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memorandum

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subject Hamilton Wetlands Post-Construction As-Built Survey Review – Breach and Completion Contract.

This memorandum presents the ESA's post-construction assessment of the Hamilton Wetland Restoration Project following the Breach and Completion Contract.

This memorandum is divided into three main sections:

1. Summary of As-Built Survey Data – A review of the available as-built survey data provided by the contractor and augmented with ESA Year 0 survey data, including a discussion of survey coverage and identification of project features which were not included in the as-built surveys.

2. Post-Construction Assessment of Project Features – A review of the as built condition of major project elements compared to design grades and tolerances, and an assessment of whether the elements are performing as intended.

3. Assessment and recommendations – A brief discussion of the potential implications and concerns related to areas where the construction appears to have deviated from design and or the conditions indicate reduced project performance. Remedial actions to rectify deficiencies are provided to inform the adaptive management of the site.

SUMMARY OF AS-BUILT SURVEY DATA

The Breach - Completion construction contractor conducted as-built surveys for most of the project elements included in the Breach – Completion contract as well as for elements completed during earlier phases of construction under different contracts. ESA received the following datasets for review both during construction and subsequent to construction:

Post Construction Aerial Survey:

- Post Construction Aerial Photogrammetry - Aerial Photogrammetric survey of site augmented with hydrographic survey of Outboard Levee Breach, Pilot Channel and Access Channel, 0.5' Contour map. CLE Engineering. June 2014.

Post Construction Ground Surveys:

- Post Construction Interior Hydrographic Survey including the expanded settling basin and intertidal berm breaches. CLE Engineering. January 2015.
- South Seasonal Wetlands Survey by Marathon Construction, GPS point survey. January 2014.
- Tidal Panne Survey by Marathon Construction, GPS point survey. February 2014.
- Year 0 Monitoring Survey by ESA, GPS and Hydrographic Survey. January and February 2015

Survey Coverage

A post-construction survey surface was produced by CLE (under contract with Marathon Construction) following the completion of grading. This surface is a composite of June 2014 aerial photogrammetric survey data and supplemental bathymetric survey data in the vicinity of the main breach that was collected by CLE Engineering in 2014. The extents of this post-construction survey are shown in Figure 1. This survey surface reflects the water surface elevation rather than finish grades in areas of the of the project site that were below water; including the Expanded Settling Basin, areas near ITTBs 14, 25 and 26, and the channels outboard of the North Seasonal Wetlands and South Seasonal Wetlands.

In January 2015 CLE conducted a supplemental hydrographic survey to measure bed elevations in the Expanded Settling Basin and at internal breaches 14, 25 & 26. The extents of this hydrographic survey are shown in Figure 1.

Additional post-construction surveys were conducted by Marathon Construction at the Tidal Panne area and in the South Seasonal Wetlands. Figure 1 shows the locations of the additional post-construction survey points.

In December 2014 ESA collected spot elevations during a site visit, including several points along the Outboard Levee Crest, the Tidal Pannes, and South Seasonal Wetlands.

Finally, ESA collected ground survey data as part of the Year-0 Monitoring effort. This survey included bathymetry along the main internal breaches, and along the main breach channel from the Expanded Settling Basin to the Pilot Channel. The survey also included cross sections taken at key locations along the Outboard Levee, a profile along the Tidal Panne Berm and pond crest elevation profiles for South Seasonal Wetlands Ponds 1, 2, 3 and 4.

The above mentioned survey datasets provide data for much of the project site. However the provided as-built surveys and additional survey datasets do not capture several project features which were underwater at the time of the aerial photogrammetry flight. Figure 1 highlights areas where project features are obscured by the water surface or otherwise not captured by the existing survey datasets. Note that this review does not necessarily identify all locations of missing survey data or inaccurate mapping.

The obscured features include:

- The Expanded Settling Basin Channel: The as-built survey contours appear show the water surface elevation in the area where the channel inboard of the main breach is located.

- Marsh areas outboard of NSW and SSW: During the post-construction site visit ESA identified two locations where pre-existing topographic/bathymetric sills may be inhibiting drainage of the SSW and NSW areas at low tides. These pre-existing sills may have formed during and after placement of dredge material and were not captured in pre- or post-construction surveys but were visible during low tides at the time of our site visit. These features could impact on the drainage of the two NSW and SSW. ESA has conducted supplemental surveys of these features as part of ongoing monitoring of the restoration site.

The project specifications required supplemental surveys (either bathymetric or using other methods) to capture project elements which were underwater at the time of the aerial mapping. It appears that bathymetric surveys for the main breach, expanded settling basin, ITBB 14 and outboard pilot channel were provided in the Aerial Photogrammetric survey and the supplemental bathymetric survey. ESA has made efforts to adapt the ongoing monitoring survey locations to include key features which were not captured in the post-construction surveys.

POST-CONSTRUCTION ASSESSMENT OF PROJECT FEATURES

ESA has used the available survey data to characterize the post-construction condition of the main project elements and assess whether these features were constructed in accordance to the project design. The following sections list the main project elements and the available survey data for that element, and present ESA's assessment of each element's post-construction condition.

The following project features were not evaluated in this assessment:

- Demolition
- Bay Trail
- Planting and re-vegetation

South Seasonal Wetlands

The South Seasonal Wetlands consist of a cluster of 5 ponds, marshplain areas and a tidal channel network. The ponds are intended to overtop during high water events, with the design of each pond including a carefully selected "crest elevation" defining the elevation of the pond perimeter. The ponds also included a specified bed elevation and the grading was designed to provide soil cover areas with low-level DDT contaminated soils.

Critical functions for the ponds include:

1) Provide ponded depths and durations to support avian habitat, and
2) Prevent tidal channel formation that could reduce the depth of cover over low level DDE stockpiles.

Figures 2 through 5 show the as-built survey data for the various SSW ponds including points collected by Marathon post construction, Aerial photogrammetry, and points surveyed by ESA around the pond crest. Figure 6 shows the difference between the design grade and the post-construction aerial photogrammetry, and Figure 7 shows the difference between the design grade and the post-construction ground survey. Figure 6 highlights significant areas of the SSW marshplain and ponds generally below design grades beyond the design tolerance. Figure 7 shows a smaller extent of out-of-tolerance elevations, but still shows many areas significantly outside of the +/-0.5 ft design tolerance.

Figures 8 and 9 show cross sections cut through the 5 ponds, and Figures 10 and 11 show profiles taken along the pond crests comparing design and surveyed grades. The post construction aerial photogrammetric survey cross-sections generally plot below design grades, while the post construction point survey (collected soon after completion) are closer to design grades. In general, the as-built pond sill elevations were lower than specified in the design, with portions of all 5 pond crests found to have elevations lower than allowed by the design tolerance. In some locations, erosion has lowered portions of the sill up to 1 foot below design grade as shown in the profiles (ESA 2015 surveys). Crest elevations below design grades subject the ponds to increased tidal exchange and increase drainage during low tides, reducing the habitat value of these areas and increasing the likelihood of erosion. Observations made during the Year-0 monitoring effort note that Pond 1 drains almost completely during low tides due to the emergence of small erosional channels through the pond crest.

The bed elevations of all ponds meet the design tolerance. While no specific design tolerance was specified for pond area, the areas of all ponds except Pond 1 were found to be generally comparable to the areas indicated in the design. Pond 1 was found to be 20,000 SF smaller than design, a ~15% reduction in area.

Table 1 compares the key design dimensions of the South Seasonal Wetlands ponds with those measured by the as-built surveys.

Table 1 – SSW Pond As-Built vs Design Grades (ft NAVD) and Area

Feature	Dimension	Design (Tolerance)	Marathon Ground Survey	Photogrammetric & Hydrographic Survey	ESA Monitoring Surveys	Within Tolerance?
Pond 1	Crest Elevation	6.75' (±0.15')	6.4' to 6.8'	6.5' to 7.0'	6.0' to 7.4'	**No**
	Bed Elevation	6.0' (±0.15')	5.9' to 6.1'	6.0'		Yes
	Pond Area	3.65 ac	3.08 ac	-	-	N/A
Pond 2	Crest Elevation	7.25' (±0.15')	6.7' to 7.2'	6.5' to 7.0'	6.2' to 7.6'	**No**
	Bed Elevation	5.5' (±0.15')	5.4' to 5.7'	5.5'	-	Yes
	Pond Area	5.08 ac	5.04 ac	-	-	N/A
Pond 3	Crest Elevation	7.25' (±0.15')	6.9' to 7.1'	6.5'	5.95' to 7.4'	**No**
	Bed Elevation	5.5' (±0.15')	5.45' to 5.6'	5.5'	-	Yes
	Pond Area	1.16 ac	1.18 ac	-	-	N/A
Pond 4	Crest Elevation	6.75' (±0.15')	6.2' to 6.8'	6.0' to 6.5'	5.8' to 7.0'	**No**
	Bed Elevation	4.5' (±0.15')	4.4' to 4.65'	4.5'	-	Yes
	Pond Area	2.80 ac	2.84 ac	-	-	N/A
Pond 5	Crest Elevation	7.75' (±0.15')	7.4' to 7.65'	7.0 to 7.5'	-	**No**
	Bed Elevation	5.5' (±0.15')	5.4' to 5.65'	5.5'	-	Yes
	Pond Area	2.71 ac	2.82 ac	-	-	N/A

Tidal Pannes

The Tidal Pannes are a cluster of shallow, sculpted ponds adjacent to the NSW along the northwest edge of the tidal wetlands area. These pannes are intended to overtop during spring and king tides, capturing and ponding water through subsequent neap tides. The key design parameters for the Tidal Pannes are the pond bed elevations and the elevation of the sills that define the perimeter of the ponds.

Figure 12 shows the as-built surveys for the Tidal Pannes including contours from the aerial photogrammetry, spot elevations collected post construction, and spot elevations along the NSW berm collected by ESA. Figure 13 shows the difference between the design grade and the post-construction ground survey. Figure 14 shows the difference between the design grade and the post-construction aerial photogrammetry. Figure 15 shows typical cross sections of the Tidal Pannes. Note that the point survey data show close agreement to the design grades, while the aerial photogrammetry survey shows larger deviations from the design grade.

There are three sills located at the Tidal Pannes which define the edges of the pannes and separate the Tidal Pannes from the outboard marsh and the inboard North Seasonal Wetlands. The design grade of the outboard sill is 6.5' NAVD. The CLE aerial survey shows the post-construction grade using 0.5' contour intervals, which does not provide sufficient detail to determine whether the sill elevation meets the +/-0.15' design tolerance. The point survey data collected by Marathon Construction includes several points taken at 200'-300' intervals along the outboard sill. The elevations of these points range from 6.27' to 7.08' NAVD. The low end of this range is below the design tolerance, while the high end is 0.58' above design grade and significantly beyond the 0.15' tolerance.

In December 2014, approximately 10 months after the Marathon survey, ESA staff walked the length of the outboard sill during a low tide and observed several locations where low points in the sill were allowing water to drain from the pannes and showed signs of erosion leading to tidal channel formation. ESA collected spot elevations at the lowest erosional channel, finding the eroded channel at 6.16' NAVD, which is 0.34' below design grade. This eroded channel will limit the depth of ponding in the lower tidal pannes. As these channels continue to incise, the lower tidal pans may not maintain ponding and function as intended.

The design grade of the middle pond sill is 7.0' NAVD. The CLE aerial survey shows a continuous flat expanse at 6.5' NAVD where this sill should be located. This may suggest that the sill elevation is lower than the design grade, but also could be due to the limitations of the surveys 0.5' contour interval. The Marathon point survey showed the sill ranging from 6.93' to 7.34' NAVD shortly following construction, with the majority of the sill appearing to be within tolerance in the post construction ground survey. This sill should be monitored to confirm that it is within tolerance and that the upper pannes will maintain ponding and function as intended.

The design grade of the lowered NSW levee, which separates the Tidal Pannes from the North Seasonal Wetlands, is 8.0' NAVD. The CLE aerial survey shows this levee between 7.5 and 8.0' NAVD. Survey points collected by ESA in January 2015 as part of the Year 0 Monitoring effort show sections of the levee as low as 7.37' NAVD, 0.48' bellow tolerance. Overtopping and erosion was observed during the December 2014 storms. Table 2 compares the key design dimensions of the Tidal Pannes with those measured by the as-built surveys:

Table 2 – Tidal Panne As-Built vs Design Elevations

Feature	Dimension	Design (Tolerance)	Marathon Ground Survey	CLE Aerial Photogrammetry & Hydrographic Survey	ESA Monitoring Surveys	Within Tolerance?
Outboard Pond Sill	Crest Elevation	6.5' (±0.15')	6.4' to 7.4'	6.0' to 6.5'	Low point @ 6.16'	**No**
Middle Pond Sill	Crest Elevation	7.0' (±0.15')	6.9' to 7.3'	6.5'	-	**No?**
Inboard (NSW) Levee	Crest Elevation	8.0' (±0.15')	-	7.0 to 8.0	Low points @ 7.34' & 7.54'	**No**

Wildlife Corridor Transition

The Wildlife Corridor Transition, located at the north end of the Wildlife Corridor (WLC), is intended to provide a gradual transition from the broad, flat transitional slope along the WLC to narrower wetland bench along the tidal channel adjacent to the North Seasonal Wetlands. The project design calls for a broad transition area with slopes ranging from about 40 to 80:1. Figure 16 shows a plan view of the design grade and post-construction aerial photogrammetry contours at the WLC Transition. Figure 17 shows two cross sections through the WLC Transition, highlighting the extent to which the as-built grades are lower than the design grades. The majority the WLC Transition area is between 0.5 and 1ft below than the design grade, and does not meet the specified tolerance.

The finished grades ranging from 0.5 to 1 ft below the design grade will result in a narrower transitional slope in this area, significantly reducing vegetated habitat area and reducing high tide refugia adjacent to the NSW tidal channel corridor.

Intertidal Berm Breaches 25, 26, & 14

The project design includes three breaches (ITBB 25, 26 and 14) in the inter-tidal berms to allow tidal channels to scour to full depth within the site.

Figure 18 shows a plan view of ITBB 25 and 26, showing the location of the available survey datasets at these two breaches, including the CLE Hydrographic Survey from early 2015 (shown as contours) and the ESA Monitoring Surveys, both conducted in Jan/Feb 2015 and Sept 2015. Figure 19 shows cross sections and profiles for these two breaches. Figure 19 also shows channels ESB 25 and 26 excavated within the expanded settling basin. Figures 20 and 21 show the plan view of ITBB 14, and a cross section and profile for this breach.

Table 3 summarizes the findings of the post-construction surveys. Both the CLE and ESA surveys show excavated grades higher than the design grade. The bottom width of all three intertidal berm breaches approximately matches the design width, however the excavated depths were all above tolerance at the time of surveys. The excavated depths ranged from 1.5 to 3 feet above design grades at ITTB 25, 1.5 to 2 feet above design grade at ITTB 26, and 1 to 2.5 feet above design at ITTB 14. Since the surveys were performed several months following construction, it is not clear if these intertidal berm breaches were under-excavated at the time of construction or if the soft dredge material migrated into the excavated breach. The more recent monitoring surveys conducted in the fall of 2015 suggest that these intertidal berm breaches may be filling with poorly consolidated sediment from the adjacent mudflats, these findings will be discussed further in the Year-1 monitoring report. The evolution of these breaches will continue to be monitored.

Also in the vicinity of ITTB 25 and 26 are excavated channels ESB 25 and 26 within the expanded settling basin. Based on the CLE hydrographic survey (Feb 2015), Channel ESB 25 appears to be excavated to design width and depth in the reach to the east of the bifurcation with ESB 26. However, west of the bifurcation, ESB 25 appears to have been under excavated in both width (80’ constructed vs. 210’ design width) and depth (EL -5.5’ constructed vs. EL -6.5’ design). Channel ESB 26 appears to approximately match the design width, while being under excavated in depth (EL 4.5’ constructed vs. EL 6.0’ design). Similar to the intertidal berm breaches, it’s not clear if the ESB channels were excavated to depth during construction, and the surveyed depths reflect sediment and dredge materials settling within the low channel bottom.

Table 3 – Inter-Tidal Berm Breaches 25, 26 and 14

Feature	Dimension	Design (Tolerance)	Marathon Ground Survey	CLE Hydrographic Survey	ESA Monitoring Surveys	Within Tolerance?
ITBB 25	Bottom Width	500’	-	500’	510’	Yes
	Bottom Elevation	-6.5’ (±1.0’)	-	-3.5’ to -5’	Not surveyed	**No?**
ITBB 26	Bottom Width	305’	-	Full width not surveyed	300’	Yes
	Bottom Elevation	-6’ (±1.0’)	-	-3.5’ to -4.5’	-2’ to -4’	**No?**
ITBB 14	Bottom Width	230’	-	240’	245’	Yes
	Bottom Elevation	-4.5’ (±1.0’)	-	-2.5 to -3.5’	1’ to -2’	Yes

Outboard Levee Breach

The Outboard Levee Breach provides the tidal connection between the restored wetland and San Francisco Bay. The Outboard Levee Breach includes the Main Breach area, where the breach channel is cut through the levee and marsh areas adjacent to the levee, as well as the pilot channel and access channel which extend across the outboard marsh and mudflats.

CLE conducted hydrographic surveys of the breach areas in 2014, shortly following the completion of channel construction. This survey data was spliced into the Post-Construction Aerial Photogrammetry survey. ESA has conducted additional surveys along the Outboard Levee Breach as part of ongoing monitoring. Figure 22 shows the plan view of the breach region and Figures 23 and 24 shows several cross sections cut across the Main Breach and Pilot Channel. Figure 25 shows a plan view of the Pilot and Access Channels and Figures 26 and 27 shows cross sections of these channels through the outboard mudflat. Figure 28 shows a profile along the thalweg of the breach. Table 2 below compares the key design dimensions of the Main Breach and Pilot Channel with those measured by the as-built surveys.

The CLE survey indicates that breach excavated through the levee is significantly shallower than specified in the design at cross sections A, B and C; and narrower than specified at cross section C. However, survey data collected by ESA as part of the Year-0 monitoring show depths 2 to 4 feet deeper than the as-built survey at cross sections A and C, which appear to show that the breach was excavated to design grades within tolerance. It is not clear why there is a 2 to 4 foot difference between the as-built survey and the Year-0 Monitoring survey at these cross sections.

Figure 22 also shows the design limit of grading for the breach channel. The figure shows where the as-built grading does not extend to the limits of grading specified in the design. Specifically, the transition between the breach to the pilot channel was constructed ~40 ft inboard of the station specified in the design. This reduced excavation footprint resulted in a reduced channel width at Section C (Figure 24), with a constructed base width of about 110’ vs. the 210’ design width.

The CLE survey shows that the width and depth of the outboard Pilot Channel generally conform to the design dimensions. At the pilot channel, the excavated depth is within tolerance of the design grades, and subsequent surveys by ESA document that the pilot channel has experienced incision following construction. By contrast, surveys of the Access Channel indicate that the outboard most 600' of the Access Channel was under-excavated by 1.5 to 2 ft above design grade and outside the contract tolerance (+0.0' to -2.0').

Table 4 – Main Breach As-Built vs Design Dimensions

Feature	Dimension	Design (Tolerance)	Marathon Ground Survey	CLE Aerial Photogrammetry & Hydrographic Survey	ESA Monitoring Surveys	Within Tolerance?
Main Breach @ Levee	Bed Elevation	-6.5' (±1.0')	-	-3' to -6'	-5' to -6'	Yes / close
	Bottom Width	210' (±0.5')	-	220'	-	Yes
	Top Width	417' (±0.5')	-	400'	-	Yes
Main Breach @ Outboard Transition	Bed Elevation	-6.5' (±1.0')	-	-4'	-5' to -7.5'	Yes / close
	Bottom Width	210' (±0.5')	-	125'	120'	**No**
	Top Width	417' (±0.5')	-	205'	-	**No**
Pilot Channel & Access Channel inboard of STA 17+50	Bed Elevation	El. Varies (+0'/-2')	-	Varies, see Figure 28	Varies, see Figure 28	Yes
	Bottom Width	40' (±0.5')	-	Varies, ~40	-	Yes
	Top Width	Varies, ~161'	-	Varies, ~160'	-	Yes
Access Channel STA 17+50 to 24+00	Bed Elevation	El. Varies (+0'/-2')	-	Varies, see Figure 28	Varies, up to 2' above design grade, see Figure 28	**No**
	Bottom Width	40' (±0.5')	-	Varies, ~40	-	Yes
	Top Width	Varies, ~161'	-	Varies, ~160'	-	Yes

Outboard Levee Lowering

The outboard levee separates the restored project area from the existing bayfront marsh. This levee was to be lowered to provide a smooth transition between the inboard and outboard marshes. The design grade of this feature sloped from ~EL 7.0 ft (@ limit of native marsh vegetation) along the outboard marsh to EL 5.1 ft at the inboard side of the levee. The as-built crest elevation was found to be considerably higher than the design grade, reaching elevations up to 8.72 ft, and consistently exceeding EL 8.0 ft for long stretches. Figure 29 shows a plan

view of the outboard levee, including the location of spot elevations collected by ESA. Figure 30 shows several cross sections cut along the length of the outboard levee, showing as-built grades captured by the aerial photogrammetry as well as the design grade. Figure 31 shows a profile along the centerline of the outboard levee, showing as-built grades captured by the aerial photogrammetry, as well as high points captured in the ESA monitoring survey. This figure also highlights the EL 7.0 ft, the maximum allowed elevation of the lowered levee.

