COTTONWOOD CREEK / MOONLIGHT BEACH

FACILITIES AND COST BENEFIT ANALYSIS

Prepared for:
The City of Encinitas

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May 21, 2003

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1.0 COTTONWOOD CREEK HYDRAULIC ANALYSIS

1.1 Existing Conditions Analysis

The Hydrologic Engineering Center's River Analysis System (HEC-RAS version 3.1) computer program was used to evaluate the ocean outfall pipes, culverts, and natural channels within the Moonlight Beach/Cottonwood Creek area. Specifically, the reach of Cottonwood Creek from Highway 101 downstream to the outfall at the Pacific Ocean was examined. The culvert crossing under Third Street, channel capacity upstream of Third Street, and the ocean outfall pipes under B Street were three locations of particular concern. Cross section data for the project reach was input into the HEC-RAS computer program using topography provided by the City of Encinitas. See Figure 1 for the HEC-RAS cross section locations within the study reach of Cottonwood Creek.

To determine the design discharge values for our study, the results from a detention basin analysis performed for Cottonwood Creek Park were combined with the results from our HEC-1 hydrologic analysis. The flow in the creek at the eastern side of Vulcan Avenue is controlled by the outflow from the 36-inch and 96-inch risers proposed in the Hydrology and Water Quality Report (prepared by Nolte Associates, Inc. dated January 2003) at Cottonwood Creek Park. The detention basin analysis of Cottonwood Creek Park determined the outflow values for the 100-, 50-, 25-, and 10-year storm frequencies. The confluence of these flow values with the runoff entering Cottonwood Creek near Second and Fourth Street provide the design discharge values at various points of interest for our study. Table 1 below summarizes the flow values in Cottonwood Creek.

Table 1: Cottonwood Creek Flow Results

	Design Discharge (cfs)			
Storm Frequency	Outflow from Cottonwood Creek Park Detention Basin	Second Street	Fourth Street	Total
10-Year	640	91	36	767
25-Year	790	118	48	956
50-Year	929	145	61	1135
100-Year	961	204	90	1255

Debris, brush, and rock are present in varying amounts along Cottonwood Creek. Based on our site visit conducted March 30, 2003, we determined that Manning's roughness coefficients range from 0.03 to 0.05. We also made some simplifying assumptions at the upstream entrance to the ocean outfall pipes. Currently, there are three Corrugated Metal Pipe Arches (CMPAs) and one 10' x 4' Reinforced Concrete Box (RCB) culvert that discharge into the Pacific Ocean. We approximated the flow capacity of the RCB with an 86" x 62" CMPA to simplify hydraulic calculations. The area available to carry flow in this CMPA is less than the 40-square feet provided by the RCB, however, due to the conservative nature of this assumption, we feel this equivalent system best represents the existing conditions. Lastly, we have assumed a slope of 1.5% for our equivalent CMPA ocean outfall system due to insufficient information in this area.

To map the floodplain limits on Moonlight Beach (downstream of B Street), we used the bypass flow total not captured by the culverts passing under B Street and performed a normal depth calculation using a representative cross section of the beach.

1.2 Results

The four storm frequencies analyzed for this report all show that there is flooding in the right overbank area just upstream from the pump station (cross section 170). Water then subsequently spills onto B Street and travels westerly down the street before discharging onto Moonlight Beach.

During the 100-year storm, the majority of water that remains in Cottonwood Creek will be captured by the 6' x 4' double box culvert that passes under Third Street. However, water will pond to approximately one foot above the top of the culvert and then overland release along the western side of the pump station. The 50-, 25-, and 10-year storm events also display the same tendency of discharging along the western side of the pump station, however, the water surface elevations (WSELs) predictably decrease with the storm frequency.

Farther downstream, the 100-year and 50-year storm will overtop the culverts passing below B Street and discharge onto Moonlight Beach. The WSEL for the 25-year storm event is just below the headwall and thus, does not discharge onto the street. The CMPAs provide enough conveyance capacity to completely capture (no ponding) the 10-year storm event.

There is also evidence of overflow spill on B Street near cross section 140. However, based on our site inspection, there is significant sediment deposition and debris restricting the hydraulic capacity of the channel in this location. The channel could adequately be able to convey the 10-year design storm with a regular maintenance program.

Figure 1 illustrates the 100-year and 10-year floodplain limits.

1.3 Proposed Alternatives

Although the culverts that pass under B Street are overtopped during a 100-year and 50-year storm event, the area of primary concern is just upstream from the pump station. As mentioned above, all four specified storm frequencies are not contained within the channel at this location, allowing flow to discharge onto B Street. This is also true even if the existing culverts at B Street and Third Street are replaced with larger structures.

The locations near cross sections 165 and 170 were identified as being the most hydraulically deficient. We analyzed an option of widening the channel in these two areas to allow enough conveyance to keep the flow within the creek banks. We were constricted on the right overbank by the pump station at both locations. The steep slope along the left overbank of cross section 165 and proximity to Third Street limited our ability to widen the channel in that direction. Ultimately, we widened the channel at cross section 170 to approximately 110 feet and at cross section 165 the channel was widened to approximately 45 feet. However, with the existing double 6'x 4' RCB culvert at Third Street, the channel was still unable to carry the 10-year flow.

Third Street Alternatives

The following alternatives at the Third Street culvert crossing are proposed with the channel improvements discussed above:

Alternative 1:

This alternative involves adding a 10' x 4' RCB culvert to the existing double 6' x 4' RCBs. We also recommend constructing a wing wall along the right overbank to prevent water from discharging along the pump station and onto B Street, as it has historically done. This alternative had the desired effect of lowering the 10-year WSEL so that water does not discharge onto B Street at locations near cross section 170. However, water is still able to discharge onto B Street with the 25-, 50-, and 100-year storms.

Alternative 2:

This alternative involves constructing a 24' x 6' CON/SPAN culvert to span the 88' feet of Third Street. Wing walls should also be included along the right overbank to prevent the discharge of water near the pump station. Benefits from choosing this alternative include a more aesthetically pleasing design, minimal entrance loss, and more area to convey flow than in Alternative 1. Additionally, this alternative was able to sufficiently lower both the 10-year and 25-year WSELs at cross section 170 so that water does not discharge onto B Street. However, the 50-year and 100-year still discharge onto B Street in this location.

Alternative 3:

Replacing the double 6' x 4' RCB culvert with a triple 7' x 5' RCB culvert and constructing a wing wall to protect the right overbank comprise this alternative. This alternative keeps only the 10-year WSEL within the channel banks and also has the highest WSEL at the upstream culvert face of the three alternatives.

Alternative 2 is our recommended alternative for Third Street due to it having the lowest 10-year WSEL of the three alternatives at its upstream face and its ability to contain the 10-year and 25-year design storms within the channel banks at cross sections 165 and 170.

To address larger flows, such as those associated with a 50-year and 100-year storm event, an overflow spillway could be constructed in the right overbank area upstream of the pump station. Flow could then be diverted from the channel in this location, onto B Street, and then back into the channel immediately downstream of the Third Street crossing. Under this assumption, the following two alternatives presented are designed to convey the 100-year design storm:

B Street Alternatives

Alternative 1:

This alternative involves constructing a 24' x 6' CON/SPAN culvert to span approximately 260 feet under B Street. Similar to Alternative 2 listed above, this would have an aesthetically pleasing design and minimal entrance loss.

Alternative 2:

This alternative involves constructing a triple 10' x 5' RCB culvert. Due to the additional cross-sectional area of this alternative, the 100-year upstream WSEL at the culvert face is slightly lower than in Alternative 1.

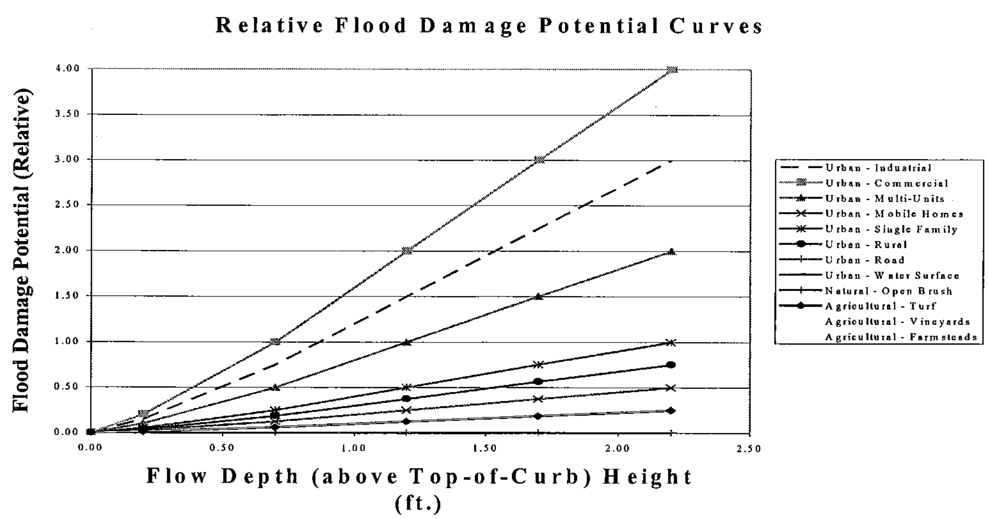
See Appendix A for a summary of the hydraulic calculations under existing conditions with the 100-, 50-, 25-, and 10-year storm frequencies. We have also included the hydraulic results for Alternative 2 at both Third Street and B Street (Appendix B). These were the two alternatives with the lowest WSELs at the upstream culvert faces.

1.4 Cost Benefit Analysis

To compare the cost of the proposed alternatives to potential flooding hazards, the Cost-to-Benefit Index (CBI) presented in the County of San Diego Flood Control Master Plan prepared by Nolte Associates, Inc. was used.

Figure 2 below is used to determine flood damage potential given a 100-year design storm. Two assumptions are inherent in the development of this curve: 1) As flood depth increases beyond some minimum depth (top-of-curb), the resulting damage increases; and 2) Flood damage in commercial areas exceeds damage in residential areas that will exceed damage in community park areas that will be twice as costly as the damage associated with the flooding of open spaces.

Figure 2: Relative Flood Damage Potential Curves



Once the recommended improvement costs have been determined to eliminate the identified defiencies, the Cost-to-Benefit Index can be calculated as follows:

$$\text{CBI (Cost-to-Benefit Index)} = \frac{\text{Flood Damage Potential}}{\text{Improvement Costs}}$$

The unit cost assumptions listed in the County of San Diego Flood Control Master Plan were used to determine the improvement costs associated with the proposed alternatives. Table 2 summarizes the unit costs pertinent to this study:

Table 2: Unit Cost Summary

Item Description	Unit Cost	Assumptions
Excavation	$20.00 / C.Y.	Excavation volume equals channel cross-section plus lining thickness (if any)
RCB	$800.00 / C.Y.	Structural concrete includes manholes, junction structures, rebar, formwork, earthwork, etc.
RCP	$4.00 / L.F./ inch of diam.	Costs include construction contigencies for manholes, junction structures, etc.
Curb inlet	$4,000.00/inlet	Average inlet cost is $4,000. No type has been specified

Using our HEC-RAS model under existing conditions, the 100-year floodplain level in B Street adjacent to Third Street is approximately 1.5 feet above the top of curb. Using this value and an urban-single family classification, from Figure 2 we have determined the Flood Damage Potential to be approximately 0.65. The total cost of the three proposed alternatives has been calculated with the estimated cost of excavation for the channel included.

The 100-year WSEL at the B Street culvert crossing is contained within the 6-inch curb. Thus, we don't have a CBI value for the alternatives at this location. Consequently, the alternatives at the B Street culvert crossing should be compared on cost. Included in the table below are the improvement costs for all the proposed alternatives and the CBI value at the Third Street culvert crossing.

Table 3: Improvement Cost Summary

	Alternative	Volume (C.Y.)	Unit Cost	Total Imp. Cost ($)	RFDP	CBI
Third St.	Channel Grading	2200	20	44,000	0.65	
	1	150	800	164,000	0.65	1.00
	2	400	800	364,000	0.65	0.45
	3	350	800	324,000	0.65	0.50
B St.	1	1150	800	920,000	NA	NA
	2	1450	800	1,160,000	NA	NA

2.0 FOURTH STREET STORM DRAIN SYSTEM

During a significant storm event, runoff has historically ponded at the intersection of Fourth Street and A Street before cascading southerly down Fourth Street to Cottonwood Creek. This area has become a safety hazard due to the quantity and velocity of the water as it sheet flows down Fourth Street. One alternative that has been discussed with the City is to construct several curb inlets along Fourth Street near the intersection with Sylvia Street. This proposal would allow a significant amount of water to be captured before reaching A Street. Using our Rational Method study, we determined that the contributing flow to this point from all upstream areas for storm frequencies of 100-, 50-, 25, and 10-year are: 75 cfs, 63 cfs, 57 cfs, and 51 cfs, respectively.

Based on topography provided to us by the City, we have determined the slope of Fourth Street as it approaches Sylvia Street to be approximately 3.03%. Total inlet lengths are sized using 20 foot increments while allowing minimal bypass flow.

In evaluating the spread of water across Fourth Street as it nears the intersection with Sylvia Street, we have again assumed a 3.03% longitudinal slope. Other assumptions include using a 2% road cross slope, 18-inch gutter width, 9.4% gutter slope, and a 6-inch curb. Assuming that the total flow in the street is evenly divided on both sides, it can be seen that under all storm frequencies water spreads beyond the allowable width for safe vehicular traveling. Similarly, the WSEL is above the top-of-curb height for all storm frequencies. A summary of the inlet calculations and costs is provided in the table below.

Table 4: Curb Inlet Summary

Storm Frequency	Design Discharge (cfs)	Number of inlets (20 foot lengths)	Bypass Flow (cfs)	Cost ($)
10-Year	51	4	0.8	16,000
25-Year	57	4	1.9	16,000
50-Year	63	4	3.3	16,000
100-Year	75	5	0.8	20,000

To capture any residual bypass flow (see Table 4), inlets could be placed at the downstream intersection of Fourth Street and A Street.

When sizing the storm drain pipe required to convey 100% of the flow captured by the inlets, the average slope taken from the intersection of Fourth Street and Sylvia Street to B Street was used. This slope, determined to be approximately 4.15%, along with the assumption of using reinforced concrete pipe (RCP), resulted in a pipe diameter of 36 inches for all storm frequencies.

Using the unit cost for RCP specified in Table 2 and a length assumed to be approximately 920 feet, we have assumed a cost of $132,500 (including junction structures, manholes, etc.) for the storm drain pipe.

3.0 FEASIBILITY OF RIPARIAN AREA

The area between Highway 101 and Fourth Street has been identified as a possible location for a riparian area that would provide a number of benefits including water quality enhancement. Specifically, the areas immediately upstream and downstream of Third Street are to be considered for construction of riparian habitat, wetlands and/or sedimentation basins.

The major limitation in constructing wetland and sedimentation basins is the availability of open space. To enhance the removal of nutrients and oxygen-depleting compounds, a series of alternating bands of open water and shallow beds planted with suitable plant species should comprise the wetland. Wetland cells typically have a length to width ratio ranging from 2:1 to 10:1. Additionally, for cost efficient construction and long-term maintenance, wetland cells typically range in width from 140 to 200 feet. Downstream from Third Street, there is not enough area on either side of Cottonwood Creek to intercept flows given these dimensions, treat the water, and divert it back into the main channel. The same problem is true, albeit to a lesser degree, upstream from the Third Street culvert crossing. Treating the water and diverting the water back into the main channel would be difficult considering the small available area.

Another problem threatening the viability of constructing wetland or sedimentation basins are the difficult hydraulic conditions in the area. The channel is extremely narrow with existing side slopes that are already fairly steep. Our hydraulic analysis of the area demonstrates that the right overbank upstream from the Third Street culvert crossing floods during a 10-year design storm. This reach of the channel will require significant channel widening in order to contain flood flows and prevent it from spilling onto B Street. This channel widening will reduce the amount of available land required to construct wetland and/or sedimentation basins to an even greater degree.

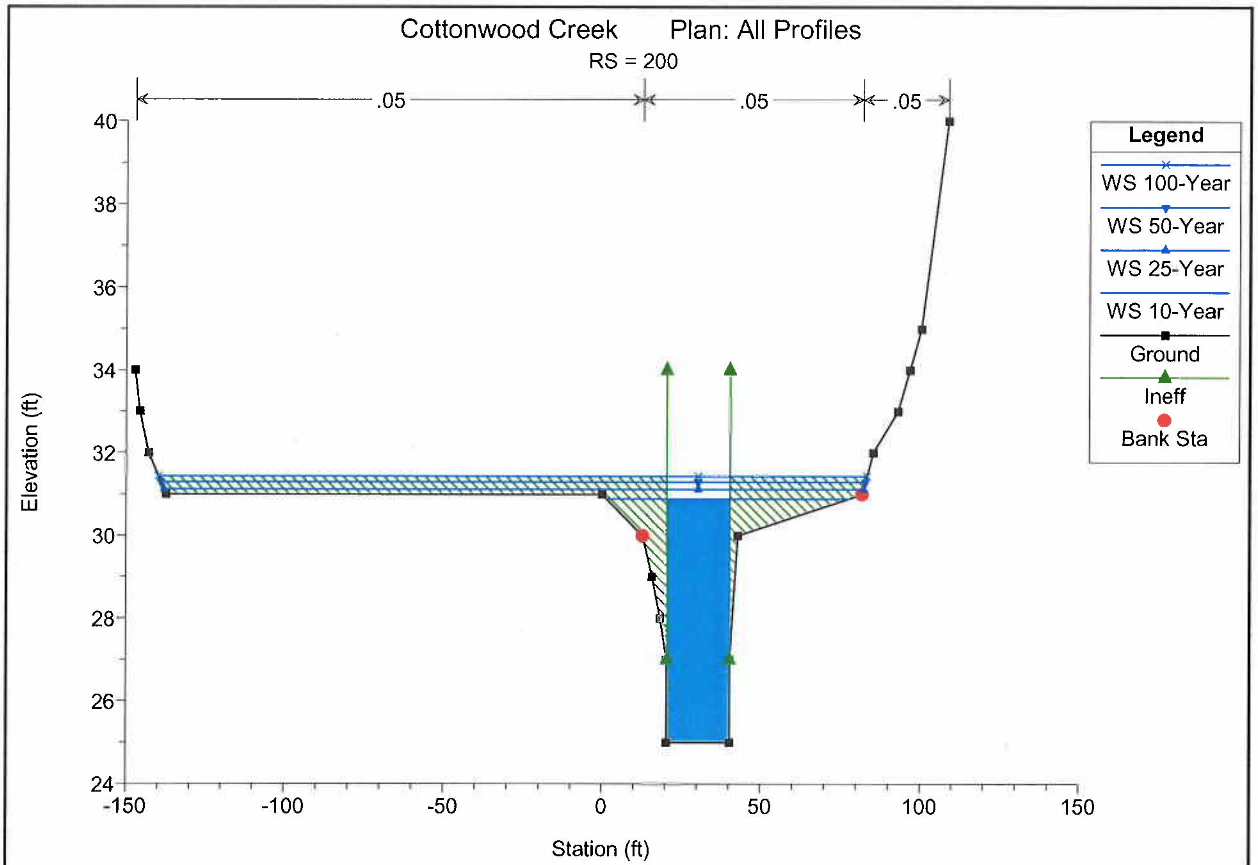
The existence of standing water and the subsequent presence of vectors near any wetland or sedimentation basin is also a deterrent for such a system given the public setting. Although mosquitoes can be controlled through strict maintenance of the wetlands and improved design features (i.e., steep sided basins with adjustable water levels), the increase in cost may mitigate the desired benefit of improved water quality.

We feel that any constructed wetlands and/or sedimentation basin would only provide a small increase in improving the water quality. The main reason for this conclusion is the upstream presence of Cottonwood Creek Park. The proposed park enhancements increase water quality primarily through settling and biological degradation. Because the majority of flow in Cottonwood Creek downstream from Highway 101 discharges from this park (see Table 1), water entering this section of the creek has already been treated. The small (relative to total) remainder of runoff that enters Cottonwood Creek downstream from Highway 101 via Second and Fourth Street combined with the limited ability for it to be adequately treated, leads us to conclude that a riparian area primarily used to improve water quality is not cost-effective. Our conclusion is based on the understanding that the long-term operation and maintenance of the riparian area will be the City's responsibility and not be privately funded.

