS-1
OS-2
OS-3
DEVELOPED DRAINAGE BASIN TABLE
SITE
Vicinity Map
1" = 100'
TUTT BOULEVARD EXTENSION
HISTORIC DRAINAGE PLAN
Colorado Springs, CO
APPLICANT/CURRENT OWNER:
CITY OF COLORADO SPRINGS
30 SOUTH NEVADA, SUITE 405
COLORADO SPRINGS, COLORADO
ENGINEER/SURVEYOR:
ROCKWELL CONSULTING, INC.
1955 N. UNION BOULEVARD, SUITE 200
COLORADO SPRINGS, COLORADO 80909
(719) 475-2575
EXHIBIT 1
SHEET 1 OF 1
ROCKWELL CONSULTING, Inc.
TUTT BOULEVARD EXTENSION
HISTORIC DRAINAGE PLAN
17-023



TUTT BOULEVARD EXTENSION DEVELOPED DRAINAGE PLAN

Colorado Springs, CO

APPLICANT/CURRENT OWNER: CITY OF COLORADO SPRINGS
30 SOUTH NEVADA, SUITE 405
COLORADO SPRINGS, COLORADO

ENGINEER/SURVEYOR: ROCKWELL CONSULTING, INC.
1955 N. UNION BOULEVARD, SUITE 200
COLORADO SPRINGS, COLORADO 80909
(719) 475-2575

1" = 100'

Scale in Feet

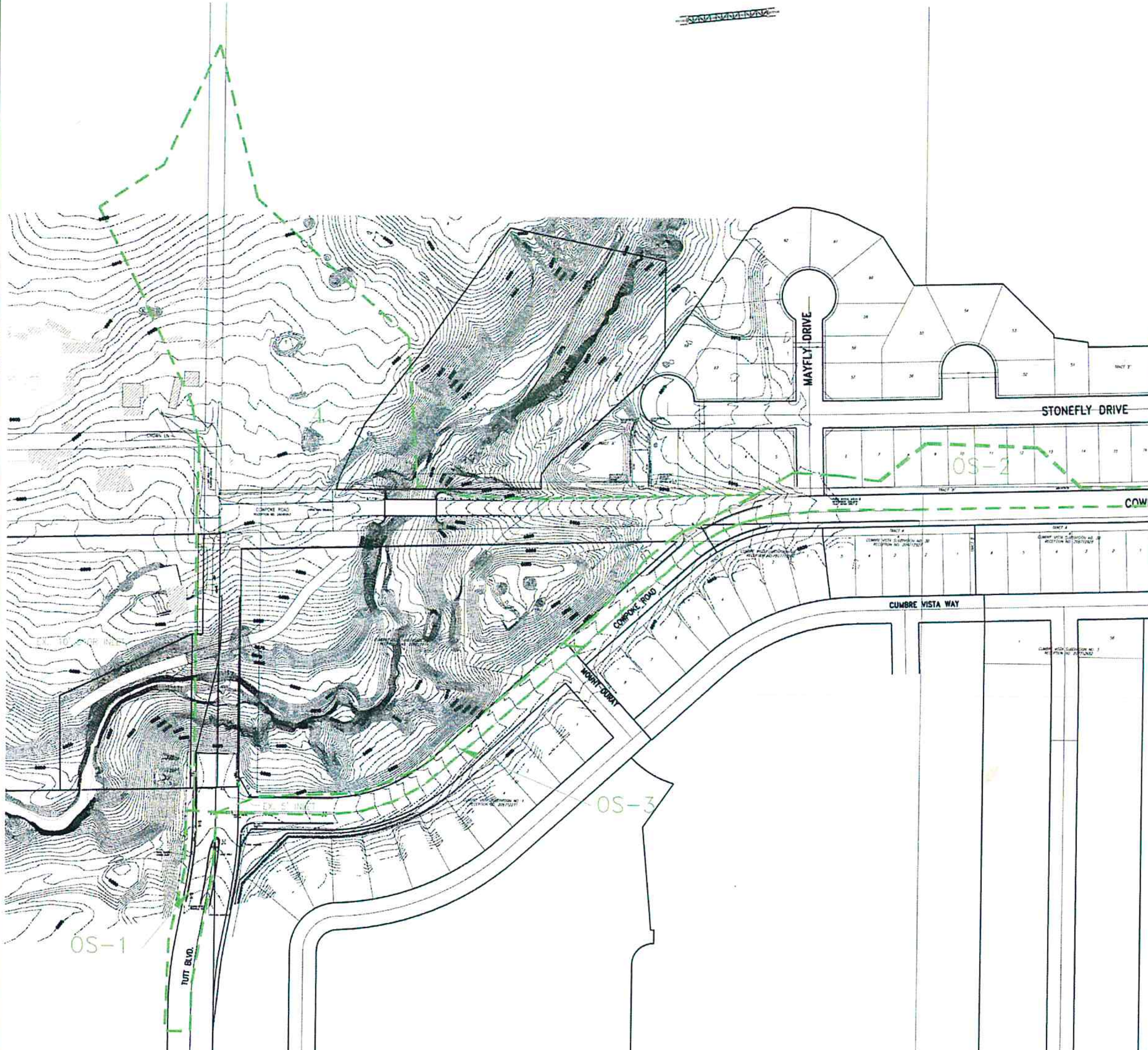
EXHIBIT 2

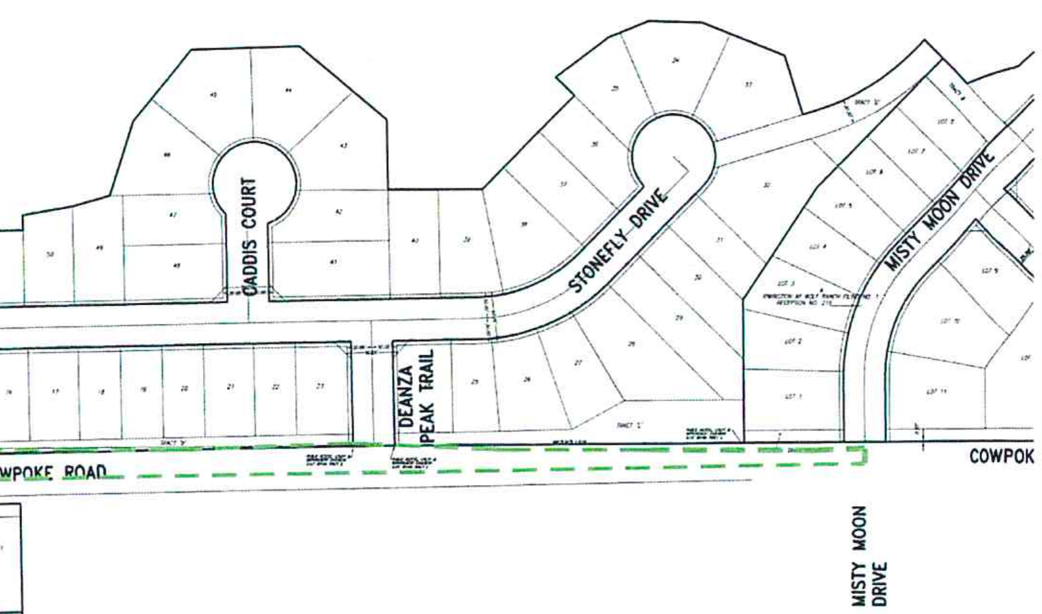
SHEET 1 OF 1

ROCKWELL CONSULTING, Inc.

TUTT BOULEVARD EXTENSION DEVELOPED DRAINAGE PLAN

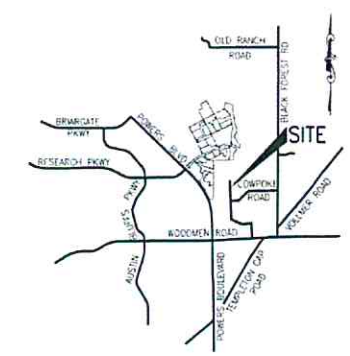
17-023





DEVELOPED DRAINAGE BASIN TABLE

BASIN	AREA (Ac.)	Q_5 (CFS)	Q_{100} (CFS)
A	14.47	6.9	36.1
OS-1		3.3	8.0
OS-2	2.26	4.6	9.6
OS-3	0.53	1.7	3.2
	-		



Vicinity Map

NOT TO SCALE

TUTT BOULEVARD EXTENSION HISTORIC DRAINAGE PLAN

Colorado Springs, CO

APPLICANT/CURRENT OWNER: CITY OF COLORADO SPRINGS
30 SOUTH NEVADA, SUITE 405
COLORADO SPRINGS, COLORADO

ENGINEER/SURVEYOR ROCKWELL CONSULTING, INC.
1955 N. UNION BOULEVARD, SUITE 200
COLORADO SPRINGS, COLORADO 80909
(719) 475-2575

1" = 100'

