Appendix D. Investigation and Analyses Report

Table of Contents

Investigation and Analyses Report for the Ashley Valley Flood & Irrigation Water Project

Appendix D

Ashley Valley Watershed
Uintah County, Utah

The purpose of the Investigation and Analyses Appendix is to present information that supports the evaluation and conclusions of the Watershed Plan and Environmental Assessment (Plan-EA). Refer to the Administrative Record for the copies of the studies referred to in this Appendix.

January 2023

TABLE OF CONTENTS

LIST OF TABLES

D.1 Introduction

The Ashley Valley Flood & Irrigation Water Project is located within the Ashley Valley Watershed, located in Uintah County, Utah. The project is to construct two detention basins, pipe and pressurize the Ashley Central Canal, and convert the open Ashley Central Canal into a flood control facility, while maintaining the open canal and water flow through the Kids Canal section of the Ashley Central Canal system. The Kids Canal Parkway path would also be improved with an asphalt surface, two pedestrian bridges, benches, garbage cans, ADA ramps, shade structures and picnic tables. As part of the cultural mitigation, an informational kiosk on the Kids Canal history would be constructed along the path, and supplemental water shares would be purchased and diverted into Kids Canal necessary to sustain the trees that remain along the canal after construction, and to provide open water for aesthetic and passive recreation purposes, and lastly public outreach materials on the Kids Canal history would be produced.

This document summarizes the investigations and analyses completed for the planning and engineering of the Ashley Valley Flood & Irrigation Water Project in preparation for the Environmental Assessment. This includes a summary of the hydraulics and hydrology for flood control and agricultural water, inundation analysis, alternatives, and the economic analysis. The planning and engineering investigations and analyses were conducted under the applicable NRCS criteria and standards. Additional information relevant to each of the sections provided in this report is available as part of the administrative record for the project. In particular, the data described in this Appendix are presented in Tables 2 through 4 of TM-001 in Appendix E.

D.2 Flood Control

The flood control components of this project include:

1. The Yellow Hills and Coal Mine Detention Basins
2. The conversion of the Ashley Central Canal to a flood conveyance facility

1. The Yellow Hills and Coal Mine Basin Drainages are located on the western slope of Ashley Valley. They are located on the north and south of Yellow Hills, which is approximately 4 miles west of Vernal, UT. Historically, floodwaters that entered Ashley Valley from the west would flow through natural drainages leading to the Green River. Canal installations along the western, northern, and eastern edges of Ashley Valley are disconnected from these drainages causing the storm runoff to run into these canals and the adjacent fields. Highline and Upper Ashley Canals are oriented perpendicular to the Yellow Hills and Coal Mine Basin drainages. From the date of their construction, both canals have intercepted floodwater from the Yellow Hills and Coal Mine drainages. When storm intensities exceed the capacity of Highline Canal, Highline Canal overtops, and

floodwaters are intercepted by the Ashley Upper Canal. If floodwaters exceed the capacity of the Ashley Upper Canal, waters will continue in their historic drainages towards their outlet to the southeast. The Highline and Ashley Upper Canals do not connect to Ashley Central Canal nor Ashley Creek. Highline and Ashley Upper Canal have a diffuse outlet in the Ashley Valley, near the base of Asphalt Ridge, approximately 3 miles south of the Ashley Central Canal terminus.

For storm events that exceed the capacity of the basins and Highline and Ashley Upper Canals, floodwaters may spread diffusely over the floodplain below Coal Mine and Yellow Hills drainages. In that scenario, floodwaters could reach Ashley Creek. Tailwater from these canals is conveyed through a web of natural channels that drain toward the Green River. With recent population growth in Ashley Valley many homes have been built in the adjacent fields that previously absorbed or transferred floodwater runoff. The Yellow Hills and Coal Mine drainages are two of the largest drainages on the western side of the valley with a combined watershed area of 17.9 square miles. According to the 2017 Ashley Valley Flood Control Study these drainages have been identified as high priority drainages that are recommended to be improved for flood control management in Ashley Valley.

2. After the irrigation water is piped, the Ashley Central Canal will remain as a flood control feature for Uintah County, Vernal City and Naples City. The Ashley Central Canal receives floodwater runoff from various locations along the existing canal. The hydraulic analysis has determined that Ashley Central Canal has the capacity to convey the 100-year flood event under current land use condition, see Figure 3 in TM-001 in Appendix E for Ashley Central Canal Contributing area. Additional floodwater will enter the canal as urbanization continues to increase unless local entities require on-site detention.

D.2.1 Hydrology and Hydraulics

The NRCS curve number methodology was used in the model to determine the runoff from each of the drainage basins. Land use and soil types were calculated for each drainage basin and curve numbers were assigned for each land use and soil type combination. The average point rainfall depths in the project watershed were obtained from the NOAA Precipitation-Frequency Atlas 14. See Section 3.1 in TM-001 in Appendix E for Ashley Central Canal modeling method and inputs.

D.2.1.1 Detention Basins

In order to eliminate risks of flooding or structure failures, only sub-grade detention basins were considered as flood control options for these detention basins. No flood risk analysis associated with breaching was performed for the design options since the detention basins are proposed subgrade.

The detention basins will fully detain storm water according to the 10-year, 24-hour storm without exercising the overflow spillway. The Coal Mine and Yellow Hills detention basins will have 26.76 ac-ft and 7.68 ac-ft, respectively, of additional storage above the 10-year peak storage, providing partial flood control for larger storm events. See TM-001-Ashley Central Canal Agricultural Water Hydraulics and Hydrology (Appendix E) for peak inflow/outflow and pond storage for 2- to 500-year events. Figure 3 of TM-001 is the delineation of the contributing drainage areas for each basin. The Yellow Hills and Coal Mine detention basins will include an outlet pipe that will direct the water to the Highline Canal and Ashley Upper Canal, respectively.

Two locations for the detention basins were considered in the evaluation. According to NRCS Conservation Practice Standards entitled Water and Sediment Control Basin (Code 638) and Pond (Code 378), as a minimum, the capacity of a detention basin must be sufficient to control the runoff from a 10-year 24-hour storm. Auxiliary spillway shall have the capacity to pass the peak flow expected from:

1. A 25-year 24-hour storm if pond storage is less than 50 ac-ft; or
2. A 50-year 24-hour storm if pond storage is larger than 50 ac-ft.

Due to the site constraints, budget, topography, and existing development around the detention basins, it was determined that it would be cost prohibitive to size the detention basins for storm events larger than the 10-year 24-hr storm. In the future, additional flood control structures will need to be considered. As more budget is made available, additional flood control efforts will be considered that include offsite retention/detention basins and flood channels. Technical Memo 001 – Ashley Central Canal Agricultural Water Hydraulics and Hydrology (Appendix E) provides the hydrologic modeling analysis, which shows inundation under every design storm event both with and without the detention basins. Although the detention basins are designed for the 10-year storm event, the modeled flooding reduction show benefits from the detention basins across all storm events.

The 10-year 24-hr peak discharges from Yellow Hills and Coal Mine basins were decreased from 255 and 145 cfs to 54 and 37 cfs respectively by construction of the detention basins. Table 1 and Table 2 summarize the peak discharge volumes. As part of the separately funded Highline and Ashley Upper Canal Project, those canals will be reconstructed to carry the outflow from the detention basins. These canal improvements have been included in the existing conditions for this analysis. The Explanatory Memo included in Appendix E describes the differences and interaction between the Yellow Hills and Coal Mine basins project and the Highline and Ashley Upper Canal Project. The discharge from the Coal Mine Detention Basin will flow into the Ashley Upper Canal and Yellow Hills will flow into the Highline Canal. Storm events in excess of the 10-year 24-hr storm will exceed the capacity of these canals. Overflow from the canals in the larger storm events will cause flooding. Those events were modeled and the construction of the basins still provides benefit in the form or reduced flooding. Technical Memo 001 – Ashley Central Canal Agricultural Water Hydraulics and Hydrology (Appendix E) describes the hydraulic analysis and modeling for floodwater volumes based on storm events.

D.2.2 Conceptual Detention Basin Design

The detention basin design shall meet the requirements outlined in NRCS Practice Standards Code 638 and Code 378.

D.2.2.1 Design Requirements

1. The detention basins shall store the floodwater generated in the Coal Mine and Yellow Hills watersheds during a 10-year design storm, and safely release the reduced discharges downstream.
2. In addition to the calculated total storm runoff volume, the ponds should have extra storage capacity for sediment. Preliminary SEDCAD modeling shows sediment loads generated during a 10-year storm event are 1,366.7 and 2,504.4 cu-yds or 0.85 and 1.6 ac-ft in Coal Mine and Yellow Hill Basins, respectively (see attached Preliminary Sediment Analysis Reports).
3. Flood guide berms that direct floodwater flowing to the ponds shall be constructed as needed. The soil materials used to build the berms shall be obtained onsite. No embankment over one foot in height is proposed.
4. Low-level outlet shall be reinforced concrete pipe (RCP) or polyvinyl chloride (PVC) pipe. Sediment and erosion protection shall be designed around its inlet and outlet.
5. Auxiliary spillway above the floodwater retarding pool shall be constructed to convey storm events larger than the design event (up to the 50-year storm).
6. Following construction of a detention basin, revegetate the disturbed areas as soon as possible.

D.2.2.2 Storage Routing Analysis for Hydraulic Design

Both detention basins will be constructed by excavating below grade. There will be no embankment constructed in association with these excavated detention basins. A low-level outlet pipe will be installed at the downstream end of the basin (east side of basin). The depth, surface area and volume (capacity) of the detention basin, the peak water storage in the basin, and the discharge through the low-level outlet were determined using the survey data, AutoCAD design, and modeling.

Low-level outlet pipes designed at 30-inch diameter, were first modeled using HY-8. A series of volume-stage-discharge scenarios were generated using AutoCAD and the HY-8 models for each detention basin. HEC-1 pond storage routings were performed for 10-year 24-hour design storm. After a series of modeling scenarios, an optimized design was determined. Model output is summarized in **Table 1**. The 10-year flow is passed through the low-level outlet pipe in both flood control basins and the spillway is not exercised during the 10-year design storm event. Peak flows in **Table 1** are the outflows through the low-level pipe. The spillway will function as an emergency spillway and further detailed analysis will be performed during final design.

Table 1: 10-Year Design Detention Basin Storage Routing Results

Pond	Peak Inflow (cfs)	Runoff Vol. (ac-ft)	D $_{Outlet Pipe}$ (in)	QPeak Out (cfs)	Peak Storage (ac-ft)	Peak S. Area (ac)
Coal Mine	145	73	30	37	42	14.8
Yellow Hills	256	99	30	54	52	12.4
Combined				90		

D.2.2.3 Design Concepts

No embankment shall be built around the detention basins. A guide berm shall be installed where needed to direct floodwater flowing into the ponds. The berm height shall be one foot or less. The detention basin below ground level shall detain the runoff generated from a 10-year 24-hr storm and release this water through the low-level outlet pipe. The low-level outlet pipe for the Yellow Hills detention basin shall run crossing Skyline Drive approximately 700 feet and into the Highline Canal. The low-level outlet pipe for the Coal Mine detention basin shall run approximately 200’ under the adjacent Highline Canal and into a natural drainage that currently conveys stormwater to the Ashley Upper Canal.

