Sediment Remedy 100% Design for Cow Pen Creek and Dark Head Cove, Middle River Remediation Site Lockheed Martin Middle River Complex Middle River, Maryland

Prepared for:

Lockheed Martin Corporation

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Revision Table					
Revision number	**Prepared by**	**Submittal to**	**Submittal dates**	**Revisions**	
				Section	**Change description**
0	Tetra Tech, Inc.	Lockheed Martin	6/8/2015	All	60% Design
1	Tetra Tech, Inc.	Lockheed Martin	10/5/2015	All	90% Design
2	Tetra Tech, Inc.	Lockheed Martin	11/4/2015	All	100% Design
3	Tetra Tech, Inc.	Lockheed Martin	12/1/2015	All	100% Design
4	Tetra Tech, Inc.	USEPA Region 3, Maryland MDE	6/17/2016	Section 3.3, 4.1, 4.2, 4.3, and Section 11 Section 1.4, Table 3.1a	Revisions per USEPA Region 3 and Maryland MDE comments Revisions per construction Contractor's removal approach in Cow Pen Creek

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APPENDICES

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ACRONYMS

ARARs	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
AWQC	ambient water quality criteria
BaPEq	benzo(a)pyrene equivalents
BMP	best management practice
CB	catch basin
CBP	Chesapeake Bay Program
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHS	Controlled Hazardous Substance
cm	centimeter(s)
cm/year	centimeter(s) per year
COBAR	Code of Baltimore County Regulations
COC	chemical(s) of concern
COMAR	Code of Maryland Regulations
CPC	Cow Pen Creek
CQAP	Construction Quality Control Plan
CST	column settling test
CWA	Clean Water Act
cy	cubic yard(s)
dBA	decibel
DEPS	Department of Environmental Protection and Sustainability
DHC	Dark Head Cove
DMU	dredge management unit
DRET	dredge elutriate test
dw	dry weight
EA	environmental assessment
EFH	essential fish habitat
ESA	Endangered Species Act
FONSI	finding of no significant impact
fps	feet per second
frac	fractionation
FS	feasibility study
g	acceleration due to gravity
GAC	granular activated-carbon

GPS	global positioning system
IDW	investigation-derived waste
IL	inlet
IRM	interim remedial measure
Lockheed Martin	Lockheed Martin Corporation
LTMMP	long-term monitoring and maintenance plan
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
MH	manhole
µm	micrometer(s)
MLW	mean low water
MLLW	mean lower-low water
MNR	monitored natural recovery
MRC	Middle River Complex
MSA	Martin State Airport
N/m2	Newton(s) per square meter
NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTU	nephelometric turbidity unit
NWP	Nationwide Permit
PAC	powdered activated-carbon
PAH	polycyclic aromatic hydrocarbon
PAI	Permits, Approvals, and Inspections
PCB	polychlorinated biphenyl
POTW	publicly owned treatment work
PPE	personal protective equipment
ppm	part(s) per million
PRG	preliminary remediation goal
psf	pound(s) per square foot
PT	pillow test
RAL	remedial action level

RAO	remedial action objective
RBDAA	risk-based disposal approval application
RTK	real-time kinematic
SAP	sampling and analysis plan
SAV	submerged aquatic vegetation
SCD	Soil Conservation District
SRA	sediment removal action
SVOC	semivolatile organic compound
TEQ	toxicity equivalents
Tetra Tech	Tetra Tech, Inc.
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UPL	upper prediction limit
U.S.	United States
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	upper tolerance limit
VOC	volatile organic compound
WQC	water quality certification
WQMP	Water Quality Monitoring Plan

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Section 1
Introduction

On behalf of Lockheed Martin Corporation (Lockheed Martin), Tetra Tech, Inc. (Tetra Tech) has prepared this design report for remediation of sediment adjacent to the Lockheed Martin Middle River Complex (MRC) in Middle River, Maryland. The remedial design is being conducted as part of the Lockheed Martin environmental restoration program and in accordance with Maryland Department of the Environment (MDE) requirements for the environmentally impaired sediment associated with the Lockheed Martin Middle River Complex (referred to herein as the MRC, or the site). Lockheed Martin completed a sediment removal action (SRA) of contaminated sediment adjacent to the storm water outfalls (Outfalls 005 East and 005 West) in Dark Head Cove in March 2015. This design report describes the detailed engineering design for the cleanup of sediment in Cow Pen Creek and the remaining sediment in Dark Head Cove adjacent to the site.

1.1 PROJECT BACKGROUND

The Middle River Complex is at 2323 Eastern Boulevard in Middle River, Maryland (Figure 1-1). In the late 1990s, Lockheed Martin began environmental investigations at Middle River Complex to assess impacts from former industrial operations. Since then, Lockheed Martin has investigated groundwater, soil, air, and sediment at the Middle River Complex.

The waters adjacent to the Middle River Complex are considered waters of the State of Maryland. The sediment remediation will be addressed by the Maryland Department of the Environment's (MDE) State Superfund Site Remediation, Land Restoration Program of the Land Management Administration Program (also known as the State Superfund Program). The Land Restoration Program oversees the assessment and cleanup of historically contaminated hazardous waste sites that have not been placed on the *National Priority List* (NPL). Because polychlorinated biphenyl (PCB) concentrations in sediment in Dark Head Cove adjacent to the Middle River Complex prior to the SRA were found to be greater than 50 parts per million (ppm) [equivalent to 50 milligrams per kilogram (mg/kg)], the United States Environmental Protection Agency (USEPA) has concurrent jurisdiction with the Maryland Department of the Environment under the Toxic Substances Control Act (TSCA) (40 *Code of Federal Regulations* [CFR] Part 761.61).

Lockheed Martin completed remedy investigations and feasibility evaluations for remediation of Middle River Complex sediment between 2005 and 2013. An evaluation of remedial alternatives and a recommended cleanup approach for sediment adjacent to the Middle River Complex were presented in a feasibility study (FS) (Tetra Tech, 2013). During the feasibility study, Lockheed Martin organized public working group meetings to keep the community informed about environmental cleanup activities associated with sediments at the Middle River Complex and also to gain an understanding of community concerns about the sediment remediation. The Maryland Department of the Environment approved the proposed remedial approach presented in the feasibility study and allowed Lockheed Martin to begin remedial activities for sediment adjacent to the Lockheed Martin Middle River Complex (MDE, 2013).

Lockheed Martin conducted further field sampling in Dark Head Cove adjacent to the storm water outfalls (Outfalls 005 East and 005 West) that drain portions of the facility (Tetra Tech, 2014a, 2014b). These outfalls originate from the location of former Building D in Tax Block E (Figure 1-2). Concentrations of polychlorinated biphenyls up to 3,600 parts per million (equivalent to 3,600 milligrams per kilogram) were detected in sediment collected in front of Outfalls 005 East and 005 West. These sediments were subject to disposal requirements under the federal Toxic Substances Control Act and regulations promulgated thereunder, primarily at 40 *Code of Federal Regulations* 761 because they had polychlorinated biphenyl concentrations that exceeded 50 milligrams per kilogram. The Maryland Department of the Environment Land Restoration Program required Lockheed Martin to install a temporary boom/silt curtain to isolate the area of high sediment polychlorinated biphenyl concentrations and to conduct a sediment removal action to limit the potential for public exposure to contaminated sediment and help prevent further contaminated-sediment migration into Dark Head Cove. Remedial actions in the Outfall 005 area as part of the sediment removal action included:

- Installation of warning signs, a boom and silt curtain (completed in May 2014)
- Additional sampling and delineation of sediment to be dredged (completed in July 2014)
- Cleanup of two storm drain outfalls (Outfalls 005 East and 005 West), and

- Dredging of contaminated sediment that are subject to the disposal requirements under 40 *Code of Federal Regulations* Part 761.75 (completed in March, 2015) (Tetra Tech, 2015a).

Additional remediation will occur in Dark Head Cove and Cow Pen Creek consistent with the approved remedial approach (USEPA, 2013; MDE, 2013), which included removal of contaminated sediment in Cow Pen Creek and Dark Head Cove and *in situ* treatment of sediment in Dark Head Cove (Figure 1-4). This document provides the design of the full remedy. Sediment-remedy construction is scheduled to take place in 2016–2018.

1.2 REMEDIATION OBJECTIVES AND GOALS

The remedial action objectives (RAOs) for site sediment were developed in the sediment remedy feasibility study (Tetra Tech, 2013). Preliminary remediation goals (PRGs) and cleanup levels were identified to meet the remedial action objectives. The findings of the remedy investigations and risk assessments (Tetra Tech, 2011a, 2013) were used to develop the RAOs described in detail in the feasibility study. The following remedial action objectives have been defined to clean up sediment at the Middle River Complex site:

- RAO 1: Reduce, to the extent practicable, human health risks associated with the consumption of resident fish by reducing bioavailable sediment concentrations and achieving a site-wide average concentration of polycyclic aromatic hydrocarbons (PAHs) (700 µg/kg), PCBs (195 µg/kg), and arsenic (18.3 mg/kg) in the areas of potential concern (AOPC).
- RAO 2: Reduce human health risks associated with exposure to chemicals of concern through direct contact with sediment and incidental sediment ingestion by achieving a site-wide average concentrations for PAHs (700 µg/kg), PCBs (1,000 µg/kg), and arsenic (18.3 mg/kg) in the AOPC.
- RAO 3: Reduce risks to benthic (i.e., sediment-dwelling) macroinvertebrates by reducing bioavailable sediment concentrations of chemicals of concern and achieving a point-based concentration of PCBs (676 µg/kg), lead (190 mg/kg), cadmium (9.96 mg/kg), copper (298 mg/kg), mercury (1.06 mg/kg), and zinc (459 mg/kg) in the AOPC.

The risk reductions identified for each remedial action objective will be achieved by meeting preliminary remedy goals; these goals define target sediment concentrations that adequately protect human health and the environment. Preliminary remediation goals are applied either on a point basis, or across the site on a site-wide weighted-average basis, depending on the exposure pathway being addressed. PRGs are thus defined as cleanup levels for site sediment. The Maryland Department of the Environment and the United States Environmental Protection Agency reviewed and approved the cleanup levels included in the sediment feasibility study (USEPA, 2013; MDE, 2013). Sediment cleanup levels identified for MRC sediment are presented in Section 2.

1.3 SOURCE CONTROL

Understanding potential sources of recontamination to the site sediment is important to determine whether the implemented remedy will likely remain protective. Results of previous sediment investigations indicate that the most likely source of PCB contamination in sediment is PCB contaminated soil in Tax Block E. It is believed that the PCBs originated from transformers at former Building D (formerly located in Tax Block E), and were possibly released during operation but may also have been released during building demolition. This source is being addressed in remedial actions planned for Block E. Release mechanisms of contamination source have been identified as the storm drainage system and soil erosion to Dark Head Cove sediment. This sediment remedy includes removal of accessible contaminated sediment from the storm drainage system and preventing erosion of soil behind the deteriorated bulkhead along Dark Head Cove. Storm drain cleanup and bulkhead soil retention elements of the sediment remedy are discussed further in this design report.

1.4 OVERVIEW OF PROJECT ELEMENTS

The selected remedy to address impacted Middle River Complex sediment, as proposed in the feasibility study (i.e., Alternative 4G in Tetra Tech, 2013) and advanced in the 30 percent design stage (Tetra Tech, 2014c) has further been refined after completion of Outfall 005 sediment removal action, and based on recent remedy investigations (Tetra Tech, 2014b) and *in situ* remediation treatability studies (Gomez-Eyles and Ghosh, 2014). Figure 1-3 shows the overall remedial design components for sediment remediation in Cow Pen Creek and Dark Head Cove. Major design components include:

- Cow Pen Creek –
    - Removal of 28,200 cubic yards (cy) of sediment over 7.1 acres along 2,600 feet (0.5 mile) of creek by excavation and dredging
    - Stream reconstruction/restoration, residual management layer placement, bank stabilization, and revegetation
- Dark Head Cove –

- Removal of 12,400 cubic yards of sediment over 3.2 acres in Dark Head Cove by dredging
- Residual management layer placement over dredged areas including Outfall 005 sediment removal action area
- Storm drain cleanouts in Blocks D and E that discharge to Dark Head Cove
- Bulkhead soil retention along Dark Head Cove
- *In situ* treatment of 13.7 acres of contaminated sediment in Dark Head Cove
- Monitored natural recovery of 0.3 acre of sediment in Dark Head Cove after *in situ* treatment
- Monitoring of *in situ* treatment areas via an operation and maintenance program to verify the remedy effectiveness

1.5 REPORT ORGANIZATION

This document is organized as follows:

Section 1—Introduction: Provides general project background and the purpose and scope of the design report.

Section 2—Background and Design Basis: Provides background regarding the site cleanup decision and the requirements that the design must meet. Previous investigations and the sources of data used in the design are described, along with project design criteria.

Section 3—Sediment Removal and Disposal: Describes the detailed design of sediment removal, dewatering, handling, disposal, and post-construction activities.

Section 4—*In situ* Treatment in Dark Head Cove: Provides details about selection of sediment-specific *in situ* amendment, field application rates, and methods.

Section 5—Monitored Natural Recovery in Dark Head Cove: Describes the natural-recovery monitoring component of the remedy.

Section 6—Storm-Drain Cleanup at Blocks D and E: Describes the design measures to clean possibly contaminated sediment in four storm drains that drain Block D and Block E.

Section 7—Stream Restoration in Cow Pen Creek: Provides proposed design elements intended to restore the channel, floodplain, and riparian areas within the excavated and dredged portions of Cow Pen Creek.

Section 8—Project Permitting: Lists the permits and processes that will be required for this project.

Section 9—Construction Sequence and Schedule: Lists the potential sequence of construction activities and the proposed construction schedule.

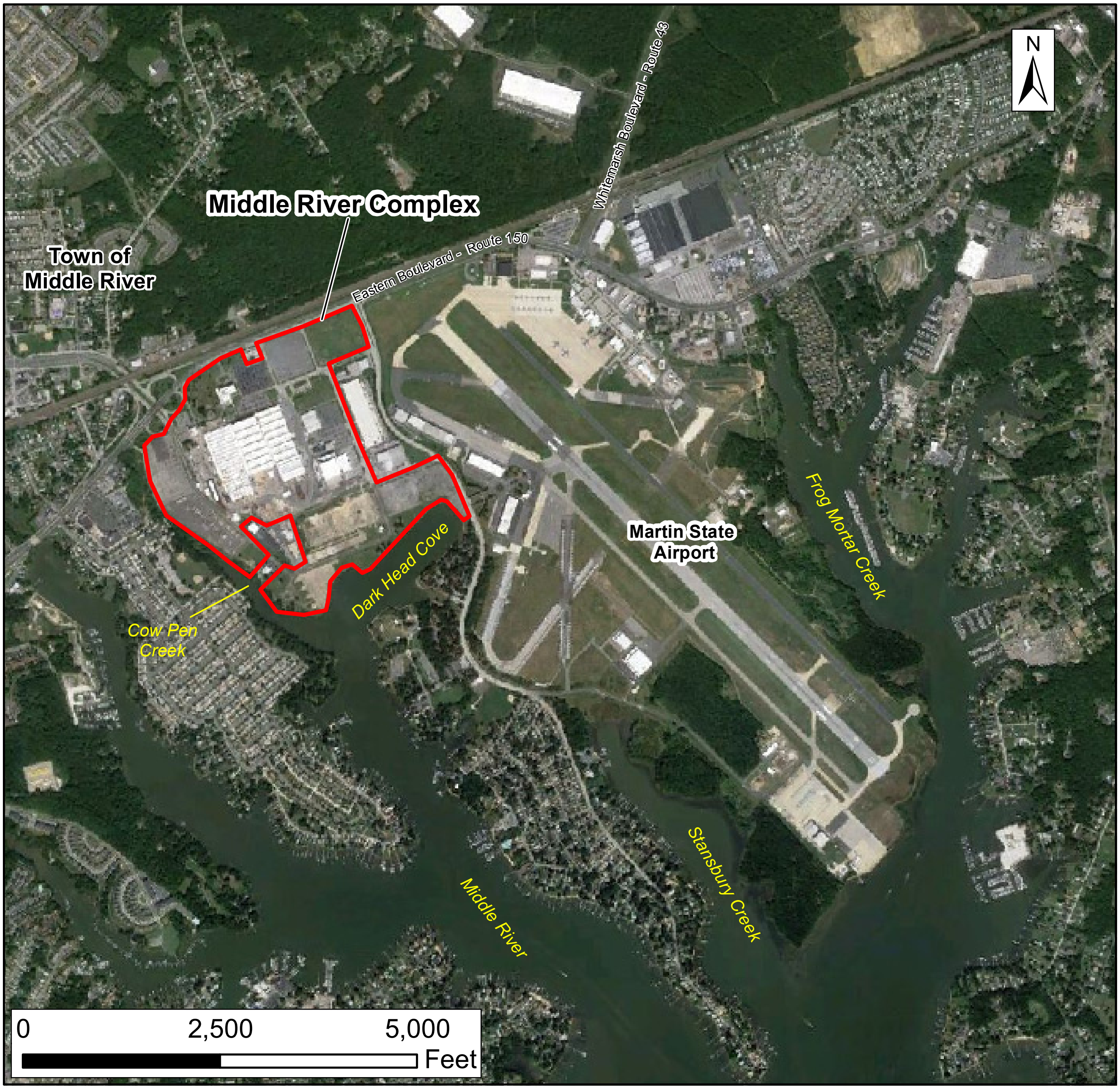
Section 10—Long-term Monitoring and Maintenance: Generally describes the long-term monitoring and maintenance activities that will be implemented.

Section 11—References: Provides a complete list of references cited in this document.

Tables and figures are included at the end of their respective sections. This document is also supported by the following appendices:

- Appendix A—Existing Conditions: Photo log, extent of contamination in Cow Pen Creek and Dark Head Cove
- Appendix B—Hydrology Analysis and Hydraulic Modeling in Cow Pen Creek
- Appendix C—Best Management Practices Analysis. A best management practices (BMP) evaluation performed in accordance with the American Society for Testing and Materials (ASTM) International "Standard Guide for Greener Cleanups" (WK35161)
- Appendix D—Design Calculations

Design drawings and the technical specifications are provided as separate documents. In addition, three ancillary documents associated with the design including the Construction Quality Assurance Plan (CQAP), the Water Quality Monitoring Plan (WQMP), and the Long-term Monitoring and Maintenance Plan (LTMMP) are also provided.



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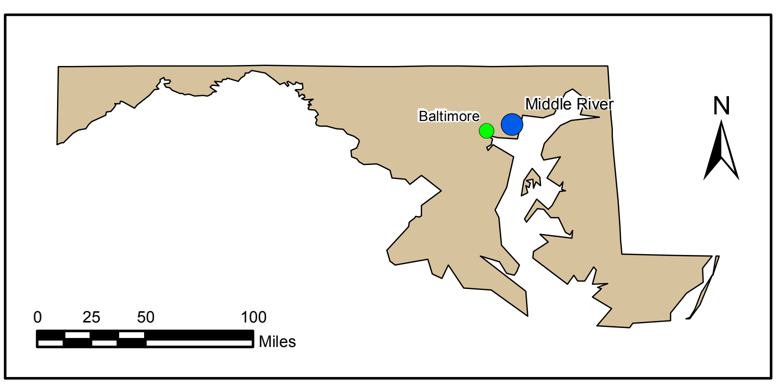

FIGURE 1-1

MIDDLE RIVER COMPLEX LOCATION MAP

Lockheed Martin Middle River Complex
Middle River, Maryland

DATE MODIFIED: 11/26/13	CREATED BY: MP

TETRA TECH

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FIGURE 1-2

SITE LAYOUT AND SITE TAX BLOCKS, MIDDLE RIVER COMPLEX

LEGEND

TAX BLOCK

STRUCTURE

RAILROAD TRACKS

Lockheed Martin Middle River Complex
Middle River, Maryland

0 300 600 Feet

N

DATE MODIFIED: 12/28/12

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REMEDIATION SUMMARY			
LOCATION	ELEVATION (FT, MLLW)	AREA (AC)	VOLUME (CY)
1) CPC EXCAVATION	2 TO -7	5.9	23,700
2) CPC DREDGING	-5 TO -13	1.2	4,600
3) DHC DREDGING	-14.5	0.7	3,500
4) DHC DREDGING	-12.0	1.2	3,750
5) DHC DREDGING	-11.0	0.4	1,200
6) DHC DREDGING	-10.5	0.8	3,950
7) DHC *IN SITU*	-10 TO -12	0.6	(N/A)
8) DHC *IN SITU*	-2 TO -11	10.6	(N/A)
9) DHC *IN SITU*	-3 TO -9	2.5	(N/A)

REMEDIATION:
COW PEN CREEK TOTAL REMOVAL : 28,300 CY
DARK HEAD COVE TOTAL REMOVAL: 12,400 CY
RESIDUAL MANAGEMENT LAYER AREA
INCLUDING OUTFALL 005 SRA = 8.1 AC
IN SITU TREATMENT AREA: 13.7 AC

NOTES:
1. AERIAL IMAGE SOURCE: GOOGLE EARTH, OCTOBER 2014.
2. HORIZONTAL DATUM: MARYLAND STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM, 1983. VERTICAL DATUM: MLLW (EPOCH 1983-2011)

FT = FEET; AC = ACRE; CY = CUBIC YARDS
MLLW = MEAN LOWER LOW WATER

LEGEND:
- TAX BLOCK
- DOCK STRUCTURES
- REMOVAL AREA
- *IN SITU* TREATMENT
- RAILROAD
- APPROX. LIMITS OF EXCAVATION AND DREDGING
- STORM SYSTEM
- STORM SYSTEM OUTFALL
- STORM DRAINS TO BE CLEANED
- SRA BOUNDARY

TETRA TECH

0 300' 600'

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

FIGURE 1-3
COW PEN CREEK AND DARK HEAD COVE
SEDIMENT REMEDIATION OVERVIEW

Section 2
Background and Design Basis

This section provides overall context for the design report and information used to determine the basis of design and develop the engineering design. Sediment cleanup levels, a summary of remedy design investigations, brief information about sediment remediation completed adjacent to Outfall 005, project design criteria, and sustainability approaches are presented in this section.

2.1 SEDIMENT CLEANUP LEVELS

Cleanup levels for contaminated sediment at the Middle River Complex (MRC) were developed from the preliminary remediation goals (PRGs) summarized in the feasibility study (FS) (Tetra Tech, 2013) and approved by the Maryland Department of the Environment (MDE) and the United States Environmental Protection Agency (USEPA). PRGs are the chemical endpoint-concentrations associated with each remedial action objective (RAO) (Table 2-1) that are believed to be sufficient to protect human health and the environment, based on available site information (USEPA, 1997). The PRGs in the FS guided evaluation of proposed remedial alternatives for contaminated sediment. PRGs are based on the RAOs which are designed to minimize risks to human health and the environment. Achievement of the PRGs also must be consistent with the applicable or relevant and appropriate requirements (ARARs). Key ARARs for this project include the MDE cleanup standards for soil and groundwater, the federal Clean Water Act, and the federal Rivers and Harbors Act.

2.2 REMEDY DESIGN INVESTIGATIONS

Lockheed Martin conducted sediment sampling to characterize the nature and extent of contamination and to complete the baseline human health and ecological risk assessments (2005 to 2010), followed by sediment remedy design investigations (2011 to 2014) to support the FS, the remedial design and the sediment removal action (SRA) around outfalls 005 East and 005 West. These investigations form the basis for the remedial design.

2.2.1 Sediment Investigations

Four sampling investigations were performed between 2005 and 2010. Sampling-depth intervals ranged from zero to six inches, six to 18 inches, 18 to 30 inches, and 30 to 54 inches below mudline. Samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and USEPA priority pollutant metals. In 2010, samples of benthic macroinvertebrate (sediment-dwelling organisms) were collected to evaluate the status of site benthic communities. Fish tissue samples were also collected from five site locations and three reference locations to measure chemical concentrations in their tissue.

The FS (Tetra Tech, 2013) summarized the nature and extent of contaminated sediment and the conclusions of the human health and ecological risk assessments for the surface water and sediment of Cow Pen Creek, Dark Head Cove, and Dark Head Creek. Chemicals of concern from the baseline human health risk assessment include PCBs, polycyclic aromatic hydrocarbons (PAHs) (expressed as benzo(a)pyrene equivalents [BaPEq]), and arsenic, with PCBs presenting the highest potential risk. The sediment chemicals of concern (COC) present a potential risk to human health via direct contact with sediment (i.e., incidental ingestion and dermal contact), or by consuming fish taken from the study area. Cancer and non-cancer risk estimates developed for the consumption-of-fish exposure pathway exceed both USEPA and MDE risk benchmarks. However, PCB concentrations reported in fish tissue samples for the study area fall within the range of concentrations reported for the general Chesapeake Bay area.

The ecological risk assessment considered potential impacts to benthic macroinvertebrates (e.g., worms), fish, birds, and mammals. No risks were identified for birds, mammals, or fish. Potential risk was identified for benthic invertebrates through direct contact with contaminated sediment. This risk is due to several metals and PCBs found at concentrations above which adverse effects to benthic organisms are expected to occur. Cadmium, copper, lead, mercury, zinc, and total PCBs have conservatively been identified as chemicals posing potential risks to benthic invertebrates, and are therefore considered ecological COCs. However, no direct connection between these constituents and adverse effects in the resident benthic community has been made. These results led to subsequent site-specific studies to better evaluate potential risks to benthic macroinvertebrates. Sediment samples were also analyzed for acid-volatile sulfides and simultaneously extracted metals to determine whether the metals are bioavailable (i.e., potentially available for biological uptake). The results show that metals are tightly bound to sulfides in the sediment and therefore unlikely to be bioavailable; this is common in estuarine environments where sulfides are abundant.

Lockheed Martin conducted remedy design investigations from 2011 to 2014. In December 2011, geotechnical cores and sediment samples were collected at selected locations distributed over the MRC sediment study area to better characterize the sediment environment and substrate (Figure 2-1). A column settling test, pillow test, and dredge elutriate[1] test were conducted to characterize sediment settling behavior and to identify possible treatment requirements for dewatering sediment. In addition to sediment-remedy design investigations, the conditions of shoreline and bulkhead along Dark Head Cove were surveyed.

In September 2013, additional delineation sediment sampling was performed to support the remedy design for the sediment adjacent to the MRC. Thirty-five locations in Cow Pen Creek were sampled to further delineate sediment concentrations of polychlorinated biphenyls (PCBs), metals, and PAHs above cleanup goals (Figure 2-2).

Bulk sediment samples were collected from four locations in Dark Head Cove to conduct bench-scale treatability studies to support the design component of *in situ* treatment using an adsorptive medium (e.g., activated carbon). Passive pore-water sampling at five locations in Dark Head Cove was also performed to provide baseline pore-water data for future evaluations related to monitoring the effectiveness of the *in situ* treatment.

In 2013, a select number of sediment samples were collected to delineate elevated PCB concentrations in Dark Head Cove near Outfall 005 (Figure 2-3) followed by additional delineation sampling conducted in June 2014 (Figure 2-4). The data were utilized to design the Outfall 005 SRA that was completed in 2015 and in this current design. The most recent sampling was conducted in the SRA area during confirmation sampling after dredging was completed. The extent of contamination in MRC sediment is compiled in Appendix A.

2.2.2 Storm-Drainage System Sediment Sampling

The MRC storm drainage system is suspected of being a continuing source of PCBs and PAHs to Cow Pen Creek and Dark Head Cove sediment. A site-wide sediment-sampling investigation of the storm-drainage system characterized sediment in the storm-drain utility lines (Tetra

[1] To *elutriate* is to separate the light and heavy particles of a substance by washing, straining, draining, or decanting.

Tech, 2014b). Sediment samples were collected on December 18–20, 2013 from the nine primary MRC storm drainage systems (Outfalls 001 through 009) and the four Martin State Airport (MSA) storm drain systems (Outfalls 9OF001, 8OF001, IN159, and WROF001A) that discharge to Dark Head Cove (Figure 2-5).

Many access points used to collect sediment samples had no sediment, or insufficient sediment present to obtain the required aliquot for a sample. Therefore, the manholes or catch basins sampled for several systems were located substantially upstream of the outfalls (e.g., MRC Outfalls 001, 002, 006, and 007), or in some cases only one or two samples per system could be collected (e.g., MRC Outfalls 003 and 004, and MSA Outfalls 8OF001 and IN159).

PCBs were detected in all 32 sediment samples collected at concentrations ranging from 0.0021 milligram per kilogram (mg/kg) (Outfall 004 system) to 780 mg/kg (Outfall 005 system). Total PCB concentrations exceed the proposed sediment remedial action level (RAL) (0.676 mg/kg) in 10 sediment samples within five outfall systems (Outfall systems 005, 007, 008, and 009, and MSA outfall system IN159). PAHs were detected in all 32 sediment samples with BaPEq concentrations ranging from 0.098 mg/kg (Outfall 003 system) to 64.0 mg/kg (Outfall 007 system). BaPEq concentrations exceeded the proposed remedial action level (RAL) (6.50 mg/kg) in seven sediment samples within five outfall systems: MRC outfall systems 005, 007, and 008; and MSA outfall systems 9OF001 and IN159. The results of the storm-drain-sediment investigation suggest that MRC Outfall 005 may act as a continuing source of PCBs and PAHs (expressed as BaPEq) to Dark Head Cove sediment (Tetra Tech, 2014c). To address this potential concern, the storm drains from Tax Block E to Outfall 005 East and West have been cleaned during the SRA (Tetra Tech, 2015).

2.2.3 Bathymetry, Topography, Navigation Depths

Tetra Tech performed a high-resolution bathymetric survey in Dark Head Cove, in accessible portions of Cow Pen Creek, and at the confluence of the two water bodies in August 2010 (Figure 2-6). The bathymetry survey mapped the morphology of Dark Head Cove in high detail and, to the extent possible (limited by dense vegetation), Cow Pen Creek. The water depth within the survey area ranged from 0.0–13.0 feet and averaged 8.0 feet, as referenced to mean lower low water (MLLW). The bathymetry survey also identified obstructions within the study area; possible debris was identified within the data, including docks, aquatic vegetation, and boat ramps (Figure 2-7).

A topographic survey of Cow Pen Creek was performed in April 2012 from its mouth (confluence with Dark Head Cove) to the culvert at Eastern Boulevard (near the traffic cloverleaf) (Figure 2-8). All elevations are reported in North American Vertical Datum 1988 (NAVD88) vertical datum. The topographic survey also surveyed debris in Cow Pen Creek. Additional topographic survey was conducted in June 2015 to delineate wetlands along the neighborhood side of the creek and refine the previous survey, mainly focused on upstream non-tidal and inter-tidal areas.

An additional bathymetric survey was completed in front of Outfall 005 after the SRA was completed in February 2015. This bathymetric survey was incorporated to the existing survey completed in Dark Head Cove and utilized in remedial design. Tetra Tech used the bathymetric and topographic surveys to develop excavation and dredging boundaries and cross-sections for the remediation design.

Navigation depth in Dark Head Cove was researched to determine any remediation restrictions. Part of Middle River, including all of Dark Head Cove is a federal navigation channel within the United States Army Corps of Engineer (USACE) Baltimore District jurisdiction (Figure 2-9). The USACE and the State of Maryland have concurrent jurisdiction over channel management. The 3.6-mile navigation-channel project was established in 1940. The project, with a channel 200 feet to 400 feet wide and 10 feet deep, was completed in 1942. The USACE has conducted various reconnaissance surveys since then, but, no additional dredging has been performed to date (USACE, 2012a). The most recent reconnaissance survey completed by the USACE was on March 29, 2011. The current mudline elevations in Dark Head Cove were surveyed as 10 feet MLLW, plus or minus 2 feet.

2.2.4 Sediment Stability

Hydrodynamic modeling estimated the stability of bed sediment in the Cow Pen Creek and Dark Head Cove forks of Dark Head Creek relative to wind- and wave-generated bottom velocities and associated shear stresses (Tetra Tech, 2011b). The analysis simulated two extreme events: high rainfall (24-hour 100-year) in the Cow Pen Creek and Dark Head Creek watersheds, and a historical storm surge and wind event based on conditions during Hurricane Isabella in September 2003. The modeling analysis used the USEPA (2002) *Environmental Fluid Dynamics*

Code hydrodynamic model to calculate likely bed stresses during the simulated events. Model-forcing functions include runoff into Cow Pen Creek and Dark Head Cove, tidal water surface elevation at the mouth of Dark Head Creek, and wind forcing over the entire model domain. Bed stresses were determined to be less than 0.1 Newton per square meter (N/m^2) over most of the study area, except for the upstream area of Cow Pen Creek, where maximum stresses reach 4 N/m^2 (Tetra Tech, 2011b).

Field investigations of critical bed stresses related to the erosion of cohesive sediment in the Chesapeake Bay region (Maa, et al., 1998, 2002, 2008) indicate that 0.1 N/m^2 is a lower boundary for critical erosion stress. Sand and non-cohesive silt beds are also stable at stresses below 0.1 N/m^2 (USACE, 2008). Therefore, this analysis suggests that, in general, the sediment bed is stable except for the upstream area of Cow Pen Creek. The 100-year, 24-hour event could transport eroded material outside of the study area; if this occurs, the corresponding total suspended solids concentration at the mouth of Dark Head Creek could range between 140 to 1,000 milligrams per liter (mg/L), and the depth of sediment erosion from the one-day event could be up to 10 centimeters (cm). Normal tidal conditions without the wind forces, including monthly spring tides, do not appear to pose erosion issues. Tetra Tech considered the results of the sediment stability analysis in developing restoration components in Cow Pen Creek.

2.2.5 Sediment Age Dating

Sediment-age dating evaluated sediment stability, estimated the period when chemicals of potential concern may have been released to sediment, and assessed natural recovery rates. Sediment cores were collected at three locations in August 2010 to evaluate sediment age, stability, and sedimentation rate. The analytical results are used to derive sedimentation rates and calendar dates for the sediment. Average inferred sedimentation rates in Dark Head Cove, Dark Head Creek, and at the mouth of Cow Pen Creek, are estimated at 0.8 centimeters per year (cm/year), 1.3 cm/year, and 0.38 cm/year, respectively (Tetra Tech, 2011b). Sedimentation rates are utilized in the design estimating natural recovery rates of sediment in Dark Head Cove.

2.2.6 Sediment Geotechnical Characteristics

Visual classification and laboratory testing of select sediment-core samples indicate that the top three to five feet of MRC sediment typically consists of elastic silt, underlain by fat clay intermixed with lean clay, sandy lean clay, and sandy elastic silt. Seven strata were encountered and classified per the Unified Soil Classification System: elastic silt, fat clay, lean clay, sandy elastic silt, sandy lean clay, organic silt, and silty sand. In Cow Pen Creek and the confluence of Dark Head Cove and Cow Pen Creek, the elastic silt stratum is underlain by fat clay. In Dark Head Cove, the elastic silt stratum is typically underlain by lean clay, sandy elastic silt, sandy lean clay, organic silt, and silty sand (Tetra Tech, 2012a). Field core-logs provide detailed information specific to the sampling locations (Tetra Tech, 2012a and 2014a). Geotechnical index properties of site sediment are summarized in Table 2-2. Refer to the sediment characterization report for the sampling locations (Tetra Tech, 2012a).

The shear strength and consolidation characteristics of MRC sediment were investigated in December 2011. *In situ* field-vane shear and laboratory-vane shear tests were conducted to determine sediment strength properties. Shear strength properties provide information for analyses regarding the slope stability of dredge cuts and the bearing capacity of underlying sediment. Consolidation tests determine the compressibility behavior of MRC sediment under the potential loading of conventional sediment capping.

The field and laboratory testing results indicate that the upper 10 feet of MRC sediment are very soft (zero to 200 pounds per square foot [psf]) to soft (200 to 500 psf). *In situ* field vane-shear tests resulted in peak shear-strength values of 10–292 psf, whereas laboratory vane-shear tests yielded peak shear-strength values of zero to 451 psf (Tetra Tech, 2012a). These sediment shear-strengths were used in this design report to evaluate the slope stability of dredge cuts.

In January 2015, additional soil samples from floodplain areas in Cow Pen Creek were also collected for characterization. The samples have 34 to 58% solids with a specific gravity of 2.65. The floodplain soils consist predominately of silt (50 to 70%) with smaller amount of sand (11 to 32%) and clay (16 to 24%). Gravel occurs in relatively small proportions (2 to 4%) in the floodplain samples. The information is utilized in restoration design to determine appropriate streambed mix and floodplain backfill material. Refer to Appendix B for detailed information.

2.2.7 Evaluation of Dewatering Sediment in Geotextile Bags

In August 2010, geotextile tube/bag tests (also known as pillow tests) were performed to test the applicability of geotextile tubes for the dewatering of MRC sediment if sediment is hydraulically dredged. Sediment from Cow Pen Creek, Dark Head Cove and at confluence of Cow Pen Creek and Dark Head Cove were tested. Sediment was characterized as elastic silt at 43.4% solids in

Cow Pen Creek, clayey sand at 54.3% solids in Dark Head Cove, and fat clay at 35.8% in the mouth of Cow Pen Creek.

Various polymers were tested during the preliminary and confirmation sediment conditioning evaluations. The dual-polymer system of WaterSolve coagulant and flocculant (Solve 425 followed by Solve 127) produced the optimum results for coagulating and flocculating sediment slurry solids which resulted in the separation of sediment solids from pore water. Sediment dewatering with the GT500 geotextile fabric produced dewatered sediment cakes with acceptable solids content (to the levels similar to *in situ* conditions) which passed paint filter tests and released minimal solids into generated pore water (Tetra Tech, 2011b).

Chemical solidification/stabilization testing was conducted on polymer conditioned dewatered sediment. Based upon the results of the evaluations conducted, Portland cement was the solidification agent that demonstrated the greatest strength in each of the three sediment samples tested. The highest dose (solidification agent: wet sediment ratio) added the most strength to the sediment matrix. The strength of a specimen tended to increase with an increase in density and solids content. The highest unconfined compression strength test recorded during the study was 11.2 pound per square inch in the 21-day specimen for the confluence sediment using 15% Portland cement. Both lime and fly ash added some strength to the sediment matrices, but not as much as that demonstrated by the Portland cement. Kiln dust did not add any strength to sediment (Tetra Tech, 2011b).

2.2.8 Dewatering Elutriate Tests and Dredge Elutriate Tests

A dewatering elutriate test (known as a pillow test [PT]) and a dredge elutriate test (DRET) were conducted in 2012 to identify possible treatment for elutriate so that it meets ambient water quality criteria (AWQC) before discharge (Tetra Tech, 2012a).

A dewatering elutriate test was performed on an 11% sediment slurry (original target slurry concentration was 10% solids) that was conditioned using a WaterSolve coagulant and flocculant (Solve 425 followed by Solve 127). Once elutriate had been generated through the PT, an elutriate sample was collected from the composite container and analyzed for PCBs by USEPA Method 608 (Aroclors). Data suggest that Aroclor 1260 was the only PCB released into elutriate generated during the dewatering elutriate test, at a concentration of 0.3 micrograms per liter (µg/L). Filtration with a 5 micrometer (µm) filter medium reduced the Aroclor 1260 concentration to below the method detection limit achieved by the analytical laboratory (0.20 µg/L).

The DRET was performed on a composite of representative dredge material to assess potential contaminant mobility in the water column during dredging. No Aroclors above detection limits were released to the water column during the DRETs; however, limited concentrations of PAHs (specifically, fluoranthene, pyrene, and metals) were released to the water column. The metals and PAH compounds detected in unfiltered samples were removed to below AWQC effluent limitations after filtration through a 0.45-µm filter medium. During the DRET tests, cadmium and lead concentrations consistently exceeded AWQC in unfiltered samples. Filtration through a 0.45-µm filter medium removed cadmium and lead concentrations to below AWQC (Tetra Tech, 2012a).

2.2.9 Column Settling Tests

A column settling test (CST) defines the anticipated settling behavior of sediment that may be dredged and predicts the distance that suspended solids may travel during dredging. A CST also allows appropriate best management practices (BMPs) to be designed to avoid potential exceedances of water quality standards. The CST results help predict potential water quality effects.

Composite sediment samples collected in December 2011 from locations across Dark Head Cove and Cow Pen Creek were tested. CST results from Cow Pen Creek samples demonstrated faster settling as compared to the Dark Head Cove test results during the first few hours of the test, likely due to the sand content of the Cow Pen Creek sediment. However, as the CST progressed, the settling velocity slowed until it resembled the rate of the Dark Head Cove sediment.

The total suspended solids (TSS) concentration for Cow Pen Creek sediment ranged from 200 mg/L to 3,400 mg/L within two-hour to 95-hour test duration. The TSS concentration associated with Dark Head Cove sediment, as determined by the CST, ranged from 16 to 1,700 mg/L within the three- to 94-hour test duration. Most of the sediment had settled and the supernatant[2] had clarified within approximately two days during the Dark Head Cove CST (Tetra Tech, 2012a).

[2] A *supernatant* is the liquid lying above sediment or settled precipitate.

2.2.10 Dark Head Cove Shoreline and Bulkhead Conditions

The Dark Head Cove shoreline comprises stone riprap/broken concrete and overgrown vegetation, reinforced concrete bulkhead constructed on embedded steel sheet piling and wooden fender piles, and stone riprap with concrete overlayment.

Numerous areas of erosion exist between the bulkhead deck and the adjacent grade. The degree of erosion and undermining of adjacent areas varies along the shoreline. The record drawings suggest that the bulkhead is mainly supported by sheet piling, so soil support of the concrete deck could be unnecessary. The site visit by the sediment dredging design team suggests that the concrete bulkhead is deteriorating. Erosion is evident on the shore side and under certain sections of the bulkhead. Cracks, spalling (i.e., chipping), and missing deck/slab are apparent at various locations. Refer to the photographs of the bulkhead and shoreline in Appendix A. A recent inspection and structural condition survey has been completed in July 2015. The underwater inspection report indicated severe deterioration of steel sheet piling throughout reinforced concrete sections of bulkhead with up to 100% section loss, moderate to severe deterioration of concrete deck in reinforced concrete sections including exposed reinforcement with up to 100% section loss, significant erosion, and backfill material loss behind the bulkhead (Tetra Tech, 2015b).

The bulkhead is supported by continuous steel sheet-piling and 12-inch-diameter wood-fender piles spaced 15 feet on center. Sheet piling and fender piles both extend to an elevation approximately 35 feet below mean low-water (MLW) level. Sheet piling is embedded into and supports the reinforced concrete bulkhead from just below mean water level to approximately 5.3 feet above it. The mudline elevation of the sheet piles in the original design drawings is shown as -10 feet to -14 feet MLW (or -9.78 to -13.78 feet MLLW). These design elevations indicate that the free length of these sheet pilings is about 15.3 feet, with a burial depth of 25 feet.

Current mudline elevations in front of the bulkhead generally range from -5 feet to -10 feet MLLW except the areas where significant erosion behind the bulkhead created soil mounds. This elevation difference shows sediment build-up of about four to five feet in front of the bulkhead, and an increase in sheet pile burial depth since it was constructed in 1940s. Fender piles appear to provide lateral support for items such as boats, water, and/or soil. Tie rods at eight feet on center extend from the top of the sheet piling approximately 30 feet into the adjacent soil and are terminated with anchor piles for lateral support. The sheet piles are deteriorated (Appendix A).

Based on the current conditions and recent underwater inspection of bulkhead, a new sheet pile bulkhead will be constructed in front of the existing deteriorated bulkhead to prevent erosion of upland soil. The project will be completed at the same timeframe as the remedial construction. Design details of bulkhead soil retention project will be presented as a separate submittal.

2.2.11 Cow Pen Creek Hydrology and Hydraulics

In support of the remedial design and restoration in Cow Pen Creek, stream flow and water elevation data were collected from January 2015 to August 2015. The hydrology and hydraulic data is used as input to perform hydraulic modeling to aid in the restoration design. The field work consisted of the installation of stream gages, manual stream discharge measurements, and collection of floodplain soil samples.

Average monthly precipitation at the site is 3.3 inches for the period between October to February and 3.5 inches year round. Precipitation frequency estimates indicate that storm totals for 24-hour periods are from 3.3 inches in the 2-year event, to 5.1 inches in the 10-year event, and 8.8 inches in the 100-year event. During the winter months, the site receives additional precipitation as snowfall. Average season snowfall is 18.2 inches and typically occurring between November and April. Average monthly snowfall ranges from 0.1 inches in April to 7.0 inches in January. However, much heavier snowfall amounts, with storm totals of up to 20 inches, can occur associated with strong storm events.

Water surface elevations at the mouth of Cow Pen Creek varied from 1.70 feet to below -2.62 feet, the elevation of the gage, relative to mean lower low water and showed a characteristic tidal signature with two high tides and two low tides per day. Field data were utilized to establish design criteria and perform hydraulic modeling of the creek. Refer to Appendix B for detailed information about creek flow investigations and hydraulic modeling.

2.3 REMEDIATION COMPLETED AT THE SITE

Lockheed Martin completed sediment remediation an area off of Outfall 005 in March 2015. The Outfall 005 SRA was completed per the remedial design (Tetra Tech, 2014d), risk-based disposal approval application (RBDAA) approved by USEPA (Tetra Tech, 2014e; USEPA, 2014), and the contractor’s work plans (Tetra Tech, 2014f). A summary of the remediation is provided below and further details are reported in the construction completion report (Tetra Tech, 2015a).

2.3.1 Outfall 005 Sediment Removal Action

2.3.1.1 Dredging, Dewatering, and Disposal

Dredging began on December 10, 2014, and was performed mechanically using a barge-mounted crane and 4-cubic-yard (cy) environmental dredge bucket. The crane was fitted with real-time kinetic/global positioning system (RTK/GPS) and on-board computer HYPACK software which allowed the crane operator to know the location and depth of the bucket during each dredge cut. The dredge cuts were systematically made in an area until the design elevations were obtained or solid subgrade material (i.e., fat clay) was encountered. Dredging was completed on February 11, 2015, before the end of the in-water work window. A comparison of the pre- and post-dredge bathymetric surveys indicates that a total of 5,272 cy of PCB-contaminated sediment were removed from the 1.3-acre area.

Dewatering and amending of the dredged sediment was performed in the two upland dewatering pads in order to satisfy the disposal facility's requirements for moisture content and strength. Because passive dewatering alone would not satisfy the disposal facility's strength requirements, amending of the sediment was also required. Amending occurred in the dewatering pads and included the addition of a combination of quicklime, Calciment, and Portland cement. Hydraulic excavators were used to mix the amendments with the sediment. This process continued until the sediment was visually dry and able to be "stacked" in a stockpile. Qualitative field tests were then performed to determine if the amended sediment met the disposal facility's requirements. The specific ratio of amendment added varied depending on the content of the dredge material but averaged approximately total 6% quicklime, 17% Calciment, and 17% Portland cement by weight.

The amended sediment was loaded into haul trucks for transport to the Chemical Waste Management TSCA-permitted landfill in Model City, New York. A total of 420 dump truck loads and one roll-off container of amended sediment and associated debris were sent to the landfill as part of this project. The associated debris primarily consisted of items that were removed from the dredge area (a boat, anchors, bottles, cans, wood debris, etc.) and the materials used to construct the sediment dewatering pads (geotextile, poly-sheeting, and gravel). The total mass disposed of at Model City was 9,928 tons including approximately 400 tons of debris with the remainder being amended sediment.

2.3.1.2 Turbidity Monitoring

Turbidity monitoring was performed during all in-water work using a combination of fixed equipment and mobile equipment. The turbidity compliance level was established by USEPA to be five nephelometric turbidity units (NTUs) above the highest current background level. Monitoring occurred continually 24-hours per day during the in-water work window at both background and compliance monitoring locations. The turbidity compliance level was exceeded due to natural events when no active in-water operations were being conducted. During in-water dredging activities the real-time readings were continually monitored and immediate modifications to operations were made if it appeared the compliance level would be exceeded for the 30 minute monitoring period due to operational activities. These immediate modifications included reducing the bucket retrieval speed and dredging from a different area. If the compliance level was exceeded for the 30 minute monitoring interval then dredging operations ceased until turbidity levels returned to an acceptable level. Based on long-term observations, additional modifications were made to the overall dredging process which included placing additional turbidity curtain, minimizing the use of tug boats to position barges, and minimizing the number of position changes performed.

2.3.1.3 Dredge Water Treatment

A total of 18,904 gallons of remediation derived (dredged) water was captured, treated, sampled, and discharged to the local Publicly Owned Treatment Works (POTW) as part of Outfall 005 dredging project. The remediation derived water primarily included water collected in the sediment dewatering pads and water generated during storm drain cleaning. The treatment process consisted of pumping the water through 5-micron and 1-micron particle size bag filters, a sand filter, and carbon filters. The treated water was sampled for suitability for discharge to the POTW. Upon receipt of the sample results, the treated water was transported to the discharge area using a 2,000-gallon water truck and pumped into the discharge tank where it was gravity fed into the existing sewer manhole.

2.3.1.4 Dredge Verification and Confirmation Sampling

Once dredging was completed in a dredge management unit (DMU), a bathymetric survey was conducted to verify that the target elevations had been achieved. Poling surveys were also conducted in areas where high native subgrade material was suspected due to hard bottom. If the bathymetric surveying and poling indicated that initial dredging was complete, confirmation samples were collected. Sample collection and chemical analyses were performed as outlined in the project sampling and analysis plan (SAP) prepared by Tetra Tech in November 2014 (Tetra Tech, 2014e).

The confirmation sampling results were compared to the Outfall 005 SRA PCB-cleanup goal of 50 mg/kg to determine if cleanup pass dredging was required. Sampling results in DMUs 2, 3, and 5 indicated that cleanup pass dredging was required in portions of these DMUs. After completing the cleanup pass dredging, the second round sampling results indicated that the cleanup goal had been met and that dredging activities were complete. Further details are provided in construction completion report (Tetra Tech, 2015).

2.3.2 Outfall 005 East and West Outfalls and Storm Drain Cleaning

Storm drain cleanout activities included storm drain plugging, storm drain cleaning and video inspection, and handling/disposing of investigation-derived wastes (Tetra Tech, 2015).

A temporary, inflatable, piping plug was installed in the upstream side of catch basin IL-30 located in the median of Chesapeake Park Plaza. Due to pressure decreasing in the upstream plug, a second temporary, inflatable plug was installed in the downstream side of catch basin IL-30. The purpose of this plug was to isolate PCB-containing sediment located upstream of this catch basin until a permanent concrete plug and a new storm drain system can be installed to replace the existing system as part of the Block E soil remedy. Inflatable plugs were also installed at the discharge point of in Outfall 005 East and Outfall 005 West to prevent water and sediment from entering Dark Head Cove during storm drain cleaning.

Approximately 470 feet of the Outfall 005 storm drain system located downstream of catch basin IL-30 were cleaned using a high-pressure water nozzle to move sediment and debris, and vacuum extracted to remove the sediment and wash water into a vacuum truck. Large objects such as wood pieces and tree branches were removed by manual means. Sediment and debris from the cleaning were placed into an open-top, watertight roll off container (with top tarp), and liquids were decanted to a 21,000-gallon water-tight fractionation tank. Residual water accumulated on the upstream side of the plug was removed before any plug was removed. Video inspections of the drainage pipes with a closed circuit television camera were conducted after the cleaning and verified that the pipes were cleaned of sediment and debris.

Concrete removed and placed in drums as part of the excavation activities to access the Outfall 005 storm drain line was picked up and disposed of off-site by Clean Harbors Environmental Services of Baltimore, Maryland. The sediment and debris (approximately three cy) were transferred to the western dewatering pad and disposed of off-site along with the SRA dredged material. The decanted water (approximately 5,200 gallons) and tank/roll-off decontamination rinsate were treated by the SRA temporary on-site water treatment system and discharged to the sanitary sewer under the project permit.

2.4 PROJECT DESIGN CRITERIA

The following overall design criteria and project-wide considerations are incorporated into the remediation design.

2.4.1 Protection of Remedy

Implemented remedy will remain protective by taking source control measures:

- Storm drain system cleanouts in Blocks D and E will be performed by removal of accessible contaminated sediment from the storm drainage system to prevent discharge to Dark Head Cove.
- Bulkhead soil retention will be achieved by constructing a new sheet pile wall to prevent erosion of soil behind the deteriorated bulkhead along Dark Head Cove.

2.4.2 Removal

- Sediment will be removed to achieve cleanup levels as defined by the PRGs determined for MRC sediment (Table 2-1). The appropriate depth of removal to achieve this cleanup level is based on available sediment characterization data (Appendix A). Removal will continue until design depth or a firm native layer is reached and confirmation samples demonstrate that the cleanup levels are achieved.
- Removal areas will not be backfilled to pre-existing grades except for non-tidal and floodplain areas in Cow Pen Creek that will need to be restored. If post-removal confirmation samples show residuals greater than the cleanup levels, removal will be followed, as necessary, by placement of a residual-management sand layer of at least six inches to control residuals generated during construction.

2.4.3 *In situ* Treatment

- A carbon-based amendment will be applied in areas to treat contaminated sediment in Dark Head Cove where bulk sediment PCB concentrations in the surface sediment are greater than 0.676 mg/kg and less than 2.7 mg/kg. The amount of carbon-based amendment to be added to the surface sediment will be 5% by weight. To meet cleanup levels, a target *in situ* treatment effectiveness of 70% reduction in bioaccumulation of PCB concentrations in tissue is assumed. Reduction of PCB concentrations in pore water will be used as an additional line of evidence to demonstrate *in situ* treatment effectiveness.

2.4.4 Navigation Depths

To comply with the navigation depth criterion, post-remediation depths in Dark Head Cove will be no shallower than the current depths. Federal navigation channel in Dark Head Cove was established at -10 feet MLLW. The current depths are -10 feet MLLW, plus or minus two feet.

2.4.5 Project Datum

- Horizontal datum: Maryland State Plane Coordinate System, North American Datum, 1983
- Vertical datum: MLLW (epoch 1983–2001); referenced to National Oceanic and Atmospheric Administration (NOAA) Tide Station No: 8574680, Baltimore, Maryland benchmarks

2.4.6 In-Water Work Window

The State of Maryland has the following time of year restrictions:

- Protection of estuarine and marine aquatic species – February 15 to June 15
- Protection of estuarine and marine aquatic life including submerged aquatic vegetation – April 1 to October 15

Based on these time of year restrictions:

- Cow Pen Creek excavation will be conducted during the period of June 16 through February 14, and
- In-water dredging in Dark Head Cove and *in situ* treatment will be conducted during the period of October 16 to February 14.

The schedule of time restrictions may need to be revised by the State of Maryland during its review of the project application for water quality certification and in consultation with the National Marine Fisheries Services and the Maryland Department of Natural Resources (MDNR).

2.4.7 Hydrology, Hydraulics, and Hydrodynamics

- Per the MDE Water Management Administration, temporary measures for dewatering and diverting flow from a reach for construction purposes will have sufficient capacity to convey 2-year flows.
- Dewatering and diverting flow from Cow Pen Creek operations will be performed by equipment with capacity to convey a minimum 2-year 24-hour flow event (3.3. inches

precipitation) of 20 cubic feet per second (cfs). Redundant pumping equipment will be available at the site to handle 10-year flow event of 30 cfs.

- Bank stabilization will be designed to withstand to a minimum 2-year 24-hour flow event. In Cow Pen Creek, a 2-year event produces 20 cfs, higher than bankfull discharge of 6 cfs. Bank stabilization methods will be designed to withstand minimum bank shear stresses of 1.2 pound per square feet (psf) and a flow velocity of 3.1 feet per second (fps).

- Non-native stream bed material to be placed in Cow Pen Creek for restoration will be designed to withstand the threshold shear stresses to be determined using the 2-year flow 24-hour flow event.

2.4.8 Geotechnical

- To minimize sloughing and water quality impacts during construction, in-water dredge slopes will be designed such that a safety factor of 1.3 for the dredge slopes is achieved during construction (USACE, 2000).

- The site is in the United States Geological Survey Seismic Zone 1 with an effective peak ground acceleration of 0.075g (International Code Council, 2006). A seismic criterion for dredge slope stability is not required at the site.

2.4.9 Winds and Waves

- A shoreline protection structure will be designed to withstand a 50-year storm event. The nominal design value for three-second gust wind speeds occurring at 50-year mean recurrence-intervals is 90 miles per hour (40 meters per second). Winds of this speed could cause wave heights of 2.7 and 1.8 feet at the western and eastern shorelines of Dark Head Cove, respectively.

2.4.10 Sediment Dewatering

- Sediment dewatering after removal (i.e., by excavation or dredging) will be performed to meet the disposal facility's moisture content and strength requirement (if applicable). Dewatered sediment will meet USEPA's paint filter test criterion. This criterion may need to be revised per the specific requirements of the landfill to be identified by the Contractor.

2.4.11 Water Treatment

- Water produced from sediment dewatering will be collected and treated to meet discharge and disposal requirements. The requirements will be defined in the POTW discharge permit. This permit will be issued by Baltimore County Public Works.

2.4.12 Stream Restoration

- The non-tidal portion of the creek will be reconstructed. Current functions and values of the habitat elements in Cow Pen Creek will be restored to the extent practical. Details of the restoration elements will be refined per the guidance and requirements provided by the resource agencies including MDE (Tidal and Non-Tidal Wetlands divisions), MDNR, NOAA National Marine Fisheries Service, and Maryland Aviation Administration.

2.5 SUSTAINABILITY

The project design incorporates sustainability concepts, including those in USEPA's "green remediation strategy" (USEPA, 2010). To the extent practicable, renewable energy sources, locally produced/sourced materials and supplies, reduction/elimination of waste, efficient use of resources and energy, and other practices were incorporated into the remedial design and will be implemented during remedial construction. The USEPA has a green remediation strategy that applies to all Superfund cleanups to enhance the environmental benefits of federal cleanup programs by promoting sustainable technologies and practices (USEPA, 2010). The green remediation strategy aims to:

- Protect human health and the environment by achieving remedial action goals
- Support sustainable human and ecological use and reuse of remediated land
- Minimize impacts to water quality and water resources
- Reduce air toxics emissions and greenhouse gas production
- Minimize material use and waste production
- Conserve natural resources and energy

Green remediation comprises a range of BMPs that can be applied throughout the cleanup. These practices offer potential means to improve waste management; conserve or preserve energy, fuel, water, and other natural resources; reduce greenhouse gas emissions; promote sustainable long-term stewardship; and reduce adverse impacts on local ecological and human communities during and after remediation.

Sustainable practices consider economic and natural resources, ecology, human health and safety, and quality of life in implementing a given project. For remediation projects, sustainability means implementing projects in a manner that meets traditional remediation requirements (e.g., protection of human health and the environment, compliance with regulations, and meeting contaminant-mass removal goals), while also considering sustainable practices that can minimize the overall environmental footprint of the project. Consistent with the USEPA green remediation strategy, Lockheed Martin routinely explores and implements sustainability measures to reduce the environmental footprint of cleanup activities. Using appropriate BMPs during cleanup and construction will minimize potential environmental impacts. The BMPs currently under consideration are outlined in Section 3.3, and the project BMP analysis is provided in Appendix C.

Table 2-1

Summary of Preliminary Remediation Goals for Risk-Driver Chemicals of Concern in Lockheed Middle River Complex Sediment

Risk driver chemical of concern	Spatial scale of exposure	RAO 1: recreational user: consumption of fish	RAO 2: direct human contact with sediment	RAO 3: benthic organisms
Total PCBs (µg/kg dw)	Site-wide	Background (195)[1]	1000	N/A
	Point	N/A	N/A	676
BaPEq (µg TEQ/kg dw)	Site-wide	Background (700/2,000)[2]	Background (700/2,000)	N/A
	Point	N/A	N/A	N/A
Arsenic (mg/kg dw)	Site-wide	Background (18.3)[3]	Background (18.3)	N/A
	Point	N/A	N/A	N/A
Lead (mg/kg dw)	Site-wide	N/A	N/A	N/A
	Point	N/A	N/A	Background (190)[3]

Notes:

[1]Recommended background concentration is the UPL calculated based on the combined NOAA/USEPA data set. Significant variation observed in data set. PCBs were not detected in the MRC background data set.

[2]Recommended background concentration is the maximum detected concentration reported for the MRC study-area-specific background-sediment data set. Significant variation observed in data set. The 700 µg/kg value is for BaPEq calculated using positive results only. The 2,000 µg/kg value is for BaPEq calculated using one-half of the detection limit for non-detected results.

[3]Recommended background concentration is UTL calculated for the MRC study-area-specific background-sediment data set. Reasonable agreement with combined USEPA/NOAA data sets.

Acronyms:

BaPEq: benzo(a)pyrene-equivalents
dw: dry weight
mg/kg: milligram(s) per kilogram
MRC: Middle River Complex
µg/kg: microgram(s) per kilogram
N/A: not available/not applicable
PCBs: polychlorinated biphenyls
NOAA: National Oceanic and Atmospheric Administration
RAO: remedial action objective
TEQ: toxicity equivalents
USEPA: U.S. Environmental Protection Agency
UPL: upper prediction limit
UTL: upper tolerance limit

Table 2-1

Summary of Preliminary Remediation Goals for Risk-Driver Chemicals of Concern in Lockheed Middle River Complex Sediment

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Risk driver chemical of concern	Spatial scale of exposure	RAO 1: recreational user: consumption of fish	RAO 2: direct human contact with sediment	RAO 3: benthic organisms
Cadmium (mg/kg dw)	Site-wide	N/A	N/A	N/A
	Point	N/A	N/A	9.96
Copper (mg/kg dw)	Site-wide	N/A	N/A	N/A
	Point	N/A	N/A	298
Mercury (mg/kg dw)	Site-wide	N/A	N/A	N/A
	Point	N/A	N/A	1.06
Zinc (mg/kg dw)	Site-wide	N/A	N/A	N/A
	Point	N/A	N/A	459

Notes:

[1]Recommended background concentration is the UPL calculated based on the combined NOAA/USEPA data set. Significant variation observed in data set. PCBs were not detected in the MRC background data set.

[2]Recommended background concentration is the maximum detected concentration reported for the MRC study-area-specific background-sediment data set. Significant variation observed in data set. The 700 µg/kg value is for BaPEq calculated using positive results only. The 2,000 µg/kg value is for BaPEq calculated using one-half of the detection limit for non-detected results.

[3]Recommended background concentration is UTL calculated for the MRC study-area-specific background-sediment data set. Reasonable agreement with combined USEPA/NOAA data sets.

Acronyms:

BaPEq: benzo(a)pyrene-equivalents
dw: dry weight
mg/kg: milligram(s) per kilogram
MRC: Middle River Complex
µg/kg: microgram(s) per kilogram
N/A: not available/not applicable
PCBs: polychlorinated biphenyls
NOAA: National Oceanic and Atmospheric Administration
RAO: remedial action objective
TEQ: toxicity equivalents
USEPA: U.S. Environmental Protection Agency
UPL: upper prediction limit
UTL: upper tolerance limit

Table 2-2
Geotechnical Index Parameters

Sampling location	Depth (ft)	Classification	Water content (%)	Percent solids (%)	Sand content (%)	Unit weight (pcf)	Fines content (%)	Liquid limit (%)	Plastic limit (%)	Plasticity index
CPC-1	0.5–2.0	Elastic Silt (MH)	—	—	8.3	—	91.7	65	33	32
CPC-1	4.5–5.0	Fat Clay (CH)	133	43	12.0	84	88.0	70	30	40
CPC-2	0.5–2.0	Elastic Silt (MH)	—	—	2.8	—	97.2	75	40	35
CPC-2	5.0–5.5	Elastic Silt (MH)	—	—	5.2	—	94.8	73	40	33
DHC-1	0.5–2.0	Elastic Silt (MH)	—	—	6.5	—	93.5	63	33	30
DHC-1	5.0–5.5	Sandy Lean Clay (CL)	—	—	40.7	—	59.3	34	18	16
DHC-2	1.7–1.9	Elastic Silt (MH)	147	41	9.3	83	90.7	57	32	25
DHC-2	5.0–5.5	Sandy Elastic Silt (MH)	—	—	35.5	—	64.5	58	39	19
DHC-3	1.7–2.0	Elastic Silt (MH)	124	45	9.6	85	90.4	64	32	32
DHC-3	5.0–5.5	Sandy Lean Clay (CL)	—	—	46.8		50.2	29	18	11
DHC-4	1.2–1.7	Fat Clay (CH)	180	36	1.0	79.5	99.0	73	37	39
DHC-4	5.0–5.5	Lean Clay with Sand (CL)	—	—	21.6	—	78.4	27	17	10
DHC-5	0.5–2.0	Elastic Silt (MH)	—	—	2.5	—	97.5	77	38	39
DHC-5	5.0–5.5	Sandy Lean Clay (CL)	—	—	42.0	—	58.0	48	25	23
DHC-6	0.5–2.0	Elastic Silt (MH)	—	—	11.8	—	88.2	73	40	33
DHC-6	5.0–5.5	Sandy Lean Clay (CL)	—	—	40.0	—	60.0	30	18	12
DHC-7	0.5–2.0	Elastic Silt (MH)	—	—	10.5	—	89.4	86	52	34
DHC-7	5.0–5.5	Elastic Silt (MH)	146	41	5.8	83.5	94.2	68	33	35
DHC-8	2.3–3.1	Silt (ML)	103	49	8.5	88	91.5	49	28	21
DHC-8	5.0–5.5	Silty Sand (SM)	—	—	78.1	—	21.9	50	50	NP
Floodplain in CPC – S1	0.5 - 1.0	Sandy Elastic Silt (MH)	—	58	32	—	66	—	—	—
Floodplain in CPC – S2	0.5 - 1.0	Elastic Silt (MH)	—	44	11	—	88	—	—	—
Floodplain in CPC – S3	0.5 - 1.0	Sandy Elastic Silt (MH)	—	34	23	—	74	—	—	—

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Figure 2-1
Historical Sediment Sample Locations
Lockheed Martin, Middle River Complex
Middle River, Maryland

Legend

- Sediment Sample Locations- 2011
- Sediment Sample Locations- 2005
- Sediment Sample Locations- Nov 2008
- Delineation Sample Locations - 2010
- Treatability Testing Sample Location- 2011

500 250 0 500 Feet

Drawn By: MP 11/26/13
Checked By:
Approved By:

Map Document: (K:\GProject\middle_river\Maps\Figure 3-1_sediment_sample_locations 022712.mxd)
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Figure 2-2
Cow Pen Creek Sediment
Sample Locations, 2013
Lockheed Martin Middle River Complex
Middle River, Maryland

Legend

- Sediment Core/Sample Location - 2013
- Sediment Sample Location- 2011
- Delineation Sample Location - 2010
- Sediment Sample Locations- Nov 2008
- Sediment Sample Location- 2005
- Storm Drain Outfall

200 100 0 200
Feet

Drawn By: MP 11/26/13
Checked By:
Approved By:

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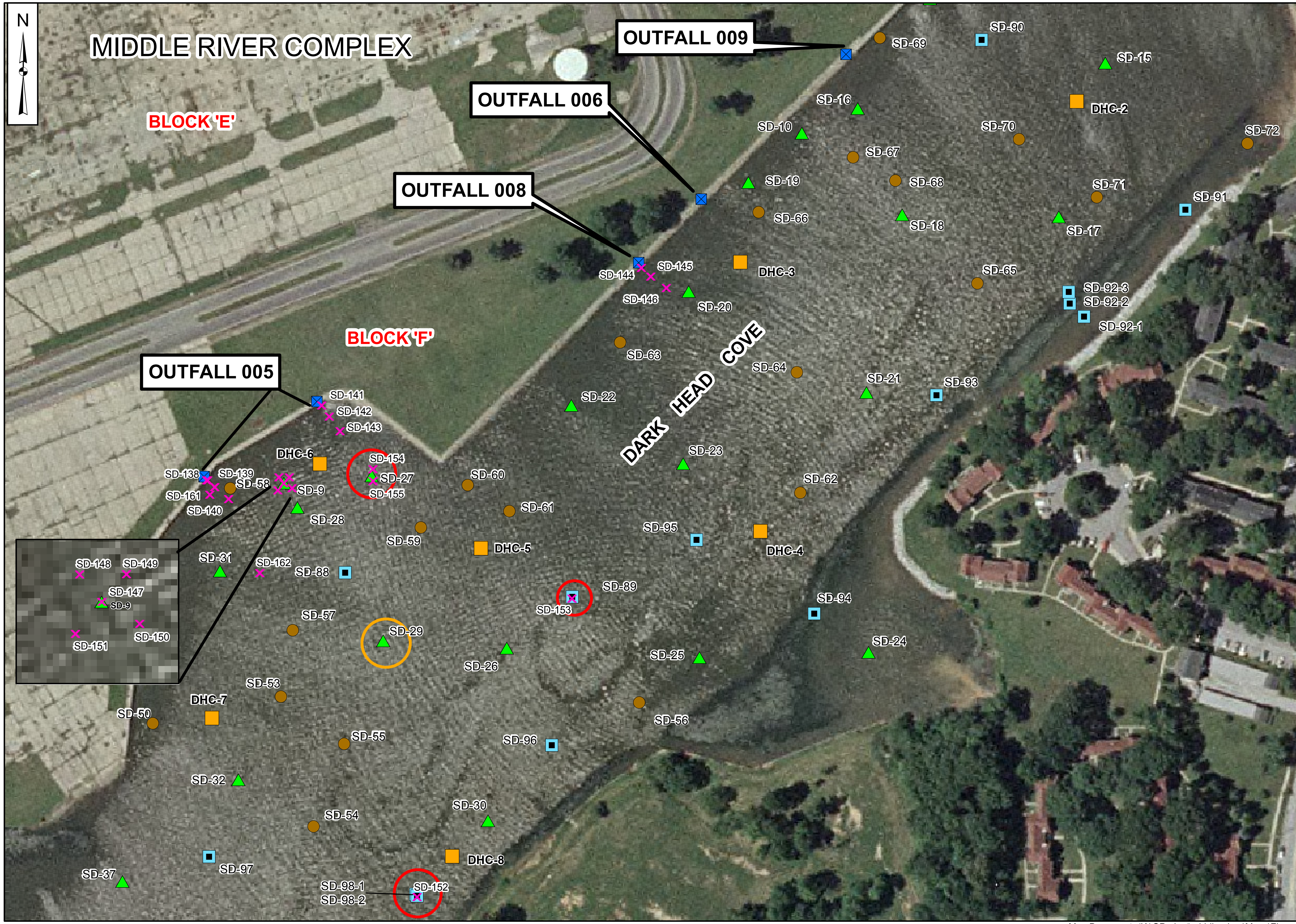

TETRA TECH

Figure 2-3
Dark Head Cove Sediment
Sample Locations, 2013
Lockheed Martin Middle River Complex
Middle River, Maryland

Legend

- Sediment Core/Sample Location - 2013
- Sediment Sample Location- 2011
- Delineation Sample Location - 2010
- Sediment Sample Locations- Nov 2008
- Storm Drain Outfall
- Sediment Sample Location- 2005
- Treatability Testing Sample Location- 2011
- Treatability Testing Sample Location- 2013

100 50 0 100
Feet

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Checked By:
Approved By:

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FIGURE 2-4

DARK HEAD COVE SEDIMENT SAMPLE LOCATIONS, 2014

LEGEND

- 2014 Core/Sample Location
- Pre-2014 Core/Sample Location
- Boom / Silt Curtain
- Outfall

Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2014 ESRI and its data suppliers).

