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Meadow Creek Restoration Alternatives Analysis and Conceptual Design Report

PREPARED FOR

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Acronyms

°C	degrees Celsius
District	San Luis Obispo County Flood Control and Water Conservation District
DO	dissolved oxygen
°F	degrees Fahrenheit
ft	foot or feet
HDPE	high-density polyethylene
in.	inch or inches
lb/ft^2	pound per square foot
mg/L	milligrams per liter
NAVD 88	North American Vertical Datum of 1988
sec	second or seconds
sq ft	square feet
SRG	self-regulating gate
SSLOC	South San Luis Obispo County Sanitation District
WSE	water surface elevation

1 INTRODUCTION

1.1 Background

Stillwater Sciences was retained by the San Luis Obispo County Flood Control and Water Conservation District (District) to develop and evaluate alternatives to increase habitat for the growth and survival of smolt and rearing juvenile steelhead (*Oncorhynchus mykiss*) and to generally enhance and protect wildlife and fisheries habitat in Lower Meadow Creek and Arroyo Grande lagoons (project). The lagoons also provide habitat for two other federally listed species: California red-legged frog (*Rana draytonii*) and tidewater goby (*Eucyclogobius newberryi*). The project is a requirement of a Jeopardy Biological Opinion (BO) issued by the National Marine Fisheries Service (NMFS) for the Arroyo Grande Creek Waterway Management Program. The Jeopardy BO includes requirements for implementation of three Reasonable and Prudent Alternatives (RPAs) that would avoid the (1) likelihood of jeopardizing the continued existence of or (2) destruction or adverse modification of critical habitat for the federally threatened South–Central California Coast Distinct Population Segment of steelhead. The District has completed rehabilitation of natural geomorphic conditions and steelhead habitat conditions in accordance with RPA sub-element 1(a), and 2(b) and 2(c). This project will implement RPA sub-element 3(a).

Consistent with sub-element 3(a), the project goals are as follows:

1. Enhance conditions for juvenile steelhead in degraded habitat, including but not limited to increasing habitat complexity, discernible flow, deep-water refugia, and riparian banks for shading;
2. Increase the hydrologic connectivity between Lower Meadow Creek and Arroyo Grande lagoons; and
3. Ensure the project does not exacerbate existing flooding conditions in surrounding developed areas.

1.2 Alternatives Formulation

Restoration planning and design work associated with this project to date includes a data review and gaps analysis (Stillwater Sciences 2022, Appendix E) and the characterization of existing conditions (Stillwater Sciences 2022). These work products have been reviewed and feedback has been provided by a Science Panel which consists of representatives from the National Marine Fisheries Service (NMFS), California State Parks, the San Luis Obispo Coastal Resources Conservation District, Creek Lands Conservation (501(c)3 non-profit), the U.S. Army Corps of Engineers, and the South San Luis Obispo County Sanitation District (SSLOCSD). This report builds upon that work and presents five restoration alternatives. Specifically, this report presents five preliminary alternatives (Section 2) and detailed hydraulic, sediment transport, and habitat analysis of two alternatives selected for more detailed analysis (Section 3), as well as detailed analysis, description, and 30% designs for a final selected alternative.

2 CONCEPTUAL RESTORATION ALTERNATIVES (1-5)

2.1 Site Overview

Lower Meadow Creek and Arroyo Grande lagoons are located in the coastal community of Oceano, California, where the downstream extent of Lower Meadow Creek Lagoon meets Arroyo Grande Lagoon before draining to the Pacific Ocean (Figure 1). The project area, per RPA3, includes 8.3 acres of Lower Meadow Creek Lagoon and surrounding uplands areas. The larger study area (outlined by the black box in Figure 1) was evaluated in the existing conditions report (Stillwater Sciences 2022). Five alternatives were developed within the study area (Figure 2) including three alternatives encompassing Lower Meadow Creek Lagoon, (Alternatives 1 to 3), one alternative encompassing Lower Arroyo Grande Creek and Lagoon (Alternative 4) and one alternative improving the connection between Lower and Upper Meadow Creek lagoons (Alternative 5).

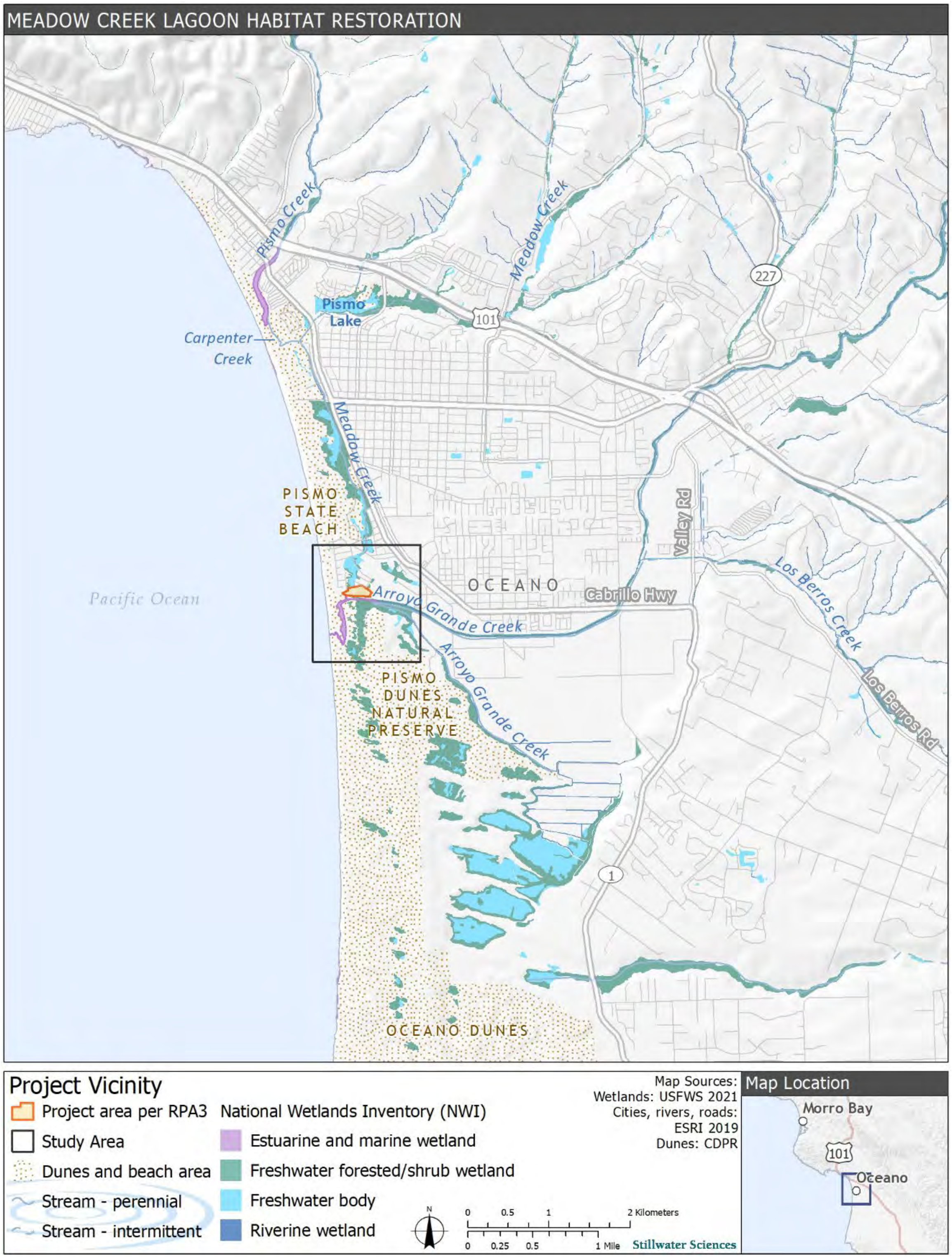


Figure 1. Project vicinity and original project area per RPA3.

2.2 Site Description

Appendix A presents a base map of the project and the immediate surrounding area. The base map shows existing infrastructure, general alignments of Lower Meadow Creek and Arroyo Grande Creek, and property boundaries. The terrain data were derived from a combination of an aerial survey (Central Coast Aerial Mapping 2021) and bathymetric surveys (Cannon 2012a, 2017) to characterize the overland topography and lagoon bathymetry, respectively. In the project area, Arroyo Grande Creek is a linear channel constrained between earthen levees with riprap protection along both toes of the channel. The terminus of the northern levee extends across the former confluence of Lower Meadow Creek and Arroyo Grande Creek, separating Lower Meadow Creek Lagoon to the north of the levee and Arroyo Grande Lagoon to south of the levee (Appendix A).

Lower Meadow Creek and Arroyo Grande lagoons are joined via the Sand Canyon outlet structure (Appendix A), which consists of two arch-pipe culverts approximately 48 inches (in.) wide by 71 in. tall in cross section and 65 feet (ft) in length. Based on the bathymetry survey data (Cannon 2012a,b), the invert elevations of the two flap gates are 6.44 ft and 6.46 ft North American Vertical Datum of 1988 (NAVD 88) on the inlet side (Lower Meadow Creek Lagoon); and 5.36 ft and 5.83 ft NAVD 88 on the outlet side (Arroyo Grande Lagoon). The inlets of the culverts are equipped with a trash rack. At the outlet of each culvert are iron flap gates (Hydrogate Model 50C or similar) that prevent high flows in Arroyo Grande Lagoon, as well as high tides in the Pacific Ocean, from flowing into Lower Meadow Creek Lagoon. A manually operated winch system is installed to allow opening and closing of the flap gates as needed (e.g., monthly inspection) (Coastal San Luis Resource Conservation District 2013, ESA PWA 2013). When the flap gates are not manually operated, a small differential pressure on the back of the gates causes them to open automatically, allowing water to drain from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon. When the water level on the downstream side of the gates exceeds the water level on the upstream side, the gates close automatically.

Approximate alignments of subsurface and overhead utilities within or near the project area are based on data provided by the District and are shown in Appendix A. A shallow 36-in.-diameter asbestos-bonded corrugated-metal pipe ocean outfall runs along the north side of Arroyo Grande Creek levee. The centerline of the ocean outfall is indicated to be 8 ft away from the northern toe of the levee. Although the SSLOCSD (1979, 1997) estimated the cover along Lower Meadow Creek Lagoon to be between 1 to 2 ft below ground, further investigation by the District in 2022 found the outfall is at or near the ground surface in some locations. According to SSLOC, the outfall is operated mostly as a gravity line but becomes pressurized under rare circumstances when high-flow events are combined with storm surges at the outlet.

Just outside the project area, a buried 10-in.-diameter high-density polyethylene (HDPE) waterline crosses Lower Meadow Creek Lagoon between Maui Circle and Utah Avenue (i.e., around STA 3+30 of the Lower Meadow Creek alignment, shown in Appendix A). The deepest section of the waterline is indicated to be approximately 10 ft below the Lower Meadow Creek Lagoon flowline (Terra Verde 2018). In the same alignment, there is also an abandoned 8-in.-diameter asbestos-cement pipe waterline that remained in place when the 10-in.-diamter HDPE waterline was installed. The depth of the abandoned 8-in.-diameter waterline is waterline is unknown, thus a typical cover of 3 ft will be assumed for conceptual design purposes.

Figure 2. Project study area.

2.3 Conceptual Restoration Alternatives

Three alternatives that focus on Lower Meadow Creek Lagoon were developed (Alternatives 1 through 3). In addition, an alternative for Arroyo Grande Lagoon (Alternative 4) and an alternative improving the hydrological connection between Lower and Upper Meadow Creek lagoons (Alternative 5) were developed.

2.3.1 Alternative 1: Lower Meadow Creek restoration with setback levee and outfall modification

Alternative 1 includes a levee setback, removing 1,000 ft of levee, modifying the existing SSLOCSD outfall profile, and widening the connection between Lower Meadow Creek and Arroyo Grande lagoons at the existing Sand Canyon outlet structure (Figure 3) to improve hydrologic and habitat connectivity. The SSLOCSD outfall modifications that were considered included either lowering the pipe in place or relocating the pipe, both of which would require conversion from a gravity-fed to a pumped system. This alternative also includes restoring steelhead rearing habitat by excavating pools, excavating channels, and increasing habitat complexity using engineered wood habitat structures. This alternative was not advanced further because: (1) The outfall is operated primarily as a gravity line by SSLOCSD, which precludes the outfall from being buried deeper or relocated (Appendix B, *SSLOC Letter*) unless it is fully converted to a pumped system. Converting the outfall to a pumped system was evaluated but was removed from consideration because of substantial construction and operation costs and the need to negotiate responsibilities between the District and SSLOCSD. And (2) The modeling of the levee setback for the 2- to 10-year flood resulted in a small, but consistent, incremental increase rise in flood water elevations over existing conditions (Appendix C). Even greater increases in flood water elevations are expected under larger magnitude storms (e.g., 100-year flood).

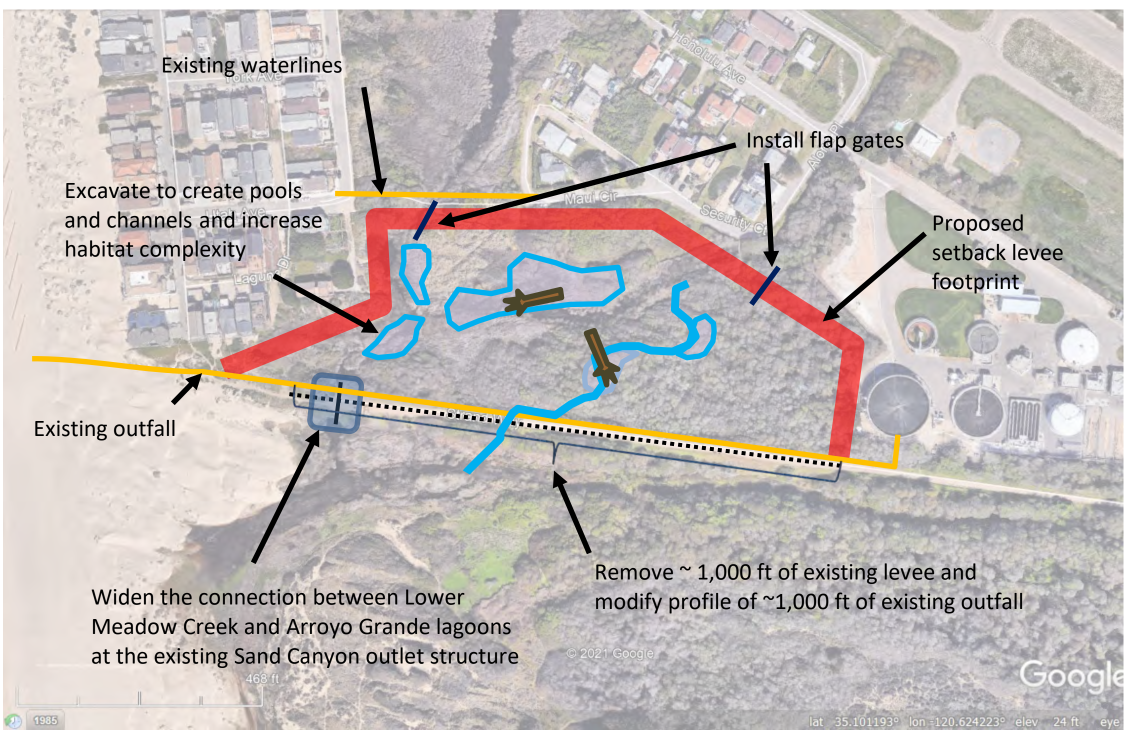


Figure 3. Alternative 1: Lower Meadow Creek Lagoon restoration with levee setback and outfall modification.

2.3.2 Alternative 2: Lower Meadow Creek restoration with setback levee and outfall protection

Alternative 2 includes a levee setback, removing 1,000 ft of levee, protecting the existing SSLOCSD outfall in place, and widening the connection between Lower Meadow Creek and Arroyo Grande lagoons at the existing Sand Canyon outlet structure (Figure 4) to improve hydrologic and habitat connectivity. This alternative also includes restoring steelhead rearing habitat by excavating pools, excavating channels, and increasing habitat complexity with engineered wood habitat structures. This alternative was not advanced further for several reasons: (1) the presence of the shallowly-buried outfall would limit open hydrologic exchange between Lower Meadow Creek and Arroyo Grande lagoons as envisioned under RPA 3; (2) removal of the levee would expose the outfall to increased scour from Arroyo Grande Creek, and protective armoring of the outfall which would further limit opportunities for open exchange between the lagoons would be required, (3) removing the levee would increase the scour risk to this outfall even if it was armored with rock, posing a long-term maintenance concern for SSLOCSD (Appendix B, *SSLOC Letter*), and (4) the modeling of the levee set-back for the 2- to 10-year flood resulted in a small, but consistent, incremental increase rise in flood water elevations (Appendix C). Even greater increases in flood water elevations are expected under larger magnitude storms (e.g., 100-year flood).

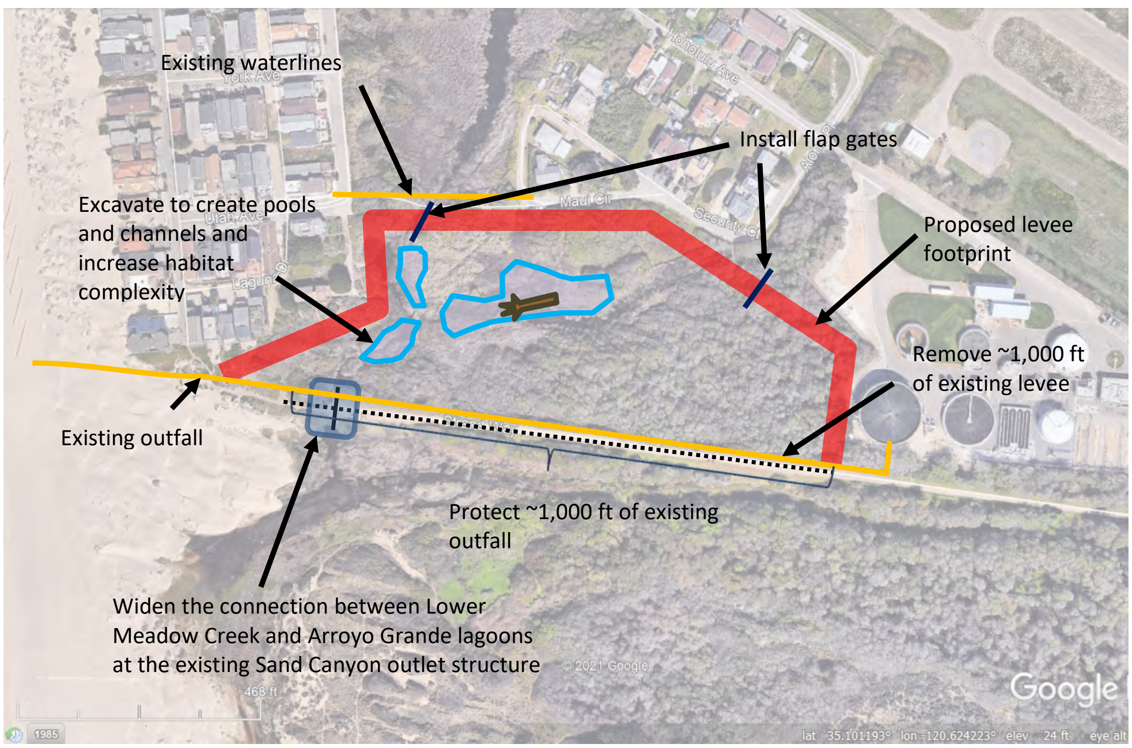


Figure 4. Alternative 2: Lower Meadow Creek Lagoon restoration with levee setback and outfall protection.

2.3.3 Alternative 3: Lower Meadow Lagoon restoration and gate modification

Alternative 3 includes modifying the existing Sand Canyon outlet structure with a new gate(s) that improves hydrologic and habitat connectivity between Lower Meadow Creek and Arroyo Grande lagoons and restores steelhead rearing habitat by excavating pools, excavating channels, and increasing habitat complexity with engineered wood habitat structures in Lower Meadow Creek Lagoon (Figure 5). This alternative is not anticipated to increase the flood risk. Because this project was anticipated to meet all three project goals, it was selected as an alternative for further analysis and is evaluated in Section 3.

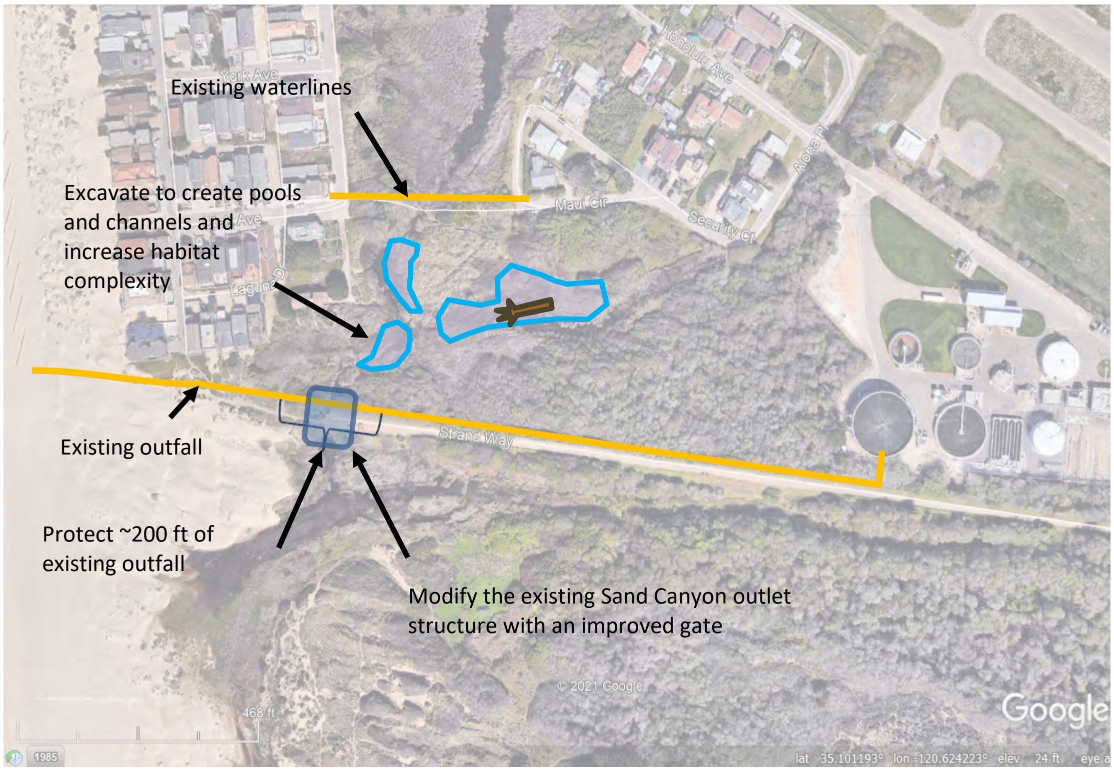


Figure 5. Alternative 3: Lower Meadow Creek Lagoon restoration with gate modification.

2.3.4 Alternative 4: Arroyo Grande Lagoon restoration

Alternative 4 includes restoring steelhead rearing habitat by excavating pools and excavating channels and increasing habitat complexity by placing engineered wood habitat structures in Arroyo Grande Lagoon (Figure 6). This alternative does not propose to improve connectivity between Lower Meadow Creek and Arroyo Grande lagoons. Nonetheless, this alternative provides potential habitat improvements and is not anticipated to increase the flood risk. As such, this alternative was selected as an alternative for further analysis and is evaluated in Section 3.

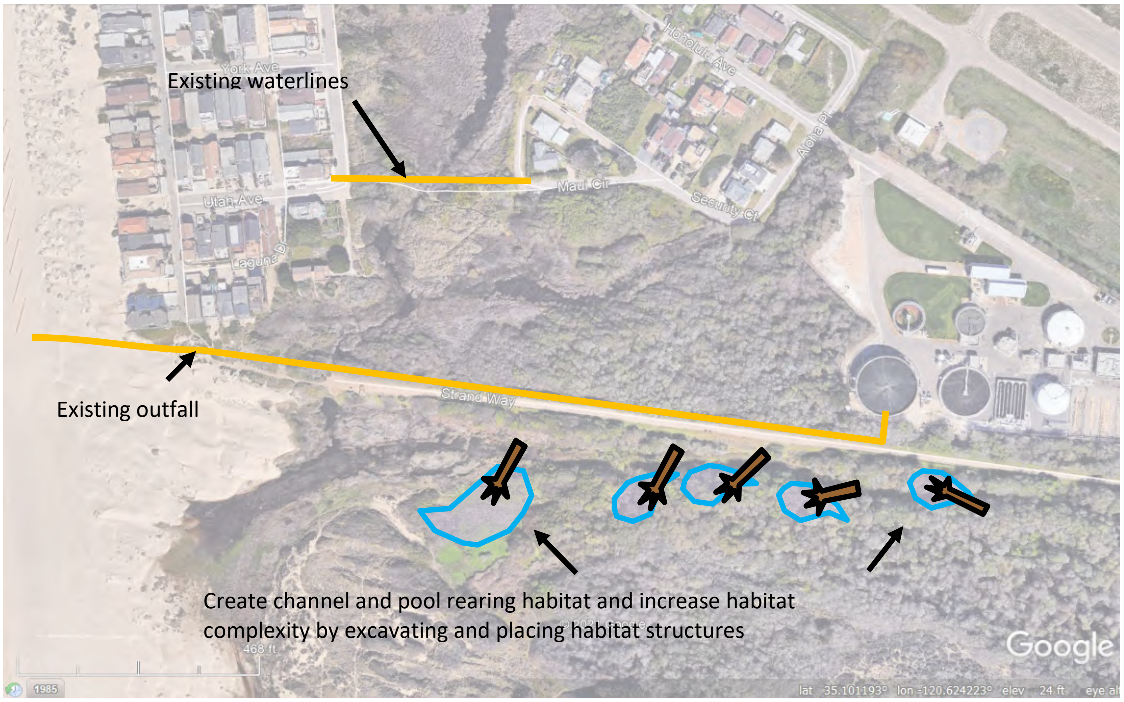


Figure 6. Alternative 4: Arroyo Grande Lagoon restoration.

2.3.5 Alternative 5: Improve connection between Lower and Upper Meadow Creek lagoons

Alternative 5 includes improving the connection between Lower and Upper Meadow Creek lagoons to improve hydrological and habitat connectivity between them (see Figure 2). Upper Meadow Creek Lagoon provides more than 10 acres of existing open water habitat with potentially suitable and deep-water refugia habitat for rearing steelhead. Under existing conditions, hydrological connection exists during flood events and to an extent during winter baseflow conditions. However, the connection is limited due to sediment and organic material accumulations. This alternative was not advanced further because of concerns about observed invasive species in Upper Meadow Creek Lagoon (particularly largemouth bass), which are documented predators of juvenile steelhead, and concerns regarding suitable water quality conditions for juvenile steelhead in Upper Meadow Creek Lagoon. This alternative also raised uncertainties regarding hydrologic effects on recreational warm-water fishery resources upstream (perennial pools bordering Air Park Drive and Pier Avenue) and potential resource conflicts. The District is currently monitoring water quality in Upper Meadow Creek Lagoon, primarily to inform potential future water quality conditions in a restored Lower Meadow Creek Lagoon (Alternative 3), but this information can also be used to evaluate Alternative 5 if this restoration concept were pursued in the future. These water quality data are summarized in Section 3.2.4.1.

3 SELECTED ALTERNATIVES (ALTERNATIVES 3 AND 4)

3.1 Criterion for Evaluation

Conceptual designs for Alternatives 3 and 4 were further developed to optimize the habitat conditions for juvenile steelhead and the hydrologic connectivity between Lower Meadow Creek and Arroyo Grande lagoons. Additionally, each alternative was evaluated for potential infrastructure considerations (e.g., flood risk, levee scour risk, and flap gate improvements) and other considerations (e.g., water quality conditions, biotic considerations, sediment transport/sedimentation, sea level rise, and construction costs).

3.1.1 Steelhead rearing habitat

Each alternative was developed to increase and enhance the amount of steelhead rearing habitat. Based on estuary habitat categories developed during a study of the existing conditions, the following specific steelhead rearing habitat criteria were developed to evaluate each alternative (Stillwater Sciences 2022):

- Suitable rearing habitat (water depths > 1.6 ft to 4.0 ft; water velocity < 1 ft/second [sec]),
- Deep water refugia (water depths > 4.0 ft and water velocity < 1 ft/sec),
- Cover (e.g., perimeter of riparian edges), and
- Habitat complexity (e.g., number of engineered wood habitat structures).

3.1.2 Hydrologic and habitat connectivity

Each alternative was developed and evaluated as appropriate to determine whether the proposed conditions under each alternative could improve the following:

- Fish movement, and
- Hydrologic exchange at lower flows.

3.1.3 Infrastructure considerations

The potential impact of each alternative on adjacent infrastructure was investigated as appropriate by evaluating the following:

- Flood risk,
- Levee scour risk, and
- Flap gate improvements.

3.1.4 Other considerations

Finally, a number of additional considerations were evaluated for each alternative:

- Water quality,
- Biotic considerations not listed above,
- Sediment transport and sedimentation,
- Sea level rise considerations, and
- Planning level construction costs.

3.2 Alternative 3: Lower Meadow Lagoon Restoration and Gate Replacement

Alternative 3 is designed to enhance existing steelhead and tidewater goby habitats and create access to additional areas of new habitat by grading pools and alcoves along the existing remnant Lower Meadow Creek Lagoon channels combined with engineered wood habitat structures and edge-water riparian and brackish marsh plantings. Alternative 3 includes replacing the existing Sand Canyon outlet structure flap gate(s) with a self-regulating gate(s) (SRG). The SRG would be designed to avoid increases in flooding in Lower Meadow Creek Lagoon, enhance hydrological exchange, and enhance fish movement between Lower Meadow Creek Lagoon and Arroyo Grande Lagoon. No structural changes (e.g., size or height) to the two culverts comprising the Sand Canyon outlet structure are proposed. The invert of the culverts cannot be lowered due to the presence of the shallowly-buried outfall as previously described. If this alternative is selected, additional hydraulic analysis to refine operational water levels and timing will occur at each future design phase. Conceptual designs for Alternative 3 shown in Figure 7 include a project footprint of 6.7 acres, an excavation footprint of 1.37 acres, a maximum excavation depth of 9 ft (used in modeling), and an excavation volume of 8,100 cubic yards.

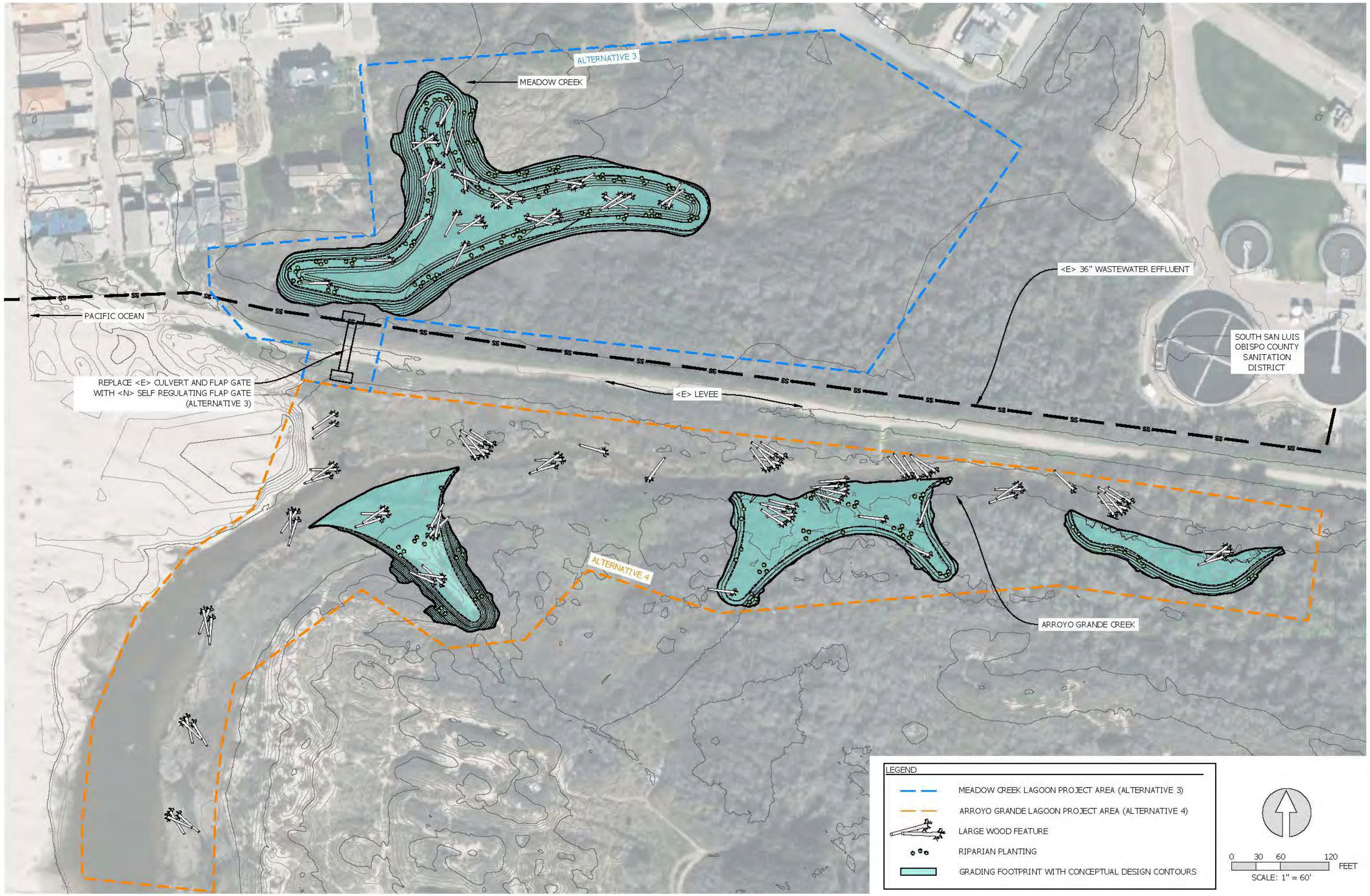


Figure 7. Conceptual designs for Alternative 3 (north of levee) and Alternative 4 (south of levee).

3.2.1 Steelhead rearing habitat

Stillwater Sciences conducted a habitat suitability analysis for both existing conditions and with-proposed project conditions under Alternative 3. The analysis used depth and velocity criteria developed for juvenile steelhead. Hydraulic modeling results were binned and overlapped to create area polygons for suitable rearing and deep-water refugia steelhead habitat. For each alternative, suitable habitat was compared to existing conditions to calculate the area of increased steelhead habitat to support comparison of alternatives and eventual selection of a preferred alternative.

Currently, the suitable steelhead rearing habitat in Lower Meadow Creek is estimated at approximately 36,119 square feet (sq ft) during typical winter baseflow conditions, but no deep-water refugia is available. In addition, Lower Meadow Creek Lagoon within the Alternative 3 project footprint currently lacks habitat complexity. The habitat improvements proposed under Alternative 3 would result in an increase to approximately 63,706 sq ft (76% increase) of suitable winter rearing habitat and 36,977 sq ft of deep-water refugia habitat in the winter (Figure 8, Table 1).

In summer under existing conditions approximately 3,619 sq ft of suitable rearing habitat are available, but no deep-water refugia is available. Alternative 3 would result in an increase to approximately 45,677 sq ft (>1,000% increase) of suitable summer rearing habitat. This area would not provide deep-water refugia (>4 ft depth of water) under typical summer conditions but could provide such habitat during more atypical, wetter summer conditions (Figure 9, Table 1). Proposed spring habitat conditions were also evaluated and would be similar to winter conditions. Alternative 3 would also create 520 linear ft of new riparian edge habitat under typical winter conditions and increase habitat complexity through the construction and placement of 16 engineered wood habitat structures (Table 1). The proposed engineered wood habitat structures under Alternative 3 would be designed to provide cover and complexity for juvenile steelhead. It is anticipated that because the water levels in Lower Meadow Creek Lagoon would fluctuate, the engineered wood habitat structures would be inundated at times, but at other times when the lagoon water surface elevation is low, some of the structures would be dry. Therefore, the engineered wood habitat structures are proposed to be placed at varying bed elevations to increase the probability that a portion of the project would consistently provide habitat function at different water surface elevation levels. In addition, structures would be designed to be as “tall” as possible so that as the water surface elevation (WSE) varies, a continuity of a habitat complexity and cover would remain. Further details pertaining to fish movement benefits are discussed in the next section (3.3.2 Hydrologic and habitat connectivity).

Table 1. Summary of evaluation criteria for Alternative 3 and 4. Habitat reported is based on juvenile steelhead criteria. Light blue shading indicates the alternative that best achieves each evaluated metric and light gray shading indicates metrics for which the alternatives have equal performance.

	Winter Suitable Habitat (sq ft)	Winter Deep-water Refugia (sq ft)	Summer Suitable Habitat (sq ft)	Summer Deep-water Refugia (sq ft)	Habitat Structures (#)	Riparian Perimeter (ft)	Hydrologic Exchange	Fish Movement*	Sediment Management	Flood Risk	Levee Scour Risk	Water Quality	Conceptual Constructio n Cost	Water Surface Elevation Increase Due to Sea Level Rise?**
Existing Conditions (EC): Lower Meadow Creek Lagoon	~36,119	~0	~3,619	~0	0	~840	None	Limited	Around SCOS	Yes	Limited	Poor to good	N/A	None
Alternative 3: Lower Meadow Creek Lagoon	~63,706	~36,977	~45,677	~0	16	~1,360	Improved during freshet or tidal exchange conditions	Improved	Around SCOS (unchanged from EC)	Yes (unchanged from EC)	Limited (unchanged from EC)	Some improvement but poor conditions would continue to exist in some seasons	$4,083,000	None (unchanged from EC)
Existing Conditions (EC): Arroyo Grande Lagoon	~5,197	~0	~921	~0	0	~2,500	Unrestricted	Unrestricted	Around SCOS	Yes	Yes	Good	N/A	Minor localized increases of 0.1 to 1.0 ft
Alternative 4: Arroyo Grande Lagoon	~42,140	~241	~2,091	~0	22	~2,960	Unrestricted (unchanged from EC)	Unrestricted (unchanged from EC)	Around SCOS (unchanged from EC)	Minor change	Yes (slightly reduced from EC)	Good (unchanged from EC)	$4,582,000	Minor localized increases of 0.1 to 1.0 ft

Notes: N/A = Not Apopplicable
SCOS = Sand Canyon Outlet Structure
* Includes movement of all fish including but not limited to juvenile steelhead and non-native species
*** Under the Medium-High Risk Aversion 2070 scenario with open outlet/inlet, high tide and a sea level rise of 3.3 ft.

Terrian Model	Area Square Feet	Percent Increase
Suitable Habitat		
Existing Conditions	36,119	76%
Proposed Conditions	63,706	
Deep Water Refugia		
Proposed Conditions	36,977	NA

Figure 8. Steelhead suitable rearing habitat, deep-water refugia, and total inundated area during winter baseflow conditions under Alternative 3.

Terrian Model	Area Square Feet	Percent Increase
Suitable Habitat		
Existing Conditions	3,619	1162%
Proposed Conditions	45,677	
Deep Water Refugia		
Proposed Conditions	0	NA

Figure 9. Steelhead suitable rearing habitat, deep-water refugia, and total inundated area during summer baseflow conditions under Alternative 3.

3.2.2 Hydrologic and habitat connectivity

Alternative 3 includes restoring habitat in Lower Meadow Creek Lagoon and replacing the existing iron flap gate(s) at the Sand Canyon outlet structure with a SRG system (see Section 3.2.3.3 for details). Flap gates are known to limit fish movement and reduce habitat connectivity especially when placed in tidal and muted tidal environments. In terms of hydrologic and habitat connectivity, the combination of proposed restored habitat in Lower Meadow Creek Lagoon and the installation of a SRG system is anticipated to:

- Provide restored habitat in Lower Meadow Creek Lagoon for fish to access during all hydrologic conditions when water depth in the Sand Canyon outlet structure culverts is sufficiently deep;
- Increase the duration of time during which fish can move between Arroyo Grande and Lower Meadow Creek lagoons;
- Increase the frequency of events wherein water flows from Arroyo Grande Lagoon into Lower Meadow Creek Lagoon, for example during small storm events (e.g., herein called *freshets*) and during high-tide or overwash conditions, and,
- Improve water quality in Lower Meadow Creek Lagoon (see Section 3.2.4.1 for details).

To evaluate the fish movement and hydrologic exchange potential between the two lagoons during lower flow conditions, Stillwater Sciences analyzed available stage data from January 2017 to May 2023 for both Arroyo Grande Lagoon and Lower Meadow Creek Lagoon. This time period was selected because in 2016 a project improving the conveyance of Meadow Creek watershed stormflows out to the Pacific Ocean via Carpenter Creek (Figure 1) was implemented, which reduced flows into Lower Meadow Creek Lagoon and may have impacted Lower Meadow Creek Lagoon stage dynamics. All fish movement and hydrologic exchange potential analysis between the lagoons are informed by the following:

- The controlling existing inverts of the Sand Canyon outlet structure culverts on the upstream end of the culverts (Lower Meadow Creek Lagoon side) are 6.44 and 6.46 ft NAVD 88. These inverts are not proposed for modification and are assumed to be the same under existing and proposed conditions;
- A design closure threshold elevation for the proposed SRG(s) is preliminarily proposed for 8.3 ft NAVD88 (see details on preliminary design criteria for the proposed SRG improvements in Section 3.2.3.3); and,
- The pressure transducers installed on either side of the Sand Canyon outlet structure are situated approximately 1 ft above the invert or ground elevation. Specifically, the pressure transducers do not begin to record until a WSE reaches an elevation of 6.60 NAVD 88 on the Arroyo Grande Lagoon side and 7.23 ft NAVD 88 on the Lower Meadow Creek Lagoon side.

Based on available data (January 2017 to May 2023) approximately 19.1% of the time, WSE's in Arroyo Grande Lagoon are lower than an elevation of 6.60 ft NAVD88. Based on visual observations in this WSE elevational range, water is either typically flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon or the culverts are dry. When water is flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon, the water depth would be approximately two inches deep on the upstream end of the culvert(s) (Lower Meadow Creek Lagoon side) or less. While these WSE conditions occur primarily in summer, they can also occur in spring or fall. The proposed installation of an SRG system is assumed to have minimal improvements to fish movement or hydrologic exchange potential under these WSE conditions.

Approximately 18.2% of the time, WSE's in Arroyo Grande Lagoon are between an elevation of 6.60 ft NAVD88 and 6.94 ft NAVD88. Based on visual observations in this WSE elevational range, water is typically flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon. When water is flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon, the water depth would be between approximately two to six inches deep on the upstream end of the culvert(s) (Lower Meadow Creek Lagoon side).

Approximately 11.2% of the time, WSE's in Arroyo Grande Lagoon are between an elevation of 6.94 ft NAVD88 and 7.23 ft NAVD88. Based on visual observations in this WSE elevational range, water is typically flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon. When water is flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon, the water depth on the upstream end of the culvert(s) would be between approximately six to nine and a half inches deep.

In summary, WSE conditions that result in backwatering in MCL (6.60 ft NAVD88 < Arroyo Grande Lagoon WSE < 7.23 ft NAVD88) can occur in all seasons, including during some summers (e.g. WY2017, WY2019). While under existing conditions fish can move through the culverts under these WSE conditions, the existing accessible habitat on the Lower Meadow Creek Lagoon side is limited. Under proposed conditions fish moving through the culverts at these depths would have access to improved habitat conditions. If the restored habitat contains a higher abundance of non-native species, then the non-native species could also be able to move into Arroyo Grande Lagoon and Creek. Since in this WSE elevational range (6.6 ft NAVD88 < Arroyo Grande Lagoon WSE < 7.23 ft NAVD88) water has been observed to be typically flowing from Lower Meadow Creek Lagoon into Arroyo Grande Creek Lagoon, the WSE in Lower Meadow Creek Lagoon typically exceeds the WSE in Arroyo Grande Lagoon and the existing iron flap gate stays open. Under these typical conditions, there is no opportunity for water quality to improve in Lower Meadow Creek Lagoon from water flowing from Arroyo Grande Lagoon (where water quality conditions are on average better than Lower Meadow Creek Lagoon ([see Section 3.2.4.1 and Section 3.3.4.1]).

Under existing conditions, in this elevational range (6.6 ft NAVD88 < Arroyo Grande Lagoon WSE < 7.23 ft NAVD88), the Arroyo Grande Lagoon WSE has been observed to occasionally exceed the Lower Meadow Creek Lagoon WSE due to freshets or high-tide or overwash conditions (Stillwater Sciences 2022). For example, in early November 2021 when the sand bar elevation was low, wave overwash was observed flowing into the Arroyo Grande Lagoon during high tides (~6.5 ft NAVD 88) and raising the Arroyo Grande WSE. However, this event did not result in flow into the then dry Lower Meadow Creek Lagoon because the existing iron flap gates were closed (Stillwater Sciences 2022). With the installation of a proposed SRG system, water could flow into Lower Meadow Creek Lagoon from Arroyo Grande Lagoon under this type of tidal event. This has the potential for improving both fish movement opportunities and water quality conditions in Meadow Creek Lagoon, which can include low D.O. concentrations at any time of year (see Section 3.2.4 for further discussion). While this type of tidal influence could occur in any season, it is the least likely to occur in summer when the sand bar has an average elevation of 13 ft NAVD88. The duration or frequency of such events in this WSE elevational range cannot be quantitatively evaluated due to the absence of Lower Meadow Creek Lagoon WSE data below 7.23 ft NAVD88.

Approximately 40.5% of the time the WSE's in Arroyo Grande Lagoon are between an elevation of 7.23 ft NAVD88 and 8.3 ft NAVD88. When water is flowing from Lower Meadow Creek Lagoon into Arroyo Grande Lagoon, the water depth on the upstream end of the culvert(s) would be approximately nine and half to twenty-two inches deep. These conditions can occur in all seasons but primarily occur in winter and spring. While under existing conditions fish can move through the culverts at these depths, the existing habitat in Lower Meadow Creek Lagoon side is limited. However, under proposed conditions fish moving through the culverts would have access to restored habitat. If the restored habitat contains a higher abundance of non-native species, then the non-native species will also be able to move into Arroyo Grande Lagoon and Creek. Under existing conditions, in this range of WSEs, the Arroyo Grande Lagoon WSE occasionally exceeds the Lower Meadow Creek Lagoon WSE (e.g., during freshets or tidal exchange) and the existing iron flap gate closes. With the installation of a SRG system, during these events water could flow into Lower Meadow Creek Lagoon from Arroyo Grande Lagoon. An analysis of available data (when the WSE in Lower Meadow Creek Lagoon is greater than 7.23 ft NAVD88) shows that if an SRG had been installed and operated to close at the proposed closure threshold (8.3 ft NAVD88) water could have flowed into Lower Meadow Creek Lagoon from Arroyo Grande Lagoon during at least seven hydrologic events over a period of 6 years ranging from a single to multiple days in duration (see Section 3.2.3 for details). These additional opportunities for water flowing from Arroyo Grande Lagoon into Lower Meadow Creek Lagoon create the potential for improving fish movement as well as water quality conditions in Lower Meadow Creek Lagoon (see Section 3.2.4.1 for details).

Approximately 11.0% of the time the WSE's in Arroyo Grande Lagoon exceed an elevation of 8.3 ft NAVD88. Under both existing and proposed conditions, the existing iron flap gate or the proposed SRG would be closed whenever the Arroyo Grande Lagoon WSE exceeds the Meadow Creek Lagoon WSE.

In summary, analysis of historical available WSE data (2017-2023) suggests that restoring habitat in Lower Meadow Creek Lagoon and replacing the existing iron flap gate(s) at the Sand Canyon outlet structure with a SRG system could result in a system that provides:

- Potential fish movement through the culverts and connection to improved physical habitat conditions in Lower Meadow Creek Lagoon approximately 18% of the time under conditions when the water depth is between approximately two and six inches deep on the upstream end of the existing culverts (6.60 NAVD88 < Arroyo Grande Lagoon WSE < 6.94 NAVD88);
- Potential fish movement though the culverts and connection to the improved physical habitat conditions in Lower Meadow Creek Lagoon approximately 52% of the time under conditions when the water depth is greater than approximately six inches deep on the upstream end of the existing culverts (Arroyo Grande Lagoon WSE > 6.94 NAVD88) AND the proposed SRG gate is open (< 8.3 ft NAVD88);
- Limited potential fish movement through the culvert and connection to the improved physical habitat conditions in Lower Meadow Creek Lagoon approximately 30% of the time. Limited fish movement potential is anticipated during the lowest WSE conditions (Arroyo Grande WSE < 6.6 ft NAVD88) (19% of the time) and highest WSE conditions (Arroyo Grande WSE > 8.3 ft ft NAVD88) (11% of the time). And,
- Potential for improved water quality conditions in Lower Meadow Creek Lagoon from water flowing from Arroyo Grande Lagoon. From 2017 to 2023 this occurred at least 7 times over a period of 6 years ranging from a single to multiple days in duration based on available WSE data for (Arroyo Grande Lagoon and Meadow Creek Lagoon WSE> 7.23 ft NAVD88) and when the proposed SRG gate system is proposed to be open (Arroyo Grande WSE < 8.3 ft NAVD88). Additional potential for improvements to water

conditions in Lower Meadow Creek Lagoon are anticipated when WSE's are below 7.23 ft NAVD88 but WSE data for both lagoons is required to conduct this analysis.

For Alternative 3, analysis of recent water surface elevation data from pressure transducers installed at ground elevation in 2024 would allow for a more complete hydraulic analysis of the Sand Canyon outlet structure and a proposed SRG system during future phases of design (65% design) to optimize proposed SRG operation to maximize habitat benefits.

3.2.3 Infrastructure considerations

3.2.3.1 Flood risk

Using the calibrated existing conditions two-dimensional (2D) hydraulic model as the foundation, cbec modeled the 2-year, 5-year, 10-year, and 100-year floods for three outlet/inlet scenarios (open outlet/inlet and low tide, open outlet/inlet and high tide, and closed oulet/inlet and high tide, respectively) under Alternative 3 (Appendix D). WSE differences did not significantly change between existing conditions and proposed conditions for any of the design flow simulations under Alternative 3. Modeling results and assumptions are explained in detail in Appendix D. The design objective for the proposed SRG system is to replicate the current function of the existing flap gate during high-flow (flood) events, so when the SRG is properly designed and sized, combined with grading changes in MCL, there is no discernable change in flood risk. Determination of the design criteria for the SRG is described in Section 3.2.3.2. The sandbar management report names flood risks associated with the limited flood storage volume under gate-closed conditions in Meadow Creek Lagoon. Proposed grading features in alternative 3 were designed to increase habitat and also increase storage volume in MCL such that when combined with a SRG system the overall effect would be considered negligible. Mitigating these flood risks is an essential part of this alternative and the performance of the design should be iteratively evaluated during 65% design phases to ensure that there are no increases in flooding. Model results may lead to design refinements such as only retrofitting a single culvert and maintaining the other as a flap gate. However, if during future design refinements increased storage capacity in MCL is found to be sufficient to mitigate additional flood risk, then both culverts could be considered for a SRG retrofit, although such a potential retrofit is not anticipated to provide benefits for fish movement.

3.2.3.2 Levee scour risk

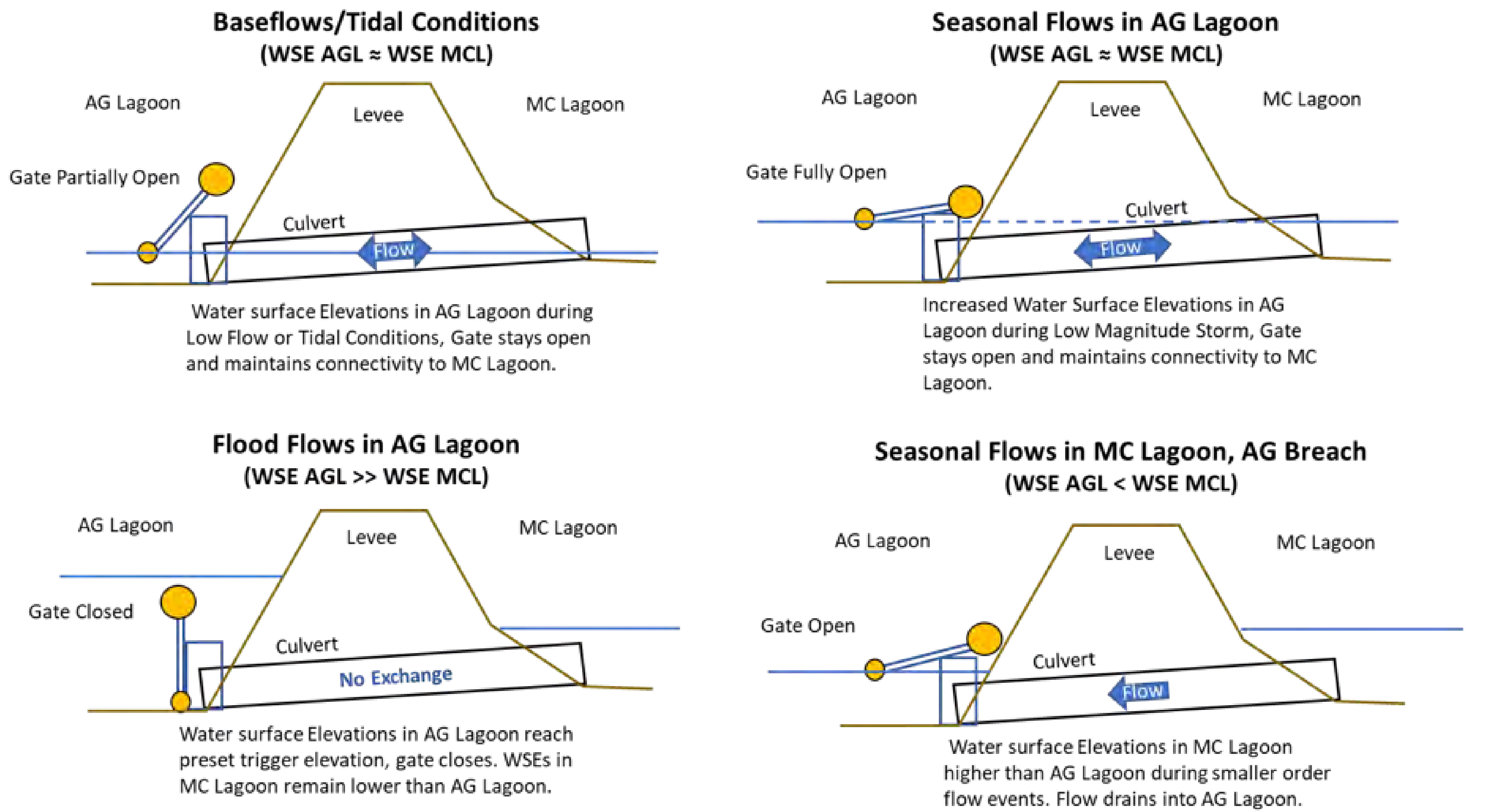
Because Alternative 3 does not include any changes near the levee, the existing levee scour risk would not be affected.

3.2.3.3 Self-regulating gate

SRGs are a specific type of “flapped” gate that are used to increase hydrologic exchange during typical tidal and seasonal streamflow cycles; they passively close during storm or flood conditions to protect against flooding. Therefore, when compared to traditional flap gates, SRGs can be designed to provide the same level of protection to properties and infrastructure as a standard flap gate. A typical modern intertidal SRG system, or self-regulating tidegate,[1] is shown in the picture to the right.

SRGs rely on buoyancy elements installed along the flap gate which maintain open conditions during low-flow exchanges. Additional floats are fixed to lever arms, or components of the flap gate, so that when water levels on the outside of the gate rise, the floats also rise until the flap is forced completely closed, remaining closed until water levels outside the levee recede again. SRGs can be designed to meet specific opening and closure criteria for a given site. The design could involve one of several options. Retrofitting the Sand Canyon outlet structure with SRGs would likely involve extending culvert pipes and upgrading the foundation and concrete headwall on the downstream (Arroyo Grande Lagoon) side of the Sand Canyon outlet structure to accommodate the swing radius of the SRGs. The main length of the culvert pipes would be kept in place to avoid disturbance to the wastewater outfall situated below grade on the north side toe of the levee. On the upstream (Lower Meadow Creek Lagoon) side of the existing outlet structure, the trash rack should be assessed for fish passage. If assessment determines the trash rack impacts fish movement, it can be upgraded. Typical operational modes of an SRG are demonstrated in Figure 10.

