

# SINCLAIR WASH RESTORATION PROJECT

CENE 486 Engineering Design  
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Figure 1: Sinclair Wash Reach

# Introduction

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## Client

Mark Lamer, Senior Lecturer NAU, P.E.

- Construction plan set for stream revitalization
- Healthy, restored section of the wash



## Background

- Site features multiple low points not on thalweg
- Large volume of vegetation and debris
- Culverts are undersized

# Site Location

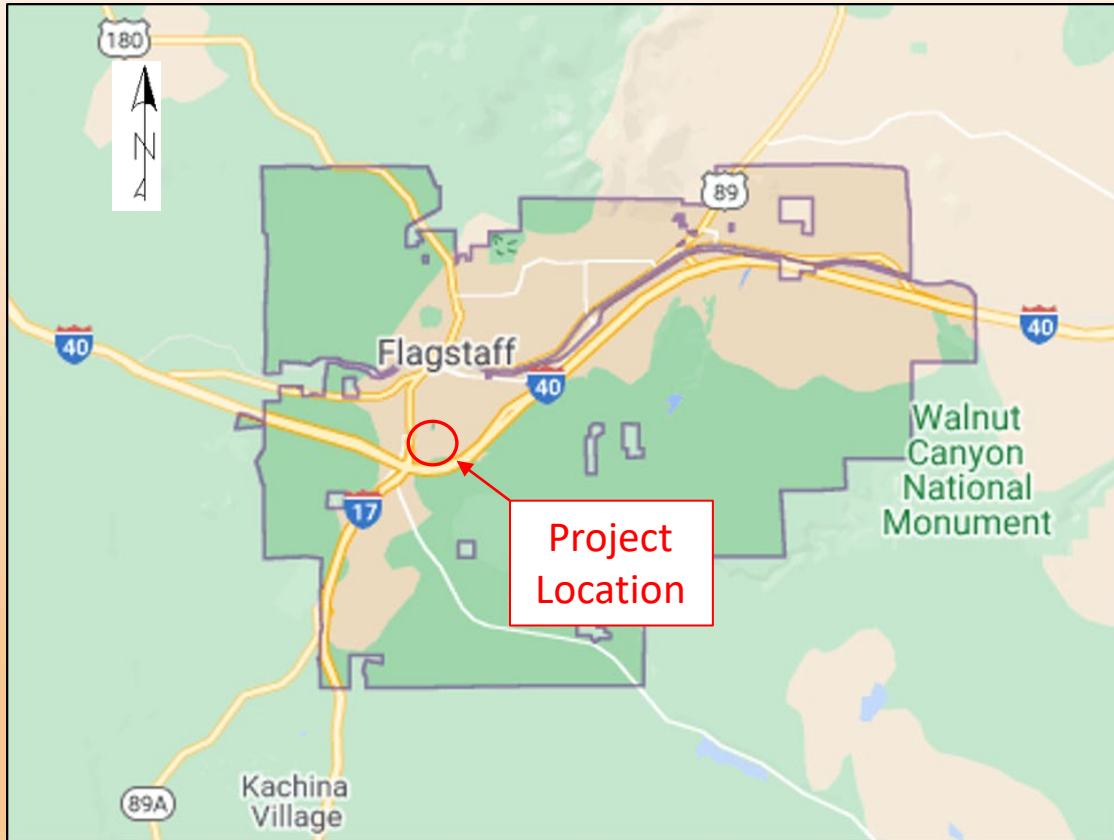


Figure 2: Site Location With Respect to NAU Boundary [1]

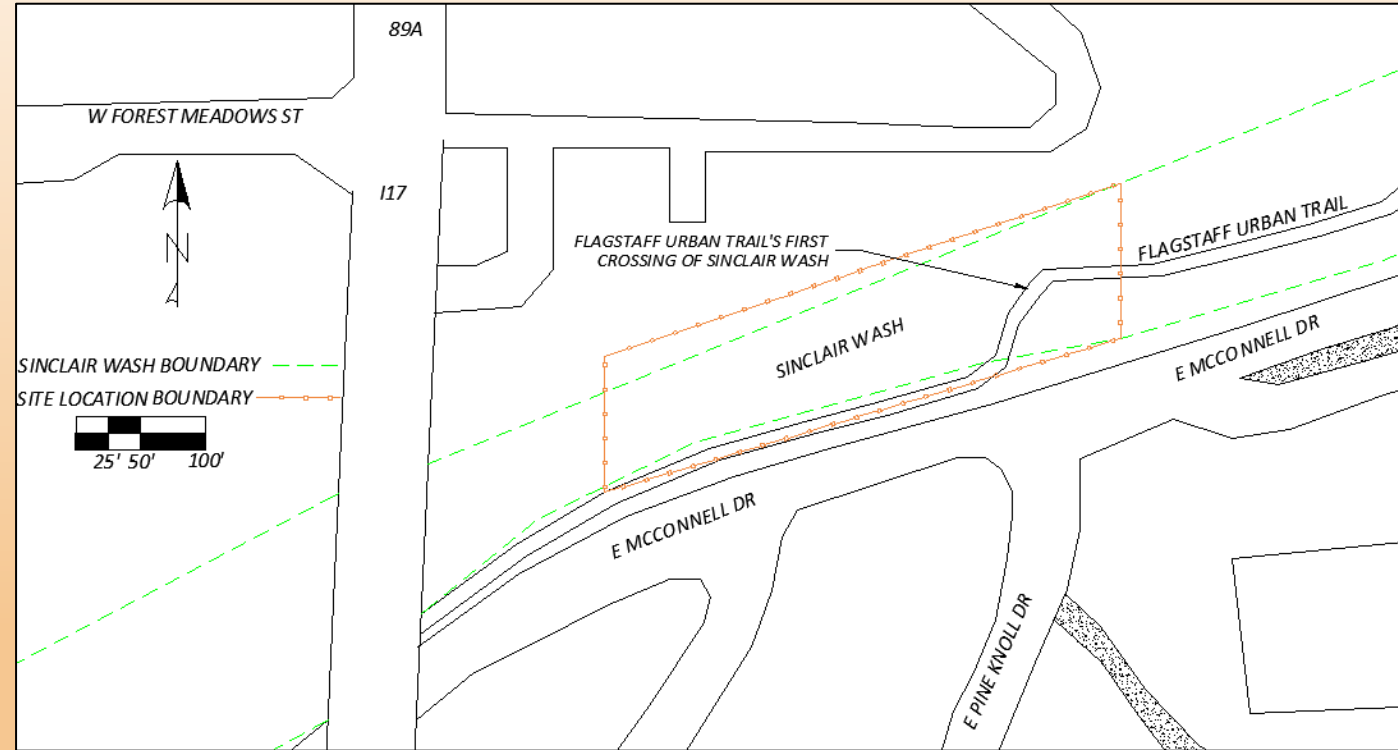


Figure 3: Site Location With Respect to I-17

# Preliminary Work

## Site Investigation

- Upstream culvert entrances blocked by debris
- Scour pool directly downstream of culvert