Lockheed Martin Middle River Complex
Middle River, Maryland

0 80 160 Feet

N

DATE MODIFIED: 09/24/14

CREATED BY: JEE

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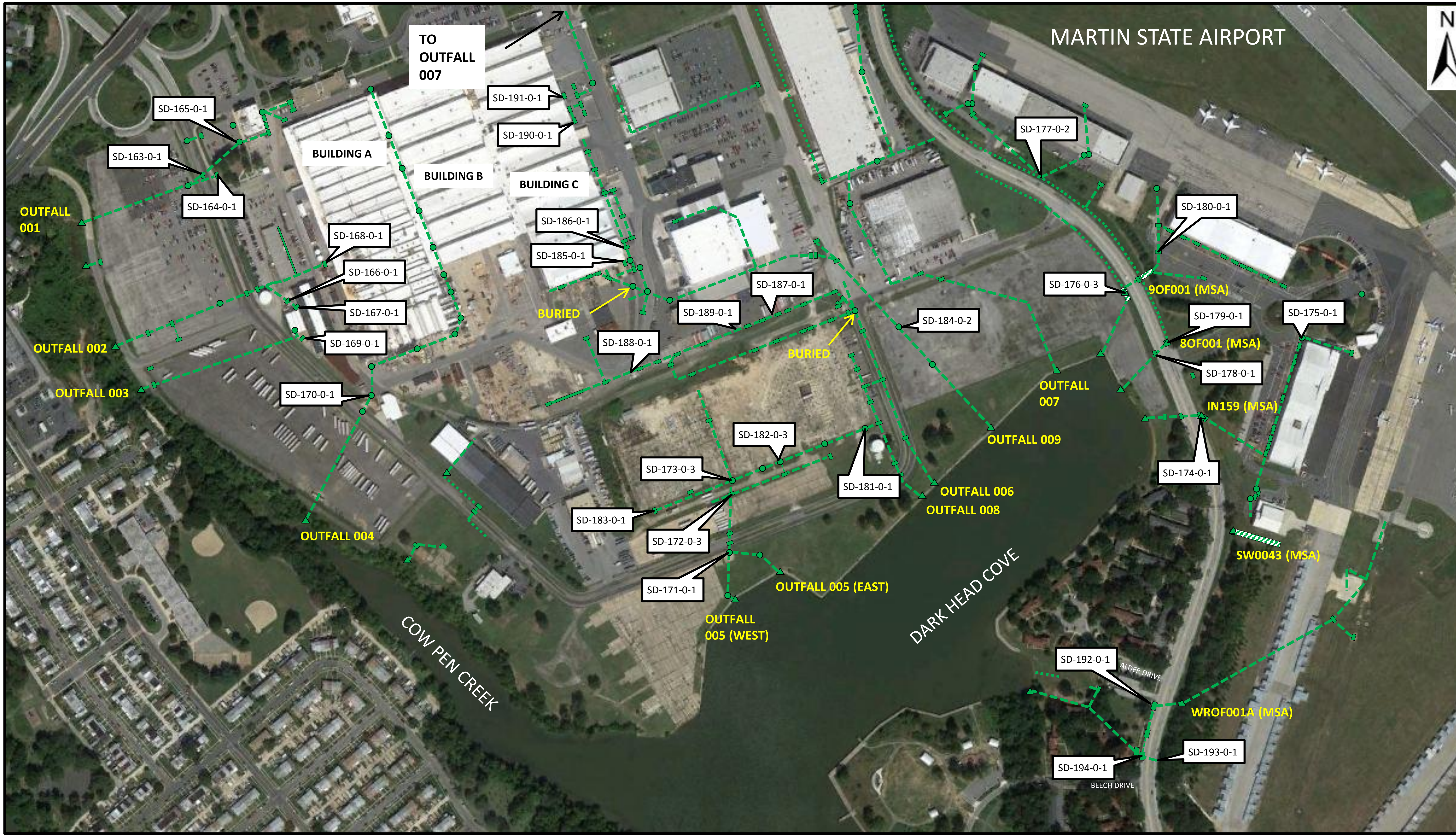


FIGURE 2-5

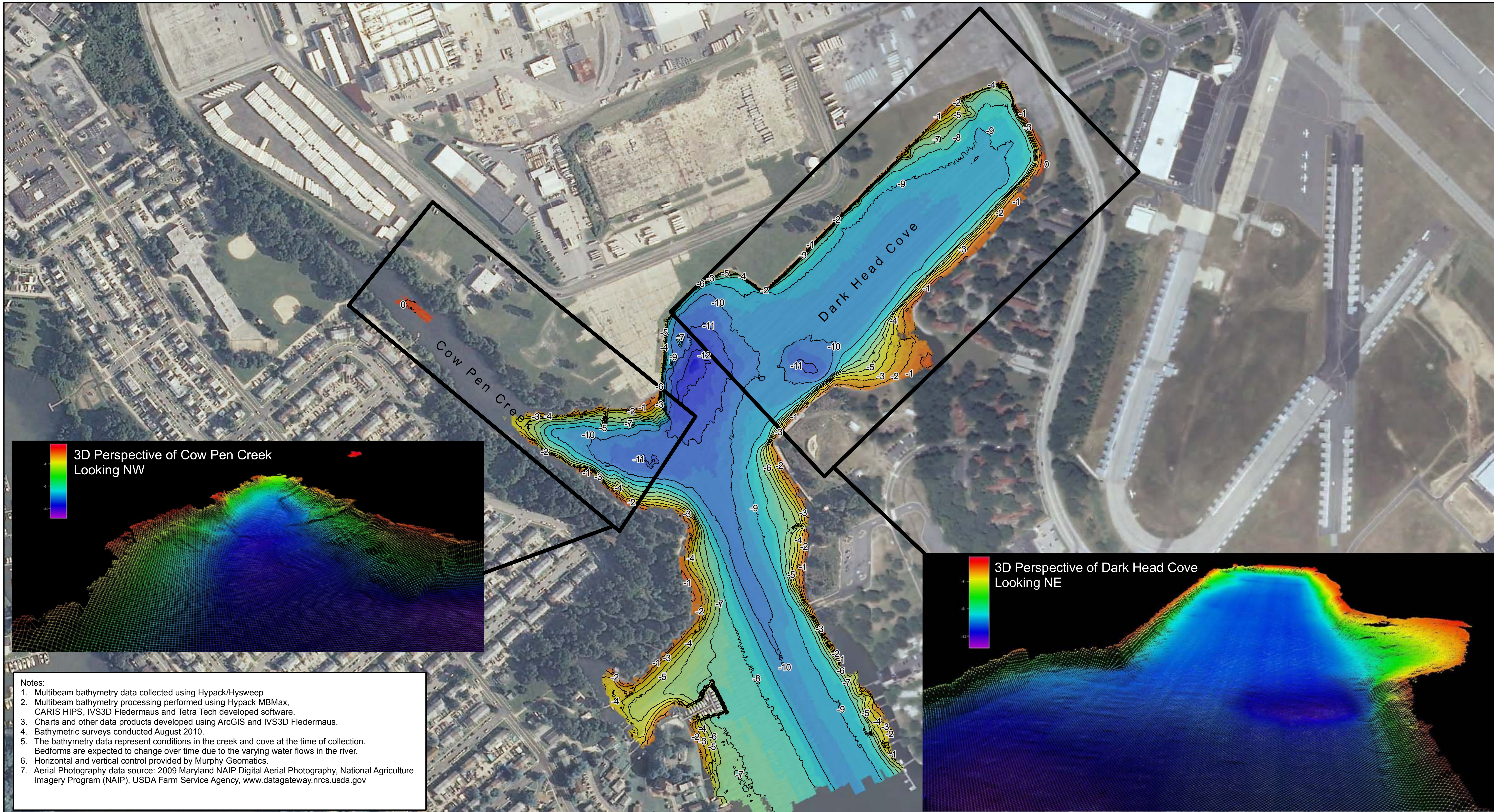
STORM DRAINAGE SYSTEMS SEDIMENT SAMPLING LOCATIONS-2013

MIDDLE RIVER COMPLEX AND MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND

BASED ON TAI 2002 UTILITY PLAN, MARTIN STATE AIRPORT UTILITY COVERAGE, AERIAL PHOTOGRAPHS, TETRA TECH FIELD SURVEYS, AND TETRA TECH SITE INSPECTIONS; ALL UTILITIES BASED ON TAI 2002 UTILITY PLAN AND MARTIN STATE AIRPORT COVERAGE NOT VERIFIED IN THE FIELD

0 — 400 FEET

- STORM DRAIN PIPE
- OPEN CHANNEL
- OUTFALL
- STORM DRAIN MANHOLE
- CATCH BASIN (GRATED INLET)
- STORM WATER INFILTRATION TRENCH



Notes:
1. Multibeam bathymetry data collected using Hypack/Hysweep
2. Multibeam bathymetry processing performed using Hypack MBMax, CARIS HIPS, IVS3D Fledermaus and Tetra Tech developed software.
3. Charts and other data products developed using ArcGIS and IVS3D Fledermaus.
4. Bathymetric surveys conducted August 2010.
5. The bathymetry data represent conditions in the creek and cove at the time of collection. Bedforms are expected to change over time due to the varying water flows in the river.
6. Horizontal and vertical control provided by Murphy Geomatics.
7. Aerial Photography data source: 2009 Maryland NAIP Digital Aerial Photography, National Agriculture Imagery Program (NAIP), USDA Farm Service Agency, www.datagateway.nrcs.usda.gov

Elevation (ft)

-0.5 - 0; -1 - -0.5; -1.5 - -1; -2 - -1.5; -2.5 - -2; -3 - -2.5; -3.5 - -3; -4 - -3.5; -4.5 - -4; -5 - -4.5; -5.5 - -5; -6 - -5.5; -6.5 - -6; -7 - -6.5; -7.5 - -7; -8 - -7.5; -8.5 - -8; -9 - -8.5; -9.5 - -9; -10 - -9.5; -10.5 - -10; -11 - -10.5; -11.5 - -11; -12 - -11.5; -12.5 - -12; -12.9 - -12.5

1 ft Contour

N E S W

0 100 200 300 400
US Survey Feet
1:5,000

Geodetic Settings		Survey Equipment	
Horizontal Datum	State Plane NAD-83	**Multibeam Sonar**	RESON 7125/Ross 875-X
Projection	Maryland FIPS 1900	**Positioning System**	Leica 1230 RTK GPS/Applanix
Horizontal Units	US Survey Feet	**Heading Sensor**	Applanix POS MV
Vertical Units	US Survey Feet	**Motion Sensor**	Applanix POS MV
Vertical Datum	MLLW	**Sound Speed Profilers**	Falmouth NXIC/Seabird SBE 19
Vertical Control	Murphy Geomatics, MIDR14	**Dates Surveyed**	August 3 & 4, 2010
Horizontal Control	Murphy Geomatics, MIDR14	**Cell Size/Grid Method**	3ft/CARIS Uncertainty

Figure 2-6 Middle River Site Bathymetry

TetraTech Inc.
19803 North Creek Parkway
Bothell, WA 98011
1 (425) 482 7600

Survey Technicians:	B. Johnston, C. Burt	**Plate** 1
Drafted by:	MJ Watson	
Checked by:	R. Feldpausch, B. Bridge	**Sheet:** 1 of 1

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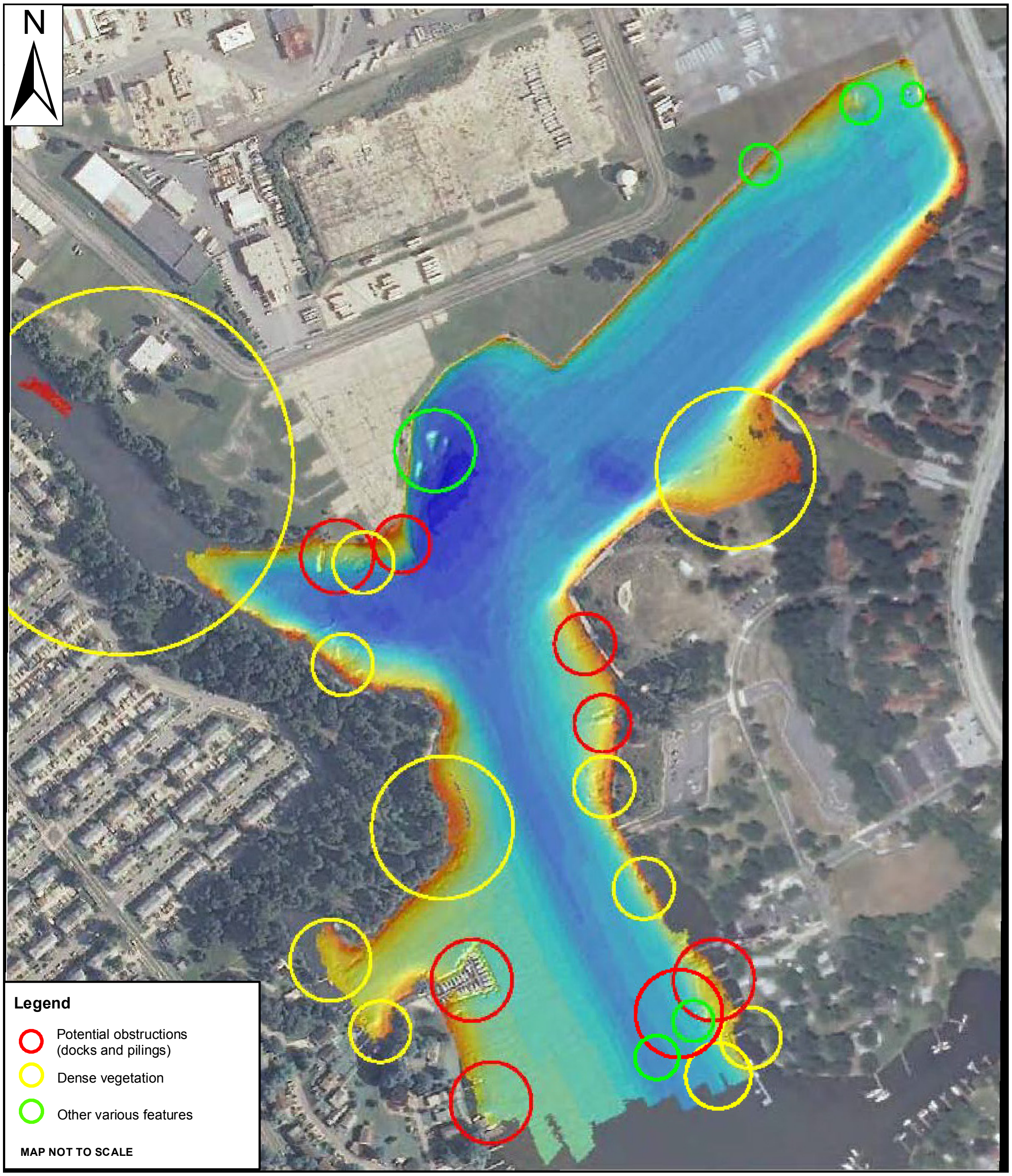

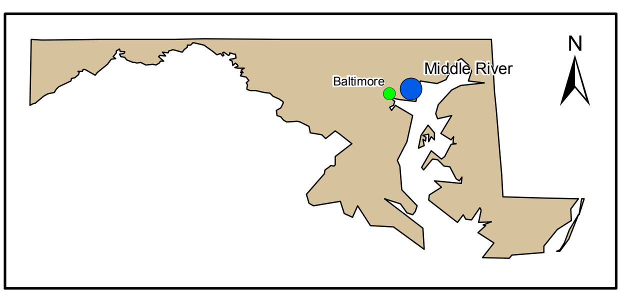

FIGURE 2-7

POTENTIAL DEBRIS TARGETS

Lockheed Martin Middle River Complex
Middle River, Maryland

DATE MODIFIED:	CREATED BY:
3/4/14	MP

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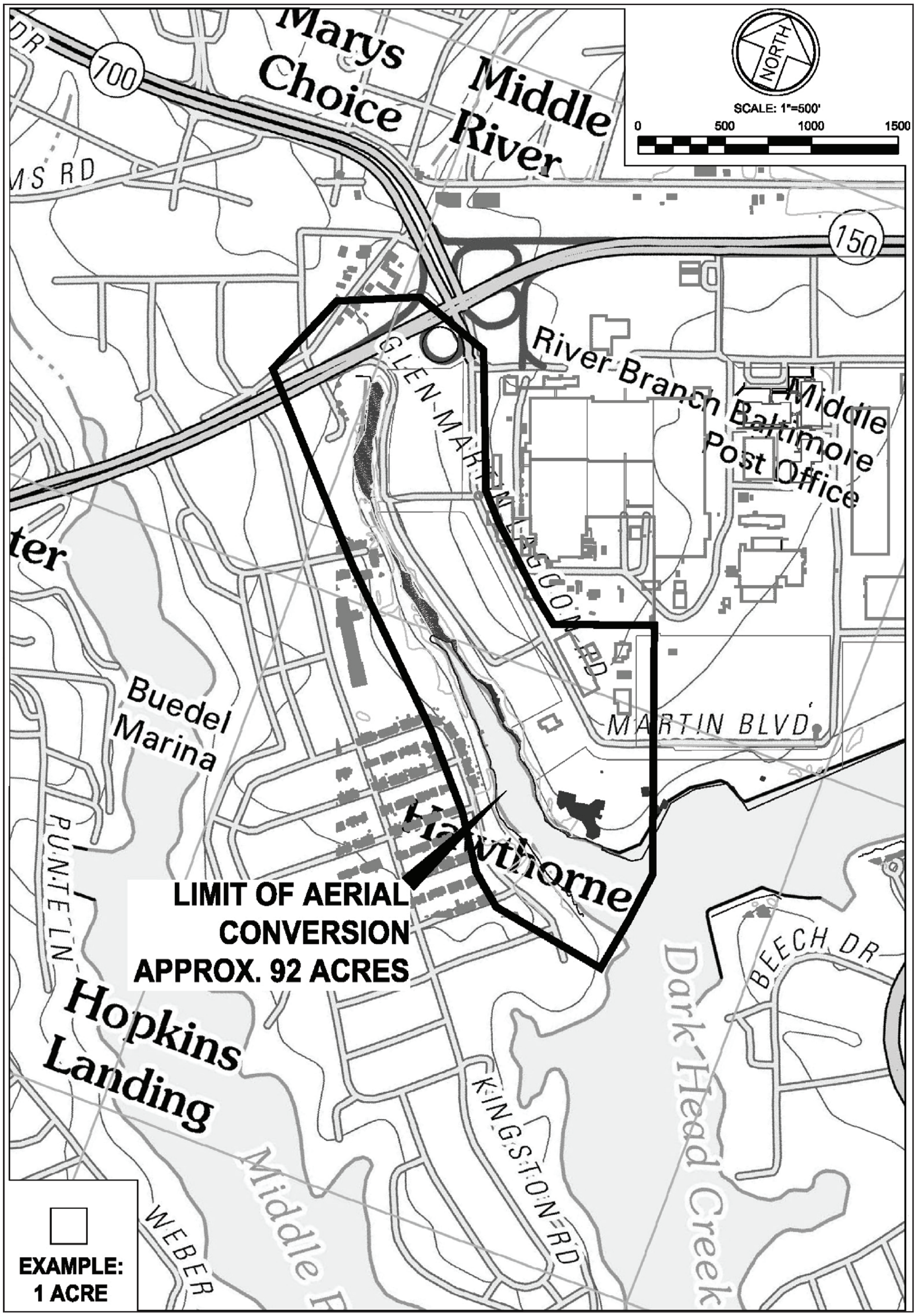

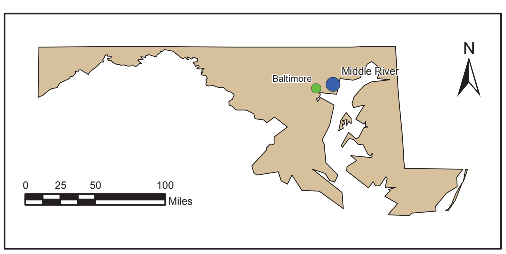

FIGURE 2-8

COW PEN CREEK MAPPING LIMITS

Lockheed Martin Middle River Complex
Middle River, Maryland

DATE MODIFIED:	CREATED BY:
3/4/14	MP

TETRA TECH

Map Document: (K:\GProject\middle_river\Maps\Cow Pen Creek Mapping Limits.mxd)
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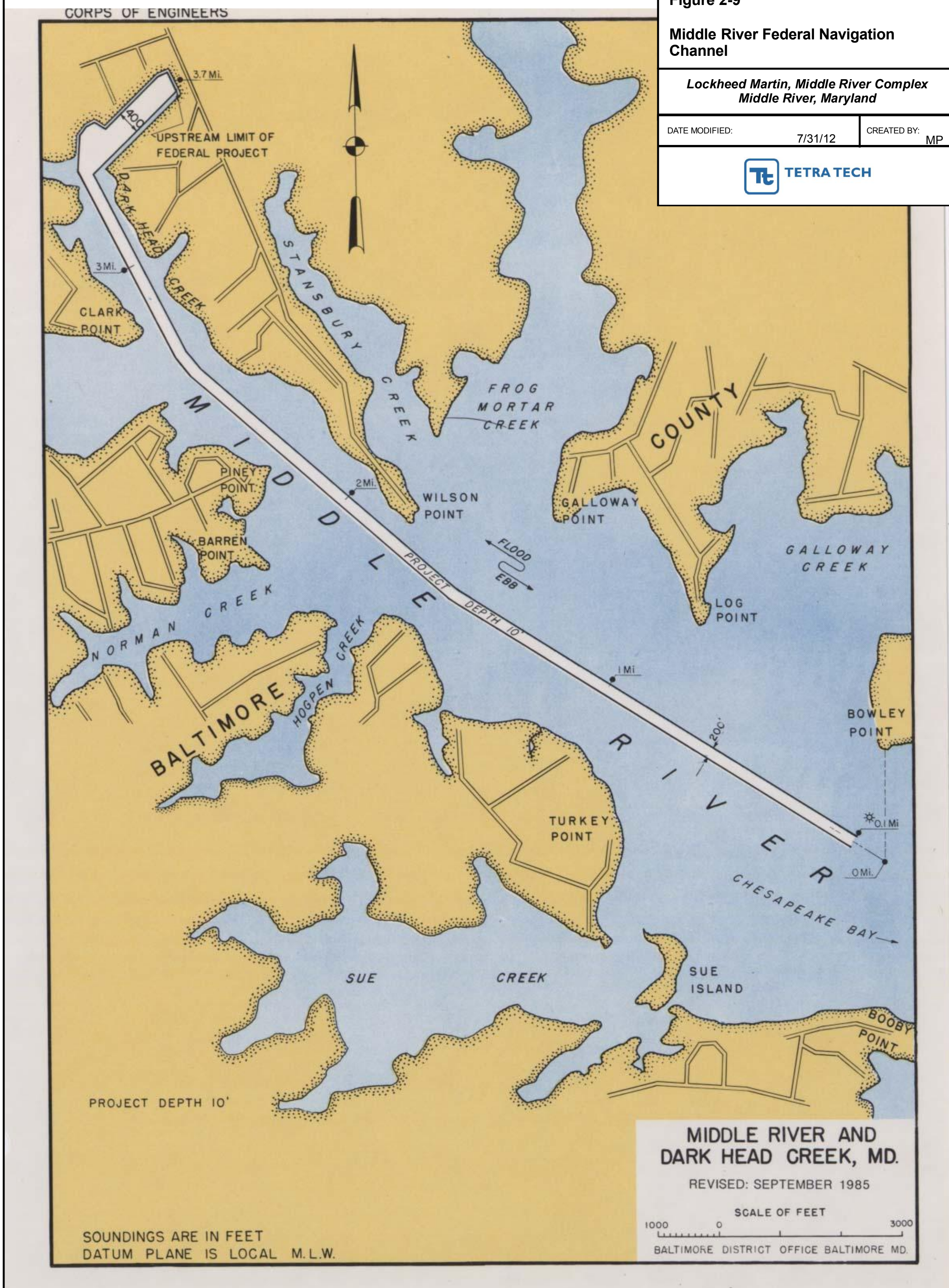
Figure 2-9

Middle River Federal Navigation Channel

Lockheed Martin, Middle River Complex
Middle River, Maryland

DATE MODIFIED: 7/31/12	CREATED BY: MP

TETRA TECH



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Section 3
Sediment Removal and Disposal

Contaminated sediment in Cow Pen Creek will be removed by excavation and dredging. Contaminated sediment in Dark Head Cove will be removed by dredging. An overview of the excavation and dredging within Cow Pen Creek and Dark Head Cove is illustrated in Figures 3-1 and 3-2. Dredged sediment and debris will be handled at an adjacent upland dewatering pad for transport and disposal at an upland landfill. This section describes the following:

- The dredge-prism design
- Measures to address potential impacts of dredging, including assumptions for residuals management
- Basis of verification sampling
- Basis for dredging equipment selection
- Sediment dewatering, handling, transport, and disposal activities
- Post-construction activities

Refer to project design drawings (provided under separate cover) for details of removal. Project specifications are provided under separate cover.

3.1 DREDGE PRISM DESIGN

A major component of the dredge-plan design is defining the dredge prism. The required dredge prism for Cow Pen Creek and Dark Head Cove sediment represents the elevation, grades, and horizontal extent of contaminated sediment (i.e., sediment with concentrations greater than the cleanup levels) that a dredging contractor will be required to remove to implement the remedial action. The primary objective of the dredge prism design is to ensure that contaminated sediment requiring removal falls within the horizontal and vertical extent of the dredge prism, to the extent practicable. The dredge prism design relies on field and laboratory data, so the precision of data points (i.e., contamination depth and extent, bathymetry, topography) affects the certainty level that the dredge prism encompasses all contaminated sediment. Methodology to design a dredge prism that could achieve the remediation goals is summarized below and illustrated in Figure 3-3.

3.1.1 Neatline Depths

The first step in designing a dredge prism is to define the neatline depth (i.e., the minimum depth to capture all contaminated sediment exceeding the remedial goal) based on sediment core data generated during the FS and pre-remedial design sampling. The distribution and horizontal and vertical extent of chemical concentrations in Middle River Complex (MRC) sediment were determined (a) on the basis of samples from four depth intervals in the sediment (i.e., zero to 6 inches, 6 to 18 inches, 18 to 30 inches, and >30 to 52 inches), (b) on the laboratory results for those samples analyzed for polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbon (PAHs), and metals, and (c) on the subsequent human health and ecological risk assessments. The distribution and horizontal and vertical extent of these chemical concentrations is presented in Thiessen polygons assembled around sampling locations (i.e., half the distance to the next sampling point).

During the feasibility study (FS), these polygons and depth intervals were used to estimate the volume of contaminated sediment requiring removal. The depth of removal varies in the remediation area, based on the vertical extent of chemical of concern (COC) concentrations that exceed sediment cleanup levels designed to meet the remedial action objectives (RAOs). Sediment cleanup levels (i.e., the preliminary remediation goals [PRGs] calculated for the project) are summarized in Table 2-1.

The 2013 sediment-sampling results were incorporated into the existing sediment-sampling database as part of the remedial design process. The 2013 sampling effort was implemented to refine the design neatline depths. Contamination depths that define neatline depths were plotted along Cow Pen Creek and in Dark Head Cove. Existing topographic survey and bathymetric survey data were used to develop cross-sections. These profiles are compiled and presented in Appendix A.

Additional sampling in Dark Head Cove in May 2014 provided additional data to support removing sediment having elevated PCB concentrations at the Outfall 005 sediment removal action (SRA) area. Post-construction SRA confirmation sampling was completed in March 2015. Dark Head Cove profiles in Appendix A were developed based on the most recent data.

3.1.2 Excavation and Dredge Prism

The neatline depths and prism is refined to construct the dredge prism based on the extent of contamination, target sediment-removal depths, and anticipated dredge operations. Other considerations in the design include geomorphic site conditions, the presence of adjacent structures, and the anticipated dredge operation such as the typical precision of construction equipment and allowances for box cuts and layback slopes. Allowable overdredge and residual-management measures also typically factor into the removal prism. An overview of the Cow Pen Creek and Dark Head Cove removal plans is shown in Figures 3-1 and 3-2.

3.1.2.1 Geomorphic Conditions

Geomorphic interpretations are typically used to support sediment contamination investigations, because sediment and related contaminant distributions are influenced by in-stream processes. Topography and bathymetry play important roles in determining which areas of the creek are depositional and which are erosional, thus facilitating identification of erosion and deposition of contaminated sediment and contaminant delineation. The removal prism also considers the geomorphic conditions of each sediment sampling location in Cow Pen Creek. For example, in the non-tidal portion of the Cow Pen Creek, a series of floodplain areas are subject to similar fluvial processes, so samples collected in these areas can be used to infer similar contaminant distributions in the creek.

3.1.2.2 Removal Techniques

The dredge prisms were designed to remove sediment to the target depths where cleanup goals can be achieved while achieving efficient constructability. Thus, the dredge prism is more conservative and includes more targeted material than the neatline defined by the data. Considerations for removal techniques are further discussed below.

3.1.2.3 Dredge Slopes

Geotechnical conditions, erosion or sediment-migration potential, and hydraulic conditions were considered to determine the excavation and dredging slopes. Removal slopes include the bank excavation slopes and lateral/longitudinal in-water removal slopes. A slope of 2H:1V (two run horizontal to one rise vertical) was selected as the default excavation slope along the banks of Cow Pen Creek. This design slope represents the slope expected to be stable during construction and to prevent slope failure during implementation. The dredge cut slopes along banks were selected based on the existing side slopes and required dredge depths to meet cleanup goals. The bank slopes were steepened or flattened based on topography and to minimize disturbance to floodplain or adjacent structures (e.g., guardrails, stone walls, gabion walls), while ensuring contaminant removal. All excavated banks along the creek will require bank stabilization and revegetation to reduce potential erosion and bank failure.

In front of the vertical sheet-pile bulkhead-wall in Dark Head Cove, sediment will be dredged at a slope of 1H:1V to remove the most contaminated sediment located closer to the bulkhead, except areas where there are accumulated soil piles eroded from deteriorated bulkhead will be removed (Refer to Section 3.7). Current mudline elevations indicate that sediment has built up in front of the bulkhead and the depth of dredging is not expected to exceed the original dredge depth; thus, dredging-accumulated sediment closer to the concrete bulkhead is not expected to destabilize the structure. New sheet pile wall will be constructed in front of the existing bulkhead, which will provide additional support during dredging. Refer to Section 3.3 for discussion of structural stability considerations during dredging in Dark Head Cove. In front of the riprap shorelines, a 2H:1V slope will be used.

Geotechnical evaluation of slope stability analysis indicates that the 2H:1V slope provides a stable dredge cut with a minimum factor of safety of 1.3 to minimize in-water sloughing during dredging in Cow Pen Creek and Dark Head Cove (Appendix D). Therefore, a 2H:1V slope was also applied to dredging slopes in open water areas. In Cow Pen Creek, flatter slopes were selected for water flow direction (i.e., along a longitudinal profile) to maintain the natural slope of the creek bed and to achieve a gradual transition between the required dredge elevation and the existing mudline elevation.

3.1.2.4 Allowable Overdredge

The allowable overdredge is a thickness of sediment below the required dredge prism that is typically included when estimating the total removal volume, to account for dredging equipment accuracy and tolerances. The design of the dredge prism reflects the difficulty involved in any dredge excavating down to an exact surface; to achieve a required elevation or grade, the dredge ends up removing some excess material below the extent required to remove contamination. The contractor will be given an overdredge allowance for equipment flexibility and constructability concerns to be handled in the field. A nominal overdredge depth of six inches is allowed as part of this design considering tolerance for surface and control precision.

3.1.2.5 Residuals-Management Layer

A residuals-management layer consisting of a nominal six-inch clean sand layer (free of debris, wood, organic matter, and other extraneous material, and less than 5% fines) will be placed over removal areas to control residual contamination. The layer will be placed after the post-removal survey has been completed and verification samples confirm that the cleanup levels have been met. In Cow Pen Creek, the residuals-management layer material will be selected by considering an appropriate creek substrate that would restore and improve existing habitat conditions. Placement of a clean layer over removal areas in Cow Pen Creek will be coordinated with installation of erosion control measures along the banks and in floodplains.

3.1.3 Dredge Volumes

Once the appropriate depths and side slopes have been selected at specific cross-sections, they are then combined with consistent slopes or depths to make a proposed surface using *AutoCAD®/Civil3D®* engineering design software. This prism is then reanalyzed to confirm that adequate sediment at the site will be removed (based on known contamination depths), to confirm that the dredge prism is implementable taking into consideration geotechnical characteristics of the sediment and the limitation of the dredging equipment, and to optimize the removal volume. This exercise may require iterations of the previous steps until the prism can be finalized. The proposed surface is then compared to the existing surface to determine dredge/excavation prism or volume. Removal and residuals-management-layer volumes are summarized in Table 3-1.

3.2 REMOVAL OF CONTAMINATED SEDIMENT

Sediment in Cow Pen Creek will be removed from the Lockheed Martin side of the creek; no equipment staging or access from the opposite side of the creek will be allowed. Sediment in Dark Head Cove will be removed by in-water dredging.

This section provides brief information about the construction approach. Refer to the design drawings and project specifications for detailed information. The contractor will develop means and methods of the construction in the work plans at later stages of the project.

3.2.1 Removal by Excavation

Sediment will be excavated from the shallow portions (less than 5 feet deep) of Cow Pen Creek (Table 3-1a). Work will start from the sediment removal location farthest upstream and move progressively downstream. Tentative locations of creek access are shown in the design drawings (provided under separate cover). The contractor will field verify and determine the access locations based on the field conditions.

Upstream portions of Cow Pen Creek will be isolated in sections and creek water will be diverted downstream to create dry work areas. Containment options (cofferdam structures) include sandbag or gravel bag berms, sheet piles, concrete blocks, or aqua-barriers (i.e., inflatable dams) to be installed transversely (across the creek) or longitudinally (partial channel isolation). Once temporary barriers are installed, creek water and storm water runoff will be conveyed downstream either by a closed bypass pumping system (e.g., pipe, flexible hose) or through an open channel. Open channel conveyance would be through the existing channel restricted to contain the current flow within only part of the channel through longitudinal barriers to create a partial channel isolation. The dredging contractor will select the necessary dewatering equipment and operate the creek dewatering system in a manner approved by the engineer. Any accumulated water due to rain and groundwater flow in dewatered segments during excavation will be collected and treated upland (refer to Section 3.5).

A potential failure of the dewatering operations could cause inundation of the work area, excessive turbidity, and schedule delays, as well as a possible health and safety concern. The contractor will have properly sized equipment (to accommodate 20 cubic feet per second [cfs]) with a redundant pumping system (to accommodate 30 cfs), and will monitor and inspect the equipment to prevent and recover from such a potential risk. Refer to construction specifications for dewatering equipment requirements and design drawings (provided under separate cover) for details of diversion techniques recommended by the Maryland Department of the Environment (MDE, 2000).

In Cow Pen Creek, low-ground pressure-tracked equipment configured with long-reach excavation arms can access the slopes and streambed from the banks of Cow Pen Creek or from the creek bed. The excavation equipment can also remove debris as it is encountered. Unknown soil conditions should be considered in selecting equipment and during construction. If the equipment needs to operate inside the creek, stabilization mats or temporary placement of fill will likely be required to avoid equipment settlement into the sediment. Land-based excavators are well suited to accurately and efficiently remove sediment to design depths; they can also be used to place clean fill and habitat restoration materials. The field equipment will likely include an excavator, an excavator with thumb, and a dozer equipped with a global positioning system (GPS) receiver. Production rate of excavation activities is expected to be 100 to 200 cubic yards (cy) per day.

All disturbed areas in the creek will be stabilized, restored, and revegetated. Refer to Section 7 for restoration of the creek.

3.2.2 Removal by Dredging

At the mouth of Cow Pen Creek where water depths increase to approximately five feet and deeper, and in Dark Head Cove, mechanical dredging equipment will be used to dredge sediment. Mechanical dredging is the selected methodology over hydraulic dredging where a slurry with 8% to 10% solids is typically produced. Mechanical dredging is selected based on the experience during Outfall 005 SRA and the following factors:

- Ability of mechanical dredging equipment to meet project requirements, including compliance with applicable water quality criteria
- Ability of mechanical dredging to achieve higher solids loadings in the dredged materials, without necessitating costly and area-intensive dewatering methods
- Ability of mechanical dredging equipment to remove any debris that is encountered
- The lesser quantities of water produced by mechanical dredging (compared to hydraulic dredging) that can be treated on-site and discharged to a POTW rather than requiring more time-consuming National Pollutant Discharge Elimination System (NPDES) permitting.

Land-based removal from the shorelines of Dark Head Cove is not anticipated because of the unstable conditions of the bulkhead. A new sheet pile wall will be constructed in front of the existing bulkhead before dredging is started in Dark Head Cove. The main design criterion of the new bulkhead wall would be to retain soil behind it. The new sheet pile wall would not be subject to additional loads due to equipment operations upland.

The production rate of dredging is expected to be 200 to 300 cy per day. Sediment in Cow Pen Creek and Dark Head Cove has high fines (84%) and high water content (77% by volume, 140% by weight) contractor will develop this plan based on the confirmation sampling requirements provided in the Construction Quality Assurance Plan (CQAP) submitted along with this design package and the EPA-approved RBDAA.

3.3 POTENTIAL IMPACTS OF REMOVAL

The primary function of this remediation project is to improve and protect the environment while taking measures to minimize any short-term effects from excavation and dredging operations. Potential impacts of remediation construction in Cow Pen Creek and Dark Head Cove, and the measures to minimize these impacts including best management practices (BMPs), are presented in this section.

3.3.1 Short-term Water Quality Considerations

The main impact to the environment during in-water removal operations is increased turbidity caused by suspended sediment and potential contamination associated with the particulates. Turbidity measures water clarity as impacted by the amount of particles suspended in water. Sediment disturbance during dredging could temporarily increase turbidity and allow re-suspended sediment to be transported to adjacent areas.

Water quality will be monitored during dredging in accordance with the general considerations summarized here. Details of the process are provided in the Water Quality Monitoring Plan. Dredging will likely be suspended during a large storm. The decision to suspend operations will be made based on health and safety considerations, wind speeds, wave conditions, and other factors (severe cold/freezing conditions, winter storm warnings,) that would indicate potential issues to the safe and successful in-water operations. The contractor's project manager and health and safety officer will determine if conditions warrant suspension of operations. Water quality monitoring results will be reported regularly to the USEPA and MDE; they will also be contacted should adverse conditions result in suspension of operations.

3.3.1.1 Silt Curtain

A silt curtain will be installed around the in-water work area at the mouth of Cow Pen Creek and also in Dark Head Cove to control the migration of suspended sediment during sediment dredging. The silt curtain will protect the surrounding area by encasing the entire work area, including the dredge, *in situ* treatment, residual management layer placement areas, the offloading area, and all dredging equipment.

The depth of the curtain will be sized to accommodate normal tidal conditions. The curtain will be selected to withstand a typical current of up to three feet per second, under normal tidal conditions, and monthly spring-tide waves up to two feet in height (Tetra Tech, 2013).

Ensuring that the curtains do not touch the bottom in tidal and/or wind- and wave-action situations is generally recommended (Francingues and Palermo, 2005). A minimum one-foot gap should be maintained between the ballast and the bottom of the skirt at mean low water (MLW). Movement of the lower skirt over the bottom (due to tidal reverses or wind and wave action on the flotation system) could fan and stir sediment already settled-out during dredging. The curtains will be monitored and inspected during construction to ensure performance.

3.3.1.2 Turbidity Monitoring

Water quality during the dredging activities will be monitored by measuring turbidity at multiple locations around the dredge area and comparing with measurements collected from background locations. The monitoring approach uses background monitoring locations, early warning locations near the dredging activity inside the silt curtain and compliance monitoring points beyond the silt curtain. The turbidity compliance levels will be determined by MDE during the permitting process and by the USEPA during the approval of risk-based disposal approval application. Refer to the Water Quality Monitoring Plan (WQMP) submitted with this design package for details of turbidity monitoring.

Column settling tests (CST) conducted in 2011 (Tetra Tech, 2012a) were evaluated to predict the distance that any water quality impacts could travel during dredging and to provide the basis for the location of the silt curtain and the compliance points. CST results suggest that suspended sediment may travel 100 feet to 200 feet in the mouth of Cow Pen Creek and Dark Head Cove respectively before settling. Refer to the silt curtain design considerations in Appendix D for evaluation of the CST results.

Having backup monitoring equipment available on-site will allow for replacement as soon as possible after detection of a failure. Having multiple background and compliance locations will limit the impact of any temporary failure of a single monitor and would not be cause for stopping dredging operations. Simultaneous failure of multiple meters such that no data were being collected at two of the three compliance locations would be cause for stopping dredging operations until the meters could be repaired or replaced. The water quality monitoring operations will include the regular inspection and calibration checks of the turbidity monitoring equipment.

3.3.2 Best Management Practices

The overall goal of the dredging is to remove impacted sediment while minimizing dispersion of contaminated sediment and limiting the development and production of dredging-related residuals. The use of appropriate BMPs will be required in the specifications, and will be addressed during development and review of the contractor's work plan. The contractor must limit potential impacts during construction of the remedy and during sediment removal by implementing the following measures and BMPs during construction, as appropriate:

- ***Dredging schedule:*** Sediment removal will be limited to the allowable in-water work window. The in-water work window will be established in the permit for this project. The anticipated dredge and *in situ* treatment work window for Dark Head Cove is October 16 through February 14. Cow Pen Creek excavation work window is anticipated to be June 16 to February 14 dependent on obtaining approval to work during the submerged aquatic vegetation time of year restriction for the area that will be subject to remediation.

- ***Silt curtain:*** Silt curtains will be installed around the dredge operations to control migration of suspended sediment during dredging. The curtain will protect the surrounding environment by encasing the area being dredged. The dredge area, offloading area, and all dredging equipment will be within the encased area. The curtains will be inspected and monitored during construction to ensure performance.

- ***Construction methods:*** Real-time kinematic global positioning system (RTK GPS) will be used to control vertical and horizontal movement of the dredge bucket, thus minimizing reworking of the sediment bed and minimizing the volume of sediment removed. The dredge operator typically has access to real-time turbidity data from all monitoring stations, and can adjust the operational procedure (cycle time, cleaning, etc.) to ensure that the NTU readings do not exceed the specified level above background.

- ***Erosion and sedimentation controls:*** The contractor will install erosion and sediment controls in the upland areas as they are depicted on the design drawings. The contractor will implement these controls throughout the project and adjust as needed to comply with the grading permit and other agency requirements.

- ***Management of water that has contacted contaminated sediment:*** The water draining from stockpiles of dredged material and storm water that contacts contaminated sediment in upland dewatering pad or in active work areas of Cow Pen Creek during excavation will be contained, treated on-site or transported to a disposal facility. Treated water will be sampled to comply with discharge permit disposal requirements.

- ***Water quality monitoring:*** Water quality (i.e., turbidity) will be monitored during in-water work as described above in Section 3.3.1.

- ***Spill prevention controls:*** The contractor will have a spill prevention, control, and countermeasure plan in place to protect the environment from spills and releases of any hazardous materials or petroleum products, per Maryland state guidelines. Spill prevention measures will be applied during construction, sediment offloading from the barge, and transporting dredged and dewatered sediment. Sediment offloading areas will be equipped with a spill protection apron, timber mats lined with geomembrane, berm, and super silt fence to ensure capture of any spillage. The contractor will perform continuous inspections over the lined and bermed sediment offload area and offloading operations to ensure that any incidental spillage from the operations is addressed immediately and cleaned up. The laborers assigned to the material handling area will continuously monitor the areas where the sediment is swung from the barge to the truck and the route from the truck loading area to the sediment dewatering pad during all periods of upland sediment handling. The laborers will immediately recover and thoroughly clean up any spillage that may occur, and all sediment cleaned up will be placed within the confines of the sediment dewatering pad. Sediment transport to the disposal facility will be via trucks equipped with an impermeable liner to prevent any leakage. The trucks will be inspected to prevent any spills during transport. The spill prevention, control, and countermeasure plan and BMPs will be outlined in the contractor's remedial action work plan.

- ***Air, noise, and dust/odor monitoring:*** Dust particles and odors from project activities will be controlled at all times. Dust and odor management can include: wetting excavation areas, unpaved traffic lanes, and sediment stockpiles; covering trucks loaded with sediment; covering stockpiles with plastic sheeting during inactive periods; and by daily (at a minimum) sweeping during dry weather of any paved on-site truck routes, loader paths, and loading and stockpile areas. The contractor's health and safety plan will adhere to all project requirements. Monitoring within the work zone will be able to evaluate and confirm or trigger the use of best management practices to ensure acceptable conditions beyond the work zone.

- ***Traffic control:*** The proposed haul route for the staging area is shown on the design drawings. The contractor will implement traffic mitigation measures that will minimize off-site traffic impacts during construction.

3.3.3 Dredge-Residuals Management

Residuals are contaminated sediment remaining in or adjacent to the dredging footprint after the removal/dredging operation is complete. The residuals generated are post-dredge surface sediment that has been dislodged or suspended by the dredging and is subsequently redeposited on the bottom of the water body. Undisturbed residuals are contaminated sediment found at the post-dredge sediment surface that has been uncovered by dredging but not fully removed. Residual contamination is typically evaluated in surface sediment following completion of the remedial dredging. The following management approaches will be implemented to address potential residual contamination in Cow Pen Creek and Dark Head Cove:

- The default corrective action to address residual contamination after dredging will be to place the residuals-management layer. Refer to Construction Quality Assurance Plan (CQAP) for application methodology and contingency actions.
- Appropriate BMPs will be specified during dredging to minimize residual contamination sources during dredging. A few examples of mechanical dredging BMPs are as follows:
  - An enclosed “environmental-type” bucket can (to the extent practicable) reduce potential resuspension of contaminated sediment during dredging. Enclosed buckets offer advantages when excavating light, loose materials, or those with high water contents.
  - Dredge buckets will not be overfilled. The loaded bucket will be retrieved from the bed at a slow and continuous rate.
  - Dredge residuals appear to be particularly significant at sites with considerable debris. Debris removal before dredging will reduce resuspension during dredging.
  - Stable cut-slopes will be maintained during dredging to reduce potential sloughing.
  - RTK GPS will be used to maintain vertical and horizontal control of the dredge bucket.

3.3.4 Creek Bank Stability and Dredge-Cut Slope Stability

A bank failure due to overly steep cuts during excavation would cause erosion, excessive turbidity in the creek, and potential damage to adjacent structures, as well as pose a health and safety concern. Excavated banks will be stabilized immediately by temporary measures followed by the permanent measures. Refer to design drawings and Section 7 for more discussion about bank stabilization measures.

Unstable in-water dredge cuts could cause sloughing and short-term water quality impacts during dredging. Available site-specific geotechnical data were analyzed to ensure dredge-cut slope stability within the dredge prism during construction. The target safety factor for this analysis is 1.3, based on United States Army Corps of Engineers (USACE) recommendations regarding submerged and semi-submerged dredge slopes (USACE, 2000). Geotechnical slope evaluations indicate that a 2H:1V and gentler in-water dredge slope is stable and would not cause sloughing during construction, providing a safety factor of 1.5. Slope stability calculations are in Appendix D.

The site is in the United States Geological Survey (USGS) Seismic Zone 1, which corresponds to an effective peak ground acceleration of 0.075g (International Code Council, 2006). Probabilistic seismic-hazard analyses for the MRC site (through USGS deaggregation plots) result in 0.006g, 0.02g, and 0.07g for nominal 100-year, 500-year, and 2,500-year events, respectively. These peak ground-accelerations correspond to weak-to-light shaking with none-to-very-light potential damage (USGS, 2011). MRC sediment would be expected to remain stable under known regional seismic conditions.

3.3.5 Structural Considerations

In Dark Head Cove, the supporting elements of the concrete bulkhead have deteriorated. The condition of additional lateral-support elements (i.e., tie rods extending from the top of the sheet piling into the adjacent soil and terminated with anchor piles) is unknown. A new sheet pile wall will be constructed in front of the deteriorated wall to retain soil behind it. Removal of sediment from in front of the bulkhead and shorelines, and the additional load from upland equipment operations, are reviewed below.

3.3.5.1 Dredging in Front of Concrete Bulkhead

The mudline elevation facing the sheet piles is -10 feet to -14 feet MLW (or -9.78 to -13.78 mean lower-low water [MLLW]) in the original 1943 design drawings. Current mudline elevations in front of bulkhead generally range from -5 feet to -10 feet MLLW except the areas where significant erosion behind the bulkhead has created soil mounds. This elevation difference shows that an average of three to four feet of sediment has built up in front of the bulkhead; thus, the original sheet pile burial depth of 25 feet has increased since its construction in 1940s. Dredging in front of the concrete bulkhead back to the design depths will not change the original burial depth of the sheet piles, and additional support would be provided by installing a new sheet pile wall; therefore, it is not expected to destabilize the bulkhead.

Despite the protective dredge operations, there is a risk of bulkhead destabilization during construction. To mitigate such risk, the new sheet pile wall will be monitored during dredging for any movement. Apparent signs of distress or movement of the wall will be monitored by visual observations.

3.3.5.2 Dredging in Front of Riprap Shoreline

The dredge prism in the riprap shoreline area will start at the waterward edge/toe of the riprap, and will slope down (2H:1V) to the design depth. Dredging underneath riprap will not be performed.

A pre-dredge bathymetric survey will be required to verify pre-existing (i.e., before dredging) shoreline conditions and riprap and mudline toe elevations.

Despite the protective dredge operations, riprap shorelines can be destabilized during construction and may need to be repaired. Riprap shorelines will be monitored during construction for any movement. If destabilized, the shorelines will be armored with riprap or articulated concrete mattress. A draft design of armoring requirements is included in shoreline stabilization calculations in Appendix D. Riprap shoreline monitoring requirements and contingency actions are included in the CQAP.

3.3.5.3 Upland Operations over the Bulkhead

No equipment operations will be allowed on the bulkhead. Operations immediately beyond the bulkhead (in the grassy strip between the tarmac and the bulkhead) will also be restricted. If necessary, equipment will operate at a setback distance (minimum 40 feet) to minimize additional lateral pressure to the bulkhead due to equipment load (Tetra Tech, 2014d).

3.3.6 Noise, Air Quality, and Odor Considerations

3.3.6.1 Noise

Noise control practices will comply with the State of Maryland *Code of Maryland Regulations* (COMAR) noise regulations Title 26.02.03 (Table 3-2). Construction activities will be limited to daytime hours and will not exceed 90 decibels (dBA) at any property outside of the construction site. Night-time construction activities are not expected; however, if they are required, sound levels at properties outside of the construction site will remain below those listed in Table 3-2.

All noise-producing construction equipment and vehicles using internal combustion engines will be equipped with mufflers, air-inlet silencers where appropriate, and any other shrouds, shields, or other noise-reducing features in good operating condition that meet or exceed original factory specification. Mobile or fixed “package” equipment (e.g., air compressors) will be equipped with shrouds and noise control features that are readily available for that type of equipment.

3.3.6.2 Air Quality and Odor

Sediment stockpiling could release fugitive dust and will require MDE review and approval of mitigation measures. Air quality within work zone will be monitored to ensure that constituent levels in ambient air do not exceed MDE standards for visual emissions, and suspended particulates in compliance with Maryland's "Environment Article," COMAR 26.11.04 and the federal Clean Air Act.

Air quality monitoring will include measurements of potential odor sources and comparison to their respective thresholds. Dust particles and odors from the project will be controlled at all times, including times when work is not in progress. Typical odor sources may include decaying organic material, hydrogen sulfide, which has a rotten egg odor. If the odor exceeds thresholds, mitigation measures may include covering sediment stockpiles, covering open water sumps at the dewatering pad, installing a misting system, and/or adding water treatment system enhancements.

3.4 SEDIMENT DEWATERING

Sediment removed from Cow Pen Creek and Dark Head Cove will be gravity dewatered on a dewatering pad. Dredged sediment will also be dewatered at the barge before being transferred to an upland dewatering pad. Passive dewatering is generally preferred because it is easy to implement and costs less, provided the project has adequate space and time to allow sediment to dewater. Other dewatering techniques include dewatering slurried sediment (e.g., by hydraulic dredging or slurried at the barge) in geotextile bags by gravity dewatering and active dewatering techniques where mechanical equipment is used to press and filter water from the dredged sediment. The dewatering technique selected for this project is discussed below.

3.4.1 Dewatering Excavated Sediment

Excavated sediment will be trucked from Cow Pen Creek to the dewatering pad for dewatering. The water content of excavated sediment will probably be close to the *in situ* water content. The water content of excavated sediment is anticipated to require minimal dewatering and amendment addition before passing the USEPA's paint filter test to determine if the material has water content sufficiently low enough to allow the material to be disposed of at a landfill. If the disposal facility has certain strength requirement, excavated sediment will likely require mixing with amendments at higher quantities than the amount necessary to pass the paint filter test only. An amendment amount of 6% is assumed to be added to dewater excavated sediment and allow it to pass the paint filter test. Refer to Section 3.6 for further discussion related to disposal requirements. The contractor must have a contingency plan to achieve dewatering in winter conditions.

Temporary erosion- and sediment-control measures will be in place to prevent or minimize storm water and surface water from contacting stockpiled material. The stockpiles will be covered by plastic sheeting during inactive periods, at the end of each work day, just before and during precipitation, and as necessary to control dust, erosion, and odors. The dewatering pad and containment system will be built on the existing paved area adjacent to Cow Pen Creek at Block G. The dewatering pad and containment system will consist of a dewatering pad, a containment enclosure, and a water collection sump. Dewatering pads will have storage capacity to hold excavated sediment to be produced during a one-week construction period to accommodate time for dewatering and loading excavated sediment. Production rate of excavation is expected to be 100 to 200 cy per day, or up to 1,500 cy per week. Total capacity of dewatering pads to be built at Block G is approximately 2,700 cy. Refer to the design drawings (under separate cover) for dewatering pad layout and system components.

3.4.2 Barge Dewatering

Mechanically dredged sediment will initially be placed on the barge positioned adjacent to the dredge site and within the silt curtain that is configured to allow gravity drainage of sediment. Some degree of gravity drainage will occur on the barge. Sideboards or Jersey barriers can be installed around the perimeter of a flat-deck barge and along scuppers at the deck line. Water released from the sediment is filtered through a filter medium (e.g., woven geotextile fabric) placed across the scuppers, which also control and prevent sediment discharges. The barge can be staged within the dredging area to allow continued dewatering before offloading and transfer of the impacted sediment to the upland dewatering pad. Barge dewatering was authorized by MDE as part of the Section 401 water quality certification during the Outfall 005 SRA (Tetra Tech, 2015) and is expected to be authorized again as part of the full remedy.

3.4.3 Dewatering Mechanically Dredged Sediment

Mechanical dredging operations will be similar to Outfall 005 SRA dewatering operations. A dewatering pad and containment system will be built on the existing concrete/asphalt tarmac adjacent to Dark Head Cove at Block F. Dredged material will be offloaded from the barge into sealed dump trucks using a crane placed onto a crane barge. The dump trucks will transport the materials to the staging area for additional dewatering (refer to Section 3.6).

The sediment will be placed in bermed dewatering pad(s) with impermeable liners. The dewatering pad will be constructed with a sloping base and a sump to facilitate further drainage and collection of water released from the sediment. Staging areas will be sized to contain dredged sediment, with provisions for typical rainfall and storm water. Dewatering pads will have storage capacity to hold dredged sediment to be produced during a one-week construction period to accommodate time for dewatering and loading dredged sediment. Production rate of dredging is expected to be 300 cy per day, or up to 1,800 cy per week. Total capacity of dewatering pads to be built at Block F is approximately 2,500 cy. The actual design configuration and location of the staging area(s) will be determined by the contractor. Material within the dewatering pad will be agitated and amendments will be mixed in to accelerate natural drying by drainage and evaporation. Based on experience on Outfall 005 SRA, an amendment amount of 12% is assumed to be added to dewater sediment and to be able to pass the paint filter test. Dewatered material will be sampled and subjected to the requirements of the USEPA paint filter test and strength testing (if applicable) to meet disposal facility's disposal requirements.

3.5 WATER TREATMENT OPERATION

Management of the water collected over the dewatering pad, and some degree of treatment, will be required before disposal. At the sediment staging area, dewatering will be accomplished either passively on a dewatering pad, or, alternatively, through a mechanical process. In addition to the water generated from dewatering, rainwater captured within containment systems will also have to be managed through treatment before disposition. Water accumulating in the dewatering pad will be transferred to settling and holding tanks. Once solids have settled, the water will be processed through an on-site water treatment system. The system will consist of sand filters, bag/cartridge filters, and/or a granular activated-carbon (GAC) unit. Multiple tanks, pumps, transfer hoses or pipes, and filtration components will be required for the water holding, clarification, and management system. Processing the wastewater will reduce the total suspended solids content and contaminant concentrations such that the treated water meets effluent limitations for final disposal.

Options for final disposal of the treated water include discharge to a POTW or at a permitted facility. Discharge to the POTW will require that the effluent be routinely sampled, in accordance with discharge permit requirements. Current design is based on the assumption that treated water from removal operations will be discharged to the POTW.

During the course of this project, about 36,000 gallons of water are expected to be generated from handling the sediment removed from dredging in Dark Head Cove and in the mouth Cow Pen Creek. This volume represents water generated from dredging approximately 20,500 cy of sediment (including six-inch overdredge volume). Excavated sediment is anticipated to have less free water than the dredged sediment, as additional water would be collected in the dredge bucket during dredging. About 41,000 gallons of water is expected to be generated during handling approximately 26,000 cy (including three-inch overdredge volume) of sediment excavated from Cow Pen Creek. These estimates are based on the SRA experience that the Outfall 005 sediment released insignificant amount of water by gravity when placed on the dewatering pad.

Any rainfall on sediment in upland dewatering pads will also be collected and treated. The storm water volume to be collected in dewatering pads is estimated to be in the range of 46,000 to 70,000 gallons (the average rainfall to 10-year storm event) at Block F (during handling dredged sediment from Dark Head Cove) and 73,000 to 112,000 gallons at Block G (during handling excavated sediment from Cow Pen Creek). The contractor will supply contingency equipment and enough storage capacity for normal rainfall and for the 10-year storm event to manage any storm water collected at the dewatering pad. Any accumulated rainfall and groundwater in excavation cells will also be collected during excavation of the creek in segments. Contact groundwater is estimated to be in the range of 0.1 gallon/minute per 1,000 square feet in the excavation cells based on the groundwater flow modeling (Tetra Tech, 2012b). Refer to Appendix B for groundwater flow evaluations. Refer to dewatering pad design considerations in Appendix D for mass balance calculation and details of the dredge dewater and contact storm water volume estimates.

Specific components of the water treatment system will be determined by the operations contractor. For design purpose, the system is anticipated to have settling tanks, pre-treatment and post-treatment tanks, and one full and one redundant system with sand filters, bag/cartridge filter units, and GAC units. The contractor will monitor and inspect water treatment system components to prevent any failure, schedule delay, permit violation, or project shutdown.

3.6 SEDIMENT HANDLING AND DISPOSAL

Sediment remaining to be dredged from Cow Pen Creek and Dark Head Cove have PCB concentrations less than 50 mg/kg and will be disposed of at a permitted upland Subtitle D landfill. The Grows North Landfill of Morrisville, Pennsylvania and the King and Queen Landfill in Little

Plymouth, Virginia (Lockheed Martin–approved disposal facilities) have been identified as acceptable upland Subtitle D disposal facilities for the dredged sediment. These landfills are approved to receive sediment that passes the paint filter test and reportedly have no specific strength requirements. If dewatered sediment is not stackable, the facilities may impose a daily volume acceptance limit. Additional disposal locations can be considered if proposed by the contractor.

Transloading, staging, stockpiling, and dewatering methods will comply with project requirements. The contractor should be prepared to handle sediment in winter conditions. Large storms, handling frozen sediment, and sediment that does not pass the USEPA's paint filter test at the landfill due to severe weather conditions are some of the issues related to construction in winter. The restricted in-water work window and operations in winter conditions could cause slower than anticipated production and unexpected delays.

The contractor will be responsible for providing an appropriate offloading facility and the transportation logistics to transport sediment to the disposal site. This could include using the staging areas or alternative locations. A manifest for each waste shipment to be transported to the off-site disposal facility will be prepared in accordance with all applicable federal, state, and local regulations.

Dredged and dewatered sediment will likely be transported by trucks equipped with impermeable liners. The distances of Grows North Landfill of Morrisville, Pennsylvania and the King and Queen Landfill in Little Plymouth, Virginia to the site are 125 miles and 170 miles, respectively. Trucks will be inspected before leaving the site to prevent any spillage and overloading.

Transport by rail is generally more cost effective if rail spurs with terminal facilities are available and loading/unloading logistics can be arranged at both the MRC and at the landfill. The MRC has a rail spur operated by CSX Transportation; Tilley Chemical Company, an MRC tenant, uses it. The railroad network is connected to the Subtitle D Grows North Landfill (Figure 3-4). Transportation by rail will require an update of the system including placement of new switch and new rails. The current design and construction cost estimate is based on truck transport; however, the feasibility of rail transportation with consideration of the availability of loading areas, a cost-effective quantity of rail cars, space to stage empty railcars, the loading of railcars, and the switching/movement of loaded cars into traffic flow can be explored by the contractor during the bid process.

Similar to rail operations, transport of dredged sediment by barge is generally more cost effective than truck transport. Neither of the identified landfill facilities can accommodate unloading sediment transported by barge. During the bid process, the contractor can explore transport by barge option to another Subtitle D landfill approved by Lockheed Martin.

3.7 DEBRIS HANDLING AND DISPOSAL

Debris in Cow Pen Creek was surveyed and visually inspected as part of the 2012 topographic survey. The findings of the debris survey and preliminary actions taken to address debris are summarized in Table 3-3. Presence of debris within the removal footprint will be field verified by the contractor. Large debris items will have to be removed from the sediment to minimize impacts and removal operations. Debris will likely be removed by excavation equipment as sediment removal progresses. Removed debris will be placed on the dewatering pad for follow-on evaluation. Existing debris will be reused or recycled, to the extent practicable.

Reuse opportunities include bank stabilization and stream restoration. Concrete and stone debris will be swept and brushed clean of adhering sediment and visually inspected to ensure that it is visibly clean. This debris may be recycled at an approved recycling facility. Wood debris for possible reuse for restoration or recycling at an approved recycling facility will also be brushed clean or pressure washed of all adhering sediment. Wood that is visibly stained or that cannot be cleaned will be transported for disposal at a Subtitle D solid waste landfill. Total debris estimate for Cow Pen Creek sediment is about 20 tons of wood and 180 tons of concrete and rubble. It is anticipated that most of this woody debris will probably be used on-site or recycled.

Additional debris may be encountered during excavation. Buried debris may include drums or electrical transformers. The contractor will coordinate with Lockheed Martin if any unidentified debris is found during the construction. Refer to project specifications to address handling buried debris.

Lockheed Martin recently conducted underground storage tank and transformer investigations close to the left bank of Cow Pen Creek as part of the upland soil remedial construction work at MRC in August and September 2015 (Tetra Tech, 2015c). Based on these investigations, scattered concrete debris piles along about 300 feet the left bank of Cow Pen Creek have been identified for removal. This debris is assumed to be generally on the surface of the bank. However, if the debris extends into the bank, additional excavation and backfill may be required on an “as needed” basis. This remediation work will be completed during the sediment remedial construction in Cow Pen Creek. Refer to the design drawings and project specifications for details.

Any in-water debris encountered on the bottom sediment will be removed by barge-mounted dredge cranes and/or excavators using various types of attachments such as grapples and clamshells as necessary. Debris in Dark Head Cove was evaluated during the high-resolution multi-beam bathymetric survey in 2010. The survey indicated a submerged car, some possibly dumped materials, and a few mounds within the removal area. The submerged car was found by a fisherman at about 15 feet off the bulkhead, at the northeast corner of Dark Head Cove. The Baltimore County dive team identified it as a 1980 Mazda; the pulled-off tag expired in 1983 (Morgan, 2013). Debris in Dark Head Cove will be placed on a barge and transported to the staging area pending its evaluation for recycling or disposal.

Images of the debris are in Appendix A; Table 3-4 contains a summary of debris. The survey also identified a few mounds that were likely once used to support now-removed docks and structures. The mounds and other protrusions from the mudline within the removal area are accounted for in the estimated removal quantities. A few soil piles were identified in front and west of Outfall 007 that were formed due to erosion behind the deteriorated bulkhead. These soil piles are not located within the removal area. During debris handling operations in Dark Head Cove, up to 100 cy volume of soil piles will be removed. Removed soil debris will be disposed along with the rest of the dredged sediment.

Two recycling facilities have been identified near the project site that will accept debris collected from the excavation and dredging. The first is the local residential recycling center, the Eastern Sanitary Landfill Solid Waste Management Facility in White Marsh, Maryland. It accepts clean concrete and commercial waste from projects within Baltimore County. The second facility is the Honeygo Run Reclamation Center, a private landfill/reclamation center in Perry Hall, Maryland; it accepts construction debris from commercial project sites. Additional recycling locations can be considered if proposed by the contractor.

3.8 POST-CONSTRUCTION ACTIVITIES

Post-construction activities are actions that must be performed to complete demobilization from the project site. Some post-construction activities can, to some degree, be performed during project operations. The following activities will be required after completion of all remediation operations:

- ***Silt curtain removal:*** Silt curtains will be removed.
- ***Waste transport and disposal:*** Waste generated during decontamination and dismantling of the dewatering pads will need disposal/transport, as will the removed and dewatered sediment. To the extent possible, materials and supplies will be recycled or repurposed for further use. However, some waste, such as used liners, will require appropriate designation and proper disposal.
- ***Decontamination operations:*** Construction equipment and reusable materials must be decontaminated before returning to rental suppliers or releasing for other use. Potentially contaminated sediment must be thoroughly removed from all surfaces while on-site, to prevent the release of contaminated materials. Additionally, some water filtration equipment might require removal of contaminated media upon its return to the vendor's facility.
- ***Water treatment system removal:*** Components of the water treatment system will have to be thoroughly drained to remove residual water. Once drained, all interconnecting pumps, pipes, and hoses can be removed. The system components can then be tested for contamination, subjected to additional decontamination if necessary, and returned to the equipment supplier.
- ***Dewatering pad(s) removal:*** The dewatering pads can be dismantled once all potentially contaminated sediment has been removed and decontamination has been completed. Reusable materials (such as jersey barriers) can be repurposed and released for other use. The asphalt or compacted aggregate work surface, if appropriately decontaminated, can be kept or physically removed and recycled. The gravel layer can also, to some extent, likely be removed and released for other use, and the remaining gravel and geotextile materials can be removed and disposed of as waste.
- ***Site restoration:*** When all equipment, materials, and supplies have been removed, the site can then be restored and returned to its previous use. Site lots used as staging areas will likely require no further restoration. Any disturbed ground surface during sediment offloading operations (i.e., grass strip between the tarmac and the bulkhead) will require additional restoration. Such restoration will include vegetation and temporary erosion controls until vegetation becomes established. No upland disturbance associated with storm drain plugging and cleanout is anticipated. Site restoration activities will also include implications of any spill as follows:
    - Where spillage of any contaminated material onto unprotected ground has occurred, spilled material will be cleaned and the location marked for final testing before demobilization.
    - Where protective liners are removed, such as those used in the dewatering pads and spill protection areas, the liner will be inspected for holes and tears. Those locations

will be surveyed or marked and the underlying soil shall be tested and, if necessary, disposed of before demobilization is complete.

  - Where underlying soil, including sand shows staining or other evidence of leakage the soil shall be tested and, if necessary, disposed of before demobilization is complete.

- ***Demobilization:*** Remaining construction equipment and temporary office facilities will be removed, including any infrastructure and utility connections. Any construction-related temporary signs and fences would be removed. Construction access and other disturbed areas will be restored.

- ***Monitoring:*** Long-term monitoring of *in situ* treatment areas in Dark Head Cove and restored areas in Cow Pen Creek will be initiated after construction is complete. Periodic inspections will monitor erosion or other losses of slope stability in restored areas of the creek. Inspections will be performed after heavy rains, storms, or at high tide because of the increased potential for material loss or other disruptions during such events. Refer to the Long-term Monitoring and Maintenance Plan submitted under separate cover.

Table 3-1a

Cow Pen Creek Remediation Volume Estimates

*Cow Pen Creek—Removal by excavation (5.9 acres)**		
Action/Location	**Depth (feet)**	**Volume (cubic yards)**
Removal (Station 8+00 to 31+10)	Up to 6 feet deep, 2 feet to -7 feet (mean lower low water)	23,600
Overdredge (3-inch)	0.25	2,350
Residuals-management layer (Station 19+00 to 31+00)	0.5	2,750
Streambed Mix (Station 8+00 to 19+00)	0.5	200
Backfill Stream and Floodplain Reconstruction (Station 8+00 to 19+00)	Varies	3,200
Wetland Bench Construction (Station 19+00 to 25+50)	Varies	1,600
*Cow Pen Creek—Removal by dredging (1.2 acre)**		
Action/Location	**Depth (feet)**	**Volume (cubic yards)**
Removal (Station 30+80 to 34+00)	Up to 7.5 feet, -5 to -13 feet (mean lower-low water)	4,600
Overdredge (6-inch)	0.5	950
Residuals-management layer	0.5	700
Cow Pen Creek—Total removal (7.1 acre)		
Total removal area	7.1 acres	28,200
Total overdredge	—	3,300
Total residuals-management layer	—	3,500

*Note that the dredge line (i.e. the anticipated boundary between excavation and dredge in Cow Pen Creek) and associated dredge volume as indicated in Figure 1-3 is subject to change based on the construction Contractor’s removal approach. Total removal volume in Cow Pen Creek will remain the same.

Table 3-1b

Dark Head Cove Remediation Volume Estimates

Dark Head Cove—Removal by dredging (3.2 acres)		
Action/Location	**Depth (feet)**	**Volume (cubic yards)**
Dredge Area A (0.7 acre)	-13.5 feet to -14.5 feet	3,500
Dredge Area B (1.2 acre)	-12.0 feet	3,750
Dredge Area C (0.4 acre)	-11.0 feet	1,200
Dredge Area D (0.8 acre)	-10.5 feet	3,950
Dark Head Cove—Total removal (3.2 acres)		
Removal	Up to 7 feet deep, -10.5 feet to -14.5 feet (mean lower-low water)	12,400
Overdredge	0.5	2,520
Dark Head Cove—Total residual management layer area (4.4 acres)		
Residuals-management layer (including Outfall 005 area)	0.5	2,650

Table 3-2

Maximum Allowable Noise Level for Receiving Land Use Categories

Day/Night	Industrial (dBA)	Commercial (dBA)	Residential (dBA)
Day	75	67	65
Night	75	62	55

Source: State of Maryland Environment Article, Title 3-101 and COMAR, Title 26.02.03

Table 3-3

Debris Survey in Cow Pen Creek

Page 1 of 3

Debris type	Closest station	Dimensions/notes	Action
Pier pilings	34+50	Approximately 24 vertical piles from former pier	No action; outside of removal area
Concrete rubble	34+00	Approximately 700 square feet, along approximately 80 feet of the north bank	No action; outside of removal area
Tree debris	33+00	Tree trunks and branches embedded in sediment along the north bank	No action; outside of removal area
Fallen utility pole	30+00	30-foot utility pole parallel to the creek in the floodplain	No action; outside of removal area
Boulders and tree debris	26+00	Seven large boulders and one tree trunk along north bank	Return to bank to preserve stability after excavation
24-inch corrugated metal pipe	26+00	Storm-drain outfall	No action; outside of removal area
Post	25+00	Scattered poles, 2–3 inches in diameter, of mixed type (metal and wood) extending five feet from the sediment	Remove, recycle, dispose
Wooden pier	25+00	3-foot by 5-foot square area on south bank	Preserve
Tree debris	24+00	Quantity unknown	Reuse above mudline parts as habitat. Remove, recycle, and dispose of parts below mudline.
12-inch and four-inch corrugated metal pipe and chain-link fence	24+00	12-inch and 4-inch corrugated metal pipe storm drain pipes under a chainlink fence	No action; outside of removal area

Table 3-3

Debris Survey in Cow Pen Creek
Page 2 of 3

Debris type	Closest station	Dimensions/notes	Action
12-inch reinforced concrete pipe debris	23+00	12-inch cement pipe or culvert, approximately four feet long	No action; outside of removal area
Concrete rubble	22+00	600 square foot pile of broken concrete along north bank	Remove, recycle, dispose
Scattered concrete/asphalt rubble	19+00 to 22+00	6,400 square foot area of small broken pieces along the north bank extending into the middle of the creek	Remove, recycle, and dispose. This area may require additional excavation under debris and backfill of bank. Refer to the design drawings and project specifications.
15-inch corrugated- metal pipe	21+00	Storm-drain outfall	No action; outside of removal area
Tree debris	20+50	Quantity unknown; two locations	Reuse above-mudline parts as habitat; remove, recycle, and dispose of parts below mudline
42-inch corrugated-metal pipe	19+00	Large metal culvert adjacent to a standing tree	No action; outside of removal area
Tree debris	18+50	Quantity unknown	Reuse above mudline parts as habitat; remove, recycle, and dispose of parts below mudline
36-inch reinforced-concrete pipe debris	16+00	A 36-inch cement pipe or culvert, approximately four feet long	No action; outside of removal area
Concrete rubble	15+00	Large concrete blocks buried under plants and soil along north bank	Remove, recycle, dispose
Fallen tree	15+00	A 36-inch-thick tree lying across the creek, approximately 90 feet long	Reuse above mudline parts as habitat; remove, recycle, and dispose of parts below mudline.
Wood/stone debris	14+00	100 square foot area in the creek	Place along the bank to stabilize it
Stone debris	14+00	Stone scattered throughout creek	Place along the bank to stabilize it
Stone wall/foundation	12+00	80 square foot area along south bank	No action; outside of removal area
Fallen utility poles	12+00	Two 15-foot-long utility poles	Remove, recycle, dispose
Stone debris	12+00	Stone scattered throughout creek	Reuse for habitat

Table 3-3

Debris Survey in Cow Pen Creek
Page 3 of 3

Debris type	Closest station	Dimensions/notes	Action
Floodplain clearing	12+00 to 19+00	Approximately 17 trees to be removed in conjunction with sediment removal	Reuse above mudline parts as habitat; remove, recycle, and dispose of parts below mudline.
Riprap	11+00	Along the south bank	Preserve
Cement stairs and debris	10+00	52.5 square foot area in creek	Preserve
18-inch corrugated-metal pipe	10+00	18-inch corrugated metal storm-drain pipe along south bank	Preserve or repair/replace after excavation
24-inch reinforced-concrete pipe	10+00	24-inch reinforced-concrete pipe storm-drain along south bank	Preserve or repair/replace after excavation
24-inch Advanced Drainage System drain	10+00	24-inch Advanced Drainage System storm-drain pipe along south bank	No action; outside of removal area
Tires, metal pipe, mattress	8+00	Two tires, a small metal pipe, and a discarded mattress of unknown size	Remove, recycle, dispose
Lumber	8+00	Two-foot by six-foot piece of lumber and several posts	Remove, recycle, dispose

Table 3-4

Debris Survey in Dark Head Cove

Debris type	Closest station	Dimensions/notes	Action
Vehicle	26+00	1980 Mazda. Target #1 in Appendix A3	Pull off for recycling/disposal
Soil piles	23+00	Target #2	Removal and disposal of up to 100 cy of soil piles
Soil piles	18+00	Target #3	No action. Part of *in situ* treatment area
Two mounds (sediment mounds or possible debris)	4+50	Target #4	Part of removal area

NOTES:

1. EXCAVATION AREA: 5.9 ACRES (2FT TO -7FT MEAN LOWER LOW WATER (MLLW))
   EXCAVATION VOLUME: 23,600 CY.
2. DREDGE AREA: 1.2 ACRES (-5 TO -13FT MLLW), REMOVE VOLUME: 4,600 CY.
3. CONTRACTOR WILL FIELD VERIFY STAGING AREA AND ASSOCIATED FEATURES.