APPENDIX A
Existing Conditions HEC-RAS output

HEC-RAS Plan: All Prof. River: Cottonwood Creek Reach: Ocean Outfall

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)	
Ocean Outfall	200	10-Year	731.00	25.00	30.89	28.46	31.49	0.005219	6.20	117.85	76.31	0.45
Ocean Outfall	200	25-Year	908.00	25.00	31.12	29.00	31.97	0.007103	7.42	122.37	220.37	0.53
Ocean Outfall	200	50-Year	1074.00	25.00	31.30	29.47	32.43	0.009027	8.53	125.95	221.99	0.60
Ocean Outfall	200	100-Year	1165.00	25.00	31.44	29.73	32.71	0.009882	9.05	128.71	223.24	0.63
Ocean Outfall	190	10-Year	731.00	24.00	29.39	29.39	30.46	0.018531	8.41	95.84	121.94	0.79
Ocean Outfall	190	25-Year	908.00	24.00	29.89	29.89	30.91	0.015853	8.49	127.55	145.50	0.75
Ocean Outfall	190	50-Year	1074.00	24.00	30.25	30.25	31.24	0.014412	8.58	153.68	181.46	0.73
Ocean Outfall	190	100-Year	1165.00	24.00	30.37	30.37	31.40	0.014625	8.81	162.94	188.06	0.73
Ocean Outfall	180	10-Year	731.00	21.00	25.70	25.70	26.59	0.016249	7.92	108.25	63.01	0.77
Ocean Outfall	180	25-Year	908.00	21.00	26.01	26.01	26.99	0.016485	8.47	128.11	64.45	0.79
Ocean Outfall	180	50-Year	1074.00	21.00	26.27	26.27	27.33	0.016638	8.92	145.12	65.72	0.80
Ocean Outfall	180	100-Year	1165.00	21.00	26.39	26.39	27.50	0.016907	9.19	153.28	66.32	0.81
Ocean Outfall	170	10-Year	731.00	19.00	23.17		23.36	0.009194	3.80	218.60	192.84	0.54
Ocean Outfall	170	25-Year	908.00	19.00	23.37		23.58	0.008660	4.00	258.63	205.26	0.53
Ocean Outfall	170	50-Year	1074.00	19.00	23.55		23.78	0.008240	4.16	295.53	216.07	0.53
Ocean Outfall	170	100-Year	1165.00	19.00	23.65		23.88	0.007881	4.21	317.69	222.31	0.52
Ocean Outfall	165	10-Year	731.00	19.00	21.45	21.45	22.11	0.020558	5.17	115.49	92.05	0.78
Ocean Outfall	165	25-Year	908.00	19.00	21.69	21.69	22.41	0.018833	5.27	138.04	97.98	0.76
Ocean Outfall	165	50-Year	1074.00	19.00	21.88	21.88	22.66	0.018102	5.42	157.37	102.79	0.75
Ocean Outfall	165	100-Year	1165.00	19.00	21.98	21.98	22.79	0.017926	5.52	167.25	105.17	0.75
Ocean Outfall	160	10-Year	731.00	16.15	20.38	20.18	20.80	0.012367	6.32	157.43	102.93	0.60
Ocean Outfall	160	25-Year	908.00	16.15	20.71	20.38	21.11	0.011274	6.14	193.23	109.67	0.58
Ocean Outfall	160	50-Year	1074.00	16.15	20.94	20.53	21.36	0.011361	6.24	218.65	114.21	0.59
Ocean Outfall	160	100-Year	1165.00	16.15	20.97	20.61	21.44	0.012915	6.66	221.49	114.70	0.62
Ocean Outfall	155		Culvert									
Ocean Outfall	150	10-Year	731.00	14.04	18.76	18.76	19.34	0.004819	6.82	145.00	115.76	0.66
Ocean Outfall	150	25-Year	908.00	14.04	18.91	18.91	19.61	0.005853	7.60	162.85	120.25	0.73
Ocean Outfall	150	50-Year	1074.00	14.04	19.18	19.18	19.83	0.005350	7.56	198.36	137.01	0.70
Ocean Outfall	150	100-Year	1165.00	14.04	19.25	19.25	19.94	0.005531	7.80	208.55	137.94	0.72
Ocean Outfall	140	10-Year	731.00	13.00	16.56	16.56	17.31	0.012497	7.50	121.94	78.97	0.84
Ocean Outfall	140	25-Year	908.00	13.00	16.82	16.82	17.66	0.012604	8.05	142.30	79.60	0.86
Ocean Outfall	140	50-Year	1074.00	13.00	16.85	16.85	17.98	0.016783	9.36	144.83	79.68	0.99
Ocean Outfall	140	100-Year	1165.00	13.00	17.20	17.20	18.14	0.012320	8.68	173.83	87.65	0.87
Ocean Outfall	130	10-Year	767.00	7.40	12.71	10.21	13.11	0.003059	5.06	151.44	28.50	0.39
Ocean Outfall	130	25-Year	956.00	7.40	13.54	10.66	14.01	0.003095	5.46	175.13	28.50	0.39
Ocean Outfall	130	50-Year	1135.00	7.40	13.94	11.05	14.52	0.003605	6.07	190.60	57.62	0.42
Ocean Outfall	130	100-Year	1255.00	7.40	14.18	11.31	14.82	0.003873	6.44	204.62	63.44	0.44
Ocean Outfall	125		Culvert									
Ocean Outfall	120	10-Year	767.00	3.50	6.31	6.31	7.73	0.008300	9.57	80.16	28.50	1.01
Ocean Outfall	120	25-Year	956.00	3.50	6.76	6.76	8.40	0.008159	10.29	92.91	28.50	1.00
Ocean Outfall	120	50-Year	1135.00	3.50	7.16	7.16	9.00	0.008092	10.90	104.17	28.50	1.00
Ocean Outfall	120	100-Year	1255.00	3.50	7.41	7.41	9.38	0.008077	11.27	111.33	28.50	1.01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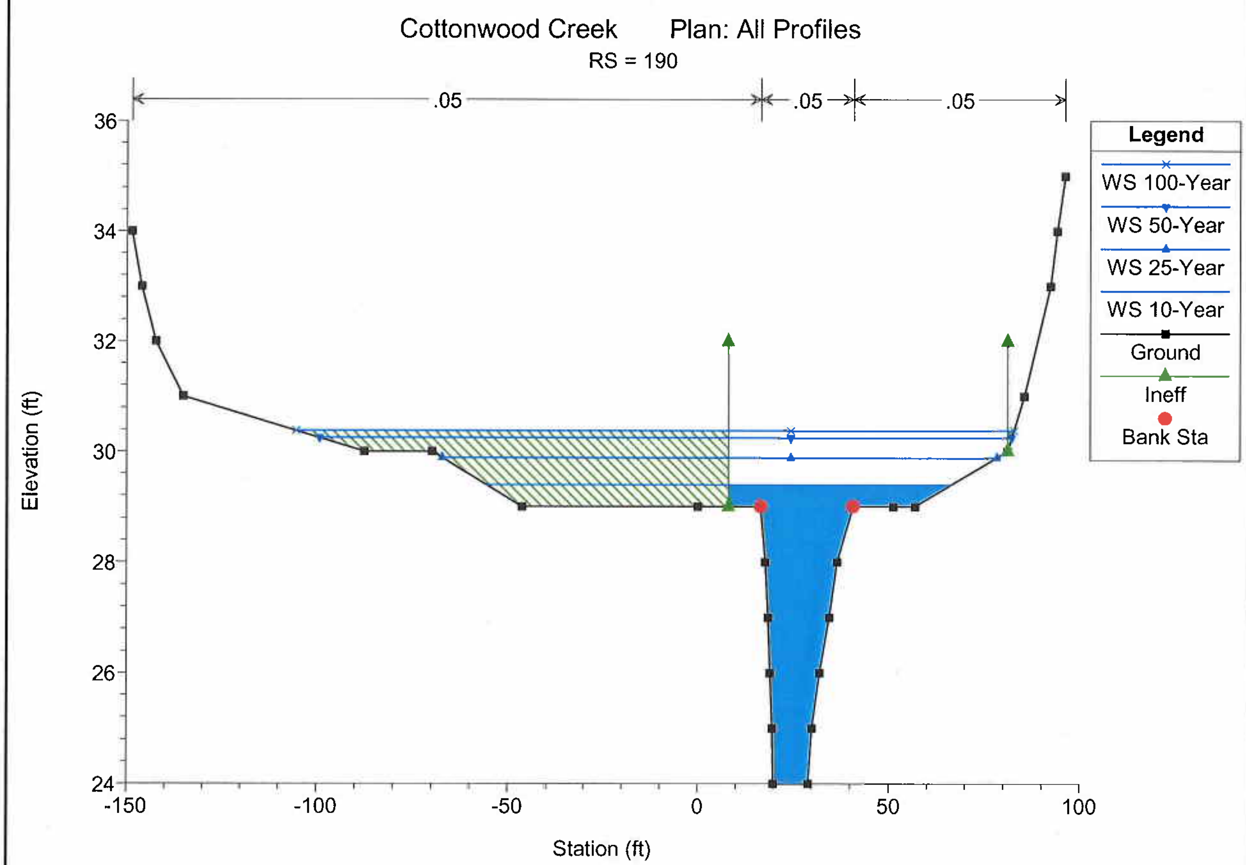
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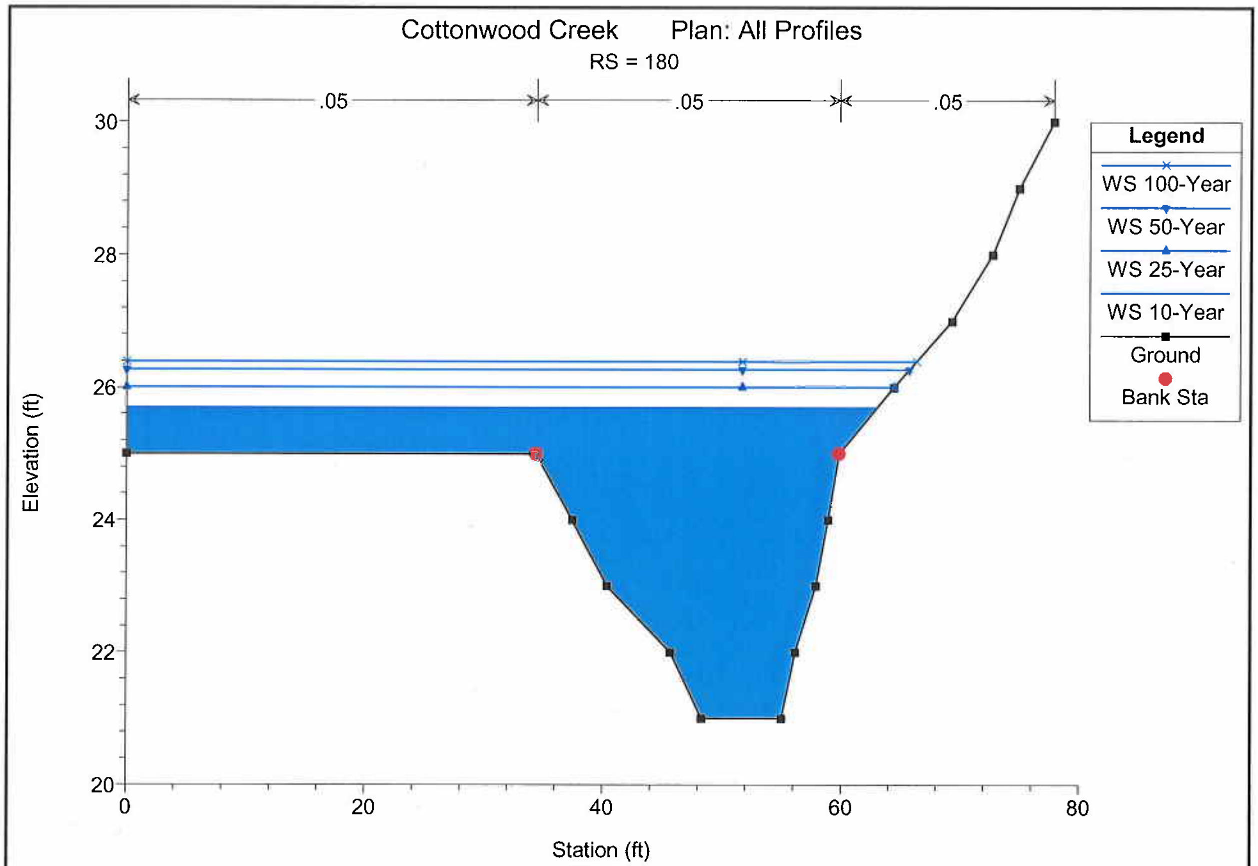

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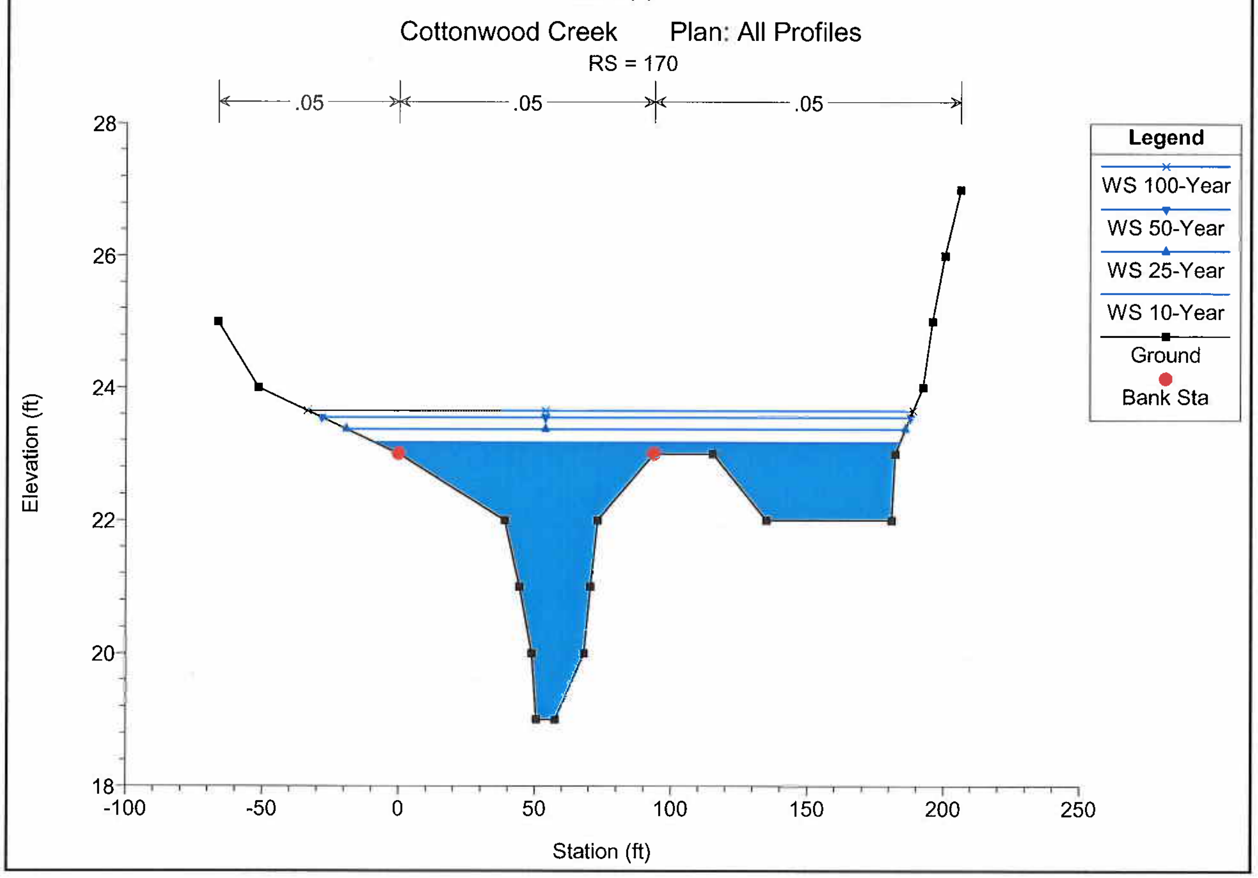

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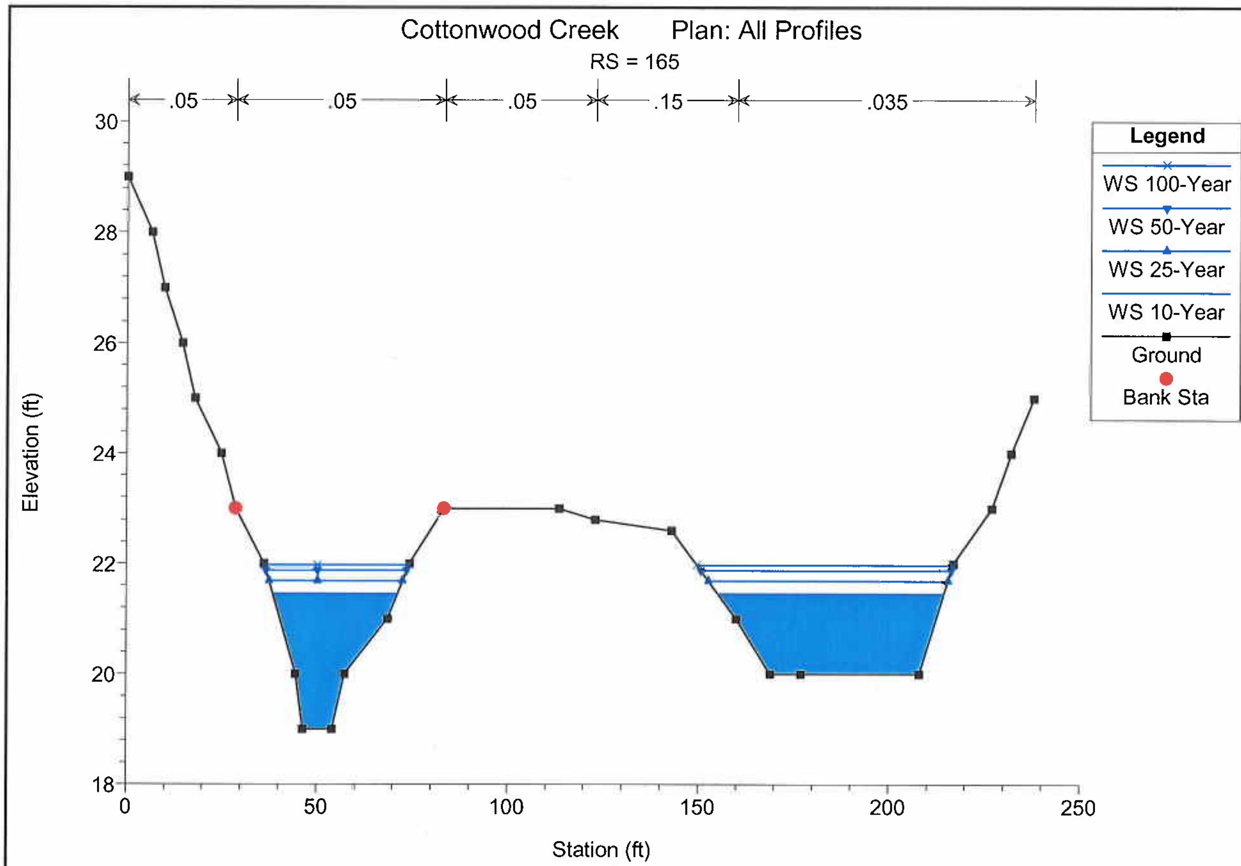
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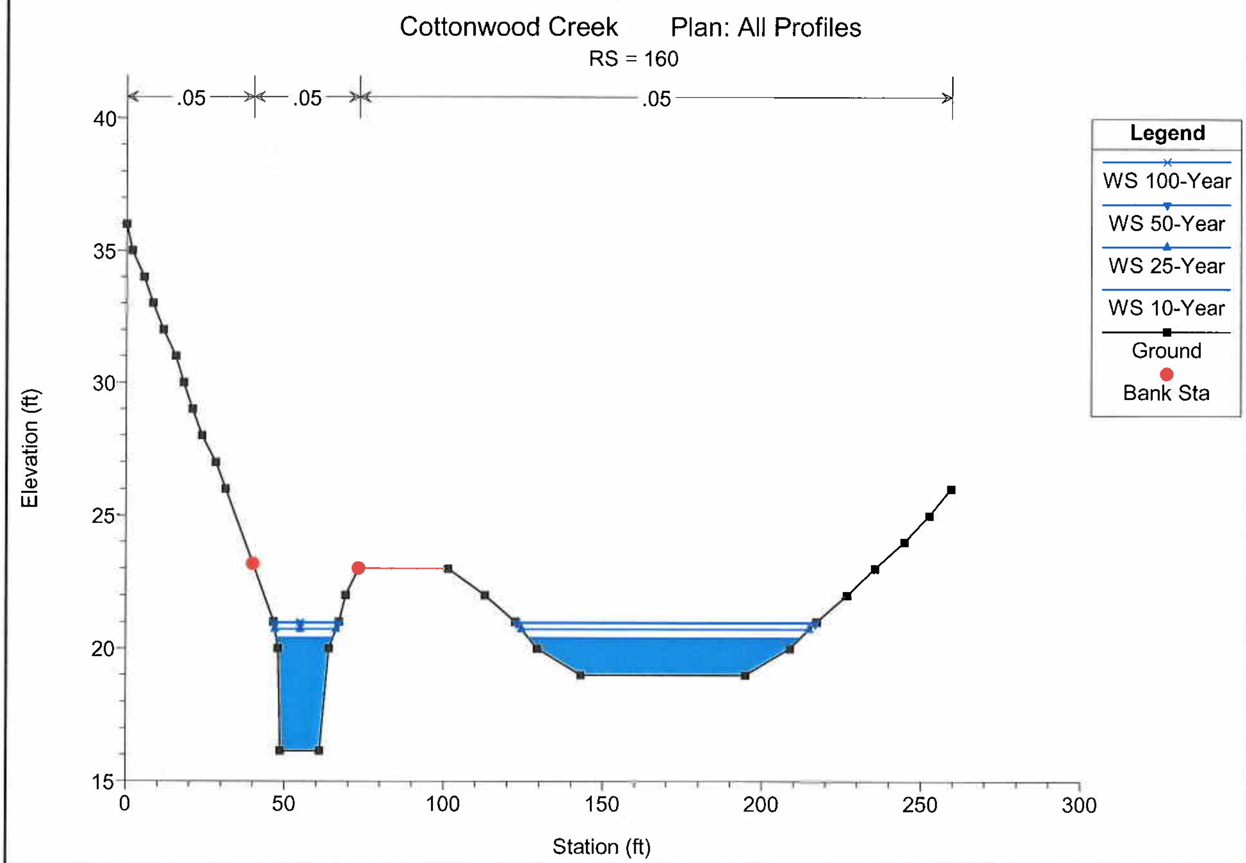
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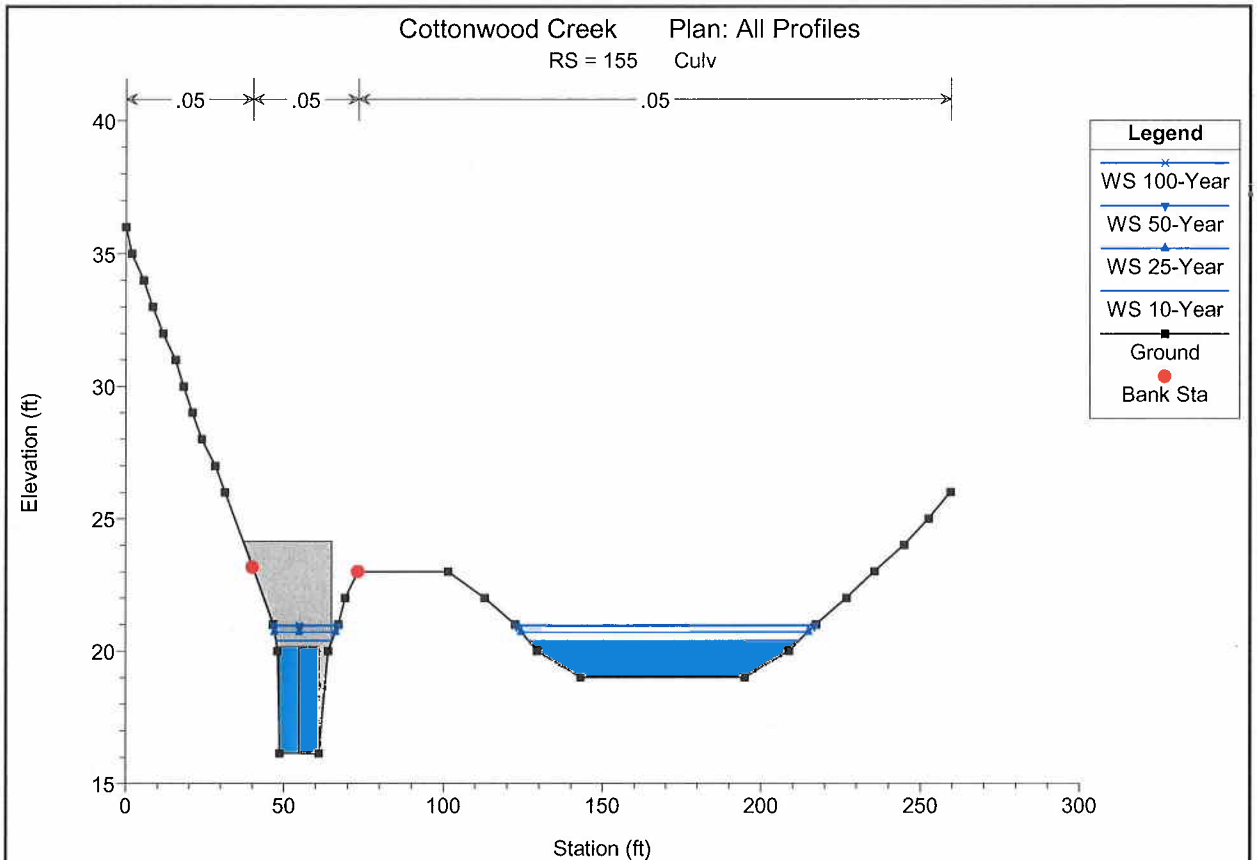
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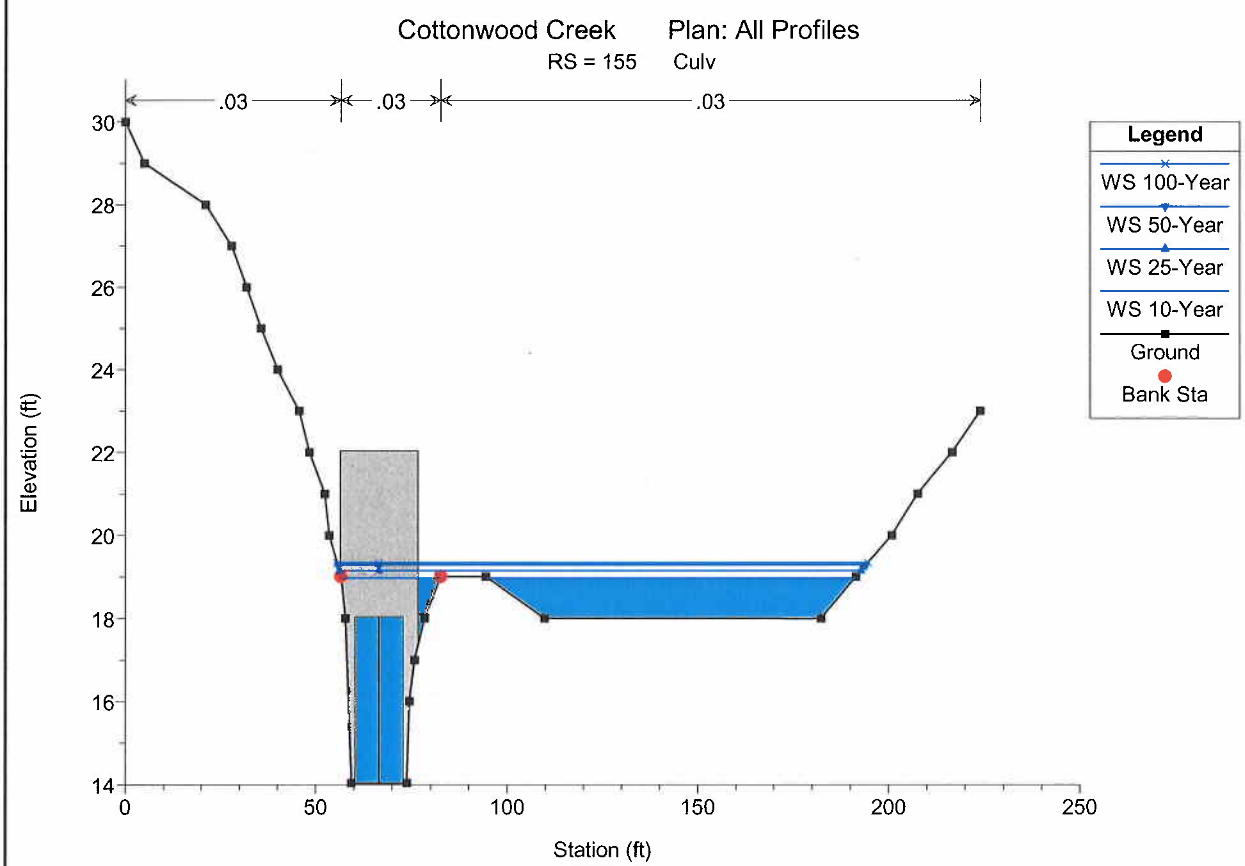
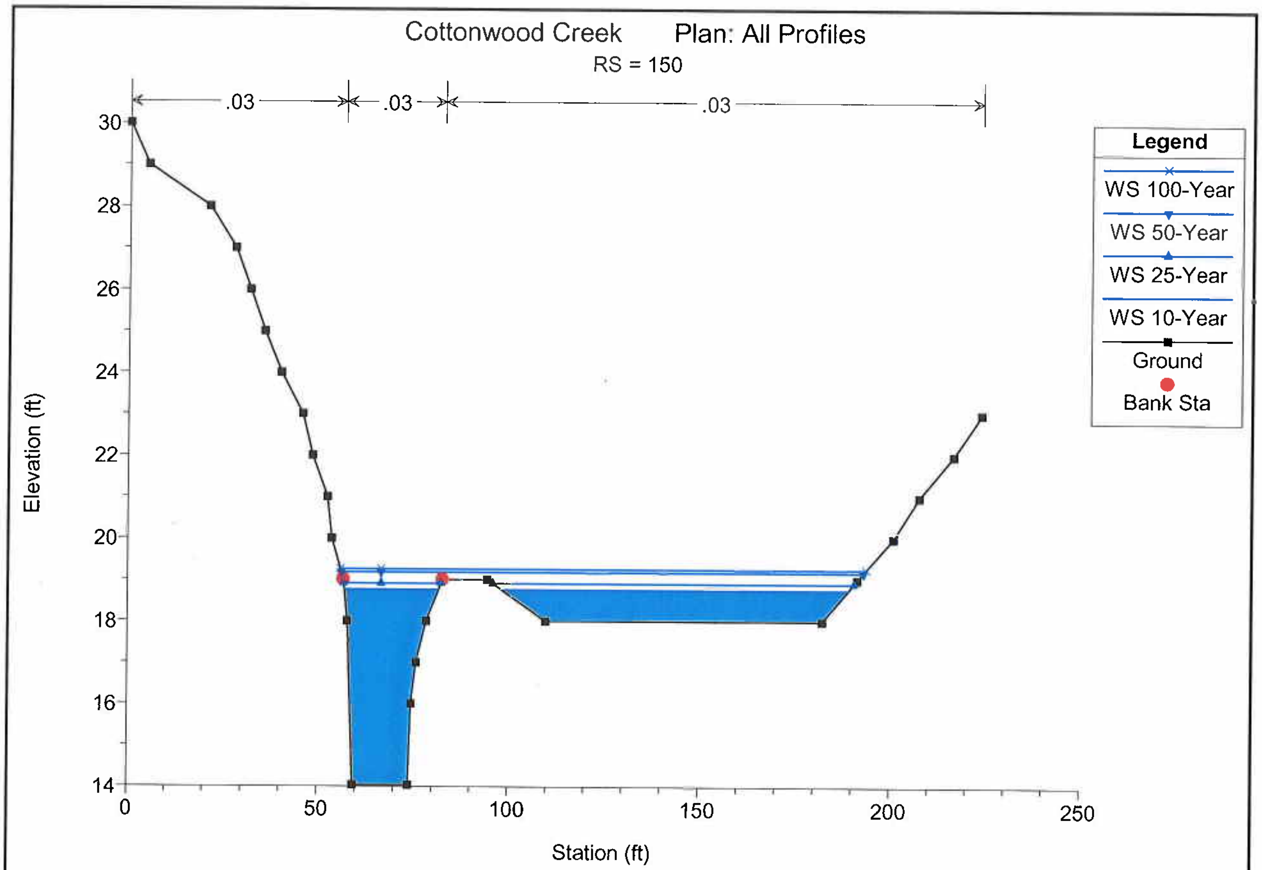

