SINCLAIR WASH RESTORATION PROJECT

REPORT

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Version: Final Report

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NAU	Northern Arizona University
CS	Cross-section
N/A	Not Applicable
D	Diameter
CMP	Corrugated Metal Pipe
FUTS	Flagstaff Urban Trail System
cfs	Cubic feet per second
ROB	Right of Bank
LOB	Left of Bank
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
HEC-RAS	Hydraulic Engineering Center's – River Analysis System

Acknowledgments

We would like to thank our client, technical advisor, and grading instructor Mark Lamer, for providing technical and educational guidance.

1.0 Project Introduction

1.1 Background

The Sinclair Wash Restoration Feasibility Study, completed by HYD Engineering, identified three sites along Sinclair Wash in need of restoration. The first site chosen was approximately 156-ft east of the I-17 culvert and extended past the first FUTS crossing of the wash. It was chosen due to the multiple low points that caused ponding, and the vast amounts of vegetation that impeded flow through the channel. The second site chosen was 550-ft northeast of the San Francisco Street culvert and extended 870-ft in the same direction. An overgrowth of vegetation and thalweg cutback were the identified areas of concern for the site. The final site chosen, expanded from 1000-ft southwest of the Lone Tree Culvert to the entrance of the same culvert. This site was chosen based on the observed ponding and dirt/gravel lining that would increase erosion rates.

To address the issues observed in each section of the wash, HYD Engineering proposed a trapezoidal channel design with a smaller trapezoidal cut at the bottom of the channel. This allowed the channel bed to convey water for high and low flows. The design would be implemented at each cross-section and vary based on the bank-full area. Sites #1-3 required the respective bank-full areas, 10.95-ft^2, 20.693-ft^2, and 20.23-ft^2. The site profiles were changed to reflect a ripple, pool, run, glide design, along with channel side cuts placed at an H:V ratio of 3:1. Natural grasses were seeded along the channel and banks of the wash, per City of Flagstaff Stormwater Design Manual 8.4.4.

While all three sites had similar channel issues and design solutions, HYD Engineering identified an additional issue at Site #1. The current CMP culverts (3, 2.5-ft barrels) produce overtopping and damage to the channel, reducing functionality throughout the site and along the FUTS crossing. To repair this issue, HYD Engineering proposed that a prefabricated bridge replace the FUTS crossing. However, HYD Engineering also suggested that further study and analysis be completed to determine the adequate culvert design. Therefore, Site #1 was selected for completion of the Sinclair Wash Restoration Project.

As a continuation, this project aimed to restore a section of the Sinclair Wash near the I-17 culvert to its proper riparian habitat through an aerial assessment and the completion of a detailed restoration plan. The assessment collected data on the current channel conditions, adjacent infrastructure, and problematic stream crossings to provide design alternatives for the area. The restoration plan was completed to improve the natural riparian ecosystem within and around the channel section, reduce flooding, erosion, and sedimentation produced by rainfall events, and promote recreational use along the Flagstaff Urban Trail.

1.2 Location

The site is in Flagstaff, Arizona on the Northern Arizona University campus and adjacent to the Flagstaff Urban Trail System. It is a section of the Sinclair Wash which lies 156-ft east of the I-17 and McConnell Dr. overpass. See Figures 1-3 for site location images.

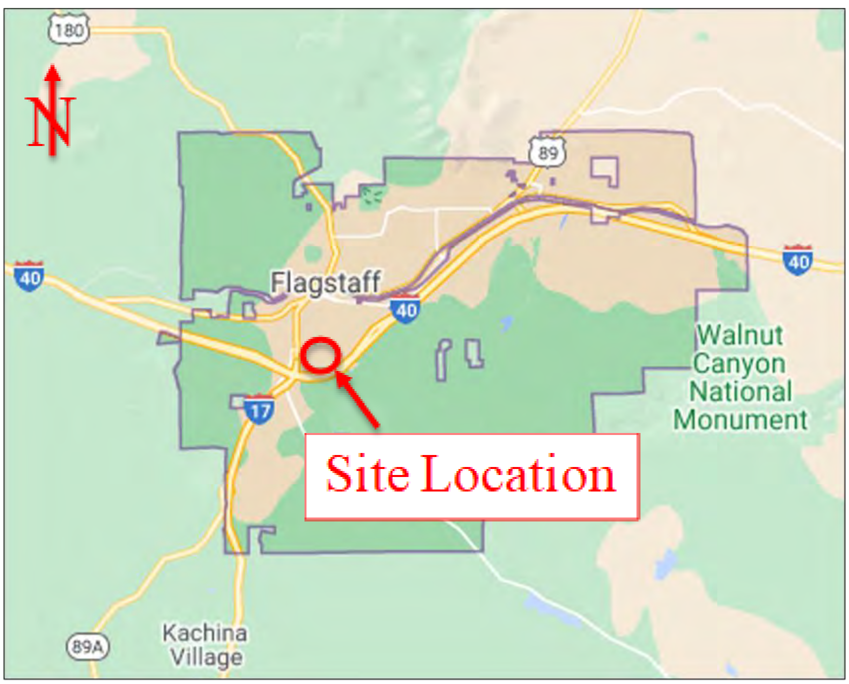


Figure 1: Site Location with Respect to Flagstaff Boundary

Figure 1 presents the site location with respect to Flagstaff's boundary. Figure 2 displays the site location with respect to Northern Arizona University's boundary.

Figure 2: Site Location with Respect to NAU's Boundary

The site location is circled in red and can be identified within Figures 1 and 2. Figure 3 depicts the site location with respect to I-17. The site boundary has been outlined in orange.

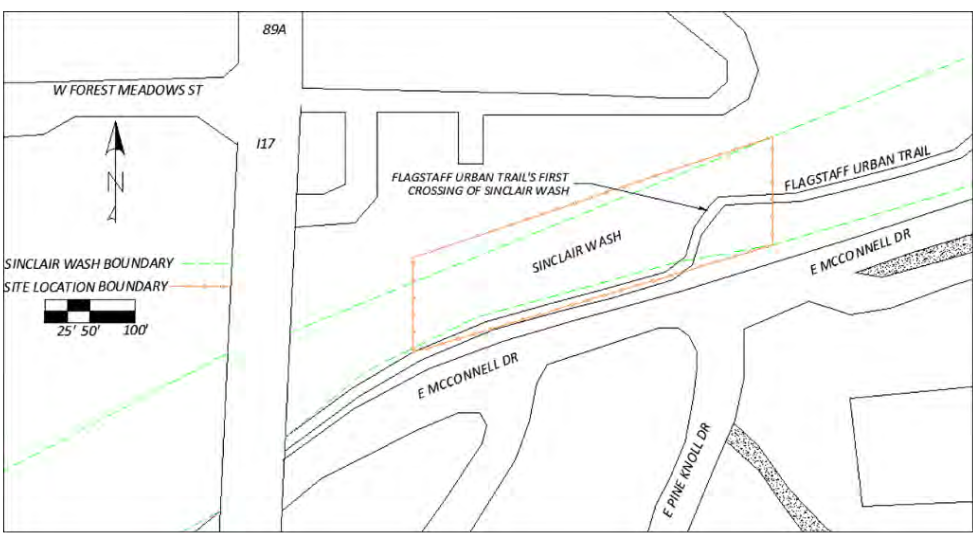


Figure 3: Site Boundary

The site boundary is 156-ft east of the I-17 culvert and continues past the first crossing of the wash along the Flagstaff Urban Trail System. This has been illustrated in Figure 3.

1.3 Current Conditions

Various problems continue to occur throughout the Sinclair Wash, including sedimentation build up (aggradation), erosion (degradation), inconsistency between low points within the channel, and vegetation overgrowth. Aggradation and degradation of the channel section has caused sediment to deposit amongst new places, thus impeding the normal flow of the channel and creating low points in other areas. Overgrown vegetation has resulted in ponding, flooding, and growth of non-native (invasive) flora. The Sinclair Wash floods following heavy rainstorms or large snow melt events. This causes the adjacent Flagstaff Urban Trail to erode and generates risk to anyone utilizing the trail.

2.0 Site Investigation

Red Rock Engineering conducted an initial site investigation. The safety plan was created and signed by each member completing the site investigation prior to arrival (See Appendix 1: Safety Plan for Initial Site Investigation). The site was divided into six cross-sections. These cross-sections have been identified and provided below (See Figure 4). The first cross-section was used to indicate the beginning of the site.

Figure 4: Cross-Sections for Site

Drainage course assessments, site condition analyses, and inventories for areas of concern were devised for each cross-section. Observations for each cross-section also included the span directly following the previous cross-section. There were no observations collected for Cross-Section #0 (STA 0+00) as it was used for reference. The recorded observations for Cross-Section #1 (STA 0+70) have been provided below (See Table 1).

Table 1: Cross-Section #1 Observations

CROSS-SECTION #1 (STA 0+70)	
Drainage Course Assessment	Clear, well-defined flow path (barriers defining the drainage course are considered high enough for average rainfall events) Drainage course consists primarily of dirt
Site Conditions	Ample grass/vegetation surrounding the drainage course. Growing flowers (presence of nutrients and ability to support life) Debris (scattered) Dry (at least one month passed since most recent rainfall)
Inventory: Areas of Concern	Too much grass to identify what is underneath vegetation (not along channel center)

Images of Cross-Section #1 were collected by the team members responsible for conducting the site investigation (See Appendix 2: Cross Section #1 – STA 0+70 Images). The recorded observations for Cross-Section #2 (STA 1+40) have been provided below (See Table 2).

Table 2: Cross-Section #2 Observations

CROSS-SECTION #2 (STA 1+40)	
Drainage Course Assessment	Blocked/poorly defined flow path (due to overgrown vegetation)
Site Conditions	Ample buildup of debris Foliage obstructing entire channel pathway. High Manning's value (excess debris and overgrown vegetation) Terrain for flow path was ill-defined (a clear channel path was difficult to distinguish)
Inventory: Areas of Concern	High volume of debris Ill-defined flow path

Images of Cross-Section #2 were collected by the team members responsible for conducting the site investigation (See Appendix 3: Cross Section #2 – STA 1+40 Images). The recorded observations for Cross-Section #3 (STA 2+10) have been provided below (See Table 3).

Table 3: Cross-Section #3 Observations

CROSS-SECTION #3 (STA 2+10)	
Drainage Course Assessment	Flow path began to open and widen (moving from barrier between CS#2 & CS#3 to barrier between CS#3 & CS#4)
Site Conditions	No barrier present between dirt flow path and side barriers Rocky; fewer debris (compared to CS#2)
Inventory: Areas of Concern	Large area established beside primary flow path; appears to be an unfinished channel (assumed to act like a dam)

Images of Cross-Section #3 were collected by the team members responsible for conducting the site investigation (See Appendix 4: Cross Section #3 – STA 2+10 Images). The recorded observations for Cross-Section #4 (STA 2+80) have been provided below (See Table 4).

Table 4: Cross-Section #4 Observations

CROSS-SECTION #4 (STA 2+80)	
Drainage Course Assessment	Rocky path began to open (moving from barrier between CS#3 & CS#4 to barrier between CS#4 & CS#5)
Site Conditions	Minor debris proceeding culvert inlet (west end of culvert) Debris were still present at inlet of culvert (obstruct flow through culvert inlet) (west end of culvert)
Inventory: Areas of Concern	Two of three culvert inlets (west ends of culverts) present were completely blocked; third culvert severely restricted.

Images of Cross-Section #4 were collected by the team members responsible for conducting the site investigation (See Appendix 5: Cross Section #4 – STA 2+80 Images). The recorded observations for Cross-Section #5 (STA 3+50) have been provided below (See Table 5).

Table 5: Cross-Section #5 Observations

CROSS-SECTION #5 (STA 3+50)	
Drainage Course Assessment	Wide, well-defined flow path
Site Conditions	All (three) culvert outlets (east) were identifiable. Little debris present; rocky, less vegetation (comparably)
Inventory: Areas of Concern	N/A

Images of Cross-Section #5 were collected by the team members responsible for conducting the site investigation (See Appendix 6: Cross Section #5 – STA 3+50 Images). The recorded observations for the crossing and culverts have been provided below (See Table 6).

Table 6: Culvert Observations

CULVERT DATA	
Measurements	D = 2.5' Elevation = 3.5/4' from crown Material: CMP
Culvert Conditions	Restricted flow Buildup of debris Looking upstream: left and center culverts are blocked, right culvert is hindered.
Inventory: Areas of Concern	Extreme dirt/debris buildup on 2 left-most culverts (looking upstream); took some digging to find middle inlet; right inlet was not found.

Images of the crossing and culverts were collected by the team members responsible for conducting the site investigation (See Appendix 7: Culvert Photographs).

3.0 Analysis of Previous Studies

Red Rock Engineering employed results from the feasibility study conducted by HYD Engineering. The study identified three sections of the Sinclair Wash requiring restoration within NAU property boundaries. Reported issues within the I-17 channel reach, included channel erosion, low points not along the thalweg, excessive vegetation, and concerns pertaining to the culvert intersecting the Flagstaff Urban Trail System. Red Rock Engineering also employed surveying and hydraulic modeling data provided from previous capstone teams to model the channel and estimate earthwork quantities. [1].

Hydraulic modeling data entailed effective and corrected effective models presented by HYD Engineering. These models were employed to progressively model hydraulic flow properties along the Sinclair Wash. HYD Engineering did not provide geotechnical data for Sinclair Wash. [1]. Red Rock Engineering performed a geotechnical analysis to obtain the necessary data for classifying existing soils (See Section 2.4).

Based on the results found during the site investigation it can be determined that the existing channel conditions have many geomorphic instabilities. The first is debris such as rocks or trash hindering the flow path in many areas. The second is the overgrown brush obstructing substantial portions of the thalweg causing water to lose too much velocity creating sedimentation. The final is high sediment deposition and overgrown vegetation blocking the inlets and outlets at the FUTS trail crossing three-barrel culverts. The sum of these instability issues is causing the stream to aggrade upstream and degrade downstream of the FUTS culverts. This is evident when compared to the prominent level of sedimentation in the inlets of the FUTS Culverts as well as low points not along the thalweg found in the site investigation. A design solution presented by the 2019-2020 Capstone team suggests the profile of the channel be changed to fit the profile of a ripple-run-pool-glide. This and other designs solutions will be considered in the final plan set. All identified instability issues will be addressed in the final channel reach design [1].

4.0 Geotechnical Analysis

The Field Sampling Plan was created prior to visiting the Sinclair Wash. This plan entails the sampling methodology and required materials as well as the quantity and locations of each sample. The document was completed and signed by each team member in attendance (See Appendix 8: Field Sampling Plan).

Beginning at cross-section 0+70 and ending at cross-section 3+50 (seen in Figure 4), one sample was collected at the ROB, LOB, and thalweg. Each cross section has a total of 3 samples. In addition to these, 5 additional samples were collected randomly, giving a total of 20 soil samples. See Appendix 9 for random soil sampling pictures.

At each sampling location any debris or plants were removed from the area and the surface soil was removed. A 1 gallon bag was used as the volume of sample needed. After the samples were collected they were placed in tins and allowed to dry out. After drying any plant and debris in the sample was removed. The Atterberg Limit Tests were completed followed by a sieve analysis. Appendices 10 - 29 give all raw data for the Atterberg Limit Tests and sieve analysis in addition to the particle size distribution curve, the casagrande plasticity chart, and the AASHTO classification chart. Appendix 30 shows the AutoCAD exhibit of the location of each sample and the AASHTO classification. Appendix 31 shows the AutoCAD exhibit of the location of each sample and the USCS classification. The classifications of the soil will be used to conduct the geomorphic assessment of the channel reach.

5.0 Geomorphic Assessment

The geomorphic assessment entailed classifying stream types for both upstream and downstream of the culverts according to the Rosgen Geomorphic Classification. The stream was divided into upstream and downstream classifications due to the differences in flow type, elevation, and channel features. Characteristics applicable for both upstream and downstream classifications have been provided below (See Table 7).

Table 7: Worksheet 12 Stream Characteristics

Stream Name:	**Sinclair Wash**				
Basin Name:	SB#1	**Drainage Area:**	6086.4 acres		9.51 mi^2
Location:	Northern Arizona University & I-17 Overpass; Flagstaff, AZ				
Township & Range:	10324005R	**Section & Quarter:**	28	**Latitude/Longitude:**	35.17917, -111.65776
Observers:	Hannah Fischer, Jakob Brischke, Kylie Hemmele, Stephanie Seymour			**Date:**	4/6/2021

The drainage area was determined as the area of the watershed using USGS StreamStats (See Appendix 32: USGS StreamStats Report). The Coconino County Parcel Viewer was employed for determining the township/range and section/quarter for the channel reach. The stream type for each channel segment was determined using the corresponding enrichment ratio, width/depth ratio, channel sinuosity, water surface slope, and particle size index (See Table 8).

Table 8: Stream Type Classifications

ID	Characteristic					Stream Type
	ER (ft/ft)	(W_{bkf} / d_{bkf})	K	S (ft/ft)	D_{50} (mm)	
Upstream	0.7002	19.893	1.19201	0.006048	3	F4-F5
Downstream	0.7746	5.1384	1.0743	0.0272	1.98	G4-G5

Both upstream and downstream classifications were identified as ranges between two stream type subsections due to variable compositions in channel materials. Measurements calculated using cross-sectional data for upstream and downstream of the culverts were determined using cross-sections immediately preceding and following these culverts, respectively.

6.0 Biological and Ecological Assessment

The Sinclair Wash was monitored to assess surrounding environmental interactions. The area is highly trafficked during non-COVID NAU semesters. Students commute around the area to access campus. Flagstaff civilians and pets use the Flagstaff urban trail intersecting this section of the wash. Construction occurs near the wash along I-17 during the warmer months.

Local flora was classified to differentiate native, invasive, and noxious species. Native flora for this area of the wash includes smooth sumac, creeping barberry, silvery cinquefoil, western wheatgrass, spike muhly, and little bluestem grass. Invasive species include Siberian elm, golden tickseed, curly dock, common dandelion, sweet clover, New Mexico vervain, Kentucky bluegrass, smooth brome, intermediate wheatgrass, and creeping foxtail [2, 3, 4]. Noxious species include Russian knapweed and field bindweed (See Appendix 33: Flora Identification).

Local fauna was examined to determine respective site interactions and potential endangerment. This investigation indicated that the site does not currently support endangered species. Fauna discovered throughout the site are native (See Appendix 34: Fauna Identification) [5, 6].

The findings from these assessments were used to create the invasive/noxious species abatement and native species revegetation plan. This plan entails removing invasive/noxious species from the wash and replacing them with native species through the use of hydro-seeding. Each respective species was indicated with unique symbols on the AutoCAD illustration (See Appendix 35: Revegetation Plan). Ponderosa pine trees and creeping barberry were removed from the wash as they are not considered riparian vegetation and impeded the flow of water through the channel.

7.0 Open Channel Design

7.1 Effective Model

A 2019 capstone team completed a hydraulic analysis of the I-17 reach along Sinclair Wash. [7]. Utilizing HEC-RAS 5.0.5, an effective model (Liszewski model) was designed to mimic the initial site conditions. The Liszewski model was designed with eight cross-sections (see Appendix 36) and three culverts (see Appendix 37), which were analyzed at 350cfs, 670cfs, and 890cfs or the 10-, 50-, and 100-year storm events, respectively. Cross-section and culvert summary tables for the produced results can be found in Appendix 38 and 39. A 3D image of the model can be found in Appendix 40. Pertinent data from the effective model can be seen below in Table 9.

Table 9: HEC-RAS Effective Model Data

HEC-RAS Effective Model Data				
Station	**W.S Elevation (ft)**	**Velocity (ft/s)**	**Q (ft^3)**	**Froude #**
6378.119	6865.84	1.36	890	0.11
6378.119	6864.57	1.41	670	0.13
6289.358	6865.77	1.19	890	0.09
6289.358	6864.46	1.22	670	0.11
6230.611	6865.71	1.20	890	0.09
6230.611	6864.38	1.22	670	0.10
6161.003	6865.60	1.64	890	0.12
6161.003	6864.21	1.73	670	0.15
6090.144	6865.5	2.18	890	0.16
6090.144	6864.06	2.33	670	0.21
6068.609	6865.41	1.75	890	0.13
6068.609	6863.98	2.20	670	0.20
6012.663	6865.42	1.96	890	0.14
6012.663	6863.76	2.36	670	0.20
5997.055	6865.4	2.05	890	0.16
5997.055	6863.69	2.50	670	0.24

The previous conditions indicate that the channel was functioning properly with the current, three-barrel culvert. However, when this data is compared to more current conditions implies that there could be a possible inaccuracy or instability within the Effective Model.

7.2 Corrective Effective Model

Red Rock Engineering completed an updated hydraulic analysis of the I-17 reach along Sinclair Wash. Utilizing HEC-RAS 5.0.7, a corrective effective model was produced to mimic the current site conditions. The Corrective Effective Model contains a total of 18 cross sections (see Appendix 41) taken every 25 feet from the most upstream end of the study area. Cross sections are also taken 5 feet upstream of the inlet and 5 feet downstream of the outlet for the FUTS triple barrel culverts (see Appendix 42). The 100-year and 50-year storms of 890 CFS and 670 CFS respectively are used as the flow profiles per FEMA FIS. Refer to Appendix 43 and 44 for cross-section and culvert summary tables. A 3D image of the model can be found in Appendix 45. The cross-sectional data for the model can be seen in Appendix 46. Pertinent data from the corrected and effective model can be seen below in Table 10.

Table 10: HEC-RAS Corrected Effective Model Data

HEC-RAS Corrected Effective Model Data				
Station	**W.S Elevation (ft)**	**Velocity (ft/s)**	**Q (ft^3)**	**Froude #**
10+00	6862.04	6.06	890	0.67
10+00	6861.62	5.47	670	0.65
10+25	6862.38	4.84	890	0.45
10+25	6861.93	4.21	670	0.42
10+30	6862.41	5.07	890	0.47
10+30	6961.96	4.43	670	0.44
10+89	6871.12	1.28	890	0.07
10+89	6870.76	1.00	670	0.05
11+04	6871.13	1.21	890	0.06
11+04	6870.77	0.94	670	0.05
11+29	6871.43	1.11	890	0.06
11+29	6870.77	0.87	670	0.05
11+54	6871.14	0.95	890	0.05
11+54	6870.77	0.74	670	0.04
11+79	6871.14	0.94	890	0.05
11+79	6870.77	0.73	670	0.04
12+04	6871.14	0.85	890	0.05
12+04	6870.77	0.67	670	0.04
12+29	6871.14	0.76	890	0.04
12+29	6870.78	0.60	670	0.03
12+54	6871.15	0.70	890	0.04
12+54	6870.18	0.55	670	0.03
12+79	6871.15	0.66	890	0.04
12+79	6870.78	0.52	670	0.03
13+04	6871.15	0.65	890	0.03
13+04	6870.78	0.51	670	0.03
13+29	6871.15	0.66	890	0.04
13+29	6870.78	0.52	670	0.03
13+54	6871.15	0.66	890	0.04
13+54	6870.78	0.52	670	0.03
13+79	6871.15	0.67	890	0.04
13+79	6870.78	0.52	670	0.03
14+04	6871.15	0.67	890	0.04
14+04	6870.18	0.52	670	0.03
14+29	6871.15	0.70	890	0.04
14+29	6870.78	0.55	670	0.03

When comparing the current conditions (corrective effective model) of the channel to the previous conditions (effective model) it is clear that the channel no longer functions properly with the current three-barrel culvert. In the Corrected Effective model immediately downstream of the culvert, at station 10+30, the velocity and Froude numbers increase, while the water surface elevation values decrease for the design (670) and check (890) storms. This data indicates that the culverts are severely undersized and are ponding just upstream of the culvert, causing overtopping of the FUTS.

7.3 Culvert Design

Typically, the 25 year and 100-year storm events would be used for the design and check storm, respectively. However, no data could be found for the 25-year storm. The 10- and 50-year flow were interpolated to determine an estimate for the 25-year storm. Due to this estimation and the requirement by Flagstaff that the 100-year water surface elevation cannot be exceeded, data from the check storm will be used for each culvert to compare and finalize a design.

The current culvert has multiple issues. These include, two of three barrels being blocked by debris, and a scour pool at the outlet. The team determined that the debris at the inlet of the culverts is due to high headwater which decreases the waters velocity. When the velocity decreases all suspended particles and debris begin to settle at the inlet. Due to this the team concluded that the new design should not increase the current headwater levels. In addition, Flagstaff mandates that the water surface elevation cannot exceed the 100-year water surface elevation. After research was done the maximum water surface elevation was determined to be 6864.4 feet. The scour pool is occurring due to a high velocity exiting the culvert. In addition there is no channel protection to combat the high velocity. The team will refer to Flagstaff requirements for culverts to ensure that the new design velocity is acceptable and if needed will also design channel protection for the outlet.

Appendices 47 - 48 show the Culvert Master reports for the current culvert. Due to 2 of the 3 culverts being blocked the CulvertMaster model has a single 30" culvert. It can be seen in the results from the reports that the current culvert is inadequate. For the design and check storm the culvert is only carrying 7% and 4% of the discharge, respectively. Based on this model Red Rock Engineering determined that large and multiple barrel culverts will be needed to convey the 25- and 200-year storm events.

Three alternative culvert designs were chosen. The first design is a six-barrel CMP culvert with a diameter of 96 inches. The second design will be a 9–foot high by 12-foot long, triple box culvert. The final design will be a three-barrel three-sided culvert with sized at 9–foot high by 12-foot long. CulvertMaster does not have an option to model a 3-sided culvert, the team modeled the bridge as a triple box culvert. The manning's value was changed from .013 for concrete to .04 to match the natural channel bed.

Each design was initially modeled in Culvert Master and the following results were found. See Appendices 49–51 for culvert designer/analyzer reports. See Table 11 for culvert master data.

Table 11: Culvert Master Data

Corrected Effective Culvert					
Storm Interval	**H.W. Elevations (ft)**	**Velocities (ft/s)**	**Discharge (cfs)**	**Control**	**Flow Regime**
100-yr (890cfs)	6864.84	7.76	114.31	Outlet	N/A
Six CMP Barrel Culverts					
100-yr (890cfs)	6864.4	8.5	890	Outlet	Subcritical
Three Concrete Box Culverts					
100-yr (890cfs)	6864.26	9.84	890	Inlet	Supercritical
3-Sided Bridge					
100-yr (890cfs)	6864.62	9.27	890	Outlet	Subcritical

The headwater elevation was used to determine if the culvert caused the headwater to increase above the allowable water surface elevation. The velocity was compared to standards set by Flagstaff channels to ensure they are in compliance. Discharge was recorded for all culvert options as well to ensure the culvert was not undersized. Culvert control was also recorded in addition to the flow regime. Following this, a decision matrix was used to analyze the data.

The team created the decision matrix with 4 criteria, upstream water surface elevation, downstream velocity, aesthetics, and cost. The upstream water surface elevation and downstream velocity were the most important to ensure the culvert design was in compliance and thus were weighted at 0.3 each. The next most important aspect was the cost, this was weighted at 0.25. Aesthetics were considered as well and weighted at 0.15. A value of 3 was given for the least increase in upstream headwater surface elevation, a score of 1 was given for the most increase. A value of 3 was given for the least increase in upstream velocity, a score of 1 was given for the most increase. The most aesthetically pleasing received a score of 3 and the least received a score of 1. The least expensive option was given a 3 and the most expensive was given a 1. See Appendix 52 for cost calculations for each design.

The following decision matrix in Table 12 was used to determine which design produced optimal results. This design was implemented in HEC-RAS and used to model the proposed solution.

Table 12: Culvert Design Decision Matrix

Alternatives	Upstream Water Surface	Downstream Velocity	Aesthetics	Cost	TOTAL
Weights	0.3	0.3	0.15	0.25	1
Six Barrel "96	1	2	1	3	1.8
Tripple Box Culvert	3	1	2	2	2
3-Sided Bridge	2	3	3	1	2.2

The triple barrel, 3-sided culvert received the highest score. It had the highest water surface elevation, and the second-best velocity. It scored the best in both aesthetics and cost. The water surface elevation was higher than the 100-year storm, but this will be addressed in the HEC RAS model where the team will be able to adjust the channel and the culvert to ensure the water surface elevation is below the 100-year storm event. In addition, the velocity is still considered to be high according to Flagstaff and channel protection will need to be implemented.

7.4 Proposed HEC RAS Model

The proposed HEC-RAS model was created by modifying the Effective corrected model to include the proposed triple barrel three-sided culvert, as well as channel cross section modifications. Per FEMA FIS the 100-year, 50-year, and 25-year storm events at 890 Cfs, 670 cfs and 470 cfs respectively are used for the flow profiles in HEC-RAS. In addition to the proposed tipple barrel three-sided box culvert several cross sections needed to be modified to form a more trapezoidal channel cross section. This was done to reduce the water surface elevation (WSE) further below the FEMA FIS specified 100-year storm value of 6864.5 ft. The FEMA FIS Sinclair wash water surface elevation chart that was used to find this value can be seen in Appendix 53.

The cross sections were only modified between overbank locations to attempt to preserve the original form of the channel as well as to minimize earthwork. During the design it was also determined that the current FUTS trail that parallels the study reach of Sinclair wash needed to be raised several feet, as the existing trail is below the FEMA specified 100-year WSE. Calculations were performed in excel to raise the FUTS trail while still maintaining the existing slopes to the overbank and road locations for each cross section. In order to preserve the natural meander and form in the majority of the channel reach, large cross section modifications were limited to 50 feet upstream and downstream of the proposed culvert to include from cross sections 11+29 to 10+00.

Although large geometric changes were limited, it was determined the thalweg through the study reach had minimal to no slope in sections, to rectify this thalweg elevations in every cross section were changed so the thalweg slope matches the overall average slope of the channel reach. Refer to Appendix 54 – 55 for the cross-section and culvert diagrams. Refer to Appendix 56 and 57 for the cross-section and culvert summary tables. The 3D HEC-RAS rendering of the proposed channel can be found in Appendix 58. Seen below in Table 13 is pertinent data from the Proposed HEC-RAS model, all values are in compliance with both FEMA-FIS and City of Flagstaff design standards.

Table 13: HEC-RAS Proposed Model Data

HEC-RAS Proposed Model Data				
Station	**W.S. Elev (ft)**	**Velocity (ft/s)**	**Q Total (ft^3/s)**	**Froude #**
14+29	6863.63	1.55	890	0.12
14+29	6862.91	1.36	670	0.12
14+04	6863.62	1.63	890	0.13
14+04	6862.9	1.45	670	0.13
13+79	6863.62	1.4	890	0.11
13+79	6862.9	1.21	670	0.1
13+54	6863.61	1.38	890	0.1
13+54	6862.89	1.2	670	0.1
13+29	6863.6	1.48	890	0.12
13+29	6862.88	1.3	670	0.11
13+04	6863.6	1.37	890	0.1
13+04	6862.88	1.2	670	0.1
12+79	6863.6	1.21	890	0.09
12+79	6862.88	1.03	670	0.08
12+54	6863.6	1.26	890	0.09
12+54	6862.88	1.07	670	0.08
12+29	6863.58	1.39	890	0.1
12+29	6862.87	1.18	670	0.09
12+04	6863.57	1.49	890	0.1
12+04	6862.86	1.26	670	0.09
11+79	6863.54	1.98	890	0.15
11+79	6862.83	1.72	670	0.14
11+54	6863.53	1.96	890	0.14
11+54	6862.82	1.67	670	0.13
11+29	6863.51	2.07	890	0.14
11+29	6862.81	1.75	670	0.13
11+04	6863.47	2.45	890	0.18
11+04	6862.78	2.09	670	0.16
10+89	6863.46	2.49	890	0.18
10+89	6862.77	2.11	670	0.16
10+30	6858.85	7.36	890	0.77
10+30	6858.4	6.57	670	0.73
10+25	6858.84	6.36	890	0.64
10+25	6858.37	5.67	670	0.62
10+00	6858.67	6.41	890	0.67
10+00	6858.18	5.82	670	0.66

8.0 Plan Set

The final plan set can be found in Appendix 59. This was sent directly to the client. The cover page details the location of the project and identifies the page numbers and the corresponding sheets. The plan sheet shows the existing plan view of the section of the Sinclair Wash, in addition to the proposed plan view. The profile sheets have a profile view of each cross section and the thalweg. Identified on each are the existing and proposed surface. Following the profile sheets are a channel details and culvert details sheet. The channel details sheet has callouts for all changes along the reach of the channel. The culvert details sheet has a plan and profile view of the culvert with dimensions and relevant information for the client and construction team.

8.1 Site Changes

There were multiple issues with the existing section of the wash that have been addressed in the proposed design. First, the FUTS was at an elevation 2 feet below the 100-year water surface elevation. The proposed design has raised the FUTS to increase usability during storm events. The three-sided culvert was also implemented in the design and replaces the existing triple barrel culverts. Directly north and south of the culvert the FUTS is proposed to slope up to meet the top of the three-sided culvert. Based on the exit velocity of the culvert, riprap will be used to protect the channel bed at the outlet from a scour pool. In addition, gravel will be added to the top of the three-sided culvert as it will be used as a crossing of the FUTS. For safety reasons, railings will be implemented on the crossing as well. Multiple low points throughout the channel reach will be filled in the proposed design. In the existing profile it can be seen that the thalweg upstream of the culvert had no slope. This was adjusted in the final design so that the entire channel has a consistent slope throughout to allow the water to convey through the channel and not pond. The jump seen in the thalweg profile is due to the culvert and will not actually be implemented in place, rather the consistent slope will still be utilized. In the 50 feet before and after the culvert the channel is proposed to be modified into a trapezoidal shape. This was done to increase the capacity of the channel and reduce the water surface elevation upstream to below the 100-year water surface elevation. Minimal modifications outside of the 50-foot range were made to allow the Sinclair wash to naturally flow and restore itself. The velocities calculated by HEC-RAS fell in the range of 4.0 to 10.0 feet per second, outlet armoring in the form of dumped rock riprap is required by the City of Flagstaff Stormwater design manual. The median riprap size (D50) calculated per the city of Flagstaff standards is determined to be 11.5 inches. The length of the apron was also calculated in accordance with the City of Flagstaff and determined to be 104 feet. Since there is a well-defined channel downstream of the apron, no width was required to be calculated, instead width was assumed to be the width of the channel bed.

9.0 Summary of Engineering Work

The proposed and completed schedules for the restoration work have been provided in the following sections, respectively.

9.1 Proposed Schedule

The proposed schedule for the project can be seen in Appendix 60. This schedule was produced with the intention to complete all the technical work by the 60% submittals.

9.2 Project Schedule

The completed schedule for the project can be seen in Appendix 61. The schedule was altered to account for delays in laboratory access and weather conditions. The majority of the technical work was completed between the 30% and 90% submittals.

10.0 Summary of Engineering Costs

The completed staffing hours and cost of construction have been detailed in the following sections, respectively.

10.1 Staffing Hours

The completed staffing hours can be seen in Table 14 below. A complete breakdown of the hours for each position can be seen in Appendix 62.

Table 14: Final Staffing Hour Summary

Final Staffing Summary	
Position	Hours
Senior Engineer	108
Project Engineer	170
Laboratory Technician	103
Intern	117
Total	**498**

A total of 498 hours were spent on the completion of this project. This total is relatively close to the anticipated hours of 502, as seen in Table 15 below.

Table 15: Proposed Staffing Hour Summary

Proposed Staffing Summary	
Position	Hours
Senior Engineer	95
Project Engineer	182
Laboratory Technician	79
Intern	146
Total	**502**

The team initially anticipated the intern and project engineer would complete the majority of hours. However, the laboratory technician and senior engineer ended up completing more hours due to the significant technical work required for this project.

10.2 Cost of Construction

The cost of construction includes a line item break down of the revegetation, culvert, and earthwork cost needed to implement the proposed solution. The cost to construct the project can be seen in Table 16 below.

Table 16: Cost of Construction

Item	Unit	Unit Price	Quantity/Area	Subtotal
Revegetation				
Clearing & Grubbing	acre	$4,037.50	0.316	$1,275.85
Tree Removal	per tree	$800.00	87	$69,600.00
Misc. Work (Noxious Plant Control – Manual)	yd^2	$0.70	7637.035	$5,345.92
Misc. Work (Noxious Plant Control – Herbicide)	yd^2	$0.39	7637.035	$2,978.44
Seeding (Area > 1-acre)	acre	$5,537.73	1.52	$8,417.35
Three Culverts (12 × 9)				
Gravel	ton	$40.00	9.867	$394.68
Contractor Quality Control	L.Sum	$31,051.13	1	$31,051.13
Construction Survey & Layout	L.Sum	$20,000.00	1	$20,000.00
Box Culvert & Labor	L.F.	$1,540.50	45	$66,915.00
Wingwalls & Labor	L.F.	$3,562.00	4	$14,248.00
Earthwork				
Excess Dirt Removal & Disposal	yd^3	$47.15	270.65	$12,761.15
Cut & Fill	yd^3	$8.00	3112.93	$24,903.44
Riprap (Dumped)	yd^3	$190.24	154	$29,296.96
TOTAL COST				**$287,187.93**

The final construction cost calculated for completion of this project is $287,187.93.

10.3 Cost of Engineering Work

The cost of engineering work is categorized by personnel work, laboratory facility usage, and required project supplies. The proposed cost of engineering work can be seen in Table 17 below.

Table 17: Proposed Cost of Engineering Work

Proposed Cost of Engineering Services Summary				
Personnel	**Classification**	**Hours**	**Rate ($/Hour)**	**Cost**
	Senior Engineer	95.25	$218.79	$20,840
	Project Engineer	182	$141.68	$25,786
	Lab Technician	79	$98.01	$7,743
	Intern	146	$32.13	$4,691
Subtotal				$59,059
Lab Facilities	**Classification**	**Days**	**Rate ($/Days)**	**Cost**
	Geotechnical Lab	3	$100.00	$300
Subtotal				$300
Supplies	**Classification**	**Quantity**	**Rate ($/Quantity)**	**Cost**
	Shovel	4	$50.00	$200
	Gallon Ziplock Bags	25	$0.13	$3
Subtotal				$203
Total Cost				**$59,563**

The proposed cost of engineering services was anticipated to be $59,563. While the final cost of the project didn't include a supplies section, the final cost still came out above the anticipated. The final cost can be seen in Table 18 below.

Table 18: Final Cost of Engineering Work

Final Cost of Project				
Personnel	**Classification**	**Hours**	**Rate ($/Hour)**	**Cost**
	Senior Engineer	108	$218.79	$23,575
	Project Engineer	1	$141.68	$24,060
	Lab Technician	103	$98.01	$10,136
	Intern	117	$32.13	$3,768
Subtotal				$61,538
Lab Facilities	**Classification**	**Days**	**Rate ($/Days)**	**Cost**
	Geotechnical Lab	17	$100.00	$1,700
Subtotal				$1,700
Total Cost				**$63,239**

The final cost of engineering services amounted to $63,239. The majority of the cost resides in the personnel work at $61,538, followed by the lab facility use at $1,700. The cost for the engineering services comes out to $3,676 above the anticipated amount, due to the additional lab time required to complete the geotechnical work and increase in senior engineer and lab technician hours. A breakdown of personnel work can be seen in Appendix 63.

11.0 Impacts

The team completed an impact analysis for the proposed design. The information collected from this impact analysis will be provided to stakeholders to ensure satisfactory project completion and benefits to all parties involved. Social, environmental, and economic impacts were analyzed for achieving the triple bottom line.

11.1 Social

Restoration of the Sinclair Wash will have significant social impacts during and following restoration completion. Negative impacts are expected during construction operations as the geomorphologic design impacts nearby establishments. These impacts are anticipated to become positive following implementation of the design due to improved guidance of stormwater runoff and improvement of natural growth surrounding the channel. Improvements are anticipated to increase foot traffic, safety, and overall usability of the site.

Commute through Northern Arizona University campus along E McConnell Dr. between the I-17 overpass and WA Franke College of Business will be significantly impacted. The I-17 off-ramp intersecting E McConnell Dr. will also be impacted as this off-ramp may require closure to minimize commute through this area. Individuals commuting through this area will have to utilize alternate routes during wash restoration as the removal and replacement of culverts may necessitate heavy machinery requiring spatial accommodation. This is expected to greatly impact commuters as additional time may have to be budgeted to reach destinations using alternate routes. Nearby establishments will receive secondhand effects of road closures as visitation to these organizations may decrease dramatically during restoration. Employees of these establishments will be required to use alternate routes and budget accordingly to arrive to work on time. Residents within proximity to the restoration area will also be affected as they would have to use alternate routes multiple times daily until restoration has been completed. Frequent users of the Flagstaff Urban Trail System will have to plan accordingly as this section of the trail will be closed during construction.

Increased foot traffic is anticipated following restoration as this segment of the Sinclair Wash will become more aesthetically pleasing. The aesthetic appearance of the area will be enhanced following removal of debris and flourishment of native flora. This will encourage ecotourism throughout the Sinclair Wash as well as promote usage of the Flagstaff Urban Trail System. Another important component to augmented safety includes compacted dirt with the installation of replacement culverts. Compacted dirt will reduce the potential for injuries by increasing the frictional force between objects coming into contact with the trail. This minimizes the possibility of runners slipping or bicycle wheels losing traction. Safety would also be augmented due to the removal of debris. This would reduce the level of toxins within the area and ultimately minimize disbursement of bacteria. As a final safety measure, railings will be implemented on the crossing of the wash.

11.2 Environmental

Restoration of the Sinclair Wash necessitates considerable environmental impacts. These environmental impacts include removal of debris as well as reduction of invasive and noxious species. The removal of debris will ultimately improve water quality by reducing the level of toxins being transported via flow through the channel. Reduction of invasive and noxious species will allow for native species to repopulate. Downstream of the section of the wash will also see a decrease in invasive and noxious species as seeds from this section of the reach will not be transported downstream.

The primary concern of wash restoration from the environmental perspective is the removal of debris. Elimination of debris will improve flow within the channel by reducing blockage and permitting natural flow. Removing debris from the channel reach will also improve water quality by reducing toxins and bacteria transported through the wash. Compacting soil within the channel reach and surrounding the replacement culverts will further reduce aggradation and degradation. This minimizes erosion by reducing the amount of sediment transported throughout the wash.

Reduction of invasive species will also allow the channel reach to operate naturally and eliminate the possibility of invasive and/or noxious species impacting the growth of native vegetation. Introduction of new, native vegetation will promote growth and expansion of native species to replace the presence of invasive/noxious species. Replacing invasive and noxious flora with native species will also ensure invasive and noxious seeds do not disperse throughout the area.

11.3 Economic

Significant economic impacts are anticipated during completion of the Sinclair Wash. This is primarily due to the budget required for restoration of the channel reach as well as removal and replacement of the existing culverts. Minimal economic impact is anticipated following completion of restoration as commuters and visitors of the area are not required to pay to utilize the area.

Channel restoration as well as removal and replacement of the culverts will have considerable economic impacts. These economic impacts primarily include the purchasing of materials and labor. The replacement culvert materials will generate the greatest economic impact for this project. Cut/Fill material will also need to be purchased to raise the Flagstaff Urban Trail System crossing the channel. Other material that would need to be purchased includes seeding for native fauna following removal of invasive and noxious species. Labor required to complete restoration as well as removal and replacement of culverts will also generate significant economic impacts. This is because labor is required for each phase of the project, including removal, movement, and installation of culverts as well as the removal of debris and native revegetation.

Restoration of the Sinclair Wash will generate economic impacts for local residents. This may include increases in taxes to obtain necessary funds to complete wash restoration. Students attending Northern Arizona University may also notice increases in semesterly costs as the restoration area is located on-campus. Alternative routes implemented during restoration may increase the commuting distance for drivers and ultimately increase the funds they are contributing to gasoline. Nearby establishments may experience negative impacts as commute through this area will be temporarily interrupted. Businesses may experience reduction of sales for goods and services due to temporary road closure.

12.0 Conclusion

Red Rock Engineering has provided the client with a final plan set that has the proposed design. There are construction notes and details included in the plan set to be shared with the construction project manager. The final proposed design is in compliance with Flagstaff City's requirements and is able to convey the 25 and 100 year storm event. At the completion of construction and revegetation, the channel will be restored to its natural riparian habitat, will remain a natural channel with its natural meander intact. The project was completed over budget and on time. Impacts of the proposed project have been thoroughly researched and discussed. Any changes to the plan set provided to the client should be approved by Red Rock Engineering prior to implementation.

13.0 References

[1] S. B. X. W. Eric Lima, "Sinclair Wash Restoration Project," Northern Arizona University - Engineering Department, Flagstaff, 2020.

[2] J. B. a. C. Casey, "Native Plants for Northern Arizona Landscapes Draft A," The Arboretum at Flagstaff, Flagstaff, 2000.

[3] A. O. a. L. E. Epple, A Field Guide to The Plants of Arizona, Conneticut: The Globe Pequot Press, 1995.

[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].

[5] Arizona Game and Fish Deparment, "Airizonas Online Environmental Review Tool," NatureServe, 2021. [Online]. Available: https://ert.azgfd.gov/content/map. [Accessed 24 January 2021].

[6] Arizona Game and Fish, "Wildlife | Northern Arizona," AZ.gove | Arizona Game and Fish Department , 2021. [Online]. Available: https://www.azgfd.com/wildlife/viewing/wheretogo/north/. [Accessed 24 January 2021].

[7] C. L. a. A. Najjar, "Feasibility Analysis for Stream revitalization and Electronic Monitoring," Northern Arizona University, Flagstaff, 2019.

14.0 Appendices

Appendix 1: Safety Plan for Initial Site Investigation

Safety Plan for Initial Site Investigation

Individual Responsibilities

Kylie Hemmele

To ensure my safety during the site investigation, I will wear bright, obvious clothing and a safety vest. I will also refrain from crossing streets, however if I must cross a street I will cross in a legal manner. Also, when I am near the street, I will stand clear of the street by either standing on a sidewalk or when a sidewalk is not present, standing a minimum of three feet away from the street edge. I will take notes while in the field on the following tables.

Stephanie Seymour

To ensure my safety during the site investigation, I will rent a safety vest and wear clothes that are appropriate for the weather and allow me to be easily seen. In addition, I will only cross the street when needed and when legally allowed to do so. I will also be located in an area that is easily seen yet at least three feet away from the street edge. I will take photographs of the site to back up any notes we take.

Protective Clothing

Our team will wear protective clothing whenever in the field. We will use the safety vests. This will ensure our team is visible no matter what time of day we are in the field. Our team will also ensure we are dressed appropriately for the weather conditions during our time in the field.

Location and Time

Our team will be doing a site investigation at the designated reach of the Sinclair Wash near McConnell Dr and Pine Knoll Dr at 10:30 a.m. on Saturday, October 10, 2020. During this time we will do our initial site investigation and record all observations and pictures in the following pages.

