Proposed Compensatory Mitigation and Monitoring Plan

Union Pacific Railroad Great Salt Lake Causeway Culvert Closure and Bridge Construction Project

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Prepared for
Union Pacific Railroad
Omaha, NE 68179

Prepared by
HDR Engineering, Inc.
Kidd Waddell
Wally Gwynn

Contents

Tables

Figures

Appendices

1.0 Project Description

1.1 Purpose of This Plan

What is the proposed project?

The proposed project is defined as the permanent closure of the east culvert of UPRR's Great Salt Lake railroad causeway. The project includes constructing a 180-foot-long bridge structure and a control berm that creates a 150-foot-long opening through the causeway to allow water and salt transfer between Gilbert and Gunnison Bays as compensatory mitigation for closing both the east and west culverts.

Union Pacific Railroad (UPRR) operates trains on a rock-filled causeway built by UPRR's predecessor in 1959 across Utah's Great Salt Lake. UPRR is seeking authorization of permanent closure of the east culvert in the causeway for implementation of a previously authorized compensatory mitigation action to offset the effects of closing the east and west culverts of the causeway by constructing a new bridge with an opening in the causeway. These actions are referred to in this document as the proposed project.

The proposed project requires an Individual Permit (IP) from the U.S. Army Corps of Engineers (USACE) and a Utah 401 Water Quality Certification from the Utah Division of Water Quality (UDWQ). In order to obtain these authorizations, UPRR has prepared this Compensatory Mitigation and Monitoring Plan (CMMP) for USACE and UDWQ approval. The specific conditions that require UPRR to submit a CMMP are:

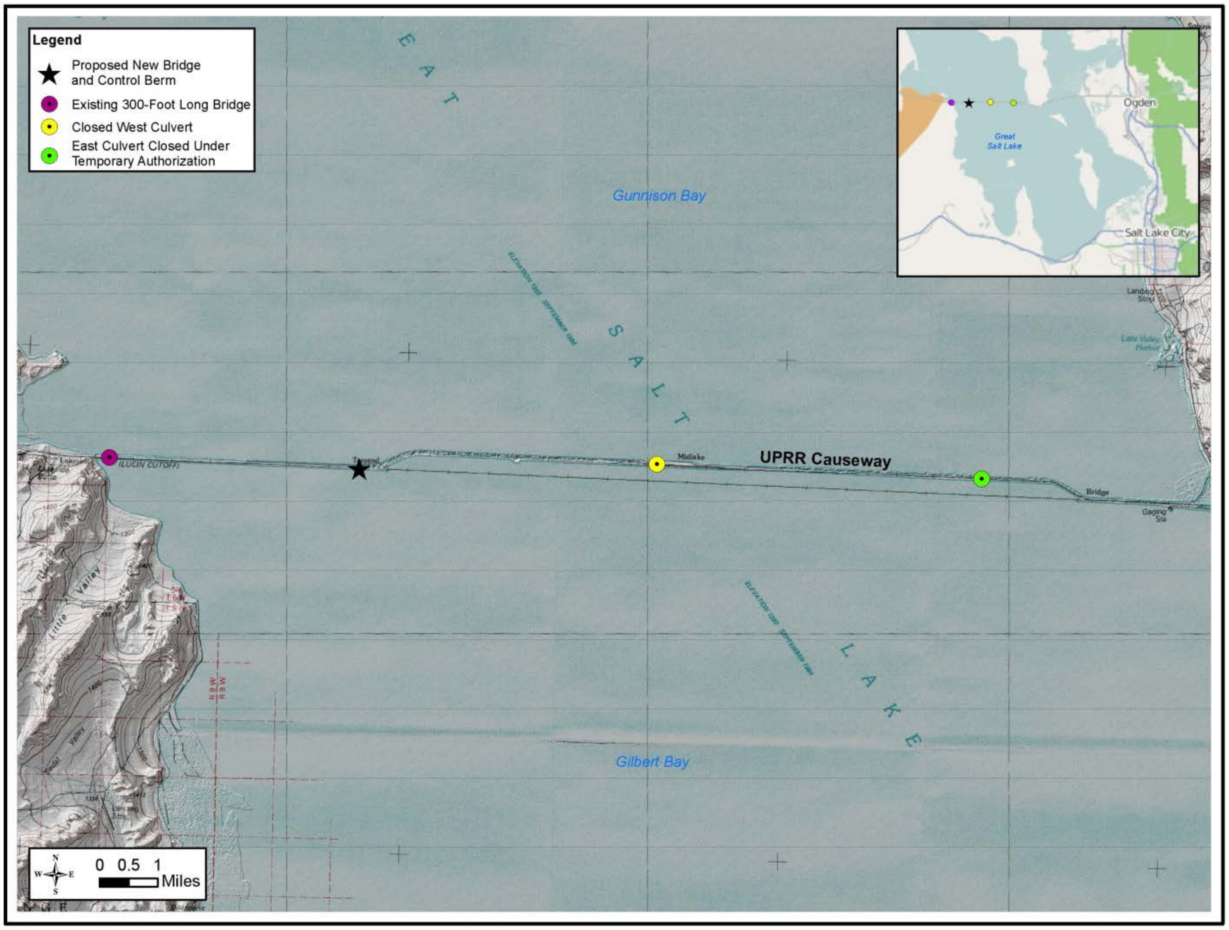
- Special Conditions 2 through 6 of the Nationwide Permit (NWP) authorization issued by USACE in August 2012 (USACE 2012b)
- Special Conditions 2 and 6 of the Nationwide Permit authorization issued by USACE in December 2013 (USACE 2013b)
- Conditions 4b and 5 of the Utah 401Water Quality Certification issued by UDWQ in December 2013 (UDWQ 2013)
- Individual Permit Application submitted by UPRR (UPRR 2014a)

Additionally, UPRR has submitted a request for an easement to the Utah Division of Forestry, Fires and State Lands to secure UPRR's access rights over the causeway at this location. As described in the December 13, 2013, USACE and UDWQ public notice for the project, UPRR is seeking authorization for permanent closure of the east culvert (which was closed previously under a temporary emergency authorization) and implementation of a previously authorized compensatory mitigation action to mitigate the effects of closing the east and west culverts of the causeway by constructing a new bridge with an opening in the causeway. UPRR's original compensatory mitigation plan was to construct a 180-foot-long bridge structure with a causeway opening that would replace the aquatic functions provided by the east and west culverts before they were closed (UPRR 2013a). At that time, USACE authorized construction of the bridge subject to UPRR's submission and USACE's and UDWQ's approval of a final compensatory mitigation and monitoring plan. This proposed CMMP replaces the UPRR mitigation and monitoring plan proposed to and rejected by USACE in 2013.

1.2 Project Background and Project Description

The proposed project is located in the Great Salt Lake, which is in northwestern Utah. UPRR operates trains on a rock-fill causeway, which separates the lake into areas that are called the North Arm and the South Arm. Water and salt are conveyed back and forth between the lake's North and South Arms through the permeable causeway rock fill and the existing 300-foot-long bridge. Until recently, water and salt were also conveyed back and forth between the lake's North and South Arms through two culverts (the east and west culverts located in the causeway. The east culvert is about 6 miles west of Promontory Point, and the west culvert is about 11 miles west of Promontory Point (see Figure 1-1). Both culverts are about 15 feet wide by about 20 feet deep. Over time, the culverts settled and became submerged.

Figure 1-1. UPRR Project Area



When inspections revealed that the culverts were settling and breaking with the risk of collapsing, UPRR met with USACE, UDWQ, and other agencies and then applied in May 2011 for the necessary approvals to close the two culverts. At that time, UPRR also proposed to construct a 180-foot-long bridge and causeway opening to compensate for the loss of water and salt transfer between the North and South Arms that the culverts had historically contributed.

Following the emergency closure of the west culvert, as discussed in more detail below, UPRR re-evaluated its proposal and the project's potential adverse effects in response to concerns raised by several state and federal agencies. As the re-evaluation continued, the condition of the culverts continued to deteriorate. USACE authorized the permanent closure of the west culvert in November 2012 on an emergency basis (USACE 2012b). Along with the November 2012 authorization for closing the west culvert, USACE authorized UPRR's compensatory mitigation proposal concept—construction of a 180-foot-long bridge with a 180-foot-long causeway opening—that would replace the arm-to-arm water and salt transfer function that was previously provided by the free-flowing east and west culverts, subject to submission of a compensatory mitigation and monitoring plan.

In December 2013, it became necessary for UPRR to close the east culvert under an emergency authorization from USACE when additional inspections identified the imminent risk of the east culvert failing. The 2013 emergency closure of the east culvert also required the approval of UDWQ. USACE authorized temporary closure of the east culvert (USACE 2013b), and UDWQ provided a conditional Utah 401 Water Quality Certification for this temporary closure (UDWQ 2013). USACE's temporary culvert closure authorization included direction to UPRR to submit an individual permit application to provide a permanent solution.

What is the objective of UPRR's compensatory mitigation?

The objective of the mitigation is to duplicate, as closely as possible, the aquatic function (water and salt transfer) lost due to the closure of the east and west culverts by constructing a new causeway opening.

As reflected in USACE's direction to UPRR, the objective of UPRR's compensatory mitigation is to duplicate, as closely as possible, the transfer of water and salt that was occurring through the causeway, between the North and South Arms of the lake, with the free-flowing culverts functioning as documented in November 2012 when it was necessary to close the first culvert (the west culvert).

The elements of the project and compensatory mitigation proposed by UPRR that are subject to authorization under the federal Clean Water Act consist of the following:

- Authorization for the east culvert to remain closed permanently (this would be an administrative action because the east culvert was previously closed pursuant to the emergency permitting action; it authorized the temporary closure of the failing east culvert pending UPRR's completion of its impacts re-evaluation and development of a final compensatory mitigation solution)
- Construction of a temporary shoofly to accommodate rail traffic while the compensatory mitigation (bridge) is installed
- Construction of a 180-foot-long bridge structure and an adjacent control berm to create a 150-foot-long opening through the causeway (referenced herein as the causeway opening or 150-foot-long causeway opening) as compensatory mitigation for the effects of the project (closure of the two culverts) on waters of the U.S, subject to approval of a written compensatory mitigation, monitoring, and adaptive management plan (this CMMP).

What is the shoofly?

The shoofly is a temporary embankment with railroad tracks. The shoofly would be established to reroute train traffic onto a temporary alignment so that construction could occur along the permanent alignment.

The new causeway opening associated with the proposed bridge and control berm is designed to compensate for the effects on waters of the U.S. associated with the east culvert closure as well as the previously approved closure of the west culvert. The control berm is a critical element of adaptive management. This CMMP is prepared in support of USACE and UDWQ requirements to ensure that the compensatory mitigation achieves that objective.

2.0 Water and Salt Balance Modeling and Other Studies Completed by UPRR in Support of the Project

This section will discuss the analytical approach to define project effects on the lake ecosystem and support this CMMP. Summarized are the studies conducted including the water and salt balance modeling report, bridge evaluation report, and resource evaluation report, which also support this CMMP.

2.1 Analytical Approach

During the process of reviewing UPRR's original permitting proposal and proposed compensatory mitigation and monitoring plan in 2012 and 2013, federal and state agencies raised a number of concerns about the potential adverse effects of the project and the sufficiency of the original proposed CMMP, which UPRR submitted in January 2013 pursuant to USACE NWP 14. USACE rejected that CMMP on February 14, 2013, saying:

> [T]he Corps is unable to determine [that] the new causeway breach would adequately replace the functions of the culverts and that it would not cause additional adverse effects to the Great Salt Lake and, therefore, we cannot approve the current mitigation plan.

On February 21, 2013, USACE further stated:

> Additionally, since the emergency authorization was issued, we have received additional comments from the Utah Division of Water Quality underscoring the unknown effects of the culvert closure and new breach construction. There remain uncertainties about the ability for the new breach to provide the same functions as the culverts and the [proposed new] breach exacerbating the differing salinity concentration [differences] between the North and South Arms of the lake.

Among other things, virtually every agency commenting on UPRR's proposal insisted that UPRR update, calibrate, and use the U.S. Geological Survey's (USGS) 1998 Water and Salt Balance Model of the Great Salt Lake, Utah (referred to in this document as the 1998 USGS Model) to evaluate the effects of carrying out UPRR's proposal on the water and salt balance between the two arms of the lake. UDWQ had been raising concerns about the project since 2011, asserting the need for additional studies and the necessity of using the USGS Water and Salt Balance Model (September 8, 2011, letter to the Utah Public Lands Policy Coordination Office). In a March 2013 letter, UDWQ raised similar objections to the January 2013 CMMP and again called for UPRR to update and recalibrate the 1998 USGS Model (March 1, 2013, letter from Utah Public Lands Policy Coordination Office to USACE).

Based on these concerns, USACE stated in its February 21, 2013, letter:

> [T]he Corps suggests UPRR revise its mitigation and monitoring plan to address the Corps' and other agencies' comments and concerns. Further, to help inform the Corps' decision, we strongly encourage UPRR to update the U.S. Geological Survey's Salt Balance Model, working with USGS, to better understand and predict the likely effects of the project on the Great Salt Lake.

In response to these concerns, UPRR undertook a significant re-evaluation of the potential effects of the proposed project in 2013 and met with USACE, UDWQ, and other agencies to coordinate the development of a revised approach. UPRR developed and submitted a comprehensive impacts re-evaluation plan dated September 25, 2013 (UPRR 2013b) that reflected this effort. Pursuant to the September 25 plan, UPRR proposed, and has since completed, several studies to support the impacts re-evaluation. The water and salt balance modeling requested by the agencies is the central element of this impacts evaluation. The analytical approach used in these studies to assess project impacts and confirm the mitigation proposal was necessarily tied to the model. Similarly, the results of these studies, the feedback that USACE, UDWQ, and other coordinating agencies provided during regular in-person progress meetings and the resulting CMMP are likewise tied to this same USGS model–based analytical approach described in the September 25 plan. The results of the modeling and other impacts evaluation studies are summarized below and are referenced throughout this document.

2.2 Summary of the Water and Salt Balance Modeling

In the first major step of the impacts re-evaluation, UPRR conducted a three-step water and salt balance modeling process based on the 1998 USGS Model, as requested by all the agencies. The modeling re-evaluated the effects of closing the east and west culverts and constructing the originally proposed 180-foot-long bridge with a 180-foot-long opening in the railroad causeway on the water and salt balance between the North and South Arms of the Great Salt Lake. The steps in the three-step modeling plan were as follows:

- **Modeling step 1:** development of the 1998 UPPR/U.S. Geological Survey (USGS) Model to run under historic hydrologic conditions for the period 1987–1998, plus simulations
- **Modeling step 2:** development of the 2012 UPRR/USGS Model to run under historic hydrologic conditions for the period 1987–2012, plus calibration and simulations
- **Modeling step 3:** development of the 2012 UPRR/USGS Varying Hydrology Model to run under constant wet, mild, and dry conditions for 25 years, plus simulations

The 2012 UPRR/USGS Model simulations (modeling step 2) were based on 26 years of data, and the 2012 UPRR/USGS Varying Hydrology Model (modeling step 3) simulated 25 years of bridge operation. For each step of the modeling plan, the UPRR/USGS model simulated the water surface elevation (WSE), salinity, and salt loads of the North and South Arms of the Great Salt Lake for the following two simulations:

- **Culvert Simulation – Simulated conditions for the east and west culverts before closure of the west culvert in 2012:** The east and west culverts were represented as they existed in November 2012: open and free flowing, and the elevations of the culvert inverts were those from 2012. With these simulations, there are three mechanisms for transferring water and salt through the causeway: the existing 300-foot-long bridge, the two culverts, and the causeway fill. For the purpose of UPRR's modeling and its entire impacts re-evaluation, these causeway conditions are considered the baseline against which the effects of changes associated with the project are compared.
- **Proposed Bridge Simulation – Simulated conditions associated with the bridge proposed as compensatory mitigation for the culvert closures:** The originally proposed 180-foot-long bridge was included as a defined opening in the causeway, and the two culverts were removed (assumed to be filled). With these simulations, there are three mechanisms for transferring water and salt through the causeway: the existing 300-foot-long bridge, the originally proposed 180-foot-long causeway opening, and the causeway fill.

UPRR compared the results of the culvert and proposed bridge simulations for each modeling step (UPRR 2014b). The lake conditions that were compared were WSE; flows through the causeway fill, the existing 300-foot-long bridge, the originally proposed 180-foot-long causeway opening, and the culverts; North and South Arm salt loads; and North and South Arm salinity. For each modeling step, the simulation of the causeway opening at 180 feet long resulted in a more dense (more saline) South Arm than with the baseline culvert simulation. Likewise, the North Arm was less dense (less saline) in the simulation of the causeway opening at 180 feet long than in the culvert simulation. This is primarily attributable to greater north-to-south flows relative to south-to-north flows for the simulation with the 180-foot-long causeway opening than for the baseline simulation with the free-flowing culverts. Thus, there would be greater net salt transfer from the North Arm to the South Arm with a 180-foot-long causeway opening in place than with the free-flowing culverts in place.

2.3 Summary of the Bridge Evaluation Report and Related Modeling

Based on the results of this three-step modeling effort, UPRR conducted the second element of the September 25, 2013, plan: evaluating adjustments to the geometry of the opening associated with the originally proposed 180-foot-long bridge. As described in the September 25 plan, the purpose of this evaluation was to identify any adjustments to that opening that would more closely duplicate the baseline function and the effects of the east and west culverts than would the original proposal. UPRR studied the effects of various alternative causeway opening geometries on the water and salt balance between the North and South Arms. UPRR compared to the culvert simulation results the results for each alternative causeway opening studied. The results were presented in a Bridge Evaluation Report (UPRR 2014c) submitted to USACE and UDWQ on June 2, 2014.

This evaluation was conducted to determine the appropriate size of the causeway opening to meet the compensatory mitigation objective, which is to duplicate, as closely as possible the aquatic function (water and salt transfer) that was lost due to the closure of the two culverts. The bridge evaluation used the 2012 UPRR/USGS models that had been created for modeling steps 2 and 3. Four alternate causeway opening sizes were incorporated into the model codes for comparison to the culvert simulation.

Based on the analysis of the results of the water and salt balance model simulations described in the Bridge Evaluation Report, UPRR determined that a 150-foot-long causeway opening with an invert elevation of 4,183 feet would most closely match the results of the culvert simulation most of the time.

What is an invert?

An invert is the bottom elevation of a causeway opening.

Based on the Bridge Evaluation Report, UPRR proposed a change in the causeway opening geometry from a 180-foot-long causeway opening with an invert elevation of 4,178 feet to a 150-foot-long causeway opening with an invert elevation of 4,183 feet. The results of the water and salt balance modeling indicate that the lake conditions in the North and South Arms are most similar for this causeway opening geometry compared to those conditions that would occur under the culvert simulations for the parameters of total causeway flow ratios, salinity ratios, and salt loads. This analysis shows that there would be a slight change in the water and salt transfer from what occurred through the causeway with the culverts in place but that the causeway with the adjusted opening geometry would best replace the aquatic function of the culverts and would provide water and salt transfer through the causeway that would be most similar to that provided by the culverts.

Therefore, as described in the September 25, 2013, plan, UPRR revised the proposed project to include a 150-foot-long causeway opening with an invert elevation of 4,183 feet and analyzed the potential adverse effects of the project as revised (with the 150-foot-long causeway opening) on other Great Salt Lake resources.

2.4 Summary of the Resource Evaluation Report

Based on the results of the modeling and the adjustments to the causeway opening described in the Bridge Evaluation Report, UPRR prepared a Resource Evaluation Report (UPRR 2014d) as part of re-evaluating the effects of closing the east and west culverts and constructing the proposed 180-foot-long bridge structure, control berm, and 150-foot-long causeway opening on the water and salt balance between the North and South Arms of the Great Salt Lake. The Resource Evaluation Report was the third element of the re-evaluation described in the September 25, 2013, letter from UPRR to USACE (UPRR 2013b).

The Resource Evaluation Report provides background information about the project alternatives and discusses the potential effects of UPRR's proposed project on the lake's ecological resources compared to baseline conditions. Under the baseline conditions, both culverts are open and free flowing, and the water and salt balance varies from year to year based on a number of factors including lake levels, surface water inflows, density gradients, and causeway characteristics. The culverts are located in the causeway in their positions and elevations as of November 2012, before the west culvert was closed. Under the baseline conditions, the causeway openings included the existing 300-foot-long bridge west of the west culvert and the free-flowing east and west culverts. In addition, water and salt transferred through the permeable rock-fill causeway.

For consistency with the modeling performed in the first element of the impacts re-evaluation, the Resource Evaluation Report used the described baseline conditions and the baseline scenario to evaluate the potential effects of the proposed project on various resources. These baseline conditions had also been used for developing the culvert simulations that were evaluated as part of the evaluation of project impacts using the water and salt balance model (UPRR 2014b). The baseline scenario recognizes and reflects the natural variability in lake conditions, such as lake level, salinity, and salt load, over time that existed or would have been associated with the culverts if they had remained at their 2012 location and elevation. On this basis, the resource analyses described in the Resource Evaluation Report focused on how the proposed project and/or bridge alternatives may affect those resources over time.

In other words, the baseline scenario is not a specific WSE or salinity level in the two arms at any given point but is the WSEs or salinity levels that would exist over time with the culverts open and free flowing with natural and historic variability taken into account. The modeling and resource evaluations assessed potential project effects by first establishing the predicted conditions over time under the baseline scenario and then comparing those conditions with the conditions predicted to occur with the culverts closed and the compensatory mitigation causeway opening in place, taking account the lake's natural and historic variability.

To complete the impacts analysis as described in UPRR's September 25, 2013, impacts re-evaluation plan, the Resource Evaluation Report considered whether the slight changes in water and salt balance that would occur with this project (that is, with the 180-foot-long bridge, control berm, and 150-foot-long causeway opening) would have a significant adverse effect on the lake resources described in the report. In order to determine whether the proposed project's potential adverse effects on these resources would be significant, the analyses in the report considered how and whether changes in salinity caused by the project would cause a significant adverse effect on beneficial uses of the Great Salt Lake as designated by UDWQ.

What are beneficial uses?

Lakes, rivers, and other water bodies have uses to humans and other life. These uses are called beneficial uses.

Each resource evaluated in the report included specific factors for determining whether the proposed project would result in changes to those factors that may cause an effect on a specific resource or resources, outside the historic variability, in a way that would result in a significant adverse effect on the lake's beneficial uses.

During public and agency review of UPRR's original proposal to close the existing culverts and as a result of the recent permanent closure of the west culvert and temporary closure of the east culvert, resource agencies and commenters on UPRR's proposals have expressed concerns about potential impacts to Great Salt Lake ecological resources that may result from closing the culverts and constructing the compensatory mitigation (causeway opening). UPRR addressed those concerns in part by evaluating potential adverse effects on those resources in the Resource Evaluation Report. As a result, the resources studied for that report were:

- Water chemistry
- Water quality
- Deep brine layer
- Mercury and methyl mercury
- Biological resources
- Lake circulation

The report concluded with a summary of the potential effects of the project as well as a summary of the project's relationship to the public interest factors evaluated by USACE in its permitting decisions. Table 2-1 below is the summary of project effects from the Resource Evaluation Report (UPRR 2014d).

The resource evaluation identified that, for this project, water quality effects are defined as changes caused by the project that are outside the historic salinity range, as determined by the water and salt balance model results. Lake salinity and salt load changes are used as a surrogate for specific water quality parameters (UDWQ 2014). The Resource Evaluation Report concluded that, with no significant change in salinity, the factors that affect the fate and transport of specific water quality parameters would not be changed, so there would be no significant water quality effect.

