Appendix E.10. Technical Memoranda

TM001 – Design Criteria

TM002 – Hydrology

TM003 – Sedimentation

TM004 – Hydraulics

TM005 – Geotechnical

TM006 – Economics

TM007 – Design Drawings

TM008 – Probable Costs

TM009 – Hazard Classifications

TM001 – Design Criteria

1.0 Introduction

There are significant flooding issues in Sevier County in and around the Richfield City area. The proposed solutions to mitigate these issues involve the construction of several detention/debris basins, flood channels, and overflow structures. The feasibility of constructing debris basins at Flat Canyon, Lind Canyon, Tank Canyon, and Wood Canyon was evaluated. A smaller sediment/debris trap structure was also considered at the mouth of Wood Canyon. The project would also require existing flood channels to be improved and extended, as the channels would receive attenuated flood waters from other hydraulic structures. Table 1-1 summarizes the applicable design standards that were considered for design.

Table 1-1. Design Criteria Considered for Each Project Element

Design Criteria & Practice Standards	Flat, Lind, Tank, and Wood Canyons Debris Basins	Wood Canyon Sediment Control Basin	North Flood Channel	South Flood Channel
NRCS Technical Release 210-60 (TR-60)	X			
Sedimentation Design Criteria	X			
Earth Embankments Design Criteria	X			
Principal Spillway Design Criteria	X			
Auxiliary Spillway Design Criteria	X			
Utah Administrative Code R655	X			
R655-11-6: Embankment Requirements	X			
R655-11-7: Outlet Requirements	X			
R655-11-8 Spillway Requirements	X			
NRCS Conservation Practice Standard (CPS) Structure for Water Control (Code 587)			X	X
NRCS CPS Open Channel (Code 582)			X	X
NRCS CPS Water and Sediment Control Basin (Code 638)		X		
NRCS CPS Lined Waterway or Outlet (Code 468)			X	X

2.0 Design Criteria

2.1 NRCS Technical Release 210-60 (TR-60)

TR-60 (NRCS 2019) provides minimum requirements for planning and designing earth dams and associated spillways. TR-60 applies to "all low hazard potential dams with a product of effective storage times the effective height of the dam of 3,000 acre-feet^2 or more, dams more than 35 feet in effective height, and all significant and high hazard dams." This standard includes criteria on dam hazard classification, design storms, freeboard, sedimentation, drawdown, embankment, and spillways. The guidelines also reference other applicable standards and requirements not listed here.

2.2 Utah Administrative Code R655

The following rules are the Utah Dam Safety standards that are applicable for detention/debris basins that are also considered dams.

- Utah Administrative Code "R655-10: Dam Safety Classifications, Approval Procedures and Independent Reviews" outlines the procedures necessary to obtain approval to design, construct, operate, and remove a dam (UAC 2016a).
- Utah Administrative Code "R655-11: Requirements for the Design, Construction and Abandonment of Dams" outlines the minimum design requirements for dams constructed in Utah (UAC 2016b).
- Utah Administrative Code "R655-12: Requirements for Operational Dams" outlines the minimum operational requirements for dams (UAC 2016c).

2.3 NRCS National Engineering Handbook (NEH)

The National Engineering Handbook (NEH; NRCS 2010a) provides design criteria for a number of different engineering applications.

2.4 NRCS Conservation Practice Standards (CPS)

NRCS conservation practice standards contain information on why and where each practice is applied, and set forth the minimum planning criteria that must be met during the implementation of each practice in order for it to achieve its intended purposes. The following CPS are considered for this project

2.4.1 Structure for Water Control (Code 587)

CPS Code 587 (NRCS 2017a) provides the minimum design criteria for water management systems that control the stage, discharge, distribution, delivery, or direction of water flow. The proposed design contains several culverts and hydraulic structures such as overflow weirs, dump gates, and overshot structures.

2.4.2 Open Channel (Code 582)

CPS Code 582 provides the minimum design criteria for improvement, construction, and restoration of open channels (NRCS 2015). The proposed project contains two flood channels. Both flood channels

require improvement and restoration of their existing condition. New portions of these flood channels would also be constructed to improve flood management and water conveyance.

2.4.3 Water and Sediment Control Basin (Code 638)

CPS Code 638 provides the minimum design criteria for water and sediment control basins (NRCS 2017b). The purpose of these sediment basins is to trap sediment and reduce and manage runoff. The proposed design contains two sediment control basins to be located below Wood Canyon to trap sediment and reduce runoff into the Sevier Valley Canal.

2.4.4 Lined Waterway or Outlet (Code 468)

CPS Code 468 describes the minimum design criteria for lined waterways or outlets (NRCS 2010b). One purpose is to provide for safe conveyance of runoff from structures without causing erosion or flooding. The design considers armoring of flood channels to prevent erosion.

3.0 References

Natural Resources Conservation Service (NRCS). 2010a. National Engineering Handbook (NEH).

——. 2010b. Lined Waterway or Outlet 468. Natural Resources Conservation Service.

——. 2015. CPS Open Channel 582. September 2015.

——. 2017a. CPS Structure for Water Control (Code 587). October 2017.

——. 2017b. CPS Water and Sediment Control Basin (Code 638). October 2017.

——. 2019. Technical Release 210-60: Earth Dams and Reservoirs (TR-60).

Utah Administrative Code (UAC). 2016a. R655-10: Dam Safety Classifications, Approval Procedures and Independent Reviews.

——. 2016b. R655-11: Requirements for the Design, Construction and Abandonment of Dams.

——. 2016c. R655-12: Requirements for Operational Dams.

TM002 – Hydrology

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1.0 Design Storms

This hydrology analysis focuses primarily on Flat Canyon. This report summarizes the hydrology approach at large, but primarily focuses on the analysis related to sizing a debris basin for Flat Canyon. However, the hydrology for frequency storms used to complete the economics and sizing of improvements other than debris basins is also documented for Flat Canyons.

The design storms used for the analysis of the debris basin sites were developed to meet the requirements of the NRCS and Utah Dam Safety. Applicable guidelines include Earth Dams and Reservoirs – Technical Release 210-60 (TR-60; NRCS 2019a) and Utah Dam Safety Rules R655-10 and R655-11. The design criteria were also based on the dam structures being classified as high hazard, as recommended in *TM009 – Hazard Classification*.

1.1 Utah Dam Safety Criteria

Utah Dam Safety Rule R655-11-4 requires the development of storms following Hydrometeorological Report No. 49 (HMR-49; NOAA 1984) and two studies specifically for Utah, namely the “2002 Update for Probable Maximum Precipitation, Utah 72 Hour Estimates to 5,000 sq. mi. - March 2003" (USUL; Jensen 2003) and "Probable Maximum Precipitation Estimates for Short Duration, Small Area Storms in Utah - October 1995 " (USUS; Jensen 1995). The USUL and USUS studies were developed after HMR-49 to provide a better representation of actual conditions in Utah.

Precipitation depths developed from USUL and USUS are referred to as the Spillway Evaluation Precipitation (SEP) values, whereas those depths developed strictly following HMR-49 are referred to as the Probable Maximum Precipitation (PMP). Hydrographs developed from the SEP values are referred to as the Spillway Evaluation Flood (SEF), whereas hydrographs developed from the PMP values are referred to as the Probable Maximum Flood (PMF). It was never intended that the precipitation depths developed following USUL and USUS would exceed those developed following HMR-49. Therefore, only the lowest precipitation depths between the SEPs and PMPs were considered.

The final Inflow Design Hydrograph (IDF) is determined by routing the SEF and PMF storms through a given reservoir to determine the critical event. This critical event is then compared to the 100-year 6-hour storm and the 100-year 24-hour storm with a saturated subwatershed (Antecedent Moisture Condition III [AMC III]). The state rules also require that the 100-year storms must be routed with appropriate allowances for freeboard. The final controlling storm is then adopted as the Utah Dam Safety IDF.

Freeboard requirements include 1) routing the IDF, 2) containing the wave action (wave height, runup, and setup) during a 100-mph wind event, 3) routing the 100-year storm event with enough freeboard to contain wave action resulting from a 50-mph wind event and 4) a minimum normal freeboard of 3 feet. For the purposes of this analysis, a reasonably conservative freeboard residual was reserved by oversizing the emergency spillway with a minimum height of 7.5 feet and a corresponding width as needed to pass the required design storms. This conservative approach gives us an approximate size for a 30% design and has a relatively small impact on the design and construction cost. The final design would include a more detailed analysis of freeboard requirements.

The principal spillways for the debris basins will not be equipped with a valve or gate to ensure the spillway is always open and functional. The outlet pipe will be protected against clogging by installation of oversized trash/debris racks integrated into the outlet structure. Therefore, the principal spillways were modeled as open during all storm events with a starting water surface elevation at the estimated 100-year sediment elevation (see *TM003-Sedimentation* for additional information).

Two computer programs were obtained from Utah Dam Safety to aid in the calculation of the SEP and PMP values as well as develop the SEF and PMF hyetographs. The program input includes the latitude and longitude of each drainage basin centroid. The program output was verified by comparing to independent estimates calculated using USUS, USUL, and HMR-49.

The 100-year 6-hour and 100-year 24-hour AMC III storms were developed by using the NOAA Atlas 14 precipitation depths and applying them to the temporal distributions published in the same report (Bonnin et al. 2011). The second quartile median distributions were used for the General Precipitation Area. The 100-year storms were also applied to the Soil Conservation Service (SCS) Type II distribution based on the location of the subwatersheds within the United States. This was done for comparison purposes in determining a reasonably conservative design. The SCS Type II distribution typically results in a more conservative design due to a high rainfall volume in a short period of time.

1.2 NRCS Criteria

The FBH and ASH are developed following the most applicable references from the National Weather Service (NWS). These references include HMR-49 in estimating the PMP and PMF, which are used as the FBH. The USUL and USUS special probable maximum precipitation studies used by Utah Dam Safety in conjunction with HMR-49 have been accepted by the NRCS for the purposes of the FBH (letter of acceptance dated March 6, 2007). Therefore, by following the Utah Dam Safety criteria in evaluating the local short-duration storm and general long-duration storm, the FBH is also evaluated. It should also be noted that TR-60 requires the evaluation of 6-hour and 24-hour storms. The local short-duration storm and general long-duration storm per Utah Dam Safety standards have durations of 6 hours and 72 hours, respectively; therefore, to meet both NRCS and Utah Dam Safety requirements, the 6-hour, 24-hour, and 72-hour storms were evaluated using USUL and USUS. The critical SEF or PMF as applicable is adopted as the FBH.

The ASH is developed by applying an equation from TR-60 Figure 2-2 to estimate the precipitation depth and applying to a short duration storm distribution. For a high hazard dam, this precipitation equation is P100 + 0.26*(PMP-P100). Conservatively, the PMP values (rather than the SEP values) were used to estimate the precipitation depths for this storm. Hyetographs were developed for each subwatershed by applying the precipitation depths to the temporal distributions published by NOAA (Bonnin et al. 2011). The second quartile median distributions were used for the General Precipitation Area. Both a 6-hour and 24-hour duration ASH were developed for each subwatershed to evaluate the spillway capacity.

The PSH for a high hazard dam is a 100-year 10-day duration storm that must be passed through the principal spillway without initiating the auxiliary spillway. The precipitation depths for this storm were taken from NOAA Atlas 14 (Bonnin et al. 2011) and the distribution was developed following the procedures outlined in National Engineering Handbook – Design Hydrographs (Section 4, Chapter 21) (NRCS 2019b). This storm was routed through the debris basins with the starting elevation set at the 100-year sediment storage elevation (see *TM003-Sedimentation* for additional information).

The capacity of the emergency spillway was evaluated by routing the FBH with no residual freeboard and the ASH with freeboard. The minimum freeboard can be estimated following guidance found in Technical Release No. 69 – Riprap for Slope Protection against Wave Action (Soil Conservation Service 1983a). However, the analysis found that the debris basins are capable of passing the ASH with a freeboard in excess of 5 feet; therefore, for the purposes of this study and a 30% design, this was assumed to be adequate.

In addition to the design storms for the proposed debris basins, the economic analysis in *TM006-Economics* required the development of eight frequency storm events. The return intervals evaluated are the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year events.

Precipitation depths for these storms were taken from NOAA Atlas 14 (Bonnin et al. 2011) and applied to the SCS Type II distribution based on the location of the subwatersheds within the United States. The drainage basins for these storms were extended downstream of the proposed debris basins to critical infrastructure such as the culvert crossings on I-70.

1.3 Precipitation Depths

Precipitation depths for each of the storm events were estimated for the SEP and PMP by using the Utah Dam Safety programs discussed earlier based on the centroid location of each drainage basin. The precipitation depths for the remaining storms were estimated by calculating the average precipitation depth over each drainage basin. This was done by downloading the NOAA Atlas 14 precipitation raster data and calculating the average over each drainage basin area using ArcGIS. A summary of the precipitation depths used is shown in Table 1-1.

Table 1-1. Precipitation Depth Summary

Storm Distribution	Storm Duration	Flat Canyon
Local SEP	Local Short Duration Storms (6-hour)	4.37
Local PMP	Local Short Duration Storms (6-hour)	10.81
General SEP	General Long Duration Storms (24-hour)	8.51
General PMP	General Long Duration Storms (24-hour)	9.40
General SEP	General Long Duration Storms (72-hour)	10.25
General PMP	General Long Duration Storms (72-hour)	14.36
10-year	6-hour storms	NA
100-year	6-hour storms	2.08
2-year	24-hour storms	1.30
5-year	24-hour storms	1.59
10-year	24-hour storms	1.83
25-year	24-hour storms	2.16
50-year	24-hour storms	2.43
100-year	24-hour storms	2.70
200-year	24-hour storms	2.86
500-year	24-hour storms	3.36
100-year	10-day storms	4.57

As shown in Table 1-1, the precipitation depth for the Local SEP is significantly smaller for Flat Canyon compared to the other storms. The reason for this is the aerial adjustment factor, which is based on the watershed size. This factor is applied automatically within the Utah Dam Safety computer program mentioned previously. As shown in Table 2-1, Flat Canyon has a larger watershed, resulting in a larger aerial reduction.

2.0 Hydrologic Modeling Parameter Estimates

Hydrologic modeling parameters were estimated for each of the subwatersheds as described below. In accordance with TR-60, the SCS Curve Number and SCS Unit Hydrograph methods were used in the model.

2.1 Subwatershed Topographic Characteristics

The best available LIDAR surface was obtained from the Utah Automated Geographic Reference Center (AGRC). This surface was utilized to determine the drainage basin boundaries, elevations, slopes, and longest watercourse lengths. The drainage basin boundaries are shown on the exhibit in Attachment A.

Note that the exhibit includes two drainage basin boundaries for Flat Canyon, with the larger drainage basin in the upper subwatershed to the mouth of the drainage, and the smaller drainage basin just downstream to features such as canals and major culverts. These areas were shown separately in order to estimate flows at different locations to support the sizing of improvements such as debris basins and channels, as well as different parts of the analysis that account for the larger area (e.g., economics analysis). For simplicity in presenting the analysis, only the larger upper subwatershed hydrology is presented below, focusing on the debris basin locations. The smaller downstream subwatersheds are shown to demonstrate how the subwatersheds were expanded slightly to include downstream areas as needed for the analysis. Table 2-1 presents a summary of the basin topography information for the subwatersheds draining to the mouth of each drainage.

Table 2-1. Watershed Topographic Characteristics

Parameter	Flat Canyon
Drainage basin area (square miles)	16.5
Longest watercourse length (miles)	9.1
Average drainage basin slope (%)	37.6

2.2 Hydrologic Soil-Cover Complexes and SCS Curve Numbers

The spatially distributed hydrologic soils data was obtained from the local USDA soils scientist. Soil data from the NRCS Web Soil Survey website was also reviewed and found to agree with this data where overlapping occurred; however, the soil data available through the Web Soil Survey was not as complete and detailed as the data provided by the local USDA office. Therefore, the more complete soil data set from the USDA soils scientist was used, which shows the Hydrologic Soil Group (HSG) ratings that range from A to D, with the majority of the subwatersheds being characterized with a HSG of B and D at 24% and 74% total subwatershed area, respectively.

Aerial imagery, field visits, and photographs were reviewed to characterize the land cover types of the subwatershed areas according to the tables found in Part 630 in the National Engineering Handbook (NEH), Chapter 9, Hydrologic Soil-Cover Complexes (NRCS 2004). The majority of the land cover in the subwatersheds consists of sage-grass and pinyon-juniper vegetative types with varying hydrologic conditions. Note that the hydrologic conditions account for the condition of the land cover itself and the percentage of ground cover. Most of the land cover types were assigned as poor or fair condition, with the exception of a relatively small portion that was assumed to be in good condition based aerial imagery and field visits. The exhibit in Attachment A shows the spatial distribution of each combination of land cover type and soil group within the study area.

Based on the HSGs, land cover types, and land cover hydrologic conditions, SCS curve number (CN) values for an antecedent moisture condition type II (AMC II) were selected based on Table 9-2 of the NEH (NRCS

2004). A summary of CNII values is provided in Table 2-2. The exhibit in Attachment A shows the spatial distribution of the soil-cover complexes and resulting CNII values.

Table 2-2. Summary of AMC II SCS Curve Numbers

Cover Type	Hydrologic Condition	Hydrologic Soil Group A	Hydrologic Soil Group B	Hydrologic Soil Group C	Hydrologic Soil Group D
Pinyon-juniper	Poor	69*	75	85	89
Pinyon-juniper	Fair	48*	58	73	80
Pinyon-juniper	Good	28*	41	61	71
Sage-grass	Poor	59*	67	80	85
Sage-grass	Fair	42*	51	63	70
Sage-grass	Good	26*	35	47	55

* CN_{II} values for soil group A have not been developed; therefore, CN numbers were extrapolated and found to match the trends of other soil-land cover complexes.

The area weighted average CN_{II} for each drainage basin was calculated. The saturated soil condition or antecedent moisture condition III (AMC III) area weighted CN (CN_{III}) was also calculated for each drainage basin using the following equation:

$$CN_{III} = \frac{23 * CN_{II}}{10 + 0.13 * CN_{II}}$$

The area weighted CN_{II} and CN_{III} values for each drainage basin are summarized Table 2-3.

Table 2-3. Area Weighted SCS Curve Numbers

Subwatershed	CN_{II}	CN_{III}
Flat Canyon	68.5	83.3

2.3 Initial Abstraction

The initial abstraction was estimated following the SCS methodology outlined in the National Engineering Handbook (NRCS 2004). The equations to estimate the initial abstraction only require a basin's CN number. See this reference for more detail on the equations and methodology. Table 2-4 shows the initial abstractions that were used in design.

Table 2-4. Initial Abstraction

Subwatershed	Ia – CN II (in)	Ia – CN III (in)
Flat Canyon	0.92	0.40

2.4 Lag Time

The lag times (Lg) for each the subwatersheds were estimated following two different methods for comparison from Chapter 15 – Time of Concentration of the NEH (NRCS 2010), namely, the velocity method and the subwatershed lag method. The velocity method consists of flow path segments broken up into sheet flow, shallow concentrated flow, and opened channel flow. Each segment requires the length and slope as well as the land cover type, flow type, and typical open channel geometry depending on the segment type. The watershed lag method uses an empirical equation that requires the subwatershed's watercourse length, average basin slope, CN, and area. These parameters were delineated and estimated

using topographic data, aerial imagery, and field visits. See the reference for these methods for further information on the equations and methodologies. Note that they both account for the land cover type and slope of each watershed. The estimated lag times for this study are shown in Table 2-5. The time of concentration velocity along the flow path for each lag time ranged from approximately 4 to 7 feet per second. The velocity method is considered more accurate due to the more detailed input required and is reasonably conservative in comparison with the estimates using the watershed lag method; therefore, the velocity method estimates were used for all hydrology.

Table 2-5. Estimated Lag Times using the SCS Velocity and Subwatershed Lag Methods

Subwatershed	Velocity Method (hr)	Subwatershed Lag Method (hr)
Flat Canyon	1.35	1.60

2.5 Transform Method

The SCS unit hydrograph was selected as the transform method for all hydrology as recommended and discussed in Chapter 16 – Hydrographs of the NEH (NRCS 2007). One variable of the SCS unit hydrograph is the Peak Rate Factor (PRF), which is generally adjusted depending on the steepness of a given watershed and to calibrate hydrology models. PRFs can range from 100 for a relativity flat watershed to 600 for a steep watershed. Given the watershed slopes of this study, the standard PRF of 484 was considered a reasonably conservative estimate where it is on the higher range of PRF values.

3.0 Hydrologic Modeling

The U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS, version 4.3) was used for all modeling. This model was used to estimate flows for the design and economic storms as well as to route the design storm hydrographs and size the proposed debris basin.

3.1 Hydrologic Model Input

The hydrology parameters discussed previously were input into the model. The model included the drainage basins as well as the debris basin to allow for the routing of hydrographs.

3.1.1 Sedimentation

TR-60 (NRCS 2019a) and Section 3 – Sedimentation of the NEH (SCS 1983b) discuss the need to account for sediment accumulation in debris basins. These guidelines recommend that storage is reserved for sediment accumulation over the design life of a dam, typically between 50 and 100 years. A 100-year sediment storage volume was accounted for in the hydrologic model by determining the height of the sediment volume and setting the model start elevation and principal spillway height at the sediment height. In this way, the bottom portion of the reservoir is modeled as full of sediment. For more information on how the sediment volumes were estimated, see *TM003-Sedimentation*. The 100-year sediment volumes and heights are shown in Table 3-1.

Table 3-1. Debris Basin Geometric Parameters

Metrics	Flat Canyon
Volume at emergency spillway crest (acre-feet)	827
Volume at dam crest (acre-feet)	1120
100-year sediment volume (acre-feet)	359

Metrics	Flat Canyon
100-year water storage volume (acre-feet)	468
Depth* to emergency spillway crest (feet)	55.0
Depth* to dam crest (feet)	65.0
Depth* to 100-year sediment volume (feet)	34.7
Elevation (NAVD 88) of bottom of debris basin (feet)	5544
Elevation (NAVD 88) of emergency spillway crest (feet)	5599
Elevation (NAVD 88) of dam crest (feet)	5609
Elevation (NAVD 88) of 100-year sediment (feet)	5578.7

• Depths are relative to upstream toe of dam to represent true depth of sediment or water.

3.1.2 Stage-Storage-Discharge Relationships

A stage-storage relationship for the proposed debris basin was developed using AutoCAD and is included in Attachment B. The parameters for the principal and emergency spillways of the proposed debris basin were input directly into the hydrologic model. For the 30% design, a simple orifice element was used to simulate the principal spillway outlet, and a broad-crested weir was used to simulate the emergency spillway. The emergency spillway height for Flat Canyon was set at 10 feet with a width of 40 feet to accommodate high flows. A summary of the proposed debris basin volumes, depths, and elevations is provided in Table 3-1.

3.2 Hydrologic Modeling Results

The Utah Dam Safety SEP and 100-year design storms, as well as the NRCS FBH, ASH, and PSH storms, were routed through the proposed debris basin to determine the critical event. The 6-hour local SEP controlled the design of all Utah Dam Safety storms and was therefore adopted as the IDF. The IDF was also adopted as the NRCS FBH. The 100-year storm with an AMC II condition and the PSH were used to size the principal spillway based on the criteria that the emergency spillway should not be engaged during these events and the downstream peak flow cannot exceed the limiting capacities discussed previously. The controlling storms and corresponding flows and depths are shown in Table 3-2. The minimum sizes for the principal spillway conduit and auxiliary spillway dimensions are shown in Table 3-3.

Table 3-2. Hydrologic Modeling Results for the Controlling Design Storms

Metrics	Controlling Storm	Flat Canyon
Peak inflow (cfs)	IDF/FBH (6-hour SEF)	6826.5
Peak outflow (cfs)	IDF/FBH (6-hour SEF)	3666.5
Peak water surface depth (feet)*	IDF/FBH (6-hour SEF)	64.5
Freeboard to dam crest (feet)	IDF/FBH (6-hour SEF)	0.5
Peak inflow (cfs)	100-year 24-hour (NOAA Distribution)	519.8
Peak outflow (cfs)	100-year 24-hour (NOAA Distribution)	178.3
Peak water surface depth (feet)*	100-year 24-hour (NOAA Distribution)	46.4

Metrics	Controlling Storm	Flat Canyon
Freeboard to emergency spillway crest (feet)	100-year 24-hour (NOAA Distribution)	8.6
Peak inflow (cfs)	100-year 24-hour (SCS Distribution)	1145.3
Peak outflow (cfs)	100-year 24-hour (SCS Distribution)	182.2
Peak water surface depth (feet)*	100-year 24-hour (SCS Distribution)	46.9
Freeboard to emergency spillway crest (feet)	100-year 24-hour (SCS Distribution)	8.1
Peak inflow (cfs)	PSH (10-day)	605.4
Peak outflow (cfs)	PSH (10-day)	232.7
Peak water surface depth (feet)*	PSH (10-day)	54.6
Freeboard to emergency spillway crest (feet)	PSH (10-day)	0.4

*Depths are relative to upstream toe of dam to represent true depth of sediment or water.

Table 3-3. Minimum Required Spillway Sizing

Spillway	Parameter	Flat Canyon
Principal	Inner Diameter (inches)	43.9
Auxiliary	Side Slope (H:V)	2:1
Auxiliary	Crest Length (feet)	40
Auxiliary	Depth (feet)	10

The modeling results show that the proposed design of the debris basin is sufficient in reducing peak flows from the 100-year storm to limiting downstream capacities.

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Attachment A. Hydrology Analysis Map

- Proposed Project Locations
- I-70 Culvert Crossings
- Canals
- Streams
- Watersheds
- Municipal Boundaries

Curve Number (Land Cover Type | Hydrologic Condition | Hydrologic Soil Group)

- 41 (Pinyon-juniper | Good | B)
- 47 (Sage-grass | Good | C)
- 51 (Sage-grass | Fair | B)
- 59 (Sage-grass | Poor | A)
- 61 (Pinyon-juniper | Good | C)
- 67 (Sage-grass | Poor | B)
- 70 (Sage-grass | Fair | D)
- 71 (Pinyon-juniper | Good | D)
- 75 (Pinyon-juniper | Poor | B)
- 80 (Pinyon-juniper | Fair | D)
- 85 (Sage-grass | Poor | D)
- 89 (Pinyon-juniper | Poor | D)

MILLARD COUNTY
SEVIER COUNTY

Wood Canyon
Wood Canyon - Lower
Wood Canyon WASCOBs
Wood Canyon I-70 Point of Discharge
Flat Canyon
Flat Canyon I-70 Point of Discharge
Flat Canyon - Lower
Flat Canyon Basin
Richfield
Annabella
Central Valley
Elsinore
Sevier Valley Canal
Elsinore Canal
Richfield Canal
Sevier River
119
120
118
258
70

N

0 0.5 1 Miles

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Sevier County

Sevier County Watershed Plan
Hydrology Analysis Map

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Hydrology_Overview

Project Number: 1804-224 | Drawn by: JWW 05-19 | Last Edit: 10/23/2024

Sevier County

Scale: 1" = 1 Miles

1

Attachment B. Hydrologic Model Input & Output

Stage-Storage Data for Flat Canyon Debris Basin

Depth (feet)	Elevation (feet)	Area (square feet)	Area (acre)	Incremental Volume (acre-feet)	Notes
0	5544	0	0.00	0.00	
2	5546	27,877.11	0.64	0.43	
4	5548	75,121.37	1.72	2.70	
6	5550	125,670.55	2.89	7.26	
8	5552	181,702.83	4.17	14.28	
10	5554	234,716.81	5.39	23.81	
12	5556	285,297.41	6.55	35.73	
14	5558	340,293.45	7.81	50.08	
16	5560	402,195.06	9.23	67.10	
18	5562	460,235.97	10.57	86.89	
20	5564	514,540.12	11.81	109.25	
22	5566	576,980.57	13.25	134.30	
24	5568	647,091.49	14.86	162.38	
26	5570	720,005.31	16.53	193.75	
28	5572	794,140.34	18.23	228.50	
30	5574	829,210.46	19.04	265.76	
32	5576	852,177.91	19.56	304.36	
34	5578	873,181.03	20.05	343.97	
36	5580	895,359.06	20.55	384.57	
38	5582	918,288.07	21.08	426.20	
40	5584	942,032.35	21.63	468.91	
42	5586	966,035.79	22.18	512.71	
44	5588	990,196.90	22.73	557.62	
46	5590	1,016,351.51	23.33	603.68	
48	5592	1,044,974.46	23.99	651.00	
50	5594	1,075,802.17	24.70	699.69	
52	5596	1,105,807.93	25.39	749.74	
54	5598	1,144,474.02	26.27	801.40	
55	5599	1,077,772.09	24.74	826.90	Spillway Crest
56	5600	1,183,644.92	27.17	854.84	
58	5602	1,225,793.02	28.14	910.15	
60	5604	1,267,024.99	29.09	967.38	
62	5606	1,311,388.83	30.11	1026.56	
64	5608	1,360,593.36	31.24	1087.90	
65	5609	1,397,243.86	32.08	1119.56	Dam Crest

Attachment C. Hydrographs

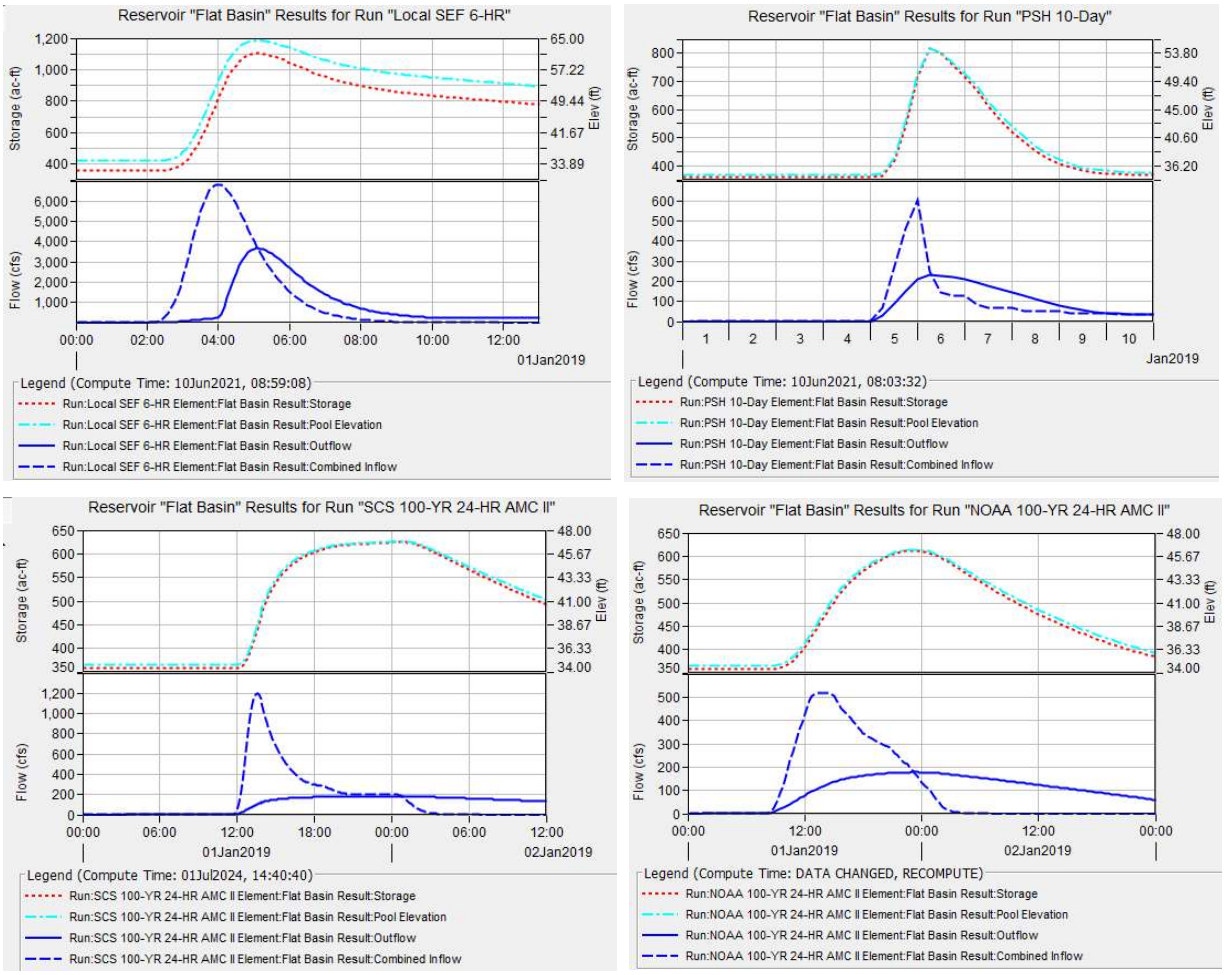

Figure C-1. Flat Canyon Hydrology Model Controlling Hydrographs

TM003 – Sedimentation

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1.0 Introduction

A sedimentation analysis was completed to predict the sediment loads resulting from the subwatersheds considered in the Watershed Plan. These sediment load rates were used in estimating sediment load volumes over time for debris basins and other hydraulic structures proposed in the Watershed Plan. In the late 1980s, two debris basins were constructed as part of a flood control project at the outlets of Dairy Canyon and Cottonwood Canyon. These basins are contiguous with the other subwatersheds being studied as part of the Watershed Plan and have been in operation and collected sediment for more than 30 years. While there are many methods that can be used to determine sedimentation rates, measured field data is considered the most reliable. Based on this assumption, all other methods were calibrated to the measured data. Four separate methods were used to estimate sedimentation rates for each subwatershed:

1. Observed data (measured data from Dairy Canyon and Cottonwood Canyon)
2. U.S. Department of Agriculture (USDA) mapped sedimentation rates for the State of Utah from 1973
3. Pacific Southwest Inter-Agency Committee (PSIAC) Method
4. Rangeland Hydrology and Erosion Model Web Tool (RHEM) Method

Each of these methods is discussed in the following sections. Attachment A shows a map with each subwatershed that was analyzed.

2.0 Observed Data

The sediment rates for the two existing debris basins (Dairy Canyon and Cottonwood Canyon) were calculated using the existing sediment elevations and stage-storage curves. LIDAR data collected in 2018 was used to obtain the elevations; the LIDAR data was collected by FEMA and was provided through the Utah Automated Geographic Reference Center (AGRC 2018). Table 2-1 shows the sediment pool elevation, depth of sediment, volume of sediment, operation life, average sediment deposition rates, and sedimentation yield rates.

Table 2-1. Observed Sedimentation Data

Basin	Existing elevation of sediment (feet)	Depth of sediment (feet)	Volume of sediment (acre-feet)	Operation life (years)	Deposition rate (acre-feet/year)	Yield rate (acre-feet/ mile^2/year)
Dairy Canyon	5473.3	9.3	23.0	32	0.72	0.38
Cottonwood Canyon	5431.7	5.7	113.0	32	3.53	0.17

Based on conversations with Richfield City and Sevier County, there has been no sediment removal from the Dairy Canyon basin. The Cottonwood Canyon basin has had some material removed in the past; however, based on feedback from Richfield City and others, the amount of sediment removed was relatively small. It has been assumed that the removal of the sediment was negligible and within the typical margin of error expected with this type of analysis. Figure 2-1 and Figure 2-2 show the sediment levels for both debris basins in relation to the outlets. The stage-storage curves that were used to determine volumes can be found in Attachment B.

Figure 2-1. Dairy Canyon debris basin outlet with sediment level

Figure 2-2. Cottonwood Canyon debris basin outlet with sediment level

2.1 USDA Sedimentation Map

The 1973 USDA map of sedimentation rates in Utah was referenced to determine the yield class for each subwatershed. Most subwatersheds did not fall within a single yield class, so an area-weighted yield rate was determined for each subwatershed. The average value for each yield class shown on the USDA map was used. The estimated sediment yield rates for each subwatershed are shown in Table 2-2. The USDA sedimentation map is included in Attachment C. Due to the nature of the data, this method was not calibrated using the observed data.

Table 2-2. Sedimentation Yield Rate Estimates based on USDA Sedimentation Map

Subwatershed	Subwatershed area (mile^2)	Yield rate (acre-feet/ mile^2/year)	Deposition rate (acre-feet/year)
Dairy Canyon	1.9	0.70	1.31
Cottonwood Canyon	20.7	0.21	4.32
Flat Canyon	16.4	0.41	6.75

2.2 PSIAC Sediment Yield Method

The Pacific Southwest Inter-Agency Committee (PSIAC) method for estimating sediment yield is based on a combination of nine physical factors affecting sedimentation in a subwatershed (PSIAC 1968). These factors have ranges according to various physical characteristics of the subwatershed and were estimated based on site visits, LIDAR data, soil data from USDA soil scientist, and land cover data (AGRC 2018, USGS 2018). The sum of these factors has an associated sedimentation rate that is based on several studies in which sedimentation rates were measured. Factor values for each of the subwatersheds are provided in Table 2-3. Physical factors such as channel erosion and sediment transport and upland erosion were calibrated within a reasonable range based on the observed data. After calibration, the results were found to be similar to the observed data approach. Attachment D shows the model output for each of the subwatersheds and a more detailed definition of each factor.

Table 2-3. PSIAC Method Sediment Yield Factors and Ratings

Factor	Rating Range	Dairy Canyon	Cottonwood Canyon	Flat Canyon
Surface Geology	0-5	4	3	3
Soils	0-10	8	3	3
Climate	0-10	4	4	4
Runoff	0-10	5	5	5
Topography	0-10	10	10	10
Ground Cover	-10-10	-7	-7	-7
Land Use	-10-10	-9	-9	-7
Upland Erosion	0-25	20	6	10
Channel Erosion and Sediment Transport	0-25	7	5	5

2.3 RHEM Model

The Rangeland Hydrology and Erosion Model Web Tool (RHEM; available at https://dss.tucson.ars.ag.gov/rhem/) is an event-based model that predicts soil loss according to relationships developed specifically for rangeland (Hernandez 2017, Nearing et al. 2011). Parameters used in the RHEM model for the subwatersheds are provided in

Table 2-4. Several of the subwatersheds were divided into smaller watershed basins for calculation purposes.

Table 2-4. RHEM Method Parameter Values

RHEM Parameters	Dairy Canyon	Cottonwood Canyon	Flat Canyon
Climate Station	Ferron	Bryce Canyon Natl PK	Koosharem
Rainfall (in)	8.19	15.12	9.06
Dominant Soil Texture Class	Sandy Loam	Sandy Loam	Sandy Clay Loam
Slope Shape	Uniform	Uniform	Uniform
Slope (ft/ft)	39.1	40.0	37.49
Cover- Bunchgrass	9%	9%	11%
Cover- Forbs/Annuals	5%	5%	5%
Cover- Shrubs	15%	15%	18%
Cover- Sod Grass	0%	0%	0%
Cover- Basal Plant Cover	9%	9%	10%
Cover- Rock Cover	15%	15%	16%
Cover- Litter Cover	30%	30%	29%
Cover- Biological Crust Cover	0%	0%	0%

The parameters used for each subwatershed were estimated based on a combination of site visits, LIDAR data, soil data from USDA soil scientist, land cover data, satellite imagery, and environmental surveys (AGRC 2018, USGS 2018). The online RHEM model uses existing climate stations to obtain rainfall data. In accordance with the RHEM model Tutorial Guide, climate stations with similar elevations to the average elevation of each subwatershed were used (Hernandez et al. 2016) to better obtain representative rainfall values based on elevation rather than site proximity.

The RHEM method was calibrated based on the results obtained from the observed data approach. In relation to other methods, the RHEM method has relatively few parameters to use in calibration. The rainfall and soil texture parameters are not suitable for calibration because any changes in these parameters produce a drastic change in the final model results. The cover characteristics were obtained by an environmental survey of the area, and the resulting values were used for both the PSIAC and RHEM methods. To remain consistent across methods, the cover characteristic parameters were not adjusted.

As a result, only the slope parameter was used to calibrate the model. While the initial values for slope were obtained from LIDAR, these values represented an average slope over the entire subwatershed. The equations used in the RHEM model are based on channel slopes rather than overland flow slopes. The final values used were adjusted within a reasonable range of channel slopes to produce a result similar to the observed data method.

2.4 Design Sedimentation Rate

The estimated sedimentation rates are summarized in Table 2-5. While the USDA Sedimentation Map is generally acceptable for broad-scale estimates of sedimentation rates, it is not recommended for specific sites, but rather for quick conservative estimates. After calibration, the RHEM method and the PSIAC method yielded results that were similar to observed data. However, the PSIAC method produced

sedimentation rates with a lowest percent error of 3 percent and 0 percent for Dairy Canyon and Cottonwood Canyon, respectively.

Table 2-5. Summary of Sediment Yield Rates

Subwatershed	Area (mile^2)	Method	Sedimentation rate (acre-feet/ mile^2/year)	Deposition rate (acre-feet /year)	100 years of sediment (acre-feet)
Dairy Canyon	1.9	USDA Sedimentation Map	0.70	1.33	133
		PSIAC	0.37	0.70	70
		RHEM	0.37	0.70	70
		Observed Data	0.38	0.72	72
Cottonwood Canyon	20.7	USDA Sedimentation Map	0.21	4.32	432
		PSIAC	0.17	3.53	353
		RHEM	0.19	3.94	394
		Observed Data	0.17	3.53	353
Flat Canyon	17.1	USDA Sedimentation Map	0.40	6.81	681
		PSIAC	0.21	3.59	359
		RHEM	0.25	4.28	428

The sedimentation rates obtained from the PSIAC method were considered the most reliable and the method selected for further use in the Watershed Plan. This selection is principally due to the method having been calibrated to yield results similar to the real-time observed data. The final design sedimentation rates for each basin are presented in Table 2-6. Attachment A shows an overview map of each subwatershed with each corresponding sedimentation rate and loading rate indicated.

Table 2-6. Final Design Sedimentation Yield Rate Estimates based on PSIAC Method

Subwatershed	Sediment rate (acre-feet/ mile^2/year)	Deposition rate (acre-feet/year)	100 years of sediment (acre-feet)
Flat Canyon	0.21	3.59	359

3.0 References

Automated Geographic Reference Center (AGRC). 2018. Utah Automated Geographic Reference Center. https://gis.utah.gov/data/. Accessed 10-23-2019.

Nearing, M.A., H. Wei, J. J. Stone, F. B. Pierson, K. E. Spaeth, M. A. Weltz, D. C. Flanagan, and M. Hernandez. 2011. A Rangeland Hydrology and Erosion Model. Transactions of the American Society of Agricultural and Biological Engineers (ASABE) 54:3.

Hernandez, M., M. A. Nearing, M. A. Weltz, K. E. Spaeth, G. Armendariz, F. B. Pierson, C. J. Williams, O. Z. Al-Hamdan, S. K. Nouwakpo, and C. Green. 2016. Rangeland Hydrology and Erosion Model Tutorial Guide: Desert Southwest Grassland, Limy Slopes 12-16" PZ Ecological Site. United States Department of Agriculture, Agricultural Research Service, Southwest Watershed Research Center, Tucson, Arizona, General Technical Report 1, March 2016. 26 p.

Hernandez, M., M.A. Nearing, O. Z. Al-Hamdan, F. B. Pierson, G. Armendariz, M. A. Weltz, K. E. Spaeth, C. J. Williams, S. K. Nouwakpo, D. C. Goodrich, C. L. Unkrich, M. H. Nichols, and C. D. Holifield Collins. 2017. The Rangeland Hydrology and Erosion Model: A Dynamic Approach for Predicting Soil Loss on Rangelands. American Geophysical Union.

Pacific Southwest Inter-agency Committee (PSIAC). 1968. Report of the Water Management Subcommittee on Factors Affecting Sediment Yield in the Pacific Southwest Area and Selection and Evaluation of Measures for Reduction of Erosion and Sediment Yield.

U.S. Geological Survey (USGS). 2018. National Land Cover Database. https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects. Accessed 10-23-2019.

