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North Campus Open Space Restoration Project As-Built Grading and Hydrology Report

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Publication Date

2018-07-26

Data Availability

The data associated with this publication are available upon request.

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**North Campus Open Space Restoration Project
As-Built Grading and Hydrology Report**

July 2018



1. Introduction

This report describes the as-built geomorphology and hydrology of the North Campus Open Space (NCOS) restoration project at the completion of the grading phase of the project. Topics covered include: a comparison of the predicted and as-built grading elevations, as-built cross-sections and thalwegs of the two main channels, and a comparison of the hydrology of the project site before and after the completion of the grading phase. A selection of photos of the project site taken before and after the completion of grading are provided at the end of the report. Ongoing project work not covered in this report includes: trail and bridge construction, planting and site maintenance, and the planned construction of a visitor interpretative plaza and maintenance equipment shed.

2. Comparison of Predicted and As-built Grading

The grading portion of the NCOS restoration project was completed in October 2017, and an as-built digital elevation model (DEM) of the final grading was produced in early November 2017. Maps showing representations of the designed and final as-built grading elevations are provided in Figures 1 and 2.

A comparison of the as-built DEM with the designed plan (predicted maximum grading model) shows that the majority of the grading was completed per specifications, within a less than 0.8-foot elevation margin of error tolerance (see Figure 3). The as-built elevation of the southwest corner of the site, called the "Mesa", is at the lower end of the predicted range, generally between 1 to 10 feet lower than the maximum predicted by the design model (Figure 3). This likely resulted from the excavated fill taking up less volume than was predicted by the maximum fill model, possibly due to compaction and/or an overly conservative design.

Another apparent deviation, where as-built elevations appear to be above the predictions of the design model, is primarily due to the presence of water in the main channels of the wetland, and in one of the ponds in the western arm at the time that the aerial survey for the as-built DEM was conducted. The water surface was near 5 feet in elevation, which is 1 to 1.5 feet above the lowest graded elevations in the channels and pond. In addition, a few small areas near the main channels were graded 1 to 1.5 feet higher than planned to create some topographical diversity in the form of subtle islands in the wetland, and small hummocks on the periphery. These topographical variations are visible in Figures 2 and 3. Other small areas above the predicted elevations are from retained trees and features along the peripheral edges of the project area that were captured in the aerial survey.

In addition to the maps in Figures 1 to 3, pre and post-grading aerial and landscape photos of the project are provided at the end of this report.

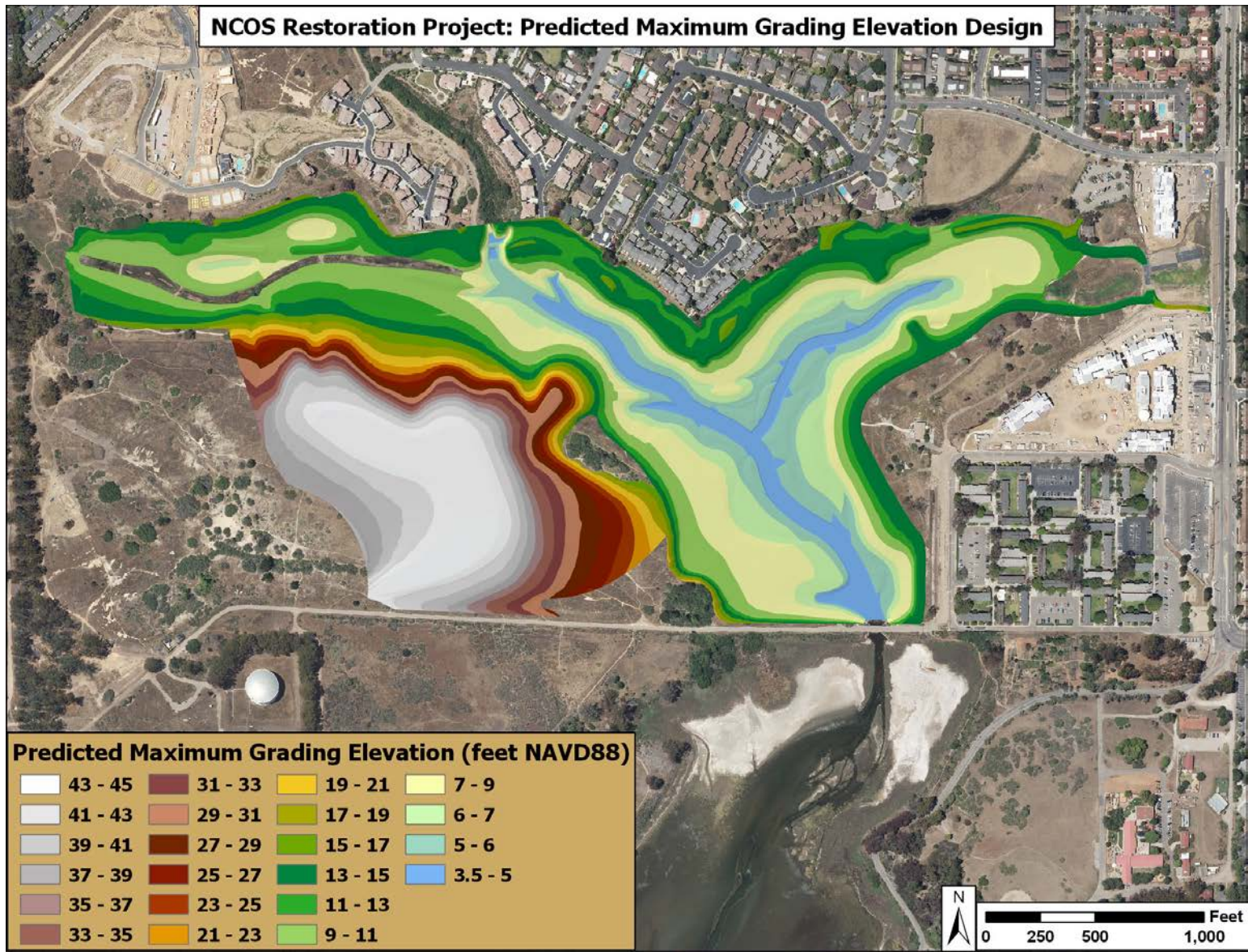


Figure 1. Map showing a representation of the predicted maximum grading elevation design for the NCOS Restoration Project.

