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Technical Memorandum No. 29-TRU-8150-FEA-2018-3

Truckee Canal Engineering and Economic Feasibility Design Study

Newlands Project
Mid-Pacific Region

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U.S. Department of the Interior
Bureau of Reclamation

July 2019

Mission Statements

The Department of the Interior conserves and manages the Nation’s natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation’s trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Tim P. Brown P.E.

Prepared: Tim P Brown, P.E
Civil Engineer, Civil Structures 86-68150

P.E.

Lead Checker: Ryan Kent
Civil Engineer, Civil Structures 86-68150

P.E.

Peer Review: Jason Wagner, P.E.
Civil Engineer, Civil Structures 86-68150

P.E.

Approval: Technical Approval, Wylie Duke, P.E.
Manager, Water Conveyance, 86-68140

10/7/2019 Date

REVISIONS					
Date	Description	Prepared	Checked	Technical Approval	Peer Review

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Abbreviations and Acronyms

1D	one-dimensional
ac	Acre
ac-ft	Acre-feet
Alt	Alternative
CAS	Corrective Action Study
CPT	Cone Penetration Test
DEC	Design, Estimating, and Construction
EES	Engineering and Economic Study
EIS	Environmental Impact Statement
EPMs	Environmental Performance Measures
FPST	Fallon Paiute-Shoshone Tribe
ft	feet
ft^3/s	cubic feet per second (also abbreviated cfs)
GEO	Geomembrane
HATT	Hydrologic Analysis Technical Team
HEC-RAS	The U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System
LBAO	Lahontan Basin Area Office
M&I	Municipal and industrial
Misc	Miscellaneous
NAVD88	North American Vertical Datum 1988
NV	Nevada
OM& R	Operation, maintenance, and replacement
OCAP	Operating Criteria and Procedures
PFM	Potential Failure Modes
PLPT	Pyramid Lake Paiute Tribe
PP8	Pour Point Eight
RA	Risk Analysis
RET	Risk Evaluation Team
SOD	Safety of Dams
SRA	Submit, review, and approve
Sta.	Station
TCID	Truckee-Carson Irrigation District
TSC	Technical Service Center, Denver, CO
TM	Technical Memorandum
W&W	Wetlands Wildlife
WTP	Willingness to Pay
XM	Extraordinary Maintenance
YR	Year

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EXECUTIVE SUMMARY

Project overview

The Bureau of Reclamation's Technical Service Center (TSC) prepared this Engineering and Economic Study (EES) to evaluate risk reduction measures along the Truckee Canal (Canal) located in western Nevada (Lyon and Churchill Counties) and develop feasibility level design risk reduction alternatives and associated construction cost estimates. The Canal originates at the Derby Diversion Dam on the Truckee River, approximately 20 miles east of Reno, Nevada, and ends at Lahontan Reservoir.

The TSC was requested to evaluate risk reduction recommendations and develop feasible alternatives with sufficient detail for comparison. Tasks to be completed as part of this study include:

1. Evaluate risk reduction recommendations and develop feasible risk reduction alternative plans for comparison.

2. Coordinate the proposed feasible risk reduction alternative plans with an environmental impact statement (EIS) being prepared concurrently by Lahontan Basin Area Office.

3. Complete an economic and financial feasibility analysis for the risk reduction alternative plans using a phased construction approach that would be implemented over time.

4. Recommend an alternative risk reduction plan that maximizes public benefits with appropriate consideration of costs.

Risk reduction alternatives

This study developed a two-phased implementation plan to reduce the risks and improve the Canal to safely convey an operating flow of 600 ft^3/s. Phase I addresses static and seismic risks. Phase 2 addresses hydrologic risks. Five alternatives were developed to reduce all identified risks. Proposed risk mitigation includes embankment modifications, structure modification or replacement, and detention ponds with active waterway structures. The table below presents a summary of the five alternatives studied.

Table ES-1.—Phase 1 and phase 2 canal improvement alternatives

Alternative Number	Phase 1 Embankment	Phase 1 Structures	Phase 2 Hydrologic Actions
1	Line the Canal—full prism—geomembrane/concrete (0.3 miles) within Derby reach AND geomembrane/soil (5.5 miles) and geomembrane/half concrete (0.2 miles) within Fernley and Lahontan reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (2,900 feet [ft]) at 3 inflow points and geomembrane/soil (2,900 ft) AND construct TC 11 detention pond (322 AF), Mason detention pond (180 AF), and Downstream detention pond (17 AF)
2	Line the Canal—full prism—geomembrane/concrete (0.3 miles) within Derby reach AND geomembrane/soil (5.5 miles) and geomembrane/half concrete (0.2 miles) within Fernley and Lahontan reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (2,900 ft) at 3 inflow points and geomembrane/soil (2,900 ft) AND construct TC 11 detention pond (133 AF), Mason detention pond (101 AF) AND Line the Canal—full prism—geomembrane/soil (4.1 miles) within the Fernley and Lahontan Reaches.
3	Line the Canal—full prism—geomembrane/concrete (0.3 miles) within Derby reach AND geomembrane/soil (5.5 miles) and geomembrane/half concrete (0.2 miles) within Fernley and Lahontan reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (2,900 ft) at 3 inflow points and geomembrane/soil (2,900 ft) AND Line the Canal—full prism—geomembrane/soil (6.7 miles) within the Fernley and Lahontan Reaches.

Table ES-1.—Phase 1 and phase 2 canal improvement alternatives

Alternative Number	Phase 1 Embankment	Phase 1 Structures	Phase 2 Hydrologic Actions
4	Line the Canal—full prism—geomembrane/concrete (6.0 miles) within the Derby, Fernley, and Lahontan Reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (5800 ft) at 3 inflow points AND Line the Canal—full prism—geomembrane/concrete (6.7 miles) within the Fernley and Lahontan Reaches.
5	Line the Canal—full prism—geomembrane/concrete (6.0 miles) within the Derby, Fernley, and Lahontan Reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Line the Canal—full prism—geomembrane/concrete (12.1 miles) within the Fernley and Lahontan Reaches.

Phase 1 Canal improvements include lining and replacement or modifications to existing checks and Hazen gage structures. Phase 2 Canal improvements were developed with the assumption that all Phase 1 improvements would be implemented.

Four of the five alternatives listed above were carried forward for consideration. Alternative 5 was not carried forward in the selection of alternatives primarily based on its high cost, but also because it is very similar to Alternative 4. Engineering drawings were not produced for this alternative; however, for general information purposes, costs for concrete lining the Canal were combined with costs developed for Phase I work and summarized with contingencies costs. The cost estimate worksheets have been included in Appendix C.

Costs

Cost estimates were prepared for this project in accordance with applicable Reclamation Manual – Policy, Directive and Standards. Non-contract costs were developed by the Lahontan Basin Area Office in coordination with the TSC. The cost estimates include escalation during construction. The project indexes are uniformly escalated to midpoint of construction, based on the construction schedules developed.

The following table provides a breakdown of the Contract, Field, and Construction Costs by alternative.

Table ES-2.—Contract, field, and construction costs by alternative

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Subtotal Costs (Phase 1 and Phase 2 Alternative Features)	$53,128,840	$64,881,317	$68,244,085	$69,731,935
Mobilization @ ±10%	$5,300,000	$6,400,000	$6,800,000	$ 6,900,000
Contract Cost Allowances ±15%	$9,571,160.40	$10,718,683.40	$11,955,915.40	$ 12,368,065
Contract cost (rounded)	**$68,000,000**	**$82,000,000**	**$87,000,000**	**$89,000,000**
Construction contingencies @ ±25%	$16,000,000	$21,000,000	$21,000,000	$ 21,000,000
Field cost	$84,000,000	$103,000,000	$108,000,000	$ 110,000,000
Escalation @ ±3%/yr. for 6.5 yrs	$18,000,000	$22,000,000	$23,000,000	$23,000,000
Non-contract costs	$16,220,000	$17,900,000	$15,780,000	$15,390,000
Construction cost	**$118,220,000**	**$142,900,000**	**$146,780,000**	**$148,390,000**

Operations maintenance and replacement annual costs

Annual OM&R costs for a 50-year life were developed for the ponds, structures, and lining systems for each alternative. These costs do not include costs for maintaining existing infrastructure. It is assumed that Truckee-Carson Irrigation District (TCID) already has an OM&R program in place for its facilities and therefore costs to initiate such a program are not needed. The total estimated OM&R costs by alternative are presented in the table below:

Table ES-3.—Project OM&R costs by category and alternative (discounted present values)

Feature	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Gated Wasteway Structures and Equipment	$1,972,000	$1,311,000	$0	$0
Canal Linings	$33,153,980	$50,522,497	$65,000,000	$38,000,000
Detention Ponds	$846,019	$477,502	$0	$0
Total	**$35,972,000**	**$52,311,000**	**$65,000,000**	**$38,000,000**

Economic considerations

An economic analysis was prepared to provide a consistent basis for comparing the proposed risk reduction alternatives described in this report. The economic analysis compared the benefits and costs of each of the risk reduction alternatives relative to the baseline conditions to determine the least cost (cost effective) risk reduction alternative. The table below summarizes the results of the cost effectiveness analysis. Alternative 1 was found to be the least cost alternative after comparing the present value of the total project costs and the present value of the total project benefits for each alternative.

Table ES-4.—Summary of result by alternative

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Costs				
Construction (PV)	$80,283,030	$97,353,008	$100,342,572	$102,889,794
OM&R (PV)	$35,972,000	$52,311,000	$65,000,000	38,000,000
Costs Total	**$116,255,030**	**$149,664,008**	**$165,342,572**	**$140,889,794**
Benefits				
Irrigation Benefit value (PV)	$1,899,923	$3,841,709	$4,804,758	$4,804,758
M&I Benefit value (PV)	$3,409	($7,852)	$1,230	$1,230
Hydropower - Benefit Value (PV)	$106,222	$39,285	$84,735	$84,735
Recreation Benefit value (PV)	$1,010,849	$2,296,908	$2,759,189	$2,759,189
W&W Benefit value (PV)	$28,309	$56,905	$71,349	$71,349
Benefits Total	**$3,048,712**	**$6,226,955**	**$7,721,261**	**$7,721,261**
Total Costs Less Benefits	**$113,206,318**	**$143,437,053**	**$157,621,311**	**$133,168,533**

Construction considerations

A summary level construction schedule was developed for the proposed work by alternatives. The longest overall construction duration for the project features in Phase 1 and Phase 2 activities spans approximately 9 years and 10 months. The construction schedule was set using an assumed award date of June 1, 2021. The award date was determined by allowing 2 years for the funding and the final design process to be completed.

Activities in the construction schedule were assigned to a calendar. Most construction activities occur based on a normal five-day work week with no work on holidays. Submittals and fabrication activities are assumed to span a seven-day week, so the durations projected for these activities are calendar days, instead of the “work days”.

Costs for construction activities assumed that there would be four contracts awarded for this project. Each contract would be structured with the flexibility of awarding contract options that were based on the amount of work that could be completed during a canal outage. The four contracts and options are:

Contract 1: Check Structures - Award option for each structure

Contract 2: Canal Lining - Award option for specified canal length

Contract 3: Bango Check Modifications and Hazen Gage Replacement - Single award

Contract 4: Detention Ponds and Gate Structures - Award options for each site

Structuring the contracts in this manner allows for incremental construction funding and for the work to be completed within the assumed 10-year construction window.

Environmental considerations

Reclamation completed the Administrative Draft Truckee Canal XM EIS in December 2018 [16]. Impacts associated with key findings are summarized in table 9-1. Refer to the EIS for additional details on environmental considerations.

Table ES-5.—Summary of Environ Consequences mental

Resource	Key Findings
Water resources	While minor differences in water resource impacts exist among each alternative, based on compliance with applicable environmental protection measures, environmental laws, and regulations, the alternatives would not result in significant direct, indirect, or cumulative impacts on surface water or water quality for the City of Fernley. These lined areas would reduce artificial groundwater recharge. Dr. Greg Pohll's 2012 modeling indicated that Canal seepage in the Fernley area ranged from 14,000 to 22,000 acre-feet per year (AFY). Water Resource Environmental Performance Measures (EPMs) could be implemented to reduce impacts on shallow groundwater users.
Cultural and historic resources	Results from the cultural resources analysis indicate that replacement and modifications of features and historic characteristics of the Canal, a historic property, may result in an adverse effect on the Canal and would have an adverse impact on cultural resources. Section 106 consultation, the implementation of the programmatic agreement, and compliance with EPMs would lessen the impacts on cultural resources.
Indian trust assets	The implementation of any of the action alternatives would not adversely affect Indian trust assets (ITAs).
Vegetation	While minor differences in vegetation impacts exist among each alternative, compliance with applicable EPMs, environmental laws, and regulations; therefore, the alternatives would not result in significant direct, indirect, or cumulative impacts on vegetation.

Table ES-5.—Summary of Environ Consequences mental

Resource	Key Findings
Wildlife	While minor differences in wildlife impacts exist among each alternative, compliance with applicable EPMs, environmental laws, and regulations; therefore, the alternatives would not result in significant direct, indirect, or cumulative impacts on wildlife.
Aquatic resources	While minor differences in aquatic resources impacts exist among each alternative, based on compliance with EPMs, applicable environmental laws, and regulations, the alternatives would not result in significant direct, indirect, or cumulative impacts on aquatic resources.
Listed species	While minor differences in the potential for impacts on listed species exist among each alternative, based on compliance with EPMs, applicable environmental laws, and regulations, the alternatives would not result in significant direct, indirect, or cumulative impacts on listed species. There would be no impacts on western yellow-billed cuckoo proposed critical habitat under any alternative.
Air quality and climate change	Impacts on air quality would be localized and short term under all action alternatives. Because EPMs would reduce fugitive dust emissions generated by soil-disturbing activities during construction, the alternatives would not result in significant direct, indirect, or cumulative impacts on air quality.
Geology and soils	Impacts on geology and soils would be localized and short term under all action alternatives. Because EPMs would reduce impacts on geology and soils during construction, the alternatives would not result in significant direct, indirect, or cumulative impacts on geology.
Health and safety	Impacts on health and safety would be localized and short term under all action alternatives. Because EPMs would reduce impacts on health and safety, the alternatives would not result in significant direct, indirect, or cumulative impacts.
Socioeconomic resources	All action alternatives would temporarily increase construction employment and direct and indirect economic contributions; however, based on the Project Area construction workforce and economy, impacts would be minimal. All action alternatives include lining that would reduce the risk of flooding, thereby reducing the socioeconomic impacts on adjacent property owners and the local community. These lined areas would eliminate Canal seepage that may result in a reduction in artificial groundwater recharge, with potential indirect economic impacts on shallow groundwater users.
Environmental justice	No disproportionate adverse impacts are anticipated on low-income or minority populations under any alternative. Under all action alternatives, construction could result in short-term, location-specific impacts on area populations from increased dust; however, low-income or minority populations would not be disproportionately affected. Under all action alternatives, the proposed Canal lining and other measures would reduce the potential for flooding but may increase the impacts on shallow groundwater users in all populations.

Recommended alternative for final design

Each of the four alternatives evaluated met the safety requirements of the purpose and need in the EIS. Although Alternative 4 did not have the least cost when considering benefits and costs, it did provide the best overall value to the project when considering all other factors and was found to be the preferred alternative to continue into final design. Negative factors against Alternatives 1 and 2 which utilize detention ponds include the following;

- The detention ponds are remote and are not fenced. Because of their configurations, the site could be attractive to off road vehicles and could be subject to vandalism. Vandalism costs are not included in the OM&R costs.

- The bottom of the detention ponds are not lined and do not provide any water conservation.

- The large size of the ponds, especially those in Alternative 1, will take up a substantial amount of unusable space for the duration of the project.

- Any development down slope of the ponds could increase risk exposure to Reclamation and would require another corrective action to mitigate the risk.

- When the gated structures are operational and the ponds fill with water, Reclamation will be exposed to some risk until the water in the ponds subsides.

- As with the Canal embankment, the pond embankments are subject to vegetation growth and rodent damage.

- Gates are difficult to seal and leakage is likely during canal operations creating a potential wetland creation.

In addition to the negative factors listed above for detention ponds, the following are negative factors with the use of soil over geomembrane liners:

- Soil along the invert and prism slopes will continue to require vegetation and sediment removal activities. This activity is easier when the cover is concrete instead of soil.

- The selection of roughness values was somewhat subjective during the development of the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) models used to represent soil over geomembrane lining options. The models were highly sensitive to changes in these values depending on assumptions made regarding the quality of maintenance performed and final values ultimately relied on engineering judgement. This sensitivity implies the successful performance of the canal with soil over geomembrane lining is directly related to the quality of maintenance performed on the lining.

- Multiple lining systems (i.e., concrete/geomembrane and soil/geomembrane) complicates O&M.

Factors that make Alternative 4 favorable include the following:

- Alternative 4 provides the highest risk reduction compared to all other alternatives.
- Alternative 4 reduces identified risks without introducing new ones.
- Alternative 4 is the least cost alternative to maintain.
- The use of canal lining in Alternative 3 and 4 provide the highest water conservation and the most benefits compared to the other alternatives containing detention ponds.
- Alternative 4 is the most efficient and most reliable overall water delivery system when compared to the other alternatives.
- Alternative 4 could be constructed in phases over a 9 year construction window, prioritizing the reaches based on risk. Canal lining does not require specialized construction methods and could be completed by TCID.

1 INTRODUCTION

The United States Department of the Interior (DOI), Bureau of Reclamation (Reclamation) prepared this EES. Its purpose is to analyze the risk reduction recommendations of proposed extraordinary maintenance (XM) to address safety needs along the Truckee Canal (Canal) in western Nevada (Lyon and Churchill Counties). The Canal originates at the Derby Diversion Dam on the Truckee River, approximately 20 miles east of Reno, Nevada, and ends at Lahontan Reservoir. Figure 1-1 presents the Truckee Canal XM EES Project Area (Project Area).

The Canal is part of the Newlands Project. The Secretary of the Interior authorized it in 1903, and it was constructed between 1903 and 1905. It is among Reclamation's first projects (Hardesty 1906). Although the United States owns, and Reclamation administers, the Canal, in 1926 it transferred the care and operations and maintenance (O&M) of the Newlands Project to the Truckee-Carson Irrigation District (TCID; Contract No. I1r–93). The current 25-year contract between Reclamation and the TCID was signed in 1996 (Contract No. 7–07–20–X0348). Reclamation's Lahontan Basin Area Office (LBAO) oversees the contract for the TCID's operation and maintenance of the Canal.

1.1 Summary of problem

Ten breaches have occurred on the Canal since its construction (Paul and Slaven 2009). On January 5, 2008, the Canal north embankment breached as a result of efforts to capture storm flows occurring on the Truckee River. This resulted in an uncontrolled water release that caused flooding and damage to 590 properties in the city of Fernley, Nevada. The breach occurred approximately 12 miles downstream of the Derby Diversion Dam. The TCID repaired the breach in February 2008, and the Canal reopened in March 2008. TCID Letter to Reclamation requesting assistance The TCID Board of Directors requested support from Reclamation and formally agreed to enter into a repayment contract with Reclamation for planning and engineering studies for repair of the Canal [1].

1.2 Authorization

Public Law 111-11 provides Reclamation with the authority to fund work on a project such as the Newlands Project, where the O&M responsibilities have been transferred to a local entity, subject to a repayment contract. The TCID entered into a pre-construction repayment contract (Contract No. 14-WC-20-4597) with Reclamation for the purposes of funding and completing the EIS, EES, and final construction designs and contracting specifications.

1.3 Federal objective

The Federal Objective, as set forth in the Water Resources Development Act of 2007, specifies that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

(1) Seeking to maximize sustainable economic development;

(2) Seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and

(3) Protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

In consideration of the many competing demands for limited Federal resources, it is intended that Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic, and social goals, include monetary and non-monetary effects and allow for the consideration of both quantified and unquantified measures.

1.4 Purpose

In accordance with the 1996 O&M contract, Reclamation needs to evaluate TCID's request to improve the structural integrity to reduce the risk of a Canal breach for public safety. The purpose is to enable the TCID to complete necessary repairs to restore safe operation of the Canal, so Newlands Project water rights can be served under the existing Newlands Project Operating Criteria and Procedures (OCAP; 43 CFR, Part 418.20) and in compliance with decrees, contracts, and other applicable laws, as funding becomes available.

The purpose of this EES is to evaluate risk reduction recommendations and develop feasibility level design alternative risk reduction plans and associated construction cost estimates. The risk reduction recommendations would evaluate risks due to static (embankment failure), seismic (earthquake), and hydrologic (hydrologic inflows to the Canal) failure modes.

1.5 Scope

The EES was prepared by Reclamation's Technical Service Center (TSC). The TSC was requested to evaluate risk reduction recommendations and develop feasible alternatives with sufficient detail for comparison. Tasks to be completed as part of this study include:

1. Evaluate risk reduction recommendations and develop feasible risk reduction alternative plans for comparison.
2. Coordinate the proposed feasible risk reduction alternative plans with an environmental impact statement (EIS) being prepared concurrently by LBAO.
3. Complete an economic and financial feasibility analysis for the risk reduction alternative plans using a phased construction approach that would be implemented over time.
4. Recommend an alternative risk reduction plan that maximizes public benefits with appropriate consideration of costs.

2 BACKGROUND

2.1 Project description

The Truckee Canal was constructed between 1903 and 1905 as part of the Newlands Project and is among Reclamation's oldest facilities. Water is diverted into the Truckee Canal from the Truckee River at the Derby Diversion Dam, about 20 miles east of Reno, Nevada (NV). The Canal is about 31 miles long and discharges into Lahontan Reservoir, at the left abutment of Lahontan Dam. The Truckee Canal crosses about 20 natural drainages within a 100 square mile drainage area.

On January 5, 2008 a portion of the Canal embankment failed causing flooding and property damage within Fernley, Nevada. The 2008 Canal failure was a result of seepage and internal erosion that caused the Canal embankment to breach. The internal erosion was a result of animal burrows and decayed root systems that contributed to the unstable canal embankment. Additionally, the operator was attempting to capture floodwaters from the Truckee River to meet the Lahontan Reservoir storage targets. The ramp up, which is the increase in the Canal stage elevation, was greater than one foot over a 24-hour period and was also thought to be a contributing factor in the Canal failure.

This study evaluated several engineering alternatives to avoid a similar canal failure as well as other potential canal failure modes. The alternatives were evaluated on their initial costs for construction; on-going costs for Operations, Maintenance, and Replacement (OM&R); and economic benefits. The alternative with the best overall value would be recommended to continue into final design.

2.2 Project area

The Project Area includes the entire 31 miles of the Canal, from Derby Dam to Lahontan Reservoir, a 100-foot buffer on each side of the Canal from the centerline, four staging areas, and three detention ponds. Figure 1-1 presents the Truckee Canal XM EES Project Area.

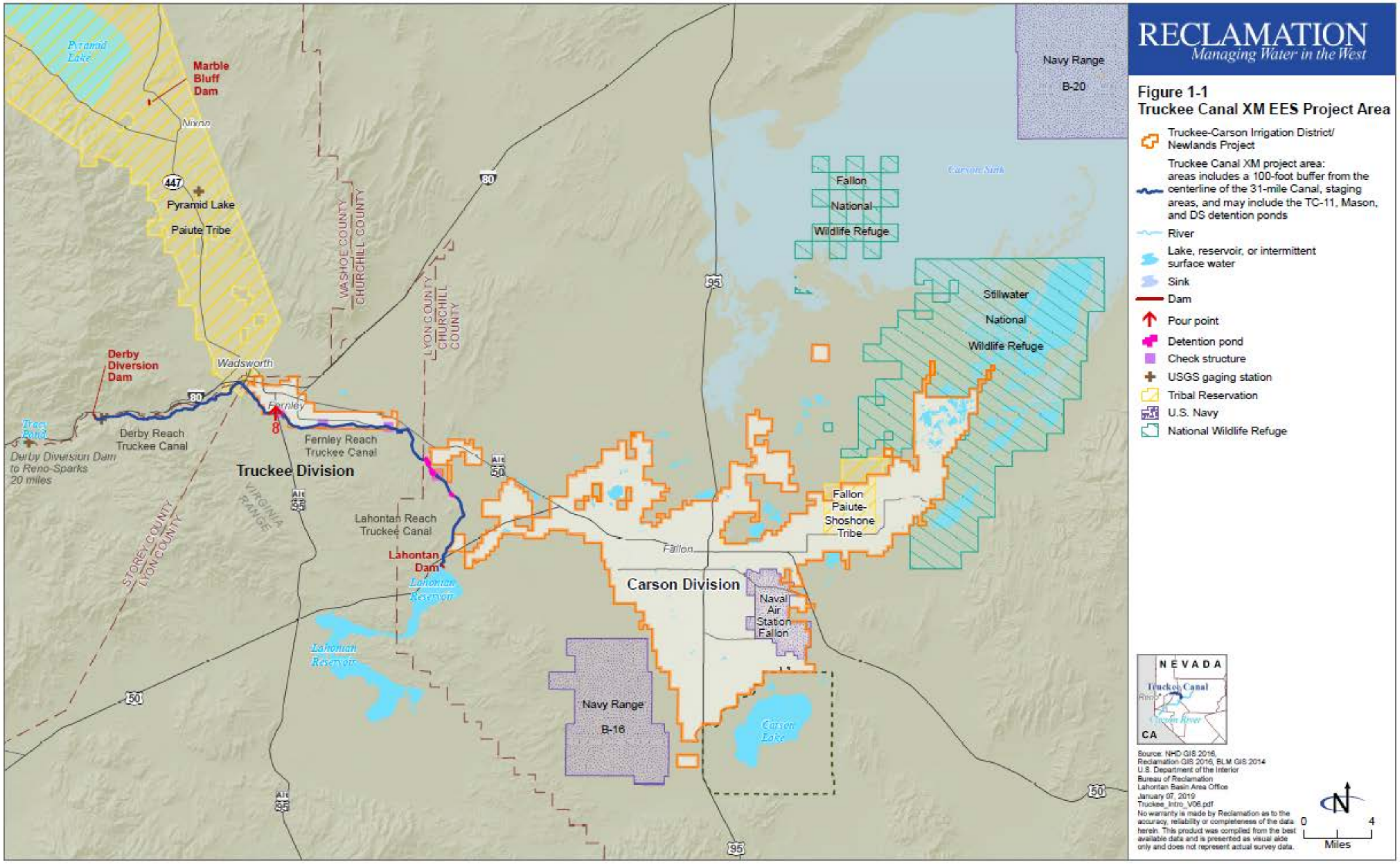


Figure 1-1.—Truckee Canal Project Area.

2.3 Canal operation

Diversions from the Truckee River to the Canal are managed in accordance with the requirements of the 1997 Adjusted Operating Criteria and Procedures (OCAP). Reclamation establishes allowable diversions by evaluating snow pack information, seasonal precipitation models, current storage levels in Lahontan Reservoir, and other downstream water right projections. Once Reclamation establishes the allowable monthly diversions, it is up to TCID to monitor flows in the Truckee River and make day-to-day decisions on the amount of flow to divert at the Derby Diversion Dam.

Normal operations of the Truckee Canal prior to 2008 included flows ranging from about 300 to 1,000 ft^3/s. Flows were varied throughout the year to divert project water from the Truckee River, to make deliveries along the Canal, and to supplement inflows to Lahontan Reservoir for eventual use in the Fallon, Nevada area (Newlands Project, Carson Division). The Canal was typically operated at about 300 ft^3/s for much of the year, and then increased to about 700 ft^3/s in the winter when more water was available to be diverted from the Truckee River. Operating the Canal from about 300 to 1,000 ft^3/s results in the water surface fluctuating about 3 to 5 feet. Use of the check structures also results in water surface fluctuations, but without a change in the flow rate. Flows were typically checked, gates shut at the check structures to artificially raise the water surface, during the spring and summer months and then unchecked during the winter months when deliveries are not needed.

Following the 2008, failure the Canal has been operating under a safety restriction. The restriction was initially established at four staff gauge locations within the Fernley Reach, corresponding to the 350 ft^3/s flow rate. The recommendation to control the flow rate was recently modified [2] by removing the flow rate restriction and establishing stage-level restrictions based on the 2014 updated risk analysis findings. The revised stage-level restriction has a corresponding unchecked unvegetated flow capacity of about 540 ft^3/s and summertime vegetated flow capacity of about 300 ft^3/s.

During the summer months, diversions to the Canal are typically less than 300 ft^3/s. Five check structures along the Canal's length are used to check the water surface to make deliveries. While the flow rate through the Canal is typically less than 300 ft^3/s, the stage-level is raised approaching the restricted level. The existing check structures include manually operated central gates and side boards filling the outer bay openings. Changing the gate setting requires an operator to drive to each check structure site. The side boards, in most cases, have not been removed for many years and may not be removable if there is water in the Canal.

During the winter months, the Truckee Canal is used solely for conveyance of Truckee River water to Lahontan Reservoir to meet storage targets. The Canal is operated in an unchecked condition by raising the check structure gates above the water surface. The side boards are typically left in place.

