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January 21, 2022

VIA EMAIL AND PRIVATE CARRIER

Anuradha Mohanty
Land and Materials Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite: 625
Baltimore, Maryland 21230

Subject: Transmittal of the Cow Pen Creek Bank Stabilization and Floodplain Reconstruction Monitoring: 2021 Report
Lockheed Martin Corporation – Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Ms. Mohanty,

For your review, please find enclosed two hard copies with a CD of the above-referenced document. This prepared report monitors the stabilized bank and reconstructed floodplain of Cow Pen Creek in July 2018, September 2019, August 2020, and September 2021 following the completion of the sediment remediation project in 2017. This report includes results from each of these four monitoring events. Cow Pen Creek is located adjacent to the Lockheed Martin Middle River Complex in Middle River, Maryland.

Please note for this project, this is intended to be the last monitoring report addressing the parameters of Bank Stabilization and Floodplain Reconstruction.

If possible, we respectfully request to receive MDE's document review comments by March 4, 2022.

Please let me know if you have any questions. My office phone is (301) 548-2209.

Sincerely,

Thomas D. Blackman
Project Lead, Environmental Remediation

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COW PEN CREEK
BANK STABILIZATION AND FLOODPLAIN RECONSTRUCTION MONITORING: 2021 REPORT
LOCKHEED MARTIN MIDDLE RIVER COMPLEX
2323 EASTERN BOULEVARD
MIDDLE RIVER, MARYLAND

Prepared for:
Lockheed Martin Corporation

Prepared by:
Tetra Tech, Inc.

January 2022

Revision: 0

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ACRONYMS AND ABBREVIATIONS

BWI	Baltimore/Washington International Airport
cfs	cubic feet per second
CPC	Cow Pen Creek
GIS	geographic information system
GPS	global positioning system
Lockheed Martin	Lockheed Martin Corporation
MDE	Maryland Department of the Environment
MRC	Middle River Complex
NOAA	National Oceanic and Atmospheric Administration
NWLON	National Water Level Observation Network
NWS	National Weather Service
SAV	submerged aquatic vegetation
Tetra Tech	Tetra Tech, Inc.

SECTION 1
INTRODUCTION

On behalf of Lockheed Martin Corporation (Lockheed Martin), Tetra Tech, Inc., (Tetra Tech) monitored the stabilized bank and reconstructed floodplain of Cow Pen Creek (CPC) in July 2018, September 2019, August 2020, and September 2021 following the completion of the sediment remediation project in 2017. This report includes results from each of these four monitoring events. Cow Pen Creek is located adjacent to the Lockheed Martin Middle River Complex (MRC) in Middle River, Maryland.

1.1 PURPOSE OF BANK STABLIZATION AND FLOODPLAIN RECONSTRUCTION MONITORING

As part of the sediment remedy at the Middle River Complex, the upper portion of Cow Pen Creek, including both the stream channel and adjacent floodplain area, was excavated to remove contaminated sediment. Subsequent to sediment excavation, these areas were restored per the approved *Sediment Remedy 100% Design for Cow Pen Creek and Dark Head Cove* (Tetra Tech, 2016). Creek restoration included reconstruction of its main channel and floodplains, placement of new channel substrate, streambank stabilization, wetlands restoration, and revegetation of areas disturbed by sediment removal. The overall goal of restoration and mitigation was to replace the extent, function, and value of Cow Pen Creek wetlands and waters impacted by the sediment remediation project. Documentation of the sediment removal action is provided in *Season Two Cow Pen Creek Sediment Remedy Completion Report* (Tetra Tech, 2018a).

This monitoring report focuses on bank stabilization and floodplain reconstruction of the upper (non-tidal and inter-tidal) portions of Cow Pen Creek. The overall objective of this monitoring is to evaluate whether the channel and its floodplain are remaining stable and are maintaining expected vegetative cover during the post-construction period. Annual monitoring can be used to assess progress toward project goals. The project design report (Tetra Tech, 2016) called for streambank and floodplain monitoring over a four-year post-construction period, and specified the

following performance measures for evaluating the restored channel of Cow Pen Creek during each year of monitoring:

- 85% (minimum) native vegetation cover on banks and floodplains
- 15% (maximum) barren ground on banks and floodplains
- 10% (maximum) unstable banks
- 85% (minimum) streambank length occupied by restoration treatments

Furthermore, revegetation specifications for Cow Pen Creek following the sediment remedy (Tetra Tech, 2017) state that:

- invasive species may not cover more than 5% of the project area at any time
- one year after construction, upland restoration areas must achieve a 75% cover by native species, and wetland restoration areas must achieve a 75% cover by native wetland species
- bare spots in the upland and wetland restoration areas may not be larger than 10 square feet
- no more than eight linear feet of planted coir may be unvegetated

1.2 OBJECTIVES

The objectives for the bank stabilization and floodplain reconstruction monitoring are to:

- assess the stability of stream banks along the restored section of Cow Pen Creek
- monitor the establishment of native vegetative cover and other restoration treatments along stream banks
- evaluate vegetation established in the reconstructed floodplain area

SECTION 2
EXISTING SITE CONDITIONS AND BACKGROUND

The Lockheed Martin Middle River Complex (MRC), which is part of the Chesapeake Industrial Park, is located at 2323 Eastern Boulevard in Middle River, Maryland, approximately 11.5 miles northeast of downtown Baltimore. The 161-acre site contains 12 main buildings. The property also includes an active industrial area and yard, perimeter parking lots, an athletic field, a concrete-covered vacant lot, a trailer and parts storage lot, and numerous grass-covered green spaces along the facility's perimeter. Locked chain-link fences restrict access to all exterior lots and the main industrial area. The site is bordered by Eastern Boulevard (Route 150) to the north, Dark Head Cove to the south, Cow Pen Creek to the west, and Wilson Point Road and Martin State Airport to the east.

In 2014, Lockheed Martin began the removal of sediment contaminated by MRC historical operations in several areas within Dark Head Cove and Cow Pen Creek. Portions of Dark Head Cove and the lower reaches of Cow Pen Creek were dredged and restored by the placement of a six-inch-thick sand layer (i.e., the residual management layer). During the remediation of the upstream portion of Cow Pen Creek, the stream channel was essentially removed and reconstructed. An overview of the stream and floodplain reconstruction within Cow Pen Creek is illustrated on Figure 2-1. The extent of the restored area in the upper portion of Cow Pen Creek is from Station 8+00 to Station 19+00 according to stationing notation at the time of the remedial action (station notation was altered post-restoration), and this area extends from current Station 0+00 to Station 11+00 (using post-remediation notation). All disturbed areas in this segment of the creek were stabilized, restored, and revegetated between 2016 and 2017.

Existing functions and values (e.g., habitat, physical, and chemical conditions, as well as scenic, recreational, and other values) in Cow Pen Creek were restored to the extent practicable following

the removal of contaminated sediment. The restoration plan was developed to target the replacement of specific functions and values by designing features to provide aquatic/fisheries habitat, provide moderate flood flow, stabilize the shoreline and retain sediment, remove toxicants, and provide aesthetic and recreational values. Restored features included installing structures (e.g., root wads and logs on the floodplain) and replanting emergent vegetation to restore/improve habitat. Natural channel meanders were also created, and floodplain forest/shrub vegetation was replanted to moderate flood-flow, stabilize shorelines, retain sediment, and aid in reducing toxicants. Other features, including replanting of riparian vegetation, were designed to restore the visual/aesthetic appeal of the stream corridor.

The design for restoration of Cow Pen Creek included the following elements:

- reconstruction of the main channel and floodplains;
- placement of new channel substrate;
- streambank stabilization; and
- revegetation of areas disturbed by the removal.

Stream restoration features are detailed in the design document (Tetra Tech, 2016) and are summarized below.

2.1 MAIN CHANNEL AND FLOODPLAIN RECONSTRUCTION

The purpose of the restoration project was to restore the creek's active channel by reconstructing its channel and floodplain, thereby providing a more natural stream system that would benefit the resident fish species and other aquatic organisms and improve flood flow functions and values within the creek. The upper section of Cow Pen Creek was excavated, and the existing channel was modified from its original configuration in accordance with the approved design. The channel and floodplain were reconstructed (as illustrated in Figure 2-2) by placing clean fill material within the affected creek section. Newly constructed channel banks were stabilized by temporary erosion-control mats and subsequently revegetated. Fill material was covered by topsoil suitable to promote establishment of floodplain vegetation.

2.2 CHANNEL SUBSTRATE

As part of the sediment remedy, a residuals-management sand layer was placed over all sediment removal areas downstream of Station 19+00. The use of appropriate channel substrate was intended to restore/improve fisheries habitat and flood flow functions/values by creating a more natural streambed. Appropriate bed sediment composition for the non-tidal (Station 8+00 to 13+00) and inter-tidal (Station 13+00 to 19+00) portions of the creek was determined using a creek-specific hydraulic model. That analysis indicated that non-native bed material consisting of a graded mixture of silts to cobble-sized material, with a median grain size of 51 millimeters (two inches) and 25 millimeters (one inch) in non-tidal and inter-tidal areas (respectively), would withstand erosive forces while providing a suitable spawning habitat for resident fish. Based on the bed stresses indicated by hydrodynamic modeling, the streambed substrate could transition to a graded sand (less than one-millimeter grain size) in the downstream portion of the inter-tidal area.

2.3 STREAMBANK STABILIZATION AND RIPARIAN REVEGETATION

Streambanks that were disturbed during excavation (and thus subject to erosion) were stabilized by grading to gentle slopes to allow for effective vegetative stabilization. In some sections, stabilization entailed conventional rigid techniques (e.g., rock toe). An approximately 200-foot segment along the Hawthorne neighborhood side of the creek was stabilized and protected with rock toe structures. In the lower portion of the restored stream reach, wetlands that provide vegetative stabilization were constructed along banks of the creek. Woody vegetative bank-stabilization techniques used living plant materials with the goal of providing a desired ecological benefit per Maryland Department of the Environment (MDE) guidelines (MDE, 2000). This woody vegetation on waterway banks is intended to reinforce the soil and protect the surface from scour by establishing a soil–root matrix.

Bank stabilization techniques included the use of biodegradable erosion control blankets coupled with the installation of vegetation designed to replace the specific wetland types (i.e., emergent, forested, and scrub-shrub wetlands) adjacent to the creek, a root-wad revetment, and rock toe and fiber-roll toe protection. Live staking of vegetation was also employed along certain sections of the creek bank. Woody debris removed from the creek and floodplains during clearing and

excavation was cleaned of all adhering sediment and used in certain locations for habitat enhancement.

The revegetation plan for the upper portion of Cow Pen Creek (Tetra Tech, 2017) included measures to restore upland, forested wetland, and scrub-shrub wetland along the excavated areas of the creek. Native forest and scrub-shrub plant species typical to streams along the upper Chesapeake Bay were replanted in disturbed and excavated areas along Cow Pen Creek.

The species list and planting plan was provided as part of the restoration design (Tetra Tech, 2016). Restoring riparian vegetation and shoreline/banks in affected areas was intended to promote shoreline vegetative cover, which would provide bank stabilization and habitat and food for resident aquatic species. Restoration of native vegetative habitats was designed to restore/improve terrestrial habitat, stabilize shorelines, retain and remove sediment and toxicants, restore/improve fisheries habitat by creating overhanging vegetation, and restore visual/aesthetic appeal of the stream corridor. Seeding and planting were completed in January 2018. Additional planting of black willows and arrow arum was completed in spring 2020 to increase the amounts of forested wetlands and emergent wetlands.

Per the project design (Tetra Tech, 2016) and subsequent monitoring work plan (Tetra Tech, 2018b), annual evaluations of the restored wetland areas, reconstructed floodplain, and creek channel were to occur from 2018 until 2020, with optional monitoring in 2021, to determine if the restoration project has met the performance standards. The standards specified for the floodplain and streambanks are listed in Section 1.1. Annual monitoring has tracked creek conditions, with the expectation that performance standards would be met by the end of this multi-year monitoring period.

SECTION 3
STREAMBANK, FLOODPLAIN, AND UPLANDS MONITORING AND DATA COLLECTION

Cow Pen Creek bank stabilization and floodplain reconstruction monitoring was conducted once per year (during the summer) from 2018 through 2021 per the monitoring work plan (Tetra Tech, 2018b). Annual monitoring was conducted each year between June and August, and after a two-year rainfall or after a higher flow event. If a two-year rainfall or flow event did not occur between June and August during a given year, monitoring was instead conducted in September, preferably after rainfall. Precipitation frequency estimates were prepared for the hydrology and hydraulics study as part of the sediment remedy design (Appendix A in Tetra Tech, 2016); these estimates indicated that a 24-hour rainfall total of 3.3 inches represents a two-year storm event. That study also estimated a corresponding two-year flow for Cow Pen Creek at 19.2 cubic feet per second (cfs).

Monitoring for the first year of post-reconstruction (in 2018) was conducted on July 26-27, 2018, and followed the methods detailed in the *Cow Pen Creek Bank Stabilization and Floodplain Reconstruction Monitoring Work Plan* (Tetra Tech, 2018b). Consistent with the established weather criteria in the work plan, monitoring in 2018 took place after a two-year rain event. Monitoring for year 2019 was conducted on September 27-30, 2019 following the same methods, as no qualifying two-year rain events occurred during the June-August 2019 window, and no appreciable rain was recorded in September 2019. Monitoring for year 2020 was conducted on August 5-18, 2020, after a two-year rain that occurred on August 5, and continued after another qualifying event occurred on August 12, 2020. Monitoring for year 2021 was conducted on September 7-8, 2021, as a qualifying two-year rain event did not occur between June and August 2021. A large rainfall event did occur prior to the September 7-8 monitoring, as detailed below.

3.1 WEATHER AND TIDAL CONDITIONS—2021

From June through August 2021, field staff tracked weather conditions to select an appropriate qualifying two-year event. Data from National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) and nearby Weather Underground stations were employed.

Daily rainfall totals for the NOAA NWS station at Baltimore/Washington International Airport (BWI), and at nearby Weather Underground stations at Goldentree/Orems Elementary and Carroll Island, for the dates before and during the sampling period, are shown in Table 3-1. The Carroll Island weather station recorded rainfall accumulation of more than 5.6 inches, and the Goldentree/Orems station recorded more than 3.9 inches of accumulation during a 24-hour period on September 1, 2021. This large rainfall was associated with the remnants of Hurricane Ida, which moved through Maryland as it travelled across from the Gulf of Mexico toward the northeastern United States.

The 2021 Cow Pen Creek monitoring survey began on September 7 and was completed on September 8, 2021. Weather for the two days of monitoring was clear to partly cloudy to cloudy. Floodplain surveys were conducted primarily on September 8, while streambank data were collected September 7. Surveys on both dates included photo documentation.

Monthly precipitation totals for September 2020 through September 2021 are listed in Table 3-2 and are shown graphically on Figure 3-1. The BWI station received above-average rainfall for nine of those 13 months.

Observed tidal water levels in Baltimore Harbor at NOAA's Fort McHenry station, Patapsco River, from August 19–September 8, 2021, are presented on Figure 3-2. Tide levels during the weeks preceding the monitoring were generally above NOAA's long-term predicted levels. Very high tide associated with the September 1 rain event is evident, but tide levels had returned to a more typical, slightly elevated pattern prior to September 7. NOAA predictions follow moon cycles and are developed using observational data from the National Water Level Observation Network (NWLON) stations (NOAA, 2020).

3.2 ASSESSMENT OF STREAMBANKS

Conditions observed during the initial post-remediation monitoring in 2018 are considered as baseline against which subsequent monitoring events can be compared. The methods used to assess the streambank in 2021 are discussed below; specific performance measures observed in 2021, as compared to previous monitoring years (2018 to 2020), can be found in Section 5.1.

Visual observations used to evaluate streambank stability and vegetative cover during the annual surveys were recorded following the methods detailed in the monitoring plan (Tetra Tech, 2018b). Field methods for assessing streambank stability and vegetative cover were derived from guidance by Harris (2006) and Volkman (2006); these documents provide methods for a quantitative characterization along linear segments of streambank. Cow Pen Creek streambanks were assessed using estimates of the percentage of streambank length occupied by specific vegetative classes, with the following observed conditions:

1. No vegetation, stable, no erosion
2. No vegetation, unstable, actively eroding
3. Vegetation, stable, no erosion
4. Vegetation, unstable, actively eroding

Streambank visual observations were made from the current water's edge to the top of the bank. The entire length within the restored reach of Cow Pen Creek (post-construction Stations 0+00 through 11+00, the same area originally designated as Stations 8+00 through 19+00) was assessed. Field staff worked in a downstream direction, beginning at the upstream end of the restored reach (Station 0+00) and proceeding downstream to the lower end. Monitored locations, the upper and lower ends of the entire reach, and intermediate points along the bank were recorded by the field team using global positioning system (GPS) instruments. Each bank (right bank and left bank, looking downstream) was assessed separately. Data were recorded electronically using a custom-designed form built within the ArcGIS Field Maps application. Locations of field observation points were recorded at the water's edge using GPS, so that each point can serve as a reference point for comparison with other years' data.

Longitudinal sections of the stream bank were designated using station notation. Proximity to existing features such as guardrail, stairs, outfalls, or gabion walls was noted. At each section,

observations of vegetative cover, bank stability, and erosion were recorded. The upper and lower end of each longitudinal segment was designated (to the nearest foot) using station notation, and the distance along the stream thalweg (the line of lowest elevation in the stream) was used to measure and record segment break points (e.g., Segment 0+00 to 0+75, Segment 0+75 to 1+60). After field work was complete, the segment lengths along the thalweg were verified using the as-built channel survey. Erosion severity ratings (minor, moderate, severe) were assigned based on field observations and photo documentation. For comparison with previous years, erosion severity ratings were also assigned for years 2018-2020 based on notes and photo documentation.

To provide additional information on vegetative cover, the field crew also recorded the presence of woody vegetation within three height class categories at each segment: (1) less than three feet, (2) 3-15 feet, and (3) more than 15 feet. The crew recorded the presence of herbaceous cover (if more than 10% vegetated) or noted if the surface was barren (if less than 10% vegetated), and noted the presence of large woody debris, rock, or other restoration structures where vegetation was not present. Presence and estimated percent cover of invasive species were also recorded.

Bank conditions were documented by taking digital photographs of each segment at regular intervals along the right and left banks, and by representative photographs looking upstream and downstream. Photographic locations were recorded (GPS point, direction) so that similar views can be compared with previous annual surveys.

3.3 ASSESSMENT OF RECONSTRUCTED FLOODPLAIN

The reconstructed floodplains were monitored similarly to the reconstructed streambanks, and their stability is also being assessed over time (as compared to the 2018 conditions) by observing the establishment of vegetation. Per design (Tetra Tech, 2016), the reconstructed floodplain was to be monitored for at least three years (2018 through 2020), with optional monitoring in 2021, to occur concurrent with bank assessments. The methods used to assess reconstructed floodplains in 2021 are summarized below; specific performance measures observed in 2021, as compared to baseline and conditions present in previous monitoring years (2020, 2019, and 2018), can be found in Section 5.1.

Similar to the streambank assessments, observations began at the upper end of the restored reach (Station 0+00) and extended to the lower end of the restored stream section (Station 11+00). A series of 10 transects was established to assess vegetative condition; these transects extended from the top of bank to the edge of the floodplain within the reconstructed area. Three transects were established within each of three sections along the restored reach (Stations 0+00 to 3+00, 3+00 to 7+00, and 7+00 to 11+00): at the upstream end, at one-third of the way downstream, and at two-thirds of the way downstream. The downstream end of the last section was also assessed. Transects along these sections crossed through areas of upland wetland, forested wetland, and scrub-shrub wetland that had been planted as part of the restoration project. The original transect lines established in 2018 were used for each year of the floodplain monitoring.

At each floodplain transect, the first field observation point on each side (left and right bank) was located at the top of the bank using GPS, so that these surveyed locations could serve as reference points for future observations. These points are used to evaluate the extent of any observed lateral erosion. Along each transect, the field crew ran a measuring tape and recorded (in feet, from the distance at the top of the bank) the presence of vegetation in segments. Segment breaks were made where changes in condition were noted. Break points were also noted at transitions between vegetation community types (upland vs. wetland). After field work was complete, segment distances by vegetation community type were confirmed using the revegetation plan. The most recent wetland survey available at the time of the bank stabilization/floodplain monitoring is used to set segment break points between vegetation community types. For 2021 monitoring, the 2020 wetland delineation (Tetra Tech, 2020a) was used to prepare for field work; locations were confirmed once the 2021 wetland delineation was available (Tetra Tech, 2021). No changes in these locations were needed based on the 2021 delineation.

Within each segment, coverage was noted as vegetated or not vegetated. “Not vegetated” was defined as having less than 10% vegetative cover along the linear segment assessed. The field crew also recorded the presence of woody vegetation along each segment within three height class categories: (1) less than 3 feet, (2) 3–15 feet, and (3) more than 15 feet. The crew recorded the presence of herbaceous cover (if more than 10% vegetated). The presence and estimated percent cover of invasive species were also recorded, as were any observed bare spots larger than 10 square feet in the reconstructed floodplain area.

Vegetative conditions along the floodplain were documented by taking photographs at regular intervals along transects, and by representative photographs looking across the replanted areas. Photographic locations were recorded (GPS point, direction) so that similar views can be photographed during subsequent monitoring. GPS transect locations and representative photograph locations from 2018 were used to locate survey points during subsequent monitoring, so that new information and photographs could be compared with baseline (2018) observations.

SECTION 4
DATA COLLECTED

4.1 SUMMARY OF DATA COLLECTED

Data were collected along Cow Pen Creek streambanks and in established transects across the floodplain, as shown in Figure 4-1. Photograph locations of representative creek areas and other features of note along the channel are shown on Figure 4-2. Bank erosion and stability conditions observed in 2021 are depicted on Figure 4-3, and Figure 4-4 is a map showing areas with invasive plant species. Figure 4-5 shows areas of possible concern noted for erosion/vegetative cover observed in the 2021 survey, and Figure 4-6 shows streambank and floodplain survey points along with as-built survey data.

Appendix A contains representative photographs of the channel conditions (upstream and downstream views at transect locations), and photographs taken during streambank assessments showing bank condition, floodplain transects, and other views. Appendix A Photos A-74 through A-110 show four-year side-by-side annual comparisons of targeted locations of interest (i.e., comparing conditions in each survey conducted in 2018, 2019, 2020, and 2021) with photographs taken from a similar GPS location and compass bearing. Photos A-111 through A-116 show two-year comparisons (2020 vs. 2021) for several locations. Appendix B lists global positioning system (GPS) coordinates at streambank and floodplain assessment points. Appendix C contains figures and tables from the 2018, 2019, and 2020 monitoring reports (Tetra Tech, 2018d, 2019a, 2020b).

4.1.1 Streambank Assessment—2021

Summer 2021 streambank assessment data are summarized by individual bank segments in Table 4-1; bank conditions were assessed using the following criteria:

- Vegetation cover present (yes or no)
- Bank stability (stable or unstable)
- Active erosion (yes or no)

Based on field observations, bank erosion severity was further characterized as minor, moderate, or severe. Areas with more significant erosion were classified as severe, while areas with less substantial erosion were classified as minor or moderate.

Additional details about vegetation, the presence of invasive species, and proximity to structural features are summarized in Table 4-2. Summary indicators were independently assessed and calculated separately for both banks, and values were combined to represent overall totals for the entire restored stream reach in Table 4-3.

Bank conditions were rated as stable along 97% of total stream bank length (2,144 of 2,216 total feet) as shown in Figure 4-3. Areas with evident, severe, and active bank erosion were observed along 3% (72 feet) of total bank length, 36 feet of which was unvegetated and 36 feet of which was vegetated.

The lowermost, tidal portion of the project area was stable, except for a small portion (36 feet) of the right bank that was unvegetated and actively eroding (Figure 4-5, point location T). This area was not part of the restoration project and features a nearly vertical red clay bank influenced by an immediately adjacent bare earth footpath above. The footpath prevents the establishment of stabilizing vegetation, as its well-worn and compacted soils have been impacted by local residents that walk and bike along the path within this public area.

In the upper, nontidal area, severe erosion was noted at three areas directly affected by storm flow:

- One 13-foot-long section noted as unstable featured a stormwater outfall pipe running perpendicular to the stream (left bank above station 01+86, see Photos A-9 and A-118). At this location, the stream bank has eroded back approximately 4 feet along the pipe, a result of overland and streamflow during storm events. In January 2021, new coir logs were placed along the left bank about 20 feet upstream of this area to mitigate overland flow.
- Severe erosion was also noted in a 12-foot-long segment on the left bank (at station 02+18), the result of a stormwater outfall across the stream on the right bank. This segment was also noted in the 2020 monitoring report; the flow from this outfall has been cutting around the left side of boulders at a stone riffle structure in the channel causing increased erosion on the left bank (see Photo A-12). A comparison of the 2020 and 2021 conditions at this

location (Photo A-121) confirmed the increase in erosion below the tree roots on the left bank.

- In addition, an 11-foot-long segment of the right bank (at station 01+82) has been affected by an outfall discharging storm flow from across the creek on the left bank (Photo A-10).

A number of other bank segments exhibiting less severe erosion were noted in the upper to middle portion of the project area, which is directly impacted by instream and outfall stormwater flows originating from the surrounding watershed. Primarily, these areas of erosion showed evidence of flows affecting the lower bank, beneath a well-vegetated and stable upper bank. Segments with moderate to minor erosion were considered stable, consistent with the characteristics expected of a dynamic and evolving stream ecosystem, which typically makes channel adjustments over time in response to stream flow. Overall, 12% of the bank length (271 feet) exhibited moderate erosion and 17% of bank length (382 feet) was rated as minor erosion.

This type of lower streambank erosion was noted in the 2020 monitoring report in areas exhibiting erosion, and occurred as undercutting below a vegetated and stable upper streambank. Erosion has continued in these areas in 2021, appears to be minor to moderate in nature, and is not currently threatening the stability of the stream banks.

- The longest of the undercut areas is within a 277-foot-long section along the upper left bank (seven segments, from stations 01+54 to 04+31). This area includes two short, severely eroding segments affected by stormwater outfalls (described above), as well as a longer length of lower bank undercutting below an intact upper bank (see examples, Photos A-17, A-18, and A-22).
- A portion of the upper right bank (between stations 01+20 and 03+13) including one short, severely eroding segment (described above), and four segments (totaling 164 feet) with moderate to minor erosion with low bank undercut (see example, Photo A-14). Within this same reach, one segment along the right bank (40 feet at station 02+22) (see Photo A-13) was stabilized with rip-rap and vegetation, but was experiencing some minor erosion of sediment around the rip-rap.
- Similar evidence of minor, low bank erosion was observed along 165 feet of the middle of the right bank (stations 05+32 to 06+97) (Photo A-30).

Over the entire restored area of Cow Pen Creek, all the bank length classified as stable was also vegetated (2,144 feet). Stable banks with vegetation included 455 feet of bank characterized as tidal mudflat (256 feet along left bank, 199 feet along right bank). These tidal areas were either fully vegetated or included well-vegetated herbaceous tidal wetlands situated above stable mudflats. These tidally inundated areas are for the most part vegetated at the water's edge during high tide, but the intertidal areas lack vegetation (or are only sparsely vegetated), while thicker vegetation is present further inland along these sections of stream. Since this condition is typical of healthy, stable tidal wetlands, it is considered vegetated and stable. Furthermore, about 100 feet of this tidal mudflat bank included matting still in place from the original installation, providing additional stabilization.

Along nearly all streambank areas, vegetation was growing well and appeared robust and healthy. In all, approximately 2,180 feet of the total bank length was vegetated, representing 98% of the total stream length. Of this vegetated length, 2,144 feet (98%) was classified as stable (Tables 4-1 and 4-3). These figures include the tidal sections with vegetation present above a stable mudflat, as described above.

Areas noted in previous years' monitoring reports as "armored with structural treatments" (containing rip-rap, logs, and rootwads) were covered with vegetation in 2021 and were included in the vegetated totals.

The presence of woody vegetation along streambanks was recorded and classified using three height classes (Table 4-2) described in Section 3.2. Within the 43 streambank segments assessed, 18 had woody vegetation less than three feet tall, 29 segments had woody vegetation 3-15 feet tall, and 14 segments had woody vegetation taller than 15 feet. These numbers confirm observations of a general increase of woody vegetation over time along the streambanks, and growth of woody vegetation into the higher height classes.

Invasive species were present along the streambank in various locations along both the right and left banks (see Figure 4-4 and Table 4-2). The most commonly observed invasive species was Japanese honeysuckle (*Lonicera japonica*, 6 locations). Other species observed were Chinese bush clover (also called Chinese lespedeza, *Lespedeza cuneata*, 4 locations), rose of Sharon (*Hibiscus*

syriacus, 3 locations), common reed (*Phragmites australis,* 2 locations), and multiflora rose (*Rosa multiflora,* 1 location).

The extent of invasive species cover was not widespread; in most (11 of 12) segments in which they were detected, these species each covered 20% or less of each assessed segment length. Overall, the estimated percent cover by invasive plant species along the entire stream bank was 4.8%.

The tidal portion of the restored reach supports herbaceous vegetation and some small woody plants, although tidal inundation has limited the establishment of original and replanted woody vegetation. Some tidal mudflat areas directly adjacent to the stream were only sparsely vegetated at the time of monitoring, while areas upgradient had more dense vegetation cover, predominantly emergent herbaceous vegetation. In the 2021 wetland delineation (Figure 4-1), wetland areas were mapped as forested, scrub/shrub, and emergent wetlands, along with tidal mudflat areas.

4.1.2 Floodplain Vegetation Assessment—2021

Summer 2021 floodplain assessment data for the 10 transects and for individual segments within transects are summarized in Table 4-4, and include the following parameters: the presence of herbaceous vegetation, presence of woody vegetation in three size classes, percent cover of invasive species, and associated notes. Segment breaks were indicated by a change in vegetation type or condition. Transects were subdivided into wetland (floodplain) and upland segments by cross-checking field observations with mapped information from the most recent wetland survey available at the time of field work, conducted in August 2021.

Summary values were independently assessed and calculated separately for both banks and combined as overall values to represent the entire set of assessed transects. Across all surveyed wetland and upland transects, the entire length was vegetated with herbaceous and/or woody vegetation. In all, 7.9% (57 feet) of the assessed segment length (725 feet) lacked herbaceous vegetation; this was observed mostly in upland area and only within segments with woody vegetation that shaded the understory. Overall, 3.7% (27 feet) of the assessed segment length lacked woody vegetation in surveyed transects. Most of this length (16 feet) was in one upland

area on the upper left bank, which was planted only in grasses, and where woody vegetation was not expected.

Along the lower, tidal portion of the project area, 0.14 acres were mapped as tidal mudflats during the 2021 wetland delineation (Figure 4-1). As shown on Table 4-5, using these mapped data, the total floodplain transect length representing unvegetated sections of tidal mudflats was 14% (54 feet). By bank, approximately 18% (44 of 247 feet) of the wetland transect length on the left side was mapped as tidal mudflats, while 7% (10 of 140 feet) of the length was mapped as tidal mudflats on the right side. Except for these tidal mudflats, no bare patches greater than 10 square feet were noted.

During the floodplain transect assessments, invasive plants were noted within or near several transects, mostly on the left side of the stream. Four invasive species were observed. The most common was Chinese bush clover (6 locations, 10% to 60% cover), which was found in dense patches. Less common were multiflora rose (3 locations, 10% to 20% cover), common reed (2 locations, 0 to 10% cover), and Japanese honeysuckle (2 locations, 0% to 5% cover). Also observed onsite, but outside of the floodplain transects, was the invasive narrowleaf cattail (*Typha angustifolia*), mixed with the native broadleaf cattail (*Typha latifolia*). In total, the estimated percent cover by invasive plant species over all floodplain transects was 11.6%. Upland areas had a greater estimated percent (16.5%) of invasive plant as compared to wetland areas (4.6%).

4.2 COMPARISON OF DATA ACROSS YEARS

Results of Cow Pen Creek monitoring in 2021, as compared to 2018 through 2020, document that the creek channel is stable along most of its length, and that bank, wetland, and upland vegetation in most areas is becoming well-established. Side-by-side photographs from the four monitoring years (see Appendix A) show that vegetation is thriving and that banks are being maintained in a stable condition at many locations.