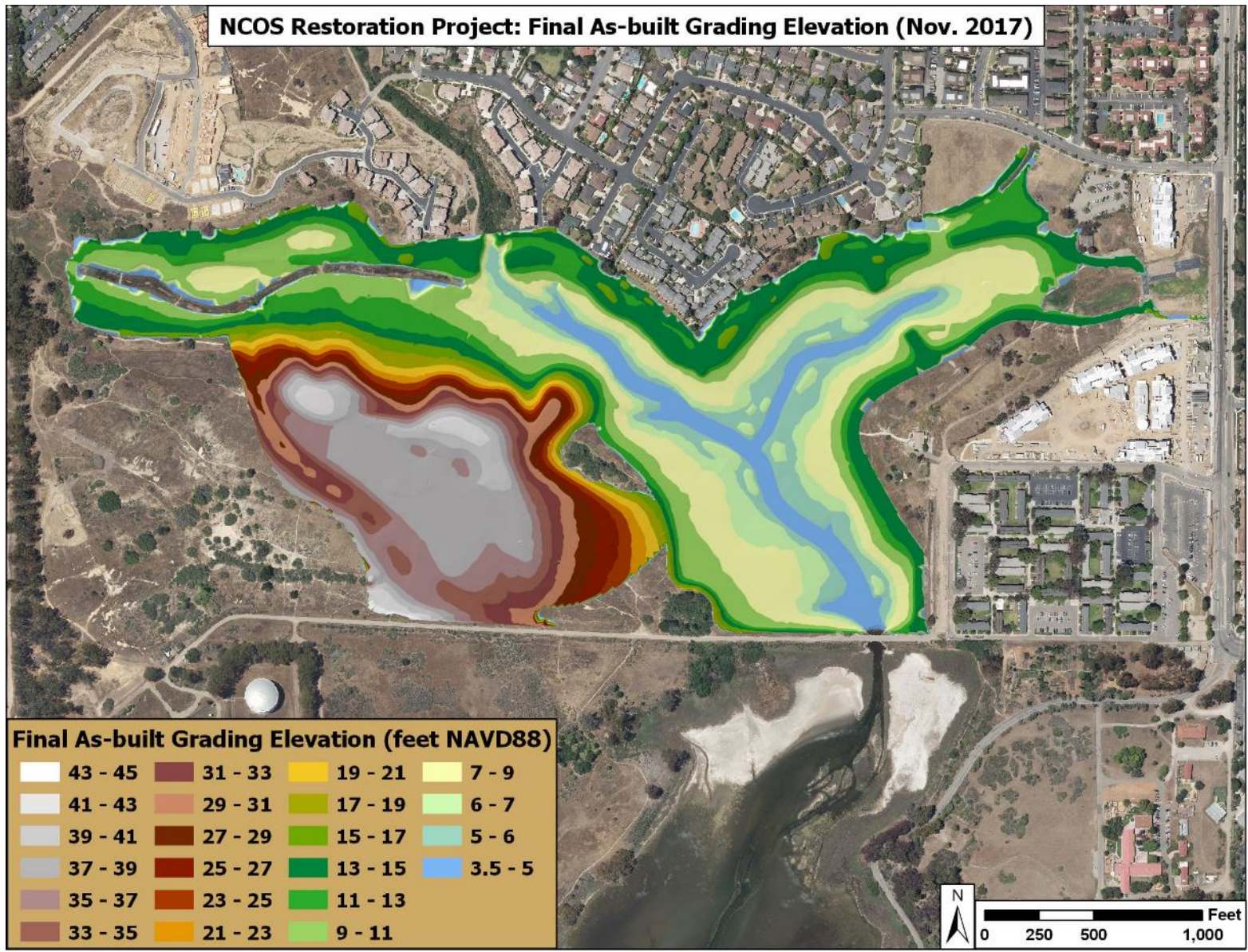


Figure 2. Map showing a representation of the final, as-built grading elevation of the NCOS Restoration Project, derived from an aerial survey digital elevation model completed in November 2017.

NCOS Restoration Project: Elevation Difference (feet) between As-built and Predicted Maximum Grading

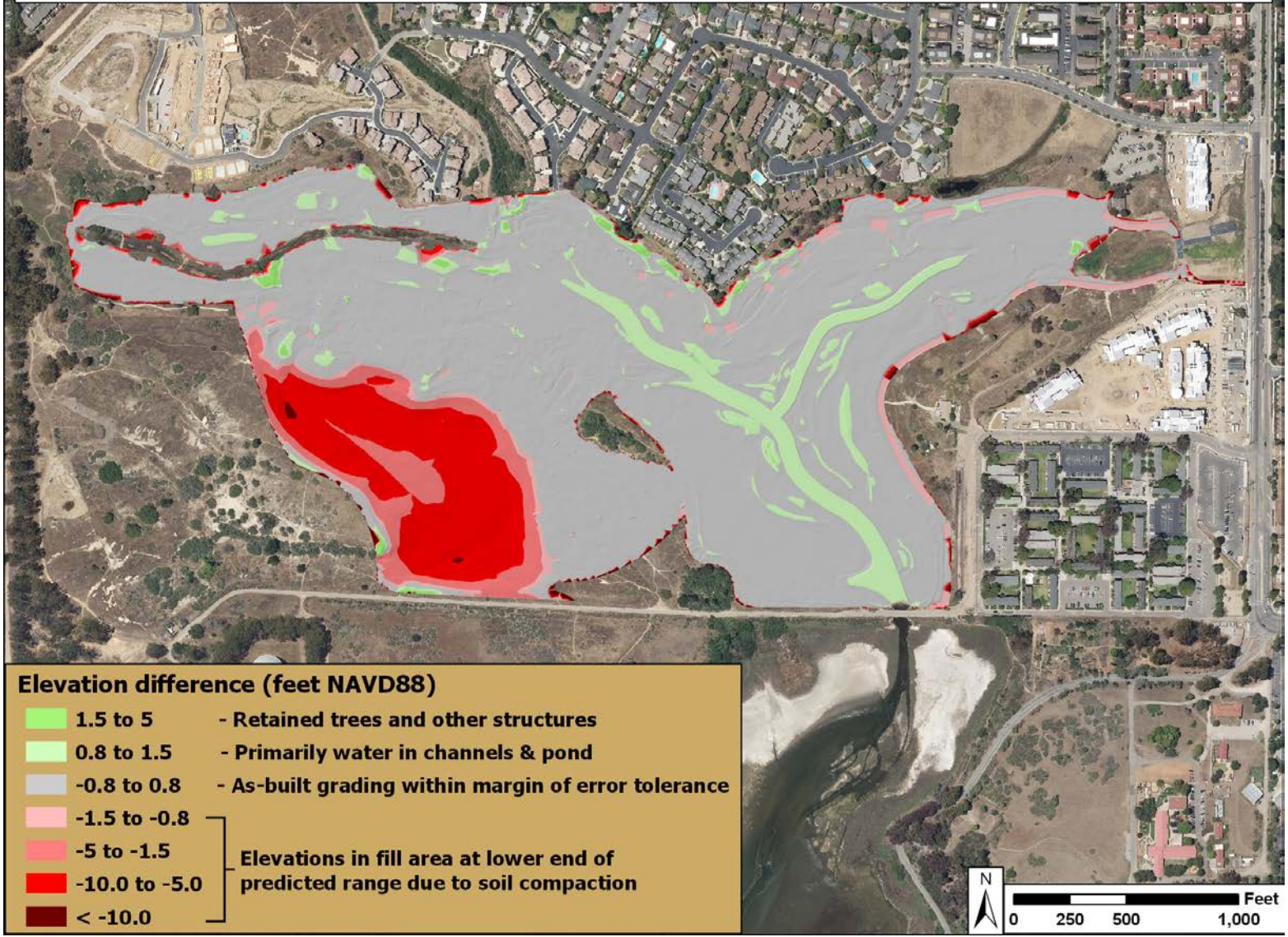


Figure 3. Map showing the elevation difference (in feet NAVD88) between the as-built and predicted maximum grading elevation design of the NCOS Restoration Project.