## Previous Studies

- Surveying data of the channel reach
- HEC-RAS Effective Model

## Biological and Ecological Assessment

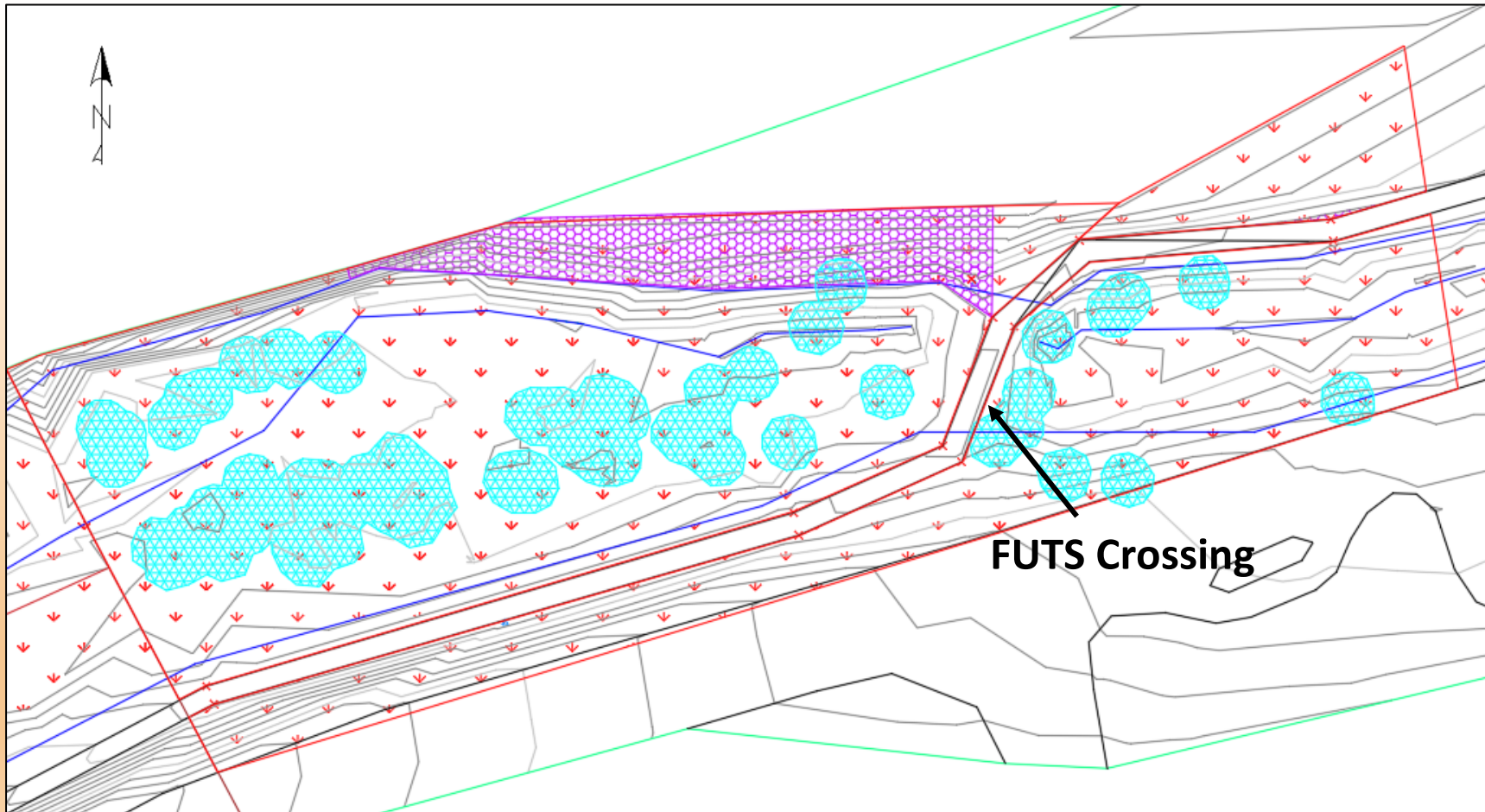
- Flora: 52.6% invasive, 10.5% noxious, 36.8% native
- Fauna: 100% native species
- Interaction with Flagstaff Urban Trail System, NAU, and construction on I-17



**Figure 4: Ponding in Thalweg Upstream of Culvert**



**Figure 5: Field Bindweed - Noxious**



- Remove
- Eliminate  
invasive/noxious;  
replant native
- Keep

Figure 6: Revegetation Plan Set

# Revegetation Plan

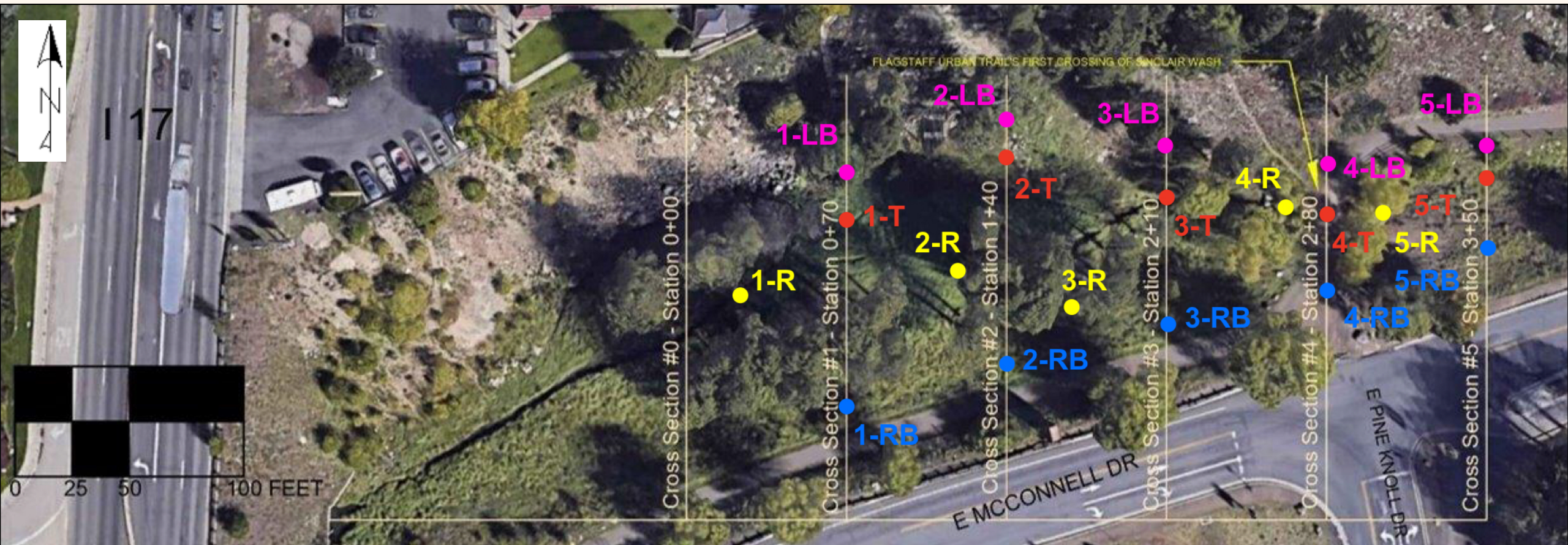


Figure 7: Soil Sampling Plan

# Geotechnical Work

# Geomorphic Assessment

Table 1: Stream Classifications

Characteristic	Upstream	Downstream
Entrenchment Ratio, ER (ft/ft)	0.70	0.77
Width/Depth Ratio ( $W_{bkf} / d_{bkf}$ )	19.9	5.14
Channel Sinuosity, K	1.19	1.07
Water Surface Slope, S (ft/ft)	0.01	0.03
Channel Materials (Particle Size Index), $D_{50}$ (mm)	3.00	1.98
<b>Stream Type</b>	<b>F4-F5</b>	<b>G4-G5</b>