0 25 50 100 200
Scale in Feet

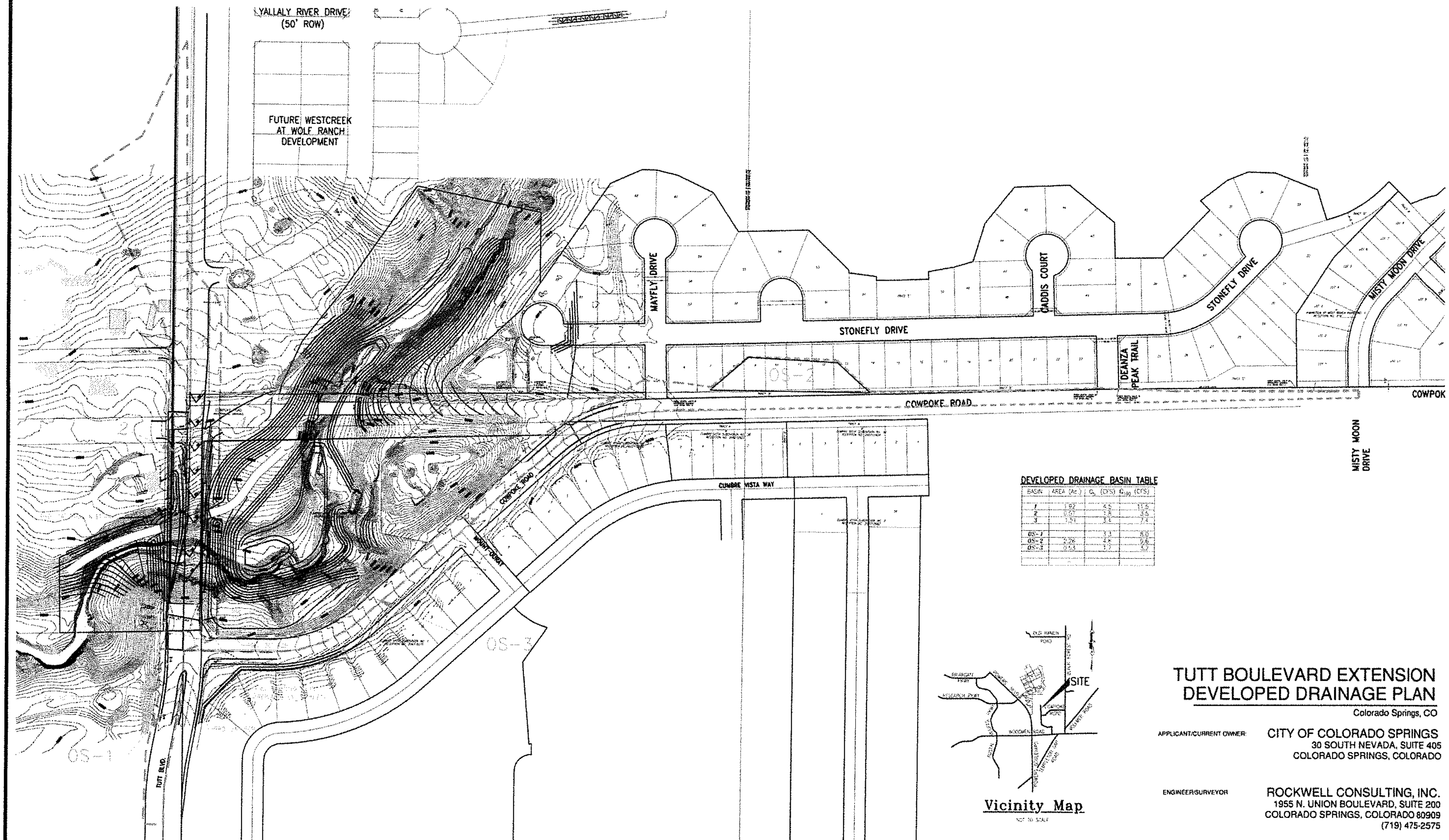
EXHIBIT 1

SHEET 1 OF 1

ROCKWELL CONSULTING, Inc.

TITLE: TUTT BOULEVARD EXTENSION HISTORIC DRAINAGE PLAN

SCALE: 1"=100'	DRAWN BY: JH	17-023
DATE: 4/15/19	CHECKED BY: KDR	JOB NO.



DEVELOPED DRAINAGE BASIN TABLE

BASIN	AREA (Ac.)	Q_5 (CFS)	Q_{100} (CFS)
1	1.92	4.5	11.5
2	0.57	1.8	3.5
3	2.51	3.4	7.4
OS-1		3.3	8.0
OS-2	2.26	4.5	9.6
OS-3	0.53	1.7	5.2

TUTT BOULEVARD EXTENSION DEVELOPED DRAINAGE PLAN

Colorado Springs, CO

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ENGINEER/SURVEYOR: ROCKWELL CONSULTING, INC.
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EXHIBIT 2

SHEET 1 OF 1

ROCKWELL CONSULTING, Inc.