3. Channel Cross-sections and Thalwegs

Baseline, as-built channel geomorphology cross-section and thalweg transects were established and measured with a high accuracy (within 5 cm) RTK GPS unit in November, 2017, one month after the completion of grading. These include seven cross-section transects between the 10-foot elevation contour lines on opposite sides of the Main and East channels, across Phelps creek (downstream of the bridge) and the downstream side of Venoco Bridge, and seven additional transects across the width of the sub-tidal channel (Figure 4). Profile charts of four of the transects are provided in Figures 5 and 6. The seven sub-tidal transects and the longer Main and East channel cross-sections are used together for an overall baseline thalweg elevation measurement (Table 1). The sub-tidal elevations of these transects demonstrate that the channel bathymetry was constructed as per plan specifications. The baseline cross-section and thalweg transects will be re-surveyed in 2019 and 2021.

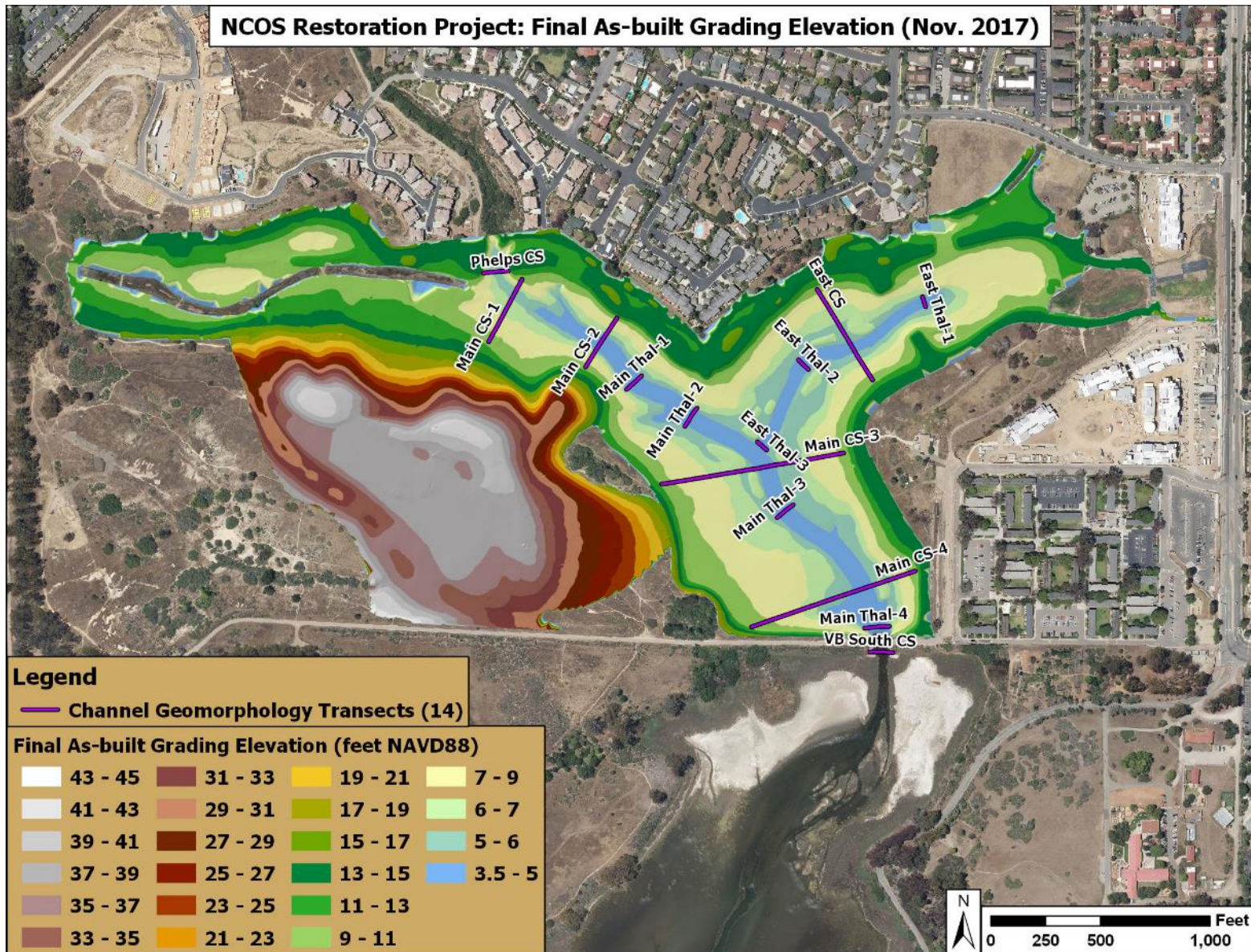


Figure 4. Map showing the Main and East channel geomorphology cross-section and thalweg transects, overlaid on the as-built grading elevation of the NCOS Restoration Project.

