Lockheed Martin Corporation
6801 Rockledge Drive MP: CCT-246
Bethesda, MD 20817
Telephone 301-548-2209

January 21, 2020

VIA PRIVATE CARRIER

Brian Dietz
Interim Program Administrator
Land Restoration Program
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: 2019 Report
Lockheed Martin Corporation – Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Mr. Dietz,

For your review please find enclosed two hard copies with a CD of the above-referenced document. This report includes results from the 2019 Cow Pen Creek Bank Stabilization and Floodplain Reconstruction monitoring event adjacent to the Lockheed Martin Middle River Complex in Middle River, Maryland.

If possible, we respectfully request to receive MDE's document review comments by March 3, 2020.

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

Sincerely,

Thomas D. Blackman
Project Lead, Environmental Remediation

cc: (via email without enclosure)
Gary Schold, MDE
Mark Mank, MDE
Christine Kline, Lockheed Martin
Norman Varney, Lockheed Martin
Dave Brown, MRAS
Tom Green, LMCPI
Michael Martin, Tetra Tech
Cannon Silver, CDM Smith

cc: (via Secure Information Exchange)
Jann Richardson, Lockheed Martin
Scott Heinlein, LMCPI
Christopher Keller, LMCPI
Glen Harriel, LMCPI

cc: (via mail with enclosure)
Mike Musheno, LMCPI
Budd Zahn, MRAS

COW PEN CREEK
BANK STABILIZATION AND FLOODPLAIN RECONSTRUCTION MONITORING: 2019 REPORT
LOCKHEED MARTIN MIDDLE RIVER COMPLEX
2323 EASTERN BOULEVARD
MIDDLE RIVER, MARYLAND

Prepared for:
Lockheed Martin Corporation

Prepared by:
Tetra Tech, Inc.

January 2020

Revision: 0

Michael Martin, P.G.
Regional Manager

Nancy Roth
Project Manager

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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
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 and September 2019, following the completion of the sediment remediation project in 2017. This report CPC

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 excavation, these areas were restored per the approved *Sediment Remedy 100% Design for Cow Pen Creek and Dark Head Cove* prepared by Tetra Tech in 2016. Creek restoration included reconstruction of its main channel and floodplains, placement of new channel substrate, streambank stabilization and vegetation, 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 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 five-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, vegetation installation specifications in 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 bounded by Eastern Boulevard (Route 150) to the north, Dark Head Cove to the south, Cow Pen Creek to the west, 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 (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 stream and floodplain reconstruction in the upper portion of Cow Pen Creek is from Station 8+00 to Station 19+00, according to design stationing notation. Station notation was altered post-restoration. Using post-remediation station notation, the restored area extends from Station 0+00 to Station 11+00. 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 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 to 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
- revegetation of areas disturbed by the removal.

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

2.1 MAIN CHANNEL AND FLOODPLAIN RECONSTRUCTION

The purpose of the project was to restore the creek's active channel by reconstructing its channel and floodplain, thereby providing a more natural stream system that will 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 form was somewhat modified from its original configuration in accordance with the approved design. The restoration approach for this section of the creek was designed to reconstruct the channel and floodplain (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 adding woody structures (i.e., existing logs) and using conventional rigid techniques (e.g., rock toe). An approximately 200-foot segment along the Hawthorne neighborhood side of creek was stabilized and protected with rock toe structures. In the lower portion of the restored stream reach, wetlands were constructed along banks of the creek which provide vegetative stabilization. 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, scrub-shrub wetlands) present 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 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 the areas disturbed and excavated 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 will 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.

The restored wetland areas, reconstructed floodplain, and creek channel will be evaluated annually from 2018 until 2020, with optional monitoring in 2021, to determine if the restoration project has met the performance standards specified in the project design report (Tetra Tech, 2016). These standards for the floodplain and streambanks are listed in Section 1.1. Annual monitoring will be employed to track creek conditions, with the expectation that performance standards will be met by the end of this multi-year monitoring period.

SECTION 3
STREAMBANK, FLOODPLAIN, AND UPLANDS DATA COLLECTION

3.1 MONITORING

Per the monitoring work plan (Tetra Tech, 2018b), bank stabilization and floodplain reconstruction monitoring will be conducted once per year (during the summer) from 2018 through 2020 with optional monitoring in 2021. Each year, monitoring is to be conducted between June and August, and after a two-year rainfall or after a higher flow event. If a two-year rainfall or flow event does not occur between June and August during a given year, monitoring is instead conducted in September, preferably after rainfall. Precipitation frequency estimates prepared for the hydrology and hydraulics study of the sediment remedy design (Appendix A in Tetra Tech 2016) indicate that a 24-hour rainfall total of 3.3 inches represents the two-year storm event; the corresponding two-year flow for Cow Pen Creek is estimated at 19.2 cubic feet per second (cfs).

Monitoring for year 2018, the first year of post-reconstruction monitoring, was conducted on July 26-27, 2018, and monitoring activities 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. No qualifying two-year rain events occurred during the June-August 2019 window, and no appreciable rain was recorded in September 2019.

3.1.1 Weather and Tidal Conditions

3.1.1.1 Weather and Tidal Conditions—2018

During June–July 2018, field staff tracked weather conditions to select an appropriate qualifying two-year event. Daily rainfall totals for the dates before and during the sampling period are shown

in Table 3-1. Rainfall was widespread throughout the Baltimore area on July 21-24, 2018. At Baltimore/Washington International Airport (BWI), 4.77 inches of rain fell on July 21 and 4.07 inches fell on July 24. At Baltimore Inner Harbor, more than two inches of rain fell on July 21 and more than one inch on both July 24 and July 25. Based on this rainfall, and after allowing time for water levels in Cow Pen Creek to return to a safe level for access, monitoring was conducted on July 26-27, 2018.

Weather during the two days of monitoring was clear to partly cloudy and cloudy. Rainfall on July 27, 2018 occurred after monitoring was complete.

Monthly precipitation totals for July 2017 - July 2018 are shown in Figure 3-1 and Table 3-2. Baltimore received slightly below-average rainfall during fall 2017. Precipitation totals were above average during February, April, May, and July 2018, with more than twice the average rainfall in May 2018 and July 2018.

Observed tidal water levels in Baltimore Harbor at the National Oceanic and Atmospheric Administration (NOAA) Fort McHenry station, Patapsco River, were above long-term predicted levels during the July 2018 monitoring period, with an average of 0.55 feet above predicted tide levels (see Figure 3-2). Tide levels during the days preceding the monitoring were even higher. An examination of Fort McHenry water-level data for May-July 2018 revealed that higher-than-predicted water levels were common during this period.

3.1.1.2 Weather and Tidal Conditions—2019

During June–September 2019, field staff tracked weather conditions to select an appropriate qualifying two-year event. Daily rainfall totals for the dates before and during the sampling period are shown in Table 3-3. Rainfall accumulations of 3.3 inches during a 24-hour period did not occur in the Baltimore area during this period. At Baltimore/Washington International Airport (BWI), total rainfall of 2.39 inches and 0.16 inches (respectively) occurred during August 2019 and September 2019, while at Baltimore Inner Harbor, total respective rainfall of 5.29 inches and 0.08 inches was measured. Because a two-year rainfall did not occur between June and August 2019, the Cow Pen Creek monitoring survey was conducted on September 27-30, 2019.

Weather for the two days of monitoring was clear to partly cloudy to cloudy. No significant rainfall had occurred during the week prior to monitoring (Table 3-3).

Monthly precipitation totals for August 2018 through September 2019 are listed in Table 3-4 and are shown graphically on Figure 3-3. Baltimore received above average rainfall during fall 2018 and winter 2018-2019. Precipitation totals were above average during September, November, December 2018 and during January, February, and March 2019. Baltimore received below average rainfall during April, June, July, and September 2019.

Observed tidal water levels in Baltimore Harbor at NOAA's Fort McHenry station, Patapsco River, from September 23-30, 2019 are presented in Figure 3-4. Tide levels during the days preceding the monitoring were above long-term predicted levels.

3.1.2 Assessment of Streambanks

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

Conditions observed during the initial post-remediation monitoring in 2018 are considered to be a baseline against which future monitoring events can be compared to assess changes in bank stability. This report includes both 2018 and 2019 results.

Streambank visual observations were made from the 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 collector application. Locations of field observation points were recorded at the water's edge using GPS, so that each point will serve as a reference point for recording future observations.

Longitudinal sections of the stream bank were designated by 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.

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 of invasive species was 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 photographed during subsequent annual surveys.

3.1.3 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 initial 2018 survey conditions) by observing the establishment of vegetation. The reconstructed floodplain will be monitored for at least three years (2018 through 2020), with optional monitoring in 2021, to occur concurrent with bank assessments. This report includes both 2018 and 2019 results.

During July 2018 monitoring, as with 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). To assess vegetative condition, a series of 10 transects was established, extending from the top of bank to the edge of the floodplain within the reconstructed area. 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), three transects were established: 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, forested wetland, and scrub-shrub wetland that had been planted as part of the restoration project.

At each floodplain transect, the initial field observation point for each side (left and right bank) were located at the top of the bank using GPS, providing locations that will serve as fixed reference points for future observations. These points can be 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. For the 2019 monitoring event, the most recent vegetation mapping (based on information from a wetland delineation and survey performed in August 2019) was used to set segment break points between vegetation community types.

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 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). The presence of invasive species was 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 2019 survey points, so that new information and photographs could be compared with 2018 observations.

SECTION 4
DATA COLLECTED

4.1 SUMMARY OF DATA COLLECTED

Within the Cow Pen Creek (CPC) study area, data were collected along streambanks and in transects across the floodplain (Figures 4-1 and 4-2). Findings of the field assessments from 2018 and 2019 are described herein. Locations of representative photographs along the channel and other views of the project area are shown on Figures 4-3 and 4-4. Survey-year comparisons of bank erosion are on Figures 4-5 (2018) and 4-6 (2019), and maps showing invasive plant species by survey year are shown on Figure 4-7 (2018) and Figure 4-8 (2019). Figures 4-9 and 4-10 (respectively) compare areas of concern noted during the 2018 and 2019 surveys for erosion and vegetative cover, and Figures 4-11 and 4-12 show respective 2018 and 2019 streambank and floodplain survey points.

Appendix A presents a photo log containing representative photographs of the channel (upstream and downstream views at transect locations) and photographs taken during streambank assessments showing floodplain transects and other views. Appendix A Photos A-67 through A-103 show side-by-side annual comparisons of targeted locations of interest (i.e., compare conditions in 2018 and 2019) with photographs taken from a similar GPS location and compass bearing. Appendix B lists global positioning system (GPS) coordinates at field assessment points for both the streambank and floodplain assessments.

4.1.1 Streambank Assessment

4.1.1.1 Streambank Assessment—2018

Summer 2018 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)

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

Stable conditions were observed along 92% of total stream bank length (2113 of 2300 total feet). Stable banks without vegetation included several areas with structural stabilization treatments (158 feet total, 6.9% of total bank length), including a 34-foot section of the left bank armored with a root-wad structure and several sections (124 feet total) of unvegetated rip-rap along the right bank. A 119-foot portion of the lower right bank lacked vegetation but had matting in place and deposits of fine sediment. Another two segments (93 feet total) of the lower right bank appeared to be unvegetated yet stable; these sections were near the downstream end of the project and were stabilized with matting, coir log, and wood. Overall, 1770 feet of the total bank length (2140 feet) was vegetated, representing 83% of the unarmored bank length. Of this vegetated total bank length, 1743 feet were observed to be stable with no evidence of erosion.

Bank erosion was observed along 8% (187 feet) of total bank length, with 7% (160 feet) without vegetation, and 1.2% (27 feet) with vegetation. On the left bank, only one small area (noted as 9 feet) was eroding from under matting due to runoff. On the right bank, erosion was noted in several sections (178 feet total), the longest (53 feet) of which was associated with a red clay bank, which had matting installed on the lower bank.

The presence of herbaceous vegetation is one indication of vegetation establishment. Along most of the vegetated streambank, herbaceous vegetation was growing well. Areas that lacked herbaceous vegetation included:

- The lower portion of the left streambank and the adjacent floodplain were underwater at the time of sampling; conditions indicated that these areas are frequently inundated.
- A few sections of the right streambank lacked herbaceous cover, and were associated with sediment erosion, sediment deposition and elevated water level, or clay banks where

vegetation was not established, particularly in areas of elevated water level associated with tidal influence.

