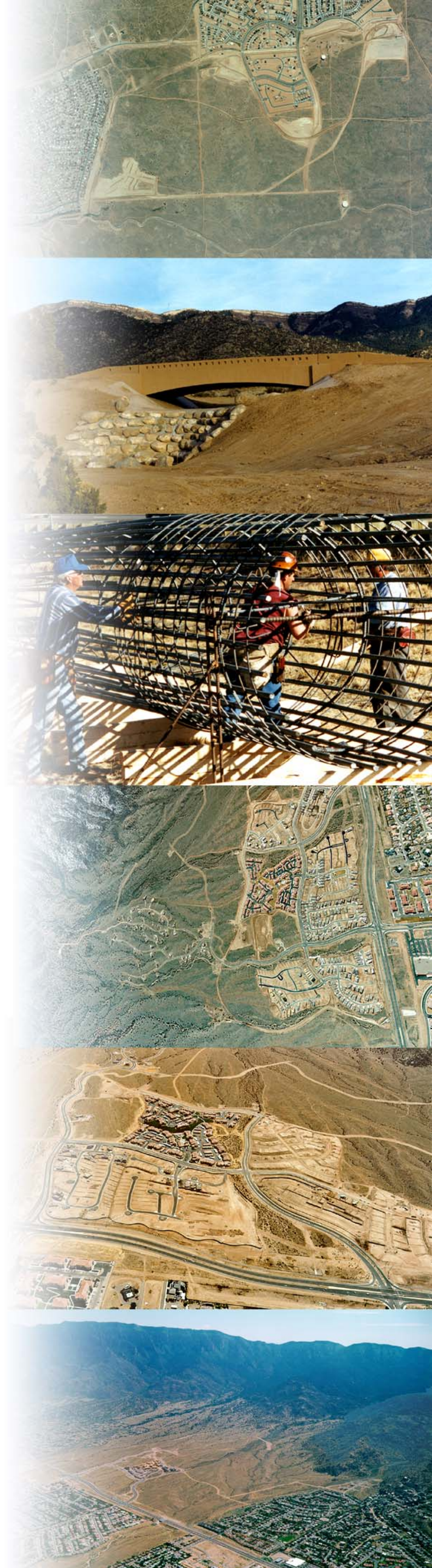
AMENDMENT NO. 2

DRAINAGE MASTER PLAN FOR THE MIREHAVEN MASTER PLANNED COMMUNITY

(TRACTS N-2 & M OF THE WATERSHED SUBDIVISION)



FEBRUARY 2015

Prepared for:

Pulte Homes of New Mexico
7601 Jefferson St NE – Suite 320
Albuquerque, NM 87109

Prepared by:

Bohannan Huston

Engineering
Spatial Data
Advanced Technologies

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FEBRUARY 25, 2015

Prepared for:

PULTE HOMES OF NEW MEXICO

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ALBUQUERQUE, NM 87109

Prepared by:

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Project Manager

______________________ 2/24/15

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Drainage Engineer

Bohannan Huston

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PURPOSE

This report is Amendment No. 2 to the Drainage Master Plan (DMP) for the Mirehaven Master Planned Community, Bohannan Huston Inc., November 2013, which was prepared for Pulte Homes of New Mexico. The DMP provided master drainage analysis to support the future backbone drainage infrastructure for the proposed development that will consist of approximately 950 single family residential lots on approximately 285 acres. The DMP was approved by the City of Albuquerque on December 4, 2013, with Amendment No. 1 being approved on April 9, 2014. Since that approval, there have been ongoing discussions with the project owner, Pulte Homes of New Mexico; as a result, the design concept for the Mirehaven Arroyo Improvements has been modified. These modifications include replacing all vertical wall sections, vertical wall drop structures and sloped wire-tied riprap with sloped 1:1.5 shotcrete. This Amendment provides the updated analysis for the Mirehaven Arroyo Improvements and replaces some of the Subsections of Section VI of the approved DMP. All other sections of the DMP remain the same and are not restated here.

VI. PROPOSED MIREHAVEN ARROYO IMPROVEMENTS

The improvements that are proposed for the Mirehaven Arroyo are planned to be constructed from the existing crossing structure at Tierra Pintada west to the property boundary of the Petroglyph National Monument. The proposed improvements include: a training dike immediately downstream of (and outside of) the Petroglyph National Monument property boundary; channel improvements with a trapezoidal section; shotcrete drop structures with shotcrete aprons on the downstream end; a crossing structure at the proposed future roadway; buried shotcrete scour protection; and a COA maintenance road with three access locations along the north side of the channel along with maintenance access at both sides of the training dike. The proposed channel will be a composite trapezoidal channel with the side slopes of the channel being constructed of shotcrete and the bottom of the channel being earthen. A HEC-RAS model was created for the proposed improvements to aid in the design of the proposed channel, scour protection, crossing structure and drop structures. This model uses Manning's "n" values of 0.018, 0.035, and 0.045, corresponding to shotcrete, natural channel, and gravel mulch portions of the channel. HEC-RAS model outputs, select cross sections, figure showing HEC-RAS sections in plan view and a profile showing existing ground (based on the previous design described in Addendum No. 1), interim ground and proposed ground are included in Appendix A.

A. PROPOSED CHANNEL

The proposed channel will convey flows from the existing Mirehaven Arroyo upstream of the project location and developed flows from the proposed development of the Watershed subdivision. The maximum flowrate in the channel is 1,500 cfs, which occurs at the inlet to the existing culvert crossing structure at Tierra Pintada Drive and is the design flowrate for the entire reach of the proposed improvements. The design flowrate is taken from the *West I-40 DMP* that was updated in 2011.

The channel will be an earthen trapezoidal channel that begins at Tierra Pintada and extends west approximately 3,000 ft upstream to the proposed training dike and will have a downstream slope of 0.7 percent. This slope was selected based on the equilibrium slope analysis discussed in the approved DMP. The channel bottom width varies from 25 ft at Tierra Pintada (the width of the existing section at Tierra Pintada), to 66 ft approximately 200 ft upstream of that crossing. From there, the channel bottom width varies between 64 ft and 115 ft upstream to the proposed future roadway crossing where the channel bottom width is reduced to 46 ft. Upstream of the future roadway crossing, the channel bottom width varies between 61 ft and 88 ft upstream to the training dike. The bottom of the channel will be designed with a 2 percent cross slope from the banks to the center of the channel. See Exhibit 1 for a plan view of the proposed improvements.

The channel improvements are designed to include freeboard above the 100-yr WSEL. The channel depth is designed to contain the water surface elevation in the channel as well as superelevation as discussed in the section below. The channel section has also been designed with a gravel mulch lined section to extend from the top of the channel depth at a slope of 3:1 (horizontal to vertical) vertically 2 ft to account for freeboard. Freeboard was calculated per Section 22.3.C.4 of the COA DPM (see Appendix A). Exhibit 2 shows a portion of the plan view and details of the proposed channel.

1. EQUILIBRIUM SLOPE ANALYSIS

The equilibrium slope was established previously with the original DMP and is discussed in that report.

2. SUPERELEVATION ANALYSIS

A superelevation analysis was conducted to determine amount of rise in the water surface along the proposed channel wall along the outside of each channel curve to determine the minimum depth for the proposed channel section. The analysis utilized the methods and equations in Section 22.3.C.3.a.2 of the COA DPM for superelevation for trapezoidal channels under subcritical flow conditions. This requires inputs of velocity, depth of flow (values taken from HEC-RAS model), bank slope, channel bottom width, radius of the channel curve (determined using AutoCAD), and the gravity constant of 32.2 ft/s^2.

These inputs were entered into a spreadsheet that calculated the superelevation at representative cross sections from the HEC-RAS model. The calculated superelevation was then added to the depth of flow to determine the maximum height of the water surface and ultimately the channel depth. The analysis indicates that the maximum depth of 3 ft will be required for the channel except at the outlet of the training dike, drop structures and crossing locations where the wall elevations are determined by water surface elevation (plus freeboard and superelevation) as dictated by the upstream and downstream channel features and geometry. Calculations for this analysis are included in Appendix A.

B. SHOTCRETE DROP STRUCTURES

Drop structures are required for the proposed channel described above to control the grade in the channel and maintain the channel design slope of 0.7 percent. The Mirehaven Arroyo in its existing condition has an approximate slope of 2.2 percent giving a change in slope of 1.5 percent from the existing slope to the proposed channel slope. With the proposed channel and proposed training dike being approximately 3,400 ft upstream (in combined length), this gives a change in grade from the existing arroyo to the proposed channel of 51 ft.

Each proposed drop structure is designed to be a sloped shotcrete drop structure at a slope of 1.5:1 (horizontal to vertical); there will be 3-3 ft drops, 2-6 ft drops, 4-4 ft drops and 2-5 ft drops for a total of 11 structures that will be needed to establish channel longitudinal slope of 0.7 percent. For maintenance access, the drop structures will also include a slope paving access ramp that matches the channel section from the top of the drop structure to the downstream channel invert at a slope of 6:1 (horizontal to vertical), with side slopes that tie to the channel bottom at a 1.5:1 (horizontal to vertical) from the outside edge of the access ramp. The drop structures will also include shotcrete protection upstream and downstream of each structure. At all structures, the shotcrete protection will extend horizontally upstream 4.5 ft and will be toed down to the scour depth while the downstream protection will vary in length from 29 ft to 40 ft. This downstream protection length is based on drop structure dimension calculations discussed in the section below. A summary of the drop structure dimensions is included in Table 1 below. See Exhibit 3 for plan and sections for proposed drop structures.

Table 1: Drop Structure Dimensions

Drop Structure Location	Crest Width (ft)	Drop Height (ft)	Required Length of Drop (ft)	Design Length of Drop (ft)
Sta. 40+23	61	4	32.8	33.0
Sta. 38+71	61	4	32.8	33.0
Sta. 36+85	61	6	38.4	39.0
Sta. 32+33	64	4	32.2	33.0
Sta. 28+98	68	3	28.3	29.0
Sta. 28+18	68	4	31.9	32.0
Sta. 23+22	46	5	39.4	40.0
Sta. 21+20	69	3	28.2	29.0
Sta.18+98	70	5	34.0	35.0
Sta. 13+73	66	6	37.7	38.0
Sta. 12+75	55	3	30.6	31.0

1. DROP STRUCTURE DIMENSION ANALYSIS

To determine the length of the drop structures, a drop structure dimension analysis was performed for each drop structure. This analysis uses the equations for drop structure lengths in the document *Open Channel Flow*, Henderson, 1966, and requires input of crest width (varies from 55 ft to 70 ft), design flow rate (1,500 cfs), critical depth (determined from HEC-RAS) and height of vertical drop (varies from 3 ft to 6 ft).

The analysis indicates that for the 3 ft drop structures the required length of protection downstream of the structure ranges from 29 ft to 31 ft. This variation in length is due to the variation in the crest widths. Drop structures with smaller crest widths require longer lengths of the structure. The required length of protection downstream for the 6 ft drops ranges from 38 ft to 39 ft. For the 4 ft and 5 ft drop structures, the required length of protection downstream ranges 32 ft and 40 ft. Calculations for this analysis are included in Appendix B.

C. TRAINING DIKE

The training dike will convey flows from the existing Mirehaven Arroyo into the proposed Mirehaven Channel Improvements. The training dike is designed to be a 4 ft high earthen embankment with side slopes of 6:1 (horizontal to vertical) on the north side and 4:1 (horizontal) on the south side that extends upstream to ensure that all flow is directed into the proposed channel. This earthen section will also include shotcrete protection at a slope of 1.5:1 (horizontal to vertical) from the 100-yr WSEL to the scour depth. The north embankment will tie to the north proposed channel wall and extend approximately 190 ft north and west to the property boundary with the Petroglyph National Monument. The south embankment will tie the south proposed channel wall and will extend approximately 460 ft upstream in a south westerly direction.

D. FUTURE ROADWAY CROSSING STRUCTURE

As discussed previously in the DMP, a proposed future roadway crossing structure will be located at the intersection of the proposed roadway and the proposed channel. Due to phasing of the community, the channel improvements will be constructed before this crossing. Therefore, the details of the crossing structure have not been determined, and it is not included in this analysis. The future crossing structure will be evaluated and designed such that it does not adversely impact the hydraulics of the channel and provides adequate freeboard.

E. SCOUR PROTECTION

To protect the proposed improvements from local scour, shotcrete will be used along the channel and training dike. Throughout the channel and at the training dike, this scour protection is designed to be buried shotcrete, which is 7 inches thick, from the toe of the slope to the calculated scour depth at a slope of 1.5:1 (horizontal to vertical). The overall shotcrete protection will be from the 100-year water surface elevation and extend downward to provide local scour protection. A summary of the depth of this scour protection is included in Table 2 below. A discussion of the analysis of this scour depth is included in the following section.

Table 2: Scour Depth

Location	Design Scour Depth (ft)
Training Dike	3
Sta. 40+23 to Sta. 13+20	3
Sta. 13+20 to Sta. 12+20	4

1. SCOUR DEPTH ANALYSIS

To determine the scour depths to be used in the design of the Mirehaven Arroyo Improvements, a scour depth analysis was conducted. The scour depth analysis uses equation 3.89 of the *Sediment and Erosion Design Guide*, prepared by Resource Consultants & Engineers, Inc. dated November 1994, and calculates the scour depth along a flood wall when flow is parallel to the wall. This equation requires inputs of depth of flow and the Froude number at locations along the wall. These inputs were determined from the HEC-RAS model that was run in a mixed flow regime. This flow regime was selected due to the fact that the scour depth increases during supercritical flow.

The HEC-RAS outputs were then used to create a spreadsheet to calculate the depth of scour at each HEC-RAS cross section. The results of this analysis are summarized in the table above. Calculations and references for this analysis are included in Appendix B.

F. MAINTENANCE/PEDESTRIAN ACCESS

The design of the Mirehaven Arroyo Improvements also includes a 20 ft wide City of Albuquerque maintenance road. This maintenance road will be located on the north side of the channel and will have a cross slope of 2 percent away from the proposed top of the channel. See Exhibit 2 for typical maintenance road section. The design will include five access ramps at or near the locations of the previously approved design. Two access locations will be located just downstream and upstream of the proposed future roadway crossing; two will be located at the training dike allowing access to both the north and south sides of the channel and one at the existing Tierra Pintada Crossing on the north side. These locations are shown on Exhibit 1. Each access ramp will consist of a shotcrete ramp with a minimum width of 12 ft and a maximum slope of 6:1 (horizontal to vertical).

G. INTERIM CONDITIONS

The interim conditions were established previously with the original DMP and Amendment 1 and are discussed in those reports. The design changes discussed in this report are predominantly to the channel improvements which are within the drainage easement. Any grading changes outside the easement will be minor and will not change the overall interim conditions. The grading will tie to other City projects (Project No. 650381 and 650383).

APPENDIX A: MIREHAVEN ARROYO HYDRAULIC CALCULATIONS/ANALYSIS

MIREHAVEN ARROYO
IMPROVEMENTS
HEC-RAS PLAN
01/2015

N

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SCALE: 1"=100'

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Bohannan Huston
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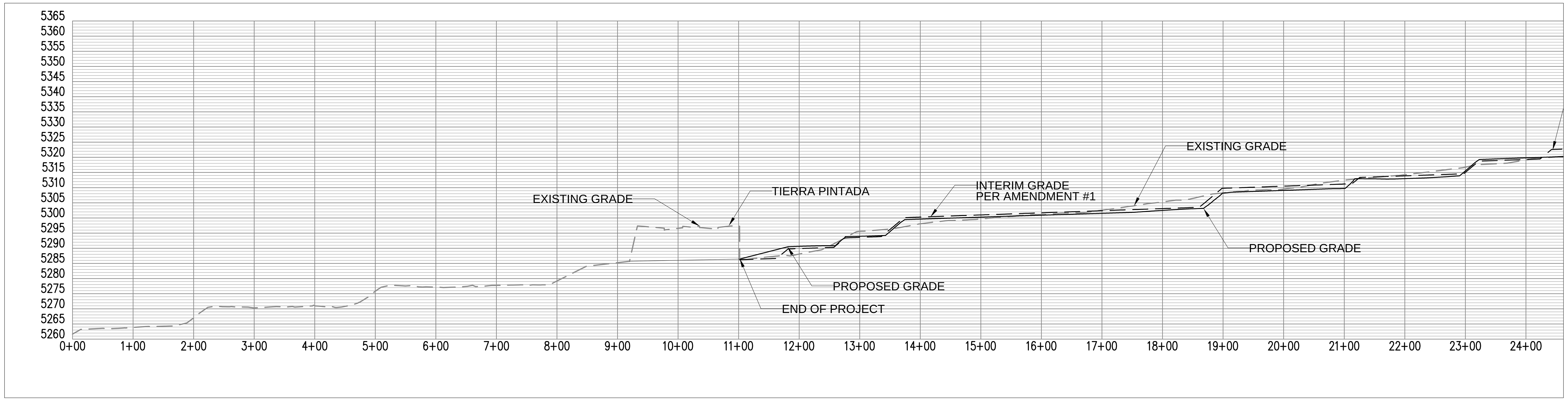

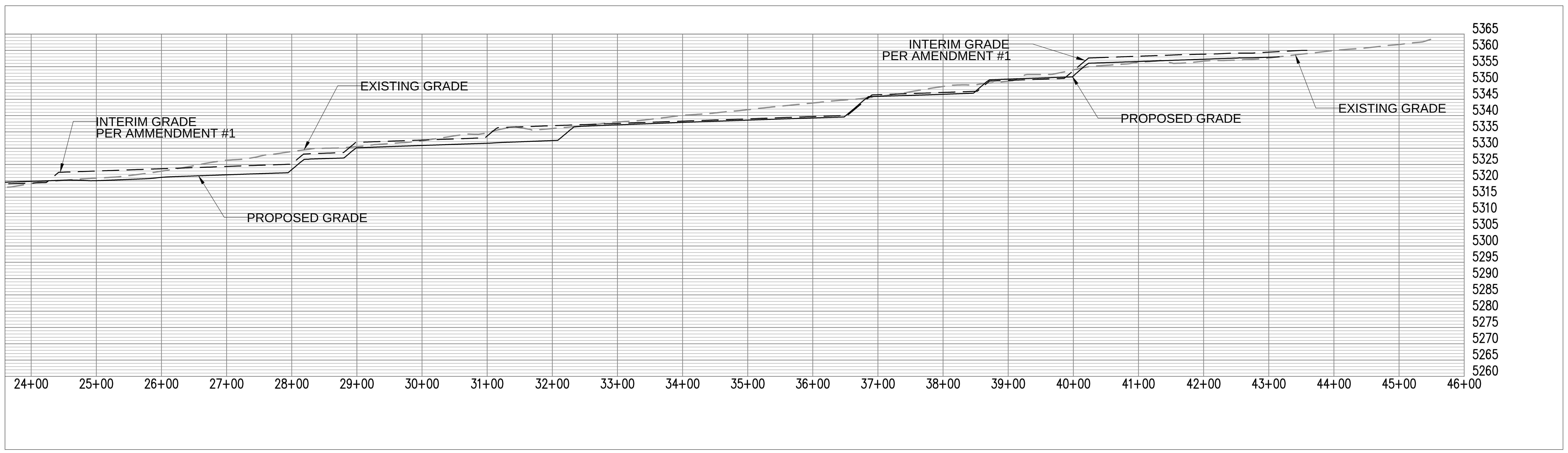

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VERT. SCALE: 1"=20'

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Layout1

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MIREHAVEN ARROYO IMPROVEMENTS

HEC-RAS PROFILE

DRAWN BY: JDE	DATE: 02/09/2015	
CHECKED BY: AE	PROJECT NO. 20130375	SHEET NO.