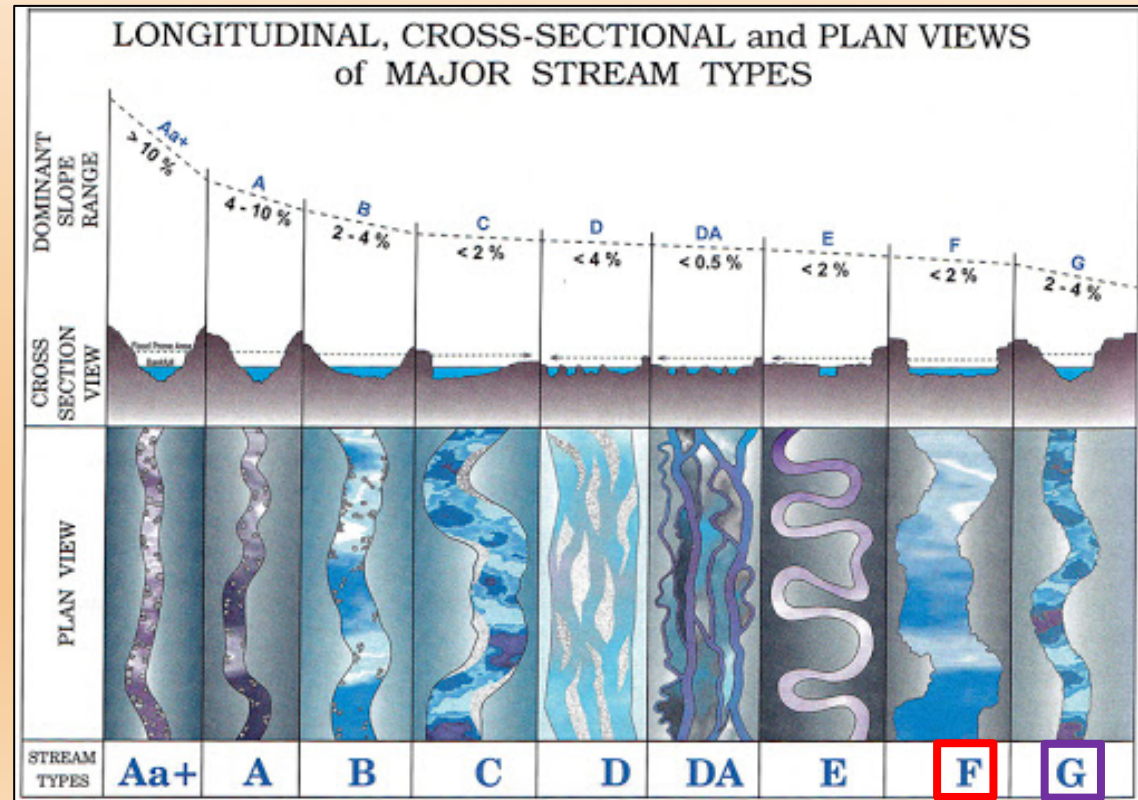
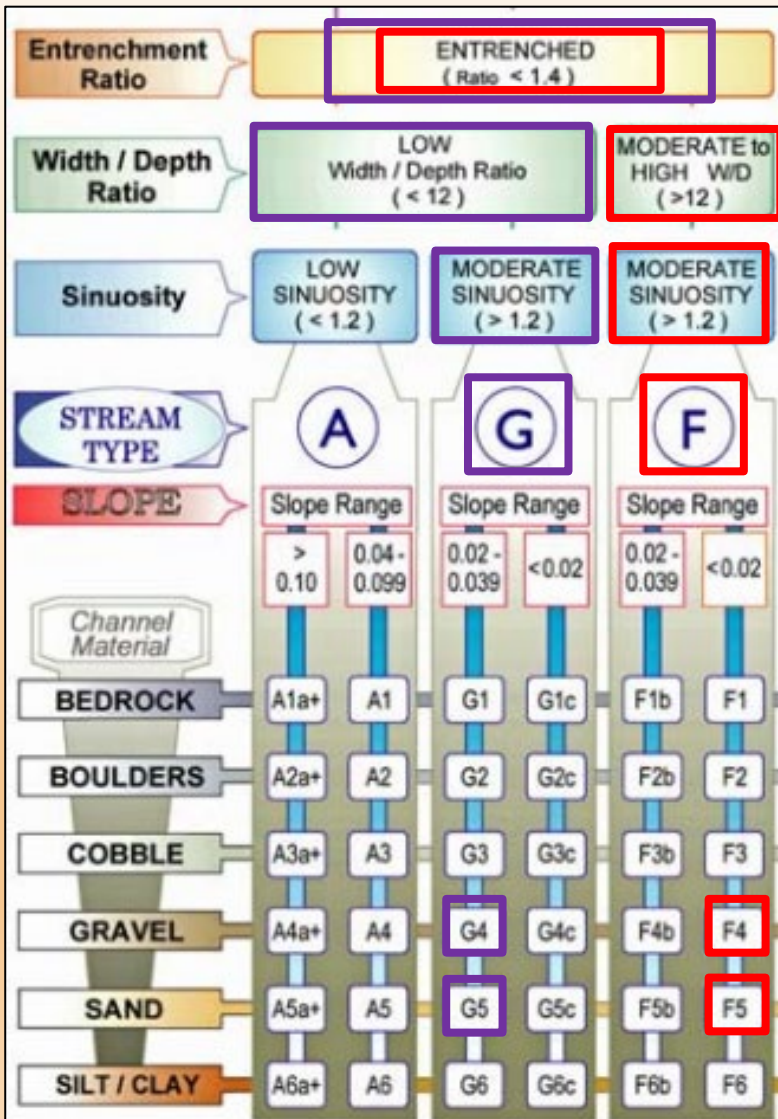


