BUREAU OF RECLAMATION

Longley Meadows Fish Habitat Enhancement Project – Floodplain Hydraulic Analysis

Upper Grande Ronde River, Oregon

U.S. Department of the Interior

March 2020

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Longley Meadow Fish Habitat Enhancement Project Technical Memorandum No. 1

Upper Grande Ronde River, Oregon

prepared by

Columbia-Pacific Northwest Regional Office

River Systems Restoration Group, PN-3100

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Cover Photo: Longley Meadows (Grande Ronde Model Watershed/C. Stone)

Revisions

Date	Description	Prepared	Checked	Technical Approval	Peer Review

Contents

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Executive Summary

The purpose of this memorandum is to satisfy Union County floodplain development permit requirements for the Longley Meadows Fish Habitat improvement project. The intent of the Longley Meadows Fish Habitat improvement project is to restore processes to the Grande Ronde River through the project reach that lead to improved habitat conditions for ESA-listed salmonids. A central goal for this project is to improve natural river-floodplain connectivity within this uninhabited reach of the Grande Ronde River, which will support flood improvements to the Grande Ronde River downstream of the project area.

The project is located in an Approximate Zone A mapped area (Union County FIS, 1978). A two-dimensional USACE HEC-RAS model was utilized to develop an existing conditions base flood elevation (BFE) profile for the project reach. The detailed hydraulic study for this project results in a base flood area that is significantly smaller than the existing FEMA Approximate Zone A. The HEC-RAS model was then applied to proposed conditions and compared. Results indicate the Longley Meadows project will not raise the BFE more than one foot (maximum rise of 0.8-feet within project).

The Longley Meadows Fish Habitat improvement project is largely an earthwork project and consists of 42,000 cubic yards of excavation and fill within the project area (all currently mapped in the Approximate Zone A floodplain). Existing native materials within the floodplain are to be re-worked. Excavation will take place through the project area to create new river channels and floodplain depressions. Excavated materials will be utilized to fill portions of existing channels and as surplus topographic features located outside of existing 100-year flood elevations. No excavated native material will be removed from the project area and only a limited amount of locally-sourced alluvial rock will be imported to the project area.

Quantities are as follows:

- 42,000 CY Excavation (re-worked within the project area)
- 900 CY alluvial rock imported

The primary purpose of the Longley Meadows Fish Habitat Restoration Project is to provide benefits to fish and wildlife. Additional benefits will include more frequent activation of the existing floodplain that is moderately disconnected through historic anthropogenic actions along with a greater potential to store and retain ice during break-up. The result will be a more functional floodplain that provides improved flood conditions on the Grande Ronde River downstream.

Introduction

This memorandum analyzes the potential flood impacts associated with the Longley Meadow Fish Habitat Enhancement Project (project) sponsored by The Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The land within the project area is owned by the U.S. Forest Service (USFS) and the La Grande Rifle and Pistol Club (La Grande Gun Club). The project includes restoration of approximately 1.5 miles of the Grande Ronde River. Under current conditions the floodplain is not activated on an annual basis as the river is overly widened and/or incised due to long term impacts from anthropogenic disturbances. The long-term rehabilitation vision (CTUIR's River Vision) for the project is to improve physical and ecological processes by rehabilitating and restoring the project area to achieve immediate and long-term benefits to spring-summer Chinook salmon, summer steelhead, bull trout, and resident fishery resources at all life stages.

Benefits to salmonids will be achieved through restoration and rehabilitation of the whole floodplain ecosystem. Targeting of present and specific limiting factors such as temperature will achieve immediate benefits to salmon. Long-term benefits will be realized through a focus on restoring fluvial habitat-forming processes, floodplain and groundwater hyporheic connectivity, riparian and wetland plant communities, and instream complexity and diversity commensurate with the reach's natural potential.

The project consists of a large amount of earthwork which will be accomplished by re-working the xisting native materials within the floodplain. Excavation will take place through the project area to create new river channels and floodplain depressions. Excavated materials will be utilized to fill portions of existing channels and as surplus topographic features located outside of existing 100-year flood elevations. No excavated native material will be removed from the project area and only a limited amount of rock will be imported to the project area. Quantities are as follows:

- 42,000 CY Excavation (re-worked within the project area)
- 900 CY imported rock

It is understood from conversations with Union County staff and CTUIR that a memorandum addressing the 1-ft maximum rise, materials imported and/or exported on the project site and establishing BFEs are required to be provided to the County. This memorandum will address analysis of potential flood impacts related to the project.

Location

The project is located in eastern Oregon west of the City of La Grande just west of Highway 244 between river miles (RM) 143.6 and 142.0 of the Grande Ronde River (GRR) (Figure 1). s