However, in a few sections along the banks, erosion associated with stormwater outfalls as noted in 2020 continued to be evident in 2021. In other sections, undercutting associated with storm flows continues to affect portions of the lower bank, even where vegetation is present along the upper part of the bank. This effect was evident along more of the streambank in 2021, as compared

to that seen in 2019 and 2020. The observations of lower-bank erosion and undercutting appeared to be minor to moderate in severity.

Vegetation continues to provide good cover within the wetland and upland areas in 2021, as it did in previous years, having filled in several bare areas observed in 2018. Woody vegetation in the two larger size classes (three to 15 feet tall, and taller than 15 feet) was observed more frequently in 2021 than previous years, documenting that trees and shrubs have continued to establish and grow throughout the restored area. The invasive common reed was observed at fewer locations in 2021 than in 2020. Chinese bush clover appeared to be well-established at several locations in the floodplain area, with a slight increase in percent cover from 2020 to 2021.

SECTION 5
CONCLUSIONS

5.1 COMPARISON TO PERFORMANCE MEASURES

The project design report (Tetra Tech, 2016) specified four performance measures for evaluating the restored channel of Cow Pen Creek during each year of monitoring including:

- 10% (maximum) unstable banks
- 85% (minimum) streambank length occupied by restoration treatments
- 85% (minimum) native vegetation cover on banks and floodplains
- 15% (maximum) barren ground on banks and floodplains.

Comparisons of 2018 to 2021 annual monitoring results to the four post-remediation performance measures are summarized in Table 5-1 and are discussed in more detail below. The monitoring results provide an assessment of conditions over four years post-construction and support the following overall conclusions about the restoration of the streambanks and floodplain at Cow Pen Creek and its status in fall 2021.

Vegetation has established well along the streambank and within the floodplain area. Vegetation covers nearly the entire area, as the bare spots noted with the initial monitoring in 2018 have filled in with vegetation during the three years since that time. Most (98%) of the overall streambank length is vegetated. Sections of tidal mudflat, included in the total vegetated length, occupy 20% of the entire streambank length. These tidally inundated areas are generally vegetated at the water's edge during high tide, but the intertidal areas lack vegetation (or are only sparsely vegetated), while thicker vegetation is present farther inland along these sections of stream. On an areal basis, the unvegetated portion of mudflats account for 14% of floodplain area. Additional planting of emergent herbaceous vegetation on these tidal mudflats may be appropriate to increase plant cover.

Structural treatments, including rip-rap, log structures, and a large rootwad revetment are continuing to provide bank stability where installed. Vegetation covers these structures, enhancing

long-term stability and ecological value. Minor erosion near structures does not pose a serious threat to their integrity at this time.

Native species have become well established and dominate the area; however, a few invasive species are found in patchy distributions along the streambanks and in the floodplain area.

The vegetation and structures installed throughout the restoration are providing good stability for the Cow Pen Creek stream channel and its banks. Evidence of increased undercutting has occurred over time, even along sections with a well-vegetated upper bank. This type of erosion has been observed in the non-tidal upper to middle portion of the restored area. The lower-bank erosion does not appear to be related to the bank treatments, but instead is a response to stormflows originating from this highly urbanized watershed. Within a dynamically stable stream ecosystem, some amount of streambank change is natural as the stream adjusts, as water and sediment are transported, and as stream flows continue to form and shape the channel. Changes in bank condition as seen at Cow Pen Creek appear to be within the expected range for similar urban streams in this region. Enhancing stormwater management for parking lots and other impervious areas in the watershed would reduce this stressor. Urban stormwater management is a broad regional concern not readily addressed by a single property owner, as much of the watershed drainage area falls within surrounding residential developments, roadways, and commercial lands, and beyond the immediate Lockheed Martin property boundaries.

Note that in the performance measures comparison discussion, the influence of tidal water levels on the vegetated area should be considered. During the two-day monitoring period in July 2018, water levels at the National Oceanic and Atmospheric Administration (NOAA) Fort McHenry station in Baltimore Harbor were (on average) 0.55 feet above predicted tide levels. Higher-than-predicted water levels were also common during the preceding days and months (May–July 2018). At that time, some post-construction settling (as compared to pre-construction and pre-remediation elevations) had possibly occurred in the floodplain; however, baseline elevation data were not collected to specifically confirm whether settling had occurred.

During the two-day monitoring period in September 2019, water levels at the Fort McHenry station were approximately 2–4 inches above predicted tide levels, and in August 2020 and

September 2021, water levels at the station were up to 1 foot above predicted tide levels. Tides with higher than predicted levels appear to be occurring more commonly than in the past (based on periodic observations by onsite staff at other times of the year, as well as preliminary analysis of predicted vs. actual tide levels at Baltimore Harbor), and inundation of most lower Cow Pen Creek areas has been observed during the more recent (in 2019 through 2021) site monitoring episodes.

Performance criteria for the streambank stabilization and floodplain restoration have been met, as evidenced by the results in this report. For each of the four performance criteria, detailed findings from 2021 are compared to those of previous years as follows.

- 10% (maximum) unstable banks:
    - In 2021, areas classified as unstable and exhibiting severe bank erosion were observed along 3% of total bank length.
        - This finding is similar to 2020, when the streambank was unstable/severely eroding along 3% of its length. In comparison, in 2019, the streambank was unstable for 3% of its length, and 2% of its length in 2018.
        - Results for 2021 also indicated bank areas with moderate to minor erosion along 29% of bank length, mostly associated with undercutting below a stable, vegetated, upper bank. Results for 2020 had included moderate to minor erosion along 21% of bank length. In 2019, these types of areas were found along 17% of bank length. In 2018, moderate to minor erosion was found along 6% of bank length.
    - In 2021, streambank conditions were classified as stable along 97% of total stream bank length.
        - In 2020, the streambank was rated as stable along 97% of its length, compared to 97% in 2019, and 98% in 2018.
- 85% (minimum) streambank length occupied by restoration treatments:
    - In 2021, 98% of the streambank length was occupied by restoration treatments. This length was all vegetated, including areas with rip-rap and wood structures that have over time become covered with vegetation.
        - In comparison, in 2020, approximately 95% of total streambank length was occupied by restoration treatments, all vegetated.

        - In 2019, coverage by treatments was 90%, including 88% vegetated, 1% unvegetated but with structures, and 1% with other restoration treatments such as matting and coir log.

        - in 2018 coverage by treatments was 93%, including 77% vegetated, 7% unvegetated but with structures, and 9% with other treatments.

- 85% (minimum) native vegetation cover on banks and floodplains:

    - In 2021, vegetation covered 98% of the bank length.

        - In 2020, vegetation covered 95% of the bank length, as compared to 89% (of unarmored bank length) in 2019, and 83% (of unarmored bank) in 2018.

    - Nearly 100% of assessed floodplain transects were vegetated in 2021, 2020, and 2019, as compared to the 25% bare floodplain areas observed in October 2018 (Tetra Tech, 2018c). Enhancement of vegetation cover is being considered for tidally influenced mudflat areas of the floodplain (14% of area, based on the 2021 wetland assessment).

    - In July 2018, treatment for invasive vegetation (predominantly common reed) was conducted at several bank and floodplain areas in the upper portion of the creek. At that time, yearly follow-up inspections for invasive species along the streambank were recommended, with mitigative spraying (if warranted), and have been conducted bi-annually in subsequent years.

    - Limited patches of invasive vegetation were observed in small areas along the banks during more recent surveys (2019–2021):

        - In 2021, invasive species along the streambank included common reed, Chinese bush clover, Japanese honeysuckle, rose of Sharon, and multiflora rose

            - In 2020, with Chinese bush clover and other species noted: rose of Sharon, mimosa, forsythia, common reed, Japanese honeysuckle, and English ivy

            - In 2019, common reed, barnyard grass, and burdock were noted

        - In 2021, a few occurrences of invasive species (where noted along the streambank) were greater than 20% cover, but most were less than 10%, as compared to generally 10% or less in 2020

        - In 2021, the percent cover by invasive plant species along the entire stream bank was estimated at 4.8%.

- Limited areas of invasive vegetation were also present on the floodplain during more recent surveys (2019–2021):
    - In 2021, invasive species observed along certain floodplain transects included common reed, Chinese bush clover, Japanese honeysuckle, and multiflora rose; the most extensive was Chinese bush clover at 10 to 60% cover at those locations
        - In 2020, noted species included common reed, Chinese bush clover, and multiflora rose
        - In 2019, common reed and Chinese bush clover were noted
    - In 2021, the estimated percent cover by invasive plant species over all floodplain transects was 11.6%
    - In 2020, where invasive species were found only along certain floodplain transects, estimated percent cover ranged from <5% to 50%

- 15% (maximum) barren ground on banks and floodplains:
    - In 2021, 2% of the total bank length (36 of 2,216 feet) was barren, i.e., without vegetation or other bank treatments. Tidal mudflat areas make up another 20% of bank length (455 feet) and were included in vegetated totals.
        - In 2020, about 5% of the total bank length (103 of 2194 feet) had been barren (without vegetation or other bank treatments), with another 22% (494 feet) in tidal mudflats. This is compared to 11% (222 of 2197 feet) in 2019, and 7% (160 of 2300 feet) in 2018.
    - About 0.14 acres of the wetland area (14%) were occupied by tidal mudflats lacking vegetation, or only sparsely vegetated. None of the other floodplain wetland or upland areas were found to be barren in 2021, 2020, or 2019. In contrast, in 2018, an observed 25% of bare floodplain wetland area was observed, while bare upland areas were minimal.

5.2 COMPLETION OF STREAMBANK AND FLOODPLAIN MONITORING REQUIREMENTS

Year 2021 was the final year planned for streambank and floodplain monitoring. Maintenance activities conducted in fall 2021 included invasive species control in areas with common reed and other invasive species to determine whether treatments to date have effectively controlled growth of invasive plants, and to determine whether additional treatments are needed to eliminate spreading. Note that outside of those areas previously identified in the mudflats and wetland

benches, no significant bare patches in need of replanting or reseeding were identified in 2021. In accordance with the project's wetlands permit (State of Maryland, Wetlands License No. 15-1119), additional planting of emergent herbaceous vegetation may be appropriate.

With the completion of the 2021 monitoring documented in this report, streambank and floodplain monitoring for Cow Pen Creek is complete and no further monitoring is required.

SECTION 6
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FIGURES

Figure 2-1 Extent of Cow Pen Creek Stream Channel and Floodplain Reconstruction

Figure 2-2 Stream and Floodplain Cross-Sections, Cow Pen Creek Restoration

Figure 3-1 Monthly Precipitation Totals, January 2020–September 2021, Baltimore/Washington International Airport.

Figure 3-2 Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River, August 19 – September 8, 2021

Figure 4-1 Cow Pen Creek Study Area–2021

Figure 4-2 Photograph locations of representative areas and other features of note along Cow Pen Creek–2021

Figure 4-3 Observed locations of bank erosion along Cow Pen Creek–2021

Figure 4-4 Observed locations of invasive plant species along Cow Pen Creek–2021

Figure 4-5 Noted areas of concern for erosion/vegetative cover along Cow Pen Creek–2021

Figure 4-6 Cow Pen Creek Study Area–2021 Field Survey Points

SECTION 2 FIGURES

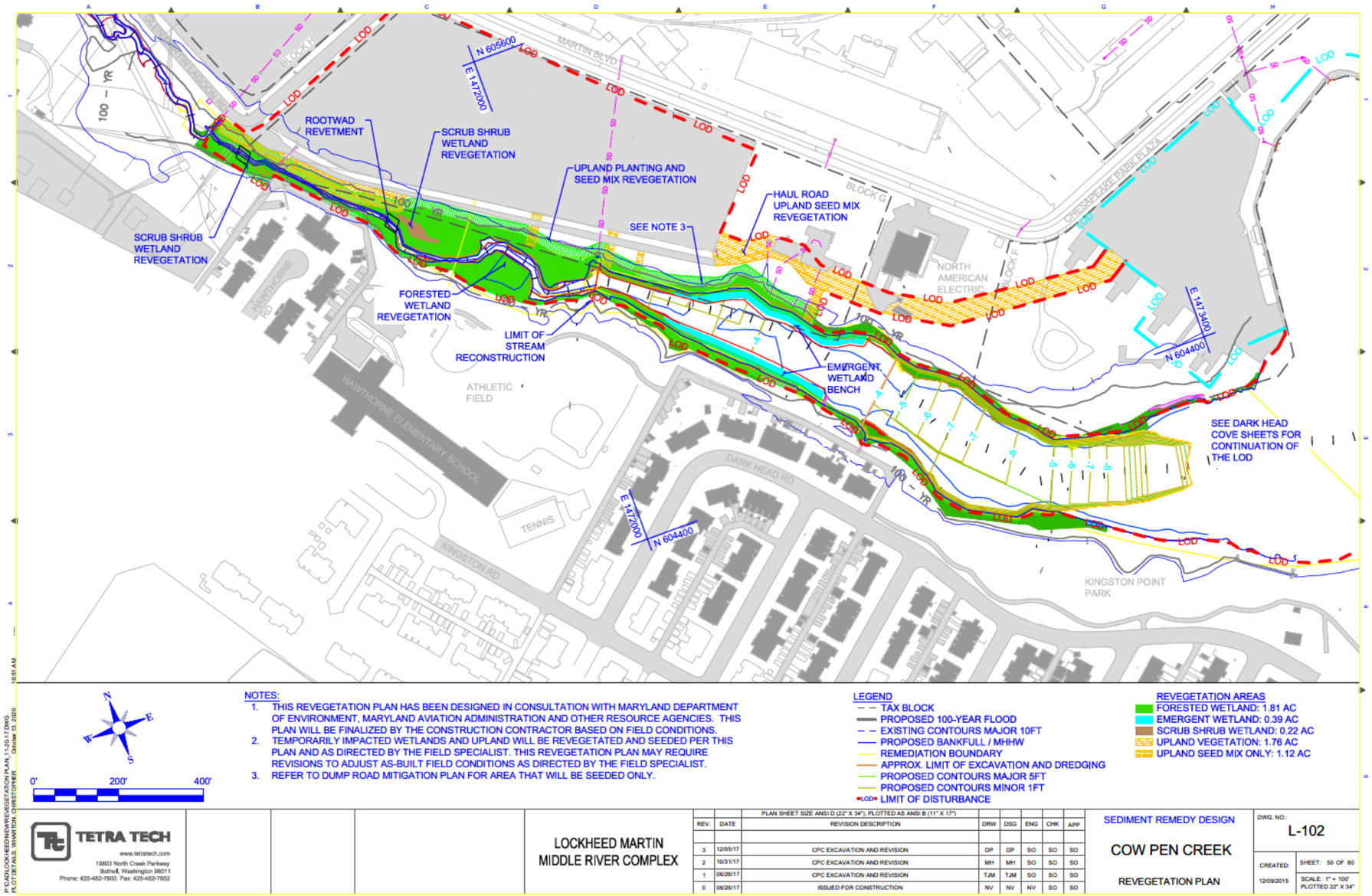
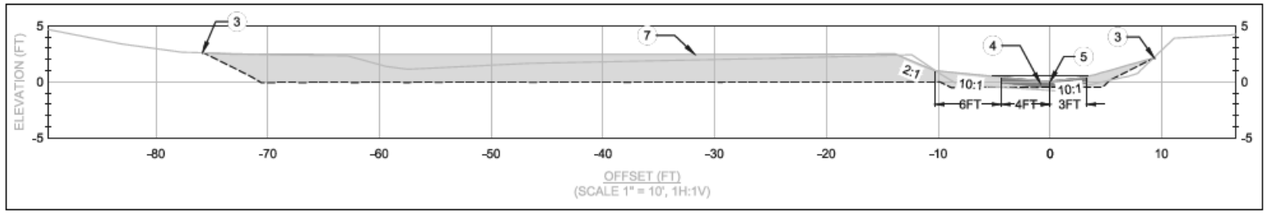
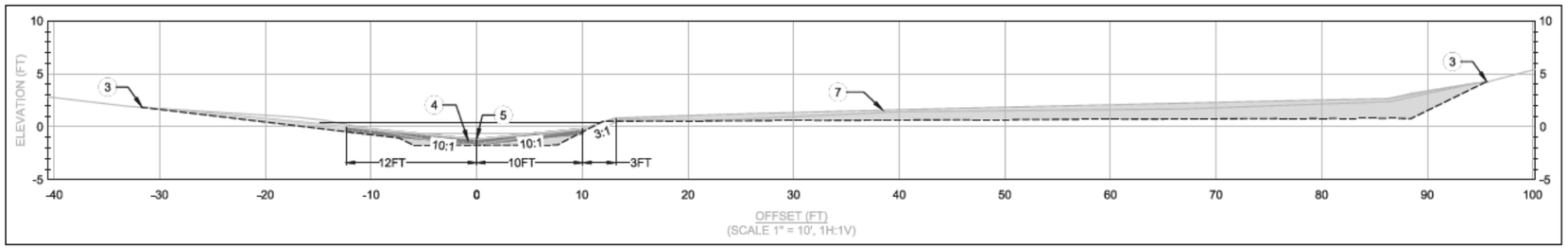


Figure 2-1. Extent of Cow Pen Creek Stream Channel and Floodplain Reconstruction
(Source: November 2017 revegetation plan [Tetra Tech, 2017])

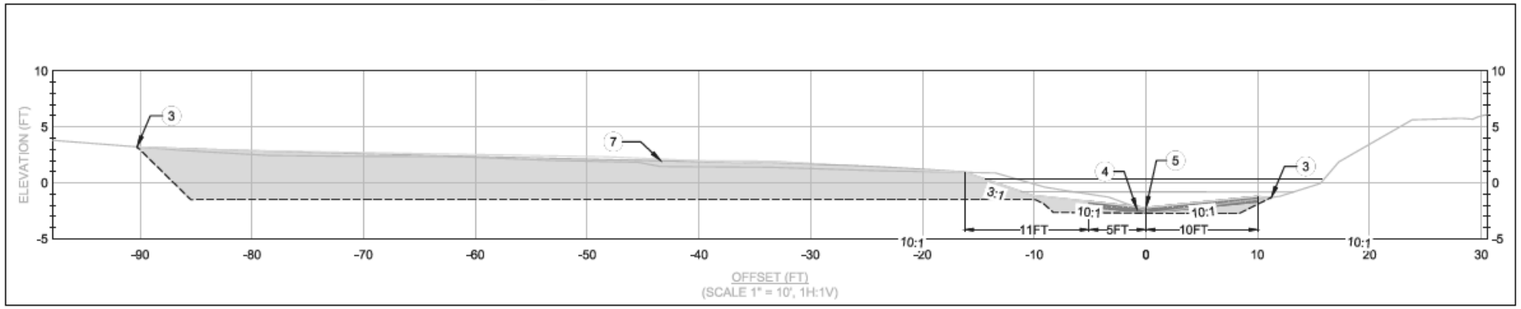


H C-225 CROSS SECTION AT STATION 6+72

NOTES:
3 EXISTING GRADE MATCH POINT.
4 STREAMBED MIX WILL BE PLACED ALONG BOTTOM OF CHANNEL AT 6IN MINIMUM DEPTH.
5 PROPOSED THALWEG.
7 PLACE TEMPORARY EROSION CONTROL MAT ALONG EXCAVATED AND BACKFILLED SLOPES.



I C-226 CROSS SECTION AT STATION 8+66



J C-226 CROSS SECTION AT STATION 9+75

LEGEND:
EXISTING GRADE
PROPOSED GRADE
REMEDIATION GRADE
BACKFILL
TOE ROCK
STREAM BED MIX
PROPOSED BANKFULL/MHHW
PROPOSED BASEFLOW/MLLW

P:\CAD\LOCKHEED\NEW\STREAM RECONSTRUCTION SHEETS.DWG
PLOT DETAILS: WHARTON, CHRISTOPHER September 20, 2018 11:31 AM

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-482-7600 Fax: 425-482-7652

LOCKHEED MARTIN
MIDDLE RIVER COMPLEX

PLAN SHEET SIZE ANSI D (22" X 34"), PLOTTED AS ANSI B (11" X 17")

REV.	DATE	REVISION DESCRIPTION	DRW	DSG	ENG	CHK	APP
3	12/05/17	CPC EXCAVATION AND REVISION	DP	DP	SO	SO	SO
2	10/31/17	CPC EXCAVATION AND REVISION	MH	MH	SO	SO	SO
1	06/26/17	CPC EXCAVATION AND REVISION	TJM	TJM	SO	SO	SO
0	06/26/17	ISSUED FOR CONSTRUCTION	NV	NV	NV	SO	SO

SEDIMENT REMEDY DESIGN
COW PEN CREEK
STREAM RESTORATION SECTIONS

DWG. NO.: C-231
CREATED: 12/09/2015
SHEET: 46 OF 80
SCALE: 1" = 5'
PLOTTED 22" X 34"

Figure 2-2. Stream and Floodplain Cross-Sections, Cow Pen Creek Restoration
(Source: Tetra Tech, 2016)

SECTION 3 FIGURES

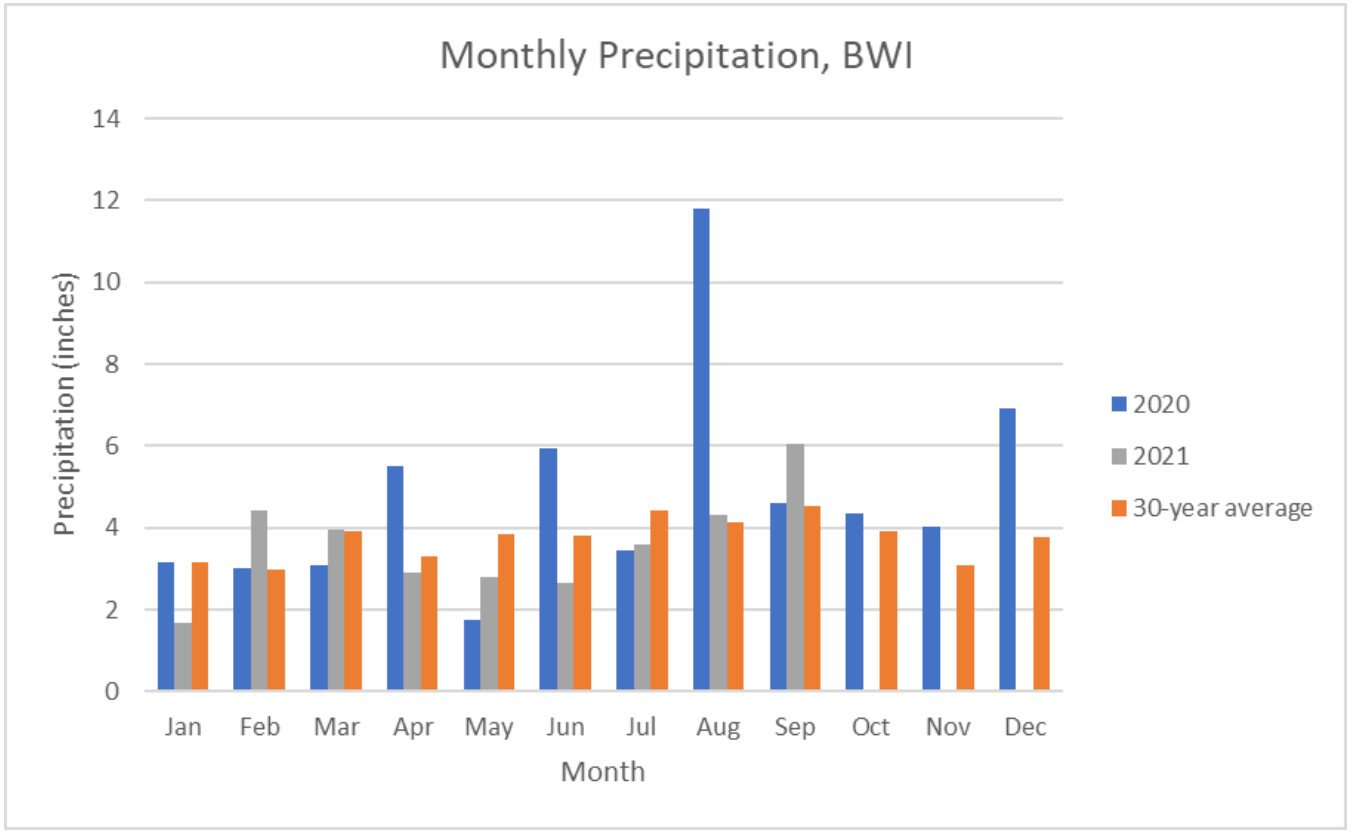


Figure 3-1. Monthly Precipitation Totals, January 2020–September 2021, Baltimore/Washington International Airport.

(Based on historical data from Weather Underground)
(Figure was generated on October 05, 2021 and does not include any of October – December 2021)

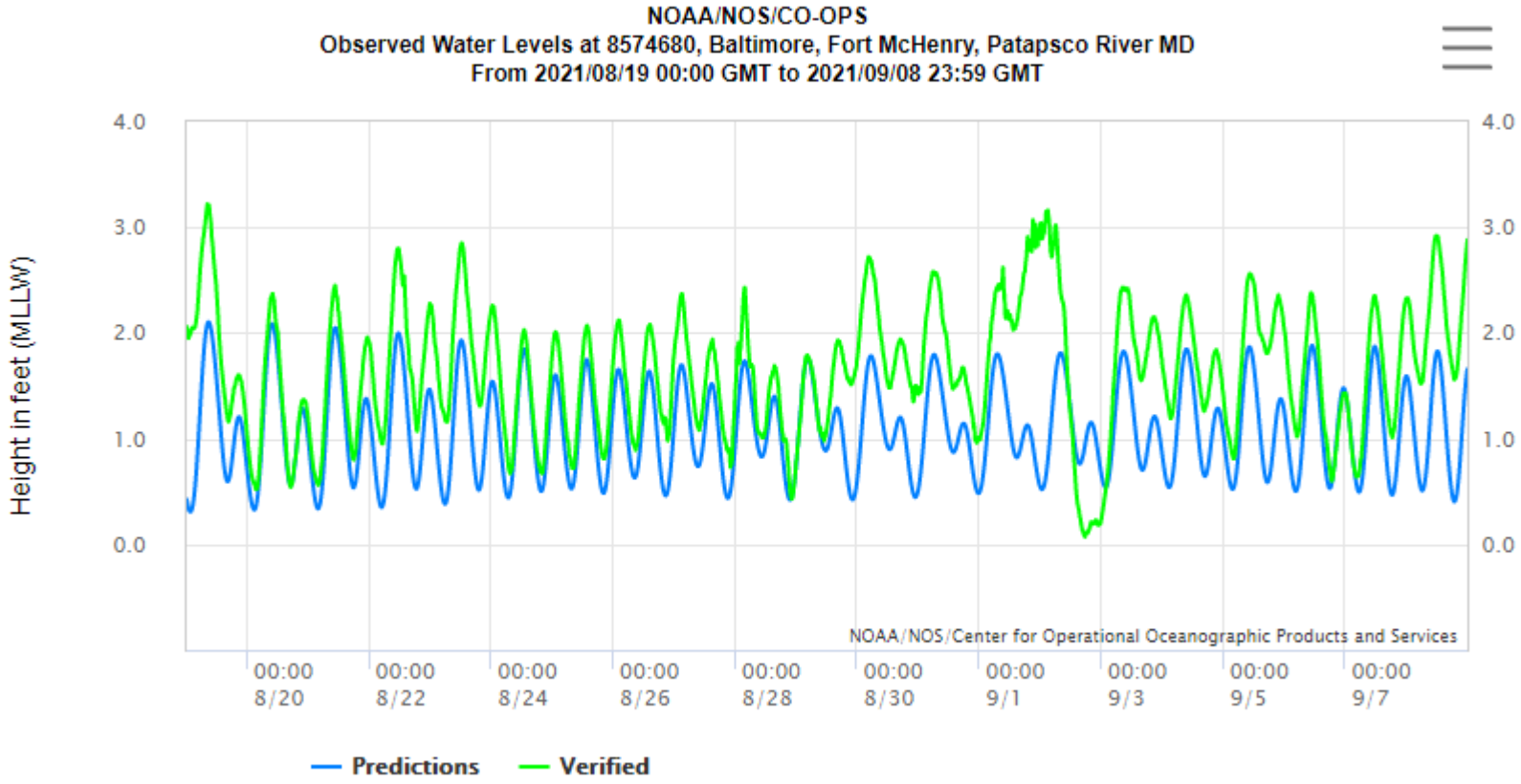


Figure 3-2. Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River, August 19 – September 8, 2021.