TITLE: TUTT BOULEVARD EXTENSION DEVELOPED DRAINAGE PLAN

SCALE: 1"=100' | DRAWN BY: JH
DATE: 4/15/19 | CHECKED BY: KDR
JOB NO. 17-023

APPENDIX F

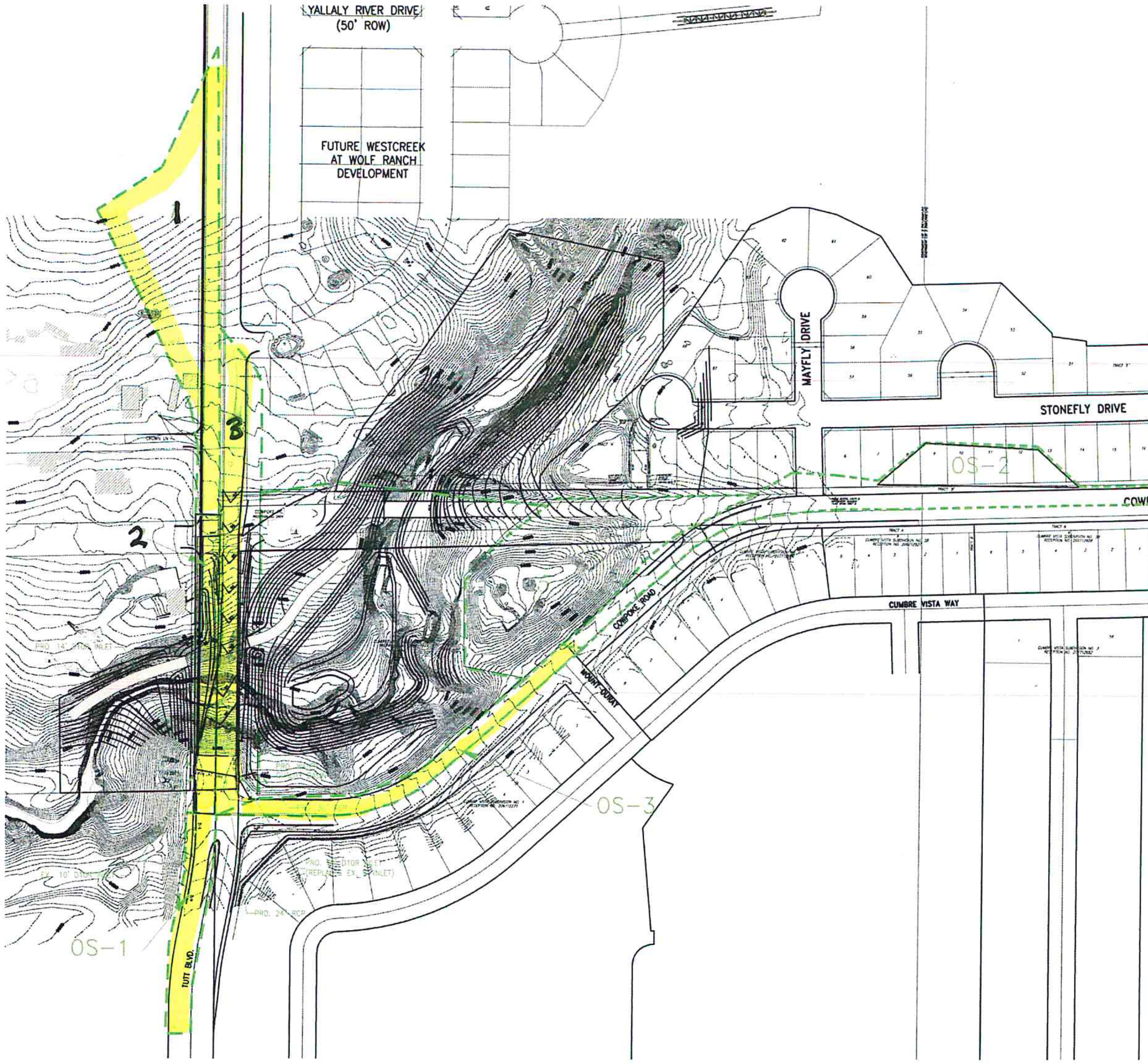
TUTT BOULEVARD WATER QUALITY BASIN DESIGN CALCULATIONS

Table EDB-4. EDB component criteria

	On-Site EDBs for Watersheds up to 1 Impervious Acre[1]	EDBs with Watersheds between 1 and 2 Impervious Acres[1]	EDBs with Watersheds up to 5 Impervious Acres	EDBs with Watersheds over 5 Impervious Acres	EDBs with Watersheds over 20 Impervious Acres
Forebay Release and Configuration	EDBs should not be used for watersheds with less than 1 impervious acre.	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch configuration	Release 2% of the undetained 100-year peak discharge by way of a wall/notch or berm/pipe[2] configuration
Minimum Forebay Volume		1% of the WQCV	2% of the WQCV	3% of the WQCV	3% of the WQCV
Maximum Forebay Depth		12 inches	18 inches	18 inches	30 inches
Trickle Channel Capacity		≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity	≥ the maximum possible forebay outlet capacity
Micropool		Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2	Area ≥ 10 ft^2
Initial Surcharge Volume		Depth ≥ 4 inches	Depth ≥ 4 inches	Depth ≥ 4 in. Volume ≥ 0.3% WQCV	Depth ≥ 4 in. Volume≥ 0.3% WQCV

[1] EDBs are not recommended for sites with less than 2 impervious acres. Consider a sand filter or rain garden.

[2] Round up to the first standard pipe size (minimum 8 inches).



DEVELOPED DRAINAGE BASIN TABLE

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2	0.57	1.8	3.5
3	1.51	3.4	7.4
OS-1	1.6	3.3	8.0
OS-2	2.26	4.6	9.6
OS-3	0.53	1.7	3.2
	–		

Vicinity Map
NOT TO SCALE

TUTT BOULEVARD EXTENSION
DEVELOPED DRAINAGE PLAN

Colorado Springs, CO

APPLICANT/CURRENT OWNER: CITY OF COLORADO SPRINGS
30 SOUTH NEVADA, SUITE 405
COLORADO SPRINGS, COLORADO

ENGINEER/SURVEYOR: ROCKWELL CONSULTING, INC.
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COLORADO SPRINGS, COLORADO 80909
(719) 475-2575

1" = 100'
0 25 50 100 200
Scale in Feet

EXHIBIT 2

SHEET 1 OF 1

FILE: 06021DEVDWG 4/15/19

ROCKWELL CONSULTING, Inc.

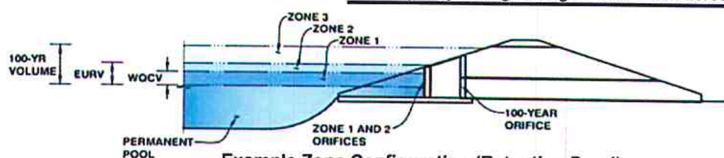
TITLE:	TUTT BOULEVARD EXTENSION DEVELOPED DRAINAGE PLAN		
SCALE: 1"=100'	DRAWN BY: JH	17-023	
DATE: 4/15/19	CHECKED BY: KDR	JOB NO.	

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Cottonwood Creek PR-2 WQ basin

Basin ID: Water quality storage design   Area = 6.14 acres



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	6.14	acres
Watershed Length =	900	ft
Watershed Slope =	0.015	ft/ft
Watershed Imperviousness =	79.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	
Water Quality Capture Volume (WQCV) =	0.165	acre-feet
Excess Urban Runoff Volume (EURV) =	0.538	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.454	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	0.597	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	0.741	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	0.906	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	1.031	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	1.197	acre-feet
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet
Approximate 2-yr Detention Volume =	0.426	acre-feet
Approximate 5-yr Detention Volume =	0.561	acre-feet
Approximate 10-yr Detention Volume =	0.698	acre-feet
Approximate 25-yr Detention Volume =	0.748	acre-feet
Approximate 50-yr Detention Volume =	0.777	acre-feet
Approximate 100-yr Detention Volume =	0.820	acre-feet

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
	inches

Depth Increment = 1 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
78.5	--	0.00	--	--	--	0	0.000		
80	--	1.50	--	--	--	4,069	0.093	3,011	0.069
82	--	3.50	--	--	--	8,306	0.191	15,427	0.354
83	--	4.50	--	--	--	10,669	0.245	24,914	0.572
84	--	5.50	--	--	--	13,257	0.304	36,877	0.847
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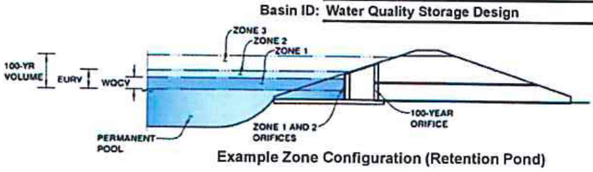
Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Cottonwood Creek PR-2 WQ Basin

Basin ID: Water Quality Storage Design



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.34	0.165	Orifice Plate
Zone 2 (EURV)	4.36	0.373	Orifice Plate
Zone 3			
		0.538	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	4.36	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	17.40	inches
Orifice Plate: Orifice Area per Row =	1.09	sq. inches (diameter = 1-3/16 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	7.569E-03	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.45	2.91					
Orifice Area (sq. inches)	1.09	1.09	1.09					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected	
Invert of Vertical Orifice =			ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =			ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =			inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =			ft^2
Vertical Orifice Centroid =			feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Not Selected	Not Selected	
Overflow Weir Front Edge Height, Ho =			ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =			feet
Overflow Weir Slope =			H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =			feet
Overflow Grate Open Area % =			%, grate open area/total area
Debris Clogging % =			%

Calculated Parameters for Overflow Weir

	Not Selected	Not Selected	
Height of Grate Upper Edge, H_t =			feet
Over Flow Weir Slope Length =			feet
Grate Open Area / 100-yr Orifice Area =			should be ≥ 4
Overflow Grate Open Area w/o Debris =			ft^2
Overflow Grate Open Area w/ Debris =			ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Not Selected	Not Selected	
Depth to Invert of Outlet Pipe =			ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter =			inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Not Selected	Not Selected	
Outlet Orifice Area =			ft^2
Outlet Orifice Centroid =			feet
Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=		ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =		feet
Spillway End Slopes =		H:V
Freeboard above Max Water Surface =		feet

Calculated Parameters for Spillway

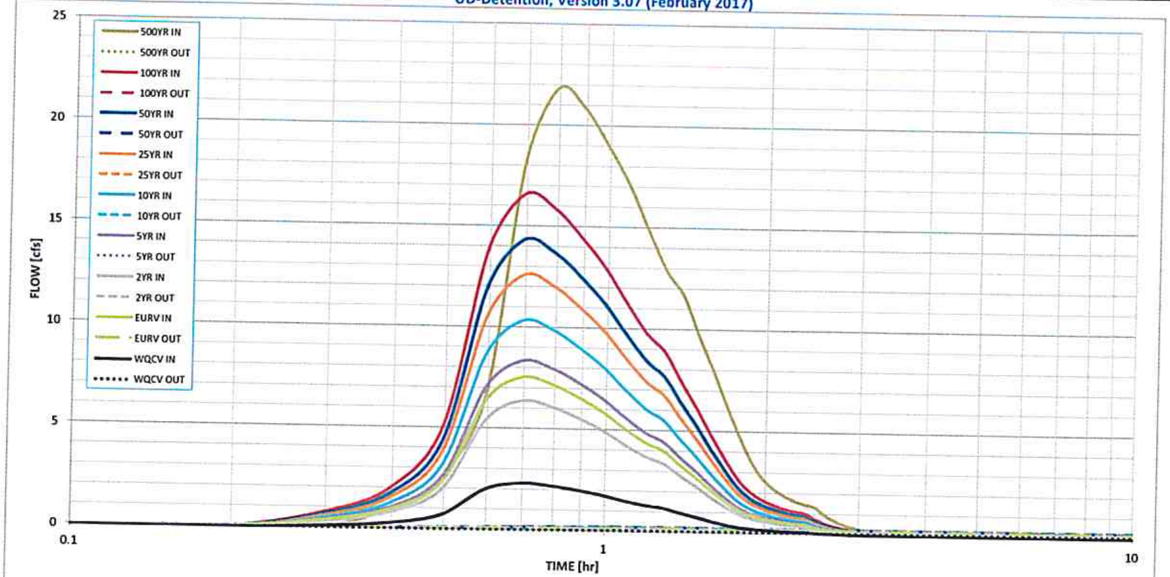
Spillway Design Flow Depth=		feet
Stage at Top of Freeboard =		feet
Basin Area at Top of Freeboard =		acres