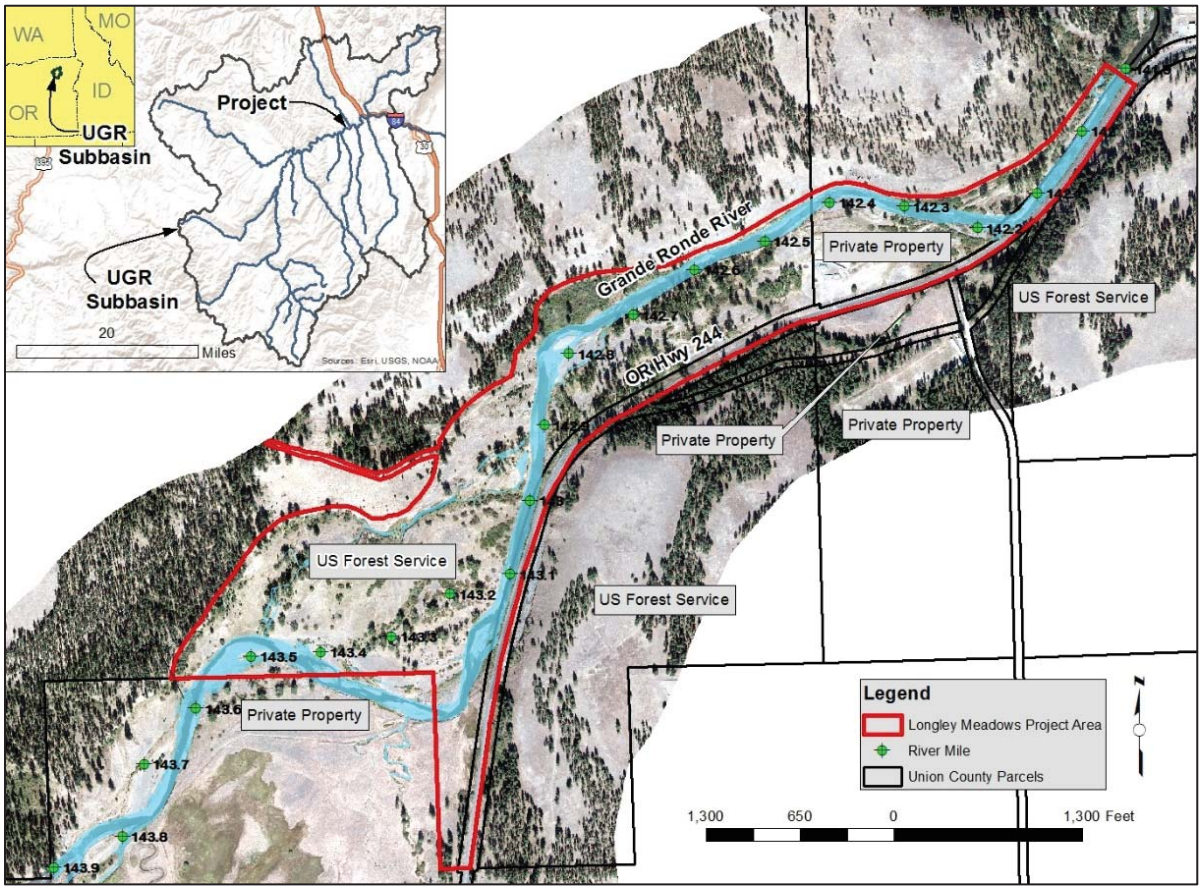

Figure 1**| Longley Meadows Fish Habitat Enhancement Project Area (Note: lower project area boundary has been reduced to RM 142.2)**

Authority

The U.S. Bureau of Reclamation (Reclamation) and Bonneville Power Administration (BPA) contribute to the implementation of salmonid habitat improvement projects in the Grande Ronde Subbasin to help meet commitments contained in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) (National Oceanic and Atmospheric Administration [NOAA] Fisheries 2008) and the 2010 and 2014 Supplemental BiOps (NOAA Fisheries 2010, 2014). This BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions to protect salmon and steelhead listed under the Endangered Species Act (ESA) across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments and follow the requirements of the NOAA and U.S. Fish and Wildlife Service [USFWS] BiOp as outlined under BPA's Habitat Improvement Program III (HIP III, version 4.0). Reclamation provides technical assistance to identify, prioritize, develop, design, and implement sustainable fish habitat improvement projects and to help focus those projects on

addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the ESA.

Project Partners

CTUIR and USFS have a vested interest in achieving and maintaining high-quality ecological conditions for aquatic species along the Upper Grande Ronde (UGR). To assist in achieving this goal, CTUIR and USFS have partnered with Reclamation's Environmental Services and the River Systems Restoration Group to develop designs for the project on the UGR. Table 1 below lists the individuals and organizations collaborating on the project.

Table 1| **Names and Titles of Sponsors and Organizations Collaborating on the Project**

Name	Entity	Role/Responsibility
Allen Childs	CTUIR	Project Sponsor, Habitat Biology, Project Management, Implementation
Bill Gamble	USFS	Wallowa-Whitman National Forest District Ranger, Cooperative Landowner, Permitting
Sarah Brandy	USFS	Wallowa-Whitman National Forest District Fish Biologist, Project Liaison
Jeff Peterson	Reclamation	Environmental Services Habitat Program Manager
Darrell Dyke	Reclamation	Subbasin Liaison, La Grande
Al Simpson	Reclamation	Subbasin Liaison, La Grande
Mike Knutson, P.E.	Reclamation	Technical Oversight
Justin Nielsen, P.E.	Reclamation	Lead Design Engineer
Julie Bryant, P.E.	Reclamation	Hydraulic Model, Design Team
Brian Drake, P.E.	Reclamation	Project Manager
Cardno, Inc.	Cardno	Reclamation Consultant: Design Support, Large Woody Material (LWM) Design, Permitting, Construction Engineering Support

Site Description and Project Summary

The project site consists of a broad unconfined floodplain in the upper portion of the project site and a moderately confined floodplain in the lower portion of the site. The river is relatively disconnected from the floodplain as a result of a legacy of anthropogenic disturbances including splash damming and simplification of the channel (removal of wood) resulting in a low number of pools and channel diversity. This reach was targeted for restoration as part of a basin wide assessment of existing physical conditions and biological importance for salmonids. This reach ranked highly for the potential for improvement of physical processes that benefit salmonids with low risk to existing infrastructure and private property.

The project site contains multiple anthropogenic features including Highway 244, which includes reaches of riprapped bank adjacent to the Grande Ronde River (GRR), Mount Emily historic railroad grade and associated borrow ditches, various structures and berms that encompass the La

Grande Gun Club, and electric power lines. Riprapped banks along Highway 244 are currently armoring the road prism and will remain in place per communications with Oregon Department of Transportation (ODOT) to provide highway protection. Though the riprap is to remain in place, placement of native fill material against the riprap is acceptable. Fill may be placed in several areas to move the river away from the highway, effectively burying the riprap in place and promoting a natural vegetated bankline away from the highway. A few sections of the historic railroad grade impede floodplain interaction while others currently protect Highway 244 from flooding. The project has three areas which are to be used if excess fill is generated. Two of the fill areas are located along the highway. The third location would enhance an existing shooting berm thus protecting potential public users from target shooting.