[1] [Waterman_SRT_TideGate_SpecSheet.pdf (watermanusa.com)]



Notes: AGL = Arroyo Grande Lagoon, MCL = Lower Meadow Creek Lagoon, WSE = water surface elevation

Figure 10. Typical operational modes of the self-regulating gate.

In order to replicate the existing gate's ability to prevent flooding, the SRG needs to close at the same flood flow elevation range as the existing gate, specifically when the stage hydrograph in Arroyo Grande Lagoon overtakes the stage in Lower Meadow Creek Lagoon under high-flow scenarios. To determine this threshold design elevation, Stillwater Sciences analyzed stage data from 2017 to 2023 for both Arroyo Grande Lagoon and Lower Meadow Creek Lagoon stage gages (see Figure 11) to understand how often and at what range of elevations water levels in Arroyo Grande Lagoon surpassed water levels in Lower Meadow Creek Lagoon under existing conditions. Stillwater Sciences assumed that when water levels in Arroyo Grande Lagoon surpassed water levels in Lower Meadow Creek Lagoon, the gate was closed. A comparison of stage data was performed, and conditional filtering of the data was applied such that, when water levels in Arroyo Grande Lagoon exceeded water levels in Lower Meadow Creek Lagoon during the approximately six-year record, the daily average WSEs and daily maximum WSEs were tabulated for both lagoons. The daily average values for Arroyo Grande Lagoon were used to establish the elevation ranges for opening and closing the proposed SRG. Figure 11 shows the results for threshold WSE (ft NAVD 88), AGL daily max stage (ft NAVD 88), daily average stage (ft NAVD 88), and the difference between Lower Meadow Creek Lagoon stage and Arroyo Grande Lagoon stage (ft NAVD 88), which correspond to periods of existing flap gate closure. Figure 11 also shows the average threshold WSE of all existing flap gate closure events (elevation 8.3 ft NAV D88), which may be considered a starting point for establishing the preliminary threshold design closure elevation for the proposed SRG.

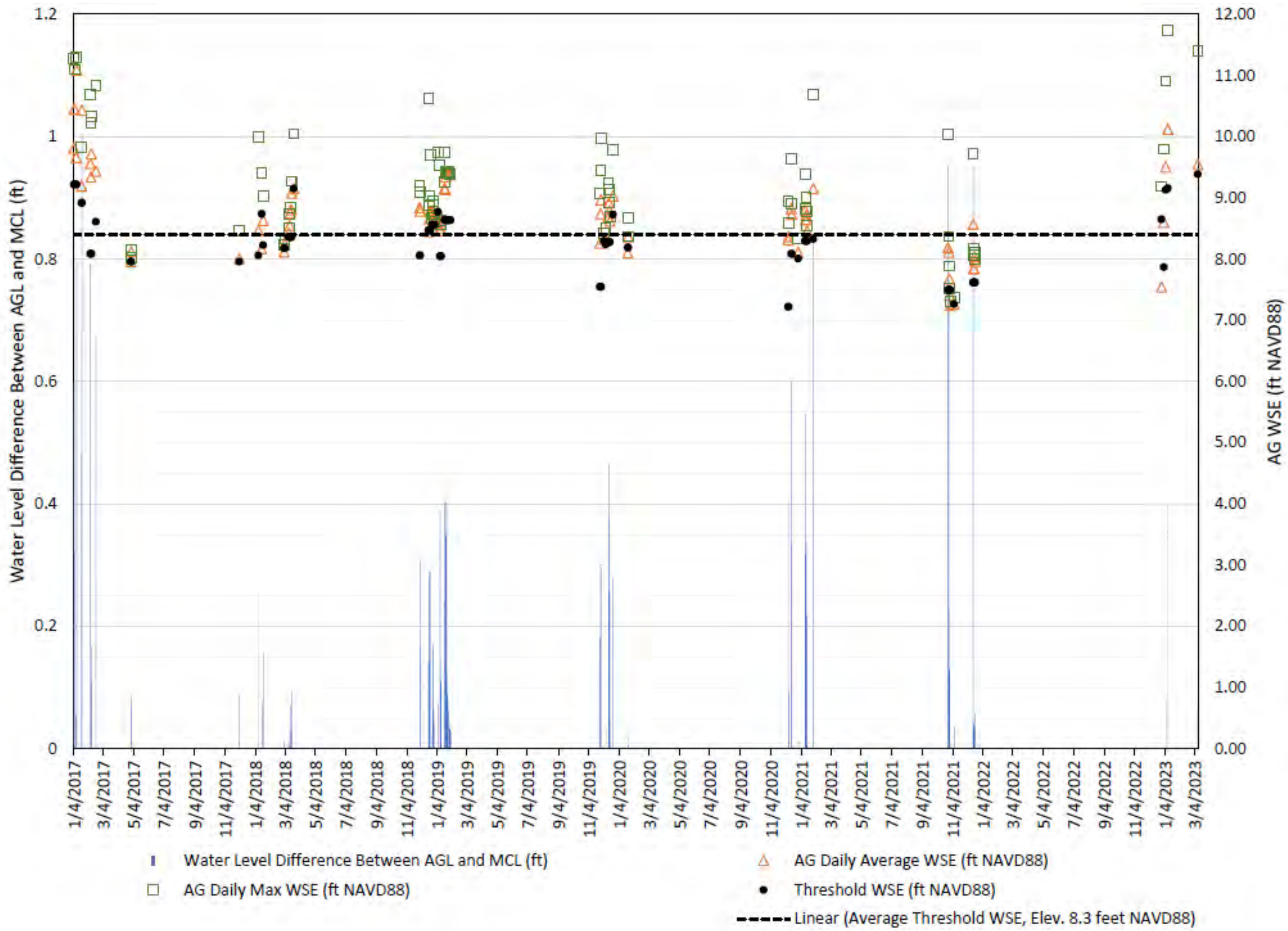


Figure 11. Daily average and daily maximum water surface elevations in Arroyo Grande Lagoon (AGL) for events where water surface elevations in Arroyo Grande Creek were greater than in Lower Meadow Creek Lagoon (MCL). Analysis based on 15-minute stage data at MCL and AGL water level gages. (WSE = Water Surface Elevation).

Tabular data for this analysis are presented in Appendix E. A preliminary gate-closure elevation criteria was established from the data presented in Figure 11. The average of the threshold values (the elevation at which the water level in Arroyo Grande Lagoon surpassed the water level in Lower Meadow Creek Lagoon) was calculated and can be used as a conservative estimate for the SRG-closure elevation, which would not affect flood risk in areas adjacent to Lower Meadow Creek Lagoon. Table 2 shows relevant geometries/elevations of the existing culverts as well as the proposed WSEs for the preliminary proposed operating range of the SRG.

Table 2. Geometries and ground elevations for existing culverts and proposed self-regulating gate retrofit water surface elevations at the Sand Canyon outlet structure.

	Description	Geometry
Existing	Culvert 1 upstream invert	6.44 ft NAVD 88
	Culvert 1 downstream invert	5.36 ft NAVD 88
	Culvert 2 upstream invert	6.46 ft NAVD 88
	Culvert 2 downstream invert	5.83 ft NAVD 88
	Culvert 1 and 2 pipe type and dimensions	Arched, 48 in. x 71 in.
Proposed	Self-regulating gate opened range	6.44 ft to 8.30 ft NAVD88
	Self-regulating gate closed range	> 8.30 ft NAVD 88

All flap gates—whether SRG or traditional flap gates—carry a risk of mechanical malfunction and issues resulting from sedimentation and require regular inspection and maintenance. Some SRGs feature more moving and mechanical linkages than others and, as such, could require more maintenance. An SRG that features minimal mechanical features and functions should be selected. Intertidal oceanic exposure can corrode metals and exacerbate corrosion of dissimilar metals; therefore, only the highest quality compatible alloys should be used for all mechanical, hinge, and bearing components. SRGs that feature inflatable ballast can provide increased operational modes; however, they are at risk of puncture and malfunction; therefore, SRGs with solid core floats should be selected (Caltrans 2016). In addition, floating debris can clog any kind of tide gate, and if warranted, debris screens could be incorporated in front of the SRGs to prevent malfunction. However, any debris screen should be carefully selected to ensure that potential fish movement would not be impaired. Additionally, SRGs require increased vertical and horizontal clearance at the culvert inlet and can lead to expanded disturbance or present practical construction issues. Beyond ensuring the correct elevation for SRG closure is used, SRGs are not expected to present additional risk to people or property within the levee system, when compared to the existing traditional flap gate.

3.2.4 Other considerations

3.2.4.1 Water quality

In lagoon habitats similar to Lower Meadow Creek Lagoon, dissolved oxygen (DO) concentrations greater than 5 milligrams per liter (mg/L) are considered suitable for steelhead rearing (ISU 2008, as cited in Daniels et al. 2010). DO concentrations near saturation (9.0 mg/L) are generally required for growth, but rearing steelhead can survive at DO concentrations as low as 1.5–2.0 mg/L at low temperatures (Moyle 2002). A daily average temperature <26 degrees Celsius (°C) (78.8 degrees Fahrenheit [°F]), as measured at the bottom of the water column, has been proposed as a criterion for evaluating potential restoration in Lower Meadow Creek Lagoon. While the proposed SRG system under Alternative 3 is anticipated to increase hydrological exchange and improve water quality during non-flood flows, it would not remediate other existing factors that may affect existing water quality, including but not limited to factors such as stormwater flows or septic inputs.

Existing DO and temperature measurements in Lower Meadow Creek Lagoon and Upper Meadow Creek Lagoon (which serves as a potential proxy for water quality conditions that could exist in Lower Meadow Creek Lagoon if it is restored) have ranged from poor to good. Water quality surveys conducted by Althouse and Meade, Inc. (2011) found that DO levels in Upper and Lower Meadow Creek lagoons were chronically low (<5 mg/L) and water temperatures ranged from a low of 10.3°C (50.5°F) in December to a high of 24.5°C (76.1°F) in September. On August 16, 2012, Terra Verde (2012a) conducted a subsequent water quality survey along Upper Meadow Creek Lagoon from Pier Avenue through Lower Meadow Creek Lagoon. While moderate to high DO values (ranging from 6.78 to 10.48 mg/L) and water temperatures ranging from 21.7°C (71.0°F) to 22.1°C (71.8°F) were measured downstream from Pier Avenue to Air Park Drive, lower DO values (ranging from 1.32 mg/L to 4.24 mg/L) and water temperatures ranging from 16.7°C (62.0°F) to 21.5°C (70.7°F) were measured downstream of Air Park and downstream through Lower Meadow Creek Lagoon.

The District began collecting spot water quality measurements once a month in four locations along Upper Meadow Creek Lagoon and one location in Lower Meadow Creek Lagoon (Figure 12) in April of 2023. The District selected Upper Meadow Creek Lagoon locations that have a similar range of depths as a restored Lower Meadow Creek Lagoon. The existing Upper Meadow Creek Lagoon has less hydrological exchange events than a restored Lower Meadow Creek Lagoon would be anticipated to have.

From April 2023 to August 2024, DO values in Upper Meadow Creek Lagoon were widely variable, ranging from poor (1.5–2.0 mg/L) to values that are optimal for growth (> 9 mg/L) for juvenile steelhead, and generally stayed above lethal concentrations (Appendix F). Temperatures met target criteria, ranging from 11 to 21°C (~52 to 70°F) as measured at the bottom of the water column, depending on month and location (Appendix F). For the period monitored, water quality conditions were generally better in the dry season than in the wet season. Water quality was measured in only one location in Lower Meadow Creek Lagoon due to thick vegetation and difficult access. This location (MCL#2) is situated adjacent the Sand Canyon outlet structure and generally showed unsuitable DO (1.8–4.7 mg/L) with the exception of one measurement (January 12, 2024, 9.8 mg/L). Temperatures met target criteria, ranging from 9 to 19°C (~48 to 66°F). The District continues to collect data. Alternative 3 is anticipated to improve but not fully remediate water quality conditions in Lower Meadow Creek Lagoon.

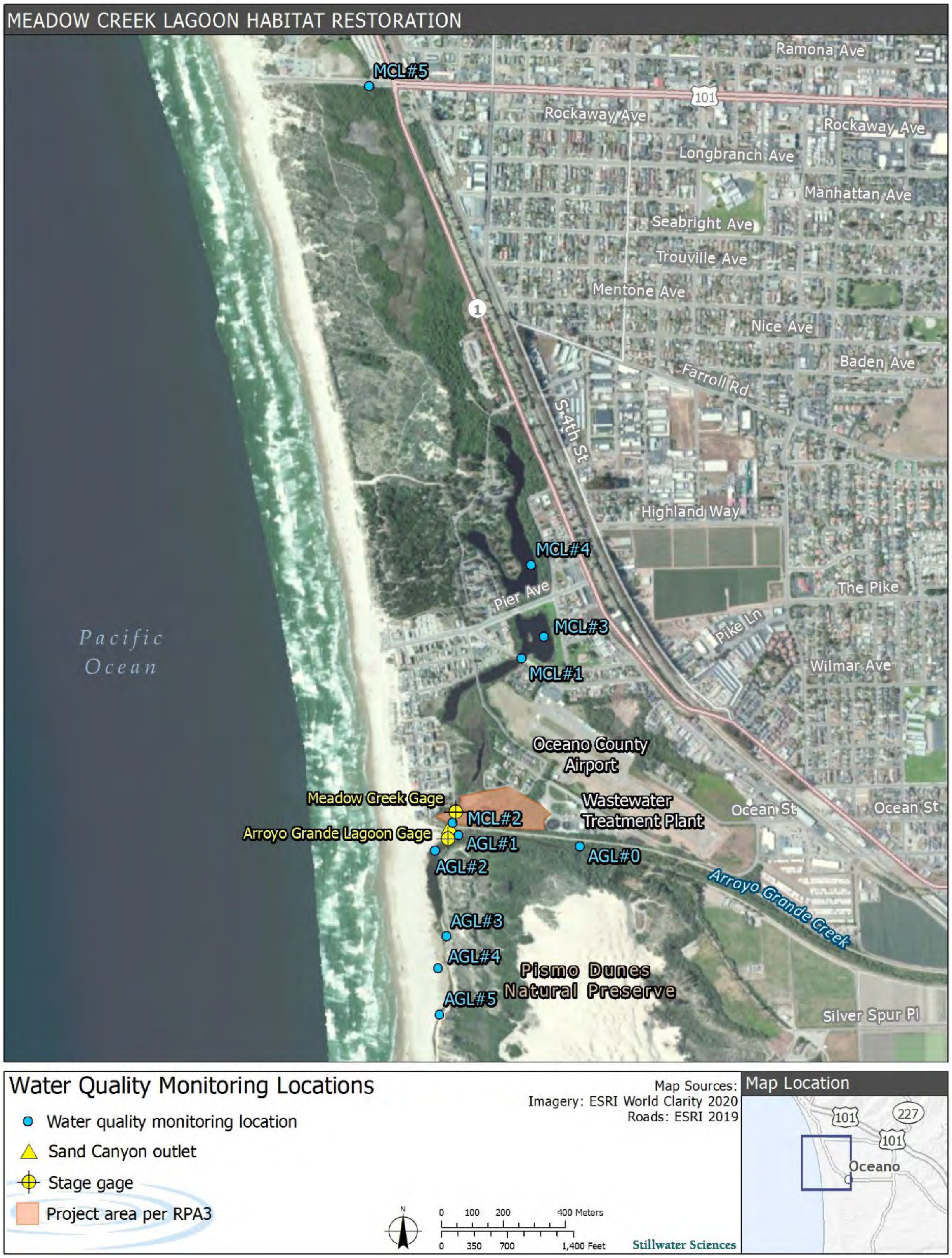


Figure 12. Monthly water quality monitoring stations (April 2023 to present). See Appendix E for data summary.

3.2.4.2 Biotic considerations

In addition to the increase in habitat described for steelhead in Section 3.2.1, tidewater goby (which have been found in Lower Meadow Creek Lagoon), would benefit from proposed improvements. Specifically, since tidewater goby use shallower habitat than steelhead, suitable habitat for tidewater goby is anticipated to be equal to or greater than the habitat area reported for steelhead. On the other hand, California red-legged frogs (CRLFs) have not been observed in Lower Meadow Creek Lagoon since 2012, when a single adult CRLF was observed (Terra Verde 2012b). CRLF habitat would be enhanced by the proposed improvements by increasing potential breeding pools compared to existing conditions and providing enhanced riparian habitat (riparian edge habitat providing shade, cover, and vegetation structure). Adult bullfrogs (a documented threat to CRLFs) have been observed in high abundances (Cleveland Biological 2020). If Alternative 3 were selected, the bullfrog population could have an adverse impact on the habitat value for CRLF as well as on a CRLF population that might colonize the restoration area (through predation).

Upstream of Lower Meadow Creek Lagoon, largemouth bass, which prey on juvenile steelhead, have been observed (Terra Verde 2012b). Carp are also present throughout the Meadow Creek system and they may prey on small fish. Because Upper and Lower Meadow Creek lagoons are hydrologically connected, largemouth bass are expected to become established in the areas that are recommended for excavation under Alternative 3. Carp have already been observed in that area. If Alternative 3 were selected, the largemouth bass and carp populations could have an adverse impact on the quality of steelhead habitat and on juvenile steelhead rearing in Lower Meadow Creek Lagoon.

3.2.4.3 Sediment transport and sedimentation

Sediment transport was not modeled for Alternative 3 because it is assumed that there is little sediment input from Meadow Creek, which is a small, highly urban watershed that also has an additional outlet to the ocean at Carpenter Creek (see Figure 1). Furthermore, Upper Meadow Creek Lagoon consists of nearly 2 miles of low-gradient open water and heavily vegetated marsh that filters and captures all coarse-grained sediment and precludes it from reaching Lower Meadow Creek Lagoon. The proposed habitat restoration elements are designed to increase habitat complexity, increase suitable steelhead rearing habitat, and provide deep-water refugia for rearing steelhead. The ponds that were dredged in 1939 in Upper Meadow Creek Lagoon have not filled with sediment to date (Stillwater Sciences 2022) and provide a useful proxy for the minimal sedimentation risk for the pools proposed for excavation under Alternative 3.

No new sediment maintenance actions are proposed under Alternative 3. Current sediment maintenance activities including monitoring and removing sediment in the immediate area around the Sand Canyon outlet structure would continue.

3.2.4.4 Sea-level Rise

The Medium-High Risk Aversion 2070 scenario as described in Stillwater Sciences (2022) was simulated under an open outlet/inlet and high tide scenario for the 2-year and 100-year floods. Stages were increased by 3.3 ft to model impacts from sea-level rise. The WSE in Lower Meadow Creek Lagoon did not rise under the sea-level-rise modeling scenario because the levee separating Lower Meadow Creek and Arroyo Grande lagoons does not become inundated or overtopped even in the 100-year floods. Details of the modeling approach, assumptions and results for sea-level rise are presented in Appendix D.

3.2.4.5 Construction costs

Planning level construction costs for Alternative 3 are presented in Table 3.

Table 3. Planning level cost estimate for Alternative 3.

Item No.	Description	Quantity	Unit	Unit Cost	Cost
1	Mobilization	1	Lump sum	$200,000	$200,000
2	Access Roads and Staging	10,240	Square foot	$10	$102,400
3	Clearing and Grubbing	59,554	Square foot	$2	$119,108
4	Temporary Marsh Crossings	1	Lump sum	$26,300	$26,300
5	Dewatering	1	Lump sum	$150,000	$150,000
6	Material Excavation, Haul and Disposal	8,100	Cubic yard	$150	$1,215,000
7	Fine Grading	1,654	Cubic yard	$30	$49,628
8	Large Wood Import and Install	44	Logs	$8,000	$352,000
9	Boulder Ballast	0	Tons	$260	$0
10	Riparian and Aquatic Planting	1,000	Plug or container	$20	$20,000
11	Erosion Control	1	Lump sum	$75,000	$75,000
12	Engineering oversight	1	Lump sum	$100,000	$100,000
13	Maintenance and Monitoring - 5yr	5	Lump sum	$118,330	$591,650
14	Outlet Structure SR Gate	2	Lump sum	$200,000	$400,000
Subtotal (Rounded Up)			**$3,402,000**		
Contingency (20%) (Rounded Up)			**$681,000**		
Total			**$4,083,000**		

3.3 Alternative 4: Arroyo Grande Creek Lagoon Restoration

Alternative 4 includes the restoration of steelhead rearing habitat by excavating pools, excavating channels in conjunction with engineered wood habitat structures, and increasing habitat complexity in Arroyo Grande Lagoon. This alternative does not address hydrologic and habitat connectivity between Lower Meadow Creek and Arroyo Grande lagoons. Conceptual designs for Alternative 4 are shown in Figure 7 and include a project footprint of 7.58 acres, an excavation footprint of 1.24 acres, a maximum excavation depth of 12.5 ft (used in modeling), and an excavation volume of 5,320 cubic yards.

3.3.1 Steelhead rearing habitat

Stillwater Sciences conducted a habitat suitability analysis comparing existing and proposed conditions using the same methods described for Alternative 3 (see Section 3.1.1). Under existing conditions, approximately 5,197 sq ft of suitable rearing habitat are available during typical winter baseflow conditions in Arroyo Grande Lagoon, and no deep-water refugia is available in the winter. The habitat improvements proposed in Alternative 4 would result in an increase of approximately 42,140 sq ft (over an 800% increase) of suitable rearing habitat and 241 sq ft of deep water refugia habitat in winter (Figure 13, Table 1). Currently, approximately 921 sq ft of suitable rearing habitat is available in the summer, and no deep-water refugia is available. Alternative 4 would result in approximately 2,091 sq ft (127% increase) of suitable rearing habitat and would not provide summer-time deep-water refugia (Figure 14, Table 1). Spring habitat conditions were also evaluated and would improve, similar to winter conditions (Table 1). Alternative 4 would also create 460 ft of new riparian edge habitat under typical winter conditions and increase habitat complexity through the construction and placement of 22 wood structures (Table 1). Engineered wood habitat structures are proposed to be placed at different elevations, providing habitat complexity at varying degrees of lagoon inundation.

The engineered wood habitat structures would be designed to provide cover and complexity for juvenile steelhead that are rearing in the lagoon and both juveniles and adults that are migrating through the lagoon. It is anticipated that because the engineered wood habitat structures would be placed in a dynamic environment, they would provide habitat function at times, but at other times when the lagoon is low, some of the structures would be dry or certain lagoon areas may become temporarily abandoned (see Section 3.3.4.3 for further discussion), leaving the engineered wood habitat structures out of the wetted channel entirely. Therefore, the engineered wood habitat structures would be placed at varying bed elevations to increase the probability that a portion of the project would consistently provide habitat function as natural processes alter the dynamic lagoon environment. Scour adjacent to structures is also anticipated, increasing habitat complexity and adjacent water depth.

Engineered wood habitat structures should be expected to evolve and change over time. They would be held in place using one or a combination of various mechanisms (e.g., embedment, vertical piles, anchors) to provide long-term stability (see Section 3.3.4.4). For example, engineered wood habitat structures may accumulate or shed wood that is being transported by Arroyo Grande Creek, bedforms near the engineered wood habitat structures are expected to adjust seasonally and annually, and the degree of inundation of each habitat structure should be expected to change over time. For example, some engineered wood habitat structures are proposed to be placed in what was temporarily the abandoned southern Arroyo Grande Lagoon (see Section 3.3.4.3 for recent geomorphic evolution of the Arroyo Grande Lagoon system). In addition, structures would be designed to be as “tall” as possible so that as WSE varies, the continuity of a habitat complexity and cover would remain.

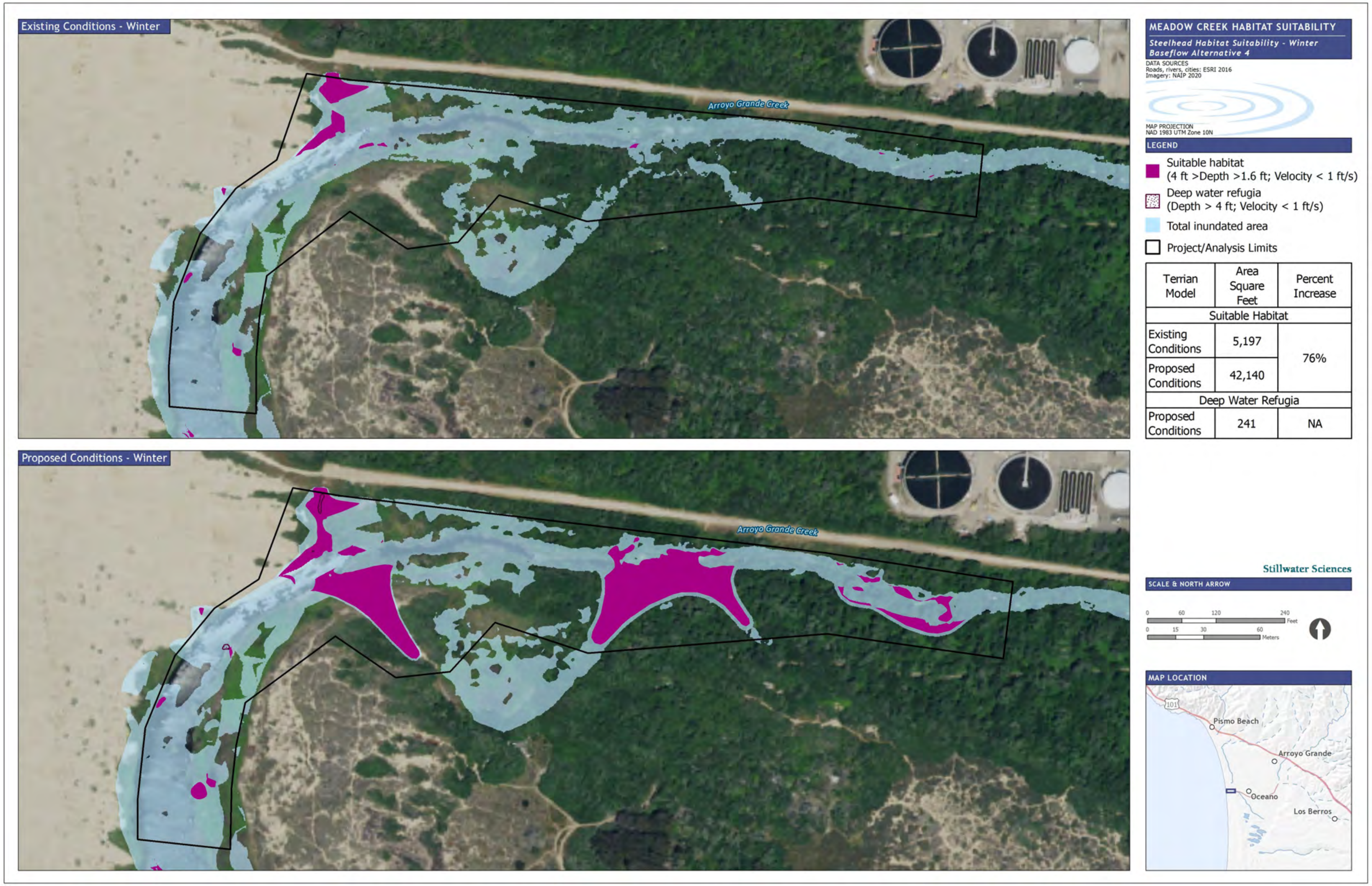


Figure 13. Steelhead suitable rearing habitat, deep-water refugia, and total inundated area during winter baseflow conditions under Alternative 4.

Terrian Model	Area Square Feet	Percent Increase
Suitable Habitat		
Existing Conditions	921	127%
Proposed Conditions	2,091	
Deep Water Refugia		
Proposed Conditions	0	NA

Figure 14. Steelhead suitable rearing habitat, deep-water refugia, and total inundated area during summer baseflow conditions under Alternative 4.

3.3.2 Hydrologic and habitat connectivity

Hydrologic or habitat connectivity would not change under Alternative 4. However, Alternative 4 has the potential to enhance steelhead migration habitat in Arroyo Grande Creek, which Alternative 3 would not achieve. RPA 3 focused on juvenile rearing habitat because of the County's selected location in Meadow Creek Lagoon, which was presumed not to provide habitat for migration. Alternative 4 provides the opportunity to consider enhanced migration corridors (e.g., migrating juveniles).

3.3.3 Infrastructure considerations

3.3.3.1 Flood risk

Using the calibrated existing conditions 2D hydraulic model as the foundation, cbec modeled the 2-year, 5-year, 10-year and 100-year floods for three scenarios (open outlet/inlet and low tide, open outlet/inlet and high tide, and closed outlet/inlet and high tide) under Alternative 4 (Appendix D). In general, simulation results indicate a WSE decrease of up to 1 ft throughout much of Lower Arroyo Grande Creek and Lagoon. Minor increases in WSEs were shown around Stations 800 and 1700 as a result of increased complexity of flow paths compared to existing conditions. Figures 19 to 24 in Appendix D show these patterns of WSE changes. If Alternative 4 is selected, the preliminary modeling results will be used to refine future Alternative 4 design iterations to minimize localized WSE increases. This could include modifications to the restoration polygons to avoid, for example, increases in WSE at the Sand Canyon flap gate and/or scour patterns (see Section 3.3.3.2). These necessary design modifications are not expected to significantly impact habitat quantity and/or quality included in Alternative 4. Modeling results and assumptions are explained in detail in Appendix D.

3.3.3.2 Levee scour risk

The risk of erosion along the levee is inherent because the levee was constructed directly beside and through the confluence of Lower Meadow Creek and Arroyo Grande lagoons. The hydraulic model results in Appendix D suggest that reach-scale average shear stress for existing and proposed conditions stay in the same order of magnitude. Proposed conditions under Alternative 4 show a higher degree of variance in the overall distribution of shear stress, suggesting that some areas may be more prone to scour, while other areas may be more prone to sediment deposition. Specifically, at all flow events under Alternative 4, areas of increased shear stress occur where engineered woody habitat structures (seen as roughness modifications in the model [n = 0.1]) are present, as is the intent of the proposed design. At all existing conditions flow events, an area of high shear stress (> 1.0 pound per square foot [lb/ft^2]) occurs near Station 700. The magnitude of the shear stress in this area is reduced in the 2-year flood event for proposed conditions under Alternative 4, but no changes in shear stress between existing and proposed conditions are seen at higher flow events. Overall, a higher variance in shear stress and the subsequent risk of erosion under Alternative 4 proposed conditions can be mitigated through design refinement involving the orientation of proposed grading and the location of proposed engineered habitat structures.

3.3.3.3 Self-regulating gate (SRG)

An SRG is not proposed under Alternative 4.

3.3.4 Other considerations

3.3.4.1 Water quality

Previously available data suggested that summer water quality conditions in Arroyo Grande Lagoon are brackish in nature, with moderate to low DO (<5 mg/L) (Terra Verde 2012b, Rischbieter 2017) and high summer daytime pH levels indicative of lagoons with substantial algal growth (Rischbieter 2016). Arroyo Grande Lagoon can shrink during periods of drought and become desiccated during a prolonged period of drought.

Recently, the District began collecting spot water quality measurements once a month in five locations along Lower Arroyo Grande Creek and Arroyo Grande Lagoon (Figure 12). Locations were selected to help inform potential water quality conditions under Alternative 4. From April 2023 to February 2024, water quality conditions were consistently suitable to optimal, ranging from 5–22 mg/L), including consistent periods that are optimal for juvenile steelhead growth (> 9 mg/L) (Appendix F). Temperature also met criteria, which generally ranged from 9 to 22°C (~48 to 72°F) as measured at the bottom of the water column, depending on month and location (Appendix F). While for the period monitored, water quality conditions declined in the peak of the dry season, they remained generally suitable. The District continues to collect data.

3.3.4.2 Biotic considerations

Annual fisheries surveys have documented a continual presence of tidewater goby in Arroyo Grande Lagoon since 2005 and they have been captured throughout the Arroyo Grande Lagoon in the "tens of thousands" (Rischbieter 2017). CRLF in all life stages have been consistently documented in Arroyo Grande Lagoon during surveys conducted from 2008 through 2020 (Rischbieter 2009a,b; Cleveland et al. 2019; Cleveland Biological 2020; Tera Verde 2012a; Stillwater Sciences 2022).

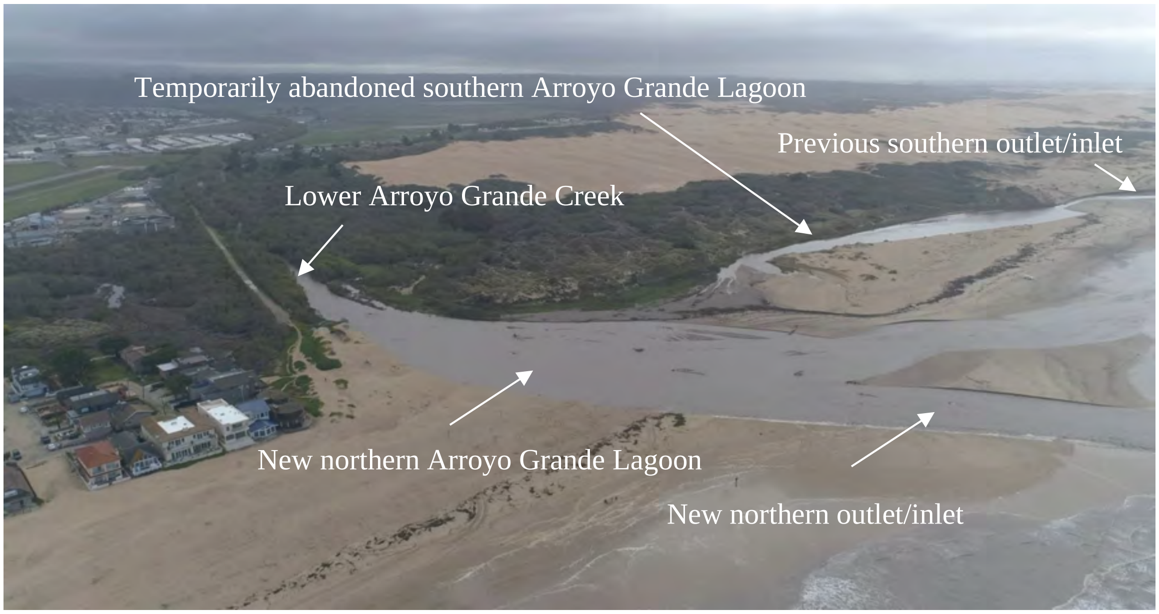
Proposed steelhead habitat restoration under Alternative 4 is anticipated to benefit both species positively by providing a wide range of pool depths, improving access to low velocity high flow refuge habitat, and providing enhanced riparian habitat (riparian edge habitat providing shade, cover, and vegetation structure), protection from invasive predators, and increasing overall habitat complexity.

3.3.4.3 Geomorphology, sediment transport, and sedimentation

Lower Arroyo Grande Creek and Lagoon are highly dynamic environments that experience short-term (e.g., seasonal) and longer-term (e.g., decadal) geomorphic adjustments. Processes that affect geomorphic changes in Lower Arroyo Grande Creek and Lagoon include but are not limited to the magnitude, duration and timing of flood events; amount and timing of fluvial sediment deposition and/or scour; amount and timing of wind-blow sediment deposition and/or scour, and lateral channel migration or avulsion. These processes will be active with or without the restoration proposed under Alternative 4. The sediment transport models developed for this study do not incorporate coastal processes and are not generally intended for predicting seasonal changes in beach, dune, and lagoon geometry. However, the sediment transport model does identify and simulate outlet/inlet erosion and breaching caused by high outflow rates during simulated storms primarily to inform conditions within the proposed project footprint.

Historic aerial photographs confirm that the lagoon outlet may flow directly to the ocean or may meander behind the beach berm to an ocean discharge location further south. The existing conditions sediment transport modeling using the southern discharge location as a baseline

(Stillwater Sciences 2022) indicated the outlet/inlet was anticipated to remain in its southern position during small storm events, with the formation of a second outlet/inlet breach farther north during larger storm events. A new northern outlet/inlet formed in the larger flood events in the winter of 2022/23 (see photo below) closer to the levee.



The northern outlet/inlet remained open, and the southern outlet/inlet remained closed through the spring and summer of 2023. When the sand bar associated with the new northern outlet/inlet closed sometime in the late summer or early fall of 2023, the southern and northern Arroyo Grande Lagoon areas became inundated, creating a massive lagoon system (see photo to right, October 13, 2023).

A sediment transport model using HEC-RAS 6.4.1 was developed to simulate sediment transport shear stress and bedform changes under the 2-year, 5-year, 10-year and 100-year flood events for the open outlet/inlet and low tide scenario under Alternative 4 (Appendix D). It was assumed the greatest changes would occur under the open outlet/inlet plus low tide scenario. Overall, sediment transport model results indicate that the total volume of bed changes quantified between existing and proposed conditions are relatively small when compared to the overall length and surface area of Arroyo Grande Creek and Lagoon that were simulated.

The net changes in sediment erosion and deposition were used to evaluate the impact of proposed alternatives on sediment transport and sedimentation processes and conditions. For both existing and proposed condition elevational changes were predominantly on the order of plus or minus 0.5 feet for floods with lower recurrence intervals (e.g. 2-yr, 5-yr), with the proportion of the bed experiencing elevation changes in the plus or minus 1.5 feet range increasing at higher flood events (e.g., 100-year storm (Figures 33 to 36, Appendix D). The The volumetric amounts of deposition and erosion sediment in Arroyo Grande Creek and Lagoon under existing and proposed conditions are presented in Tables 12 and 13 in Appendix D. The relatively small difference in volumetric change between existing and proposed conditions is presented in Table 14 in Appendix D and suggests that Alternative 4 would not contribute to the larger scale erosional changes which are inherent in a dynamic lagoon system. In general, the magnitude and spatial expanse of erosion increase just downstream of the roughness elements (see Appendix D, Figures 29 to 32). The sediment transport models show that the differences in deposition and scour in existing and proposed conditions are small and primarily focused on proposed habitat features within the restoration area, which is the goal of the conceptual design of Alternative 4. The sediment transport modeling demonstrates that the Alternative 4 footprint has no bearing on erosion along the barrier beach.

While the model assumes a single lagoon configuration, results for other lagoon configurations (e.g., discharge straight to ocean) are expected to be similar, with no material net change between existing and proposed conditions and similar patterns of localized changes around the Alternative 4 structures are anticipated.

No new proposed sediment maintenance is recommended under Alternative 4. Current sediment maintenance activities including monitoring and removing sediment in the immediate area around the concrete foundation of the Sand Canyon outlet structure would continue.

3.3.4.4 Habitat structure dynamics

Large wood structures are composed of one or more pieces of wood and can be ballasted in varying levels of stability through one or a combination of the following techniques: embedment, vertical piles, anchoring to an existing tree, and/or boulder ballast. Large wood structures can influence geomorphic processes of localized scour, gravel sorting and deposition, increase aquatic and riparian habitat diversity and complexity, and create roughness along the banks to resist erosion. Large wood structures mimic naturally occurring treefall and wood accumulation observed in stream channels with high quality aquatic habitats. Large wood structures are often used in restoration to provide additional cover, increase complexity, and catalyze progression of natural channel evolution processes.

Wood structures are positioned, oriented, and embedded in existing or proposed ground to produce desired benefits which include but are not limited aquatic habitat cover; high flow refugia; sediment sorting; localized accretion, scour, and deposition; creation of desired velocities and depths; weir flow; and flow steering and bank protection.

Wood structures can be installed with varying levels of anchoring to achieve the desired level of stability or resistance to movement. The following two approaches (natural and engineered) are described and proposed and can be evaluated for installation if Alternative 4 is selected:

- Natural approach: includes placement of most wood structures without anchoring, or with light embedment into native soil. This approach anticipates more movement through sliding, rotating, and changes in ballast with flow variability.
- Engineering approach: includes one or more of the anchoring techniques described above with the objective of keeping wood structures in place.

In both approaches, minor scour and wrack accumulation may help the structure stay in place because it will increase resistant forces via wedging against anchored points and underlying substrate. However, some structures may have the potential to rotate and/or translate if significant scour and racking of additional wood occurs.

Stability of the wood structures is designed to minimize risk to infrastructure, while remaining cost effective and minimizing aesthetic or ecological adverse effects of over-ballasting in the project area. Stability calculations and on-site engineering and geomorphic expertise will guide the final layout, design plans and specifications, and construction of the structures. To further ensure the quality of anchoring, Stillwater Sciences recommends that a contractor is selected who has previous experience with implementing large wood projects.

3.3.4.5 Sea-level rise

The Medium-High Risk Aversion 2070 scenario was simulated under an open outlet/inlet and high tide scenario for the 2-year and 100-year floods. Stages were increased by 3.3 ft to model sea-level-rise impacts under Alternative 4. With proposed restoration actions, there were no WSE increases during the smaller 2-year flood event. There was a localized increase of 0.1 to 0.25 ft at the Sand Canyon outlet structure (Station 1700) during the 100-year event and a larger increase of 0.5 to 1 ft near the terrain modification (Figure 15). These projected increases are not anticipated to substantially interfere with the proposed design and function of Alternative 4. Details of sea-level modeling approach, assumptions and results are presented in Appendix D.

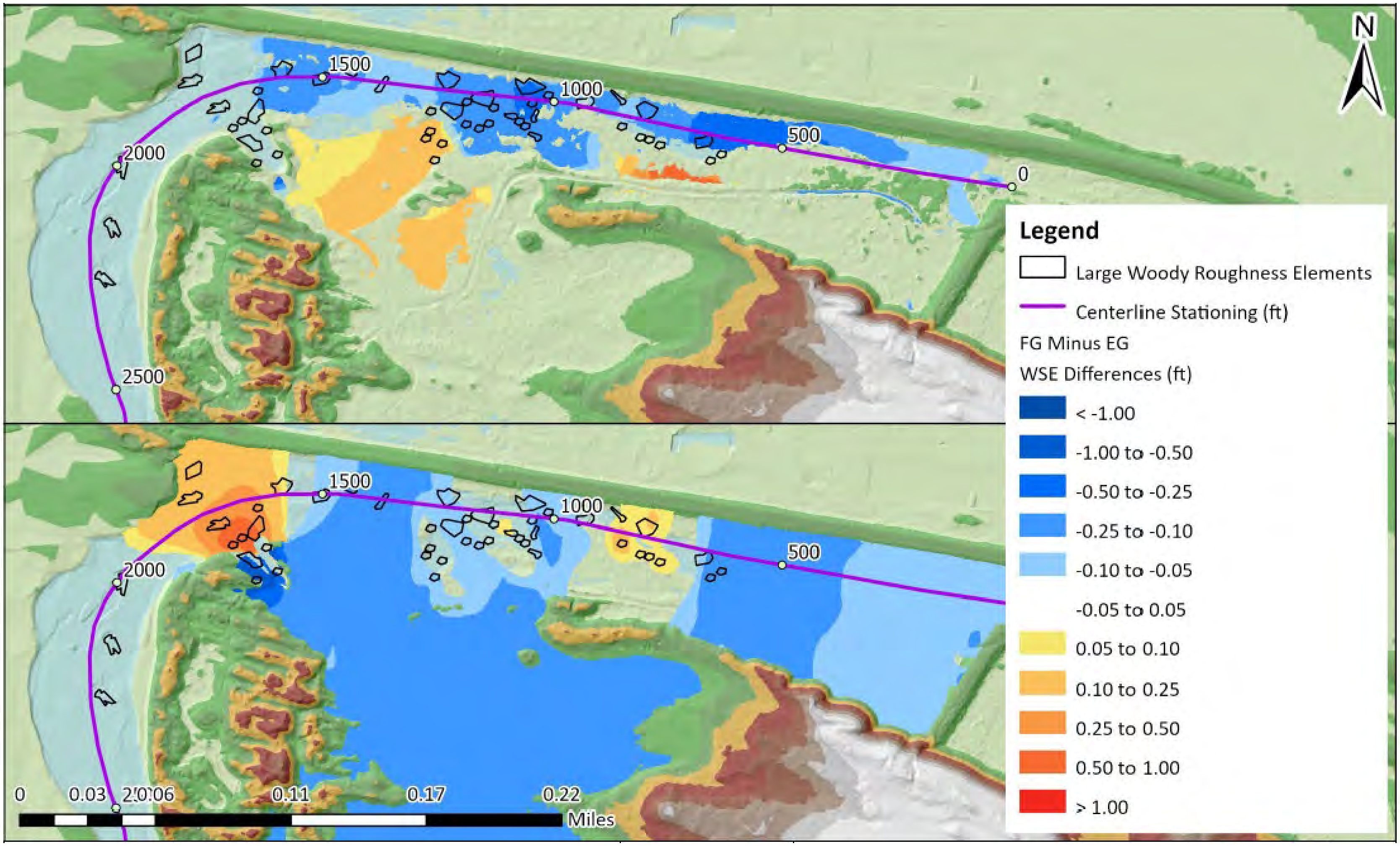


Figure 15. Water surface elevation differences between existing (non-restored) and proposed (restored) conditions for modeling runs of a medium high-risk sea level rise scenario (3.3 ft of sea level rise) for the 2-year flood (top image) and the 100-year flood (bottom image).

3.3.4.6 Construction costs

Planning level construction costs under Alternative 4 are presented in Table 4.

Table 4. Planning level cost estimate for Alternative 4.

Item No.	Description	Quantity	Unit	Unit Cost	Cost
1	Mobilization	1	Lum sum	$200,000	$200,000
2	Access Roads and Staging	23,400	Square foot	$10	$234,000
3	Clearing and Grubbing	53,870	Square foot	$1	$70,829
4	Temporary Creek/Lagoon Crossings	3	Lum sum	$26,300	$78,900
5	Dewatering	1	Lum sum	$150,000	$150,000
6	Material Excavation, Haul and Disposal	5,320	Cubic yard	$150	$798,000
7	Fine Grading	1,496	Cubic yard	$30	$44,892
8	Large Wood Import and Install	148	Logs	$8,000	$1,184,000
9	Boulder Ballast	1,000	Tons	$260	$260,000
10	Riparian and Aquatic Planting	1,500	Plug or container	$20	$30,000
11	Erosion Control	1	Lum sum	$75,000	$75,000
12	Engineering oversight	1	Lump sum	$100,000	$100,000
13	Maintenance and Monitoring - 5yr	5	Lump sum	$118,330	$591,650
14	Outlet Structure SRG gate	0		$170,000	$0
SubTotal (Rounded Up)			**$3,818,000**		
Contingency (20%) (Rounded Up)			**$764,000**		
Total			**$4,582,000**		

3.4 Summary of Alternatives Evaluation

Table 1 summarizes the results for each alternative with respect to the metrics. The evaluated criteria indicate similarities and differences relative to potential physical process and ecological response.

4 FINAL SELECTED ALTERNATIVE

4.1 Design Description

4.1.1 Overview

Final selected alternatives were presented to the Science Panel during a meeting on December 9th, 2024. On February 24th, 2025, the District provided the panel rationale for selection of Alternative 3 with elements of Alternative 4 to be considered as adaptive management. At the March 26th Science Panel meeting, this approach was confirmed with the understanding that the Science Panel would review the specific success criteria developed as part of this report (described below in Section 4.4). As described in Section 3.2, this alternative is designed to enhance existing steelhead and tidewater goby habitats and create access to additional areas of new habitat by grading pools and alcoves along the existing remnant Lower Meadow Creek Lagoon channels, combined with engineered wood habitat structures and edge-water riparian and brackish marsh plantings (Figure 16). The 30% designs for Alternative 3 (hereafter referred to as "the Project") are shown in Appendix G. The Project design includes a project footprint of 1.7 acres, an excavation footprint of 1.37 acres, a maximum excavation depth of 9 ft, and an excavation volume of 9,010 cubic yards.

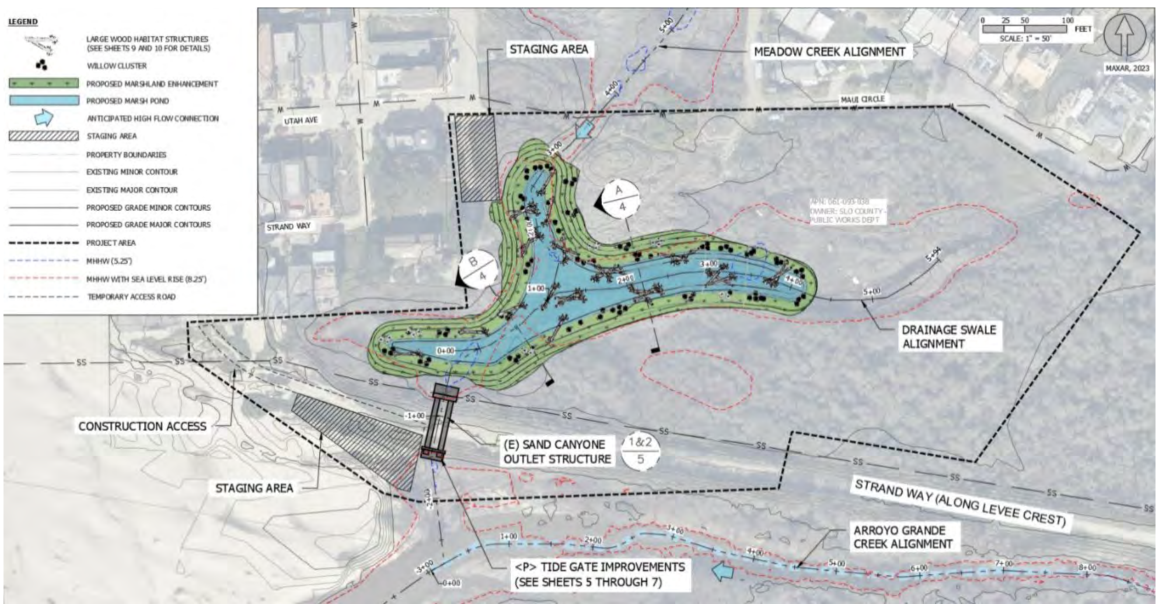


Figure 16. Meadow Creek Lagoon Enhancement Project – 30% Design – Plan.

4.1.2 Grading geometry

The Meadow Creek Lagoon enhancement features grading to create added depth in Meadow Creek Lagoon. Depths for this design were selected based on meeting steelhead juvenile and fry rearing depth and velocity criteria and were hydraulically modeled to confirm that the Alternative 3 planform increases suitable habitat. Figure 17 and 18 show profile and typical section views of the proposed grading plan in Meadow Creek Lagoon.

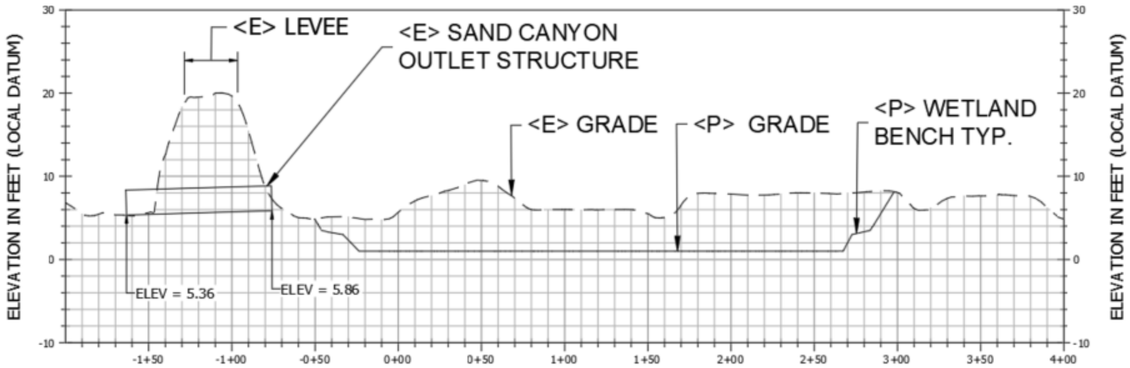


Figure 17. Meadow Creek Lagoon Enhancement Project – 30% Design – Profile.

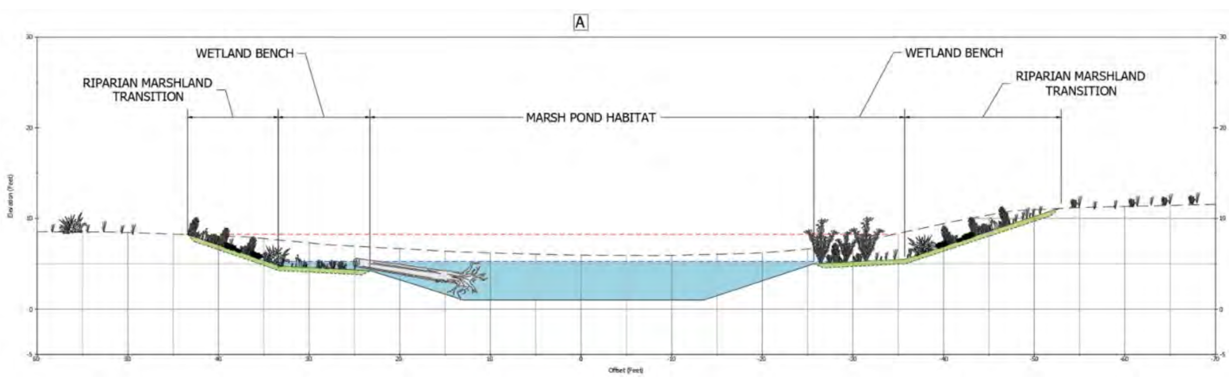


Figure 18. Meadow Creek Lagoon Enhancement Project – 30% Design – Typical section.

4.1.3 Self-regulating tide gate

The Project includes replacing the eastern Sand Canyon outlet structure flap gates with a side-hinged self-regulating gate (SRG) (e.g., Figure 19). During the 60% design phase it will be determined if the western culvert with flap gate will either be kept as-is or replaced with a newer gate to maintain adequate drainage of Meadow Creek Lagoon during flood conditions. The SRG is designed to avoid increases in flooding in Lower Meadow Creek Lagoon, enhance hydrological exchange, and enhance fish movement between Lower Meadow Creek Lagoon and Arroyo Grande Lagoon. Side-hinged tide gates are generally more fish-friendly than traditional top-hinged (flap) gates because they create a consistent depth column of water when open. This allows the gate to meet passage criteria for fish more readily, when adequate water levels are present, and may result in better water circulation properties than a top hinged gate.

Figure 19. Meadow Creek Lagoon Enhancement Project – 30% Design – Example of a self-regulating side hinge gate.

Side hinged gates do not require electricity and instead operate based on hydraulic valves, lines, and floats which force the gates open and closed under set water levels. No structural changes (e.g., size or height) to the two culverts comprising the Sand Canyon outlet structure are proposed. The invert of the culverts cannot be lowered due to the presence of the Wastewater Treatment plant outfall pipe as previously described in Section 3.2.2.

To evaluate the fish movement and hydrologic exchange potential between the two lagoons during lower flow conditions, Stillwater Sciences analyzed available stage data from January 2017 to May 2023 for both Arroyo Grande Lagoon and Lower Meadow Creek Lagoon, as described in Section 3.2.2. This analysis is sufficient to inform the 30% designs described here, and additional analysis to refine operational water levels and timing will be conducted for the 65% design phase using all available stage data at that time.

4.2 Construction

4.2.1 Construction period, methods, and impacts

In general, construction windows for lagoon projects tend to be narrow, with biological constraints as well as seasonal fluctuations in lagoon water levels governing timing and pace of construction. The construction period for Meadow Creek will likely be based around avoiding impacts to steelhead, California red-legged frog, and other aquatic organisms. The standard construction period for in-water work projects is July 15th through October 15th. Project windows may need to be skewed toward spring to avoid high water levels due to mouth closure in Arroyo Grand Creek.

Construction will be achieved by creating temporary access routes and/or crossings and using low ground pressure (LGP) dump trucks and small, LGP excavators and dozers. Temporary access routes are anticipated along the levee, and through the existing marsh and riparian corridor on the western edge of the site. Construction habitat fencing may be used to isolate and protect terrestrial habitats during staging in upland areas. Biological impacts resulting from Project construction are intended to be temporary based on careful isolation and relocation measures and the use of low ground pressure equipment.

Construction will include dewatering and excavation within Meadow Creek Lagoon and disposal of dredged materials offsite. Depending on the prior winter season, water from upper Meadow Creek may need to be managed via isolation, screening and pumping.