The design indicates that the levee lowering should create a slope from the existing elevation 7.0' contour on the outboard side of the levee to the inboard El 5.1 ft contour. Therefore we would expect the post-construction grades along the levee centerline to be between EL 5.1 and 7.0 ft, however the post-construction survey shows elevations above EL 7.0 ft almost contiguously between stations 0+00 and 23+00, and at several other locations along the length of the levee. This suggests that nearly half of the outboard levee was not lowered to the correct elevation.

Table 5 – Outboard Levee Lowering As-Built vs Design Dimensions

Feature	Dimension	Design (Tolerance)	Marathon Ground Survey	CLE Aerial Photogrammetry & Hydrographic Survey	ESA Monitoring Surveys	Within Tolerance?
Outboard Levee Crest Elevation	STA 0+00 to 10+00	7.0' sloping to 5.1' (±0.5' & >50% ±0.25')	-	7.5' to 8.0'	High point at 8.7	**No**
	STA 10+00 to 20+00		-	6.8' to 7.9'	High point at 8.3	**No**
	STA 20+00 to 30+00		-	6.0' to 8.0'	High point at 8.3	**No**
	STA 30+00 to 43+00 (excluding Main Breach)		-	6.5' to 7'	High point at 7.3	**Yes**

Intertidal Berm Lowering

There are 7 intertidal berms which were lowered as part of the project design. These berms act as wave breaks and provide areas at marshplain elevation that are expected to support more rapid vegetation colonization. The design indicates that the berms should be lowered EL 6.1' NAVD with a +0.0' / - 0.5' tolerance (with >50% within 0.25' of design grade).

The Aerial photogrammetry survey shows that 3 out of the 7 berms were lowered below the allowed tolerance for more than 10% of the berm length; while two additional berms show isolated areas that are below tolerance but generally appear to conform to the design. The Aerial survey shows several berms exceeding elevation 6.0 but below elevation 6.5', however the vertical resolution of the aerial survey is not sufficient to determine whether any of these berms exceed EL 6.1'.

Feature	Dimension	Design (Tolerance)	Marathon Ground Survey	CLE Aerial Photogrammetry & Hydrographic Survey	ESA Monitoring Surveys	Within Tolerance?
Intertidal Berm 1	Crest Elevation	6.1' (+0 to -0.5' & >50% +0 to -0.25')	-	5.0' to 6.0'* (5% below 5.5')	-	Yes/Close
Intertidal Berm 2	Crest Elevation		-	4.5' to 5.5'* (14% below 5.5')	-	**No**
Intertidal Berm 3	Crest Elevation		-	5.0' to 5.5'* (4% below 5.5')	-	Yes/Close
Intertidal Berm 4	Crest Elevation		-	5.5' to 6.0'*	-	Yes
Intertidal Berm 5	Crest Elevation		-	5.0' to 5.5'* (25% below 5.5')	-	**No**
Intertidal Berm 6	Crest Elevation		-	5.5' to 6.0'*	-	Yes
Intertidal Berm 7	Crest Elevation			5.0' to 5.5'* (70% below 5.5')	-	**No**

*CLE aerial survey data was provided as 0.5' contours. The elevation range shown is based on the highest and lowest contour line shown along each berm crest. Higher and/or lower areas may exist but cannot be distinguished due to the resolution of the aerial survey.

OBSERVATIONS FROM ONGOING MONITORING

Over the past year, ESA has been conducting ongoing monitoring at the project site. This monitoring has included observations of water levels, sediment geomorphology, vegetation, bird species, fish usage and photo documentation.

The sediment geomorphology observations included ground surveys intended to document the evolution of key project features over time. These features include the North Seasonal Wetlands outboard berm, sill and outboard channel, as well as the South Seasonal Wetlands pond sills and outboard channel. The monitoring surveys show the following:

- The South Seasonal Wetland pond crests were surveyed and found to contain segments that are below the design elevations. Pond 1 in particular has exhibited significant erosion and channel formation, resulting in nearly complete drainage of the pond area during low tides. Under current conditions the hydrology of Pond 1 is more comparable to a mudflat or tidal marsh area rather than a seasonal wetland pond. The other pond crests appear to be sufficiently intact to provide ponded habitat, however they too may transition to mudflat or tidal marsh should their crests continue to erode.

- A cross section was surveyed along the lowered NSW/Tidal Pannes levee and along the outboard Tidal Panne sill. As noted in the Tidal Pannes section above, the lowered levee crest is lower than the design elevation at several locations, and has overtopped and exhibited signs of scour during high tide events.

Also the Tidal Pannes Sill also has several areas of erosion that limit ponding within the tidal pannes. Repeated surveys of the berm crest over coming years will provide greater insight as to the rate at which the berm is eroding, and will inform future adaptive management, if needed.

ASSESSMENT AND RECOMMENDATIONS

Based on the post-construction survey data and subsequent Year 0 and preliminary Year 1 monitoring data, ESA offers the following assessments with recommendations related to key features that could affect project success. Assessments are provided in order of the significance of the impact to project success:

- *The South Seasonal Wetland Pond perimeter sill elevations are too low:* The perimeter sill elevations of all five South Seasonal Wetland Ponds are lower than specified in the design. These sills were intended to limit overtopping into the ponds, creating intermittently inundated habitat areas and reducing the likelihood of scour. The design included a compacted sill (compacted to 95% R.C.) to guide tidal flows into and out of each pond. However, with numerous erosional cuts through the lower perimeter elevations will allow for more frequent inundation and provide flow paths which appear to be encouraging channel growth near or in the ponds, limiting the desired habitat from establishing. The sill erosion and channel formation at Pond 1 is particularly advanced. The formation of channels in the vicinity of the seasonal wetlands ponds is highly problematic. Channels would prevent the occurrence of ponded water, reducing the habitat value for wading birds. Furthermore, eroding channels could allow tidal channels to form potentially scouring into the clean cover material over the low-level DDT contaminated soils, violating the project permit requirements and possibly allowing contaminants to mobilize from the ponds.

    - Place compacted fill around the perimeter of each pond to achieve design sill elevations.

    - Plant mid and high marsh plantings (as appropriate) along the entire length of each sill around the perimeter of each pond to help establish a dense cover of vegetation to limit erosion.

    - In areas of eroding rills and small channels, coir matting may be utilized to further stabilize the surface and hold plant material in place to limit erosion.

- *The Tidal Panne sills are too low:* The lower elevation of the Tidal Panne sills will reduce the duration of ponding and may lead to unwanted channel formation, preventing the desired habitat from establishing. The Tidal Pannes are intended to flood only during higher high tides, and to capture ponded water to create habitat for wading birds. The appearance of low points along the outboard berm is particularly concerning as these locations are likely to encourage tidal channel formation, which would reduce the extent of ponded water during low tides. In addition the low points in the lowered NSW/Tidal Panne levee are also allowing for erosional rills and channels to form which could possibly create a connection between the NSW and the larger tidal wetland restoration.

    - Place compacted fill along the Tidal Panne sills and the lowered NSW/Tidal Panne levee to achieve design elevations.

- Plant mid and high marsh plantings (as appropriate) along the entire length of each sill and the lowered NSW/Tidal Panne levee to help establish a dense cover of vegetation to limit erosion.

- In areas of eroding rills and small channels, coir matting may be utilized to further stabilize the surface and hold plant material in place to limit erosion.

- *The Outboard Levee is too high:* The higher crest of the outboard levee is preventing occasional overtopping and inundation along the levee crest which will limit sediment delivery to the site during storm surges. In addition the higher elevation will limit natural colonization of native vegetation along the lowered levee because considerable stretches of the outboard levee crest are well above the tide range. Up to 4 to 5 acres of the outboard levee may be too high for native vegetation to establish.

    - Lower the outboard levee to design grades including the clean clay soil cap as required by the contract.

    - If lowering the outboard levee is not practicable, native plantings appropriate for high marsh and transitional zones (similar to those for the Wildlife Corridor) should be planted along the higher reaches of the outboard levee limit establishment of non-native vegetation including perennial pepperweed.

    - Vegetation establishment should be closely monitored and non-native control efforts should be undertaken to limit the establishment of non-native plant communities on the higher areas of the outboard levee.

- *Intertidal Berms lowered beyond tolerance*: Intertidal Berms 2, 5 and 7 were lowered below the design tolerance. These intertidal berms lowered to below design grades will impact the effectiveness of the intertidal berms for breaking up wind waves. Additionally, the berms below the elevation for ready colonization with pickleweed, and will need to rely upon cordgrass establishment to vegetate the berms. However, cordgrass is more difficult to establish and generally requires a number of growing seasons to develop healthy stands.

    - Monitor erosion and vegetation establishment. If necessary, native marsh plantings may be required to vegetate the lowest intertidal berms to limit erosion and to maintain function for wind wave suppression.

- *The Outboard Levee Breach and outer Access Channel dimensions are under-excavated:* The reduced dimensions of the main breach may restrict tidal flows into and out of the restored site, reducing both the tidal prism and the tide range. The reduced tidal prism may limit sediment transport into the site, decreasing the rate of accretion on the marsh plain. The reduced tide range may inhibit the establishment of marsh vegetation by reducing the extent of intertidal area within the site. In addition, the Access Channel was under-excavated and is shallower than design which can limit low tide drainage. It is expected that over time the breach will scour and enlarge, however the likely rate of scour is unknown and will be limited by the reduced breach excavation.

- Monitoring of the Outboard Levee Breach is expected to confirm that breach is expanding and confirm hydrology improvement via review of water level data. If monitoring indicates that tidal hydrology is not acceptable, consider excavation to expand breach.

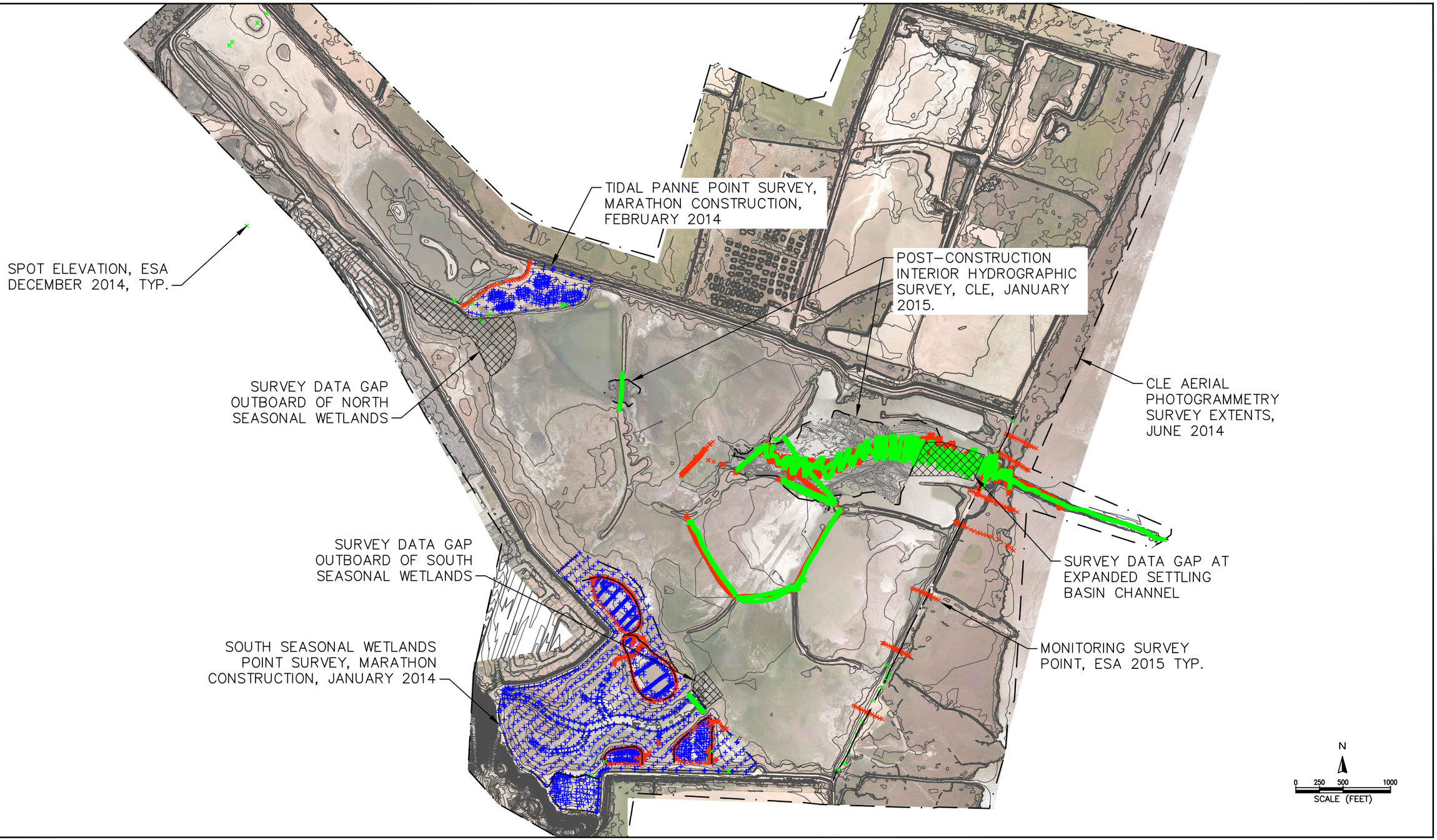
- If low tide drainage remains limited, consider excavation of the Access Channel to full depth and possibly extension of the Access Channel further across the outboard mudflat.

- *The Wildlife Corridor Transition area is too low*: The finish grades at the Wildlife Corridor Transition area are up to 1ft lower than the design grades. This causes more frequent inundation of this tidal marsh area, and reduces the extent of high tide refugia adjacent to the NSW wetland channel corridor. Some parts of the transition area may not fully vegetate, and instead persist as mudflat or subtidal habitat.

    - Monitor vegetation establishment along Wildlife Corridor Transition. If colonization rates are unsatisfactory possible management actions include enhanced planting or placement of additional fill material.

    - Monitor for predation of special status species (California Ridgeway Rail and Salt Marsh Harvest Mouse) along the NSW wetland corridor. If predation is significant near the Wildlife Corridor Transition, placement of additional material to meet design grades would expand refugia habitat in this area.

LIST OF FIGURES



SOURCE:USACE, ESA

ESA

+ POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

× MONITORING SURVEY POINT, ESA, JAN-FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

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FIGURE 1

Post-Construction Surveys

MARATHON GROUND SURVEY POINT, JANUARY 2014, TYP.

POND 1 CREST PROFILE

LOW SPOT IN POND CREST

LOW SPOT IN POND CREST

MONITORING SURVEY POINT, ESA 2015 TYP.

LOW SPOT IN POND CREST

POND 2 CREST PROFILE

N

0 12.5 25 50

SCALE (FEET)

SOURCE:Ground Survey - Marathon 2014; Aerial Photogrametry - CLE 2014

+POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

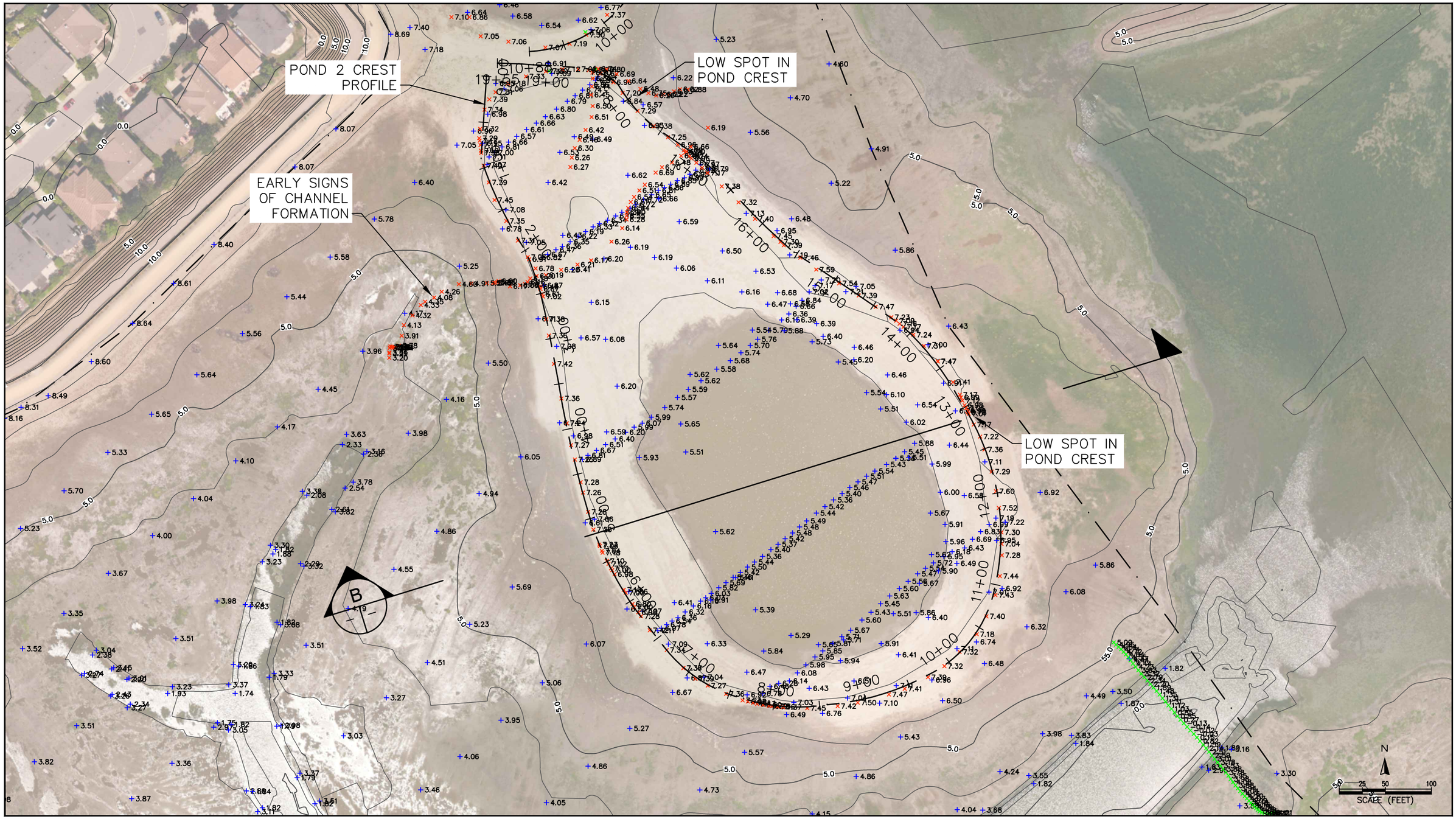
×MONITORING SURVEY POINT, ESA, JAN-FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