The presence of woody vegetation was also recorded. Along streambanks, woody vegetation was present in two height classes: those less than three feet tall and those 3-15 feet tall. Some of the planted woody vegetation, particularly in the lower part of the restored area, showed poor survival. In the planted wetland flat areas, woody plants appeared to be subjected to frequent inundation, as evidenced by the presence of submerged aquatic vegetation (SAV).

Common reed (*Phragmites australis*) was present along the streambank in some of the uppermost segments; no other invasive plants were noted.

4.1.1.2 Streambank Assessment—2019

Summer 2019 streambank assessment data are summarized by individual bank segments in Table 4-4; bank conditions were assessed using the following criteria:

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

Additional details about vegetation, the presence of invasive species, and proximity to structural features are summarized in Table 4-5. Summary indicators were independently assessed and calculated separately for both banks, and were combined to represent overall values for the entire restored stream reach in Table 4-6.

Bank conditions were rated as stable along 90% of total stream bank length (1,975 of 2,197 total feet), and much of that length (1,931 feet) was vegetated. Stable banks without vegetation included one area with structural stabilization treatments (23 feet total, 1.2% of total bank length), namely a 23-foot section of the right bank armored with rip-rap and log structures. Another 19-foot portion of the right bank lacked vegetation but had matting in place, providing bank stabilization, and the presence of nearby small willows was noted.

Overall, 1,931 feet of the total bank length was vegetated, representing 89% of the unarmored bank length. Of this vegetated total bank length, the entire length was rated as stable.

Bank erosion was observed along 10% (222 feet) of total bank length, all of which was unvegetated. On the left bank, one area (five feet) was eroding from under matting due to road runoff (Photo A-2) while another area (17 feet long) was associated with an outfall. On the right bank, erosion was noted in several sections, with the longest (82 feet long) exhibiting bank scour with some modest stabilization provided by matting. Another right bank section (52 feet) was stabilized at the bank toe by matting but had a steep eroding bank above. Another area (53 feet) on the right side was associated with a raw clay bank, while another section (15 feet) was an undercut bank with erosion under the matting.

Within the streambank length rated as stable, most of this length (1,707 feet) was indeed stable with no evidence of erosion. There were, however, some noncontiguous sections (224 feet total) where the top portion of the bank was stabilized by vegetation, but the lower part of the bank showed some erosion and undercutting resulting from streamflow and/or tidal influence. This included two sections along the left bank (215 feet total) and one nine-foot section along the right bank. A small section of the left bank (two feet long) was unvegetated and rated stable but was also subject to some erosion at the lower bank. This section was fairly stable because the bank was covered with matting; however some erosion was occurring behind the matting, as a result of road runoff. These situations are noted as two new categories in Tables 4-4 and 4-6.

Along most of the vegetated streambank, herbaceous vegetation was generally growing well. Areas that lacked herbaceous vegetation included the areas of bank erosion discussed above.

Presence of woody vegetation was also recorded. Along streambanks, woody vegetation was present in three height classes (Table 4-5): those less than three feet tall, 3-15 feet tall, and taller than 15 feet.

Invasive species were present along the streambank in some of the uppermost segments on the left bank, as well as at the upper to middle portion of the right bank (see Figure 4-4). Three invasive species were observed: common reed, barnyard grass (*Echinochloa crus-galli*), and burdock (*Arctium sp*.).

4.1.2 Floodplain Vegetation Assessment

4.1.2.1 Floodplain Vegetation Assessment—2018

Summer 2018 floodplain assessment data for the 10 transects and for individual segments within transects are summarized in Table 4-7, including: the presence of herbaceous vegetation (yes/no), presence of woody vegetation in three size classes (less than three feet tall, 3-15 feet tall, and more than 15 feet tall), presence of invasive species (yes/no), and 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 on the vegetation type planned for the restoration effort.

Summary values were independently assessed and calculated separately for both banks and were combined to represent overall values for the entire set of assessed transects. Summary results in Table 4-8 are also broken into the two classes (wetland vs. upland revegetation).

Across all transects combined, 10% (80 feet) of the assessed segment length lacked herbaceous vegetation. The longest area (48 feet) was in the lower right bank, where a wetland mudflat was present (transect at 8+33). The other two areas without herbaceous vegetation (20 and 12 feet long) were both on the right bank under existing tree canopy.

Overall, 10% (89 feet) of the assessed segment length lacked woody vegetation in surveyed transects. Much of this total length (35 feet) was in four streamside areas, which were planted only in grasses, and where woody vegetation was not expected. A large fallen tree was within one 14-foot-long segment on the right bank (transect at 7+00). There was also a 40-foot-long section of upland vegetation on the left bank near the downstream end of the project area (transect at 11+00), where vegetation was sparse and lacked woody vegetation.

A substantial number of trees, particularly within the forested wetlands planted at the lower end of the project area, were dead at the time of monitoring. These forested wetland areas had signs of longer than anticipated inundation, and SAV was growing between the planted trees. On July 26, 2018, approximately 40 dead trees were noted in the wetland area outside of tree tubes, and 50 trees within the wetland area inside tree tubes were also dead. The field team observed

additional dead trees in the upland area. Coincidentally, construction field staff were onsite on July 27 removing tree tubes from trees throughout much of the project area.

During floodplain transect assessment, invasive plants (common reed) were noted within or near the uppermost transects, on both sides of the stream. No other invasive plants were noted.

Eight bare patches greater than 10 square feet were noted and photographed (Table 4-9), seven in wetland areas and one in the upland area. In addition to these areas, additional patches were noted where planted vegetation was sparse, and netting was visible. These areas of sparse vegetation were noted but not counted as individual bare patches since they were not completely bare. Locations of areas with noted erosion or vegetation cover concerns are shown on the map in Figure 4-9.

Start points of floodplain monitoring transects, which had been field-placed at the top of the bank on both sides of the stream, corresponded well with as-built survey contours, as illustrated in Figure 4-10. These benchmarks can be used during subsequent annual surveys to check for lateral erosion of the banks.

4.1.2.2 Floodplain Vegetation Assessment—2019

Summer 2019 floodplain assessment data for the 10 transects and for individual segments within transects are summarized in Table 4-10, and include the following parameters: the presence of herbaceous vegetation (yes/no), presence of woody vegetation in three size classes (less than three feet tall, 3-15 feet tall, and more than 15 feet tall), presence of invasive species (yes/no), 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, conducted in August 2019 (Tetra Tech, 2019).

Summary values were independently assessed and calculated separately for both banks and combined as overall values to represent the entire set of assessed transects. Summary results in Table 4-11 are also broken into the two classes (wetland vs. upland revegetation).

Across all transects, 0% (0 feet) of the assessed segment length lacked herbaceous vegetation. Overall, 7.2% (52 feet) of the assessed segment length lacked woody vegetation in surveyed transects. This entire length (52 feet) was in three streamside areas on the upper left bank, which were planted only in grasses, and where woody vegetation was not expected.

During floodplain transect assessment, invasive plants were noted within or near several transects, most on the left side of the stream. Four invasive species were observed: common reed, Chinese lespedeza (*Lespedeza cuneata*), multiflora rose (*Rosa multiflora*), and honeysuckle (*Lonicera japonica*).

No bare patches greater than 10 square feet were noted within the project area. Locations of areas with noted erosion or vegetation cover concerns are shown on the map in Figure 4-9.

Start points of floodplain monitoring transects, which had been field-placed at the top of the bank on both sides of the stream, corresponded well with as-built survey contours, as illustrated in Figure 4-10. These second-year benchmarks can be used as reference during subsequent annual monitoring to check for lateral erosion of the banks.

4.2 COMPARISON OF DATA ACROSS YEARS

Results of 2019 monitoring, in comparison with 2018 monitoring, document that the channel is generally stable and that bank, wetland, and upland vegetation is becoming well-established at the Cow Pen Creek site. Side-by-side photographs from the two monitoring years (see Appendix A) show that vegetation is thriving and that banks are being maintained in a stable condition.

Herbaceous cover blanketed the wetland and upland areas in 2019, 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 2019, documenting that trees and shrubs have had a chance to establish and grow throughout the study area. The occurrence of the invasive common reed was less prevalent in 2019; however, three other invasive species were observed. For example, in 2019, Chinese bush clover was observed in thick patches along several parts of the floodplain and upland area.

Streambanks are generally stable and are supported by streambank vegetation, particularly along the upper portion of banks. However, in a few linear sections, ongoing erosion associated with stream and tidal flows appears to be undercutting the lower banks.

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

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.

5.1.1 Comparison to Performance Measures—2018

This section lists those measures and provides supporting summary information from 2018 monitoring.

- 10% (maximum) unstable banks
    - Streambank was unstable/eroding along 8% of its length (187 of 2300 feet).
    - Streambank was stable, with no erosion, along 92% of its length (2113 of 2300 feet).
- 85% (minimum) streambank length occupied by restoration treatments:
    - Approximately 93% (2140 of 2300 feet) of total streambank length was occupied by restoration treatments.
    - Vegetation was present on 1770 of 2140 feet, and 370 of 2140 feet were covered by other treatments (root-wad, rip-rap, and stable matting/coir).
- 85% (minimum) native vegetation cover on banks and floodplains
    - Vegetation covers 83% (1770 feet) of the unarmored bank length (2142 feet).

- Invasive vegetation (common reed) was being actively treated in the several limited small areas of banks and floodplain in the upper portion of the stream. Spraying to control common reed in the floodplain was observed on July 27, 2018 during monitoring. Follow-up inspections for invasive species along the streambank should be conducted, and spraying applied, if warranted.

- 15% (maximum) barren ground on banks and floodplains
    - Nearly 7% of the total bank length (160 of 2300 feet) was barren (without vegetation or other bank treatments).
    - Approximately 25% of floodplain wetland area was documented as bare, based on observations obtained during the October 2018 field inspection (see Figure 4-1 in the wetland restoration monitoring report [Tetra Tech, Inc., 2018c]).
    - Bare areas in the upland area of the creek were minimal.

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 NOAA Fort McHenry station in Baltimore Harbor were (on average) 0.55 feet above predicted tide levels and had been even higher during the preceding days. Higher-than-predicted water levels were also common during the preceding months (May-July 2018).

In the floodplain area, some settling has possibly occurred post-construction, in comparison with elevations at time of construction. However, data were not collected to specifically confirm whether settling has occurred.

5.1.2 Comparison to Performance Measures—2019

This section lists the performance measures and provides supporting summary information from 2019 monitoring.

- 10% (maximum) unstable banks:
    - Streambank was unstable/eroding along 10% of its length (222 of 2197 feet).
    - Streambank was stable, with little to no erosion, along 90% of its length (1975 of 2197 feet).

- 85% (minimum) streambank length occupied by restoration treatments:

- Approximately 90% (1973 of 2197 feet) of total streambank length was occupied by restoration treatments.
- Vegetation was present along 1931 feet, and 42 feet were covered by other treatments (logs, rip-rap, and stable matting/coir).

- 85% (minimum) native vegetation cover on banks and floodplains:
  - Vegetation covers 89% (1931 feet) of the unarmored bank length (2174 feet).
  - 100% of floodplain transects were vegetated.
  - Limited patches of invasive vegetation were observed in small areas along the banks, including common reed, barnyard grass, and burdock. Similarly, some areas of invasive vegetation were present on the floodplain, including common reed and Chinese bush clover.

- 15% (maximum) barren ground on banks and floodplains:
  - About 11% of the total bank length (222 of 2197 feet) was barren (without vegetation or other bank treatments).
  - None of the floodplain wetland or upland areas were documented as bare.

The influence of tidal water levels on the vegetated area should be considered. During the two-day monitoring period in September 2019, water levels at NOAA Fort McHenry station in Baltimore Harbor were approximately two to four inches above predicted tide levels. Tides higher than predicted levels may be more common than in the past; in fact, site observations show the frequent inundation of most of lower Cow Pen Creek during high tides.

5.2 FUTURE MONITORING/MAINTENANCE EVENTS

The next monitoring event for the streambank stabilization and floodplain assessment is planned for summer 2020. Recommended maintenance activities for fall 2019 or spring 2020 are as follows:

- Revisit areas noted with common reed and other invasive species, determine whether treatments to date have effectively controlled growth of invasive plants and determine whether additional treatments are needed to eliminate spreading.
- No bare patches in need of replanting or reseeding were identified in 2019.

5.3 OTHER RECOMMENDATIONS

Other recommendations include continued monitoring of bank condition, particularly to evaluate lower bank conditions where creek banks are subject to undercutting by upstream flow and/or due to tidal influence. Improved stormwater management (for example, management of flow from upstream areas and runoff from a nearby parking lot that drains to the left side of the stream) would likely provide the stream channel some protection from the flashy, erosive flows it currently experiences.