Attachment A. Sedimentation Analysis Overview Map

Canals
Streams
Watersheds
Municipal Boundaries
Sedimentation Rate (Ac-Ft per Year per Sq Mi)
0.15
0.17
0.21
0.38

MILLARD COUNTY
SEVIER COUNTY

Wood Canyon
0.44Acre-ft
per Year

Cottonwood
Canyon
Calculated
3.53Acre-ft
per Year

Cottonwood Canyon Debris Basin
Built in 1987 (32-years old)
Existing Sediment Depth of 5.7 feet

Dairy Canyon Debris Basin
Built in 1987 (32-years old)
Existing Sediment Depth of 9.3 feet

Dairy Canyon
Calculated
0.72Acre-ft
per Year

Flat Canyon
3.59Acre-ft
per Year

70
119
120
118
258
Richfield
Richfield Canal
Sevier Valley Canal
Elsinore Canal
Sevier River
Annabella
Central
Valley
Elsinore

N
0 0.5 1 Miles

Jones & DeMille Engineering
- Shaping the Quality of Life -
800.748.5275 www.jonesanddemille.com

Sevier County

Sevier County Watershed Plan
Sedimentation Analysis Overview Map

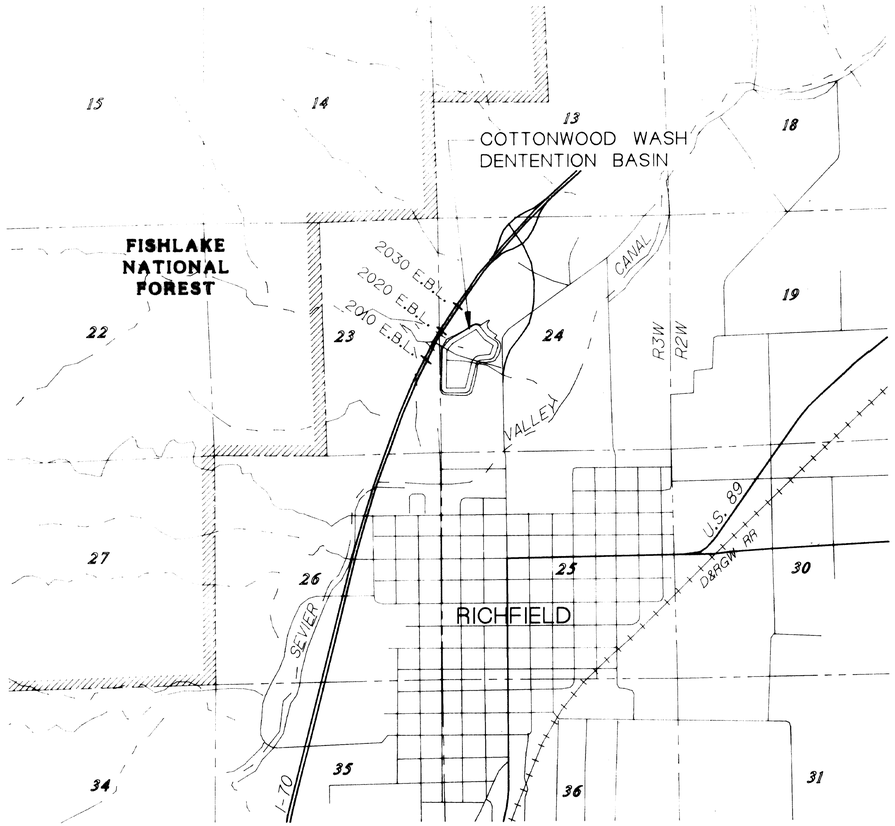
Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Sedimentation_Analysis
Project Number: 1804-224 | Drawn by: JWW 05-19 | Last Edit: 10/23/2024

Sevier County
Scale: 1" = 1 Miles
1

Attachment B. Debris Basin Drawings

COTTONWOOD WASH DETENTION BASIN

DRAWING NO. RF-1



INDEX TO SHEETS

SHEET No.	DESCRIPTION
1	TITLE SHEET & INDEX TO SHEETS
2 & 2A	TYPICAL SECTIONS
3	SUMMARY SHEET
4	PLAN SHEET
5	OUTLET PIPE DETAILS
6	INLET STRUCTURE
7	OUTLET STRUCTURE
8	OUTLET ENERGY DISSIPATING STRUCTURE
9 & 10	IRRIGATION DIVERSION STRUCTURE
11 & 12	STEEL SCHEDULE
13 & 14	IRRIGATION DITCH PLAN AND PROFILE

GENERAL NOTES

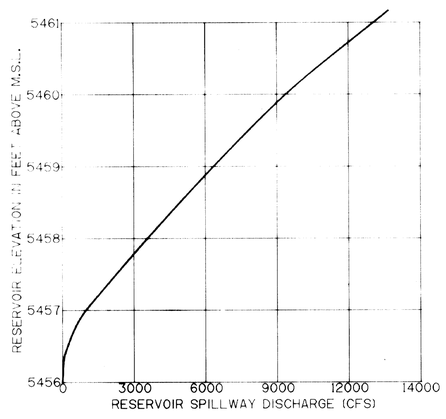
MATERIALS, CONSTRUCTION, AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, EDITION OF 1979, AND SUPPLEMENTS THERETO WHICH ARE IN EFFECT ON THE DATE OF REQUEST FOR BIDS.

ALL REINFORCING STEEL SHALL BE DEFORMED BILLET-STEEL BARS CONFORMING TO ASTM DESIGNATION A615, GRADE 60.

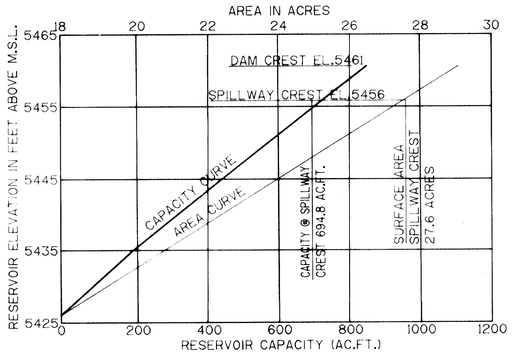
TYPE II CEMENT (LOW ALKALI) REQUIRED.

ALL STRUCTURAL STEEL SHALL BE STRUCTURAL CARBON STEEL CONFORMING TO AASHTO DESIGNATION M-183 (ASTM A36).

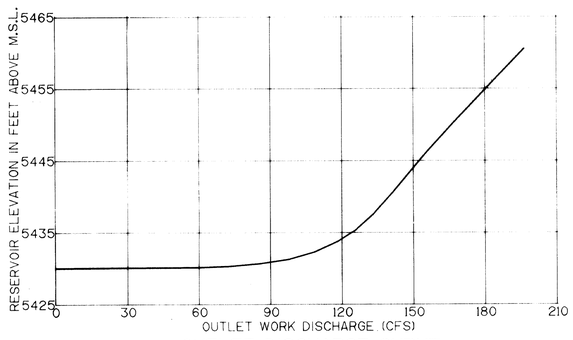
ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123.



SPILLWAY DISCHARGE CURVE



CAPACITY & AREA CURVES



OUTLET DISCHARGE CURVE

APPROVAL

IN ACCORDANCE WITH S 73-5-5, UTAH CODE ANNOTED 1953, AS AMENDED, APPROVAL IS HEREBY GIVEN FOR THE CONSTRUCTION OF THE COTTONWOOD WASH DETENTION BASIN NEAR RICHFIELD, UTAH.

Robert D. Morgan 2-20-86
UTAH STATE ENGINEER DATE

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE CONSTRUCTION OF THE COTTONWOOD WASH DETENTION BASIN WERE PREPARED BY ME FOR RICHFIELD CITY, UTAH.

R. Stone Cramer 2/21/86
ENGINEER DATE

PROFESSIONAL LICENSE NO. 4678

PROJECT NUMBERS
I-70-1(24)40
& F-069(7)

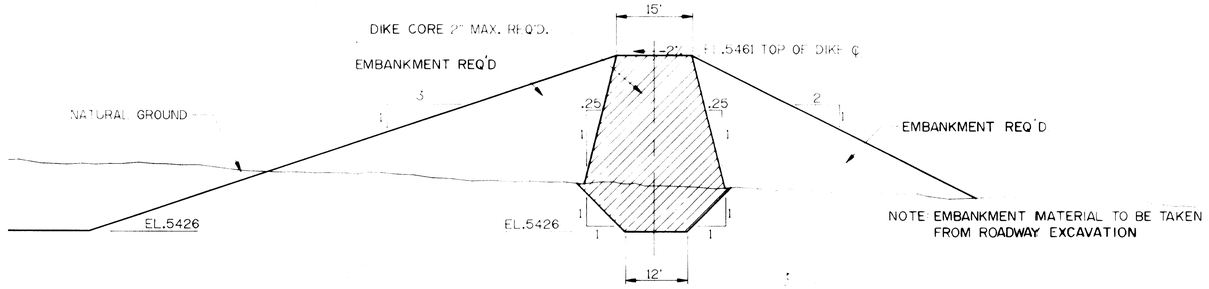
COTTONWOOD WASH
DETENTION BASIN
TITLE SHEET

DREAMER & REESE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN		NONE
APPROVED	DATE	DRAWING NO.	
	2/86	RF-1	
REVISION	DATE	SHEET NO.	
		UT 644	1

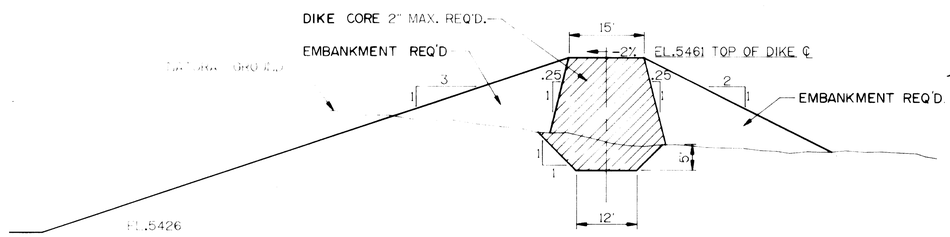
Title

TYPICAL SECTIONS



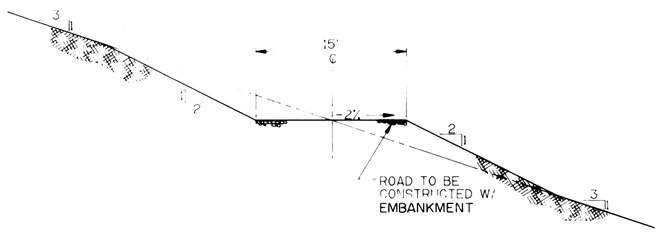
TYPICAL SECTION #1

DIKE FILL HEIGHT OVER 10 FEET



TYPICAL SECTION #2

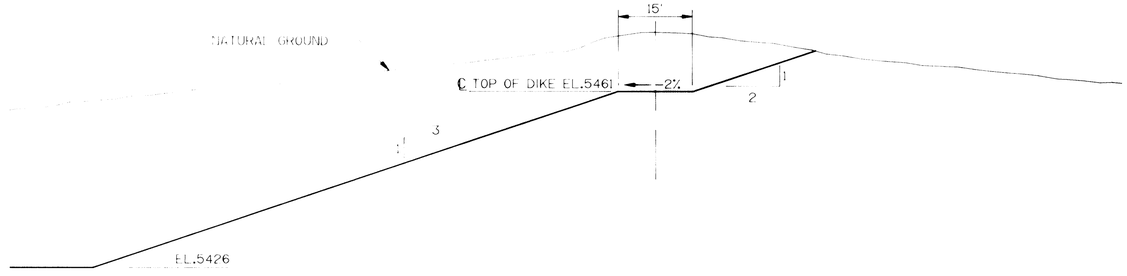
DIKE FILL HEIGHT UNDER 10 FEET



TYPICAL SECTION

ACCESS ROAD
INSIDE OF BASIN
DIKE BEGINS AT ℄ DIKE
STA. 15+00

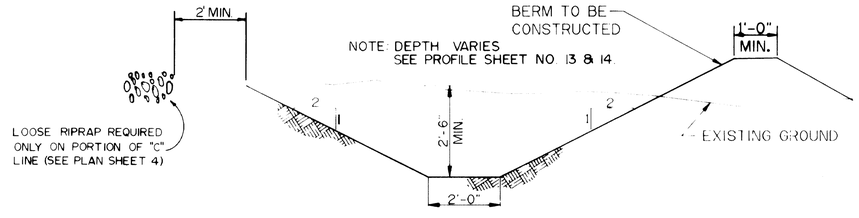
NOTE: MAINTAIN DITCH A MINIMUM OF 5' (ft.) FROM TOE OF DIKE.



TYPICAL SECTION #3

DIKE IN CUT

NOTE: BERM TO BE CONSTRUCTED ON LOWER SIDE OF DITCH



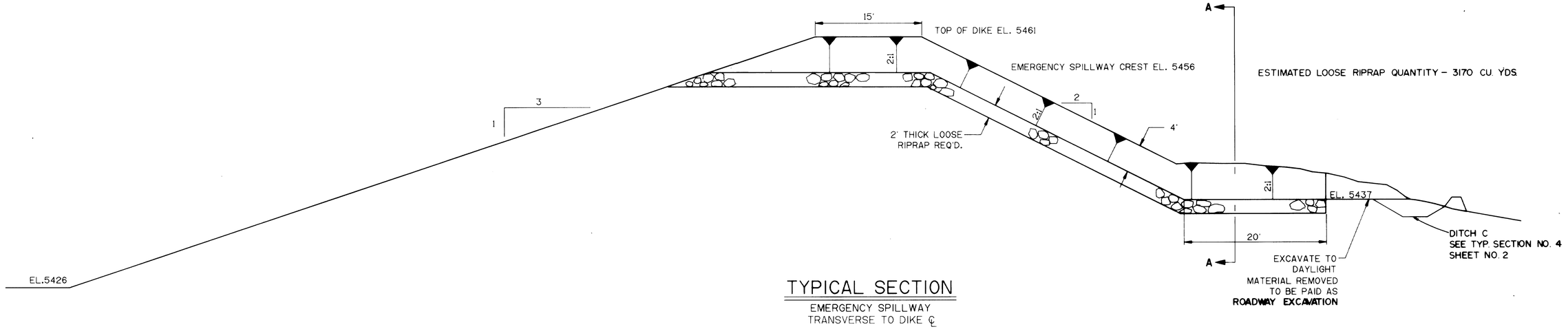
TYPICAL SECTION #4

SMALL DITCH EXCAVATION
(IRRIGATION DITCH)
DITCHES A, B, & C

PROJECT NUMBERS I-70-I(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN** TYPICAL SECTIONS	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG	CHECKED KRN	DRAWN LOB/AKB	SCALE NONE
			APPROVED	DATE	DRAWING NO. RF-1	
			REVISION	DATE	SHEET NO. 2	

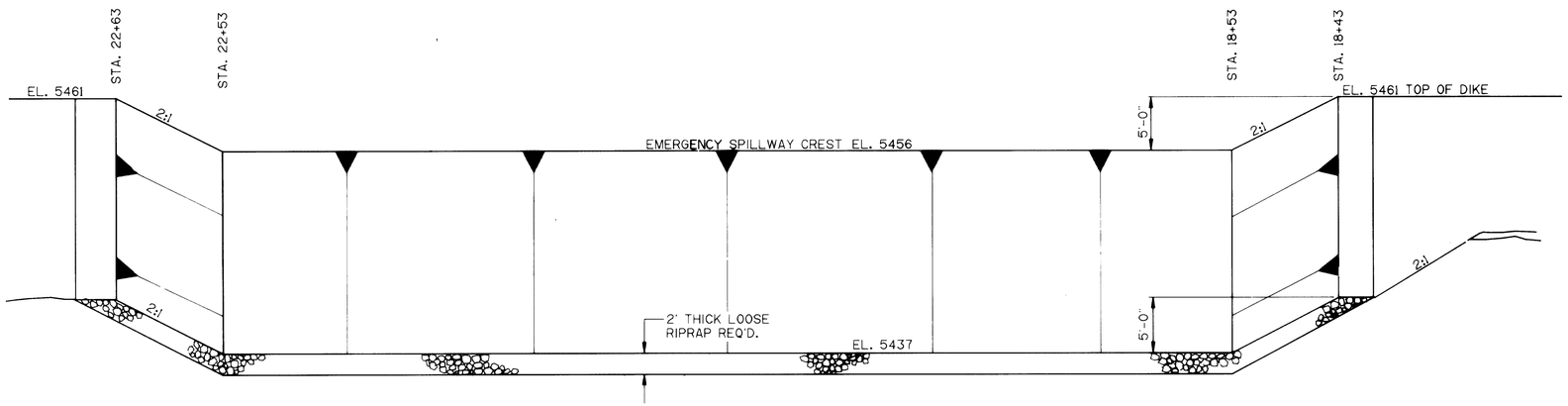
Typscc

TYPICAL SECTIONS



TYPICAL SECTION

EMERGENCY SPILLWAY
TRANSVERSE TO DIKE ℄



SECTION A-A

PROJECT NUMBERS I-70-1(24)40 & F-069(7)	**COTTONWOOD WASH** **DETENTION BASIN** TYPICAL SECTIONS	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN LOB/AKB / SCALE NONE APPROVED / DATE / DRAWING NO. RF-1 REVISION / DATE / SHEET NO. 2A

SUMMARY OF ITEMS

CODE	ITEM	UNIT	QUANTITY
	ROADWAY EXCAVATION	CU.YD.	117,400
	DIKE CORE 2" MAX.	CU.YD.	~~81,403~~ 81,852 ~~86,272~~
	CONCRETE CLASS AA(AE)	CU.YD.	729.719 ~~750~~
	CONCRETE SMALL STRUCTURES CLASS AA(AE)	CU.YD.	6.356 ~~7~~
	REINFORCING STEEL	LB.	~~81,852~~ ~~70,300~~
	TRASHRACK / MANHOLE	LUMP	~~1~~ 1
	42" REINFORCED CONCRETE PIPE	LN.FT.	850
	LOOSE RIP RAP	CU.YD.	4057.90 ~~4,100~~
	SMALL DITCH EXCAVATION	CU.YD.	1098.9 ~~5,900~~
	~~30" PIPE CULVERT~~	~~LN.FT.~~	~~120~~
	6' CHAIN LINK FENCE TYPE I	LN.FT.	144.8 ~~22~~
	GRANULAR FILTER MATERIAL	CU.YD.	490.24 ~~500~~
	BRACED POST (9' METAL)	EACH	17 ~~3~~
	~~30" CORRUGATED METAL PIPE~~	~~LN.FT.~~	~~30~~

EARTHWORK SUMMARY

LANES OR LINE	FROM STATION	TO STATION	DIKE QUANTITIES EMBANKMENT CUBIC YDS.	DIKE QUANTITIES DIKE CORE 2" MAX. CUBIC YDS.	COMPACTION FACTOR	EMBANKMENT X FACTOR CUBIC YDS.	DIKE CORE 2" MAX. X FACTOR CUBIC YDS.	ROADWAY EXCAVATION	REMARKS
℄ DIKE	10+00	17+56.10	632	1,719	1.1	695	1,891		
	17+56.10	24+24.11	10,608	18,224		11,669	20,046		
	24+24.11	27+85.56	18,928	10,783		20,821	11,861		
	27+85.56	31+50.35	20,956	10,518		23,052	11,570		
	31+50.35	38+96.60	27,986	23,203		30,784	25,524		
	38+96.60	44+99.90	22,810	18,642		25,091	20,507		
	44+99.90	55+12.95	4,807	12,183		5,288	13,401		
	55+12.95	57+46	0	0					
TOTAL								951,400	TOTAL EXCAVATION FROM DETENTION BASIN
F-069(7)								- 51,532	TRANSFER TO SHT. RC-3B
I-70-I(24)40								- 677,668	TRANSFER TO SHT. 3B
								- 104,800	2" DIKE CORE MATERIAL (SEE SPECIAL PROVISION)
		TOTAL	106,727	~~86,272~~		117,400	104,800	117,400	
		USE		81,852 ~~86,272~~				117,400	

NOTE: TOTAL EXCAVATION FROM BASIN SHALL BE A MINIMUN OF 951,400 CU.YD.

SUMMARY OF STRUCTURAL ITEMS

ITEM	UNIT	QUANTITY
CONCRETE CLASS AA(AE)	CU.YD.	729.719 ~~750~~
CONCRETE SMALL STRUCTURES CLASS AA(AE)	CU.YD.	6.356 ~~7~~
REINFORCING STEEL	LB.	~~81,852~~ ~~70,300~~
TRASHRACK / MANHOLE	LUMP	~~1~~ 1

MISCELLANEOUS SUMMARY

DESCRIPTION	UNIT	QUANTITY	REMARKS	CONST. SOURCE REFER. BOOK	PAGE
LOOSE RIP RAP	CU.YD.	4057.90 ~~4,100~~		35	60
SMALL DITCH EXCAVATION	CU.YD.	1098.9 ~~5,900~~			
42" REINFORCED CONCRETE PIPE	LN.FT.	850			
~~30" PIPE CULVERT~~	~~LN.FT.~~	~~120~~			
6' CHAIN LINK FENCE TYPE I	LN.FT.	144.8 ~~22~~		101	70,78
GRANULAR FILTER MATERIAL	CU.YD.	490.24 ~~500~~		35	57,58
BRACED POST (9' METAL)	EACH	17 ~~3~~		101	70,78
~~30" CORRUGATED METAL PIPE~~	~~LN.FT.~~	~~30~~			

PROJECT NUMBERS
I-70-I(24)40
& F-069(7)

COTTONWOOD WASH
DETENTION BASIN

SUMMARY SHEET

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED BEG	CHECKED KRN	DRAWN DRL	SCALE NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION R.O.	DATE 8-22-86	SHEET NO.	3

CURVE DATA

MK	RAD.	ARC.	CRD.	TAN.
1	205.76	59.58	59.37	30.00
2	118.46	168.41	154.59	102.00
3	238.82	75.37	75.06	38.00
4	122.53	166.54	154.01	99.00
5	113.26	125.40	119.09	70.00
6	115.70	139.99	131.60	80.00
7	122.36	160.31	149.09	94.00
8	121.47	194.29	184.23	125.00
9	145.80	105.19	102.92	55.00

NOTE:
FOR DRILL HOLE LOGS SEE SHEET NO. 5

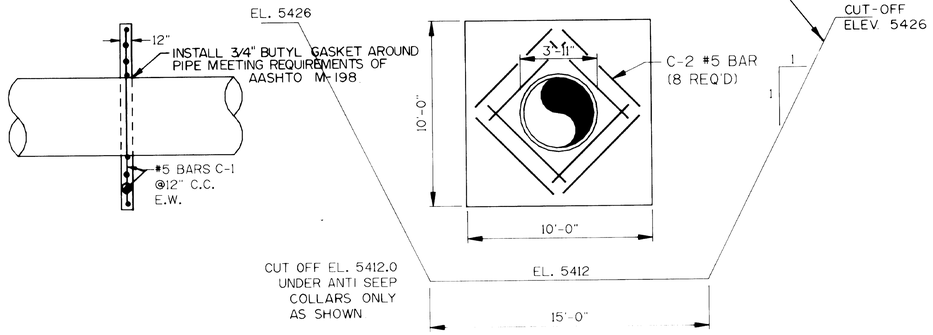
EXISTING POWER POLES
SMALL DITCH EXCAVATION LINE "B" REQ'D. SEE SHEET NO. 14
54" PIPE
PT 18+40.31
30 LN.FT. 60" PIPE CULVERT REQ'D.
CONC. DITCH
EMERGENCY SPILLWAY SEE SHEET NO. 2A
EXISTING DITCH
EXISTING COUNTY ROAD
CONC. DIV. BOX W/ 2 HAND SLIDE GATES
CONC. DITCH
INLET CHANNEL REQ'D. SEE TYPICAL SECTION ON SHEET NO. 2J ON I-70 PORTION OF PLANS
HAND SLIDE GATE
N 165,890 E 1,833,130
N 165,590 E 1,833,375
ACCESS ROAD SEE TYPICAL SECTION SHEET NO. 2
N 165,510 E 1,832,490
CONCRETE INLET STRUCTURE REQ'D SEE DETAILS ON SHEET NO. 6
24" 120' R.C.P.
90 LN.FT. 30" PIPE CULVERT REQ'D.
SMALL DITCH EXCAVATION LINE "C" REQ'D. SEE SHEET NO. 14
CENTER LINE OF R.C.H.F.D. CONNECTOR ROAD
EXISTING COUNTY ROAD R/W LINE
N 165,420 E 1,833,640
STILLING BASIN REQ'D SEE DETAILS ON SHEET NO. 6
OUTLET STRUCTURE REQ'D SEE DETAILS ON SHEET NO. 7 AND SHEET NO 5 FOR LOCATION
BOTTOM EL. 5426
WATER STORAGE CAPACITY - 615 ACRE FEET
SEDIMENT STORAGE CAPACITY - 79.8 ACRE FEET
HIGHWAY R/W & N/A LINE
WEST BOUND LANE
EAST BOUND LANE
SEE SHEET #5 OF THE I-70 PORTION OF ROADWAY PLANS & STR. DWG. NO. 2308
30 LN.FT., 36" PIPE CULVERT REQ'D.
DROP INLET
24" x 72" R.C.P.
CENTERLINE STA 2008+90
40°
N 165,060 E 1,833,505
N 165,020 E 1,833,125
INSTALL 850 LN. FT. OF 42" R.C.P. OUTLET PIPE. SEE DETAILS ON SHEET NO. 5
INTERSECTION OF ℄ DIKE AND ℄ OUTLET PIPE LOCATED S 19°06'03" 3346.00 FEET FROM THE NW CORNER OF SECTION 24, T23S, R3W, S.L.B.&M.
℄ ROAD STA. 212+49
℄ PIPE STA. 16+65
OUTLET ENERGY DISSIPATING STRUCTURE REQ'D. SEE DETAILS ON SHEET NO. 8
EXISTING CHANNEL
HOSPITAL
SMALL DITCH EXCAVATION LINE "A" REQ'D. SEE SHEET NO. 13
N 164,272 E 1,832,285
N 164,275 E 1,832,930
EXISTING DITCH
D.H.1
D.H.2
D.H.3
D.H.4
D.H.5
D.H.6
D.H.7
D.H.8
D.H.9

NOTE:
ALL CONCRETE DITCHES PAID BY OTHERS

PROJECT NUMBERS I-70-1(24)40 & F-069(7)	COTTONWOOD WASH DETENTION BASIN	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN AKB / SCALE
	PLAN SHEET		APPROVED / DATE / DRAWING NO. RF-1
			REVISION / DATE / SHEET NO. 4

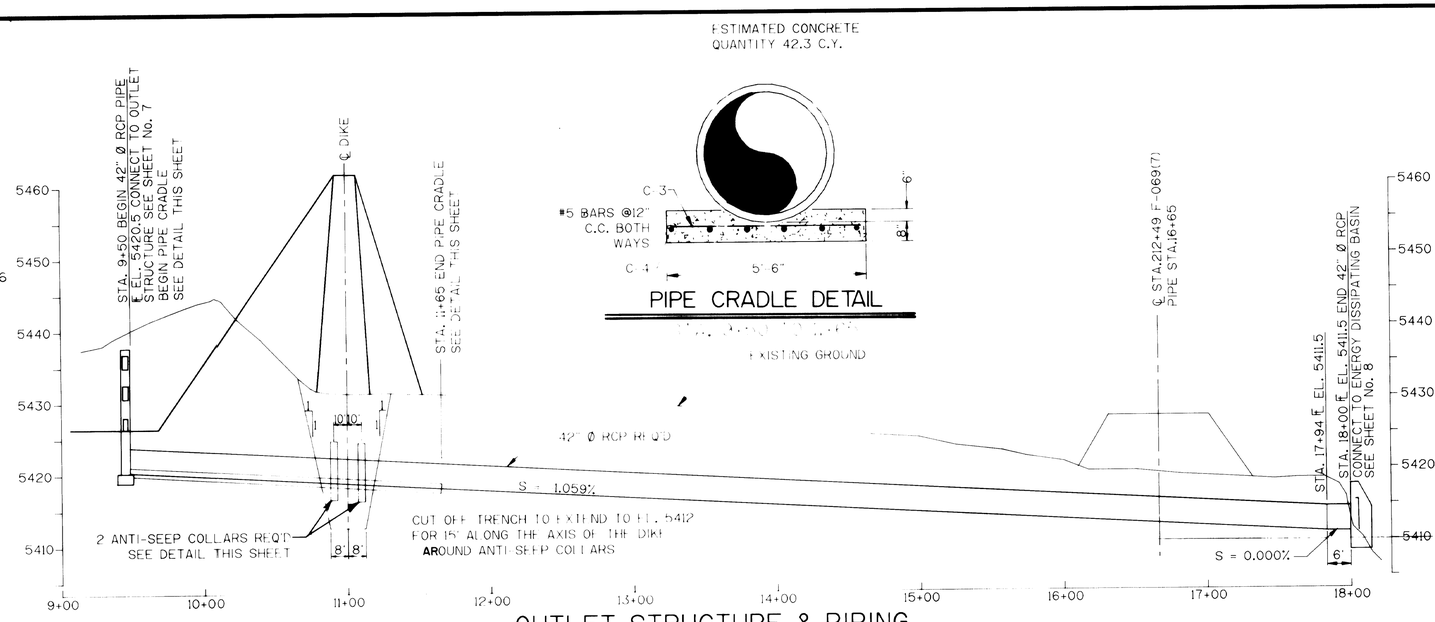
ESTIMATED CONCRETE QUANTITY 6.5 CY

NOTE: BUTYL GASKET TO BE INCLUDED IN PRICE BID FOR CONCRETE SMALL STRUCTURES CLASS AA (AE)



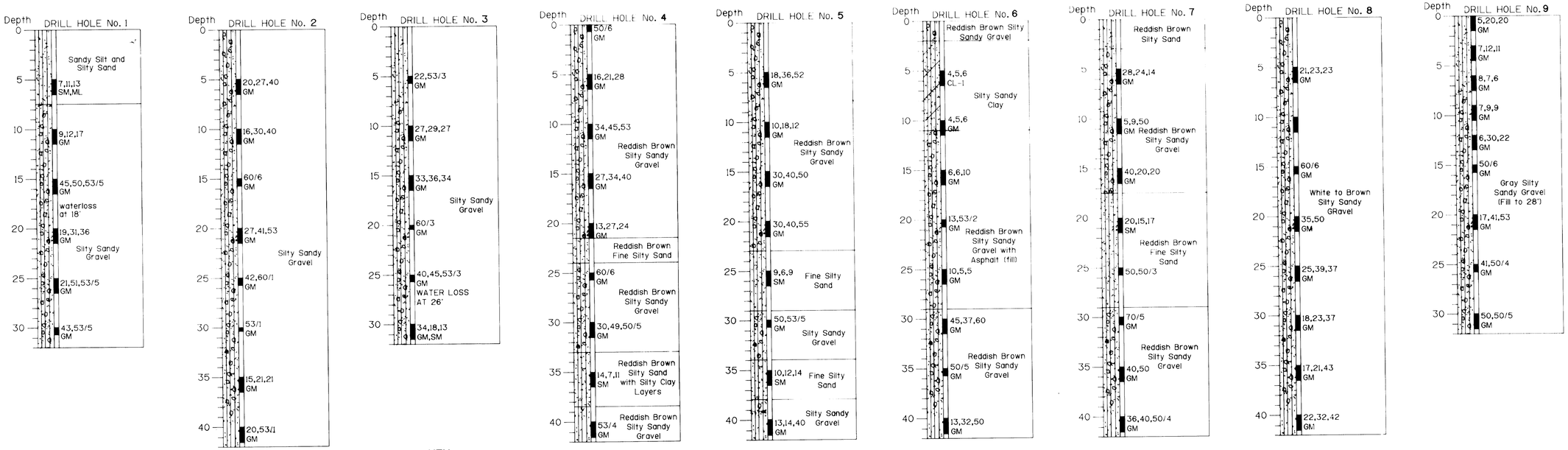
ANTI-SEEP COLLAR DETAIL

(2 REQ'D)



OUTLET STRUCTURE & PIPING

NOTE: 42" RCP CLASS TO BE DETERMINED BY STD. DRAWING 605-20 OF THE UTAH DEPT. OF HIGHWAYS STANDARD PLANS FOR ROAD & BRIDGE CONSTRUCTION.



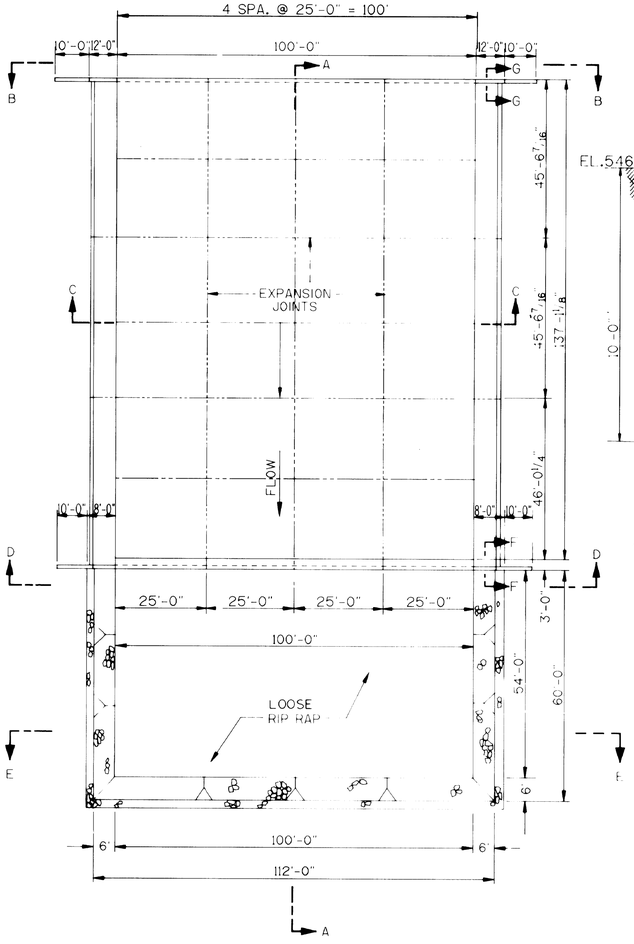
KEY

- SAMPLE LOCATION
- X,0.30 TORVANE VALUE
- UNDISTURBED SAMPLE
- 5,6,6 No. OF BLOWS PER 6" WITH STD. SPOON
- GROUND WATER ELEVATION

DRILL HOLE LOGS

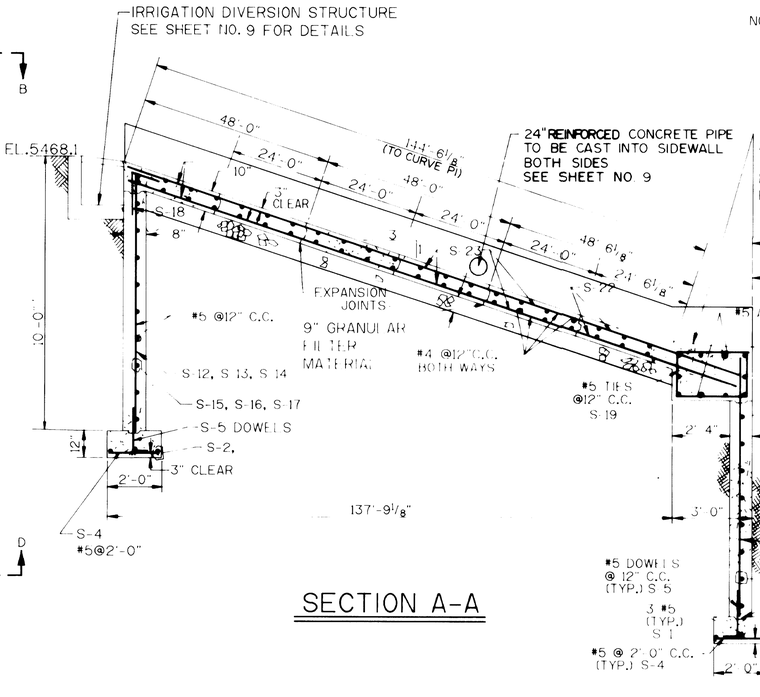
FOR LOCATIONS SEE SHEET NO. 4

PROJECT NUMBERS I-70-1(21)40 OF F-069(7)	COTTONWOOD WASH DETENTION BASIN	DREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG	CHECKED KRN	DRAWN LOB/AKB	SCALE NONE
	OUTLET PIPE DETAILS - DRILL LOGS		APPROVED	DATE	DRAWING NO. RF-1	
			REVISION	DATE	SHEET NO. 5	



PLAN

INLET STRUCTURE & STILLING BASIN

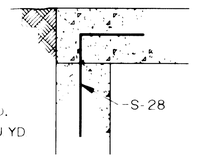


SECTION A-A

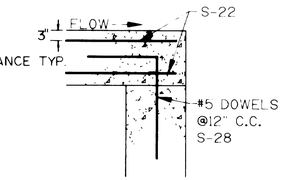
NOTES:
1. ALL STEEL WILL BE #4 BARS, UNLESS NOTED.
2. UNLESS OTHERWISE NOTED BAR SPACING WILL BE 12" C.C.
3. PAYMENT FOR JOINT SEALANT AND WATER STOP SHALL BE INCLUDED IN THE PRICE BID FOR CONCRETE CLASS AA(AE).

Δ = 18°26'06"
D = 3.00°
T = 5.95'
R = 18.49'

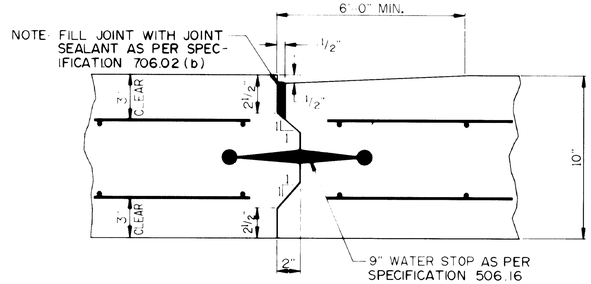
ESTIMATED CONCRETE QUANTITY - 670 CU YD.
ESTIMATED LOOSE RIPRAP QUANTITY - 917 CU YD



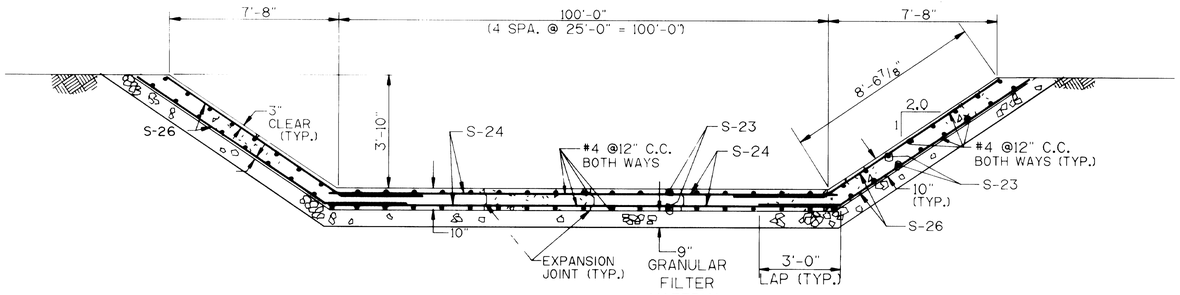
SECTION G-G



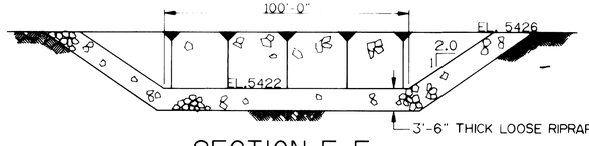
SECTION F-F



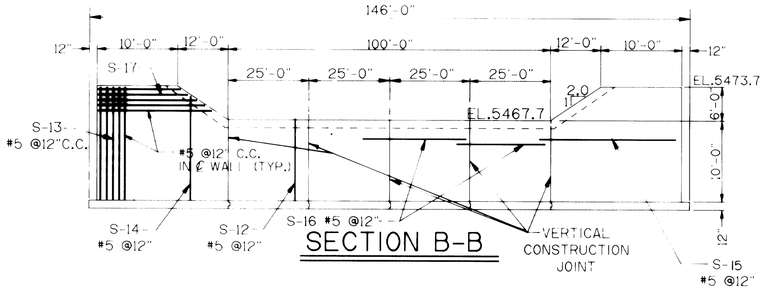
TYPICAL EXPANSION JOINT



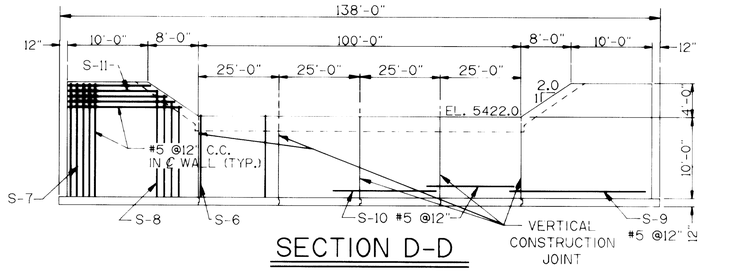
SECTION C-C



SECTION E-E



SECTION B-B



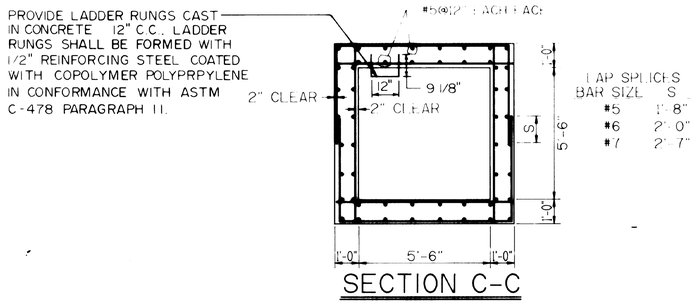
SECTION D-D

PROJECT NUMBERS I-70-1(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN**	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN LOB / SCALE NONE
	INLET STRUCTURE		APPROVED / DATE / DRAWING NO. RF-1
			REVISION / DATE / SHEET NO. 6

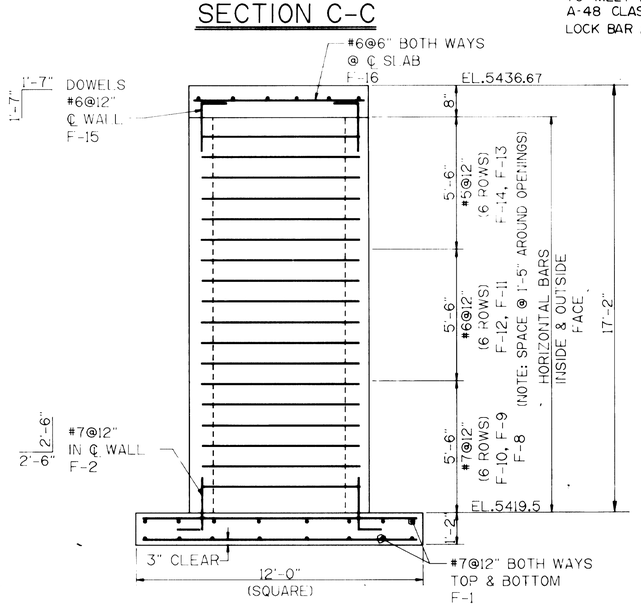
NOTES:

1. GATE CONSTRUCTED AS PER 705.02 OF THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD & BRIDGE CONSTRUCTION EDITION OF 1979 & SUBSEQUENT ADDENDA.
2. BITUMINOUS FILLER SHALL BE INCLUDED IN THE PRICE BID FOR 42" RCP.
3. LADDER RUNGS TO BE INCLUDED IN THE PRICE BID FOR CONCRETE CLASS AA(AE).
4. ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM123 JOINTS WELDED IN FIELD SHALL BE COATED WITH ONE COAT ZINC CHROMATE PRIMER FOLLOWED WITH A GRAY ENAMEL AS PER 713.02.

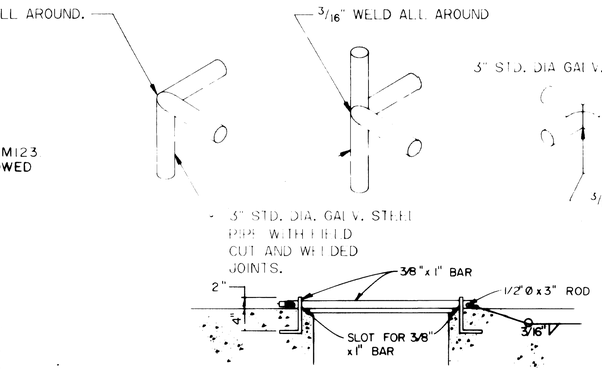
ESTIMATED CONCRETE QUANTITY - 22.4 CU.YD.



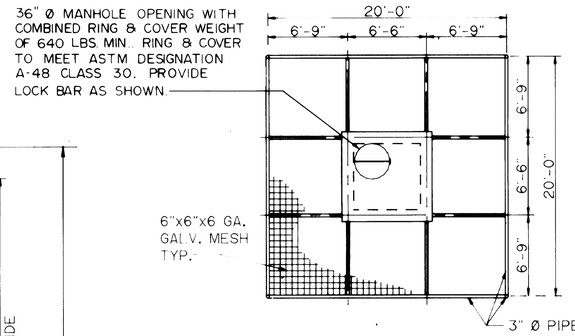
SECTION C-C

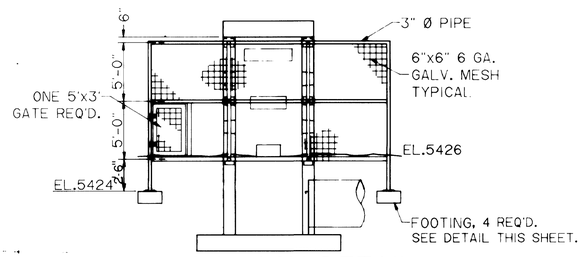


SECTION B-B



LOCK BAR DETAIL

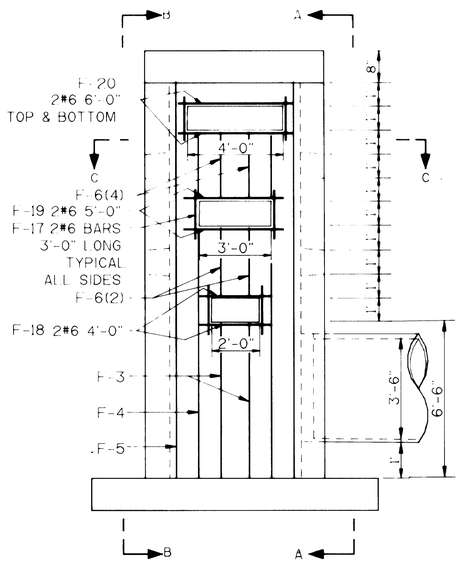




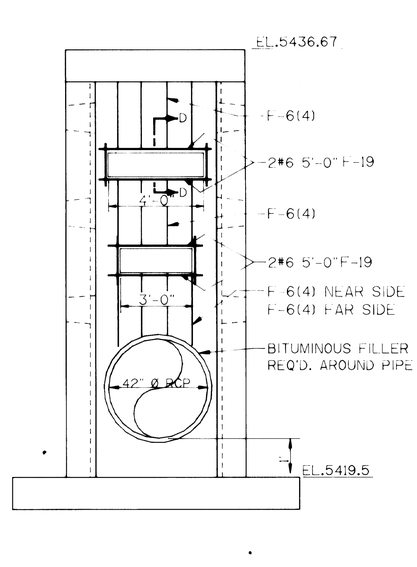
TRASH RACK DETAIL

WIRE SUPPORT DETAILS

SECTION D-D



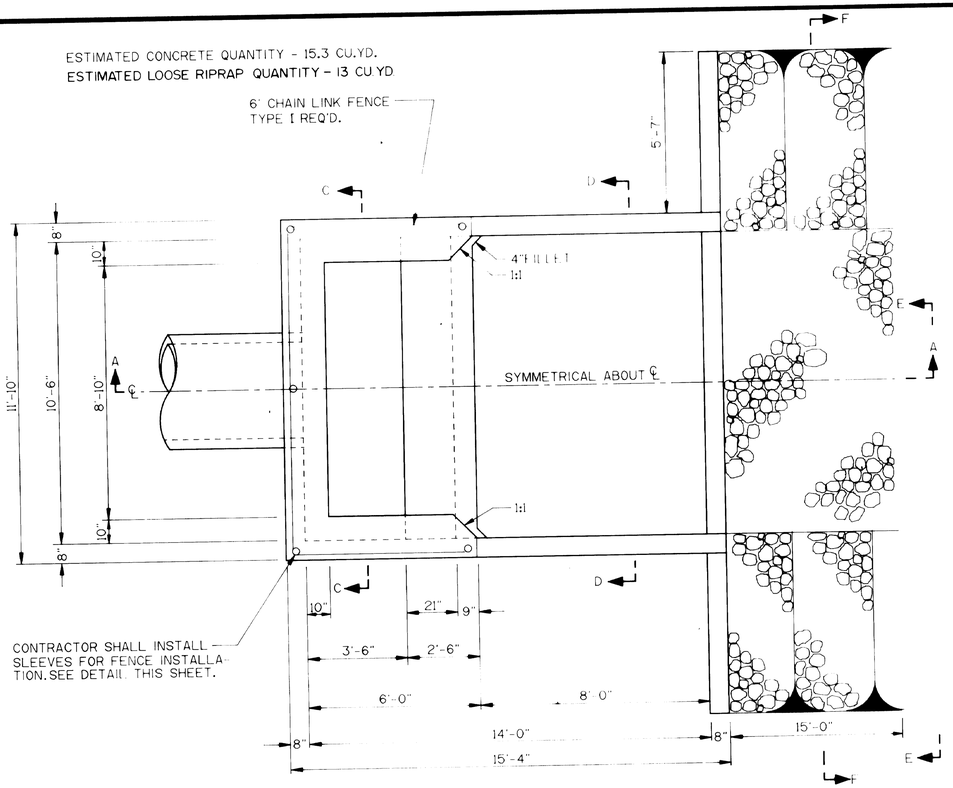
OUTLET STRUCTURE



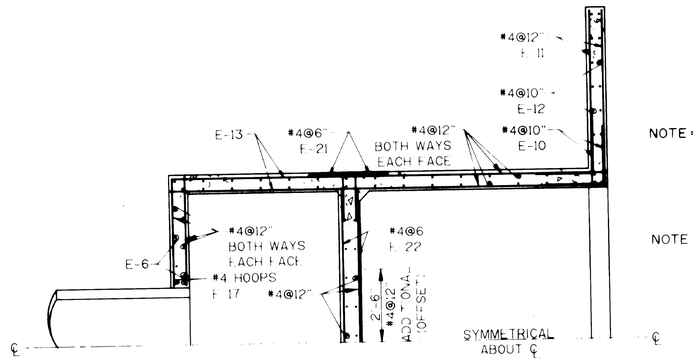
SECTION A-A

PROJECT NUMBERS I-70-I(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN** OUTLET STRUCTURE	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BEG / CHECKED KRN / DRAWN DRL / SCALE NONE	
			APPROVED / DATE	DRAWING NO. RF-1
			REVISION / DATE	SHEET NO. 7

ESTIMATED CONCRETE QUANTITY - 15.3 CU.YD.
ESTIMATED LOOSE RIPRAP QUANTITY - 13 CU.YD.