Figure 8: Rosgen Geomorphic Classification

Figure 9: Rosgen Geomorphic Classification

# Channel Cross-Sections

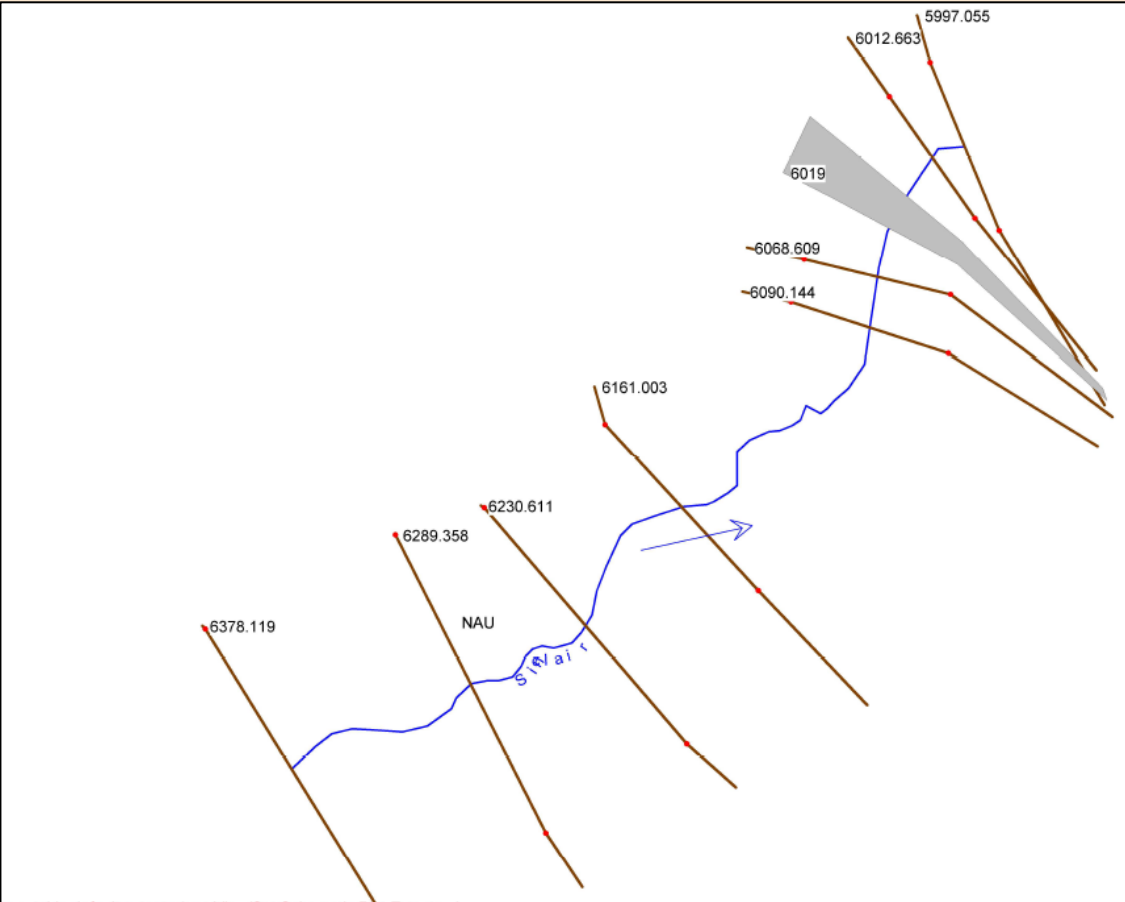


Figure 10: Effective Model Cross-sections

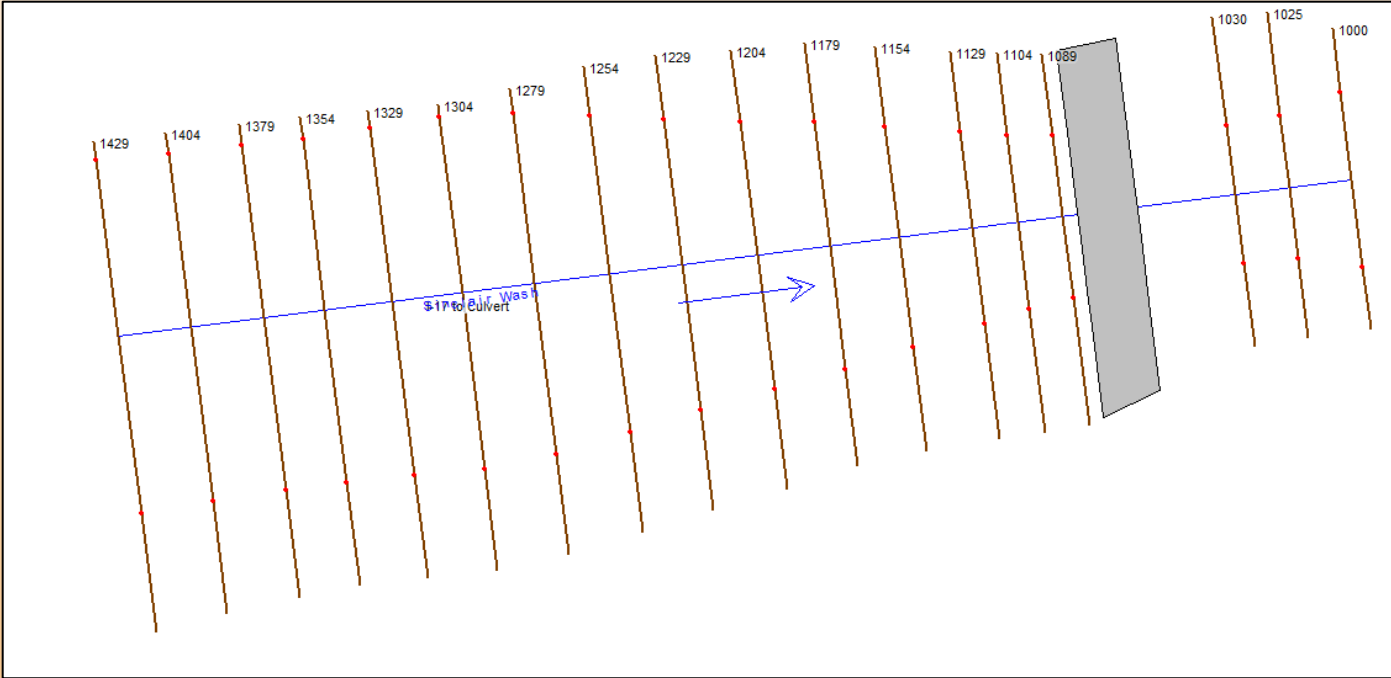


Figure 11: Corrected Effective Model Cross-sections



# Corrected-Effective Model

**Table 2: Corrected Effective Model Data**

HEC-RAS Data - 100 Year Storm					
Location	Values	W.S Elevation (ft)	Velocity (ft/s)	Q (ft <sup>3</sup> )	Froude #
Upstream	Min.	6871.13	0.66	890	0.03
	Max	6871.15	1.23	890	0.07
Downstream	Min.	6862.04	4.48	890	0.45
	Max	6862.41	6.06	890	0.67

**Table 3: Corrected Effective Model Assessment**

Model Assessment				
Characteristics	W.S Elevation	Velocity	Q	Froude #
Requirement	6864.4 ft (FEMA FIS Data)	Not exceed 18 fps (COFSDM)	Storm Event Interval (FEMA FIS)	Max of 0.86 (COFSDM)
Pass/Fail	Fail	Pass	Pass	Pass



**Figure 12: FUTS Crossing of Sinclair Wash**

# Existing Culvert Conditions



Figure 13: Culvert Inlet Conditions



Figure 14: Culvert Outlet Conditions



Figure 15: Scour Pool Ponding  
Culvert Outlet

Table 4: Existing Culvert Data

Storm Intervals	Storm Interval Flow Rate	Culvert Discharge	Culvert Exit Velocity
	ft <sup>3</sup> /s	ft <sup>3</sup> /s	ft/s
25 Year	470	38.58	8.36
100 Year	890	32.24	7.91