Installation of self-regulating tide gates will require temporary coffer dams on the Arroyo Grande Creek Lagoon side of the levee to create enough space for equipment to mount the self-regulating tide gate.

4.2.2 Quantities and cost estimate

Construction quantities and cost estimate were originally developed based on 30% designs of Alternative 3 and are revised for the Project based on more recent projected construction costs (Table 5).

Table 5. Planning level cost estimate for the Project.

Description	Quantity	Unit	Unit Cost	Cost
Mobilization/Demobilization	1	LS	$90,000.00	$90,000
SWPPP	1	LS	$29,200.00	$29,200
Clearing and Grubbing	1.74	ACRE	$16,000.00	$27,900
Temporary Access Roads	260	CY	$21.00	$5,500
Dewatering and Water Management	1	LS	$33,800.00	$33,800
Exclusionary Fencing	2300	LF	$27.00	$62,100
Rough Grading and Disposal	9006	CY	$42.00	$378,300
Fine Grading	908	CY	$58.00	$52,700
Log and Hardware Import	28	EA	$2,500.00	$70,000
Ballast Rock Import	56	TONS	$506.00	$28,400
Wood Structures - Installation	28	EA	$5,843.00	$163,700
Upland Seeding with Mulch	0.375	ACRE	$15,900.00	$6,000
Wetland Bench Plantings	2615	PLUGS/CONTAINER	$13.00	$34,000
Tide Gate Import and Installation	2	EA	$275,000.00	$550,000
Erosion Control	1	LS	$65,000.00	$65,000
Engineering Construction Support	1	LS	$100,000.00	$100,000
Maintenance and Monitoring - 5yr	5	EA	$65,000.00	$325,000
SubTotal				**$2,021,600**
Contingency (20%)				**$404,400**
Total				**$2,426,000**

4.3 Operation and Maintenance

4.3.1 Self-regulating tide gate

It is anticipated that operations and maintenance at the Sand Canyon outlet structure will not change significantly from existing conditions. The Meadow Creek Lagoon side will require cleaning of the existing trash rack. The Arroyo Grande Creek Lagoon side will likely require monitoring for the build-up of sediment due to sedimentation in the lagoon and wind-transport (dune migration) of sand from the beach. The tide gate will require annual inspection of its hydraulic systems and may also require adjustments to its operating range based on outcomes of monitoring and adaptive management.

4.3.2 Sediment considerations

As described in Section 3.2.4.3, sediment transport was not modeled for Alternative 3 because it is assumed that there is little sediment input from Meadow Creek, which is a small, highly urban watershed that also has an additional outlet to the ocean at Carpenter Creek (see Figure 1). No additional sediment maintenance actions are proposed. It is assumed that current routine maintenance of the existing tide gate, including monitoring and removing sediment in the immediate area around the Sand Canyon outlet structure would continue. Routine maintenance is anticipated to include:

- Monthly visual inspection of the entire structure for signs of wear, damage, or corrosion (especially rust on metal parts). Check for loose bolts, screws, or structural components and tighten them as needed.
- As needed, remove accumulated sediment, mud, algae, leaves, and debris from around the gate, hinges, and the channel area.
- Periodically (around every 6-12 months) apply a suitable, heavy-duty lubricant (e.g., marine-grade grease or silicone oil) to all moving parts, including hinges, pins, and any operating mechanisms, to reduce friction and prevent rust.
- Monthly fully open and close the gate to ensure smooth operation and prevent it from getting stuck or unresponsive.

4.4 Monitoring and Adaptive Management

A Habitat Monitoring Plan (HMP) will be developed and included in final designs for the Project. The HMP will describe that following implementation of the Project, monitoring will be conducted to evaluate its success. Monitoring will be conducted to evaluate the "restoration goal" as stipulated in the RPA 3 (see Section 1.1), including:

Juvenile and smolt steelhead suitable rearing habitat, defined as:

- Rearing habitat (water depths > 1.6 ft to 4.0 ft; water velocity < 1 ft/second [sec]),
- Deep water refugia (water depths > 4.0 ft and water velocity < 1 ft/sec),
- Cover (e.g., perimeter of riparian edges), and
- Habitat complexity (e.g., number of wood habitat structures).

Restored connectivity between Meadow Creek and Arroyo Grande Creek Lagoons, defined as:

- Fish movement, and
- Hydrologic exchange at lower flows.

Monitoring will be conducted prior to and following construction. Post-construction monitoring will be conducted at least 12 months following implementation (and not more than 18 months), to ensure full implementation of Project from a range of hydraulic conditions prior to monitoring. During each monitoring event suitable habitat for smolt and rearing steelhead will be delineated on an aerial image collected by an unmanned aircraft system (UAS) above the Project site. Monitoring will be conducted during typical winter and summer flow and water surface elevation conditions.

A two-person crew will map suitable habitat for steelhead during each monitoring effort based on the mapping criteria described above. Each mapped polygon will represent an area that meets all of the habitat requirements (depth, velocity, cover, etc.). Polygon delineation will use a pre-determined color (or style) to differentiate between life stages being mapped. Depth and velocity will be measured with a topset wading rod and flow velocity meter (e.g., Marsh-McBirney Flowmate 2000).

Following 12 months of operation, the amount of time that the gates are open or closed will be evaluated in comparison with water surface elevation within both AG and Meadow Creek lagoons. During times when the gate is open, hydrologic exchange will be assumed to occur. During periods that the gate is open with suitable water depths for fish passage, the potential for fish migration will be assumed to have occurred. The Project will be deemed "successful" if, following implementation, restoration goals of the project, and at least 75% of the predicted increase in suitable habitat is realized, as summarized in Table 6.

Table 6. Summary of monitoring success criteria for the Project.

Metric	Existing Condition	Anticipated Outcome	*Success Criteria*
Suitable rearing habitat during winter (ft^2)	~36,119	~63,706	*47,780*
Suitable rearing habitat during summer (ft^2)	~3,619	~45,677	*34,258*
Deep-water refugia during winter (ft^2)	~0	~36,977	*27,733*
Deep-water refugia during summer (ft^2)	~0	~0	*~0*
Hydrologic Exchange	Limited	Improved	*Improved*
Fish Movement	Limited	Improved	*Improved*

Following monitoring efforts, results will be summarized and provided as a technical memo to the Science Panel. If success criteria are achieved, the Meadow Creek Restoration Project will be assumed to have achieved the goals of RPA sub-element 3. If success criteria are not achieved, the District will consider appropriate maintenance or modifications to the project, pursuant to the Project HMP in consultation with the permitting agencies. This could include additional large woody debris features, additional excavation, or other efforts to improve suitable habitat for steelhead, and connectivity between Meadow Creek Lagoon and Arroyo Grande Creek Lagoon, as described as goals of RPA sub-element 3.

5 REFERENCES

Althouse and Meade, Inc. 2011. Final Report for the Meadow Creek Water Quality Monitoring Project, Grover Beach San Luis Obispo County, California. Prepared for Coastal San Luis Resource Conservation District.

Caltrans (California Department of Transportation). 2016. Tide gates: technical and ecological considerations. Prepared by Caltrans, Division of Research, Innovation and System Information.

Cannon. 2012a. Meadow Creek Lagoon Bathymetric Survey DWG files.

Cannon. 2012b. Meadow Creek Lagoon Bathymetric Survey Map Exhibit.

Cannon. 2017. Arroyo Grande Lagoon Bathymetric Survey DWG file.

Central Coast Aerial Mapping. 2021. AG Creek Flooding Project EXT 210423 DWG file.

Cleveland Biological. 2020. California red-legged frog survey report. Prepared for California Department of Parks and Recreation, Oceano Dunes District, Off-highway Motor Vehicle Recreation Division.

Cleveland et al. 2019. California Red-Legged Frog Survey Report. Prepared for CA Department of Parks and Recreation, Oceano Dunes District, Off-highway Motor Vehicle Recreation Division.

Coastal San Luis Resource Conservation District. 2013. Sand Canyon Outlet structure alternatives analysis. Prepared for San Luis Obispo County Flood Control and Water Conservation District.

Daniels, M., D. Frank, R. Holloway, B. Kowalski, P. Krone-Davis, S. Quan, E. Stanfield, A. Young, and F. Watson. 2010. Evaluating good water quality habitat for steelhead in Carmel Lagoon: fall 2009. Publication No. WI-2010-03. The Watershed Institute, California State Monterey Bay.

ESA PWA. 2013. Arroyo Grande Lagoon interim sandbar management plan. Prepared for County of San Luis Obispo Department of Public Works. October 9, 2013.

Moyle, P. B. 2002. Inland fishes of California. Revised edition. University of California Press, Berkeley.

Rischbieter, D. 2009a. Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary 2008 Monitoring Report. California State Parks.

Rischbieter, D. 2009b. Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary 2009 Monitoring Report. California State Parks.

Rischbieter, D. 2016. Arroyo Grande Lagoon and Adjacent Waters Fishery and Aquatic Resources Summary 2015 Monitoring Report. California State Parks.

Rischbieter, D. 2017. Arroyo Grande Lagoon and Adjacent Waters Fishery and Aquatic Resources Summary 2016 Monitoring Report. California State Parks.

SSLOC (South San Luis Obispo County Sanitation District). 1979. Ocean Outfall Engineering Plan and Profile. Prepared by the South San Louis Obispo County Sanitation District, California.

SSLOC. 1997. Ocean Outfall Engineering Plan and Profile. Prepared by the South San Louis Obispo County Sanitation District, California.

Stillwater Sciences. 2022. Meadow Creek Lagoon Existing Conditions, Technical Memorandum. Prepared by Stillwater Sciences, Morro Bay, California for the San Luis Obispo County Water Conservation and Flood Control District, San Luis Obispo, California.

Terra Verde. 2012a. Biological resources assessment Meadow Creek Lagoon. Prepared for San Luis Obispo County Flood Control and Water Conservation District. October 2012.

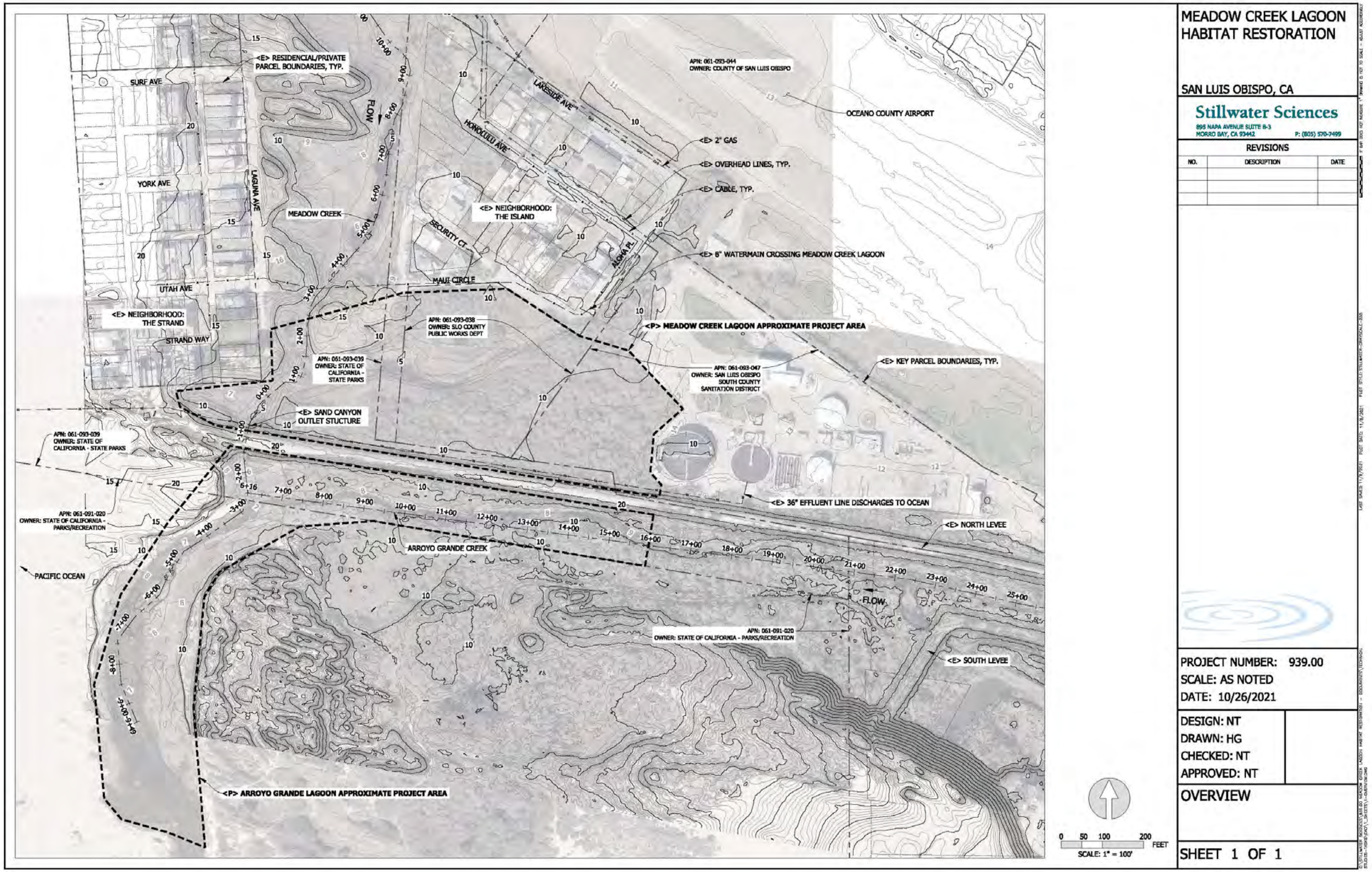
Terra Verde. 2012b. An Analysis of the Geographic Extent of Regulated Waters and Wetlands in the Meadow Creek Lagoon. Prepared for San Luis Obispo County Flood Control and Water Conservation District. December 2012.

Terra Verde. 2018. Application for Emergency Permit Pursuant to Section 30624(a) of the Coastal Act for the Oceano Community Service District Emergency Waterline Replacement Project, Oceano, California. April.

Appendices

Appendix A

Base Map


MEADOW CREEK LAGOON HABITAT RESTORATION
SAN LUIS OBISPO, CA
Stillwater Sciences
895 NAPA AVENUE SUITE B-3
MORRO BAY, CA 93442
P: (805) 570-7499
REVISIONS
NO.
DESCRIPTION
DATE
PROJECT NUMBER: 939.00
SCALE: AS NOTED
DATE: 10/26/2021
DESIGN: NT
DRAWN: HG
CHECKED: NT
APPROVED: NT
OVERVIEW
SHEET 1 OF 1
SCALE: 1" = 100'
FEET
<E> RESIDENCIAL/PRIVATE PARCEL BOUNDARIES, TYP.
SURF AVE
YORK AVE
UTAH AVE
LAGUNA AVE
STRAND WAY
<E> NEIGHBORHOOD: THE STRAND
MEADOW CREEK
FLOW
LAKESIDE AVE
HONOLULU AVE
SECURITY CT
ALOHA PL
MAUI CIRCLE
<E> NEIGHBORHOOD: THE ISLAND
APN: 061-093-044 OWNER: COUNTY OF SAN LUIS OBISPO
OCEANO COUNTY AIRPORT
<E> 2" GAS
<E> OVERHEAD LINES, TYP.
<E> CABLE, TYP.
<E> 8" WATERMAIN CROSSING MEADOW CREEK LAGOON
<P> MEADOW CREEK LAGOON APPROXIMATE PROJECT AREA
APN: 061-093-038 OWNER: SLO COUNTY PUBLIC WORKS DEPT
APN: 061-093-039 OWNER: STATE OF CALIFORNIA - STATE PARKS
APN: 061-093-047 OWNER: SAN LUIS OBISPO SOUTH COUNTY SANITATION DISTRICT
<E> KEY PARCEL BOUNDARIES, TYP.
<E> SAND CANYON OUTLET STUCTURE
APN: 061-093-039 OWNER: STATE OF CALIFORNIA - STATE PARKS
APN: 061-091-020 OWNER: STATE OF CALIFORNIA - PARKS/RECREATION
<E> 36" EFFLUENT LINE DISCHARGES TO OCEAN
<E> NORTH LEVEE
ARROYO GRANDE CREEK
PACIFIC OCEAN
FLOW
APN: 061-091-020 OWNER: STATE OF CALIFORNIA - PARKS/RECREATION
<E> SOUTH LEVEE
<P> ARROYO GRANDE LAGOON APPROXIMATE PROJECT AREA

Appendix B

South San Luis Obispo County Sanitation District Letter

SOUTH SAN LUIS OBISPO COUNTY SANITATION DISTRICT

Post Office Box 339, Oceano, California 93475-0339
1600 Aloha Oceano, California 93445-9735
Telephone (805) 489-6666 FAX (805) 489-2765
www.sslocsd.org

April 21, 2022

Mr. Eric Laurie
Project Engineer
Public Works
County of San Luis Obispo

Subject: Formal Concern Regarding Meadowcreek Lagoon Restoration Project Alternatives

Mr. Laurie:

The South San Luis Obispo County Sanitation District has been engaged in the County/Flood Control District's pursuit of restoration of the Meadow Creek Lagoon to enhance local Steelhead habitat. The District strives to remain a supportive and collaborative partner in these endeavors.

As discussed in the April 7th, 2022, science panel meeting several of the alternatives and modified alternatives include relocating the north levy. The discussed levy relocation scenarios would result in critical District infrastructure being exposed or relocated and reconfigured to be a force-main (pumped).

The District has reviewed and considered the impacts that would arise from the various alternatives and has determined that any alternatives that remove levy protection of the District outfall line or that requires the District to construct, and or operate a more complex and energy intensive force-main(pumped) outfall as not being reasonable or practical for the District to agree to.

Additionally, the District would like to communicate concern in regard to the levy's relocation toward the District's treatment facility. This relocation could result in increased flood frequency and magnitude for the Treatment Plant and our neighbors. The District acknowledges that detailed hydrologic modeling could confirm whether this concern remains valid.

Thank you for your consideration,

Jeremy Ghent
District Administrator

Appendix C

cbec Technical Memo: Hydraulic Modeling of Setback Levee Alternatives

Hydrology | Hydraulics | Geomorphology | Design | Field Services

TECHNICAL MEMORANDUM

Date:	May 31, 2022
To:	Aleks Wydzga, Stillwater Sciences
From:	Greg Kamman, Haley Tupen and Chris Hammersmark
Project:	21-1007-3: Meadow Creek Lagoon Habitat Restoration Project
Subject:	Hydraulic Modeling Results of Levee Setback Alternative

1 Purpose and Approach

cbec has completed a hydraulic modeling analysis to evaluate changes in flood risk associated with a proposed levee setback alternative. The levee setback alternative evaluated includes a setback levee configuration with outfall water control structure sized and constructed identical to the existing Sand Canyon Outfall structure (see Figure 1). Using the calibrated existing 2D hydraulic model as the foundation, cbec developed a hydraulic model representative of the levee setback alternative. A levee setback alternative terrain model was developed by Stillwater and provided to cbec for integration into the hydraulic model.

The model was used to simulate water levels and inundation areas for the 2-, 5-, and 10-year recurrence design floods with a closed Arroyo Grande Lagoon inlet and high ocean tide[1]. Peak inflow rates for design flood simulations are presented in Table 1. A comparison of levee setback and existing conditions simulated water surface elevations and inundation areas were used to identify and quantify changes in flood risk in upper Meadow Creek Lagoon.

Table 1: Maximum Inflow Rates (cfs) for Simulated Floods

Model Reach	Flood Recurrence Interval		
	2-year	**5-year**	**10-year**
Arroyo Grande Creek (AGC)	498	1,744	3,360
Los Berros Creek (LBC)	283	992	1,911
AGC + LBC	781	2,736	5,271
Meadow Creek	109	133	256

[1] This scenario is representative of late fall inlet conditions and flood magnitudes, with an inlet invert elevation of 11.0 feet NAVD88 and static high tide elevation of 5.25 feet NAVD88.

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2 Hydraulic Modeling Results

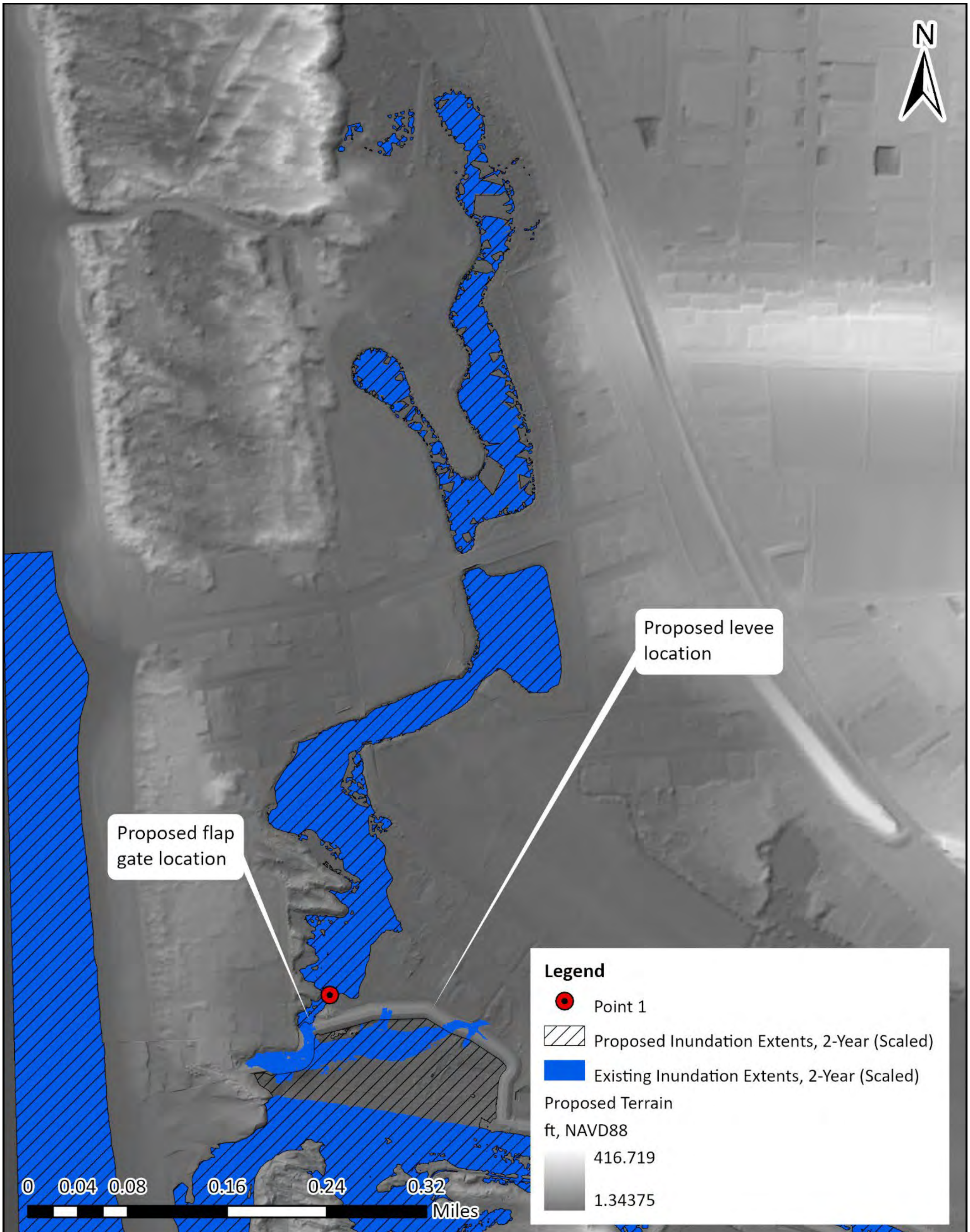
Simulated maximum inundation areas under existing and the levee setback alternative (Proposed Inundation Extents) conditions within the project area are overlain in Figures 1 through 3 for the 2-, 5-, and 10-year design floods, respectively. Except for increased inundation in Meadow Creek Lagoon south of the setback levee, changes in inundation area appear small to none at the map scale used in Figures 1 through 3. However, Figures 4 through 6 present color-coded increases in water surface elevation under the levee setback condition versus those under existing conditions. These results indicate a small but consistent incremental rise in Meadow Creek Lagoon water surface elevations (WSE) north of the setback levee. The increases in WSE are also illustrated in the simulated design flood hydrographs presented in Figures 7 through 9, which plot simulated WSE immediately upstream of the levee setback culvert (Point 1 on Figures 1 through 6). The maximum WSE change (increase) between levee setback and existing conditions for each design flood simulation are provided in Table 2. These results indicate the net change in WSE increases as design flood magnitude increases. Thus, we would expect even greater increases in upper Meadow Creek Lagoon WSE under larger magnitude storms.

Table 2: Increase in Maximum WSE in Meadow Creek Lagoon under the Levee Setback Alternative

Flood Recurrence Interval	Feet	Inches
2-year	0.07	0.88
5-year	0.09	1.09
10-year	0.18	2.17

Note: WSE hydraulic model results at Point 1 on Figures 1-6.

Hydraulic model results were used to evaluate the potential for modifying the culverts through the setback levee (e.g., increase size or invert elevations) to mitigate for the increased WSE without the aid of pumping. However, simulation results indicate that water surface elevations on Arroyo Grande Creek or downstream side of the setback levee rise sooner and remain higher than those on the upstream (north) side of the levee through passage of the flood. This creates backwater conditions that close the tide gates through the rise and peak in storm flow, which would negate any potential increase in culvert flow conveyance associated with increasing the culvert peak capacity or shifting invert levels. At best, culvert improvements (e.g., side-hinge tide gates that open sooner) could accelerate post-storm drainage from Meadow Creek Lagoon, but that won't mitigate the increased peak WSE.



Notes:

cbec

Meadow Creek Restoration

Existing and proposed inundation extents (2-year)

Project No. 21-1007 | Created By: HT | **Figure 1**

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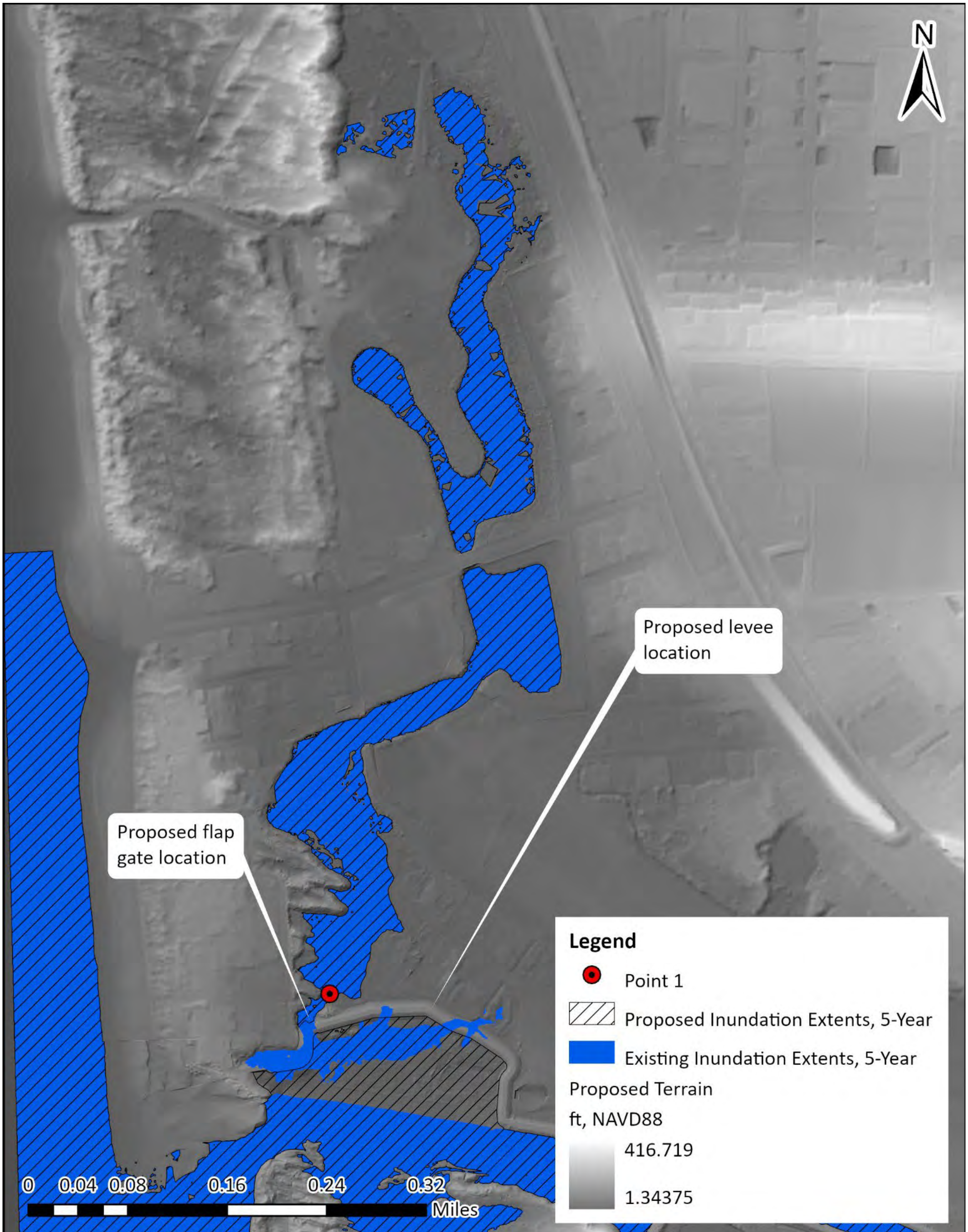

Notes:	cbec	*Meadow Creek Restoration* **Existing and proposed inundation extents (5-year)**		
		Project No. 21-1007	Created By: HT	**Figure 2**

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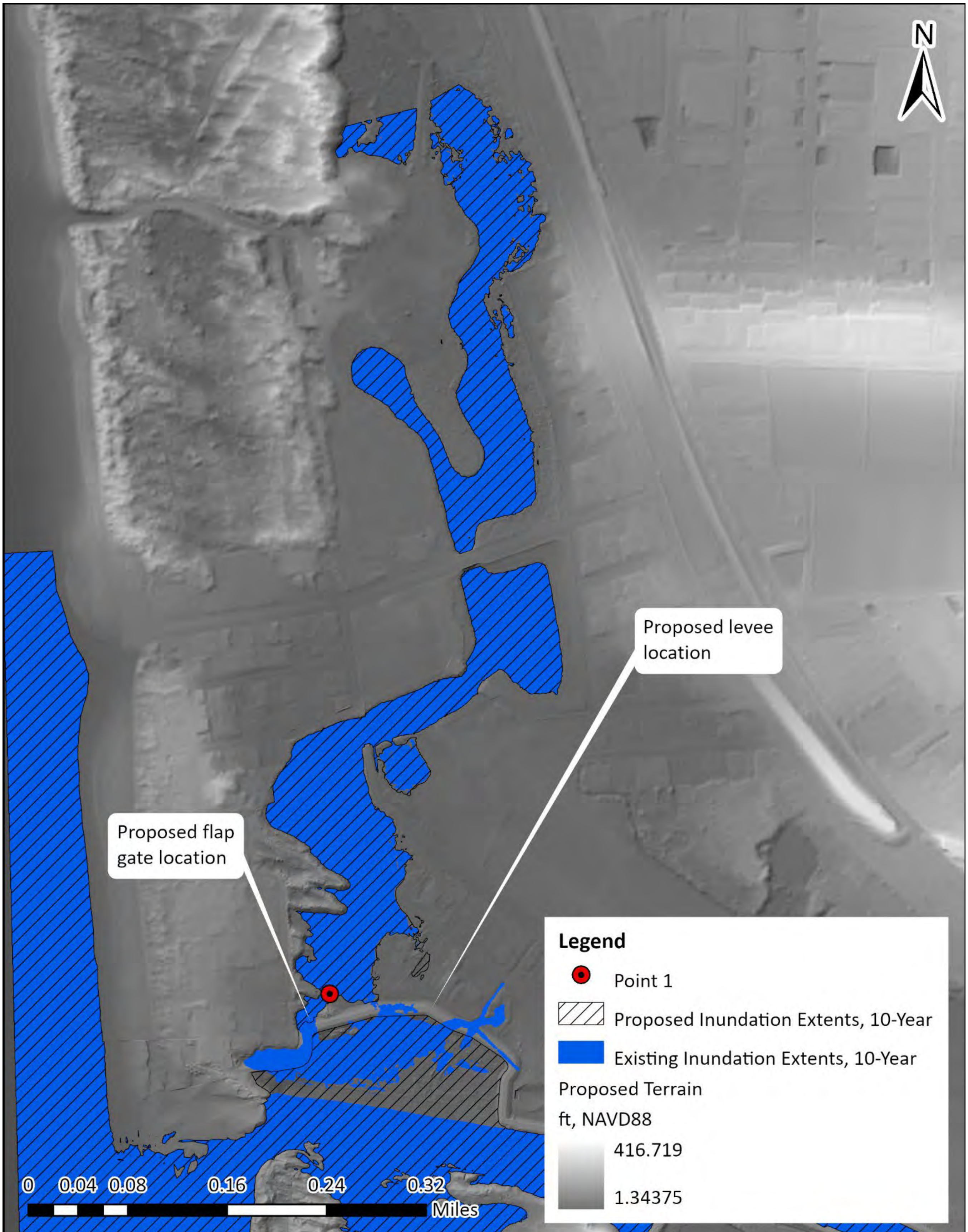

Notes:	cbec	*Meadow Creek Restoration* **Existing and proposed inundation extents (10-year)**		
		Project No. 21-1007	Created By: HT	**Figure 3**

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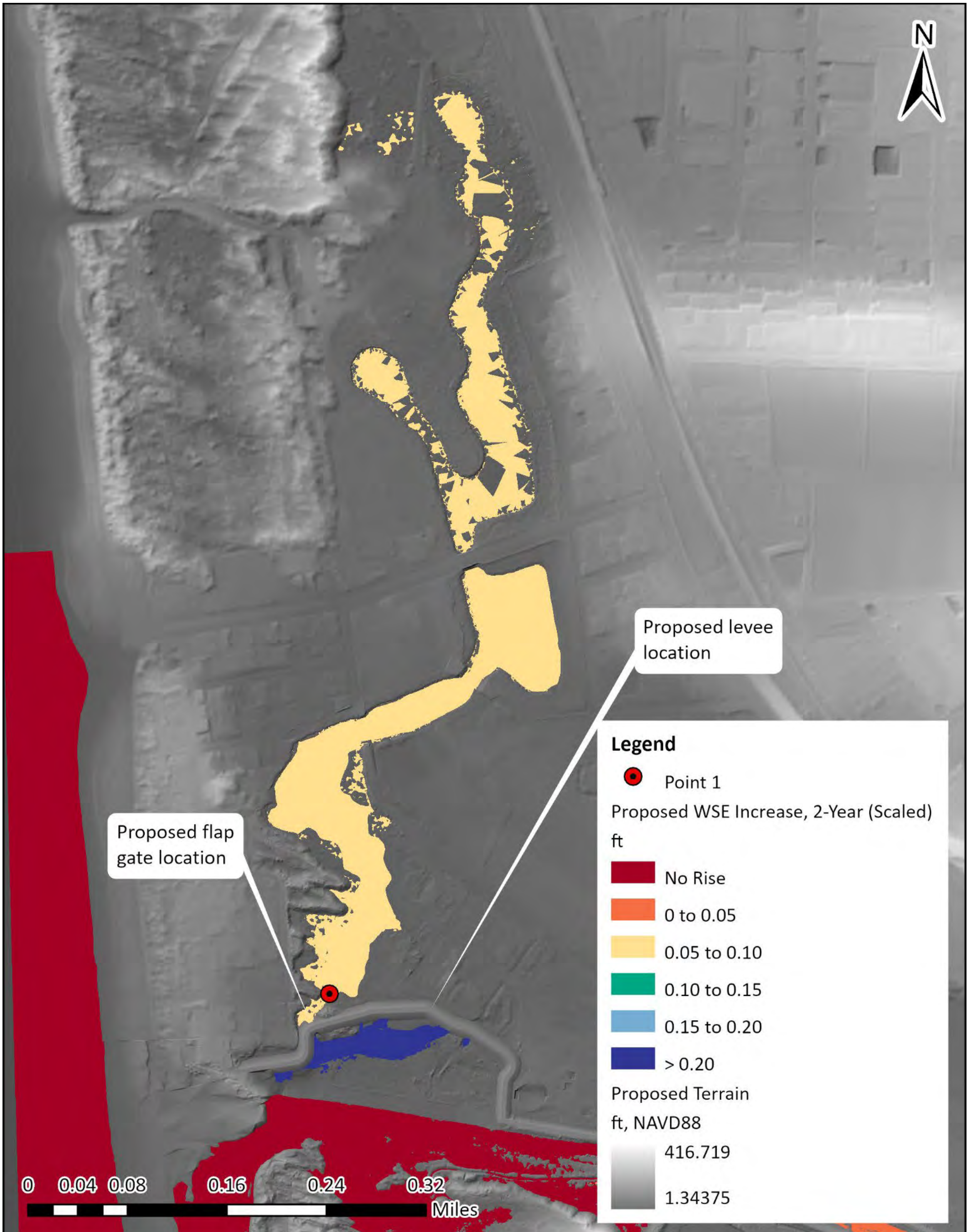
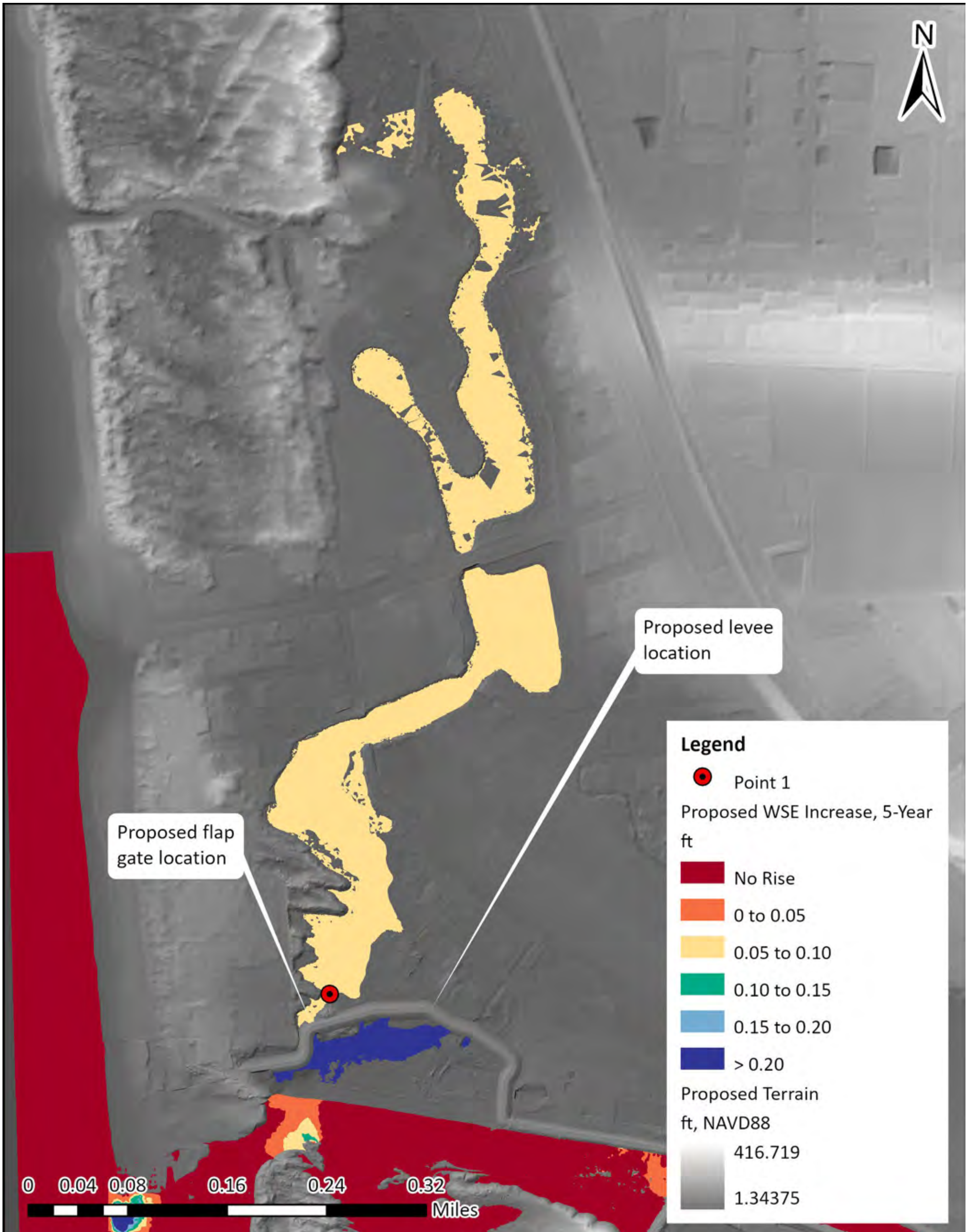


Notes:	cbec	*Meadow Creek Restoration* **Existing vs. proposed WSE differences (2-year)**		
		Project No. 21-1007	Created By: HT	**Figure 4**



Notes:	cbec	*Meadow Creek Restoration* **Existing vs. proposed WSE differences (5-year)**		
		Project No. 21-1007	Created By: HT	**Figure 5**

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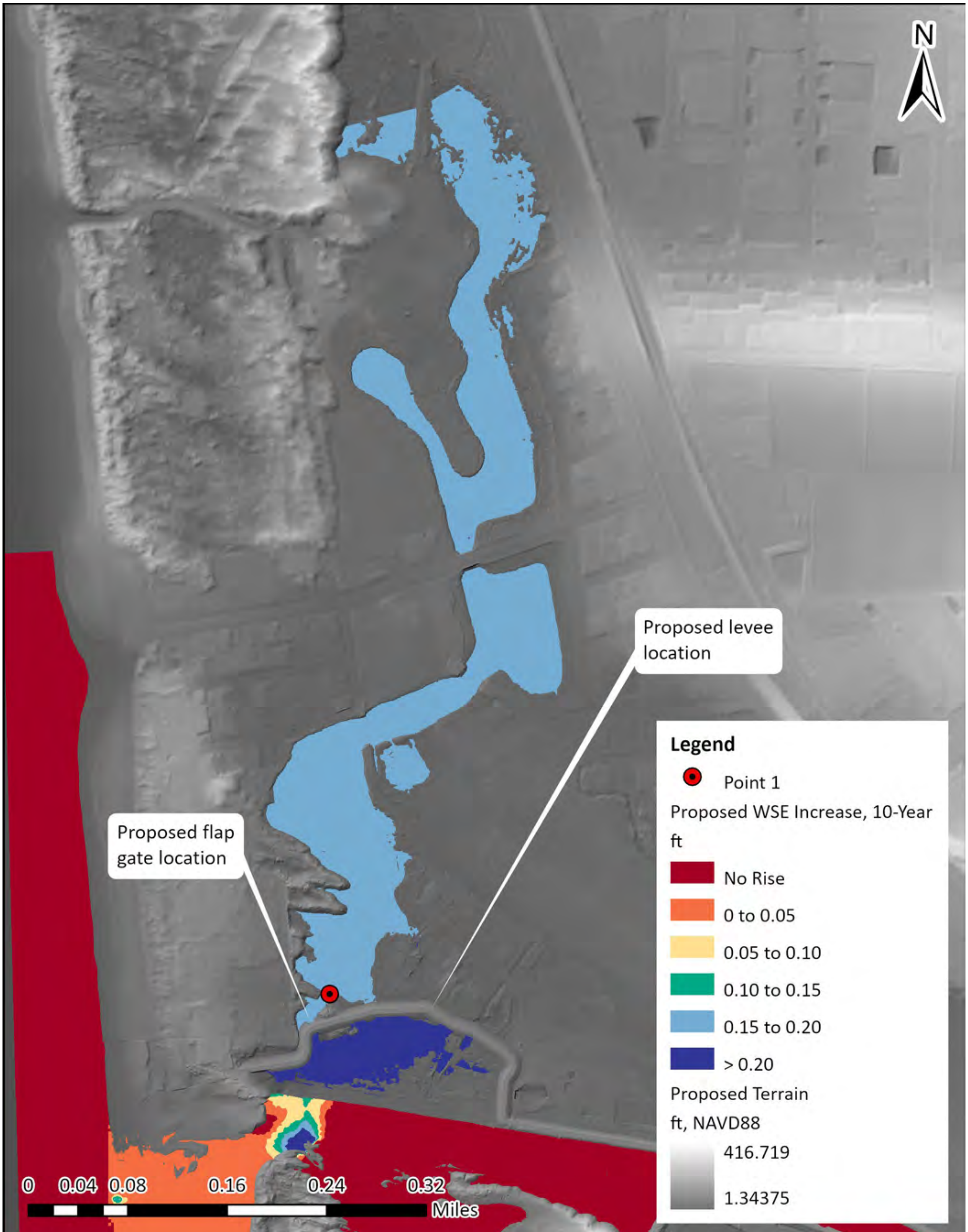

Notes:	cbec	*Meadow Creek Restoration* **Existing vs. proposed WSE differences (10-year)**		
		Project No. 21-1007	Created By: HT	**Figure 6**

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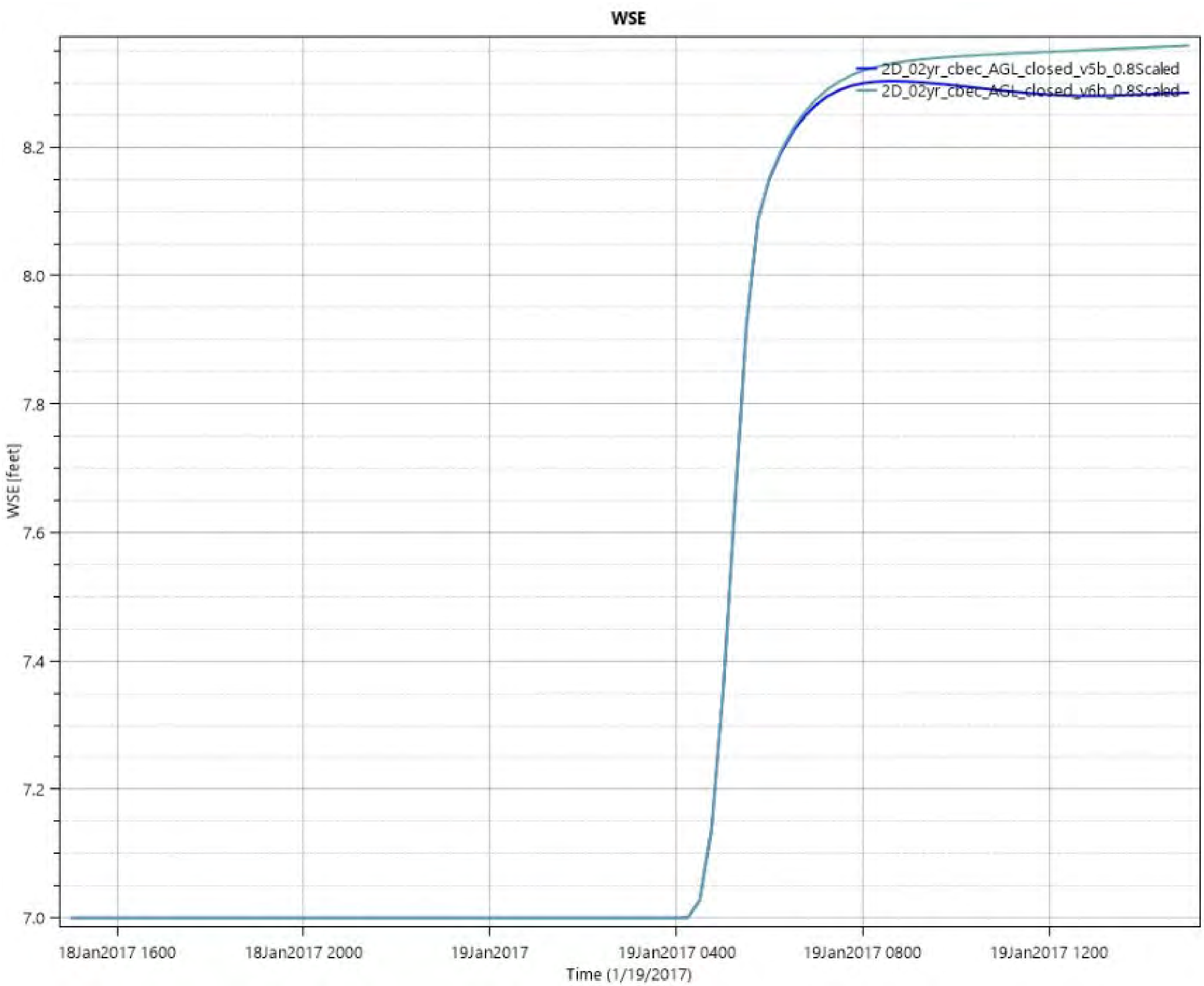
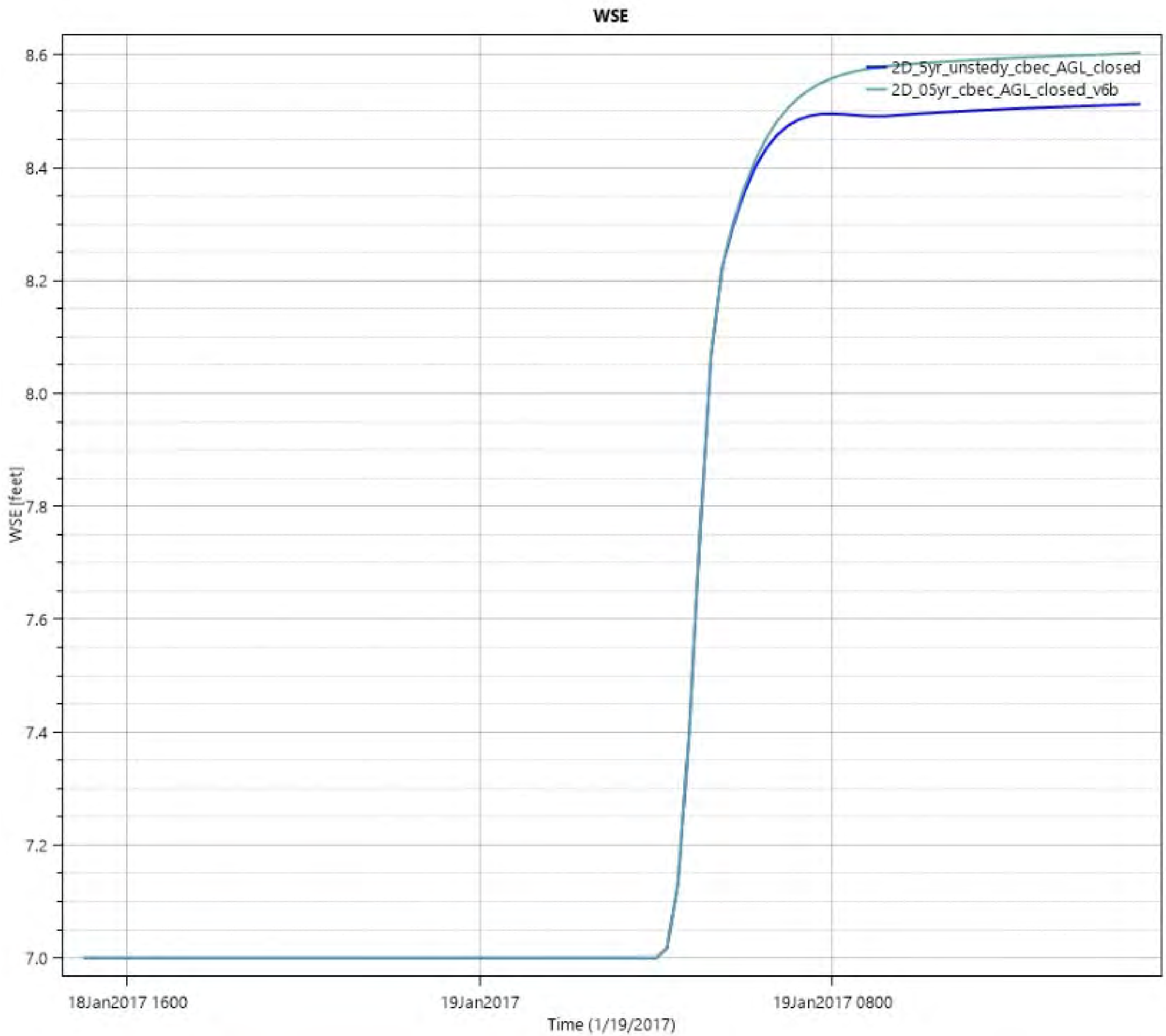
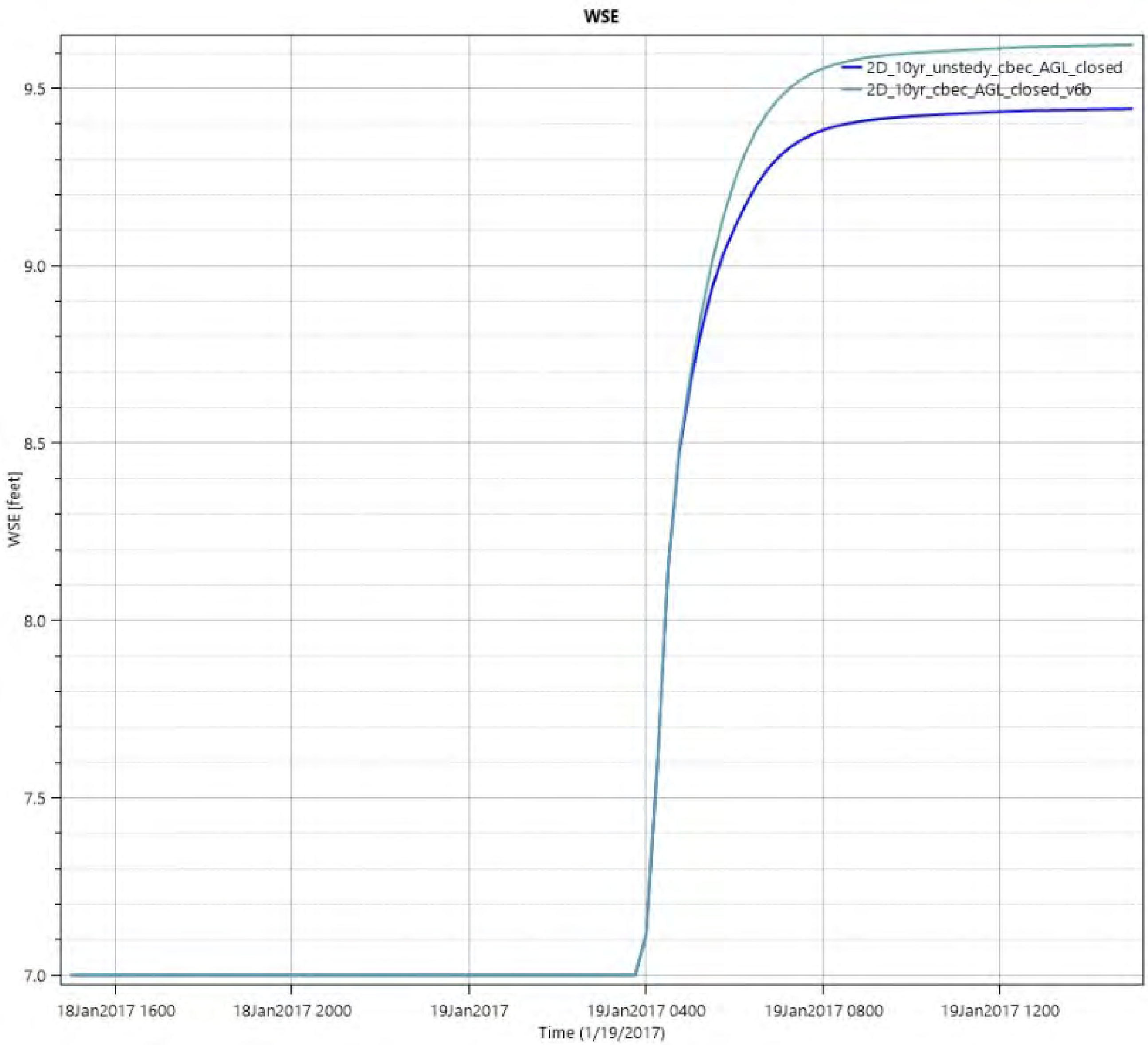


Notes:	cbec	*Meadow Creek Restoration* **Stages at Point 1 (2-year)**		
		Project No. 21-1007	Created By: HT	**Figure 7**



Notes: Existing (dark blue) and proposed (light blue) conditions	cbec	*Meadow Creek Restoration* **Stages at Point 1 (5-year)**	
		Project No. 21-1007	Created By: HT	**Figure 8**



Notes: Existing (dark blue) and proposed (light blue) conditions		*Meadow Creek Restoration* **Stages at Point 1 (10-year)**		
		Project No. 21-1007	Created By: HT	**Figure 9**

Appendix D

cbec Technical Memo: Hydraulic and Sediment Transport Modeling of Alternatives 3 and 4

Hydrology | Hydraulics | Geomorphology | Design | Field Services

TECHNICAL MEMORANDUM

Date:	February 23, 2024
To:	Aleks Wydzga, Stillwater Sciences
From:	Greg Kamman, cbec eco engineering
Project:	21-1007-4: Meadow Creek Lagoon Habitat Restoration Project
Subject:	Hydraulic Analysis of Proposed Alternatives

1 Introduction and Purpose

This Technical Memorandum presents the model development methods and simulation results associated with hydraulic analysis of project Alternatives 3 and 4. This work was completed to assist in evaluating the feasibility of Alternatives in meeting project objectives. Using the calibrated existing conditions 2D hydraulic model as the foundation, cbec developed a single hydraulic model combining the geometry of project Alternatives 3 and 4. The model was used to evaluate design concepts to maximize desired ecological conditions without adversely impacting flood conveyance capacity. The HEC-RAS sediment transport module was also used to simulate sediment transport and deposition patterns on Arroyo Grande Creek and lagoon. Simulation results include: water depths and wetland/lagoon inundation areas; flow velocity; shear stress; and sediment erosion and deposition patterns under a suite of design flood flow events as well as winter and spring baseflow periods. The model was also used to evaluate impacts of a future sea level rise scenario.