An auxiliary spillway shall be installed for each basin at the downstream overbank (east side of pond). The auxiliary spillway for the Yellow Hills detention basin will flow into an existing ditch that will flow into the Highline Canal. The auxiliary spillway for the Coal Mine detention basin will flow into the adjacent Highline Canal, with a spill location in the Highline Canal that connects to a drainage that flows into the Ashley Upper Canal. The spillway shall be a broad crested weir without a defined downstream edge (natural grade) – length: varied, bottom width: approximately 100 feet, crest elevation: natural grade + 0.5 feet, height of spillway sides: 1.5 feet or less, and spillway side slopes: 3:1 (h:v). A riprap protection shall be placed on top, abutments and upstream face of the spillway channel. The spillway channel entrance will be protected with a gabion rock grade control weir buried in the entrance location. The buried gabions will be grouted in place. If needed, grass lining will be planted on the gabion weir to match the existing conditions. The capacity of the auxiliary spillway is the peak flow of a 50-year 24-hour storm, which would be 486 cfs from Coal Mine Basin, and 755 cfs from Yellow Hills Basin. See Technical Memo-001 – Ashley Central Canal Agricultural Water Hydraulics and Hydrology (Appendix E) for basin stage-discharge for each detention basin. The detention basins provide partial flood runoff attenuation that reduces the peak slightly for the larger storm events, but do not fully control flood volumes from those larger storm events. For storm events that exceed the 50-year storm runoff water would flow following the topology of the land towards the canals as it has historically done, although the basins will provide some attenuation even with the larger events.

D.2.3 Recommendations for Detention Basin Design

Based on the hydrologic and preliminary AutoCAD analysis, the recommended design concepts for the Coal Mine and Yellow Hills detention basins are summarized in **Table 2**.

Table 2: Recommended Flood Control Pond Design Data

Detention Basin	Coal Mine	Yellow Hills
Bottom Elevation (ft)	5722.00	5721.00
Top Elevation (ft)	5730.00	5732.00
Total Volume (ac-ft)	68.4	72.3
Diameter of Low Level Outlet Pipe (in)	30 (RCP or PVC)	30 (RCP or PVC)
Invert Elevation of Low Level Outlet Pipe (ft)	5722.5	5721.5
Approx. Length of Low Level Outlet Pipe (ft)	770	315
10-year 24-hour Design Storm Peak Inflow (cfs)	145	256
10-year 24-hour Design Storm Peak Outflow (cfs)	42	52
10-year 24-hour Design Storm Peak Stage (ft)	5725.1	5725.2
10-year 24-hour Design Storm Peak Storage Volume (ac-ft)	42	52
Auxiliary Spillway Crest Elevation (ft)	5727.1	5727.4
Approx. Length of Spillway Crest (ft)	100	100
Approx. Width of Spillway Crest (ft)	100	100
Storage Capacity at Spillway Crest (ac-ft)	75.5	78.7
Surface Area at Spillway Crest (ft^2)	15.1	13

D.2.3.1 Inundation Modeling and Mapping

Hydrologic analysis and flood routing and mapping were performed both with and without the proposed detention basins being present. The proposed basins attenuate the peak flow and reduce the outflow for all storm events. The modeled flows from the basin were used in the 2-dimensional model routing.

The 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year storm events runoff flow and storage was provided, which incorporates the canal improvements from a separate funded project that will being constructed prior to the construction of the detention basins.

The hydrologic model results were compared against the peak runoff results against Stream Stats and previous completed FEMA studies. Stream Stats peak flow estimates were obtained for the two watersheds but, unfortunately two of the three input parameters were outside the data range limits for both watersheds. Because the input parameters are outside of the data range limits, a percent error of predication was not calculated, which could be very high and reduces the confidence level in the Stream Stats peak flow estimates. The delineated FEMA floodplain is a Zone A. The FEMA floodplain was delineated using approximate methods and can be highly inaccurate.

The provided flood flows were loaded into HEC-RAS 2D model for flood routing and mapping. The HEC-RAS 2D model is a 2-dimensional surface water model that calculates where water will travel in all directions via overland flow. Section 4.2.2 in TM-001 discusses the modeling and Figure 5 in TM-001 illustrates the inflow hydrographs and boundary condition locations. Culvert sizes and locations were not surveyed, so they were not modeled in the existing or proposed hydraulic HEC-RAS modeling.

The Highline and Ashley Upper Canals improvements that have been designed by Sunrise Engineering and are being constructed currently were included in the modeling as an existing condition in both the existing and proposed modeling scenarios to demonstrate the reduction in the floodplain from the detention basins. **Table 3** identifies the total number of homes, commercial buildings, and acres of agricultural land that would be flooded without the detention basins. **Table 4** includes the same information under the scenario of the detention basins being in place. Flood control benefits were calculated using all storm events.

Table 3: Summary of Flooding Impacts of Existing Scenario

Flooded Structures/Land	Depth (ft)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
Number of Residential Homes	<1	3	91	188	298	390	488	535
	1-3	-	8	13	22	27	34	40
	>3	-	2	2	4	6	8	8
Number of Mobile Homes	<1	-	-	-	1	1	1	1
	1-3	-	-	-	-	-	-	-
	>3	-	-	-	-	-	-	-
Number of Commercial Structures	<1	-	7	29	45	69	117	136
	1-3	-	1	1	3	6	12	13
	>3	-	-	-	-	-	-	-
Number of Other Structures	<1	-	-	-	-	-	2	4
	1-3	-	-	-	-	-	-	-
	>3	-	-	-	-	-	-	-
Number of Roadways	<1	2	49	82	111	127	140	148
	1-3	1	2	5	8	17	21	24
	>3	-	1	1	1	1	1	1
Agricultural (Acres)	<1	3.0	138.9	307.6	458.4	548.3	632.1	662.4
	1-3	0.6	10.1	24.1	42.4	61.8	82.8	87.8
	>3	-	0.9	2.4	7.6	9.8	11.9	13.1

Table 4: Summary of Flooding Impacts of Proposed Scenario

Flooded Structures/Land	Depth (ft)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
Number of Residential Homes	<1	-	1	5	43	197	256	471
	1-3	-	-	-	1	13	20	34
	>3	-	-	-	1	2	3	8
Number of Mobile Homes	<1	-	-	-	-	-	1	1
	1-3	-	-	-	-	-	-	-
	>3	-	-	-	-	-	-	-
Number of Commercial Structures	<1	-	-	-	1	30	39	106
	1-3	-	-	-	-	2	3	10
	>3	-	-	-	-	-	-	-
Number of Other Structures	<1	-	-	-	-	-	-	-
	1-3	-	-	-	-	-	-	-
	>3	-	-	-	-	-	-	-
Number of Roadways	<1	-	1	7	30	84	111	138
	1-3	-	-	1	2	5	9	19
	>3	-	-	-	-	1	1	1
Agricultural (Acres)	<1	1.1	2.8	27.1	106.9	323.4	387.2	585.1
	1-3	0.1	0.6	3.6	12.8	28.9	38.9	77.6
	>3	-	-	0.1	1.5	3.2	4.6	11.8

D.2.3.2 Ashley Central Canal – Flood Control System

Floodwater volumes that would enter the Ashley Central Canal were analyzed to determine if any flooding would occur in the existing canal once the piping project is completed and the channel is used exclusively for flood control. Innovyze's water modeling software Infoswmm was used for the analysis. The Ashley Central Canal receives floodwater runoff from surrounding areas. Drainage basins were delineated at all locations where floodwater will enter the canal either with existing inlets or through sheet flow. The watershed drainage for Ashley Central Canal is disconnected hydraulically from Yellow Hills and Coal Mine watersheds and Highline and Ashley Upper Canals. See TM-001 (Appendix E) for Ashley Central Canal hydrology and channel capacity analysis. The Explanatory Memo included in Appendix E describes the differences and interaction between the Yellow Hills and Coal Mine basins project and the Highline and Ashley Upper Canal Project.

Canal cross-sections were calculated for each segment of the canal using survey data. The culvert cross-sections were input into the model and the survey data was used to identify upstream and downstream invert elevations. There are several culverts that will have the new pressurized irrigation line installed in the existing culvert upon completion of the piping project. These culverts were modeled with a reduced width to accommodate the reduction in flow area.

The open segments of Ashley Central Canal were analyzed to determine the capacity of each canal section for the 100-year storm event. No section of the canal exceeded 23% of the canal's capacity to carry the floodwater. The culverts were also analyzed and are presented in **Table 5**.

Table 5: Model Output Results for Culvert Capacities

Culvert Location	Culvert Type[1]	Dimensions (ft)	Culvert Capacity (cfs)	Modeled Max Flow (cfs)	Percent Full (%)
1500 East 2536 South	Box Culvert	3x3.8	180.6	54.4	30%
1500 N 2499 West	Box Culvert	4x5	102.2	7	7%
1500 South 915 West	Box Culvert	4x5.8	54.6	63.1	115%
1500 West 620 North	Box Culvert	3.5x12	426.5	18.3	4%
2000 East 2500 South	Pipe	3	71.9	50.0	70%
210 South 1500 West	Pipe	4	49.7	21.6	43%
250 South 1500 West	Pipe	5	313.5	20.3	7%
2500 South 1572 East	Box Culvert	3x4	124.4	50.0	40%
2500 South 450 West	Box Culvert	6x2.2	224.0	66.1	30%
2500 West 1653 North	Pipe	5.5	12.6	0.8	6%
200 East 2600 South	Pipe	3	61.0	49.6	81%
400 South 1500 West	Ellipse	4.6x6.7	82.0	49.6	81%
500 North 1500 West	Box Culvert	2.6x13.3	317.1	18.4	6%
500 South 1500 West	Box Culvert	3x8	298.8	46.4	16%
500 West 2350 South	Box Culvert	4x5	112.5	70.4	63%
1450 West HWY-40	Box Culvert	4x10.5	334.4	51.0	15%
1500 West Main Street	Ellipse	3x4.3	175.5	21.2	12%
2600 South Vernal Ave	Box Culvert	6x2.3	299.6	62.1	21%

Note [1]: All box culverts are shown at reduced size to allow for slip lined canal pipe.

Naples City intends to pipe the lower portion of the canal from the crossing at 1572 East and 2500 South to the end of the canal. This pipe was sized to convey 35 cfs at 1% slope. The pipe size was calculated to be 36” RCP. Refer to Technical Memo 001 – Ashley Central Canal Agricultural Water Hydraulics and Hydrology (Appendix E) prepared by J-U-B for additional information.

D.3 Agricultural Water

The Ashley Central Canal is an open, unlined canal that conveys irrigation water to shareholders throughout the Ashley Valley. The canal was constructed in the early 1900s and has remained in use for irrigation management to the present. The canal receives water from Ashley Creek, a natural drainage with headwaters in the Ashley National Forest north of Vernal, and the Steinaker Service Canal which is fed by Steinaker Reservoir located approximately 3-miles north of Vernal.