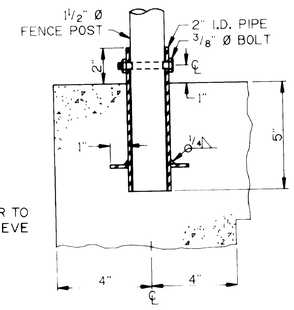
PLAN



SECTION B-B

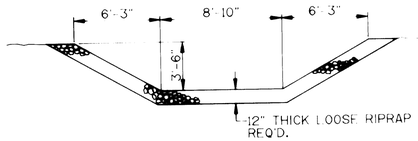
NOTE #1 FENCE SLEEVE TO BE INCLUDED IN BID PRICE FOR 6' CHAIN LINK FENCE TYPE I.

NOTE #2 FIELD BEND REBAR TO ACCOMODATE SLEEVE

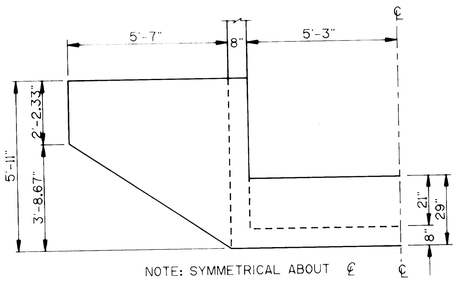


NOTE #3
ALL EXPOSED METAL WILL BE HOT DIP GALVANIZED IN ACCORDANED WITH ASTM-123

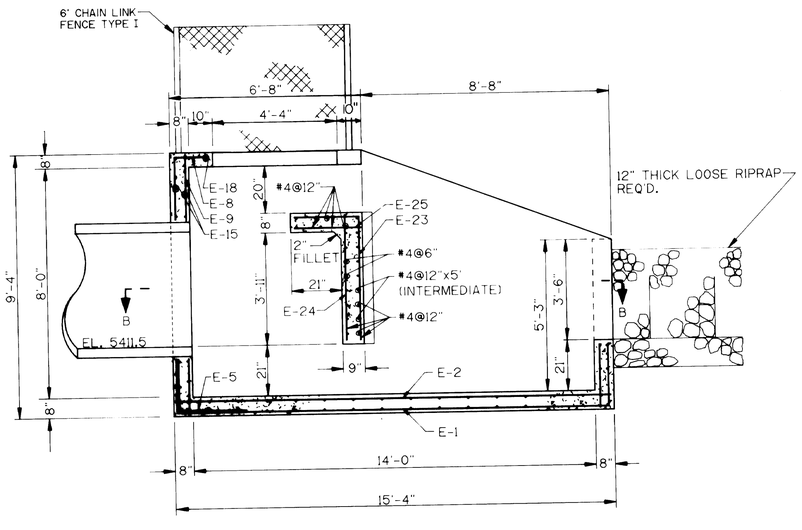
FENCE POST SLEEVE DETAIL



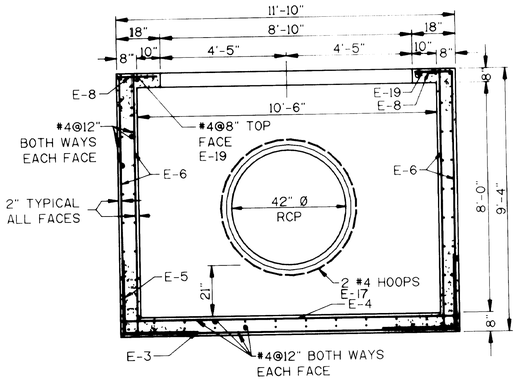
SECTION F-F



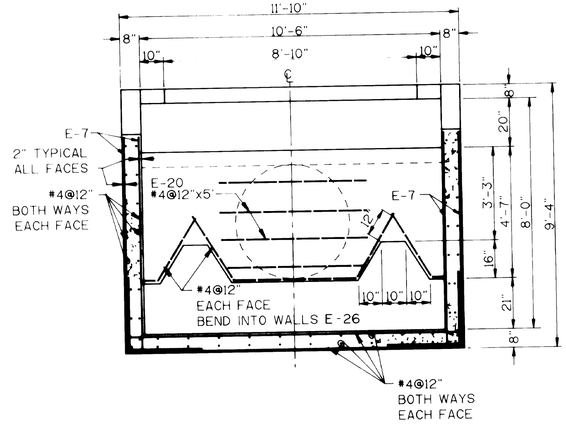
SECTION E-E



SECTION A-A



SECTION C-C



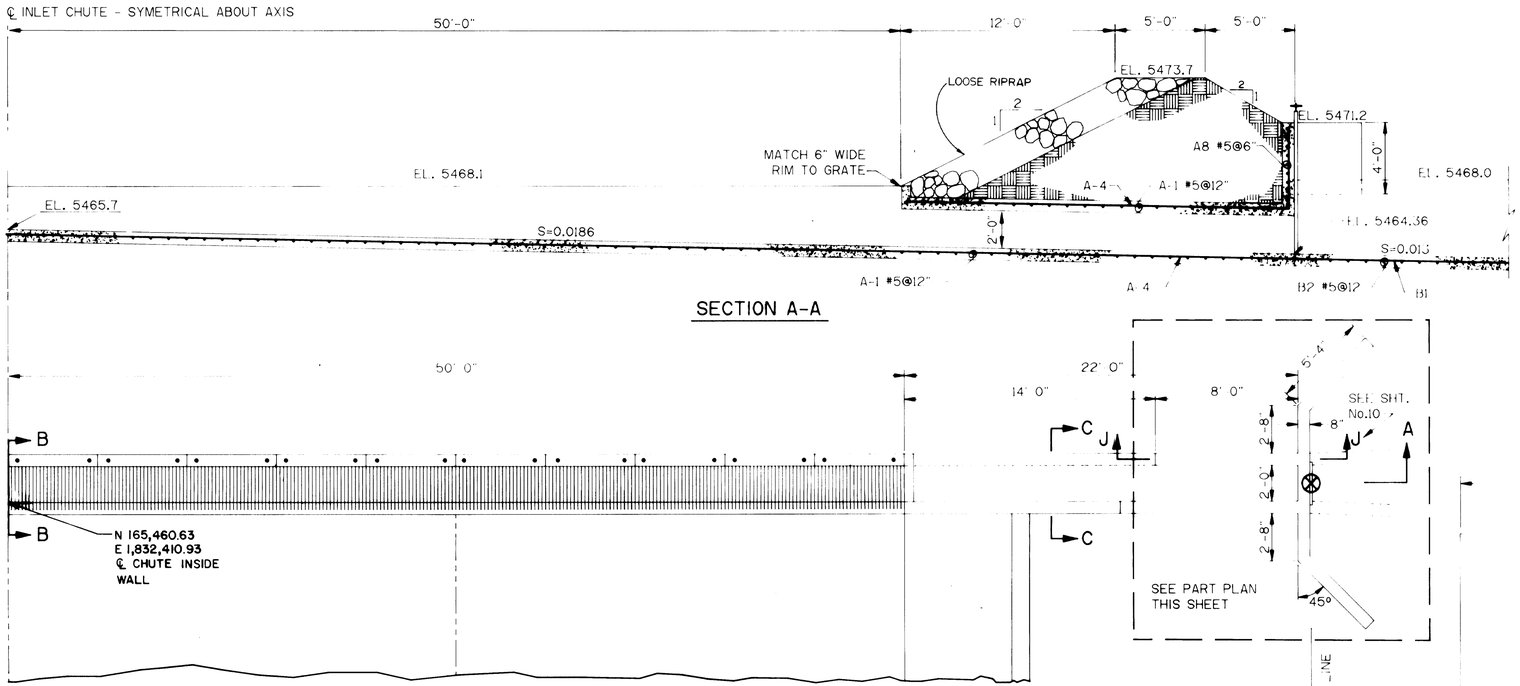
SECTION D-D

PROJECT NUMBERS
I-70-1(24)40
& F-069(7)

COTTONWOOD WASH
DETENTION BASIN
OUTLET ENERGY DISSIPATING STRUCTURE

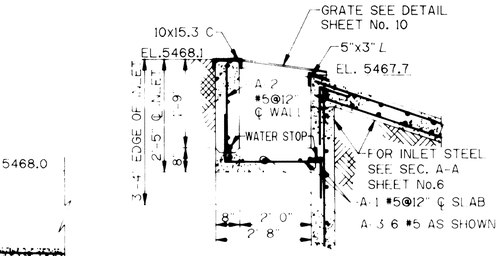
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
B.E.G	KRN	AKB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-1	
REVISION	DATE	SHEET NO.	
		8	

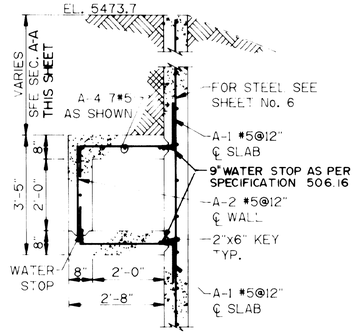


SECTION A-A

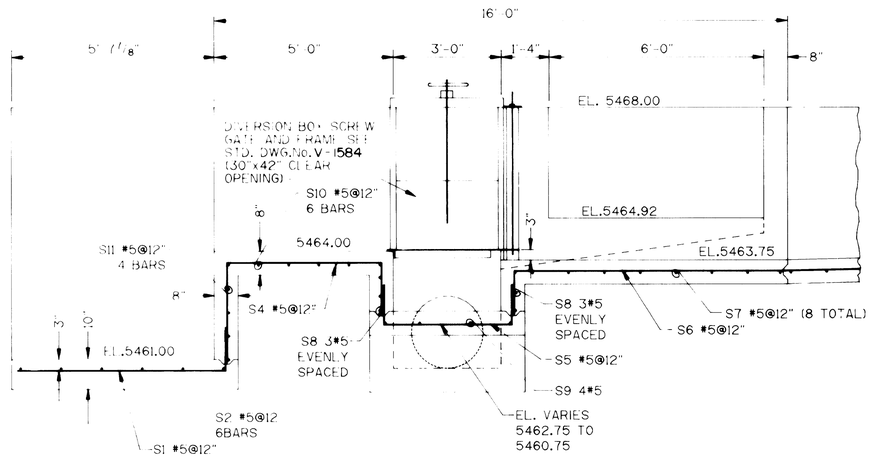
PLAN - IRRIGATION DIVERSION STRUCTURE



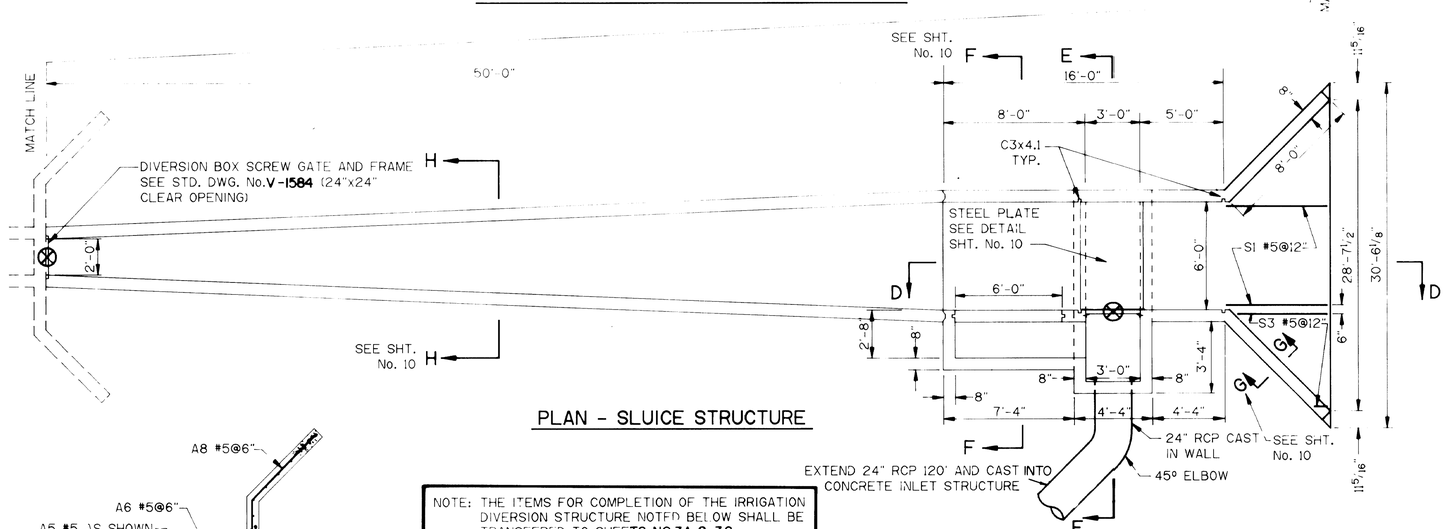
SECTION B-B



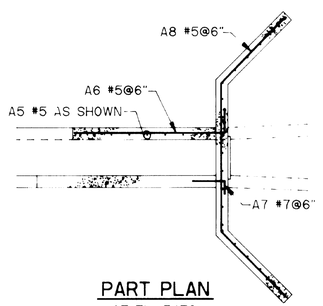
SECTION C-C



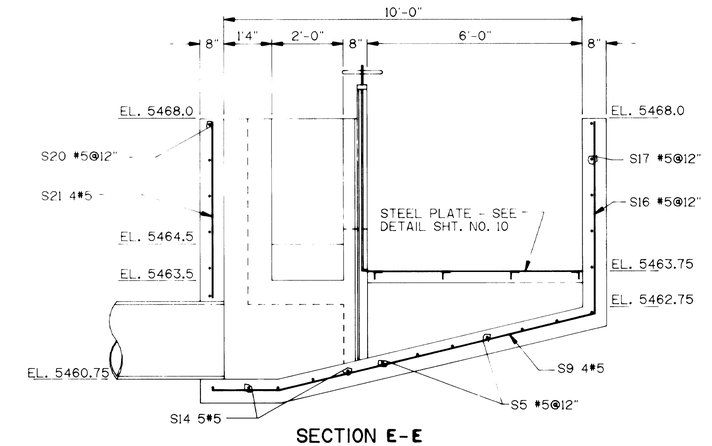
SECTION D-D



PLAN - SLUICE STRUCTURE



PART PLAN
AT EL. 5470



SECTION E-E

NOTE: THE ITEMS FOR COMPLETION OF THE IRRIGATION DIVERSION STRUCTURE NOTED BELOW SHALL BE TRANSFERED TO SHEETS NO 3A & 3G OF I-70 PORTION OF ROADWAY PLANS.

1- CONCRETE CLASS AA (AE) 90 CU. YD.

2- STRUCTURAL STEEL 9,100 LBS.

3- 2 EA. 24"x24" DIVERSION BOX SCREW GATE AND FRAME.

4- 2 EA. 34"x42" DIVERSION BOX SCREW GATE AND FRAME.

5- 240 LN. FT. 24" REINFORCED CONCRETE PIPE.

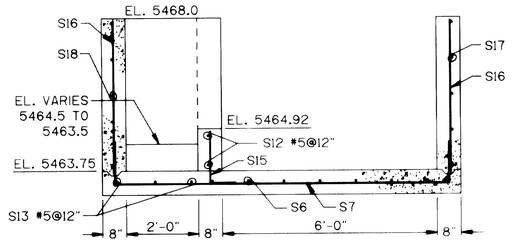
PROJECT NUMBERS
I-70-1(124)46
OF F-069(7)

COTTONWOOD WASH DETENTION BASIN

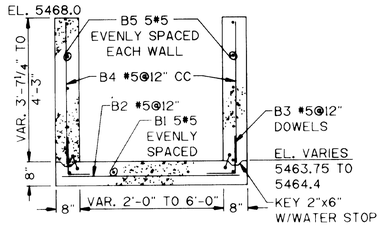
IRRIGATION DIVERSION STRUCTURE

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

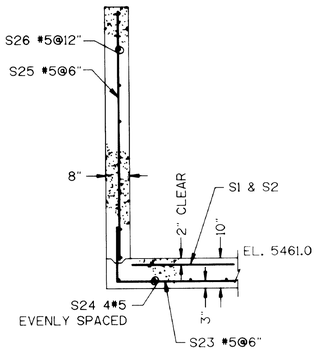
DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	AKB	NONE
APPROVED	DATE		RF-1
REVISION	DATE	SHEET NO.	9



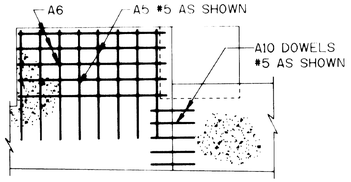
SECTION F-F



SECTION H-H



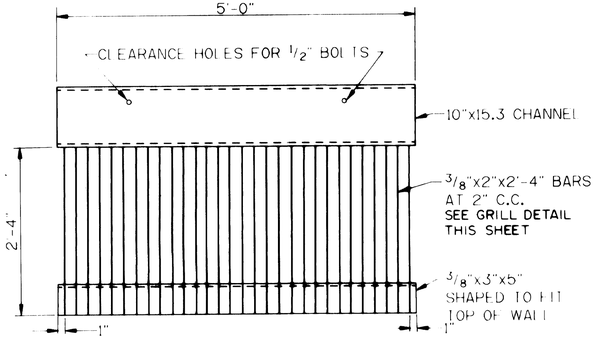
SECTION G-G



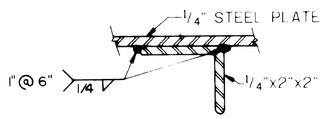
NOTE: FOR DIMENTIONS SEE SEC. A-A SHT. 9

SECTION J-J

NOTE: GRILL TO BE CONSTRUCTED IN 5 FT. LENGTHS AND GALVANIZED.



DETAIL OF 5 FT. GRILL SECTION



TYPICAL WELD DETAIL

STRUCTURE NOTES:

1. REINFORCING STEEL SHALL BE #5 @ 12" C.C. EACH WAY.
2. ALL REINFORCING STEEL SHALL BE POSITIONED IN THE CENTER OF THE WALL UNLESS OTHERWISE SPECIFIED.
3. LAP ALL REINFORCING STEEL 18" MIN. AND 30" MIN. AT ALL BENDS.
4. ALL EXPOSED CONCRETE EDGES SHALL BE CHAMFERED 1" OR ROUNDED.

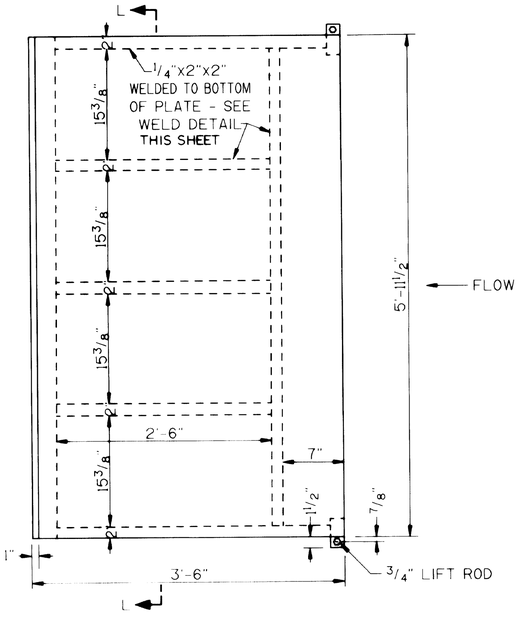
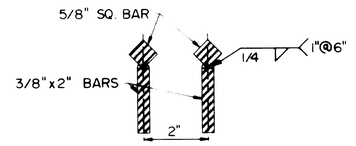
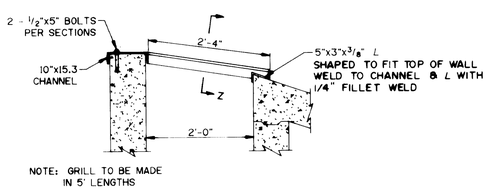


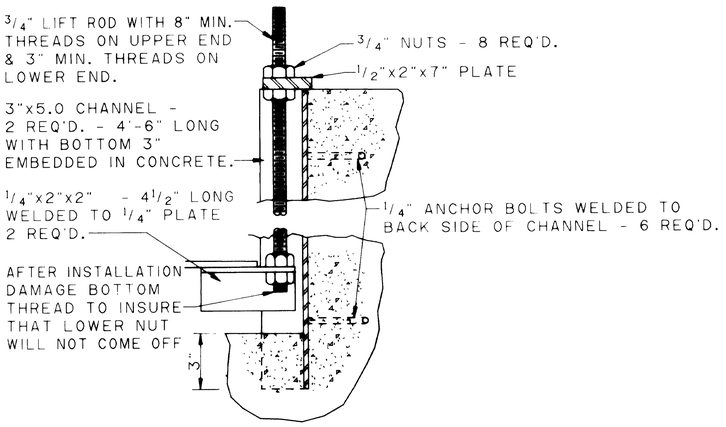
PLATE PLAN VIEW



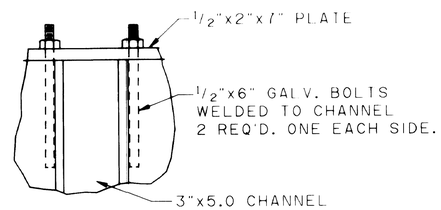
SECTION Z-Z



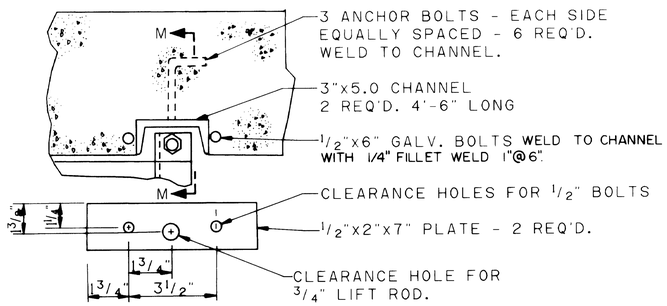
GRILL DETAIL



DETAIL SECTION M-M



FRONT VIEW



LIFT DETAIL

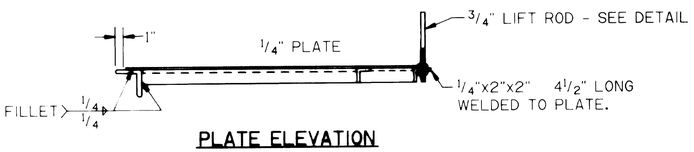


PLATE ELEVATION

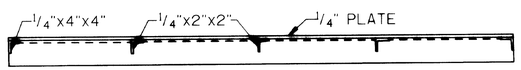
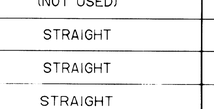
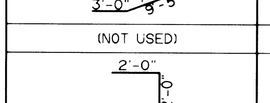
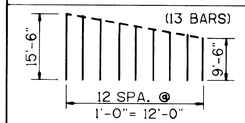
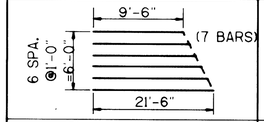
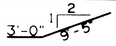


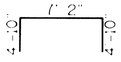
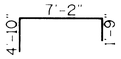
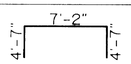
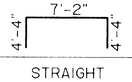
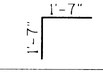
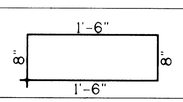
PLATE SECTION L-L

PROJECT NUMBERS I-70-I(24)40 & F-069(7)	**COTTONWOOD WASH DETENTION BASIN**	DESIGNED BEG	CHECKED KRN
	IRRIGATION DIVERSION STRUCTURE DETAILS	DRAWN DRL	SCALE NONE
	CH2M HILL / BRAMKER & NOBLE, ENGINEERS	APPROVED	DATE
		DRAWING NO. RF-1	
		REVISION	DATE
		SHEET NO. 10	

STEEL SCHEDULE
INLET STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT 4 SPLICES @ 1'-6"	#5	S-1	28'-10"	FOOTING	15	451
STRAIGHT 5 SPLICES @ 1'-6"	#5	S-2	25'-7"	FOOTING	18	480
(NOT USED)	-	S-3	-	(NOT USED)	-	-
STRAIGHT	#5	S-4	1'-6"	FOOTING	144	225
	#5	S-5	3'-10"	FOOTING	286	1143
STRAIGHT	#5	S-6	9'-6"	FOOTING WALL	101	1,001
STRAIGHT	#5	S-7	13'-6"	FOOTING WALL	20	282
	#5	S-8	103'-6"	FOOTING WALL	2 SETS	216
STRAIGHT	#5	S-9	19'-6"	FOOTING WALL	22	447
STRAIGHT	#5	S-10	26'-6"	FOOTING WALL	44	1216
	#5	S-11	67'-6"	FOOTING WALL	2 SETS	141
STRAIGHT	#5	S-12	9'-6"	FOOTING WALL	101	1,001
STRAIGHT	#5	S-13	15'-6"	FOOTING WALL	20	323
	#5	S-14	162'-6"	FOOTING WALL	2 SETS	339
STRAIGHT	#5	S-15	23'-6"	FOOTING WALL	22	539
STRAIGHT	#5	S-16	26'-6"	FOOTING WALL	44	1216
	#5	S-17	108'-6"	FOOTING WALL	2 SETS	226
	#5	S-18	4'-0"	WALL/SLAB	101	421
	#5	S-19	9'-0"	SLAB	101	948
STRAIGHT	#5	S-20	26'-6"	SLAB	40	1106
(NOT USED)	-	S-21	-	(NOT USED)	-	-
STRAIGHT	#4	S-22	27'-0"	SLAB	248	4473
STRAIGHT	#4	S-23	23'-6"	SLAB	1240	19466
STRAIGHT	#4	S-24	24'-6"	SLAB	1200	19639
(NOT USED)	-	S-25	-	(NOT USED)	-	-
	#4	S-26	12'-5"	SLAB	600	4977
(NOT USED)	-	S-27	-	(NOT USED)	-	-
	#5	S-28	4'-0"	SLAB/WALL	50	209

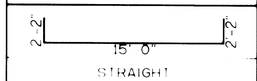
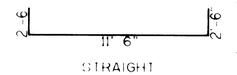
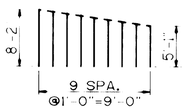
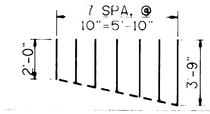
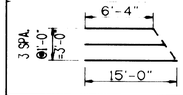
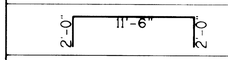
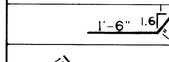
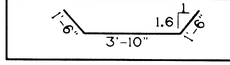
STEEL SCHEDULE
OUTLET STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT	#7	F-1	11'-6"	FOOTING	52	1,223
	#7	F-2	5'-0"	FOOTING	24	246
STRAIGHT	#5	F-3	6'-3"	WALL	8	53
STRAIGHT	#5	F-4	10'-3"	WALL	8	86
STRAIGHT	#5	F-5	16'-3"	WALL	12	204
STRAIGHT	#5	F-6	2'-6"	WALL	32	84
STRAIGHT	#5	F-7	8'-3"	WALL	4	35
	#7	F-8	16'-10"	WALL	6	207
	#7	F-9	13'-9"	WALL	6	169
STRAIGHT	#7	F-10	7'-2"	WALL	21	308
	#6	F-11	16'-4"	WALL	12	295
STRAIGHT	#6	F-12	7'-2"	WALL	24	259
	#5	F-13	15'-10"	WALL	12	199
STRAIGHT	#5	F-14	7'-2"	WALL	24	180
	#6	F-15	3'-2"	WALL/ROOF	24	115
STRAIGHT	#6	F-16	7'-2"	ROOF	18	194
STRAIGHT	#6	F-17	3'-0"	WALL	40	181
STRAIGHT	#6	F-18	4'-0"	WALL	8	49
STRAIGHT	#6	F-19	5'-0"	WALL	24	181
STRAIGHT	#6	F-20	6'-0"	WALL	8	73
STRAIGHT	#5	J-1	1'-8"	TRASH RACK FOOTING	32	56
	#5	J-2	4'-4"	TRASH RACK FOOTING	16	73
STRAIGHT	#5	C-1	10'-0"	ANTI SEEP COLLAR	16	167
STRAIGHT	#5	C-2	6'-0"	ANTI-SEEP COLLAR	8	50
STRAIGHT	#5	C-3	5'-0"	PIPE CRADLE	216	1126
STRAIGHT 30 SPLICES @ 1'-6"	#5	C-4	37'-0"	PIPE CRADLE	36	1389

SUMMARY OF BARS

76,461.1	FEET OF #4 BARS @ 0.668 LBS./FT. =		51,076
14,987.5	FEET OF #5 BARS @ 1.043 LBS./FT. =		15,632
896.8	FEET OF #6 BARS @ 1.502 LBS./FT. =		1,347
1,053.3	FEET OF #7 BARS @ 2.044 LBS./FT. =		2,153
	TOTAL =		70,208
	USE =		70,300

STEEL SCHEDULE
OUTLET ENERGY DISSIPATING STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#4	E-1	19'-4"	BOTTOM SLAB	11	143
STRAIGHT	#4	E-2	15'-0"	BOTTOM SLAB	11	111
	#4	E-3	16'-6"	BOTTOM SLAB	16	177
STRAIGHT	#4	E-4	16'-6"	BOTTOM SLAB	16	177
	#4	E-5	5'-0"	BOTTOM SLAB DOWEL	56	188
STRAIGHT	#4	E-6	8'-6"	WALL (VERT)	48	273
	#4	E-7	66'-3"	WALL (VERT)	4 SETS	178
	#4	E-8	3'-2"	WALL/ROOF DOWEL	26	55
STRAIGHT	#4	E-9	2'-0"	WALL (VERT)	10	14
	#4	E-10	4'-0"	WING WALL DOWEL	28	75
STRAIGHT	#4	E-11	5'-5"	WING WALL (HORIZ)	20	73
	#4	E-12	31'-4"	WING WALL (VERT)	4 SETS	84
STRAIGHT	#4	E-13	15'-0"	WALL (HORIZ)	24	241
	#4	E-14	38'-8"	WALL (HORIZ)	4 SETS	104
	#4	E-15	15'-6"	WALL (HORIZ)	12	125
	#4	E-16	5'-11"	WALL (HORIZ)	20	80
	#4	E-17	12'-8"	WALL	2	17
STRAIGHT	#4	E-18	11'-6"	ROOF	3	24
STRAIGHT	#4	E-19	6'-4"	ROOF	6	26
STRAIGHT	#4	E-20	5'-0"	BAFFLE	10	34
	#4	E-21	3'-4"	BAFFLE	40	90
STRAIGHT	#4	E-22	10'-2"	BAFFLE	16	109
	#4	E-23	6'-5"	BAFFLE	12	52
STRAIGHT	#4	E-24	4'-3"	BAFFLE	12	35
STRAIGHT	#4	E-25	2'-2"	BAFFLE	12	18
	#4	E-26	3'-0"	BAFFLE	4	8
	#4	E-27	6'-10"	BAFFLE	2	10

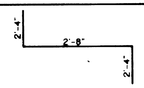
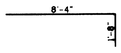
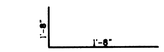
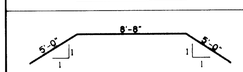
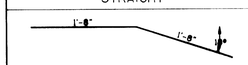
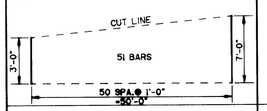
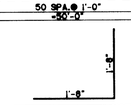
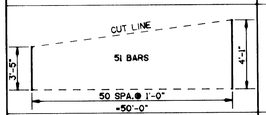
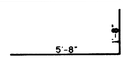
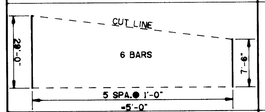
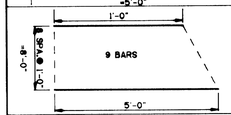
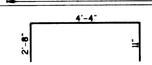
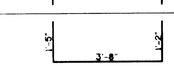
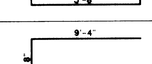
PROJECT NUMBERS
I-70-1(124)40
& F-069(7)

COTTONWOOD WASH
DETENTION BASIN
STEEL SCHEDULE

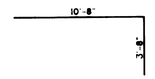
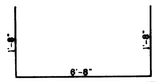
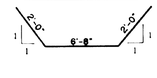
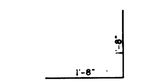
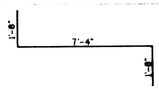
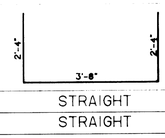
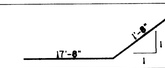
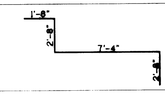
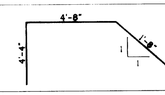
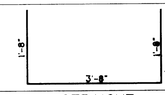
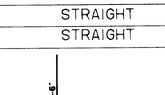
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED BEG	CHECKED KRN	DRAWN DRL	SCALE NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION	DATE	SHEET NO.	11

STEEL SCHEDULE
IRRIGATION DIVERSION STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#5	A-1	5'-4"	INLET BOX	192	1068.0
STRAIGHT	#5	A-2	2'-2"	INLET BOX	146	329.9
STRAIGHT	#5	A-3	37'-8"	INLET BOX	24	942.9
STRAIGHT	#5	A-4	21'-6"	INLET BOX	6	134.5
STRAIGHT	#5	A-5	7'-6"	INLET BOX	16	100.1
	#5	A-6	10'-0"	INLET BOX	36	375.5
	#5	A-7	3'-4"	INLET BOX	36	125.2
	#5	A-8	18'-8"	INLET BOX WING WALL	18	350.4
STRAIGHT	#5	A-9	3'-6"	WING WALL	38	138.7
	#5	A-10	3'-4"	DOWELS- INLET BOX OPEN CHANNEL-	26	90.4
STRAIGHT	#5	B-1	27'-0"	OPEN CHANNEL	20	563.2
	#5	B-2	255'-0"	OPEN CHANNEL	2 SETS	531.9
	#5	B-3	3'-4"	OPEN CHANNEL DOWELS- SLAB & WALL	204	709.2
	#5	B-4	191'-3"	OPEN CHANNEL	4 SETS	797.9
STRAIGHT	#5	B-5	27'-0"	OPEN CHANNEL	40	1126.4
	#5	P-1	7'-4"	SLUICE STR.	14	107.1
	#5	P-2	108'-0"	SLUICE STR.	2 SETS	225.3
	#5	P-3	27'-0"	SLUICE STR.	4 SETS	112.6
	#5	P-4	7'-11"	SLUICE STR.	14	115.6
	#5	P-5	6'-3"	SLUICE STR.	14	91.3
	#5	P-6	10'-0"	SLUICE STR.	14	146.0
	#5	P-7	12'-0"	SLUICE STR.	16	200.3

STEEL SCHEDULE
IRRIGATION DIVERSION STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#5	P-8	14'-4"	SLUICE STR.	12	179.4
	#5	P-9	13'-2"	SLUICE STR.	8	109.9
	#5	P-10	10'-0"	SLUICE STR.	12	125.2
	#5	P-11	10'-8"	SLUICE STR.	8	89.0
	#5	P-12	3'-4"	SLUICE STR.	18	62.6
	#5	P-13	10'-8"	SLUICE STR.	6	66.8
	#5	P-14	8'-4"	SLUICE STR.	10	86.9
STRAIGHT	#5	P-15	7'-4"	SLUICE STR.	4	30.6
STRAIGHT	#5	P-16	4'-0"	SLUICE STR.	86	358.8
	#5	P-17	19'-4"	SLUICE STR.	10	201.6
	#5	P-18	14'-4"	SLUICE STR.	10	149.5
	#5	P-19	10'-8"	SLUICE STR.	10	111.3
	#5	P-20	7'-0"	SLUICE STR.	12	87.6
STRAIGHT	#5	P-21	5'-0"	SLUICE STR.	8	41.7
STRAIGHT	#5	P-22	1'-0"	SLUICE STR.	10	10.4
	#5	P-23	7'-0"	SLUICE STR.	68	496.5
STRAIGHT	#5	P-24	7'-6"	SLUICE STR.	16	125.2
STRAIGHT	#5	P-25	6'-10"	SLUICE STR.	68	484.6
STRAIGHT	#5	P-26	7'-8"	SLUICE STR.	32	255.9
					TOTAL	11,455.9
					USE	11,500

NOTE: TOTAL REINFORCING STEEL QUANTITY TRANSFERRED TO SHEET NO. 36 OF I-70 PORTION OF ROADWAY PLANS.

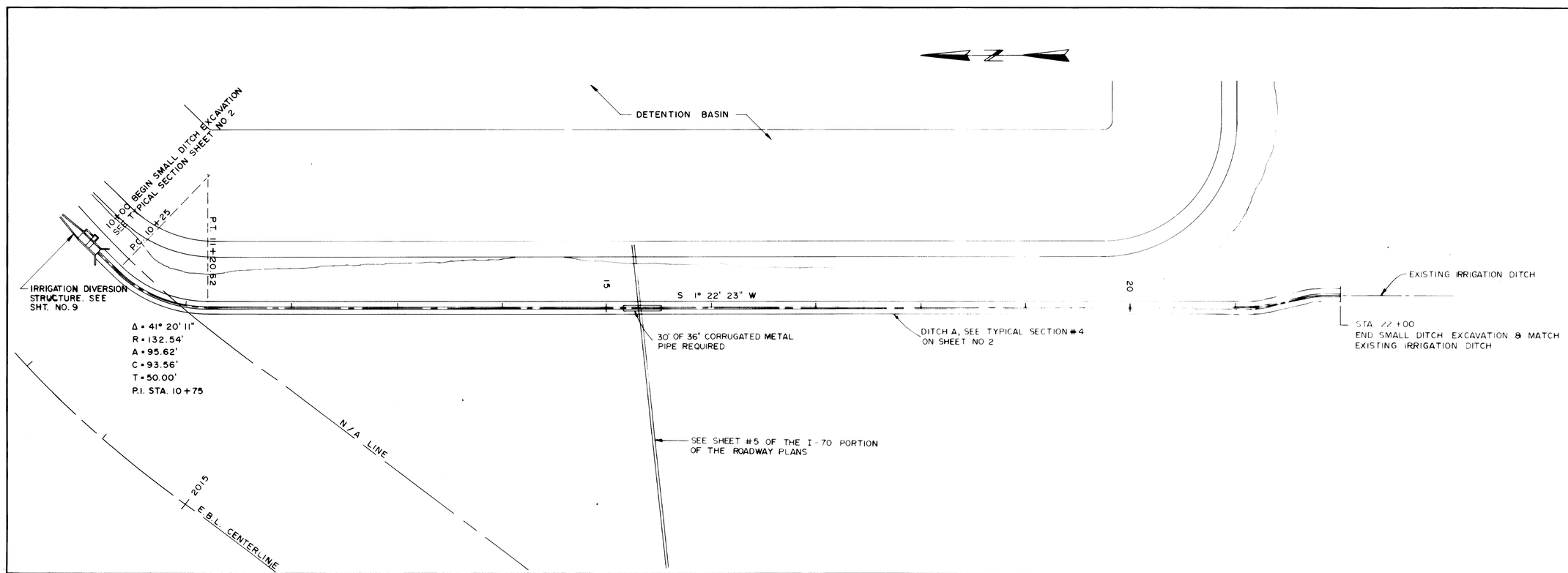
PROJECT NUMBERS
I-70-1(24)40
& F-068(7)

COTTONWOOD WASH
DETENTION BASIN
STEEL SCHEDULE

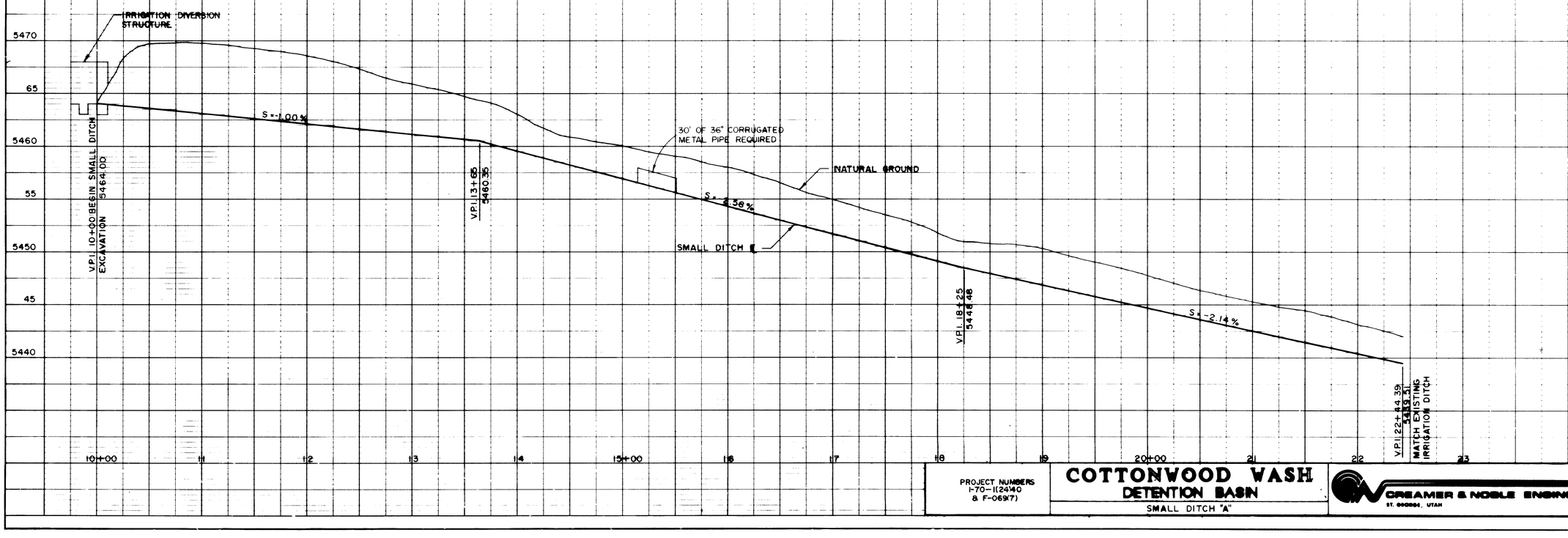
CREAMER & NOBLE ENGINEERS
FT. COLLINS, COLORADO

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	DRL	NONE
APPROVED	DATE	DRAWING NO.	
		RF-1	
REVISION	DATE	SHEET NO.	
		12	