Benefits to salmonids will be achieved through restoration and rehabilitation of the whole floodplain ecosystem for the project site reach of approximately 1.5-miles of the Grande Ronde River. Targeting of present and specific limiting factors such as temperature will achieve immediate benefits to salmon. Long-term benefits will be realized through a focus on restoring fluvial habitat-forming processes, floodplain and groundwater hyporheic connectivity, riparian and wetland plant communities, and instream complexity and diversity commensurate with the reach's natural potential.

Primary project features include:

- Sections of main channel Grande Ronde River realignment and fill of existing main channel Grande Ronde River alignment;
- Construction of riffles that mimic natural features;
- Construction of gravel bar features;
- Construction of channel banks;
- Excavation, placement and compaction of native fill material;
- Construction of a network of side channels and connections to existing off-channel features including swales, remnant channel scars, and low areas to create side channels and ponds;
- Engineered Log Jams (e.g., meander jams, channel-spanning jams, apex jams, small wood placement acting similarly to beaver dams, channel margin jams, and deflector jams);
- Individual large wood habitat pieces (e.g., sweepers, floodplain roughness);
- Bioengineered bank treatments; and
- Creation and enhancement of alcoves and oxbows.

FEMA Designation

The Longley Meadows Fish Habitat Enhancement project is located within an Approximate Zone A as indicated in the FIRM Panel 275 0f 675 community panel number 410216 0275 B, provided by FEMA. Given that the project area falls within an Approximate Zone A, there is no existing base flood elevation (BFE) for the project area.

It should be noted that the FEMA Approximate Zone A on panel 275 0f 675 for the project area extends to the east of Hwy 244. Hydraulic modeling was completed for the project using HEC-RAS 5.0.7 for both the existing and proposed conditions. Model results indicate that there is no highway overtopping at the 100-year flood which is further demonstrated below. Aerial drone footage from recent floods, spring of 2019 and winter of 2020, indicate that water ponds on the east side of the highway (not river side) at the base of ephemeral draws. This flooding is presumably the result of undersized culverts not capable of passing hillslope drainage and not water from the mainstem river.

Hydrology

An extensive hydrologic investigation was performed as part of the basis of design for this project and for the Bird Track Springs Fish Habitat Enhancement project located upstream. A brief summary of the investigation is detailed below.

The project reach sits at approximately 3,080-foot elevation and drains an approximately 474-square-mile (mi^2) watershed extending to a maximum elevation of 7,923 feet. The mean annual precipitation is 26.2 inches, most of which falls as snow during winter months. As a result, the annual hydrograph is dominated by snowmelt-derived high flows from April to May. Peak flows also occasionally occur from winter rainstorms. The low flow season typically extends from August through December. Most of the basin is forested (over 73%) and has very little development (less than 0.1% estimated impervious area) (USGS 2014). Watershed characteristics of key points(Figure 2) along the mainstem GRR are shown in Table 2.