[Observed values (green line) are compared with long-term predicted levels (blue line)].
NOAA data from
https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20210819&edate=20210908&timezone=GMT&datum=MLLW&interval=6&action=

SECTION 4 FIGURES

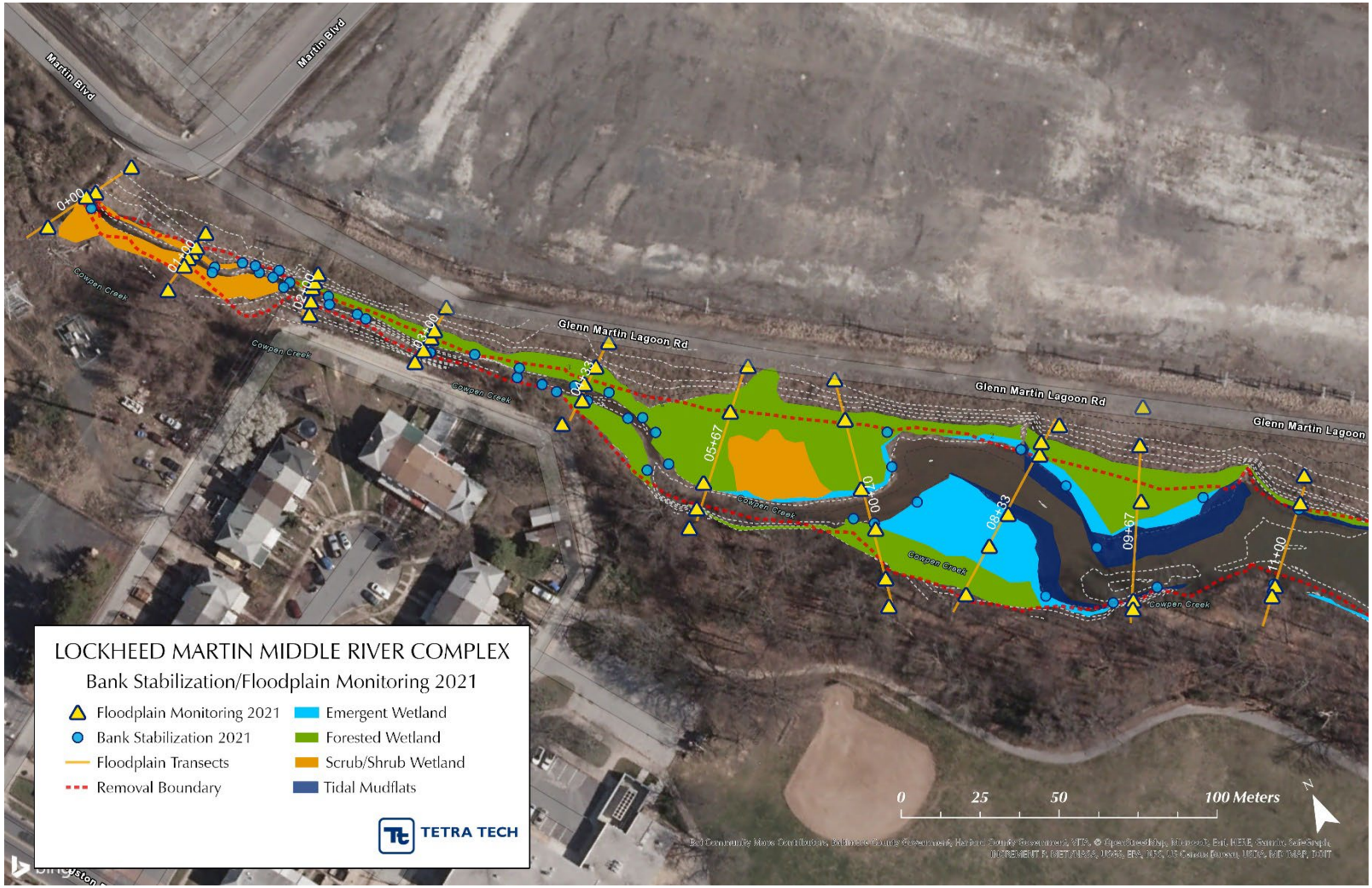
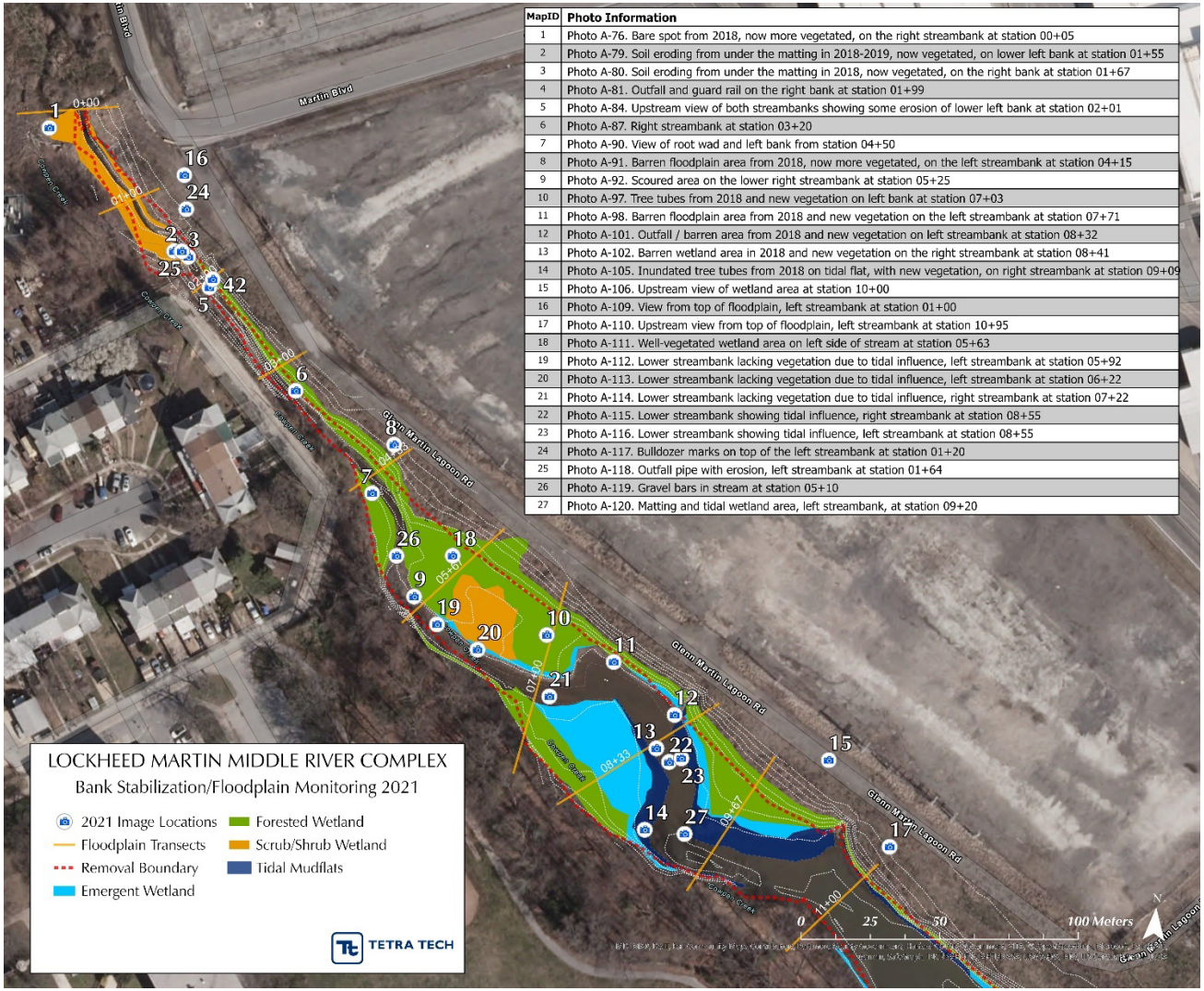


Figure 4-1. Cow Pen Creek Study Area–2021

[Shows bank stabilization monitoring segment endpoints along both streambanks (blue circles) and floodplain survey points (yellow triangles) along 10 floodplain transects. Upland and wetland vegetation types are from the 2021 wetland field survey (Tetra Tech 2021).]



MapID	Photo Information
1	Photo A-76. Bare spot from 2018, now more vegetated, on the right streambank at station 00+05
2	Photo A-79. Soil eroding from under the matting in 2018-2019, now vegetated, on lower left bank at station 01+55
3	Photo A-80. Soil eroding from under the matting in 2018, now vegetated, on the right bank at station 01+67
4	Photo A-81. Outfall and guard rail on the right bank at station 01+99
5	Photo A-84. Upstream view of both streambanks showing some erosion of lower left bank at station 02+01
6	Photo A-87. Right streambank at station 03+20
7	Photo A-90. View of root wad and left bank from station 04+50
8	Photo A-91. Barren floodplain area from 2018, now more vegetated, on the left streambank at station 04+15
9	Photo A-92. Scoured area on the lower right streambank at station 05+25
10	Photo A-97. Tree tubes from 2018 and new vegetation on left bank at station 07+03
11	Photo A-98. Barren floodplain area from 2018 and new vegetation on the left streambank at station 07+71
12	Photo A-101. Outfall / barren area from 2018 and new vegetation on left streambank at station 08+32
13	Photo A-102. Barren wetland area in 2018 and new vegetation on the right streambank at station 08+41
14	Photo A-105. Inundated tree tubes from 2018 on tidal flat, with new vegetation, on right streambank at station 09+09
15	Photo A-106. Upstream view of wetland area at station 10+00
16	Photo A-109. View from top of floodplain, left streambank at station 01+00
17	Photo A-110. Upstream view from top of floodplain, left streambank at station 10+95
18	Photo A-111. Well-vegetated wetland area on left side of stream at station 05+63
19	Photo A-112. Lower streambank lacking vegetation due to tidal influence, left streambank at station 05+92
20	Photo A-113. Lower streambank lacking vegetation due to tidal influence, left streambank at station 06+22
21	Photo A-114. Lower streambank lacking vegetation due to tidal influence, right streambank at station 07+22
22	Photo A-115. Lower streambank showing tidal influence, right streambank at station 08+55
23	Photo A-116. Lower streambank showing tidal influence, left streambank at station 08+55
24	Photo A-117. Bulldozer marks on top of the left streambank at station 01+20
25	Photo A-118. Outfall pipe with erosion, left streambank at station 01+64
26	Photo A-119. Gravel bars in stream at station 05+10
27	Photo A-120. Matting and tidal wetland area, left streambank, at station 09+20

Figure 4-2. Photograph locations of representative areas and other features of note along Cow Pen Creek–2021

**[See Appendix A, Photos A-76 through A-120, for more details.
Upland and wetland vegetation types are from the 2021 wetland survey.]**

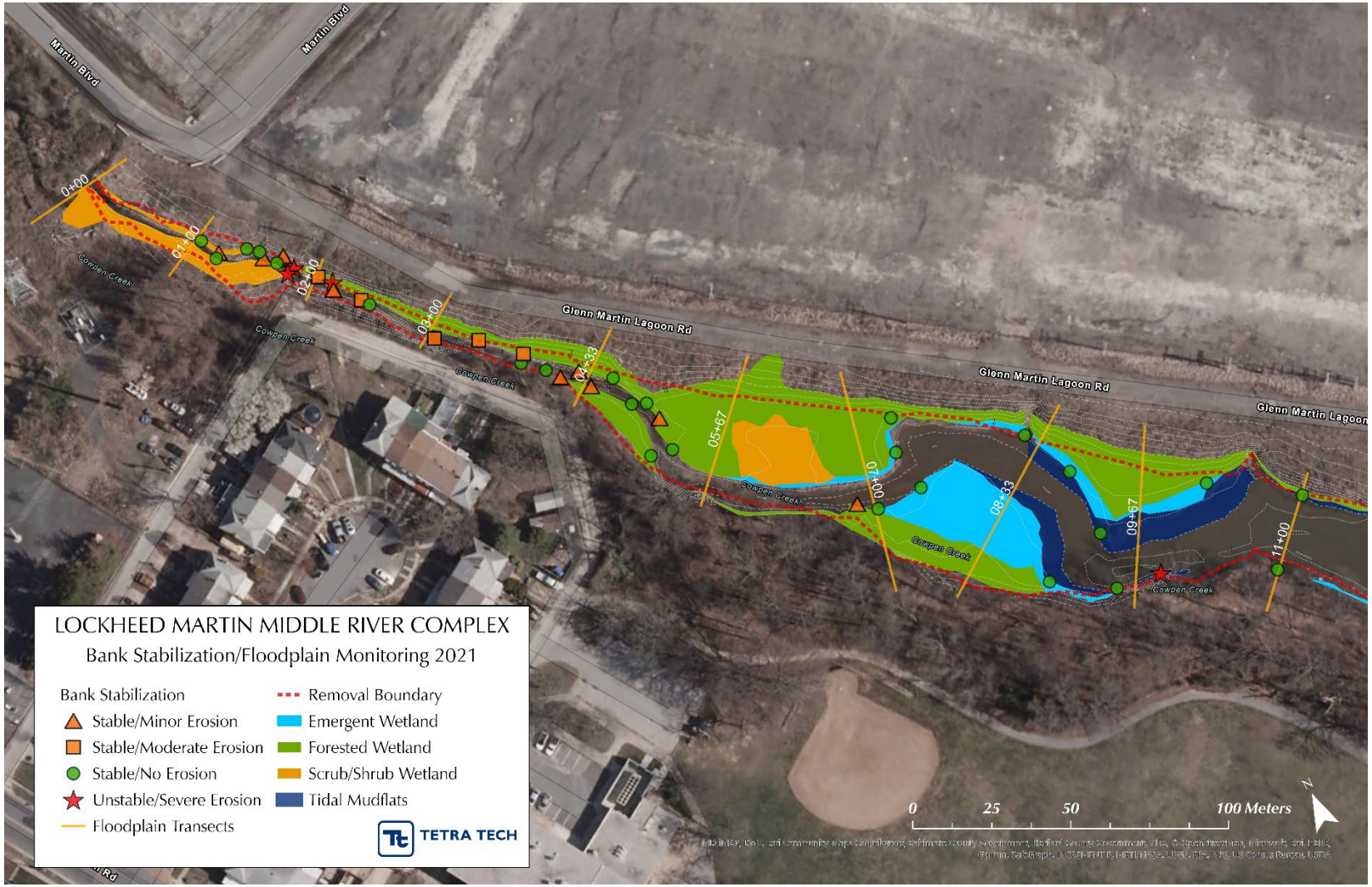
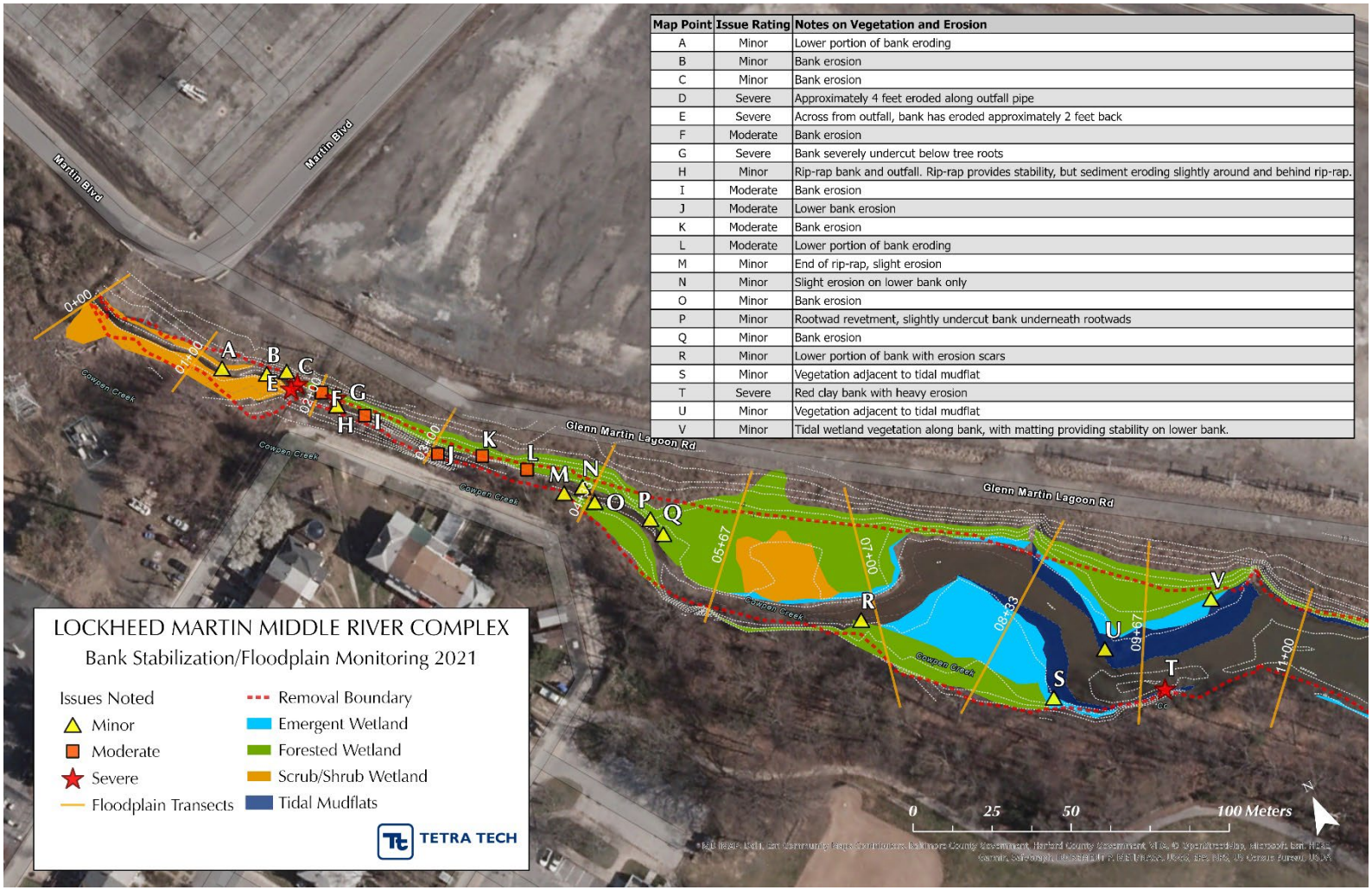


Figure 4-3. Observed locations of bank erosion along Cow Pen Creek–2021
[Bank stabilization monitoring refers to observations and data collected during the streambank assessment. Stability and erosion ratings noted in lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from the 2021 wetland survey.]

Figure 4-4. Observed locations of invasive plant species along Cow Pen Creek–2021

[Bank stabilization monitoring refers to observations and data collected during the streambank assessment. Upland and wetland vegetation types are from the 2021 wetland survey].



Map Point	Issue Rating	Notes on Vegetation and Erosion
A	Minor	Lower portion of bank eroding
B	Minor	Bank erosion
C	Minor	Bank erosion
D	Severe	Approximately 4 feet eroded along outfall pipe
E	Severe	Across from outfall, bank has eroded approximately 2 feet back
F	Moderate	Bank erosion
G	Severe	Bank severely undercut below tree roots
H	Minor	Rip-rap bank and outfall. Rip-rap provides stability, but sediment eroding slightly around and behind rip-rap.
I	Moderate	Bank erosion
J	Moderate	Lower bank erosion
K	Moderate	Bank erosion
L	Moderate	Lower portion of bank eroding
M	Minor	End of rip-rap, slight erosion
N	Minor	Slight erosion on lower bank only
O	Minor	Bank erosion
P	Minor	Rootwad revetment, slightly undercut bank underneath rootwads
Q	Minor	Bank erosion
R	Minor	Lower portion of bank with erosion scars
S	Minor	Vegetation adjacent to tidal mudflat
T	Severe	Red clay bank with heavy erosion
U	Minor	Vegetation adjacent to tidal mudflat
V	Minor	Tidal wetland vegetation along bank, with matting providing stability on lower bank.

Figure 4-5 Noted areas of concern for erosion/vegetative cover along Cow Pen Creek–2021
[Upland and wetland vegetation types are from the 2021 wetland survey.]

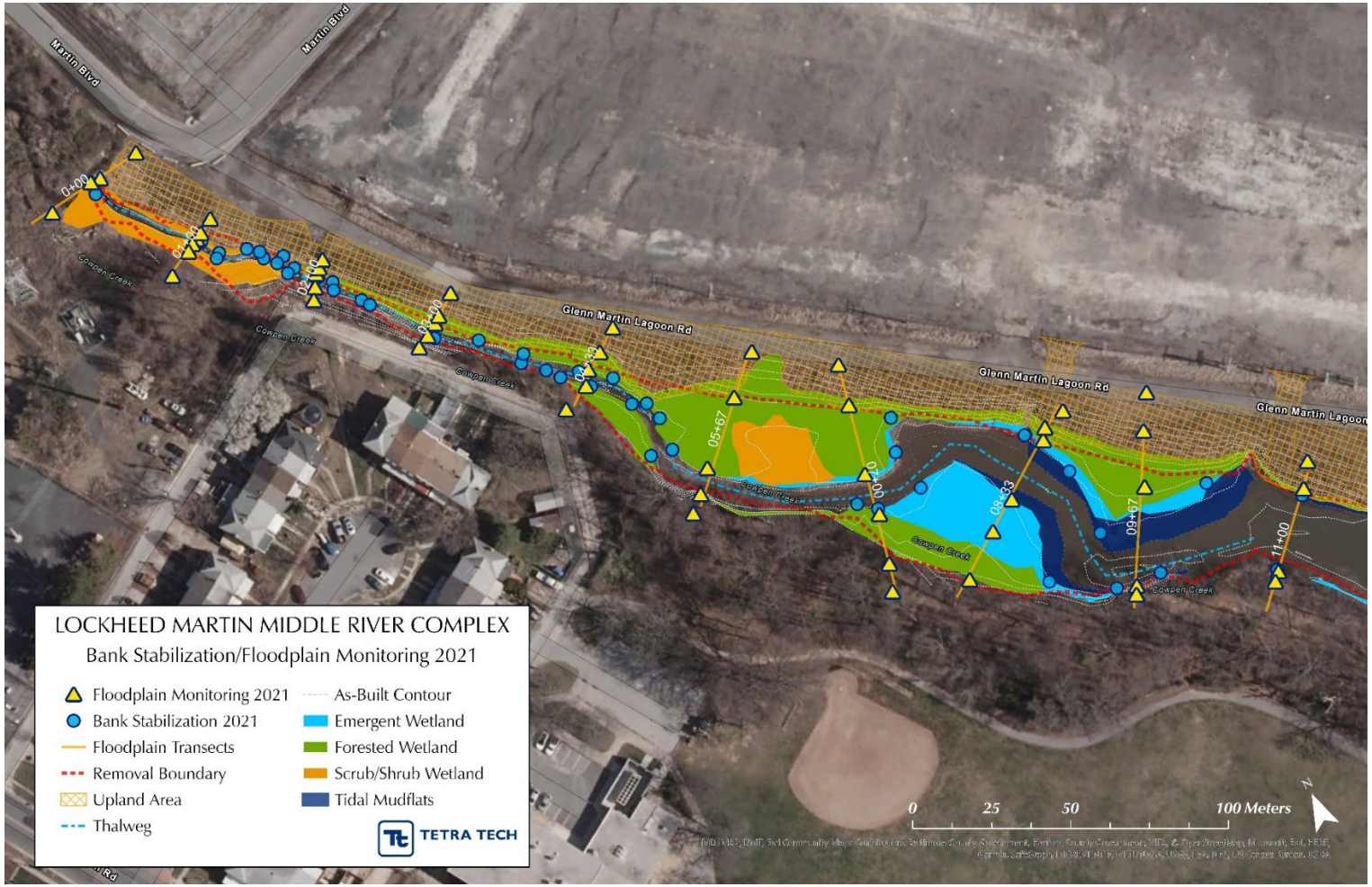


Figure 4-6. Cow Pen Creek study area– 2021 field survey points

[Floodplain monitoring refers to observations and data collected during floodplain transect surveys. Floodplain transect start points (yellow triangles closest to stream along transect) were field-placed at top of bank on both sides of stream. As-built survey is from April 2019; upland and wetland vegetation types are from the 2021 wetland survey.]

TABLES

Table 3-1– Daily Rainfall Totals prior to and including the Summer 2021 Monitoring Period

Table 3-2– Monthly Precipitation Totals, September 2020 – September 2021

Table 4-1– Conditions Observed by Streambank Segment, September 2021

Table 4-2– Vegetation Observed by Streambank Segment, September 2021

Table 4-3–Summary of Streambank Conditions, September 2021

Table 4-4–Conditions Observed within Floodplain Transect Segments, September 2021

Table 4-5–Summary of Transect Length as Tidal Mudflat, from 2021 Wetland Survey

Table 5-1- Comparison of Annual Streambank and Floodplain Monitoring Results to Performance Standards, 2018 to 2021

SECTION 3 TABLES

Table 3-1: Daily Rainfall Totals Prior to and Including the Summer 2021 Monitoring Period

Date	Baltimore/Washington International Airport (inches)	Goldentree/Orems Elementary (inches)	Carroll Island (inches)
8/31/2021	0.69	0.00	0.00
9/1/2021	2.02	3.94	5.64
9/2/2021	2.11	0.00	0.00
9/3/2021	0.00	0.00	0.00
9/4/2021	0.00	0.00	0.00
9/5/2021	0.00	0.04	0.05
9/6/2021	0.07	0.04	0.04
9/7/2021	0.00	0.00	0.00
9/8/2021	0.00	0.00	0.00

(Based on historical data from Weather Underground)

Table 3-2: Monthly Precipitation Totals, September 2020 through September 2021

Month	Monthly Precipitation, Baltimore/Washington International Airport (inches)		Monthly Precipitation, Carroll Island (inches)
	30-Year Average	Observed Monthly Total	Observed Monthly Total
Sep 2020	4.50	4.60	6.04
Oct 2020	3.90	4.36	5.34
Nov 2020	3.09	4.01	6.15
Dec 2020	3.78	6.92	4.51
Jan 2021	3.17	1.67	2.21
Feb 2021	2.98	4.41	4.77
Mar 2021	3.90	3.94	5.16
Apr 2021	3.32	2.91	2.89
May 2021	3.85	2.79	2.86
Jun 2021	3.82	2.65	4.84
Jul 2021	4.41	3.59	3.40
Aug 2021	4.12	4.33	5.08
Sep 2021	4.53	6.04	10.14

(Based on historical data from Weather Underground)

SECTION 4 TABLES

Table 4-1– Conditions Observed by Streambank Segment, September 2021

(*Indicates minor to moderate erosion, but a stable streambank)

Bank segment			Condition			Segment length by vegetation and stability class				
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, stable, minor to moderate erosion (feet)	Vegetation, unstable, actively eroding (feet)
Left	01+02	94	Yes	Stable	No	0	0	94	0	0
Left	01+19	17	Yes	Stable*	Minor	0	0	0	17	0
Left	01+47	28	Yes	Stable	No	0	0	28	0	0
Left	01+54	7	Yes	Stable	No	0	0	7	0	0
Left	01+73	19	Yes	Stable*	Minor	0	0	0	19	0
Left	01+86	13	Yes	Unstable	Severe	0	0	0	0	13
Left	02+06	20	Yes	Stable*	Moderate	0	0	0	20	0
Left	02+18	12	Yes	Unstable	Severe	0	0	0	0	12
Left	03+46	128	Yes	Stable*	Moderate	0	0	0	128	0
Left	03+85	39	Yes	Stable*	Moderate	0	0	0	39	0
Left	04+31	46	Yes	Stable*	Minor	0	0	0	46	0
Left	04+57	26	Yes	Stable	No	0	0	26	0	0
Left	04+90	33	Yes	Stable	No	0	0	33	0	0

Table 4-1– Conditions Observed by Streambank Segment, September 2021

(*Indicates minor to moderate erosion, but a stable streambank)

Bank segment			Condition			Segment length by vegetation and stability class				
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, stable, minor to moderate erosion (feet)	Vegetation, unstable, actively eroding (feet)
Left	05+06	16	Yes	Stable*	Minor	0	0	0	16	0
Left	05+32	26	Yes	Stable	No	0	0	26	0	0
Left	07+52	220	Yes	Stable	No	0	0	220	0	0
Left	07+72	20	Yes	Stable	No	0	0	20	0	0
Left	08+36	64	Yes	Stable	No	0	0	64	0	0
Left	08+83	47	Yes	Stable	No	0	0	47	0	0
Left	09+28	45	Yes	Stable	No	0	0	45	0	0
Left	10+63	135	Yes	Stable	No	0	0	135	0	0
Left	11+17	54	Yes	Stable	No	0	0	54	0	0
Right	01+20	112	Yes	Stable	No	0	0	112	0	0
Right	01+60	40	Yes	Stable*	Minor	0	0	0	40	0
Right	01+71	11	Yes	Stable	No	0	0	11	0	0
Right	01+82	11	Yes	Unstable	Severe	0	0	0	0	11

Table 4-1– Conditions Observed by Streambank Segment, September 2021

(*Indicates minor to moderate erosion, but a stable streambank)

Bank segment			Condition			Segment length by vegetation and stability class				
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, stable, minor to moderate erosion (feet)	Vegetation, unstable, actively eroding (feet)
Right	02+22	40	Yes	Stable*	Minor	0	0	0	40	0
Right	02+46	24	Yes	Stable*	Moderate	0	0	0	24	0
Right	02+53	7	Yes	Stable	No	0	0	7	0	0
Right	03+13	60	Yes	Stable*	Moderate	0	0	0	60	0
Right	03+85	72	Yes	Stable	No	0	0	72	0	0
Right	04+06	21	Yes	Stable	No	0	0	21	0	0
Right	04+19	13	Yes	Stable*	Minor	0	0	0	13	0
Right	04+45	26	Yes	Stable*	Minor	0	0	0	26	0
Right	04+82	37	Yes	Stable	No	0	0	37	0	0
Right	05+32	50	Yes	Stable	No	0	0	50	0	0
Right	06+97	165	Yes	Stable*	Minor	0	0	0	165	0
Right	07+12	15	Yes	Stable	No	0	0	15	0	0
Right	07+46	34	Yes	Stable	No	0	0	34	0	0

Table 4-1– Conditions Observed by Streambank Segment, September 2021

(*Indicates minor to moderate erosion, but a stable streambank)

Bank segment			Condition			Segment length by vegetation and stability class				
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, stable, minor to moderate erosion (feet)	Vegetation, unstable, actively eroding (feet)
Right	09+40	194	Yes	Stable	No	0	0	194	0	0
Right	09+69	29	Yes	Stable	No	0	0	29	0	0
Right	10+05	36	No	Unstable	Severe	0	36	0	0	0
Right	11+15	110	Yes	Stable	No	0	0	110	0	0

Table 4-2– Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2021

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present	Invasive species name, estimated percent cover	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
Left	01+02	94	Herbaceous Cover	Yes	Yes	No		Yes	Common reed, 0-5%	None
Left	01+19	17	Herbaceous Cover	No	Yes	No	Lower portion of bank eroding away slightly	No		None
Left	01+47	28	Herbaceous Cover	No	No	No		No		None
Left	01+54	7	Herbaceous Cover	Yes	Yes	No	Coir log at bank, repaired January 2021	No		None
Left	01+73	19	Herbaceous Cover	No	No	No		Yes	Chinese bush clover, 20%	None
Left	01+86	13	Herbaceous Cover	No	No	No	Approximately 4 feet eroded along outfall pipe	No		Outfall
Left	02+06	20	Herbaceous Cover	No	No	No		No		None
Left	02+18	12	Herbaceous Cover	Yes	Yes	Yes	Bank severely undercut below tree roots	No		Tree
Left	03+46	128	Herbaceous Cover	Yes	Yes	Yes		No		None
Left	03+85	39	Herbaceous Cover	No	Yes	No	Lower portion of bank eroding away	No		None
Left	04+31	46	Herbaceous Cover	Yes	Yes	Yes	Slight erosion on lower bank only	No		None
Left	04+57	26	Herbaceous Cover	No	Yes	Yes	Stream widens at this point and the bank has a lower floodplain elevation	No		None

Table 4-2– Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2021

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present	Invasive species name, estimated percent cover	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
Left	04+90	33	Herbaceous Cover	Yes	Yes	No	Rootwad revetment, undercut bank underneath root wads	No		Rootwad structure
Left	05+06	16	Herbaceous Cover	No	No	No		No		None
Left	05+32	26	Herbaceous Cover	Yes	Yes	No	Cobble lining stream and bottom of bank. Top of bank includes large low-lying wetland area.	No		None
Left	07+52	220	Herbaceous Cover	No	Yes	No		No		None
Left	07+72	20	Herbaceous Cover	No	Yes	No	Tidal marsh	No		None
Left	08+36	64	Herbaceous Cover	No	Yes	Yes		Yes	Chinese bush clover, 10%	None
Left	08+83	47	Herbaceous Cover	No	Yes	No		No		None
Left	09+28	45	Herbaceous Cover	No	No	No	Tidal emergent wetland on bank	No		None
Left	10+63	135	Herbaceous Cover	No	No	Yes	Tidal wetland on bank. Matting on lower part of bank.	No		None
Left	11+17	54	Herbaceous Cover	No	Yes	No	Tidal bank	Yes	Chinese bush clover, 30%	Outfall
Right	01+20	112	Herbaceous Cover	No	Yes	No		Yes	Common reed, 10%	None
Right	01+60	40	Herbaceous Cover	No	Yes	Yes		No		None

Table 4-2– Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2021

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present	Invasive species name, estimated percent cover	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
Right	01+71	11	Herbaceous Cover	No	No	No		No		None
Right	01+82	11	Herbaceous Cover	No	No	No	Across from outfall, bank has eroded approximately 2 feet back	No		Outfall
Right	02+22	40	Herbaceous Cover	Yes	Yes	No	Rip-rap bank with outfall present. The riprap makes the bank ultimately stable, but sediment from around and behind the riprap is eroding.	No		Outfall, rip-rap
Right	02+46	24	Herbaceous Cover	Yes	Yes	Yes		No		None
Right	02+53	7	Herbaceous Cover	No	Yes	No		No		None
Right	03+13	60	Herbaceous Cover	Yes	Yes	Yes	Lower bank erosion, more so than last year.	Yes	Japanese honeysuckle, 20%	None
Right	03+85	72	Herbaceous Cover	Yes	Yes	Yes	Rip-rap	Yes	Japanese honeysuckle, 0-5%; Rose of Sharon, 0-5%	Rip-rap
Right	04+06	21	Herbaceous Cover	Yes	Yes	Yes		Yes	Japanese honeysuckle, 10%; Rose of Sharon,20%	None

Table 4-2– Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2021

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present	Invasive species name, estimated percent cover	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
Right	04+19	13	Herbaceous Cover	Yes	Yes	No	End of rip-rap	Yes	Japanese honeysuckle, 20%; Rose of Sharon, 10%	Rip-rap
Right	04+45	26	Herbaceous Cover	Yes	Yes	No		Yes	Japanese honeysuckle, 0-5%	None
Right	04+82	37	Herbaceous Cover	No	No	No		No		None
Right	05+32	50	Herbaceous Cover	No	No	No	Bank includes emergent wetland area	No		None
Right	06+97	165	Herbaceous Cover	Yes	Yes	Yes	Lower portion of bank with erosion scars	Yes	Japanese honeysuckle, 10%	None
Right	07+12	15	Herbaceous Cover	No	No	No		No		None
Right	07+46	34	Herbaceous Cover	Yes	No	No	Bank includes tidal flat	No		None
Right	09+40	194	Herbaceous Cover	Yes	Yes	No		No		None
Right	09+69	29	Herbaceous Cover	Yes	Yes	Yes		No		None
Right	10+05	36	No	No	No	No	Red clay bank with heavy erosion	No		None
Right	11+15	110	Herbaceous Cover	No	Yes	Yes		Yes	Chinese bush clover, 10%; Multiflora rose, 0-5%;	None