Cottonwood Creek Plan: All Profiles
RS = 155 Culv
.03
.03
.03
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
30
28
26
24
22
20
18
16
14
0
50
100
150
200
250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Elevation (ft)
Station (ft)
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18
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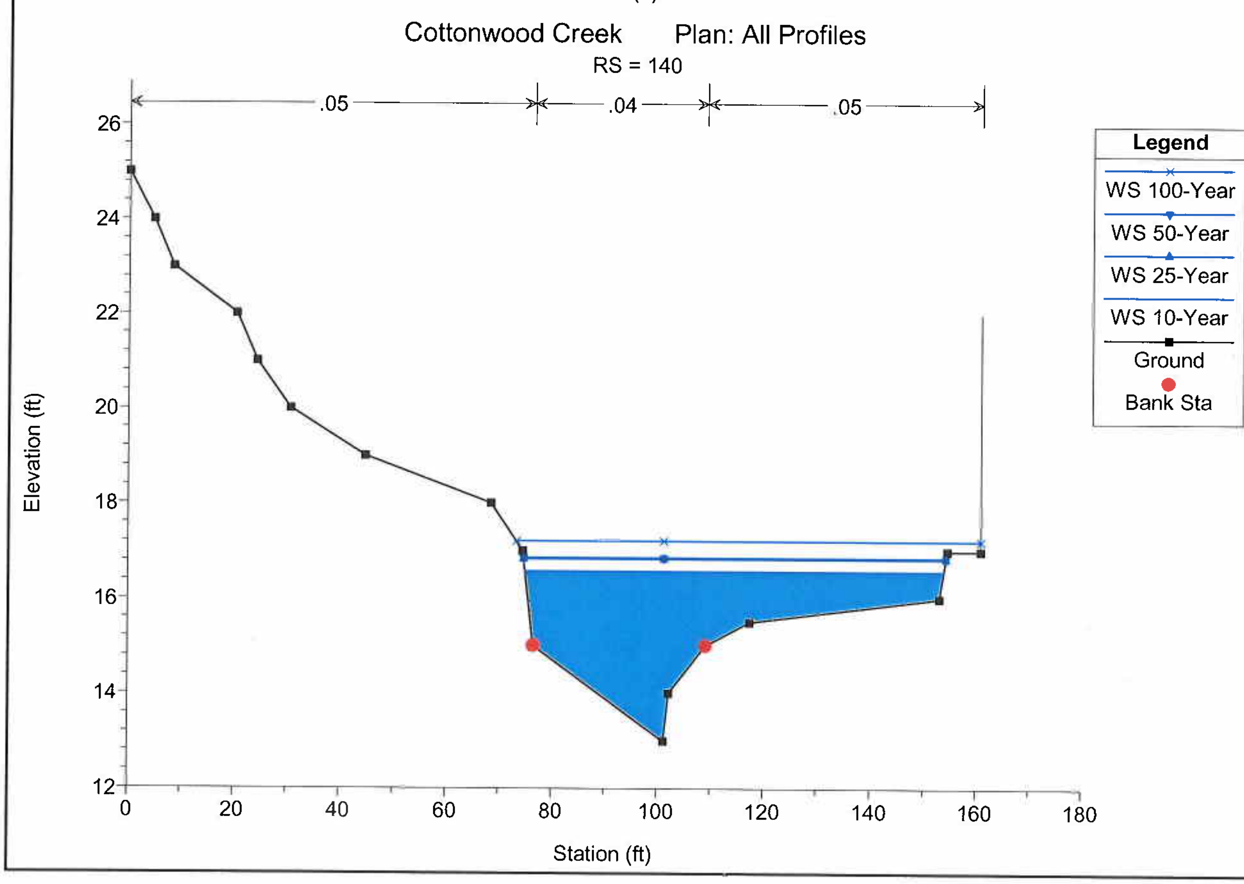
0
50
100
150
200
250
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta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Elevation (ft)
Station (ft)
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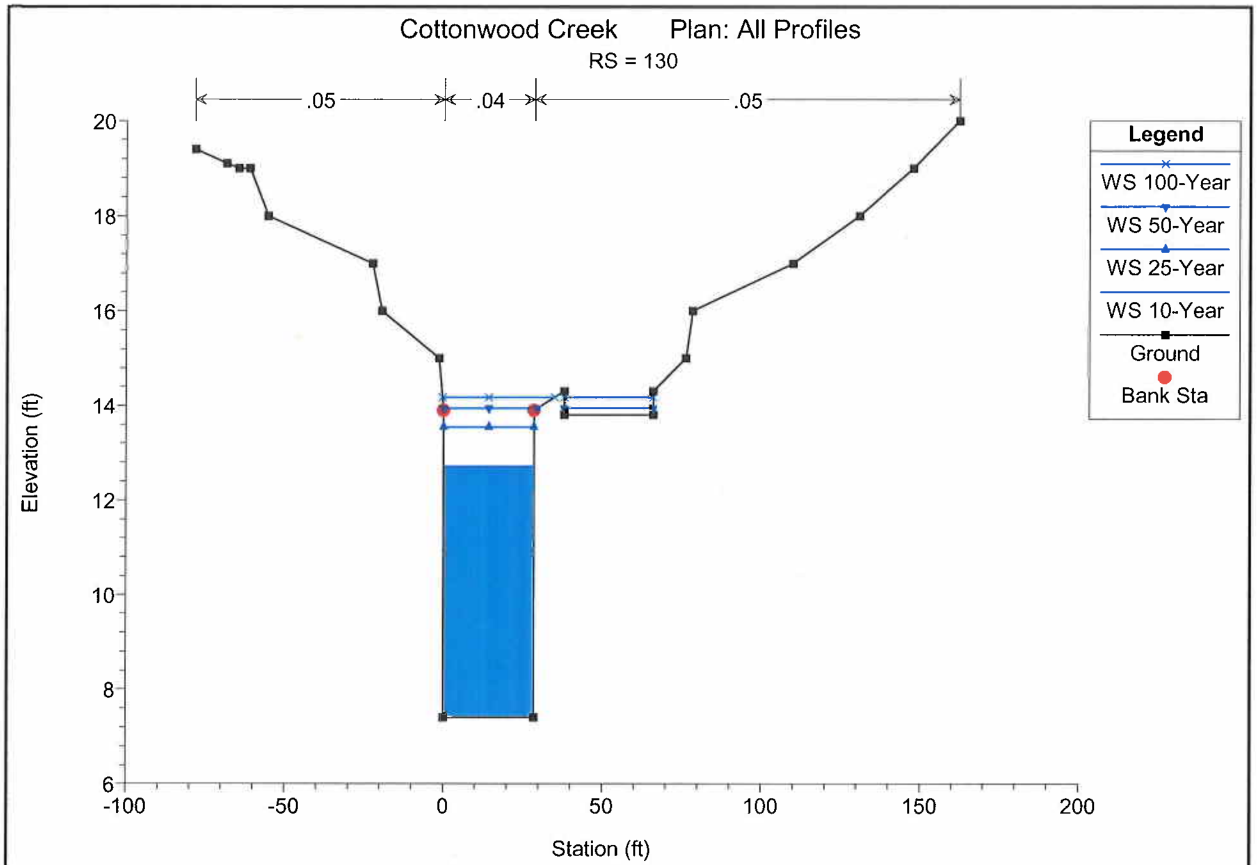
14
12
0
20
40
60
80
100
120
140
160
180
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta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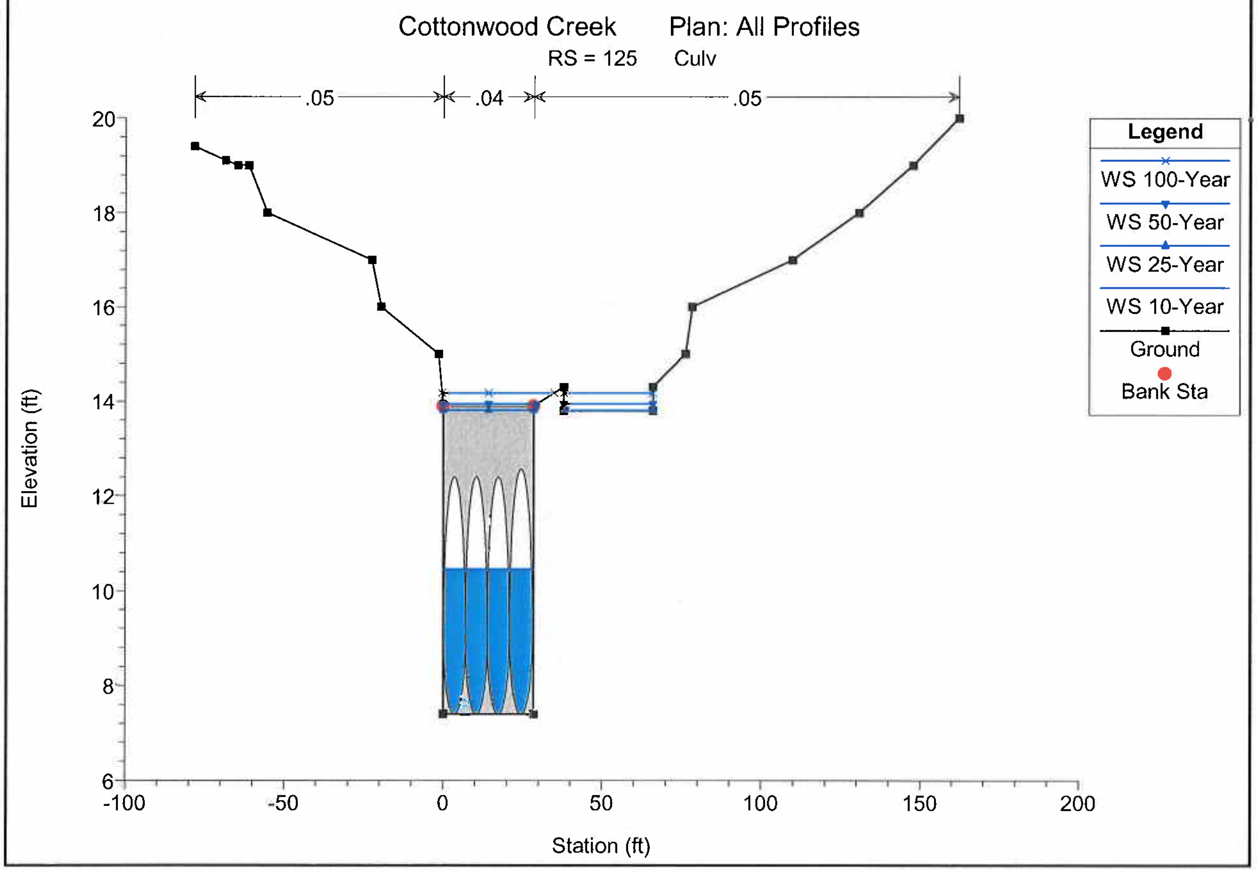
Elevation (ft)
Station (ft)
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta


Cottonwood Creek Plan: All Profiles
RS = 125 Culv
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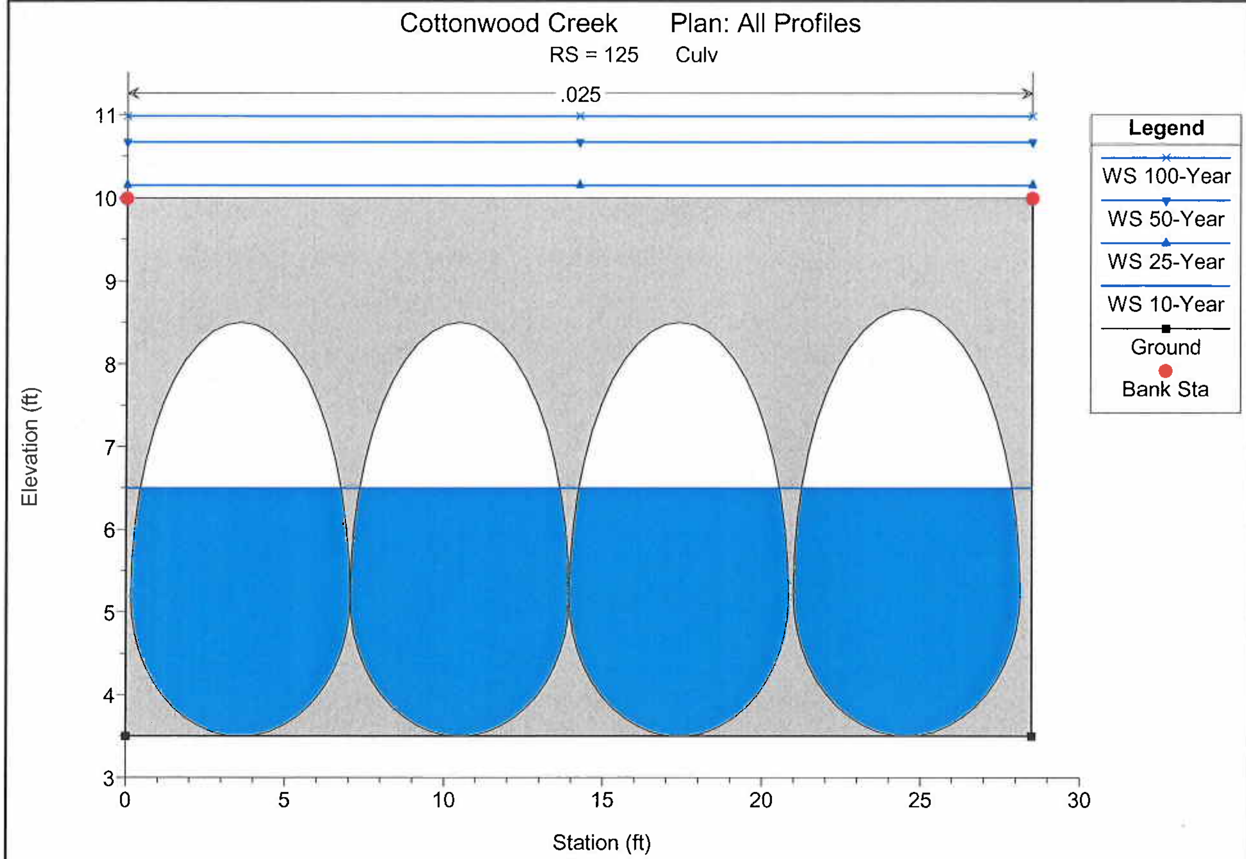
.04
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta



Cottonwood Creek Plan: All Profiles
RS = 125 Culv
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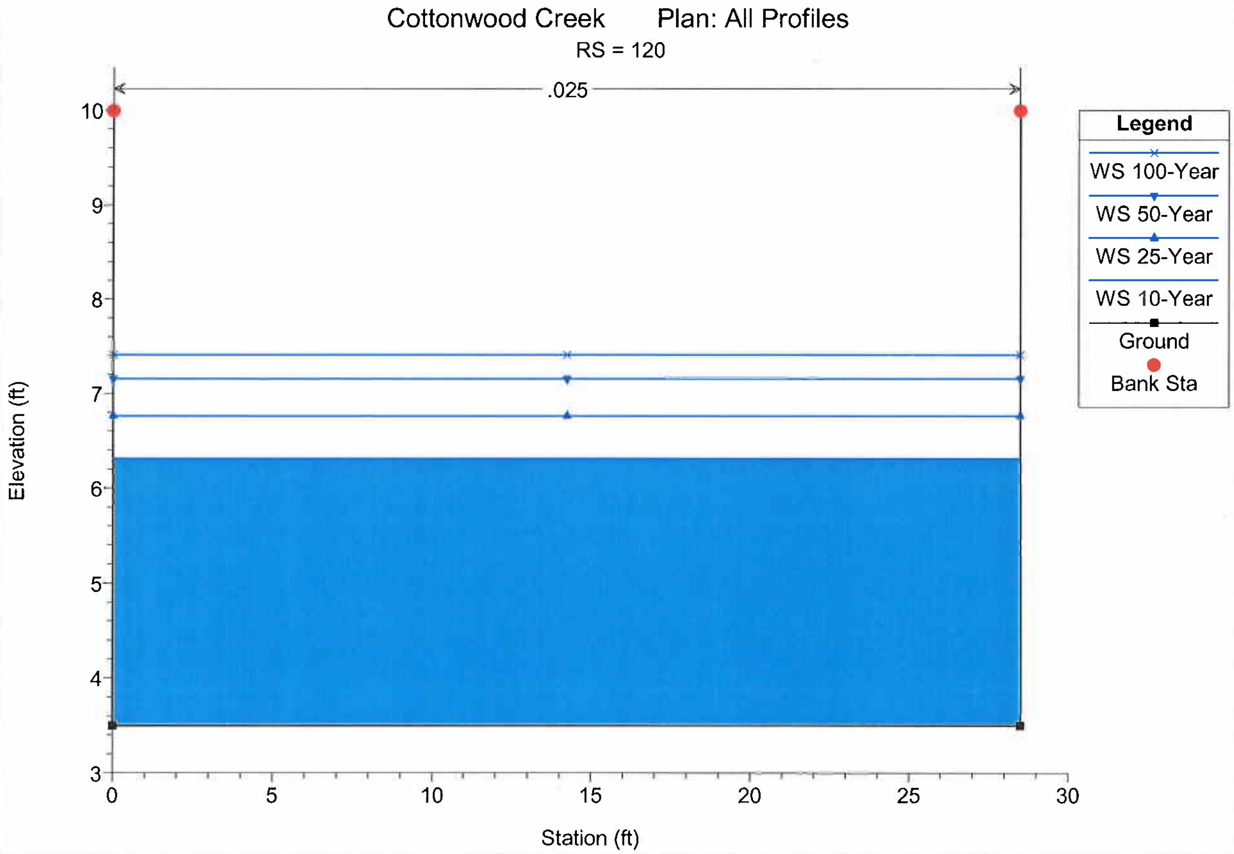
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