2.4 Risk analysis process

Following the January 2008 Canal breach, Reclamation completed analyses and studies to identify risk areas and potential risk reduction recommendations. Reclamation's risk analysis approach for the Canal assisted with the development of criteria that is now used for evaluating Canal risks of which the guidance includes:

- "Bureau of Reclamation's Canal Hazard Program," Reclamation Manual, Directives and Standards FAC 01-12, 2019.
- "Risk Analysis Process for Urbanized Canals", Technical Service Center, U.S. Bureau of Reclamation and AMD, Denver, Colorado, April 2018, draft or most current (Reclamation 2018b).
- "Best Practices for Dam and Levee Safety Risk Analysis", U.S. Bureau of Reclamation and U.S. Army Corps of Engineers, Denver, Colorado, April 2017.
- "Canals and Related Structures, Design Standards No. 3, Chapter 7, Cross Drainage for Canals", U.S. Bureau of Reclamation, Department of Interior, Denver, Colorado, November, 2013, draft.

2.4.1 Previous risk studies

Initial risk analysis [3] and subsequent Design, Estimating and Construction (DEC) review [4] were completed in 2008 to determine whether the Canal could safely be put back in service, identify an appropriate flow/stage-level restriction, and identify which loading conditions and potential failure modes (PFMs) pose the highest risks. The PFMs with the highest identified risks were estimated to result from internal erosion through the left embankment, overtopping from ice jams, overtopping from flood inflows, and increased risk of internal erosion during flooding without overtopping.

In early 2014, LBAO requested that TSC update baseline risk estimates made following the 2008 Canal failure and use the risk analysis findings to update the existing flow/stage-level restriction. The results were also used to develop appropriate long-term structural risk reduction recommendations. A risk analysis process was developed specifically for the Canal as part of the initial risk analysis studies and was updated by the 2014 risk estimating team. The updated risk analysis process is outlined in a technical memorandum titled: *Proposed Risk Analysis Process for the Truckee Canal, Decision Document and Technical Memorandum*, dated July, 2014 [5]. The risk analysis process document outlined the approach for estimating the risks and how the findings would be used to support development of a revised flow/stage-level restriction and to identify areas along the Canal needing improvement.

A risk evaluation team (RET) meeting was held at TSC in Denver, Colorado the week of August 18, 2014. The RET was composed of Reclamation staff from TSC, LBAO, the Mid-Pacific (MP) Regional Office and staff from TCID. The risk analysis meeting was held to update previous risk estimates made from 2008 through 2010, reflect improvements to the Canal and its operation since 2008, consider additional data and engineering analyses, and implement the updated risk analysis process. Findings from the updated risk analysis are presented in the report titled; "*Updated Risk Analysis – Truckee Canal, Issue Evaluation - Report of Findings, Newlands Project, Nevada, Technical Service Center, Bureau of Reclamation, Department of Interior, Denver, Colorado*", dated June, 2015 [6]. The updated risk analysis indicated the highest risk levels as:

- internal erosion failure through the embankment when the stage-level is elevated,
- internal erosion failure through the embankment or overtopping in the event of an ice jam,
- seismic cracking leading to internal erosion failure through the embankment, and
- flooding or inflows into the Canal leading to internal erosion failure through the embankment or overtopping.

A high degree of observed embankment flaws (animal burrows) along with the lack of flood protection features in the downstream two-thirds of the Canal were the key factors leading to the high risks. Reclamation later determined that the updated risk analysis did not adequately capture unpredictable severe storm events and changing runoff conditions. These risks combined with embankment vulnerabilities of the Canal would continue to present a potential threat to the integrity of the Canal and public safety due to flooding.

2.4.2 Hydrologic hazard analysis studies

The Canal crosses 20 natural drainages with contributing basins ranging from less than 1 square mile to nearly 45 square miles for a total of approximately 100 square miles. The drainages collect precipitation from the areas south and west of the Canal alignment. The original Canal construction design did not include any wasteways, drainage crossings, or detention ponds. As a result, these natural drainages discharge directly into the Canal. The approximate location where runoff enters the Canal have been defined as “pour points”. Location of the pour points are shown on Figure 2-1. The larger inflows mainly impact the Fernley and Lahontan reaches and have the potential to result in overtopping of the Canal embankment.

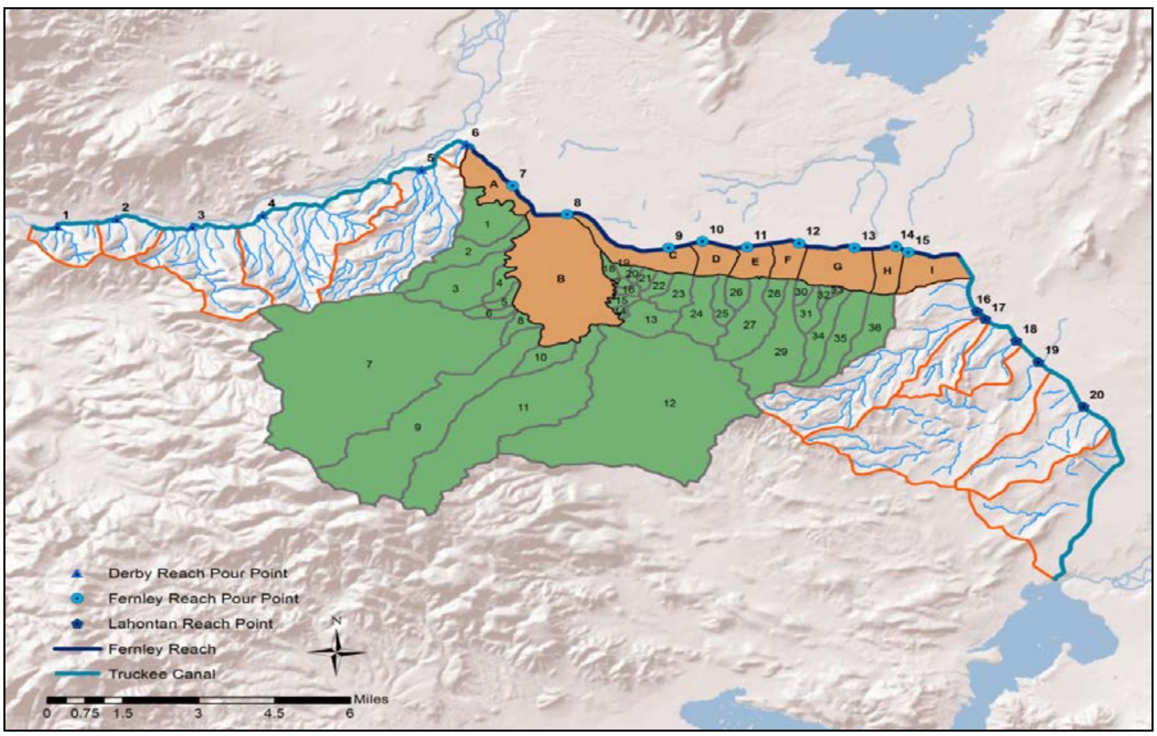


Figure 2-1.—Location of lateral inflow pour points along the Truckee Canal.

In 2016 and 2017, TSC and an outside contractor completed updates to the hydrologic hazard analyses. The Hydrologic Analysis Technical Team (HATT) evaluated the past analyses and made adjustments to the rainfall and overland flow modeling and incorporated rainfall measurements and subsequent Canal inflows from a large general storm event that occurred in January 2017. The work is summarized in a report titled; *Enhanced Truckee Canal Hydrologic Hazard Analysis Technical Memorandum TM-2017-2. Lahontan Basin Area*

Office, US Department of the Interior, Bureau of Reclamation, David Ford Consulting Engineers, Sacramento, California, October 2017 [7]. Key findings are summarized below.

The evaluation indicated there was some uncertainty in the estimated rainfall totals that were used to calibrate the runoff model(s) for the July 2013 summer storm event. The HATT, in consultation with the National Weather Service, recommended that more weight be applied to the estimated rainfall totals from the interpreted radar data than from CoCoRaHS (Community Collaborative Rain, Hail & Snow [Program]) gages in the Fernley, Nevada area. The HATT updated the constant loss rates for each subbasin by using the unadjusted precipitation radar values from the July 2013 event. The new loss rates increased overland volume contributed by the alluvial fans. The use of radar data as-is without any ground corrections given uncertainty with gage measurements resulted in both higher total rainfall for the 2013 event and higher constant loss values in the model. The updated calibration resulted in constant loss values being increased by a factor of about two. While the loss rates increased from previous studies, they are only about 35% of the measured infiltration rates. The updated runoff model was then used to estimate the potential runoff from the 6-hour design storm.

In January 2017, a large severe storm event occurred in the project area. Reclamation deployed rain gauges in the contributing subbasins prior to the storm and monitored runoff from select drainages and pour points to the Canal. Measured rainfall totals over a 48-hour period ranged from 1.25 to 3.4-inches. Cumulative runoff onto Alluvial Fan B, above Pour Point No. 8, was estimated to have exceeded 1,000 ft^3/s. Peak inflows to the Canal were estimated to be about 100 to 200 ft^3/s. Runoff approaching Pour Point No. 8 flooded SH-95 and homes north of Sage Drive, caused damage to the right canal bank as water entered the Canal, and deposited sediment into the Canal. An evaluation of the collected data indicated that previously developed constant loss values for a general storm-type event were appropriate and no changes were needed to the model.

To address the previous RET's uncertainties regarding the short duration spatial and temporal distribution of model storms along with the use of an aerial reduction factor, Reclamation developed a new rainfall distribution model to estimate the potential runoff. The updated rainfall distribution model utilizes a concentric, elliptical-shaped rainfall distribution, oriented with the long-axis at 35 and 125-degree offsets from north. The highest rainfall totals are represented at the center of the ellipse and decrease outwards. The orientation of the elliptical shape represents two potential travel patterns a local storm might follow across the contributing drainage. When analyzing the 6-hour thunderstorm type event, maximum point rainfall at the center of the ellipse is 1.54-inches and decreases linearly outwards. Seven storm centerings were chosen to represent a range of locations where the highest rainfall might occur.

Results of the updated analysis confirmed that the critical storm is a thunderstorm-type event. While runoff to the Canal is expected from a general storm-type event, the rainfall rate is slower and the combination of infiltration and attenuation on the alluvial fans reduces the potential for overtopping the Canal during winter months.

When evaluating the potential runoff from the 6-hour thunderstorm event, the response from the individual storm centerings was considered. Storm centering locations “BS” and “Lower” resulted in the largest runoff to the Canal. Peak inflows at Pour Point No. 8 were estimated to range from about 0 to 600 ft^3/s depending on the storm centering location. Large inflows were also identified at Pour Point Nos. 16 and 19, ranging from about 300 to 1,400 ft^3/s depending on the storm centering location.

Reclamation completed flood routings using the latest HEC-RAS model for the Canal. Initial Canal diversion representing stage-level/flows of 60, 150, 350, and 600 ft^3/s were used in the modeling. The HEC-RAS model was set to reflect the Canal in an unchecked condition with summertime vegetated roughness values. The Canal’s response from the individual storm centerings was analyzed to evaluate the potential for overtopping. Plots of the maximum water surface profiles were prepared to interpret the location of the potential overtopping and the results were used to revise the hydraulic risks identified in the 2015 Risk Analysis. The findings were documented in the 2018 Updated Hydrologic Risk Analysis Technical Memorandum, dated March 2018 [8].

Reclamation also prepared composite water surface profiles representing the maximum water surface rise in the Canal considering each of the storm centering locations. While this assumes multiple storm centerings at the same time, the information was provided to the RET as a worst-case scenario. Details of the analysis are provided in the report titled; *Truckee Canal Flood Hydraulic Analysis*, dated October 2017 [9].

3 Design Data and Engineering Analysis

Reclamation recognized that for the risk reduction recommendations to effectively reduce risk, they may need to be combined. Completed risk analyses identified the vulnerable areas along the Canal. The TSC determined that risk mitigation for static, seismic, and hydrologic loadings were not stand-alone alternatives; rather, they are the pieces of an alternative that, when combined, provide a possible solution for managing risk.

In 2016, the TSC completed the *Decision Document: Proposed Long-term Risk Reduction and Design Criteria for the Truckee Canal, Newlands Project, Nevada* [10] structural risk reduction measures designed to address the Long-term Risk Reduction. The design criteria was then used to develop appraisal level corrective action alternatives to address the risks identified in the 2015 updated risk analysis. The corrective action alternatives were documented in the *Truckee Canal Corrective Action Study, Technical Memorandum QY-2016-8311-1. Truckee-Carson Project, Nevada, Lahontan Basin Area Office* [11] completed in 2017. The designs presented in this report generally followed the design and risk reduction criteria found in the design criteria used in the CAS. Deviations in the design criteria are discussed below.

3.1 Seismic loadings for embankments

Two primary seismic failure mode scenarios for the Canal embankments were evaluated during the baseline risk analyses: (1) shaking causing liquefaction of the Canal's foundation, leading to damage of the embankment; or (2) the shaking does not cause foundation liquefaction but still results in damage to the embankment. The seismic loadings used for the baseline risk analysis and those used for new designs are nearly identical.

Seismic loadings used to design above ground structures were developed using probabilistic Risk Targeted (MCE_R) ground motion. Design spectral accelerations were developed from MCE_R values and adjusted for site class effects. Seismic loadings used for embankments and below ground structures were developed using the peak ground accelerations and adjusted for site class effects (PGA_M) for the 2,500-yr return period ground motions. This return period corresponds to a 2% probability of exceedance in a 50-yr period.

There has been an update to the *ASCE/SEI 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers*, *Reston Virginia*, *2017* [12] design code for seismic loading since the risk analysis and the Corrective Action Study (CAS) were completed. A comparison of the design spectral acceleration parameters used for the CAS and this EES are shown in table 3-1.

Table 3-1.—Design Spectral Accelerations

	S_{DS}	S_{D1}	PGA_M
ASCE 7-10	0.913	0.517	0.601
ASCE 7-16	0.938	0.610	0.710

3.2 Hydrologic loading

Hydrologic concerns exist due to the current local infrastructure, which allows upslope drainages to enter the Canal at 20 pour points. These natural drainage channels collect precipitation from the south and west sides of the Canal. There are no wasteways in the lower reaches of the Canal to release high flows that have the potential to overtop the Canal. Additionally, inflows to the Canal contribute sediment to the Canal, which tend to settle out within the lower reaches of the Canal.

The *Enhanced Truckee Canal Hydrologic Hazard Analysis Technical Memorandum (Reclamation 2017c)* [7] documents the hydrologic inflows into the Canal. The analysis established a set of Canal inflow hydrographs representing 100-year runoff from the Canal watershed. The analysis computed a 100-year, 6-hour thunderstorm; a 100-year, 24-hour general storm; and a 100-year, 48-hour general storm for each of the drainage basins contributing to the 20 natural drainages that cross the Canal. Using a 1-D HEC-RAS model to determine the Canal's response to multiple scenarios and 26 storm centerings, it was recommended to use 7 of the storm centerings for determining Canal risk reduction alternatives. These centerings are Lower 125, F 125, Center 125, BE 125, BS 125, Bw 125, and Upper 125 from the Hydrologic Hazard Analysis Technical Memorandum. The data developed in the analysis was used to inform the HEC-RAS model for the selection of alternatives for analysis in the EES.

3.3 Hydraulic model parameters

For this EES, the TSC updated the hydrological loadings for a HEC-RAS model to determine Canal stage levels (water surface profiles) under various base flow and drainage inflow scenarios. These hydrologic loadings and scenarios will guide the design for risk reduction. The updated HEC-RAS model included the replacement of the Fernley, Anderson, Allendale, and Mason check structures. The Hazen Gage downstream of Bango check was updated to model a new flume. The replacement of the Hazen Gage would help to reduce backwater effects that could exacerbate the risk of overtopping upstream from the gage and the replacement of the check structures reduces the risk of ice jams raising the stage upstream.

No other Canal structures were altered from the previous HEC-RAS model. The model used vegetated Manning's *n* values to determine worst-case scenario stage levels from the updated storm inflow hydrographs. Phase 1 Canal improvements were also included in the updated HEC-RAS model. The purpose of the hydraulic analysis is to determine what Canal improvements are needed to keep the water surface elevation below the risk threshold.

The TSC performed an unsteady flow analysis using HEC-RAS with a base flow of 350 ft^3 in the Canal and roughness coefficient corresponding to a summer time (vegetated) event. The unsteady analysis incorporated the updated hydrologic inflows for the seven different storm centerings. Multiple scenarios were modeled to determine the best approach in reducing the stage level in the Canal. The alternatives modeled used a variety of lining improvement locations/lengths as well as placement and sizing of detention ponds to address Canal risk. The TSC modeled various iterations of each alternative until the locations of moderate to high risk were mitigated. The seven storm centerings resulted in varying water surface elevations within each alternative due to the different time of concentrations between the storm centerings. Each alternative was updated and improved to accommodate any of the seven storm centering inflows.

3.4 Survey topography

Survey data used in this study were obtained from a LIDAR based survey completed in 2008 with a reported vertical accuracy of +/- 0.5 ft. The survey data is in the State Plane Coordinate System having a horizontal datum of North American Datum (NAD) 1983 State Plane Zone Nevada West in U.S. survey feet and vertical datum of North American Vertical Datum 1988 (NAVD88) in U.S. survey feet.

During the final designs for the check structures, the Canal alignment used for the risk analysis was modified to better match the existing Canal centerline. The beginning station location was also relocated near the center of the Truckee River, as opposed to the center of the Canal headworks. Consequently, stationing referenced in this report do not correlate with the stationing references in previous reports. See drawing 29-D-FIGURE 2 for Canal alignment and stationing definitions used for this EES.
The correlating final design stationing and 2014 RA stationing are shown in Table 3-2.

Table 3-2.—Check structure station locations

Check Structure	Final Design Station	2014 RA Station
Fernley Check	707+85	696+34
Andersen Check	862+50	860+42
Allendale Check	1071+25	1059+15
Mason Check	1317+00	1303+80
Bango Check	1477+08	1466+50

3.5 Geologic investigations

Geologic data packages were prepared by the MP Geology group, including the individual drill hole and cone penetration test (CPT) logs, surface observations and geologic mapping, and geologic subsurface profiles and cross sections [13]. Additional geologic observations were made during the Fernley Reach turnout replacements in 2012. The observations were documented by the MP geology group [14].

4 RISK REDUCTION CRITERIA

Canal Stage levels are water surface profiles that are established by the Canal geometry but are also heavily influenced by the amount of vegetation in the Canal. The Canal typically develops heavy vegetation during the late spring and summer months that influences stage levels. As a result, the stage levels for each of the flows evaluated during the risk analysis were developed using HEC-RAS models with roughness coefficients that represented an earthen canal with heavy vegetation.

This feasibility design study used a maximum design flow rate of 600 ft^3/s to determine the size and configuration of the Canal and appurtenant structures. A comparison was made between the 350 ft^3/s vegetated water surface profile used in the CAS and the 600 ft^3/s unvegetated water surface profiles used for this study. The water surface used to evaluate the risk at the 350 ft^3/s vegetated flow rate is at or below the water surface for 600 ft^3/s throughout most of the Canal reaches (see figure 4-1).

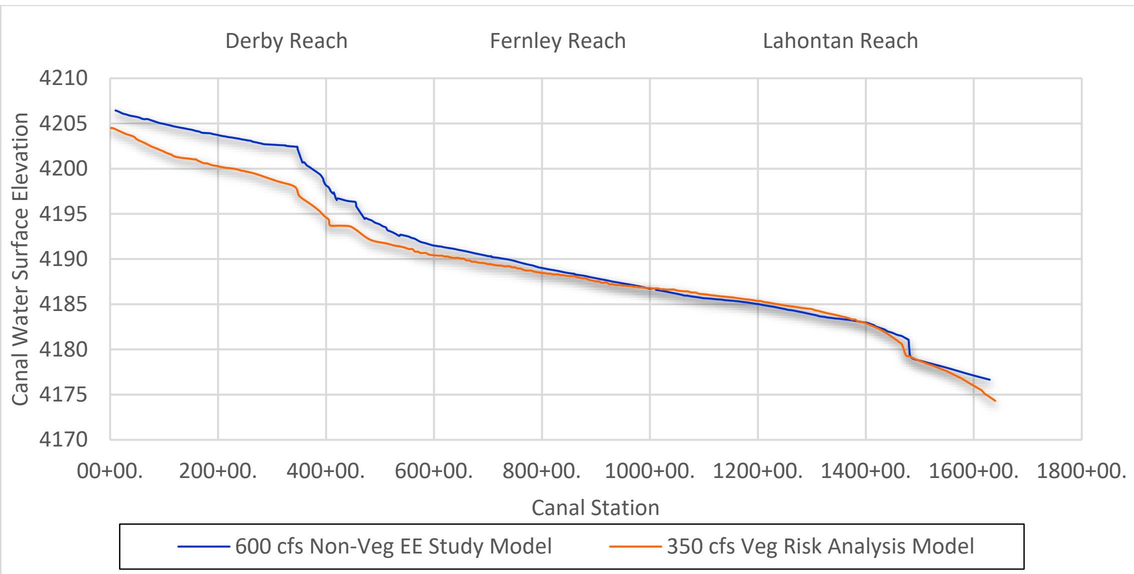


Figure 4-1.—350- and 600-ft^3/s water surface comparison.

In those areas where the water surface profile for the 600 ft^3/s flow rate was above the water surface profile used in the 2015 risk analysis, the same risk evaluation procedures defined in the 2015 risk analysis were followed to identify additional reaches where the probability of failure were increased as a result of the higher water surface. The comparison of the two water surfaces, and a review of the failure probabilities concluded that there were no changes to the static risks identified in the 2015 risk analysis. The risk analysis procedures followed, along with a summary of the risk analysis results, are included in Appendix A.

4.1 Flood routing risk reduction criteria

The 2018 Updated Hydrologic Risk Analysis technical memorandum [8] identified freeboard issues in the vegetated models on the lower Fernley Reach and sections on the Lahontan Reach. The RET developed a revised flood routing risk reduction criteria that was used to evaluate the need to line canal sections because of rising water surfaces caused by hydraulic loadings. The criteria used in the analysis is presented below:

- Areas where linear embankment improvements are not implemented, the flood protection features should be designed to maintain at least 3 feet of canal bank freeboard.
- Areas where the linear embankment improvements are implemented, the flood protection features should be designed to maintain at least 1 foot of canal bank freeboard.
- The 600 ft^3/s unvegetated stage-level will be used to develop the base flow at the onset of the storm.
- Summertime vegetated roughness values will be used in the HEC-RAS flood routing model.
- The existing baseline HEC-RAS model will be modified to reflect the lining options being considered, prism reshaping, and addition of the new check structures.
- Check structure gate operation will assume the new radial gates can be raised and allow the Canal to operate in an unchecked condition during the flood event.

5 RISK REDUCTION ALTERNATIVES

This study developed a two-phased implementation plan to reduce the risks and improve the Canal to safely convey the design operating flow of 600 ft^3/s. Phase I addresses static and seismic risks. Phase 2 addresses hydrologic risks. Proposed risk mitigation includes embankment modifications, structure modification or replacement, and detention ponds with active waterway structures. Five alternatives were developed to reduce all identified risks. Table 5-1 presents a summary of the five alternatives studied.

Phase 1 Canal improvements include lining and replacement or modifications to existing check structures and Hazen gage structures. Phase 1 improvements were developed to address the PFM associated with the static and seismic risks identified in the 2015 risk study. The PFMs include:

- PFM1 – Internal Erosion through the Embankment
- PFM5 – Ice Jams Leading to Internal Erosion or Overtopping
- PFM8 – Internal Erosion along Embankment Penetrations

Phase 2 Canal improvements were developed to address PFM10-Flooding Leading to Overtopping and PFM11-Flooding Leading to Internal Erosion. Phase 2 Canal improvements were developed with the assumption that all Phase 1 improvements would be implemented.

Twenty-nine plan and profile engineering drawings (Drawings 29-D-FIGURE 3 to -32) depicting each of the design features proposed are included in Appendix B- Engineering drawings. A description of Phase 1 options and Phase 2 alternatives is discussed in the following sections.

5 Risk reduction alternatives

Table 5-1.—Phase 1 and Phase 2 canal improvement alternatives

Alternative Number	Phase 1 Embankment	Phase 1 Structures	Phase 2 Hydrologic Actions
1	Line the Canal—full prism—geomembrane/concrete (0.3 miles) within Derby reach AND geomembrane/soil (5.5 miles) and geomembrane/half concrete (0.2 miles) within Fernley and Lahontan reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (2,900 feet [ft]) at 3 inflow points and geomembrane/soil (2,900 ft) AND construct TC 11 detention pond (322 AF), Mason detention pond (180 AF), and Downstream detention pond (17 AF)
2	Line the Canal—full prism—geomembrane/concrete (0.3 miles) within Derby reach AND geomembrane/soil (5.5 miles) and geomembrane/half concrete (0.2 miles) within Fernley and Lahontan reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (2,900 ft) at 3 inflow points and geomembrane/soil (2,900 ft) AND construct TC 11 detention pond (133 AF), Mason detention pond (101 AF) AND Line the Canal—full prism—geomembrane/soil (4.1 miles) from Fernley check to Bango check structure,
3	Line the Canal—full prism—geomembrane/concrete (0.3 miles) within Derby reach AND geomembrane/soil (5.5 miles) and geomembrane/half concrete (0.2 miles) within Fernley and Lahontan reaches	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (2,900 ft) at 3 inflow points and geomembrane/soil (2,900 ft) AND Line the Canal—full prism—geomembrane/soil (6.7 miles) from Fernley check to Bango check structure,

Table 5-1.—Phase 1 and Phase 2 canal improvement alternatives

Alternative Number	Phase 1 Embankment	Phase 1 Structures	Phase 2 Hydrologic Actions
4	Line the Canal—full prism—geomembrane/concrete (6.0 miles) from the Derby Dam to the Mason check structure	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Armor Pour Point 8—full prism—geomembrane/concrete (5800 ft) at 3 inflow points AND Line the Canal—full prism—geomembrane/concrete (6.7 miles) from Fernley check to Bango check structure,
5	Line the Canal—full prism—geomembrane/concrete (6.0 miles) from the Derby Dam to the Mason check structure	Replace four check structures (Fernley, Anderson, Allendale, and Mason), modify radial gates at Bango Check, and remove and replace Hazen Gage with a long-throated flume	Line the Canal—full prism—geomembrane/concrete (12.1 miles) from Fernley check to Bango check structure,

5.1 Phase 1 embankment and structure improvements

Phase 1 embankment improvements consist of lining approximately 6.0 miles of the Canal's high-risk areas. Three canal lining systems are proposed for this study. Each of the lining types proposed have a geomembrane liner that covers the full canal prism. The difference between each lining types is the cover over the geomembrane liner. The three lining types proposed are: line the full prism section with a geomembrane liner and 3-1/2 inches of concrete cover; line the full prism with a geomembrane liner and cover the left prism slope with 3-1/2 inches of concrete and the invert and right prism slope with 18-inches of soil cover; line the full prism with a geomembrane liner and 18-inches of soil cover.

In previous studies, the geomembrane liner and 18-inches of soil cover system had the least cost per mile of the three lining systems proposed and was used in the high-risk areas where only one order of magnitude risk reduction was required. The geomembrane liner with the left slope of the prism lined with 3-1/2 inches of concrete cover system was used in the higher risk areas where two orders of magnitude risk reduction was required (Sta. 743+10 to Sta. 753+10). Approximately 0.3 miles of full prism geomembrane liner and 3-1/2 inches of concrete cover the low points in a short section near Tunnel 3. Geomembrane liner protected by a 3-1/2 inches of concrete provides the highest level of risk reduction.

Table 5-2 lists the start and stop stations and corresponding lengths of canal improvements required to reduce the embankment risks (static and seismic) in the Canal with a 600 ft^3/s design flow rate, and to maintain the revised flood routing risk reduction criteria defined in Section 4.1. These start and stop stations are the same for all five alternatives.

Table 5-2.—Phase 1 canal lining improvement requirements for static and seismic risk reduction

Phase 1 Linear Canal Improvements				
Station Start	Station End	Length (ft)	Lining Cover Type	
			Alternative 1, 2, & 3	Alternative 4 & 5
440+15.	456+15.	1600	Full Concrete Section Cover	Full Concrete Section Cover
708+00.	743+00.	3500	Soil	Full Concrete Section Cover
743+00.	753+00.	1000	1/2 Concrete & 1/2 Soil	Full Concrete Section Cover
753+00.	838+00.	8500	Soil	Full Concrete Section Cover
888+05.	958+05.	7000	Soil	Full Concrete Section Cover
1023+00.	1098+00.	7500	Soil	Full Concrete Section Cover
1128+00.	1138+50.	1050	Soil	Full Concrete Section Cover
1270+25.	1285+25.	1500	Soil	Full Concrete Section Cover

Phase 1 structure improvements include the removal and replacement of four check structures, modifications to the Bango check, and removal and replacement of the Hazen Gage. The four checks to be removed and replaced include the Fernley, Anderson, Allendale, and Mason Checks. Bango Check is located on the lower end of the Lahontan reach. The Hazen Gage is an in-line V-notch weir located just downstream of Bango Check.

The new check structures will be constructed with wider gate bays and weir openings to minimize the potential for ice and debris jams at the approach. The automated gates will also improve operational control and provide the ability to isolate the Canal in the event of a future Canal failure. Check structure construction documents, including drawings and specifications, were completed 2017.