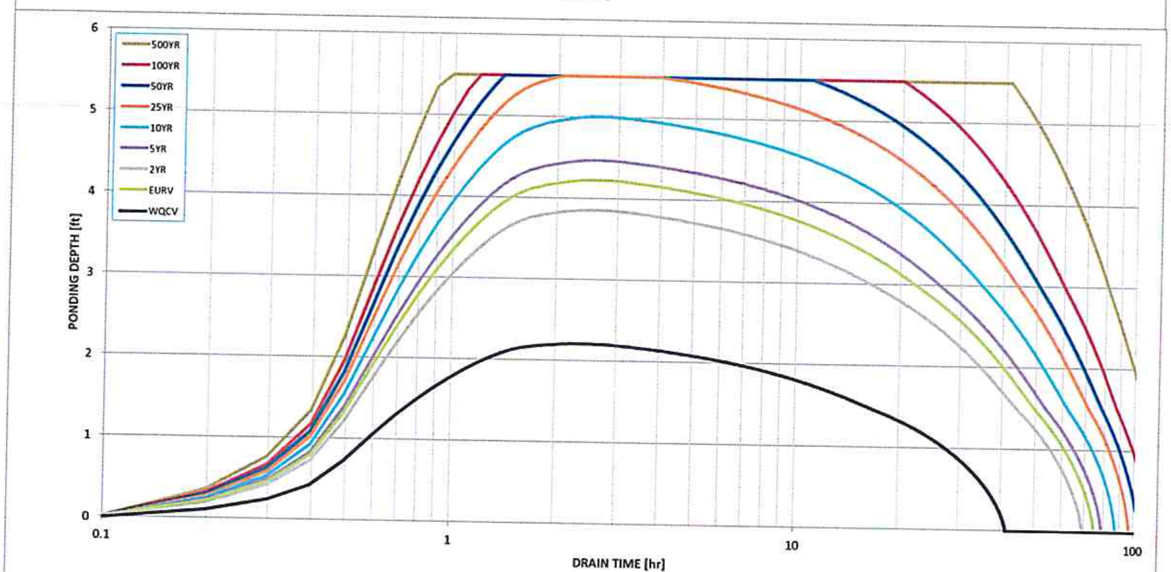
Routed Hydrograph Results

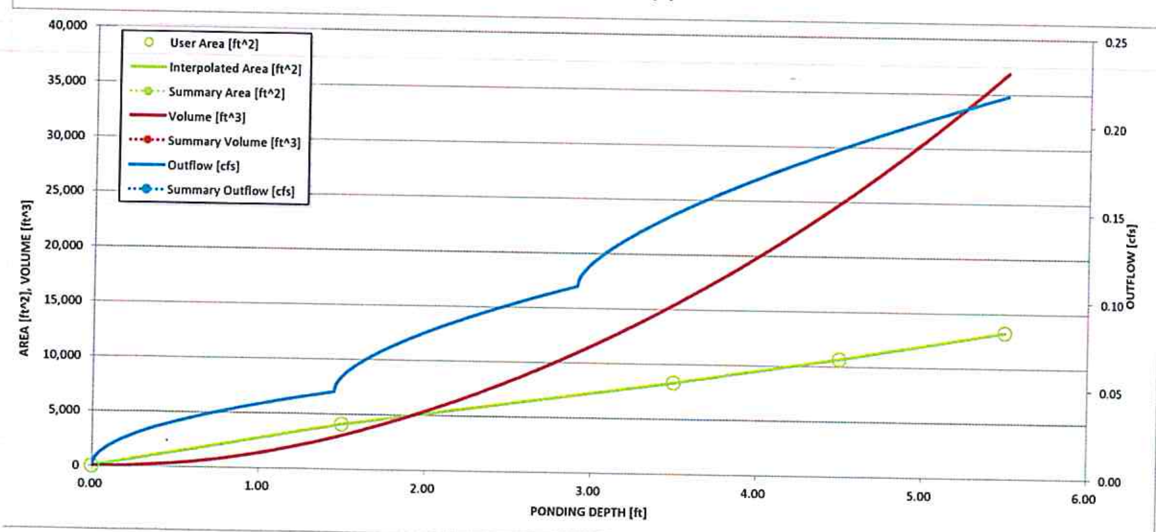
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.20
Calculated Runoff Volume (acre-ft) =	0.165	0.538	0.454	0.597	0.741	0.906	1.031	1.197	1.580
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.164	0.537	0.453	0.596	0.740	0.904	1.030	1.195	1.578
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.16	0.54	0.75	1.02	1.54
Predevelopment Peak Q (cfs) =	0.0	0.0	0.1	0.1	1.0	3.3	4.6	6.2	9.4
Peak Inflow Q (cfs) =	2.3	7.5	6.3	8.3	10.3	12.6	14.3	16.6	21.8
Peak Outflow Q (cfs) =	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.8	0.2	0.1	0.0	0.0	0.0
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	N/A	N/A	N/A	N/A
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	67	62	70	77	84	90	98	115
Time to Drain 99% of Inflow Volume (hours) =	40	71	66	75	83	91	98	106	126
Maximum Ponding Depth (ft) =	2.22	4.22	3.85	4.47	5.00	5.50	5.50	5.50	5.50
Area at Maximum Ponding Depth (acres) =	0.13	0.23	0.21	0.24	0.27	0.30	0.30	0.30	0.30
Maximum Volume Stored (acre-ft) =	0.149	0.505	0.424	0.562	0.702	0.847	0.847	0.847	0.847

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

City of Colorado Springs
Cottonwood PR2 WQ Basin
Volume Calculation

Stage	Elevation	Area sq. ft.	Area Acres	Avg. Area	Increment	Incremental Volume	Cumulative Volume
0	78.5	0	0.00				
				0.05	1.5	0.07	0.07
1.5	80	4,069	0.09				
				0.14	2	0.28	0.35
3.5	82	8,306	0.19				
				0.22	1	0.22	0.57
4.5	83	10,669	0.24				
				0.27	1	0.27	0.85
5.5	84	13257	0.30				

Kiowa Engineering Corporation
Project No. 13064

KIOWA ENGINEERING CORPORATION

JOB Tutt/PR-2

SHEET NO. ______ OF ______

CALCULATED BY RNW DATE 3-20-18

CHECKED BY ______ DATE ______

SCALE WQ Basin - Tutt Blvd

WQ BASIN - Tutt Blvd.

AREA SERVED (Refer to Tutt Blvd Extension Drainage Report, Rockwell Consulting)

SB	Area (SF)	Area (Ac)	% Imp
1	83662	1.93	45
2	24818	0.57	95
3	65951	1.51	95
OS-1	69696	1.60	95
OS-3	23033	0.53	95

Total 6.14 Acres

Wtd % Imp: $\frac{4.21(.95) + 1.93(.45)}{6.14} = 79.1\%$

Length of basin 1600'

Slope 1.5% Avg

Presedementation / Forebay Sizing

Forebay Location	100 Yr Flow	Detention WQCV	Total Detention Forebay Vol (3% WQCV)	Tributary Area	% of Total Trib Area	Required Forebay Volume	Forebay Area	Forebay Depth	Forebay Volume	Required Forebay Volume	Discharge Design Flow (2% 100yr)	Calculated Opening Width (1" min)
Tutt WQ	50.5cfs	7,187 cf	216cf	6.14ac	100.0%	216cf	90sf	1.25-ft	113 cf	216cf	1.01 cfs	5.9-inch

Opening Width Equation for Rectangular Opening

$L = Q / (CH^{1.5}) \times 12 + 0.2xH$ (UD-BMP Spreadsheet -- EDB tab)　　C = 3.0

Forebay Overflow Calculation

Description	Water Surf Elev	Crest Elev	Crest Length	Flow Depth	**Calc'd Flow**
Tutt WQ	6,881.00	6,880.5	24.0 ft	0.50 ft	25.5 cfs

Weir Equation:

$Q = CLH^{1.5}$　　C = 3.0

C = Weir coefficient (dimensionless), C = 3.0 (most cases)

L = Length of weir at Crest, in ft. Not including sideslopes.

Grate	Safety Grate or Trash Rack	Type of Grate (see below)	R Value		Outlet Diameter or Min. Dimension	A_{ot} Total Outlet/ Orifice Area	A_t/A_{ot}	Minimum Gross Grate Area
			Table	User Input				
G1	Trash	WS	0.60		0.3-in	0.0203sf	37.49	1.27sf
G2	Safety	Other	N/A	0.70	54.0-in	15.90sf	4.00	90.86sf

A_t / A_{ot} = Ratio of Total Grate Open Area to Total Outlet Area (taken from UDSCM Fig OS-1: Trash Rack Sizing)

A_t = Total Grate Open Area (R-Value x Grate Area) (Example: 1'Wx6'H Well Screen=1'x6'x0.60=3.6ft^2)

A_{ot} = Total Outlet Area (Example: If orifice plate includes 3-1"dia holes A_{ot}=2.356in^2=0.016ft^2)

Safety Grate: $A_t / A_{ot} = 77e^{-0.124D}$ -- (Outlet Diameter or Minimum Dimension less than 24-inches)

Trash Rack: $A_t / A_{ot} = 38.5e^{-0.095D}$ (Outlet Diameter or Minimum Dimension less than 24-inches)

Outlet Diameter is orifice plate hole size of pipe out of structure

Minimum Gross Grate Area: Calculated from outside dimension of grate

R Value = Net Open Area / Gross Rack Area

Type of Grate	Abbreviation	R-Value
Bar Grate 2" O.C. Cross Rods	BG 2	0.71
Bar Grate 4" O.C. Cross Rods	BG 4	0.77
Well Screen	WS	0.60
Other	Other	

Grate G1: 1.27 sf / **3' high** = 0.127 ft (1.5 in). Use **8" wide opening** to match opening needed for WQ plate.