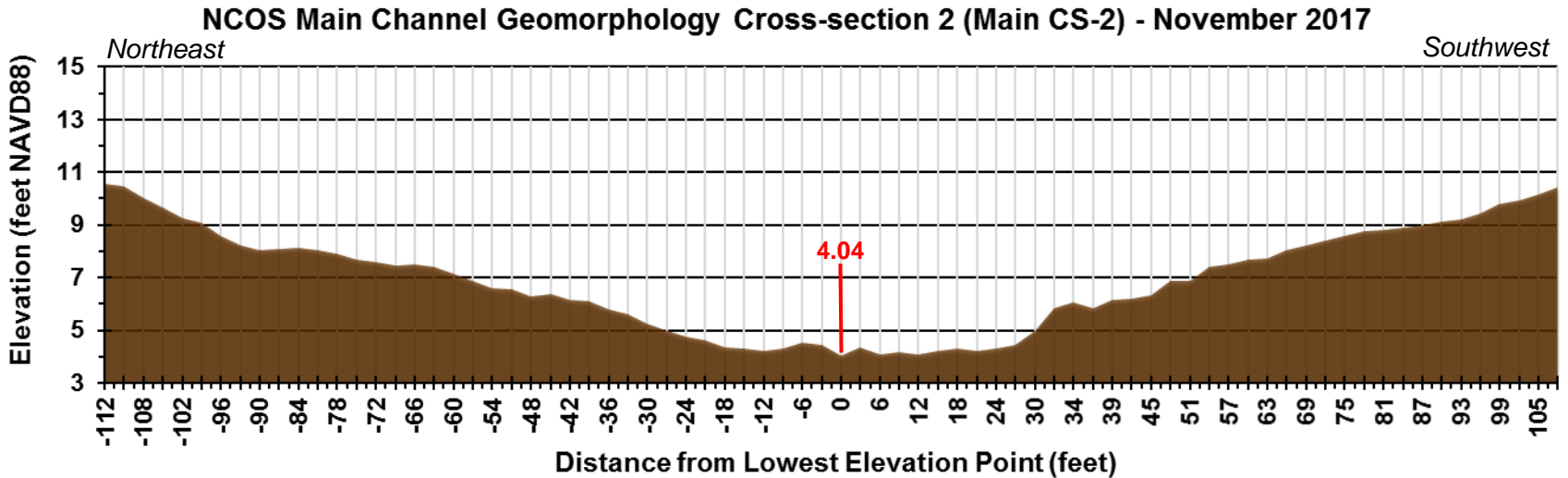
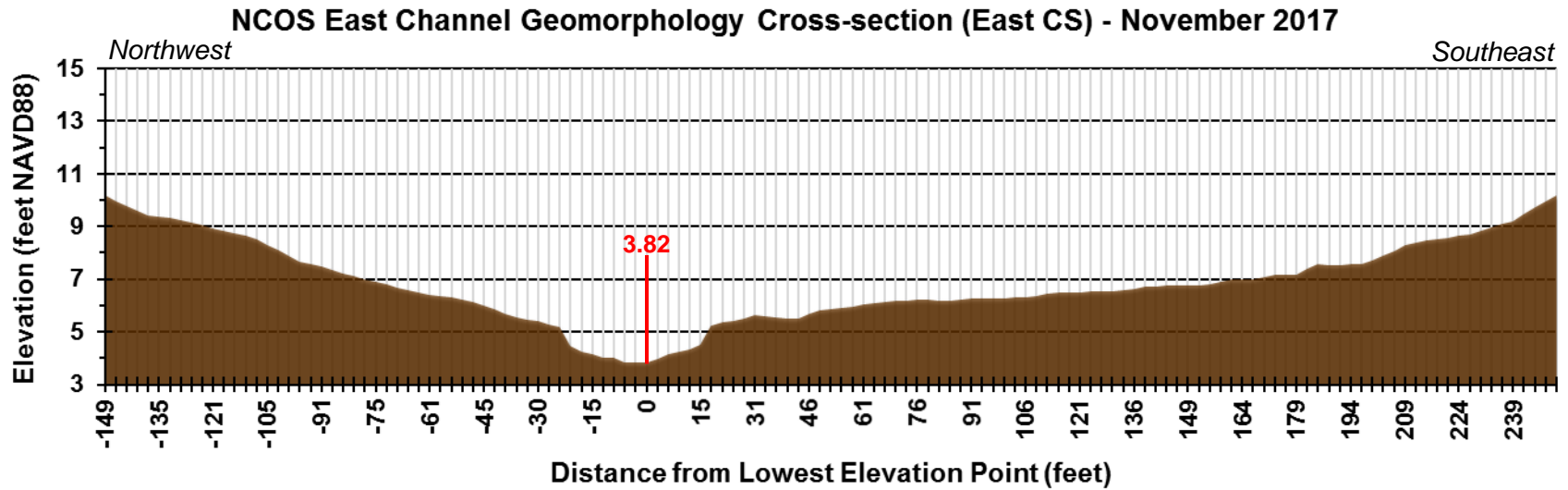
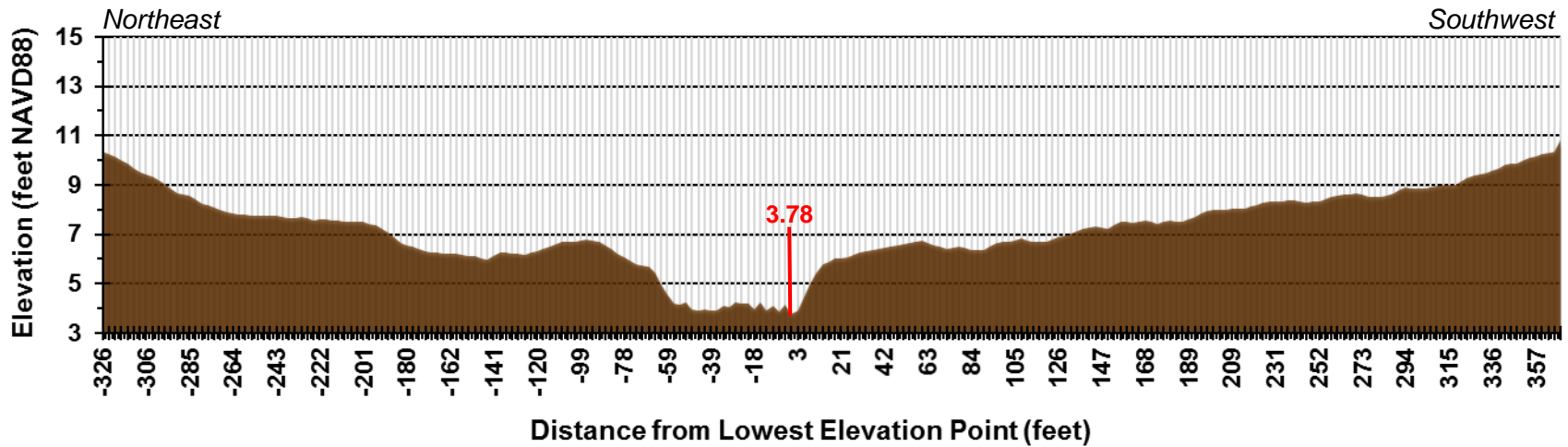


Figure 5. Profiles of as-built elevation cross-section transects in the East Channel (East CS) and the upper portion of the Main Channel (Main CS) of NCOS. The lowest elevation recorded is indicated in red. See Figure 4 for a map of the transects.