SECTION 6
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FIGURES

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

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

Figure 3-1 Monthly Precipitation Totals July 2017 through July 2018, Baltimore Inner Harbor

Figure 3-2 Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River, July 21-27, 2018

Figure 3-3 Monthly Precipitation Totals August 2018 through September 2019, Baltimore Inner Harbor

Figure 3-4 Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River, September 23-30, 2019

Figure 4-1 Map of Cow Pen Creek study area showing 2018 bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (yellow) along 10 floodplain transects

Figure 4-2 Map of Cow Pen Creek study area showing 2019 bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (green) along 10 floodplain transects

Figure 4-3 Map of Cow Pen Creek study area showing 2018 locations of representative photographs along the stream channel (upstream and downstream views at each transect) and photographs of other features of note

Figure 4-4 Map of Cow Pen Creek study area showing 2019 locations of representative photographs along the stream channel (upstream and downstream views at each transect) and photographs of other features of note

Figure 4-5 Map of Cow Pen Creek study area showing 2018 locations of bank erosion, noted as lower endpoints of segments assessed along both streambanks

Figure 4-6 Map of Cow Pen Creek study area showing 2019 locations of bank erosion, noted as lower endpoints of segments assessed along both streambanks

Figure 4-7 Map of Cow Pen Creek study area showing 2018 locations of invasive plant species, noted as lower endpoints of segments assessed along both streambanks

Figure 4-8 Map of Cow Pen Creek study area showing 2019 locations of invasive plant species, noted as lower endpoints of segments assessed along both streambanks

Figure 4-9 Map of Cow Pen Creek study area showing 2018 locations of areas noted based on concerns for erosion or vegetative cover condition

Figure 4-10 Map of Cow Pen Creek study area showing 2019 locations of areas noted based on concerns for erosion or vegetative cover condition

Figure 4-11 Map of Cow Pen Creek study area showing 2018 streambank and floodplain field survey points, along with as-built survey topography

Figure 4-12 Map of Cow Pen Creek study area showing 2019 streambank and floodplain field survey points, along with as-built survey topography

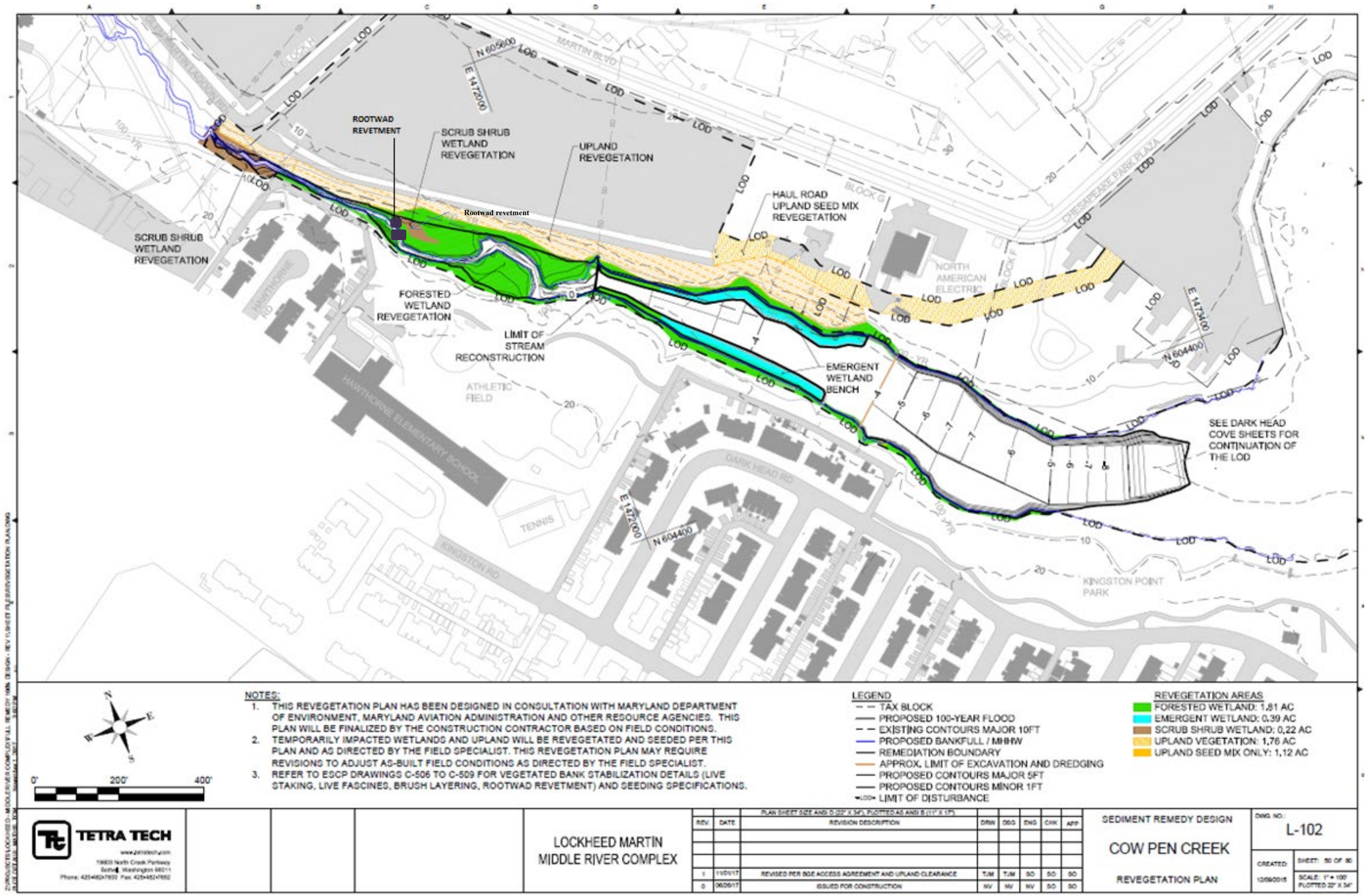


Figure 2-1. Extent of Cow Pen Creek Stream Channel and Floodplain Reconstruction.
Source: November 2017 revegetation plan (Tetra Tech, 2017b)

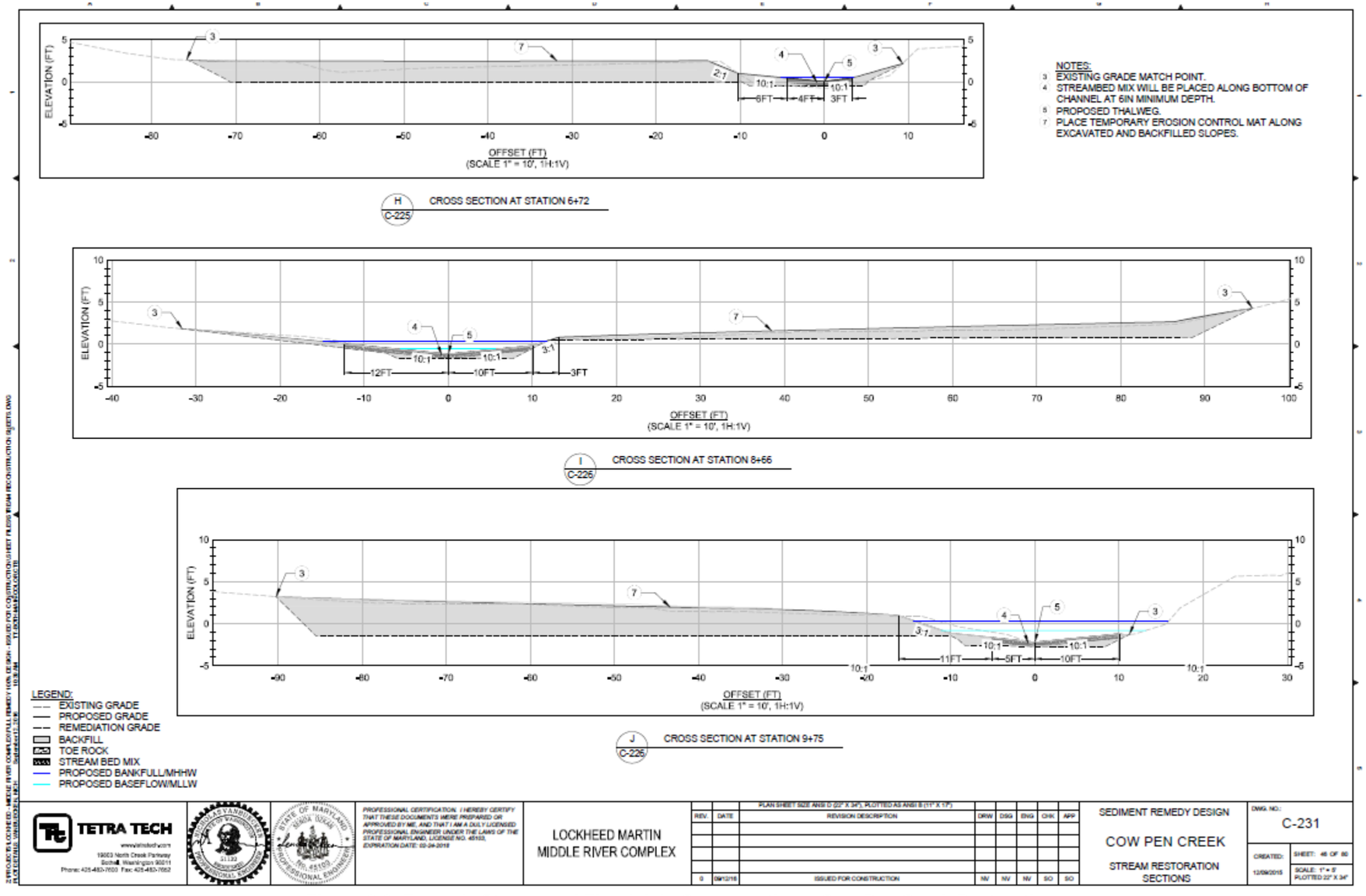


Figure 2-2. Example Stream and Floodplain Cross-sections, Cow Pen Creek Restoration
Source: Tetra Tech, 2016b

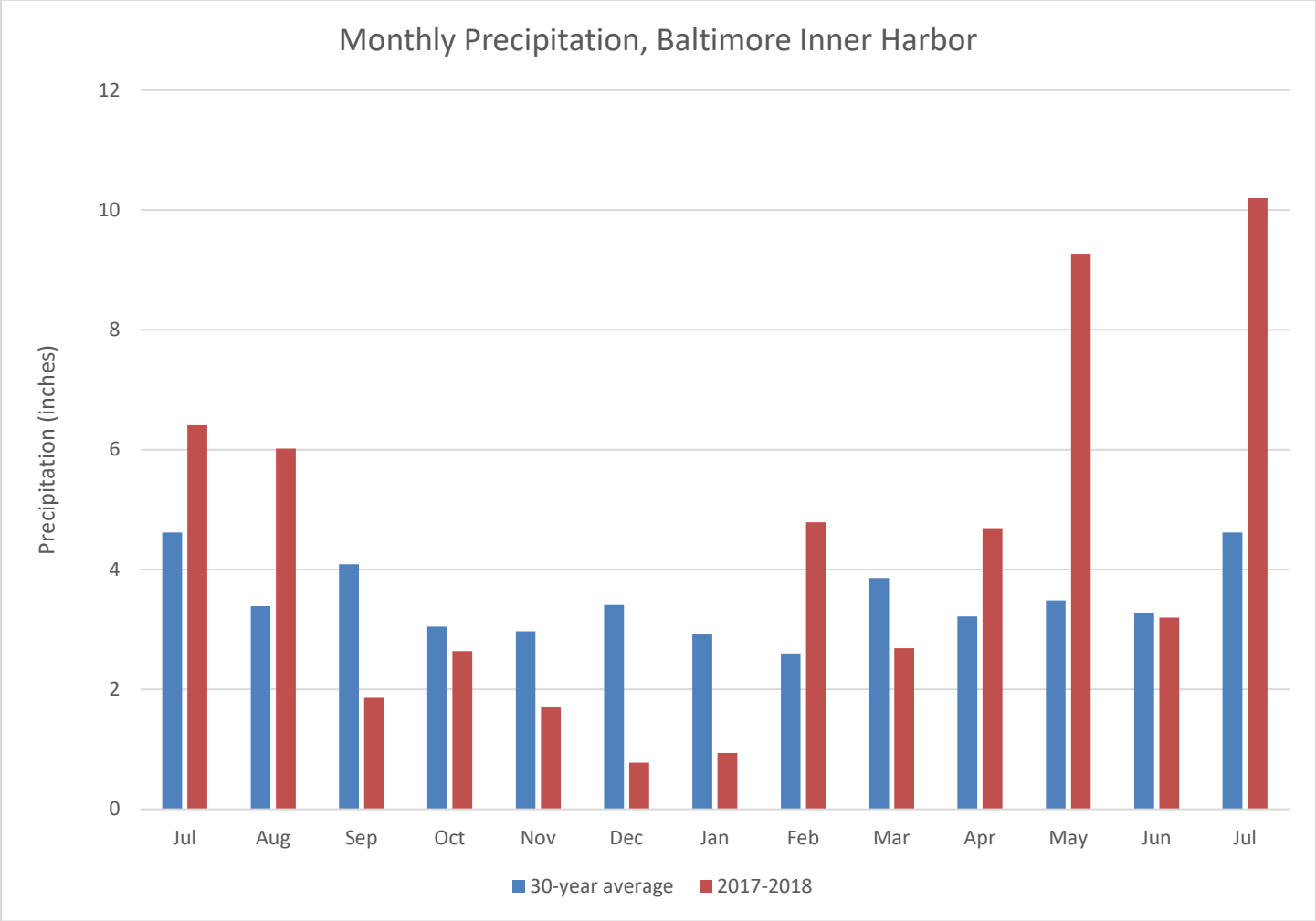


Figure 3-1. Monthly Precipitation Totals July 2017 through July 2018, Baltimore Inner Harbor
Based on data from National Weather Service, summarized by Iowa State University, https://mesonet.agron.iastate.edu