Signatures

10/10/2020

Kylie Hemmele Date

10/10/2020

Stephanie Seymour Date

Appendix 2: Cross Section #1 – Station 0+70 Photographs

Figure 5: Station 0+70 Channel – Downstream

Figure 6: Station 0+70 Channel – Upstream

Appendix 3: Cross Section #2 – Station 1+40 Photographs

Figure 7: Station 1+40 Channel – Downstream

Figure 8: Station 1+40 Channel Embankment

Appendix 4: Cross Section #3 – Station 2+10 Photographs

Figure 9: Station 2+10 Channel – Downstream

Figure 10: Station 2+10 Channel – Upstream

Figure 11: Station 2+10 Channel Debris

Figure 12: Station 2+10 Channel Overgrowth

Figure 13: Station 2+10 Channel Obstruction

Appendix 5: Cross Section #4 – Station 2+80 Photographs

Figure 14: Station 2+80 Channel – Downstream

Figure 15: Station 2+80 Channel – Upstream

Figure 16: Station 2+80 Channel Overgrowth

Figure 17: Station 2+80 Channel Debris

Figure 18: Station 2+80 Channel Conditions

Appendix 6: Cross Section #5 – Station 3+50 Photographs

Figure 19: Station 3+50 Channel – Downstream

Appendix 7: Culvert Photographs

Figure 20: Culvert Inlets

Figure 21: Culvert Outlets

Figure 22: Left (South) Culvert Outlet

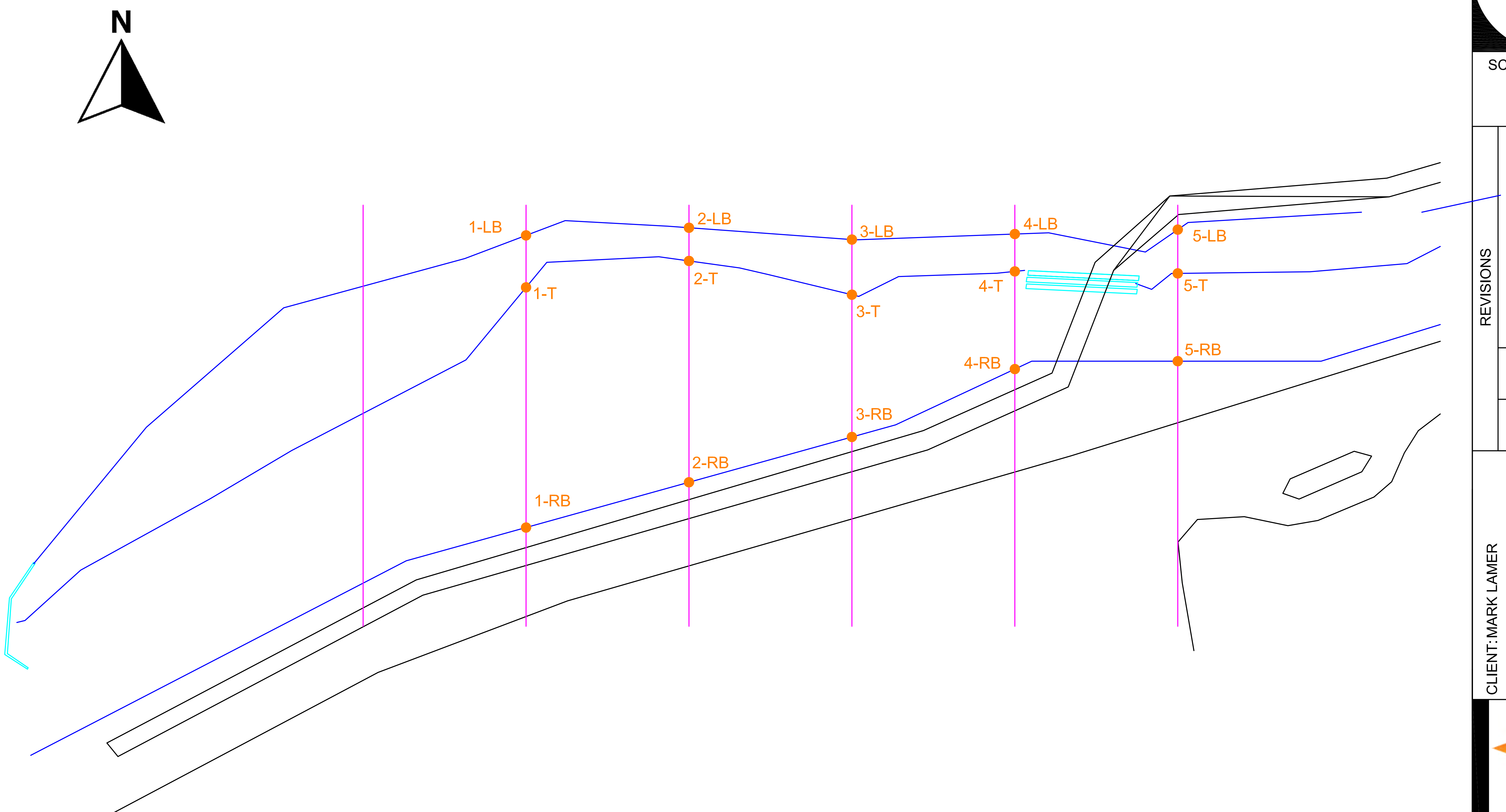
Figure 23: Center Culvert Outlet

Figure 24: Right (North) Culvert Outlet

Figure 25: Culvert Inlet Obstruction

Figure 26: Culvert Inlet Conditions

Appendix 8: Field Sampling Plan



SHEET

OF

SCALE:

0

REVISIONS

CLIENT: MARK LAMER

PROJECT: SINCLAIR WASH

AUTHOR: S. SEYMOUR

DATE: 03/25/2021

Red Rock Engineering

Appendix 9: Soil Sampling Photos

Figure 27: Random Soil Sample Location #1

Figure 28: Random Soil Sample Location #2

Figure 29: Random Soil Sample Location #3

Figure 30: Random Soil Sample Location #4

Figure 31: Random Soil Sample Location #5

Appendix 10: Sample 1 Soil Classification

Table 19: Sieve Analysis Raw Data – Sample 1

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	773.7	2153.7	1380	60.3	60.3	39.7
10	2	447	734.9	287.9	12.6	72.9	27.1
20	0.85	381.3	642.6	261.3	11.4	84.3	15.7
40	0.425	395.3	395.3	0	0.0	84.3	15.7
60	0.25	343.6	411.2	67.6	3.0	87.3	12.7
150	0.106	337.7	442.3	104.6	4.6	91.8	8.2
200	0.075	326.1	391.3	57.7	2.5	94.4	5.6
Pan	NA	369.8	491.4	129.1	5.6	100.0	0.0
Sum	xx	xx	Wts =	2288.2			

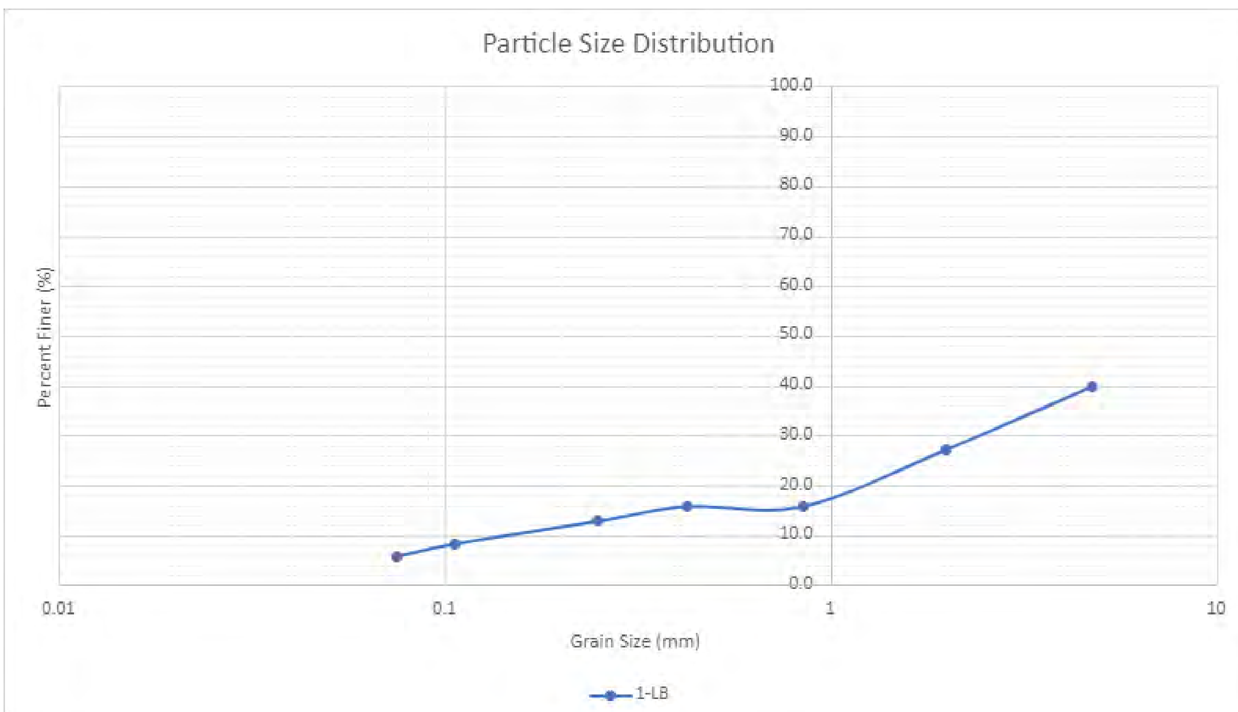


Figure 32: Particle Distribution Curve – Sample 1

Table 20: Liquid Limit Raw Data – Sample 1

Sample 1					
Cross Section	0+70	1			
Location/Name	Left of Bank	1-LB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	19.8	13.1	13.7	14.1	13.5
Mass of Can and Moist Sample, (g)	43.7	39.1	35.5	43.7	46
Mass of Can and Dry Sample, (g)	36.4	31.5	29.6	35.6	38.3
Moisture Content, (%)	44.0	41.3	37.1	37.7	31.0
Number of Drops, N	6	22	30.0	37	50
Liquid Limit	39				

Table 21: Plastic Limit Raw Data – Sample 1

Sample 1			
Cross Section	0+70	1	
Location/Name	Left of Bank	1-LB	
Mass of Can, (g)	13.9	13.9	19.9
Mass of Can and Moist Sample, (g)	14.9	14.6	20.6
Mass of Can and Dry Sample, (g)	14.8	14.4	20.3
Moisture Content, (%)	11.1	40.0	75.0
Plastic Limit	42.0		

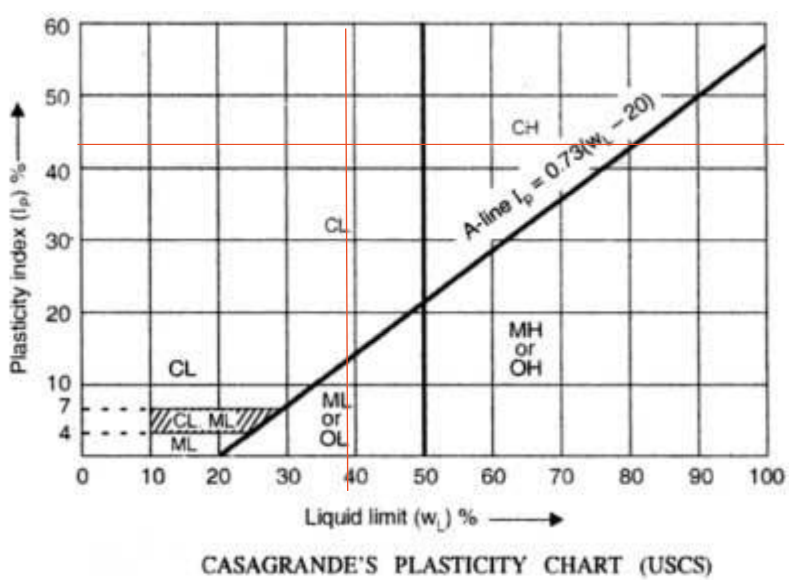


Figure 33: Casagrande's Plasticity Chart - Sample 1

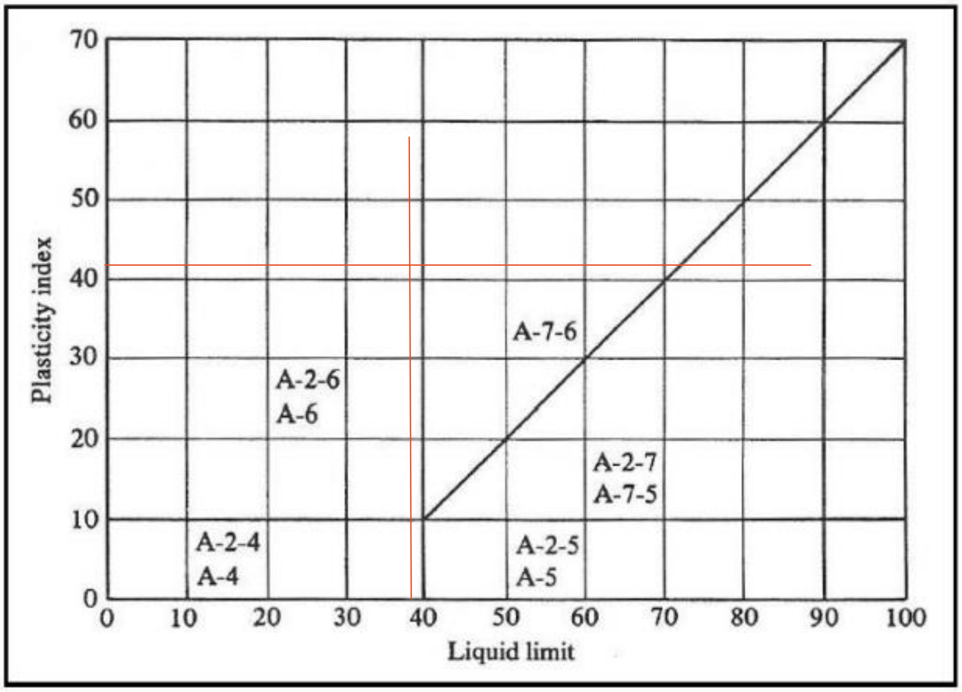


Figure 34: AASHTO Classification Chart - Sample 1

Appendix 11: Sample 2 Soil Classification

Table 22: Sieve Analysis Raw Data – Sample 2

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	515.1	678.9	163.8	8.8	8.8	91.2
10	2	469.8	963.8	494	26.6	35.4	64.6
20	0.85	414.6	1021.7	607.1	32.7	68.2	31.8
40	0.425	360.9	631.6	270.7	14.6	82.7	17.3
60	0.25	345.7	434.7	89	4.8	87.5	12.5
150	0.106	338.5	409.2	70.7	3.8	91.3	8.7
200	0.075	318.6	348.5	57.7	3.1	94.5	5.5
Pan	NA	362.5	493.2	102.9	5.5	100.0	0.0
Sum	xx	xx	Wts =	1855.9			

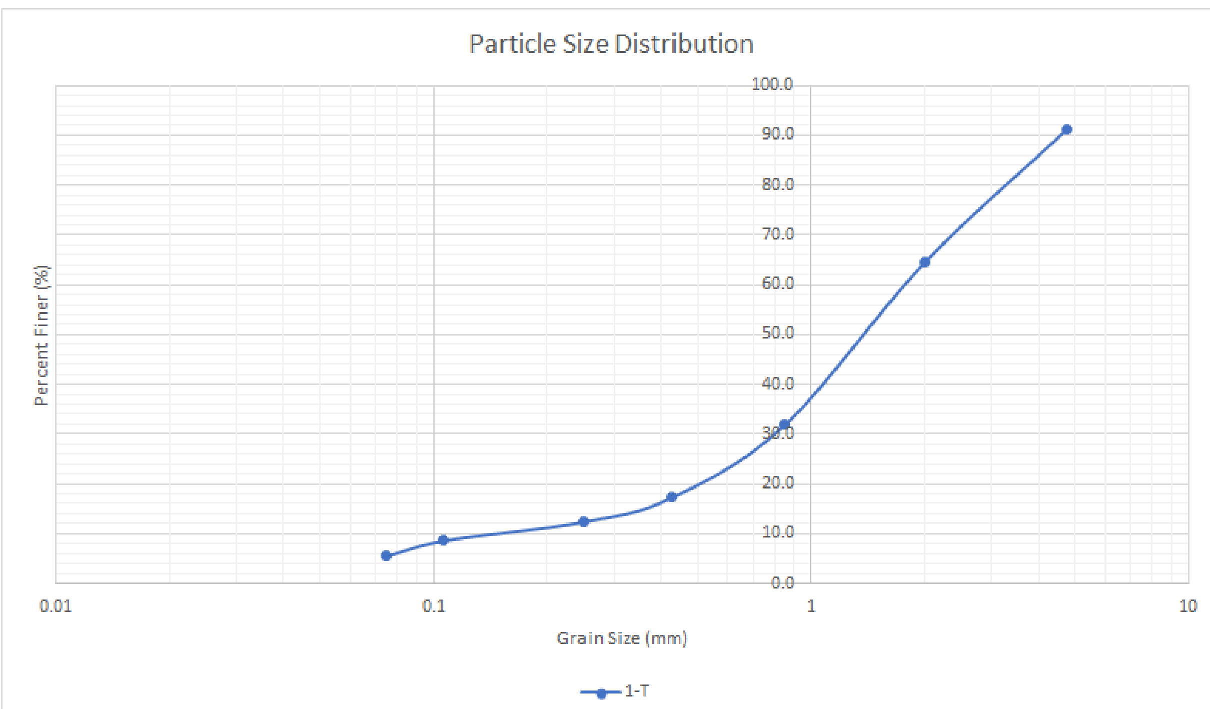


Figure 35: Particle Distribution Curve – Sample 2

Table 23: Liquid Limit Raw Data – Sample 2

Sample 2					
Cross Section	0+70	1	[redacted]		
Location/Name	Thalweg	1-T			
Moisture Can ID	3	1	5	2	4
Mass of Can, (g)	13.8	13.1	13.2	13.3	13.1
Mass of Can and Moist Sample, (g)	16.8	14.8	16.7	16.5	14.9
Mass of Can and Dry Sample, (g)	15.9	14.3	15.7	15.6	14.4
Moisture Content, (%)	42.9	41.7	40.0	39.1	38.5
Number of Drops, N	30	32	40.0	46	49
Liquid Limit	44				

Table 24: Plastic Limit Raw Data – Sample 2

Sample 2			
Cross Section	0+70	1	[redacted]
Location/Name	Thalweg	1-T	
Mass of Can, (g)	13.5	13.3	13.4
Mass of Can and Moist Sample, (g)	15.3	15.6	15.6
Mass of Can and Dry Sample, (g)	14.8	14.9	15
Moisture Content, (%)	38.5	43.8	37.5
Plastic Limit	40		

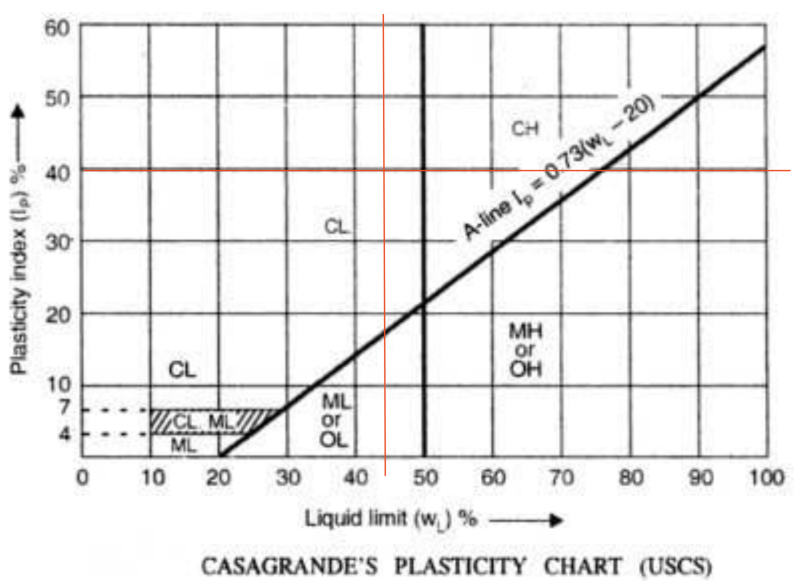


Figure 36: Casagrande's Plasticity Chart - Sample 2

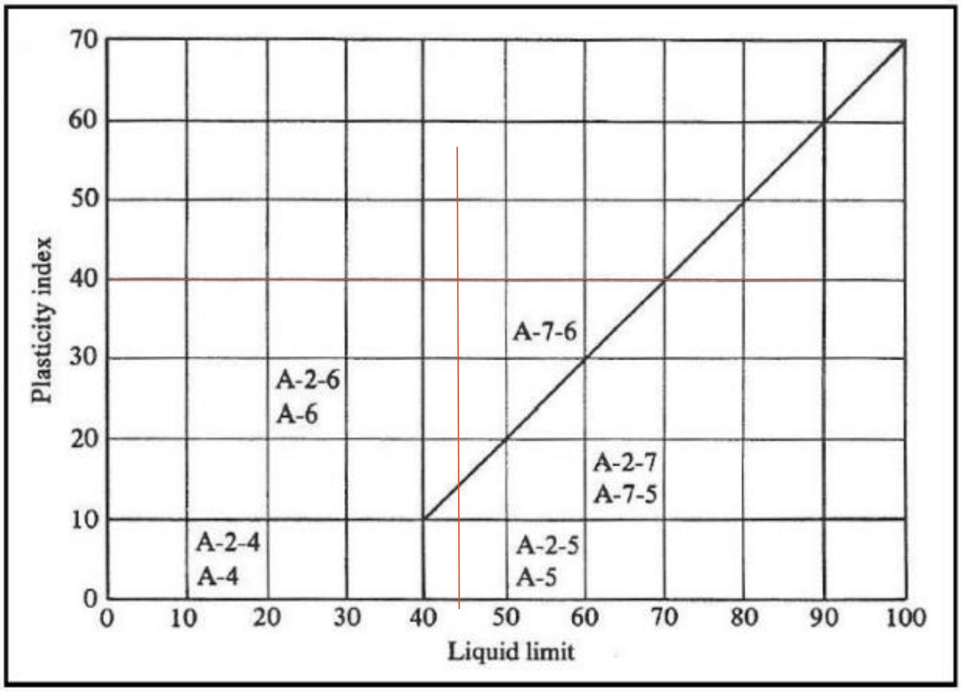


Figure 37: AASHTO Classification Chart - Sample 2

Appendix 12: Sample 3 Soil Classification

Table 25: Sieve Analysis Raw Data – Sample 3

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	515.1	733.4	218.3	9.9	9.9	90.1
10	2	469.6	897.8	428.2	19.5	29.4	70.6
20	0.85	414.6	893.3	478.7	21.8	51.2	48.8
40	0.425	397	695.2	298.2	13.6	64.8	35.2
60	0.25	345.7	505	159.3	7.3	72.1	27.9
150	0.106	337.7	521.6	183.9	8.4	80.5	19.5
200	0.075	318.5	421.5	70.8	3.2	83.7	16.3
Pan	NA	362.4	688.4	358.2	16.3	100.0	0.0
Sum	xx	xx	Wts =	2195.6			

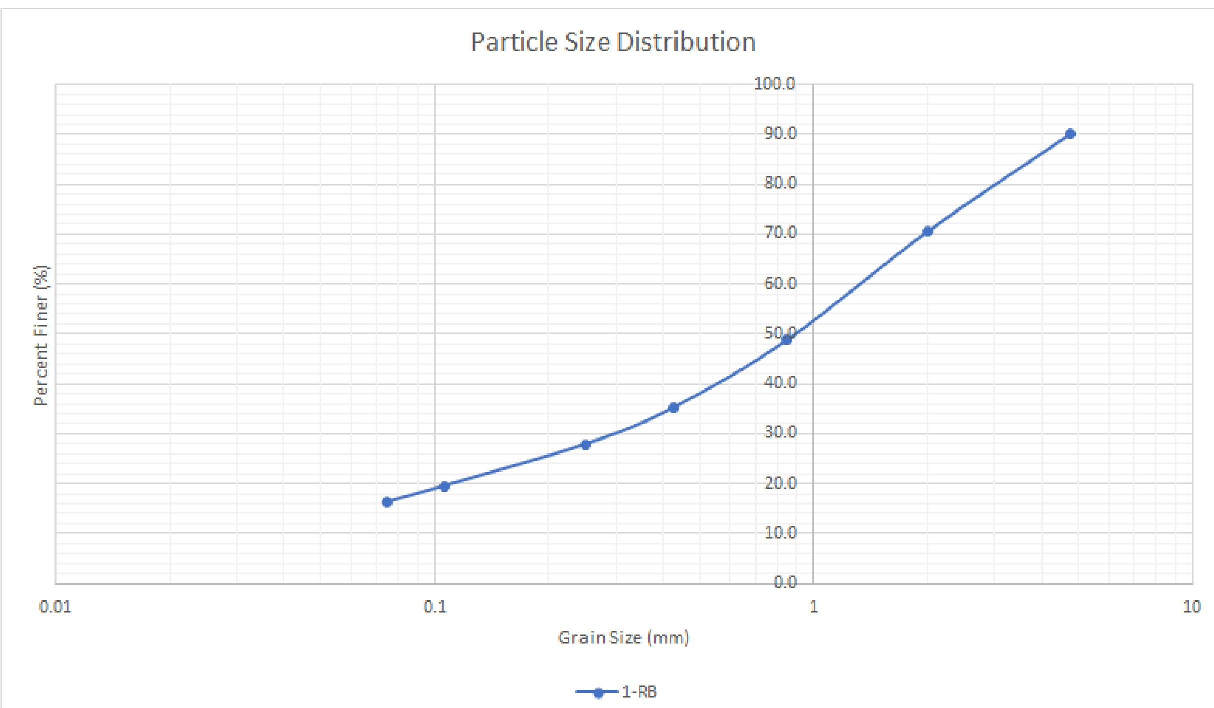


Figure 38: Particle Distribution Curve – Sample 3

Table 26: Liquid Limit Raw Data – Sample 3

Sample 3					
Cross Section	0+70	1	[redacted]		
Location/Name	Right of Bank	1-RB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.3	13.3	13.7	13.7	13.1
Mass of Can and Moist Sample, (g)	50.1	53.4	27.1	50.7	41.6
Mass of Can and Dry Sample, (g)	41	44.1	23.9	42.3	35.6
Moisture Content, (%)	32.9	30.2	31.4	29.4	26.7
Number of Drops, N	6	20	37.0	49	80
Liquid Limit	31				

Table 27: Plastic Limit Raw Data – Sample 3

Sample 3			
Cross Section	0+70	1	[redacted]
Location/Name	Right of Bank	1-RB	
Mass of Can, (g)	13.1	13.2	19.7
Mass of Can and Moist Sample, (g)	14.2	16.8	23.9
Mass of Can and Dry Sample, (g)	14	16	22.9
Moisture Content, (%)	22.2	28.6	31.3
Plastic Limit	27		

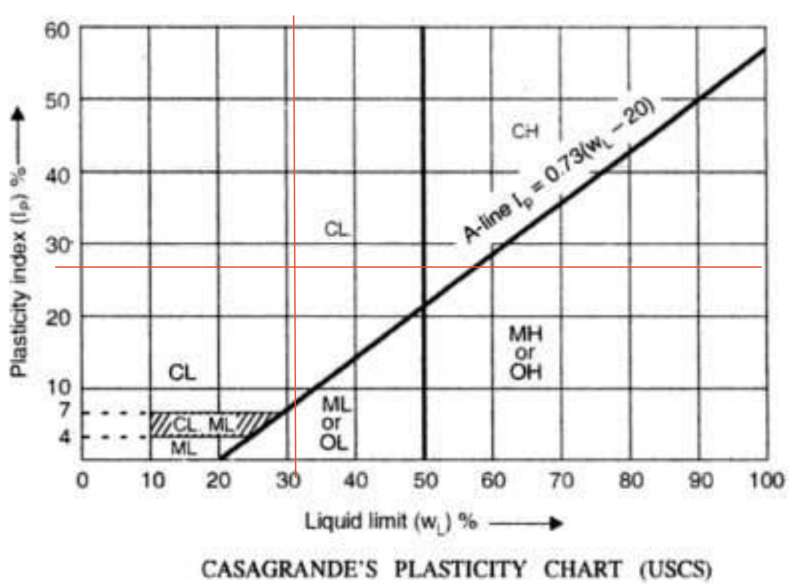


Figure 39: Casagrande's Plasticity Chart - Sample 3

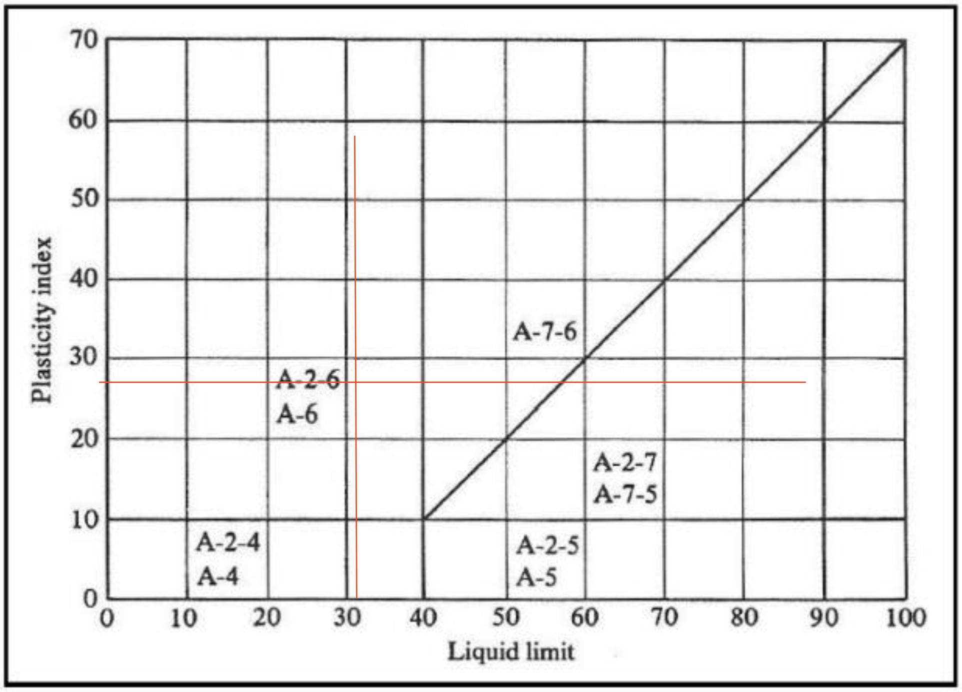


Figure 40: AASHTO Classification Chart - Sample 3

Appendix 13: Sample 4 Soil Classification

Table 28: Sieve Analysis Raw Data – Sample 4

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	769.5	1300.3	530.8	32.7	32.7	67.3
10	2	447.4	816	368.6	22.7	55.4	44.6
20	0.85	394.9	721.3	326.4	20.1	75.5	24.5
40	0.425	391.6	548.6	157	9.7	85.1	14.9
60	0.25	345.7	406.7	61	3.8	88.9	11.1
150	0.106	337.8	410	72.2	4.4	93.3	6.7
200	0.075	296.8	336.3	7.9	0.5	93.8	6.2
Pan	NA	370	438.9	100.5	6.2	100.0	0.0
Sum	xx	xx	Wts =	1624.4			

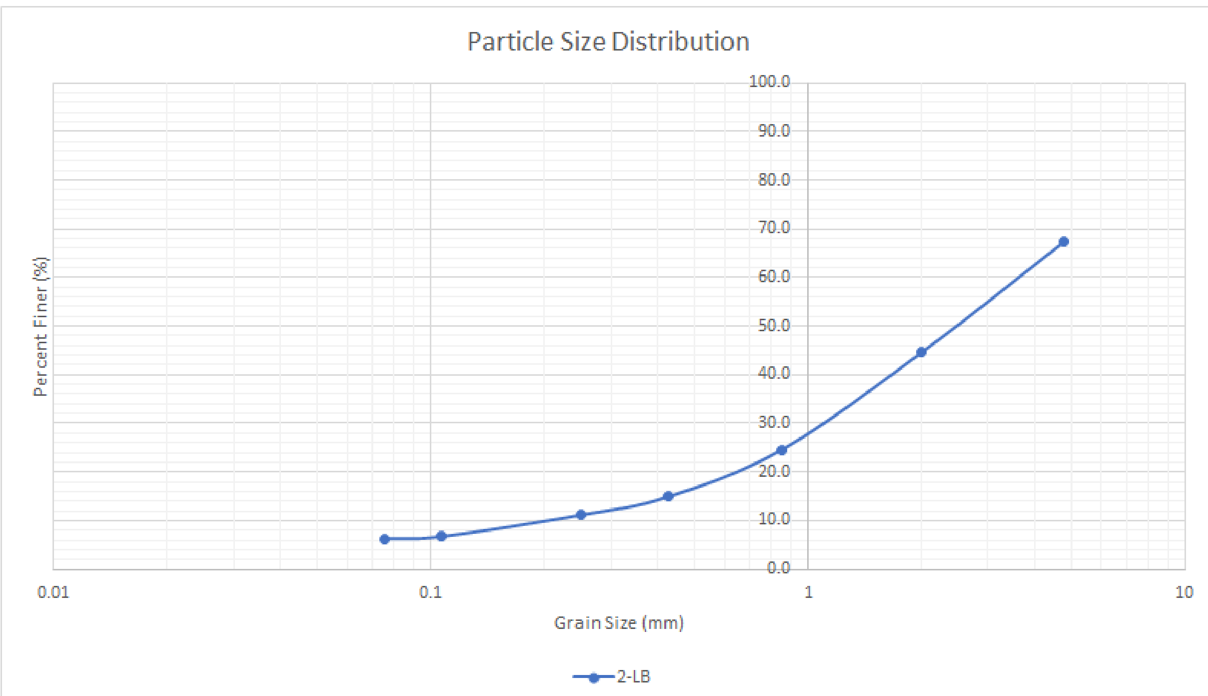


Figure 41: Particle Distribution Curve – Sample 4

Table 29: Liquid Limit Raw Data – Sample 4

Sample 4					
Cross Section	1+40	2	[redacted]		
Location/Name	Left of Bank	2-LB			
Moisture Can ID	1	5	2	4	3
Mass of Can, (g)	14.1	13.5	13.6	13.3	13.4
Mass of Can and Moist Sample, (g)	16.4	16.5	17.1	15.6	17.9
Mass of Can and Dry Sample, (g)	15.8	15.8	16.2	15	16.8
Moisture Content, (%)	35.3	30.4	34.6	35.3	32.4
Number of Drops, N	31	37	42.0	46	50
Liquid Limit	34				

Table 30: Plastic Limit Raw Data – Sample 4

Sample 4			
Cross Section	1+40	2	[redacted]
Location/Name	Left of Bank	2-LB	
Mass of Can, (g)	14.5	13.5	12.3
Mass of Can and Moist Sample, (g)	16.1	15.4	14.4
Mass of Can and Dry Sample, (g)	15.7	14.9	13.9
Moisture Content, (%)	33.3	35.7	31.3
Plastic Limit	33		

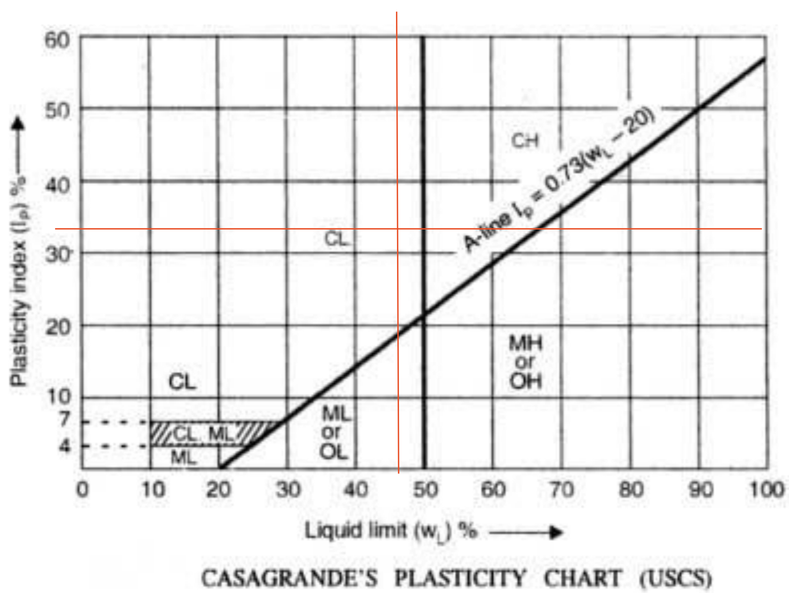


Figure 42: Casagrande's Plasticity Chart - Sample 4

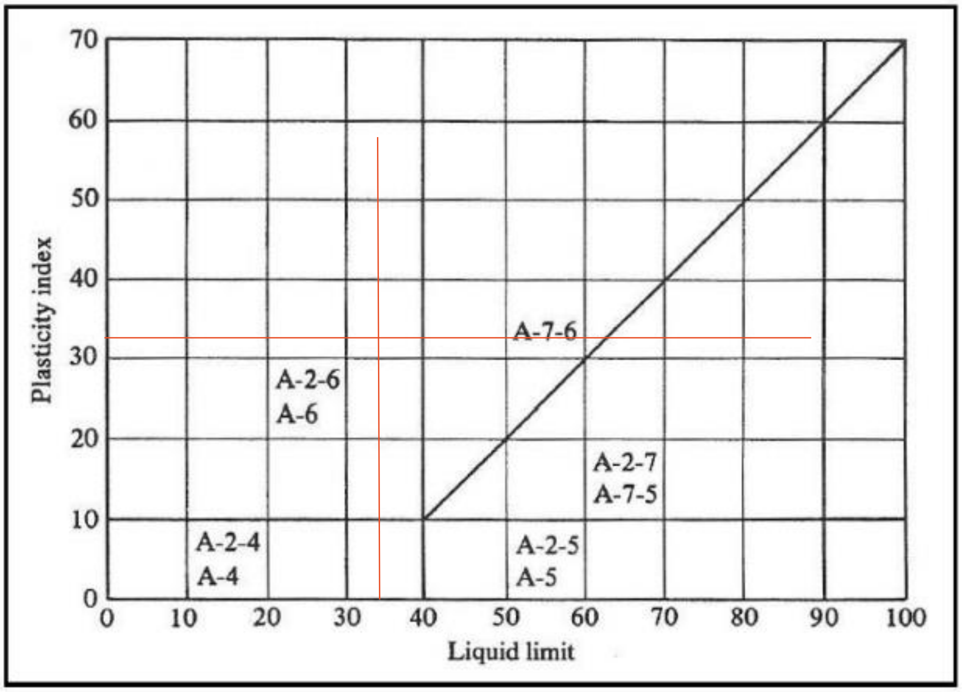


Figure 43: AASHTO Classification Chart - Sample 4

Appendix 14: Sample 5 Soil Classification

Table 31: Sieve Analysis Raw Data – Sample 5

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	522.4	1097.4	575	42.9	42.9	57.1
10	2	443.9	768.8	324.9	24.2	67.2	32.8
20	0.85	619.2	813.8	194.6	14.5	81.7	18.3
40	0.425	394.9	472.3	77.4	5.8	87.5	12.5
60	0.25	367.2	401.2	34	2.5	90.0	10.0
150	0.106	338.6	376	37.4	2.8	92.8	7.2
200	0.075	293.2	323.4	21.4	1.6	94.4	5.6
Pan	NA	366.3	432.7	75.2	5.6	100.0	0.0
Sum	xx	xx	Wts =	1339.9			

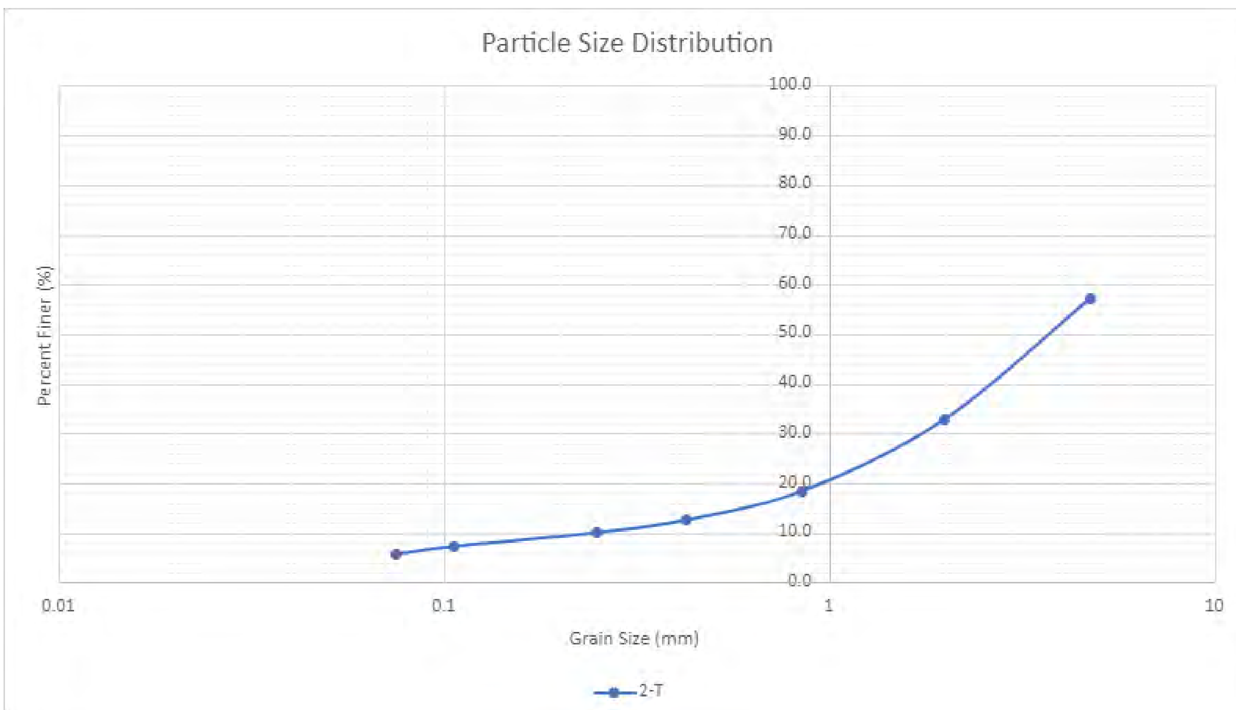


Figure 44: Particle Distribution Curve – Sample 5

Table 32: Liquid Limit Raw Data – Sample 5

Sample 5					
Cross Section	1+40	2			
Location/Name	Thalweg	2-T			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.5	13.4	13.4	13.7	13.4
Mass of Can and Moist Sample, (g)	16	16.9	16.5	24.3	17.3
Mass of Can and Dry Sample, (g)	15.5	16.2	15.6	21.5	16.3
Moisture Content, (%)	25.0	25.0	40.9	35.9	34.5
Number of Drops, N	6	12	24.0	36	43
Liquid Limit	33				

Table 33: Plastic Limit Raw Data – Sample 5

Sample 5			
Cross Section	1+40	2	
Location/Name	Thalweg	2-T	
Mass of Can, (g)	13.5	13.6	13.3
Mass of Can and Moist Sample, (g)	15.2	16.1	15.9
Mass of Can and Dry Sample, (g)	14.8	15.4	15.2
Moisture Content, (%)	30.8	38.9	36.8
Plastic Limit	36		

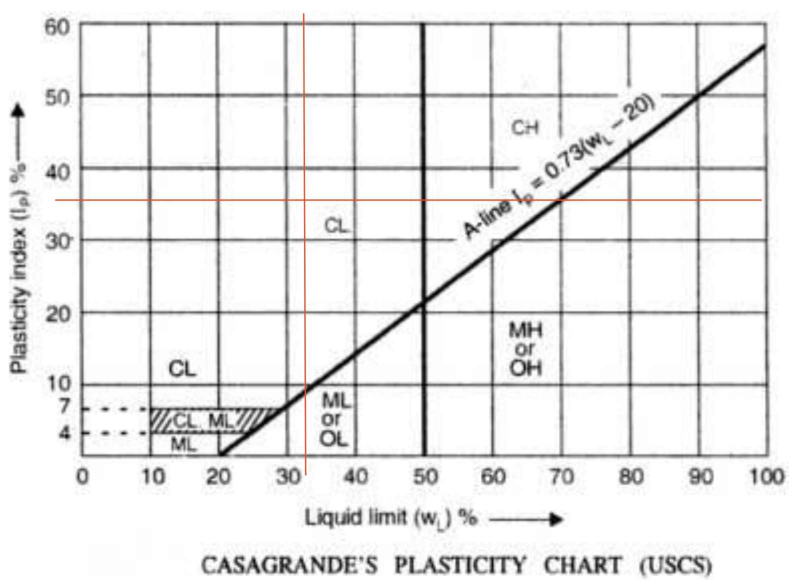


Figure 45: Casagrande's Plasticity Chart - Sample 5

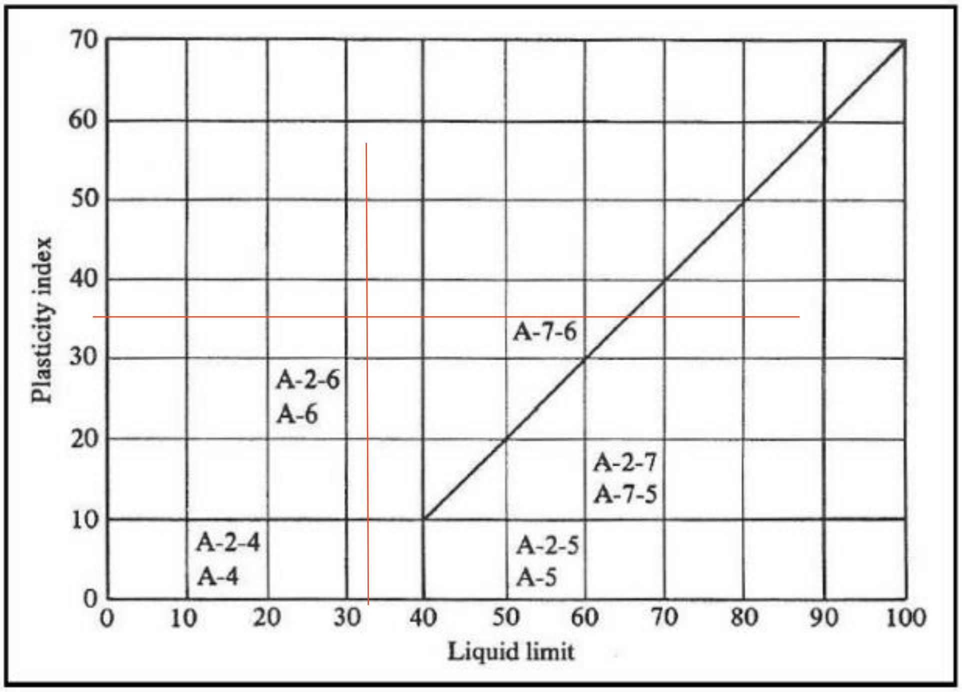


Figure 46: AASHTO Classification Chart - Sample 5

Appendix 15: Sample 6 Soil Classification

Table 34: Sieve Analysis Raw Data – Sample 6

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	774.6	1000.8	226.2	15.2	15.2	84.8
10	2	449.7	872.1	422.4	28.4	43.6	56.4
20	0.85	396.6	764.3	367.7	24.7	68.3	31.7
40	0.425	392.1	589.5	197.4	13.3	81.6	18.4
60	0.25	373.4	452.8	79.4	5.3	86.9	13.1
150	0.106	341.2	424.2	83	5.6	92.5	7.5
200	0.075	299.6	339.6	33.5	2.3	94.7	5.3
Pan	NA	363.6	435.7	78.6	5.3	100.0	0.0
Sum	xx	xx	Wts =	1488.2			

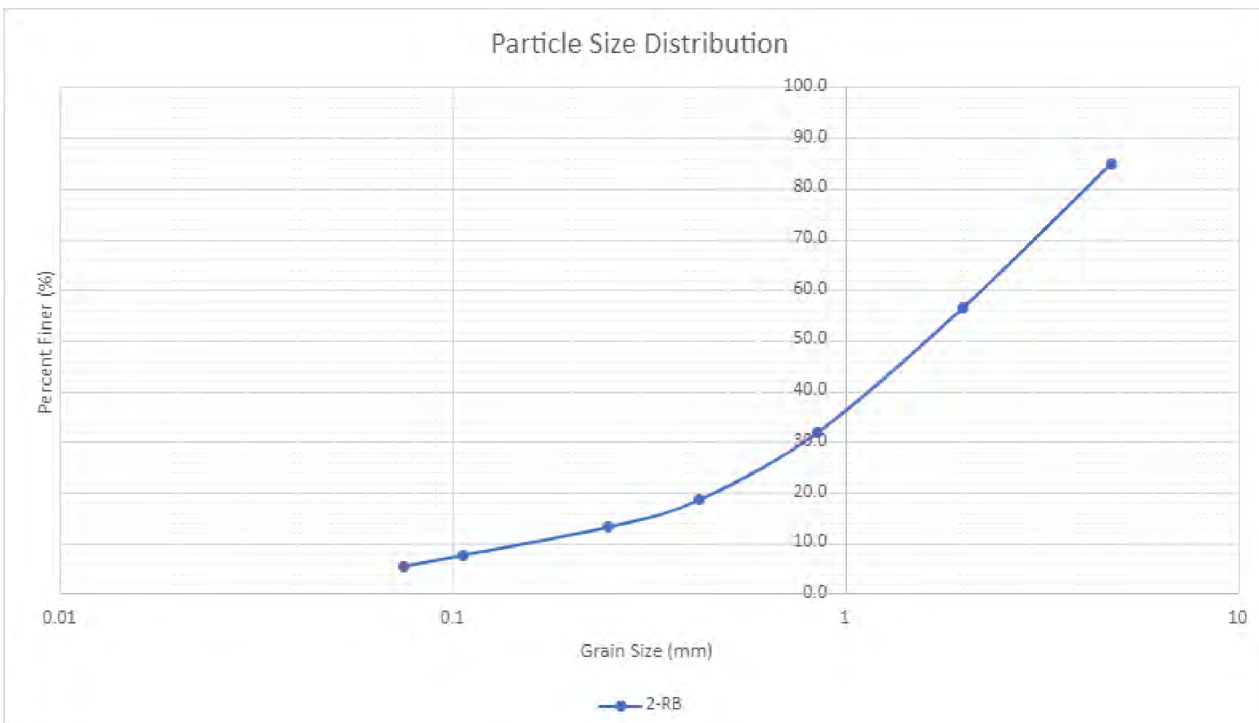


Figure 47: Particle Distribution Curve – Sample 6

Table 35: Liquid Limit Raw Data – Sample 6

Sample 6					
Cross Section	1+40	2			
Location/Name	Right of Bank	2-RB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.3	13.3	13.6	13.2	13.3
Mass of Can and Moist Sample, (g)	19.6	15.3	17	15.6	16
Mass of Can and Dry Sample, (g)	17.9	14.8	16.1	14.8	15.2
Moisture Content, (%)	37.0	33.3	36.0	50.0	42.1
Number of Drops, N	8	15	27.0	35	55
Liquid Limit	39				

Table 36: Plastic Limit Raw Data – Sample 6

Sample 6			
Cross Section	1+40	2	
Location/Name	Right of Bank	2-RB	
Mass of Can, (g)	13.5	13.1	13.3
Mass of Can and Moist Sample, (g)	15.6	15.5	15.1
Mass of Can and Dry Sample, (g)	15	14.9	14.5
Moisture Content, (%)	40.0	33.3	50.0
Plastic Limit	41		

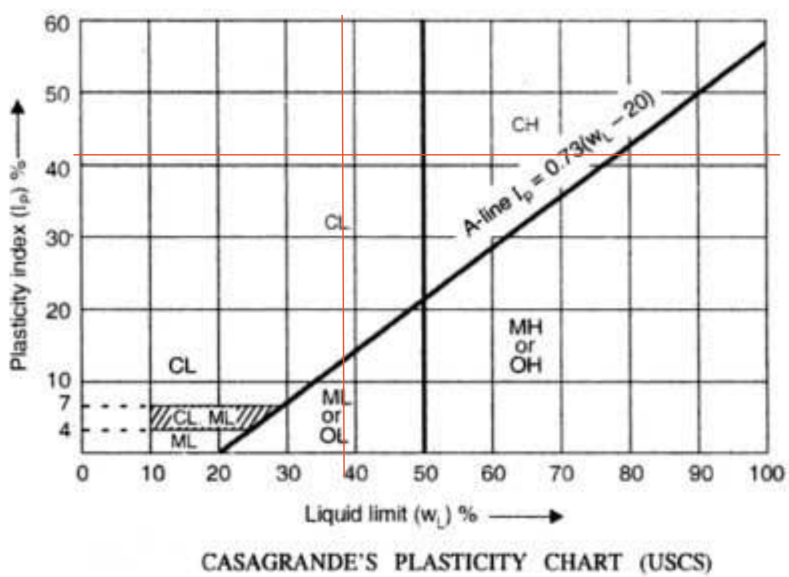


Figure 48: Casagrande's Plasticity Chart - Sample 6

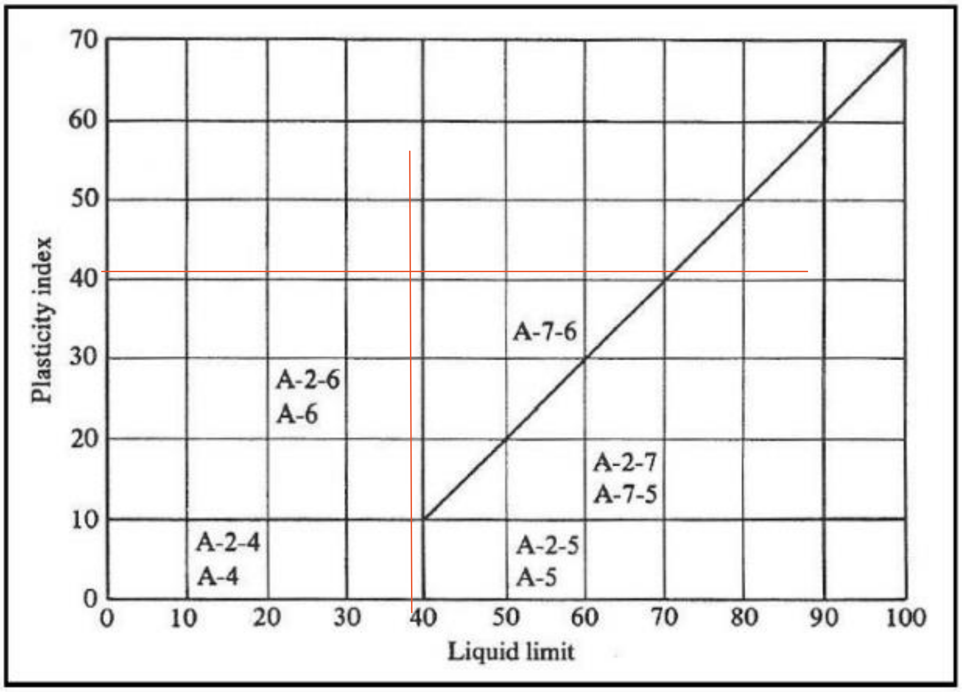


Figure 49: AASHTO Classification Chart - Sample 6

Appendix 16: Sample 7 Soil Classification

Table 37: Sieve Analysis Raw Data – Sample 7

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	769.4	1364.7	595.3	30.7	30.7	69.3
10	2	458.8	1011.7	552.9	28.5	59.1	40.9
20	0.85	416.2	811	394.8	20.3	79.5	20.5
40	0.425	381.7	547.9	166.2	8.6	88.0	12.0
60	0.25	349.8	421.8	72	3.7	91.7	8.3
150	0.106	339.1	411.1	72	3.7	95.4	4.6
200	0.075	319	358.4	24.4	1.3	96.7	3.3
Pan	NA	370.8	420.2	64.4	3.3	100.0	0.0
Sum	xx	xx	Wts =	1942			