PLAN
SURVEYED
PLOTTED
NOTE BOOK ALIGNMENT CHECKED
NO BY DATE



PROFILE
SURVEYED
PLOTTED
NOTE BOOK GRADES CHECKED
NO BY DATE
STRUCTURE NUMBERS CHECKED

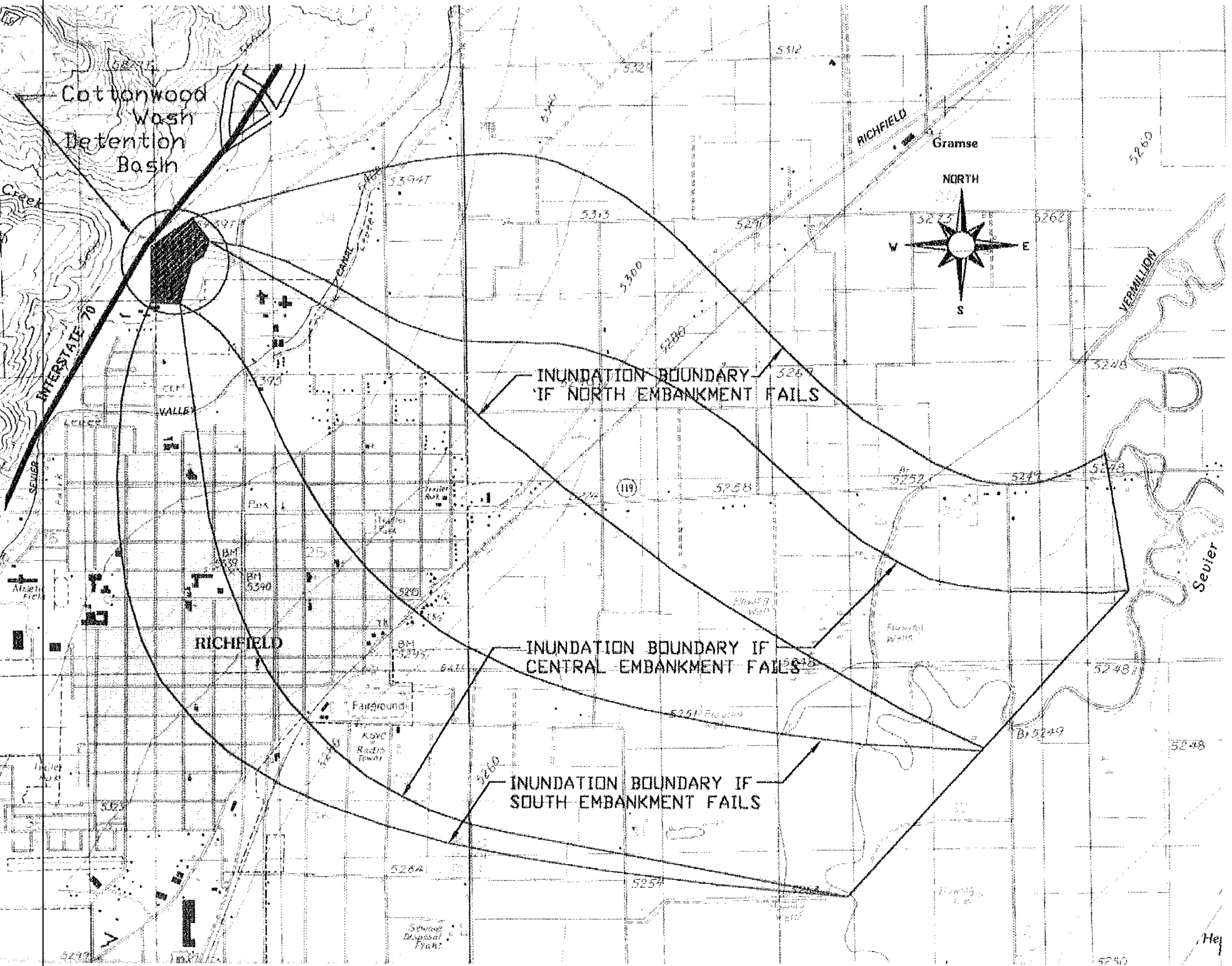


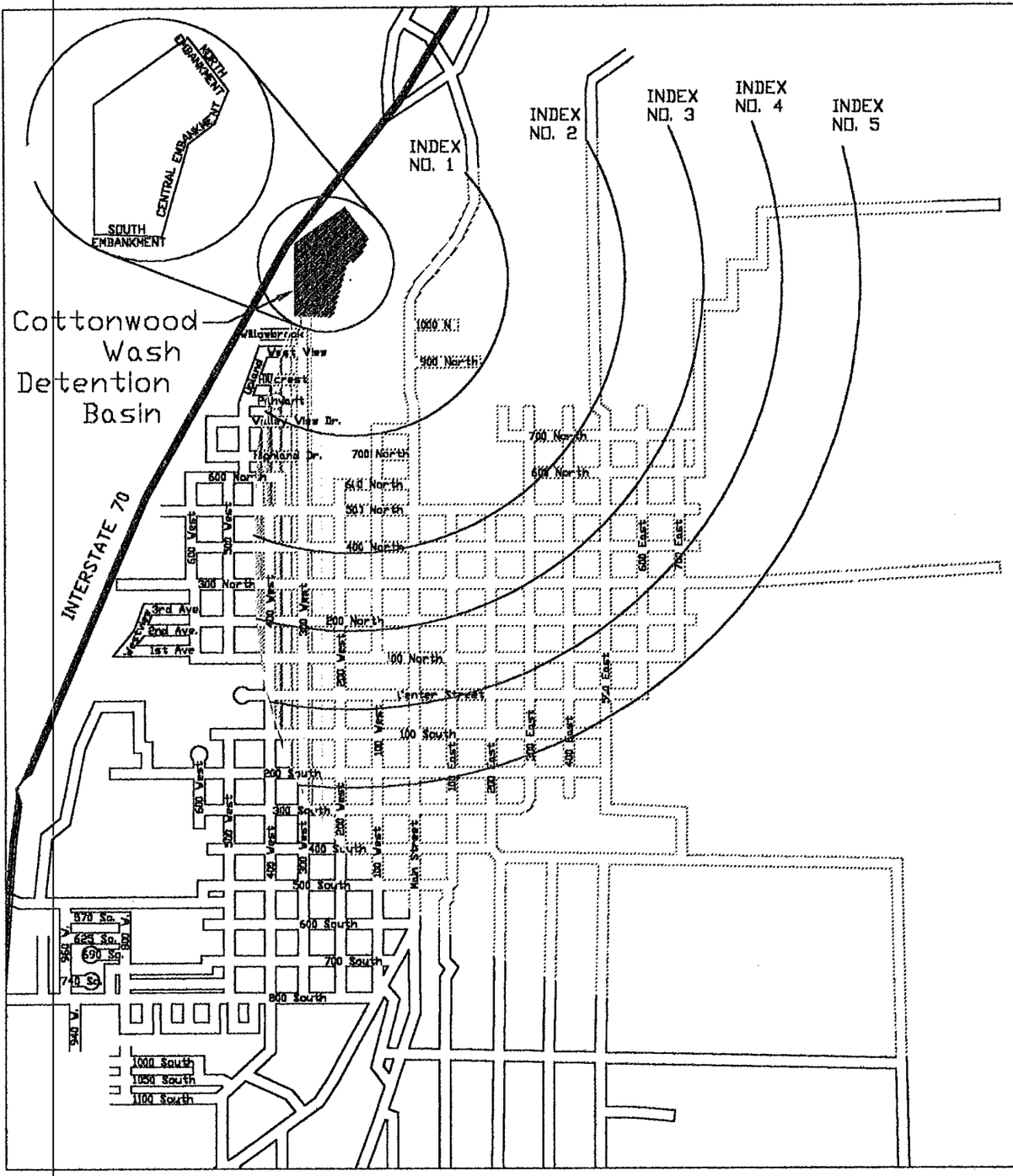
PROJECT NUMBERS
I-70-1(24)40
& F-069(7)

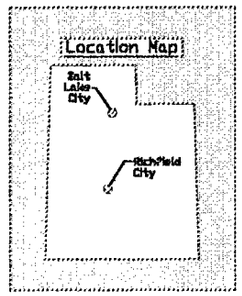
COTTONWOOD WASH
DETENTION BASIN
SMALL DITCH "A"

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
SEL	KRN	SEL	NONE
APPROVED	DATE	DRAWING NO.	RF-1
REVISION	DATE	SHEET NO.	13


Cottonwood Wash Detention Basin
INTERSTATE 70
RICHFIELD
Gramse
NORTH
W
E
S
VERMILLION
Sevier
INUNDATION BOUNDARY IF NORTH EMBANKMENT FAILS
INUNDATION BOUNDARY IF CENTRAL EMBANKMENT FAILS
INUNDATION BOUNDARY IF SOUTH EMBANKMENT FAILS
Fairgrounds
Park
Trailer Park
Sewage Disposal Plant
Athletic Field
KSVC Radio Tower
BM 5390
BM 5395
(119)

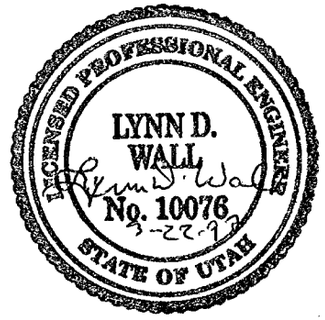


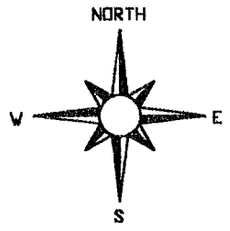


		SUNNY DAY FAILURE			RAINY DAY FAILURE		
INDEX NO.	DISTANCE FROM DAM (MILES)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.4	0.50	2.6	13130	0.57	3.1	19756
2	0.7	0.63	2.0	10576	0.67	2.4	16800
3	0.9	0.73	2.1	9390	0.73	2.4	15681
4	1.1	0.83	1.2	8721	0.83	1.5	14879
5	1.3	1.00	1.7	7778	0.97	2.0	13627
6	2.8	1.97	1.0	1605	2.10	1.3	3278

Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

THIS MAP SHOWS A TOTAL INUNDATION AREA. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW SPECIFIC AREAS OF INUNDATION IF CERTAIN SECTIONS OF THE EMBANKMENT FAIL, I.E. THE NORTH, CENTRAL, OR SOUTH EMBANKMENTS.





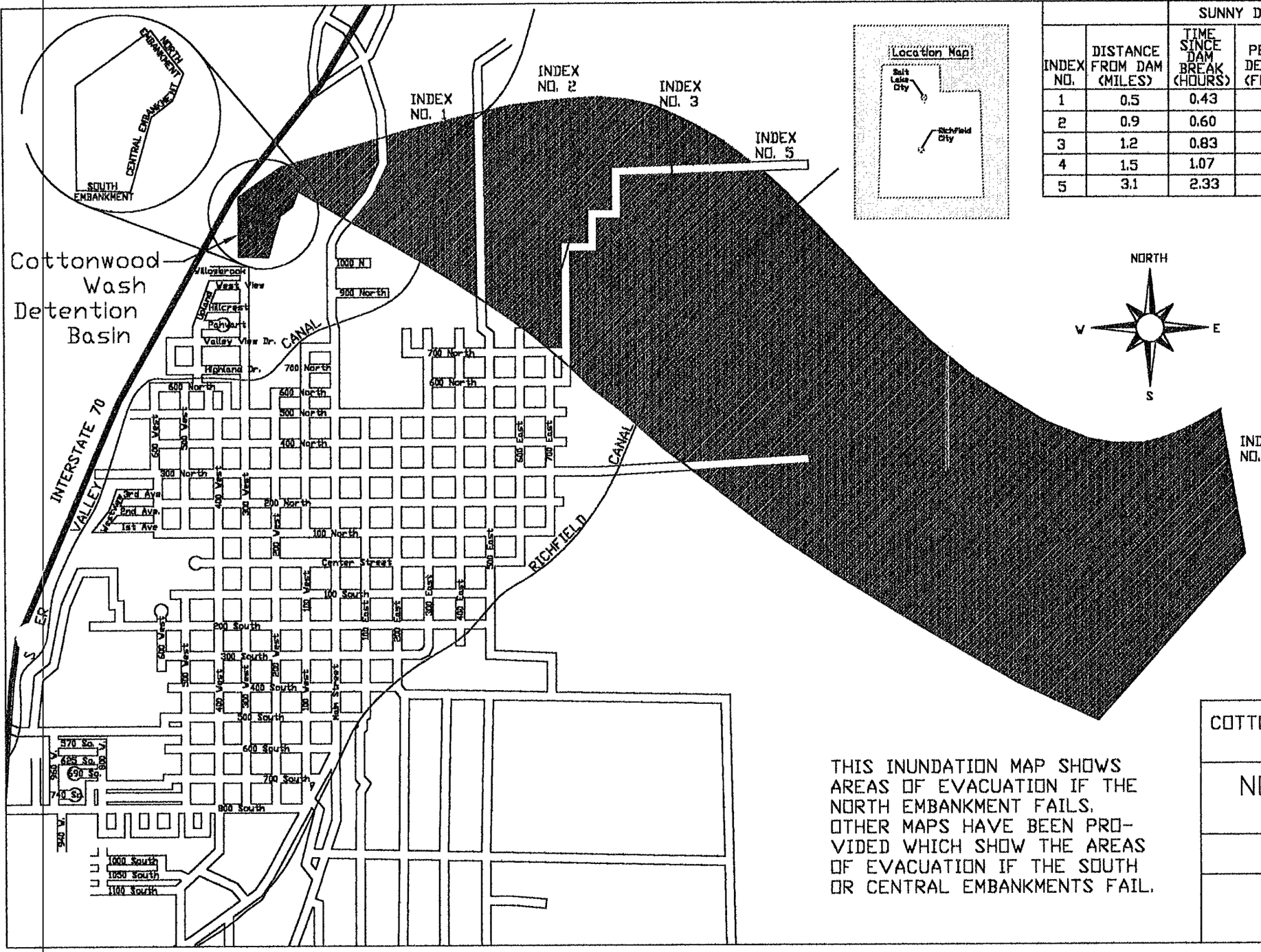
COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

EMBANKMENT FAILURE

INUNDATION MAP

SCALE: NONE

INUNDATION AREA



		SUNNY DAY FAILURE			RAINY DAY FAILURE		
INDEX NO.	DISTANCE FROM DAM (MILES)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.5	0.43	3.0	6104	0.43	3.9	12926
2	0.9	0.60	1.7	4770	0.60	2.3	10751
3	1.2	0.83	1.1	3628	0.80	1.5	8674
4	1.5	1.07	0.7	3231	0.97	1.1	7891
5	3.1	2.33	1.0	894	2.50	1.5	2945

Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
3-27-97
STATE OF UTAH

THIS INUNDATION MAP SHOWS AREAS OF EVACUATION IF THE NORTH EMBANKMENT FAILS. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW THE AREAS OF EVACUATION IF THE SOUTH OR CENTRAL EMBANKMENTS FAIL.

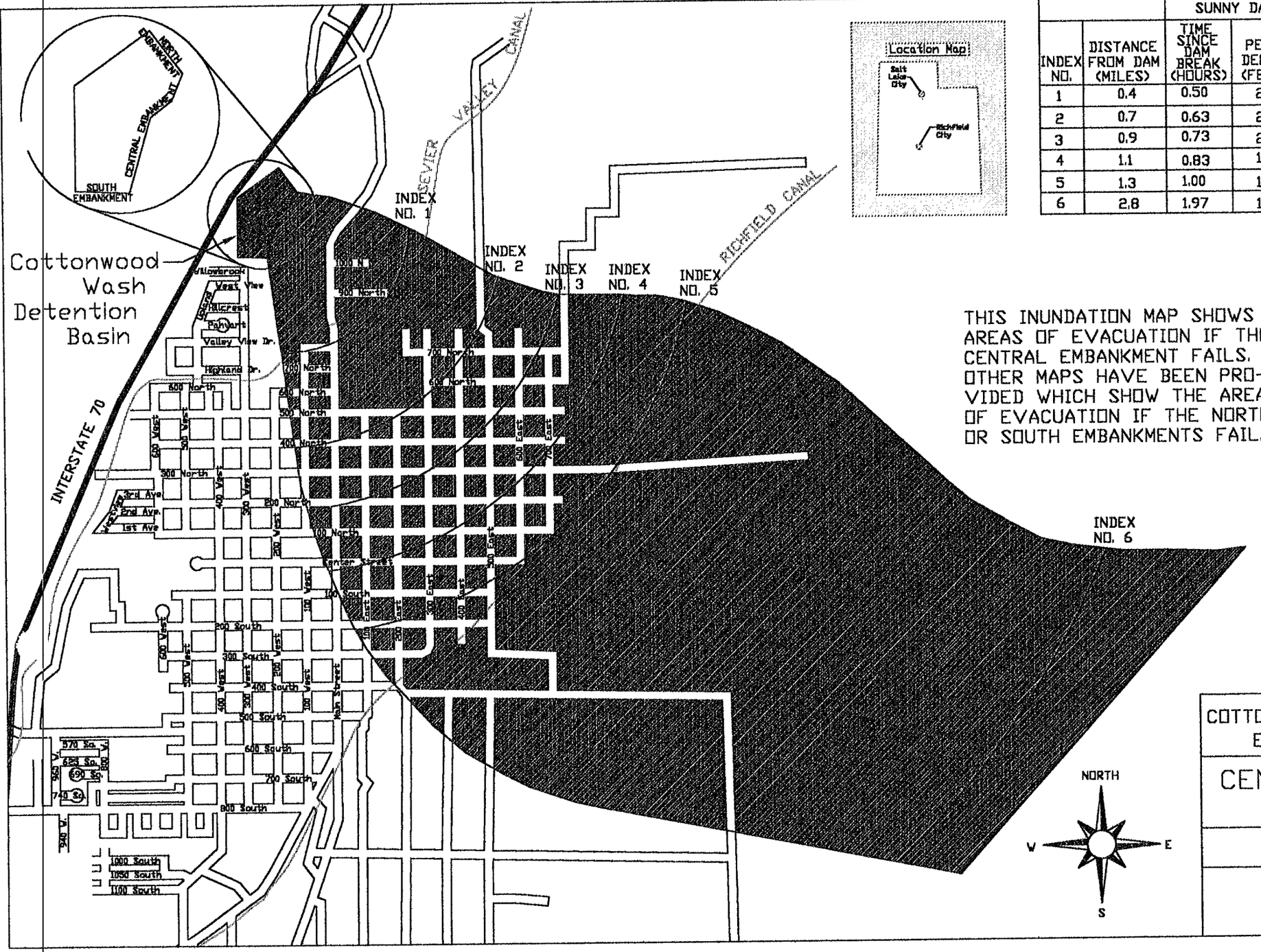
COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

NORTH EMBANKMENT FAILURE

INUNDATION MAP

SCALE: NONE

INUNDATION AREA



		SUNNY DAY FAILURE			RAINY DAY FAILURE		
INDEX NO.	DISTANCE FROM DAM (MILES)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.4	0.50	2.6	13130	0.57	3.1	19756
2	0.7	0.63	2.0	10576	0.67	2.4	16800
3	0.9	0.73	2.1	9390	0.73	2.4	15681
4	1.1	0.83	1.2	8721	0.83	1.5	14879
5	1.3	1.00	1.7	7778	0.97	2.0	13627
6	2.8	1.97	1.0	1605	2.10	1.3	3278

THIS INUNDATION MAP SHOWS AREAS OF EVACUATION IF THE CENTRAL EMBANKMENT FAILS. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW THE AREAS OF EVACUATION IF THE NORTH OR SOUTH EMBANKMENTS FAIL.

Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
3-22-97
STATE OF UTAH

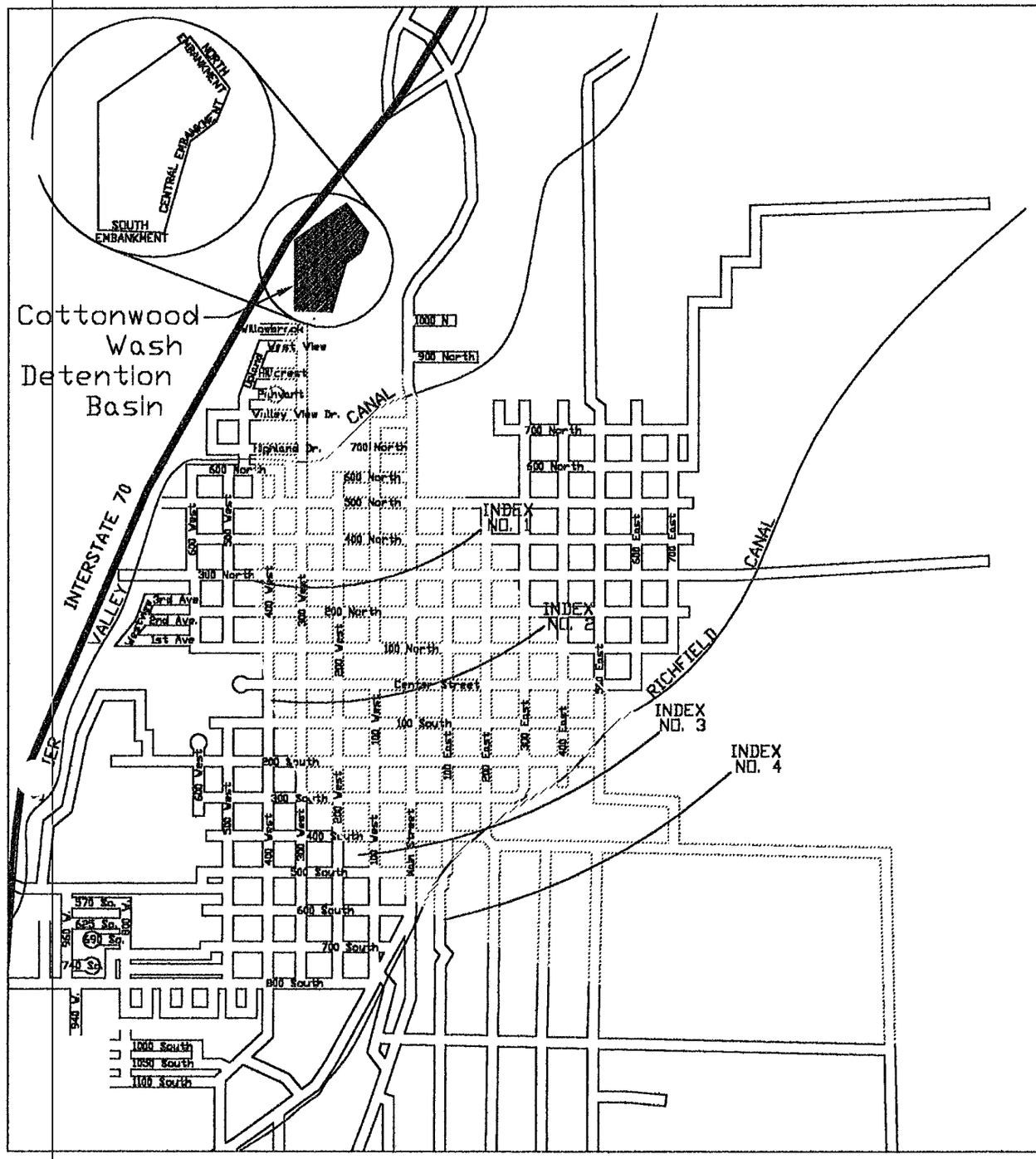
COTTONWOOD WASH DETENTION DAM EMERGENCY ACTION PLAN

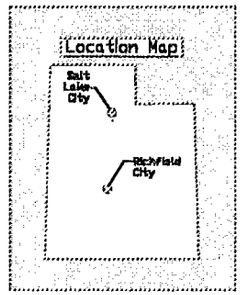
CENTRAL EMBANKMENT FAILURE

INUNDATION MAP

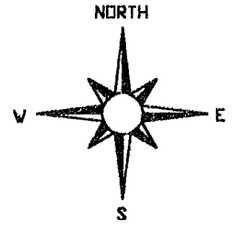
SCALE: NONE

INUNDATION AREA



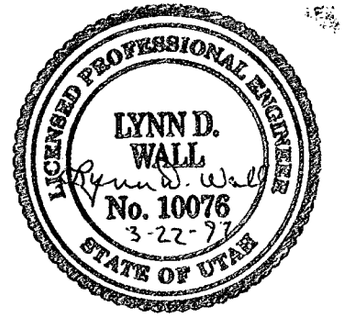


INDEX NO.	DISTANCE FROM DAM (MILES)	SUNNY DAY FAILURE			RAINY DAY FAILURE		
		TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.7	0.50	1.5	6112	0.53	2.0	11886
2	1.0	0.70	2.1	5332	0.70	2.8	10680
3	1.4	0.97	1.1	4160	0.90	1.4	8947
4	1.6	1.13	1.3	3926	1.03	1.7	8586
5	3.1	2.43	1.2	1108	2.63	1.7	2980



Notes:
A sunny day failure is defined as a failure which occurs as a result of piping through the dam.
A rainy day failure is defined as a failure which occurs as a result of storm flows overtopping the dam.

THIS INUNDATION MAP SHOWS AREAS OF EVACUATION IF THE SOUTH EMBANKMENT FAILS. OTHER MAPS HAVE BEEN PROVIDED WHICH SHOW THE AREAS OF EVACUATION IF THE NORTH OR CENTRAL EMBANKMENTS FAIL.



COTTONWOOD WASH DETENTION DAM
EMERGENCY ACTION PLAN

SOUTH EMBANKMENT FAILURE

INUNDATION MAP

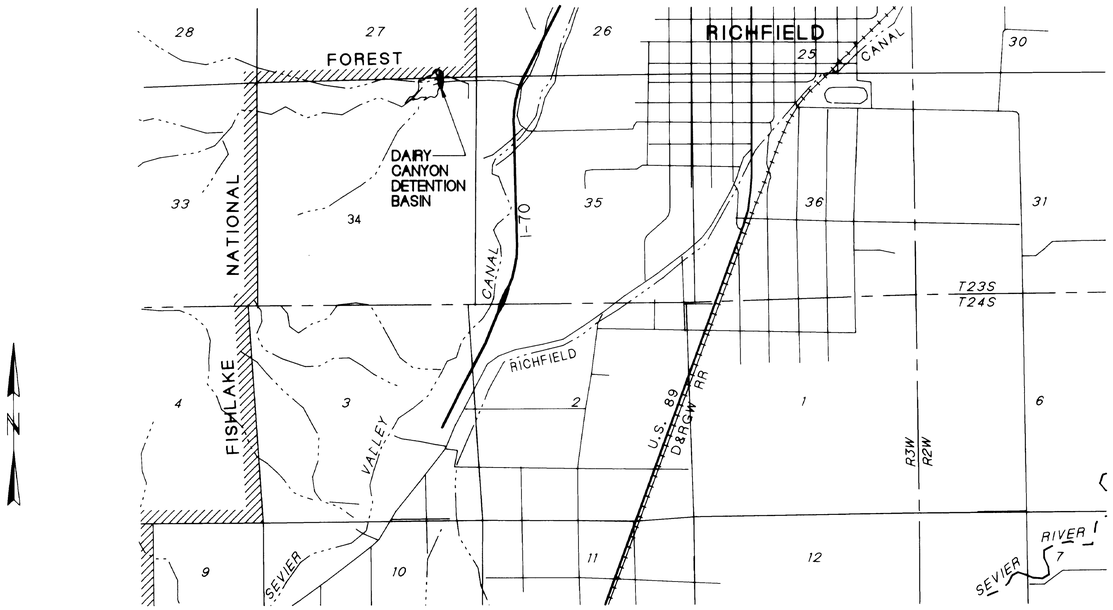
SCALE: NONE

INUNDATION AREA

"AS CONSTRUCTED"

DAIRY CANYON DETENTION BASIN

DRAWING NO. RF-2



INDEX TO SHEETS

SHEET No.	DESCRIPTION
1	TITLE SHEET & INDEX TO SHEETS
2	TYPICAL SECTIONS
3	SUMMARY SHEET
4	PLAN SHEET
5	DRILL HOLE & TEST PIT LOGS
6	OUTLET PIPE DETAILS
	STRUCTURAL
7	OUTLET STRUCTURE
8	ENERGY DISSIPATING STRUCTURE
9	STEEL SCHEDULE

GENERAL NOTES

MATERIALS, CONSTRUCTION, AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, EDITION OF 1979, AND SUPPLEMENTS THERETO WHICH ARE IN EFFECT ON THE DATE OF REQUEST FOR BIDS.

ALL REINFORCING STEEL SHALL BE DEFORMED BILLET-STEEL BARS CONFORMING TO ASTM DESIGNATION A615, GRADE 60, (EPOXY COATED).

TYPE II CEMENT (LOW ALKALI) REQUIRED.

ALL STRUCTURAL STEEL SHALL BE STRUCTURAL CARBON STEEL CONFORMING TO AASHTO DESIGNATION M-183 (ASTM A36).

ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123

OWNER'S ACCEPTANCE

RICHFIELD CITY HEREBY CERTIFIES THAT THE CITY ACCEPTS THE PLANS AND SPECIFICATIONS FOR THE CONSTRUCTION OF THE DAIRY CANYON DETENTION BASIN.

8/20/87
DATE

ENGINEER'S CERTIFICATE

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE CONSTRUCTION OF THE DAIRY CANYON DETENTION BASIN WERE PREPARED BY ME FOR RICHFIELD CITY, UTAH.

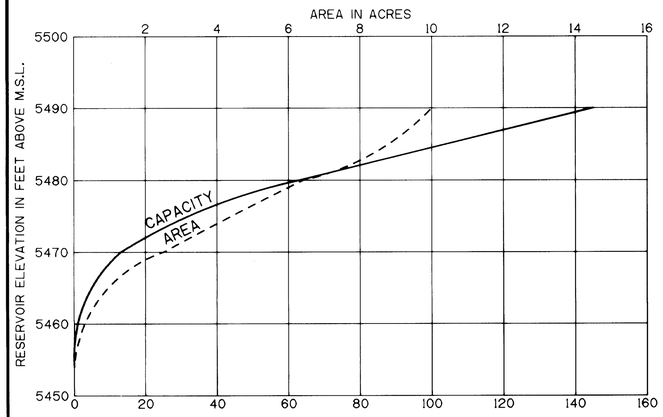
ENGINEER 8/20/87
DATE

PROFESSIONAL LICENSE NO. 4629

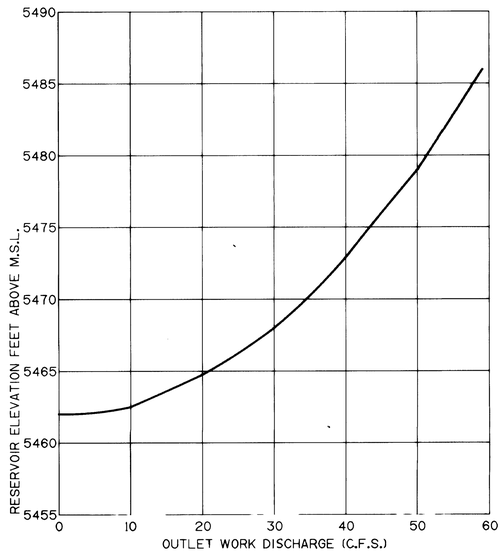
APPROVAL

IN ACCORDANCE WITH S 73-5-5, UTAH CODE ANNOTATED, 1953, AS AMMENDED, APPROVAL IS HEREBY GIVEN FOR THE CONSTRUCTION OF THE DAIRY CANYON DETENTION BASIN NEAR RICHFIELD, UTAH.

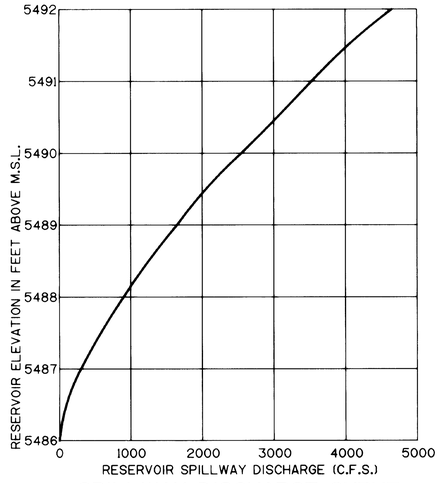
8-20-87
UTAH STATE ENGINEER DATE



CAPACITY & AREA CURVES



OUTLET DISCHARGE CURVE



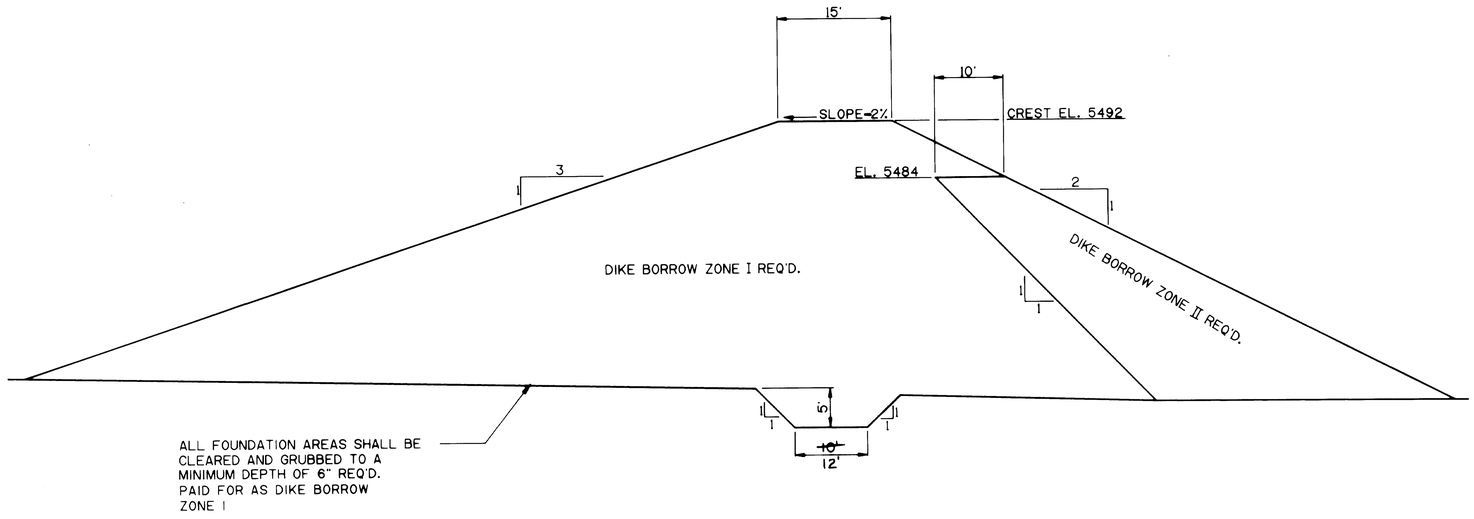
SPILLWAY DISCHARGE CURVE

PROJECT NUMBERS I-70-K23(36)	DAIRY CANYON DETENTION BASIN	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH	DESIGNED BBB	CHECKED KRN	DRAWN LOB	SCALE NONE
	TITLE SHEET & INDEX TO SHEETS		APPROVED	DATE	DRAWING NO. RF-2	
			REVISION	DATE	SHEET NO. 1	

As-Built Corr. 1987

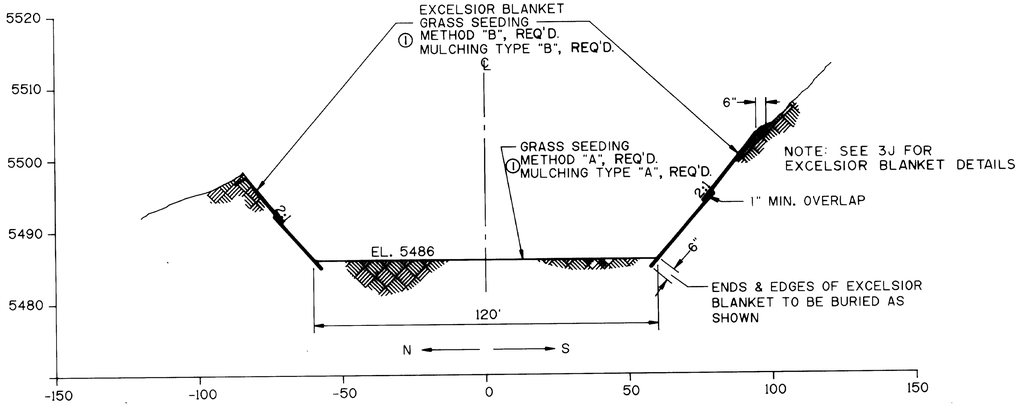
UT006

"AS CONST'D."



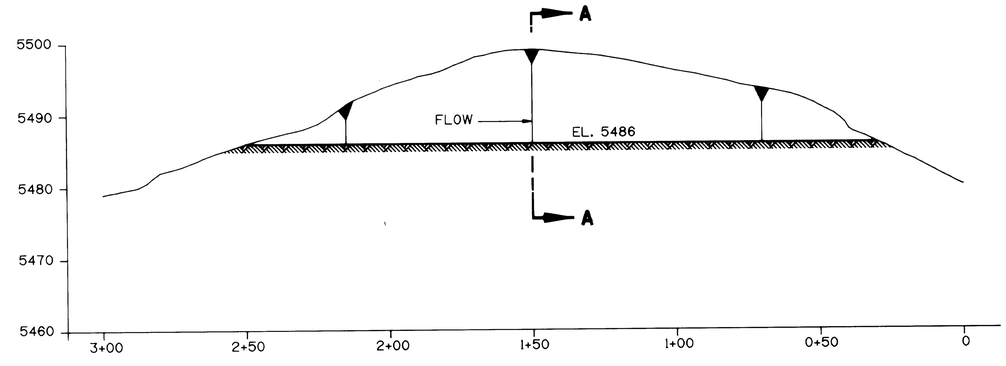
TYPICAL DIKE SECTION

STA. 10+70 TO STA. 16+45



SECTION A-A

STA. 1+50



TYPICAL SECTION

EMERGENCY SPILLWAY
ALONG SPILLWAY ℄

NO.	BY	DATE	TYPE	REMARKS
①	SEL	9/9		ADD "REQ'D"

REVISIONS

PROJECT NUMBER
I-70-1(23)36

DAIRY CANYON
DETENTION BASIN

TYPICAL SECTIONS

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	LOB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-2	
REVISION	DATE	SHEET NO.	
		2	

TYPEC.DGN

Sections

"AS CONST'D."

SUMMARY OF ITEMS

CODE	ITEM	UNIT	QUANTITY
	DIKE BORROW ZONE I	CU.YD.	~~34,450~~ 33672.59
	DIKE BORROW ZONE II	CU.YD.	~~7,250~~ 7344.07
	LOOSE RIP RAP	CU.YD.	~~180~~ 219.5
	24" REINFORCED CONCRETE PIPE	LN.FT.	208
	CONCRETE CLASS AA(AE) (ESTIMATED QUANTITY 42 CU.YD.)	LUMP	●
	REINFORCING STEEL, EPOXY COATED	LB.	5,300
	TRASHRACK / MANHOLE	LUMP	●
	6' CHAIN LINK FENCE TYPE I	LN.FT.	~~21~~ 22
	BRACED POSTS	EACH	~~3~~
	SEEDING TYPE "A"	ACRE	1
	SEEDING TYPE "B"	ACRE	1
	MULCHING TYPE "A"	ACRE	1
	MULCHING TYPE "B"	ACRE	1
	EXCELSIOR BLANKET	SQ.YD.	1,500
	SUBGRADE PREPARATION	CU.YD.	~~1,000~~ 4763.51
	ROADWAY EXC — KEYWAY	CU.YD.	1457.15
	SMALL DITCH EXC.	CU.YD.	558.62

SUMMARY OF STRUCTURAL ITEMS

ITEM	UNIT	QUANTITY
CONCRETE CLASS AA(AE) (ESTIMATED QUANTITY 42 CU.YD.)	LUMP	●
REINFORCING STEEL, EPOXY COATED	LB.	5,300

SEEDING SCHEDULE

SEED No.	NAME: BOTANICAL	NAME: COMMON	LBS. LIVE SEED PER ACRE: METHOD "A"	LBS. LIVE SEED PER ACRE: METHOD "B"
1	AGROPYRON RIPARIUM	SODAR WHEATGRASS	5	10
2	AGROPYRON CRISTATUM	FAIRWAY CRESTED WHEATGRASS	5	10
3	SPOROBOLUS AIROIDES	ALKALI SACATON	5	10
4	MEDICAGO SATIVA	SPREADER II ALFALFA	2	4
		TOTAL POUNDS LIVE SEED PER ACRE	17	34

SEED SUBSTITUTION

SEED No.	SUBST.	NAME: BOTANICAL	NAME: COMMON	LBS. LIVE SEED PER ACRE: METHOD "A"	LBS. LIVE SEED PER ACRE: METHOD "B"
1	A	AGROPYRON SMITHII	WESTERN WHEATGRASS	5	10
2	A	AGROPYRON DESERTORUM	CRESTED WHEATGRASS	5	10
3	A	AGROPYRON DASYSTACHYUM	THICKSPIKE WHEATGRASS	5	10
4	A	MEDICAGO SATIVA	ALFALFA "RAMBLER"	2	4

NOTES:

1. ALL AREAS 3:1 AND FLATTER WITHIN THE EMERGENCY SPILLWAY SEED BY METHOD "A" (DRILL) AND MULCH WITH TYPE "A"
2. ALL AREAS STEEPER THAN 3:1 WITHIN THE EMERGENCY SPILLWAY SEED BY METHOD "B" AND MULCH COMPLETE WITH EXCELSIOR MAT.

EARTHWORK SUMMARY

LANES OR LINE	FROM STATION	TO STATION	BORROW: DIKE BORROW ZONE I (CUBIC YDS.)	BORROW: DIKE BORROW ZONE II (CUBIC YDS.)	COMPACTION FACTOR (CUBIC YDS.)	ZONE I EMBANKMENT X FACTOR (CUBIC YDS.)	ZONE II EMBANKMENT X FACTOR (CUBIC YDS.)		REMARKS
DIKE ℄	10+00	10+80	30	0	1.1	33	0		
DIKE ℄	10+80	11+30	348	0	1.1	383	0		
DIKE ℄	11+30	11+80	1016	72	1.1	1118	79		
DIKE ℄	11+80	12+30	2001	267	1.1	2201	294		
DIKE ℄	12+30	12+80	2770	530	1.1	3047	583		
DIKE ℄	12+80	13+30	3190	758	1.1	3509	834		
DIKE ℄	13+30	13+80	3393	872	1.1	3732	959		
DIKE ℄	13+80	14+30	3530	927	1.1	3883	1020		
DIKE ℄	14+30	14+80	3879	1049	1.1	4267	1154		
DIKE ℄	14+80	15+30	4977	1339	1.1	5475	1473		
DIKE ℄	15+30	15+80	5725	1144	1.1	6298	1258		
DIKE ℄	15+80	16+50	3570	263	1.1	3927	289		
		TOTAL	34,429	7,221		37,873	7,943		
		USE	34,450	7,250					

MISCELLANEOUS SUMMARY

DESCRIPTION	UNIT	QUANTITY	REMARKS	CONST. SOURCE REFER. BOOK	CONST. SOURCE REFER. PAGE
LOOSE RIP RAP	CU.YD.	~~180~~ 219.5	DISSIPATION STRUCTURE & CHANNEL		
24" REINFORCED CONCRETE PIPE	LN.FT.	208			
6' CHAIN LINK FENCE TYPE I	LN.FT.	~~21~~ 22	DISSIPATION STRUCTURE		
BRACED POSTS	EACH	~~3~~ 4	DISSIPATION STRUCTURE		
TRASHRACK / MANHOLE	LUMP	●	OUTLET STRUCTURE		
SEEDING METHOD "A"	ACRE	1	EMERGENCY SPILLWAY		
SEEDING METHOD "B"	ACRE	1	EMERGENCY SPILLWAY		
MULCHING TYPE "A"	ACRE	1	EMERGENCY SPILLWAY		
MULCHING TYPE "B"	ACRE	1	EMERGENCY SPILLWAY		
EXCELSIOR BLANKET	SQ.YD.	1,500	EMERGENCY SPILLWAY		
SUBGRADE PREPARATION	CU.YD.	~~1000~~ 4763.51	BELOW BORROW		

PROJECT NUMBER I-70-1(23)36

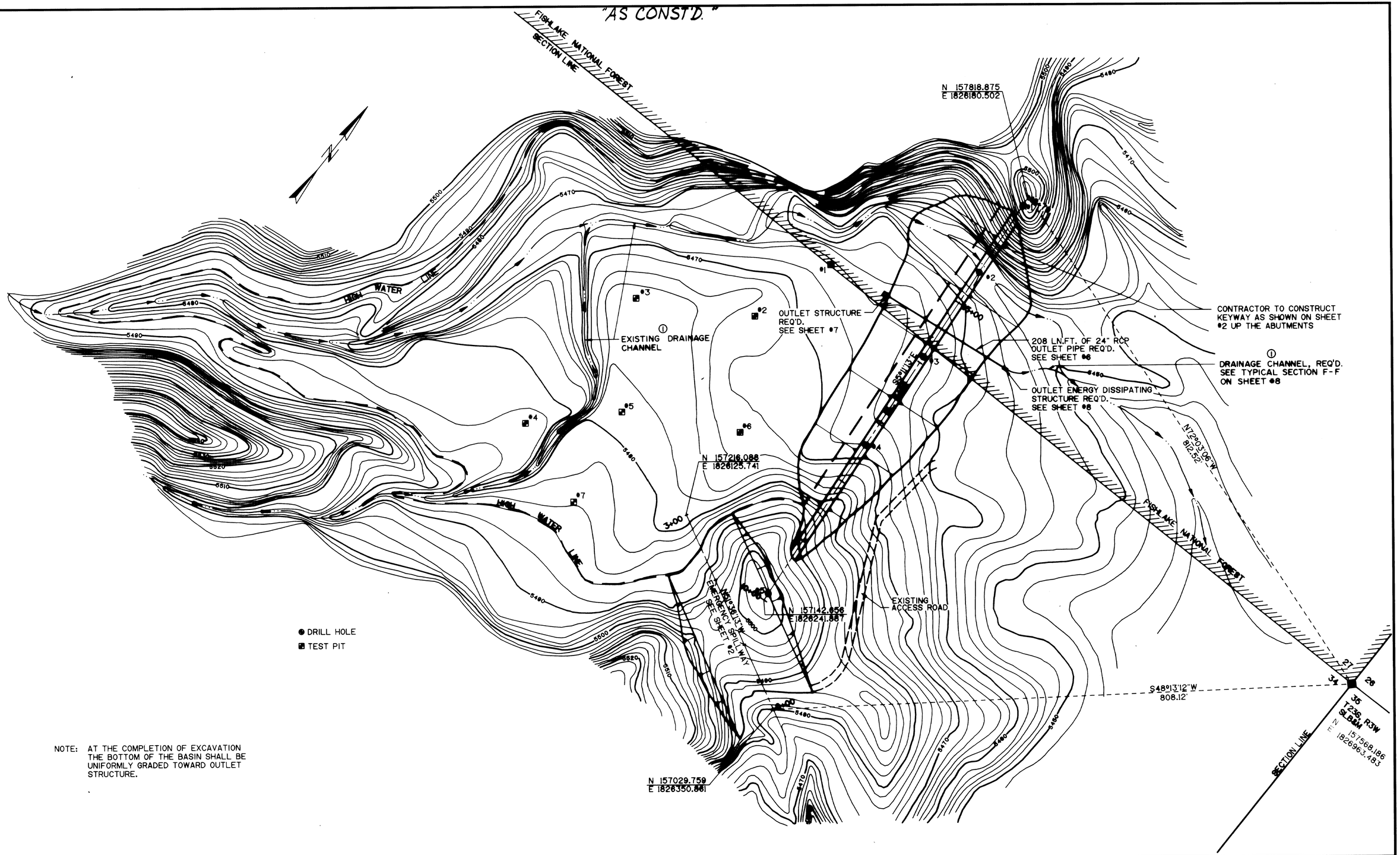
DAIRY CANYON
DETENTION BASIN
SUMMARY SHEET

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	AKB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-2	
REVISION	DATE	SHEET NO.	
		3	

Summary

"AS CONST'D."