# Proposed Culvert Designs

## Alternative #1

- 6 Barrel CMP Culverts
- 96 in. Diameter
- Mitered to Slope Entrance
- Total Cost: \$54,000.00



Figure 16: 96" CMP Barrels

## Alternative #2

- Triple Box Concrete Culverts
- 12 x 9 ft
- 90° Headwall w 45° Bevels
- Total Cost: \$66,915.00



Figure 17: Triple Box Culvert

## Alternative #3

- 3-Sided Triple Box Culvert
- 12 x 9 ft
- 90° Headwall with Wingwalls
- Total Cost: \$81,163.00



Figure 18: Triple box Culvert with Wingwalls

Parameters					
Alternatives	Upstream Water Surface	Downstream Velocity	Aesthetics	Cost	TOTAL
Weights	0.30	0.30	0.15	0.25	1.0
6 Barrel 96"	1	2	1	3	1.8
Triple Box Culvert	3	1	2	2	2.0
<b>3-Sided Triple Box Culvert</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>2.2</b>

Table 5: Decision Matrix

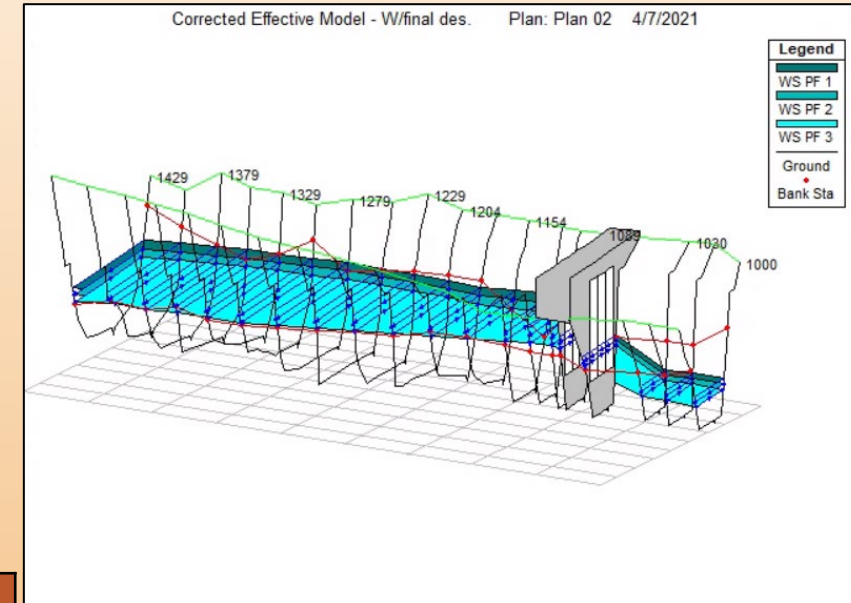
# Proposed HEC-RAS

**Table 6: Proposed Model Data**

HEC-RAS Data - 100 Year Storm					
Location	Values	W.S Elevation (ft)	Velocity (ft/s)	Q (ft <sup>3</sup> )	Froude #
Upstream	Min.	6863.3	1.21	890	0.09
	Max	6863.63	2.49	890	0.18
Downstream	Min.	6858.67	6.36	890	0.64
	Max	6858.85	7.36	890	0.77

**Table 7: Proposed Model Assessment**

Model Assessment				
Characteristics	W.S Elevation	Velocity	Q	Froude #
Requirement	6864.4 ft per FEMA FIS Data	Not exceed 18 fps per COF Stormwater Design Manual	Storm Event Interval per FEMA FIS Data	0.86 per COF Stormwater Design Manual
Pass/Fail	Pass	Pass	Pass	Pass