Bango Check has three bays and is appropriately sized for the design flows, however, two of the three bays are boarded, and the only operable gate is manually controlled. Hazen Gage is an in-line broad crested V-notch weir used to measure Canal flows on the lower reaches of the Canal. Hydrologic modeling indicates the design configuration and the existing elevation of the weir cause significant backwater effects resulting in deeper water depths and potentially increased sedimentation upstream of the structure. Modifications to these two structures improves the flow capacity and reduces the backwater effects in the Canal.

Bango Check modifications include the fabrication and installation of three automated radial gates. The gates will be powered by a new emergency generator set similar to those used on the new check structures. The plan for the Hazen Gage is to replace the existing V-notch weir with a long-throated flume. These modifications are designed to reduce sediment accumulation, minimize backwater effects, and provide an increased flow capacity to convey flood flows through the Lahontan reach. Figure 5-1 graphically presents the proposed Phase 1 Canal lining types and their locations.

5.2 Description of alternatives

5.2.1 Alternative 1

The design approach for Alternative 1 limited Canal lining to Phase 1 start and stop stationing and lining sections of the Canal at Pour Point 8 (Sta. 650+00 to Sta. 708+00). The Pour Point 8 armoring was designed to allow storm runoff to safely enter the Canal by protecting the Canal bank from erosion. Structure improvements included the addition of gated wasteway structures and detention ponds to attenuate the rising Canal water surface caused by Canal inflows from a hydrologic event. Alternative 1 includes the construction of three detention ponds with gated structures located on the lower reaches of the Canal. Figure 5-1 presents the locations of the Canal lining and the three detention ponds.

The detention ponds were strategically located on the lower reaches of the Canal where the Canal water depths are at their deepest points due to the flat slopes (0.00018 ft/ft) in the Canal alignment and where the runoff inflows begin to accumulate. The three ponds were located on Reclamation owned property in areas with little or no urban development. As a result, they do not require additional right-of-way and/or land acquisition.

The detention ponds were sized to capture the peak flows entering the Canal by utilizing active (gated) wasteway structures that open during peak flow events. The gated structures would direct peak flows into the detention ponds when the Canal stage rises above the 600 ft^3/ft stage level. When the Canal stage lowers to safe levels, the gates will close allowing the Canal to convey remaining storm and diversion flows. Actively operating the wasteways and detention ponds minimizes the size of the ponds and significantly reduces the risk of overtopping of the Canal. Table 5-3 lists design information for the Alternative 1 detention ponds.

Table 5-3.—Design information for Alternative 1 detention ponds

Pond ID	Canal Station	Pond Volume (ac-ft)	Inflow (ft^3)	Pond Invert	Pond WS EL	Area (ac)	Pond Top of Bank EL
TC 11 Detention Pond	1257+58.03	322	940	4167.0	4181.0	23.5	4183.0
Mason Detention Pond	1294+59.59	180	890	4173.0	4182.0	19.7	4184.0
Downstream Detention Pond	1388+18.08	17	395	4173.0	4181.0	2.2	4183.0

TC 11 Detention Pond is located on the downslope side of the Canal. Mason Detention Pond and Downstream Detention Pond are located on the upslope side of the Canal. In areas of fill, the detention pond embankments include a geomembrane liner located 18-inches below the surface. The invert of the detention ponds are not lined and any water stored in these ponds will infiltrate through the bottom of the pond, evaporate, or be released back into the Canal.

A diesel engine generator will be provided to power the gates. Batteries and a battery charger will be provided for continuous power to the SCADA system, security equipment and monitoring devices. The engine generator will automatically start when the battery voltage is low in order to recharge the batteries or when the gates are required to operate. The Canal will be monitored by the SCADA system using an input from a level sensor for each detention pond. When the predetermined high-water mark is reached, the gates for the associated detention pond will open to allow water from the Canal to flow into the detention pond. When the Canal water level lowers to the acceptable level, the gates for the associated detention pond will close. All gates for the associated detention pond will operate at the same time.

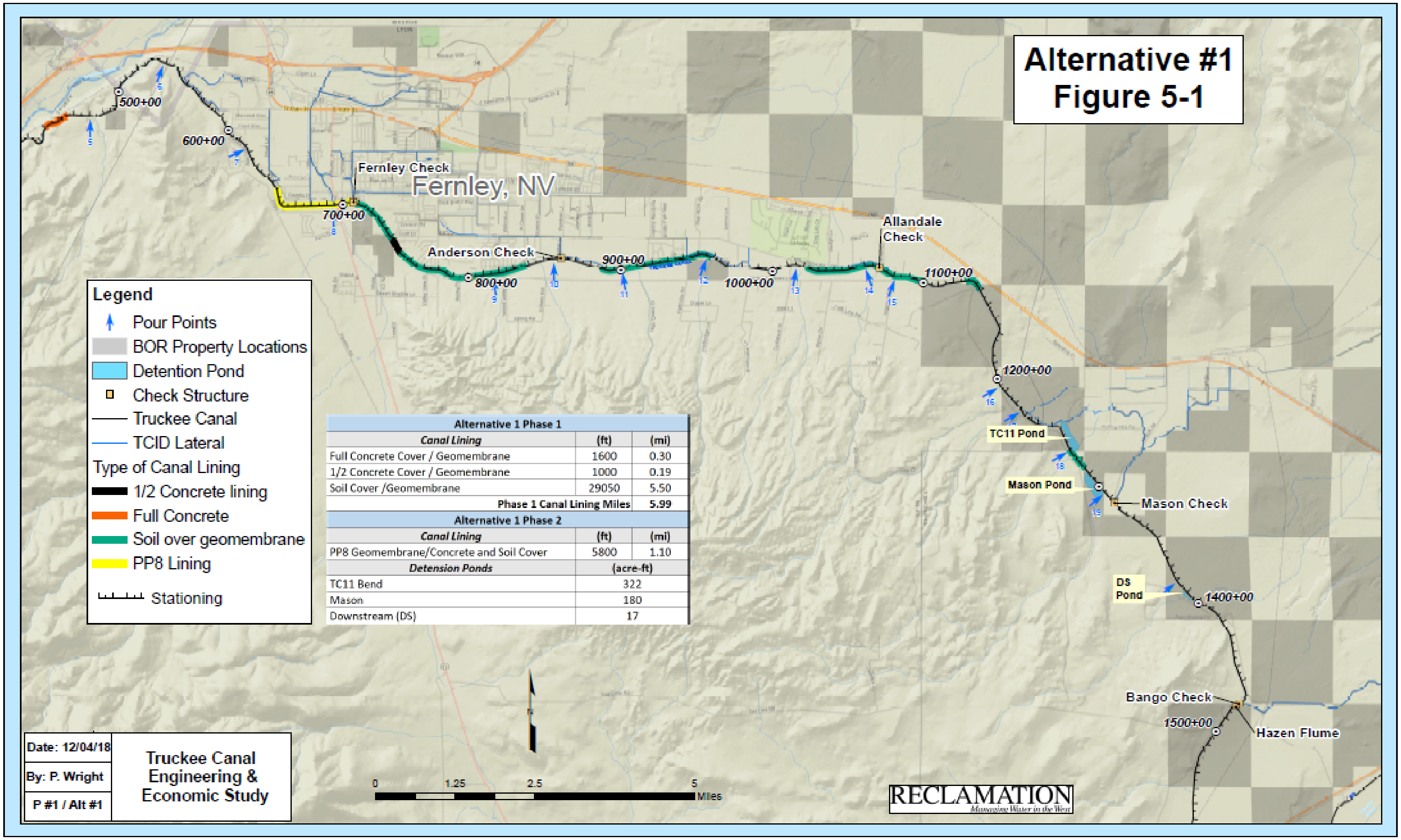


Figure 5-1.—Alternative 1 risk reduction features.

5.2.2 Alternative 2

The design approach for Alternative 2 reduced the number and size of detention ponds utilizing additional lining to convey the hydrologic loading. The improved canal section improves the conveyance conditions which reduces the need for detention ponds. The detention ponds were sized incorporating the additional canal lining improvements which optimized the combined use of canal lining and detention ponds.

Alternative 2 includes 6.0 miles of Phase 1 lining and approximately 4.1 miles of Phase 2 soil over geomembrane lining, and detention ponds at the TC 11 and Mason Detention Pond locations. Like Alternative 1, the detention ponds include gated wasteway structures. Figure 5-2 presents Alternative 2 Canal lining and detention pond locations. Table 5-4 lists the locations for Phase 2 lining requirements. Table 5-5 lists the statistical information for Alternative 2 detention ponds.

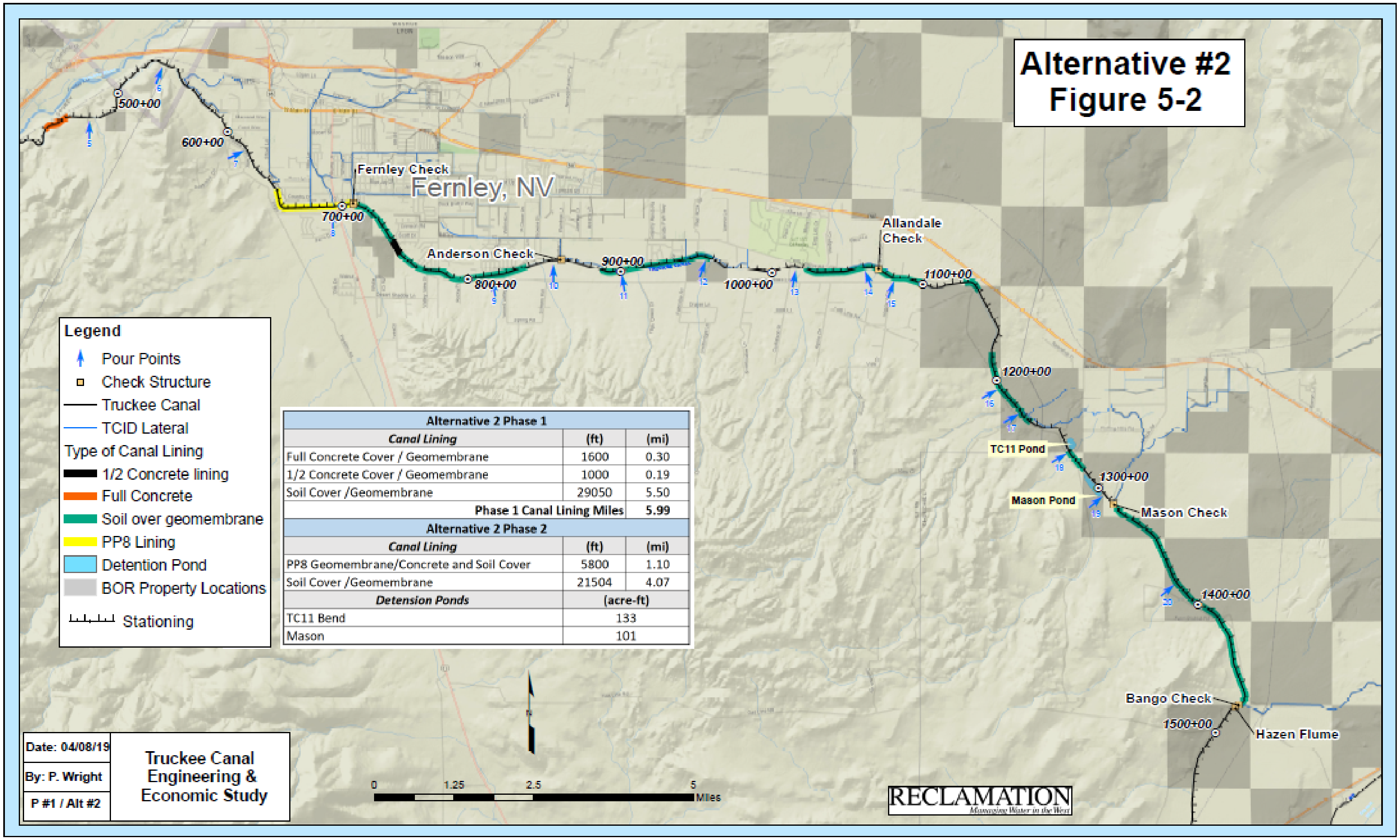
Table 5-4.—Alternative 2 Phase 2 canal improvement requirements

Linear Canal Improvements		
Station Start	Station End	Length (ft)
1182+13	1234+82	5269
1314+57	1476+92	16235

Table 5-5.—Statistical information for Alternative 2 detention ponds

Pond ID	**Canal Station**	**Pond Volume (ac-ft)**	**Inflow (ft^3)**	**Pond Invert EL.**	**Pond WS EL.**	**Area (ac)**	**Pond Bank EL.**
TC 11 Detention Pond	1257+57	133	620	4167	4181	6.6	4183
Mason Detention Pond	1294+59	101	860	4173	4182	11.5	4184

The power and controls for the TC 11 and Mason Detention Pond gates included in Alternative 2 are the same as in Alternative 1.



Alternative 2 Phase 1		
Canal Lining	(ft)	(mi)
Full Concrete Cover / Geomembrane	1600	0.30
1/2 Concrete Cover / Geomembrane	1000	0.19
Soil Cover /Geomembrane	29050	5.50
Phase 1 Canal Lining Miles		5.99
Alternative 2 Phase 2		
Canal Lining	(ft)	(mi)
PP8 Geomembrane/Concrete and Soil Cover	5800	1.10
Soil Cover /Geomembrane	21504	4.07
Detension Ponds	(acre-ft)	
TC11 Bend	133	
Mason	101	

Figure 5-2.—Alternative 2 risk reduction features.

5.2.3 Alternative 3

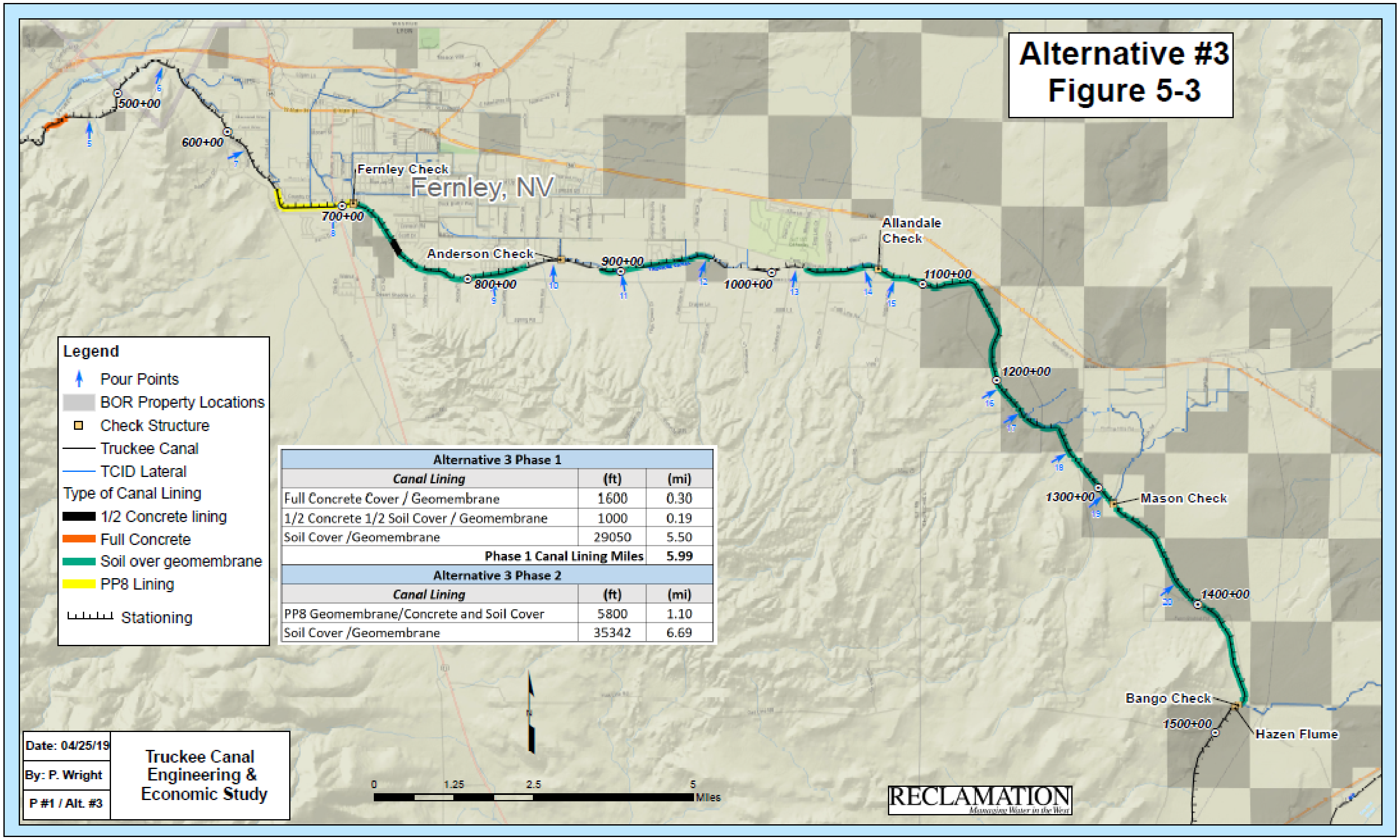
The design approach for Alternative 3 eliminated the use of detention ponds and only includes canal lining where freeboard was less than 3-feet. Alternative 3 includes 6.0 miles of Phase 1 lining and approximately 6.7 miles of additional soil over geomembrane lining. Figure 5-3 presents Alternative 3 Canal lining locations. Table 5-6 lists the start and stop stations and corresponding lengths of Canal improvements required for Alternative 3.

Table 5-6.—Alternative 3 Phase 2 canal improvement requirements

Linear Canal Improvements		
Station Start	**Station End**	**Length (ft)**
1098+00	1128+00	3000
1138+50	1270+25	13175
1285+25	1476+92	19167

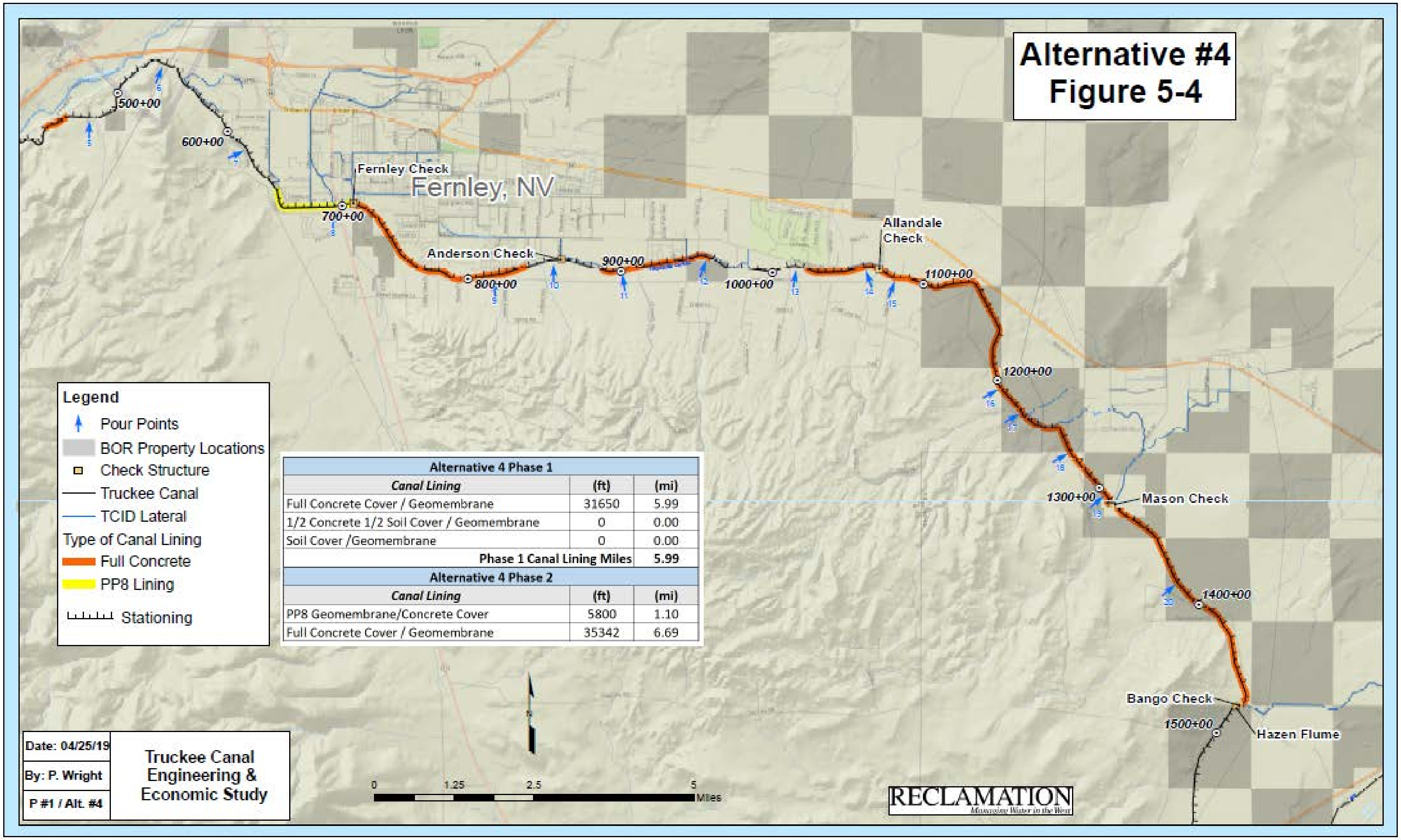
5.2.4 Alternative 4

Alternative 4 Phase 1 and Phase 2 lining locations are the same as in Alternative 3. The only difference between these two alternatives is the Canal lining cover at all Phase 1 and Phase 2 locations is 3-1/2 inches of concrete. Like Alternative 3, the design intent was to eliminate the use of detention ponds and only includes Canal lining where freeboard was less than 3-feet. The use of a concrete cover was designed to improve the design life of the lining system and reduce OM&R costs. Alternative 4 includes lining 6.0 miles for Phase 1 and 6.7 miles of Phase 2 lining to reduce hydrologic risks. The total length of lining improvements for Alternative 4 is approximately 12.7 miles. Figure 5-4 presents Alternative 4 Canal lining locations. The Phase 2 start and stop stations and corresponding lengths of Canal improvements are identical to those listed in Table 5-6.



Alternative 3 Phase 1		
Canal Lining	(ft)	(mi)
Full Concrete Cover / Geomembrane	1600	0.30
1/2 Concrete 1/2 Soil Cover / Geomembrane	1000	0.19
Soil Cover /Geomembrane	29050	5.50
Phase 1 Canal Lining Miles		**5.99**
Alternative 3 Phase 2		
Canal Lining	(ft)	(mi)
PP8 Geomembrane/Concrete and Soil Cover	5800	1.10
Soil Cover /Geomembrane	35342	6.69

Figure 5-3.—Alternative 3 risk reduction features.



Alternative 4 Phase 1		
Canal Lining	(ft)	(mi)
Full Concrete Cover / Geomembrane	31650	5.99
1/2 Concrete 1/2 Soil Cover / Geomembrane	0	0.00
Soil Cover /Geomembrane	0	0.00
Phase 1 Canal Lining Miles		5.99
Alternative 4 Phase 2		
Canal Lining	(ft)	(mi)
PP8 Geomembrane/Concrete Cover	5800	1.10
Full Concrete Cover / Geomembrane	35342	6.69

Figure 5-4.—Alternative 4 risk reduction features.

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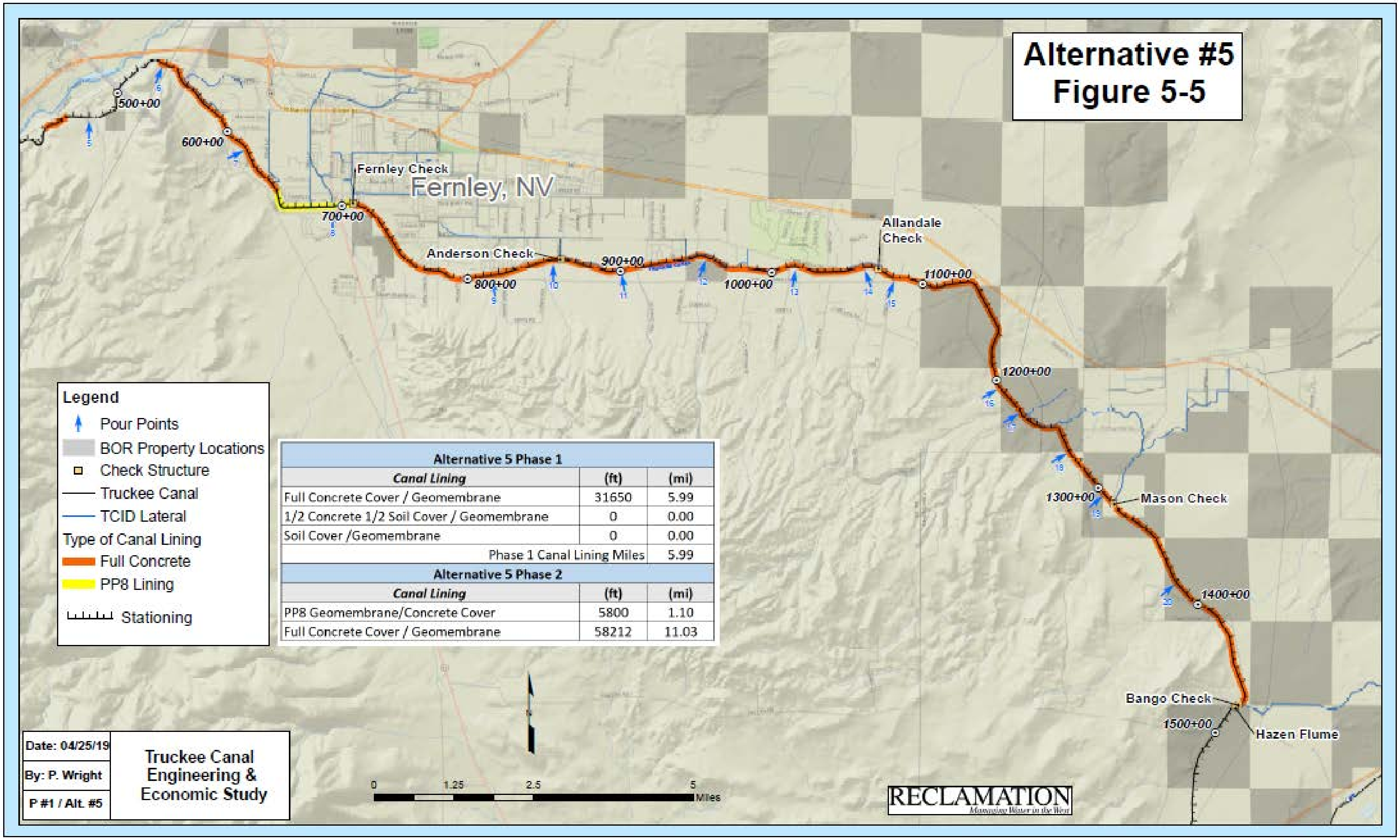
5.2.5 Other alternatives considered

There were two other alternatives considered during this study that were rejected early in the design process and were not included in the economic analysis. The first is Alternative 5 which includes full concrete and geomembrane lining of the Canal between the USGS gage on the Canal near Wadsworth, NV to the USGS gage on the Canal located near Hazen, NV. This alternative was not carried forward in the selection of alternatives based on its high cost. Engineering drawings were not produced for this alternative; however, for general information purposes, costs for concrete lining the Canal were combined with costs developed for Phase I work and summarized with contingencies costs. The cost estimate worksheets have been included in Appendix C. See Figure 5-5 for Alternative 5 canal lining locations.

The final alternative considered was a “no action”, or non-structural alternative. This alternative would take no action to reduce any of the known risks in the Canal. In such an event, a long-term “no action” restriction would be imposed limiting the peak operating range to about 100 to 140 ft^3/s to further lower the stage-level and associated risks. This stage restriction would be determined using an unchecked condition (meaning that the check structures would not be allowed to check water surface levels above the stage level restrictions) which would result in several turnouts becoming inoperable without mechanical assistance. The “no action” alternative would result in no measurable reduction of seepage through the Canal.

“No action” stage restrictions would reduce the risks along the Canal where static and seismic failure modes controlled the risk analysis. They will not reduce risks where hydrologic failure modes control. Analytical models accounting for Pour Point 8 inflows show that storm runoff from a return period as low as 25 years has the potential to enter the Canal and exceed the Canal capacity. Because of the high likelihood of failure due to hydrologic loading immediately uphill of the city of Fernley, the loss of benefits to stakeholders, the potential for loss of life, and the potential for causing similar damage experienced from the 2008 failure, the “no action” alternative was removed from further consideration.



Alternative 5 Phase 1		
Canal Lining	(ft)	(mi)
Full Concrete Cover / Geomembrane	31650	5.99
1/2 Concrete 1/2 Soil Cover / Geomembrane	0	0.00
Soil Cover /Geomembrane	0	0.00
Phase 1 Canal Lining Miles		5.99
Alternative 5 Phase 2		
Canal Lining	(ft)	(mi)
PP8 Geomembrane/Concrete Cover	5800	1.10
Full Concrete Cover / Geomembrane	58212	11.03

Figure 5-5.—Alternative 5 risk reduction features.

6 FEASIBILITY-LEVEL COST ESTIMATES

6.1 Field costs summary

Field costs for each of the alternatives ranged between $84,000,000 and $110,000,000. Table 6-1 shows Subtotal Costs separated into each of the Phase 1 and Phase 2 risk reduction alternatives. Table 6-2 provides a breakdown of their Contract, Field, and Construction Costs. A summary of Non-contract costs is provided in Section 6.2.