NOTE: AT THE COMPLETION OF EXCAVATION THE BOTTOM OF THE BASIN SHALL BE UNIFORMLY GRADED TOWARD OUTLET STRUCTURE.

NO.	BY	DATE	TYPE	REMARKS
1	SEL	9/9		ADD EXIST. & NEW DRAIN. CH.

REVISIONS

PROJECT NUMBER 1-70-1(33)00

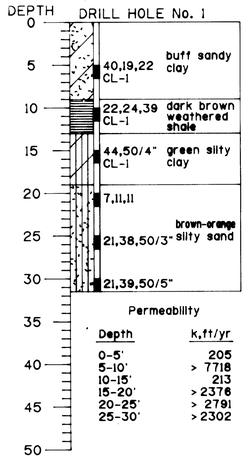
DAIRY CANYON
DETENTION BASIN
PLAN SHEET

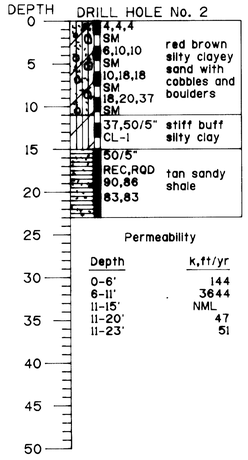
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

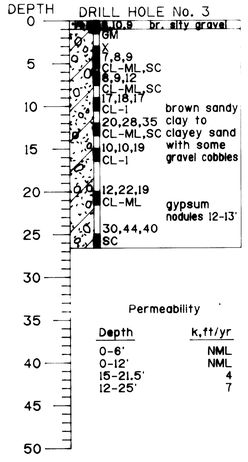
DESIGNED BBB	CHECKED KRN	DRAWN LOB	SCALE NONE
APPROVED	DATE	DRAWING NO. RF-2	
REVISION	DATE	SHEET NO. 4	

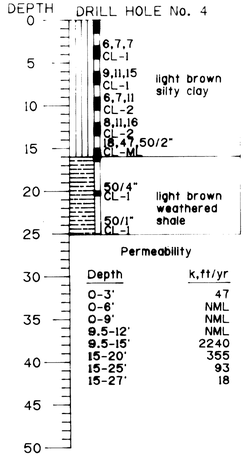
PLAN1.DGN

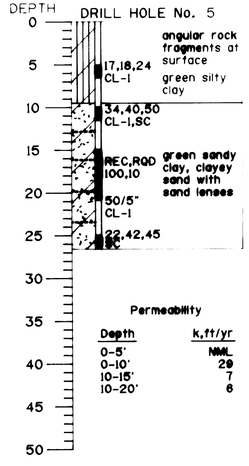
"AS CONST'D."

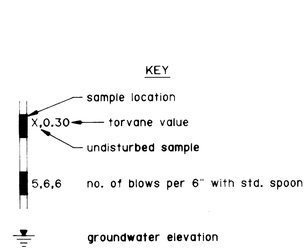












NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM USED TO DESIGNATE SOIL TYPE.

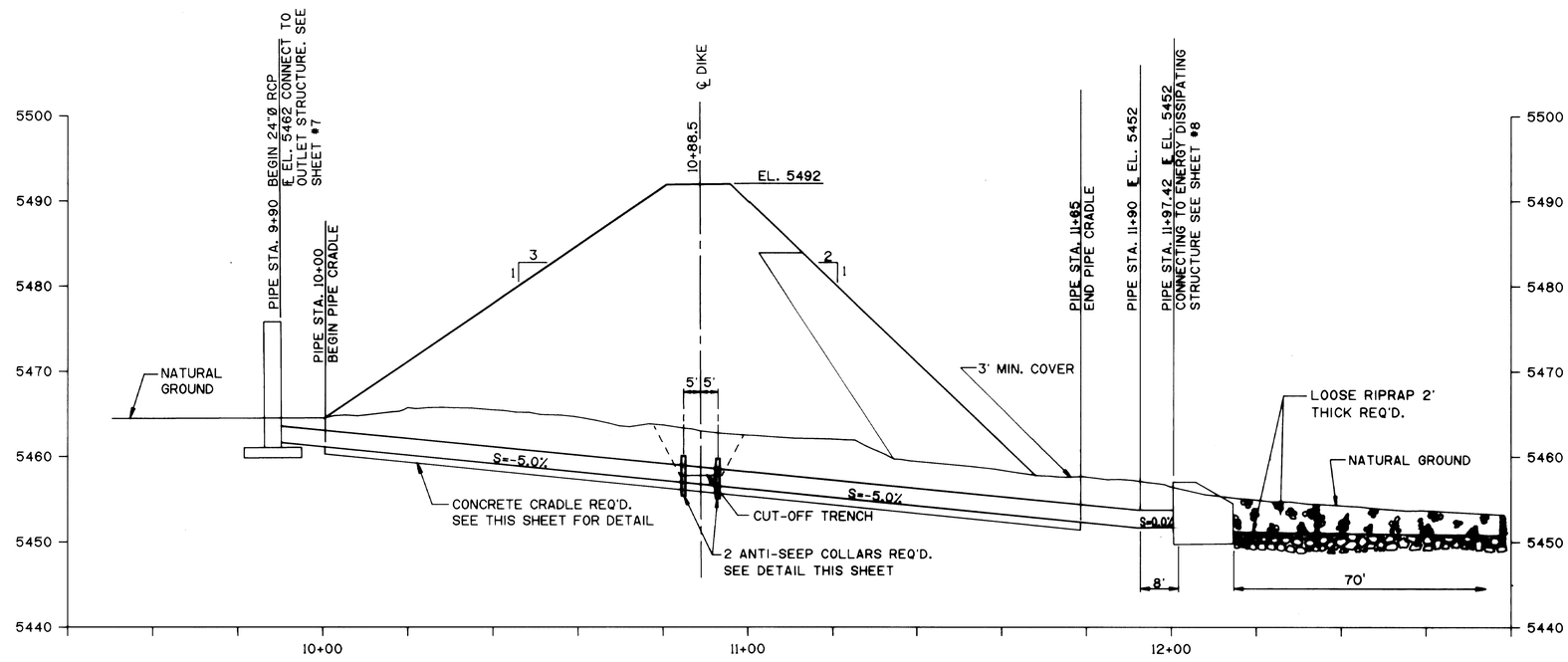
PROJECT NUMBER
I-70-K23(3)6

DAIRY CANYON
DETENTION BASIN
DRILL HOLE & TEST PIT LOGS

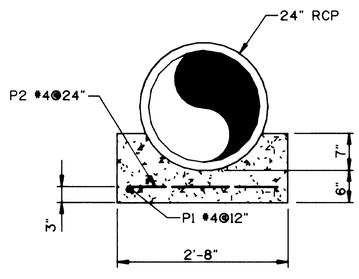
CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BBB	KRN	LCJ	NONE
APPROVED	DATE	DRAWING NO.	RF-2
REVISION	DATE	SHEET NO.	5

"AS CONST'D."



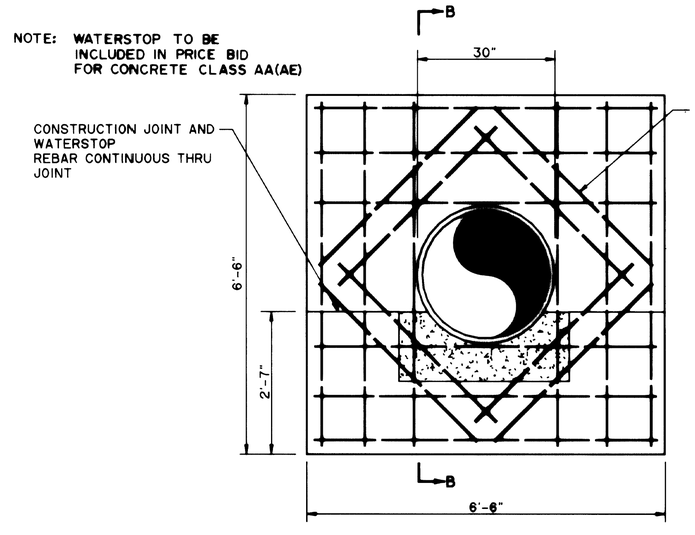
OUTLET PIPING DETAIL



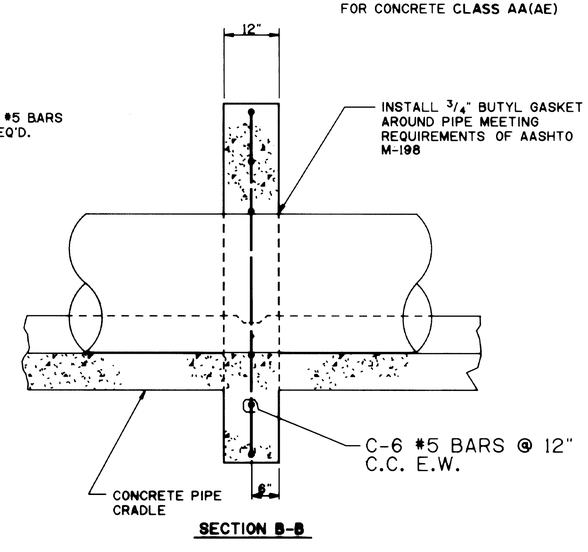
PIPE CRADLE DETAIL

ESTIMATED CONCRETE QUANTITY 12.5 CU.YD.

NOTE: WATERSTOP TO BE INCLUDED IN PRICE BID FOR CONCRETE CLASS AA(AE)



NOTE: BUTYL GASKET TO BE INCLUDED IN PRICE BID FOR CONCRETE CLASS AA(AE)



SECTION B-B

ANTI-SEEP COLLAR DETAIL

ESTIMATED CONCRETE QUANTITY 3 CU.YD. (2 REQ'D.)

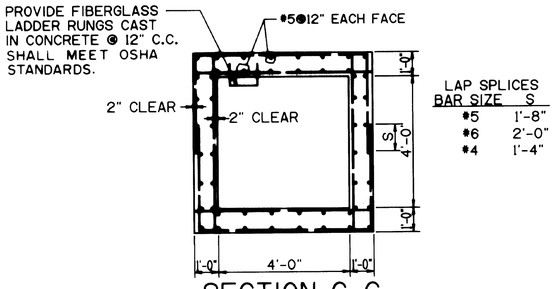
PROJECT NUMBER 1-70-122103	DAIRY CANYON DETENTION BASIN OUTLET PIPE DETAILS		DESIGNED RRB	CHECKED KRH	DRAWN LCJ	SCALE NONE
			APPROVED	DATE	DRAWING NO. RF-2	
			REVISION	DATE	SHEET NO. 6	

"AS CONST'D."

NOTES:

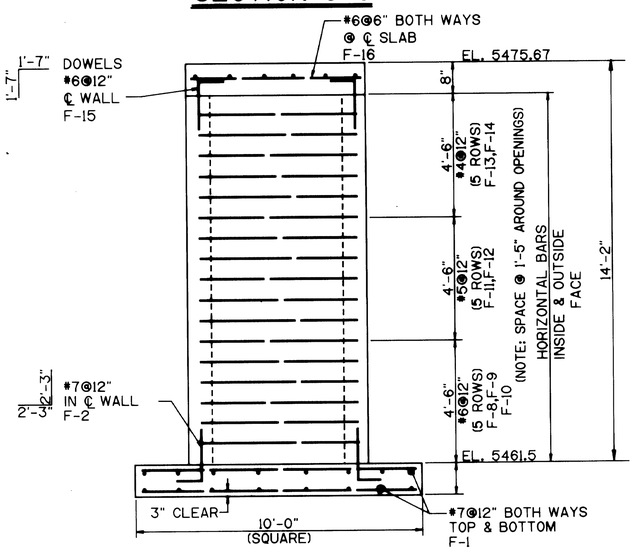
1. GATE CONSTRUCTED AS PER 705.02 OF THE STATE OF UTAH STANDARD SPECIFICATIONS FOR ROAD & BRIDGE CONSTRUCTION EDITION OF 1979 & SUBSEQUENT ADDENDUMS.
2. BUTYL GASKET SHALL BE INCLUDED IN THE PRICE BID FOR 24" RCP.
3. LADDER RUNGS TO BE INCLUDED IN THE PRICE BID FOR CONCRETE CLASS AA(AE).
4. PAINT WELDED JOINTS WITH ONE COAT ZINC CHROMATE PRIMER FOLLOWED WITH A GRAY ENAMEL AS PER 713.02
5. ALL EXPOSED STRUCTURAL STEEL SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM 123.

ESTIMATED CONCRETE QUANTITY - 14.9 CU.YD.

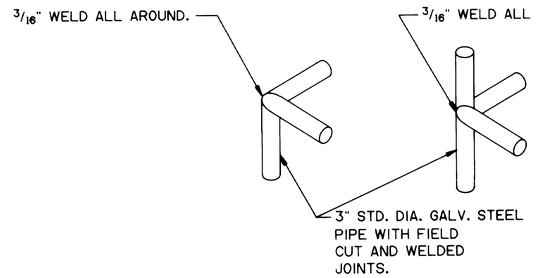


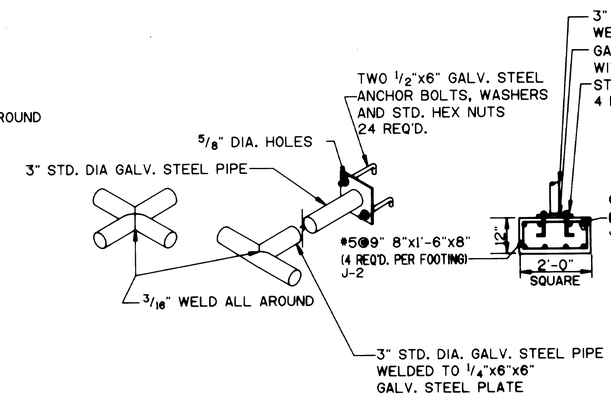
LAP SPLICES	
BAR SIZE	S
#5	1'-8"
#6	2'-0"
#4	1'-4"

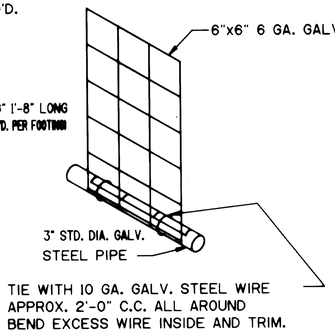
SECTION C-C



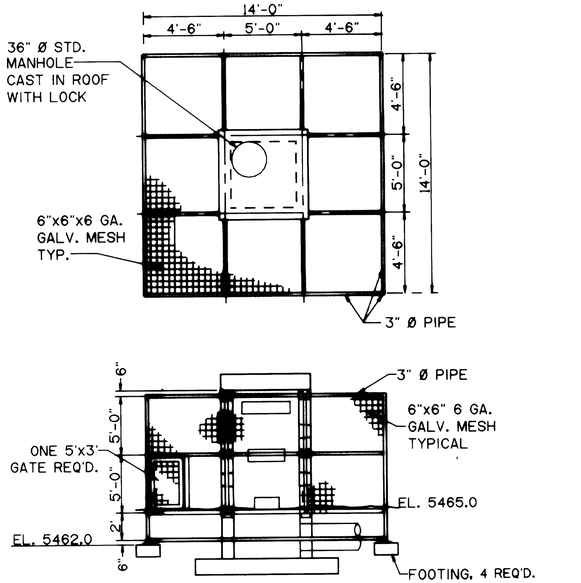
SECTION B-B



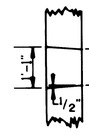




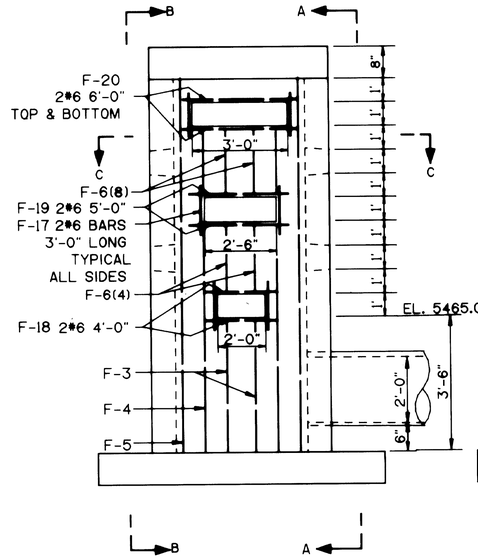
WIRE SUPPORT DETAILS



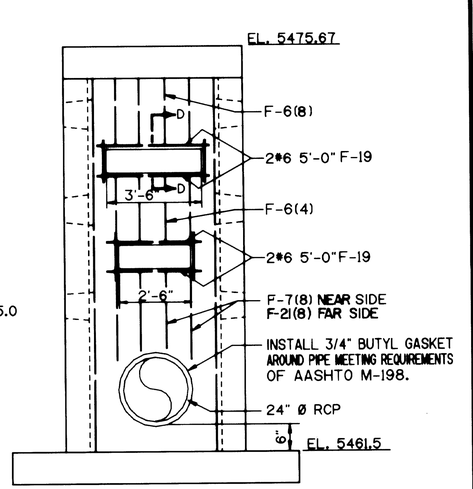
TRASH RACK DETAIL



SECTION D-D



OUTLET STRUCTURE

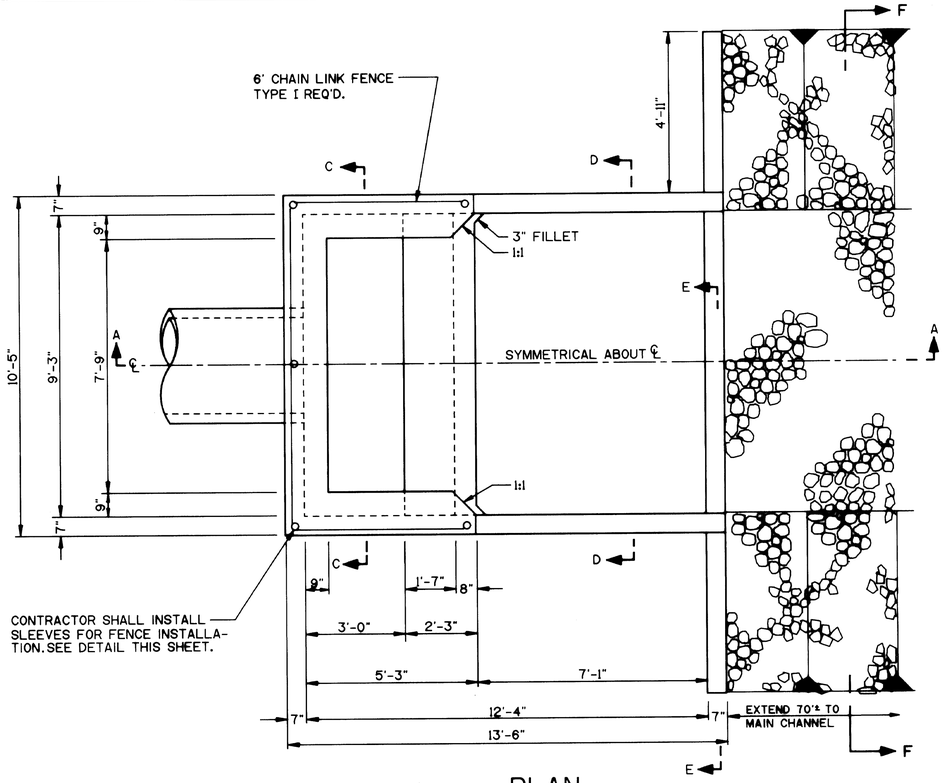


SECTION A-A

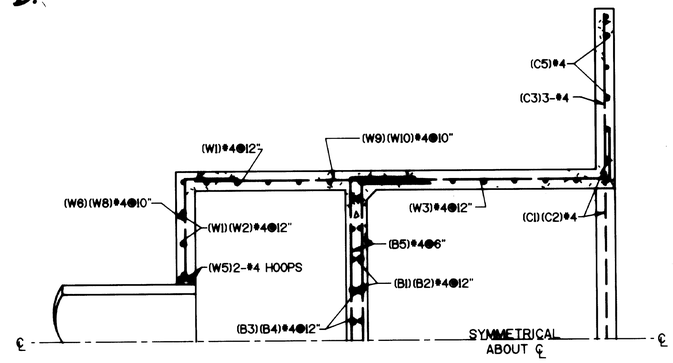
PROJECT NUMBER I-70-1(23)36	DAIRY CANYON DETENTION BASIN OUTLET STRUCTURE	CREAMER & NOBLE ENGINEERS ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BEG	KRN	DRL	NONE
APPROVED	DATE	DRAWING NO.	
		RF-2	
REVISION	DATE	SHEET NO.	
		7	

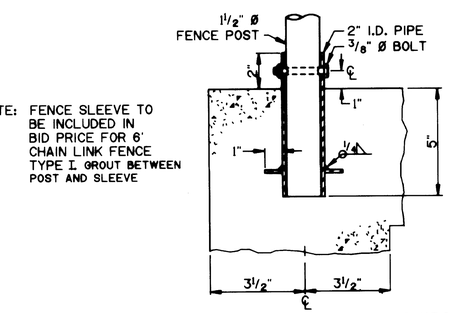
"AS CONST'D."



PLAN



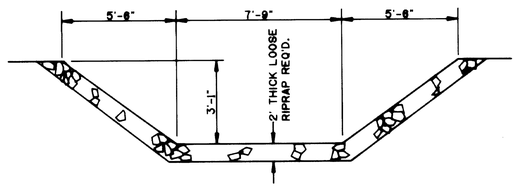
SECTION B-B



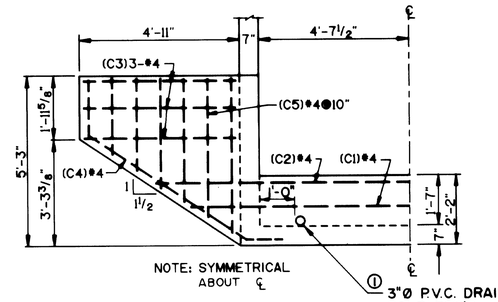
NOTE: FENCE SLEEVE TO BE INCLUDED IN BID PRICE FOR 6' CHAIN LINK FENCE TYPE I GROUT BETWEEN POST AND SLEEVE

NOTE: ALL EXPOSED METAL WILL BE HOT DIP GALVANIZED IN ACCORDANCE WITH ASTM-123.

FENCE POST SLEEVE DETAIL

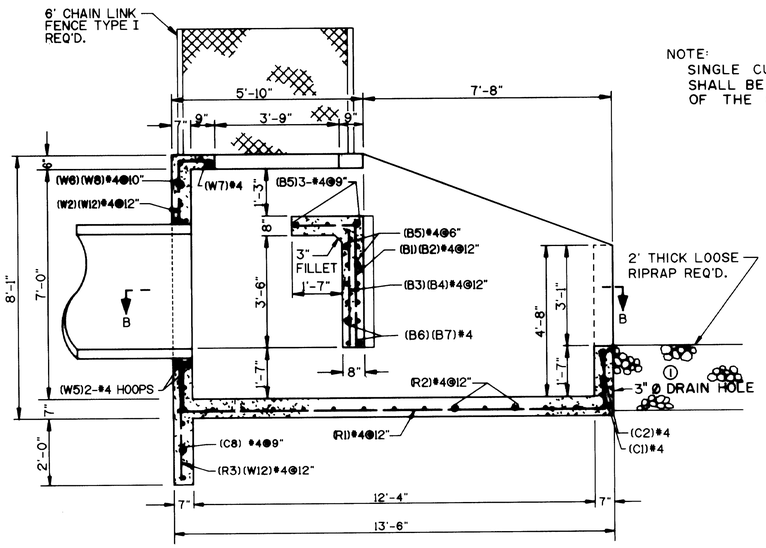


SECTION F-F



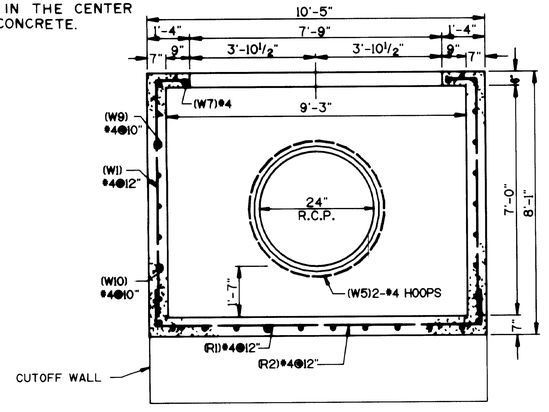
NOTE: SYMMETRICAL ABOUT ℄

SECTION E-E

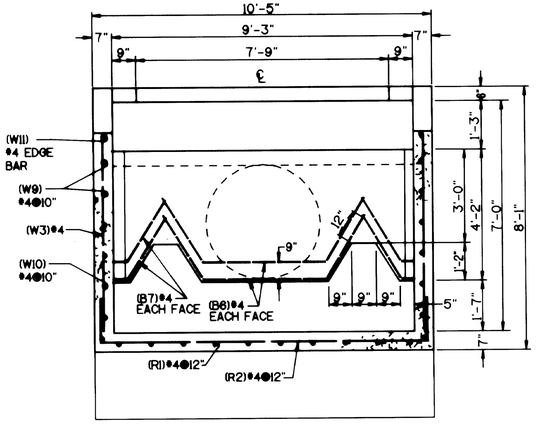


SECTION A-A

NOTE:
SINGLE CURTAIN OF STEEL SHALL BE IN THE CENTER OF THE CONCRETE.



SECTION C-C



SECTION D-D

ESTIMATED QUANTITIES
CONCRETE 11.3 CU.YD.

NO.	BY	DATE	TYPE	REMARKS
①	SEL	9/9		ADD 3"Ø P.V.C. PIPE HOLE

REVISIONS

PROJECT NUMBER I-70-1(23)36

DAIRY CANYON DETENTION BASIN

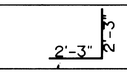
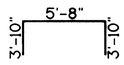
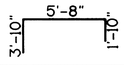
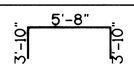
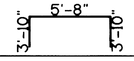
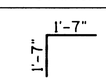
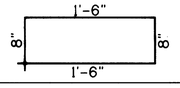
ENERGY DISSIPATING STRUCTURE

DREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

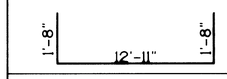
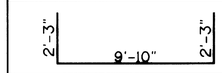
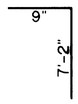
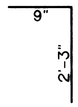
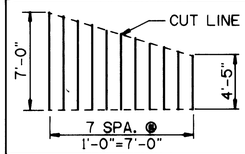
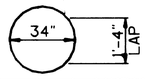
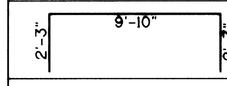
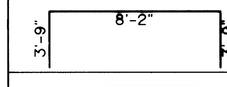
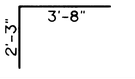
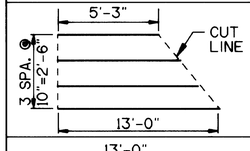
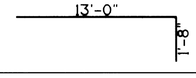
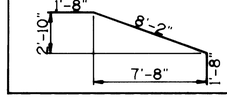
DESIGNED BBB	CHECKED KRN	DRAWN LOB	SCALE NONE
APPROVED	DATE	DRAWING NO. RF-2	
REVISION	DATE	SHEET NO. 8	

"AS CONST'D."

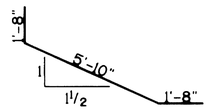
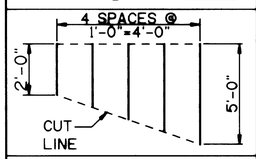
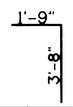
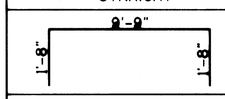
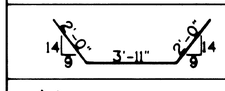
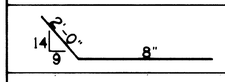
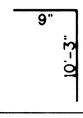
STEEL SCHEDULE
OUTLET STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT	#7	F-1	9'-6"	FOOTING	44	855
	#7	F-2	4'-6"	FOOTING	22	202
STRAIGHT	#5	F-3	3'-3"	WALL	8	27
STRAIGHT	#5	F-4	7'-3"	WALL	8	60
STRAIGHT	#5	F-5	13'-11"	WALL	8	116
STRAIGHT	#5	F-6	2'-9"	WALL	48	138
STRAIGHT	#5	F-7	2'-6"	WALL	8	21
	#6	F-8	13'-4"	WALL	6	120
	#6	F-9	11'-4"	WALL	4	68
STRAIGHT	#6	F-10	5'-8"	WALL	18	153
	#5	F-11	13'-4"	WALL	10	139
STRAIGHT	#5	F-12	5'-8"	WALL	20	118
	#4	F-13	13'-4"	WALL	10	92
STRAIGHT	#4	F-14	5'-8"	WALL	20	76
	#6	F-15	3'-2"	WALL/ROOF	22	105
STRAIGHT	#6	F-16	5'-6"	ROOF	26	216
STRAIGHT	#6	F-17	3'-0"	WALL	40	180
STRAIGHT	#6	F-18	4'-0"	WALL	48	289
STRAIGHT	#6	F-19	5'-0"	WALL	24	180
STRAIGHT	#6	F-20	5'-8"	WALL	8	68
STRAIGHT	#5	F-21	5'-3"	WALL	8	44
STRAIGHT	#5	J-1	1'-8"	TRASH RACK FOOTING	32	56
	#5	J-2	4'-10"	TRASH RACK FOOTING	16	81
STRAIGHT	#4	P1	40'-0"	PIPE CRADLE	18	482
STRAIGHT	#4	P2	2'-2"	PIPE CRADLE	101	146
STRAIGHT	#5	C6	6'-0"	CUT OFF COLLAR	24	150
STRAIGHT	#5	C7	4'-0"	CUT OFF COLLAR	16	67

STEEL SCHEDULE
OUTLET ENERGY DISIPATING STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
	#4	R1	16'-3"	FLOOR	11	119
	#4	R2	14'-4"	FLOOR	13	124
	#4	W1	7'-11"	WALL	10	53
	#4	W2	3'-0"	WALL	3	6
	#4	W3	45'-8"	WALL	2 SETS	61
NOT USED	-	W4	-	NOT USED	-	-
	#4	W5	10'-4"	WALL	2	14
	#4	W6	14'-4"	WALL	6	57
	#4	W7	15'-8"	ROOF	1	10
	#4	W8	5'-11"	WALL	10	40
	#4	W9	36'-6"	WALL	2 SETS	49
	#4	W10	14'-8"	WALL	14	137
	#4	W11	11'-6"	WALL - EDGE BAR	2	15

STEEL SCHEDULE
OUTLET ENERGY DISIPATING STRUCTURE

BEND	SIZE	MARK	LENGTH	LOCATION	# REQ.	WT.(LBS)
STRAIGHT	#4	C1	12'-7"	WINGWALL	1	8
STRAIGHT	#4	C2	14'-11"	WINGWALL	1	10
STRAIGHT	#4	C3	5'-0"	WINGWALL	6	20
	#4	C4	9'-2"	WINGWALL	2	12
	#4	C5	17'-6"	WINGWALL	2 SETS	23
	#4	B1	5'-5"	BAFFLE	8	30
	#4	B2	4'-3"	BAFFLE	2	6
STRAIGHT	#4	B3	3'-8"	BAFFLE	8	20
STRAIGHT	#4	B4	2'-6"	BAFFLE	2	3
	#4	B5	13'-1"	BAFFLE	11	96
	#4	B6	7'-11	BAFFLE	4	21
	#4	B7	2'-8"	BAFFLE	8	14
	#4	W12		WALL	8	55
STRAIGHT	#4	C8	9'-10"	CUTOFF WALL	3	20
STRAIGHT	#4	R3	3'-8"	CUTOFF WALL	4	10

SUMMARY OF BARS

2738 FEET OF #4 BARS @ 0.668 LBS/FT.= 1830
974 FEET OF #5 BARS @ 1.043 LBS/FT.= 1017
917 FEET OF #6 BARS @ 1.502 LBS/FT.= 1378
517 FEET OF #7 BARS @ 2.044 LBS/FT.= 1056

ALL REINFORCING STEEL SHALL BE EPOXY COATED

TOTAL WT. 5281
USE 5300

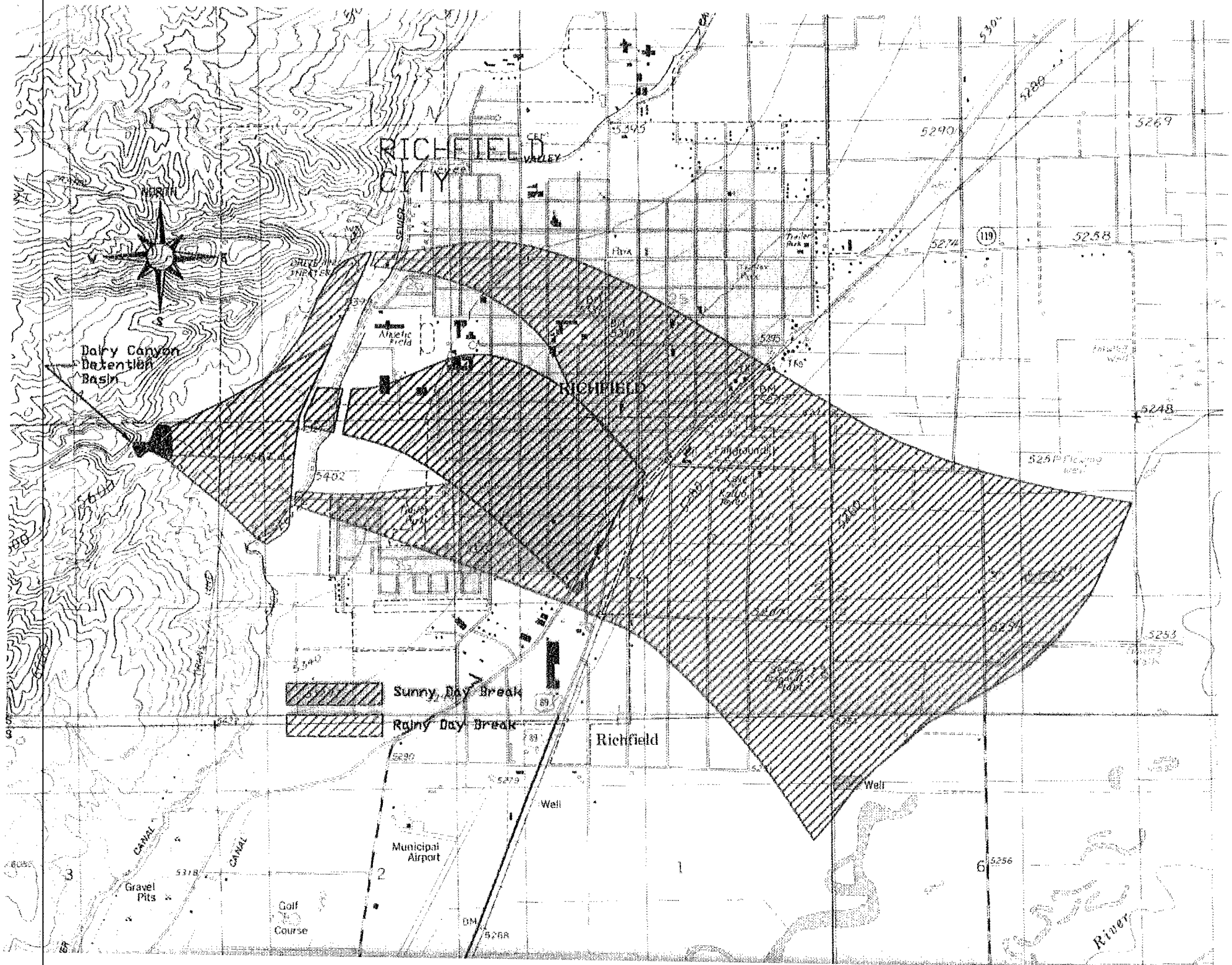
PROJECT NUMBER
I-70-1237(6)

DAIRY CANYON
DETENTION BASIN

STEEL SCHEDULE

CREAMER & NOBLE ENGINEERS
ST. GEORGE, UTAH

DESIGNED	CHECKED	DRAWN	SCALE
BSB	KRN	AKB	NONE
APPROVED	DATE	DRAWING NO.	
		RF-2	
REVISION	DATE	SHEET NO.	
		9	


RICHFIELD CITY
NORTH
Dairy Canyon Detention Basin
Athletic Field
RICHFIELD
Sunny Day Break
Rainy Day Break
Richfield
Well
Well
Municipal Airport
Gravel Pits
Golf Course
CANAL
CANAL
River
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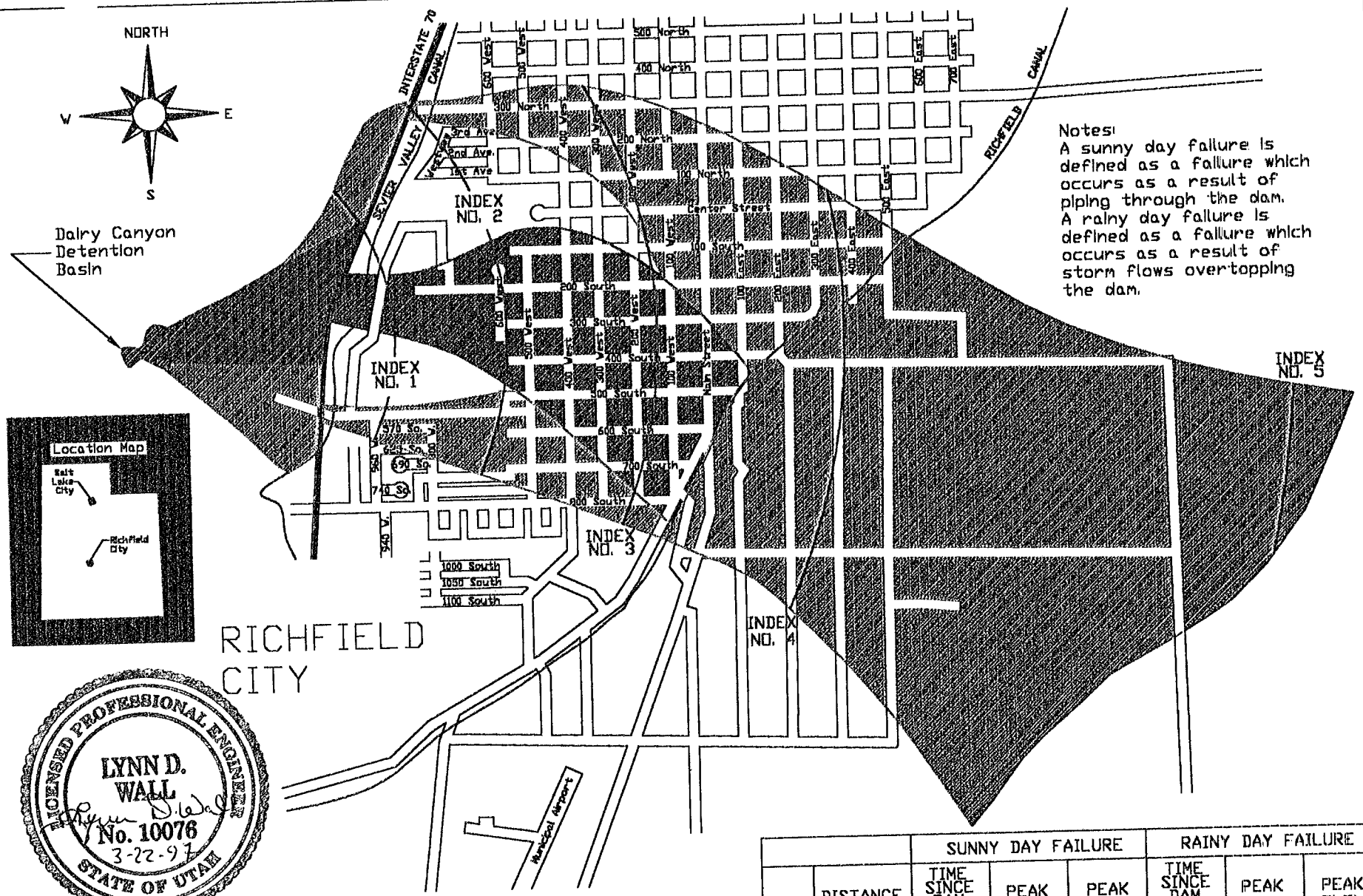

LICENSED PROFESSIONAL ENGINEER
LYNN D. WALL
No. 10076
3-22-97
STATE OF UTAH

		SUNNY DAY FAILURE			RAINY DAY FAILURE		
INDEX NO.	DISTANCE FROM DAM (MILES)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)	TIME SINCE DAM BREAK (HOURS)	PEAK DEPTH (FEET)	PEAK FLOW (CFS)
1	0.6	0.43	0.4	1634	0.50	0.7	4678
2	0.9	1.47	0.4	446	1.00	1.0	2488
3	1.3	2.20	0.5	350	1.43	0.9	1955
4	1.8	2.90	0.5	305	1.83	1.0	1678
5	3.0	4.53	0.5	148	3.06	1.0	800

SCALE: NONE

INUNDATION AREAS

SUNNY DAY FAILURE

RAINY DAY FAILURE

DAIRY CANYON DETENTION DAM EMERGENCY ACTION PLAN INUNDATION MAP

Attachment C. USDA Sedimentation Map

- EXPLANATION -

Yield Class	Yield Rate 1/ (Ac.Ft/Sq.Mi/Yr.)	Total Area (Sq.Mi.)
1	> 3.0	____
2	1.0-3.0	____
3	0.5-1.0	____
4	0.2-0.5	____
5	0.1-0.2	____
6	< 0.1	____

▼ 0.45 AVERAGE ANNUAL SUSPENDED SEDIMENT YIELDS DETERMINED FROM SEDIMENT TRANSPORT RECORDS. RATES ARE IN Ac.Ft/Sq.Mi/Yr.

80 - 20 ECT. (PERCENT OF SHEET AND RILL EROSION - PERCENT OF CHANNEL AND GULLY EROSION.

Subregion Number	Subregions
4	SNAKE
1	BEAR LAKE
1	GREAT SALT LAKE
1	SEVIER LAKE
2	GREEN RIVER
2	SAN JUAN - COLORADO
1	UPPER MAIN STEM
3	LOWER MAIN STEM

1/ DO NOT USE THESE RATES TO DETERMINE SEDIMENT YIELDS AT SPECIFIC SITES. LARGE VARIATIONS IN SEDIMENT RATES MAY OCCUR WITHIN THE DELINEATED AREAS.

SOURCES OF INFORMATION

1. GREAT BASIN, UPPER COLORADO AND LOWER COLORADO REGIONS, COMPREHENSIVE FRAMEWORK STUDY, APPENDICES VIII, WATERSHED MANAGEMENT, JUNE 1971, PACIFIC SOUTHWEST INTER-AGENCY COMMITTEE/WATER RESOURCES COUNCIL.
2. UTAH STATE SOILS MAP AND SOILS DESCRIPTIONS.
3. RESERVOIR SURVEYS BY SCS & USBR
4. SUSPENDED LOAD MEASUREMENTS BY USGS, USBR & SCS.
5. WATERSHED STUDIES BY SCS.
6. GENERAL KNOWLEDGE OF THE STATE FROM REGULAR SCS PROGRAM WORK.