Hamilton Post-Construction Assessment

FIGURE 2

As-Built Surveys - SSW Pond 1



SOURCE:Ground Survey - Marathon 2014; Aerial Photogrametry - CLE 2014

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

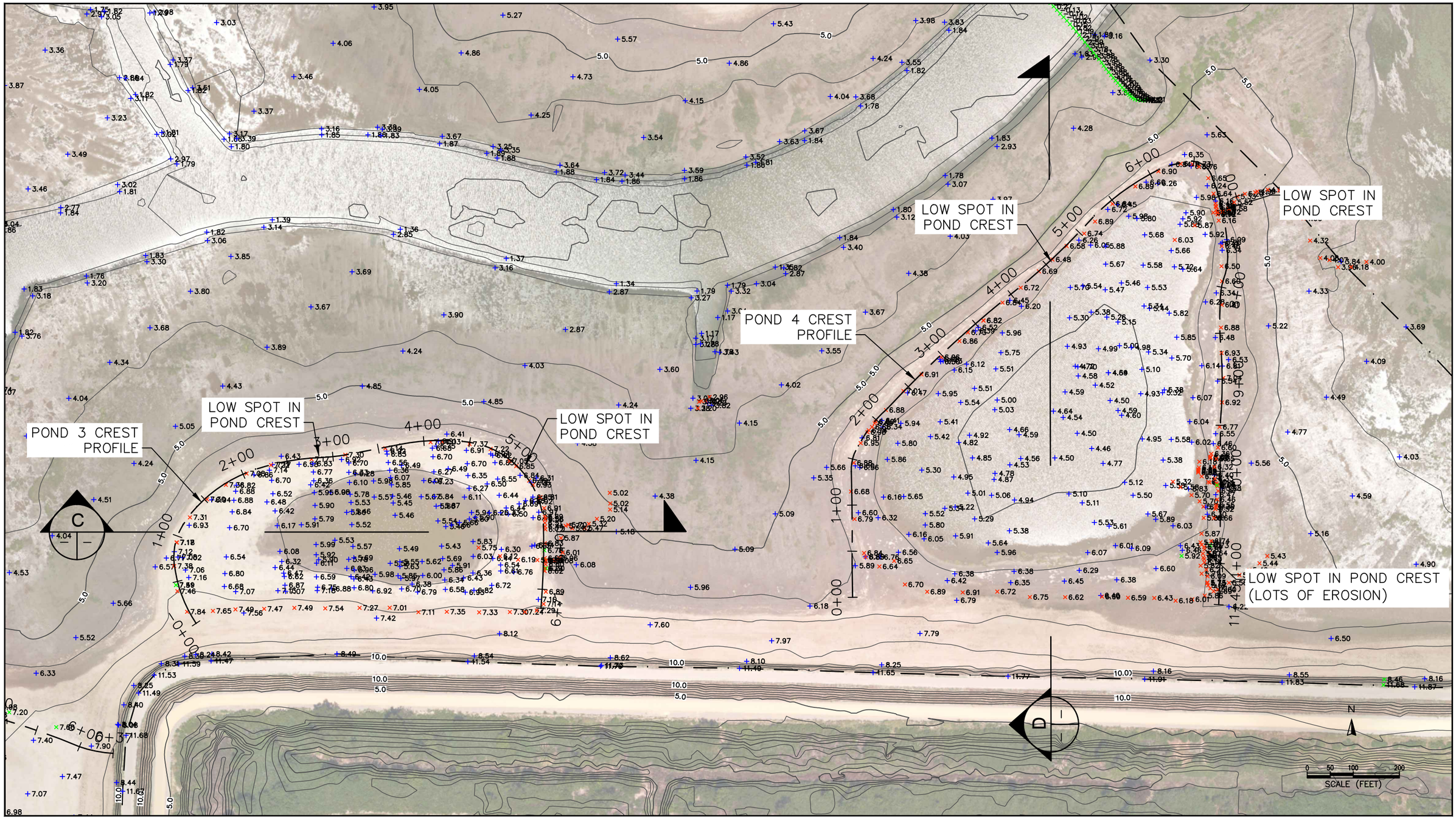
×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

Hamilton Post-Construction Assessment

FIGURE 3

As-Built Surveys - SSW Pond 2



SOURCE:USACE, ESA

+ POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

× MONITORING SURVEY POINT, ESA, JAN–FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

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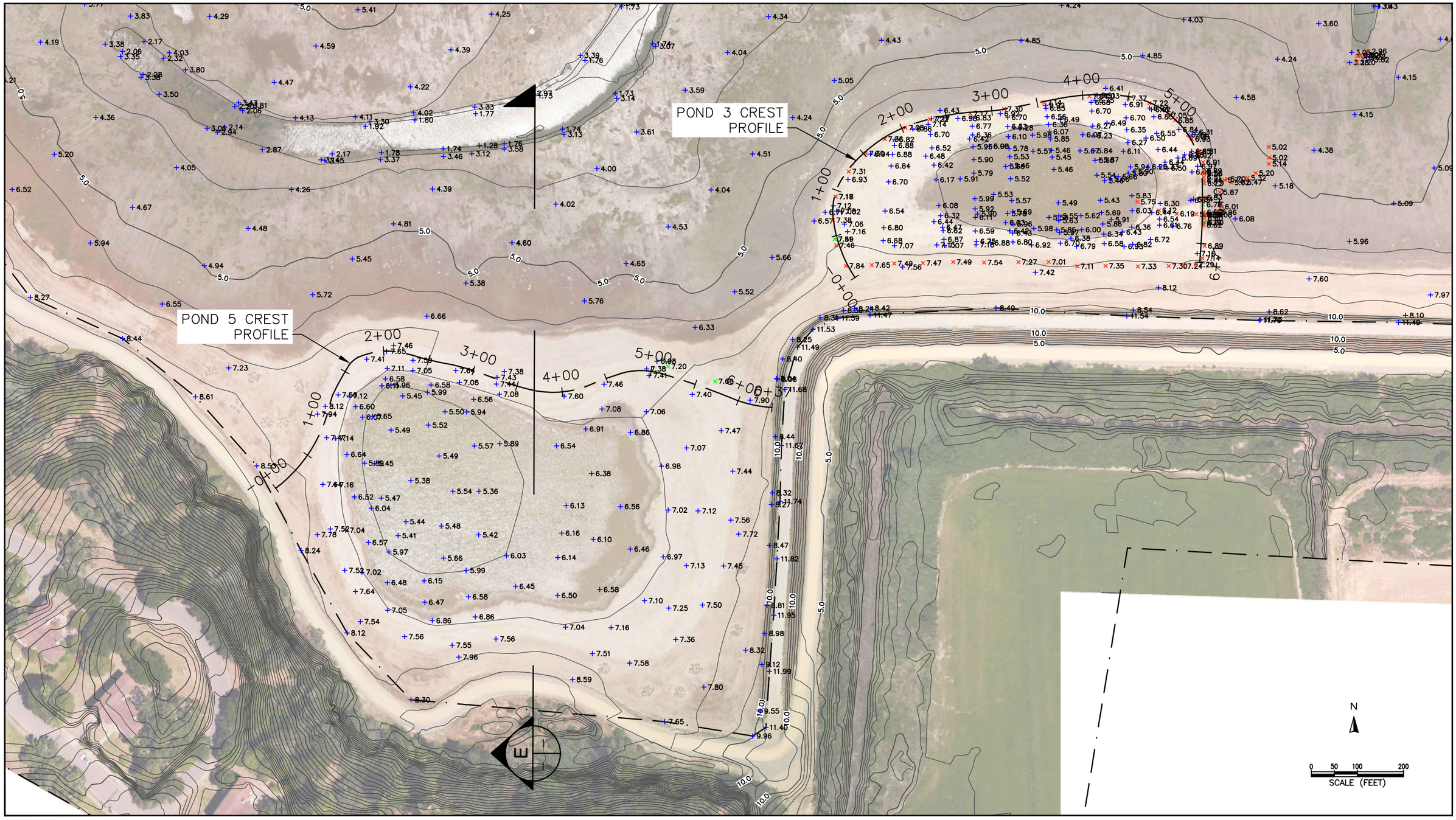
FIGURE 4

As-Built Surveys - SSW Ponds 3 & 4



SOURCE:Ground Survey - Marathon 2014; Aerial Photogrametry - CLE 2014

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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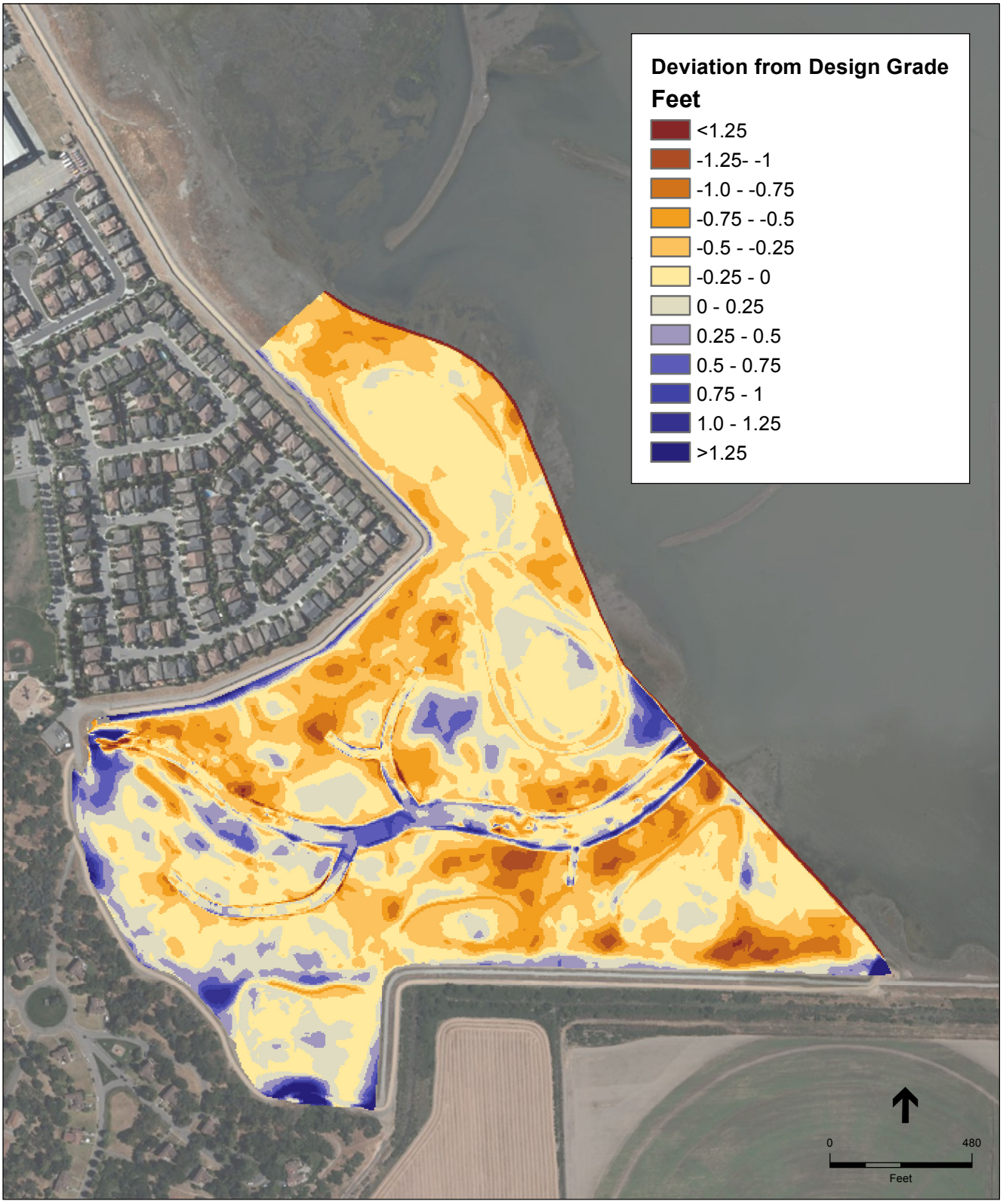
FIGURE 5

As-Built Surveys - SSW Pond 5



SOURCE:

Post-Construction Aerial Photgrametry - CLE, June 2014

Note: Negative number indicates as-built elevaiton below design grade.

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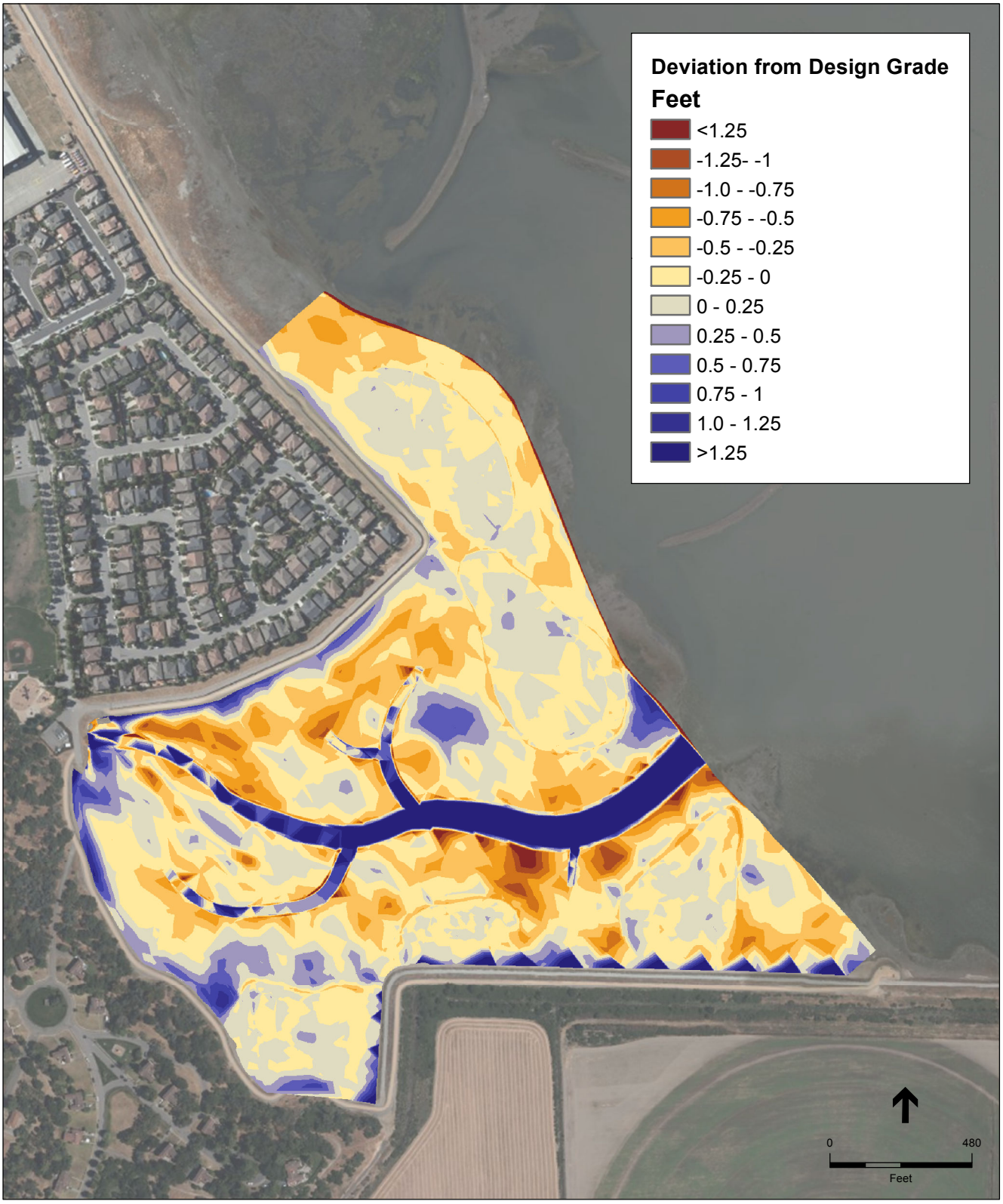
Figure 6

South Seasonal Wetlands, June 2014
Post Construction Aerial Photogrammetry
vs Design Grade



SOURCE:

As-Built Point Survey - Marathon, January 2014

Note: Negative number indicates as-built elevaiton below design grade.

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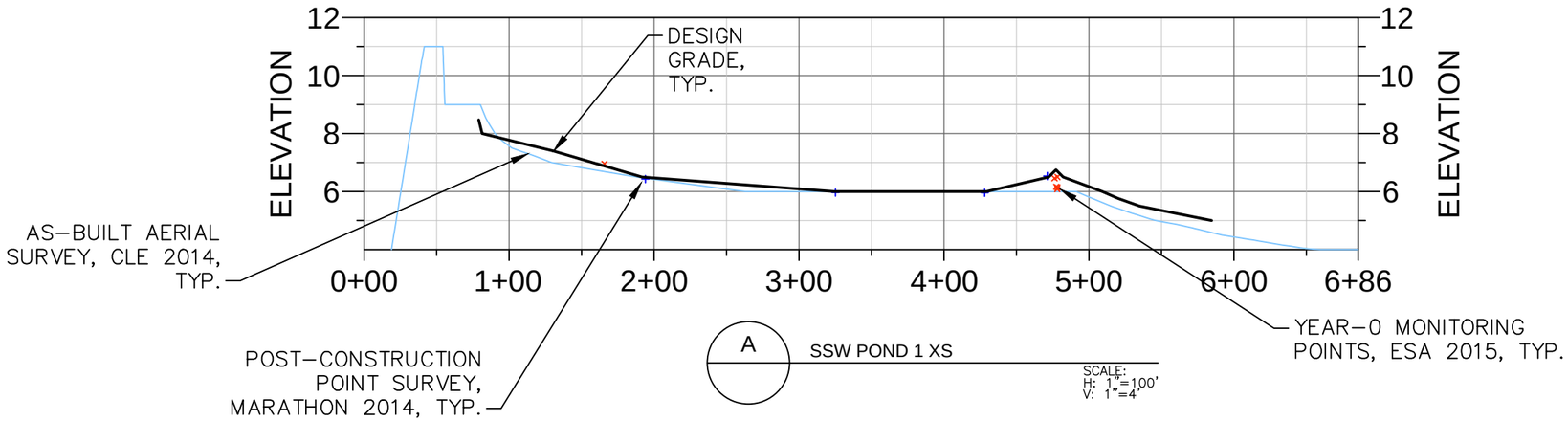
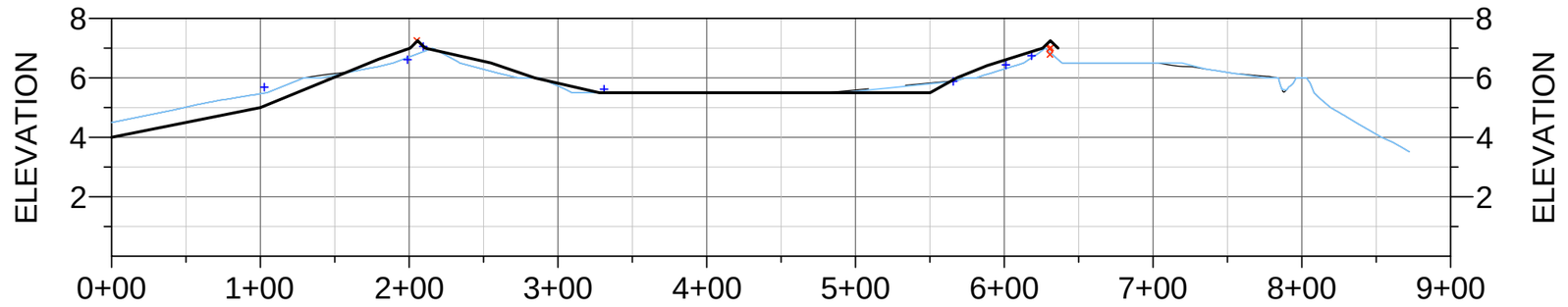
Figure 7

South Seasonal Wetlands
As-Built Point Survey
vs Design Grade



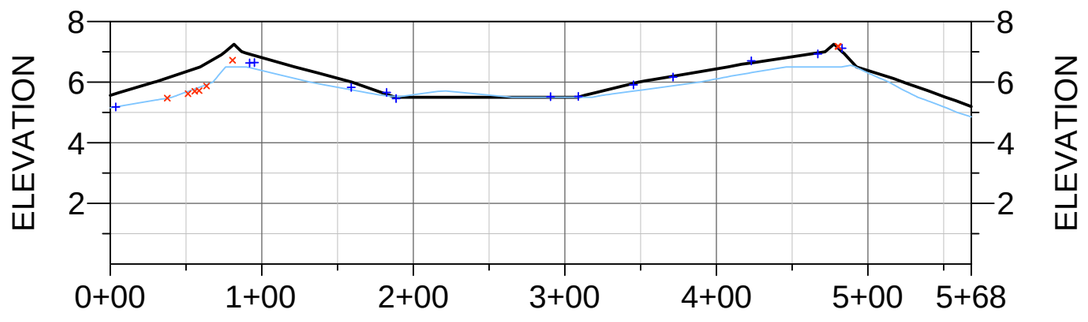
A SSW POND 1 XS

SCALE: H: 1"=100' V: 1"=4'



B SSW POND 2 XS

SCALE: H: 1"=100' V: 1"=4'



C SSW POND 3 XS

SCALE: H: 1"=100' V: 1"=4'

SOURCE:

ESA

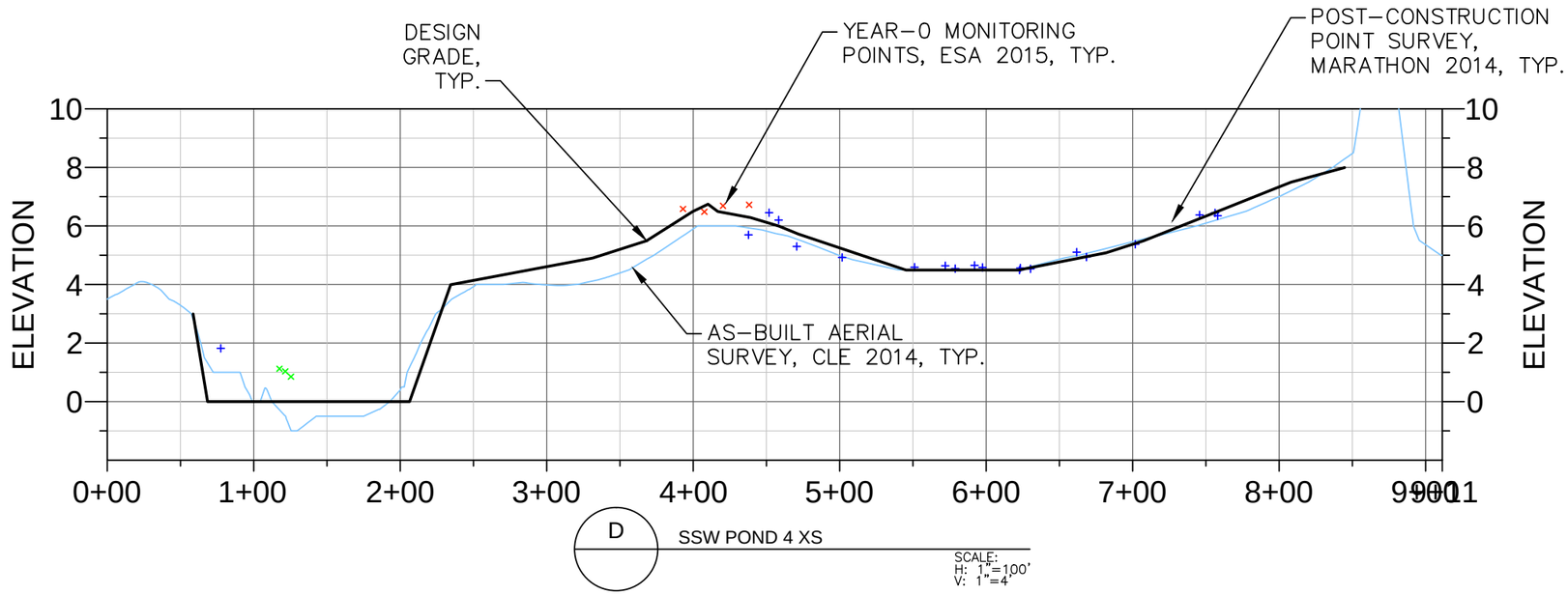
+ POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

× MONITORING SURVEY POINT, ESA, JAN-FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

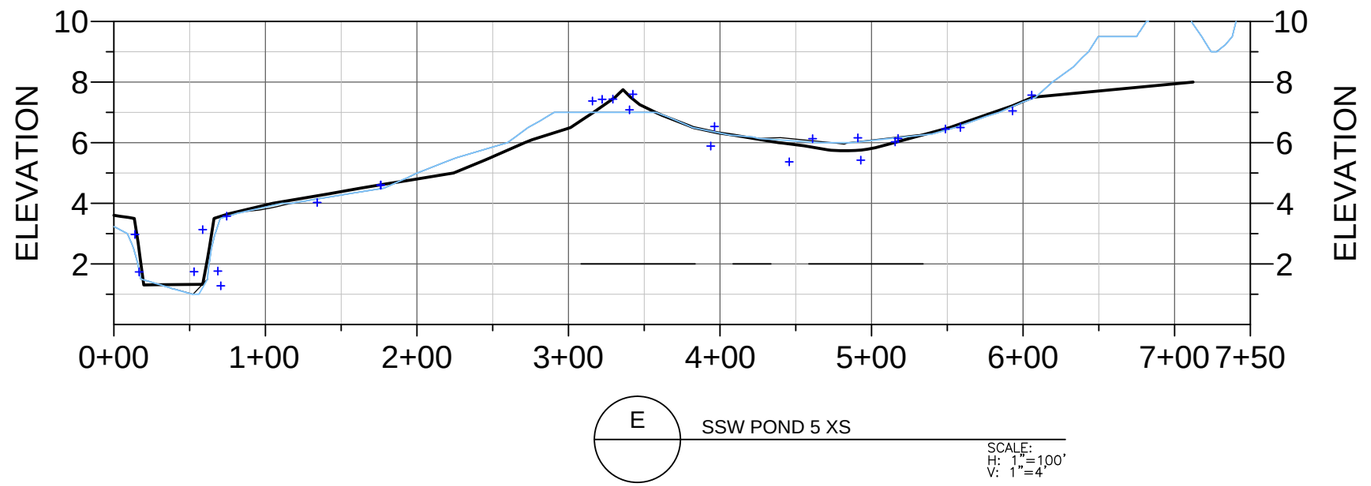
FIGURE 8

South Seasonal Wetlands Cross Sections 1



D SSW POND 4 XS

SCALE:
H: 1"=100'
V: 1"=4'



E SSW POND 5 XS

SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:

ESA

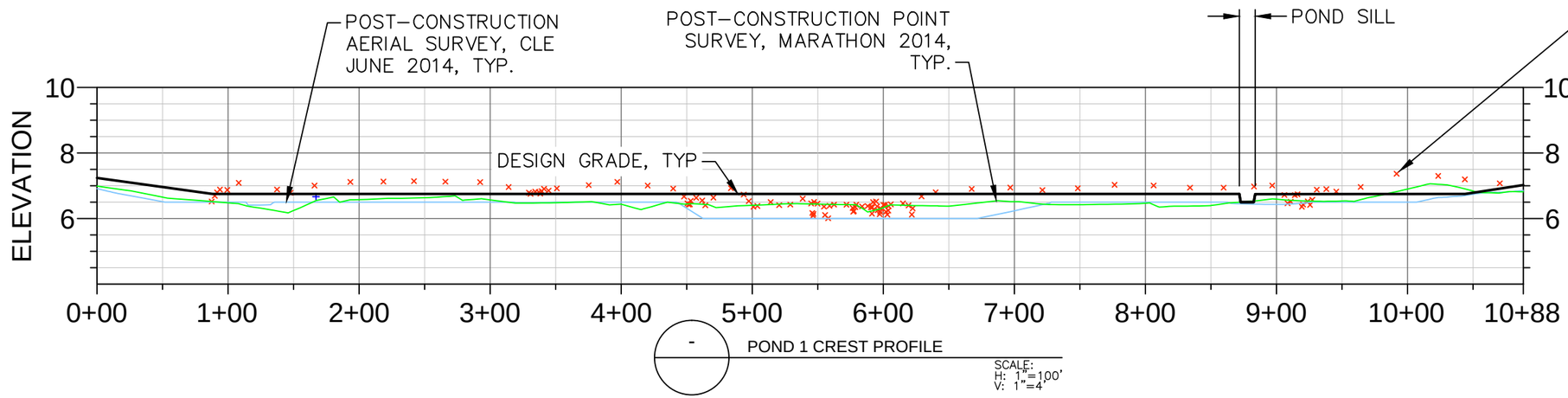
+ POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

× MONITORING SURVEY POINT, ESA, JAN–FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

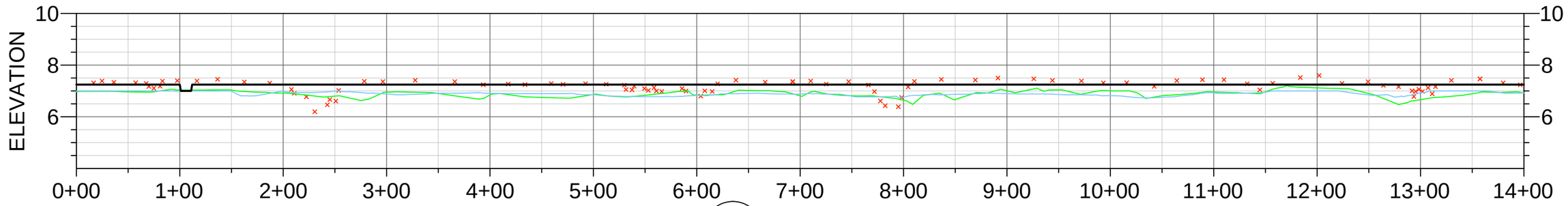
FIGURE 9

South Seasonal Wetlands Cross Sections 2



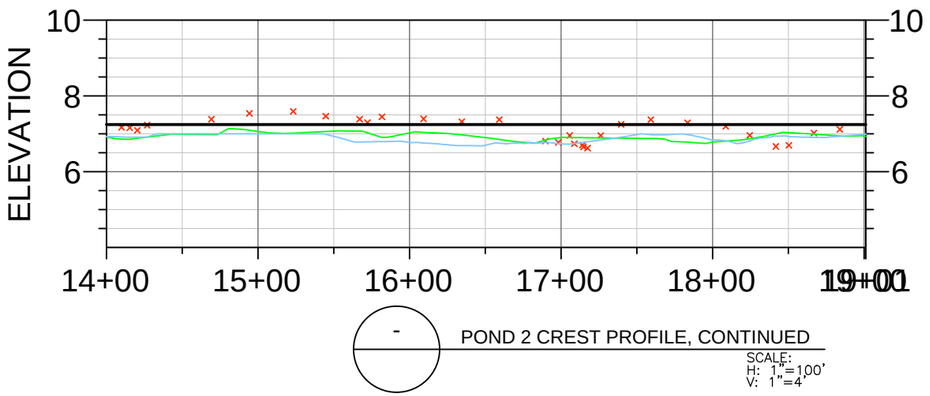
POND 1 CREST PROFILE

SCALE:
H: 1"=100'
V: 1"=4'



POND 2 CREST PROFILE

SCALE:
H: 1"=100'
V: 1"=4'



POND 2 CREST PROFILE, CONTINUED

SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:USACE, ESA

+POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

×MONITORING SURVEY POINT, ESA, JAN-FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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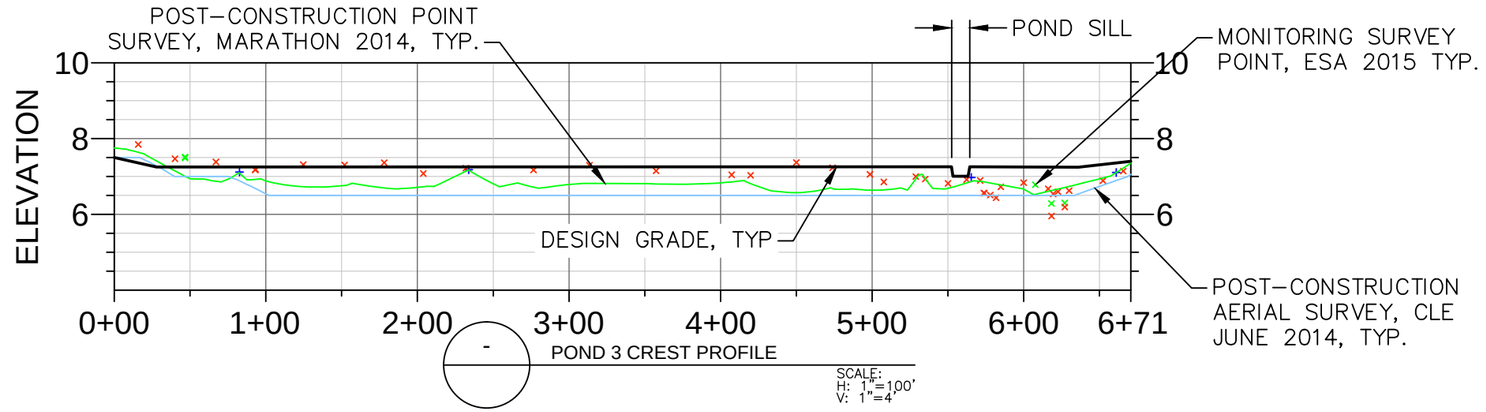
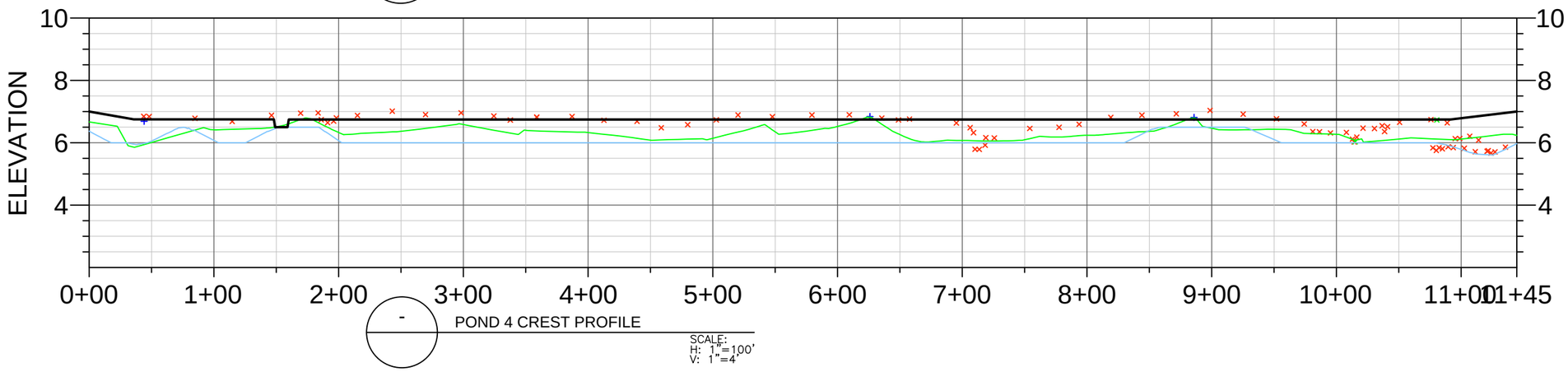
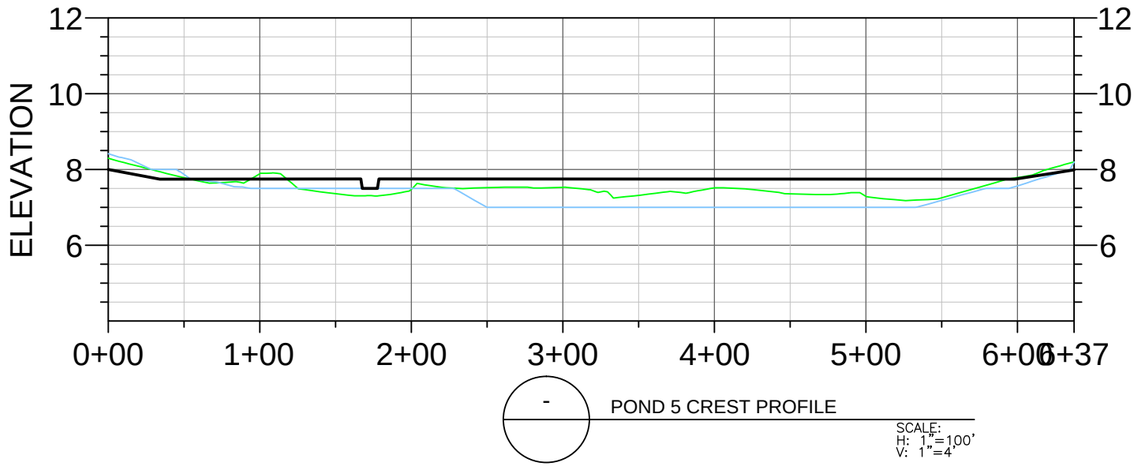
FIGURE 10

South Seasonal Wetland Pond Crests 1







SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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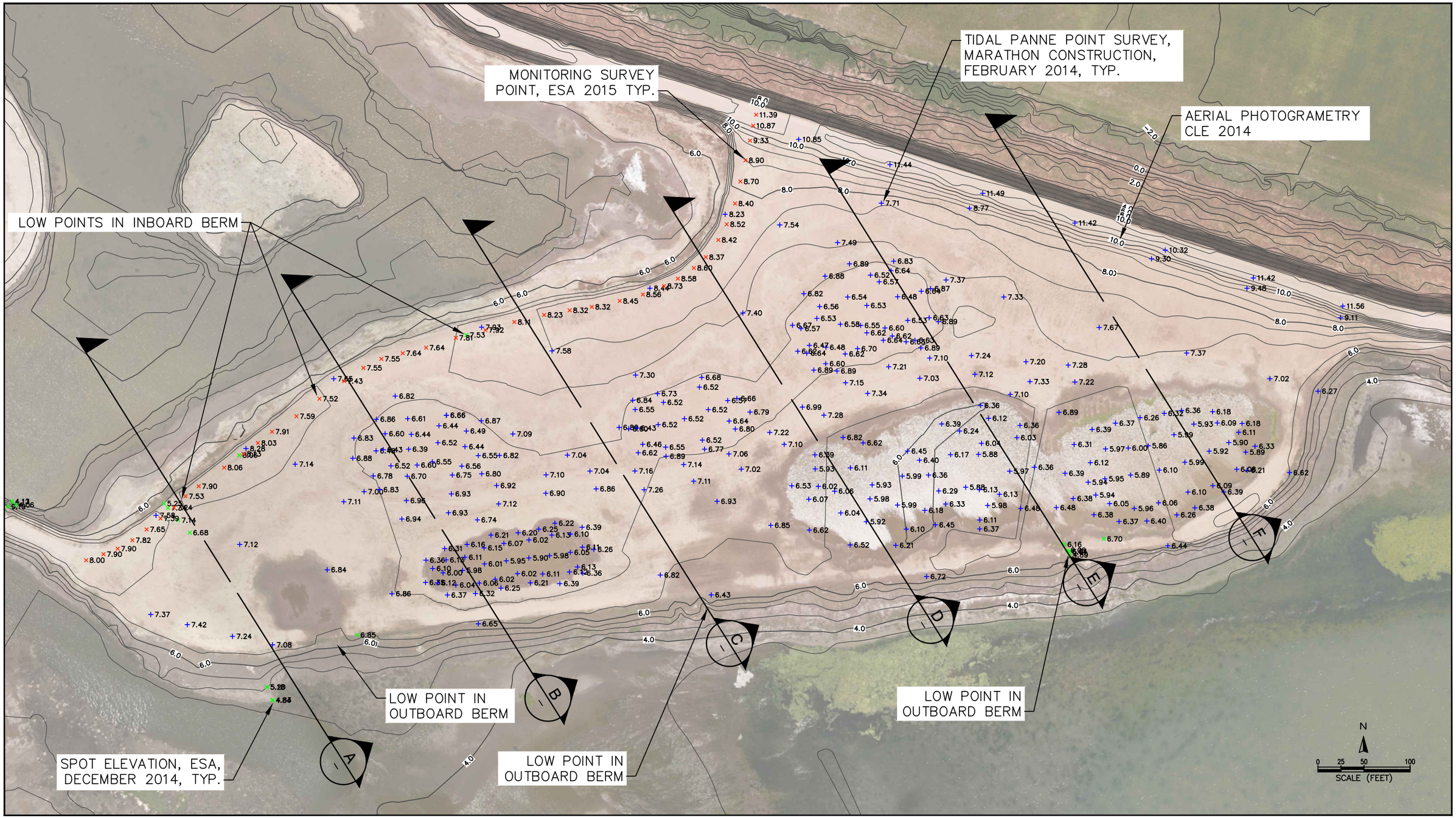
FIGURE 11

South Seasonal Wetland Pond Crests 2



SOURCE:USACE, ESA

ESA

+ POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

× MONITORING SURVEY POINT, ESA, JAN–FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

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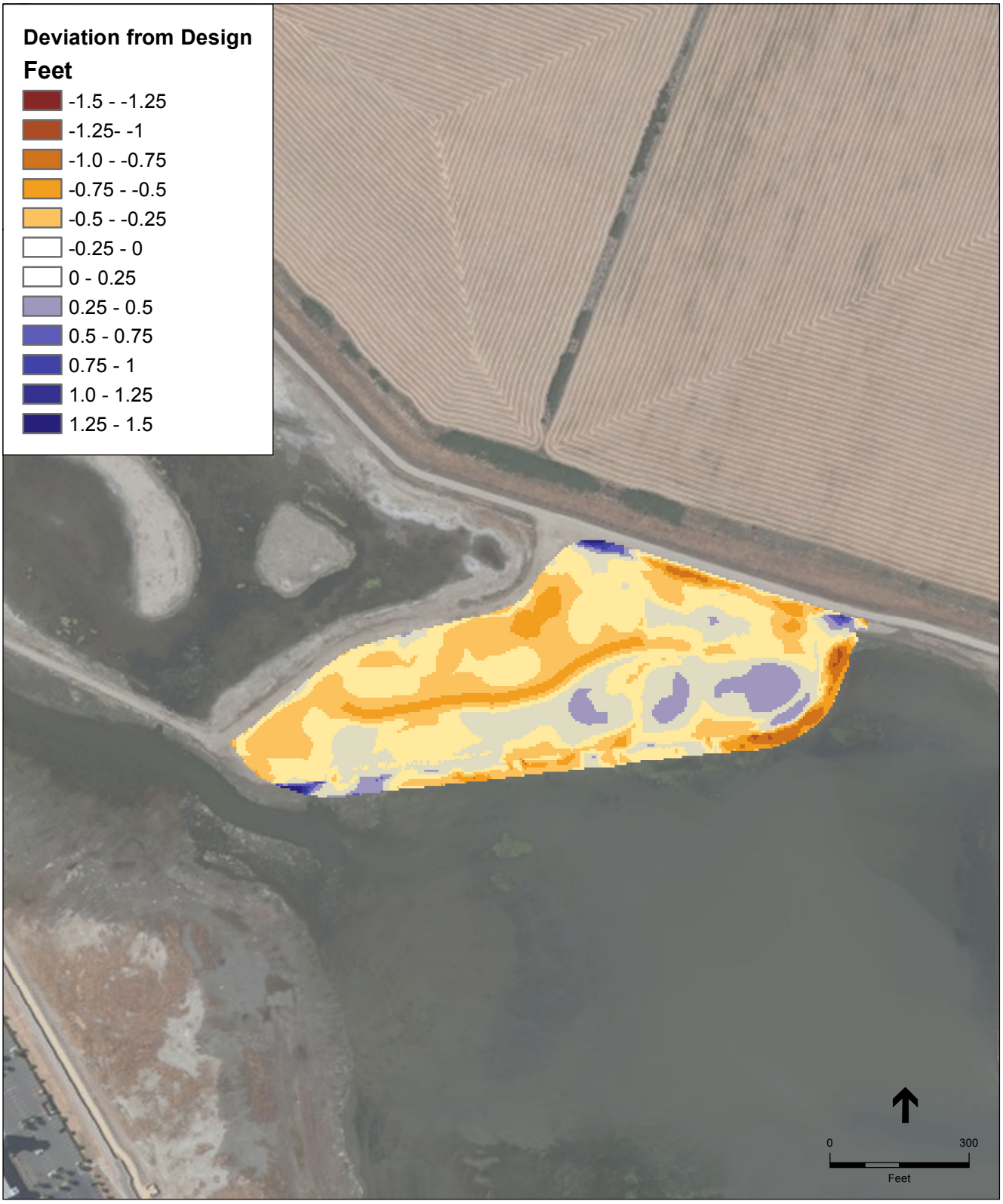
FIGURE 12

Tidal Panne Survey Data



SOURCE:

Post-Construction Point Survey - Marathon Construction, February 2014

Note: Negative number indicates as-built elevation below design grade.