2 Proposed Alternatives Model Development

Proposed project Alternatives are described in the December 2022 report entitled, "Meadow Creek Lagoon Habitat Restoration Project, Oceano, San Luis Obispo County, California", prepared by the Environmental Programs Division, County of San Luis Obispo Department of Public Works and County of San Luis Obispo Flood Control and Water Conservation District. This Technical Memorandum focuses on the hydraulic analysis of Alternatives 3 and 4. Hydraulic analysis of Alternatives 1 and 2 are presented in cbec's May 31, 2022, Technical Memorandum entitled, "Hydraulic Modeling Results of Levee Setback Alternatives." Because Alternative 3 (located in Meadow Creek Lagoon) and Alternative 4 (located in the mainstem Arroyo Grande Creek) are geographically separated by an intervening levee, there isn't significant influence and interaction of the flow hydraulics and sediment transport between one Alternative area on the other. Therefore, a single hydraulic model was developed that integrates both Alternative components.

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Sections 2.1 through 2.5 describe prior hydraulic models at the site and processes to update with the Alternative 3 and 4 terrain, geometries, structures, and roughness before any new modeling was performed. Peak flow, baseflow, sediment transport, and sea level rise models are detailed in Sections 3, 4, 5, and 6.

2.1 Prior Hydraulic Models

There have been several hydrology and hydraulic studies of Arroyo Grande and Meadow Creeks completed by the County for various programs over the last decade. cbec leveraged a pair of existing modeling tools and data sets from these studies to aide development of an integrated one and two-dimensional (1/2D) HEC-RAS hydraulic model to predict flood water levels for peak flood events of various return periods (including but not limited to the 2- and 100-year return periods) and other physical parameters under existing conditions. Prior models used include ESA's 2016 model of Meadow Creek Lagoon and Waterway's 2021 1/2D model of lower Arroyo Grande Creek. How these models were utilized is described below.

2.2 Topographic/Bathymetric Data

2.2.1 Overview of Elements Incorporated Into Alternative 3/4 Model

Topographic data included in the model come from multiple sources. In order of most recently collected, these include: (1) 2021 LiDAR provided by Cannon Engineering that covers the Arroyo Grande watershed from just upstream of the confluence of Arroyo Grande Creek (AGC) and Los Berros Creek (LBC) extending downstream to the outlet, also covering Meadow Creek Lagoon (MCL) up to Pier Avenue; (2) 2018 LiDAR collected by FEMA which covers the entire watershed and study area; (3) 2017 survey data of Arroyo Grande Creek Lagoon (AGL) collected by Cannon Engineers, extending roughly from the Sand Canyon flap gates to the lagoon outlet; and (4) 2012 bathymetry data for MCL collected by Cannon Engineers extending from Pier Avenue to the Sand Canyon flap gates. The topographic data for Arroyo Grande Creek and Lagoon represents a snapshot in time in a highly dynamic system, but the comparison of relative changes between EG and FG conditions are likely consistent and representative even in a highly variable system. The topography within MCL is more stable over time and representative of long-term conditions.

2.2.2 Workflow of Mosaicking Different Elements

The mosaicking[1] priority of each topographic dataset was done to best capture details of the lagoon bathymetry and overbank areas. All datasets were projected into NAD83 (2011) State Plane CA Zone 5 and vertically referenced to NAVD88. Each dataset was resampled to a 2-foot (ft) cell size and snapped to a common raster grid to avoid shifting during the mosaicking process. First, the 2018 LiDAR was used as a base terrain from which to mosaic the remaining datasets since it had the most extensive coverage and no data gaps. Next, the 2021 LiDAR surface was mosaiced on top, providing more up-to-date elevation

[1] For purposes of this study, mosaicking refers to the combination of the different terrain surfaces (topography and bathymetry) into the most representative and current terrain/bathymetric surface within the model domain.

details on the levees, overbanks, and channel areas. Neither LiDAR dataset contained elevations below the water surface, and therefore the AGL and MCL survey surfaces were added in to provide bathymetry below the waterline.

Owing to the constantly changing topography at the AGL beach outlet and to a lesser extent within MCL, these surfaces were cropped to a smaller extent such that they would mosaic seamlessly into the 2021 LiDAR. To accomplish this, the MCL and AGL surfaces were subtracted from the 2021 LiDAR surface to identify the bank line contour where each surface was within < 0.1 ft of the LiDAR. The bathymetry datasets were then clipped along this contour and mosaiced into the 2021 LiDAR. This has the effect of having the most recent detailed topographic coverage above the waterline that transitions seamlessly into the bathymetry of each lagoon.

2.2.3 Modification of Terrain Layer

Once the terrain was added into HEC-RAS, bridges in MCL were removed through RAS-Mapper's terrain editing tools. These included Pier Avenue, Air Park Drive, and Lakeside Avenue Bridges. Additionally, Meadow Creek Lagoon was burned down to an elevation of 4 ft to represent bathymetry present in the pre-existing one-dimensional (1D) cross sections in the area. This resulting edited terrain represented existing ground (EG) at the site. Figure 1 shows the extent of the EG terrain in relation to the model domain.

cbec received two patch DEM files from Stillwater Sciences detailing proposed terrain modifications north (Alternative 3) and south (Alternative 4) of the MCL/AGL levee. These patch DEM files were mosaicked onto the EG terrain to complete a future grade (FG) terrain scenario including both Alternative 3 and Alternative 4 design grades. Figure 2 shows terrains incorporating EG and FG modifications near the Sand Canyon Outlet Structure.

2.3 Model Geometry (mesh refinements)

The updated HEC-RAS model developed uses a two-dimensional (2D) mesh encompassing MCL, the lowermost reach of AGC, and AGL. The 2D area uses 50 ft cell spacing in most areas with refinement regions of 20-25 ft around the levees, bridges, MCL, and AGL. The 2D model is coupled to the preexisting 2021 Waterways 1D-2D model near the wastewater treatment plant. The bridges inside of MCL and the Sand Canyon flap gates are modeled as full 2D features embedded in the mesh. Figure 3 provides a simplified view of the final model geometry, including rivers, cross sections, boundary conditions, mesh extents, and structural data.

2.4 Roughness Data

Roughness layers for the model were produced using a plant survey from Terra Verde Consulting (2012), data from the USGS's National Land Cover Dataset[2] (NLCD 2019), and manual edits based on aerial imagery to refine roughness areas of channel and bare earth/coastal shrub around AGL. Roughness values at 1D cross sections throughout AGC were manually edited during the model calibration process.

Figure 4 shows the final roughness layer and calibration regions used in all EG simulations. Manning's n values associated with the roughness layer can be seen in Table 1.

Table 1. Final land classification and Manning's n values used during modeling.

Land Classification	Manning's n
Barren Land Rock, Sand, Clay	0.03
Developed, Open Space	0.035
Developed, Low Intensity	0.08
Developed, Medium Intensity	0.12
Developed, High Intensity	0.15
Cultivated Crops	0.05
Shrub, Scrub	0.05
Grassland, Herbaceous	0.04
Hay, Pasture	0.045
Evergreen Forest	0.15
Mixed Forest	0.12
Woody Wetlands	0.07
Emergent Herbaceous Wetlands	0.045
Open Water	0.035

Figure 5 shows large woody elements associated with Alternative 4 FG model geometry. A Manning's n value of n = 0.1 was assigned to these areas during modeled simulations.

2.5 Calibration

The model was re-calibrated to stabilize model runtime errors and ensure seamless transition between geometric elements throughout the domain. Re-calibration included geometry edits like re-aligning bridges, refining the curvilinear mesh in Meadow Creek and Arroyo Grande Lagoons, and tightening up connections between cross sections and 2D overbank areas, among others. Additionally, computation options were revisited and refined to tolerate smaller water surface elevation errors throughout the model.

[2] https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects

The model was calibrated to stages at San Luis Obispo County gages 770 (MCL), 769 (AGL), and 734 (AGC at 22nd St Bridge) by iteratively editing roughness values in 2D areas and AGC cross sections. The final calibrated model was then used as the base setup for all models described in the following sections.

3 Proposed Alternative Peak Flow Analyses

During model development, cbec used the best available data for Arroyo Grande Creek flows. Similarly, cbec used the best available data synthesis methods for Meadow Creek given there is no historic flow monitoring data available.

3.1.1 Development of Arroyo Grande Creek and Los Berros Creek Input Flows

Inflow hydrographs in the AGC watershed were produced using rating curves the County developed for AGC at the 22nd street gage and upstream on Los Berros Creek at Valley Road. Inflows on upper LBC were calculated by applying the rating curve to the calibration event stage data obtained from the County's website[3]. For inflows to upper AGC, the rating curve at 22nd street was used to calculate the flow hydrograph on the mainstem and then the LBC hydrograph was subtracted from these values to calculate the model inflow hydrograph at upper AGC. Location of the County's gages used for rating curve development and model boundary conditions can be seen in Figure 6.

3.1.2 Development of Meadow Creek Lagoon Input Flows

There are no current or historic flow monitoring gages on Meadow Creek from which to estimate peak design flow rates. Therefore, peak design flow estimates were derived using a standard unit area conversion method against the Los Berros Creek gage.

3.1.3 Development of Tidal Boundary Conditions

The outflow boundary condition of the model is a tidal timeseries using data obtained for the NOAA Port San Luis tide station. Tide-elevation data from this station were referenced to NAVD88 and resampled to 15-minute intervals. Low tides during the calibration period dropped below the minimum elevation of the model terrain briefly several times. The controlling outlet invert elevation through the sand barrier is 1.5 ft NAVD88 therefore the lagoon cannot drain below this elevation even when tides drop to negative elevations. The lowest points on the tidal time series were truncated at a base-stage of 1.5 ft NAVD88 to account for this and improve model stability.

[3] https://wr.slocountywater.org/map/?sensor_class=20&view=51a30d03-3991-46af-9d23-7bc0f56a118f

3.1.4 Model Initial Conditions

Model initial conditions in all cases involved 6 hours of warmup time to fill the lagoons and increase streamflow to an appropriate starting level. Initial water levels in AGL and MCL were adopted from November-March average WSE values in Table 2 and increased over the warmup period.

Table 2. Mean seasonal water levels in Meadow Creek and Arroyo Grande Lagoons (2012-2018).

Site	April-June		July-October		November-March	
	Avg WSE	Avg Depth	Avg WSE	Avg Depth	Avg WSE	Avg Depth
Arroyo Grande Lagoon (ID 769)	7.5	0.9	7.0	0.4	8.0	1.4
Meadow Creek Lagoon (ID 770)	7.6	0.4	7.3	dry	7.9	0.7

* Table from Stillwater Sciences, 2022.

3.2 Peak Flow Boundary Conditions

Model boundary conditions consist of three inflow boundaries and one outflow boundary. The inflow boundary conditions are on Meadow Creek Lagoon adjacent to Seabright Avenue, on upper Arroyo Grande Creek near Fair Oaks Avenue, and on Los Berros Creek near Century Lane. The Outflow boundary condition is a tidal stage boundary at the outlet of AGC.

Simulations were completed for a range of flood flow events under varying inlet and tidal boundary conditions. Creek inflow boundary conditions simulated using the HD model included floods having 2-, 5-, 10-, and 100-year recurrent intervals. This suite of 4 storm events is hereafter referred to as the design flows. Table 3 presents the peak design flow magnitudes at inflows to upstream model reaches.

Table 3. Maximum model inflow rates (cfs) for simulated floods.

Model Reach	Flood Recurrence Interval			
	2-year	5-year	10-year	100-year
Arroyo Grande Creek (AGC)	498	1,744	3,360	13,114
Los Berros Creek (LBC)	283	992	1,911	7,459
AGC + LBC	781	2,736	5,271	20,573
Meadow Creek	38	133	256	1,000

Three varying combinations of AGL inlet geometry and tidal conditions were analyzed using the design flows, including: 1) maximum inlet opening and high tide (IO/HT); 2) maximum inlet opening and low tide (IO/LT); and 3) inlet closed and high tide (IC/HT) (see Table 4). The open inlet channel geometry and invert elevation (5.3 ft NGVD88) matches that surveyed in the Cannon 2017 topographic/bathymetric survey of AGL. The closed inlet condition reflects a summer/fall barrier beach profile with an elevation of 11.0 feet NAVD88 as reported in ESA's 2013 report.

Ocean tide levels were held static through each design flow simulation. The high tide simulations used the mean higher high water (MHHW) tidal datum from NOAA's Port San Luis tide station of 5.3-ft NAVD88. Low tide simulations used a value of 1.5-ft NAVD88, which is the minimum elevation of the model terrain. To maintain model stability, tidal elevations should not be lower than the minimum model geometry elevation.

Table 4. Model downstream boundary conditions at Arroyo Grande Creek Lagoon inlet.

Downstream Boundary Condition	Inlet Condition	Inlet Invert Elevation (ft NAVD88)	Tide Level (ft NAVD88)
IO/HT	open	5.3	5.3
IO/LT	open	5.3	-0.08*
IC/HT	closed	11.0	5.3

* - The lowest points on the tidal time series were truncated at a base-stage of 1.5 ft NAVD88 to account for this and improve model stability.

3.3 Peak Flow Simulation Results

Peak WSE results for open inlet, low tide (IO/LT) conditions are summarized in Table 5. Meadow Creek and Arroyo Grande Lagoon water surface elevations presented in tables and hydrographs are for locations just north and south of the Sand Canyon culvert structure, respectively. WSE hydrographs in Arroyo Grande and Meadow Creek Lagoons for all four flow events are shown in Figure 7, Figure 8, Figure 9, and Figure 10.

Table 5. Peak water surface elevations for open inlet, low tide scenarios.

Model Location	Water Surface Elevation (ft)							
	Existing Grade				Future Grade			
	2 yr	5 yr	10 yr	100 yr	2 yr	5 yr	10 yr	100 yr
Meadow Creek Lagoon	8.37	9.21	10.09	16.23	8.37	9.20	10.08	16.25
Arroyo Grande Lagoon	9.95	12.40	14.18	15.78	9.93	12.42	14.26	15.94

Peak WSE results for open inlet, high tide (IO/HT) conditions are summarized in Table 6. WSE hydrographs in Arroyo Grande and Meadow Creek Lagoons for all flow events are shown in Figure 11, Figure 12, Figure 13, and Figure 14.

Table 6. Peak water surface elevations for open inlet, high tide scenarios.

Model Location	Water Surface Elevation (ft)							
	Existing Grade				Future Grade			
	2 yr	5 yr	10 yr	100 yr	2 yr	5 yr	10 yr	100 yr
Meadow Creek Lagoon	8.37	9.21	10.09	16.23	8.37	9.20	10.08	16.25
Arroyo Grande Lagoon	9.95	12.40	14.18	15.79	9.93	12.42	14.25	15.94

Peak WSE results for closed inlet, high tide (IC/HT) conditions are summarized in Table 7. WSE hydrographs in Arroyo Grande and Meadow Creek Lagoons for all flow events are shown in Figure 15, Figure 16, Figure 17, and Figure 18.

Table 7. Peak water surface elevations for closed inlet, low tide scenarios.

Model Location	Water Surface Elevation (ft)							
	Existing Grade				Future Grade			
	2 yr	5 yr	10 yr	100 yr	2 yr	5 yr	10 yr	100 yr
Meadow Creek Lagoon	8.38	9.21	10.10	16.25	8.38	9.21	10.09	16.27
Arroyo Grande Lagoon	12.13	13.37	14.45	15.92	12.13	13.38	14.52	16.07

At all inlet and tidal stage combinations, WSE increases (if any) were present at consistent flows and locations in AGL. FG terrain and roughness additions did not result in any WSE increases along the levee or at the Sand Canyon Outlet Structure during the 2 and 5-year flow events. During all 10-year flow events, FG grading and roughness caused an increase in WSE of < 0.1 ft at both the Outlet Structure and midway along the levee. During all 100-year simulations, these localized increases rose to 0.1 – 0.25 ft. There were no significant changes in WSE differences (FG minus EG) in MCL associated with Alternative 3 under any of the design flow simulations.

A plan view of WSE differences (FG minus EG) along AGC and AGL for open inlet, low tide (IO/LT) scenarios can be seen in Figure 19 and Figure 20. Differences for open inlet, high tide (IO/HT) scenarios can be found in Figure 21 and Figure 22. Closed inlet, high tide (IC/HT) WSE differences can be seen in Figure 23 and Figure 24.

3.4 Discussion of Results

Areas of WSE increase associated with Alternative 4 grading and roughness are seen at all inlet and tidal conditions, particularly 10 and 100-year flows. However, these areas are localized, including near the Sand Canyon Outlet Structure, and results do not reflect a larger pattern of WSE increase throughout Arroyo Grande Lagoon. In fact, larger patterns indicate WSE decrease of up to 1 ft throughout Arroyo Grande Creek and lower Lagoon. The proposed Alternative 4 grading creates a high flow diversion channel that directs return flows into AGC near the Sand Canyon Outlet Structure, leading to localized WSEs in this area. The design team is confident that the Alternative 4 grading plan can be modified to reduce, if not eliminate, localized increases in WSE, if deemed necessary.

It should be noted here that tidal exchange into the project area can be limited by AGL/AGC bed morphology and elevation changes. For example, AGL/AGC channel bed elevations in the modeled 2017 terrain surface reach 8.0-feet NAVD88 downstream of the Sand Canyon outlet structure, between river stations 1700 and 2000. The elevated channel bed in combination with AGC flows likely attenuate the tidal signature in simulated AGC water surface elevations. This is also why there does not appear to be signatures of tidal influence in the measured AGC water levels at the County gage outside of the Sand Canyon Outlet Structure.

4 Proposed Alternatives Baseflow Analyses

Using the same terrains and modifications described in the Peak Flow Analyses section, a model was developed to simulate tidal conditions and flows during representative winter and spring baseflow periods (I.e., intervening stable flow periods between rainfall-runoff events). The purpose of this modeling effort was to capture peak seasonal stage conditions at the tidal boundary as well as simulate baseflow, or typical low flows, during these periods. WSE increases – if any – due to proposed terrain and roughness changes were observed and noted.

4.1 Baseflow Boundary Conditions

To develop inflows for EG and FG baseflow simulations, daily stage values were obtained from San Luis Obispo County gage #734 at Arroyo Grande Bridge for years 2008 through 2023. A median stage value was then computed for winter (January/February) and spring (March/April) time periods, which was then converted to a flow value using the county-established rating curve at Arroyo Grande Bridge. Inflows for upper Arroyo Grande, Los Berros, and Meadow Creeks were calculated by calculated by unit drainage area scaling to the Arroyo Grande Bridge gauge resulting in watershed area ratios of 0.9, 0.1, and 0.076, respectively. These ratios are applied to Arroyo Grande Bridge baseflows to estimate modeled inflows. Boundary condition inflows for winter and spring periods are presented in Table 8.

Table 8. Inflows for baseflow winter and spring model simulations.

Scenario	Inflow (cfs)		
	Arroyo Grande Creek	Los Berros Creek	Meadow Creek
Winter	91.84	10.2	6.98
Spring	78.11	8.68	5.94

Within the months of January/February and March/April, simulation periods were then identified that captured maximum spring tide events within each season. The selected simulation periods encompassed January 24-30, 2021, and April 23-30, 2021. Tidal stages were obtained from the NOAA gage at Port San Luis, CA, and minimum and maximum tidal stages for both simulation periods are presented in Table 9.

Table 9. Maximum and minimum tidal stages at Port San Luis, CA.

Scenario	Observed Water Level (ft)	
	Minimum	Maximum
Winter	-0.95	6.63
Spring	-1.39	6.2

4.2 Baseflow Simulation Results

Figure 25 and Figure 26 detail EG and FG water surface elevations in MCL and AGL for representative winter and spring baseflow periods, respectively. Figure 27 shows AGC WSE differences during winter and spring baseflow periods due to proposed Alternative 4 terrain and roughness changes. For all proposed seasonal scenarios, no WSE increases were noted in AGC and MCL along the AGL levee. A small area of increased WSE was noted near the southern portion of Arroyo Grande Lagoon. In winter, this increase is between 0.05 and 0.1 ft; in spring, between 0.1 to 0.25 ft. And is due to off-channel deepening associated with the Alternative 4 grading plan.

4.3 Model Limitations and Recommendations

As noted in Section 4.1, a median stage value was used to compute inflows for each seasonal period. Average stage values and corresponding flows were initially tested but resulted in model instabilities and crashes. Median values correspond to representative seasonal stages and flows that could be adequately simulated in the model.

5 Proposed Alternatives Sediment Transport Analyses

A model was developed in HEC-RAS 6.4.1 to simulate sediment transport shear stress and bedform changes due to proposed Alternative terrain and roughness modifications. The approach is described in the following sections.

5.1 Approach

5.1.1 Geometry

Model geometry described in Section 2.3 was simplified to solely include 2D elements and remove bridges, which are currently incompatible with 2D sediment transport models in HEC-RAS. The model mesh described in Section 2.3 was extended upstream in Arroyo Grande Creek to the 22nd St Bridge, a distance of roughly 0.95 miles. This increase in distance between the AGC inflow boundary condition and the area of interest was intended to stabilize the model and avoid common sediment transport model runtime errors. Figure 28 depicts final sediment transport model geometry, including all 2D elements and the expanded mesh extents.

5.1.2 Boundary Conditions

Meadow Creek Lagoon inflows and tidal connection stages were identical to those used in the Peak Flow Analyses model for all OI/LT, OI/HT, and CI/HT simulations. Arroyo Grande Creek inflows were extracted from Peak Flow results at cross section 6857 of the hydraulic model(?) at the 22nd St Bridge. **Table 10** presents the peak design flow magnitudes at inflow locations.

Table 10. Maximum model design flow rates (cfs) for simulated sediment transport modeling floods.

Model Reach	Flood Recurrence Interval			
	2-year	5-year	10-year	100-year
Arroyo Grande Creek at 22nd St Bridge	731	2,566	4,939	7,849
Meadow Creek	38	133	256	1000

5.1.3 Bed Material

Bed sediment samples were obtained during a prior study in 2006 at many locations throughout Arroyo Grande and Los Berros Creeks (Swanson Hydrology + Geomorphology, 2006). Details of the four most downstream samples can be found in Table 11 and locations can be seen in Figure 28.

Table 11. Bed substrate results for the Arroyo Grande mainstem and Los Berros flood control channels.

Bed Sample ID	Percent of Material in Bed Sample							
	0-2 mm	2-4 mm	4-8 mm	8-16 mm	16-32 mm	32-64 mm	64-128mm	>128 mm
PC-11	2	1	3	14	13	17	1	0
PC-12	2	1	1	9	27	10	1	0
PC-13	100	0	0	0	0	0	0	0
PC-14	4	4	4	13	16	10	1	0

** data and description from Table 4.7, Swanson Hydrology + Geology, 2006

The most downstream of these four samples is sample PC-14, which is located at river station 100 on Figure 29 and is within the upper 100-feet of the limits of Alternative 4. Based on field observations, this sediment type extends downstream to at least river station 1300, where bed and bank material becomes mixed with more beach/dune sand. We propose the collection of additional samples during the 30% design and analysis phase to capture major bed material changes extending down through AGL. However, this grain-size distribution is held constant during model simulations of both EG and FG conditions and the relative changes between these conditions would remain consistent regardless of bed material size.

Sample PC-14, was expressed as a percent finer bed gradation and applied across the sediment transport model mesh extents. To comply with model needs, the existing PC-14 gradation in Table 10 was scaled proportionally so all bins added to 100 percent. Both existing and scaled PC-14 gradations can be seen in Table 16 in Appendix A – Sediment Transport.

5.1.4 Modeling Parameters and Computation Options

Many computation options were developed using best practice recommendations in the HEC-RAS 2D Sediment Technical Reference Manual (HEC 2023). See Table 17 in Appendix A – Sediment Transport for a list of these computation options and tolerances.

5.2 Sediment Transport Simulation Results

Sediment transport was only modeled in AGC and AGL as there is little to no bedload sediment input delivered to the Alternative 3 site in lower MCL. The presence of nearly 2 miles of low gradient open water and heavily vegetated marsh that filters and captures all coarse-grained sediment precludes it from reaching lower MCL. Maximum shear stress comparisons between EG and FG open inlet, low tide (IO/LT) design flow simulations can be seen in Figure 29, Figure 30, Figure 31, and Figure 32. Final bed elevation change in feet for EG and FG design flow simulations can be seen in Figure 33, Figure 34, Figure 35, and Figure 36.

Final bed elevation rasters were compared with existing and future grade terrains to compute volume change of bed sediment in the area of interest. Results for existing conditions simulations can be seen in Table 12, where negative net change values denote erosion and positive net change values denote deposition during the flood event.

Table 12. Volume change of sediment (CY) in Arroyo Grande Lagoon during EG simulations.

Scenario	Deposition (CY)	Erosion (CY)	Net Change (CY)
2-yr Flood Recurrence Interval			
Open outlet, low tide	733	724	9
Open outlet, high tide	727	717	10
Closed outlet, high tide	177	175	2
10-yr Flood Recurrence Interval			
Open outlet, low tide	4,398	6,047	-1,649
Open outlet, high tide	4,175	5,997	-1,822
Closed outlet, high tide	4,771	5,378	-607
100-yr Flood Recurrence Interval			
Open outlet, low tide	11,088	10,666	422
Open outlet, high tide	10,928	11,205	-277
Closed outlet, high tide	14,445	9,434	5,011

Results for future grade simulations can be seen in Table 13, where negative net change values denote erosion and positive net change values denote deposition.

Table 13. Volume change of sediment (CY) in Arroyo Grande Lagoon during FG simulations.

Scenario	Deposition (CY)	Erosion (CY)	Net Change (CY)
2-yr Flood Recurrence Interval			
Open outlet, low tide	677	694	-17
Open outlet, high tide	670	685	-15
Closed outlet, high tide	183	205	-22
10-yr Flood Recurrence Interval			
Open outlet, low tide	4,664	6,422	-1,758
Open outlet, high tide	4,419	6,340	-1,921
Closed outlet, high tide	5,105	5,892	-787
100-yr Flood Recurrence Interval			
Open outlet, low tide	11,616	11,620	-4
Open outlet, high tide	11,835	12,156	-321
Closed outlet, high tide	15,339	10,749	4,590

Table 14 presents the difference in deposition, erosion, and net change between FG and EG simulations. Negative values indicate a reduction in each variable (i.e., negative deposition value indicated a reduction in deposition under FG versus EG conditions). Under all flood events and downstream boundary combinations, there is an increase in channel bed erosion under the FG condition within the limits of grading associated with Alternative 4.

Table 14. Difference in volume changes of sediment (CY) between FG and EG conditions.

Scenario	Deposition (CY)	Erosion (CY)	Net Change (CY)
2-yr Flood Recurrence Interval			
Open outlet, low tide	-56	-30	-26
Open outlet, high tide	-57	-32	-25
Closed outlet, high tide	6	30	-24
10-yr Flood Recurrence Interval			
Open outlet, low tide	266	375	-109
Open outlet, high tide	244	343	-99
Closed outlet, high tide	334	514	-180
100-yr Flood Recurrence Interval			
Open outlet, low tide	528	954	-426
Open outlet, high tide	907	951	-44
Closed outlet, high tide	894	1,315	-421

These changes in the volume sediment erosion are consistent with the anticipated changes in bed morphology and habitat creation associated with installation of instream structures. They are also very small when compared to the entire volume of erosion that occurs in Arroyo Grande Lagoon during storm events. Under existing conditions during large floods, massive erosion of the barrier beach can occur (as modeled in Existing Conditions Report and as occurred during the winter of 2022/23. A comparison of

Alternative 4 project area erosion to the total volume of erosion through the Arroyo Grande Lagoon barrier beach is provided in Table 15.

Table 15. Percent erosion volume from Alternative 4 project area vs. total Arroyo Grande Lagoon area under FG conditions for design storms.

Scenario	2-yr	10-yr	100-yr
Open outlet, low tide	0%	9%	<1%
Open outlet, high tide	-6%	17%	1%
Closed outlet, high tide	0%	2%	<1%

Table 15 reveals that during the 100-yr design flow simulations when the barrier beach and inlet are highly eroded, the amount of erosion in the Alternative 4 project area is 1% or less of the total volume of eroded material from the combined barrier beach and Alternative 4 project area.

5.3 Discussion of Results

At all existing conditions flow events, an area of high shear stress (> 1.0 lb/ft^2) occurs near river station 700 on AGC. The magnitude of the shear stress in this area is reduced in the 2-year FG results but is consistent between EG and FG at higher flow events. At all flow events, areas of increased shear stress occur where Alternative 4 FG roughness modifications (n = 0.1) are present.

Overall, sediment transport model results indicate that the total volume of bed changes quantified are relatively very small when compared to the overall length and surface area of AGC channel simulated. As presented below, the largest bed changes occur through the lagoon outlet and sandy barrier beach.

When examining bed change results in the AGC channel around Alternative 4, deposition consistently increases in areas of proposed FG roughness elements. At lower flows, magnitude and spatial expanse of erosion increase just downstream of the roughness elements. At higher flows, the roughness elements seem to provide a buffer, and expanse of erosion downstream decreases.

When comparing EG and FG volumetric changes of sediment throughout Arroyo Grande Lagoon, large erosional increases are seen at the barrier beach outlet and tidal conditions. Lower flows, terrain modifications, and roughness additions may combine here to create erosional losses throughout the area. At all 100-year simulations, smaller erosional losses are seen across all outlet and tidal conditions. Here, large flood flows may already result in significant erosional losses at the outlet and beach during EG flows, and terrain and roughness modifications only slightly increase these losses. All 10-year simulation results show only small increases in deposition between EG and FG. Here, flow depths may be just great enough to be slightly affected by FG roughness additions and create depositional areas near large woody structures.

5.4 Model Limitations and Recommendations

Available sediment sampling data represents a gravel distribution with little sandy deposits at the site (SHG, 2006). More recent aerial imagery suggests that more sand might be present than is represented in the model. Further modeling may require obtaining current and complete samples to better reflect the distribution of sand and gravel-bed compositions and movement at the site. However, for this evaluation of conceptual alternatives the best available published information was used and it is anticipated that the relative magnitude of change between simulated EG and FG conditions would not change significantly.

6 Proposed Sea-Level Rise Analyses

A model was developed to simulate the effects of sea-level rise on water surface elevations along the AGL levee under EG and FG conditions. Approach and results are described in the following sections.

6.1 Sea-Level Rise Boundary Conditions

Sea-level rise geometry and inflow boundary condition reflect those of the Peak Flow Analyses described in Section 3.2. Low, medium, and high-risk aversion sea-level rise stage additions were identified and tabulated in 6. See cbec's 1/21/2022 report entitled "Hydraulic and Sediment Transport Modeling of Existing Conditions, Meadow Creek Lagoon Habitat Restoration Project" for discussion of the source of sea-level rise estimates used for this analysis.

Table 6. Projected sea-level rise (in feet) for Port San Luis (high emissions scenario).

Year	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
2070	1.7	3.3	5.0
2080	2.1	4.3	6.4
2090	2.6	5.3	8.0
2100	3.1	6.7	9.9

For this modeling effort, the Medium-High Risk Aversion 2070 scenario was simulated, and open inlet/high tide stages (IO/HT) were increased by 3.3 ft of sea-level rise.

6.2 Sea-Level Rise Simulation Results

Peak WSE results for open inlet, high tide conditions are summarized in Table 17. WSE differences between EG and FG sea level rise scenarios are shown in plan view in Figure 37.

Table 157. Simulated Peak water surface elevations with and without sea-level rise at the Sand Canyon Outlet Structure.

Model Location	Water Surface Elevation (ft)							
	WithoutSea Level				With Sea Level Rise			
	EG		FG		EG		FG	
	2 yr	100 yr	2 yr	100 yr	2 yr	100 yr	2 yr	100 yr
MCL	8.37	16.23	8.37	16.25	8.38	16.23	8.38	16.25
AGL	9.95	15.79	9.93	15.94	10.0	15.79	9.98	15.94

FG terrain and roughness additions did not result in any WSE increases along the levee or at the Sand Canyon Outlet Structure during the 2-year sea level rise scenario. During the 100-year sea level rise scenario, FG grading and roughness caused localized increases in WSE of up to 1.0 ft on the channel bank opposite the Sand Canyon Outlet Structure and 0.1 to 0.25 ft midway along the levee.

When compared to peak design flow results without sea level rise (Section 3), small WSE increases (< 0.1 ft) are present at 2-year flows in AGL. WSE results for 100-year sea level rise scenario remain constant when compared to peak design flow results with no sea level rise. The causes for these increases between EG and FG under the sea level rise scenario are the same as those that occurred during the non-sea-level rise simulations and discussed in Section 3.4.

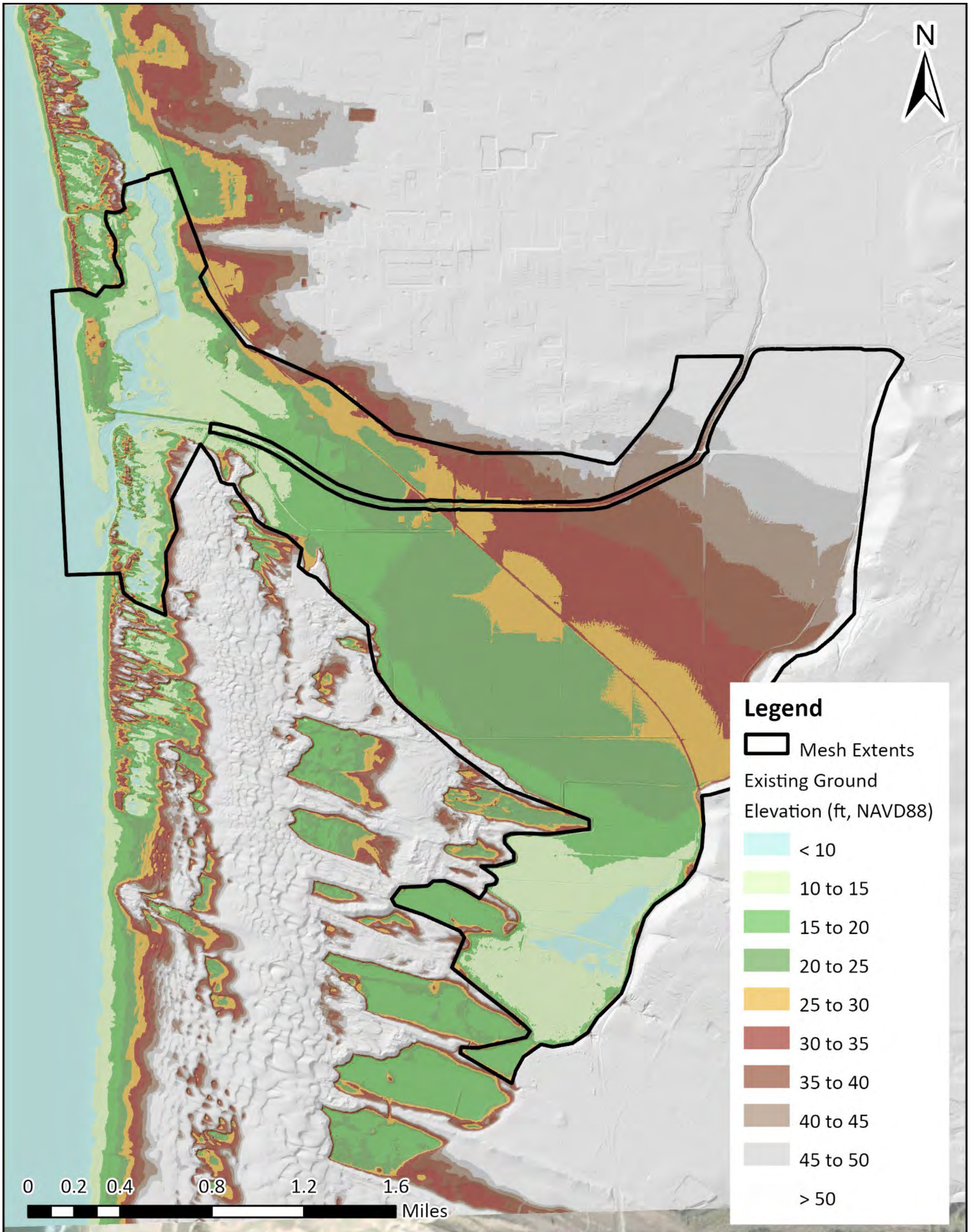
Finally, no WSE changes are observed between and the with and without Sea Level Rise scenarios during the 100-year event. This is due to a high point present in both EG and FG terrains just upstream of Station 2200 that discontinues any upstream tidal influence.

7 REFERENCES

HEC 2023. HEC-RAS River Analysis System: 2D Sediment Technical Reference Manual, Version 6.3. US Army Corps of Engineers.

Stillwater Sciences, 2022, Meadow Creek Lagoon Existing Conditions Technical Memorandum. Prepared for: San Luis Obispo County Water Conservation and Flood Control District, January, 65p.

Swanson Hydrology + Geomorphology, 2006, Final Arroyo Grande Creek Erosion, Sedimentation and Flooding Alternatives Study. Prepared for: Coastal San Luis Resource Conservation District, January 4, 196p.



Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **Terrain extents and model domain**		
		Project No. 21-1007	Created By: HNT	**Figure 1**

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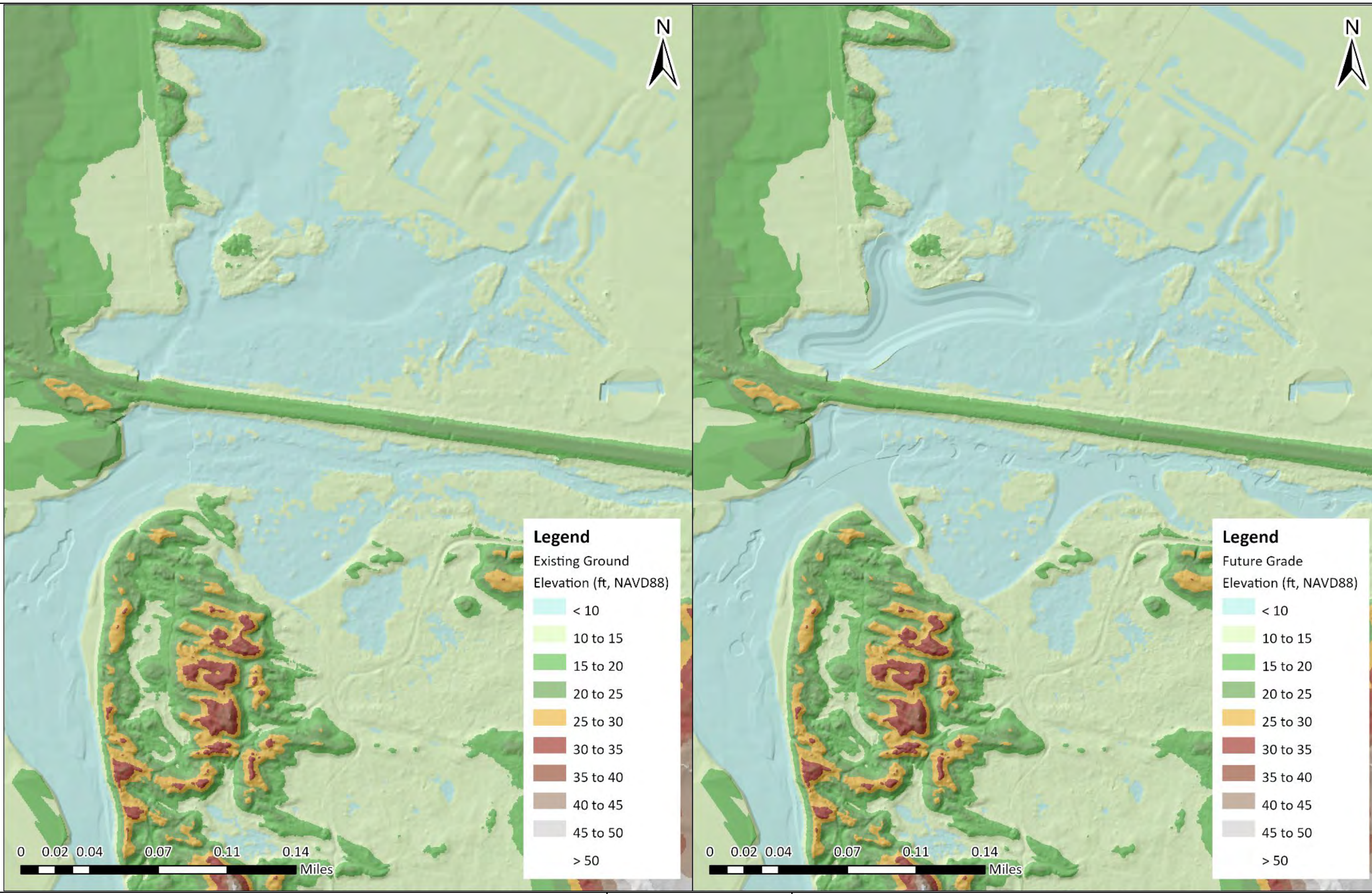

Notes:

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Meadow Creek Lagoon Habitat Restoration

EG and FG terrains

Project No. 21-1007	Created By: HNT	**Figure 2**

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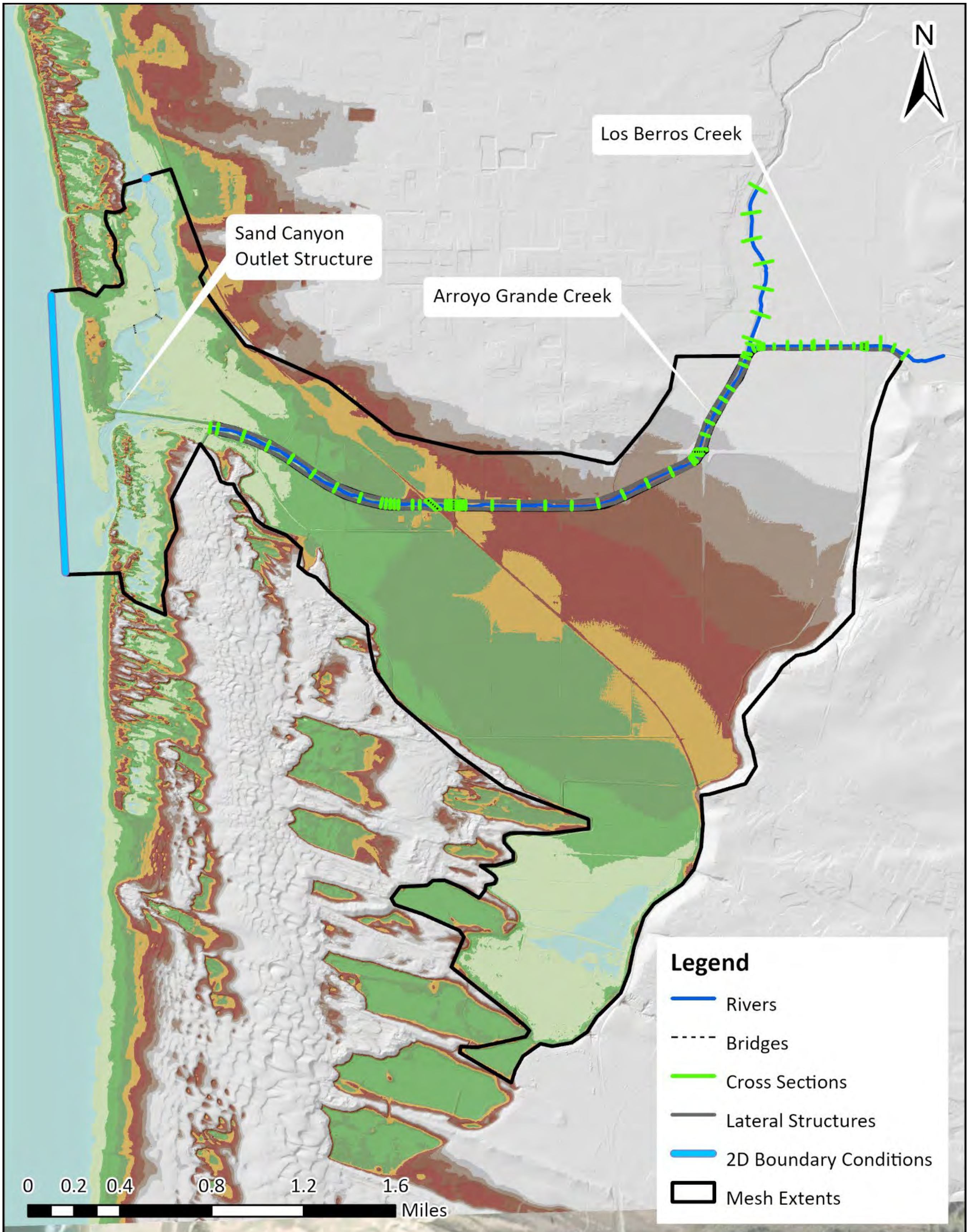

Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **Model geometry**		
		Project No. 21-1007	Created By: HNT	**Figure 3**

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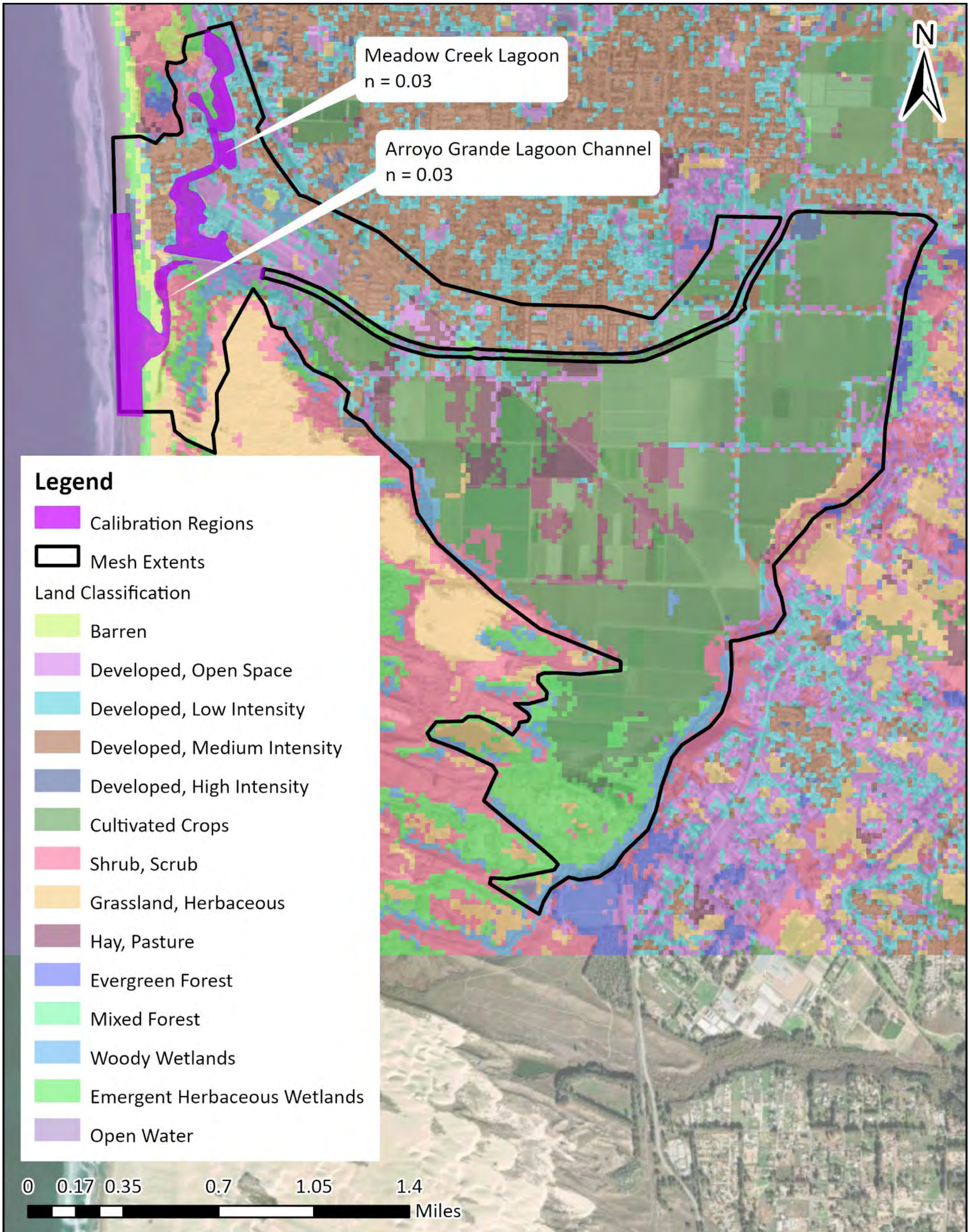

Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **Final roughness layer**		
		Project No. 21-1007	Created By: HNT	**Figure 4**

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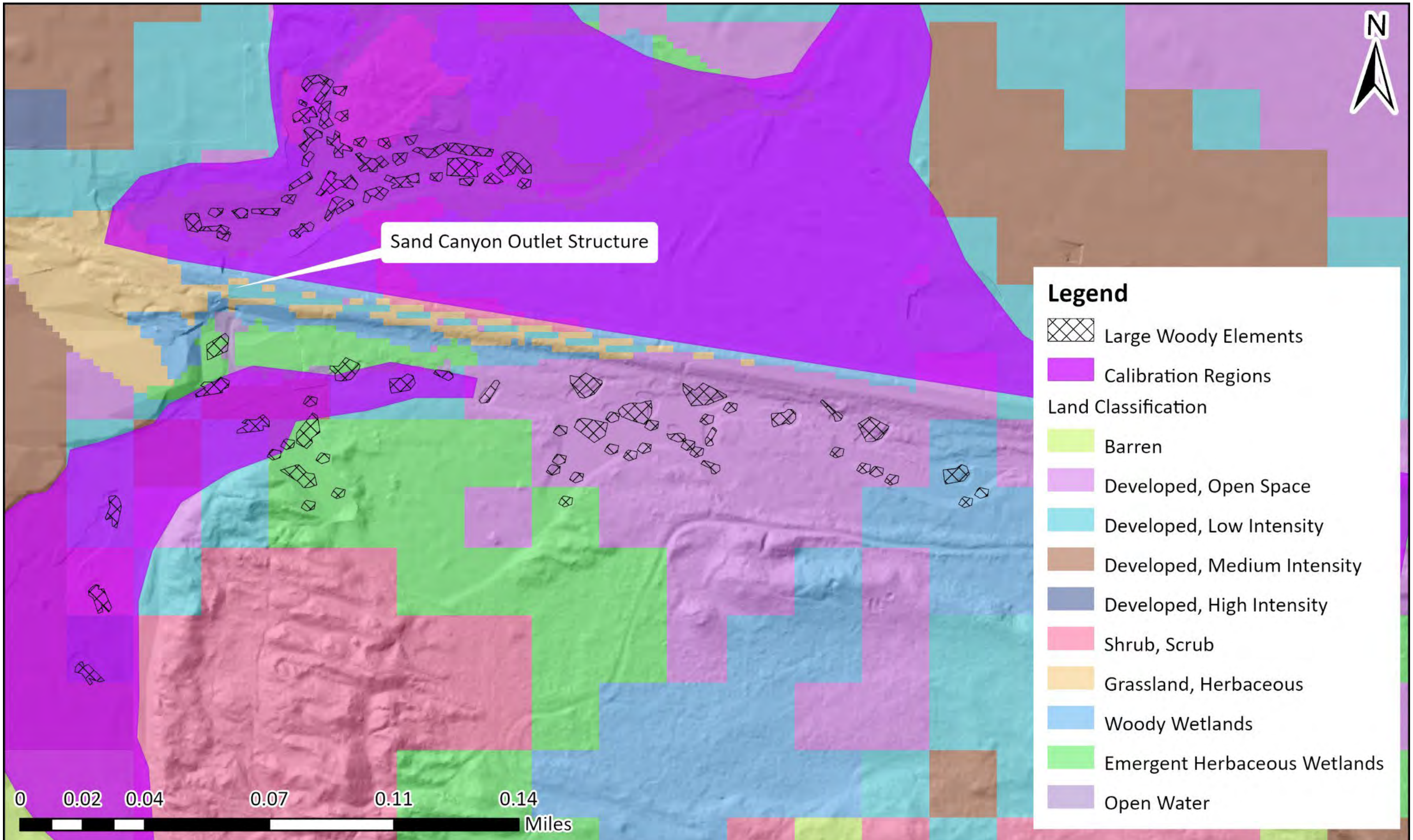

Notes:

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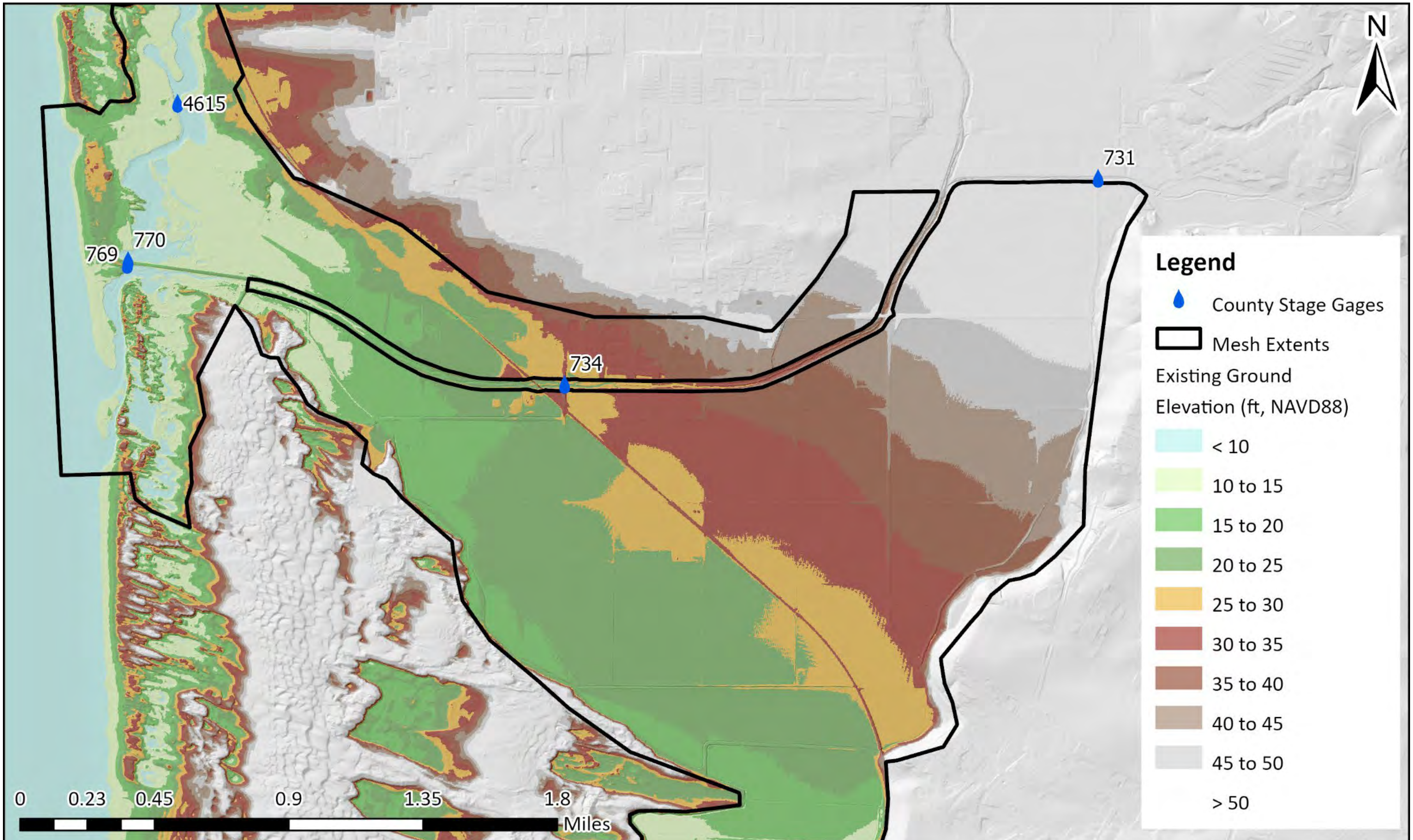
Meadow Creek Lagoon Habitat Restoration