ESTIMATED SEDIMENT YIELD RATES FOR THE STATE OF UTAH

EROSION & SEDIMENTATION -70
WESTERN U.S. WATER PLAN
AUGUST 1973
(SUBJECT TO REVISION)

prepared by
U.S.D.A., Soil Conservation Service
Geologist, Bob L. Bridges

10 5 0 5 10 15
scale in miles

Attachment D. PSAIC Model Output

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Cottonwood Canyon

Watershed:	Westwd EWP	**Square Miles:**	21	**Acres (sq mi * 640):**	13,248
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	3
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	3
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	10
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-7
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	35 30 16 -7
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-9
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	6
	Alternative Calculation	Percent of area with apparent erosion			22
				Calculated Points	10
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	5

		Subtotal (a) thru (g)	9
		Subtotal (h) thru (i)	11
		Grand total	20
		Soil Bulk Density (gram/cm3)	NA
Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.17
Acres:	13,248	**Sediment Yield (Tons/acre/year)**	0.52
		Total Sediment (Tons/year)	6,908

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Dairy Canyon

Watershed:	Westwd EWP	**Square Miles:**	2	**Acres (sq mi * 640):**	1,216
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	4
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	8
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	10
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-7
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	35 30 16 -7
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-9
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	20
	Alternative Calculation	Percent of area with apparent erosion			35
				Calculated Points	16
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	7
				Subtotal (a) thru (g)	15
				Subtotal (h) thru (i)	27
				Grand total	42
				Soil Bulk Density (gram/cm3)	NA
		Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.37
		Acres:	1,216	**Sediment Yield (Tons/acre/year)**	0.52
				Total Sediment (Tons/year)	634

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Flat Canyon

Watershed:	Westwd EWP	**Square Miles:**	16	**Acres (sq mi * 640):**	10,496
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	3
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	3
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	10
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-7
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	33 29 16 -7
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-7
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	10
	Alternative Calculation	Percent of area with apparent erosion			35
				Calculated Points	16
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	5

		Subtotal (a) thru (g)	11
		Subtotal (h) thru (i)	15
		Grand total	26
		Soil Bulk Density (gram/cm3)	NA
Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.21
Acres:	10,496	**Sediment Yield (Tons/acre/year)**	0.52
		Total Sediment (Tons/year)	5,473

Pacific Southwest Interagency Committee Sediment Yield Procedure (PSIAC) - Wood Canyon

Watershed:	Westwd EWP	**Square Miles:**	3	**Acres (sq mi * 640):**	1,856
Factor	**Discipline**	**PSIAC Rating**			**Points**
(a) Surface Geology	Geologist	Marine shales and related mudstones and siltstones	Rocks of Medium Hardness Moderately weathered Moderately fractured	Massive, hard formations	
		5	3	0	3
(b) Soils	Soil Scientist	Fine textured; easily dispersed; saline alkaline; high shrink swell characteristcis; single grain silt and fine sands	Medium textured soil	High percentage of rock fragments	
		Single grain silt and fine sands	Occasional rock fragements Cliché layers	Aggregated clays High in organic matter	
		10	5	0	2
(c) Climate	Local	Storms of several day's duration with short periods of intense rainfall	Storms of moderate duration and intensity	Humid climate with rainfall of low intensity	
		Frequent intense convective storms	Infrequent convective storms	Precipitation in form of snow	
		Freeze-thaw occurrences		Arid climate, low intensity storm Arid climate; rare convective storms	
		10	5	0	4
(d) Runoff	Hydrologist	High peak flows per unit area	Moderate peak flows per unit area	Low peak flow per unit area	
		Large volume of flow per unit area	Moderate volume of flow per unit area	Low volume of runoff per unit area	
				Rare runoff events	
		10	5	0	5
(e) Topography	GIS Specialist	Steep upland slopes (in excess of 30%)	Moderate upland slopes (less than 20%)	Gentle upland slopes (less than 5%)	
		High relief; little or no floodplain development	Moderate fan or floodplain development	Extensive alluvial plains	
		10	5	0	7
(f) Effective Ground Cover	GIS Specialist	Ground cover does not exceed 20%	Cover not exceeding 40%	Area completely protected by vegetation, rock fragments, litter	
		Vegetation sparse; little or no litter	Noticeable litter		
		No rock in surface soil cover	If trees present, understory not well developed	Little opportunity for rainfall to reach erodible material	
		10	0	-10	-5
	Alternative Calculation	Alternative Calculation: Enter percent of surface covered by vegetation, litter and rock		Vegetation (%) Litter (%) Rock (%) Calculated Points	25 29 14 -5
(g) Land Type and Management Quality	GIS Specialist	Almost all of area overgrazed or historic overgrazing impacts still active	<50% of area overgrazed or with historic overgrazing impacts still active	No recent logging	
		All of area recently burned	<50% of area recently logged	Good grazing management or historic overgrazing impact under control	
		Roads in need of O&M or improved design	Ordinary road and other construction		
		Almost all of area is badlands with minimal armor	Almost all of area is badlands with 50% of area covered with armor	Badlands are totally armored	
		10	0	-10	-9
(h) Upland Erosion	Geologist	More than 50% of the area characterized by concentrated flow erosion with increasing gully development	About 25% of the area characterized by concentrated flow erosion with increasing gully development	No apparent signs of erosion	
		25	10	0	5
	Alternative Calculation	Percent of area with apparent erosion			35
				Calculated Points	16
(i) Channel Erosion and Sediment Transport	Geologist	Eroding banks, continously or at frequent intervals, with deep flow of long duration	Moderate flow depths, medium flow duration with occasionally eroding banks or bed	Wide shallow channels with flat gradients and shor flow duration	
		Active headcuts and degradation in tributary channels		Channels in massive rock, large boulders, or well vegetated Articially controlled channels	
		25	10	0	5
				Subtotal (a) thru (g)	7
				Subtotal (h) thru (i)	10
				Grand total	17
				Soil Bulk Density (gram/cm3)	NA
		Watershed:	Westwd EWP	**Sediment Yield (Ac ft/sq mi/year)**	0.15
		Acres:	1,856	**Sediment Yield (Tons/acre/year)**	0.52
				Total Sediment (Tons/year)	968

TM004 – Hydraulics

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Attachment A. Historical Flood Maps
Attachment B. Flat Canyon Flood Inundation Maps
Attachment C. Hydraulic Analysis Support Information

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1.0 Flood Modeling

A hydraulic analysis was performed to complete flood modeling to support the economic analysis and determine existing and proposed flood channel capacities.

Richfield has a long history of flooding; flood damage dates back to when the town was first settled (Schick International 1977, Bakaitis 2016). These studies document repeated floods in and around Richfield City back to 1950. More recent flood events have been documented by county emergency and road department personnel. These include 2014, 2016, and 2018 events. Attachment A shows a map of locations where historic flooding has occurred. Storm events have consistently revealed several infrastructure limitations:

- The watersheds west of Richfield produce large sediment-laden flows that drain directly into the Sevier Valley and Richfield canals. The canals are not designed to handle such flows and have breached in the past, impacting downstream properties.
- The canals convey flows through Richfield City and other populated areas of Sevier County, resulting in high flood damage and amplified risk.
- Agricultural lands are also impacted when storm flows overtop canals or where overshot structures convey flow directly onto these properties.

Local and county leaders provided additional information on frequent flooding locations. Measured flood data was not available for these events; therefore, this data could not be used to calibrate the hydraulic model. However, the results of the flood modeling closely simulated the general flooding areas of historic events.

1.1 Hydraulic Model Setup

The U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS 5.0.6) was used to create a combined one-dimensional (1D) and two-dimensional (2D) model to simulate flooding in Richfield and the surrounding area. This combined 1D\2D model can perform hydrodynamic routing within an unsteady flow analysis. The Sevier Valley Canal and Richfield Canal, which have historically overtopped and contributed to flooding, were modeled using the 1D unsteady-state flow portions of the model. These canals were then breached at critical locations. The breached flows were modeled using the 2D unsteady-state flow portions of the model.

1.1.1 Terrain Data

The surface used to build the model was derived from 2018 LiDAR data with a 1-meter resolution. The LiDAR data was downloaded from the Utah Automated Geographic Reference Center (AGRC) and processed using ESRI's ArcGIS software. The surface covers the entire project area so there was no need to supplement the analysis with additional data.

1.1.2 Computational Mesh

A 2D flow area was defined to encompass the inundation areas for the maximum storm event. This same 2D flow area was then used for all the smaller storm events. The grid size for each of the scenarios is shown in Table 1-1. Figure 1-1 shows the 2D flow areas and boundary conditions for the Flat Canyon model.

Table 1-1. Computation Mesh Gride Size for Each Scenario

Scenario	Grid Size (feet)
Flat Canyon	20

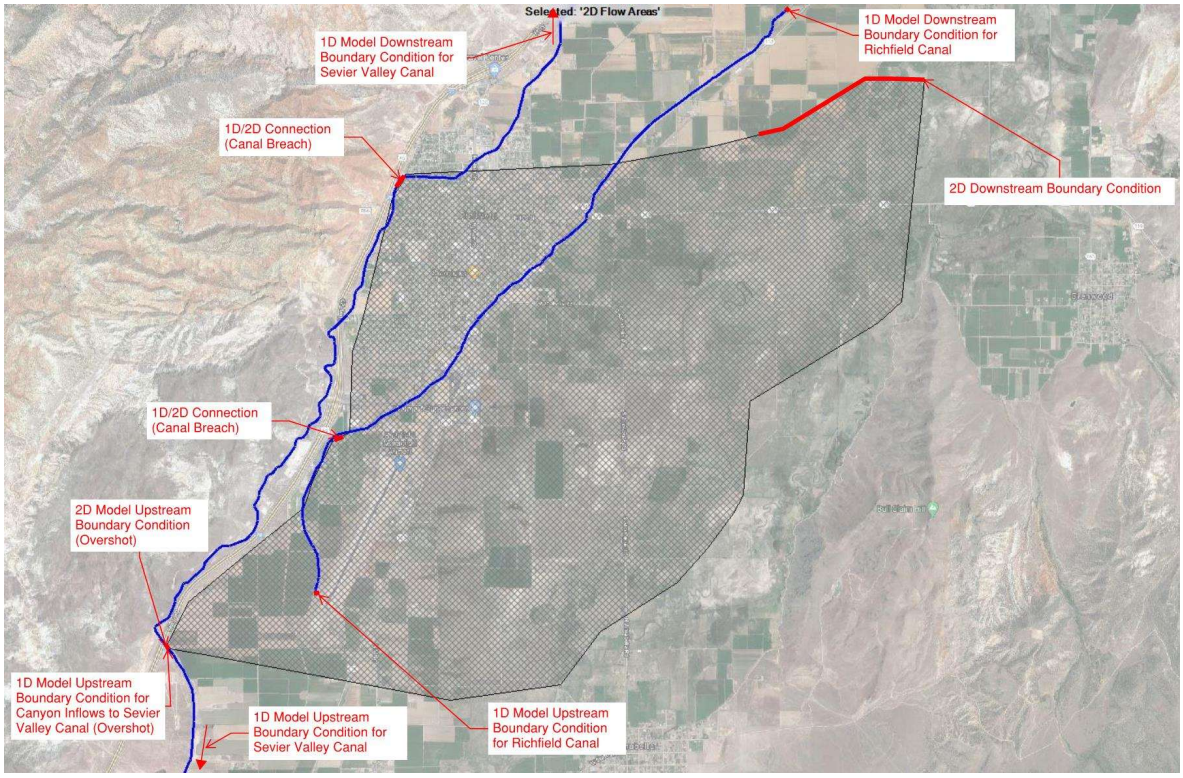

Figure 1-1. Flat Canyon 2D Flow Mesh and Boundary Conditions

1.1.3 Land Cover

Model Manning's roughness values were determined by utilizing the 2016 NLCD dataset for the modeling area. The Manning's n values were assigned to the following areas: the canals, agricultural fields, non-vegetated soils, parks and recreational areas, residential areas, and roads. The specific values were determined based on-site visits and photographs as well as guidance from various references including the book Open-Channel Hydraulics (Chow, 1959). The final land cover types and corresponding Manning's n values used in the HEC-RAS model are shown in Table 1-2.

Table 1-2. Model Boundary Conditions

Land Cover Type	Manning's n Value
Agricultural Field	0.06
None Vegetated Soil	0.025
Parks and Recreational Areas	0.04
Residential Areas	0.075
Roads	0.025

1.1.4 Boundary Conditions

Boundary conditions were defined for both the 1D and 2D positions of the model. Table 1-3 shows the type of boundary condition used for each model. Upstream boundary condition flow hydrographs are presented in *TM002 – Hydrology*. Refer to Figure 1-1 and for spatial placement of each boundary condition.

Table 1-3. Model Boundary Conditions

Modeling Parameters	Applicable Scenario	Type
1D Model Upstream Boundary Condition for Sevier Valley Canal	Flat	Flow Hydrograph
1D Model Upstream Boundary Condition for Canyon Inflows to Sevier Valley Canal (Overshot)	Flat	Lateral Inflow Hydrograph
1D Model Downstream Boundary Condition for Sevier Valley Canal	Flat	Normal Depth
1D Model Upstream Boundary Condition for Richfield Canal	Flat	Flow Hydrograph
1D Model Downstream Boundary Condition for Richfield Canal	Flat	Normal Depth
2D Model Upstream Boundary Condition (Overshot)	Flat	Flow Hydrograph
1D/2D Connection (Canal Breach)	Flat	Lateral Inflow Structure
2D Downstream Boundary Condition	Flat	Normal Depth

1.1.5 Assumptions

The model runtime was set to 72 hours to allow for the complete hydrographs to pass through the model domain. Some of the major assumptions of the hydraulic model included the following:

1. No infiltration or evaporation losses, i.e., attenuation is due solely to flood storage
2. Pressure distribution is hydrostatic
3. Hydraulic roughness based on steady, uniform, and fully turbulent flow
4. Channel elements are represented by uniform channel geometry and roughness
5. Minor culverts were considered plugged
6. Sevier Valley and Richfield Canals were modeled with 100 cfs of excess capacity each (200 cfs combined) for the existing conditions (based on discussions with the canal companies)
7. High-intensity localized storms generating isolated runoff

1.1.6 Model Calibration

Qualitative data (location of flooding, general flooding extents, etc.) was used to calibrate the model because limited measured flood and stormwater data were available for model calibration. While velocities and depths were evaluated to determine if values were within reasonable ranges, qualitative data was principally used. Historic flooding areas are identified on the map provided in Attachment A. This information was used to verify flood modeling results.

1.2

1.2 Modeling Scenarios

The hydraulic modeling scenarios were broken into existing and proposed conditions for Flat Canyon. The existing and proposed conditions were modeled for all eight recurrence intervals. The recurrence intervals modeled include the 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year 24-hour storm events. This resulted in a total of 16 separate model runs. Each canyon was modeled independently. A specific description of each of the modeled scenarios is described below.

1.2.1 Flat Canyon Existing Conditions Scenario

During smaller storm events, water from Flat Canyon flows across the canal and enters the south flood channel, eventually flowing into the Richfield Canal. During larger storm events, flows from Flat Canyon spill into the Sevier Valley Canal over the sides of the overshot structure; the remaining flows drain to the Richfield Canal via the south flood channel. Figure 1-4 shows the overshot structure during a larger storm event.

Flat Canyon storm flows entering the Sevier Valley Canal were modeled starting at the overshot structure, which was represented as a lateral inflow hydrograph boundary condition. A rating curve was generated to model the eight different storm events at the varying flows.

Figure 1.2-4. Sevier Valley Canal Overshot Structure near Flat Canyon (2016 Storm Event)

Breach parameters were defined at known critical problem areas along both the Sevier Valley Canal and Richfield Canal. Based on the modeling of higher flood events, both canals would breach at these specified locations, causing flooding. As discussed in Section 1.1.5, the existing conditions model assumed there was an additional 100 cfs of capacity and 1 foot of freeboard in both the Sevier Valley Canal and Richfield Canal (200 cfs combined capacity). During the model simulations, if the 1 foot of freeboard was exhausted and the water surface elevation exceeded the bank elevation by 0.25 feet, then the canal would breach. The breach location along the Sevier Valley Canal was located near 500 North and College Avenue in Richfield City. The breach location for the Richfield Canal was located near the golf course, west of Home Depot.

These breach locations can be seen on the series of maps provided in Attachment B; these maps also show the expected inundation depths and inundation boundaries for Flat Canyon.

1.2.2 Flat Canyon Proposed Conditions Scenario

The peak discharge from the proposed Flat Canyon debris basin for the 200- and 500-year events were determined to be 192.9 cfs and 231.9 cfs, respectively. This flow would be split, with 150 cfs going to the south flood channel and 50 cfs going to the Sevier Valley Canal. The 150 cfs in the south flood channel will again be split, with 50 cfs being diverted to the Richfield Canal and the remaining 100 cfs continuing down the south flood channel to be discharged to the Sevier River. The 50 cfs in the Sevier Valley Canal would be diverted into the north flood channel and discharged into the Richfield Canal (adding a total of 100 cfs to the Richfield Canal). 2,100 feet downstream of this confluence 100 cfs would be diverted from the Richfield Canal back into the north flood channel and discharged to the Sevier River. As mentioned previously, these canals can take 100 cfs with 1 foot of freeboard, each; which is why the 200- and 500-year events are contained. As a result, the post-project conditions resulted in no flooding up to the 500-year event

2.0 Flood Channel Analysis

2.1 Existing South Flood Channel Evaluation

The existing south flood channel starts near the mouth of Flat Canyon, on the east side of I-70 just below an existing metal overshot structure. The south flood channel is earthen with three relatively straight segments and two nearly 90-degree bends. The channel is approximately 8,000 linear feet long with an average slope of about 0.0121 feet/foot. The channel has a typical trapezoidal cross-section with a bottom width of 6 feet, a top width of 25 feet, and a depth of 6 feet. Using Manning's equation with an n value of 0.035, the capacity of the channel was calculated to be approximately 577 cfs. The channel terminates at the Richfield Canal near the Richfield Municipal Airport. Existing channel capacity calculations are provided in Attachment C.

The existing overshot structure currently directs flows over the county road, onto agricultural fields, through a pig farm, and into the south flood channel. Flows that overwhelm the overshot structure drain into the Sevier Valley Canal. Flows directed into the south flood channel are conveyed to the Richfield Canal. Both canals are often at capacity when major storm events occur within Flat Canyon. This increases the risk of the canals being breached.

2.2 South Flood Channel Proposed Measures

The proposed improvement is to enlarge the south flood channel to accommodate the attenuated 100-year storm flow from the proposed Flat Canyon debris basin. This would enable the channel to convey flows from Flat Canyon to the Sevier River while removing flows and associated risks from the canals during 100-year and smaller storm events.

2.2.1 South Flood Channel Flat Canyon Overshot Structure

The overshot structure would be reconstructed to allow flows to be bifurcated into the south flood channel and into the Sevier Valley Canal. The overshot would outlet to a grouted riprap rock chute with an energy dissipation pool at the head of the south flood channel. Assuming the attenuated flows from Flat Canyon to be 200 cfs, at least 150 cfs would be conveyed over the canal and into the south flood channel,

while up to 50 cfs would pass over the sides of the overshot into the Sevier Valley Canal. The sides of the overshot structure would act as lateral weirs. Calculation information is provided in Attachment C.

2.2.2 South Flood Channel Upgrades

Both bends in the south flood channel would be widened, reshaped, and armored with riprap to prevent erosion. The existing culverts, which include two parallel 12-foot by 5-foot concrete box culverts under I-70, one 6-foot-diameter corrugated metal culvert, and one 12-foot by 5-foot concrete box culvert, all have sufficient hydraulic capacity for the proposed design flows. Box culvert abutments and culvert pipe entrances will be armored with riprap. Any vertical channel banks would be reshaped to reduce bank erosion and meet the minimum cross-sectional area necessary to safely carry the flows. All work would be conducted within a 100-foot-wide corridor centered over the 7,900-linear-foot-long channel. The proposed channel capacity calculations are provided in Attachment C.

2.2.3 South Flood Channel Pipeline Inlet Structure

A pipe inlet structure would be installed in the channel to route flows through a flood pipeline to the Sevier River. The inlet structure would be located upstream of the Richfield Canal and would route flows either over or under the canal. The inlet structure would have a trash rack to protect the flood pipeline from flood debris. The trash rack would be over-sized for partial emergency plugging and be accessible to allow raking and cleaning of floating debris by backhoe or other large equipment.

2.2.4 Closed Conduit Flood Pipeline

The closed conduit flood pipeline would consist of one 48-inch-diameter pipeline beginning at the splitter structure. The pipe would pass under Highway 118 and cross private lands, with the top of the pipe buried below normal cultivation practice depths (two feet or more where possible). The estimated pipeline alignment length is 8,943 feet. The pipeline would be capable of conveying a maximum of 100 cfs and have access manholes at all angle points and spaced no more than 1,000 feet apart to allow for pipe inspection and regular cleaning. Placement of the manholes would be coordinated with agricultural landowners to reduce land use conflicts as much as possible. Table 2-1 shows additional design information.

Table 2-1. South Flood Channel Pipeline Design Information.

Parameter	Value
Proposed Pipe Size	48-inch (DR26)
Proposed Pipe Material	HDPE
Estimated Length (feet)	8,943
Maximum Flow Capacity (cfs)	100
Maximum Velocity (feet/second)	7.96
Maximum Pressure (psi)	30
Upstream Invert (feet)	5,336.32
Downstream Invert (feet)	5273
Average Slope (feet/foot)	0.0071

Figure 2-1 shows the pipeline elevation profile with the hydraulic gradeline, static pressure, and dynamic pressure.

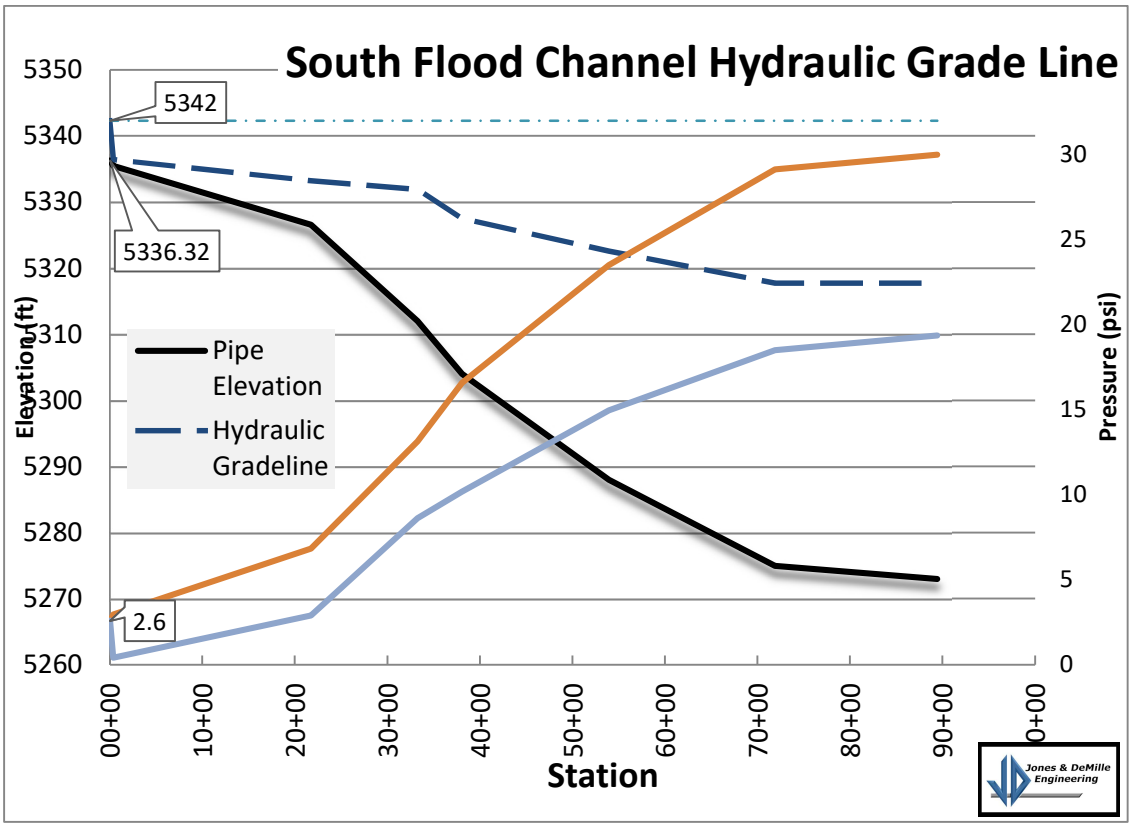

Figure 2-1. South Flood Channel Hydraulic Gradeline Profile

2.2.5 Pipe Outlet Structure and New Channel and Dike to Sevier River

The pipe outlet structure would consist of a concrete headwall with flap gate to prevent reverse flows.

A channel and dike would be constructed downstream of the outlet structure to convey water to the Sevier River. The channel would have a 15-ft bottom width with a depth of 3.33’ and side slopes of 3:1. The dike would be constructed on the south side of the channel with a 4’ top and 3:1 side slope. The height of the dike would vary as needed to achieve required freeboard.

Tailwater conditions were analyzed to ensure adequate channel capacity during Sevier River flood conditions. The maximum recorded flow for the Sevier River near Richfield is 1,078 cfs. LiDAR data were used to obtain ground surface elevations for the area below the proposed outlet. Assuming a Manning’s n value of 0.035 and a slope of 0.0003, the maximum flood depth was estimated to be 5.70 feet (EL = 5369 feet). This results in the maximum flood elevation being approximately 4 feet below the proposed outlet elevation. As a result, the tailwater conditions would not affect the flood channel capacity at the outlet.

2.3 North Flood Channel Existing Condition

The channel is approximately 7,100 linear feet of earthen channel and has an average slope of about 0.012 feet/foot. The channel has a typical trapezoidal cross-section with a bottom width of 6 feet, a top width of 26 feet, and a depth of 6 feet. Using Manning’s equation with an n value of 0.035, the capacity of the channel was calculated to be approximately 725 cfs with 1 foot of freeboard. The channel outlets into the Richfield Canal at the intersection of Highway 118 and 2070 East. Existing channel capacity calculations and cross-section information can be found in Attachment C.

There are several locations along the channel where the bank has eroded (see Figure 2-2). Modeling results indicate that maximum velocity could be as high as 10 feet per second.

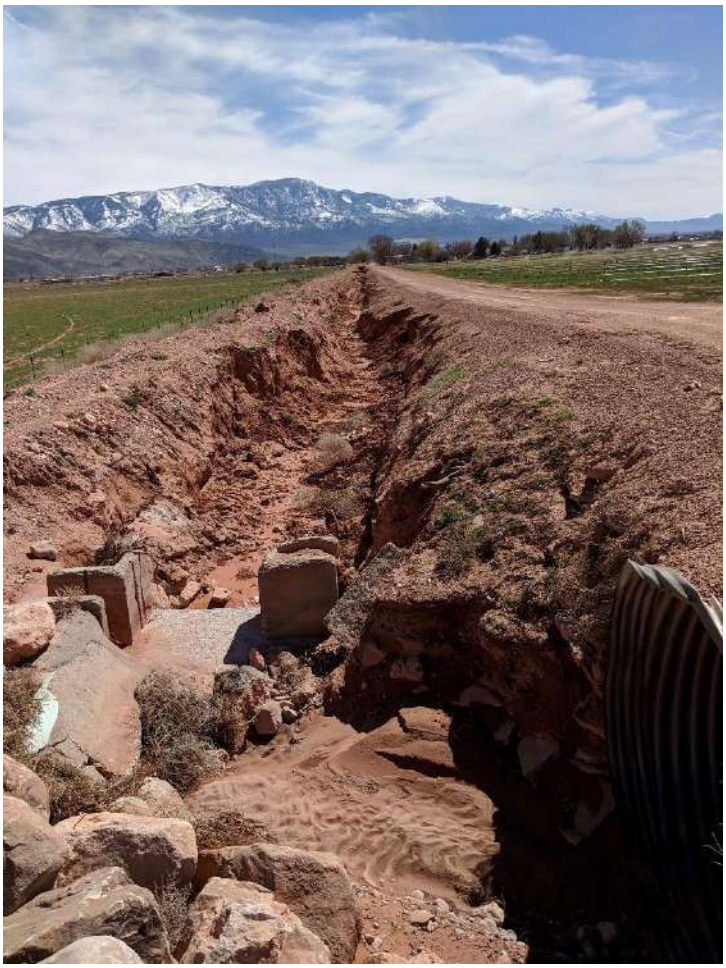

Figure 2-2. Eroded Banks on the North Flood Channel

2.4 North Flood Channel Proposed Measures

The existing flood channel would be re-shaped to convey the partially attenuated flows from up to the 100-year event as well as extend the channel to the Sevier River.

2.4.1 Sevier Valley Canal Emergency Overflow Structure

An emergency overflow structure would be constructed on the bank of the Sevier Valley Canal to divert up to 50 cfs from the canal into the north flood channel. The nearest outlets to the Sevier River from the proposed overflow structure are 8 miles upstream (proposed south flood channel) or 6.5 miles downstream (Wilkinson Wash Dump Gate). The emergency overflow structure would consist of a cast-in-place concrete headwall with a broad crested weir and spillway that transitions to a grouted riprap spillway and basin. The weir flowline would be set above the normal canal high water mark. There would also be an auxiliary emergency dump gate with conduit through the canal bank into the grouted riprap spillway basin that could be manually operated to divert up to approximately 50 cfs from the bottom of the canal in advance of a flood surge. A preliminary design of this structure is provided in Attachment C, which also provides a hydraulic flow rating table for the proposed structure.

2.4.2 North Flood Channel Upgrades

The existing channel is an earthen channel made up of five relatively straight reaches with five approximately 90-degree bends. The channel conveys flows through agricultural lands for approximately 6,800 feet before draining into the Richfield Canal. The 90-degree bends have been maintained and armored over the years with broken concrete, large rocks, and concrete grout.

The upgrades to the channel would include reshaping vertical banks and armoring the existing channel bends with riprap to maintain the existing hydraulic conveyance capacity of 725 cfs. Channel reshaping would include building up the banks where necessary to provide freeboard and meet the minimum consistent cross-sectional area necessary to safely carry the historic and design flows. All work would be conducted within a 100-foot-wide corridor centered on the channel. Preliminary channel geometry and riprap sizing can be found in Attachment C.

There are four culverts that have been installed in the channel to provide access for farms, private residences, and county roads. Based on the analysis, all four crossings have sufficient hydraulic capacity and would not need to be replaced. The results can be found in Attachment C.

2.4.3 Richfield Canal Emergency Overflow and Pipe Inlet Structure

An emergency overflow and a pipe inlet structure would be constructed in the bank of the Richfield Canal approximately 2,100 feet downstream of the north flood channel. The structure would divert up to 100 cfs from the canal into a pipeline that would convey flows to the Sevier River. The emergency overflow structure would consist of a cast-in-place concrete headwall with a broad-crested weir and spillway that transitions to a grated pipe inlet structure. The trash rack would be constructed to allow raking and cleaning of floating debris by backhoe or other large equipment. The weir flowline would be set above the normal canal high water mark. A preliminary design of this structure is provided in Attachment D, which also contains a hydraulic flow rating table for the proposed structure.

2.4.4 Closed Conduit Flood Pipeline

The closed conduit flood pipeline would be a buried 48-inch-diameter pipeline between the Richfield Canal and the Vermillion Canal dumpgate. The pipeline would cross under Highway 118, through agricultural lands below normal cultivation depths, and under the Vermillion Canal to drain into an existing channel that outlets to the Sevier River.

The estimated length of pipe is 6,700 feet. The pipeline would be capable of conveying a maximum of 100 cfs and have access manholes at all angle points spaced at no more than 1,000 feet apart to allow for pipe inspection and cleaning. Placement of the manholes would be coordinated with landowners to reduce surface use conflicts as much as possible. Table 2-2 shows additional design details. Figure 2-3 shows the pipeline elevation profile with the hydraulic gradeline, static pressure, and dynamic pressure.

Table 2-2. North Flood Channel Pipeline Design Information

Parameter	Value
Proposed Pipe Size	48-inch (DR26)
Proposed Pipe Material	HDPE
Estimated Length (feet)	6,700
Maximum Flow Capacity (cfs)	100
Maximum Velocity (feet/second)	9.43
Maximum Pressure (psi)	21

Parameter	Value
Upstream Invert (feet)	5289
Downstream Invert (feet)	5245
Average Slope (feet/foot)	0.0072

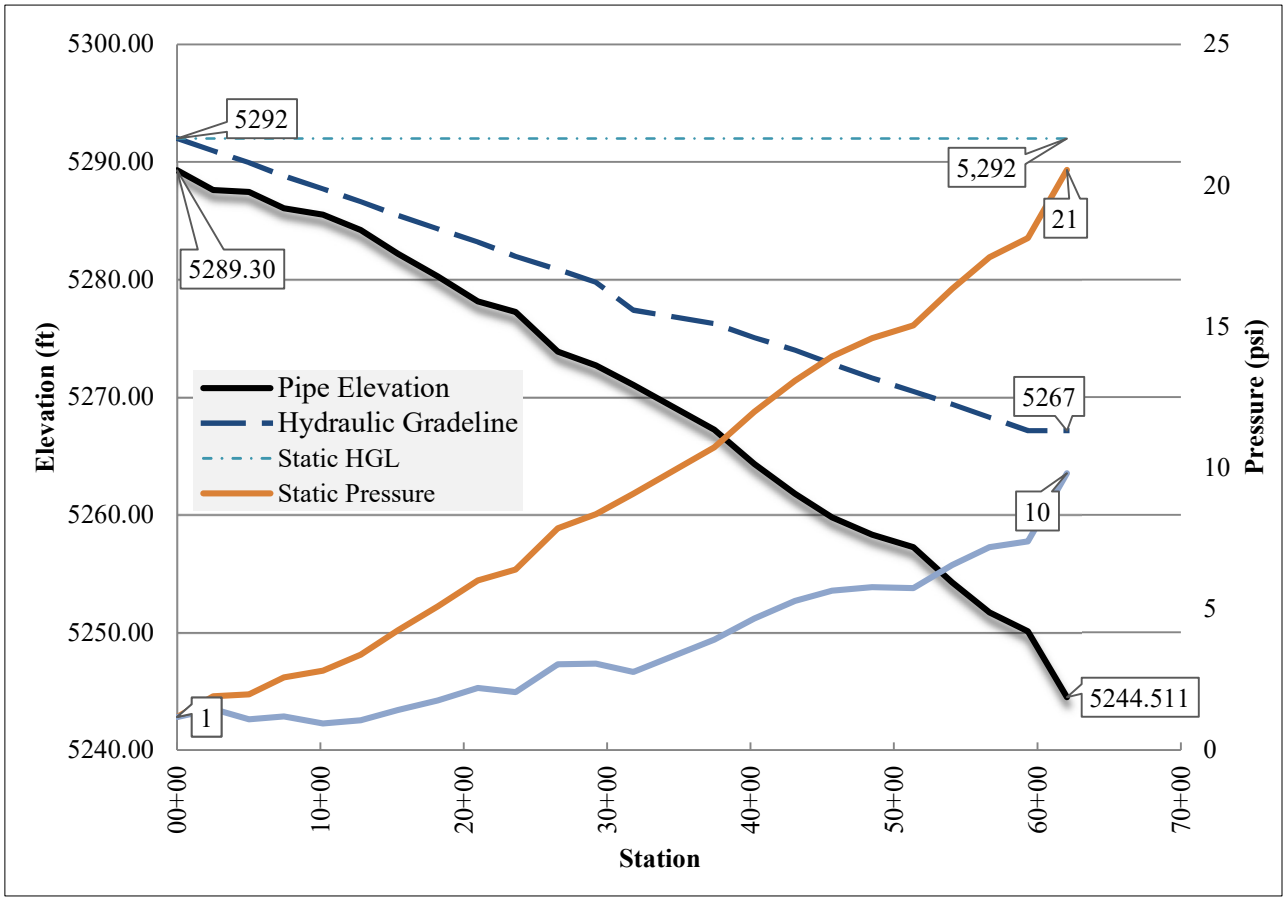

Figure 2-3. North Flood Channel Hydraulic Gradeline Profile

2.4.5 Pipe Outlet Structure to the Sevier River

The pipe outlet structure would consist of a concrete headwall with flap gate. Flows would drain into an existing 640-foot-long channel that drains directly into the Sevier River. The existing flood channel has a capacity of approximately 400 cfs with 1 foot of freeboard, which is adequate for the two maximum inflows. The channel capacity calculations can be found in Attachment C.

2.4.6 Sevier Valley Canal Control Gate Structure

As part of the north flood channel improvements, a flood control gate would be installed on the Sevier Valley Canal to increase conveyance capacity. There is currently a stop-log structure at the end of the Sevier Valley Canal that is used to increase the water surface elevation so that water can be delivered at turnouts along the canal. When flood water enters the canal, the operator must anticipate increased flows and manually remove the stop logs to decrease the water surface elevation and the risk of a canal breach. This method requires timely identification of a flood risk and having an operator available and able to access the site.

A new concrete structure with an automated control gate and downstream riprap armoring would be installed to replace the existing stop-log structure. The gates could be radial or Rubicon that would actuate when the water surface elevations exceed normal operating levels. The gate would open to allow the flood waters to continue downstream while maintaining canal operating levels and minimizing the risk of the canal breaching.

3.0 References

Bakaitis, C. 2016. Sevier County Natural Hazard Assessment for Pre-Disaster Mitigation. Available at: http://sixcounty.com/wp-content/uploads/2016/01/Section-6-Sevier-County.pdf (accessed 6-25-2019).

Chow, V. T. 1959. Open-Channel Hydraulics. A McGraw-Hill Classic Textbook Reissue. McGraw Hill Book Company, New York.

Natural Resources Conservation Service (NRCS). 2017. CPS Water and Sediment Control Basin (Code 638). October 2017.

Schick International. 1977. Richfield Flood Control Feasibility Investigation. Prepared for Utah State Soil Conservation Commission. June 1977.

Attachment A. Historical Flood Maps

Historical Flooding Issues
Watersheds
Canals
Streams

North Flood Channel
15
10
70
11
13
Wood Canyon
Wood Canyon - Lower
16
8
118
119
1
Cottonwood Canyon Debris Basin
9
Richfield
4
9
Cottonwood Canyon
2
120
17
Tank Canyon
5
1
14
9
Dariy Canyon Debris Basin
Lind Canyon
12
1
9
Dairy Canyon
7
21
20
Central Valley
Richfield Canal
Elsinore Canal
Sevier Valley and Piute Canal
19
Existing SouthFlood Channel
18
6
3
Flat Canyon - Lower
Two 20'x7' Box Culverts
NRCS Grade Control Strucutres
N
0 0.25 0.5 Miles

Map ID	Flooding Areas and Infrastructure
1	Active Development Area
2	Five 48" Culverts Used to Convey Tank Canyon Flows to Sevier Valley Canal
3	Flat Canyon Over Chute Structure
4	Frequent Flooding Area due to Flat Canyon Strom Flows from Richfield Canal
5	Frequent Flooding Area
6	Frequent Flooding of County Road due to Flat Canyon Flows from Over Chute
7	Golf Course Often Flooded with Flat Canyon Storm Flows from Richfield Canal
8	High Debris and Sediment Loads from Wood Canyon Impacting Sevier Valley Canal
9	High Risk Breach Location (County, 2018)
10	Homes Flooded due to North Flood Channel Flows from Richfield Canal (July 2018)
11	I-70 Closure due to Flooding (July 2018)
12	Known Problem Area (Backhoe Often Parked Here During Flood Events)
13	Known Problem Area (Flooding Occurs due Storm Flows Overtopping Sevier Valley Canal)
14	Known Problem Area (Strom Flows in Sevier Valley Canal Cause Flooding near Bridge)
15	Known Problem Area (Unprotected Bend in South Flood Channel)
16	One 20'x7' Box Culvert (Large Amounts of Sediment Reducing Culvert Capacity)
17	One 48" Culvert Used to Convey Lind Canyon Flows to Sevier Valley Canal
18	Regular Flooding Area due to Flat Canyon Flows from Over Chute
19	Regular Flooding Area due to Flat Canyon Flows from Over Chute and South Flood Channel
20	South Flood Channel Discharges Into Richfield Canal
21	Steep Canal Bank Susceptible to Breaching due to Flat Canyon Flows
*	**Flooding Areas Not Shown On Map:** Richfield Damed in All Sectors (May 1983), County Wide Flooding (1984), Property Damage (July 1985), Crop and Proerty Damage (August 1991), Poperty Damage (May 1994), Crop and Property Damage (August 1996), Property Damage (September 1997), Crop and Property Damage (September 1998), Property Damage (April-June 2005), Richfield Damage to Businesses Outdoor Property and Frontage Road Closure (July 2014)

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Sevier County

Sevier County Watershed Plan
Historical Floods

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_HH\1804-224_HH.aprx - EXH_Historical_Floods
Project Number: 1804-224 | Drawn by: JWW 05-19 | Last Edit: 05/17/2019

Sevier County
Scale: 1" = 0.5 Miles
1

Attachment B. Flat Canyon Flood Inundation Maps

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 2-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

Annabella

Central Valley

Elsinore

Elsinore Canal

Richfield Canal

Sevier River

119

120

70

118

258

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 2-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

1

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 5-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

119

Richfield

120

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 5-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

2

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 10-Year Event

- 0 - 1 ft
- 1 - 2 ft
- 2 - 5 ft
- 5 - 10 ft
- >10 ft

Piute Canal

Sevier Valley Canal

Richfield

119

120

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 10-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

3

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 25-Year Event

- 0 - 1 ft
- 1 - 2 ft
- 2 - 5 ft
- 5 - 10 ft
- >10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 25-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

4

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 50-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 50-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

5

Canals

Municipal Boundaries

Flat Canyon Flood Depths - 100-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

No flooding occurs up to the 100-year event because the 100-year event is the design event for the project. Therefore, no flood depths are shown for with project condition.