The Proposed Project will pipe the entire Ashley Central Canal from the Thornburg Diversion to the last irrigation turnout. The pressurized pipe will be installed in the bank of the canal leaving the existing open canal in place as a flood control facility. The pipeline construction and placement for most of the 9.6 miles of the Ashely Central Canal would be designed in the east bank of the canal. The section of the Ashley Central Canal between 500 North and Main Street is referred to as the Kids Canal. Currently, this section of Ashley Central Canal is open with significant tree coverage sustained by seepage. However, most of the trees along Kids Canal are growing on the east bank of the canal. The proposed design has been modified through this section to install the pipeline in the west bank of the canal adjacent to 1500 West. Trees present along the west bank would be protected, whenever feasible. The majority, if not all, of the trees on the east bank will be preserved. Less than a third of the trees on the west bank are anticipated to survive construction, however the majority of those that can be preserved will be on the lower section near Main Street. The design rendering for the Kids Canal is included in Appendix B.

Kids Canal would remain open and unlined. The Kids Canal Parkway path would be improved with an asphalt surface, two pedestrian bridges, benches, garbage cans, ADA ramps, shade structures and picnic tables. As part of the cultural mitigation, an informational kiosk on the Kids Canal history would be constructed along the path, and supplemental water shares would be purchased and diverted into Kids Canal to sustain the trees that remain along the canal after construction, and to provide water for aesthetic and passive recreation purposes, and lastly public outreach materials on the Kids Canal history would be produced. On August 9, 2022, Uintah County Special Services District #1 voted to allow water associated with the Uintah County Golf Course to flow through Kids Canal. The golf course water is currently delivered through the existing turnout near 500 S. This water typically fluctuates between 1 to 2 cfs throughout the irrigation season. In addition to the golf course water, Uintah County has agreed to purchase additional water equivalent to 0.5 cfs for the duration of the irrigation season. Fifteen primary water shares (15 ac-ft) have already been purchased by ACIC and designated for use in the Kids Canal section. The Uintah County Special Services District #1 meeting minutes, and documentation from ACIC for the primary water shares are included in Appendix E. Supplemental water would be introduced back into Kids Canal by modifying an existing user turnout near the upper end of Kids Canal to allow water to be turned into the Kids

Canal section. This turnout would include a valve and meter. At the end of the Kids Canal, the supplemental water would flow into the Uintah County pipe inlet. Water would be collected in a box and would flow into a new non-pressurized pipe to an existing Ashley Central Canal user turnout near 500 S where it would be delivered to existing shareholders on the canal. A Flow Measurement Study for the Kids Canal was conducted in August 2022 to determine the amount of water required to sustain the preserved trees and provide enough flow to account for seepage. The Flow Measurement Study demonstrated that 1.75 cfs through Kids Canal would be required to sustain the trees, to carry water to the lowest portion of Kids Canal, and to provide flow for passive recreation purposes. Although studies demonstrate that the proposed supplemental water should be enough to support the trees, additional water may be necessary depending on the water year (Appendix E).

The Ashley Central Canal was analyzed to determine the pipe sizes required to transport irrigation water currently flowing in the open canal. Innovyze's water modeling software Infowater was used for the analysis. The Ashley Canal receives water from two sources, Ashley Creek and the Steinaker Service Canal.

The system was analyzed in 2 phases. Phase 1 includes piping from the Thornburg Diversion on Ashley Creek to the Steinaker Service Canal inlet. The pressure break will allow water from the Steinaker Service Canal to enter the piped system. Phase 2 is from the Steinaker Service Canal inlet to the last user turnout on the canal.

The piped canal system was analyzed considering two sections:

Ashley Creek Inlet to SC turnout 3.7

This section of canal was sized to convey early season high creek flows. It was determined that this section of the pipeline would be sized to convey a peak flow of 35 cfs. A maximum velocity of 5 ft/s was used to size the pipeline.

1. **Service Canal inlet to end of canal**

This section of canal was sized to convey 65 cfs. A maximum velocity of 5 ft/s was used to size the pipeline. The demands used in the model were provided by Ashley Central Irrigation Company. The irrigated acreage at each turnout location was provided. Refer to Technical Memo 001 Ashley Central Canal Agricultural Water Hydraulics and Hydrology prepared by J-U-B for additional information regarding irrigation demands.

The model was used to determine the pipe sizes required to provide the calculated demands in the system and maintain a peak velocity less than 5 ft/s. High density polyethylene (HDPE) pipe sizes were used. HDPE pipe is broken into "DR" ratings based on maximum service pressure in the pipe. The static pressure for each node in the model was identified and the pipe DR ratings were determined to ensure safe operation of the system.

When the Steinaker Service Canal is eventually piped, the pressure break will be eliminated and a pressure reducing station will be installed at the Steinaker Service Canal inlet location. If this happens, the pressures in the system will increase by approximately 20 psi. The DR value for each pipe below the Steinaker Service Canal inlet was calculated taking into account the increased pressure when the Steinaker Service Canal is piped. Pipe type, size and length are summarized in **Table 6**. The Conservancy District will provide funds to increase pipe size ($400,000) to accommodate the increase in pressure rate related to water delivery from Steinaker Service Canal. Two points of delivery will be consolidated into one delivery point.

Table 6: Pipe type, Size and Length

Pipe Type	Units	Total Length
48" HDPE DR 41 PIPE	LF	6700
42" HDPE DR 41 PIPE	LF	10300
36" HDPE DR 41 PIPE	LF	3800
36" HDPE DR 26 PIPE	LF	7500
34" HDPE DR 41 PIPE	LF	2600
32" HDPE DR 41 PIPE	LF	3400
30" HDPE DR 41 PIPE	LF	1200
28" HDPE DR 41 PIPE	LF	1000
28" HDPE DR 26 PIPE	LF	4500
26" HDPE DR 21 PIPE	LF	3900
26" HDPE DR 17 PIPE	LF	3000
24" HDPE DR 32.5 PIPE	LF	385
20" HDPE DR 15.5 PIPE	LF	2300
18" HDPE DR 32.5 PIPE	LF	2275
18" HDPE DR 13.5 PIPE	LF	1300
16" HDPE DR 13.5 PIPE	LF	800

The Thornburg Diversion which diverts water from Ashley Creek into the Ashley Central Canal is also part of the Proposed Project. The Thornburg Diversion also diverts into three other ditches, Rockpoint, Dodds and The Island Ditch. The diversion would be reconstructed and would be sized to accommodate the existing maximum diversion rates for all four ditches. A new screen will be constructed for the Ashley Central Canal but the existing screening structure for the other ditches will remain. The flush gate will be designed to match the existing flush capacity of 500 cfs. The ditch flows are summarized in **Table 7**.

Table 7: Thornburg Diversion Design Flows

Ditch	Flow (cfs)
Ashley Central Canal	45
Island Ditch	20
Rockpoint	15
Dodd’s Ditch	3

Refer to Technical Memo 001 Ashley Central Canal Agricultural Water Hydraulics and Hydrology prepared by J-U-B for additional information.

D.4 Alternatives

Other alternatives that were investigated as part of the study include the No Action Alternative, Alternative 1, Alternative 2, and Alternative 3. Alternative 1 included a fully pressurized piped system for Ashley Central Canal, while Alternative 2 included sections of non-pressured gravity flow for the Ashley Central Canal piping. The Preferred Alternative (Alternative 3) was a fully pressurized piped system for the Ashley Central Canal which gave the greatest benefit to the system users and facilitated the most efficient irrigation systems. The Preferred Alternative differs from Alternative 1 in that it includes specific design measures for Kids Canal and the revised recreation component focused on the Kids Canal Parkway path, and associated cultural mitigation measures that would address the Kids Canal water feature. In addition to benefiting the system users, the Preferred Alternative would address community concerns and comments regarding preservation of the Kids Canal. Refer to the Plan-EA for a more detailed discussion on the alternatives.

D.5 Preferred Alternative Cost Estimate

The cost estimate for the preferred alternative is $19,601,669. The cost estimate is broken out in **Table 8** Agricultural Water Management, **Table 9** Flood Control and Detention Facilities and **Table 10** Recreational Facilities.

Table 8: Agricultural Water Management

Item	Description	Quantity	Unit	Unit Price	Total Amount
1	Mobilization	LS	1	$600,000.00	$600,000
2	Traffic Control	LS	1	$50,000.00	$50,000
3	Clear and Grub	LS	1	$500,000.00	$500,000
	Mainline Piping				
4	48" HDPE DR 41 PIPE	LF	6700	$155.00	$1,038,500
5	42" HDPE DR 41 PIPE	LF	10300	$124.00	$1,277,200
6	36" HDPE DR 41 PIPE	LF	3800	$99.00	$376,200
7	36" HDPE DR 26 PIPE	LF	7500	$131.00	$982,500
8	34" HDPE DR 41 PIPE	LF	2600	$93.00	$241,800
9	32" HDPE DR 41 PIPE	LF	3400	$87.00	$295,800
10	30" HDPE DR 41 PIPE	LF	1200	$79.00	$94,800
11	28" HDPE DR 41 PIPE	LF	1000	$70.00	$70,000
12	28" HDPE DR 26 PIPE	LF	4500	$89.00	$400,500
13	26" HDPE DR 21 PIPE	LF	3900	$90.00	$351,000
14	26" HDPE DR 17 PIPE	LF	3000	$102.00	$306,000
15	20" HDPE DR 15.5 PIPE	LF	2300	$69.00	$158,700
16	18” HDPE DR 13.5 PIPE	LF	1300	$72.00	$93,600
17	16” HDPE DR 13.5 PIPE	LF	800	$60.00	$48,000

Item	Description	Quantity	Unit	Unit Price	Total Amount
	Mainline Fittings				
18	Furnish and Install 48" HDPE Bend	EA	1	$8,000.00	$8,000
19	Furnish and Install 42" HDPE Bend (Various angles)	EA	2	$7,000.00	$14,000
20	Furnish and Install 36" HDPE Bend (Various angles)	EA	9	$6,000.00	$54,000
21	Furnish and Install 32" HDPE Bend (Various angles)	EA	11	$5,500.00	$60,500
22	Furnish and Install 30" HDPE Bend (Various angles)	EA	7	$5,000.00	$35,000
23	Furnish and Install 28" HDPE Bend (Various angles)	EA	10	$4,500.00	$45,000
24	Furnish and Install 26" HDPE Bend (Various angles)	EA	4	$4,000.00	$16,000
25	Furnish and Install 22" HDPE Bend (Various angles)	EA	5	$3,500.00	$17,500
26	Furnish and Install 48"x42" Eccentric HDPE Reducer	EA	1	$15,000.00	$15,000
27	Furnish and Install 42"x36" Eccentric HDPE Reducer	EA	1	$12,000.00	$12,000
28	Furnish and Install 36"x34" Eccentric HDPE Reducer	EA	1	$8,500.00	$8,500
29	Furnish and Install 34"x32" Eccentric HDPE Reducer	EA	1	$5,500.00	$5,500
30	Furnish and Install 32"x30" Eccentric HDPE Reducer	EA	1	$5,000.00	$5,000
31	Furnish and Install 30"x28" Eccentric HDPE Reducer	EA	1	$4,600.00	$4,600
32	Furnish and Install 28"x26" Eccentric HDPE Reducer	EA	1	$4,200.00	$4,200
33	Furnish and Install 26"x24" Eccentric HDPE Reducer	EA	1	$3,800.00	$3,800