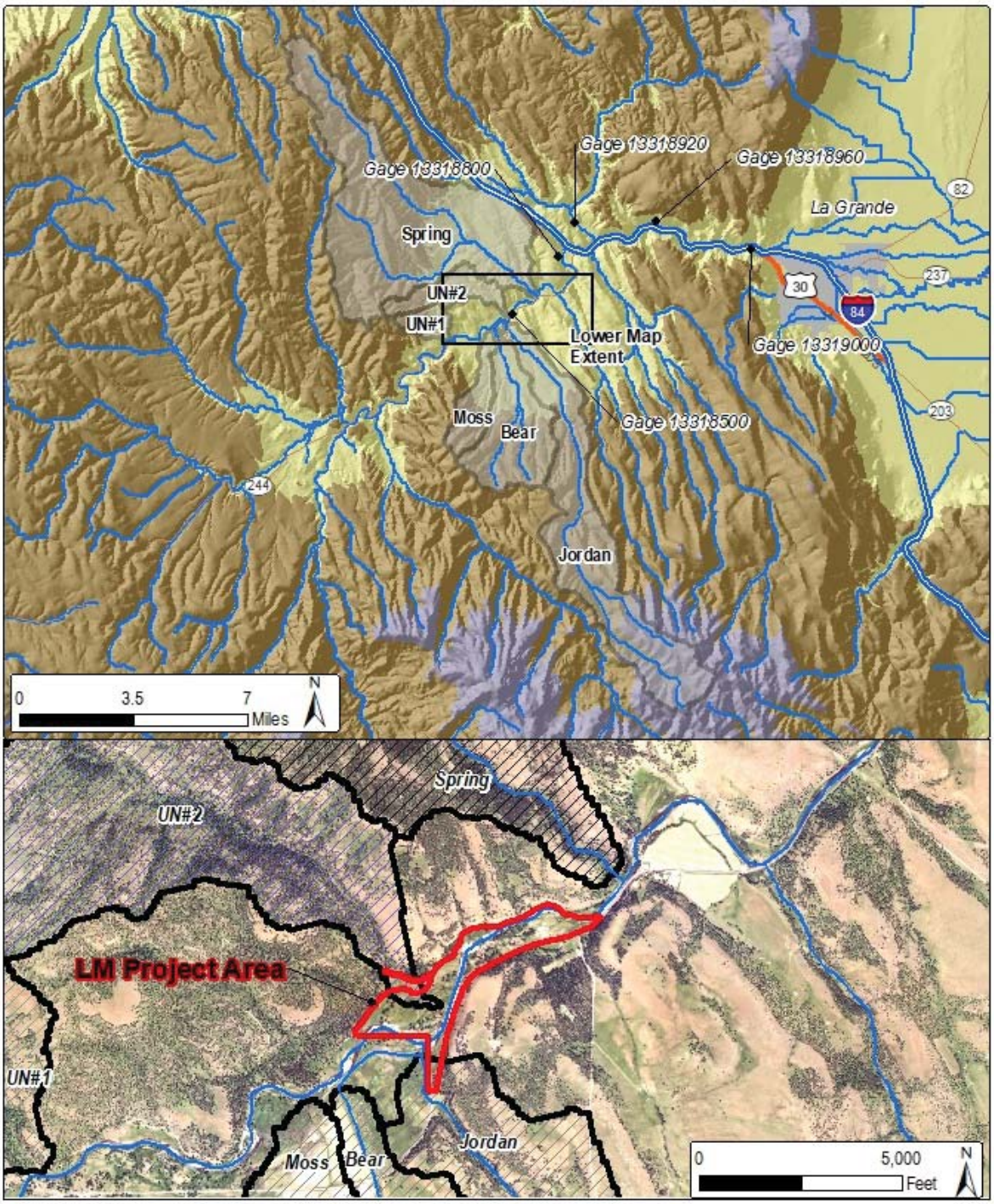

Figure 2| **Key Watershed Characteristics along the Mainstem GRR**

Three tributary streams enter the project area from adjacent valley walls. Figure 2 shows the project reach and the watersheds of Jordan Creek entering from the south (river right), and Spring Creek and an unnamed tributary entering from the north (river left). None of the three tributary streams have stream gaging records. A summary of the general attributes of the tributary basins is provided in Table 2. Despite its small drainage area, the unnamed tributary (Unnamed Tributary 2) was included in the analysis to provide a full picture of possible flow inputs along the project reach.

Table 2 **|Watershed Characteristics of Key GRR Mainstem Sites and Tributaries Contributing to the Project Reach**

Watershed Outlet Description	River Mile	Drainage Area (mi^2)	Outlet Elevation (feet)	Maximum Elevation (feet)	Mean Annual Precipitation (inches)
Mainstem Grande Ronde					
Upper Project Reach Boundary	143.6	474.0	3,080	7,923	26.4
Historic Stream Gage Location (13318500)	142.9	495.7	3,060	7,923	26.2
Lower Project Reach Boundary	141.9	525	3,050	7,923	26.3
Tributary Outlets					
Jordan Creek (enters right)	143.3	17.7	3,078	6,057	26.0
Unnamed Tributary 2 (enters left)	143.1	2.8	3,074	4,352	23.0
Spring Creek (enters left)	141.95	26.6	3,050	4,650	27.3

Stream gages used in the analysis are listed in Table 3 below.

Table 3**| Stream Gages in the Grande Ronde River Basin Used in the Hydrologic Analysis**

Station Number	Name	Agency	River Mile	Drainage Area (mi^2)	Start Year	End Year
13319000	Grande Ronde R at La Grande, OR	USGS	132	686	1903	1989
13318960	Grande Ronde R Near Perry, OR	OWRD	135.9	677	1997	Current
13318920	Five Points Cr at Hilgard, OR	OWRD	137.7	71.9	1992	Current
13318800	Grande Ronde R at Hilgard, OR	USGS	139.3	544	1966	1981
13318500*	Grande Ronde R Near Hilgard, OR*	USGS	142.9	495.7	1937	1956

*Historical gage 13318500 is located within the project reach.

OWRD = Oregon Water Resources Department

A summary of the peak return interval discharges for the upstream end of the project area as well as the three contributing tributaries is provided in Table 4 below. The predicted discharges were used for modeling and design. Based on the minimal flow contribution, Unnamed Tributary 2 was not used in the modeling effort. This resulted in a 100-year flow of 7,811 cfs at the downstream end of the project. Per the flood insurance study performed for Union County the 100-year flood at the Grande Ronde River in La Grande is 10,095 cfs. Multiple tributaries converge with the Grande

Ronde between the lower end of the project including but not limited to Whiskey Creek, Rock Creek, and Five Points Creek.

Table 4| **Longley Meadows Project - Annual Peak Flows Used for Hydraulic Modeling Efforts**

Annual Probability	Annual Return Interval	Q – Grande Ronde River (RM 143.6) (cfs)	Q – Jordan Creek (cfs)	Q – Unnamed Tributary 2 (cfs)	Q – Spring Creek (cfs)
0.5	2	2,113	90	22	122
0.2	5	3,210	148	37	200
0.1	10	4,025	190	48	257
0.04	25	5,153	245	62	332
0.02	50	6,062	288	73	389
0.01*	100	7,031	332	85	448
*Base Flood (100-year return interval)					

Recent and Historic Floods

Recent floods include a significant event in April of 2019 which was approximately a 20- to 50-year recurrence. Additionally, there was another significant flood event in February of 2020. This most recent event caused extensive damage regionally with the majority of damage occurring on the west side of the Blue Mountains. Locally near the project, this event caused significant flooding to perennial and ephemeral drainages blocking culverts which then caused floods to overtop the highway. Both of these recent events are attributed to rain on snow.

Significant floods that occurred in Union County were recorded in March of 1931, March of 1932, May of 1956, January of 1965, March of 1972, February of 1986, January of 1997, May of 2011 and March of 2014. The flood of record occurred on January 30th, 1965 having a recurrence interval greater than the 50-year event in the Grande Ronde River basin.

Methodology

The USACE HEC-RAS 5.0.7 two-dimensional (2D) hydraulic modeling was utilized for the project design and for this hydraulic analysis. The project Basis of Design Report contains a detailed summary of the analysis. A brief summary of the hydraulic analysis is below.

An existing conditions model was developed and calibrated using available flood data to ensure it accurately represents inundation limits. Then the existing channel and floodplain topography were modified using Autodesk Civil3d to create proposed channels and to enhance existing channels to achieve the desired habitat uplift detailed in the project goals and objectives. The proposed topography was then modeled to determine the response for a range of annual and peak flows. This process was repeated iteratively until the desired habitat uplift was achieved without negative impacts to property and infrastructure.

Modeling results from the project design were utilized to evaluate the existing and proposed hydraulics on the floodplain at the 100-year reoccurrence flood (base flood) in this analysis. The sections below describe the key elements used to generate and calibrate the existing and proposed conditions model.