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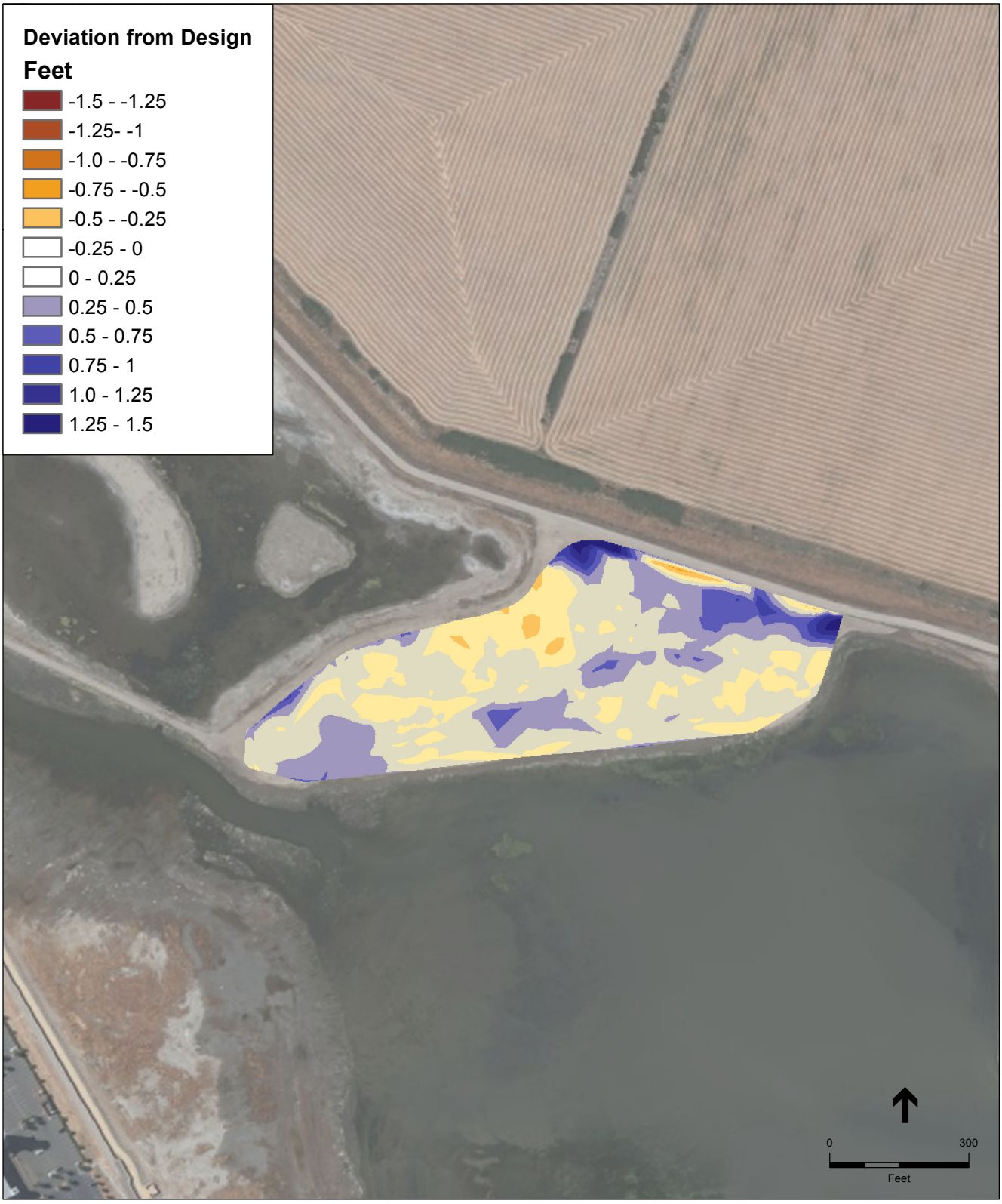
Figure 13

Tidal Panne February 2014
Post-Construction Point Survey
vs Design Grade



SOURCE:

Post-Construction Aerial Photogrametry - CLE, June 2014

Note: Negative number indicates as-built elevation below design grade.

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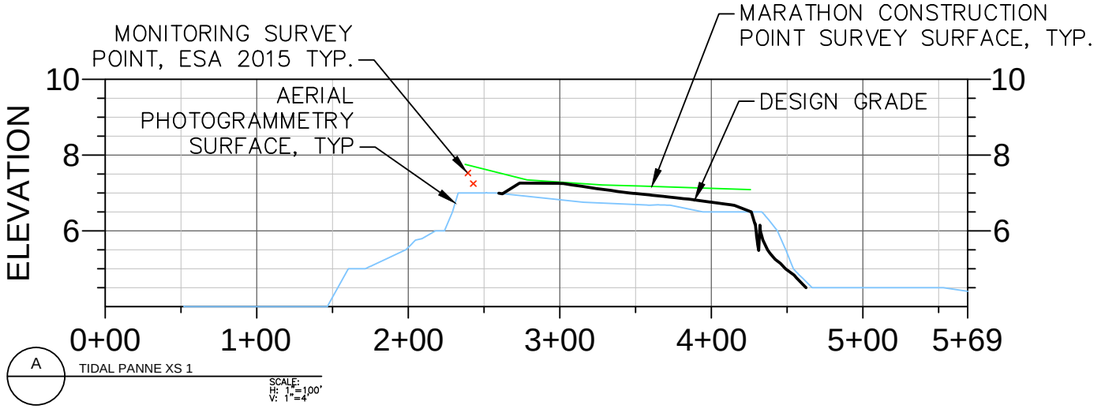
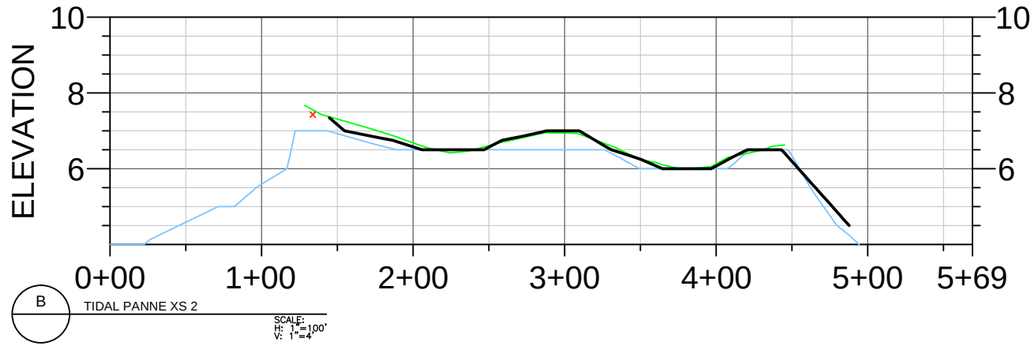
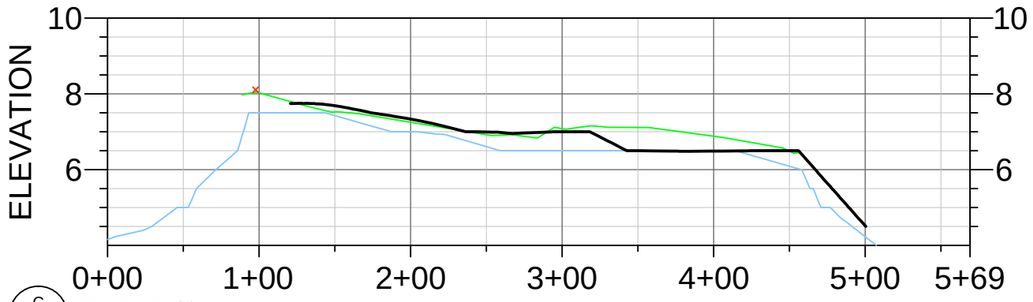
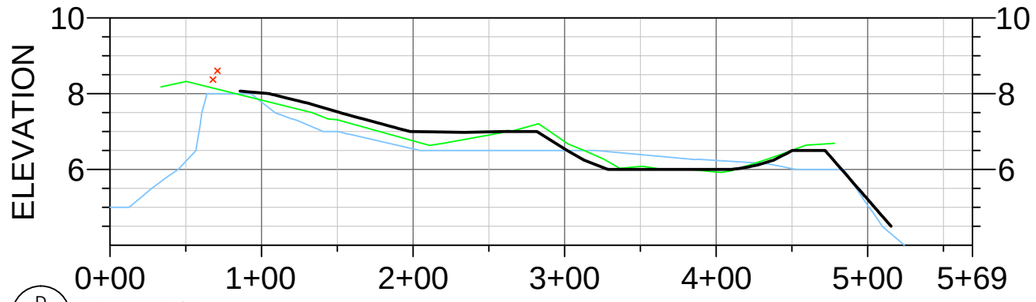
Figure 14

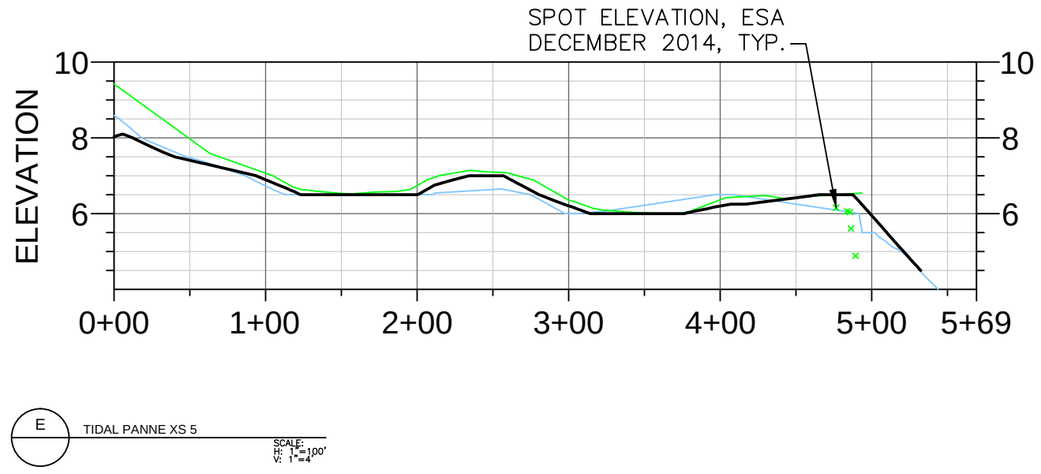
Tidal Panne January 2014
Post-Construction Aerial Photogrammetry
vs Design Grade

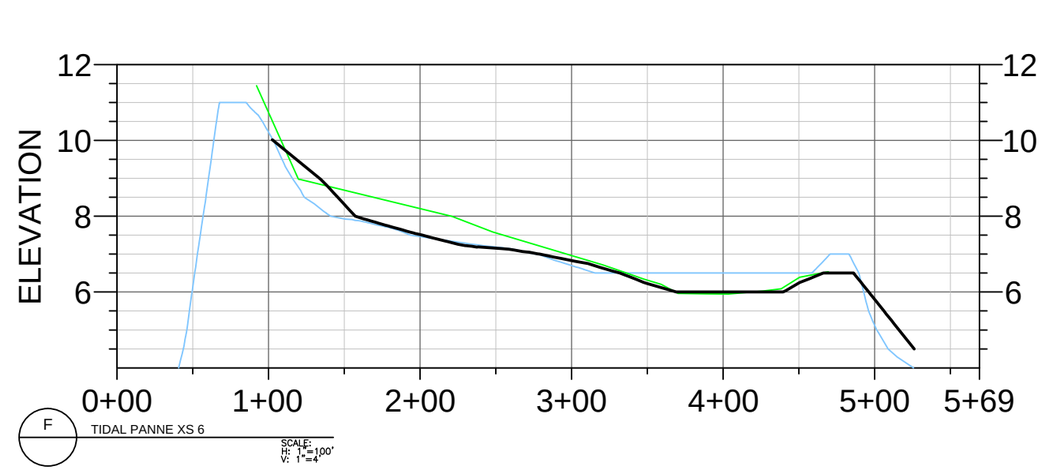












SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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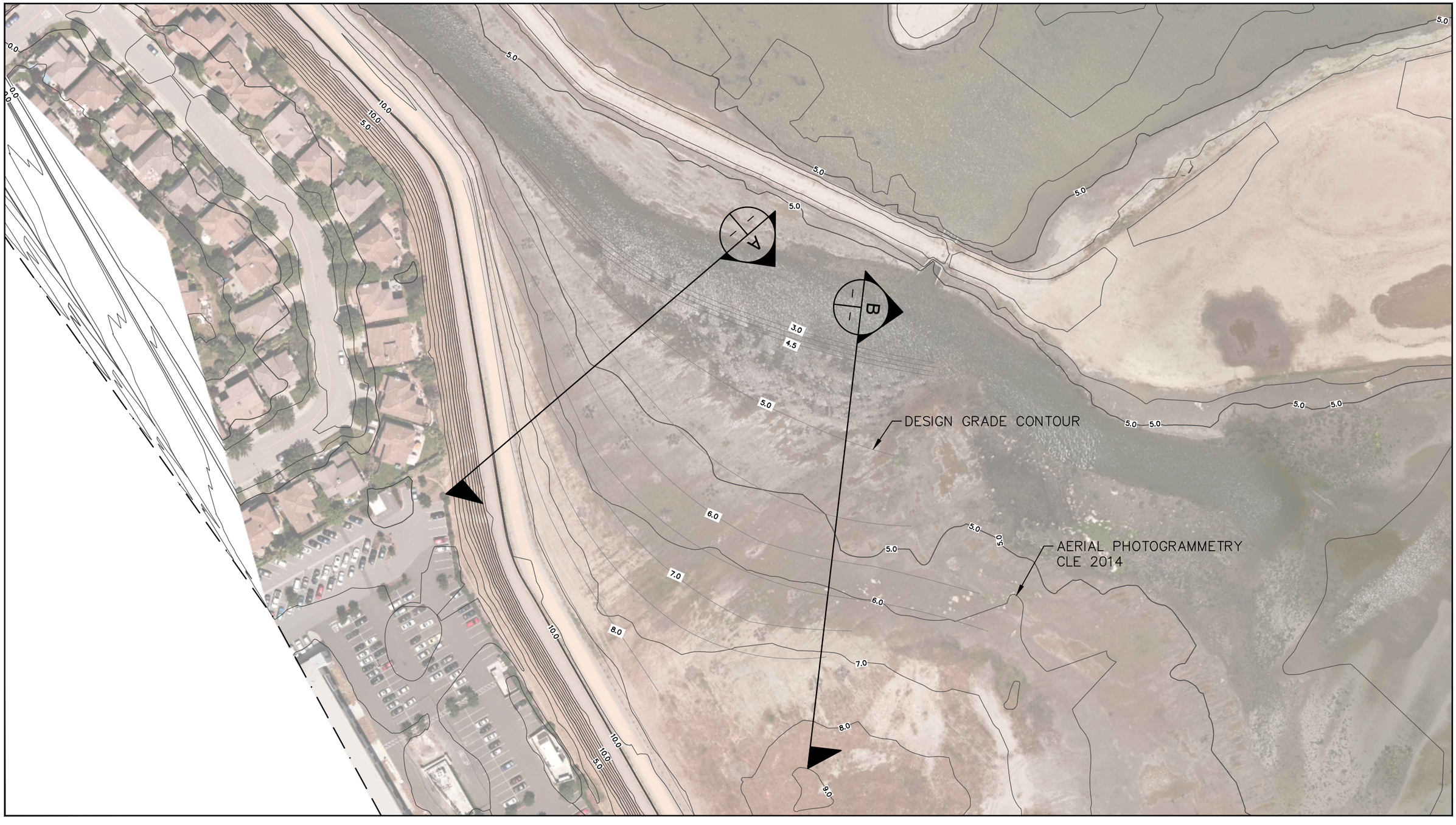
FIGURE 15

Tidal Panne Survey Cross Sections



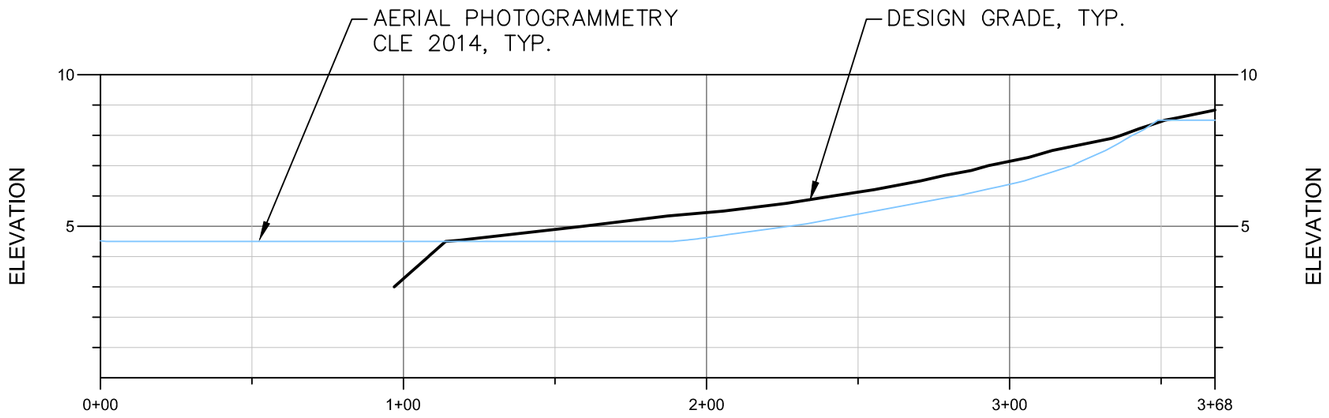
SOURCE:USACE, ESA

Hamilton Post-Construction Assessment

FIGURE 16

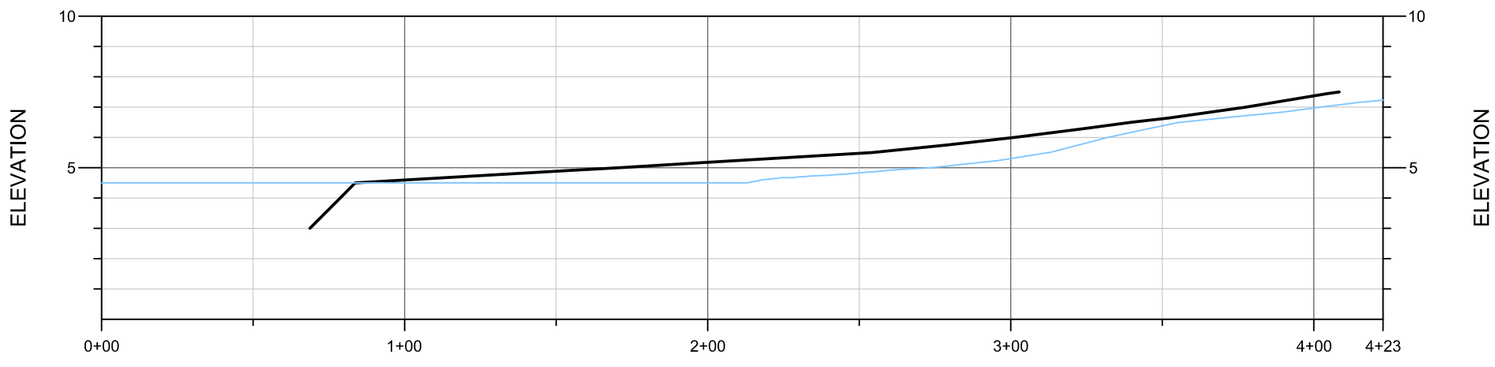
Wildlife Corridor Transition Plan

ESA



A TIDAL PANNE XS 1

SCALE:
H: 1"=50'
V: 1"=5'