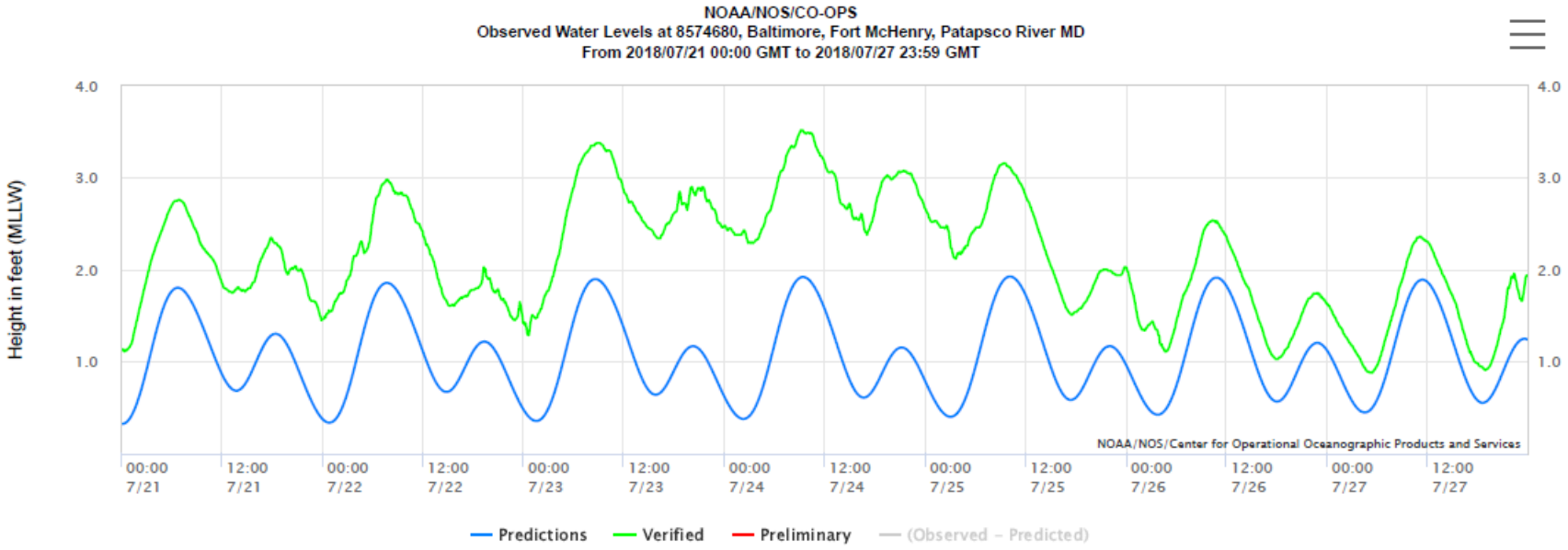


Figure 3-2. Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River, July 21-27, 2018. Observed values (green line) are compared with long-term predicted levels (blue line). NOAA data from https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20180721&edate=20180727&timezone=GMT&datum=MLLW&interval=6&action=

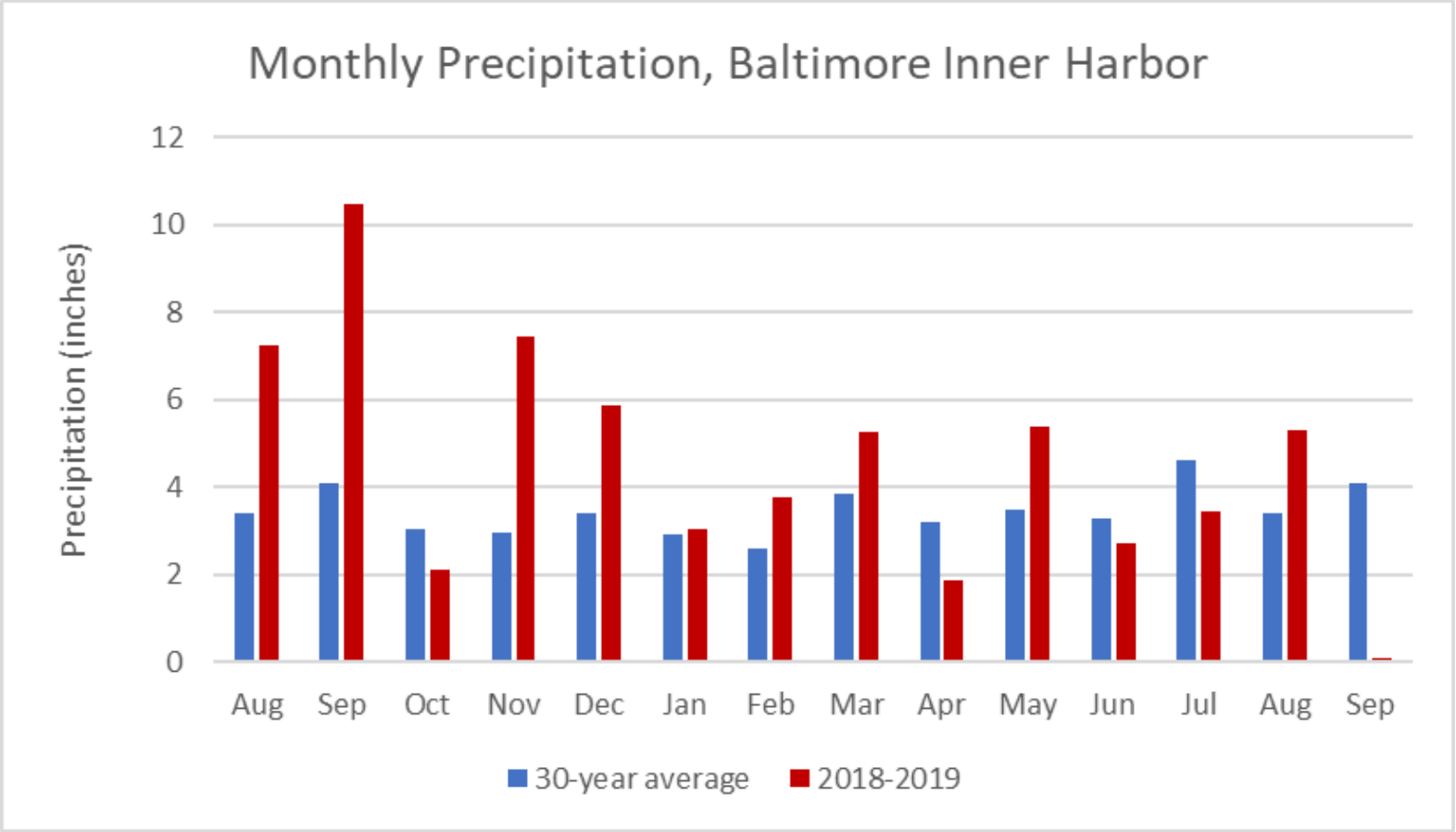


Figure 3-3. Monthly Precipitation Totals August 2018 through September 2019, Baltimore Inner Harbor. Based on data from National Weather Service, summarized by Iowa State University, https://mesonet.agron.iastate.edu

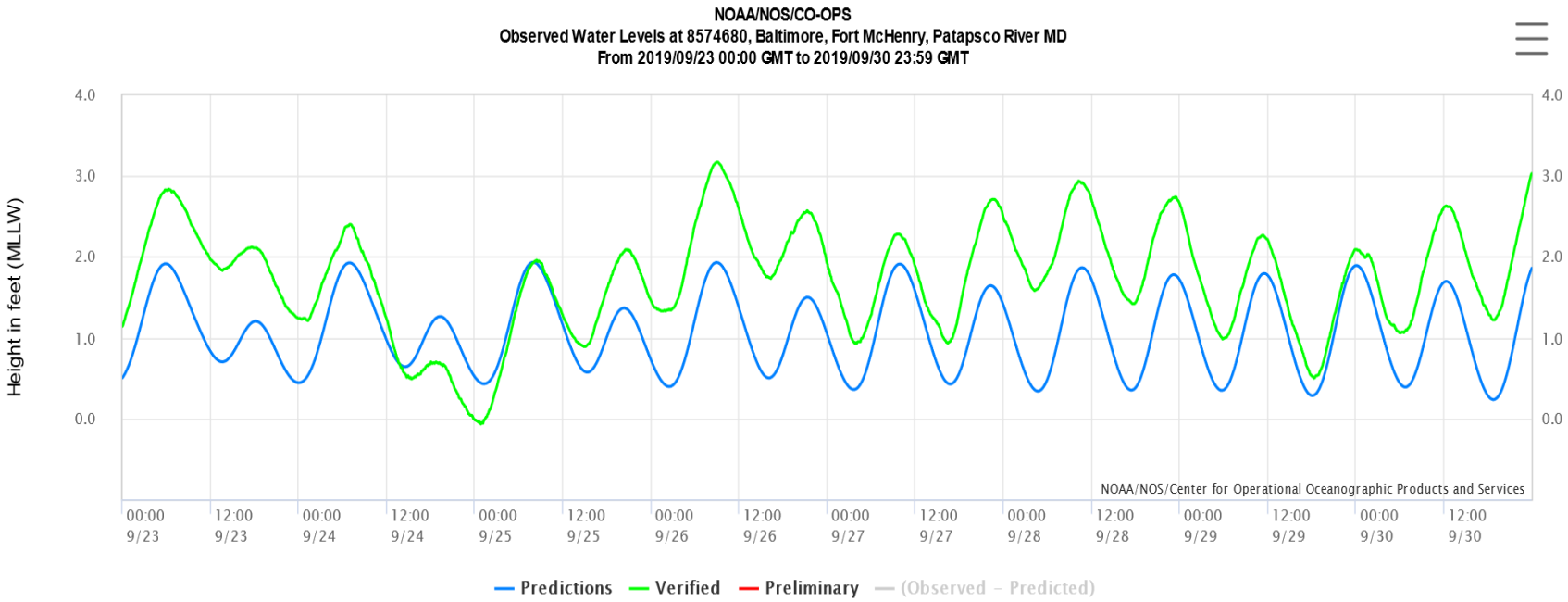


Figure 3-4 Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River September 23-30, 2019. Observed values (green line) are compared with long-term predicted levels (blue line). NOAA data from https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20180721&edate=20180727&timezone=GMT&datum=MLLW&interval=6&action=

Figure 4-1 Map of Cow Pen Creek study area showing 2018 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 November 2017 revegetation plan.