Table 6-1.—Subtotal costs

	Phase	Details	Costs
Alternative 1	Phase 1	Canal Lining (Full Concrete/ Geomembrane)	$2,565,350
		Canal Lining (1/2 Concrete)	$752,800
		Canal Lining (Soil / Geomembrane)	$21,378,500
		Hazen Gage Replacement	$148,600
		Check Structures Replacement	$9,334,735
		Bango Check Gate Modifications	$976,600
		Subtotal	**$35,156,585**
	Phase 2	Pour Point 8 Improvements	$3,242,000
		TC11 Detention Pond	$6,602,520
		Mason Detention Pond	$6,655,575
		DS Pond	$1,472,160
		Subtotal	**$17,972,255**
		Alternative subtotal	**$53,128,840**

Table 6-2.—Subtotal costs (continued)

	Phase	Details	Costs
Alternative 2	Phase 1	Canal Lining (Full Concrete/ Geomembrane)	$2,565,350
		Canal Lining (1/2 Concrete)	$752,800
		Canal Lining (Soil / Geomembrane)	$21,378,500
		Hazen Gage Replacement	$148,600
		Check Structures Replacement	$9,334,735
		Bango Check Gate Modifications	$976,600
		Subtotal	**$35,156,585**
	Phase 2	Pour Point 8 Improvements	$3,242,000
		Canal Lining (Soil / Geomembrane)	$17,783,500
		TC11 Pond	$4,879,700
		Pond Mason Pond	$3,819,532
		Subtotal	**$29,724,732**
		Alternative subtotal	**$64,881,317**
Alternative 3	Phase 1	Canal Lining (Full Concrete/ Geomembrane)	$2,565,350
		Canal Lining (1/2 Concrete)	$752,800
		Canal Lining (Soil / Geomembrane)	$21,378,500
		Hazen Gage Replacement	$148,600
		Check Structures Replacement	$9,334,735
		Bango Check Gate Modifications	$976,600
		Subtotal	**$35,156,585**
	Phase 2	Pour Point 8 Improvements	$3,242,000
		Canal Lining (Soil / Geomembrane)	$29,845,500
		Subtotal	**$33,087,500**
		Alternative subtotal	**$68,244,085**

Table 6-1.—Subtotal costs (continued)

	Phase	Details	Costs
Alternative 4	**Phase 1**	Canal Lining (Full Concrete/ Geomembrane)	$27,301,400
		Canal Lining (1/2 Concrete)	$0
		Canal Lining (Soil / Geomembrane)	$0
		Hazen Gage Replacement	$148,600
		Check Structures Replacement	$9,334,735
		Bango Check Gate Modifications	$976,600
		Subtotal	**$37,761,335**
	Phase 2	Pour Point 8 Improvements	$3,848,400
		Canal Lining Full Concrete/ Geomembrane)	$28,122,200
		Subtotal	**$31,970,600**
		Alternative subtotal	**$69,731,935**

Table 6-2.—Contract, field, and construction costs

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Subtotal Costs (Phase 1 and Phase 2 Alternative Features)	$53,128,840	$64,881,317	$68,244,085	$69,731,935
Mobilization @ ±10%	$5,300,000	$6,400,000	$6,800,000	$ 6,900,000
Contract Cost Allowances ±15%	$9,571,160	$10,718,683	$11,955,915	$ 12,368,065
Contract cost (rounded)	**$68,000,000**	**$82,000,000**	**$87,000,000**	**$89,000,000**
Construction contingencies @ ±25%	$16,000,000	$21,000,000	$21,000,000	$ 21,000,000
Field cost	$84,000,000	$103,000,000	$108,000,000	$ 110,000,000
Escalation @ ±3%/yr. for 6.5 yrs	$18,000,000	$22,000,000	$23,000,000	$23,000,000
Non-contract costs[1]	$16,220,000	$17,900,000	$15,780,000	$15,390,000
Construction cost	**$118,220,000**	**$142,900,000**	**$146,780,000**	**$148,390,000**

1 Includes Escalation

6.2 Explanation of costs

***Origin and Source of the Cost Estimates* –** These estimates were prepared by the Estimating Services Group at Reclamation's Technical Service Center (Denver, Colorado). The estimates are in accordance with Reclamation Manual Directives and Standards FAC 09-01 and FAC 09-03.

***Purpose and Intended Use of the Cost Estimates* –** Feasibility-level construction costs for the Canal risk reduction project were developed by preparing estimate worksheets and assembling the worksheets in groups representing related features. The first group of estimate worksheets included Phase 1 features. The second group includes costs for the Check Structures. The third through sixth groups include costs for each of the four alternatives. As discussed earlier, the last group of cost estimate worksheets are Alternative 5 costs which are included for information purposes.

Typical production rates, typical construction practices, procurement using a request for proposals contracting method, current construction economic conditions, and site conditions (as provided) were assumed and applied to these cost estimates.

The cost estimates were prepared utilizing feasibility-level design information. These designs are at a planning stage; therefore, the resulting estimates have inherent levels of risk and uncertainty. The cost estimates are intended to be used as a basis for budget authorization, appropriation, and funding.

***Feasibility-Level Cost Estimates – Basic Scope* –** Feasibility cost estimates are based on information and data obtained during planning level investigations. These investigations provide sufficient information to permit the preparation of preliminary layouts and designs, from which approximate quantities for each kind, type, or class of material, equipment, or labor were obtained. These estimates may be used to assist in the selection of a preferred plan, to determine the economic feasibility of construction features, and to support seeking construction authorization.

***Basis of Cost Estimate* –** The feasibility estimate unit prices were developed using a semi-detailed method. Specific construction activities were identified for major cost drivers. Costs for labor, equipment, materials, and other resources were developed. Production rates, overheads, and taxes were applied to develop the applicable unit prices. Vendor quotations were obtained for major equipment, materials, supplies, and other items. Minor cost items were priced using historical bid and industry standard reference cost data.

Price Level – All unit prices are in July 2018 dollars.

Mobilization – A value of 10-percent was used for mobilization. Mobilization costs include contractor costs for mobilizing personnel, equipment, and materials to the project site for initial project setup; establishment of offices, buildings, and other necessary general facilities for the contractor's operations at the site; premiums paid for performance and payment bonds; and other miscellaneous items. The assumed 10-percent value in the cost estimates is based upon past experience of similar jobs.

Escalations – An allowance for escalation from the July 2018 unit price level to the "Notice to Proceed" milestone was included in the estimate. Based on the preliminary draft schedule, it was assumed that the Notice to Proceed milestone for construction would occur approximately in June 2022 with a midpoint of construction January 2024.

For projects that are to be developed over an extended period of time, or at some distant time in the future, it is prudent to incorporate some consideration of the time value of money. The cost estimates also include escalation during construction in the unit prices. The construction duration varies by alternative with the longest estimated to be approximately 9 years and 10 months.

Design Contingency – In accordance with *Reclamation Manual* Directive and Standard FAC 09-01 (4) (E) (1) (Reclamation 2007c), design contingencies, now referred to as Contract Cost Allowances, allow for uncertainties within the design and the respective level of detail and knowledge used to develop the estimated cost. Contract Cost Allowances are intended to account for three types of uncertainties inherent as a project advances from the planning stage through final design, which directly affects the estimated cost of the project. These include (1) minor unlisted items, (2) minor design and scope changes, and (3) minor cost estimating refinements. The *Cost Estimating Handbook*, "Appraisal Estimate" section (pages 2–7), recommends that unlisted items be at least 10 percent. A value of 15 percent was used for this EES.

Minor unlisted items that were not quantified or priced in the cost estimate include, but are not limited to, clearing and grubbing, construction access roads, erosion control; and replacing topsoil. Minor design and scope changes that may also occur include, but are not limited to, the presence of poor soil conditions that could not be used for canal embankment or geomembrane soil cover.

Allowance for Procurement Strategies – A line item allowance for procurement strategies is typically included in the feasibility cost estimates to account for additional costs when solicitations will be advertised and awarded under other than full and open competition. These include solicitations that will be set aside under socio-economic programs, along with solicitations that may limit competition or allow award to other than the lowest bid or proposal. It was assumed that each of the contracts were to be full and open contracts and therefore there were no allowances for procurement strategies.

These estimates assume a request for sealed bids will be issued. Contractors' bid would be evaluated, and their proposed costs would be compared to other proposals and to the project construction cost estimate.

Construction Contingency – Feasibility estimates include a percentage allowance for construction contingencies as a separate item to cover additional costs due to unforeseeable difficulties at the site, changed site conditions, and other difficulties encountered by the contractor and negotiated during the construction period. The allowance is based on engineering judgment of the risks of site conditions, reliability of the site data, adequacy of the projected quantities, and general knowledge of site conditions.

The estimates include a value of 25 percent for design contingencies based on past experience with similar projects.

Non-contract Costs

Non-contract costs were added into the project's cost estimate and economic cost-benefit analysis. The following non-contract cost items were reviewed for inclusion in the non-contract costs in the report:

- Water rights permits and other permits (Clean Water Act, etc.)
- Environmental monitoring (e.g., archeological-cultural resources, biological resources)
    - Pre-construction biological/cultural resource surveys
    - Revegetation/restoration of impacted habitats and other mitigation costs
- Engineering and other costs
    - Final Designs
    - Risk Assessment Update
    - Construction Support
    - Establishing Power Source
- Procurement Contract Administration
    - Contracts - Design, Construction, Utilities, Surveys, Cultural / Environmental
    - Pre-solicitation Procurement documents
    - Pre-Bid Meetings

  - TPEC Reviews
  - Post Award and Pre-Notice to Proceed
- Project management and other administrative actions
  - Planning
  - Public Outreach
  - Water District Coordination
  - Outage Coordination
- Construction Support Activities
  - Construction Management
  - Quality Assurance
  - Utility Location Survey
  - Utility Relocation
- Closeout
  - Preparation of construction reports and closeout
  - Budgets and Accounting
  - Design Operating Criteria Reports

Summary of Non-Contract Costs for each Alternative

The non-contract costs for each Alternative were estimated at 14 to 19% of the Field costs. Table 6-3 is a summary of the non-contract costs estimated by alternative.

Table 6-3.—Summary of non-contract costs for Alternatives 1-4

Alternative 1

	Engineering Design	Engineering Support and Design Data	Administration and Project Management	Construction Oversight
Contract 1 – Check Structures	$ 2,100,000	$330,000	$650,000	$1,230,000
Contract 2 – Canal Lining - Award option for specified Canal length	$ 2,290,000	$490,000	$800,000	$1,590,000
Contract 3 – Bango Check Modifications and Hazen Gage Replacement - Single award	$ 500,000	$250,000	$590,000	$550,000
Contract 4 – Detention Ponds and Gate Structures - Award options for each site	$ 1,600,000	$580,000	$890,000	$1,780,000

6 Feasibility-level cost estimates

Alternative 2

	Engineering Design	Engineering Support and Design Data	Administration and Project Management	Construction Oversight
Contract 1 – Check Structures	$ 2,100,000	$330,000	$650,000	$1,230,000
Contract 2 – Canal Lining - Award option for specified Canal length	$ 4,070,000	$580,000	$890,000	$1,780,000
Contract 3 – Bango Check Modifications and Hazen Gage Replacement - Single award	$ 500,000	$250,000	$590,000	$550,000
Contract 4 – Detention Ponds and Gate Structures - Award options for each site	$ 1,500,000	$490,000	$800,000	$1,590,000

Alternative 3

	Engineering Design	Engineering Support and Design Data	Administration and Project Management	Construction Oversight
Contract 1 – Check Structures	$ 2,100,000	$330,000	$650,000	$1,230,000
Contract 2 – Canal Lining - Award option for specified Canal length	$ 3,540,000	$1,070,000	$1,600,000	$2,870,000
Contract 3 – Bango Check Modifications and Hazen Gage Replacement - Single award	$ 500,000	$250,000	$590,000	$1,050,000
Contract 4 – Detention Ponds and Gate Structures - Award options for each site	$ -	$ -	$ -	$ -

Alternative 4

	Engineering Design	Engineering Support and Design Data	Administration and Project Management	Construction Oversight
Contract 1 – Check Structures	$ 2,100,000	$330,000	$650,000	$1,230,000
Contract 2 – Canal Lining - Award option for specified Canal length	$ 3,650,000	$1,070,000	$1,600,000	$2,870,000
Contract 3 – Bango Check Modifications and Hazen Gage Replacement - Single award	$ 500,000	$250,000	$590,000	$550,000
Contract 4 – Detention Ponds and Gate Structures - Award options for each site	$ -	$ -	$ -	$ -

6.3 Operation, maintenance, and replacement annual costs

Presented below are the annual OM&R costs for a 50-year life for the ponds and structures, and canal lining systems grouped by Alternative. These costs do not include costs for operating and maintaining the new check structures or the long-throated flume. It is assumed that TCID already has an OM&R program in place for its facilities and therefore costs to initiate such a program are not needed. The four OM&R cost categories are labor, diesel fuel, maintenance materials, and replacement. The replacement costs are based on the periodic replacement of equipment and material over the life of the project. These replacement costs are present-valued to today's dollars, and the annual equivalent cost is estimated to be consistent with the annual operations and maintenance costs. It is also assumed that the Canal will only operate approximately 80 percent of the year, based upon historical flow data from the USGS Wadsworth gaging station. The assumptions used for each of these four categories along with summary tables for each component can be found in Appendix C – Feasibility Level OM&R Quantities and Cost Estimates.

<u>Detention Pond and Gated Wasteway Structures</u>

Detention Pond Embankments

Detention ponds are created by constructing soil embankments around the perimeter of the pond area. The ponds and surrounding embankments will be dry during most of their design life and will be subject to off road vehicle use, erosion and animal damage. See drawings 29-D-FIGURE 36 through 29-D-FIGURE 38 for details of the proposed detention ponds.

The 50-year life cycle cost of the detention ponds in each alternative is shown in Table 6-4. It was assumed that each year for 50 years, 1/50 (2%) of the embankment would be replaced. Suitable equipment would be used to remove/replace embankment.

Gated Wasteway Structures

Canal flows into the detention ponds are controlled using multiple 10-feet by 10-feet slide gates supported by a reinforced concrete wasteway structure. The slide gates are power operated using an engine generator (EG) located in a controlled building adjacent to the wasteway structure.

The 50-year life cycle cost for the gated wasteway structures and supporting electrical and mechanical systems for each alternative is shown in Table 6-4. It was assumed routine O&M activities would be necessary to maintain the operation of the EG set, gates, and hoist motor. The hoist motors and drive chain equipment would be removed and replaced on a 25-year cycle.

<u>Canal Linings</u>

Geomembrane with Soil Cover

This lining method assumes the geomembrane is overlain by 18 inches of soil for protection from solar ultraviolet damage and damage from vehicles, animal traffic and vandalism. See Drawing 29-D-FIGURE 35 for details of geomembrane liner with soil cover.

The Canal prism must be maintained to convey flows. For this estimate, it was assumed that 20% of the earth cover underlain by geomembrane would be trimmed (shaped) to original condition yearly using suitable equipment. Unimproved sections of the Canal would also require cleanout; however, costs for this activity were not included because it was assumed it would be the same for each alternative.

The 50-year life cycle cost of geomembrane with soil cover in each alternative is shown in Table 6-4. It was assumed that each year for 50 years, 1/50 (2%) of the soil cover is removed and replaced and 2% of the geomembrane is repaired by patching. Suitable equipment would be used to remove/replace earth cover and geomembranes patched as specified by the manufacturer of the geomembrane.

Geomembrane with Concrete Cover

This lining method assumes the geomembrane is overlain by 3.5 inches of concrete for protection from solar ultraviolet damage and damage from vehicles, animal traffic and vandalism. See Drawing 29-D-FIGURE 33 for details of geomembrane liner with concrete cover.

The 50-year life cycle cost of geomembrane with concrete cover in each alternative is shown in Table 6-4. It was assumed that each year for 50 years, 1/50 (2%) of the concrete cover is removed and replaced and 2% of the geomembrane is repaired by patching. Suitable equipment would be used to remove/replace concrete cover between sawcuts at joints and geomembranes patched as specified by the manufacturer of the geomembrane.

Geomembrane partly covered with concrete and the remainder with soil

Some areas of the Canal would receive geomembrane partly overlain by concrete with the remainder overlain by soil as shown in Drawing 29-D-FIGURE 34. The assumptions for maintenance costs are the same for the combination as that described above for the individual components.

Summary

The total estimated OM&R costs for the detention ponds, gated wasteway structures, and lining options are presented below in Table 6-4.

Table 6-4.—Estimated project OM&R costs by category (discounted present values)

Feature	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Gated Wasteway Structures and Equipment	$1,972,000	$1,311,000	$0	$0
Canal Linings	$33,153,980	$50,522,498	$65,000,000	$38,000,000
Detention Ponds	$846,020	$477,502	$0	$0
Total	**$35,972,000**	**$52,311,000**	**$65,000,000**	**$38,000,000**

7 ECONOMIC ANALYSIS

7.1 Purpose

The purpose of the economic analysis presented in this section is to provide a consistent basis for comparing the proposed risk reduction alternatives described in this EES. The economic analysis will compare the benefits and costs of each of the risk reduction alternatives relative to the baseline conditions to determine the least cost (cost effective) risk reduction alternative.

A cost effectiveness analysis is distinctly different from a benefit cost analysis. The economics discipline has defined cost effectiveness as a method that seeks to identify the least-cost way to achieve a given objective, without considering whether there is any economic justification for achieving that objective.

7.2 Summary of results

Table 7-1 summarizes the results of the cost effectiveness analysis. Alternative 1 was found to be the least cost alternative after comparing the present value of the total projects costs and the present value of the total project benefits for each alternative.

Table 7-1.—Summary of result by alternative (discounted present values)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Costs				
Construction (PV)	$80,283,030	$97,353,008	$100,342,572	$102,889,794
OM&R (PV)	$35,972,000	$52,311,000	$65,000,000	38,000,000
Costs Total	**$116,255,030**	**$149,664,008**	**$165,342,572**	**$140,889,794**
Benefits				
Irrigation Benefit value (PV)	$1,899,923	$3,841,709	$4,804,758	$4,804,758
M&I Benefit value (PV)	$3,409	($7,852)	$1,230	$1,230
Hydropower - Benefit Value (PV)	$106,222	$39,285	$84,735	$84,735
Recreation Benefit value (PV)	$1,010,849	$2,296,908	$2,759,189	$2,759,189
W&W Benefit value (PV)	$28,309	$56,905	$71,349	$71,349
Benefits Total	**$3,048,712**	**$6,226,955**	**$7,721,261**	**$7,721,261**
Total Costs Less Benefits	**$113,206,318**	**$143,437,053**	**$157,621,311**	**$133,168,533**

The following sections outline the approach used to estimate the benefits and costs summarized above.

7.3 Water operations modeling and alternatives

The economic analysis is dependent upon the water operations modeling for each of the risk reduction alternatives including the baseline conditions. A *Water Operations Planning Study Technical Memorandum (DOI-BOR-LBAO, July 2018)* [15] was completed by LBAO that quantified water availability and reliability for the risk reduction alternatives as well as baseline conditions. This memorandum is incorporated herein by reference (Water Operations Planning Study).

The Water Operations Planning Study discusses the assumptions and modeling results for the alternatives plus baseline conditions which were the basis for the economics analysis.

The Water Operations Planning Study estimated demands for water supply (irrigation, municipal and industrial (M&I), wetlands and wildlife (W&W), reservoir elevation, and hydropower generation). A rough linear approximation of the demand for surface water was developed by creating two separate demand sets: an initial demand set representative of water user demands in 2018 and a demand set representative of water user demands in 2042. For the purposes of this EES, the demand sets were held constant for each alternative analyzed and a linear interpolation between the sets is used to approximate the annual impacts of the alternatives. The linear interpolation approach assumes that the rate of change between the demand sets is constant between the initial demand set and the demands projected at 2042.

The economic analysis used a 50-year period to estimate benefits and costs. Water demands and generation beyond 2042 were held constant at the 2042 projected level to the end of the 50-year period of analysis.

7.4 Benefits analysis by alternative

Several economic analyses have been conducted recently in this area including the Boca Dam Safety of Dams Modification and the 2017 CAS. This analysis was conducted using some of the economic data (e.g. the per-unit benefit values) that were estimated for these studies (the details of these calculations are described in Appendix D). The per-unit benefit values for each resource (i.e., irrigation, recreation, etc.) were combined with the water deliveries and hydropower impacts for each alternative as measured in the Water Operations Planning Study. The costs for each alternative were subtracted from the estimated benefits for each alternative to determine the least cost risk reduction alternative. The annual economic benefits were used to calculate the present value of these benefits using 50-year period of analysis and the current Planning Rate (2.875 percent).

The following describes how each of the benefit categories were estimated. Note benefits for Alternative 4 are the same as for Alternative 3.

7.4.1 Irrigation per-unit benefit values

The net irrigation per-unit benefit values by water user group are reported in table 7-2. The weighted average net benefits are shown in both $/acre and $/acre foot in columns 6 and 7 respectively. These results were estimated for Boca Safety of Dams study but are appropriate for this analysis. The details of these calculations are described in Appendix D.

Table 7-2.—Net irrigation per-unit benefits

<table>
<tr><th>Water User Group (1)</th><th>Representative Farm (2)</th><th>Weighted Avg. Gross Benefit ($/acre) (3)</th><th>Avg. Annual Water Delivery Costs ($/acre) (4)</th><th>Weighted Avg. Net Benefit ($/acre) (5)</th><th>Weighted Avg. Water Demand (ac-ft /acre) (6)</th><th>Weighted Avg. Net Benefit ($/ac-ft) (7)</th></tr>
<tr><td rowspan="2">Truckee Meadows Ag</td><td>Alfalfa/Corn Silage</td><td rowspan="2">$128.02</td><td rowspan="2">$20.73</td><td rowspan="2">$107.29</td><td rowspan="2">3.71</td><td rowspan="2">$28.92</td></tr>
<tr><td>Irrigated Pasture</td></tr>
<tr><td rowspan="2">Lower Truckee Ag</td><td>Alfalfa/Corn Silage</td><td rowspan="2">$320.66</td><td rowspan="2">$20.73</td><td rowspan="2">$299.93</td><td rowspan="2">4.41</td><td rowspan="2">$68.01</td></tr>
<tr><td>Irrigated Pasture</td></tr>
<tr><td rowspan="2">Carson Division</td><td>Alfalfa/Corn Silage</td><td rowspan="2">$465.15</td><td rowspan="2">$79.46</td><td rowspan="2">$385.69</td><td rowspan="2">3.56</td><td rowspan="2">$108.34</td></tr>
<tr><td>Irrigated Pasture</td></tr>
<tr><td rowspan="2">Truckee Division</td><td>Alfalfa/Corn Silage</td><td rowspan="2">$368.79</td><td rowspan="2">$79.46</td><td rowspan="2">$289.33</td><td rowspan="2">4.50</td><td rowspan="2">$64.30</td></tr>
<tr><td>Irrigated Pasture</td></tr>
<tr><td rowspan="2">FPST</td><td>Alfalfa/Corn Silage</td><td rowspan="2">$450.75</td><td rowspan="2">$79.46</td><td rowspan="2">$371.29</td><td rowspan="2">3.50</td><td rowspan="2">$106.08</td></tr>
<tr><td>Irrigated Pasture</td></tr>
<tr><td>PLPT AG</td><td>Alfalfa/Corn Silage</td><td>$440.93</td><td>$0</td><td>$440.93</td><td>4.14</td><td>106.50</td></tr>
</table>

7.4.1.1 Irrigation benefits – by Alternative

Table 7-3 shows the initial and future water demand and the estimated linear rate of change based on the hydrology modeling for each alternative. These values were used to derive the annual water demands for the 50-year period of analysis. The per-unit net irrigation benefits shown in table 7-2 are multiplied by the annual water demands for the 50-year period of record. The present value of the annual stream of benefits for the 50-year period of record are shown in table 7-4.

Table 7-3.—Linear interpolation of the irrigation demands – by alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Water User Group	**Demand Set**	**Initial**	**Future**	**Initial**	**Future**	**Initial**	**Future**
Truckee Meadows Ag.	Impact to Irrigation Water Supply (ac-ft)	*0.00*	*0.49*	-0.98	-0.49	0.00	0.08
	Linear Interpolation Annual Rate of Change	*0.02*		0.02		0.00	
Lower Truckee Ag	Impact to Irrigation Water Supply (ac-ft)	*0.00*	*0.00*	-0.03	-0.03	0.00	0.00
	Linear Interpolation Annual Rate of Change	*0.00*		0.00		0.00	
Carson Div	Impact to Irrigation Water Supply (ac-ft)	*628.51*	*394.30*	1319.71	768.56	1620.16	981.31
	Linear Interpolation Annual Rate of Change	*-7.81*		-18.37		-21.30	
Truckee Div	Impact to Irrigation Water Supply (ac-ft)	*6.93*	*5.10*	8.89	5.67	13.46	9.67
	Linear Interpolation Annual Rate of Change	*-0.06*		-0.11		-0.13	
FPST	Impact to Irrigation Water Supply (ac-ft)	*43.69*	*27.41*	91.74	53.43	112.63	68.22
	Linear Interpolation Annual Rate of Change	*-0.54*		-1.28		-1.48	
PLPT AG	Impact to Irrigation Water Supply (ac-ft)	*0.35*	*0.48*	-0.97	-3.59	-0.71	-3.28
	Linear Interpolation Annual Rate of Change	*0.00*		-0.09			-0.09
Total Irrigation-use Impacts		*679.48*	*427.82*	1418.36	823.51	1745.54	1055.97

Table 7-4.—Irrigation economic impacts by alternative (nominal and discounted present values of the annual stream of benefits for the 50-year period or record)

Water User Group	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
Truckee Meadows Ag.	Nominal Economic Impact	$714	-$977	$0
	Present Value Economic Impact	$312	-$604	$0
Lower Truckee Ag	Nominal Economic Impact	$0	-$109	$0
	Present Value Economic Impact	$0	-$59	$0
Carson Div	Nominal Economic Impact	$3,049,885	$6,137,433	$7,704,040
	Present Value Economic Impact	$1,764,368	$3,588,155	$4,479,102
Truckee Div	Nominal Economic Impact	$23,307	$27,097	$44,126
	Present Value Economic Impact	$13,170	$15,670	$25,081
FPST	Nominal Economic Impact	$209,361	$420,139	$528,000
	Present Value Economic Impact	$121,061	$245,687	$306,964
PLPT AG	Nominal Economic Impact	$1,864	-$15,086	-$13,701
	Present Value Economic Impact	$1,011	-$7,139	-$6,388
	Grand Total Nominal Irrigation Use Economic Impacts	$3,285,131	$6,568,497	$8,262,495
	Grand Total PV Irrigation Use Economic Impacts	$1,899,923	$3,841,709	$4,804,758

7.4.2 Municipal and industrial

This report uses the Willingness to Pay (WTP) values that were previously determined for the Boca SOD study. The WTP can be defined as the dollar amount that an entity is willing to pay or give up to obtain an ac-ft of M&I water supply. Previous studies used actual observed market behavior (i.e., water rights transactions) to derive the value of M&I water supply. The details of this analysis are found in Appendix D. The per-unit-values used in this analysis are shown in table 7-5.

Table 7-5.—Net M&I per-unit benefits

Water User Group	Net Present Value of M&I Water Supply	Equivalent Annual Net Benefit
Truckee Meadows M&I	$5,164.12	$147.95
Middle Truckee Water Users (Vista to Derby)	$5,164.12	$147.95
Truckee Carson Irrigation District	$1,366.33	$39.27
Fallon Paiute-Shoshone Tribe	$1,366.33	$39.27
Pyramid Lake Paiute Tribe	$1,366.33	$39.27

7.4.2.1 M&I benefits – by Alternative

Table 7-6 shows the initial and future water demand and the estimated linear rate of change based on the hydrology modeling for each Alternative. These values were used to derive the annual water demands by year for the 50-year period of analysis. The per-unit net benefit M&I benefits shown in Table 7-5 are multiplied by the annual changes in water demands for the 50-year period of record. The nominal and present value of the annual stream of benefits for the 50-year period of record, for each alternative, are shown in table 7-7.