Large woody roughness elements

Project No. 21-1007	Created By: HNT	**Figure 5**



Notes:

cbec

Meadow Creek Lagoon Habitat Restoration

San Luis Obispo County gage locations

Project No. 21-1007	Created By: HNT	**Figure 6**

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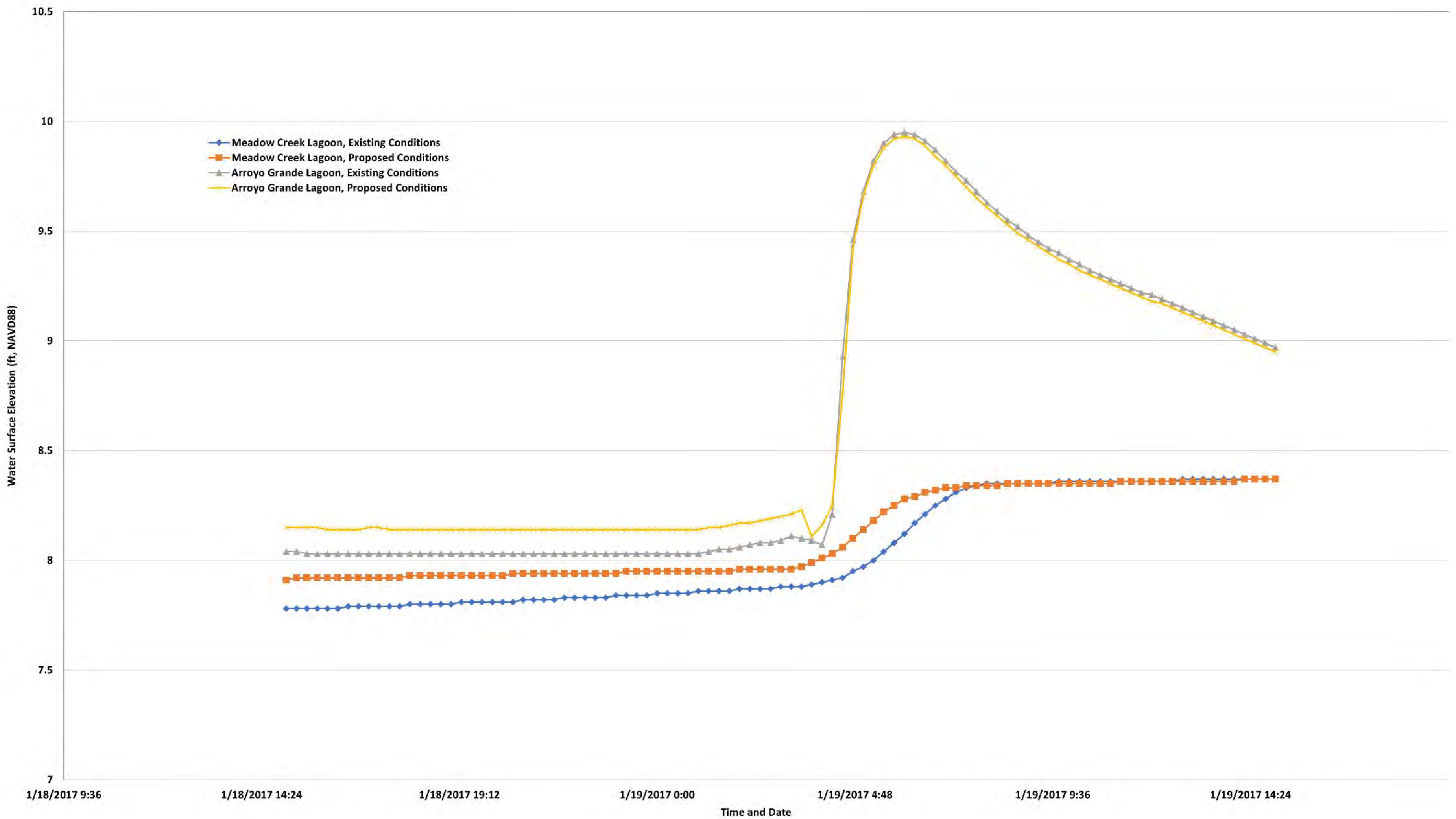

Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (2YR, OI, LT)**		
		Project No. 21-1007	Created By: HNT	**Figure 7**

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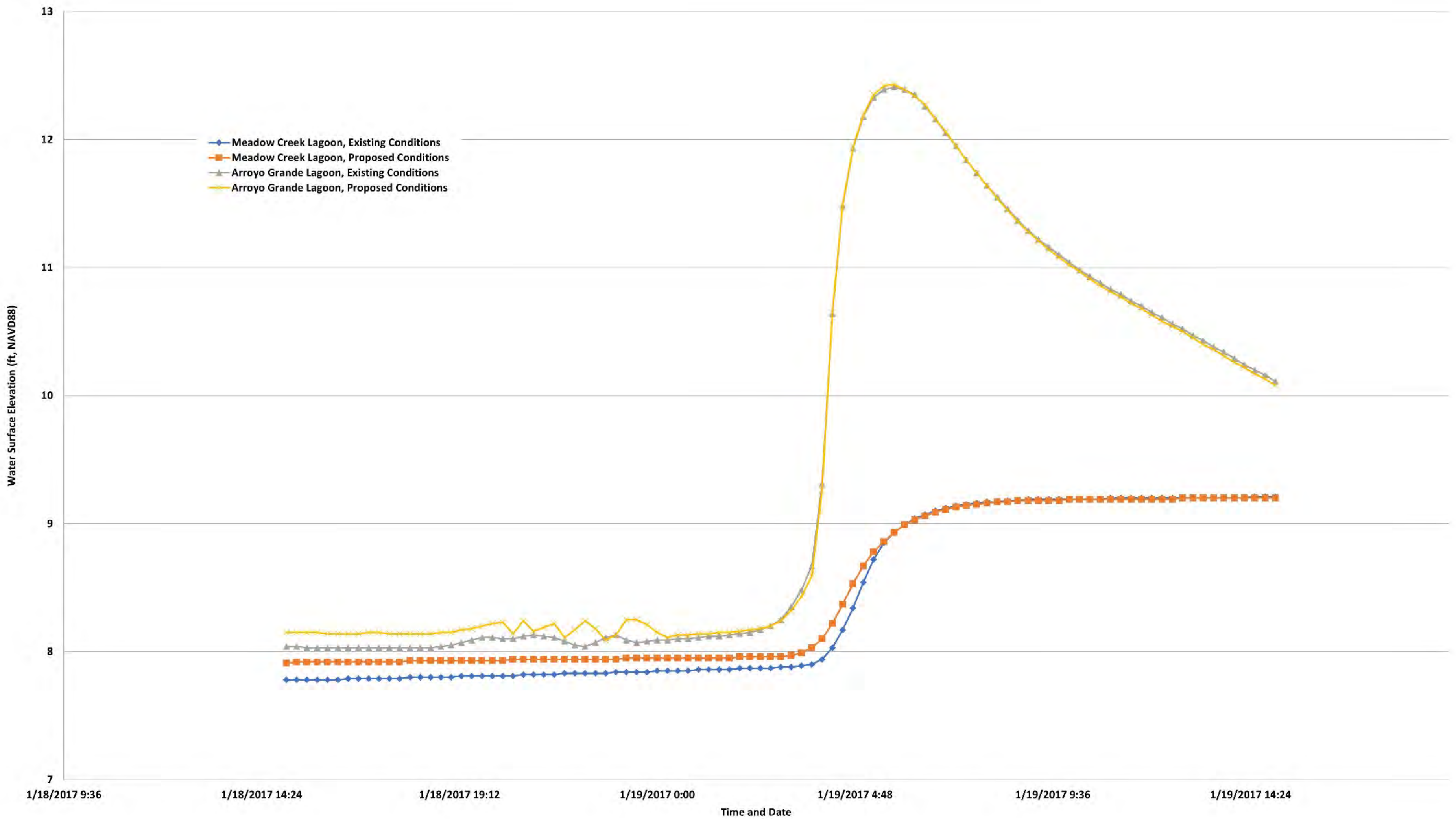
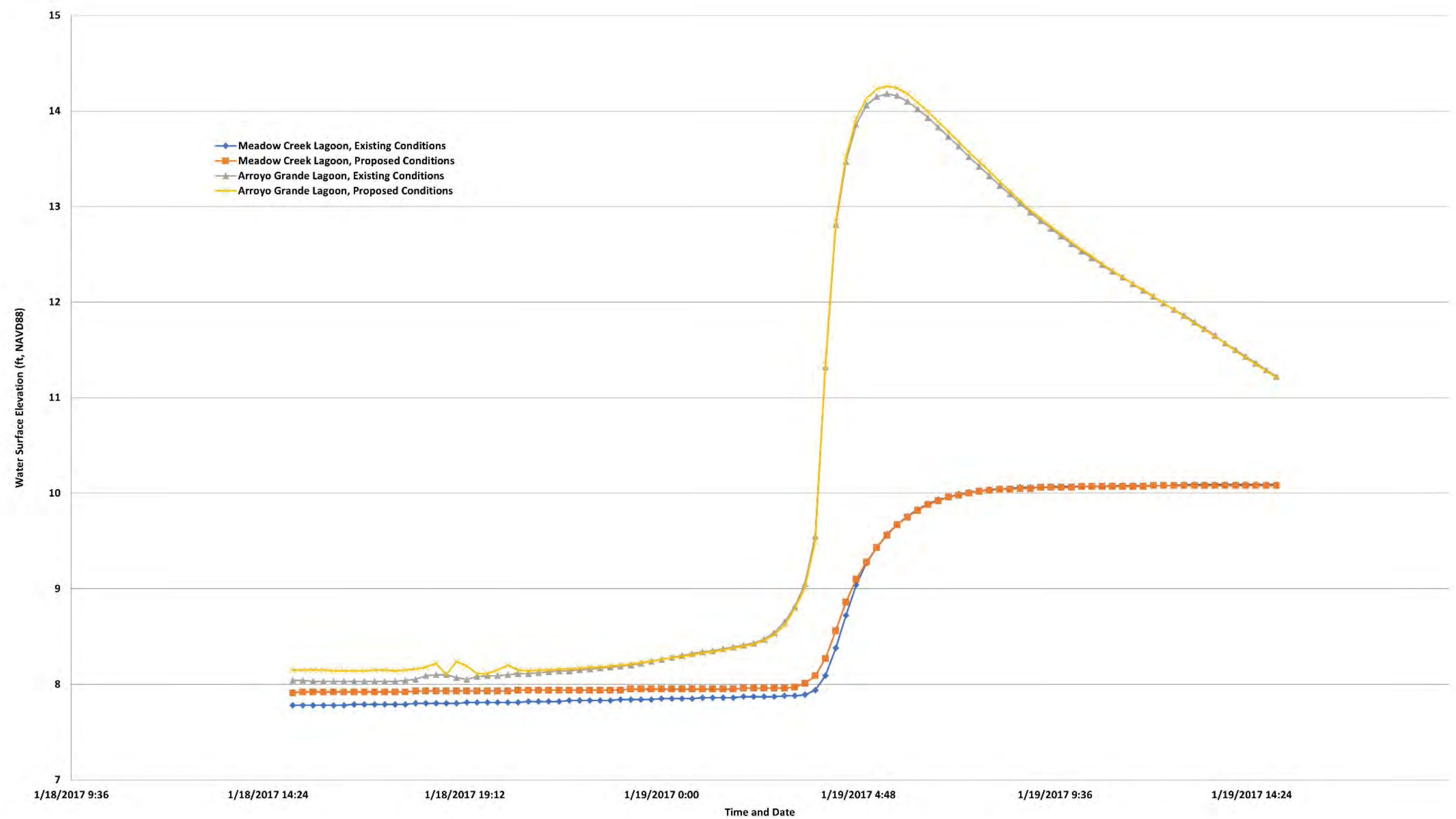
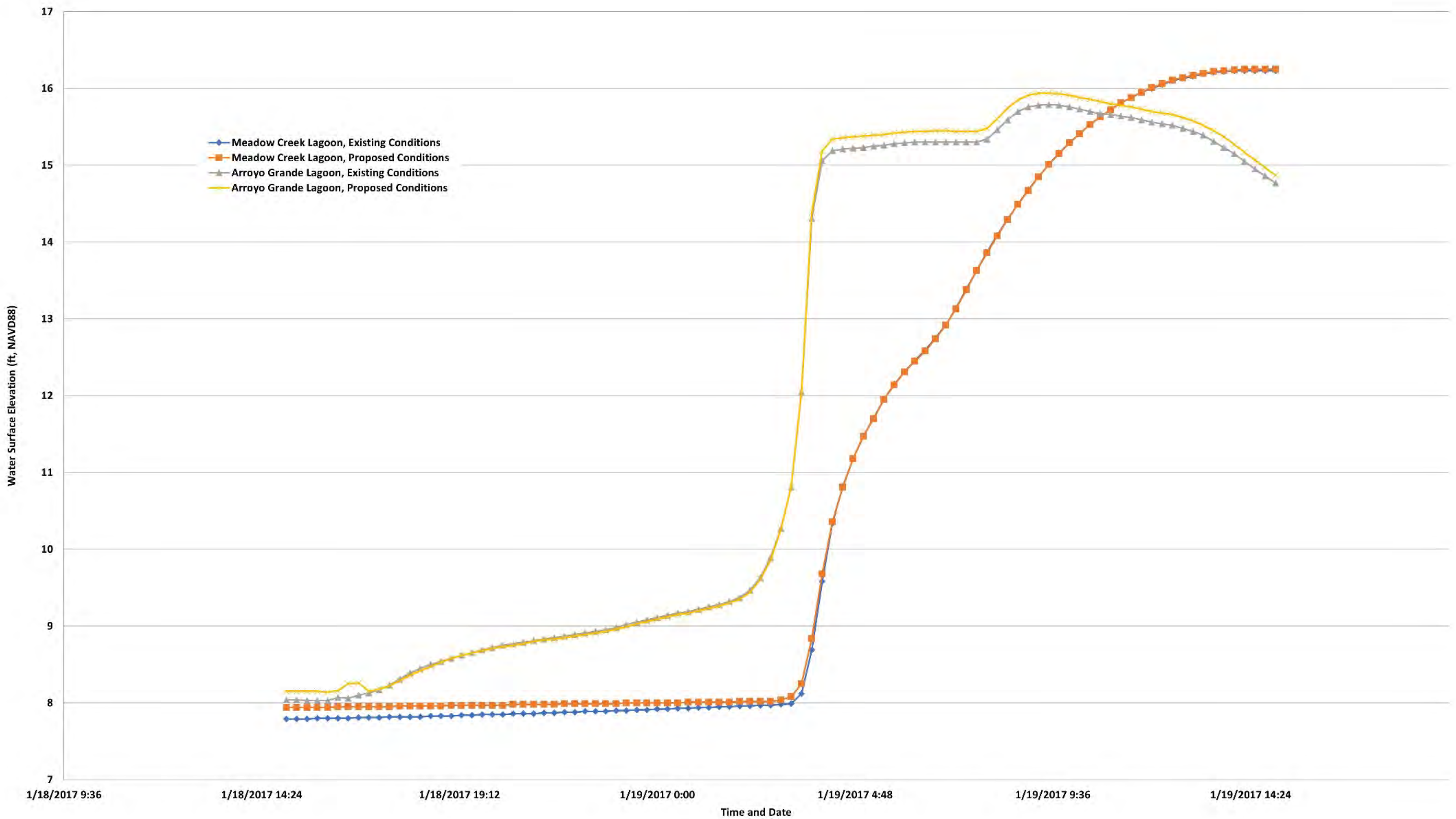


Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (5YR, OI, LT)**		
		Project No. 21-1007	Created By: HNT	**Figure 8**



Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (10YR, OI, LT)**		
		Project No. 21-1007	Created By: HNT	**Figure 9**



Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (100YR, OI, LT)**		
		Project No. 21-1007	Created By: HNT	**Figure 10**

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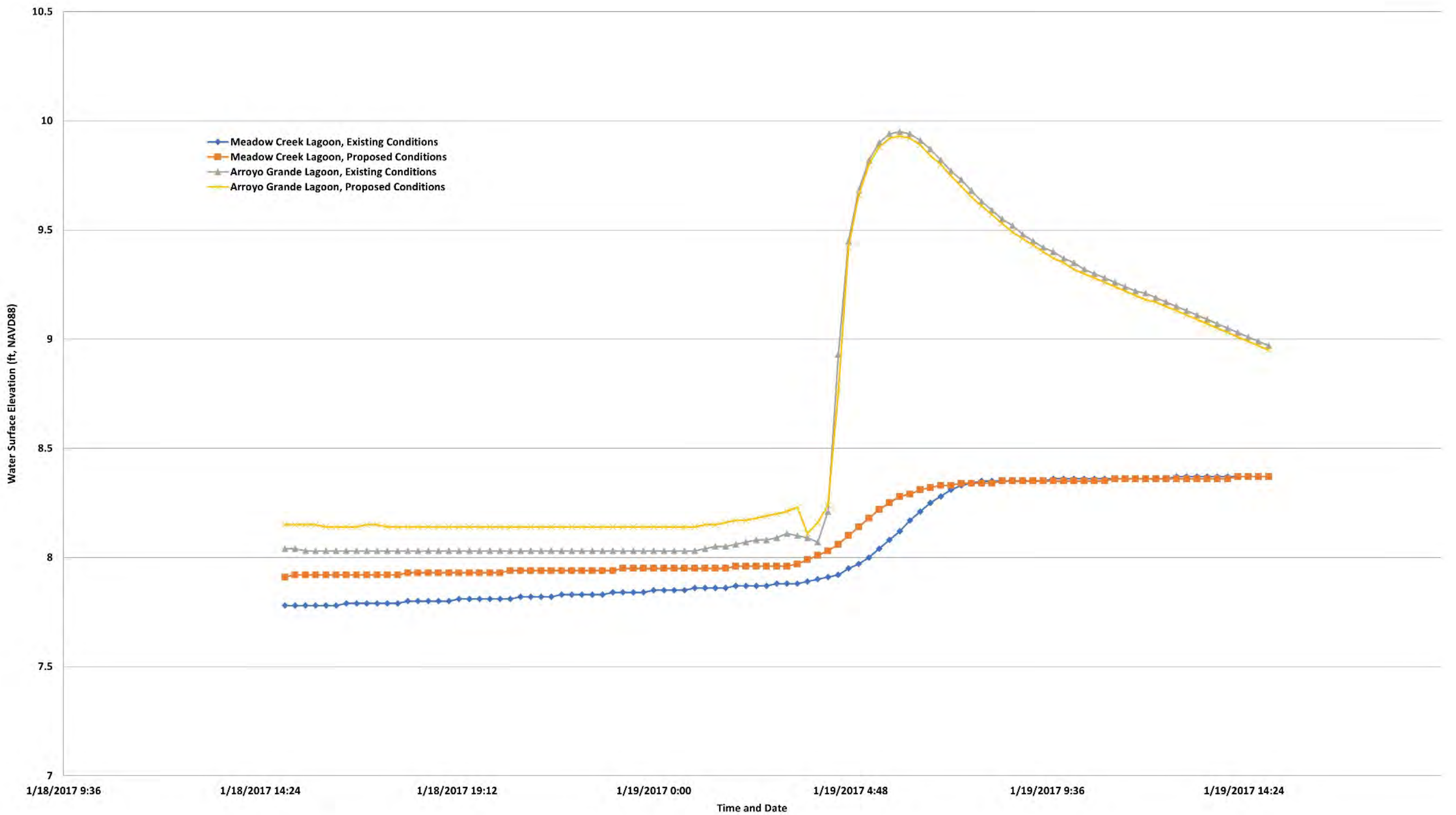

Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (2YR, OI, HT)**		
		Project No. 21-1007	Created By: HNT	**Figure 11**

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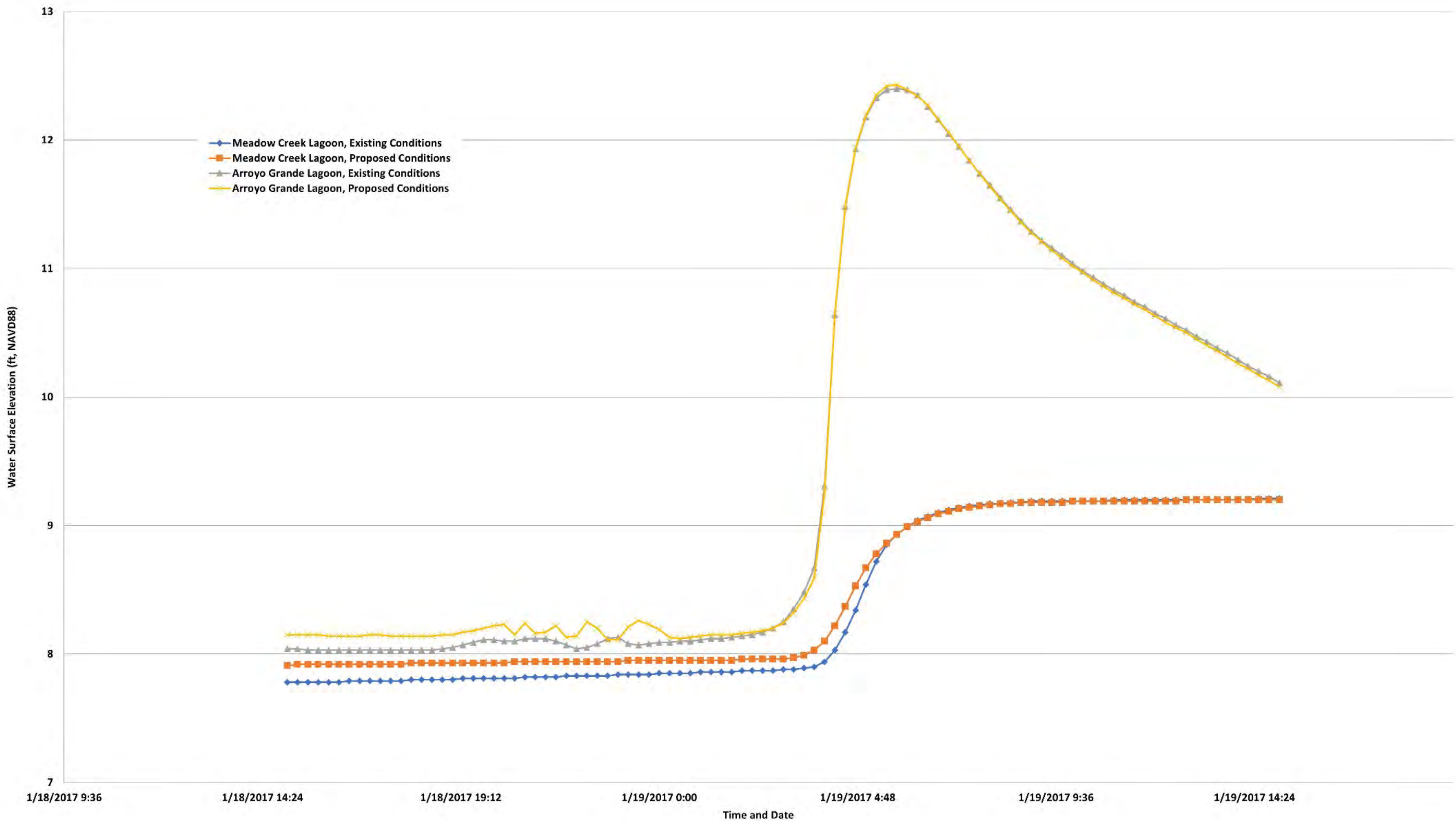

Notes:	*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (5YR, OI, HT)**		
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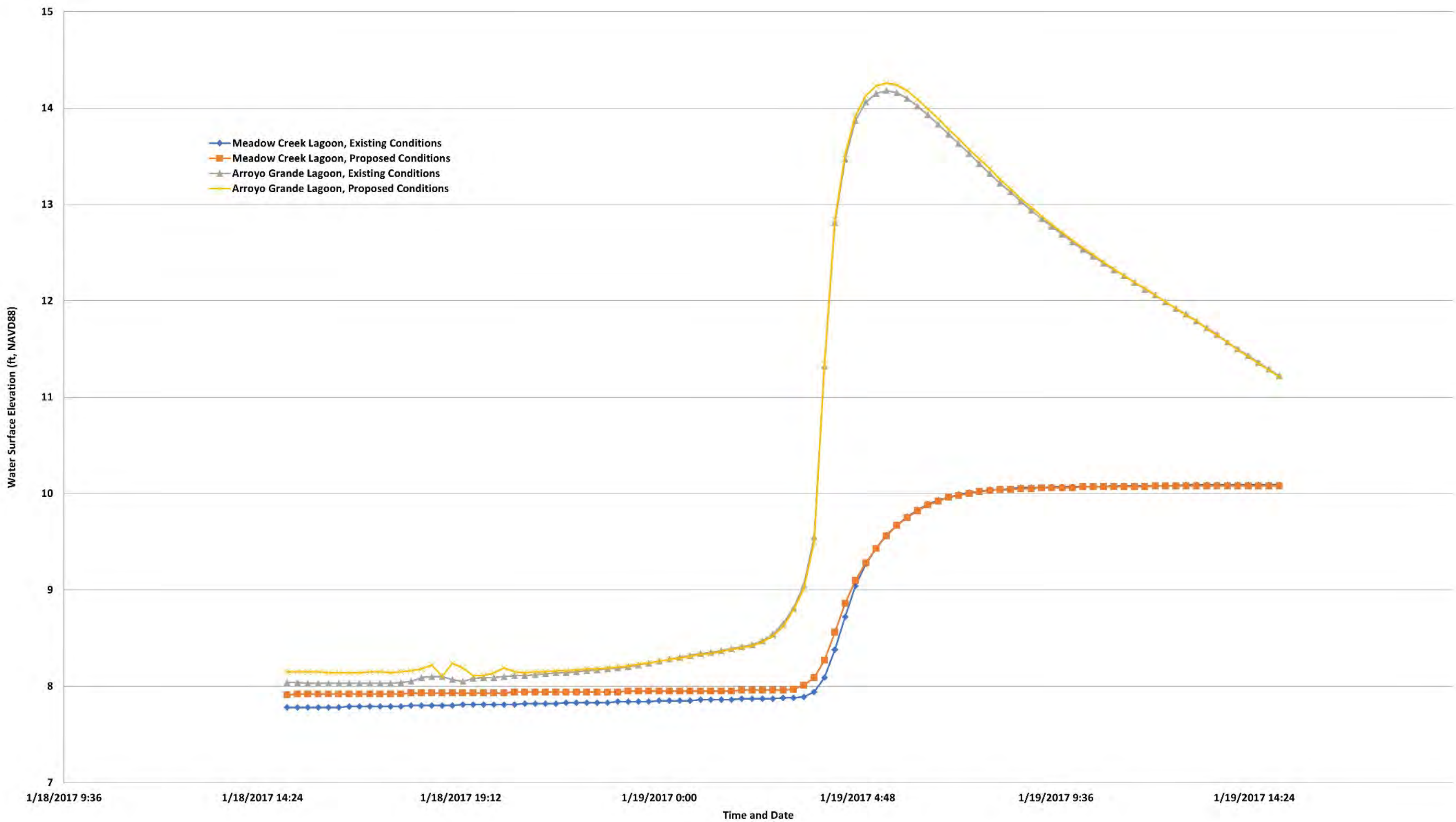
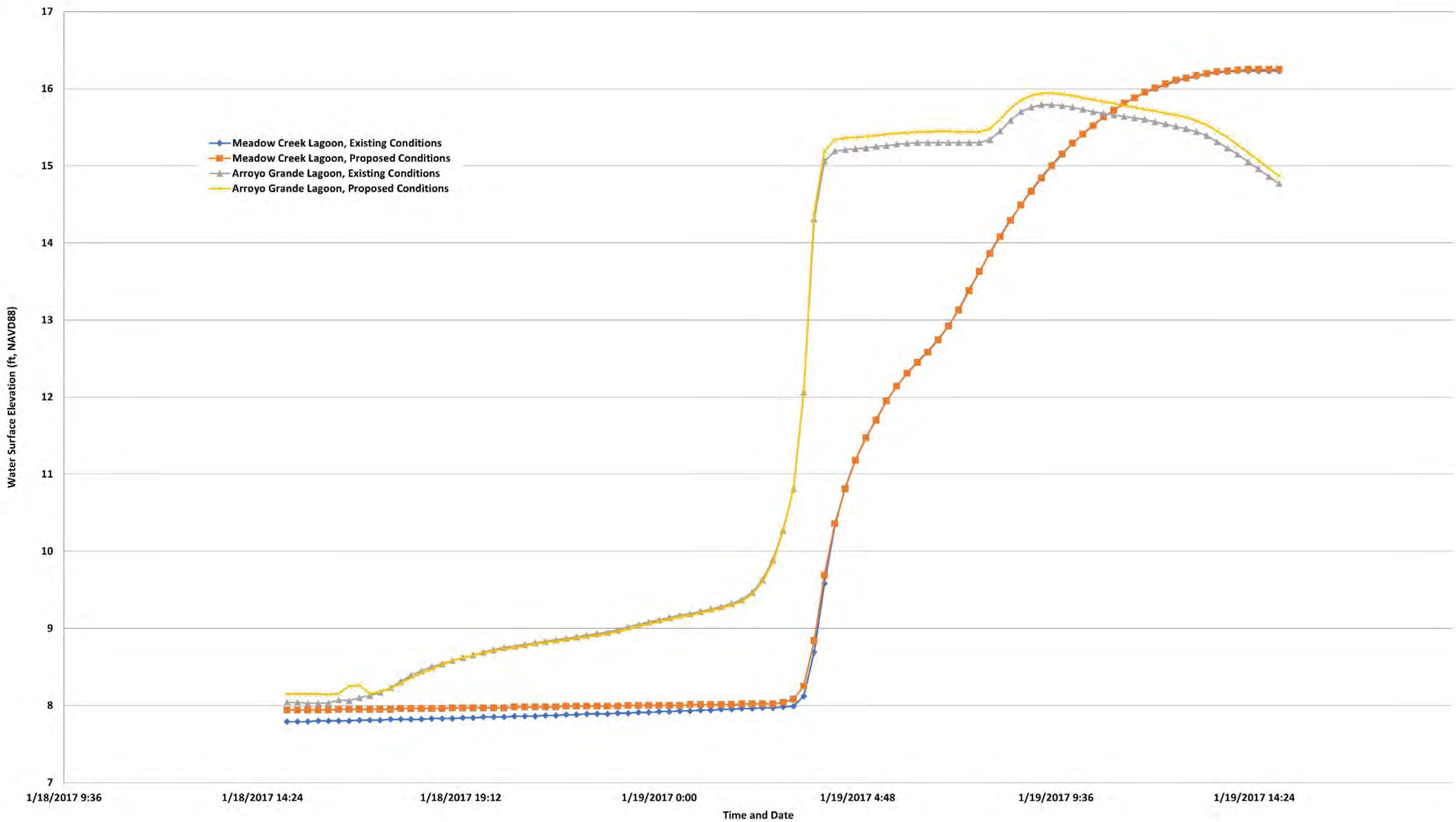
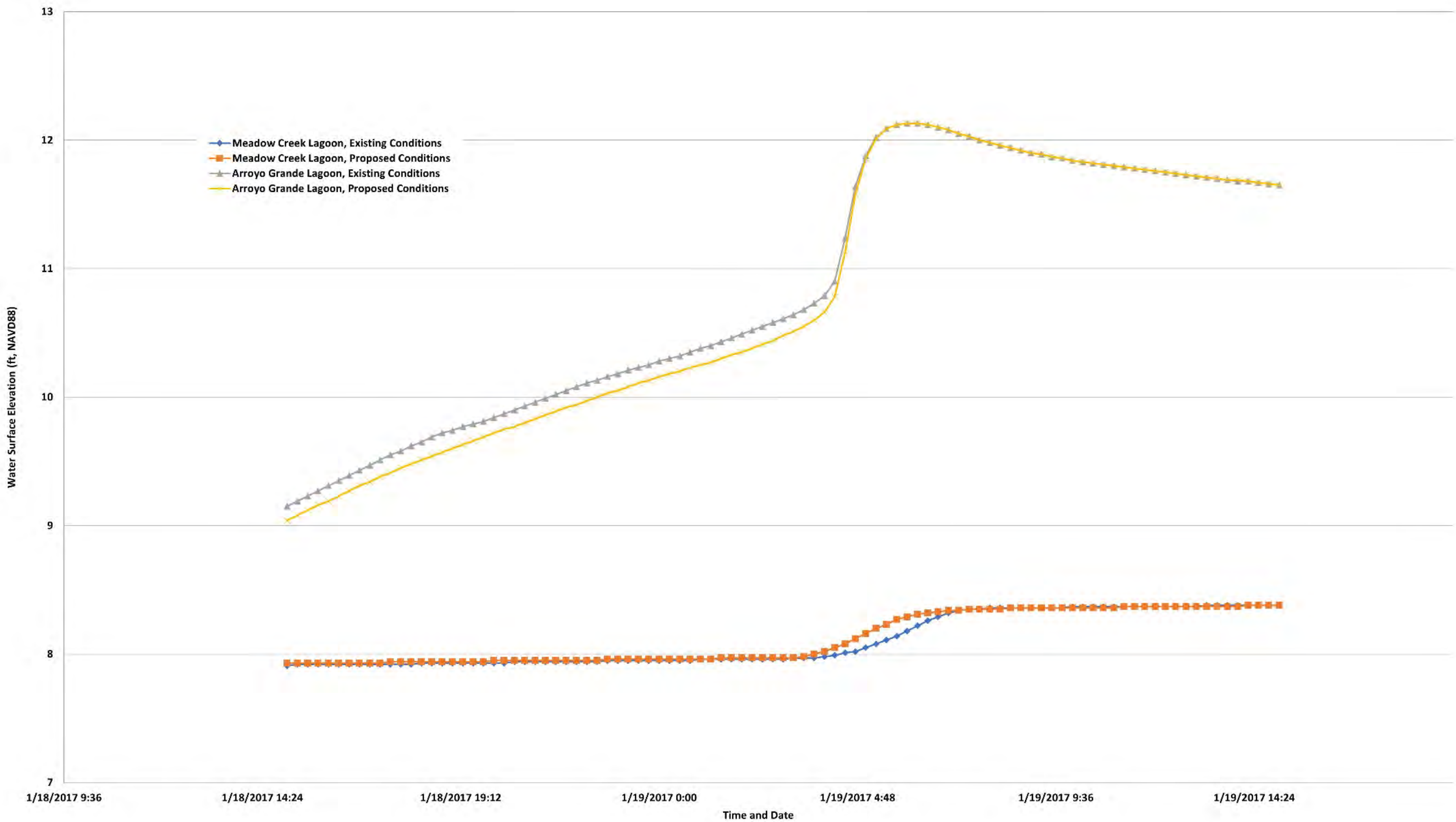


Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (10YR, OI, HT)**		
		Project No. 21-1007	Created By: HNT	**Figure 13**



Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (100YR, OI, HT)**		
		Project No. 21-1007	Created By: HNT	**Figure 14**



Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (2YR, CI, HT)**		
	cbec	Project No. 21-1007	Created By: HNT	**Figure 15**

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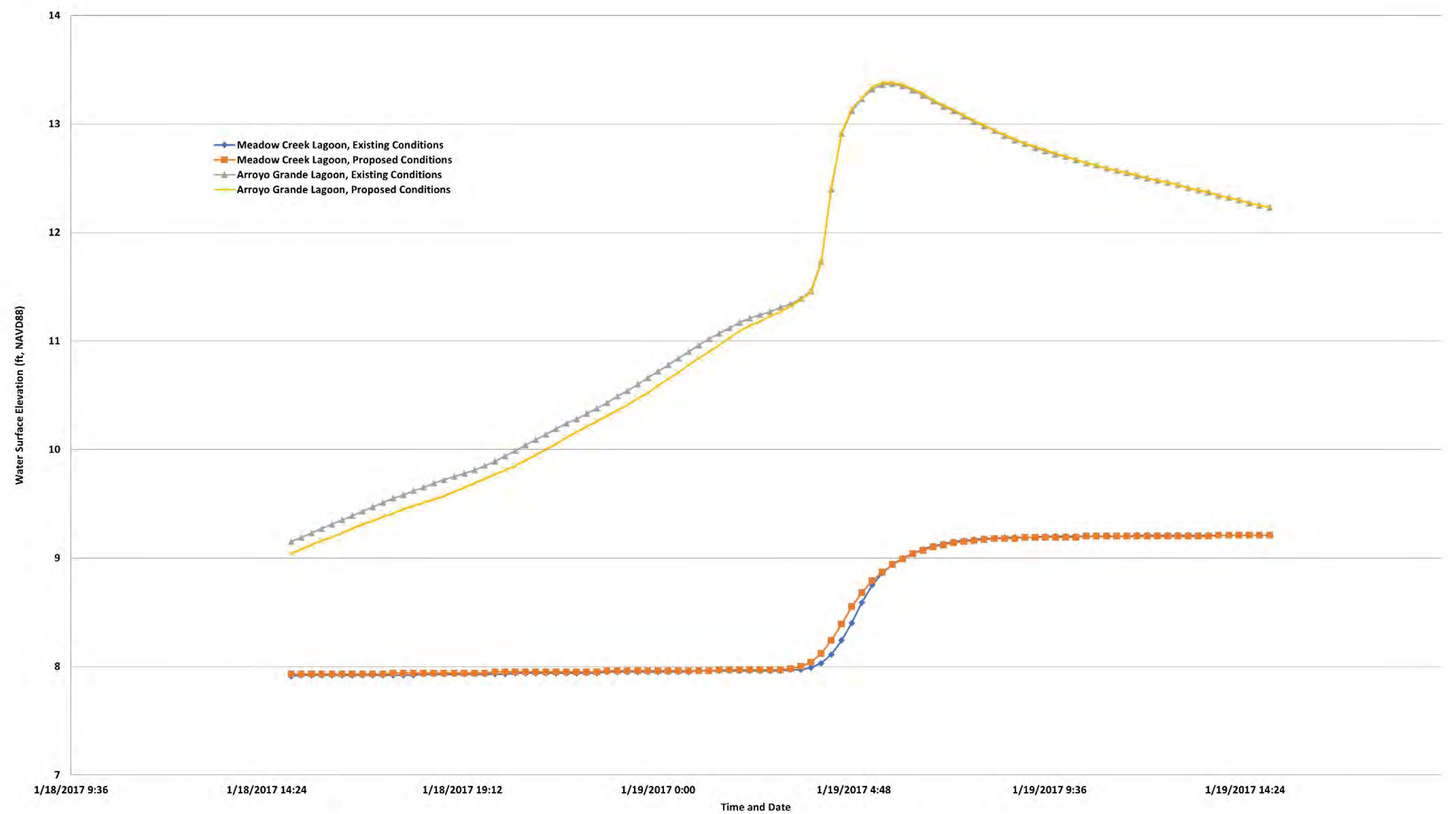

Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (5YR, CI, HT)**		
		Project No. 21-1007	Created By: HNT	**Figure 16**

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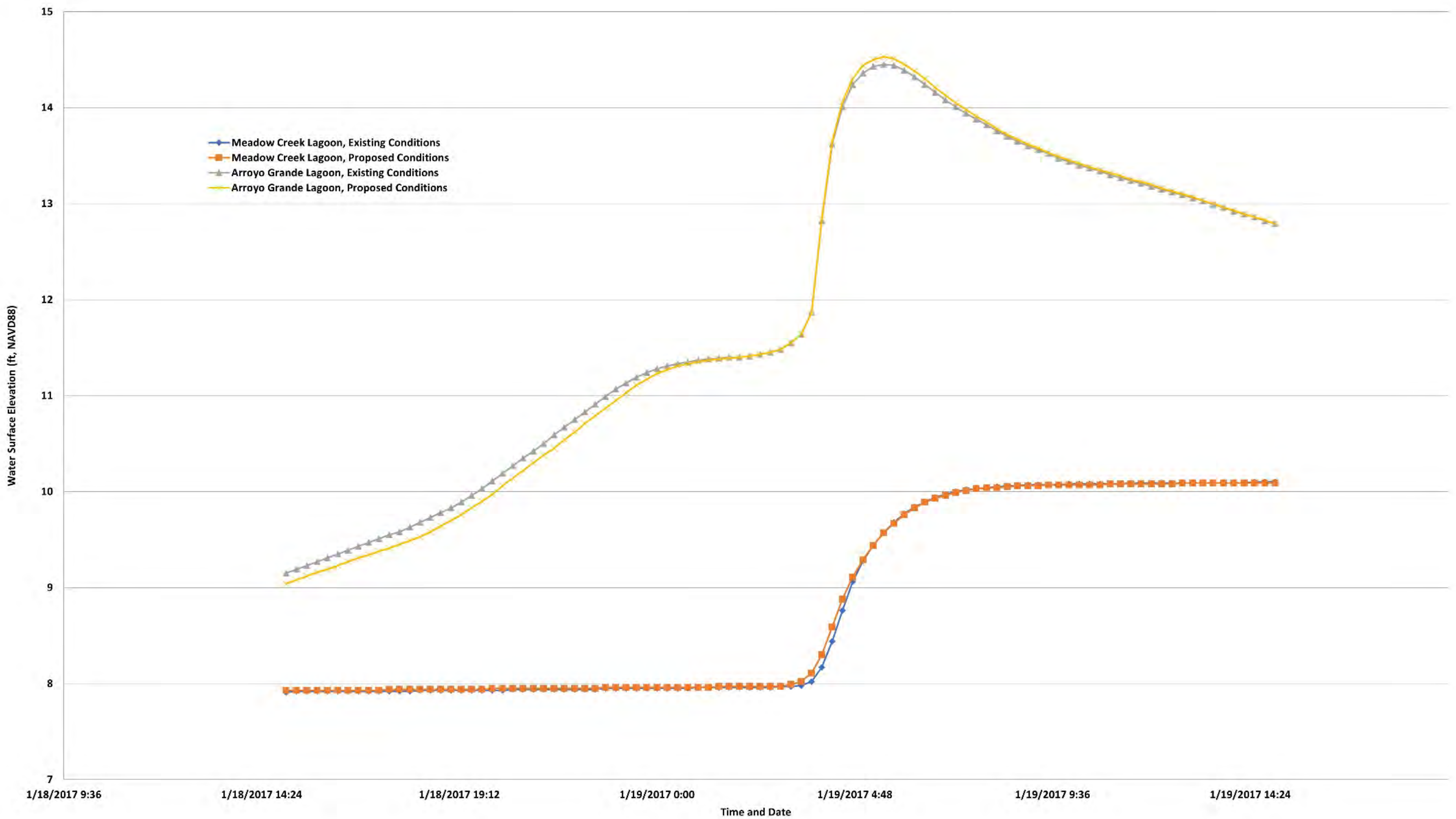

Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (10YR, CI, HT)**		
	cbec	Project No. 21-1007	Created By: HNT	**Figure 17**

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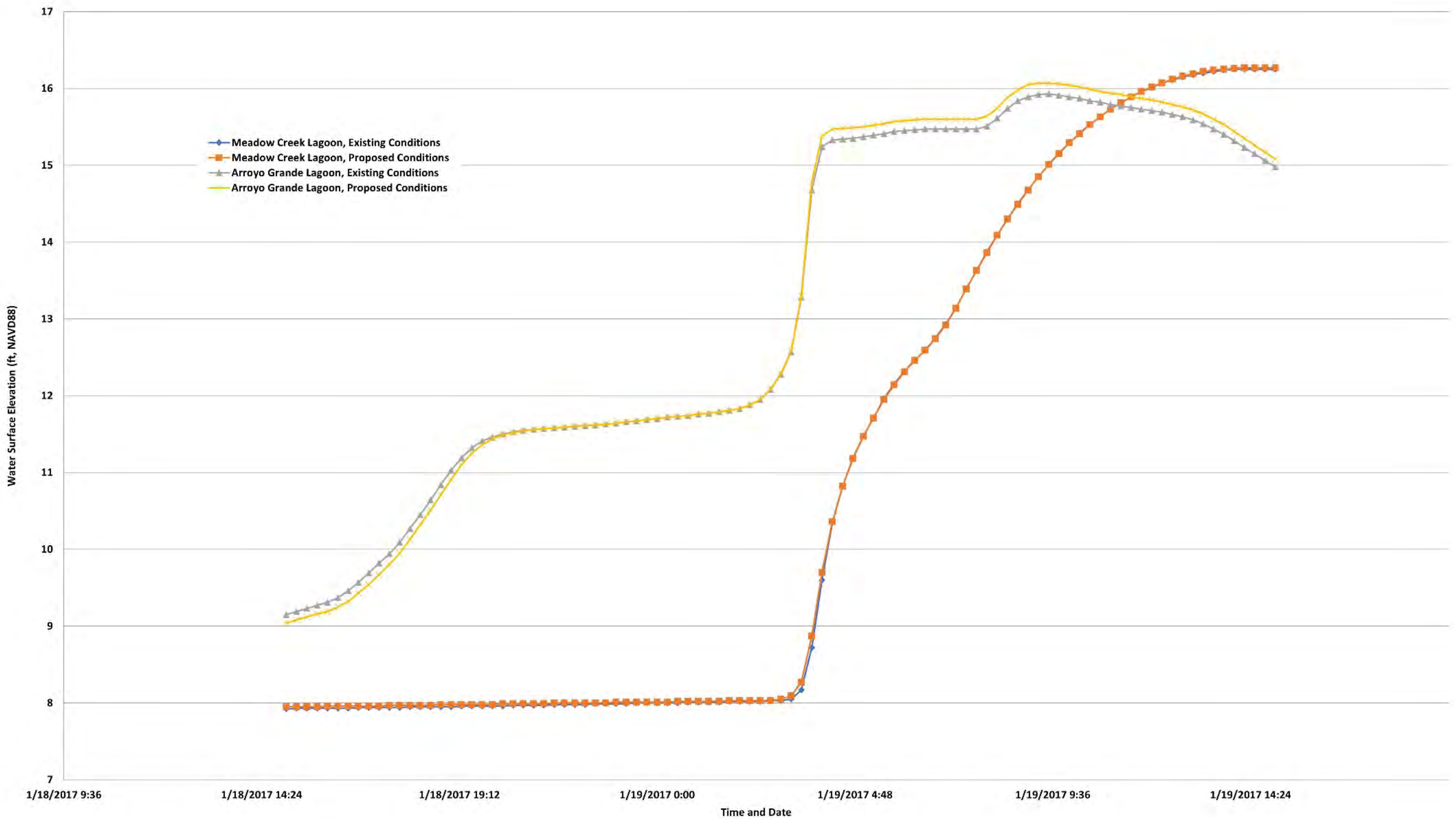

Notes:		*Meadow Creek Lagoon Habitat Restoration* **MCL and AGL WSE results (100YR, CI, HT)**		
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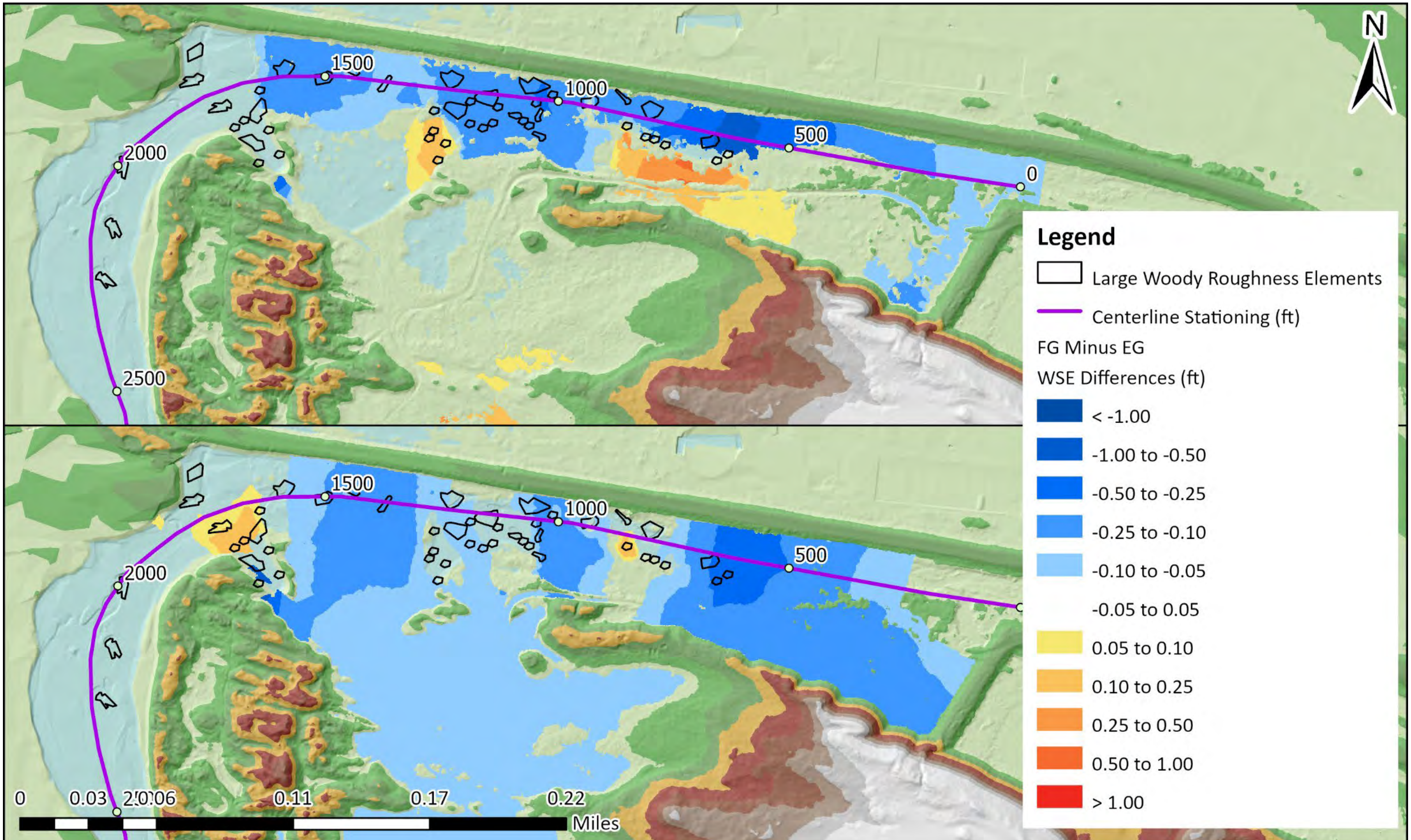


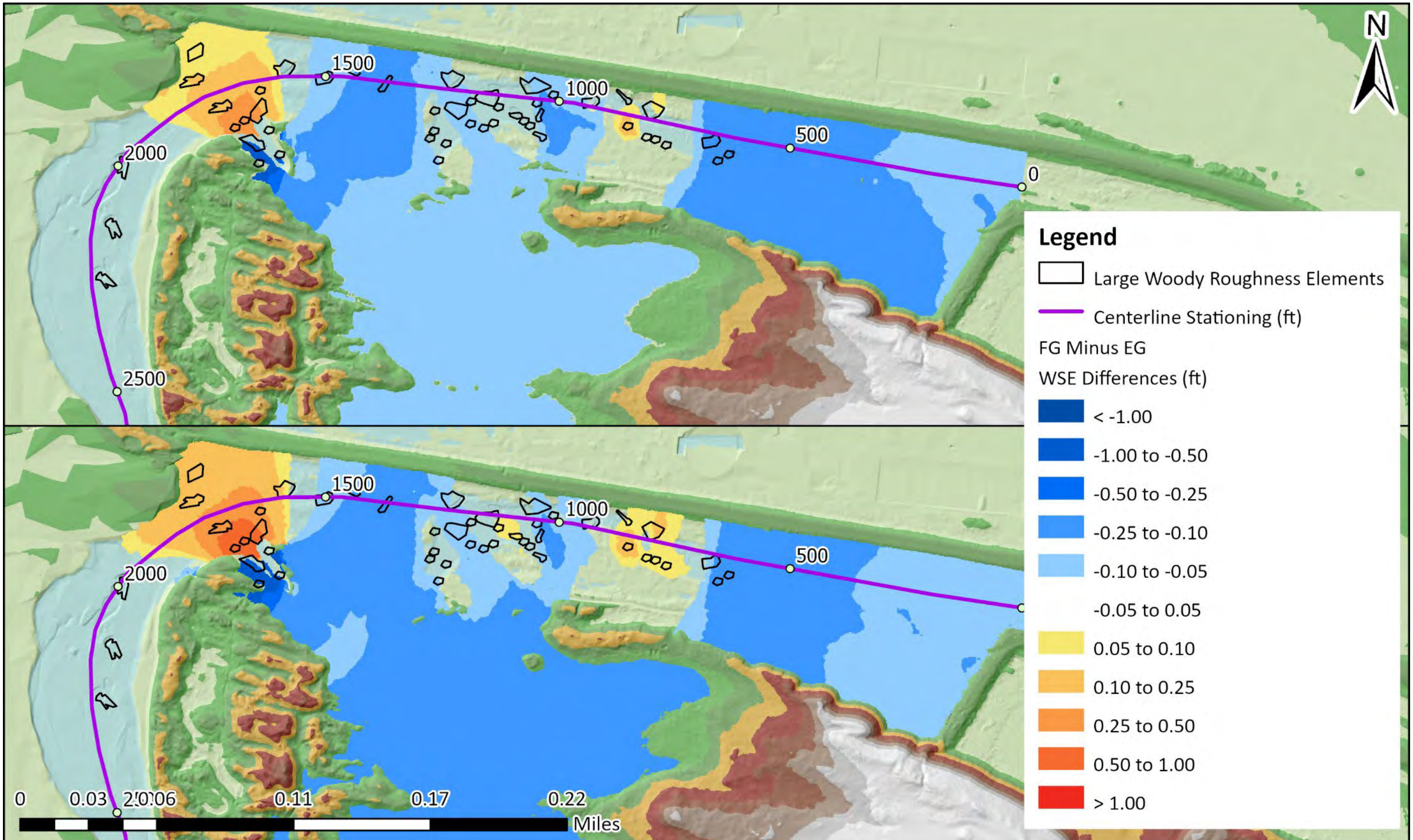
Notes: Water surface elevation differences (FG minus EG) for 2-year (top) and 5-year (bottom) open inlet, low tide scenarios.

cbec

Meadow Creek Lagoon Habitat Restoration

WSE differences (FG minus EG) – OI, LT

Project No. 21-1007	Created By: HNT	**Figure 19**



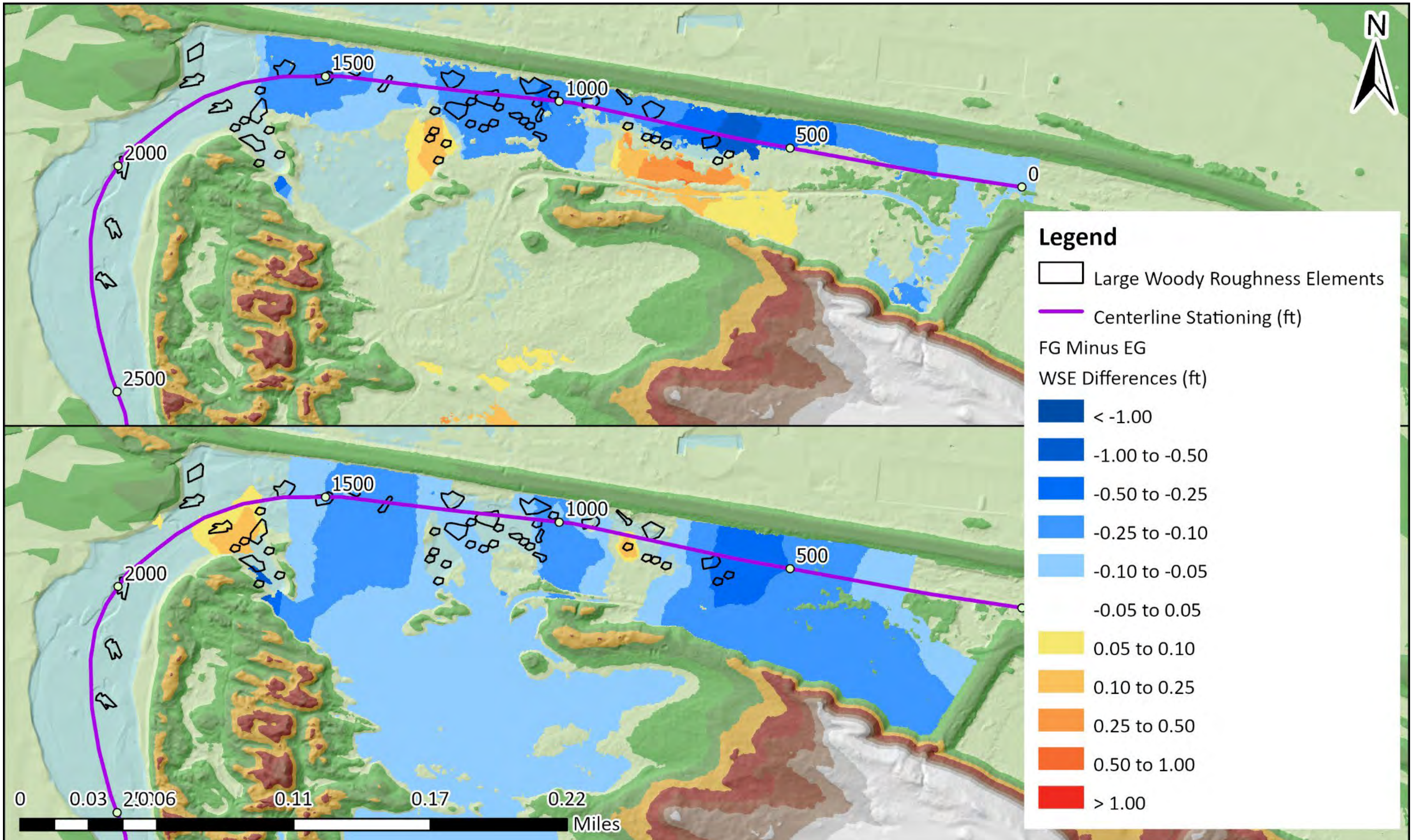
Notes: Water surface elevation differences (FG minus EG) for 10-year (top) and 100-year (bottom) open inlet, low tide scenarios.