LEGEND:

- BANKFULL/MHHW
- REMOVAL BOUNDARY
- APPROXIMATE LIMIT OF EXCAVATION AND DREDGING
- TRUCK ROUTE
- STAGING AREA
- REMOVAL CONTOUR
- STORM DRAIN OUTFALL
- SD — STORM DRAIN SYSTEM

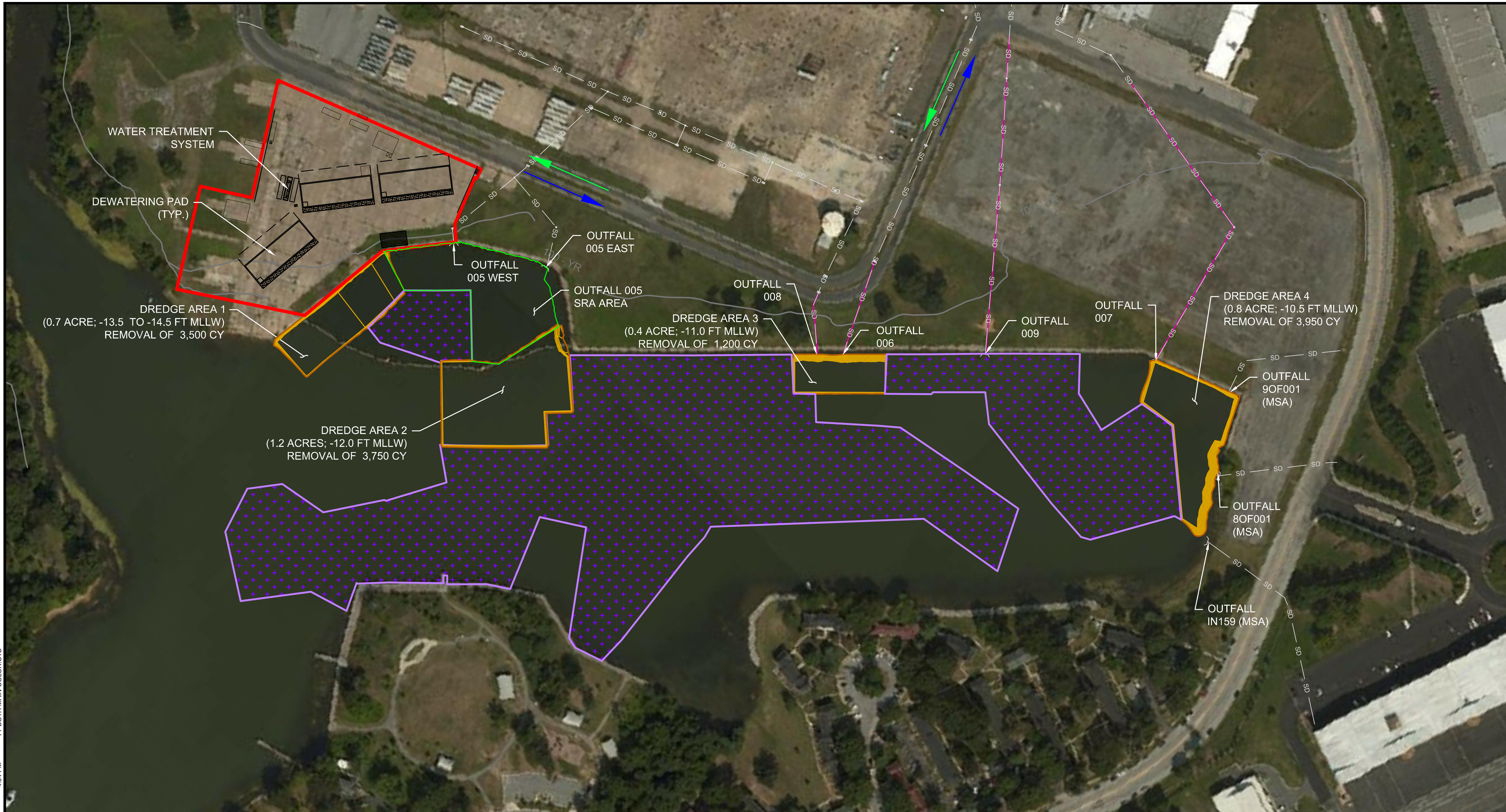
TETRA TECH

0' 200' 400'

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

FIGURE 3-1
COW PEN CREEK
SEDIMENT REMEDY

Z:\PROJECTS\LOCKHEED - MIDDLE RIVER COMPLEX\BODR 60% FIGURES\FIGURE 3-1 OVERVIEW OF PROJECT ELEMENTS - CPC.DWG
PLOT DETAILS: JOBMANN, AMANDA October 29, 2015 4:02 PM TT-BOTH-MAIN-COLOR.CTB



NOTES:

1. DREDGE AREA: 3.2 ACRES (-10.5FT TO -14.5FT MEAN LOWER LOW WATER (MLLW)). REMOVAL VOLUME: 12,400 CY.
2. IN SITU TREATMENT AREA: 13.7 ACRES.
3. STORM DRAIN CLEANING: 1,880FT.
4. CONTRACTOR WILL FIELD VERIFY STAGING AREA AND ASSOCIATED FEATURES.

SRA = SEDIMENT REMOVAL ACTION

LEGEND:

- REMOVAL BOUNDARY
- DREDGE SURFACE CONTOUR
- STORM DRAIN OUTFALL
- *IN SITU* TREATMENT AREA
- STORM DRAIN SYSTEM
- STORM DRAINS TO BE CLEANED
- TRUCK ROUTE
- STAGING AREA
- SRA BOUNDARY

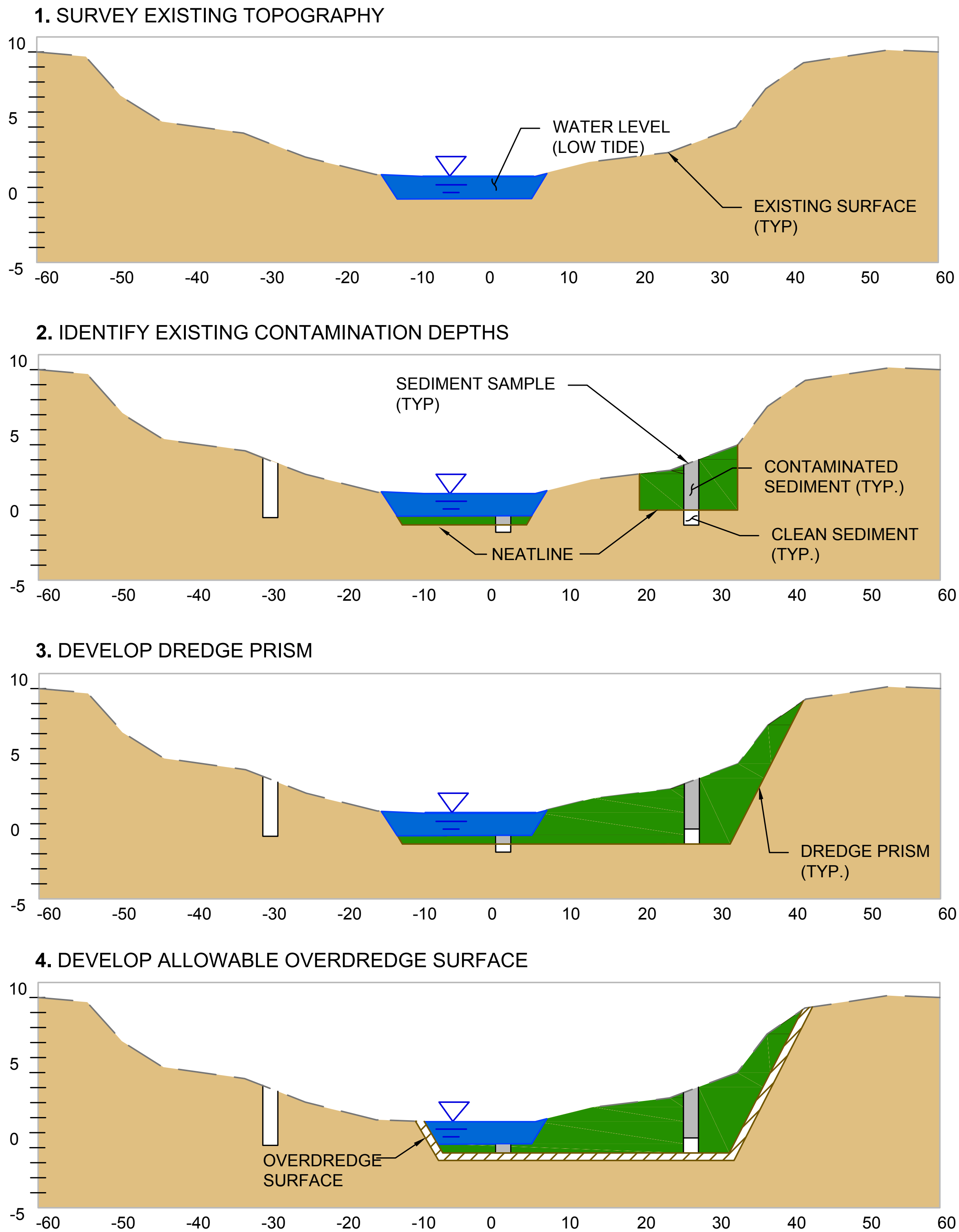
TETRA TECH

N

0' 200' 400'

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

FIGURE 3-2
DARK HEAD COVE
SEDIMENT REMEDY



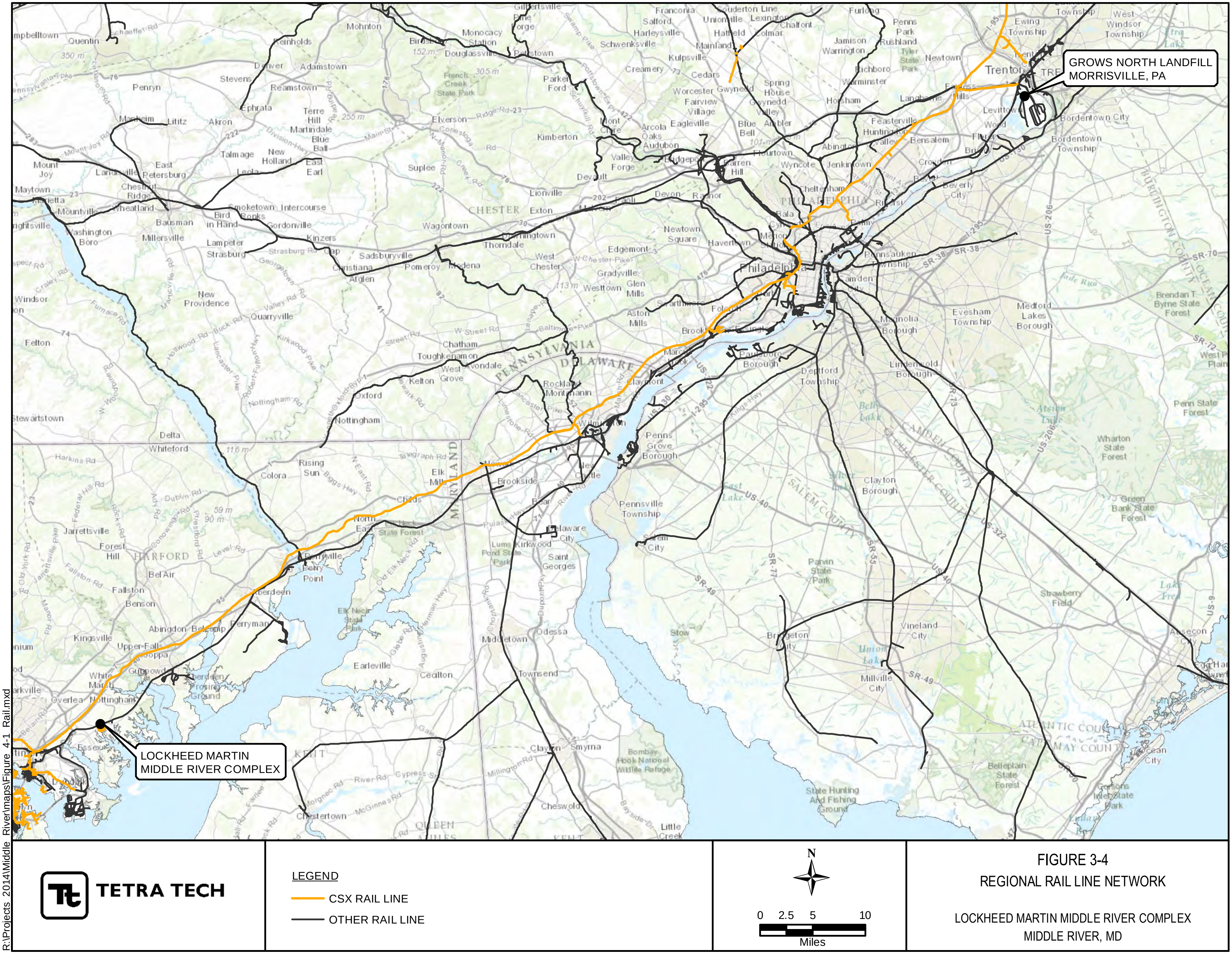
DREDGE PRISM DESIGN STEPS:

1. IDENTIFY EXISTING CONDITIONS: TOPOGRAPHY, GEOMORPHOLOGY, HYDRAULICS, GEOTECHNICAL, ETC.
2. SEDIMENT SAMPLING TO DETERMINE CONTAMINATION DEPTHS. DEVELOP NEATLINE AT DEPTH OF KNOWN CONTAMINATION
3. EXPAND REMOVAL SURFACE TO REPRESENTATIVE CONTAMINATION AREAS.
4. DEVELOP ALLOWABLE OVERDREDGE SURFACE

TETRA TECH

LOCKHEED MARTIN
MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

Figure 3-3
Dredge Prism Design Steps



TETRA TECH

FIGURE 3-4
REGIONAL RAIL LINE NETWORK

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

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Section 4

In Situ Treatment in Dark Head Cove

Contaminated sediment in the approximately 13.7 acre of Dark Head Cove will be remedied by *in situ* treatment (Figure 3-2). Powdered activated carbon will be the active amendment added to the sediment. This section presents details of the *in situ* treatment of contaminated sediment in Dark Head Cove.

4.1 TREATABILITY TESTING

In 2013, bulk sediment samples were collected from four locations during pre-design investigation work for laboratory treatability studies. The objective of the laboratory treatability studies was to determine the effectiveness of adding carbon-based amendments to reduce the concentrations and bioavailability of contaminants in sediment pore water. Treatability studies were performed to help identify the most effective type of amendment for reducing polychlorinated biphenyl (PCB) and polycyclic aromatic hydrocarbon (PAH) concentrations in sediment pore water and determine the effectiveness of selected amendments to reduce uptake of PCBs and PAHs by benthic organisms.

4.1.1 Selection of *In Situ* Amendment

Recent work has demonstrated that contaminant bioavailability in sediment can be reduced by amending the sediment with suitable sorbents (Beckingham and Ghosh, 2011; Ghosh et al., 2011). The impact (response) of a receptor (organism) is dependent on a contaminant’s toxicity and the dose (amount introduced) to the receptor. A primary route of contaminant exposure for aquatic organisms is through the dissolved phase (pore water and surface water). Reducing the dissolved phase concentration and the bioavailability of a contaminant can be an effective remedial strategy at contaminated sediment sites.

Sediment treatability study: Site sediment was used in site-specific studies to test the effectiveness of several carbon-based amendments at reducing contaminant bioavailability. The amendments evaluated in the treatability study include powdered activated-carbon (PAC), granular activated-carbon (GAC), biochar, organoclay, and coke. A treatability study assessed the reductions in PAH and PCB concentrations in both pore water and in the uptake by benthic organism that were achieved by various carbon-based amendments, with the following methodology and the results:

- Measurement of PCB/PAH concentrations in untreated sediment and pore water: Four sediment samples collected at the site were analyzed in triplicate for PCB congeners and PAHs (16 United States Environmental Protection Agency [USEPA] priority pollutant PAHs). The sediment samples were also analyzed for total organic carbon and native black carbon. Two sediment samples with PCB concentrations representative of areas where *in situ* treatment is proposed were selected for pore-water measurements, performed in triplicate at the laboratory using passive equilibrium samplers. These measurements are the baseline for comparison after treatment with sorbent amendments.

- Amendment of PCB/PAH-impacted sediment using a range of sorbent amendments (PAC, GAC, organoclay, biochar, and coke): This study included two site sediment samples. A portion of each sediment batch was amended with a 2% dose of PAC, or with a 5% dose of PAC, GAC, organoclay, biochar, or coke. These six treatments plus an untreated control for each batch were carried out in triplicate. The amended sediments were allowed to equilibrate for one month before use in equilibrium and bioavailability assessments.

- Measurement of PCB/PAH pore water concentration after treatment: Pore water PCB/PAH concentrations in treated and untreated sediment were measured to assess changes in PCB/PAH-partitioning after treatment with the range of sorbents. These measurements were conducted in triplicate and used a passive sampling technique to measure pore water. Treatment study data show that the highest reductions in PCB pore water concentrations were achieved using 5% PAC and the biochar (94.9–99.5% and 99.6–99.8%, respectively). Reduction in pore water concentrations for the other amendments was lower: 67–81.6% for GAC, 36.6–58.2% for organoclay, and 36.3–40.3% for coke. Refer to Figure 4-1 for graphical presentation of the results.

Bioaccumulation studies with treated and untreated sediment: The most effective amendments (5% PAC and biochar) were selected for laboratory bioaccumulation-assays using a freshwater oligochaete (i.e., worms). The bioaccumulation studies followed standard test guidelines and evaluated the amendments' effectiveness at reducing biological uptake of PCBs and PAHs in organisms near the base of the benthic food-chain. Each of the two sediment samples was dosed with selected sorbents (PAC and biochar) at 5% by dry weight. Bioaccumulation assessments were conducted in quadruplicate. The results of the bioaccumulation study showed reductions of greater than 95.7% for biochar and greater than 93.4% for PAC in the uptake of PCBs by fresh water oligochaetes (*Lumbriculus variegatus*). Refer to Figure 4-2.

4.1.2 *In Situ* Amendment Volume and Application Areas

In situ treatment will be applied to the approximately 13.7-acre area in Dark Head Cove primarily to address PCB contamination in the surface sediments above 0.676 mg/kg and below 2.7 mg/kg. The *in situ* treatment will also reduce the bioavailability of PAHs. The application areas are shown on Figure 3-2 and on the design drawings. Based on the treatability test results, *in situ* amendment will be added to the top 10 centimeters (cm) of sediment at 5% by dry weight. This application rate results in an *in situ* amendment mass for activated carbon of about 18 tons/acre using a site specific dry unit weight of 36 pounds per cubic foot (pcf). Approximately 250 tons of PAC will be placed in Dark Head Cove.

4.1.3 *In Situ* Treatment Effectiveness

Reductions in PCBs and PAHs pore water concentrations were conservatively estimated at 50% in the feasibility study (FS). The PCB cleanup goal for benthic organisms in sediment is 0.676 milligram per kilogram (mg/kg). Achievement of this cleanup goal is based on a point-based location to protect benthic organisms in sediment. The treatability study results demonstrated that the reduction in sediment pore water concentrations when adding 5% by dry weight of PAC or biochar is greater than 90%, and in most tests greater than 95% (see Figures 4-1 and 4-2). Reductions in pore water concentration and bioavailability from the application of the *in situ* amendment in the field will have a higher level of variability than for the treatability study with well-mixed sediments conducted under controlled conditions in a laboratory. Results from the pilot studies conducted on the Grasse River sediments (Beckingham and Ghosh, 2011) found reductions in PCB bioaccumulation between 69 and 95% one year after the application of activated carbon. Results from the Grasse River study have also found that over longer time periods (three years) the reductions in bioaccumulation increase with the longer exposure of PCBs to activated carbon.

At MRC, *in situ* treatment will use activated carbon which preferentially binds PCBs, resulting in a reduction in worm tissue PCB concentrations and sediment pore water concentrations compared to baseline. The reduction in pore water concentrations or worm tissue does not have a direct relationship to bulk sediment concentrations and to the site point based cleanup goal of 0.676 mg/kg and therefore, direct bulk sediment analyses cannot be used to confirm the effectiveness of the remedy towards meeting remedial action objectives (RAOs). The reduction in worm tissue and pore water PCB concentrations will be used as a surrogate to measure remedy effectiveness. The goals for the *in situ* treatment of MRC sediment will be a reduction of 70% for tissue by the bioaccumulation testing and a reduction of 80% for the pore water measurements. These are not numerical criteria that must be met for final approval of the in situ remedy or to determine if contingent actions would be necessary following remedy implementation. Rather, these goals for the *in situ* remediation will be evaluated to develop a weight of evidence that will be considered in the *in situ* treatment effectiveness evaluation.

The treatability study results (i.e., >90% reductions in pore water and biological uptake) suggest that the *in situ* amendment effectiveness will achieve the cleanup goals. Based on the state of the science and uncertainty going from the laboratory to the field, a 70% reduction in worm tissue and 80% reduction in sediment pore water concentrations was selected as the design criterion. *In situ* treatment effectiveness based on the selected design criterion would leave a 0.3 acre of an area with PCB concentrations greater than the cleanup goal for benthic organisms, which would require monitored natural recovery (MNR). Refer to Appendix D for the *in situ* effectiveness estimates in Dark Head Cove and Section 5 for MNR estimates.

4.2 *IN SITU* TREATMENT APPLICATION

The *in situ* treatment material will be added using a barge- or vessel-mounted spreader or equipment approved for use after a pilot demonstration. Natural processes such as physical mixing during placement and bioturbation following placement will be used to mix the *in situ* treatment material with surface sediments.

4.2.1 *In Situ* Amendment Materials

The active *in situ* treatment ingredient within amendment material will be powdered activated carbon (PAC). The amount of carbon-based *in situ* active ingredient (i.e, PAC) to be placed over surface sediment in Dark Head Cove to meet the target 5% by dry weight is 250 tons. The two commercially available products for delivery of powdered activated carbon to the sediment are: SediMite™ (manufactured by Sediment Solutions) or AquaGate+PAC™ (manufactured by AquaBlok, Ltd.). Both products bind the PAC to an aggregate material to make heavier particles that will settle through the water column to the sediment surface, maximizing the efficiency of placement in the targeted treatment areas. Over time, after placement, the activated carbon disaggregates and mixes into the biologically active layer of the sediment. Both products have been demonstrated to be effective in delivering PAC to the sediment through the water column (refer Section 4.2.2).

The *in situ* amendment will be applied in a manner and form that will readily transfer through the water column to the sediment surface. After placement, the *in situ* amendment will be allowed to mix into surface sediment via bioturbation by benthic organisms and burrowing organisms and other natural sediment mixing processes.

In situ amendments will be shipped in bulk to the site by truck or in super sacks or similar packaging. On-site, the *in situ* amendment material will be stored in a lined area and covered if delivered in bulk. Amendment delivered in super sacks or similar packaging will be stored in an area of adequate size until loaded for delivery to the barge for placement. Samples of the delivered *in situ* amendment material will be tested before placement in the sediment. Samples will be collected to verify the content of the active material.

4.2.2 *In Situ* Amendment Application Method and Equipment

In situ amendment will be placed on the sediment surface in the areas of Dark Head Cove identified for *in situ* amendment application using barge- or vessel-mounted equipment. The vessel-mounted equipment (e.g., telebelt or spreader) will place material at a constantly measured rate to ensure that the correct amount of amendment is placed into the water column. Acceptable placement methods include broadcast spreaders, conveyor systems, hydraulic pumping and placement with the use of diffusers or tremies, and the excavator bucket or clamshell release of material just above the receiving water surface. The material will be spread over the water's surface and allowed to sink through the water column to the sediment surface forming a thin layer (e.g., less than 1 inch) before being incorporated into the sediment.

The largest application of SediMite™ was performed in a 5-acre lake in Dover, Delaware in 2013 (Cargill, 2015). The majority of the application was performed using a tele-belt. Near-shore, difficult to reach areas were applied using an air horn, vortex machine, and hand broadcast. An optimum dose of target 3 to 5% by dry weight was achieved. AquaGate+PAC™ Material has been applied with a wide range of conventional equipment (i.e. excavators, stone slingers, Telebelt, etc.). Applications include Upper Canal Creek, Aberdeen, Maryland (using pneumatic spreader, bark blower, hydroseeder); Puget Sound Shipyard, Bremerton, Washington in 2012 (using telebelt);

Passaic River Mile 10.9, Newark, New Jersey in 2013 (using telebelt); and Little Creek, Norfolk, Virginia in 2013 (using pneumatic spreader).

A recent application at Lake Machado Restoration Project in Los Angeles, California used roller drum spreading technique. A fabricated 20 foot wide roller drum staged on a portable barge dispersed material stored in a 37 ton hopper bin consistently and reliably. The thickness of the lift placed on the mudline surface was monitored by an onboard computer equipped with software similar to Hypack. Approximately 40,000 tons of AquaBlok, Ltd. product was placed in 3 lifts of 2 inches each over a 20 acre footprint. Not a single location failed the tolerance of +/- 1 inch according to the Project Manager for the City of Los Angeles (Prada, 2016).

The experience gained over the number of applications performed provide a high level of confidence in placement uniformity and ability to achieve relatively tight tolerances (Patmont et al., 2014).

4.3 CONFIRMATION SAMPLING OF AREAS RECEIVING *IN SITU* TREATMENT

Post-placement confirmation sampling of areas undergoing *in situ* treatment will be conducted after placement operations are complete to ensure that adequate amendment has been placed in the surface sediment. Verification of the *in situ* material placement will be done by collecting samples for visual measurements and by collection of 15 samples per acre for measurement of total organic carbon and black carbon to ensure that the target loading to the sediment is achieved and is consistently within acceptable limits. Post-placement confirmation-sampling results will be compared to the target amounts required for the *in situ* amendment. Corrective action will be taken if the measured amount of *in situ* amendment fails to meet performance requirements. Post-placement contingency actions could include:

- Monitored natural recovery
- Additional sampling to verify the accuracy of the initial sampling data
- Additional placement of *in situ* amendment material (if appropriate)

A confirmation-sampling plan and the need for additional response actions to address post-placement inaccuracies is provided in the Construction Quality Assurance Plan. The *in situ* confirmation sampling will include at a minimum the following elements:

- Means and methods to confirm the amount of amendment placed by sampling and analysis of sediment carbon content and carbon type
- Means and methods to confirm the distribution of the amendment placement

Measurements of the effectiveness of the *in situ* amendment will be part of the long-term monitoring at the site. An initial period of time (e.g., at least one year) will be required for the amendment to mix into the sediment and be in contact with the contaminants to have a measureable impact on the pore water concentrations and to see a measureable reduction in tissue concentrations. Additional details on the effectiveness monitoring is provided in the Long-term Monitoring and Maintenance Plan.

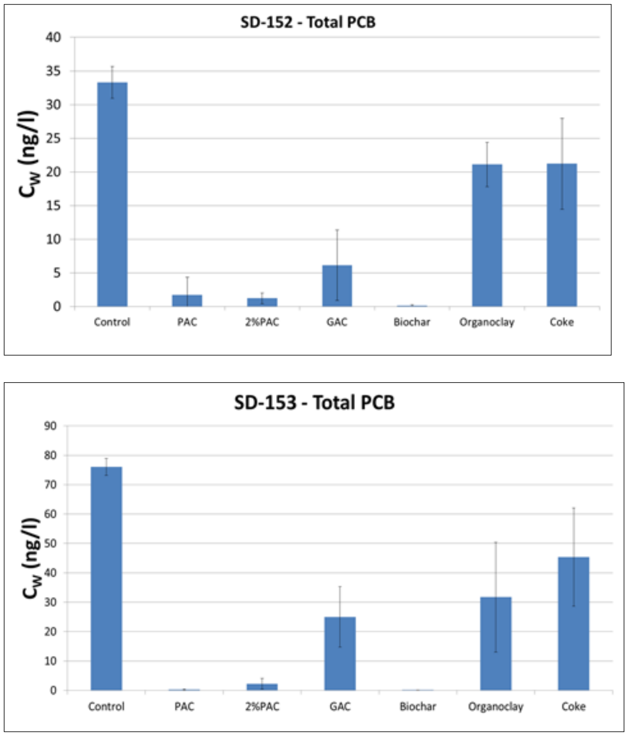

Figure 4-1. Reduction in Polychlorinated Biphenyl Pore Water Concentrations with Amendments

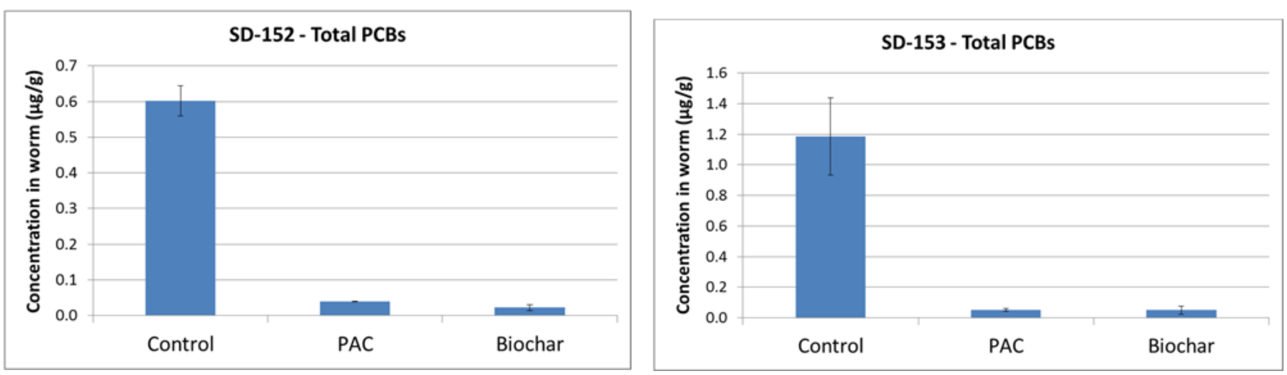

Figure 4-2. Reduction in Bioaccumulation of Polychlorinated Biphenyls in Oligochaete (Worm) Tissue with Amendments

Section 5

Monitored Natural Recovery at Dark Head Cove

The remedy proposed for implementation in Dark Head Cove includes monitoring the natural recovery of sediment as a supplemental remedial technology at locations where *in situ* amendment will be applied, and where long-term monitoring indicates that *in situ* treatment has not sufficiently reduced bioavailability. As discussed in Section 3, monitored natural recovery (MNR) has been retained as a contingency action in the long-term monitoring plan. This section describes natural recovery rate estimates for the site and the role of natural recovery in achieving cleanup goals in Dark Head Cove.

MNR relies on natural processes to return sediment concentrations to background levels. MNR requires an adequate sedimentation rate and deposition of less contaminated sediment over existing sediment to reduce surface concentrations and meet cleanup goals within a specified period, usually within 10–30 years. Sedimentation-rate analyses for Dark Head Cove, Cow Pen Creek, and the confluence of the two water bodies downstream of the site indicate that the highest sedimentation rates are expected in the confluence of Dark Head Cove and Cow Pen Creek, downstream of the site (approximately 1.1 to 1.7 centimeters per year [cm/yr]).

Sedimentation rates in Dark Head Cove and at the mouth of Cow Pen Creek are between 0.8 to 0.99 cm/yr and 0.3 to 0.51 cm/yr, respectively (Tetra Tech, 2011b). MNR assumes a quasi-steady-state equilibrium condition of continual mixing between the newly deposited layer and the underlying sediment through bioturbation and other physical mixing processes that can reduce contaminant concentrations in the biologically active zone. It is assumed that 15 centimeters (cm) of sedimentation would be required to achieve a 50% reduction in surface contaminant concentrations. The average time needed to achieve this 50% reduction in concentrations of chemicals of concern (COC) (i.e., intrinsic half-time) through natural sedimentation is typically approximated by exponential-decay curves. The intrinsic half-times for a 15-cm-deep mixed layer associated with an average deposition rate of 0.8 cm/year is estimated as 13 years for Dark Head

Cove (Tetra Tech, 2011b). Based on *in situ* treatment effectiveness (i.e., 70% reduction in sediment pore water concentrations) approximately 0.3 acre of an area would have PCB concentrations greater than the cleanup goal for benthic organisms one year after placement of the *in situ* amendment and would require three years of MNR. Refer to Appendix D for the MNR evaluations in Dark Head Cove.

Section 6

Storm-Drain Cleanout in Block D and E

The conceptual site model developed during environmental investigations at the Middle River Complex (MRC) indicates that polychlorinated biphenyls (PCBs) have been released in Tax Block E and transported through the storm-drain system into Dark Head Cove. An interim remedial measure (IRM) for the Tax Block E storm-drain system was completed in 2011 to minimize transport of contaminated sediment to off-site locations (Tetra Tech, 2012c). This design includes a provision to clean up possibly contaminated sediments from the interior of the storm drains that drain Block E and Block D at the MRC. These drains discharge storm water through Outfalls 006, 007, 008, and 009 to Dark Head Cove (Figure 3-2). Outfalls 005 East and 005 West were cleaned out during the Outfall 005 sediment removal action (SRA) in 2015.

6.1 STORM DRAIN COMPONENTS

The current storm drain system consists of groups of surface water inlets (IL) (e.g., grated drains), catch basins (CB), manholes (MH), and underground pipes. Refer to the design drawings to review the Block D and E storm drain components. The storm drain system discharges to Dark Head Cove via five outfall systems: Outfalls 005, 006, 007, 008, and 009. These outfall systems are explained below.

6.1.1 Outfall 005 System

The Outfall 005 system drains surface water from the southern portion of Block E via two parallel lines consisting of a series of inlets and manholes. The system was cleaned up during the Outfall 005 SRA (Tetra Tech, 2015).

6.1.2 Outfall 006 System

The Outfall 006 system drains surface water from the northern portion of Block E via a series of inlets. Pipe sizes range from 15 inches in diameter at upstream CB-11 to 30 inches in diameter at downstream inlet IL-25 to Outfall 006. This system discharges to Dark Head Cove via Outfall 006. The upper line segments of the Outfall 006 system to IL-25 were cleaned in 2011 as part of the IRM. The subject of this design is the segment from IL-25 to Outfall 006, about 200 feet.

6.1.3 Outfall 007 System

The portion of the Outfall 007 system to be cleaned up is from a manhole located at Dark Head Cove road to Outfall 007, about 700 feet length of 48-inch-diameter corrugated metal pipe.

6.1.4 Outfall 008 System

The Outfall 008 system runs north–south and drains surface water from the eastern portion of Block E via a series of inlets and pipes beginning at upstream inlet IL-7 in the east–central portion of Block E. Pipe sizes range from 15 inches in diameter at upstream inlet IL-7 to 24 inches in diameter from IL-1 to Outfall 008. This system discharges to Dark Head Cove via Outfall 008. The upper line segments of the Outfall 008 system to IL-1were cleaned in 2011. The subject of this design is the 110-foot segment from IL-1 to Outfall 008.

6.1.5 Outfall 009 System

The portion of the Outfall 009 system to be cleaned up is from MH 11 located at Block D to the Outfall 009, about 360 feet length of 24inch-diameter corrugated metal pipe.

6.2 PREVIOUS STORM-DRAIN CLEANUP ACTIVITIES

This section describes storm-drain cleanup efforts to date in Block E and during the Outfall 005 SRA. Refer to the *Block E Storm Drain System Interim Remedial Measures (IRM) Final Site Remediation Report* and D*raft Construction Completion Report Outfall 005 Sediment Removal Action* for details of these previous efforts (Tetra Tech, 2012c and 2015).

IRM on-site activities were completed in September 2011. Temporary plugs were installed before cleaning each pipe segment to prevent sediment/debris and water from discharging into Dark Head Cove, and to keep the previously cleaned downstream segments clean. Cleaning generally began at the farthest downstream segment of each storm-drain-outfall system and progressed upstream along the line. Cleaning involved inserting a jet nozzle into the downstream structure and propelling it toward the upstream structure. As the nozzle was pulled back, liquid and solid material was vacuumed into a jet-vacuum truck. All solid, semi-solid, and liquid material resulting from cleaning was removed at the downstream manhole of the section being cleaned.

The storm-drain lines were cleaned to restore at least 95% of their original flow capacity. After a pipe segment was cleaned, the mobile closed-circuit television truck was positioned at the upstream structure and a robotic crawler camera equipped with a multi-angle lens was inserted into the drainpipe to video-inspect the downstream structure. All observations were recorded on a computer hard drive; an audio commentary accompanied the video inspection. Once all cleaning and video inspection were complete, the temporary plugs were removed and the operation moved to the next upstream pipe segment. This procedure was repeated until the last pipe segment was reached. All manholes and inlets repaired or replaced during the IRM were documented (Tetra Tech, 2012b).

The lower portion of the Outfall 005 storm-drain system was cleaned out during the Outfall 005 SRA in December 2014. Similar to IRM activities, storm-drain cleanout during the SRA included storm-drain plugging, storm-drain cleaning and video inspection, and handling/disposing of investigation-derived wastes (IDW). Refer to Section 2.3 for further details.

6.3 STORM-DRAIN CLEANUP

Table 6-1 summarizes the storm-drain system cleanout planned for this project. Methods to be used in the storm-drain cleanup are similar to those previously discussed for the IRM and Outfall 005 SRA. Storm-drain-sediment debris is expected to include sediment, sludge, dirt, sand, rocks, concrete fragments, grease, roots, and other solid and semi-solid materials. Mud, vegetation, and debris were observed during studies in 2009 and 2011 (Tetra Tech, 2014b).

The Maryland Department of the Environment (MDE) and the Baltimore County Department of Public Works will be contacted regarding any required permits, and these agencies will be provided with applicable notifications. Work plans related to this cleanup will be submitted to the MDE and the United States Environmental Protection Agency (USEPA) for review before the work begins.

All work will be done from above ground, where possible. If this is not possible, entry will be made in accordance with federal Occupational Safety and Health Administration procedures for confined-space entry. Where necessary, field personnel will establish and maintain sediment and erosion-control measures to minimize turbidity and the transport to surface water of suspended solids and other materials that could degrade water quality, in accordance with the project specifications and environmental protection and erosion-control measures. Both temporary and permanent control measures will be employed, including hay bales around inlets, curb diversion, outfall plugs, roll-off containers for sediment collection, fractionation (frac) tanks for water collection, seeding, and concrete repair.

Field personnel will limit soil and sediment disturbance solely to work areas, to the extent practicable. Temporary control measures will be inspected daily and after each rain. Disturbed areas will be permanently stabilized (to the extent practicable) before control measures are removed.

6.3.1 Storm-Drain-System Cleaning

Storm-drain pipe-systems will be cleaned using a high-pressure water nozzle to move sediment and vacuum extraction to remove the sediment and wash water into a vacuum truck. The water nozzles used for this purpose are configured with multiple rear-facing water jets. The storm-drain pipe segment to be cleaned will be accessed via manhole, catch basin, or other structure. To prevent possibly contaminated sediment from being released during cleaning, an inflatable plug (or suitable alternative control) must be used to contain sediment and wash water within the pipe segment. The water nozzle is typically inserted into the pipe segment to be cleaned at the access structure. The water nozzle is allowed to self-propel from the point of entry to the end of the pipe segment.

As the water nozzle is mechanically withdrawn from the pipe segment, the high-pressure jets force the sediment back toward the point of entry. The moved sediment is then removed using a vactor truck. The vactor-truck vacuum nozzle is placed in the manhole during the cleaning and uses vacuum extraction to remove the wash water and displaced sediment. Multiple passes or evolutions are required for long pipe segments, or for segments heavily laden with debris.

Temporary inflatable plugs will also be installed at the discharge outfalls to prevent water and sediment from entering Dark Head Cove during storm-drain cleaning. The plugs will be inflated to the manufacturer’s recommended pressure. A pressure gauge will be attached to each plug, and pressure readings will be taken approximately every two hours to confirm that the plugs are not leaking.

6.3.2 Repair/Replace Storm Drains, Inlets and Manholes

Although not anticipated for this effort, some repairs to portions of storm drains, the inlets and manholes might be needed. Repairs could include replacing broken sections of storm drains, rebuilding structures using brick, concrete, grout, and/or cast-iron frames and covers. Crushed-stone backfill and concrete or vegetation surfaces will be used as needed to return the repaired structure/location to its original or better condition. All repair work will ensure that debris does not drop into the cleaned drainage system. All repairs will be documented and photographed.

6.3.3 On-Site Water Treatment and Discharge

Water and liquids removed from the storm drains will be transferred from the jet/vacuum trucks into a designated roll-off container for later on-site treatment and discharge. The waste management procedure is summarized in Section 6.4.

6.3.4 Post-Construction Activities

When the cleanup has been completed, all upland disturbed areas will be restored to approximately pre-existing grades. Seed and topsoil will be distributed across all disturbed vegetated areas. Sediment controls, including silt fences and hay bales, will be installed to minimize sediment re-entering cleaned drain lines. Restored areas will be monitored and maintained for one complete growing season, provided the subject areas are not used for storage, continued development, or construction by others within the defined timeline.

6.4 WASTE MANAGEMENT

Cleanup wastes will be handled as IDW in accordance with the waste management plan, and will be properly disposed of off-site. The types of waste generated to date by the overall remediation effort suggest that wastes generated during this cleanup effort will probably consist of sediment, debris, wastewater, and personal protective equipment (PPE). Sediment, debris, and wastewater will be stored in roll-offs (lined with disposable plastic liners) and frac tanks, which will be labeled appropriately. The roll-offs and frac tanks will be staged on the dewatering pad for sampling and waste characterization. PPE waste will be disposed of in solid waste dumpsters at the MRC.

Sediment and debris removed as a result of cleaning the Outfall 006, 007, 008 and 009 storm-drain systems is not expected to have high-level PCBs that would trigger Toxic Substances Control Act (TSCA) regulations (40 *Code of Federal Regulations* [CFR] Part 761.75). Sediment and debris removed from the outfalls will be transported to and disposed of at a Lockheed Martin–approved disposal facility. The Grows North Landfill in Morrisville, Pennsylvania or King and Queen Landfill in King and Queen County, Virginia are currently the designated facilities. Sediment stored in roll-offs will be sampled for all landfill-required analytes before disposal. If TSCA-level PCBs are detected in the sediment, it will be transported via lined and sealed trucks to a Lockheed Martin-approved chemical waste facility permitted under TSCA standards for a chemical waste landfill (e.g., Model City, New York or Deer Park, Texas), after confirmation that the sediment meets the facility's acceptance criteria.

All wastewater from cleaning the storm-drain lines will be transferred from the jet-vacuum truck to a roll-off container designated for decanting, to allow sediment and small debris entrained in the water to settle out. Once the sediment and small debris have settled, the water in these decanting roll-offs will be pumped into the frac tanks using sump pumps. All wastewater stored in the frac tanks will be treated on-site at the wastewater treatment system installed as part of this sediment remedy. Alternatively, the same disposal methodology used in the 2011 IRM can be followed (i.e., pumping out to Clean Harbors [a state-licensed and Lockheed Martin–approved facility] for disposal at its facility in Baltimore, Maryland).

Table 6-1

Storm-Drain-System Cleanup

Structure	Size and construction	September 2011 (construction notes during IRM)
Outfall 006		
Outfall 006	Circular, 30-inch-diameter; concrete	Pipe appears clear of debris. Survey could not be conducted due to flooded pipe.
Pipe: IL-25 to Outfall 006	Circular, 30-inch-diameter; concrete, 200 feet	Survey could not be conducted due to flooded pipe.
Outfall 007		
Outfall 007	Circular, 48-inch-diameter; concrete	n/a
Pipe: MH to Outfall 007	Circular, 48-inch-diameter; concrete, 700 feet	n/a
Outfall 008		
Outfall 008	Circular, 24-inch-diameter; concrete	Outfall submerged; no survey conducted
Pipe: IL-1 to Outfall 008	Circular; 24-inch-diameter; concrete, 110 feet	Clean with flowing water
IL-1	Rectangular; 24-inch by 30-inch; brick, steel grate	No cracks, leaks observed. Little to no sediment
Outfall 009		
Outfall 009	Circular, 24-inch-diameter; concrete	n/a
Pipe: IL-26 to Outfall 009	Circular, 24-inch-diameter; concrete, 870 feet	n/a

MH: manhole
ft: feet
IL: inlet
in.: inch or inches
n/a: not applicable (not observed)

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Section 7
Stream Restoration in Cow Pen Creek

Existing functions and values (e.g., habitat, physical, and chemical conditions, as well as scenic, recreational, and other values) in Cow Pen Creek will be restored to the extent practical following the removal of contaminated sediment. Specifically, existing functions and values that were identified during the functional assessment conducted at the site and that would be impacted by the remediation effort are primarily habitat, water quality, and visual-related conditions including:

- Fish and Shellfish Habitat
- Floodflow Alteration
- Sediment/Toxicant/Pathogen Retention
- Nutrient Removal/Retention/Transformation
- Sediment/Shoreline Stabilization
- Wildlife Habitat
- Recreation
- Visual Quality/Aesthetics
- Production Export

The restoration plan has therefore been developed to target the replacement of these specific functions and values by designing features to provide aquatic/fisheries habitat, moderate floodflow, stabilize the shoreline and retain sediment, remove toxicants, and provide aesthetic and recreational values. These features will include installing in-water structures and replanting emergent vegetation to restore/improve fisheries habitat, and creating natural channel meanders and replanting floodplain forest/shrub vegetation to moderate floodflow, stabilize shorelines, and retain and remove sediment and toxicants. Other features, including replanting of riparian vegetation, have been designed to restore visual/aesthetic appeal of the stream corridor.

The following sections describe the specific design elements that will restore the active channel, floodplain, and riparian areas and replace the identified functions and values found in the excavated portions of Cow Pen Creek. Restoration efforts will be coordinated with the appropriate resource agencies including the United States Army Corps of Engineers (USACE), the MDE Tidal and Non-tidal Wetlands Divisions, the National Marine Fisheries Service (NMFS), the United States Fish and Wildlife Service (USFWS), Maryland Fishery Resource Office, Maryland Department of Natural Resources (MDNR), and the Baltimore County Department of Environmental Impact Review. Input from the community and from the other organizations, such as the Maryland Bass Nation, Middle River Bass Anglers, Gunpowder Conservancy, and Chesapeake Bay Foundation, has also been considered, as appropriate. Interested parties will have an opportunity to review and provide input during the permit approval process for this remediation effort.

The proposed design for restoration has the following elements:

1) reconstruction of the main channel and floodplains
2) placement of new channel substrate
3) streambank stabilization
4) revegetation of areas disturbed by the removal

Stream restoration features are shown in the design drawings and summarized in Figure 7-1. Refer to the design drawings for details and restoration features.

7.1 FLOODPLAIN AND CHANNEL RECONSTRUCTION

The non-tidal section of Cow Pen Creek will be excavated and the existing channel form will be modified. The proposed restoration design for this section of the creek is to reconstruct the channel (Station 8+00 to 19+00) and floodplains (Station 12+00 to 19+00). This design will be accomplished by placing clean, native fill material to reconstruct the channel and the floodplain in locations within the affected creek section. Newly constructed channel banks will be stabilized by temporary erosion-control mats, followed by vegetation. Native fill material will be covered by topsoil suitable to promote establishment of floodplain vegetation. By reconstructing the channel and the floodplain, the project will restore the creek's active channel and provide a more natural stream system that will benefit the resident fish species and improve flood flow functions and values in Cow Pen Creek.

7.2 CHANNEL SUBSTRATE

The application of a suitable substrate is an opportunity for habitat improvement where a residuals-management sand layer will be placed over all removal areas, as part of the default remedy. Using diverse substrates to restore the removal area will provide suitable spawning habitat for resident fish. Varying substrate depths will produce ideal spawning habitat for fish species in some areas of Cow Pen Creek.

An 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 completed utilizing the hydraulic modeling completed for the creek (Appendix B). The analysis indicates that non-native bed material will consist of a graded mixture of silts to cobble-sized material with a median grain size of 51 millimeters (2 inches) and 25 millimeters (1 inch) in non-tidal and inter-tidal areas, respectively, to withstand the erosive forces while providing a suitable spawning habitat for resident fish. Based on the bed stresses from hydrodynamic modeling, the streambed substrate could transition to a graded sand (less than 1 millimeter) in the downstream portion of the inter-tidal area. Therefore, use of appropriate channel substrate will help to restore/improve fisheries habitat and floodflow functions/values by creating a more natural streambed. Refer to Appendix B for detailed discussion.

7.3 STREAMBANK STABILIZATION

Streambanks that are disturbed during excavation, and thus subject to erosion, will be stabilized by grading to gentle slopes to allow effective vegetative stabilization, by adding woody structures utilizing existing logs, and by conventional rigid techniques (e.g., rock toe) to protect an approximately 200-foot segment along the Hawthorne neighborhood side of creek. Wetland benches will be constructed along about a 600-foot segment in inter-tidal and tidal areas along both banks of the creek, to allow planting wetland vegetation and provide vegetative stabilization.

Woody vegetative bank-stabilization techniques use living plant materials to stabilize the stream bank to provide the desired ecological benefit (MDE, 2000). Physical vegetative coverage on banks reinforces underground soil and protects the surface from scour by establishing a soil–root matrix. These methods have certain limitations, and are not applicable for all erosion sites (USFWS, 2002). Erosion-control sites treated by vegetative bank-stabilization methods will require monitoring.

Bank stabilization techniques utilized in the current design include temporary erosion control blankets with follow-on vegetation designed to replace the specific wetland types (i.e., emergent, forested, scrub-shrub wetlands), a root-wad revetment, rock toe and fiber roll toe protection. Other vegetative bank stabilization techniques (brush layering, live staking, and live fascines) have also been evaluated and are to be installed along certain sections of banks subject to field verification. Root-wad revetment will be installed at a scoured location of the creek. The revetment will be stabilized with other logs and rocks and is expected to enhance fish rearing habitat by creating scour pool and overhead cover. Refer to design drawings and project specifications.

In-water construction work will be restricted to certain times of the year to minimize potential impacts to important fish, wildlife, and habitat resources. The typical in-water work window based on state requirements is from October 15 to February 15; however, this timeframe may not be appropriate for establishment of vegetation that would serve as bank stabilization. Lockheed Martin is currently working with USACE, MDE, and DNR to allow in-water work in Cow Pen Creek during the summer and early fall restriction period. Woody debris removed from the creek and floodplains during clearing and excavation will be swept clean of all adhering sediment, and will be utilized to extent possible for restoration, bank stabilization, and toe protection purpose. Utilization of existing woody debris will be field-determined during construction. Characteristics of useable woody debris will include debris with current structural integrity and of sufficient size to provide bank stabilization and/or stream cover for fish habitat. Refer to the design drawings and specifications under separate cover for current stream restoration elements. The preferred use of vegetative stabilization will help to 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.

7.4 REVEGETATION

Excavated areas will be planted to restore the functions and values of the creek. The revegetation plan will include measures to restore forested wetland, scrub-shrub wetland, and emergent wetland. Native forest, scrub shrub and emergent plant species typical to tidal streams along the upper Chesapeake Bay will be replanted in the appropriate locations within Cow Pen Creek to restore and replace the extent of each wetland community removed during excavation/dredging. The combined elements of the restoration of channel features, structures and processes, along with replanting of the specific amount and type of wetland habitats removed during excavation is expected to replace the wetland functions and values lost in Cow Pen Creek during the remediation effort.

The species list will be finalized per guidance from the Maryland Department of the Environment (MDE) and Maryland Aviation Administration (MAA) because of the proximity of Martin State Airport during the permitting process. Restoring riparian vegetation and shoreline/banks in affected areas will promote shoreline vegetative cover, which will provide bank stabilization and habitat and food for resident fish. The current planned construction duration in Cow Pen Creek is June 16, 2017, to February 14, 2018. It is anticipated that the upstream areas of Cow Pen Creek would be planted in late summer to early fall; however, some planting may need to be completed later than the construction duration, at the appropriate season, to establish vegetation and facilitate its growth.

Other restoration projects conducted in the area for similar species (Chesapeake Bay Program [CBP], 2013; USACE, 2013; MDNR, 2013) have also been evaluated and incorporated into restoration elements as applicable to Cow Pen Creek. The CBP's habitat restoration goals include restoring fish passage, improving wetland areas, and planting bay grasses, with a goal to annually plant 20 acres of bay grass in and around Chesapeake Bay (STAC, 2011; CBP, 2013). Restoration of native vegetative habitats will help to restore/improve overall habitat, stabilize shorelines, retain and remove sediment and toxicants, and restore visual/aesthetic appeal of the stream corridor.

Both the restored wetland areas and creek channel will be evaluated over a five year period to determine if they have met specific performance standards. Restored wetlands will be evaluated for the performance standards described in the *Performance Standards and Monitoring Protocol for Permittee Responsible Non-tidal Wetland Mitigation Sites* (MDE and USACE IRT, 2015a) and the *Performance Standards and Monitoring Protocols for Permittee Responsible Tidal Wetland Mitigation Sites* (MDE and USACE IRT, 2015b)—collectively referred to as the IRT Monitoring Protocol— while the creek channel will be evaluated for the following performance measures:

1) A minimum of 85% native vegetation cover on banks and floodplains during each year of monitoring

2) A maximum of 15% barren ground on banks and floodplains each year of monitoring

3) A maximum of 10% unstable banks during each year of monitoring

4) A minimum of 85% streambank length occupied by restoration treatments during each year of monitoring

On-site monitoring of restored wetlands will be conducted in accordance with the methods specified in the IRT Monitoring Protocol. This will include conducting site wetland monitoring at least once during the growing season (between May 1 and September 30 for forested/scrub-shrub systems and between June 15 and September 30 for emergent systems) during each year of the standard five year monitoring period.

An additional vegetative habitat, submerged aquatic vegetation (SAV), has also been found within both Cow Pen Creek and Dark Head Cove. An SAV survey conducted in Cow Pen Creek and Dark Head Cove in June/July 2015 found a total of approximately 6.5 acres of SAV that will be affected by project dredging and/or excavation. The average rake density of SAV cover in Cow Pen Creek was found to be 10-15%, while in Dark Head Cove the average rake density was found to be between 0-10% rake cover. Species composition is dominated by common, disturbance oriented, and non-native species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and coontail (*Ceratophyllum demersum*). Several native SAV species were observed, including wild celery (*Vallisneria sp.*), pondweed (*Stuckenia sp*), curly pondweed (*Potamogeton crispus*), clasping leaf pondweed (*Potamogeton perfoliatus*), and horned pondweed (*Zannichellia palustris*). However, these species were observed on far fewer occasions during site sampling.

SAV that will be impacted by excavation/dredging will be restored on-site and in-kind. The SAV restoration effort will be conducted in collaboration with DNR, NMFS, USACE, and MDE personnel and will involve replanting native SAV within the 6.5-acre area being impacted by project activities.

Replanting plans include collection of native water celery (*Vallisneria americana*) seed from known nearby genetic stock during the fall period when seed and pods are ripe (likely during

October). State DNR and NMFS personnel will be consulted to identify a site for seed collection and to assist with planning for the collection effort. Any necessary collection permits or agency approvals will also be obtained prior to seed collection. Collected seed will be kept in refrigerated storage at a state/federal facility until the following April. If an acceptable wild collection site is not identified, then seed will be acquired from an accredited nursery.

Prior to replanting the site, a residual management layer of sand will be placed over the excavated/dredged sediment. This layer of sand will help to establish a suitable substrate for germination and growth of SAV.

A minimum of 100,000 seeds per acre will be broadcast sown within their pods over the 6.5-acre impact area during the month of April. In addition, a number of several square meter exclosures will be set up within the project area that will protect young water celery plants from predation until plants reach the water surface and are capable of withstanding herbivory. These exclosures will provide better assurance that at least a minimum cover of SAV will survive to continue to colonize other areas of the site if areas outside of the exclosures fail.

Site monitoring to evaluate germination success, percent cover, and species composition will be conducted for a minimum of five years, with monitoring during years 1-4 involving the use of diver(s) to non-intrusively sample SAV along designated transects. Monitoring during the last year or two (year five and beyond) will involve resampling the site using the rake method to determine if the site has achieved the target rake density.

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NOTES:

1. CHANNEL AND FLOODPLAIN IN NON-TIDAL AREAS WILL BE RECONSTRUCTED FOLLOWING EXCAVATION.
2. EXCAVATED BANKS WILL BE STABILIZED.
3. EXCAVATED FLOODPLAIN AND WETLAND WILL BE REVEGETATED.

LEGEND:

- BANKFULL/MHHW
- REMOVAL BOUNDARY
- APPROXIMATE LIMIT OF EXCAVATION AND DREDGING
- STAGING AREA
- REMOVAL CONTOUR
- FORESTED WETLAND VEGETATION
- SCRUB-SHRUB WETLAND VEGETATION
- EMERGENT WETLAND VEGETATION
- UPLAND VEGETATION
- EXISTING WETLAND

TETRA TECH

N

0' 200' 400'

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

FIGURE 7-1
COW PEN CREEK
RESTORATION ELEMENTS

Z:\PROJECTS\LOCKHEED - MIDDLE RIVER COMPLEX\FULL REMEDY FIGURES\SHEET FILES\FIGURE 7-1 RESTORATION ELEMENTS.DWG
PLOT DETAILS: JOBMANN, AMANDA October 29, 2015 5:25 PM TT-BOTH-MAIN-COLOR.CTB

Section 8
Project Permitting

This section describes the anticipated permits needed to complete the planned remediation of Cow Pen Creek and Dark Head Cove. This includes all federal, state, and local (county) permits required for excavation and dredging of contaminated material, disposal, and site restoration.

8.1 PROJECT IMPACTS TO REGULATED RESOURCES

Activities associated with the proposed remediation project that may affect regulated resources (and therefore require regulatory review and approval) include the dredging and excavation of Cow Pen Creek and adjacent wetlands and floodplains, storm-drain cleanout and dredging in Dark Head Cove, dewatering and disposal of excavated material, forest clearing for site access, and upland ground-disturbance/site-grading. Dredging/excavating contaminated sediment, dewatering through installation of cofferdam cells during excavation, and restoration work in Cow Pen Creek and Dark Head Cove could potentially cause dredge/fill material to discharge into wetlands and waters of the United States and the State of Maryland. These activities require authorization under Section 404 of the federal Clean Water Act (CWA) and the Maryland Tidal and Non-tidal Wetlands Protection Acts, as well as state water quality certification (WQC) under Section 401 of the CWA.

Authorization under Sections 401 and 404 of the CWA will be satisfied by an Individual Permit. State authorization under the Maryland Tidal and Non-tidal Wetlands Protection Acts will require separate approval from both the Maryland Department of the Environment (MDE) Tidal and MDE Non-tidal wetlands divisions. It is expected that both the tidal and non-tidal approvals will require state individual permits/licenses for a major action.

A single Joint Permit Application will be submitted to both the United States Army Corps of Engineers (USACE) and MDE for review and approval regarding impacts to waters of the United States (U.S.) and waters of the State of Maryland under the Tidal and Non-tidal Wetlands Protection Acts.

Dredging/excavation of the adjacent wetlands and upland area would also affect portions of the 100-year floodplain. This will require MDE approval as part of the MDE authorization for impacts to wetlands, waters, and floodplains.. Activities in the floodplain will also require review and approval by the Baltimore County Public Works under *Baltimore County Code* Article 32, Title 8, "Floodplain Management."

Dredging/excavation can also affect certain federally listed threatened and endangered aquatic species and/or federal essential-fish habitat, which requires consultation with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) to ensure compliance with Section 7 of the federal Endangered Species Act (ESA) and Section 305(b)(2) of the federal Magnuson-Stevens Fishery Conservation and Management Act. In a letter dated March 3, 2015, NMFS stated that no federally listed species under their jurisdiction will be exposed to any direct or indirect effects of the action; therefore, no further Section 7 consultation is required for the project. Initial discussions with NMFS regarding Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act, which include impacts to essential fish habitat (EFH) and submerged aquatic vegetation (SAV) indicated that additional consultation will be required. Consultation will likely conclude that the project will have no adverse impact on EFH; however, impacts to SAV will need to be quantified and mitigated. In a letter dated March 15, 2015, the United States Fish and Wildlife Service (USFWS) stated that no federally listed species under their jurisdiction will be exposed to any direct or indirect effects of the action; therefore, no further Section 7 consultation with the USFWS is required for the project.

In addition, the northern long-eared bat was listed in May 2015 as threatened by the USFWS under the federal ESA, and was simultaneously listed as threatened by the Maryland Department of Natural Resources (MDNR) under the Maryland State ESA. Because the project will involve clearing of forest habitat, the USFWS was informally consulted to determine the potential effects on this species. In a letter dated July 23, 2015, the USFWS stated that due to the urban location of the proposed action, the northern long-eared bat will not be exposed to any direct or indirect effects of the action; therefore, no further Section 7 consultation with the USFWS is required for this species.

Dredge and fill may also affect recreational and anadromous[3]fish-spawning areas; however, these impacts will be mitigated through avoidance of in-water work during the restricted fish spawning season between February 15 and June 15, and in coordination and approval by both MD DNR and the Maryland Historical Trust.

Portions of Cow Pen Creek will be dewatered in stages before excavation begins. Water removed from each segment of Cow Pen Creek before excavation will be pumped around the cofferdam and discharged to downstream surface waters in nearby Dark Head Cove as typically allowed under the Section 404/401 CWA and Maryland Tidal and Non-tidal Wetlands authorization, and is therefore unlikely to require specific National Pollutant Discharge Elimination System (NPDES) (Section 402 CWA) permitting. In addition, a Private Aids to Navigation permit will be acquired from the United States Coast Guard (USCG) for placement of downstream marker buoys the turbidity curtain and turbidity monitoring devices.

Excavated sediment and soils will be dewatered on a dewatering pad, temporarily stockpiled in an adjacent upland area, and trucked (or rail-hauled) off-site to an approved disposal facility. Sediment stockpiling could release fugitive dust and will require MDE review and approval of mitigation measures to ensure compliance with Maryland's "Environment Article," *Code of Maryland Regulations* (COMAR) Title 2, Subtitle 4, and the federal Clean Air Act.

Water removed through dredge dewatering will be treated on-site. Treated water can be discharged to the local Baltimore County publicly owned treatment work (POTW), or placed in containers at the site and subsequently disposed of at an approved disposal facility. Discharging to a POTW would require a permit through the Baltimore County Public Works Department under *Baltimore County Code*, Article 20, Title 5, Section 114, "Industrial Wastewater Discharges." Approved off-site disposal of wastewater generated during dewatering will require contamination profiling and coordination of disposal volumes and schedule with the approved disposal facility.

Activities in the upland area adjacent to Cow Pen Creek within Lockheed Martin property would include ground disturbance from equipment used in excavation/restoration and haul-truck loading/unloading. Other ground disturbance in the upland area could include site grading to allow for site access and use of stockpiling/staging areas. Ground disturbance may exceed 5,000 square feet and will therefore require a Construction General Permit for storm water runoff

[3]A fish that migrates from saltwater to fresh water to spawn.

during construction from the MDE. Site grading and ground disturbance will also require a Grading Permit from the Baltimore County Department of Environmental Protection and Sustainability (DEPS) Storm water Engineering Department, as well as approval of an erosion and sediment control plan from both the Baltimore County DEPS and the Baltimore County Soil Conservation District (SCD).

Follow-up inspection of all installed erosion and sediment control measures will be conducted by the Baltimore County Department of Permits, Approvals, and Inspections (PAI). Fugitive dust emissions from construction-related ground disturbance will also be addressed as part of the air permitting described above. A storm water management plan approved by the Baltimore DEPS is not anticipated to be required at this time because no impervious surfaces will be created; however, the project will require a written variance from Baltimore County DEPS regarding storm water management requirements.

All physical disturbances, including those in Cow Pen Creek, the adjacent floodplain and wetlands, and the adjacent uplands, will take place within the Chesapeake Bay Critical Area and are thus regulated under Maryland's Chesapeake Bay Critical Area Protection Act. Specific regulated resources that will likely be affected by this remediation effort include forested areas, wetlands/waterways, steep slopes, and the 100-foot tidal buffer. Disturbance/removal of these resources will require review and approval by the Baltimore County DEPS Environmental Impact Review, the agency responsible for administering the Chesapeake Bay Critical Area Protection Act for the project area. Mitigation for impacts to these resources in the critical area will likely involve replacement of forest cover and lost wetlands. Mitigation of wetland features will be included as part of the Cow Pen Creek restoration plan as described above; however, DEPS will be consulted to ensure that any concerns they may have regarding details of the final plan are addressed. Mitigation of tree/forest clearing in the upland will be conducted separately and will include replanting lost trees/forest cover in accordance with standard critical area planting requirements.

A National Environmental Policy Act (NEPA) analysis of remediation project effects may be required to evaluate the project's overall environmental impact for the dredge/fill impacts associated with the project. If a NEPA analysis is required, we expect that an environmental assessment (EA) will adequately address the NEPA requirements. It is also expected that the EA will be reviewed and approved by the USACE (the lead federal agency) and that the USACE will issue a Finding of No Significant Impact (FONSI), due to the moderate amount of physical disturbance associated with this remediation effort, and the ultimate benefit to water quality, recreation, and the human environment that will be achieved.

8.2 FEDERAL, STATE, AND LOCAL AGENCIES INVOLVED

As described above, the project will conform to all applicable codes, standards, and/or permitting requirements from the following federal, state, and local (county) regulatory agencies:

Federal

- USACE
- United States Environmental Protection Agency (USEPA)
- USCG
- NOAA NMFS
- USFWS

State

- MDE
- MDNR
- Maryland Historical Trust

County

- Baltimore County DEPS, Environmental Impact Review, Stormwater Management, and Permits, Approvals, and Inspections
- Baltimore County SCD
- Baltimore County Public Works
- Maryland Critical Area Commission

Table 8-1 lists the regulations, statutes, and required permits likely applicable to the project. Tetra Tech will continue to consult with applicable federal, state, and local agencies to identify any additional permits that may be required and will inform Lockheed Martin if any additional permits are identified.

8.3 PERMITTING PROCESS AND SCHEDULE

The permitting process began with a pre-application Joint Evaluation meeting with the USACE, USEPA, MDE (Tidal and Non-Tidal Wetlands divisions), and other relevant agency staff. This meeting evaluated the 60% design to determine the appropriate level of permitting related to anticipated impacts to waters/wetlands of the U.S. and Maryland, SAV, sensitive species/habitat, and historic and other resources. This meeting was followed by a more detailed discussion of the impact calculations/determinations and proposed mitigation/restoration design plans on September 10, 2015. Information obtained during this and the previous meeting will be used to develop both a final Joint Permit Application to be submitted in November 2015, as well as a draft NEPA Environmental Assessment in early 2016. In addition, the JPA will include a description of all mitigation to wetlands and waters and will also include final consultation with both DNR and NMFS regarding mitigation for SAV. This information will be included in the NEPA analysis and be used to complete the impact analysis. Following a 30-day public and agency comment period, the final EA will be submitted to the USACE to develop the FONSI.

The Joint Permit Application, critical area review, general construction permit, industrial wastewater discharge permit, grading permit, and erosion- and sediment-control review and approval will all be completed following the final design stage. These permits require detailed design plans indicating the specific locations of all temporary and permanent disturbance limits and a determination/characterization of discharges to the POTW. Once the limits of disturbance have been identified, the total impact to regulated resources can be calculated and mitigation requirements, if any, for the Joint Permit Application and critical area review can be assessed. Following a determination/characterization of any discharges to the POTW, a final permit can be submitted to Baltimore County Public Works for approval.

Draft grading and erosion and sediment control plans will then be submitted to the Baltimore County PAI, DEPS, and the Baltimore County SCD. The Notice of Intent for coverage under the Construction General Permit will be submitted to MDE. Following review and approval of the erosion and sediment control plans and a 45-day public notice period, MDE will approve covering the project under the Construction General Permit.

The anticipated schedule to complete project permitting (assuming that a NEPA EA will be required) is as follows:

1) NEPA environmental assessment (including NOAA, USFWS, MDNR, and Maryland Historical Trust Review)—six to nine months from the 90% design

   a. Draft EA preparation—three months

   b. USACE review and public/agency comment period—three months

   c. Final EA and FONSI—three months

2) Joint Permit Application, critical area review, industrial wastewater permit, grading permit, and erosion and sedimentation plans—nine to 12 months from the 90% design

   a. Prepare applications—three to six months

   b. Agency review and public comment period (if required)—three months

   c. Preparation and approval of final permits—three months

Table 8-1

List of Federal, State, and Local Permits
Page 1 of 4

Regulation/statute	Agency	Permit description
Federal regulations/statutes		
Section 404 Clean Water Act (33 United States Code [U.S.C.] 1344) United States Army Corps of Engineers (USACE) Regulations, 33 *Code of Federal Regulations* (CFR) Part 320–330	USACE and USEPA	Section 404 Clean Water Act, "Joint Federal/State Application for Dredging, Filling, and Alteration of Waters of the United States, Including Wetlands:" Permits available in Maryland include the "Maryland State Programmatic General Permit" (MDSPGP-4) for impacts limited to (generally) less than 1-acre, and individual permits for larger impacts. Other permits available include Nationwide Permit 38 for cleanup activities associated with hazardous waste.
National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.)	The USACE is the expected lead federal agency responsible for completing a NEPA analysis for the project as it is performed under a Section 404/10 permit; however, USEPA may be involved because of their oversight of Section 402-related discharges	NEPA review/analysis is required for federal actions, including the issuance of federal permits. Depending on the nature of project activities and expected effects on the environment, the project may be categorically excluded from further analysis, or require preparation of an environmental assessment or impact statement.
Section 10 Rivers and Harbors Act—33 U.S.C. 403, et seq.	USACE and USEPA (USCG Review)	Section 10 Rivers and Harbors Act permit for work in navigable waters of the United States including structures and general alteration
Essential Fish Habitat—Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act	National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA NMFS)	Essential fish habitat (EFH) consultation and review is required for projects with possible impacts on EFH. Consultation will determine whether EFH will be affected. If EFH exists in the project area, the National Marine Fisheries Service (NMFS) must approve avoidance, minimization, and mitigation measures developed to reduce or eliminate impacts.