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Sevier County

Sevier County Watershed Plan
Flat Canyon Flood Depths - 100-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

6

Canals

Municipal Boundaries

Flat Canyon Without Project Flood Depths - 200-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

120

119

70

Annabella

Central Valley

118

Elsinore Canal

Elsinore

258

Richfield Canal

Sevier River

N

0 2,000 4,000 Feet

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Sevier County

Sevier County Watershed Plan
Flat Canyon Without Project Flood Depths - 200-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

Scale: 1" = 4,000'

7

Canals

Municipal Boundaries

Flat Canyon Without Project Flood Depths - 500-Year Event

0 - 1 ft

1 - 2 ft

2 - 5 ft

5 - 10 ft

>10 ft

Piute Canal

Sevier Valley Canal

Richfield

Annabella

Central Valley

Elsinore

Elsinore Canal

Richfield Canal

Sevier River

119

120

118

258

70

N

0 2,000 4,000 Feet

Jones & DeMille Engineering

- Shaping the Quality of Life -

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Sevier County

Sevier County Watershed Plan
Flat Canyon Without Project Flood Depths - 500-Year Event

Map Name: H:\JD\Proj\1804-224\Design\GIS\Projects\Hydraulics and Hydrology\1804-224_Depths\1804-224_Depths.aprx - EXH_01_10_Depths_Flat_Canyon

Project Number: 1804-224 | Drawn by: JWW 03-21 | Last Edit: 03/08/2021

Sevier County

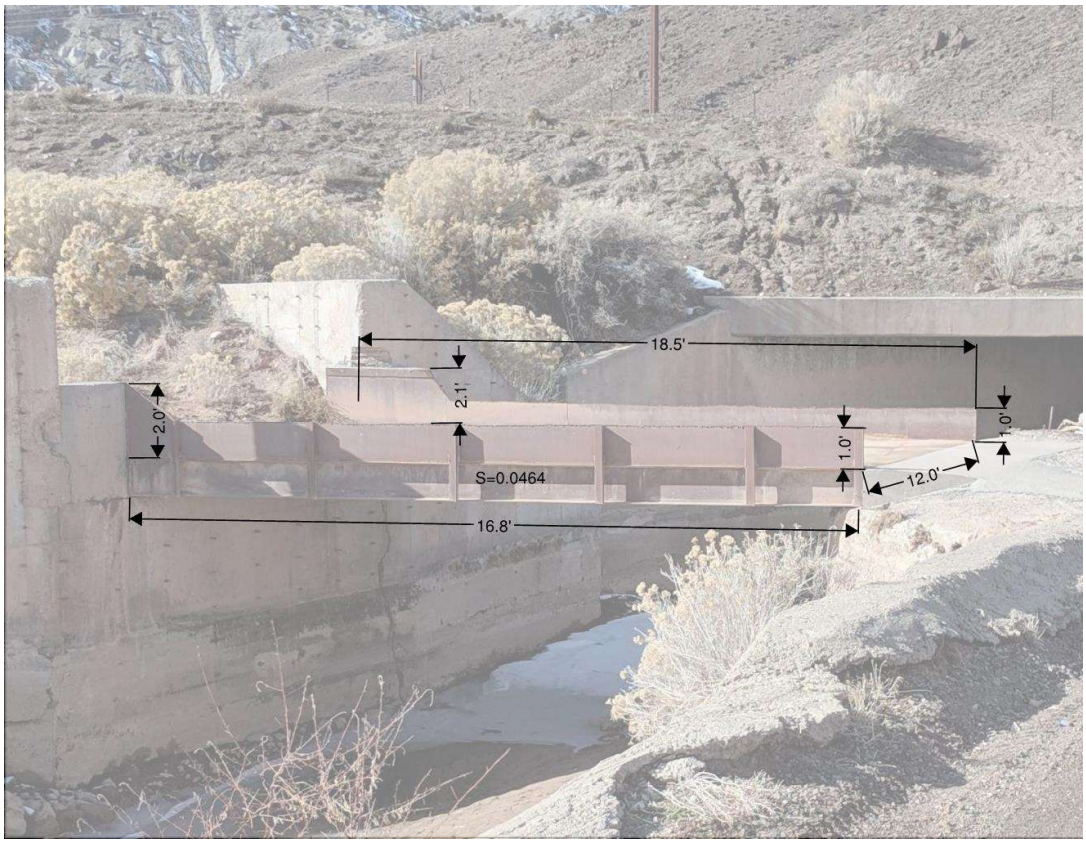
Scale: 1" = 4,000'

9

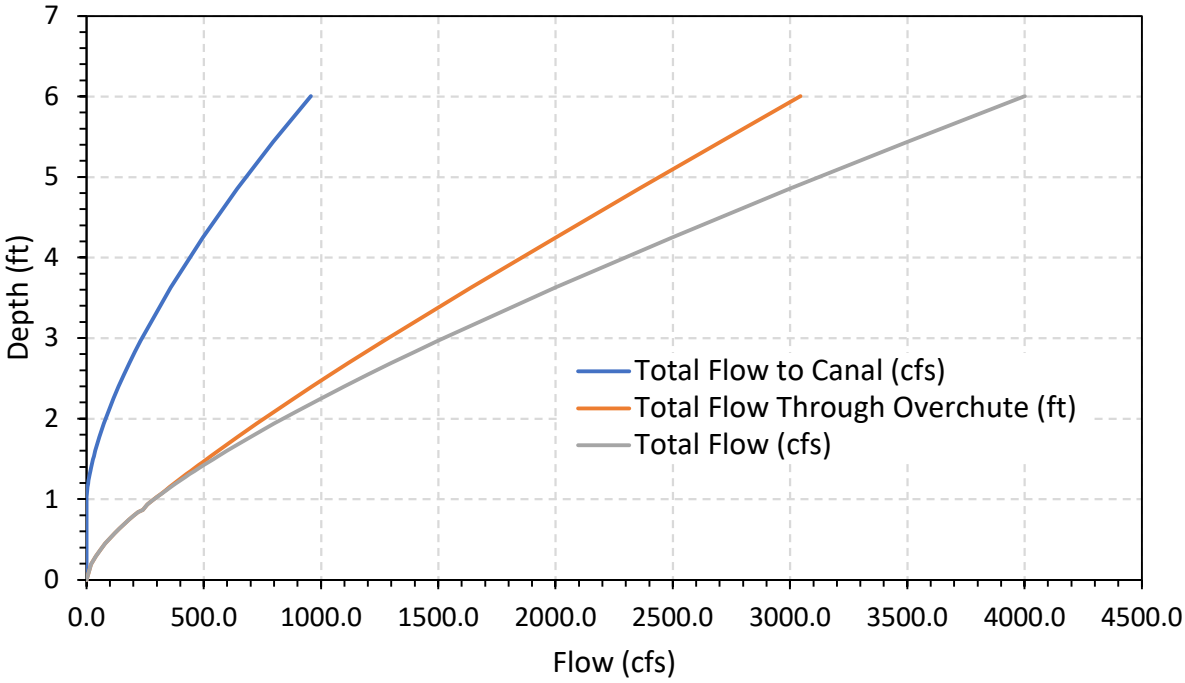
Attachment C. Hydraulic Analysis Support Information

South Flood Channel Design Information

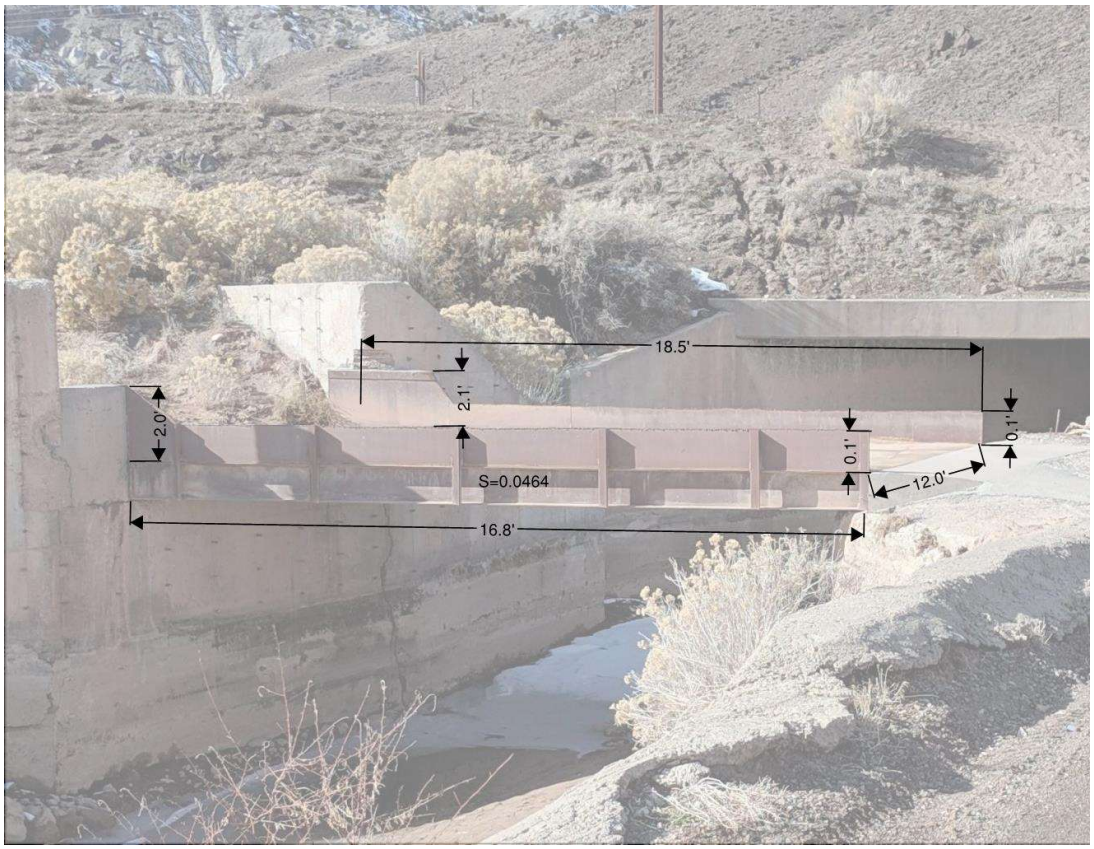
Existing Conditions: Overshot Structure



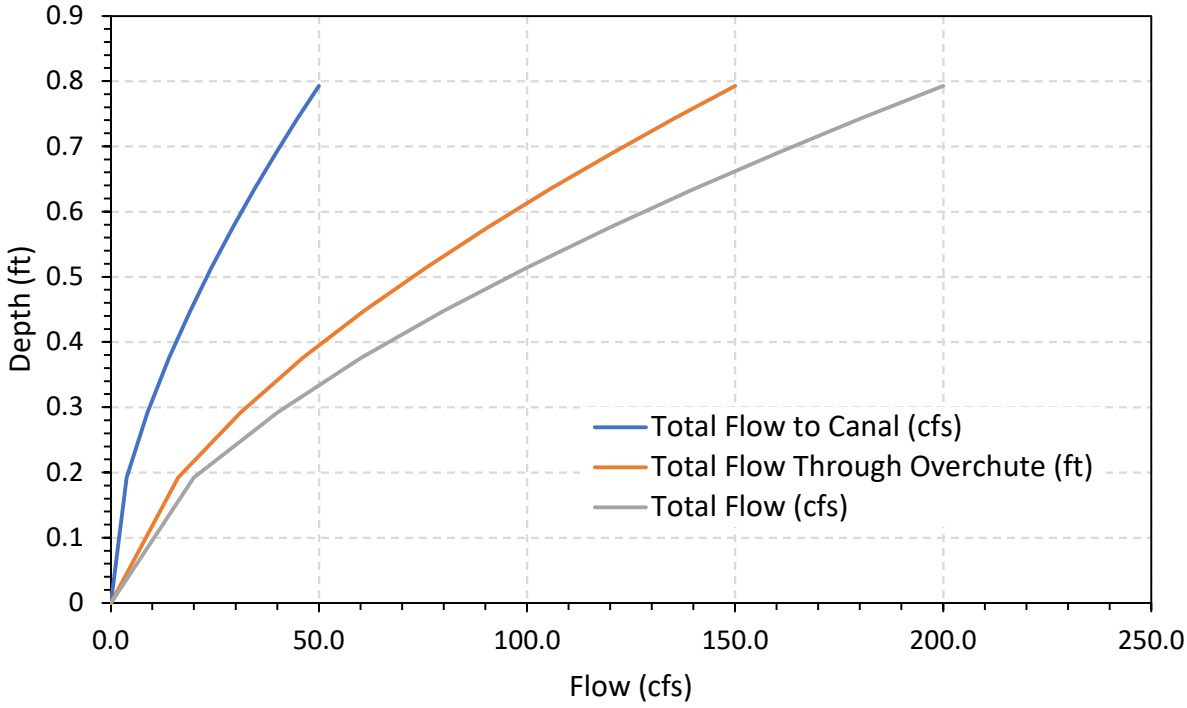
Existing Conditions: Overshot Structure Rating Curve



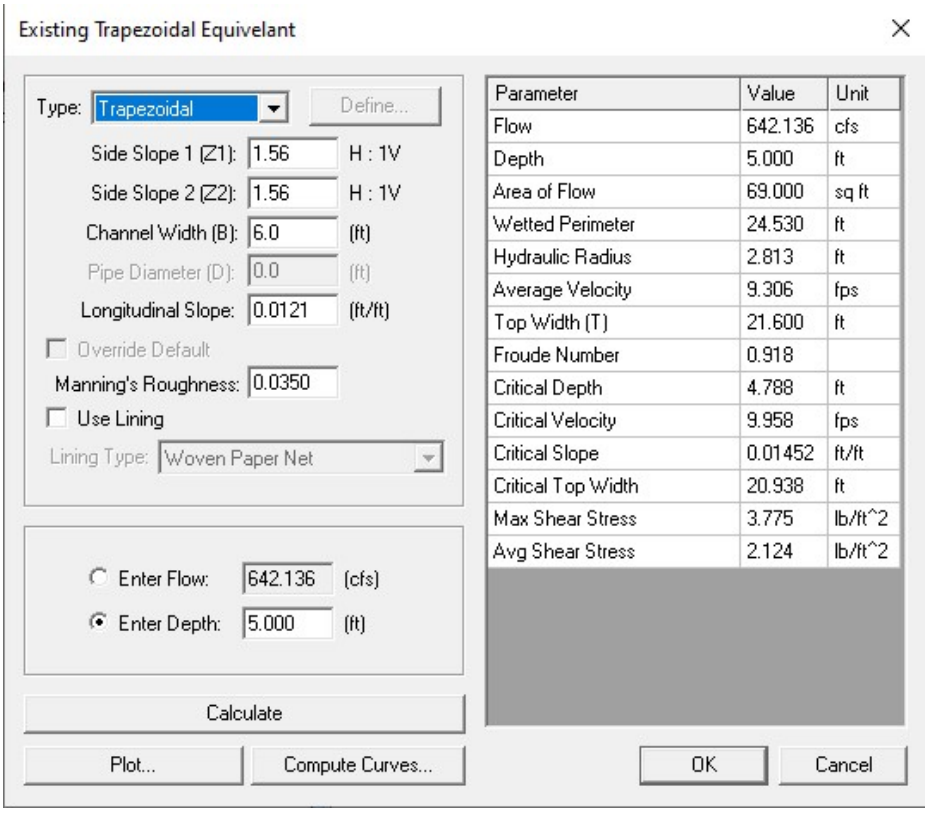
Proposed Conditions: Overshot Structure



Proposed Conditions: Overshot Structure Rating Curve

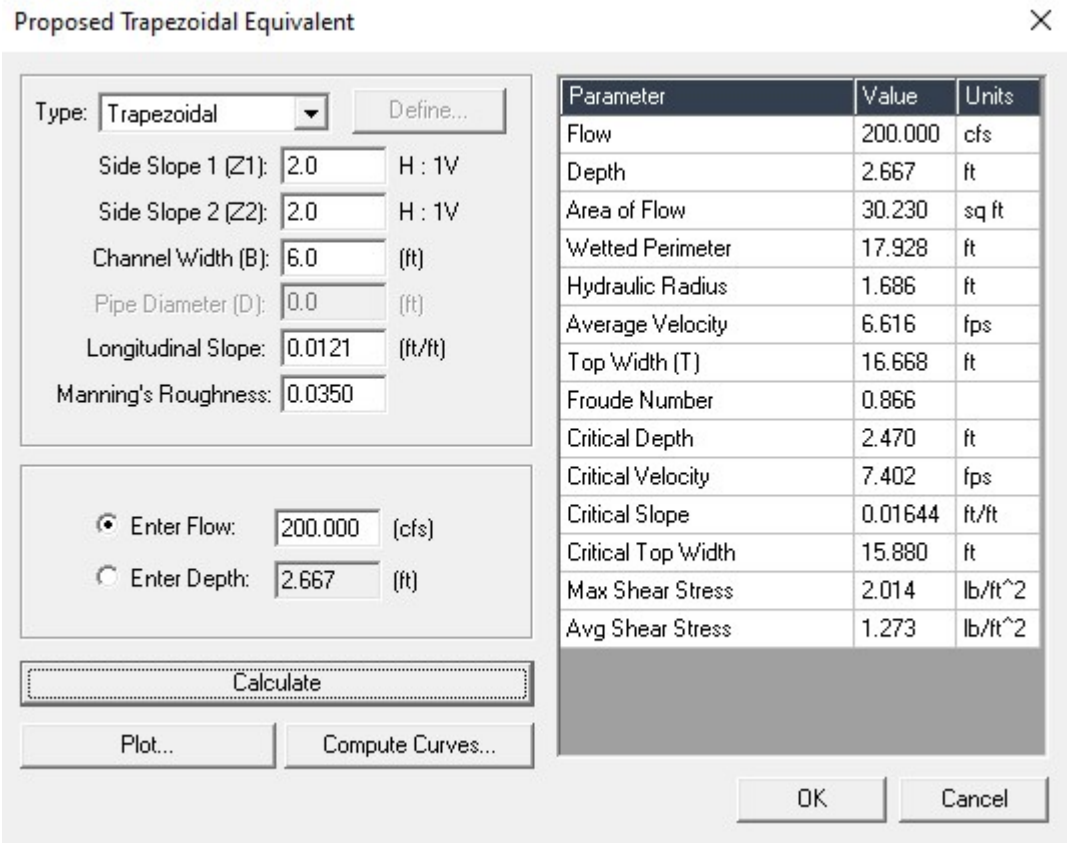


Existing Conditions: South Flood Channel

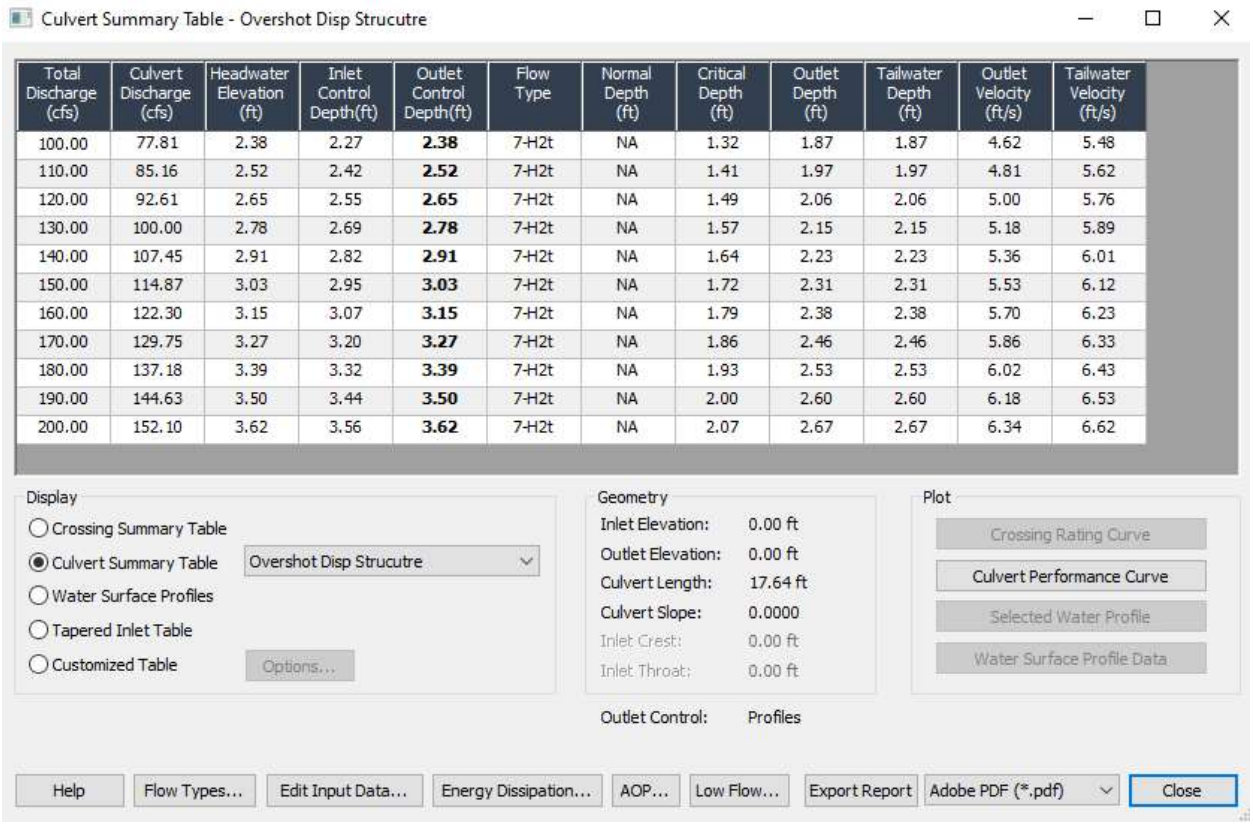


Parameter	Value	Unit
Flow	642.136	cfs
Depth	5.000	ft
Area of Flow	69.000	sq ft
Wetted Perimeter	24.530	ft
Hydraulic Radius	2.813	ft
Average Velocity	9.306	fps
Top Width (T)	21.600	ft
Froude Number	0.918	
Critical Depth	4.788	ft
Critical Velocity	9.958	fps
Critical Slope	0.01452	ft/ft
Critical Top Width	20.938	ft
Max Shear Stress	3.775	lb/ft^2
Avg Shear Stress	2.124	lb/ft^2

Proposed Conditions: South Flood Channel

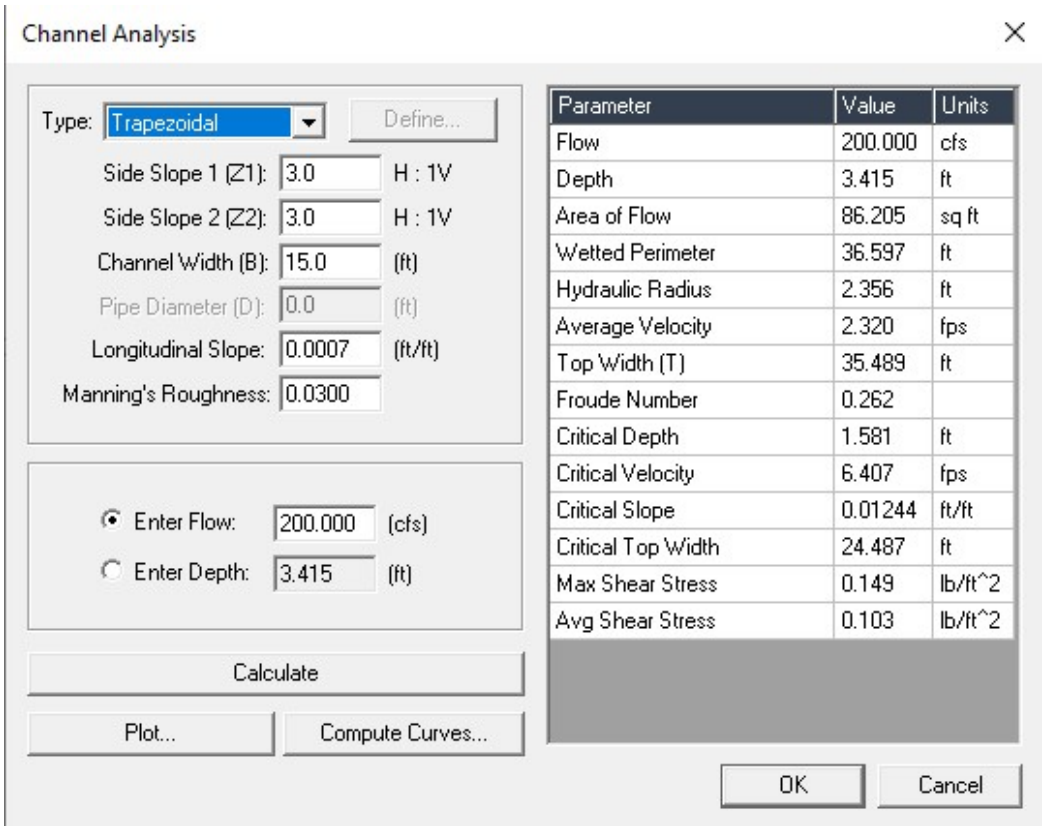


Proposed Conditions: South Flood Channel 48” Culvert



Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	77.81	2.38	2.27	**2.38**	7-H2t	NA	1.32	1.87	1.87	4.62	5.48
110.00	85.16	2.52	2.42	**2.52**	7-H2t	NA	1.41	1.97	1.97	4.81	5.62
120.00	92.61	2.65	2.55	**2.65**	7-H2t	NA	1.49	2.06	2.06	5.00	5.76
130.00	100.00	2.78	2.69	**2.78**	7-H2t	NA	1.57	2.15	2.15	5.18	5.89
140.00	107.45	2.91	2.82	**2.91**	7-H2t	NA	1.64	2.23	2.23	5.36	6.01
150.00	114.87	3.03	2.95	**3.03**	7-H2t	NA	1.72	2.31	2.31	5.53	6.12
160.00	122.30	3.15	3.07	**3.15**	7-H2t	NA	1.79	2.38	2.38	5.70	6.23
170.00	129.75	3.27	3.20	**3.27**	7-H2t	NA	1.86	2.46	2.46	5.86	6.33
180.00	137.18	3.39	3.32	**3.39**	7-H2t	NA	1.93	2.53	2.53	6.02	6.43
190.00	144.63	3.50	3.44	**3.50**	7-H2t	NA	2.00	2.60	2.60	6.18	6.53
200.00	152.10	3.62	3.56	**3.62**	7-H2t	NA	2.07	2.67	2.67	6.34	6.62

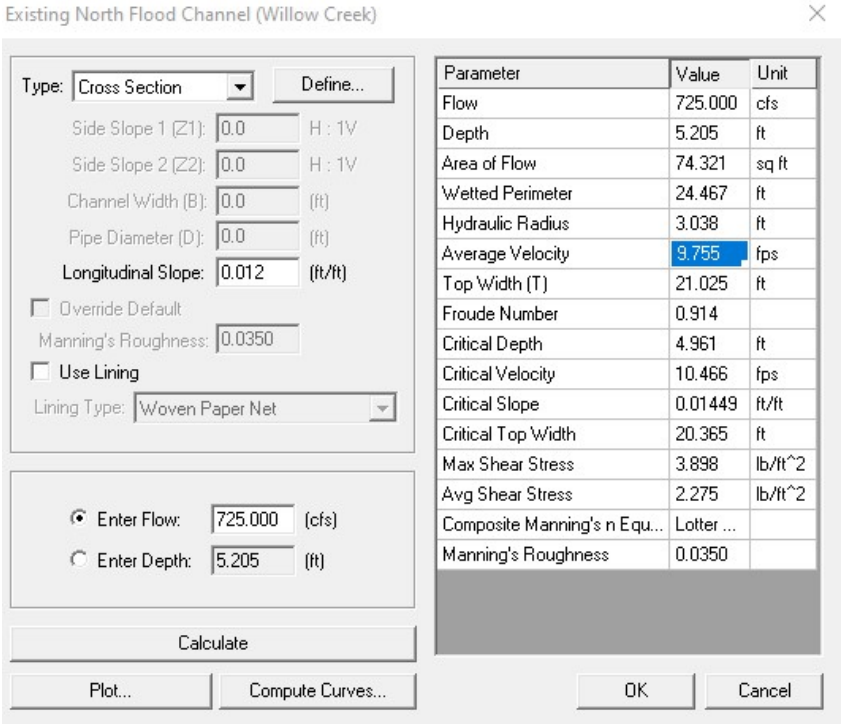
Proposed Condition: New Channel to Sevier River

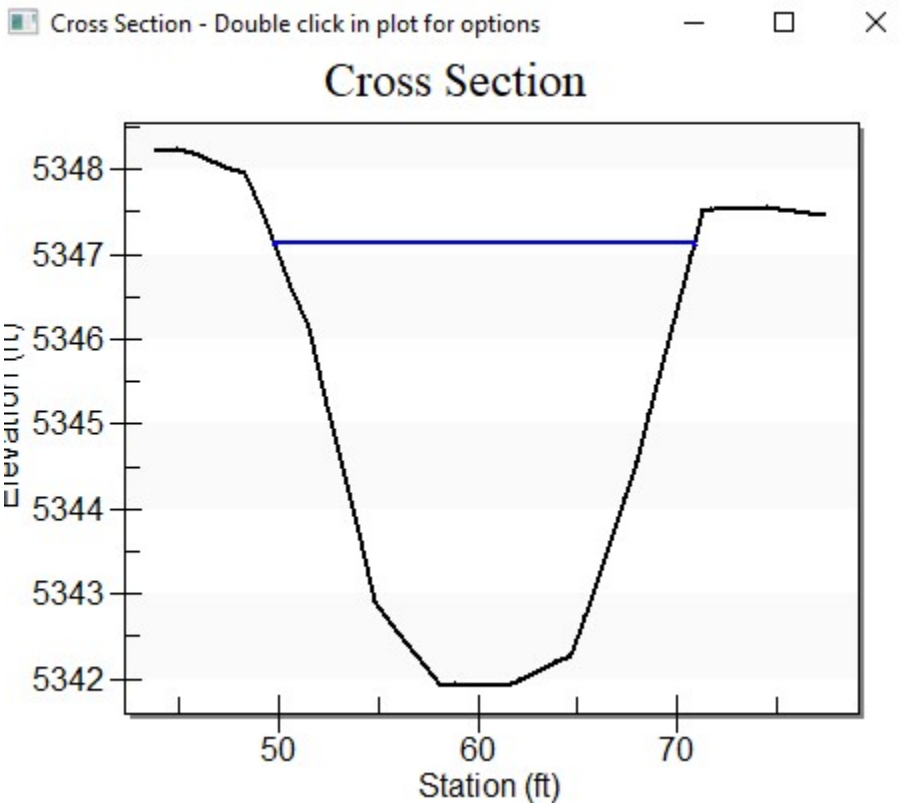


Parameter	Value	Units
Flow	200.000	cfs
Depth	3.415	ft
Area of Flow	86.205	sq ft
Wetted Perimeter	36.597	ft
Hydraulic Radius	2.356	ft
Average Velocity	2.320	fps
Top Width (T)	35.489	ft
Froude Number	0.262	
Critical Depth	1.581	ft
Critical Velocity	6.407	fps
Critical Slope	0.01244	ft/ft
Critical Top Width	24.487	ft
Max Shear Stress	0.149	lb/ft^2
Avg Shear Stress	0.103	lb/ft^2

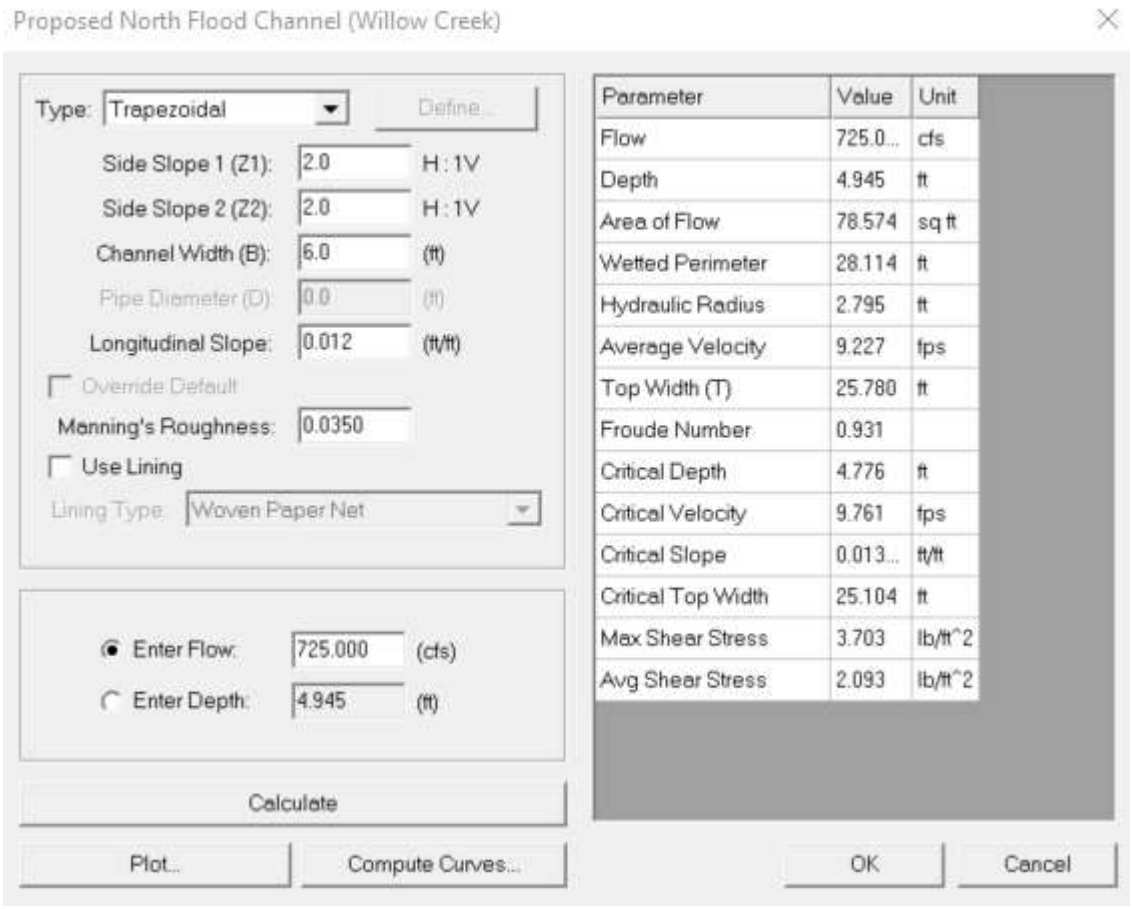
North Flood Channel Design Information

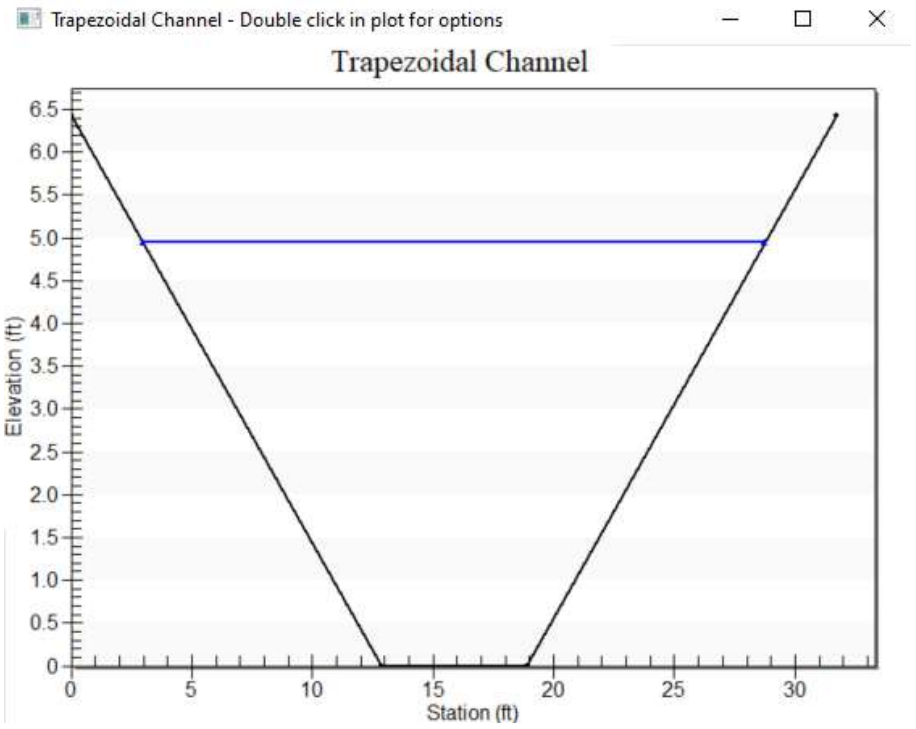
Existing Conditions: Willow Creek Flood Channel





Proposed Conditions: Willow Creek Flood Channel





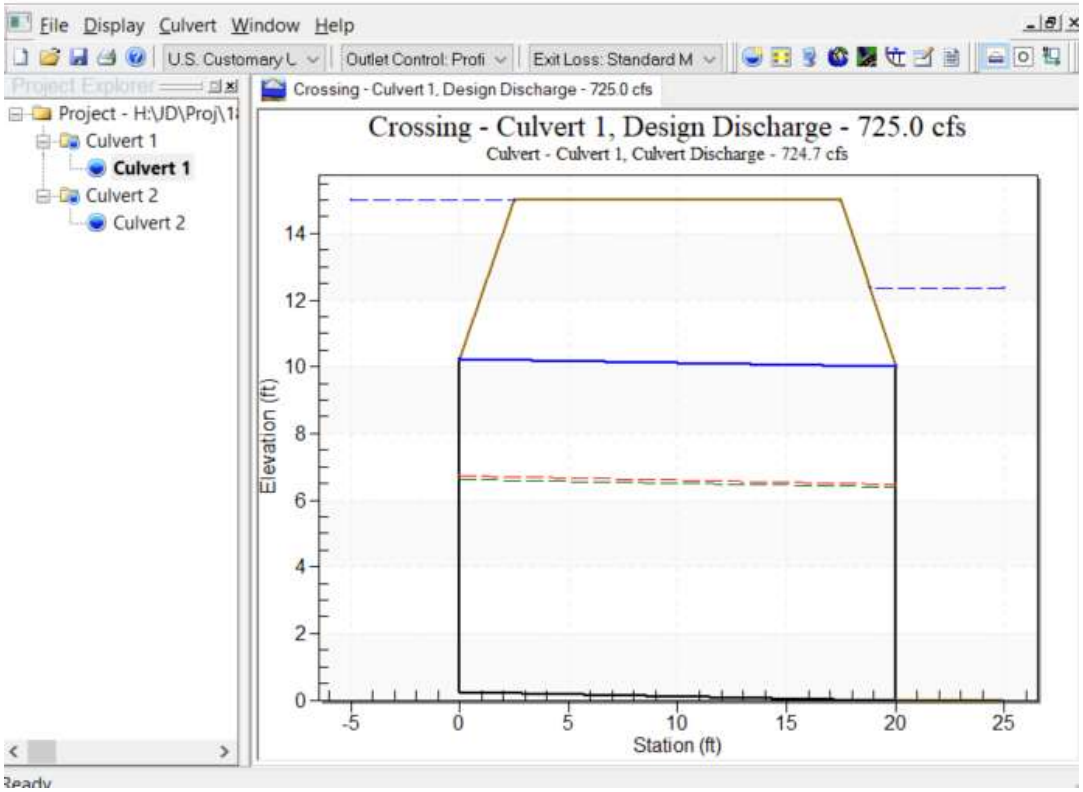
Proposed North FLood Channe Riprap

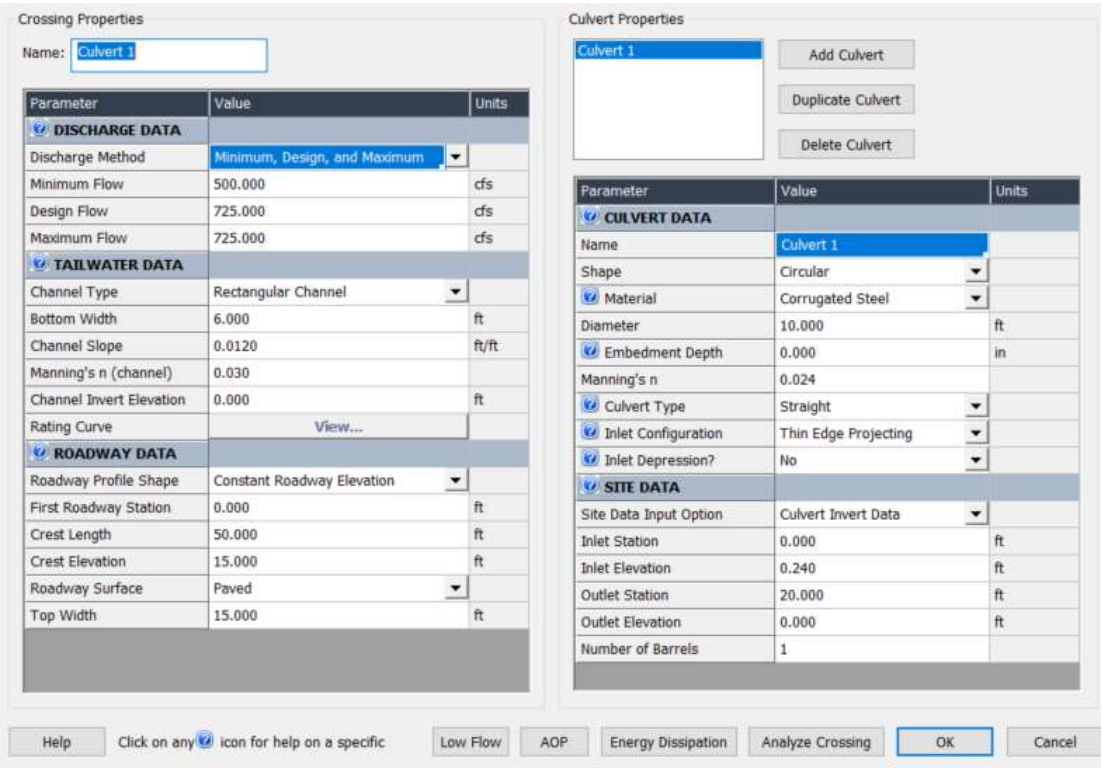
Lining: Riprap, Cobble, or Gravel

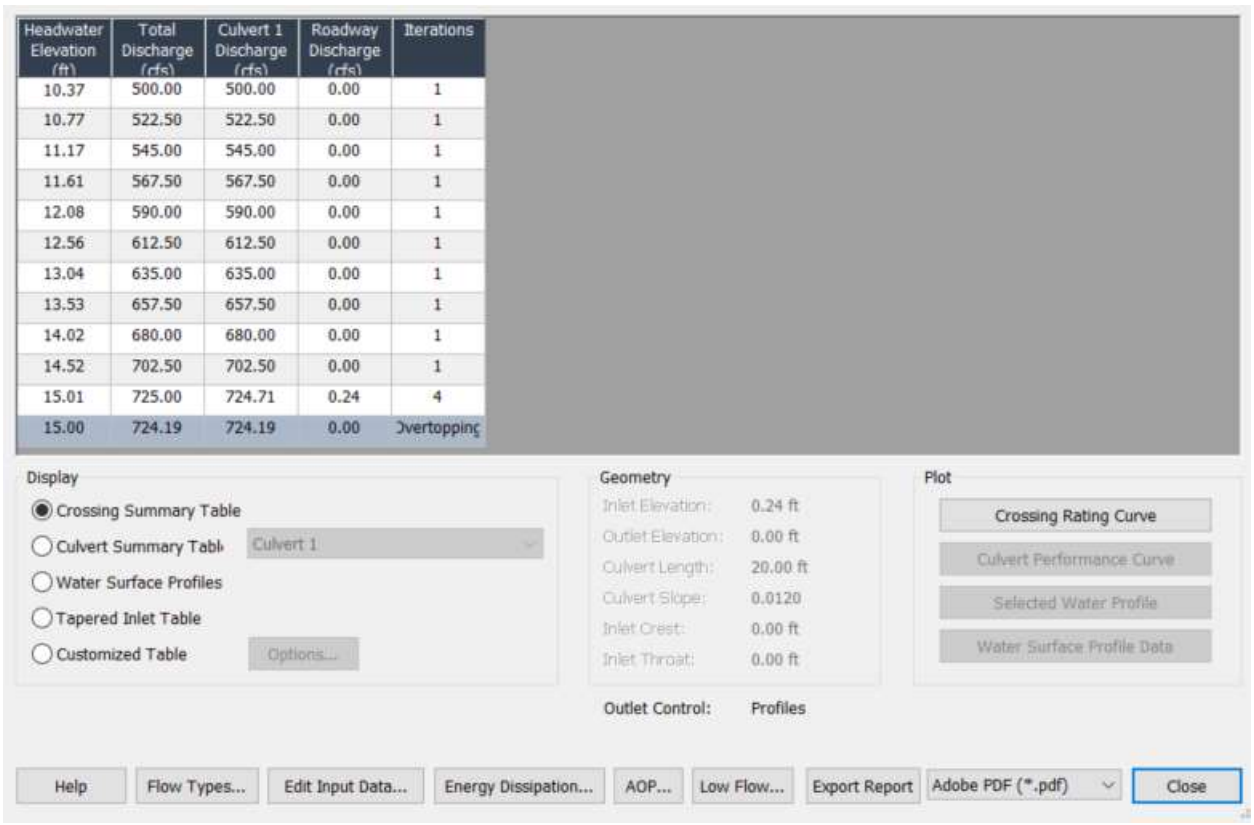
Parameter	Value	Units	Notes
	Channel Calculator...		
Design Flow	725.000	cfs	
Channel Depth	6.894	ft	
Slope	0.012	ft/ft	
Bottom Width	6.000	ft	
Side Slope 1	2.000	ft/ft	
Side Slope 2	2.000	ft/ft	
Area	136.425	ft^2	
Top Width	33.577	ft	
Wetted Perimeter	36.832	ft	
Hydraulic Radius	3.704	ft	
Average Velocity	5.314	ft/s	
Input Parameters			
D50	1.500	ft	
Riprap Specific Weight	165.000	lb/ft^3	
Water Specific Weight	62.400	lb/ft^3	
Riprap Shape	angular		This is used with D50 to compute the angle of repose (See HEC-1...
Safety Factor	1.000		
Calculated Safety Factor	**1.500**		
Results			
Riprap Properties			
Angle of Repose	41.900	Degre...	
Manning's n			
Relative Flow Depth	2.709		
n (Blodgett)	0.073		
Bottom Shear			
V*	1.632		
Reynold's Number	201168.947		
Shield's Parameter	0.150		
Maximum Shear Stress on the Channel Bottom	5.162	lb/ft^2	
Permissible Shear	23.085	lb/ft^2	
The channel bottom is stable			
Stable D50	0.503	ft	
Side Shear			
K1	0.802		
K2	0.743		
Kb	2.000		
Side Shear	4.140	lb/ft^2	
Permissible Side Shear	17.145	lb/ft^2	
The channel side is stable			
Stable Side D50	0.543	ft	
Bend Shear			
Curvature Radius	40.000	ft	No further correction will occur once R/T > 10
Shear in Bend Bottom	10.325	lb/ft^2	
The bottom of the bend is stable			
Length of Protection beyond PT	37.698	ft	
Additional Freeboard Required because of Su...	0.737	ft	
Shear on Bend Side	8.280	lb/ft^2	
The side of the bend is stable			

North Flood Channel: Culvert Exhibit

North Flood Channel: Culvert 1

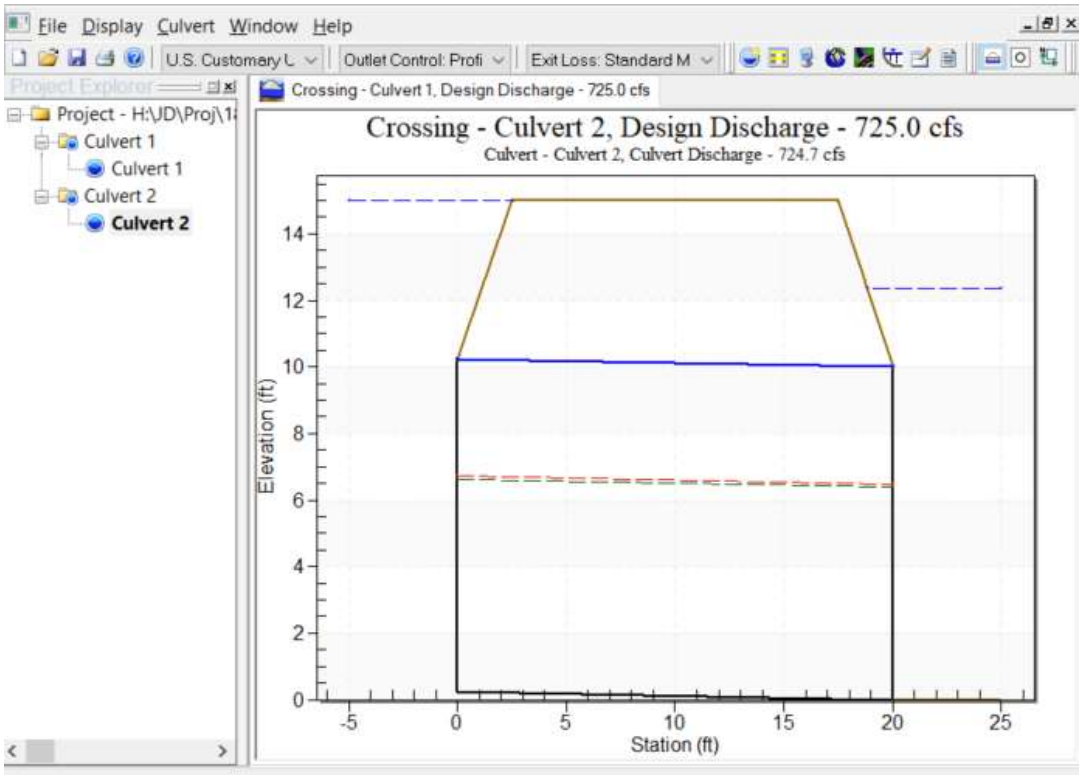






Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.37	500.00	500.00	0.00	1
10.77	522.50	522.50	0.00	1
11.17	545.00	545.00	0.00	1
11.61	567.50	567.50	0.00	1
12.08	590.00	590.00	0.00	1
12.56	612.50	612.50	0.00	1
13.04	635.00	635.00	0.00	1
13.53	657.50	657.50	0.00	1
14.02	680.00	680.00	0.00	1
14.52	702.50	702.50	0.00	1
15.01	725.00	724.71	0.24	4
15.00	724.19	724.19	0.00	Overtopping

North Flood Channel: Culvert 2



Crossing Properties

Name: Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	500.000	cfs
Design Flow	725.000	cfs
Maximum Flow	725.000	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	6.000	ft
Channel Slope	0.0120	ft/ft
Manning's n (channel)	0.030	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	50.000	ft
Crest Elevation	15.000	ft
Roadway Surface	Paved	
Top Width	15.000	ft