Item	Description	Quantity	Unit	Unit Price	Total Amount
34	Furnish and Install 24"x22" Eccentric HDPE Reducer	EA	1	$3,400.00	$3,400
35	Furnish and Install 22"x18" Eccentric HDPE Reducer	EA	1	$3,000.00	$3,000
36	Furnish and Install 18"x16" Eccentric HDPE Reducer	EA	1	$2,600.00	$2,600
	Mainline Air Valve Assemblies				
37	Furnish and Install Air Valve Assembly Type 8 (8" Branch - (3) 4" Valves)	EA	8	$15,000.00	$120,000
38	Furnish and Install Air Valve Assembly Type 6 (6" Branch - (2) 4" Valves)	EA	10	$11,000.00	$110,000
39	Furnish and Install Air Valve Assembly Type 4 (4" Branch - (1) 4" Valve)	EA	16	$7,000.00	$112,000
40	Furnish and Install Air Valve Assembly Type 3 (3" Branch - (1) 3" Valve)	EA	13	$6,000.00	$78,000
41	Furnish and Install Air Valve Assembly Type 2 (2" Branch - (1) 2" Valve)	EA	5	$4,000.00	$20,000
	Turnout Assemblies				
42	Turnout Assembly	EA	40	$30,000.00	$1,200,000
	Imported Materials				
43	Imported Trench Foundation Material Type A5	TON	800	$22.00	$17,600
44	Imported Pipe Bedding Material Type A3	TON	12000	$26.00	$312,000
45	Imported Trench Backfill Material Type A1	TON	8000	$26.00	$208,000
	Miscellaneous				
46	Thornburg Diversion Structure	LS	1	$360,000.00	$360,000
47	Temporary Inlet Screening Structure	LS	1	$50,000.00	$50,000
48	Temporary Outlet Structure	LS	1	$20,000.00	$20,000

Item	Description	Quantity	Unit	Unit Price	Total Amount
49	Junction Box (At service canal intake)	LS	1	$15,000.00	$15,000
50	Dewatering	LS	1	$100,000.00	$100,000
51	Remove existing structures	LS	1	$20,000.00	$20,000
52	Furnish and Install Above Ground Utility Markers	EA	110	$150.00	$16,500
53	Reseeding (Approximately 40 acres)	LS	1	$40,000.00	$40,000
	Cultural Mitigation				
54	Main Street Inlet Structure	LS	1	$25,000.00	$25,000
55	18" HDPE DR 32.5 PIPE	LF	2275	$51.00	$116,025
56	24" HDPE DR 32.5 PIPE	LF	385	$65.00	$25,025
57	McNaughten Gulch Tie-In to Take Out 13	LS	1	$10,000.00	$10,000
58	Connect to Turnout 13	LS	1	$10,000.00	$10,000
59	Imported Foundation Material	TON	200	$35.00	$7,000
60	Imported Bedding Material	TON	2,000	$35.00	$70,000
61	Imported Backfill Material	TON	500	$30.00	$15,000
62	Cement Treated Fill	CY	60	$500.00	$30,000
63	Water For Kids Canal	LS	1	$130,000.00	$130,000
64	Kids Canal Turnout	EA	1	$25,000.00	$25,000
65	3-Sided Kiosk	EA	1	$15,000.00	$15,000
66	Public Outreach Materials	LS	1	$10,000.00	$10,000
	Cultural Mitigation Subtotal				$488,050
	Construction Subtotal				$10,489,350
	Construction Contingency	15%			$1,573,403
	Construction Total				**$12,062,753**
	Design				$674,033
	Construction Engineering (8%)	8%			$839,148
	Project Administration (NRCS)	4%			$419,574
	Project Administration (Sponsor)	1	Lump Sum		$4,000
	Permits	1	Lump Sum		$15,000

Item	Description	Quantity	Unit	Unit Price	Total Amount
	Total Agricultural Water Management				**$14,014,508**

Table 9: Flood Control and Detention Facilities

Item	Description	Quantity	Unit	Unit Price	Total Amount
1	Mobilization (5%)	1	LS	$87,600.00	$87,600
2	Subsurface Investigation	12	HR	$500.00	$6,000
3	Materials Sampling & Testing	1	LS	$20,000.00	$20,000
4	Dust Control & Watering	1	LS	$30,000.00	$30,000
5	30" DR 21 HDPE	1550	LF	$165.00	$255,750
6	New Outlet Headworks	1	LS	$20,000.00	$20,000
7	Connection to Existing Flood Channel	1	LS	$8,000.00	$8,000
8	Pond Excavation	480000	CY	$5.00	$2,400,000
9	Drainage berm Construction from excavated soil	4000	CY	$7.00	$28,000
10	Spillway Apron	1	LS	$35,000.00	$35,000
11	Road Crossing	1	LS	$12,500.00	$12,500
	Naples 2500 S Flood Control Pipe				
12	Mobilization	1	LS	$50,000.00	$50,000
13	Traffic Control	1	LS	$25,000.00	$25,000
14	Furnish and Install 36 inch ADS	3200	LF	$80.00	$256,000
15	Furnish and Install 72” manhole	8	EA	$4,500.00	$36,000
16	Furnish and Install Inlet Box	4	EA	$3,000.00	$12,000
17	Connect to existing box culvert	1	EA	$8,000.00	$8,000
18	Remove existing culvert	14	EA	$1,000.00	$14,000
19	Asphalt Driveway Crossing	3	EA	$1,000.00	$3,000
20	Gravel Driveway Crossing	11	EA	$500.00	$5,500
21	Asphalt Repair	500	SF	$3.00	$1,500
22	Imported Unclassified Fill	10000	TON	$12.00	$120,000
23	Import Bedding and Backfill Material	2500	TON	$15.00	$37,500
24	Import pipe foundation material	600	TON	$20.00	$12,000
25	Import Top Soil Material	100	TON	$25.00	$2,500
26	Misc. Surface Restoration	1	LS	$50,000.00	$50,000

Item	Description	Quantity	Unit	Unit Price	Total Amount
	Construction Subtotal				$3,535,850
	Construction Contingency	15%			$530,378
	Construction Total				**$4,066,228**
	Design				$104,607
	Construction Engineering (8%)	8%			$282,868
	Project Administration (NRCS)	4%			$141,434
	Project Administration (Sponsor)	1	Lump Sum		$4,000
	Permits	1	Lump Sum		$15,000
	Land Acquisition	1	EA	$254,000.00	$254,000
	Total Flood Control and Detention				**$4,868,137**

Table 10: Recreational Facilities

Item	Description	Quantity	Unit	Unit Price	Total Amount
1	Mobilization	1	LS	$26,000.00	$26,000
2	Preconstruction Video	1	LS	$200.00	$200
3	4" Bituminous Surfacing On 8" UBC - 10' Wide	1,990	LF	$95.00	$189,100
4	Clearing & Grubbing, Earthwork & Grading	1,990	LF	$10.00	$19,900
5	6" Concrete Sidewalk/Trail On 3" UBC - 4' Wide	730	LF	$120.00	$87,600
6	35' x 10' Pedestrian Bridge	2	EA	$70,000.00	$140,000
7	Picnic Tables	3	EA	$1,500.00	$4,500
8	Benches	4	EA	$1,000.00	$4,000
9	Garbage Cans	3	EA	$450.00	$1,400
10	Bollards	4	EA	$500.00	$2,000
11	ADA Ramps	4	EA	$10,000.00	$40,000
12	Shade Structures	2	EA	$15,000.00	$30,000
13	Construction Staking	1	LS	$6,5000.00	$6,500
	Construction Subtotal				$551,200
	Construction Contingency	15%			$82,680
	Construction Total				**$633,880**
	Design				$0
	Construction Engineering (8%)	8%			$44,096

Item	Description	Quantity	Unit	Unit Price	Total Amount
	Project Administration (NRCS)	4%			$22,048
	Project Administration (Sponsor)	1	Lump Sum		$4,000
	Permits	1	Lump Sum		$15,000
	Total Recreation Facilities				**$719,024**

D.6 Economic Evaluation

The NWPM (NRCS 2015a) was used as a reference for the economic analysis along with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (U.S. Water Resources Council, 1983). P&G was developed to define a consistent set of project formulation and evaluation instructions for federal agencies that carry out water and related land resource implementation studies. The basic objective of P&G is to determine whether benefits from proposed actions exceed project costs for federally funded projects. P&G also requires that the "National Economic Development" or NED Alternative, which maximizes monetary net benefits, be selected for implementation unless there is an overriding reason for selecting another alternative based on federal, state, local, or international concerns related to the social and environmental accounts.

D.6.1 Economic Benefits

D.6.1.1 Flood Damage Reduction

Damage reduction economic benefits were calculated for reducing flooding in Vernal, Utah. Benefits were assessed based on the equivalent annual damage reduction expected through implementation of the With Project Alternative (Preferred Alternative) as compared with the Without Project Alternative (No Action Alternative) baseline. Assumptions and calculations of flood and watershed protection damage reduction benefits are discussed below.

The Without Project Alternative does not include flood protection measures. The With Project Alternative includes two large detention basins that will reduce flood levels.

The term of the agreement for the Preferred Alternative is 103 years, accounting for a 100-year project life, and a 3-year installation period. All costs and benefits were discounted to a net present value, then annualized over the 100-year evaluation period using the FY2020 Federal Water Resources Discount Rate of 2.75%.

Average annual flood damages were calculated using the cumulative probability method as specified in the URB1 manual (SCS 1990). The 5-, 10-, 25-, 50-, 100-, 200- and 500-year storm events for each alternative were modeled. Mapping of the flood extents, and inundation to structures, transportation infrastructure, and lands was calculated through GIS analysis.

Inundated buildings were classified into one of three categories: inundated less than 1 foot, inundated 1 to 3 feet, or inundated 3 feet or more, for each storm event. Depth-damage functions were collected from the U.S. Army Corps of Engineers to use for each type of building. These types of structures included mobile homes, permanent homes, commercial buildings, and “other” (which includes schools and churches). Most of the structures damaged were homes.

A large majority of the homes in the damage area are one-story no basement, so this damage function was used as a proxy for all homes inundated. For the mobile homes, commercial buildings and “other” category, separate applicable damage functions were used.

Median values for the buildings flooded were calculated from data collected from Uintah County property tax records. Due to the high number of buildings affected, a sample of each type of building that was flooded was used. A replacement value was estimated for each structure based on this data to apply to the depth-damage functions. Contents values were estimated at 50 percent for mobile homes, permanent homes and “other”, and 100 percent for businesses.

Table 11 provides existing flood damage under present conditions (Without Project Alternative). **Table 12** provides flood damage under the Preferred Alternative (With Project Alternative).