UPRR determined, based on the water and salt balance modeling, that the proposed project would cause a slight change in salinity of the South Arm compared to the effect of the baseline conditions (free-flowing culverts). The slight increase in salinity is within the historic variability in salinity that has been documented for the lake. Based on a review of the lake's salinity over time and these effects on resources within this range of variability, UPRR determined that the effect of the proposed project would not cause a change in the variable salinity nature of the lake such that it would adversely affect the lake's beneficial uses (recreation and wildlife and their necessary food chain).

Using salinity as a surrogate for water quality as endorsed by UDWQ, the resource evaluation led to a similar conclusion with regard to the effects of the proposed project on water quality. Since the lake's beneficial uses would not be adversely affected as long as the project performs consistent with the analysis, UPRR determined that the proposed project—permanent closure of the east culvert and constructing a new causeway opening associated with the bridge to mitigate the effects of closing the east and west culverts—would not cause a significant change in the salinity variability such that there would be no significant adverse effects on the lake's beneficial uses.

Table 2-1. Summary of Project Effects

No-Action Alternative	Proposed Project	Alternatives
Water Chemistry		
Effects on South Arm Salinity (Compared to Baseline Conditions)		
Long-term effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	• 2012 UPRR/USGS Model: 1.3% average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.3% increase for wet cycle, 0.2% increase for mild cycle, and 1.2% decrease for dry cycle	Alternative A (180-foot-long causeway opening with invert at 4,178 feet) • 2012 UPRR/USGS Model: 2.7% average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.5% increase for wet cycle, 1.0% increase for mild cycle, and 2.6% increase for dry cycle Alternative B (150-foot-long causeway opening with invert at 4,178 feet) • 2012 UPRR/USGS Model: 1.9% average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.4% increase for wet cycle, 0.5% increase for mild cycle, and 0.9% increase for dry cycle Alternative D (150-foot-long causeway opening with invert at 4,188 feet) • 2012 UPRR/USGS Model: 0.2% average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.2% increase for wet cycle, 0.3% decrease for mild cycle, and 5.3% decrease for dry cycle
Effects on South Arm Salt Load (Compared to Baseline Conditions)		
Long-term effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	• 2012 UPRR/USGS Model: 0.2-billion-ton (BT) average increase. The total lake salt load is estimated at 4.55 BT. • 2012 UPRR/USGS Varying Hydrology Model: 0.07-BT increase for wet cycle, 0.03-BT increase for mild cycle, and 0.17-BT decrease for dry cycle	Alternative A (180-foot-long causeway opening with invert at 4,178 feet) • 2012 UPRR/USGS Model: 0.35-BT average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.12-BT increase for wet cycle, 0.15-BT increase for mild cycle, and 0.33-BT increase for dry cycle Alternative B (150-foot-long causeway opening with invert at 4,178 feet) • 2012 UPRR/USGS Model: 0.24-BT average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.10-BT increase for wet cycle, 0.08-BT increase for mild cycle, and 0.09-BT increase for dry cycle Alternative D (150-foot-long causeway opening with invert at 4,188 feet) • 2012 UPRR/USGS Model: 0.01-BT average increase • 2012 UPRR/USGS Varying Hydrology Model: 0.05-BT increase for wet cycle, 0.06-BT decrease for mild cycle, and 0.67-BT decrease for dry cycle

Table 2-1. Summary of Project Effects

No-Action Alternative	Proposed Project	Alternatives
Water Chemistry (*continued*)		
Construction Effects		
Construction effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	Possible short-term water quality effects, due to constructing and removing the temporary shoofly, that are not expected to affect local or lakewide water chemistry	(All alternatives except no action) Possible short-term water quality effects due to constructing and removing the temporary shoofly
Post-construction Short-Term Effects		
Post-construction short-term effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	Possible rapid salinity and WSE changes in the project area during the transition period	(All alternatives except no action) Possible rapid salinity and WSE changes in the project area during the transition period
Water Quality		
Long-term, construction, and post-construction short-term effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	**Long-term Effects** Analysis uses salinity as a surrogate for specific water quality parameters; see *Water chemistry* above **Construction Effects** Possible short-term water quality effects, due to constructing and removing the temporary shoofly, that are not expected to affect local or lakewide water quality parameters **Post-construction Short-Term Effects** Possible rapid salinity and WSE changes in the project area during the transition period that are not expected to affect water quality parameters	**Long-term Effects** See *Water chemistry* above

Table 2-1. Summary of Project Effects

No-Action Alternative	Proposed Project	Alternatives
Deep Brine Layer		
Effects on Ratio of South-to-North Flow to North-to-South Flow (Compared to Baseline Conditions)		
Long-term effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	• 2012 UPRR/USGS Model: decrease of 0.33 • 2012 UPRR/USGS Varying Hydrology Model: decrease of 0.10 for wet cycle, decrease of 0.05 for mild cycle, and increase of 0.17 for dry cycle • Mild-cycle ratio would most closely match the baseline conditions under the 2012 UPRR/USGS Varying Hydrology Model	Alternative A (180-foot-long causeway opening with invert at 4,178 feet) • 2012 UPRR/USGS Model: decrease of 0.61 • 2012 UPRR/USGS Varying Hydrology Model: decrease of 0.16 for wet cycle, 0.23 for mild cycle, and 0.25 for dry cycle • Poorest match to the baseline conditions Alternative B (150-foot-long causeway opening with invert at 4,178 feet) • 2012 UPRR/USGS Model: decrease of 0.46 • 2012 UPRR/USGS Varying Hydrology Model: decrease of 0.13 for wet cycle, 0.13 for mild cycle, and 0.09 for dry cycle • Dry-cycle ratio would most closely match the baseline conditions under the 2012 UPRR/USGS Varying Hydrology Model Alternative D (150-foot-long causeway opening with invert at 4,188 feet) • 2012 UPRR/USGS Model: decrease of 0.05 • 2012 UPRR/USGS Varying Hydrology Model: decrease of 0.07 for wet cycle, increase of 0.07 for mild cycle, and increase of 1.03 for dry cycle • Would most closely match the baseline conditions under the 2012 UPRR/USGS Model and the wet-cycle ratio under the 2012 UPRR/USGS Varying Hydrology Model
Construction Effects		
Construction effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	No effect	No effect

Table 2-1. Summary of Project Effects

No-Action Alternative	Proposed Project	Alternatives
Deep Brine Layer (*continued*)		
Post-construction Short-Term Effects		
Post-construction short-term effects similar to either proposed project or one of the alternatives, depending on the approved compensatory mitigation.	Could increase the Gilbert and Gunnison Bay density gradients for a short time when the bridge is opened; otherwise not expected to affect long-term variability in the density gradient	Same as proposed project for all alternatives
Mercury (Hg) and Methyl Mercury (MeHg)		
Same as proposed project	**Long-term Effects** • Not a source of Hg and not near known sources of Hg • No effects on the factors (source, lake inflows, lake hydrodynamics, and biotic and abiotic processes) thought to contribute to MeHg behavior in the Great Salt Lake **Construction Effects** No effect **Post-construction Short-Term Effects** Could increase Gilbert Bay density gradient for a short time when the bridge is opened; otherwise not expected to affect factors that affect MeHg availability as a result	**Long-term Effects** Same as proposed project for all alternatives

Table 2-1. Summary of Project Effects

No-Action Alternative	Proposed Project	Alternatives
Biological Resources		
Same as proposed project	**Long-term Effects** • No effects on salinity variability, so no effects on any brine shrimp life stages • No effects on lake levels, so no effects on any brine fly life stages **Construction Effects** Potential short-term water quality effects could cause short-term local effects on brine shrimp and brine fly habitats **Post-construction Short-Term Effects** Possible rapid changes in salinity and WSE could temporarily cause local, direct effects on brine shrimp and brine flies but would not adversely affect lakewide conditions that support these elements of the lake's beneficial uses (necessary food chain)	**Long-term Effects** Same as proposed project for all alternatives
Lake Circulation		
Same as proposed project	**Long-term Effects** No effects on factors that influence lake circulation patterns in Gilbert or Gunnison Bays **Construction Effects** No effects on factors that influence lake circulation patterns **Post-construction Short-Term Effects** No effects on factors that influence lake circulation patterns	**Long-term Effects** Same as proposed project for all alternatives

3.0 Proposed Compensatory Mitigation and Monitoring Plan

3.1 Contents of This Plan

This plan sets forth the mitigation objectives, performance standards, monitoring and adaptive management elements and all other applicable elements of the USACE regulatory requirements for compensatory mitigation and monitoring plans as well as the requirements of UDWQ for water quality certification under Clean Water Act Section 401. The mitigation method for compensating for these otherwise unavoidable impacts approved by USACE and UDWQ is to construct a 180-foot-long bridge structure and control berm and to create a 150-foot-long causeway opening to be located at railroad milepost 739.78.

UPRR has developed this plan to confirm its mitigation and monitoring responsibilities associated with the entire project. This plan includes monitoring designed to confirm that the approved performance standards (and, therefore, the project's mitigation objectives) are met and describes adaptive management measures that will be undertaken in progressive steps if the causeway opening is not meeting the performance standards.

UPRR has prepared this CMMP to be consistent with USACE's compensatory mitigation regulation [33 Code of Federal Regulations (CFR) 332.4(c)(2)(14)], USACE's guidance and direction to UPRR (USACE 2014), and the requirements of UDWQ for water quality certification. USACE directed that the CMMP should be designed to confirm that the mitigation duplicates the aquatic functions (water and salt transfer) lost due to culvert closure and thereby ensure that the proposed project would have a less-than-minimal effect on the environment (USACE 2013a). UDWQ required that monitoring parameters, frequency of monitoring, and proposed triggers be identified in the mitigation and monitoring plan. In addition, UDWQ required identification of mitigation options that may be implemented based on monitoring results (UDWQ 2013).

This CMMP is based in part on the studies summarized in Section 2.0, Water and Salt Balance Modeling and Other Studies Completed by UPRR in Support of the Project, of this document. Table 3-1 below lists the information provided in this plan, the previous document(s) in which the information was discussed in detail and the section in this plan where the information is discussed.

UPRR determined the project performance standards using the uniform performance standards as a guide and following USACE's *Uniform Performance Standards for Compensatory Mitigation* worksheet (USACE 2012a).

Table 3-1. Cross-References for Information Required in This Plan

Required Information	USACE Compensatory Mitigation Regulation Reference	Previous Document(s)	Section in This Plan
Mitigation plan	33 CFR 332.4(c)	Bridge Evaluation Report and Resource Evaluation Report	3.0
Objectives	33 CFR 332.4(c)(2)	Bridge Evaluation Report and Resource Evaluation Report	3.2
Site selection	33 CFR 332.4(c)(3)	Final Modeling Report, Bridge Evaluation Report, and Resource Evaluation Report	3.3
Site protection instrument	33 CFR 332.4(c)(4)	None	3.4
Baseline conditions	33 CFR 324.4(c)(5)	Bridge Evaluation Report and Resource Evaluation Report	3.5
Determination of compensation	33 CFR 332.4(c)(6)	Final Modeling Report, Bridge Evaluation Report, and Resource Evaluation Report	3.6
Mitigation work plan	33 CFR 332.4(c)(7)	Final Modeling Report and Bridge Evaluation Report	3.7
Maintenance plan	33 CFR 332.4(c)(8)	None	3.8
Performance standards	33 CFR 332.4(c)(9)	Final Modeling Report, Bridge Evaluation Report, and Resource Evaluation Report	3.9
Monitoring requirements	33 CFR 332.4(c)(10)	Final Modeling Report and Bridge Evaluation Report	3.10
Adaptive management plan	33 CFR 322.4(c)(12)	Final Modeling Report and Bridge Evaluation Report	3.12
Long-term management plan	33 CFR 332.4(c)(11)	None	3.13
Financial assurances	33 CFR 332.4(c)(13)	None	3.14
Other information	33 CFR 332.4(c)(14)	Final Modeling Report, Bridge Evaluation Report, and Resource Evaluation Report	3.15

3.2 Objectives

The objective of UPRR's compensatory mitigation is to duplicate, as closely as possible, the aquatic function lost due to the closure of the west culvert and the proposed project and thereby ensure that the proposed project would have no more than a minimal effect on the environment. For purposes of this project, that aquatic function is the transfer of water and salt that was occurring through the causeway between the North and South Arms of the lake with the free-flowing culverts functioning as documented in November 2012 when it was necessary to close the first culvert (the west culvert).

3.3 Site Selection

As previously approved by USACE, the compensatory mitigation mechanism is placing a new opening in the causeway associated with construction of a new bridge and control berm. The following factors were considered in the mitigation site selection process (that is, the location of the compensatory mitigation causeway opening).

3.3.1 Hydrologic Conditions, Soil Characteristics, and Alignment Considerations

The proposed location of the 180-foot-long bridge, control berm, and 150-foot-long causeway opening is in the railroad embankment west of the west culvert. This location is necessary due to railway geometry, soil geotechnical conditions, and hydrologic considerations.

The existing causeway traverses the lake from Promontory Point on the east side of the lake to Lakeside, Utah, on the west side. UPRR reviewed USGS lake bathymetry for the North and South Arms of the lake to determine the deepest part of the lake along the causeway. UPRR selected the proposed location for the new bridge by excluding the geotechnically unstable area of the culverts and avoiding curved segments of railroad track.

The bridge would be located in the causeway at the location that provides the deepest lake water available at a geotechnically stable location and that avoids curved segments of railroad track. When the WSE is at 4,195 feet, the bridge bottom (invert) would be at an elevation of 4,183 feet, and about 12 feet of water would flow through the causeway opening. The lake bottom at the bridge location is at an elevation of about 4,178 feet. This elevation would allow the bridge bottom to be lowered to meet the lake bottom if this were necessary to meet adaptive management or lake management strategies.

UPRR considered placing the bridge, control berm, and causeway opening farther to the west, toward Lakeside. However, as the causeway approaches Lakeside, the lake bottom rises, making the lake shallower. Bridge locations to the west were not considered due to the shallow lake bottom in that area, which would result in a lower water depth through the bridge and less water and salt transfer through the causeway.

The bridge could not feasibly be constructed in the same location as the culverts due to the unstable geotechnical soil conditions found in this section of the causeway, which includes the east and west culvert locations. These unstable soil conditions led to the failure of the culverts, so this area is an unacceptable location for the new bridge structure and causeway opening.

3.3.2 Watershed Approach

The USACE watershed approach for compensatory mitigation sites evaluates factors that applicants should consider when selecting the type and location of the compensatory mitigation. These factors include current trends in habitat loss or conversion, the cumulative effects of past development activities, and existing environmental concerns, such as water quality, within the same watershed. USACE identifies the extent of the watershed to be the same 8-digit Hydrologic Unit Code (HUC) and sub-watershed where the proposed project would be located.

The HUC is a unique code assigned to watersheds by the U.S. Geological Survey (USGS). The Great Basin Region is region 16, the Great Salt Lake Subregion is subregion 1602,the Great Salt Lake Accounting Unit is accounting unit 160203, and the Great Salt Lake is cataloging unit 1602310 (USGS, no date). The lake's watershed is further subdivided, but, for this project, the 8-digit HUC is sufficient because the proposed project and its mitigation site would be located within the same cataloging unit (the open water of the lake). Consistent with USACE's watershed approach, the proposed mitigation site is located within the same 8-digit HUC (16020310) and sub-watershed as the area of potential impacts from the proposed project.

The proposed mitigation site location in the causeway provides water and salt transfer capability, hydrologic connection, and habitat connectivity between the North and South Arms similar to that provided by the culverts when they were functioning in 2012 before the west culvert was closed.

The selected mitigation site location would allow transfer of water and salt through the causeway that would be most similar to what occurred with the free-flowing culverts (for more information, see Section 2.2, Summary of the Water and Salt Balance Modeling). The location of the mitigation site also would provide a hydrologic connection between the two arms of the lake that would allow water to flow from the North Arm to the South Arm and vice versa. The results of the water and balance modeling indicate that lake conditions in the North and South Arms with the proposed bridge geometry would be the most similar to the lake conditions under the culvert simulations for the parameters of total causeway flow ratios, salinity ratios, and salt loads.

This analysis shows that there would be a slight change in the lake salinity and salt loads and that the proposed bridge geometry would best replace the aquatic function of the culverts and would provide water and salt transfer through the causeway similar to what was provided by the culverts.

The proposed mitigation location would provide the same open-water habitat connectivity as the culverts, since both locations allow the open water of the North Arm (Gunnison Bay) and the South Arm (which includes Gilbert Bay and other bays) to be exchanged through openings in the causeway and the causeway's permeable rock fill. The water quality of the open waters of Gunnison and Gilbert Bays are protected by the State of Utah to meet the beneficial uses of recreation and wildlife.

3.3.3 Size and Location of Site Relative to Hydrologic Sources

The proposed mitigation site in the railroad causeway is of adequate size and nature to support constructing, operating, and maintaining a bridge structure, control berm, and causeway opening. There is one other bridge in the causeway west of the proposed site location, and this existing 300-foot-long bridge allows similar aquatic function as the proposed mitigation bridge. The existing bridge, which was constructed in 1984, is located closer to Lakeside and has a bridge bottom of about 4,192 feet in elevation.

The proposed mitigation site is located between the North and South Arms of the lake. The proposed project would not use water from the lake but would allow lake water to transfer between the two arms.

3.3.4 Compatibility with Land Uses and Management Plans

The location of the mitigation site would be compatible with current transportation land use in the project area. The site would be located in the Great Salt Lake, which is managed consistent with the direction in the *Great Salt Lake Comprehensive Management Plan* (UDFFSL 2013). The Utah Division of Forestry, Fire and State Lands (UDFFSL) is responsible for managing state sovereign lands, including the Great Salt Lake. UPRR has submitted an application for an easement and will continue to work with UDFFSL as needed to ensure that construction and operation of the mitigation project on the causeway are consistent with all applicable access authorizations and requirements.

3.3.5 Effects of Mitigation Project on Resources

During public and agency reviews of UPRR's original proposal to close the existing culverts, and as a result of the recent permanent closure of the west culvert and temporary closure of the east culvert, resource agencies and commenters on UPRR's proposals expressed concerns that closure of the culverts and implementation of the mitigation (building a new bridge with a causeway opening) as then proposed could adversely affect the resources in the lake in addition to adversely affecting the water and salt balance. Therefore, as summarized in Section 2.4, Summary of the Resource Evaluation Report, UPRR conducted resource reviews based on the comments it received and submitted evaluations of the following resources in the Resource Evaluation Report to the agencies (UPRR 2014d):

- Water chemistry
- Water quality
- Deep brine layer
- Mercury and methyl mercury
- Biological resources
- Lake circulation

UPRR studied each resource to determine the following information:

- **Affected environment:** the current environment (existing conditions) pertaining to the resource and the current scientific understanding of the resource
- **Environmental consequences:** the proposed project's potential effects on the resource with various alternative bridges and with the no-action alternative, and any short-term post-construction effects

The results of the resource evaluations are summarized in Table 2-1, Summary of Project Effects, on page 12.

3.3.6 Other Relevant Factors

UPRR reviewed other relevant factors including public interest factors as identified in 33 CFR 340.4 and summarized the applicability of each factor to the proposed project. The factors included in the review are conservation, economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership and, in general, the needs and welfare of the people.

The review of the public interest factors is provided in Table 9-2, Summary of the Project's Relationship to the USACE Public Interest Review Factors, of the Resource Evaluation Report (UPRR 2014d).

3.4 Site Protection Instrument

UPRR is currently working with UDFFSL to obtain an easement to operate and maintain rail facilities for the alignment of the existing causeway where the bridge structure and causeway opening would be located. Because the proposed mitigation (bridge structure and causeway opening) would be part of the railroad causeway and infrastructure, it would be protected and maintained in the normal course of railroad operation and maintenance with no additional site protection instrument.

3.5 Baseline Conditions

3.5.1 Project Site and Proposed Mitigation Site

The proposed project site is located along the UPRR Great Salt Lake causeway as shown on Figure 1-1, UPRR Project Area, on page 4. The existing aquatic resources at the project site are classified as open saline waters of Gilbert and Gunnison Bays of the Great Salt Lake by the UDWQ Standards of Quality for Waters of the U.S. (Utah Administrative Code R317-2-6, Use Designations, as in effect March 1, 2014). The baseline conditions at the project site are the same as those of the proposed mitigation site because both the project site and the mitigation site are located within the lake and are near each other.

The physical conditions at the project site (culvert locations) are similar to those of the proposed mitigation site (bridge location) because both the project site and the mitigation site are located on the causeway, are within the lake, and are near each other. However, for purpose of the impacts re-evaluation associated with the project and the establishment of performance standards, the baseline conditions have been analyzed and described as discussed below and in Section 2.0, Water and Salt Balance Modeling and Other Studies Completed by UPRR in Support of the Project.

Because the culverts prior to closure contributed to but were not the only source of water and salt transfer between the North and South Arms, baseline conditions were evaluated in the context of the overall water and salt transfer through the causeway that occurred with the culverts in place. UPRR conducted water and salt balance modeling of the lake to determine the baseline conditions. The term *baseline conditions* refers to the ecological and physical state of the project area before either culvert was closed and before the compensatory mitigation project is implemented.

Under the baseline conditions, both culverts are open and free flowing, and the water and salt balance between the two arms of the lake varies from year to year based on a number of factors including lake levels, surface water inflows, density gradients, and causeway characteristics. The culverts are located in the causeway in their positions as of November 2012, before the west culvert was closed. The causeway openings include the opening through the existing 300-foot-long bridge west of the culverts and the free-flowing east and west culverts. Water also flows through the permeable rock-fill causeway.

UPRR used these baseline conditions to evaluate the effects of the proposed project on various resources because these conditions were present during recent studies focused on the lake and were used for developing the culvert simulations that were evaluated as part of the evaluation of impacts using the water and salt balance model. UPRR presented the findings pertaining to the baseline conditions and potential impacts of the proposed in the Modeling Report, Bridge Evaluation Report, and Resource Evaluation Report (UPRR 2014b, 2014c, 2014d).

Except for the position of the culverts before closure, the baseline scenario is not tied to a specific date because lake conditions and its resources have varied over time. The baseline scenario represents the natural variability in lake conditions such as lake level, salinity, and salt load over time so that the resource analyses described in the Resource Evaluation Report could assess how potential project and/or bridge alternatives may affect those resources over and above the natural variability over time. These are the conditions that would be associated with the culverts when they were open and free flowing in November 2012, before it became necessary to close the first culvert (the west culvert).

3.5.2 Reference Site

No reference site is identified for this mitigation plan.

3.6 Determination of Compensatory Mitigation

As summarized in Section 2.0, Water and Salt Balance Modeling and Other Studies Completed by UPRR in Support of the Project, UPRR prepared and submitted (on September 25, 2013) an impacts re-evaluation plan for conducting water and salt balance modeling and determining the effects of the proposed project on the lake's ecological resources. The final modeling and the bridge evaluation studies were conducted to assess whether the proposed mitigation would provide the required compensation for project effects on aquatic resources (UPRR 2014b, 2014c). In conducting these studies, UPRR determined that a 150-foot-long causeway opening with an invert elevation of 4,183 feet would best match the aquatic functions (water and salt transfer) of the east and west culverts when they were free-flowing and in their 2012 positions and thereby result in less-than-minimal effects.

Given the unique nature of this project and its potential adverse effects on aquatic resources, the compensatory mitigation solution is providing a new opening in the causeway to replace the aquatic functions lost as a result of the culvert closures. There are no credits available that would satisfy the mitigation objectives for this project. Therefore, UPRR does not intend to obtain credits from an approved mitigation bank or in-lieu fee program for this proposed project.