NCOS Main Channel Geomorphology Cross-section 3 (Main CS-3) - November 2017



NCOS Main Channel Geomorphology Cross-section 4 (Main CS-4) - November 2017

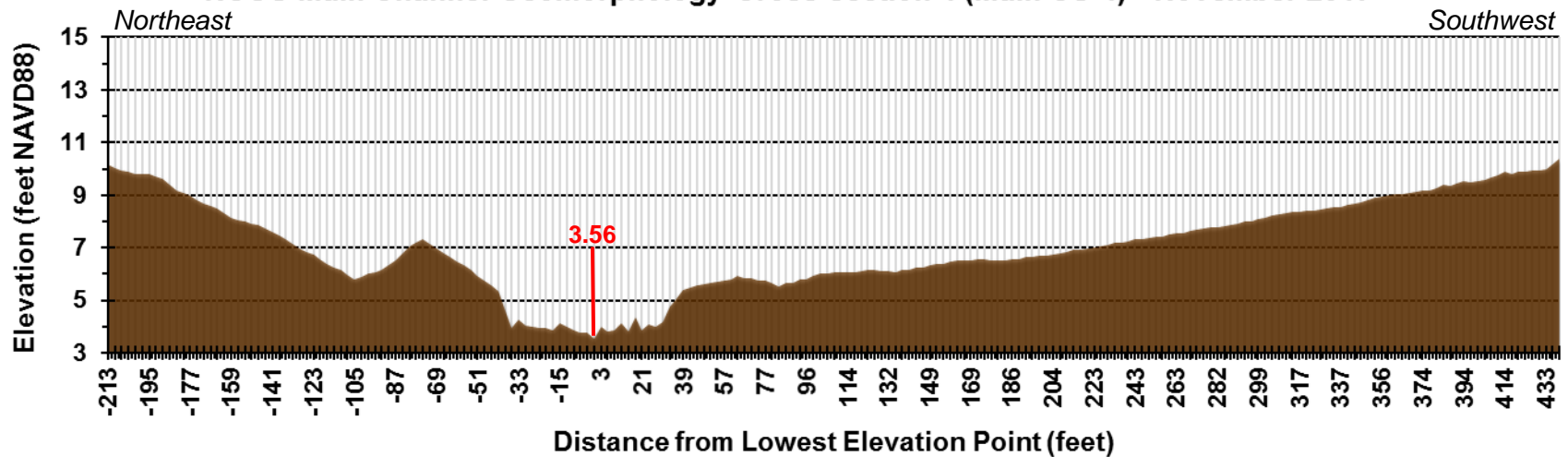


Figure 6. Profiles of as-built elevation cross-section transects in the mid and lower portions of the Main Channel (Main CS) of NCOS. The lowest elevation recorded is indicated in red. See Figure 4 for a map of the transects.

Table 1. Lowest elevations of the East and Main channel cross-section and subtidal transects, which together provide a baseline thalweg elevation of the as-built grading of the NCOS restoration project. Refer to Figure 4 for a map showing the location of each transect.

Transect Label (upstream to downstream)	Lowest Elevation (feet NAVD88)
East Thal-1	3.87
East CS	3.82
East Thal-2	3.67
East Thal-3	3.39
Main CS-1	5.45
Main CS-2	4.04
Main Thal-1	3.71
Main Thal-2	3.78
Main CS-3	3.78
Main Thal-3	3.62
Main CS-4	3.56
Main Thal-4	3.24

Note: CS = Cross-section, Thal = sub-tidal transect for Thalweg

4. Hydrology

Prior to the NCOS restoration project, half of the wetland's potential water-holding capacity was supplanted by soil deposited to create the golf course. This caused water levels to rise rapidly to flood levels at the interface between the incoming creeks and the former wetland. Before the restoration of NCOS began, water levels recorded in Phelps and Devereux Creeks would rise by at least 3 feet immediately following rainfall amounts above 0.3 inches per hour, as was recorded in January 2017 (Figure 7). In March 2018, five months after the completion of the grading of the restoration project, the amount of water level rise has decreased by a foot or more in both creeks following similar rain events (Figure 8). See Figure 9 for a map showing the location of the water level loggers.

In the winter of 2016-17, it took 6 inches of rain to cause Devereux Slough to breach the sand bar (on 1/9/17) and connect the system to the ocean. Following the completion of the grading in October 2017, the slough did not breach until rainfall totals reached 7.8 inches on 3/22/18, reflecting an increased water holding capacity of the system. This increased capacity is also reflected in the hypsometric curve in Figure 10. The sand bar at the mouth of the slough usually holds the water in the system up to about 9.5 feet elevation. The blue line in Figure 9 shows the capacity of the system before the project, when the mouth would breach after holding about 200 acre feet of water. The orange line shows the post-project capacity of the system, indicating it will hold closer to 350 acre feet before it breaches. The conclusion is that the hydrology of the as-built, restored system at NCOS closely follows the modeled predictions, and provides increased wetland capacity, habitat diversity and flood protection.

Precipitation and Water Elevations in NCOS Tributaries and Devereux Slough - January 2017

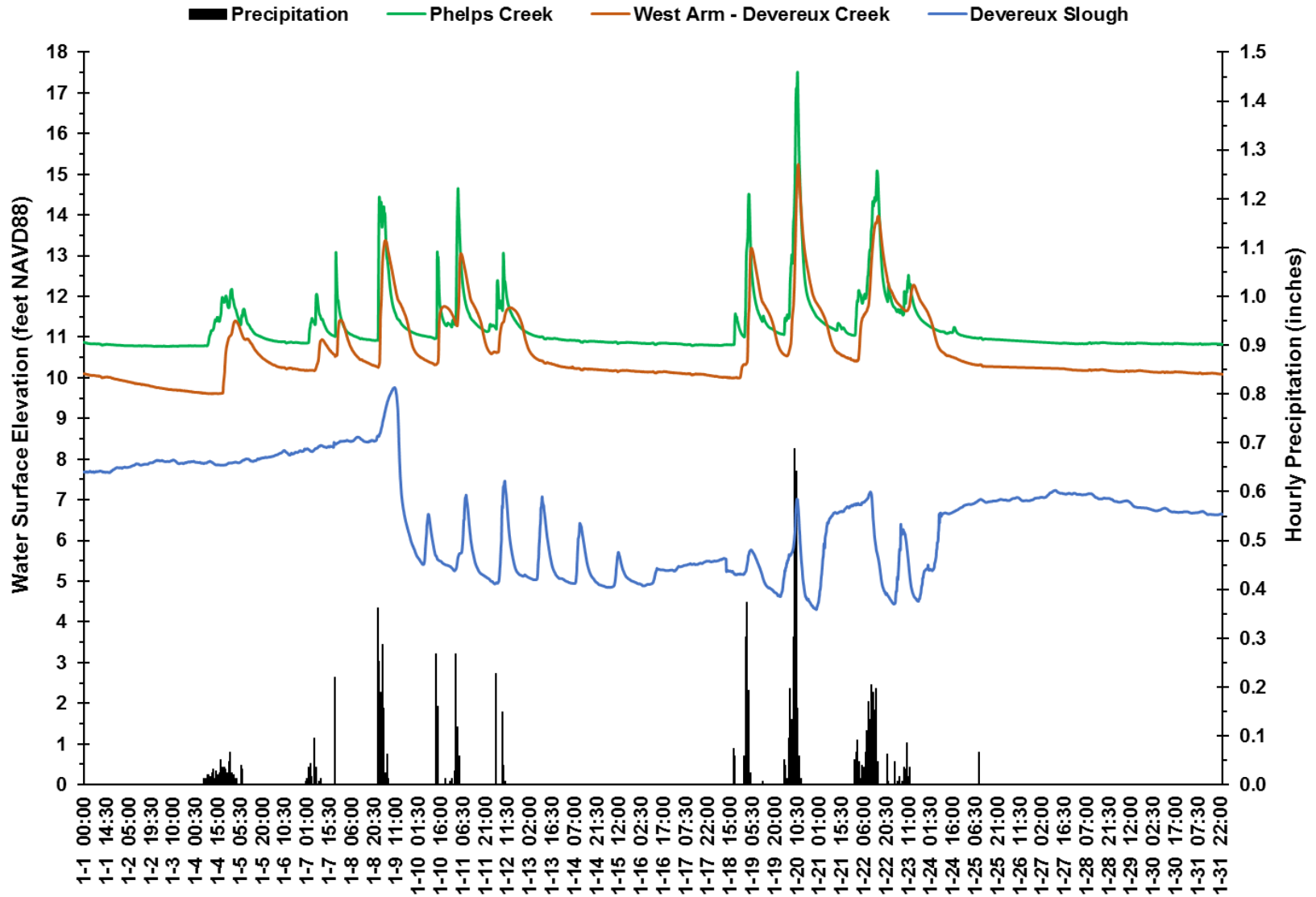


Figure 7. Pre-grading NCOS water surface elevations and precipitation, January 2017.