B TIDAL PANNE XS 2

SCALE:
H: 1"=50'
V: 1"=5'

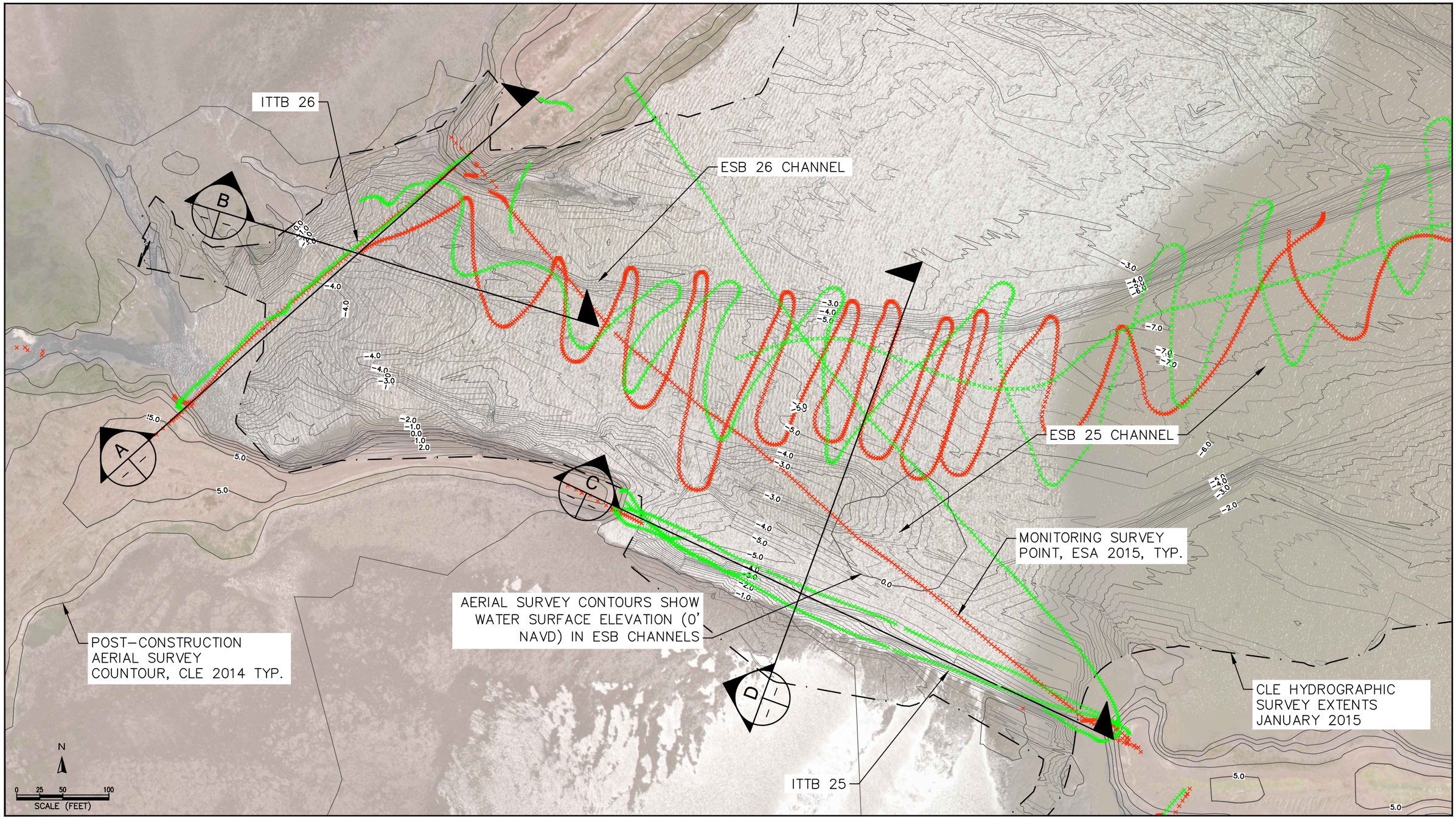
SOURCE:USACE, ESA

Hamilton Post-Construction Assessment

FIGURE 17

Wildlife Corridor Transition Cross Sections

ESA



SOURCE:

ESA

CONTOURS: CLE AERIAL PHOTOGRAMMETRY & BATHYMETRIC SURVEYS

✳ POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

× MONITORING SURVEY POINT, ESA, JAN-FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

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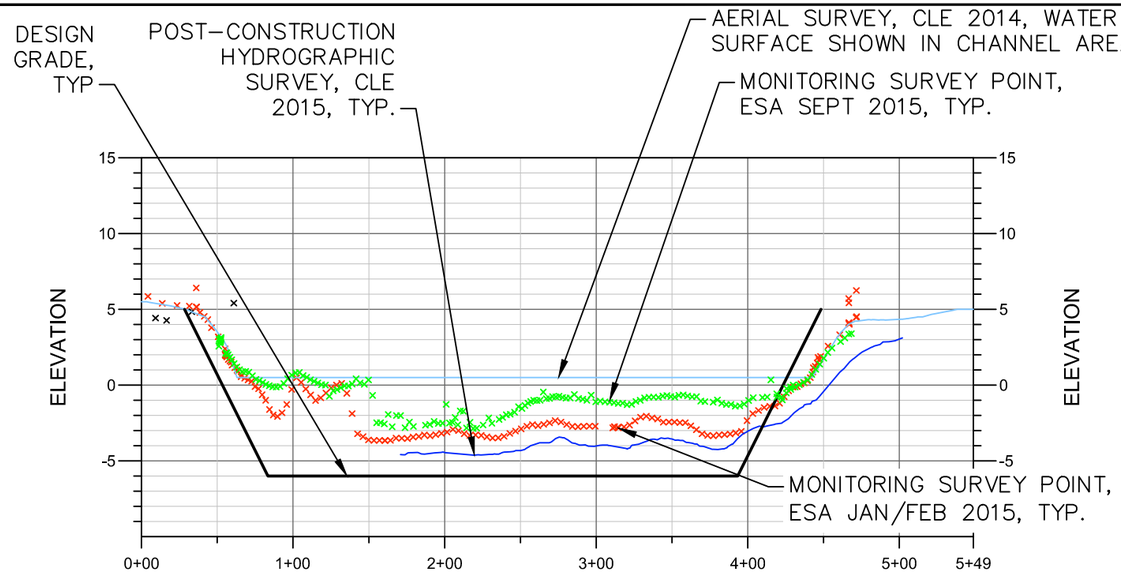
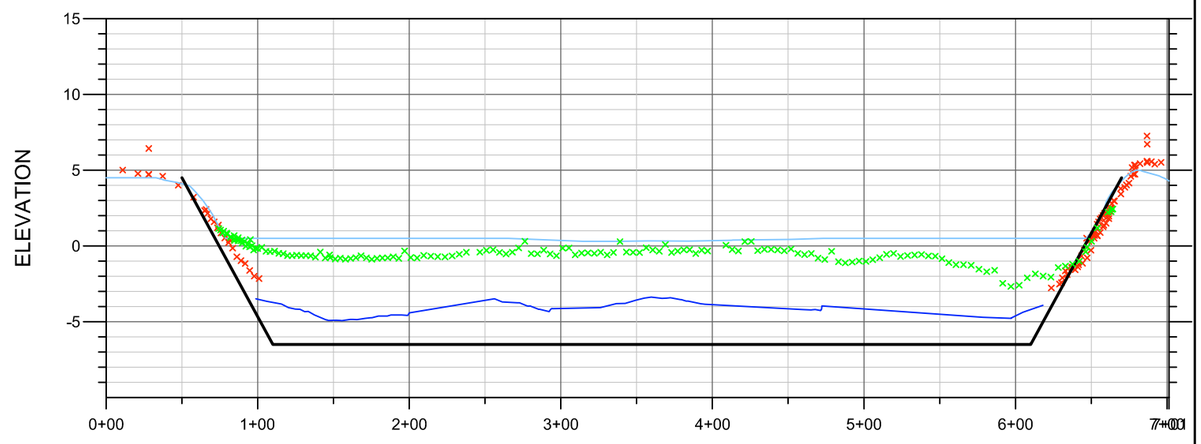
FIGURE 18

ITBB 25 & 26



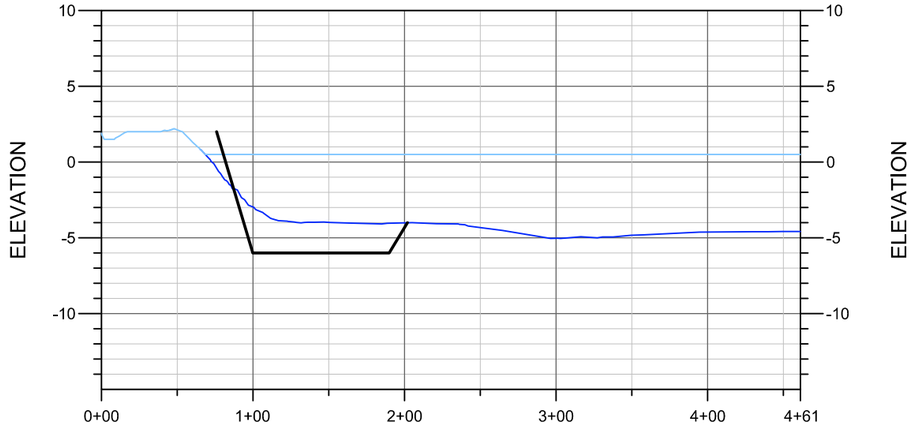
A ITBB 26 CROSS SECTION

SCALE:
H: 1"=50'
V: 1"=5'



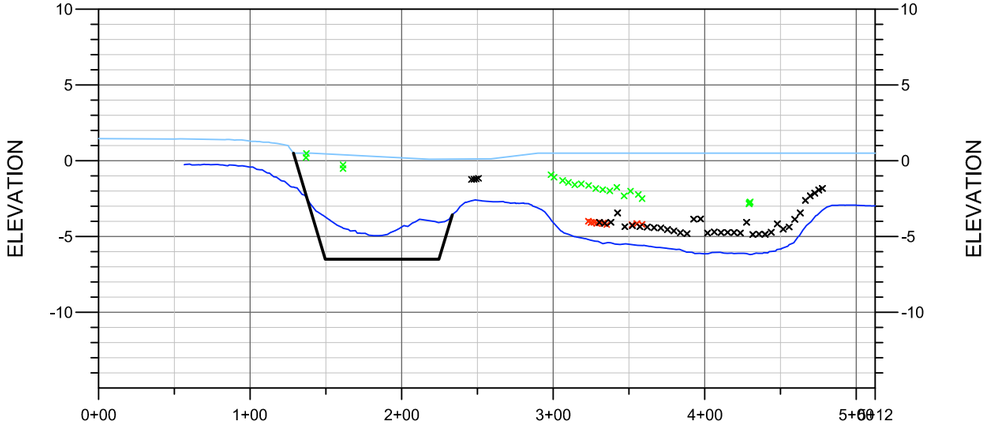
C ITBB 25 CROSS SECTION

SCALE:
H: 1"=100'
V: 1"=4'



B ITBB 26 THALWEG

SCALE:
H: 1"=50'
V: 1"=5'



D ITBB 25 THALWEG

SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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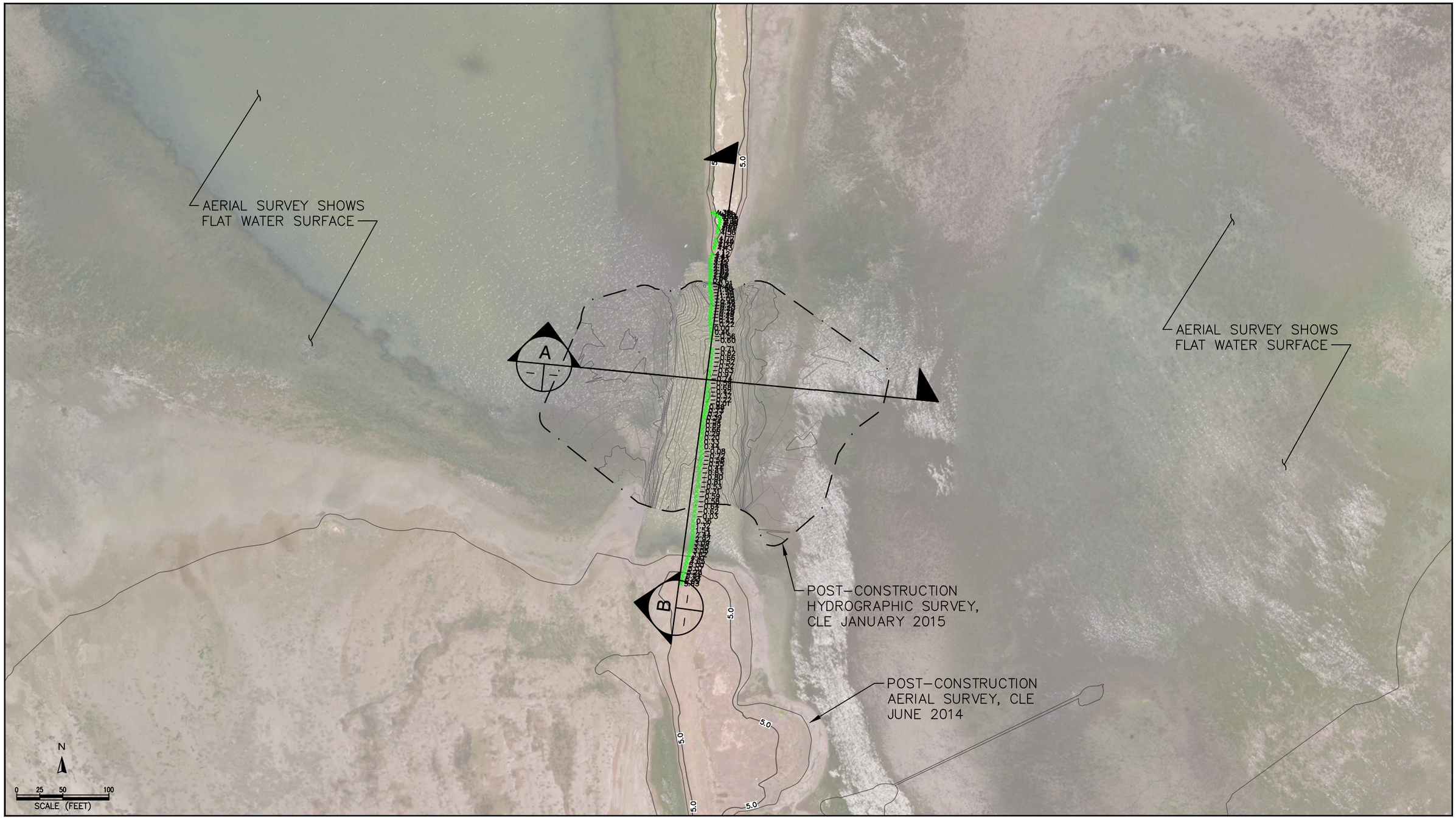
FIGURE 19

ITBB 25 & 26 Cross Sections



SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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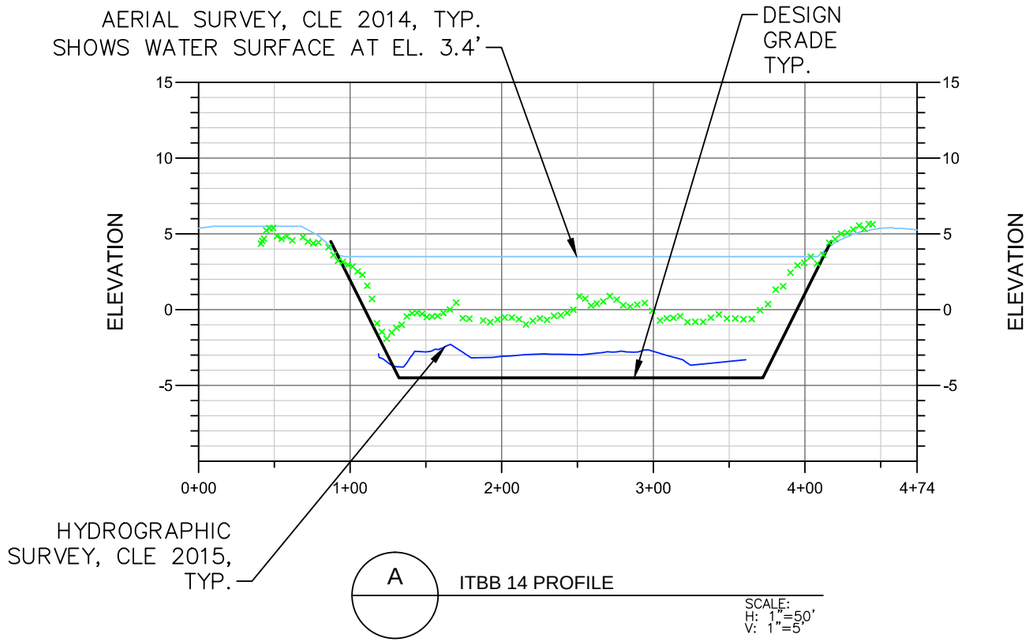
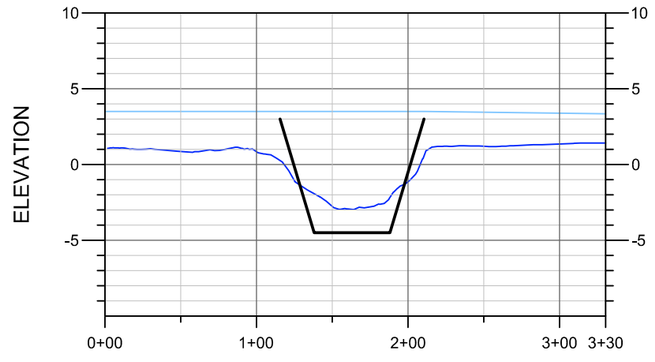
FIGURE 20

ITBB 14



A ITBB 14 PROFILE

SCALE:
H: 1"=50'
V: 1"=5'



B ITBB 14 THALWEG

SCALE:
H: 1"=50'
V: 1"=5'

SOURCE:USACE, ESA

+POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

×MONITORING SURVEY POINT, ESA, JAN-FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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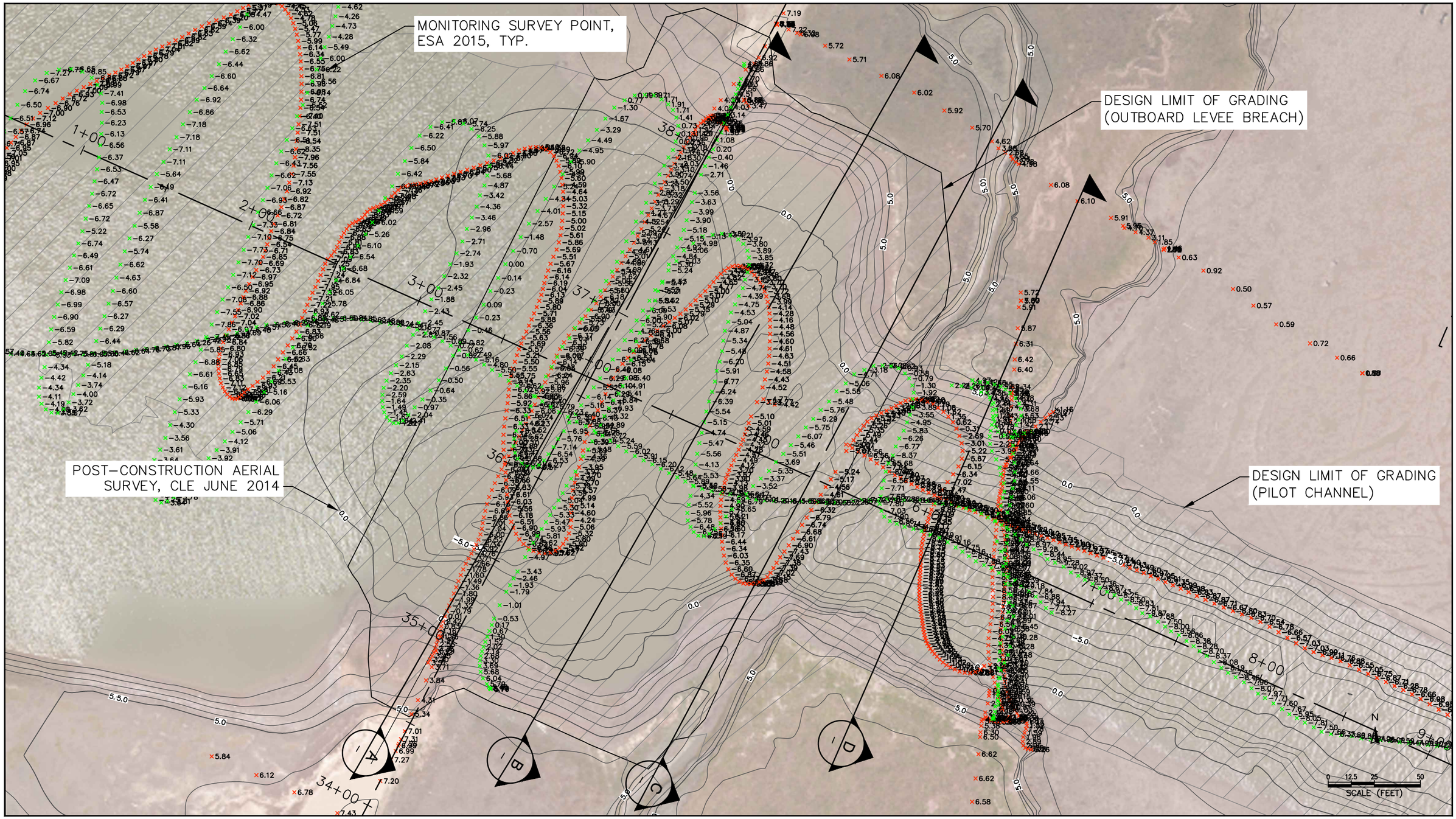
FIGURE 21