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev

Reach	River Sta	Plan	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)	
Reach	4535.000	Final_Sub_N_.018	1501.00	5362.56	5365.82	5365.82	5366.84	0.013219	7.52	187.00	91.52	0.97
Reach	4535.000	Final_N_.018	1501.00	5362.56	5365.54	5365.82	5366.89	0.020204	8.73	162.14	85.79	1.17
Reach	4460.000	Final_Sub_N_.018	1501.00	5360.96	5364.27	5364.27	5365.22	0.014765	7.75	191.69	102.26	1.01
Reach	4460.000	Final_N_.018	1501.00	5360.96	5363.97	5364.27	5365.29	0.022447	9.16	162.95	93.27	1.23
Reach	4410.000	Final_Sub_N_.018	1501.00	5360.15	5362.82	5362.82	5363.77	0.014732	8.01	191.77	102.39	1.01
Reach	4410.000	Final_N_.018	1501.00	5360.15	5362.37	5362.82	5363.97	0.030733	10.31	148.13	93.15	1.42
Reach	4360.000	Final_Sub_N_.018	1501.00	5359.03	5361.45	5361.45	5362.32	0.015089	7.61	200.77	116.89	1.01
Reach	4360.000	Final_N_.018	1501.00	5359.03	5361.13	5361.45	5362.42	0.027575	9.27	164.17	111.09	1.33
Reach	4310.000	Final_Sub_N_.018	1501.00	5358.05	5361.02		5361.42	0.006448	4.76	295.22	162.83	0.65
Reach	4310.000	Final_N_.018	1501.00	5358.05	5361.02	5360.57	5361.42	0.006448	4.76	295.22	162.83	0.65
Reach	4260.000	Final_Sub_N_.018	1501.00	5357.70	5360.95		5361.18	0.002579	3.85	392.88	167.55	0.44
Reach	4260.000	Final_N_.018	1501.00	5357.70	5360.95		5361.18	0.002579	3.85	392.88	167.55	0.44
Reach	4210.000	Final_Sub_N_.018	1501.00	5357.35	5360.87		5361.05	0.001940	3.56	432.56	170.86	0.39
Reach	4210.000	Final_N_.018	1501.00	5357.35	5360.87		5361.05	0.001940	3.56	432.56	170.86	0.39
Reach	4153.776	Final_Sub_N_.018	1501.00	5356.95	5360.64		5360.92	0.002400	4.29	356.28	126.23	0.44
Reach	4153.776	Final_N_.018	1501.00	5356.95	5360.64		5360.92	0.002400	4.29	356.28	126.23	0.44
Reach	4122.257	Final_Sub_N_.018	1501.00	5356.73	5360.45		5360.83	0.002777	4.92	304.24	103.98	0.49
Reach	4122.257	Final_N_.018	1501.00	5356.73	5360.45		5360.83	0.002777	4.92	304.24	103.98	0.49
Reach	4086.582	Final_Sub_N_.018	1501.00	5356.48	5360.14		5360.70	0.004081	5.98	250.29	85.08	0.60
Reach	4086.582	Final_N_.018	1501.00	5356.48	5360.14		5360.70	0.004081	5.98	250.29	85.08	0.60
Reach	4053.607	Final_Sub_N_.018	1501.00	5356.25	5359.72	5359.17	5360.51	0.006170	7.13	210.35	73.80	0.73
Reach	4053.607	Final_N_.018	1501.00	5356.25	5359.72	5359.17	5360.51	0.006170	7.13	210.35	73.80	0.73
Reach	4023.759	Final_Sub_N_.018	1501.00	5356.04	5358.96	5358.96	5360.21	0.012420	8.97	167.31	67.95	0.98
Reach	4023.759	Final_N_.018	1501.00	5356.04	5358.96	5358.96	5360.21	0.012420	8.97	167.31	67.95	0.98
Reach	4016.758	Final_Sub_N_.018	1501.00	5352.41	5355.75	5355.75	5357.01	0.003582	9.12	169.44	69.40	1.00
Reach	4016.758	Final_N_.018	1501.00	5352.41	5354.35	5355.75	5359.68	0.025833	18.70	81.99	50.04	2.52
Reach	3970.000	Final_Sub_N_.018	1501.00	5351.67	5355.08		5355.94	0.006845	7.47	200.86	69.39	0.75
Reach	3970.000	Final_N_.018	1501.00	5351.67	5353.52	5354.59	5357.29	0.075832	15.60	96.35	64.71	2.21

HEC-RAS   River: Stream   Reach: Reach   Profile: 100-yr Dev (Continued)

Reach	River Sta	Plan	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)	
Reach	3920.000	Final_Sub_N_.018	1501.00	5351.32	5354.75	5354.24	5355.60	0.006660	7.40	202.56	69.46	0.74
Reach	3920.000	Final_N_.018	1501.00	5351.32	5354.75	5354.24	5355.60	0.006660	7.40	202.56	69.46	0.74
Reach	3871.282	Final_Sub_N_.018	1501.00	5350.98	5353.90	5353.90	5355.15	0.012454	8.98	167.18	67.92	0.98
Reach	3871.282	Final_N_.018	1501.00	5350.98	5353.90	5353.90	5355.15	0.012454	8.98	167.18	67.92	0.98
Reach	3865.282	Final_Sub_N_.018	1501.00	5347.21	5350.88	5350.88	5352.13	0.003624	9.12	169.57	69.81	1.01
Reach	3865.282	Final_N_.018	1501.00	5347.21	5349.49	5350.88	5354.38	0.021562	17.91	85.76	48.95	2.32
Reach	3846.415	Final_Sub_N_.018	1501.00	5346.86	5350.26		5351.11	0.006676	7.39	203.03	69.98	0.74
Reach	3846.415	Final_N_.018	1501.00	5346.86	5348.48	5349.75	5353.54	0.124684	18.09	83.11	64.59	2.77
Reach	3820.000	Final_Sub_N_.018	1501.00	5346.66	5350.05		5350.93	0.006953	7.50	199.90	69.34	0.75
Reach	3820.000	Final_N_.018	1501.00	5346.66	5348.94	5349.58	5351.20	0.032725	12.07	124.44	65.99	1.52
Reach	3770.000	Final_Sub_N_.018	1501.00	5346.31	5349.71		5350.58	0.006902	7.49	200.38	69.38	0.75
Reach	3770.000	Final_N_.018	1501.00	5346.31	5349.71	5349.23	5350.58	0.006902	7.49	200.38	69.38	0.75
Reach	3720.000	Final_Sub_N_.018	1501.00	5345.96	5349.37	5348.87	5350.23	0.006772	7.44	201.61	69.48	0.74
Reach	3720.000	Final_N_.018	1501.00	5345.96	5349.37	5348.87	5350.23	0.006772	7.44	201.61	69.48	0.74
Reach	3685.282	Final_Sub_N_.018	1501.00	5345.72	5348.64	5348.64	5349.89	0.012409	8.97	167.38	67.95	0.98
Reach	3685.282	Final_N_.018	1501.00	5345.72	5348.64	5348.64	5349.89	0.012409	8.97	167.38	67.95	0.98
Reach	3676.157	Final_Sub_N_.018	1501.00	5340.32	5344.00	5344.00	5345.46	0.003524	10.01	156.46	54.05	1.01
Reach	3676.157	Final_N_.018	1501.00	5340.32	5342.28	5344.00	5349.14	0.034952	20.96	71.85	44.17	2.89
Reach	3648.004	Final_Sub_N_.018	1501.00	5339.53	5343.17		5343.93	0.005272	6.96	215.15	68.65	0.67
Reach	3648.004	Final_N_.018	1501.00	5339.53	5341.05	5342.44	5347.07	0.157779	19.72	76.23	62.06	3.09
Reach	3620.000	Final_Sub_N_.018	1501.00	5339.30	5342.96		5343.77	0.005698	7.21	207.72	66.86	0.69
Reach	3620.000	Final_N_.018	1501.00	5339.30	5341.54	5342.31	5344.13	0.037925	12.92	116.25	62.35	1.63
Reach	3570.000	Final_Sub_N_.018	1501.00	5338.97	5342.09	5342.02	5343.34	0.011050	8.96	167.41	63.07	0.94
Reach	3570.000	Final_N_.018	1501.00	5338.97	5342.09	5342.02	5343.34	0.011050	8.96	167.41	63.07	0.94
Reach	3520.000	Final_Sub_N_.018	1501.00	5338.57	5341.51	5341.51	5342.76	0.012295	8.98	167.18	67.35	0.97
Reach	3520.000	Final_N_.018	1501.00	5338.57	5341.51	5341.51	5342.76	0.012295	8.98	167.18	67.35	0.97
Reach	3470.000	Final_Sub_N_.018	1501.00	5338.09	5341.21	5340.92	5342.12	0.008546	7.78	199.56	80.41	0.82

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev (Continued)

Reach	River Sta	Plan	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)	
Reach	3470.000	Final_N_.018	1501.00	5338.09	5341.21	5340.92	5342.12	0.008546	7.78	199.56	80.41	0.82
Reach	3420.000	Final_Sub_N_.018	1501.00	5337.61	5341.13		5341.69	0.004994	6.03	248.94	89.30	0.63
Reach	3420.000	Final_N_.018	1501.00	5337.61	5341.13		5341.69	0.004994	6.03	248.94	89.30	0.63
Reach	3370.000	Final_Sub_N_.018	1501.00	5337.25	5340.95		5341.46	0.003831	5.85	266.53	90.92	0.57
Reach	3370.000	Final_N_.018	1501.00	5337.25	5340.95		5341.46	0.003831	5.85	266.53	90.92	0.57
Reach	3320.000	Final_Sub_N_.018	1501.00	5337.01	5340.63		5341.23	0.005145	6.24	240.17	83.77	0.64
Reach	3320.000	Final_N_.018	1501.00	5337.01	5340.63		5341.23	0.005145	6.24	240.17	83.77	0.64
Reach	3270.000	Final_Sub_N_.018	1501.00	5336.76	5340.20	5339.58	5340.94	0.005898	6.90	217.35	74.62	0.70
Reach	3270.000	Final_N_.018	1501.00	5336.76	5340.20	5339.58	5340.94	0.005898	6.90	217.35	74.62	0.70
Reach	3233.282	Final_Sub_N_.018	1501.00	5336.52	5339.37	5339.37	5340.59	0.012638	8.86	169.41	70.65	0.98
Reach	3233.282	Final_N_.018	1501.00	5336.52	5339.37	5339.37	5340.59	0.012638	8.86	169.41	70.65	0.98
Reach	3227.282	Final_Sub_N_.018	1501.00	5332.93	5336.33	5336.33	5337.55	0.003645	9.00	171.27	71.96	1.01
Reach	3227.282	Final_N_.018	1501.00	5332.93	5334.91	5336.33	5340.09	0.025424	18.41	83.13	51.22	2.49
Reach	3208.590	Final_Sub_N_.018	1501.00	5332.38	5335.65		5336.49	0.006927	7.36	203.79	72.22	0.75
Reach	3208.590	Final_N_.018	1501.00	5332.38	5333.89	5335.17	5339.15	0.139616	18.43	81.60	66.93	2.90
Reach	3170.000	Final_Sub_N_.018	1501.00	5332.04	5335.39	5334.90	5336.22	0.006798	7.33	204.85	72.15	0.74
Reach	3170.000	Final_N_.018	1501.00	5332.04	5334.46	5334.90	5336.26	0.023924	10.78	139.41	69.37	1.31
Reach	3120.000	Final_Sub_N_.018	1501.00	5331.68	5334.52	5334.52	5335.73	0.012622	8.83	170.12	71.27	0.98
Reach	3120.000	Final_N_.018	1501.00	5331.68	5334.52	5334.52	5335.73	0.012622	8.83	170.12	71.27	0.98
Reach	3070.000	Final_Sub_N_.018	1501.00	5331.16	5334.19		5334.91	0.007043	6.78	221.78	88.39	0.74
Reach	3070.000	Final_N_.018	1501.00	5331.16	5334.19	5333.74	5334.91	0.007043	6.78	221.78	88.39	0.74
Reach	3020.000	Final_Sub_N_.018	1501.00	5330.72	5334.10		5334.57	0.003987	5.49	273.87	97.81	0.56
Reach	3020.000	Final_N_.018	1501.00	5330.72	5334.10		5334.57	0.003987	5.49	273.87	97.81	0.56
Reach	2970.000	Final_Sub_N_.018	1501.00	5330.39	5333.95		5334.38	0.003312	5.22	287.99	96.89	0.52
Reach	2970.000	Final_N_.018	1501.00	5330.39	5333.95		5334.38	0.003312	5.22	287.99	96.89	0.52
Reach	2920.000	Final_Sub_N_.018	1501.00	5330.17	5333.51	5332.82	5334.15	0.005335	6.40	234.81	83.64	0.65
Reach	2920.000	Final_N_.018	1501.00	5330.17	5333.51	5332.82	5334.15	0.005335	6.40	234.81	83.64	0.65

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev (Continued)

Reach	River Sta	Plan	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)	
Reach	2898.282	Final_Sub_N_.018	1501.00	5329.98	5332.75	5332.75	5333.92	0.012829	8.69	172.81	74.66	0.98
Reach	2898.282	Final_N_.018	1501.00	5329.98	5332.75	5332.75	5333.92	0.012829	8.69	172.81	74.66	0.98
Reach	2894.282	Final_Sub_N_.018	1501.00	5327.58	5330.65	5330.65	5331.83	0.003579	8.81	174.28	75.39	1.00
Reach	2894.282	Final_N_.018	1501.00	5327.58	5329.57	5330.65	5333.56	0.026508	16.15	94.23	72.35	2.46
Reach	2880.837	Final_Sub_N_.018	1501.00	5327.08	5330.33		5331.11	0.006404	7.08	212.11	75.02	0.73
Reach	2880.837	Final_N_.018	1501.00	5327.08	5328.66	5329.79	5332.91	0.103956	16.55	90.75	70.00	2.55
Reach	2855.037	Final_Sub_N_.018	1501.00	5326.82	5330.02	5329.66	5330.92	0.007856	7.61	197.31	72.88	0.79
Reach	2855.037	Final_N_.018	1501.00	5326.82	5329.20	5329.66	5331.02	0.024893	10.83	138.71	70.42	1.33
Reach	2818.282	Final_Sub_N_.018	1501.00	5326.44	5329.31	5329.31	5330.53	0.012541	8.88	169.04	69.96	0.98
Reach	2818.282	Final_N_.018	1501.00	5326.44	5329.31	5329.31	5330.53	0.012541	8.88	169.04	69.96	0.98
Reach	2813.282	Final_Sub_N_.018	1501.00	5322.86	5326.37	5326.37	5327.60	0.003639	9.05	170.39	70.81	1.01
Reach	2813.282	Final_N_.018	1501.00	5322.86	5324.94	5326.37	5330.06	0.024060	18.29	83.71	50.04	2.43
Reach	2794.821	Final_Sub_N_.018	1501.00	5322.51	5325.65	5325.33	5326.61	0.008320	7.87	190.58	70.02	0.81
Reach	2794.821	Final_N_.018	1501.00	5322.51	5324.05	5325.33	5329.19	0.129538	18.22	82.53	65.23	2.81
Reach	2770.000	Final_Sub_N_.018	1501.00	5322.25	5325.16	5325.12	5326.35	0.011976	8.77	171.26	69.88	0.96
Reach	2770.000	Final_N_.018	1501.00	5322.25	5324.43	5325.12	5326.81	0.037059	12.39	121.31	67.70	1.60
Reach	2720.000	Final_Sub_N_.018	1501.00	5321.79	5325.11		5325.79	0.005782	6.64	226.30	81.13	0.68
Reach	2720.000	Final_N_.018	1501.00	5321.79	5325.11	5324.48	5325.79	0.005782	6.64	226.30	81.13	0.68
Reach	2670.000	Final_Sub_N_.018	1501.00	5321.35	5325.08		5325.51	0.003080	5.24	286.61	91.34	0.51
Reach	2670.000	Final_N_.018	1501.00	5321.35	5325.08		5325.51	0.003080	5.24	286.61	91.34	0.51
Reach	2620.000	Final_Sub_N_.018	1501.00	5320.93	5325.06		5325.35	0.001815	4.31	346.82	99.67	0.40
Reach	2620.000	Final_N_.018	1501.00	5320.93	5325.06		5325.35	0.001815	4.31	346.82	99.67	0.40
Reach	2570.000	Final_Sub_N_.018	1501.00	5320.36	5325.06		5325.25	0.001082	3.65	429.46	116.32	0.31
Reach	2570.000	Final_N_.018	1501.00	5320.36	5325.06		5325.25	0.001082	3.65	429.46	116.32	0.31
Reach	2520.000	Final_Sub_N_.018	1501.00	5320.05	5325.01		5325.20	0.000937	3.54	443.61	113.84	0.29
Reach	2520.000	Final_N_.018	1501.00	5320.05	5325.01		5325.20	0.000937	3.54	443.61	113.84	0.29
Reach	2470.000	Final_Sub_N_.018	1501.00	5320.15	5324.63		5325.10	0.002633	5.47	274.60	73.94	0.48
Reach	2470.000	Final_N_.018	1501.00	5320.15	5324.63		5325.10	0.002633	5.47	274.60	73.94	0.48

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev (Continued)

Reach	River Sta	Plan	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)	
Reach	2420.000	Final_Sub_N_.018	1501.00	5319.97	5323.74		5324.83	0.007136	8.33	179.49	55.95	0.78
Reach	2420.000	Final_N_.018	1501.00	5319.97	5323.74		5324.83	0.007136	8.33	179.49	55.95	0.78
Reach	2370.000	Final_Sub_N_.018	1501.00	5319.62	5323.22	5322.96	5324.43	0.008516	8.81	169.91	55.43	0.85
Reach	2370.000	Final_N_.018	1501.00	5319.62	5323.22	5322.96	5324.43	0.008516	8.81	169.91	55.43	0.85
Reach	2322.282	Final_Sub_N_.018	1501.00	5319.17	5322.50	5322.50	5323.95	0.011326	9.61	155.77	54.81	0.96
Reach	2322.282	Final_N_.018	1501.00	5319.17	5322.50	5322.50	5323.95	0.011326	9.61	155.77	54.81	0.96
Reach	2314.185	Final_Sub_N_.018	1501.00	5314.61	5318.90	5318.90	5320.31	0.003629	9.79	160.09	58.98	1.02
Reach	2314.185	Final_N_.018	1501.00	5314.61	5317.23	5318.90	5323.35	0.021922	20.25	77.17	37.04	2.38
Reach	2290.505	Final_Sub_N_.018	1501.00	5313.89	5316.70	5316.70	5317.86	0.013275	8.65	173.53	75.91	0.99
Reach	2290.505	Final_N_.018	1501.00	5313.89	5315.30	5316.70	5322.08	0.224058	20.91	71.85	68.31	3.57
Reach	2220.000	Final_Sub_N_.018	1501.00	5313.10	5316.68		5317.14	0.003701	5.56	278.87	98.32	0.55
Reach	2220.000	Final_N_.018	1501.00	5313.10	5316.68	5315.70	5317.14	0.003701	5.56	278.87	98.32	0.55
Reach	2170.000	Final_Sub_N_.018	1501.00	5312.78	5316.54		5316.96	0.003113	5.30	293.41	98.50	0.51
Reach	2170.000	Final_N_.018	1501.00	5312.78	5316.54		5316.96	0.003113	5.30	293.41	98.50	0.51
Reach	2120.282	Final_Sub_N_.018	1501.00	5312.68	5315.44	5315.44	5316.61	0.012859	8.67	173.24	75.20	0.98
Reach	2120.282	Final_N_.018	1501.00	5312.68	5315.44	5315.44	5316.61	0.012859	8.67	173.24	75.20	0.98
Reach	2115.282	Final_Sub_N_.018	1501.00	5309.82	5312.98	5312.98	5314.16	0.003638	8.80	174.31	75.95	1.00
Reach	2115.282	Final_N_.018	1501.00	5309.82	5311.82	5312.98	5316.20	0.022431	16.90	90.17	57.27	2.33
Reach	2101.362	Final_Sub_N_.018	1501.00	5309.51	5312.43	5312.25	5313.43	0.010098	8.03	186.85	76.12	0.88
Reach	2101.362	Final_N_.018	1501.00	5309.51	5311.10	5312.25	5315.58	0.118438	17.01	88.37	72.11	2.67
Reach	2070.000	Final_Sub_N_.018	1501.00	5309.22	5312.22		5313.09	0.009169	7.47	200.92	82.84	0.83
Reach	2070.000	Final_N_.018	1501.00	5309.22	5311.53	5311.94	5313.21	0.026562	10.39	144.58	79.78	1.35
Reach	2020.000	Final_Sub_N_.018	1501.00	5308.70	5312.12		5312.68	0.004681	6.07	255.70	94.45	0.62
Reach	2020.000	Final_N_.018	1501.00	5308.70	5312.12	5311.35	5312.68	0.004681	6.07	255.70	94.45	0.62
Reach	1970.000	Final_Sub_N_.018	1501.00	5308.42	5311.91		5312.44	0.004655	5.80	258.82	93.27	0.61
Reach	1970.000	Final_N_.018	1501.00	5308.42	5311.91		5312.44	0.004655	5.80	258.82	93.27	0.61
Reach	1920.000	Final_Sub_N_.018	1501.00	5308.20	5311.26	5310.90	5312.10	0.007942	7.34	204.17	79.68	0.79

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev (Continued)