Table 11: Existing Flood Damage

Storm	Mobile Homes	Homes			Commercial		Other		Present Value of Damage	Average Annual Damage
	<1 ft	<1 ft	1-3 ft	>3 ft	<1 ft	1-3 ft	<1 ft	1-3 ft		
2-YR	-	3	-	-	-	-	-	-	$65,678	$605,986
5-YR	-	91	8	2	7	1	-	-	$3,974,231	$697,859
10-YR	-	188	13	2	29	1	-	-	$9,982,951	$786,011
25-YR	1	298	22	4	45	3	-	-	$16,217,410	$396,603
50-YR	1	390	27	6	69	6	-	-	$23,442,915	$296,993
100-YR	1	488	34	8	117	12	-	2	$35,955,688	$287,646
500-YR	1	535	40	8	136	13	-	4	$40,941,616	$81,883
									Total	$3,152,981

Prepared November 2021.

Table 12: Preferred Alternative Flood Damage

Storm	Mobile Homes	Homes			Commercial		Other		Present Value of Damage	Average Annual Damage
	<1 ft	<1 ft	1-3 ft	>3 ft	<1 ft	1-3 ft	<1 ft	1-3 ft		
2-YR	-	-	-	-	-	-	-	-	$ 21,893	-
5-YR	-	1	-	-	-	-	-	-	$ 109,464	$ 6,568
10-YR	-	5	-	-	-	-	-	-	$ 1,157,676	$ 38,014
25-YR	-	43	1	1	1	1	-	-	$ 10,508,076	$ 116,658
50-YR	-	197	13	2	2	30	2	-	$ 13,952,198	$ 122,301
100-YR	1	256	20	3	3	39	3	-	$ 32,457,313	$ 111,618
500-YR	1	471	34	8	8	106	10	-	$ 40,941,616	$ 64,915
									Total	$ 460,073

Prepared November 2021.

Table 13 provides floodwater damage reduction benefits calculated for the With Project and Without Project Alternatives, and the resulting damage reduction with implementation of the project.

Table 13: Floodwater Damage Reduction Benefits (Dollars) /1

Item	Estimated Average Annual Damage		
	Without Project (No Action Alternative)	With Project (Preferred Alternative)	Damage Reduction
Residential	$1,454,300	$216,500	$1,237,800
Commercial	$1,448,700	$207,600	$1,241,100
Other	$3,500	-	$3,500
Total	**$2,906,500**	**$424,100**	**$2,482,400**

1/ Price base 2019. Calculated using FY 2020 Water Resources Discount Rate (2.75%), using 100-year evaluation period and 103-year period of analysis. Prepared November 2021.

The two detention basins in the Preferred Alternative provide a high level of flood control. For example, it is estimated that 662 structures are inundated by the 100-year event under existing conditions, while 322 structures are inundated with the Preferred Alternative implemented.

Many of the buildings flooded without the project are commercial properties of relatively high value. The flooding runs through Main Street, which is primarily a commercial area, including hotels, a grocery store, a car dealership, and a museum. The “other” category of buildings flooded have a relatively high value as well, as they include schools and churches.

These two factors, along with the relatively low installation and O&M costs, account for a high benefit to cost ratio of 4.7 to 1 (**Table 16**).

D.6.1.2 Water Efficiency/Water Quality

Project measures are projected to save 4,812.7 ac-ft per year. There will be water quality benefits to several water bodies (Ashley Creek, Green River, Colorado River) by installation of these measures as well. There will be water quality benefits to several water bodies (Ashley Creek, Green River, Colorado River) by installation of these measures as well. Farmers will have the opportunity to move from flood irrigation to sprinkler irrigation systems. Tailwater from flood irrigation practices can impact water quality with the nutrients and silt loads that they carry.

In order to estimate the economic benefits of these measures, a crop budget analysis was performed using alfalfa hay budgets developed by Utah State University Extension for Uintah County (Godfrey et al., 2006). Prices paid for inputs in the budget were updated to 2020 dollars using the Producer Prices Paid Index (ERS/NASS, 2011). The normalized price for hay from ERS was used (2020). It was estimated that yields would increase due to a more consistent flow of water as well as the opportunity to irrigate more acreage. The estimated yield increase was 1.5 tons of hay per acre, for an increase in profitability of $205 per acre. This was applied to the estimated irrigated acreage in the project area (3,169). This resulted in an annual benefit of almost $650,000.

Table 14: Summary of Irrigation Benefit Calculations

Benefit Metric	Benefit Amount
Irrigated Farms, Utah /1	13,159
Acres Irrigated, Utah /1	1,097,219
Average acres per irrigated farm	83
Number of turnouts in project measures	38
Estimated total acres irrigated in project area	3,169
Estimated per acre benefit to project (crop budget analysis)	$205
Estimated benefit per year	$649,686

/1 2017 Ag. Census. Prepared November 2021.

D.6.1.3 Recreation

There are anticipated economic benefits due to recreation use from measures to be installed or preserved with the project. These include retaining the Kids Canal and providing supplemental water to Kids Canal from the Uintah County Golf Course and improving the Kids Canal Parkway path with an asphalt surface, two pedestrian bridges, benches, garbage cans, ADA ramps, shade structures and picnic tables. Fifteen primary water shares (15 ac-ft) have already been purchased by ACIC and designated for use in the Kids Canal section.

Usage of the proposed measures was estimated from a survey of another PL-566 project in Utah installing similar measures in a residential area. The survey recorded walkers, joggers, and bikers over a two-day period. Adjustments were made to account for the fact that the original survey was for measures that would provide access to a popular bird-watching marsh, which this project does not. The original survey also addressed measures that would connect with an existing popular well-known trail system. This adjustment was estimated at five percent of the original survey.

Adjustments were also made to account for reduced usage in winter months (assuming 4 months of the year there would be little to no usage). A further adjustment was made to account for the likelihood that the new measures would pull usage from existing trails and pathways. This adjustment was estimated at fifty percent.

A value was put on the resulting estimated usage by the benefits transfer method from a study published in the Journal of Leisure Research (Bergstrom et al., 1991). This study estimated the consumer surplus from jogging/running and walking on trails. The values were updated to 2020 dollars using the Consumer Price Index (BLS, 2020). The jogging/running value was applied to biking, as they were thought to be more similar in nature.

Table 15 summarizes the results of the recreation benefit calculation.

Table 15: Summary of Recreation Value Estimation

Type of User	Estimated Usage per Year (Days)	Value (Consumer Surplus per Day, 2020 Dollars)	Estimated Value per Year
Walker	1,789	21	$ 36,895
Jogger/Runner	578	5	$ 3,132
Biker	4,948	5	$ 24,738
Total			$ 64,765

Prepared November 2021.

D.6.2 Benefit Cost Ratio

The total project net average annual economic benefit is $2,466,400 for the Preferred Alternative, and the benefit cost ratio is 4.7 to 1. **Table 16** provides the calculated annual benefits, costs, benefit cost ratios, and net annual benefits for each of the project measures.

Table 16: Benefit Cost Ratios[1]

Project Measure	Total Annual Benefits	Total Annual Costs	Benefit Cost Ratio	Net Annual Economic Benefit
Agricultural Water Management*	**$599,200**	**$501,700**	**1.2**	**$97,500**
Recreation*	**$59,700**	**$32,300**	**1.8**	**$27,400**
Flood Control	**$2,482,400**	**$140,900**	**17.6**	**$2,341,500**
Total	**$3,141,300**	**$674,900**	**4.7**	**$2,466,400**

1-Price base 2019. Calculated using FY 2020 Water Resources Discount Rate (2.75%), annualized over 100-year period of analysis. Prepared November 2021.

*The Agriculture Water Management and Recreational benefits indicated in Table 16, are the discounted values from Tables 14 and 15.

D.6.3 Sources

Bergstrom, J.C. and H.K. Cordell. 1991. An analysis of the demand for and value of outdoor recreation in the United States. Journal of Leisure Research 23(1):67-86.

Bureau of Labor Statistics (BLS). 2020. Consumer Price Index-All Urban Consumers. 1982-84 Index.

Economic Research Service (ERS). National Agricultural Statistics Service (NASS). Producer Prices
Paid Index. 2011 Index.

ERS. NASS. State-level normalized price-received estimates for commodities. ERS report year 2020.

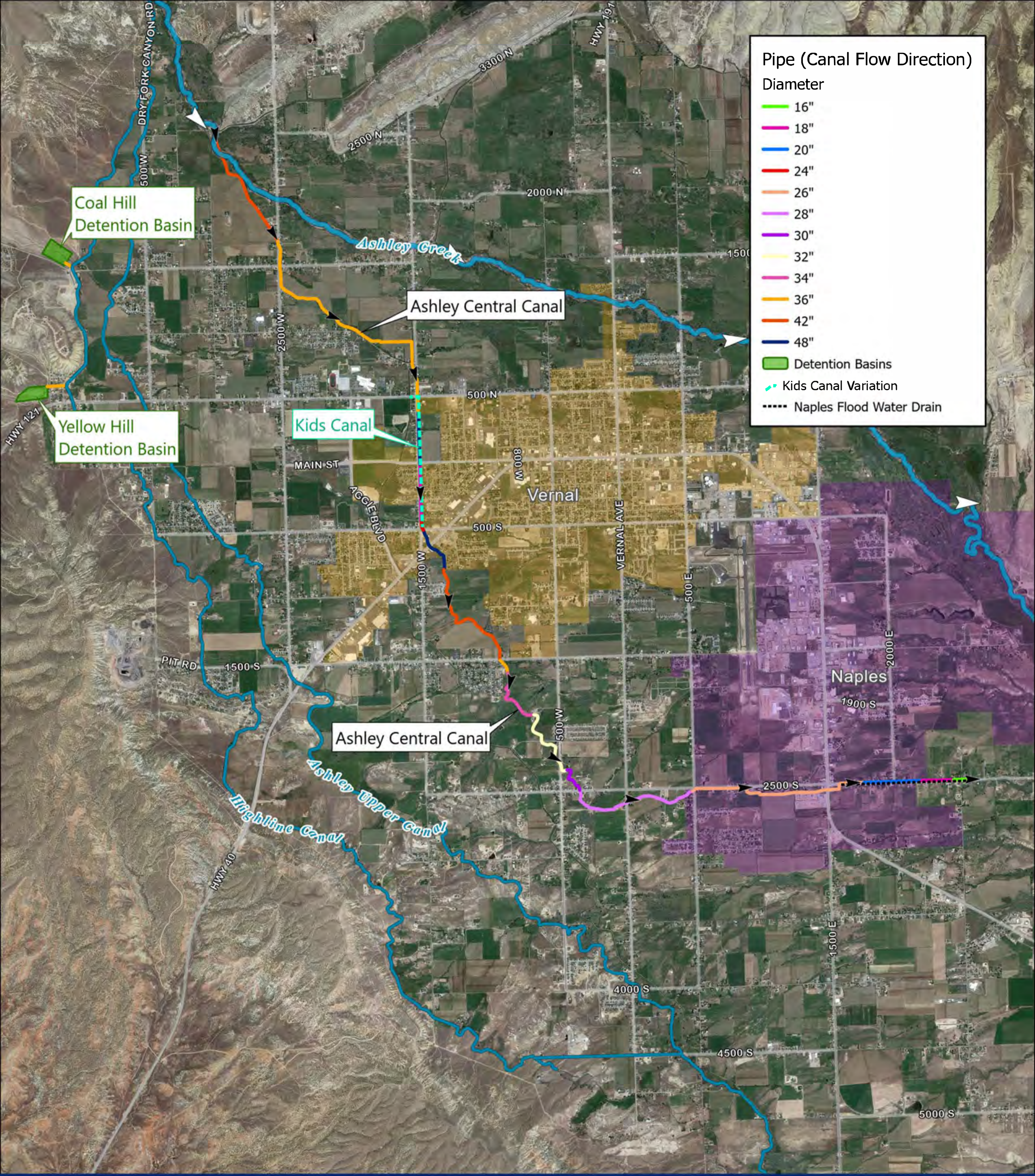
Soil Conservation Service (SCS). 1990. Urban Floodwater Damage Economic Evaluation: URB1. Documentation for Computer Program.