Table 7-6.—Linear interpolation of the M&I demands – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Water User Group	Demand Set	Initial	Intermediate	Initial (2018)	Intermediate (2042)	Initial (2018)	Intermediate (2042)
Truckee Meadows M&I Use	Impact to M&I Water Supply (ac-ft)	0.00	0.65	-1.30	-0.65	0.00	0.11
	Linear Interpolation Annual Rate of Change	0.02		0.02		0.00	
Truckee Meadows Water Authority (TMWA)	Impact (Ground Water Pumping) to M&I Water Supply (ac-ft)	0.32	-0.54	7.61	6.27	7.77	5.99
	Linear Interpolation Annual Rate of Change	-0.03		-0.04		-0.06	
	Impact (conservation) to M&I Water Supply (ac-ft)	0.02	0.80	0.01	-1.89	-0.03	0.69
	Linear Interpolation Annual Rate of Change	0.03		-0.06		0.02	
Middle Truckee	Impact to M&I Water Supply (ac-	0.00	0.00	0.00	0.00	0.00	0.00

Table 7-6.—Linear interpolation of the M&I demands – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Water User Group	**Demand Set**	**Initial**	**Intermediate**	**Initial (2018)**	**Intermediate (2042)**	**Initial (2018)**	**Intermediate (2042)**
M&I	ft)						
	Linear Interpolation Annual Rate of Change	0.00		0.00		0.00	
City of Fernley	Impact (Ground Water Pumping) to M&I Water Supply (ac-ft)	0.00	-34.30	0.00	-49.72	0.00	-83.13
	Linear Interpolation Annual Rate of Change	-1.14		-1.66		-2.77	
	Impact to M&I Water Supply (ac-ft)	0.00	0.00	0.00	0.00	0.00	0.00
	Linear Interpolation Annual Rate of Change	0.00		0.00		0.00	
Truckee Div M&I-Use & Lyon County	Impact to M&I Water Supply (ac-ft)	0.00	0.00	0.00	0.00	0.00	0.00
	Linear Interpolation Annual Rate of Change	0.00		0.00		0.00	
Carson Div M&I Use & City of Fallon	Impact to M&I Water Supply (ac-ft)	0.00	0.00	0.00	0.00	0.00	0.00
	Linear Interpolation Annual Rate of Change	0.00		0.00		0.00	
PLPT	Impact to M&I Water Supply (ac-ft)	0.00	0.00	0.00	0.00	0.00	0.00
	Linear Interpolation Annual Rate of Change	0.00		0.00		0.00	

Table 7-7.—M&I economic impacts – by Alternative (nominal and present values of the annual stream of benefits for the 50-year period of record)

Water User Group	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
Truckee Meadows M&I Use	Nominal Economic Impact	$3,063	-$6,586	$0
	Present Value Economic Impact	**$1,339**	**-$3,892**	**$0**
TMWA (ground water pumping)	Nominal Economic Impact	$0	$0	$0
	Present Value Economic Impact	**$0**	**$0**	**$0**
TMWA (conservation)	Nominal Economic Impact	$4,706	-$9,081	$2,861
	Present Value Economic Impact	**$2,070**	**-$3,960**	**$1,230**
Middle Truckee M&I	Nominal Economic Impact	$0	$0	**0**
	Present Value Economic Impact	**$0**	**$0**	**$0**
City of Fernley	Nominal Economic Impact	$0	$0	$0
	Present Value Economic Impact	**$0**	**$0**	**$0**
Truckee Div M&I-Use & Lyon County	Nominal Economic Impact	$0	$0	$0
	Present Value Economic Impact	**$0**	**$0**	**$0**
Carson Div M&I Use & City of Fallon	Nominal Economic Impact	$0	$0	$0
	Present Value Economic Impact	**$0**	**$0**	**$0**
PLPT	Nominal Economic Impact	$0	$0	$0
	Present Value Economic Impact	**$0**	**$0**	**$0**
	Grand Total Nominal M&I Use Economic Impacts	$7,769	-$15,667	$2,861
	Grand Total PV M&I Use Economic Impacts	**$3,409**	**-$7,852**	**$1,230**

7.4.3 Wetland & Wildlife water supply benefits

This report uses the WTP values that were estimated for the Boca SOD study which were based on actual observed market values. Project water rights have been purchased by various entities that have converted water rights from irrigation water use to the purpose of Wetland and Wildlife (W&W) at a rate of 2.99 ac-ft per acre. The water rights transactions examined included transactions of Newlands Project water that were readily identified as being used for W&W water supply and excluded transactions that were clearly used for purposes other than W&W. These data and the estimation process are described in detail in Appendix D. The WTP estimates are provided in table 7-8.

Table 7-.8.—W&W per-unit benefits

Water User Group	Net Present Value of W&W Water Supply	Equivalent Annual Net Benefit
Newlands Project W&W	$2,825.27	$81.23

7.4.3.1 W&W benefits – by Alternative

Table 7-9 shows the initial and future water demand and the estimated linear rate of change based on the hydrology modeling for each alternative. These values were used to derive the annual water demands by year for the 50-year period of analysis. The per-unit net benefit W&W benefits shown in table 7-8 are multiplied by the annual changes in water demands for the 50-year period of record. The nominal and present value of the annual stream of benefits for the 50-year period are shown in table 7-10.

Table 7-9.—Linear interpolation W&W water demands – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Water User Group	**Demand Set**	**Initial**	**Intermediate**	**Initial**	**Intermediate**	**Initial**	**Intermediate**
Newlands Project W&W	Impact to W&W Water Supply (ac-ft)	13.02	12.66	27.34	24.67	33.57	31.50
	Linear Interpolation Annual Rate of Change	-0.0100		-0.0900		-0.0700	

Table 7-10.—W&W Economic Benefits – by Alternative (nominal and present values of the annual stream of benefits for the 50-year period of record)

Water User Group	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
Newland Project W&W Use	W&W-use Water Supply Impacts	N/A	N/A	N/A
	Nominal Economic Impact	$52,050	$103,491	$130,456
	Present Value Economic Impact	**$28,309**	**$56,905**	**$71,349**
	Grand Total Nominal W&W Use Economic Impacts	$52,050	$103,491	$130,456
	Grand Total PV W&W Use Economic Impacts	**$28,309**	**$56,905**	**$71,349**

7.4.4 Recreation

Recreational use at Lahontan Reservoir was estimated based on water levels for each alternative. This analysis used a regression analysis conducted for previous studies in the area to estimate visitation based on estimated water levels. The benefit values per visit estimated for previous studies are shown in table 7-11. These recreation values were based on a benefit transfer approach. Both the regression analysis and the benefit values per visit are described in Appendix D. The net recreation benefit value related to a change in water level for each alternative were calculated as the product of the estimated visitation relationship and the benefit value per recreation visit.

Table 7-11.—Recreation per-unit benefit values

Recreation Site	Change in Annual Visitation Associated with a One Foot Change in Reservoir Elevation	Avg. Benefit per Visitor ($/visit)	Economic Value of a One Foot Change in Reservoir Elevation
Lahontan Reservoir	6,293	$9.28	$58,399

7.4.4.1 Recreation benefits by Alternative

Table 7-12 shows the initial and future estimated visitation based on modeled reservoir elevations. The visitation estimates are based on a linear rate of change between the initial and future reservoir levels for each alternative. These values were used to derive the annual visitation by year for the 50-year period of analysis. The per-unit net recreation benefits values shown in table 7-11 are multiplied by the annual estimated visitation for the 50-year period of record. The results of this calculation are shown in table 7-13.

Table 7-12.—Linear interpolation of recreation reservoir visitation – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Recreati on Site	**Demand Set**	**Visits Initial**	**Visits Intermediate**	**Visits Initial (2018)**	**Visits Intermediate (2042)**	**Visits Initial (2018)**	**Visits Intermediate (2042)**
Lahontan Reservoir	Impact (visits) to Lahontan Reservoir WL	5,287.00	3,007.00	12,072	6,786	14,452.40	8,191.00
	Linear Interpolation Annual Rate of Change	-76.00		-176.20		-208.71	

Table 7-13.—Recreation economic benefits – by Alternative (nominal and present values of the annual stream of benefits for the 50-year period of record)

Recreation site	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
Lahontan Reservoir	Nominal Economic Impact	$1,723,203	$3,909,042	$4,701,264
	Present Value Economic Impact	**$1,010,849**	**$2,296,908**	**$2,759,189**
	Grand Total Nominal W&W Use Economic Impacts	$1,723,203	$3,909,042	$4,701,264
	Grand Total PV W&W Use Economic Impacts	**$1,010,849**	**$2,296,908**	**$2,759,189**

7.4.5 Hydropower

This analysis uses the monthly hydropower benefits estimates, shown in table 7-14, that were derived for previous studies in the area. These estimates are equivalent to monthly gross hydropower benefits. The derivation methods used to estimate these benefits are explained in detail in is Appendix D.

Table 7-14.—Monthly wholesale electricity prices

Month	Weighted Avg. Net Benefit ($/MW)
1	$34.29
2	$38.09
3	$31.77
4	$36.66
5	$37.20
6	$42.69
7	$44.93
8	$43.19
9	$42.09
10	$38.57
11	$38.43
12	$38.93

7.4.5.1 Hydropower benefits – by Alternative

The monthly hydropower generation at Lahontan and Stampede (shown in tables 7-15 and 7-16 respectively) were estimated based on the initial and future hydrologic conditions. Monthly hydropower generation were based on a linear rate of change between the initial and future generation data for each alternative. The per-unit monthly hydropower benefit values shown in table 7-14 are multiplied by the monthly generation for the 50-year period of record. The results of these calculations are shown for Lahontan and Stampede in tables 7-17 and 7-18 respectively.

Table 7-15.—Linear interpolation hydropower generation Lahontan – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Month	**Demand Set**	**Initial (MW)**	**Intermediate (MW)**	**Initial (MW)**	**Intermediate (MW)**	**Initial (MW)**	**Intermediate (MW)**
1	Hydropower Generation Impact	0.16	0.01	0.17	0.02	0.17	0.03
	Linear Interpolation Annual Rate of Change	-0.0100		0.0000		-0.0000	
2	Hydropower Generation Impact	0.02	0.01	0.07	0.01	0.10	0.02
	Linear Interpolation Annual Rate of Change	0.0000		0.0000		0.0000	
3	Hydropower Generation Impact	0.29	0.00	0.44	0.00	0.50	0.02
	Linear Interpolation Annual Rate of Change	-0.0100		-0.0100		-0.0200	

Table 7-15.—Linear interpolation hydropower generation Lahontan – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Month	Demand Set	Initial (MW)	Intermediate (MW)	Initial (MW)	Intermediate (MW)	Initial (MW)	Intermediate (MW)
4	Hydropower Generation Impact	0.93	0.22	1.58	0.38	1.98	0.45
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0400		-0.0500	
5	Hydropower Generation Impact	1.18	0.51	2.28	0.97	2.71	1.21
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0400		-0.0500	
6	Hydropower Generation Impact	0.95	0.67	2.06	1.33	2.45	1.63
	Linear Interpolation Annual Rate of Change	-0.0100		-0.0200		-0.0300	
7	Hydropower Generation Impact	1.24	0.74	2.71	1.73	3.23	2.06
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0300		-0.0400	
8	Hydropower Generation Impact	1.29	0.78	3.03	1.87	3.54	2.33
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0400		-0.0400	
9	Hydropower Generation Impact	1.51	.88	3.79	2.17	4.48	2.59
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0500		-0.0600	
10	Hydropower Generation Impact	1.93	1.00	5.10	2.37	6.09	2.34
	Linear Interpolation Annual Rate of Change	-0.0300		-0.0900		-0.1300	
11	Hydropower Generation Impact	1.53	0.84	3.57	2.05	4.09	0.96
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0500		-0.1000	
12	Hydropower Generation Impact	1.05	0.35	1.88	0.84	6.09	2.92
	Linear Interpolation Annual Rate of Change	-0.0200		-0.0300		-0.1100	
Average Monthly Impacts	Hydropower Generation Impact	1.01	0.50	2.22	1.15	2.95	1.38
Total Annual Impacts	Hydropower Generation Impact	**12.07**	**5.99**	**26.66**	**13.74**	**35.25**	**16.56**

Table 7-16.—Hydropower generation Stampede – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Month	Demand Set	Initial (MW)	Intermediate (MW)	Initial (MW)	Intermediate (MW)	Initial (2018) (MW)	Intermediate (2042) (MW)
1	Hydropower Generation Impact	4.61	-10.16	-26.63	-24.02	0.00	-26.05
	Linear Interpolation Annual Rate of Change	-0.6200		0.1100		-1.0900	
2	Hydropower Generation Impact	-2.86	-22.20	-37.17	-33.49	0.00	-34.00
	Linear		-0.8100				

Table 7-16.—Hydropower generation Stampede – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Month	**Demand Set**	**Initial (MW)**	**Intermediate (MW)**	**Initial (MW)**	**Intermediate (MW)**	**Initial (2018) (MW)**	**Intermediate (2042) (MW)**
	Interpolation Annual Rate of Change			0.1500		-1.4200	
3	Hydropower Generation Impact	6.04	-40.07	-38.23	-51.84	0.00	-46.29
	Linear Interpolation Annual Rate of Change	-1.9200		-0.5700		-1.9300	
4	Hydropower Generation Impact	6.82	-37.39	-16.53	-35.11	0.00	-42.20
	Linear Interpolation Annual Rate of Change	-1.8400		-0.7700		-1.7600	
5	Hydropower Generation Impact	6.44	183.97	57.32	202.15	0.00	221.43
	Linear Interpolation Annual Rate of Change	7.4000		6.0300		9.2300	
6	Hydropower Generation Impact	-8.87	149.51	-23.79	160.90	0.00	154.66
	Linear Interpolation Annual Rate of Change	6.6000		7.7000		6.4400	
7	Hydropower Generation Impact	-8.08	-45.81	-26.41	-39.72	-0.06	-44.64
	Linear Interpolation Annual Rate of Change		-1.5700	-0.5500		-1.8600	
8	Hydropower Generation Impact	1.42	-11.24	-16.29	-17.91	0.00	-18.82
	Linear Interpolation Annual Rate of Change		-0.5300	-0.0700		-0.7800	
9	Hydropower Generation Impact	1.05	-50.92	-14.13	-57.82	0.00	-66.70
	Linear Interpolation Annual Rate of	-2.1700		-1.8200		-2.7800	

Table 7-16.—Hydropower generation Stampede – by Alternative

		Alternative 1		Alternative 2		Alternative 3 and 4	
Month	**Demand Set**	**Initial (MW)**	**Intermediate (MW)**	**Initial (MW)**	**Intermediate (MW)**	**Initial (2018) (MW)**	**Intermediate (2042) (MW)**
	Change						
10	Hydropower Generation Impact	5.50	85.14	20.08	63.85	0.00	71.50
	Linear Interpolation Annual Rate of Change	3.3200		1.8200		2.9800	
11	Hydropower Generation Impact	-0.85	-0.93	4.30	-1.30	0.00	-3.86
	Linear Interpolation Annual Rate of Change	0.0000		-0.2300		-0.1600	
12	Hydropower Generation Impact	-0.11	-75.58	-23.74	-89.06	0.00	-91.55
	Linear Interpolation Annual Rate of Change	-3.1400		-2.7200		-3.8100	
Average Monthly Impacts	Hydropower Generation Impact	0.92	10.36	-11.77	6.39	0.00	6.12
Total Annual Impacts	Hydropower Generation Impact	11.10	124.30	-141.23	76.62	-0.06	**73.48**

Table 7-17.—Hydropower economic benefits Lahontan – by Alternative (nominal and discounted values of the annual stream of benefits for the 50-year period of record)

Month	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
1	Nominal Economic Impact	-$72	$294	$294
	Present Value Economic Impact	**-$2**	**$160**	**$160**
2	Nominal Economic Impact	$30	$127	$195
	Present Value Economic Impact	**$16**	**$69**	**$106**
3	Nominal Economic Impact	$127	$365	$130
	Present Value Economic Impact	**$103**	**$233**	**$140**
4	Nominal Economic Impact	$944	$1,369	$1,731
	Present Value Economic Impact	**$591**	**$902**	**$1,138**
5	Nominal Economic Impact	$1,427	$3,465	$3,112
	Present Value Economic Impact	**$854**	**$1,959**	**$1,889**
6	Nominal Economic Impact	$1,577	$3,515	$3,910
	Present Value Economic Impact	**$902**	**$1,998**	**$2,259**
7	Nominal Economic Impact	$1,851	$4,691	$5,402
	Present Value Economic Impact	**$1,101**	**$2,690**	**$3,124**
8	Nominal Economic Impact	$1,890	$4,759	$5,862

Table 7-17.—Hydropower economic benefits Lahontan – by Alternative (nominal and discounted values of the annual stream of benefits for the 50-year period of record)

Month	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
	Present Value Economic Impact	**$1,119**	**$2,768**	**$3,366**
9	Nominal Economic Impact	$2,313	$5,792	$6,805
	Present Value Economic Impact	**$1,346**	**$3,369**	**$3,964**
10	Nominal Economic Impact	$2,521	$6,244	$6,550
	Present Value Economic Impact	**$1,493**	**$3,762**	**$4,095**
11	Nominal Economic Impact	$2,148	$4,865	$3,873
	Present Value Economic Impact	**$1,248**	**$2,846**	**$2,517**
12	Nominal Economic Impact	$1,235	$2,446	$7,417
	Present Value Economic Impact	**$754**	**$1,453**	**$4,486**
	Total Lahontan Hydropower Impact (Nominal)	**$15,990**	**$37,932**	**$45,282**
	Total Lahontan Hydropower Impact (PV)	**$9,524**	**$22,208**	**$27,243**

Table 7-18.—Hydropower economic benefits Stampede – by Alternative (nominal and discounted values of the annual stream of benefits for the 50-year period)

Month	Impacts	Alternative 1	Alternative 2	Alternative 3 and 4
1	Nominal Economic Impact	-$14,098	-$41,750	-$38,686
	Present Value Economic Impact	**-$5,336**	**-$23,046**	**-$16,918**
2	Nominal Economic Impact	-$37,374	-$64,885	-$55,982
	Present Value Economic Impact	**-$16,915**	**-$35,800**	**-$24,482**
3	Nominal Economic Impact	-$53,546	-$79,465	-$63,462
	Present Value Economic Impact	**-$22,412**	**-$41,120**	**-$27,753**
4	Nominal Economic Impact	-$57,306	-$59,523	-$66,780
	Present Value Economic Impact	**-$23,749**	**-$29,209**	**-$29,204**
5	Nominal Economic Impact	$296,893	$338,775	$355,374
	Present Value Economic Impact	**$131,094**	**$159,333**	**$155,413**
6	Nominal Economic Impact	$272,673	$289,435	$284,546
	Present Value Economic Impact	**$117,259**	**$121,251**	**$124,438**
7	Nominal Economic Impact	-$91,171	-$84,916	-$86,624
	Present Value Economic Impact	**-$41,776**	**-$43,358**	**-$37,896**
8	Nominal Economic Impact	-$20,635	-$38,311	-$34,867
	Present Value Economic Impact	**-$8,703**	**-$20,444**	**-$15,248**
9	Nominal Economic Impact	-$92,316	-$109,020	-$121,106
	Present Value Economic Impact	**-$40,139**	**-$50,795**	**-$52,963**
10	Nominal Economic Impact	$143,142	$111,379	$118,962
	Present Value Economic Impact	**$63,711**	**$52,769**	**$52,025**
11	Nominal Economic Impact	-$1,638	-$891	-$6,364
	Present Value Economic Impact	**-$888**	**$476**	**-$2,783**
12	Nominal Economic Impact	-$126,738	-$155,803	-$153,515
	Present Value Economic Impact	**-$55,448**	**-$72,982**	**-$67,136**
	Total Stampede Hydropower Impact (Nominal)	**$217,886**	**$105,025**	**$131,496**
	Total Stampede Hydropower Impact (PV)	**$96,698**	**$17,077**	**$57,492**

7.5 Costs

The treatment of inflation and escalation are important considerations in economic and engineering analyses. The economists and engineers may approach the treatment of inflation and escalation differently based on the objectives and criteria of the analyses. The following discusses these topics based first on engineering objectives and criteria and second based on economics.

Cost estimates from an engineering standpoint are required to plan, seek authorization and appropriations, design, construct, and operate and maintain Reclamation's projects. The treatment of inflation and escalation is an important consideration for cost engineers when estimating feasibility level estimates for authorization and appropriations. Improperly accounting for inflation in the cost estimates used for seeking project funding may lead to cost overruns.

According to the U.S. Department of the Interior Agency Specific Procedures (DOI ASP), 707 Departmental Manual 1 Handbook, the prices of goods and services used in economic evaluations should reflect real or constant prices which exclude inflation. The cost estimate used for purposes of this economic analysis are not escalated for inflation. The annual construction cost estimates are shown in table 7-19. The present value of the OM&R cost estimates are shown in table 7-20.

Table 7-19.—Annual construction cost estimates by year of expenditure (un-escalated)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
2018	$0	$0	$0	$0
2019	$0	$0	$0	$0
2020	$0	$0	$0	$0
2021	$0	$0	$0	$0
2022	$23,300,000	$23,300,000	$22,800,000	$50,200,000
2023	$15,000,000	$23,900,000	$23,100,000	$11,700,000
2024	$22,100,000	$22,100,000	$23,900,000	$11,600,000
2025	$10,000,000	$24,900,000	$21,300,000	$14,700,000
2026	$2,900,000	$2,900,000	$15,500,000	$14,600,000
2027	$2,900,000	$2,900,000	$2,900,000	$8,600,000
2028	$4,000,000	$2,900,000	$2,900,000	$2,900,000

Table 7-19.—Annual construction cost estimates by year of expenditure (un-escalated)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
2029	$8,700,000	$4,000,000	$2,900,000	$2,900,000
2030	$7,200,000	$4,400,000	$4,000,000	$3,900,000
2031	$800,000	$5,700,000	$800,000	$1,000,000
2032	$0	$0	$0	$0
2033	$0	$0	$0	$0

Table 7-20.—Estimated present value of OM&R costs by Alternative

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Total	$35,972,000	$52,311,000	$65,000,000	$38,000,000

8 CONSTRUCTION CONSIDERATIONS

A summary level construction schedule was developed for the proposed work by alternatives and is provided in figures 8-1 through 8-5. The longest overall construction duration for the project features in Phase 1 and Phase 2 activities spans approximately 9 years and 10 months. The construction schedule was set using an assumed award date of June 1, 2021. The award date was determined by allowing 2 years for the funding and the final design process to be completed. Utilizing this award date, the completion dates for each alternative are listed in the table below.

Table 8-1.—Award and completion dates by Alternative

	Award Date	Completion Date	Duration
Alternative 1	Jun-21	Aug-30	9 Years 2 Months
Alternative 2	Jun-21	Oct-30	9 Years 4 Months
Alternative 3	Jun-21	Apr-31	9 Years 10 Months
Alternative 4	Jun-21	Apr-31	9 Years 10 Months

As the construction schedule was being developed, a constraint for the duration not to exceed 10-years was imposed. Yearly spending or budget caps were developed after the construction schedule was developed. The construction schedule was based on a logical sequencing of work activities and interdependencies between features. The durations used for activities in the schedule were based on past performance of similar work for Reclamation projects and based on information from the construction industry. The durations incorporate time for weather delays and normal equipment breakdowns. As the preliminary designs and concepts are developed, the activity durations will be somewhat better defined. Typical construction protocols will be employed. Access, staging, and storage areas will be identified for the particular construction work areas or pieces. Winter construction techniques will be required.

The construction schedule was developed with the assumption that all in-canal construction activities would be completed during Canal outages. Although the Canal is operated to meet demands based on OCAP requirements and does not have regularly occurring outages, for purposes of this study, outages were assumed to occur each year for 5 months during the winters. Canal improvement work would be completed first. Canal work has been divided into work that can be accomplished in 3 ½ to 4 ½ month sections. Construction of the check structures would follow. It was assumed that check structure gate installation and testing could occur while the Canal is operable. The Hazen Gage station removal and replacement occurs at the end of the construction work. It has been assumed that the project will have one prime contractor and several specialty subcontractors to complete the various construction activities concurrently.

Activities in the construction schedule were assigned to a calendar. Most construction activities occur based on a normal five-day work week with no work on holidays. Submittals and fabrication activities are assumed to span a 7-day week, so the durations projected for these activities are calendar days, instead of the “work days” that are used for most other activities.

Costs for construction activities assumed that there would be four contracts awarded for this project. Each contract would be structured with the flexibility of awarding contract options that were based on the amount of work that could be completed during a Canal outage. The four contracts and options are:

Contract 1: Check Structures - Award option for each structure

Contract 2: Canal Lining - Award option for specified Canal length

Contract 3: Bango Check Modifications and Hazen Gage Replacement - Single award

Contract 4: Detention Ponds and Gate Structures - Award options for each site

Structuring the contracts in this manner allows for incremental construction funding and for the work to be completed within the assumed 10-year construction window.

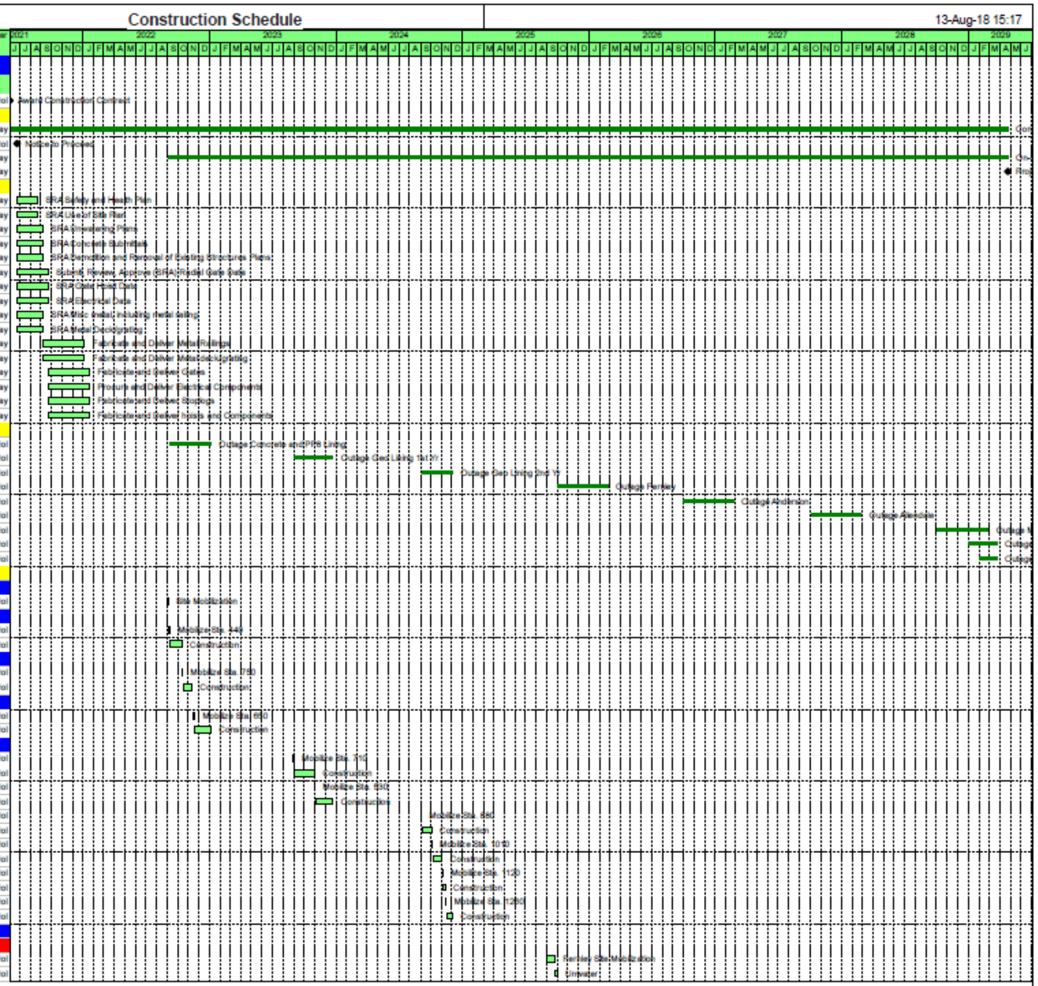
Abbreviations used in the schedule include:

Alt	Alternative
SRA	Submit, review, and approve
GEO	Geomembrane
MISC	Miscellaneous
PP8	Pour Point Eight
Sta.	Station
YR	Year

Overall, the construction schedules presented here provide one scenario of many possible scenarios to complete the project. The schedule will be further developed and the construction contract award date will be adjusted during or after the final design phase of the project.