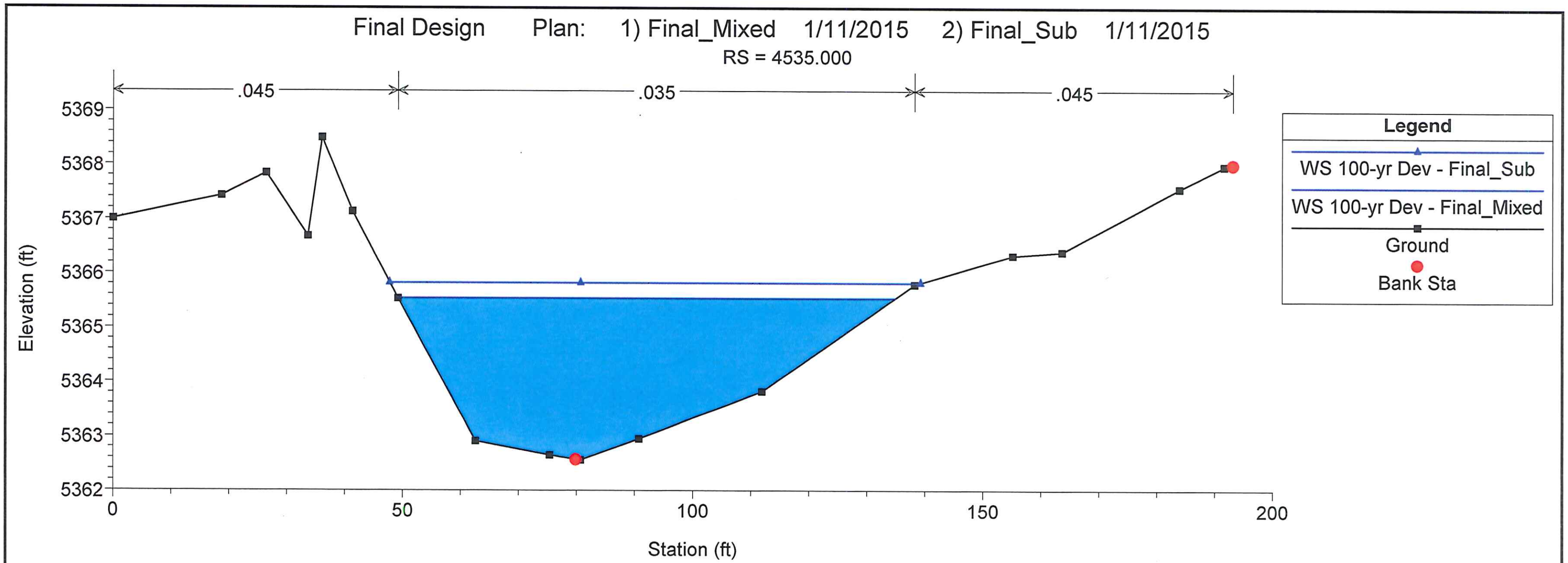
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	1920.000	Final_N_.018	1501.00	5308.20	5311.26	5310.90	5312.10	0.007942	7.34	204.17	79.68	0.79
Reach	1898.282	Final_Sub_N_.018	1501.00	5307.96	5310.70	5310.70	5311.86	0.012950	8.65	173.77	76.09	0.98
Reach	1898.282	Final_N_.018	1501.00	5307.96	5310.70	5310.70	5311.86	0.012950	8.65	173.77	76.09	0.98
Reach	1891.051	Final_Sub_N_.018	1501.00	5303.45	5306.90	5306.90	5308.06	0.003510	8.79	175.36	77.74	1.01
Reach	1891.051	Final_N_.018	1501.00	5303.45	5305.24	5306.90	5311.23	0.034364	19.76	77.15	53.45	2.84
Reach	1868.360	Final_Sub_N_.018	1501.00	5303.00	5305.94		5306.85	0.008541	7.64	196.60	76.41	0.82
Reach	1868.360	Final_N_.018	1501.00	5303.00	5304.40	5305.64	5309.56	0.148979	18.24	82.42	71.78	2.97
Reach	1820.000	Final_Sub_N_.018	1501.00	5302.50	5305.19	5305.19	5306.32	0.013185	8.55	175.80	79.11	0.99
Reach	1820.000	Final_N_.018	1501.00	5302.50	5304.92	5305.19	5306.38	0.020079	9.72	154.67	78.30	1.20
Reach	1770.000	Final_Sub_N_.018	1501.00	5302.03	5304.58	5304.58	5305.61	0.013517	8.15	184.31	90.04	0.99
Reach	1770.000	Final_N_.018	1501.00	5302.03	5304.58	5304.58	5305.61	0.013517	8.15	184.31	90.04	0.99
Reach	1720.000	Final_Sub_N_.018	1501.00	5301.50	5304.20		5304.90	0.009403	6.74	222.93	107.89	0.82
Reach	1720.000	Final_N_.018	1501.00	5301.50	5304.20	5303.93	5304.90	0.009403	6.74	222.93	107.89	0.82
Reach	1670.000	Final_Sub_N_.018	1501.00	5300.95	5304.08		5304.50	0.004540	5.17	290.71	121.25	0.58
Reach	1670.000	Final_N_.018	1501.00	5300.95	5304.08		5304.50	0.004540	5.17	290.71	121.25	0.58
Reach	1620.000	Final_Sub_N_.018	1501.00	5300.52	5304.01		5304.29	0.002523	4.34	353.44	131.11	0.45
Reach	1620.000	Final_N_.018	1501.00	5300.52	5304.01		5304.29	0.002523	4.34	353.44	131.11	0.45
Reach	1570.000	Final_Sub_N_.018	1501.00	5300.17	5303.93		5304.17	0.001862	3.96	387.97	132.21	0.39
Reach	1570.000	Final_N_.018	1501.00	5300.17	5303.93		5304.17	0.001862	3.96	387.97	132.21	0.39
Reach	1520.000	Final_Sub_N_.018	1501.00	5299.92	5303.83		5304.08	0.001793	4.05	381.41	124.06	0.39
Reach	1520.000	Final_N_.018	1501.00	5299.92	5303.83		5304.08	0.001793	4.05	381.41	124.06	0.39
Reach	1470.000	Final_Sub_N_.018	1501.00	5299.78	5303.64		5303.97	0.002531	4.55	329.40	107.80	0.45
Reach	1470.000	Final_N_.018	1501.00	5299.78	5303.64		5303.97	0.002531	4.55	329.40	107.80	0.45
Reach	1420.000	Final_Sub_N_.018	1501.00	5299.71	5303.08		5303.75	0.005496	6.57	228.44	80.28	0.67
Reach	1420.000	Final_N_.018	1501.00	5299.71	5303.08		5303.75	0.005496	6.57	228.44	80.28	0.67
Reach	1373.282	Final_Sub_N_.018	1501.00	5299.32	5302.13	5302.13	5303.32	0.012741	8.77	171.25	72.80	0.98
Reach	1373.282	Final_N_.018	1501.00	5299.32	5302.13	5302.13	5303.32	0.012741	8.77	171.25	72.80	0.98

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev (Continued)

Reach	River Sta	Plan	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)	
Reach	1365.281	Final_Sub_N_.018	1501.00	5294.63	5298.28	5298.28	5299.44	0.008682	8.60	173.91	75.15	0.98
Reach	1365.281	Final_N_.018	1501.00	5294.63	5296.56	5298.28	5302.61	0.106949	19.77	76.10	50.38	2.77
Reach	1342.651	Final_Sub_N_.018	1501.00	5294.24	5297.47		5298.32	0.007311	7.40	202.93	74.09	0.76
Reach	1342.651	Final_N_.018	1501.00	5294.24	5295.98	5297.04	5299.78	0.085326	15.67	95.97	69.60	2.32
Reach	1320.000	Final_Sub_N_.018	1501.00	5294.07	5297.14		5298.12	0.009118	7.94	189.19	73.11	0.84
Reach	1320.000	Final_N_.018	1501.00	5294.07	5296.46	5296.89	5298.24	0.024470	10.74	139.95	71.06	1.32
Reach	1275.282	Final_Sub_N_.018	1501.00	5293.45	5296.51	5296.51	5297.86	0.003295	9.42	163.88	62.60	0.99
Reach	1275.282	Final_N_.018	1501.00	5293.45	5296.43	5296.51	5297.86	0.003622	9.70	159.09	62.37	1.03
Reach	1270.281	Final_Sub_N_.018	1501.00	5291.10	5296.81		5297.19	0.000447	5.11	311.31	68.13	0.40
Reach	1270.281	Final_N_.018	1501.00	5291.10	5296.81	5294.54	5297.19	0.000447	5.11	311.31	68.13	0.40
Reach	1260.172	Final_Sub_N_.018	1501.00	5290.94	5296.81		5297.19	0.000373	5.10	315.18	63.64	0.38
Reach	1260.172	Final_N_.018	1501.00	5290.94	5296.81		5297.19	0.000373	5.10	315.18	63.64	0.38
Reach	1220.000	Final_Sub_N_.018	1501.00	5290.74	5296.08		5297.09	0.003906	7.95	186.28	43.66	0.62
Reach	1220.000	Final_N_.018	1501.00	5290.74	5296.08		5297.09	0.003906	7.95	186.28	43.66	0.62
Reach	1181.535	Final_Sub_N_.018	1501.00	5290.50	5295.62		5296.95	0.002134	9.25	162.24	39.99	0.81
Reach	1181.535	Final_N_.018	1501.00	5290.50	5295.62		5296.95	0.002134	9.25	162.24	39.99	0.81
Reach	1170.000	Final_Sub_N_.018	1501.00	5289.91	5295.91		5296.79	0.001174	7.51	199.96	42.76	0.61
Reach	1170.000	Final_N_.018	1501.00	5289.91	5295.91		5296.79	0.001174	7.51	199.96	42.76	0.61
Reach	1120.000	Final_Sub_N_.018	1501.00	5287.37	5296.30		5296.59	0.000256	4.36	344.05	52.01	0.30
Reach	1120.000	Final_N_.018	1501.00	5287.37	5296.30		5296.59	0.000256	4.36	344.05	52.01	0.30
Reach	1106.630	Final_Sub_N_.018	1501.00	5286.68	5296.33	5291.05	5296.57	0.000189	3.91	384.08	54.30	0.26
Reach	1106.630	Final_N_.018	1501.00	5286.68	5296.33	5291.05	5296.57	0.000189	3.91	384.08	54.30	0.26
Reach	1003.396		Culvert									
Reach	899.1468	Final_Sub_N_.018	1501.00	5285.21	5288.84	5288.84	5290.35	0.015159	10.82	155.82	50.37	1.09
Reach	899.1468	Final_N_.018	1501.00	5285.21	5288.84	5288.84	5290.35	0.015159	10.82	155.82	50.37	1.09
Reach	847.1920	Final_Sub_N_.018	1501.00	5283.90	5286.96	5286.96	5288.35	0.013326	9.43	159.20	58.22	1.00
Reach	847.1920	Final_N_.018	1501.00	5283.90	5286.18	5286.97	5288.84	0.036586	13.08	114.78	55.09	1.60

HEC-RAS River: Stream Reach: Reach Profile: 100-yr Dev (Continued)