Table 4-3– Summary of Streambank Conditions, September 2021

	Total streambank length by vegetation and stability class					
Bank	**No vegetation, stable, no erosion (feet)**	**No vegetation, unstable, actively eroding (feet)**	**Vegetation, stable, no erosion (feet)**	**Vegetation, stable, minor to moderate erosion (feet)**	**Vegetation, unstable, actively eroding (feet)**	**Total (feet)**
Total length, left bank	0	0	799	285	25	1,109
Total length, right bank	0	36	692	368	11	1,107
Total length, both banks	0	36	1491	653	36	2,216

Table 4-4– Conditions Observed within Floodplain Transect Segments, September 2021

Stream bank	Station	Segment start and end points, as distance from top of bank (feet)		Upland or wetland revegetation area	Herbaceous vegetation cover present	Woody vegetation by height class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes
		Start point (feet)	End point (feet)			Woody vegetation present < 3 feet	Woody vegetation present 3–15 feet	Woody vegetation present >15 feet			
Left	00+00	0	40	Upland	Yes	No	Yes	No		Yes	Chinese bush clover, 20%
Left	01+00	0	4	Wetland	No	Yes	Yes	No		No	
		4	20	Upland	Yes	No	No	No		No	
Left	02+00	0	4	Wetland	Yes	No	Yes	Yes		No	
		4	15	Upland	Yes	No	Yes	Yes		No	
Left	03+00	0	6	Wetland	Yes	No	Yes	No		No	
		6	34	Upland	No	Yes	Yes	No		No	
Left	04+33	0	13	Wetland	Yes	Yes	Yes	Yes		No	
		13	41	Upland	Yes	No	Yes	Yes		No	
Left	05+67	0	62	Wetland	Yes	No	Yes	Yes		No	
		62	99	Upland	Yes	No	Yes	Yes		Yes	Common reed, 10%; Chinese bush clover, 10%
Left	07+00	0	57	Wetland	Yes	No	Yes	No		No	

Table 4-4– Conditions Observed within Floodplain Transect Segments, September 2021

Stream bank	Station	Segment start and end points, as distance from top of bank (feet)		Upland or wetland revegetation area	Herbaceous vegetation cover present	Woody vegetation by height class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes
		Start point (feet)	End point (feet)			Woody vegetation present < 3 feet	Woody vegetation present 3–15 feet	Woody vegetation present >15 feet			
Left	07+00	57	88	Upland	Yes	Yes	Yes	No		Yes	Chinese bush clover, 50%
Left	08+33	0	11	Wetland	Yes	No	No	No		No	
		11	37	Upland	Yes	No	Yes	Yes		Yes	Multiflora rose, 10%
Left	09+67	0	47	Wetland	Yes	No	Yes	No		Yes	Chinese bush clover, 30%
		47	75	Upland	Yes	No	Yes	No		Yes	Chinese bush clover, 60%
Left	11+00	0	21	Upland	Yes	No	Yes	No		Yes	Chinese bush clover, 50%; Japanese honeysuckle, 0-5%
Right	00+00	0	35	Upland	Yes	No	Yes	No		Yes	Common reed, 0-5%
Right	01+00	0	6	Wetland	Yes	No	Yes	No		No	
		6	27	Upland	Yes	No	Yes	Yes		No	
Right	02+00	0	11	Upland	Yes	Yes	Yes	Yes		No	
Right	03+00	0	12	Upland	Yes	No	Yes	Yes		No	

Table 4-4– Conditions Observed within Floodplain Transect Segments, September 2021

Stream bank	Station	Segment start and end points, as distance from top of bank (feet)		Upland or wetland revegetation area	Herbaceous vegetation cover present	Woody vegetation by height class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes
		Start point (feet)	End point (feet)			Woody vegetation present < 3 feet	Woody vegetation present 3–15 feet	Woody vegetation present >15 feet			
Right	04+33	0	18	Upland	Yes	No	Yes	Yes		No	
Right	05+67	0	15	Upland	Yes	No	Yes	Yes		Yes	Multiflora rose, 10%; Japanese honeysuckle, 0-5%
Right	07+00	0	19	Wetland	Yes	No	Yes	No		No	
		19	44	Upland	No	Yes	Yes	Yes		Yes	Multiflora rose, 20%
Right	08+33	0	60	Wetland	Yes	No	Yes	No		No	
		60	75	Wetland	Yes	No	Yes	No		No	
Right	09+67	0	8	Upland	Yes	No	No	Yes		No	
Right	11+00	0	10	Upland	Yes	Yes	Yes	Yes		No	

Table 4-5– Summary of Transect Length as Tidal Mudflat, from 2021 Wetland Delineation

	Length of floodplain transect as tidal mudflat (feet)	**Length of floodplain transect – all wetland types** (feet)
Total length, left bank	44	247
Total length, right bank	10	140
Total length, both banks	54	387

SECTION 5 TABLES

Table 5-1: Comparison of Annual Streambank and Floodplain Monitoring Results to Performance Standards, 2018 to 2021

Performance Standard	2018	2019	2020	2021
Maximum of 10% unstable banks	2% unstable 6% moderate/minor erosion	3% unstable 17% moderate/minor erosion	3% unstable 21% moderate/minor erosion	3% unstable; severe erosion 29% moderate/minor erosion or channel adjustment approaching dynamic equilibrium
Minimum of 85% streambank length occupied by restoration treatments (vegetation and structural	93%	90% Including mudflat sections	95% total 73% + 22% of length is in mudflat sections along tidal area. Although bare along stream edge, vegetation is present further inland.	98% total 78% + 20% of length is in mudflat sections along tidal area. Although bare along stream edge, vegetation is present further inland.
Minimum of 85% native vegetation cover on banks and floodplains	83% cover on unarmored bank Invasive Phragmites in several small areas	89% cover on unarmored bank (including mudflat sections) Limited patches of invasive vegetation along banks and floodplain	95% total 73% cover on bank + 22% of length in mudflats, as described above All armored structures now covered by vegetation Limited patches of invasive vegetation along banks and floodplain	98% total 78% cover on bank + 20% of length in mudflats, as described above All armored structures now covered by vegetation Limited patches of invasive vegetation along banks (estimated 5% cover) and floodplain (estimated 12% cover)

Maximum of 15% barren ground on banks and floodplains	7% of bank length 25% of floodplain wetland area Minimal bare area in upland	11% of bank length 15% of floodplain wetland area None of upland areas bare	5% of bank length +22% in tidal mudflats 14% of floodplain wetland area (only where tidally inundated) None of upland areas bare	2% of bank length +20% in tidal mudflats 14% of floodplain wetland area (only where tidally inundated) None of upland areas bare

APPENDICES

APPENDIX A— 2021 PHOTO LOG

Photo A-1. Left streambank above station 01+02.

Photo A-2. Right streambank above station 01+20.

Photo A-3. Left streambank above station 01+19.

Photo A-4. Left streambank above station 01+47.

Photo A-5. Left streambank above station 01+54.

Photo A-6. Right streambank above station 01+60.

Photo A-7. Left streambank above station 01+73.

Photo A-8. Right streambank above station 01+71.

Photo A-9. Left streambank above station 01+86.

Photo A-10. Right streambank above station 01+82.

Photo A-11. Left streambank above station 02+06.

Photo A-12. Left streambank above station 02+18.

Photo A-13. Right streambank above station 02+22.

Photo A-14. Right streambank above station 02+46.

Photo A-15. Right streambank above station 02+53.

Photo A-16. Right streambank above station 03+13.

Photo A-17. Left streambank above station 03+46.

Photo A-18. Left streambank above station 03+85.

Photo A-19. Right streambank above station 03+85.

Photo A-20. Right streambank above station 04+06.

Photo A-21. Right streambank above station 04+19.

Photo A-22. Left streambank above station 04+31.

Photo A-23. Right streambank above station 04+45.

Photo A-24. Left streambank above station 04+57.

Photo A-25. Right streambank above station 04+82.

Photo A-26. Left streambank above station 04+90.

Photo A-27. Left streambank above station 05+06.

Photo A-28. Right streambank above station 05+32.

Photo A-29. Left streambank above station 05+32.

Photo A-30. Right streambank above station 06+97.

Photo A-31. Right streambank above station 07+12.

Photo A-32. Left streambank above station 07+52.

Photo A-33. Right streambank above station 07+46.

Photo A-34. Left streambank above station 07+72.

Photo A-35. Left streambank above station 08+36.

Photo A-36. Left streambank above station 08+83.

Photo A-37. Left streambank above station 09+28.

Photo A-38. Right streambank above station 09+40.

Photo A-39. Right streambank above station 09+69.

Photo A-40. Left streambank above station 10+63.

Photo A-41. Left streambank above station 11+17.

Photo A-42. Right streambank above station 11+15.

Photo A-44. Floodplain transect at station 00+00, right bank, 0 feet to 35 feet from top of bank.

Photo A-45. Floodplain transect at station 01+00, Left bank, 0 feet to 4 feet from top of bank.

Photo A-46. Floodplain transect at station 01+00, Left bank, 4 feet to 20 feet from top of bank.

Photo A-47. Floodplain transect at station 01+00, right bank, 0 feet to 6 feet from top of bank.

Photo A-48. Floodplain transect at station 01+00, right bank, 6 feet to 27 feet from top of bank.

Photo A-49. Floodplain transect at station 02+00, left bank, 0 feet to 4 feet from top of bank.

Photo A-50. Floodplain transect at station 02+00, left bank, 4 feet to 15 feet from top of bank.

Photo A-51. Floodplain transect at station 02+00, right bank, 0 feet to 11 feet from top of bank.

Photo A-52. Floodplain transect at station 03+00, left bank, 0 feet to 6 feet from top of bank.

Photo A-53. Floodplain transect at station 03+00, left bank, 6 feet to 34 feet from top of bank.

Photo A-54. Floodplain transect at station 03+00, right bank, 0 feet to 12 feet from top of bank.

Photo A-55. Floodplain transect at station 04+33, left bank, 0 feet to 13 feet from top of bank.

Photo A-56. Floodplain transect at station 04+33, left bank, 13 feet to 41 feet from top of bank.

Photo A-57. Floodplain transect at station 04+33, right bank, 0 feet to 18 feet from top of bank.

Photo A-58. Floodplain transect at station 05+67, left bank, 0 feet to 62 feet from top of bank.

Photo A-59. Floodplain transect at station 05+67, left bank, 62 feet to 99 feet from top of bank.

Photo A-60. Floodplain transect at station 05+67, right bank, 0 feet to 15 feet from top of bank.

Photo A-61. Floodplain transect at station 07+00, left bank, 0 feet to 57 feet from top of bank.

Photo A-62. Floodplain transect at station 07+00, left bank, 57 feet to 88 feet from top of bank.

Photo A-63. Floodplain transect at station 07+00, right bank, 0 feet to 19 feet from top of bank.

Photo A-64. Floodplain transect at station 07+00, right bank, 19 feet to 44 feet from top of bank.

Photo A-65. Floodplain transect at station 08+33, left bank, 0 feet to 11 feet from top of bank.

Photo A-66. Floodplain transect at station 08+33, left bank, 11 feet to 37 feet from top of bank.

Photo A-67. Floodplain transect at station 08+33, right bank, 0 feet to 60 feet from top of bank.

Photo A-68. Floodplain transect at station 08+33, right bank, 60 feet to 75 feet from top of bank.

Photo A-69. Floodplain transect at station 09+67, left bank, 0 feet to 47 feet from top of bank.

Photo A-70. Floodplain transect at station 09+67, left bank, 47 feet to 75 feet from top of bank.

Photo A-71. Floodplain transect at station 09+67, right bank, 0 feet to 8 feet from top of bank.

Photo A-72. Floodplain transect at station 11+00, left bank, 0 feet to 21 feet from top of bank.

Photo A-73. Floodplain transect at station 11+00, right bank, 0 feet to 10 feet from top of bank.

A

B

C

D

Photo A-74. Downstream view from thalweg at station 00+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-75. Upstream view from thalweg at station 00+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-76. Bare spot from 2018, which has become more vegetated, on the right streambank at station 00+05, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-77. Downstream view from thalweg at station 01+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D) .

A

B

C

D

Photo A-78. Upstream view from thalweg at station 01+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-79. Soil eroding from under the matting on the lower left bank at station 01+55, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-80. Soil eroding from under the matting in 2018, which is now vegetated, on the right bank at station 01+67, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-81. Outfall and guard rail on the right bank at station 01+99, 2018 (A), 2019 (B), 2020 (C), and 2021(D).

A

B

C

D

Photo A-82. Downstream view from thalweg at station 02+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-83. Upstream view from thalweg at station 02+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-84. Upstream view of both streambanks showing some erosion of lower left bank at station 02+01, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-85. Downstream view from thalweg at station 03+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-86. Upstream view from thalweg at station 03+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-87. Right streambank at station 03+20, 2018 (A), 2019 (B), 2020 (C), 2021 (D).

A

B

C

D

Photo A-88. Downstream view from thalweg at station 04+33, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-89. Upstream view from the thalweg at station 04+33, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-90. View of root wad and left bank from station 04+50, 2018 (A), 2019 (B), 2020 (C), 2021 (D).

A

B

C

D

Photo A-91. Barren floodplain area from 2018, which has become more vegetated, on the left streambank at station 04+15, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-92. Barren area on the right streambank at station 05+25, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-93. Downstream view from thalweg at station 05+67, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-94. Upstream view from thalweg at station 05+67, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-95. Downstream view from thalweg at station 07+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-96. Upstream view from thalweg at station 07+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-97. Tree tubes from 2018 and new vegetation on left bank at station 07+03, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-98. Barren floodplain area from 2018 and new vegetation on the left streambank at station 07+71, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-99. Downstream view from thalweg at station 08+33, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-100. Upstream view from thalweg at station 08+33, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-101. Outfall / barren area and new vegetation on left streambank at station 08+32, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-102. Barren wetland area (2018) and new vegetation on the left streambank at station 08+41, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-103. Downstream view from thalweg at station 09+67, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-104. Upstream view from thalweg at station 09+67, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-105. Inundated tree tubes from 2018 on tidal flat, with new vegetation, on the right streambank at station 09+09, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-106. Upstream view of wetland area at station 10+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-107. Downstream view from thalweg at station 11+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-108. Upstream view from thalweg at station 11+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-109. View from top of floodplain, left streambank at station 01+00, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

C

D

Photo A-110. Upstream view from top of floodplain, left streambank at station 10+95, 2018 (A), 2019 (B), 2020 (C), and 2021 (D).

A

B

Photo A-111. Well-vegetated wetland area on left side of stream (facing toward stream from middle of wetland) at station 05+63, 2020 (A) and 2021 (B).

A

B

Photo A-112. Lower streambank lacking vegetation due to tidal influence, left streambank at station 05+92, 2020 (A) and 2021 (B).

A

B

Photo A-113. Lower streambank lacking vegetation due to tidal influence, left streambank at station 06+22, 2020 (A) and 2021 (B).

A

B

Photo A-114. Lower streambank lacking vegetation due to tidal influence, right streambank at station 07+22, 2020 (A) and 2021 (B).

A

B

Photo A-115. Lower streambank showing tidal influence, right streambank at station 08+55, 2020 (A) and 2021 (B).

A

B

Photo A-116. Lower streambank showing tidal influence, left streambank at station 08+55, 2020 (A) and 2021 (B).

Photo A-117. Bulldozer marks on top of the left streambank at station 01+20, September 2021.

Photo A-118. Outfall pipe with erosion, left streambank at station 01+64, September 2021.

Photo A-119. Gravel bars in stream at station 05+10, September 2021.

Photo A-120. Matting and tidal wetland area, left streambank, at station 09+20, September 2021.

A

B

Photo A-121. Erosion below tree roots, left streambank above station 02+18 in 2020 (A) and 2021 (B)

APPENDIX B— GPS COORDINATES FOR FIELD ASSESSMENT POINTS

Table B-1. GPS Coordinates for 2018 Streambank Assessment Segment End Points			
Approximate Station Location, Segment End Point	**Stream Bank**	**Latitude (decimal degrees)**	**Longitude (decimal degrees)**
01+25	left	39.32805945	-76.43757453
01+38	left	39.32803824	-76.43751032
01+48	left	39.32802417	-76.43749153
02+64	left	39.32778604	-76.43720827
04+55	left	39.32744288	-76.43672891
04+88	left	39.32735891	-76.43666332
05+93	left	39.32712318	-76.43649747
07+10	left	39.32698836	-76.43612279
07+71	left	39.32704243	-76.43590582
08+75	left	39.32683994	-76.43565922
10+68	left	39.32668088	-76.43526631
11+80	left	39.32649977	-76.43498392
01+56	right	39.32800191	-76.43747875
01+67	right	39.32797489	-76.43746981
01+78	right	39.32794746	-76.43743987
02+12	right	39.32788661	-76.43734745
03+05	right	39.32769574	-76.43712868
03+22	right	39.32765913	-76.4370867
03+60	right	39.32755278	-76.43693809
03+79	right	39.3275211	-76.43688173
03+90	right	39.32750221	-76.43685038
04+98	right	39.32725653	-76.43668024
05+30	right	39.32717492	-76.43665703
05+58	right	39.32712596	-76.43657258
07+00	right	39.32696839	-76.43620208
09+09	right	39.32664972	-76.43580695
09+42	right	39.32657164	-76.43569628
09+93	right	39.32654319	-76.4355053
10+70	right	39.32650552	-76.43526257
11+10	right	39.3264603	-76.43520634
11+35	right	39.32641238	-76.4351342

Table B-2. GPS Coordinates for 2018 Floodplain Transect Locations. Coordinates listed are for start point of field-assessed segment.

Station	Stream Bank	Approximate Location of Transect Start (ft), as Distance from Top of Bank	Approximate Location of Transect End (ft), as Distance from Top of Bank	Latitude (decimal degrees)	Longitude (decimal degrees)
00+00	left	0	43	39.32832101	-76.43780533
01+00	left	0	38	39.3281118	-76.43762388
02+00	left	0	4	39.32792956	-76.43736539
02+00	left	4	35	39.32793457	-76.43735399
03+00	left	0	34	39.32772479	-76.43711486
04+33	left	0	50	39.32748373	-76.43678264
05+67	left	0	59	39.32717466	-76.43658438
05+67	left	59	113	39.32729764	-76.43644428
07+00	left	0	54	39.32701752	-76.43618656
07+00	left	54	112	39.32716346	-76.43614878
08+33	left	0	5	39.32693326	-76.43568858
08+33	left	5	49	39.32694056	-76.43567333
09+67	left	0	33	39.32670472	-76.43551738
09+67	left	33	81	39.32678517	-76.43546558
11+00	left	0	17	39.3265887	-76.43507907
11+00	left	17	57	39.32662116	-76.43503966
00+00	right	0	9	39.32832483	-76.43784294
00+00	right	9	29	39.32831805	-76.43788409
00+00	right	29	42	39.32831856	-76.43795238
01+00	right	0	9	39.32808954	-76.43767885
01+00	right	9	29	39.32808936	-76.43768018
02+00	right	0	10	39.32811097	-76.43765489
03+00	right	0	7	39.32769945	-76.43717015
04+33	right	0	6	39.32746753	-76.43681399
04+33	right	6	17	39.3274544	-76.43683035
05+67	right	0	5	39.32713547	-76.43662788
07+00	right	0	14	39.32694816	-76.43622954
07+00	right	14	33	39.32690906	-76.43625661
08+33	right	0	48	39.32685006	-76.43583683
08+33	right	48	78	39.3267693	-76.43596625
08+33	right	78	87	39.32672503	-76.43605887
09+67	right	0	12	39.32654735	-76.43561067
11+00	right	0	4	39.32643668	-76.43523064
11+00	right	4	26	39.3264367	-76.43523817

Table B-3. GPS Coordinates for 2019 Streambank Assessment Segment End Points			
Approximate Station Location, Segment End Point	**Stream Bank**	**Latitude (decimal degrees)**	**Longitude (decimal degrees)**
01+36	left	39.32805187	-76.43755645
01+45	left	39.32803944	-76.437529
01+52	left	39.32803571	-76.4375064
01+57	left	39.32802507	-76.43748625
01+59	left	39.32802224	-76.43748419
01+66	left	39.32801048	-76.43745542
01+83	left	39.32797699	-76.43742254
01+91	left	39.32795782	-76.43740175
01+98	left	39.32794353	-76.43738265
02+32	left	39.32786791	-76.43728847
04+13	left	39.32751912	-76.43683754
04+57	left	39.32743966	-76.43671809
04+86	left	39.327364	-76.4366547
07+57	left	39.32708623	-76.43603443
08+55	left	39.32686217	-76.4356589
10+50	left	39.32669228	-76.43527249
11+00	left	39.32658431	-76.43508559
01+37	right	39.32803419	-76.43755634
01+46	right	39.32803216	-76.43752703
01+91	right	39.32794742	-76.43742076
02+14	right	39.32789031	-76.43734909
02+27	right	39.32786315	-76.43731882
03+09	right	39.32769131	-76.43712839
03+80	right	39.32755498	-76.43694792
04+03	right	39.32751622	-76.43688093
04+19	right	39.32748575	-76.43684698
04+76	right	39.32737801	-76.43670731
05+22	right	39.32726568	-76.43671726
05+41	right	39.32719977	-76.43672715
05+93	right	39.32708469	-76.4365575
06+82	right	39.32698299	-76.43626065
07+38	right	39.32694879	-76.4360542
09+26	right	39.32662982	-76.43582841
09+45	right	39.32656136	-76.43569192
09+98	right	39.32653191	-76.43550972
10+97	right	39.32646976	-76.43522779

Table B-4. GPS Coordinates for 2019 Floodplain Transect Locations. Coordinates listed are for start point of field-assessed segment.

Station	Stream Bank	Approximate Location of Transect Start (ft), as Distance from Top of Bank	Approximate Location of Transect End (ft), as Distance from Top of Bank	Latitude (decimal degrees)	Longitude (decimal degrees)
00+00	left	0	42	39.32832843	-76.43780772
01+00	left	0	4	39.32811597	-76.43762976
01+00	left	4	20	39.32812002	-76.43761711
02+00	left	0	4	39.32792874	-76.43737125
02+00	left	4	15	39.32793598	-76.43735933
03+00	left	0	6	39.32771906	-76.43713205
03+00	left	6	34	39.32772805	-76.43711543
04+33	left	0	13	39.32748199	-76.43677982
04+33	left	13	41	39.32750434	-76.43674325
05+67	left	0	62	39.32717415	-76.43658094
05+67	left	62	99	39.32729923	-76.43643349
07+00	left	0	57	39.32701634	-76.43618469
07+00	left	57	88	39.32717026	-76.43614896
08+33	left	0	11	39.32692281	-76.4357053
08+33	left	11	37	39.32693972	-76.43567399
09+67	left	0	47	39.32668276	-76.43553148
09+67	left	47	75	39.32679795	-76.43545285
11+00	left	0	21	39.32658321	-76.43508195
00+00	right	0	35	39.32832563	-76.4378479
01+00	right	0	6	39.32810795	-76.43764946
01+00	right	6	27	39.32809911	-76.43766868
02+00	right	0	11	39.3279115	-76.43739199
03+00	right	0	12	39.32770573	-76.43715244
04+33	right	0	18	39.32746148	-76.43681158
05+67	right	0	15	39.32713165	-76.43663334
07+00	right	0	19	39.32693479	-76.4362079
07+00	right	19	44	39.32688368	-76.43621816
08+33	right	0	60	39.32684945	-76.43583115
08+33	right	60	75	39.32675304	-76.43599906
09+67	right	0	8	39.32654893	-76.43562105
11+00	right	0	10	39.326441	-76.43524563

Table B-5. GPS Coordinates for 2020 Streambank Assessment Segment End Points			
Approximate Station Location, Segment End Point	**Stream Bank**	**Latitude (decimal degrees)**	**Longitude (decimal degrees)**
00+94	Left	39.32813261	-76.43764676
01+42	Left	39.32804335	-76.43752922
01+75	Left	39.32797828	-76.43742507
01+83	Left	39.32793251	-76.43737216
02+05	Left	39.32792332	-76.43735468
02+20	Left	39.3279038	-76.4373203
02+62	Left	39.32780471	-76.4372279
04+04	Left	39.3275501	-76.4368729
04+47	Left	39.32746434	-76.43675619
04+95	Left	39.32735647	-76.4366576
06+04	Left	39.32710995	-76.43651837
07+65	Left	39.3271133	-76.4360653
08+67	Left	39.32684994	-76.43573382
10+76	Left	39.32663691	-76.43527554
11+00	Left	39.32653164	-76.43505561
01+20	Right	39.32805327	-76.43759796
01+31	Right	39.32803453	-76.43757151
01+84	Right	39.3279503	-76.43743784
02+09	Right	39.3279178	-76.4373695
02+29	Right	39.32786561	-76.43731903
02+87	Right	39.32774301	-76.43718709
03+60	Right	39.3276051	-76.4370183
04+06	Right	39.3275281	-76.4368806
04+22	Right	39.32749118	-76.43684448
04+63	Right	39.32741796	-76.43672815
05+44	Right	39.3272126	-76.4367274
05+65	Right	39.32714639	-76.43665578
06+13	Right	39.3270465	-76.4365487
06+90	Right	39.3270081	-76.43625224
07+40	Right	39.3268848	-76.4360651
09+42	Right	39.3266374	-76.4357912
09+52	Right	39.3265884	-76.4357863
09+60	Right	39.3265725	-76.4357362
10+09	Right	39.3265457	-76.4355347
10+94	Right	39.32650522	-76.43524155

Table B-6. GPS Coordinates for 2020 Floodplain Transect Locations. Coordinates listed are for start point of field-assessed segment.

Station	Stream Bank	Approximate Location of Transect Start (ft), as Distance from Top of Bank	Approximate Location of Transect End (ft), as Distance from Top of Bank	Latitude (decimal degrees)	Longitude (decimal degrees)
00+00	left	0	40	39.32831925	-76.4378089
01+00	left	0	4	39.32810739	-76.43762527
01+00	left	4	20	39.32811234	-76.43761161
02+00	left	0	4	39.3279316	-76.43735641
02+00	left	4	15	39.32793717	-76.43734979
03+00	left	0	6	39.32771611	-76.43711332
03+00	left	6	34	39.3277282	-76.43709665
04+33	left	0	13	39.32747363	-76.43677163
04+33	left	13	41	39.32750923	-76.43671834
05+67	left	0	62	39.3271621	-76.43657822
05+67	left	62	99	39.32728921	-76.43643335
07+00	left	0	57	39.32701486	-76.43618074
07+00	left	57	88	39.32716463	-76.43614904
08+33	left	0	11	39.32692017	-76.43568101
08+33	left	11	37	39.32696189	-76.43560371
09+67	left	0	47	39.3267389	-76.4350305
09+67	left	47	75	39.32679356	-76.43546896
11+00	left	0	21	39.32658321	-76.43508195
00+00	right	0	35	39.32833603	-76.4376818
01+00	right	0	6	39.32810155	-76.43764259
01+00	right	6	27	39.32809588	-76.43765604
02+00	right	0	11	39.32790245	-76.43738483
03+00	right	0	12	39.3276971	-76.43714883
04+33	right	0	18	39.327464	-76.4368103
05+67	right	0	15	39.3271267	-76.43663458
07+00	right	0	19	39.32693374	-76.43620664
07+00	right	19	44	39.32681365	-76.43622748
08+33	right	0	60	39.32685137	-76.43585555
08+33	right	60	75	39.3267326	-76.43600912
09+67	right	0	8	39.32663593	-76.43560672
11+00	right	0	10	39.32654579	-76.43509356

Table B-7. GPS Coordinates for 2021 Streambank Assessment Segment End Points			
Approximate Station Location, Segment End Point	**Stream Bank**	**Latitude (decimal degrees)**	**Longitude (decimal degrees)**
01+02	left	39.32810782	-76.43761893
01+19	left	39.32806781	-76.43758775
01+47	left	39.32804988	-76.43751105
01+54	left	39.32803239	-76.43748176
01+73	left	39.32800152	-76.43742561
01+86	left	39.32796738	-76.43741234
02+06	left	39.32792747	-76.43736062
02+18	left	39.32790375	-76.43733006
03+46	left	39.32765208	-76.43702295
03+85	left	39.32758328	-76.43692383
04+31	left	39.32749677	-76.43680217
04+57	left	39.32745163	-76.43672215
04+90	left	39.32737004	-76.43666563
05+06	left	39.32732849	-76.43665034
05+32	left	39.32725379	-76.43665480
07+52	left	39.32704064	-76.43608179
07+72	left	39.32711410	-76.43605319
08+36	left	39.32695495	-76.43572914
08+83	left	39.32684077	-76.43565734
09+28	left	39.32668934	-76.43565130
10+63	left	39.32669027	-76.43531781
11+17	left	39.32657720	-76.43508528
01+20	right	39.32805927	-76.43760050
01+60	right	39.32801546	-76.43747923
01+71	right	39.32799328	-76.43745016
01+82	right	39.32796342	-76.43743453
02+22	right	39.32788701	-76.43733697
02+46	right	39.32784116	-76.43727724
02+53	right	39.32782434	-76.43726089
03+13	right	39.32769720	-76.43713471
03+85	right	39.32756676	-76.43694110
04+06	right	39.32752977	-76.43688520
04+19	right	39.32750204	-76.43685660
04+45	right	39.32745535	-76.43678853
04+82	right	39.32738261	-76.43670471
05+32	right	39.32726140	-76.43671710
06+97	right	39.32697343	-76.43624389
07+12	right	39.32694470	-76.43619524
07+46	right	39.32694710	-76.43606009
09+40	right	39.32664004	-76.43584115
09+69	right	39.32656420	-76.43567532
10+05	right	39.32655410	-76.43554387

11+15	right	39.32645206	-76.43523889

Table B-8. GPS Coordinates for 2021 Floodplain Transect Locations. Coordinates listed are for start point of field-assessed segment.