Topographic Survey and Site Reconnaissance

The existing topographic surface was developed with a combination of the resources below:

- Watershed Science, Inc. LiDAR (April 9-10, 2013) - Hillslopes and areas beyond floodplain
- Anderson Perry & Associates topographic survey (August 2014) – Floodplain and existing channels
- Reclamation ancillary topographic survey (June 2018) – Floodplain areas not surveyed by Anderson Perry & Associates
- Reclamation ancillary topographic survey (September and October 2019) – Dynamic areas changed significantly by high flows

Survey data through the project area are approximately 4- to 5-years old. There was a significant high flow event in April of 2019, approximately a 20-50-year flood. Banklines in dynamic areas retreated more than10 feet and significant bar growth (sediment deposition) in several areas occurred. In general, the floodplains remained largely intact although there are areas within floodplain channels where localized erosion/head cutting occurred. Key areas of noticeable change as a result of high flows, channel realignment, and connections to upstream and downstream existing channel sections were resurveyed in the Fall of 2019 by Reclamation. Elevations were spot checked and compared with the existing surface to verify accuracy.

Hydraulics

Impacts of restoration actions on the hydrologic condition within the Project have been investigated using the 2D USACE HEC-RAS 5.0.7 hydraulic model developed as part of the project design process. The 2D HEC-RAS model solves the Saint-Venant equations for fluid flow within the two-dimensional (X,Y) mesh. Fluid flow in the vertical (Z) direction is not calculated but assumed to be negligible. Hydraulic parameters are calculated by balancing conservation of momentum and conservation of mass through the boundaries of each element of the 2D mesh, which is generated from the mesh overlain on site topography and bathymetry. The model extents are illustrated in Figure 3 and Figure 4 for the existing and proposed conditions below.

Boundary Conditions and Model Calibration

The model for both the existing and proposed design conditions each have four boundary conditions as depicted in Figure 3 and Figure 4 by red lines on the edge of the 2D mesh. Starting at the upstream end (southwest end) of the project and moving downstream the boundary conditions are as follows: Upstream GRR, Jordan Creek, Spring Creek, and Downstream GRR. The Upstream GRR, Jordan Creek, and Spring Creek boundaries all utilized simulated unsteady flow hydrographs extrapolated from the annual peak flows provided in Table 4. The Downstream GRR boundary

condition is set with using normal depth and initial stage. The normal depth is pulled from the surface in the vicinity of the downstream boundary condition which is used to estimate the energy slope.

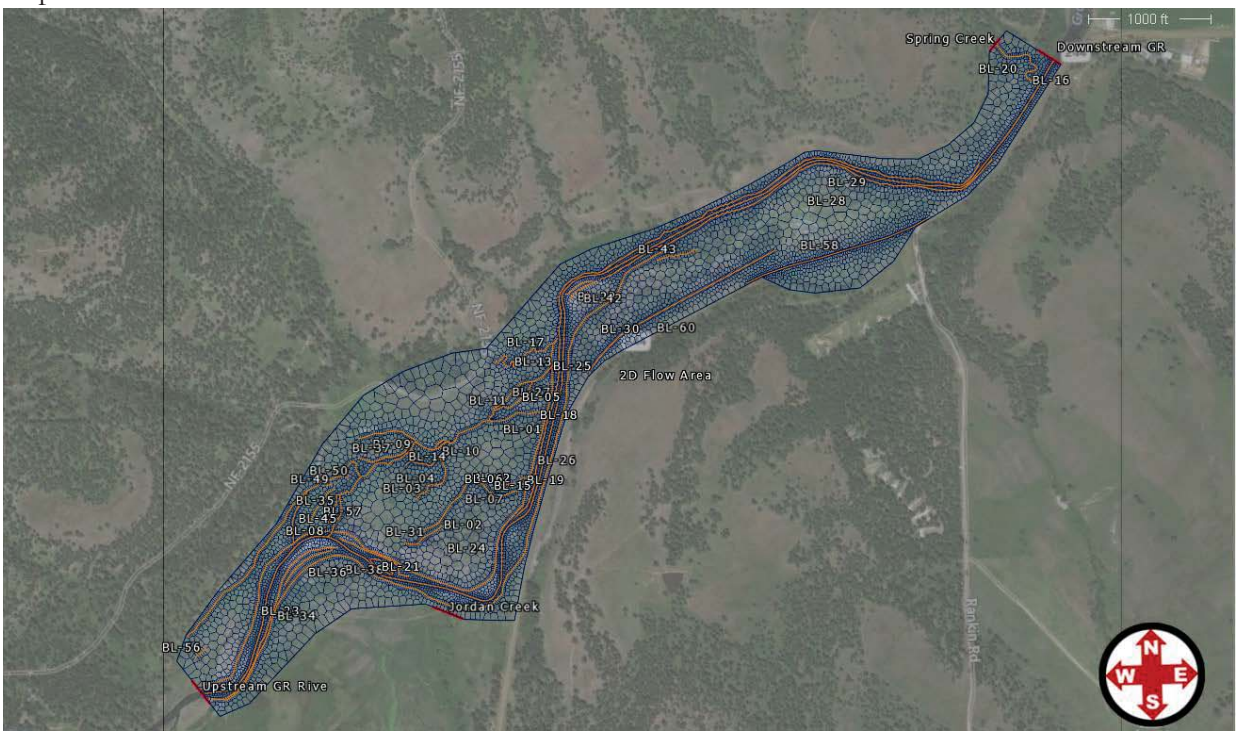

Figure 3| **Existing Conditions Breaklines, Adaptive 2D Mesh & 2D Model Boundary**