Meadow Creek Lagoon Habitat Restoration

WSE differences (FG minus EG) – OI, LT

Project No. 21-1007	Created By: HNT	**Figure 20**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig020.docx
9/28/2023



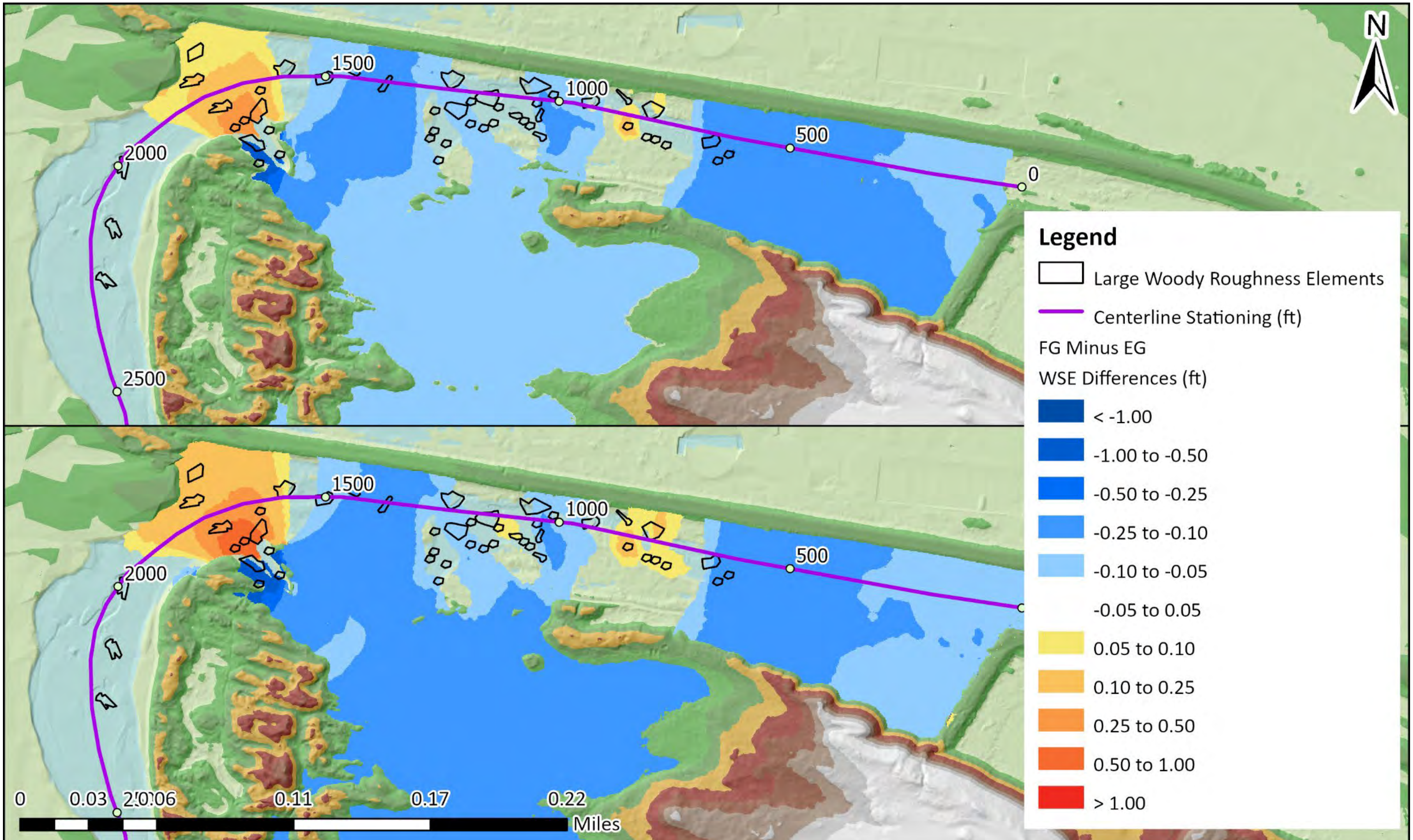
Notes: Water surface elevation differences (FG minus EG) for 2-year (top) and 5-year (bottom) open inlet, high tide scenarios.

Meadow Creek Lagoon Habitat Restoration

WSE differences (FG minus EG) – OI, HT

Project No. 21-1007	Created By: HNT	**Figure 21**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig021.docx
9/28/2023



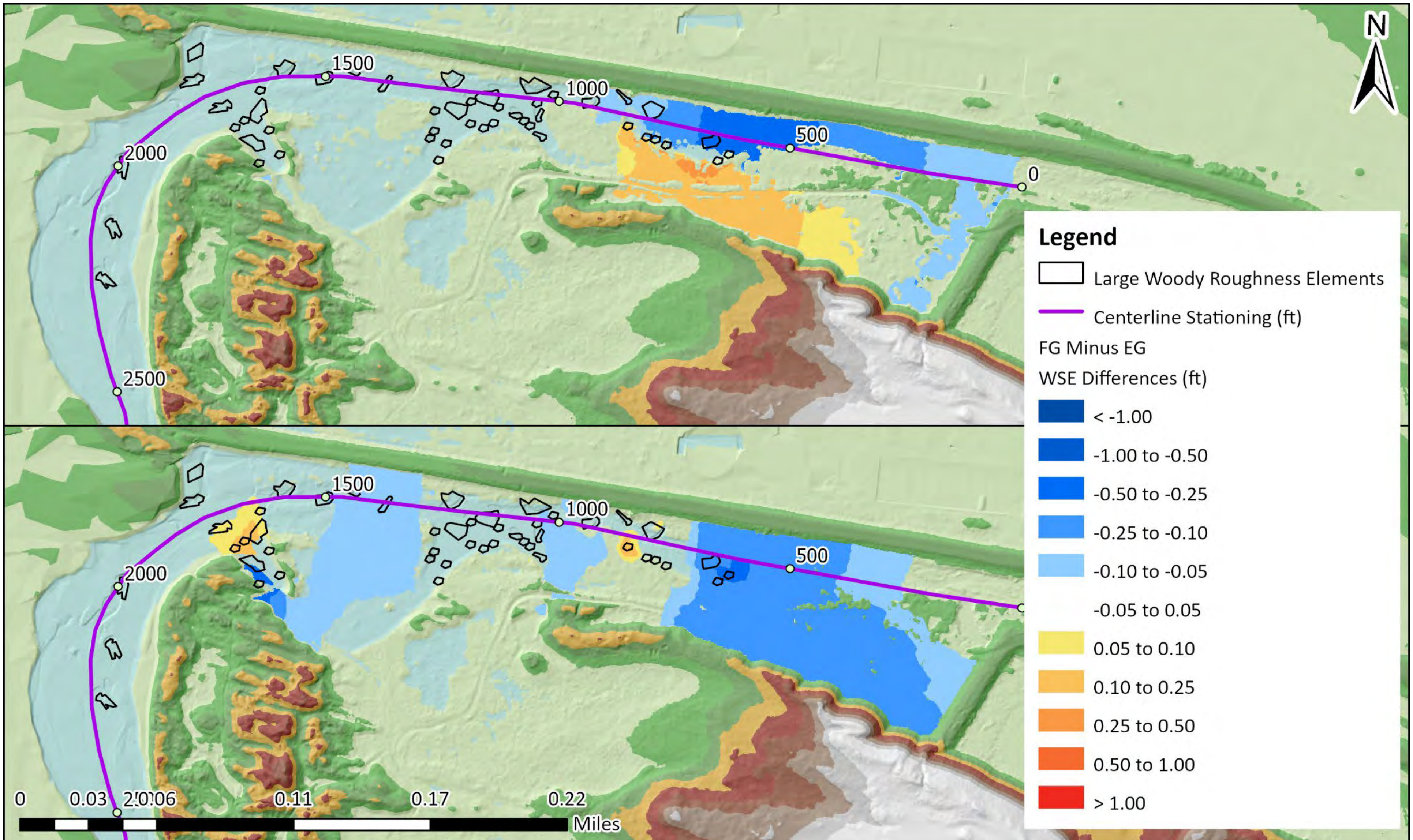
Notes: Water surface elevation differences (FG minus EG) for 10-year (top) and 100-year (bottom) open inlet, high tide scenarios.

Meadow Creek Lagoon Habitat Restoration

WSE differences (FG minus EG) – OI, HT

Project No. 21-1007	Created By: HNT	**Figure 22**

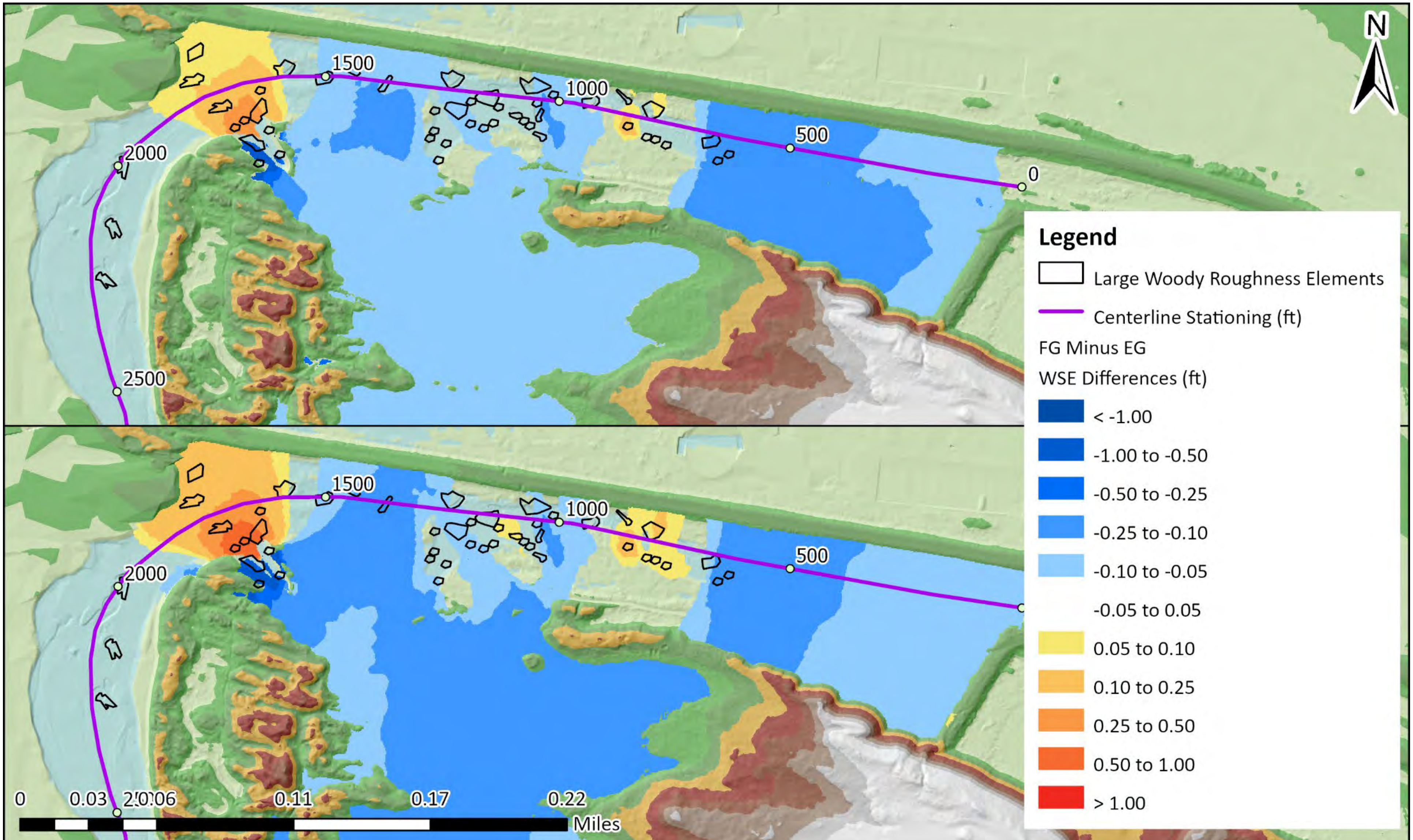
D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig022.docx
9/28/2023



Notes: Water surface elevation differences (FG minus EG) for 2-year (top) and 5-year (bottom) closed inlet, high tide scenarios.

Meadow Creek Lagoon Habitat Restoration		
WSE differences (FG minus EG) – CI, HT		
Project No. 21-1007	Created By: HNT	**Figure 23**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig023.docx
9/28/2023



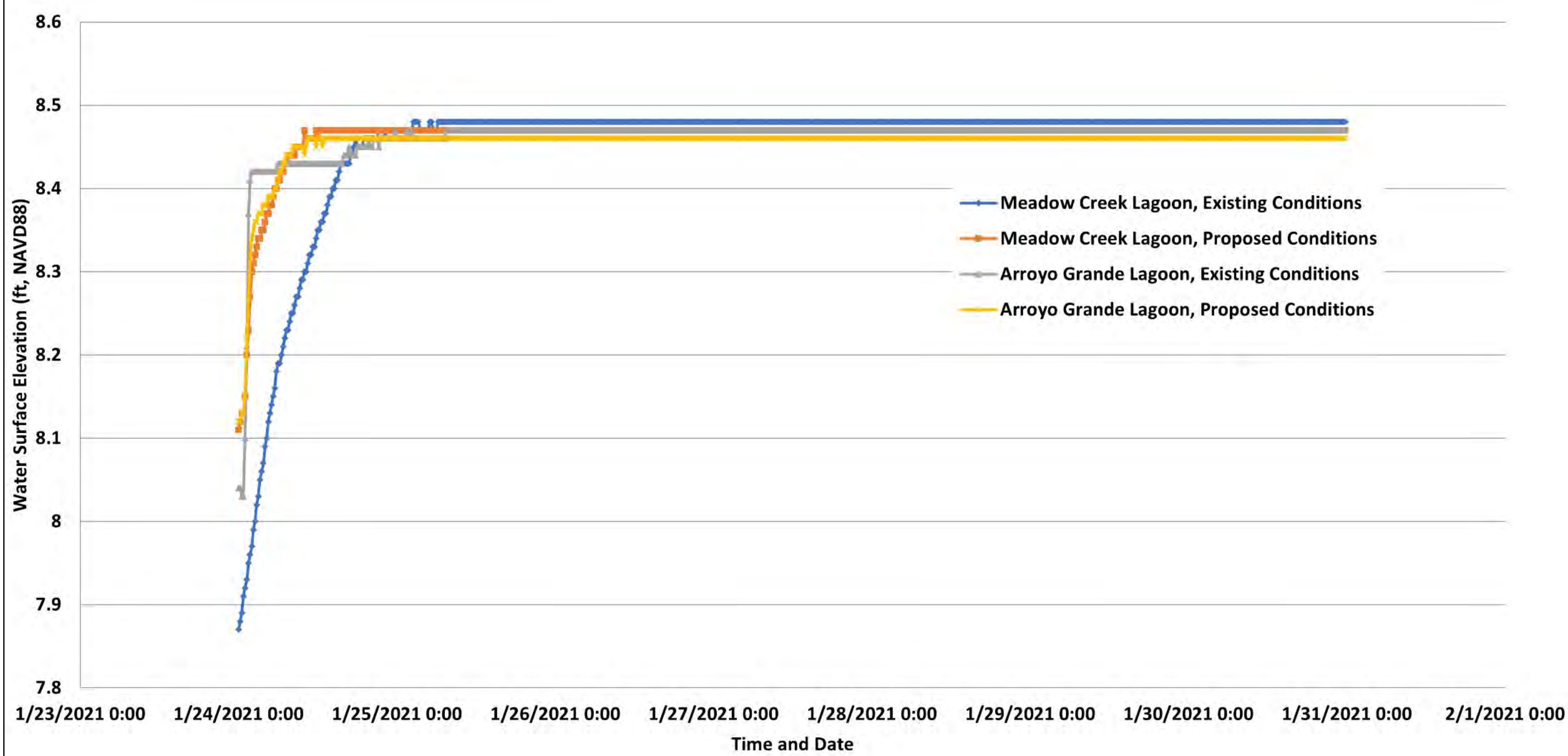
Notes: Water surface elevation differences (FG minus EG) for 10-year (top) and 100-year (bottom) closed inlet, high tide scenarios.

cbec

Meadow Creek Lagoon Habitat Restoration

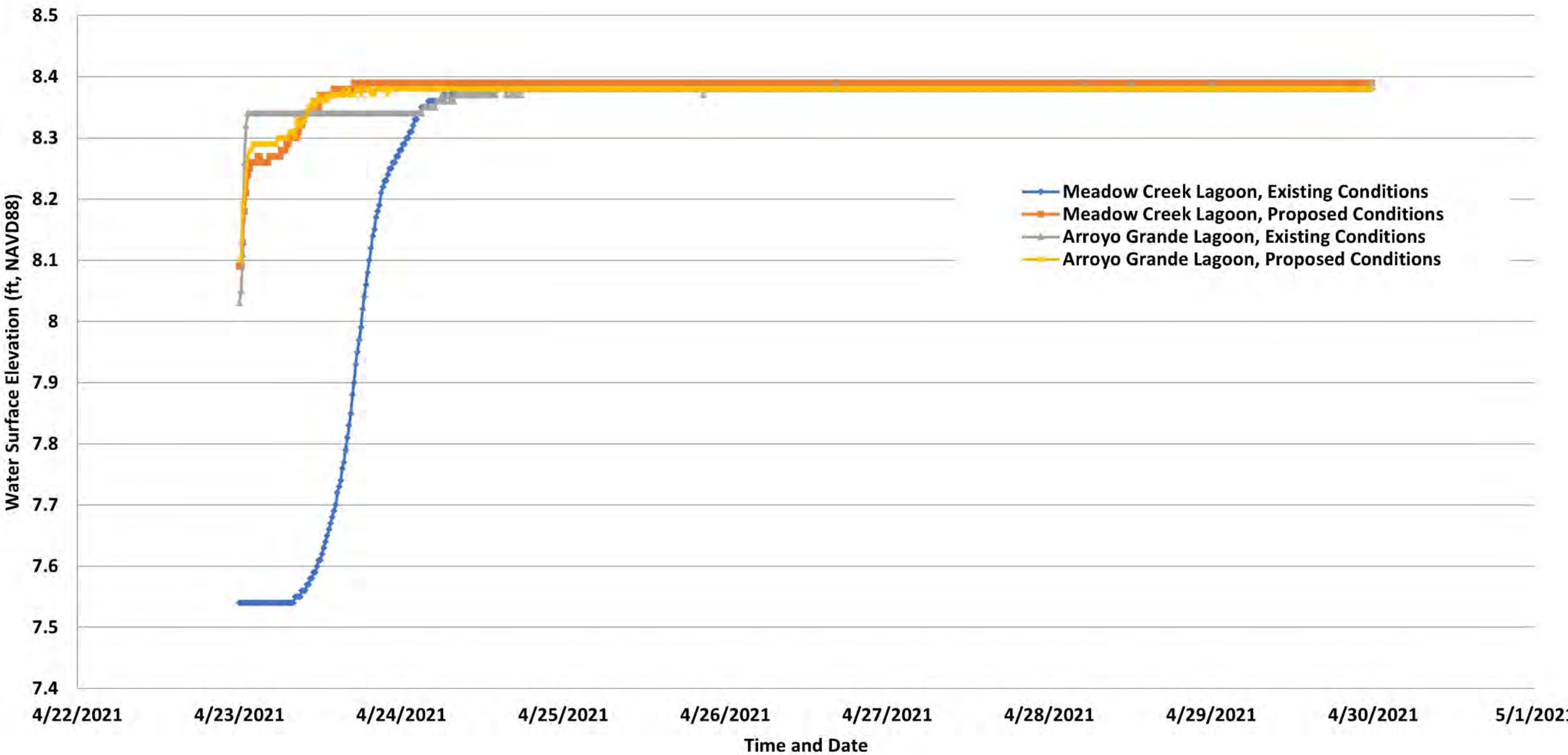
WSE differences (FG minus EG) – CI, HT

Project No. 21-1007	Created By: HNT	**Figure 24**



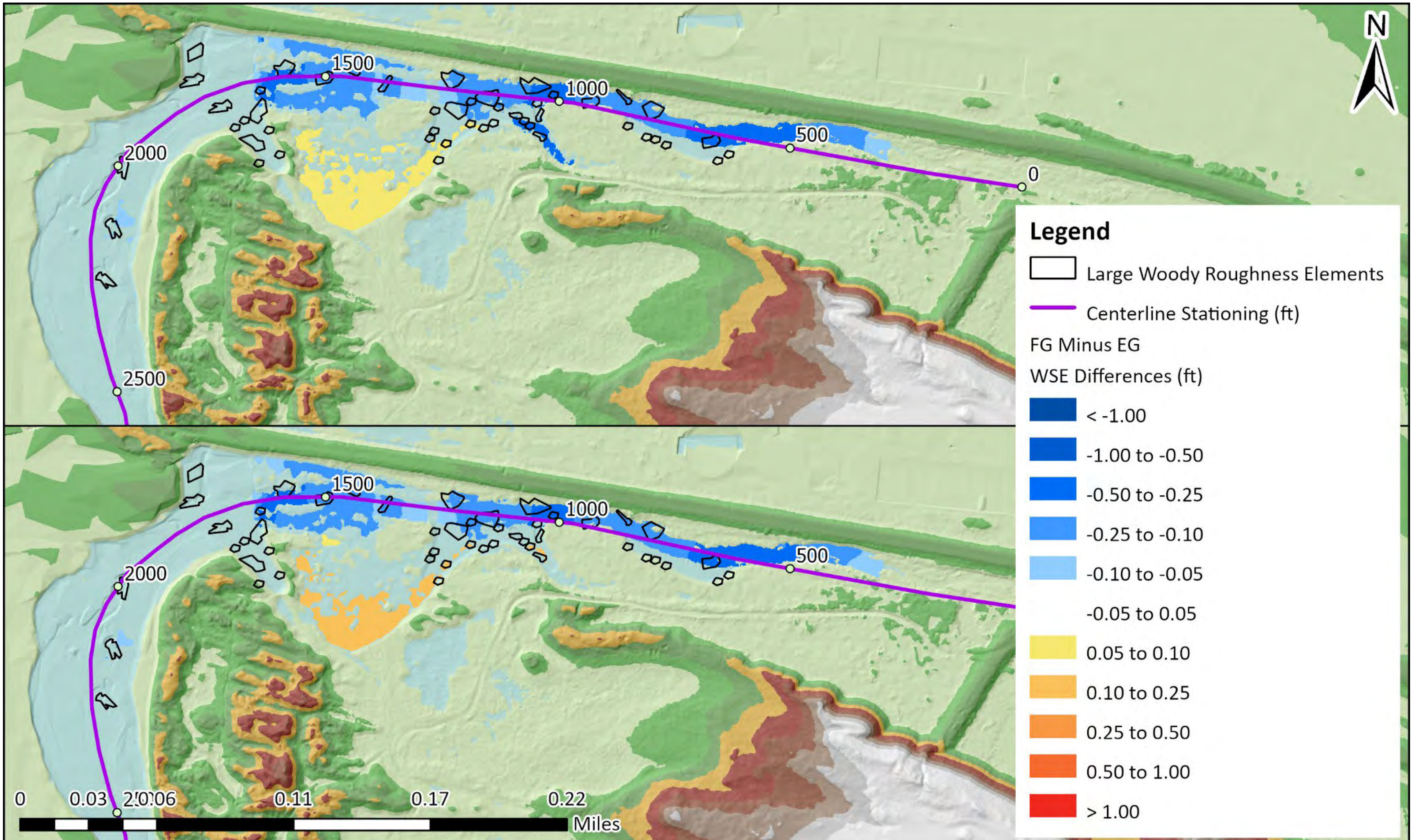
Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **Winter baseflow WSE results**		
		Project No. 21-1007	Created By: HNT	**Figure 25**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig025.docx
9/28/2023



Notes:	cbec	*Meadow Creek Lagoon Habitat Restoration* **Spring baseflow WSE results**		
		Project No. 21-1007	Created By: HNT	**Figure 26**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig026.docx
9/28/2023



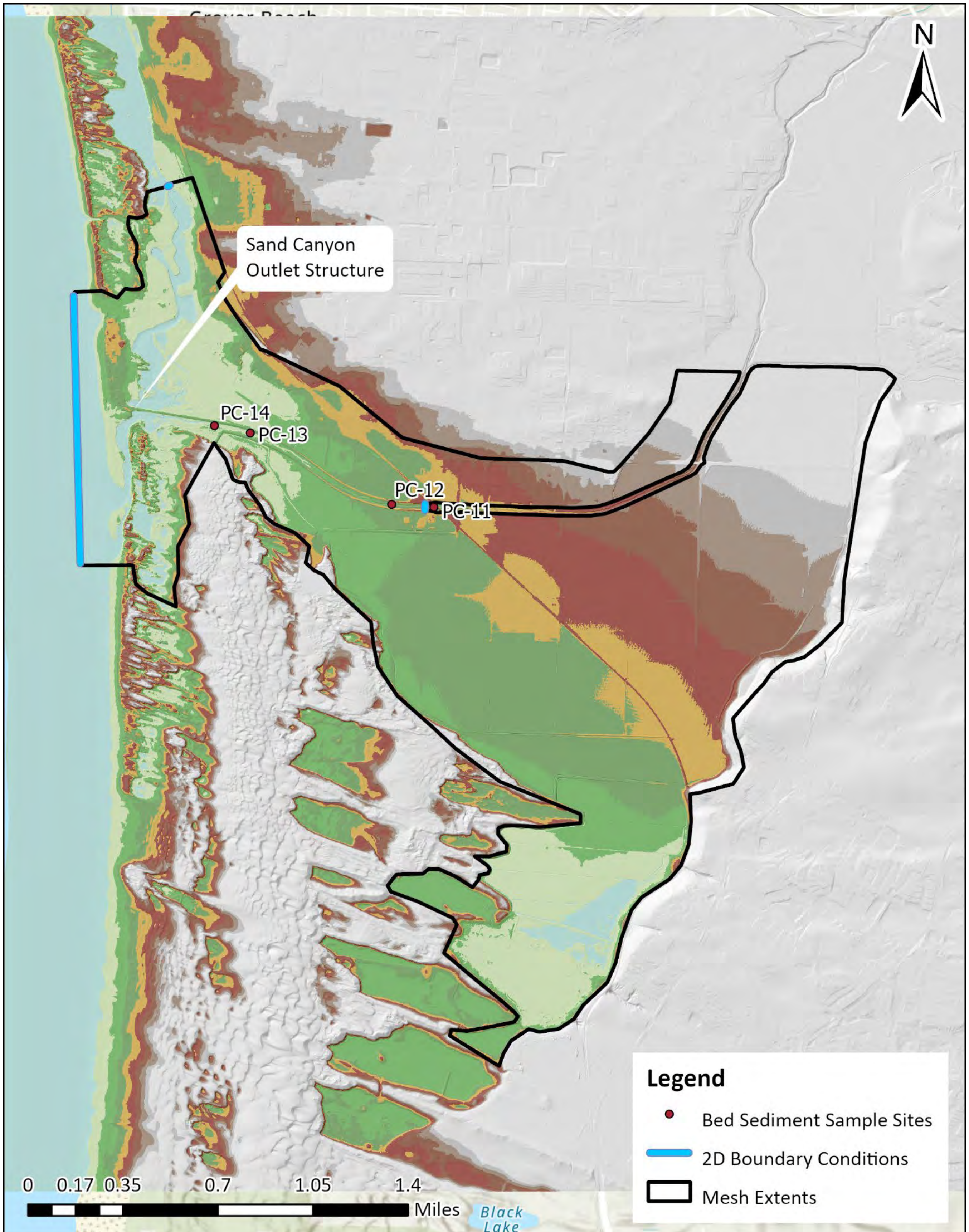
Notes: Water surface elevation differences (FG minus EG) for winter (top) and spring (bottom) baseflow scenarios.

Meadow Creek Lagoon Habitat Restoration

Baseflow WSE differences (FG minus EG)

Project No. 21-1007	Created By: HNT	**Figure 27**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig027.docx
9/28/2023



Notes:

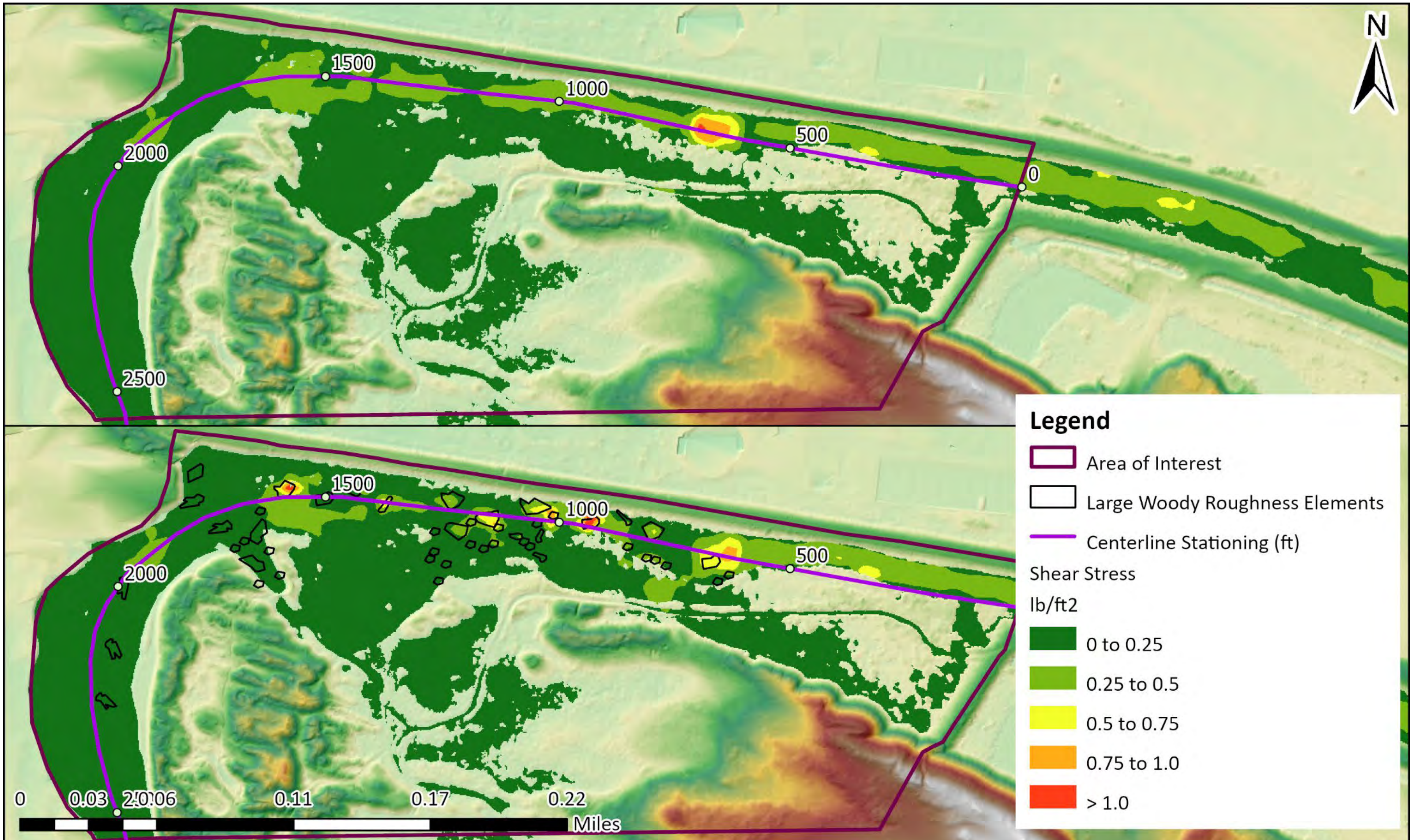
cbec

Meadow Creek Lagoon Habitat Restoration

Sediment transport model geometry

Project No. 21-1007 | Created By: HNT | **Figure 28**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig028.docx
9/28/2023



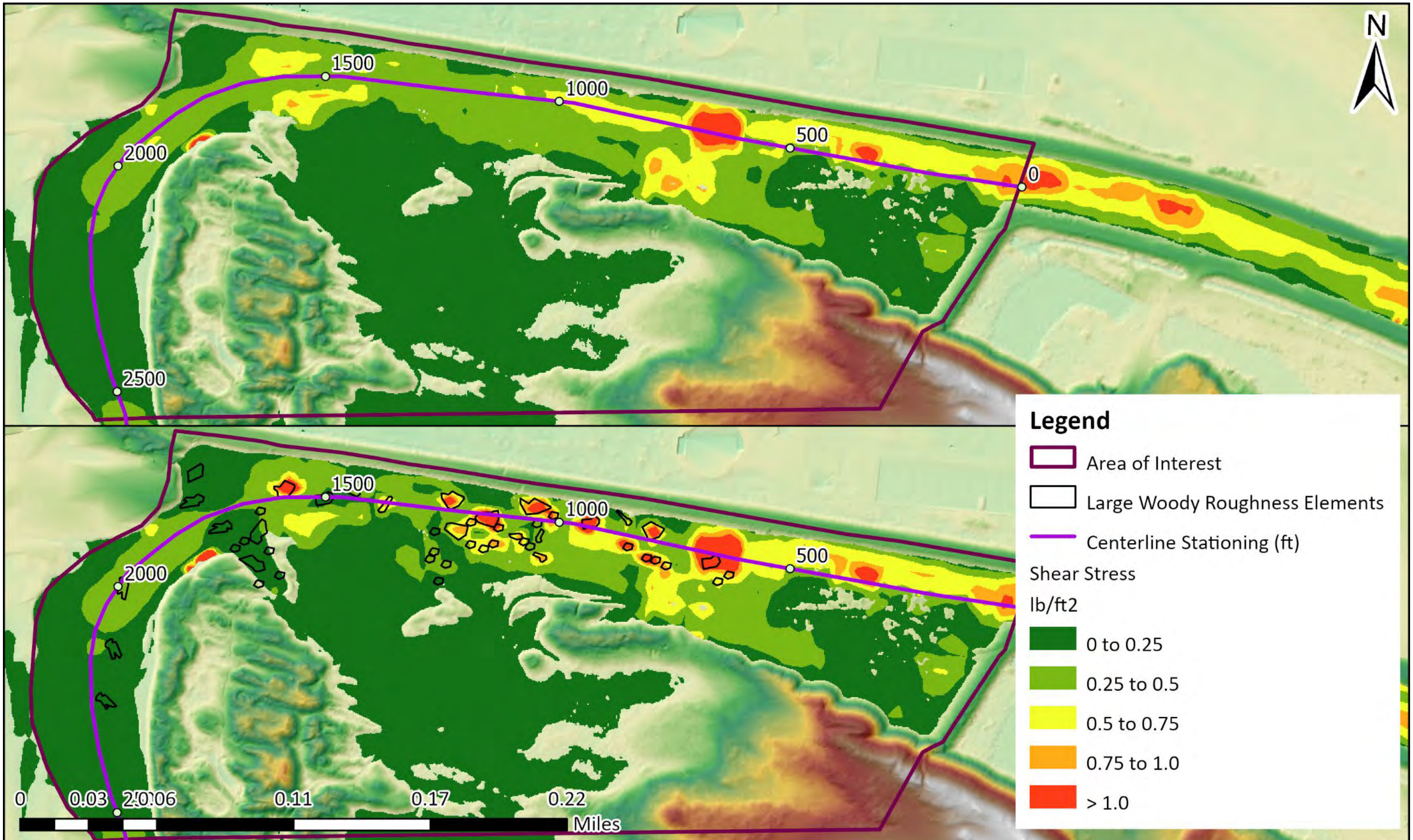
Notes: Shear stress results for EG (top) and FG (bottom) sediment transport model results for 2-year, open inlet, low tide scenarios.

cbec

Meadow Creek Lagoon Habitat Restoration

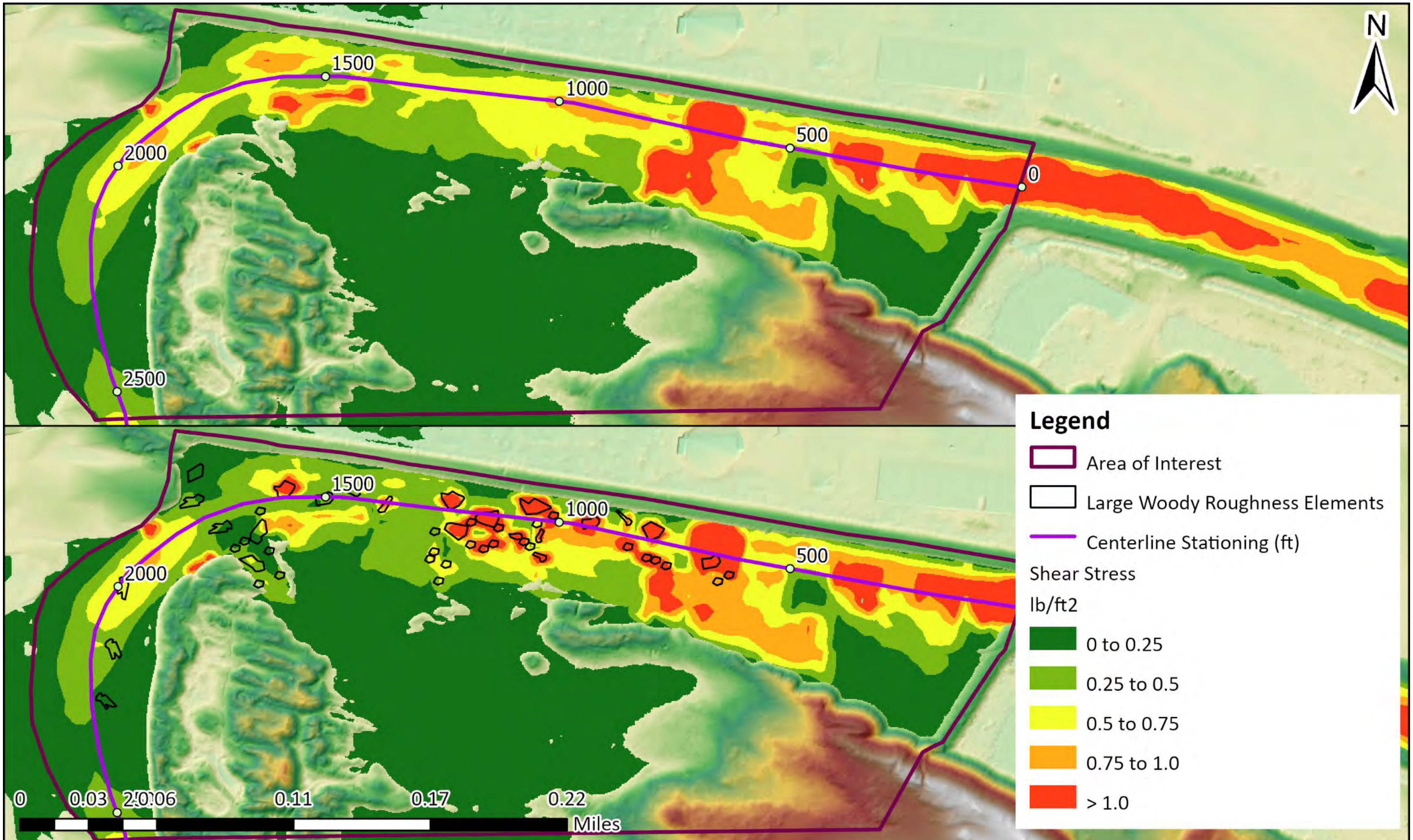
Sediment transport shear stress (2YR, OI, LT)

Project No. 21-1007	Created By: HNT	**Figure 29**



Notes: Shear stress results for EG (top) and FG (bottom) sediment transport model results for 5-year, open inlet, low tide scenarios.

Meadow Creek Lagoon Habitat Restoration	
Sediment transport shear stress (5YR, OI, LT)	
Project No. 21-1007	Created By: HNT	**Figure 30**

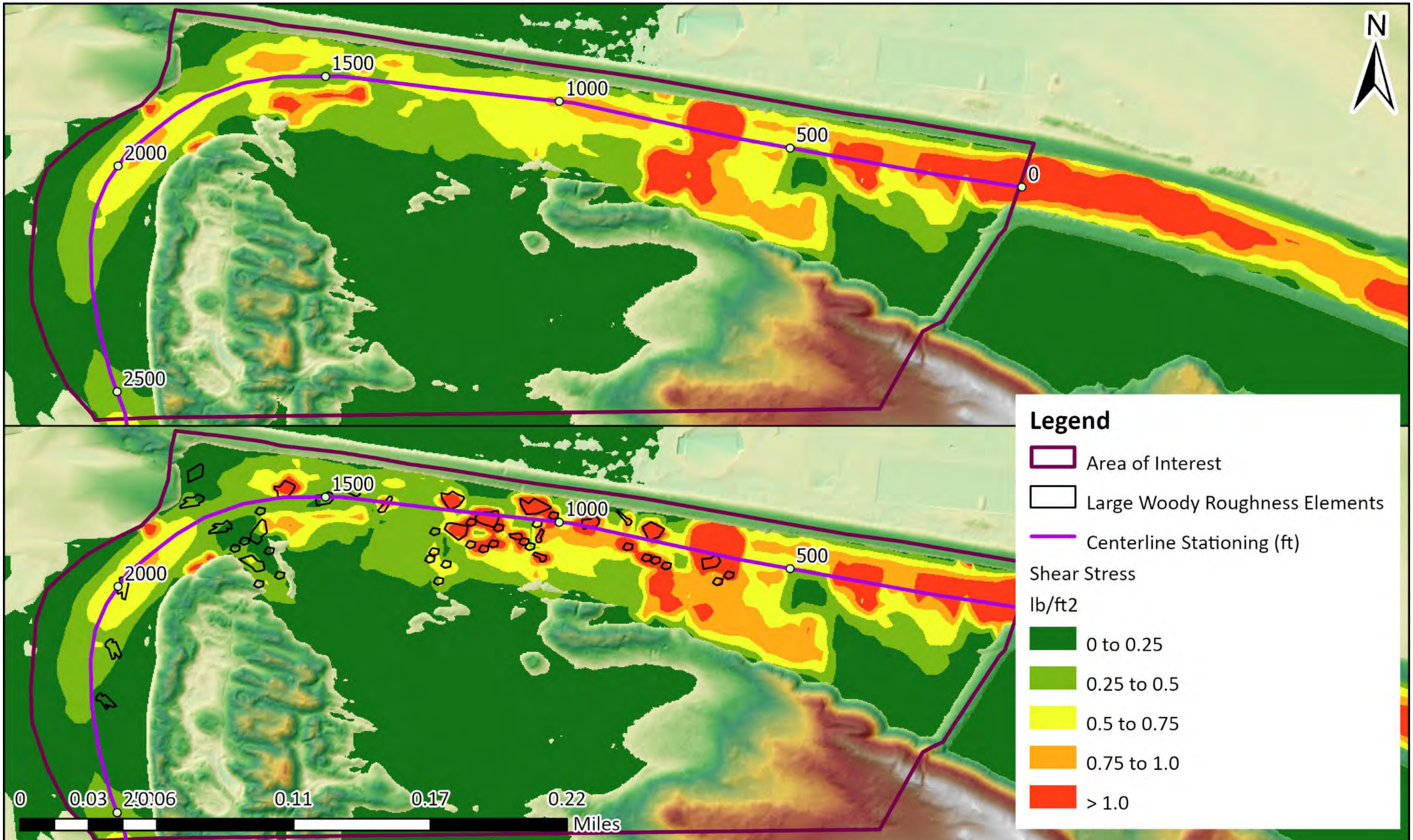


Notes: Shear stress results for EG (top) and FG (bottom) sediment transport model results for 10-year, open inlet, low tide scenarios.

Meadow Creek Lagoon Habitat Restoration

Sediment transport shear stress (10YR, OI, LT)

Project No. 21-1007 | Created By: HNT | **Figure 31**



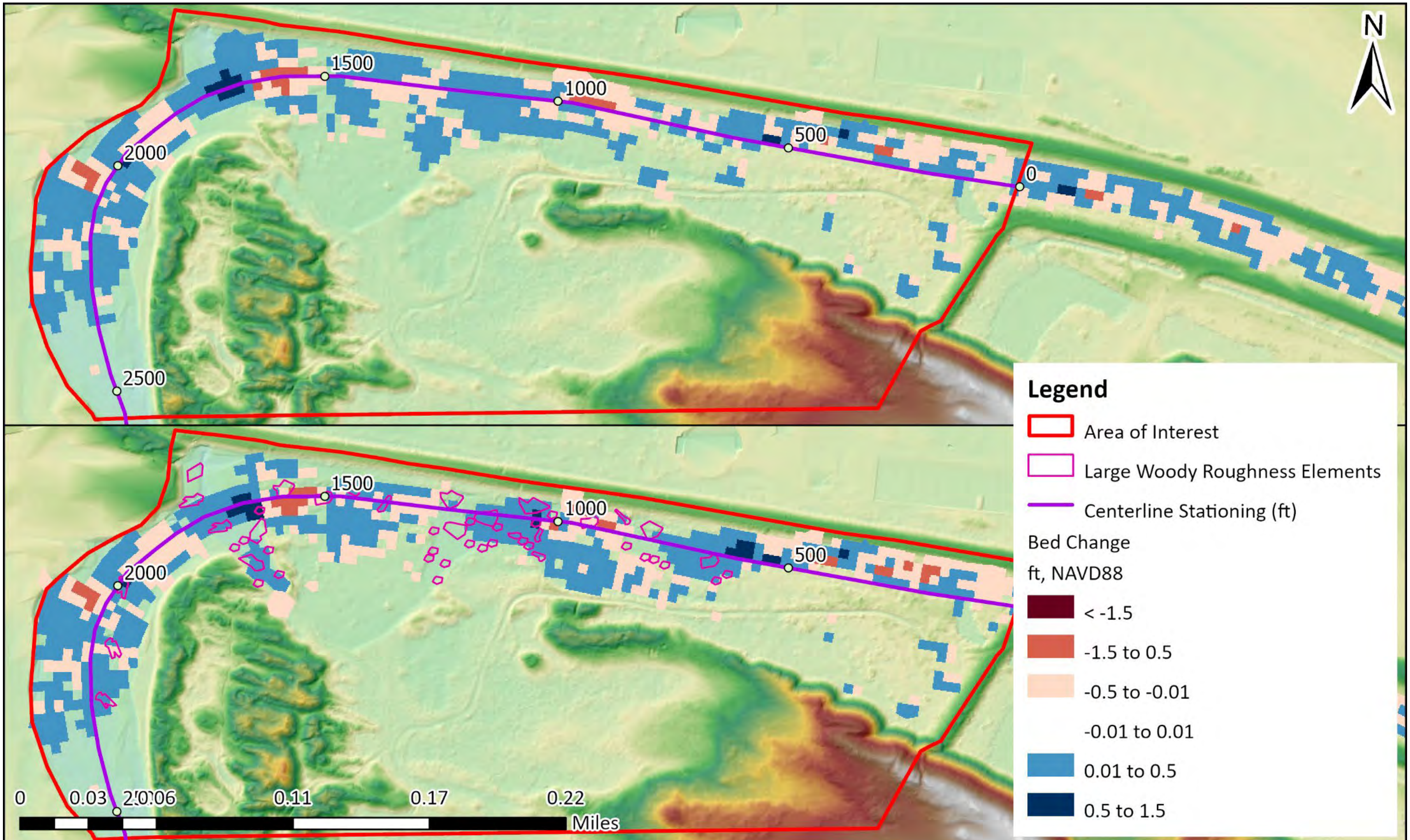
Notes: Shear stress results for EG (top) and FG (bottom) sediment transport model results for 100-year, open inlet, low tide scenarios.

Meadow Creek Lagoon Habitat Restoration

Sediment transport shear stress (100YR, OI, LT)

Project No. 21-1007	Created By: HNT	**Figure 32**

D:\Work_D\Projects\21-1007-2_Meadow_Creek\900_Reporting\Figures\Fig032.docx
9/28/2023



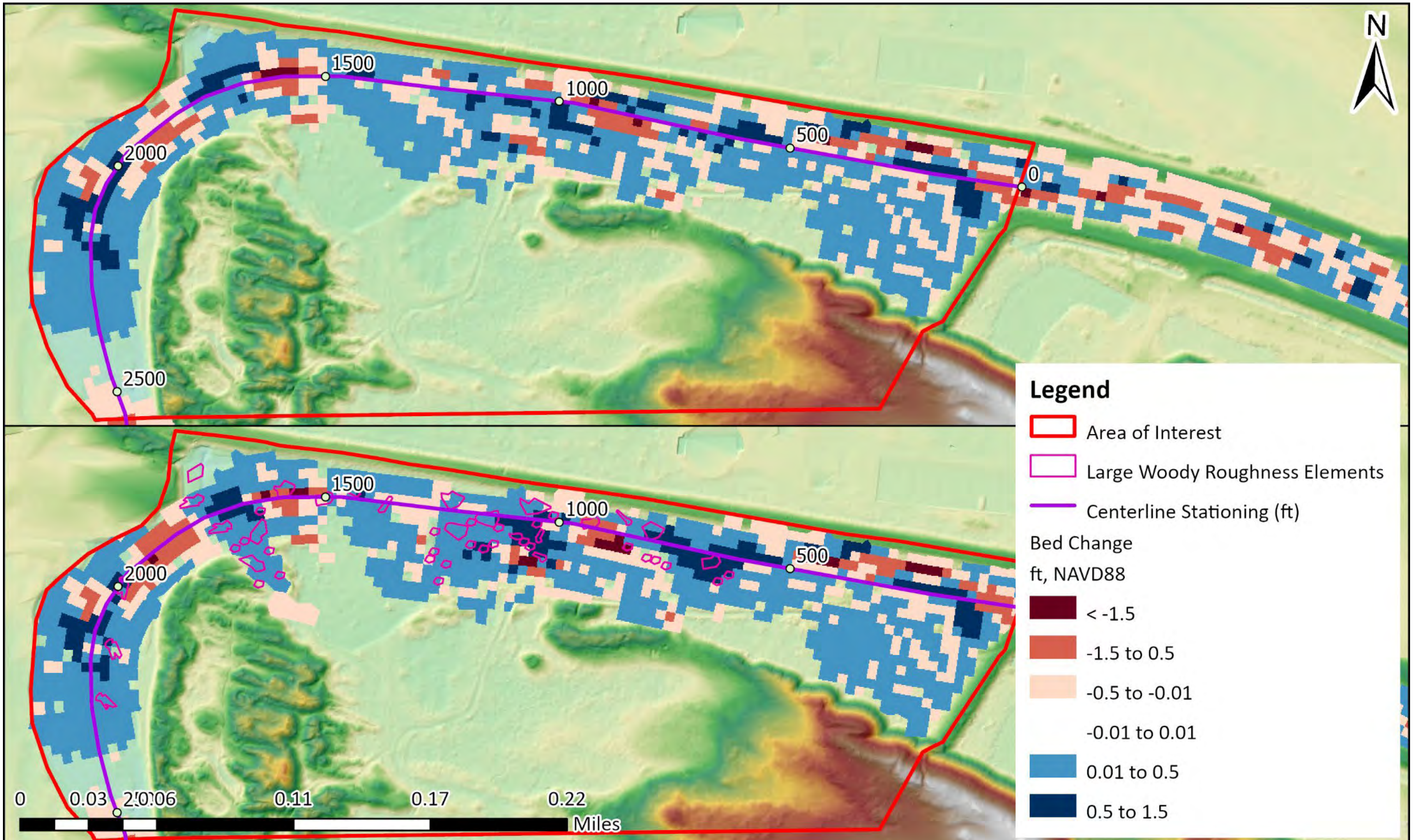
Notes: Bed change results for EG (top) and FG (bottom) sediment transport model results for 2-year, open inlet, low tide scenarios.

cbec

Meadow Creek Lagoon Habitat Restoration

Sediment transport bed change (2YR, OI, LT)

Project No. 21-1007	Created By: HNT	**Figure 33**

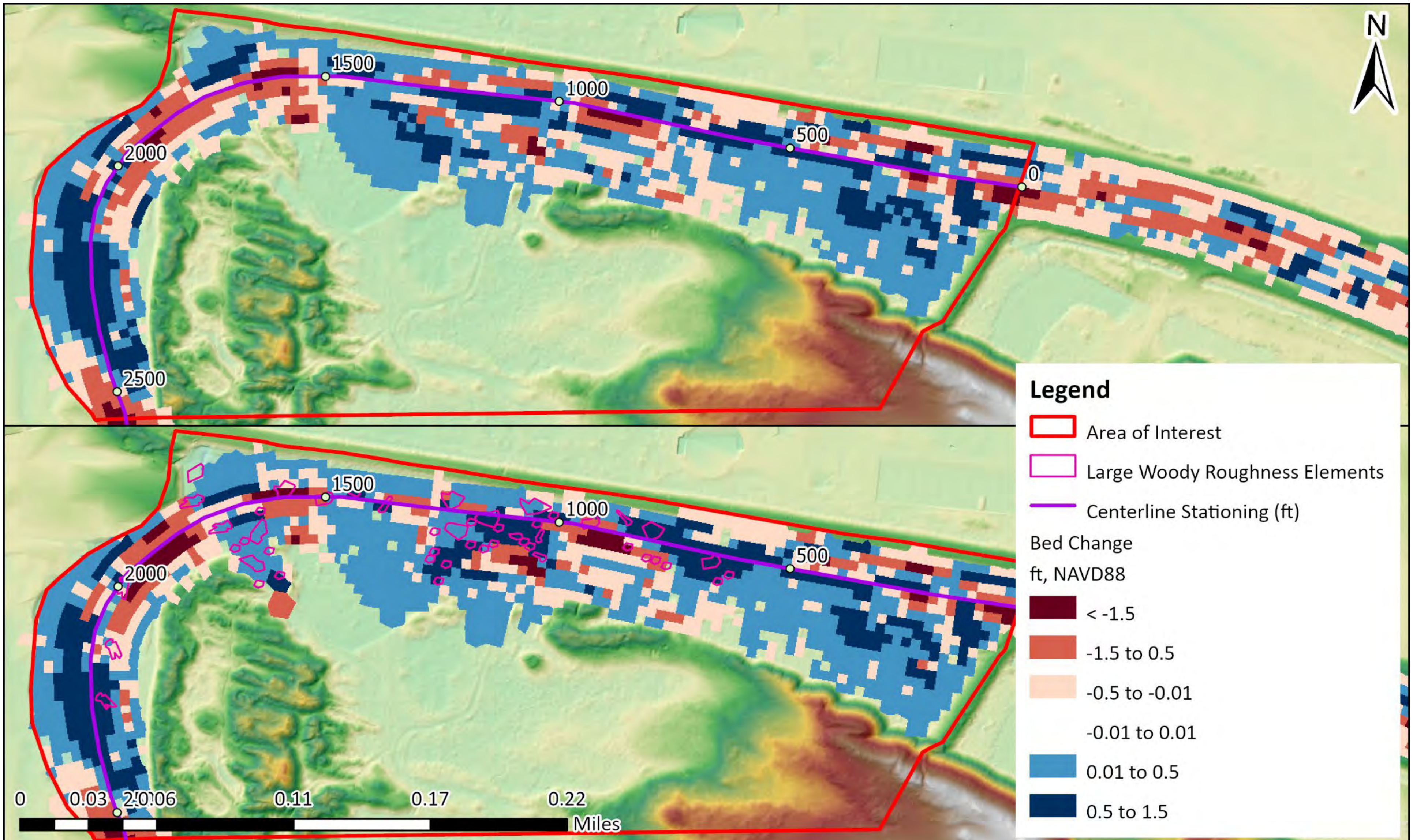


Notes: Bed change results for EG (top) and FG (bottom) sediment transport model results for 5-year, open inlet, low tide scenarios.