Reach	River Sta	Plan	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)	
Reach	772.1919	Final_Sub_N_.018	1501.00	5277.59	5281.67		5282.41	0.005619	6.92	216.98	66.17	0.67
Reach	772.1919	Final_N_.018	1501.00	5277.59	5279.57	5280.83	5284.12	0.092833	17.13	87.62	56.87	2.43
Reach	699.9867	Final_Sub_N_.018	1501.00	5277.41	5281.31		5281.98	0.005826	6.54	229.68	79.08	0.68
Reach	699.9867	Final_N_.018	1501.00	5277.41	5281.31	5280.56	5281.98	0.005826	6.54	229.68	79.08	0.68
Reach	599.9421	Final_Sub_N_.018	1501.00	5277.00	5280.09	5279.95	5281.14	0.011538	8.22	182.53	74.53	0.93
Reach	599.9421	Final_N_.018	1501.00	5277.00	5280.09	5279.95	5281.14	0.011538	8.22	182.53	74.53	0.93
Reach	500.0074	Final_Sub_N_.018	1501.00	5275.50	5278.69	5278.69	5279.87	0.013886	8.69	172.73	74.74	1.01
Reach	500.0074	Final_N_.018	1501.00	5275.50	5278.69	5278.69	5279.87	0.013886	8.69	172.73	74.74	1.01
Reach	400.0000	Final_Sub_N_.018	1501.00	5270.51	5274.77		5275.45	0.005687	6.61	227.06	75.45	0.67
Reach	400.0000	Final_N_.018	1501.00	5270.51	5272.87	5273.99	5276.78	0.083879	15.87	94.59	64.04	2.30
Reach	300.0000	Final_Sub_N_.018	1501.00	5270.27	5273.42	5273.42	5274.56	0.013782	8.56	175.43	77.41	1.00
Reach	300.0000	Final_N_.018	1501.00	5270.27	5273.42	5273.42	5274.56	0.013835	8.57	175.20	77.38	1.00
Reach	200.0000	Final_Sub_N_.018	1501.00	5266.92	5270.21	5270.21	5271.49	0.013423	9.07	165.40	65.26	1.00
Reach	200.0000	Final_N_.018	1501.00	5266.92	5269.36	5270.21	5272.13	0.043324	13.36	112.36	59.97	1.72
Reach	100.0000	Final_Sub_N_.018	1501.00	5263.85	5266.83	5266.83	5268.11	0.013497	9.08	165.38	65.38	1.01
Reach	100.0000	Final_N_.018	1501.00	5263.85	5266.24	5266.83	5268.39	0.029736	11.75	127.72	62.12	1.44
Reach	0.0000	Final_Sub_N_.018	1501.00	5261.62	5265.09	5265.09	5266.41	0.013329	9.22	162.86	62.30	1.00
Reach	0.0000	Final_N_.018	1501.00	5261.62	5265.08	5265.08	5266.41	0.013374	9.23	162.68	62.28	1.01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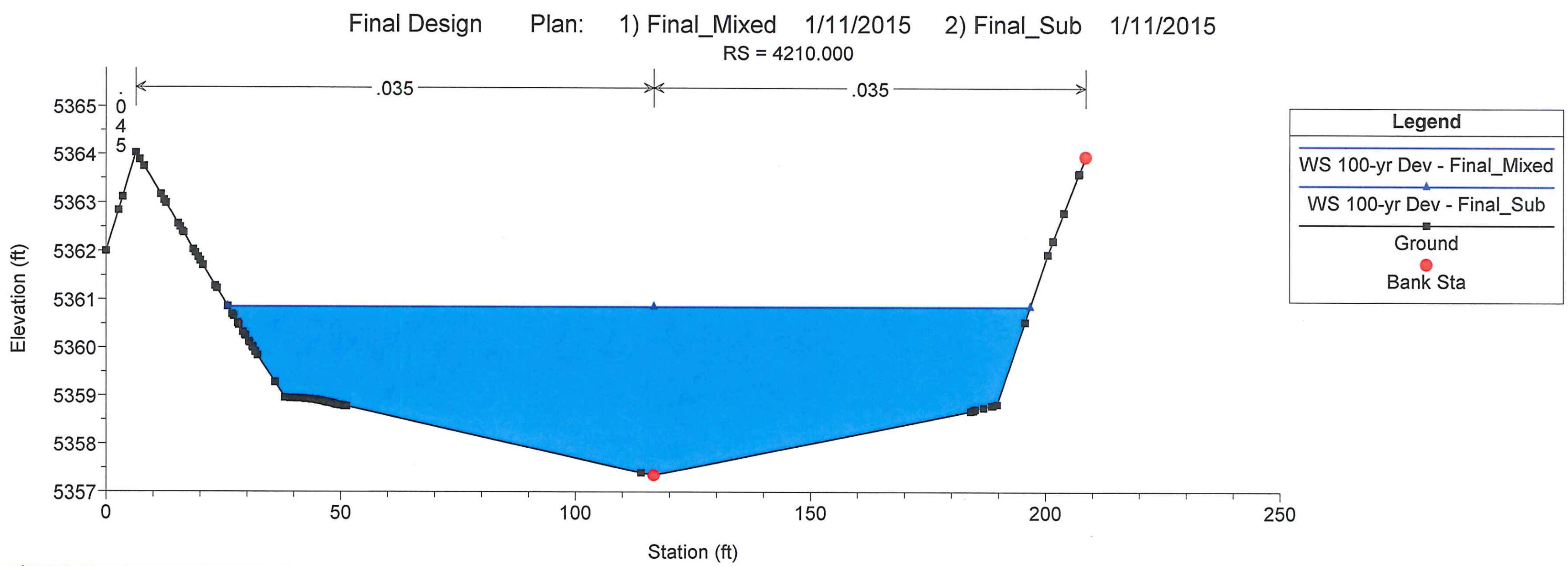
.045
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 100-yr Dev - Final_Sub
WS 100-yr Dev - Final_Mixed
Ground
Bank Sta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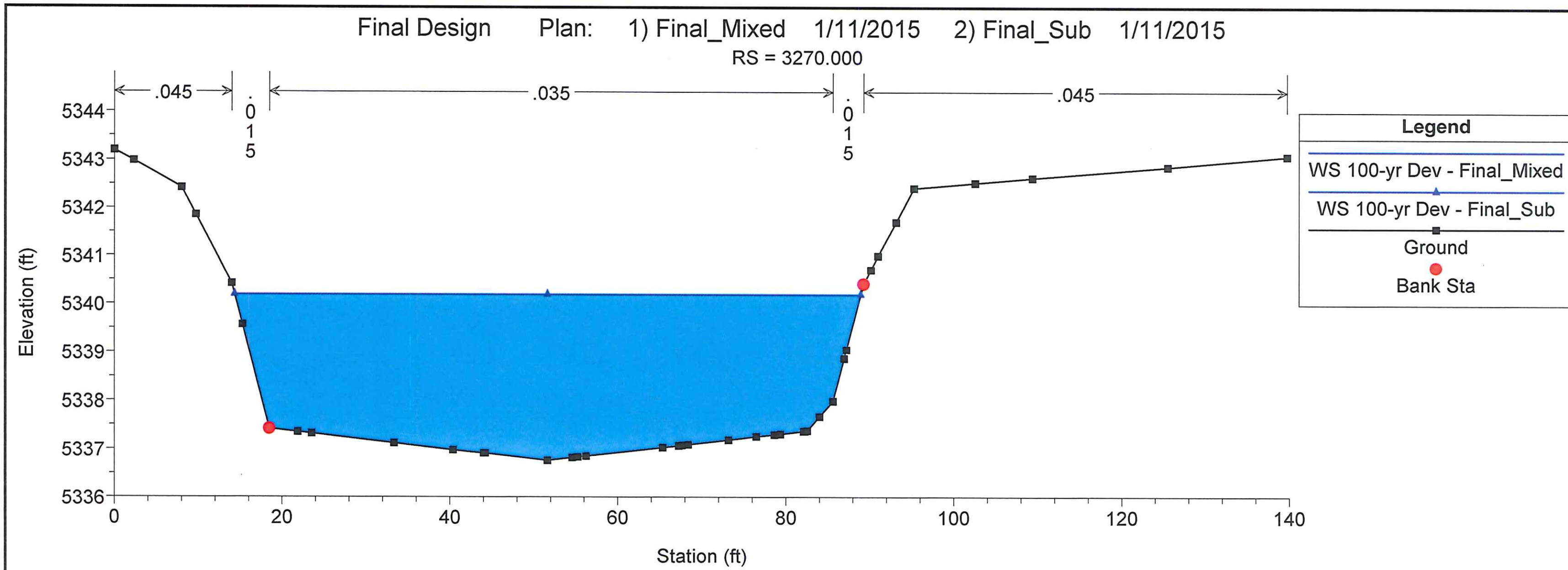
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta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.035
.045
.015
.015
Elevation (ft)
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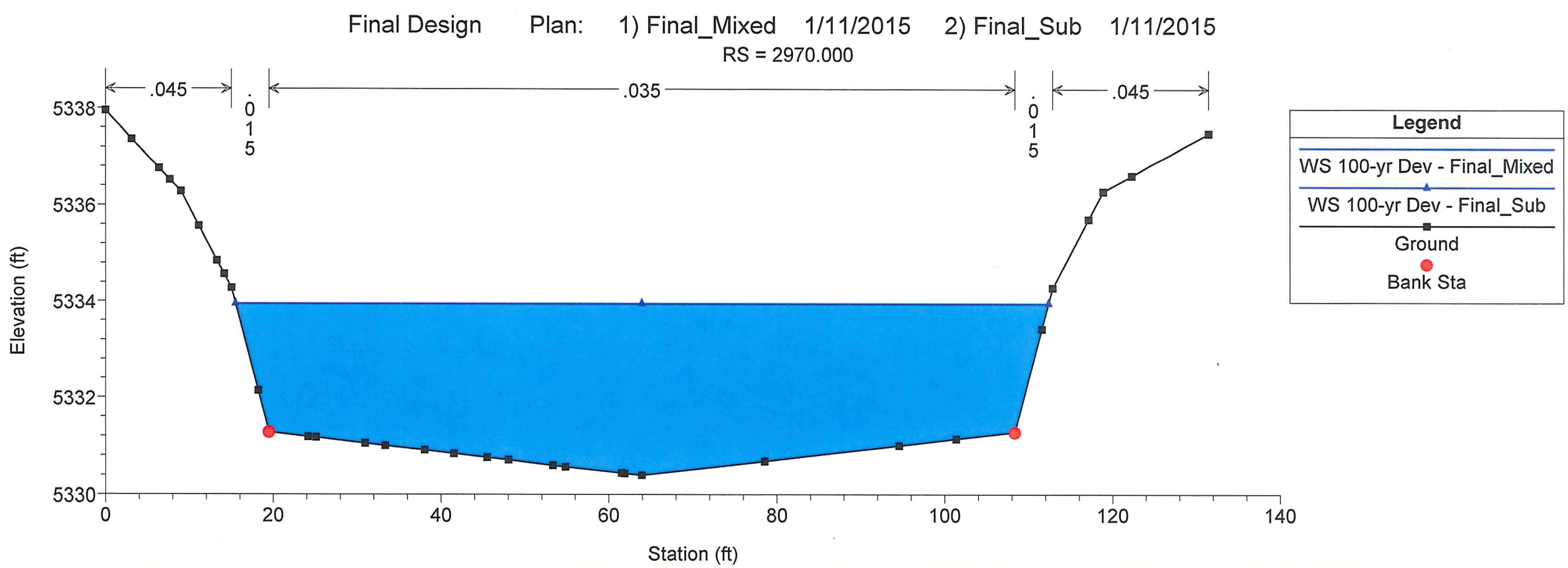
5343
5342
5341
5340
5339
5338
5337
5336
Station (ft)
0
20
40
60
80
100
120
140
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta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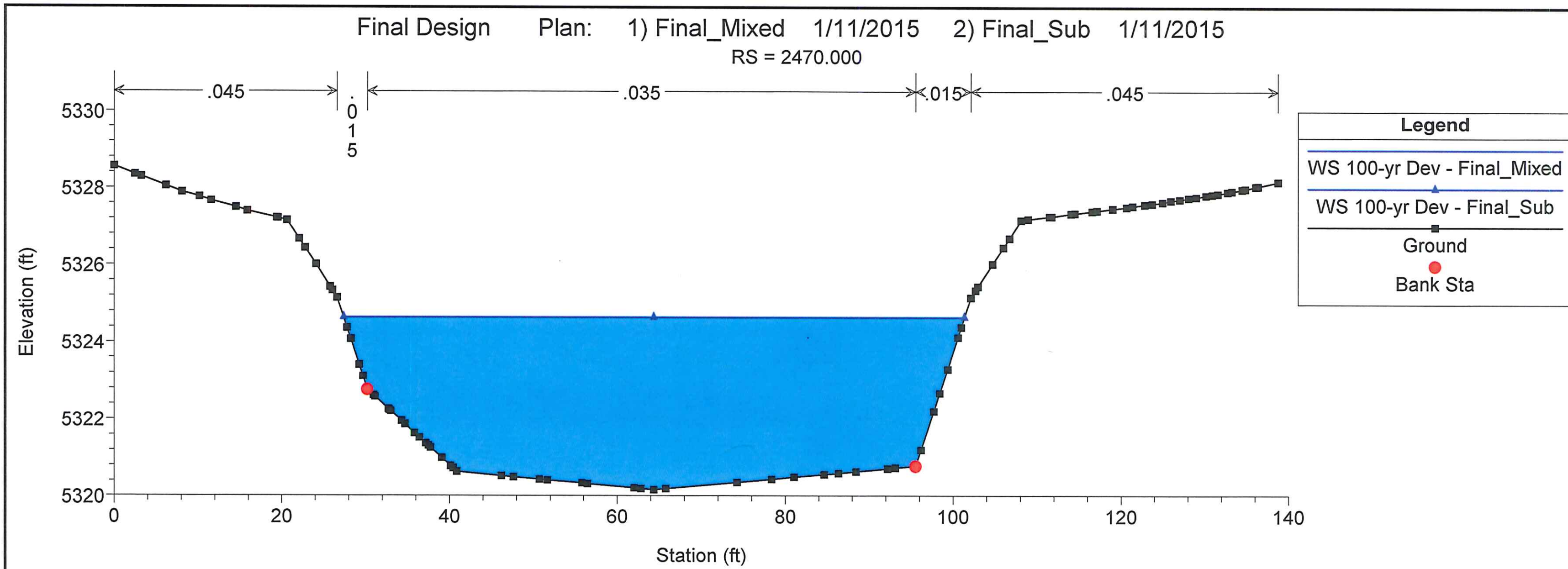
.035
.045
.015
.015
Elevation (ft)
5338
5336
5334
5332
5330
Station (ft)
0
20
40
60
80
100
120
140
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta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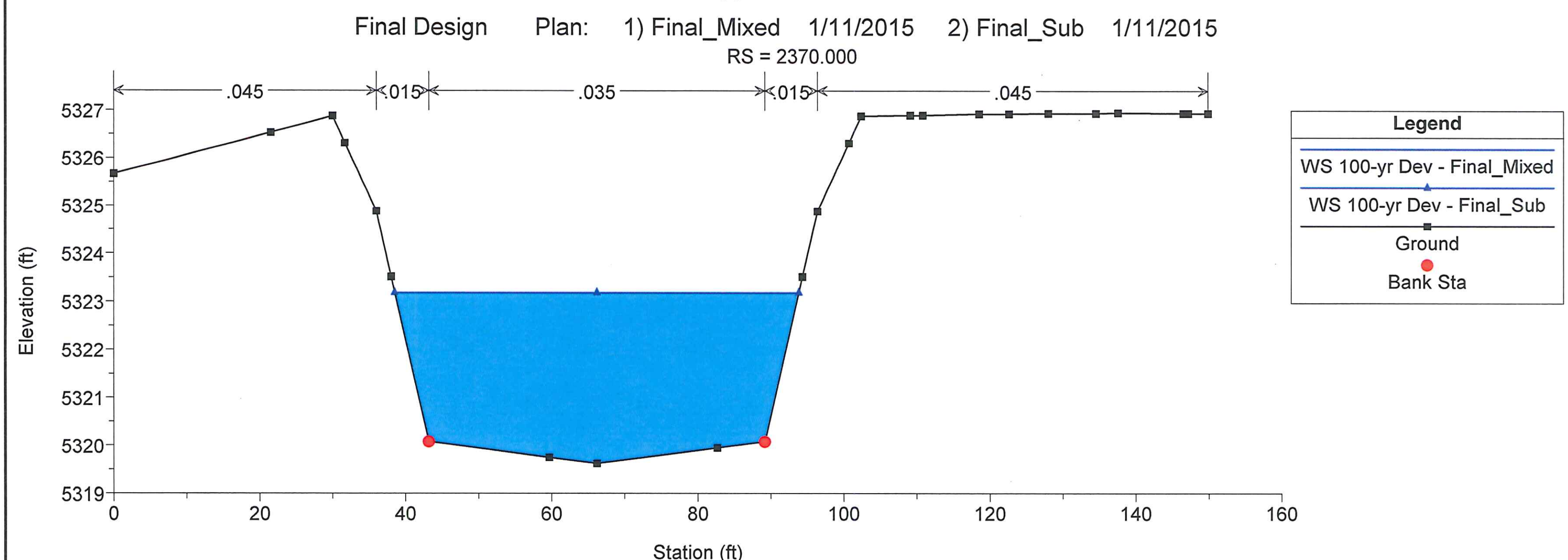
.015
.035
.015
.045
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta
Elevation (ft)
5330
5328
5326
5324
5322
5320
0
20
40
60
80
100
120
140
Station (ft)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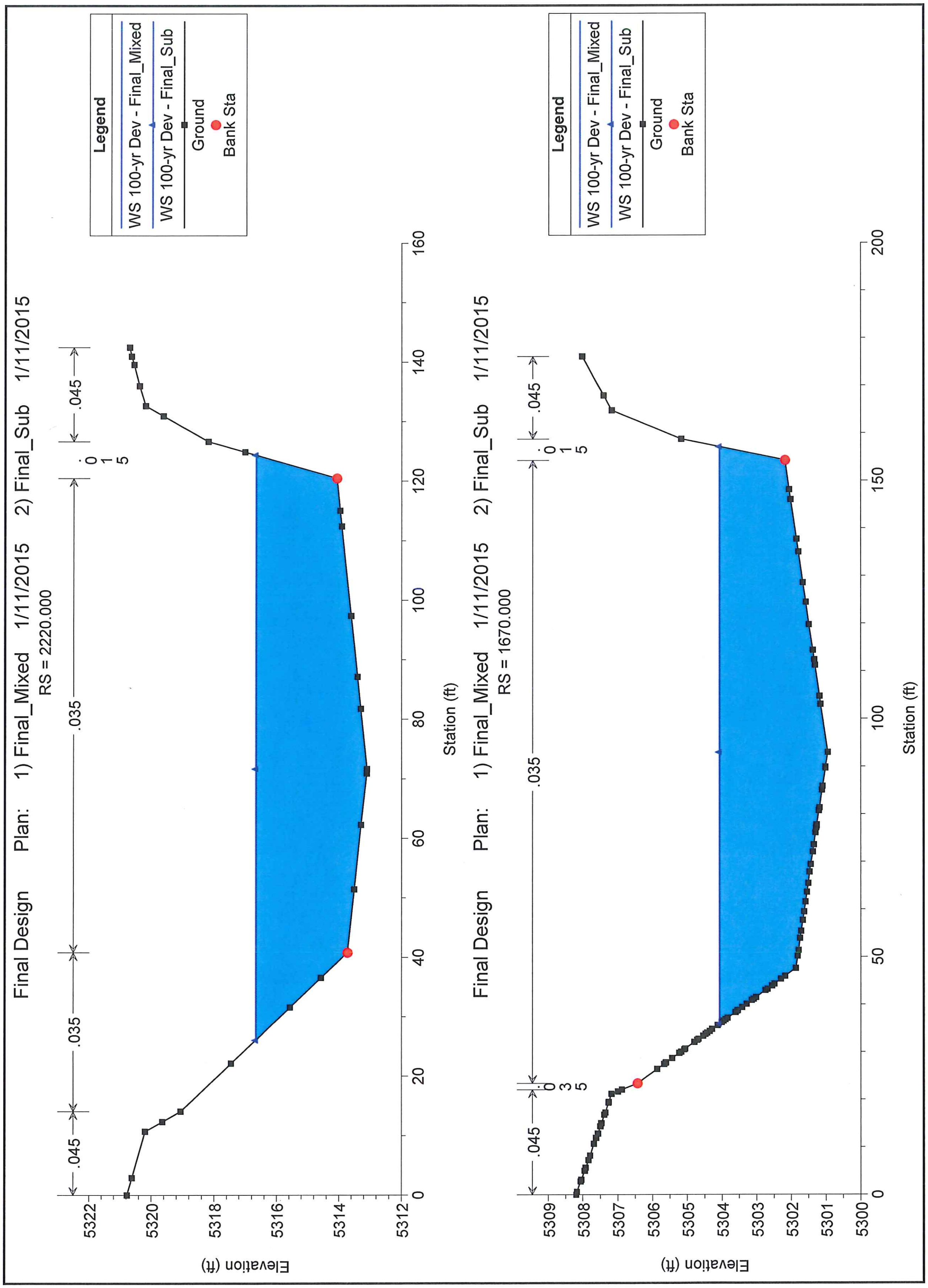
.015
.035
.015
.045
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta
Elevation (ft)
5327
5326
5325
5324
5323
5322
5321
5320
5319
0
20
40
60
80
100
120
140
160
Station (ft)



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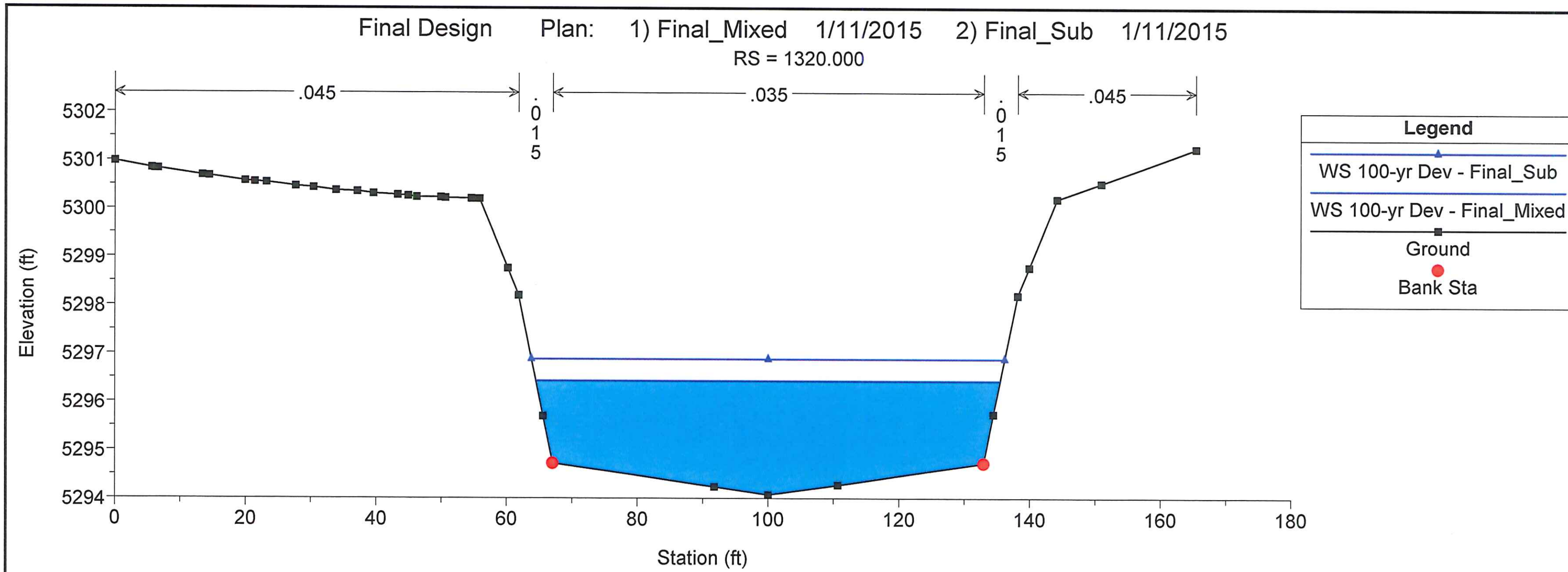
.045
.035
.035
.045
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta
Elevation (ft)
Station (ft)
Final Design Plan: 1) Final_Mixed 1/11/2015 2) Final_Sub 1/11/2015
RS = 1670.000
.045
.035
.045
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta
Elevation (ft)
Station (ft)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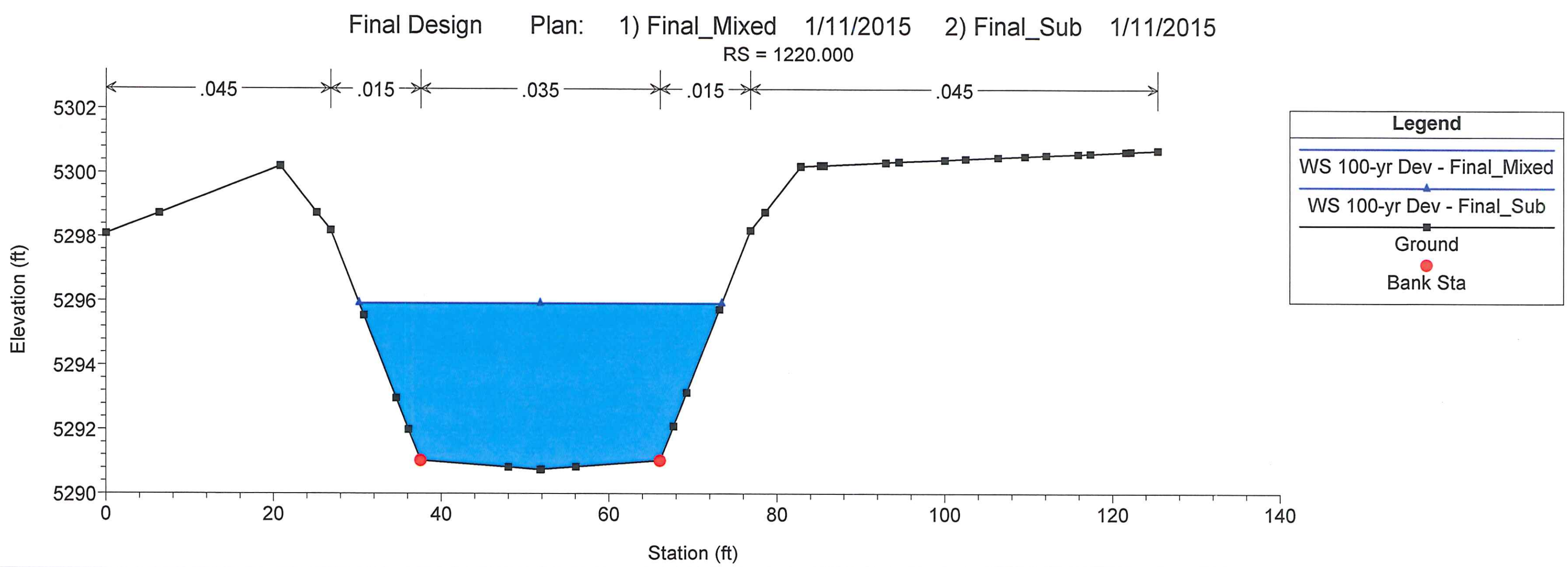
.015
.035
.015
.045
Elevation (ft)
Station (ft)
Legend
WS 100-yr Dev - Final_Sub
WS 100-yr Dev - Final_Mixed
Ground
Bank Sta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.015
.035
.015
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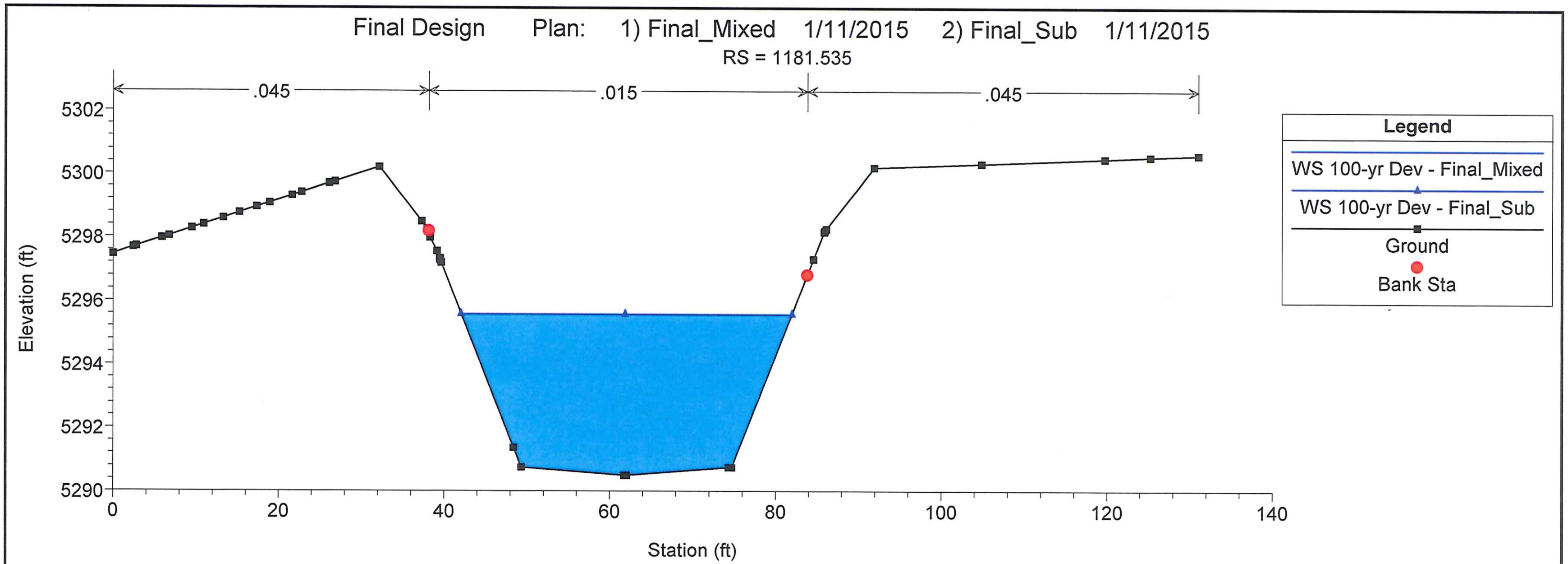
Elevation (ft)
Station (ft)
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta



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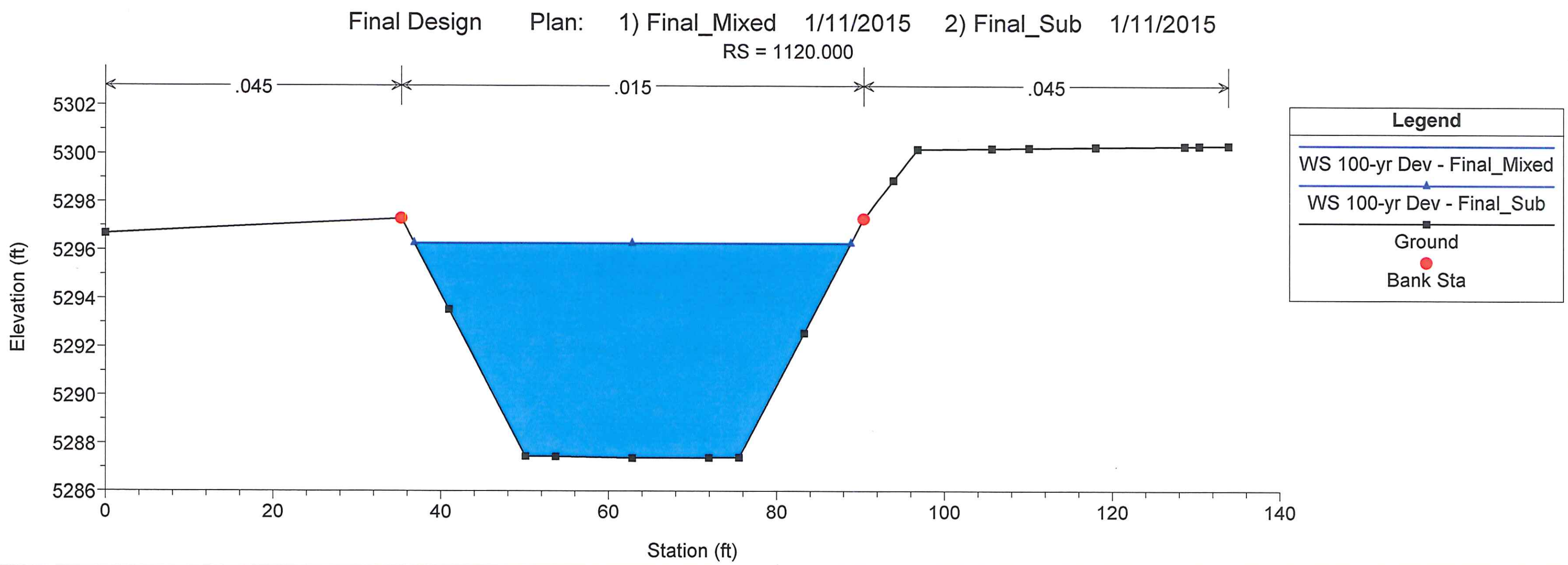
.015
.045
Elevation (ft)
5302
5300
5298
5296
5294
5292
5290
0
20
40
60
80
100
120
140
Station (ft)
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta



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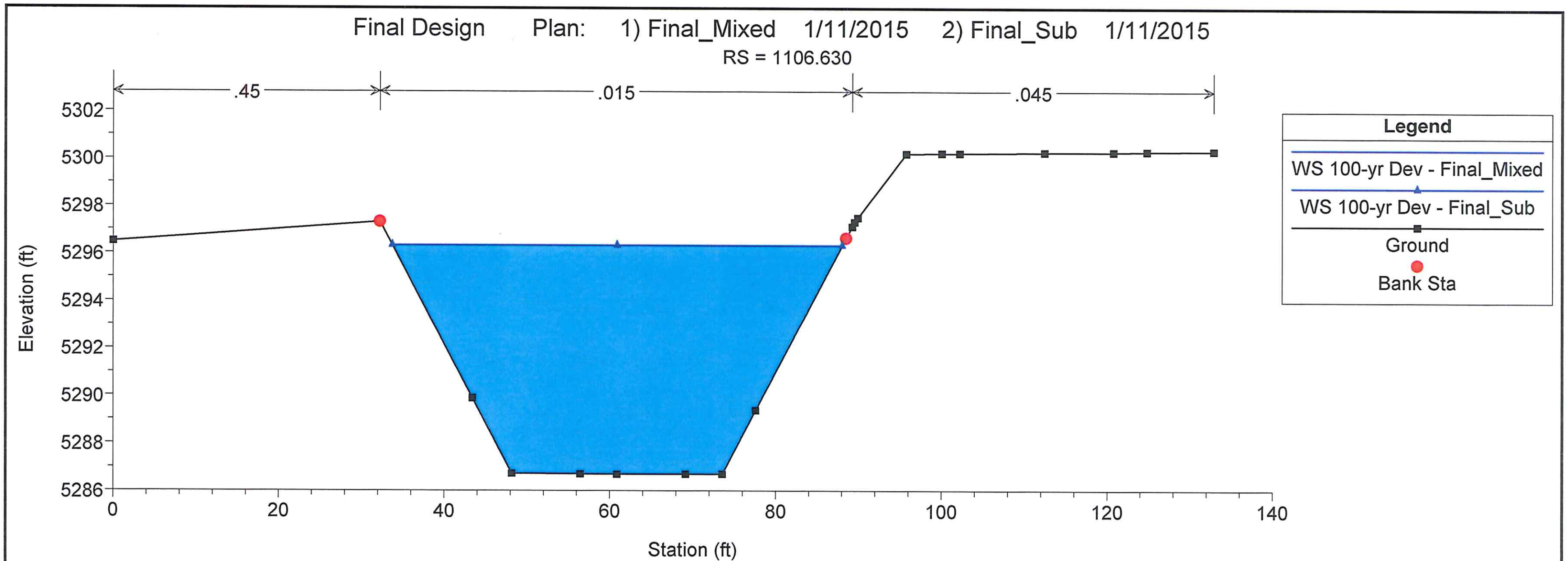
.015
.045
Elevation (ft)
5302
5300
5298
5296
5294
5292
5290
5288
5286
0
20
40
60
80
100
120
140
Station (ft)
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta



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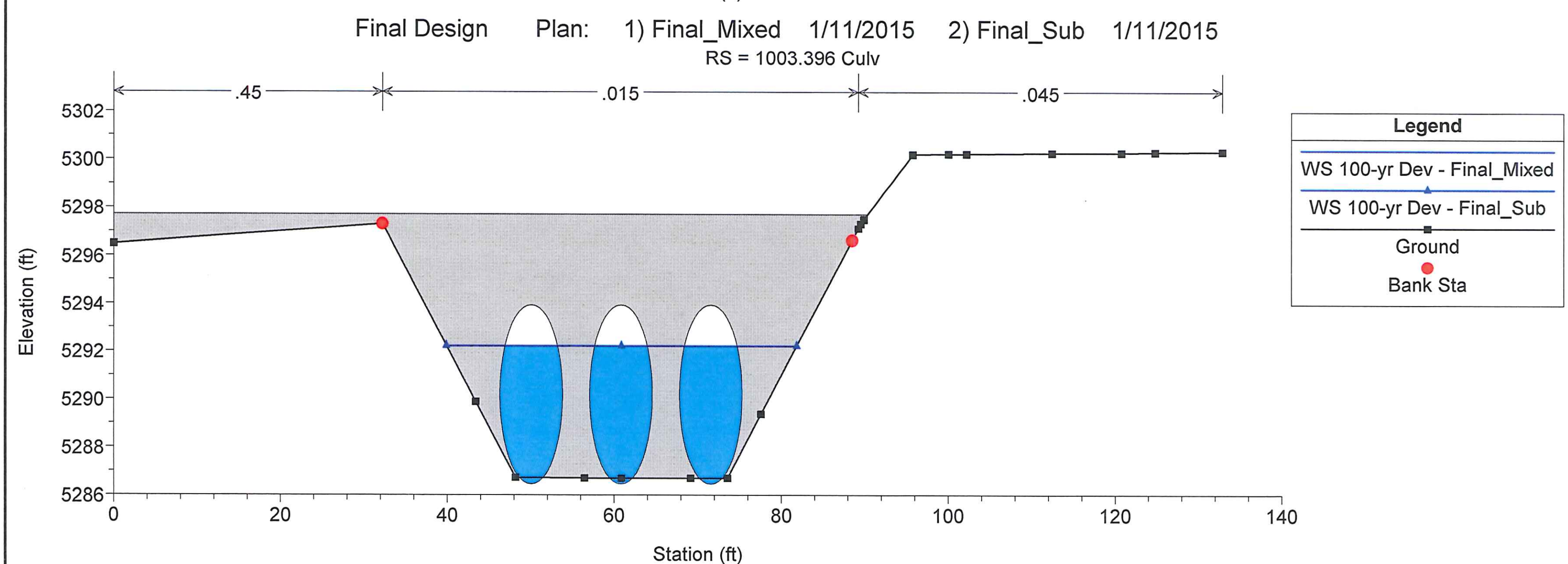
.45
.015
.045
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta
Elevation (ft)
5302
5300
5298
5296
5294
5292
5290
5288
5286
0
20
40
60
80
100
120
140
Station (ft)



Final Design Plan: 1) Final_Mixed 1/11/2015 2) Final_Sub 1/11/2015
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.45
.015
.045
Legend
WS 100-yr Dev - Final_Mixed
WS 100-yr Dev - Final_Sub
Ground
Bank Sta
Elevation (ft)
5302
5300
5298
5296
5294
5292
5290
5288
5286
0
20
40
60
80
100
120
140
Station (ft)

Mirehaven Arroyo
Superelevation Calculations

Reference: "City of Albuquerque, DPM" (pg. 22-126)

Superelevation can be determined by $S = (1.15 \times V^2 \ (b + 2zD) \div (2gr))$

where z = cotangent of bank slope
b = Channel Bottom Width
D = Depth
r = radius of channel centerline

	1	2	3	4	5	6	7	8	9	10
River Sta	Q Total	Depth Sub	Bank Slope	Bottom Width	Vel Chnl Sub	Top Width Sub	Radius	Superelevation Sub	Sub Depth+Super	Minimum Wall Height
								(Ssub)	(2+8)	(9-(.02*Bottom Width/2))
(ft)	(cfs)	(ft)	(H:V)	(ft)	(ft/s)	(ft)	(ft)	(ft)	(ft)	(ft)
4260	1500	3.3	4	61	3.9	167.6	250.0	0.1	3.3	2.7
4210	1500	3.5	4	61	3.6	170.9	250.0	0.1	3.6	3.0
4153.776	1500	3.7	4	61	4.3	126.2	250.0	0.1	3.8	3.2
4122.257	1500	3.7	4	61	4.9	104.0	200.0	0.2	3.9	3.3
4086.582	1500	3.7	4	61	5.9	85.1	200.0	0.3	3.9	3.3
4053.607	1500	3.5	4	61	7.1	73.8	200.0	0.4	3.9	3.3
3970	1500	3.4	1.5	61	7.4	69.4	255.0	0.3	3.6	3.0
3820	1500	3.4	1.5	61	7.5	69.3	255.0	0.3	3.6	3.0
3420	1500	3.5	1.5	72	6.0	89.3	350.0	0.2	3.7	3.0
2970	1500	3.6	1.5	90	5.2	96.9	320.0	0.2	3.7	2.8
2855.037	1500	3.2	1.5	65	7.6	72.9	320.0	0.2	3.4	2.8
2720	1500	3.3	1.5	65	6.6	81.1	375.0	0.2	3.5	2.8
2520	1500	5.0	1.5	88	3.5	113.8	375.0	0.1	5.0	4.1
2020	1500	3.4	1.5	69	6.1	94.5	350.0	0.1	3.6	2.9
1868.36	1500	2.9	1.5	69	7.6	76.4	350.0	0.2	3.2	2.5

up to a distance L_f from the brink equal to a few pipe diameters. The figures given by Smith are:

$Q/D^2\sqrt{gD}$	0.65	0.54	0.47
y_c/D	0.82	0.75	0.70
L_f/D	0.25	0.65	2.6

from which it appears that y_c/D would have to be less than 0.6 for a free surface to exist over a substantial distance back from the brink. Vennard [23] suggests that the flow should be ventilated by holes drilled along the top of the pipe; this would have the effect of increasing L_f. Of course, no measures of this sort would be effective unless the slope and roughness of the pipe are such that uniform flow is possible when the pipe runs part full.

The Base of the Overfall

The situation is illustrated in Fig. 6-16, which shows a complete "drop structure" such as is installed at intervals in steep channels in order to dissipate energy without scouring the channel. We are concerned here with the events occurring where the jet strikes the floor and turns downstream at section 1.

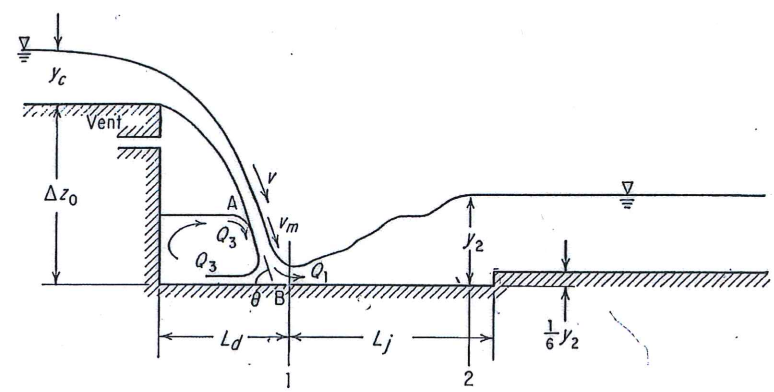


Figure 6-16. *The Drop Structure*

In this region there will be a great deal of energy loss because of circulation induced by the jet in the pool which forms beneath the nappe. The function of this pool is to supply the horizontal thrust required to turn the jet into the horizontal direction. The amount of the energy loss has been determined by the experiments of Moore [24], results of which are plotted in Fig. 6-17. Interesting comment on these results is provided by the analysis of White, who in a discussion of Ref. [24] assumed the following mechanism by which the jet sets up circulation in the pool: near the point A, a thin layer of water, with experiment is remarkably good considering the approximations that must be inherent in this formulation of the problem.

This analysis by White is commended to the reader as a good example of the way in which skilful formulation and a grasp of fundamentals can yield surprisingly exact solutions of problems which may at first glance appear intractable by theoretical methods. The details can be worked out by the reader as an exercise (Probs. 6.10 and 6.11).

The Drop Structure

Figure 6-17 shows that the energy loss E_L at the base of an overfall may be 50 percent or more of the initial energy, referred to the basin floor as datum. If, as in Fig. 6-16, there is a hydraulic jump downstream of section 1 dissipating further energy, the energy loss in the entire "drop structure" may be very substantial. The loss due to the hydraulic jump is readily calculated (Prob. 6.12) in terms of the parameters of Fig. 6-17, and a curve is plotted on that figure displaced to the left of the E_1/y_c curve by the amount E_J/y_c, where E_J is the loss in the jump. This left-hand curve then indicates the remaining specific energy E_2 downstream of the jump. It is seen that the ratio E_2/y_c does not vary greatly with $\Delta z_0/y_c$; this suggests that a value of 2.5 for E_2/y_c may form a satisfactory basis for a preliminary design (Probs. 6.13 and 6.14).

Rand [25] assembled the results of experimental measurements made by himself, by Moore [24], and others, and from them obtained the following exponential equations, which fit the data with errors of 5 percent or less:

$$\frac{y_1}{\Delta z_0} = 0.54\left(\frac{y_c}{\Delta z_0}\right)^{1.275} \qquad (6\text{–}37a)$$

or

$$\frac{y_1}{y_c} = 0.54\left(\frac{y_c}{\Delta z_0}\right)^{0.275} \qquad (6\text{–}37b)$$

$$\frac{y_2}{\Delta z_0} = 1.66\left(\frac{y_c}{\Delta z_0}\right)^{0.81} \qquad (6\text{–}38)$$

$$\frac{L_d}{\Delta z_0} = 4.30\left(\frac{y_c}{\Delta z_0}\right)^{0.09} \qquad (6\text{–}39)$$

$$L_j = 6.9(y_2 - y_1) \qquad (6\text{–}40)$$

where L_d and L_j are the horizontal distances covered by the jet and the hydraulic jump respectively, as shown in Fig. 6-16. With the help of these equations the designer can proportion the simple drop structure completely. The upward step of $y_2/6$ at the end of the structure, shown in Fig. 6-16, is a standard design feature which helps to localize the jump immediately below the overfall.

MIREHAVEN ARROYO DROP STRUCTURE ANALYSIS
BH JOB NO. 20130375
Last Updated: *1/12/2015* **JDE**
HYDRAULIC COMPUTATIONS TO DETERMINE THE DROP STRUCTURE DIMENSIONS

Drop Structure Location	Crest Width (ft) B	2011 DMP Q100 (cfs)	x-section side slope 1V:zH	Critical Depth (ft) Yc	Brink Depth (ft) Yb	Brink Vel (fps) Vb	Last Step height (ft) h	Length of bench (ft) LD	Slope of steps S	Rounded Total drop height (ft) Hd	Number of drops	1.5:1 Length	HENDERSON, pg 200 eq. 6-37b Y1	eq. 6-38 Y2	eq. 6-40 Lj	Total Length of Drop Struct. (ft)	Design Length of Drop Struct. (ft)
Sta. 40+23	61	1500	1.5	2.9	2.1	11.78	4	7.3	0.55	4.0	1.0	6.0	1.4	5.1	25.5	32.8	33.0
Sta. 38+71	61	1500	1.5	2.9	2.1	11.74	4	7.2	0.55	4.0	1.0	6.0	1.5	5.2	25.6	32.8	33.0
Sta. 36+85	61	1500	1.5	2.9	2.1	11.82	6	8.4	0.71	6.0	1.0	9.0	1.3	5.5	29.4	38.4	39.0
Sta. 32+33	64	1500	1.5	2.9	2.0	11.46	4	7.0	0.57	4.0	1.0	6.0	1.4	5.1	25.2	32.2	33.0
Sta. 28+98	68	1500	1.5	2.8	2.0	11.14	3	6.2	0.48	3.0	1.0	4.5	1.5	4.7	22.1	28.3	29.0
Sta. 28+18	64	1500	1.5	2.9	2.1	11.38	4	7.0	0.57	4.0	1.0	6.0	1.4	5.1	25.3	32.3	33.0
Sta. 23+22	46	1500	1.5	3.3	2.4	13.65	5	9.3	0.54	5.0	1.0	7.5	1.6	6.0	30.2	39.4	40.0
Sta. 21+20	69	1500	1.5	2.8	2.0	11.02	3	6.1	0.49	3.0	1.0	4.5	1.5	4.7	22.1	28.2	29.0
Sta.18+98	70	1500	1.5	2.7	2.0	10.94	5	7.2	0.69	5.0	1.0	7.5	1.3	5.1	26.5	34.0	35.0
Sta. 13+73	66	1500	1.5	2.8	2.0	11.31	6	8.0	0.75	6.0	1.0	9.0	1.2	5.4	28.7	37.7	38.0
Sta. 12+75	55	1500	1.5	3.1	2.2	12.47	3	7.1	0.42	3.0	1.0	4.5	1.7	5.1	23.5	30.6	31.0

Notes:
1. The crest width shown is the maximum crest width for any drop
2. Q100 from the 2011 DMP for Developed Conditions.
3. Cross-Sectional Area 1.5:1 for Drops 1-11
4. Total Drop Height of each Drop Structure
5. Max height of drop is 6 feet.
6. Total length of structure = number of drops times the length of a step plus jump length.
7. "L", length of step, was computed using the Trajectory Method, per Black Arroyo Physical Model Study by R. Heggen, Oct. 20, 1990
8. Yc from Momentum Program and Brink Velocity read off Output from Momentum based on Brink Depth calculation.
9. Yb is calculated as 0.715 Yc Henderson, pg194

$$\frac{Y_s}{Y_1} = 4\ F_{r_1}^{0.33} \tag{3.88}$$

where Y_s = equilibrium depth of scour (measured from the mean bed level to the bottom of the scour hole)
Y_1 = average upstream flow depth in the main channel
a = abutment and embankment or wall length projecting into main channel
F_{r1} = upstream Froude Number

3.5.4. Scour Along a Flood Wall

Flow Parallel to the Wall. The probable mechanism causing scour along a flood wall when the flow is parallel to the wall is an increased boundary shear stress produced by locally increased velocity gradients that result from the reduced roughness of the flood wall, as compared to the natural channel. It is reasonable to conclude that this scour will continue until the local flow area has increased enough to reduce the local velocity, and hence the local boundary shear stress, to values typical of the rest of the channel cross section.

The distribution of boundary shear stress around the perimeter of a channel is not constant. In channels of uniform roughness, this distribution has been quantified both analytically (Olson and Florey, 1952; and Replogle and Chow, 1966) and experimentally (Ippen and Drinker, 1962; Davidian and Cahal, 1963; Rajaratnam and Muralidhar, 1969, Kartha and Leutheusser, 1970; and Schall, 1979). These results indicate that the boundary shear stress has a maximum value near the channel centerline, and a secondary peak about one-third of the way up the sideslope. On average, the maximum on the bottom is about 0.97 times the average boundary shear stress (e.g., as defined by γRS) for the cross section and the maximum on the side is about 0.76 times the average boundary shear stress. However, experimental data indicated a range of values, with maximum shear stresses as much as 1.6 times the average. In general, the boundary shear stress distribution is more uniform as the width to depth ratio increases.