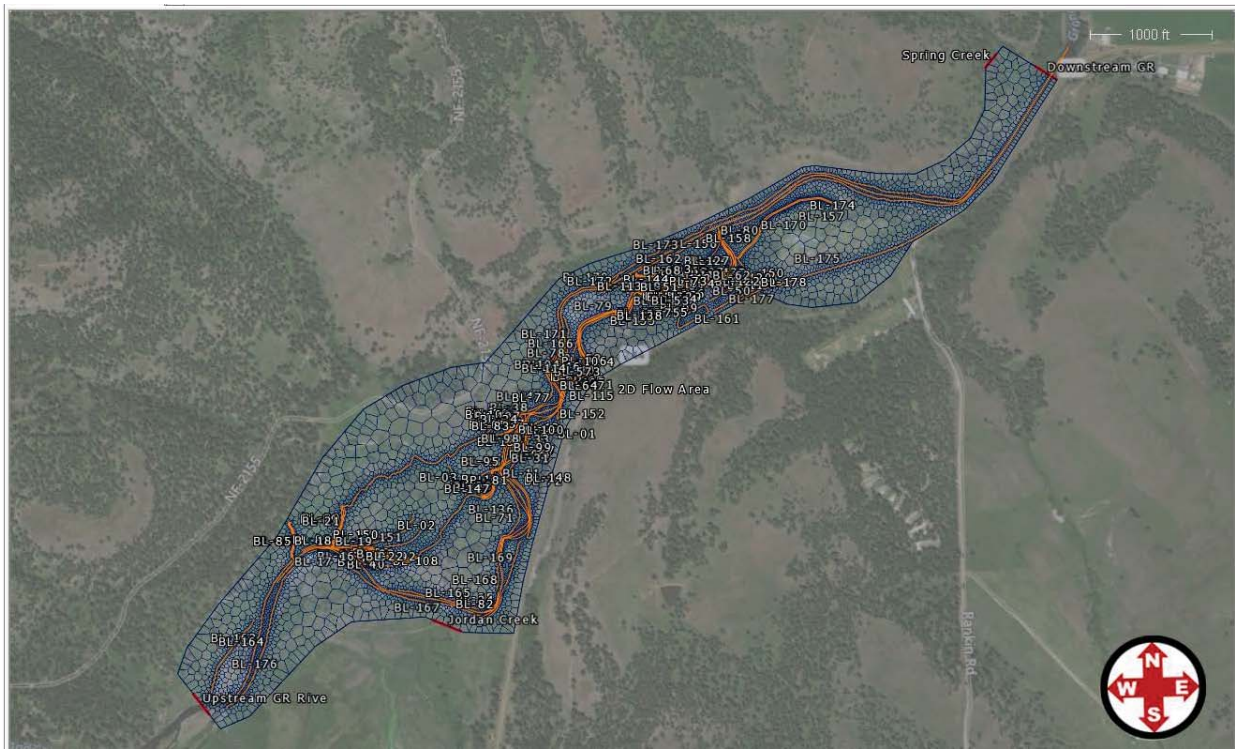

Figure 4| **Proposed Conditions Breaklines, Adaptive 2D Mesh & 2D Model Boundary**

Calibration of the 2D HEC-RAS Model was performed utilizing the wetted boundary during the April 9-10, 2013 LiDAR data collection flight which corresponds to a flowrate of 792 cfs. The model was also calibrated with an existing condition Sediment and River Hydraulics 2D model using the wetted boundary, performed by the Reclamation's Technical Service Center which provided modeling for Birdtrack Springs, Bear Creek Ranch, and Longley Meadows.

The third form of calibration utilized drone footage from February 18th, 2016 performed by the Grande Ronde Model Watershed. The gage near Perry at the time of the footage showed a flow of 2,200 cfs, which corresponds to approximately 1,408 cfs or roughly the bankfull flow (1481 cfs) for the project site. For calibration a visual comparison of the inundation was performed. Figure 5 below captures the flows at the second bend of the project moving downstream. Based on the comparison the inundation limits produced by the model correlate well with the drone footage for this area.

Figure 5| **Drone Footage and Existing Condition Calibration at Bend 2**

Similarly, drone footage for bend 3 (see Figure 6 below) compared to the model results for the bankfull flow correlates well.

Figure 6| **Drone Footage and Existing Condition Calibration at Bend 3**

Using multiple methods to calibrate the model has added validity to the existing conditions model. As a result of recent flood events and the model's proven accuracy in predicting the outcome of those flood conditions, the design team has a high level of confidence in the model's ability to predict inundation limits, depths, and velocities for both existing and proposed conditions.

100-Year Flood Simulations

Since the project area is located in a FEMA Approximate Zone A no base flood elevations (BFEs) were previously established. Therefore, the calibrated existing conditions 2D hydraulic model was used to establish the existing BFEs for the project.

Per the Guide for Approximate Zone A Areas (FEMA 1995) and considering the extensive length of the project, the BFE varies from the upstream end to the downstream end by more than 1 foot. As such, a BFE was determined every 500 feet along the existing GRR centerline, which resulted in 19 different BFEs along the length of the project reach. The BFE at each cross-section at 500-ft intervals through the project reach is provided in NAVD88 vertical datum in Table 5 below.

Table 5| **Existing Base Flood Elevations for the Project Area**

Grande Ronde River Centerline Stationing	Existing Base Flood Elevation (NAVD88)
100+00	3086.5
105+00	3085.1
110+00	3082.6
115+00	3081.4
120+00	3079.2
125+00	3077.9
130+00	3076.8
135+00	3075.4
140+00	3073.9
145+00	3072.4

Grande Ronde River Centerline Stationing	Existing Base Flood Elevation (NAVD88)
150+00	3071.4
155+00	3069.5
160+00	3067.9
165+00	3065.4
170+00	3064.3
175+00	3062.5
180+00	3061.4
185+00	3060.3
190+00	3058.9

Results

Existing vs Proposed Inundation

The 100-year inundation area for the existing conditions is approximately 152.6 acres. Refer to the left image of Figure 7 and Figure 8 for the existing conditions inundation area. The 100-year inundation for the proposed conditions is approximately 153.3 acres. Refer to the right image of Figure 7 and Figure 8 for the proposed condition inundation limits. Each figure has a red circle highlighting the main area of change when comparing the existing and proposed conditions.