3.7 Mitigation Work Plan

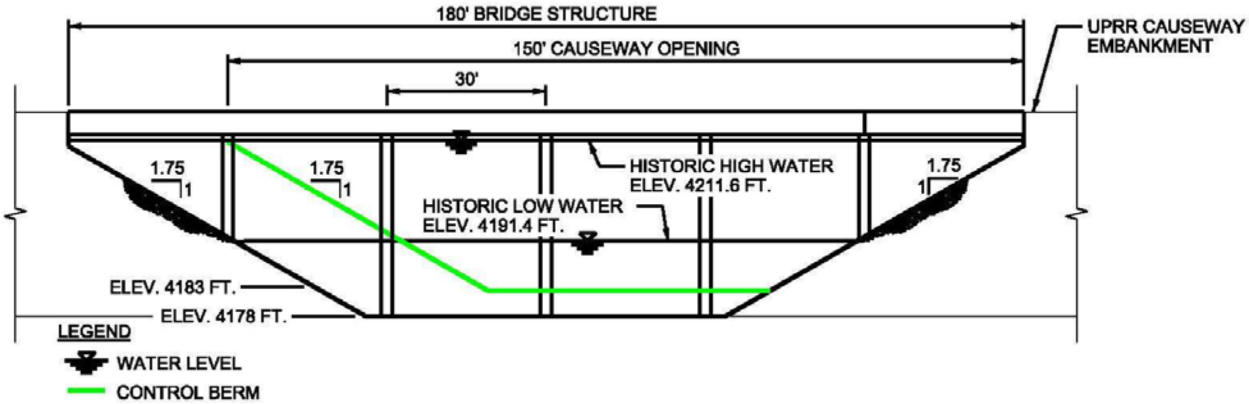
This section includes conceptual design plans for the proposed causeway opening, construction and removal of the temporary shoofly, and permanent closure of the east culvert. The sequence of construction activity and the construction schedule are also discussed. The permanent closure of the east culvert is an administrative approval, so no construction activities are required to complete the permanent closure of the east culvert.

As reflected in the modeling and resource evaluation reports (UPRR 2014b, 2014c, 2014d), UPRR determined that a 150-foot-long causeway opening would most likely match the contribution to water and salt transfer through the causeway that was previously provided by the culverts and have less-than-minimal effects on the environment. However, to facilitate adaptive management and future lake management activities, UPRR proposes to construct a 180-foot-long bridge structure with a control berm to create a 150-foot-long causeway opening with an invert at 4,183 feet. The control berm may be adjusted as described below to enlarge or reduce the causeway opening if such an action is triggered by the monitoring and adaptive management to meet the performance standard as set forth in this plan. The following sections describe the bridge structure, the control berm that would create the causeway opening, and adaptive management.

3.7.1 Conceptual Design Plans

UPRR has developed conceptual design plans for the proposed project, including constructing and removing the temporary shoofly, constructing the bridge structure, and constructing the control berm. Appendix A, Conceptual Bridge and Control Berm Design Plans, includes conceptual bridge plans that illustrate the 180-foot-long bridge structure, including bridge span, side slopes, bridge invert, the control berm, and shoofly geometry. Figure 3-1 illustrates the key geometric features of the proposed bridge structure and causeway opening geometry.

Figure 3-1. Proposed Bridge and Causeway Opening Geometry

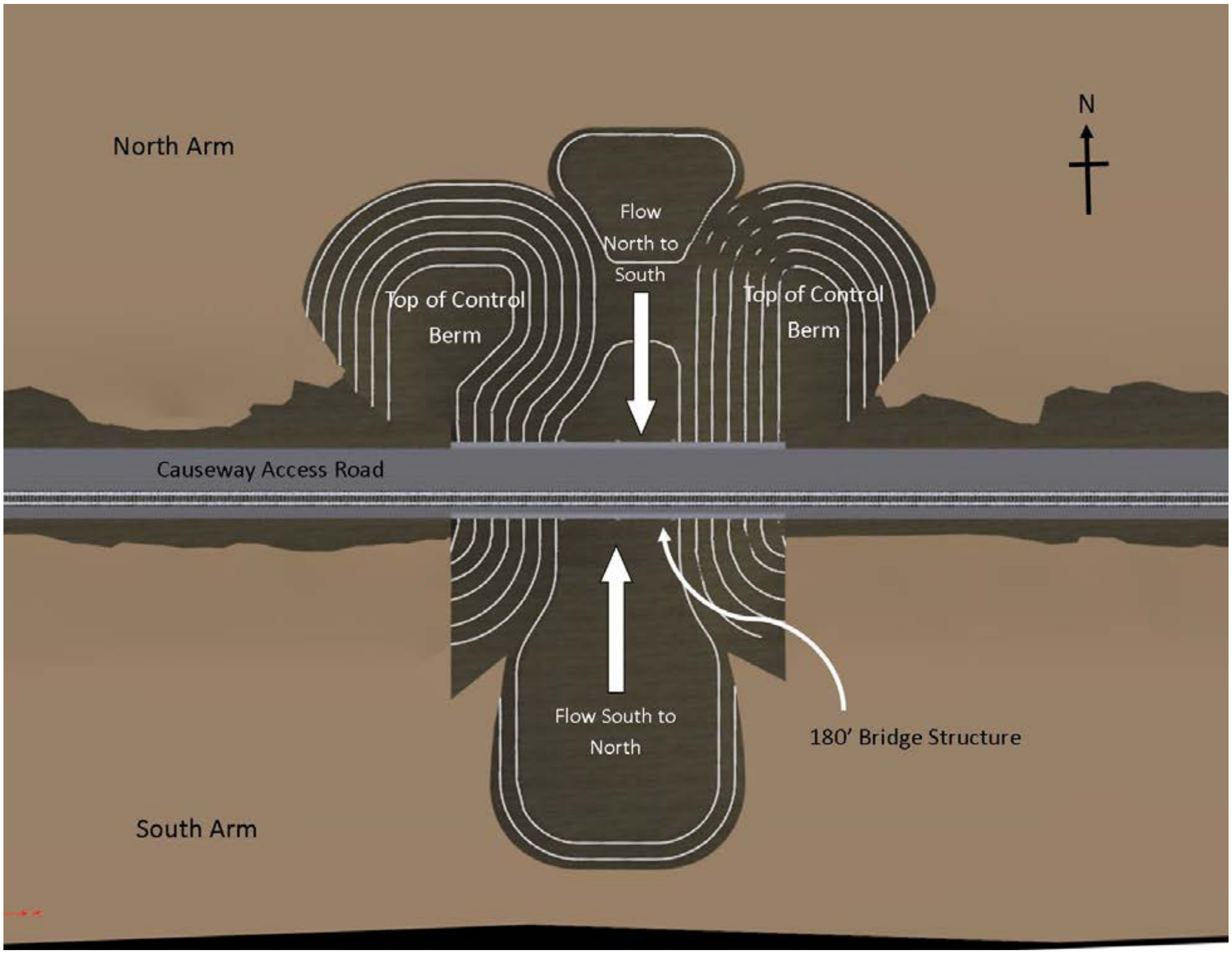


The main elements of the mitigation structure are the 180-foot-long bridge structure and the earthen control berm. The control berm would be located on the north side of the causeway to create an effective 150-foot-long opening through the causeway. The control berm would include a raised invert that elevates the natural lake bed from 4,178 feet to 4,183 feet. This elevated invert caused by the control berm would also restrict north-to-south flows through the causeway.

The control berm geometry was determined by the water and salt balance model to effectively narrow the 180-foot-long bridge structure to a 150-foot-long opening, thereby providing the appropriate ratio of north-to-south flows compared to south-to-north flows as described in the Bridge Evaluation Report (UPRR 2014c). The model simulations indicated that the causeway with the 150-foot-long opening would most closely duplicate the contribution of salt transfer by the causeway with the culverts before they were closed. UPRR determined that the construction of the 180-foot-long bridge with the control berm to adjust the opening to 150 feet long would be beneficial for implementing adaptive management measures in the future, if required. The control berm would be placed just north of the causeway and may be accessed from the causeway access road. With this configuration, work may be conducted on the control berm while not directly interfering with the causeway railroad access road, railroad operations, or bridge structure.

Figure 3-2 presents a conceptual view of the causeway with the bridge structure, railroad causeway access road, and control berm.

Figure 3-2. Proposed Bridge and Control Berm Plan View



Upon approval of the CMMP, UPRR will develop detailed engineering drawings, specifications, and construction documents for the approved bridge and control berm. UPRR will design the bridge structure in accordance with the American Railway Engineering and Maintenance-of-Way Association's recommended practices. The construction documents will include details on the best management practices that will be implemented during construction activities. The detailed construction documents would be implemented by a contractor under UPRR's direction and approval.

Upon completion of the final design, UPRR will submit the drawings and associated data required by USACE, data such as volume of material placed below the ordinary high water level and the volumes associated with removing the material from the causeway and placement of fill to create the control berm.

3.7.2 Construction Sequencing and Schedule

UPRR would implement the proposed project in accordance with the following activity sequencing and schedule. Main construction activities would consist of three elements: constructing the temporary shoofly, constructing the bridge, and removing the temporary shoofly. These main construction activities are described in Table 3-2, including their approximate durations. Some of the activities can occur simultaneously; that is, UPRR can work on several activities at once.

Table 3-2. Main Construction Activities

Main Construction Activity	Anticipated Start Date	Duration (days)
Construct shoofly	3/9/2015	30
Transfer traffic to shoofly	4/20/2015	5
Mobilize	4/27/2015	7
Survey and construction stake alignment and grade	5/4/2015	2
Construct south bridge, piles, and caps	5/6/2015	56
Install south bridge superstructure and backfill	7/15/2015	1
Install south bridge ballast, ties, and rail	7/17/2015	10
Transfer traffic to south bridge	7/27/2015	1
Construct north bridge, piles, and caps	7/28/2015	66
Install north bridge superstructure and backfill	10/13/2015	1
Install north bridge maintenance road	10/14/2015	1
Construct control berm and remove shoofly	10/19/2015	25
Construction completed	11/25/2015	1

3.8 Maintenance Plan

UPRR will conduct maintenance activities through the permit monitoring period to ensure that the mitigation site remains functional once the initial construction is completed (Table 3-3).

Table 3-3. Five-Year Maintenance Activities

Maintenance Activity	Anticipated Frequency	Duration (days)
Visual bridge structure inspection	Annual	2

Regular structure maintenance activities would continue after the permit monitoring period as part of the UPRR bridge maintenance program.

3.9 Performance Standards

UPRR has developed performance standards to establish criteria that UPRR will apply to determine whether the compensatory mitigation project is achieving its mitigation objective. The objective of UPRR's compensatory mitigation is to duplicate, as closely as possible, the aquatic function (water and salt transfer) lost due to the closure of the east and west culverts by constructing the new causeway opening associated with the compensatory mitigation bridge and control berm.

To develop appropriate performance standards, UPRR reviewed USACE's Uniform Performance Standards (UPS) procedures as described in *12505-SPD Regulatory Program Uniform Performance Standards for Compensatory Mitigation Requirements* (USACE 2012a). UPRR completed the UPS worksheet and determined that the following performance standards and criteria describe the mitigation activity. General information from the worksheet is summarized in Table 3-4, and the performance standards and targets are listed in Table 3-5 below.

UPRR reviewed the USACE Attachment 12505.1, *Table of Uniform Performance Standards for Compensatory Mitigation Requirements*, to identify applicable performance standards (PS) based on aquatic resource type and performance standard categories. Of the 42 performance standards listed in the table, UPRR identified performance standards that describe the proposed mitigation activity and will be used to determine whether the mitigation is successful in meeting the objective.

Table 3-4. Information about the UPRR Mitigation Site per the Uniform Performance Standards Worksheet

Line No.[a]	Description	UPRR Site Mitigation
1	Mitigation site name	UPRR causeway bridge, MP 739.78
1	Cowardin/HGM (hydrogeo-morphic) type	Non-wetland water of the U.S.
1	Habitat type	Saline deep open water
1	Site coordinates	Latitude 41.220833, Longitude –112.766389
1	Reference site	Not applicable
2	Mitigation objective	Specific aquatic resource
3	Mitigation type	Re-establishment
4	Primary type of site treatment	Hydrological manipulation
5	Aquatic resource type	Other: Saline open water
6	Performance standard categories	Physical, hydrologic, water quality(ecological)

[a] Line number in the UPS worksheet.

3.9.1 Causeway Opening Geometry Performance Standards

The proposed performance standards are focused on ensuring that the bridge structure and control berm are constructed and maintained as designed or with agreed-upon altered geometry and that the causeway opening remains unobstructed, free flowing, and protected against erosion. The performance standards also focus on maintaining the degree of inundation of the causeway opening (the water depth in the causeway opening in relation to varying lake levels) and the salt balance between the lake's North and South Arms. These standards are summarized in Table 3-5. Adaptive management measures that will be taken if the project is found to be not meeting these performance standards are described in Section 3.12, Adaptive Management Plan.

Table 3-5. Causeway Opening Geometry Performance Standards

PS No.	PS Type	Description	Measure and Frequency	Target
1	Physical	The mitigation bridge site will remain stable without excessive erosion or accumulation of debris.	Annual cross-section measurements at the mitigation site at four intervals, upstream and downstream, east and west	Average bridge site contours remain within 10% of as-built or agreed-upon altered geometry
2	Hydrologic	The causeway opening area and geometry (depth, width, and length) will be maintained to convey water between the North and South Arms at varying lake levels.	Annual cross-section measurements of the depth, width, and length to calculate average opening area and average contours	Average opening area remains within 10% of as-built or agreed-upon altered average geometry
3	Hydrologic	The causeway opening will be accessible to inundation of waters with no obvious restrictions present.	Measure and report quarterly water depth through the causeway opening	Average water depth remains within 10% of as-built or agreed-upon altered condition at specific lake levels
4	Hydrologic	The geometry and average grading contours of the bridge site and control berm will be maintained.	Annual measurements of control berm at appropriate intervals upstream and downstream	Average control berm contours remain within 10% of as-built or agreed-upon altered geometry

3.9.2 Water Quality (Salinity and Salt Balance) Performance Standard

Based on water and salt balance modeling, UPRR determined that the aquatic function of the causeway culverts would be best duplicated by constructing a 150-foot-long causeway opening with an invert elevation of 4,183 feet (UPRR 2014c, 2014d). That is, the water and salt transfer through the causeway between the North and South Arms of the lake with this causeway opening would best match the water and salt transfer through the causeway with the two free-flowing culverts under most modeling conditions. Just as lake salinities were the water quality parameters used in the modeling of impacts to evaluate the effects of replacing the culverts with the causeway opening, lake salinities and salt balance are the basis of the water quality performance standards in this CMMP. The water quality performance standard is summarized in Table 3-6.

Table 3-6. Water Quality(Salinity and Salt Balance) Performance Standard

PS No.	PS Type	Description	Measure and Frequency	Target
5	Water quality (salinity)	The causeway with the mitigation should provide water and salt transfer similar to that of the free-flowing culverts before closure, with South Arm salinity within the ranges predicted by the 2012 model and historic variability. Any project-caused variation of South Arm salinity outside those ranges will have a less-than-minimal effect on lake aquatic resources that are protected by beneficial uses.	Sample and report quarterly lake salinity values at depth at one UGS location in the North Arm and three UGS locations in the South Arm	Project-caused changes to South Arm salinity remain within the historic and 2012 model ranges as defined.

UGS = Utah Geological Survey

Salinity and salt balance performance standards are established in this CMMP to confirm that the project is meeting the mitigation objective and, if it is not, to undertake adaptive management measures pursuant to Section 3.12, Adaptive Management Plan. The monitoring and analysis described in Section 3.10, Monitoring and Reporting, will be conducted to determine whether the causeway with the mitigation is duplicating the water and salt transfer previously provided by the causeway with the free-flowing culverts or whether an adjustment to the causeway opening must be made.

UPRR has, in coordination with UDWQ, defined the water quality (salinity) performance standard based on South Arm salinity ranges for historic data and 2012 UPRR/USGS Model simulations. The analysis is summarized below and detailed in Appendix B, Historic and Water and Salt Balance Model Salinity Ranges Analysis.

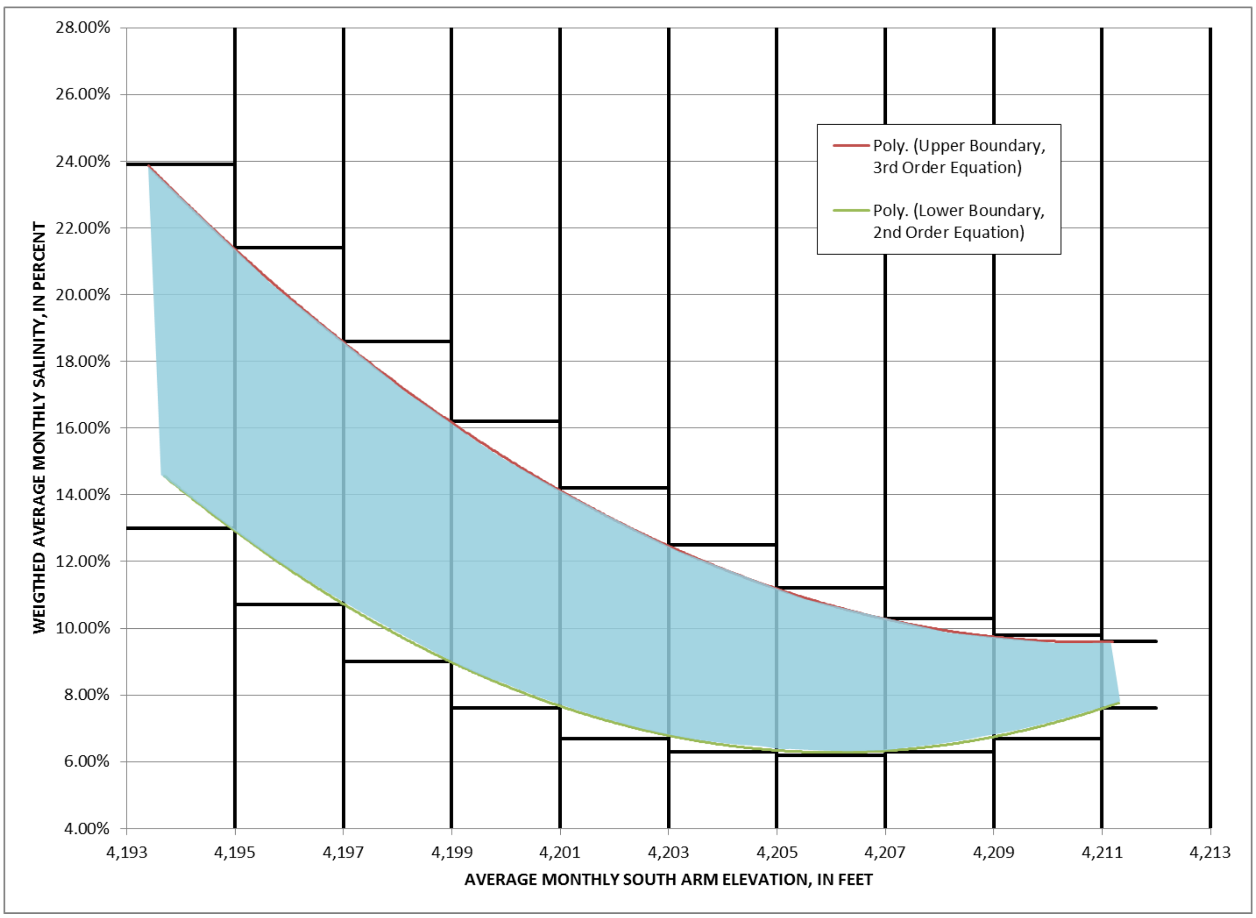
Historic South Arm Salinity Range

UPRR used the Utah Geological Survey's (UGS) Great Salt Lake Brine Density Database to define the historic salinity range (UGS 2012). By analyzing the reported density, total dissolved solids by percent weight (% wt TDS), and WSE data for the three Gilbert Bay locations of AC3, AS2, and FB2, UPRR developed a graph of average South Arm salinity compared to reported South Arm WSE taken on the day that UGS conducted the sampling. These three sampling locations were chosen because of the amount of data collected consistently over the period of record (1966–2011) and because these sampling locations were used by USGS and UPRR to calibrate the water and salt balance model.

A qualitative analysis of the uncertainty and error associated with the collection and analysis of the UGS data was conducted, and UPRR, with UDWQ concurrence, applied a 5% error to the averaged data to develop the graph shown in Figure 3-3 and in Table 3-7 on page 32.

If lake WSEs rise or fall outside the historic range, UPRR will, in consultation with USACE and UDWQ, extrapolate an extension of the historic data graph to cover the higher or lower WSEs. UPRR will then compare the salinity monitoring results to the extended historic data range

Figure 3-3. Historic South Arm Salinity Range

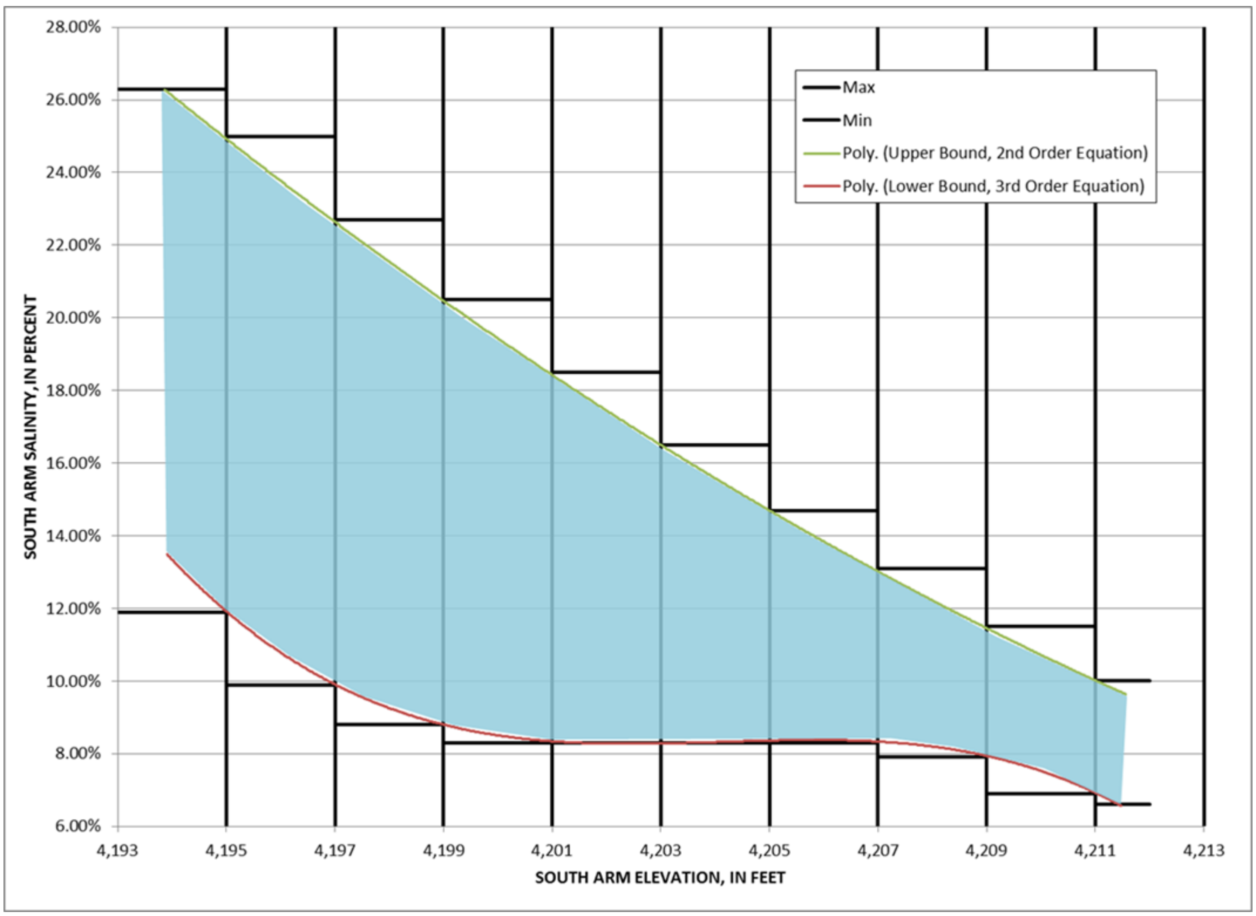


2012 UPRR/USGS Model South Arm Salinity Range

The 2012 UPRR/USGS water and salt balance model simulations computed lake salinities based on historic inflows and evaporation rates and causeway opening configurations for the period of 1987–2012 (UPRR 2014b). The UPRR Bridge Evaluation Report (UPRR 2014c) compared the lake salinities and salt loads for the free-flowing culvert simulation with the proposed bridge opening simulation. The South Arm salinity range computed by the model simulations compared to the model-computed WSE is graphically represented in Figure 3-4 and numerically represented in Table 3-7 below. The salinity range represents the lake salinities computed by the water and salt balance model based on actual inflows and evaporation rates (1987–2012) as documented in the Bridge Evaluation Report.