Similar information is not available for channel cross sections of nonuniform roughness; however, reasonable conclusions can be drawn from intuitive arguments. For a straight channel with a flood wall with smoother roughness than the rest of the channel along one side, the boundary shear stress distribution would be skewed towards the flood wall side of the channel. The sideslope peak value would be larger and could possibly be greater than the peak along the channel bed, which would also be shifted off the centerline location. These effects would be more pronounced in narrow channels and/or channels with steep sideslopes. As the channel gets wider, or the sideslope flattens, these effects would be diminished.

Insight on the magnitude of these effects can be obtained by consideration of local velocity conditions as determined by conveyance weighting concepts. The analysis assumes that the boundary roughness within the channel can be divided into two distinct regions: one region defining the roughness of the channel and the other defining the roughness of the channel bottom (note that this division of roughness, while logical, is not always analytically useful as it can create numerical problems leading to errors in the computation of conveyance for the entire cross section).

For purposes of illustration, assume a wide, shallow natural channel has uniform roughness with an n value of 0.03, but with a concrete flood wall the n value of the bank region is reduced by a factor of two, to 0.015. Evaluation of the distribution of discharge by conveyance weighting shows that this reduction of n nearly doubles the conveyance, discharge and velocity adjacent to bank (i.e., next to the flood wall). Now, recognizing that boundary shear stress is proportional to velocity squared, this increase in velocity increases the boundary shear stress by a factor of 4.

Based on the results for a uniform roughness channel, where the maximum boundary shear on the channel sideslope is about 0.76 times the average boundary shear stress, these results suggest that the maximum boundary shear stress along the flood wall could be as much as 3 times the average boundary shear stress. However, this is not totally accurate given the simplistic assumptions made and the likely changes in the distribution pattern that would result under flood wall conditions. In any event, this simplified analysis suggests that significant increases in the boundary shear stress are possible adjacent to the flood wall.

For purposes of the Design Guide, it is appropriate to define a shear stress multiplier that can be applied to the average boundary shear stress to define the locally increased boundary shear stress adjacent to a flood wall. Based on the above argument, a shear stress factor of 3 will be utilized. Recognizing that boundary shear stress is proportional to velocity squared, the reduction in velocity necessary to lower the shear stress to an acceptable value is defined by the inverse of the square root of the shear stress multiplier (0.577) for a shear stress factor of 3. For the reduction in velocity to occur, the flow area must then be increased by the inverse of this factor (1/0.577 = 1.73). For a vertical flood wall, this calculation simplifies to a unit width basis and the scour depth is a multiplier of the flow depth ($0.73Y_1$).

It is important to understand that this provides a first approximation of the potential scour along a flood wall due to flow parallel to the wall. Using this relation, the total scour along the wall due to parallel flow can be approximated as the sum of the above relation which results from a differential in shear stress plus scour associated with the passage of antidunes (see Equation 3.68). This results in the following relationship:

$$\frac{Y_s}{Y_1} = 0.73 + 0.14\pi F_r^2 \qquad (3.89)$$

This equation is applicable only where parallel flow can be assured (e.g., flood walls along both arroyo banks).

Flow Impinging on the Wall at an Angle

As discussed in the previous section, when an obstruction such as an abutment projects into the flow, the depth of scour at the nose of the obstruction can be estimated from Equation 3.88. Considering the physical configuration of the channels for which the data on which this relation is based, this can reasonably be assumed to be the upper limit of the scour that could be expected for flow along a flood wall when the flow impinges on the wall at an approximately 90° angle. The total scour along a flood wall, thus, will vary as a proportion of that given by Equations 3.88 and 3.89. If it is assumed that the relative significance of the two scour mechanisms is related to the change in momentum associated with the change in flow direction from some angle to the wall to a direction parallel to the wall (see **Figure 3.30**), the two relations can be combined using a weighting factor based on the sine or cosine of the angle, respectively. The resulting relationship is given by:

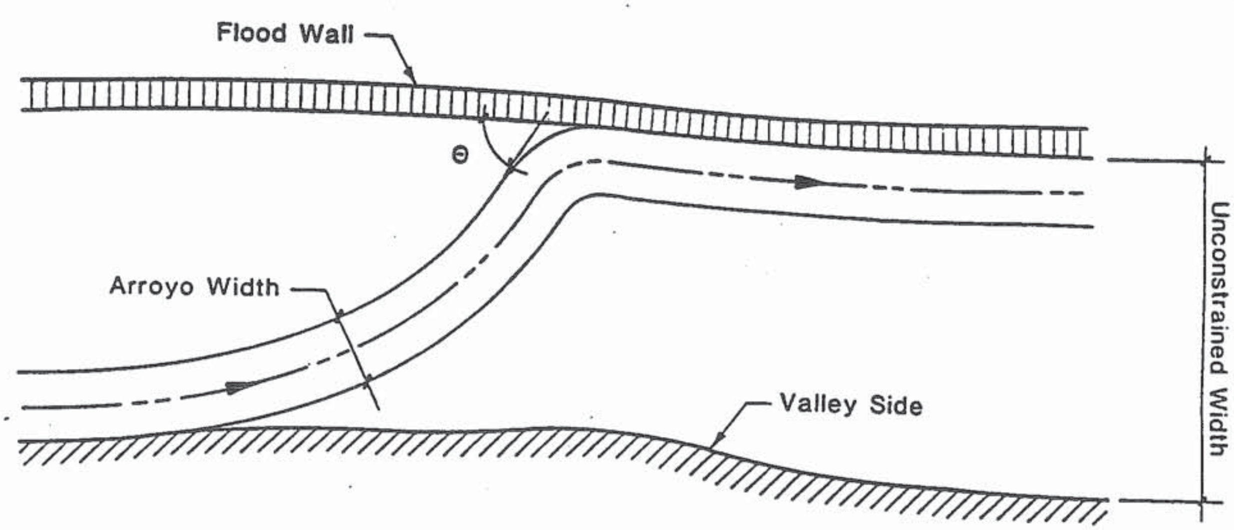


Figure 3.30. Schematic of channel alignment associated with a flood wall.

Mirehaven Arroyo @ Watershed Subdivision

"Sediment and Erosion Design Guide", Resource Consultants & Engineers, Inc., Nov. 1994
prepared for Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA)
pages 3-88 to 3-90

Scour along a flood wall when the flow is parallel to the wall

Ys = Y*(0.73+0.14*3.14*Fr^2)

where, Ys = Scour Depth
Y = Depth
Fr = Froude Number

Input from HEC-RAS model. Updated by JDE on 01/10/2015 for proposed Mirehaven Arroyo Improvements
HEC-RAS Plans Are Located Here: P:\20130375\WR\Calculations\Programs\HEC-RAS\FinalDesign\FinalDesign.prj

Indicates location of Drops Channel will be protected by Shotcrete to End of Drop Structure.
Indicates location of Crossing Structure where channel will be protected from end of upstream Drop to Crossing Structure

River Station	Min. Channel	W.S. Elev	Y= Average Depth	Fr	Ys	Ys
		(Mixed)	**(Mixed)**	**(Mixed)**	**(Mixed)**	**(Design)**
4535	5362.56	5365.54	1.89	1.17	2.52	2.52
4460	5360.96	5363.97	1.75	1.23	2.44	2.44
4410	5360.15	5362.37	1.59	1.42	2.57	2.57
4360	5359.03	5361.13	1.48	1.33	2.23	2.23
4310	5358.05	5361.02	1.81	0.65	1.66	1.66
4260	5357.7	5360.95	2.34	0.44	1.91	1.91
4210	5357.35	5360.87	2.53	0.39	2.02	2.02
4153.776	5356.95	5360.64	2.82	0.44	2.30	2.30
4122.257	5356.73	5360.45	2.93	0.49	2.45	2.45
4086.582	5356.48	5360.14	2.94	0.6	2.61	2.61
4053.607	5356.25	5359.72	2.85	0.73	2.75	2.75
4023.759	5356.04	5358.96	2.46	0.98	2.83	2.83
4016.758	5352.41	5354.35	1.64	2.52	5.78	5.78
3970	5351.67	5353.52	1.49	2.21	4.29	4.29
3920	5351.32	5354.75	2.92	0.74	2.83	2.83
3871.282	5350.98	5353.9	2.46	0.98	2.83	2.83
3865.282	5347.21	5349.49	1.75	2.32	5.42	5.42
3846.415	5346.86	5348.48	1.29	2.77	5.30	5.30
3820	5346.66	5348.94	1.89	1.52	3.30	3.30
3770	5346.31	5349.71	2.89	0.75	2.82	2.82
3720	5345.96	5349.37	2.9	0.74	2.82	2.82
3685.282	5345.72	5348.64	2.46	0.98	2.83	2.83
3676.157	5340.32	5342.28	1.63	2.89	7.18	7.18
3648.004	5339.53	5341.05	1.23	3.09	6.06	6.06
3620	5339.3	5341.54	1.86	1.63	3.53	3.53
3570	5338.97	5342.09	2.65	0.94	2.96	2.96
3520	5338.57	5341.51	2.48	0.97	2.84	2.84
3470	5338.09	5341.21	2.48	0.82	2.54	2.54
3420	5337.61	5341.13	2.79	0.63	2.52	2.52
3370	5337.25	5340.95	2.93	0.57	2.56	2.56
3320	5337.01	5340.63	2.87	0.64	2.61	2.61

3270	5336.76	5340.2	2.91	0.7	2.75	2.75
3233.282	5336.52	5339.37	2.4	0.98	2.77	2.77
3227.282	5332.93	5334.91	1.62	2.49	5.60	5.60
3208.59	5332.38	5333.89	1.22	2.9	5.40	5.40
3170	5332.04	5334.46	2.01	1.31	2.98	2.98
3120	5331.68	5334.52	2.39	0.98	2.75	2.75
3070	5331.16	5334.19	2.51	0.74	2.44	2.44
3020	5330.72	5334.1	2.8	0.56	2.43	2.43
2970	5330.39	5333.95	2.97	0.52	2.52	2.52
2920	5330.17	5333.51	2.81	0.65	2.57	2.57
2898.282	5329.98	5332.75	2.31	0.98	2.66	2.66
2894.282	5327.58	5329.57	1.3	2.46	4.41	4.41
2880.837	5327.08	5328.66	1.3	2.55	4.67	4.67
2855.037	5326.82	5329.2	1.97	1.33	2.97	2.97
2818.282	5326.44	5329.31	2.42	0.98	2.79	2.79
2813.282	5322.86	5324.94	1.67	2.43	5.56	5.56
2794.821	5322.51	5324.05	1.27	2.81	5.34	5.34
2770	5322.25	5324.43	1.79	1.6	3.32	3.32
2720	5321.79	5325.11	2.79	0.68	2.60	2.60
2670	5321.35	5325.08	3.14	0.51	2.65	2.65
2620	5320.93	5325.06	3.48	0.4	2.79	2.79
2570	5320.36	5325.06	3.69	0.31	2.85	2.85
2520	5320.05	5325.01	3.9	0.29	2.99	2.99
2470	5320.15	5324.63	3.71	0.48	3.08	3.08
2420	5319.97	5323.74	3.21	0.78	3.20	3.20
2370	5319.62	5323.22	3.07	0.85	3.22	3.22
2322.282	5319.17	5322.5	2.84	0.96	3.22	3.22
2314.185	5314.61	5317.23	2.08	2.38	6.70	6.70
2290.505	5313.89	5315.3	1.05	3.57	6.65	6.65
2220	5313.1	5316.68	2.84	0.55	2.45	2.45
2170	5312.78	5316.54	2.98	0.51	2.52	2.52
2120.282	5312.68	5315.44	2.3	0.98	2.65	2.65
2115.282	5309.82	5311.82	1.57	2.33	4.89	4.89
2101.362	5309.51	5311.1	1.23	2.67	4.75	4.75
2070	5309.22	5311.53	1.81	1.35	2.77	2.77
2020	5308.7	5312.12	2.71	0.62	2.44	2.44
1970	5308.42	5311.91	2.78	0.61	2.48	2.48
1920	5308.2	5311.26	2.56	0.79	2.57	2.57
1898.282	5307.96	5310.7	2.28	0.98	2.63	2.63
1891.051	5303.45	5305.24	1.44	2.84	6.16	6.16
1868.36	5303	5304.4	1.15	2.97	5.30	5.30
1820	5302.5	5304.92	1.98	1.2	2.70	2.70
1770	5302.03	5304.58	2.05	0.99	2.38	2.38
1720	5301.5	5304.2	2.07	0.82	2.12	2.12
1670	5300.95	5304.08	2.4	0.58	2.11	2.11
1620	5300.52	5304.01	2.7	0.45	2.21	2.21
1570	5300.17	5303.93	2.93	0.39	2.33	2.33
1520	5299.92	5303.83	3.07	0.39	2.45	2.45
1470	5299.78	5303.64	3.06	0.45	2.51	2.51
1420	5299.71	5303.08	2.85	0.67	2.64	2.64
1373.282	5299.32	5302.13	2.35	0.98	2.71	2.71
1365.281	5294.63	5296.56	1.51	2.77	6.20	6.20
1342.651	5294.24	5295.98	1.38	2.32	4.27	4.27
1320	5294.07	5296.46	1.97	1.32	2.95	2.95
1275.282	5293.45	5296.43	2.55	1.03	3.05	3.05
1270.281	5291.1	5296.81	4.57	0.4	3.66	3.66
1260.172	5290.94	5296.81	4.95	0.38	3.93	3.93
1220	5290.74	5296.08	4.27	0.62	3.84	3.84
1181.535	5290.5	5295.62	4.06	0.81	4.14	4.14
1170	5289.91	5295.91	4.68	0.61	4.18	4.18

1120	5287.37	5296.3	6.62	0.3	5.09	5.09
1106.63	5286.68	5296.33	7.07	0.26	5.37	5.37

Mirehaven Arroyo
Freeboard Calcualtions

Reference: "City of Albuquerque, DPM" (pg. 22-130)

Freeboard can be determined by $Freeboard(ft) = 0.7(2 + .025Vd^{1/3})$

Maximum Required Freeboard (ft)= 1.71

River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Depth (ft)	Vel Chnl (ft/s)	Required Freeboard (ft)
4535	Final_Mixed	1501	5362.56	5365.54	2.98	8.73	1.55
4535	Final_Sub	1501	5362.56	5365.82	3.26	7.52	1.54
4460	Final_Mixed	1501	5360.96	5363.97	3.01	9.16	1.56
4460	Final_Sub	1501	5360.96	5364.27	3.31	7.75	1.55
4410	Final_Mixed	1501	5360.15	5362.37	2.22	10.31	1.53
4410	Final_Sub	1501	5360.15	5362.82	2.67	8.01	1.52
4360	Final_Mixed	1501	5359.03	5361.13	2.1	9.27	1.51
4360	Final_Sub	1501	5359.03	5361.45	2.42	7.61	1.51
4310	Final_Mixed	1501	5358.05	5361.02	2.97	4.76	1.48
4310	Final_Sub	1501	5358.05	5361.02	2.97	4.76	1.48
4260	Final_Mixed	1501	5357.7	5360.95	3.25	3.85	1.47
4260	Final_Sub	1501	5357.7	5360.95	3.25	3.85	1.47
4210	Final_Mixed	1501	5357.35	5360.87	3.52	3.56	1.47
4210	Final_Sub	1501	5357.35	5360.87	3.52	3.56	1.47
4153.776	Final_Mixed	1501	5356.95	5360.64	3.69	4.29	1.49
4153.776	Final_Sub	1501	5356.95	5360.64	3.69	4.29	1.49
4122.257	Final_Mixed	1501	5356.73	5360.45	3.72	4.92	1.51
4122.257	Final_Sub	1501	5356.73	5360.45	3.72	4.92	1.51
4086.582	Final_Mixed	1501	5356.48	5360.14	3.66	5.98	1.53
4086.582	Final_Sub	1501	5356.48	5360.14	3.66	5.98	1.53
4053.607	Final_Mixed	1501	5356.25	5359.72	3.47	7.13	1.54
4053.607	Final_Sub	1501	5356.25	5359.72	3.47	7.13	1.54

River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Depth (ft)	Vel Chnl (ft/s)	Required Freeboard (ft)
4023.759	Final_Mixed	1501	5356.04	5358.96	2.92	8.97	1.55
4023.759	Final_Sub	1501	5356.04	5358.96	2.92	8.97	1.55
4016.758	Final_Mixed	1501	5352.41	5354.35	1.94	18.7	1.61
4016.758	Final_Sub	1501	5352.41	5355.75	3.34	9.12	1.58
3970	Final_Mixed	1501	5351.67	5353.52	1.85	15.6	1.57
3970	Final_Sub	1501	5351.67	5355.08	3.41	7.47	1.55
3920	Final_Mixed	1501	5351.32	5354.75	3.43	7.4	1.55
3920	Final_Sub	1501	5351.32	5354.75	3.43	7.4	1.55
3871.282	Final_Mixed	1501	5350.98	5353.9	2.92	8.98	1.55
3871.282	Final_Sub	1501	5350.98	5353.9	2.92	8.98	1.55
3865.282	Final_Mixed	1501	5347.21	5349.49	2.28	17.91	1.64
3865.282	Final_Sub	1501	5347.21	5350.88	3.67	9.12	1.60
3846.415	Final_Mixed	1501	5346.86	5348.48	1.62	18.09	1.57
3846.415	Final_Sub	1501	5346.86	5350.26	3.4	7.39	1.55
3820	Final_Mixed	1501	5346.66	5348.94	2.28	12.07	1.56
3820	Final_Sub	1501	5346.66	5350.05	3.39	7.5	1.55
3770	Final_Mixed	1501	5346.31	5349.71	3.4	7.49	1.55
3770	Final_Sub	1501	5346.31	5349.71	3.4	7.49	1.55
3720	Final_Mixed	1501	5345.96	5349.37	3.41	7.44	1.55
3720	Final_Sub	1501	5345.96	5349.37	3.41	7.44	1.55
3685.282	Final_Mixed	1501	5345.72	5348.64	2.92	8.97	1.55
3685.282	Final_Sub	1501	5345.72	5348.64	2.92	8.97	1.55
3676.157	Final_Mixed	1501	5340.32	5342.28	1.96	20.96	1.64
3676.157	Final_Sub	1501	5340.32	5344	3.68	10.01	1.61
3648.004	Final_Mixed	1501	5339.53	5341.05	1.52	19.72	1.57
3648.004	Final_Sub	1501	5339.53	5343.17	3.64	6.96	1.55
3620	Final_Mixed	1501	5339.3	5341.54	2.24	12.92	1.57
3620	Final_Sub	1501	5339.3	5342.96	3.66	7.21	1.55
3570	Final_Mixed	1501	5338.97	5342.09	3.12	8.96	1.56
3570	Final_Sub	1501	5338.97	5342.09	3.12	8.96	1.56