Meadow Creek Lagoon Habitat Restoration

Sediment transport bed change (5YR, OI, LT)

Project No. 21-1007	Created By: HNT	**Figure 34**



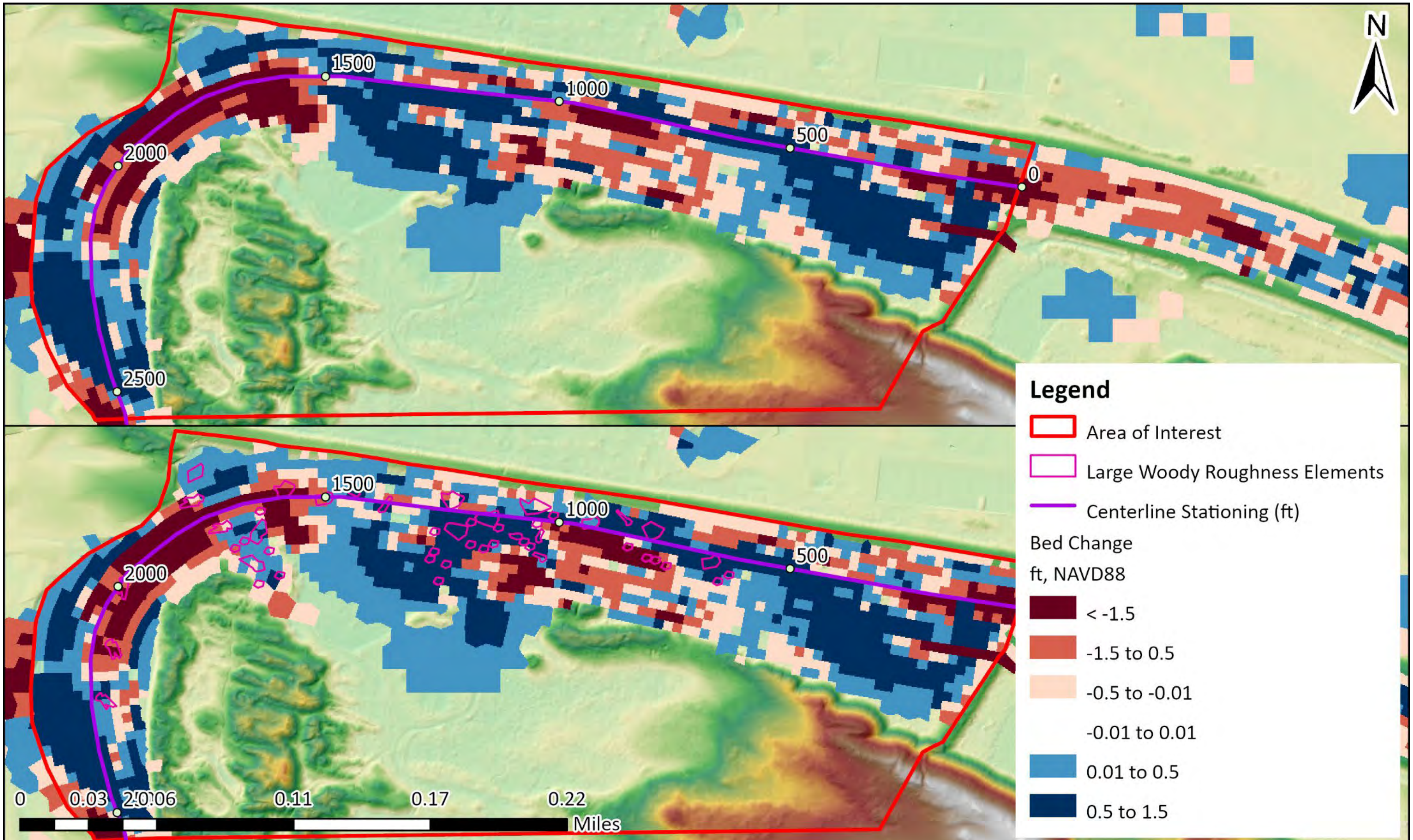
Notes: Bed change results for EG (top) and FG (bottom) sediment transport model results for 10-year, open inlet, low tide scenarios.

cbec

Meadow Creek Lagoon Habitat Restoration

Sediment transport bed change (10YR, OI, LT)

Project No. 21-1007	Created By: HNT	**Figure 35**

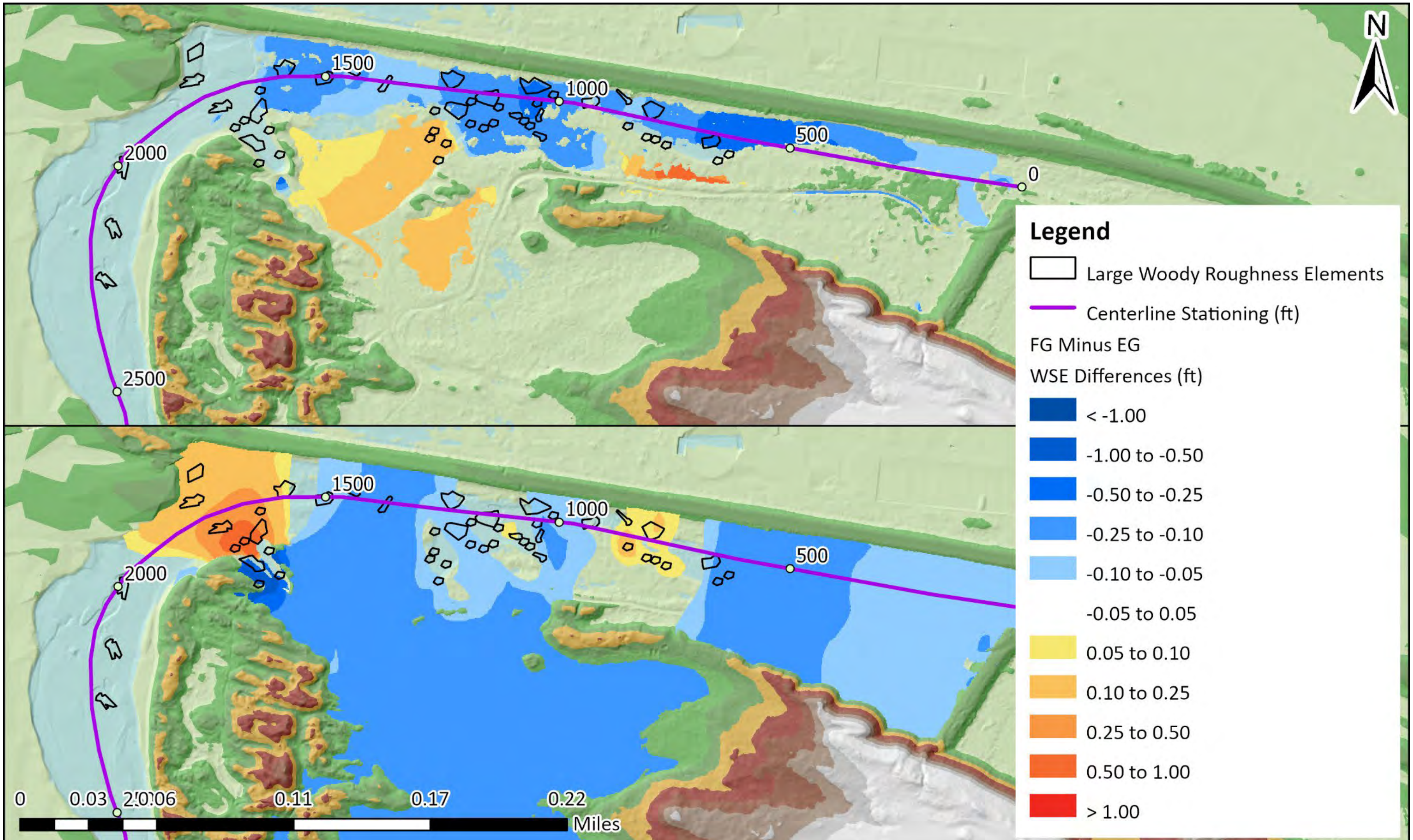


Notes: Bed change results for EG (top) and FG (bottom) sediment transport model results for 100-year, open inlet, low tide scenarios.

Meadow Creek Lagoon Habitat Restoration

Sediment transport bed change (100YR, OI, LT)

Project No. 21-1007	Created By: HNT	**Figure 37**



Notes: WSE differences (FG minus EG) for 2-year (top) and 100-year (bottom) sea level rise modeling scenarios.

cbec

Meadow Creek Lagoon Habitat Restoration

Sea level rise WSE differences

Project No. 21-1007	Created By: HNT	**Figure 37**

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9/28/2023

8 APPENDICES

8.1 Appendix A – Sediment Transport

Table 16. PC-14 existing and edited bed gradations.

Class	Diam (mm)	% in Class		% Finer	
		PC-14	PC-14 Edited	PC-14	PC-14 Edited
Clay	0.002 – 0.004	0	0	0	0
Very Fine Material (VFM)	0.004 – 0.008	0	0	0	0
Fine Material (FM)	0.008 – 0.016	0	0	0	0
Medium Material (MM)	0.016 – 0.032	0	0	0	0
Coarse Material (CM)	0.032 – 0.0625	0	0	0	0
Very Fine Sand (VFS)	0.0625 – 0.125	0	0	0	0
Fine Sand (FS)	0.125 – 0.25	0	0	0	0
Medium Sand (MS)	0.25 – 0.5	0	0	0	0
Coarse Sand (CS)	0.5 – 1	0	0	0	0
Very Coarse Sand (VCS)	1 – 2	4	7	4	7
Very Fine Gravel (VFG)	2 – 4	4	8	8	15
Fine Gravel (FG)	4 – 8	4	8	12	23
Medium Gravel (MG)	8 – 16	13	25	25	48
Coarse Gravel (CG)	16 – 32	16	31	41	79
Very Coarse Gravel (VCG)	32 – 64	10	19	51	98
Small Cobble (SC)	64 – 128	1	2	52	100
Large Cobble (LC)	128 – 256	0	0	0	0
Small Boulders (SB)	256 – 512	0	0	0	0
Medium Boulders (MB)	512 – 1024	0	0	0	0
Large Boulders (LB)	1024 – 2048	0	0	0	0

Table 17. Sediment transport modeling parameters and computation options.

Parameter	Value	Units	Notes
Sediment Boundary Condition	Equilibrium Load		Equilibrium load used when inflow sediment load not known
Transport Function	Laursen (Copeland)		Valid from silts to gravel; most appropriate for velocity, energy gradient, and channel width characteristics here
Sorting Method	Active Layer		
Fall Velocity Method	Soulsby		
Layer Thickness	10	ft	
Bed-Load Correction Factor	Van Rijn-Wu		Recommended

Suspended-Load Correction	Exponential Conc Profile		Recommended
Total-Load Diffusion Method	Weighted Suspended and Bedload		Recommended
Susp Diffusion Method	Dynamic		Recommended
Bed Load Diffusion Method	Dynamic		
Adaptation Coefficient Total Load	30	ft	
Hiding Function	Wu et al		Hiding Exponent = 0.8
Active Layer Thickness	X d90		Multiplier = 10; Min Thickness = 0.1 ft
2D Transport Advection Scheme	Exponential		Recommended
Sediment Matrix Solver	FGMRES-SOR		

Appendix E

Water Level Analysis Results

Values in the table below show threshold elevation (elevation at which water level in AGL surpassed water level in MCL), daily average and daily maximum WSEs in Arroyo Grande Creek Lagoon for days when water levels in AGL were greater than MCL.

Water Level Difference Between AGL and MCL (ft)		Threshold WSE (ft NAVD88)	AG Daily Average WSE (ft NAVD88)	AG Daily Max WSE (ft NAVD88)	Max-Ave WSE (ft)
Date	**Difference (ft)**				
1/4/2017	0.60	9.22	9.82	11.28	1.46
1/5/2017	0.32	9.22	10.45	11.1	0.65
1/8/2017	0.05	9.22	9.66	11.3	1.64
1/9/2017	0.80	9.22	11.09	12.5	1.41
1/19/2017	0.48	8.92	9.20	9.83	0.63
1/20/2017	1.01	8.92	10.44	12.04	1.60
2/6/2017	0.79	8.09	9.56	10.68	1.12
2/7/2017	0.11	8.09	9.34	10.23	0.89
2/8/2017	0.17	8.09	9.72	10.33	0.61
2/17/2017	0.67	8.61	9.44	10.84	1.40
4/28/2017	0.07	7.96	7.96	8.03	0.07
4/29/2017	0.09	7.96	8.12	8.15	0.03
12/2/2017	0.09	7.96	8.01	8.47	0.46
1/9/2018	0.25	8.06	8.46	10	1.54
1/16/2018	0.08	8.74	8.17	9.41	1.24
1/19/2018	0.16	8.23	8.63	9.03	0.40
3/2/2018	0.01	8.18	8.12	8.24	0.12
3/3/2018	0.00	8.18	8.26	8.33	0.07
3/11/2018	0.01	8.36	8.43	8.51	0.08
3/13/2018	0.03	8.36	8.55	8.74	0.19
3/14/2018	0.07	8.36	8.76	8.84	0.08
3/16/2018	0.03	8.36	8.81	9.27	0.46
3/17/2018	0.09	8.36	9.08	9.27	0.19
3/21/2018	0.00	9.15	9.16	10.05	0.89
11/29/2018	0.31	8.06	8.84	9.2	0.36
11/30/2018	0.17	8.06	8.79	9.09	0.30
12/17/2018	0.14	8.47	8.45	10.62	2.17
12/18/2018	0.28	8.47	8.66	9.03	0.37
12/19/2018	0.29	8.47	8.78	8.89	0.11
12/20/2018	0.29	8.47	8.77	9.7	0.93

Water Level Difference Between AGL and MCL (ft)		Threshold WSE (ft NAVD88)	AG Daily Average WSE (ft NAVD88)	AG Daily Max WSE (ft NAVD88)	Max-Ave WSE (ft)
Date	**Difference (ft)**				
12/24/2018	0.02	8.56	8.57	8.68	0.11
12/25/2018	0.16	8.56	8.78	8.95	0.17
12/26/2018	0.17	8.56	8.80	8.88	0.08
12/27/2018	0.06	8.56	8.70	8.73	0.03
12/28/2018	0.04	8.56	8.64	8.68	0.04
12/29/2018	0.00	8.56	8.60	8.61	0.01
1/5/2019	0.07	8.77	8.78	9.74	0.96
1/9/2019	0.39	8.05	8.47	9.53	1.06
1/10/2019	0.15	8.05	8.50	8.57	0.07
1/11/2019	0.11	8.05	8.56	8.63	0.07
1/18/2019	0.40	8.64	9.16	9.74	0.58
1/19/2019	0.24	8.64	9.14	9.26	0.12
1/20/2019	0.35	8.64	9.34	9.4	0.06
1/21/2019	0.45	8.64	9.41	9.43	0.02
1/22/2019	0.40	8.64	9.43	9.43	0.00
1/23/2019	0.13	8.64	9.42	9.43	0.01
1/24/2019	0.09	8.64	9.41	9.42	0.01
1/25/2019	0.08	8.64	9.43	9.43	0.00
1/26/2019	0.06	8.64	9.42	9.42	0.00
1/27/2019	0.05	8.64	9.40	9.41	0.01
1/28/2019	0.03	8.64	9.39	9.39	0.00
1/29/2019	0.03	8.64	9.39	9.39	0.00
1/30/2019	0.03	8.64	9.38	9.39	0.01
11/26/2019	0.18	7.55	8.26	9.07	0.81
11/27/2019	0.30	7.55	8.74	9.45	0.71
11/28/2019	0.30	7.55	8.97	9.98	1.01
12/4/2019	0.00	8.3	8.32	8.42	0.10
12/8/2019	0.03	8.24	8.33	8.51	0.18
12/13/2019	0.37	8.28	8.70	9.24	0.54
12/14/2019	0.46	8.28	8.92	9.14	0.22
12/15/2019	0.26	8.28	8.79	8.92	0.13
12/16/2019	0.05	8.28	8.63	8.69	0.06
12/22/2019	0.28	8.73	9.03	9.79	0.76
1/21/2020	0.01	8.19	8.10	8.37	0.27
1/22/2020	0.04	8.19	8.37	8.67	0.30

Water Level Difference Between AGL and MCL (ft)		Threshold WSE (ft NAVD88)	AG Daily Average WSE (ft NAVD88)	AG Daily Max WSE (ft NAVD88)	Max-Ave WSE (ft)
Date	**Difference (ft)**				
12/8/2020	0.40	7.22	8.32	8.95	0.63
12/9/2020	0.09	7.22	8.37	8.59	0.22
12/14/2020	0.60	8.09	8.83	9.64	0.81
12/15/2020	0.33	8.09	8.73	8.91	0.18
12/28/2020	0.01	8.01	8.11	8.34	0.23
1/11/2021	0.55	8.3	8.79	9.38	0.59
1/12/2021	0.32	8.3	8.65	8.82	0.17
1/13/2021	0.34	8.3	8.72	9.01	0.29
1/14/2021	0.22	8.3	8.65	8.77	0.12
1/15/2021	0.01	8.3	8.46	8.55	0.09
1/27/2021	0.83	8.33	9.15	10.68	1.53
10/25/2021	0.95	7.5	8.19	10.04	1.85
10/26/2021	0.77	7.5	8.12	8.37	0.25
10/27/2021	0.23	7.5	7.68	7.89	0.21
10/28/2021	0.13	7.5	7.41	7.52	0.11
10/29/2021	0.01	7.5	7.24	7.32	0.08
11/6/2021	0.04	7.27	7.27	7.38	0.11
12/14/2021	0.95	7.62	8.57	9.72	1.15
12/15/2021	0.04	7.62	7.85	8.06	0.21
12/16/2021	0.04	7.62	7.84	8.17	0.33
12/17/2021	0.06	7.62	8.04	8.1	0.06
12/18/2021	0.04	7.62	7.97	8	0.03
12/27/2022		8.65	7.54	9.19	1.65
1/1/2023		7.87	8.60	9.8	1.20
1/5/2023	0.08	9.13	9.51	10.91	1.40
1/9/2023	0.40	9.16	10.12	11.74	1.62
3/10/2023	0.07	9.39	9.55	11.4	1.85

(outlined box)	Indicates one specific storm event
(green)	Max verses daily average WSE Difference < 0.5 ft
(yellow)	Max verses daily average WSE Difference < 1 ft
(orange)	Max verses daily average WSE Difference < 1.5 ft
(red)	Max verses daily average WSE Difference < 2 ft
(dark red)	Max verses daily average WSE Difference > 2 ft

Appendix F

Water Quality Monitoring Results

Site	**Description**	**Date**	**Water Depth**	**DO**	**Temp**	**pH**	**Salinity**
			feet	**mg/L**	**°C**	**SU**	
MCL#1	**Air Park Dr Bridge**	4/12/2023	1	3	14.8	na	0.50
		4/12/2023	2	2.85	14.3	na	0.50
		4/12/2023	3	1.43	14.5	na	0.49
		4/12/2023	4	na	na	na	na
		4/12/2023	5	0.53	14.1	na	0.50
		5/18/2023	1	5.82	18.8	na	0.75
		5/18/2023	2	5.56	18.9	na	0.75
		5/18/2023	3	5.34	18.9	na	0.76
		6/14/2023	0.5	7.96	20.6	7.43	0.75
		6/14/2023	1	7.96	20.6	7.43	0.75
		6/14/2023	2	7.59	20.6	7.42	0.75
		6/14/2023	3	7.56	20.6	7.41	0.75
		7/13/2023	0.5	3.35	20.2	7.22	0.80
		7/13/2023	1	3.22	20.1	7.22	0.80
		7/13/2023	2	2.98	20.1	7.22	0.80
		8/16/2023	0.5	10.12	21.6	7.93	0.76
		8/16/2023	1	9.87	21.6	8.02	0.76
		8/16/2023	2	9.98	21.6	8.18	0.76
		8/16/2023	3	7.92	21.5	8.00	0.77
		9/12/2023	0.5	8.57	20.2	7.12	0.78
		9/12/2023	1	8.83	20.3	7.54	0.78
		9/12/2023	2	8.43	20.3	7.58	0.78
		9/12/2023	3	7.91	20.2	7.54	0.78
		10/18/2023	0.5	9.51	18.8	7.64	0.77
		10/18/2023	1	8.76	18.7	7.58	0.77
		10/18/2023	2	7.89	18.5	7.52	0.77
		10/18/2023	3	7.61	18.2	na	0.78
		11.16.2023	0.5	9.61	14.6	7.42	1.25
		11.16.2023	1	9.44	14.5	7.44	1.26
		11.16.2023	2	8.73	14.5	7.44	1.27
		11.16.2023	3	8.7	14.2	7.45	1.30
		11.16.2023	4	8.3	14.2	7.43	1.31
		12.14.2023	0.5	5.01	12.2	7.24	0.89
		12.14.2023	1	5.22	12.2	7.22	0.88
		12.14.2023	2	5.01	12.1	7.27	0.89
		12.14.2023	3	5.21	11.9	7.34	0.91

Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
		1.12.2024	0.5	5.96	11.6	7.17	0.68
		1.12.2024	1	5.44	11.4	7.18	0.68
		1.12.2024	2	4.87	11.1	7.20	0.69
		1.12.2024	3	4.95	10.9	7.26	0.68
		1.12.2024	4	4.75	10.9	7.24	0.68
		2.8.2024	0.5	2.38	12.1	6.81	0.64
		2.8.2024	1	2.15	12.0	6.83	0.63
		2.8.2024	2	2.04	11.9	6.58	0.63
		2.8.2024	3	1.92	11.9	6.86	0.63
		2.8.2024	4	1.86	11.9	6.87	0.63
MCL#2	**Sand Canyon Outlet Structure**	4/12/2023	1	2.34	17.0	na	0.58
		5/18/2023	0.5	2.08	16.0	6.65	0.81
		6/14/2023	0.5	1.78	17.6	7.19	0.79
		7/13/2023	0.5	2.3	16.7	7.12	0.85
		8/16/2023	0.5	2.96	19.0	8.56	1.95
		9.12.2023	0.5	2.74	17.5	7.44	0.93
		9.12.2023	1	2.54	17.4	7.39	0.93
		10.18.2023	0.5	2.43	14.3	7.20	1.09
		10.18.2023	1	2.25	14.4	7.09	1.34
		11.16.2023	0.5	2.93	13.0	6.95	7.44
		11.16.2023	1	2.61	13.0	6.56	13.00
		12.14.2023	0.5	4.65	8.6	7.16	2.25
		12.14.2023	1	3.9	8.9	7.07	3.05
		1.12.2024	0.5	9.84	8.7	8.18	3.59
		1.12.2024	1	9.72	8.6	8.30	3.82
		2.8.2024	0.5	3.29	11.5	7.31	0.66
		2.8.2024	1	3.1	11.5	7.22	0.66
MCL #3	**Deepest location in lagoon between Pier and Air Park bridges**	4/12/2023	na	na	na	na	na
		5/18/2023	na	na	na	na	na
		6/14/2023	0.5	8.08	20.7	7.43	0.74
		6/14/2023	1	7.63	20.6	7.43	0.74
		6/14/2023	2	7.67	20.6	7.41	0.76
		6/14/2023	3	6.15	20.5	7.32	0.74
		6/14/2023	4	4.11	19.7	7.09	0.73

Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
		7/13/2023	0.5	4.55	20.5	7.27	0.78
		7/13/2023	1	4.46	20.5	7.27	0.78
		7/13/2023	2	4.41	20.4	7.25	0.78
		7/13/2023	3	4.13	20.4	7.24	0.78
		7/13/2023	4	3.18	19.8	6.92	0.77
		8/16/2023	0.5	10.74	21.6	8.76	0.75
		8/16/2023	1	10.16	21.6	8.77	0.75
		8/16/2023	2	9.4	21.5	8.19	0.75
		8/16/2023	3	8.91	21.4	8.42	0.74
		8/16/2023	4	8.93	20.9	8.01	0.73
		9.12.2023	0.5	9.26	20.3	7.7	0.77
		9.12.2023	1	9.20	20.4	7.69	0.77
		9.12.2023	2	8.79	20.3	7.64	0.77
		9.12.2023	3	7.39	20.3	7.5	0.76
		9.12.2023	4	6.99	19.6	7.37	0.75
		10.18.2023	0.5	11.89	18.9	7.8	0.76
		10.18.2023	1	11.12	18.8	7.72	0.76
		10.18.2023	2	9.13	18.6	7.58	0.76
		10.18.2023	3	8.98	18.6	7.53	0.75
		10.18.2023	4	na	na	na	0.76
		11.16.2023	0.5	9.67	14.7	7.51	1.23
		11.16.2023	1	9.59	14.6	7.53	1.23
		11.16.2023	2	9.57	14.5	7.54	1.23
		11.16.2023	3	9.61	14.4	7.53	1.23
		11.16.2023	4	8.32	14.4	7.51	1.24
		12.14.2023	0.5	5.47	12.4	7.31	0.87
		12.14.2023	1	5.35	12.4	7.21	0.87
		12.14.2023	2	5.32	12.2	7.27	0.88
		12.14.2023	3	5.32	12.1	7.3	0.88
		12.14.2023	4	5.29	12.2	7.3	0.87
		1.12.2024	0.5	5.99	11.3	7.32	0.67
		1.12.2024	1	5.42	11.4	7.26	0.67
		1.12.2024	2	4.92	11.1	7.25	0.67
		1.12.2024	3	5.02	11.1	7.26	0.67
		1.12.2024	4	5.25	10.9	7.27	0.67
		1.12.2024	5	4.6	10.9	7.26	0.67
		2.8.2024	0.5	2.86	12.2	6.95	0.66
		2.8.2024	1	2.68	12.6	6.97	0.65
		2.8.2024	2	2.73	12.5	7.5	0.68
		2.8.2024	3	3.00	12.6	7.09	0.71

Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
		2.8.2024	4	3.07	12.7	7.11	0.74
		2.8.2024	5	2.30	12.7	6.92	0.73
MCL#4	**North of Pier Ave**	4/12/2023	na	na	na	na	na
		5/18/2023	na	na	na	na	na
		6/14/2023	0.5	3.4	----	----	----
		6/14/2023	5	0.72	---	---	----
		7/13/2023	0.5	3.92	20.8	7.41	0.79
		7/13/2023	1	3.97	20.7	7.43	0.79
		7/13/2023	2	3.56	20.5	7.4	0.79
		7/13/2023	3	3.33	20.4	7.39	0.79
		7/13/2023	4	3.29	20.3	7.39	0.79
		7/13/2023	5	2.95	20.2	7.36	0.79
		7/13/2023	6	2.52	20.2	7.33	0.79
		8/16/2023	0.5	2.91	22	8.34	0.82
		8/16/2023	4	2.6	----	----	
		9.12.2023	0.5	3.61	20.7	7.43	0.84
		9.12.2023	4	3.39	20.6	7.44	0.84
		10.18.2023	0.5	5.61			
		10.18.2023	3	5.04			
		11.16.2023	0.5	3.46	13.5	7.43	0.83
		11.16.2023	5	3.13	13.3	7.43	0.83
		12.14.2023	0.5	2.37	11.1	7.11	0.79
		12.14.2023	5	2.3	11	7.28	0.79
		1.12.2024	0.5	6.72	11.2	7.29	0.68
		1.12.2024	1	7.89	11.3	7.34	0.68
		1.12.2024	2	5.79	10.6	7.25	0.68
		1.12.2024	3	3.92	10.6	7.24	0.68
		1.12.2024	4	3.32	10.5	7.23	0.68
		1.12.2024	5	3.11	10.5	7.22	0.68
		2.8.2024	0.5	2.26	12.2	7.02	0.61
		2.8.2024	1	2.07	12	7.03	0.61
		2.8.2024	2	1.97	11.9	7.03	0.61
		2.8.2024	3	1.89	12	7.04	0.61
		2.8.2024	4	1.82	11.9	7.05	0.61
		2.8.2024	5	1.79	11.9	7.05	0.61

Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
AGL#0	**AG Creek (upstream)**	4/12/2023	1	9.64	14.8	na	0.68
		5/18/2023	0.5	9.63	16.4	8.27	0.98
		5/18/2023	1	9.65	16.4	----	0.98
		5/18/2023	2	9.65	16.4	----	0.98
		6/14/2023	0.5	11.17	17.5	8.69	1.00
		7/13/2023	0.75	16.02	17.2	8.84	1.35
		8/16/2023	0.5	8.89	17.7	9.6	1.25
		8/16/2023	1	8.75	17.7	9.4	1.26
		9.12.2023	0.5	9.43	16.5	8.34	1.21
		9.12.2023	1	9.44	16.5	8.32	1.22
		10.18.2023	0.5	6.82	16.5	7.65	1.87
		10.18.2023	1	6.53	16	7.63	1.86
		11.16.2023	0.5	4.96	15.5	7.87	1.97
		11.16.2023	1	4.42	15.4	7.83	2.78
		12.14.2023	0.5	8.05	13	7.75	2.00
		12.14.2023	1	7.4	11.9	7.83	2.00
		1.12.2024	0.5	12.05	9.5	8.88	1.33
		1.12.2024	1	12.19	9.5	8.93	1.33
		2.8.2024	0.5	10.66	11.3	8.67	0.87
		2.8.2024	1	10.73	11.2	8.73	0.87
AGL#1	**AG Creek/Lagoon (upstream Flap Gate)**	4/12/2023	0.5	9.72	14.2	na	0.69
		4/12/2023	2	9.72	14.3	na	0.70
		5/18/2023	0.5	9.50	15.9	7.83	1.00
		5/18/2023	1	9.52	15.9	na	1.02
		5/18/2023	2	9.52	15.9	na	1.00
		6/14/2023	0.5	10.91	16.4	8.28	1.09
		7/13/2023	0.5	13.06	16.8	8.06	1.82
		7/13/2023	1	13.06	16.9	7.98	3.08
		8/16/2023	0.5	5.2	18.8	8.9	2.54
		8/16/2023	3	2	18.9	8.76	52.73
		9.12.2023	0.5	17.75	18	7.5	1.15
		9.12.2023	1	16.75	18.3	7.89	1.12
		10.18.2023	0.5	17.59	16.8	8.18	2.05
		10.18.2023	1	19.61	16.9	8.26	2.36
		10.18.2023	2	22.03	17.7	8.26	3.92
		11.16.2023	0.5	9.62	14.7	7.72	31.10
		11.16.2023	1	10.84	14.7	8.06	34.06
		11.16.2023	2	11.92	15.3	7.9	49.78

Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
		12.14.2023	0.5	7.74	10.5	7.08	7.35
		12.14.2023	1	8.69	10.9	7.46	9.65
		12.14.2023	2	8.61	16.2	7.25	24.52
		1.12.2024	0.5	10.4	8.6	8.42	1.65
		1.12.2024	1	10.2	8.7	8.4	1.65
		1.12.2024	2	10.54	11.2	7.8	2.15
		2.8.2024	0.5	9.46	11.4	8.08	na
		2.8.2024	1	9.75	10.7	8.25	na
AGL#2	**AG Creek/Lagoon (downstream of Flap Gate)**	4/12/2023	0.5	9.67	14.4	na	0.69
		4/12/2023	2	9.76	14.4	na	0.69
		5/18/2023	na	na	na	na	na
		6/14/2023	0.5	10.54	16.5	8.28	1.06
		7/13/2023	0.5	11.81	16.9	8.02	1.92
		7/13/2023	1	11.69	17.2	7.88	9.29
		8/16/2023	0.5	10.12	19.3	9.62	5.69
		9.12.2023	0.5	21.45	18.3	8.39	1.29
		9.12.2023	1	16.16	18.5	7.95	1.33
		10.18.2023	0.5	19.84	17.2	8.37	2.24
		10.18.2023	1	23.7	17.4	8.45	4.18
		10.18.2023	2	19.66	19	7.93	17.17
		11.16.2023	0.5	10.91	15.4	7.76	27.96
		11.16.2023	1	11.11	15.1	8.05	30.82
		11.16.2023	2	13.2	15	8.29	35.24
		12.14.2023	0.5	9.64	8.8	7.73	6.49
		12.14.2023	1	10.21	10.2	7.73	9.60
		12.14.2023	2	12.72	14.1	7.78	20.99
		1.12.2024	0.5	10.35	8.9	8.42	2.02
		1.12.2024	1	10.26	8.9	8.32	2.90
		2.8.2024	0.5	8.62	11.1	7.8	0.99
		2.8.2024	1	8.51	11	7.82	0.98
		2.8.2024	2	8.88	10.8	7.93	1.05
AGL#3	**AG Lagoon (Upper)**	4/12/2023	0.5	7.2	18.2	na	26.73
		4/12/2023	2	7.38	18.2	na	26.73
		5/18/2023	0.5	9.21	18.5	8.41	25.26
		5/18/2023	1	9.25	18.7	----	25.30
		5/18/2023	2	6.45	19.3	----	33.97
		5/18/2023	2.58	3.95	18.8	----	45.00
		6/14/2023	0.5	9.29	21.7	8.36	51.00
		6/14/2023	1	9.35	21.7	8.36	51.12

Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
		6/14/2023	2	9.1	21.6	8.33	52.12
		7/13/2023	0.5	9.1	21.4	9.08	28.34
		7/13/2023	1	10.02	21.1	9.12	28.39
		7/13/2023	2	9.62	20.5	9.16	28.71
		8/16/2023	0.5	7.46	22.8	9.24	22.00
		8/16/2023	1	7.35	22.8	9.23	22.04
		9.12.2023	0.5	10.25	19.4	8.23	3.41
		9.12.2023	1	2.76	19.7	7.66	4.75
		10.18.2023	0.5	12.61	19.8	8.39	5.04
		10.18.2023	1	8.57	19.8	8.12	6.17
		10.18.2023	2	6.8	19.3	8	6.29
		11.16.2023	0.5	5.45	14.9	8.23	33.40
		11.16.2023	1	6.15	14.5	8.35	33.46
		12.14.2023	0.5	13.58	13.5	8.07	37.65
		12.14.2023	1	13.82	13.5	8.2	37.70
		12.14.2023	2	14.33	13.5	8.27	37.75
		1.12.2024	0.5	9.27	10	8	61.43
		1.12.2024	1	9.22	10	8.09	61.41
		1.12.2024	2	9.23	10	8.18	61.41
		2.8.2024	0.5	8.25	12.1	8.19	46.03
		2.8.2024	1	8.22	12.2	8.2	46.41
		2.8.2024	2	8.23	11.6	8.24	50.67
		2.8.2024	0.5	8.25	12.1	8.19	3.41
AGL#4	**AG Lagoon (Middle, at Staff Plate)**	4/12/2023	na	na	na	na	na
		5/18/2023	0.5	9.06	18.7	8.61	25.39
		5/18/2023	1	9.03	18.8	-	25.47
		6/14/2023	0.5	8.25	21.1	8.31	49.78
		7/13/2023	0.5	6.95	21.4	8.82	27.75
		8/16/2023	0.5	8.13	22.3	9.3	22.04
		8/16/2023	1	8.2	22.4	9.3	22.06
		9.12.2023	0.5	8.29	21.1	8.12	5.64
		9.12.2023	1	8.27	21.1	8.11	5.65
		9.12.2023	2	8.23	21.1	8.12	5.66
		10.18.2023	0.5	3.7	19.9	7.84	6.54
		10.18.2023	1	4.99	19.7	7.98	6.46
		10.18.2023	2	8.23	19.7	8.29	6.70
		11.16.2023	0.5	8.36	15.5	8.42	34.70
		11.16.2023	1	8.25	15.3	8.41	34.85
		11.16.2023	2	8.13	15.2	8.4	35.11

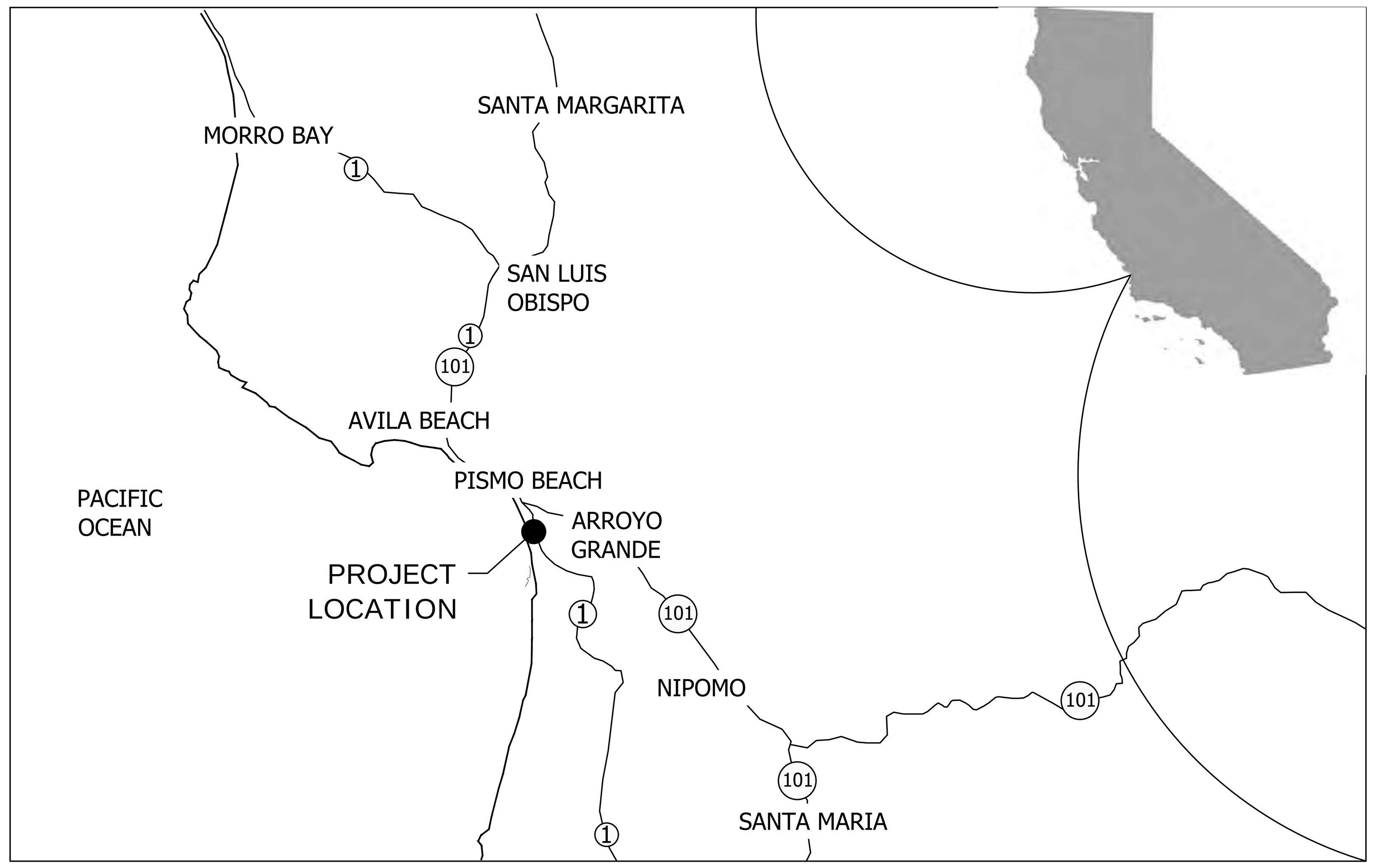
Site	Description	Date	Water Depth	DO	Temp	pH	Salinity
			feet	mg/L	°C	SU	
		12.14.2023	0.5	13.93	12	8.49	36.43
		12.14.2023	1	14.44	12	8.51	36.43
		12.14.2023	2	14.49	12.1	8.49	36.48
		1.12.2024	0.5	10.08	10.4	7.71	59.92
		2.8.2024	0.5	9.5	12.5	8.26	48.21
AGL#5	**AG Lagoon (Lower nearer outlet/sandbar)**	4/12/2023	na	na	na	na	na
		5/18/2023	na	na	na	na	na
		6/14/2023	0.5	8.71	21	8.28	50.31
		7/13/2023	0.5	4.43	20.8	8.65	26.73
		8/16/2023	0.5	8.05	22	9.08	21.40
		8/16/2023	1	8.13	22	9.17	21.44
		9.12.2023	0.5	8.27	20.7	8.09	5.57
		9.12.2023	1	8.21	20.8	7.98	5.59
		9.12.2023	2	7.49	20.8	7.97	5.62
		10.18.2023	0.5	5	19.6	7.88	6.44
		10.18.2023	1	4.9	19.5	7.89	6.44
		10.18.2023	2	4.72	19.5	7.87	6.44
		10.18.2023	3	4.78	19.5	7.89	6.44
		11.16.2023	0.5	7.69	15.6	8.32	37.79
		11.16.2023	1	7.61	15.5	8.37	37.80
		11.16.2023	2	7.29	15.4	8.35	37.93
		12.14.2023	0.5	12.09	11.1	8.35	34.41
		12.14.2023	1	12.37	11.3	8.41	34.79
		1.12.2024	dry	dry	dry	dry	dry
		2.8.2024	dry	dry	dry	dry	dry

Appendix G

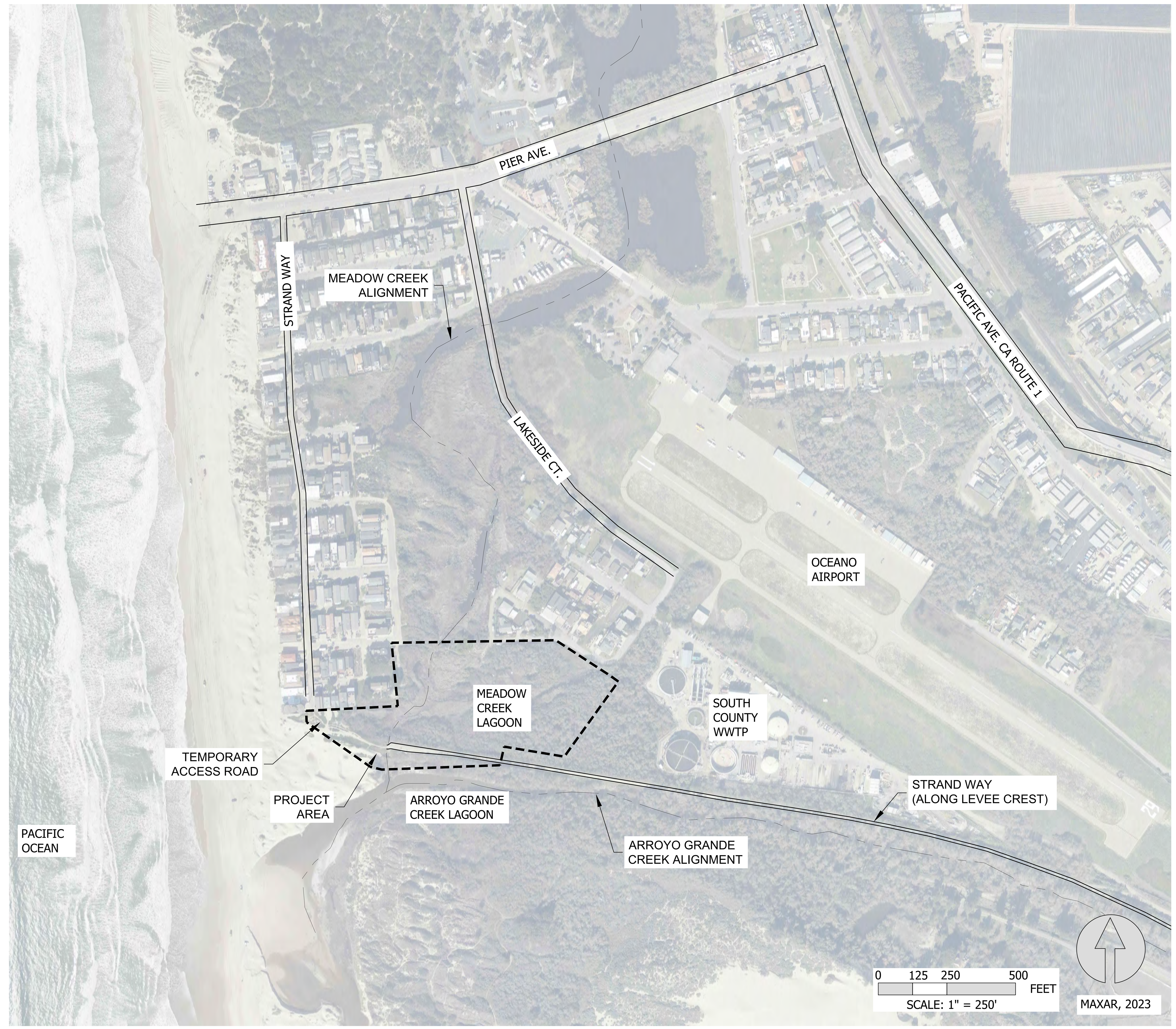
Meadow Creek Lagoon Enhancement Project – 30% Design

MEADOW CREEK HABITAT ENHANCEMENT PROJECT
30% DESIGN DRAWINGS

PROJECT VICINITY



PROJECT LOCATION AND EXISTING FEATURES



DESIGN QUANTITIES:

CUT: 9,006 CY (UNADJUSTED/BANK)

FILL: 1300 CY (ADJUSTED FOR 30% SETTLEMENT LOSSES)

IMPORT BALLAST ROCK: 56 TONS

IMPORT 6" MINUS TRACTION ROCK: 77 CY (108 TONS)

IMPORT LOGS COUNT: 28

ABBREVIATIONS AND SYMBOLS:

<E>	EXISTING
<P>	PROPOSED
TYP	TYPICAL
ELEV.	ELEVATION
NMNP	NORTH MARSH AND NORTH POND
ROW	RIGHT-OF-WAY
PIP	PROTECT IN PLACE

3 — DETAIL # ON SHEET
8 — SHEET #

Sheet List Table	
Sheet Number	Sheet Title
1	TITLESHEET
2	EXISTING CONDITIONS PLAN
3	SITE PLAN AND PROFILE
4	TYPICAL SECTIONS
5	EXISTING SAND CANYON OUTLET STRUCTURE - PLAN AND PROFILE
6	EXISTING TIDE GATE - PROFILE DETAILS
7	EXISTING TIDE GATE - SECTION DETAILS
8	PROPOSED TIDE GATE - DETAILS
9	HABITAT ENHANCEMENT DETAILS
10	HABITAT ENHANCEMENT DETAILS (2)

MEADOW CREEK LAGOON HABITAT RESTORATION

SAN LUIS OBISPO, CA

Stillwater Sciences
895 NAPA AVENUE SUITE B-3
MORRO BAY, CA 93442
P: (805) 570-7499

REVISIONS

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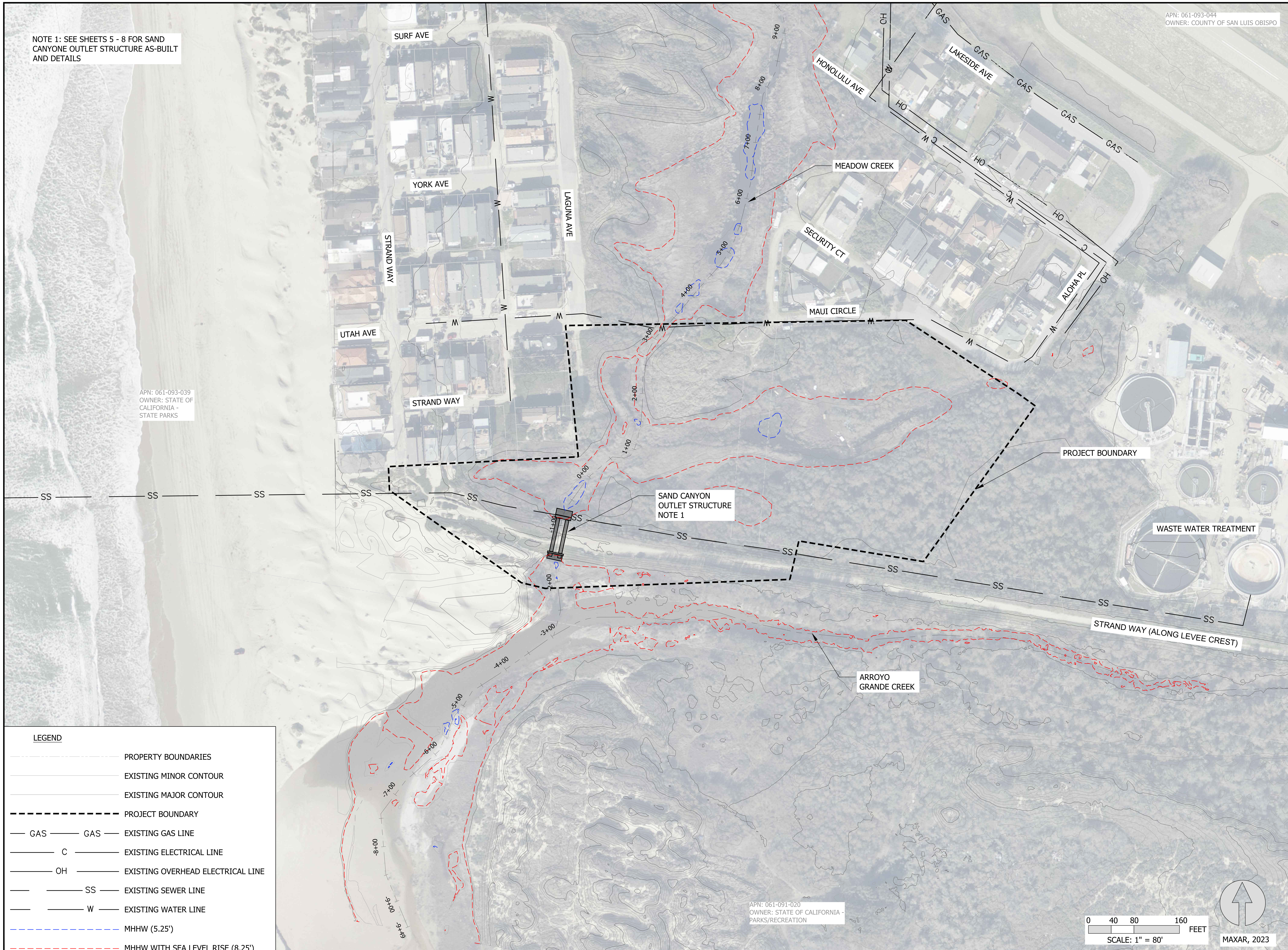
TITLESHEET

SHEET 1 OF 10



LEGEND

	PROPERTY BOUNDARIES
	EXISTING MINOR CONTOUR
	EXISTING MAJOR CONTOUR
	PROJECT BOUNDARY
GAS — GAS	EXISTING GAS LINE
C	EXISTING ELECTRICAL LINE
OH	EXISTING OVERHEAD ELECTRICAL LINE
SS	EXISTING SEWER LINE
W	EXISTING WATER LINE
	MHHW (5.25')
	MHHW WITH SEA LEVEL RISE (8.25')