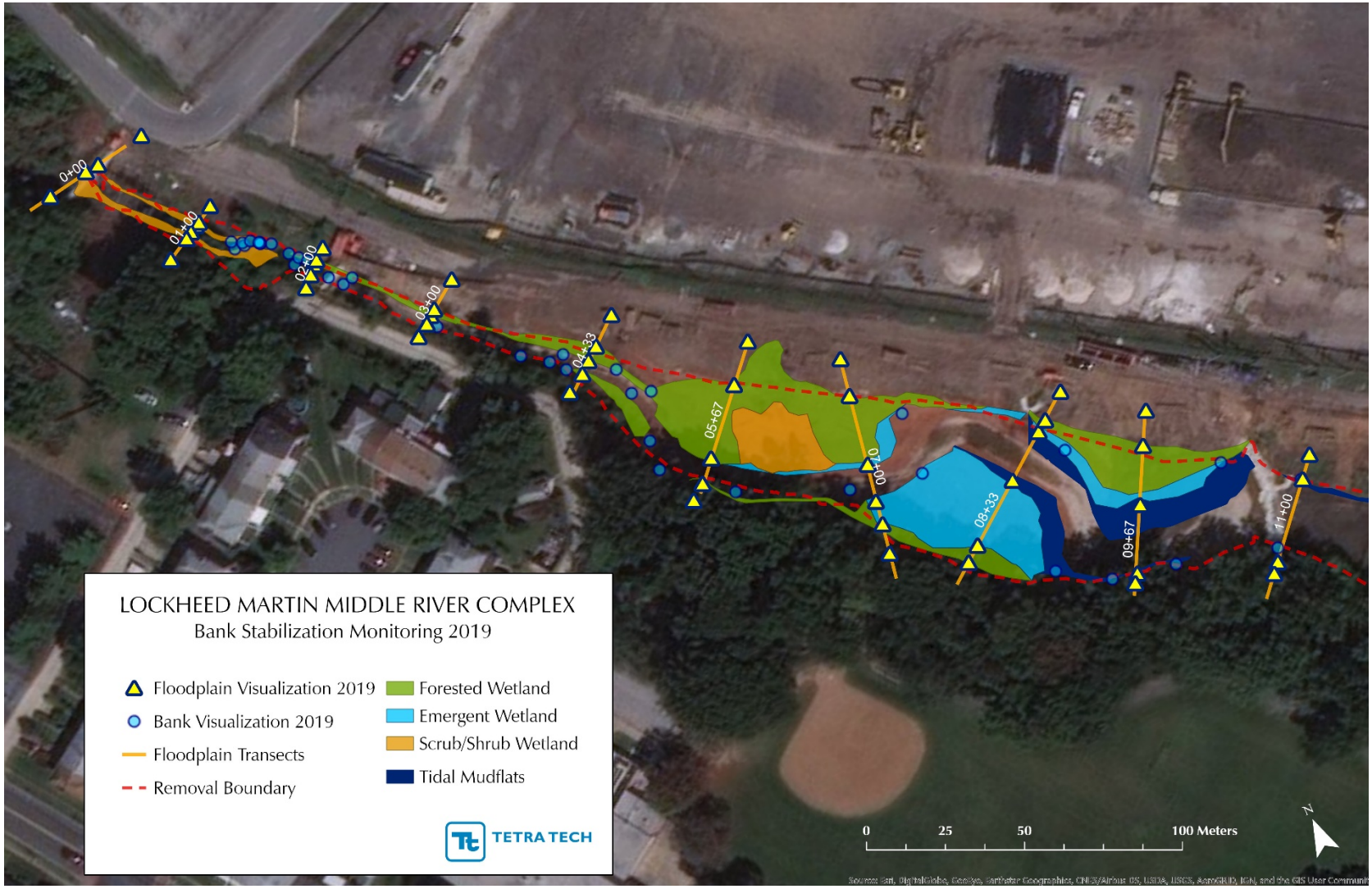
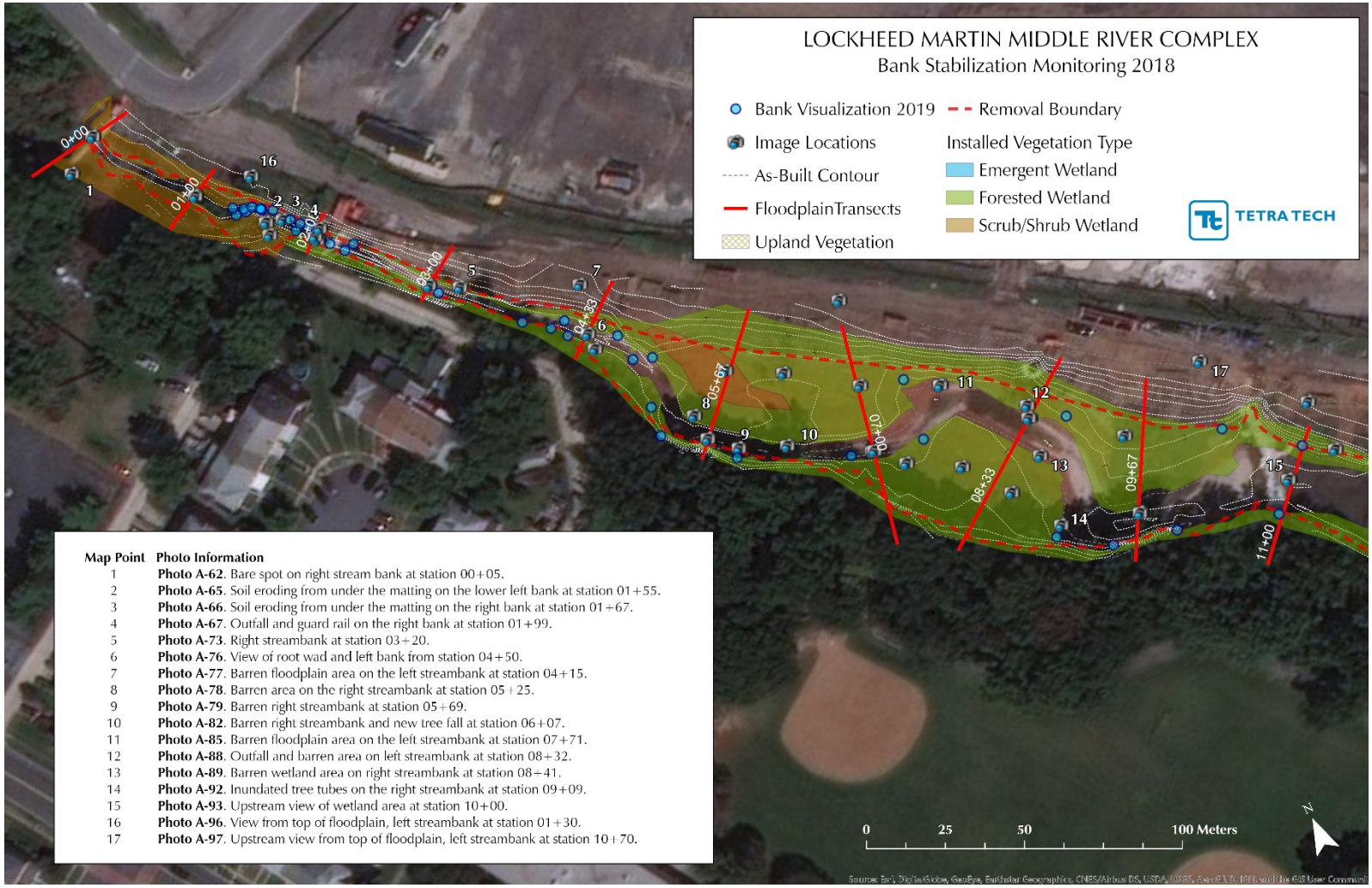
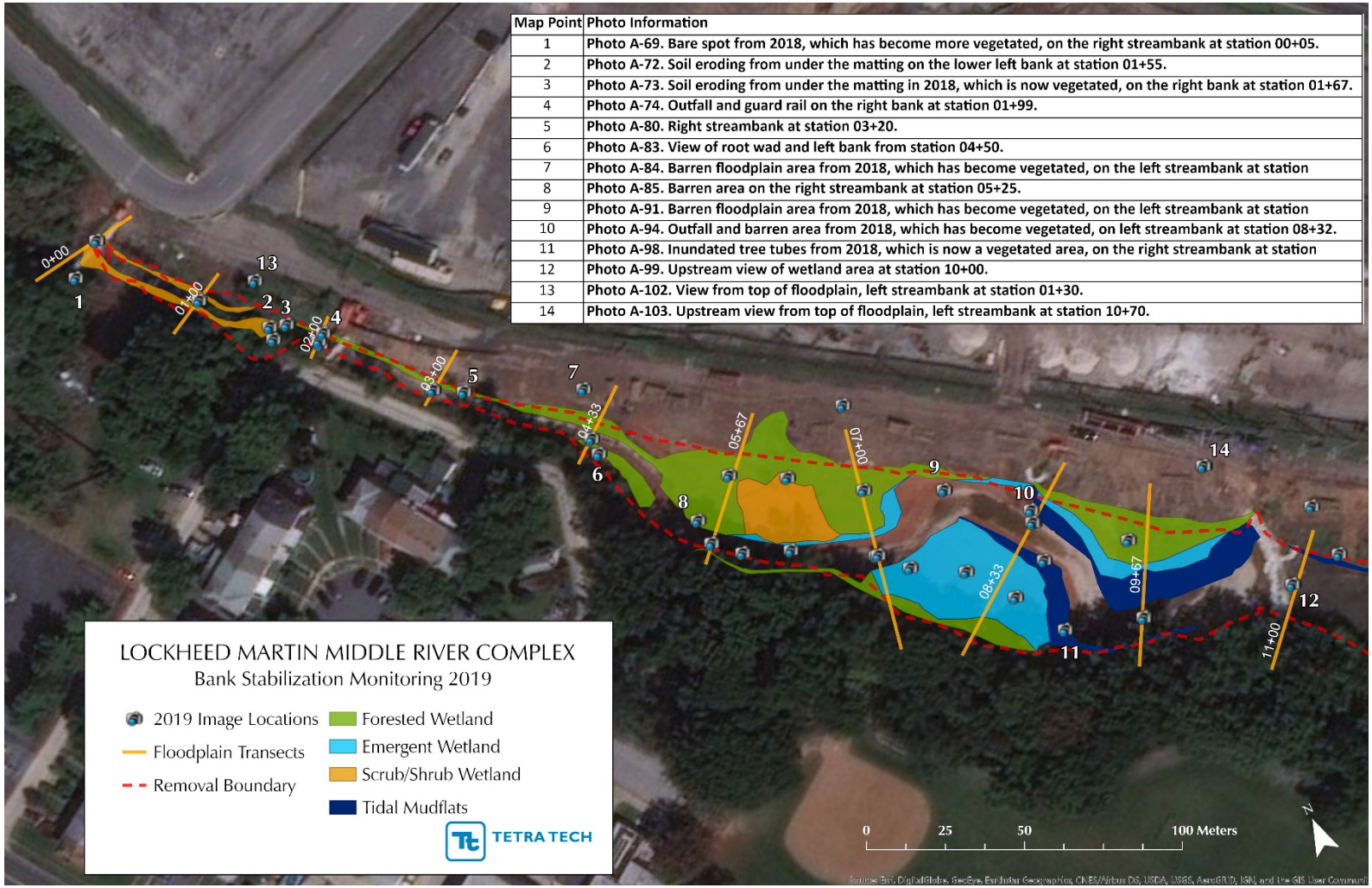


Figure 4-2 Map of Cow Pen Creek study area showing 2019 bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (green) along 10 floodplain transects. Upland and wetland vegetation types are from a 2019 wetland field survey.



Map Point	Photo Information
1	**Photo A-62**. Bare spot on right stream bank at station 00+05.
2	**Photo A-65**. Soil eroding from under the matting on the lower left bank at station 01+55.
3	**Photo A-66**. Soil eroding from under the matting on the right bank at station 01+67.
4	**Photo A-67**. Outfall and guard rail on the right bank at station 01+99.
5	**Photo A-73**. Right streambank at station 03+20.
6	**Photo A-76**. View of root wad and left bank from station 04+50.
7	**Photo A-77**. Barren floodplain area on the left streambank at station 04+15.
8	**Photo A-78**. Barren area on the right streambank at station 05+25.
9	**Photo A-79**. Barren right streambank at station 05+69.
10	**Photo A-82**. Barren right streambank and new tree fall at station 06+07.
11	**Photo A-85**. Barren floodplain area on the left streambank at station 07+71.
12	**Photo A-88**. Outfall and barren area on left streambank at station 08+32.
13	**Photo A-89**. Barren wetland area on right streambank at station 08+41.
14	**Photo A-92**. Inundated tree tubes on the right streambank at station 09+09.
15	**Photo A-93**. Upstream view of wetland area at station 10+00.
16	**Photo A-96**. View from top of floodplain, left streambank at station 01+30.
17	**Photo A-97**. Upstream view from top of floodplain, left streambank at station 10+70.