Table 8-1

List of Federal, State, and Local Permits
Page 2 of 4

Regulation/statute	Agency	Permit description
Federal regulations/statutes		
Section 7(a)(2), Endangered Species Act Consultation; 7 U.S.C. §136, 16 U.S.C. §1531 et seq.	USFWS and/or NOAA NMFS	Section 7 Endangered Species Act consultation and review: Federal agencies issuing permits must consult with the USFWS/NOAA NMFS regarding possible impacts to listed species and/or critical habitat. Consultation begins with an assessment as to whether listed species/habitat may be affected. If so, a formal determination of impacts and avoidance, minimization (conservation) measures are to be developed. An Incidental Take Permit is available for any remaining unavoidable taking.
Bald and Golden Eagle Protection Act (16 U.S.C. 668–668c), enacted	USFWS	USFWS review of possible impacts or disturbance to bald eagle and/or bald eagle nests: Avoidance, minimization, and mitigation measures must be employed for activities that might possibly disturb bald eagles. A non-purposeful take permit is available if the taking cannot be avoided.
State regulations/statutes		
Maryland Department of the Environment (MDE), Tidal Wetlands Protection Act, Code of Maryland Regulations (COMAR) 26.24	MDE Board of Public Works and the Maryland Wetlands/Waterways Division	MDE Tidal Wetlands Protection Act Permit: Any impacts to tidal wetlands or waters requires a tidal permit from the MDE. The “Maryland State Programmatic General Permit” (MDSPGP-4) allows up to a half-acre and/or 400 cubic yards of tidal dredging. Dredging in excess of this threshold requires an individual permit.
MDE Non-Tidal Wetlands Protection Act, COMAR 26.23	MDE Wetlands/Waterways Division	MDE Non-Tidal Wetlands Protection Permit: Impacts to Non-Tidal Wetlands and Waters of the State: Any impacts to non-tidal wetlands or waters require a tidal permit from the MDE. The MDSPGP-4 allows up to 1 acre of disturbance (other criteria may apply). Disturbance in excess of this threshold requires an individual permit.
Section 307, Federal Coastal Zone Management Act	Maryland Department of Natural Resources (MDNR)	Section 307, Federal Coastal Zone Management, Coastal Zone Consistency: Federal actions must be consistent with state’s coastal management program.
Section 401 of the Clean Water Act (“Water Quality Certification”) and “Environment Article” Title 9 Sections 9-313—9-323, *Annotated Code of Maryland*	MDE Wetlands/Waterways Division or Board of Public Works	Section 401, Water Quality Certification: State certifies that Section 404 and tidal and non-tidal wetlands permits meet state water quality standards and may include special conditions, such as certain water quality protection measures and/or point of compliance water-quality monitoring.

Table 8-1

List of Federal, State, and Local Permits
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Regulation/statute	Agency	Permit description
State regulations/statutes		
Section 402 Clean Water Act (33 U.S.C. 1342) and 40 CFR 122.26; Maryland "Environment Article," Title 9, Subtitle 3: COMAR 26.08.04	MDE Construction Stormwater Division	Section 402 Clean Water Act, Construction General Permit for Construction Stormwater: Projects that disturb 1 acre or more of ground must obtain a Construction General Permit for permitting storm water runoff during project construction. Approval of this permit is contingent upon approval of the site erosion and sediment control plan by the Soil Conservation District.
Section 402 Clean Water Act "National Pollutant Discharge Elimination System (NPDES)," 40 CFR Part 122 through 125, and 131, "Environment Article," Title 9, Subtitle 3; COMAR 26.08.01–26.08.04, and for the pretreatment permit, COMAR 26.08.08	MDE NPDES program	Section 402 Clean Water Act, NPDES Permit: Direct discharges to waters of the United States, including those from outfalls from treated wastewater, must obtain a permit and authorization. Surface water discharges are regulated through combined state and federal permits under NPDES.
Section 106, National Historical Preservation Act (Public Law 89 665; 16 U.S.C. 470 et seq.)	Maryland Historical Trust	Section 106 of the National Historic Preservation Act historic/cultural resource review: Possible impacts to any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register
Maryland Nongame and Endangered Species Conservation Act (Annotated Code of Maryland, 10-2A-01; also, COMAR 08.03.08)	MDNR	Nongame and Endangered Species Conservation Act-listed species and habitat review: Possible impacts to state listed species and habitat
Section 7-222 of the "Environment Article," and COMAR 26.14	MDE Controlled Hazardous Substance (CHS) Enforcement Division	Oversees assessment and cleanup of hazardous waste sites

Table 8-1
List of Federal, State, and Local Permits
Page 4 of 4

Regulation/statute	Agency	Permit description
Local regulations/statutes		
Critical Area Commission, Title 8, Subtitle 18 of the "Natural Resources Article," Annotated Code of Maryland	State Critical Area Commission	Critical area plan/permit approval: Possible impacts to critical area resources
Section 1.04 of the Code of Baltimore County Regulations (COBAR), "Baltimore County Grading Permit"	Baltimore County DEPS Stormwater Engineering and Baltimore County Soil Conservation District	Grading that disturbs more than 5,000 square feet or more than 100 cubic yards of fill material; includes review of erosion and sediment control plans
Section 402 Clean Water Act (33 U.S.C. 1342) and 40 CFR 122.26; "Environment Article," Title 4, Subtitle 1 for erosion and sediment control and Subtitle 2 for stormwater management (COMAR 26.17.01 and 26.17.02); COBAR Article 33 Title 4, "Baltimore County Stormwater Management"	Baltimore County DEPS—Stormwater Engineering Department	Stormwater management plan approval: County review of concept, development, and final stormwater management plans for the project site, or granting of a variance
Article 20 Title 5 Section 114 of the Baltimore County Code, "Industrial Wastewater Discharges"	Baltimore County Public Works	Industrial wastewater discharge to publicly owned treatment works permit: Submission of permit application, including anticipated treatment measures and post-treatment contaminant concentrations; likely to involve a Category 1 permit for a major facility
Article 32 Title 8 of the Baltimore County Code, "Floodplain Management"	Baltimore County Public Works	Regulations pertaining to development within the 100-year floodplain

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Section 9
Construction Sequence, Cost and Schedule

This section discusses the construction sequence, main construction elements, and general construction schedule. The overall sequence will be determined by the contractor in the contractor's remedial action work plan.

9.1 CONSTRUCTION SEQUENCE

The anticipated on-site construction sequence is summarized below. Some activities can be performed simultaneously. The sequence is subject to change per the contractor's planned operations and the construction schedule. Proper planning and successful completion of each task are essential to implement the project within the schedule.

9.1.1 Construction Season 1 – Remediation in Dark Head Cove and in Mouth of Cow Pen Creek

Construction will start after a construction contractor is selected by Lockheed Martin Corporation (Lockheed Martin), all construction permits are obtained, construction work plans are reviewed and approved by Lockheed Martin, and construction readiness review is completed. Lockheed Martin will also schedule a public information session to inform the public about the start of construction.

9.1.1.1 Preliminary Field Work

1) Mobilization: establishing the infrastructure necessary for field operations. Non-field tasks, such as contracting and procurement, along with preliminary site reconnaissance activities and site access coordination. Delivery of materials/supplies, equipment, and personnel to the project site. Establishment of field office and staging area. Coordination with landfill facilities and verification of truck haul routes
2) Upland site preparation: installation of upland temporary erosion and sediment controls, staging areas, upland support facilities, dewatering pad, water treatment system, and traffic control and haul route coordination

3) Removal area site preparation: installation of temporary erosion and sediment controls and in-water environmental controls (silt curtain, water quality monitoring equipment), debris removal, clearing, utility coordination

4) Pre-removal survey: pre-removal bathymetric survey to establish baseline conditions.

9.1.1.2 Remediation

1) New sheet pile bulkhead in Dark Head Cove will be constructed. Sheet piles will be installed before dredging begins. Installation will start in front of Block F to accommodate dredge material transloading. Design details to be provided as a separate submittal.

2) Storm drain cleaning: performed per the design drawings and specifications before Dark Head Cove dredging.

3) Dredging in the mouth of Cow Pen Creek and Dark Head Cove: dredging per the design drawings and specifications.

4) Post-dredging survey: post-removal survey in dredged areas.

5) Confirmation sampling: sampling per the confirmation sampling and analysis plan in removal areas.

6) Contingency dredging if confirmation results warrants per the contingency plan.

7) Sediment dewatering and water treatment: gravity dewatering and mixing with sediment amendment of removed sediment over the dewatering pad. All water generated during dewatering will be treated at an on-site water treatment system before discharge to publicly owned treatment work (POTW) or to an off-site facility.

8) Transport and disposal: dewatered sediment transport by trucks to the designated landfill, debris transport to a recycling facility or to the designated landfill.

9) Residuals-management layer placement: placement per the design drawings and specifications over removal areas after verification of removal depths and confirmation sampling.

9.1.1.3 Site Restoration and Demobilization:

1) Miscellaneous construction debris transport and disposal, removal of spill apron, temporary erosion and sediment controls, the water treatment system and dewatering pads, seeding and stabilization matting over disturbed areas, and decontamination operations. Some components can be restored for the next construction season.

9.1.2 Construction Season 2 – Remediation in Cow Pen Creek and *In situ* Treatment in Dark Head Cove

9.1.2.1 Preliminary Field Work

Repeat mobilization activities in construction season 1. Construction will start after all construction permits are obtained, access agreements are in place, construction work plans are reviewed and approved by Lockheed Martin, and construction readiness review is completed. Lockheed Martin will also schedule a public information session to inform the public about the start of construction. Preliminary field work in Cow Pen Creek also includes the following activities:

1) Installation of construction fence along Hawthorne neighborhood
2) Clearing and grubbing of remediation areas. Clearing area includes floodplain and forested areas.
3) Installation of temporary access roads
4) Pre-removal topographic survey

9.1.2.2 Remediation

1) *In situ* treatment in Dark Head Cove: apply *in situ* treatment amendment per the design drawings and specifications during October 15 to February 14 work window.
2) Dewatering excavation areas in segments: Contractor will select a dewatering method at upstream locations in the creek and create work areas in segments before excavation.
3) Excavation in Cow Pen Creek: excavation per the design drawings and specifications.
4) Post-excavation survey: post-removal survey in excavated areas.
5) Confirmation sampling: sampling per the confirmation sampling and analysis plan in removal areas.
6) Contingency excavation if confirmation results warrants per the contingency plan.
7) Bank stabilization, outlet protections, and stream restoration: restoring the creek following removal, or simultaneously per the design drawings and specifications. Outlet protections of storm drain outfalls that were damaged or impacted during excavation will be rebuilt.
8) Sediment dewatering and water treatment: gravity dewatering and mixing with sediment amendment of removed sediment over the dewatering pads. All water generated during dewatering will be treated at an on-site water treatment system before discharge to POTW or to an off-site facility.
9) Transport and disposal: dewatered sediment transport by trucks to the designated landfill, debris transport to a recycling facility or to the designated landfill.

9.1.2.3 Site Restoration and Demobilization:

1) Site restoration and demobilization: waste transport and disposal, removal of the water treatment system and dewatering pad, and decontamination operations

9.2 CONSTRUCTION COST ESTIMATE

An engineering estimate of the construction cost is provided under separate cover.

9.3 CONSTRUCTION SCHEDULE

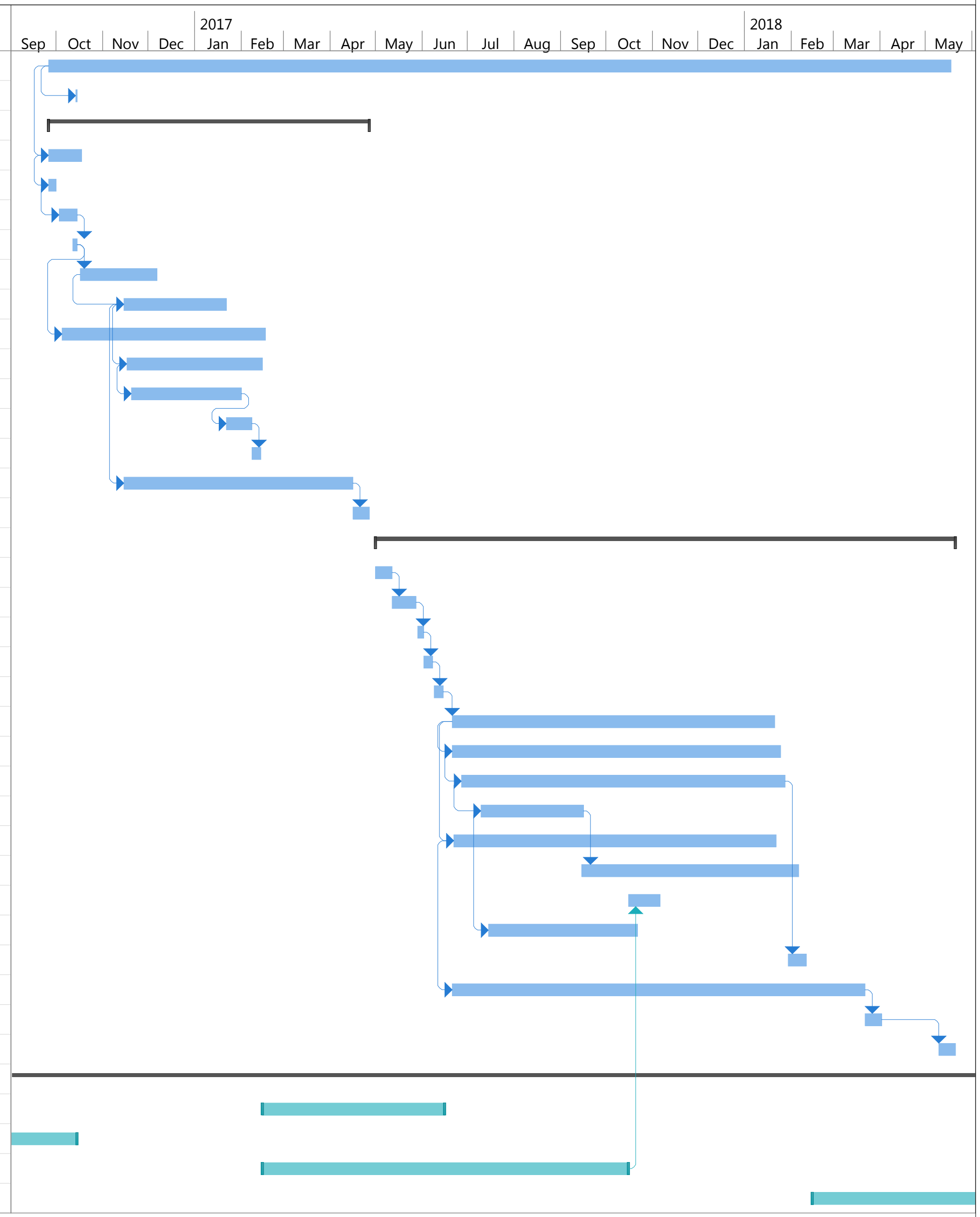
We expect that construction will be completed in two seasons:

- Construction Season 1: October 16, 2016–February 14, 2017 — Bulkhead soil retention, storm-drain cleaning, dredging in Cow Pen Creek and Dark Head Cove
- Construction Season 2: June 16, 2017–February 14, 2018 — Excavation and restoration in Cow Pen Creek and *in situ* treatment in Dark Head Cove

The preliminary construction schedule for this project is provided in Figure 9-1. The preliminary schedule is based on the assumptions that all necessary agency approvals and permits can be obtained prior to initiation of the work.

Figure 9-1. Anticipated Construction Schedule

ID	Task Name	Duration	Start	Finish
1	**Project Duration**	**599 days**	**Mon 9/26/16**	**Thu 5/17/18**
2	**Approval of RBDAA, Permits**	**1 day**	**Fri 10/14/16**	**Fri 10/14/16**
3	**Dark Head Cove Remediation**	**213 days**	**Mon 9/26/16**	**Wed 4/26/17**
4	Mobilization	22 days	Mon 9/26/16	Mon 10/17/16
5	Bathymetric survey	5 days	Mon 9/26/16	Fri 9/30/16
6	Upland site preparation, erosion controls, silt curtains	12 days	Mon 10/3/16	Fri 10/14/16
7	Baltimore County Inspection Review	3 days	Wed 10/12/16	Fri 10/14/16
8	Bulkhead sheetpile installation	51 days	Mon 10/17/16	Tue 12/6/16
9	Dredging	68 days	Tue 11/15/16	Sat 1/21/17
10	Water quality monitoring	135 days	Wed 10/5/16	Thu 2/16/17
11	Bathymetric surveys	90 days	Thu 11/17/16	Tue 2/14/17
12	Confirmation sampling	73 days	Sun 11/20/16	Tue 1/31/17
13	Residual management layer (RML) placement	17 days	Sun 1/22/17	Tue 2/7/17
14	Contingency dredge, RML placement	6 days	Wed 2/8/17	Mon 2/13/17
15	Dewatering, transport, disposal	152 days	Tue 11/15/16	Sat 4/15/17
16	Demobilization	11 days	Sun 4/16/17	Wed 4/26/17
17	**Cow Pen Creek Remediation**	**385 days**	**Mon 5/1/17**	**Sun 5/20/18**
18	Mobilization	11 days	Mon 5/1/17	Thu 5/11/17
19	Upland site preparation, erosion controls	16 days	Fri 5/12/17	Sat 5/27/17
20	Baltimore County Inspection Review	4 days	Mon 5/29/17	Thu 6/1/17
21	Clearing vegetation	6 days	Fri 6/2/17	Wed 6/7/17
22	Topographic survey	6 days	Fri 6/9/17	Wed 6/14/17
23	Excavation (including dewatering controls)	214 days	Wed 6/21/17	Sat 1/20/18
24	Topographic survey - verification of excavation depths	218 days	Wed 6/21/17	Wed 1/24/18
25	Confirmation sampling	215 days	Tue 6/27/17	Sat 1/27/18
26	Stream/floodplain reconstruction	68 days	Mon 7/10/17	Fri 9/15/17
27	Bank stabilization	214 days	Thu 6/22/17	Sun 1/21/18
28	Residual management layer placement	144 days	Fri 9/15/17	Mon 2/5/18
29	In situ treatment	21 days	Mon 10/16/17	Sun 11/5/17
30	Revegetation	99 days	Sat 7/15/17	Sat 10/21/17
31	Contingency excavation, RML placement	12 days	Tue 1/30/18	Sat 2/10/18
32	Dewatering, transport, disposal	274 days	Wed 6/21/17	Wed 3/21/18
33	Demobilization	11 days	Thu 3/22/18	Sun 4/1/18
34	Contingency revegetation	11 days	Thu 5/10/18	Sun 5/20/18
35	**Time of Year Restrictions**	**852 days**	**Mon 2/15/16**	**Fri 6/15/18**
36	Fish spawning	121 days	Wed 2/15/17	Thu 6/15/17
37	Submerged Aquatic Vegetation	243 days	Mon 2/15/16	Fri 10/14/16
38	Submerged Aquatic Vegetation	243 days	Wed 2/15/17	Sun 10/15/17
39	Fish spawning	121 days	Thu 2/15/18	Fri 6/15/18



Date: Fri 10/2/15

Task | Summary | Deadline
Milestone | Project Summary | Progress

Section 10

Long-term Monitoring and Maintenance

Cleanup activities include long-term post-remedial monitoring to verify remedy success and contingency response measures. The cleanup goals for Cow Pen Creek and Dark Head Cove will be achieved at the end of construction. Achievement of the cleanup goals at the end of the remedial action will be verified by confirmation sampling in removal areas and confirmation of the placement of amendments in *in situ* treatment application areas. Refer to Long-term Monitoring and Maintenance Plan submitted under separate cover. The Long-term Monitoring and Maintenance Plan outlines monitoring of the effectiveness of the *In Situ* treatment in Dark Head Cove and the success of the habitat restoration in Cow Pen Creek. Contingency options are also identified.

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Section 11
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APPENDIX A—EXISTING CONDITIONS

APPENDIX A1—PHOTO LOG

Photo 1. CPC Station 9+95, looking northeast at stairs to Glen Martin Lagoon road.

Photo 2. CPC Station 10+10, looking northeast at 18" CMP.

Photo 3. CPC Station 10+60, looking east at the creek.

Photo 4. CPC Station 11+00, looking northeast at riprap and debris.

Photo 5. CPC Station 11+30, looking southeast at creek.

Photo 6. CPC Station 13+00, looking northeast at debris in creek.

Photo 7. CPC Station 17+40, looking east at creek floodplain.

Photo 8. CPC Station 17+40, looking east at creek floodplain.

Photo 9. CPC Station 17+70, looking north at wetland.

Photo 10. CPC Station 17+70, looking north at wetland.

Photo 11. CPC Station 17+70, looking northeast at wetland.

Photo 12. CPC Station 18+65, Outfall 004 (42 inch corrugated metal pipe).

Photo 13. CPC Station 23+75, looking northwest at creek mudflats.

Photo 14. CPC Station 24+15, looking northwest at gabion wall.

Photo 15. CPC Station 28+15, looking northwest at creek confluence.

Photo 16. CPC Station 28+50, looking west at Kingston Point Park.

Photo 17. Block G looking at south east.

Photo 18. Block G and Glen Martin Lagoon Road looking at south east.

Photo 19. Block G south east corner.

Photo 20. Block G looking at north east.

Photo 21. DHC Station 3+00, looking south edge of concrete boat launch.

Photo 22. DHC Station 3+50, looking southeast from Block F.

Photo 23. DHC Station 4+00, looking northeast at Block F.

Photo 24. DHC Station 13+00, looking northeast along riprap with concrete overlay.

Photo 25. DHC Station 17+50, looking southeast at Outfall 006.

Photo 26. DHC Station 17+50, looking northeast at Outfall 006 (30" RCP).

Photo 27. DHC Station 20+50, looking southwest along bulkhead towards riprap.

Photo 28. DHC Station 24+50, looking west along bulkhead.

Photo 29. DHC Station 23+00, looking east along bulkhead.

Photo 30. DHC Station 25+00, looking southeast at Outfall 07 (48 inch corrugated metal pipe).

Photo 31. DHC Station 26+00, looking southeast along riprap and broken concrete.

APPENDIX A2— EXTENT OF CONTAMINATION IN COW PEN CREEK AND DARK HEAD COVE

NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.

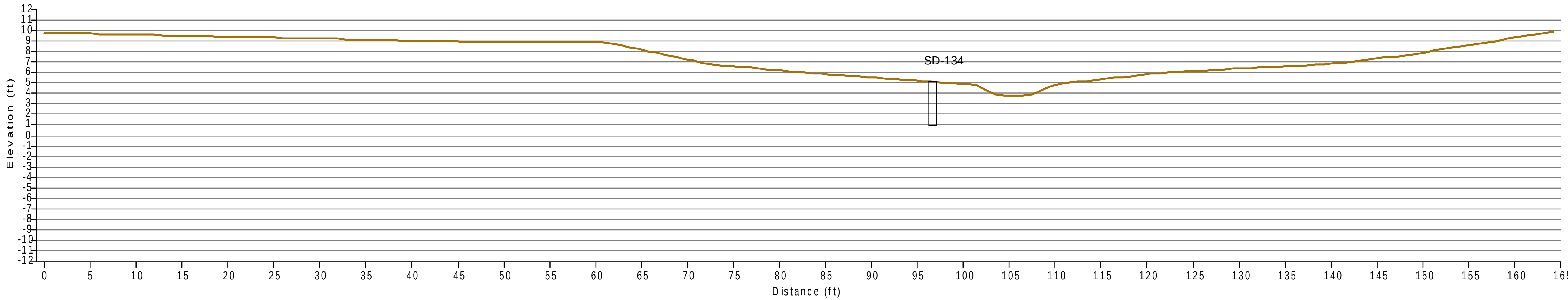
TETRA TECH

0 50 100 200
Feet

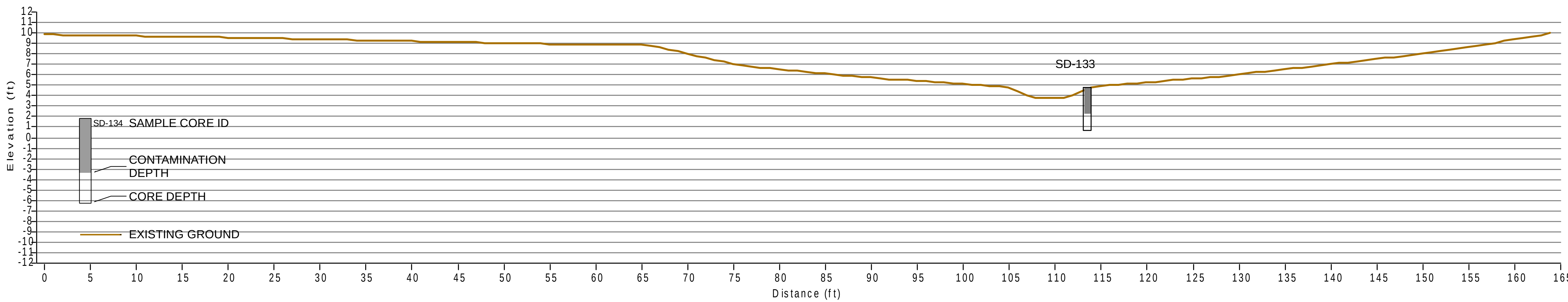
Lockheed Martin Middle River Complex
Middle River, MD

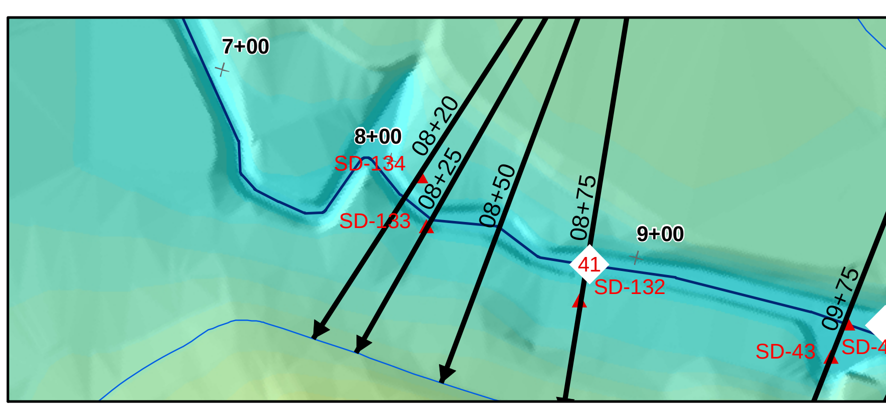
Figure A-1
Cow Pen Creek Transects

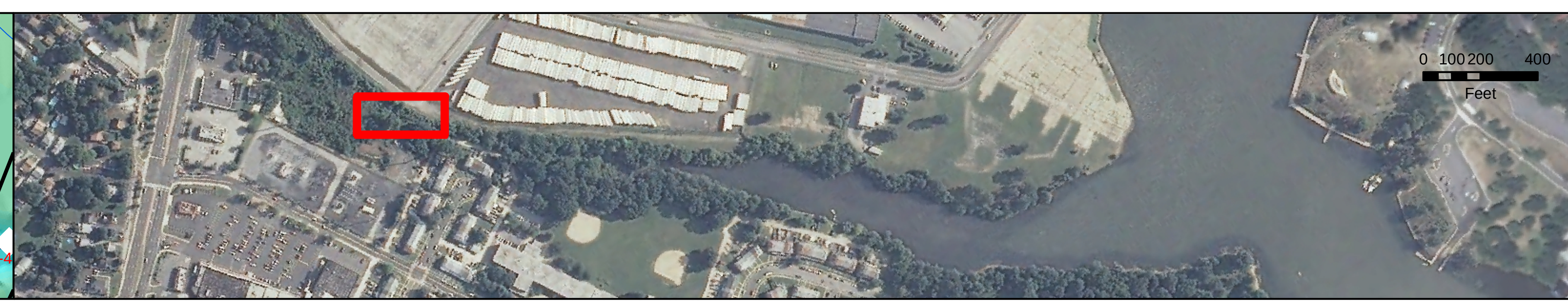
Profile 08+20



Profile 08+25







NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

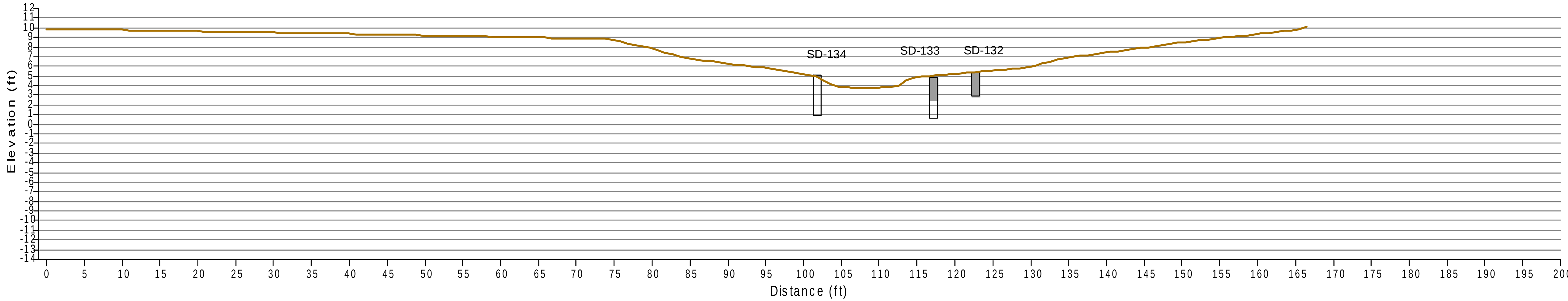
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

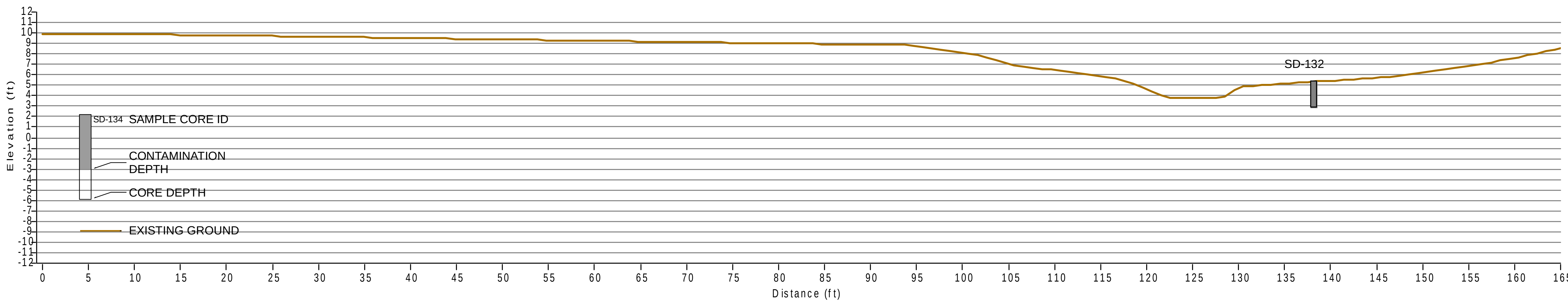
Figure A-2
Cow Pen Creek
Profiles 08+20 & 08+25

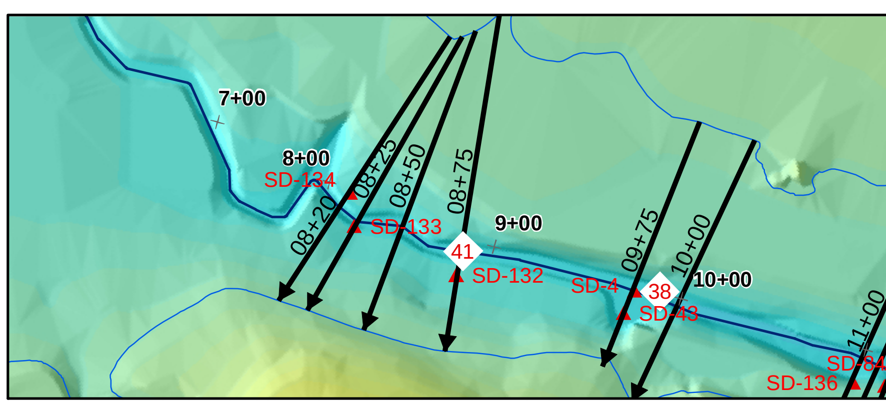
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-2_08+20_08+25_CPC.mxd

Profile 08+50



Profile 08+75





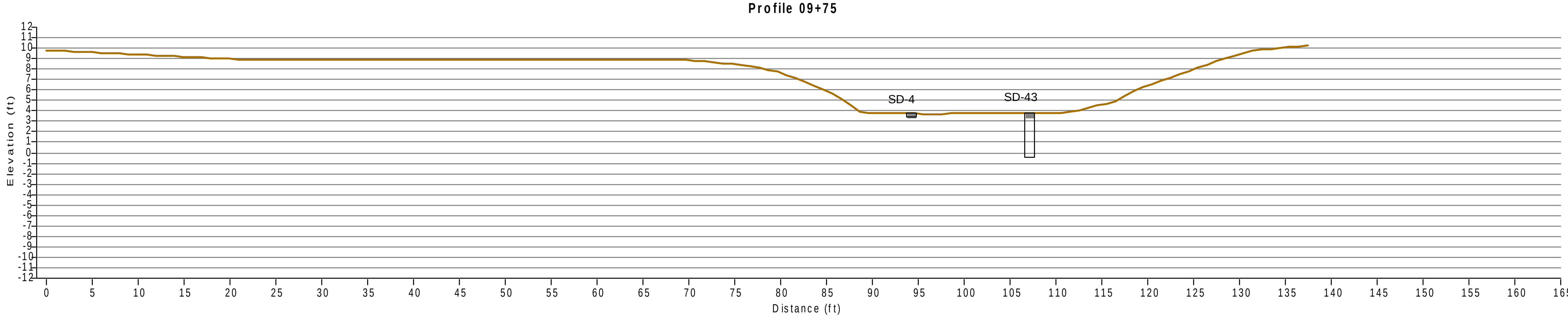
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

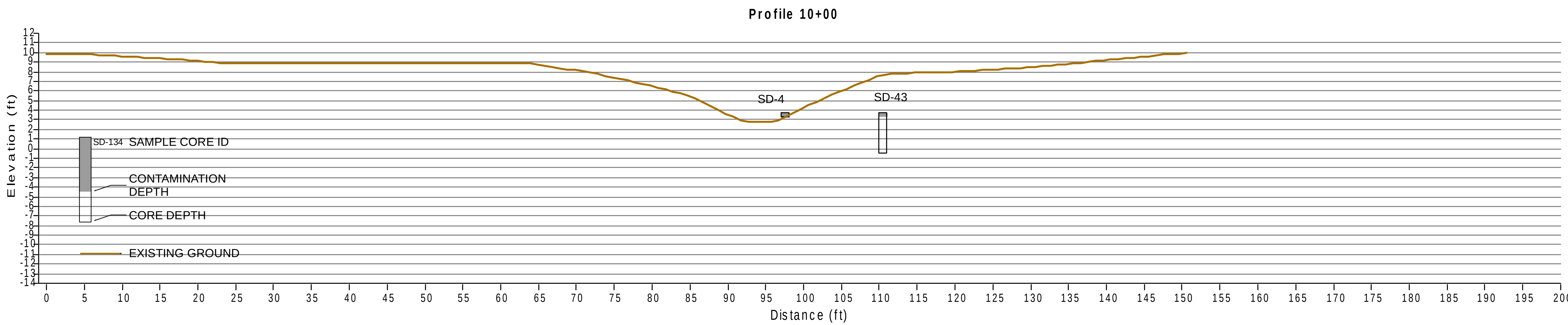
TETRA TECH

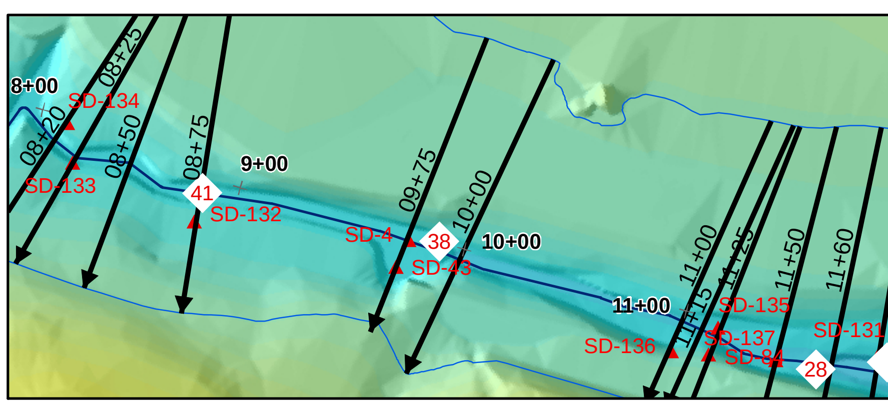
Lockheed Martin Middle River Complex
Middle River, MD

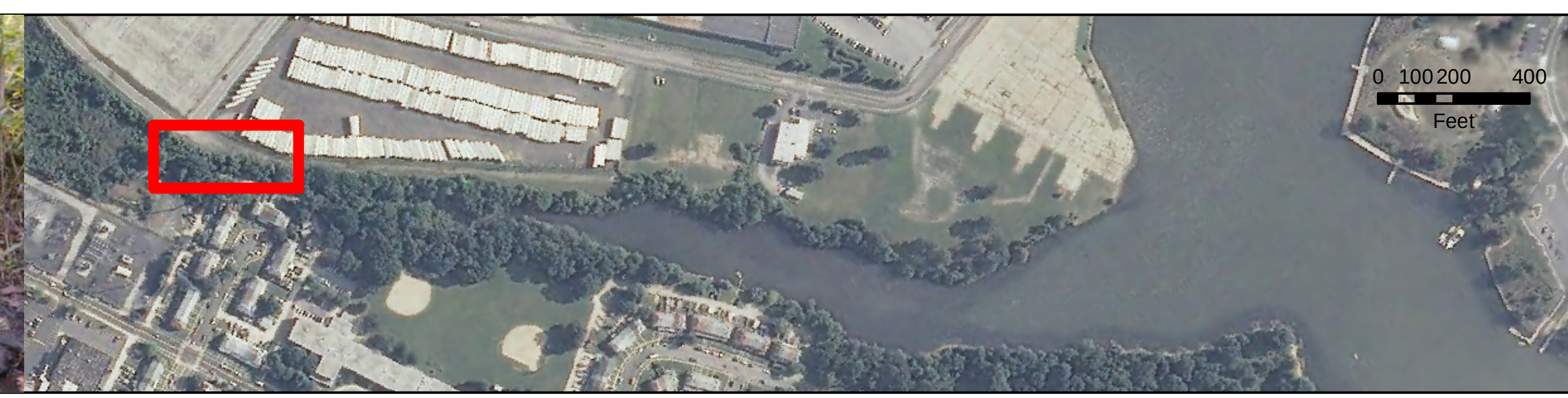
Figure A-3
Cow Pen Creek
Profiles 08+50 & 08+75

Document Path: R:\Projects 2013\Middle River CowCreek\maps\AppendixA-3 08+50 08+75 CPC.mxd









NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

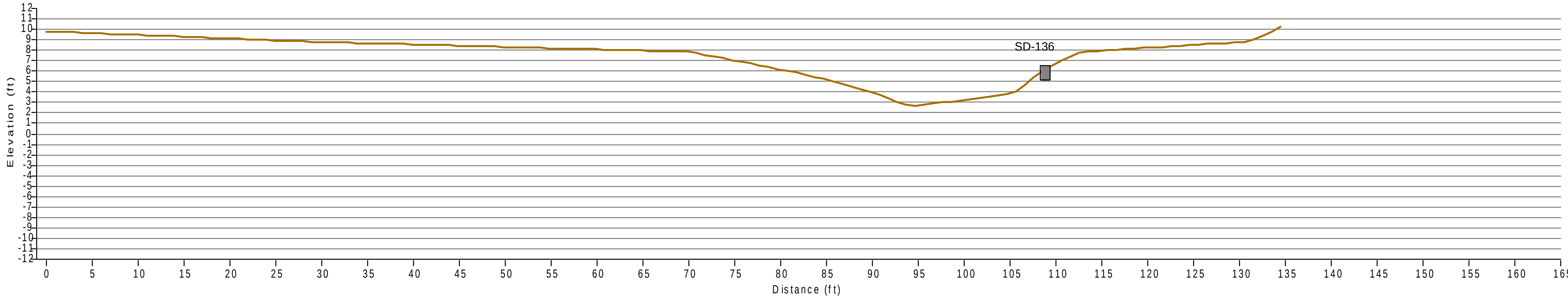
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

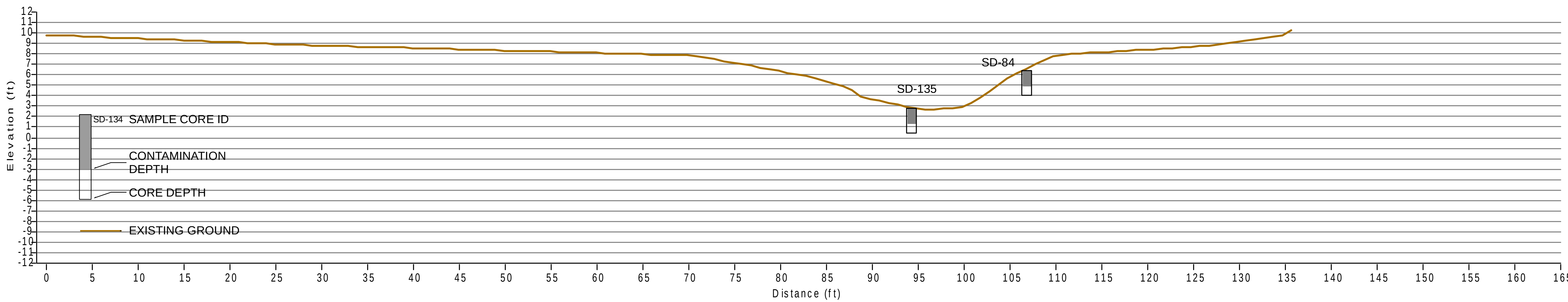
Figure A-4
Cow Pen Creek
Profiles 09+75 & 10+00

Document Path: R:\Projects_2013\Middle River_CowCreek\maps\AppendixA-4_09+75_10+00_CPC.mxd

Profile 11+00



Profile 11+25



NOTES:

1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

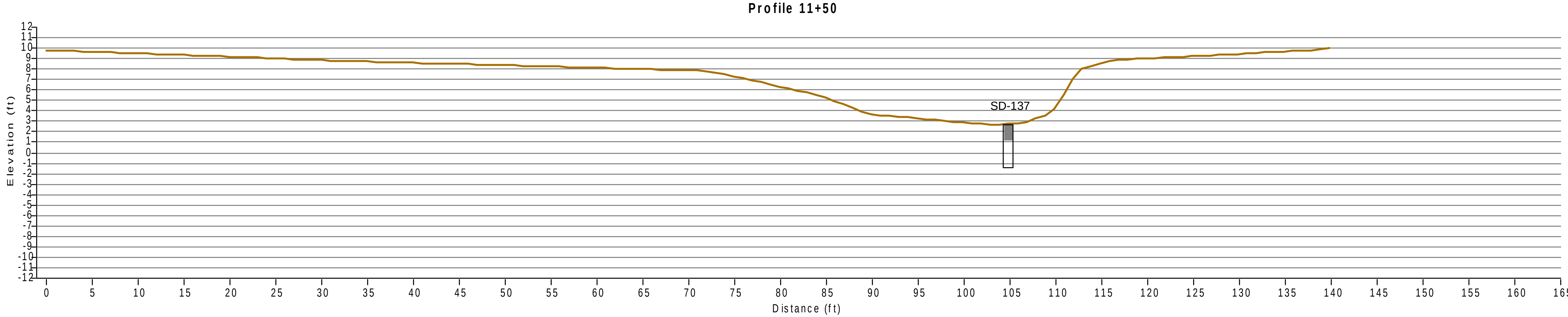
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

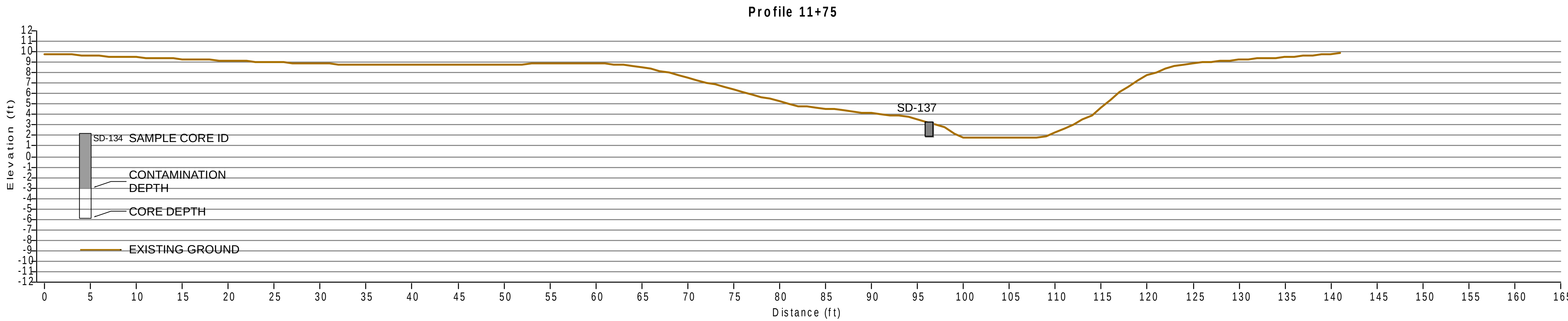
Figure A-5
Cow Pen Creek
Profiles 11+00 & 11+25

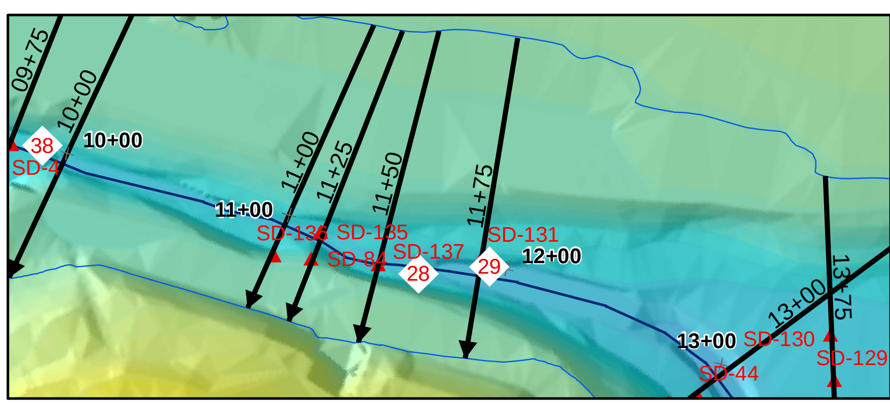
Document Path: R:\Projects 2013\Middle River CowCreek\maps\AppendixA\A-5 11+00 11+25 CPC.mxd

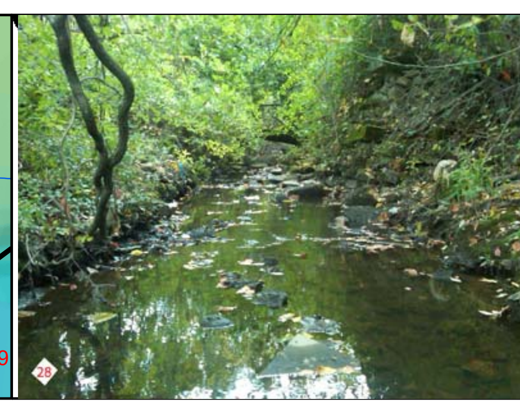
Profile 11+50

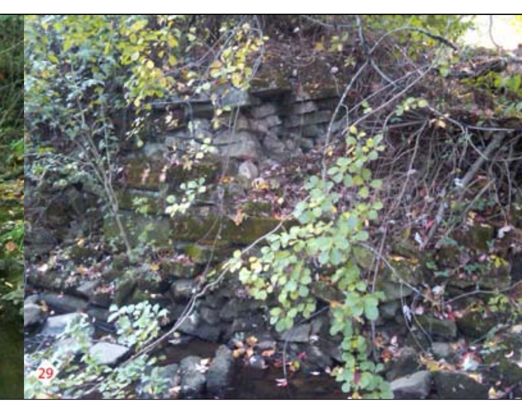


Profile 11+75









NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

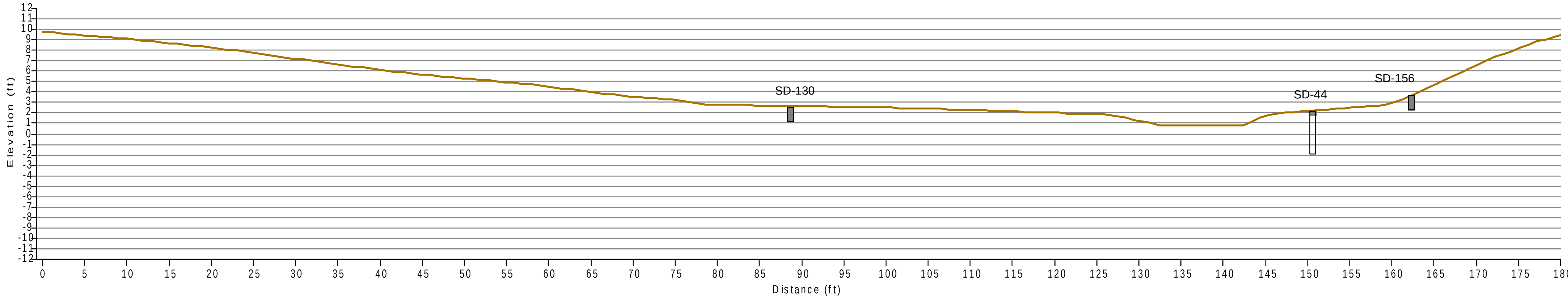
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

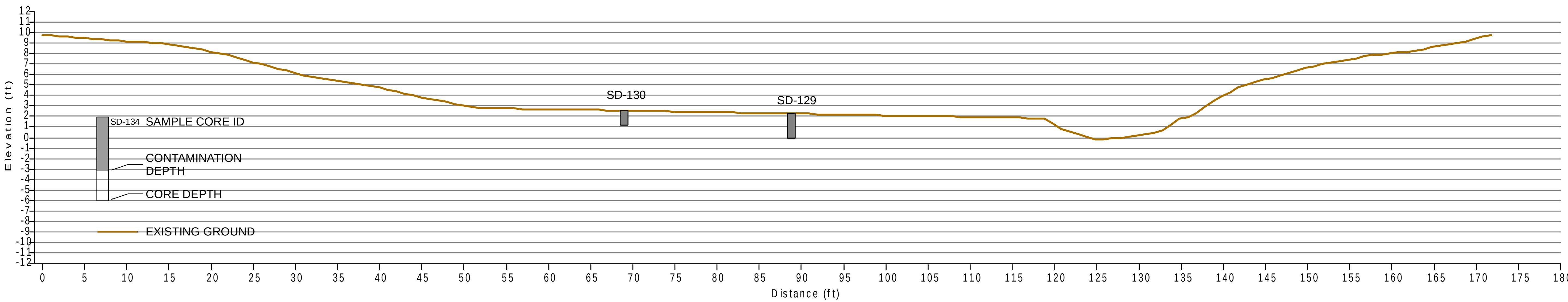
Figure A-6
Cow Pen Creek
Profiles 11+50 & 11+75

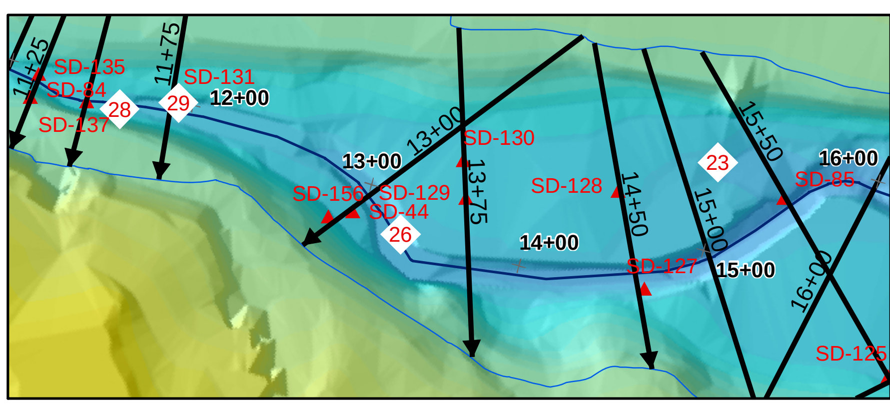
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-6_11+50_11+75_CPC.mxd

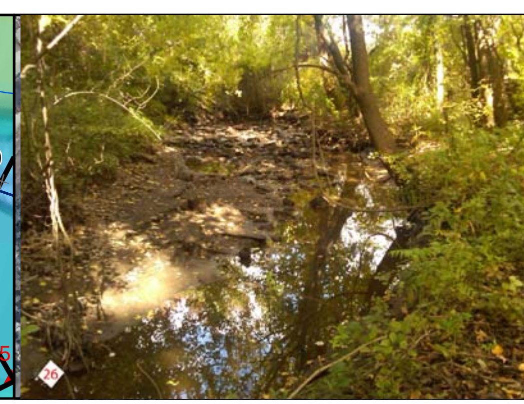
Profile 13+00



Profile 13+75







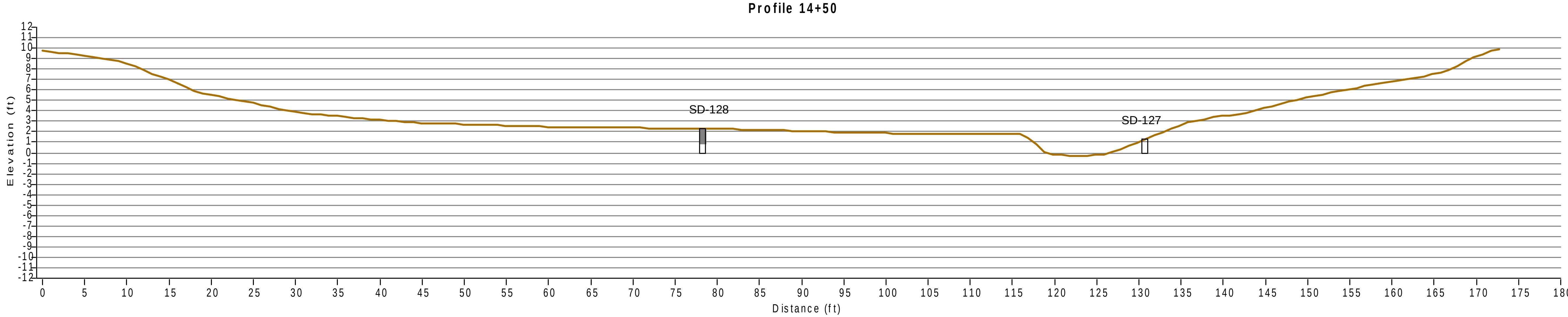
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

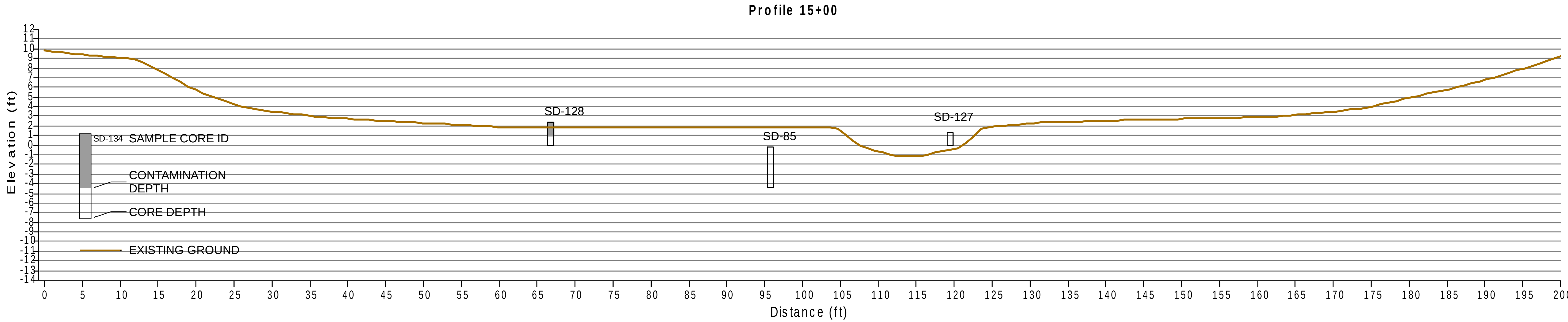
TETRA TECH

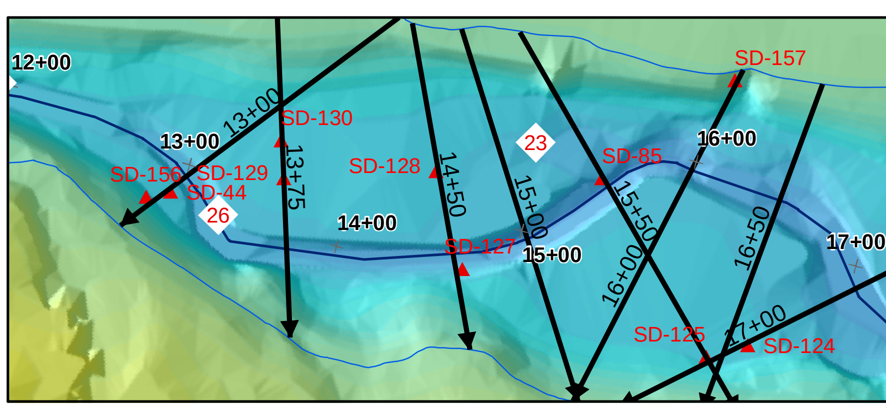
Lockheed Martin Middle River Complex
Middle River, MD

Figure A-7
Cow Pen Creek
Profiles 13+00 & 13+75

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-7_13+00_13+75_CPC.mxd







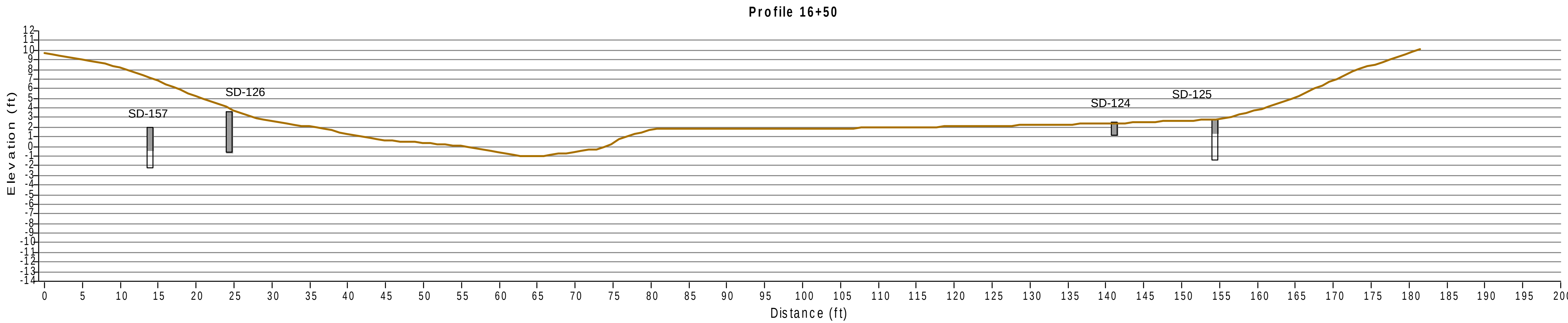
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

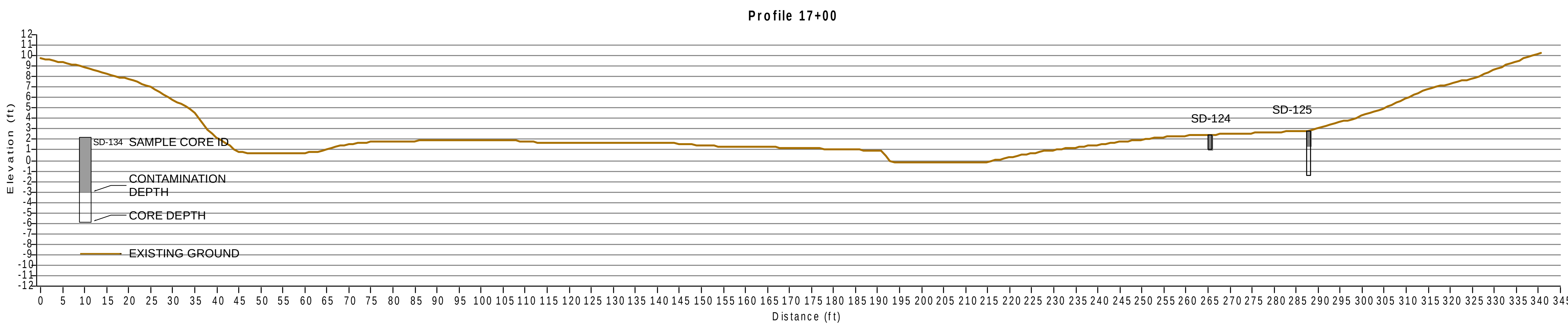
TETRA TECH

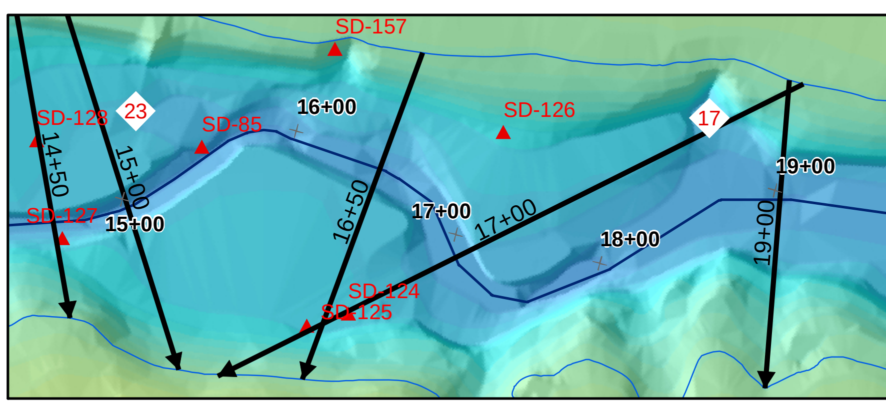
Lockheed Martin Middle River Complex
Middle River, MD

Figure A-8
Cow Pen Creek
Profiles 14+50 & 15+00

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-8_14+50_15+00_CPC.mxd







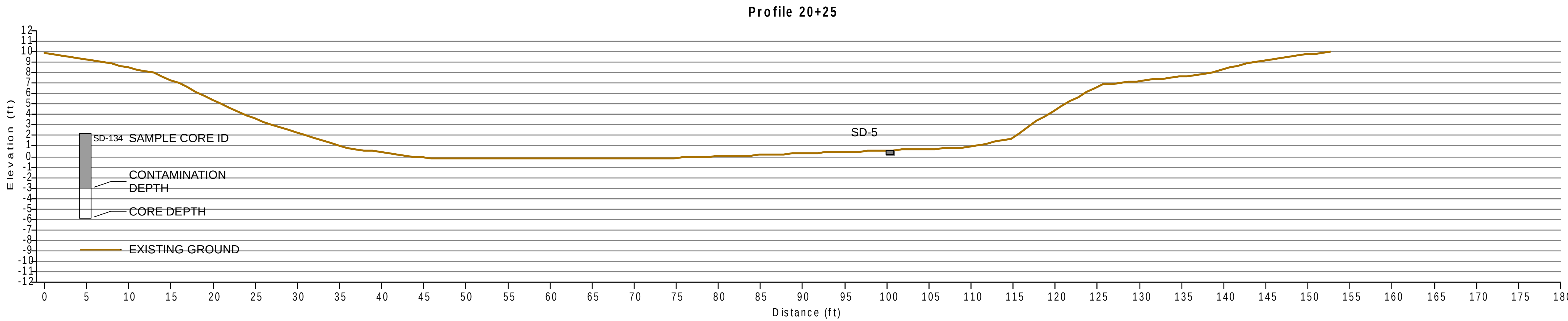
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

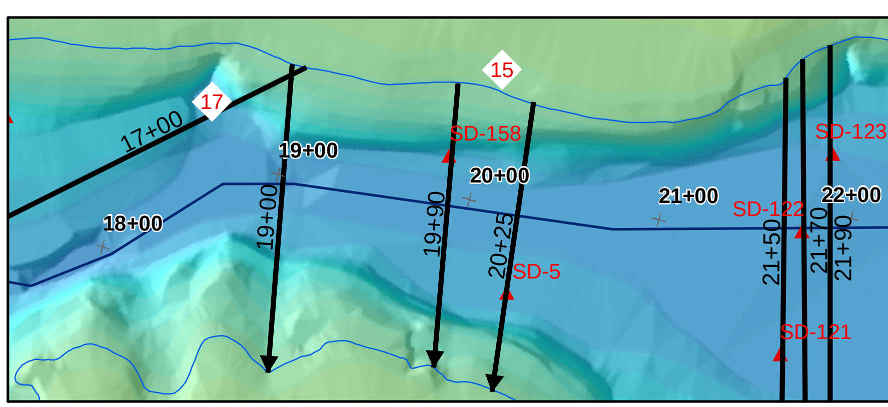
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-9
Cow Pen Creek
Profiles 16+50 & 17+00

Document Path: R:\Projects 2013\Middle River CowCreek\maps\Appendix\A-9 16+50 17+00 CPC.mxd





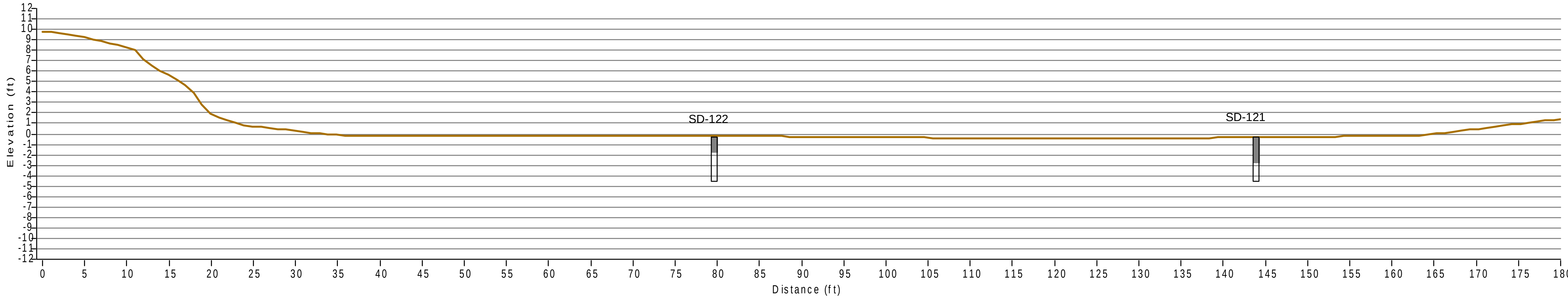
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

TETRA TECH

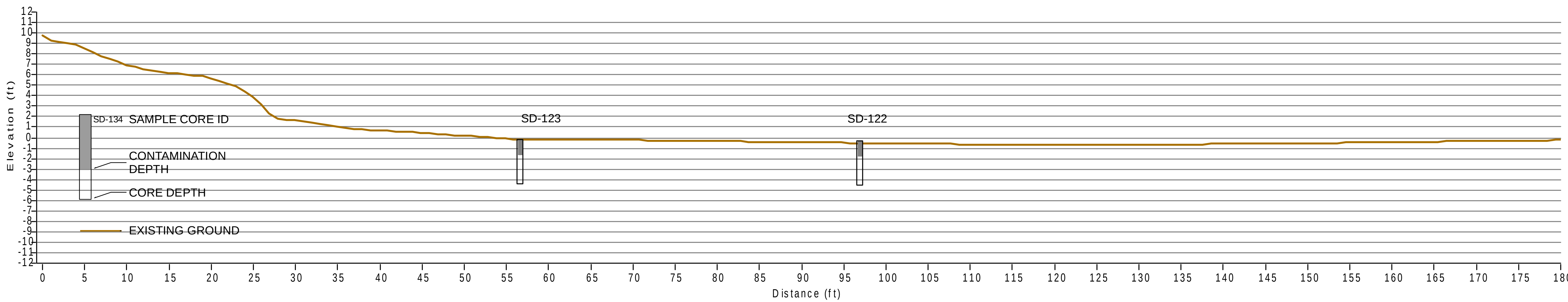
Lockheed Martin Middle River Complex
Middle River, MD

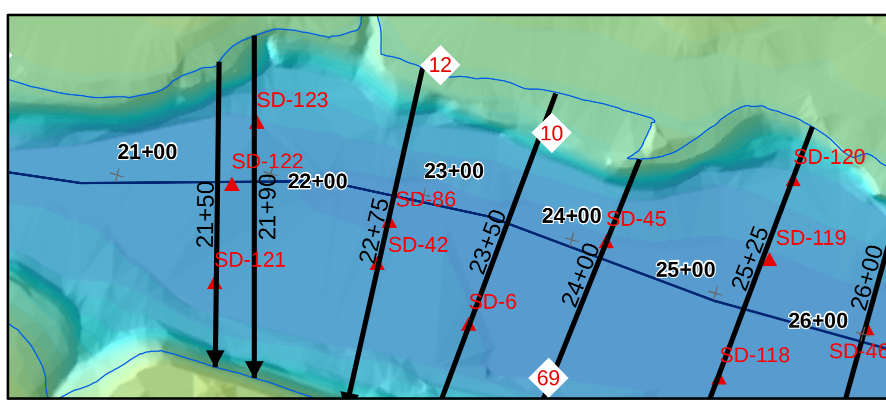
Figure A-10
Cow Pen Creek
Profiles 19+00 & 20+25

Profile 21+50



Profile 21+90





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

TETRA TECH

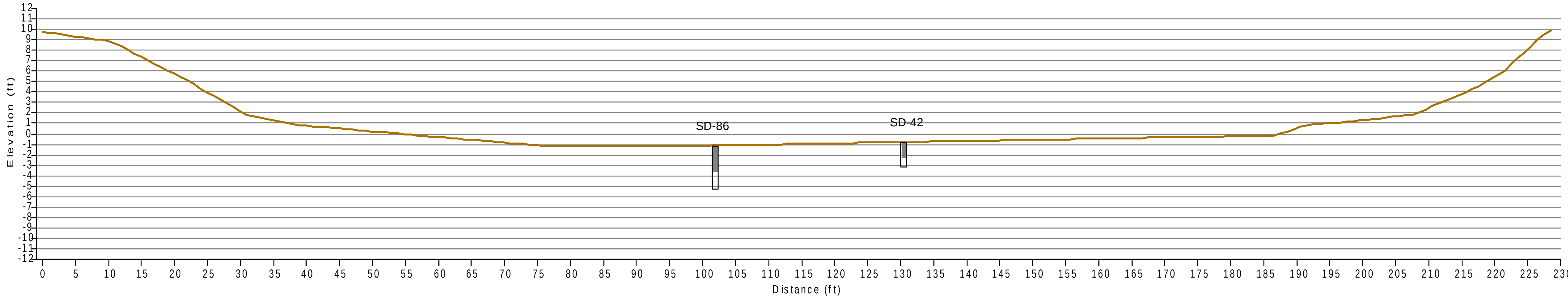
N E S W

Lockheed Martin Middle River Complex
Middle River, MD

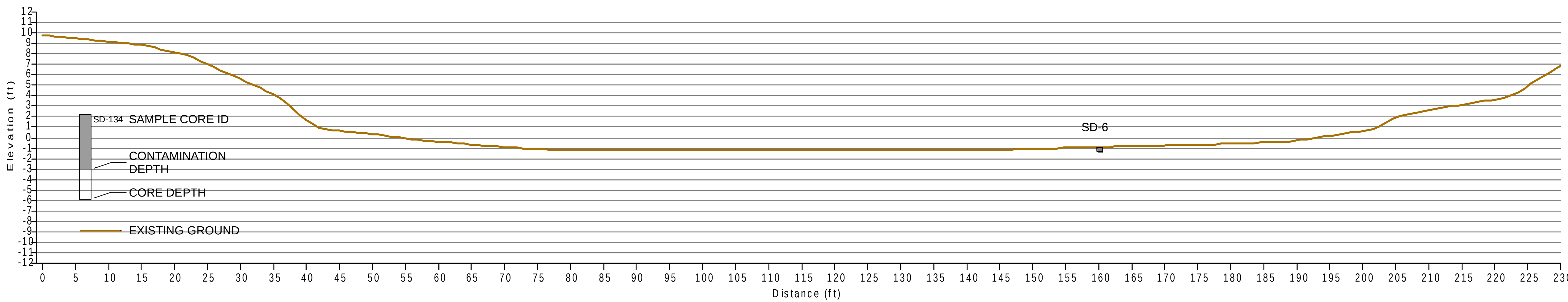
Figure A-11
Cow Pen Creek
Profiles 21+50 & 21+90