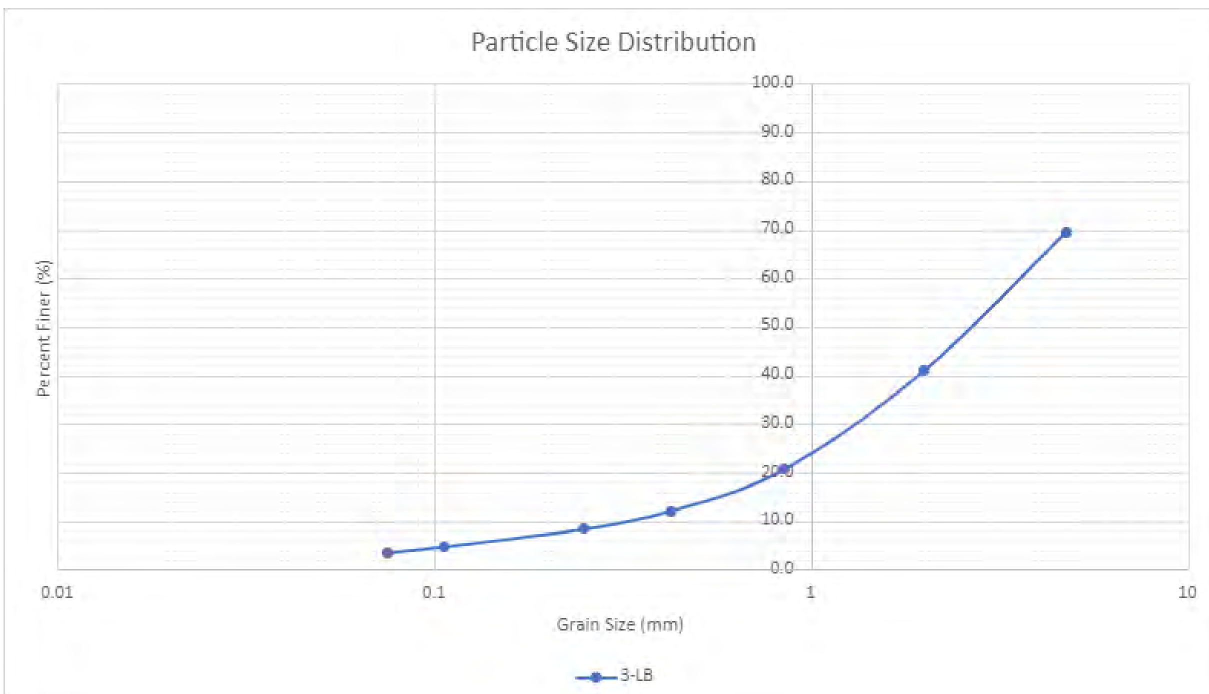


Figure 50: Particle Distribution Curve – Sample 7

Table 38: Liquid Limit Raw Data – Sample 7

Sample 7					
Cross Section	2+10	3			
Location	Left of Bank	3-LB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.6	13.3	13.4	13.6	13.4
Mass of Can and Moist Sample, (g)	17.7	19.0	18.3	20.6	17
Mass of Can and Dry Sample, (g)	16.7	17.8	17.2	19.0	16.4
Moisture Content, (%)	32.3	26.7	28.9	29.6	20.0
Number of Drops, N	7	24	28.0	43	50
Liquid Limit	29				

Table 39: Plastic Limit Raw Data – Sample 7

Sample 7			
Cross Section	2+10	3	
Location	Left of Bank	3-LB	
Mass of Can, (g)	13.1	19.7	12.6
Mass of Can and Moist Sample, (g)	15.3	22.0	15.0
Mass of Can and Dry Sample, (g)	15.0	21.3	14.4
Moisture Content, (%)	15.8	43.7	33.3
Plastic Limit	31		

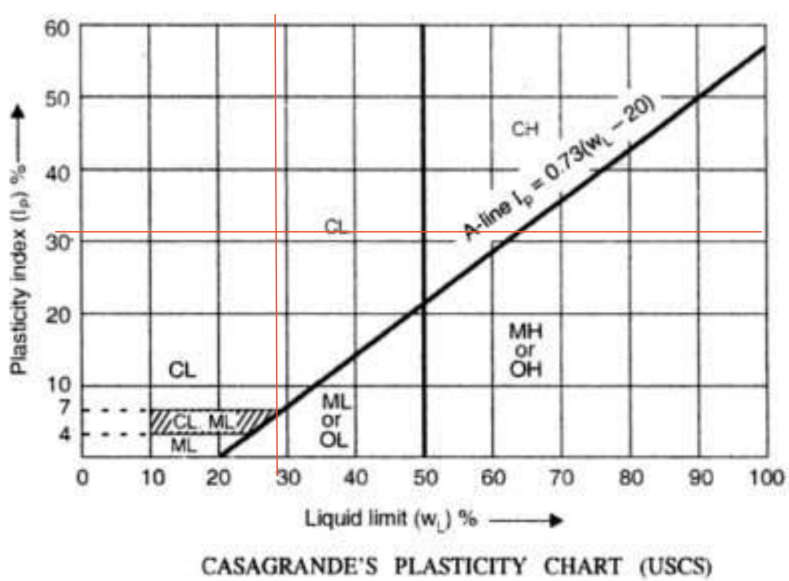


Figure 51: Casagrande's Plasticity Chart - Sample 7

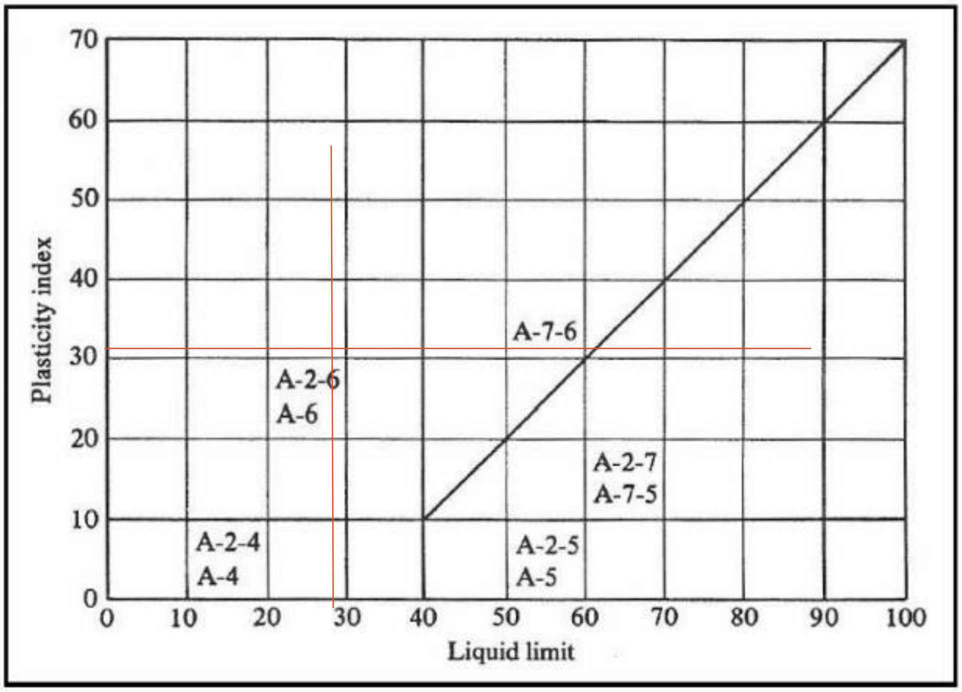


Figure 52: AASHTO Classification Chart - Sample 7

Appendix 17: Sample 8 Soil Classification

Table 40: Sieve Analysis Raw Data – Sample 8

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	517.1	1181.2	664.1	39.4	39.4	60.6
10	2	470.8	824.6	353.8	21.0	60.4	39.6
20	0.85	396	633.3	237.3	14.1	74.5	25.5
40	0.425	361	477.3	116.3	6.9	81.4	18.6
60	0.25	347.3	405.1	57.8	3.4	84.8	15.2
150	0.106	345.2	442.5	97.3	5.8	90.6	9.4
200	0.075	536.4	538.2	0	0.0	90.6	9.4
Pan	NA	365.45	521.9	158.25	9.4	100.0	0.0
Sum	xx	xx	Wts =	1684.85			

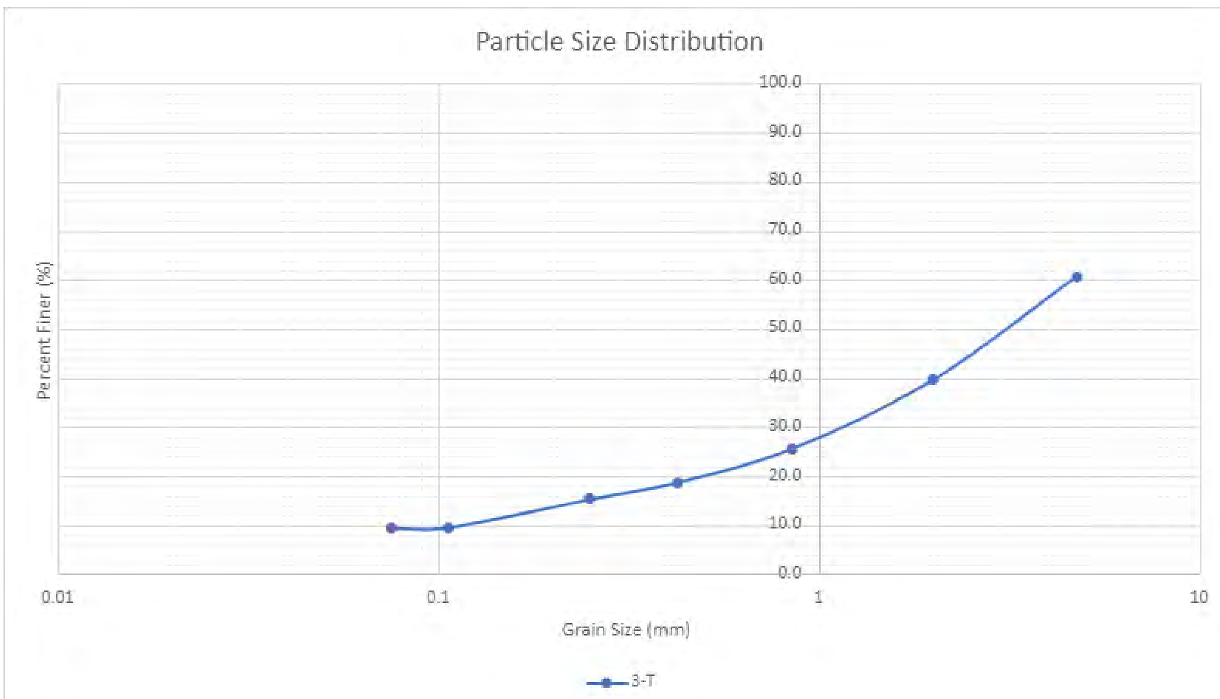


Figure 53: Particle Distribution Curve – Sample 8

Table 41: Liquid Limit Raw Data – Sample 8

Sample 8					
Cross Section	2+10	3	[redacted]		
Location	Thalweg	3-T			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.3	13.4	13.6	19.7	13.3
Mass of Can and Moist Sample, (g)	16	16.7	17	23.9	16.4
Mass of Can and Dry Sample, (g)	15.2	15.9	16.2	23.0	15.9
Moisture Content, (%)	42.1	32.0	30.8	27.3	19.2
Number of Drops, N	8	14	27.0	37	49
Liquid Limit	31				

Table 42: Plastic Limit Raw Data – Sample 8

Sample 8			
Cross Section	2+10	3	[redacted]
Location	Thalweg	3-T	
Mass of Can, (g)	13.3	19.5	13.8
Mass of Can and Moist Sample, (g)	15.4	21.6	16.2
Mass of Can and Dry Sample, (g)	14.9	21.2	15.7
Moisture Content, (%)	31.3	23.5	26.3
Plastic Limit	27		

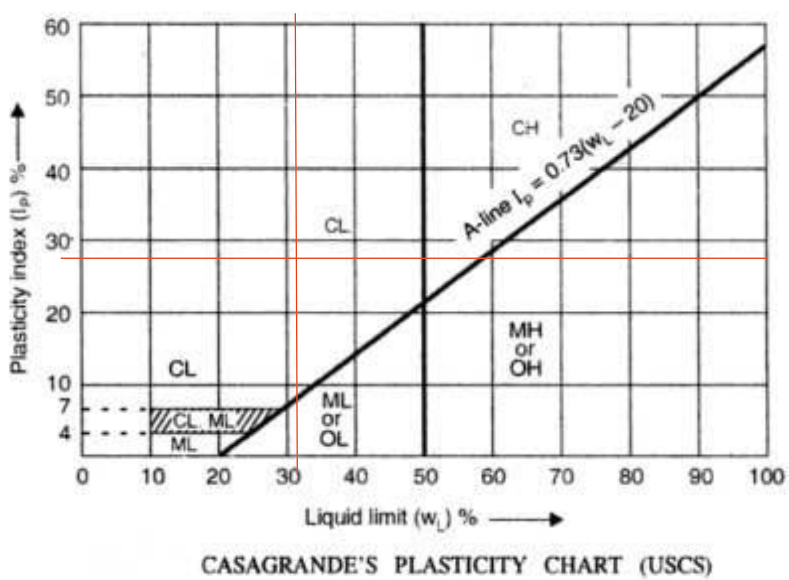


Figure 54: Casagrande's Plasticity Chart - Sample 8

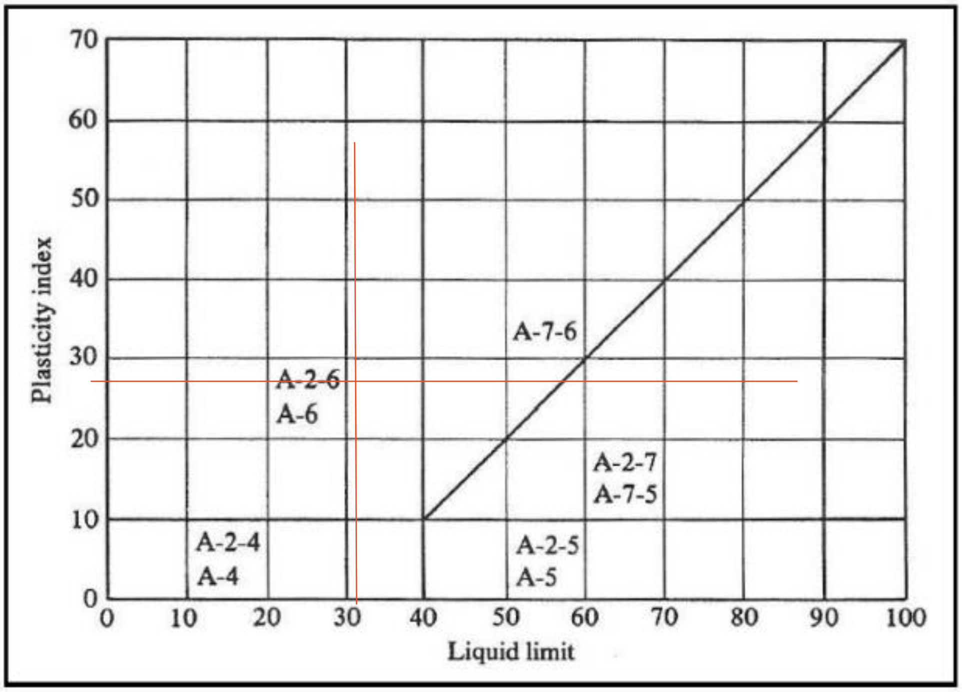


Figure 55: AASHTO Classification Chart - Sample 8

Appendix 18: Sample 9 Soil Classification

Table 43: Sieve Analysis Raw Data – Sample 9

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	772.4	1082.3	309.9	20.8	20.8	79.2
10	2	454.3	882.2	427.9	28.7	49.5	50.5
20	0.85	631.4	946.2	314.8	21.1	70.7	29.3
40	0.425	397	528.1	131.1	8.8	79.5	20.5
60	0.25	373.2	443.1	69.9	4.7	84.2	15.8
150	0.106	338.7	430.3	91.6	6.1	90.3	9.7
200	0.075	298.7	341.1	34.1	2.3	92.6	7.4
Pan	NA	365.5	467.4	110.2	7.4	100.0	0.0
Sum	xx	xx	Wts =	1489.5			

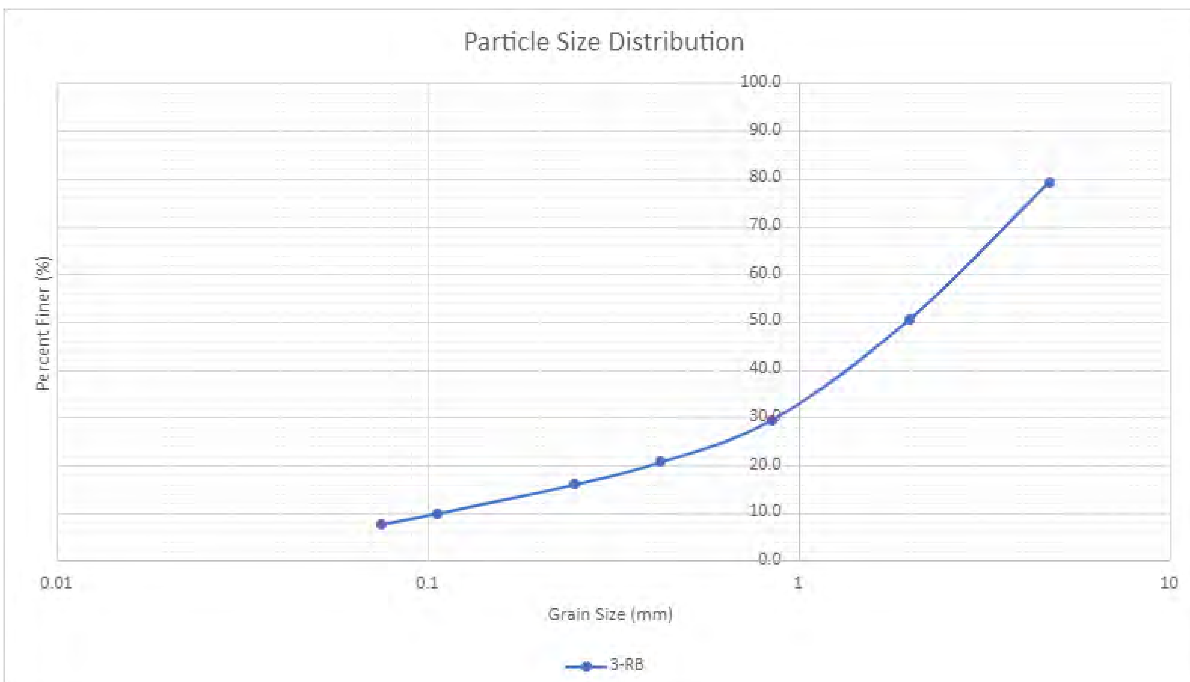


Figure 56: Particle Distribution Curve – Sample 9

Table 44: Liquid Limit Raw Data – Sample 9

Sample 9					
Cross Section	2+10	3	[redacted]		
Location	Right of Bank	3-RB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.3	13.6	12.9	19.7	13.1
Mass of Can and Moist Sample, (g)	17	14.6	14.9	28.1	15.9
Mass of Can and Dry Sample, (g)	15.9	14.4	14.4	26.1	15.3
Moisture Content, (%)	42.3	25.0	33.3	31.3	27.3
Number of Drops, N	13	24	30.0	42	50
Liquid Limit	34				

Table 45: Plastic Limit Raw Data – Sample 9

Sample 9			
Cross Section	2+10	3	[redacted]
Location	Right of Bank	3-RB	
Mass of Can, (g)	13.2	19.6	19.7
Mass of Can and Moist Sample, (g)	14.9	21.9	21.3
Mass of Can and Dry Sample, (g)	14.4	20.9	21.2
Moisture Content, (%)	41.7	76.9	6.7
Plastic Limit	42		

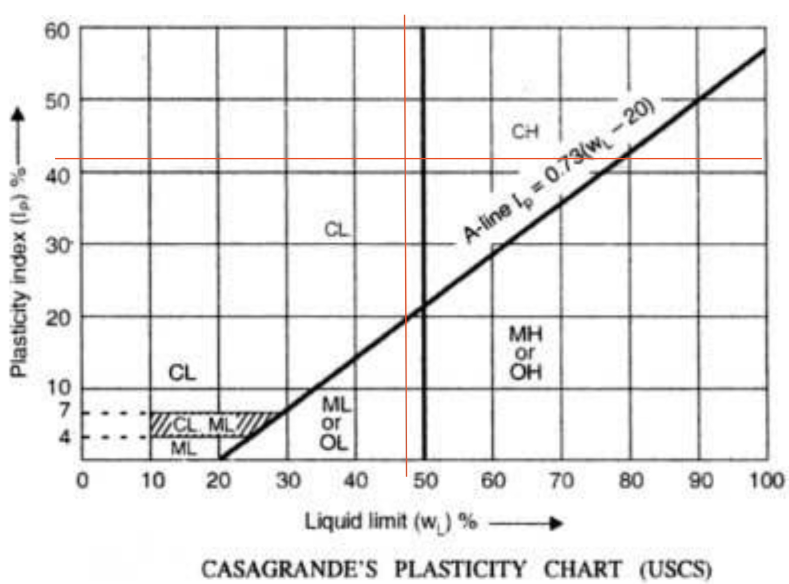


Figure 57: Casagrande's Plasticity Chart - Sample 9

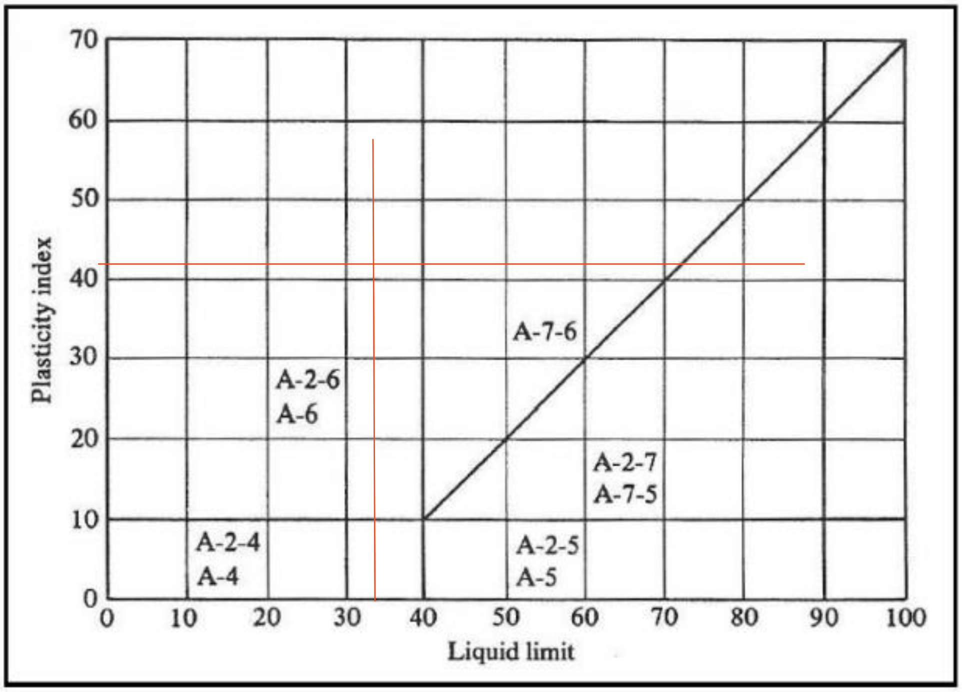


Figure 58: AASHTO Classification Chart - Sample 9

Appendix 19: Sample 10 Soil Classification

Table 46: Sieve Analysis Raw Data – Sample 10

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	770.7	1053.4	282.7	19.2	19.2	80.8
10	2	455	1010	555	37.6	56.8	43.2
20	0.85	632.1	927.8	295.7	20.1	76.9	23.1
40	0.425	396.9	508.2	111.3	7.5	84.4	15.6
60	0.25	540.6	603.6	63	4.3	88.7	11.3
150	0.106	338.6	408	69.4	4.7	93.4	6.6
200	0.075	326.9	358.3	24.9	1.7	95.1	4.9
Pan	NA	363.2	429.1	72.4	4.9	100.0	0.0
Sum	xx	xx	Wts =	1474.4			

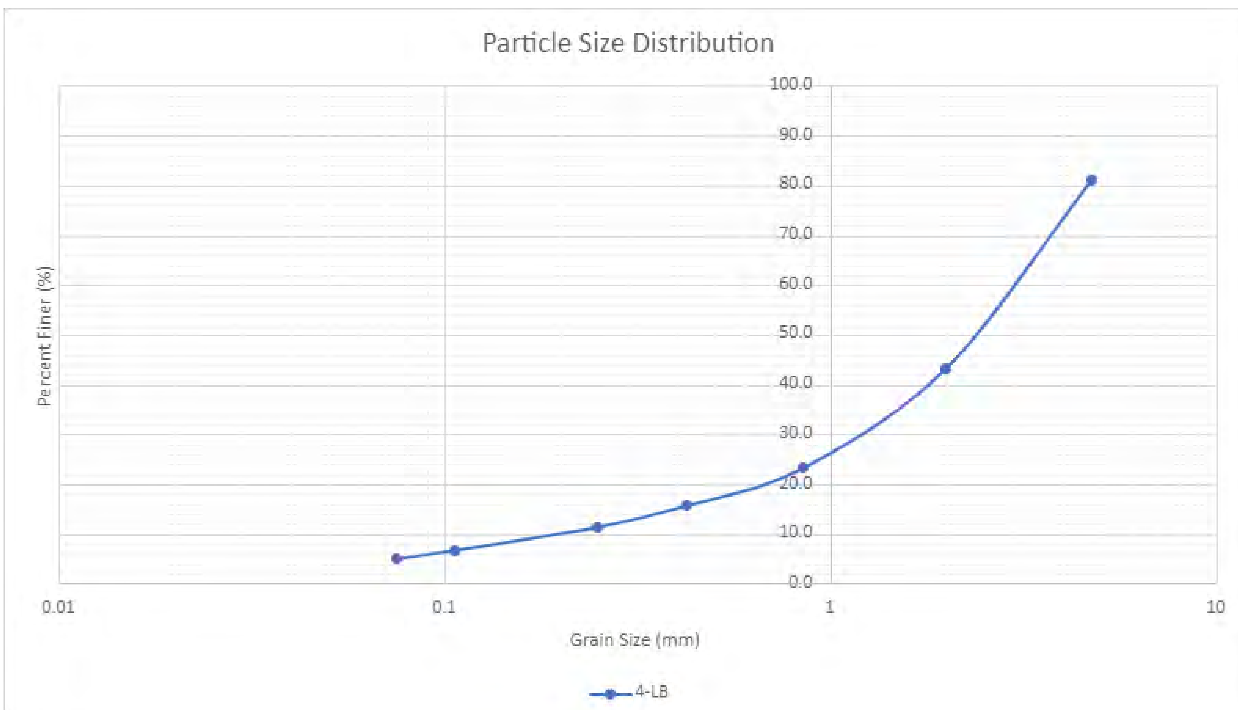


Figure 59: Particle Distribution Curve – Sample 10

Table 47: Liquid Limit Raw Data – Sample 10

Sample 10					
Cross Section	2+80	4	[redacted]		
Location/Name	Left of Bank	4-LB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.2	12.8	13.3	13.3	13
Mass of Can and Moist Sample, (g)	16.4	15.9	16.4	15.8	15.5
Mass of Can and Dry Sample, (g)	15.6	15.2	15.5	15.2	15.0
Moisture Content, (%)	33.3	29.2	40.9	31.6	25.0
Number of Drops, N	8	12	26.0	34	50
Liquid Limit	32				

Table 48: Plastic Limit Raw Data – Sample 10

Sample 10			
Cross Section	2+80	4	[redacted]
Location/Name	Left of Bank	4-LB	
Mass of Can, (g)	13.4	13.3	13.2
Mass of Can and Moist Sample, (g)	15.4	15.0	15.3
Mass of Can and Dry Sample, (g)	14.9	14.6	14.7
Moisture Content, (%)	33.3	30.8	40.0
Plastic Limit	35		

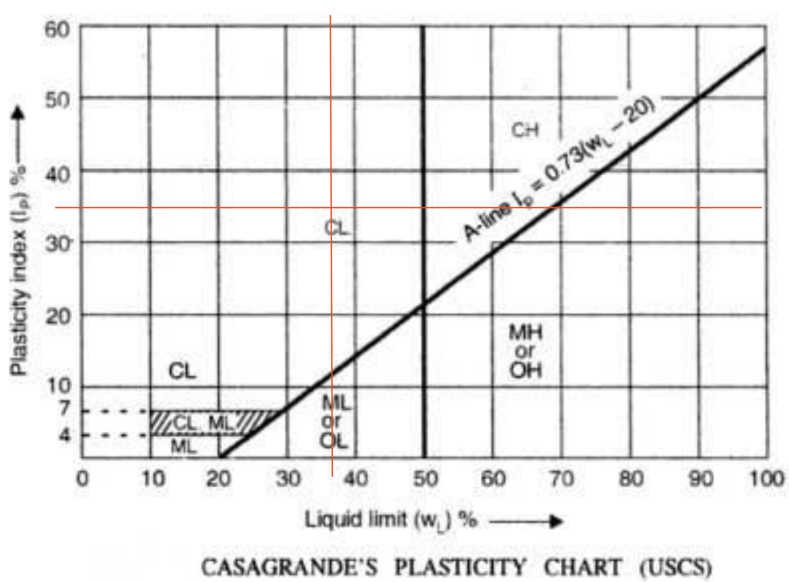


Figure 60: Casagrande's Plasticity Chart - Sample 10

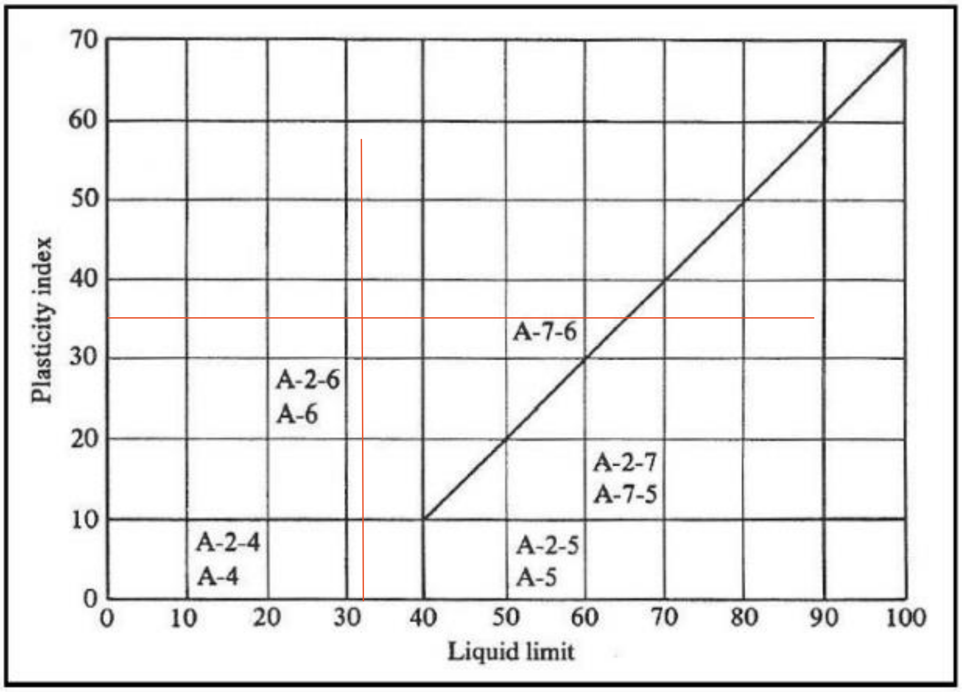


Figure 61: AASHTO Classification Chart - Sample 10

Appendix 20: Sample 11 Soil Classification

Table 49: Sieve Analysis Raw Data – Sample 11

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	517.5	1257.8	740.3	37.6	37.6	62.4
10	2	470	1004.4	534.4	27.2	64.8	35.2
20	0.85	395.4	745.2	349.8	17.8	82.6	17.4
40	0.425	360.8	520	159.2	8.1	90.7	9.3
60	0.25	345.6	393	47.4	2.4	93.1	6.9
150	0.106	343.6	393.7	50.1	2.5	95.7	4.3
200	0.075	298.4	321.9	12.9	0.7	96.3	3.7
Pan	NA	365.2	427.2	72.6	3.7	100.0	0.0
Sum	xx	xx	Wts =	1966.7			

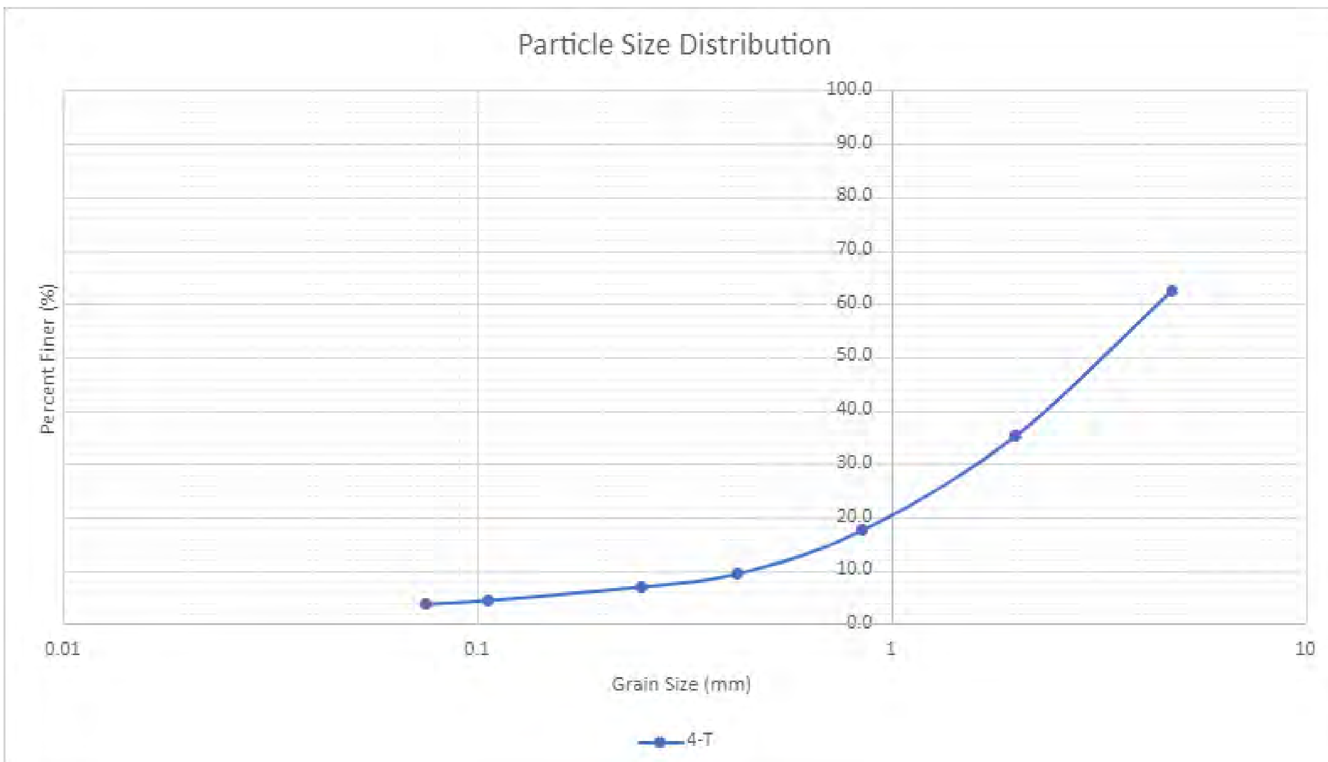


Figure 62: Particle Distribution Curve – Sample 11

Table 50: Liquid Limit Raw Data – Sample 11

Sample 11					
Cross Section	2+80	4	[redacted]	[redacted]	[redacted]
Location/Name	Thalweg	4-T	[redacted]	[redacted]	[redacted]
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.6	14.1	13.2	13.7	13.1
Mass of Can and Moist Sample, (g)	17.2	17.3	16.4	17.8	16.9
Mass of Can and Dry Sample, (g)	16.3	16.5	15.6	16.8	16
Moisture Content, (%)	33.3	33.3	33.3	32.3	31.0
Number of Drops, N	10	19	27.0	40	55
Liquid Limit	33				

Table 51: Plastic Limit Raw Data – Sample 11

Sample 11			
Cross Section	2+80	4	[redacted]
Location/Name	Thalweg	4-T	[redacted]
Mass of Can, (g)	13.0	14.4	13.5
Mass of Can and Moist Sample, (g)	14.9	16.9	15.6
Mass of Can and Dry Sample, (g)	14.5	16.3	15.1
Moisture Content, (%)	26.7	31.6	31.3
Plastic Limit	30		

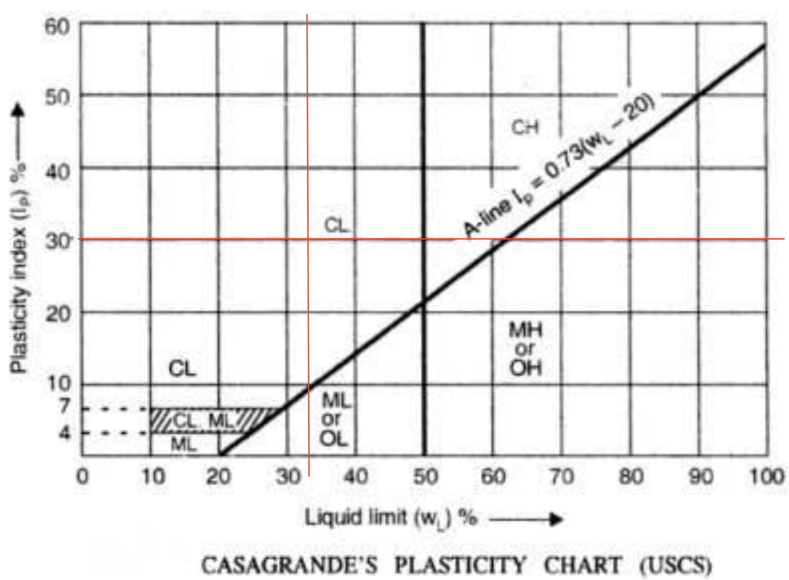


Figure 63: Casagrande's Plasticity Chart - Sample 11

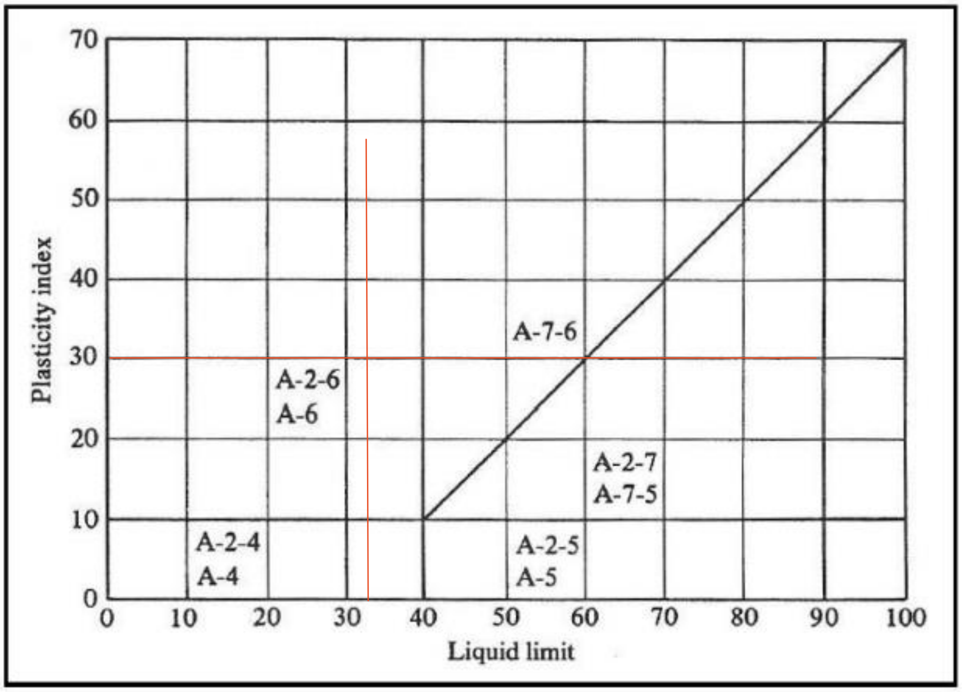


Figure 64: AASHTO Classification Chart - Sample 11

Appendix 21: Sample 12 Soil Classification

Table 52: Sieve Analysis Raw Data – Sample 12

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	769.1	1464.4	695.3	36.2	36.2	63.8
10	2	453.2	928.2	475	24.7	60.9	39.1
20	0.85	631	1015.4	384.4	20.0	80.9	19.1
40	0.425	396.8	556.3	159.5	8.3	89.2	10.8
60	0.25	540.7	601.1	60.4	3.1	92.3	7.7
150	0.106	338.7	405.8	67.1	3.5	95.8	4.2
200	0.075	293.2	320.3	11.6	0.6	96.4	3.6
Pan	NA	362.3	416.2	69.4	3.6	100.0	0.0
Sum	xx	xx	Wts =	1922.7			

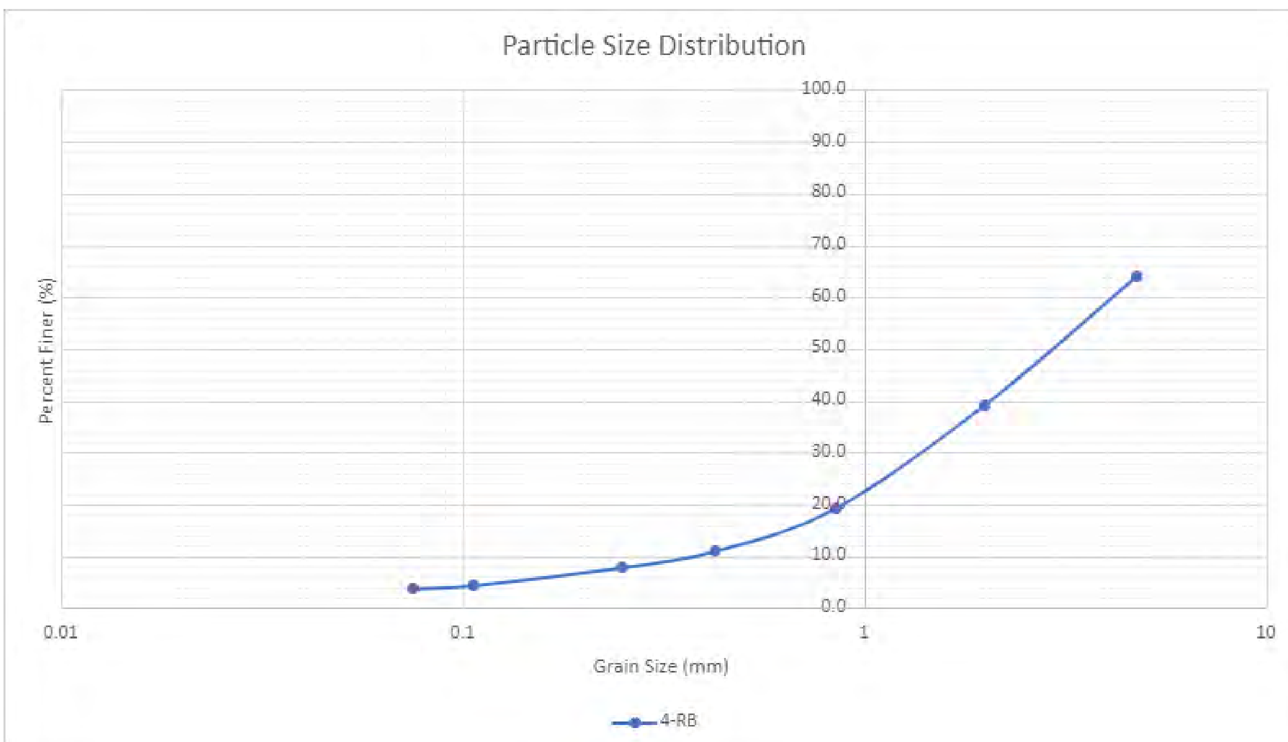


Figure 65: Particle Distribution Curve – Sample 12

Table 53: Liquid Limit Raw Data – Sample 12

Sample 12					
Cross Section	2+80	4			
Location/Name	Right of Bank	4-RB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	19.4	22.6	13.6	13	14.6
Mass of Can and Moist Sample, (g)	24	27.3	18.3	17.1	19
Mass of Can and Dry Sample, (g)	23.0	26.1	17.2	16.1	17.9
Moisture Content, (%)	27.8	34.3	30.6	32.3	33.3
Number of Drops, N	10	17	28.0	37	60
Liquid Limit	31				

Table 54: Plastic Limit Raw Data – Sample 12

Sample 12			
Cross Section	2+80	4	
Location/Name	Right of Bank	4-RB	
Mass of Can, (g)	13.2	13.4	13.6
Mass of Can and Moist Sample, (g)	14.6	15.3	15.4
Mass of Can and Dry Sample, (g)	14.3	14.8	15.0
Moisture Content, (%)	27.3	35.7	28.6
Plastic Limit	31		

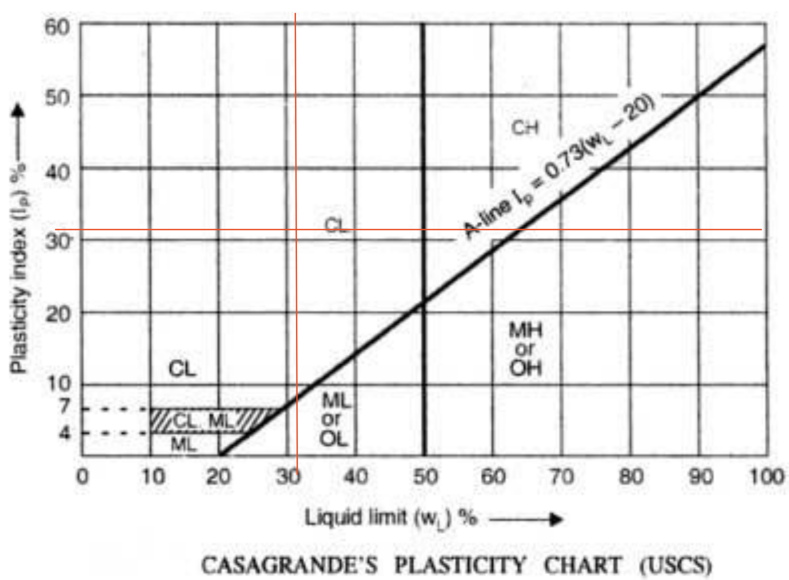


Figure 66: Casagrande's Plasticity Chart - Sample 12

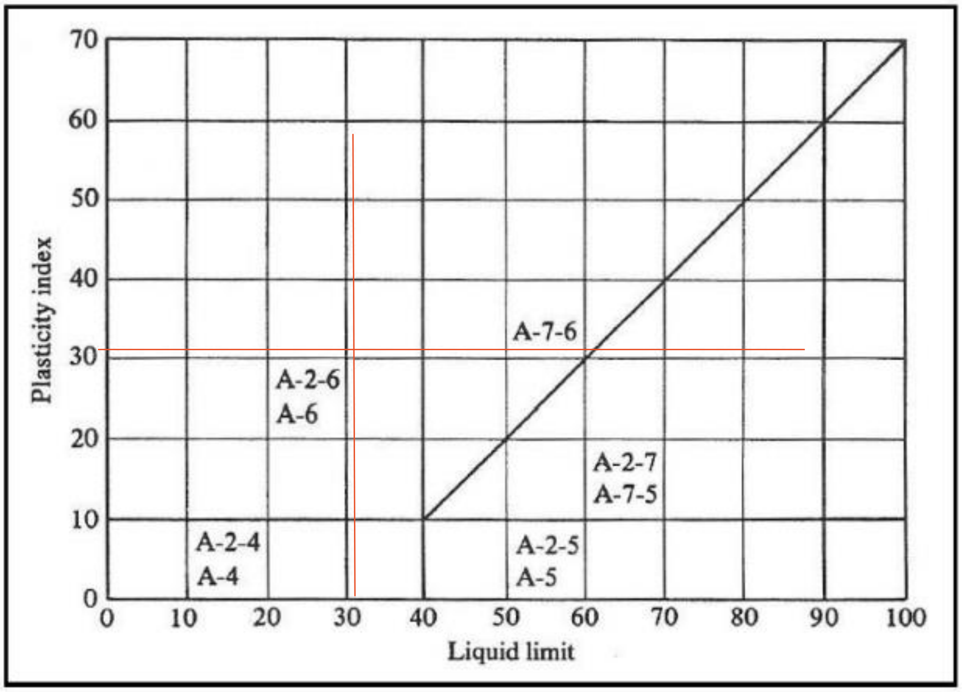


Figure 67: AASHTO Classification Chart - Sample 12

Appendix 22: Sample 13 Soil Classification

Table 55: Sieve Analysis Raw Data – Sample 13

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	769.4	1593.3	823.9	31.0	31.0	69.0
10	2	457.7	981.2	523.5	19.7	50.7	49.3
20	0.85	414.6	959.7	545.1	20.5	71.3	28.7
40	0.425	380.6	703.3	322.7	12.2	83.4	16.6
60	0.25	367.2	538.3	171.1	6.4	89.9	10.1
150	0.106	339.5	488.2	148.7	5.6	95.5	4.5
200	0.075	326.1	375	22.7	0.9	96.3	3.7
Pan	NA	369.9	441.4	97.7	3.7	100.0	0.0
Sum	xx	xx	Wts =	2655.4			