Figure 8-1. Truckee Canal Corrective Action Phase 1

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
Truckee Canal Check Structure Replacement Jun 2018 Phase 1						
CANAL WORK						
1000	Award Construction Contract	0d	03-Jun-21*		1787d	5 Day w/Hol
General						
G-1010	Contract Duration	2882d	03-Jun-21	23-Apr-29	0d	7 Day
G-1000	Notice to Proceed	0d	24-Jun-21		1787d	5 Day w/Hol
G-1020	On-Site Work	2425d	03-Sep-22	23-Apr-29	0d	7 Day
G-1030	Project Complete	0d		23-Apr-29	0d	7 Day
Submittals, Procurement, Fabrication						
G-1040	SRA Safety and Health Plan	60d	24-Jun-21	22-Aug-21	2604d	7 Day
G-1050	SRA Use of Site Plan	60d	24-Jun-21	22-Aug-21	2801d	7 Day
G-1060	SRA Unwatering Plans	75d	24-Jun-21	06-Sep-21	2786d	7 Day
G-1070	SRA Concrete Submittals	75d	24-Jun-21	06-Sep-21	2786d	7 Day
G-1080	SRA Demolition and Removal of Existing Structures Plans	75d	24-Jun-21	06-Sep-21	2786d	7 Day
G-1090	Submit, Review, Approve (SRA) Radial Gate Data	90d	24-Jun-21	21-Sep-21	2573d	7 Day
G-1100	SRA Gate Hoist Data	90d	24-Jun-21	21-Sep-21	2771d	7 Day
G-1110	SRA Electrical Data	90d	24-Jun-21	21-Sep-21	2651d	7 Day
G-1130	SRA Misc metal, including metal railing	75d	24-Jun-21	06-Sep-21	2666d	7 Day
G-1140	SRA Metal Deck/grating	75d	24-Jun-21	06-Sep-21	2666d	7 Day
G-1160	Fabricate and Deliver Metal Railings	120d	07-Sep-21	04-Jan-22	2666d	7 Day
G-1170	Fabricate and Deliver Metal deck/grating	120d	07-Sep-21	04-Jan-22	2666d	7 Day
G-1180	Fabricate and Deliver Gates	120d	22-Sep-21	19-Jan-22	2651d	7 Day
G-1200	Procure and Deliver Electrical Components	120d	22-Sep-21	19-Jan-22	2651d	7 Day
G-1210	Fabricate and Deliver Stoplogs	120d	22-Sep-21	19-Jan-22	2651d	7-Day
G-1220	Fabricate and Deliver hoists and Components	120d	22-Sep-21	19-Jan-22	2573d	7 Day
Outage Summary						
A1001	Outage Concrete and PP8 Lining	82d	08-Sep-22	05-Jan-23	1600d	5 Day w/Hol
A1003	Outage Geo Lining 1st Yr	77d	05-Sep-23	22-Dec-23	1354d	5 Day w/Hol
A1006	Outage Geo Lining 2nd Yr	61d	05-Sep-24	02-Dec-24	1115d	5 Day w/Hol
A1010	Outage Fernley	99d	02-Oct-25	23-Feb-26	793d	5 Day w/Hol
A2001	Outage Anderson	99d	01-Oct-26	22-Feb-27	540d	5 Day w/Hol
A3000	Outage Allendale	99d	06-Oct-27	25-Feb-28	283d	5 Day w/Hol
A4000	Outage Masson	99d	05-Oct-28	26-Feb-29	29d	5 Day w/Hol
A5000	Outage Bango	58d	02-Jan-29	22-Mar-29	11d	5 Day w/Hol
A6000	Outage Hazen	35d	02-Feb-29	22-Mar-29	0d	5 Day w/Hol
Construction						
Inital Mobilization						
A1500	Site Mobilization	5d	29-Aug-22	02-Sep-22	1552d	5 Day w/Hol
Full Concrete						
F1100	Mobilize Sta. 440	2d	06-Sep-22*	07-Sep-22	1600d	5 Day w/Hol
F1110	Construction	25d	08-Sep-22	12-Oct-22	1600d	5 Day w/Hol
1/2 Concrete						
H1100	Mobilize Sta. 750	2d	13-Oct-22	14-Oct-22	1600d	5 Day w/Hol
H1120	Construction	20d	17-Oct-22	11-Nov-22	1600d	5 Day w/Hol
PP8 Lining						
P1100	Mobilize Sta. 650	5d	14-Nov-22	18-Nov-22	1600d	5 Day w/Hol
P1110	Construction	30d	21-Nov-22	05-Jan-23	1600d	5 Day w/Hol
Soil Over Geo						
G1120	Mobilize Sta. 710	2d	31-Aug-23*	01-Sep-23	1354d	5 Day w/Hol
G1130	Construction	40d	05-Sep-23	30-Oct-23	1354d	5 Day w/Hol
G1100	Mobilize Sta. 530	2d	31-Oct-23	01-Nov-23	1354d	5 Day w/Hol
G1110	Construction	35d	02-Nov-23	22-Dec-23	1354d	5 Day w/Hol
G1140	Mobilize Sta. 880	2d	03-Sep-24*	04-Sep-24	1115d	5 Day w/Hol
G1150	Construction	20d	05-Sep-24	02-Oct-24	1115d	5 Day w/Hol
G1160	Mobilize Sta. 1010	2d	03-Oct-24	04-Oct-24	1115d	5 Day w/Hol
G1170	Construction	20d	07-Oct-24	01-Nov-24	1115d	5 Day w/Hol
G1180	Mobilize Sta. 1120	2d	04-Nov-24	05-Nov-24	1115d	5 Day w/Hol
G1190	Construction	5d	06-Nov-24	12-Nov-24	1115d	5 Day w/Hol
G1200	Mobilize Sta. 1260	2d	13-Nov-24	14-Nov-24	1115d	5 Day w/Hol
G1210	Construction	10d	15-Nov-24	02-Dec-24	1115d	5 Day w/Hol
Check Structure						
Fernley Construct Check Stucture						
A1100	Fernley Site Mobilization	17d	02-Sep-25*	24-Sep-25	793d	5 Day w/Hol
A1110	Unwater	5d	25-Sep-25	01-Oct-25	793d	5 Day w/Hol



Remaining Level of Effort | Actual Work | Remaining Work

Truckee Canal Check Structure Replacement Jun 2018 Phase 1

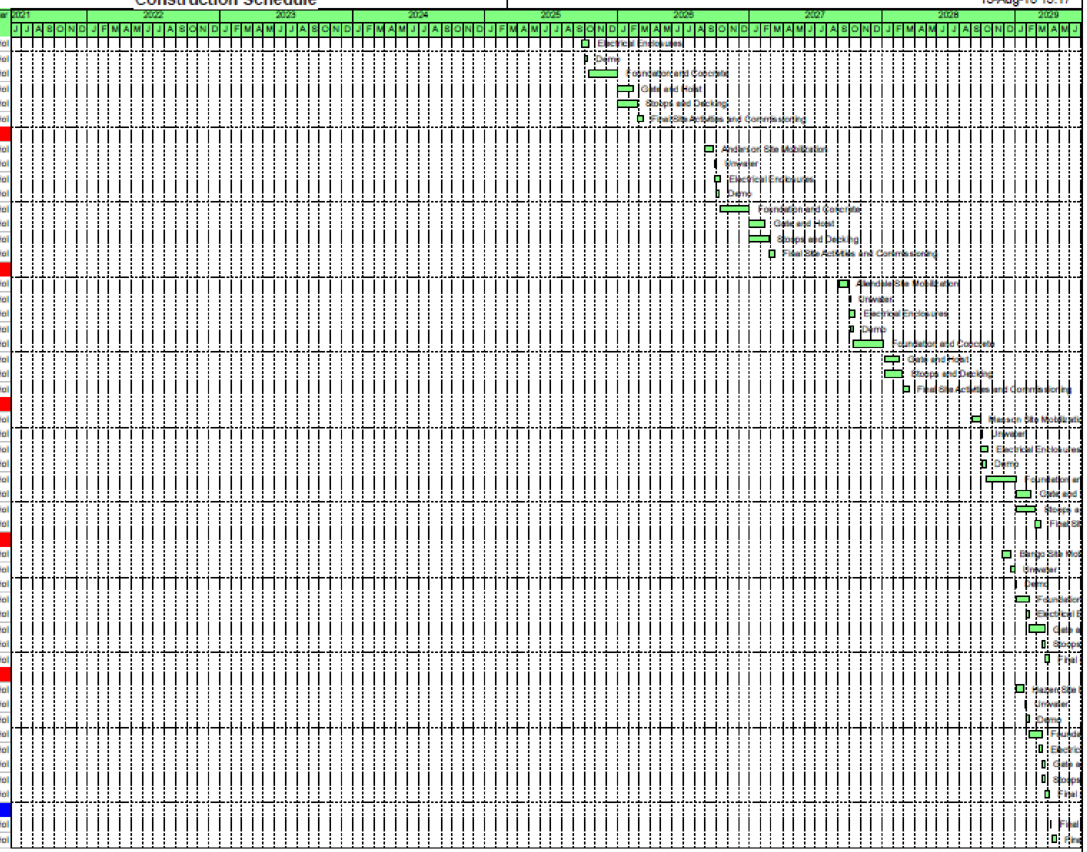
Today's Date: 13-Aug-18

Figure 8-1.—Truckee Canal Corrective Action Phase 1 – Construction Schedule.

8 Construction considerations

Figure 8-1. Truckee Canal Corrective Action Phase 1 — Construction Schedule — 13-Aug-18 15:17

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
A1130	Electrical Enclosures	15d	25-Sep-25	15-Oct-25	852d	5 Day w/Hol
A1120	Demo	7d	02-Oct-25	10-Oct-25	793d	5 Day w/Hol
A1140	Foundation and Concrete	55d	13-Oct-25	31-Dec-25	793d	5 Day w/Hol
A1150	Gate and Hoist	30d	02-Jan-26	12-Feb-26	800d	5 Day w/Hol
A1160	Stoops and Decking	37d	02-Jan-26	23-Feb-26	793d	5 Day w/Hol
A1180	Final Site Activities and Commissioning	11d	24-Feb-26	10-Mar-26	793d	5 Day w/Hol
Anderson Construct Check Stucture						
A2000	Anderson Site Mobilization	17d	31-Aug-26*	23-Sep-26	540d	5 Day w/Hol
A2010	Unwater	5d	24-Sep-26	30-Sep-26	540d	5 Day w/Hol
A2030	Electrical Enclosures	15d	24-Sep-26	14-Oct-26	599d	5 Day w/Hol
A2020	Demo	7d	01-Oct-26	09-Oct-26	540d	5 Day w/Hol
A2040	Foundation and Concrete	55d	12-Oct-26	30-Dec-26	540d	5 Day w/Hol
A2050	Gate and Hoist	30d	31-Dec-26	11-Feb-27	547d	5 Day w/Hol
A2060	Stoops and Decking	37d	31-Dec-26	22-Feb-27	540d	5 Day w/Hol
A2070	Final Site Activities and Commissioning	11d	23-Feb-27	09-Mar-27	540d	5 Day w/Hol
Allendale Construct Check Stucture						
A3010	Allendale Site Mobilization	17d	03-Sep-27*	28-Sep-27	283d	5 Day w/Hol
A3020	Unwater	5d	29-Sep-27	05-Oct-27	283d	5 Day w/Hol
A3040	Electrical Enclosures	15d	29-Sep-27	19-Oct-27	342d	5 Day w/Hol
A3030	Demo	7d	06-Oct-27	14-Oct-27	283d	5 Day w/Hol
A3050	Foundation and Concrete	55d	15-Oct-27	05-Jan-28	283d	5 Day w/Hol
A3060	Gate and Hoist	30d	06-Jan-28	16-Feb-28	290d	5 Day w/Hol
A3070	Stoops and Decking	37d	06-Jan-28	25-Feb-28	283d	5 Day w/Hol
A3080	Final Site Activities and Commissioning	11d	28-Feb-28	13-Mar-28	283d	5 Day w/Hol
Masson Construct Check Stucture						
A4010	Masson Site Mobilization	17d	05-Sep-28*	27-Sep-28	0d	5 Day w/Hol
A4020	Unwater	5d	28-Sep-28	04-Oct-28	0d	5 Day w/Hol
A4040	Electrical Enclosures	15d	28-Sep-28	18-Oct-28	88d	5 Day w/Hol
A4030	Demo	7d	05-Oct-28	13-Oct-28	0d	5 Day w/Hol
A4050	Foundation and Concrete	55d	16-Oct-28	04-Jan-29	0d	5 Day w/Hol
A4060	Gate and Hoist	30d	05-Jan-29	15-Feb-29	36d	5 Day w/Hol
A4070	Stoops and Decking	37d	05-Jan-29	26-Feb-29	29d	5 Day w/Hol
A4080	Final Site Activities and Commissioning	11d	27-Feb-29	13-Mar-29	29d	5 Day w/Hol
Bango Add Gates						
A5010	Bango Site Mobilization	17d	29-Nov-28	21-Dec-28	0d	5 Day w/Hol
A5020	Unwater	5d	22-Dec-28	29-Dec-28	0d	5 Day w/Hol
A5030	Demo	3d	02-Jan-29	04-Jan-29	0d	5 Day w/Hol
A5050	Foundation and Concrete	25d	05-Jan-29	08-Feb-29	0d	5 Day w/Hol
A5040	Electrical Enclosures	5d	02-Feb-29	08-Feb-29	11d	5 Day w/Hol
A5060	Gate and Hoist	30d	09-Feb-29	22-Mar-29	11d	5 Day w/Hol
A5070	Stoops and Decking	5d	16-Mar-29	22-Mar-29	11d	5 Day w/Hol
A5080	Final Site Activities and Commissioning	11d	23-Mar-29	06-Apr-29	11d	5 Day w/Hol
Hazen Construct Gage Stucture						
A6010	Hazen Site Mobilization	17d	03-Jan-29	25-Jan-29	0d	5 Day w/Hol
A6020	Unwater	5d	26-Jan-29	01-Feb-29	0d	5 Day w/Hol
A6030	Demo	5d	02-Feb-29	08-Feb-29	0d	5 Day w/Hol
A6050	Foundation and Concrete	25d	09-Feb-29	15-Mar-29	0d	5 Day w/Hol
A6040	Electrical Enclosures	5d	09-Mar-29	15-Mar-29	0d	5 Day w/Hol
A6060	Gate and Hoist	5d	16-Mar-29	22-Mar-29	0d	5 Day w/Hol
A6070	Stoops and Decking	5d	16-Mar-29	22-Mar-29	0d	5 Day w/Hol
A6080	Final Site Activities and Commissioning	11d	23-Mar-29	06-Apr-29	0d	5 Day w/Hol
Final Site Activities						
S-1050	Final Inspection	3d	09-Apr-29	11-Apr-29	0d	5 Day w/Hol
S-1060	Final Punchlist, Cleanup Site and Demobilize from Site	8d	12-Apr-29	23-Apr-29	0d	5 Day w/Hol



Remaining Level of Effort — Actual Work — Remaining Work | Truckee Canal Check Structure Replacement Jun 2018 Phase 1 | *Today's Date: 13-Aug-18*

Figure 8-1.—Truckee Canal Corrective Action Phase 1 – Construction Schedule.

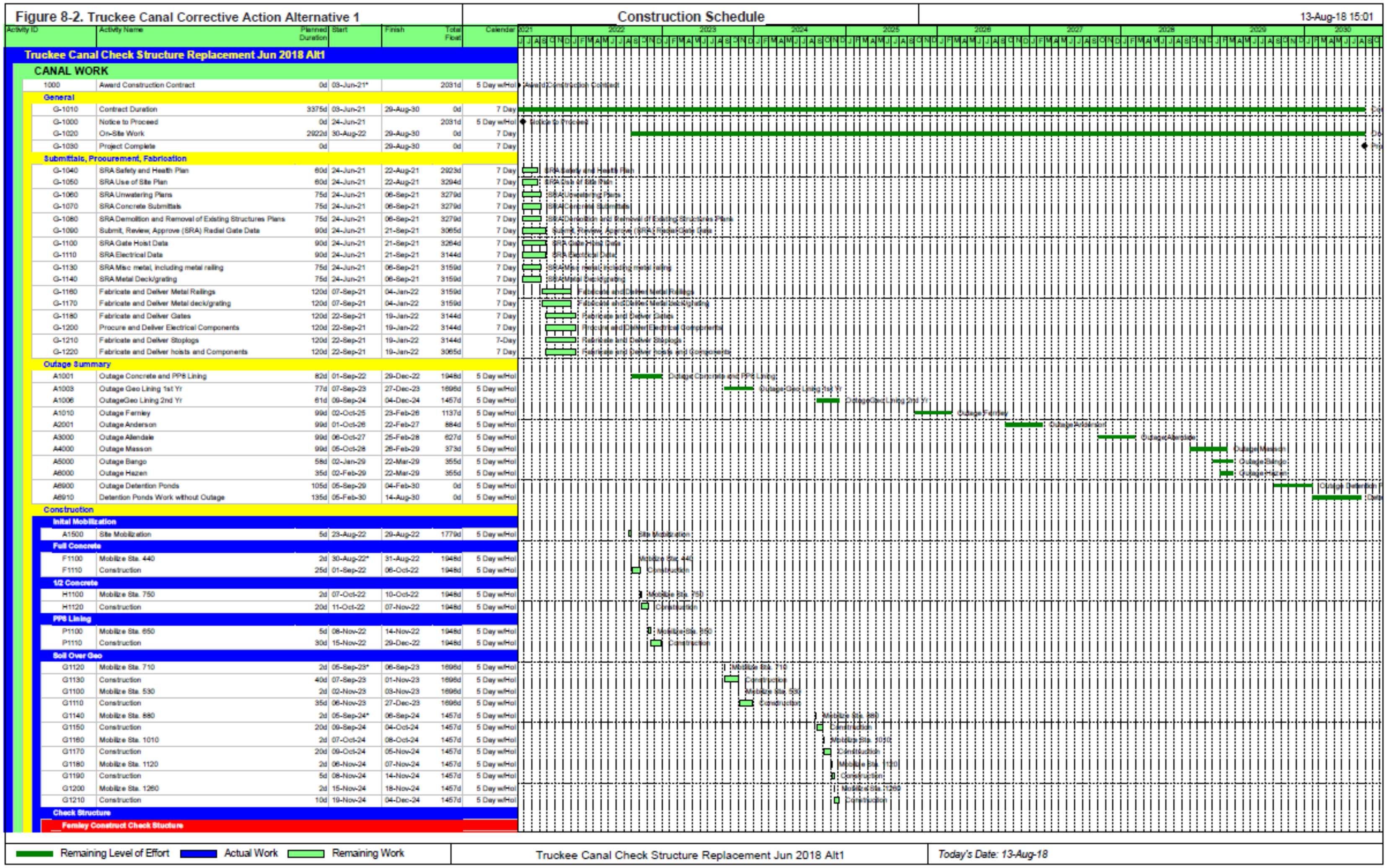
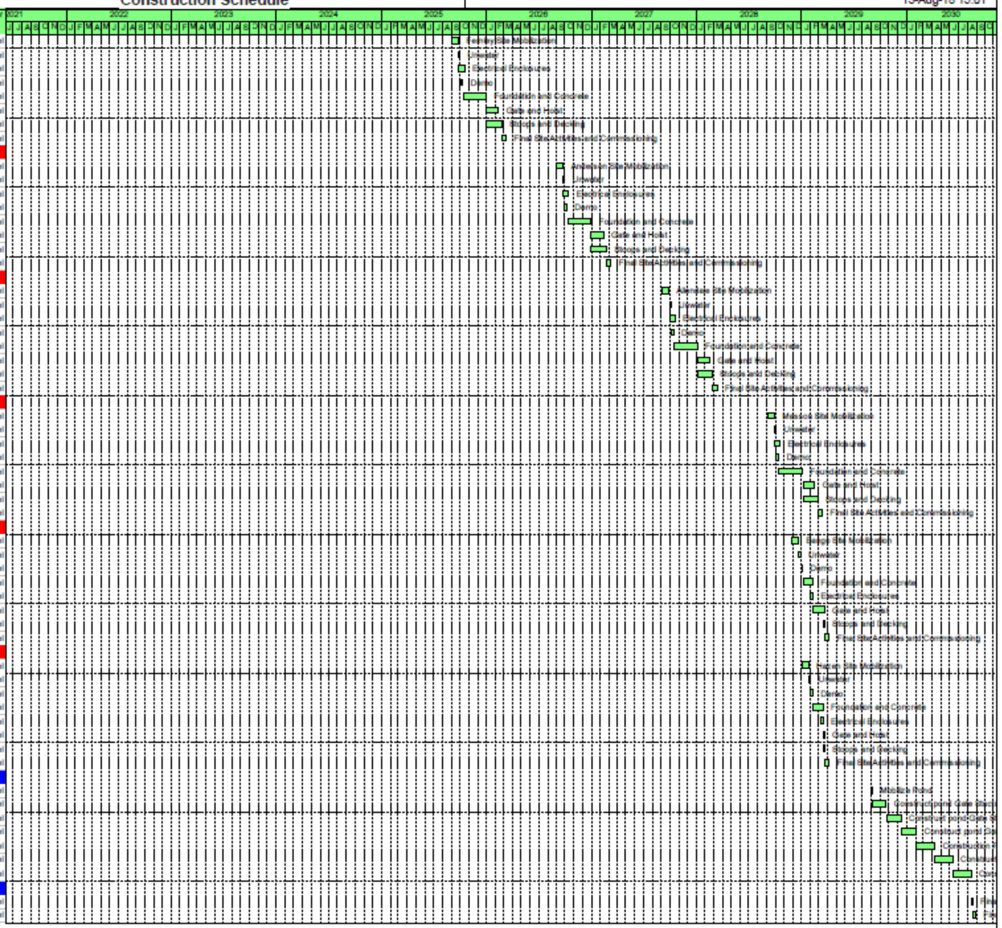


Figure 8-2.—Truckee Canal Corrective Action Alternative 1 – Construction Schedule.

8 Construction considerations

Figure 8-2. Truckee Canal Corrective Action Alternative 1 — Construction Schedule — 13-Aug-18 15:01

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
A1100	Fernley Site Mobilization	17d	02-Sep-25*	24-Sep-25	1137d	5 Day w/Hol
A1110	Unwater	5d	25-Sep-25	01-Oct-25	1137d	5 Day w/Hol
A1130	Electrical Enclosures	15d	25-Sep-25	15-Oct-25	1196d	5 Day w/Hol
A1120	Demo	7d	02-Oct-25	10-Oct-25	1137d	5 Day w/Hol
A1140	Foundation and Concrete	55d	13-Oct-25	31-Dec-25	1137d	5 Day w/Hol
A1150	Gate and Hoist	30d	02-Jan-26	12-Feb-26	1144d	5 Day w/Hol
A1160	Stoops and Decking	37d	02-Jan-26	23-Feb-26	1137d	5 Day w/Hol
A1180	Final Site Activities and Commissioning	11d	24-Feb-26	10-Mar-26	1137d	5 Day w/Hol
Anderson Construct Check Stucture						
A2000	Anderson Site Mobilization	17d	31-Aug-26*	23-Sep-26	884d	5 Day w/Hol
A2010	Unwater	5d	24-Sep-26	30-Sep-26	884d	5 Day w/Hol
A2030	Electrical Enclosures	15d	24-Sep-26	14-Oct-26	943d	5 Day w/Hol
A2020	Demo	7d	01-Oct-26	09-Oct-26	884d	5 Day w/Hol
A2040	Foundation and Concrete	55d	12-Oct-26	30-Dec-26	884d	5 Day w/Hol
A2050	Gate and Hoist	30d	31-Dec-26	11-Feb-27	891d	5 Day w/Hol
A2060	Stoops and Decking	37d	31-Dec-26	22-Feb-27	884d	5 Day w/Hol
A2070	Final Site Activities and Commissioning	11d	23-Feb-27	09-Mar-27	884d	5 Day w/Hol
Allendale Construct Check Stucture						
A3010	Allendale Site Mobilization	17d	03-Sep-27*	28-Sep-27	627d	5 Day w/Hol
A3020	Unwater	5d	29-Sep-27	05-Oct-27	627d	5 Day w/Hol
A3040	Electrical Enclosures	15d	29-Sep-27	19-Oct-27	686d	5 Day w/Hol
A3030	Demo	7d	06-Oct-27	14-Oct-27	627d	5 Day w/Hol
A3050	Foundation and Concrete	55d	15-Oct-27	05-Jan-28	627d	5 Day w/Hol
A3060	Gate and Hoist	30d	06-Jan-28	16-Feb-28	634d	5 Day w/Hol
A3070	Stoops and Decking	37d	06-Jan-28	25-Feb-28	627d	5 Day w/Hol
A3080	Final Site Activities and Commissioning	11d	28-Feb-28	13-Mar-28	627d	5 Day w/Hol
Masson Construct Check Stucture						
A4010	Masson Site Mobilization	17d	05-Sep-28*	27-Sep-28	355d	5 Day w/Hol
A4020	Unwater	5d	28-Sep-28	04-Oct-28	355d	5 Day w/Hol
A4040	Electrical Enclosures	15d	28-Sep-28	18-Oct-28	432d	5 Day w/Hol
A4030	Demo	7d	05-Oct-28	13-Oct-28	355d	5 Day w/Hol
A4050	Foundation and Concrete	55d	16-Oct-28	04-Jan-29	355d	5 Day w/Hol
A4060	Gate and Hoist	30d	05-Jan-29	15-Feb-29	380d	5 Day w/Hol
A4070	Stoops and Decking	37d	05-Jan-29	28-Feb-29	373d	5 Day w/Hol
A4080	Final Site Activities and Commissioning	11d	27-Feb-29	13-Mar-29	373d	5 Day w/Hol
Bango Add Gates						
A5010	Bango Site Mobilization	17d	29-Nov-28	21-Dec-28	355d	5 Day w/Hol
A5020	Unwater	5d	22-Dec-28	29-Dec-28	355d	5 Day w/Hol
A5030	Demo	3d	02-Jan-29	04-Jan-29	355d	5 Day w/Hol
A5050	Foundation and Concrete	25d	05-Jan-29	08-Feb-29	355d	5 Day w/Hol
A5040	Electrical Enclosures	5d	02-Feb-29	08-Feb-29	355d	5 Day w/Hol
A5060	Gate and Hoist	30d	09-Feb-29	22-Mar-29	355d	5 Day w/Hol
A5070	Stoops and Decking	5d	16-Mar-29	22-Mar-29	355d	5 Day w/Hol
A5080	Final Site Activities and Commissioning	11d	23-Mar-29	06-Apr-29	355d	5 Day w/Hol
Hazen Construct Gage Stucture						
A6010	Hazen Site Mobilization	17d	03-Jan-29	25-Jan-29	355d	5 Day w/Hol
A6020	Unwater	5d	26-Jan-29	01-Feb-29	355d	5 Day w/Hol
A6030	Demo	5d	02-Feb-29	08-Feb-29	355d	5 Day w/Hol
A6050	Foundation and Concrete	25d	09-Feb-29	15-Mar-29	355d	5 Day w/Hol
A6040	Electrical Enclosures	5d	09-Mar-29	15-Mar-29	355d	5 Day w/Hol
A6060	Gate and Hoist	5d	16-Mar-29	22-Mar-29	355d	5 Day w/Hol
A6070	Stoops and Decking	5d	16-Mar-29	22-Mar-29	355d	5 Day w/Hol
A6080	Final Site Activities and Commissioning	11d	23-Mar-29	06-Apr-29	355d	5 Day w/Hol
Detention Ponds						
D1100	Mobilize Pond	2d	31-Aug-29*	04-Sep-29	0d	5 Day w/Hol
D1105	Construct pond Gate Stucture Pond 1	35d	05-Sep-29	23-Oct-29	0d	5 Day w/Hol
D1125	Construct pond Gate Stucture Pond 2	35d	24-Oct-29	13-Dec-29	0d	5 Day w/Hol
D1145	Construct pond Gate Stucture Pond 3	35d	14-Dec-29	04-Feb-30	0d	5 Day w/Hol
D1110	Construction Pond 1	45d	05-Feb-30	08-Apr-30	0d	5 Day w/Hol
D1130	Construction Pond 2	45d	09-Apr-30	11-Jun-30	0d	5 Day w/Hol
D1150	Construction Pond3	45d	12-Jun-30	14-Aug-30	0d	5 Day w/Hol
Final Site Activities						
S-1050	Final Inspection	3d	15-Aug-30	19-Aug-30	0d	5 Day w/Hol
S-1060	Final Punchlist, Cleanup Site and Demobilize from Site	8d	20-Aug-30	29-Aug-30	0d	5 Day w/Hol



Remaining Level of Effort | Actual Work | Remaining Work

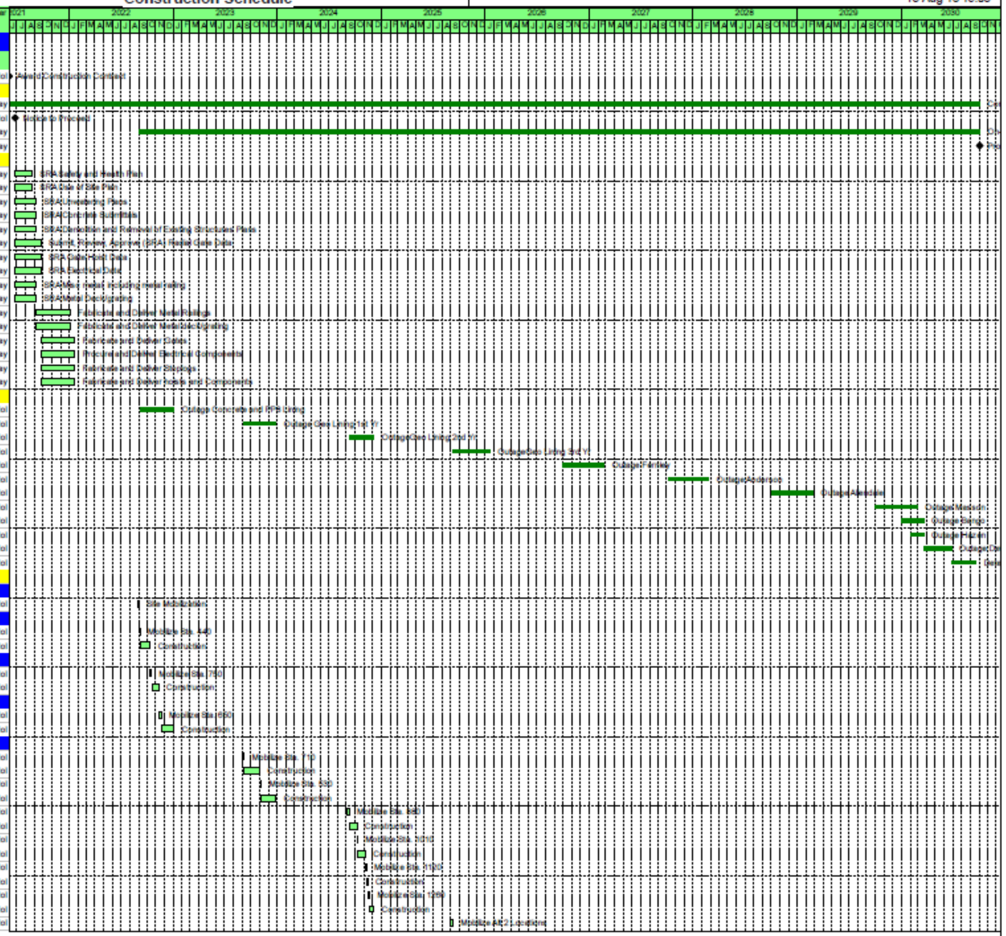
Truckee Canal Check Structure Replacement Jun 2018 Alt1

Today's Date: 13-Aug-18

Figure 8-2.—Truckee Canal Corrective Action Alternative 1 – Construction Schedule.