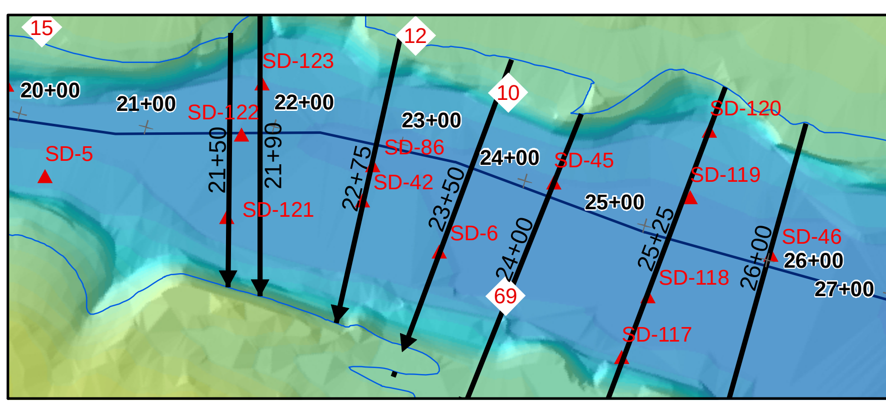
Document Path: R:\Projects 2013\Middle River CowCreek\maps\Appendix\A-11 21+50 21+90 CPC.mxd

Profile 22+75



Profile 23+50





NOTES:
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2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
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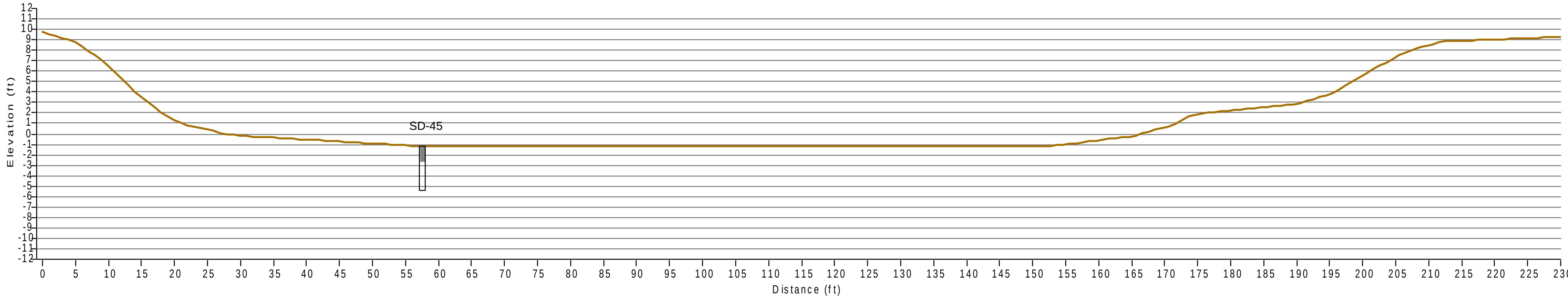
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

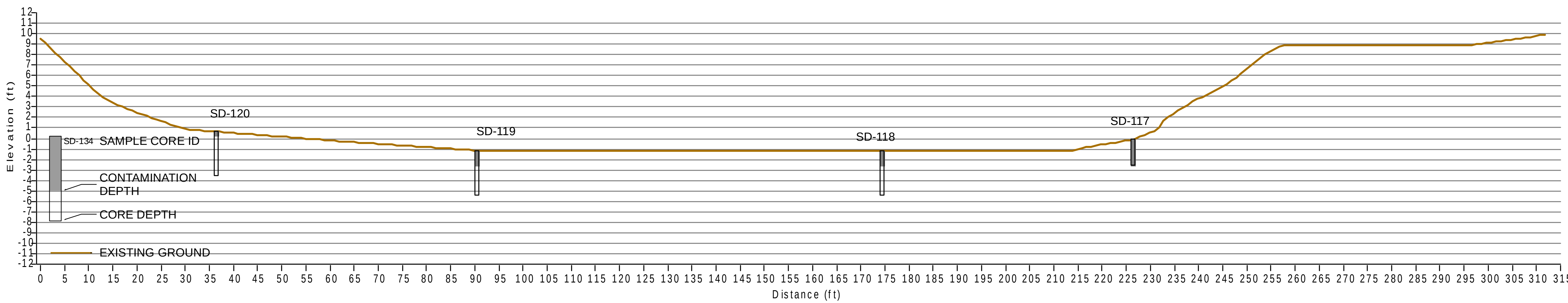
Figure A-12
Cow Pen Creek
Profiles 22+75 & 23+50

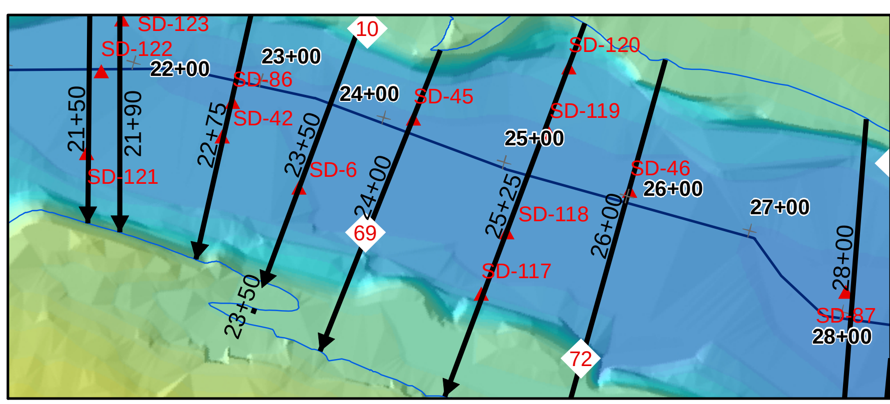
Document Path: R:\Projects 2013\Middle River CowCreek\maps\AppendixA\A-12 22+75 23+50 CPC.mxd

Profile 24+00



Profile 25+25





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
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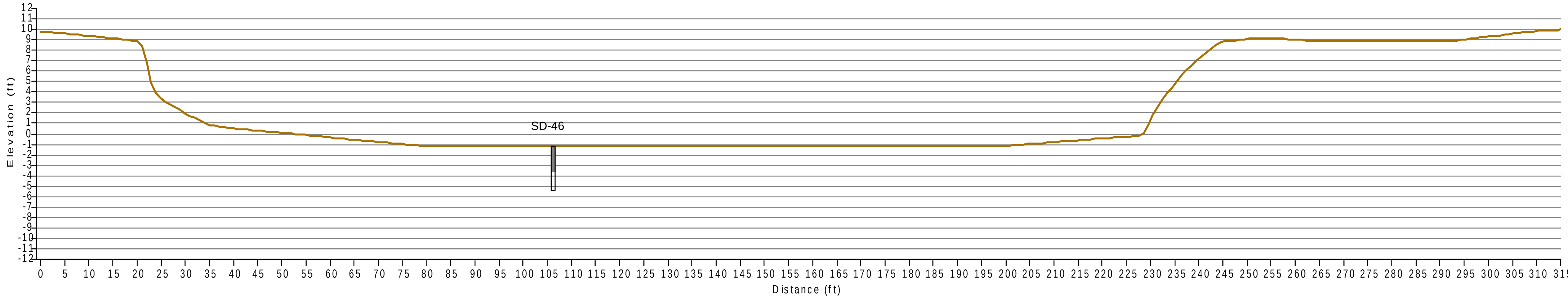
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

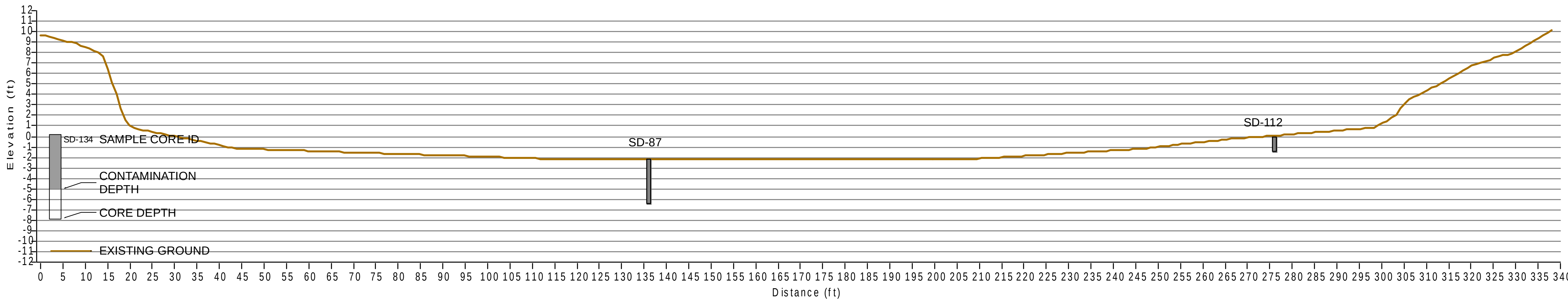
Figure A-13
Cow Pen Creek
Profiles 24+00 & 25+25

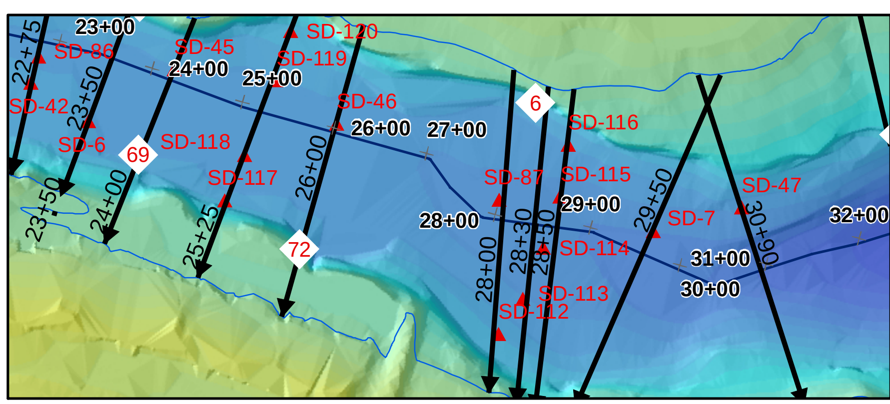
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-13_24+00_25+25_CPC.mxd

Profile 26+00



Profile 28+00





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
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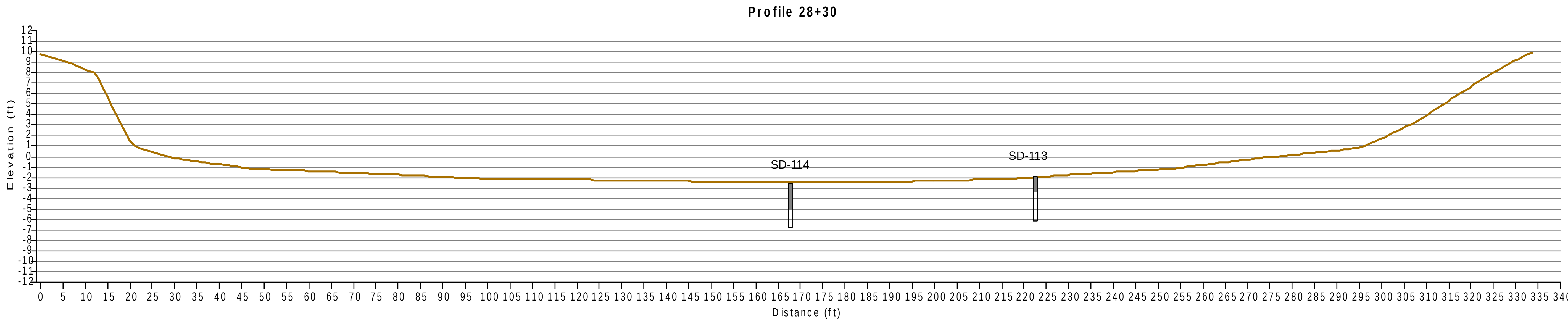
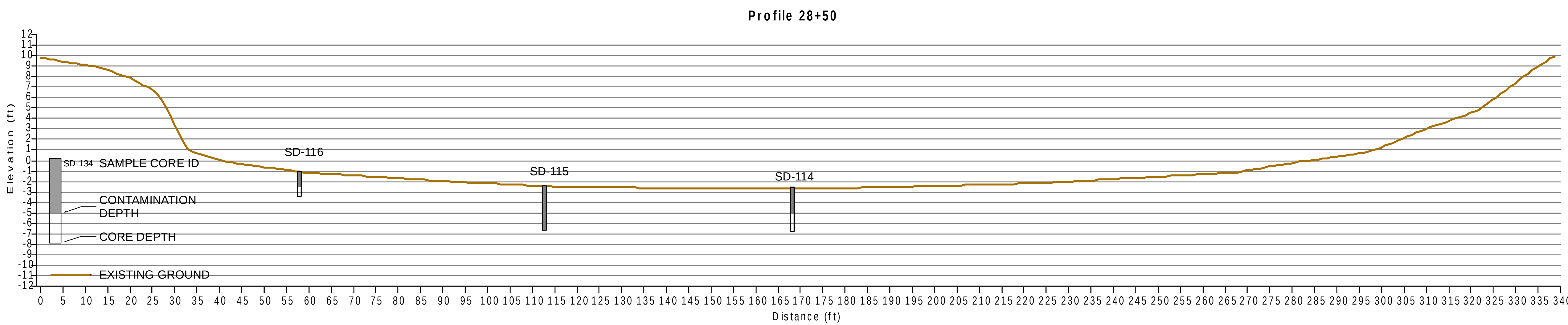
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-14
Cow Pen Creek
Profiles 26+00 & 28+00

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-14_26+00_28+00_CPC.mxd





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
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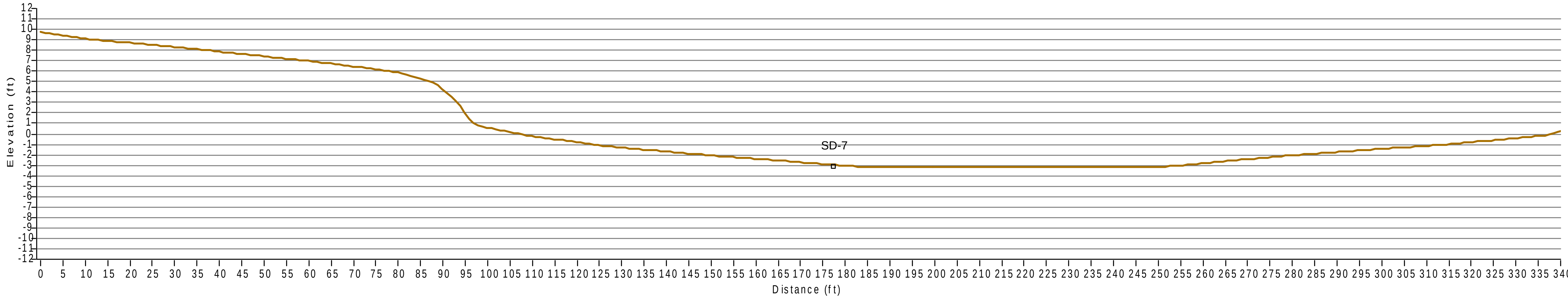
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

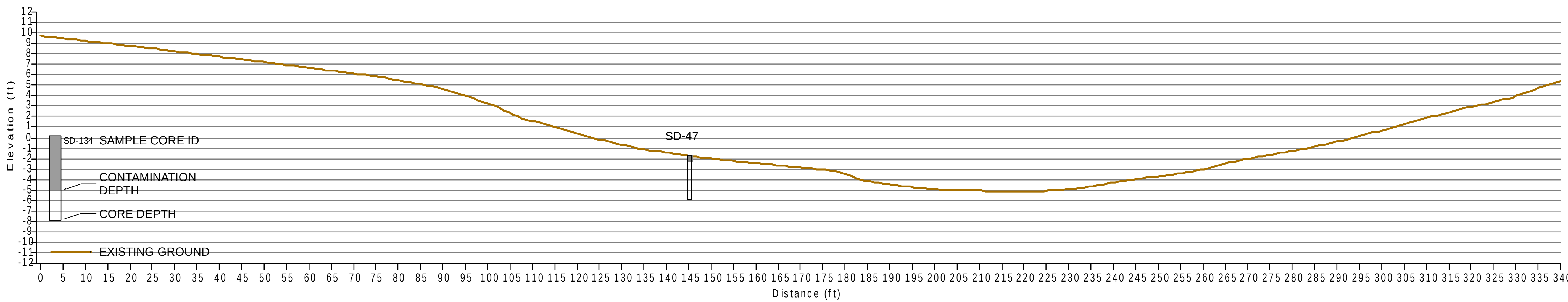
Figure A-15
Cow Pen Creek
Profiles 28+30 & 28+50

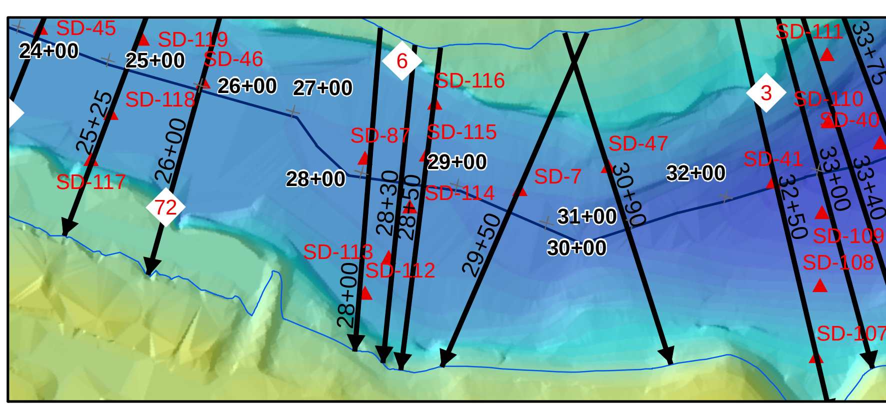
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-15_28+30_28+50_CPC.mxd

Profile 29+50



Profile 30+90





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

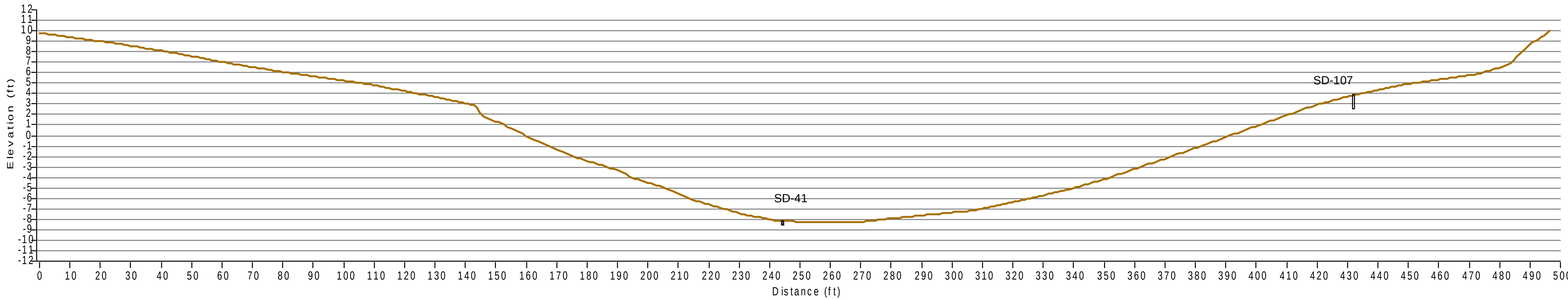
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

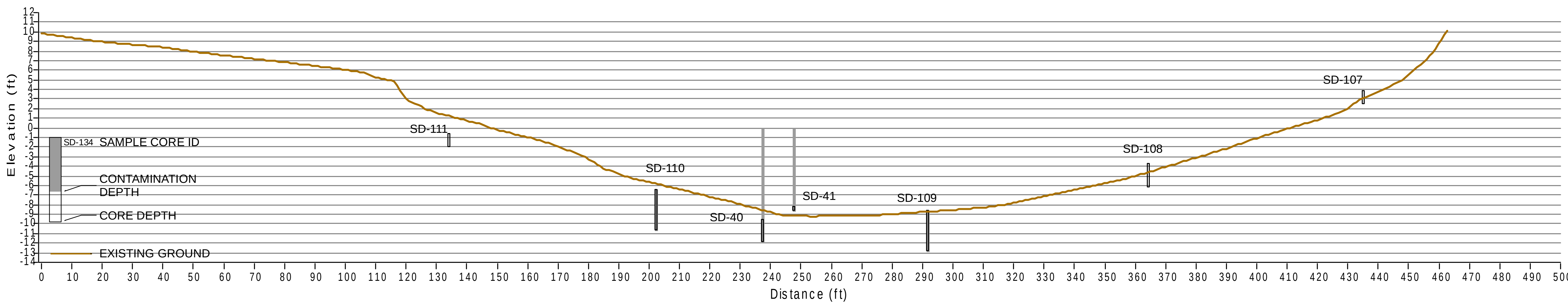
Figure A-16
Cow Pen Creek
Profiles 29+50 & 30+90

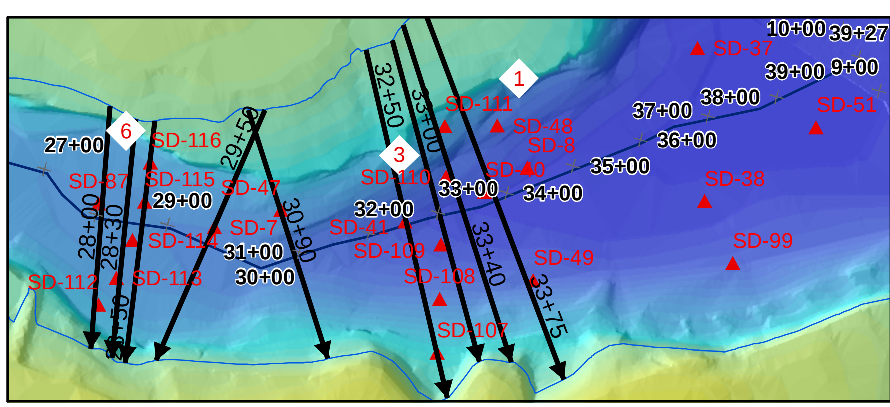
Document Path: R:\Projects 2013\Middle River CowCreek\maps\Appendix\A-16 29+50 30+90 CPC.mxd

Profile 32+50



Profile 33+00





NOTES:

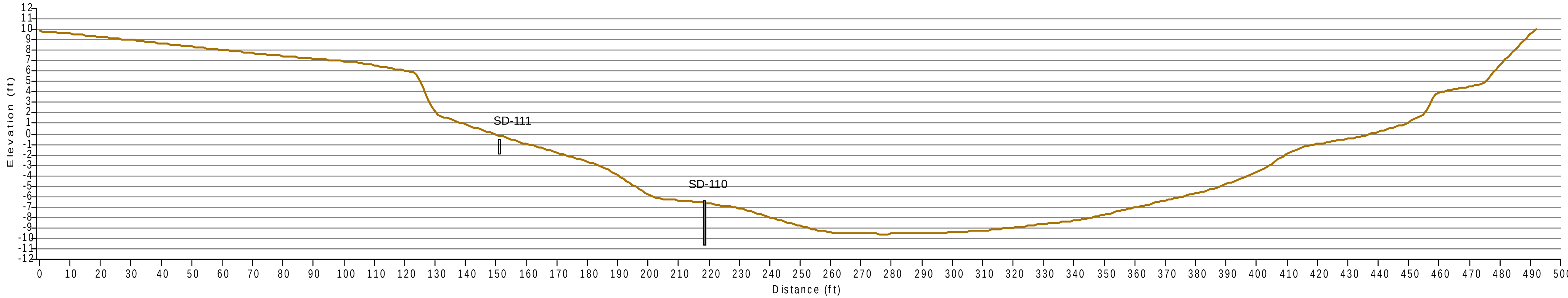
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

TETRA TECH

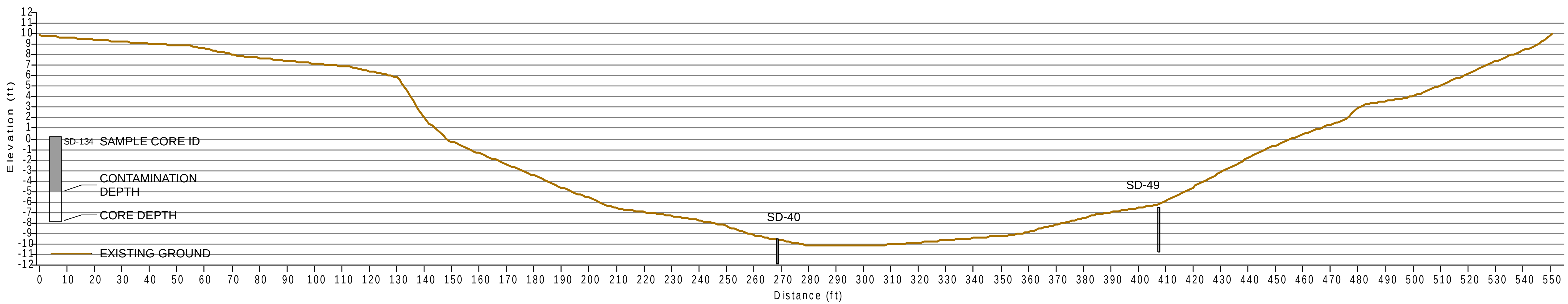
Lockheed Martin Middle River Complex
Middle River, MD

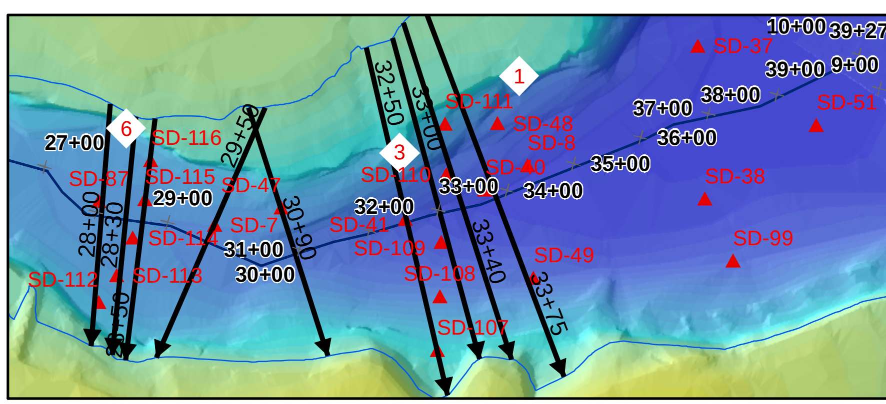
Figure A-17
Cow Pen Creek
Profiles 32+50 & 33+00

Profile 33+40



Profile 33+75





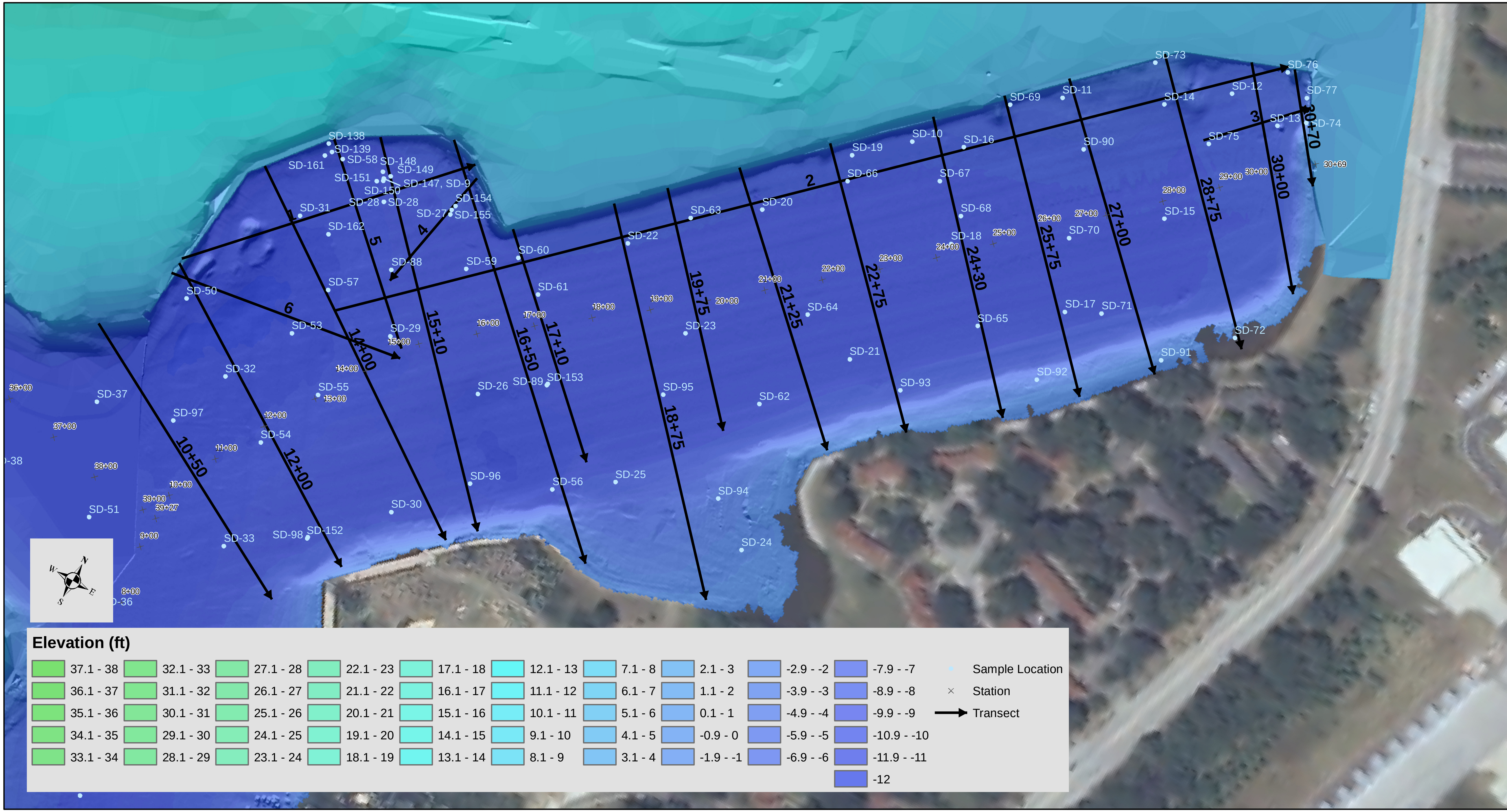
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-18
Cow Pen Creek
Profiles 33+40 & 33+75

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-18_33+40_33+75_CPC.mxd



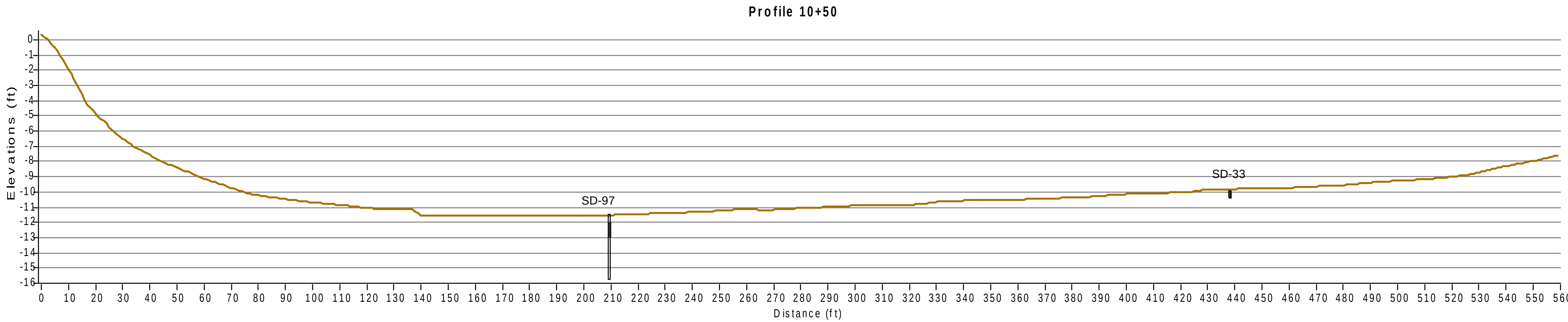
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.

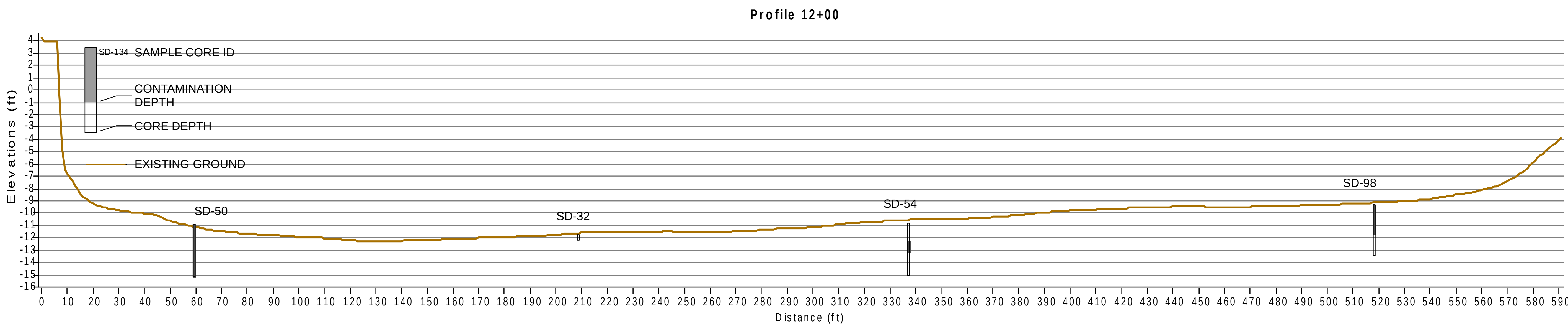
TETRA TECH

0 50 100 200
Feet

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-19
Dark Head Cove Transects





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

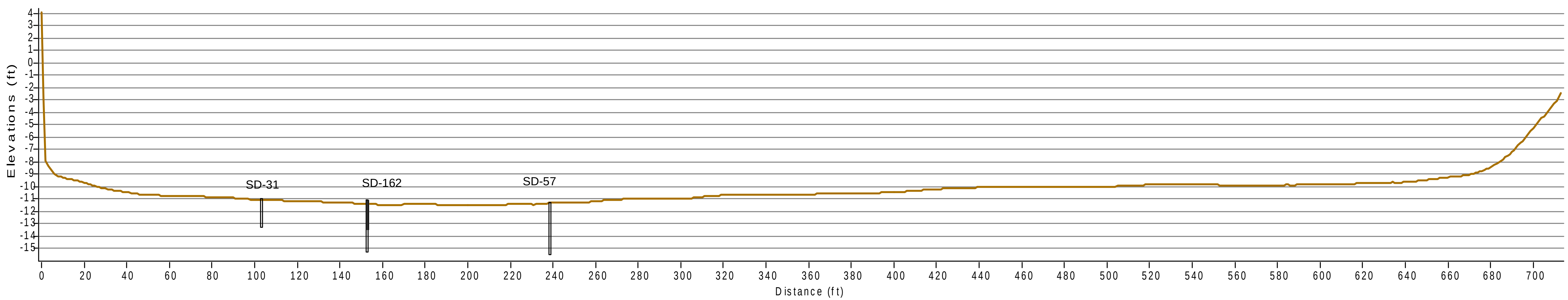
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

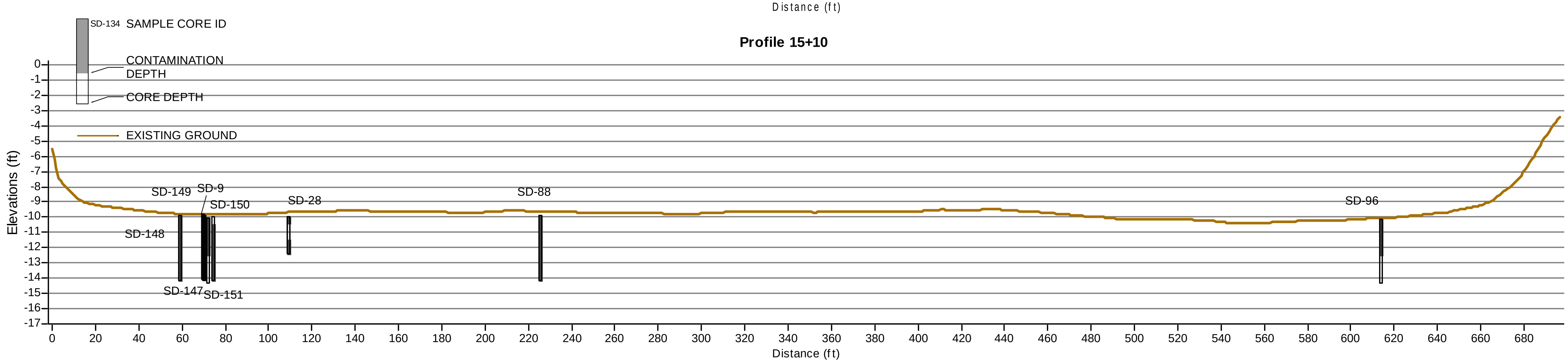
Figure A-20
Dark Head Cove
Profiles 10+50 & 12+00

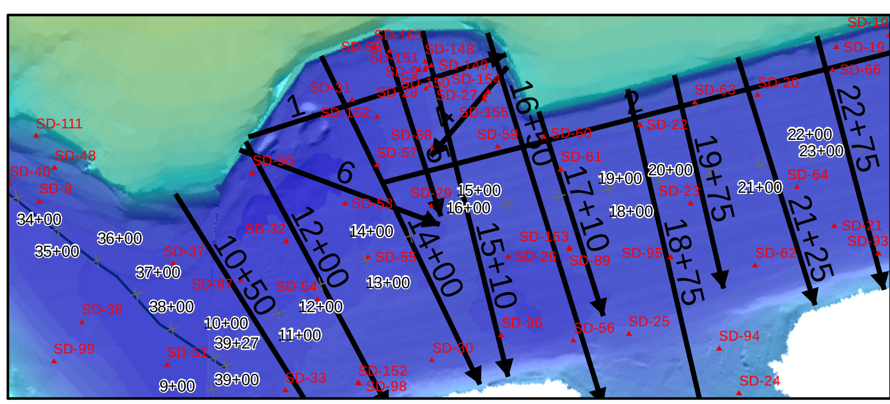
Document Path: R:\Projects 2013\Middle River CowCreek\maps\AppendixA-20 10+50 12+00 DHC.mxd

Profile 14+00



Profile 15+10





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

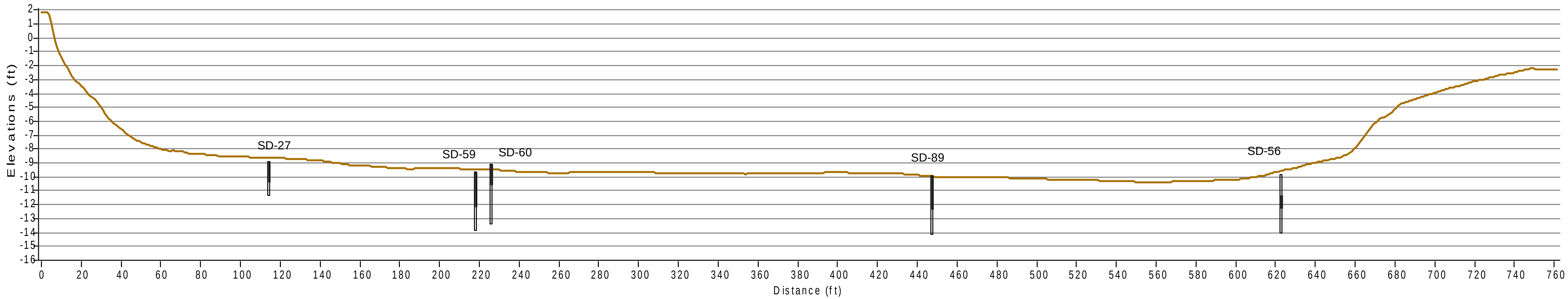
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

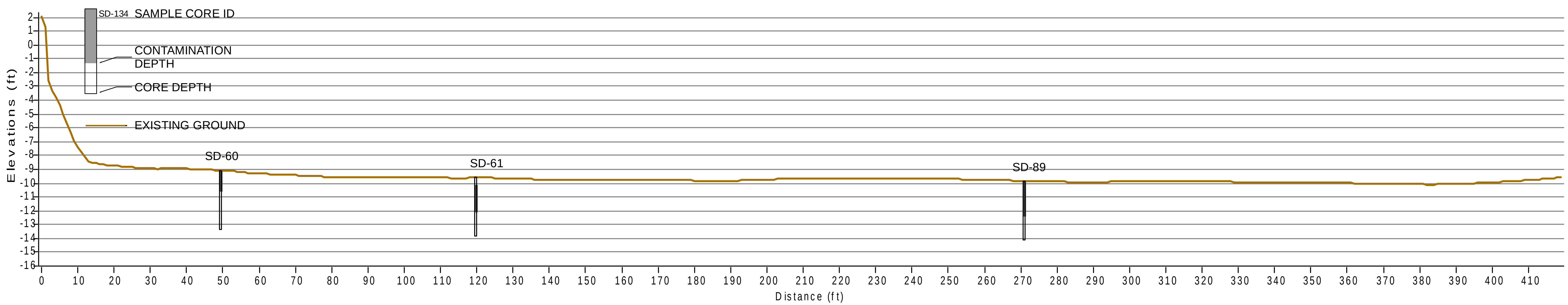
Figure A-21
Dark Head Cove
Profiles 14+00 & 15+10

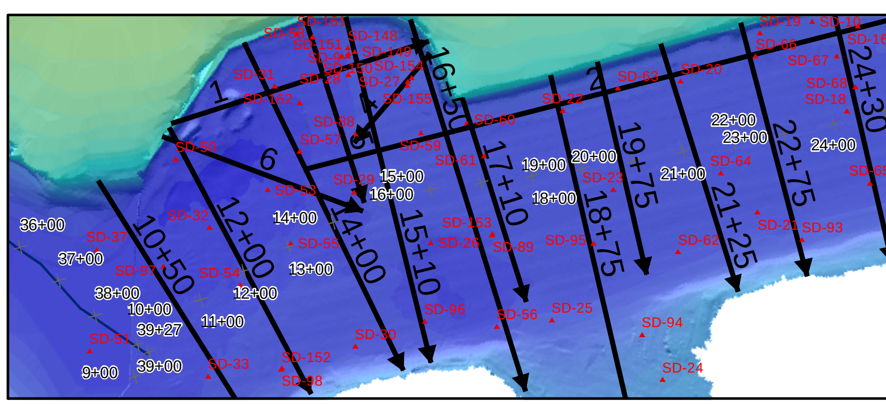
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-21_14+00_15+10_DHC.mxd

Profile 16+50



Profile 17+10





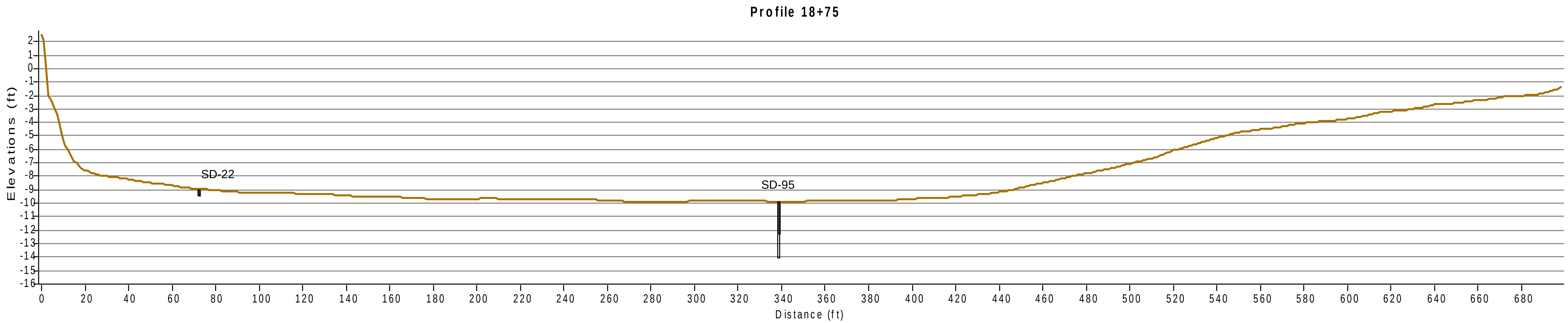
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

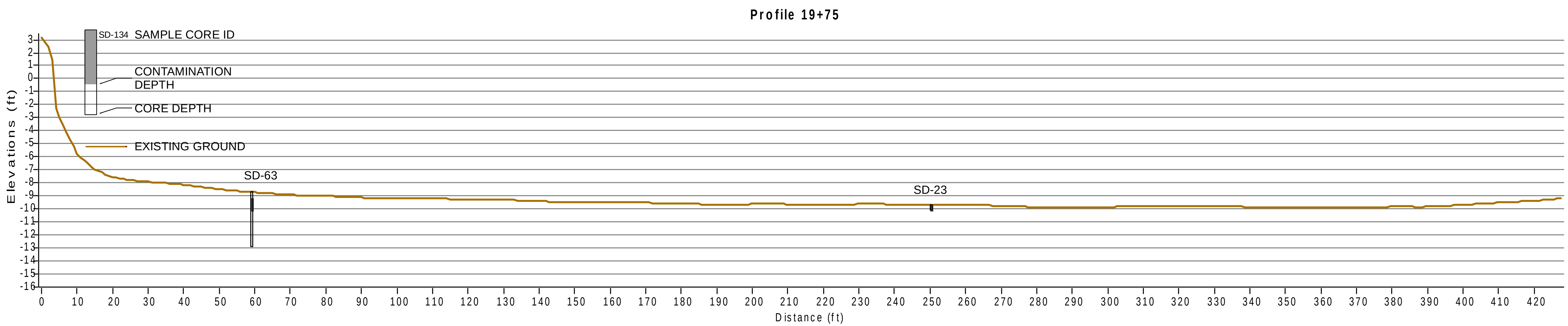
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-22
Dark Head Cove
Profiles 16+50 & 17+10

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-22_16+50_17+10_DHC.mxd





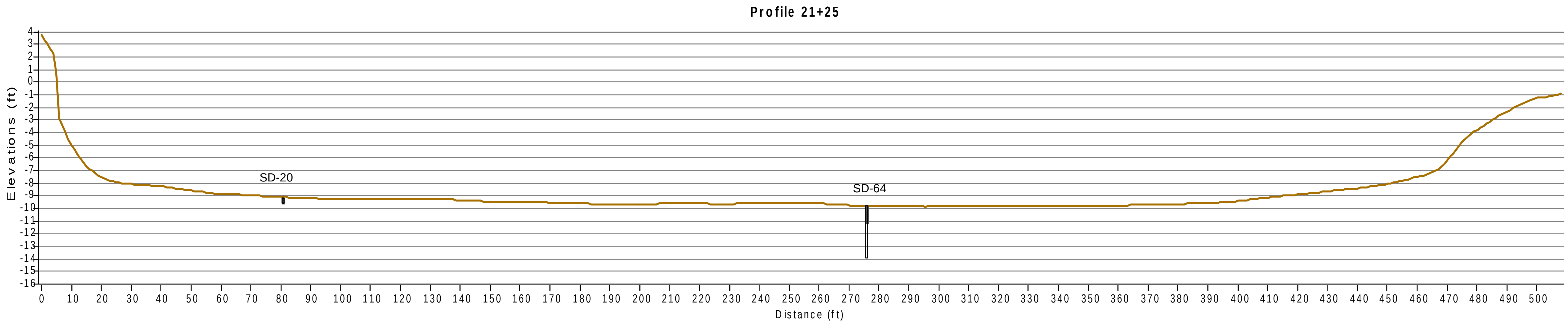
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

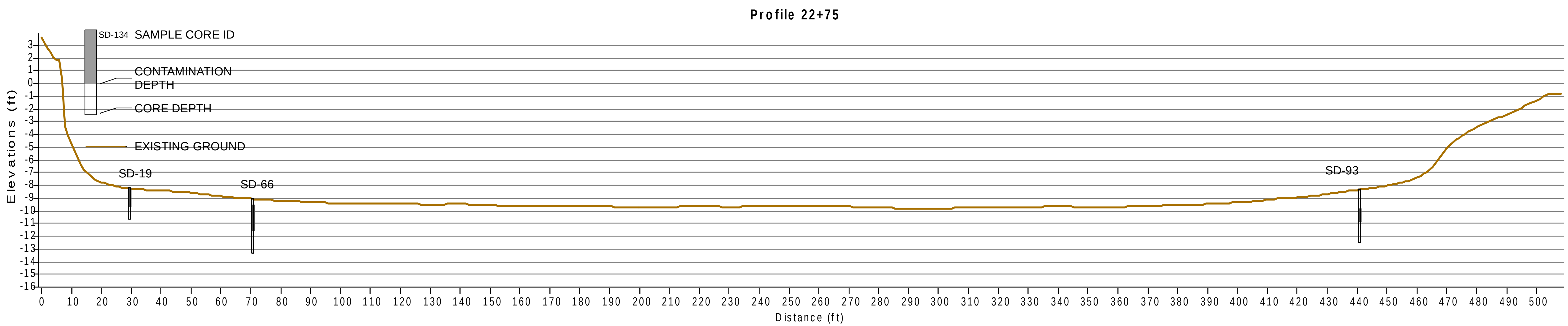
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-23_18+75_19+75_DHC.mxd

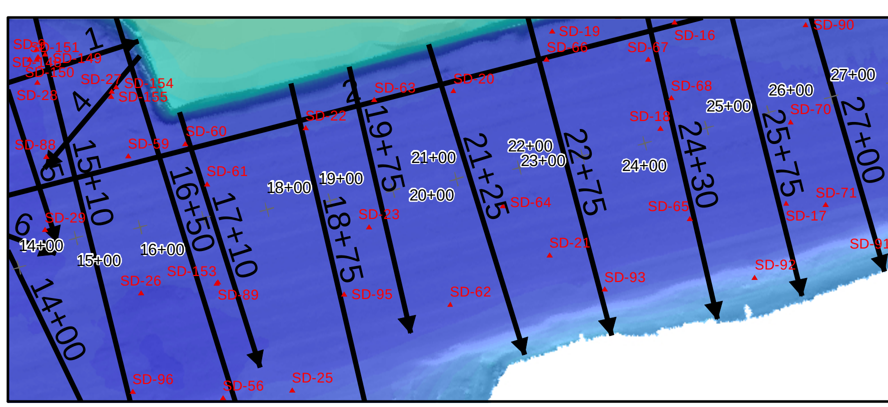
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-23
Dark Head Cove
Profiles 18+75 & 19+75







NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

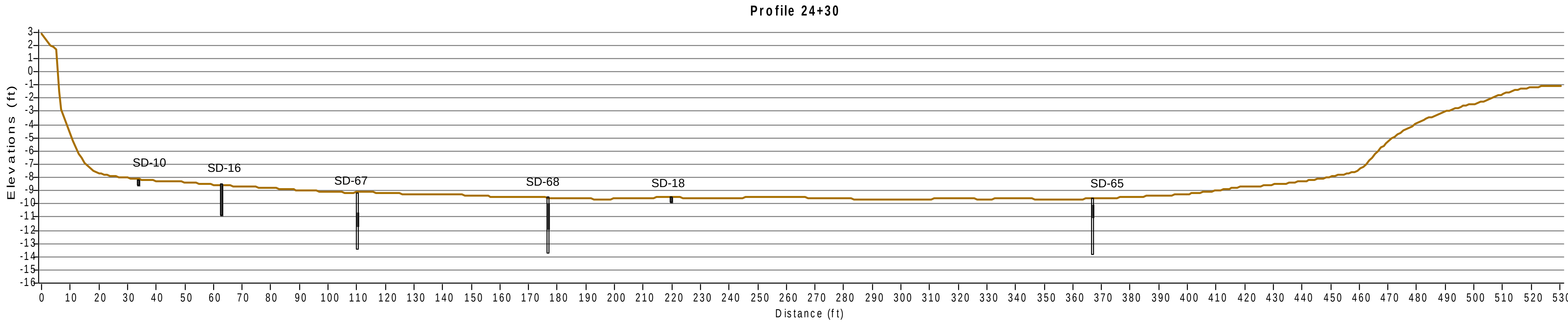
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

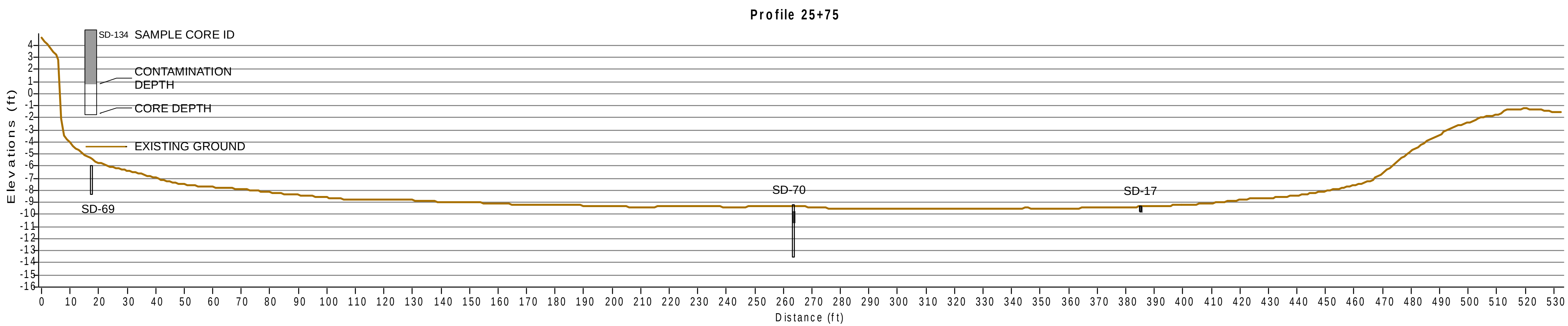
Figure A-24
Dark Head Cove
Profiles 21+25 & 22+75

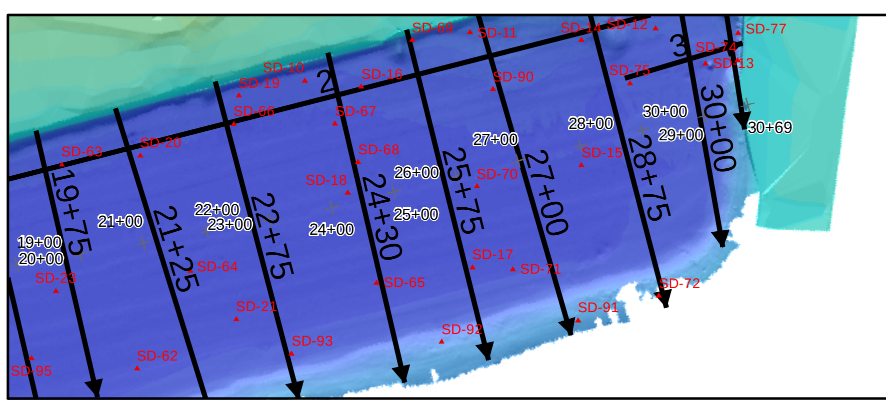
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-24_21+25_22+75_DHC.mxd

Profile 24+30



Profile 25+75





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

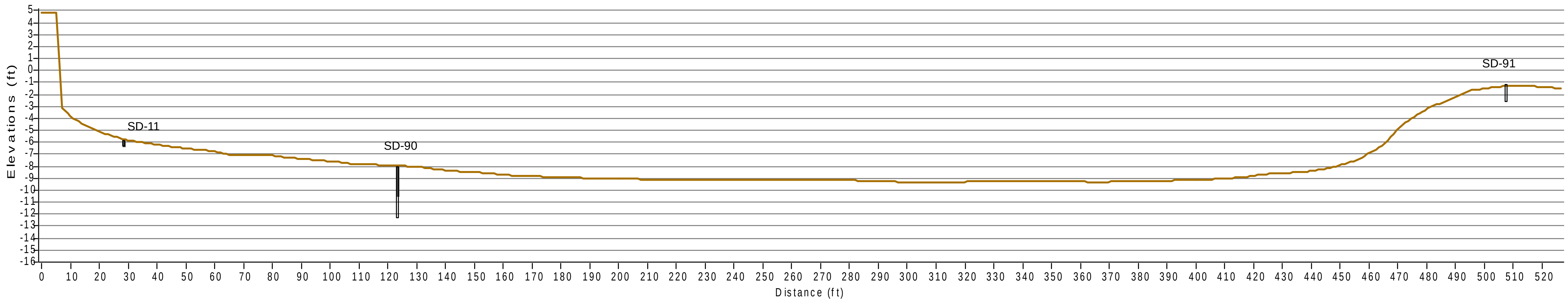
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

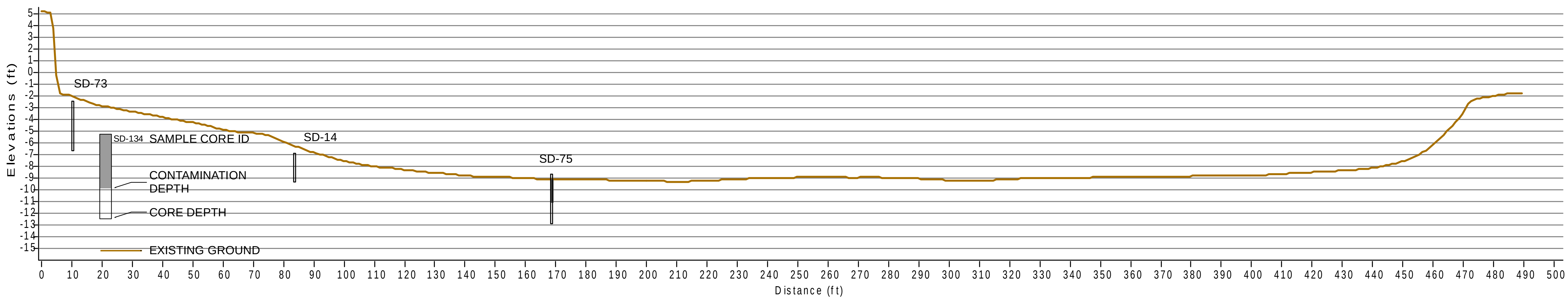
Figure A-25
Dark Head Cove
Profiles 24+30 & 25+75

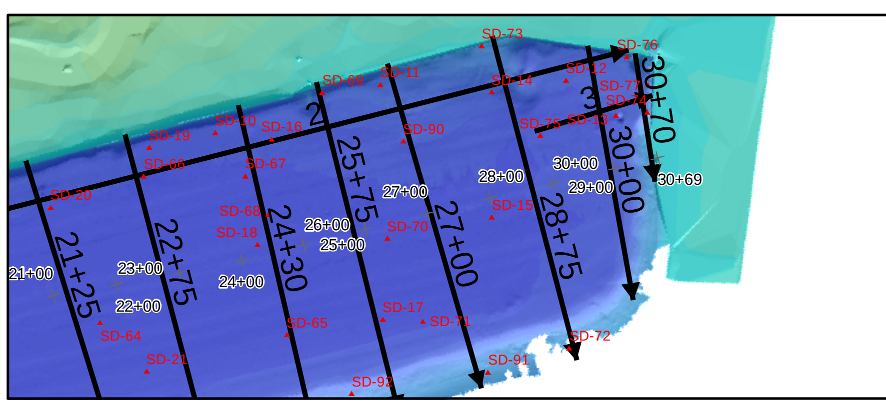
Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA\A-25_24+30_25+75_DHC.mxd

Profile 27+00



Profile 28+75





NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

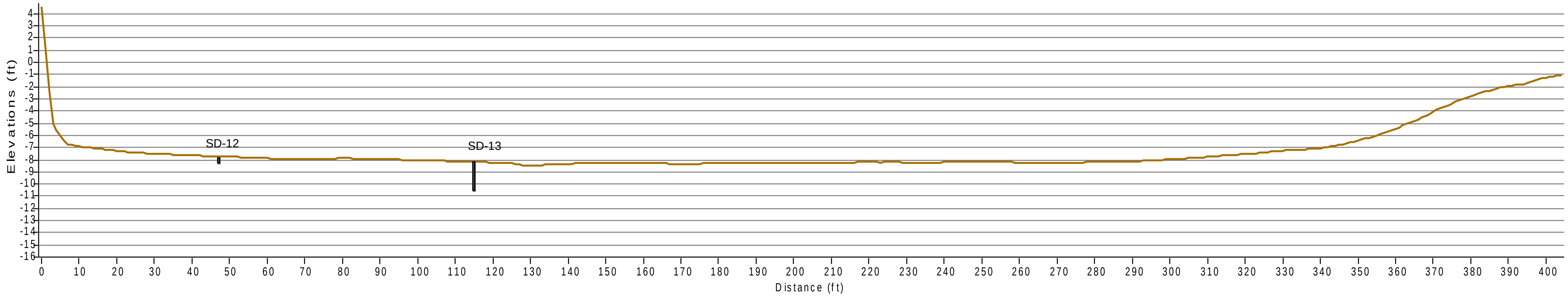
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

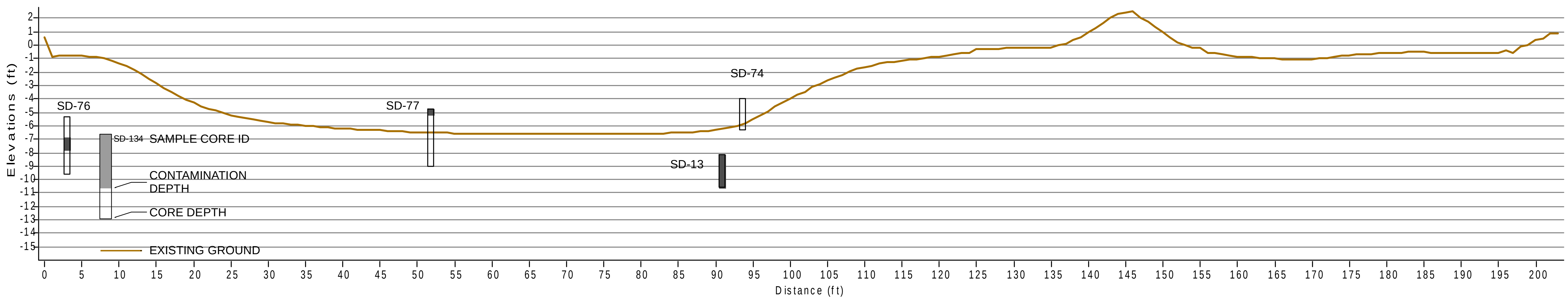
Figure A-26
Dark Head Cove
Profiles 27+00 & 28+75

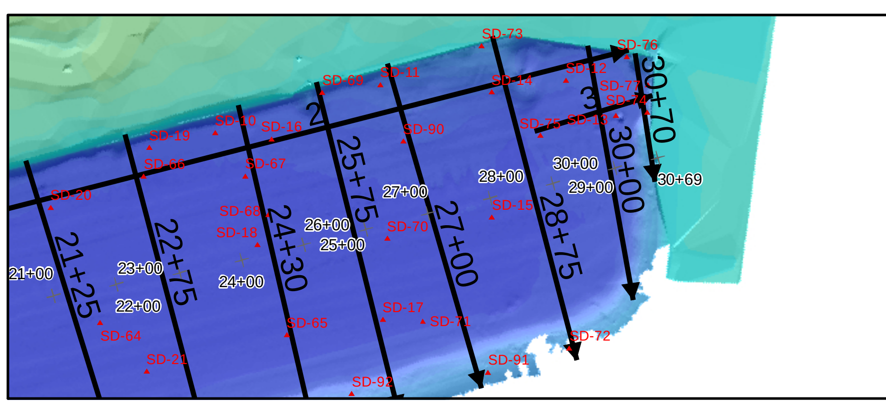
Document Path: R:\Projects 2013\Middle River CowCreek\maps\AppendixA-26 27+00 28+75 DHC.mxd

Profile 30+00



Profile 30+70





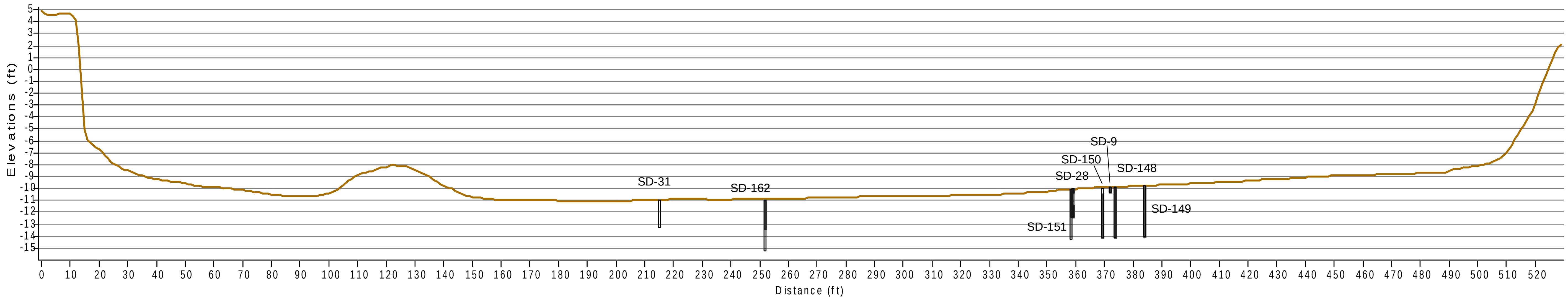
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

TETRA TECH

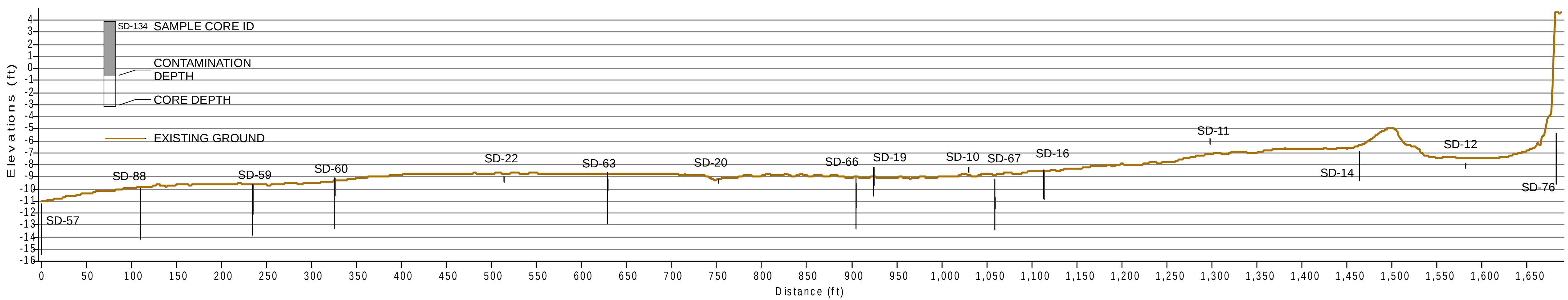
Lockheed Martin Middle River Complex
Middle River, MD

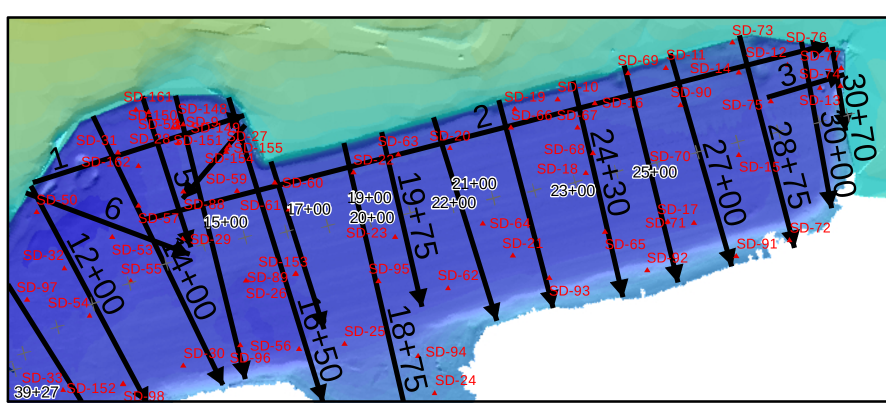
Figure A-27
Dark Head Cove
Profiles 30+00 & 30+70

Profile 1



Profile 2





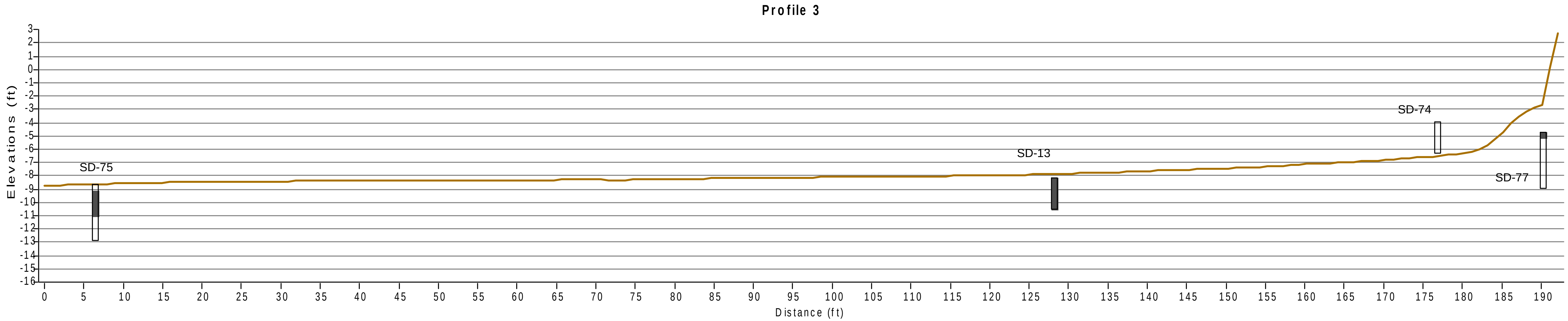
NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

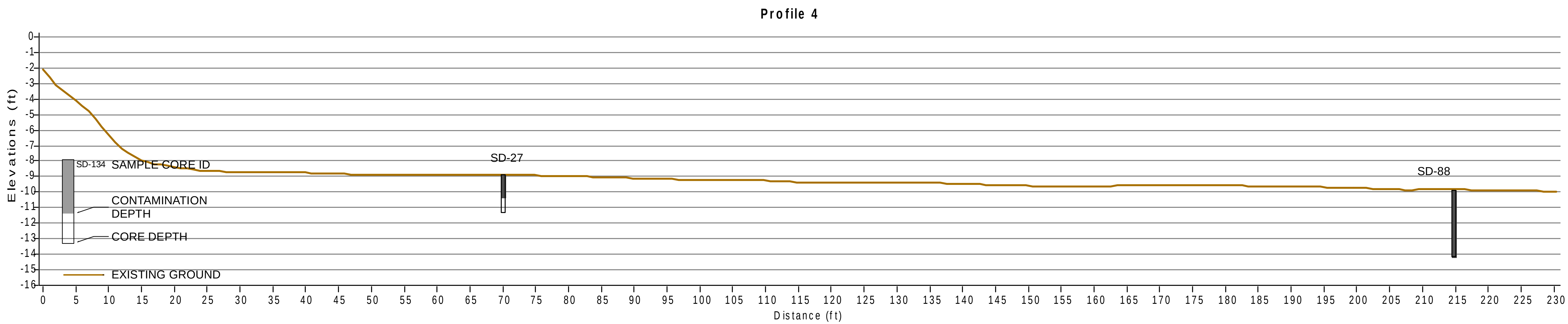
TETRA TECH

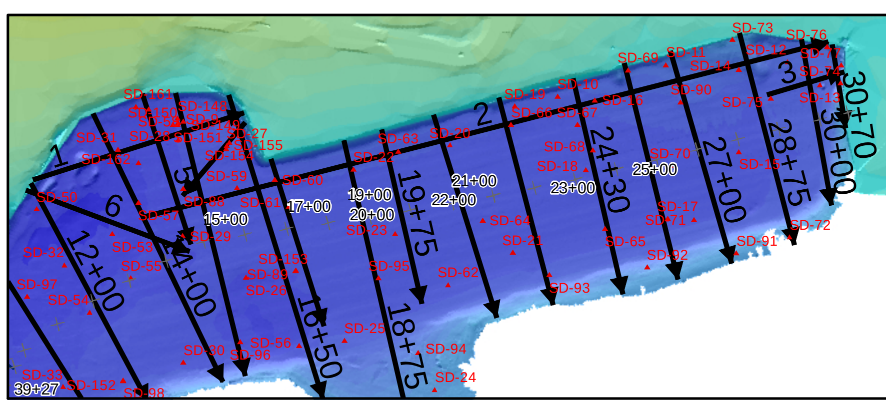
Lockheed Martin Middle River Complex
Middle River, MD

Figure A-28
Dark Head Cove
Profiles 1 & 2

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA\A-28_1_2_DHC.mxd







NOTES:

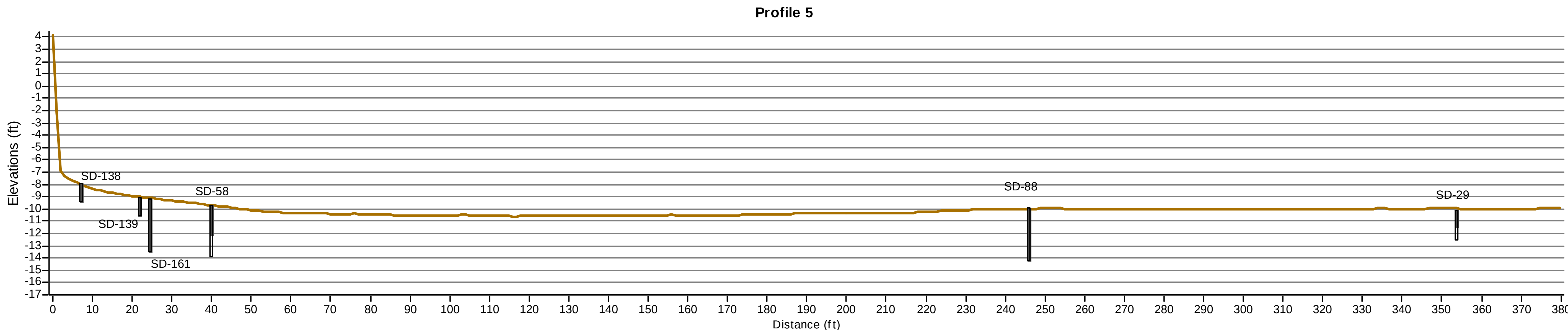
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

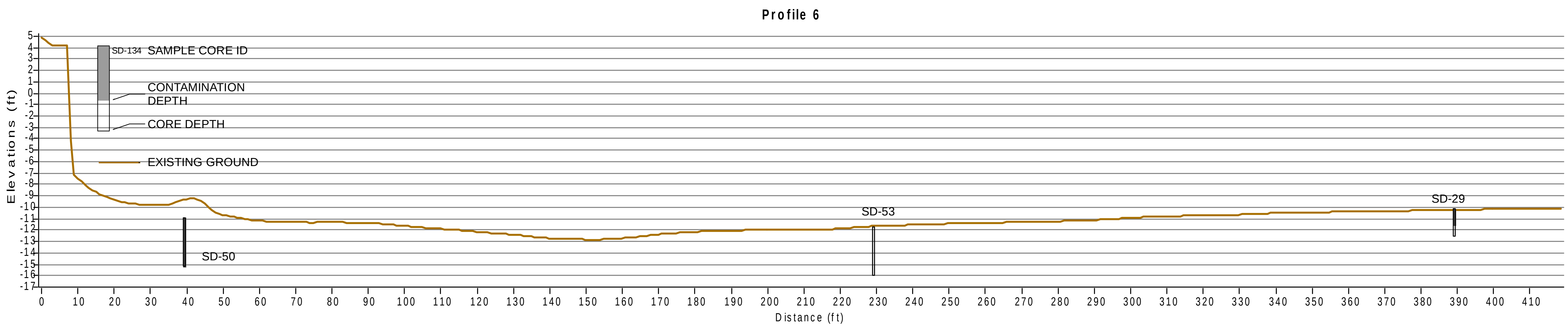
TETRA TECH

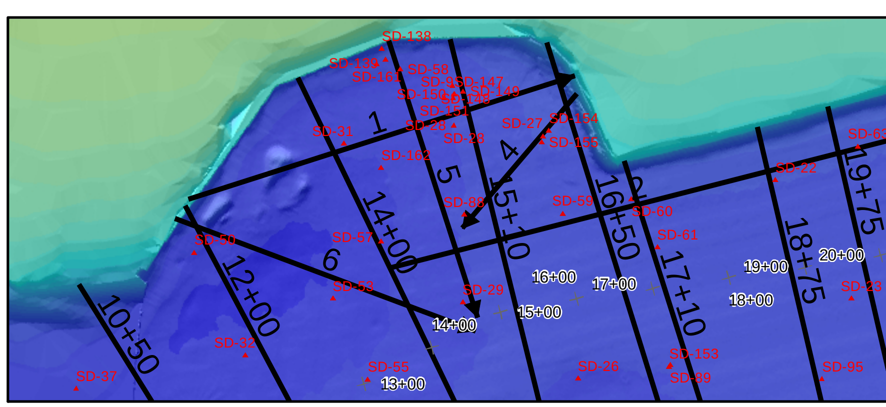
Lockheed Martin Middle River Complex
Middle River, MD

Figure A-29
Dark Head Cove
Profiles 3 & 4

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\AppendixA-29_3_4_DHC.mxd







NOTES:
1. Vertical Datum: Mean Lower Low Water (MLLW) for the 1983 to 2001 tidal epoch.
2. Horizontal Datum: North American 1983 Datum, Maryland State Plane Coordinate System.
3. Top of core may not coincide with existing ground due to sample location offset from profile transect.