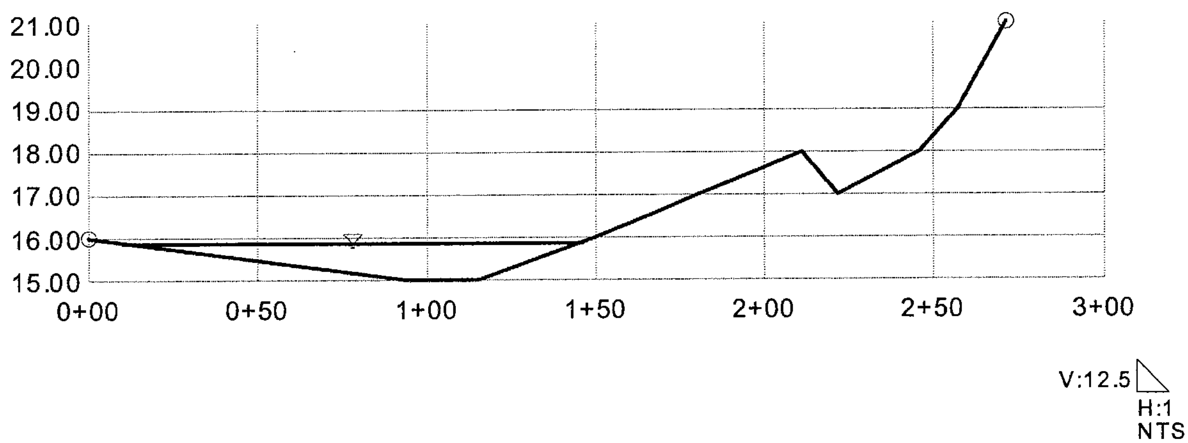


Cottonwood Creek Plan: All Profiles
RS = 120
.025
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

Cross Section 110
Cross Section for Irregular Channel

Project Description	
Worksheet	Irregular Channel
Flow Element	Irregular Channel
Method	Manning's Formul
Solve For	Channel Depth

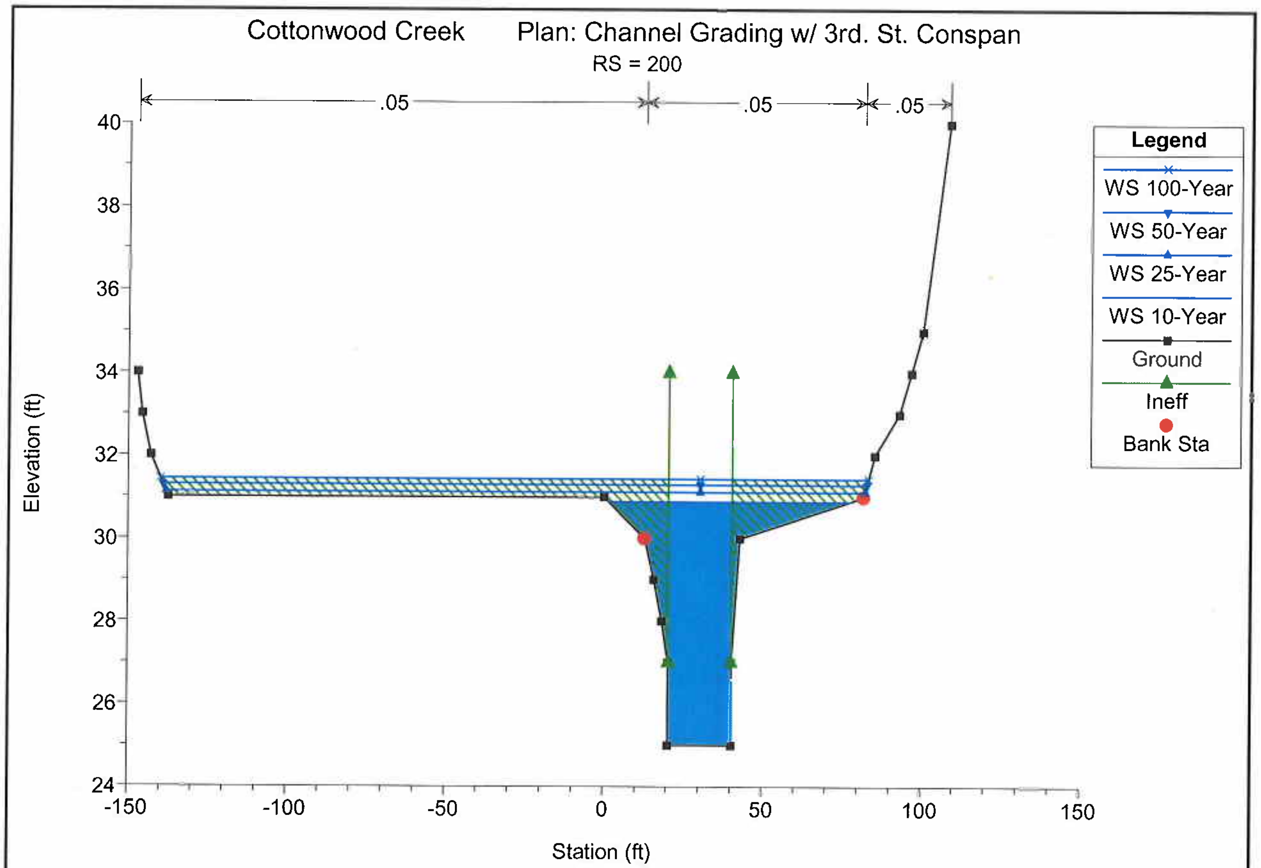
Section Data		
Mannings Coefficiei	0.035	
Slope	0.015000	ft/ft
Water Surface Elev	15.89	ft
Elevation Range	;.00 to 21.00	
Discharge	232.00	cfs

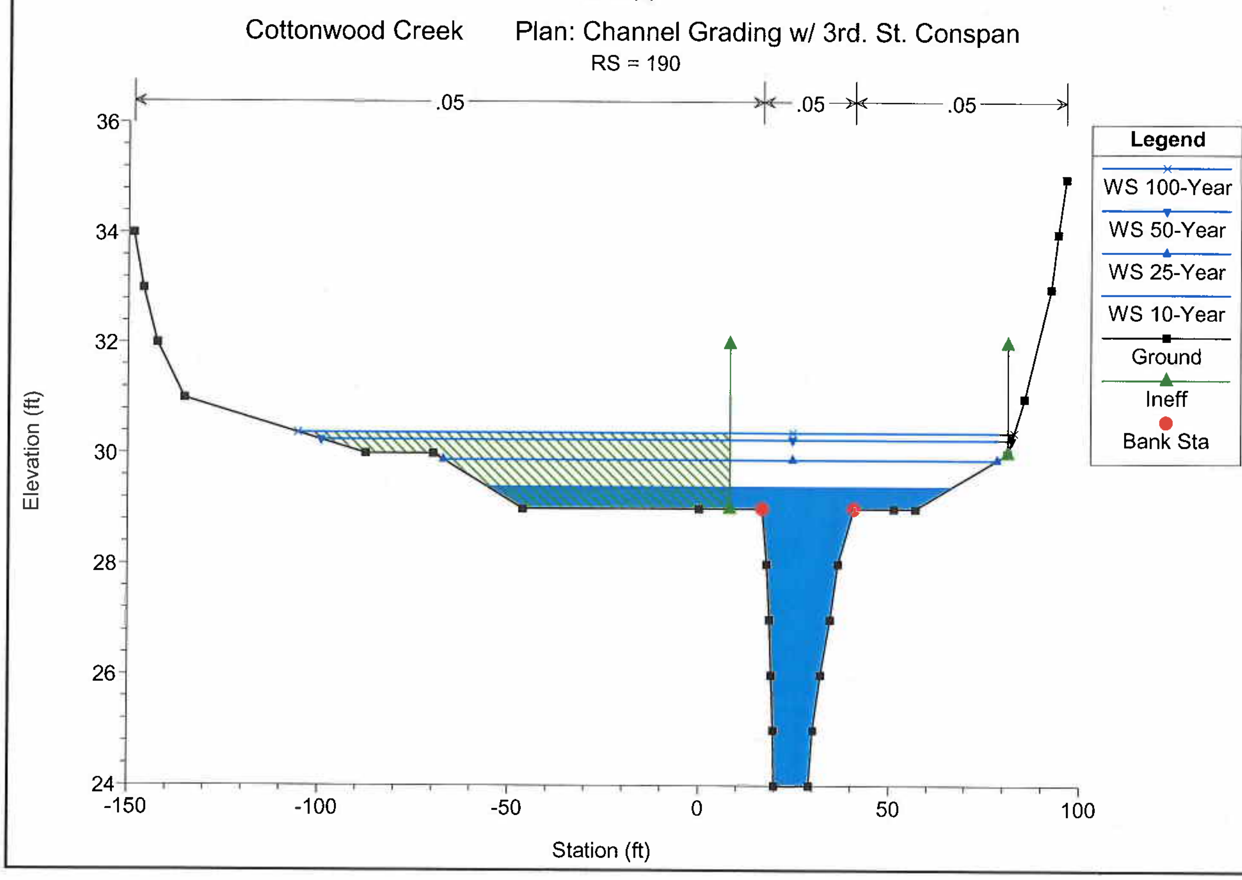


<u>APPENDIX B</u>
Third Street and B Street Recommended Alternatives

HEC-RAS Plan: Channel Grad River: Cottonwood Creek Reach: Ocean Outfall

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)	
Ocean Outfall	200	10-Year	731.00	25.00	30.89	28.46	31.49	0.005219	6.20	117.85	76.31	0.45
Ocean Outfall	200	25-Year	908.00	25.00	31.12	29.00	31.97	0.007103	7.42	122.37	220.37	0.53
Ocean Outfall	200	50-Year	1074.00	25.00	31.30	29.47	32.43	0.009027	8.53	125.95	221.99	0.60
Ocean Outfall	200	100-Year	1165.00	25.00	31.44	29.73	32.71	0.009882	9.05	128.71	223.24	0.63
Ocean Outfall	190	10-Year	731.00	24.00	29.39	29.39	30.46	0.018531	8.41	95.84	121.94	0.79
Ocean Outfall	190	25-Year	908.00	24.00	29.89	29.89	30.91	0.015853	8.49	127.55	145.50	0.75
Ocean Outfall	190	50-Year	1074.00	24.00	30.25	30.25	31.24	0.014412	8.58	153.68	181.46	0.73
Ocean Outfall	190	100-Year	1165.00	24.00	30.37	30.37	31.40	0.014625	8.81	162.94	188.06	0.73
Ocean Outfall	180	10-Year	731.00	21.00	25.67	25.67	26.59	0.016760	8.00	106.86	62.91	0.78
Ocean Outfall	180	25-Year	908.00	21.00	26.01	26.01	26.99	0.016428	8.46	128.28	64.46	0.79
Ocean Outfall	180	50-Year	1074.00	21.00	26.27	26.27	27.33	0.016649	8.92	145.09	65.72	0.80
Ocean Outfall	180	100-Year	1165.00	21.00	26.40	26.40	27.50	0.016775	9.16	153.73	66.35	0.81
Ocean Outfall	170	10-Year	731.00	19.00	22.46	20.10	22.50	0.000736	1.71	426.64	136.88	0.17
Ocean Outfall	170	25-Year	908.00	19.00	22.94	20.27	22.99	0.000727	1.84	493.25	140.61	0.17
Ocean Outfall	170	50-Year	1074.00	19.00	23.35	20.41	23.40	0.000631	1.83	639.86	234.57	0.16
Ocean Outfall	170	100-Year	1165.00	19.00	23.24	20.49	23.30	0.000828	2.06	613.92	232.96	0.19
Ocean Outfall	165	10-Year	731.00	19.00	21.15	21.15	22.17	0.030617	8.13	89.96	43.83	1.00
Ocean Outfall	165	25-Year	908.00	19.00	21.47	21.47	22.65	0.029694	8.71	104.22	44.41	1.00
Ocean Outfall	165	50-Year	1074.00	19.00	22.08	21.76	23.11	0.020353	8.16	131.57	46.08	0.85
Ocean Outfall	165	100-Year	1165.00	19.00	23.01	21.91	23.17	0.002376	3.05	370.45	198.41	0.30
Ocean Outfall	160	10-Year	731.00	16.15	20.43	19.15	21.11	0.010608	6.62	110.42	28.73	0.60
Ocean Outfall	160	25-Year	908.00	16.15	21.22	19.61	21.92	0.009667	6.76	134.36	31.71	0.58
Ocean Outfall	160	50-Year	1074.00	16.15	21.97	20.01	22.68	0.008426	6.76	158.96	33.64	0.55
Ocean Outfall	160	100-Year	1165.00	16.15	22.26	20.26	23.00	0.008496	6.90	168.82	34.85	0.55
Ocean Outfall	155		Culvert									
Ocean Outfall	150	10-Year	731.00	14.04	17.57	17.01	18.54	0.006545	7.87	92.93	29.22	0.78
Ocean Outfall	150	25-Year	908.00	14.04	17.91	17.48	19.12	0.007578	8.83	102.82	30.19	0.84
Ocean Outfall	150	50-Year	1074.00	14.04	18.66	18.66	19.43	0.004744	7.46	179.77	122.50	0.68
Ocean Outfall	150	100-Year	1165.00	14.04	18.77	18.77	19.56	0.004878	7.63	193.28	125.72	0.69
Ocean Outfall	140	10-Year	731.00	13.00	16.08	16.08	16.94	0.011772	7.60	110.63	78.22	0.81
Ocean Outfall	140	25-Year	908.00	13.00	16.40	16.40	17.32	0.011362	8.04	135.63	78.86	0.81
Ocean Outfall	140	50-Year	1074.00	13.00	16.66	16.66	17.64	0.011095	8.40	156.58	79.38	0.81
Ocean Outfall	140	100-Year	1165.00	13.00	16.79	16.79	17.80	0.011046	8.60	166.95	79.64	0.82
Ocean Outfall	130	10-Year	767.00	7.40	12.71	10.21	13.11	0.003059	5.06	151.44	28.50	0.39
Ocean Outfall	130	25-Year	956.00	7.40	13.54	10.66	14.01	0.003095	5.46	175.13	28.50	0.39
Ocean Outfall	130	50-Year	1135.00	7.40	13.94	11.05	14.52	0.003605	6.07	190.60	57.62	0.42
Ocean Outfall	130	100-Year	1255.00	7.40	14.18	11.31	14.82	0.003873	6.44	204.62	63.44	0.44
Ocean Outfall	125		Culvert									
Ocean Outfall	120	10-Year	767.00	3.50	6.31	6.31	7.73	0.008300	9.57	80.16	28.50	1.01
Ocean Outfall	120	25-Year	956.00	3.50	6.76	6.76	8.40	0.008159	10.29	92.91	28.50	1.00
Ocean Outfall	120	50-Year	1135.00	3.50	7.16	7.16	9.00	0.008092	10.90	104.17	28.50	1.00
Ocean Outfall	120	100-Year	1255.00	3.50	7.41	7.41	9.38	0.008077	11.27	111.33	28.50	1.01


Cottonwood Creek Plan: Channel Grading w/ 3rd. St. Conspan
RS = 200
.05
.05
.05
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
40
38
36
34
32
30
28
26
24
-150
-100
-50
0
50
100
150


Cottonwood Creek Plan: Channel Grading w/ 3rd. St. Conspan
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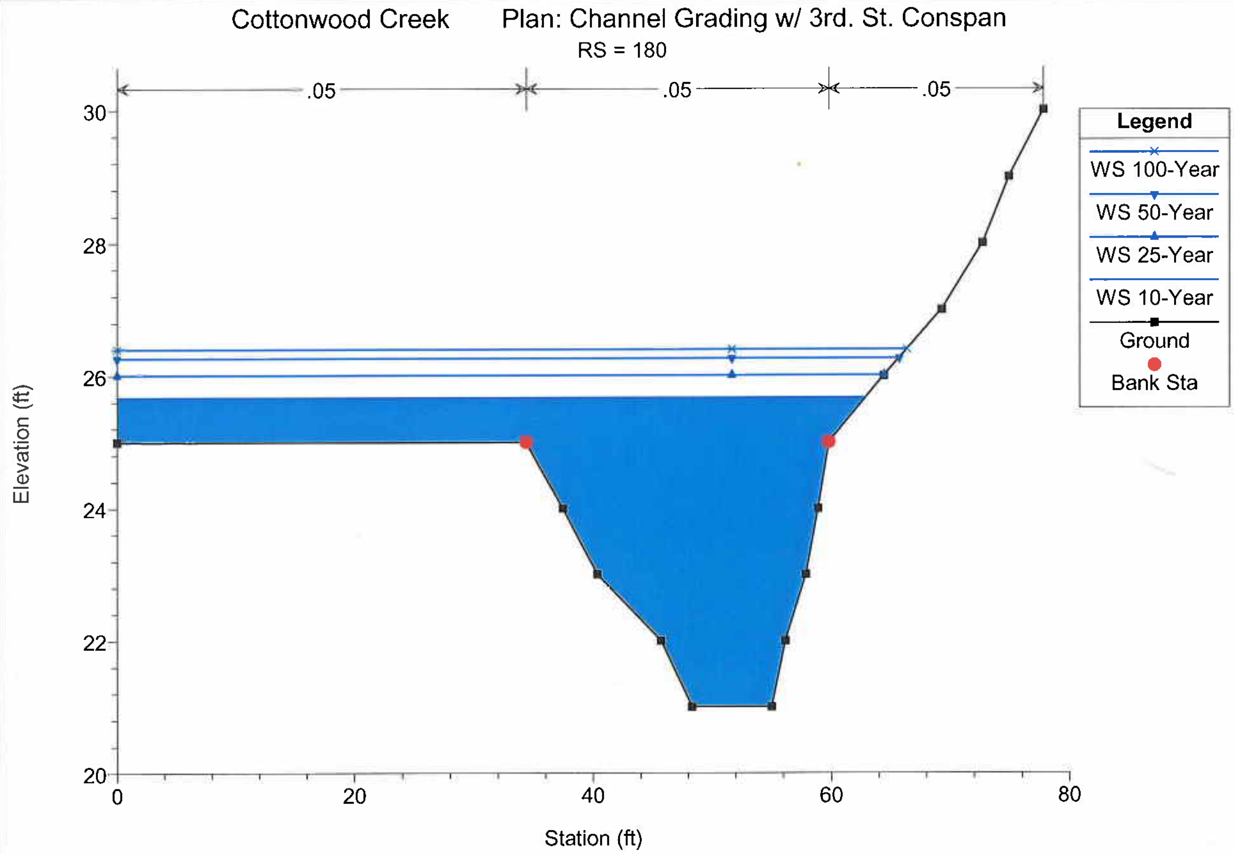
.05
.05
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
36
34
32
30
28
26
24
-150
-100
-50
0
50
100


Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
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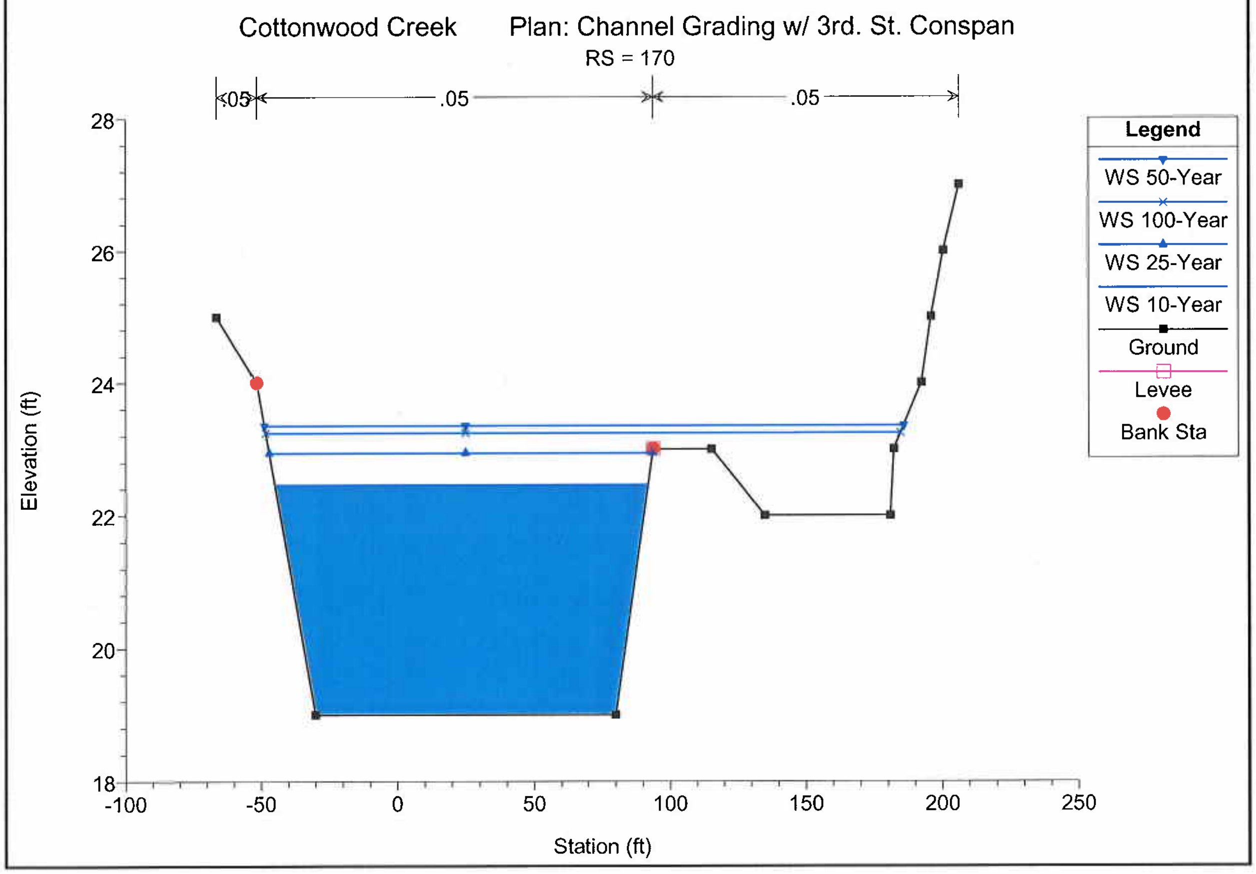
.05
.05
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
30
28
26
24
22
20
0
20
40
60
80


Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
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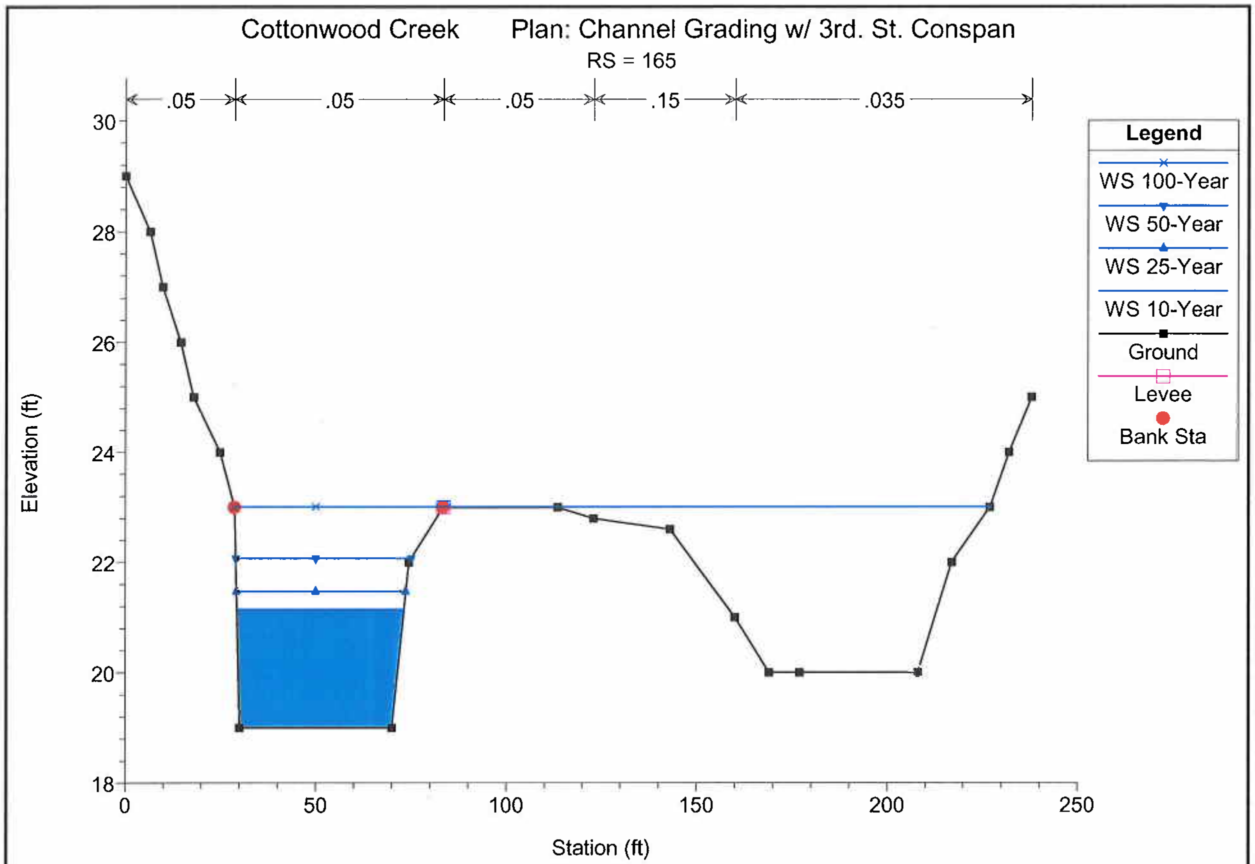
.05
Legend
WS 50-Year
WS 100-Year
WS 25-Year
WS 10-Year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
28
26
24
22
20
18
-100
-50
0
50
100
150
200
250



Cottonwood Creek Plan: Channel Grading w/ 3rd. St. Conspan
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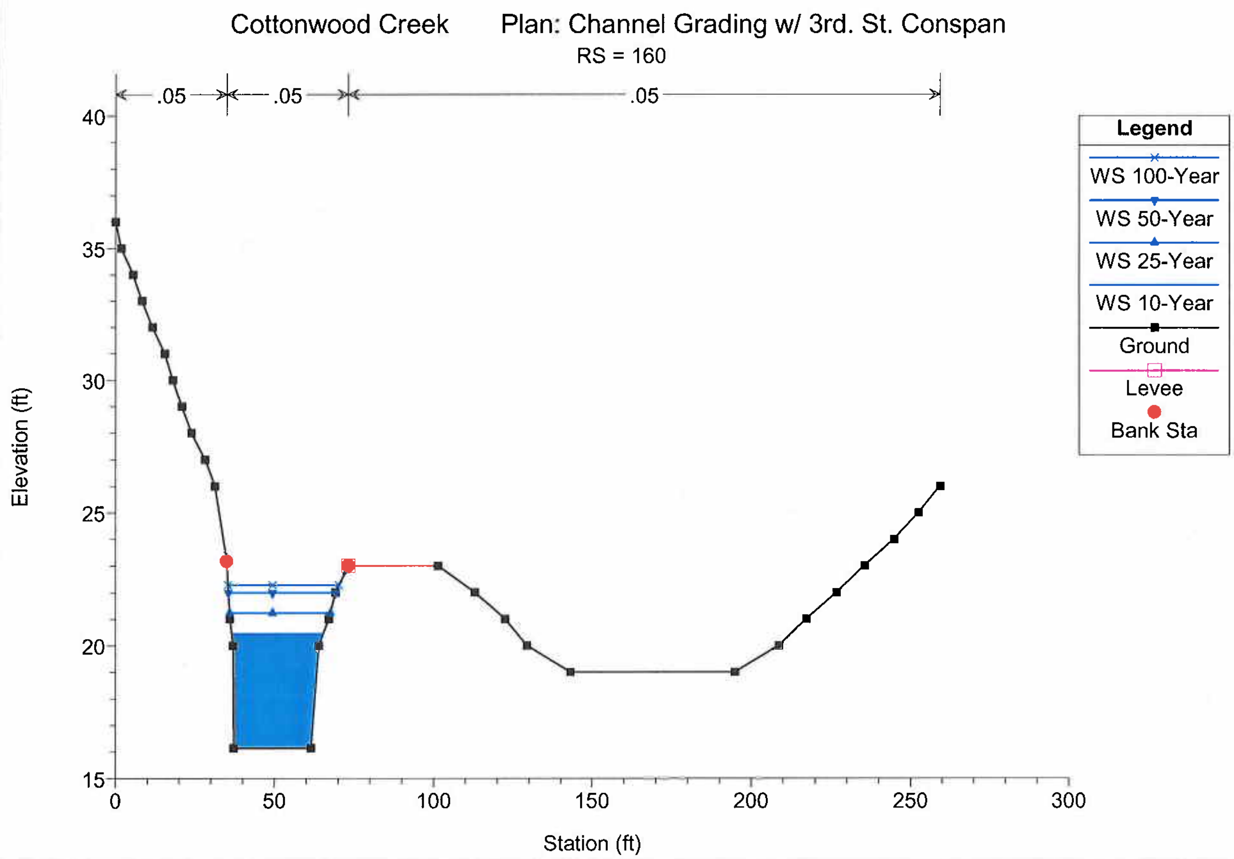
.05
.15
.035
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)



Cottonwood Creek Plan: Channel Grading w/ 3rd. St. Conspan
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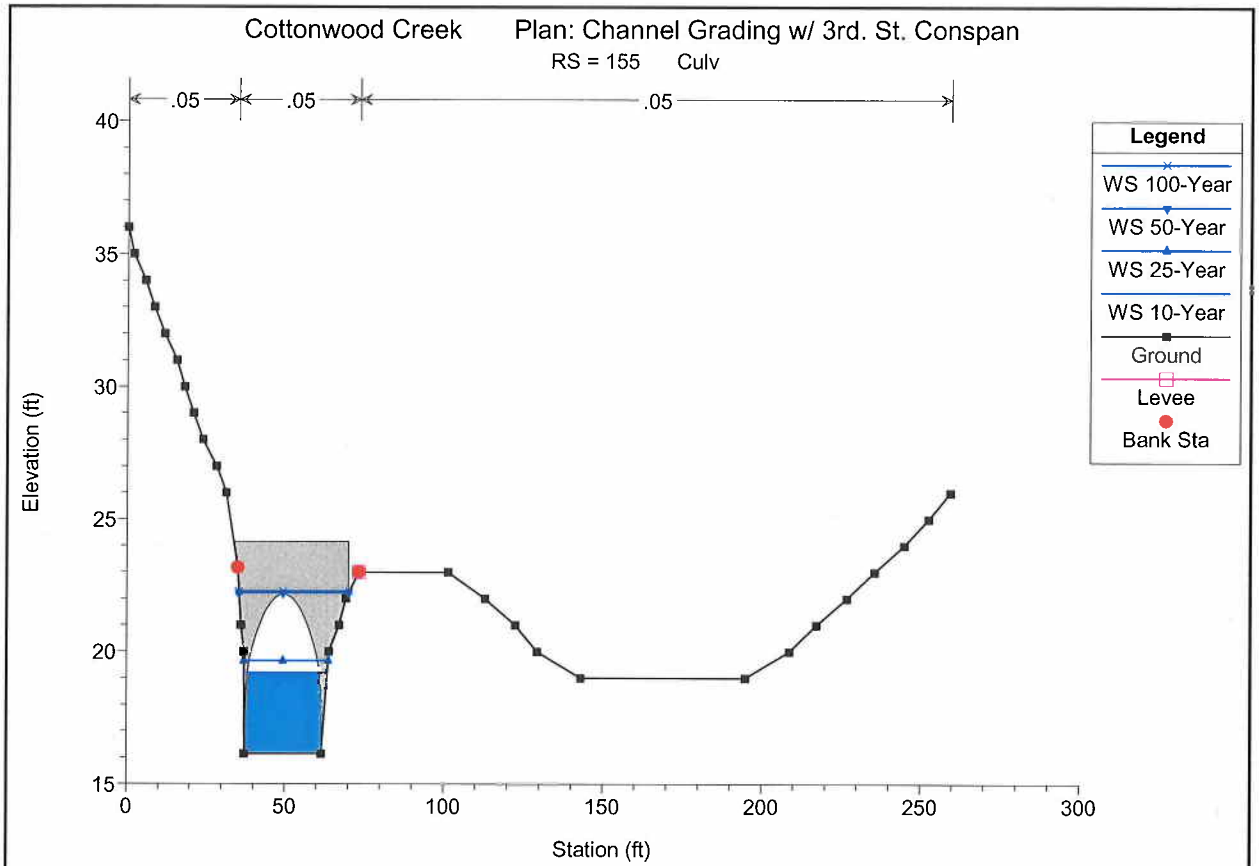
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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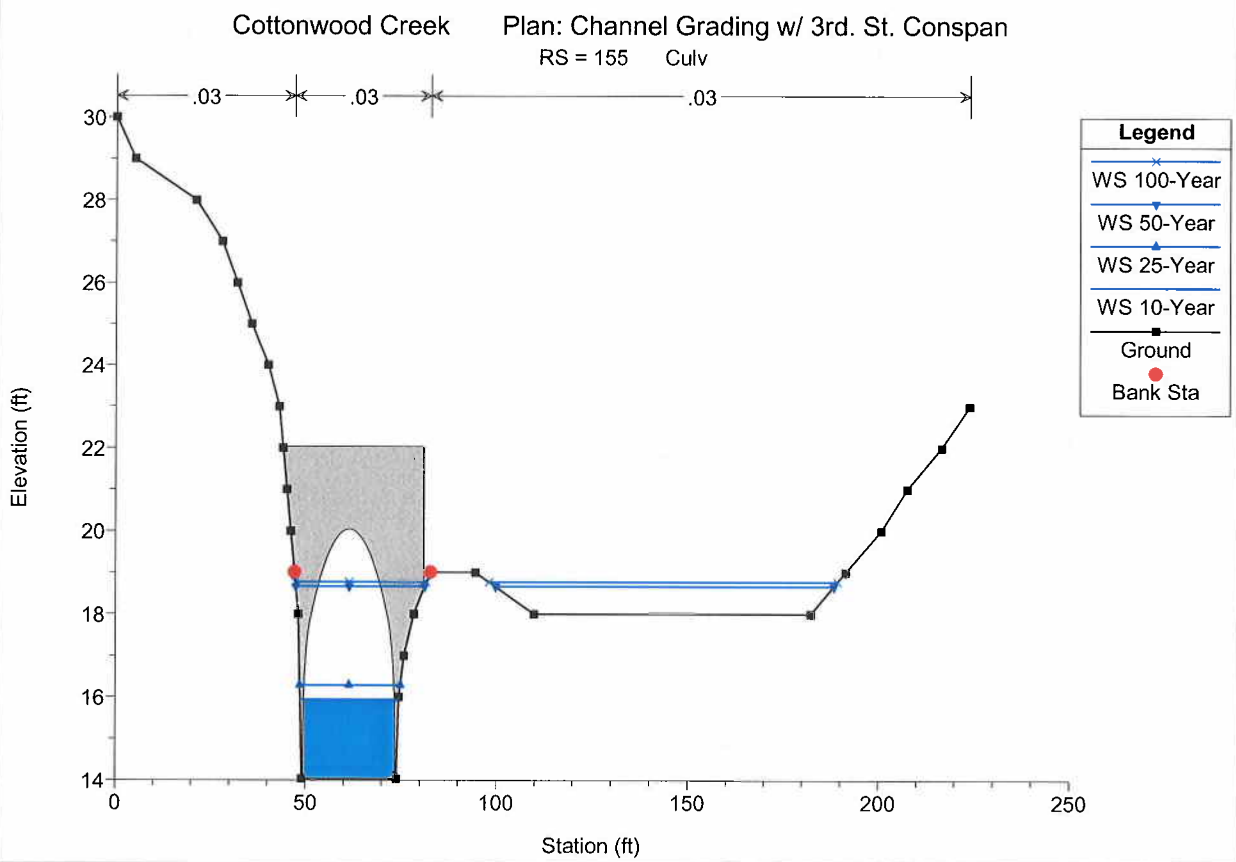
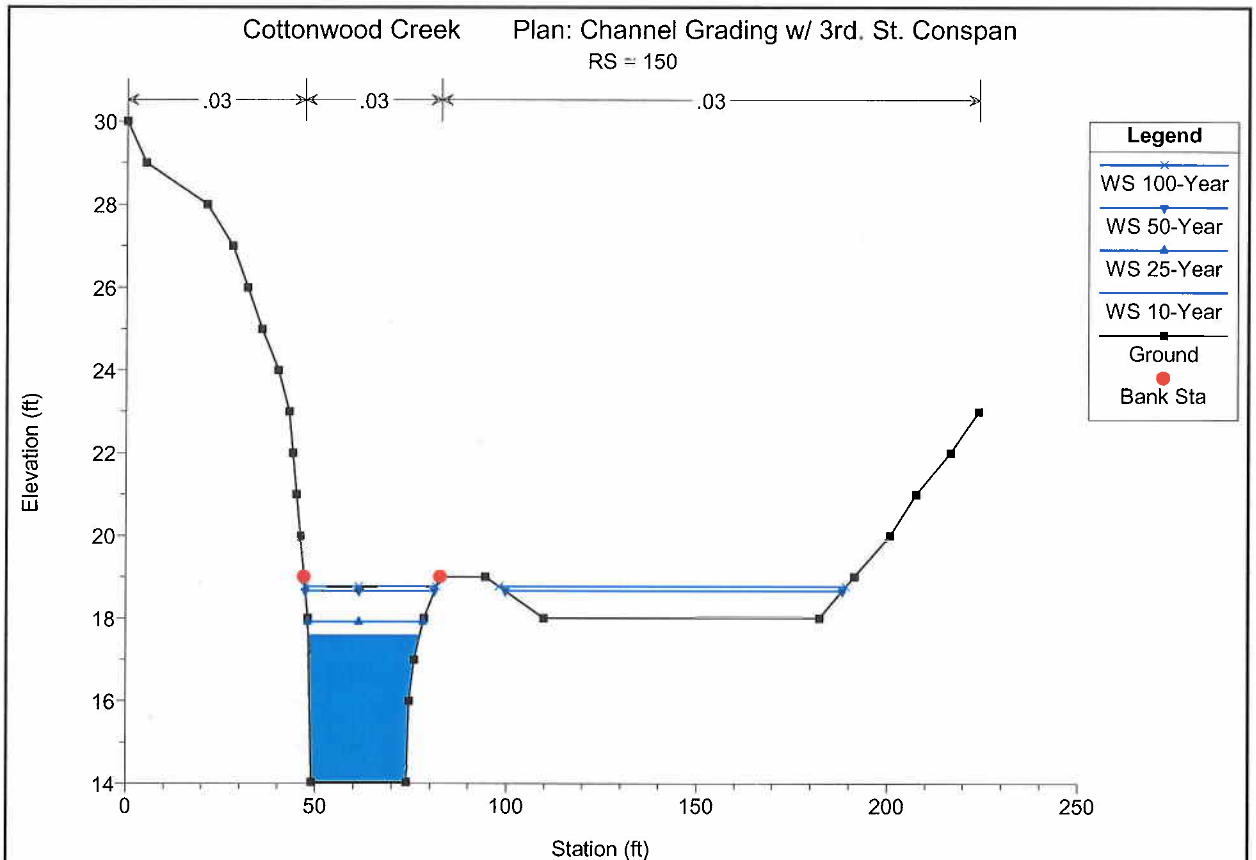
.05
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Levee
Bank Sta
Elevation (ft)
15
20
25
30
35
40
0
50
100
150
200
250
300
Station (ft)


Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
RS = 155 Culv
.03
.03
.03
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
14
16
18
20
22
24
26
28
30
0
50
100
150
200
250
Station (ft)


Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
RS = 150
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.03
.03
Elevation (ft)
Station (ft)
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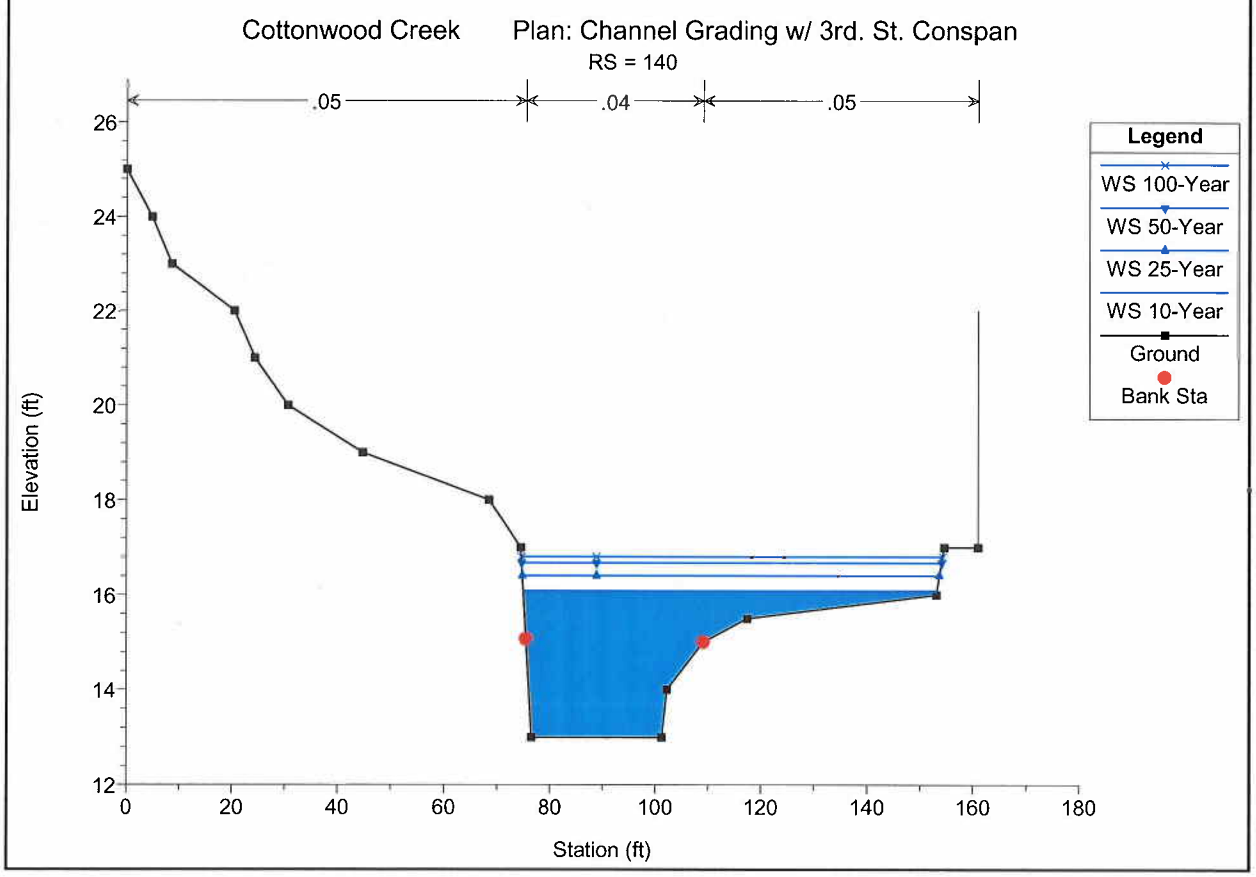
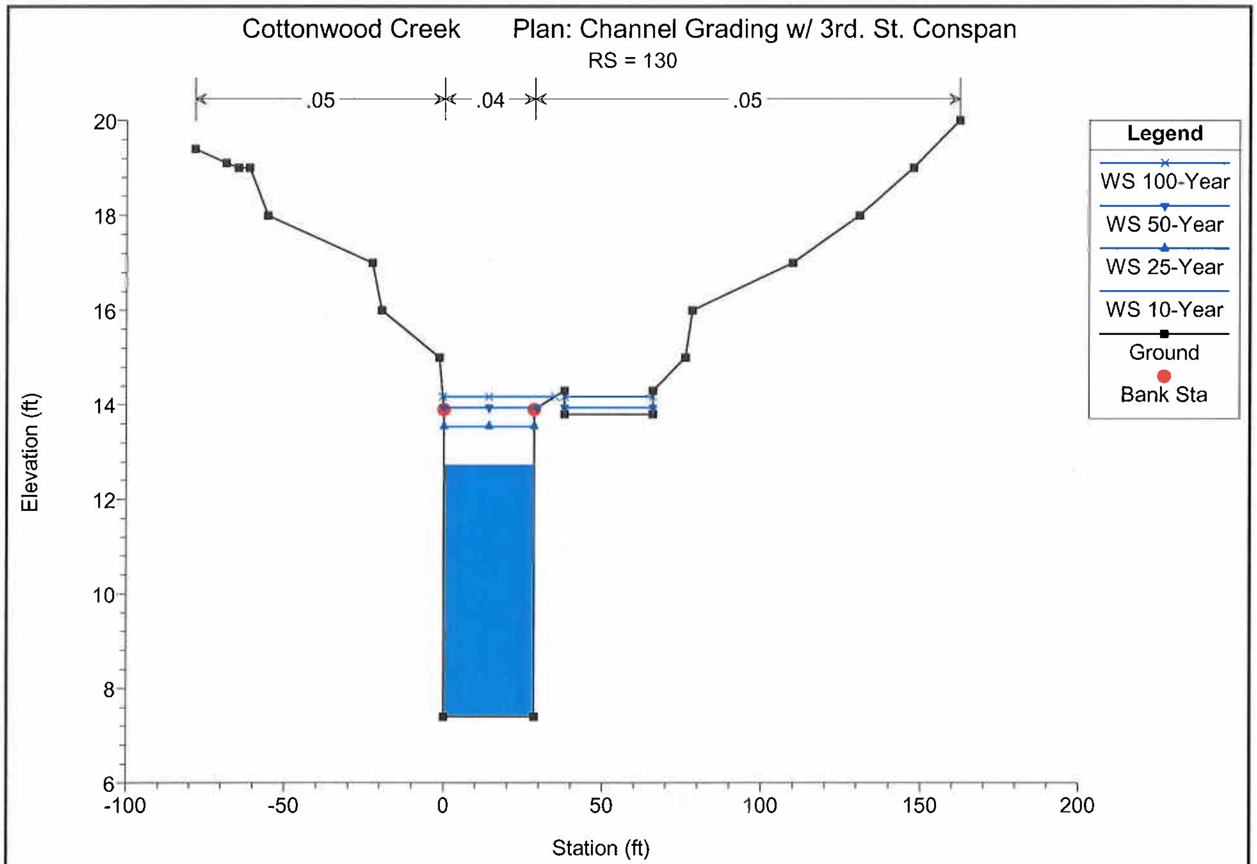
24
22
20
18
16
14
0
50
100
150
200
250
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta


Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
RS = 140
.05
.04
.05
Elevation (ft)
Station (ft)
26
24
22
20
18
16
14
12
0
20
40
60
80
100
120
140
160
180
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta



Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
RS = 130
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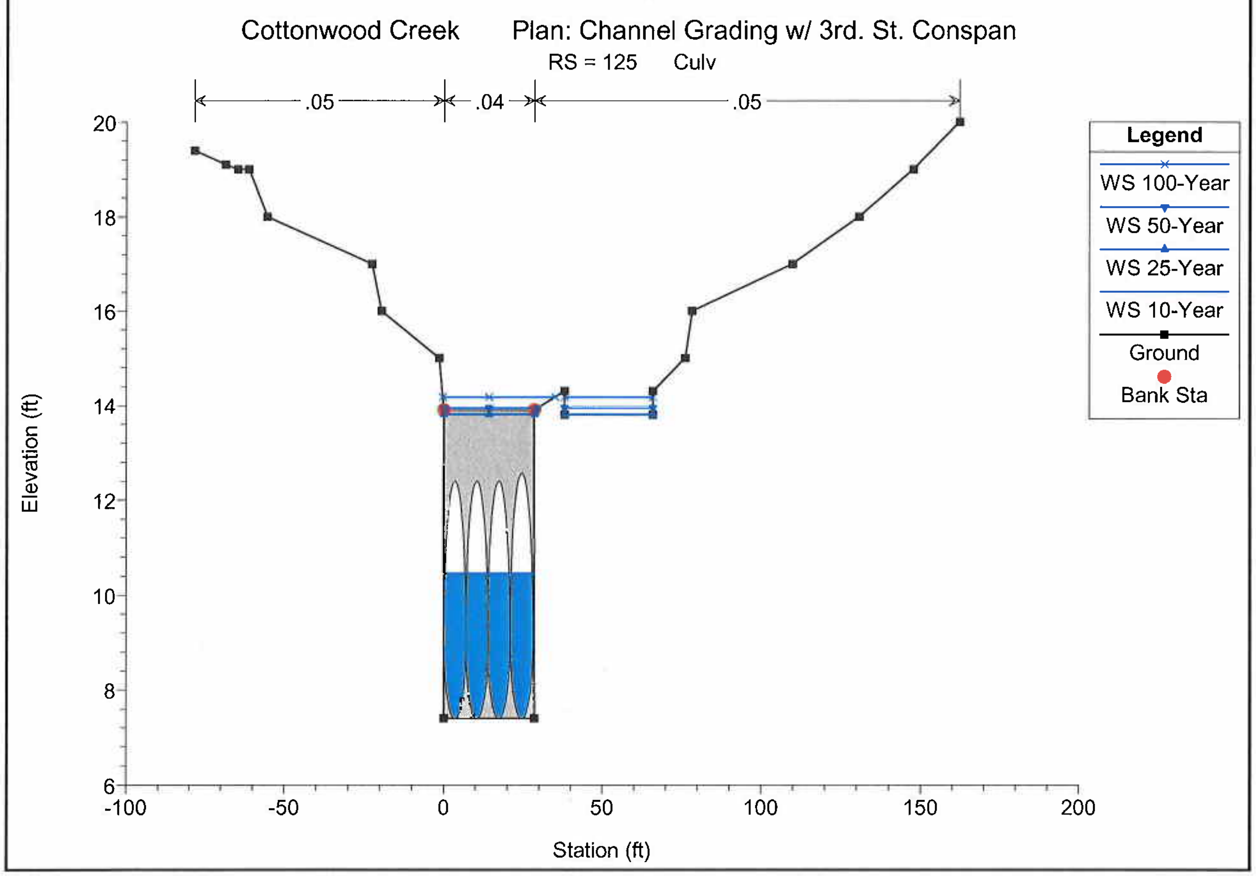
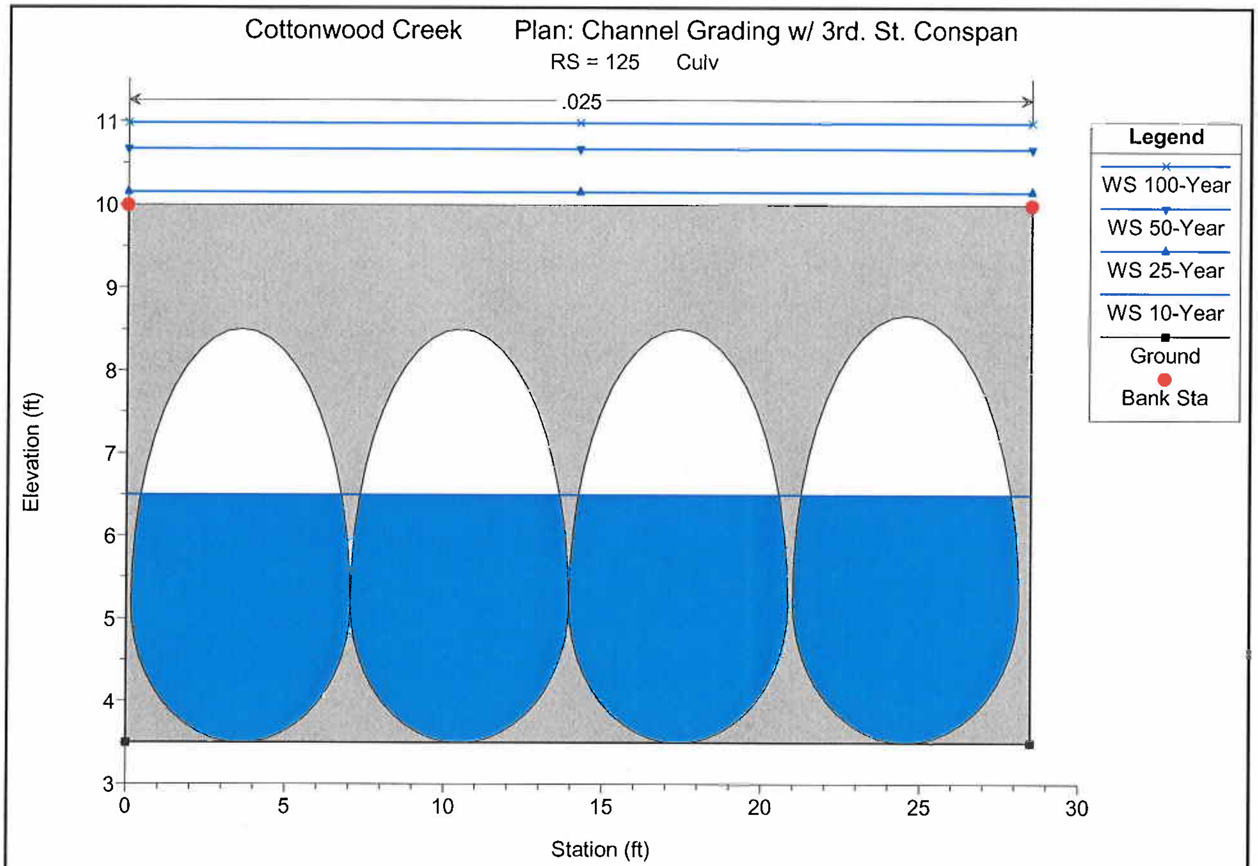
.04
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta



Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
RS = 125 Culv
.05
.04
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta



Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
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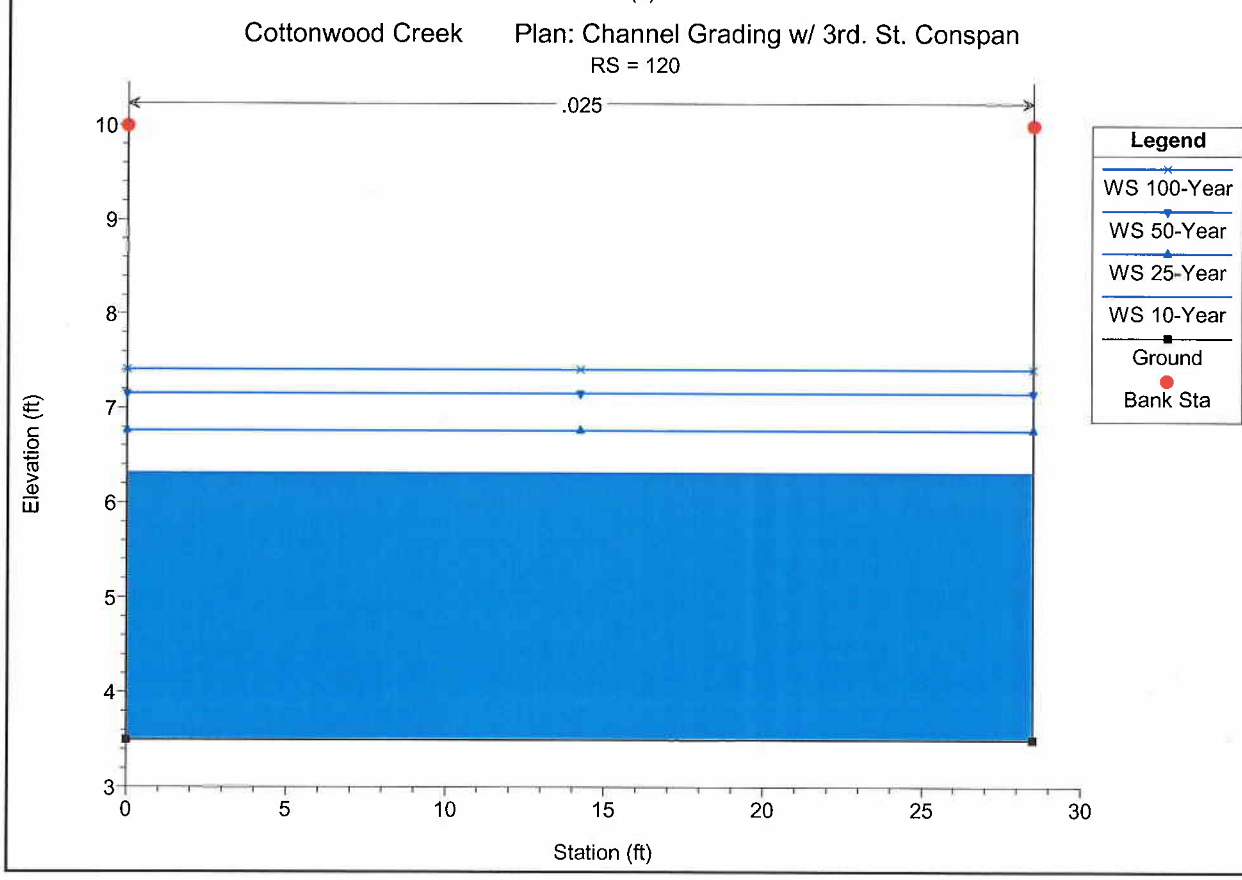
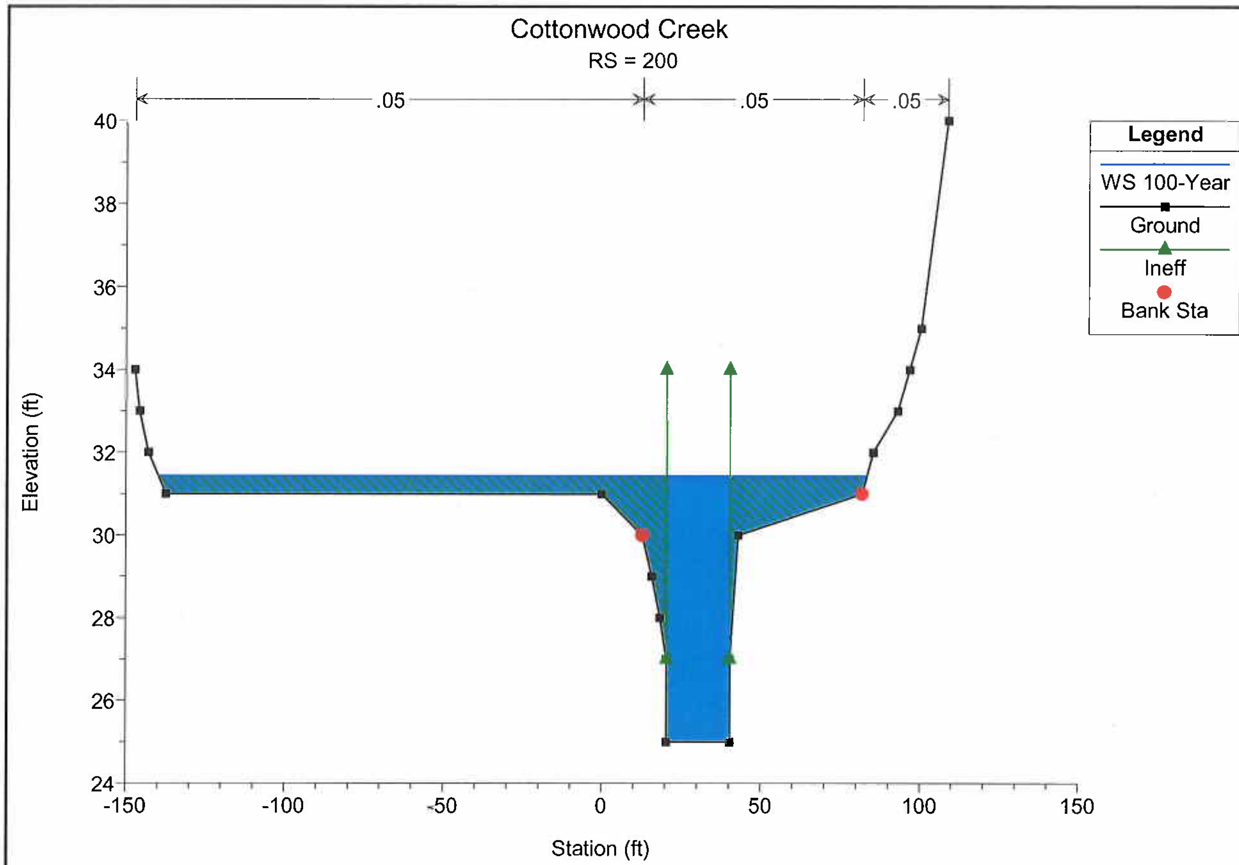
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



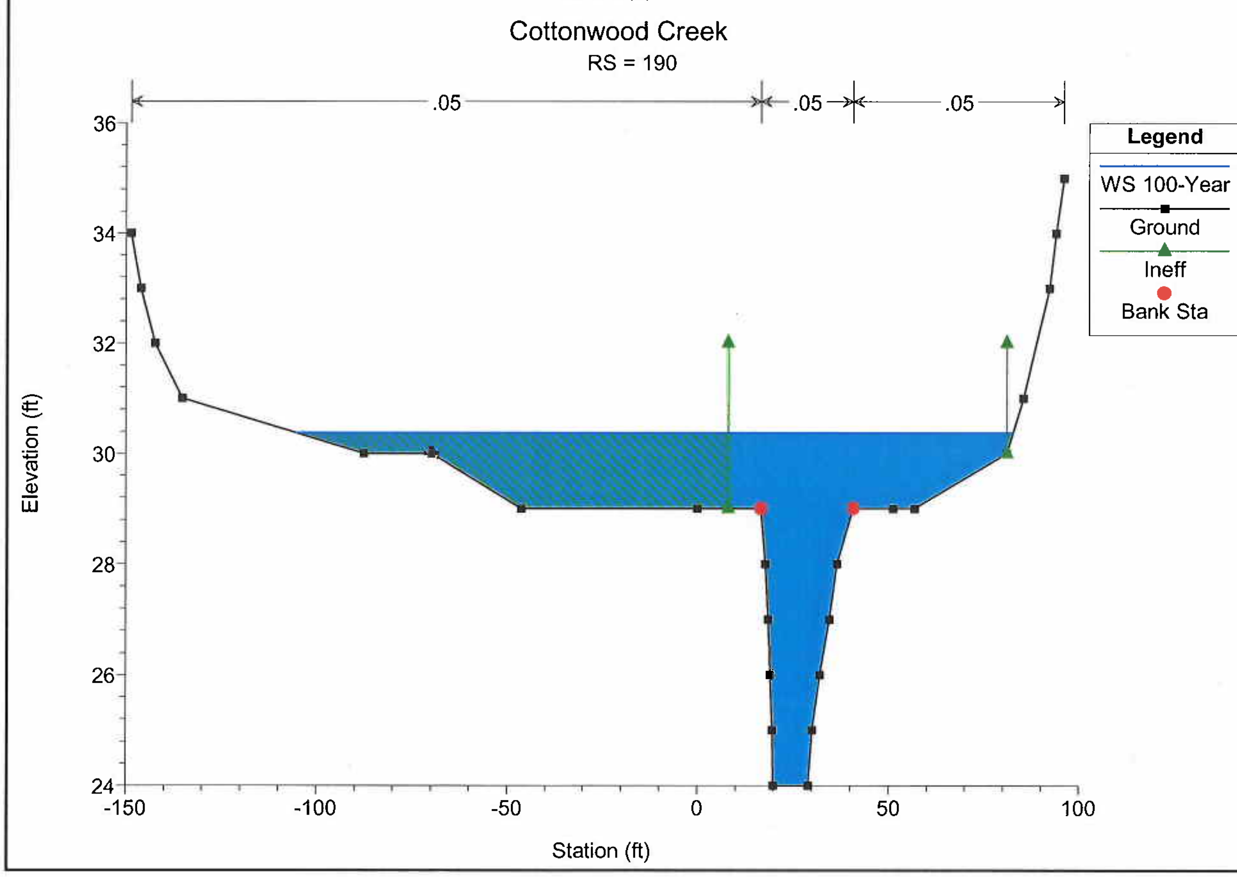
Cottonwood Creek
Plan: Channel Grading w/ 3rd. St. Conspan
RS = 120
.025
Legend
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

HEC-RAS Plan: 100-Year River: Cottonwood Creek Reach: Ocean Outfall Profile: 100-Year

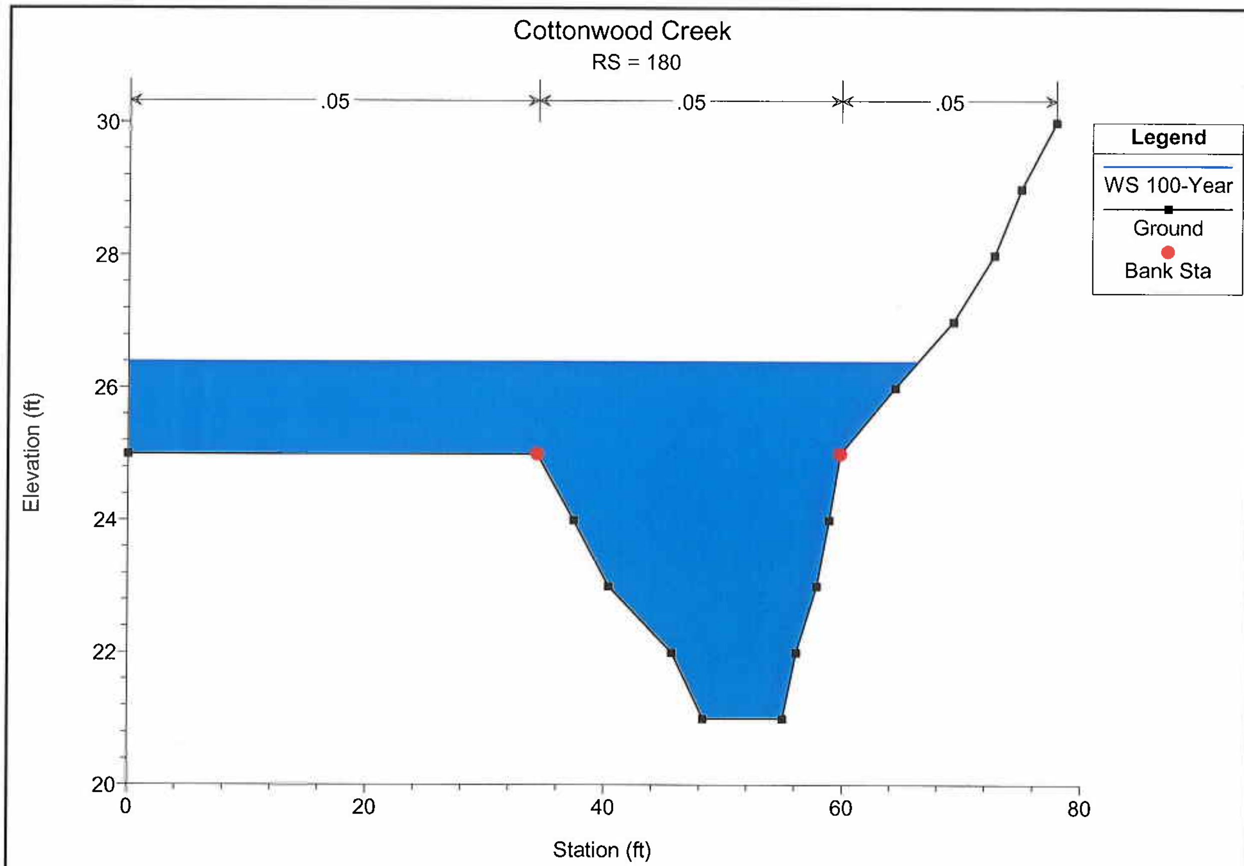
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ocean Outfall	200	100-Year	1165.00	25.00	31.44	29.73	32.71	0.009882	9.05	128.71	223.24	0.63
Ocean Outfall	190	100-Year	1165.00	24.00	30.37	30.37	31.40	0.014625	8.81	162.94	188.06	0.73
Ocean Outfall	180	100-Year	1165.00	21.00	26.39	26.39	27.50	0.016907	9.19	153.28	66.32	0.81
Ocean Outfall	170	100-Year	1165.00	19.00	23.65		23.88	0.007877	4.21	317.75	222.33	0.52
Ocean Outfall	165	100-Year	1165.00	19.00	21.98	21.98	22.79	0.017925	5.52	167.25	105.17	0.75
Ocean Outfall	160	100-Year	1165.00	16.15	20.95	20.61	21.43	0.013229	6.73	219.51	114.36	0.63
Ocean Outfall	155		Culvert									
Ocean Outfall	150	100-Year	1165.00	14.04	19.26	19.26	19.94	0.005515	7.79	208.78	137.96	0.71
Ocean Outfall	140	100-Year	1165.00	13.00	16.80	16.80	17.80	0.010984	8.60	167.08	79.65	0.82
Ocean Outfall	130	100-Year	1255.00	7.40	13.41	10.87	14.00	0.003742	6.14	204.40	34.00	0.44
Ocean Outfall	125		Culvert									
Ocean Outfall	120	100-Year	1255.00	3.50	6.97	6.97	8.73	0.007792	10.63	118.07	34.00	1.01