ITBB 14 Cross Sections



SOURCE:USACE, ESA

ESA

+POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

×MONITORING SURVEY POINT, ESA, JAN-FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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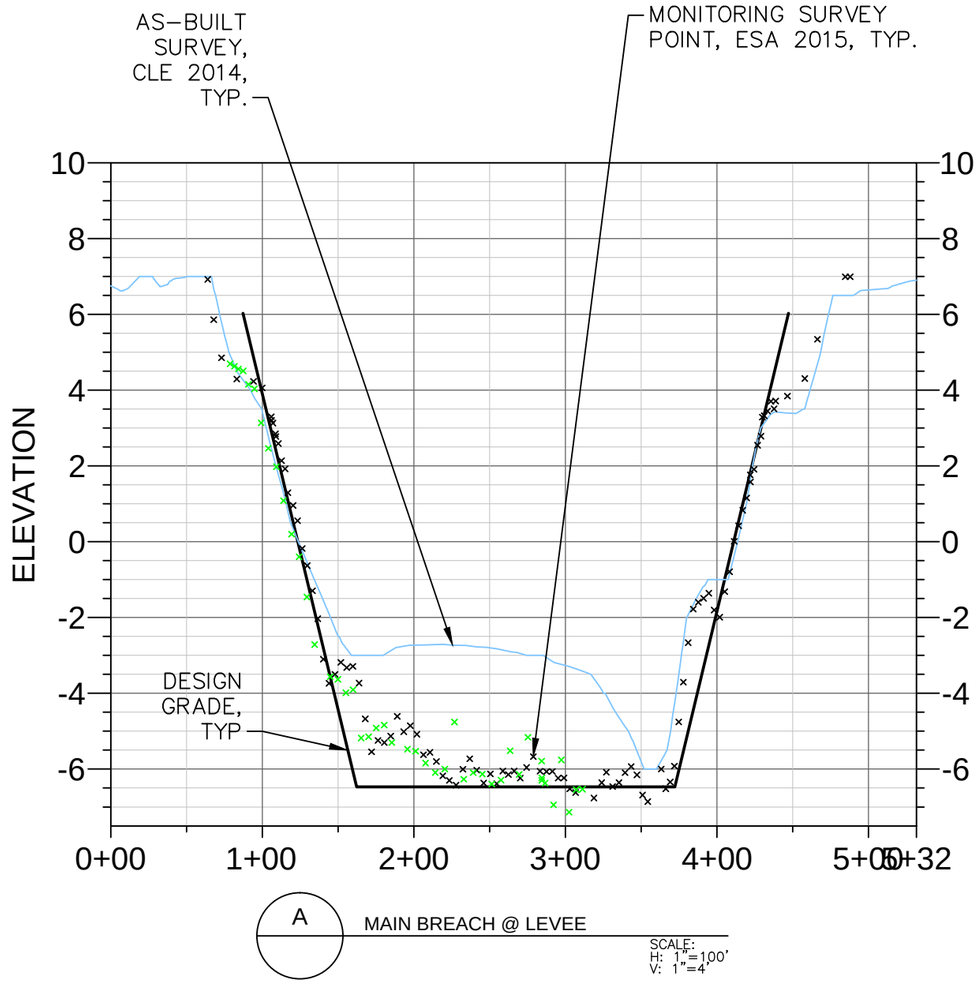
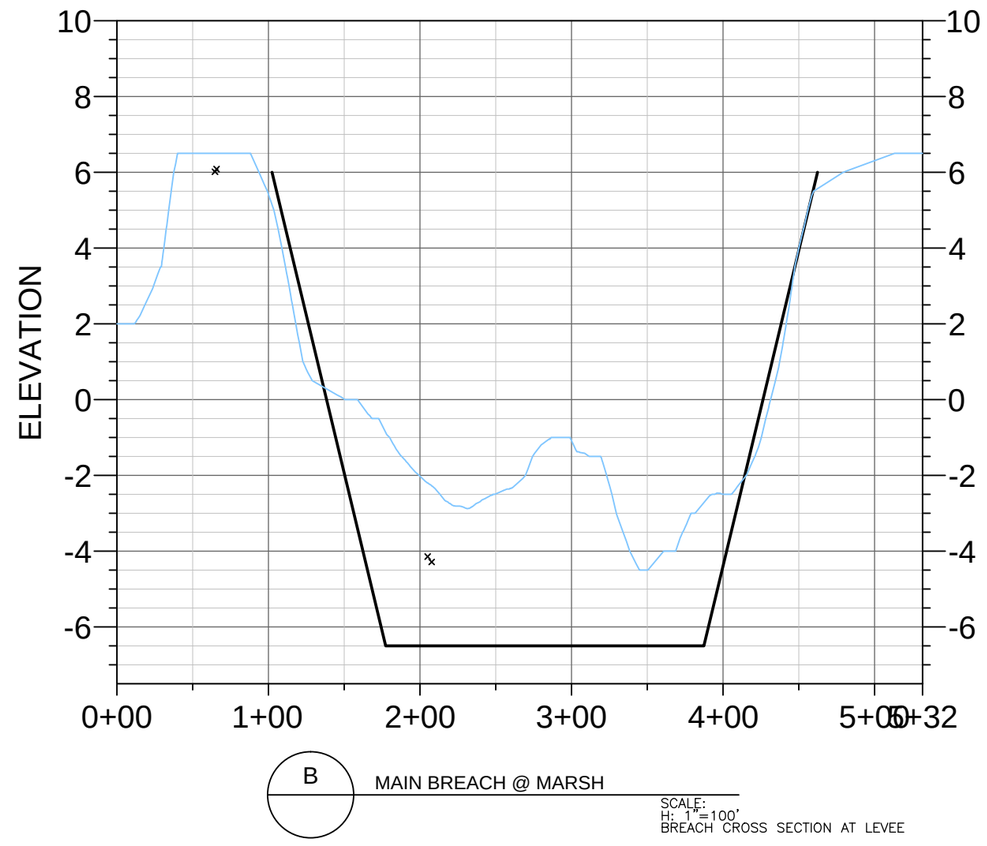
FIGURE 22

As-Built Survey Data - Outboard Levee Breach



A MAIN BREACH @ LEVEE

SCALE:
H: 1"=100'
V: 1"=4'



B MAIN BREACH @ MARSH

SCALE:
H: 1"=100'
BREACH CROSS SECTION AT LEVEE

SOURCE:USACE, ESA

+POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

×MONITORING SURVEY POINT, ESA, JAN-FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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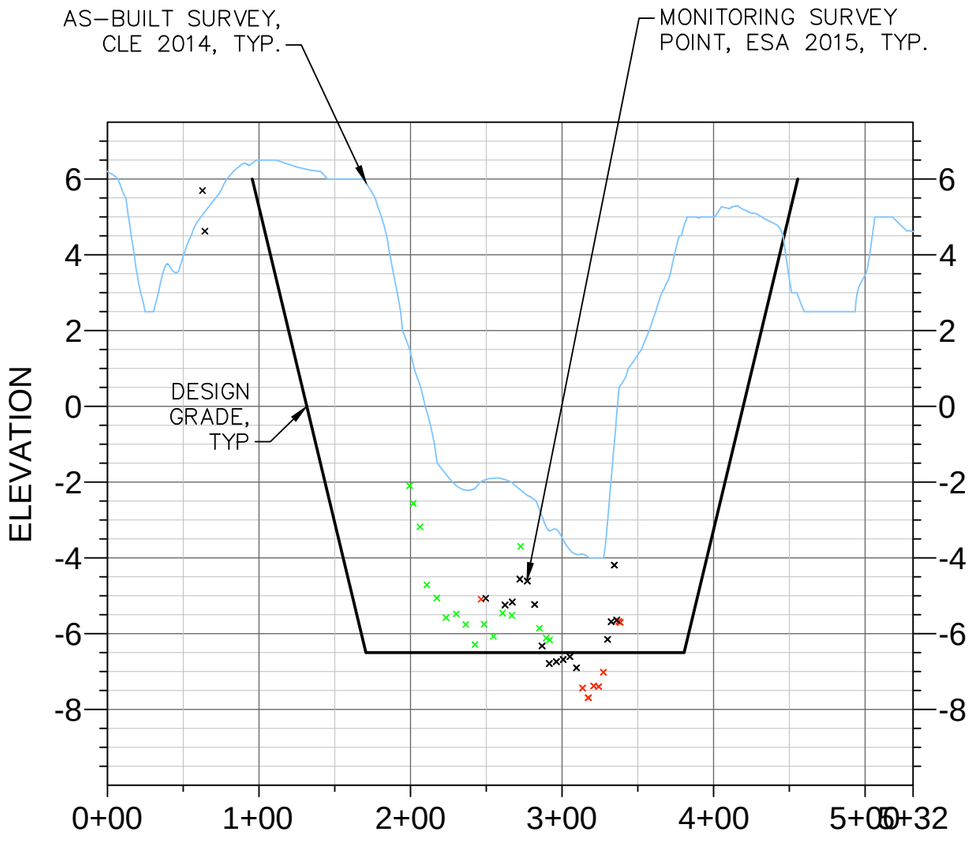
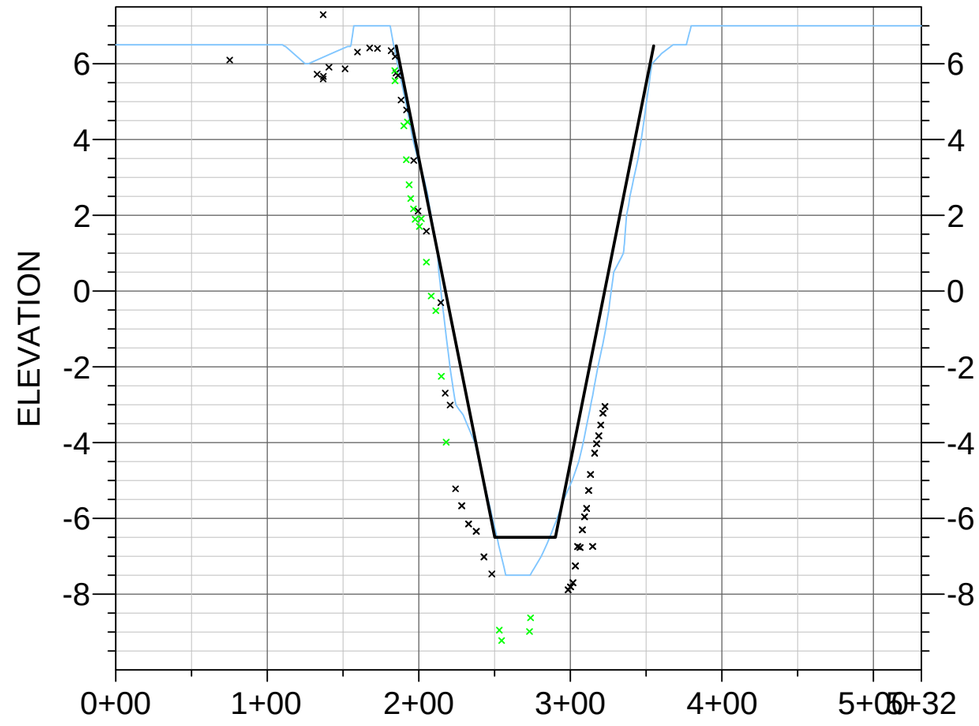
FIGURE 23

As-Built Survey Data - Outboard Levee Breach
Cross Sections 1



C MAIN BREACH @ OUTBOARD TRANSITION
SCALE:
H: 1"=100'
V: 1"=4'



D MAIN BREACH @ PILOT CHANNEL
SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:USACE, ESA

ESA

+ POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

× MONITORING SURVEY POINT, ESA, JAN–FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015

FIGURE 24

As-Built Survey Data - Outboard Levee Breach
Cross Sections 2

CLE AERIAL PHOTOGRAMMETRY SURVEY EXTENTS, JUNE 2014

DESIGN LIMIT OF GRADING

PILOT CHANNEL

ACCESS CHANNEL

E

F

G

H

I

J

K

N

0 50 100 200

SCALE (FEET)

SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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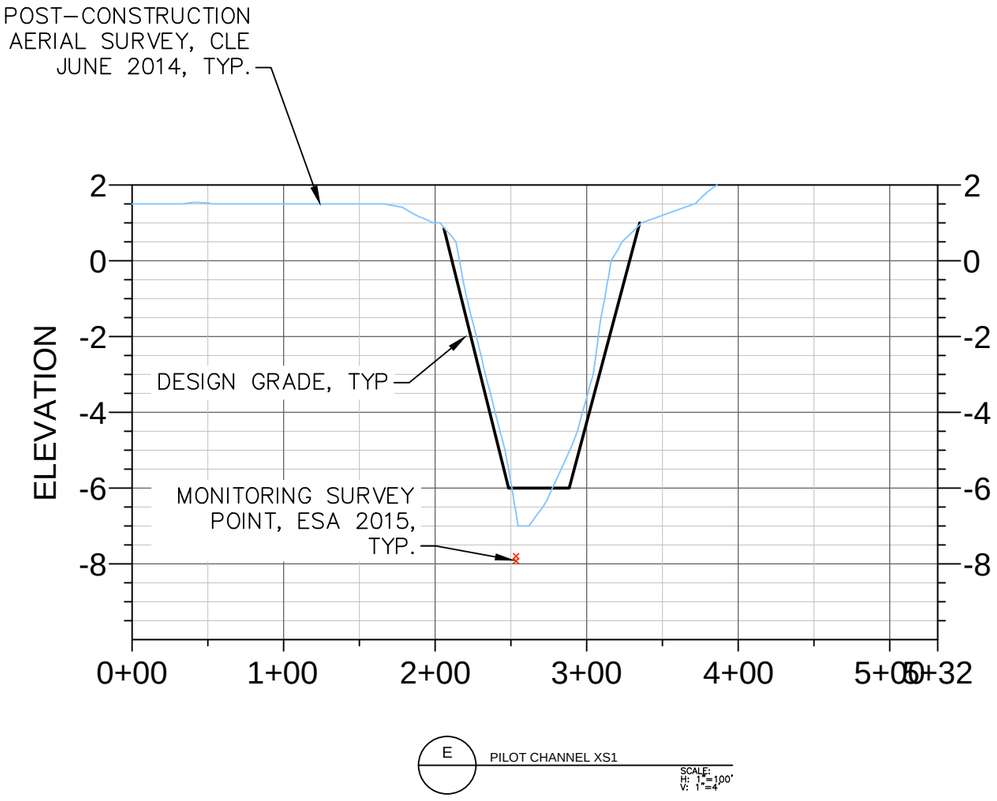
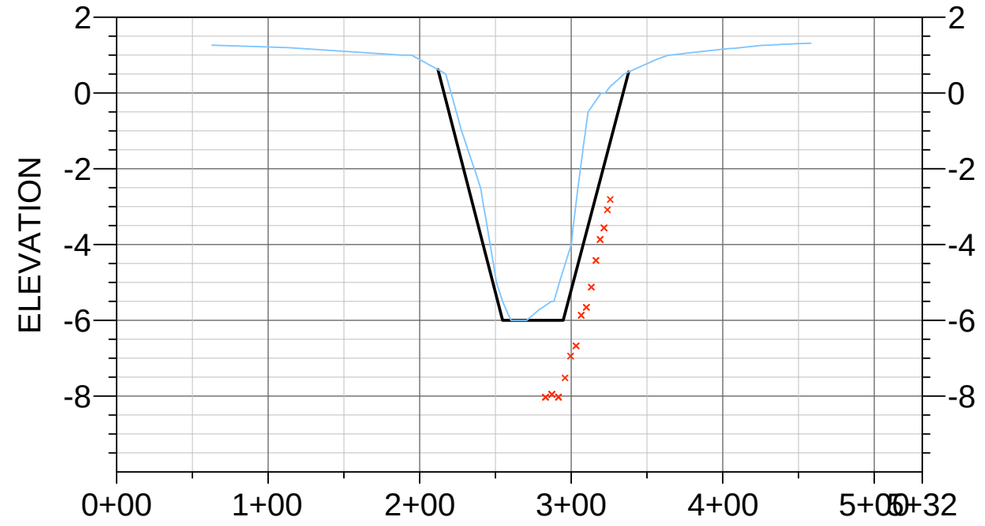
FIGURE 25

As-Built Survey Data - Pilot Channel and Access Channel



E PILOT CHANNEL XS1

SCALE: H: 1"=100' V: 1"=4'



F PILOT CHANNEL XS 2

SCALE: H: 1"=100' V: 1"=4'

SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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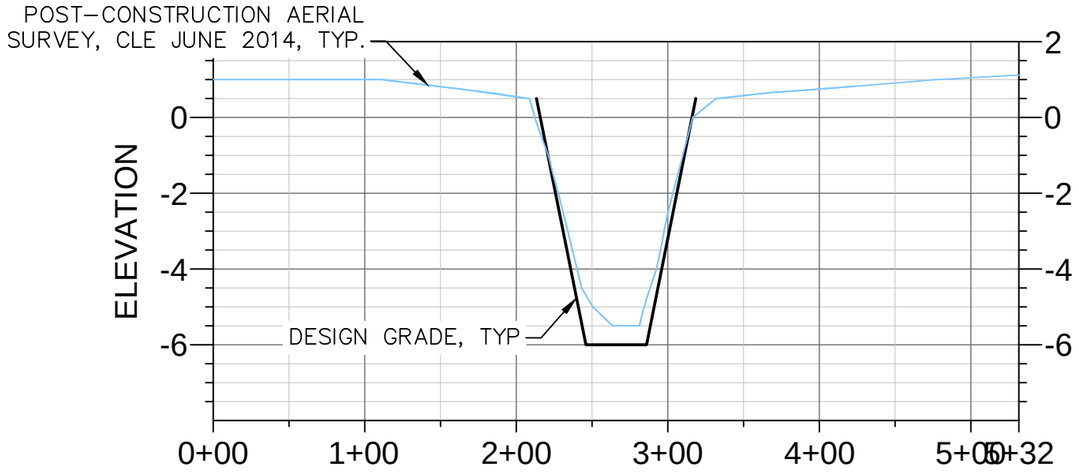
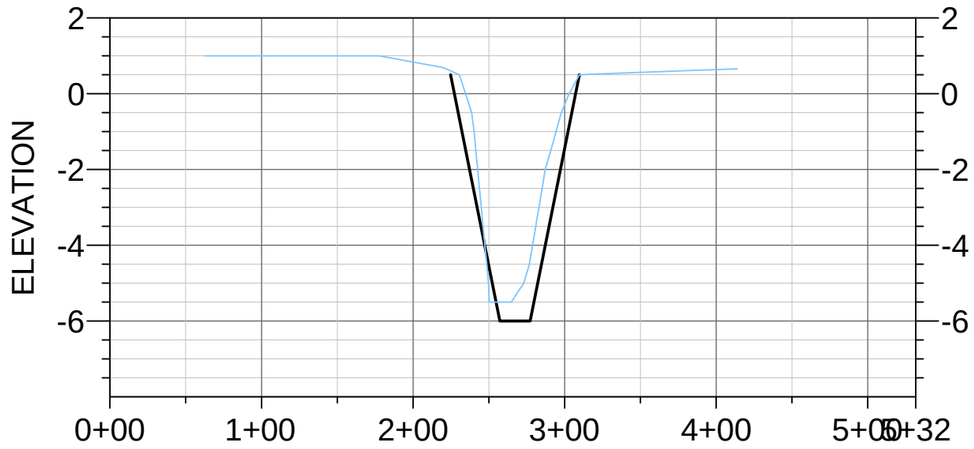
FIGURE 26