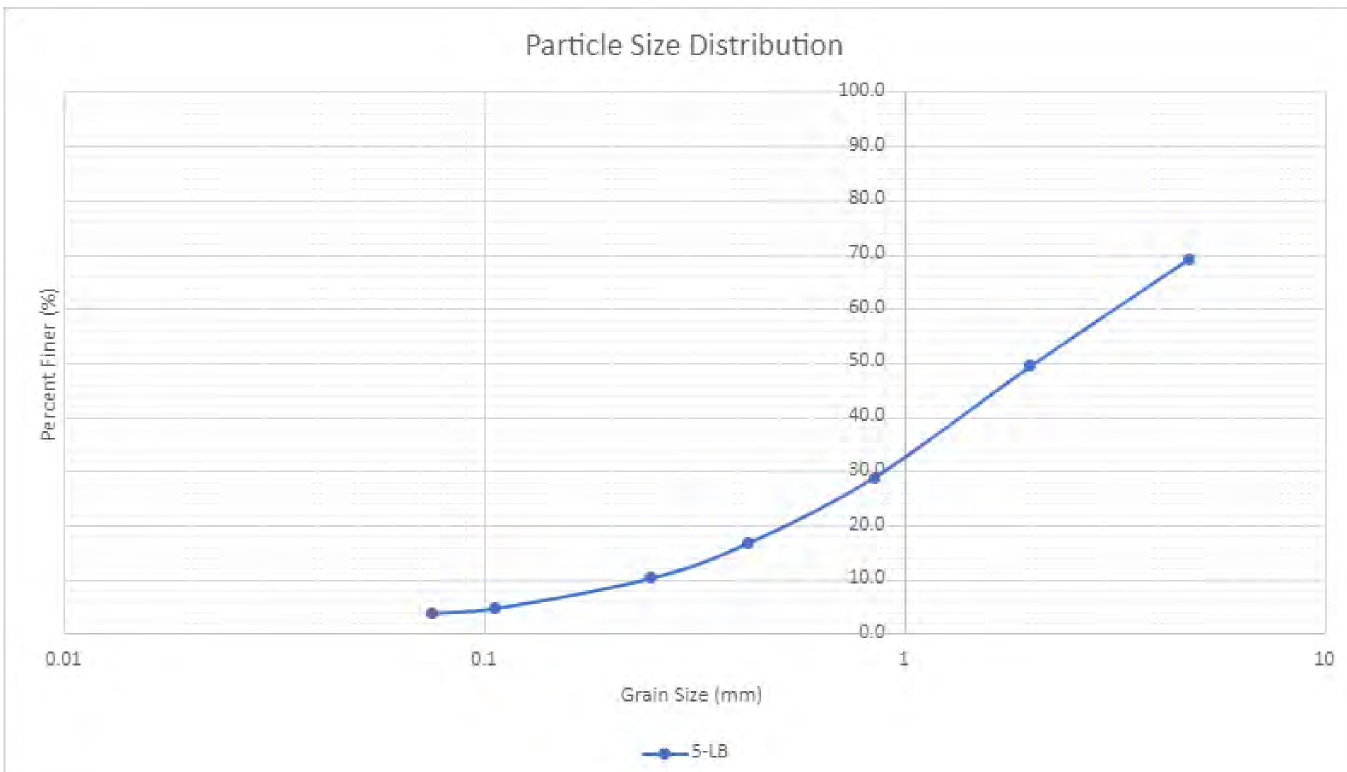


Figure 68: Particle Distribution Curve – Sample 13

Table 56: Liquid Limit Raw Data – Sample 13

Sample 13					
Cross Section	3+50	5			
Location/Name	Left of Bank	5-LB			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.1	13.4	13.4	13.1	19.5
Mass of Can and Moist Sample, (g)	17.2	17	16.2	15.1	21.3
Mass of Can and Dry Sample, (g)	16.1	16.2	15.8	14.3	21.2
Moisture Content, (%)	36.7	28.6	16.7	66.7	5.9
Number of Drops, N	7	13	30.0	47	58
Liquid Limit	31				

Table 57: Plastic Limit Raw Data – Sample 13

Sample 13			
Cross Section	3+50	5	
Location/Name	Left of Bank	5-LB	
Mass of Can, (g)	12.0	13.6	13.3
Mass of Can and Moist Sample, (g)	14.0	16.2	14.9
Mass of Can and Dry Sample, (g)	13.6	15.6	14.5
Moisture Content, (%)	25.0	30.0	33.3
Plastic Limit	29		

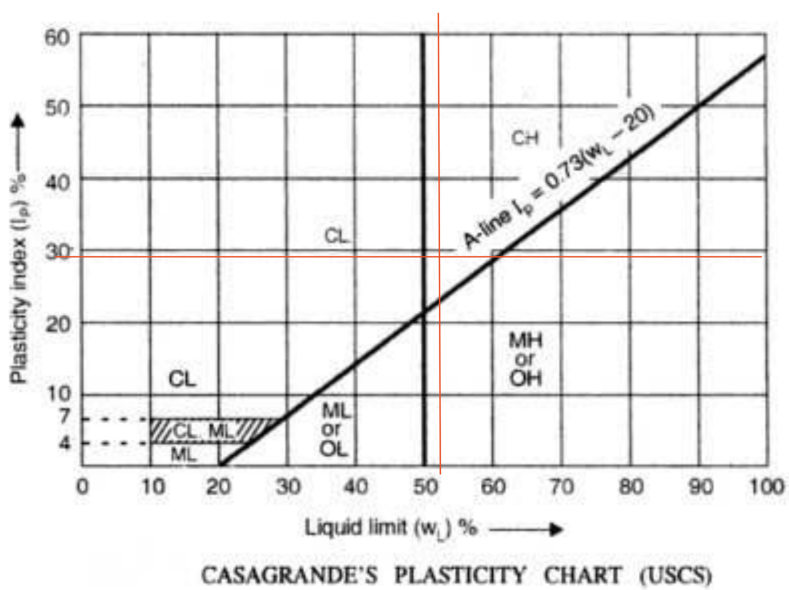


Figure 69: Casagrande's Plasticity Chart - Sample 13

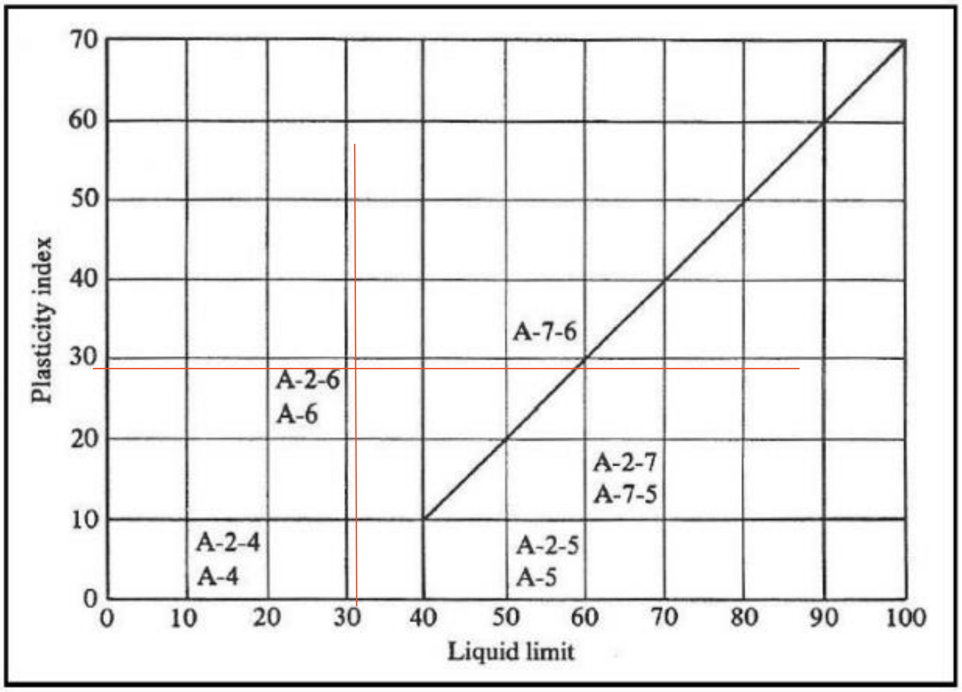


Figure 70: AASHTO Classification Chart - Sample 13

Appendix 23: Sample 14 Soil Classification

Table 58: Sieve Analysis Raw Data – Sample 14

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	774.5	1810.5	1036	49.3	49.3	50.7
10	2	444	1004.5	560.5	26.7	76.0	24.0
20	0.85	619.6	989.7	370.1	17.6	93.6	6.4
40	0.425	395.1	483.4	88.3	4.2	97.8	2.2
60	0.25	371.9	387.4	15.5	0.7	98.5	1.5
150	0.106	338.5	349.8	11.3	0.5	99.0	1.0
200	0.075	298.8	305.8	3.6	0.2	99.2	0.8
Pan	NA	365.5	378.6	16.5	0.8	100.0	0.0
Sum	xx	xx	Wts =	2101.8			

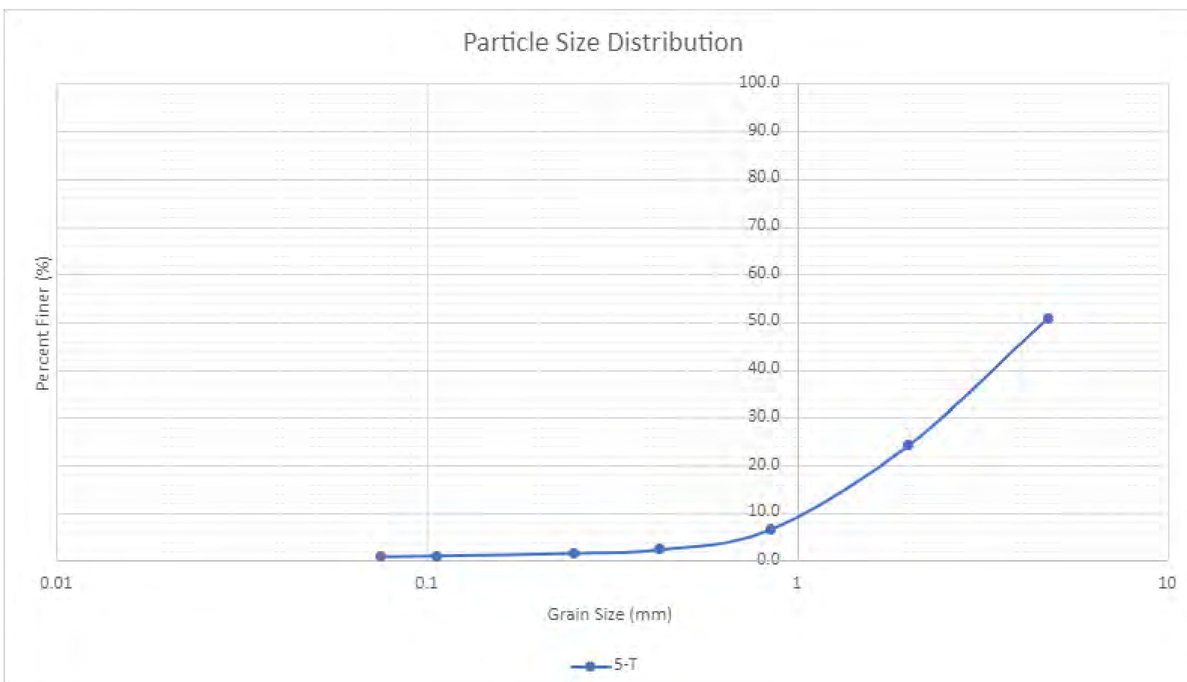


Figure 71: Particle Distribution Curve – Sample 14

Table 59: Liquid Limit Raw Data – Sample 14

Sample 14					
Cross Section	3+50	5			
Location/Name	Thalweg	5-T			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	19.7	13.4	13.4	19.5	13.3
Mass of Can and Moist Sample, (g)	21.7	17.3	16.9	23.4	16.4
Mass of Can and Dry Sample, (g)	21.2	16.4	16.1	22.5	15.8
Moisture Content, (%)	33.3	30.0	29.6	30.0	24.0
Number of Drops, N	15	32	37.0	45	65
Liquid Limit	32				

Table 60: Plastic Limit Raw Data – Sample 14

Sample 14			
Cross Section	3+50	5	
Location/Name	Thalweg	5-T	
Mass of Can, (g)	13.5	13.5	13.6
Mass of Can and Moist Sample, (g)	15.5	15.0	15.2
Mass of Can and Dry Sample, (g)	15	14.6	14.8
Moisture Content, (%)	33.3	36.4	33.3
Plastic Limit	34		

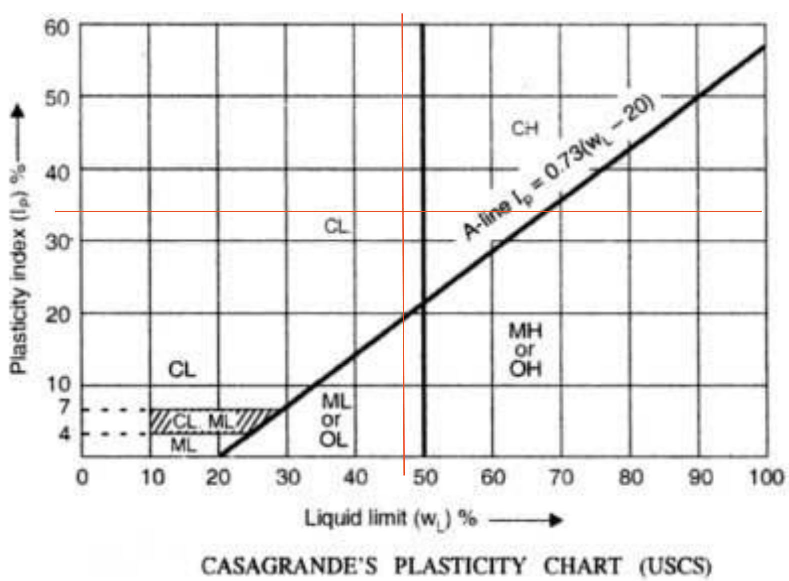


Figure 72: Casagrande's Plasticity Chart - Sample 14

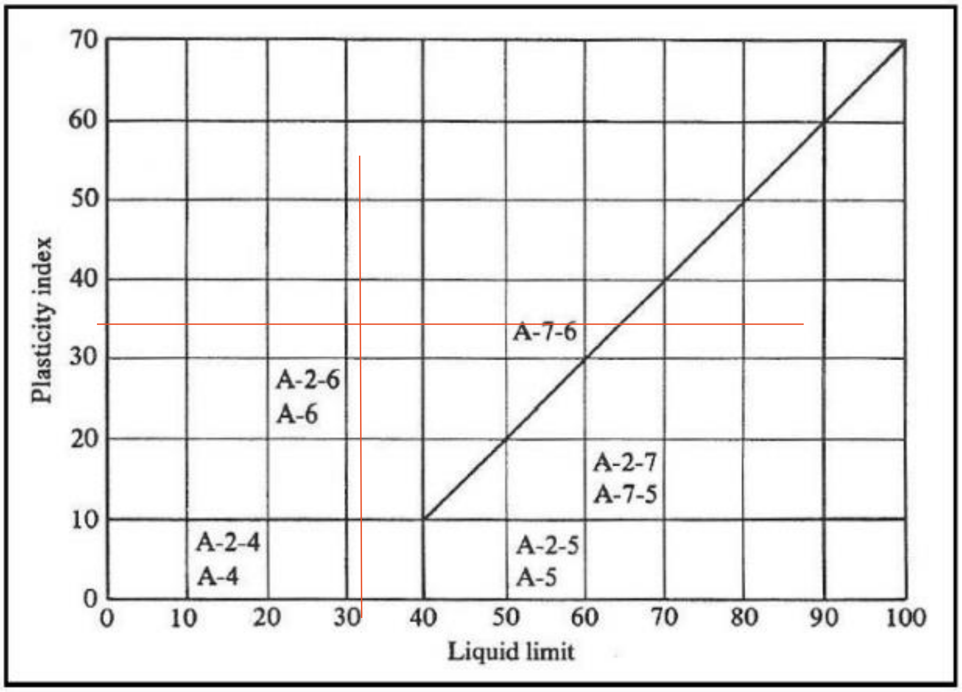


Figure 73: AASHTO Classification Chart - Sample 14

Appendix 24: Sample 15 Soil Classification

Table 61: Sieve Analysis Raw Data – Sample 15

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	775.6	1613.2	837.6	47.7	47.7	52.3
10	2	445.8	898.1	452.3	25.7	73.4	26.6
20	0.85	395.7	661.4	265.7	15.1	88.5	11.5
40	0.425	360.8	441.1	80.3	4.6	93.1	6.9
60	0.25	535.9	560.8	24.9	1.4	94.5	5.5
150	0.106	344.4	370.4	26	1.5	96.0	4.0
200	0.075	326.1	336.9	6.4	0.4	96.3	3.7
Pan	NA	365.3	388.2	64.4	3.7	100.0	0.0
Sum	xx	xx	Wts =	1757.6			

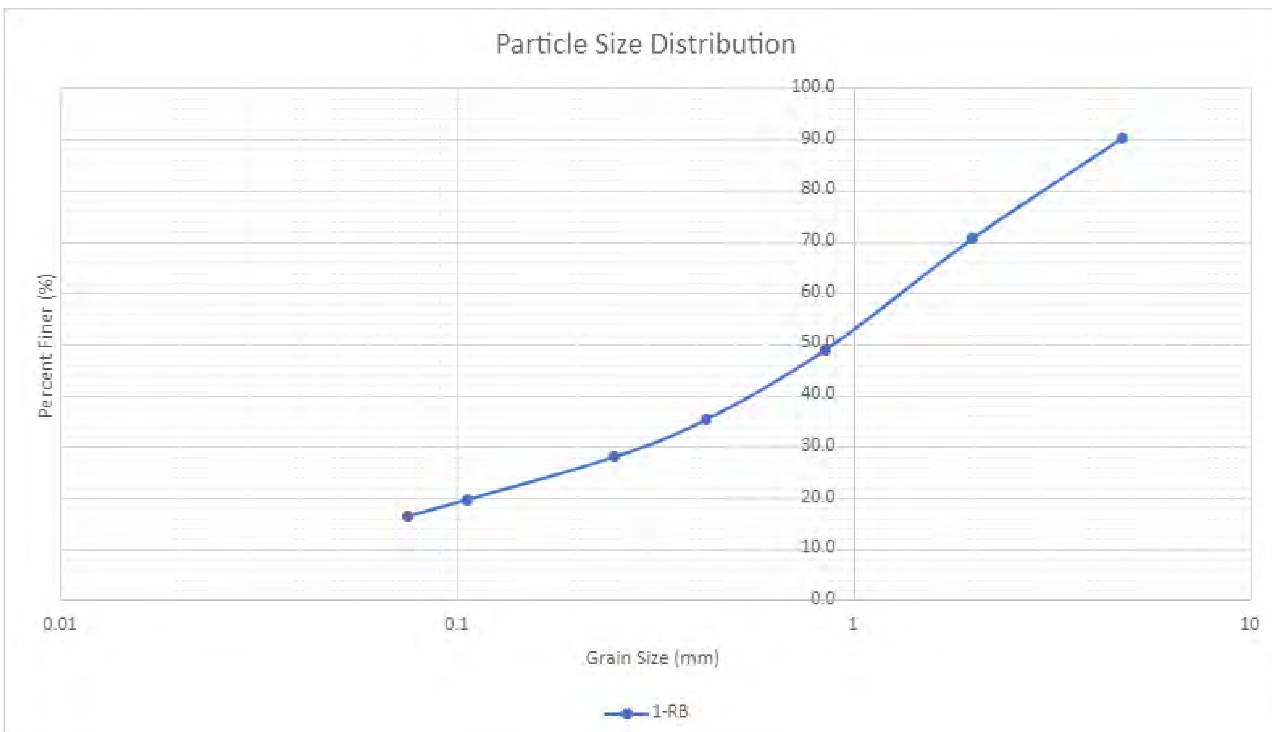


Figure 74: Particle Distribution Curve – Sample 15

Table 62: Liquid Limit Raw Data – Sample 15

			[redacted]		
			[redacted]		

Table 63: Plastic Limit Raw Data – Sample 15

Sample 15			
Cross Section	3+50	5	[redacted]
Location/Name	Right of Bank	5-RB	[redacted]
Mass of Can, (g)	14.3	13	12.2
Mass of Can and Moist Sample, (g)	16.4	14.9	13.9
Mass of Can and Dry Sample, (g)	16.0	14.6	13.5
Moisture Content, (%)	23.5	18.8	30.8
Plastic Limit	24		

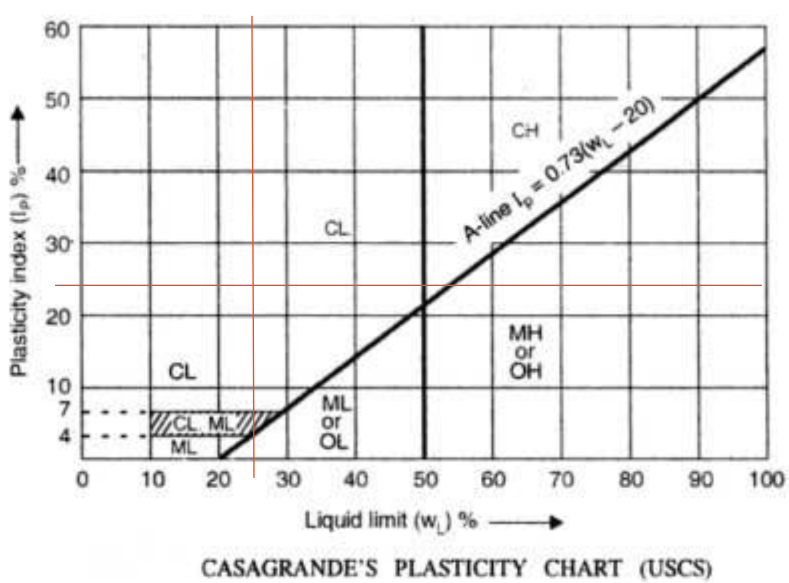


Figure 75: Casagrande's Plasticity Chart - Sample 15

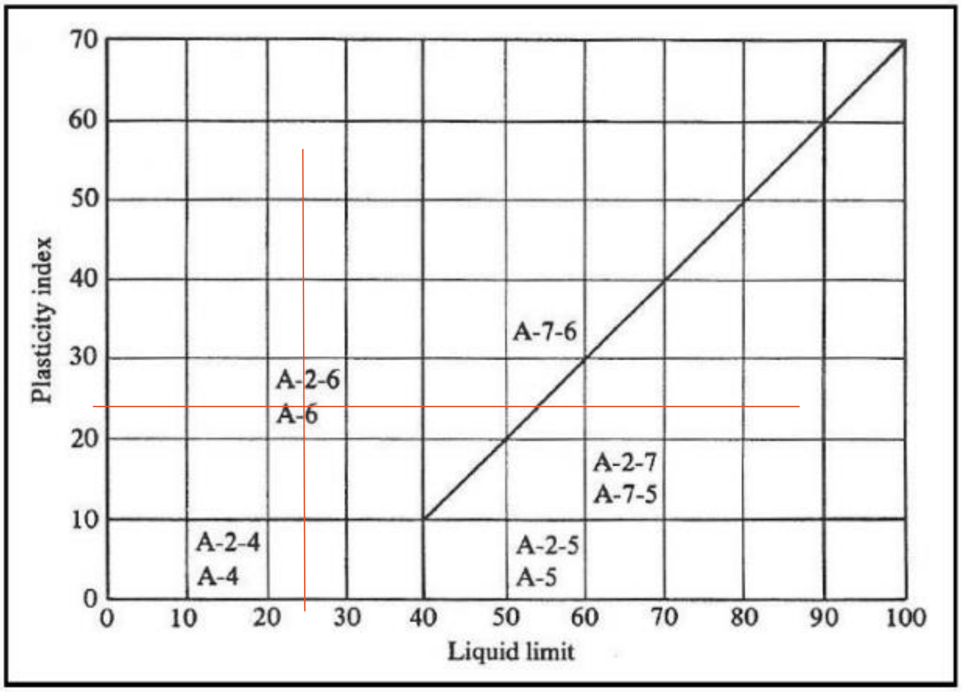


Figure 76: AASHTO Classification Chart - Sample 15

Appendix 25: Sample 16 Soil Classification

Table 64: Sieve Analysis Raw Data – Sample 16

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	515.3	704.4	189.1	17.5	17.5	82.5
10	2	469.7	859.2	389.5	36.0	53.5	46.5
20	0.85	414.7	733.3	318.6	29.5	82.9	17.1
40	0.425	360.8	477.8	117	10.8	93.8	6.2
60	0.25	345.6	368.9	23.3	2.2	95.9	4.1
150	0.106	338.6	354	15.4	1.4	97.3	2.7
200	0.075	318.4	325	5.3	0.5	97.8	2.2
Pan	NA	362.4	384.7	23.6	2.2	100.0	0.0
Sum	xx	xx	Wts =	1081.8			

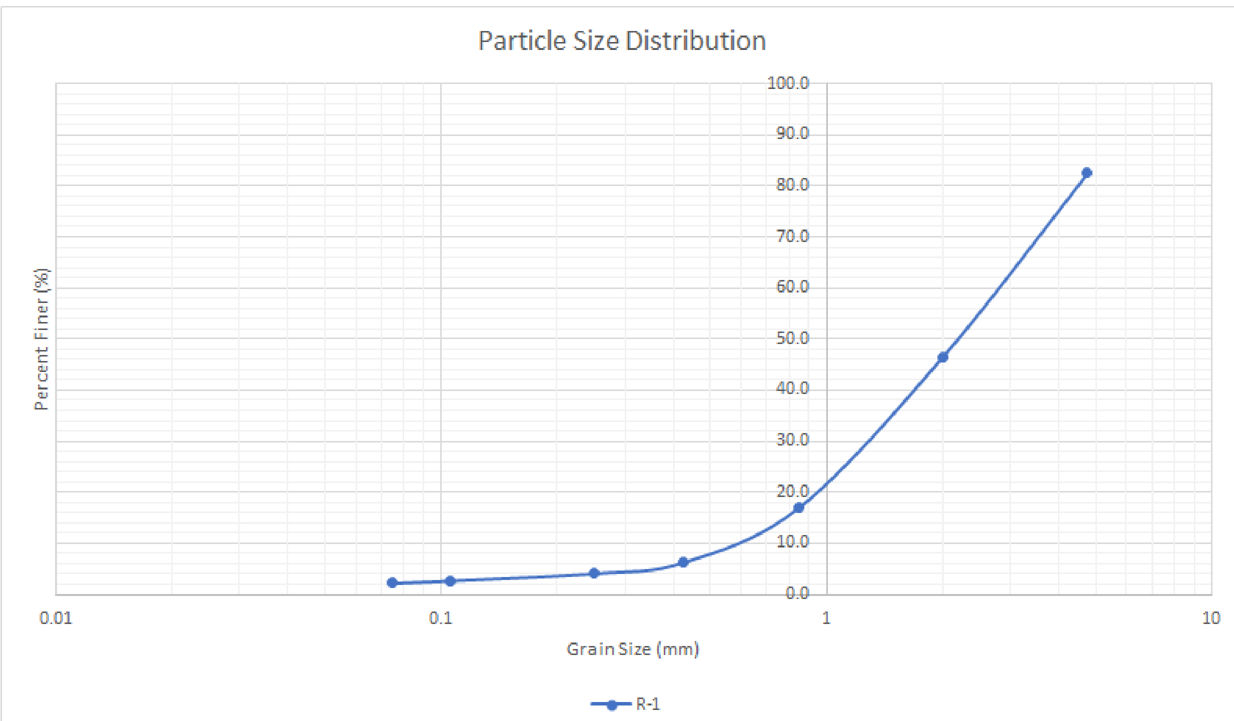


Figure 77: Particle Distribution Curve – Sample 16

Table 65: Liquid Limit Raw Data – Sample 16

Sample 16					
Cross Section	N/A		[redacted]		
Location/Name	Random	R-1			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	11.9	13.3	13	13	13.5
Mass of Can and Moist Sample, (g)	19.6	22.5	21.8	21.8	24.6
Mass of Can and Dry Sample, (g)	16.4	18.9	18.6	18.5	20.5
Moisture Content, (%)	71.1	64.3	57.1	60.0	58.6
Number of Drops, N	6	10	25.0	30	65
Liquid Limit	63				

Table 66: Plastic Limit Raw Data – Sample 16

Sample 16			
Cross Section	N/A		[redacted]
Location/Name	Random	R-1	
Mass of Can, (g)	13	12.5	13.3
Mass of Can and Moist Sample, (g)	13.5	13.1	14
Mass of Can and Dry Sample, (g)	13.3	12.9	13.6
Moisture Content, (%)	66.7	50.0	133.3
Plastic Limit	83		

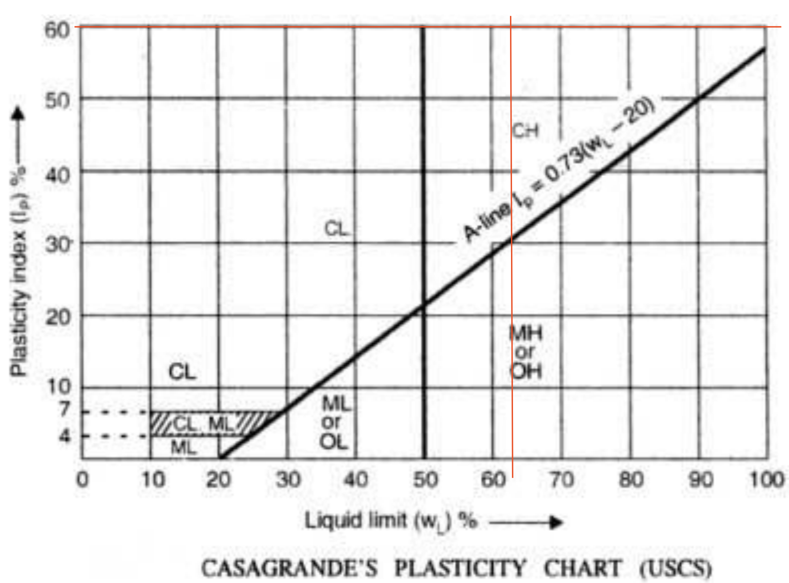


Figure 78: Casagrande's Plasticity Chart - Sample 16

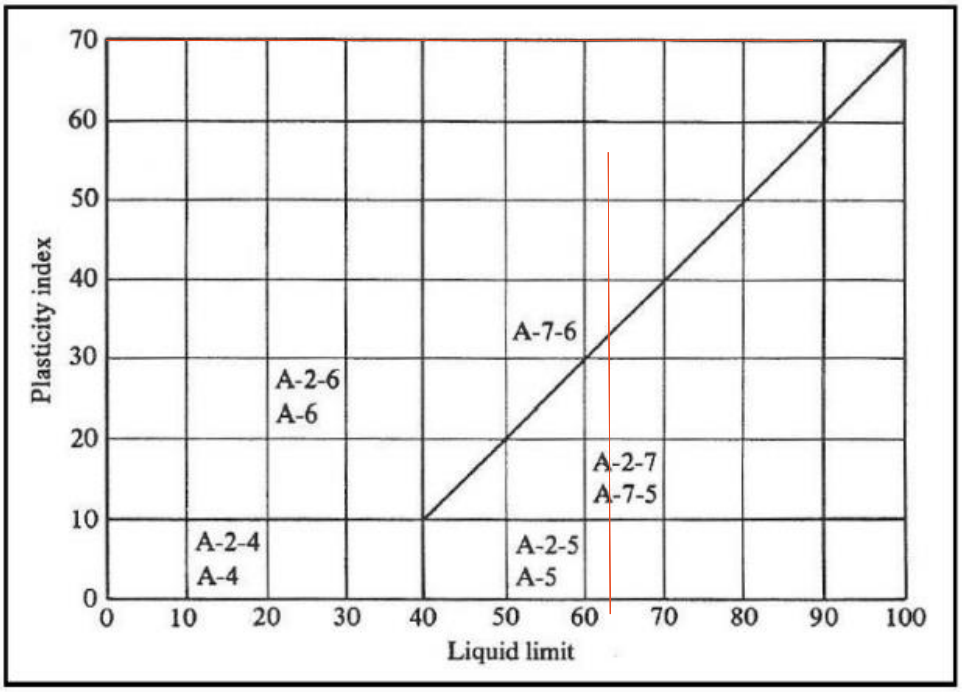


Figure 79: AASHTO Classification Chart - Sample 16

Appendix 26: Sample 17 Soil Classification

Table 67: Sieve Analysis Raw Data – Sample 17

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	768.6	1468.5	699.9	24.5	24.5	75.5
10	2	470	1135.5	665.5	23.3	47.8	52.2
20	0.85	395.3	1000.5	605.2	21.2	69.0	31.0
40	0.425	391.3	762.5	371.2	13.0	82.0	18.0
60	0.25	535.8	715.5	179.7	6.3	88.3	11.7
150	0.106	338.4	493.5	155.1	5.4	93.8	6.2
200	0.075	326	388.5	26.6	0.9	94.7	5.3
Pan	NA	369.9	485.5	151.5	5.3	100.0	0.0
Sum	xx	xx	Wts =	2854.7			

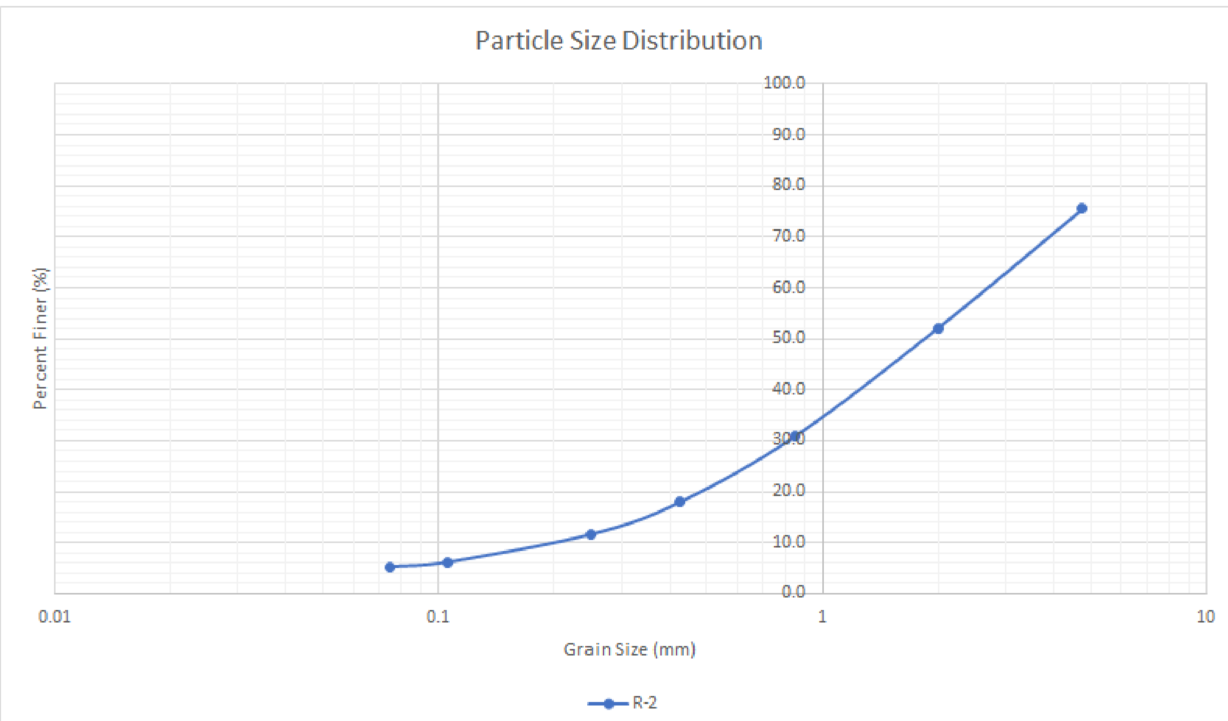


Figure 80: Particle Distribution Curve – Sample 17

Table 68: Liquid Limit Raw Data – Sample 17

Sample 17					
Cross Section	N/A		[redacted]		
Location/Name	Random	R-2			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.2	14.7	13.1	13.9	13.5
Mass of Can and Moist Sample, (g)	24.2	22.1	22.5	26	25.5
Mass of Can and Dry Sample, (g)	21.7	20.4	20.2	23.2	23.1
Moisture Content, (%)	29.4	29.8	32.4	30.1	25.0
Number of Drops, N	10	18	25.0	33	40
Liquid Limit	29				

Table 69: Plastic Limit Raw Data – Sample 17

Sample 17			
Cross Section	N/A		[redacted]
Location/Name	Random	R-2	
Mass of Can, (g)	13.4	19.5	13.2
Mass of Can and Moist Sample, (g)	14.1	20.4	14
Mass of Can and Dry Sample, (g)	14	20.3	13.9
Moisture Content, (%)	16.7	12.5	14.3
Plastic Limit	14		

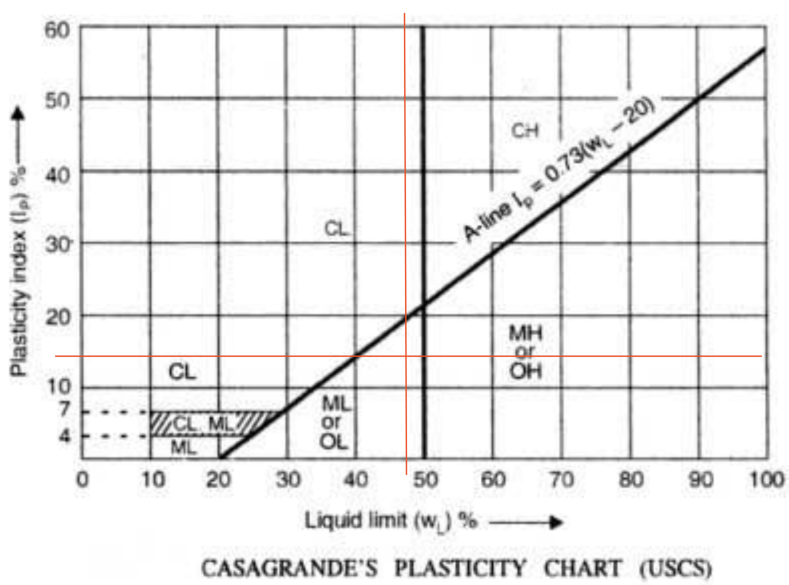


Figure 81: Casagrande's Plasticity Chart - Sample 17

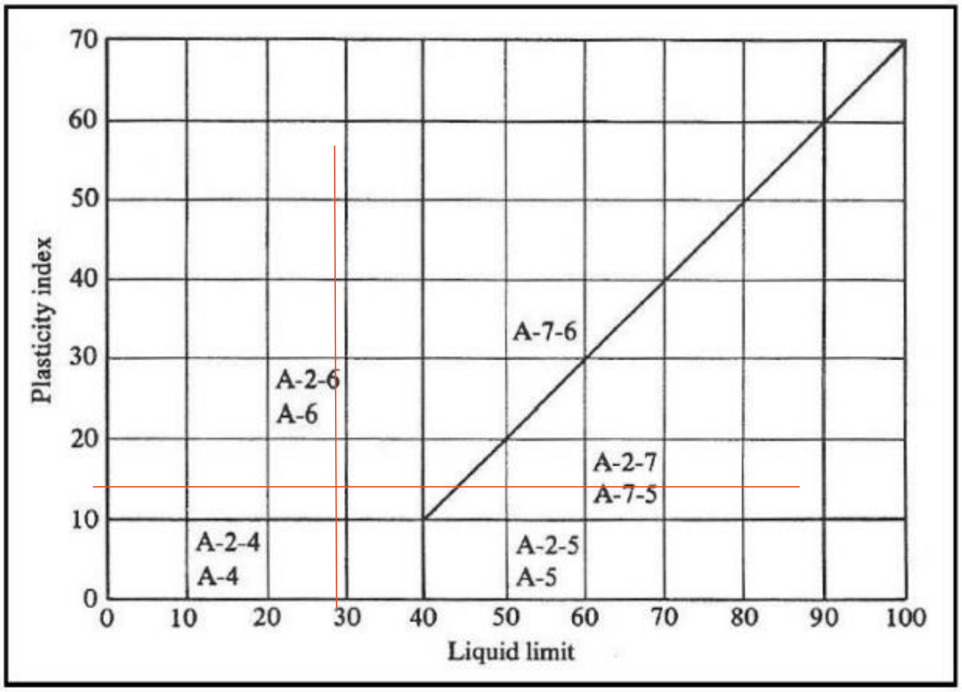


Figure 82: AASHTO Classification Chart - Sample 17

Appendix 27: Sample 18 Soil Classification

Table 70: Sieve Analysis Raw Data – Sample 18

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	773.7	1003.5	229.8	10.5	10.5	89.5
10	2	445.5	1074.5	629	28.8	39.4	60.6
20	0.85	394.4	986.5	592.1	27.1	66.5	33.5
40	0.425	380.3	668	287.7	13.2	79.7	20.3
60	0.25	348.6	457	108.4	5.0	84.7	15.3
150	0.106	339.5	456.5	117	5.4	90.0	10.0
200	0.075	296.7	347	36.6	1.7	91.7	8.3
Pan	NA	365.2	532.5	181	8.3	100.0	0.0
Sum	xx	xx	Wts =	2181.6			

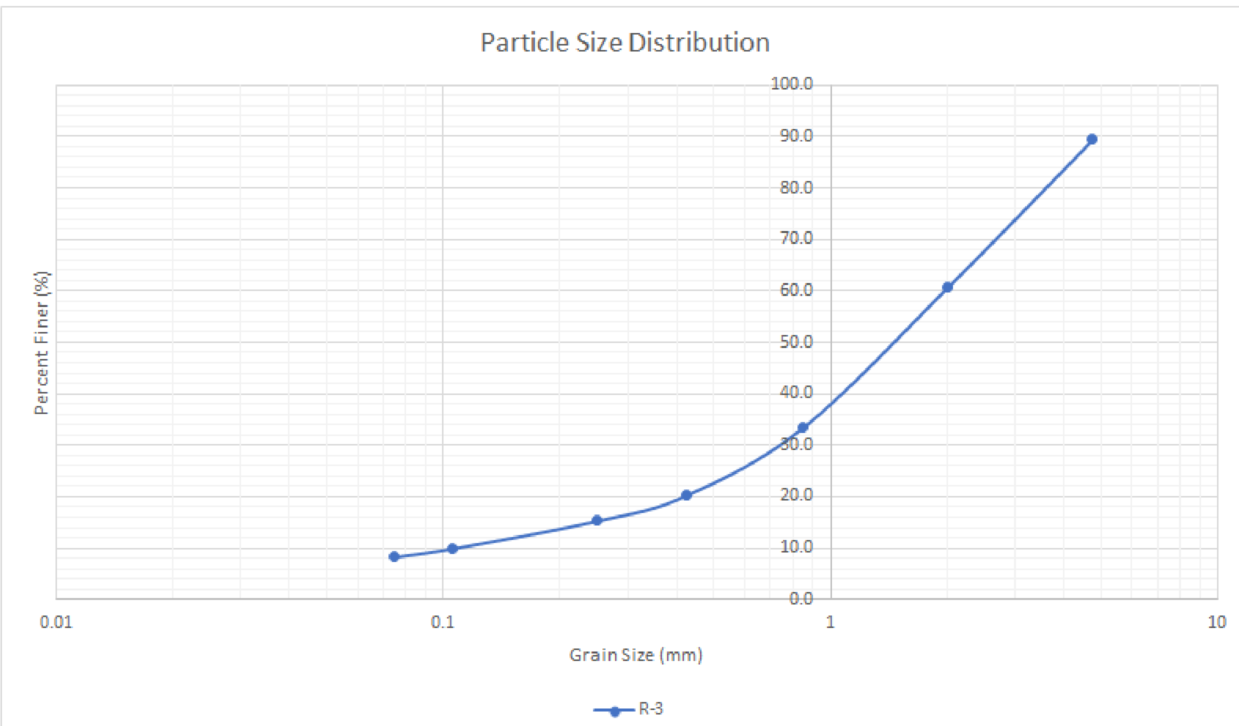


Figure 83: Particle Distribution Curve – Sample 18

Table 71: Liquid Limit Raw Data – Sample 18

Sample 18					
Cross Section	N/A		[redacted]		
Location/Name	Random	R-3			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.8	13.9	13.2	13.3	13.3
Mass of Can and Moist Sample, (g)	21	21.5	18.5	20	19
Mass of Can and Dry Sample, (g)	19	19.5	16.9	18.7	18.1
Moisture Content, (%)	38.5	35.7	43.2	24.1	18.8
Number of Drops, N	15	20	40.0	45	50
Liquid Limit	36				

Table 72: Plastic Limit Raw Data – Sample 18

Sample 18			
Cross Section	N/A		[redacted]
Location/Name	Random	R-3	
Mass of Can, (g)	13.5	21.9	22.6
Mass of Can and Moist Sample, (g)	14.6	23.1	23.8
Mass of Can and Dry Sample, (g)	14.2	22.8	23.5
Moisture Content, (%)	57.1	33.3	33.3
Plastic Limit	41		

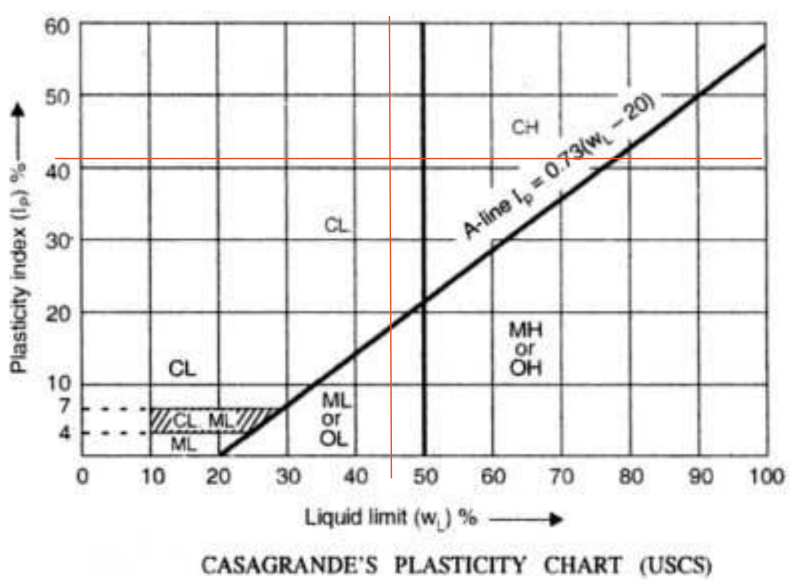


Figure 84: Casagrande's Plasticity Chart - Sample 18

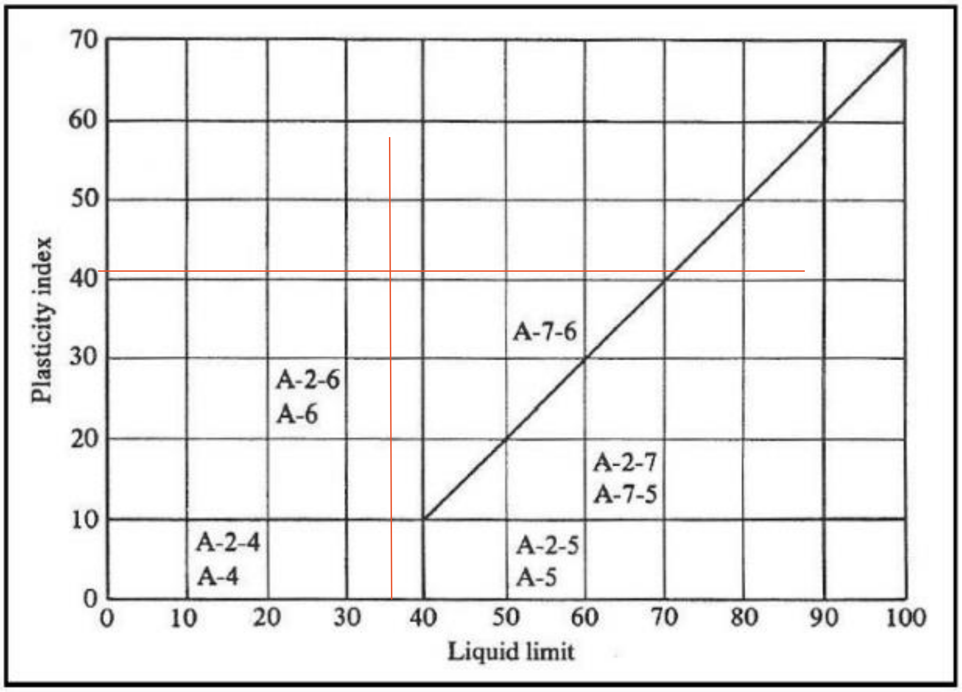


Figure 85: AASHTO Classification Chart - Sample 18

Appendix 28: Sample 19 Soil Classification

Table 73: Sieve Analysis Raw Data – Sample 19

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	768.8	1529	760.2	25.3	25.3	74.7
10	2	457.2	1180	722.8	24.0	49.3	50.7
20	0.85	630.9	1349.9	719	23.9	73.2	26.8
40	0.425	360.8	784.8	424	14.1	87.3	12.7
60	0.25	371.9	539.9	168	5.6	92.9	7.1
150	0.106	343.6	463	119.4	4.0	96.9	3.1
200	0.075	298.5	328.7	23.9	0.8	97.7	2.3
Pan	NA	365.5	429.4	70.2	2.3	100.0	0.0
Sum	xx	xx	Wts =	3007.5			

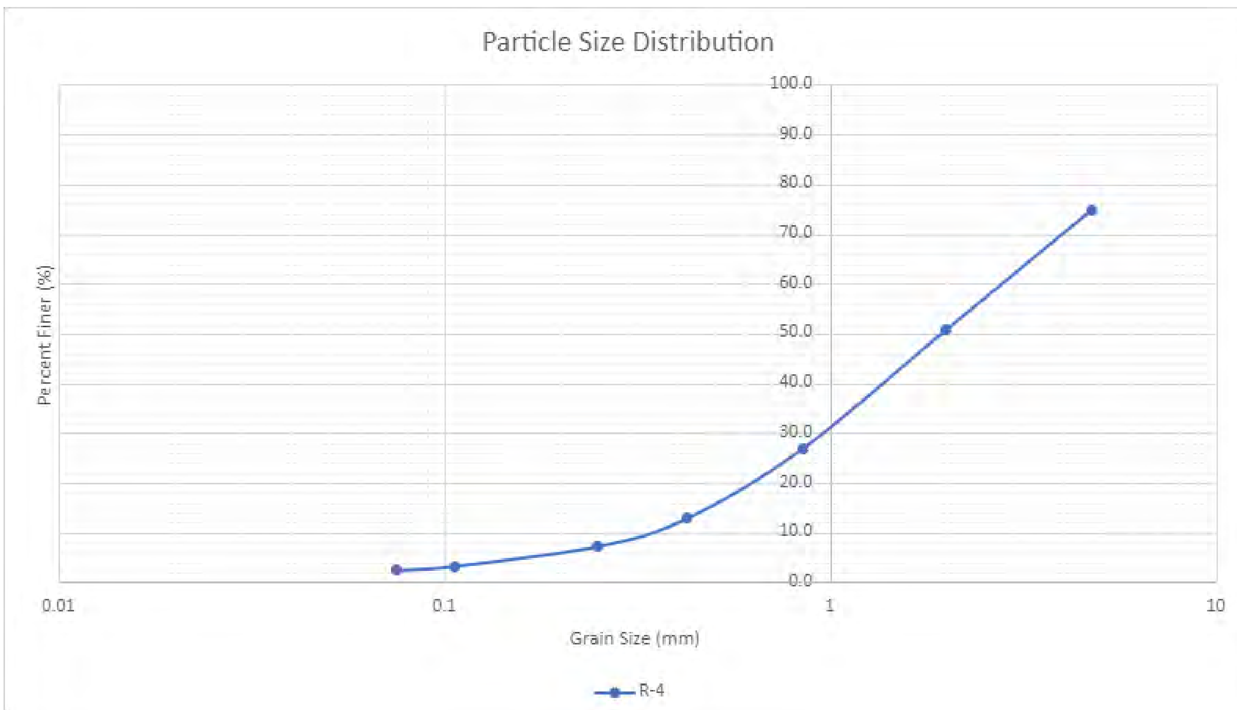


Figure 86: Particle Distribution Curve – Sample 19

Table 74: Liquid Limit Raw Data – Sample 19

Sample 19					
Cross Section	N/A				
Location/Name	Random	R-4			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.2	13.4	19.3	13.3	19.4
Mass of Can and Moist Sample, (g)	19.9	19.8	30.4	21.2	23.6
Mass of Can and Dry Sample, (g)	18.8	18.7	28.5	19.7	22.9
Moisture Content, (%)	19.6	20.8	20.7	23.4	20.0
Number of Drops, N	15	20	25	36	60
Liquid Limit	21				

Table 75: Plastic Limit Raw Data – Sample 19

Sample 19			
Cross Section	N/A		
Location/Name	Random	R-4	
Mass of Can, (g)	13.3	13.6	13.4
Mass of Can and Moist Sample, (g)	14.4	14.4	13.9
Mass of Can and Dry Sample, (g)	14.2	14.3	13.8
Moisture Content, (%)	22.2	14.3	25.0
Plastic Limit	21		