Culvert Properties

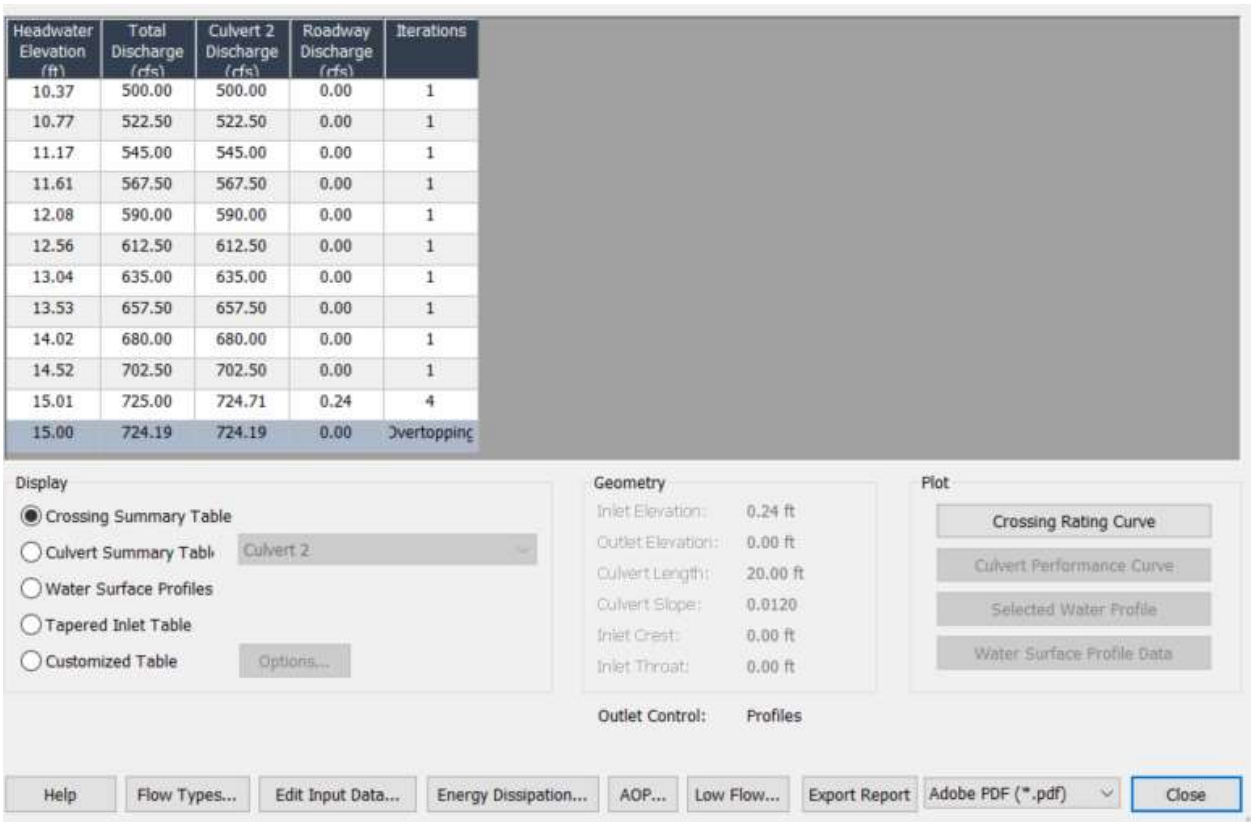
Culvert 2

Add Culvert

Duplicate Culvert

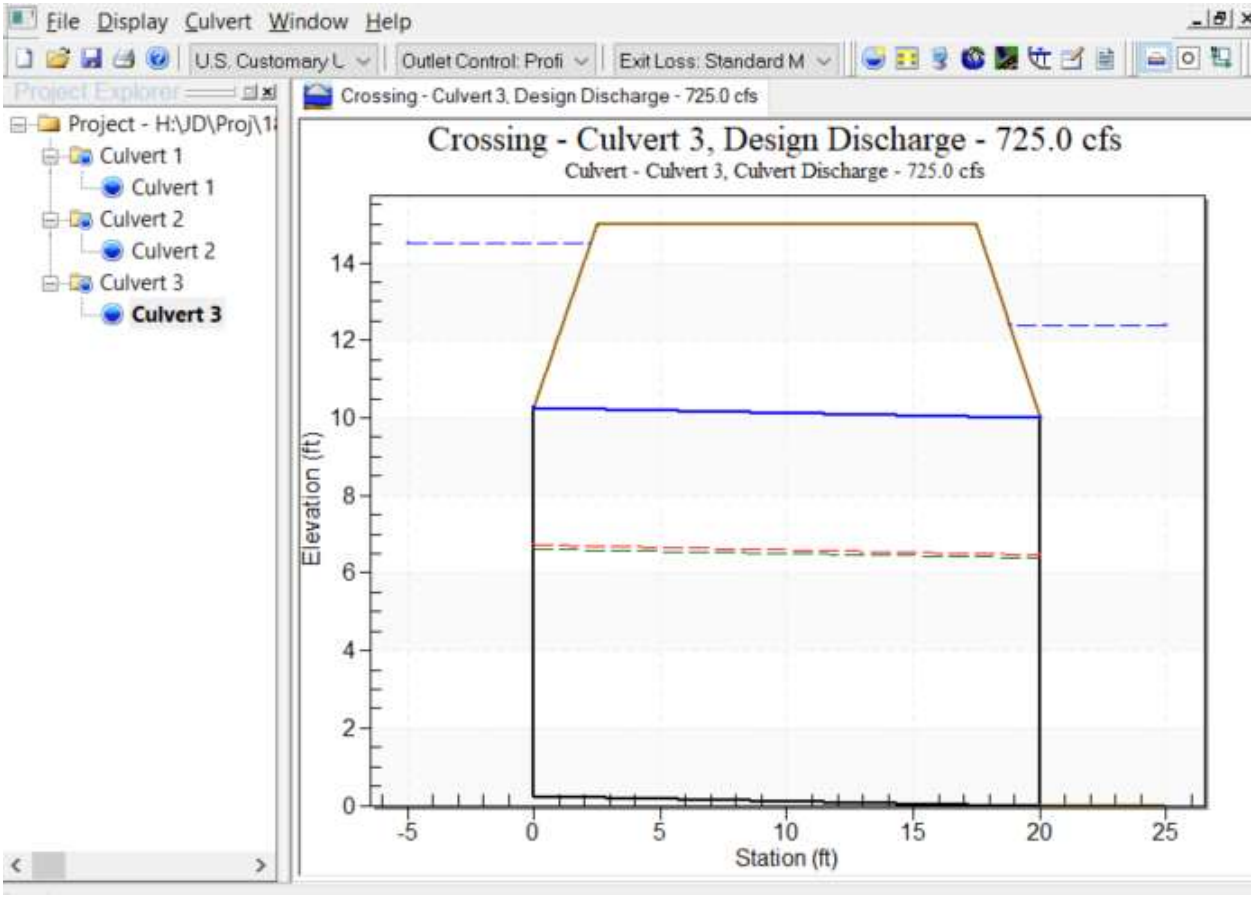
Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 2	
Shape	Circular	
Material	Corrugated PE	
Diameter	10.000	ft
Embedment Depth	0.000	in
Manning's n	0.024	
Culvert Type	Straight	
Inlet Configuration	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.240	ft
Outlet Station	20.000	ft
Outlet Elevation	0.000	ft
Number of Barrels	1	



Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.37	500.00	500.00	0.00	1
10.77	522.50	522.50	0.00	1
11.17	545.00	545.00	0.00	1
11.61	567.50	567.50	0.00	1
12.08	590.00	590.00	0.00	1
12.56	612.50	612.50	0.00	1
13.04	635.00	635.00	0.00	1
13.53	657.50	657.50	0.00	1
14.02	680.00	680.00	0.00	1
14.52	702.50	702.50	0.00	1
15.01	725.00	724.71	0.24	4
15.00	724.19	724.19	0.00	Overtopping

North Flood Channel: Culvert 3



Crossing Properties

Name: Culvert 3

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	500.000	cfs
Design Flow	725.000	cfs
Maximum Flow	725.000	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	6.000	ft
Channel Slope	0.0120	ft/ft
Manning's n (channel)	0.030	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	50.000	ft
Crest Elevation	15.000	ft
Roadway Surface	Paved	
Top Width	15.000	ft

Culvert Properties

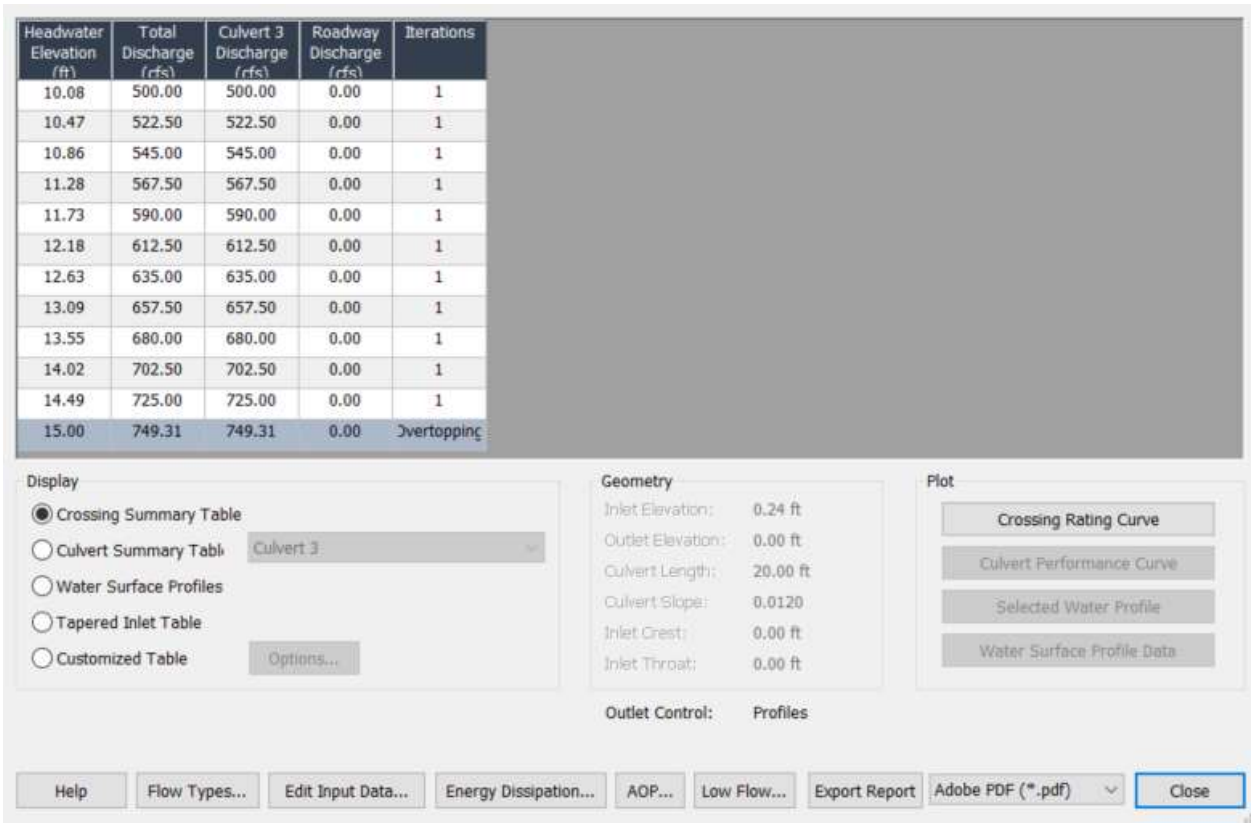
Culvert 3

Add Culvert

Duplicate Culvert

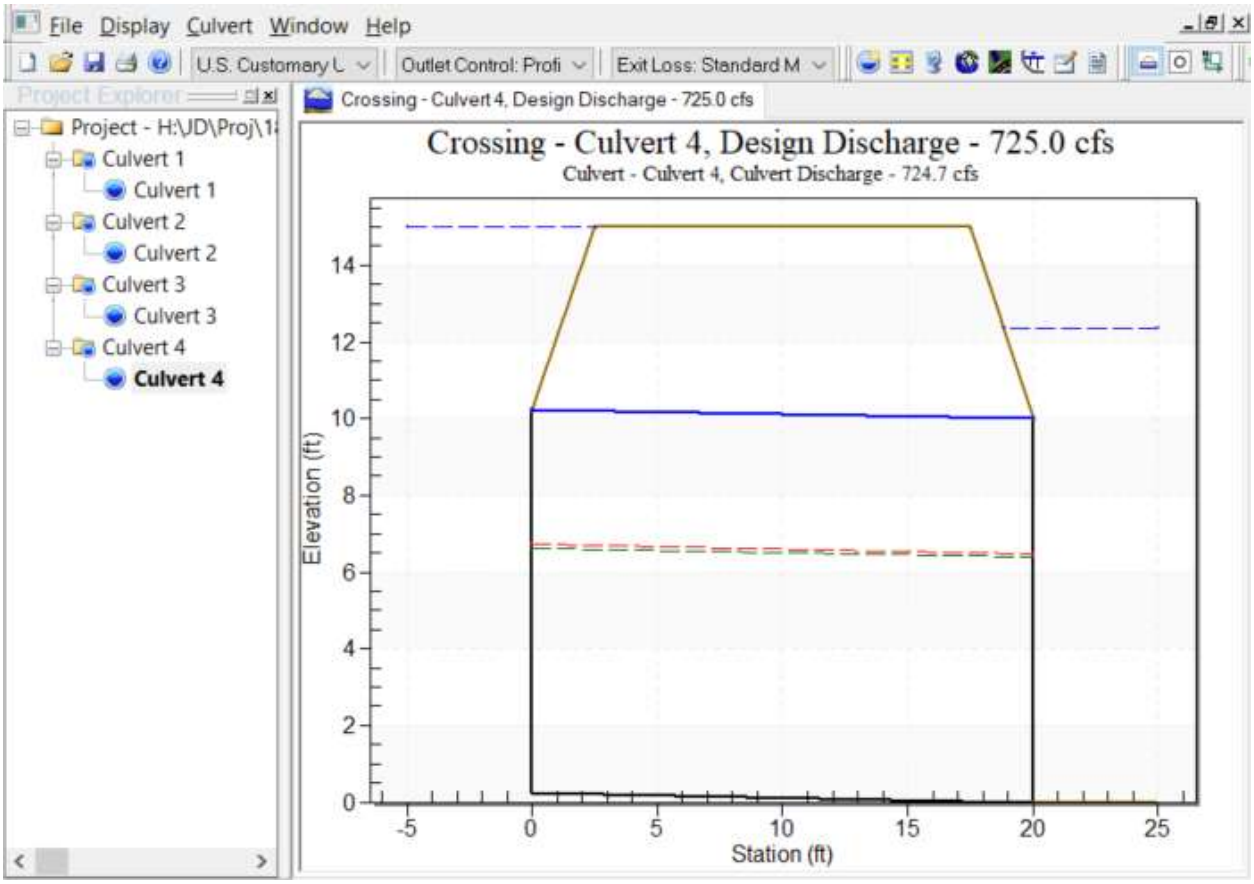
Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 3	
Shape	Circular	
Material	Corrugated Steel	
Diameter	10.000	ft
Embedment Depth	0.000	in
Manning's n	0.024	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.240	ft
Outlet Station	20.000	ft
Outlet Elevation	0.000	ft
Number of Barrels	1	



Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.08	500.00	500.00	0.00	1
10.47	522.50	522.50	0.00	1
10.86	545.00	545.00	0.00	1
11.28	567.50	567.50	0.00	1
11.73	590.00	590.00	0.00	1
12.18	612.50	612.50	0.00	1
12.63	635.00	635.00	0.00	1
13.09	657.50	657.50	0.00	1
13.55	680.00	680.00	0.00	1
14.02	702.50	702.50	0.00	1
14.49	725.00	725.00	0.00	1
15.00	749.31	749.31	0.00	Overtopping

North Flood Channel: Culvert 4



Crossing Properties

Name: Culvert 4

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	500.000	cfs
Design Flow	725.000	cfs
Maximum Flow	725.000	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	6.000	ft
Channel Slope	0.0120	ft/ft
Manning's n (channel)	0.030	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	50.000	ft
Crest Elevation	15.000	ft
Roadway Surface	Paved	
Top Width	15.000	ft

Culvert Properties

Culvert 4

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 4	
Shape	Circular	
Material	Corrugated Steel	
Diameter	10.000	ft
Embedment Depth	0.000	in
Manning's n	0.024	
Culvert Type	Straight	
Inlet Configuration	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.240	ft
Outlet Station	20.000	ft
Outlet Elevation	0.000	ft
Number of Barrels	1	

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.37	500.00	500.00	0.00	1
10.77	522.50	522.50	0.00	1
11.17	545.00	545.00	0.00	1
11.61	567.50	567.50	0.00	1
12.08	590.00	590.00	0.00	1
12.56	612.50	612.50	0.00	1
13.04	635.00	635.00	0.00	1
13.53	657.50	657.50	0.00	1
14.02	680.00	680.00	0.00	1
14.52	702.50	702.50	0.00	1
15.01	725.00	724.71	0.24	4
15.00	724.19	724.19	0.00	Overtopping

Display

- (●) Crossing Summary Table
- ( ) Culvert Summary Tabl — Culvert 4
- ( ) Water Surface Profiles
- ( ) Tapered Inlet Table
- ( ) Customized Table — Options...

Geometry

Inlet Elevation:	0.24 ft
Outlet Elevation:	0.00 ft
Culvert Length:	20.00 ft
Culvert Slope:	0.0120
Inlet Crest:	0.00 ft
Inlet Throat:	0.00 ft

Outlet Control: Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Existing Conditions: Richfield Canal for North Flood Channel

Existing Richfield Canal

Type: Cross Section | Define...

Side Slope 1 (Z1): 0.0 H : 1V
Side Slope 2 (Z2): 0.0 H : 1V
Channel Width (B): 0.0 (ft)
Pipe Diameter (D): 0.0 (ft)
Longitudinal Slope: 0.0016 (ft/ft)
Override Default
Manning's Roughness: 0.0300
Use Lining
Lining Type: Woven Paper Net

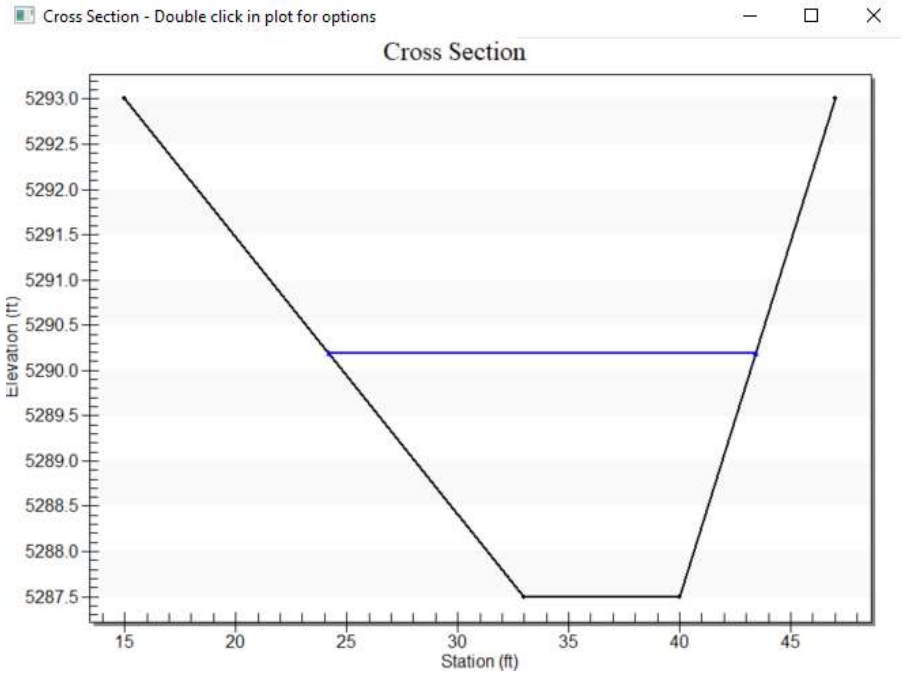
Enter Flow: 100.000 (cfs)
Enter Depth: 2.688 (ft)

Calculate

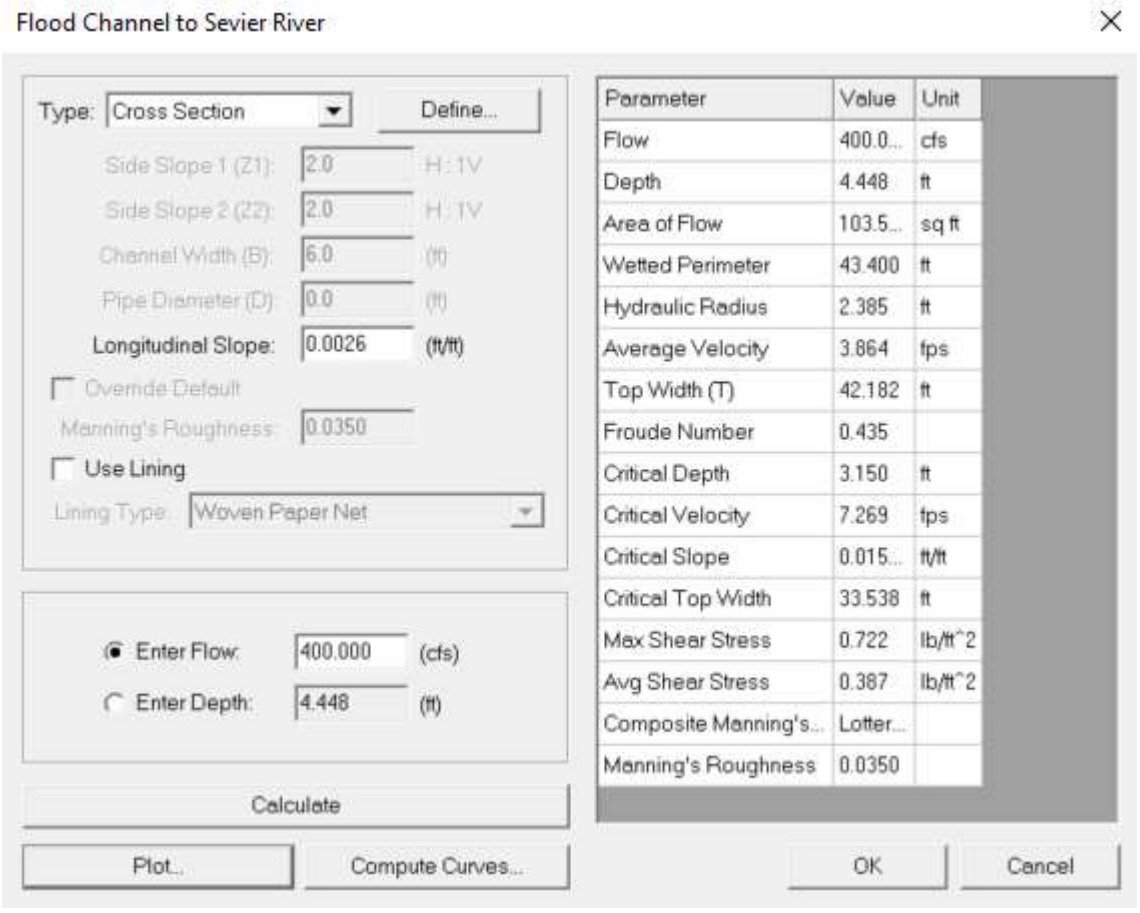
Plot... | Compute Curves...

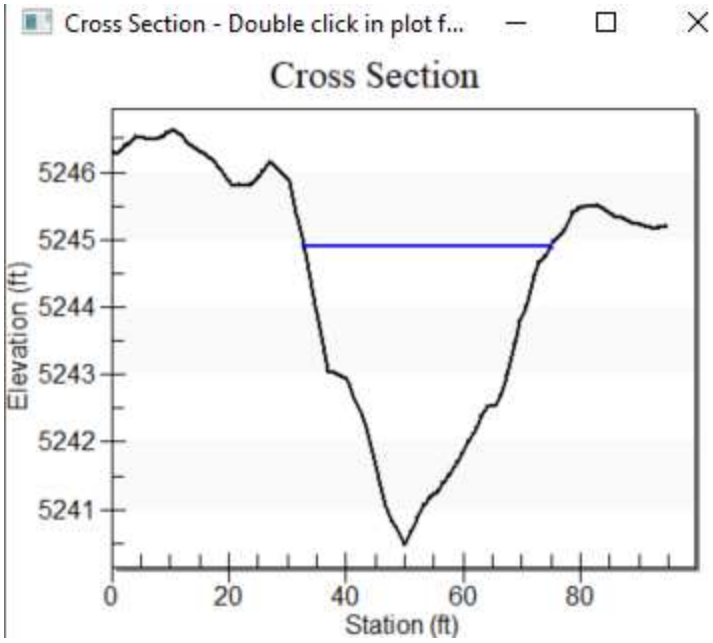
Parameter	Value	Unit
Flow	100.0...	cfs
Depth	2.688	ft
Area of Flow	35.232	sq ft
Wetted Perimeter	20.548	ft
Hydraulic Radius	1.715	ft
Average Velocity	2.838	fps
Top Width (T)	19.217	ft
Froude Number	0.369	
Critical Depth	1.552	ft
Critical Velocity	6.119	fps
Critical Slope	0.013...	ft/ft
Critical Top Width	14.056	ft
Max Shear Stress	0.268	lb/ft^2
Avg Shear Stress	0.171	lb/ft^2
Composite Manning's...	Lotter...	
Manning's Roughness	0.0300	

OK | Cancel



North Flood Channel to Sevier River





North Flood Channel Sevier River Tailwater Analysis

Sevier River Flood Stage

Type: Cross Section | Define...

Side Slope 1 (Z1): 2.0 H : 1V
Side Slope 2 (Z2): 2.0 H : 1V
Channel Width (B): 6.0 (ft)
Pipe Diameter (D): 0.0 (ft)
Longitudinal Slope: 0.0004 (ft/ft)
Override Default
Manning's Roughness: 0.0350
Use Lining
Lining Type: Woven Paper Net

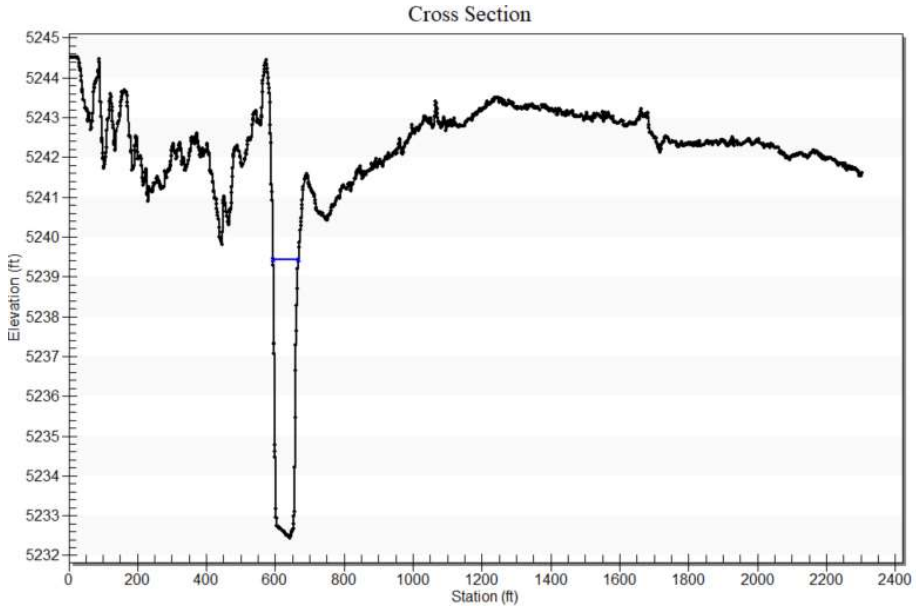
Enter Flow: 1078.000 (cfs)
Enter Depth: 6.987 (ft)

Calculate

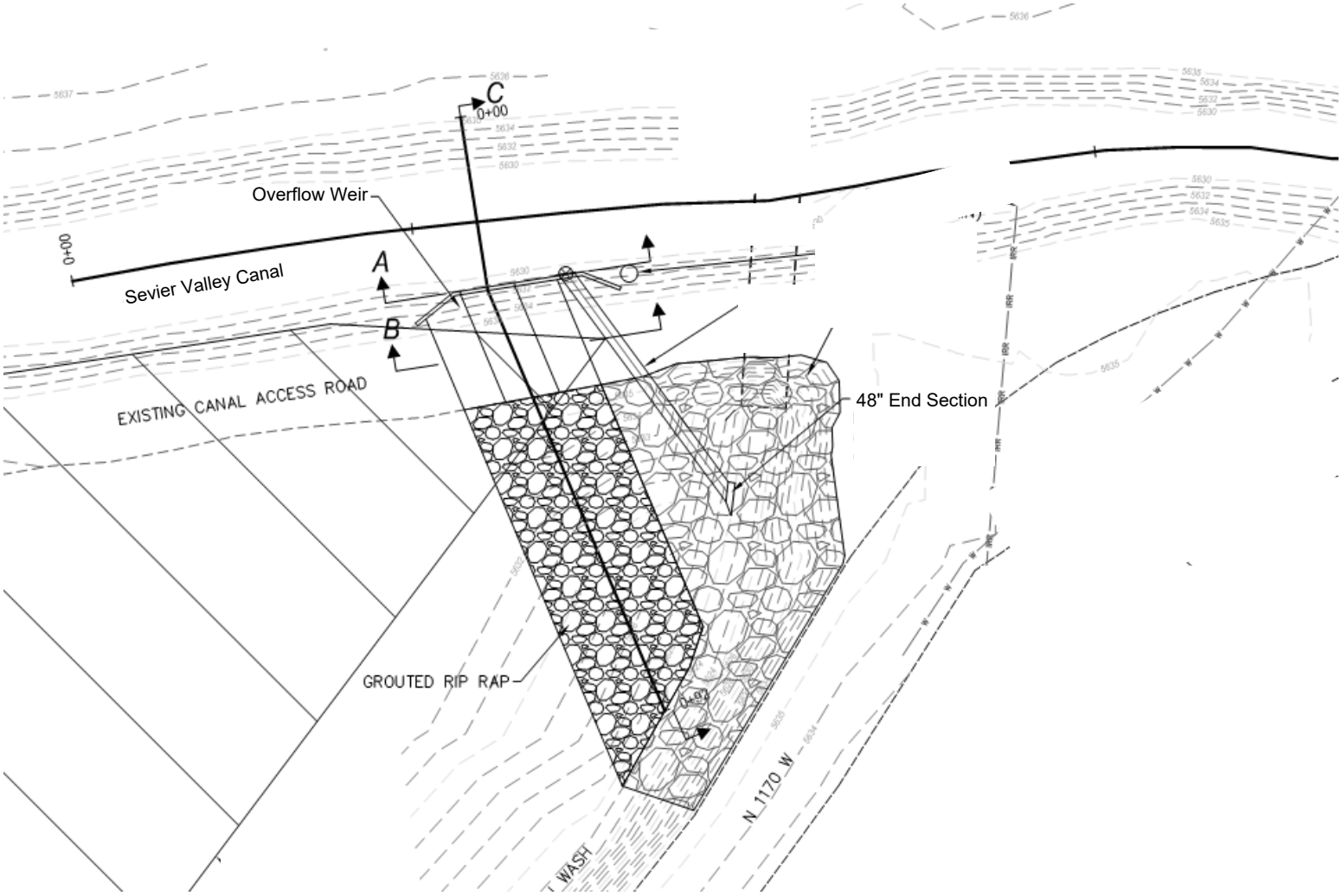
Plot... | Compute Curves...

Parameter	Value	Unit
Flow	1078....	cfs
Depth	6.987	ft
Area of Flow	415.5...	sq ft
Wetted Perimeter	77.829	ft
Hydraulic Radius	5.339	ft
Average Velocity	2.594	fps
Top Width (T)	73.723	ft
Froude Number	0.193	
Critical Depth	2.506	ft
Critical Velocity	8.426	fps
Critical Slope	0.014...	ft/ft
Critical Top Width	58.032	ft
Max Shear Stress	0.174	lb/ft^2
Avg Shear Stress	0.133	lb/ft^2
Composite Manning's...	Lotter...	
Manning's Roughness	0.0350	

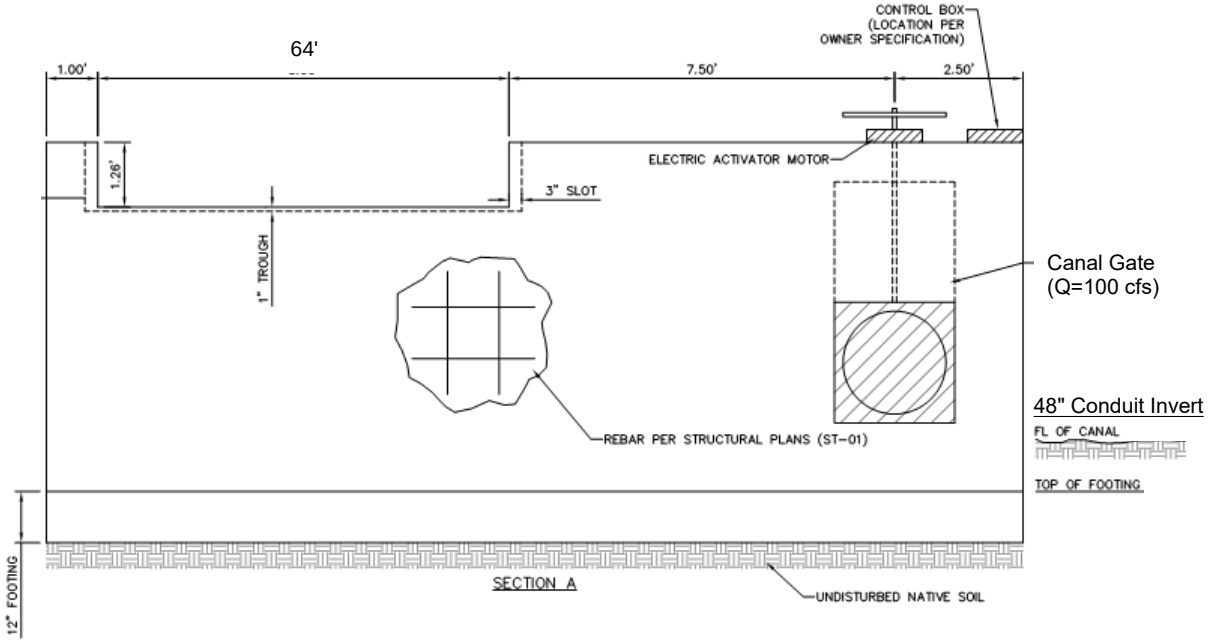
OK | Cancel



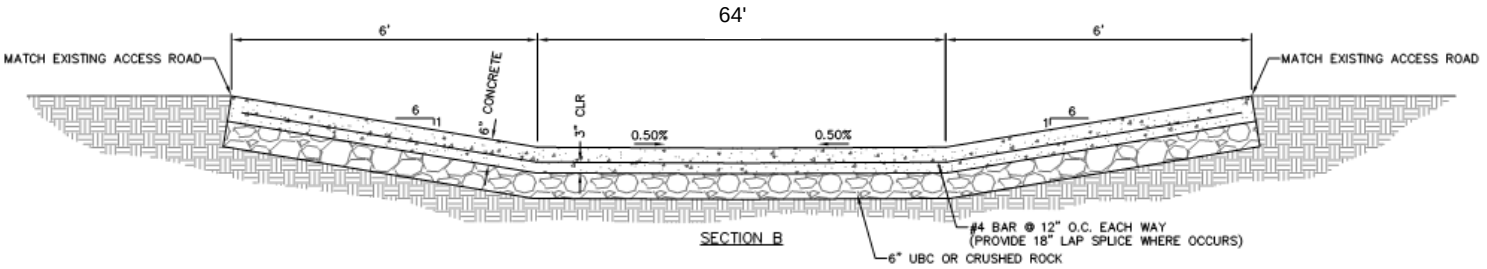
Attachment D. Overflow Weir Details



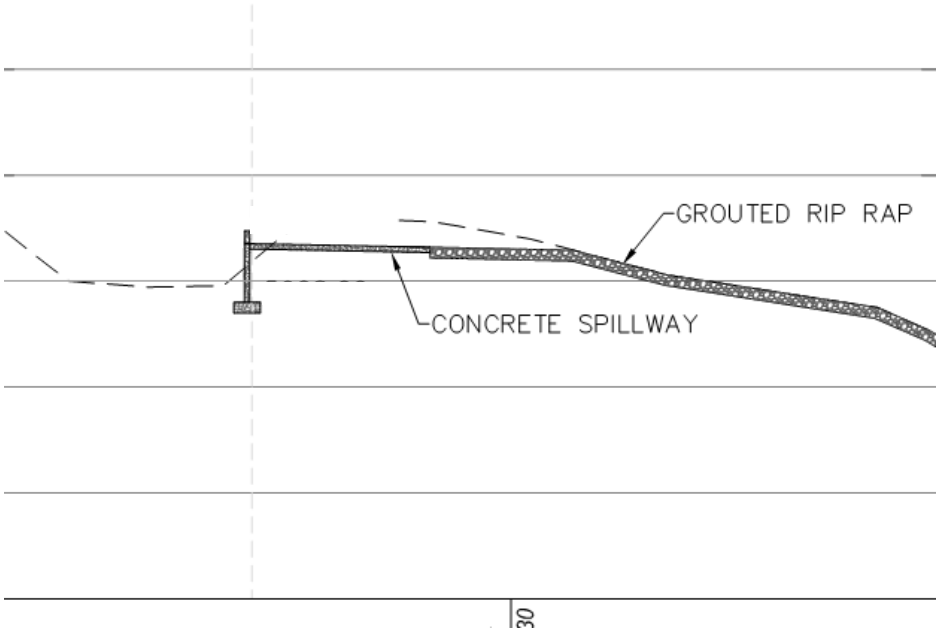
Sevier Valley Canal Emergency Overflow Plan View



Section A



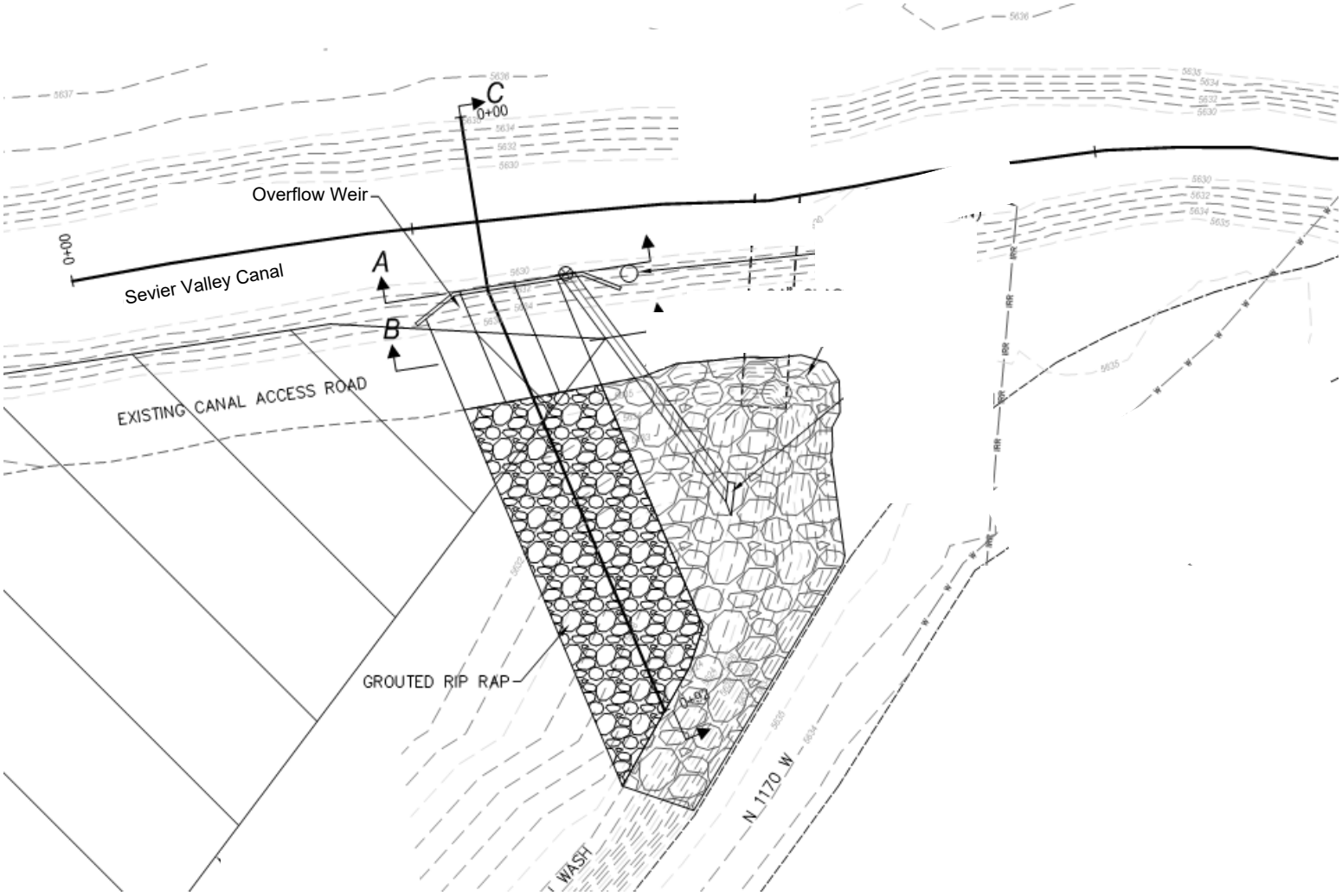
Section B



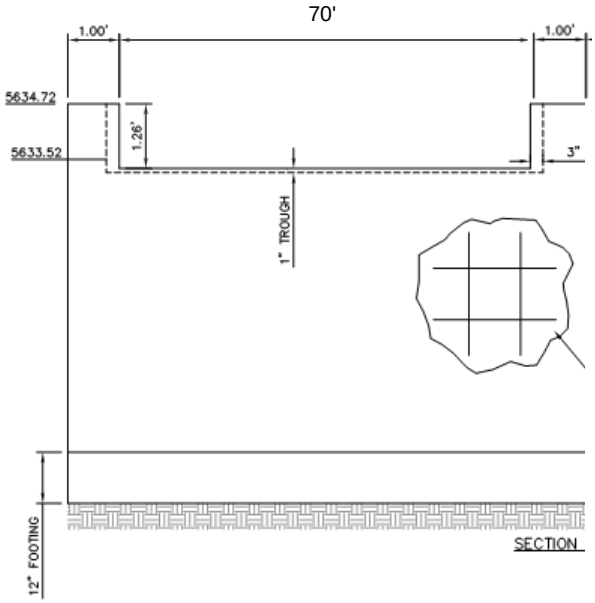
Section C

Canal Depth (ft)*	Canal Flows (cfs)*	Weir Head (ft)	Weir Flow (cfs)
2.825	150	0	0.0
2.861	154	0.036	0.9
2.921	161	0.096	3.8
2.981	168	0.156	7.9
3.038	175	0.213	12.6
3.095	182	0.27	18.0
3.15	189	0.325	23.7
3.204	196	0.379	29.9
3.256	203	0.431	36.2
3.308	210	0.483	43.0
3.359	217	0.534	49.9
3.408	224	0.583	57.0
3.457	231	0.632	64.3
3.505	238	0.68	71.8
3.552	245	0.727	79.3
3.598	252	0.773	87.0
3.644	259	0.819	94.9
3.689	266	0.864	102.8
3.733	273	0.908	110.7
3.776	280	0.951	118.7
3.819	287	0.994	126.8
3.861	294	1.036	135.0
3.903	301	1.078	143.3
3.944	308	1.119	151.5
3.984	315	1.159	159.7
4.024	322	1.199	168.1
4.063	329	1.238	176.3
4.102	336	1.277	184.7
4.14	343	1.315	193.0
4.178	350	1.353	201.4

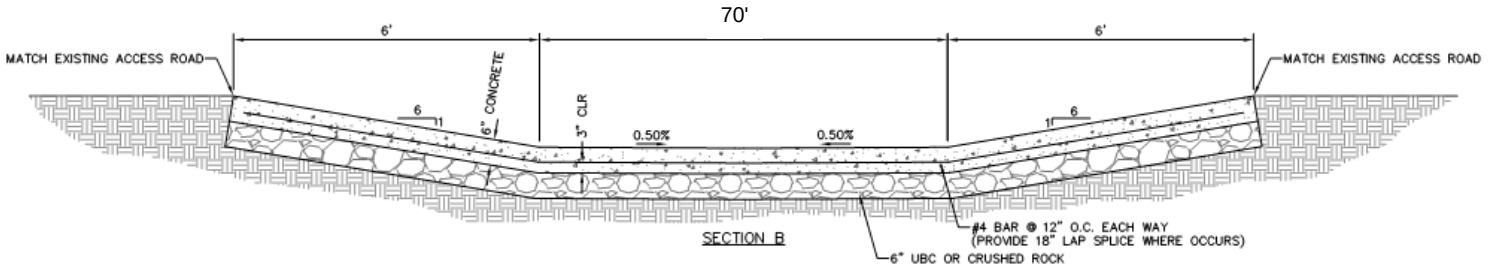
Flow Table



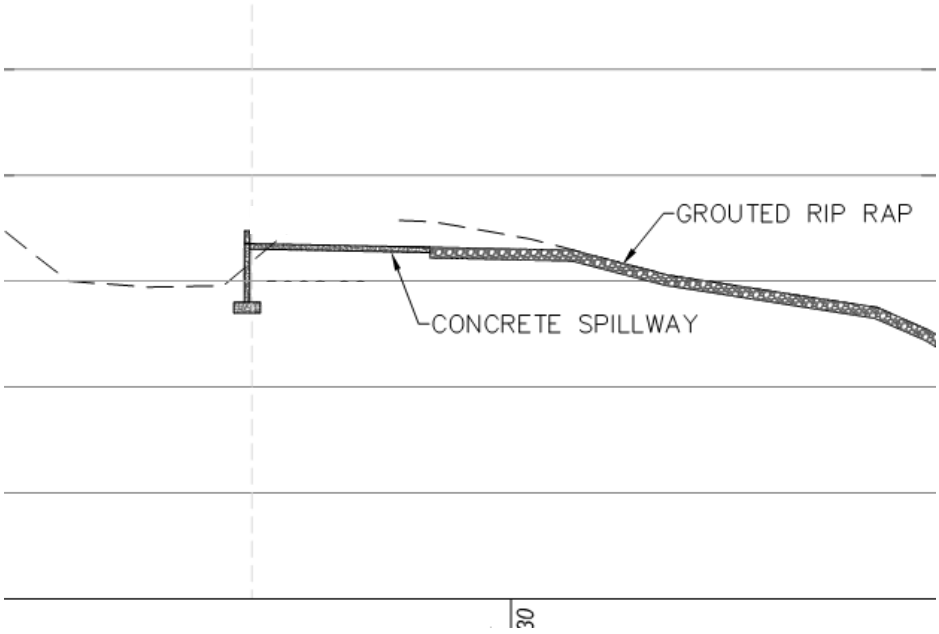
Richfield Canal Emergency Overflow Plan View



Section A



Section B



Section C

Canal Depth (ft)*	Canal Flows (cfs)*	Weir Head (ft)	Weir Flow (cfs)
3.805	204.0	0.036	1.0
3.858	210.0	0.089	3.7
3.91	216.0	0.141	7.4
3.961	222.0	0.192	11.8
4.011	228.0	0.242	16.7
4.061	234.0	0.292	22.1
4.11	240.0	0.341	27.9
4.158	246.0	0.389	34.0
4.205	252.0	0.436	40.3
4.252	258.0	0.483	47.0
4.298	264.0	0.529	53.9
4.343	270.0	0.574	60.9
4.388	276.0	0.619	68.2
4.432	282.0	0.663	75.6
4.476	288.0	0.707	83.2
4.519	294.0	0.75	90.9
4.562	300.0	0.793	98.9

Flow Table