Figure 4-3. Map of Cow Pen Creek study area showing 2018 locations of representative photographs along the stream channel (upstream and downstream views at each transect) and photographs of other features of note (map points 1-17, with photograph descriptions). For photographs, see Appendix A of 2018 monitoring report (Tetra Tech 2018d). Upland and wetland vegetation types are from November 2017 revegetation 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 4-4. Map of Cow Pen Creek study area showing 2019 locations of representative photographs along the stream channel (upstream and downstream views at each transect) and photographs of other features of note (map points 1-14, with photograph descriptions). For photographs, see Appendix A, Photos A-67 through A-103. Upland and wetland vegetation types are from the August 2019 wetland survey.

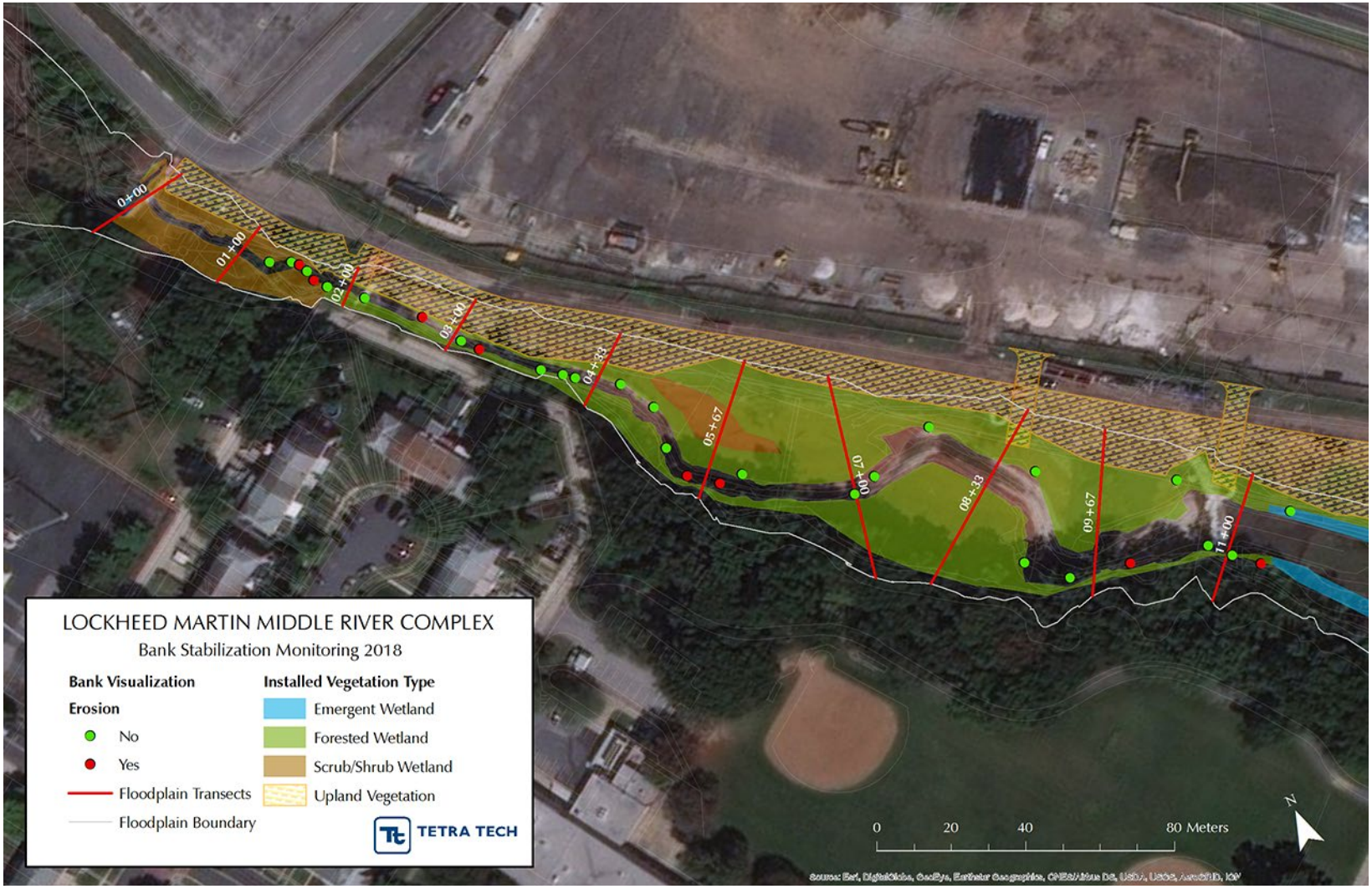


Figure 4-5. Map of Cow Pen Creek study area showing 2018 locations of bank erosion, noted as lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from November 2017 revegetation plan.

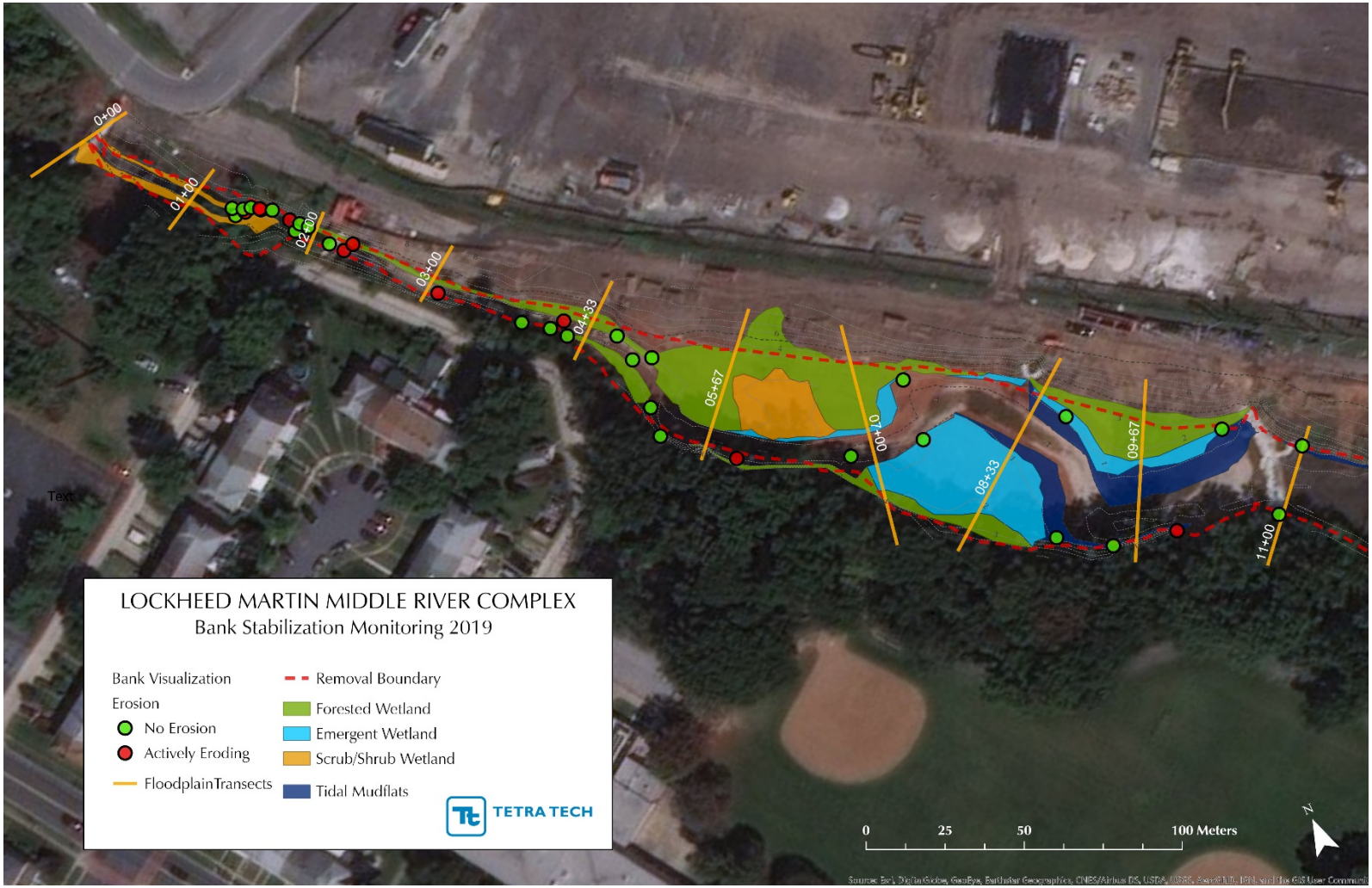


Figure 4-6. Map of Cow Pen Creek study area showing 2019 locations of bank erosion, noted as lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019).

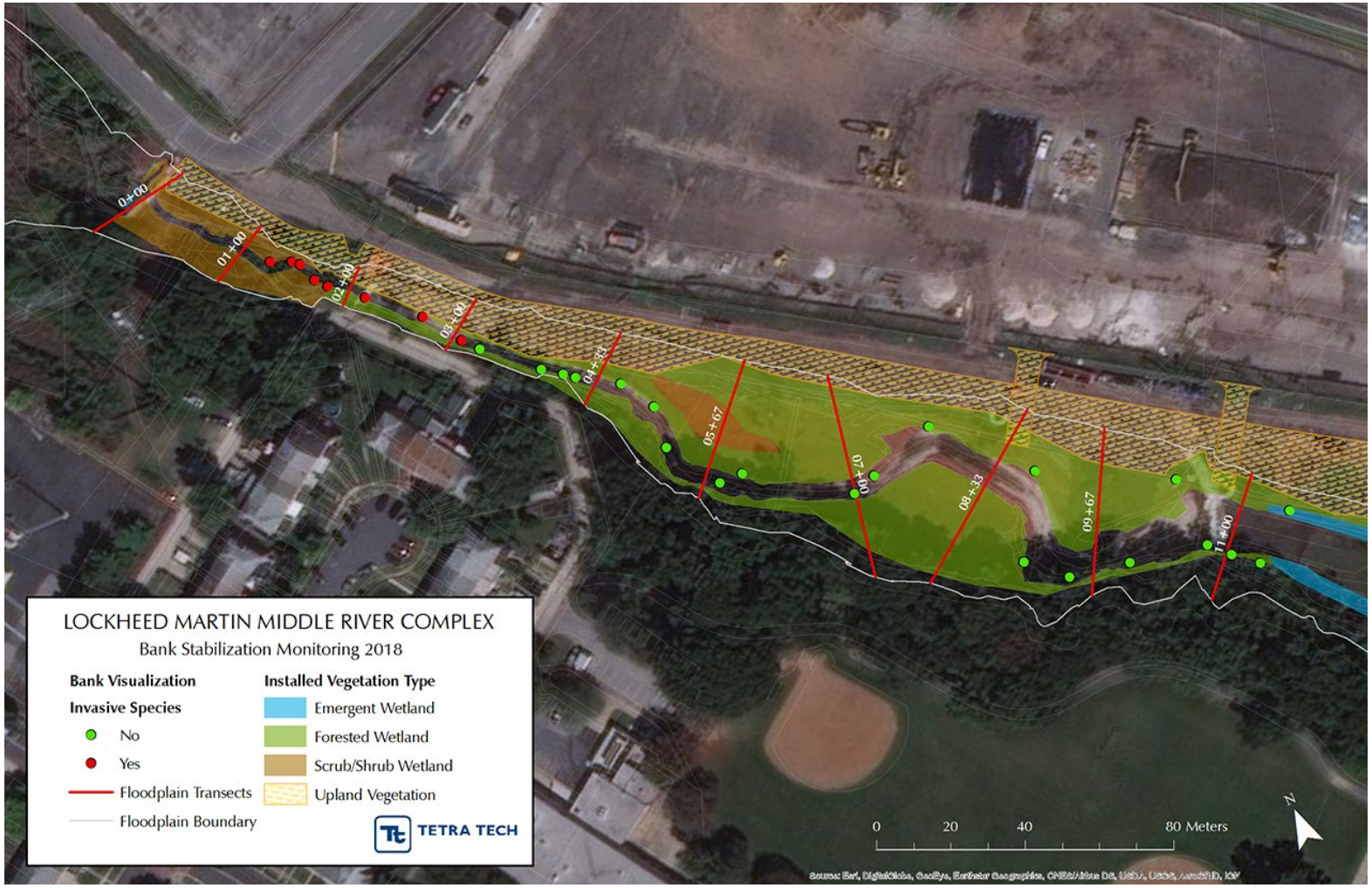


Figure 4-7. Map of Cow Pen Creek study area showing 2018 locations of invasive plant species, noted as lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from November 2017 revegetation plan (Tetra Tech 2017).