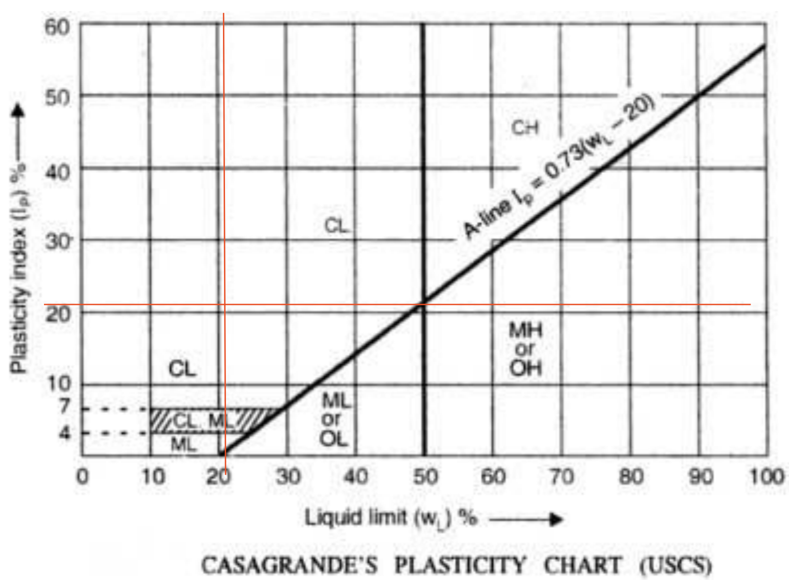


Figure 87: Casagrande's Plasticity Chart - Sample 19

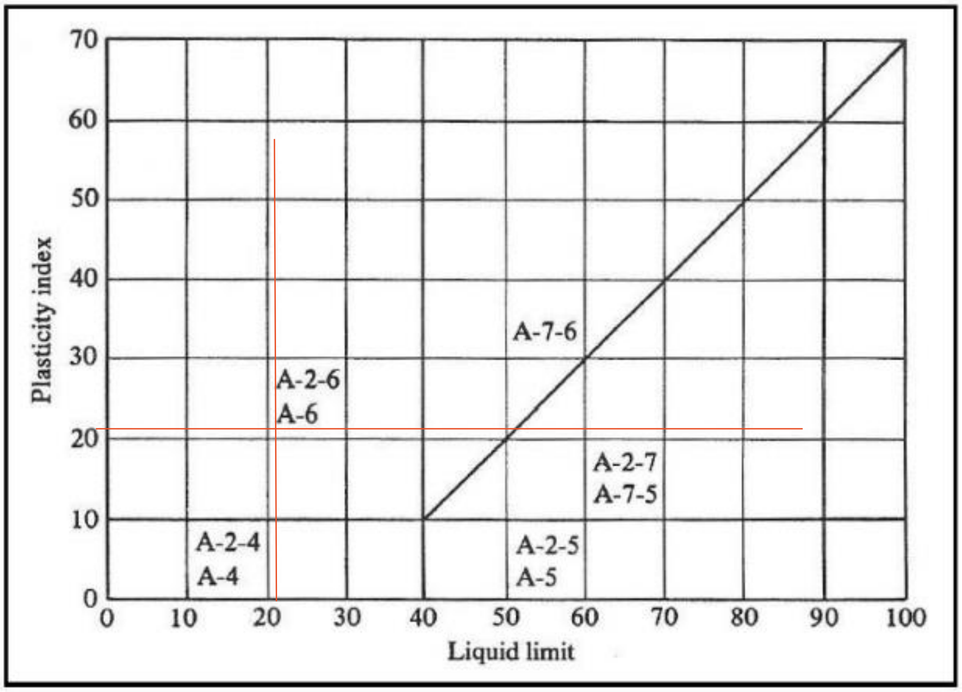


Figure 88: AASHTO Classification Chart - Sample 19

Appendix 29: Sample 20 Soil Classification

Table 76: Sieve Analysis Raw Data – Sample 20

Sieve #	Sieve Opening (mm)	Mass of Sieve, A (g) empty	Mass of Sieve and Retained Sample, B (g)	Mass of Sample, Wn (g) A-B	Percent Mass Retained, Rn	Cumulative Mass Retained, Rn	Percent Finer
4	4.75	515.8	1256.4	740.6	43.9	43.9	56.1
10	2	470.2	816.5	346.3	20.5	64.5	35.5
20	0.85	415.2	680.1	264.9	15.7	80.2	19.8
40	0.425	380.5	545.1	164.6	9.8	90.0	10.0
60	0.25	348.6	403.6	55	3.3	93.2	6.8
150	0.106	339.5	384.1	44.6	2.6	95.9	4.1
200	0.075	318.7	334.2	13.4	0.8	96.7	3.3
Pan	NA	362.3	416.4	56.2	3.3	100.0	0.0
Sum	xx	xx	Wts =	1685.6			

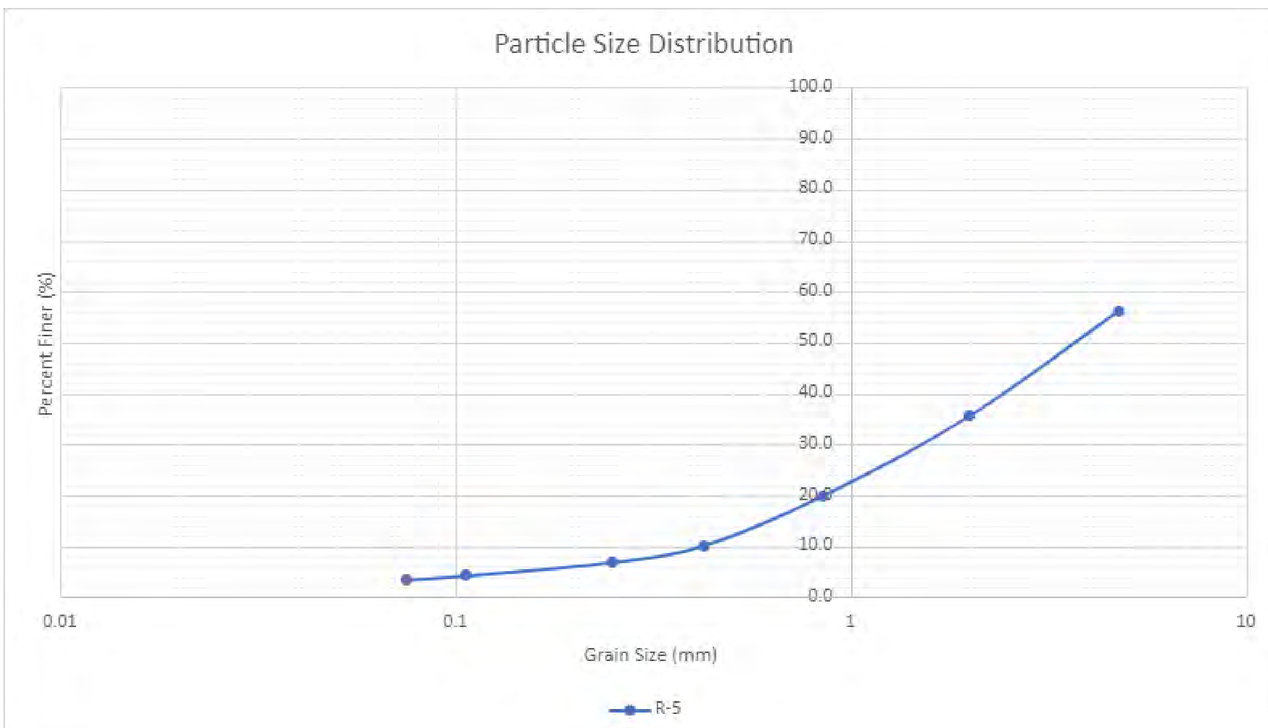


Figure 89: Particle Distribution Curve – Sample 20

Table 77: Liquid Limit Raw Data – Sample 20

Sample 20					
Cross Section	N/A				
Location/Name	Random	R-5			
Moisture Can ID	1	2	3	4	5
Mass of Can, (g)	13.2	13.5	13.3	19.6	13.2
Mass of Can and Moist Sample, (g)	22.7	18.7	18.4	24.1	17.7
Mass of Can and Dry Sample, (g)	20.3	17.5	17.2	23.1	16.8
Moisture Content, (%)	33.8	30.0	30.8	28.6	25.0
Number of Drops, N	10	15	22.0	40	62
Liquid Limit	30				

Table 78: Plastic Limit Raw Data – Sample 20

Sample 20			
Cross Section	N/A		
Location/Name	Random	R-5	
Mass of Can, (g)	13.4	13.4	13.4
Mass of Can and Moist Sample, (g)	13.8	14	14
Mass of Can and Dry Sample, (g)	13.7	14	14
Moisture Content, (%)	33.3	0.0	0.0
Plastic Limit	11		

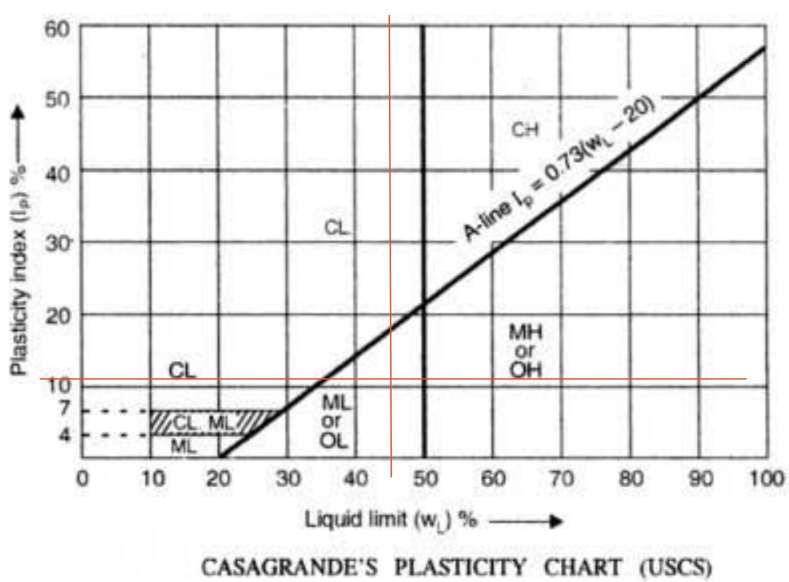


Figure 90: Casagrande's Plasticity Chart - Sample 20

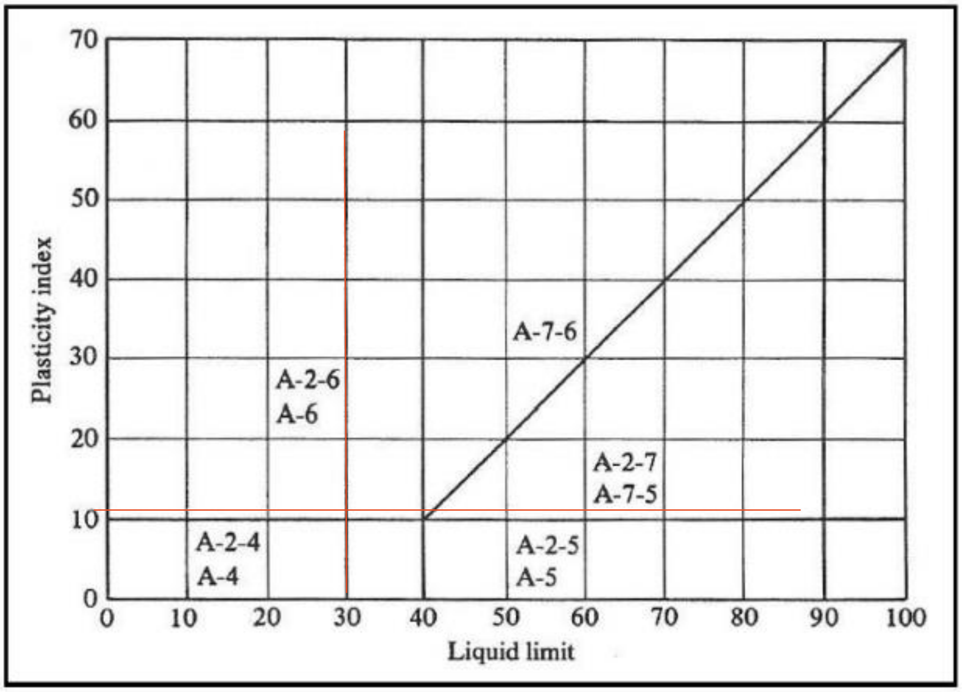
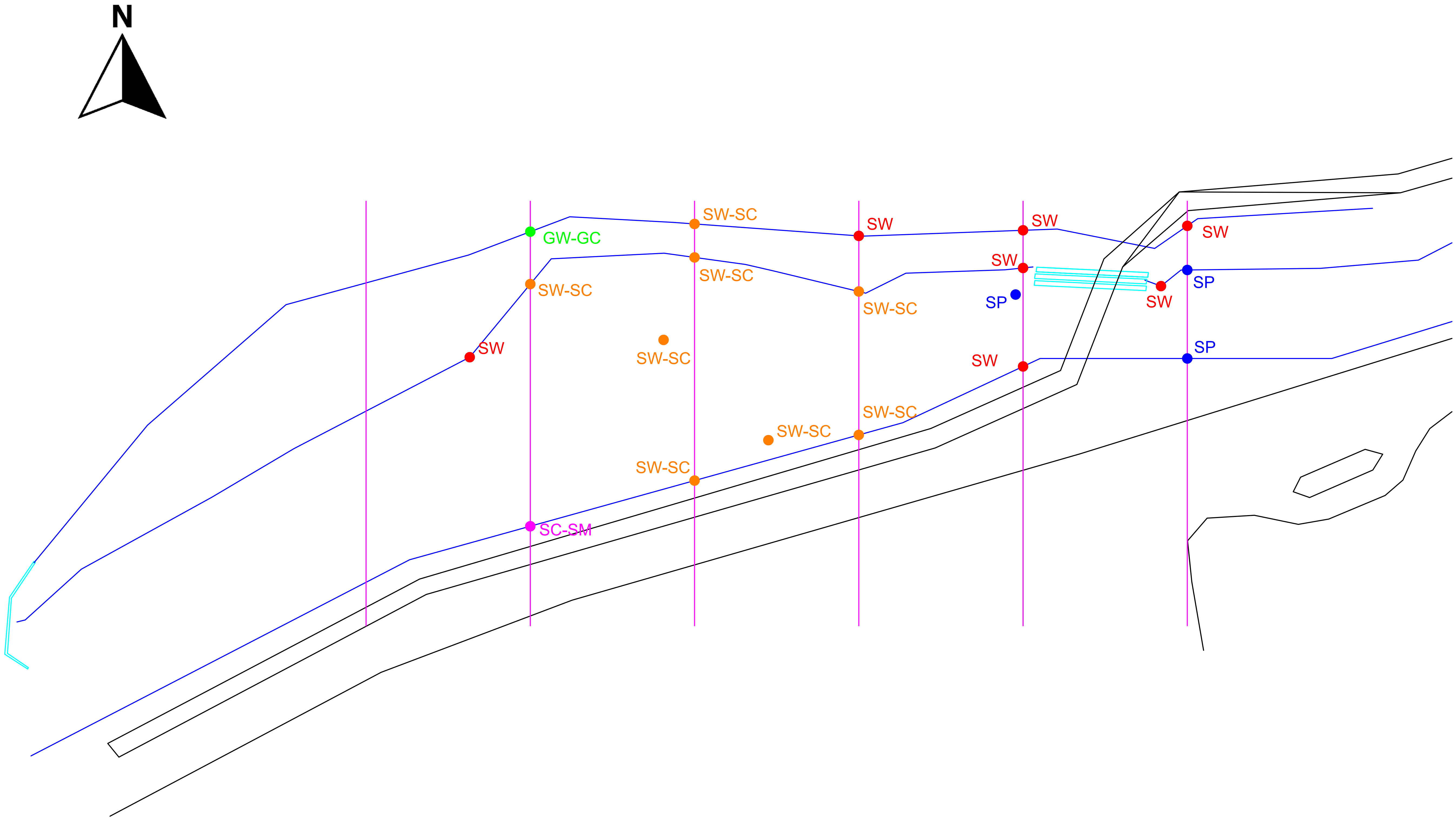


Figure 91: AASHTO Classification Chart - Sample 20

Appendix 30: USCS Classification AutoCAD Exhibit



SHEET 1 OF 1

SCALE: 1" TO 20'

0 5 10 20

REVISIONS

CLIENT: MARK LAMER

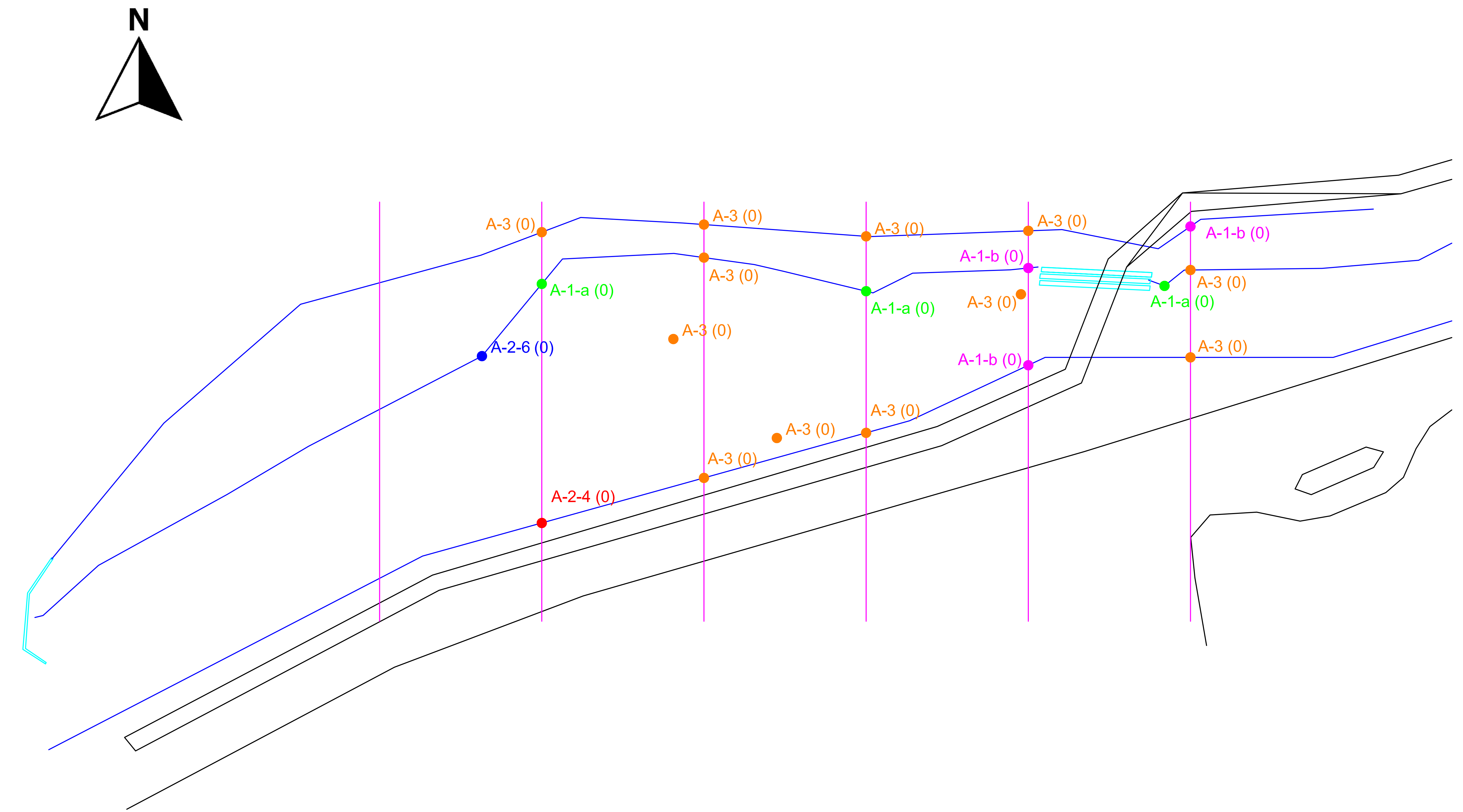
PROJECT: USCS CLASSIFICATION

AUTHOR: S. SEYMOUR

DATE: 03/25/2021

RED ROCK ENGINEERING

Appendix 31: AASHTO Classification AutoCAD Exhibit



SHEET 1 OF 1

SCALE: 1:20

0 5 10 20

REVISIONS

CLIENT: MARK LAMER

PROJECT: AASHTO CLASS.

AUTHOR: S. SEYMOUR

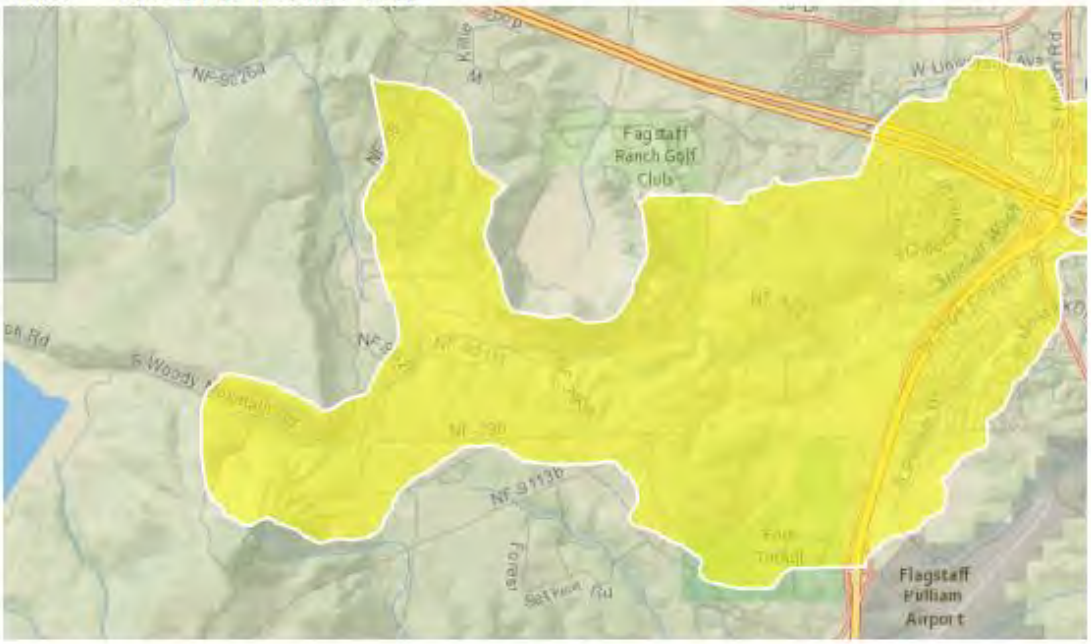
DATE: 03/29/2021

RED ROCK ENGINEERING

Appendix 32: USGS StreamStats Report

StreamStats Report

Region ID: AZ
Workspace ID: AZ20210408000234557000
Clicked Point (Latitude, Longitude): 35.17917, -111.65776
Time: 2021-04-07 17:02:54 -0700



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CONTDA	Area that contributes flow to a point on a stream	9.51	square miles
ELEV	Mean Basin Elevation	7088.681	feet

Peak-Flow Statistics Parameters [100.0 Percent (9.5 square miles) Peak Region 2 Colorado Plateau 2014 5211]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	9.51	square miles	0.103	16017
ELEV	Mean Basin Elevation	7088.681	feet		

Peak-Flow Statistics Flow Report [100.0 Percent (9.5 square miles) Peak Region 2 Colorado Plateau 2014 5211]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SEp
50-percent AEP flood	166	ft^3/s	34.2	807	122
20-percent AEP flood	415	ft^3/s	120	1440	87.2
10-percent AEP flood	665	ft^3/s	219	2020	75.7
4-percent AEP flood	1100	ft^3/s	394	3070	68.6
2-percent AEP flood	1510	ft^3/s	551	4140	66.6
1-percent AEP flood	2010	ft^3/s	732	5520	67.3
0.5-percent AEP flood	2610	ft^3/s	933	7300	68.8
0.2-percent AEP flood	3540	ft^3/s	1200	10400	72.9

Peak-Flow Statistics Citations

Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G.,2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., http://dx.doi.org/10.3133/sir20145211. (http://pubs.usgs.gov/sir/2014/5211/)

USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Application Version: 4.5.1
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.1

Appendix 33: Flora Identification

Table 79: Flora Identification

Classification	Photo	Native, Invasive. or Noxious
Ulmus Siberian Elm		Non-native (Invasive)
Pinus ponderosa Ponderosa pine		Native to Flagstaff

Rhus glabra Smooth (common) Sumac		Native to Flagstaff
Berberis repens Creeping Barberry		Native to Flagstaff
Coreopsis Tinctoria Golden Tickseed		Non-native (Invasive)

Rumex crispus Curly dock		Non-native (Invasive)
Taraxacum officinale Common dandelion		Non-native (Invasive)

Convolvulus arvensis Field bindweed		Noxious
Potentilla hippiana Silvery cinquefoil		Native to Flagstaff

Melilotus officinalis Sweetclover		Non-native (Invasive)
Rhapnoticum repens *Russian Knapweed*		Noxious
Verbena macdougalii New Mexico Vervain		Non-native (Invasive)

<table>
<tr><td>Pascopyrum smithii
Western wheatgrass</td><td></td><td>Native to Arizona</td></tr>
<tr><td>Poa pratensis
Kentucky bluegrass</td><td></td><td>Non-native (Invasive)</td></tr>
</table>

Muhlenbergia glomerata Spike muhly		Native to Flagstaff
Bromus inermis Smooth Brome		Non-native (Invasive)
Agropyron intermedia Intermediate wheatgrass		Non-native (Invasive)

Alopecurus arundinaceus Creeping Foxtail		Non-native (Invasive)
Schizachyrium scoparium Little bluestem grass		Native to Flagstaff

Appendix 34: Fauna Identification

Table 80: Fauna Identification

Animal Species
Birds
Dark-eyed junco
Downy and hairy woodpeckers
Cinnamon teal
Ibis
Avocet
Redtail hawk
Western blue bird
Williamson's Sapsucker
Red-napped sapsucker
Pine siskins
Red-faced warble
Clark's Nutcracker
Bald eagle
White breasted & pygmy nuthatch
Mountain chickadee
Northern flicker
Acorn woodpecker
American robin
Western & mountain bluebirds
White crowned sparrows
Townsend's solitaire
Cassin's finches
Reptiles
Eastern collared lizards
Common side blotched lizard
Tiger whiptail lizard
Short horned lizard
Western Fence lizard
Plateau lizard
Mammals
Abert's Squirrels (Kaibab squirrel)
Gunnison's prairie dogs
Badgers

Appendix 35: Revegitation Plan

Keep native trees and bushes in area

Remove Ponderosa Pine trees

Remove noxious species with herbicide and hydroseed native grasses throughout area

SHEET 9 OF 9

SCALE:1" to 20'

0 5 10 20

REVISIONS		
HF	3/24	ADDED TREE POLYGONS
HF	4/02	ADJUSTED "KEEP" AREA
HF	4/21	ADDED DETAILS

CLIENT:MARK LAMER

PROJECT:REVEGITATION PLAN

AUTHOR:HANNAH FISCHER

DATE:3/3/21

RED ROCK ENGINEERING

Appendix 36: Effective Hydraulic Model Cross-Section Diagram

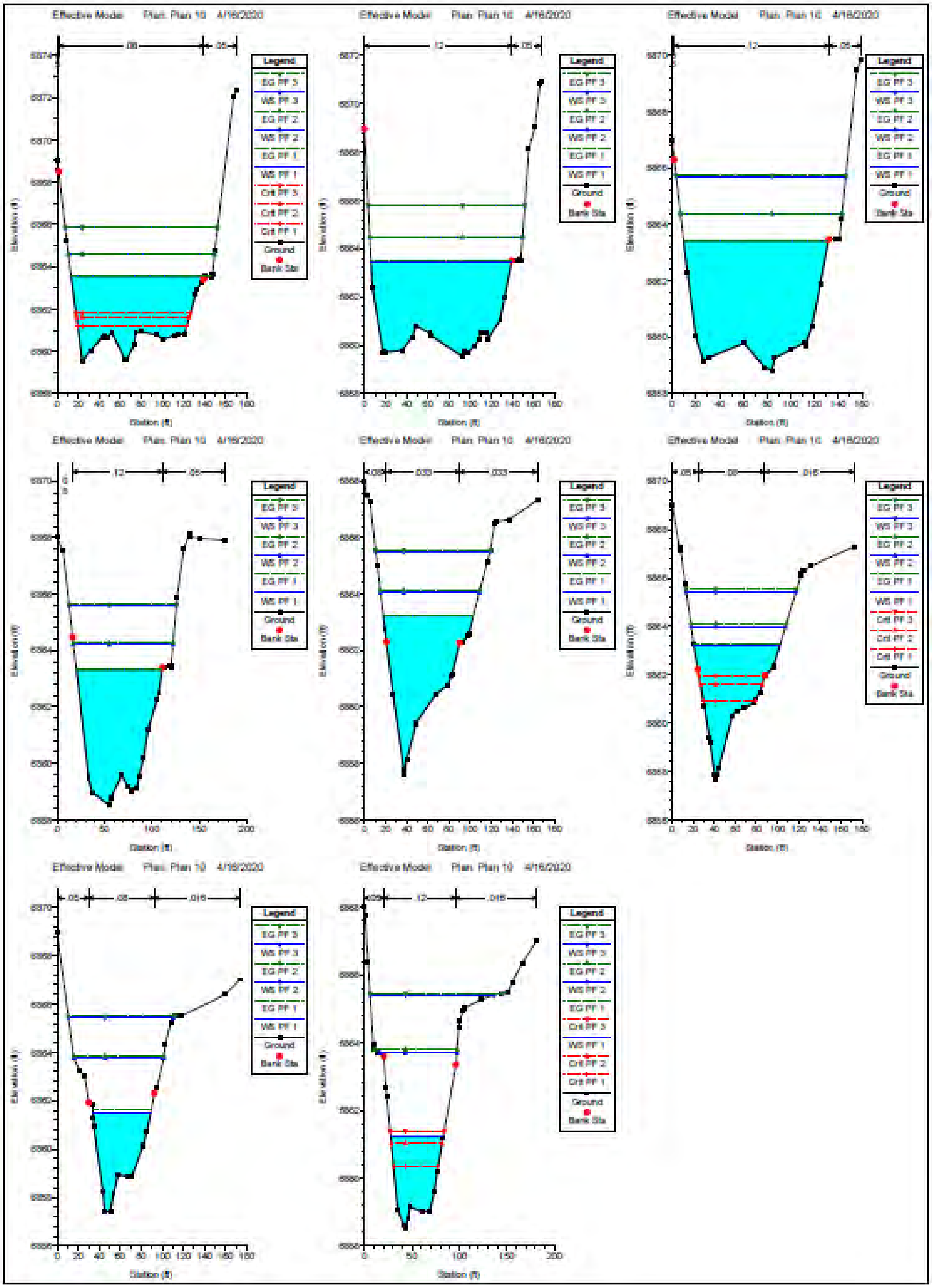


Figure 92: Effective Hydraulic Model Cross-Section Diagram

Appendix 37: Effective Hydraulic Model Culvert Diagram

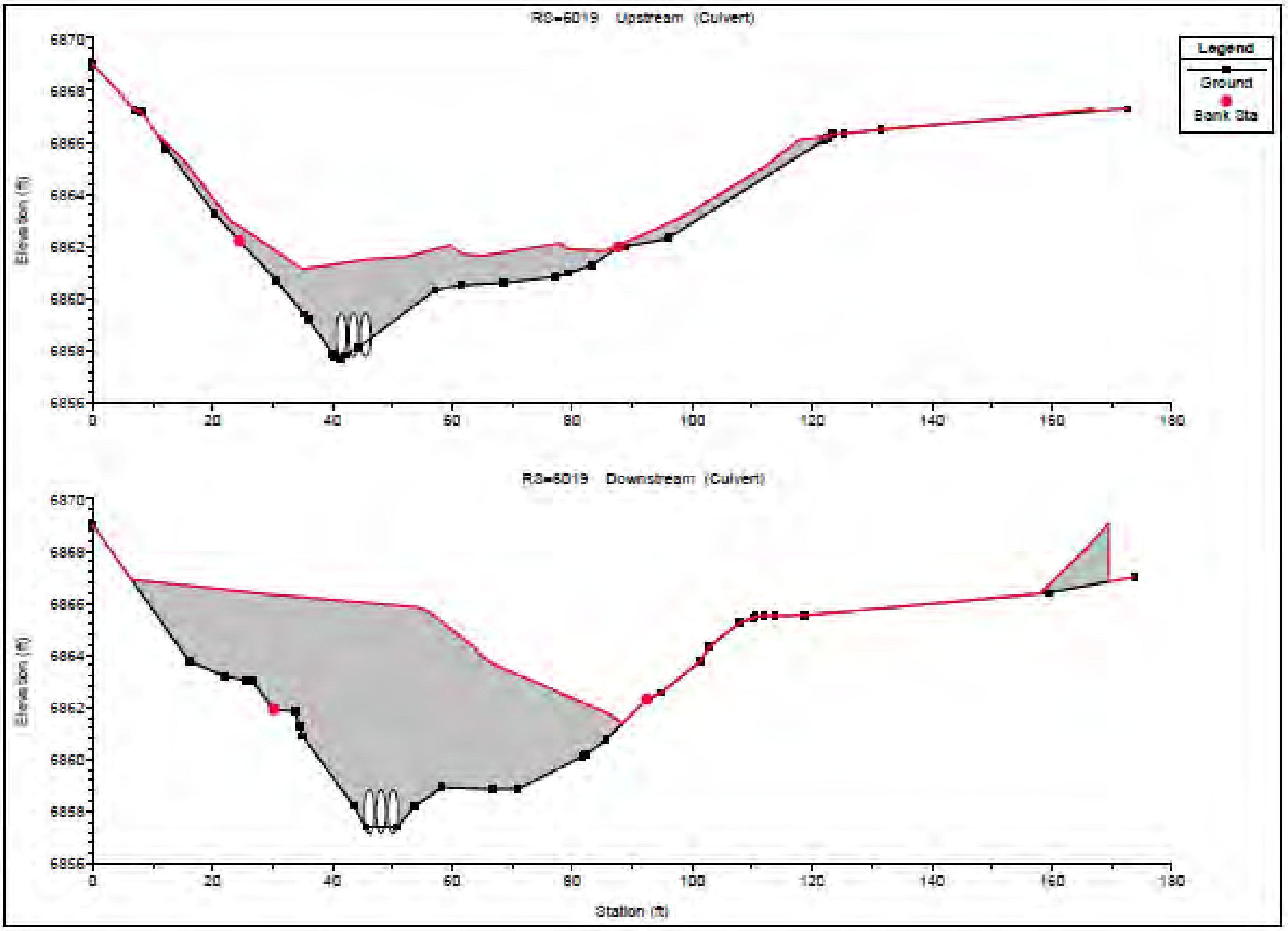


Figure 93: Effective Hydraulic Model Culvert Diagram

Appendix 38: Effective Hydraulic Model Cross-Section Summary Table

Table 81: Effective Hydraulic Model Cross-Section Summary Table

HEC-RAS Plan: Plan p06 River: Sinclair Reach: NAU

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)	
NAU	6378.119	PF 1	350.00	6859.53	6863.54	6861.19	6863.56	0.000834	1.03	339.19	130.66	0.11
NAU	6378.119	PF 2	670.00	6859.53	6864.57	6861.59	6864.60	0.001040	1.41	478.51	138.39	0.13
NAU	6378.119	PF 3	890.00	6859.53	6865.84	6861.81	6865.86	0.000671	1.36	657.91	144.46	0.11
NAU	6289.358	PF 1	350.00	6859.53	6863.46		6863.47	0.001100	0.86	407.22	133.30	0.09
NAU	6289.358	PF 2	670.00	6859.53	6864.46		6864.48	0.001546	1.22	549.88	144.73	0.11
NAU	6289.358	PF 3	890.00	6859.53	6865.77		6865.79	0.001033	1.19	741.20	148.33	0.09
NAU	6230.611	PF 1	350.00	6858.82	6863.41		6863.42	0.000851	0.82	424.27	121.93	0.08
NAU	6230.611	PF 2	670.00	6858.82	6864.38		6864.40	0.001372	1.22	553.19	136.27	0.10
NAU	6230.611	PF 3	890.00	6858.82	6865.71		6865.73	0.000968	1.20	739.44	143.17	0.09
NAU	6161.003	PF 1	350.00	6858.50	6863.31		6863.33	0.001844	1.17	298.96	90.49	0.11
NAU	6161.003	PF 2	670.00	6858.50	6864.21		6864.26	0.003036	1.73	390.22	104.72	0.15
NAU	6161.003	PF 3	890.00	6858.50	6865.60		6865.64	0.001880	1.64	540.59	112.98	0.12
NAU	6090.144	PF 1	350.00	6857.61	6863.22		6863.26	0.000268	1.57	229.31	85.37	0.16
NAU	6090.144	PF 2	670.00	6857.61	6864.06		6864.14	0.000429	2.33	304.49	93.87	0.21
NAU	6090.144	PF 3	890.00	6857.61	6865.50		6865.57	0.000249	2.18	449.92	108.35	0.16
NAU	6068.609	PF 1	350.00	6857.67	6863.19	6860.93	6863.25	0.001738	1.61	205.98	81.44	0.16
NAU	6068.609	PF 2	670.00	6857.67	6863.98	6861.59	6864.12	0.002378	2.20	272.96	89.44	0.20
NAU	6068.609	PF 3	890.00	6857.67	6865.41	6861.95	6865.55	0.000993	1.75	411.99	104.00	0.13
NAU	6019		Culvert									
NAU	6012.663	PF 1	350.00	6857.41	6861.50		6861.61	0.006779	2.69	130.18	54.71	0.31
NAU	6012.663	PF 2	670.00	6857.41	6863.76		6863.85	0.002371	2.36	284.47	85.29	0.20
NAU	6012.663	PF 3	890.00	6857.41	6865.42		6865.50	0.001059	1.96	435.16	99.06	0.14
NAU	5997.055	PF 1	350.00	6858.52	6861.22	6860.34	6861.40	0.035321	3.45	101.36	55.54	0.45
NAU	5997.055	PF 2	670.00	6858.52	6863.69	6861.01	6863.79	0.007780	2.50	267.75	81.26	0.24
NAU	5997.055	PF 3	890.00	6858.52	6865.40	6861.40	6865.46	0.003074	2.05	431.42	130.68	0.16

Appendix 39: Effective Hydraulic Model Culvert Summary Table

Table 82: Effective Hydraulic Model Culvert Summary Table

Plan: test 1 Sinclair NAU RS: 6019 Culv Group: Culvert #1 Profile: PF 1

Q Culv Group (cfs)	29.94	Culv Full Len (ft)	47.84
# Barrels	3	Culv Vel US (ft/s)	4.56
Q Barrel (cfs)	9.98	Culv Vel DS (ft/s)	4.56
E.G. US. (ft)	6863.25	Culv Inv El Up (ft)	6857.76
W.S. US. (ft)	6863.19	Culv Inv El Dn (ft)	6857.16
E.G. DS (ft)	6861.61	Culv Frctn Ls (ft)	1.13
W.S. DS (ft)	6861.50	Culv Exit Loss (ft)	0.21
Delta EG (ft)	1.63	Culv Entr Loss (ft)	0.29
Delta WS (ft)	1.69	Q Weir (cfs)	320.06
E.G. IC (ft)	6863.08	Weir Sta Lft (ft)	22.07
E.G. OC (ft)	6863.25	Weir Sta Rgt (ft)	99.15
Culvert Control	Outlet	Weir Submerg	0.02
Culv WS Inlet (ft)	6859.43	Weir Max Depth (ft)	2.11
Culv WS Outlet (ft)	6858.83	Weir Avg Depth (ft)	1.33
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	102.35
Culv Crt Depth (ft)	1.19	Min El Weir Flow (ft)	6861.38

Appendix 40: Three-Dimensional Effective Hydraulic Model

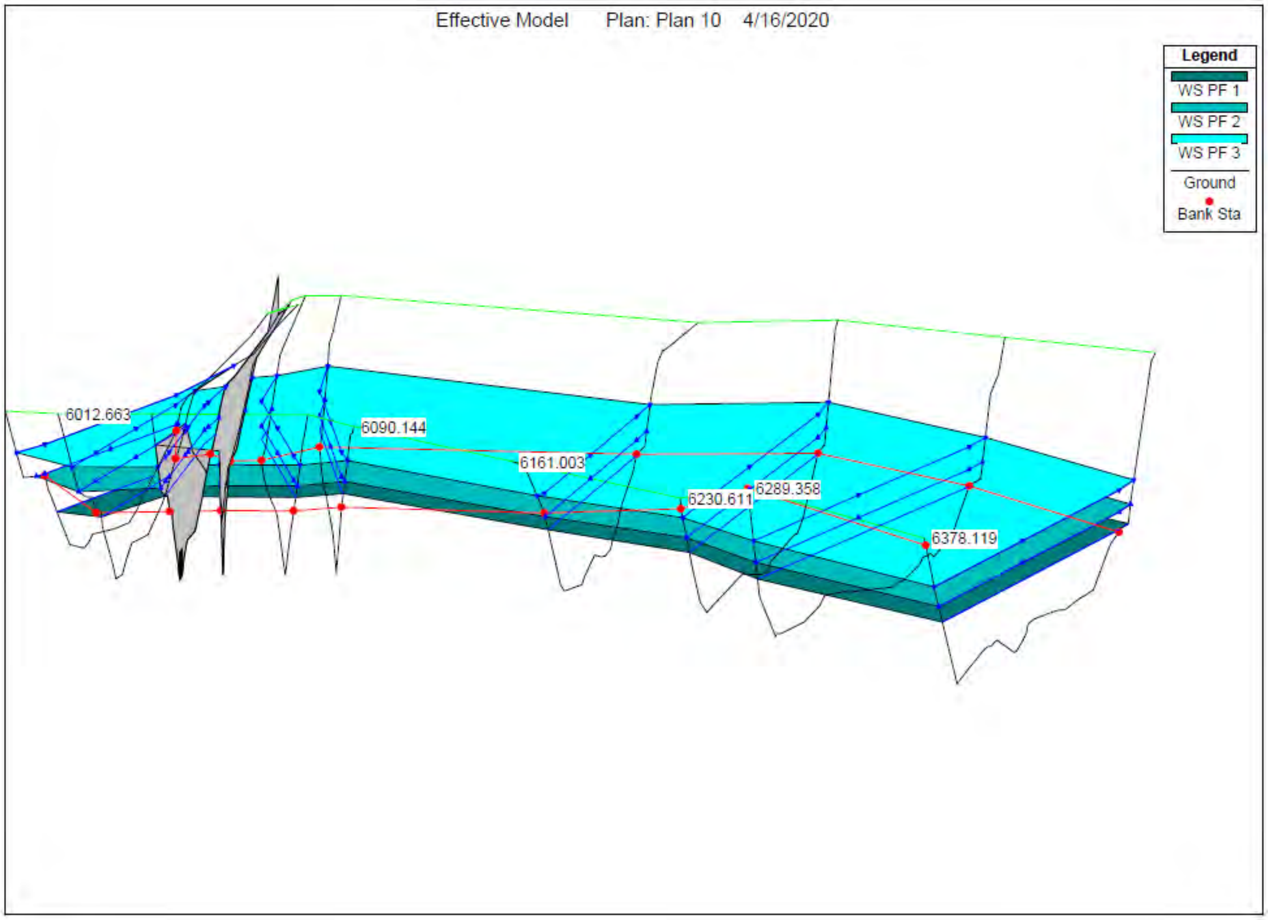
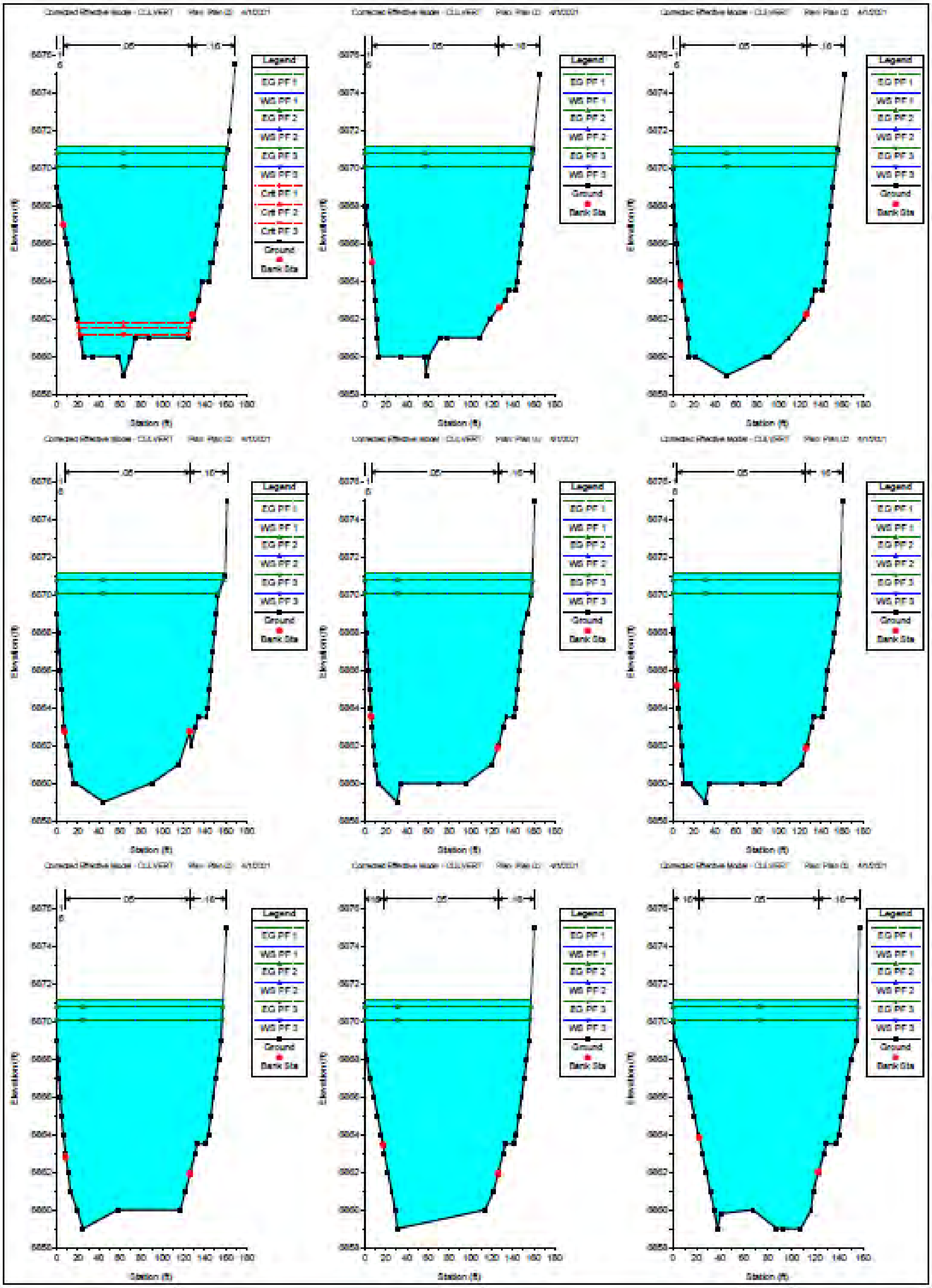
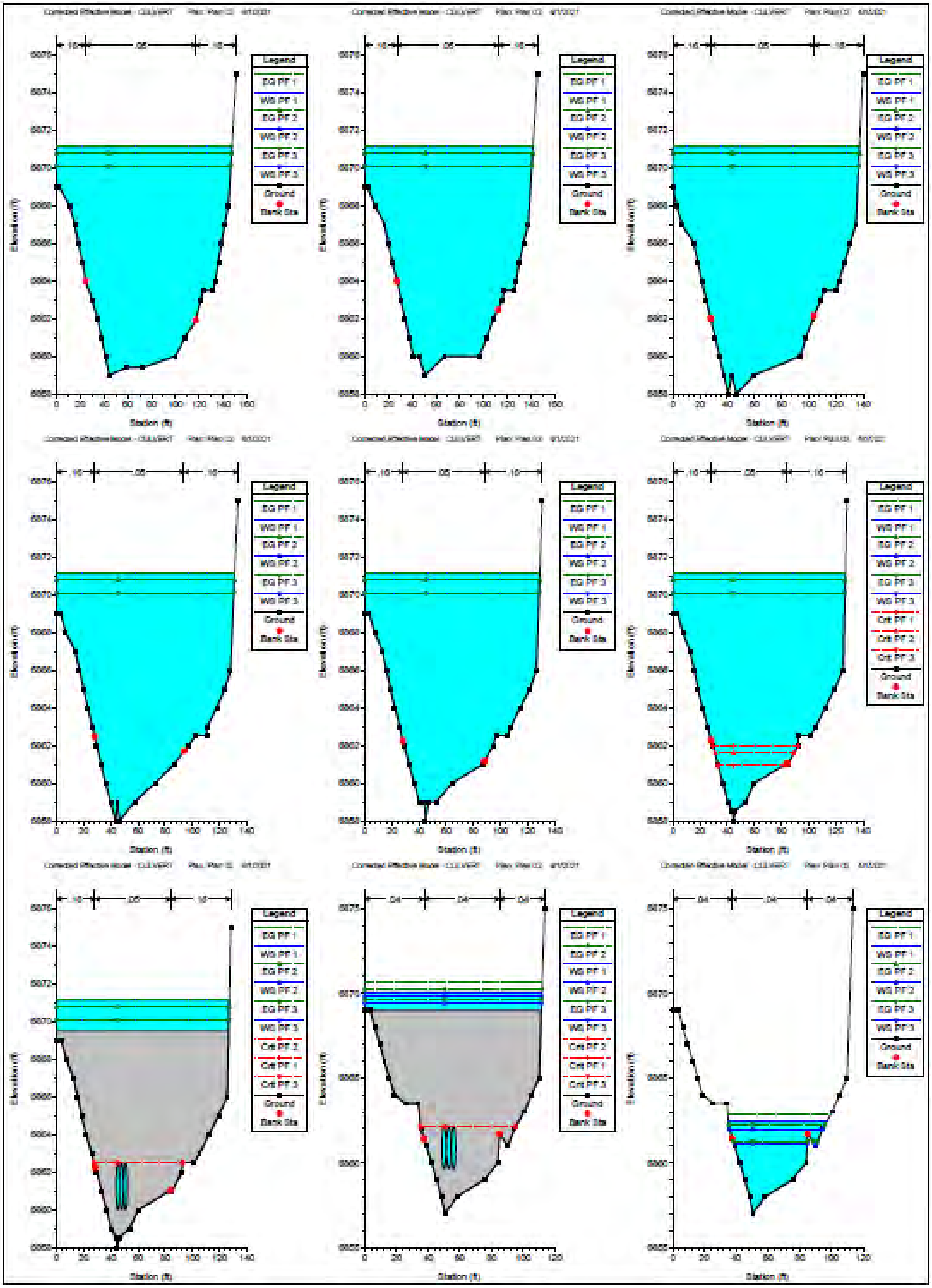