Additionally, in consultation with UDWQ, UPRR has determined that, based on the degree of precision associated with the water and salt balance model and subsequent results, a 15% error or uncertainty range should be applied to the computed numeric model results (see Appendix B, Historic and Water and Salt Balance Model Salinity Ranges Analysis). This 15% error or uncertainty range has been included in the ranges described by Figure 3-4 and Table 3-7 below.

Figure 3-4. 2012 UPRR/USGS Water and Salt Balance Model South Arm Salinity Range



Historic and 2012 UPRR/USGS Model South Arm Salinity Range Results Tabulated

UPRR conducted the analysis to represent the data represented by Figure 3-3 and Figure 3-4 in a table format (Table 3-7).

Table 3-7. Historic and 2012 UPRR/USGS Model Salinity Range by WSE

South Arm Water Surface Elevation Range (feet)	Historic South Arm Salinity Range (%)	Modeled South Arm Salinity Range (%)	Salinity Range (min. – max.)
4,193 – 4,195	13.0 – 23.9	11.9 – 26.3	11.9 - 26.3
4,195 – 4,197	10.7 – 21.4	9.9 – 25.0	9.9 – 25.0
4,197 – 4,199	9.0 – 18.6	8.8 – 22.7	8.8 – 22.7
4,199 – 4,201	7.6 – 16.2	8.3 – 20.5	7.6 – 20.5
4,201 – 4,203	6.7 – 14.2	8.3 – 18.5	6.7 – 18.5
4,203 – 4,205	6.3 – 12.5	8.3 – 16.5	6.3 – 16.5
4,205 – 4,207	6.2 – 11.2	8.3 – 14.7	6.2 – 14.7
4,207 – 4,209	6.3 – 10.3	7.9 – 13.1	6.3 - 13.1
4,209 – 4,211	6.7 – 9.8	6.9 – 11.5	6.7 – 11.5
4,211 –	7.6 – 9.6	6.6 – 10.0	6.6 – 10.0

3.10 Monitoring and Reporting

UPRR proposes to conduct the following project permit monitoring for 5 years, beginning the first quarter after the proposed bridge is constructed and operating, to ensure that the compensatory mitigation is meeting its performance standards and, if not, to trigger adaptive management.

During the temporary east culvert closure period, UDWQ required, per condition 3 of its Utah 401 Water Quality Certification, that UPRR monitor the North and South Arms' ambient lake water quality and brine shrimp conditions during the temporary closure period (UDWQ 2013). Monitoring of water quality analytes and brine shrimp during the interim closure period is described in the UPRR Interim Monitoring Plan, Temporary Closure of the East Culvert, Great Salt Lake Causeway, Revised March 10, 2014. Interim monitoring will continue until the new causeway opening is constructed and free flowing, when at that time the interim monitoring plan will be superseded by the final monitoring plan, upon CMMP approval, as provided in the water quality certification.

If the causeway opening is adjusted pursuant to the adaptive management plan, as described in Section 3.12, Adaptive Management Plan, upon completion of the causeway opening adjustments made, UPRR will restart the 5-year monitoring period to demonstrate consistency with the salinity performance standard 5. The 5-year monitoring period will not be restarted for implementation of adaptive management measures associated with keeping the causeway opening free flowing, as described in Section 3.12.1, Causeway Opening Geometry Adaptive Management, performance standards 1–4.

Upon approval of the CMMP, UPRR will develop a sampling and analysis plan and quality assurance project plan for the monitoring and additional data collection.

3.10.1 Monitoring Parameters

UPRR has determined the following monitoring parameters based on USACE's mitigation plan template and the project's performance standards. The purpose of the monitoring is three-fold:

1. Assess whether the bridge site is stable and the causeway opening area and geometry remain free flowing and unobstructed to meet project performance standards 1, 2, and 4.
2. Document whether the causeway opening is inundated by reporting lake levels and the water depth in the causeway opening to meet project performance standard 3.
3. Collect ambient water quality (salinity) data, compare with the established historic and 2012 model salinity ranges, and, if needed, update the salt balance model and impacts analysis to confirm that the project is meeting its mitigation objectives as described in project performance standard 5.

These three purposes are described further in Table 3-8. If the results of the monitoring plan reflect that the project is not meeting the performance standards, UPRR will submit a Notification of Monitoring Results That Trigger Adaptive Management as described in Section 3.10.2, Reports and Notifications, and adaptive management measures will be carried out pursuant to Section 3.12, Adaptive Management Plan.

Table 3-8. Monitoring Parameters

Purpose (PS No.)	Description	Measure and Frequency
Stability of the mitigation site (1, 2, and 4)	Assess whether the mitigation site, causeway opening average area and geometry, and control berm geometry remain stable and there is not excessive erosion or accumulation of debris.	Annual cross-section measurements of the mitigation site at four intervals, upstream and downstream through the causeway opening, to calculate average opening area and average site contours.
Hydrology (3)	Assess whether the causeway opening remains open to inundation of waters with no significant restrictions present.	Measure and report quarterly average water depth through the causeway opening.
Water quality (salinity) (5)	Monitor ambient salinity, compare results with established historic and 2012 model salinity ranges, and, when needed to determine consistency with the performance standard, update the salt balance model and impacts analysis to confirm that the project is meeting its mitigation objectives, that is, that the causeway with the mitigation provides water and salt transfer similar to that of the causeway with the free-flowing culverts before closure and that any project-caused variation from historic and modeled salinities does not adversely impact lake aquatic resources.	Sample and report quarterly lake salinity values at depth at one UGS location in the North Arm and three UGS locations in the South Arm.

UGS = Utah Geological Survey

For the water quality monitoring element of the CMMP, salinity (represented by density and total dissolved solids [TDS] concentrations) has been identified as the exclusive water quality monitoring parameter based on the following considerations:

- UDWQ has stated that the use of the water and salt balance model has been accepted for determining the mitigation and that salinity or salt load is an appropriate surrogate for parameters of concern on this project (UDWQ 2014).
- The water quality evaluation provided in the Resource Evaluation Report (UPRR 2014d) concluded that, with no significant change in salinity caused by the project, the factors that affect the fate and transport of specific water quality parameters would not be changed, such that there would be no significant adverse effect on beneficial uses.
- The project would not discharge any pollutants of concern that would change the ambient lake concentrations.

Table 3-9 lists the water quality parameters and constituents to be measured quarterly throughout the permit monitoring period. These measurements will support the determination of the ambient lake salinity at each of the monitoring locations.

Sample parameters and frequency are identified in Table 3-10 below. Data will be collected at all monitoring locations similarly.

Table 3-9. Monitoring Parameter Methods, Detection Limits, Reporting Limits, and Laboratory Hold Times

PS Number	Parameter	Method	Method Detection Limit	Method Reporting Limit	Hold Time
Field Measurements					
3	Total water depth	Troll 9500 field measurement	—	0.1 m	Field
5	Specific conductivity	SM 2510A	0.001 µmhos	0.001 µmhos	Field profile
5	Temperature	SM 2520	0.1 ºC	0.1 ºC	Field profile
5	Specific gravity	ASTM 1429[a]	0.001 (unitless)	0.001 (unitless)	__
Laboratory Analyses					
5	Density	SM 2710F	—	0.001 g/mL	7 days
5	Total dissolved solids	SM 2540C	—	5 mg/L	7 days

°C = degrees Celsius; µmhos = micromhos; ASTM = American Society for Testing and Materials; g/mL = grams per milliliter; m = meters; mg/L = milligrams per liter; PS = performance standard; SM = Standard Methods for the Examination of Water and Wastewater

[a] Specific Gravity Determinations Using a Hydrometer

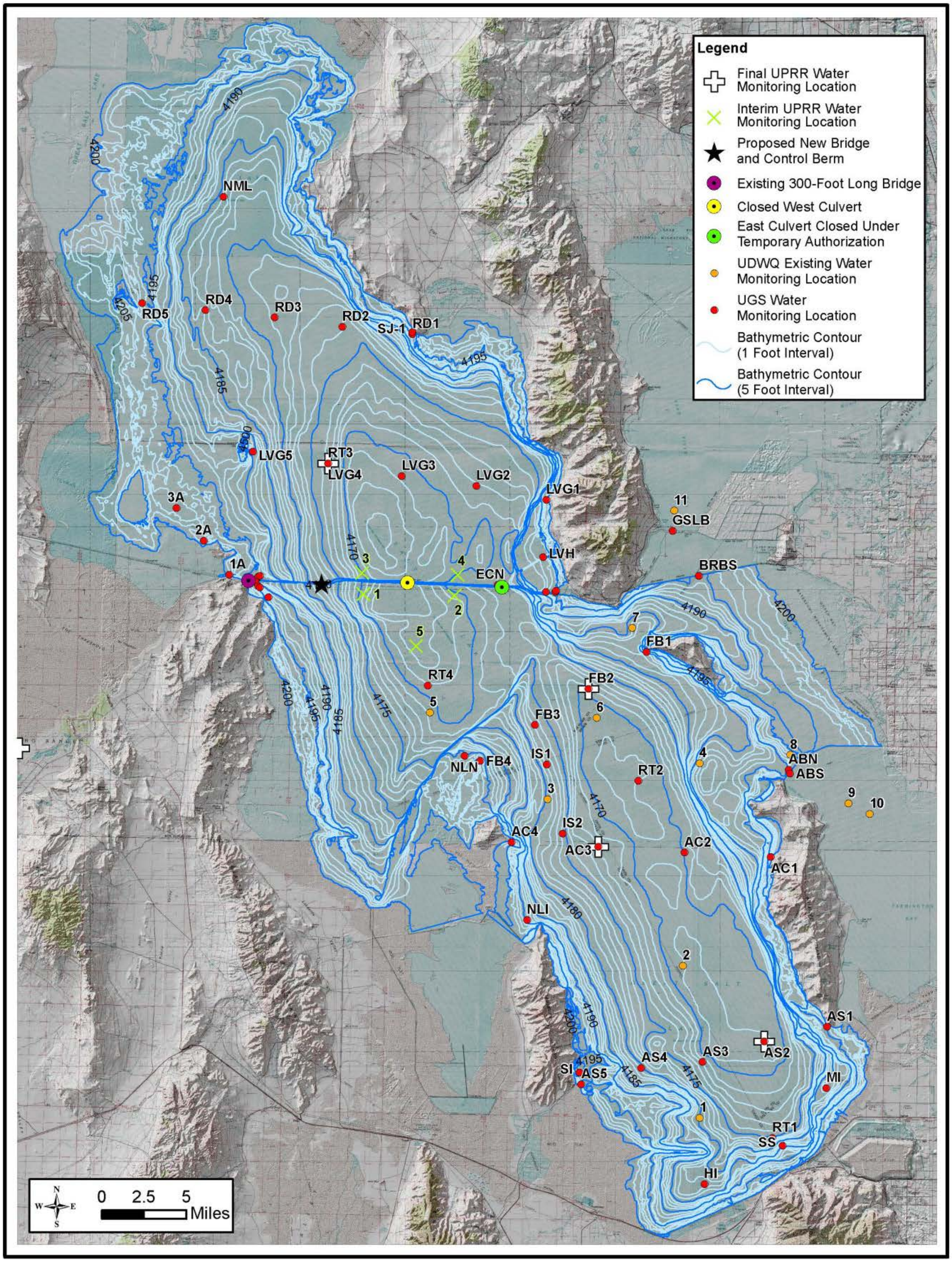
Table 3-10. Monitoring Parameters and Frequency

PS Number	Parameter	Number and Sample Depth	Frequency	Field Duplicate	Field Blank	Equipment Rinsate
3	Total water depth	One measurement taken from water surface to bottom of lake	Quarterly per year	NA	NA	NA
5	Conductivity, temperature	Vertical profile; measurements taken *in situ* every 5 feet	Quarterly per year	NA	NA	NA
5	Total dissolved solids, density, specific gravity	Vertical profile; grab samples taken every 5 feet	Quarterly per year	10% of samples	10% of samples	10% of samples

NA = not applicable; PS = performance standard

The proposed water-monitoring locations for lake salinity are shown in Figure 3-5 below. These sample locations were chosen, in coordination with UDWQ, because they are coincident with current UGS sampling locations. In this way, the monitoring data collected at the South Arm sampling locations can be compared directly to the historic South Arm salinity range determined by the analysis of the UGS data collected at the same locations. Figure 3-5 below shows the UPRR water-monitoring locations in relation to the other agency water-monitoring locations including UGS and UDWQ and the lake bathymetry.

Figure 3-5. Proposed UPRR Water-Monitoring Locations In Relation to Other Water-Monitoring Locations



3.10.2 Reports and Notifications

Quarterly Data Reports. Within 90 days of the monitoring event, UPRR will provide quarterly monitoring data reports to USACE and UDWQ containing the laboratory data and measurements made for that quarter. In addition to the monitoring data, the quarterly reports will include the additional field and laboratory data and measurements collected as described in Section 3.11, Additional Data Collection.

Annual Reports. UPRR will submit annual monitoring reports to USACE and UDWQ to provide information regarding the mitigation site conditions and how the monitoring results support the performance standards. Annual monitoring reports will be submitted on March 1 of each year after the completion of construction and each subsequent year of monitoring (assuming the project is constructed in 2015 and opened in November 2015, the first monitoring year will be 2016, and the annual report will be submitted in 2017). Each report will contain the following information:

- Monitoring team and dates of the events
- Brief description of the mitigation bridge construction and completion in relation to the monitoring event
- Narrative as to the current condition of the mitigation site, and any changes from the as-built condition as provided by data collection
- Performance standard progress assessment: whether the monitoring results reflect that the project is meeting the performance standards or have triggered any adaptive management measures pursuant to Section3.12, Adaptive Management Plan, and, if so, the status of the adaptive management effort (UPRR will be coordinating adaptive management steps with USACE and UDWQ separately)
- Dates of any corrective or maintenance activities conducted since the previous report
- Summary of monitoring event data results and photographs

In addition to the information described above, the annual monitoring reports will include the additional data collected as described in Section 3.11, Additional Data Collection.

Notifications of Monitoring Results That Trigger Adaptive Management. In addition to submitting the scheduled reports described herein, if the results of the monitoring plan show that any of the performance standards set out in Section 3.9, Performance Standards, are not being met, UPRR will so notify USACE and UDWQ and will undertake adaptive management measures as described in Section 3.12, Adaptive Management Plan.

Completion Report. After the permit monitoring period, UPRR will submit a completion report for USACE's and UDWQ's approval. The report will describe the monitoring results in relation to the mitigation objects, beneficial uses, antidegradation policy, and numeric and narrative standards and will provide a basis for cessation of monitoring. This completion report will provide the basis for USACE's and UDWQ's concurrence that the monitoring and adaptive management period is complete.

3.10.3 Salinity and Salt Balance Reporting (Performance Standard 5)

This section describes the process UPRR will follow, using the results of the ambient salinity monitoring, to determine whether the project is meeting the salinity performance standard (performance standard 5).

1. Compare Salinity Monitoring Results with the 2012 Model and Historic Salinity Ranges.

UPRR will compare the ambient salinity monitoring results for the South Arm with the 2012 model range and historic range described in Section 3.9.2, Water Quality (Salinity and Salt Balance) Performance Standard. In the event that lake levels (WSEs) rise or fall outside the historic range described in Section 3.9, Performance Standards, UPRR will, in consultation with USACE and UDWQ, extrapolate an extension of the historic data graph to cover the higher or lower WSEs. UPRR will then compare the salinity monitoring results to the extended historic data range.

2. Where Ambient Monitoring Results Are Within the Modeled and Historic (or Extended Historic) Salinity Ranges, Report and Continue Monitoring.

Where South Arm ambient salinity monitoring results are within the 2012 model and historic (or extended historic) salinity ranges, such a result indicates that the project has not caused a change to the ambient salinities from what they would have been with the culverts in place; that result indicates consistency with the mitigation objective of duplicating the aquatic functions of the now-closed culverts. UPRR's analysis presented in the Resource Evaluation Report concluded that project-caused salinity variations within the historic lake salinity range would not adversely affect the lake's beneficial uses. Using salinity as a surrogate for water quality, with no significant change in water quality caused by the project, there would be no significant adverse effect on the lake's beneficial uses.

Accordingly, if the ambient South Arm salinity monitoring results are within these ranges, the monitoring data, analyses, salinity comparison results, and determination of consistency with the performance standard will be documented in the quarterly and annual reports. No supplemental modeling and impacts assessment will be required, and UPRR will continue with quarterly ambient lake salinity monitoring and reporting in accordance with this CMMP.

3. Where Ambient Monitoring Results Are Outside Modeled and Historic(or Extended Historic) Salinity Ranges, Update Model and Resource Impacts Assessment.

If the ambient salinity monitoring results are outside the established salinity ranges (described in Section 3.9.2, Water Quality (Salinity and Salt Balance) Performance Standard), this result is an indication that potentially adverse ambient South Arm salinity conditions exist. However, just the comparison of monitoring data with modeled and historical data does not reveal the cause of such conditions and, therefore, whether the project is meeting the salinity performance standard. Additional steps must be taken to determine whether the project has caused the variation and, if so, whether that variation is having significant adverse effects on aquatic resources protected by the lake's beneficial uses.

If the South Arm ambient salinity monitoring results are outside the established 2012 model salinity range and historic (or extended historic) salinity range for two consecutive quarterly monitoring events, UPRR will notify USACE and UDWQ and initiate the update of the salt balance model and the resource impacts assessment as described herein. The purpose of this analysis will be to determine whether the variations in ambient salinity levels are caused by the project, adversely affect aquatic resources (for example, brine shrimp) protected by beneficial uses, and, therefore, do not meet salinity performance standard 5.

It is well documented that the WSEs and salinities of the lake vary by season, year, and decade. Surface inflows, WSEs, salinities, salt loads, weather patterns, low lake levels, and industry infrastructure and operations all influence the water and salt transfer between Gilbert and Gunnison Bays. For this reason, monitoring results from a full hydrological cycle (that is, four consecutive quarterly monitoring events) are necessary in order to complete the modeling and impacts analysis that must be carried out in order to determine whether a causeway opening adjustment should be made. However, to facilitate timely, efficient, and fully informed determinations of consistency with the performance standard, UPRR will, in coordination with USACE and UDWQ, start the water and salt balance model update and calibration process as well as the impacts analysis after two consecutive monitoring events result in variations outside the 2012 model and historic salinity ranges to determine whether the project has adversely affected the lake's beneficial uses and, therefore, does not meet the performance standard.

Model Update and Calibration. Once this process is initiated, UPRR will begin updating the calibrated 2012 UPRR/USGS Water and Salt Balance Model through the current year in coordination with USACE and UDWQ. Starting with the 2012 actual lake conditions, the lake hydrology, precipitation, evaporation, and other water and salt balance model input parameters will be generated to simulate lake conditions through the current year (or as close to current conditions as the data allow). However, if the results of the third or fourth consecutive quarterly ambient salinity monitoring events are within the historic and 2012 model ranges, UPRR will notify USACE and UDWQ that this updated modeling and impacts assessment will be suspended, and monitoring will continue through the permit monitoring period.

If the results of the third and fourth consecutive quarterly ambient salinity monitoring results remain outside the ranges predicted by the 2012 UPRR/USGS Model or historic variation, the data collected will be added to extend and update the model through the current year. The updated modeling and impacts assessment will be completed within 2 months of receiving the fourth quarter of consecutive ambient salinity monitoring outside the 2012 modeled and historic ranges.

The updated model will include the actual physical condition of the causeway openings (east culvert closure and new causeway opening). After the actual physical and hydrologic conditions are input into the updated model, UPRR will calibrate the new water balance and salt balance model, following similar procedures as those described in the Final Modeling Report, step 2 (UPRR 2014b). The model update will use the additional data collected pursuant to Section 3.11, Additional Data Collection.

UPRR will run the updated water and salt balance model with actual lake and causeway characteristics and will compare the results to the free-flowing culvert simulation for lake salinity and salt loads. Applying this analysis, UPRR will determine whether the project (the replacement of the culverts with the new bridge and causeway opening) is in fact duplicating, as closely as possible, the water and salt transfer that the culverts would have provided if the culverts had continued functioning (open and free flowing at 2012 elevations) instead of being closed and replaced by the bridge and causeway opening.

Aquatic Resource Impacts Assessment. As described in Section 2.1, Analytical Approach, UPRR received direction from USACE, in its February 2013 letters describing the project's mitigation objectives, that the compensatory mitigation project must (1) replace the aquatic functions of the east and west culverts (transfer of water and salt) and (2) result in less-than-minimal effects on aquatic resources. The model update will address the issue of whether the project is in fact replacing the culverts' aquatic functions (by not causing any variation of South Arm salinities from what the culverts would have produced), and the resource impacts assessment will determine whether any such variation would adversely affect aquatic resources that rely on the lake's beneficial uses.

A project-caused variation of South Arm salinities outside the model ranges also would be outside the scope of the UPRR Resource Evaluation Report (UPRR 2014d), which found that variations within the model simulations and historical variability are not likely to result in significant adverse effects on the lake's beneficial uses. Therefore, a project-caused variation of salinities outside the model ranges must be evaluated individually to determine whether it significantly adversely affects lake's aquatic resources and, therefore, its beneficial uses.

As described in more detail in the Resource Evaluation Report, the designated beneficial uses in the project area are:

- **Gilbert Bay (part of the South Arm):** Protected for frequent primary and secondary contact recreation, waterfowl, shore birds, and other water-oriented wildlife including their necessary food chain.
- **Gunnison Bay (the North Arm):** Protected for infrequent primary and secondary contact recreation, waterfowl, shore birds, and other water-oriented wildlife including their necessary food chain.

The impacts assessment would be conducted in coordination with USACE and UDWQ consistent with the methodology and analytical approach conducted for aquatic resources in the Resource Evaluation Report, with the focus being on the evaluation of potential adverse effects on the lake's aquatic resources that are protected by beneficial-use designations resulting from project-caused changes in salinity outside the historical and model simulation ranges. Project-caused adverse effects on these aquatic resources would be considered a greater-than-minimal effect under the requirements described above.

Brine shrimp and brine flies are part of the wildlife food chain of the lake, and the lake's beneficial uses include protections for shore birds and other water-oriented wildlife, including their necessary food chain. Therefore, the impacts assessment will focus mainly on project-caused salinity effects on the factors (food source, lifecycle, and predators) that affect brine shrimp and brine flies that exist in the Gilbert Bay. Brine shrimp are a keystone species in the Great Salt Lake food chain; they rely on phytoplankton for food and are a food source for corixids and migratory birds (UPRR 2014e) and are, therefore, representative of the aquatic resources of the South Arm. Accordingly, the project would have a significant adverse effect if it were to change the long-term range of salinity in the South Arm such that the change adversely affects brine shrimp and/or brine fly fecundity and survival and therefore adversely affects beneficial uses.

The evaluation will compare the measured Gilbert Bay salinities collected by UPRR during the monitoring period to published literature regarding the presence of and lifecycle influences on brine shrimp and brine flies, as represented by salinity ranges. Lifecycle influences on brine shrimp populations include food source availability (phytoplankton) and predators associated with changes of salinities outside the historic and modeled ranges. The evaluation will also review scientific studies and data that consider how salinities of the lake may influence the habitat of brine shrimp, since the brine shrimp have been documented to move between the bays of the lake based on favorable conditions.