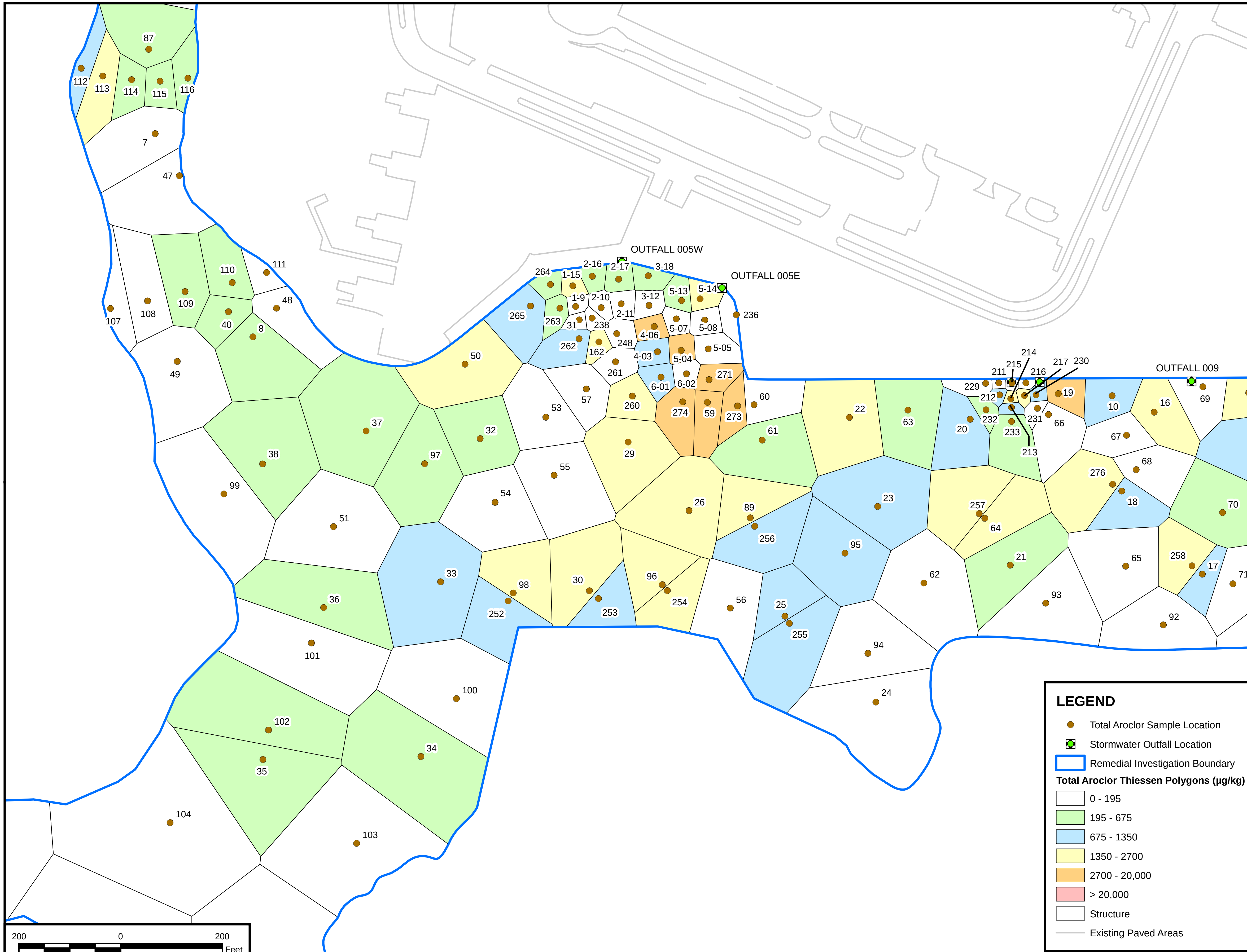
TETRA TECH

Lockheed Martin Middle River Complex
Middle River, MD

Figure A-30
Dark Head Cove
Profiles 5 & 6

Document Path: R:\Projects_2013\Middle_River_CowCreek\maps\Appendix\A-30_5_6_DHC.mxd

PGH P:\GIS\MIDDLE_RIVER\MAPDOCS\MXD\THIESSEN_MAR2015\PCB_THIESSEN_0TO6_MAR2015_REVIEW_DHC.MXD 04/10/15 JEE



TETRA TECH

MIDDLE RIVER COMPLEX DARK HEAD COVE
THIESSEN POLYGONS FOR
TOTAL AROCLOR IN SEDIMENT
0 TO 6 INCHES
MARCH 2015

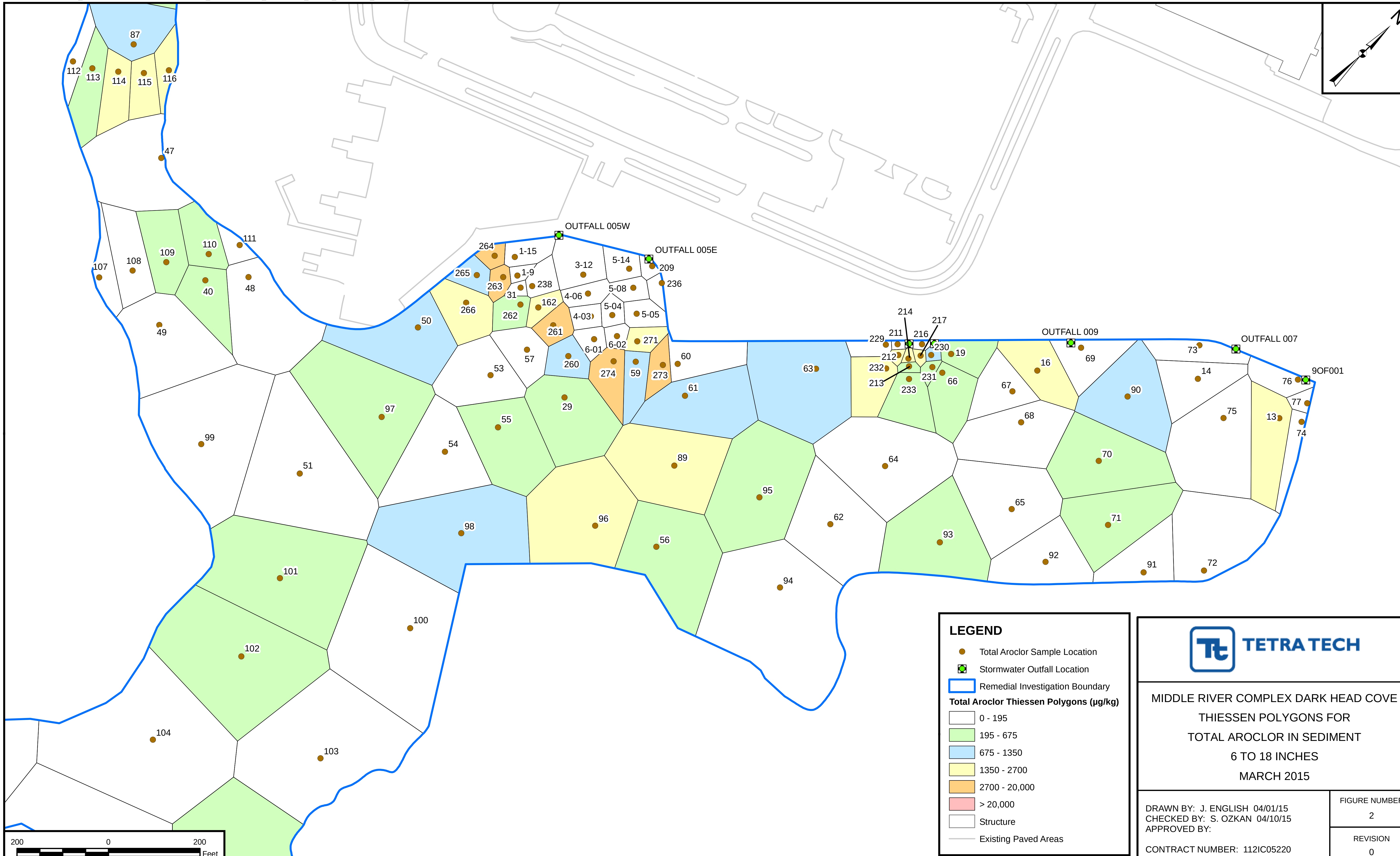
DRAWN BY: J. ENGLISH 04/01/15
CHECKED BY: S. OZKAN 04/10/15
APPROVED BY:

CONTRACT NUMBER: 112IC05220

FIGURE NUMBER
1

REVISION
0

PGH P:\GIS\MIDDLE_RIVER\MAPDOCS\MXD\THIESSEN_MAR2015\PCB_THIESSEN_6TO18_MAR2015_REVIEW_DHC.MXD 04/10/15 JEE



LEGEND

- Total Aroclor Sample Location
- Stormwater Outfall Location
- Remedial Investigation Boundary

Total Aroclor Thiessen Polygons (µg/kg)

- 0 - 195
- 195 - 675
- 675 - 1350
- 1350 - 2700
- 2700 - 20,000
- > 20,000
- Structure
- Existing Paved Areas

TETRA TECH

MIDDLE RIVER COMPLEX DARK HEAD COVE
THIESSEN POLYGONS FOR
TOTAL AROCLOR IN SEDIMENT
6 TO 18 INCHES
MARCH 2015

DRAWN BY: J. ENGLISH 04/01/15
CHECKED BY: S. OZKAN 04/10/15
APPROVED BY:

CONTRACT NUMBER: 112IC05220

FIGURE NUMBER
2

REVISION
0

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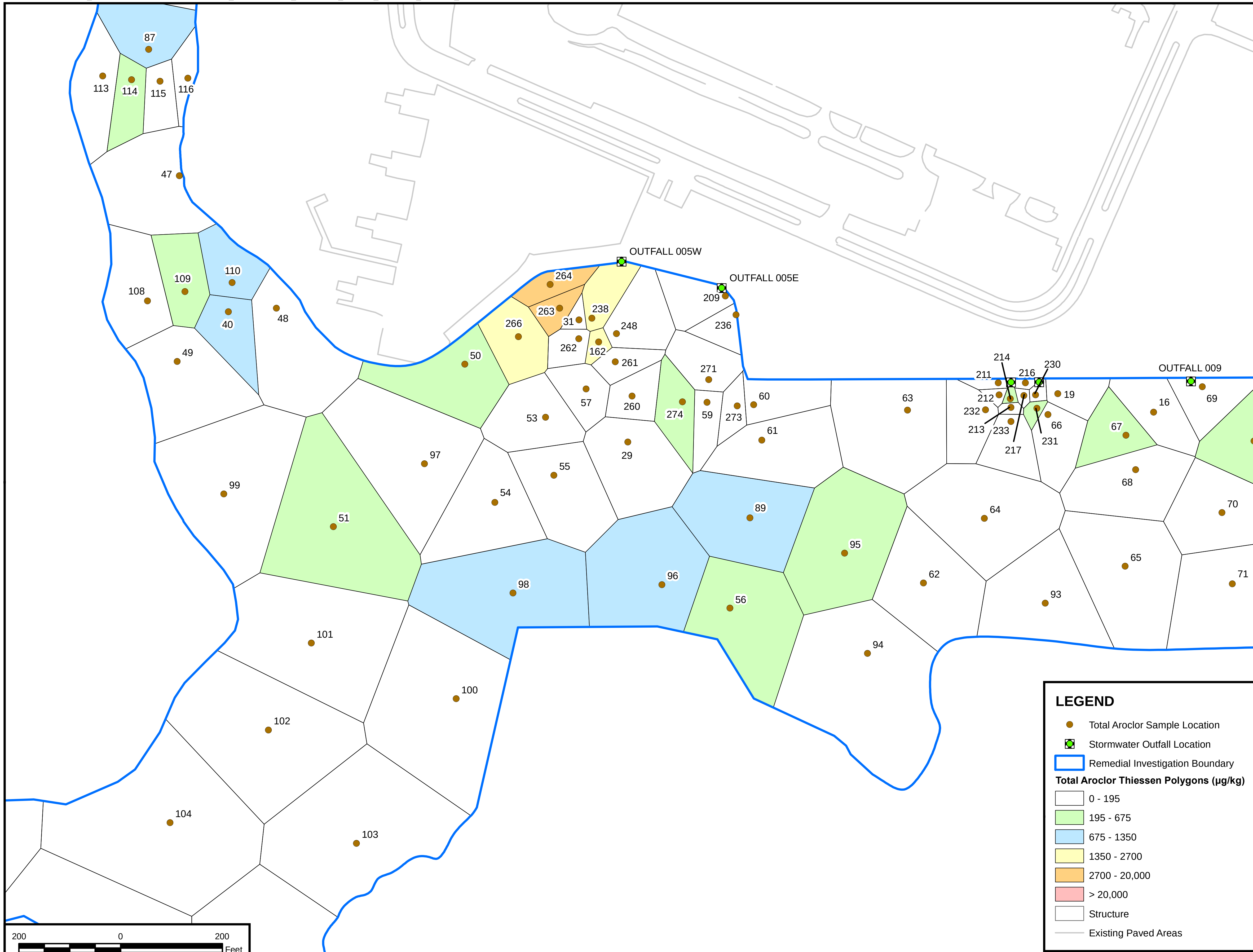

TETRA TECH

MIDDLE RIVER COMPLEX DARK HEAD COVE

THIESSEN POLYGONS FOR

TOTAL AROCLOR IN SEDIMENT

18 TO 30 INCHES

MARCH 2015

DRAWN BY: J. ENGLISH 04/01/15
CHECKED BY: S. OZKAN 04/10/15
APPROVED BY:

CONTRACT NUMBER: 112IC05220

FIGURE NUMBER
3

REVISION
0

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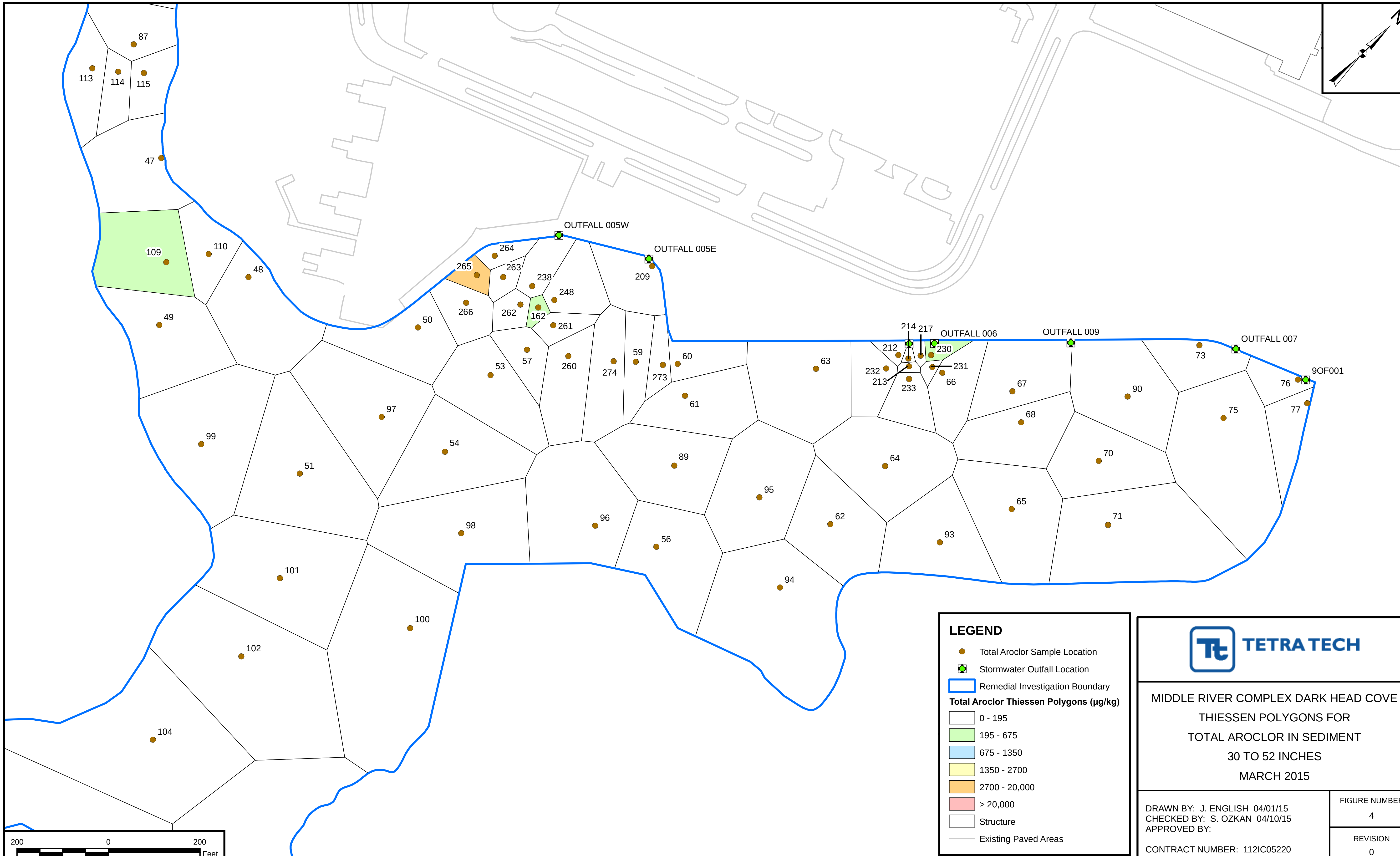


LEGEND

- Total Aroclor Sample Location
- Stormwater Outfall Location
- Remedial Investigation Boundary

Total Aroclor Thiessen Polygons (µg/kg)

- 0 - 195
- 195 - 675
- 675 - 1350
- 1350 - 2700
- 2700 - 20,000
- > 20,000
- Structure
- Existing Paved Areas

TETRA TECH

MIDDLE RIVER COMPLEX DARK HEAD COVE
THIESSEN POLYGONS FOR
TOTAL AROCLOR IN SEDIMENT
30 TO 52 INCHES
MARCH 2015

DRAWN BY: J. ENGLISH 04/01/15 CHECKED BY: S. OZKAN 04/10/15 APPROVED BY:	FIGURE NUMBER 4
CONTRACT NUMBER: 112IC05220	REVISION 0

Table A-1
Sediment Sampling and Removal Depths

Sample Descriptor	Easting	Northing	Contamination Elevation (exceeding RAO 3 PRGs) (ft MLLW)	Removal Depth (ft)	Date	Mudline Elevation (ft MLLW)
SD-001	1471109.44	606260.29	0.00	0.5	2009	9.85
SD-002	1475321.54	602798.52	0.00	0.5	2009	na
SD-003	1471137.24	606172.90	0.00	0.5	2009	9.01
SD-004	1471474.86	605525.70	2.94	0.5	2009	3.44
SD-005	1472195.69	604893.85	0.07	0.5	2009	0.57
SD-006	1472432.84	604688.84	-1.38	0.5	2009	-0.88
SD-007	1472885.58	604294.99	0.00	0.5	2009	-2.95
SD-008	1473303.25	604149.16	0.00	0.5	2009	-9.51
SD-009	1473826.06	604753.42	-10.38	0.5	2009	-13.53
SD-010	1474579.01	605261.00	-8.65	0.5	2009	-8.15
SD-011	1474764.95	605455.22	-6.33	0.5	2009	-5.83
SD-012	1475012.88	605606.29	-8.33	0.5	2009	-7.83
SD-013	1475107.78	605597.64	-10.60	2.5	2009	-8.10
SD-014	1474921.42	605532.39	0.00	2.5	2009	-6.94
SD-015	1475019.72	605362.67	-9.64	0.5	2009	-9.14
SD-016	1474660.25	605296.82	-10.96	2.5	2009	-8.46
SD-017	1474951.99	605139.04	-9.85	0.5	2009	-9.35
SD-018	1474724.57	605142.44	-10.02	0.5	2009	-9.52
SD-019	1474501.50	605189.28	-9.72	2.5	2009	-8.22
SD-020	1474414.85	605031.31	-9.67	0.5	2009	-9.17
SD-021	1474672.86	604884.38	0.00	0.5	2009	-9.68
SD-022	1474243.98	604865.81	-9.46	0.5	2009	-8.96
SD-023	1474406.83	604781.62	-10.20	0.5	2009	-9.70
SD-024	1474675.69	604507.79	0.00	0.5	2009	-2.45
SD-025	1474430.28	604500.59	-9.06	0.5	2009	-8.56
SD-026	1474150.40	604513.78	-10.72	0.5	2009	-10.22
SD-027	1473953.54	604764.23	-13.35	2.5	2009	-11.85
SD-028	1473846.00	604718.14	-12.45	2.5	2009	-13.47
SD-029	1473970.81	604524.49	-11.89	2.5	2009	-10.39
SD-030	1474123.33	604264.10	-9.89	0.5	2009	-9.39
SD-031	1473733.34	604625.96	0.00	2.5	2009	-10.30
SD-032	1473760.35	604323.19	0.00	0.5	2009	-11.61
SD-033	1473903.85	604069.95	-10.49	0.5	2009	-9.99
SD-034	1474119.10	603799.82	0.00	0.5	2009	-7.20
SD-035	1473903.85	603576.13	0.00	0.5	2009	-9.94
SD-036	1473777.23	603871.57	0.00	0.5	2009	-10.16
SD-037	1473591.52	604175.46	0.00	0.5	2009	-10.57
SD-038	1473493.11	603986.27	0.00	0.5	2009	-10.60
SD-039	1473558.10	603006.61	0.00	0.5	2009	-5.36
SD-040	1473234.91	604149.75	-12.00	2.5	2009	-9.50
SD-041	1473118.81	604170.18	-8.67	0.5	2009	-8.17
SD-042	1472400.96	604753.20	-2.02	2.5	2009	-0.52
SD-043	1471464.09	605518.52	2.92	4.3	2009	3.42
SD-044	1471678.29	605281.89	2.31	4.3	2009	2.81
SD-045	1472537.25	604690.68	-2.67	4.3	2009	-1.17
SD-046	1472655.76	604557.04	-3.75	4.3	2009	-1.25
SD-047	1472977.57	604270.23	-2.19	4.3	2009	-1.69
SD-048	1473296.59	604221.35	0.00	4.3	2009	-4.99
SD-049	1473231.98	604009.59	0.00	4.3	2009	-6.54
SD-050	1473636.05	604405.80	-15.33	4.3	2009	-11.00

Table A-1
Sediment Sampling and Removal Depths

Sample Descriptor	Easting	Northing	Contamination Elevation (exceeding RAO 3 PRGs) (ft MLLW)	Removal Depth (ft)	Date	Mudline Elevation (ft MLLW)
SD-051	1473678.72	603997.47	-13.79	4.3	2009	-11.29
SD-053	1473822.07	604444.27	0.00	4.3	2009	-11.65
SD-054	1473869.68	604255.60	-13.37	4.3	2009	-10.87
SD-055	1473914.09	604375.61	0.00	2.5	2009	-10.76
SD-056	1474343.09	604435.86	-12.39	4.3	2009	-9.89
SD-057	1473839.07	604540.02	0.00	4.3	2009	-11.26
SD-058	1473748.59	604746.62	-12.19	4.3	2009	-14.48
SD-059	1474025.93	604689.51	-12.24	4.3	2009	-9.74
SD-060	1474093.83	604750.86	-10.88	4.3	2009	-9.38
SD-061	1474154.48	604713.00	-12.33	4.3	2009	-9.83
SD-062	1474577.23	604740.09	-12.15	4.3	2009	-9.65
SD-063	1474315.31	604957.55	-10.20	4.3	2009	-8.70
SD-064	1474572.22	604914.25	-11.25	4.3	2009	-9.75
SD-065	1474834.39	605043.38	-11.08	4.3	2009	-9.58
SD-066	1474516.74	605146.58	-11.54	4.3	2009	-9.04
SD-067	1474653.87	605226.06	-11.72	4.3	2009	-9.22
SD-068	1474715.00	605192.10	-11.98	4.3	2009	-9.48
SD-069	1474692.72	605399.64	0.00	2.5	2009	-5.51
SD-070	1474894.64	605252.33	-10.74	4.3	2009	-9.24
SD-071	1475007.77	605167.94	0.00	4.3	2009	-9.13
SD-072	1475226.74	605246.10	0.00	2.5	2009	na
SD-073	1474872.00	605586.62	0.00	4.3	2009	-2.44
SD-074	1475148.13	605626.46	0.00	2.5	2009	-5.22
SD-075	1475021.35	605511.70	-11.17	4.3	2009	-8.67
SD-076	1475077.25	605685.68	-8.28	4.3	2009	-5.78
SD-077	1475127.88	605663.90	-6.27	4.3	2009	-5.77
SD-078	1471081.90	606295.75	0.00	1.5	2009	9.95
SD-079	1474716.26	602542.95	0.00	4.3	2009	na
SD-080	1474462.88	602335.15	0.00	2.5	2009	na
SD-081	1473488.83	603025.15	-4.64	2.5	2009	-3.14
SD-082	1475284.56	602783.25	0.00	2.5	2009	na
SD-083	1471272.63	605917.88	0.00	4.3	2009	6.65
SD-084	1471562.62	605417.60	-0.39	2.5	2009	1.11
SD-085	1471876.21	605175.86	0.00	4.3	2009	-0.74
SD-086	1472421.70	604772.90	-3.60	4.3	2009	-1.10
SD-087	1472762.62	604404.07	-6.78	4.3	2009	-2.45
SD-088	1473915.55	604624.12	-14.24	4.3	2009	-11.68
SD-089	1474245.58	604588.75	-12.37	4.3	2009	-9.87
SD-090	1474840.20	605396.48	-10.57	4.3	2009	-8.07
SD-091	1475136.03	605149.81	0.00	1.5	2009	-1.20
SD-092	1474968.16	605014.26	0.00	1.5	2009	-4.21
SD-093	1474774.62	604881.00	-10.87	4.3	2009	-8.37
SD-094	1474597.11	604564.24	0.00	4.3	2009	-4.46
SD-095	1474426.22	604671.50	-12.36	4.3	2009	-9.86
SD-096	1474215.96	604373.91	-12.58	4.3	2009	-10.08
SD-097	1473720.89	604212.95	-13.01	4.3	2009	-11.51
SD-098	1474020.49	604155.15	-11.78	4.3	2009	-9.28
SD-099	1473484.15	603892.01	0.00	4.3	2009	-7.20
SD-100	1474087.96	603929.47	0.00	4.3	2009	-6.40
SD-101	1473812.43	603806.70	-12.57	4.3	2009	-10.07

Table A-1
Sediment Sampling and Removal Depths

Sample Descriptor	Easting	Northing	Contamination Elevation (exceeding RAO 3 PRGs) (ft MLLW)	Removal Depth (ft)	Date	Mudline Elevation (ft MLLW)
SD-102	1473870.66	603625.00	-12.13	4.3	2009	-9.63
SD-103	1474150.12	603590.28	0.00	2.5	2009	-6.58
SD-104	1473862.17	603359.65	0.00	4.3	2009	-7.47
SD-105	1474203.63	603314.06	-13.10	4.3	2009	-8.77
SD-106	1473968.81	603078.74	0.00	4.3	2009	-7.67
SD-107	1473066.00	603990.00	0.00	1.5	2009	3.82
SD-108	1473106.92	604052.30	0.00	2.5	2009	-3.79
SD-109	1473146.16	604117.10	-12.91	4.3	2009	-8.58
SD-110	1473199.41	604195.52	-10.78	4.3	2009	-6.45
SD-111	1473233.31	604257.04	0.00	1.5	2009	-0.49
SD-112	1472692.16	604282.58	-1.58	1.5	2009	-0.08
SD-113	1472732.27	604302.24	-3.43	4.3	2009	-1.93
SD-114	1472777.71	604336.97	-5.05	4.3	2009	-2.55
SD-115	1472819.44	604374.80	-6.73	4.3	2009	-2.40
SD-116	1472853.89	604417.49	-2.50	2.5	2009	-1.00
SD-117	1472514.86	604545.84	-2.69	2.5	2009	-0.19
SD-118	1472556.48	604577.03	-2.68	4.3	2009	-1.18
SD-119	1472623.68	604627.56	-2.64	4.3	2009	-1.14
SD-120	1472662.85	604664.85	0.19	4.3	2009	0.69
SD-121	1472302.83	604795.13	-2.81	4.3	2009	-0.31
SD-122	1472344.71	604845.00	-2.18	4.3	2009	-0.68
SD-123	1472378.92	604871.86	-1.61	4.3	2009	-0.11
SD-124	1471898.65	605062.38	0.81	1.5	2009	2.31
SD-125	1471876.72	605067.90	1.39	4.3	2009	2.89
SD-126	1472016.01	605103.88	-1.43	4.3	2009	2.90
SD-127	1471789.50	605171.03	0.00	1.5	2009	0.35
SD-128	1471803.28	605221.92	0.26	2.5	2009	1.76
SD-129	1471732.85	605258.38	0.24	2.5	2009	2.74
SD-130	1471741.33	605276.28	1.20	1.5	2009	2.70
SD-131	1471627.16	605381.49	1.87	1.5	2009	3.37
SD-132	1471398.32	605579.20	2.49	2.5	2009	4.99
SD-133	1471365.32	605628.00	2.85	4.3	2009	5.35
SD-134	1471372.11	605643.98	0.00	4.3	2009	5.25
SD-135	1471572.14	605425.79	1.77	2.5	2009	3.27
SD-136	1471549.48	605427.09	0.53	1.5	2009	2.03
SD-137	1471586.58	605400.94	0.96	4.3	2009	2.46
SD-138	1473714.24	604757.54	-8.88	1.5	2009	-10.24
SD-139	1473725.99	604748.22	-10.50	1.5	2009	-14.00
SD-147	1473826.10	604753.40	-12.48	2.5	2009	-13.53
SD-148	1473818.92	604762.26	-14.22	4.3	2009	-13.69
SD-149	1473834.14	604762.34	-14.13	4.3	2009	-13.36
SD-150	1473827.07	604748.91	-14.26	4.3	2009	-13.67
SD-151	1473817.56	604743.07	-12.54	4.3	2009	-13.87
SD-152	1474020.43	604152.91	0.00	0.0	2009	-9.27
SD-153	1474245.33	604586.16	0.00	0.0	2009	-9.90
SD-154	1473956.03	604773.69	0.00	0.0	2009	-11.27
SD-155	1473955.88	604756.58	0.00	0.0	2009	-11.58
SD-156	1471665.97	605286.06	2.72	1.5	2009	4.22
SD-157	1471955.00	605155.00	3.66	2.5	2009	6.16
SD-158	1472205.33	604970.58	-1.56	4.3	2009	0.94

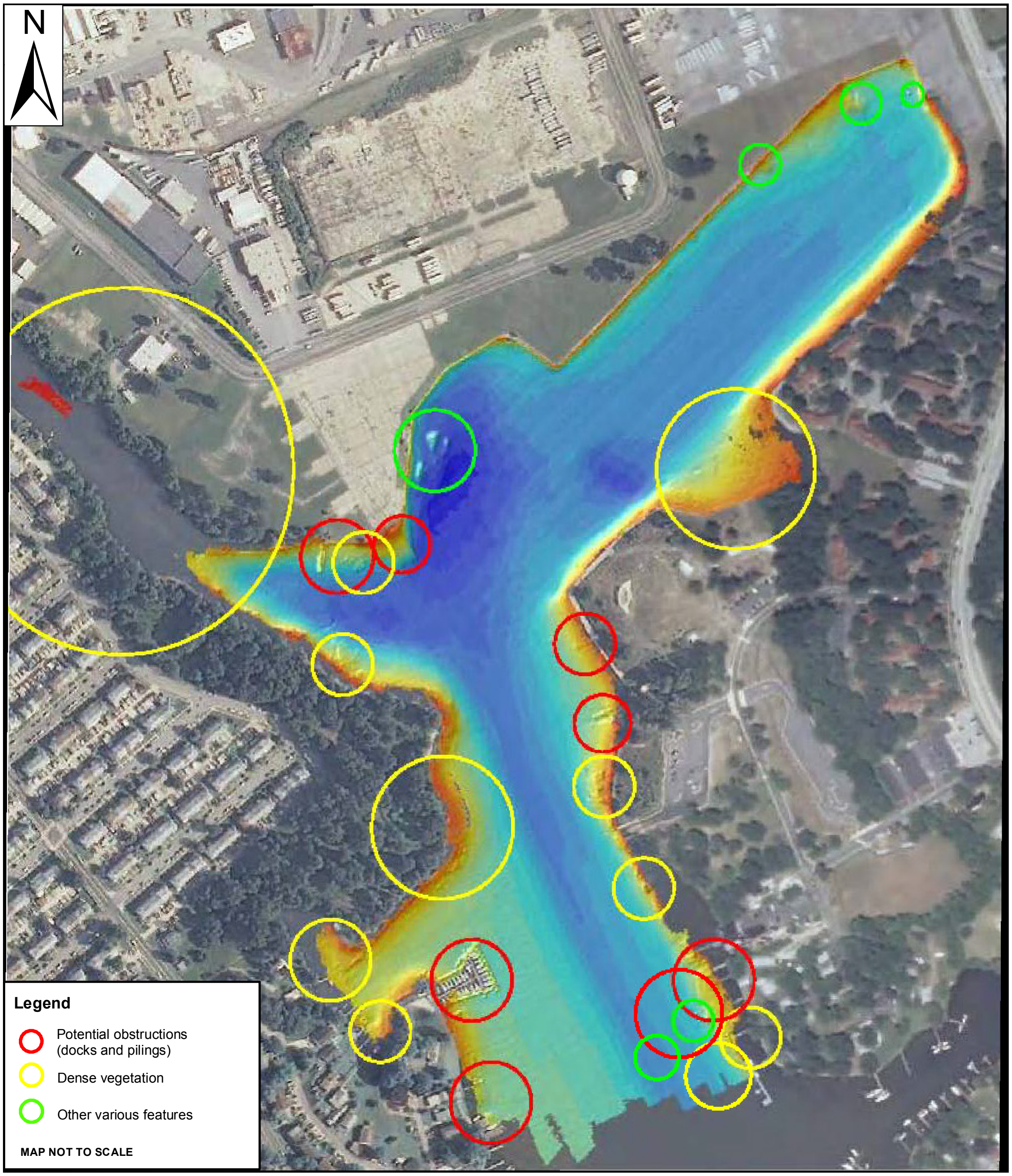
Table A-1
Sediment Sampling and Removal Depths

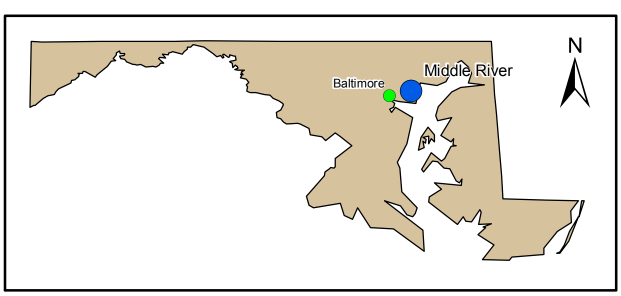
Sample Descriptor	Easting	Northing	Contamination Elevation (exceeding RAO 3 PRGs) (ft MLLW)	Removal Depth (ft)	Date	Mudline Elevation (ft MLLW)
SD-161	1473718.87	604736.78	-13.54	4.3	2009	-14.02
SD-162	1473791.22	604622.95	-13.53	4.3	2009	-11.03
SD-195	1473702.65	604737.07	-8.93	0.0	2014	-8.93
SD-197	1473733.29	604698.71	-14.07	1.5	2014	-12.57
SD-199	1473769.41	604696.17	-11.99	1.5	2014	-14.08
SD-200	1473769.34	604734.57	-11.79	1.5	2014	-14.71
SD-202	1473742.28	604777.04	-8.69	0.5	2014	-11.21
SD-204	1473856.13	604852.06	-5.70	0.5	2014	-4.46
SD-207	1473890.97	604843.81	-9.36	2.5	2014	-8.84
SD-209	1473903.62	604862.66	-3.02	0.5	2014	-2.52
SD-211	1474403.57	605121.79	-4.78	0.0	2014	-4.78
SD-212	1474421.38	605106.01	-9.74	1.5	2014	-8.24
SD-213	1474455.45	605104.95	-9.15	0.5	2014	-8.65
SD-214	1474442.54	605116.09	-9.80	1.5	2014	-8.30
SD-215	1474422.37	605139.64	-3.81	0.0	2014	-3.81
SD-216	1474441.33	605159.44	-2.05	0.0	2014	-2.05
SD-217	1474457.00	605139.49	-9.79	1.5	2014	-8.29
SD-223	1473705.57	604690.42	-11.66	1.5	2014	-12.91
SD-224	1473777.57	604763.60	-12.28	2.5	2014	-14.45
SD-225	1473781.49	604760.49	-12.41	2.5	2014	-14.28
SD-226	1473736.54	604663.86	-13.13	2.5	2014	-13.15
SD-227	1473734.33	604664.26	-12.11	1.5	2014	-13.09
SD-228	1473804.81	604732.16	-11.75	1.5	2014	-14.20
SD-229	1474385.97	605102.66	-4.45	0.0	2014	-4.45
SD-230	1474472.15	605156.71	-9.60	1.5	2014	-8.10
SD-231	1474492.76	605140.04	-11.17	2.5	2014	-8.67
SD-232	1474423.21	605066.47	-10.33	1.5	2014	-8.83
SD-233	1474474.82	605085.51	-9.04	0.0	2014	-9.04
SD-234	1473844.41	604838.84	-7.24	0.5	2014	-7.83
SD-235	1473866.52	604798.36	-11.45	2.5	2014	-12.79
SD-236	1473944.67	604851.35	0.00	0.0	2014	0.50
SD-237	1473920.36	604797.44	-11.39	2.5	2014	-12.81
SD-238	1473749.07	604646.28	-13.06	2.5	2014	-10.56
SD-239	1473824.45	604716.64	-11.86	1.5	2014	-13.34
SD-240	1473842.37	604732.63	-12.47	2.5	2014	-13.02
SD-241	1473807.82	604768.84	-12.36	2.5	2014	-14.20
SD-242	1473717.60	604644.82	-13.31	2.5	2014	-13.73
SD-243	1473817.81	604826.47	-7.57	0.5	2014	-8.59
SD-244	1473932.97	604780.60	-11.43	2.5	2014	-11.56
SD-245	1473832.59	604803.82	-11.53	2.5	2014	-12.83
SD-246	1473899.50	604790.25	-11.49	2.5	2014	-11.86
SD-247	1473938.61	604814.35	-11.36	2.5	2014	-12.15
SD-248	1473804.49	604659.28	-12.12	1.5	2014	-10.62
SD-249	1473671.61	604693.94	-11.50	2.5	2014	-10.99
SD-250	1473664.57	604665.22	-12.23	2.5	2014	-12.76
SD-251	1473773.32	604802.23	-7.91	0.5	2014	-11.08
SD-252	1474024.27	604137.16	-9.13	0.0	2014	-9.13
SD-253	1474146.85	604265.97	-9.15	0.0	2014	-9.15
SD-254	1474231.27	604372.62	-10.10	0.0	2014	-10.10
SD-255	1474446.33	604496.84	-8.18	0.0	2014	-8.18

Table A-1
Sediment Sampling and Removal Depths

Sample Descriptor	Easting	Northing	Contamination Elevation (exceeding RAO 3 PRGs) (ft MLLW)	Removal Depth (ft)	Date	Mudline Elevation (ft MLLW)
SD-256	1474263.65	604583.08	-9.96	0.0	2014	-9.96
SD-257	1474557.84	604912.88	-9.70	0.0	2014	-9.70
SD-258	1474926.16	605135.89	-9.47	0.0	2014	-9.47
SD-259	1475042.73	605355.61	-9.26	0.0	2014	-9.26
SD-260	1473912.82	604594.05	-11.53	1.5	2014	-10.20
SD-261	1473841.92	604618.18	-11.97	1.5	2014	-10.47
SD-262	1473759.24	604599.87	-11.67	0.5	2014	-11.38
SD-263	1473690.47	604615.23	-12.36	2.5	2014	-9.86
SD-264	1473644.02	604635.04	-12.17	2.5	2014	-10.52
SD-265	1473646.21	604577.25	-14.24	4.0	2014	-10.24
SD-266	1473672.19	604518.28	-13.26	2.5	2014	-10.76
SD-267	1473859.17	604682.58	-12.77	2.5	2014	-12.52
SD-268	1473910.63	604722.24	-10.83	1.5	2014	-12.20
SD-269	1473924.97	604656.58	-10.17	0.5	2014	-11.90
SD-270	1473939.67	604738.49	-10.70	1.5	2014	-11.87
SD-271	1473996.57	604723.60	-10.88	1.5	2014	-9.73
SD-272	1473998.36	604796.86	-7.49	0.0	2014	-7.49
SD-273	1474072.68	604726.42	-11.24	1.5	2014	-9.74
SD-274	1473990.76	604656.13	-11.13	1.5	2014	-9.98
SD-275	1475036.54	605511.70	-8.63	0.0	2014	-8.63
SD-276	1474702.58	605138.93	-9.62	0.0	2014	-9.62
SD-1-9	1473708.62	604638.05	-13.76	0.0	2015	-13.76
SD-1-15	1473668.99	604668.67	-13.43	0.5	2015	-12.93
SD-2-10	1473741.42	604675.89	-13.07	0.0	2015	-13.07
SD-2-11	1473774.22	604713.74	-16.34	0.0	2015	-16.34
SD-2-16	1473701.79	604706.51	-13.75	0.0	2015	-13.75
SD-2-17	1473734.59	604744.35	-14.65	0.0	2015	-14.65
SD-3-12	1473807.02	604751.58	-14.14	0.0	2015	-14.14
SD-3-18	1473767.39	604782.20	-14.50	0.0	2015	-14.50
SD-4-03	1473886.28	604690.35	-13.31	0.5	2015	-12.81
SD-4-06	1473846.65	604720.96	-13.70	0.5	2015	-13.20
SD-5-04	1473919.07	604728.19	-11.46	0.5	2015	-10.96
SD-5-05	1473951.87	604766.03	-12.00	0.0	2015	-12.00
SD-5-07	1473879.44	604758.81	-13.45	0.0	2015	-13.45
SD-5-08	1473912.24	604796.65	-11.94	0.0	2015	-11.94
SD-5-13	1473839.81	604789.42	-13.42	0.0	2015	-13.42
SD-5-14	1473872.61	604827.27	-13.06	0.5	2015	-12.56
SD-6-01	1473925.91	604659.73	-12.15	0.5	2015	-11.65
SD-6-02	1473958.71	604697.57	-11.38	0.0	2015	-11.38

APPENDIX A3—POTENTIAL DEBRIS TARGETS IN DARK HEAD COVE





POTENTIAL DEBRIS TARGETS

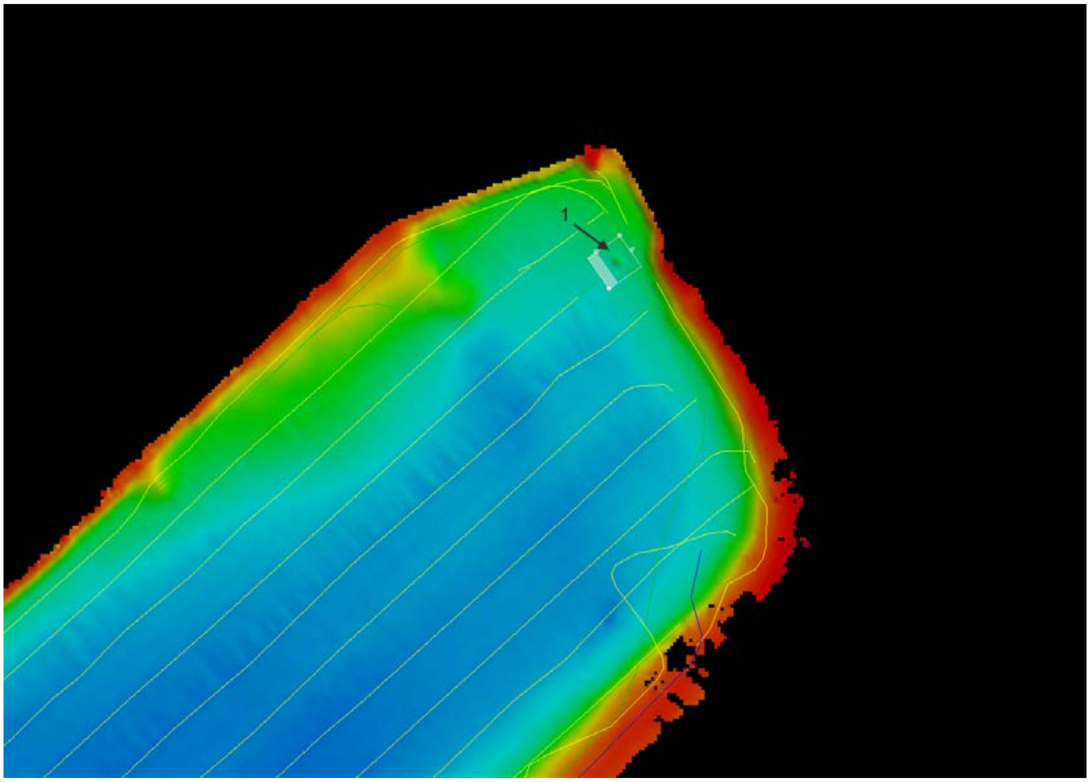
Lockheed Martin Middle River Complex
Middle River, Maryland

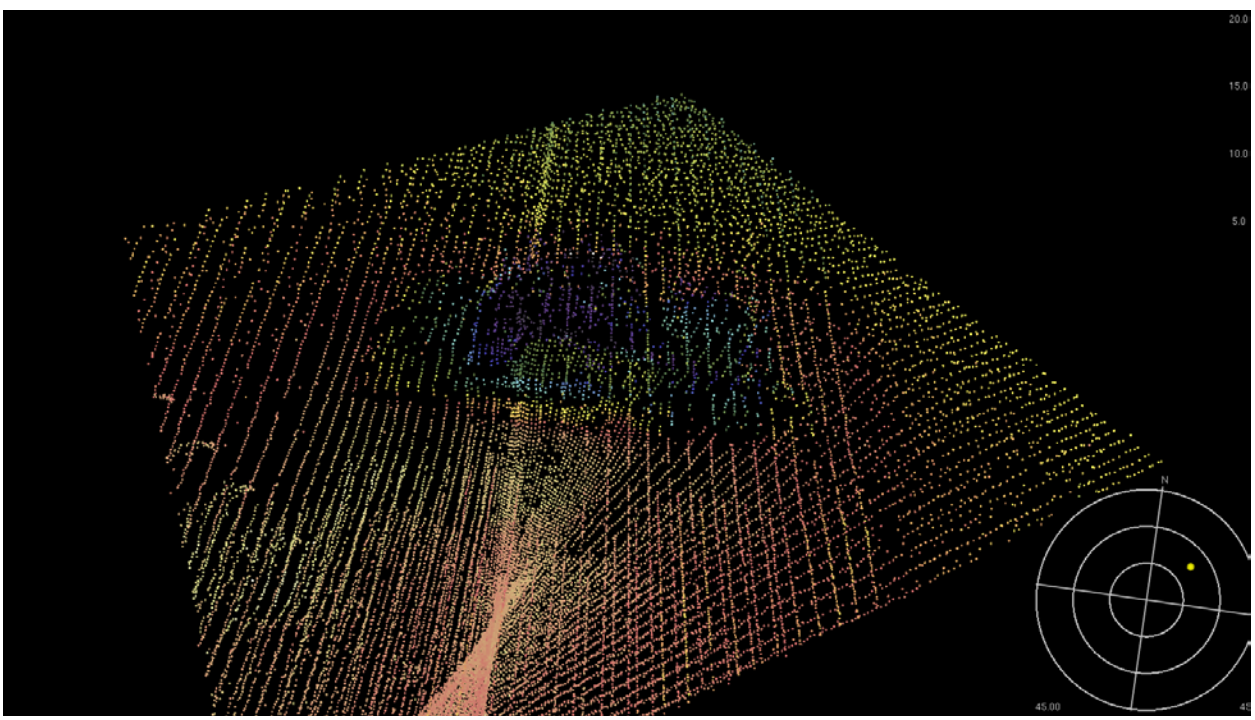
DATE MODIFIED: 3/4/14	CREATED BY: MP

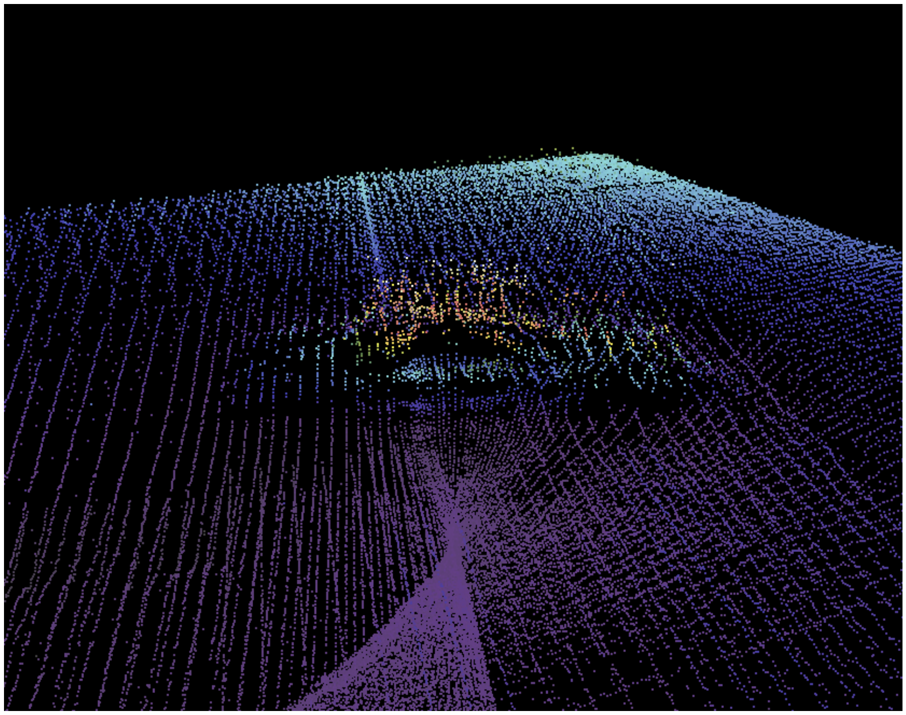
TETRA TECH

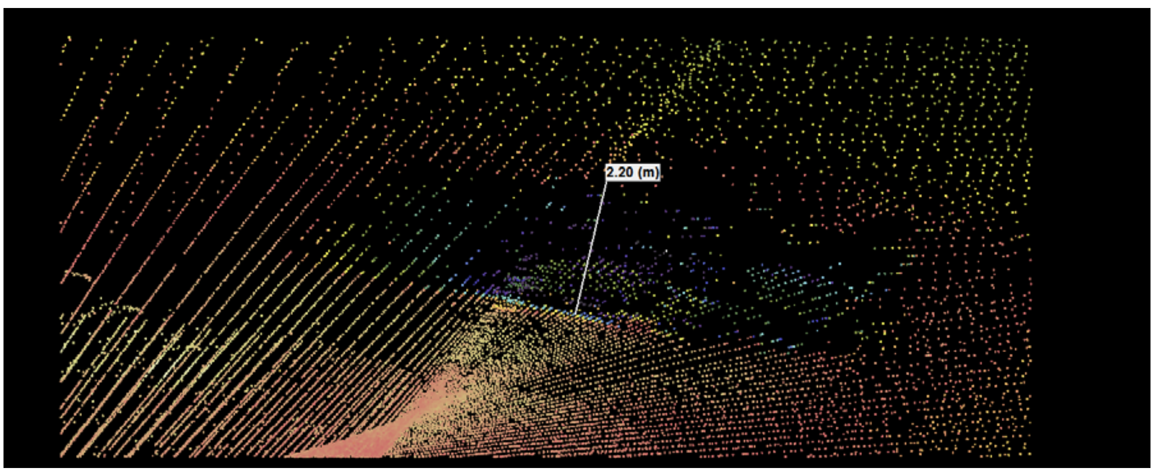
Map Document: (K:\GProject\middle_river\Maps\Cow Pen Creek Debris Survey.mxd)
3/4/2014 -- 3:38:48 PM

TARGET #1 - Vehicle. Target 2.2m x 3.58 Vertical. Exaggerated x1.2





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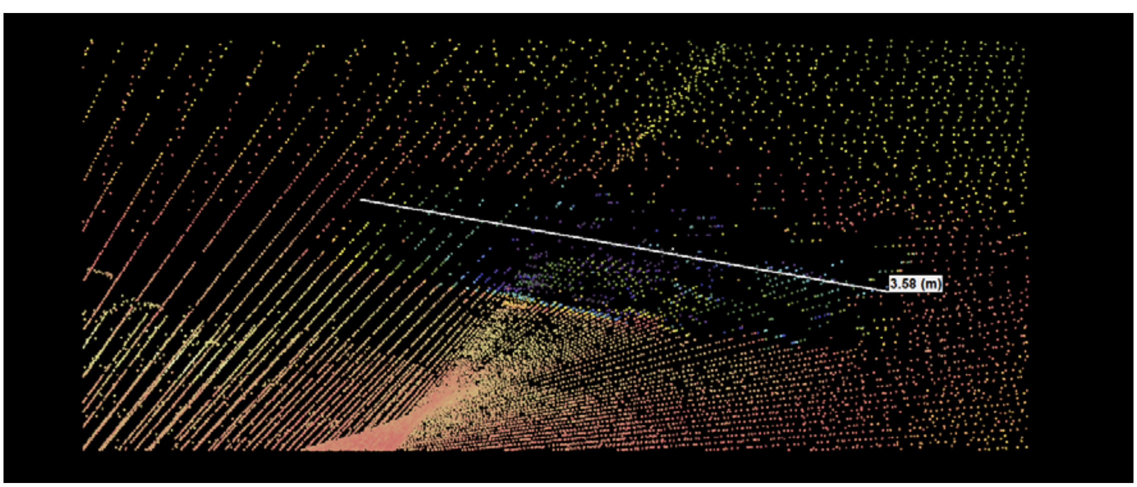
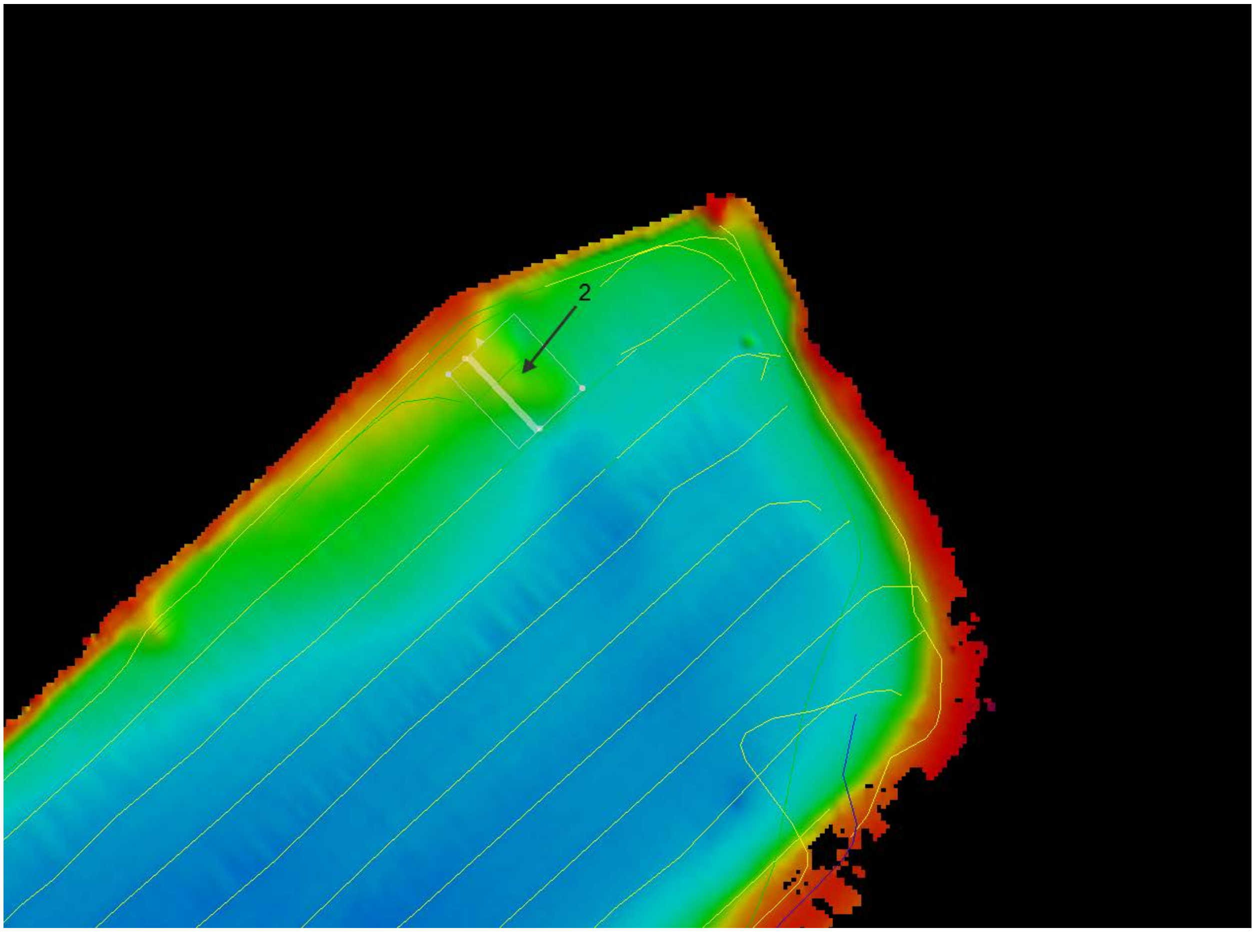
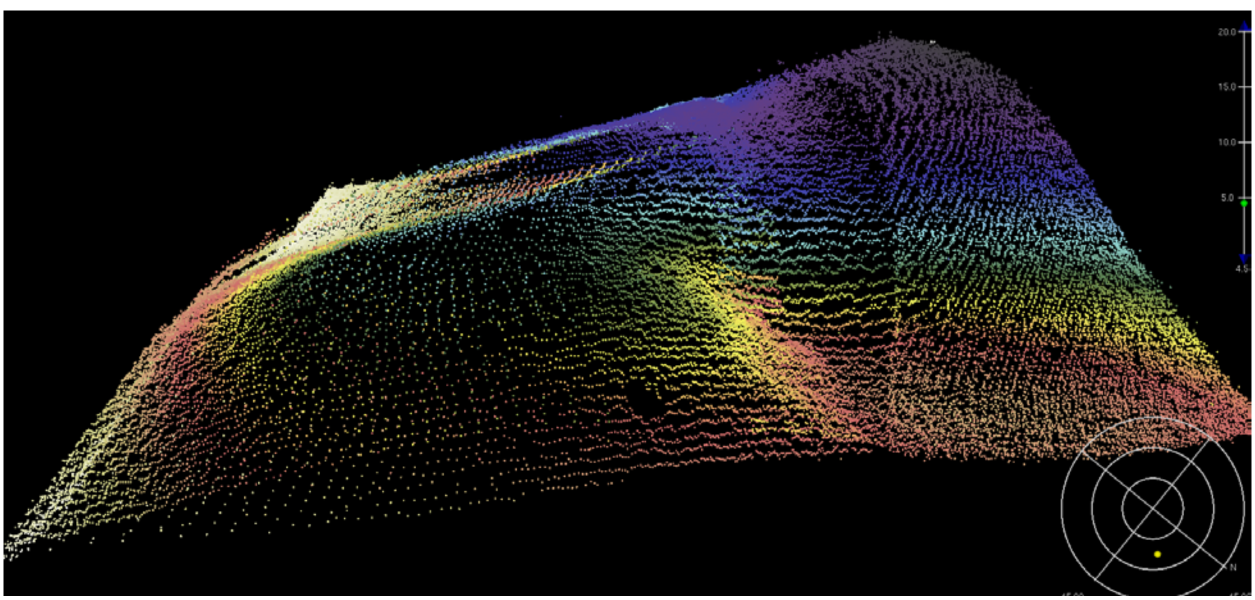
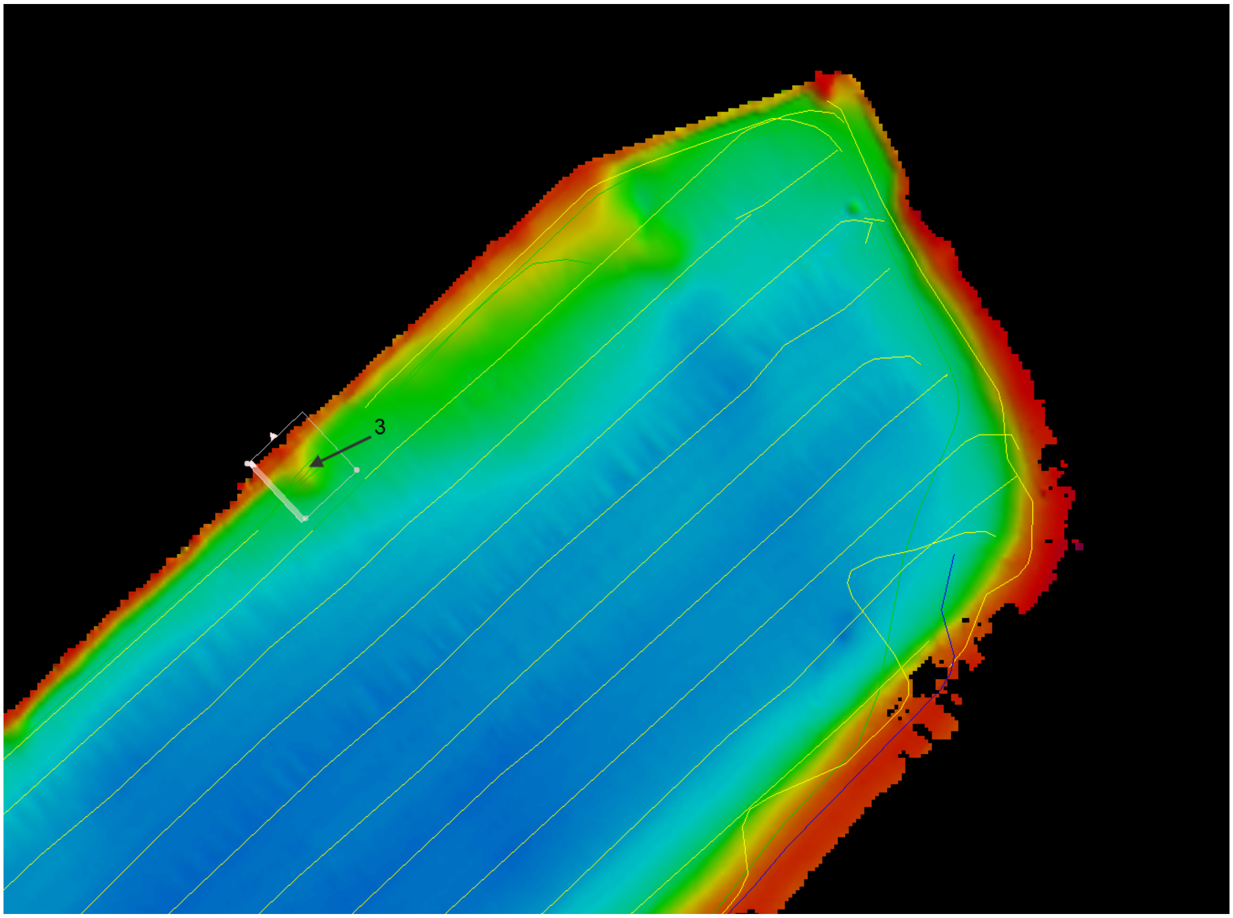

3.58 (m)

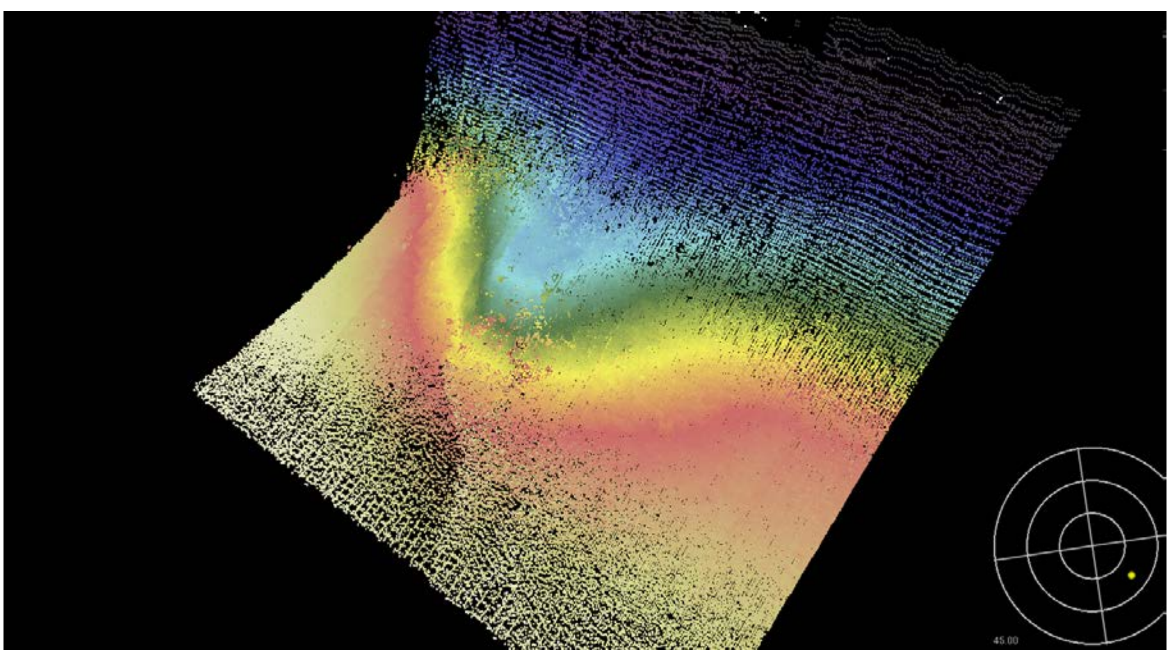
TARGET #2 – Peninsula protrusion. Possibly dumped materials. Exaggerated x.4.4