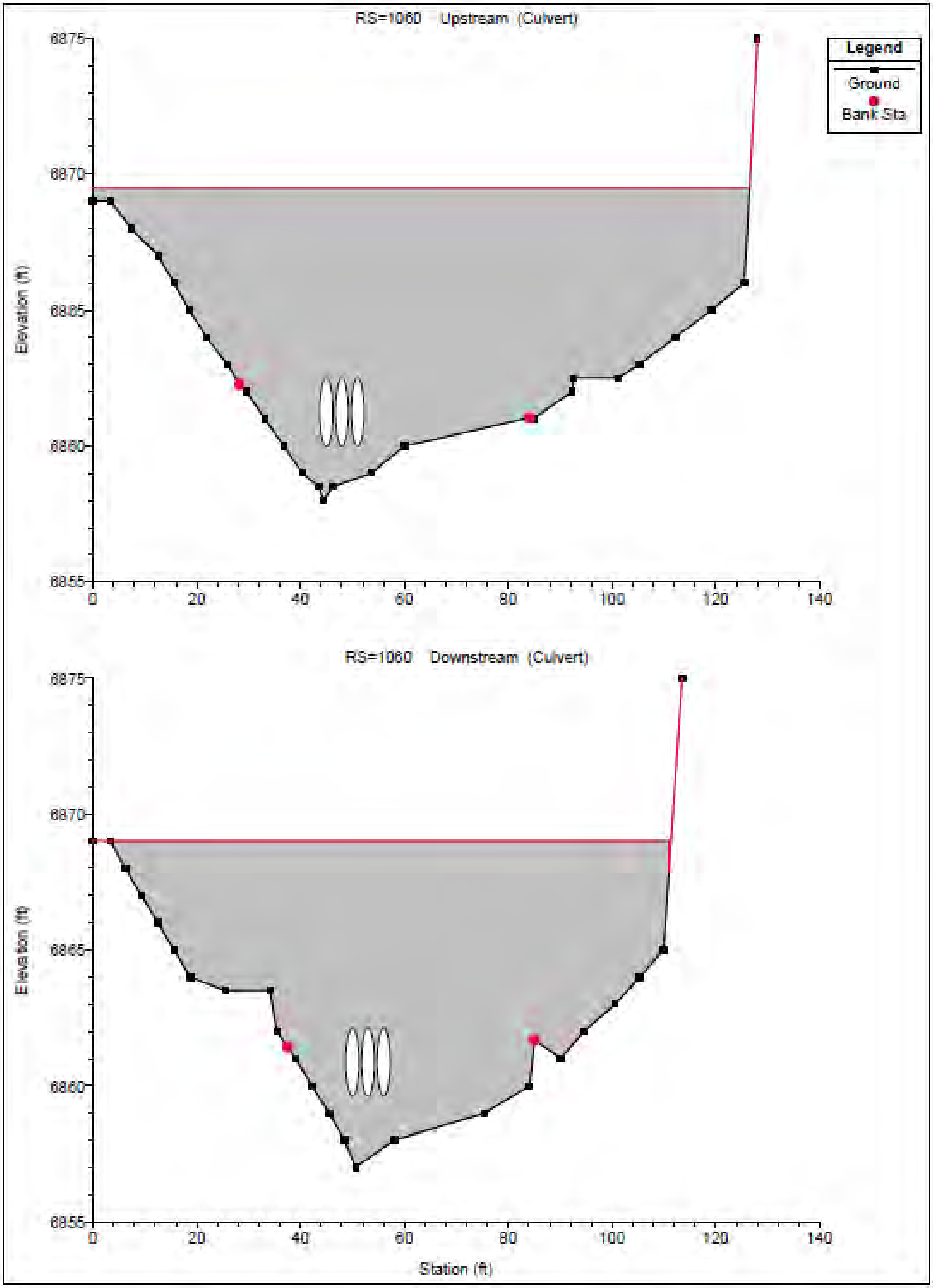
Figure 94: Three-Dimensional Effective Hydraulic Model

Appendix 41: Corrected-Effective Hydraulic Model Cross-Section Diagram




Legend
EG PF 1
WS PF 1
EG PF 2
WS PF 2
EG PF 3
WS PF 3
Ground
Bank Sta
Station (ft)
Elevation (ft)

Appendix 42: Corrected-Effective Hydraulic Model Culvert Diagram



Appendix 43: Corrected-Effective Hydraulic Model Cross-Section Summary Table

HEC-RAS Plan: Plan 02 River: Sinclair Wash Reach: I-17 to Culvert

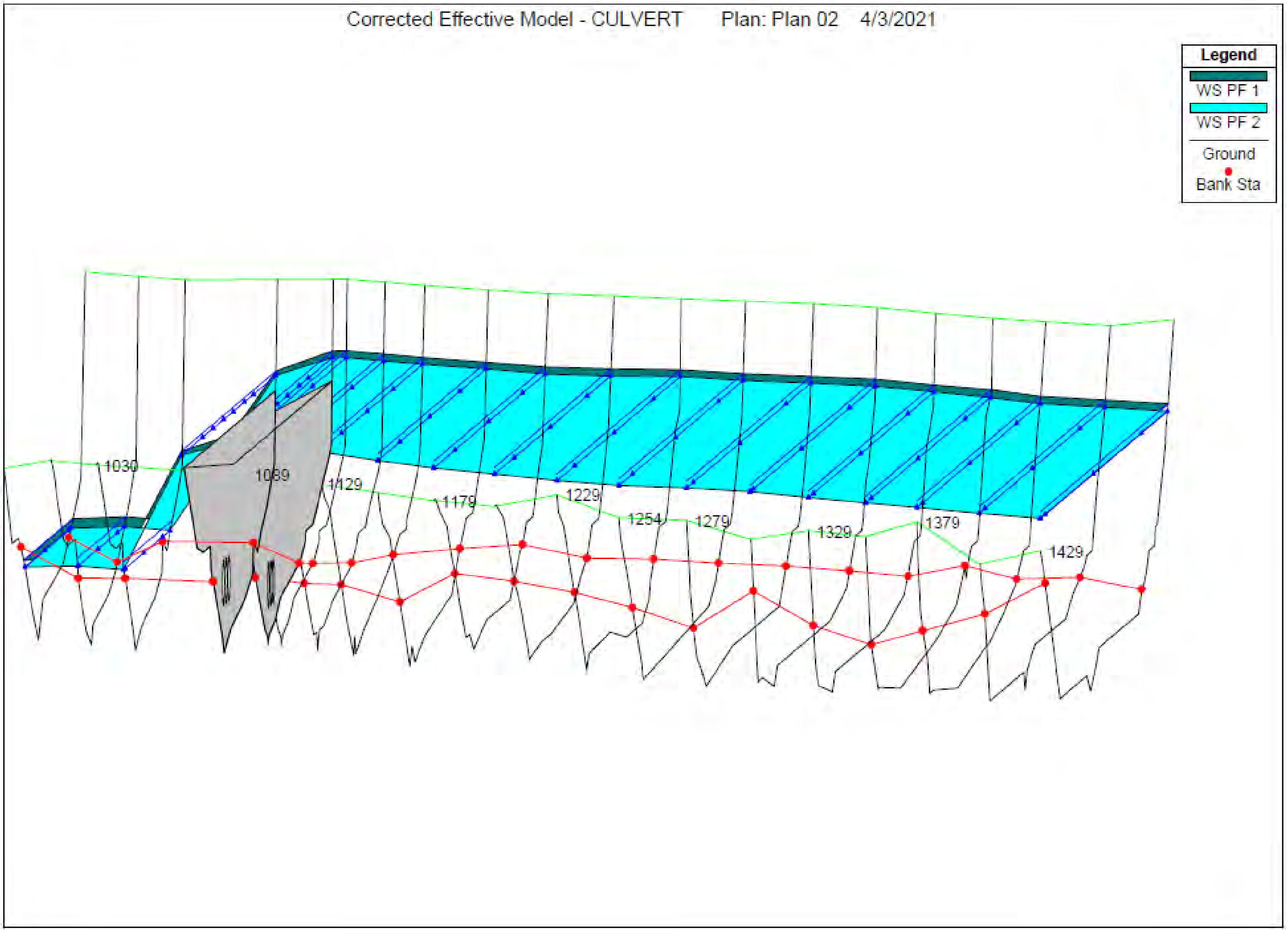
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
I-17 to Culvert	1429	PF 1	890.00	6859.00	6871.15	6861.80	6871.16	0.000025	0.69	1456.68	161.94	0.04
I-17 to Culvert	1429	PF 2	670.00	6859.00	6870.78	6861.56	6870.79	0.000016	0.54	1397.13	161.09	0.03
I-17 to Culvert	1404	PF 1	890.00	6859.00	6871.15		6871.16	0.000024	0.69	1466.95	159.76	0.04
I-17 to Culvert	1404	PF 2	670.00	6859.00	6870.78		6870.79	0.000016	0.54	1408.19	158.97	0.03
I-17 to Culvert	1379	PF 1	890.00	6859.00	6871.15		6871.16	0.000020	0.66	1522.63	156.41	0.04
I-17 to Culvert	1379	PF 2	670.00	6859.00	6870.78		6870.78	0.000013	0.51	1465.10	155.61	0.03
I-17 to Culvert	1354	PF 1	890.00	6859.00	6871.15		6871.16	0.000020	0.66	1536.65	159.66	0.03
I-17 to Culvert	1354	PF 2	670.00	6859.00	6870.78		6870.78	0.000013	0.51	1477.97	158.11	0.03
I-17 to Culvert	1329	PF 1	890.00	6859.00	6871.15		6871.15	0.000020	0.66	1535.84	158.81	0.03
I-17 to Culvert	1329	PF 2	670.00	6859.00	6870.78		6870.78	0.000013	0.51	1477.33	158.59	0.03
I-17 to Culvert	1304	PF 1	890.00	6859.00	6871.15		6871.15	0.000020	0.65	1550.10	158.79	0.03
I-17 to Culvert	1304	PF 2	670.00	6859.00	6870.78		6870.78	0.000013	0.50	1491.61	158.58	0.03
I-17 to Culvert	1279	PF 1	890.00	6859.00	6871.15		6871.15	0.000020	0.66	1554.53	157.50	0.03
I-17 to Culvert	1279	PF 2	670.00	6859.00	6870.78		6870.78	0.000013	0.51	1496.52	157.19	0.03
I-17 to Culvert	1254	PF 1	890.00	6859.00	6871.15		6871.15	0.000022	0.69	1512.94	157.60	0.04
I-17 to Culvert	1254	PF 2	670.00	6859.00	6870.78		6870.78	0.000014	0.54	1454.97	157.29	0.03
I-17 to Culvert	1229	PF 1	890.00	6859.00	6871.14		6871.15	0.000026	0.75	1423.96	155.94	0.04
I-17 to Culvert	1229	PF 2	670.00	6859.00	6870.78		6870.78	0.000017	0.59	1366.57	155.83	0.03
I-17 to Culvert	1204	PF 1	890.00	6859.00	6871.14		6871.15	0.000033	0.84	1293.80	147.56	0.04
I-17 to Culvert	1204	PF 2	670.00	6859.00	6870.77		6870.78	0.000021	0.66	1239.76	147.20	0.04
I-17 to Culvert	1179	PF 1	890.00	6859.00	6871.14		6871.15	0.000041	0.92	1205.94	141.73	0.05
I-17 to Culvert	1179	PF 2	670.00	6859.00	6870.77		6870.78	0.000026	0.72	1154.17	141.37	0.04
I-17 to Culvert	1154	PF 1	890.00	6858.00	6871.14		6871.15	0.000038	0.93	1254.47	137.38	0.05
I-17 to Culvert	1154	PF 2	670.00	6858.00	6870.77		6870.78	0.000024	0.73	1204.40	137.15	0.04
I-17 to Culvert	1129	PF 1	890.00	6858.00	6871.13		6871.15	0.000053	1.07	1151.54	131.28	0.06
I-17 to Culvert	1129	PF 2	670.00	6858.00	6870.77		6870.78	0.000034	0.84	1103.95	131.05	0.04
I-17 to Culvert	1104	PF 1	890.00	6858.00	6871.13		6871.15	0.000063	1.17	1113.39	128.81	0.06
I-17 to Culvert	1104	PF 2	670.00	6858.00	6870.77		6870.78	0.000040	0.91	1066.81	128.65	0.05
I-17 to Culvert	1089	PF 1	890.00	6858.00	6871.13	6861.97	6871.15	0.000070	1.23	1090.81	126.98	0.07
I-17 to Culvert	1089	PF 2	670.00	6858.00	6870.76	6861.58	6870.78	0.000045	0.96	1044.95	126.88	0.05
I-17 to Culvert	1060		Culvert									
I-17 to Culvert	1030	PF 1	890.00	6857.00	6862.41		6862.81	0.003567	5.08	182.56	62.01	0.47
I-17 to Culvert	1030	PF 2	670.00	6857.00	6861.96		6862.26	0.003251	4.43	155.17	58.83	0.44
I-17 to Culvert	1025	PF 1	890.00	6857.00	6862.38		6862.73	0.003141	4.84	191.28	62.37	0.45
I-17 to Culvert	1025	PF 2	670.00	6857.00	6861.93		6862.20	0.002840	4.21	163.80	59.11	0.42
I-17 to Culvert	1000	PF 1	890.00	6857.00	6862.04	6861.40	6862.61	0.007772	6.06	148.47	62.27	0.67
I-17 to Culvert	1000	PF 2	670.00	6857.00	6861.62	6861.02	6862.08	0.007770	5.47	122.82	58.11	0.65

Appendix 44: Corrected-Effective Hydraulic Model Culvert Summary Table

Plan: Plan 02   Sinclair Wash   I-17 to Culvert RS: 1060   Culv Group: Culvert #1   Profile: PF 1

Q Culv Group (cfs)	195.22	Culv Full Len (ft)	47.64
# Barrels	3	Culv Vel US (ft/s)	13.26
Q Barrel (cfs)	65.07	Culv Vel DS (ft/s)	13.26
E.G. US. (ft)	6871.15	Culv Inv El Up (ft)	6859.99
W.S. US. (ft)	6871.13	Culv Inv El Dn (ft)	6859.62
E.G. DS (ft)	6862.81	Culv Frctn Ls (ft)	4.09
W.S. DS (ft)	6862.41	Culv Exit Loss (ft)	2.34
Delta EG (ft)	8.34	Culv Entr Loss (ft)	1.91
Delta WS (ft)	8.71	Q Weir (cfs)	695.55
E.G. IC (ft)	6871.13	Weir Sta Lft (ft)	0.00
E.G. OC (ft)	6871.15	Weir Sta Rgt (ft)	126.98
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	6862.49	Weir Max Depth (ft)	1.65
Culv WS Outlet (ft)	6862.12	Weir Avg Depth (ft)	1.64
Culv Nml Depth (ft)	2.50	Weir Flow Area (sq ft)	208.63
Culv Crt Depth (ft)	2.50	Min El Weir Flow (ft)	6869.51

Appendix 45: Three-Dimensional Corrected-Effective Hydraulic Model



Appendix 46: Corrected-Effective Model HEC-RAS Cross-Section Data

Table 83: Cross-Section 1+00

1		
Cross Section 1+00		
STA	**Elevation**	**POI**
0	6869	
3.43	6868	
6.36	**6887**	**LOB**
5.5063	6866.3	
9.02	6866	
11.69	6865	
14.35	6864	
17.02	6863	
19.69	6862	
22.36	6861	
25.03	6860	
33.82	6860	
58.84	6860	
63.53	**6859**	**thalweg**
70.16	6860	
74.58	6861	
87.79	6861	
124.12	6861	
128.46	**6862.2**	**ROB**
129.5	6862	
134.65	6863	
137.7	6868	
144.94	6868	
145.72	6865	
148.2	6865	
150.68	6866	
153.12	6867	
155.64	6868	
158.12	6869	
159.06	6870	
161.66	6871	
163.56	6872	
169.26	6875.5	

Table 84: Cross-Section 1+25

2		
Cross Section 1+25		
STA	**Elevation**	**POI**
0	6868	
1.05	6868	
2.2	6867	
5	6866	
7.22	**6865**	**LOB**
8.38	6864	
9.57	6863	
10.77	6862	
11.96	6861	
13.15	6860	
34.78	6860	
56.52	6860	
57.94	**6859**	**thalweg**
60.51	6860	
70.9	6861	
78.43	6861	
109.08	6861	
118.56	6862	
127.42	**6862.6**	**ROB**
133.36	6863	
136.24	6868	
143.29	6868	
144.15	6864	
145.77	6865	
147.73	6866	
149.63	6867	
152.09	6868	
154.56	6869	
157.04	6870	
159.51	6871	
166.1	6875	

Table 85: Cross-Section 1+50

3		
Cross Section 1+50		
STA	**Elevation**	**POI**
0	6870	
1.06	6868	
2.18	6867	
3.33	**6866**	
4.46	6865	
6.66	6864	
7.35	**6863.76**	**LOB**
9.88	6863	
13.11	6862	
14.56	6861	
15.73	6860	
20.91	6860	
51.13	**6859**	**thalweg**
88.57	6860	
91.56	6860	
109.99	6861	
124.67	6862	
126.39	**6862.23**	**ROB**
132.08	6863	
134.83	6868.4	
142.21	6868	
143.31	6864	
144.95	6865	
146.58	6866	
148.22	6867	
149.86	6868	
151.5	6869	
153.68	6870	
156.15	6871	
163.14	6875	

Table 86: Cross-Section 1+75

4		
Cross Section 1+75		
STA	**Elevation**	**POI**
0	6868.94	
1.07	6868	
2.2	6867	
3.34	6866	
4.47	6865	
5.6	6864	
6.74	6863	
7.49	**6862.74**	**LOB**
9.65	6862	
12.88	6861	
16.12	6860	
17.99	6860	
44.28	**6859**	**thalweg**
90.22	6860	
115.68	6861	
126.13	**6862.74**	**ROB**
127.16	6862	
131.66	6863	
134.3	6868.19	
141.77	6868	
143.08	6864	
144.71	6865	
146.35	6866	
147.98	6867	
149.61	6868	
151.24	6869	
152.87	6870	
159.59	6871	
161.36	6875	

Table 87: Cross-Section 2+00

5		
Cross Section 2+00		
STA	**Elevation**	**POI**
0	6868.95	
1.08	6868	
2.22	6867	
3.36	6866	
4.49	6865	
5.62	6864	
6.13	**6863.54**	**LOB**
6.75	6863	
7.88	6862	
9.42	6861	
12.68	6860	
30.52	**6859**	**thalweg**
34.04	6860	
70.04	6860	
96.08	6860	
120.35	6861	
126	**6861.86**	**ROB**
126.89	6862	
131.37	6863	
133.94	6868	
141.48	6868	
142.96	6864	
144.58	6865	
146.21	6866	
147.84	6867	
149.09	6868	
153.68	6869	
158.14	6870	
161.05	6875	

Table 88: Cross-Section 2+25

6		
Cross Section 2+25		
STA	**Elevation**	**POI**
0	6868.19	
1.11	6868	
2.24	6867	
3.37	6866	
4.29	**6865.19**	**LOB**
4.51	6865	
5.64	6864	
6.77	6863	
7.9	6862	
9.03	6861	
10.49	6860	
11.6	6860	
15.85	6860	
30.43	**6859**	**thalweg**
34.46	6860	
64.56	6860	
84.5	6860	
86.25	6860	
101.34	6860	
122.29	6861	
126.06	**6861.84**	**ROB**
126.78	6862	
131.27	6863	
133.73	6868	
141.39	6868	
143.08	6864	
144.71	6865	
146.34	6866	
150.89	6867	
153.31	6868	
155.73	6869	
158.14	6870	
160.96	6875	

Table 89: Cross-Section 2+50

7		
Cross Section 2+50		
STA	**Elevation**	**POI**
0	6869	
1.13	6868	
2.27	6867	
3.4	6866	
4.53	6865	
6.05	6864	
8.39	6863	
8.62	**6862.8**	**LOB**
10.74	6862	
13.09	6861	
19.29	6860	
24.81	**6859**	**thalweg**
57.78	6860	
58.3	6860	
116.89	6860	
122.1	6861	
126.11	**6861.89**	**ROB**
126.59	6862	
131.08	6863	
133.39	6868	
141.21	6868	
143.6	6864	
146.02	6865	
148.43	6866	
150.85	6867	
153.27	6868	
155.68	6869	
160.77	6875	

Table 90: Cross-Section 2+75

8		
Cross Section 2+75		
STA	**Elevation**	**POI**
0	6869	
1.84	6868	
4.73	6867	
8.73	6866	
12.15	6865	
15.44	6864	
17.25	**6863.45**	**LOB**
18.74	6863	
22.04	6862	
25.33	6861	
28.63	6860	
30.72	**6859**	**thalweg**
114.17	6860	
122.05	6861	
126.28	**6861.9**	**ROB**
126.55	6862	
131.05	6863	
133.24	6868.19	
141.21	6868	
143.5	6864	
146.11	6865	
148.56	6866	
150.98	6867	
153.4	6868	
155.82	6869	
160.79	6875	

Table 91: Cross-Section 3+00

9		
Cross Section 3+00		
STA	**Elevation**	**POI**
0	6870	
1.78	6869	
8.3	6868	
11.56	6867	
14.81	6866	
18.06	6865	
21.32	6864	
22.27	**6863.83**	**LOB**
24.97	6863	
28.22	6862	
31.48	6861	
34.72	6860	
37.67	**6859**	**thalweg**
40.48	6859.8	
67.37	6860	
87.63	6859	
93.09	6859	
107.82	6859	
116.56	6860	
118.33	6861	
122.57	**6861.99**	**ROB**
122.7	6862	
127.22	6863	
129.3	6868.19	
137.42	6868.19	
139.56	6864	
142.19	6865	
144.81	6866	
147.33	6867	
149.76	6868	
155.31	6869	
157.07	6875	

Table 92: Cross-Section 3+25

10		
Cross Section 3+25		
STA	**Elevation**	**POI**
0	6869	
2.09	6869	
10.99	6868	
15.14	6867	
18.41	6866	
21.69	6865	
24.62	**6864**	**ROB**
30.02	6863	
34.29	6862	
37.69	6861	
41.09	6860	
44.31	**6859**	**thalweg**
59.41	6859.4	
72.17	6859.4	
100.07	6860	
107.93	6861	
117.12	**6861.89**	**ROB**
121.48	6863	
123.42	6868.19	
131.69	6868.19	
133.63	6864	
136.26	6865	
138.88	6866	
141.52	6867	
144.49	6868	
151.33	6875	

Table 93: Cross-Section 3+50

11		
Cross Section 3+50		
STA	**Elevation**	**POI**
0	6869	
2.39	6869	
8.47	6868	
16.79	6867	
20.01	6866	
23.23	6865	
27.2	**6864**	**ROB**
30.32	6863	
33.86	6862	
37.41	6861	
40.95	6860	
45.77	6859.99	
51.07	**6859**	**thalweg**
67.3	6859.99	
96.64	6860	
102.84	6861	
108.04	6862	
112.58	**6862.46**	**ROB**
115.7	6863	
117.5	6868	
125.91	6868	
127.65	6864	
130.27	6865	
133.59	6866	
137.67	6867	
145.51	6875	

Table 94: Cross-Section 3+75

12		
Cross Section 3+75		
STA	**Elevation**	**POI**
0	6869	
2.56	6868	
6.55	6867	
15.23	6866	
18.27	6865	
21.48	6864	
24.69	6863	
27.98	**6862**	**LOB**
31.11	6861	
34.32	6860	
37.53	6859	
40.74	6858	
43.35	**6859**	**thalweg**
47.02	6858	
59.9	6859	
93.76	6860	
98	6861	
103.17	6862	
103.98	**6862.14**	**ROB**
109.18	6863	
111.55	6868	
120.17	6868	
122.55	6864	
126.63	6865	
130.71	6866	
134.78	6867	
139.8	6875	

Table 95: Cross-Section 4+00

13		
Cross Section 4+00		
STA	**Elevation**	**POI**
0	6869	
2.8	6869	
6.79	6868	
13.82	6867	
16.77	6866	
19.83	6865	
23.04	6864	
26.25	6863	
27.95	**6862.47**	**LOB**
29.46	6862	
32.67	6861	
36.03	6860	
39.81	6859	
43.71	6858	
44.61	**6859**	**thalweg**
46.38	6858	
57.35	6859	
72.88	6860	
86.82	6861	
93.98	**6861.69**	**ROB**
97.43	6862	
102	6868.19	
110.56	6868.19	
110.93	6863	
117.97	6864	
123.88	6865	
127.96	6866	
133.79	6875	

Table 96: Cross-Section 4+25

14		
Cross Section 4+25		
STA	**Elevation**	**POI**
0	6869	
3.24	6869	
7.22	6868	
13.14	6867	
16.09	6866	
19.03	6865	
22.19	6864	
25.48	6863	
28.15	**6862.24**	**LOB**
28.99	6862	
32.65	6861	
36.31	6860	
40.05	6859	
43.84	6858.99	
44.82	**6858**	**thalweg**
47.39	6858.99	
52.52	6859	
64.56	6860	
87.08	6861	
88.3	**6861.17**	**ROB**
94.48	6862	
96.65	6868.19	
105.26	6868.19	
107.71	6863	
114.66	6864	
121.74	6865	
126.49	6866	
130.57	6875	

Table 97: Cross-Section 4+40

15		
Cross Section 4+40		
STA	**Elevation**	**POI**
0	6869	
3.36	6869	
7.35	6868	
12.65	6867	
15.6	6866	
18.55	6865	
21.87	6864	
25.84	6863	
28.22	**6862.26**	**LOB**
29.47	6862	
33.12	6861	
36.76	6860	
40.35	6859	
43.59	6858.5	
44.48	**6858**	**thalweg**
46.2	6858.5	
53.63	6859	
60.05	6860	
84.17	**6861.03**	**ROB**
84.91	6861	
92.36	6862	
92.68	6868	
101.23	6868	
105.33	6863	
112.27	6864	
119.2	6865	
125.52	6866	
128.08	6875	

Table 98: Cross-Section 4+99

16		
Cross Section 4+99		
STA	**Elevation**	**POI**
0	6869	
3.38	6869	
6.22	6868	
9.36	6867	
12.5	6866	
15.64	6865	
18.78	6864	
25.53	6868	
30.26	6863	
30.57	6868	
34.13	6862	
35.39	6862	
37.55	**6861.41**	**LOB**
39.06	6861	
42.21	6860	
45.49	6859	
48.49	6858	
50.59	**6857**	**thalweg**
58.06	6858	
75.52	6859	
84.1	6860	
85.11	**6861.69**	**ROB**
90.17	6861	
94.57	6862	
100.62	6863	
105.35	6864	
109.94	6865	
113.61	6875	

Table 99: Cross-Section 5+04

17		
Cross Section 5+04		
STA	**Elevation**	**POI**
0	6869	
1.44	6867	
5.65	6868	
7.98	6867	
11.1	6866	
14.25	6865	
17.38	6864	
22.29	6868	
26.74	6863	
32.19	6862.2	
35.07	6862	
36.07	**6861.23**	**LOB**
36.26	6861	
39.32	6860	
42.58	6859	
45.86	6858	
52.36	**6857**	**thalweg**
54.14	6858	
75.32	6859	
83.56	6860	
85.38	**6860.31**	**ROB**
89.52	6861	
94.66	6862	
100.11	6863	
104.61	6864	
109.11	6865	
112.22	6875	

Table 100: Cross-Section 5+29

18		
Cross Section 5+29		
STA	**Elevation**	**POI**
0	6868	
2.96	6867	
5.1	6866	
7.38	6865	
9.59	6864	
10.07	6868	
18.32	6862.2	
21.71	6863	
22.11	**6862.9**	**ROB**
25.7	6862	
29.13	6861	
32.56	6860	
35.98	6859	
44.21	**6857**	**thalweg**
49.57	6859	
75.01	6860	
81.26	6861	
82.48	**6861.19**	**ROB**
87.53	6862	
93.81	6863	
97.77	6864	
103.59	6875	

Table 101: HEC-RAS Cross-Section #1

Downstream Reach Lengths		
LOB	T	ROB
27.7	24.7	21.75
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
6.36	128.46	

Table 102: HEC-RAS Cross-Section #2

Downstream Reach Lengths		
LOB	T	ROB
29.12	25.36	20.88
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
7.22	127.42	

Table 103: HEC-RAS Cross-Section #3

Downstream Reach Lengths		
LOB	T	ROB
21.15	20.92	17.36
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
7.35	126.39	

Table 104: HEC-RAS Cross-Section #4

Downstream Reach Lengths		
LOB	T	ROB
22.23	23.26	15.1
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
7.49	126.13	

Table 105: HEC-RAS Cross-Section #5

Downstream Reach Lengths		
LOB	T	ROB
22.74	23.96	21.07
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
6.13	126	

Table 106: HEC-RAS Cross-Section #6

Downstream Reach Lengths		
LOB	T	ROB
25.02	25	24.85
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
4.29	126.06	

Table 107: HEC-RAS Cross-Section #7

Downstream Reach Lengths		
LOB	T	ROB
30.99	26	26.97
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
8.62	126.11	

Table 108: HEC-RAS Cross-Section #8

Downstream Reach Lengths		
LOB	T	ROB
30	24.86	25.31
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
17.25	126.28	

Table 109: HEC-RAS Cross-Section #9

Downstream Reach Lengths		
LOB	T	ROB
24.23	25.81	24.07
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
22.27	122.57	

Table 110: HEC-RAS Cross-Section #10

Downstream Reach Lengths		
LOB	T	ROB
23.84	25	23.95
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
24.62	117.12	

Table 111: HEC-RAS Cross-Section #11

Downstream Reach Lengths		
LOB	T	ROB
28.58	23.81	27.38
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
27.2	112.58	

Table 112: HEC-RAS Cross-Section #12

Downstream Reach Lengths		
LOB	T	ROB
25.7	25.36	26.4
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
27.98	103.98	

Table 113: HEC-RAS Cross-Section #13

Downstream Reach Lengths		
LOB	T	ROB
16	15.85	16.03
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
27.95	93.98	

Table 114: HEC-RAS Cross-Section #14

Downstream Reach Lengths		
LOB	T	ROB
9.51	15.18	11.02
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
28.15	88.3	

Table 115: HEC-RAS Cross-Section #15

Downstream Reach Lengths		
LOB	T	ROB
58.81	59.4	54.63
Manning's *n* Values		
LOB	T	ROB
0.16	0.05	0.16
Main Channel Bank Stations		
Left Bank	Right Bank	
28.22	84.17	

Table 116: HEC-RAS Cross-Section #16

Downstream Reach Lengths		
LOB	T	ROB
4.5	18.66	4.92
Manning's *n* Values		
LOB	T	ROB
0.04	0.04	0.04
Main Channel Bank Stations		
Left Bank	Right Bank	
37.55	85.11	

Table 117: HEC-RAS Cross-Section #17

Downstream Reach Lengths		
LOB	T	ROB
22.63	21.47	21.99
Manning's *n* Values		
LOB	T	ROB
0.04	0.04	0.04
Main Channel Bank Stations		
Left Bank	Right Bank	
36.07	85.38	

Table 118: HEC-RAS Cross-Section #18

Downstream Reach Lengths		
LOB	T	ROB
N/A	N/A	N/A
Manning's *n* Values		
LOB	T	ROB
0.04	0.04	0.04
Main Channel Bank Stations		
Left Bank	Right Bank	
22.11	82.48	

Appendix 47: Existing Culvert CulvertMaster Report Design Storm

Culvert Designer/Analyzer Report
Corrective Effective

Analysis Component			
Storm Event	Design	Discharge	470.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	470.00 cfs	Check Discharge	890.00 cfs

Tailwater properties: Irregular Channel

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)			
Discharge	437.76 cfs	Allowable HW Elevation	6,863.96 ft
Roadway Width	20.50 ft	Overtopping Coefficient	2.97 US
Length	53.62 ft	Crest Elevation	6,862.00 ft
Headwater Elevation	6,863.96 ft	Discharge Coefficient (Cr)	2.97
Submergence Factor (Kt)	1.00		

Sta (ft)	Elev. (ft)
0.00	6,862.00
53.62	6,862.00

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	6,863.96	ft	Discharge	32.24	cfs
Inlet Control HW Elev.	6,863.88	ft	Tailwater Elevation	6,860.70	ft
Outlet Control HW Elev.	6,863.96	ft	Control Type	Outlet Control	
Headwater Depth/Height	1.59				

Grades					
Upstream Invert	6,859.99	ft	Downstream Invert	6,859.62	ft
Length	47.63	ft	Constructed Slope	0.007770	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	1.93	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.93	ft
Velocity Downstream	7.91	ft/s	Critical Slope	0.023633	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	2.50	ft
Section Size	30 inch		Rise	2.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,863.96	ft	Upstream Velocity Head	0.67	ft
Ke	0.70		Entrance Loss	0.47	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,863.88	ft	Flow Control	Submerged	
Inlet Type	Mitered to slope		Area Full	4.9	ft²
K	0.02100		HDS 5 Chart	2	
M	1.33000		HDS 5 Scale	2	
C	0.04630		Equation Form	1	
Y	0.75000				

Appendix 48: Existing Culvert CulvertMaster Report Check Storm

Culvert Designer/Analyzer Report
Corrective Effective

Analysis Component			
Storm Event	Check	Discharge	890.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	470.00 cfs	Check Discharge	890.00 cfs

Tailwater properties: Irregular Channel

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)			
Discharge	851.45 cfs	Allowable HW Elevation	6,865.02 ft
Roadway Width	20.50 ft	Overtopping Coefficient	3.03 US
Length	53.62 ft	Crest Elevation	6,862.00 ft
Headwater Elevation	6,865.02 ft	Discharge Coefficient (Cr)	3.03
Submergence Factor (Kt)	1.00		

Sta (ft)	Elev. (ft)
0.00	6,862.00
53.62	6,862.00

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	6,865.02	ft	Discharge	38.58	cfs
Inlet Control HW Elev.	6,864.74	ft	Tailwater Elevation	6,861.85	ft
Outlet Control HW Elev.	6,865.02	ft	Control Type	Outlet Control	
Headwater Depth/Height	2.01				

Grades					
Upstream Invert	6,859.99	ft	Downstream Invert	6,859.62	ft
Length	47.63	ft	Constructed Slope	0.007770	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	2.22	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	2.10	ft
Velocity Downstream	8.36	ft/s	Critical Slope	0.028980	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	2.50	ft
Section Size	30 inch		Rise	2.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,865.02	ft	Upstream Velocity Head	0.96	ft
Ke	0.70		Entrance Loss	0.67	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,864.74	ft	Flow Control	Submerged	
Inlet Type	Mitered to slope		Area Full	4.9	ft²
K	0.02100		HDS 5 Chart	2	
M	1.33000		HDS 5 Scale	2	
C	0.04630		Equation Form	1	
Y	0.75000				

Appendix 49: Six Barrel CMP CulvertMaster Designer/Analyzer Report

Culvert Designer/Analyzer Report
Double Barrel

Peak Discharge Method: User-Specified

Design Discharge	470.00 cfs	Check Discharge	890.00 cfs

Grades Model: Inverts

Invert Upstream	6,860.00 ft	Invert Downstream	6,859.87 ft
Length	30.00 ft	Slope	0.004272 ft/ft
Drop	0.13 ft		

Headwater Model: Maximum Allowable HW

Headwater Elevation	6,864.40 ft

Tailwater properties: Irregular Channel

Tailwater conditions for Design Storm.

Discharge	470.00 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

Tailwater conditions for Check Storm.

Discharge	890.00 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	6-96 inch Circular	890.00 cfs	6,864.40 ft	8.50 ft/s

Design:Trial-1

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	6,864.40 ft	Storm Event	Check
Computed Headwater Elev:	6,864.40 ft	Discharge	890.00 cfs
Headwater Depth/Height	0.55	Tailwater Elevation	0.00 ft
Inlet Control HW Elev.	6,864.15 ft	Control Type	Outlet Control
Outlet Control HW Elev.	6,864.40 ft		

Grades			
Upstream Invert	6,860.00 ft	Downstream Invert	6,859.87 ft
Length	30.00 ft	Constructed Slope	0.004272 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	3.03 ft
Slope Type	Mild	Normal Depth	3.81 ft
Flow Regime	Subcritical	Critical Depth	3.03 ft
Velocity Downstream	8.50 ft/s	Critical Slope	0.009715 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	8.00 ft
Section Size	96 inch	Rise	8.00 ft
Number Sections	6		

Outlet Control Properties			
Outlet Control HW Elev.	6,864.40 ft	Upstream Velocity Head	0.80 ft
Ke	0.20	Entrance Loss	0.16 ft

Inlet Control Properties			
Inlet Control HW Elev.	6,864.15 ft	Flow Control	N/A
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels	Area Full	301.6 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Appendix 50: Triple Box Culvert CulvertMaster Designer/Analyzer Report

Culvert Designer/Analyzer Report
Double Box

Peak Discharge Method: User-Specified			
Design Discharge	470.00 cfs	Check Discharge	890.00 cfs

Grades Model: Inverts			
Invert Upstream	6,859.99 ft	Invert Downstream	6,859.93 ft
Length	15.00 ft	Slope	0.004270 ft/ft
Drop	0.06 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	6,864.40 ft

Tailwater properties: Irregular Channel

Tailwater conditions for Design Storm.			
Discharge	470.00 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

Tailwater conditions for Check Storm.			
Discharge	890.00 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	3-12 x 9 ft Box	890.00 cfs	6,864.26 ft	9.84 ft/s

Design:Trial-1

Solve For: Section Size

Culvert Summary					
Allowable HW Elevation	6,864.40	ft	Storm Event	Check	
Computed Headwater Elev:	6,864.26	ft	Discharge	890.00	cfs
Headwater Depth/Height	0.47		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	6,864.19	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,864.26	ft			

Grades					
Upstream Invert	6,859.99	ft	Downstream Invert	6,859.93	ft
Length	15.00	ft	Constructed Slope	0.004270	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.51	ft
Slope Type	Steep		Normal Depth	2.34	ft
Flow Regime	Supercritical		Critical Depth	2.67	ft
Velocity Downstream	9.84	ft/s	Critical Slope	0.002900	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	12.00	ft
Section Size	12 x 9 ft		Rise	9.00	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev.	6,864.26	ft	Upstream Velocity Head	1.33	ft
Ke	0.20		Entrance Loss	0.27	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,864.19	ft	Flow Control	N/A	
Inlet Type	90° headwall w 45° bevels		Area Full	324.0	ft²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

Appendix 51: 3-Sided Culvert CulvertMaster Designer/Analyzer Report

Culvert Designer/Analyzer Report
3 Sided Bridge

Peak Discharge Method: User-Specified

Design Discharge	470.00 cfs	Check Discharge	890.00 cfs

Grades Model: Inverts

Invert Upstream	6,859.99 ft	Invert Downstream	6,859.93 ft
Length	15.00 ft	Slope	0.004270 ft/ft
Drop	0.06 ft		

Headwater Model: Maximum Allowable HW

Headwater Elevation	6,864.40 ft

Tailwater properties: Irregular Channel

Tailwater conditions for Design Storm.

Discharge	470.00 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

Tailwater conditions for Check Storm.

Discharge	890.00 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	3-12 x 9 ft Box	890.00 cfs	6,864.37 ft	9.27 ft/s

Design:Trial-1

Solve For: Section Size

Culvert Summary							
Allowable HW Elevation	6,864.40	ft		Storm Event	Check		
Computed Headwater Elev:	6,864.37	ft		Discharge	890.00	cfs	
Headwater Depth/Height	0.49			Tailwater Elevation	0.00	ft	
Inlet Control HW Elev.	6,864.19	ft		Control Type	Outlet Control		
Outlet Control HW Elev.	6,864.37	ft					

Grades					
Upstream Invert	6,859.99	ft	Downstream Invert	6,859.93	ft
Length	15.00	ft	Constructed Slope	0.004270	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	2.67	ft
Slope Type	Mild		Normal Depth	5.16	ft
Flow Regime	Subcritical		Critical Depth	2.67	ft
Velocity Downstream	9.27	ft/s	Critical Slope	0.027454	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.040	
Section Material	Concrete		Span	12.00	ft
Section Size	12 x 9 ft		Rise	9.00	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev.	6,864.37	ft	Upstream Velocity Head	0.83	ft
Ke	0.20		Entrance Loss	0.17	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,864.19	ft	Flow Control	N/A	
Inlet Type	90° headwall w 45° bevels		Area Full	324.0	ft²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

Appendix 52: Cost Calculations for Proposed Culvert Designs

Culverts					
Item	Unit	Unit Price	Size	Quantity	Total
96" CMP	L.F.	$300.00	30	6	$54,000.00
Tripple Box	L.F.	$1,487.00	12' × 9'	45	$66,915.00
3-Sided Bridge	L.F.	$1,487.00	12' × 9'	45	$66,915.00
Wing Wals	EA	$3,562.00	9'	4	$14,248.00

Appendix 53: FEMA FIS Sinclair Wash Water Surface Elevations

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Sinclair Wash								
A	211	59	103	6.9	6,854.5	6,854.5	6,854.7	0.2
B	370	75	758	1.2	6,855.1	6,855.1	6,855.5	0.4
C	845	75	646	1.4	6,855.1	6,855.1	6,855.5	0.4
D	1,584	63	523	1.7	6,855.2	6,855.2	6,855.6	0.4
E	2,693	55	257	3.5	6,855.3	6,855.3	6,855.8	0.5
F	2,851	21	115	7.7	6,855.6	6,855.6	6,855.9	0.3
G	3,010	55	302	2.9	6,856.8	6,856.8	6,856.9	0.1
H	3,643	25	96	9.3	6,856.8	6,856.8	6,856.9	0.1
I	4,541	29	138	6.4	6,861.1	6,861.1	6,861.6	0.5
J	4,699	21	81	11.0	6,863.0	6,863.0	6,863.0	0.0
K	4,752	21	106	8.4	6,864.4	6,864.4	6,864.4	0.0
L	4,805	26	125	7.1	6,864.4	6,864.4	6,864.4	0.0
M	5,702	21	123	7.3	6,865.6	6,865.6	6,866.3	0.7
N	8,237	49	130	5.7	6,877.2	6,877.2	6,877.3	0.1
O	8,290	49	188	4.1	6,877.3	6,877.3	6,877.7	0.4
P	8,976	31	88	6.2	6,879.9	6,879.9	6,880.2	0.3
Q	9,134	37	274	2.0	6,885.9	6,885.9	6,885.9	0.0
R	10,032	48	135	4.1	6,886.2	6,886.2	6,886.3	0.1
S	10,718	31	97	5.7	6,888.6	6,888.6	6,888.6	0.0
T	10,930	134	636	0.9	6,894.2	6,894.2	6,895.2	1.0
U	12,514	33	67	8.2	6,900.0	6,900.0	6,900.0	0.0
V	13,517	45	137	4.0	6,904.9	6,904.9	6,905.9	0.1
W	13,992	30	67	7.0	6,908.4	6,908.4	6,908.5	0.1
X	14,203	47	246	1.9	6,909.0	6,909.0	6,909.7	0.7
Y	14,573	66	418	1.1	6,913.7	6,913.7	6,914.7	1.0
Z	14,784	95	433	1.1	6,913.7	6,913.7	6,914.7	1.0
AA	14,890	112	362	1.3	6,913.9	6,913.9	6,914.7	0.8
AB	15,576	51	129	3.6	6,913.9	6,913.9	6,914.9	1.0

[1] Feet above confluence With Rio de Flag

TABLE 9

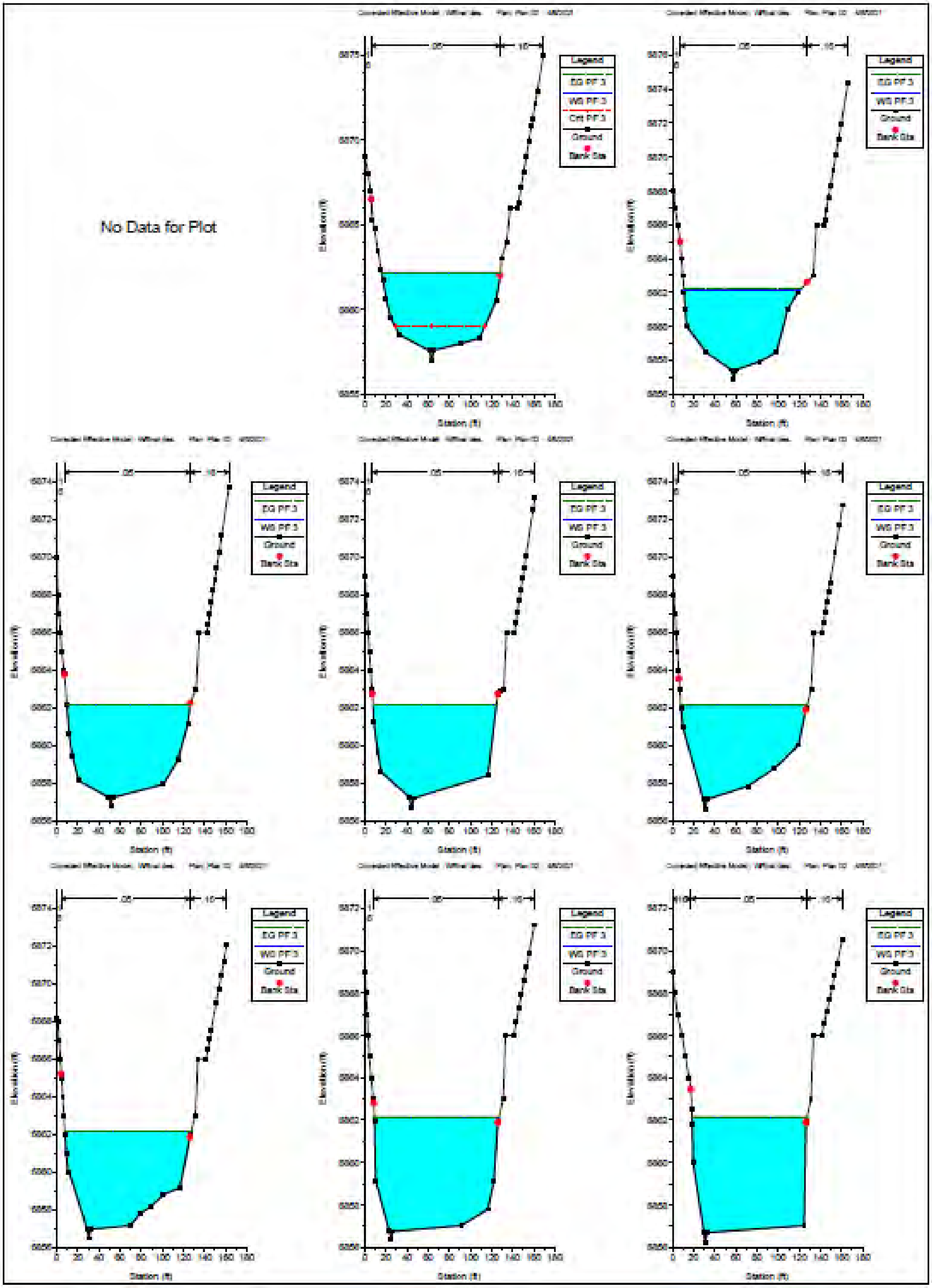
FEDERAL EMERGENCY MANAGEMENT AGENCY

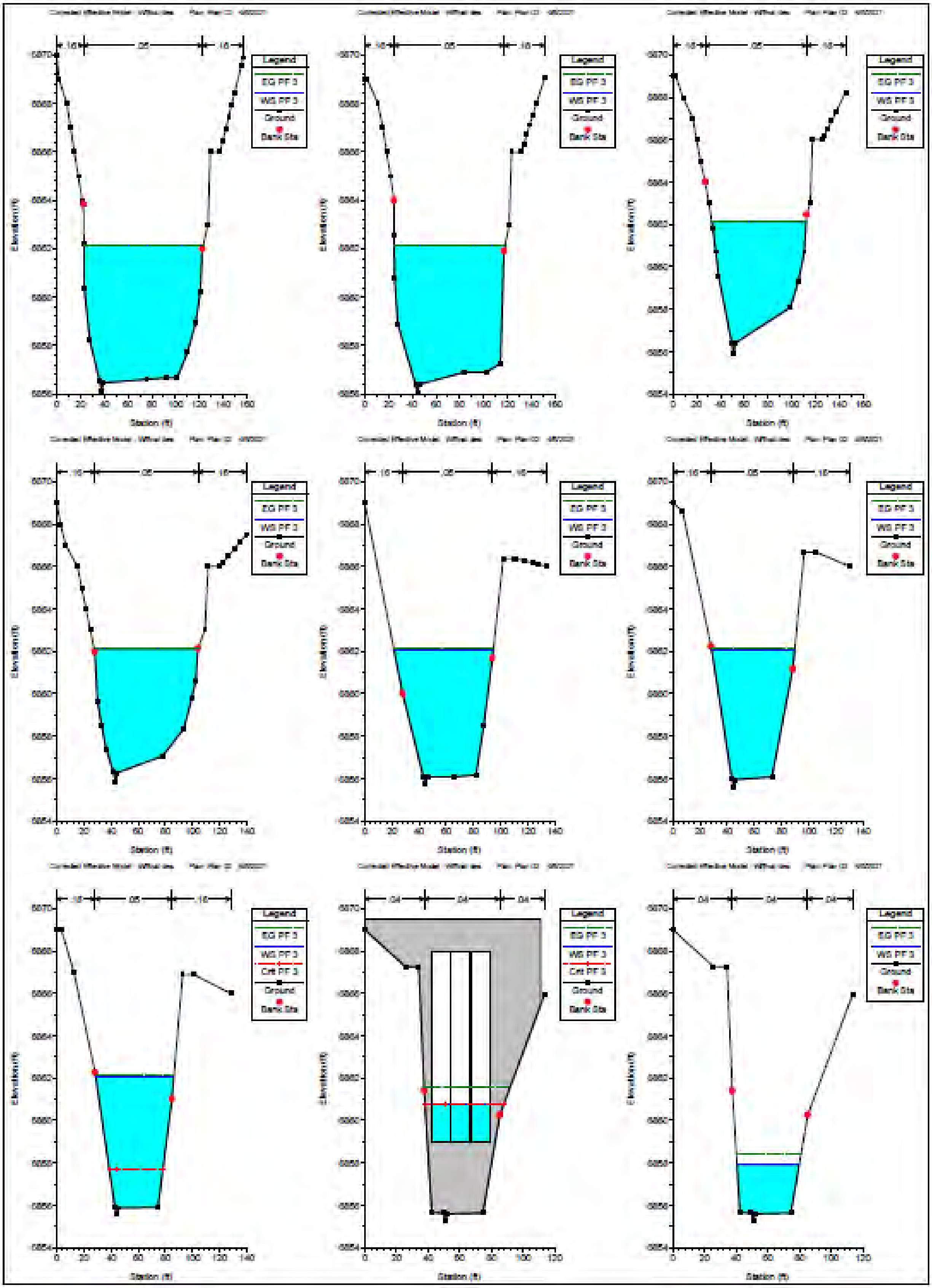
COCONINO COUNTY, AZ AND INCORPORATED AREAS

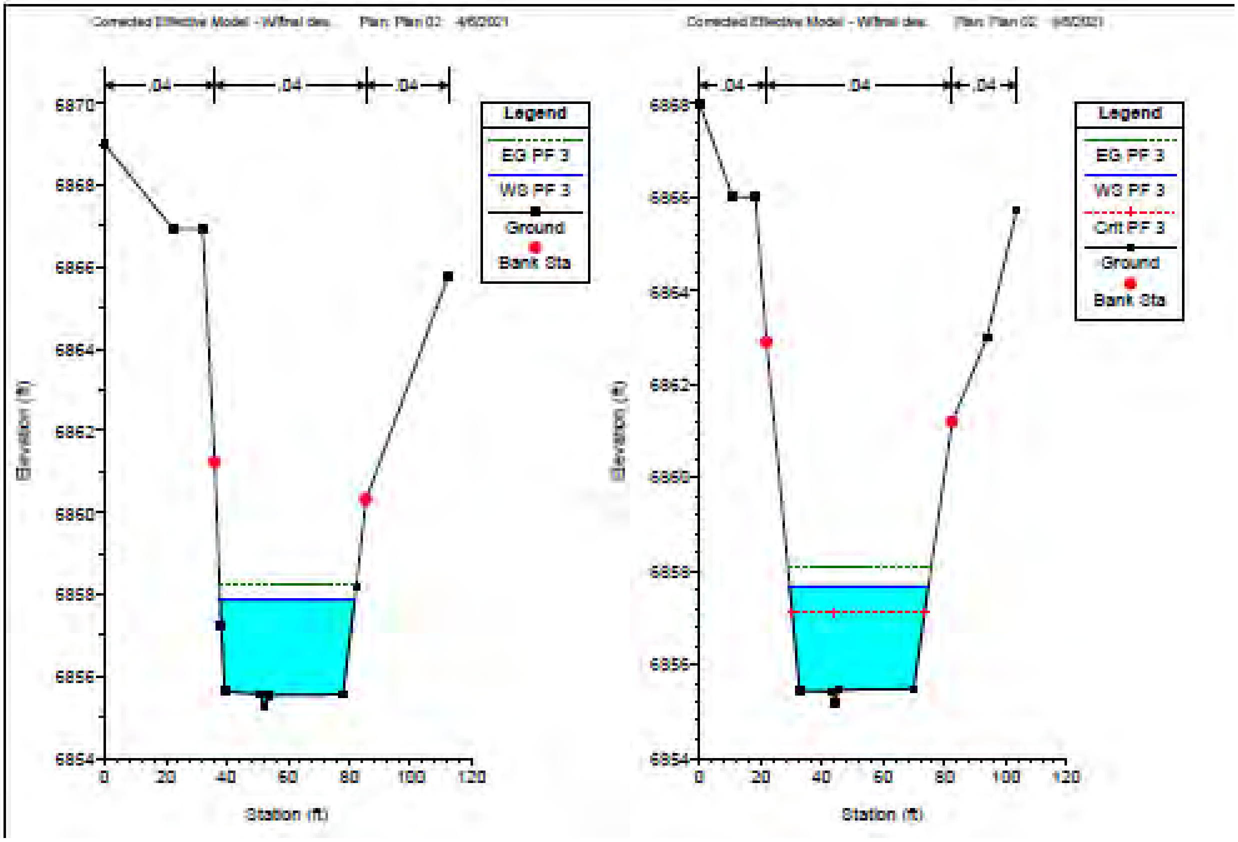
FLOODWAY DATA

SINCLAIR WASH

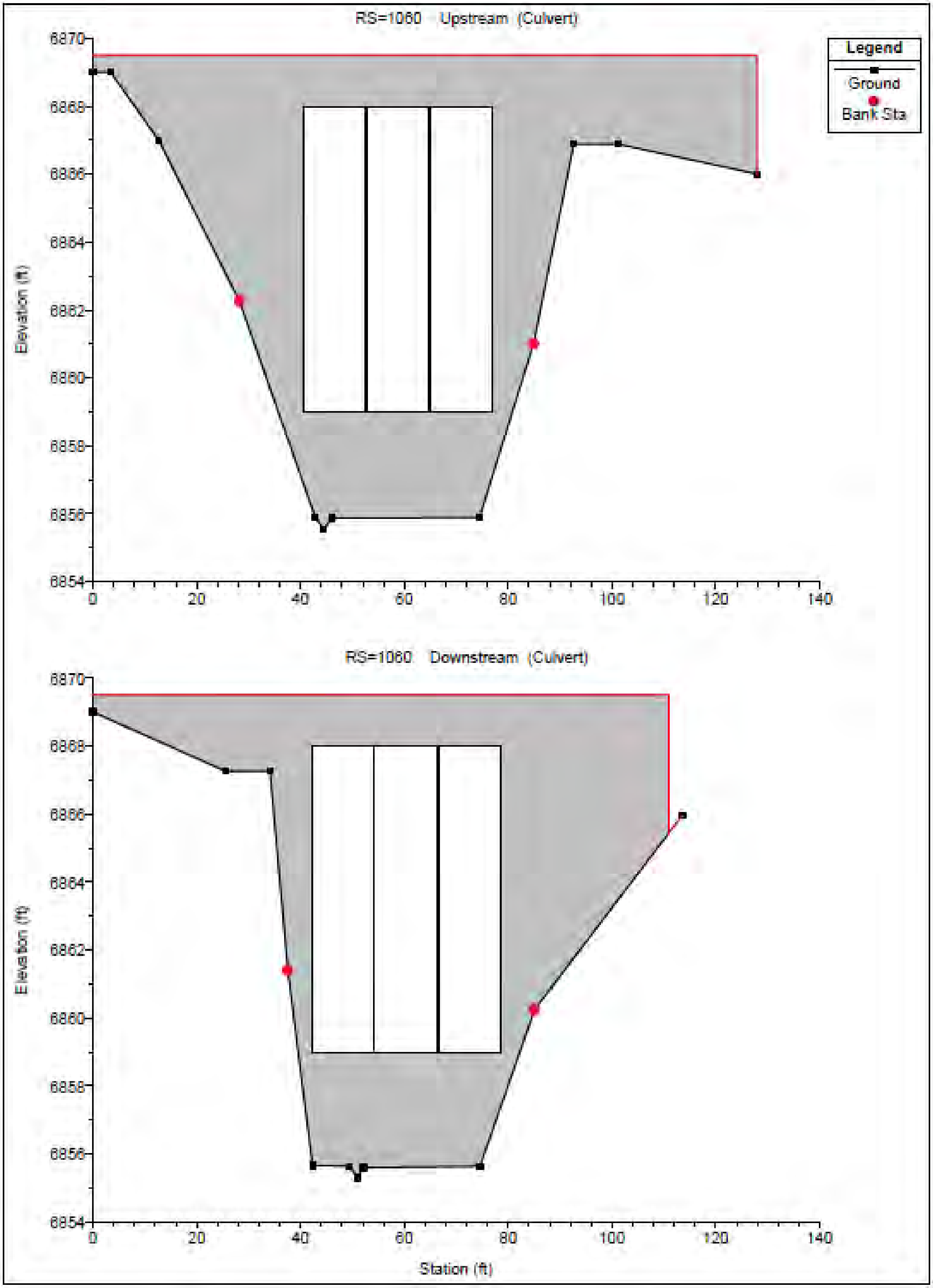
Appendix 54: Proposed Hydraulic Model Cross-Section Diagram




Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
Elevation (ft)
Station (ft)


Corrected Effective Model - W/final des. Plan: Plan 02 4/6/2021
Legend
EG PF 3
WS PF 3
Ground
Bank Sta
.04
.04
.04
Elevation (ft)
Station (ft)
Corrected Effective Model - W/final des. Plan: Plan 02 4/6/2021
Legend
EG PF 3
WS PF 3
Crit PF 3
Ground
Bank Sta
.04
.04
.04
Elevation (ft)
Station (ft)

Appendix 55: Proposed Hydraulic Model Culvert Diagram



Appendix 56: Proposed Hydraulic Model Cross-Section Summary Table

HEC-RAS Plan: Plan 02 River: Sinclair Wash Reach: I-17 to Culvert

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)	
I-17 to Culvert	1429	PF 1	890.00	6857.00	6863.63	6859.53	6863.67	0.000327	1.55	577.48	120.73	0.12
I-17 to Culvert	1429	PF 2	670.00	6857.00	6862.91	6859.27	6862.94	0.000305	1.36	492.24	115.47	0.12
I-17 to Culvert	1429	PF 3	470.00	6857.00	6862.17	6858.98	6862.19	0.000273	1.15	408.07	112.61	0.11
I-17 to Culvert	1404	PF 1	890.00	6856.89	6863.62		6863.66	0.000400	1.63	551.37	125.12	0.13
I-17 to Culvert	1404	PF 2	670.00	6856.89	6862.90		6862.93	0.000395	1.45	461.65	122.14	0.13
I-17 to Culvert	1404	PF 3	470.00	6856.89	6862.16		6862.19	0.000351	1.25	376.00	110.35	0.12
I-17 to Culvert	1379	PF 1	890.00	6856.78	6863.62		6863.65	0.000240	1.40	642.94	125.10	0.11
I-17 to Culvert	1379	PF 2	670.00	6856.78	6862.90		6862.92	0.000218	1.21	553.22	122.79	0.10
I-17 to Culvert	1379	PF 3	470.00	6856.78	6862.16		6862.18	0.000186	1.01	465.17	116.73	0.09
I-17 to Culvert	1354	PF 1	890.00	6856.68	6863.61		6863.64	0.000230	1.38	650.92	126.16	0.10
I-17 to Culvert	1354	PF 2	670.00	6856.68	6862.89		6862.92	0.000210	1.20	560.49	121.81	0.10
I-17 to Culvert	1354	PF 3	470.00	6856.68	6862.16		6862.17	0.000177	0.99	473.52	116.96	0.09
I-17 to Culvert	1329	PF 1	890.00	6856.57	6863.60		6863.64	0.000292	1.48	609.19	125.83	0.12
I-17 to Culvert	1329	PF 2	670.00	6856.57	6862.88		6862.91	0.000274	1.30	518.99	123.96	0.11
I-17 to Culvert	1329	PF 3	470.00	6856.57	6862.15		6862.17	0.000247	1.09	429.47	119.84	0.10
I-17 to Culvert	1304	PF 1	890.00	6856.47	6863.60		6863.63	0.000232	1.37	652.95	125.67	0.10
I-17 to Culvert	1304	PF 2	670.00	6856.47	6862.88		6862.90	0.000209	1.20	562.91	123.83	0.10
I-17 to Culvert	1304	PF 3	470.00	6856.47	6862.15		6862.16	0.000179	0.99	473.49	119.70	0.09
I-17 to Culvert	1279	PF 1	890.00	6856.36	6863.60		6863.62	0.000151	1.21	740.59	124.56	0.09
I-17 to Culvert	1279	PF 2	670.00	6856.36	6862.88		6862.90	0.000129	1.03	651.59	122.01	0.08
I-17 to Culvert	1279	PF 3	470.00	6856.36	6862.15		6862.16	0.000101	0.83	563.40	118.19	0.07
I-17 to Culvert	1254	PF 1	890.00	6856.25	6863.60		6863.62	0.000160	1.26	711.34	114.71	0.09
I-17 to Culvert	1254	PF 2	670.00	6856.25	6862.88		6862.89	0.000133	1.07	629.47	112.67	0.08
I-17 to Culvert	1254	PF 3	470.00	6856.25	6862.14		6862.15	0.000102	0.86	548.28	108.83	0.07
I-17 to Culvert	1229	PF 1	890.00	6856.15	6863.58		6863.61	0.000194	1.39	646.85	105.24	0.10
I-17 to Culvert	1229	PF 2	670.00	6856.15	6862.87		6862.89	0.000161	1.18	571.69	103.91	0.09
I-17 to Culvert	1229	PF 3	470.00	6856.15	6862.14		6862.15	0.000124	0.95	497.07	100.28	0.07
I-17 to Culvert	1204	PF 1	890.00	6856.04	6863.57		6863.61	0.000225	1.49	602.87	97.23	0.10
I-17 to Culvert	1204	PF 2	670.00	6856.04	6862.86		6862.88	0.000187	1.26	533.52	96.30	0.09
I-17 to Culvert	1204	PF 3	470.00	6856.04	6862.13		6862.15	0.000143	1.01	464.44	93.31	0.08
I-17 to Culvert	1179	PF 1	890.00	6855.93	6863.54		6863.60	0.000496	1.98	450.82	87.38	0.15
I-17 to Culvert	1179	PF 2	670.00	6855.93	6862.83		6862.88	0.000433	1.72	390.00	83.93	0.14
I-17 to Culvert	1179	PF 3	470.00	6855.93	6862.11		6862.14	0.000351	1.42	331.43	79.47	0.12
I-17 to Culvert	1154	PF 1	890.00	6855.83	6863.53		6863.59	0.000419	1.96	462.90	86.60	0.14
I-17 to Culvert	1154	PF 2	670.00	6855.83	6862.82		6862.87	0.000362	1.67	402.88	82.82	0.13
I-17 to Culvert	1154	PF 3	470.00	6855.83	6862.10		6862.13	0.000290	1.36	345.76	76.30	0.11
I-17 to Culvert	1129	PF 1	890.00	6855.72	6863.51		6863.58	0.000415	2.07	449.96	80.04	0.14
I-17 to Culvert	1129	PF 2	670.00	6855.72	6862.81		6862.86	0.000346	1.75	395.02	76.66	0.13
I-17 to Culvert	1129	PF 3	470.00	6855.72	6862.09		6862.12	0.000265	1.40	341.49	73.22	0.11
I-17 to Culvert	1104	PF 1	890.00	6855.61	6863.47		6863.56	0.000649	2.45	369.15	67.69	0.18
I-17 to Culvert	1104	PF 2	670.00	6855.61	6862.78		6862.85	0.000554	2.09	323.47	64.36	0.16
I-17 to Culvert	1104	PF 3	470.00	6855.61	6862.07		6862.12	0.000433	1.69	279.18	61.11	0.14
I-17 to Culvert	1089	PF 1	890.00	6855.55	6863.46	6858.59	6863.55	0.000644	2.49	362.79	63.87	0.18
I-17 to Culvert	1089	PF 2	670.00	6855.55	6862.77	6858.14	6862.84	0.000538	2.11	319.90	60.70	0.16
I-17 to Culvert	1089	PF 3	470.00	6855.55	6862.07	6857.68	6862.11	0.000409	1.69	278.37	57.65	0.13
I-17 to Culvert	1060		Culvert									
I-17 to Culvert	1030	PF 1	890.00	6855.30	6858.85		6859.70	0.010358	7.36	120.91	42.26	0.77
I-17 to Culvert	1030	PF 2	670.00	6855.30	6858.40		6859.07	0.009810	6.57	102.03	40.84	0.73
I-17 to Culvert	1030	PF 3	470.00	6855.30	6857.91		6858.42	0.009224	5.69	82.55	39.33	0.69
I-17 to Culvert	1025	PF 1	890.00	6855.27	6858.84		6859.47	0.007196	6.36	139.87	45.94	0.64
I-17 to Culvert	1025	PF 2	670.00	6855.27	6858.37		6858.87	0.006879	5.67	118.21	45.00	0.62
I-17 to Culvert	1025	PF 3	470.00	6855.27	6857.86		6858.23	0.006564	4.91	95.66	43.95	0.59
I-17 to Culvert	1000	PF 1	890.00	6855.17	6858.67	6857.94	6859.31	0.007770	6.41	138.87	48.95	0.67
I-17 to Culvert	1000	PF 2	670.00	6855.17	6858.18	6857.52	6858.71	0.007769	5.82	115.20	47.15	0.66
I-17 to Culvert	1000	PF 3	470.00	6855.17	6857.67	6857.10	6858.08	0.007769	5.14	91.46	45.28	0.64

Appendix 57: Proposed Hydraulic Model Culvert Summary Table

Plan: Plan 02 Sinclair Wash I-17 to Culvert RS: 1060 Culv Group: 3 sided RCB Profile: PF 1

Q Culv Group (cfs)	890.00	Culv Full Len (ft)	
# Barrels	3	Culv Vel US (ft/s)	6.42
Q Barrel (cfs)	296.67	Culv Vel DS (ft/s)	9.27
E.G. US. (ft)	6863.56	Culv Inv El Up (ft)	6859.00
W.S. US. (ft)	6863.46	Culv Inv El Dn (ft)	6858.99
E.G. DS (ft)	6859.70	Culv Frctn Ls (ft)	0.50
W.S. DS (ft)	6858.85	Culv Exit Loss (ft)	3.30
Delta EG (ft)	3.86	Culv Entr Loss (ft)	0.06
Delta WS (ft)	4.60	Q Weir (cfs)	
E.G. IC (ft)	6863.33	Weir Sta Lft (ft)	
E.G. OC (ft)	6863.56	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6862.85	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6861.66	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	9.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.67	Min El Weir Flow (ft)	6866.01

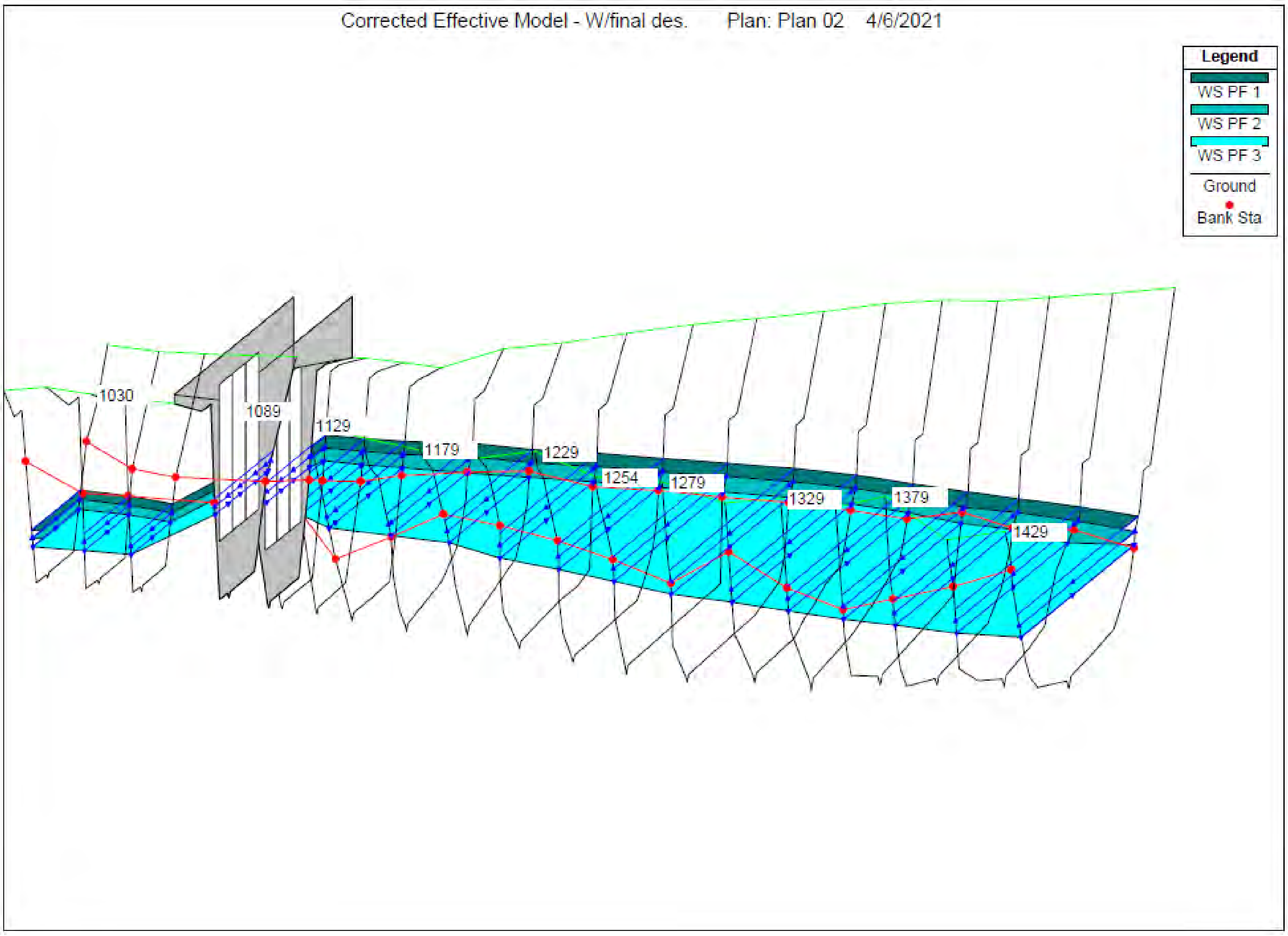
Plan: Plan 02 Sinclair Wash I-17 to Culvert RS: 1060 Culv Group: 3 sided RCB Profile: PF 2

Q Culv Group (cfs)	670.00	Culv Full Len (ft)	
# Barrels	3	Culv Vel US (ft/s)	5.65
Q Barrel (cfs)	223.33	Culv Vel DS (ft/s)	8.43
E.G. US. (ft)	6862.84	Culv Inv El Up (ft)	6859.00
W.S. US. (ft)	6862.77	Culv Inv El Dn (ft)	6858.99
E.G. DS (ft)	6859.07	Culv Frctn Ls (ft)	0.49
W.S. DS (ft)	6858.40	Culv Exit Loss (ft)	3.23
Delta EG (ft)	3.77	Culv Entr Loss (ft)	0.05
Delta WS (ft)	4.37	Q Weir (cfs)	
E.G. IC (ft)	6862.58	Weir Sta Lft (ft)	
E.G. OC (ft)	6862.84	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6862.29	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6861.20	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	9.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.21	Min El Weir Flow (ft)	6866.01

Plan: Plan 02 Sinclair Wash I-17 to Culvert RS: 1060 Culv Group: 3 sided RCB Profile: PF 2

Q Culv Group (cfs)	670.00	Culv Full Len (ft)	
# Barrels	3	Culv Vel US (ft/s)	5.65
Q Barrel (cfs)	223.33	Culv Vel DS (ft/s)	8.43
E.G. US. (ft)	6862.84	Culv Inv El Up (ft)	6859.00
W.S. US. (ft)	6862.77	Culv Inv El Dn (ft)	6858.99
E.G. DS (ft)	6859.07	Culv Frctn Ls (ft)	0.49
W.S. DS (ft)	6858.40	Culv Exit Loss (ft)	3.23
Delta EG (ft)	3.77	Culv Entr Loss (ft)	0.05
Delta WS (ft)	4.37	Q Weir (cfs)	
E.G. IC (ft)	6862.58	Weir Sta Lft (ft)	
E.G. OC (ft)	6862.84	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6862.29	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6861.20	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	9.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.21	Min El Weir Flow (ft)	6866.01

Appendix 58: Three-Dimensional Proposed Hydraulic Model



Appendix 59: Final Plan Set

SINCLAIR WASH RESTORATION

RED ROCK ENGINEERING
NORTHERN ARIZONA UNIVERSITY

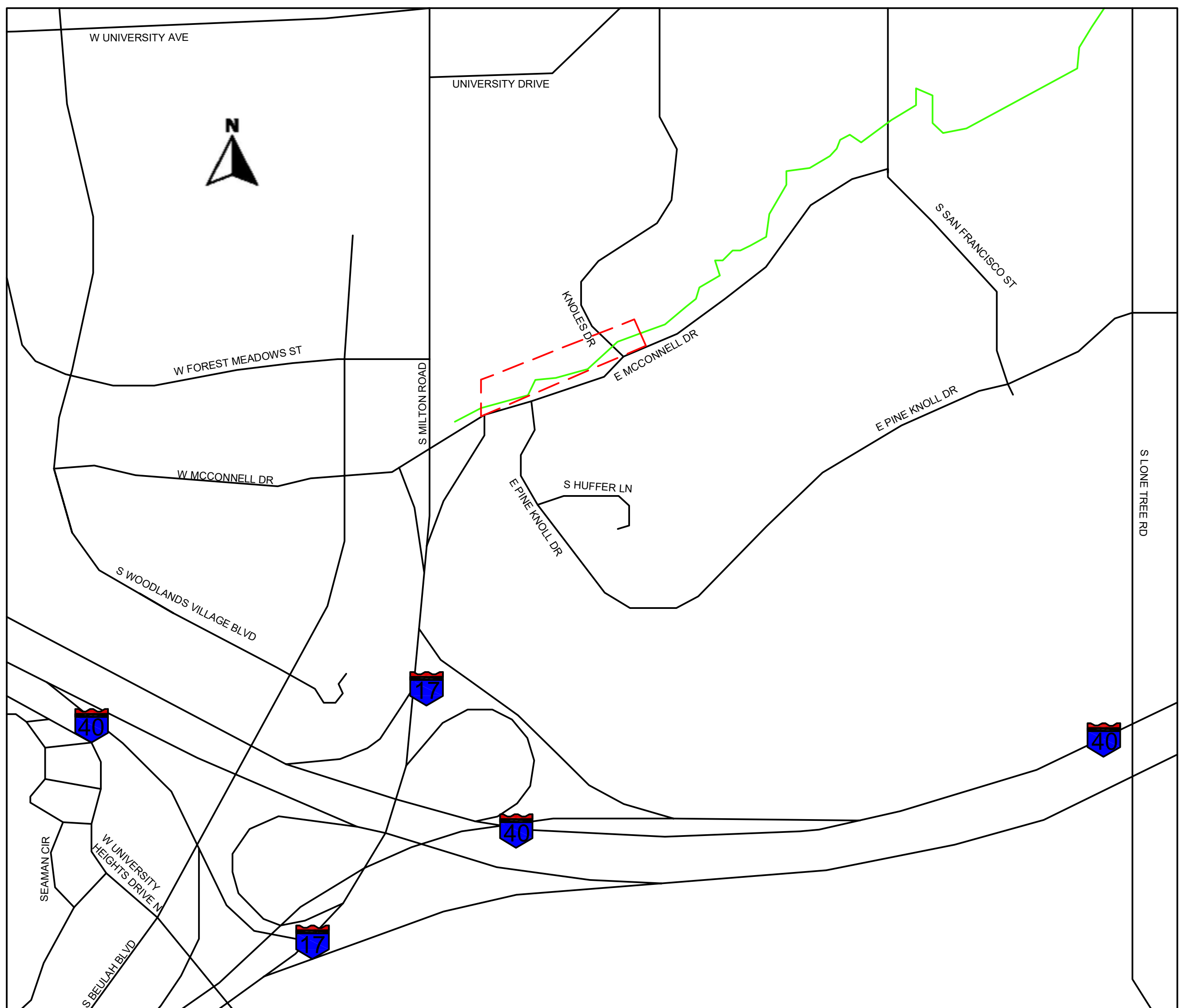
SHEET 1 OF 9

SCALE: VARIES

PROJECT LOCATION

SITE BOUNDARY   SINCLAIR WASH

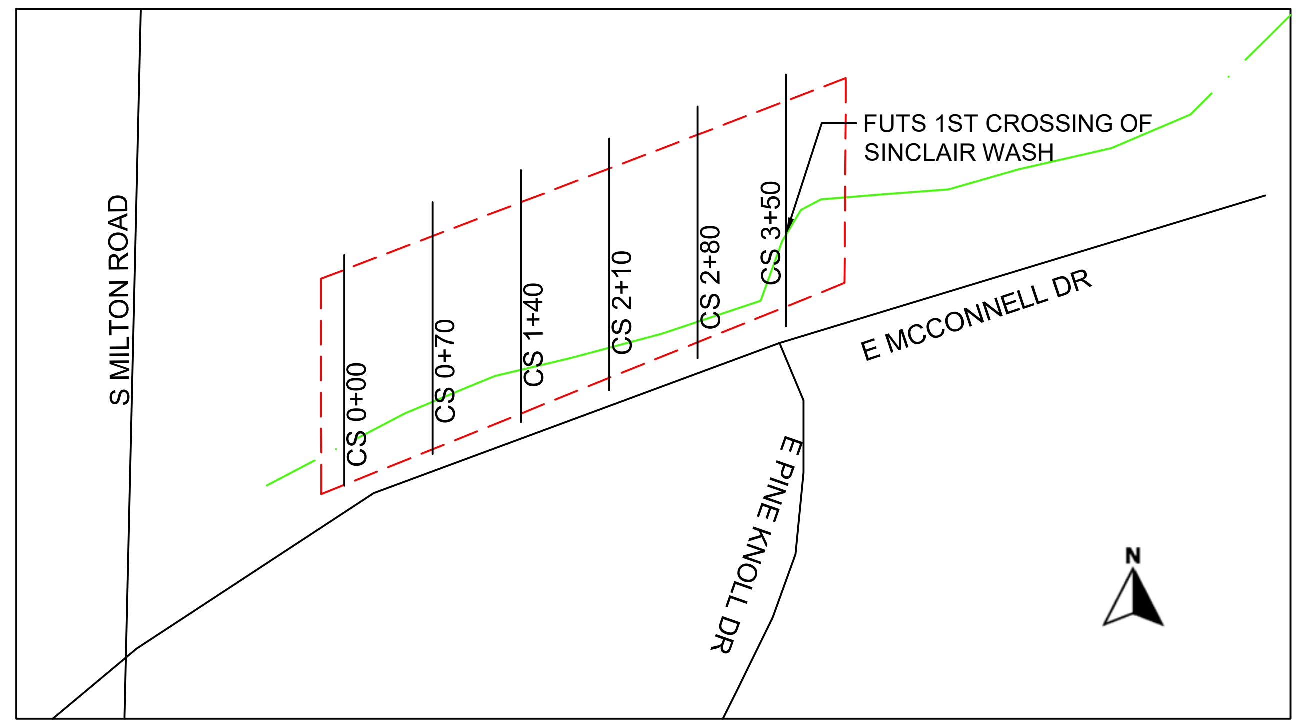
0 250 500 1000 FT



SITE PLAN

SITE BOUNDARY   SINCLAIR WASH

0 25 50 100 FT



INDEX OF SHEETS

1 - TITLE PAGE, SHEET INDEX, SITE PLAN
2 - CHANNEL PLAN VIEW
3 - CHANNEL CROSS SECTIONS & PROFILES OF CROSS SECTIONS
4 - PROFILES OF CROSS SECTIONS
5 - PROFILES OF CROSS SECTIONS
6 - PROFILE OF CROSS SECTIONS AND THALWEG
7 - CHANNEL DETAILS
8 - CULVERT DETAILS
9 - RE-VEGETATION PLAN

REVISIONS		
FIXED INDEX OF SHEETS	4/26	SS

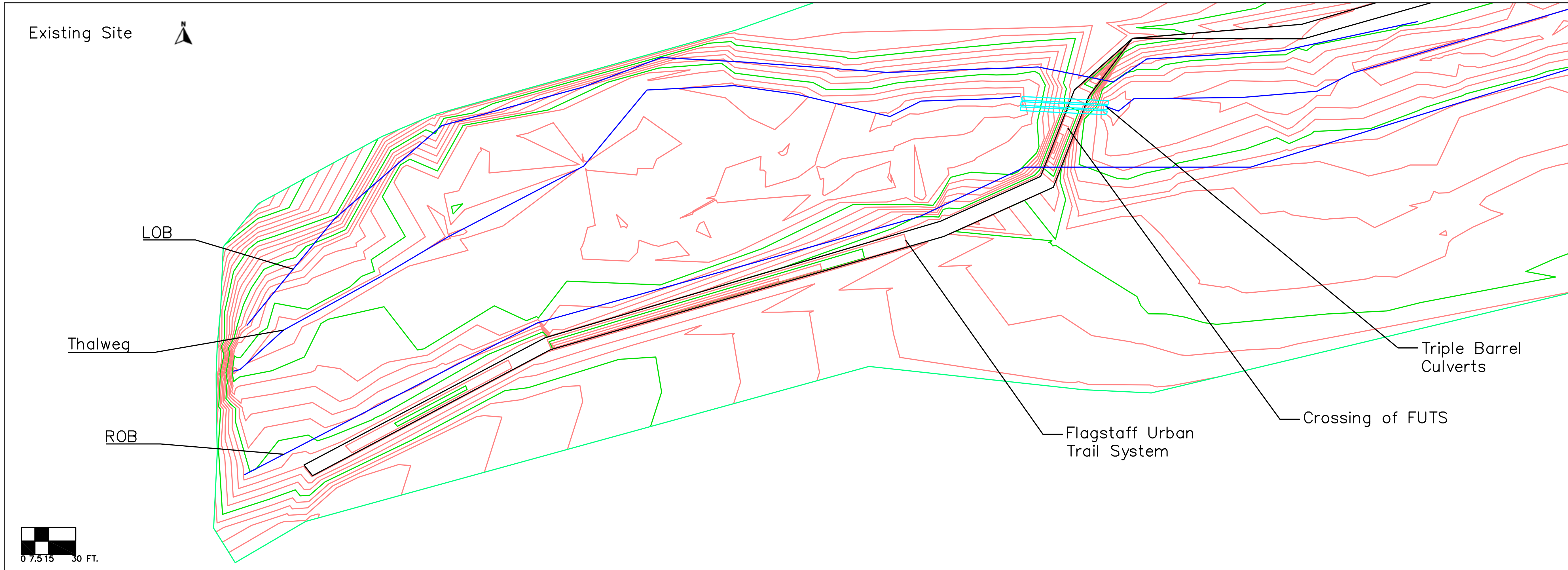
CLIENT: MARK LAMER

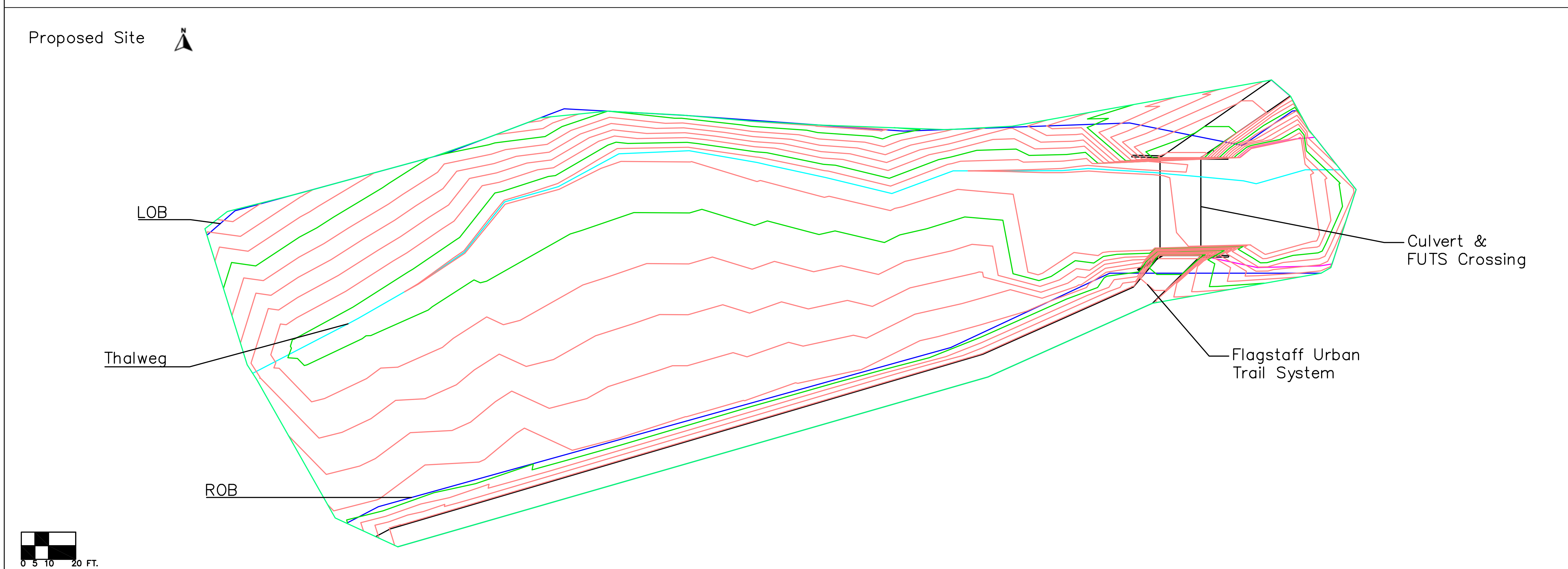
PROJECT: WASH RESTORATION

AUTHOR: S. SEYMOUR

DATE: 04/26/21

RED ROCK ENGINEERING





SHEET 2 OF 9

SCALE: VARIES

REVISIONS

Revision	Date	By
ADDED PLAN VIEWS	2/9	SS
UPATED PROPOSED VIEW	3/11	SS
FINALISED SCALE	4/26	SS

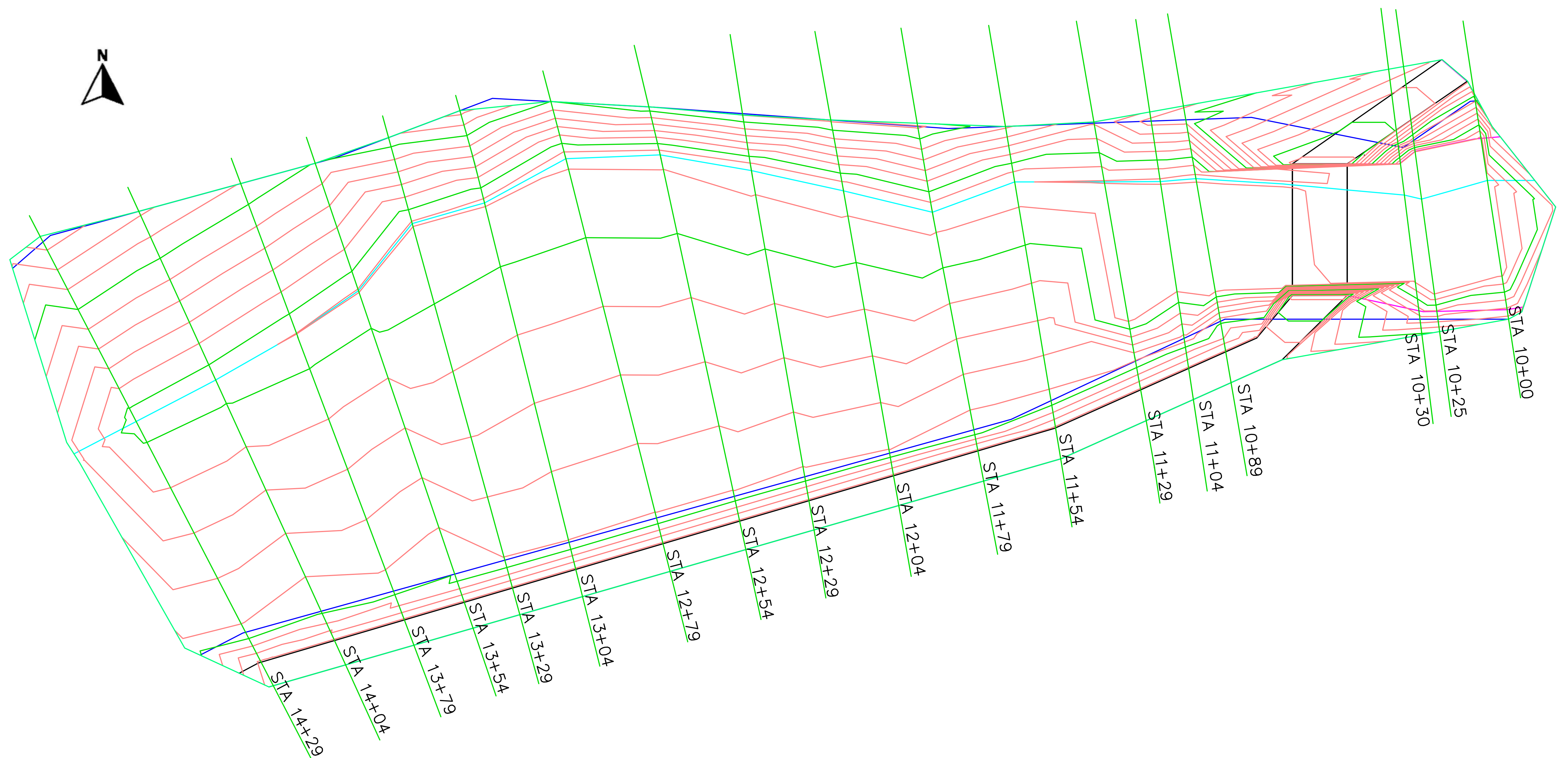
CLIENT: MARK LAMER

PROJECT: WASH RESTORATION

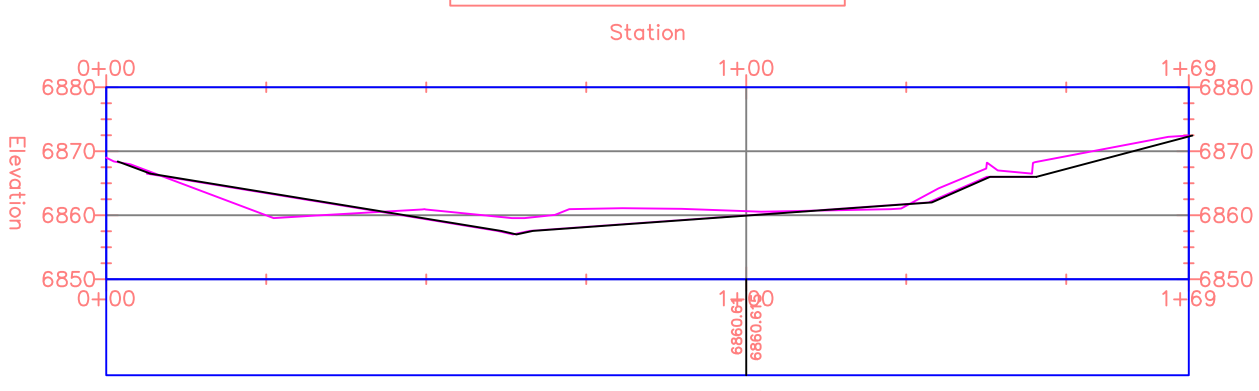
AUTHOR: S. SEYMOUR

DATE: 04/26/21

RED ROCK ENGINEERING



STA 14+29 PROFILE



EXISTING PROFILE PROPOSED PROFILE

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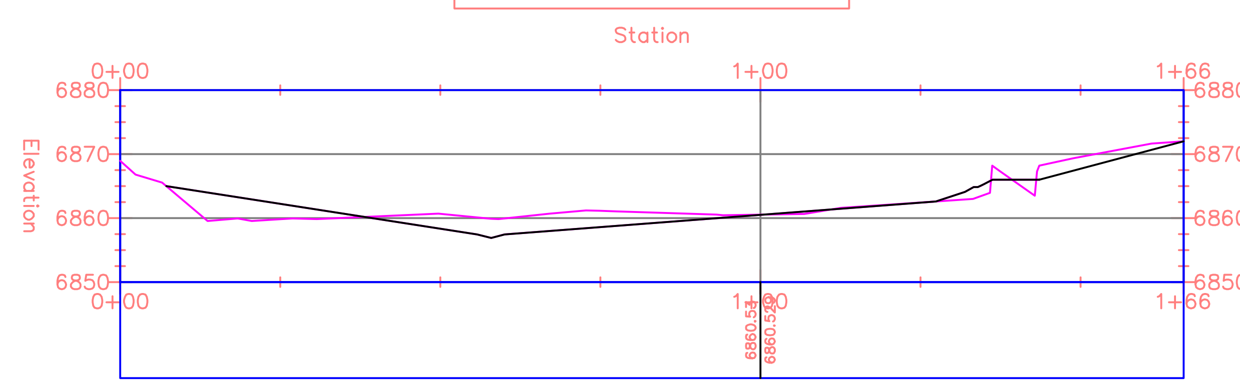


EXISTING PROFILE PROPOSED PROFILE

SHEET 3 OF 9

SCALE:1":15'

REVISIONS		
ADDED ANNOTATIONS	3/25	SS
FINALISED SCALES	4/26	SS

CLIENT:MARK LAMER

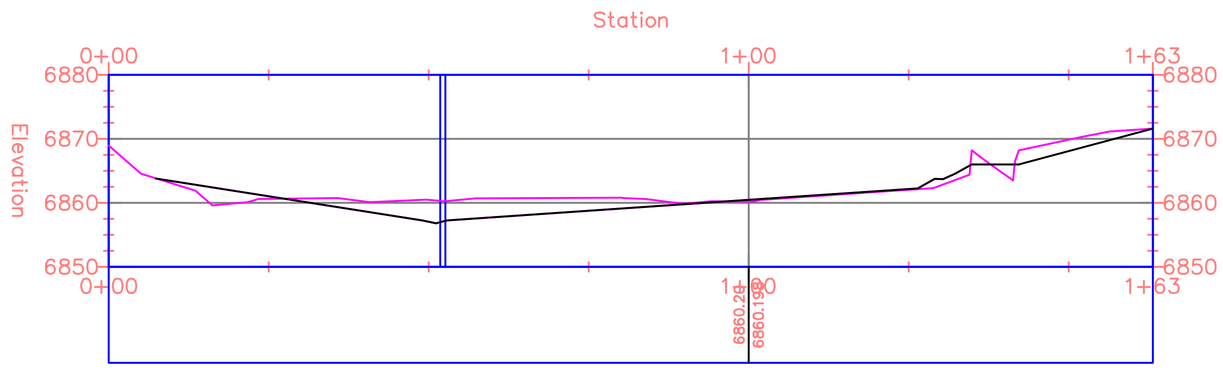
PROJECT:WASH RESTORATION

AUTHOR:S. SEYMOUR

DATE:04/26/21

RED ROCK ENGINEERING

STA 13+79 PROFILE



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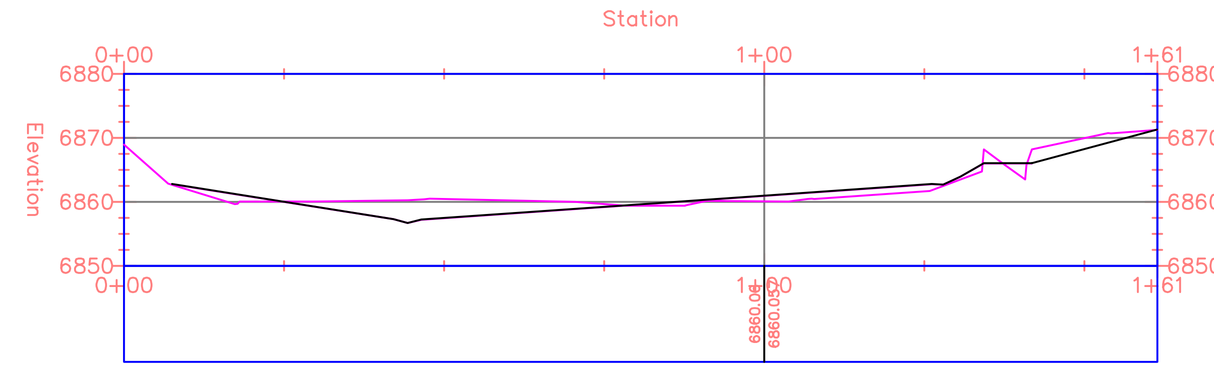

EXISTING PROFILE PROPOSED PROFILE

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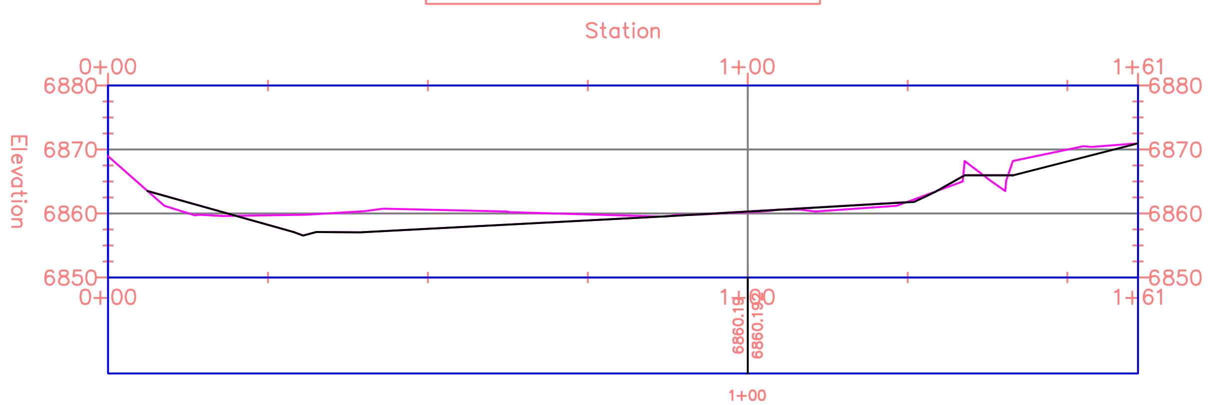

EXISTING PROFILE PROPOSED PROFILE

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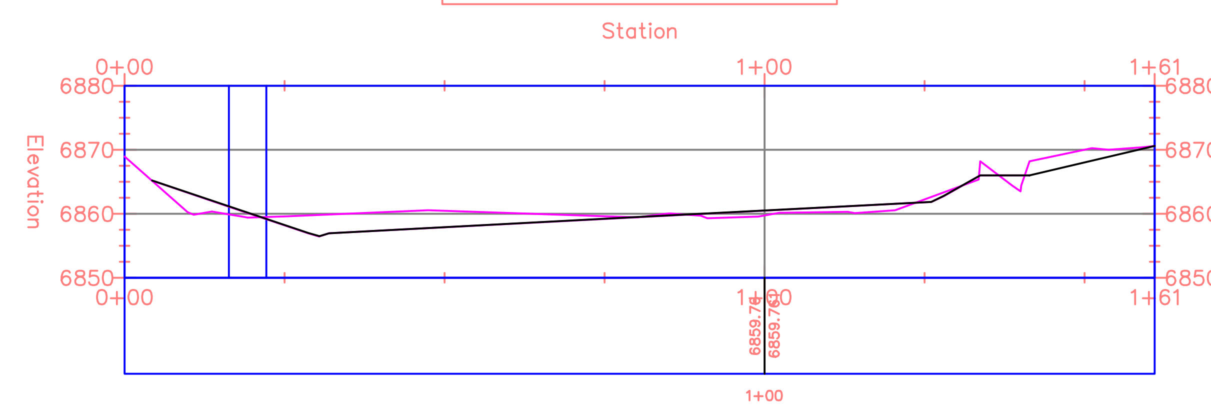

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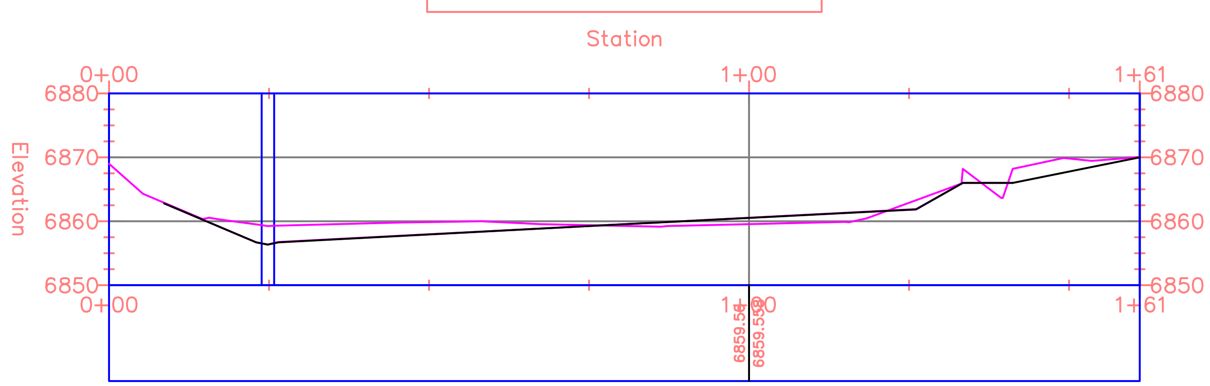
STA 12+79 PROFILE