There is a slight net increase for the proposed condition of approximately 0.5% inundation area for the 100-year recurrence interval. This slight increase could be attributed to model error though changes in the inundation area exist. As seen from both Figure 7 and Figure 8 it is apparent that significant changes due not occur in the vicinity of existing infrastructure including private property upstream and downstream, and that relatively minor changes occur on the upper floodplain on USFS land (Figure 7). Additionally, no noticeable increase in flooding occurs along the highway/floodplain interface.

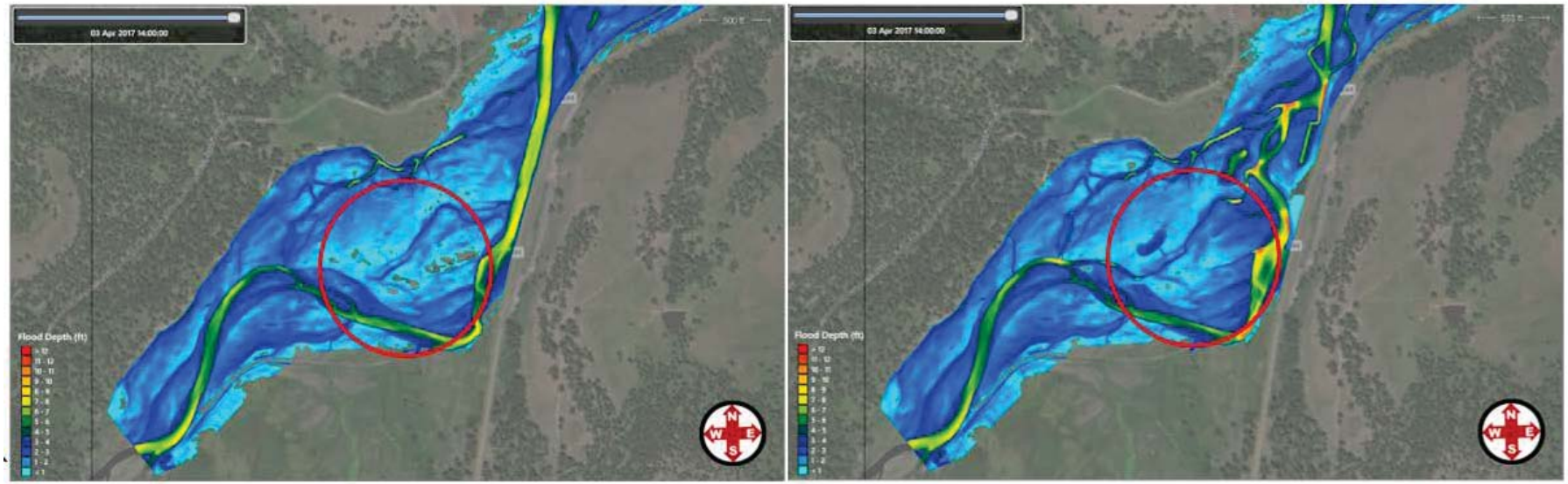

Figure 7| Existing & Proposed Conditions 100-Year Inundation Limits for the Upper Floodplain

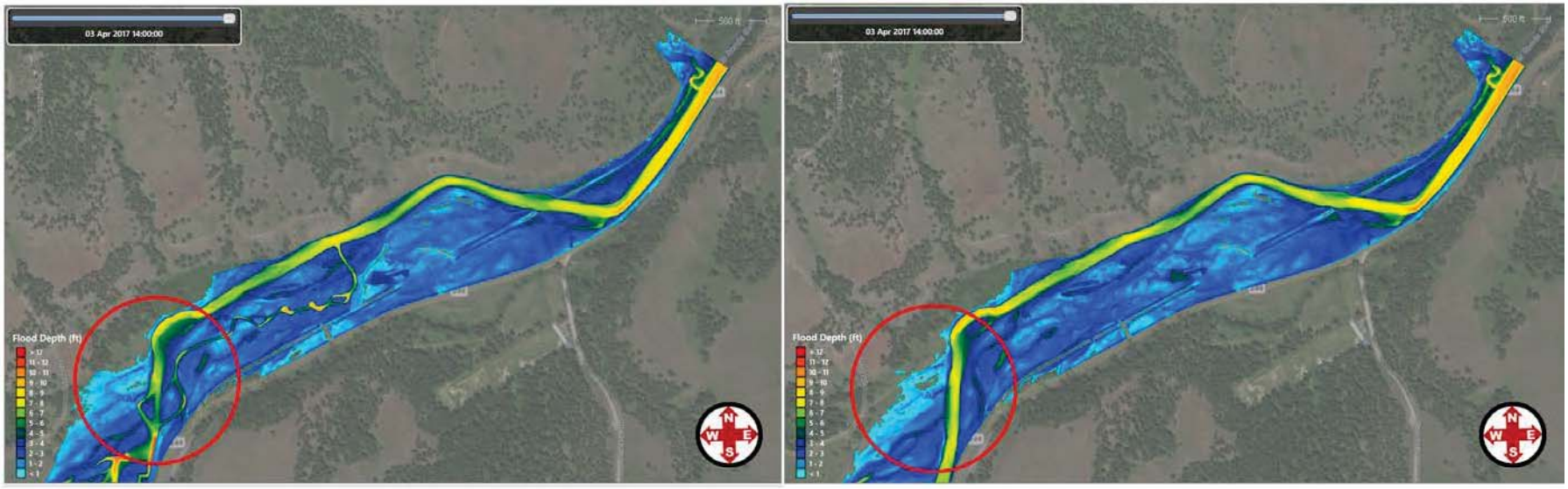

Figure 8| **Existing & Proposed Conditions 100-Year Inundation Limits for the Lower Floodplain**

Existing vs Proposed BFEs

To determine the impacts of the project on BFEs the same cross sections were used with the proposed 100-year water surface elevation to determine the new BFEs. Refer to Table 6 below for a comparison of proposed and existing BFEs. From the summary provided in Table 6 changes in BFE range from a decrease of -0.2 feet to an increase of 0.8-feet increase in BFE. A comparison of existing and proposed BFEs is also represented graphically in Figure 9 below. The major changes in BFE occur in the middle of the project on USFS land and are less than 1-foot. The water surface elevations appear to attenuate to existing conditions on both the upstream and downstream ends of the project. From this it can be concluded that no measurable changes will occur to the private property upstream or downstream of the project.