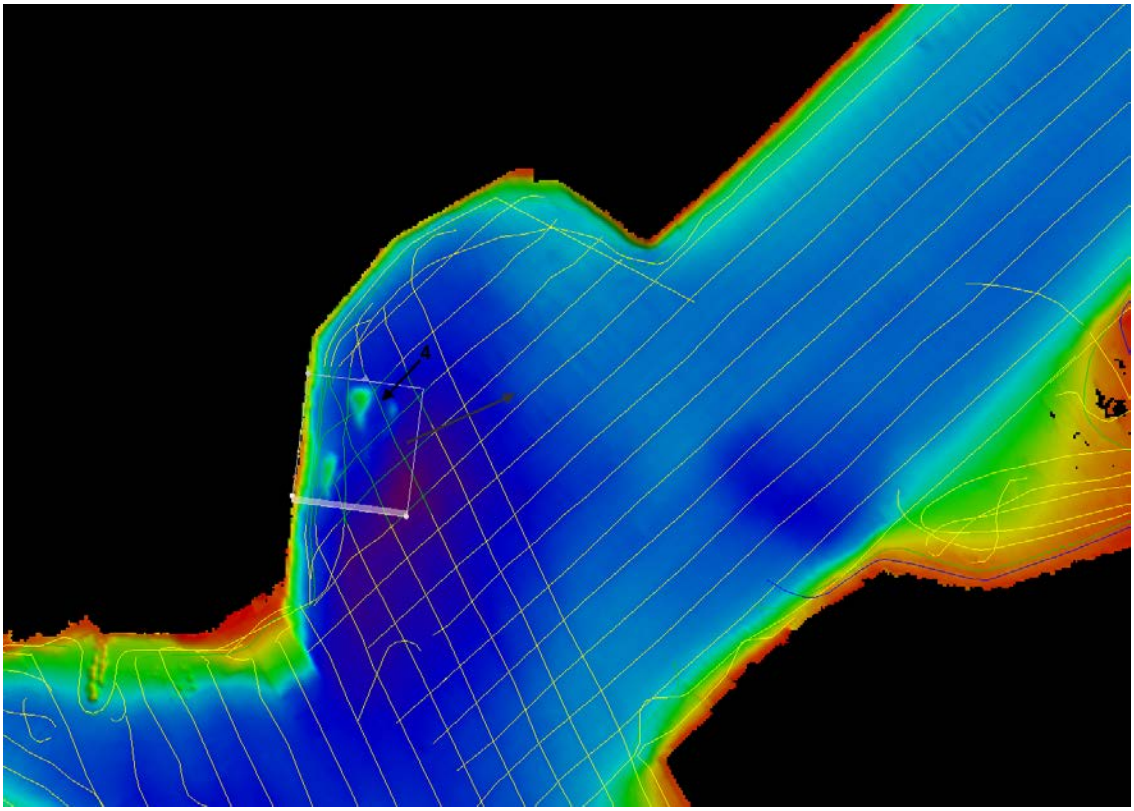


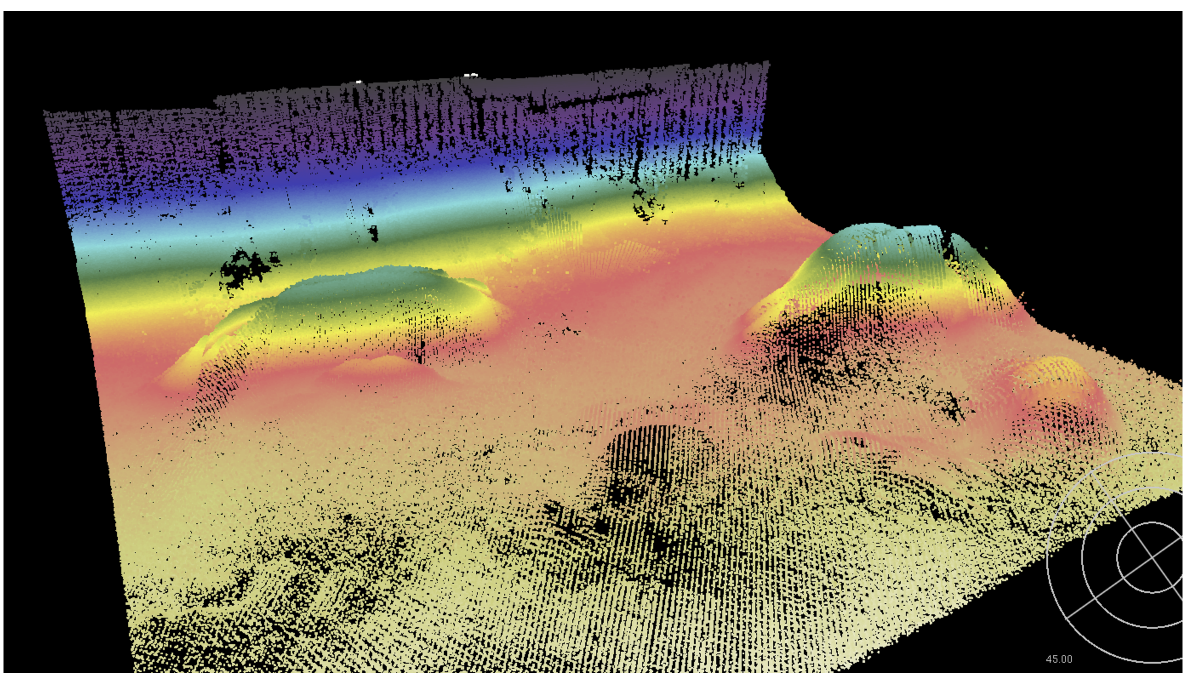
TARGET #3 Peninsula protrusion. Possibly dumped materials. Exaggerated x4.5.. 8m long, 4.4m wide

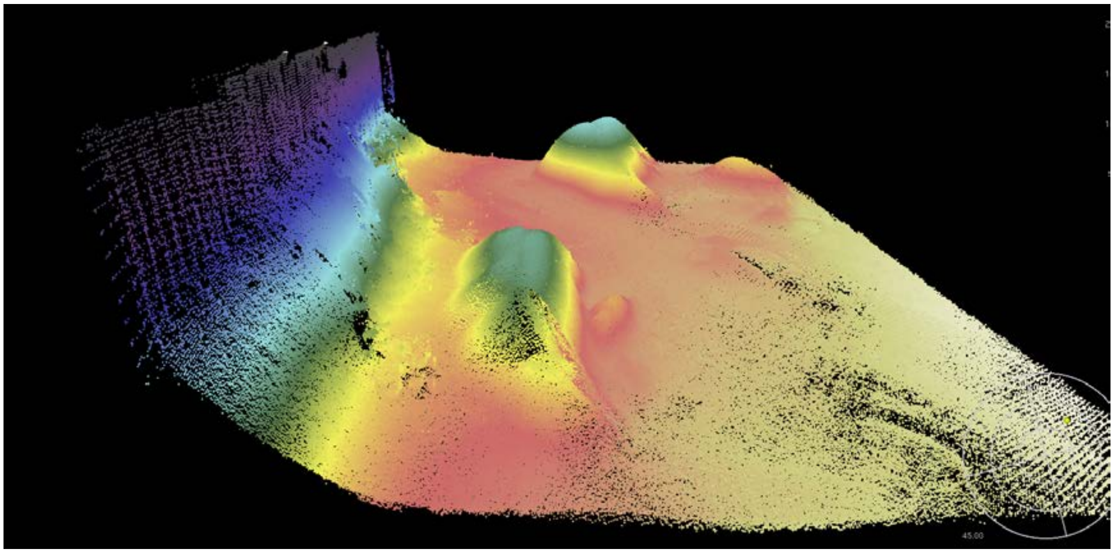


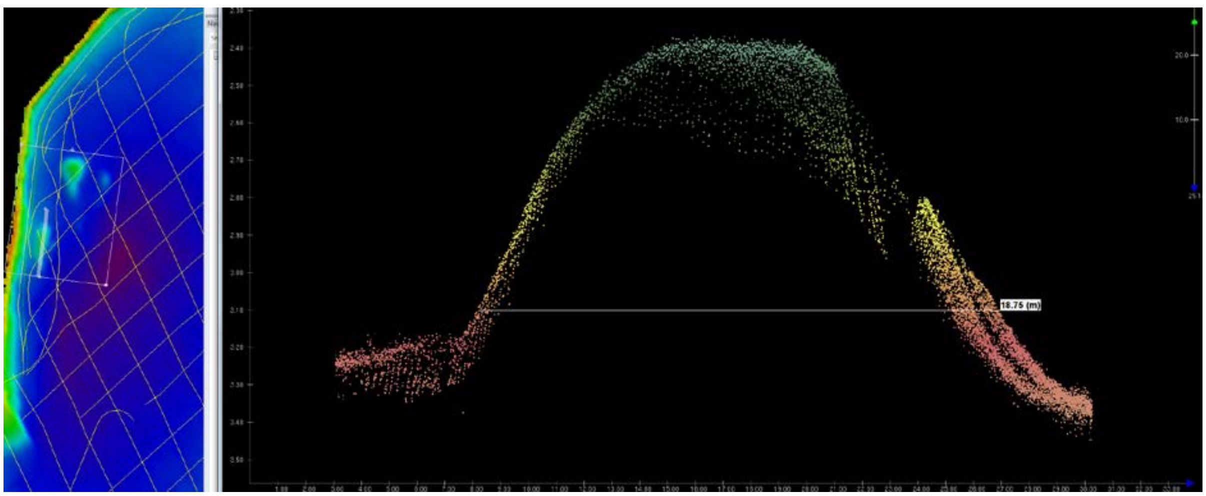


TARGET #4 –Mounds likely to support removed docks or structures. Both about 18m long and 1.3 m tall. Exaggeration x4.5. Profile image exagerrated x20



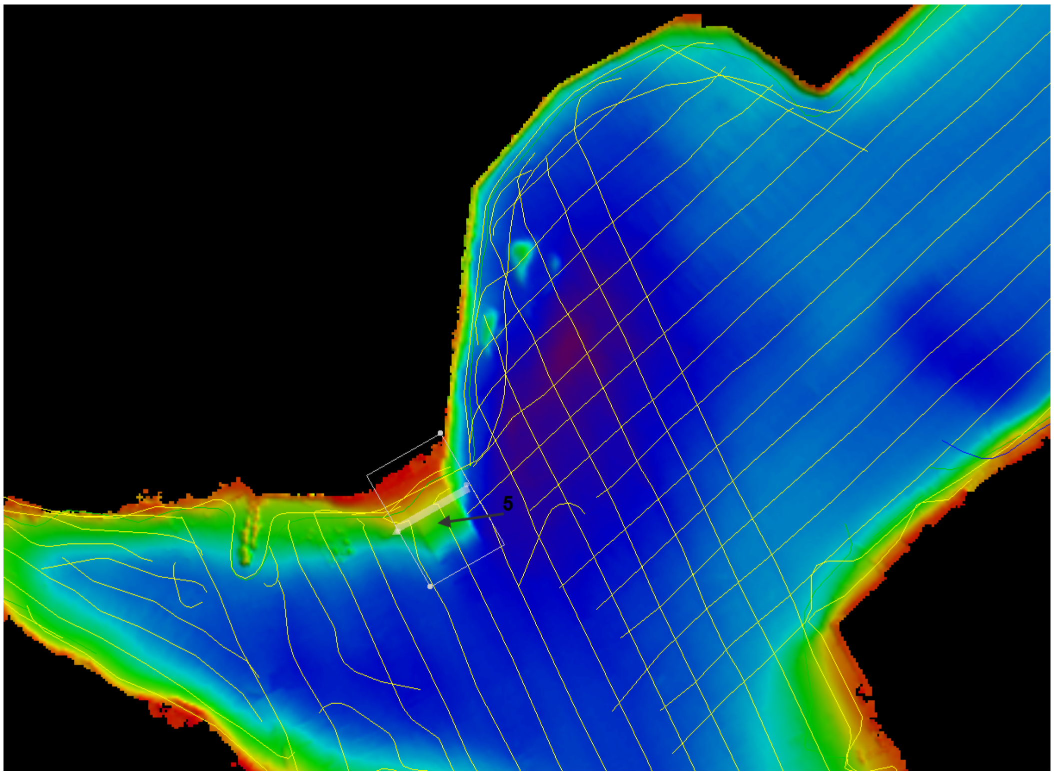


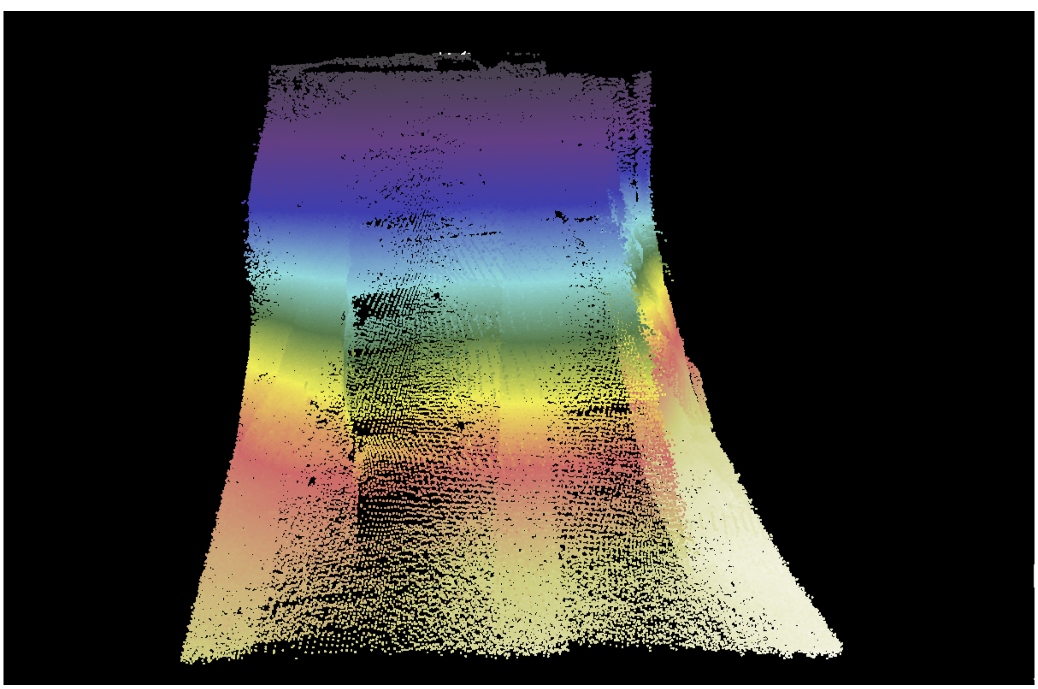


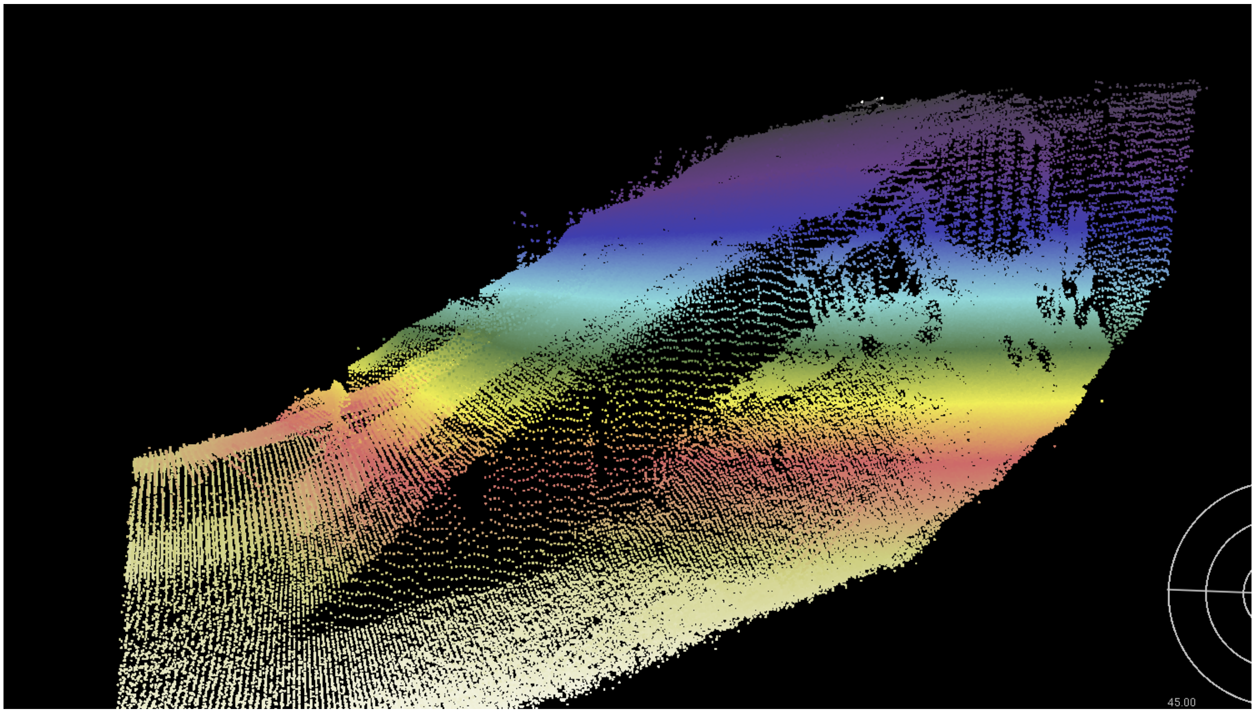

18.75 (m)


OLD DOCK /
PIER
STURCTURES

TARGET #5 Boat Ramp. 16m wide. Exaggerated x8



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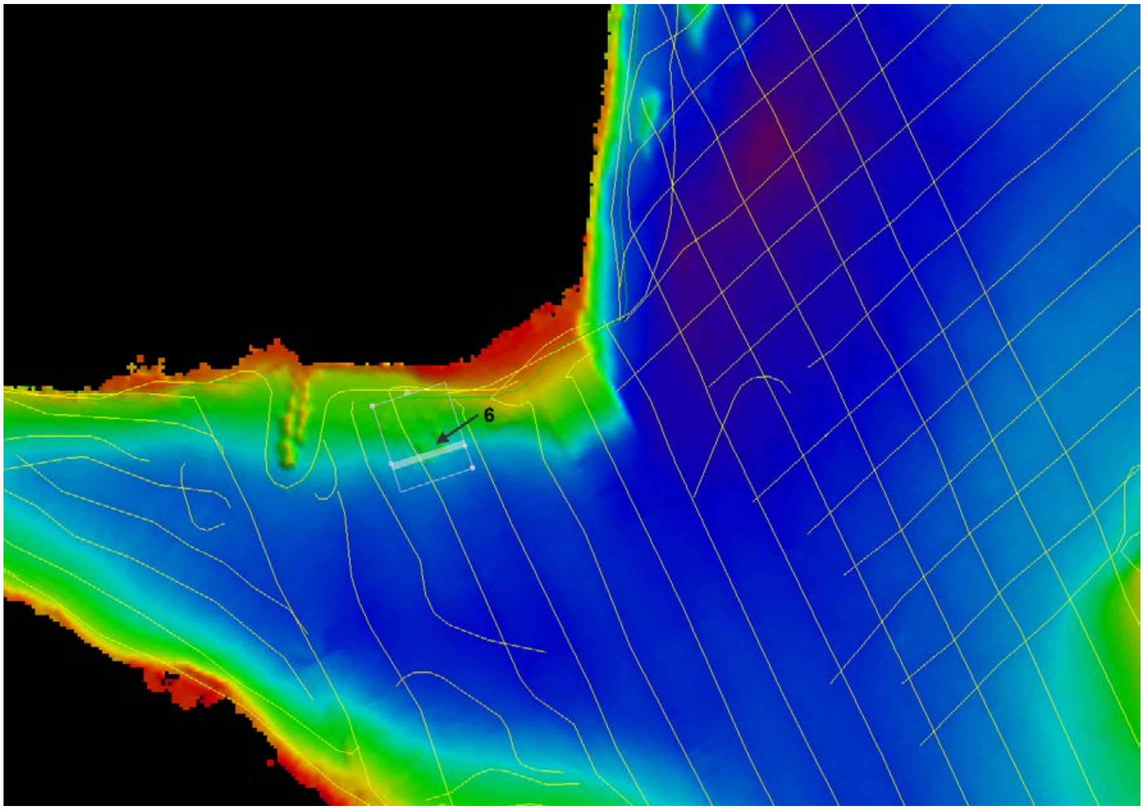
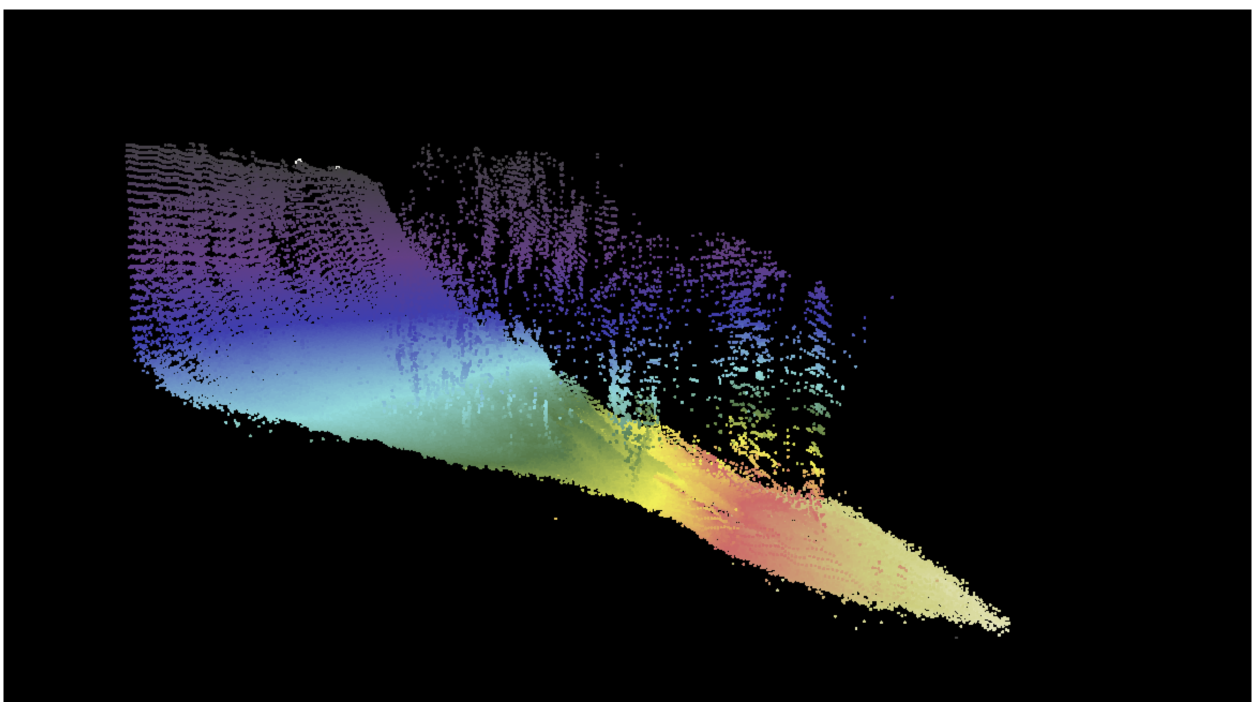
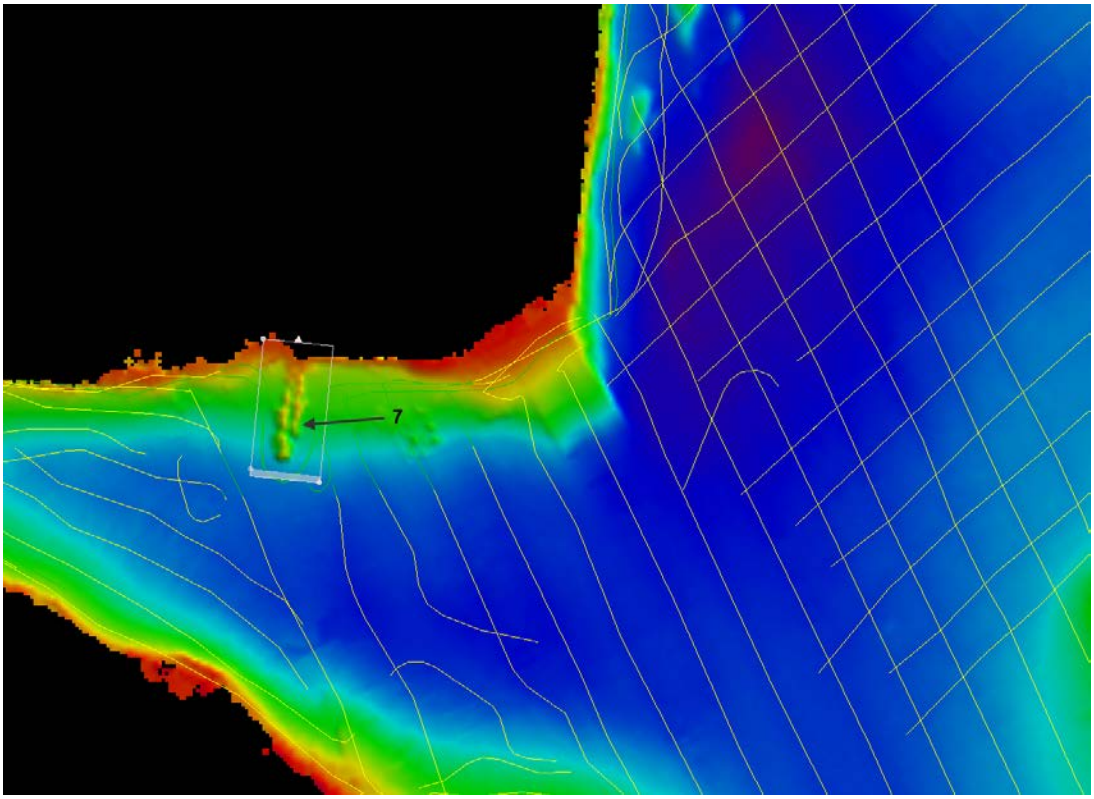
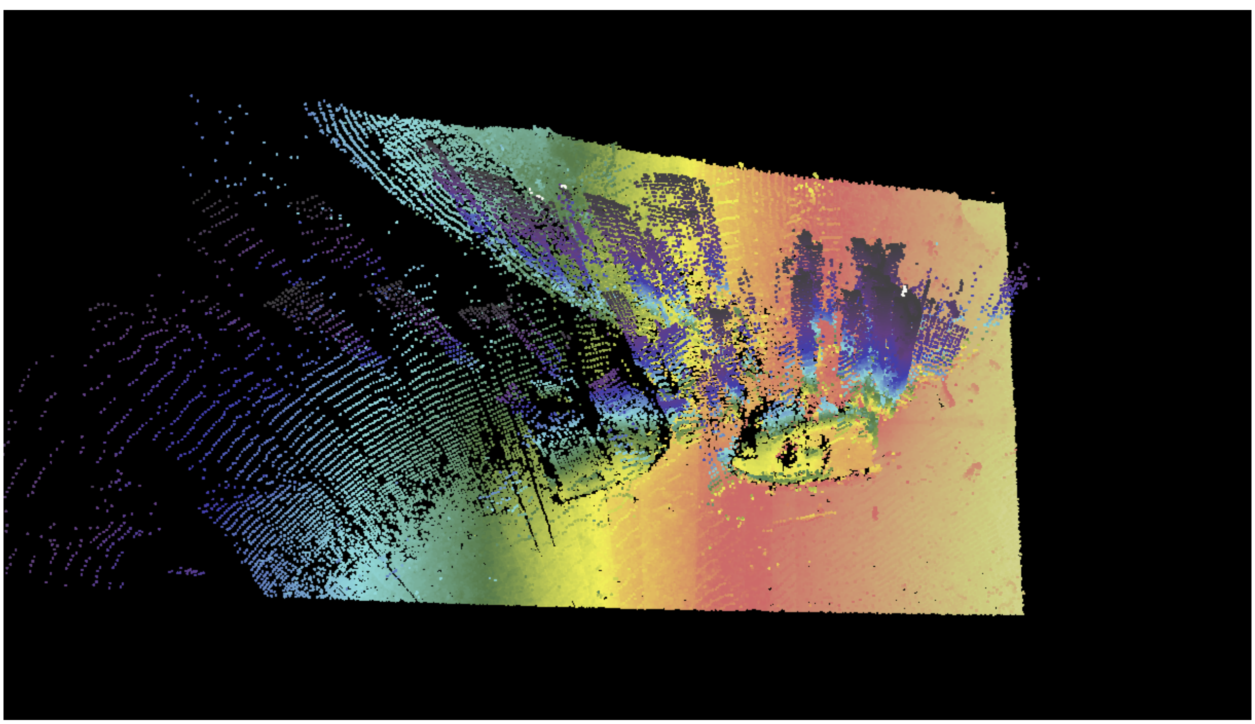
TARGET #6 - Vegitation / Acoustic Noise. No target detected. Exaggerated 5.4

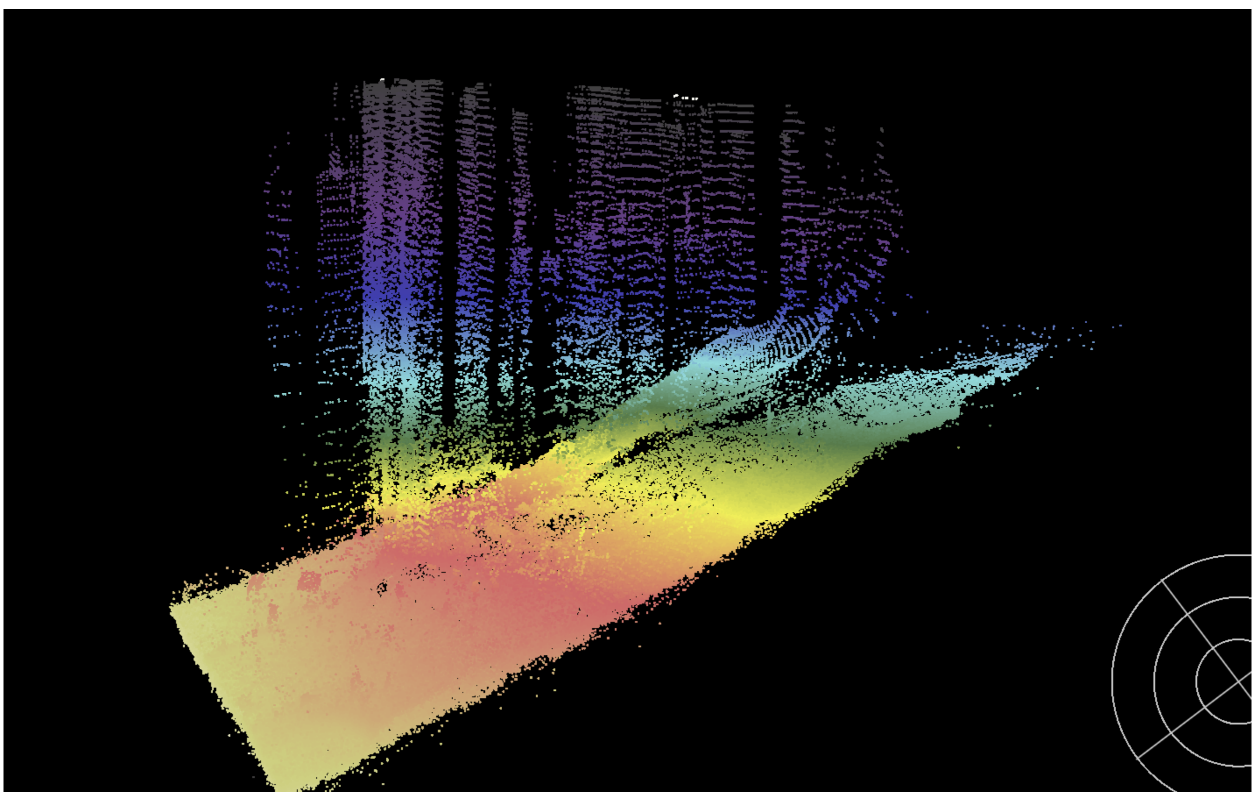




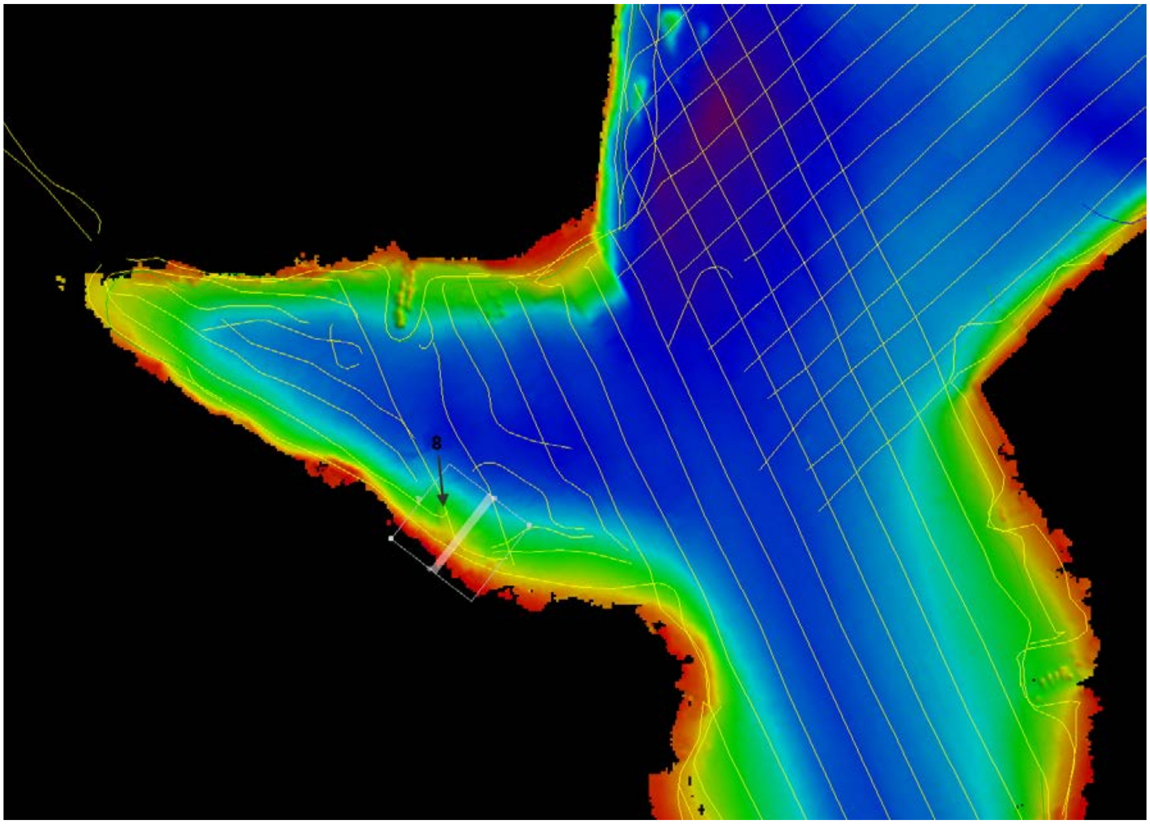
TARGET #7 - Pilings/Pier Nose. Exaggerated 7.0

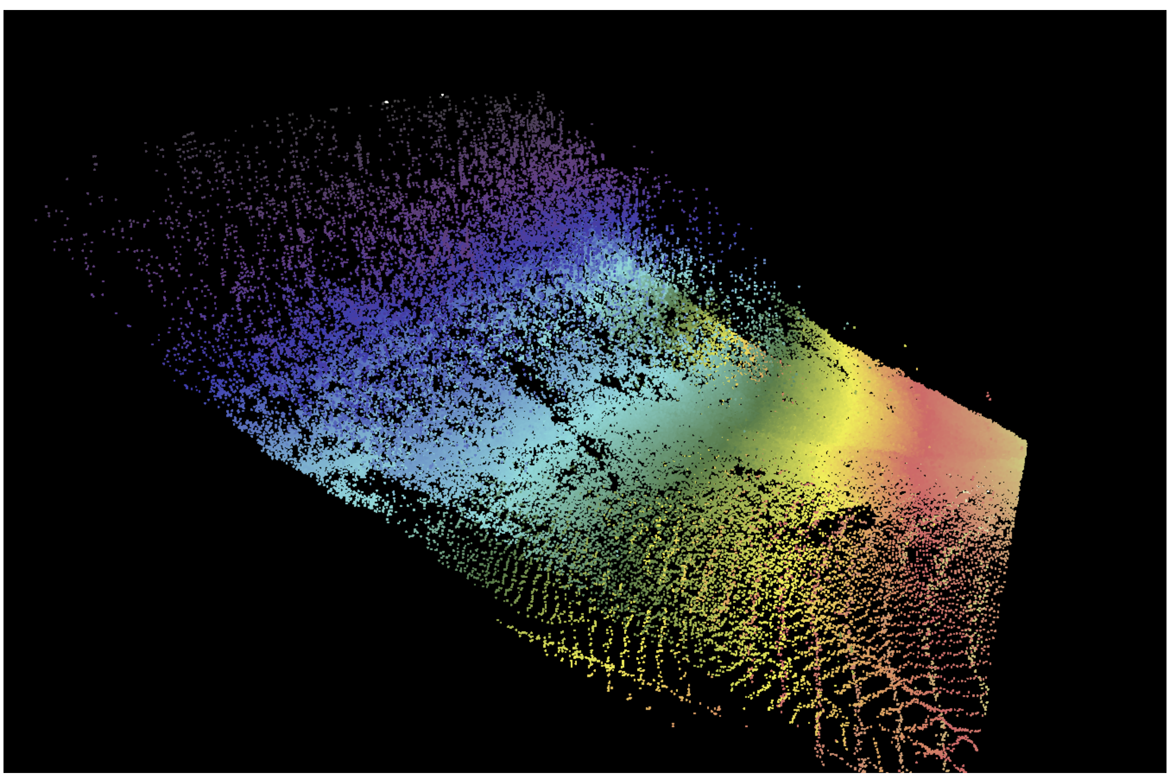




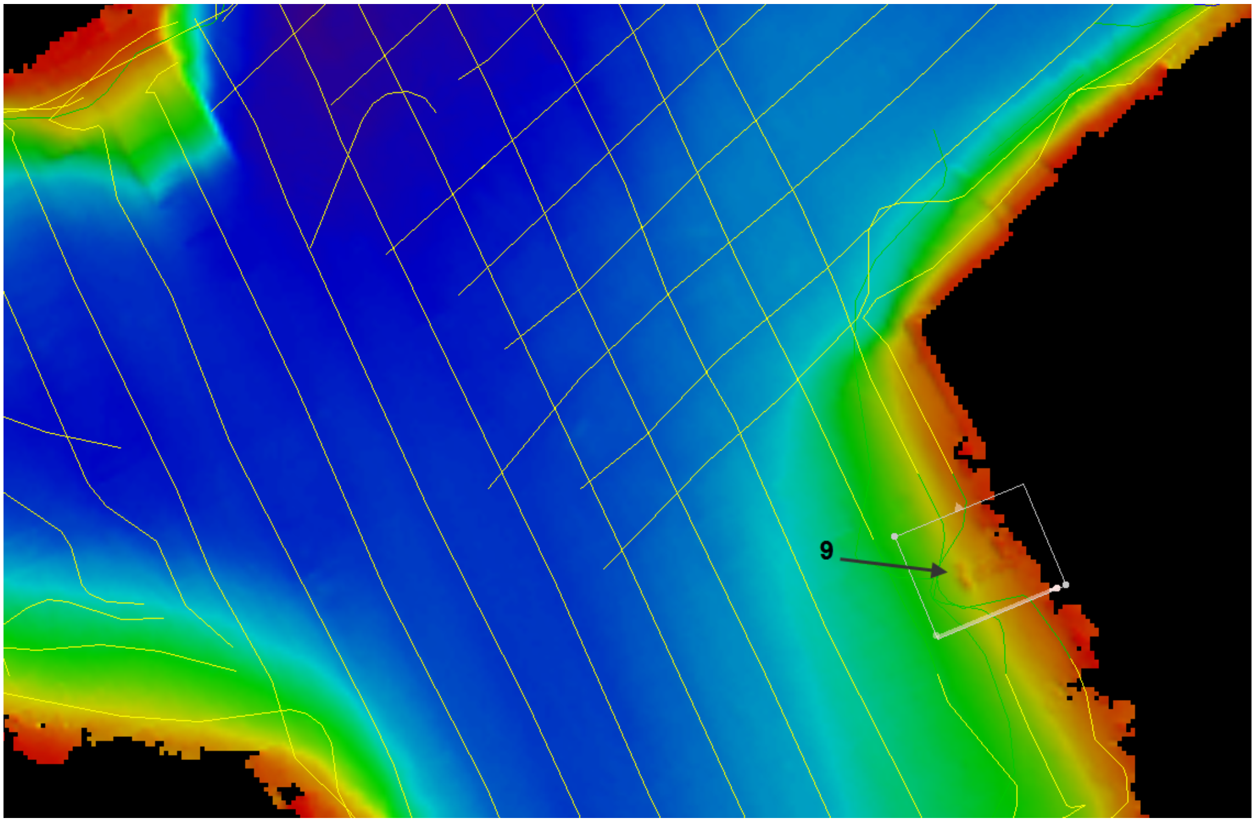


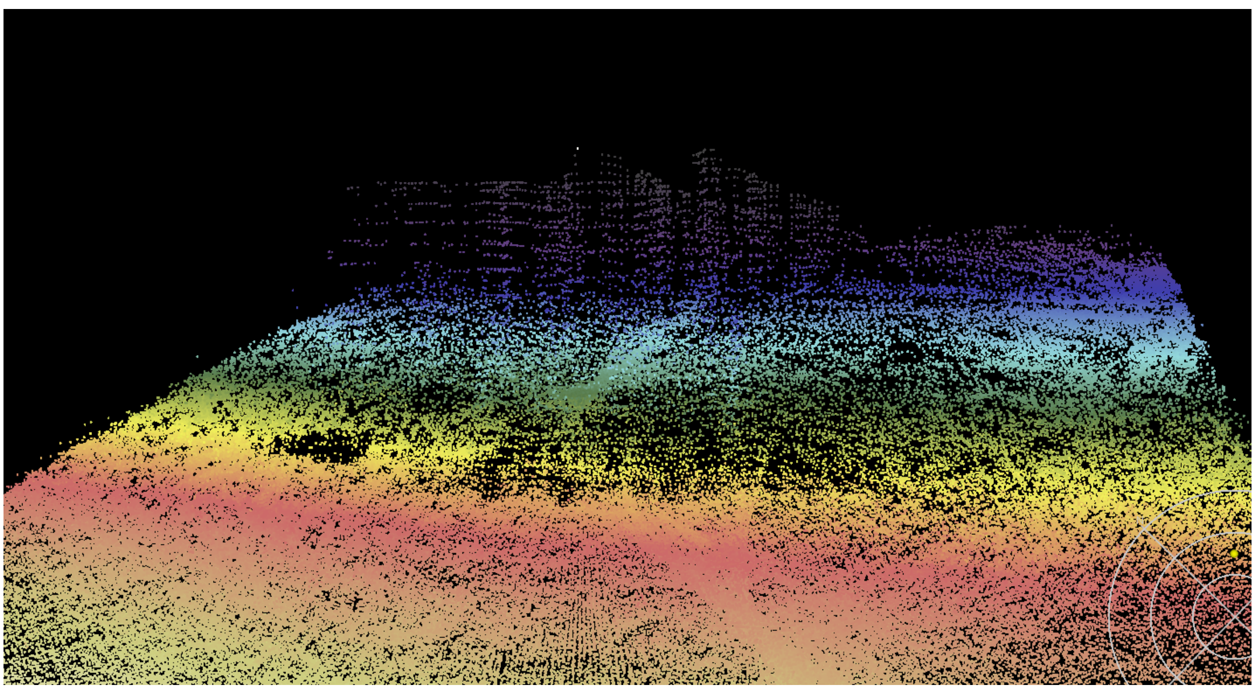
TARGET #8 - Vegetation / Acoustic Noise. No object detected. Exaggerated 5.2.

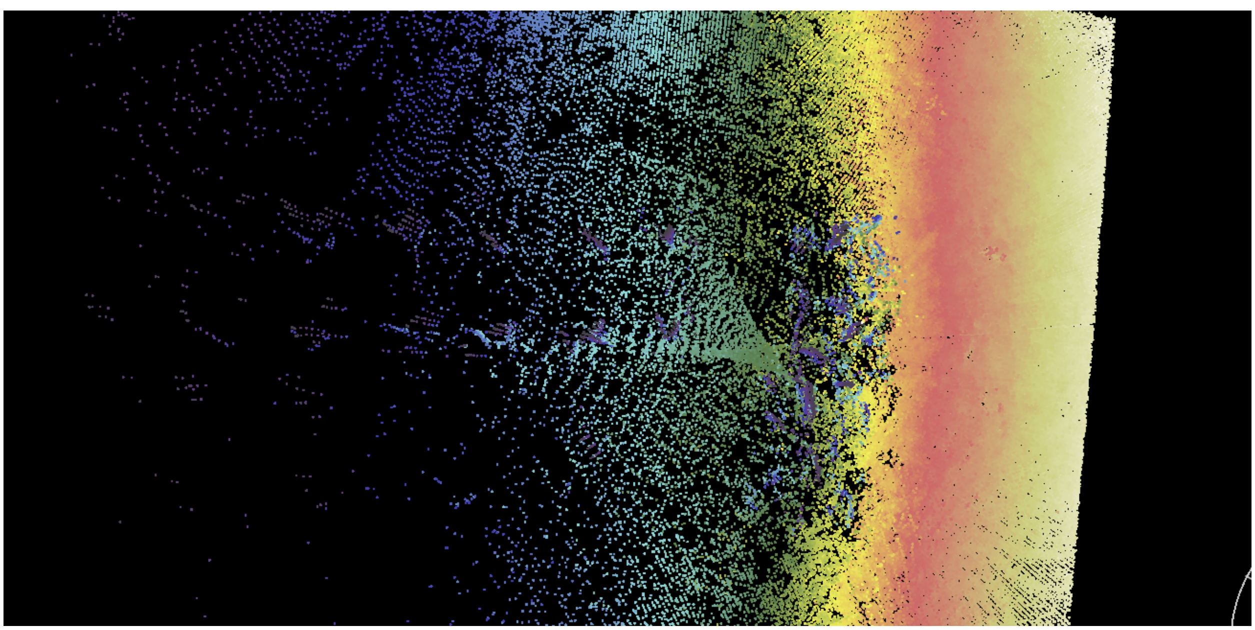




OBJECT #9 – Active Dock / Pilings. Exaggerated 5.2







APPENDIX B— HYDROLOGY ANALYSIS AND HYDRAULIC MODELING IN COW PEN CREEK

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APPENDIX B
Hydrology Analysis and Hydraulic Modeling in Cow Pen Creek

B.1 INTRODUCTION

In support of the remedial design and restoration in Cow Pen Creek, Tetra Tech collected stream flow and water elevation data from January 2015 to August 2015 in an effort to better understand the complex site hydraulics. The analysis and prediction of hydraulic conditions in tidal streams is highly challenging due to the complicated interaction of stream flow, tidal fluctuations, wind, and storm surges. The hydrology and hydraulic data are used as inputs to perform hydraulic modeling to aid in the restoration design process. The field work performed consisted the following activities:

- Installation of water level recorders
- Manual stream discharge measurements
- Collection of floodplain soil samples

B.2 PREVIOUS SURFACE WATER FIELD INVESTIGATION

Prior to the Middle River Full Remedy design, Tetra Tech had previously completed another field data collection program in 2009 where water level data was collected in Dark Head Cove and Cow Pen Creek.

Three staff gages and one long term surface water gauging station were installed in May 2009 to measure and record surface-water levels in Dark Head Cove and Cow Pen Creek. Staff gages were installed in the southeastern, southern, and southwestern shores of MRC (Figure B-1, MRC-01, MRC-02, MRC-03 locations). The gauging station was co-located with the southeastern staff-gage (MRC-01). Horizontal coordinates and vertical elevations of the staff gages and gauging station were surveyed by a Maryland licensed surveying firm. The survey results were used to convert staff-gage and gauging station readings to elevations. These data were used for numerical groundwater-flow and chemical-transport modeling conducted as part of the MRC Groundwater Remedial Action Plan (Tetra Tech, 2012).

Recorded data from the gage at MRC-01 was compared to water level data recorded at the NOAA tide station in Baltimore Harbor.

NOTES:

1. AERIAL SOURCE: GOOGLE MAPS.
2. SOIL SAMPLES S1-1 AND S1-2 WERE COMPOSITED INTO A SINGLE SAMPLE.
3. PREVIOUS WATER LEVEL FIELD DATA COLLECTION IN SUMMER 2009 (TETRA TECH, 2012).
4. BARO GAGE WAS USED TO MONITOR ATMOSPHERIC PRESSURE.
5. WATER SURFACE ELEVATION AND DISCHARGE MEASURED AT UPPER AND MID LOCATIONS, WATER SURFACE ELEVATION ONLY AT LOWER LOCATION.

LEGEND:

- WATER SURFACE ELEVATION GAGE (2015)
- FLOODPLAIN CHARACTERIZATION SOIL SAMPLES (2015)
- PREVIOUS DATA COLLECTION LOCATION (2009)

TETRA TECH

N

0 250' 500'

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MD

FIGURE B-1
MIDDLE RIVER COMPLEX
FIELD DATA COLLECTION LOCATIONS

G:\CADPROJECTS\LOCKHEED - MIDDLE RIVER COMPLEX\FIELD WORK\SHEET FILES\B-1 FIELD DATA COLLECTION LOCATIONS.DWG
PLOT DETAILS: BOWLES, WALTER March 30, 2015 9:10 AM TT-BOTH-MAIN-COLOR.CTB

B.3 2015 SURFACE WATER FIELD INVESTIGATION

B.3.1 Installation of Water Level Recorders

Tetra Tech installed electronic water-level recorders at the three locations labelled UPPER, MID, and LOWER in Figure B-1 along Cow Pen Creek to measure water surface elevations. A fourth recorder, labelled BARO, was used to remove the effects of changes in atmospheric pressure from the field data such that the pressure changes recorded by the recorders in the creek were due solely to changes in water surface elevation. The UPPER, MID, and LOWER recorders were installed in stilling wells to remove the effects of short-duration fluctuations in the water surface from the data. The UPPER gauge was located on the right bank at approximately station 8+10 near the upper limit of remediation. The MID gauge was located at approximately station 19+20 in the center of the creek. The LOWER gauge was located at the mouth of Cow Pen Creek on a wooden bulkhead wall at approximately station 35+00. The locations and elevations of the recorders in Cow Pen Creek were determined using real-time kinematic GPS and the elevations of the recorders were referenced to mean lower low water datum (MLLW). Manufacturer's data sheets describing the water level recorders are included in Attachment 1.

B.3.2 Manual Discharge Measurements

Manual discharge measurements were performed periodically at the UPPER and MID locations using a simplified version of the U. S. Geological Survey velocity-area midsection method (Turnipseed and Sauer, 2010). A Marsh-McBirney Flo-Mate 2000 electromagnetic current meter was used to measure flow velocities and depths along a stream cross section at each gage location. From these measurements, the stream discharge was calculated at each location. A manufacturer's data sheet for this instrument is included in Attachment 1.

Ideally, for the highest quality discharge measurements, a number of criteria are required in a measurement section: the channel be reasonably straight with parallel streamlines, the streambed be stable and free of obstructions that create eddies, slack water and turbulence, and velocities be greater than 0.5 ft/s. None of these conditions were obtained at the UPPER and MID locations. At the UPPER location the site location is dictated by the limits of remediation where the channel is narrow and sinuous with large amounts of natural and artificial debris obstructing flow. At the MID location, in the inter-tidal zone, there is a thick layer of very soft sediment that made wading very difficult and determination of the actual channel bottom was problematic. Additionally, the influence of tidal currents at this location complicated discharge measurements due to the ebb and flow of the tide. Measurements were planned at times when the tide was predicted to be falling but often the tide was either slack or coming in. This resulted in both upstream and downstream flow occurring in the measurement section simultaneously, further compromising discharge measurement accuracy.

B.3.3 Collection of Soil Samples

Soil samples were collected from four locations in the study area, shown in Figure B-1. These samples will be used to characterize the existing soil in the portion of the Cow Pen Creek floodplain to be reconstructed following remediation. This area was broadly divided into three sections by stream meanders and samples were collected from each area. The samples for two downstream areas, S2 and S3, consisted of a single sample from each area. The most upstream area, S1 was large enough and exhibited enough variety in vegetation and elevation that two separate samples from this area were combined to form a single composite sample. All samples were collected from the top 2 feet of soil and analyzed for grain size. Complete results from the grain size analyses are presented in Attachment 2 and summarized in Table B-1. The floodplain soils consist predominately of silt with smaller amounts of sand and clay. Gravel occurs in relatively small proportions (2 to 4 percent) in the floodplain samples.

Table B-1.
Grain Size Analysis Summary

Sample	S1	S2	S3
Percent Solids	58%	44%	34%
Specific Gravity	2.65	2.65	2.65
Soil Classification	**Percent Finer**		
Gravel	2%	2%	4%
Sand	32%	11%	23%
Coarse Sand	<1%	1%	2%
Medium Sand	8%	1%	7%
Fine Sand	23%	9%	14%
Silt	50%	69%	50%
Clay	16%	19%	24%

These results are consistent with the sediment samples collected during the Additional Sediment-Characterization Report (Tetra Tech, 2012a) in the downstream reach of Cow Pen Creek near Station 28+00 (CPC-1) and Station 35+00 (CPC-2). Near surface sediments (0.5 to 2 feet depth) were classified as elastic silt containing 92 to 97 percent fines respectively, with the remaining content consisting of sand with no gravel present.

Sediment threshold of motion analyses were conducted using the sediment properties and hydraulic modeling results (Section B.5.3). The analysis results are used to specify floodplain reconstruction and streambed material.

B.4 HYDROLOGY ANALYSIS

B.4.1 Groundwater

Groundwater flows were measured and modeled as a component of the MRC Groundwater Remedial Action Plan (Tetra Tech, 2012). The results indicate that shallow groundwater follows site topography and flows radially from the hydraulically upgradient northern–central portion of the MRC to the southwest into Cow Pen Creek and southeast into Dark Head Cove mostly following preferential flow paths in more sandy soils.

The near surface sediments along the northern portion of the project area (Station 0+00 to Station 21+00) generally have a very low hydraulic conductivity of less than 0.01 feet per day. In contrast, the southern portion (Station 21+00 to Station 36+00) have a much higher hydraulic conductivity of greater than 1.0 feet per day (up to 7 feet per day) near the surface water. Figure B-3 contains a fence diagram that shows areas of high and low hydraulic conductivity determined from groundwater monitoring wells (Tetra Tech, 2012).

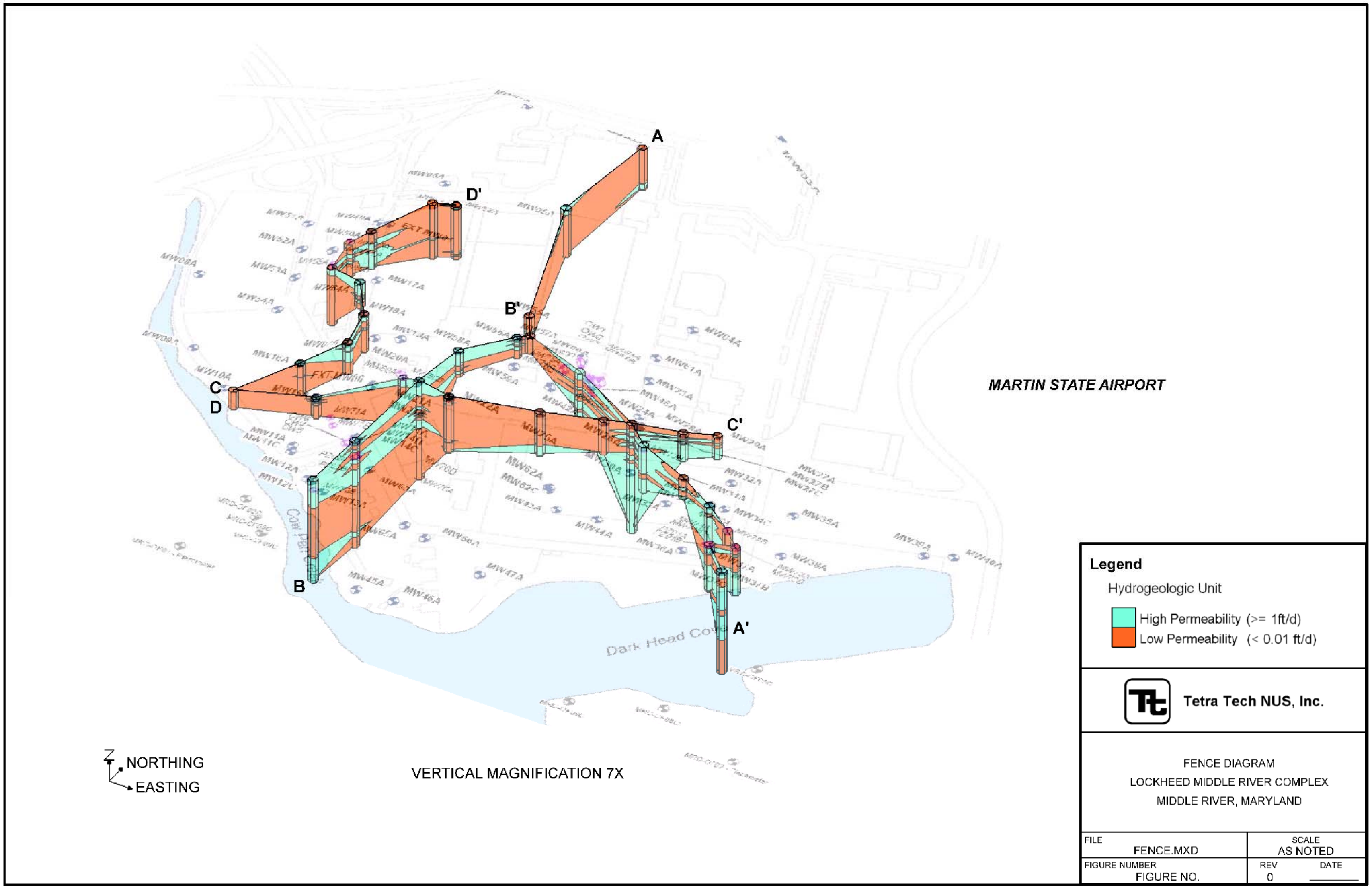

Figure B-1. Fence Diagram Showing the Location of High and Low Permeability Hydrogeologic Units

The hydraulic conductivity data were applied to produce an estimate of the amount of groundwater inflow that should be expected during excavation and removal of contaminated sediment in Cow Pen Creek. Groundwater flow modeling to identify potential groundwater extraction programs in the relatively high hydraulic conductivity area predicted flow volumes for a 1,050 foot long extraction trench excavated to an elevation of -2 feet. Total extraction from the trench was estimated to be 1.2 gallons per minute (gpm) or 0.003 cubic feet per second (cfs) (Tetra Tech, 2012: Appendix G). This flow when converted to a unit measurement equates to 0.09 gpm per 1,000 square foot (sf) of area exposed. In lieu of further analysis, this value can be assumed as similar on the residential channel bank and channel bottom which were beyond the scope of the groundwater analysis.

B.4.2 Precipitation

Average monthly precipitation at the site is 3.3 inches for the period between October to February and 3.5 inches per month year round. Precipitation frequency estimates indicate that storm totals for 24-hour periods are from 3.3 inches in the 2-year event, to 5.1 inches in the 10-year event, and 8.8 in the 100-year event.

During winter months, the project receives some additional precipitation as snowfall. Average season snowfall is 18.2 inches typically occurring between November and April. Average monthly snowfall ranges from 0.1 inches in April to 7.0 inches in January. However, much heavier snowfall amounts, with storm totals of up to 20 inches, can occur associated with strong nor'easter storm events.

B.4.3 Peak Runoff Calculation

Peak Runoff in Cow Pen Creek was calculated for three recurrence intervals including the 2-year, 10-year, and 100-year flood events. Cow Pen Creek is an ungagged stream therefore peak discharge could not be calculated from existing gage data. Because the drainage area is relatively small (0.6 square miles) and a high proportion of the watershed (36 percent) is covered by impervious surfaces, regional regression equations are not appropriate for determining peak discharges in Cow Pen Creek (Thomas et al., 2010). For this analysis, the Simple Method (SMRC 2010) was used to estimate stormwater runoff for the 2-year, 10-year, and 100-year, 24-hour precipitation events. This is the same methodology that was used to estimate flows for the

Sediment Stability Analysis (Tetra Tech, 2011a). Previous hydrodynamic modeling and sediment stability analysis were conducted to estimate the hydrologic conditions and stability of bed sediment in the Cow Pen Creek and Dark Head Cove due to wind- and wave-generated bottom velocities and associated shear stresses (Tetra Tech, 2011a).

The Simple Method (SMRC, 2010) calculates runoff as a product of runoff volume and a runoff coefficient. Data requirements for the calculation include drainage area, the amount of impervious cover, and the 24-hour precipitation for each recurrence interval. The drainage area, land use, and the percentage of impervious cover data derived in the Sediment Stability Analysis (Tetra Tech, 2011a) were utilized for these calculations. The U.S. Geological survey 10-meter digital elevation models (USGS, 2009) were the primary source of information for the watershed delineation. The delineation also incorporated site utility information for Chesapeake Park, owned by LMC Properties, Inc. Land use and impervious surface data were extracted from the National Land Cover Dataset (MRLC, 2001). These data were derived from satellite imagery taken circa 2001. The percent change in developed imperviousness data for 2001 to 2011 (Xian et al., 2011) was also reviewed to determine if there had been a significant change. Less than five percent of the drainage area exhibited any change to impervious cover which did not require updating the analysis with the more current 2011 land cover data.

Table B-2 contains the area in acres and percent impervious surface for each land-use category in the drainage area. Approximately 75 percent of the drainage area is classified as one of the four developed land use categories (open space, low intensity, medium intensity, or high intensity). Rainfall totals were taken from rainfall frequency data released by The National Weather Service that are available through the National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server (NOAA, 2006).

Table B-2.
Land Use and Impervious Area Percentage for Cow Pen Creek

Land Use Description	Percent Impervious	Area (Acres)	Percent of Total
Open Water	100%	8	--
Developed, Open Space	10%	56	15%
Developed, Low Intensity	35%	87	24%
Developed, Medium Intensity	65%	95	26%
Developed, High Intensity	90%	36	10%
Barren	50%	1	0%
Deciduous Forest	0	49	13%
Evergreen Forest	0	2	1%
Pasture/Hay	0	17	5%
Cultivated Crops	0	9	2%
Woody Wetlands	0	10	3%
Herbaceous Wetlands	0	2	1%
Total (excluding open water)		**363**	**100%**

Using the methods and data described above, peak runoff in Cow Pen Creek was estimated for the, 2-year, 10-year, and 100-year, 24-hour precipitation events, as shown in Table B-3. The baseflow discharge was a measured value recorded during five field visits. The baseflow is small and a relatively minor component (less than 10 percent) of bankfull flood flows. The bankfull discharge was not estimated based on the 24-hour precipitation event but instead back-calculated for a typical channel cross section using hydraulic modeling and compared to field observations.

Table B-3.
Precipitation and Discharge for Flow Events in Cow Pen Creek

Storm Event	24-hour Precipitation	Discharge[a]
	inches	cfs
Baseflow[b]	0	0.6
Bankfull	--[c]	6.0
2-year	3.3	19.2
10-year	5.1	29.4
100-year	8.8	50.3

[a] Discharge for the Bankfull, 2-Year, 10-Year, and 100-Year events includes runoff and baseflow.
[b] Baseflow is representative of typical low winter flow conditions measured (see Table B-4).
[c] The 24-hour precipitation associated with bankfull flows is unknown and was not used to calculate the bankfull discharge.

B.4.4 Flow Measurements

Field measured discharge values for Cow Pen Creek are shown in Table B-4. Field conditions (e.g., ice, low water) at the time of measurement sometimes resulted in some data not being collected at each event. As shown in Table B-4, discharge values at the UPPER site, above the saltwater intrusion, ranged from 0.5 cfs to 3.0 cfs. At the MID site, within the inter-tidal zone, discharges ranged from 0.4 cfs to 2.3 cfs. At the MID location there was often an obvious tidal component to the flow resulting in negative velocities (upstream flow) which reduced the accuracy of discharge calculations. The LOWER location of the creek was not measured for discharge, as the flow would be almost entirely tidally based. Instead the maximum and minimum tidal elevations were used in the hydraulic analysis to represent upper and lower limits of tidal fluctuation.

Table B-4.
Cow Pen Creek Discharge Summary

Date	UPPER		MID	
	Discharge	Water Surface Elevation[a]	Discharge	Water Surface Elevation[a]
	cfs	feet	cfs	feet
1/14/2015	0.6	3.41	0.5	-0.74
2/2/2015	3.0	3.95	NM[b]	--
2/10/2015	0.5	3.34	0.4	-0.53
3/9/2015	2.4	3.89	2.3	-1.27
4/2/2015	0.7	NA[c]	-3.8	NA[c]

[a] Water surface elevation is referenced to MLLW
[b] Not measured
[c] Not available, discharge not used in rating curve

B.4.5 Discharge Estimates

Continuous water level data was evaluated to estimate the discharge over the measurement period from January 13, 2015 to August 28, 2015. A stage discharge relation was developed by utilizing the water surface elevation data to construct an estimated hydrograph for the UPPER gauging site (which has the least tidal influence) for the period since instrument installation. The rating curve was developed utilizing field measured discharge values and water-level data recorded at 15-minute intervals. The predictive ability of this analysis is limited at higher discharges (over about

6 cfs) because those flows far exceed the flows at which discharge was measured. In addition, the water level data is confounded by the influence of tidal fluctuations, as described in Section B.4.6. Long term water-level data and future discharge measurements at higher flows could be used to further refine the accuracy of the rating curve and resulting discharge estimates.

Figure B-4 contains the average daily discharge estimates and water temperature measured at the UPPER gauging site. Estimated discharge rises and falls rapidly back to base flow over the measurement period indicating that streamflows in Cow Pen Creek are highly responsive to precipitation and runoff, also known as “flashy”. The flashy nature of the hydrograph supports the peak flow calculation methods used in Section B.4.3 which are runoff based equations. The estimated average daily discharges exceeded 6 cfs (equivalent to the estimated bankfull flow) several times throughout the data collection period and peaked at average daily discharge of 19.4 cfs on June 27, 2015.

Given the limitations on interpretation of these results described above, this analysis does provide support for the bankfull and 2-year flow peak runoff estimates included in Table B-3 and used in the hydraulic model described in Section B.5. The peak discharge an associated precipitation event were in close agreement with runoff calculation estimates. The peak daily discharge of 19.4 cfs shown in Figure B-4 is equivalent to 2-year flow event (19.2 cfs) and a 24-hour precipitation event of 3.3 inches using the peak runoff calculations in Section B.4.4 (see Table B-3). The measured 24-hour precipitation during the June 27, 2015 flow event was 3.0 which is close to the 2-year, 24-hour precipitation event providing support for the accuracy of the peak runoff estimates.

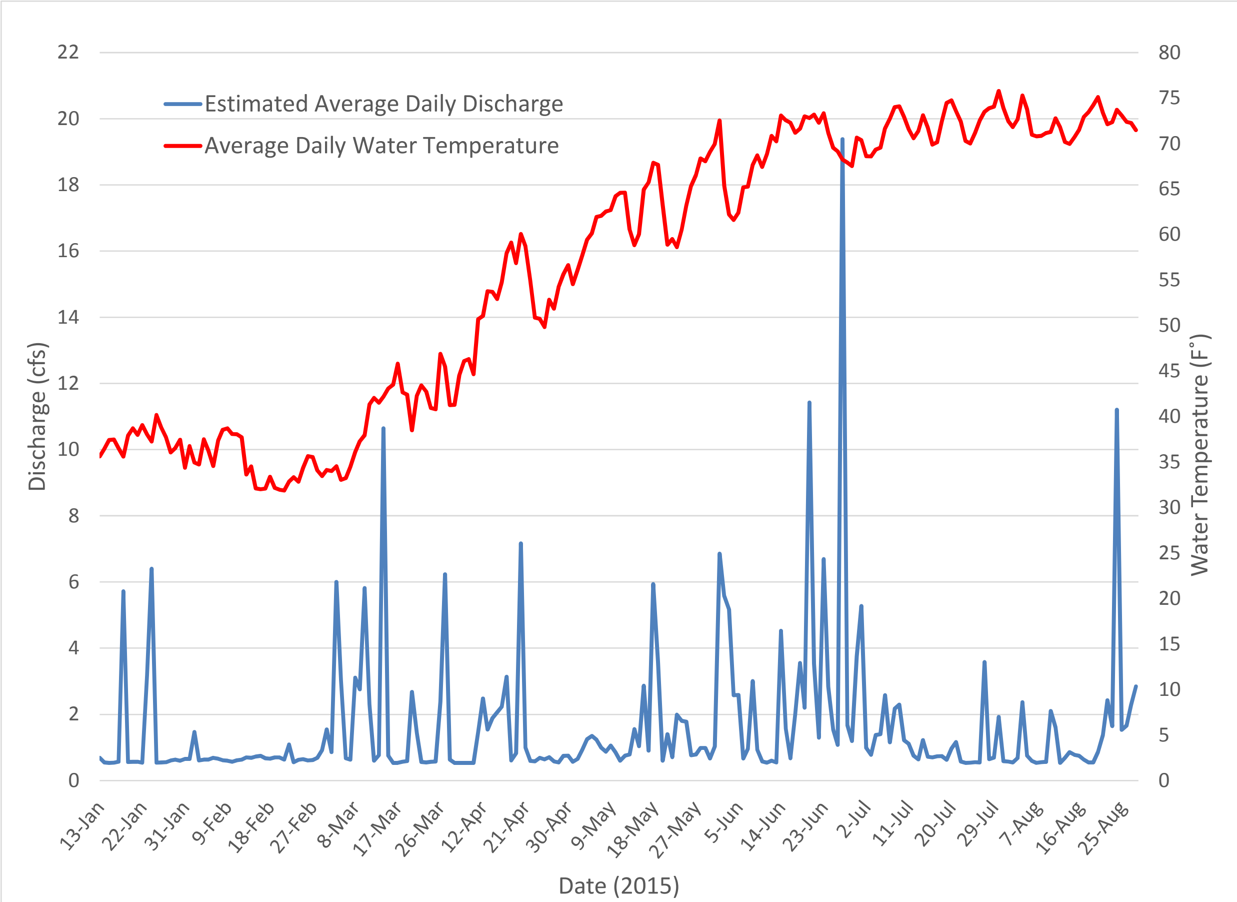

Figure B-2. UPPER Gauging Site Daily Average Estimated Discharge and Stream Temperature

B.4.6 Tides and Inter-tidal Hydraulics

The analysis and prediction of hydraulic conditions in tidal streams is highly challenging due to the complicated interaction of stream flow, tidal fluctuations, wind, and storm surges. Rising tides and/or storm surges push saltwater into the inter-tidal areas of streams. When this occurs, the relatively heavy and cold saltwater often flows beneath the freshwater forming a wedge that forces water levels to rise and flows to reverse. This tidal influence on river hydraulics can extend well beyond the limit of the saltwater intrusion due to backwater effects. The following section utilizes the water level data recorded in the tidal zone (LOWER), and outside of saltwater intrusion during regular tide cycles (UPPER), to characterize the complex hydraulics in order to inform the remediation and restoration design efforts in Cow Pen Creek.

The water level data from the LOWER site was used to establish tidal fluctuations. Water surface elevations at the mouth of Cow Pen Creek varied from 1.70 feet to below -2.62 feet, relative to mean lower low water (MLLW) and showed a characteristic tidal signature with two high tides and two low tides per day. A representative portion of the tidal curve along with the corresponding tidal curve for Baltimore Harbor is shown in Figure B-2. Baltimore Harbor is the location of the nearest NOAA tide station (NOAA, 2015) on an inlet at the western shore of Chesapeake Bay, approximately nine miles southwest of Cow Pen Creek (Figure B-1). The same tide station was used to determine project datum at the site (as shown in design drawings and calculations).