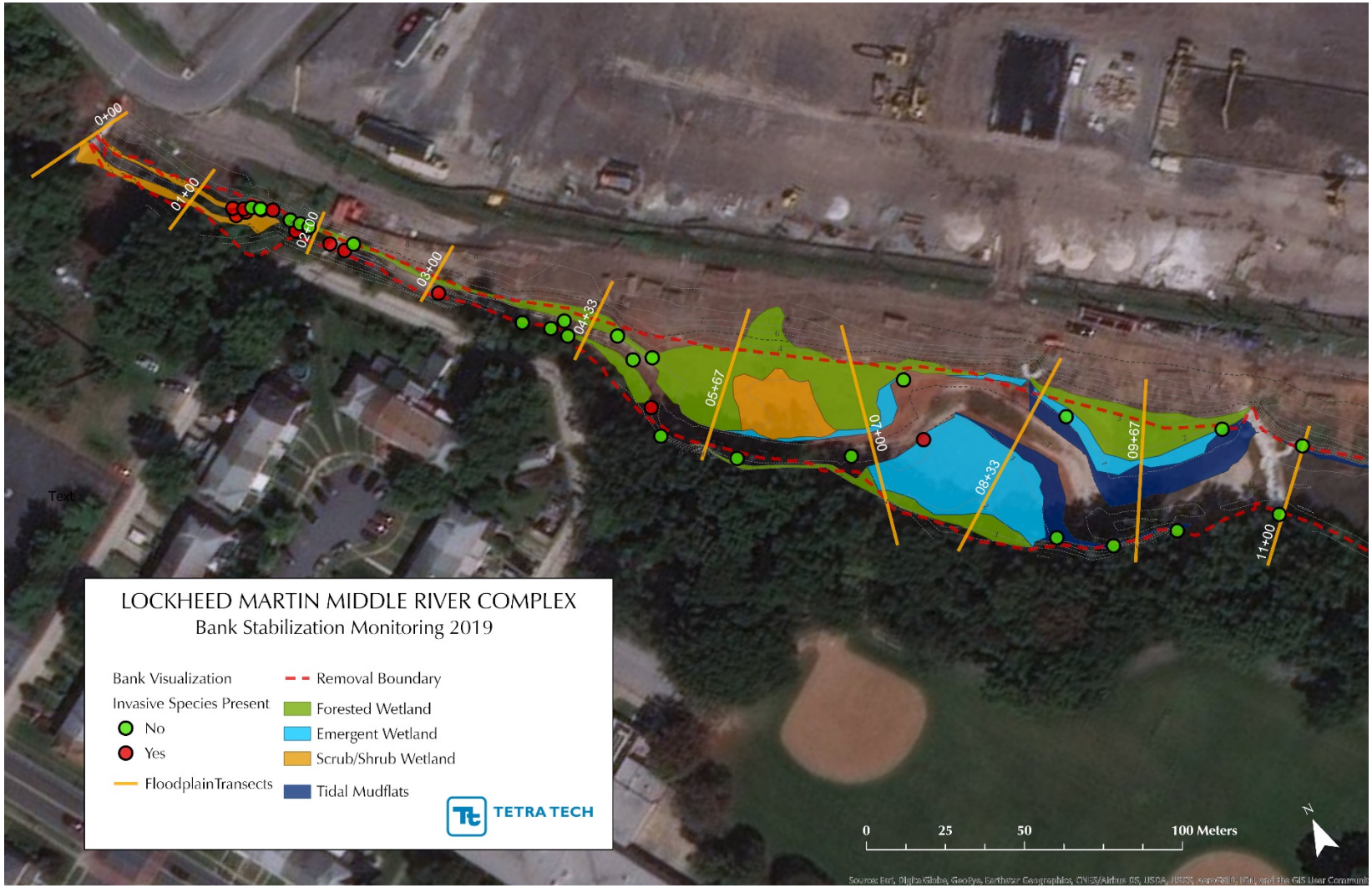


Figure 4-8. Map of Cow Pen Creek study area showing 2019 locations of invasive plant species, noted as lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019).

Figure 4-9. Map of Cow Pen Creek study area showing 2018 locations of areas noted based on concerns for erosion or vegetative cover condition. Upland and wetland vegetation types are from the November 2017 revegetation plan (Tetra Tech 2017).

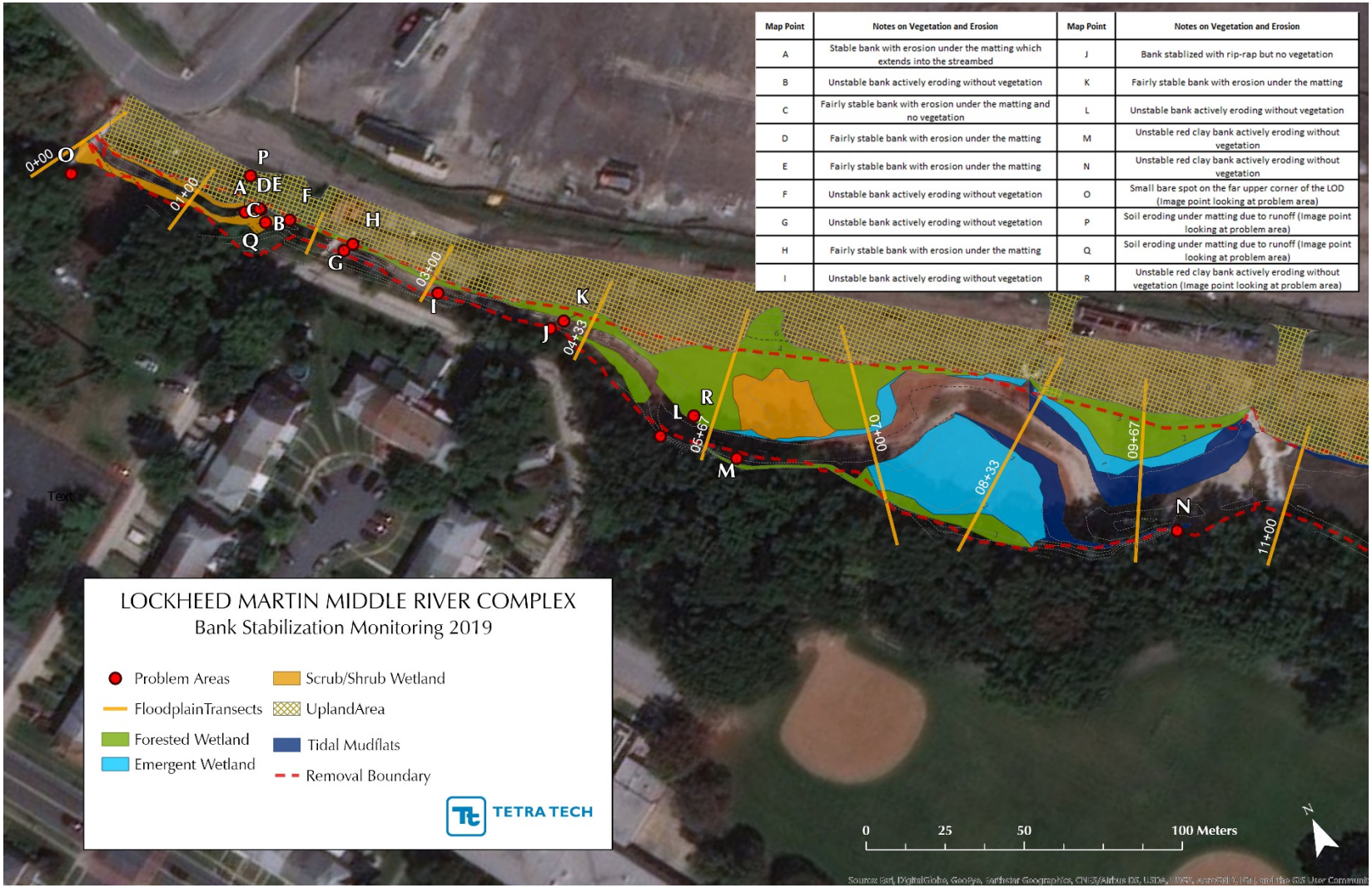


Figure 4-10. Map of Cow Pen Creek study area showing 2019 locations of areas noted based on concerns for erosion or vegetative cover condition. Upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019).

Figure 4-11. Map of Cow Pen Creek study area showing 2018 streambank and floodplain field survey points, along with as-built survey topography. 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 November 2017 revegetation plan (Tetra Tech 2017).

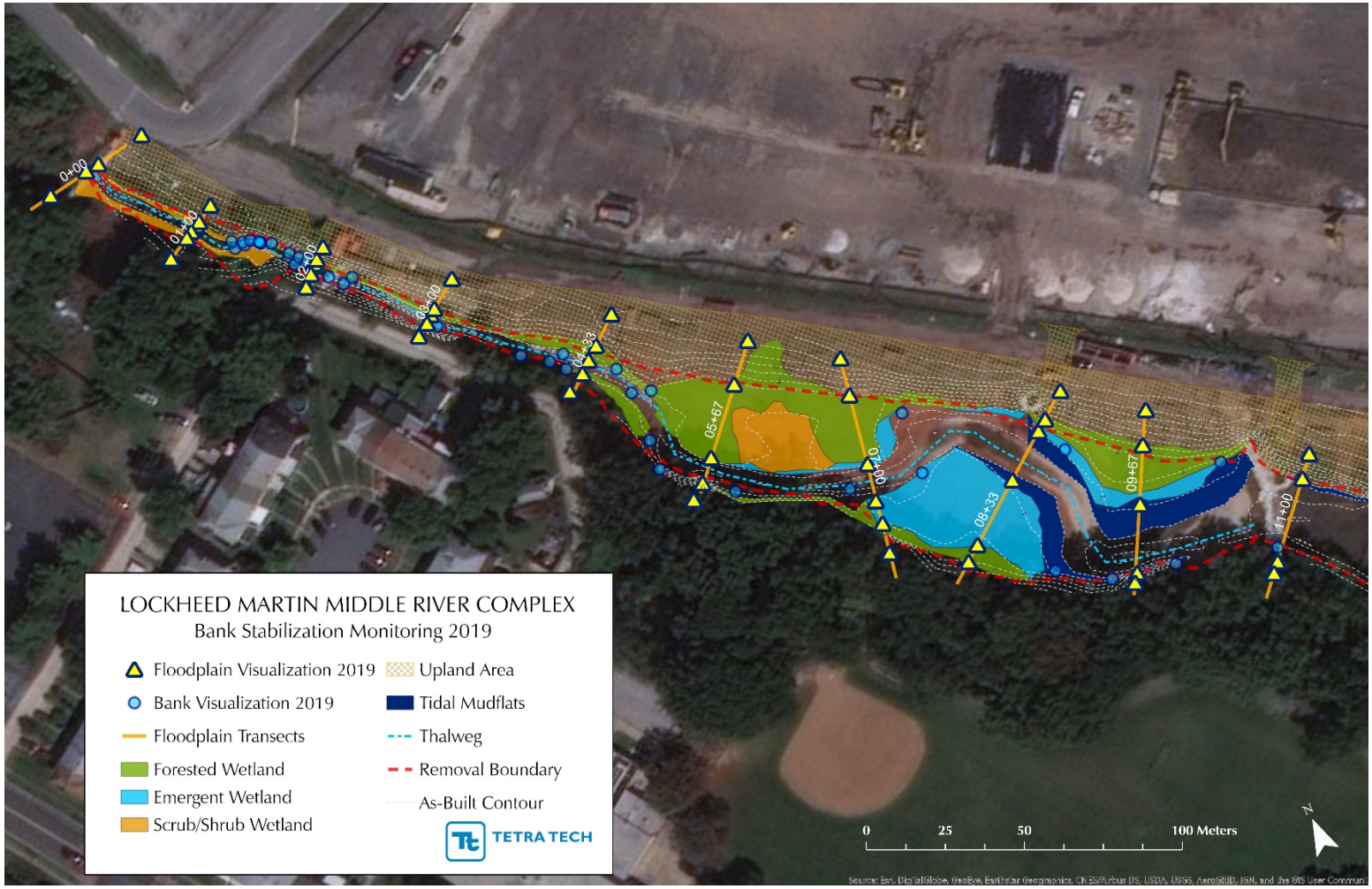


Figure 4-12. Map of Cow Pen Creek study area showing 2019 streambank and floodplain field survey points, along with as-built survey topography. Floodplain transect start points (green points closest to stream along transect) were field-placed at top of bank on both sides of stream. As-built survey is from April 2019; upland and wetland vegetation types are from the August 2019 wetland survey (Tetra Tech 2019).