Table 6| **Proposed and Existing Base Flood Elevations for the Project Area**

Grande Ronde River Centerline Stationing	Proposed Flood Elevation (NAVD88)	Existing Base Flood Elevation (NAVD88)	Increase in Flood Elevation (ft)
100+00	3086.50	3086.5	0
105+00	3085.0	3085.1	-0.1
110+00	3082.4	3082.6	-0.2
115+00	3081.3	3081.4	-0.1
120+00	3079.2	3079.2	0
125+00	3078.7	3077.9	0.8
130+00	3077.6	3076.8	0.8
135+00	3075.7	3075.4	0.3
140+00	3074.3	3073.9	0.4
145+00	3072.2	3072.4	-0.2
150+00	3071.3	3071.4	-0.1
155+00	3069.4	3069.5	-0.1
160+00	3068.3	3067.9	0.4
165+00	3065.5	3065.4	0.1
170+00	3064.6	3064.3	0.3
175+00	3062.6	3062.5	0.1
180+00	3061.3	3061.4	-0.1
185+00	3060.4	3060.3	0.1
190+00	3059.0	3058.9	0.1

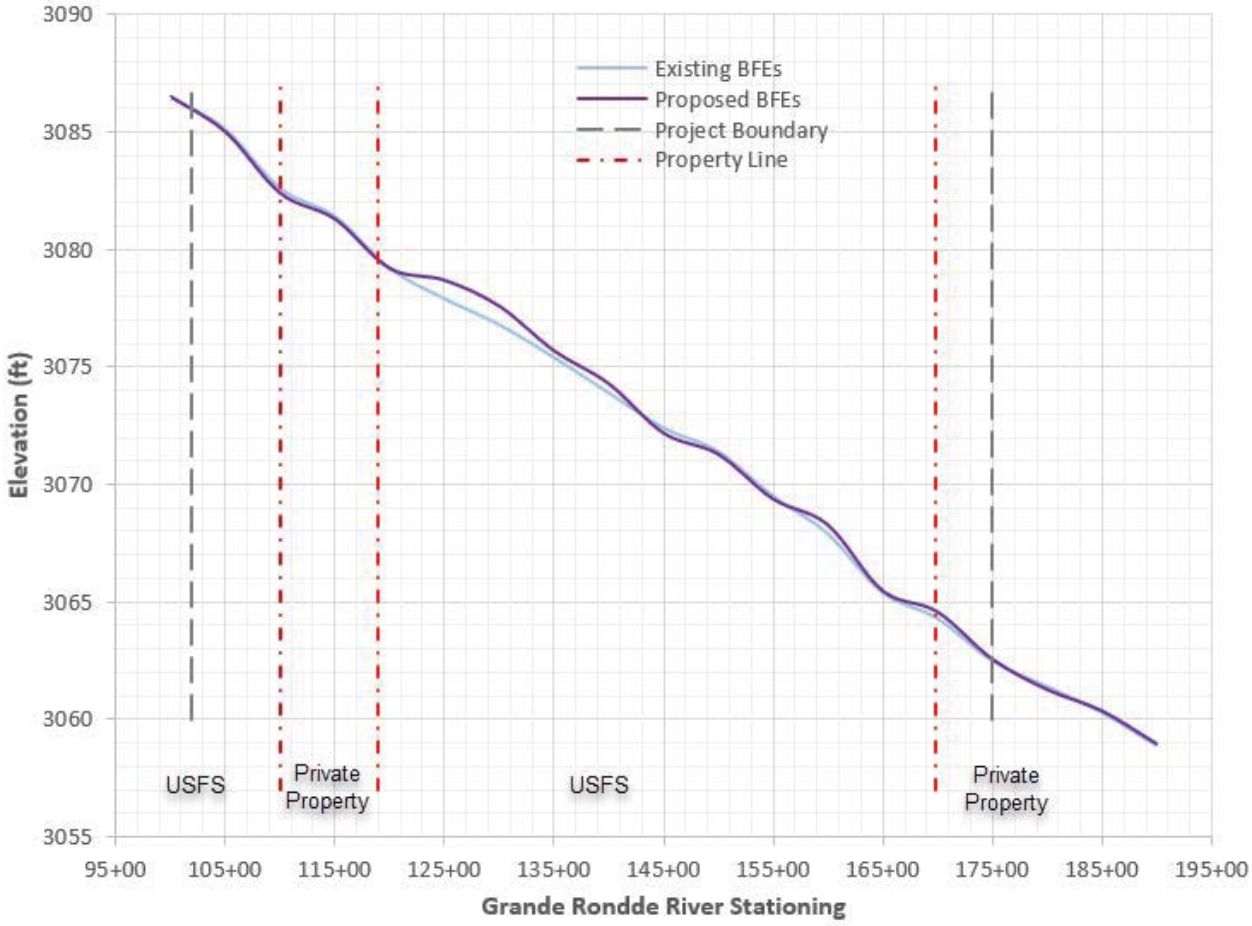

Figure 9| **Existing and Proposed Base Flood Elevations**

Conclusion

While changes to the patterns and depths of inundation within the site are expected as the result of project goals and objectives to increase the frequency of floodplain activation to promote physical processes that benefit salmonids, minimal changes occur at the 100-year flood occurrence. Based on the model results the flood elevations at the upstream and downstream ends of the project, which correspond to sections 102+00 and 175+00 respectively, are both within the model accuracy tolerance of the existing BFE. Additionally, the model results show less than 1-foot rise in any given BFE within the project site.

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References

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