Precipitation and Water Elevations in NCOS Tributaries and Devereux Slough - March 2018

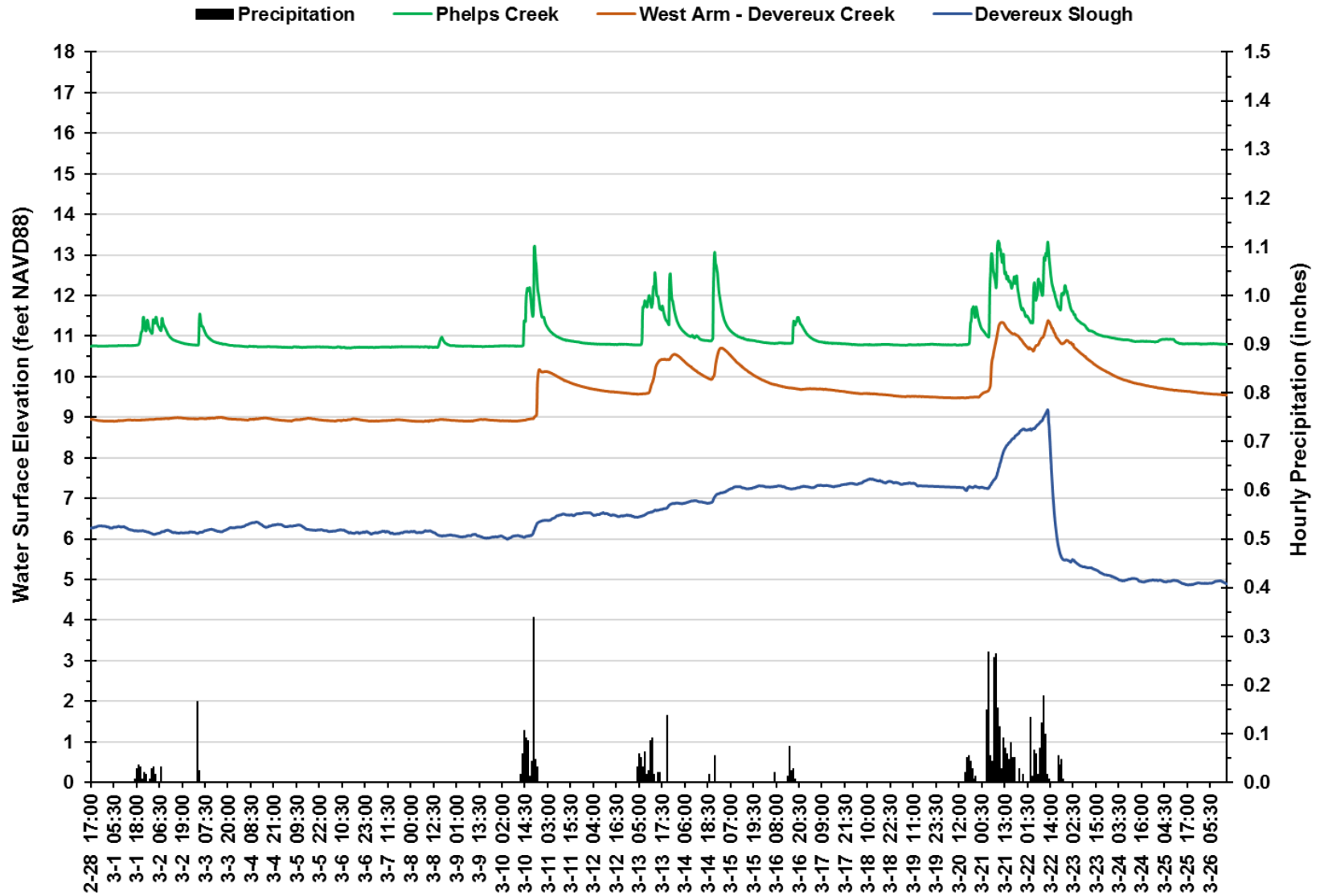


Figure 8. Post-grading NCOS water surface elevations and precipitation, March 2018.