Grate G2: 90.86 sf / **10' wide opening** = 9.09 ft (9' - 1") min. for length. However, use **4'-0" length** to satisfy maximum velocity through grate requirement (see Major Storm Grate Conditions calculations).

Trickle Channel Capacity Calculation

Description	Design Flow	Bottom Width	Channel Side Slope		Flow Depth	Channel Slope	Manning "n"	Top Width	Channel Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Channel Flow Capacity
			Left	Right									
Trickle Channel	1.0 cfs	4.0 ft	0:1	0:1	0.50 ft	0.5%	0.015	4.0 ft	2.00 sf	5.0 ft	0.40 ft	3.8 ft/sec	**7.6 cfs**

Equations:
Area (A) = $b(d)+zd^2$
b = width
d = depth

Perimeter (P) = $b+2d*(1+z^2)^{0.5}$
z = side slope
Hydraulic Radius = A/P

Velocity = $(1.49/n)R_n^{2/3} S^{1/2}$
S = Slope of the channel
n = Manning's number
R_n = Hydraulic Radius (Reynold's Number)
Flow = $(1.49/n)AR_n^{2/3} S^{1/2}$

Outlet Structure Major Storm Grate/Box Calculation

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Calc'd Crest Length	d (rad)	Flow Depth	**Calc'd Flow**	**Crest Length Used***
Tutt WQ	14 cfs	17 cfs	6,882.0	6,881.5	10.0 ft	2.63	0.50 ft	12.6 cfs	**10.0 ft**

Weir Equation:
$Q = CLH^{1.5} + CH^{5/2} \tan(d/2)$
C = Weir coefficient (dimensionless), C = 3.0 (most cases)
C = 3.0
L = Length of weir at Crest, in ft. Not including sideslopes.
Outlet Struct Capacity = Inlet Capacity Calculation at the depth to the spillway crest plus flow depth.

H = Depth of flow over the crest, in ft
d = Angle of triangle weir portion (radians)
d = 2.63 radians for 4:1 side slope
d = 2.49 radians for 3:1 side slope

Detention Basin Outlet - Initial Surcharge Sizing

Detention Basin	WQCV	Initial Surcharge Volume				
		Minimum Required		Design		
		0.3% WQCV	Min. Depth	Area	Depth	Volume
Tutt WQ	7,187 cf	22 cf	4.0-in	30 sf	9.0-in	23 cf

Tutt Water Quality Earthwork

Elevation	Area (A)	Avg. Area	Volume	Depth	Cumulative Volume		Elev.
6878.5	16sf			0.0 ft	**0cf**	**0.00ac-ft**	6878.5
6880	4,069sf	2,043sf	3,064cf	1.5 ft	**3,064cf**	**0.07ac-ft**	6880
6881	6,300sf	5,185sf	5,185cf	2.5 ft	**8,248cf**	**0.19ac-ft**	6881
6882	8,306sf	7,303sf	7,303cf	3.5 ft	**15,551cf**	**0.36ac-ft**	6882
6883	10,669sf	9,488sf	9,488cf	4.5 ft	**25,039cf**	**0.57ac-ft**	6883
6884	13,257sf	11,963sf	11,963cf	5.5 ft	**37,002cf**	**0.85ac-ft**	6884
6885	16,500sf	14,879sf	14,879cf	6.5 ft	**51,880cf**	**1.19ac-ft**	6885

Average End Area Formula: V = (A1+A2)/2 x Elev Difference

WQCV =	7,187 cf	0.17 ac-ft	6880.85 ft
EURV =	23,435 cf	0.54 ac-ft	6882.87 ft
100yr Volume =	35,719 cf	0.82 ac-ft	6883.91 ft
Spillway Crest =	51,858 cf	1.19 ac-ft	6882.10 ft
Spillway 100yr Flow Depth =	51,864 cf	1.19 ac-ft	6882.85 ft
	Spillway Freeboard Depth =		1.15 ft
Top of Embankment =	51,873 cf	1.19 ac-ft	6884.00 ft

Emergency Spillway Calculation

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Crest Length	d (rad)	Flow Depth	Calc'd Flow
Tutt	50.5 cfs	60.6 cfs	6,884.00	6,883.0	20.0 ft	2.63	1.00 ft	71.5 cfs

Weir Equation:

$Q = CLH^{1.5} + CH^{5/2} \tan(d/2)$

C = Weir coefficient (dimensionless), C = 3.0 (most cases)

C = 3.0

L = Length of weir at Crest, in ft. Not including sideslopes.

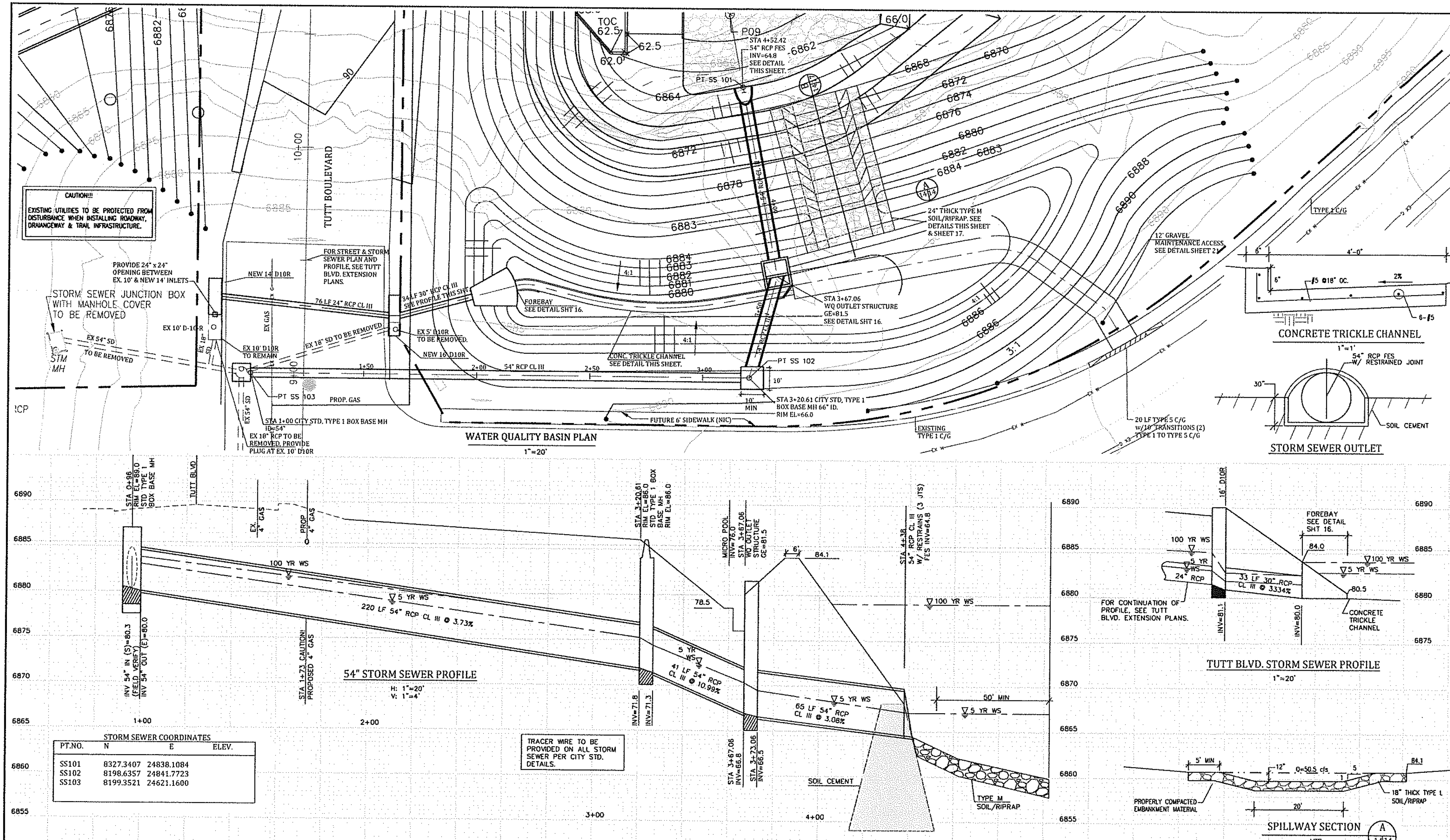
H = Depth of flow over the crest, in ft

d = Angle of triangle weir portion (radians)

d = 2.63 radians for 4:1 side slope

d = 2.49 radians for 3:1 side slope

Outlet Struct Capacity = Inlet Capacity Calculation at the depth to the spillway crest plus flow depth.