MEADOW CREEK LAGOON HABITAT RESTORATION

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EXISTING CONDITIONS PLAN

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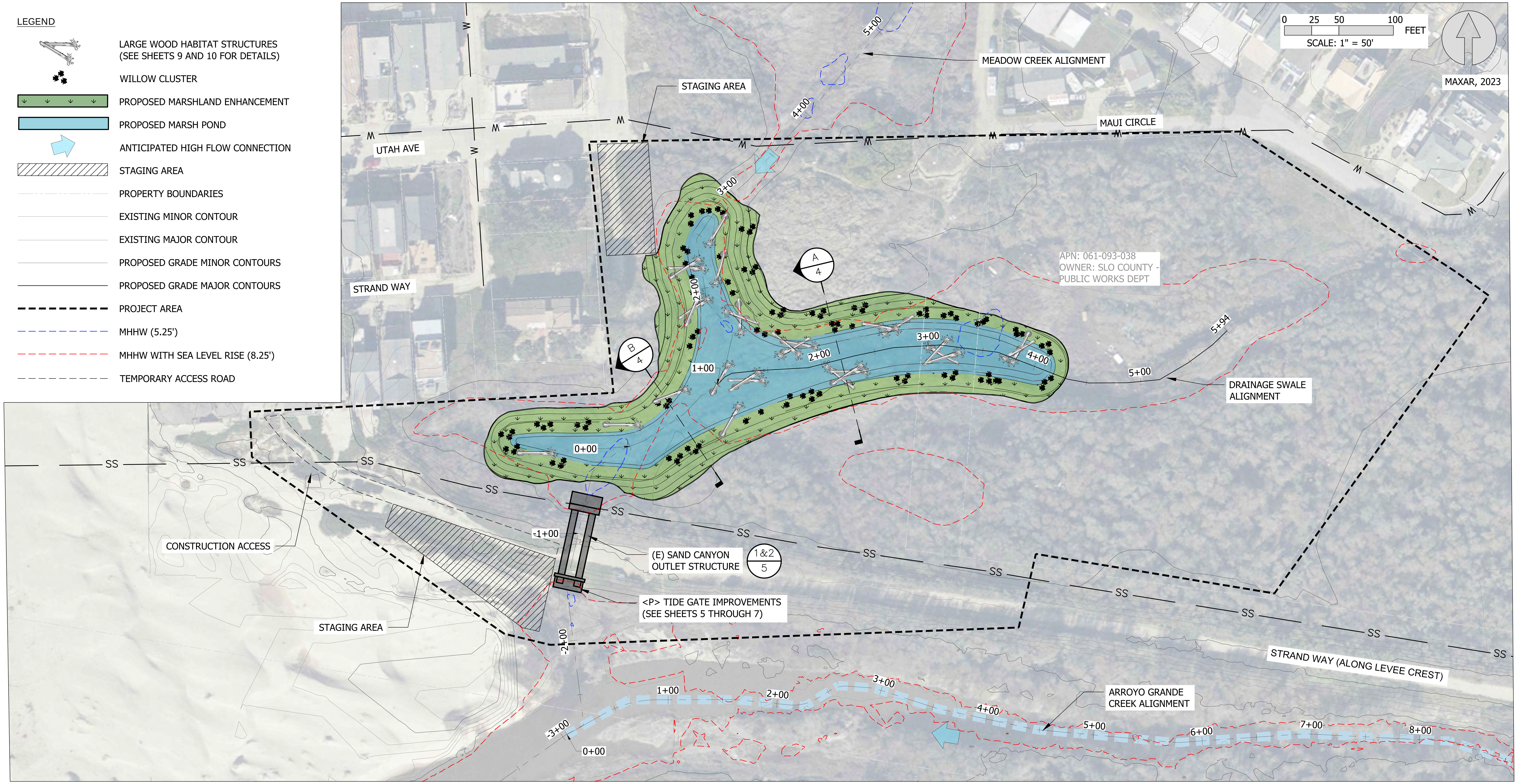
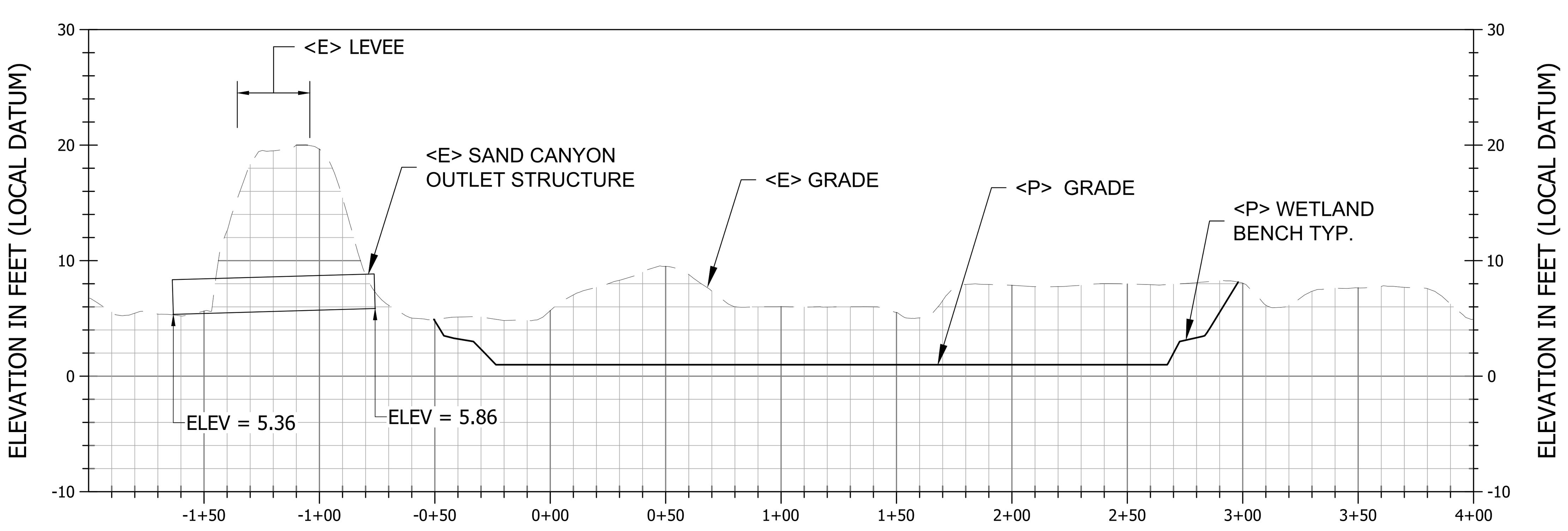
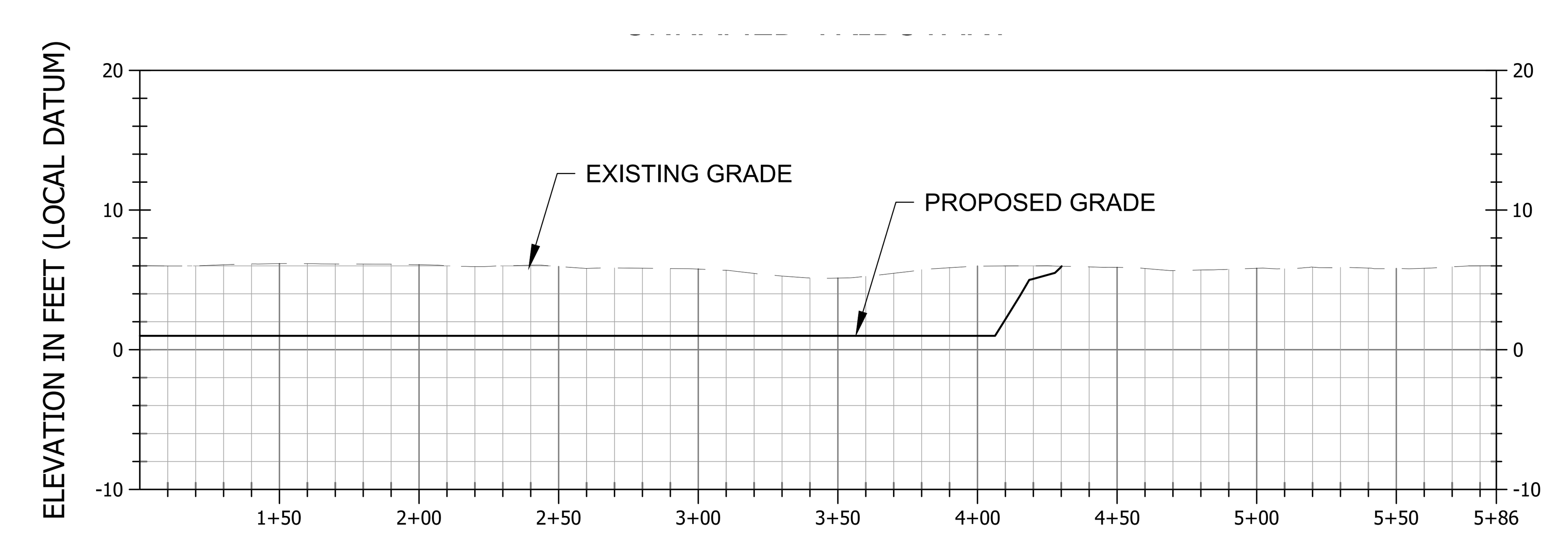


1 PLAN VIEW
SCALE: 1" = 50'



2 MEADOW CREEK PROFILE
5X VERT EXAGGERATION



3 DRAINAGE SWELL PROFILE
5X VERT EXAGGERATION

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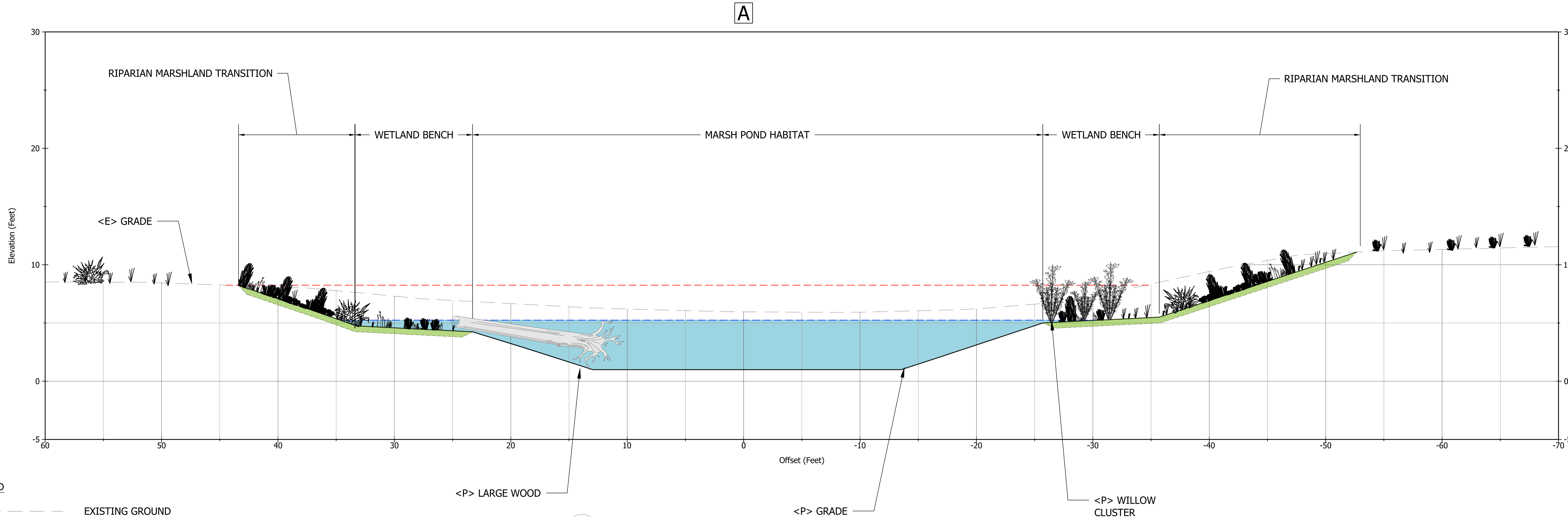
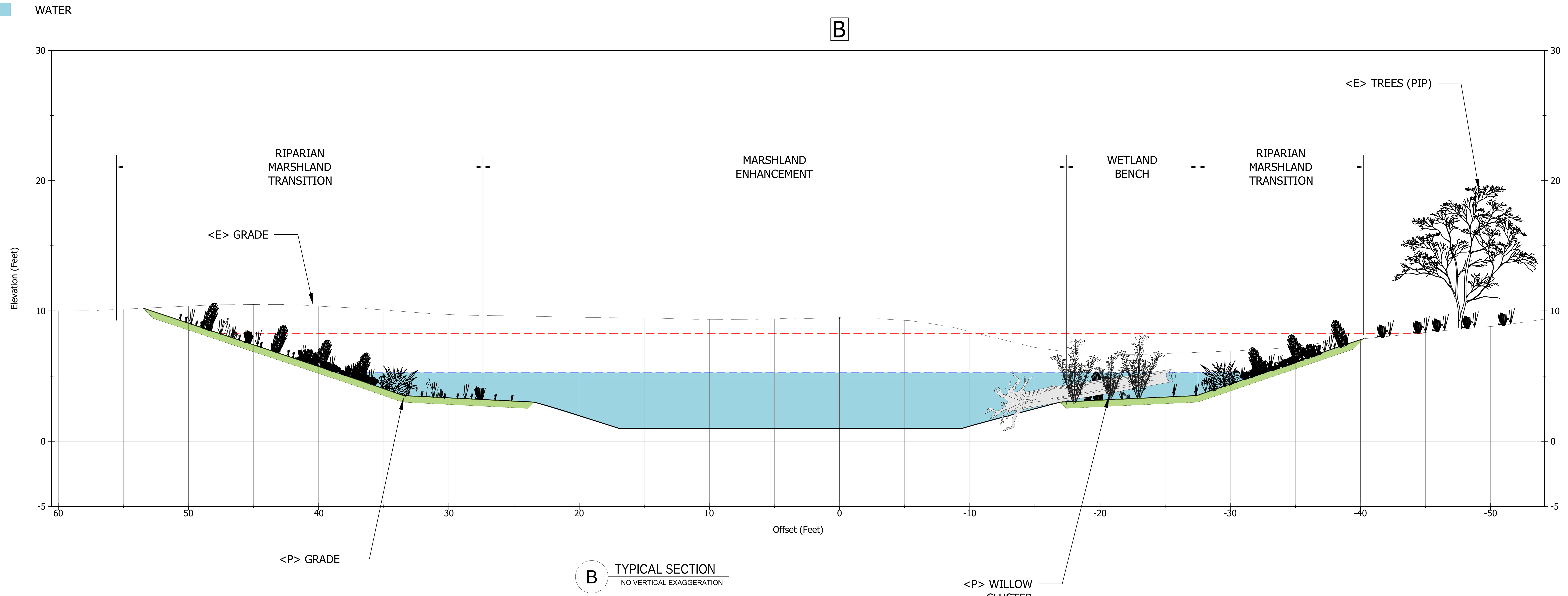
SITE PLAN AND PROFILE



A TYPICAL SECTION
NO VERTICAL EXAGGERATION

LEGEND

- EXISTING GROUND
- PROPOSED GROUND
- MHHW (5.25')
- MHHW WITH SEA LEVEL RISE (8.25')
- OVEREXCAVATION
- TOP SOIL FILL
- WATER



B TYPICAL SECTION
NO VERTICAL EXAGGERATION

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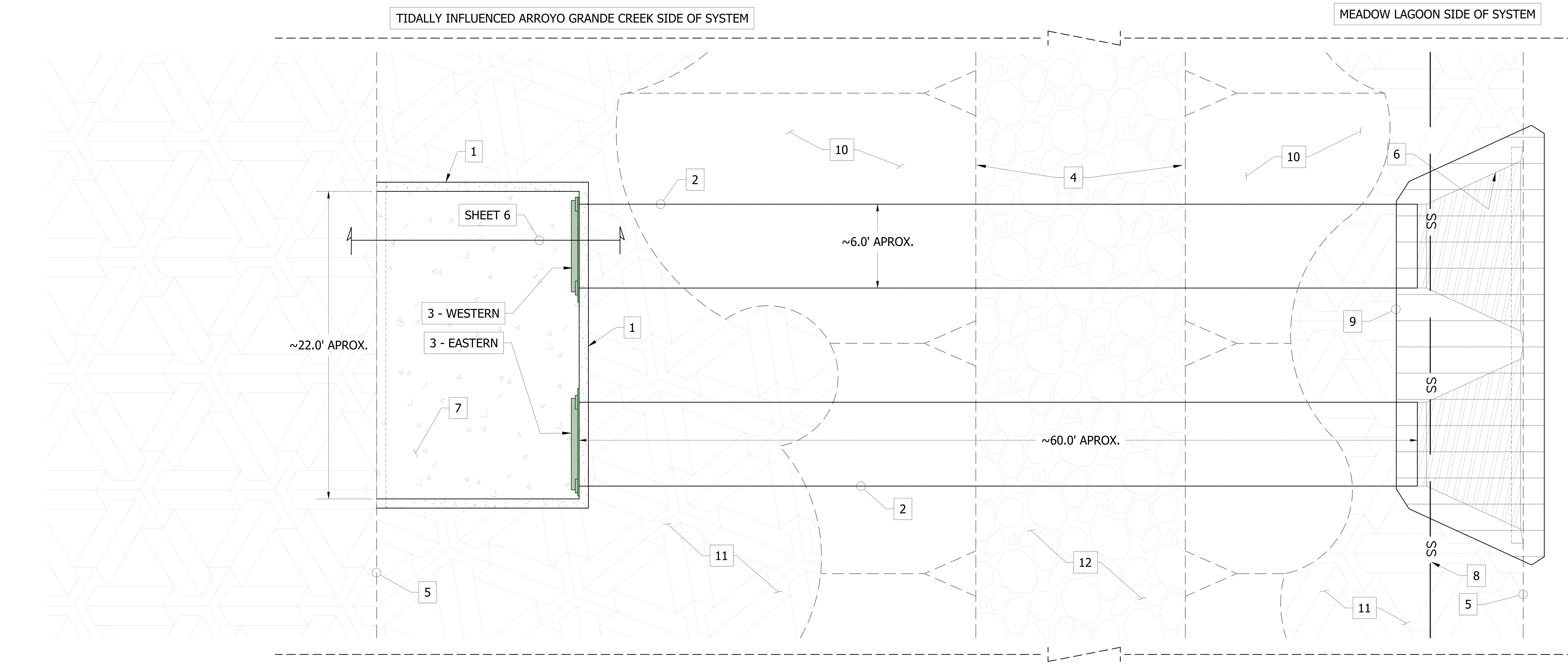
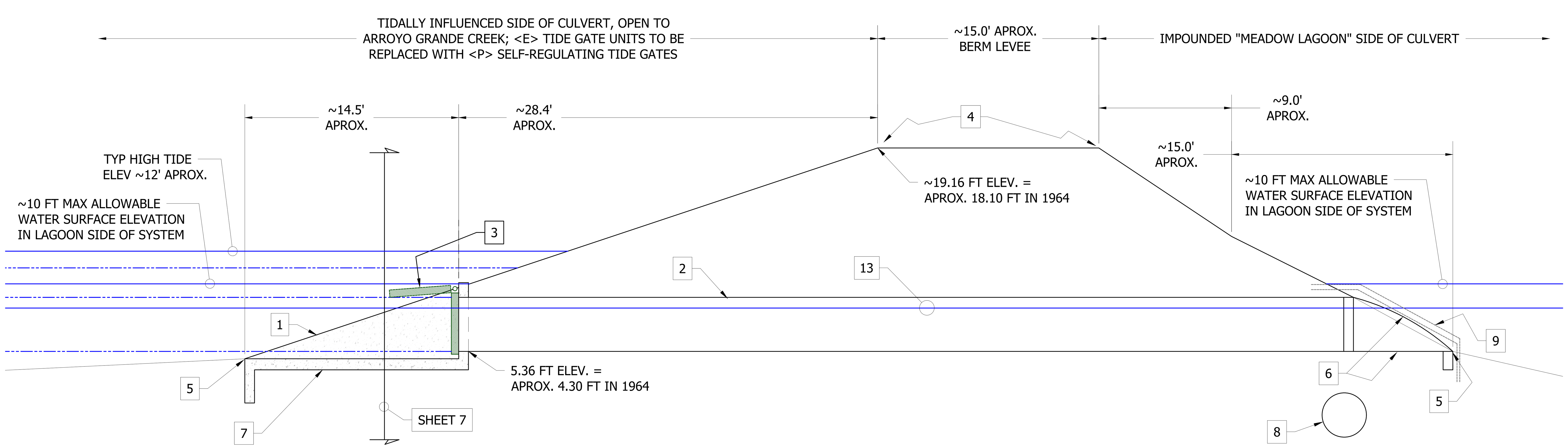
TYPICAL SECTIONS



1 PLAN - EXISTNG TIDE GATE AND LEVEE
TIDE GATES SHOWN TO BE REPLACED WITH VENDOR RECOMENDED OPTION
NTS



2 PROFILE - EXISTING TIDE GATE AND LEVEE
TIDE GATES SHOWN TO BE REPLACED WITH VENDOR RECOMENDED OPTION
NTS

NOTED FEATURES

1	<E> HEADWALL AND WINGWALL STRUCTURE FOR MOUNTING AND PROTECTION OF <P> NEW SELF-REGULATING TIDE GATE (SRTG) UNITS; SHEETS 3 & 4.
2	<E> CULVERTS SERVICED BY NEW <P> SRTG UNITS; 60' LONG COMPRESSED CULVERT, ASPHALT COATED, 10 GAGE CORRUGATED STEEL; 44" X 72" (HxW); RETAIN AND PROTECT IN PLACE; SHEETS 3 & 4.
3	<P> SIDE HINGE SELF-REGULATING TIDE GATE (SRTG) UNIT TO REPLACE EXISTING EASTERN UNIT. FOR EXISTING WESTERN TIDE GATE UNIT EITHER: RETAIN EXISTING TRADITIONAL "FLAP" TIDE GATE -OR- REPLACE WITH A NEW AND EQUIVALENT TRADITIONAL "FLAP" TIDE GATE, EITHER TOP HINGE OR SIDE HINGE. FUTURE COORDINATION WITH VENDORS AND DETAILED DESIGN WILL DETERMINE. EXISTING TIDE GATES ARE DEPICTED FOR REFERENCE.
4	<E> CRESTS ACROSS TOP OF LEVEE
5	<E> BOTTOM OF LEVEE SLOPES
6	<E> CULVERT APRONS ON MEADOW LAGOON SIDE OF <E> CULVERTS, RETAIN AND PROTECT IN PLACE.
7	<E> CONCRETE SLAB APRON POSITIONED BELOW <E> TIDE GATES OUTFALLS,ON TIDAL CREEK SIDE OF SYSTEM, PRESERVE AND ACCOMMODATE WITH RECOMMENDED <P> SRTG UNITS.
8	<E> SEWER DISCHARGE MAIN; DO NOT DISTURB; PROTECT IN PLACE.
9	<E> DEBRIS GUARD POSITIONED ON LAGOON SIDE OF SYSTEM; RETAIN AND PROTECT IN PLACE.
10	<E> LEVEE ON LAGOON SIDE IS HIGHLY MOBILE SAND DUNE; RETAIN AND PROTECT IN PLACE.
11	<E> SAND DUNE LEVEE TOPPED WITH AN HERBACEOUS MIXTURE OF SMALL SUCCULENT AND WETLAND PLANTS: RETAIN AND PROTECT IN PLACE.
12	<E> TYP VEHICLE TRAVELED WAY ALONG TOP OF DUNE, COMPOSED OF FORTIFIED SAND AND AGGREGATE COVER; RETAIN AND PROTECT IN PLACE.
13	RELEVANT WATER SURFACE ELEVATIONS SEE; SHEET 6.

ALL DIMENSION SHOWN ARE APPROXIMATE, PROVIDED FOR REFERENCE; FIELD VERIFY ALL DIMENSIONS PRIOR TO SPECIFICATION. DATUMS AND DIMENSIONS ADOPTED FROM REFERENCE DOCUMENTS AND SHALL BE VERIFIED PRIOR TO FABRICATION.

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EXISTING SAND CANYON OUTLET STRUCTURE - PLAN AND PROFILE

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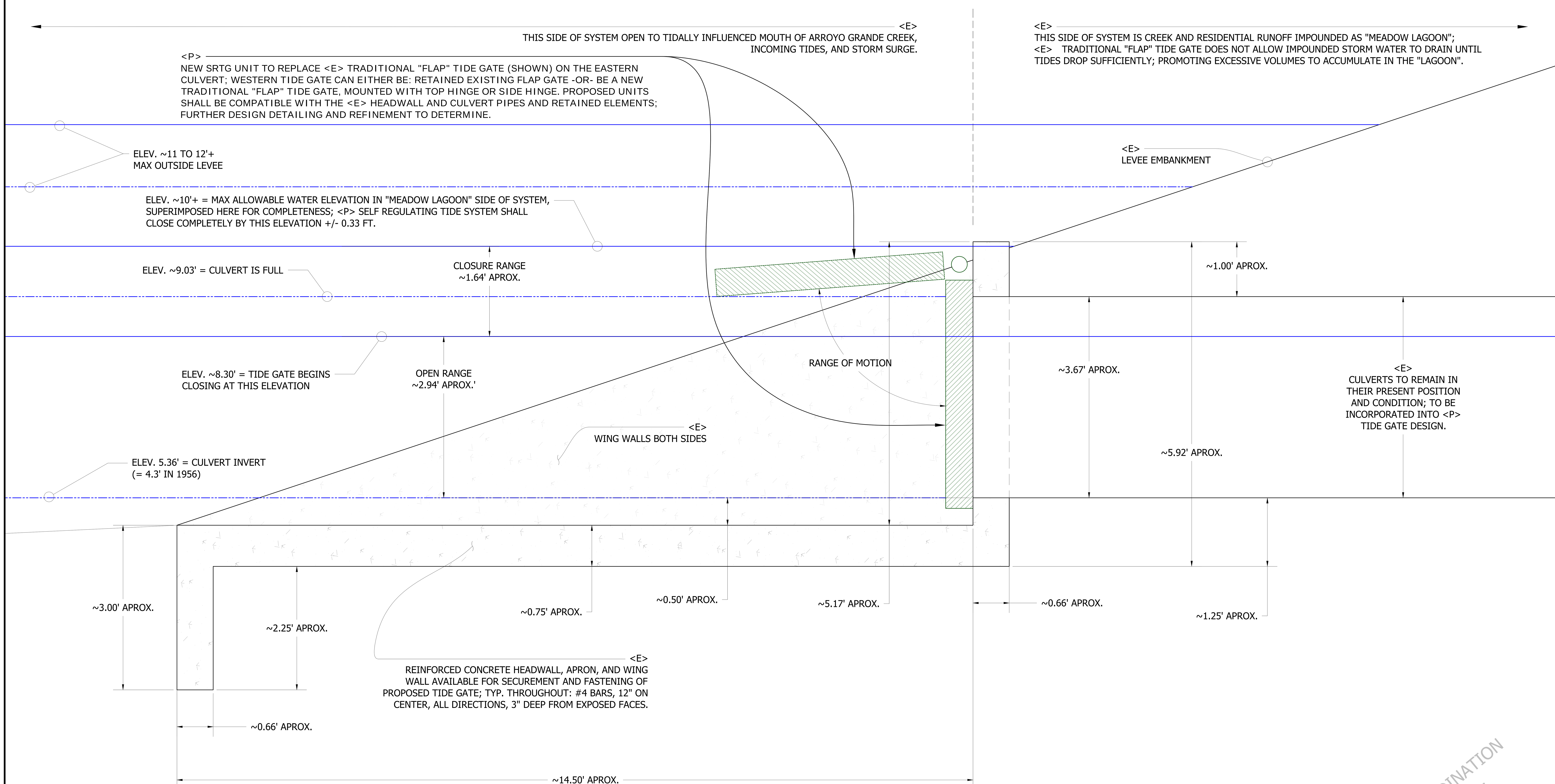

1 SECTION VIEW: EXISITING TYPICAL THROUGH HEADWALL AND CULVERT PIPING
TIDE GATES SHOWN TO BE REPLACED WITH VENDOR RECOMENDED OPTION
NTS

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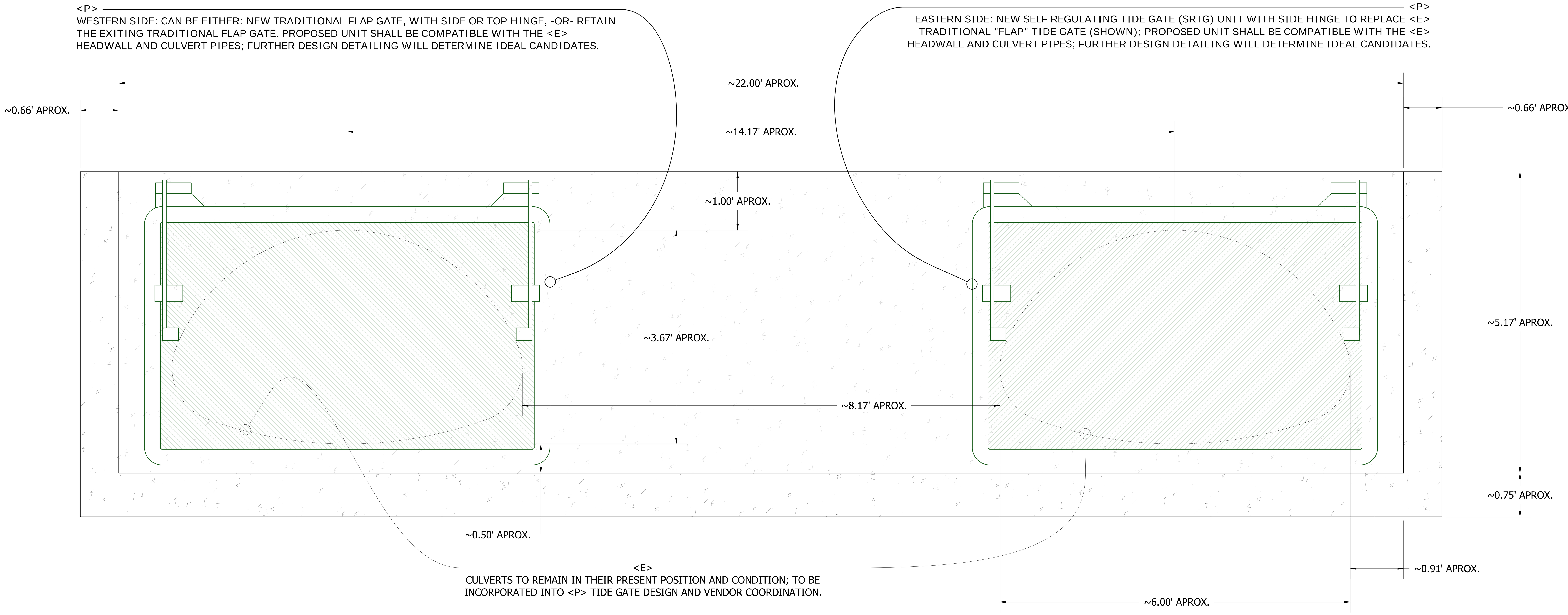
EXISTING TIDE GATE - PROFILE DETAILS



1 SECTION VIEW: EXISTING TYPICAL THROUGH HEADWALL AND WING STRUCTURE
TIDE GATES SHOWN TO BE REPLACED WITH VENDOR RECOMENDED OPTION
NTS

2 PHOTO OF EXISITNG TRADITIONAL "FLAP" TIDE GATE
TIDE GATES SHOWN TO BE REPLACED WITH VENDOR RECOMMENDED OPTION
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EXISTING TIDE GATE - SECTION DETAILS

SHEET 7 OF 10

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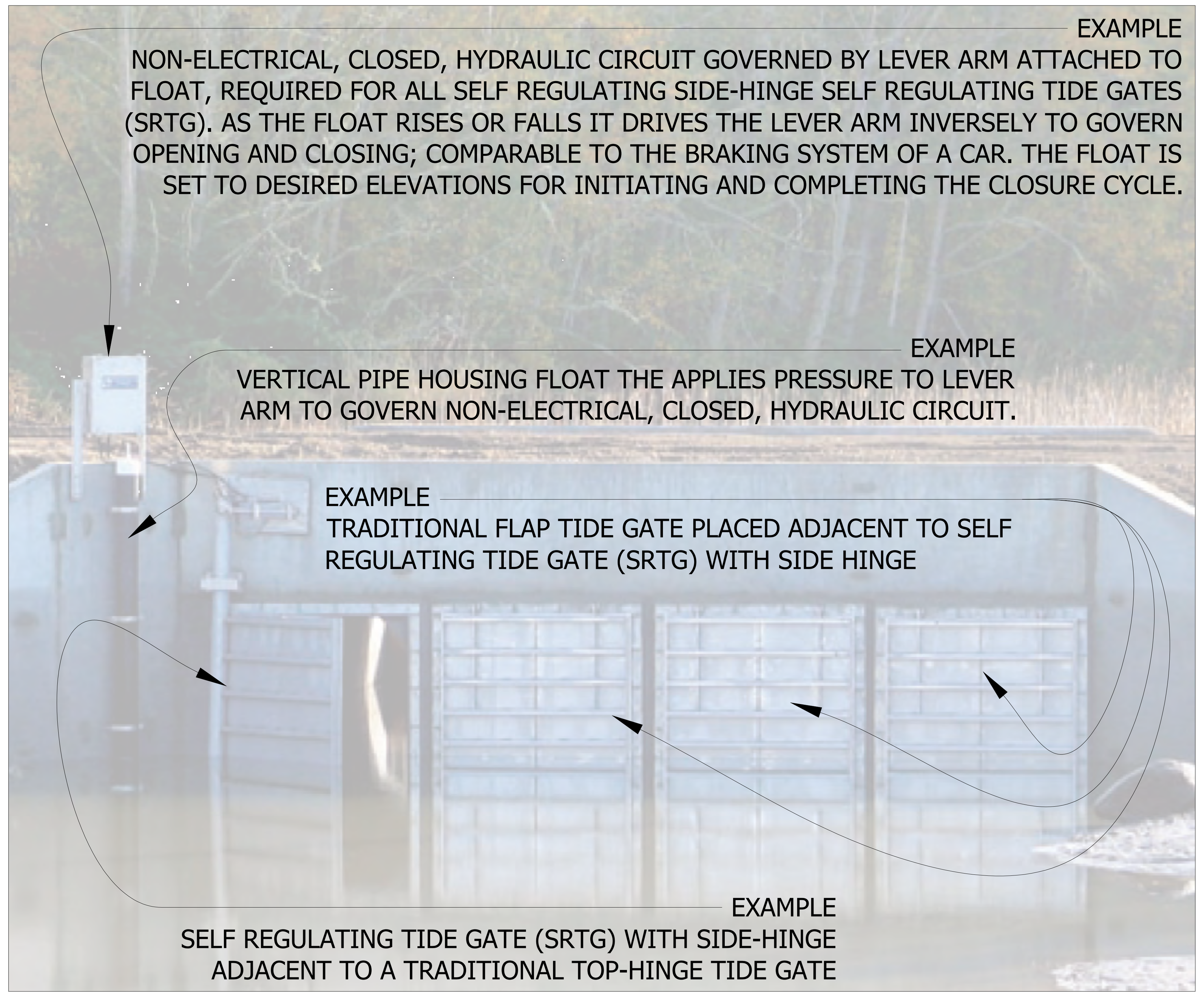
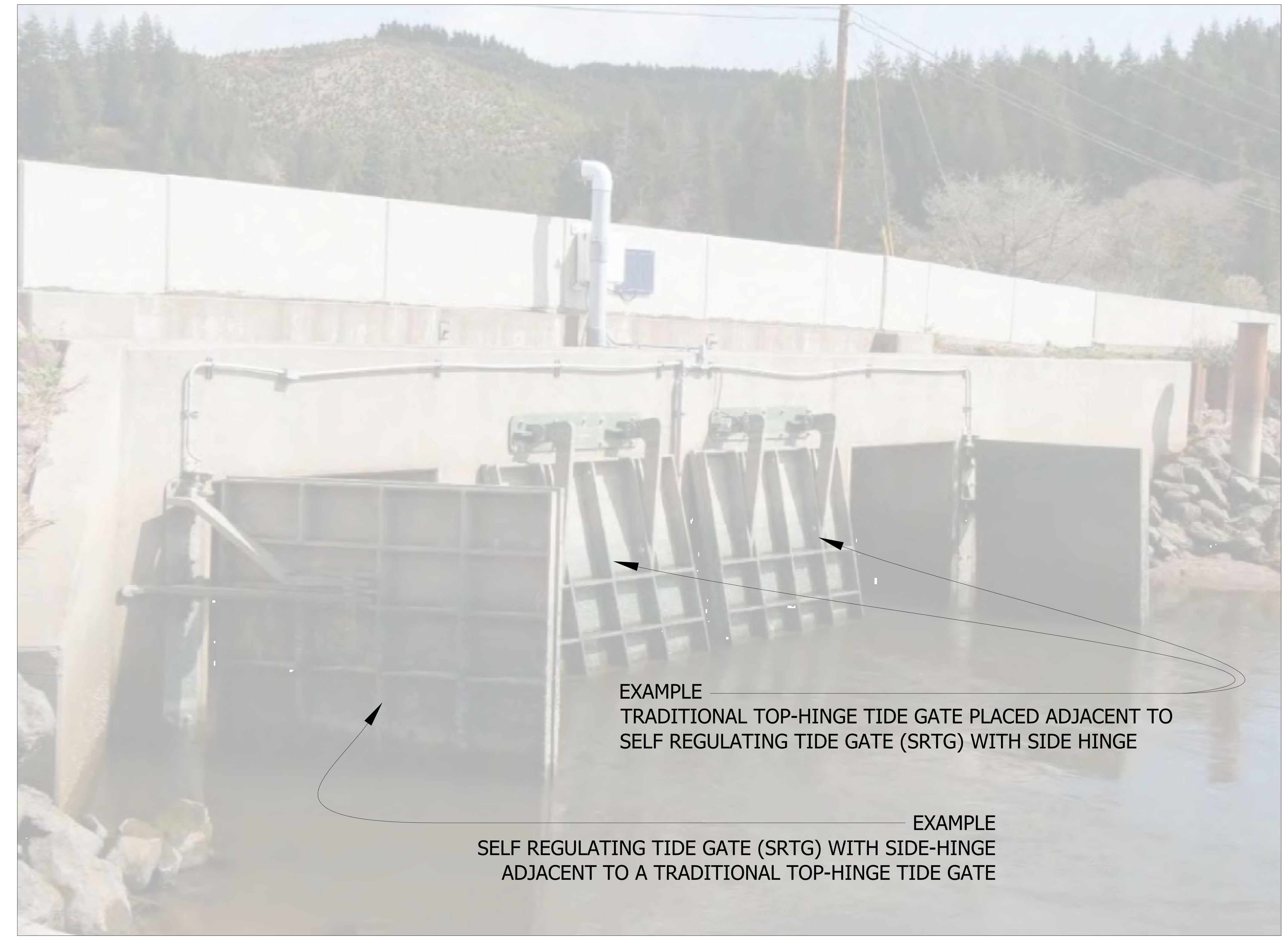
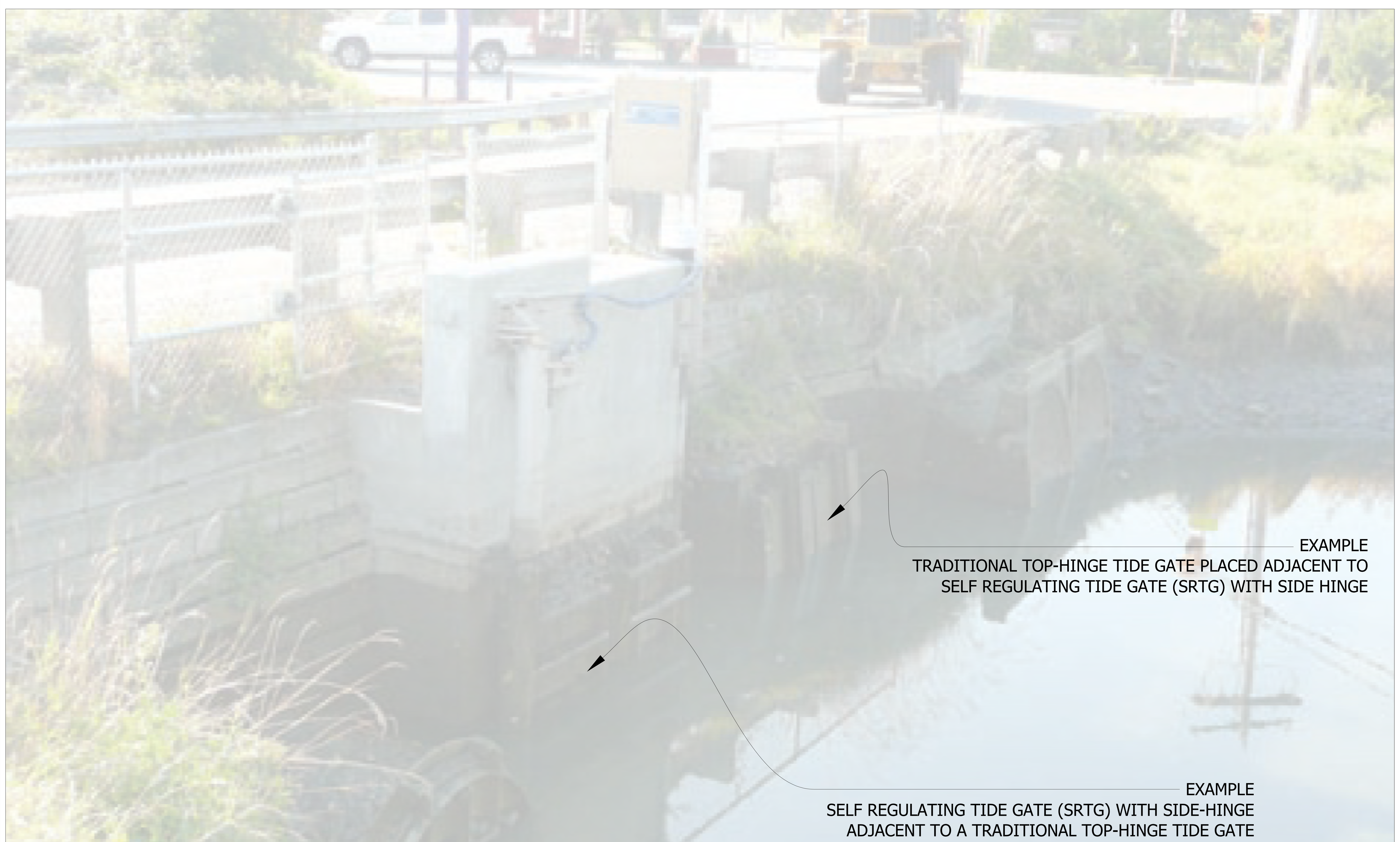


1 PHOTO OF AN EXAMPLE SIDE-HINGE SELF-REGULATING TIDE GATE(S) PAIRED WITH TRADITIONAL TOP-HINGE FLAP GATE(S)
EXAMPLE INSTALLATION FOR CONCEPTUAL REFERENCE
NTS



2 PHOTO OF AN EXAMPLE SIDE-HINGE SRTG PAIRED WITH TRADITIONAL TOP-HINGE FLAP GATE(S)
EXAMPLE INSTALLATION FOR CONCEPTUAL REFERENCE
NTS



3 PHOTO OF AN EXAMPLE SIDE-HINGE SELF-REGULATING TIDE GATE(S) PAIRED WITH TRADITIONAL TOP-HINGE FLAP GATE(S)
EXAMPLE INSTALLATION FOR CONCEPTUAL REFERENCE
NTS

EXAMPLE
VERTICAL PIPE HOUSING FLOAT THE APPLIES PRESSURE TO LEVER ARM TO GOVERN NON-ELECTRICAL, CLOSED, HYDRAULIC CIRCUIT.

EXAMPLE
NON-ELECTRICAL, CLOSED, HYDRAULIC CIRCUIT GOVERNED BY LEVER ARM ATTACHED TO FLOAT, REQUIRED FOR ALL SELF REGULATING SIDE-HINGE SELF REGULATING TIDE GATES (SRTG), PHOTO 1

4 PHOTO OF AN EXAMPLE SRT SIDE-HINGE TIDE GATE IN OPERATION
EXAMPLE INSTALLATION FOR CONCEPTUAL REFERENCE
NTS

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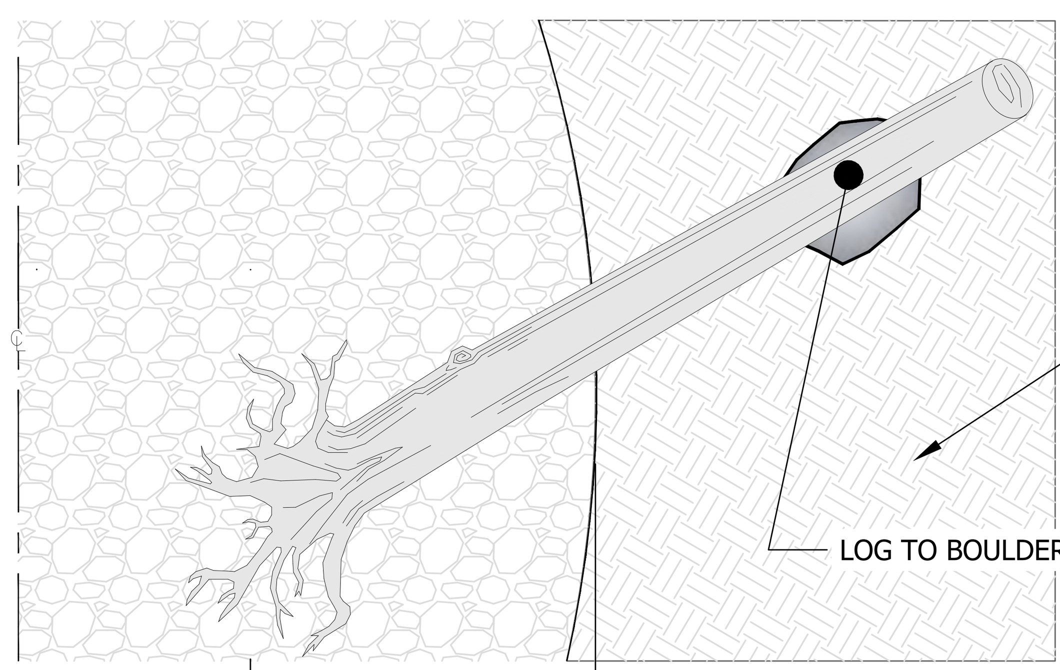
PROPOSED TIDE GATE - DETAILS

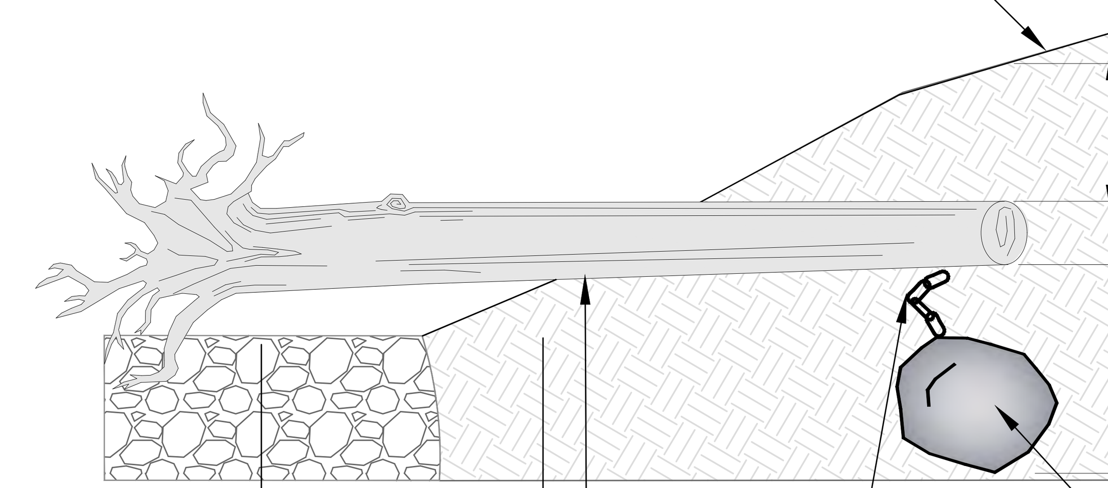
SHEET 8 OF 10

NOTES:

1. LOG STRUCTURES SHALL BE INSTALLED AS SHOWN ON PLAN VIEW SHEETS
2. WHERE SLOPES ARE DISTURBED, LOG STRUCTURES MAY BE TRENCHED INTO THE BANK TO ALLOW FOR A LOWER ANGLE AND PROVIDE MORE WOOD VOLUME IN THE ACTIVE CHANNEL
3. LOG STRUCTURE CONSTRUCTION DETAILS MAY BE MODIFIED IN THE FIELD AS APPROVED BY THE PROJECT MANAGER AND ENGINEER



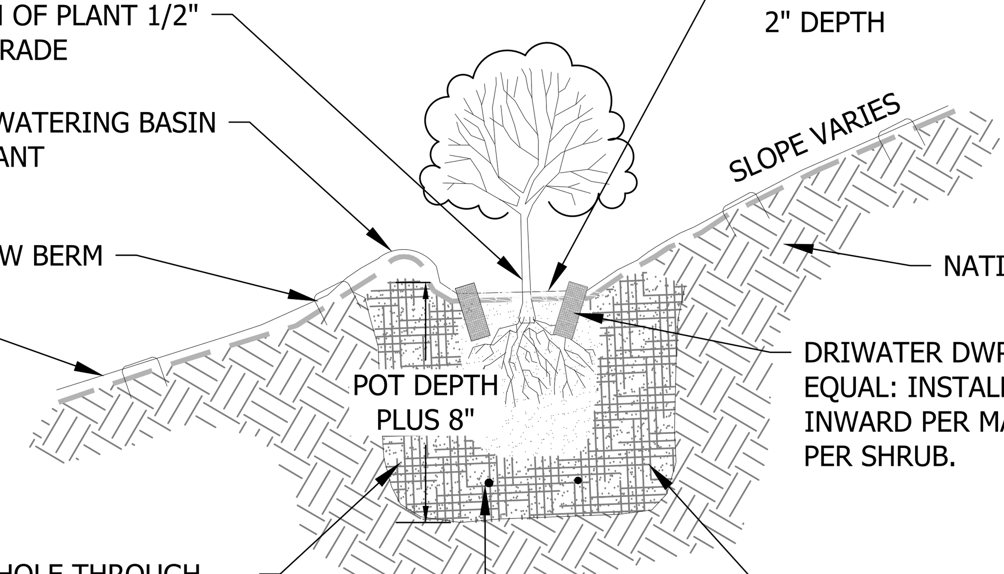
PLAN VIEW



SECTION VIEW

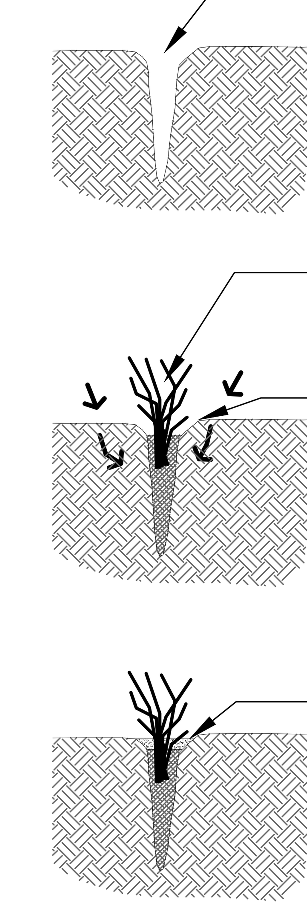
1 LOG WITH ROOTWAD - BOULDER & DEADMAN ANCHOR

NTS



2 SHRUB PLANTING

NTS



3 PLUG PLANTING

NTS

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HABITAT ENHANCEMENT DETAILS (2)

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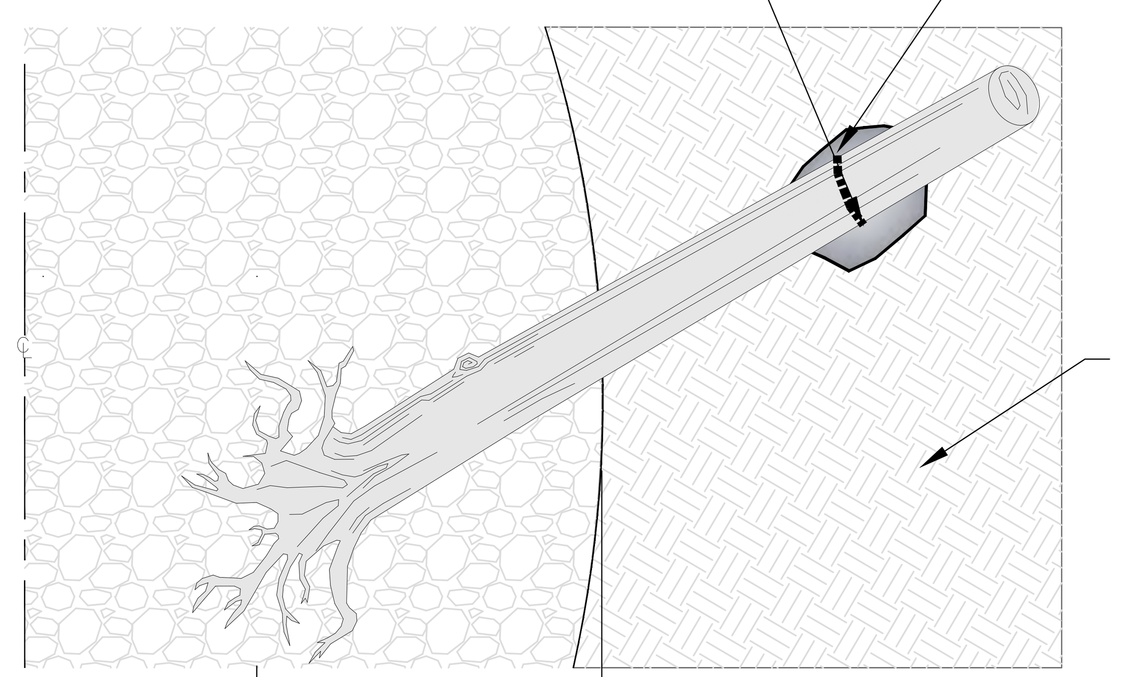
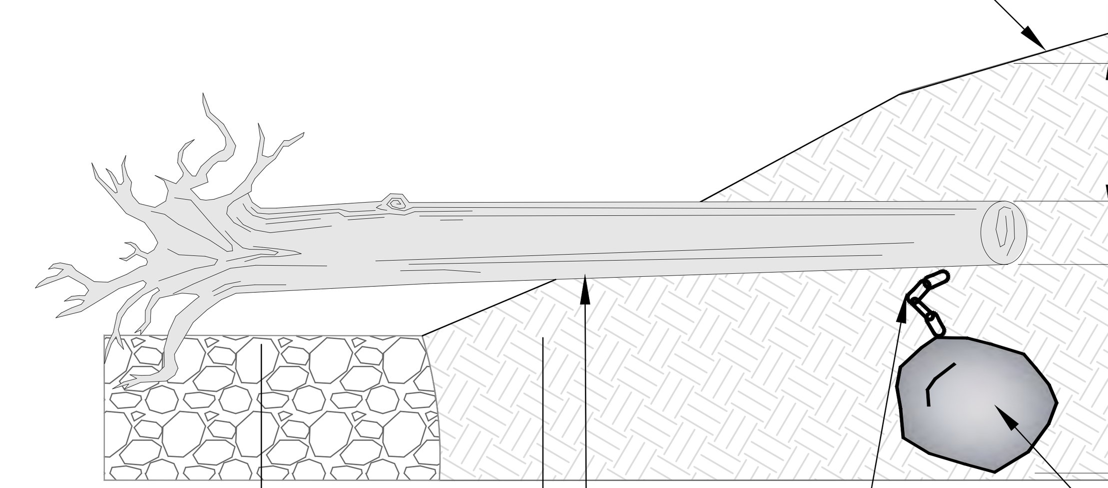


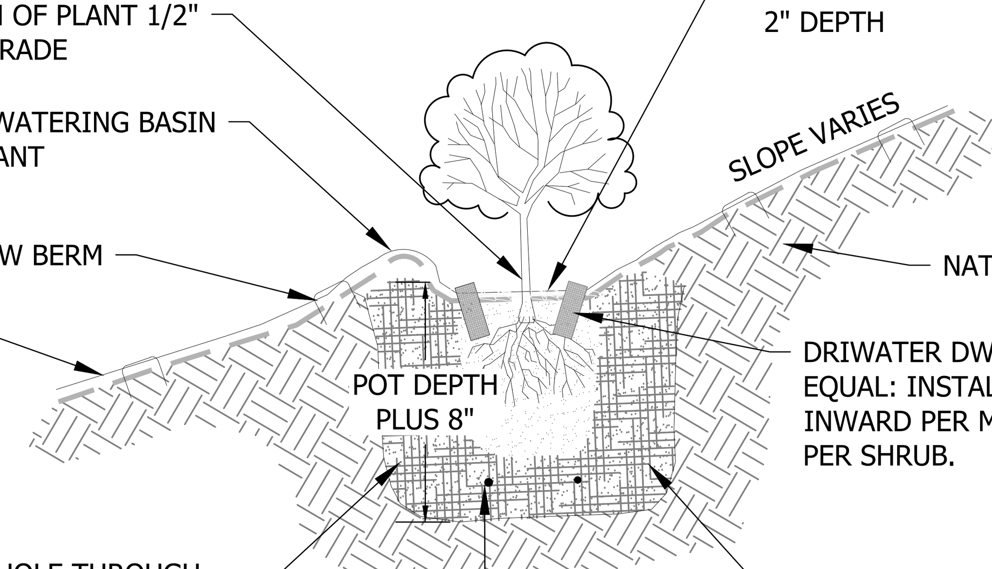
PLAN VIEW



SECTION VIEW

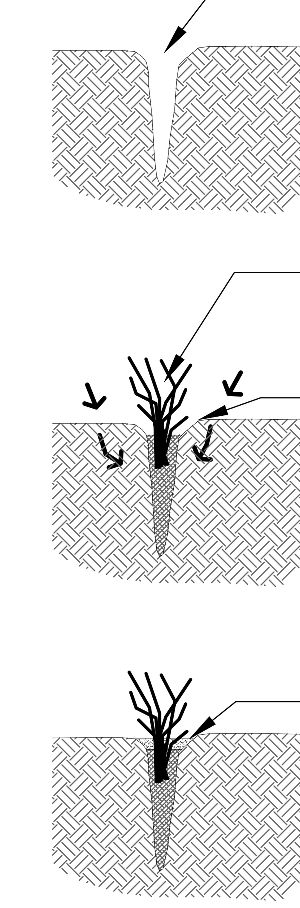
1 LOG WITH ROOTWAD - BOULDER & ROPE DEADMAN ANCHOR

NTS



2 SHRUB PLANTING

NTS



3 PLUG PLANTING

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