**Figure 19: Proposed HEC-RAS Model**

# Site Modifications

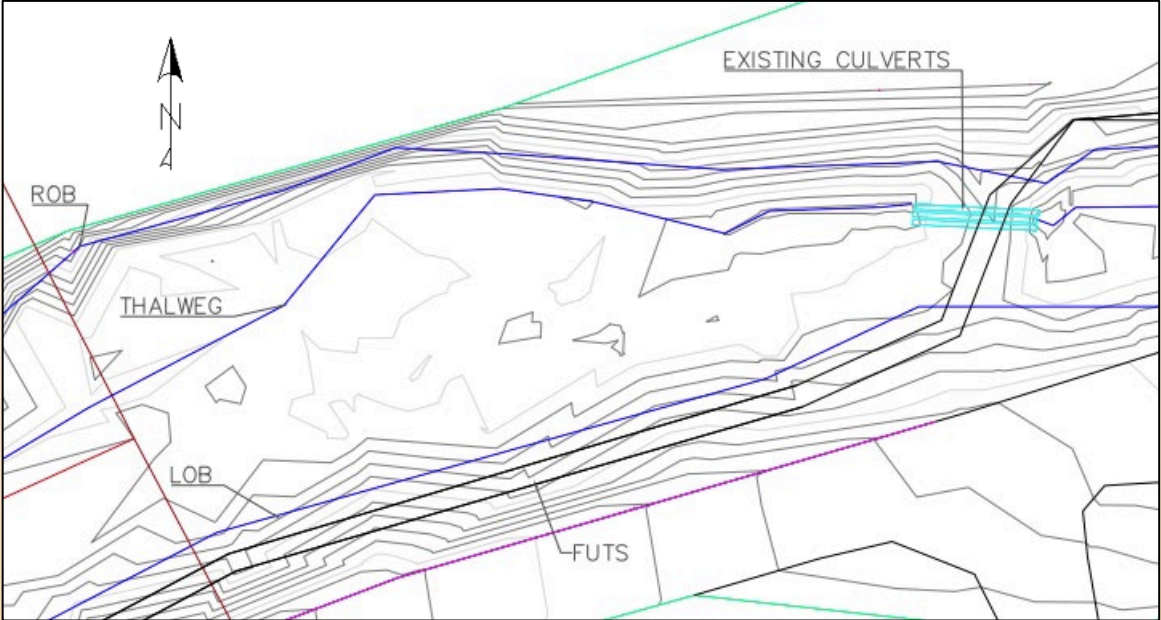


Figure 20: Existing Site

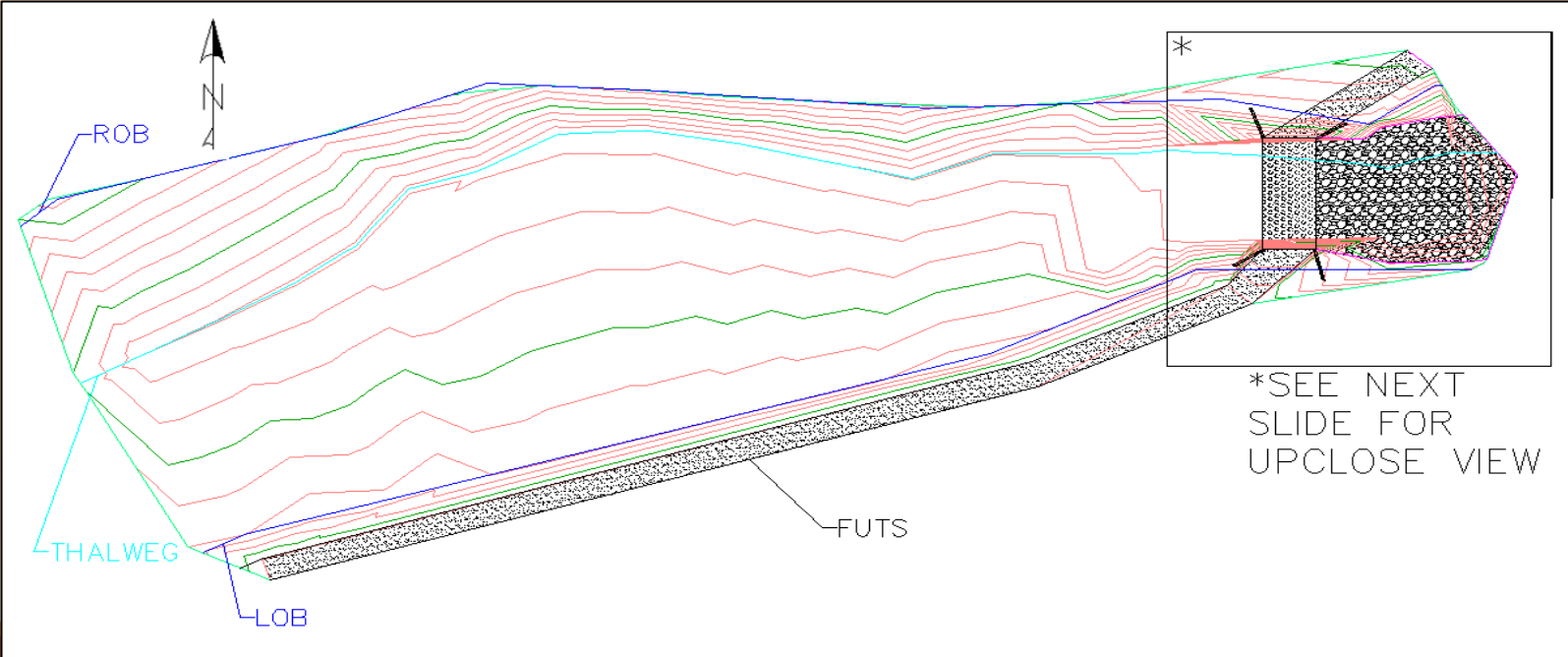


Figure 21: Proposed Site

# Proposed Site

- 1** TRIPLE BARREL THREE SIDED CULVERT WITH 90 DEG. HEADWALL AND LAYER OF  $\frac{3}{4}$  IN. PEA GRAVEL
- 2** CONCRETE WINGWALL, TYP.
- 3** DUMPED ROCK RIP RAP APRON

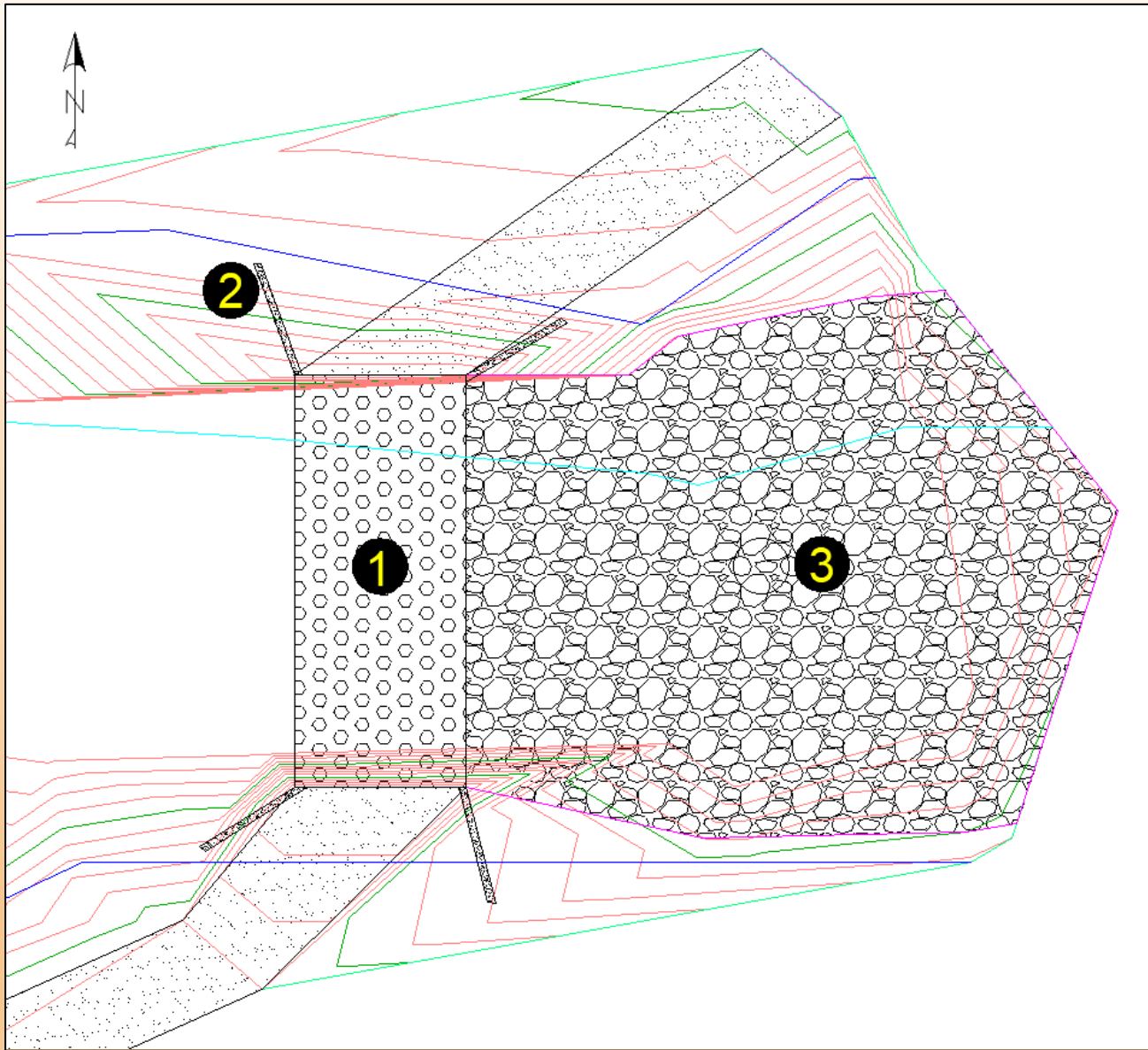
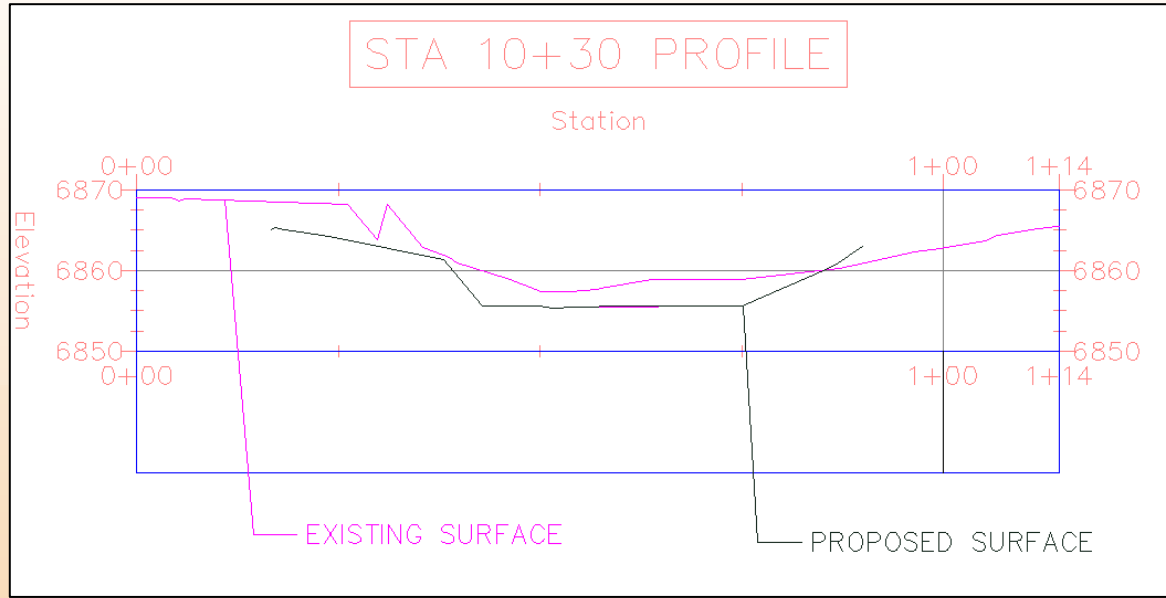
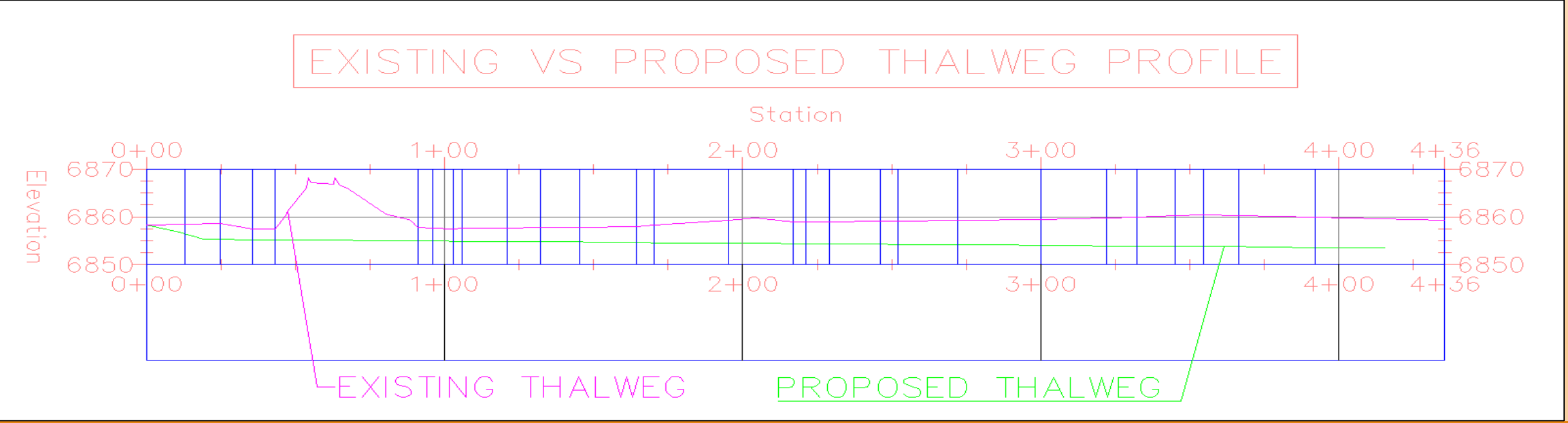