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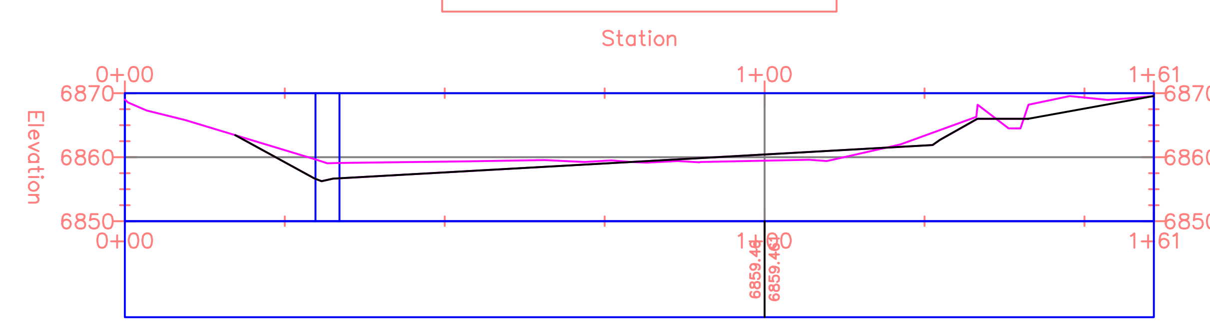


EXISTING PROFILE PROPOSED PROFILE

SHEET 4 OF 9

SCALE:1":15'

0 3.75 7.5 15

REVISIONS		
ADDED ANNOTATIONS	3/25	SS
FINALISED SCALES	4/26	SS

CLIENT: MARK LAMER

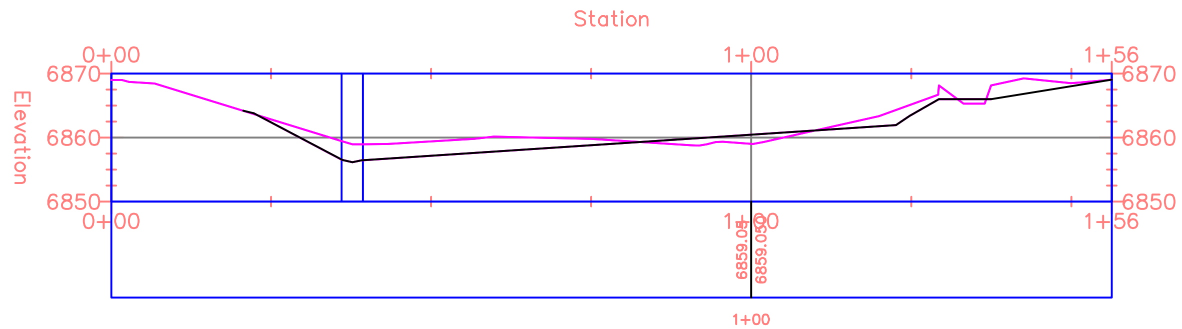
PROJECT: WASH RESTORATION

AUTHOR: S. SEYMOUR

DATE: 04/26/21

RED ROCK ENGINEERING

STA 12+29 PROFILE



EXISTING PROFILE   PROPOSED PROFILE

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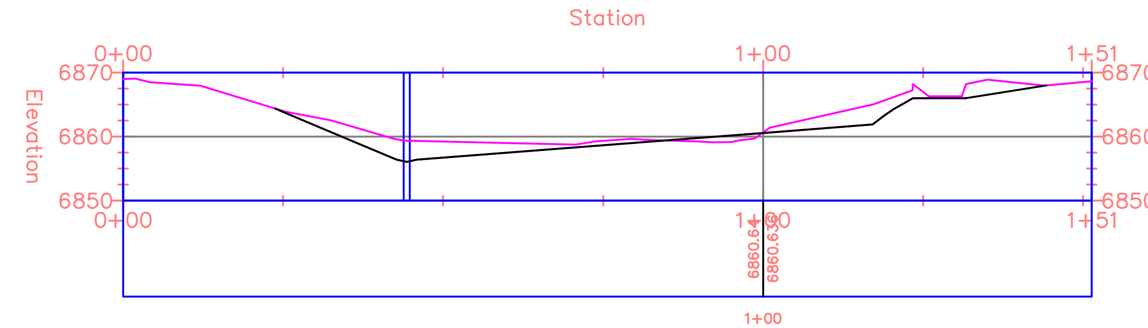

EXISTING PROFILE   PROPOSED PROFILE

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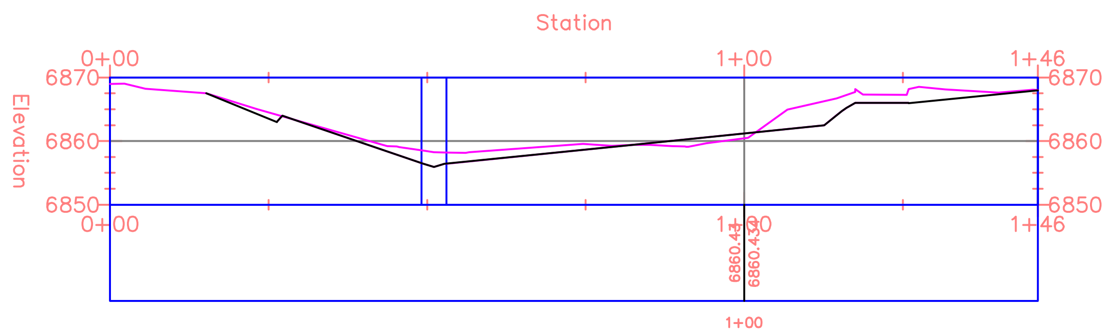

EXISTING PROFILE   PROPOSED PROFILE

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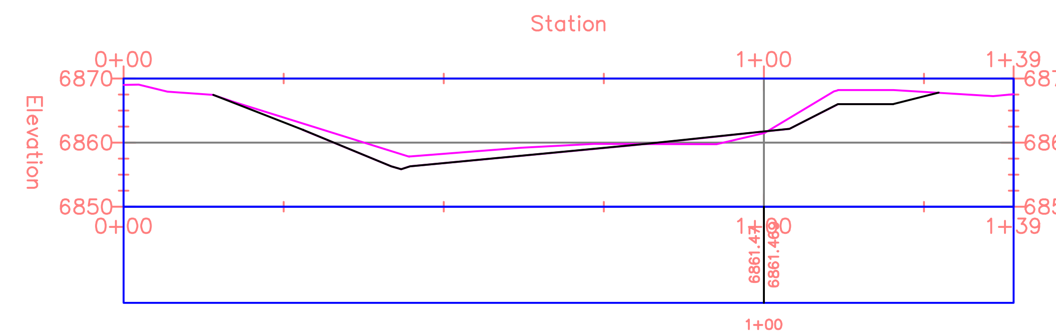

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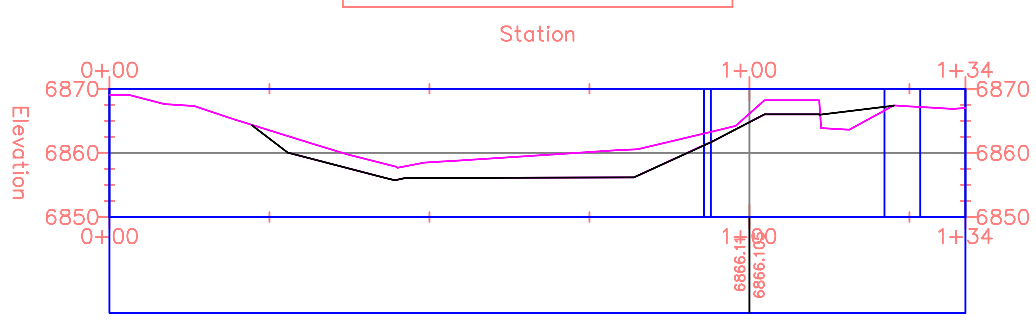
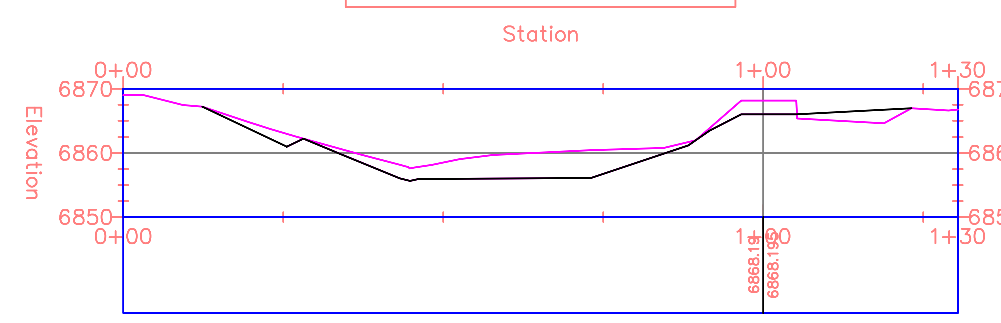


EXISTING PROFILE   PROPOSED PROFILE

STA 11+04 PROFILE



EXISTING PROFILE   PROPOSED PROFILE

SHEET 5 OF 9

SCALE:1":15'

0 3.75 7.5 15

REVISIONS

ADDED ANNOTATIONS	3/25	SS
FINALISED SCALE	4/26	SS

CLIENT: MARK LAMER

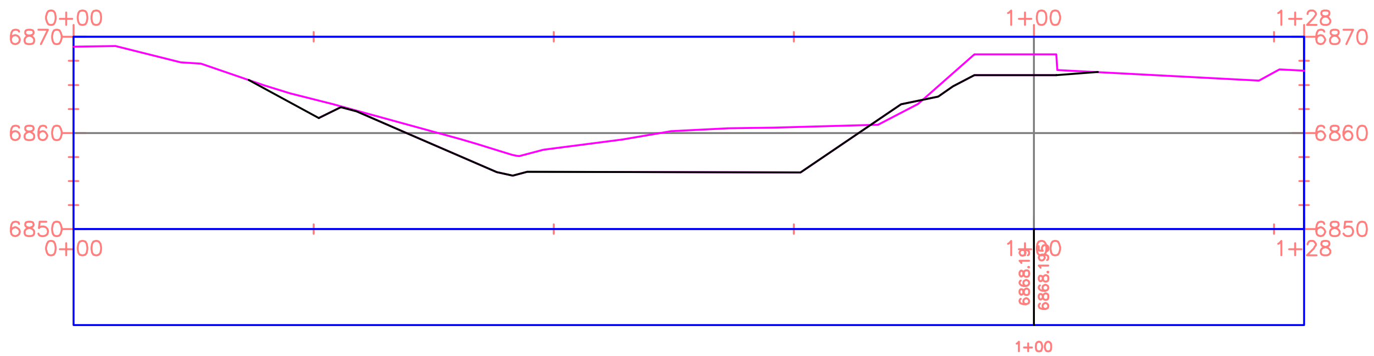
PROJECT: WASH RESTORATION

AUTHOR: S. SEYMOUR

DATE: 02/09/21

RED ROCK ENGINEERING

STA 10+89 PROFILE



EXISTING PROFILE PROPOSED PROFILE

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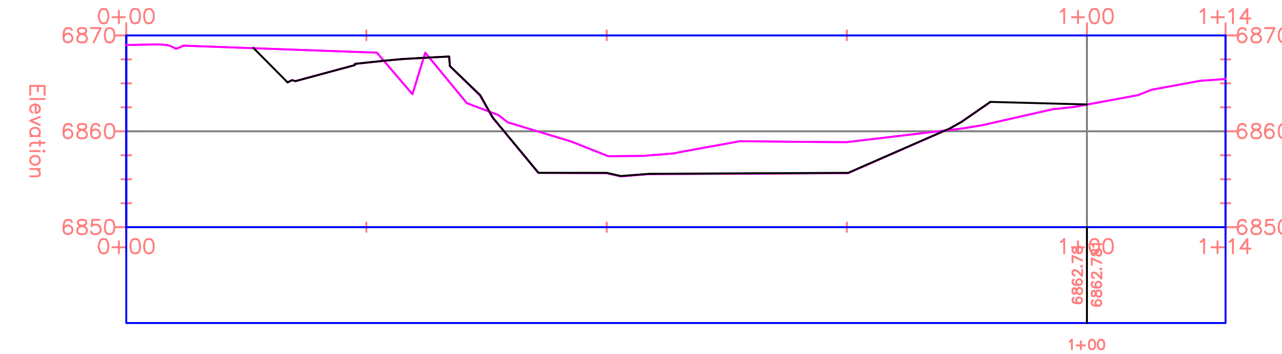
STA 10+30 PROFILE



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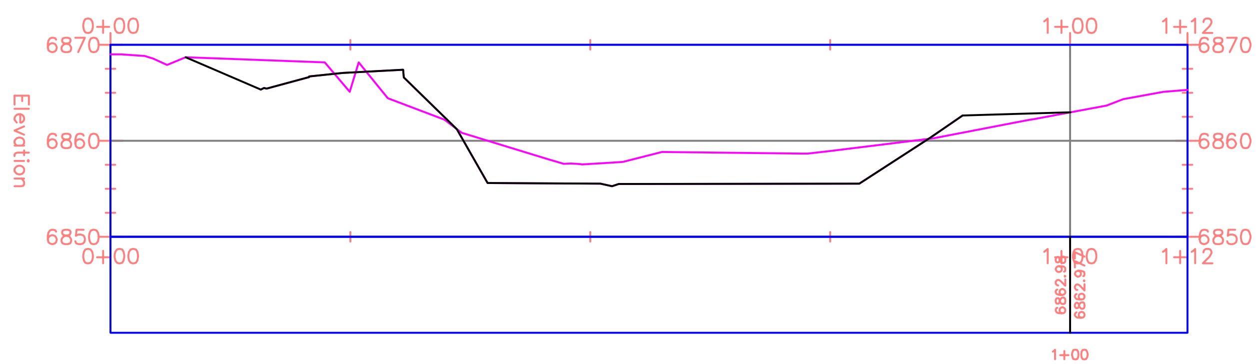
STA 10+25 PROFILE



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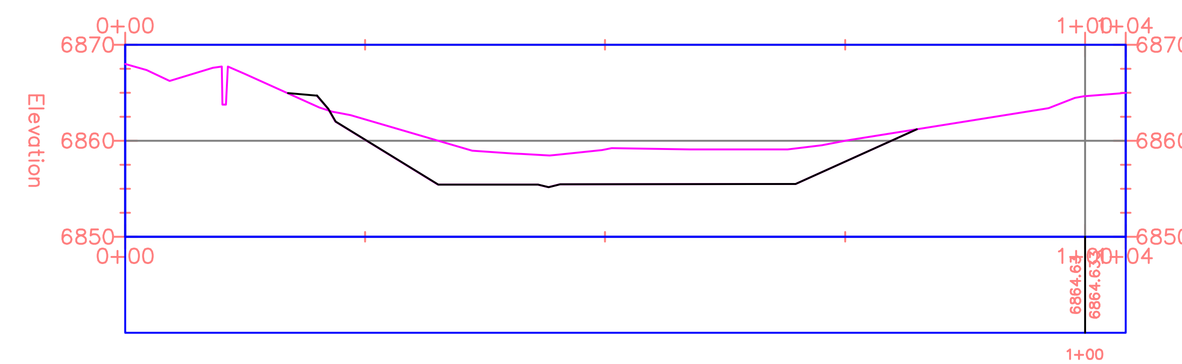
STA 10+00 PROFILE



EXISTING PROFILE PROPOSED PROFILE

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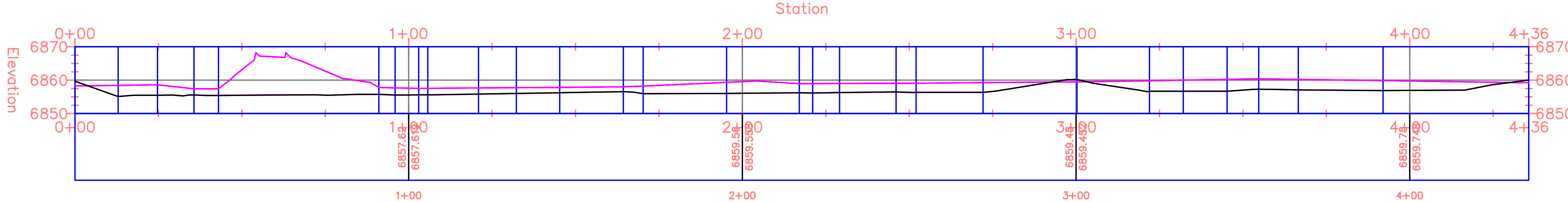
EXISTING VS PROPOSED THALWEG PROFILE



EXISTING PROFILE PROPOSED PROFILE

0 5 10 20 FT.

SHEET 6 OF 9

SCALE: VARIES

0 5 10 20

REVISIONS		
ADDED ANNOTATIONS	3/25	SS
FINALISED SCALE	4/26	SS

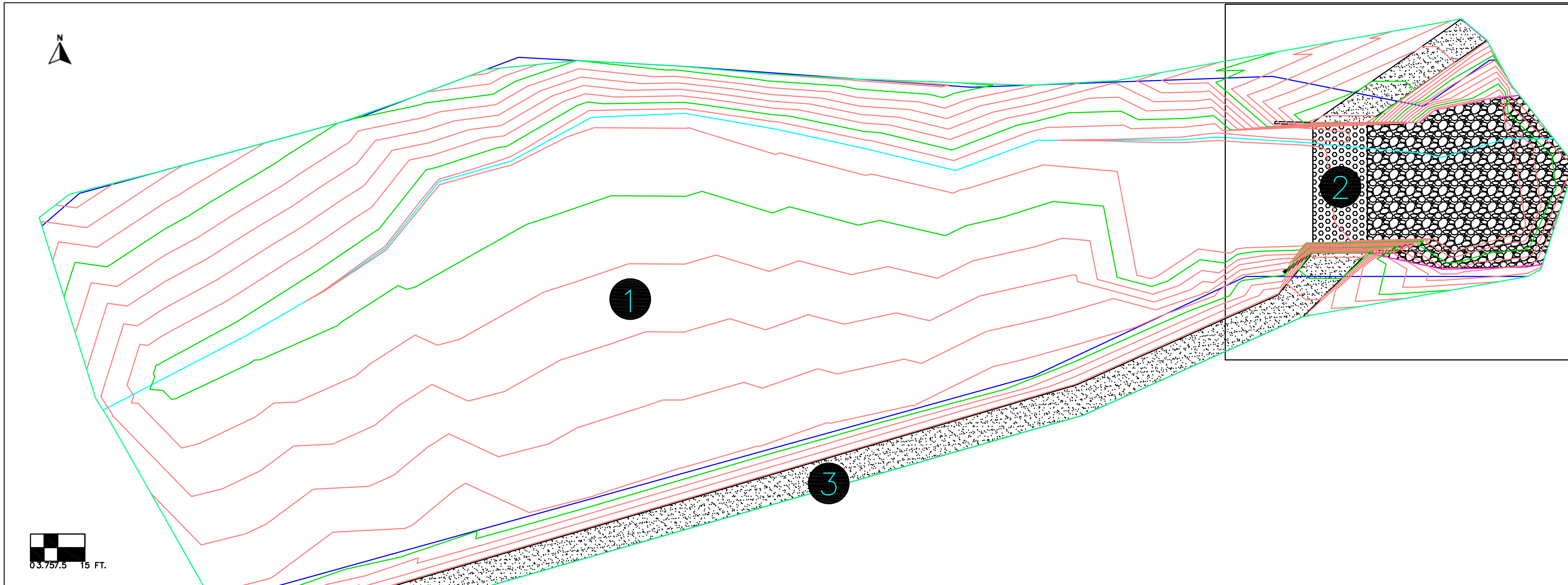
CLIENT: MARK LAMER

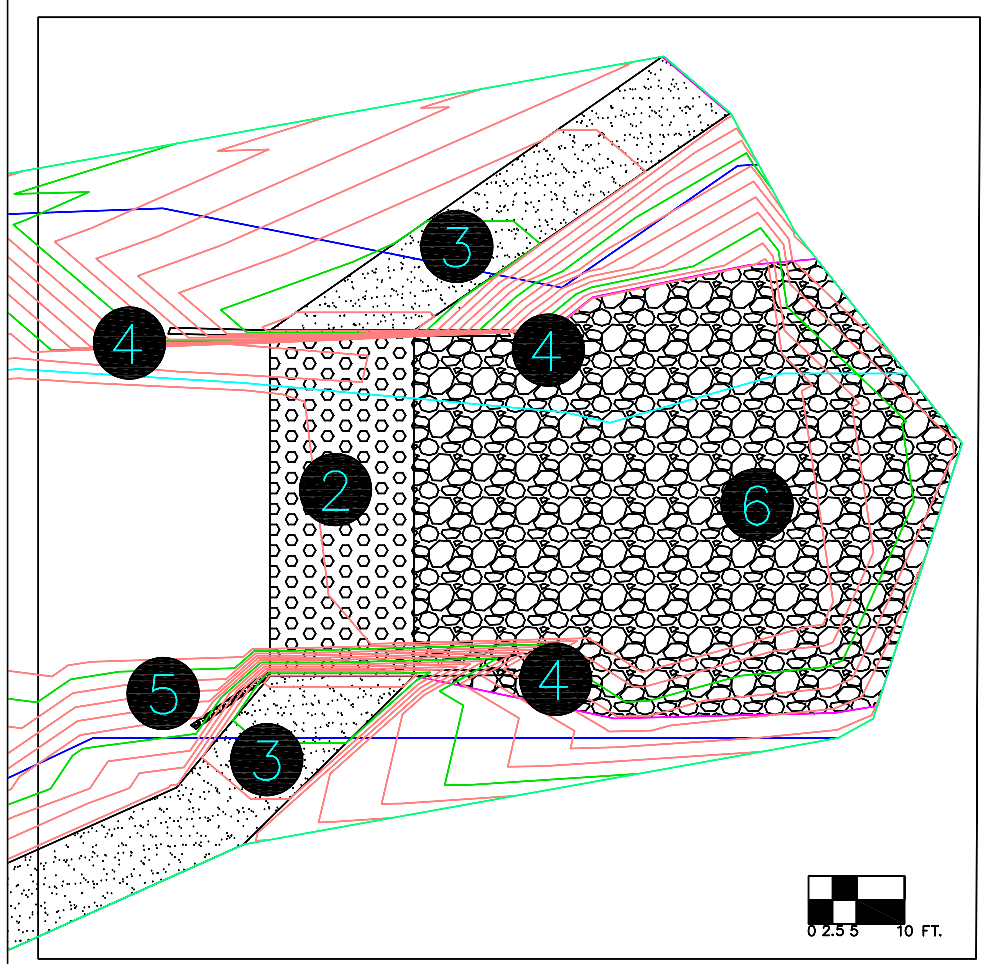
PROJECT: WASH RESTORATION

AUTHOR: S. SEYMOUR

DATE: 04/26/21

RED ROCK ENGINEERING





1. Any low points, besides the thalweg, in the channel bed upstream will need to be filled. Ensure dirt is compacted to specified level to reduce erosion.

2. Implement 3 barrel 3–Sided Culvert with safety railings and a 6” ¾ in. pea gravel cover. For more details see next sheet, Culvert Details.

3. Raise Flagstaff Urban Trial System to an elevation of 6864.4. Where trail angles to meet culvert/crossing, ensure an even slope is used. Ensure all dirt is compacted to specified level to reduce erosion.

4. Headwalls angled at 90 deg. from culvert opening, typ. For more details see next sheet, Culvert Details.

5. Angle headwall 126 deg. from culvert opening, to align with the ROB. For more details see next sheet, Culvert Details.

6. Install dumped rock rip rap along channel bed. Total length past culvert outlet is 104 feet. The median rip rap size is 11.5 inches.

SHEET 7 OF 9

SCALE: VARIES

REVISIONS

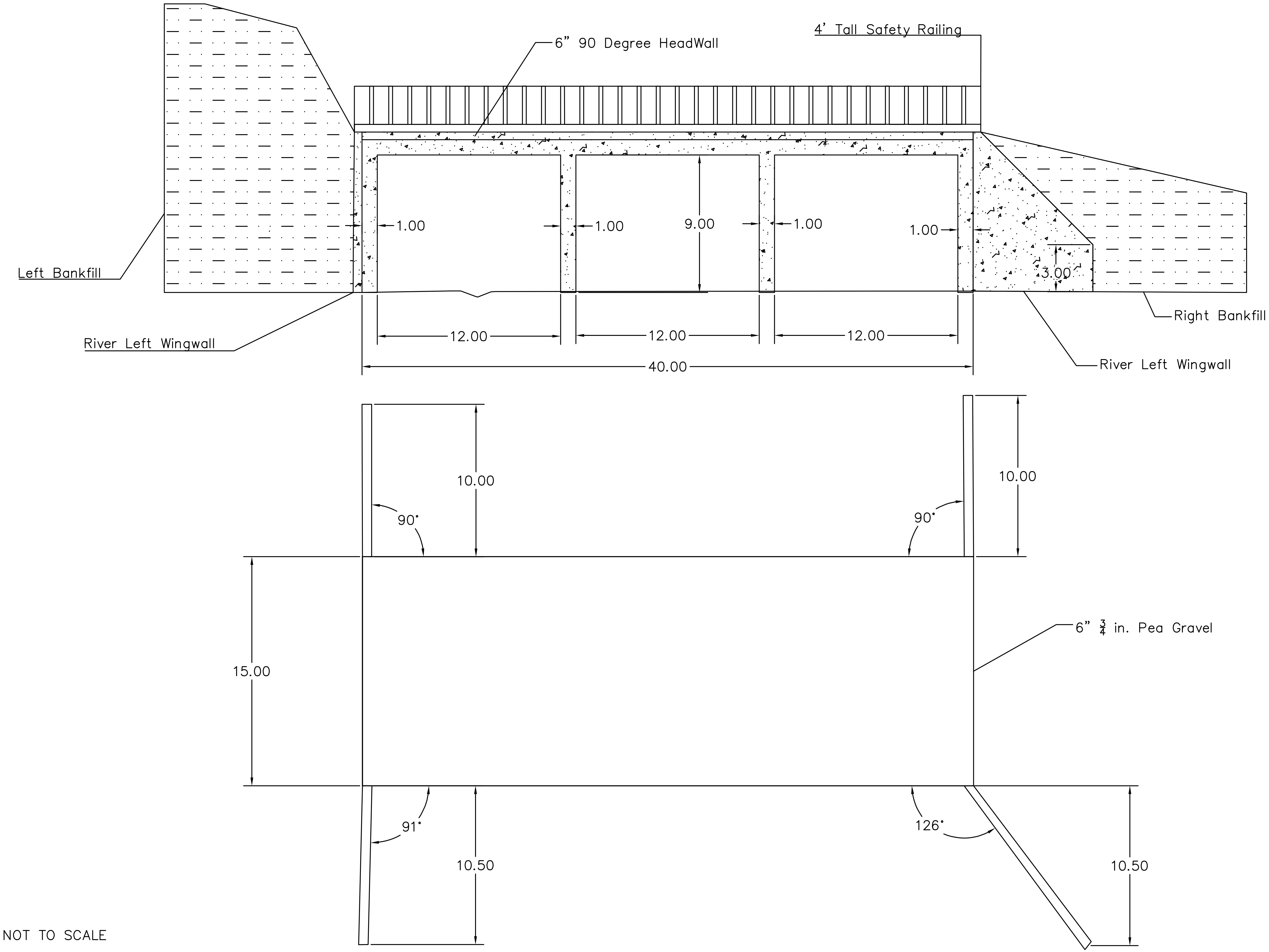
CLIENT: MARK LAMER

PROJECT: WASH RESTORATION

AUTHOR: S. SEYMOUR

DATE: 02/09/21

RED ROCK ENGINEERING



SHEET 8 OF 9

SCALE:N/A

REVISIONS		
ADDED ANNOTATIONS	4/21	JB
FINALSED SCALE	4/26	JB

CLIENT:MARK LAMER

PROJECT:WASH RESTORATION

AUTHOR:J. BRISCHKE

DATE:02/09/21

RED ROCK ENGINEERING

Keep native trees and bushes in area

Remove Ponderosa Pine trees

Remove noxious species with herbicide and hydroseed native grasses throughout area

SCALE:1" to 20'

0 5 10 20

REVISIONS

ADDED TREE POLYGONS	3/24	HF
ADJUSTED "KEEP" AREA	4/02	HF
ADDED DETAILS	4/21	HF

CLIENT:MARK LAMER

PROJECT:REVEGITATION PLAN

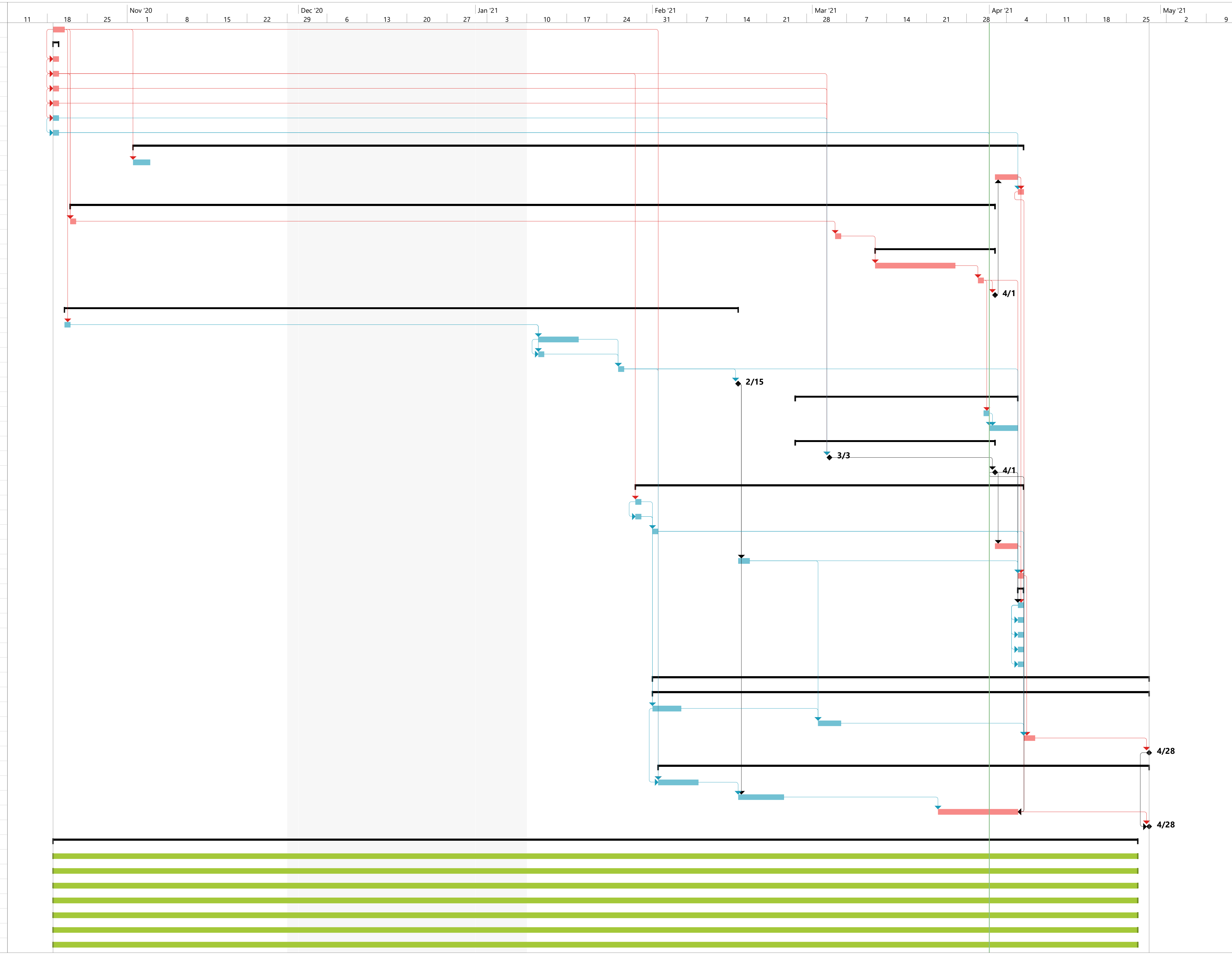
AUTHOR:HANNAH FISCHER

DATE:3/3/21

RED ROCK ENGINEERING

Appendix 61: Updated Project Schedule

ID	Task Name	Duration	Start	Finish
1	**Site Investigation**	2 days	Mon 10/19/20	Tue 10/20/20
2	**Previous Studies**	**1 day**	**Mon 10/19/20**	**Mon 10/19/20**
3	Feasibility Study	1 day	Mon 10/19/20	Mon 10/19/20
4	Surveying	1 day	Mon 10/19/20	Mon 10/19/20
5	Hydrologic	1 day	Mon 10/19/20	Mon 10/19/20
6	Hydraulic	1 day	Mon 10/19/20	Mon 10/19/20
7	Modeling	1 day	Mon 10/19/20	Mon 10/19/20
8	Geomorphologic Design	1 day	Mon 10/19/20	Mon 10/19/20
9	**Geomorphic Assessment**	**79 days**	**Mon 11/2/20**	**Tue 4/6/21**
10	Identify and Catalouge Instability Areas	3 days	Mon 11/2/20	Wed 11/4/20
11	Channel Conditions	2 days	Fri 4/2/21	Mon 4/5/21
12	Restoration Targets/Priorities	1 day	Tue 4/6/21	Tue 4/6/21
13	**Geotechnical Analysis**	**83 days**	**Thu 10/22/20**	**Thu 4/1/21**
14	Field Sampling Plan	1 day	Thu 10/22/20	Thu 10/22/20
15	Data Collection	1 day	Fri 3/5/21	Fri 3/5/21
16	**Sample Testing**	**15 days**	**Fri 3/12/21**	**Thu 4/1/21**
17	Sieve Analysis & Atterberge Limits	10 days	Fri 3/12/21	Thu 3/25/21
18	Soil Classification	1 day	Tue 3/30/21	Tue 3/30/21
19	Analysis	2 days	Wed 3/31/21	Thu 4/1/21
20	**Biological and Ecological Assessment**	**51 days**	**Wed 10/21/20**	**Mon 2/15/21**
21	Identify Surrounding Site Interactions	1 day	Wed 10/21/20	Wed 10/21/20
22	Exsisiting Flora Identification	5 days	Tue 1/12/21	Mon 1/18/21
23	Exsisting Fauna Identification	1 day	Tue 1/12/21	Tue 1/12/21
24	Invasive Species Abatement	1 day	Tue 1/26/21	Tue 1/26/21
25	Native Species Re-Vegitation Plan	4 days	Wed 2/10/21	Mon 2/15/21
26	**Open Channel Design**	**27 days**	**Fri 2/26/21**	**Mon 4/5/21**
27	Materials	1 day	Wed 3/31/21	Wed 3/31/21
28	Geomorphic Stability	3 days	Thu 4/1/21	Mon 4/5/21
29	**Hydraulics**	**25 days**	**Fri 2/26/21**	**Thu 4/1/21**
30	Culvert Master	4 days	Fri 2/26/21	Wed 3/3/21
31	HEC-RAS Analysis	14 days	Mon 3/15/21	Thu 4/1/21
32	**Plan Set**	**48 days**	**Fri 1/29/21**	**Tue 4/6/21**
33	Template	1 day	Fri 1/29/21	Fri 1/29/21
34	Cover Page	1 day	Fri 1/29/21	Fri 1/29/21
35	Construction Notes	1 day	Mon 2/1/21	Mon 2/1/21
36	Channel Plan, Profile, and Cross-Sections	2 days	Fri 4/2/21	Mon 4/5/21
37	Re-Vegitation Plan	2 days	Tue 2/16/21	Wed 2/17/21
38	Construction Details	1 day	Tue 4/6/21	Tue 4/6/21
39	**Project Impacts**	**1 day**	**Tue 4/6/21**	**Tue 4/6/21**
40	Regulatory	1 day	Tue 4/6/21	Tue 4/6/21
41	Health	1 day	Tue 4/6/21	Tue 4/6/21
42	Environmental	1 day	Tue 4/6/21	Tue 4/6/21
43	Economic	1 day	Tue 4/6/21	Tue 4/6/21
44	Social	1 day	Tue 4/6/21	Tue 4/6/21
45	**Project Deliverables**	**63 days**	**Mon 2/1/21**	**Wed 4/28/21**
46	**Client Deliverables**	**63 days**	**Mon 2/1/21**	**Wed 4/28/21**
47	30% Plan Set	5 days	Mon 2/1/21	Fri 2/5/21
48	60% Plan Set	4 days	Tue 3/2/21	Fri 3/5/21
49	90% Plan Set	2 days	Wed 4/7/21	Thu 4/8/21
50	Final Plan Set	5 days	Thu 4/22/21	Wed 4/28/21
51	**Course Deliverables**	**62 days**	**Tue 2/2/21**	**Wed 4/28/21**
52	30% Deliverables	5 days	Tue 2/2/21	Mon 2/8/21
53	60% Deliverables	6 days	Tue 2/16/21	Tue 2/23/21
54	90% Deliverables	10 days	Tue 3/23/21	Tue 4/6/21
55	Final Deliverables	2 days	Tue 4/27/21	Wed 4/28/21
56	**Project Management**	**103 days**	**Mon 10/19/20**	**Mon 4/26/21**
57	Client Meetingigs	103 days	Mon 10/19/20	Mon 4/26/21
58	Team meatings	103 days	Mon 10/19/20	Mon 4/26/21
59	Technical Advisor Meetings	103 days	Mon 10/19/20	Mon 4/26/21
60	Gradingin Instructor Meetings	103 days	Mon 10/19/20	Mon 4/26/21
61	Correspondence	103 days	Mon 10/19/20	Mon 4/26/21
62	Schedule Management	103 days	Mon 10/19/20	Mon 4/26/21
63	Resource Management	103 days	Mon 10/19/20	Mon 4/26/21

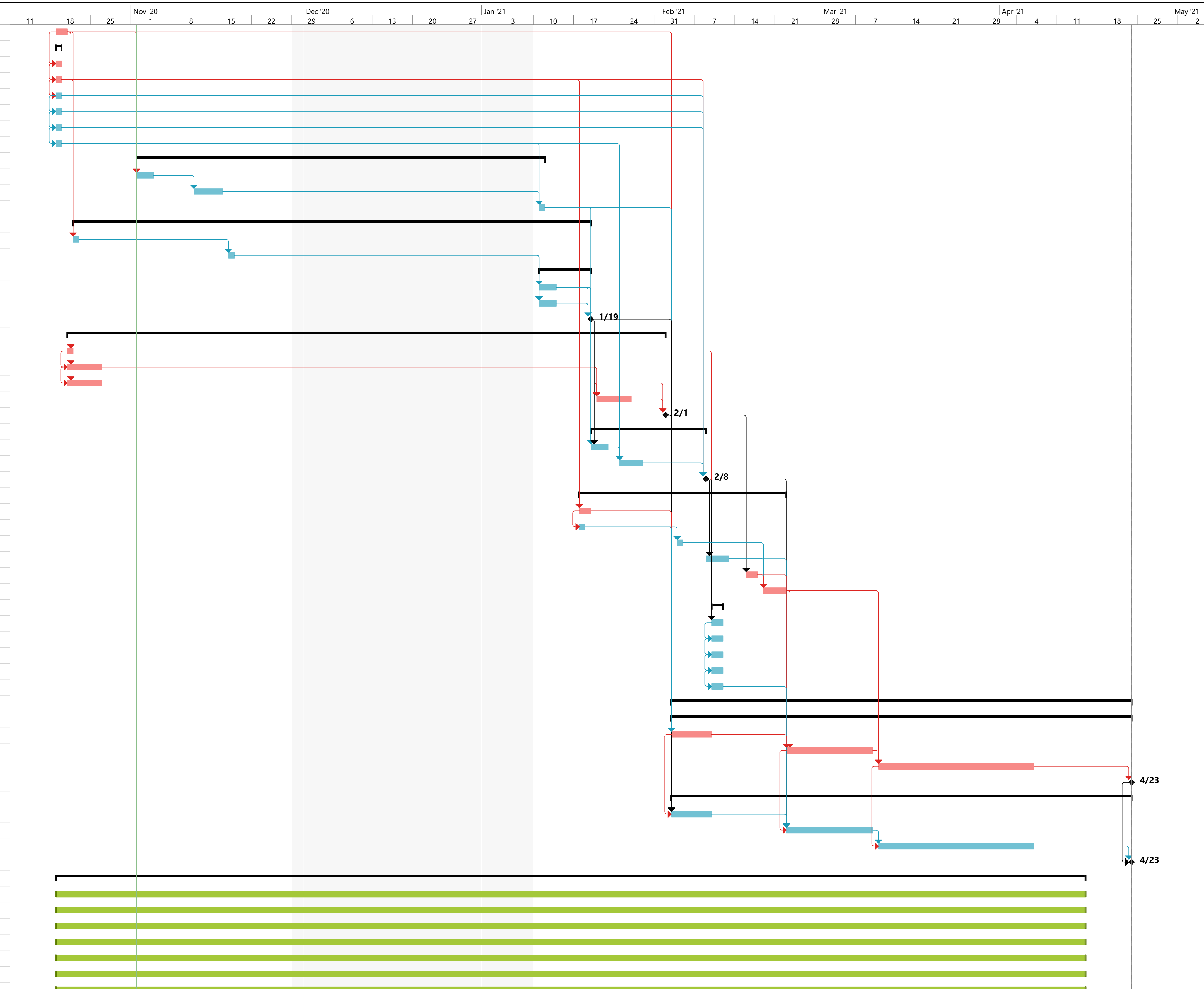


Project: Capstone Schedule - N
Date: Thu 4/1/21

Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone		Critical Split	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline		Progress	
Milestone	◆	Inactive Task		Manual Task		Manual Summary		External Tasks		Critical		Manual Progress	

Appendix 60: Proposed Schedule

ID	Task Mode	WBS	Task Name	Duration	Start	Finish
1		1	Site Investigation	2 days	Mon 10/19/20	Tue 10/20/20
2		**2**	**Previous Studies**	**1 day**	**Mon 10/19/20**	**Mon 10/19/20**
3		2.1	Feasibility Study	1 day	Mon 10/19/20	Mon 10/19/20
4		2.2	Surveying	1 day	Mon 10/19/20	Mon 10/19/20
5		2.3	Hydrologic	1 day	Mon 10/19/20	Mon 10/19/20
6		2.4	Hydraulic	1 day	Mon 10/19/20	Mon 10/19/20
7		2.5	Modeling	1 day	Mon 10/19/20	Mon 10/19/20
8		2.6	Geomorphologic Design	1 day	Mon 10/19/20	Mon 10/19/20
9		**3**	**Geomorphic Assessment**	**18 days**	**Mon 11/2/20**	**Mon 1/11/21**
10		3.1	Identify and Catalouge Instability Areas	3 days	Mon 11/2/20	Wed 11/4/20
11		3.2	Channel Conditions	3 days	Thu 11/12/20	Mon 11/16/20
12		3.3	Restoration Targets/Priorities	1 day	Mon 1/11/21	Mon 1/11/21
13		**4**	**Geotechnical Analysis**	**31 days**	**Thu 10/22/20**	**Tue 1/19/21**
14		4.1	Field Sampling Plan	1 day	Thu 10/22/20	Thu 10/22/20
15		4.2	Sample Collection	1 day	Wed 11/18/20	Wed 11/18/20
16		**4.3**	**Sample Testing**	**7 days**	**Mon 1/11/21**	**Tue 1/19/21**
17		4.3.1	Sieve Analysis	3 days	Mon 1/11/21	Wed 1/13/21
18		4.3.2	Soil Classification	3 days	Mon 1/11/21	Wed 1/13/21
19		4.3.3	Analysis	3 days	Fri 1/15/21	Tue 1/19/21
20		**5**	**Biological and Ecological Assessment**	**41 days**	**Wed 10/21/20**	**Mon 2/1/21**
21		5.1	Surrounding Interactions	1 day	Wed 10/21/20	Wed 10/21/20
22		5.2	Exsisting Flora Identification	4 days	Wed 10/21/20	Mon 10/26/20
23		5.3	Exsisting Fauna Identification	4 days	Wed 10/21/20	Mon 10/26/20
24		5.4	Invasive Species Abatement	4 days	Thu 1/21/21	Tue 1/26/21
25		5.5	Native Species Re-Vegitation Plan	4 days	Wed 1/27/21	Mon 2/1/21
26		**6**	**Open Channel Design**	**14 days**	**Wed 1/20/21**	**Mon 2/8/21**
27		6.1	Materials	3 days	Wed 1/20/21	Fri 1/22/21
28		6.2	Geomorphic Stability	4 days	Mon 1/25/21	Thu 1/28/21
29		6.3	Hydraulics	7 days	Fri 1/29/21	Mon 2/8/21
30		**7**	**Plan Set**	**26 days**	**Mon 1/18/21**	**Mon 2/22/21**
31		7.1	Template	2 days	Mon 1/18/21	Tue 1/19/21
32		7.2	Cover Page	1 day	Mon 1/18/21	Mon 1/18/21
33		7.3	Construction Notes	1 day	Thu 2/4/21	Thu 2/4/21
34		7.4	Channel Plan, Profile, and Cross-Sections	4 days	Tue 2/9/21	Fri 2/12/21
35		7.5	Re-Vegitation Plan	2 days	Tue 2/16/21	Wed 2/17/21
36		7.6	Construction Details	2 days	Fri 2/19/21	Mon 2/22/21
37		**8**	**Project Impacts**	**2 days**	**Wed 2/10/21**	**Thu 2/11/21**
38		8.1	Regulatory	2 days	Wed 2/10/21	Thu 2/11/21
39		8.2	Health	2 days	Wed 2/10/21	Thu 2/11/21
40		8.3	Environmental	2 days	Wed 2/10/21	Thu 2/11/21
41		8.4	Economic	2 days	Wed 2/10/21	Thu 2/11/21
42		8.5	Social	2 days	Wed 2/10/21	Thu 2/11/21
43		**9**	**Project Deliverables**	**58 days**	**Wed 2/3/21**	**Fri 4/23/21**
44		**9.1**	**Client Deliverables**	**58 days**	**Wed 2/3/21**	**Fri 4/23/21**
45		9.1.1	30% Plan Set	5 days	Wed 2/3/21	Tue 2/9/21
46		9.1.2	60% Plan Set	11 days	Tue 2/23/21	Tue 3/9/21
47		9.1.3	90% Plan Set	19 days	Thu 3/11/21	Tue 4/6/21
48		9.1.4	Final Plan Set	12 days	Thu 4/8/21	Fri 4/23/21
49		**9.2**	**Course Deliverables**	**58 days**	**Wed 2/3/21**	**Fri 4/23/21**
50		9.2.1	30% Deliverables	5 days	Wed 2/3/21	Tue 2/9/21
51		9.2.2	60% Deliverables	11 days	Tue 2/23/21	Tue 3/9/21
52		9.2.3	90% Deliverables	19 days	Thu 3/11/21	Tue 4/6/21
53		9.2.4	Final Deliverables	12 days	Thu 4/8/21	Fri 4/23/21
54		**10**	**Project Management**	**96 days**	**Mon 10/19/20**	**Thu 4/15/21**
55		10.1	Client Meetingigs	96 days	Mon 10/19/20	Thu 4/15/21
56		10.2	Team meatings	96 days	Mon 10/19/20	Thu 4/15/21
57		10.3	Technical Advisor Meetings	96 days	Mon 10/19/20	Thu 4/15/21
58		10.4	Gradingin Instructor Meetings	96 days	Mon 10/19/20	Thu 4/15/21
59		10.5	Correspondence	96 days	Mon 10/19/20	Thu 4/15/21
60		10.6	Schedule Management	96 days	Mon 10/19/20	Thu 4/15/21
61		10.7	Resource Management	96 days	Mon 10/19/20	Thu 4/15/21



Project: Capstone Schedule - N
Date: Mon 11/2/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Critical | Critical Split | Progress | Manual Progress

Appendix 62: Summary of Staffing Hours

POSITION		SENIOR EGR	PROJ EGR	LAB TECH	INTERN
HOURLY WAGE ($)		218.79	141.68	98.01	32.13
Σ DURATION (hour)		108	170	103	117
Σ COST ($)		$20,839.75	$25,785.76	$7,742.79	$4,690.98
TASK	**SCHEDULED DURATION (day)**	**BILLABLE DURATION (hours)**			
Task 1 – Site Investigation	2		**5**		
Task 2 – Previous Studies			**0.222**		**2.7**
Task 2.1 – Feasibility Study	1		0.037		0.45
Task 2.2 – Surveying	1		0.037		0.45
Task 2.3 – Hydrologic	1		0.037		0.45
Task 2.4 – Hydraulic	1		0.037		0.45
Task 2.5 – Modeling	1		0.037		0.45
Task 2.6 – Geomorphologic Design	1		0.037		0.45
Task 3 – Geomorphic Assessment		**0.6**	**7**	**0**	**1.3**
Task 3.1 – Identify and Catalogue Instability Areas	3		1		0.175
Task 3.2 – Channel Conditions	3		4		0.75
Task 3.3 – Restoration Targets and Priorities	1	0.6	2		0.375
Task 4 – Geotechnical		**3.72**	**0**	**81.75**	**9.29**
Task 4.1 – Field Sampling Plan	1	1.72		2	5
Task 4.2 - Data Colection				2	2
Task 4.2 – Sample Testing					
Task 4.2.1 – Sieve Analysis	4			41.25	
Task 4.2.2 – Soil Classification	3			36.5	
Task 4.3 – Analysis	3	2			2.29
Task 5 – Biological and Ecological Assessment		**1.75**	**15.75**	**0**	**5.25**
Task 5.1 – Identify Surrounding Site Interactions	1		2		
Task 5.2 – Existing Flora Identification	4		6		
Task 5.3 – Existing Fauna Identification	4		2		2
Task 5.4 – Invasive Species Abatement	4		2		1.25
Task 5.5 – Native Species Re-Vegetation Plan	4	1.75	3.75		2
POSITION		**SENIOR EGR**	**PROJ EGR**	**LAB TECH**	**INTERN**

Task 6 – Open Channel Design		**2**	**57**	**0**	**0**
Task 6.1 – Materials	3		5		
Task 6.2 – Geomorphic Stability	4		20		
Task 6.3 – Hydraulics					
Task 6.3.1 - Channel Analysis	4	1	20		
Task 6.3.2 - Culvert Analysis	3	1	12		
Task 7 – Plan Set		**1.65**	**9.32**	**0.55**	**5.48**
Task 7.1 – Template	2		0.75		1
Task 7.2 – Cover Page	1		0.75		1
Task 7.4 – Construction Notes	1		0.75		1
Task 7.5 – Channel Plan, Profile, and Cross-Sections	4	0.55	3		0.5
Task 7.6 – Re-Vegetation Plan	2	0.55	2		0.5
Task 7.7 – Construction Details	2	0.55	2.07	0.55	1.48
Task 8 – Project Impacts		**0.13**	**0**	**0**	**2.11**
Task 8.1 – Regulatory	2	0			0
Task 8.2 – Health	2	0			0
Task 8.3 – Environmental	2	0.1			0.75
Task 8.4 – Economic	2	0.015			0.75
Task 8.5 – Social	2	0.015			0.61
Task 9 – Project Deliverables		**25.47**	**36.55**	**4.43**	**52.05**
Task 10 – Project Management		**72.37**	**38.97**	**16.7**	**38.97**

Appendix 63: Billing Rate Breakdown for Personnel Work

Title Abreviations	**Position Title**	Base Pay ($/Hr)	Benefits % of base pay	Actual Pay	OH % of base pay	Actual Pay +Oh ($/hr)	Profit % of actual pay + OH	**Billing Rate ($/Hr)**
SEN.	**Senior Engineer**	$90.00	30%	$117.00	70%	$198.90	10%	**$218.79**
Eng. 1	**Engineer 1**	$70.00	60%	$112.00	15%	$128.80	10%	**$141.68**
LT	**Lab Tech**	$45.00	80%	$81.00	10%	$89.10	10%	**$98.01**
INT	**Intern**	$25.00	20%	$30.00	5%	$31.50	2%	**$32.13**