Station	Stream Bank	Approximate Location of Transect Start (ft), as Distance from Top of Bank	Approximate Location of Transect End (ft), as Distance from Top of Bank	Latitude (decimal degrees)	Longitude (decimal degrees)
00+00	left	0	40	39.32832620	-76.43780541
01+00	left	0	4	39.3281155	-76.43762948
01+00	left	4	20	39.3281236	-76.43761148
02+00	left	0	4	39.32793509	-76.43736242
02+00	left	4	15	39.32794377	-76.43734882
03+00	left	0	6	39.3277251	-76.43711643
03+00	left	6	34	39.32773695	-76.43709756
04+33	left	0	13	39.32749078	-76.43677591
04+33	left	13	41	39.3275149	-76.43672543
05+67	left	0	62	39.32718346	-76.4365875
05+67	left	62	99	39.32729985	-76.4364333
07+00	left	0	57	39.32702471	-76.43618824
07+00	left	57	88	39.32717745	-76.43614665
08+33	left	0	11	39.32692679	-76.43568764
08+33	left	11	37	39.32695045	-76.43566829
09+67	left	0	47	39.32673951	-76.43548214
09+67	left	47	75	39.32685239	-76.43541773
11+00	left	0	21	39.32658806	-76.43507401
00+00	right	0	35	39.32815064	-76.43735056
01+00	right	0	6	39.3281096	-76.43764582
01+00	right	6	27	39.32809816	-76.43766511
02+00	right	0	11	39.3279091	-76.43738171
03+00	right	0	12	39.32770759	-76.43714966
04+33	right	0	18	39.32746025	-76.43680148
05+67	right	0	15	39.32713841	-76.43663595
07+00	right	0	19	39.32693157	-76.436199
07+00	right	19	44	39.32682365	-76.43623302
08+33	right	0	60	39.32683785	-76.43583965
08+33	right	60	75	39.32679166	-76.4359269
09+67	right	0	8	39.32654963	-76.43562087
11+00	right	0	10	39.32644642	-76.43523854

APPENDIX C—HISTORICAL FIGURES AND TABLES

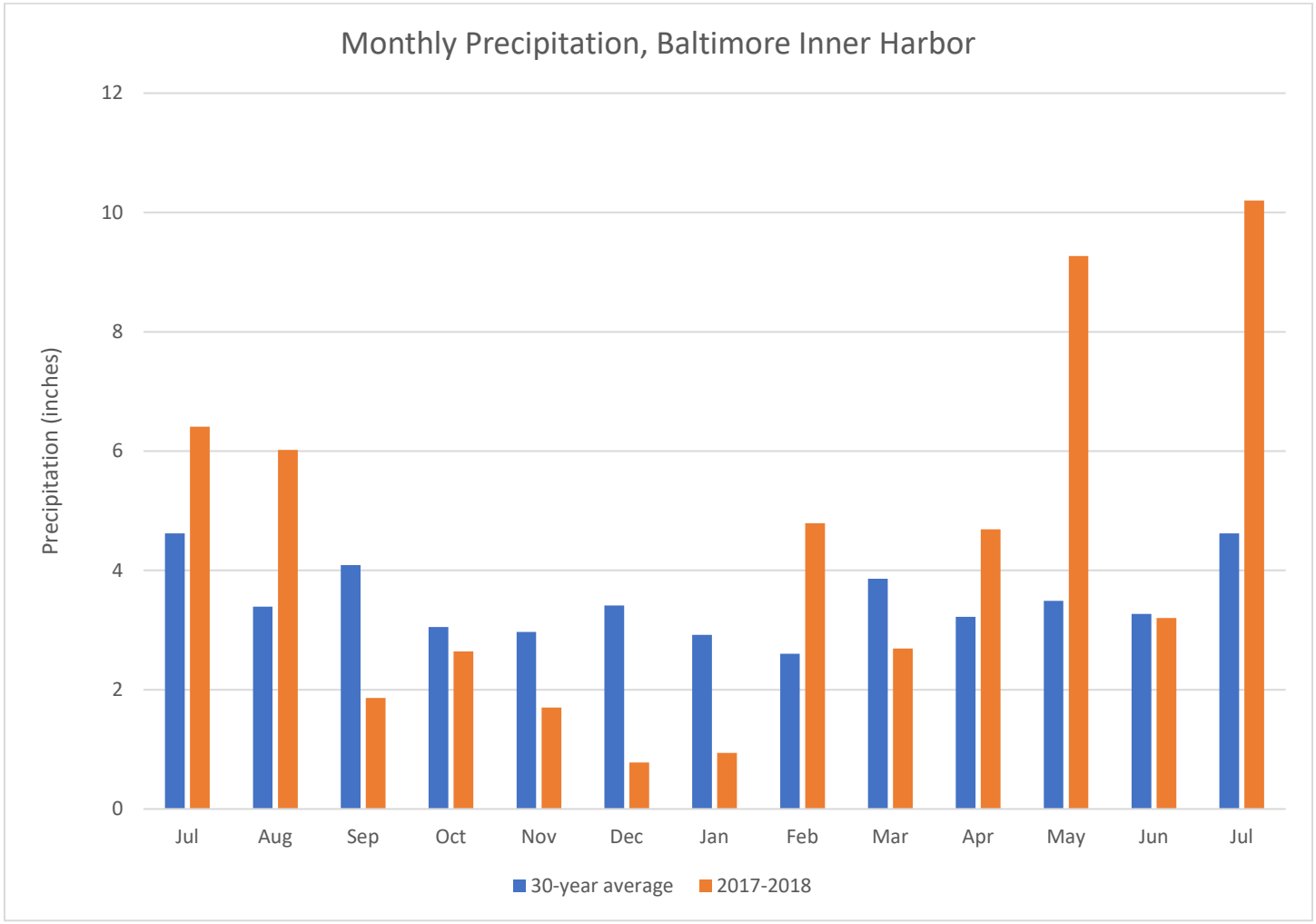


Figure C – 1. Monthly Precipitation Totals, July 2017–July 2018, Baltimore Inner Harbor

(Based on data from National Weather Service, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

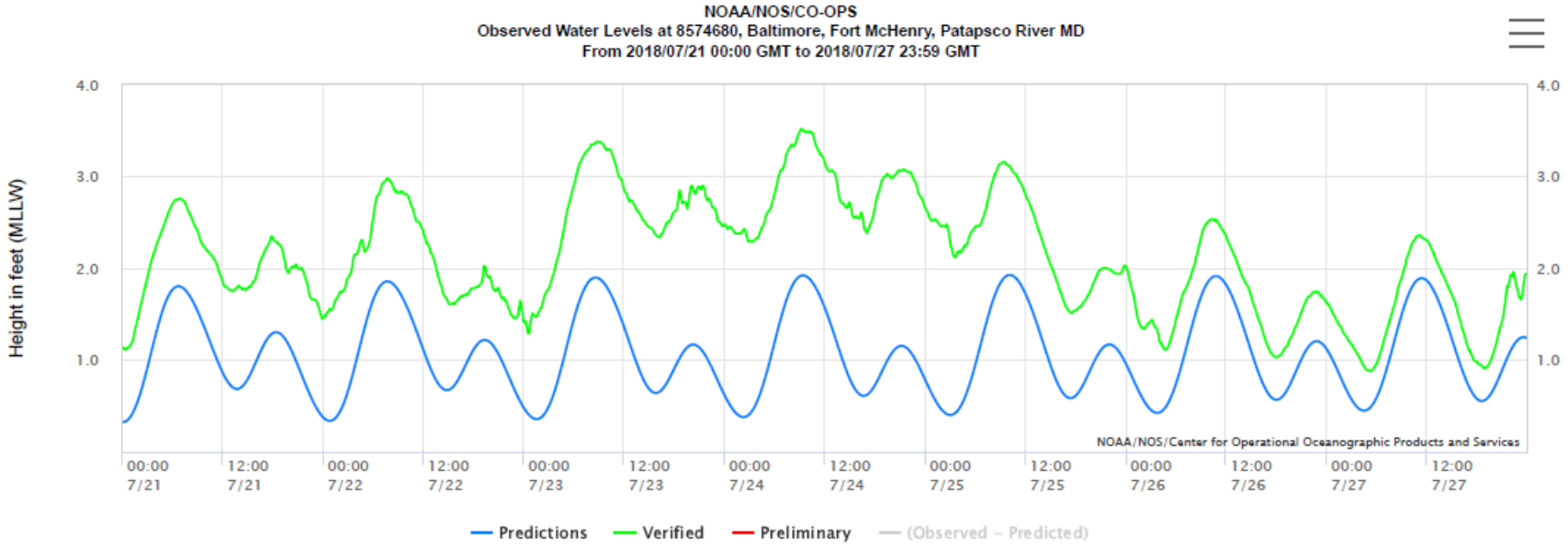


Figure C – 2. Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River,

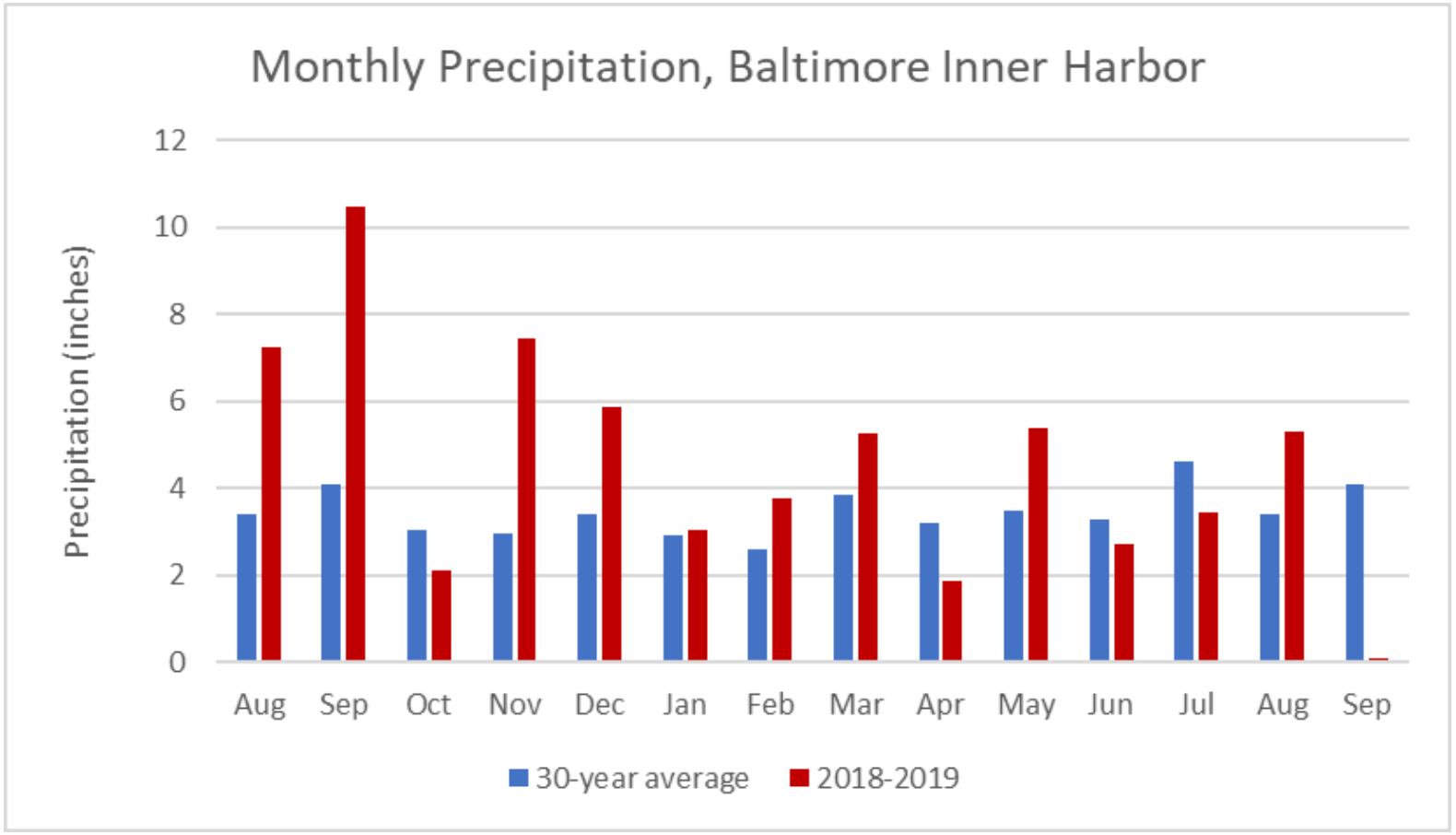


Figure C – 3. Monthly Precipitation Totals, August 2018–September 2019, Baltimore Inner Harbor.

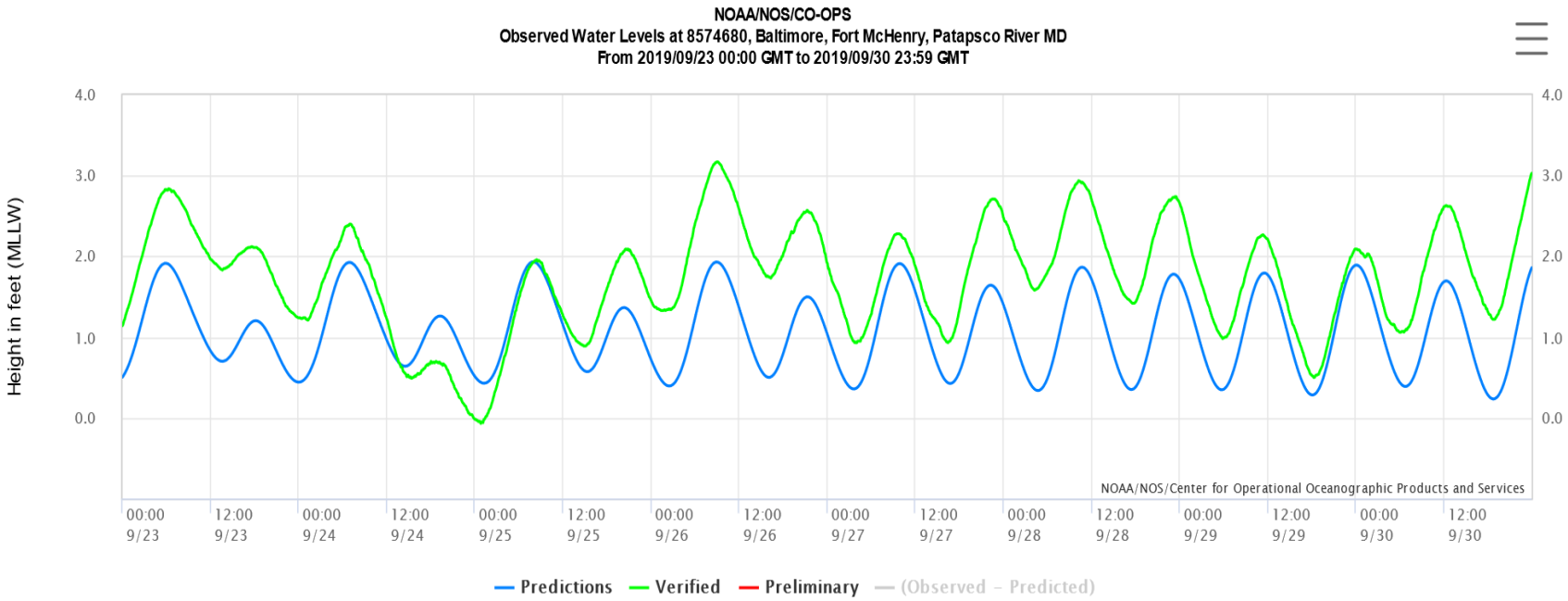


Figure C – 4. Observed water levels at NOAA tidal observation station at Baltimore, Fort McHenry, Patapsco River September 23-30, 2019

[Observed values (green line) are compared with long-term predicted levels (blue line)].
NOAA data from
https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20180721&edate=20180727&timezone=GMT&datum=MLLW&interval=6&action=

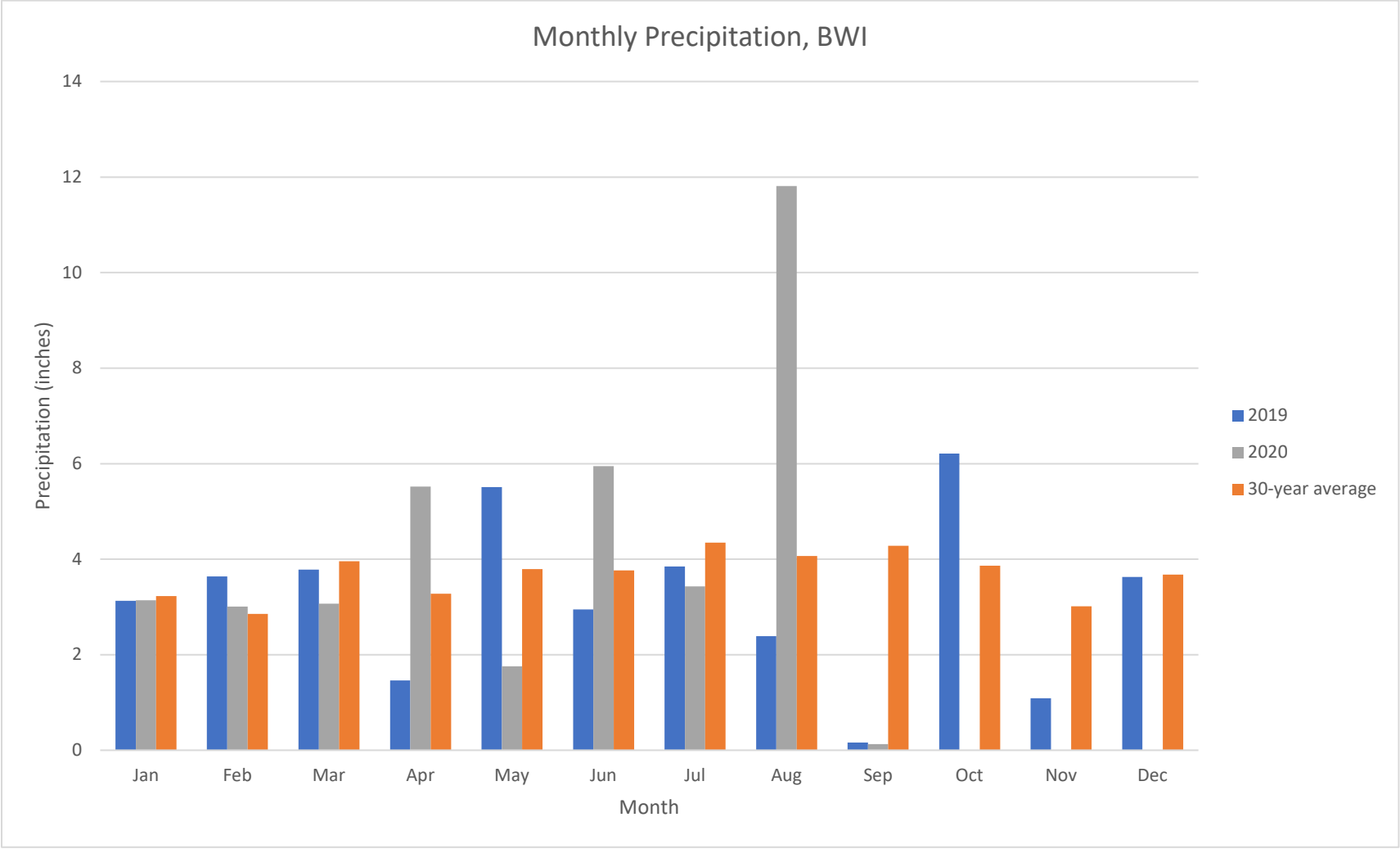


Figure C – 5. Monthly Precipitation Totals, January 2019–August 2020, Baltimore/Washington International Airport.

(Based on data from National Weather Service, summarized by Iowa State University, https://mesonet.agron.iastate.edu)
(Figure was generated in early September 2020 and does not include most of September 2020 or any of October – December 2020)

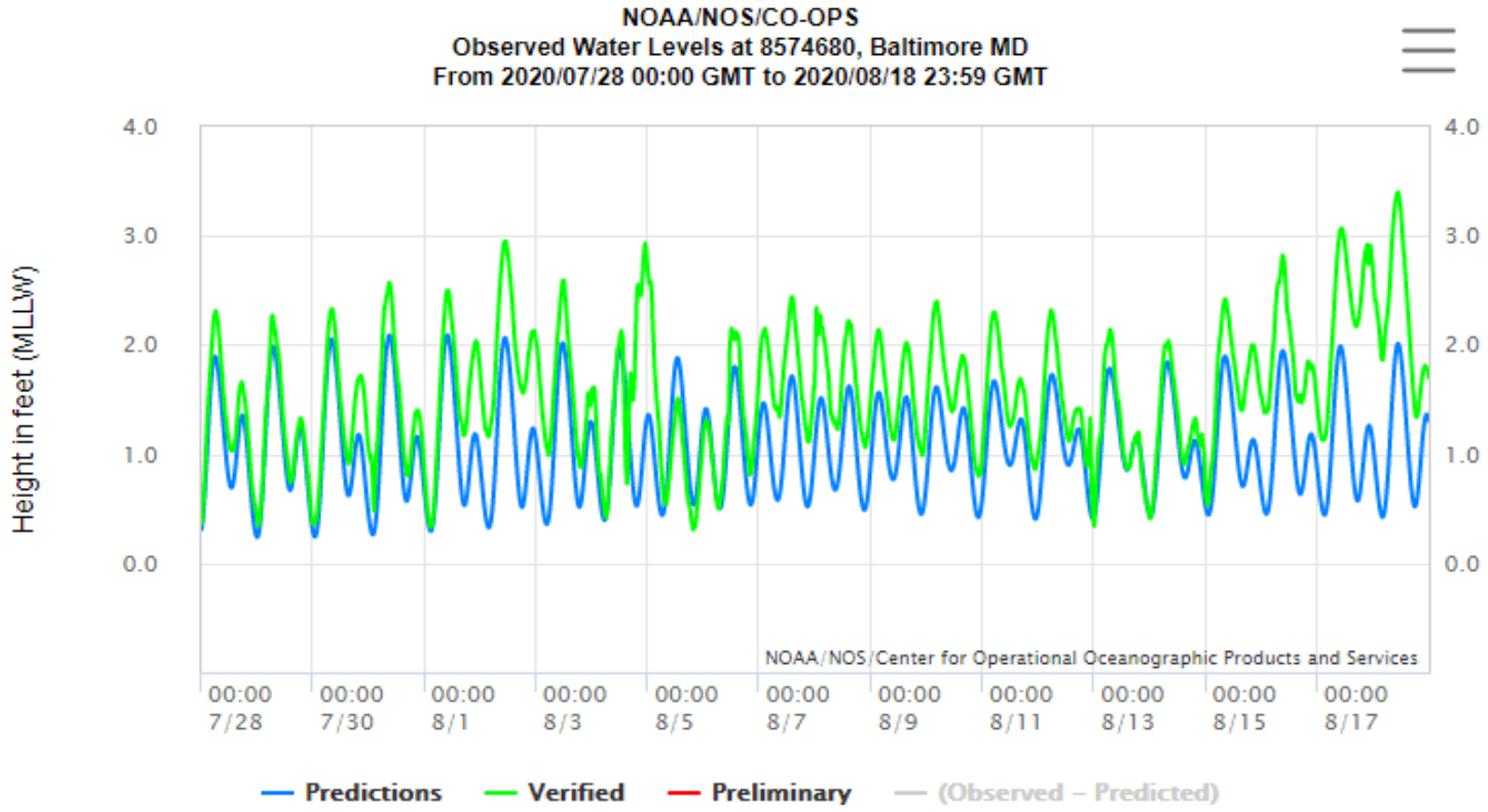


Figure C – 6. Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River, July 28–August 18, 2020.

[Observed values (green line) are compared with long-term predicted levels (blue line)].
NOAA data from
https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20200728&edate=20200818&timezone=GMT&datum=MLLW&interval=6&action=

Figure C – 7. Cow Pen Creek Study Area–2018

[Shows bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (yellow) along 10 floodplain transects. Upland and wetland vegetation types are from 2017-2018 as-built plan.]

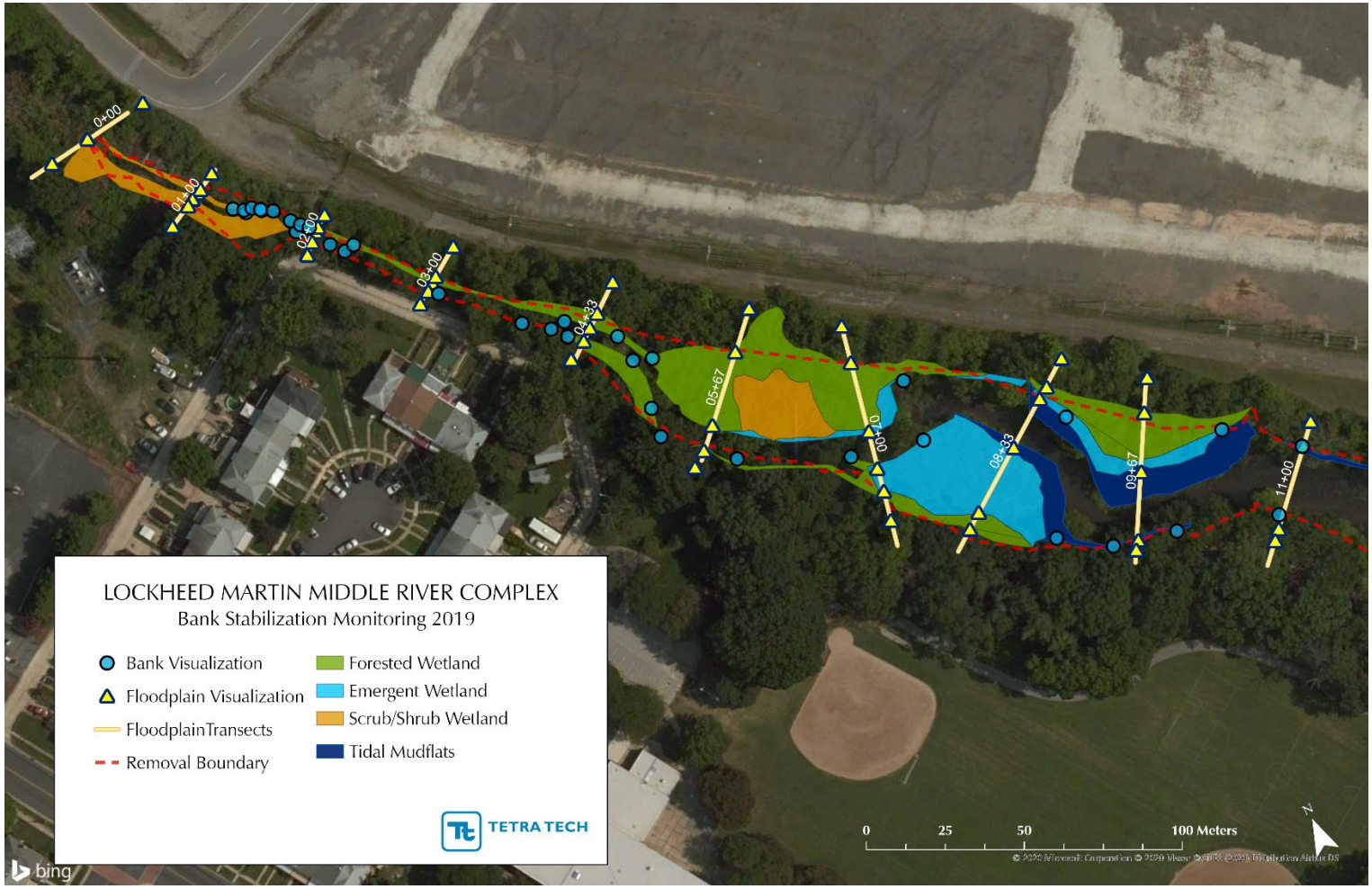


Figure C – 8. Cow Pen Creek Study Area–2019

[Shows bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (yellow) along 10 floodplain transects. Upland and wetland vegetation types are from the 2019 wetland field survey (Tetra Tech 2019b).]

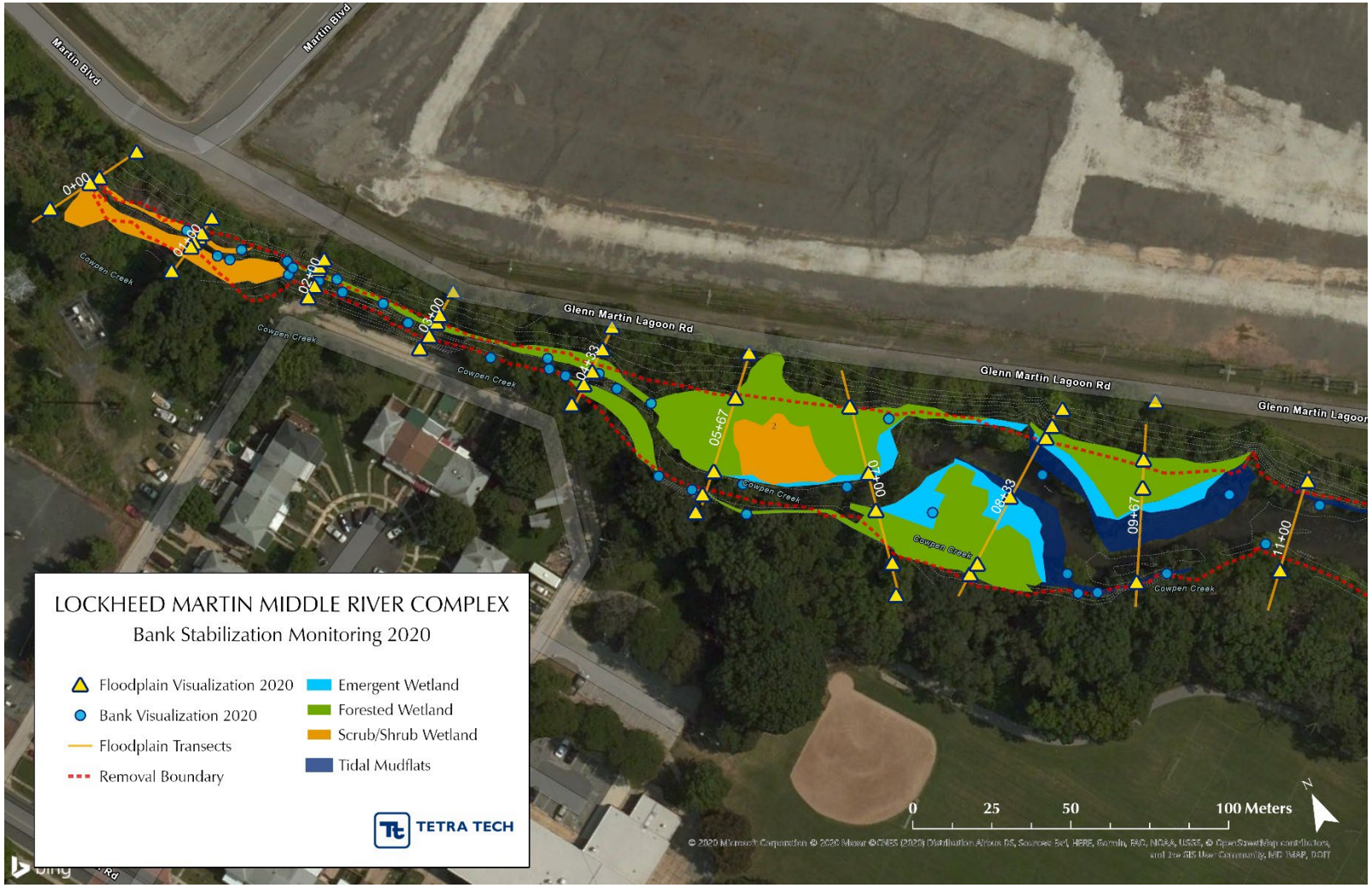


Figure C – 9. Cow Pen Creek Study Area–2020

[Shows bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (yellow) along 10 floodplain transects. Upland and wetland vegetation types are from the 2020 wetland field survey (Tetra Tech 2020a).]