U.S. Army Corps of Engineers (USACE). 2004. USACE CommercialDepthDamageFactors.xls. www.nrcs.usda.gov/wps/portal/nrcs/detail/national/nwmc/partners/?&cid=nrcs143_009725

U.S. Census Bureau. 2019. Quickfacts, Vernal, Utah.

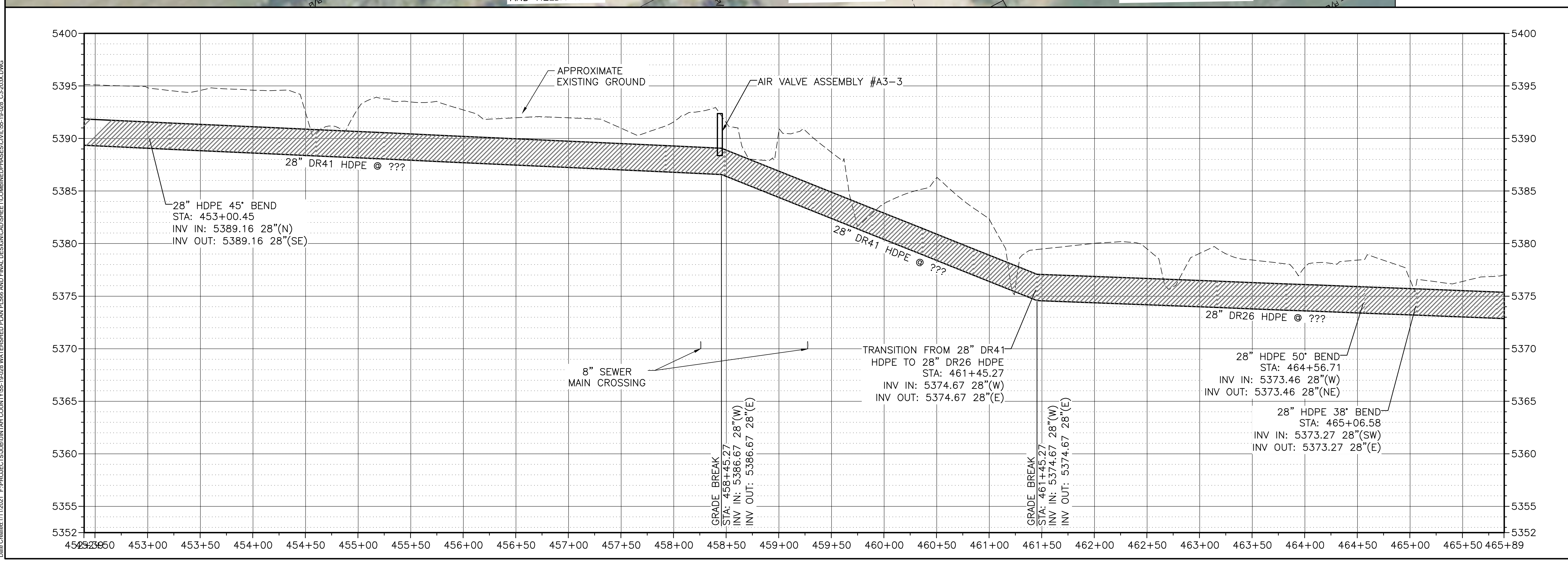
ATTACHMENT 1

CONCEPT DESIGN DRAWINGS



ASHLEY VALLEY PREFERRED ALTERNATIVE

Ashley Valley Watershed Plan EA



J-U-B ENGINEERS, INC.
J-U-B ENGINEERS, INC.
466 North 900 West
Kaysville, Utah 84037
Phone: 801.547.0393
Fax: 801.547.0397
www.jub.com

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

NO.	DESCRIPTION	BY	APR.	DATE

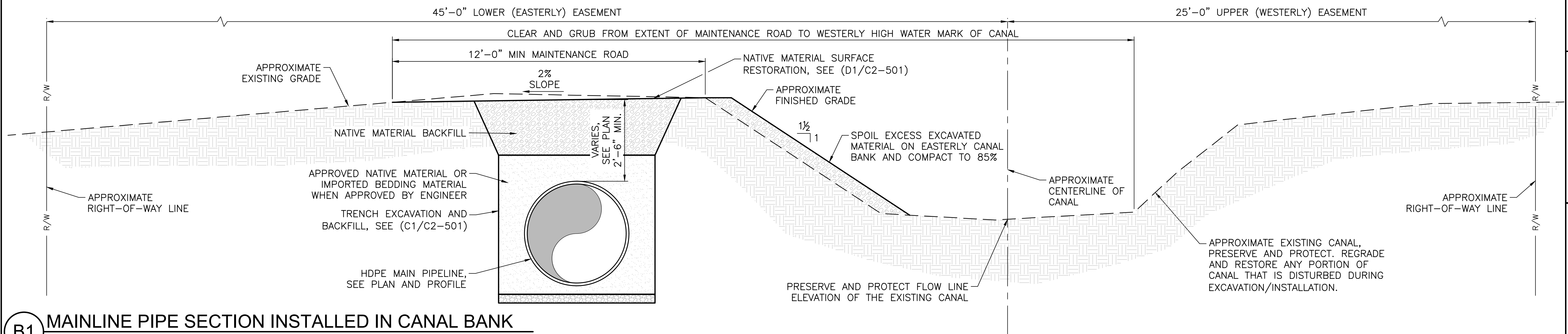
REVISION

ASHLEY CENTRAL CANAL PIPING PROJECT
ASHLEY CENTRAL IRRIGATION COMPANY

PHASE 3 PLAN AND PROFILE

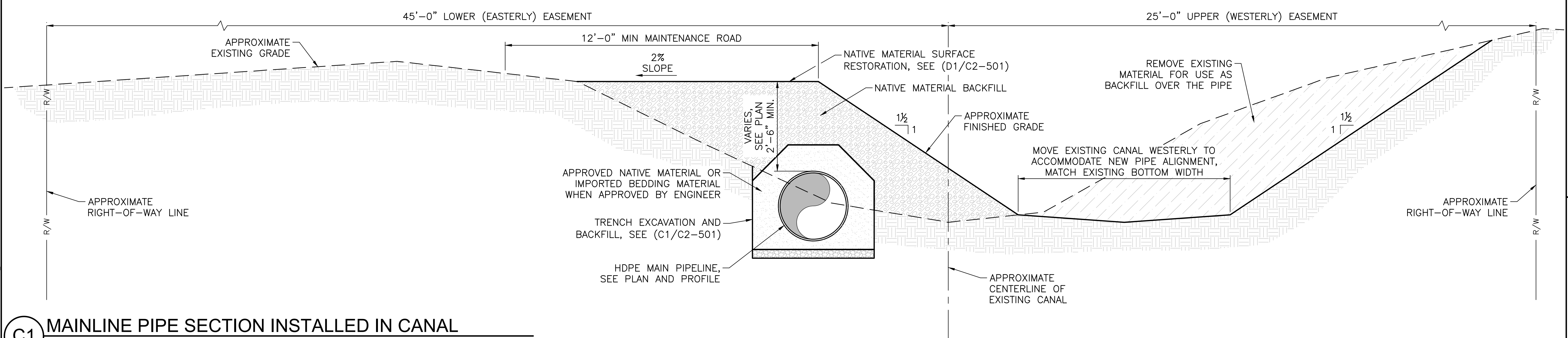
FILE: 55-19-028_C3-203X
JUB PROJ. #: 55-19-028
DRAWN BY: CR/MLJ
DESIGN BY: JRH
CHECKED BY: JSF/BRD
ONE INCH
AT FULL SIZE, IF NOT ONE INCH, SCALE ACCORDINGLY
LAST UPDATED: 1/12/2021