Figure 8-3. Truckee Canal Corrective Action Alternative 2 | Construction Schedule | 13-Aug-18 15:08

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
Truckee Canal Check Structure Replacement Jun 2018 Alt2						
CANAL WORK						
1000	Award Construction Contract	0d	03-Jun-21*		2155d	5 Day w/Hol
General						
G-1010	Contract Duration	3411d	03-Jun-21	04-Oct-30	0d	7 Day
G-1000	Notice to Proceed	0d	24-Jun-21		2155d	5 Day w/Hol
G-1020	On-Site Work	2954d	03-Sep-22	04-Oct-30	0d	7 Day
G-1030	Project Complete	0d		04-Oct-30	0d	7 Day
Submittals, Procurement, Fabrication						
G-1040	SRA Safety and Health Plan	60d	24-Jun-21	22-Aug-21	3119d	7 Day
G-1050	SRA Use of Site Plan	60d	24-Jun-21	22-Aug-21	3330d	7 Day
G-1060	SRA Unwatering Plans	75d	24-Jun-21	06-Sep-21	3315d	7 Day
G-1070	SRA Concrete Submittals	75d	24-Jun-21	06-Sep-21	3315d	7 Day
G-1080	SRA Demolition and Removal of Existing Structures Plans	75d	24-Jun-21	06-Sep-21	3315d	7 Day
G-1090	Submit, Review, Approve (SRA) Radial Gate Data	90d	24-Jun-21	21-Sep-21	3101d	7 Day
G-1100	SRA Gate Hoist Data	90d	24-Jun-21	21-Sep-21	3300d	7 Day
G-1110	SRA Electrical Data	90d	24-Jun-21	21-Sep-21	3180d	7 Day
G-1130	SRA Misc metal, including metal railing	75d	24-Jun-21	06-Sep-21	3195d	7 Day
G-1140	SRA Metal Deck/grating	75d	24-Jun-21	06-Sep-21	3195d	7 Day
G-1160	Fabricate and Deliver Metal Railings	120d	07-Sep-21	04-Jan-22	3195d	7 Day
G-1170	Fabricate and Deliver Metal deck/grating	120d	07-Sep-21	04-Jan-22	3195d	7 Day
G-1180	Fabricate and Deliver Gates	120d	22-Sep-21	19-Jan-22	3180d	7 Day
G-1200	Procure and Deliver Electrical Components	120d	22-Sep-21	19-Jan-22	3180d	7 Day
G-1210	Fabricate and Deliver Stoplogs	120d	22-Sep-21	19-Jan-22	3180d	7-Day
G-1220	Fabricate and Deliver hoists and Components	120d	22-Sep-21	19-Jan-22	3101d	7 Day
Outage Summary						
A1001	Outage Concrete and PP8 Lining	82d	08-Sep-22	05-Jan-23	1969d	5 Day w/Hol
A1003	Outage Geo Lining 1st Yr	77d	08-Sep-23	28-Dec-23	1720d	5 Day w/Hol
A1006	OutageGeo Lining 2nd Yr	61d	10-Sep-24	05-Dec-24	1481d	5 Day w/Hol
A1008	OutageGeo Lining 3rd Yr	90d	09-Sep-25	16-Jan-26	1199d	5 Day w/Hol
A1010	Outage Fernley	99d	01-Oct-26	22-Feb-27	909d	5 Day w/Hol
A2001	Outage Anderson	99d	06-Oct-27	25-Feb-28	652d	5 Day w/Hol
A3000	Outage Allendale	99d	05-Oct-28	26-Feb-29	398d	5 Day w/Hol
A4000	Outage Masson	99d	04-Oct-29	25-Feb-30	145d	5 Day w/Hol
A5000	Outage Bango	58d	31-Dec-29	21-Mar-30	127d	5 Day w/Hol
A6000	Outage Hazen	35d	01-Feb-30	21-Mar-30	127d	5 Day w/Hol
A6900	Outage Detention Ponds	70d	19-Mar-30	25-Jun-30	0d	5 Day w/Hol
A6910	Detention Ponds Work without Outage	60d	26-Jun-30	19-Sep-30	0d	5 Day w/Hol
Construction						
Inital Mobilization						
A1500	Site Mobilization	5d	29-Aug-22	02-Sep-22	1910d	5 Day w/Hol
Full Concrete						
F1100	Mobilize Sta. 440	2d	06-Sep-22*	07-Sep-22	1969d	5 Day w/Hol
F1110	Construction	25d	08-Sep-22	12-Oct-22	1969d	5 Day w/Hol
1/2 Concrete						
H1100	Mobilize Sta. 750	2d	13-Oct-22	14-Oct-22	1969d	5 Day w/Hol
H1120	Construction	20d	17-Oct-22	11-Nov-22	1969d	5 Day w/Hol
PP8 Lining						
P1100	Mobilize Sta. 650	5d	14-Nov-22	18-Nov-22	1969d	5 Day w/Hol
P1110	Construction	30d	21-Nov-22	05-Jan-23	1969d	5 Day w/Hol
Soil Over Geo						
G1120	Mobilize Sta. 710	5d	31-Aug-23*	07-Sep-23	1720d	5 Day w/Hol
G1130	Construction	40d	08-Sep-23	02-Nov-23	1720d	5 Day w/Hol
G1100	Mobilize Sta. 530	2d	03-Nov-23	06-Nov-23	1720d	5 Day w/Hol
G1110	Construction	35d	07-Nov-23	28-Dec-23	1720d	5 Day w/Hol
G1140	Mobilize Sta. 880	5d	03-Sep-24*	09-Sep-24	1481d	5 Day w/Hol
G1150	Construction	20d	10-Sep-24	07-Oct-24	1481d	5 Day w/Hol
G1160	Mobilize Sta. 1010	2d	08-Oct-24	09-Oct-24	1481d	5 Day w/Hol
G1170	Construction	20d	10-Oct-24	06-Nov-24	1481d	5 Day w/Hol
G1180	Mobilize Sta. 1120	2d	07-Nov-24	08-Nov-24	1481d	5 Day w/Hol
G1190	Construction	5d	11-Nov-24	15-Nov-24	1481d	5 Day w/Hol
G1200	Mobilize Sta. 1260	2d	18-Nov-24	19-Nov-24	1481d	5 Day w/Hol
G1210	Construction	10d	20-Nov-24	05-Dec-24	1481d	5 Day w/Hol
G2000	Mobilize Alt 2 Locations	5d	02-Sep-25*	08-Sep-25	1199d	5 Day w/Hol



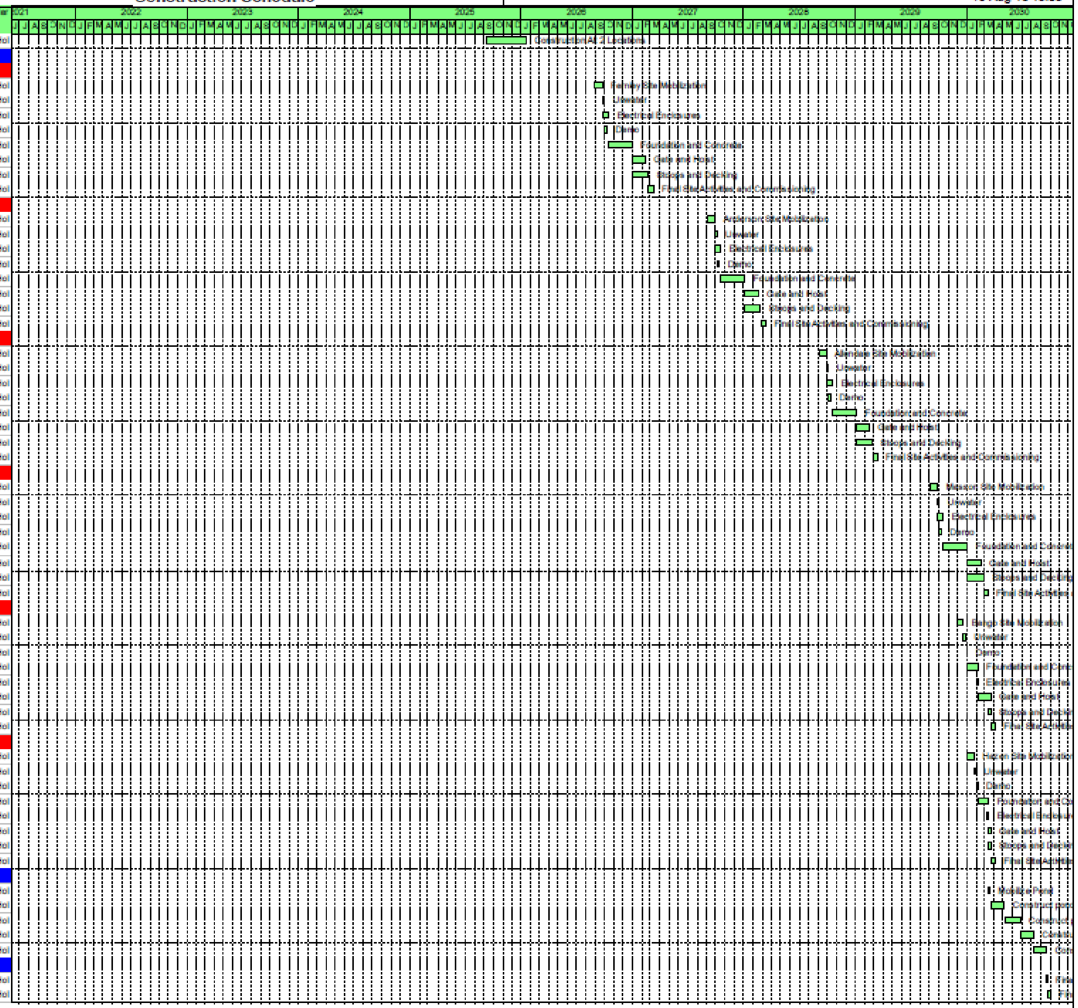
Remaining Level of Effort | Actual Work | Remaining Work | Truckee Canal Check Structure Replacement Jun 2018 Alt2 | *Today's Date: 13-Aug-18*

Figure 8-3.—Truckee Canal Corrective Action Alternative 2 – Construction Schedule.

8 Construction considerations

Figure 8-3. Truckee Canal Corrective Action Alternative 2 — Construction Schedule — 13-Aug-18 15:08

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
G2010	Construction Alt 2 Locations	90d	09-Sep-25	16-Jan-26	1199d	5 Day w/Hol
Check Structure						
Fernley Construct Check Stucture						
A1100	Fernley Site Mobilization	17d	31-Aug-26*	23-Sep-26	909d	5 Day w/Hol
A1110	Unwater	5d	24-Sep-26	30-Sep-26	909d	5 Day w/Hol
A1130	Electrical Enclosures	15d	24-Sep-26	14-Oct-26	968d	5 Day w/Hol
A1120	Demo	7d	01-Oct-26	09-Oct-26	909d	5 Day w/Hol
A1140	Foundation and Concrete	55d	12-Oct-26	30-Dec-26	909d	5 Day w/Hol
A1150	Gate and Hoist	30d	31-Dec-26	11-Feb-27	916d	5 Day w/Hol
A1160	Stoops and Decking	37d	31-Dec-26	22-Feb-27	909d	5 Day w/Hol
A1180	Final Site Activities and Commissioning	11d	23-Feb-27	09-Mar-27	909d	5 Day w/Hol
Anderson Construct Check Stucture						
A2000	Anderson Site Mobilization	17d	03-Sep-27*	28-Sep-27	652d	5 Day w/Hol
A2010	Unwater	5d	29-Sep-27	05-Oct-27	652d	5 Day w/Hol
A2030	Electrical Enclosures	15d	29-Sep-27	19-Oct-27	711d	5 Day w/Hol
A2020	Demo	7d	06-Oct-27	14-Oct-27	652d	5 Day w/Hol
A2040	Foundation and Concrete	55d	15-Oct-27	05-Jan-28	652d	5 Day w/Hol
A2050	Gate and Hoist	30d	06-Jan-28	16-Feb-28	659d	5 Day w/Hol
A2060	Stoops and Decking	37d	06-Jan-28	25-Feb-28	652d	5 Day w/Hol
A2070	Final Site Activities and Commissioning	11d	28-Feb-28	13-Mar-28	652d	5 Day w/Hol
Allendale Construct Check Stucture						
A3010	Allendale Site Mobilization	17d	05-Sep-28*	27-Sep-28	398d	5 Day w/Hol
A3020	Unwater	5d	28-Sep-28	04-Oct-28	398d	5 Day w/Hol
A3040	Electrical Enclosures	15d	28-Sep-28	18-Oct-28	457d	5 Day w/Hol
A3030	Demo	7d	05-Oct-28	13-Oct-28	398d	5 Day w/Hol
A3050	Foundation and Concrete	55d	16-Oct-28	04-Jan-29	398d	5 Day w/Hol
A3060	Gate and Hoist	30d	05-Jan-29	15-Feb-29	405d	5 Day w/Hol
A3070	Stoops and Decking	37d	05-Jan-29	26-Feb-29	398d	5 Day w/Hol
A3080	Final Site Activities and Commissioning	11d	27-Feb-29	13-Mar-29	398d	5 Day w/Hol
Masson Construct Check Stucture						
A4010	Masson Site Mobilization	17d	04-Sep-29*	26-Sep-29	0d	5 Day w/Hol
A4020	Unwater	5d	27-Sep-29	03-Oct-29	0d	5 Day w/Hol
A4040	Electrical Enclosures	15d	27-Sep-29	17-Oct-29	204d	5 Day w/Hol
A4030	Demo	7d	04-Oct-29	12-Oct-29	0d	5 Day w/Hol
A4050	Foundation and Concrete	55d	15-Oct-29	03-Jan-30	0d	5 Day w/Hol
A4060	Gate and Hoist	30d	04-Jan-30	14-Feb-30	152d	5 Day w/Hol
A4070	Stoops and Decking	37d	04-Jan-30	25-Feb-30	145d	5 Day w/Hol
A4080	Final Site Activities and Commissioning	11d	26-Feb-30	12-Mar-30	145d	5 Day w/Hol
Bango Add Gates						
A5010	Bango Site Mobilization	17d	28-Nov-29	20-Dec-29	0d	5 Day w/Hol
A5020	Unwater	5d	21-Dec-29	28-Dec-29	0d	5 Day w/Hol
A5030	Demo	3d	31-Dec-29	03-Jan-30	0d	5 Day w/Hol
A5050	Foundation and Concrete	25d	04-Jan-30	07-Feb-30	0d	5 Day w/Hol
A5040	Electrical Enclosures	5d	01-Feb-30	07-Feb-30	127d	5 Day w/Hol
A5060	Gate and Hoist	30d	08-Feb-30	21-Mar-30	127d	5 Day w/Hol
A5070	Stoops and Decking	5d	15-Mar-30	21-Mar-30	127d	5 Day w/Hol
A5080	Final Site Activities and Commissioning	11d	22-Mar-30	05-Apr-30	127d	5 Day w/Hol
Hazen Construct Gage Stucture						
A6010	Hazen Site Mobilization	17d	02-Jan-30	24-Jan-30	0d	5 Day w/Hol
A6020	Unwater	5d	25-Jan-30	31-Jan-30	0d	5 Day w/Hol
A6030	Demo	5d	01-Feb-30	07-Feb-30	0d	5 Day w/Hol
A6050	Foundation and Concrete	25d	08-Feb-30	14-Mar-30	0d	5 Day w/Hol
A6040	Electrical Enclosures	5d	08-Mar-30	14-Mar-30	127d	5 Day w/Hol
A6060	Gate and Hoist	5d	15-Mar-30	21-Mar-30	127d	5 Day w/Hol
A6070	Stoops and Decking	5d	15-Mar-30	21-Mar-30	127d	5 Day w/Hol
A6080	Final Site Activities and Commissioning	11d	22-Mar-30	05-Apr-30	127d	5 Day w/Hol
Detention Ponds						
D1100	Mobilize Pond	2d	15-Mar-30	18-Mar-30	0d	5 Day w/Hol
D1105	Construct pond Gate Stucture Pond 1	35d	19-Mar-30	06-May-30	0d	5 Day w/Hol
D1125	Construct pond Gate Stucture Pond 2	35d	07-May-30	25-Jun-30	0d	5 Day w/Hol
D1110	Construction Pond 1	30d	26-Jun-30	07-Aug-30	0d	5 Day w/Hol
D1130	Construction Pond 2	30d	08-Aug-30	19-Sep-30	0d	5 Day w/Hol
Final Site Activities						
S-1050	Final Inspection	3d	20-Sep-30	24-Sep-30	0d	5 Day w/Hol
S-1060	Final Punchlist, Cleanup Site and Demobilize from Site	8d	25-Sep-30	04-Oct-30	0d	5 Day w/Hol



Remaining Level of Effort — Actual Work — Remaining Work

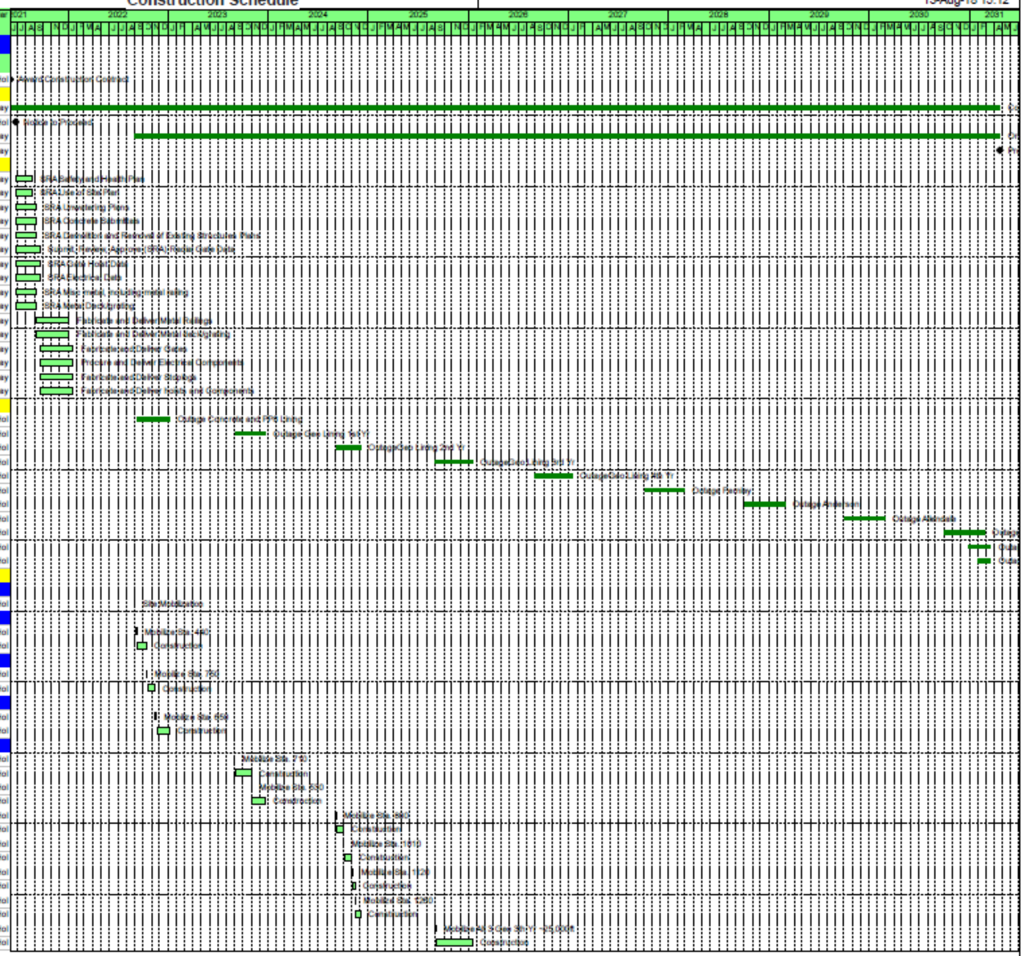
Truckee Canal Check Structure Replacement Jun 2018 Alt2

Today's Date: 13-Aug-18

Figure 8-3.—Truckee Canal Corrective Action Alternative 2 – Construction Schedule.

Figure 8-4. Truckee Canal Corrective Action Alternative 3 — Construction Schedule — 13-Aug-18 15:12

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
Truckee Canal Check Structure Replacement Jun 2018 Alt 3						
CANAL WORK						
1000	Award Construction Contract	0d	03-Jun-21*		2293d	5 Day w/Hol
General						
G-1010	Contract Duration	3610d	03-Jun-21	21-Apr-31	0d	7 Day
G-1000	Notice to Proceed	0d	24-Jun-21		2293d	5 Day w/Hol
G-1020	On-Site Work	3153d	03-Sep-22	21-Apr-31	0d	7 Day
G-1030	Project Complete	0d		21-Apr-31	0d	7 Day
Submittals, Procurement, Fabrication						
G-1040	SRA Safety and Health Plan	60d	24-Jun-21	22-Aug-21	3332d	7 Day
G-1050	SRA Use of Site Plan	60d	24-Jun-21	22-Aug-21	3529d	7 Day
G-1060	SRA Unwatering Plans	75d	24-Jun-21	06-Sep-21	3514d	7 Day
G-1070	SRA Concrete Submittals	75d	24-Jun-21	06-Sep-21	3514d	7 Day
G-1080	SRA Demolition and Removal of Existing Structures Plans	75d	24-Jun-21	06-Sep-21	3514d	7 Day
G-1090	Submit, Review, Approve (SRA) Radial Gate Data	90d	24-Jun-21	21-Sep-21	3301d	7 Day
G-1100	SRA Gate Hoist Data	90d	24-Jun-21	21-Sep-21	3499d	7 Day
G-1110	SRA Electrical Data	90d	24-Jun-21	21-Sep-21	3379d	7 Day
G-1130	SRA Misc metal, including metal railing	75d	24-Jun-21	06-Sep-21	3394d	7 Day
G-1140	SRA Metal Deck/grating	75d	24-Jun-21	06-Sep-21	3394d	7 Day
G-1160	Fabricate and Deliver Metal Railings	120d	07-Sep-21	04-Jan-22	3394d	7 Day
G-1170	Fabricate and Deliver Metal deck/grating	120d	07-Sep-21	04-Jan-22	3394d	7 Day
G-1180	Fabricate and Deliver Gates	120d	22-Sep-21	19-Jan-22	3379d	7 Day
G-1200	Procure and Deliver Electrical Components	120d	22-Sep-21	19-Jan-22	3379d	7 Day
G-1210	Fabricate and Deliver Stoplogs	120d	22-Sep-21	19-Jan-22	3379d	7-Day
G-1220	Fabricate and Deliver hoists and Components	120d	22-Sep-21	19-Jan-22	3301d	7 Day
Outage Summary						
A1001	Outage Concrete and PP8 Lining	82d	08-Sep-22	05-Jan-23	2106d	5 Day w/Hol
A1003	Outage Geo Lining 1st Yr	77d	05-Sep-23	22-Dec-23	1860d	5 Day w/Hol
A1006	OutageGeo Lining 2nd Yr	61d	05-Sep-24	02-Dec-24	1621d	5 Day w/Hol
A1007	OutageGeo Lining 3rd Yr	92d	02-Sep-25	13-Jan-26	1339d	5 Day w/Hol
A1008	OutageGeo Lining 4th Yr	92d	31-Aug-26	12-Jan-27	1086d	5 Day w/Hol
A1010	Outage Fernley	99d	06-Oct-27	25-Feb-28	789d	5 Day w/Hol
A2001	Outage Anderson	99d	05-Oct-28	26-Feb-29	535d	5 Day w/Hol
A3000	Outage Allendale	99d	04-Oct-29	25-Feb-30	282d	5 Day w/Hol
A4000	Outage Masson	99d	03-Oct-30	24-Feb-31	29d	5 Day w/Hol
A5000	Outage Bango	58d	30-Dec-30	20-Mar-31	11d	5 Day w/Hol
A6000	Outage Hazen	35d	31-Jan-31	20-Mar-31	0d	5 Day w/Hol
Construction						
Inital Mobilization						
A1500	Site Mobilization	5d	29-Aug-22	02-Sep-22	2058d	5 Day w/Hol
Full Concrete						
F1100	Mobilize Sta. 440	2d	06-Sep-22*	07-Sep-22	2106d	5 Day w/Hol
F1110	Construction	25d	08-Sep-22	12-Oct-22	2106d	5 Day w/Hol
1/2 Concrete						
H1100	Mobilize Sta. 750	2d	13-Oct-22	14-Oct-22	2106d	5 Day w/Hol
H1120	Construction	20d	17-Oct-22	11-Nov-22	2106d	5 Day w/Hol
PP8 Lining						
P1100	Mobilize Sta. 650	5d	14-Nov-22	18-Nov-22	2106d	5 Day w/Hol
P1110	Construction	30d	21-Nov-22	05-Jan-23	2106d	5 Day w/Hol
Soil Over Geo						
G1120	Mobilize Sta. 710	2d	31-Aug-23*	01-Sep-23	1860d	5 Day w/Hol
G1130	Construction	40d	05-Sep-23	30-Oct-23	1860d	5 Day w/Hol
G1100	Mobilize Sta. 530	2d	31-Oct-23	01-Nov-23	1860d	5 Day w/Hol
G1110	Construction	35d	02-Nov-23	22-Dec-23	1860d	5 Day w/Hol
G1140	Mobilize Sta. 880	2d	03-Sep-24*	04-Sep-24	1621d	5 Day w/Hol
G1150	Construction	20d	05-Sep-24	02-Oct-24	1621d	5 Day w/Hol
G1160	Mobilize Sta. 1010	2d	03-Oct-24	04-Oct-24	1621d	5 Day w/Hol
G1170	Construction	20d	07-Oct-24	01-Nov-24	1621d	5 Day w/Hol
G1180	Mobilize Sta. 1120	2d	04-Nov-24	05-Nov-24	1621d	5 Day w/Hol
G1190	Construction	5d	06-Nov-24	12-Nov-24	1621d	5 Day w/Hol
G1200	Mobilize Sta. 1260	2d	13-Nov-24	14-Nov-24	1621d	5 Day w/Hol
G1210	Construction	10d	15-Nov-24	02-Dec-24	1621d	5 Day w/Hol
G1230	Mobilize Alt 3 Geo 3th Yr ~25,000ft	2d	02-Sep-25*	03-Sep-25	1339d	5 Day w/Hol
G1240	Construction	90d	04-Sep-25	13-Jan-26	1339d	5 Day w/Hol



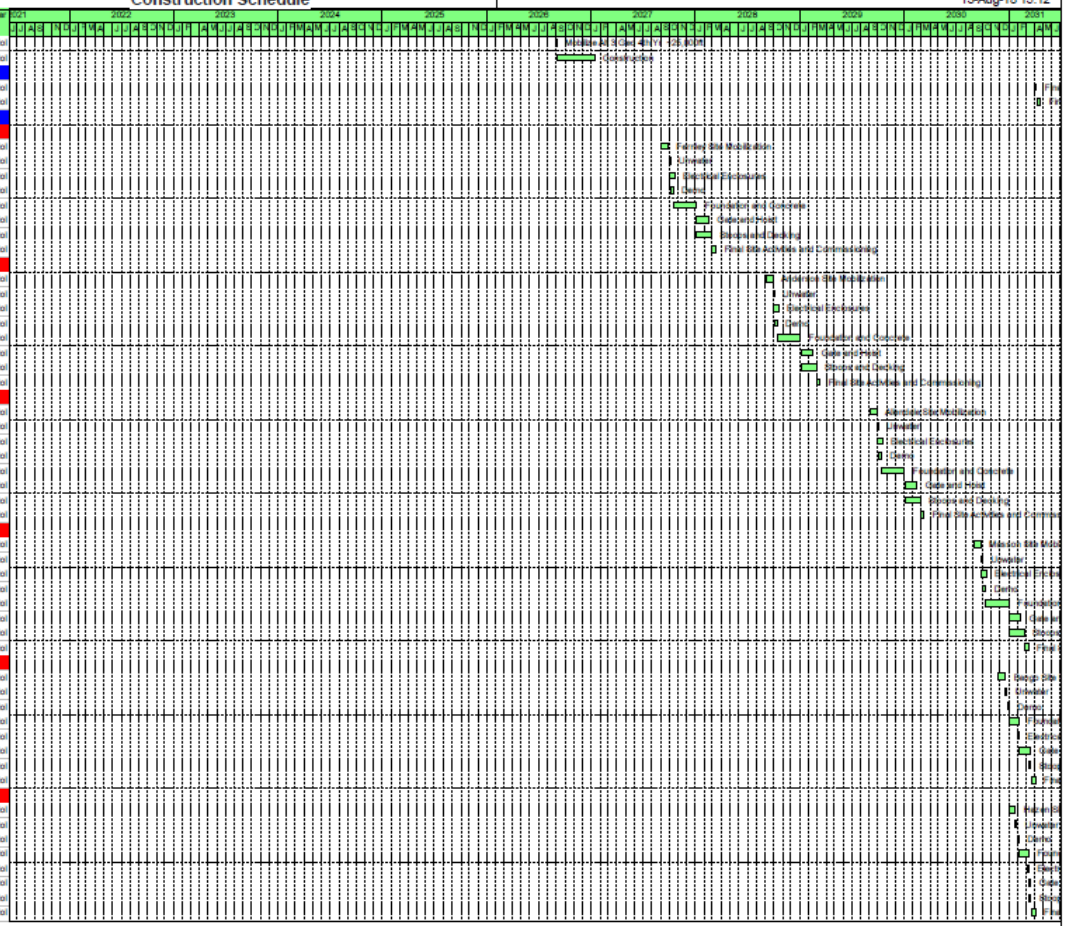
Remaining Level of Effort | Actual Work | Remaining Work — Truckee Canal Check Structure Replacement Jun 2018 Alt 3 — *Today's Date: 13-Aug-18*

Figure 8-4.—Truckee Canal Corrective Action Alternative 3 – Construction Schedule.