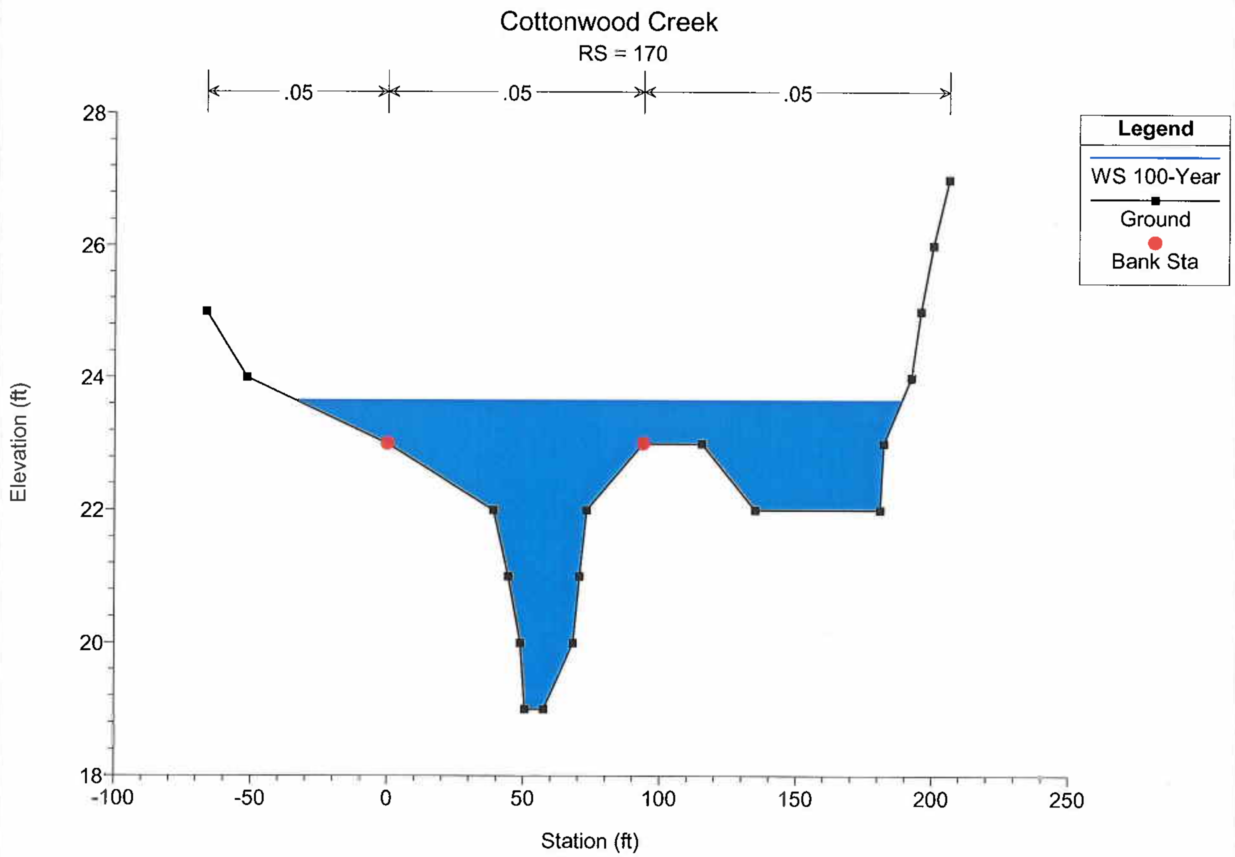
Cottonwood Creek
RS = 200
.05
.05
.05
Legend
WS 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



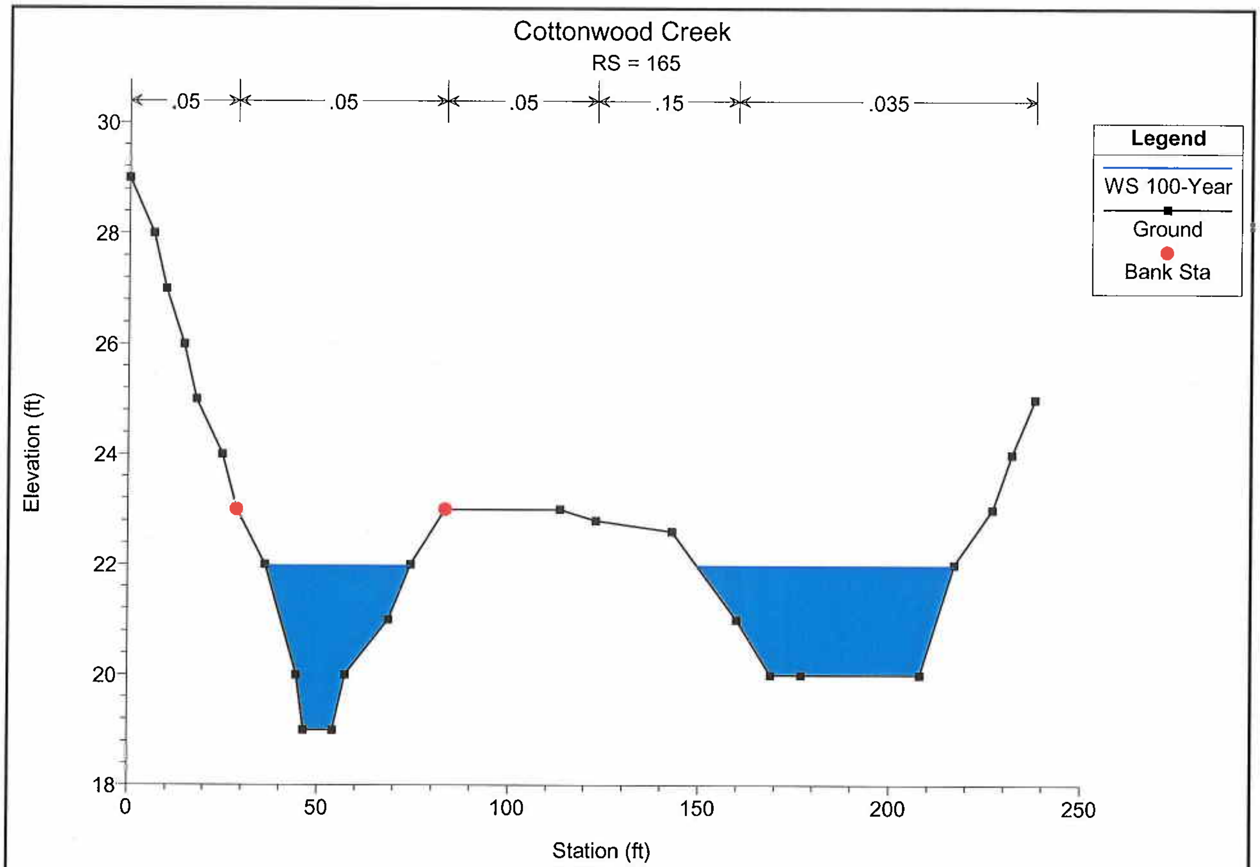
Cottonwood Creek
RS = 190
.05
.05
.05
Legend
WS 100-Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



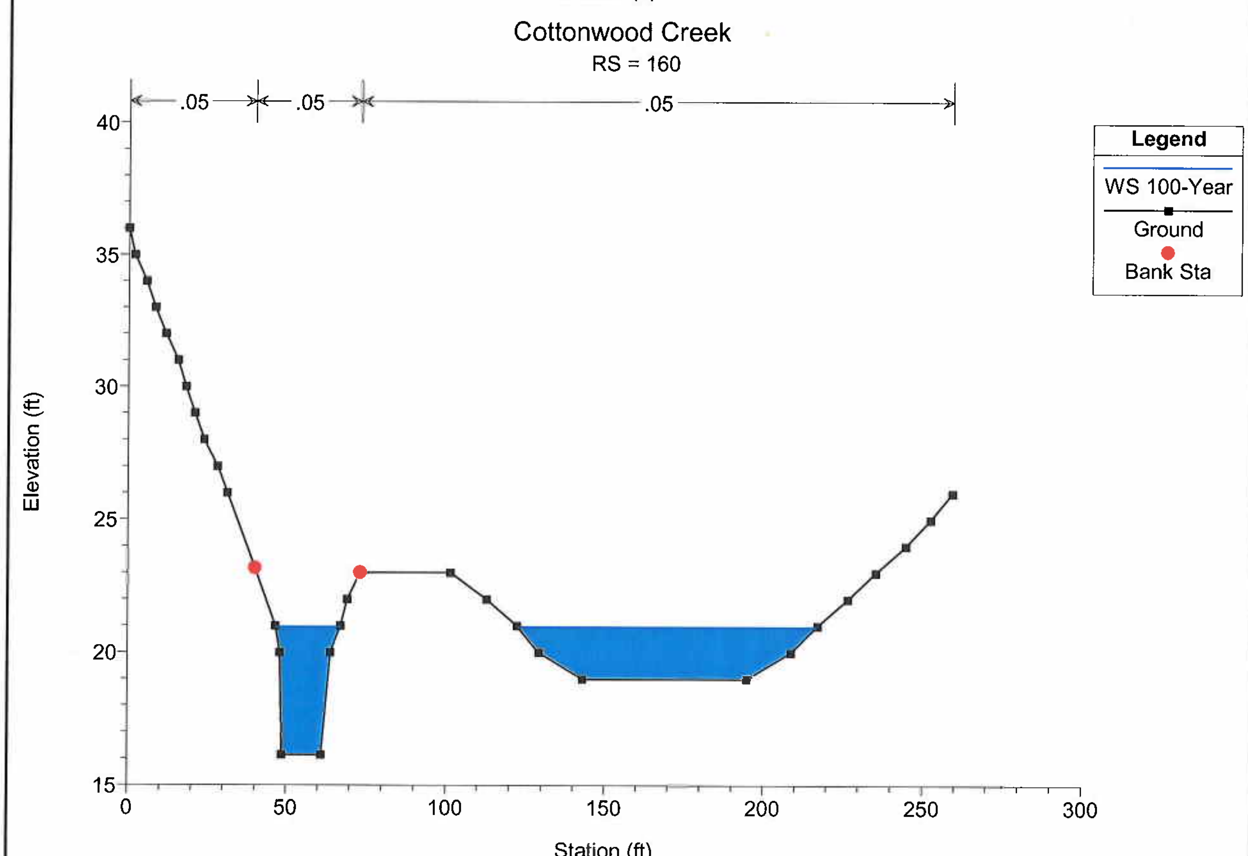
Cottonwood Creek
RS = 180
.05
.05
.05
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
30
28
26
24
22
20
0
20
40
60
80



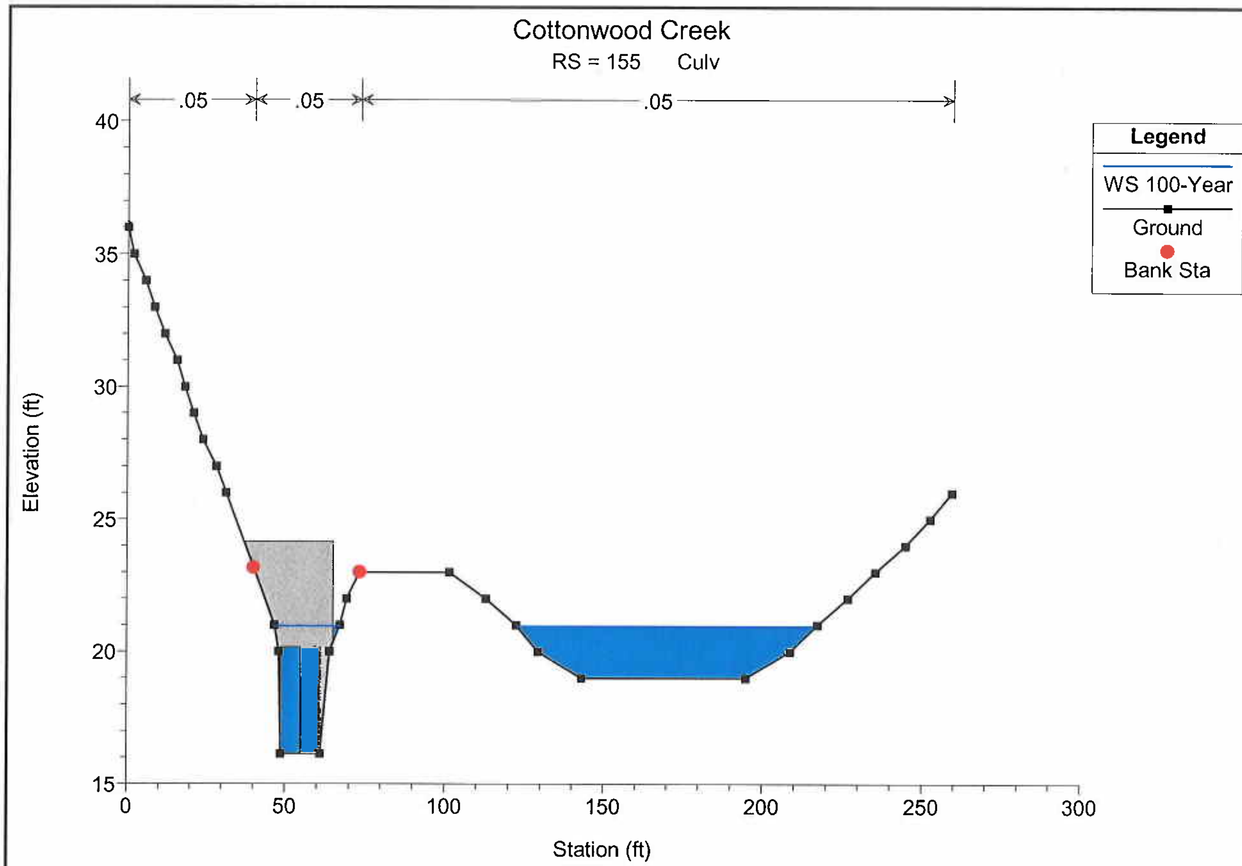
Cottonwood Creek
RS = 170
.05
.05
.05
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
28
26
24
22
20
18
-100
-50
0
50
100
150
200
250

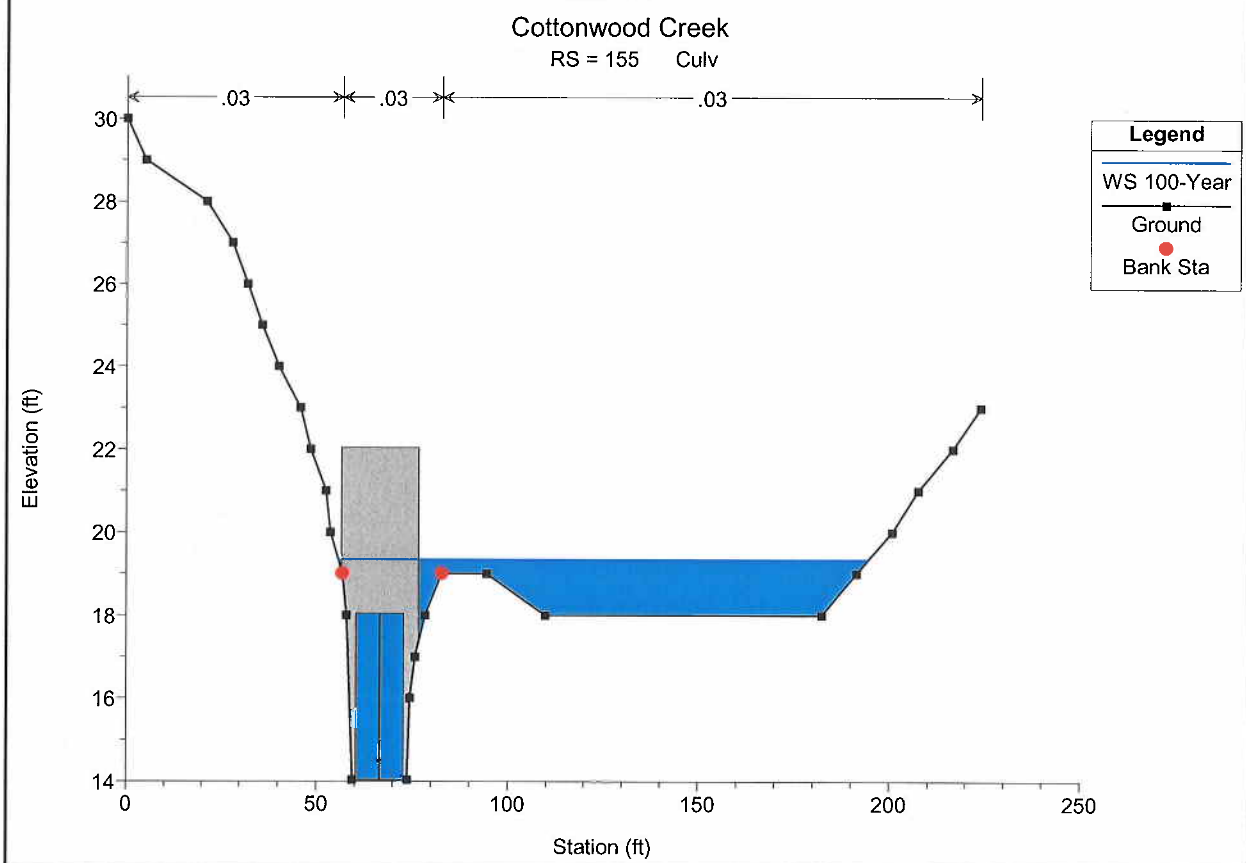


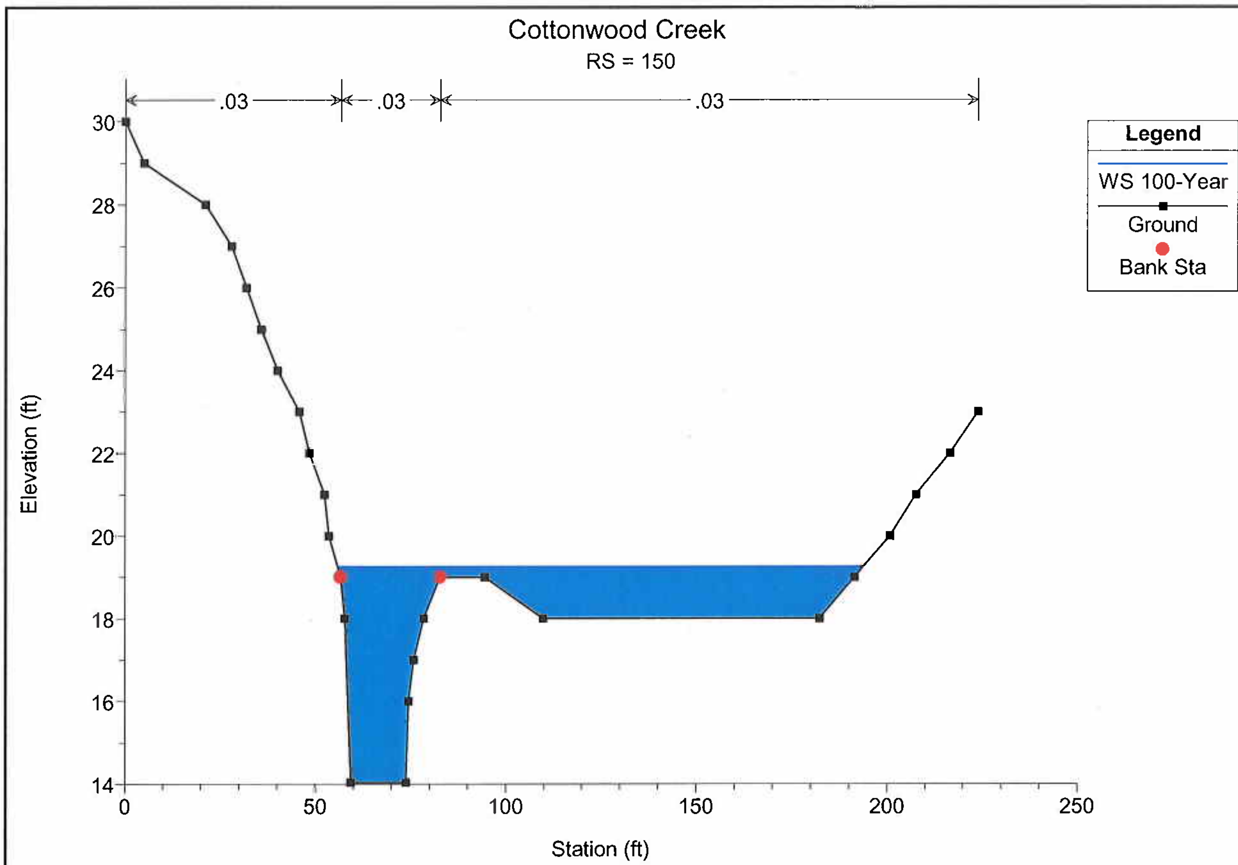
Cottonwood Creek
RS = 165
.05
.05
.05
.15
.035
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
30
28
26
24
22
20
18
0
50
100
150
200
250



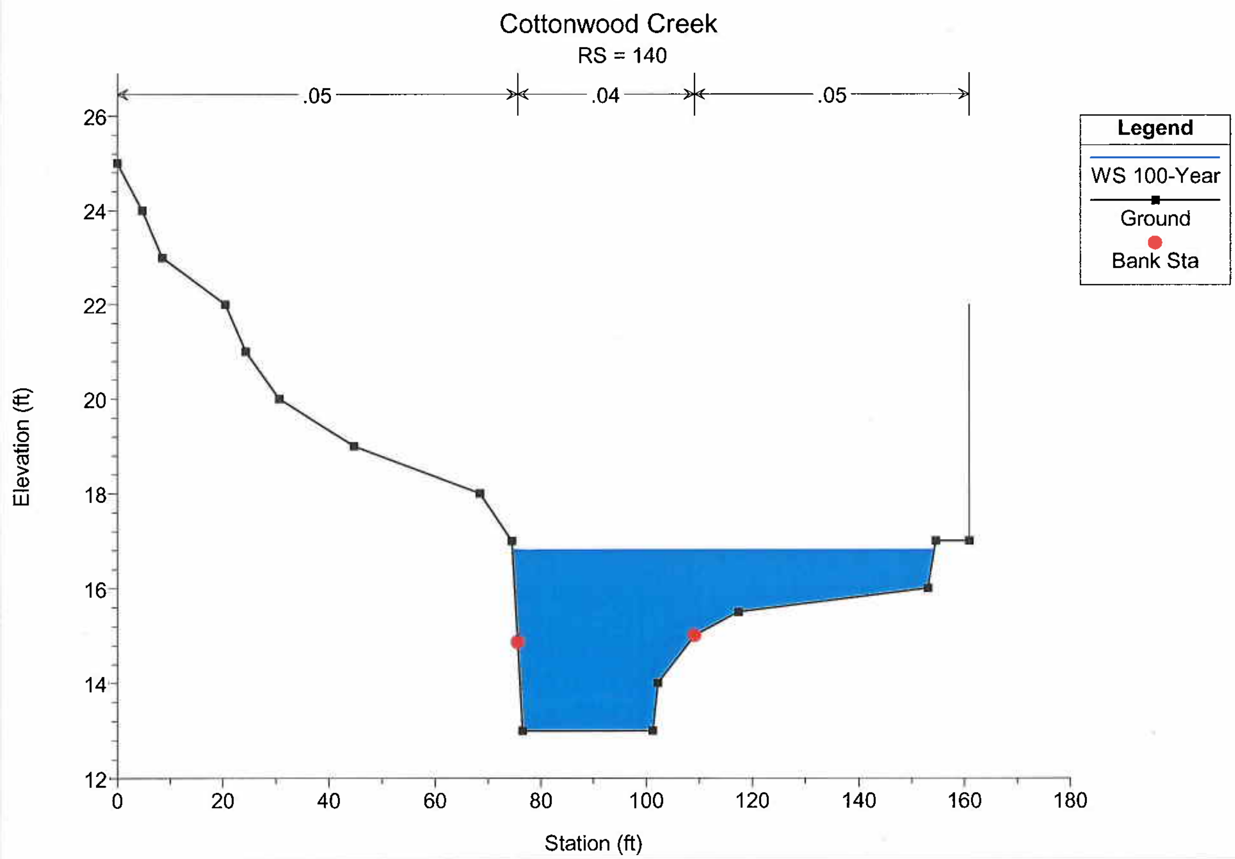
Cottonwood Creek
RS = 160
.05
.05
.05
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
40
35
30
25
20
15
0
50
100
150
200
250
300


Cottonwood Creek
RS = 155 Culv
.05
.05
.05
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
40
35
30
25
20
15
0
50
100
150
200
250
300