If a project-caused variation outside the model salinity ranges is found to adversely affect the lake's brine shrimp and brine flies (aquatic resources) that are protected by the lake's beneficial uses, the project would be considered to have a greater-than-minimal adverse effect.

Conclusions and Notifications. Based on the updated model and resource impacts assessment, UPRR will, in consultation with USACE and UDWQ, determine whether the project has caused or contributed to a change of South Arm salinities outside the model range of salinities that has adversely impacted aquatic resources protected by beneficial uses. If the project has not caused salinity variations outside the model ranges (that is, the monitoring data results are a result of influences [such as inflows, weather, and/or other industry infrastructure and operations] other than the permanent closure of the east culvert and implementation of mitigation), or if a project-caused variation has not adversely affected aquatic resources, then the project will be considered to be meeting the salinity performance standard 5, and no adaptive management measures will be required. UPRR will describe that conclusion in writing to USACE and UDWQ for their concurrence within 2 months of receiving monitoring results from the four consecutive quarters that are outside the established salinity ranges. UPRR will continue with monitoring as described in the monitoring plan for the remainder of the permit monitoring period.

If UPRR, in consultation with USACE and UDWQ, concludes, based on the updated model and aquatic resource impacts assessment, that a variation in South Arm salinities outside the model salinity range is a result of the project and has adversely affected aquatic resources protected by the lake's beneficial uses, UPRR will submit a Notification of Monitoring Results That Trigger Adaptive Management as described in Section 3.10.2, Reports and Notifications. UPRR will include a causeway opening adjustment proposal with this report, as described in Section 3.12.2, Salinity and Salt Balance Adaptive Management.

3.11 Additional Data Collection

UPRR proposes to collect and report additional data for the permit monitoring period (Table 3-11 below). These additional data would be collected and reported to assist with future lake modeling or lake-management activities. The additional data would not be used to determine compliance with performance standards but rather would be used if additional water and salt balance modeling is required—for example, as part of the updated model and impacts assessment described in Section 3.10.3, Salinity and Salt Balance Reporting (Performance Standard 5). With UDWQ input, UPRR determined that monthly additional data collection frequency is appropriate, since past flow measurements through the culverts and the existing 300-foot-long bridge were taken periodically and meet the monthly data input needs of the model.

The spot flow measurements taken at the culvert locations and existing 300-foot-long bridge locations were taken during calm weather and lake conditions to collect data during times when the flows were most stable and equalized for specific WSE and salinity conditions. In this manner, spot measurements may be used to support the model calibration process and determine model error. UPRR proposes to follow the same flow monitoring protocol as USGS and the Utah Department of Natural Resources by conducting spot measurements and determine the bidirectional flow for that monitoring date.

Table 3-11. Additional Data Collection Parameters

Topic	Measure/Frequency
Flow	Collect data to calculate monthly bidirectional water flows through the causeway opening
Deep brine layer	Report the presence of the Gilbert Bay deep brine layer at monitoring locations
Lake levels	Report North and South Arm WSE levels on monitoring dates, as reported on the USGS lake website, for context

The additional data collection results will be included in the quarterly and annual reports and submitted to the agencies during the permit monitoring period.

Table 3-12 lists the additional data to be collected monthly throughout the permit monitoring period. These measurements will support future water and salt balance modeling, if required. In addition, Table 3-13 below lists the additional data to be collected to support the calculation of bidirectional flow through the new causeway opening. These monthly measurements will be at collected at the site of the new bridge structure and at the same time as bidirectional flow measurements to assist with the determination of the flow in each direction through the new causeway opening. These measurements and subsequent calculations will be used to support future water and salt balance modeling and used in verifying the model flow computations if required.

Table 3-12. Additional Data Collection Methods

Parameter	Method [a]	Method Detection Limit	Method Reporting Limit	Hold Time
Field Measurements – Surface Water				
Lake elevation[a]	USGS automated gage	—	—	—
Depth to deep brine layer [b]	Troll 9500 field measurement	—	0.1 m	Field
Total water depth	—	—	0.1 m	Field
Temperature	SM 2520	0.1 ºC	0.1 ºC	Field profile

°C = degrees Celsius; m = meters; SM = Standard Methods for the Examination of Water and Wastewater; USGS = U.S. Geological Survey

[a] Water level data collected from USGS stations at Saltair Beach State Park and Little Valley Boat Harbor will also be compiled from ut.water.usgs.gov/greatsaltlake/elevations.

[b] *Brine layer depth* refers to the vertical zone in a water column in which salinity changes rapidly with depth. Determined from conductivity and TDS data.

Table 3-13. Additional Data To Be Collected to Calculate Bidirectional Flow

Parameter	Method[a]	Method Detection Limit	Method Reporting Limit	Hold Time
Field Measurements – Surface Water				
Depth to deep brine layer[b]	Troll 9500 field measurement	—	0.1 m	Field
Total water depth	—	—	0.1 m	Field
Temperature	SM 2520	0.1 °C	0.1 °C	Field profile
Specific gravity	ASTM 1429[c]	0.001 (unitless)	0.001 (unitless)	—
Laboratory Analyses – Surface Water				
Density	SM 2710F	—	0.001 g/mL	7 days
Total dissolved solids	SM 2540C	—	5 mg/L	7 days
Bidirectional Flow through Causeway Opening				
North-to-south velocity	ADCP field measurement	NA	NA	NA
South-to-north velocity	ADCP field measurement	NA	NA	NA
North-to-south flow	calculated	NA	NA	NA
South-to-north flow	calculated	NA	NA	NA

°C = degrees Celsius; ADCP = Acoustic Doppler Current Profiler; ASTM = American Society for Testing and Materials; g/mL = grams per milliliter; m = meters; mg/L = milligrams per liter; NA = not applicable; SM = Standard Methods for the Examination of Water and Wastewater

[a] Laboratory analytical method or field equipment.

[b] *Deep brine layer depth* refers to the vertical zone in a water column in which salinity changes rapidly with depth.

[c] Specific Gravity Determinations Using a Hydrometer

3.12 Adaptive Management Plan

To facilitate adaptive management activities identified as necessary during the permit monitoring period and future lake management activities that may be undertaken after the permit monitoring period, UPRR is proposing to construct a 180-foot-long bridge structure with an adjacent earthen control berm to create the required 150-foot-long causeway opening. With this design, adjustments to the causeway opening may be made to increase or decrease the causeway opening length, or increase or decrease the control berm invert elevation, within the ranges allowed by the bridge structure design.

UPRR will implement adaptive management as described in this section following the submission of the Notification of Monitoring Results That Trigger Adaptive Management as described in Section 3.10, Monitoring and Reporting.

3.12.1 Causeway Opening Geometry Adaptive Management

This section describes measures to be taken in a stepwise process to determine whether the causeway opening geometry has become restricted or obstructed by excessive erosion or whether debris has accumulated. This section also describes measures that may be implemented if UPRR or USACE and UDWQ, upon review of UPRR's data report, determine that the causeway opening needs to be increased and/or decreased to duplicate the as-built conditions.

UPRR will implement the following action measures in progressive steps if monitoring survey data indicate that the causeway opening geometry is outside the as-built conditions or accepted geometry and therefore does not meet the performance standard. The as-built conditions, including average opening area and control berm contours, or accepted geometry, will be set by survey data collected after the bridge structure and control berm are constructed and operating. Nominally, the opening for the causeway is described as 150 feet wide and has an invert elevation of 4,183 feet, which will be set by the control berm. The bridge structure will have a nominal opening of 180 feet and an invert elevation of 4,178 feet. These dimensions are shown in Figure 3-1, Proposed Bridge and Causeway Opening Geometry, and Figure 3-2, Proposed Bridge and Control Berm Plan View.

1. **Review quarterly water depth data and determine the extent of the causeway opening (water flow capacity) restriction or enlargement (Performance Standard 3).**

   If UPRR determines that the quarterly average water depth data show an enlargement or restriction of the flow through the causeway opening, UPRR will examine the data to determine the extent of the effect. If monitoring data suggest that the inundation (water depth) under the bridge is excessive or limited (within a variation of 10%), UPRR will examine the data to determine the extent of the effect. Once the extents are identified, UPRR will prepare a plan to remediate the deviation. This remediation may consist of rebuilding the causeway opening invert so that the invert elevation is restored to its original as-built condition.

2. **Review survey data and the extents of the restriction or enlargement of the control berm and causeway opening to determine the cause of the deviation (Performance Standards 1, 2, and 4).**

   UPRR will review the annual data and attempt to determine what caused the control berm and/or causeway opening to fill in or enlarge. Possible causes are debris accumulation caused by wind, erosion caused by wind, and excessive velocities through the causeway opening resulting in scour holes. If an event or situation caused the restriction or enlargement of the control berm and causeway opening, UPRR will, in coordination with UDWQ and USACE, design and implement a mitigation measure to attempt to prevent future similar effects on the control berm and causeway opening. Potential mitigation measures include placing additional rip-rap, increasing the size and amount of the rip-rap, removing the accumulated debris, and stabilizing the source of the debris.

   > **What is rip-rap?**
   >
   > Rip-rap is rocks that are placed to prevent scouring due to erosion.

3. **Coordinate with agencies.**

   UPRR will coordinate with USACE and UDWQ to review the plan to remediate the restriction or enlargement of the causeway opening and to implement any mitigation measure to prevent future similar effects on the causeway opening. Upon review and concurrence with the agencies, UPRR will implement the plan and conduct a survey afterward to confirm that the causeway opening will meet performance standards, which is that the causeway opening is within 10% of the as-built conditions.

UPRR will develop and submit to the agencies the remediation plan, if necessary, within 1 month of obtaining the quarterly water depth measurements or annual survey results and would implement the plan within 2 months of receiving the agencies' concurrence with the plan. Adaptive measures conducted to date will be documented in the annual monitoring report, as described in Section 3.10.2, Reports.

3.12.2 Salinity and Salt Balance Adaptive Management

UPRR will implement the following measures to adjust the causeway opening when, based on the results of the analysis described in Section 3.10.3, Salinity and Salt Balance Reporting (Performance Standard 5), UPRR, in consultation with USACE and UDWQ, determines that the project has caused a variation in South Arm salinities that adversely affects aquatic resources (brine shrimp) and therefore the salinity performance standard (performance standard 5).

Specifically, UPRR will, using the updated model, develop and propose, for USACE and UDWQ approval, modifications to the causeway opening to adjust the new opening's relative contribution to the overall water and salt transfer and meet the performance standards.

In coordination with USACE and UDWQ, UPRR will evaluate the following physical changes to the control berm that effectively creates the 150-foot-long opening in the causeway through the 180-foot-long bridge structure:

- If the analysis indicates that the South Arm is losing salt compared to the free-flowing culvert simulations, UPRR will propose lowering the existing control berm invert to increase the north-to-south flow through the breach and the resulting ratio of flows. UPRR proposes that lowering the invert will be conducted in coordination with model results. The maximum the invert will be lowered is 5 feet (to elevation 4,178 feet) to match lake bottom conditions within the immediate area of the bridge.
- If the analysis indicates that the South Arm is gaining salt compared to the free-flowing culvert simulation, UPRR will propose raising the existing control berm invert to decrease the north-to-south flow through the breach and the resulting ratio of flows. UPRR proposes that raising the invert is conducted in coordination with model results.
- In addition to the potential adjustments that may be made to the invert of the control berm, the control berm itself may be enlarged or reduced so that the depth of brine flowing through the causeway opening is smaller or larger (up to the limits of the bridge structure).

These measures will be implemented on the earthen control berm that is shown on the bridge plans in Appendix A, Conceptual Bridge and Control Berm Design Plans, and Figure 3-6 and Figure 3-7 below. Implementing the measures would not require adjusting or modifying the bridge structure, only the earthen control berm. The control berm would be located to the immediate north of the bridge structure, as shown on the drawings in Appendix A. UPRR would submit the causeway adjustment proposal within 2 months of submitting the Notification of Monitoring Results That Trigger Adaptive Management Report (within 2 months of receiving monitoring results from the four consecutive quarters that are outside the established salinity ranges as described in Section 3.10.3, Salinity and Salt Balance Reporting (Performance Standard 5)). The adjustment to the opening would be made within 2 months of receiving USACE and UDWQ concurrence with the causeway opening adjustment proposal.

Figure 3-6. Bridge and Earthen Control Berm (Isometric View Looking Southeast)

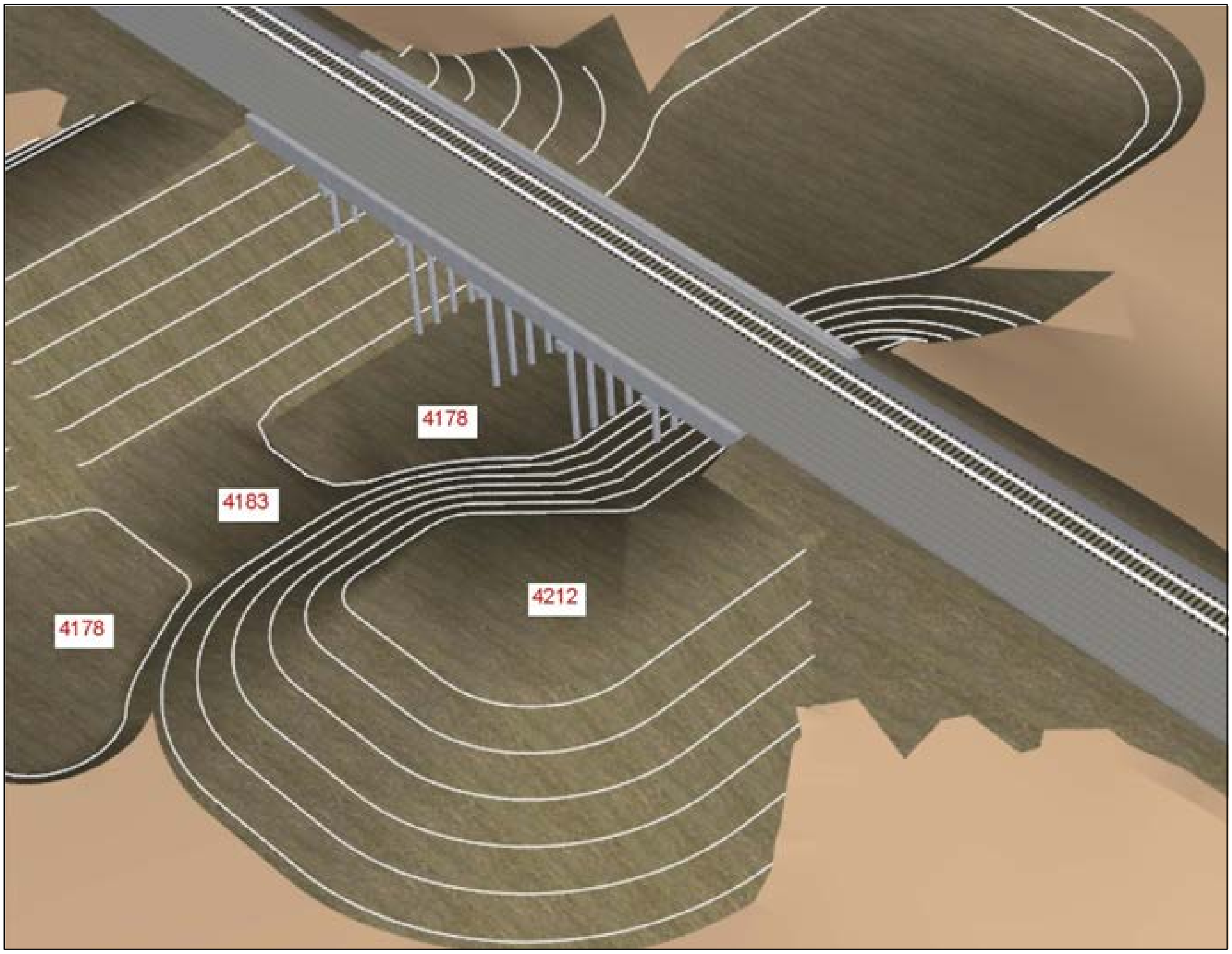
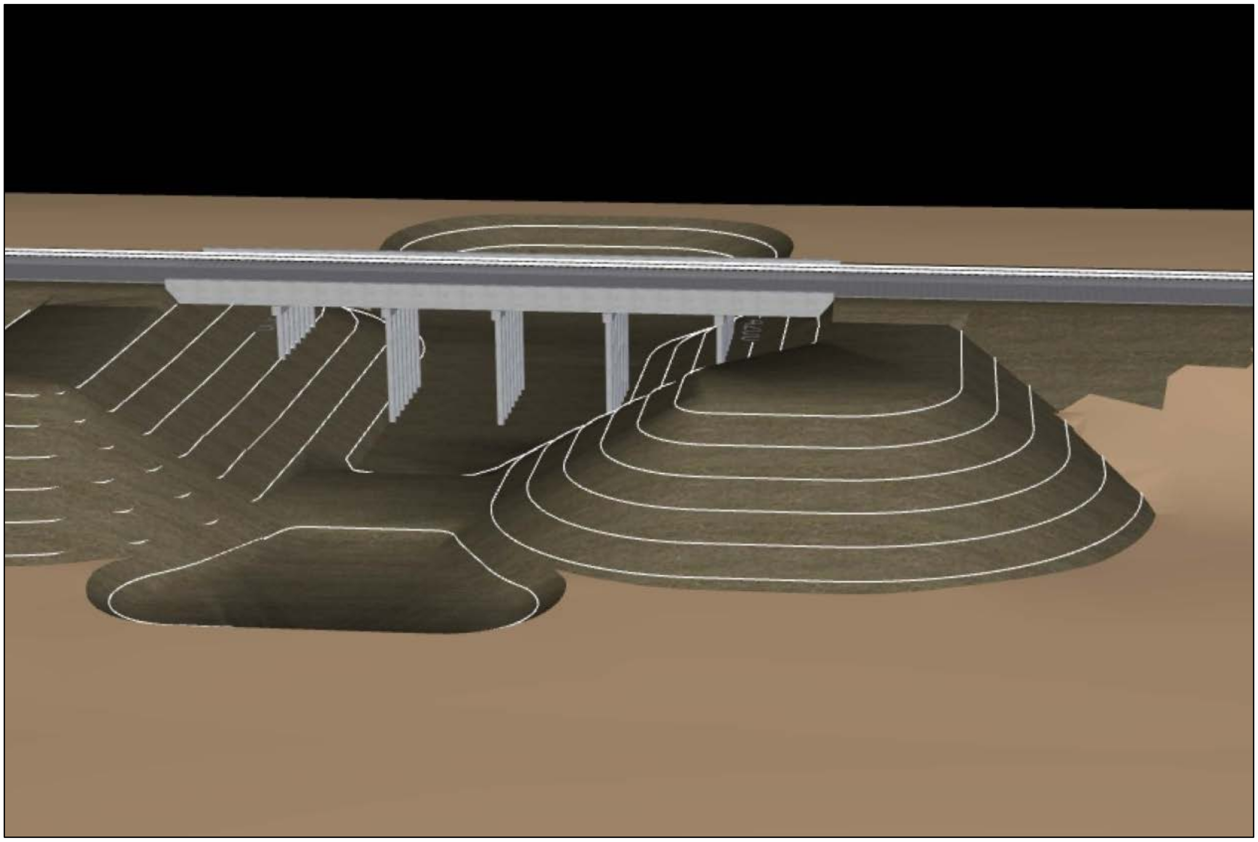


Figure 3-7. Bridge and Causeway Opening (Looking South)



3.13 Long-Term Management Plan

3.13.1 Ownership

UPRR currently owns and operates the causeway across the lake. Because the proposed bridge structure, berm, and opening would be part of the causeway, UPRR would own and operate the bridge structure and control berm. As provided below in Section 3.13.4, Active Long-Term Management Activities, the State would assume responsibility for operation and maintenance of the control berm at the point that the State institutes post-permit management activities that modify the control berm.

3.13.2 Sustainability

The bridge structure, control berm, and opening are designed to be self-sustaining; that is, there are no active engineering components (pumps), and the proposed engineered features (structure and berm) have been designed to be stable and to require minimum operation and maintenance. The bridge structure's design life is 100 years.

3.13.3 Long-Term Steward

Because the proposed mitigation (bridge structure, control berm, and causeway opening) would be part of the railroad causeway and infrastructure, it would be protected and maintained in the normal course of railroad operation and maintenance. Therefore, UPRR does not propose to name a third-party long-term steward to manage the mitigation project. UPRR would conduct all long-term maintenance activities associated with the bridge structure and causeway opening after the end of the permit monitoring period in consultation with UDFFSL and state lake mangers as needed and consistent with all applicable legal access and regulatory requirements. UPRR would conduct those long-term maintenance activities up until the point that the State of Utah institutes management activities that require modification of the control berm. At that point, management and maintenance of the control berm would be as provided in Section 3.13.4 below.

3.13.4 Active Long-Term Management Activities

After the monitoring period ends, as approved by USACE and UDWQ, UPRR would continue activities related to the bridge structure, control berm, and causeway opening that facilitate operation of the causeway and maintenance of the causeway opening per as-built conditions. However, after the permit monitoring period ends, UPRR would not continue long-term lake monitoring and salinity management activities including adjustment of the causeway opening to meet a specified lake salinity goal or objective.

UPRR recognizes that lake managers and stakeholders may wish to conduct management activities after the UPRR permit monitoring period ends to achieve a specific North or South Arm salinity or other water quality goal or objective. The new control berm and resulting causeway opening may be adjusted to meet these stated objectives. In such cases, UPRR will coordinate as necessary with USACE, UDWQ, and UDFFSL to allow state managers access to the control berm area and participate in design reviews with the State of Utah to ensure that modifications and construction activities conducted on the control berm do not jeopardize the structural integrity of the causeway or bridge structure and interfere with the operation of the rail line.

UPRR will, in consultation with UDWQ, prepare and propose a Memorandum of Understanding (MOU). The MOU will address, but may not be limited to, the following:

- The parties that will sign the MOU (UPRR and appropriate state agencies).
- Coordination to allow state lake managers and their designated agents and contractors access to the control berm area.
- If control berm modifications are determined necessary for lake management, the MOU will address determination of the responsible party for all design, construction, and maintenance costs and for complying with all applicable legal and regulatory requirements associated with the modifications and that UPRR will not be financially responsible for control berm modifications by others.
- UPRR participation in design reviews with the State of Utah to ensure that design modifications and construction and maintenance activities conducted on the control berm do not jeopardize the structural integrity of the causeway and bridge structure.
- Coordination and observation, by UPRR, during construction activities to ensure the structural integrity of the causeway and bridge structure.
- Determination of post-modification long-term management and monitoring of the control berm and causeway opening. Once the site is modified, the entity making the modifications or the state lake manager would assume responsibility for long-term management, monitoring, and maintenance of the control berm.
- After the permit period, UPRR will continue to maintain the bridge structure and the causeway to ensure safe rail operations and, if the control berm is modified, will notify the responsible party if adverse conditions are found.

3.13.5 Funding Mechanism

Because the bridge and associated causeway opening would be part of the causeway, which is a railroad structure, UPRR would self-fund the long-term operation and maintenance of the bridge structure. UPRR would fund long-term operation and maintenance of the control berm and causeway opening unless otherwise described in Section 3.13.4, Active Long-Term Management Activities.

3.13.6 Justification for Level of Funding

The level of funding to inspect the bridge, control berm, and causeway opening is undetermined. UPRR estimates that the cost to conduct these long-term operation and management activities would be funded from UPRR's general causeway operation and maintenance budgets. No additional funding would be required.