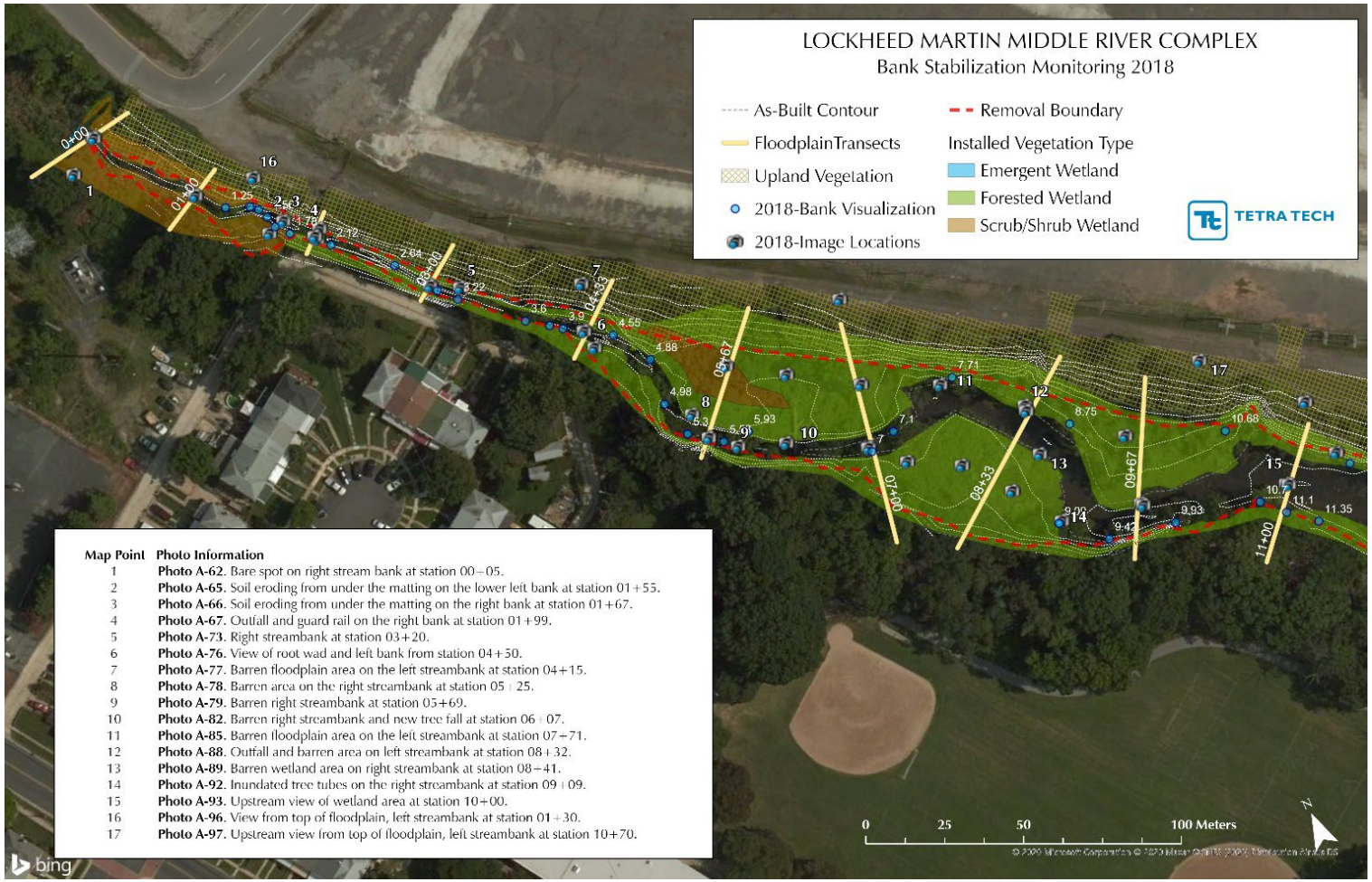
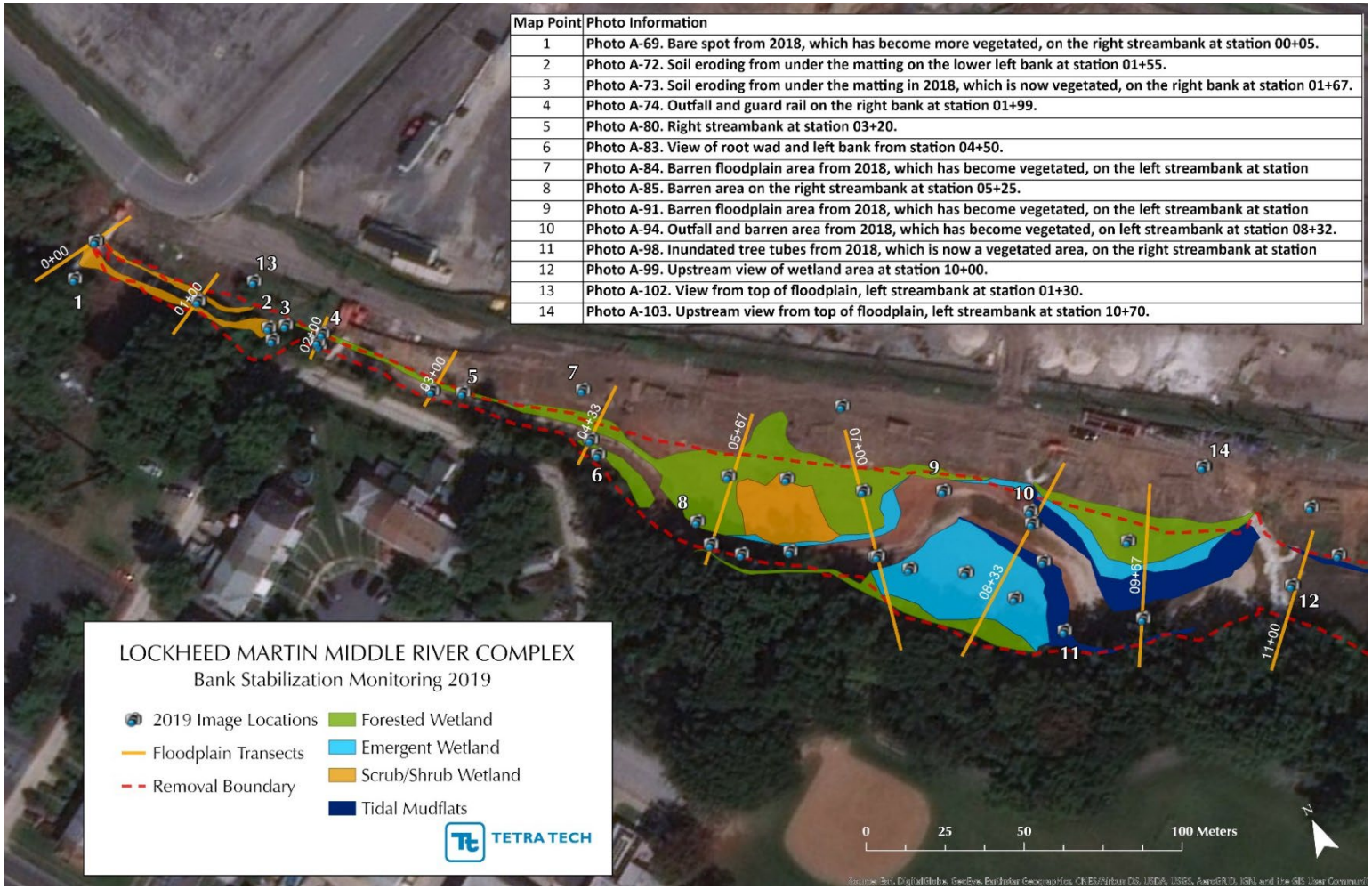


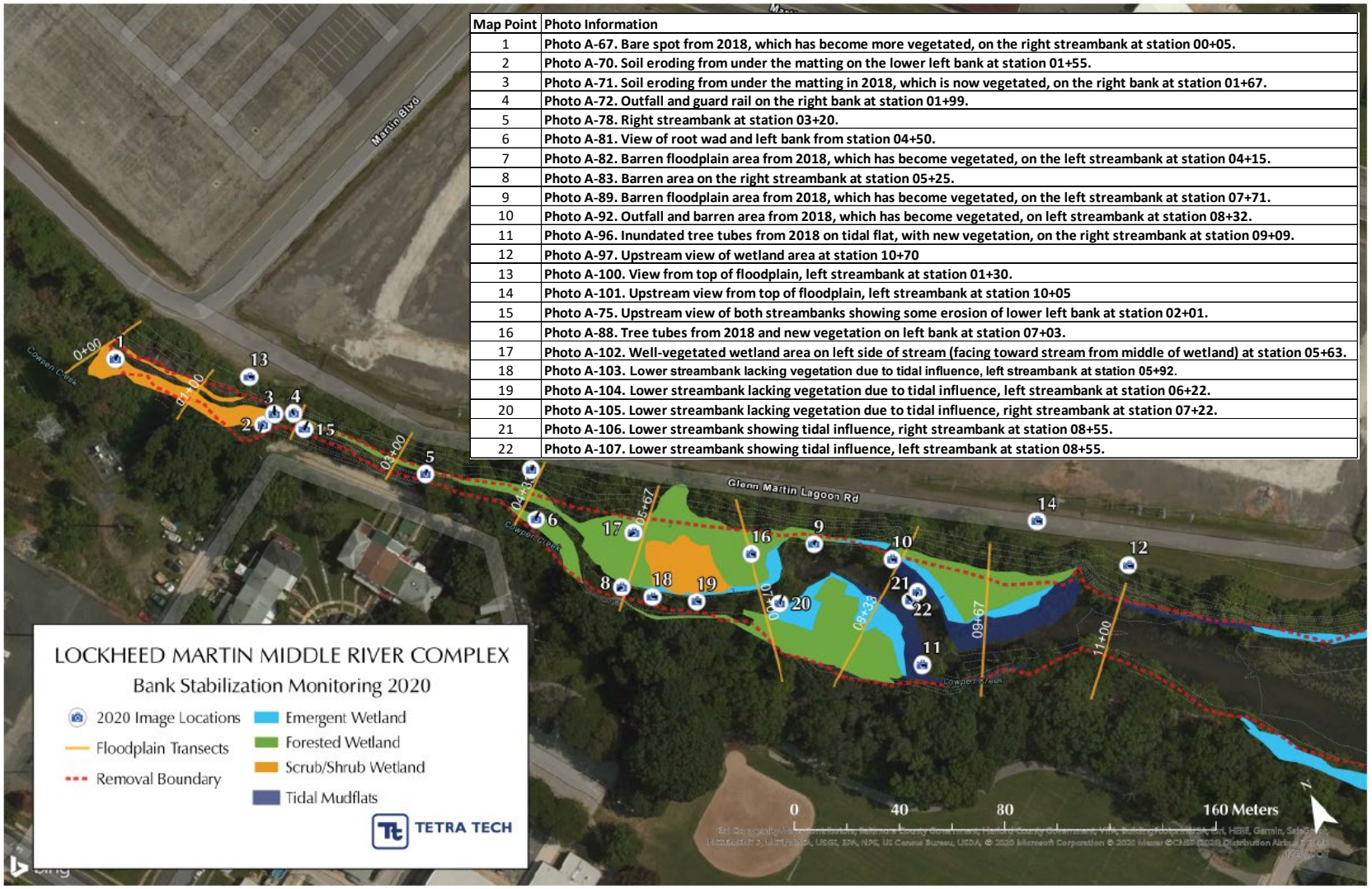
Figure C - 10. Photograph locations of representative areas and other features of note along Cow Pen Creek–2018

[See Appendix A of 2018 monitoring report (Tetra Tech 2018d) for more details. Upland and wetland vegetation types are from 2017-2018 as-built plan.]



Map Point	Photo Information
1	Photo A-69. Bare spot from 2018, which has become more vegetated, on the right streambank at station 00+05.
2	Photo A-72. Soil eroding from under the matting on the lower left bank at station 01+55.
3	Photo A-73. Soil eroding from under the matting in 2018, which is now vegetated, on the right bank at station 01+67.
4	Photo A-74. Outfall and guard rail on the right bank at station 01+99.
5	Photo A-80. Right streambank at station 03+20.
6	Photo A-83. View of root wad and left bank from station 04+50.
7	Photo A-84. Barren floodplain area from 2018, which has become vegetated, on the left streambank at station
8	Photo A-85. Barren area on the right streambank at station 05+25.
9	Photo A-91. Barren floodplain area from 2018, which has become vegetated, on the left streambank at station
10	Photo A-94. Outfall and barren area from 2018, which has become vegetated, on left streambank at station 08+32.
11	Photo A-98. Inundated tree tubes from 2018, which is now a vegetated area, on the right streambank at station
12	Photo A-99. Upstream view of wetland area at station 10+00.
13	Photo A-102. View from top of floodplain, left streambank at station 01+30.
14	Photo A-103. Upstream view from top of floodplain, left streambank at station 10+70.

Figure C – 11. Photograph locations of representative areas and other features of note along Cow Pen Creek–2019
[See Appendix A of 2019 monitoring report (Tetra Tech 2019a) for more details.
Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019b)].



Map Point	Photo Information
1	Photo A-67. Bare spot from 2018, which has become more vegetated, on the right streambank at station 00+05.
2	Photo A-70. Soil eroding from under the matting on the lower left bank at station 01+55.
3	Photo A-71. Soil eroding from under the matting in 2018, which is now vegetated, on the right bank at station 01+67.
4	Photo A-72. Outfall and guard rail on the right bank at station 01+99.
5	Photo A-78. Right streambank at station 03+20.
6	Photo A-81. View of root wad and left bank from station 04+50.
7	Photo A-82. Barren floodplain area from 2018, which has become vegetated, on the left streambank at station 04+15.
8	Photo A-83. Barren area on the right streambank at station 05+25.
9	Photo A-89. Barren floodplain area from 2018, which has become vegetated, on the left streambank at station 07+71.
10	Photo A-92. Outfall and barren area from 2018, which has become vegetated, on left streambank at station 08+32.
11	Photo A-96. Inundated tree tubes from 2018 on tidal flat, with new vegetation, on the right streambank at station 09+09.
12	Photo A-97. Upstream view of wetland area at station 10+70
13	Photo A-100. View from top of floodplain, left streambank at station 01+30.
14	Photo A-101. Upstream view from top of floodplain, left streambank at station 10+05
15	Photo A-75. Upstream view of both streambanks showing some erosion of lower left bank at station 02+01.
16	Photo A-88. Tree tubes from 2018 and new vegetation on left bank at station 07+03.
17	Photo A-102. Well-vegetated wetland area on left side of stream (facing toward stream from middle of wetland) at station 05+63.
18	Photo A-103. Lower streambank lacking vegetation due to tidal influence, left streambank at station 05+92.
19	Photo A-104. Lower streambank lacking vegetation due to tidal influence, left streambank at station 06+22.
20	Photo A-105. Lower streambank lacking vegetation due to tidal influence, right streambank at station 07+22.
21	Photo A-106. Lower streambank showing tidal influence, right streambank at station 08+55.
22	Photo A-107. Lower streambank showing tidal influence, left streambank at station 08+55.

Figure C – 12. Photograph locations of representative areas and other features of note along Cow Pen Creek–2020

**[See Appendix A of 2020 monitoring report (Tetra Tech 2020b) for more details.
Upland and wetland vegetation types are from the 2020 wetland survey (Tetra Tech 2020a).]**

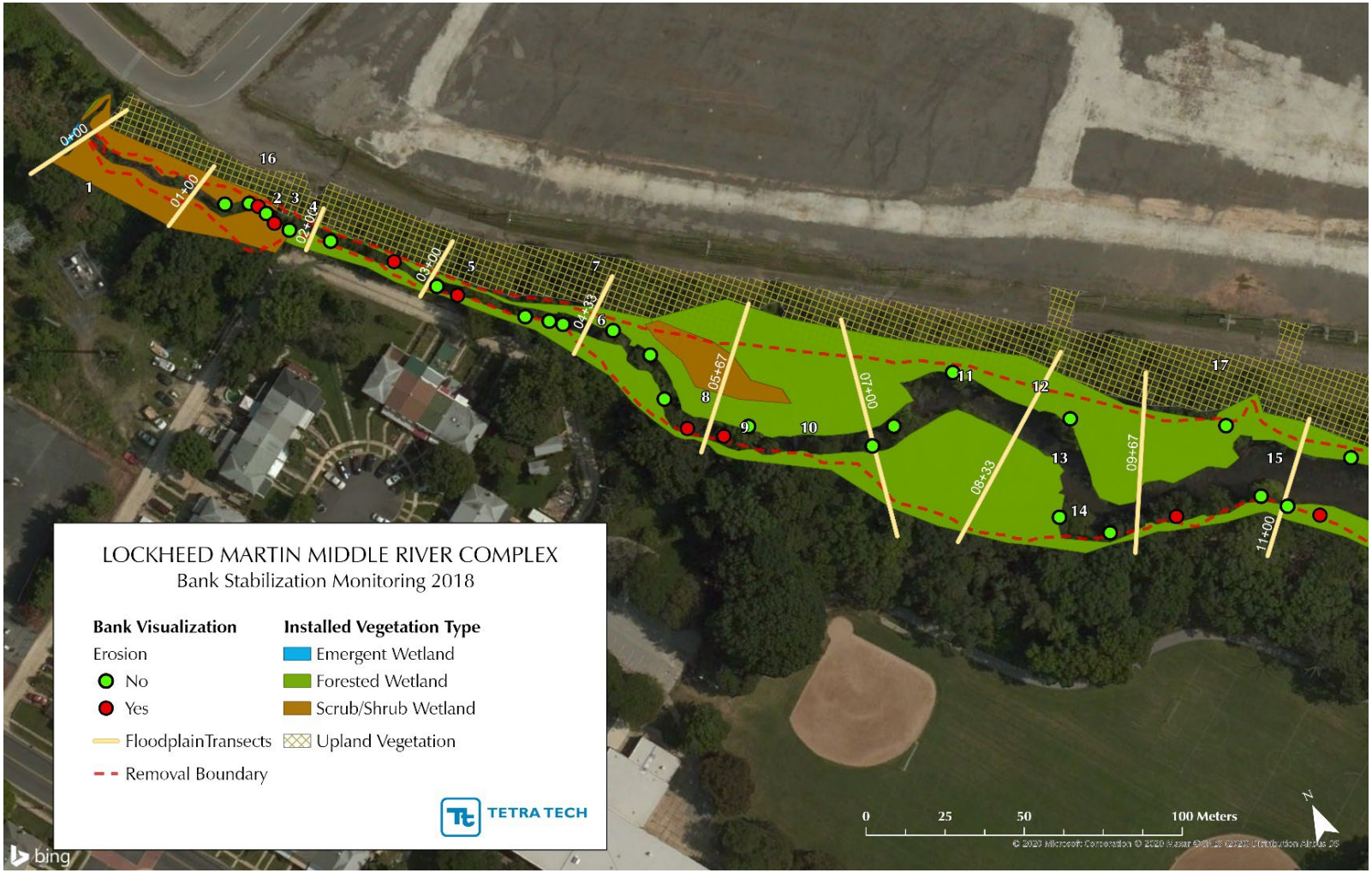


Figure C – 13. Observed locations of bank erosion along Cow Pen Creek–2018

**[Erosion noted in lower endpoints of segments assessed along both streambanks.
Upland and wetland vegetation types are from 2017-2018 as-built plan]**

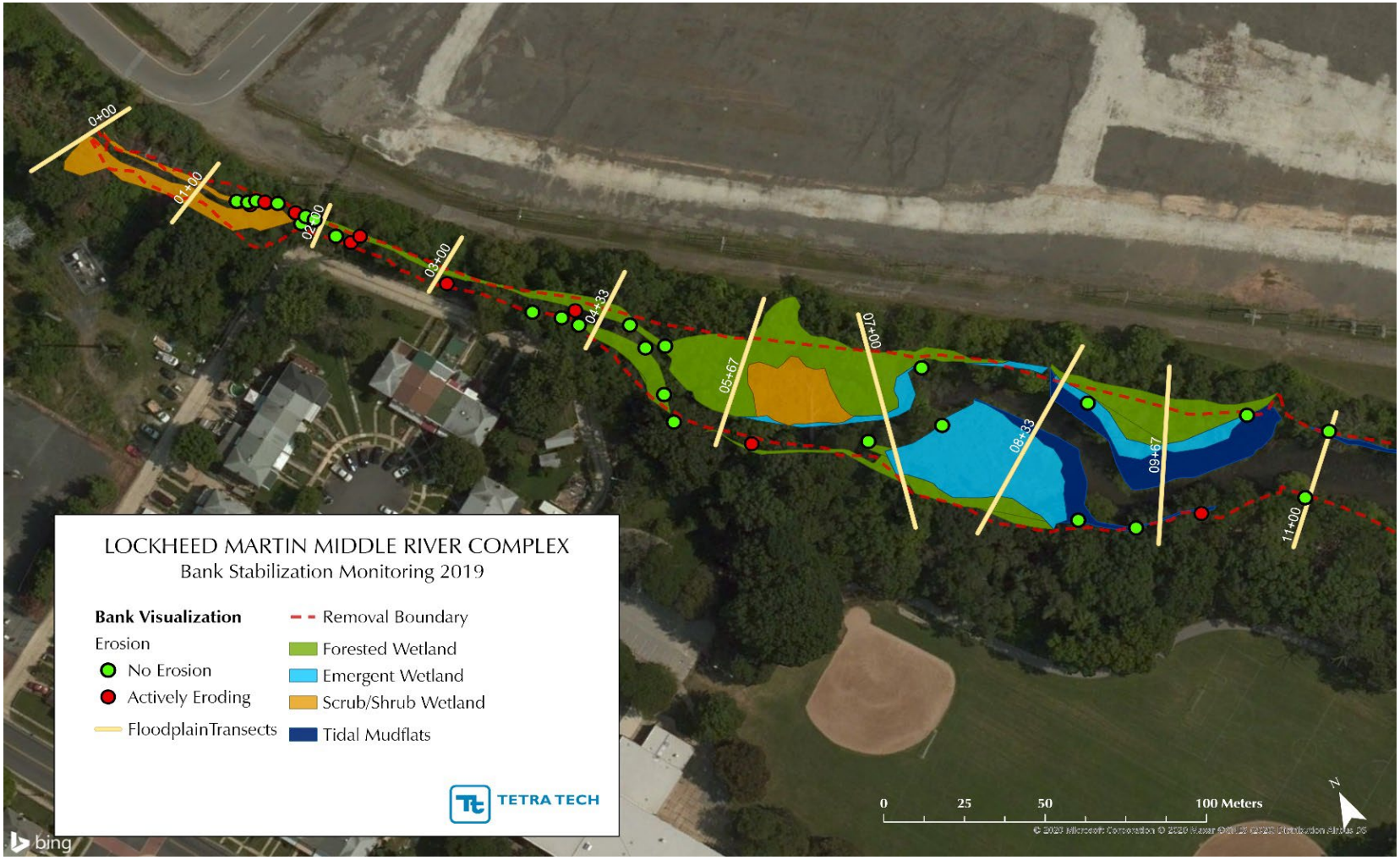


Figure C – 14. Observed locations of bank erosion along Cow Pen Creek–2019

**[Erosion noted in lower endpoints of segments assessed along both streambanks.
Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019b).]**

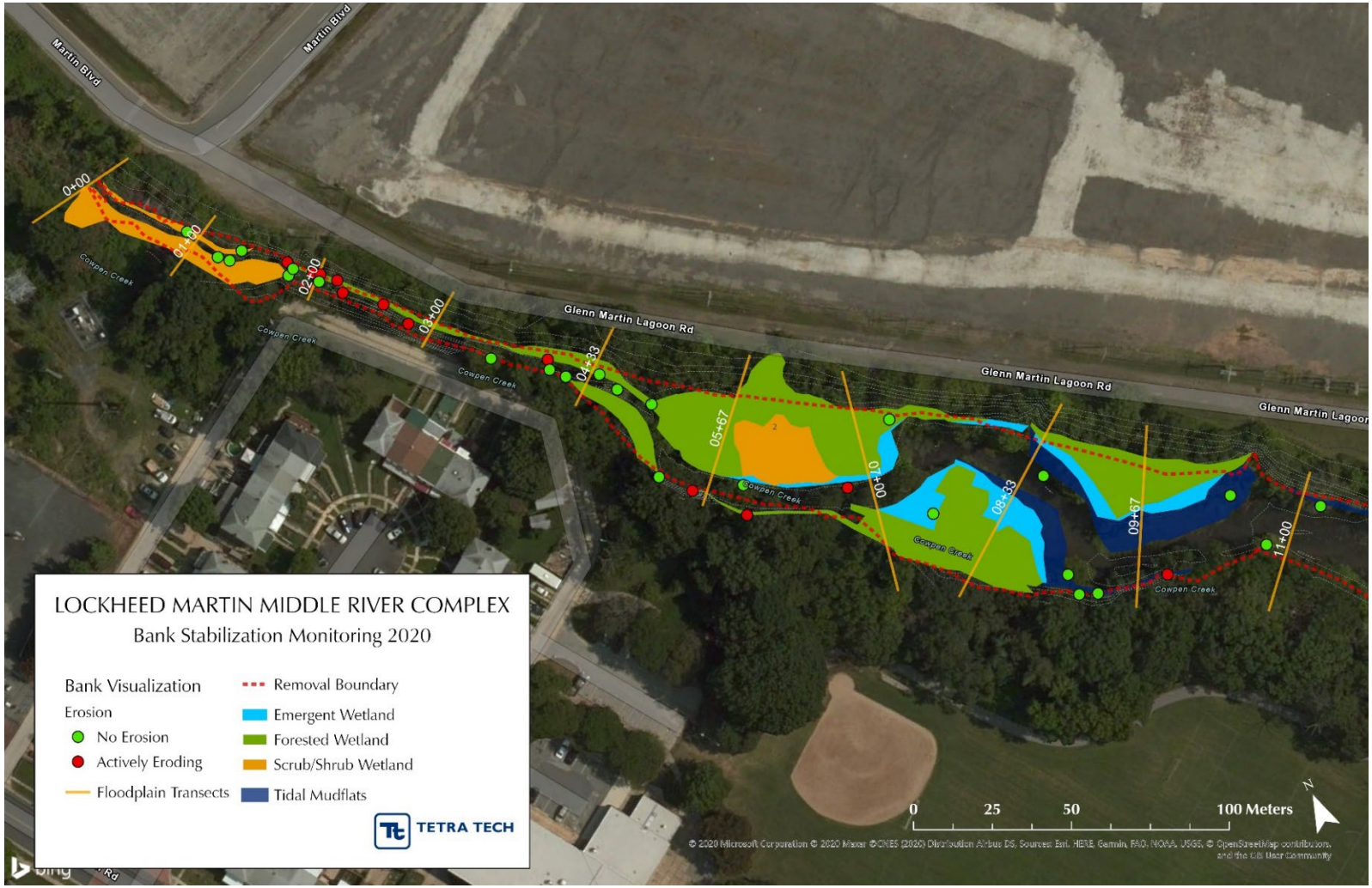


Figure C – 15. Observed locations of bank erosion along Cow Pen Creek–2020

**[Erosion noted in lower endpoints of segments assessed along both streambanks.
Upland and wetland vegetation types are from the 2020 wetland survey.]**

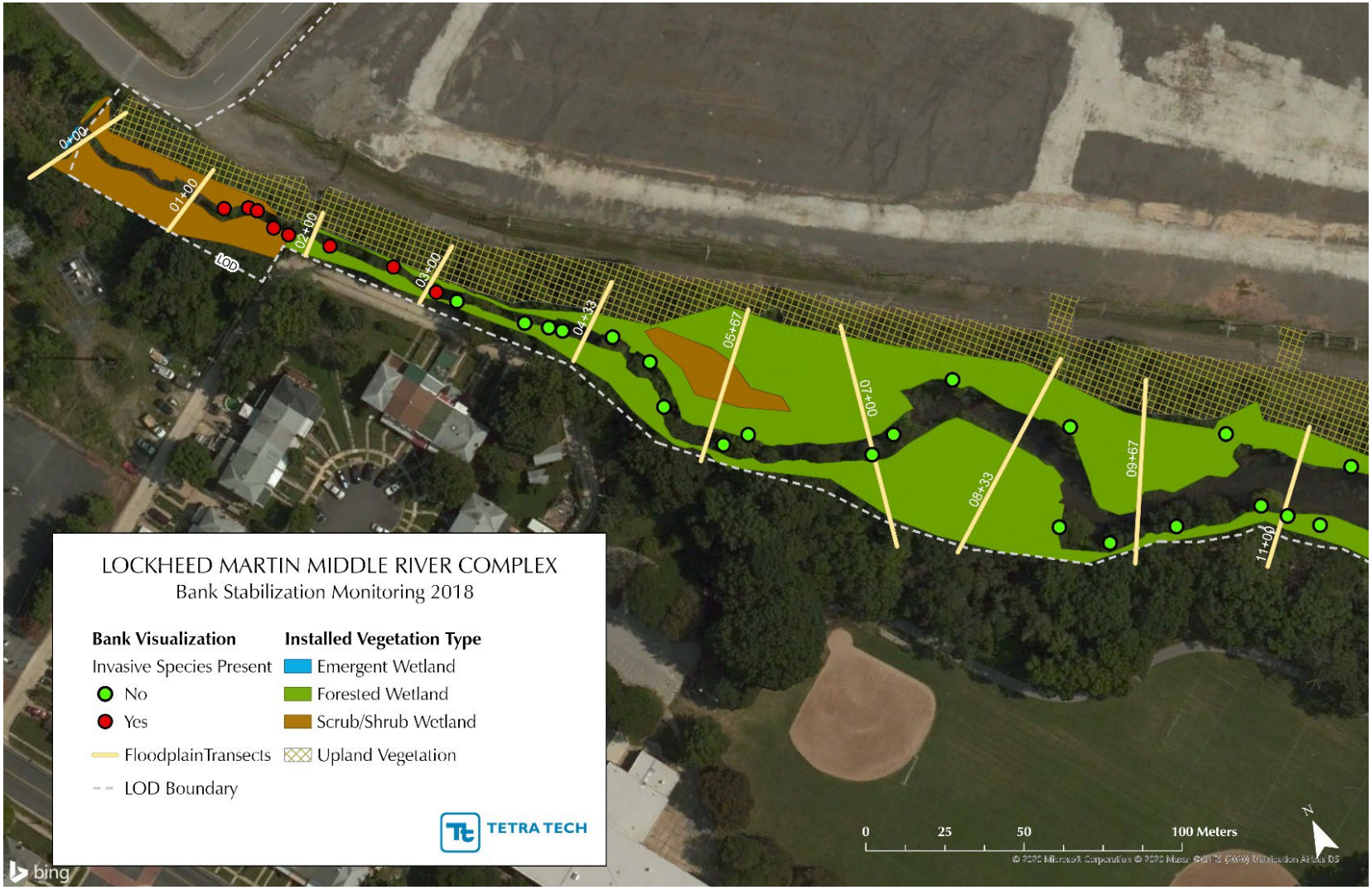


Figure C – 16. Observed locations of invasive plant species along Cow Pen Creek–2018

[Upland and wetland vegetation types are from 2017-2018 as-built plan.]

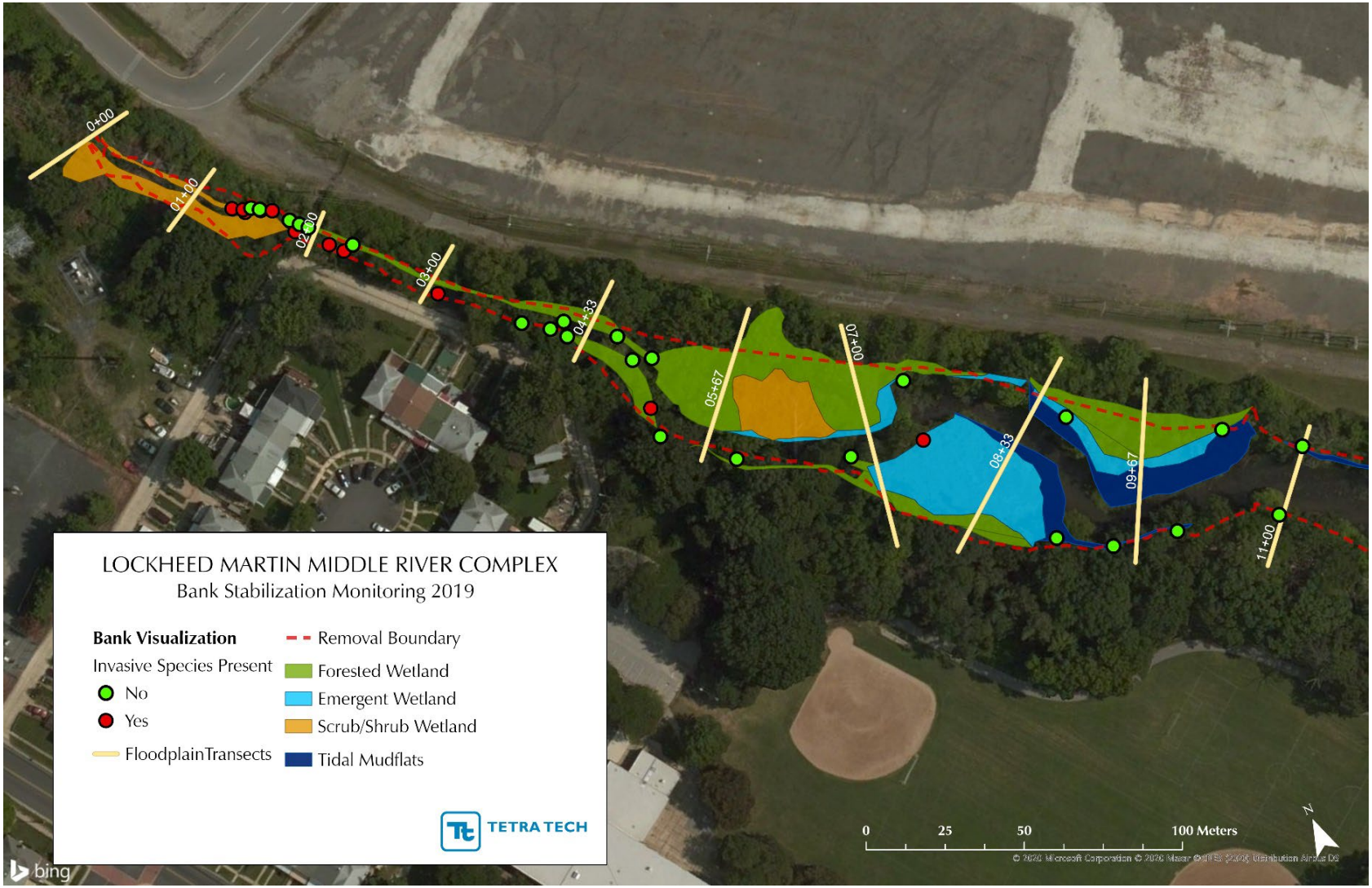


Figure C – 17. Observed locations of invasive plant species along Cow Pen Creek–2019

[Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019b).]