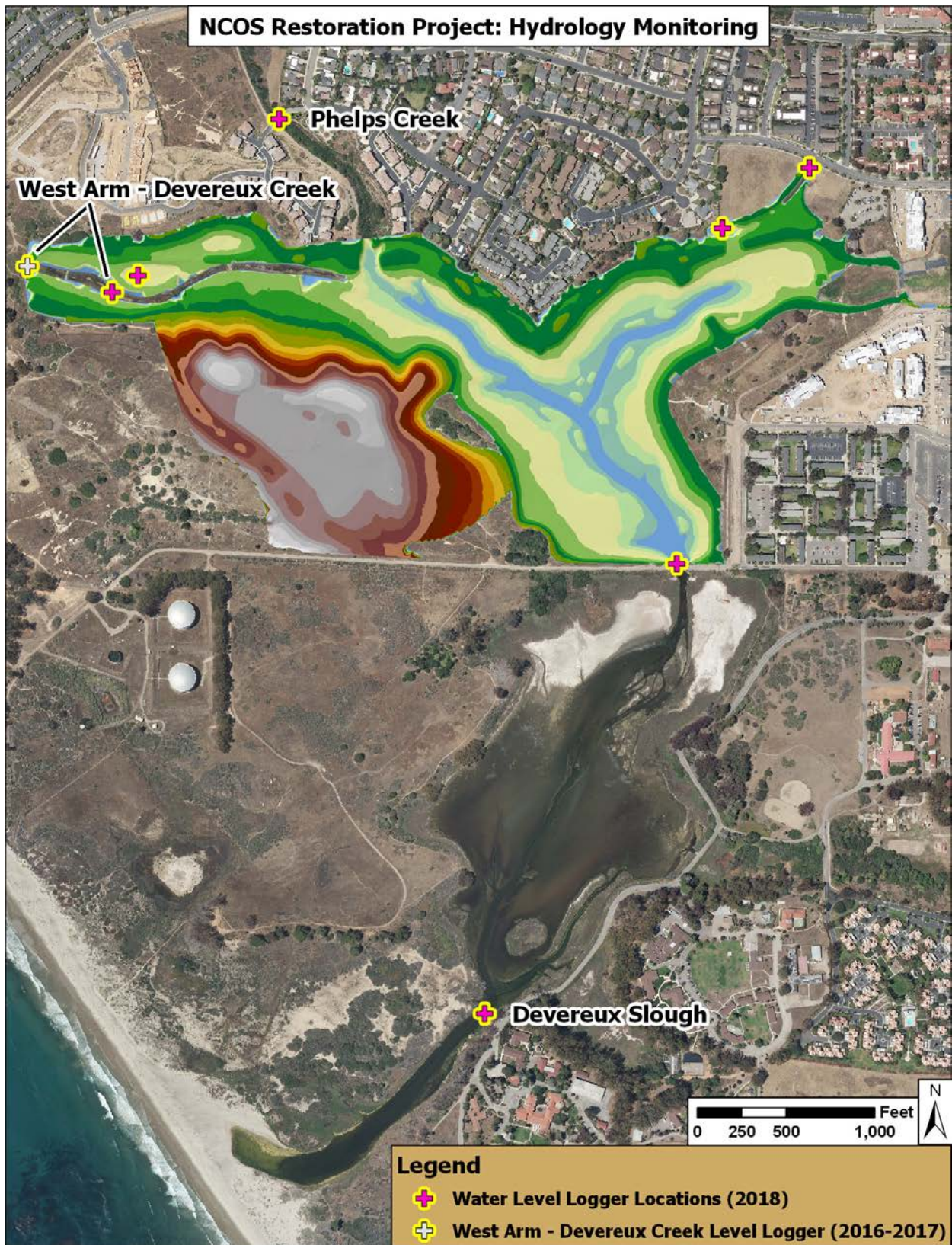


Figure 9. Map of the location of water level loggers for monitoring hydrology of the NCOS restoration site and lower Devereux Slough before (2016-2017) and after completion of the grading phase of the project.

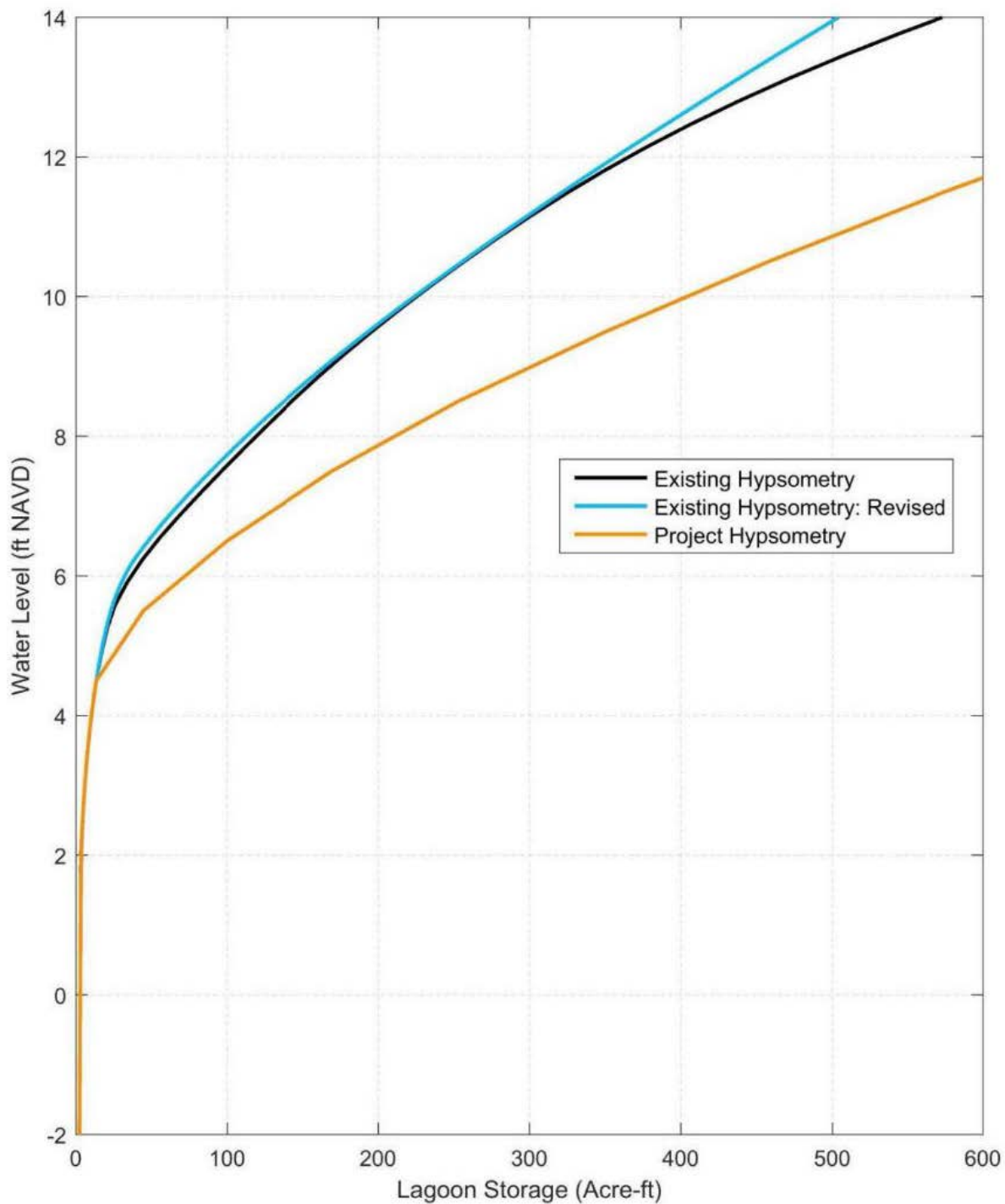


Figure 10. Comparison of pre- and post-grading water stage-storage curves for Devereux Slough (Lagoon). Notice the lower post-project water levels at equivalent water storage levels (orange line). Pre-grading hypsometry is from Rich (2013). Revised pre-grading hypsometry is based on an ESA and Stantec survey. Post-grading hypsometry is based on the ESA grading plan for NCOS.

5. Aerial and Landscape Photos

Oblique aerial photos of the NCOS project site have been periodically captured by Bill Dewey. One pre- and one post-grading aerial photo are provided on the following two pages. Quarterly landscape photo monitoring of the NCOS restoration project began in December 2016, with the first complete set of baseline, pre-grading photos taken on April 10-11, 2017. On the following pages, a subset of key photos from this baseline set are compared with photos taken after the completion of grading (April 2018). The photos are preceded by a map of the photo monitoring point locations, with the key subset photo point locations highlighted for reference (Figure 11).

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Aerial image of the North Campus Open Space project site, taken by Bill Dewey on October 7, 2009.



Aerial image of the North Campus Open Space project site after the completion of the grading phase, taken by Bill Dewey on March 18, 2018.