Figure 22: Proposed Culvert Plan View

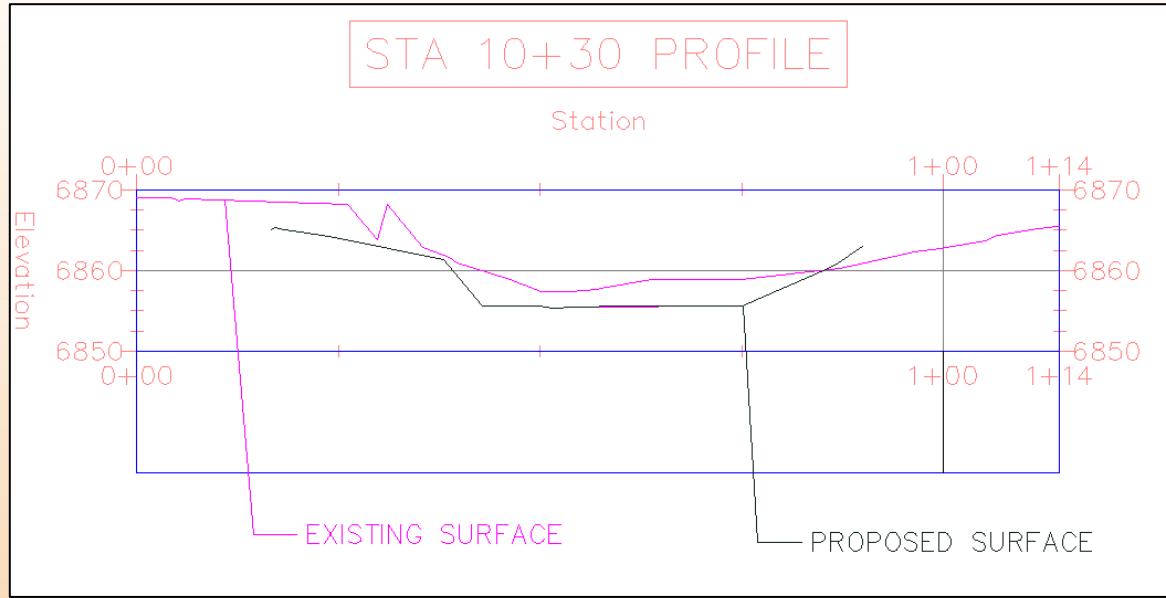
Figure 23: Proposed Culvert Plan View Call Outs