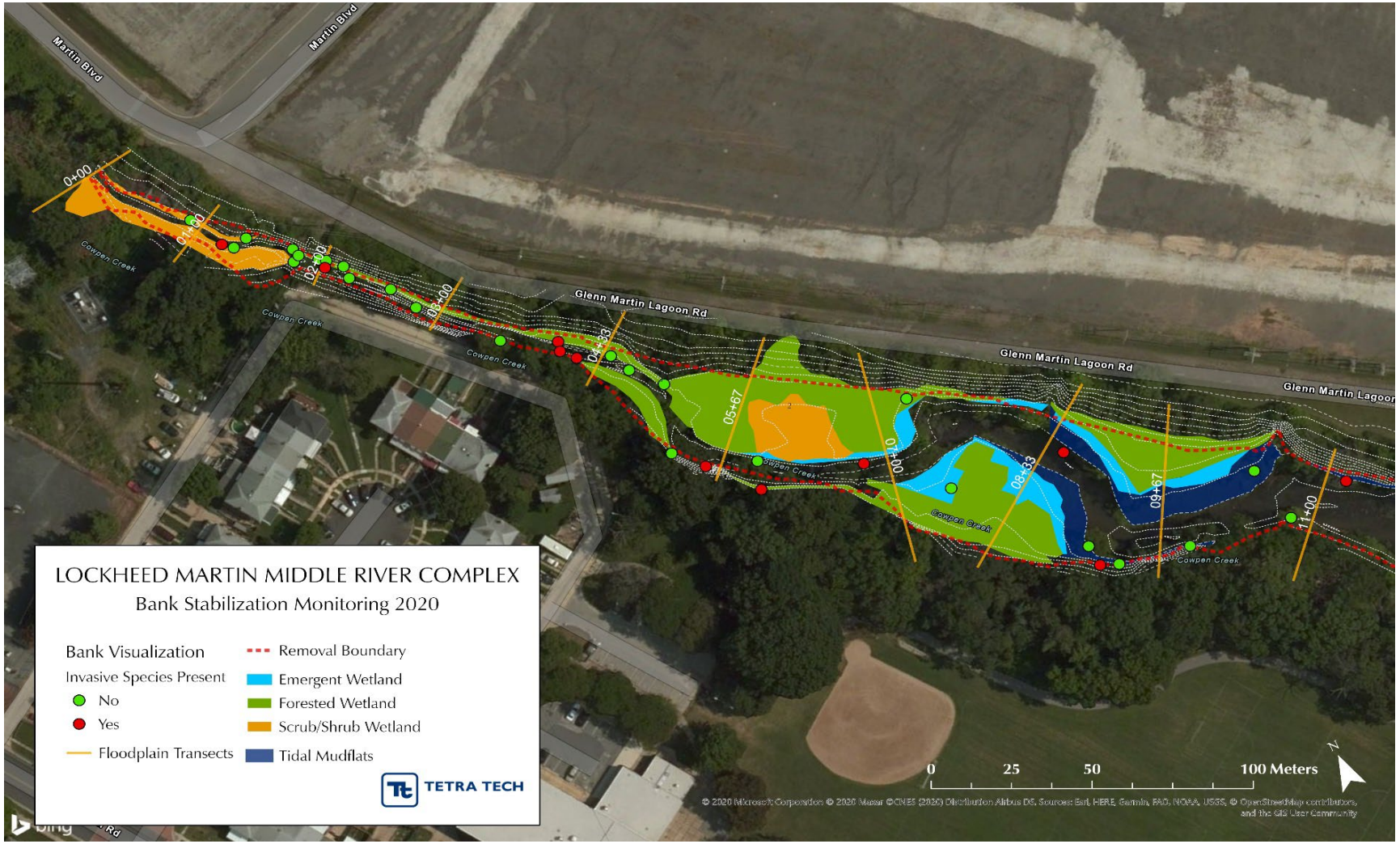


Figure C – 18. Observed locations of invasive plant species along Cow Pen Creek–2020

[Upland and wetland vegetation types are from the 2020 wetland survey (Tetra Tech 2020a).]

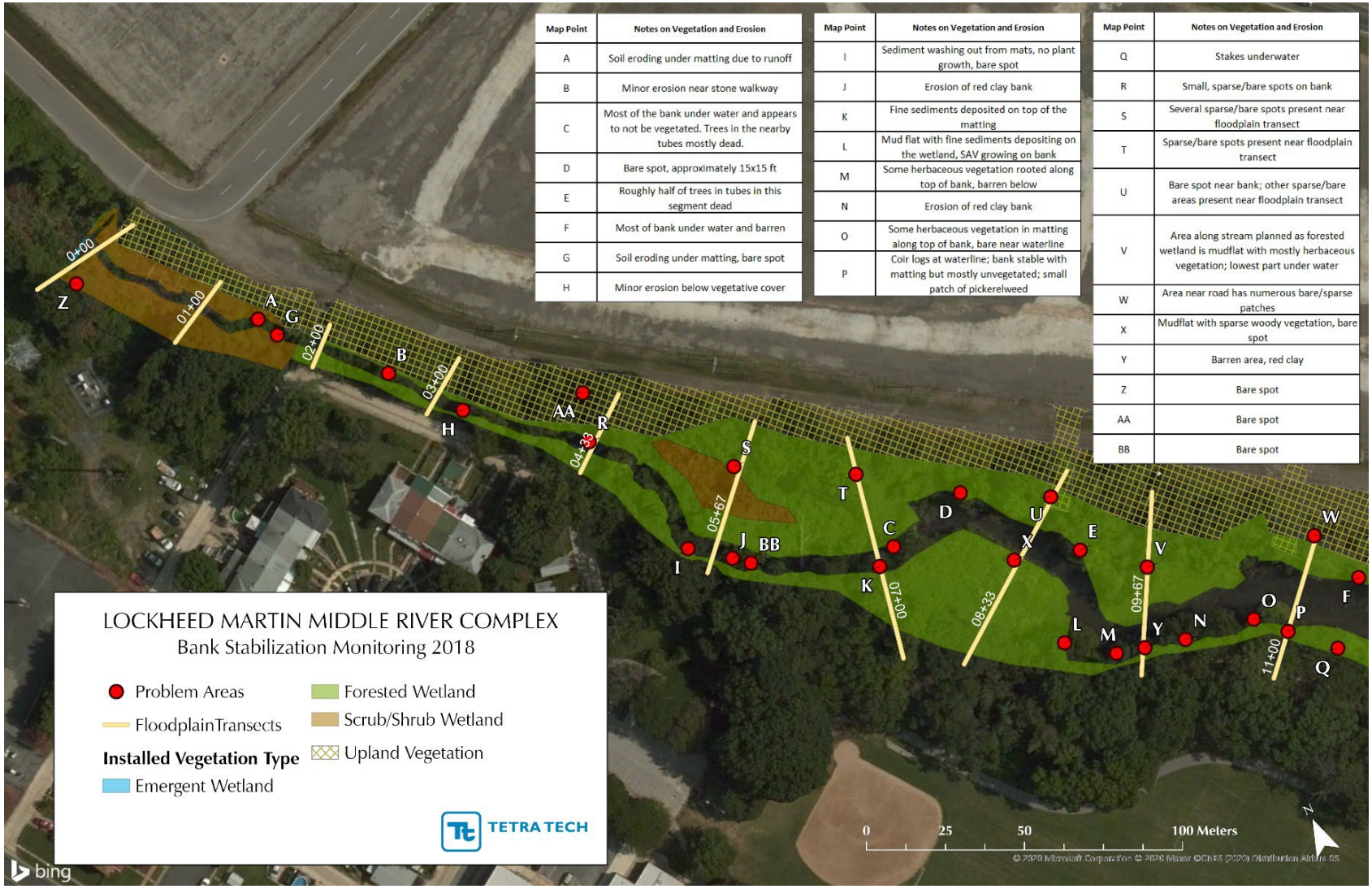
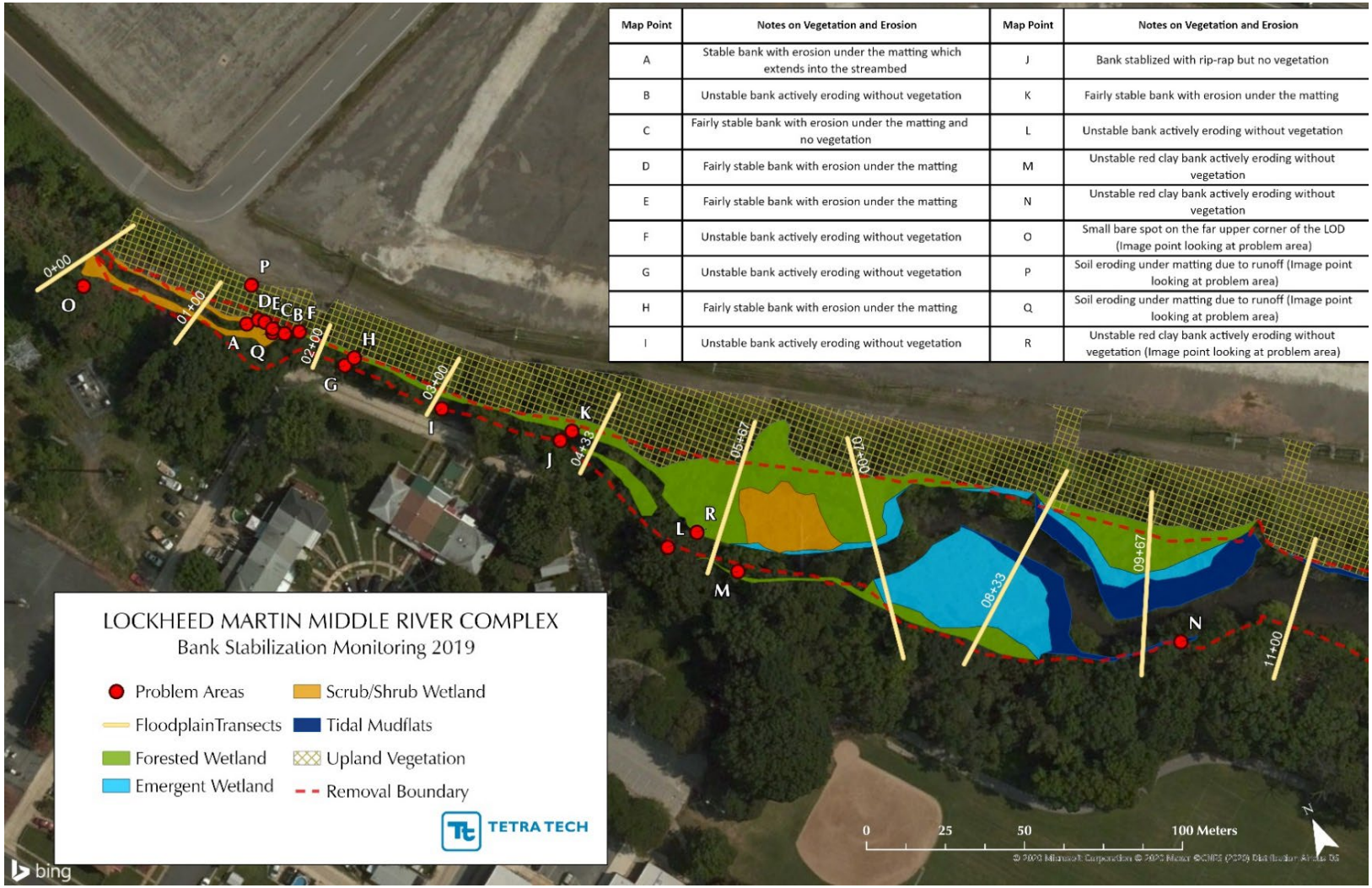


Figure C – 19. Noted areas of concern for erosion/vegetative cover along Cow Pen Creek–2018

(Upland and wetland vegetation types are from the 2017-2018 as-built plan.)



Map Point	Notes on Vegetation and Erosion	Map Point	Notes on Vegetation and Erosion
A	Stable bank with erosion under the matting which extends into the streambed	J	Bank stablized with rip-rap but no vegetation
B	Unstable bank actively eroding without vegetation	K	Fairly stable bank with erosion under the matting
C	Fairly stable bank with erosion under the matting and no vegetation	L	Unstable bank actively eroding without vegetation
D	Fairly stable bank with erosion under the matting	M	Unstable red clay bank actively eroding without vegetation
E	Fairly stable bank with erosion under the matting	N	Unstable red clay bank actively eroding without vegetation
F	Unstable bank actively eroding without vegetation	O	Small bare spot on the far upper corner of the LOD (Image point looking at problem area)
G	Unstable bank actively eroding without vegetation	P	Soil eroding under matting due to runoff (Image point looking at problem area)
H	Fairly stable bank with erosion under the matting	Q	Soil eroding under matting due to runoff (Image point looking at problem area)
I	Unstable bank actively eroding without vegetation	R	Unstable red clay bank actively eroding without vegetation (Image point looking at problem area)

Figure C – 20. Noted areas of concern for erosion/vegetative cover along Cow Pen Creek–2019

[Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019b).]

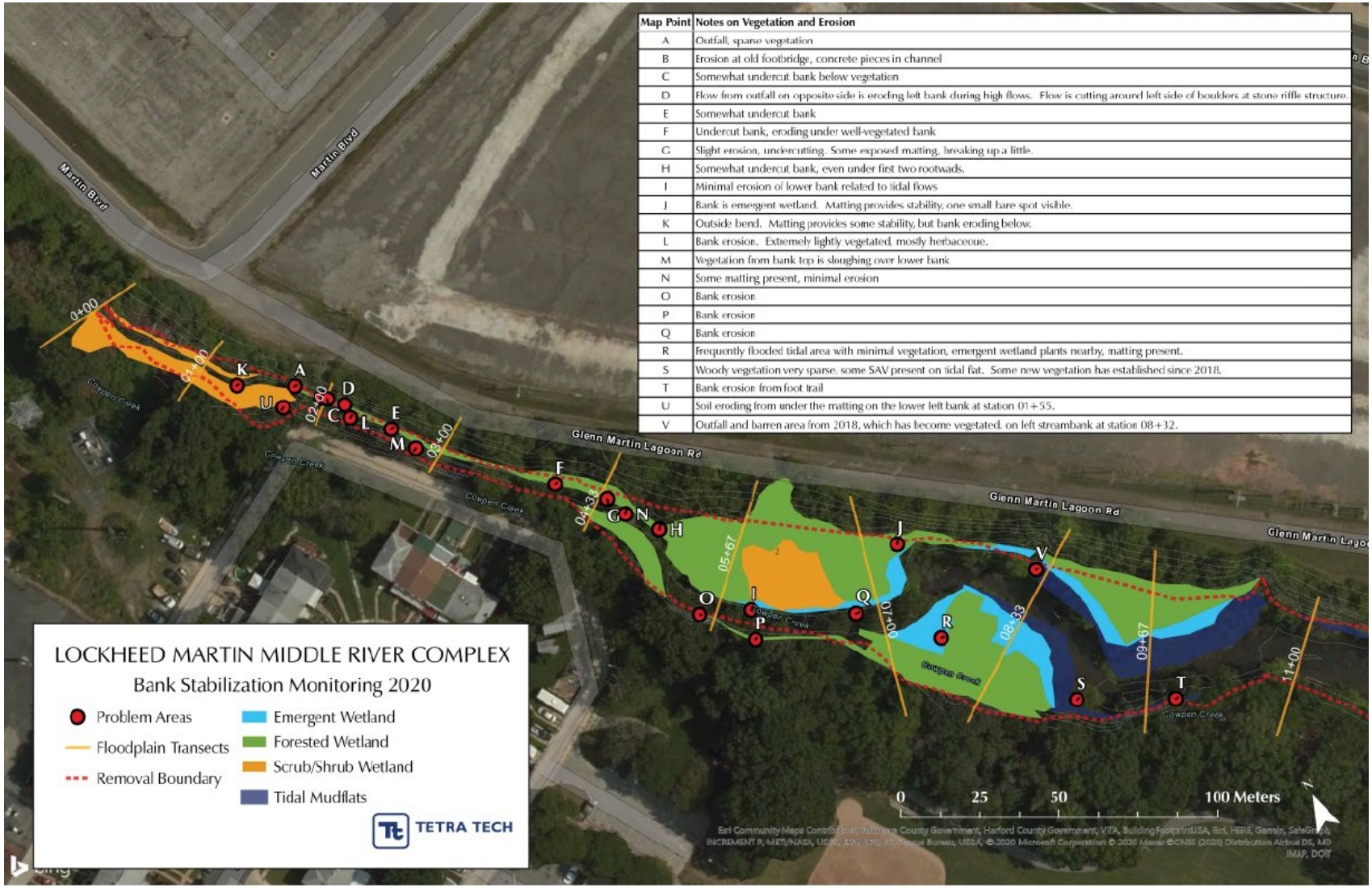


Figure C – 21. Noted areas of concern for erosion/vegetative cover along Cow Pen Creek–2020
[Upland and wetland vegetation types are from the 2020 wetland survey (Tetra Tech 2020a).]

Figure C – 22. Cow Pen Creek study area–2018 field survey points

[Floodplain transect start points (yellow points closest to stream along transect) were field-placed at top of bank on both sides of stream. As-built survey is from December 2017. Upland and wetland vegetation types are from the 2017-2018 as-built plan.]

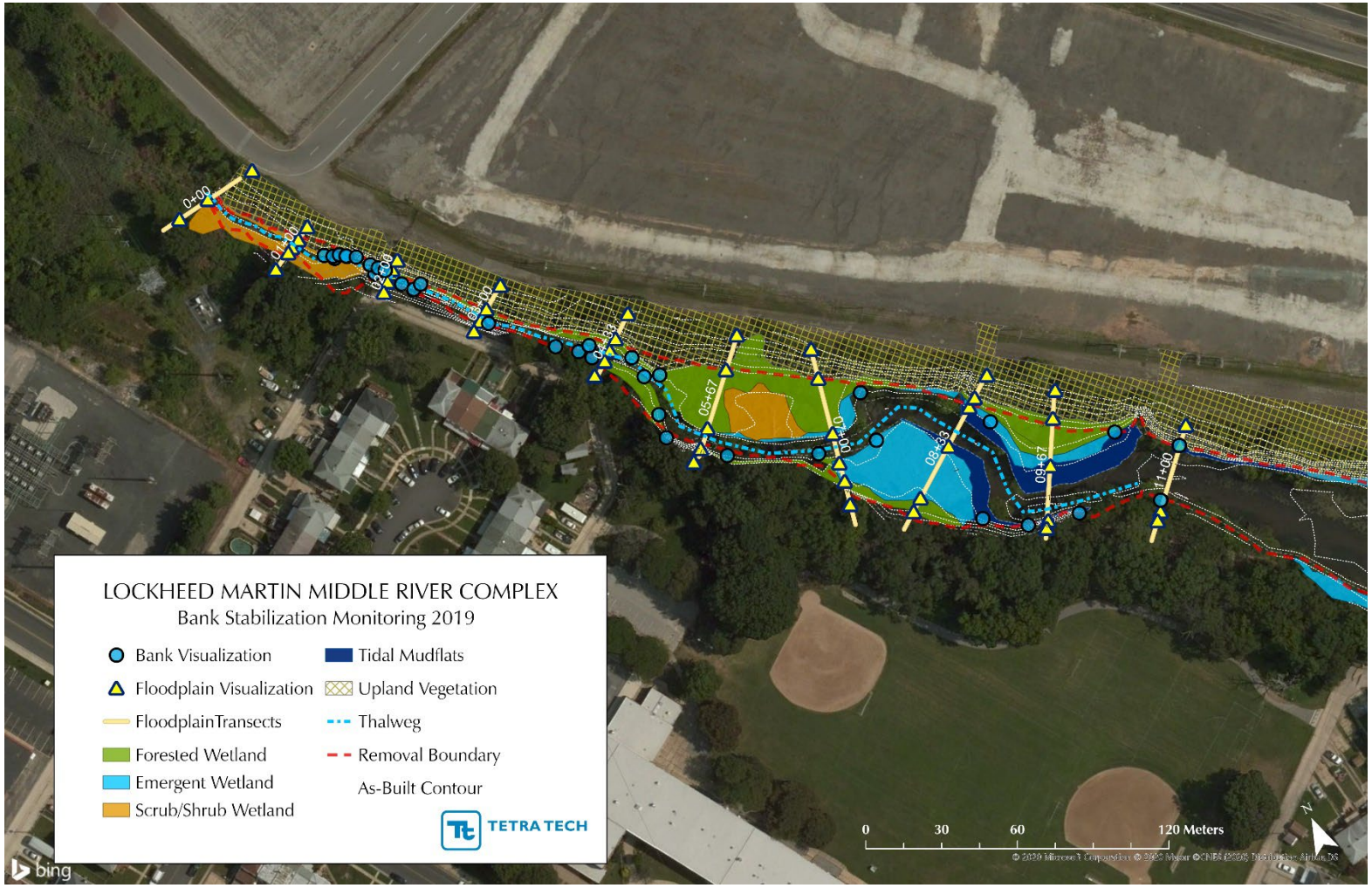


Figure C – 23. Cow Pen Creek study area–2019 field survey points

[Floodplain transect start points (yellow points closest to stream along transect) were field-placed at top of bank on both sides of stream. As-built survey is from April 2019. upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019b).]

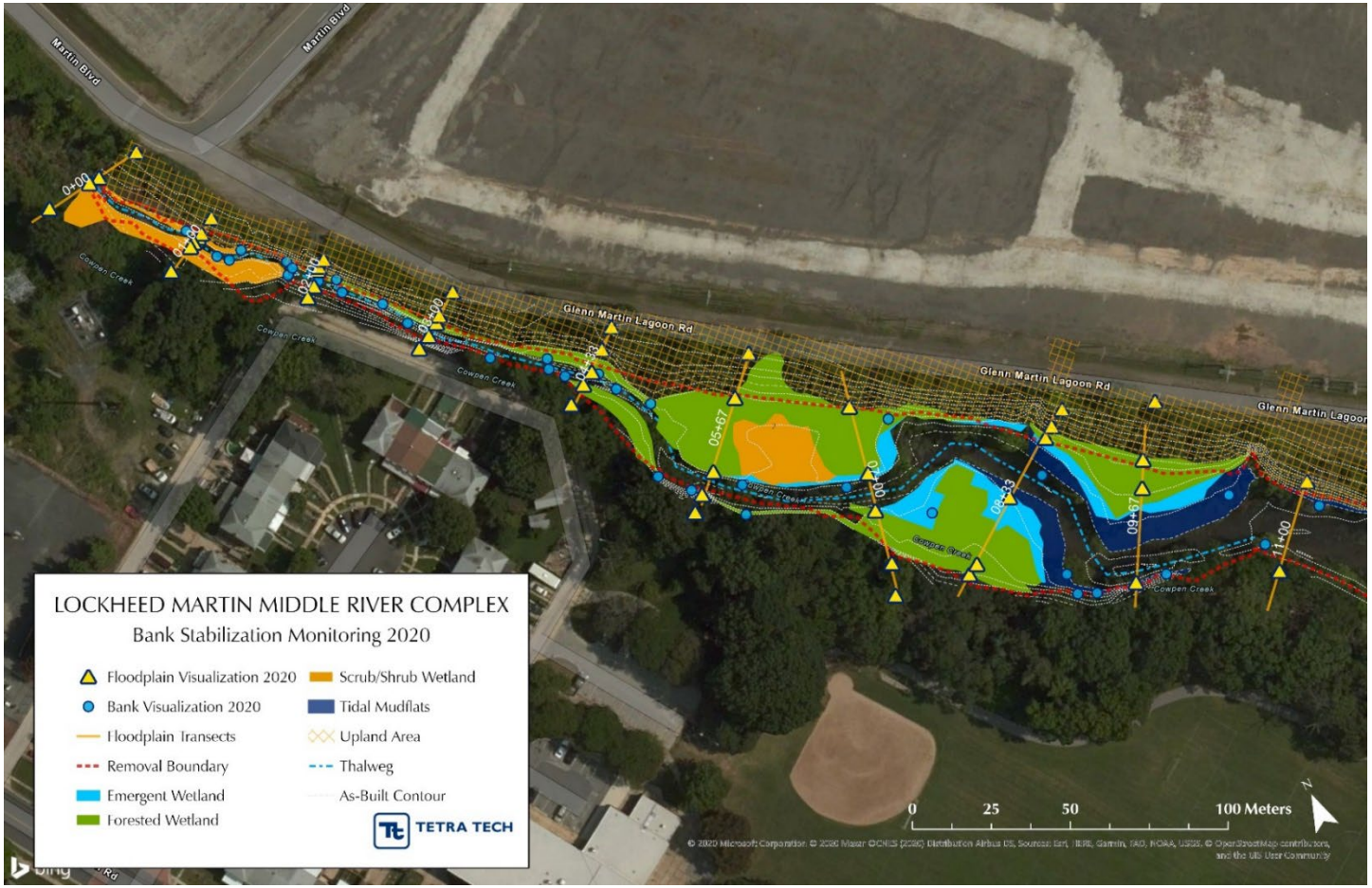


Figure C – 24. Cow Pen Creek study area– 2020 field survey points

[Floodplain transect start points (yellow triangles closest to stream along transect) were field-placed at top of bank on both sides of stream. As-built survey is from April 2019; upland and wetland vegetation types are from the 2020 wetland survey (Tetra Tech 2020a).]

Table C – 1: Daily Rainfall Totals prior to and including the Summer 2018 Monitoring Period (National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

Date	Baltimore/Washington International Airport (inches)	Baltimore Inner Harbor (inches)
7/21/2018	4.79	2.77
7/22/2018	0.50	0.96
7/23/2018	1.42	0.81
7/24/2018	4.07	1.77
7/25/2018	0.39	1.16
7/26/2018	0.00	0.00
7/27/2018	0.97	1.51

Table C – 2: Monthly Precipitation Totals, July 2017 through July 2018 (National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

Month	Monthly Precipitation, Baltimore/Washington International Airport (inches)		Monthly Precipitation, Baltimore Inner Harbor (inches)	
	30-Year Average	Observed Monthly Total	30-Year Average	Observed Monthly Total
Jul 2017	4.07	7.11	4.62	6.41
Aug 2017	3.29	4.60	3.39	6.02
Sep 2017	4.03	1.95	4.09	1.86
Oct 2017	3.33	2.99	3.05	2.64
Nov 2017	3.30	2.14	2.97	1.70
Dec 2017	3.37	0.95	3.41	0.78
Jan 2018	3.05	1.02	2.92	0.94
Feb 2018	2.90	5.28	2.60	4.79
Mar 2018	3.90	2.20	3.86	2.69
Apr 2018	3.19	3.20	3.22	4.69
May 2018	3.99	8.17	3.49	9.27
Jun 2018	3.46	4.77	3.27	3.20
Jul 2018	4.07	16.73	4.62	10.20

Table C – 3: Daily Rainfall Totals prior to and including the Summer 2019 Monitoring Period (National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

Date	Baltimore/Washington International Airport (inches)	Baltimore Inner Harbor (inches)
9/24/2019	0.00	0.00
9/25/2019	0.00	0.00
9/26/2019	0.01	0.00
9/27/2019	0.00	0.00
9/28/2019	0.00	0.00
9/29/2019	0.00	0.00
9/30/2019	Trace	0.01

Table C – 4: Monthly Precipitation Totals, August 2018 through September 2019 (National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

Month	Monthly Precipitation, Baltimore/Washington International Airport (inches)		Monthly Precipitation, Baltimore Inner Harbor (inches)	
	30-Year Average	Observed Monthly Total	30-Year Average	Observed Monthly Total
Aug 2018	3.29	3.84	3.39	7.25
Sep 2018	4.03	9.19	4.09	10.47
Oct 2018	3.33	2.69	3.05	2.12
Nov 2018	3.3	8.02	2.97	7.44
Dec 2018	3.37	6.29	3.41	5.87
Jan 2019	3.05	3.13	2.92	3.04
Feb 2019	2.9	3.64	2.6	3.76
Mar 2019	3.9	3.78	3.86	5.27
Apr 2019	3.19	1.46	3.22	1.87
May 2019	3.99	5.51	3.49	5.38
Jun 2019	3.46	2.95	3.27	2.74
Jul 2019	4.07	3.85	4.62	3.43
Aug 2019	3.29	2.39	3.39	5.29
Sep 2019	4.03	0.16	4.09	0.08

Table C – 5: Daily Rainfall Totals prior to and including the Summer 2020 Monitoring Period

Date	Baltimore/Washington International Airport (inches)[a]	Carroll Island (inches)[b]
7/28/2020	0	0.00
7/29/2020	0	0.00
7/30/2020	0.08	0.20
7/31/2020	0.42	0.25
8/1/2020	0	0.00
8/2/2020	0.0001	0.00
8/3/2020	0.24	0.27
8/4/2020	2.32	5.37
8/5/2020	0	0.00
8/6/2020	0.97	1.62
8/7/2020	0.25	2.40
8/8/2020	0	0.00
8/9/2020	0	0.00
8/10/2020	0	0.00
8/11/2020	0	3.19
8/12/2020	3.51	0.00
8/13/2020	0.56	0.61
8/14/2020	0.49	0.43
8/15/2020	0.18	0.04
8/16/2020	1.06	1.42
8/17/2020	0.26	0.29
8/18/2020	0	0.00

a. National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu

b. Weather Underground data

Table C – 6: Monthly Precipitation Totals, September 2019 through August 2020

Month	Monthly Precipitation, Baltimore/Washington International Airport (inches)[a]		Monthly Precipitation, Carroll Island (inches)[b]
	30-Year Average	Observed Monthly Total	Observed Monthly Total
Sep 2019	4.03	0.16	0.34
Oct 2019	3.33	6.21	7.01
Nov 2019	3.3	1.09	1.46
Dec 2019	3.37	3.63	4.51
Jan 2020	3.05	3.14	3.96
Feb 2020	2.9	3.01	4.71
Mar 2020	3.9	3.07	4.01
Apr 2020	3.19	5.52	7.47
May 2020	3.99	1.76	3.37
Jun 2020	3.46	5.95	5.28
Jul 2020	4.07	3.43	7.31
Aug 2020	3.29	11.81	19.19

a. National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu

b. Weather Underground data

Table C – 7: Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Condition			Segment Length by Vegetation and Stability Class			
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)
left	01+25	125	yes	stable	no	0	0	125	0
left	01+38	24	yes	stable	no	0	0	24	0
left	01+48	9	yes	unstable	yes	0	0	0	9
left	02+64	118	yes	stable	no	0	0	118	0
left	04+55	185	yes	stable	no	0	0	185	0
left	04+88	34	no	stable	no	34	0	0	0
left	05+93	112	yes	stable	no	0	0	112	0
left	07+10	123	yes	stable	no	0	0	123	0
left	07+71	60	yes	stable	no	0	0	60	0
left	08+75	91	yes	stable	no	0	0	91	0
left	10+68	196	yes	stable	no	0	0	196	0
left	11+80	77	yes	stable	no	0	0	77	0
right	01+56	166	yes	stable	no	0	0	166	0
right	01+67	14	no	unstable	yes	0	14	0	0

Table C – 7: Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Condition			Segment Length by Vegetation and Stability Class			
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)
right	01+78	8	yes	stable	no	0	0	8	0
right	02+12	36	no	stable	no	36	0	0	0
right	03+05	92	yes	stable	no	0	0	92	0
right	03+22	18	yes	unstable	yes	0	0	0	18
right	03+60	57	no	stable	no	57	0	0	0
right	03+79	19	no	stable	no	19	0	0	0
right	03+90	12	no	stable	no	12	0	0	0
right	04+98	111	yes	stable	no	0	0	111	0
right	05+30	31	no	unstable	yes	0	31	0	0
right	05+58	27	no	unstable	yes	0	27	0	0
right	07+00	119	no	stable	no	119	0	0	0
right	09+09	232	yes	stable	no	0	0	232	0
right	09+42	23	yes	stable	no	0	0	23	0
right	09+93	53	no	unstable	yes	0	53	0	0

Table C – 7: Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Condition			Segment Length by Vegetation and Stability Class			
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)
right	10+70	68	no	stable	no	68	0	0	0
right	11+10	25	no	stable	no	25	0	0	0
right	11+35	35	no	unstable	yes	0	35	0	0