3.14 Financial Assurances

UPRR will provide a letter of credit, or some other form of financial assurance acceptable to USACE, to meet permit obligations. The letter of credit will include the following anticipated costs to complete activities required under agency authorizations:

- Right-of-way
- Planning, engineering, and construction for the 180-foot-long bridge structure, associated shoofly construction and demolition, and control berm construction
- Legal fees
- 5-year monitoring and additional data collection
- 5-year maintenance
- 20% contingency costs to cover adaptive management, if required

Funding of long-term lake monitoring and subsequent modifications of the causeway opening is described in Section 3.13.4, Active Long-Term Management Activities.

3.15 Other Information

No additional information beyond that described in Section 2.0, Water and Salt Balance Modeling and Other Studies Completed by UPRR in Support of the Project, or otherwise referenced in this CMMP, was required by USACE or UDWQ.

4.0 References

[UDFFSL] Utah Division of Forestry, Fire and State Lands

2013 Final Great Salt Lake Comprehensive Management Plan and Record of Decision. March 27.

[UDWQ] Utah Division of Water Quality

2013 401 Water Quality Certification No. SPK-2011-00755, Temporary Closure of the East Culvert of Great Salt Lake Causeway. December 16.

2014 Letter to UPRR, subject "Level II Antidegradation Review Comments." May 9.

[UGS] Utah Geological Survey

2012 Great Salt Lake Brine Chemistry Database, 1966–2011.

[UPRR] Union Pacific Railroad

2013a Proposed Mitigation and Monitoring Plan, Compensatory Mitigation for Closure of East and West Culverts in the UPRR Causeway over the Great Salt Lake (SPK-2011-00755). January 4.

2013b Letter to USACE, subject "UPRR – Great Salt Lake Causeway, Culvert Closure and Bridge Construction Report – SPK-2011-00755." September 25.

2014a Individual Application, Permanent East Culvert Closure and Bridge Construction Project. January 7.

2014b Great Salt Lake Causeway Final Water and Salt Balance Modeling Report. April 4.

2014c Great Salt Lake Causeway Culvert Closure and Bridge Construction Project, Bridge Evaluation Report. June 2.

2014d Great Salt Lake Causeway Culvert Closure and Bridge Construction Project, Resource Evaluation Report. July 1.

[USACE] United States Army Corps of Engineers

2010 USACE Mitigation Plan Template, Working Draft, Subject to Change. Revised October 7, 2010.

2012a Regulatory Program Uniform Performance Standards for Compensatory Mitigation Requirements 12505-SPD. August 8.

2012b Nationwide 14 Permit Verification, UPRR Causeway West Culvert Closure and Bridge Construction, SPK-2011-00755. August 29.

2013a Letter to UPRR. February 14.

2013b Nationwide 14 Permit Verification, UPRR Causeway Temporary East Culvert Closure and Bridge Construction, SPK-2011-00755. December 6.

2014 Letter to UPRR. February 7.

[USGS] United States Geological Survey

No date Watershed Boundary Dataset. water.usgs.gov/GIS/wbd_huc8.pdf. Accessed July 7, 2014.

APPENDIX A

Conceptual Bridge and Control Berm Design Plans

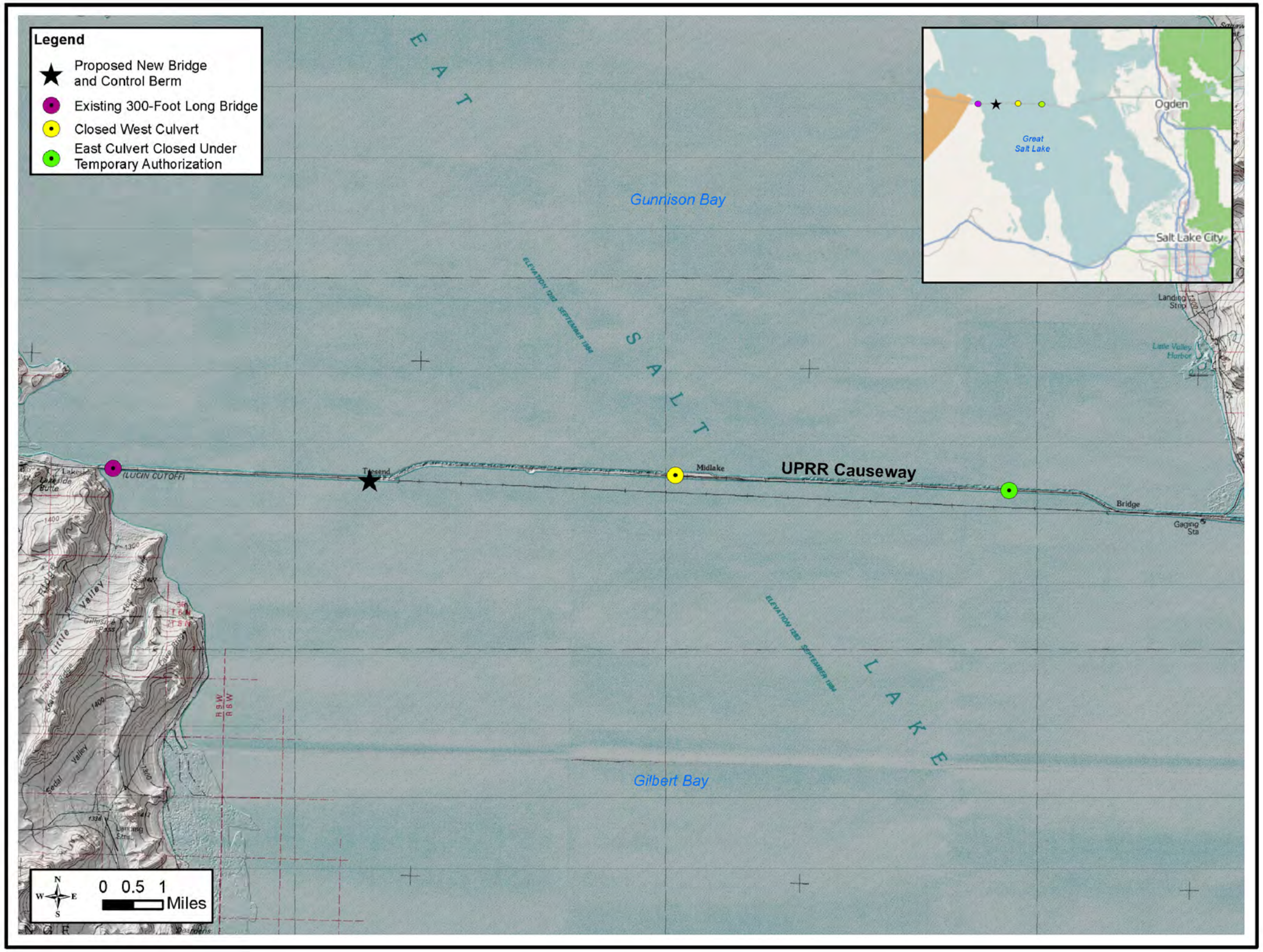
DRAWING SCHEDULE

THIS SET

SHEET NO.	DESCRIPTION
1	SITE LOCATION MAP
2	GENERAL ARRANGEMENT
3	GRADING AND RIPRAP PLAN
4	CHANNEL PROFILE
5	CHANNEL CROSS SECTIONS
6	TYPICAL SECTIONS

REF.

NO.	DWG. NO.	SHEET NO.	REV. NO.	DESCRIPTION
1	-	P002 OF P012	-	TRACK PLAN AND TOP OF RAIL PROFILE, LAKESIDE SUBDIVISION, MP. 740, CONSTRUCT BR. NO. 739.79 AND SHOO FLY
2	530000	A1	A	BOX BEAM SPANS, CONSTRUCTION PLANS
3	530000	B1-B3	A	30" BOX BEAM SPANS, CONSTRUCTION DETAILS
4	500000	BG1-BG3	F	30" x 7'-0" DOUBLE BOX BEAM, FABRICATION PLANS
5	501000	A1	-	PRECAST WINGWALL FOR 30" BOX BEAMS
6	502000	1-4	A	CONCRETE BOX BEAM HARDWARE



SITE LOCATION MAP

PERMITTING SUBMITTAL

PRELIMINARY

NOT FOR CONSTRUCTION DATE: 07/23/14

APPROVED FOR UNION PACIFIC RAILROAD CO.
BY
HDR ENGINEERING, INC
(OMAHA, NE)

BY: NATHAN P. DICKERSON

DATE:

NO.	DATE	REVISIONS
	/ /	
	/ /	
	/ /	
	/ /	

HDR

UNION PACIFIC RAILROAD
Office of AVP Engineering Design/Construction

LOCATION: BRIDGE 739.78 LAKESIDE SUB.
41.2 MILES WEST OF OGDEN, UT.

FACILITY: 180' BRIDGE
(1 TRACK AND MAINTENANCE ROAD)

DWG TITLE: SITE LOCATION MAP

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WORK ORDER: 09107			
DESIGN BY: AMM			
CHECKED BY:			
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CHECKED BY: AMM			
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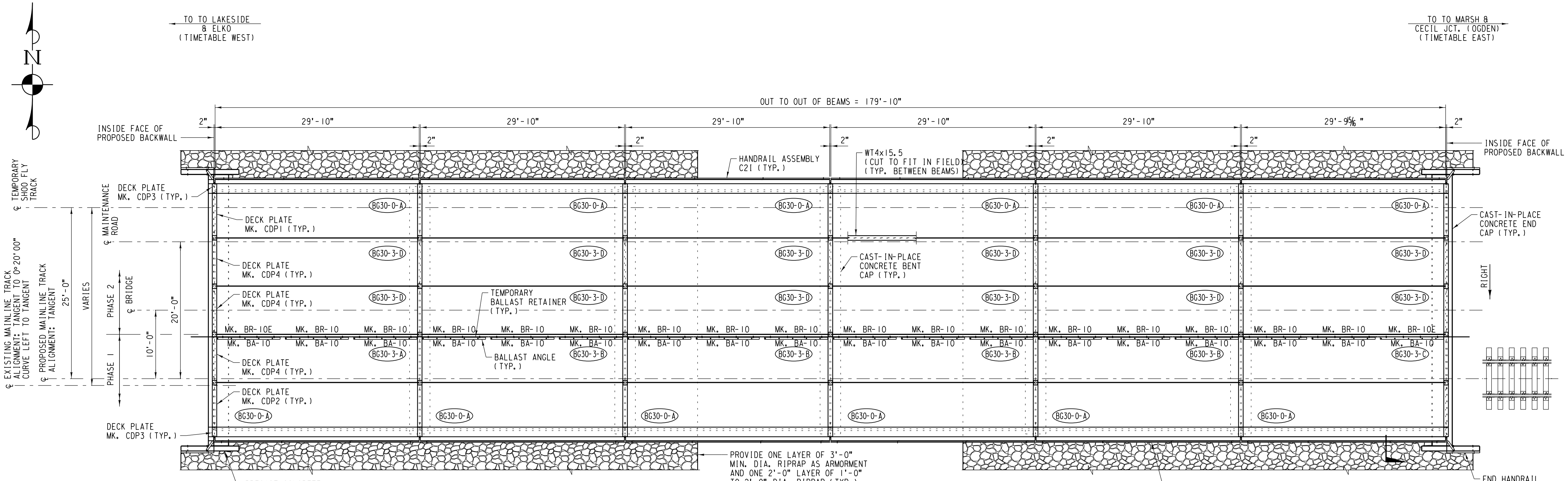
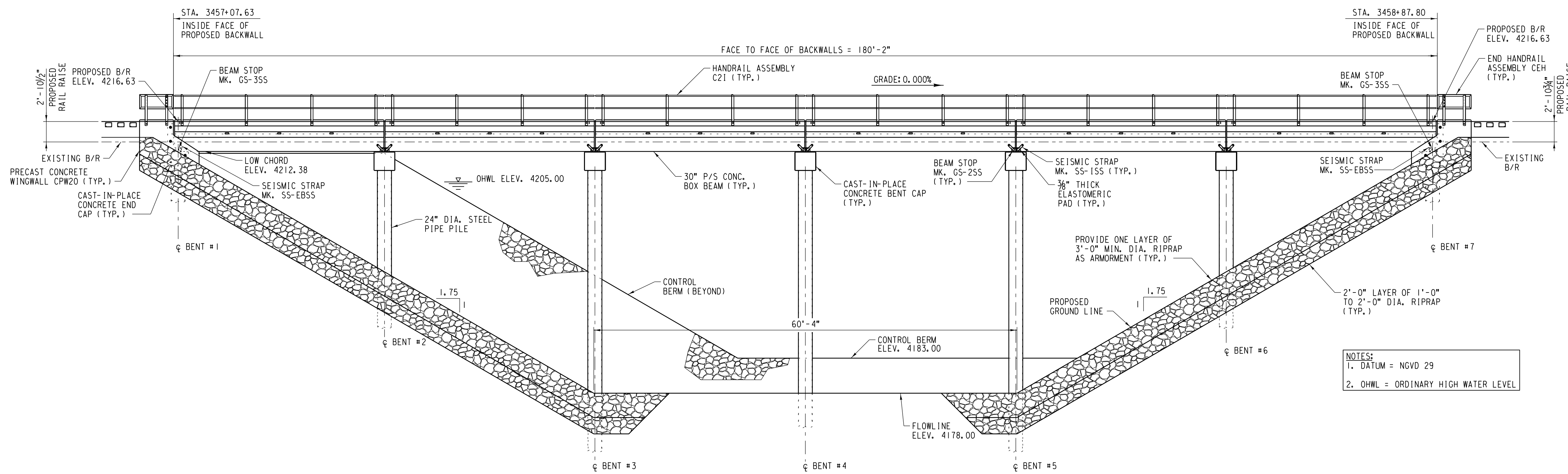


180-FT BRIDGE STRUCTURE PLAN

SCALE: 1/8" = 1'-0"



NOTES:
1. DATUM = NGVD 29
2. OHWL = ORDINARY HIGH WATER LEVEL

180-FT BRIDGE STRUCTURE ELEVATION WITH CONTROL BERM TO CREATE 150-FT OPENING LOOKING NORTH

SCALE: 1/8" = 1'-0"

PERMITTING SUBMITTAL

PRELIMINARY

NOT FOR CONSTRUCTION DATE: 07/23/14

APPROVED FOR UNION PACIFIC RAILROAD CO. BY HDR ENGINEERING, INC (OMAHA, NE)

BY: NATHAN P. DICKERSON

DATE:

NO.	DATE	REVISIONS
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	/ /	
	/ /	
	/ /	

HDR

UNION PACIFIC RAILROAD

Office of AVP Engineering Design/Construction

LOCATION: BRIDGE 739.78 LAKESIDE SUB. 41.2 MILES WEST OF OGDEN, UT.

FACILITY: 180' BRIDGE (1 TRACK AND MAINTENANCE ROAD)

DWG TITLE: GENERAL ARRANGEMENT

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CHECKED BY: LAG			
DRAWN BY: SSS	SHEET NO.		C E NUMBER
CHECKED BY: JRB	2 of 6		118793
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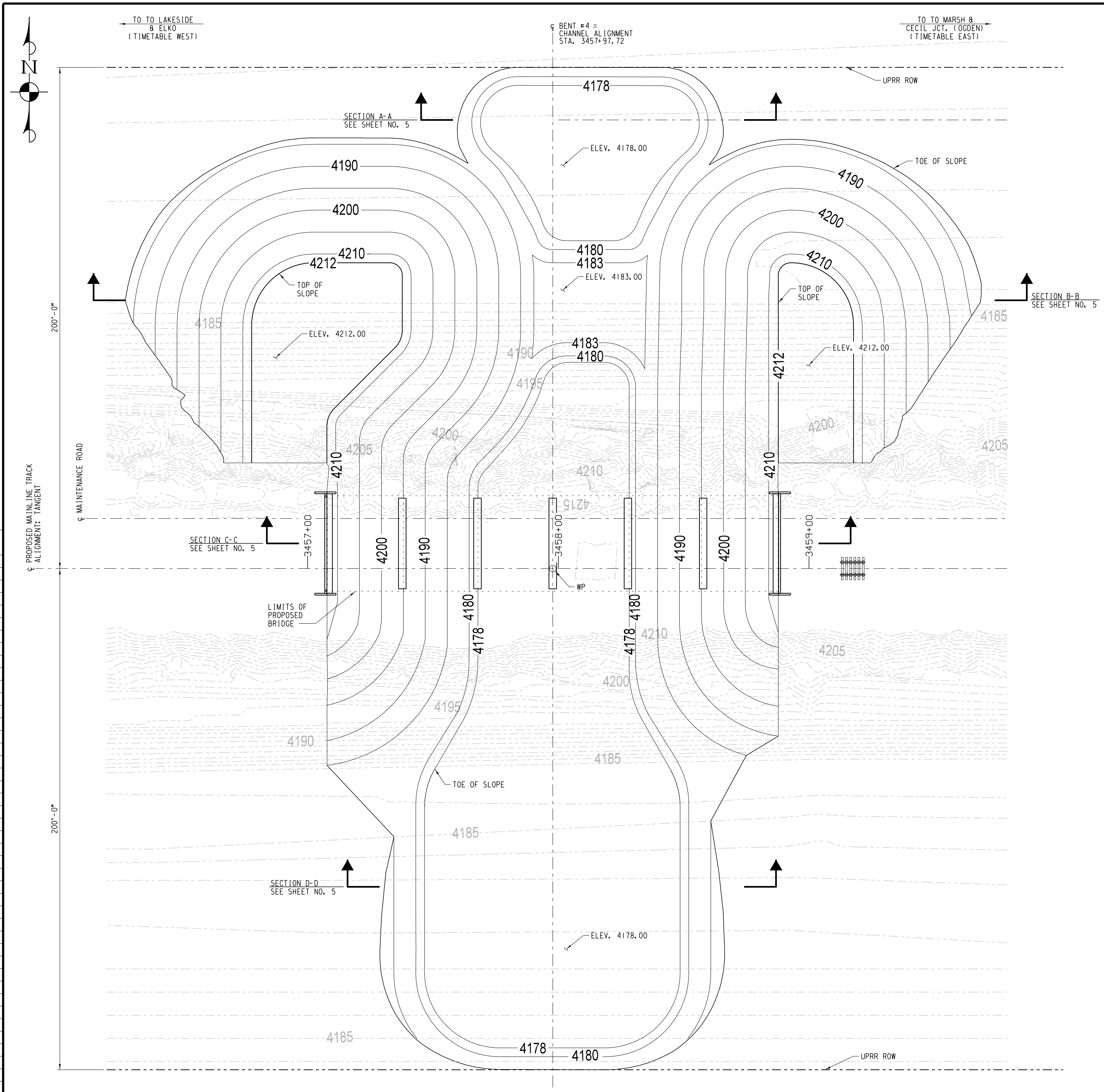
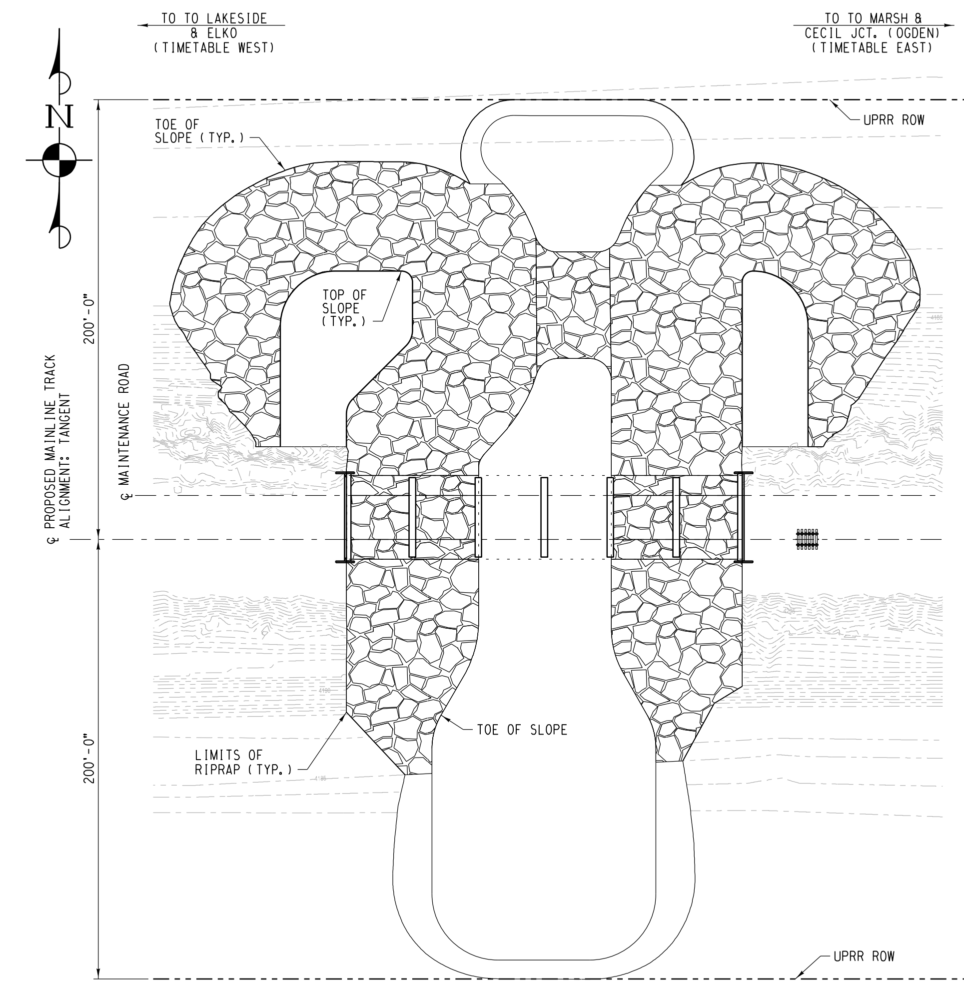


BRIDGE AND CONTROL BERM GRADING PLAN

SCALE: 1:20



RIPRAP PLAN

SCALE: 1:40

NOTE:
FOR SIZE AND THICKNESS OF RIPRAP, SEE SHEET NO. 2.

NOTES:
1. PROPOSED BRIDGE SUPERSTRUCTURE NOT SHOWN FOR CLARITY.
2. FOR CHANNEL PROFILE, SEE SHEET NO. 4.
3. WP = WORKING POINT = INTERSECTION OF ℄ PROPOSED MAINLINE TRACK AT STA. 3457+97.72 WITH ℄ BENT #4/CHANNEL ALIGNMENT AT STA. 10+00
4. FOR CHANNEL CROSS SECTIONS, SEE SHEET NO. 5.

PERMITTING SUBMITTAL

PRELIMINARY

NOT FOR CONSTRUCTION DATE: 07/23/14

NO.	DATE	REVISIONS
	/ /	
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	/ /	

APPROVED FOR
UNION PACIFIC RAILROAD CO.
BY
HDR ENGINEERING, INC
(OMAHA, NE)

BY: NATHAN P. DICKERSON

DATE:

HDR

UNION PACIFIC RAILROAD
Office of AVP Engineering Design/Construction

LOCATION: BRIDGE 739.78 LAKESIDE SUB.
41.2 MILES WEST OF OGDEN, UT.