STORM SEWER COORDINATES

PT.NO.	N	E	ELEV.
SS101	8327.3407	24838.1084	
SS102	8198.6357	24841.7723	
SS103	8199.3521	24621.1600	

Computer File Information

Creation Date:	By:
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COLORADO SPRINGS

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Kiowa Engineering Corporation

Designer:	RNW	Date:	9/15/2019
Cadd:	EAK	Date:	9/15/2019
Checker:	RNW	Date:	9/15/2019

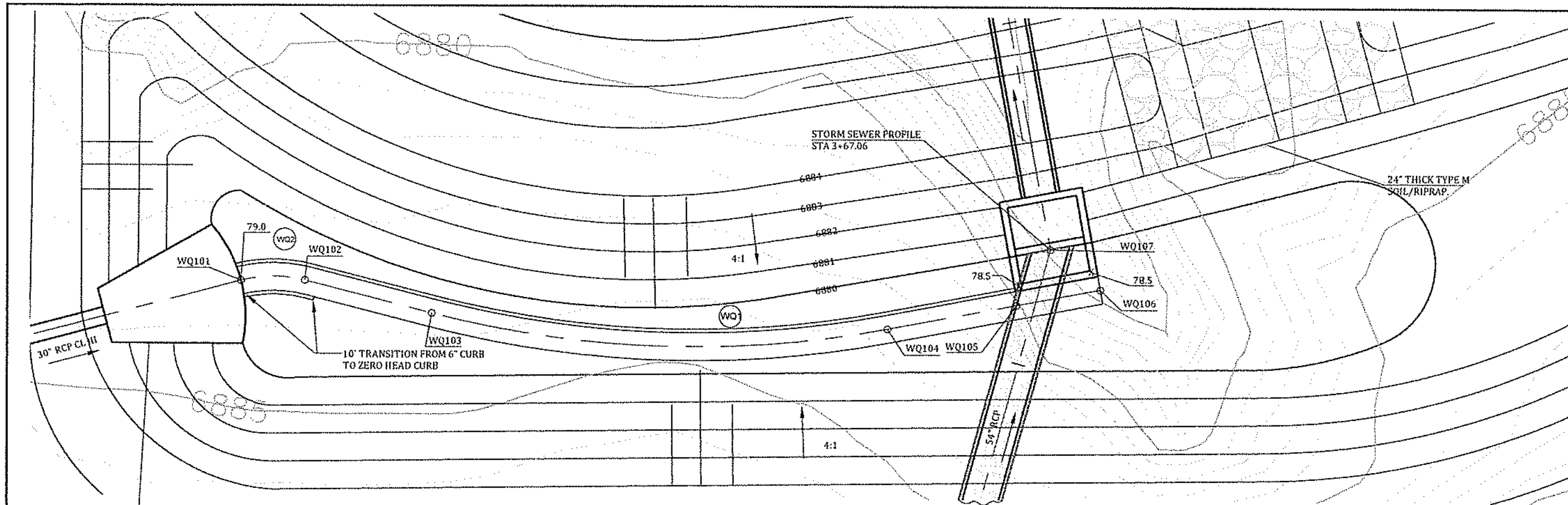
100% BIDDING PLANS

COTTONWOOD CREEK STORMWATER DETENTION BASIN PR-2

WATER QUALITY BASIN & STORM SEWER PLAN

DRAINAGE BASIN: COTTONWOOD CREEK BASIN

JOB NO. 17043 SHEET 14 OF 24



WATER QUALITY BASIN

1"=10'

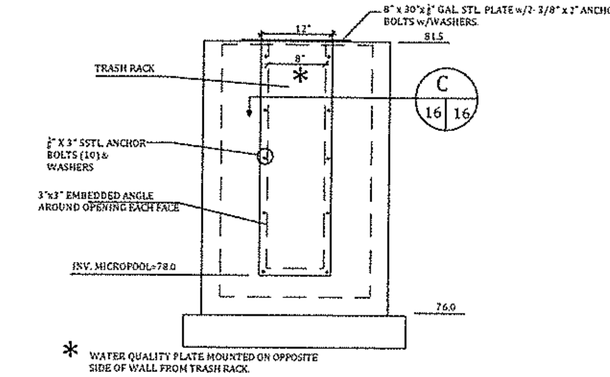
WATER QUALITY POND COORDINATES

PT.NO.	N	E	ELEV.	
WQ101	8238.6848	24738.3275	6879.0	INV TRICKLE CHANNEL
WQ102	8238.7190	24747.4163	6878.96	INV TRICKLE CHANNEL
WQ103	8234.0646	24765.5338	6878.88	INV TRICKLE CHANNEL
WQ104	8231.9495	23830.6777	6878.69	INV TRICKLE CHANNEL
WQ105	8235.4401	24849.1715	6878.60	INV TRICKLE CHANNEL
WQ106	8237.6980	24861.1339	6878.0	INV TRICKLE CHANNEL
WQ107	8253.4637	24853.9398	6881.5	TOC. OUTLET STRUCTURE