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Table 3-1

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 3-2

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 3-3

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 3-4

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 4-1

Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event
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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
right	01+78	8	yes	stable	no	0	0	8	0

Table 4-1

Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event

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	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
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 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event

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		

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event
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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	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. Upper bank has woody vegetation.	no		
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

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event

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	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
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

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event
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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	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		
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		

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, July 2018 Monitoring Event
Page 5 of 5

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	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 patch of pickerelweed	no		
right	11+35	35	herbaceous layer <10% cover	No	No	No	Stakes underwater	no		

Table 4-3
Summary of Streambank Conditions, Cow Pen Creek, July 2018 Monitoring Event

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 4-4

Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event

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
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

Table 4-4

Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event
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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	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
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

Table 4-4

Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event
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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	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 4-5

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event
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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

Table 4-5

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event
Page 2 of 5

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+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		
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		

Table 4-5

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event

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	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
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	

Table 4-5
Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event
Page 4 of 5

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	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 4-5

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek, September 2019 Monitoring Event
Page 5 of 5

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 4-6

Summary of Streambank Conditions, Cow Pen Creek, September 2019 Monitoring Event

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 4-7

Conditions Observed within Floodplain Transect Segments, Cow Pen Creek, July 2018 Monitoring Event

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			
left	07+00	0	54	Wetland	Yes	Yes	Yes	No	Sparse/bare spots present near transect	no	
		54	80	Wetland	Yes	Yes	Yes	No			

Table 4-7

Conditions Observed within Floodplain Transect Segments, Cow Pen Creek, July 2018 Monitoring Event
Page 2 of 5

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	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			

Table 4-7

Conditions Observed within Floodplain Transect Segments, Cow Pen Creek, July 2018 Monitoring Event
Page 3 of 5

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	80	112	Upland	Yes	Yes	Yes	No	Sparse/bare spots present near transect	no	
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	

Table 4-7

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek, July 2018 Monitoring Event

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	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 4-7

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek, July 2018 Monitoring Event

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 4-8

Summary of Floodplain Transect Vegetation Assessments, Cow Pen Creek, July 2018 Monitoring Event

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 4-9
Bare Spots Greater than 10 Square Feet Observed during Streambank and Floodplain Assessment, Cow Pen Creek, July 2018 Monitoring Event

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 4-10

Conditions Observed within Floodplain Transect Segments, Cow Pen Creek, September 2019 Monitoring Event

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	
left	07+00	0	57	Wetland	Yes	Yes	Yes	No		no	

Table 4-10

Conditions Observed within Floodplain Transect Segments, Cow Pen Creek, September 2019 Monitoring Event
Page 2 of 3

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	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	
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	

Table 4-10

Conditions Observed within Floodplain Transect Segments, Cow Pen Creek, September 2019 Monitoring Event

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	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 4-11

Summary of Floodplain Transect Vegetation Assessments, Cow Pen Creek, September 2019 Monitoring Event

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

APPENDICES

Appendix A—Photo Log

Appendix B—GPS Coordinates for Field Assessment Points

APPENDIX A—PHOTO LOG

Appendix A—Photo Log

Figure A-1. Right streambank, upstream view at Station 01+37.

Figure A-2. Left streambank, upstream view at Station 01+36.

Figure A-3. Left streambank at Station 01+45.

Figure A-4. Right streambank at Station 01+46.

Figure A-5. Left streambank at Station 01+52.

Figure A-6. Right streambank, upstream view at Station 01+91.

Figure A-7. Left streambank at Station 01+57.

Figure A-8. Left streambank at Station 01+66.

Figure A-9. Left streambank, upstream view at Station 01+83.

Figure A-10. Left streambank at Station 01+91.

Figure A-11. Left streambank at Station 01+98.

Figure A-12. Right streambank, upstream view at Station 02+14.

Figure A-13. Left streambank at Station 02+32.

Figure A-14. Right streambank, upstream view at Station 02+27.

Figure A-15. Right streambank, upstream view at Station 03+09.

Figure A-16. Right streambank, upstream view at Station 03+80.

Figure A-17. Left streambank, upstream view at Station 04+13.

Figure A-18. Right streambank at Station 04+03.

Figure A-19. Right streambank at Station 04+19.

Figure A-20. Left streambank, upstream view at Station 04+57.

Figure A-21. Right streambank, upstream view at Station 04+76.

Figure A-22. Left streambank at Station 04+86.

Figure A-23. Right streambank, upstream view at Station 05+22.

Figure A-24. Right streambank, upstream view at Station 05+41.

Figure A-25. Right streambank, upstream view at Station 05+93.

Figure A-26. Right streambank at Station 06+82.

Figure A-27. Left streambank, in backwater area at Station 07+57.

Figure A-28. Right streambank at Station 07+38.

Figure A-29. Right streambank, upstream view at Station 09+26.

Figure A-30. Left streambank, upstream view at Station 08+55.

Figure A-31. Right streambank at Station 09+45.

Figure A-32. Right streambank, upstream view at Station 09+98.

Figure A-33. Left streambank at Station 10+50.

Figure A-34. Right streambank, upstream view at Station 10+97.

Figure A-35. Left streambank, upstream view at Station 11+00.

Figure A-36. Floodplain transect at Station 00+00, right bank, 0 feet to 35 feet from top of bank.

Figure A-37. Floodplain transect at Station 00+00, left bank, 0 feet to 42 feet from top of bank.

Figure A-38. Floodplain transect at Station 01+00, left bank, 0 feet to 4 feet from top of bank.

Figure A-39. Floodplain transect at Station 01+00, right bank, 0 feet to 6 feet from top of bank.

Figure A-40. Floodplain transect at Station 01+00, left bank, 4 feet to 20 feet from top of bank.

Figure A-41. Floodplain transect at Station 01+00, right bank, 6 feet to 27 feet from top of bank.

Figure A-42. Floodplain transect at Station 02+00, left bank, 0 feet to 4 feet from top of bank.

Figure A-43. Floodplain transect at Station 02+00, left bank, 4 feet to 15 feet from top of bank.

Figure A-44. Floodplain transect at Station 02+00, right bank, 0 feet to 11 feet from top of bank.

Figure A-45. Floodplain transect at Station 03+00, left bank, 0 feet to 6 feet from top of bank.

Figure A-46. Floodplain transect at Station 03+00, right bank, 0 feet to 12 feet from top of bank.

Figure A-47. Floodplain transect at Station 03+00, left bank, 6 feet to 34 feet from top of bank.

Figure A-48. Floodplain transect at Station 04+33, left bank, 0 feet to 13 feet from top of bank.

Figure A-49. Floodplain transect at Station 04+33, right bank, 0 feet to 18 feet from top of bank.

Figure A-50. Floodplain transect at Station 04+33, left bank, 13 feet to 41 feet from top of bank.

Figure A-51. Floodplain transect at Station 05+67, right bank, 0 feet to 15 feet from top of bank.

Figure A-52. Floodplain transect at Station 05+67, left bank, 0 feet to 62 feet from top of bank.

Figure A-53. Floodplain transect at Station 05+67, left bank, 62 feet to 99 feet from top of bank.

Figure A-54. Floodplain transect at Station 07+00, right bank, 0 feet to 19 feet from top of bank.

Figure A-55. Floodplain transect at Station 07+00, left bank, 0 feet to 57 feet from top of bank.

Figure A-56. Floodplain transect at Station 07+00, right bank, 19 feet to 44 feet from top of bank.

Figure A-57. Floodplain transect at Station 07+00, left bank, 57 feet to 88 feet from top of bank.

Figure A-58. Floodplain transect at Station 08+33, left bank, 0 feet to 11 feet from top of bank.

Figure A-59. Floodplain transect at Station 08+33, right bank, 0 feet to 60 feet from top of bank.

Figure A-60. Floodplain transect at Station 08+33, Left bank, 11 feet to 37 feet from top of bank.

Figure A-61. Floodplain transect at Station 08+33, right bank, 60 feet to 75 feet from top of bank.

Figure A-62. Floodplain transect at Station 09+67, right bank, 0 feet to 8 feet from top of bank.

Figure A-63. Floodplain transect at Station 09+67, left bank, 0 feet to 47 feet from top of bank.

Figure A-64. Floodplain transect at Station 09+67, left bank, 47 feet to 75 feet from top of bank.

Figure A-65. Floodplain transect at Station 11+00, right bank, 0 feet to 10 feet from top of bank.

Figure A-66. Floodplain transect at Station 11+00, left bank, 0 feet to 21 feet from top of bank.

Figure A-67. Downstream view from thalweg at Station 00+00, 2018 (top) and 2019 (bottom).

Figure A-68. Upstream view from thalweg at Station 00+00, 2018 (top) and 2019 (bottom).

Figure A-69. Bare spot on the right streambank at Station 00+05, 2018 (top) and 2019 (bottom).

Figure A-70. Downstream view from thalweg at Station 01+00, 2018 (top) and 2019 (bottom).

Figure A-71. Upstream view from thalweg at Station 01+00, 2018 (top) and 2019 (bottom).

Figure A-72. Soil eroding from under the matting on the lower left bank at Station 01+55, 2018 (top) and 2019 (bottom).

Figure A-73. Soil eroding from under the matting on the right bank at Station 01+67, 2018 (top) and 2019 (bottom).

Figure A-74. Outfall and guard rail on the right bank at Station 01+99, 2018 (top) and 2019 (bottom).

Figure A-75. Downstream view from thalweg at Station 02+00, 2018 (top) and 2019 (bottom).

Figure A-76. Upstream view from thalweg at Station 02+00, 2018 (top) and 2019 (bottom).

Figure A-77. Upstream view of both streambanks at Station 02+01, 2018 (top) and 2019 (bottom).

Figure A-78. Downstream view from thalweg at Station 03+00, 2018 (top) and 2019 (bottom).

Figure A-79. Upstream view from thalweg at Station 03+00, 2018 (top) and 2019 (bottom).

Figure A-80. Right streambank at Station 03+20, 2018 (top) and 2019 (bottom).

Figure A-81. Downstream view from thalweg at Station 04+33, 2018 (top) and 2019 (bottom).

Figure A-82. Upstream view from the thalweg at Station 04+33, 2018 (top) and 2019 (bottom).

Figure A-83. View of root wad and left bank from Station 04+50, 2018 (top) and 2019 (bottom).

Figure A-84. Barren floodplain area on the left streambank at Station 04+15, 2018 (top) and 2019 (bottom).

Figure A-85. Barren area on the right streambank at Station 05+25, 2018 (top) and 2019 (bottom).

Figure A-86. Downstream view from thalweg at Station 05+67, 2018 (top) and 2019 (bottom).

Figure A-87. Upstream view from thalweg at Station 05+67, 2018 (top) and 2019 (bottom).

Figure A-88. Downstream view from thalweg at Station 07+00, 2018 (top) and 2019 (bottom).

Figure A-89. Upstream view from thalweg at Station 07+00, 2018 (top) and 2019 (bottom).

Figure A-90. Tree tubes and new vegetation on left bank at Station 07+03, 2018 (top) and 2019 (bottom).

Figure A-91. Barren floodplain area and new vegetation on the left streambank at Station 07+71, 2018 (top) and 2019 (bottom).

Figure A-92. Downstream view from thalweg at Station 08+33, 2018 (top) and 2019 (bottom).

Figure A-93. Upstream view from thalweg at Station 08+33, 2018 (top) and 2019 (bottom).

Figure A-94. Outfall / barren area and new vegetation on left streambank at Station 08+32, 2018 (top) and 2019 (bottom).

Figure A-95. Barren wetland area and new vegetation on the right streambank at Station 08+41, 2018 (top) and 2019 (bottom).

Figure A-96. Downstream view from thalweg at Station 09+67, 2018 (top) and 2019 (bottom).

Figure A-97. Upstream view from thalweg at Station 09+67, 2018 (top) and 2019 (bottom).

Figure A-98. Inundated tree tubes and new vegetation on the right streambank at Station 09+09, 2018 (top) and 2019 (bottom).

Figure A-99. Upstream view of wetland area at Station 10+00, 2018 (top) and 2019 (bottom).

Figure A-100. Downstream view from thalweg at Station 11+00, 2018 (top) and 2019 (bottom).

Figure A-101. Upstream view from thalweg at Station 11+00, 2018 (top) and 2019 (bottom).

Figure A-102. View from top of floodplain, left streambank at Station 01+30, 2018 (top) and 2019 (bottom).

Figure A-103. Upstream view from top of floodplain, left streambank at Station 10+70, 2018 (top) and 2019 (bottom).

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