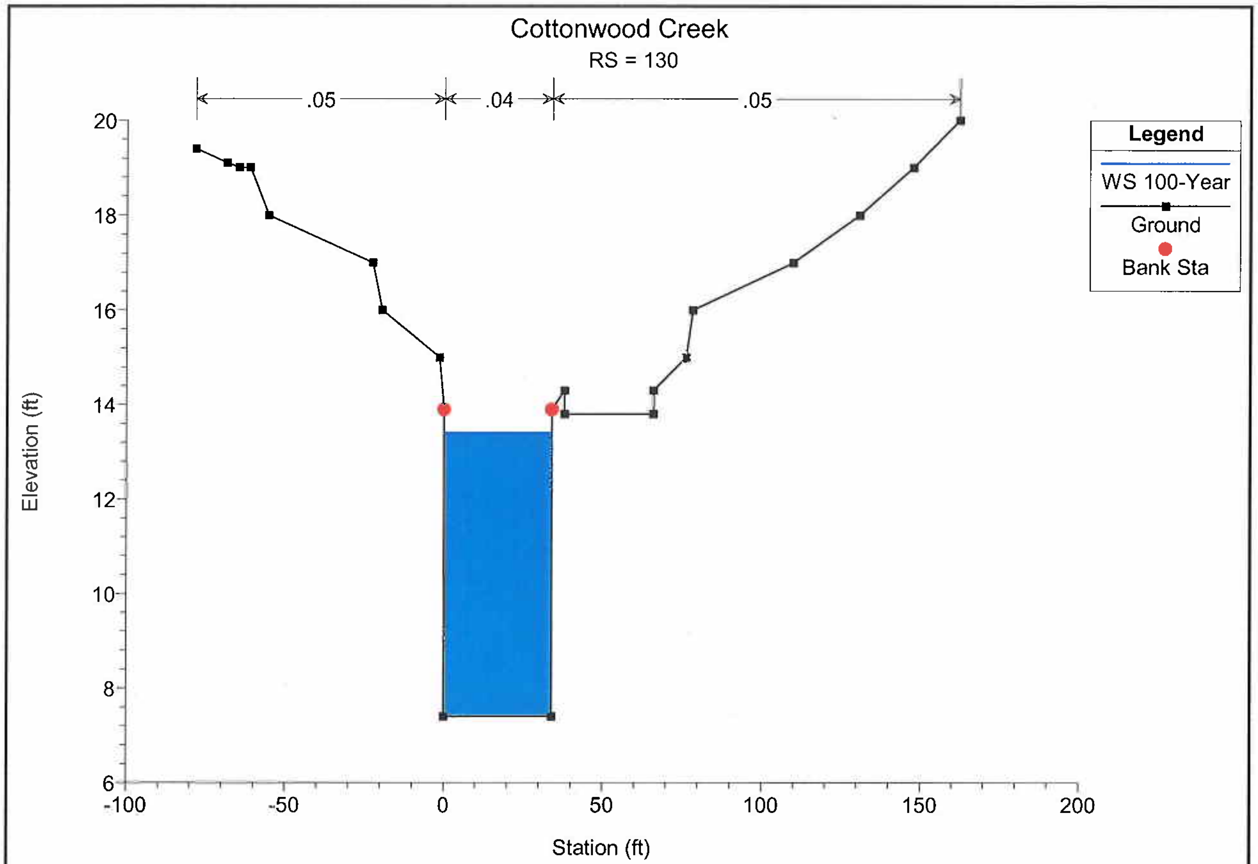

Cottonwood Creek
RS = 155 Culv
.03
.03
.03
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
30
28
26
24
22
20
18
16
14
0
50
100
150
200
250



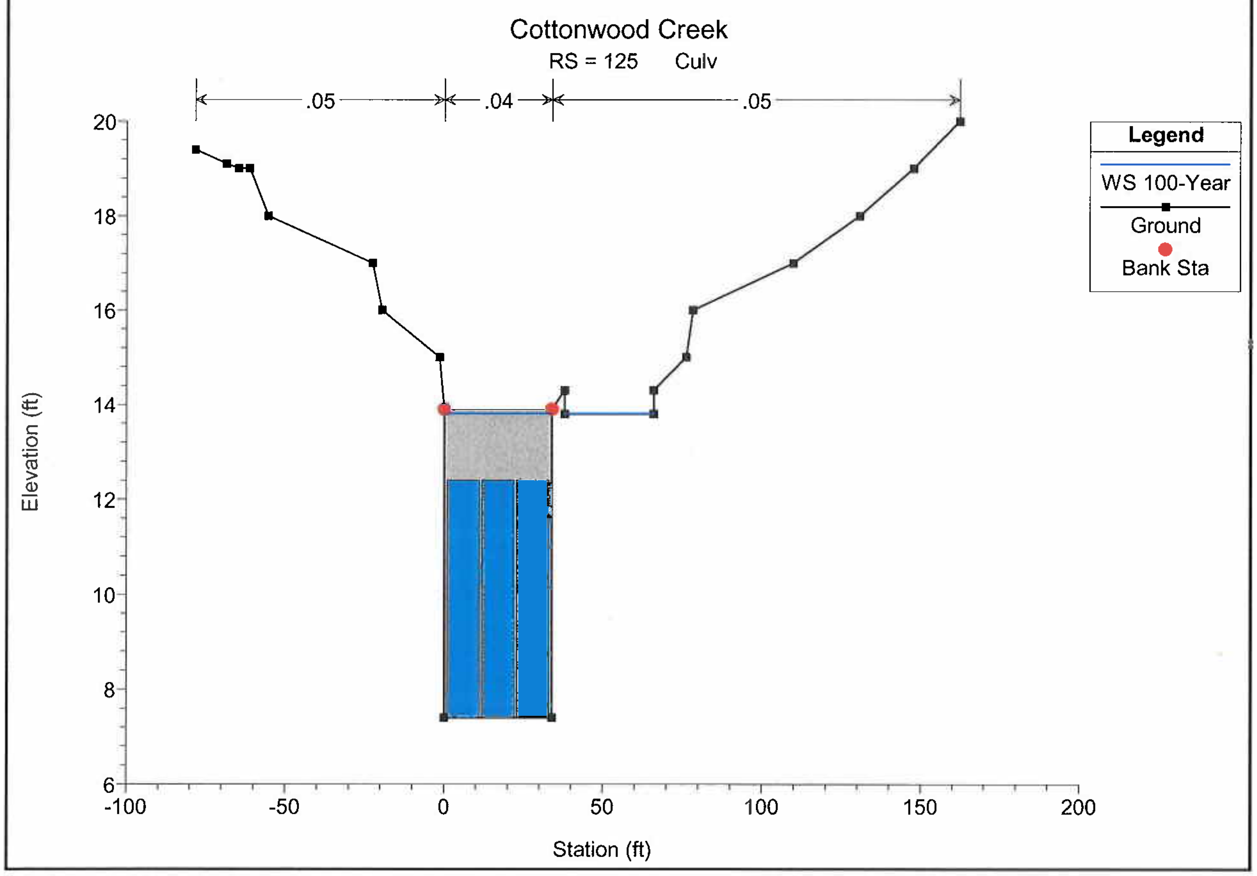
Cottonwood Creek
RS = 150
.03
.03
.03
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



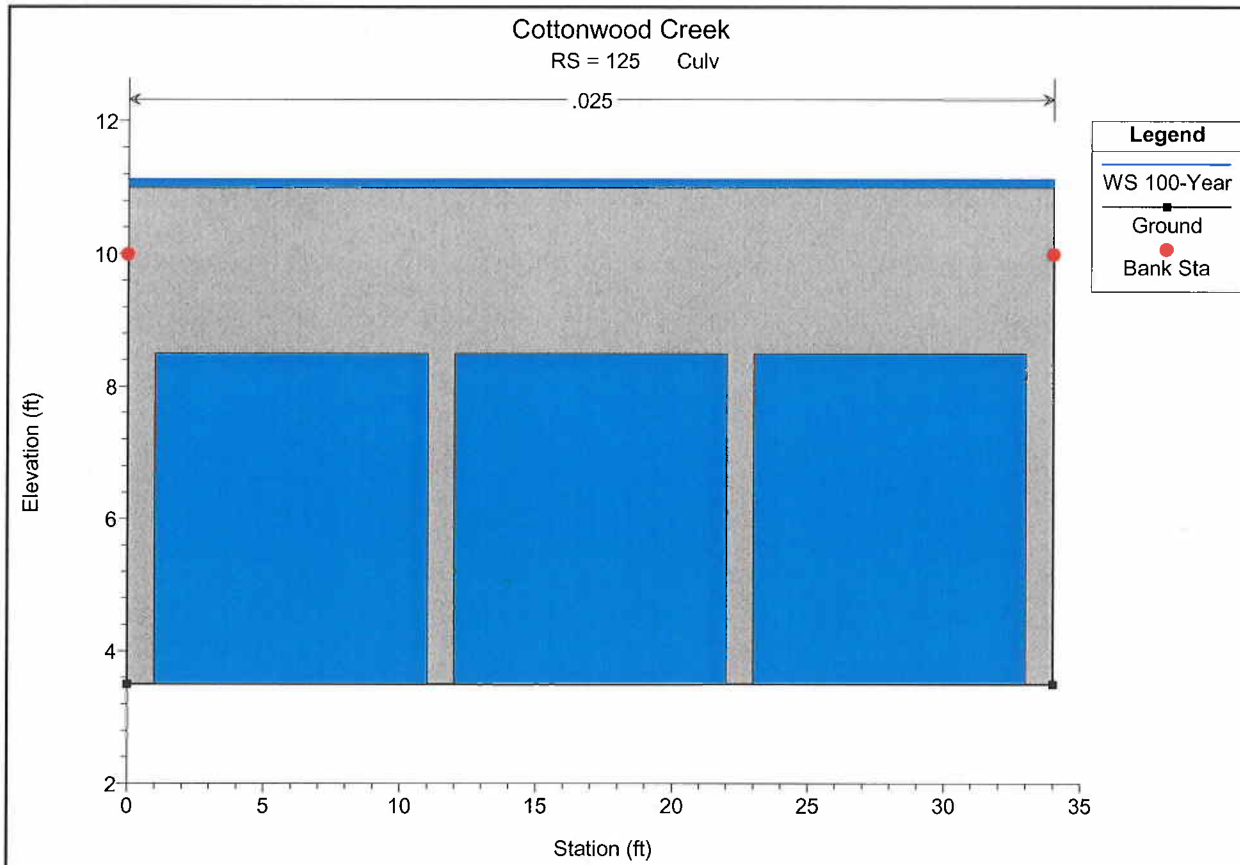
Cottonwood Creek
RS = 140
.05
.04
.05
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

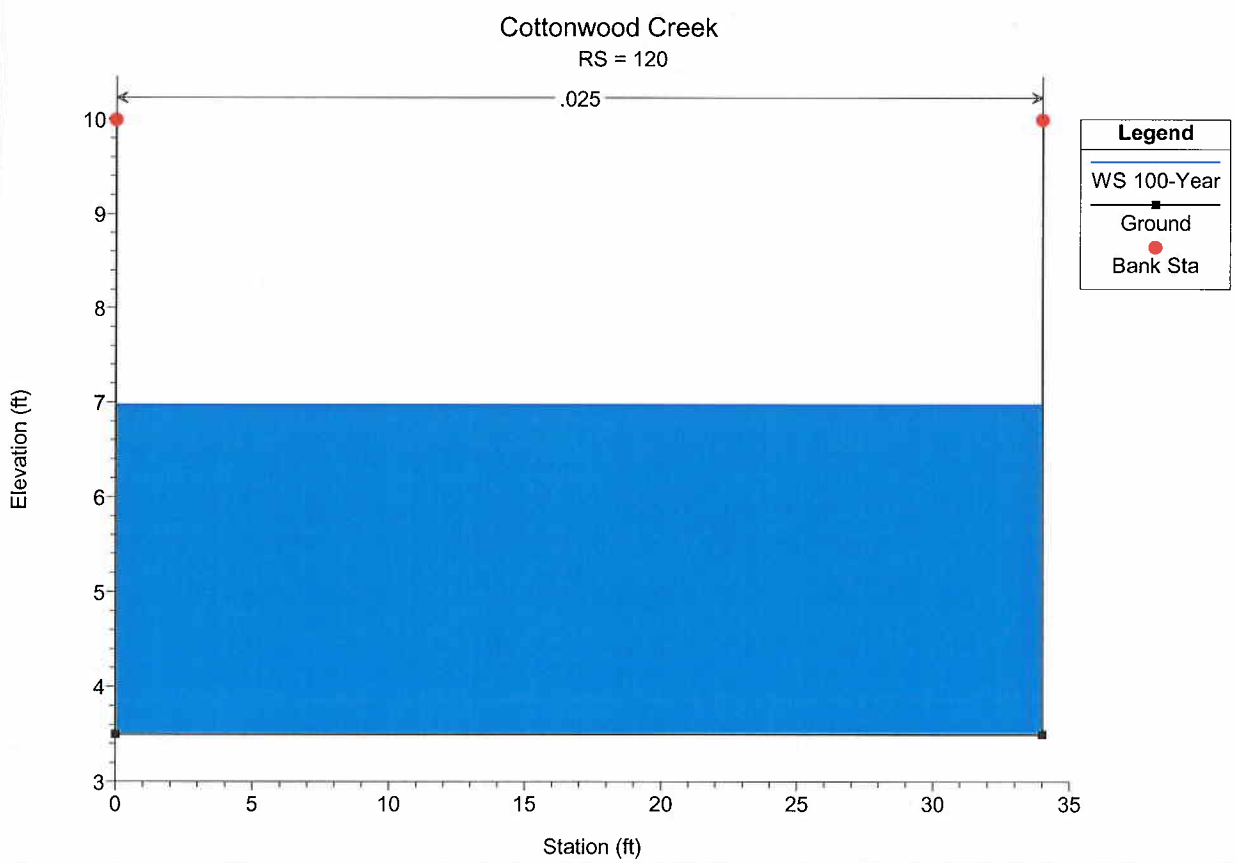


Cottonwood Creek
RS = 130
.05
.04
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year
Ground
Bank Sta



Cottonwood Creek
RS = 125 Culv
.05
.04
.05
Elevation (ft)
Station (ft)
Legend
WS 100-Year
Ground
Bank Sta


Cottonwood Creek
RS = 125 Culv
.025
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
12
10
8
6
4
2
0
5
10
15
20
25
30
35
Station (ft)


Cottonwood Creek
RS = 120
.025
Legend
WS 100-Year
Ground
Bank Sta
Elevation (ft)
10
9
8
7
6
5
4
3
0
5
10
15
20
25
30
35
Station (ft)

APPENDIX C
Fourth Street Hydraulic Calculations

100-YEAR

4th Street Curb Inlets
Worksheet for Curb Inlet On Grade

Project Description	
Worksheet	4th Street Inlets
Type	Curb Inlet On Gr
Solve For	Efficiency

Input Data		
Discharge	75.00	cfs
Slope	030300	ft/ft
Gutter Width	1.50	ft
Gutter Cross Slope	093750	ft/ft
Road Cross Slope	020000	ft/ft
Mannings Coefficie	0.017	
Curb Opening Len	100.00	ft
Local Depression	4.0	in
Local Depression \	4.00	ft

Results		
Efficiency	0.99	
Intercepted Flow	74.18	cfs
Bypass Flow	0.82	cfs
Spread	30.02	ft
Depth	0.71	ft
Flow Area	9.1	ft²
Gutter Depression	1.3	in
Total Depression	5.3	in
Velocity	8.24	ft/s
Equivalent Cross Slo	036175	ft/ft
Length Factor	0.92	
Total Interception Le	108.84	ft

50-YEAR

4th Street Curb Inlets
Worksheet for Curb Inlet On Grade

Project Description	
Worksheet	4th Street Inlets
Type	Curb Inlet On Gr
Solve For	Efficiency

Input Data		
Discharge	63.00	cfs
Slope	030300	ft/ft
Gutter Width	1.50	ft
Gutter Cross Slope	093750	ft/ft
Road Cross Slope	020000	ft/ft
Mannings Coefficie	0.017	
Curb Opening Len	80.00	ft
Local Depression	4.0	in
Local Depression \	4.00	ft

Results		
Efficiency	0.95	
Intercepted Flow	59.72	cfs
Bypass Flow	3.28	cfs
Spread	28.09	ft
Depth	0.67	ft
Flow Area	8.0	ft²
Gutter Depression	1.3	in
Total Depression	5.3	in
Velocity	7.90	ft/s
Equivalent Cross Slo	037364	ft/ft
Length Factor	0.81	
Total Interception Ler	99.21	ft

25-YEAR

4th Street Curb Inlets
Worksheet for Curb Inlet On Grade

Project Description	
Worksheet	4th Street Inlets
Type	Curb Inlet On Gr
Solve For	Efficiency

Input Data		
Discharge	57.00	cfs
Slope	030300	ft/ft
Gutter Width	1.50	ft
Gutter Cross Slope	093750	ft/ft
Road Cross Slope	020000	ft/ft
Mannings Coefficie	0.017	
Curb Opening Len	80.00	ft
Local Depression	4.0	in
Local Depression \	4.00	ft

Results		
Efficiency	0.97	
Intercepted Flow	55.14	cfs
Bypass Flow	1.86	cfs
Spread	27.04	ft
Depth	0.65	ft
Flow Area	7.4	ft²
Gutter Depression	1.3	in
Total Depression	5.3	in
Velocity	7.71	ft/s
Equivalent Cross Slo	038088	ft/ft
Length Factor	0.85	
Total Interception Ler	94.04	ft

10-YEAR

4th Street Curb Inlets
Worksheet for Curb Inlet On Grade

Project Description	
Worksheet	4th Street Inlets
Type	Curb Inlet On Gr
Solve For	Efficiency

Input Data		
Discharge	51.00	cfs
Slope	030300	ft/ft
Gutter Width	1.50	ft
Gutter Cross Slope	093750	ft/ft
Road Cross Slope	020000	ft/ft
Mannings Coefficie	0.017	
Curb Opening Len	80.00	ft
Local Depression	4.0	in
Local Depression \	4.00	ft

Results		
Efficiency	0.99	
Intercepted Flow	50.24	cfs
Bypass Flow	0.76	cfs
Spread	25.92	ft
Depth	0.63	ft
Flow Area	6.8	ft²
Gutter Depression	1.3	in
Total Depression	5.3	in
Velocity	7.50	ft/s
Equivalent Cross Slo	038929	ft/ft
Length Factor	0.90	
Total Interception Ler	88.58	ft

100-Year 4th and Sylvia Street Gutter Section
Worksheet for Gutter Section

Project Description	
Worksheet	4th Street Gutter Sec
Type	Gutter Section
Solve For	Spread

Input Data		
Slope	030300	ft/ft
Discharge	37.50	cfs
Gutter Width	1.50	ft
Gutter Cross Slo|	093750	ft/ft
Road Cross Slop	020000	ft/ft
Mannings Coeffic	0.017	

Results		
Spread	?3.03	ft
Flow Area	5.4	ft²
Depth	0.57	ft
Gutter Depress	1.3	in
Velocity	6.96	ft/s

50-Year 4th and Sylvia Street Gutter Section
Worksheet for Gutter Section

Project Description	
Worksheet	4th Street Gutter Sec
Type	Gutter Section
Solve For	Spread

Input Data		
Slope	030300	ft/ft
Discharge	31.50	cfs
Gutter Width	1.50	ft
Gutter Cross Slo|	093750	ft/ft
Road Cross Slop	020000	ft/ft
Mannings Coeffic	0.017	

Results		
Spread	21.53	ft
Flow Area	4.7	ft²
Depth	0.54	ft
Gutter Depress	1.3	in
Velocity	6.67	ft/s

25-Year 4th and Sylvia Street Gutter Section
Worksheet for Gutter Section

Project Description	
Worksheet	4th Street Gutter Sec
Type	Gutter Section
Solve For	Spread

Input Data		
Slope	030300	ft/ft
Discharge	28.50	cfs
Gutter Width	1.50	ft
Gutter Cross Slo|	093750	ft/ft
Road Cross Slop	020000	ft/ft
Mannings Coeffic	0.017	

Results		
Spread	20.72	ft
Flow Area	4.4	ft²
Depth	0.52	ft
Gutter Depress	1.3	in
Velocity	6.51	ft/s

10-Year 4th and Sylvia Street Gutter Section
Worksheet for Gutter Section

Project Description	
Worksheet	4th Street Gutter Sec
Type	Gutter Section
Solve For	Spread

Input Data		
Slope	030300	ft/ft
Discharge	25.50	cfs
Gutter Width	1.50	ft
Gutter Cross Slo|	093750	ft/ft
Road Cross Slop	020000	ft/ft
Mannings Coeffic	0.017	

Results		
Spread	19.84	ft
Flow Area	4.0	ft²
Depth	0.51	ft
Gutter Depres:	1.3	in
Velocity	6.34	ft/s

100-YEAR

Stormwater Main
Worksheet for Circular Channel

Project Description	
Worksheet	4th Street Mair
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	
Slope	041500	ft/ft
Diameter	36	in
Discharge	75.00	cfs

Results		
Depth	1.59	ft
Flow Area	3.8	ft²
Wetted Perime	4.90	ft
Top Width	2.99	ft
Critical Depth	2.72	ft
Percent Full	53.0	%
Critical Slope	0.011072	ft/ft
Velocity	19.70	ft/s
Velocity Head	6.03	ft
Specific Energ	7.62	ft
Froude Numbe	3.08	
Maximum Disc	146.15	cfs
Discharge Full	135.87	cfs
Slope Full	0.012646	ft/ft
Flow Type	;upercritical	

50-YEAR

Stormwater Main

Worksheet for Circular Channel

Project Description	
Worksheet	4th Street Mair
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	
Slope	041500	ft/ft
Diameter	36	in
Discharge	63.00	cfs

Results		
Depth	1.44	ft
Flow Area	3.3	ft²
Wetted Perime	4.58	ft
Top Width	3.00	ft
Critical Depth	2.55	ft
Percent Full	47.8	%
Critical Slope	0.008386	ft/ft
Velocity	18.86	ft/s
Velocity Head	5.53	ft
Specific Energ:	6.96	ft
Froude Numbe	3.15	
Maximum Disc	146.15	cfs
Discharge Full	135.87	cfs
Slope Full	0.008923	ft/ft
Flow Type	;upercritical	

25-YEAR

Stormwater Main
Worksheet for Circular Channel

Project Description	
Worksheet	4th Street Mair
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	
Slope	041500	ft/ft
Diameter	36	in
Discharge	57.00	cfs

Results		
Depth	1.36	ft
Flow Area	3.1	ft²
Wetted Perime	4.42	ft
Top Width	2.99	ft
Critical Depth	2.45	ft
Percent Full	45.2	%
Critical Slope	0.007373	ft/ft
Velocity	18.38	ft/s
Velocity Head	5.25	ft
Specific Energ:	6.60	ft
Froude Numbe	3.18	
Maximum Disc	146.15	cfs
Discharge Full	135.87	cfs
Slope Full	0.007304	ft/ft
Flow Type	;upercritical	

10-YEAR

Stormwater Main
Worksheet for Circular Channel

Project Description	
Worksheet	4th Street Mair
Flow Element	Circular Chann
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.013	
Slope	041500	ft/ft
Diameter	36	in
Discharge	51.00	cfs

Results		
Depth	1.27	ft
Flow Area	2.9	ft²
Wetted Perime	4.26	ft
Top Width	2.97	ft
Critical Depth	2.32	ft
Percent Full	42.4	%
Critical Slope	0.006543	ft/ft
Velocity	17.85	ft/s
Velocity Head	4.95	ft
Specific Energ	6.22	ft
Froude Numbe	3.21	
Maximum Disc	146.15	cfs
Discharge Full	135.87	cfs
Slope Full	0.005847	ft/ft
Flow Type	Supercritical	