CURVE DATA

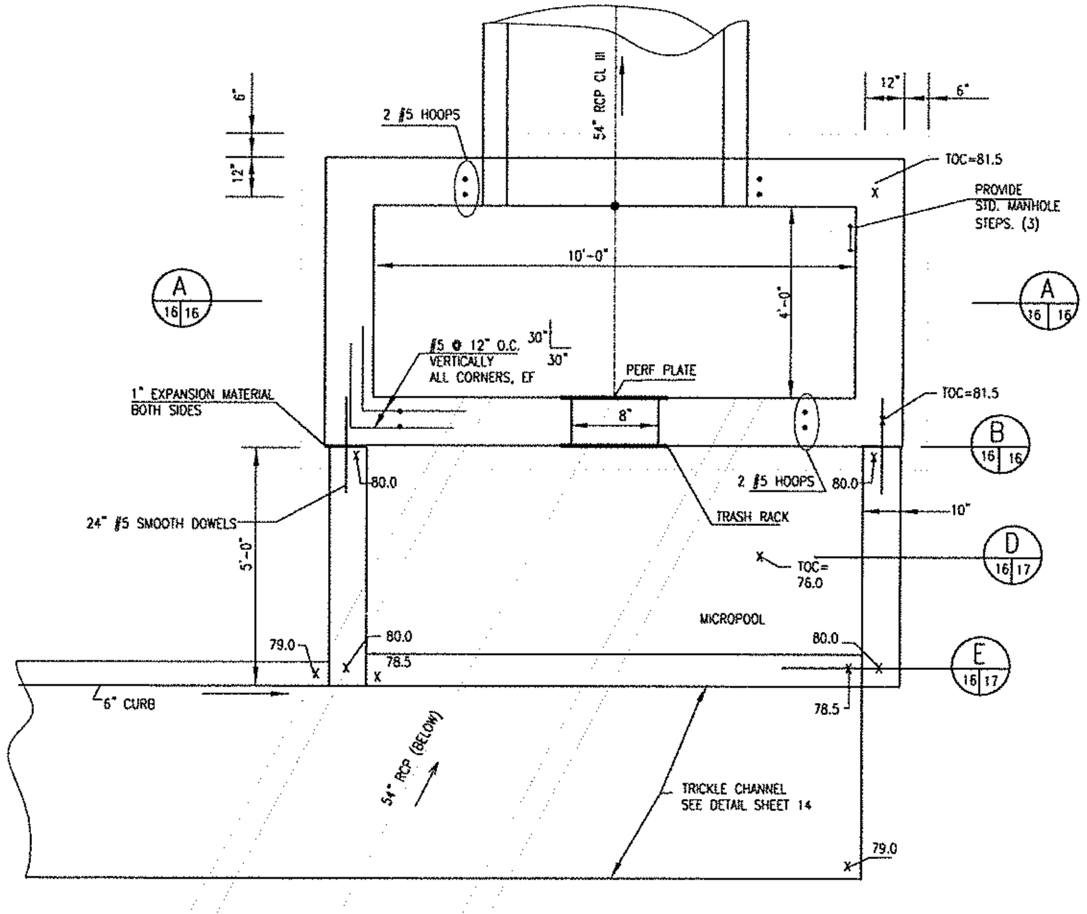
WQ1 R=150.00' L=65.70' Δ=25.10°

WQ2 R=18.00' L=9.19' Δ=29.25°



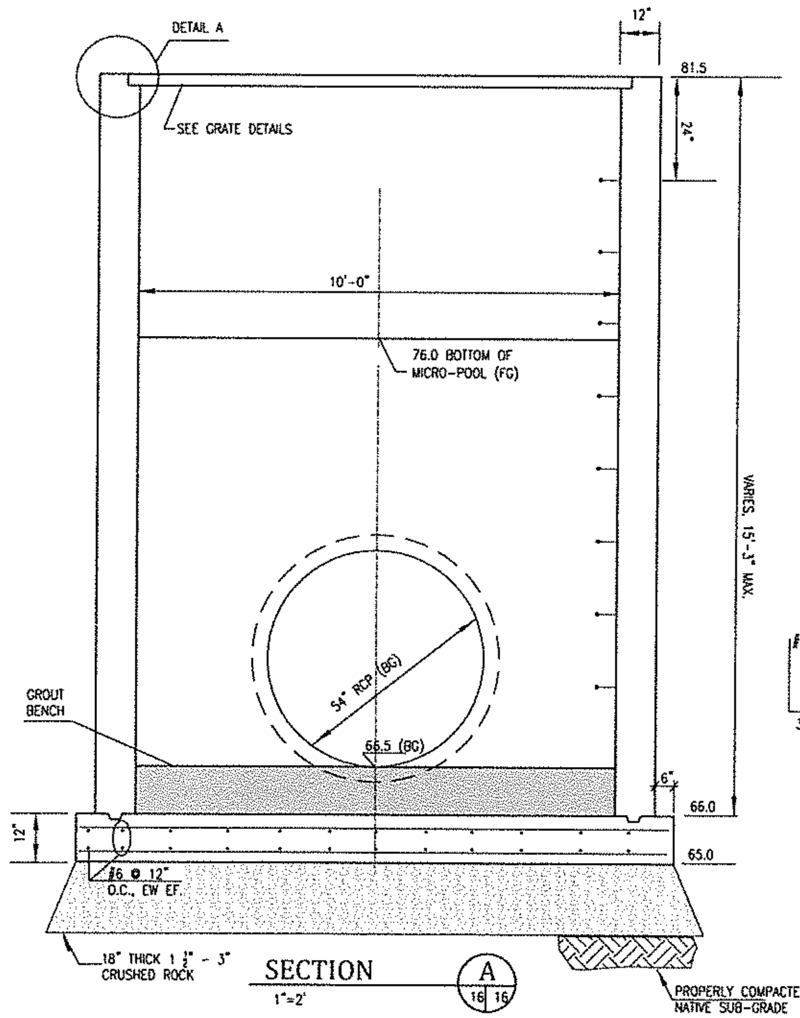
SECTION B (16/16)

NTS



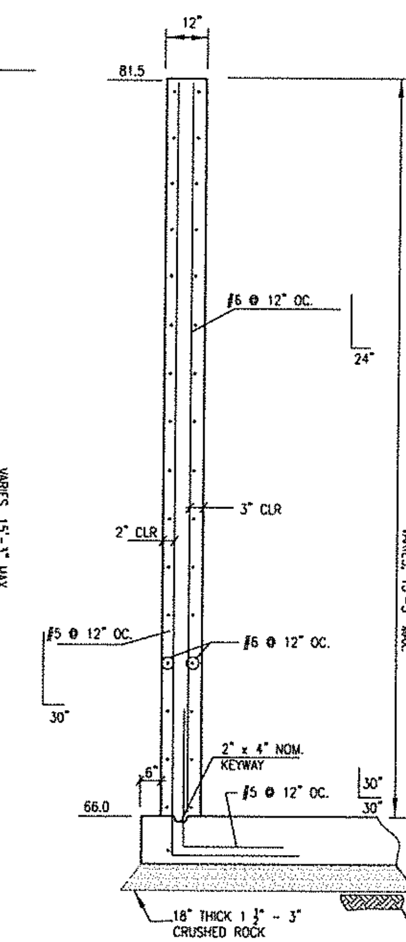
WQ OUTLET STRUCTURE PLAN

1"=2' H
1"=2' V



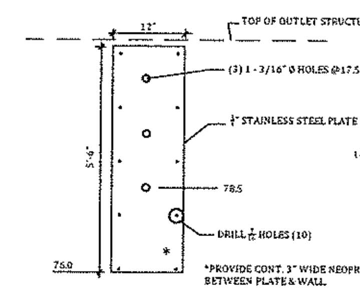
SECTION A (16/16)

1"=2'



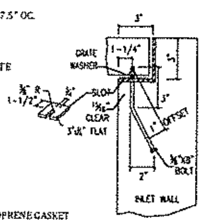
TYPICAL WALL SECTION

NTS



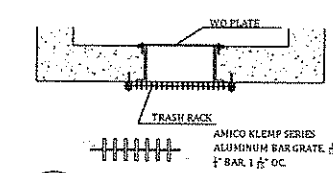
WATER QUALITY OUTLET PLATE

NTS



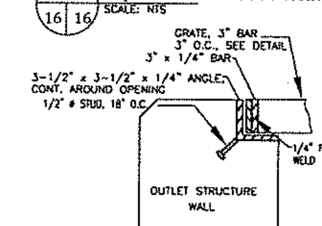
BOLT DOWN GRATE DETAIL

SCALE: NTS

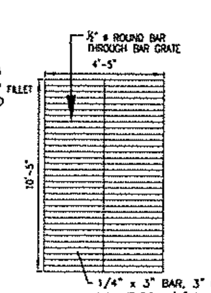


C (16/16) WQCV ORIFICE PLATE AND TRASH RACK

SCALE: NTS



DETAIL A



NOTE:
ALL GRATE DIMENSIONS TO BE FIELD VERIFIED PRIOR TO FABRICATION.
ALL GRATE MATERIALS SHALL BE GALVANIZED. GRATE MAY BE FABRICATED IN NO MORE THAN 3 EQUAL LENGTHS.

GRATE DETAIL

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Cadd: EAK	Date: 3/22/2019
Checker: RNW	Date: 3/22/2019

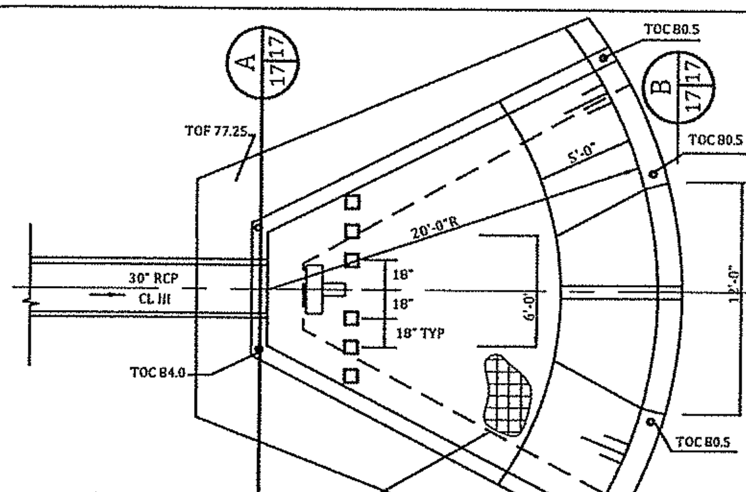
100% BIDDING PLANS

COTTONWOOD CREEK STORMWATER DETENTION BASIN PR-2

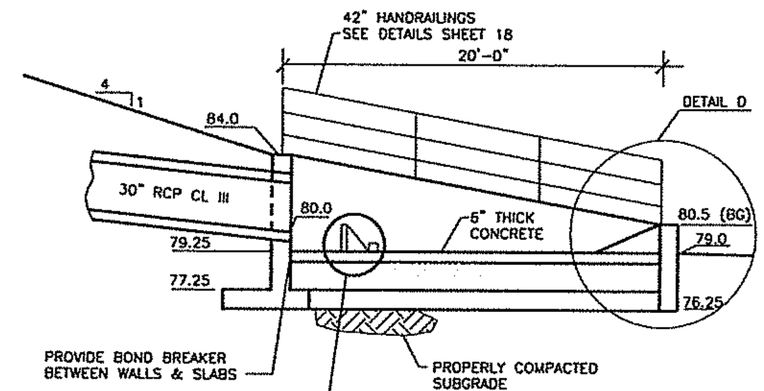
WQ STRUCTURE PLAN & DETAILS

DRAINAGE BASIN: COTTONWOOD CREEK BASIN

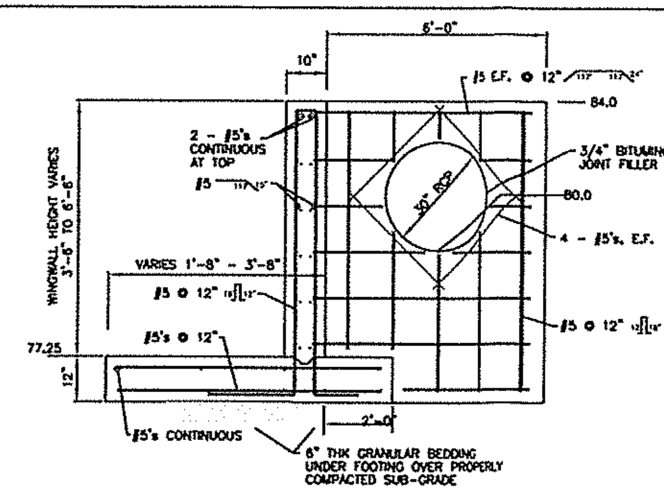
JOB NO. 17043 SHEET 16 OF 24



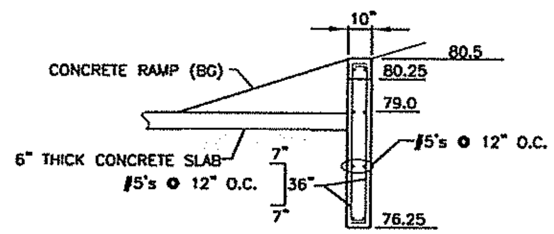
FOREBAY PLAN
1"=5'