Table C – 8: Vegetation Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
left	01+25	125	herbaceous cover	Yes	No	No		yes	Common reed	
left	01+38	24	herbaceous cover	No	No	No		yes	Common reed	
left	01+48	9	herbaceous cover	No	Yes	No	Soil eroding under matting due to runoff	yes	Common reed	
left	02+64	118	herbaceous cover	Yes	Yes	No	Some erosion near stone walkway	yes	Common reed	Stone walkway
left	04+55	185	herbaceous cover	Yes	Yes	No		no		
left	04+88	34	herbaceous layer <10% cover	Yes	Yes	No		no		Rootwad feature with vegetation cover behind rootwad
left	05+93	112	herbaceous cover	Yes	Yes	No		no		
left	07+10	123	herbaceous layer <10% cover	Yes	Yes	No	Most of the lower bank is under water and appears to not be vegetated. Trees in the nearby tubes are mostly dead.	no		

Table C – 8: Vegetation Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
							Upper bank has woody vegetation.			
left	07+71	60	herbaceous cover	Yes	Yes	No	Nearby barren section approximately 15x15 ft.	no		
left	08+75	91	herbaceous cover	Yes	Yes	No	Roughly half of trees in tubes dead	no		Outfall
left	10+68	196	herbaceous cover	Yes	Yes	No		no		
left	11+80	77	herbaceous cover	Yes	Yes	No	Lower part of bank is under water. Upper bank has vegetation.	no		Outfall
right	01+56	166	herbaceous cover	Yes	Yes	No		no		
right	01+67	14	herbaceous layer <10% cover	Yes	No	No	Soil eroding under matting	yes	Common reed	
right	01+78	8	herbaceous cover	Yes	No	No		yes	Common reed	Guardrail

Table C – 8: Vegetation Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
right	02+12	36	herbaceous layer <10% cover	Yes	No	No		yes	Common reed	Guardrail, rip-rap, outfall
right	03+05	92	herbaceous cover	No	Yes	No		yes	Common reed	Rip-rap on part of bank
right	03+22	18	herbaceous cover	Yes	No	No	Minor erosion below vegetative cover	no		
right	03+60	57	herbaceous layer <10% cover	No	No	No		no		Rip-rap
right	03+79	19	herbaceous layer <10% cover	No	No	No		no		Log and rip-rap, old bridge
right	03+90	12	herbaceous layer <10% cover	No	No	No		no		Rip-rap
right	04+98	111	herbaceous cover	Yes	No	No	Gravel bar	no		
right	05+30	31	herbaceous layer <10% cover	No	No	No	Sediment washing out from mats. No plant growth.	no		
right	05+58	27	herbaceous layer <10% cover	No	No	No	One tree in bank, >15ft. Red clay bank.	no		

Table C – 8: Vegetation Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
right	07+00	119	herbaceous layer <10% cover	No	No	No	Fine sediments deposited on top of the matting	no		
right	09+09	232	herbaceous cover	Yes	Yes	No	Mud flat with fine sediments depositing on the wetland, SAV growing on bank	no		
right	09+42	23	herbaceous layer <10% cover	No	No	No	Some herbaceous vegetation rooted along top of bank, bare below	no		
right	09+93	53	herbaceous layer <10% cover	No	No	No	Red clay bank	no		
right	10+70	68	herbaceous layer <10% cover	No	No	No	Some herbaceous vegetation in matting along top of bank, bare near waterline	no		
right	11+10	25	herbaceous layer <10% cover	No	No	No	Coir logs at waterline; bank stable with matting but mostly unvegetated; small	no		

Table C – 8: Vegetation Observed by Streambank Segment, Cow Pen Creek, July 2018

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
							patch of pickerelweed			
right	11+35	35	herbaceous layer <10% cover	No	No	No	Stakes underwater	no		

Table C – 9: Summary of Streambank Conditions, Cow Pen Creek, July 2018

Total Streambank Length by Vegetation and Stability Class						
Bank	No Vegetation, Stable, No Erosion (feet)		No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)	Total (feet)
	Armored with structures	Unarmored, Stabilized with Other Treatments (Coir Log, Matting)				
Total length, left bank	34	0	0	1,111	9	1,154
Total length, right bank	124	212	160	632	18	1,146
Total length, both banks	158	212	160	1,743	27	2,300

Table C – 10: Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Condition			Segment Length by Vegetation and Stability Class					
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)	No vegetation, stable, some erosion (feet)	Vegetation, stable, some erosion (feet)
left	01+36	136	yes	stable	no	0	0	136	0	0	0
left	01+45	9	yes	stable	no	0	0	9	0	0	0
left	01+52	7	yes	stable	no	0	0	7	0	0	0
left	01+57	5	no	unstable	yes	0	5	0	0	0	0
left	01+59	2	no	stable	yes	0	0	0	0	2	0
left	01+66	7	yes	stable	no	0	0	7	0	0	0
left	01+83	17	no	unstable	yes	0	17	0	0	0	0
left	01+91	8	yes	stable	no	0	0	8	0	0	0
left	01+98	7	yes	stable	no	0	0	7	0	0	0
left	02+32	34	yes	stable	yes	0	0	0	0	0	34
left	04+13	181	yes	stable	yes	0	0	0	0	0	181
left	04+57	44	yes	stable	no	0	0	44	0	0	0
left	04+86	29	yes	stable	no	0	0	29	0	0	0

Table C – 10: Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Condition			Segment Length by Vegetation and Stability Class					
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)	No vegetation, stable, some erosion (feet)	Vegetation, stable, some erosion (feet)
left	07+57	271	yes	stable	no	0	0	271	0	0	0
left	08+55	98	yes	stable	no	0	0	98	0	0	0
left	10+50	195	yes	stable	no	0	0	195	0	0	0
left	11+00	50	yes	stable	no	0	0	50	0	0	0
right	01+37	137	yes	stable	no	0	0	137	0	0	0
right	01+46	9	yes	stable	yes	0	0	0	0	0	9
right	01+91	45	yes	stable	no	0	0	45	0	0	0
right	02+14	23	yes	stable	no	0	0	23	0	0	0
right	02+27	13	no	unstable	yes	0	13	0	0	0	0
right	03+09	82	no	unstable	yes	0	82	0	0	0	0
right	03+80	71	yes	stable	no	0	0	71	0	0	0
right	04+03	23	no	stable	no	23	0	0	0	0	0
right	04+19	16	yes	stable	no	0	0	16	0	0	0
right	04+76	57	yes	stable	no	0	0	57	0	0	0

Table C – 10: Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Condition			Segment Length by Vegetation and Stability Class					
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)	No vegetation, stable, some erosion (feet)	Vegetation, stable, some erosion (feet)
right	05+22	46	yes	stable	no	0	0	46	0	0	0
right	05+41	19	no	stable	no	19	0	0	0	0	0
right	05+93	52	no	unstable	yes	0	52	0	0	0	0
right	06+82	89	yes	stable	no	0	0	89	0	0	0
right	07+38	56	yes	stable	no	0	0	56	0	0	0
right	09+26	188	yes	stable	no	0	0	188	0	0	0
right	09+45	19	yes	stable	no	0	0	19	0	0	0
right	09+98	53	no	unstable	yes	0	53	0	0	0	0
right	10+97	99	yes	stable	no	0	0	99	0	0	0

Table C – 11: Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
left	01+36	136	herbaceous cover	Yes	No	No		yes	Barnyard grass	
left	01+45	9	herbaceous cover	No	No	No	Cobble on bank.	yes	Barnyard grass	
left	01+52	7	herbaceous cover	No	No	No		yes	Barnyard grass	
left	01+57	5	barren	No	No	No	Bank eroding below mat. Below heavy runoff area from road	no		
left	01+59	2	barren	No	No	No	Below large runoff area from corner of road. Eroding behind matting.	no	.	
left	01+66	7	herbaceous cover	No	No	No		yes	Barnyard grass	
left	01+83	17	barren	No	No	No		no		outfall
left	01+91	8	herbaceous cover	No	No	No		no		
left	01+98	7	herbaceous cover	No	No	No		no		
left	02+32	34	herbaceous cover	No	No	No		no		

Table C – 11: Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
left	04+13	181	herbaceous cover	Yes	Yes	No	Undercut bank, eroding under well-vegetated bank.	no		
left	04+57	44	herbaceous cover	Yes	Yes	No		no		
left	04+86	29	herbaceous cover	No	Yes	No	Root wad section.	no		root wad structure
left	07+57	271	herbaceous cover	Yes	Yes	No	Bank is emergent wetland.	no		
left	08+55	98	herbaceous cover	Yes	Yes	No		no		outfall
left	10+50	195	herbaceous cover	Yes	Yes	No	Bank is emergent wetland.	no		
left	11+00	50	herbaceous cover	Yes	Yes	No		no		outfall
right	01+37	137	herbaceous cover	No	Yes	No		yes	Common reed, barnyard grass, and burdock	
right	01+46	9	herbaceous cover	No	No	No		yes	Burdock	
right	01+91	45	herbaceous cover	No	No	No		yes	Common reed	guardrail

Table C – 11: Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
right	02+14	23	herbaceous cover	Yes	Yes	No		yes	Common reed	outfall
right	02+27	13	barren	No	No	No	Undercut bank with erosion under the matting.	yes	Burdock	
right	03+09	82	herbaceous cover	No	Yes	No	Overhanging vegetation with lower bank getting scoured. Mat providing some protection.	yes	Barnyard grass	
right	03+80	71	herbaceous cover	Yes	Yes	No	Stabilized with rip-rap.	no		rip-rap
right	04+03	23	herbaceous cover	No	No	No	Stabilized by logs and riprap.	no		logs and rip-rap
right	04+19	16	herbaceous cover	Yes	Yes	No	Riprap holding bank. Plants in between rocks.	no		rip-rap
right	04+76	57	herbaceous cover	No	Yes	No		no		
right	05+22	46	herbaceous cover	Yes	Yes	No		yes	Common reed	
right	05+41	19	barren	Yes	No	No	Stable with matting. Small willows present.	no		

Table C – 11: Vegetation Observed by Streambank Segment, Cow Pen Creek, September 2019

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
right	05+93	52	barren	Yes	No	Yes	Bank is held at toe by matting. Steep clay bank.	no		
right	06+82	89	herbaceous cover	No	No	Yes	Large down tree on top of bank. Sediment deposition on top of matting.	no		tree
right	07+38	56	herbaceous cover	Yes	No	No		yes	Common reed	
right	09+26	188	herbaceous cover	No	No	No	Wetland establishing.	no		
right	09+45	19	herbaceous cover	No	No	No	Matting holding bank together.	no		
right	09+98	53	barren	Yes	No	No	Not treated, raw clay bank.	no		
right	10+97	99	herbaceous cover	Yes	Yes	No	Matting holding bank together.	no		

Table C - 12: Summary of Streambank Conditions, Cow Pen Creek, September 2019

Total Streambank Length by Vegetation and Stability Class								
Bank	No Vegetation, Stable, No Erosion (feet)		No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)	No vegetation, stable, some erosion (feet)	Vegetation, stable, some erosion (feet)	Total (feet)
	Armored with structures	Unarmored, Stabilized with Other Treatments (Coir Log, Matting)						
Total length, left bank	0	0	22	861	0	2	215	1,100
Total length, right bank	23	19	200	846	0	0	9	1,097
Total length, both banks	23	19	222	1,707	0	2	224	2,197

Table C – 13: Conditions Observed by Streambank Segment, August 2020

(*Indicates erosion observed at lower streambank, below a vegetated and stable upper streambank)

Bank segment			Condition			Segment length by vegetation and stability class			
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, unstable, actively eroding (feet)
left	00+94	94	yes	stable	no	0	0	94	0
left	01+42	48	yes	stable	no	0	0	48	0
left	01+75	33	no	unstable	yes	0	33	0	0
left	01+83	8	yes	unstable	yes	0	0	0	8*
left	02+05	22	yes	unstable	yes	0	0	0	22*
left	02+20	15	yes	unstable	yes	0	0	0	15
left	02+62	42	yes	stable	yes	0	0	0	42*
left	04+04	142	yes	stable	yes	0	0	0	142*
left	04+47	43	yes	stable	no	0	0	43	0
left	04+95	48	yes	stable	no	0	0	48	0
left	06+04	109	yes	stable	no	0	0	109	0
left	07+65	161	yes	stable	no	0	0	161	0
left	08+67	102	yes	stable	no	28	0	74	0

Table C – 13: Conditions Observed by Streambank Segment, August 2020

(*Indicates erosion observed at lower streambank, below a vegetated and stable upper streambank)

Bank segment			Condition			Segment length by vegetation and stability class			
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, unstable, actively eroding (feet)
left	10+76	209	yes	stable	no	209	0	0	0
left	11+30	24	yes	stable	no	16	0	8	0
right	01+20	120	yes	stable	no	0	0	120	0
right	01+31	11	yes	stable	no	0	0	11	0
right	01+84	53	yes	stable	no	0	0	53	0
right	02+09	25	yes	stable	no	0	0	25	0
right	02+29	20	no	unstable	yes	0	20	0	0
right	02+87	58	yes	stable	yes	0	0	0	58*
right	03+60	73	yes	stable	no	0	0	73	0
right	04+06	46	yes	stable	no	0	0	46	0
right	04+22	16	yes	stable	no	0	0	16	0
right	04+63	41	yes	stable	no	0	0	41	0
right	05+44	81	yes	stable	no	0	0	81	0

Table C – 13: Conditions Observed by Streambank Segment, August 2020

(*Indicates erosion observed at lower streambank, below a vegetated and stable upper streambank)

Bank segment			Condition			Segment length by vegetation and stability class			
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg	Vegetation	Bank stability	Erosion	No vegetation, stable, no erosion (feet)	No vegetation, unstable, actively eroding (feet)	Vegetation, stable, no erosion (feet)	Vegetation, unstable, actively eroding (feet)
right	05+65	21	yes	unstable	yes	0	0	0	21
right	06+13	48	yes	unstable	yes	0	0	0	48
right	06+90	77	yes	unstable	yes	0	0	0	77
right	07+40	50	no	stable	no	50	0	0	0
right	09+42	202	yes	stable	no	154	0	48	0
right	09+52	10	yes	stable	no	10	0	0	0
right	09+60	8	yes	stable	no	8	0	0	0
right	10+09	49	yes	unstable	yes	0	49	0	0
right	10+94	85	yes	stable	no	20	0	65	0

Table C – 14: Vegetation Observed by Streambank Segment, Cow Pen Creek, August 2020

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
left	00+94	94	herbaceous cover	No	No	No	Receiving flow from side tributary	no		
left	01+42	48	herbaceous cover	No	No	No	Stable with vegetation over matting	no		
left	01+75	33	barren	No	No	No	Outfall, sparse vegetation	no		outfall
left	01+83	8	herbaceous cover	No	No	No	Derelict footbridge, concrete pieces in channel	no		concrete from old footbridge
left	02+05	22	herbaceous cover	No	No	No	Somewhat undercut bank below vegetation	no		
left	02+20	15	herbaceous cover	No	Yes	No	Flow from outfall from right bank is crashing into and eroding left bank during high flows. Flow is cutting around left side of boulders at stone riffle structure.	no		boulders and stone riffle structure
left	02+62	42	herbaceous cover	Yes	Yes	No	Somewhat undercut bank	no		
left	04+04	142	herbaceous cover	Yes	Yes	No	Undercut bank, eroding under well-vegetated bank	yes, 10%	Chinese bush clover	

Table C – 14: Vegetation Observed by Streambank Segment, Cow Pen Creek, August 2020

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
left	04+47	43	herbaceous cover	Yes	Yes	No	Slight erosion, undercutting. Some exposed matting, breaking up a little.	no		
left	04+95	48	herbaceous cover	Yes	Yes	No	Somewhat undercut bank, even under first two rootwads.	no		rootwad structure
left	06+04	109	herbaceous cover	Yes	Yes	No	Minimal erosion of lower bank related to tidal flows	no		
left	07+65	161	herbaceous cover	Yes	Yes	No	Bank is emergent wetland. Matting providing stability. One small bare spot visible.	no		
left	08+67	102	herbaceous cover	No	Yes	No		yes, 10%	Chinese bush clover	outfall
left	10+76	209	herbaceous cover	Yes	Yes	No		no		
left	11+00	24	herbaceous cover	No	Yes	No		yes, 10%	Chinese bush clover	outfall
right	01+20	120	herbaceous cover	No	No	No		yes, <5%	Common reed	
right	01+31	11	herbaceous cover	No	No	No	Matting provides some stability, but bank eroding below. Outside bend.	no		
right	01+84	53	herbaceous cover	No	No	No		no		
right	02+09	25	herbaceous cover	No	Yes	No		yes, <5%	Mimosa	outfall

Table C – 14: Vegetation Observed by Streambank Segment, Cow Pen Creek, August 2020

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
right	02+29	20	barren	Yes	No	No	Extremely lightly vegetated, mostly herbaceous	no		
right	02+87	58	herbaceous cover	Yes	Yes	No	Vegetation from bank top is sloughing over lower bank	no		
right	03+60	73	herbaceous cover	Yes	Yes	No	Bank stabilized with riprap	no		rip-rap
right	04+06	46	herbaceous cover	Yes	Yes	No	Herbaceous vegetation growing around logs	yes, <5%	Rose of Sharon, forsythia	logs
right	04+22	16	herbaceous cover	Yes	Yes	No		yes, 20%	Rose of Sharon, forsythia, Japanese honeysuckle	
right	04+63	41	herbaceous cover	No	Yes	No	Some matting present, minimal erosion	no		
right	05+44	81	herbaceous cover	Yes	Yes	No		no		
right	05+65	21	herbaceous cover	Yes	Yes	Yes		yes, 10%	English ivy	
right	06+13	48	herbaceous cover	No	Yes	Yes		yes, <5%	Rose of Sharon	
right	06+90	77	herbaceous cover	Yes	Yes	Yes		yes, 5%	Mimosa	
right	07+40	50	barren	No	Yes	No	Frequently flooding tidal area with minimal veg, emergent wetland plants nearby, matting present	no		

Table C – 14: Vegetation Observed by Streambank Segment, Cow Pen Creek, August 2020

Bank segment			Herbaceous vegetation present (>10% cover)	Woody Vegetation by Height Class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes	Proximity to structural features
Stream bank	Approximate station location, segment endpoint (feet)	Bank segment length (feet) as measured along GIS thalweg		Woody vegetation present (<3 feet)	Woody vegetation present (3–15 feet)	Woody vegetation present (>15 feet)				
Right	09+42	202	herbaceous cover	Yes	Yes	No	Woody vegetation is very sparse, some SAV present	no		
Right	09+52	10	herbaceous cover	Yes	Yes	No	Matting is still stabilizing bank	yes, 10%	Chinese bush clover	
Right	09+60	8	herbaceous cover	Yes	Yes	No		no		
Right	10+09	49	herbaceous cover	No	Yes	Yes		no		
Right	10+94	85	herbaceous cover	Yes	Yes	No		no		

Table C – 15: Summary of Streambank Conditions, August 2020

Total streambank length by vegetation and stability class					
Bank	**No vegetation, stable, no erosion (feet)**	**No vegetation, unstable, actively eroding (feet)**	**Vegetation, stable, no erosion (feet)**	**Vegetation, unstable, actively eroding (feet)**	**Total (feet)**
Total length, left bank	253	33	585	229	1,100
Total length, right bank	242	69	579	204	1,094
Total length, both banks	495	102	1164	433	2,194

Table C – 16: Conditions Observed within Floodplain Transect Segments, July 2018

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	00+00	0	10	Wetland	Yes	Yes	No	No		yes	Common reed
		10	43	Upland	Yes	Yes	No	No			
left	01+00	0	17	Wetland	Yes	Yes	No	No		yes	Common reed
		17	38	Upland	Yes	Yes	No	No			
left	02+00	0	4	Wetland	Yes	No	No	No	Streamside area planted as grass only (0 to 4 ft)	no	
		4	16	Upland	Yes	Yes	Yes	No			
		16	35	Upland	Yes	Yes	Yes	No			
left	03+00	0	28	Wetland	Yes	No	Yes	No	Bare patch < 10 sq ft present	no	
		28	34	Upland	Yes	No	Yes	No			
left	04+33	0	12	Wetland	Yes	Yes	Yes	No	Small, sparse/bare spots on bank	no	
		12	50	Upland	Yes	Yes	Yes	No			
left	05+67	0	59	Wetland	Yes	Yes	Yes	No	Several sparse/bare spots present near transect	no	
		59	97	Wetland	Yes	Yes	Yes	No			
		97	107	Upland	Yes	Yes	Yes	No			

Table C – 16: Conditions Observed within Floodplain Transect Segments, July 2018

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	07+00	0	54	Wetland	Yes	Yes	Yes	No	Sparse/bare spots present near transect	no	
		54	80	Wetland	Yes	Yes	Yes	No			
left	08+33	0	5	Wetland	Yes	No	No	No	Streamside area grass only (0 to 5 ft); sparse/bare spots present near transect	no	
		5	30	Upland	Yes	Yes	Yes	No			
		30	49	Upland	Yes	Yes	Yes	No			
left	09+67	0	33	Wetland	Yes	Yes	Yes	No	Area along stream planned as forested wetland is mudflat with mostly herbaceous vegetation; lowest part under water	no	
		33	81	Upland	Yes	Yes	Yes	No			
left	11+00	0	17	Wetland	Yes	No	No	No	Streamside area grass only (0 to 15 ft). Area further from stream and near road has numerous bare/sparse patches. Near downstream end of project area.	no	
		17	57	Upland	Yes	No	No	No			
left	07+00	80	112	Upland	Yes	Yes	Yes	No	Sparse/bare spots present near transect	no	

Table C – 16: Conditions Observed within Floodplain Transect Segments, July 2018

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
right	00+00	0	9	Wetland	Yes	Yes	No	No	Creek in transect (at 9-29 ft), small bare section (1 ft x 4 ft)	yes	Common reed
		9	29	Wetland	Yes	Yes	No	No			
		29	42	Wetland	Yes	Yes	Yes	No			
right	01+00	0	9	Wetland	Yes	No	No	No	Streamside area has herbaceous vegetation only (0 to 9 ft). Large tree providing canopy along transect (9 to 29 ft).	yes	Common reed
		9	29	Wetland	No	Yes	Yes	No			
right	02+00	0	16	Wetland	Yes	No	Yes	Yes	Guardrail at 10 ft	no	
right	03+00	0	7	Wetland	Yes	No	Yes	No		no	
right	04+33	0	6	Wetland	Yes	Yes	No	No	Rip-rap on bank	no	
		6	17	Wetland	Yes	Yes	Yes	Yes			
right	05+67	0	5	Wetland	Yes	Yes	Yes	No		no	
right	07+00	0	14	Wetland	Yes	No	No	No	Streamside area has herbaceous vegetation only (0 to 14 ft). Large tree down in transect.	no	
		14	33	Wetland	Yes	Yes	Yes	Yes			

Table C – 16: Conditions Observed within Floodplain Transect Segments, July 2018

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
right	08+33	0	48	Wetland	No	Yes	Yes	No	Mud flat with sparse woody vegetation (0 to 48 ft from stream bank), hiking trail in outer section (78 to 81 ft) near edge of restored area	no	
		48	78	Wetland	Yes	Yes	Yes	No			
		78	87	Wetland	No	Yes	Yes	Yes			
right	09+67	0	12	Wetland	No	No	No	Yes	Barren area; red clay; under tree canopy	no	
right	11+00	0	4	N/A	No	Yes	No	No	Outside of restoration area; under tree canopy; hiking trails in transect.	no	

Table C – 17: Summary of Floodplain Transect Vegetation Assessments, Cow Pen Creek, July 2018

Length of Assessed Segments in Revegetated Area (feet)			
	Length of Assessed Segments – Floodplain / Wetland	**Length of Assessed Segments– Upland**	**Total Length**
Total length, left bank	275	331	606
Total length, right bank	248	0	248
Total length, both banks	523	331	854
Segments Without Vegetation (feet)			
	Wetland Segment Length Without Herbaceous Vegetation	**Upland Segment Length Without Herbaceous Vegetation**	**Total Length**
Total length, left bank)	0	0	0
Total length, right bank)	80	0	80
Total length, both banks)	80	0	80
	Wetland Segment Length Without Woody Vegetation	**Upland Segment Length Without Woody Vegetation**	**Total Length**
Total length, left bank	26	40	63
Total length, right bank	23	0	23
Total length, both banks	49	40	89

Table C – 18: Observed Bare Spots Greater than 10 Square Feet, July 2018

Side	Approximate Station Location	Upland or Wetland	Map Point (Figure 4-5, 2018 report	Photo (Appendix A, 2018 report)
Right	00+05	Wetland	Z	Figure A-62
Right	01+67	Wetland	G	Figure A-4
Left	04+15	Upland	AA	Figure A-77
Right	05+25	Wetland	I	Figure A-78
Right	05+69	Wetland	BB	Figure A-79
Left	07+71	Wetland	D	Figure A-85
Left	08+32	Wetland	U	Figure A-88
Right	08+41	Wetland	X	Figure A-89

Table C – 19: Conditions Observed within Floodplain Transect Segments, September 2019

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	00+00	0	42	Upland	Yes	No	No	No		no	
left	01+00	0	4	Wetland	Yes	No	No	No		yes	Common reed
		4	20	Upland		Yes	No	No		yes	Common reed and Chinese bush clover
left	02+00	0	4	Wetland	Yes	No	Yes	No		yes	Chinese bush clover present
		4	15	Upland	Yes	Yes	No	Yes		no	
left	03+00	0	6	Wetland	Yes	No	No	No		no	
		6	34	Upland	Yes	No	Yes	No		yes	Common reed
left	04+33	0	13	Wetland	Yes	No	Yes	No		no	
		13	41	Upland	Yes	No	Yes	No		no	
left	05+67	0	62	Wetland	Yes	No	Yes	No		no	
		62	99	Upland	Yes	No	Yes	No		no	

Table C – 19: Conditions Observed within Floodplain Transect Segments, September 2019

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	07+00	0	57	Wetland	Yes	Yes	Yes	No		no	
left	07+00	57	88	Upland	Yes	Yes	Yes	No		yes	Chinese bush clover
left	08+33	0	11	Wetland	Yes	Yes	Yes	No		no	
		11	37	Upland	Yes	Yes	Yes	No		yes	Multiflora rose
left	09+67	0	47	Wetland	Yes	Yes	Yes	No		no	
		47	75	Upland	Yes	Yes	Yes	No		no	
left	11+00	0	21	Upland	Yes	Yes	Yes	No		yes	Honeysuckle
right	00+00	0	35	Upland	Yes	Yes	Yes	No		no	
right	01+00	0	6	Wetland	Yes	Yes	No	No		yes	Common reed
		6	27	Upland	Yes	No	Yes	Yes		no	
right	02+00	0	11	Upland	Yes	No	Yes	Yes		no	
right	03+00	0	12	Upland	Yes	Yes	Yes	No		no	
right	04+33	0	18	Upland	Yes	Yes	Yes	Yes		no	

Table C – 19: Conditions Observed within Floodplain Transect Segments, September 2019

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
right	05+67	0	15	Upland	Yes	No	No	Yes		yes	Multiflora rose
right	07+00	0	19	Wetland	Yes	No	Yes	No		no	
		19	44	Upland	Yes	Yes	Yes	Yes		no	
right	08+33	0	60	Wetland	Yes	No	Yes	No		no	
		60	75	Wetland	Yes	No	Yes	No		no	
right	09+67	0	8	Upland	Yes	Yes	No	No		no	
right	11+00	0	10	Upland	Yes	No	Yes	No		no	

Table C – 20: Summary of Floodplain Transect Vegetation Assessments, September 2019

Length of Assessed Segments in Revegetated Area (feet)			
	Length of Assessed Segments – Floodplain / Wetland	**Length of Assessed Segments– Upland**	**Total Length**
Total length, left bank	204	268	472
Total length, right bank	100	155	255
Total length, both banks	304	423	727
Segments Without Vegetation (feet)			
	Wetland Segment Length Without Herbaceous Vegetation	**Upland Segment Length Without Herbaceous Vegetation**	**Total Length**
Total length, left bank)	0	0	0
Total length, right bank)	0	0	0
Total length, both banks)	0	0	0
	Wetland Segment Length Without Woody Vegetation	**Upland Segment Length Without Woody Vegetation**	**Total Length**
Total length, left bank	10	42	52
Total length, right bank	0	0	0
Total length, both banks	10	42	52

Table C – 21: Conditions Observed within Floodplain Transect Segments, August 2020

Stream bank	Station	Segment start and end points , as distance from top of bank (feet)		Upland or wetland revegetation area	Herbaceous vegetation cover present	Woody vegetation by height class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes
		Start point (feet)	End point (feet)			Woody vegetation present < 3 feet	Woody vegetation present 3–15 feet	Woody vegetation present >15 feet			
Left	00+00	0	40	upland	Yes	No	No	No		yes, 20%	Chinese bush clover
Left	01+00	0	4	wetland	Yes	Yes	No	No		no	
		4	20	upland	Yes	No	Yes	No		yes, 20%	Common reed
Left	02+00	0	4	wetland	Yes	No	Yes	No		no	
		4	15	upland	Yes	No	Yes	No		yes, 10%	Chinese bush clover
Left	03+00	0	6	wetland	Yes	No	No	No		no	
		6	34	upland	Yes	No	Yes	No		yes, <5%	Common reed
Left	04+33	0	13	wetland	Yes	No	Yes	No		no	
		13	41	upland	Yes	No	Yes	No		yes, 10%	Common reed
Left	05+67	0	62	wetland	Yes	No	Yes	No		no	
		62	99	upland	Yes	No	Yes	No		yes, 10%	Common reed, Chinese bush clover
Left	07+00	0	57	wetland	Yes	No	Yes	No		yes, 10%	Chinese bush clover

Table C – 21: Conditions Observed within Floodplain Transect Segments, August 2020

Stream bank	Station	Segment start and end points , as distance from top of bank (feet)		Upland or wetland revegetation area	Herbaceous vegetation cover present	Woody vegetation by height class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes
		Start point (feet)	End point (feet)			Woody vegetation present < 3 feet	Woody vegetation present 3–15 feet	Woody vegetation present >15 feet			
Left	07+00	57	88	upland	Yes	Yes	Yes	No		yes, 40%	Chinese bush clover
Left	08+33	0	11	wetland	Yes	Yes	Yes	No		no	
		11	37	upland	Yes	Yes	Yes	Yes		yes, <5%	Multiflora rose
Left	09+67	0	47	wetland	Yes	No	Yes	No		yes, <5%	Chinese bush clover
		47	75	upland	Yes	No	Yes	No		yes, 50%	Chinese bush clover
Left	11+00	0	21	upland	Yes	No	Yes	No		no	
right	00+00	0	35	upland	Yes	No	Yes	No		yes, 5%	Common reed
right	01+00	0	6	wetland	Yes	No	Yes	No		yes, 20%	Common reed
		6	27	upland	Yes	No	Yes	Yes		no	
right	02+00	0	11	upland	Yes	No	Yes	Yes		yes, 10%	Multiflora rose
right	03+00	0	12	upland	Yes	No	Yes	Yes		no	
right	04+33	0	18	upland	Yes	No	Yes	Yes		no	
right	05+67	0	15	upland	Yes	No	Yes	Yes		no	

Table C – 21: Conditions Observed within Floodplain Transect Segments, August 2020

Stream bank	Station	Segment start and end points , as distance from top of bank (feet)		Upland or wetland revegetation area	Herbaceous vegetation cover present	Woody vegetation by height class			Vegetative cover notes	Invasive species present, estimated percent cover	Invasive species notes
		Start point (feet)	End point (feet)			Woody vegetation present < 3 feet	Woody vegetation present 3–15 feet	Woody vegetation present >15 feet			
right	07+00	0	19	wetland	Yes	No	Yes	No		no	
		19	44	upland	Yes	Yes	No	Yes		yes, 10%	Multiflora rose
right	08+33	0	60	wetland	Yes	Yes	Yes	No		no	
		60	75	wetland	Yes	Yes	Yes	No		no	
right	09+67	0	8	upland	Yes	No	No	Yes		no	
right	11+00	0	10	upland	Yes	Yes	Yes	Yes		no	

Table C – 22: Summary of Transect Length as Tidal Mudflat, from 2020 Wetland Delineation

	Length of floodplain transect as tidal mudflat (feet)	**Length of floodplain transect – all wetland types** (feet)
Total length, left bank	44	247
Total length, right bank	10	140
Total length, both banks	54	387