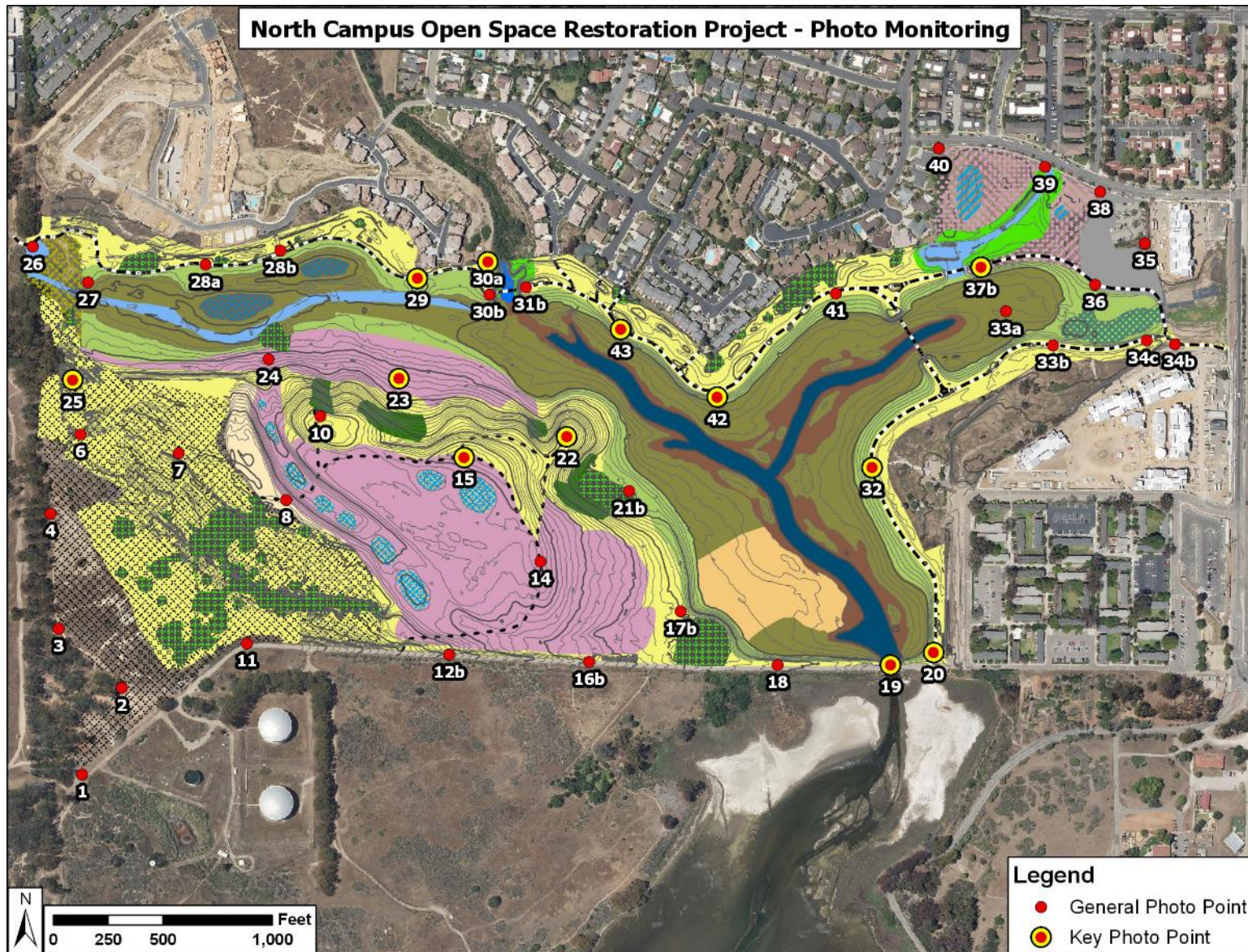


Figure 11. Map of the landscape photo monitoring point locations at the NCOS Restoration Project. The point locations of the key subset of pre-project and as-built photos provided in this report are indicated with a yellow ring.

Photo point 15-W – looking west from central high point on NCOS mesa



Baseline photo – pre-grading, April 11, 2017.

Photo point 15-W – looking west from central high point on NCOS mesa



As-built photo - April 17, 2018.

Photo point 19-N – looking north along main channel from bridge on Venoco road



Baseline photo – pre-grading, April 10, 2017.

Photo point 19-N – looking north along main channel from bridge on Venoco road



As-built photo - April 17, 2018.

Photo point 20-W – looking west from southeast corner of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 20-W – looking west from southeast corner of NCOS project site



As-built photo - April 17, 2018.

Photo point 22-E – looking east/southeast from central overlook on NCOS mesa



Baseline photo – pre-grading, April 10, 2017.

Photo point 22-E – looking east/southeast from central overlook on NCOS mesa



As-built photo - April 17, 2018.

Photo point 22-NW – looking northwest from central overlook on NCOS mesa



Baseline photo – pre-grading, April 10, 2017.

Photo point 22-NW – looking northwest from central overlook on NCOS mesa



As-built photo - April 17, 2018.

Photo point 23-E – looking east from lower slope along north side of NCOS mesa



Baseline photo – pre-grading, April 10, 2017.

Photo point 23-E – looking east from lower slope along north side of NCOS mesa



As-built photo - April 16, 2018.

Photo point 23-SW – looking southwest from lower slope along north side of NCOS mesa



As-built photo - April 16, 2018.

Photo point 25-NE – looking northeast from above the western arm of NCOS project site



Baseline photo – pre-grading, April 11, 2017.

Photo point 25-NE – looking northeast from above the western arm of NCOS project site



As-built photo - April 17, 2018.

Photo point 29-W – looking west from trail along northwest side of NCOS project site, west of Phelps Creek



Baseline photo – pre-grading, April 10, 2017.

Photo point 29-W – looking west from trail along northwest side of NCOS project site, west of Phelps Creek



As-built photo - April 16, 2018.

Photo point 30a-E – looking east from the west side of the Phelps Creek crossing



Baseline photo – pre-grading, April 10, 2017.

Photo point 30a-E – looking east from the west side of the Phelps Creek crossing



As-built photo - April 16, 2018.

Photo point 32-N – looking north from central point on the trail along the eastern side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 32-N – looking north from central point on the trail along the eastern side of NCOS project site



As-built photo - April 16, 2018.

Photo point 32-W – looking west from central point on the trail along the eastern side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 32-W – looking west from central point on the trail along the eastern side of NCOS project site



As-built photo - April 17, 2018.

Photo point 37-S – looking south from primary trail along northeast side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 37-S – looking south from primary trail along northeast side of NCOS project site



As-built photo - April 16, 2018.

Photo point 42-NE – looking northeast from central point on trail along north side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 42-NE – looking northeast from central point on trail along north side of NCOS project site



As-built photo - April 16, 2018.

Photo point 42-SE – looking southeast from central point on trail along north side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 42-SE – looking southeast from central point on trail along north side of NCOS project site



As-built photo - April 16, 2018.

Photo point 42-W – looking west from central point on trail along north side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 42-W – looking west from central point on trail along north side of NCOS project site



As-built photo - April 16, 2018.

Photo point 43-SE – looking southeast from trail along north side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 43-SE – looking southeast from trail along north side of NCOS project site



As-built photo - April 16, 2018.

Photo point 43-S – looking south from trail along north side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 43-S – looking south from trail along north side of NCOS project site



As-built photo - April 16, 2018.

Photo point 43-W – looking west from trail along north side of NCOS project site



Baseline photo – pre-grading, April 10, 2017.

Photo point 43-W – looking west from trail along north side of NCOS project site



As-built photo - April 16, 2018.