SHEET NUMBER:
C3-203



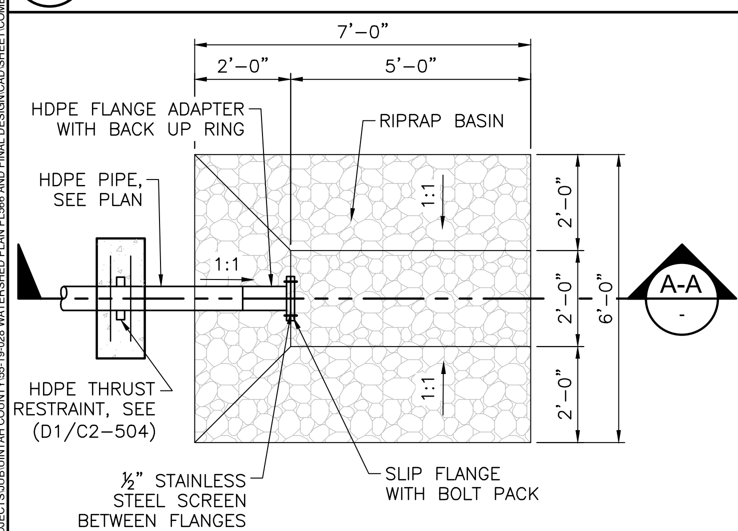
B1 MAINLINE PIPE SECTION INSTALLED IN CANAL BANK

SCALE:NOT TO SCALE

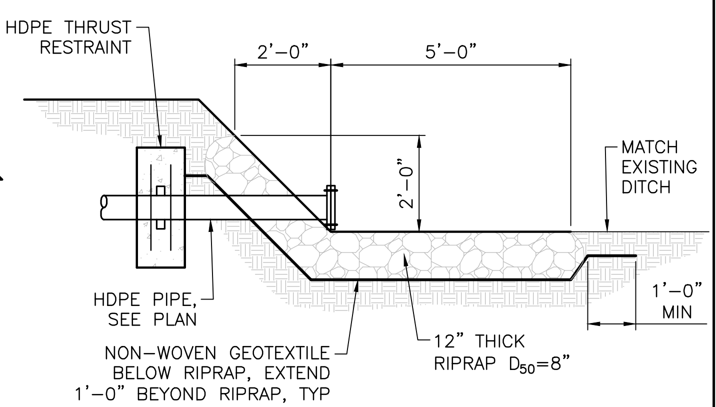


C1 MAINLINE PIPE SECTION INSTALLED IN CANAL

SCALE:NOT TO SCALE



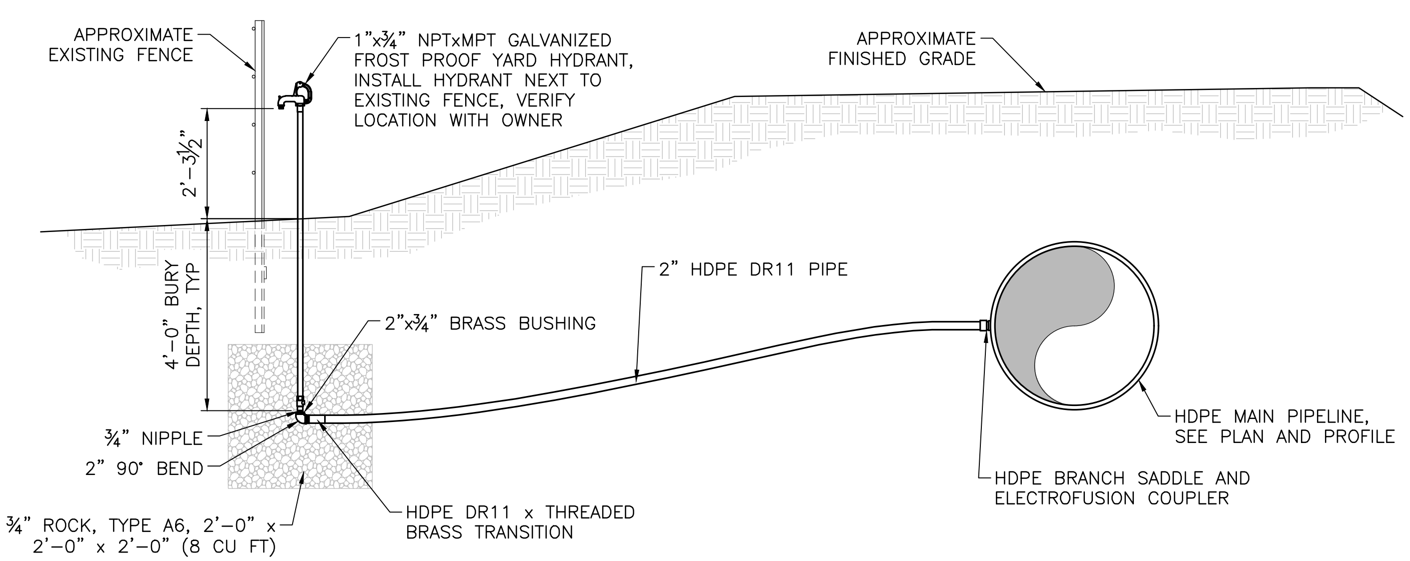
PLAN VIEW



SECTION A-A

D1 RIPRAP OUTLET

SCALE:NOT TO SCALE



D3 STOCKWATER TAP DETAIL

SCALE:NOT TO SCALE

J-U-B ENGINEERS, INC.
J-U-B ENGINEERS, INC.
466 North 900 West
Kaysville, Utah 84037
Phone: 801.547.0393
Fax: 801.547.0397
www.jub.com

PRELIMINARY PLANS

NOT FOR CONSTRUCTION

NO.	DESCRIPTION	BY	APR.	DATE

REVISION

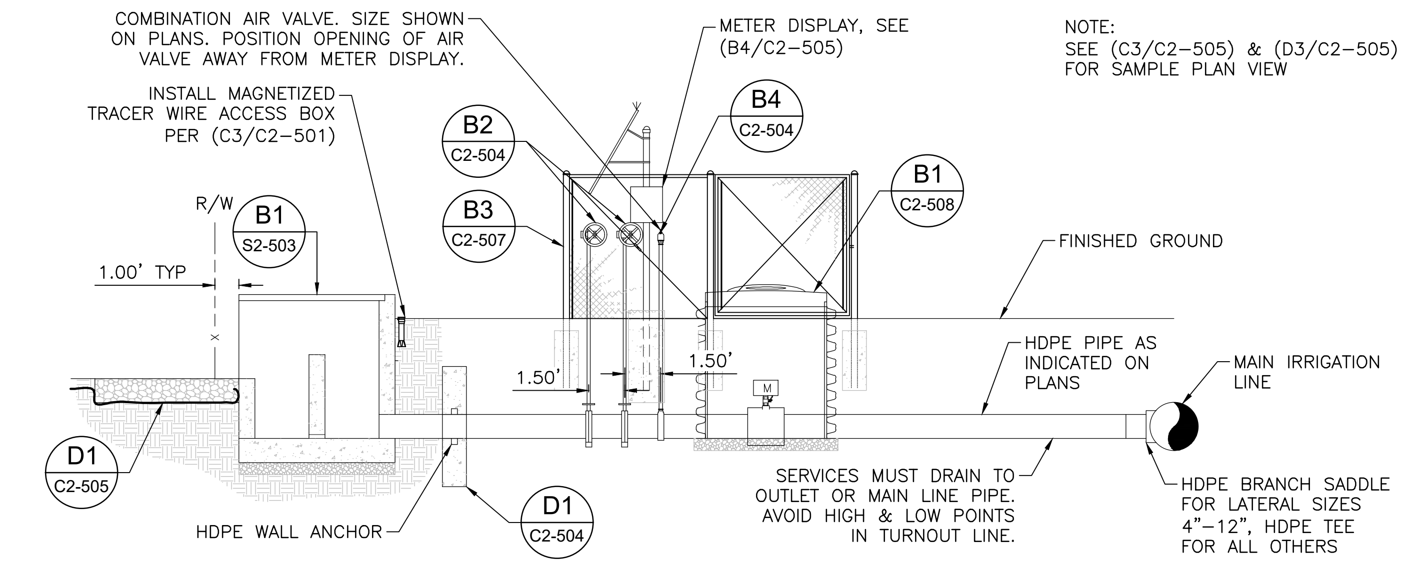
ASHLEY CENTRAL CANAL PIPING PROJECT
ASHLEY CENTRAL IRRIGATION COMPANY

TYPICAL TRENCH SECTION DETAILS

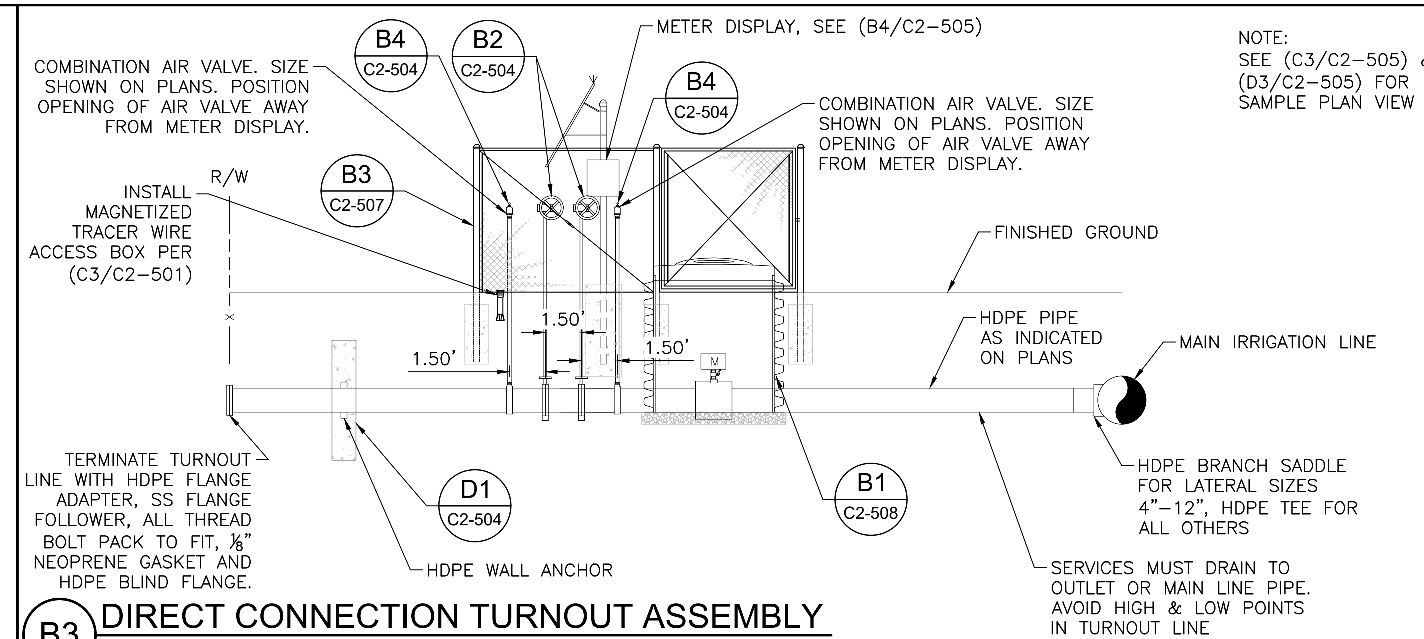
FILE: 55-19-028_C2-501X
JUB PROJ. #: 55-19-028
DRAWN BY: JRH
DESIGN BY: JRH
CHECKED BY: BKW