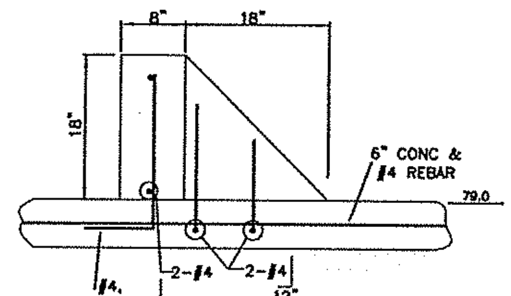
FOREBAY PROFILE
1"=5' H & V



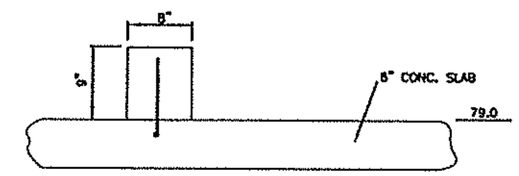
SECTION A 17/17
RCP OUTLET
NTS



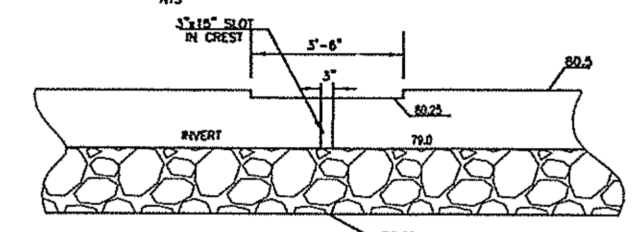
DETAIL D
NTS



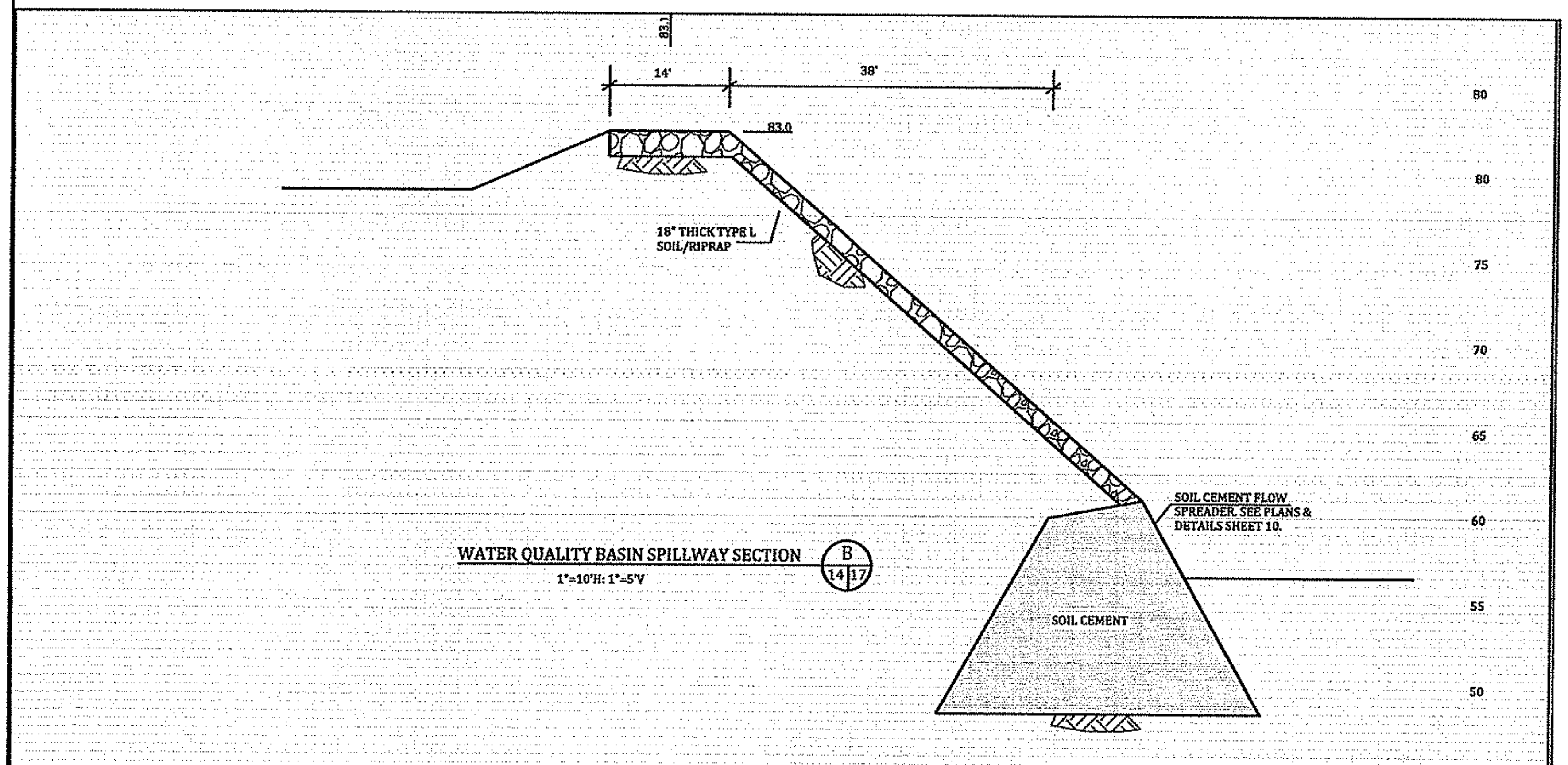
DETAIL B
1"=1'



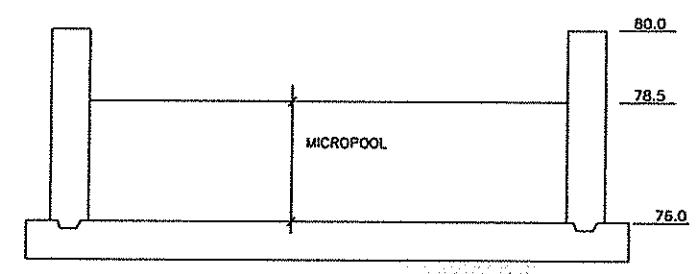
DETAIL C
1"=1'



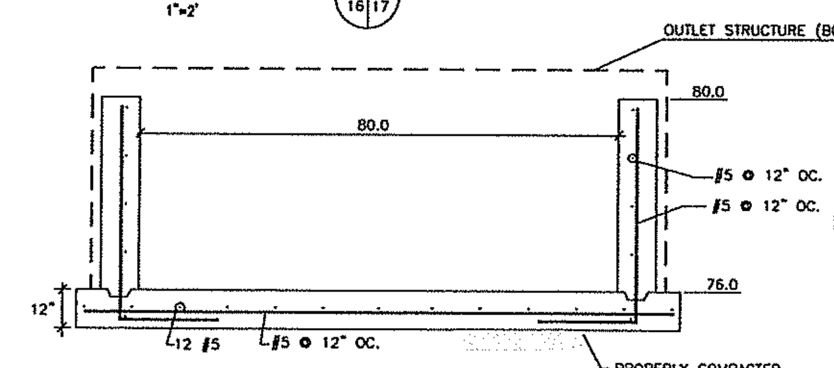
SILL WALL B 16/16
SCALE: 1"=2'



WATER QUALITY BASIN SPILLWAY SECTION B 14/17
1"=10'H: 1"=5'V



MICRO-POOL INLET E 16/17
1"=2'



MICRO-POOL ELEVATION D 16/17
1"=2'

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COTTONWOOD CREEK STORMWATER DETENTION BASIN PR-2

WATER QUALITY BASIN DETAILS

DRAINAGE BASIN: COTTONWOOD CREEK BASIN

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