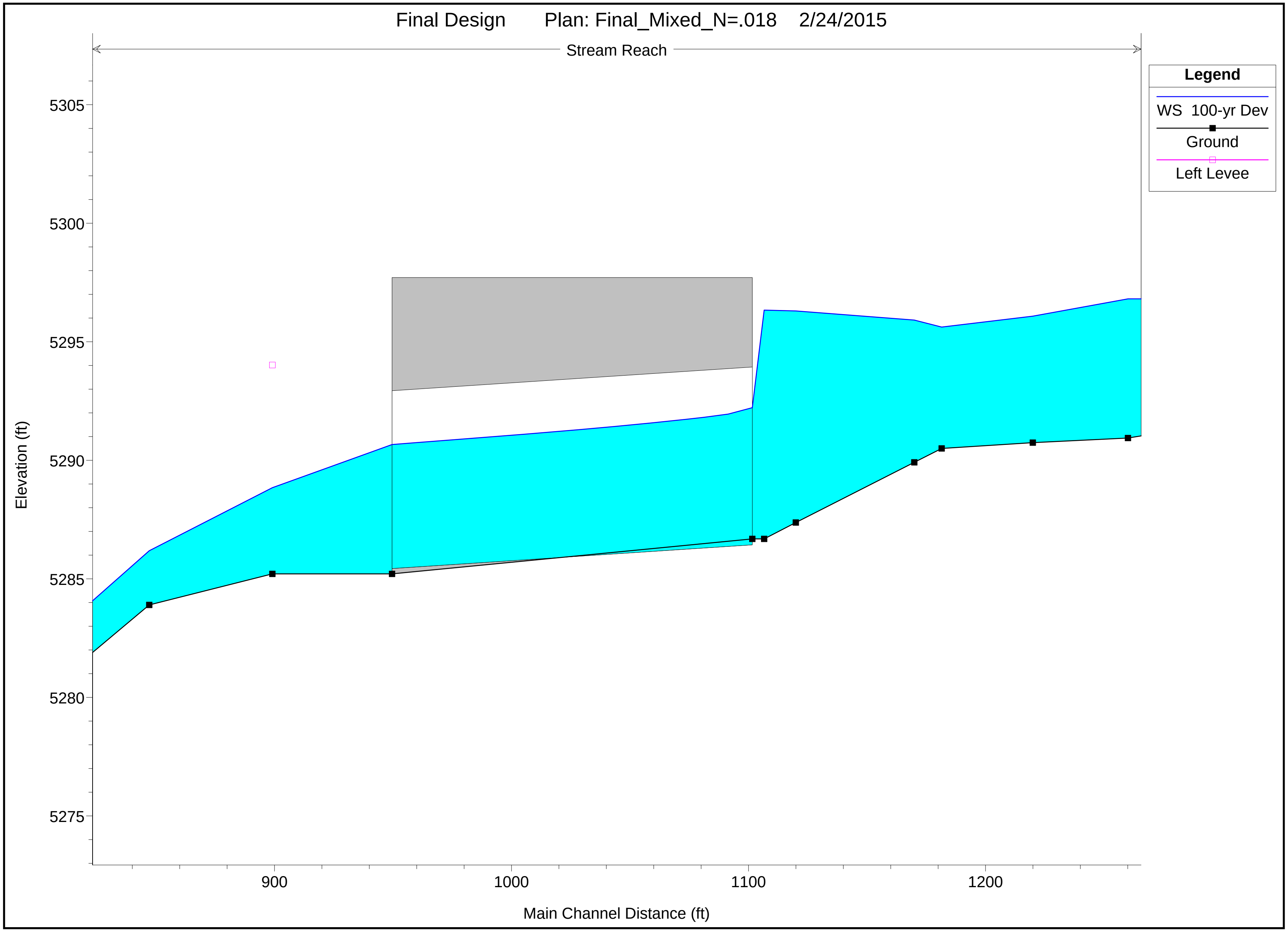
River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Depth (ft)	Vel Chnl (ft/s)	Required Freeboard (ft)
3520	Final_Mixed	1501	5338.57	5341.51	2.94	8.98	1.55
3520	Final_Sub	1501	5338.57	5341.51	2.94	8.98	1.55
3470	Final_Mixed	1501	5338.09	5341.21	3.12	7.78	1.54
3470	Final_Sub	1501	5338.09	5341.21	3.12	7.78	1.54
3420	Final_Mixed	1501	5337.61	5341.13	3.52	6.03	1.52
3420	Final_Sub	1501	5337.61	5341.13	3.52	6.03	1.52
3370	Final_Mixed	1501	5337.25	5340.95	3.7	5.85	1.53
3370	Final_Sub	1501	5337.25	5340.95	3.7	5.85	1.53
3320	Final_Mixed	1501	5337.01	5340.63	3.62	6.24	1.53
3320	Final_Sub	1501	5337.01	5340.63	3.62	6.24	1.53
3270	Final_Mixed	1501	5336.76	5340.2	3.44	6.9	1.54
3270	Final_Sub	1501	5336.76	5340.2	3.44	6.9	1.54
3233.282	Final_Mixed	1501	5336.52	5339.37	2.85	8.86	1.55
3233.282	Final_Sub	1501	5336.52	5339.37	2.85	8.86	1.55
3227.282	Final_Mixed	1501	5332.93	5334.91	1.98	18.41	1.61
3227.282	Final_Sub	1501	5332.93	5336.33	3.4	9	1.58
3208.59	Final_Mixed	1501	5332.38	5333.89	1.51	18.43	1.56
3208.59	Final_Sub	1501	5332.38	5335.65	3.27	7.36	1.54
3170	Final_Mixed	1501	5332.04	5334.46	2.42	10.78	1.55
3170	Final_Sub	1501	5332.04	5335.39	3.35	7.33	1.54
3120	Final_Mixed	1501	5331.68	5334.52	2.84	8.83	1.55
3120	Final_Sub	1501	5331.68	5334.52	2.84	8.83	1.55
3070	Final_Mixed	1501	5331.16	5334.19	3.03	6.78	1.52
3070	Final_Sub	1501	5331.16	5334.19	3.03	6.78	1.52
3020	Final_Mixed	1501	5330.72	5334.1	3.38	5.49	1.51
3020	Final_Sub	1501	5330.72	5334.1	3.38	5.49	1.51
2970	Final_Mixed	1501	5330.39	5333.95	3.56	5.22	1.51
2970	Final_Sub	1501	5330.39	5333.95	3.56	5.22	1.51
2920	Final_Mixed	1501	5330.17	5333.51	3.34	6.4	1.52

River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Depth	Vel Chnl	Required Freeboard
		(cfs)	(ft)	(ft)	(ft)	(ft/s)	(ft)
2920	Final_Sub	1501	5330.17	5333.51	3.34	6.4	1.52
2898.282	Final_Mixed	1501	5329.98	5332.75	2.77	8.69	1.54
2898.282	Final_Sub	1501	5329.98	5332.75	2.77	8.69	1.54
2894.282	Final_Mixed	1501	5327.58	5329.57	1.99	16.15	1.59
2894.282	Final_Sub	1501	5327.58	5330.65	3.07	8.81	1.56
2880.837	Final_Mixed	1501	5327.08	5328.66	1.58	16.55	1.55
2880.837	Final_Sub	1501	5327.08	5330.33	3.25	7.08	1.53
2855.037	Final_Mixed	1501	5326.82	5329.2	2.38	10.83	1.55
2855.037	Final_Sub	1501	5326.82	5330.02	3.2	7.61	1.54
2818.282	Final_Mixed	1501	5326.44	5329.31	2.87	8.88	1.55
2818.282	Final_Sub	1501	5326.44	5329.31	2.87	8.88	1.55
2813.282	Final_Mixed	1501	5322.86	5324.94	2.08	18.29	1.62
2813.282	Final_Sub	1501	5322.86	5326.37	3.51	9.05	1.59
2794.821	Final_Mixed	1501	5322.51	5324.05	1.54	18.22	1.56
2794.821	Final_Sub	1501	5322.51	5325.65	3.14	7.87	1.54
2770	Final_Mixed	1501	5322.25	5324.43	2.18	12.39	1.56
2770	Final_Sub	1501	5322.25	5325.16	2.91	8.77	1.55
2720	Final_Mixed	1501	5321.79	5325.11	3.32	6.64	1.53
2720	Final_Sub	1501	5321.79	5325.11	3.32	6.64	1.53
2670	Final_Mixed	1501	5321.35	5325.08	3.73	5.24	1.51
2670	Final_Sub	1501	5321.35	5325.08	3.73	5.24	1.51
2620	Final_Mixed	1501	5320.93	5325.06	4.13	4.31	1.50
2620	Final_Sub	1501	5320.93	5325.06	4.13	4.31	1.50
2570	Final_Mixed	1501	5320.36	5325.06	4.7	3.65	1.50
2570	Final_Sub	1501	5320.36	5325.06	4.7	3.65	1.50
2520	Final_Mixed	1501	5320.05	5325.01	4.96	3.54	1.50
2520	Final_Sub	1501	5320.05	5325.01	4.96	3.54	1.50
2470	Final_Mixed	1501	5320.15	5324.63	4.48	5.47	1.54
2470	Final_Sub	1501	5320.15	5324.63	4.48	5.47	1.54

River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Depth	Vel Chnl	Required Freeboard
		(cfs)	(ft)	(ft)	(ft)	(ft/s)	(ft)
2420	Final_Mixed	1501	5319.97	5323.74	3.77	8.33	1.58
2420	Final_Sub	1501	5319.97	5323.74	3.77	8.33	1.58
2370	Final_Mixed	1501	5319.62	5323.22	3.6	8.81	1.59
2370	Final_Sub	1501	5319.62	5323.22	3.6	8.81	1.59
2322.282	Final_Mixed	1501	5319.17	5322.5	3.33	9.61	1.59
2322.282	Final_Sub	1501	5319.17	5322.5	3.33	9.61	1.59
2314.185	Final_Mixed	1501	5314.61	5317.23	2.62	20.25	1.71
2314.185	Final_Sub	1501	5314.61	5318.9	4.29	9.79	1.64
2290.505	Final_Mixed	1501	5313.89	5315.3	1.41	20.91	1.57
2290.505	Final_Sub	1501	5313.89	5316.7	2.81	8.65	1.54
2220	Final_Mixed	1501	5313.1	5316.68	3.58	5.56	1.52
2220	Final_Sub	1501	5313.1	5316.68	3.58	5.56	1.52
2170	Final_Mixed	1501	5312.78	5316.54	3.76	5.3	1.52
2170	Final_Sub	1501	5312.78	5316.54	3.76	5.3	1.52
2120.282	Final_Mixed	1501	5312.68	5315.44	2.76	8.67	1.54
2120.282	Final_Sub	1501	5312.68	5315.44	2.76	8.67	1.54
2115.282	Final_Mixed	1501	5309.82	5311.82	2	16.9	1.60
2115.282	Final_Sub	1501	5309.82	5312.98	3.16	8.8	1.56
2101.362	Final_Mixed	1501	5309.51	5311.1	1.59	17.01	1.56
2101.362	Final_Sub	1501	5309.51	5312.43	2.92	8.03	1.54
2070	Final_Mixed	1501	5309.22	5311.53	2.31	10.39	1.54
2070	Final_Sub	1501	5309.22	5312.22	3	7.47	1.53
2020	Final_Mixed	1501	5308.7	5312.12	3.42	6.07	1.52
2020	Final_Sub	1501	5308.7	5312.12	3.42	6.07	1.52
1970	Final_Mixed	1501	5308.42	5311.91	3.49	5.8	1.52
1970	Final_Sub	1501	5308.42	5311.91	3.49	5.8	1.52
1920	Final_Mixed	1501	5308.2	5311.26	3.06	7.34	1.53
1920	Final_Sub	1501	5308.2	5311.26	3.06	7.34	1.53
1898.282	Final_Mixed	1501	5307.96	5310.7	2.74	8.65	1.54
1898.282	Final_Sub	1501	5307.96	5310.7	2.74	8.65	1.54

River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Depth (ft)	Vel Chnl (ft/s)	Required Freeboard (ft)
1891.051	Final_Mixed	1501	5303.45	5305.24	1.79	19.76	1.61
1891.051	Final_Sub	1501	5303.45	5306.9	3.45	8.79	1.58
1868.36	Final_Mixed	1501	5303	5304.4	1.4	18.24	1.55
1868.36	Final_Sub	1501	5303	5305.94	2.94	7.64	1.53
1820	Final_Mixed	1501	5302.5	5304.92	2.42	9.72	1.54
1820	Final_Sub	1501	5302.5	5305.19	2.69	8.55	1.53
1770	Final_Mixed	1501	5302.03	5304.58	2.55	8.15	1.52
1770	Final_Sub	1501	5302.03	5304.58	2.55	8.15	1.52
1720	Final_Mixed	1501	5301.5	5304.2	2.7	6.74	1.51
1720	Final_Sub	1501	5301.5	5304.2	2.7	6.74	1.51
1670	Final_Mixed	1501	5300.95	5304.08	3.13	5.17	1.49
1670	Final_Sub	1501	5300.95	5304.08	3.13	5.17	1.49
1620	Final_Mixed	1501	5300.52	5304.01	3.49	4.34	1.49
1620	Final_Sub	1501	5300.52	5304.01	3.49	4.34	1.49
1570	Final_Mixed	1501	5300.17	5303.93	3.76	3.96	1.49
1570	Final_Sub	1501	5300.17	5303.93	3.76	3.96	1.49
1520	Final_Mixed	1501	5299.92	5303.83	3.91	4.05	1.49
1520	Final_Sub	1501	5299.92	5303.83	3.91	4.05	1.49
1470	Final_Mixed	1501	5299.78	5303.64	3.86	4.55	1.50
1470	Final_Sub	1501	5299.78	5303.64	3.86	4.55	1.50
1420	Final_Mixed	1501	5299.71	5303.08	3.37	6.57	1.53
1420	Final_Sub	1501	5299.71	5303.08	3.37	6.57	1.53
1373.282	Final_Mixed	1501	5299.32	5302.13	2.81	8.77	1.54
1373.282	Final_Sub	1501	5299.32	5302.13	2.81	8.77	1.54
1365.281	Final_Mixed	1501	5294.63	5296.56	1.93	19.77	1.62
1365.281	Final_Sub	1501	5294.63	5298.28	3.65	8.6	1.58
1342.651	Final_Mixed	1501	5294.24	5295.98	1.74	15.67	1.56
1342.651	Final_Sub	1501	5294.24	5297.47	3.23	7.4	1.54
1320	Final_Mixed	1501	5294.07	5296.46	2.39	10.74	1.55

River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Depth	Vel Chnl	Required Freeboard
		(cfs)	(ft)	(ft)	(ft)	(ft/s)	(ft)
1320	Final_Sub	1501	5294.07	5297.14	3.07	7.94	1.54
1275.282	Final_Mixed	1501	5293.45	5296.43	2.98	9.7	1.57
1275.282	Final_Sub	1501	5293.45	5296.51	3.06	9.42	1.57
1270.281	Final_Mixed	1501	5291.1	5296.81	5.71	5.11	1.57
1270.281	Final_Sub	1501	5291.1	5296.81	5.71	5.11	1.57
1260.172	Final_Mixed	1501	5290.94	5296.81	5.87	5.1	1.57
1260.172	Final_Sub	1501	5290.94	5296.81	5.87	5.1	1.57
1220	Final_Mixed	1501	5290.74	5296.08	5.34	7.95	1.65
1220	Final_Sub	1501	5290.74	5296.08	5.34	7.95	1.65
1181.535	Final_Mixed	1501	5290.5	5295.62	5.12	9.25	1.68
1181.535	Final_Sub	1501	5290.5	5295.62	5.12	9.25	1.68
1170	Final_Mixed	1501	5289.91	5295.91	6	7.51	1.66
1170	Final_Sub	1501	5289.91	5295.91	6	7.51	1.66
1120	Final_Mixed	1501	5287.37	5296.3	8.93	4.36	1.63
1120	Final_Sub	1501	5287.37	5296.3	8.93	4.36	1.63
1106.63	Final_Mixed	1501	5286.68	5296.33	9.65	3.91	1.62
1106.63	Final_Sub	1501	5286.68	5296.33	9.65	3.91	1.62



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

Plan: Final_N_.018 Stream Reach RS: 1003.396 Culv Group: Culvert #1 Profile: 100-yr Dev

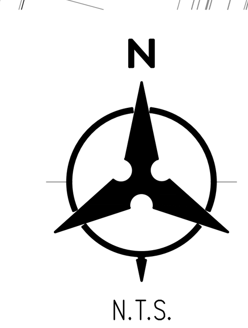
Q Culv Group (cfs)	1501.00	Culv Full Len (ft)	
# Barrels	3	Culv Vel US (ft/s)	13.68
Q Barrel (cfs)	500.33	Culv Vel DS (ft/s)	15.20
E.G. US. (ft)	5296.58	Culv Inv El Up (ft)	5286.43
W.S. US. (ft)	5296.33	Culv Inv El Dn (ft)	5285.43
E.G. DS (ft)	5290.35	Culv Frctn Ls (ft)	0.87
W.S. DS (ft)	5288.84	Culv Exit Loss (ft)	3.91
Delta EG (ft)	6.23	Culv Entr Loss (ft)	1.45
Delta WS (ft)	7.49	Q Weir (cfs)	
E.G. IC (ft)	5296.54	Weir Sta Lft (ft)	
E.G. OC (ft)	5296.58	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	5292.22	Weir Max Depth (ft)	
Culv WS Outlet (ft)	5290.66	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	5.09	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	5.79	Min El Weir Flow (ft)	5297.72

EXHIBITS

EXHIBIT 1

MIREHAVEN ARROYO IMPROVEMENTS PLAN

Bohannan ▲ Huston



MIREHAVEN ARROYO IMPROVEMENTS
WATERSHED @ MIREHAVEN
02/2015

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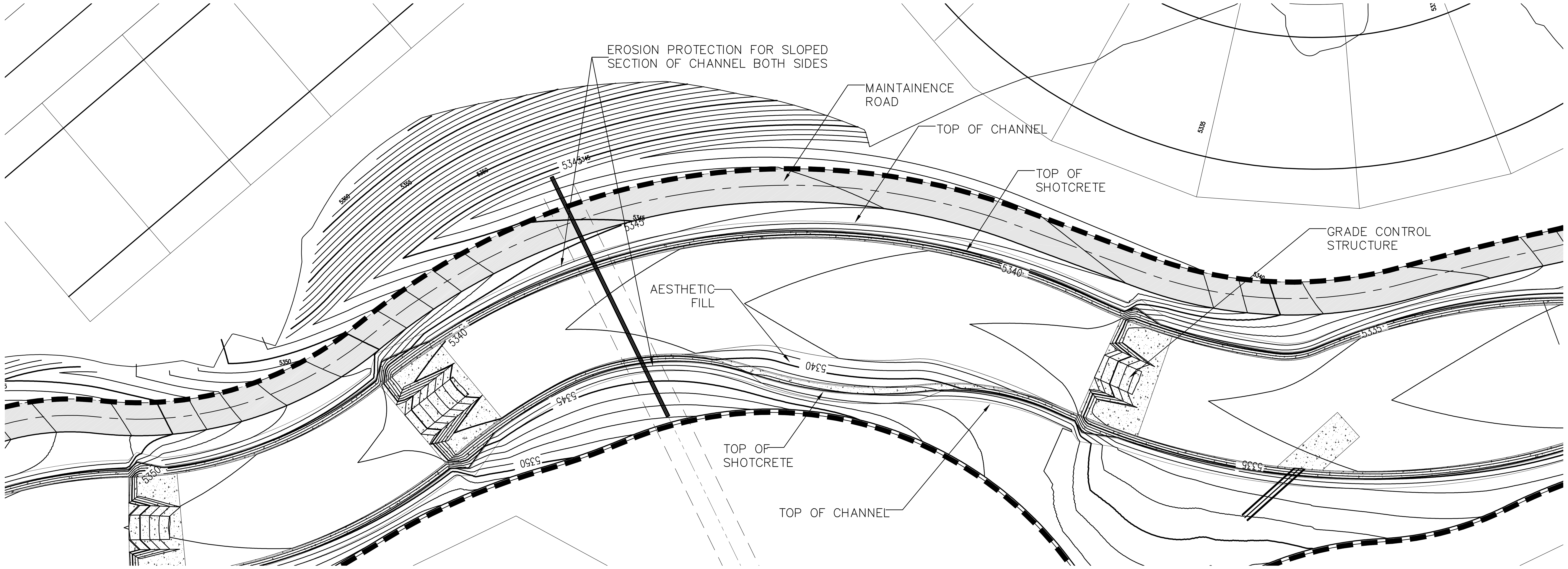
EXHIBIT 2

TYPICAL CHANNEL PLAN AND SECTION

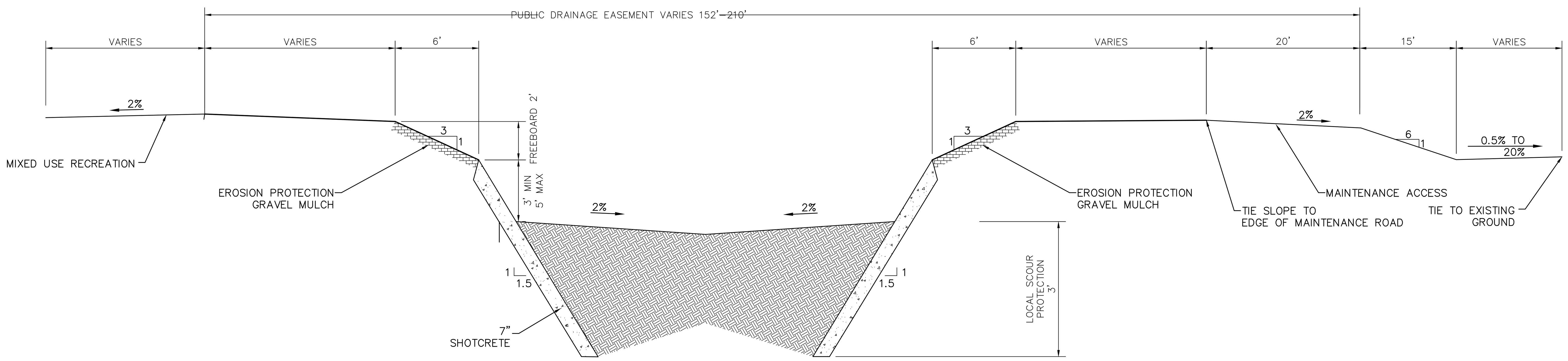
TYPICAL CHANNEL PLAN AND SECTION WATERSHED @ MIREHAVEN

02/2015



TYPICAL CHANNEL PLAN

SCALE: NTS



TYPICAL CHANNEL SECTION

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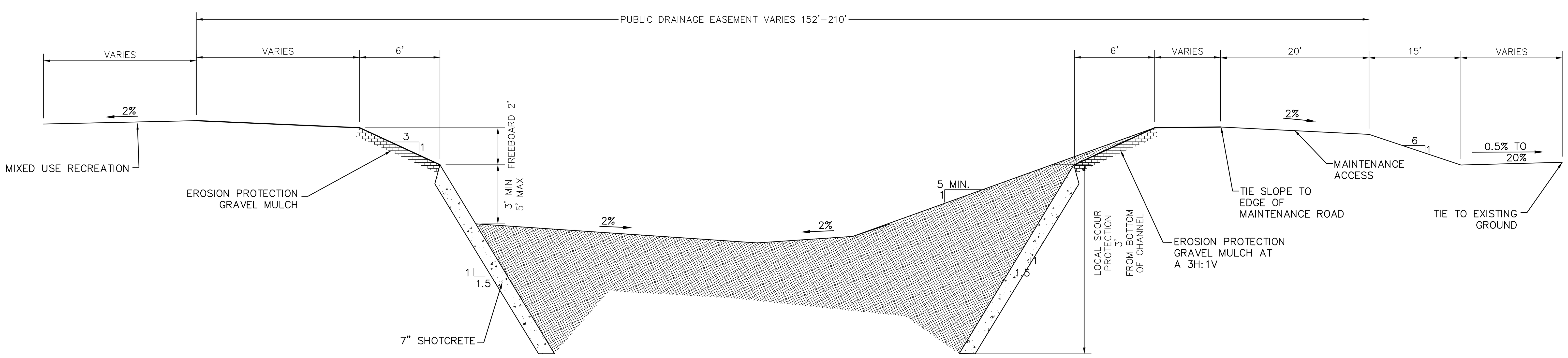