ONE INCH
AT FULL SIZE, IF NOT ONE INCH, SCALE ACCORDINGLY
LAST UPDATED: 1/12/2021

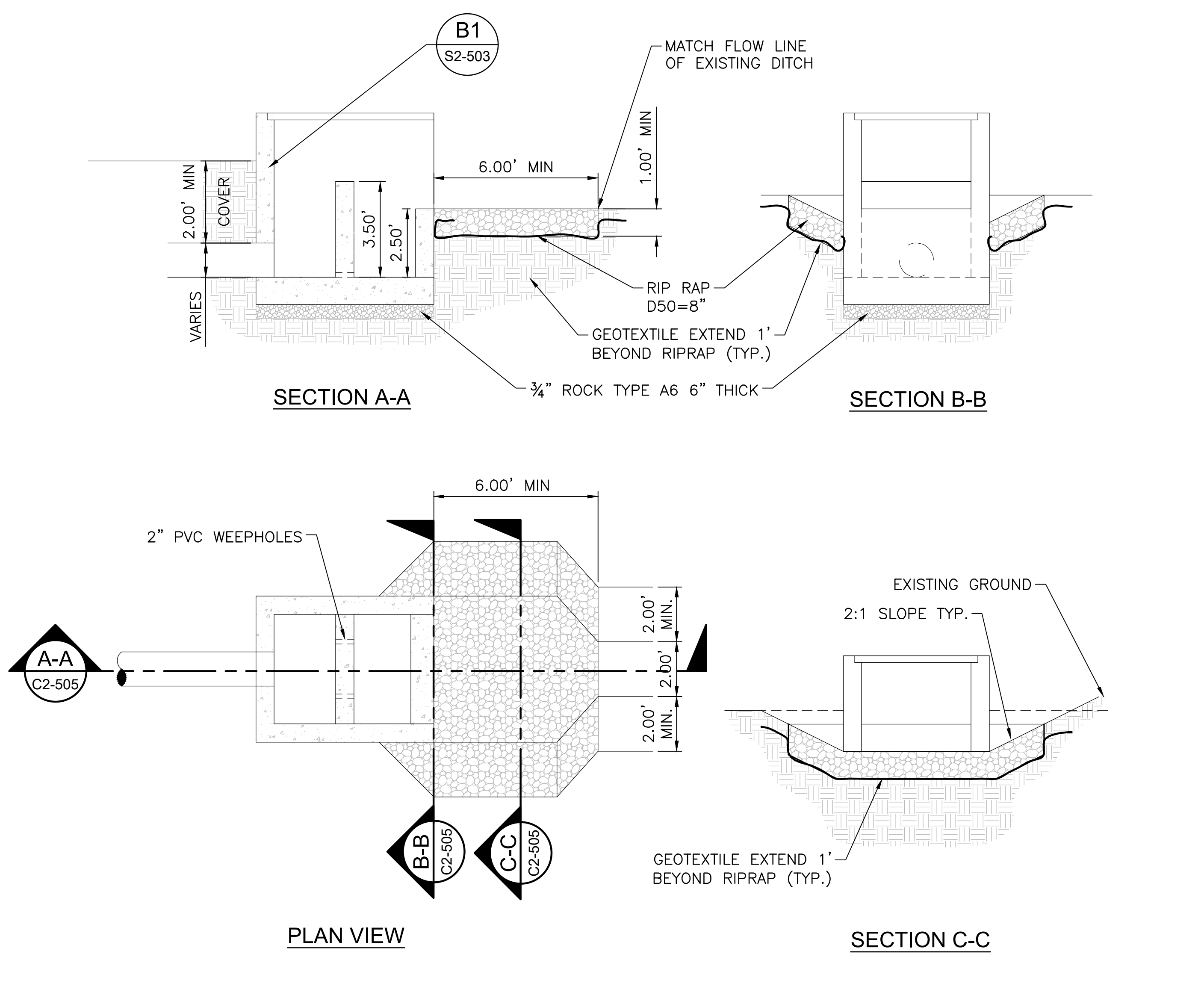
SHEET NUMBER:
C-502



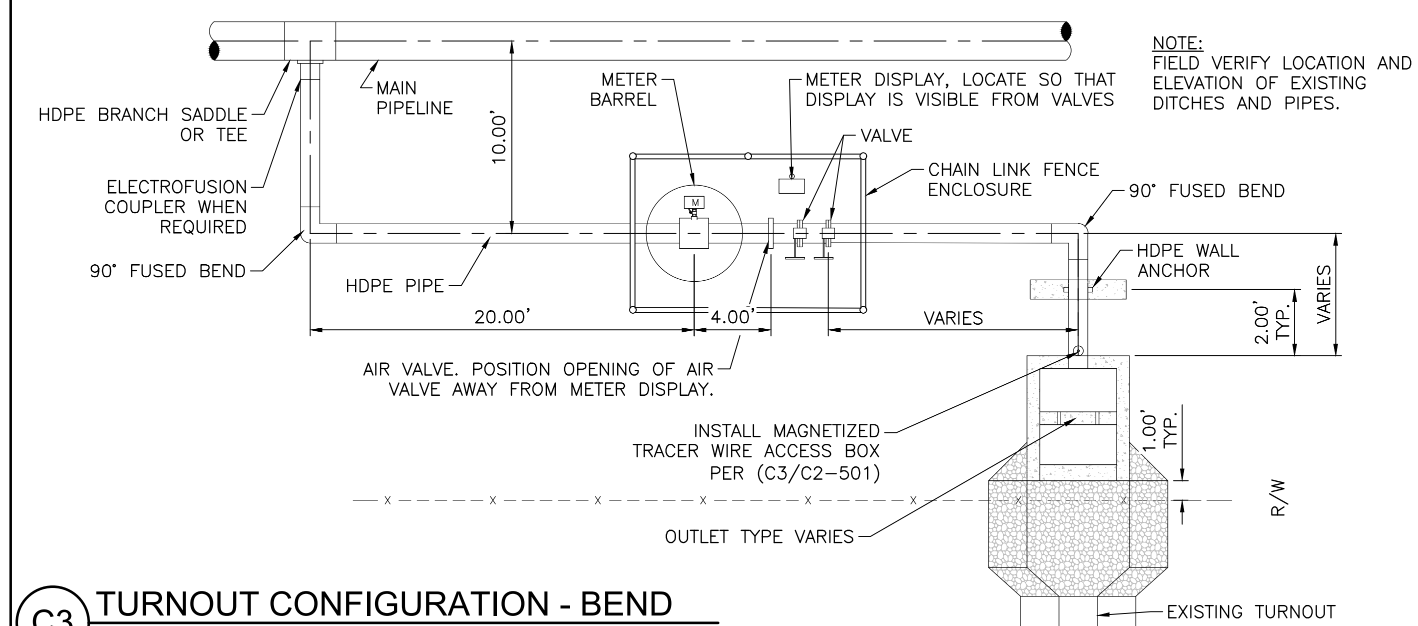
B1 BOX TURNOUT ASSEMBLY w/ RIP RAP
SCALE: 1" = 4'



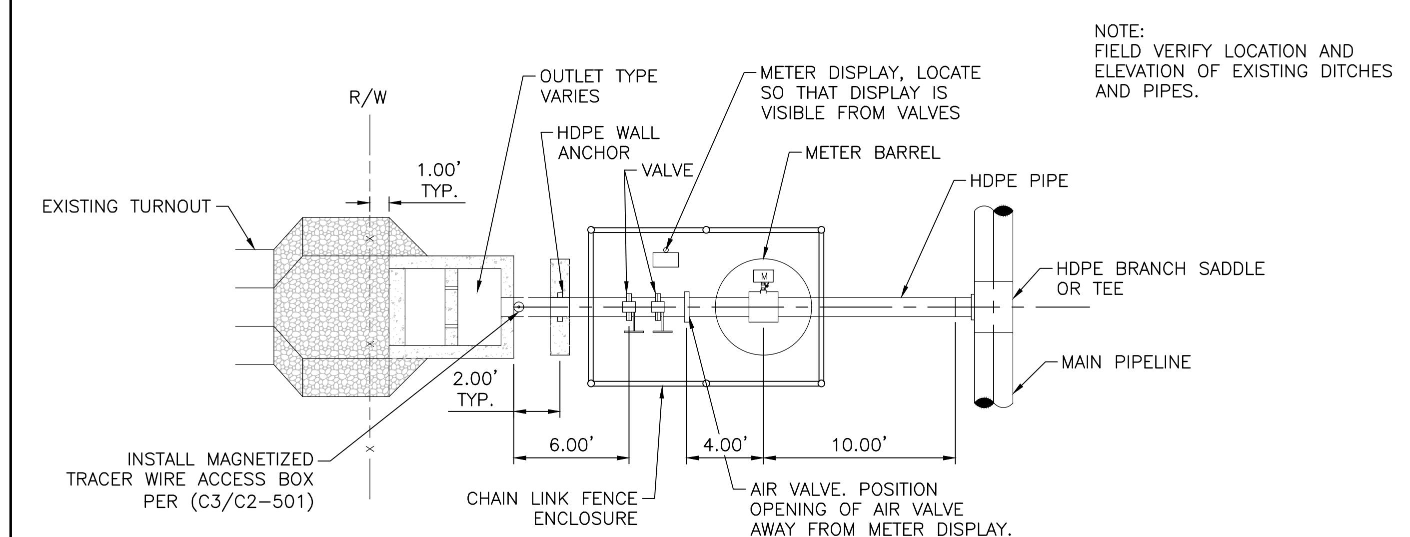
B3 DIRECT CONNECTION TURNOUT ASSEMBLY
SCALE: 1" = 4'



D1 OUTLET DISSIPATION BOX w/ ONE BAFFLE & RIP RAP
SCALE: 1" = 3'



C3 TURNOUT CONFIGURATION - BEND
SCALE: 1" = 5'



D3 TURNOUT CONFIGURATION - STRAIGHT
SCALE: 1" = 5'

J-U-B
J-U-B ENGINEERS, INC.
J-U-B ENGINEERS, INC.
466 North 900 West
Kaysville, Utah 84037
Phone: 801.547.0393
Fax: 801.547.0397
www.jub.com

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

NO.	DESCRIPTION	BY	APR.	DATE

REVISION

ASHLEY CENTRAL CANAL PIPING PROJECT
ASHLEY CENTRAL IRRIGATION COMPANY

DETAILS

FILE: 55-19-028_C2-501X
JUB PROJ. #: 55-19-028
DRAWN BY: JRH
DESIGN BY: JRH
CHECKED BY: BKW
ONE INCH
AT FULL SIZE, IF NOT ONE INCH, SCALE ACCORDINGLY
LAST UPDATED: 1/12/2021
SHEET NUMBER:
C-505

ATTACHMENT 2

PRELIMINARY SEDIMENT ANALYSIS REPORTS

Coal Mine Preliminary Sediment Analysis

Li Qi

Sunrise Engineering, Inc.

Phone: 8019712288
Email: lqi@sunrise-eng.com

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	1.700 inches

Particle Size Distribution:

Size (mm)	Map Unit 238
19.0500	100.000%
4.7500	38.000%
2.0000	33.000%
0.4250	28.000%
0.0750	23.000%
0.0030	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	

#1 *Null*

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	5,946.030	5,946.030	200.46	54.77	2,173.4	48,578	29.61	17.59

Particle Size Distribution(s) at Each Structure

Structure #1:

Size (mm)	In/Out
19.0500	100.000%
4.7500	100.000%
2.0000	89.892%
0.4250	76.272%
0.0750	62.652%
0.0030	0.000%

Structure Detail:

Structure #1 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	5,946.030	0.478	0.478	0.467	70.000	M	201.87	54.768
	Σ	**5,946.030**						**200.46**	**54.768**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.240	300.00	7.06	0.3500	1.0000	1	2,474.4	55,157	34.78	20.64
	Σ							**2,173.4**	**48,578**	**29.61**	**17.59**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	9. Small streams flowing bankfull	7.06	2,908.00	41,180.00	23.910	0.478
#1	**1**	**Time of Concentration:**					**0.478**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	9. Small streams flowing bankfull	7.06	2,908.00	41,180.00	23.910	0.478
#1	**1**	**Muskingum K:**					**0.478**

Yellow Hill Preliminary Sediment Analysis

Li Qi

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	1.700 inches

Particle Size Distribution:

Size (mm)	Map Unit 238
19.0500	100.000%
4.7500	38.000%
2.0000	33.000%
0.4250	28.000%
0.0750	23.000%
0.0030	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	

#1
Null

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	5,946.030	5,946.030	436.59	81.60	3,981.9	65,099	40.92	22.17

Particle Size Distribution(s) at Each Structure

Structure #1:

Size (mm)	In/Out
19.0500	100.000%
4.7500	92.126%
2.0000	80.004%
0.4250	67.882%
0.0750	55.760%
0.0030	0.000%

Structure Detail:

Structure #1 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	5,946.030	0.459	0.459	0.466	73.400	M	447.89	81.597
	Σ	**5,946.030**						**436.59**	**81.597**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.240	300.00	6.71	0.3500	1.0000	1	4,608.7	75,039	48.74	26.45
	Σ							**3,981.9**	**65,099**	**40.92**	**22.17**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	9. Small streams flowing bankfull	6.71	2,583.00	38,521.19	23.300	0.459
#1	**1**	**Time of Concentration:**					**0.459**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	9. Small streams flowing bankfull	6.71	2,583.00	38,521.00	23.300	0.459
#1	**1**	**Muskingum K:**					**0.459**