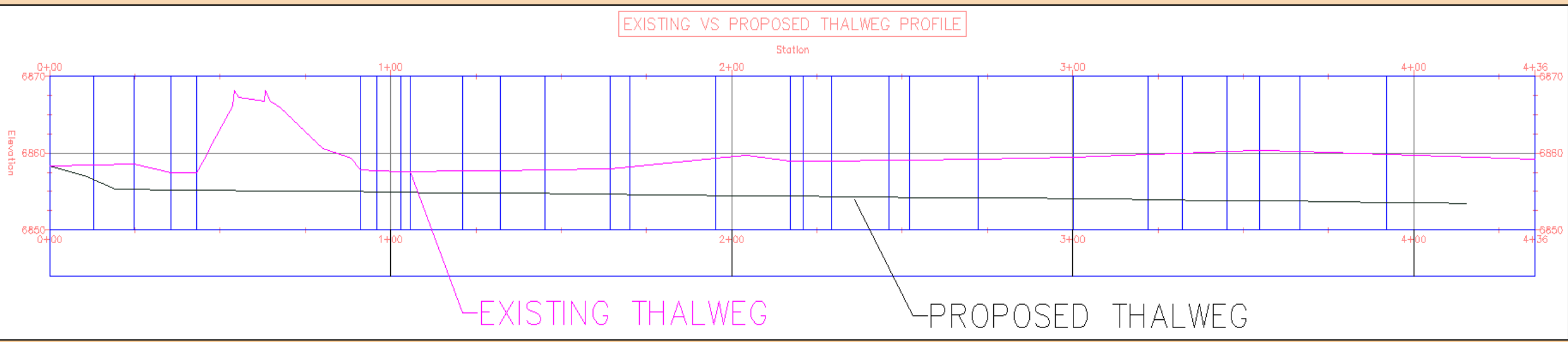
**Figure 25: Cross Section 10+30 Profile**



**Figure 26: Thalweg Profile**



**Figure 24: Cross Section 10+30 Profile**



**Figure 25: Thalweg Profile**



**Table 8: Project Cost**

Item	Unit	Unit Price	Quantity/Area	Total
<b>Revegetation</b>				
Clearing and grubbing	acres	\$4,037.50	0.316	\$1,275.85
Removal of trees	per tree	\$800.00	87	\$69,600.00
Miscellaneous work (Control of noxious plants - Manual)	Sq.Yd.	\$0.70	7637.035	\$5,345.92
Miscellaneous work (Control of noxious plants - Herbicide)	Sq.Yd.	\$0.39	7637.035	\$2,978.44
Seeding (Projects great than 1 acre)	acres	\$5,537.73	1.52	\$8,417.35
<b>3 Culverts (12 X 9)</b>				
Gravel	Ton	\$40.00	9.867	\$394.68
Contractor quality Control	L.Sum	\$31,051.13	1	\$31,051.13
Construction survey and layout	L.Sum	\$20,000.00	1	\$20,000.00
Box culvert and labor	L.F.	\$1,540.50	45	\$66,915.00
Wingwalls and labor	L.F.	\$3,562.00	4	\$14,248.00
<b>Earthwork</b>				
Remove and dispose of excess dirt	Cu.Yd.	\$47.15	270.65	\$12,761.15
Cut/Fill	Cu.Yd.	\$8.00	3112.93	\$24,903.44
Riprap (Dumped)	Cu.Yd.	\$190.24	154	\$29,296.96
<b>TOTAL</b>				<b>\$287,187.93</b>

# Project Cost

- Revegetation Work – \$87,617.57
- Culvert Work – \$132,608.81
- Earthwork – \$66,961.55

# Project Impacts

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## SOCIAL

- Geomorphologic design alternatives
  - Nearby establishments impacted
- Negative impacts expected during construction
  - Positive following implementation
    - Functionality and aesthetic appearance expected to improve
  - Increased accessibility/usability
  - Increased safety

## ENVIRONMENTAL

- Removal of debris
- Removal of invasive species
- Introduction of new, native vegetation
- Improved water quality

## ECONOMIC

- Ecotourism

# Conclusion

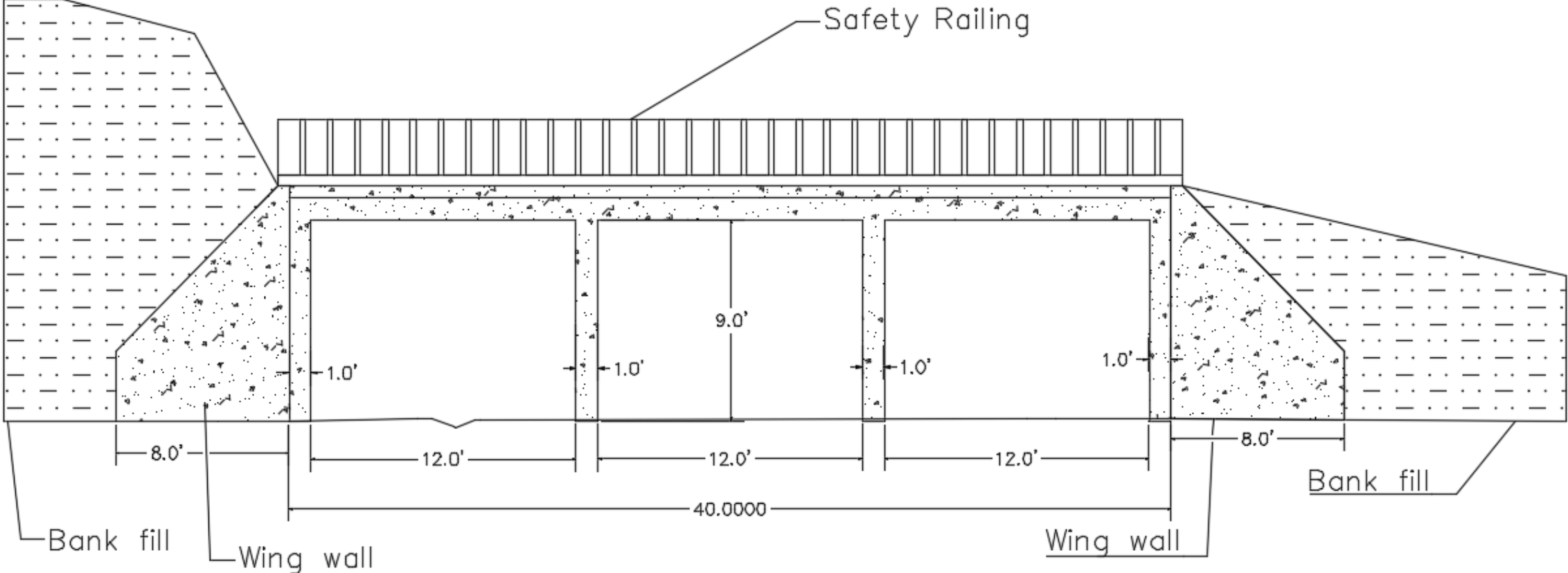


Figure 26: Proposed Culvert Profile View

# References

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- [1] Google. Maps Data. 2020 [Online]. [Accessed: 02- Nov- 2020].
- [2] "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis," [Online]. Available: [https://compass-astm-org.libproxy.nau.edu/EDIT/html\\_annot.cgi?D6913+17](https://compass-astm-org.libproxy.nau.edu/EDIT/html_annot.cgi?D6913+17). [Accessed: 02- Nov- 2020].
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- [4] University of Arizona Cooperative Extension and Flagstaff Chapter of the Arizona Native Plant Society, "Northern Arizona Invasive Plants," Coconino County, 2016. [Online]. Available: <https://www.nazinvasiveplants.org/by-image>. [Accessed 13 January 2021].
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- [6]"Bid Tabulations | ADOT", *Azdot.gov*, 2021. [Online]. Available: <https://azdot.gov/business/contracts-and-specifications/bid-tabulations>. [Accessed: 03- Apr- 2021]