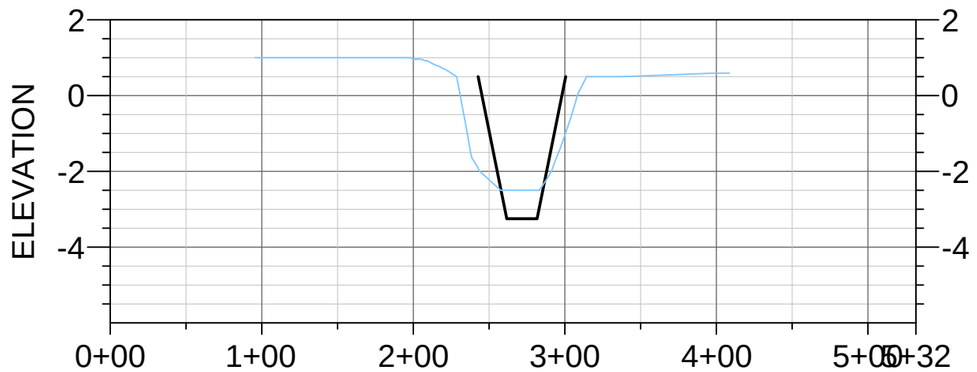
As-Built Survey Data - Pilot Channel Cross Sections



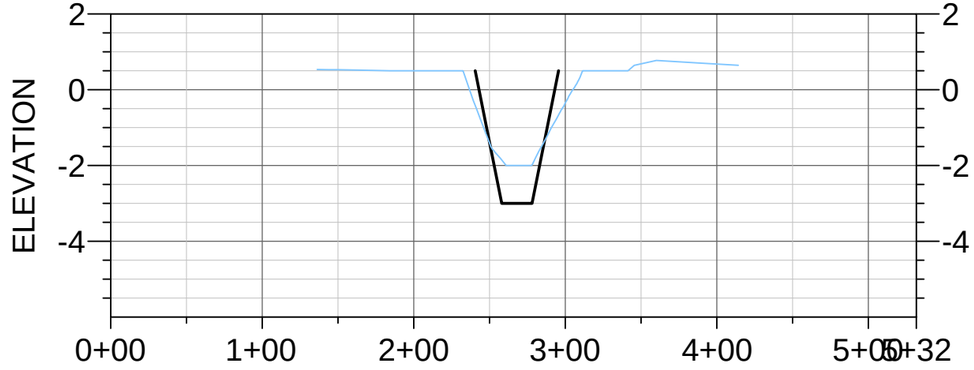
G PILOT CHANNEL XS 3
SCALE: H: 1"=100' V: 1"=4'



H ACCESS CHANNEL XS 1
SCALE: H: 1"=100' V: 1"=4'



I ACCESS CHANNEL XS 2
SCALE: H: 1"=100' V: 1"=4'



J ACCESS CHANNEL XS 3
SCALE: H: 1"=100' V: 1"=4'

SOURCE:USACE, ESA

ESA

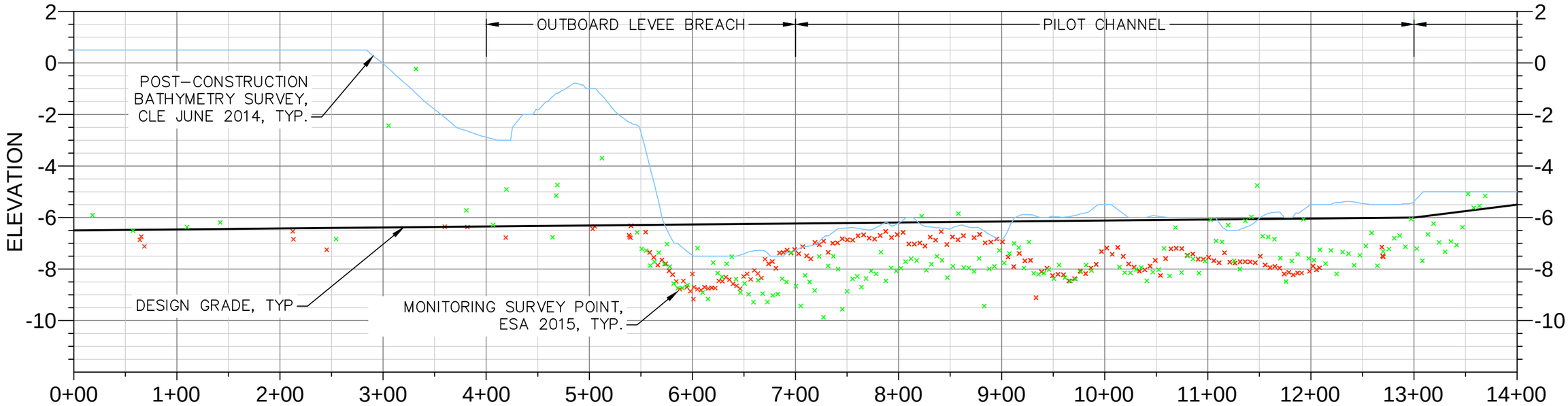
+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

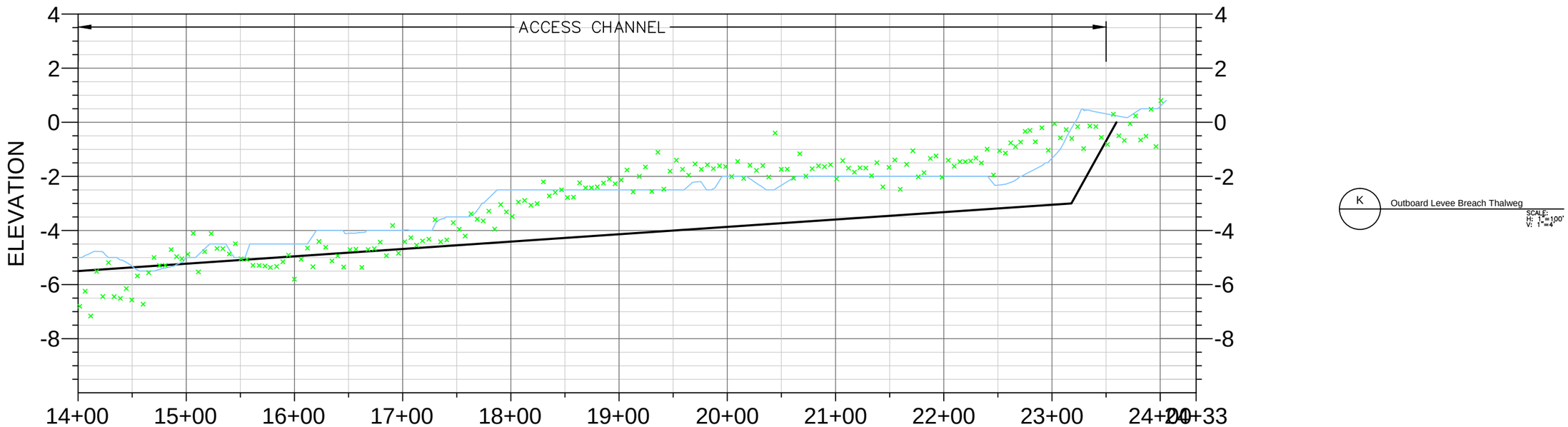
×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

FIGURE 27

As-Built Survey Data - Access Channel Cross Sections





K Outboard Levee Breach Thalweg

SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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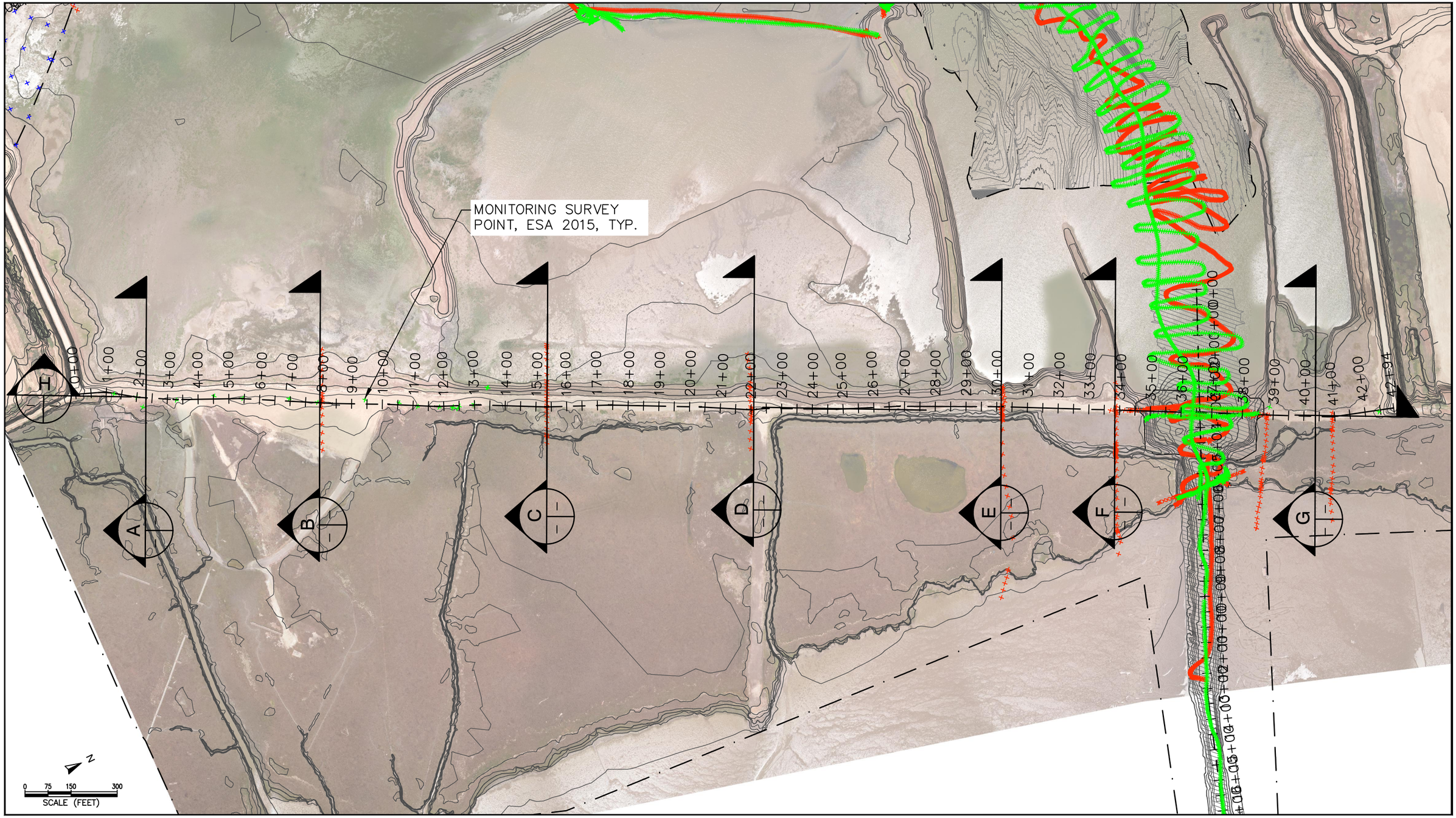
FIGURE 28

As-Built Survey Data - Outboard Levee Breach Thalweg



SOURCE:USACE, ESA

ESA

+POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

×MONITORING SURVEY POINT, ESA, JAN–FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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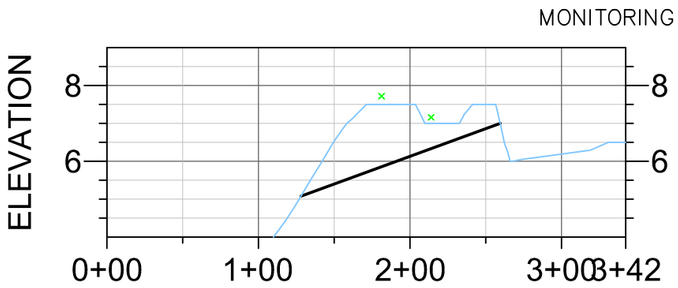
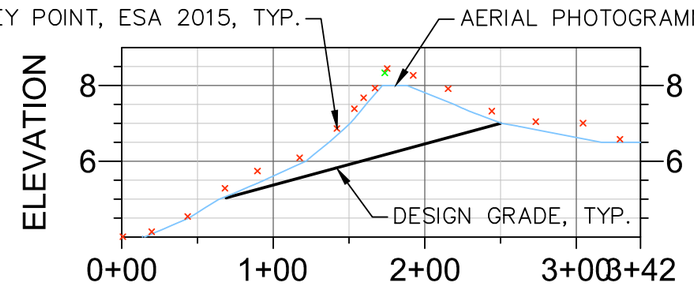
FIGURE 29

Outboard Levee Plan View



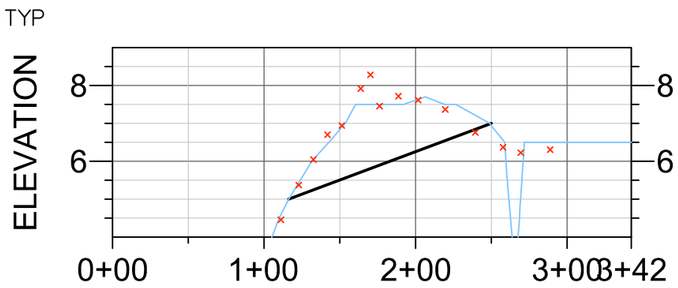
A OUTBOARD LEVEE XS 1

SCALE:
H: 1"=100'
V: 1"=4'



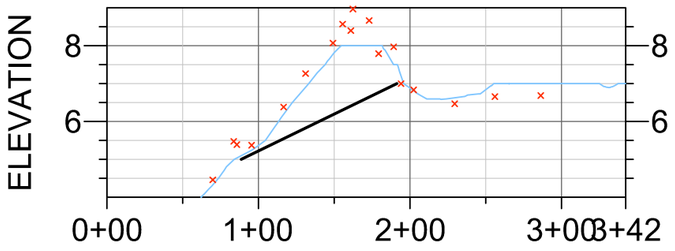
B OUTBOARD LEVEE XS 2

SCALE:
H: 1"=100'
V: 1"=4'



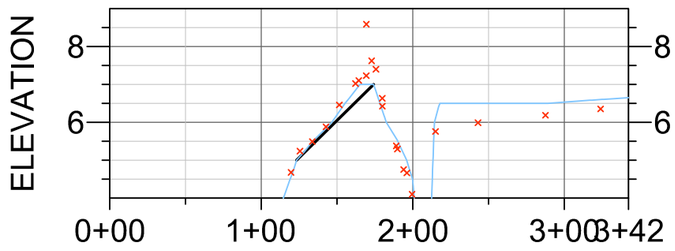
C OUTBOARD LEVEE XS 3

SCALE:
H: 1"=100'
V: 1"=4'



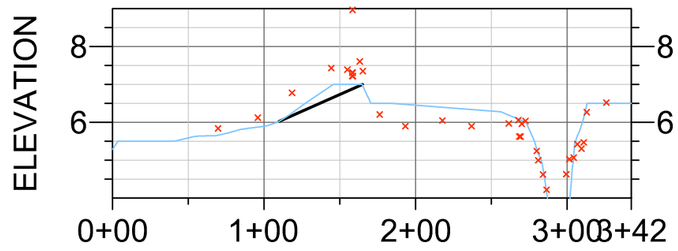
D OUTBOARD LEVEE XS 4

SCALE:
H: 1"=100'
V: 1"=4'



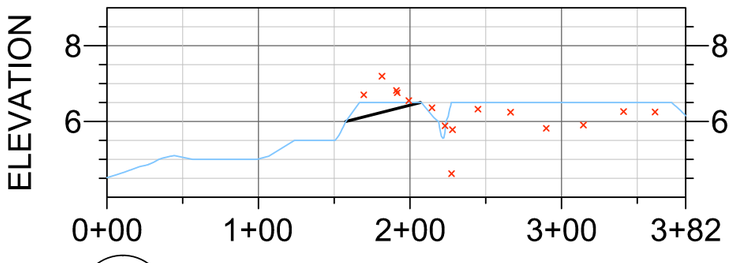
E OUTBOARD LEVEE XS 5

SCALE:
H: 1"=100'
V: 1"=4'



F OUTBOARD LEVEE XS 6

SCALE:
H: 1"=100'
V: 1"=4'



G OUTBOARD LEVEE XS 7

SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:USACE, ESA

ESA

+POST-CONSTRUCTION SURVEY POINT, MARATHON, JAN-FEB 2014

×MONITORING SURVEY POINT, ESA, JAN-FEB 2015

×MONITORING SURVEY POINT, ESA, SEPT 2015

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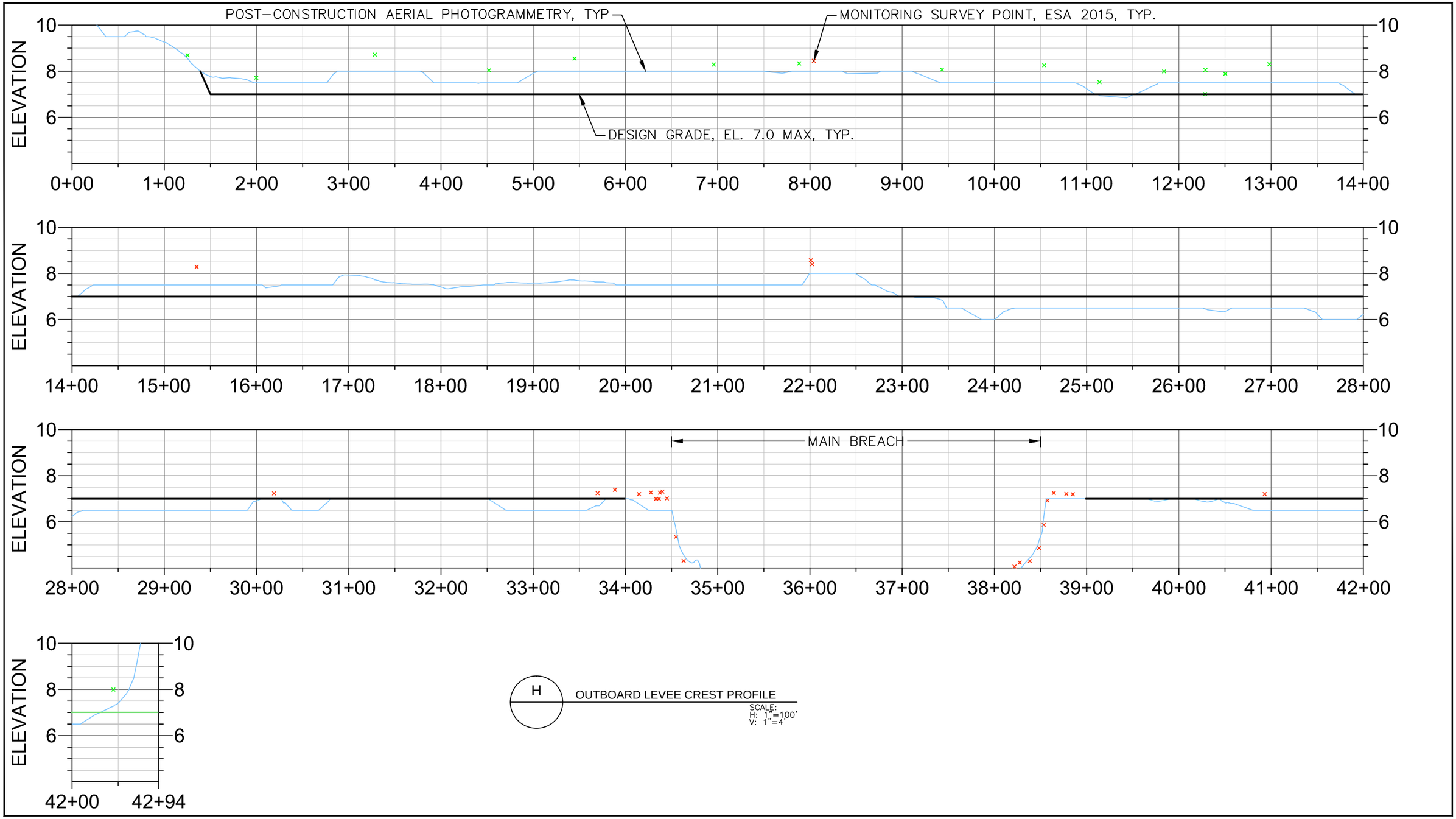
FIGURE 30

Outboard Levee Cross Sections



H OUTBOARD LEVEE CREST PROFILE

SCALE:
H: 1"=100'
V: 1"=4'

SOURCE:USACE, ESA

ESA

+ POST–CONSTRUCTION SURVEY POINT, MARATHON, JAN–FEB 2014

× MONITORING SURVEY POINT, ESA, JAN–FEB 2015

× MONITORING SURVEY POINT, ESA, SEPT 2015