FACILITY: 180' BRIDGE
(1 TRACK AND MAINTENANCE ROAD)

DWG TITLE: GRADING AND RIPRAP PLAN

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WORK ORDER: 09107	UP-SLC	
DESIGN BY: AMM	HDR-NPD	LONGITUDE: 112°45'59" W
CHECKED BY:		
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CHECKED BY: AMM	3 of 6	118793
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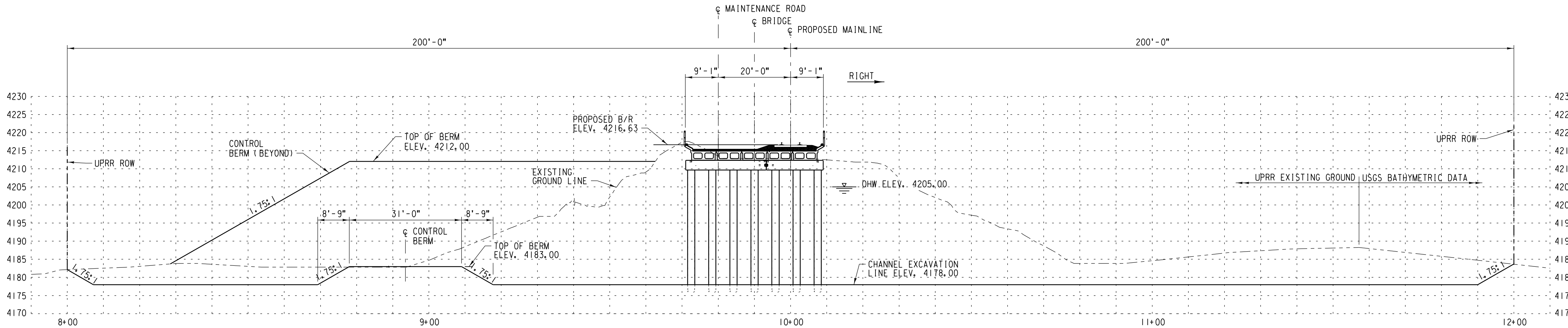

FINAL CHANNEL PROFILE
LOOKING EAST

SCALE: 1/16"=1'-0"

PERMITTING SUBMITTAL

PRELIMINARY

NOT FOR CONSTRUCTION DATE: 07/23/14

APPROVED FOR
UNION PACIFIC RAILROAD CO.
BY
HDR ENGINEERING, INC
(OMAHA, NE)

BY:
NATHAN P. DICKERSON
DATE:

NO.	DATE	REVISIONS
	/ /	
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	/ /	

HDR

UNION PACIFIC RAILROAD
Office of AVP Engineering Design/Construction

LOCATION:
BRIDGE 739.78 LAKESIDE SUB.
41.2 MILES WEST OF OGDEN, UT.

FACILITY:
180' BRIDGE
(1 TRACK AND MAINTENANCE ROAD)

DWG TITLE:
CHANNEL PROFILE

PROJECT ID: 73343	UP ENGINEER: UP-SLC HDR-NPD	LATITUDE: 41°13'15" N	
WORK ORDER: 09107		LONGITUDE: 112°45'59" W	
DESIGN BY: AMM			
CHECKED BY:			
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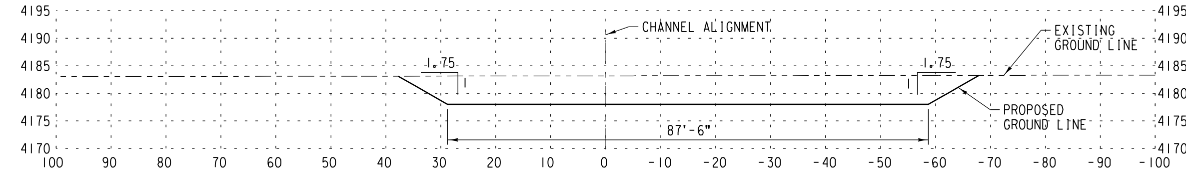

SECTION A-A
NORTH OF CONTROL BERM
LOOKING NORTH
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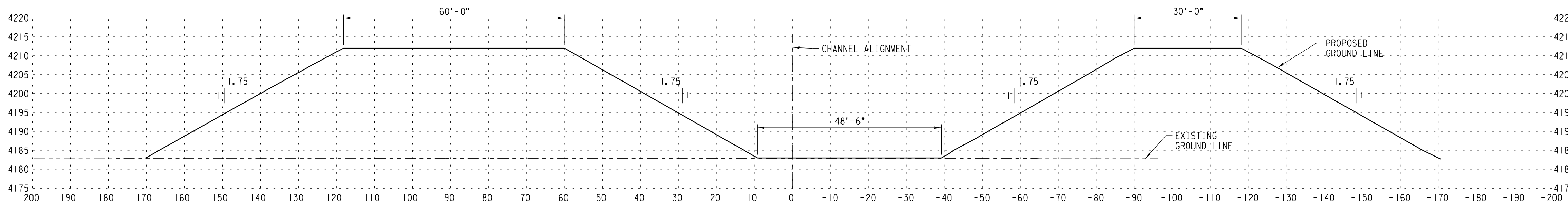
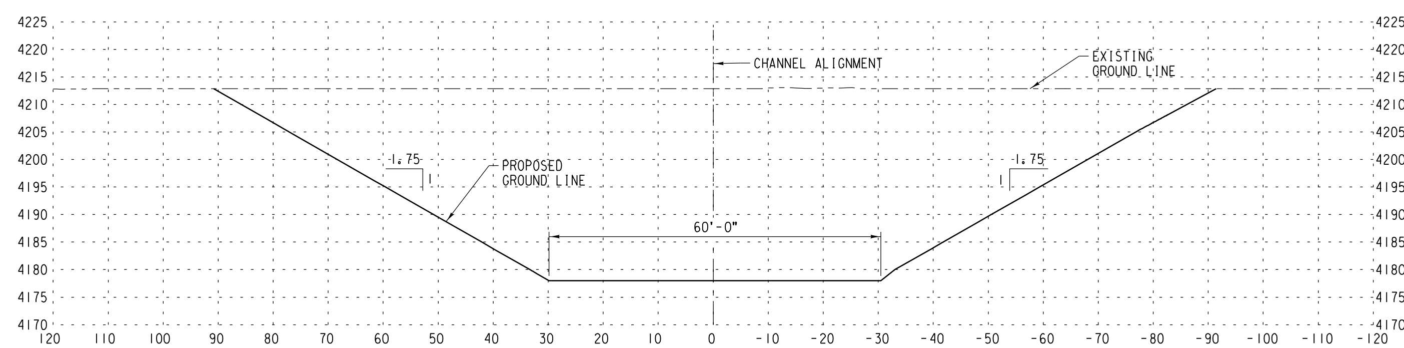
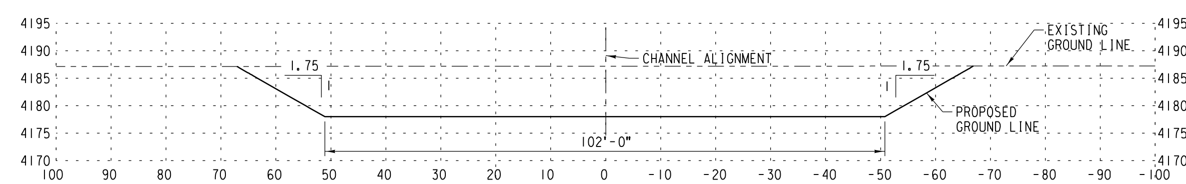


SECTION B-B
AT CONTROL BERM
LOOKING NORTH
SCALE: 1/16"=1'-0"



SECTION C-C
AT BRIDGE
LOOKING NORTH
SCALE: 1/16"=1'-0"



SECTION D-D
SOUTH OF BRIDGE
LOOKING NORTH
SCALE: 1/16"=1'-0"

NOTE:
FOR RIPRAP LIMITS, SEE SHEET NO. 3.

PERMITTING SUBMITTAL

PRELIMINARY

NOT FOR CONSTRUCTION DATE: 07/23/14

APPROVED FOR
UNION PACIFIC RAILROAD CO.
BY
HDR ENGINEERING, INC
(OMAHA, NE)

BY: NATHAN P. DICKERSON

DATE:

NO.	DATE	REVISIONS
	/ /	
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HDR

UNION PACIFIC RAILROAD
Office of AVP Engineering Design/Construction

LOCATION: BRIDGE 739.78 LAKESIDE SUB.
41.2 MILES WEST OF OGDEN, UT.

FACILITY: 180' BRIDGE
(1 TRACK AND MAINTENANCE ROAD)

DWG TITLE: CHANNEL CROSS SECTIONS

PROJECT ID: 73343	UP ENGINEER: UP-SLC HDR-NPD	LATITUDE: 41°13'15" N	
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DESIGN BY: AMM			
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CHECKED BY: AMM	5 of 6	118793	
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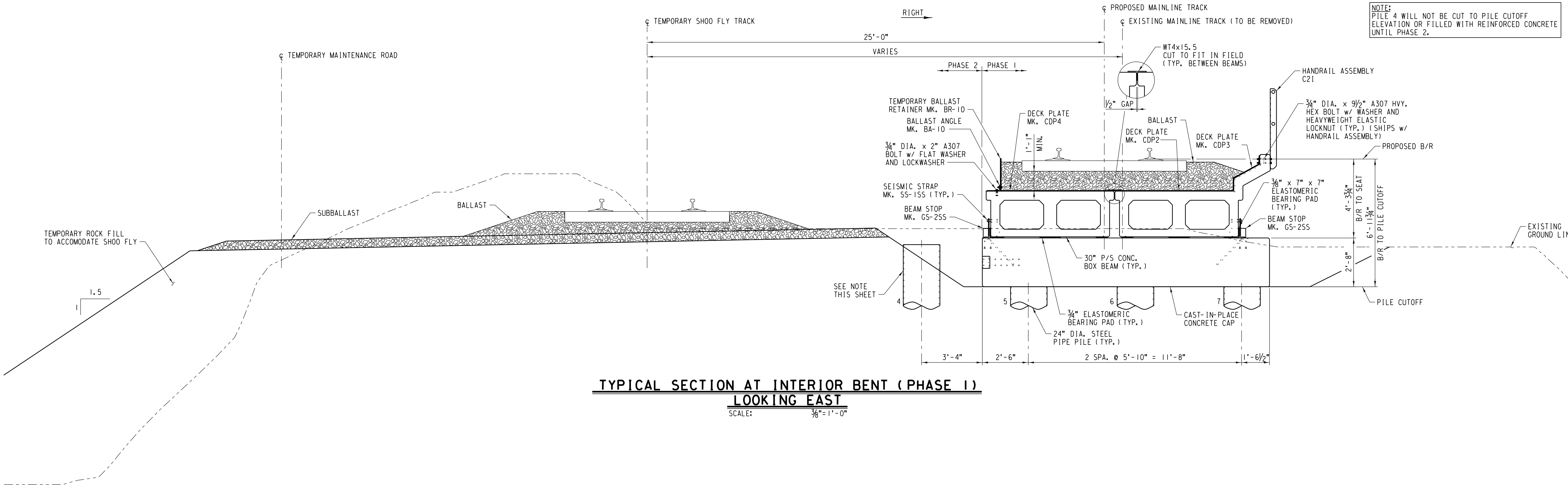
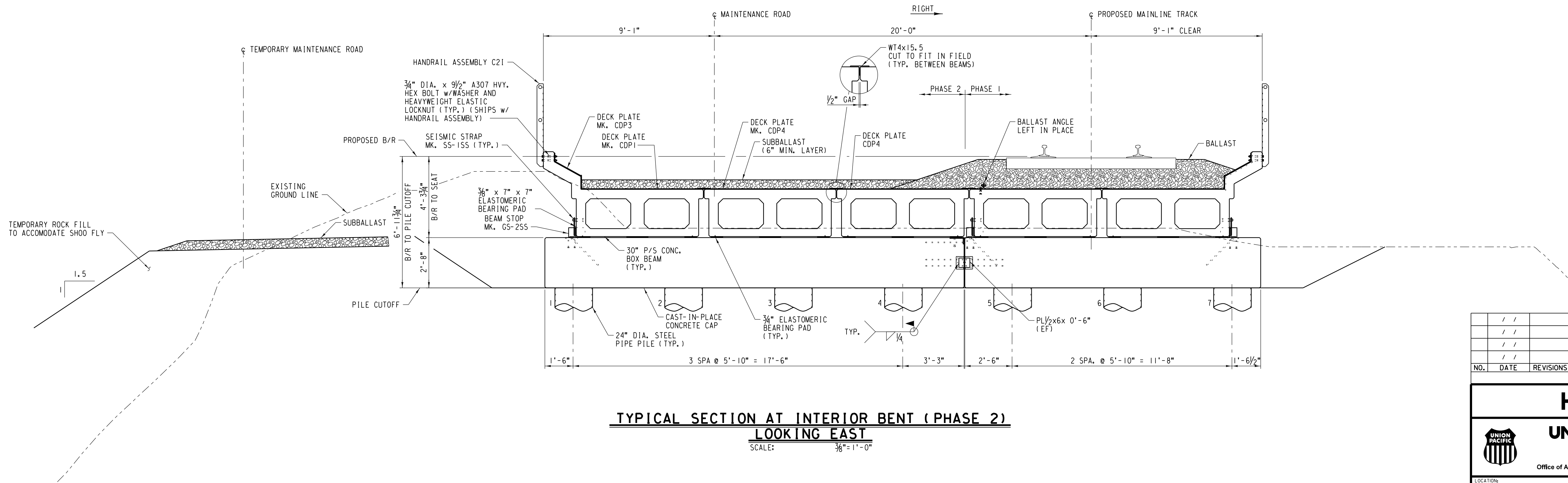


TYPICAL SECTION AT INTERIOR BENT (PHASE 1)
LOOKING EAST

SCALE: ⅜"=1'-0"



TYPICAL SECTION AT INTERIOR BENT (PHASE 2)
LOOKING EAST

SCALE: ⅜"=1'-0"

PERMITTING SUBMITTAL

PRELIMINARY

NOT FOR CONSTRUCTION DATE: 07/23/14

APPROVED FOR
UNION PACIFIC RAILROAD CO.
BY
HDR ENGINEERING, INC
(OMAHA, NE)

BY: ____
NATHAN P. DICKERSON
DATE: ____

NO.	DATE	REVISIONS
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HDR

UNION PACIFIC RAILROAD
Office of AVP Engineering Design/Construction

LOCATION:
BRIDGE 739.78 LAKESIDE SUB.
41.2 MILES WEST OF OGDEN, UT.

FACILITY:
180' BRIDGE
(1 TRACK AND MAINTENANCE ROAD)

DWG TITLE:
TYPICAL SECTIONS

PROJECT ID: 73343	UP ENGINEER:	LATITUDE:	
WORK ORDER: 09107	UP-SLC	41°13'15" N	
DESIGN BY: AMM	HDR-NPD	LONGITUDE:	
CHECKED BY: LAG		112°45'59" W	
DRAWN BY: SSS	SHEET NO.	C E NUMBER	
CHECKED BY: JRB	6 of 6	118793	
SCALE: AS NOTED			

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APPENDIX B

Historic and Water and Salt Balance Model Salinity Ranges Analysis

Appendix B. Development of Salinity Ranges for the UPRR Culvert Closure and Bridge Construction Project

B.1 Historic Salinity Range

B.1.1 Background

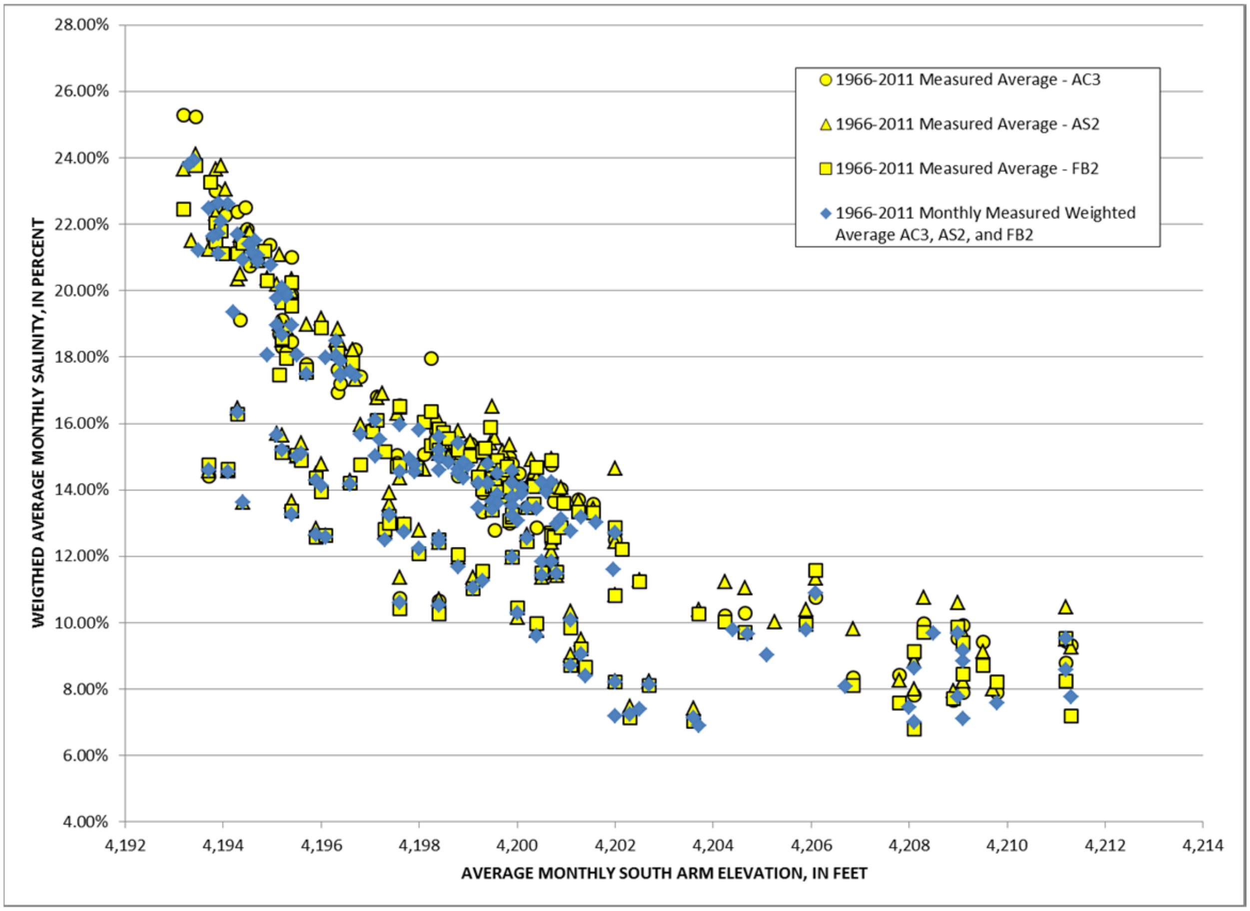
As part of the Union Pacific Railroad (UPRR) Culvert Closure and Bridge Construction Project, UPRR will use the data collected and analyzed by the Utah Geological Survey (UGS) to define the historic salinity range of the Great Salt Lake. UGS has published lake water samples for salinity and ion concentrations for 1966 to 2011 in the Great Salt Lake Brine Density Database (UGS 2012). The UGS salinity results will be averaged for specific locations in the South Arm of the Great Salt Lake, plotted, and cross-referenced to the documented water surface elevation (WSE) at the time of the sampling event. In addition, a standard error will be applied to the UGS data results to represent the sample uncertainties and accuracies. The development of the standard error is discussed in this appendix.

B.1.2 UGS Data

UPRR analyzed reported density, total dissolved solids (TDS) by percent weight (% wt TDS), and WSE data for the three South Arm sampling locations of AC3, AS2, and FB2. These three sampling locations were chosen because of the amount of data that was collected consistently over the period of record (1966–2011) and because these sampling locations were used by the U.S. Geological Survey (USGS) and UPRR to calibrate the water and salt balance model used for the project.

Discrete samples were individually averaged by depth of the sample in the water column to calculate a average density for each sample. Then the three locations were averaged to represent the average density of the South Arm of the lake. Figure B-1 illustrates the weighted average for each sampling location (AC3, AS2, and FB2) and the spatial average to represent the historical South Arm salinity range for this project plotted against the WSE reported at the time of sampling.

Figure B-1. UGS Historical and Averaged South Arm Salinity Data



B.1.3 UGS Data Uncertainty and Error Analysis

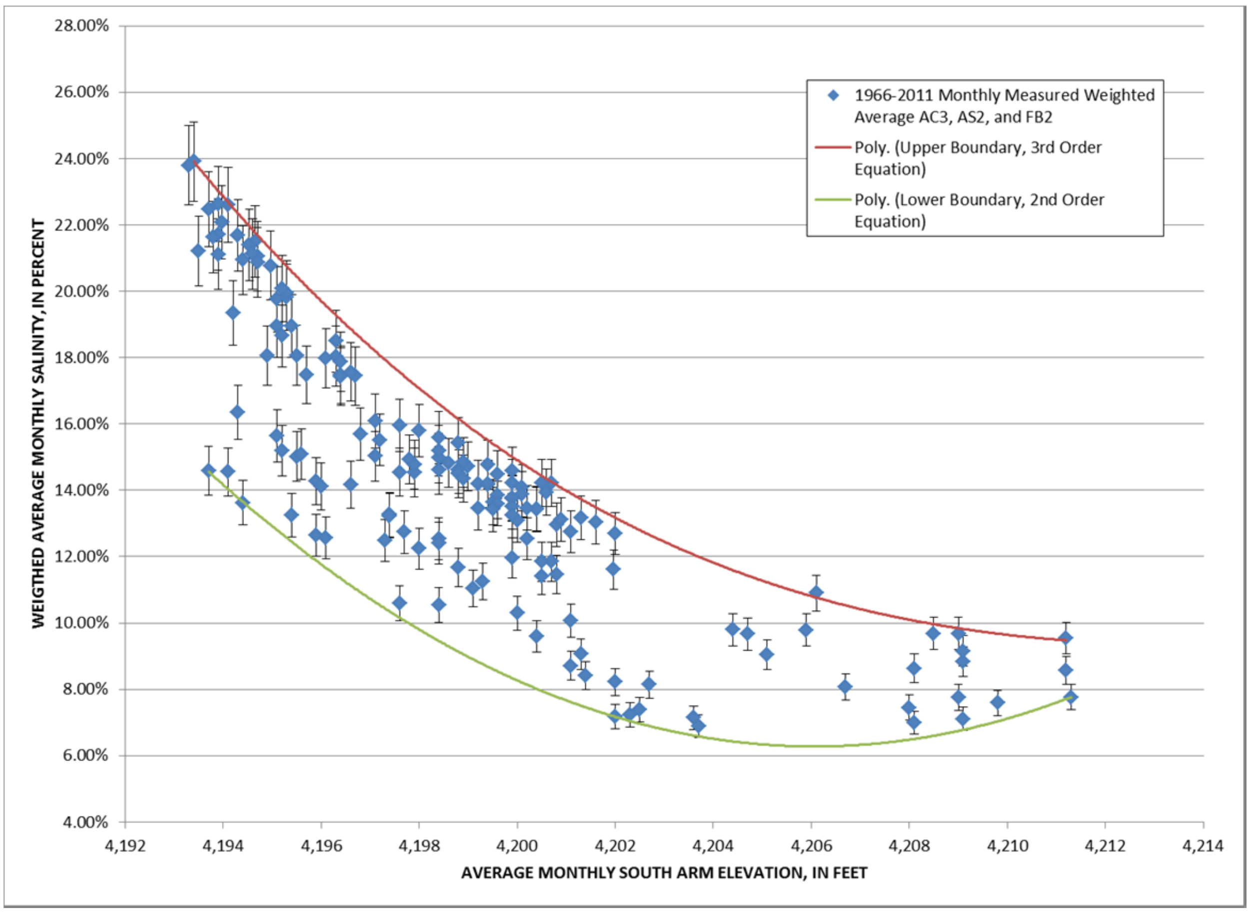
The historical data were qualitatively reviewed to determine the uncertainty or error associated with collecting and analyzing the salinity data. UPRR is unaware of any published error or uncertainty analysis associated with the UGS brine database. The following factors might affect the quality or certainty of the data. UPRR evaluated these factors and the degree of error associated with each factor.

- Field work
  - **Identification of exact sample locations.** Before GPS (global positioning system) devices were available to record location data, sampling locations were identified by standard navigational procedures. This led to some uncertainty with the spatial element of the data collection for the older samples in the database. However, the degree of error associated with this factor is considered low.
  - **Collection of sample at reported depths (due to bobbing and drifting boat).** This factor is more prevalent, since different bottom elevations have been reported for the same sampling location. This leads UPRR to believe that more error would be associated with reported sample depth than with other factors and that this error would affect the weighted average of the vertical water column.