TYPICAL CHANNEL SECTION WITH AESTHETIC FILL

SCALE: NTS

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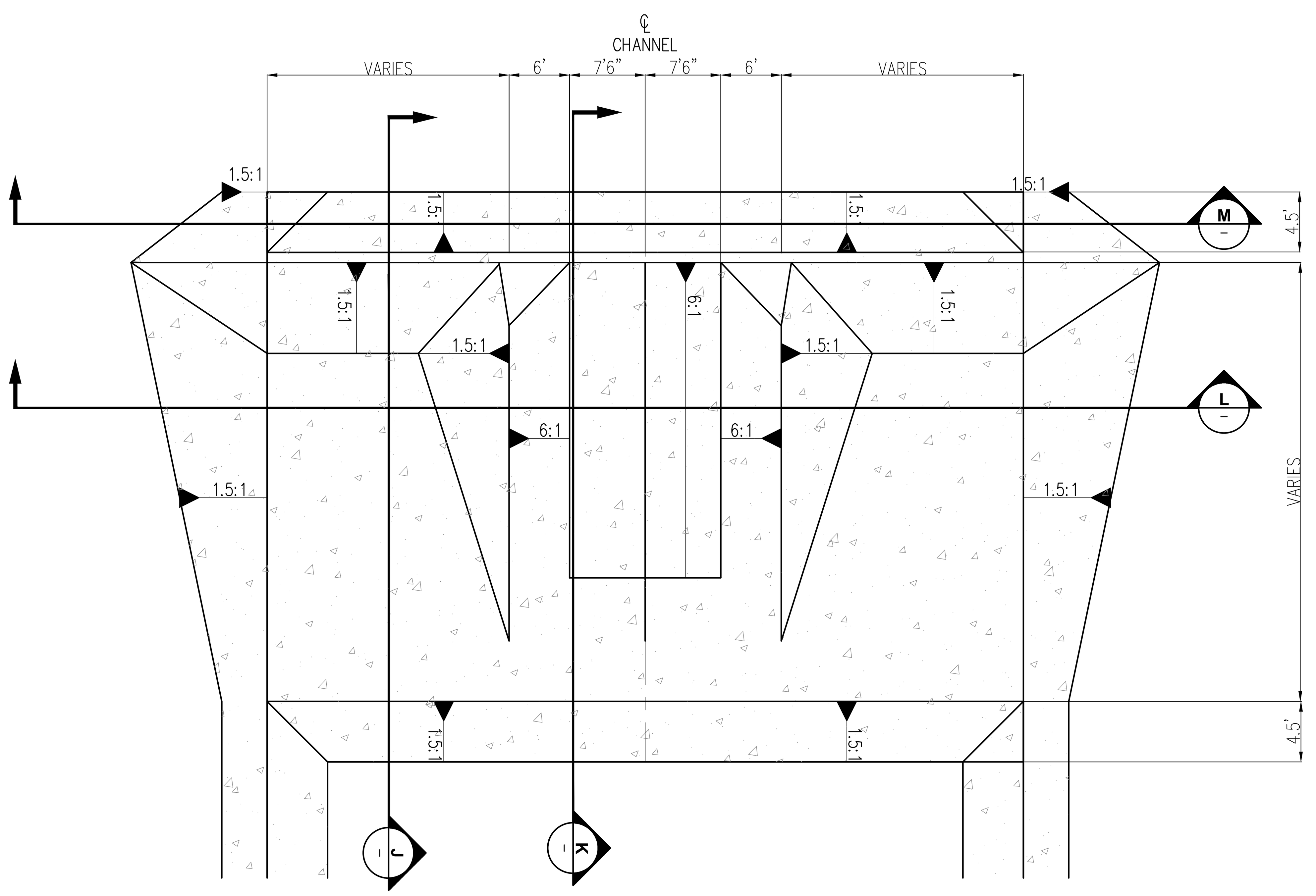
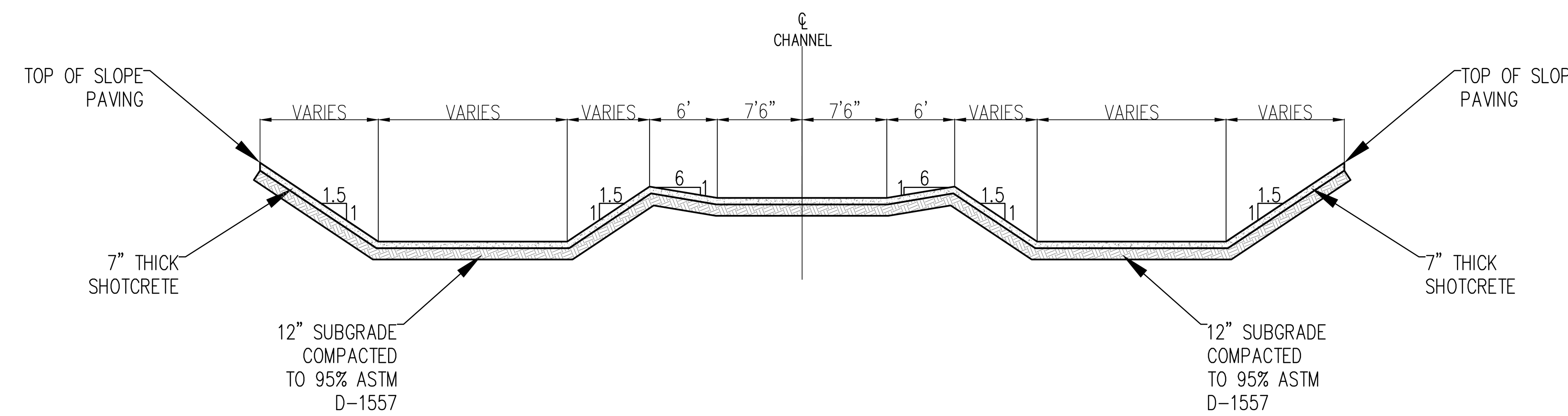
EXHIBIT 3

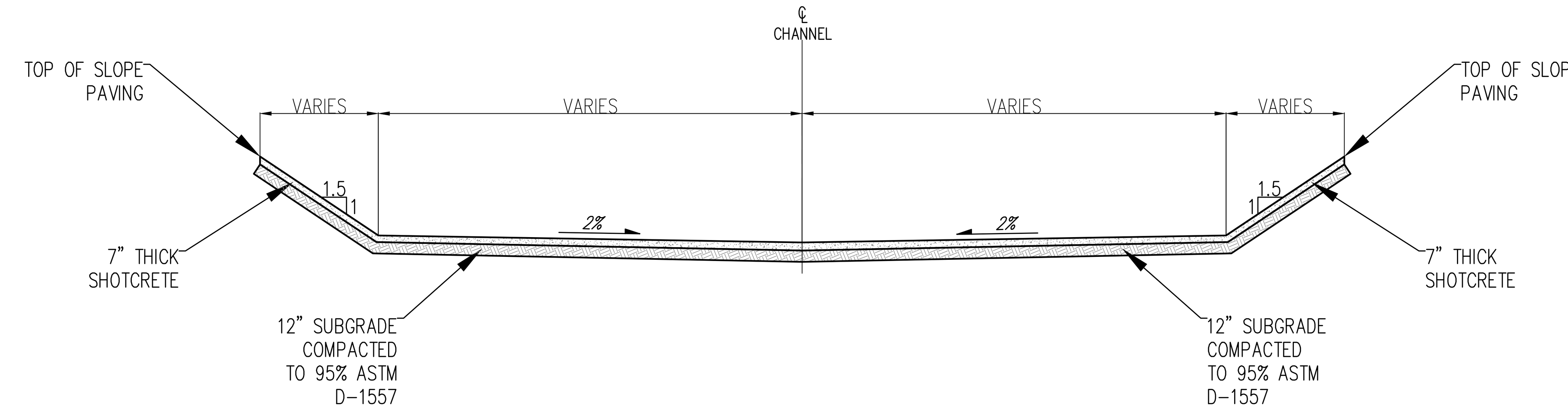
TYPICAL GRADE CONTROL STRUCTURE



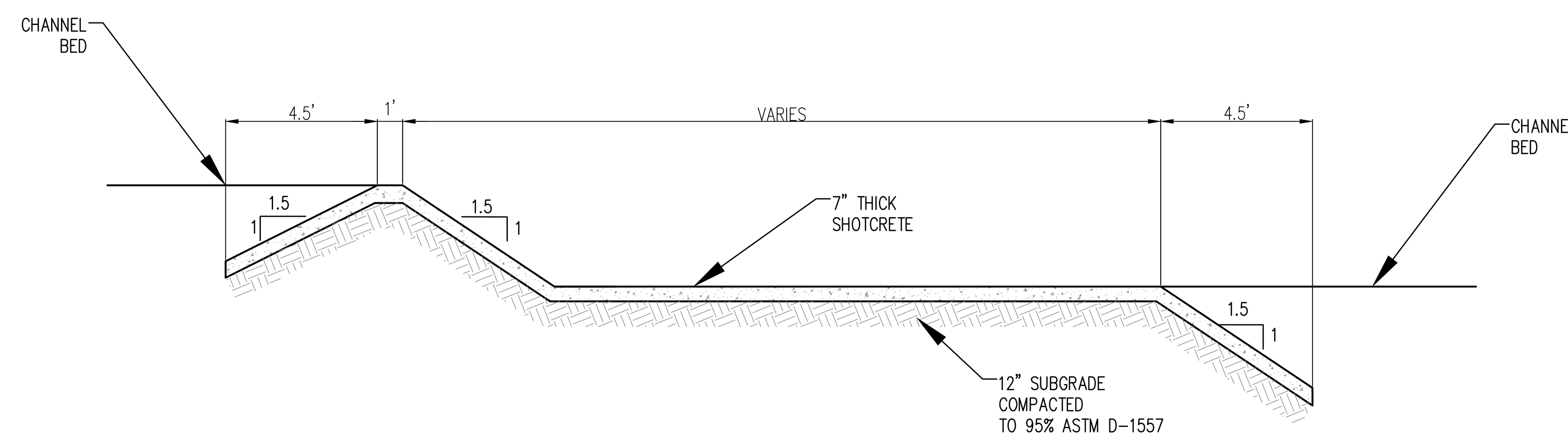
TYPICAL GRADE CONTROL STRUCTURE PLAN VIEW



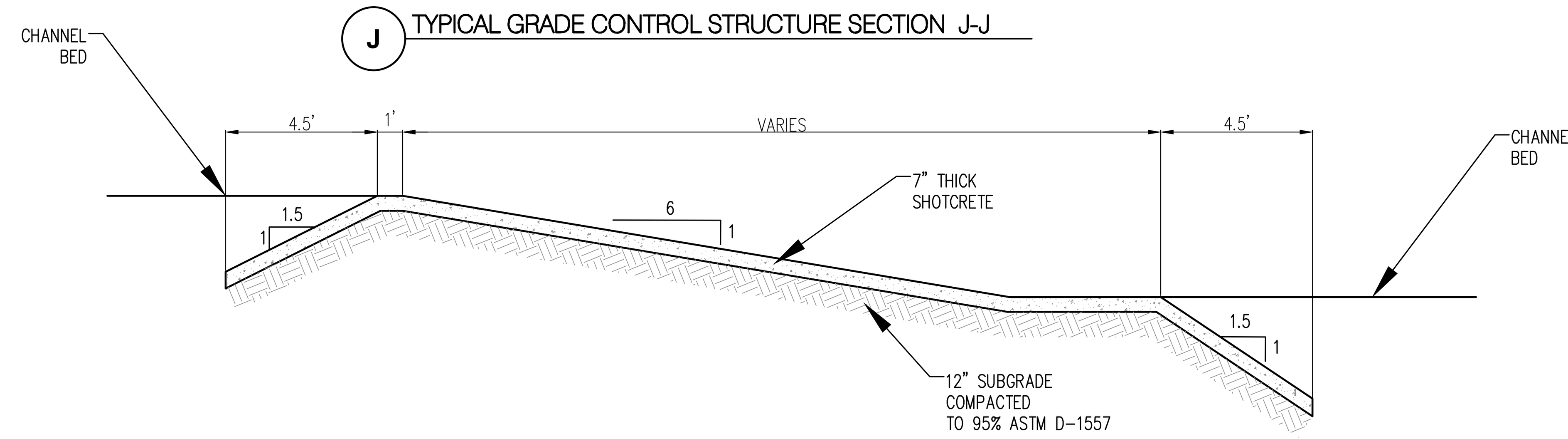
L TYPICAL GRADE CONTROL STRUCTURE SECTION L-L



M TYPICAL GRADE CONTROL STRUCTURE SECTION M-M



J TYPICAL GRADE CONTROL STRUCTURE SECTION J-J



K TYPICAL GRADE CONTROL STRUCTURE SECTION K-K

TYPICAL GRADE CONTROL STRUCTURE PLAN AND SECTION WATERSHED @ MIREHAVEN

02/2015

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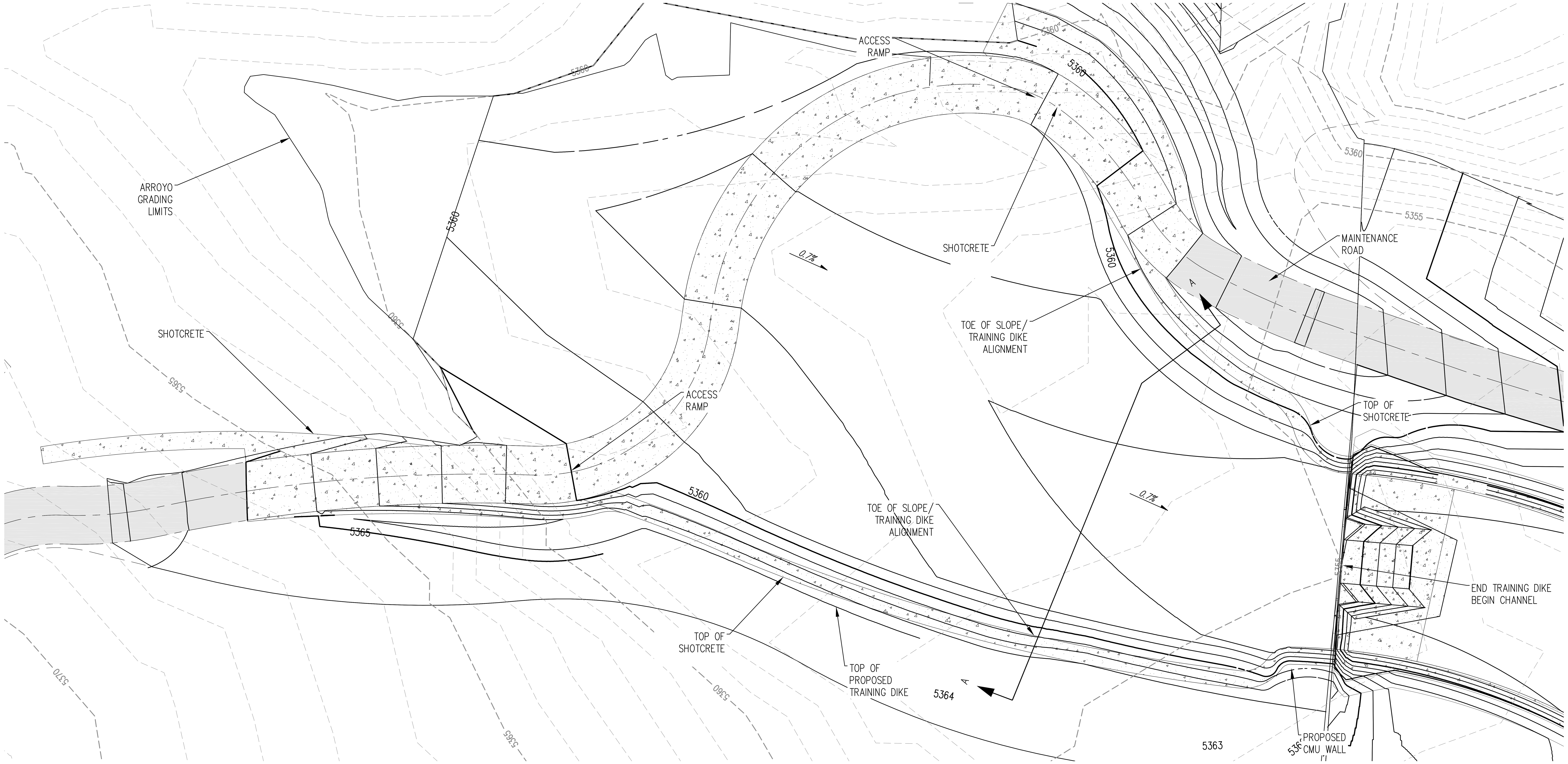
EXHIBIT 4

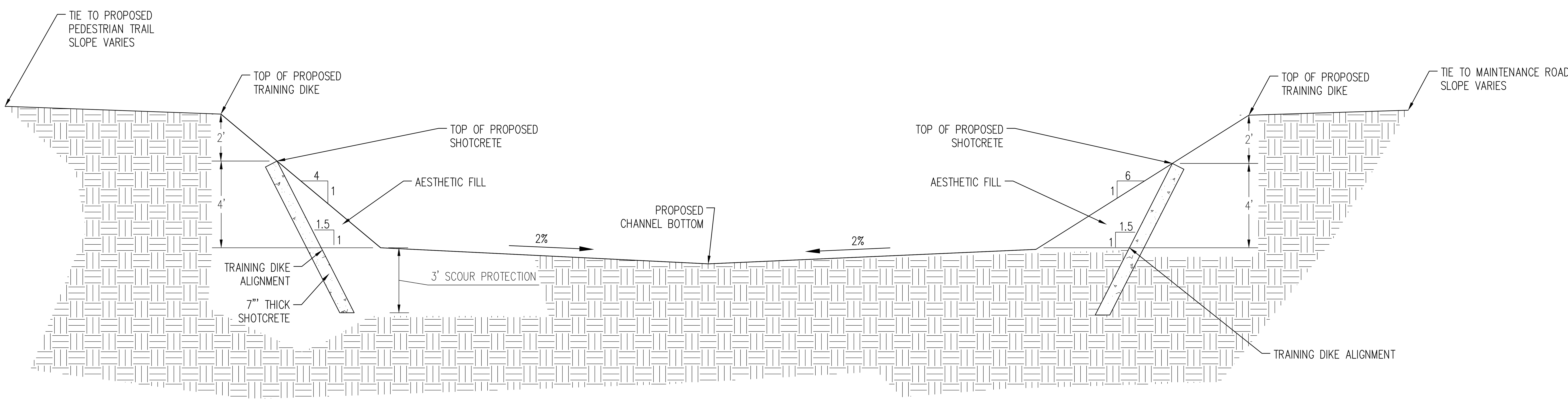
TYPICAL TRAINING DIKE PLAN AND SECTIONS

TYPICAL TRAINING DIKE PLAN AND SECTIONS WATERSHED @ MIREHAVEN

02/2015



1 TRAINING DIKE PLAN
NTS



A TRAINING DIKE SECTION
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