8 Construction considerations

Figure 8-4. Truckee Canal Corrective Action Alternative 3 — Construction Schedule — 13-Aug-18 15:12

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
G1250	Mobilize Alt 3 Geo 4th Yr ~25,000ft	2d	31-Aug-26*	01-Sep-26	1086d	5 Day w/Hol
G1260	Construction	90d	02-Sep-26	12-Jan-27	1086d	5 Day w/Hol
Final Site Activities						
S-1050	Final Inspection	3d	07-Apr-31	09-Apr-31	0d	5 Day w/Hol
S-1060	Final Punchlist, Cleanup Site and Demobilize from Site	8d	10-Apr-31	21-Apr-31	0d	5 Day w/Hol
Check Structure						
Fernley Construct Check Stucture						
A1100	Fernley Site Mobilization	17d	03-Sep-27*	28-Sep-27	789d	5 Day w/Hol
A1110	Unwater	5d	29-Sep-27	05-Oct-27	789d	5 Day w/Hol
A1130	Electrical Enclosures	15d	29-Sep-27	19-Oct-27	848d	5 Day w/Hol
A1120	Demo	7d	06-Oct-27	14-Oct-27	789d	5 Day w/Hol
A1140	Foundation and Concrete	55d	15-Oct-27	05-Jan-28	789d	5 Day w/Hol
A1150	Gate and Hoist	30d	06-Jan-28	16-Feb-28	796d	5 Day w/Hol
A1160	Stoops and Decking	37d	06-Jan-28	25-Feb-28	789d	5 Day w/Hol
A1180	Final Site Activities and Commissioning	11d	28-Feb-28	13-Mar-28	789d	5 Day w/Hol
Anderson Construct Check Stucture						
A2000	Anderson Site Mobilization	17d	05-Sep-28*	27-Sep-28	535d	5 Day w/Hol
A2010	Unwater	5d	28-Sep-28	04-Oct-28	535d	5 Day w/Hol
A2030	Electrical Enclosures	15d	28-Sep-28	18-Oct-28	594d	5 Day w/Hol
A2020	Demo	7d	05-Oct-28	13-Oct-28	535d	5 Day w/Hol
A2040	Foundation and Concrete	55d	16-Oct-28	04-Jan-29	535d	5 Day w/Hol
A2050	Gate and Hoist	30d	05-Jan-29	15-Feb-29	542d	5 Day w/Hol
A2060	Stoops and Decking	37d	05-Jan-29	26-Feb-29	535d	5 Day w/Hol
A2070	Final Site Activities and Commissioning	11d	27-Feb-29	13-Mar-29	535d	5 Day w/Hol
Allendale Construct Check Stucture						
A3010	Allendale Site Mobilization	17d	04-Sep-29*	26-Sep-29	282d	5 Day w/Hol
A3020	Unwater	5d	27-Sep-29	03-Oct-29	282d	5 Day w/Hol
A3040	Electrical Enclosures	15d	27-Sep-29	17-Oct-29	341d	5 Day w/Hol
A3030	Demo	7d	04-Oct-29	12-Oct-29	282d	5 Day w/Hol
A3050	Foundation and Concrete	55d	15-Oct-29	03-Jan-30	282d	5 Day w/Hol
A3060	Gate and Hoist	30d	04-Jan-30	14-Feb-30	289d	5 Day w/Hol
A3070	Stoops and Decking	37d	04-Jan-30	25-Feb-30	282d	5 Day w/Hol
A3080	Final Site Activities and Commissioning	11d	26-Feb-30	12-Mar-30	282d	5 Day w/Hol
Masson Construct Check Stucture						
A4010	Masson Site Mobilization	17d	03-Sep-30*	25-Sep-30	0d	5 Day w/Hol
A4020	Unwater	5d	26-Sep-30	02-Oct-30	0d	5 Day w/Hol
A4040	Electrical Enclosures	15d	26-Sep-30	16-Oct-30	88d	5 Day w/Hol
A4030	Demo	7d	03-Oct-30	11-Oct-30	0d	5 Day w/Hol
A4050	Foundation and Concrete	55d	14-Oct-30	02-Jan-31	0d	5 Day w/Hol
A4060	Gate and Hoist	30d	03-Jan-31	13-Feb-31	36d	5 Day w/Hol
A4070	Stoops and Decking	37d	03-Jan-31	24-Feb-31	29d	5 Day w/Hol
A4080	Final Site Activities and Commissioning	11d	25-Feb-31	11-Mar-31	29d	5 Day w/Hol
Bango Add Gates						
A5010	Bango Site Mobilization	17d	25-Nov-30	19-Dec-30	0d	5 Day w/Hol
A5020	Unwater	5d	20-Dec-30	27-Dec-30	0d	5 Day w/Hol
A5030	Demo	3d	30-Dec-30	02-Jan-31	0d	5 Day w/Hol
A5050	Foundation and Concrete	25d	03-Jan-31	06-Feb-31	0d	5 Day w/Hol
A5040	Electrical Enclosures	5d	31-Jan-31	06-Feb-31	11d	5 Day w/Hol
A5060	Gate and Hoist	30d	07-Feb-31	20-Mar-31	11d	5 Day w/Hol
A5070	Stoops and Decking	5d	14-Mar-31	20-Mar-31	11d	5 Day w/Hol
A5080	Final Site Activities and Commissioning	11d	21-Mar-31	04-Apr-31	11d	5 Day w/Hol
Hazen Construct Gage Stucture						
A6010	Hazen Site Mobilization	17d	31-Dec-30	23-Jan-31	0d	5 Day w/Hol
A6020	Unwater	5d	24-Jan-31	30-Jan-31	0d	5 Day w/Hol
A6030	Demo	5d	31-Jan-31	06-Feb-31	0d	5 Day w/Hol
A6050	Foundation and Concrete	25d	07-Feb-31	13-Mar-31	0d	5 Day w/Hol
A6040	Electrical Enclosures	5d	07-Mar-31	13-Mar-31	0d	5 Day w/Hol
A6060	Gate and Hoist	5d	14-Mar-31	20-Mar-31	0d	5 Day w/Hol
A6070	Stoops and Decking	5d	14-Mar-31	20-Mar-31	0d	5 Day w/Hol
A6080	Final Site Activities and Commissioning	11d	21-Mar-31	04-Apr-31	0d	5 Day w/Hol

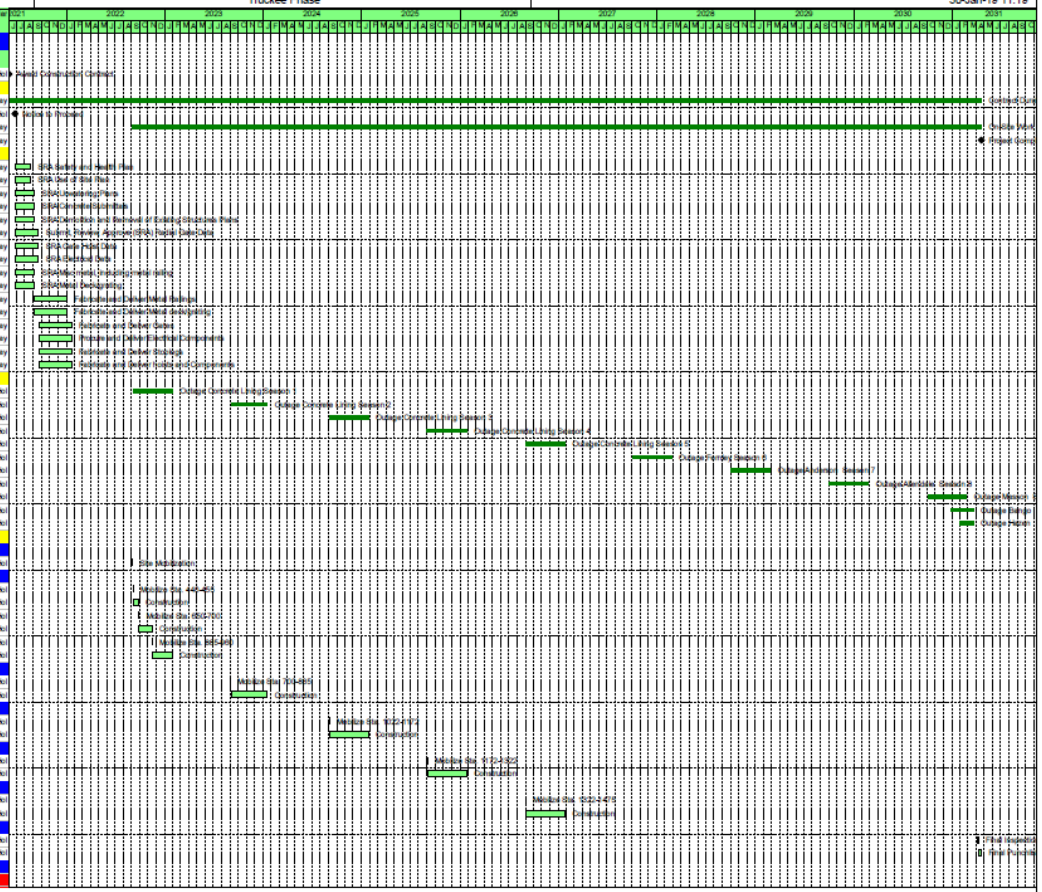


Remaining Level of Effort — Actual Work — Remaining Work | Truckee Canal Check Structure Replacement Jun 2018 Alt 3 | *Today's Date: 13-Aug-18*

Figure 8-4.—Truckee Canal Corrective Action Alternative 3 – Construction Schedule.

Figure 8-5. Truckee Canal Corrective Action Phase 1B and Alt 4 | Truckee Phase | 30-Jan-19 11:19

Activity ID	Activity Name	Planned Duration	Start	Finish	Total Float	Calendar
Truckee Canal Check Structure Replacement Jan 2019 Alt 4						
CANAL WORK						
1000	Award Construction Contract	0d	03-Jun-21*		2283d	5 Day w/Hol
General						
G-1010	Contract Duration	3610d	03-Jun-21	21-Apr-31	0d	7 Day
G-1000	Notice to Proceed	0d	24-Jun-21		2283d	5 Day w/Hol
G-1020	On-Site Work	3153d	03-Sep-22	21-Apr-31	0d	7 Day
G-1030	Project Complete	0d		21-Apr-31	0d	7 Day
Submittals, Procurement, Fabrication						
G-1040	SRA Safety and Health Plan	60d	24-Jun-21	22-Aug-21	3332d	7 Day
G-1050	SRA Use of Site Plan	60d	24-Jun-21	22-Aug-21	3529d	7 Day
G-1060	SRA Unwatering Plans	75d	24-Jun-21	06-Sep-21	3514d	7 Day
G-1070	SRA Concrete Submittals	75d	24-Jun-21	06-Sep-21	3514d	7 Day
G-1080	SRA Demolition and Removal of Existing Struct.	75d	24-Jun-21	06-Sep-21	3514d	7 Day
G-1090	Submit, Review, Approve (SRA) Radial Gate Da	90d	24-Jun-21	21-Sep-21	3301d	7 Day
G-1100	SRA Gate Hoist Data	90d	24-Jun-21	21-Sep-21	3499d	7 Day
G-1110	SRA Electrical Data	90d	24-Jun-21	21-Sep-21	3379d	7 Day
G-1130	SRA Misc metal, including metal railing	75d	24-Jun-21	06-Sep-21	3394d	7 Day
G-1140	SRA Metal Deck/grating	75d	24-Jun-21	06-Sep-21	3394d	7 Day
G-1160	Fabricate and Deliver Metal Railings	120d	07-Sep-21	04-Jan-22	3394d	7 Day
G-1170	Fabricate and Deliver Metal deck/grating	120d	07-Sep-21	04-Jan-22	3394d	7 Day
G-1180	Fabricate and Deliver Gates	120d	22-Sep-21	19-Jan-22	3379d	7 Day
G-1200	Procure and Deliver Electrical Components	120d	22-Sep-21	19-Jan-22	3379d	7 Day
G-1210	Fabricate and Deliver Stoplogs	120d	22-Sep-21	19-Jan-22	3379d	7-Day
G-1220	Fabricate and Deliver hoists and Components	120d	22-Sep-21	19-Jan-22	3301d	7 Day
Outage Summary						
A1001	Outage Concrete Lining Season 1	98d	07-Sep-22	31-Jan-23	2085d	5 Day w/Hol
A1003	Outage Concrete Lining Season 2	92d	05-Sep-23	18-Jan-24	1843d	5 Day w/Hol
A1006	Outage Concrete Lining Season 3	99d	05-Sep-24	27-Jan-25	1583d	5 Day w/Hol
A1007	Outage Concrete Lining Season 4	101d	02-Sep-25	26-Jan-26	1330d	5 Day w/Hol
A1008	Outage Concrete Lining Season 5	101d	31-Aug-26	25-Jan-27	1077d	5 Day w/Hol
A1010	Outage Fernley Season 6	99d	06-Oct-27	25-Feb-28	789d	5 Day w/Hol
A2001	Outage Anderson Season 7	99d	05-Oct-28	26-Feb-29	535d	5 Day w/Hol
A3000	Outage Allendale Season 8	99d	04-Oct-29	25-Feb-30	282d	5 Day w/Hol
A4000	Outage Masson Season 9	99d	03-Oct-30	24-Feb-31	29d	5 Day w/Hol
A5000	Outage Bango	58d	30-Dec-30	20-Mar-31	11d	5 Day w/Hol
A6000	Outage Hazen	35d	31-Jan-31	20-Mar-31	0d	5 Day w/Hol
Construction						
Initial Mobilization						
A1500	Site Mobilization	5d	29-Aug-22	02-Sep-22	2052d	5 Day w/Hol
Concrete Lining Season 1						
F1100	Mobilize Sta. 440-455	1d	06-Sep-22*	06-Sep-22	2085d	5 Day w/Hol
F1110	Construction	14d	07-Sep-22	26-Sep-22	2085d	5 Day w/Hol
H1100	Mobilize Sta. 650-700	1d	27-Sep-22	27-Sep-22	2085d	5 Day w/Hol
H1120	Construction	33d	28-Sep-22	15-Nov-22	2085d	5 Day w/Hol
P1100	Mobilize Sta. 885-960	1d	16-Nov-22	16-Nov-22	2085d	5 Day w/Hol
P1110	Construction	49d	17-Nov-22	31-Jan-23	2085d	5 Day w/Hol
Concrete Lining Season 2						
G1120	Mobilize Sta. 700-835	2d	31-Aug-23*	01-Sep-23	1843d	5 Day w/Hol
G1110	Construction	92d	05-Sep-23	18-Jan-24	1843d	5 Day w/Hol
Concrete Lining Season 3						
G1140	Mobilize Sta. 1022-1172	2d	03-Sep-24*	04-Sep-24	1583d	5 Day w/Hol
G1210	Construction	99d	05-Sep-24	27-Jan-25	1583d	5 Day w/Hol
Concrete Lining Season 4						
G1230	Mobilize Sta. 1172-1322	2d	02-Sep-25*	03-Sep-25	1330d	5 Day w/Hol
G1240	Construction	99d	04-Sep-25	26-Jan-26	1330d	5 Day w/Hol
Concrete Lining Season 5						
G1250	Mobilize Sta. 1322-1475	2d	31-Aug-26*	01-Sep-26	1077d	5 Day w/Hol
G1260	Construction	99d	02-Sep-26	25-Jan-27	1077d	5 Day w/Hol
Final Site Activities						
S-105	Final Inspection	3d	07-Apr-31	09-Apr-31	0d	5 Day w/Hol
S-106	Final Punchlist, Cleanup Site and Demobilize fro	8d	10-Apr-31	21-Apr-31	0d	5 Day w/Hol
Check Structure						
Fernley Construct Check Stucture						



Remaining Level of Effort | Actual Work | Remaining Work | Truckee Canal Check Structure Replacement Jan 2019 Alt 4 | Today's Date: 30-Jan-19

Figure 8-5.—Truckee Canal Corrective Action and Alternative 4 – Construction Schedule.

9 ENVIRONMENTAL CONSIDERATIONS

Reclamation completed the Administrative Draft Truckee Canal XM EIS in December 2018 [16]. Impacts associated with key findings are summarized in table 9-1. Refer to the EIS for additional details on environmental considerations.

Table 9-1.—Summary of Environmental Consequences

Resource	Key Findings
Water resources	While minor differences in water resource impacts exist among each alternative, based on compliance with applicable environmental protection measures, environmental laws, and regulations, the alternatives would not result in significant direct, indirect, or cumulative impacts on surface water or water quality for the City of Fernley. These lined areas would reduce artificial groundwater recharge. Dr. Greg Pohll's 2012 modeling indicated that Canal seepage in the Fernley area ranged from 14,000 to 22,000 acre-feet per year (AFY). Water Resource EPMs could be implemented to reduce impacts on shallow groundwater users.
Cultural and historic resources	Results from the cultural resources analysis indicate that replacement and modifications of features and historic characteristics of the Canal, a historic property, may result in an adverse effect on the Canal and would have an adverse impact on cultural resources. Section 106 consultation, the implementation of the programmatic agreement, and compliance with EPMs would lessen the impacts on cultural resources.
Indian trust assets	The implementation of any of the action alternatives would not adversely affect Indian trust assets (ITAs).
Vegetation	While minor differences in vegetation impacts exist among each alternative, compliance with applicable EPMs, environmental laws, and regulations; therefore, the alternatives would not result in significant direct, indirect, or cumulative impacts on vegetation.
Wildlife	While minor differences in wildlife impacts exist among each alternative, compliance with applicable EPMs, environmental laws, and regulations; therefore, the alternatives would not result in significant direct, indirect, or cumulative impacts on wildlife.
Aquatic resources	While minor differences in aquatic resources impacts exist among each alternative, based on compliance with EPMs, applicable environmental laws, and regulations, the alternatives would not result in significant direct, indirect, or cumulative impacts on aquatic resources.
Listed species	While minor differences in the potential for impacts on listed species exist among each alternative, based on compliance with EPMs, applicable environmental laws, and regulations, the alternatives would not result in significant direct, indirect, or cumulative impacts on listed species. There would be no impacts on western yellow-billed cuckoo proposed critical habitat under any alternative.
Air quality and climate change	Impacts on air quality would be localized and short term under all action alternatives. Because EPMs would reduce fugitive dust emissions generated by soil-disturbing activities during construction, the alternatives would not result in significant direct, indirect, or cumulative impacts on air quality.
Geology and soils	Impacts on geology and soils would be localized and short term under all action alternatives. Because EPMs would reduce impacts on geology and soils during construction, the alternatives would not result in significant direct, indirect, or cumulative impacts on geology.

9 Environmental considerations

Table 9-1.—Summary of Environmental Consequences

Resource	Key Findings
Health and safety	Impacts on health and safety would be localized and short term under all action alternatives. Because EPMs would reduce impacts on health and safety, the alternatives would not result in significant direct, indirect, or cumulative impacts.
Socioeconomic resources	All action alternatives would temporarily increase construction employment and direct and indirect economic contributions; however, based on the Project Area construction workforce and economy, impacts would be minimal. All action alternatives include lining that would reduce the risk of flooding, thereby reducing the socioeconomic impacts on adjacent property owners and the local community. These lined areas would eliminate Canal seepage that may result in a reduction in artificial groundwater recharge, with potential indirect economic impacts on shallow groundwater users.
Environmental justice	No disproportionate adverse impacts are anticipated on low-income or minority populations under any alternative. Under all action alternatives, construction could result in short-term, location-specific impacts on area populations from increased dust; however, low-income or minority populations would not be disproportionately affected. Under all action alternatives, the proposed Canal lining and other measures would reduce the potential for flooding but may increase the impacts on shallow groundwater users in all populations.

10 FEASIBILITY LEVEL DESIGN STUDY CONCLUSIONS

This EES study evaluated four alternatives designed to safely manage flows in the Canal under normal operation and during a flood event. The alternatives were evaluated based on their construction costs, economics, and future maintenance.

Cost Considerations

When only considering costs, Alternative 1 and Alternative 2 are favored over the other alternatives. Construction costs are lower than the other alternatives due to the generally high costs to line the Canal. Costs to line the Canal with soil or concrete over geomembrane average approximately $4 million per mile. At that rate, it takes approximately 5 miles of Canal lining to equal the costs of the detention pond and gate structure.

Construction Considerations

The constructability for each of the alternatives are similar when comparing alternatives. A better matrix to consider is the duration of the construction and the amount of time the Canal will be taken out of service. Table 10-1 below shows construction durations and Canal outages for each of the three alternatives.

Table 10-1.—Construction durations and canal outages by Alternative

	Construction Durations (Days)	Canal Outages
Alternative 1	3375	10
Alternative 2	3585	11
Alternative 3	3572	11
Alternative 4	3610	11

When evaluating construction considerations, Alternative 1 is slightly favored over the other alternatives. All of the alternatives require work within the Canal prism for reshaping, fill placement, and liner installation. Alternative 1 has less Canal lining which require fewer outages to complete the construction. Alternative 1 also has larger detention ponds that could be constructed without a Canal outage. Additionally, detention pond construction has no restrictions on the construction season.

Benefits and OM&R Considerations

Table 7-1 Summary of results by alternative in the Economics Analysis section of this report summarizes the results of the contract costs, benefits analysis, and OM&R. The results show Alternative 1 as the least cost alternative and Alternative 4 as a second choice when considering benefit and OM&R factors.

Other Considerations

The proposed detention ponds in Alternatives 1 and 2 pose significant hazards if they are ever used to capture runoff from a large storm event. The large volume of water stored in the detention ponds would cause significant damage if the embankments were to fail. Although the proposed detention pond embankments would not be considered high hazard dams due to their heights and current consequence levels, any future development downstream from these structures would increase the hazard and the potential for damage and loss of life.

Below are additional negatives associated with the use of detention ponds that make Alternative 1 and 2 less attractive.

- The detention ponds are remote and are not fenced. Because of their configurations, the site could be attractive to off road vehicles and could be subject to vandalism. Vandalism costs are not included in the OM&R costs.

- The bottom of the detention ponds are not lined and do not provide any water conservation.

- The large size of the ponds, especially those in Alternative 1, will take up a substantial amount of unusable space for the duration of the project.

- Any new development down slope of the ponds would increase Reclamation's risk exposure and could require other corrective action to mitigate the risk.

- When the gated structures are operational and the ponds fill with water, Reclamation will be exposed to some risk until the water in the ponds subsides.

- As with the Canal embankment, the pond embankments are subject to vegetation growth and rodent damage.

- Gates are difficult to seal and leakage is likely during Canal operations creating a potential wetland creation.

In addition to the negative factors listed above for detention ponds, the following are negative factors with the use of soil over geomembrane liners for Canal lining:

- Soil along the invert and prism slopes will continue to require vegetation and sediment removal activities. This activity is easier when the cover is concrete instead of soil.

- The selection of roughness values was somewhat subjective during the development of the HEC-RAS models used to represent soil over geomembrane lining options. The models were highly sensitive to changes in these values depending on assumptions made regarding the quality of maintenance performed and final values ultimately relied on engineering judgement. This sensitivity implies the successful performance of the canal with soil over geomembrane lining is directly related to the quality of maintenance performed on the lining.

- Multiple lining systems (i.e. concrete/geomembrane and soil/geomembrane) complicates O&M.

10.1 Recommended alternative for final design

Each of the four alternatives evaluated met the safety requirements of the purpose and need in the EIS. Although Alternative 4 did not have the least value when considering benefits and costs, it did provide the best overall value to the project when considering all other factors and was found to be the preferred alternative to continue into final design. Additional factors that make Alternative 4 favorable include the following:

- Alternative 4 provides the highest risk reduction compared to all other alternatives.
- Alternative 4 reduces identified risks without creating new ones.
- Alternative 4 is the least cost alternative to maintain.
- Alternative 4 is the most efficient and most reliable overall water delivery system when compared to the other alternatives.
- Alternative 4 could be constructed in phases over a 9-year construction window, prioritizing the reaches based on risk. Canal lining does not require specialized construction methods and could be completed by TCID.

10.2 Additional data needs

There are design data needs that will be required for the project as it continues into final design. The latest aerial survey of the Canal was completed in 2008. An updated aerial survey of the Canal in its current condition is recommended for use during final design. The aerial survey will need to be scheduled during a planned Canal outage. This will allow for a better estimation of the earthwork volumes for each of the alternatives. The work should also include a detailed survey of the right-of-way limits and all utilities within 200 feet of the Canal centerline. This information will be needed to identify construction disturbance outside of the existing right-of-way and any utilities requiring relocation.

CONTROLLED

11 REFERENCES

[1] 2013. TCID Letter to Reclamation requesting assistance

[2] Flow/stage level Restriction Recommendations for the Truckee Canal, Decision Document and Technical Report of Findings, Newlands Project, Nevada, Technical Service Center, Bureau of Reclamation, Department of Interior, Denver, Colorado, June 2015.

[3] "Final Risk Assessment, Truckee Canal Issue Evaluation – Report of Findings," Newlands Project, Nevada, Mid-Pacific Region Technical Service Center, Bureau of Reclamation, Department of the Interior, Denver, Colorado, February 2008.

[4] "Truckee Canal Issue Evaluation" Newlands Project, Nevada, Mid Pacific Region, Design, Estimating and Construction Office, Bureau of Reclamation, Department of the Interior, Denver, Colorado March 2008.

[5] Dam Safety Office. July 2014. Proposed Risk Analysis Process for the Truckee Canal, Decision Document and Technical Memorandum, Newlands Project, Nevada, Mid-Pacific Region. Denver: Bureau of Reclamation.

[6] Technical Service Center. June 2015. Updated Risk Analysis – Truckee Canal, Issue Evaluation - Report of Findings, Newlands Project, Nevada, Technical Service Center, Bureau of Reclamation, Department of Interior, Denver, Colorado.

[7] Enhanced Truckee Canal Hydrologic Hazard Analysis Technical Memorandum TM-2017-2. Lahontan Basin Area Office, US Department of the Interior, Bureau of Reclamation, David Ford Consulting Engineers, Sacramento, California, October 2017.

[8] Updated Hydrologic Risk Analysis, Technical Memorandum: No. QY-2017-8311-1, Newlands Project, Nevada, Technical Service Center, Bureau of Reclamation, Department of the Interior, Denver, Colorado, March 2018.

[9] Technical Memorandum: Truckee Canal Flood Hydraulic Analysis, Lahontan Basin Area Office, US Department of the Interior, Bureau of Reclamation, Carson City, Nevada, October, 2017

11 References

[10] Decision Document: Proposed Long-term Risk Reduction and Design Criteria for the Truckee Canal, Newlands Project, Nevada, Technical Service Center, Bureau of Reclamation, Department of the Interior, Denver, Colorado, December 2016.

[11] Truckee Canal Corrective Action Study, Technical Memorandum QY-2016-8311-1. Truckee-Carson Project, Nevada, Lahontan Basin Area Office, US Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, July 2017.

[12] ASCE/SEI 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers, Reston Virginia, 2017.

[13] "Summary of Geologic Investigations, 2009 through 2010, Truckee Canal", Newlands Project, Nevada, Mid-Pacific Region Office, Bureau of Reclamation, Department of Interior, Sacramento, California, July 2014.

[14] "Truckee-Carson Irrigation District (TCID) Conduit Replacement, Construction Geology", Newlands Project, Nevada, Mid-Pacific Region Office, Bureau of Reclamation, Department of Interior, Sacramento, California, July 2012.

[15] DOI-BOR-LBAO. (2018, July). Technical Memorandum, Water Operations Planning Study for the Truckee Canal Extraordinary Maintenance Engineering and Economic Study. U.S. Department of the Interior, Bureau of Reclamation,Mid Pacific Region, Lahontan Basin Area Office.

[16] Truckee Canal Extraordinary Maintenance, Draft Environmental Impact Statement, Department of the Interior, Bureau of Reclamation, Mid Pacific Region, Lahontan Basin Area Office, December 2018.