- Laboratory analysis
  - **Precision of laboratory density.** This factor is considered moderate with regard to the degree of error. UPRR used laboratory-reported density results in conjunction with % wt TDS, based on the sum of the ions, to calculate salinity because of the consistent reporting and availability of data throughout the period of record (UGS 2014).
  - **Precision of TDS concentration.** This factor is considered low with regard to the degree of error. UGS conducted laboratory analysis of TDS concentrations that included mole balance equations for cations and anions to be within an accuracy of 5% or less. This is considered very precise and would result in low error or uncertainty.

Taking these factors into consideration, UPRR determined that the total error associated with collecting and analyzing the historic salinity data is taken as 5%. Figure B-2 illustrates the historical South Arm average salinity range for use on this project and the associated 5% error.

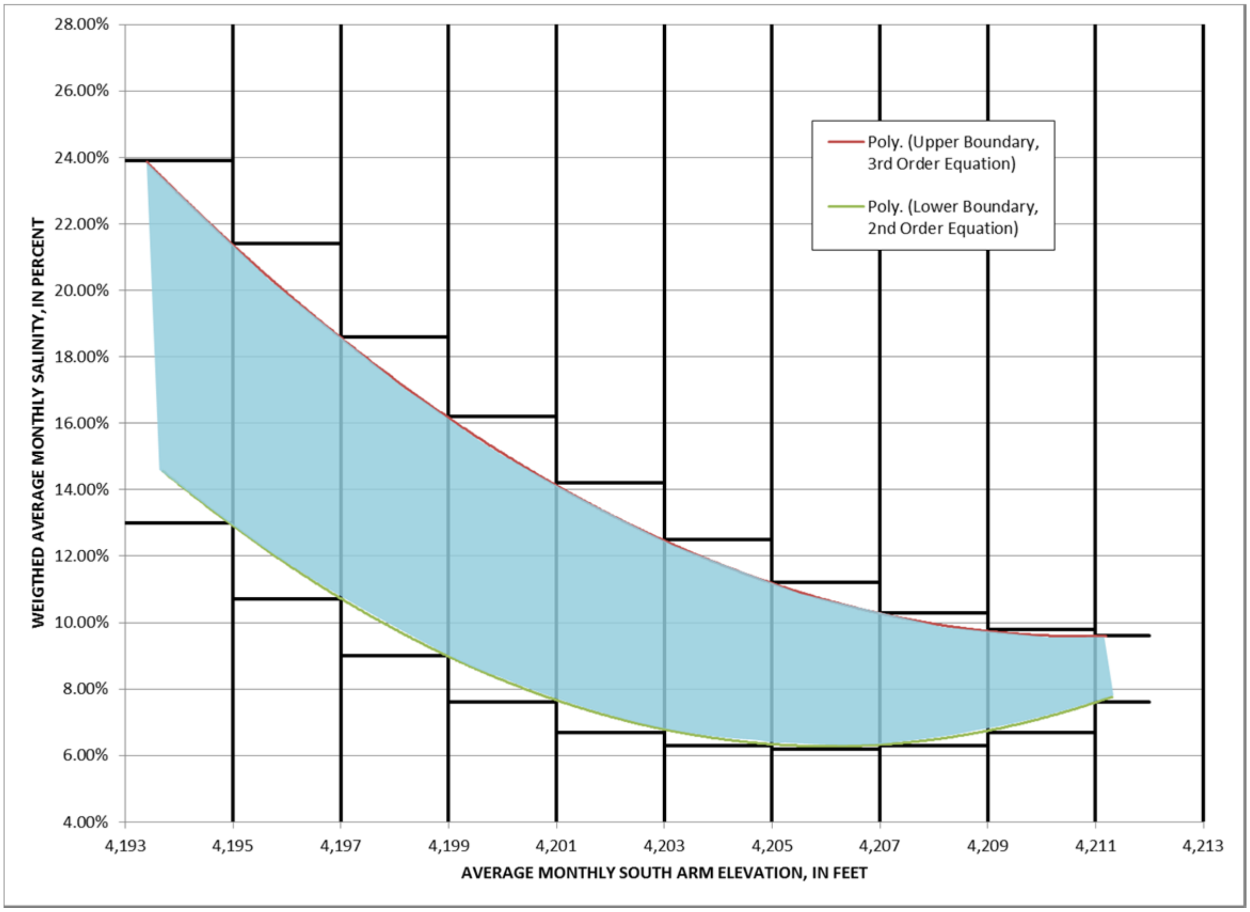
Figure B-2. UGS Historical South Arm Salinity Range and 5% Error



B.1.4 Historical Salinity Range Results

UPRR then applied the historical salinity range and calculated the range for each 2-foot South Arm WSE increment. These data are represented graphically in Figure B-3 and tabulated in Table B-1 on page B-9.

Figure B-3. UGS Historical South Arm Salinity Range by 2-foot WSE Increments



B.2 2012 UPRR/USGS Model Salinity Range

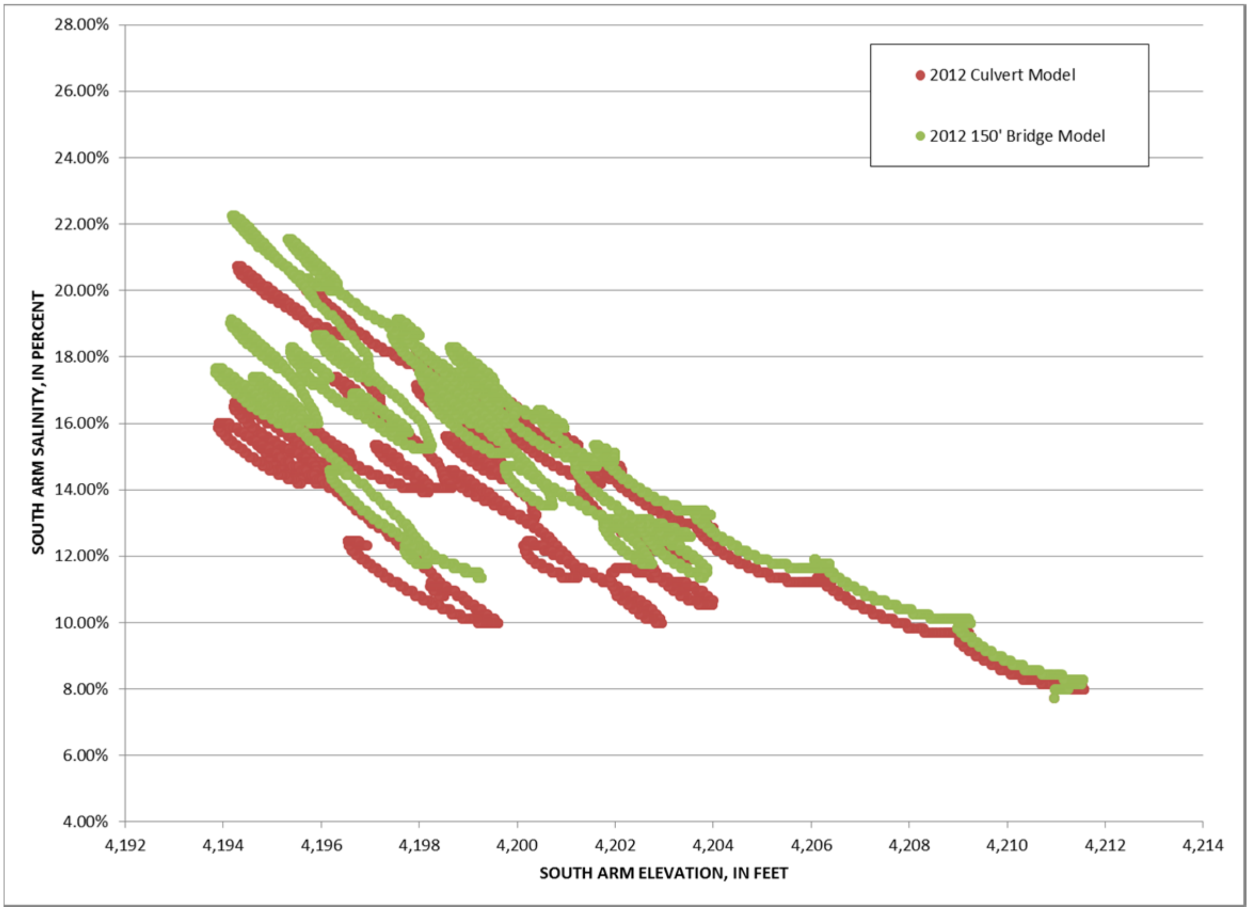
B.2.1 Introduction

UPRR will use the 2012 UPRR/USGS Model results to define the salinity range for this project (UPRR 2012a). The 2012 UPRR/USGS Model simulates lake salinities for the actual inflows and evaporation rates during the period of 1987 to 2012. The two simulations described in the Bridge Evaluation Report (UPRR 2014b)—free-flowing culverts and 150-foot-long opening with an invert at 4,183 feet—will be used. The model salinity results will be plotted against the model WSE computed as a result of the documented inflows, estimated evaporation rates, and computed transfers between the two lake arms. In addition, a standard error will be applied to the model results to represent the model uncertainties and accuracies. The development of the standard error is discussed in this appendix.

B.2.2 2012 UPPR/USGS Model Simulation Salinity Data

The 2012 UPRR/USGS Model simulations produced computed South Arm salinities for lake conditions represented by actual data for the period of 1987 to 2012. These computed salinities for the culvert simulation and 150-foot-long causeway opening simulations were presented in the Bridge Evaluation Report and are shown in Figure B-4. The figure illustrates computed South Arm salinities, for each simulation, plotted against the South Arm WSE for the period of 1987 to 2012.

Figure B-4. 2012 UPPR/USGS Model Simulation Salinity Data



B.2.3 USGS Documented Model Sensitivity and Error Analysis

The 2012 UPRR/USGS Model was developed for the UPRR Great Salt Lake Culvert Closure and Bridge Construction Project to respond to requests from regulating agencies for a project impacts evaluation that would be conducted for varying lake WSEs and varying lake hydrology influences. The development of the 2012 UPRR/USGS Model (UPRR 2014a) adds to and recalibrates the water and salt balance model developed by USGS and documented in Water-Resources Investigation Report 00-4221 (WRI 4221), *Water and Salt Balance of Great Salt lake, Utah, and Simulation of Water and Salt Movement through the Causeway, 1987–98* (USGS 2000).

USGS documented sensitivity, uncertainty, and error associated with the 1998 USGS Model for various model routines and computations (USGS 2000). These are summarized below.

- Water balance
  - Measured surface inflows contributed about 70 percent, and estimated inflows based on watershed correlations contributed about 30 percent, of the total surface inflows to the lake. The measured inflows had a 10 percent error and the estimated inflows had an error of about 20 percent. Thus, the composite error of the total surface inflow was determined to be about 13 percent. Because this error is compounded during the period of the model, USGS estimates that the 1998 WSE of about 4,203 feet would rise about 4 feet or fall about 4.5 feet with an increase or decrease of the surface inflows of 13%, respectively (USGS 2000, Figure A4).
  - Precipitation error was identified as 10%, resulting in about a 2.5-foot effect (higher and lower) on the WSE (USGS 2000, Figure A6).
  - Groundwater error was identified as 100%, with about a 2-foot effect (higher and lower) on the WSE (USGS 2000, Figure A6).
  - Accounting for all errors on surface water inflows, precipitation, groundwater, and evaporation, the WSE varied from a rise of about 7.5 feet to a drop of about 10 feet from the measured WSE of about 4,203 feet (USGS 2000, Figure A7).
  - This subroutine was calibrated by annual adjustments to the evaporation, averaging 4%, with a range of –6% to +8%. Application of a 10% evaporation error resulted in the WSE varying from a rise of about 6 feet to a drop of about 8 feet from the measured WSE of about 4,203 feet (USGS 2000, Figure A10).

USGS then applied the maximum and minimum error from all sources of inflow and outflow to generate a resulting rise and fall in WSE. For the 1998 USGS Model, the greatest variation in WSE occurred from about 1990 to 1992, with about a 2-foot rise and fall. However, at the end of the model period 1998, the model-computed WSE nearly matched the measured WSE (USGS 2000, Figure A11).

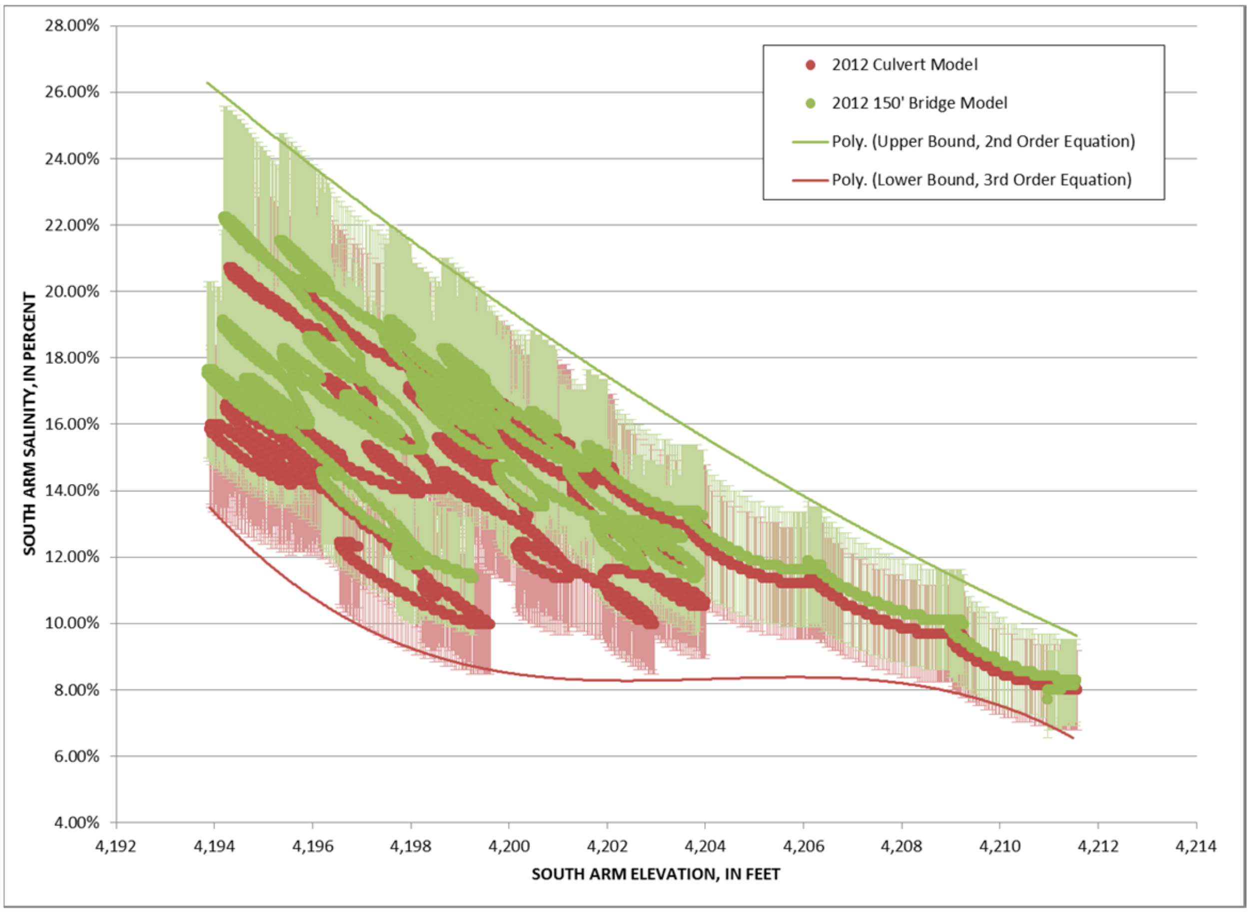
- Water and salt transfer through the causeway
  - Transfer through the causeway fill is most sensitive to the fill hydraulic conductivity parameter. During 1987 to 1998, fill flow averaged 611 acre-feet per day, compared to a theoretical computed value of 501 acre-feet per day, which is a 21% reduction from the model computations. The model-computed fill flow varied the most from the calculation during the rapidly changing WSE experienced during 1987 to 1991.
  - Flows through the culvert and existing 300-foot-long bridge were estimated as:
    - South-to-north breach flow: 30%
    - North-to-south breach flow: 116%
    - South-to-north culvert flows during 1980–1983: 13%
    - North-to-south culvert flows during 1980–1983: 62%
- Salt balance model
  - After calibration of the 1998 USGS Model, the maximum difference, comparing model-computed parameters to measured data, resulted in:
    - 0.9-foot head difference
    - 0.008-g/mL (grams per milliliter) density difference
    - 0.220-BT (billion tons) precipitated North Arm salt load difference

USGS then applied the flow errors in relation to a change in the breach invert required to match South Arm salinity. Application of these errors resulted in the following changes in breach invert elevations:

- South-to-north breach flow varied by 30%
  - Decrease in breach flow would result in a raise in the invert from 4,195 feet to 4,196 feet
  - Increase in breach flow would result in a lowering of the invert from 4,195 feet to 4,193.5 feet
- North-to-south breach flow varied by 116%
  - Decrease in breach flow would result in a raise in the invert from 4,195 feet to 4,196 feet
  - Increase in breach flow would result in a lowering of the invert from 4,195 feet to 4,192.5 feet

Taking these factors into consideration, UPRR determined that a 15% error associated with the model salinity data is appropriate Figure B-5 illustrates the 2012 UPRR/USGS Model simulation South Arm salinity range, including a 15% error, for use on this project.

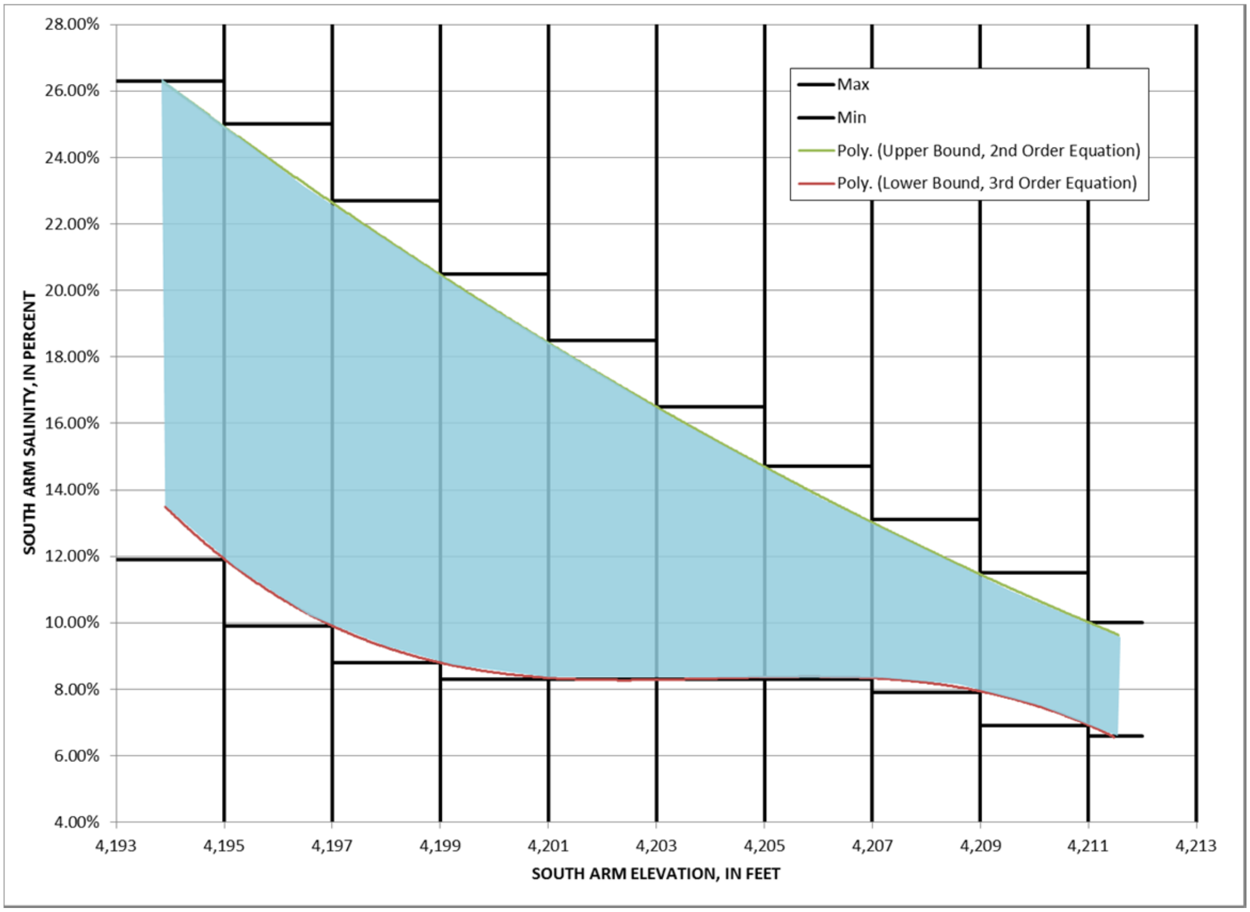
Figure B-5. 2012 UPRR/USGS Model Simulation South Arm Salinity Range Including 15% Error



B.2.4 2012 UPRR/USGS Model Salinity Range Results

UPRR then applied the model salinity range and calculated the range for each 2-foot South Arm WSE increment. This data is represented graphically in Figure B-6 and tabulated in Table B-1 on page B-9.

Figure B-6. 2012 UPRR/USGS Model South Arm Salinity Range by 2-foot WSE Increments



B.3 Historical and 2012 UPRR/USGS Model Salinity Range Results

Table B-1 presents the data in Figure B-3, UGS Historical South Arm Salinity Range by 2-foot WSE Increments, and Figure B-6, 2012 UPRR/USGS Model South Arm Salinity Range by 2-foot WSE Increments, in a table format.

Table B-1. Summary of South Arm Historical and Model Salinity Ranges by WSE

South Arm WSE (feet)		South Arm Salinity Range (%)			
		UGS Historical 1966–2011		2012 UPRR/USGS Model Simulation	
Lower	Upper	Minimum	Maximum	Minimum	Maximum
4,193	4,195	13.0	23.9	11.9	26.3
4,195	4,197	10.7	21.4	9.9	25.0
4,197	4,199	9.0	18.6	8.8	22.7
4,199	4,201	7.6	16.2	8.3	20.5
4,201	4,203	6.7	14.2	8.3	18.5
4,203	4,205	6.3	12.5	8.3	16.5
4,205	4,207	6.2	11.2	8.3	14.7
4,207	4,209	6.3	10.3	7.9	13.1
4,209	4,211	6.7	9.8	6.9	11.5
4,211	—	7.6	9.6	6.6	10.0

B.4 References

[UGS] Utah Geological Survey

2012 Great Salt Lake Brine Chemistry Database, 1966–2011.

2014 Personal communication between Andrew Rupke, UGS, and Karen Nichols, HDR, regarding laboratory density and TDS concentration analysis and associated precision. July 25.

[UPRR] Union Pacific Railroad

2014a Final Water and Salt Balance Modeling Report – Modeling Steps 1, 2, and 3. Prepared for the Union Pacific Railroad Great Salt Lake Causeway Culvert Closure and Bridge Construction Project. April 4.

2014b Bridge Evaluation Report. Prepared for the Union Pacific Railroad Great Salt Lake Causeway Culvert Closure and Bridge Construction Project. June 2.

[USGS] U.S. Geological Survey

2000 Water and Salt Balance of Great Salt Lake, Utah, and Simulation of Water and Salt Movement through the Causeway, 1987–98. Water-Resources Investigation Report 00-4221.