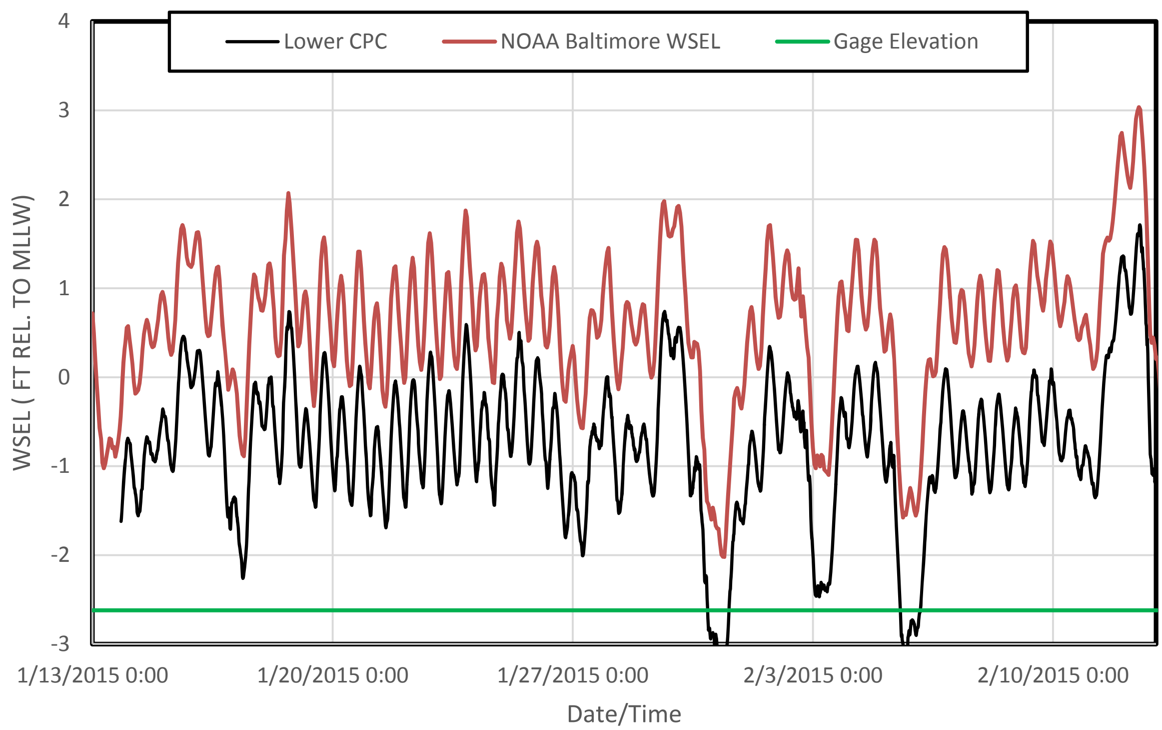

Figure B-3. Cow Pen Creek and Baltimore Harbor Tide Levels

Figure B-3 shows that the tide curves for Cow Pen Creek and Baltimore Harbor match closely, separated by a relatively constant offset. Hourly water surface elevation measurements from Baltimore Harbor were compared to the water surface elevation measurements at the mouth of Cow Pen Creek to determine this offset. The mean water surface offset between Baltimore and Cow Pen Creek was 1.34±0.1 feet with the Baltimore Harbor water surface elevation being the greater of the two. This offset was measured in a similar fashion using the water surface elevation data collected in Dark Head Cove in the summer of 2009 and determined to be 1.19±0.1 feet. With a known, relatively constant offset of 1.34 feet, the similarity of the tide curves allows the Baltimore Harbor tide curve to be used as a surrogate for the Cow Pen Creek tide curve.

The water level data from the UPPER site was utilized for characterizing the backwater effects upstream of saltwater intrusion. The UPPER site is above the elevation of any tidal elevation recorded over the measurement period and therefore an increase in water surface elevation at this location due to tides would be because of backwater effects. Figure B-4 includes the recorded daily maximum water surface elevation from the UPPER site, the daily maximum tide elevation, and precipitation for the measurement period. As expected, peak water surface elevations (blue line) at this location correspond with large precipitations events (red bars); however, there are also patterns suggesting a tidal influence at this location. Demonstrating this, figure B-4 shows similar precipitation amounts that have different corresponding maximum water surface elevations based on the tide elevation (green line) event though the tidal fluctuations are relatively small. As discussed earlier, the hydraulics controlling this pattern are highly complex and the measured water surface elevation at the UPPER site may also be impacted by many other factors including storm surge, wind-driven waves, and instream debris.

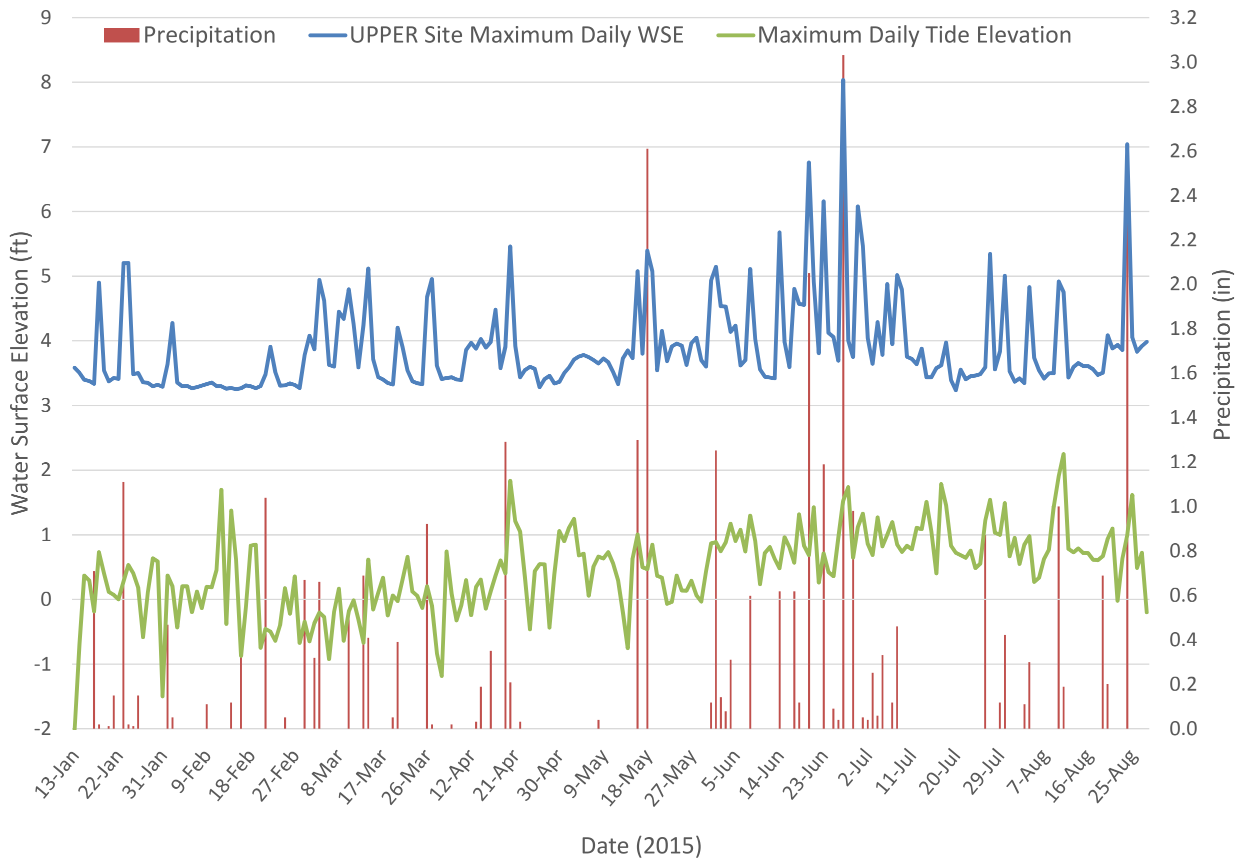

Figure B-4. UPPER site daily water surface elevation, maximum tidal elevation, and daily precipitation over the measurement period.

The scatterplot in Figure B-5 provides another graphical representation of the influence of the tide on water surface elevation at the UPPER site. This figure compares measured tidal elevation with water surface elevation at the UPPER gage to demonstrate if there is a pattern when high water surface elevations occur. The figure shows that the highest water surface elevations recorded (greater than 5 feet) only occurred during periods of higher tide (-1 to 2.25 feet elevation) which supports the concept that there are backwater effects at the UPPER site. Given these results and the predicted tidal elevation during high storm tides (see Section B.5.2), it is possible that backwater effects could result in water surface elevations higher than were observed during the measurement period. The highest extent of inundation is difficult to model accurately due to the complex hydraulics of the backwater effect but is not needed to inform most remediation and restoration design efforts. This is because backwater effects reduce velocities and diminish shear stress, thereby reducing scour potential which is supported by previous hydrodynamic modeling results indicating relatively low shear stresses in the inter-tidal area, as discussed above (Tetra Tech 2011a). The goal of the modeling is to determine maximum water heights for preparedness of construction purposes of cofferdams and erosion controls.

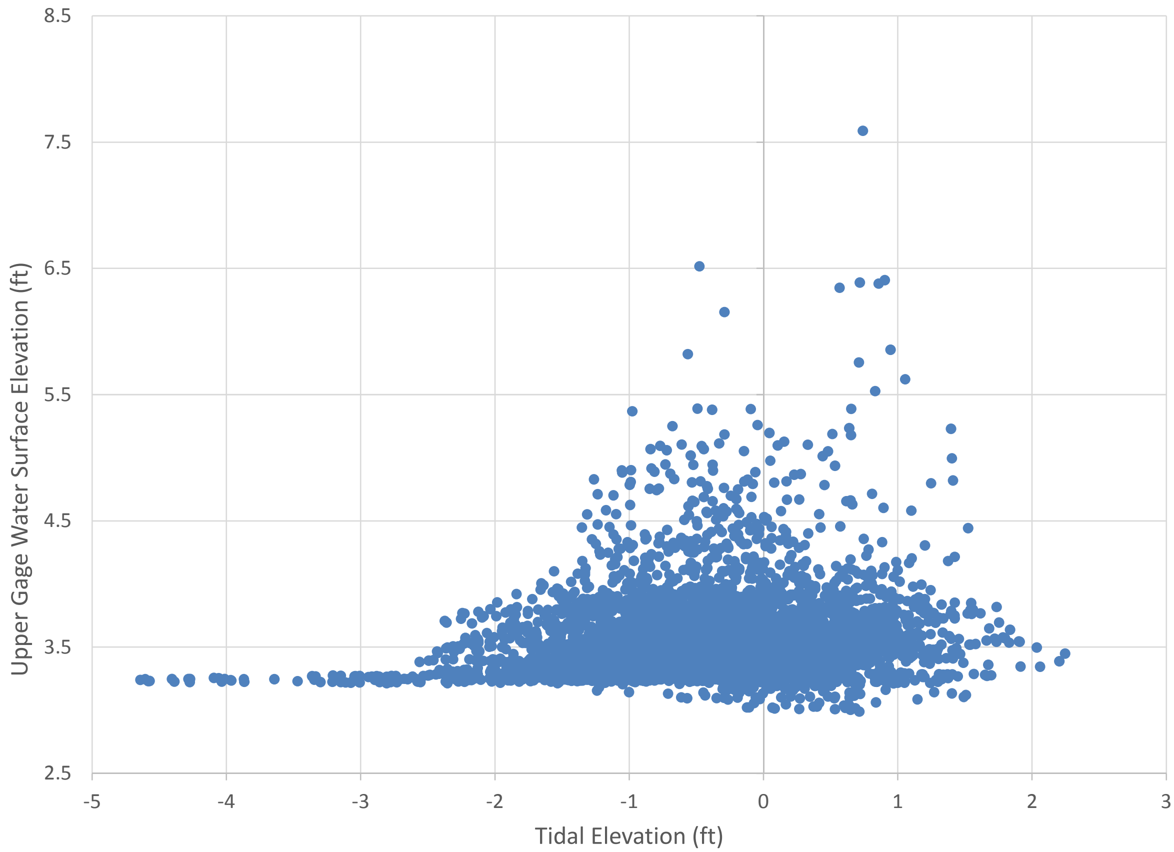

Figure B-5. Scatterplot of tide elevation and the UPPER site water surface elevation illustrating the tidal influence.

B.5 HYDRAULIC MODELING

The hydraulic modelling was conducted to inform the construction of the remediation and restoration design efforts in Cow Pen Creek. The existing conditions were modeled to develop a baseline for the site's hydraulic conditions. The proposed conditions after excavation and backfill were modeled to confirm that the creek's hydraulic conditions were maintained or improved by the design.

B.5.1 Methodology

In order to create the hydraulic model, channel characteristics of Cow Pen Creek were analyzed and brought into the modeling software (HEC-RAS 4.1). Utilizing AutoCAD Civil 3D 2015, cross sections were placed at approximately 100 foot intervals along the combined existing topographic surface (developed from data collected by Tetra Tech 2012), which combined data from the upland and bathymetric areas. An AutoCAD add-in software (SmartDraft) extracted the geometric data required for the model along the surveyed thalweg alignment of Cow Pen Creek from the design existing surface.

In order to analyze the ranges of water surface elevations (WSEs) evaluating the stormwater and tidal contributions, the creek was divided into upstream, inter-tidal and tidal areas based on the MHHW and MLLW elevations determined in Cow Pen Creek (as determined in Section B.4.6). The purpose was to group areas that were similar during conditions that occur regularly on an annual basis. Defined as such the upstream is the area above the MHHW tide, the inter-tidal is the area between MHHW and MLLW, and tidal is the area below MLLW elevations. Note that this division may be different than the extent of tidal influence determined at the site during the tidal wetland versus non-tidal wetland delineation work (Tetra Tech, 2011b).

B.5.2 Modeling Input

Input values required for the HEC-RAS model include the channel roughness (Table B-5), flow events (Table B-6), and boundary conditions. Channel roughness (Manning’s n) was estimated using field photos of the creek, field collected soil samples and by applying USGS methodology (Arcement, 1989).

Table B-5.
Summary of Manning’s n Values

Model Area	Manning’s n Values		
	Upstream	Inter-tidal Area	Tidal Area
	Station 0+00 to 13+00	Station 13+00 to 19+00	Station 19+00 to 35+00
In-stream	0.065	0.037	0.027
Floodplain	0.112	0.088	0.080

Boundary conditions were determined utilizing channel gradient for the upstream, and tidal elevation or measured WSEs for downstream. The upstream gradient value was calculated along the stream alignment using the existing surface. The downstream values varied depending on the specific flow event being modeled.

Table B-6 summarizes the combined modeled hydraulic conditions:

Table B-6.
Summary of Modeled Flow Conditions

Modeled Event	Modeled Discharge	Tidal Elevation
	cfs	feet
Base Flow, MLLW[a]	0.6	-1.34
Bankfull Flow, MHHW[a]	6.0	0.32
2-Year Storm Event, 50 in 100 Year (2-year) Tide[a,c]	19.2	3.8
10-Year Storm Event, 10 in 100 Year (10-year) Tide[a,c]	29.4	4.9
100-Year Storm Event, 1 in 100 Year (100-Year) Tide[a,c]	50.3	7.6
Bankfull Flow, MLLW[b]	6.0	-1.34
2-Year Storm Event, MLLW[b]	19.2	-1.34
10-Year Storm Event, MLLW[b]	29.4	-1.34
100-Year Storm Event, MLLW[b]	50.3	-1.34

[a] These flow events were used to calculate upper and lower flooding extents.
[b] These flow events were used to calculate worse-case scenario for stream bed mobility.
[c] The 50% exceedance probability level equals the water level expected every 2 years, the 10% exceedance probability level equals the water level expected every 10 years and the 1% exceedance probability level equals the water level expected every 100 years.

These nine model events (i.e., scenarios), were selected to represent a range of flow conditions from typical to increasingly most severe. For all nine events, a 1-D Steady State analysis was performed to provide a "snapshot" in time of the WSEs will be throughout the creek. See Attachment 3 for figures of profiles and perspective views of selected scenarios.

B.5.3 Existing Model Results

Flow Conditions

Upon running the modeling scenarios, the following patterns emerge:

During baseflow conditions, velocities remain low (mostly less than 1 fps), likely causing little scour, channel reformation, or sediment transfer. Normal tides range from about Station 26+00 up to Station 14+00 along the stream alignment (Figure B-1) not including the backwater effects and other factors described above.

During more extreme events, the WSE increase proportional to the severity of the event. At a 2-year flow event and a 2-year tide, Cow Pen Creek is inundated to approximately 12+00, just beyond the tidal flats area (Station 13+00 to Station 18+00). The 10-year tide event is similar reaching about 11+00 with comparable flow velocities. During the 100-year tide event, Cow Pen

Creek is inundated to approximately 6+00, beyond the upper most portion of the design area, but velocities remain low, in the 1 to 3 fps range.

Model results at the bankfull, 2-year, 10-year, and 100-year flood events during MLLW conditions are summarized in Table B-7. While this scenario is not likely to occur due to the high tides and high precipitation events being correlated, as discussed previously in B.4.6, it was used as the most conservative scenarios. At this tide level these cross sections are representative of existing conditions in the upstream portion of Cow Pen Creek where the shear stresses and scour potential are the greatest. Average velocity and shear stress values were highest at Station 8+21 and 12+21 where the channel is relatively constricted and narrow. Restoration of Cow Pen Creek will result in a slightly wider channel with reduced average velocity and shear stress to be similar to conditions at the existing cross section 9+24. These hydraulic characteristics were used for identifying a stable streambed mixture for remediation and restoration design and also will be used to guide bank stabilization techniques.

Table B-7.
Summary of Modeled Existing Hydraulic Characteristics

Modeled Event[a]	Station	Maximum Depth	Average Velocity	Shear Stress
		ft	ft/sec	psf
Bankfull Event, MLLW	8+21	1.2	1.2	0.2
	9+24	1.0	0.8	0.1
	11+25	1.2	0.7	0.1
	12+21	0.5	3.0	0.5
	13+12	1.0	0.8	0.1
	14+30	0.5	2.1	0.3
2-Year Storm Event, MLLW	8+21	1.9	2.0	0.4
	9+24	1.6	1.4	0.2
	11+25	1.8	1.3	0.2
	12+21	0.8	4.1	0.8
	13+12	1.4	1.3	0.4
	14+30	0.9	2.3	0.3
10-Year Storm Event, MLLW	8+21	2.4	2.4	0.6
	9+24	1.9	1.8	0.3
	11+25	2.1	1.6	0.3
	12+21	1.1	4.4	0.8

Modeled Event[a]	Station	Maximum Depth	Average Velocity	Shear Stress
		ft	ft/sec	psf
	13+12	1.6	1.7	0.6
	14+30	1.1	2.6	0.3
100-Year Storm Event, MLLW	8+21	2.8	2.8	0.7
	9+24	2.4	2.3	0.5
	11+25	2.6	2.1	0.4
	12+21	1.4	5.2	1.0
	13+12	2.0	2.1	0.9
	14+30	1.4	3.0	0.4

[a] These flow events were used to calculate worse-case scenario for stream bed mobility.

Cofferdam Design

During construction a cofferdam system will be required to provide a work area that can be dewatered for excavation. The height of the cofferdam will be sized conservatively to prevent overtopping during relatively normal hydrologic and tidal conditions. Stations were selected that would require similar size cofferdam heights. The construction contractor will likely subdivide the stations below to provide adequately sized work areas. Table B-8 demonstrates a range of conditions and suggest cofferdam heights by comparing the water surface elevation during existing conditions with the thalweg after excavation has been completed for each section. This represents the most conservative cofferdam height requirements, by assuming the water levels do not lower during construction.

Table B-8.
Summary of Cofferdam Heights

Station Range[a]	Existing Conditions Water Surface Elevation (ft)		Excavation Conditions Thalweg Elevation (ft)	Cofferdam Min. Height (ft)[b]
	2-year storm and tide event	10-year storm and tide event		
8+00 to 9+81	5.0 to 4.6	5.5 to 5.2	2.5 to 2.5	3.5
9+81 to 11+13	4.6 to 3.8	5.2 to 4.9	2.5 to 0.5	5.1
11+13 to 14+75	3.8	4.9	0.5 to -0.5	6.4
14+75 to 22+12	3.8	4.9	-0.5 to -3.0	8.9
22+12 to 26+39	3.8	4.9	-3.0 to -4.0	9.9

Station Range[a]	Existing Conditions Water Surface Elevation (ft)		Excavation Conditions Thalweg Elevation (ft)	Cofferdam Min. Height (ft)[b]
	2-year storm and tide event	10-year storm and tide event		
26+39 to 28+29	3.8	4.9	-4.0 to -7.0	12.9
28+29 to 31+07	3.8	4.9	-7.0 to -5.0	12.9

[a] Stationing based on extent of excavation.
[b] Height is determined by measuring from excavated thalweg elevation to 10-year event elevation with approximately 1 foot of freeboard.

Sediment Mobility Analysis

Adding a suitable streambed substrate is an opportunity for habitat improvement in Cow Pen Creek. Hydraulic modeling results were used to evaluate sediment mobility under existing conditions and complete an assessment of appropriate bed sediment sizes for the non-tidal portion of Cow Pen Creek (Station 0+00 to Station 13+00) to be placed during restoration. The hydraulic model indicates that the main driving factor for shear stress is the stream flow as the tides dampen all velocities in the wider inter-tidal area. The assessment was completed by applying Shield's equation and the stability criteria of Fischenich (2001). Shield's equation was applied to evaluate the threshold of motion grain size in this reach using the 2-year flow at MLLW tide recurrence interval. The threshold of motion calculations were not used specifically to size the streambed mixture but instead to gain insight into sediment transport competency as a cross check for sediment sizing. Results indicate that the threshold channel bed substrate size (for non-cohesive material) under existing conditions is gravel ranging from 24 to 33 mm (0.9 to 1.3 inches).

Sediment sizing for the non-tidal portion of Cow Pen Creek was completed by applying the stability criteria of Fischenich (2001). The median grain size (D_{50}) for the restoration streambed substrate was determined by comparing the hydraulic characteristics for the 2-year flow with the stability criteria referenced above. The 100-year flow hydraulic characteristics were used to identify the largest sediment size of the streambed substrate, representing less than 5 percent of the mixture (D_{95}). Sediment sizing based on these flows and stability criteria were chosen to identify a stable streambed mixture. Anticipated shear stresses and velocities at a 2-year flow in the restoration channel range from 0.2 to 0.8 pounds per square foot (psf) and less than 4 feet per second (ft/sec), respectively. Anticipated shear stresses and velocities in the restoration channel at a 100-year flow are expected to be less than 2.0 psf and 7.5 ft/sec, respectively. These hydraulic characteristics indicate that non-native bed material placed for restoration should consist of a graded mixture of silts to cobble-sized material with a D_{50} of 52 mm (2 inches) and a D_{95} consisting of cobbles with a maximum size of 152 mm (6 inches). This size would promote channel shape to be maintained during 2-year events and below, at a minimum.

Sediment size analyses were also evaluated for the inter-tidal portion of Cow Pen Creek (Station 13+00 to Station 19+00) by applying the stability criteria of Fischenich (2001). Sediment sizing for this portion of the creek utilized the previous hydrodynamic modeling of Dark Head Cove and the downstream portion of Cow Pen Creek (Tetra Tech, 2011). This modeling effort considered two extreme events, a high rainfall event (24-hour, 100-year) associated with a 1.6 foot spring tide level and a strong storm surge (Hurricane Isabella) accompanied by high winds. The resulting bed stresses from hydrodynamic modeling of this event ranged from 0.002 pounds per square foot (psf) to maximum stresses of 0.084 psf at the upstream extent of the inter-tidal area. The highest shear stresses were associated with the high rainfall event and spring tide which is a result that is an agreement with the tidal hydraulics and hydraulic modeling described above. Hydraulic characteristics of the inter-tidal portion of Cow Pen Creek indicate that non-native bed material placed for restoration should consist of a graded mixture of silts to gravel-sized material with D_{50} of 8 mm (0.3 inches) and a D_{95} consisting of gravel with a maximum size of 25 mm (1 inch). The D_{95} estimate is conservative considering the stability criteria of Fischenich (2001) allowing for a considerable factor of safety for sediment stability. Based on the bed stresses from hydrodynamic modeling, the streambed substrate could transition to a graded sand (less than 1 mm) in the downstream portion of the inter-tidal area where shear stresses are lower (Tetra Tech, 2011). The sediment sizing analysis results are summarized in Table B-9.

Table B-9.
Summary of Sediment Sizing Analysis

Location	Station	Median Grain Size (D_{50})		Largest Grain Size (D_{95})	
		Hydraulic Model Conditions for Stability Sizing	D_{50} (mm | inches)	Hydraulic Model Conditions for Sediment Sizing	D_{95} (mm | inches)
Non-tidal	0+00 to 13+00	2-Year	52 | 2	100-Year	152 | 6
Inter-tidal	13+00 to 19+00[a]	100-year associated with a 1.6 foot spring tide	Fine Gravel 8 | 0.3	100-year associated with a 1.6 foot spring tide with conservative factor of safety	25 | 1

[a]Streambed substrate could transition to a graded sand (less than 1 mm) in the downstream portion of the inter-tidal area where shear stresses are lower.

Note that in Table B-9, non-tidal versus inter-tidal division of creek was determined based on the hydraulic model and conservative assumptions for the restoration design. This division may be different than the extent of tidal influence determined at the site during the tidal wetland versus non-tidal wetland delineation work (Tetra Tech, 2011b).

B.5.4 Proposed Model Results

Flow Conditions

In order to evaluate the proposed hydraulic conditions, the same metrics used for the existing conditions were analyzed (see Table B-7). The modeling results in Table B-10 demonstrate that the proposed hydraulic conditions vary only slightly from the existing hydraulic conditions. Both shear stress and average velocity will be reduced in the proposed conditions in non-tidal and inter-tidal areas of the creek where the stream channel will be reconstructed.

After the completion of excavation and backfill, anticipated shear stresses and velocities at a 2-year flow in the restoration channel range from 0.1 to 0.7 pounds per square foot (psf) and less than 3.3 feet per second (ft/sec), respectively. Anticipated shear stresses and velocities in the restoration channel at a 100-year flow are expected to be less than 1.0 psf and 4.3 ft/sec, respectively. These hydraulic conditions confirm that streambed mix sizing and erosion control measures designed existing hydraulic conditions is the conservative approach and expected to be remain stable for the proposed hydraulic conditions.

Table B-10.
Summary of Modeled Proposed Hydraulic Characteristics

Modeled Event	Station	Maximum Depth	Average Velocity	Shear Stress
		ft	ft/sec	psf
Bankfull Event, MLLW	8+21	1.0	1.2	0.2
	9+24	1.1	0.9	0.1
	11+25	0.9	0.8	0.1
	12+21	0.7	1.5	0.1
	13+12	0.5	2.6	0.5
	14+30	0.7	0.9	0.0
2-Year Storm Event, MLLW	8+21	1.7	1.8	0.4
	9+24	1.7	1.5	0.3
	11+25	1.5	1.4	0.2
	12+21	1.2	2.5	0.3
	13+12	0.7	3.3	0.7
	14+30	1.1	1.4	0.1
10-Year Storm Event, MLLW	8+21	2.0	2.1	0.4
	9+24	2.0	1.9	0.4
	11+25	1.8	1.7	0.3
	12+21	1.3	3.1	0.4
	13+12	0.9	3.4	0.6
	14+30	1.3	1.7	0.1
100-Year Storm Event, MLLW	8+21	2.4	2.3	0.5
	9+24	2.4	2.4	0.6
	11+25	2.3	2.2	0.4
	12+21	1.5	4.3	0.7
	13+12	1.2	3.6	0.6
	14+30	1.6	2.3	0.2

B.6 REFERENCES

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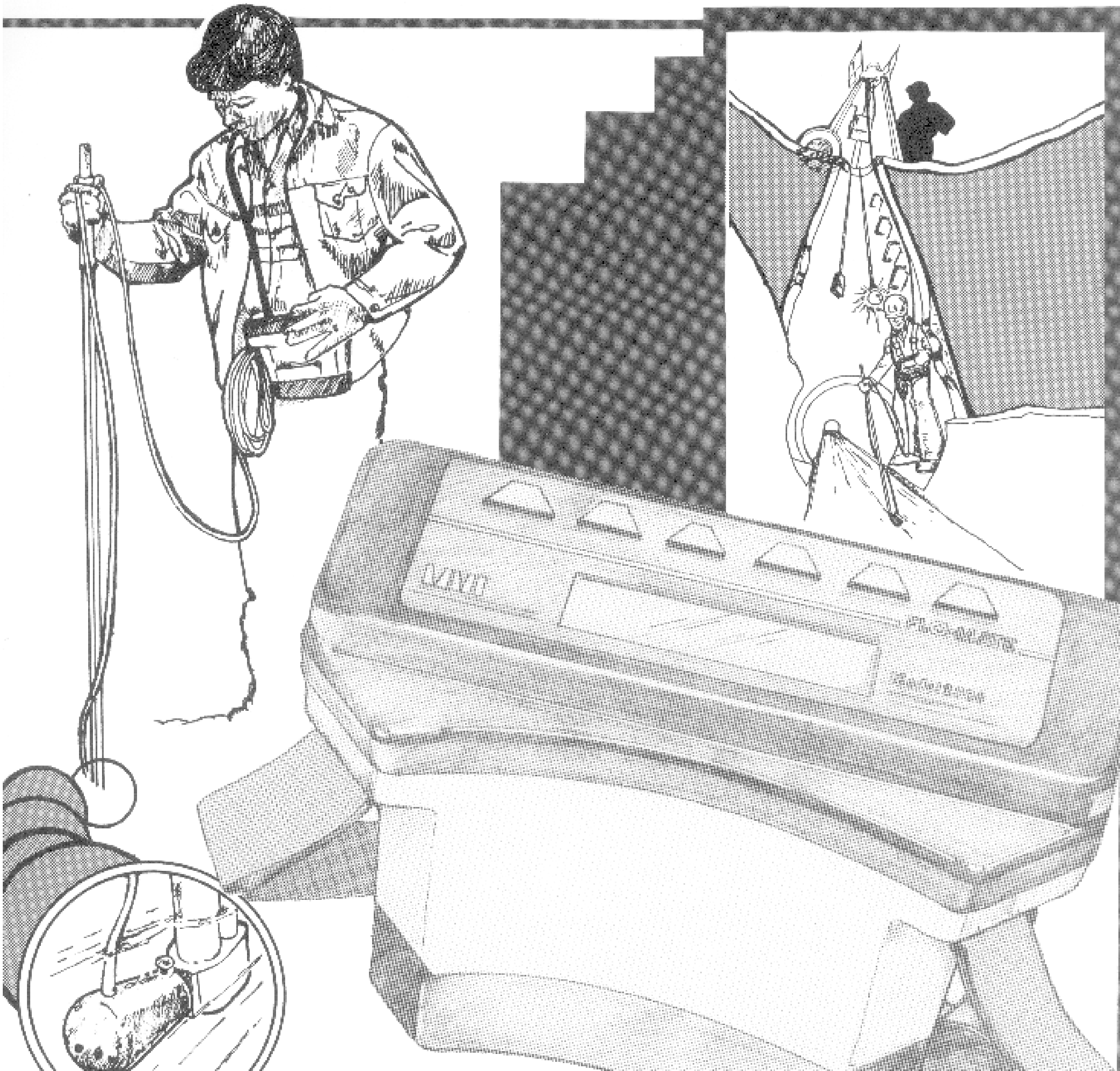
ATTACHMENT 1

Field Equipment Manufacturer’s Data Sheets



MARSH-McBIRNEY, INC.

FLO-MATE™

MODEL 2000 PORTABLE FLOWMETER
INSTRUCTION MANUAL

SPECIFICATIONS

Velocity Measurement

Method
Electromagnetic

Zero Stability
± 0.05 ft/sec

Accuracy
± 2% of reading + zero stability

Range
-0.5 to +19.99 ft/sec
-0.15 m/sec to +6 m/sec

Power Requirements

Batteries
Two D Cells

Battery Life Continuous ON hours
Alkaline 25-30
NiCad 10-15 per charge

External Power Supply (Optional)
120 V, 1 W or 220 V, 1 W

Water Resistant Electronic Case

Submersible
One Foot for 30 Seconds

Outputs

Display
3½ Digit

Signal Output Connector (Optional)
Analog 0.1 V = 1 ft/sec or 1 m/sec
2 V = Full Scale

Materials

Sensor
Polyurethane

Cable
Polyurethane jacket

Electronic Case
High Impact Molded Plastic

Weight

3 lb 9 oz with case and 20 ft of cable

2 lb 10 oz without sensor and cable

Temperature

Open-Channel-Velocity Sensor
32° F to 160° F (0° C to 72° C)

Full-Pipe Sensor (S/S Insertion Tube)
32° F to 160° F (0° C to 72° C) @ 250 psi

Electronics
32° F to 122° F (0° C to 50° C)

HOBO® U20 Water Level Logger (U20-001-0x and U20-001-0x-Ti) Manual

The HOBO U20 Water Level Logger is used for monitoring changing water levels in a wide range of applications including streams, lakes, wetlands, tidal areas, and groundwater. The loggers are typically deployed in existing wells or stilling wells installed specifically for deploying the loggers. This logger features high accuracy at a great price and HOBO ease-of-use, with no cumbersome vent tubes or desiccants to maintain.

The logger uses a maintenance-free absolute pressure sensor and features a durable stainless steel or titanium housing (depending on model) and ceramic pressure sensor. The HOBO Water Level Titanium is recommended for saltwater deployment for recording water levels and temperatures in wetlands and tidal areas. The logger uses precision electronics to measure absolute pressure and temperature and has enough memory to record over 21,700 combined pressure and temperature measurements.

HOBO Water Level Logger

Models:

- U20-001-01 (30-foot depth) and U20-001-01-Ti (30-foot depth/Titanium)
- U20-001-02 (100-foot depth) and U20-001-02-Ti (100-foot depth/Titanium)
- U20-001-03 (250-foot depth) and U20-001-03-Ti (250-foot depth/Titanium)
- U20-001-04 (13-foot depth) and U20-001-04-Ti (13-foot depth/Titanium)

Required Items:

- Coupler (COUPLER-2-B) with USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1)
- HOBOware® Pro

Accessories:

- Cable (CABLE-1-300 or CABLE-1-50) and Cable Crimp (CABLE-1-CRIMP)
- Replacement Coupler (COUPLER2-B)

Specifications

Pressure (Absolute) and Water Level Measurements U20-001-01 and U20-001-01-Ti

Operation Range	0 to 207 kPa (0 to 30 psia); approximately 0 to 9 m (0 to 30 ft) of water depth at sea level, or 0 to 12 m (0 to 40 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 207 kPa (10 to 30 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	310 kPa (45 psia) or 18 m (60 ft) depth
Water Level Accuracy*	Typical error: ±0.05% FS, 0.5 cm (0.015 ft) water Maximum error: ±0.1% FS, 1.0 cm (0.03 ft) water
Raw Pressure Accuracy**	±0.3% FS, 0.62 kPa (0.09 psi) maximum error
Resolution	<0.02 kPa (0.003 psi), 0.21 cm (0.007 ft) water
Pressure Response Time (90%)***	<1 second; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20-001-02 and U20-001-02-Ti

Operation Range	0 to 400 kPa (0 to 58 psia); approximately 0 to 30.6 m (0 to 100 ft) of water depth at sea level, or 0 to 33.6 m (0 to 111 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 400 kPa (10 to 58 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	500 kPa (72.5 psia) or 40.8 m (134 ft) depth
Water Level Accuracy*	Typical error: ±0.05% FS, 1.5 cm (0.05 ft) water Maximum error: ±0.1% FS, 3 cm (0.1 ft) water
Raw Pressure Accuracy**	±0.3% FS, 1.20 kPa (0.17 psi) maximum error
Resolution	<0.04 kPa (0.006 psi), 0.41 cm (0.013 ft) water
Pressure Response Time (90%)***	<1 second; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20-001-03 and U20-001-03-Ti

Operation Range	0 to 850 kPa (0 to 123.3 psia); approximately 0 to 76.5 m (0 to 251 ft) of water depth at sea level, or 0 to 79.5 m (0 to 262 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 850 kPa (10 to 123.3 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	1200 kPa (174 psia) or 112 m (368 ft) depth
Water Level Accuracy*	Typical error: ±0.05% FS, 3.8 cm (0.125 ft) water Maximum error: ±0.1% FS, 7.6 cm (0.25 ft) water
Raw Pressure Accuracy**	±0.3% FS, 2.55 kPa (0.37 psi) maximum error

Specifications (continued)

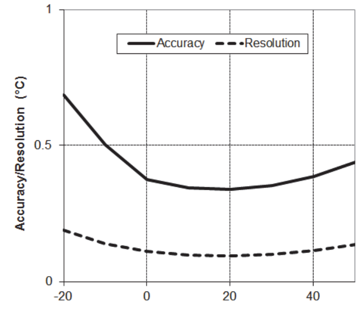
Pressure (Absolute) and Water Level Measurements U20-001-03 and U20-001-03-Ti (continued)	
Resolution	<0.085 kPa (0.012 psi), 0.87 cm (0.028 ft) water
Pressure Response Time (90%)* **	<1 second; measurement accuracy also depends on temperature response time
Pressure (Absolute) and Water Level Measurements U20-001-04 and U20-001-04-Ti	
Operation Range	0 to 145 kPa (0 to 21 psia); approximately 0 to 4 m (0 to 13 ft) of water depth at sea level, or 0 to 7 m (0 to 23 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 145 kPa (10 to 21 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	310 kPa (45 psia) or 18 m (60 ft) depth
Water Level Accuracy*	Typical error: ±0.075% FS, 0.3 cm (0.01 ft) water Maximum error: ±0.15% FS, 0.6 cm (0.02 ft) water
Raw Pressure Accuracy**	±0.3% FS, 0.43 kPa (0.063 psi) maximum error
Resolution	<0.014 kPa (0.002 psi), 0.14 cm (0.005 ft) water
Pressure Response Time (90%)***	<1 second; measurement accuracy also depends on temperature response time
Temperature Measurements (All Models)	
Operation Range	-20° to 50°C (-4° to 122°F)
Accuracy	±0.44°C from 0° to 50°C (±0.79°F from 32° to 122°F), see Plot A
Resolution	0.10°C at 25°C (0.18°F at 77°F), see Plot A
Response Time (90%)	5 minutes in water (typical)
Stability (Drift)	0.1°C (0.18°F) per year
Logger	
Real-time Clock	± 1 minute per month 0° to 50°C (32° to 122°F)
Battery	2/3 AA, 3.6 Volt lithium, factory-replaceable
Battery Life (Typical Use)	5 years with 1 minute or greater logging interval
Memory (Non-volatile)	64K bytes memory (approx. 21,700 pressure and temperature samples)
Weight	Stainless steel models: approximately 210 g (7.4 oz) Titanium models: approximately 140 g (4.8 oz)
Dimensions	2.46 cm (0.97 inches) diameter, 15 cm (5.9 inches) length; mounting hole 6.3 mm (0.25 inches) diameter
Wetted Materials	Stainless Steel models: 316 stainless steel, Viton® o-rings, acetyl cap, ceramic sensor Titanium models: Titanium, Viton o-rings, acetyl cap, ceramic sensor
Logging Interval	Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to the HOBOware software manual.
Launch Modes	Immediate start and delayed start
Offload Modes	Offload while logging; stop and offload
Battery Indication	Battery voltage can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

* Water Level Accuracy: With accurate reference water level measurement, known water density, accurate Barometric Compensation Assistant data, and a stable temperature environment.

** Raw Pressure Accuracy: Absolute pressure sensor accuracy includes all sensor drift, temperature, and hysteresis-induced errors.

*** Changes in Temperature: Allow 10 minutes in water to achieve full temperature compensation of the pressure sensor. Maximum error due to rapid thermal changes is approximately 0.5%.

Plot A



HOBO® U20L Water Level Logger (U20L-0x) Manual

The HOBO U20L Water Level Logger is used for monitoring changing water levels in a wide range of applications, including streams, lakes, wetlands, tidal areas, and groundwater. Using HOBOware® Pro, you can easily configure this logger to record absolute pressure and temperature data. This logger features a ceramic pressure sensor, durable housing, and a protective end cap for deployment in existing wells or stilling wells. Without cumbersome vent tubes or desiccants to maintain, this easy-to-use logger is an ideal solution for water level studies and research.

HOBO Water Level Logger

Models:

- U20L-01 (30-foot depth)
- U20L-02 (100-foot depth)
- U20L-04 (13-foot depth)

Required Items:

- Coupler (COUPLER2-C) with USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1, firmware version 3.2.0 or later)*
- HOBOware® Pro, version 3.5 or higher

Accessories:

- Cable (CABLE-1-300 or CABLE-1-50) and Cable Crimp (CABLE-1-CRIMP)
- Replacement Coupler (COUPLER2-C)

**If shuttle firmware version 3.2.0 or later is needed, see the Onset website or contact Onset Technical Support.*

Specifications

Pressure (Absolute) and Water Level Measurements U20L-01

Operation Range	0 to 207 kPa (0 to 30 psia); approximately 0 to 9 m (0 to 30 ft) of water depth at sea level, or 0 to 12 m (0 to 40 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 207 kPa (10 to 30 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	310 kPa (45 psia) or 18 m (60 ft) depth
Water Level Accuracy*	Typical error: ±0.1% FS, 1.0 cm (0.03 ft) water Maximum error: ±0.2% FS, 2.0 cm (0.06 ft) water
Raw Pressure Accuracy**	±0.3% FS, 0.62 kPa (0.09 psi) maximum error
Resolution	<0.02 kPa (0.003 psi), 0.21 cm (0.007 ft) water
Pressure Response Time (90%)***	<1 second at a stable temperature; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20L-02

Operation Range	0 to 400 kPa (0 to 58 psia); approximately 0 to 30.6 m (0 to 100 ft) of water depth at sea level, or 0 to 33.6 m (0 to 111 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 400 kPa (10 to 58 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	500 kPa (72.5 psia) or 40.8 m (134 ft) depth
Water Level Accuracy*	Typical error: ±0.1% FS, 3.0 cm (0.1 ft) water Maximum error: ±0.2% FS, 6.0 cm (0.2 ft) water
Raw Pressure Accuracy**	±0.3% FS, 1.20 kPa (0.17 psi) maximum error
Resolution	<0.04 kPa (0.006 psi), 0.41 cm (0.013 ft) water
Pressure Response Time (90%)***	<1 second at a stable temperature; measurement accuracy also depends on temperature response time

Pressure (Absolute) and Water Level Measurements U20L-04

Operation Range	0 to 145 kPa (0 to 21 psia); approximately 0 to 4 m (0 to 13 ft) of water depth at sea level, or 0 to 7 m (0 to 23 ft) of water at 3,000 m (10,000 ft) of altitude
Factory Calibrated Range	69 to 145 kPa (10 to 21 psia), 0° to 40°C (32° to 104°F)
Burst Pressure	310 kPa (45 psia) or 18 m (60 ft) depth
Water Level Accuracy*	Typical error: ±0.1% FS, 0.4 cm (0.013 ft) water Maximum error: ±0.2% FS, 0.8 cm (0.026 ft) water
Raw Pressure Accuracy**	±0.3% FS, 0.43 kPa (0.063 psi) maximum error
Resolution	<0.014 kPa (0.002 psi), 0.14 cm (0.005 ft) water
Pressure Response Time (90%)***	<1 second at a stable temperature; measurement accuracy also depends on temperature response time

Specifications (continued)

Temperature Measurements (All Models)

Operation Range	-20° to 50°C (-4° to 122°F)
Accuracy	±0.44°C from 0° to 50°C (±0.79°F from 32° to 122°F), see Plot A
Resolution	0.10°C at 25°C (0.18°F at 77°F), see Plot A
Response Time (90%)	10 minutes in water (typical)
Stability (Drift)	0.1°C (0.18°F) per year

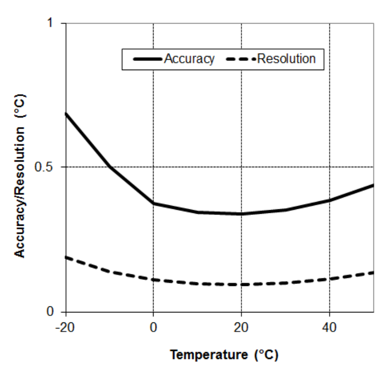
Logger

Real-time Clock	±1 minute per month 0° to 50°C (32° to 122°F)
Battery	2/3 AA, 3.6 Volt lithium, factory-replaceable
Battery Life (Typical Use)	5 years with 1 minute or greater logging interval
Memory (Non-volatile)	64K bytes memory (approx. 21,700 pressure and temperature samples)
Weight	Approximately 154 g (5.43 oz) in air Approximately 53.9 g (1.9 oz) in fresh water
Dimensions	3.18 cm (1.25 inches) diameter, 15.24 cm (6.0 inches) length; mounting hole 6.3 mm (0.25 inches) diameter
Wetted Materials	Polypropylene housing and lanyard; Viton and Buna-N O-rings; ceramic sensor in acetyl end cap; stainless steel screws suitable for saltwater
Logging Interval	Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to the *HOBOware User's Guide* for details.
Launch Modes	Immediate start and delayed start
Offload Modes	Offload while logging; stop and offload
Battery Indication	Battery voltage can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

* Water Level Accuracy: With accurate reference water level measurement, known water density, accurate Barometric Compensation Assistant data, and a stable temperature environment.

** Raw Pressure Accuracy: Absolute pressure sensor accuracy includes all sensor drift, temperature, and hysteresis-induced errors.

*** Changes in Temperature: Allow 20 minutes in water to achieve full temperature compensation of the pressure sensor. Maximum error due to rapid thermal changes is approximately 0.5%.



Plot A

ATTACHMENT 2

Floodplain Soil Sample Grain Size Analysis

Particle Size of Soils by ASTM D422

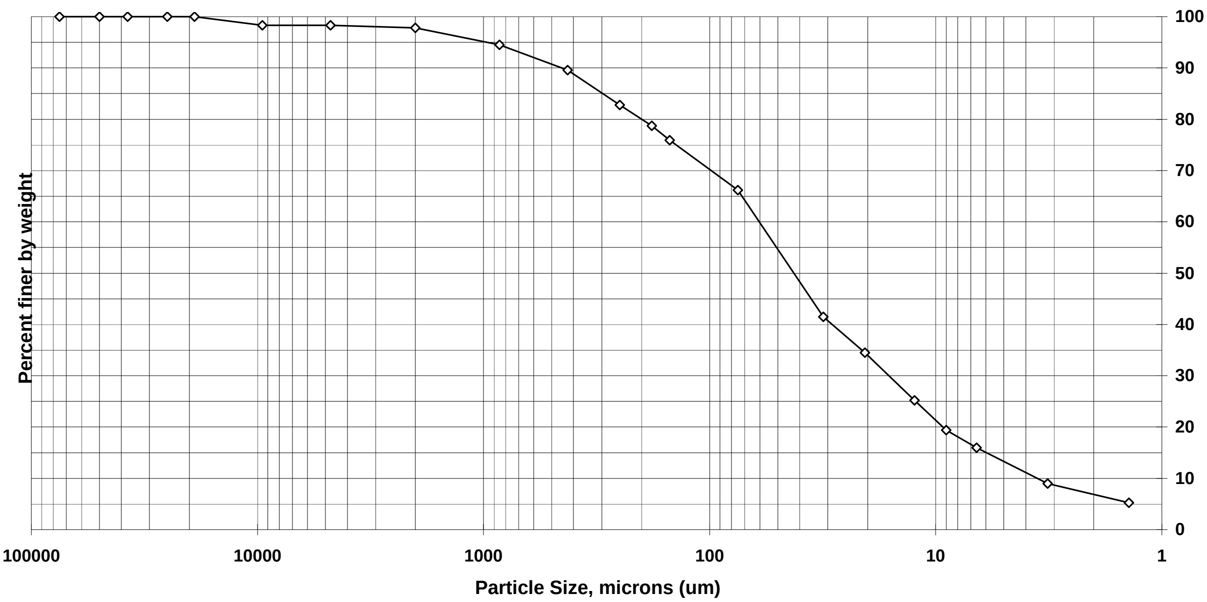
Sample ID: S1
Lab ID: 240-46383-A-1

Percent Solids: 57.5%
Specific Gravity: 2.650

Date Received: 1/16/2015
Start Date: 1/19/2015
End Date: 1/22/2015

Shape (> #10): subangular

Non-soil material: plant
Hardness (> #10): hard



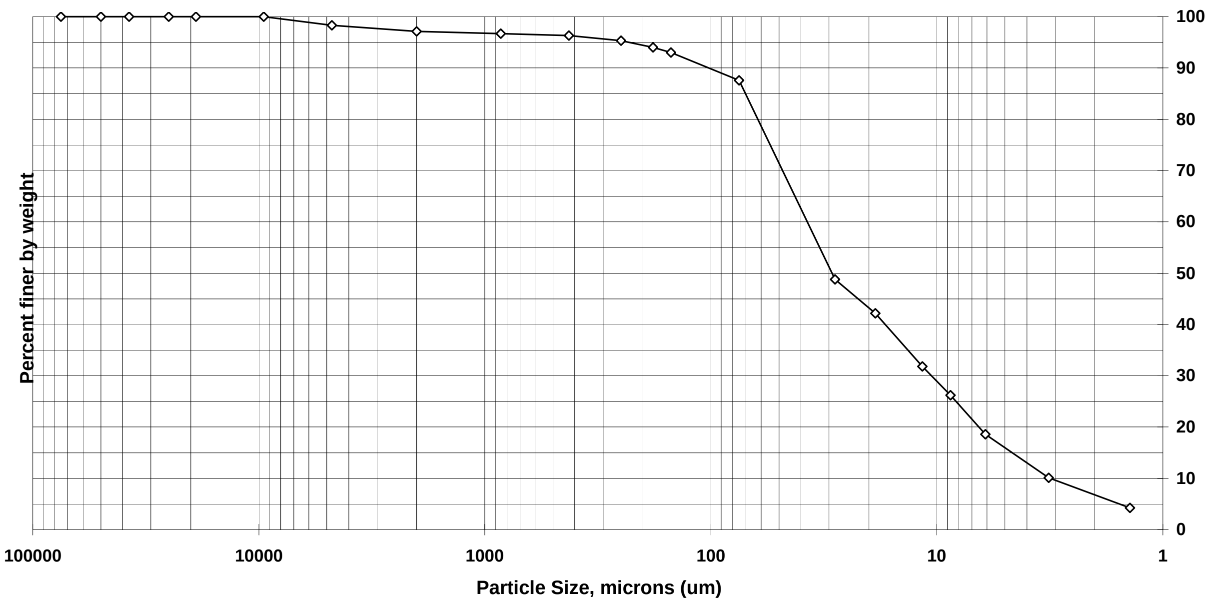
Sieve size	Particle size, um	Percent finer	Incremental percent
3 inch	75000	100.0	0.0
2 inch	50000	100.0	0.0
1.5 inch	37500	100.0	0.0
1 inch	25000	100.0	0.0
3/4 inch	19000	100.0	0.0
3/8 inch	9500	98.3	1.7
#4	4750	98.3	0.0
#10	2000	97.8	0.5
#20	850	94.5	3.3
#40	425	89.6	4.9
#60	250	82.8	6.8
#80	180	78.7	4.1
#100	150	75.9	2.8
#200	75	66.2	9.7
Hyd1	31.4	41.5	24.7
Hyd2	20.6	34.5	7.0
Hyd3	12.4	25.2	9.3
Hyd4	9	19.4	5.8
Hyd5	6.6	16.0	3.4
Hyd6	3.2	9.0	7.0
Hyd7	1.4	5.2	3.8

Soil Classification	Percent of sample
Gravel	1.7
Sand	32.1
Coarse Sand	0.5
Medium Sand	8.2
Fine Sand	23.4
Silt	50.2
Clay	16.0

Particle Size of Soils by ASTM D422

Date Received: 1/16/2015
Sample ID: S2 **Percent Solids:** 43.9% **Start Date:** 1/19/2015
Lab ID: 240-46383-A-3 **Specific Gravity:** 2.650 **End Date:** 1/22/2015

Shape (> #10): n/a **Non-soil material:** plant
Hardness (> #10): n/a



Sieve size	Particle size, um	Percent finer	Incremental percent
3 inch	75000	100.0	0.0
2 inch	50000	100.0	0.0
1.5 inch	37500	100.0	0.0
1 inch	25000	100.0	0.0
3/4 inch	19000	100.0	0.0
3/8 inch	9500	100.0	0.0
#4	4750	98.3	1.7
#10	2000	97.1	1.2
#20	850	96.7	0.4
#40	425	96.3	0.4
#60	250	95.3	1.0
#80	180	94.0	1.3
#100	150	93.0	1.0
#200	75	87.6	5.4
Hyd1	28.2	48.8	38.8
Hyd2	18.7	42.2	6.6
Hyd3	11.6	31.8	10.4
Hyd4	8.7	26.2	5.6
Hyd5	6.1	18.6	7.6
Hyd6	3.2	10.1	8.5
Hyd7	1.4	4.3	5.8

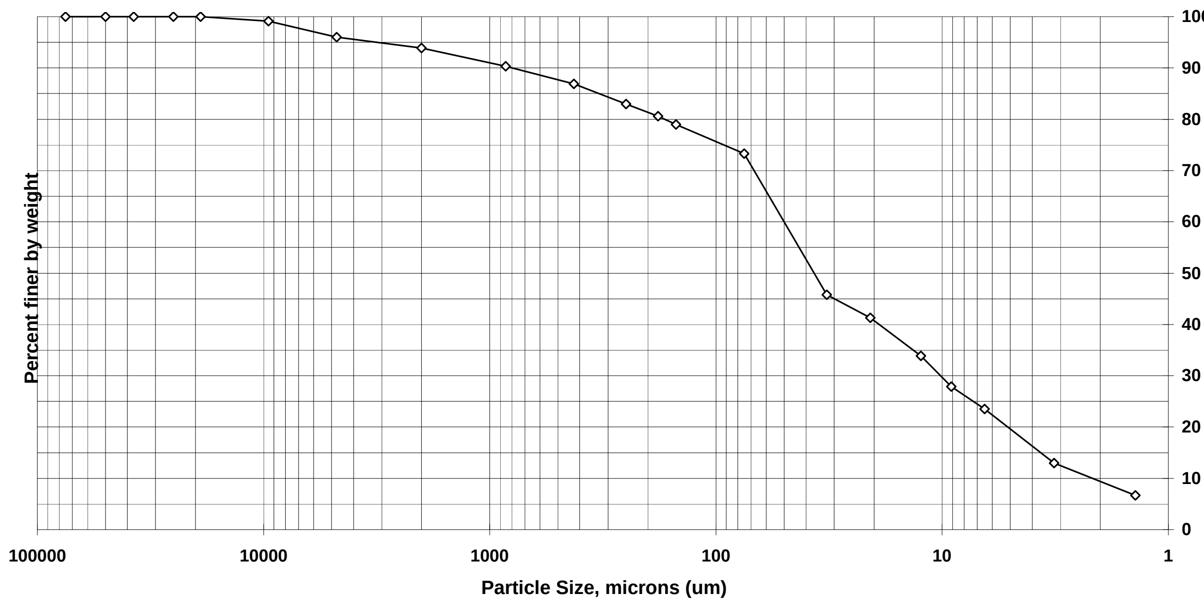
Soil Classification	Percent of sample
Gravel	1.7
Sand	10.7
Coarse Sand	1.2
Medium Sand	0.8
Fine Sand	8.7
Silt	69.0
Clay	18.6

Particle Size of Soils by ASTM D422

				Date Received:	1/16/2015
Sample ID:	S3	**Percent Solids:**	34.0%	**Start Date:**	1/19/2015
Lab ID:	240-46383-A-2	**Specific Gravity:**	2.650	**End Date:**	1/22/2015

Shape (> #10): n/a

Non-soil material: plant
Hardness (> #10): n/a



Sieve size	Particle size, um	Percent finer	Incremental percent
3 inch	75000	100.0	0.0
2 inch	50000	100.0	0.0
1.5 inch	37500	100.0	0.0
1 inch	25000	100.0	0.0
3/4 inch	19000	100.0	0.0
3/8 inch	9500	99.1	0.9
#4	4750	96.0	3.1
#10	2000	93.9	2.1
#20	850	90.3	3.6
#40	425	86.9	3.4
#60	250	83.0	3.9
#80	180	80.6	2.4
#100	150	79.0	1.6
#200	75	73.3	5.7
Hyd1	32.4	45.8	27.5
Hyd2	20.8	41.3	4.5
Hyd3	12.4	33.9	7.4
Hyd4	9.1	27.9	6.0
Hyd5	6.5	23.5	4.4
Hyd6	3.2	13.0	10.5
Hyd7	1.4	6.7	6.3

Soil Classification	Percent of sample
Gravel	4.0
Sand	22.7
Coarse Sand	2.1
Medium Sand	7.0
Fine Sand	13.6
Silt	49.8
Clay	23.5

ATTACHMENT 3

Hydraulic Modeling Results

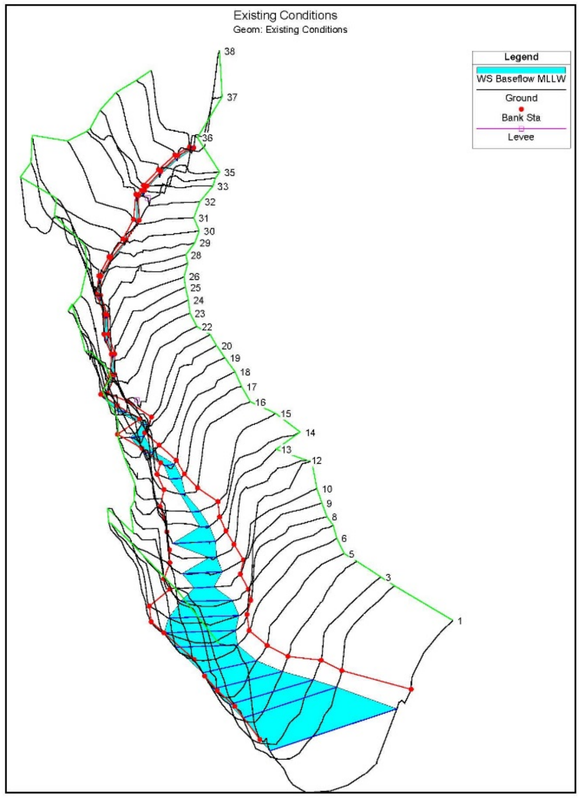


Figure A3-1. Existing Conditions Plan: Baseflow – MLLW Tide

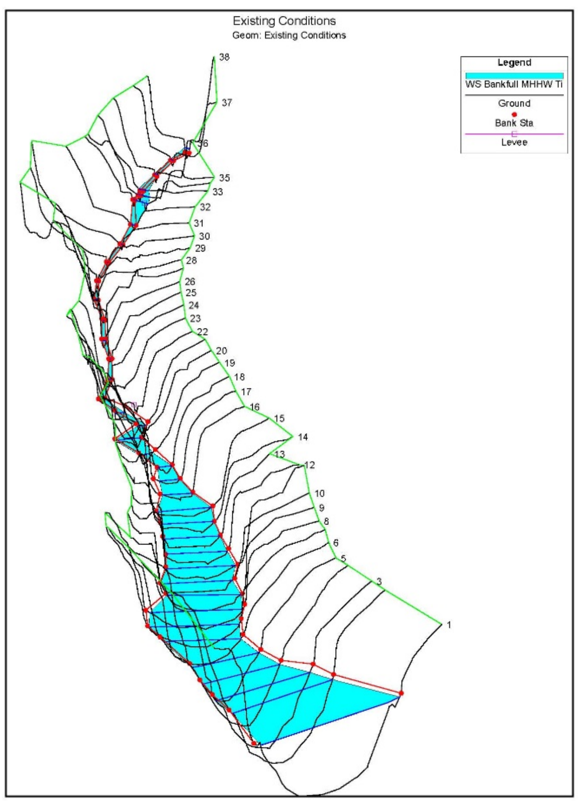


Figure A3-2. Existing Conditions Plan: Bankfull – MHHW Tide

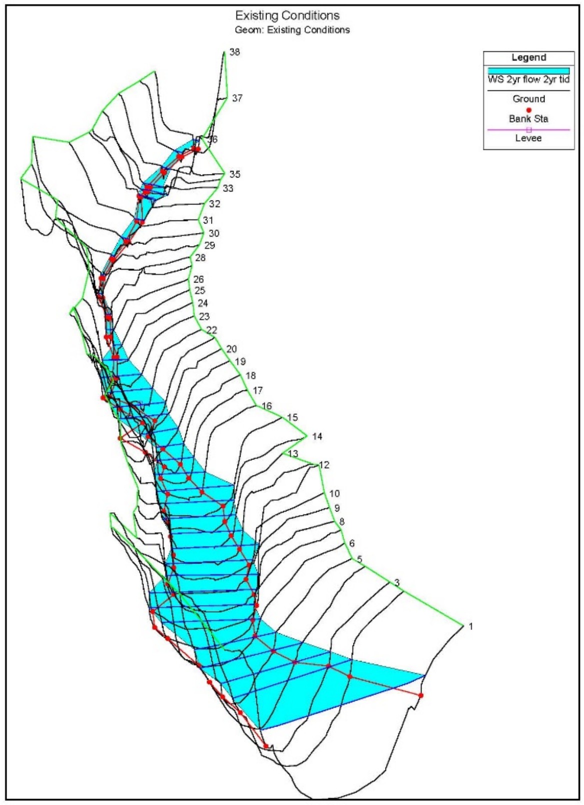


Figure A3-3. Existing Conditions Plan: 2 year flow – 2 year tide

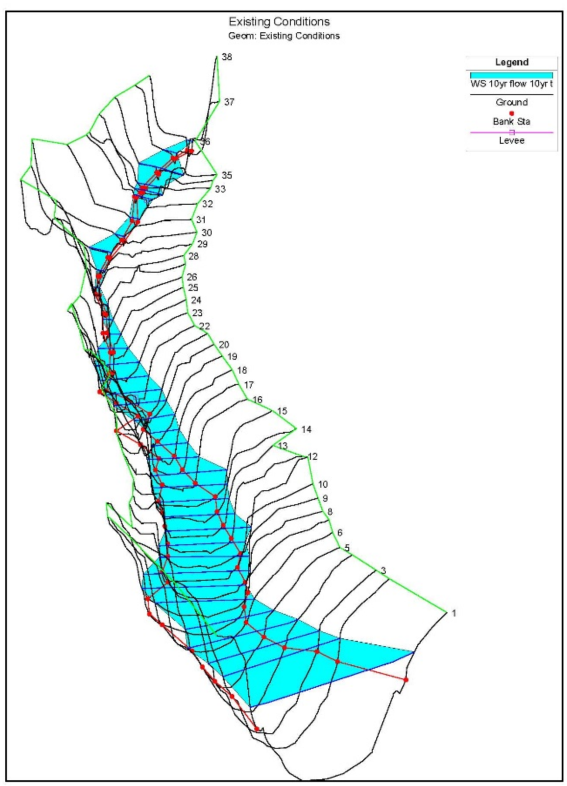


Figure A3-4. Existing Conditions Plan: 10 year flow – 10 year tide

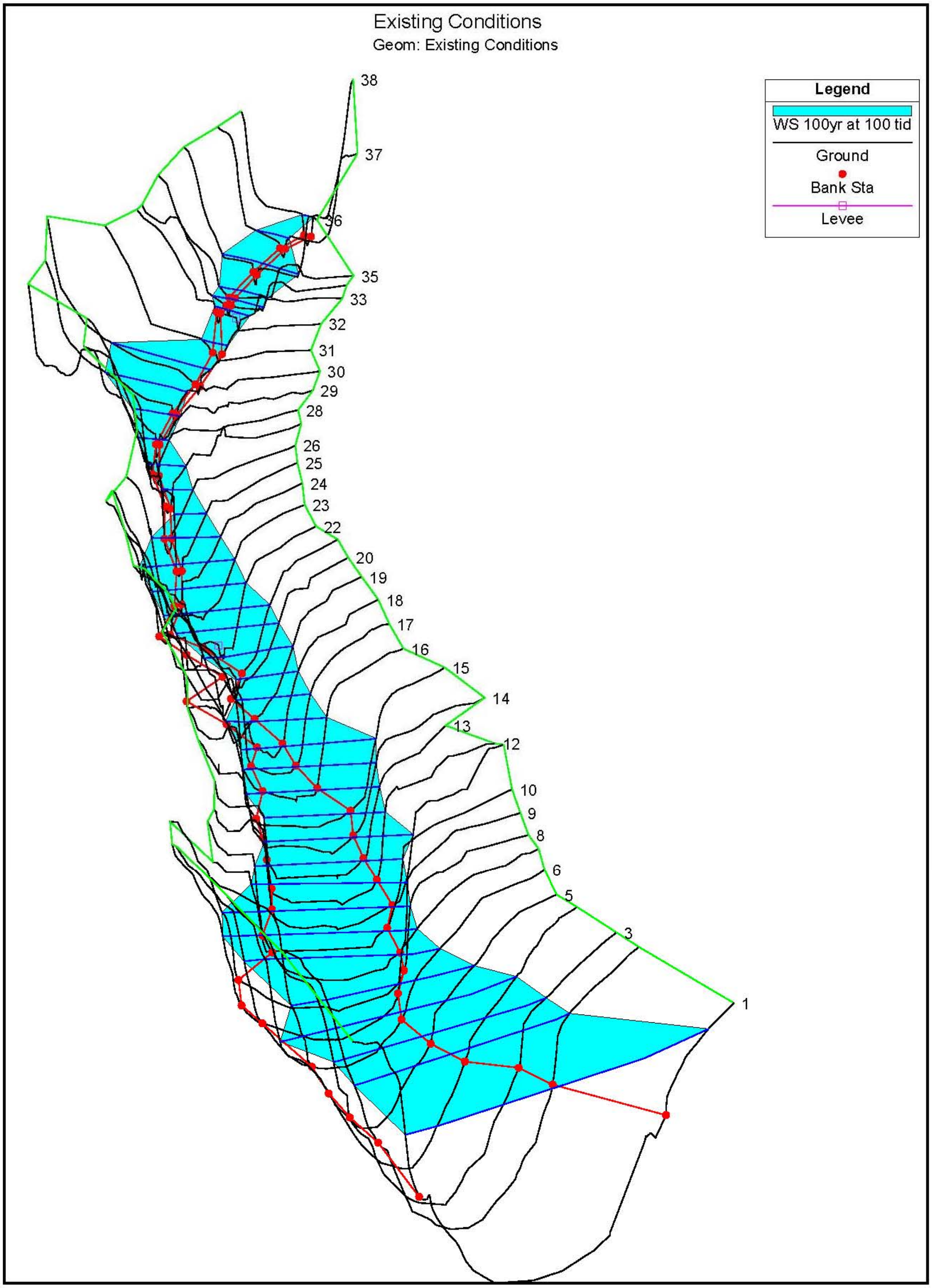


Figure A3-5. Existing Conditions Plan: 100 year flow – 100 year tide

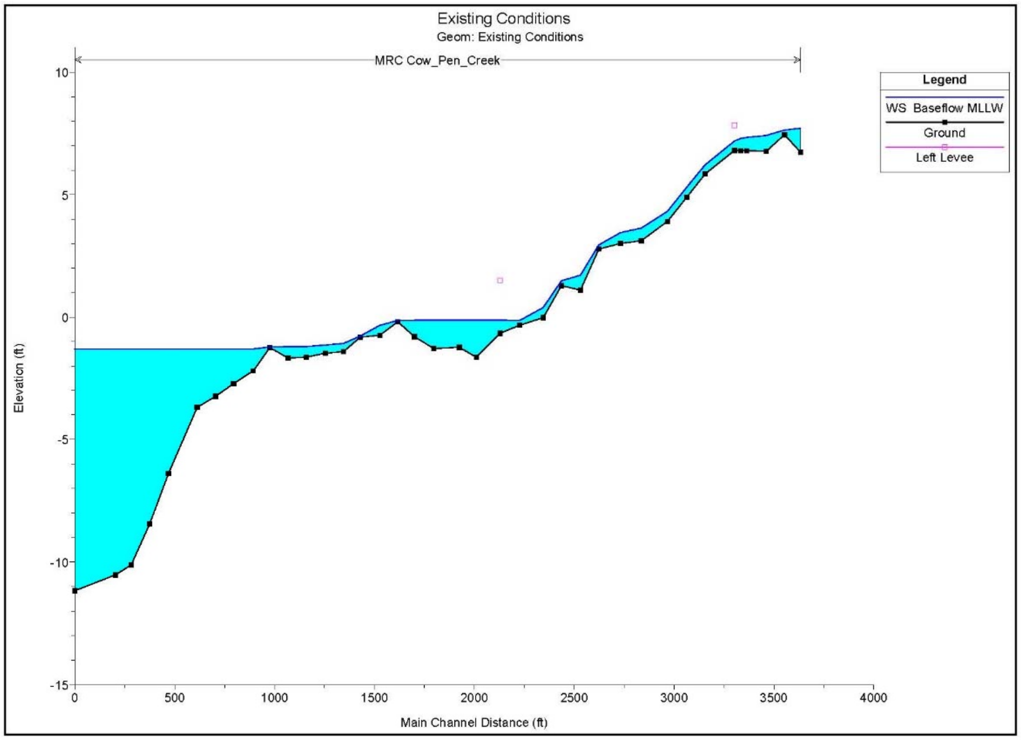


Figure A3-6. Existing Conditions Profile: Baseflow – MLLW tide

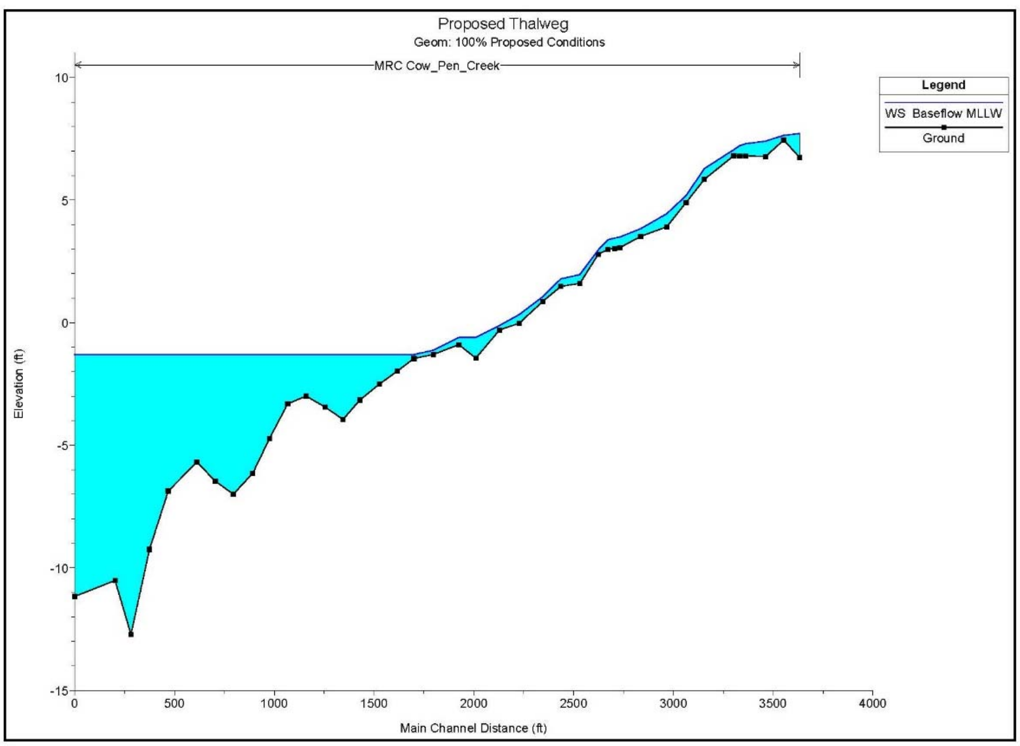


Figure A3-7. Proposed Conditions Profile: Baseflow – MLLW tide

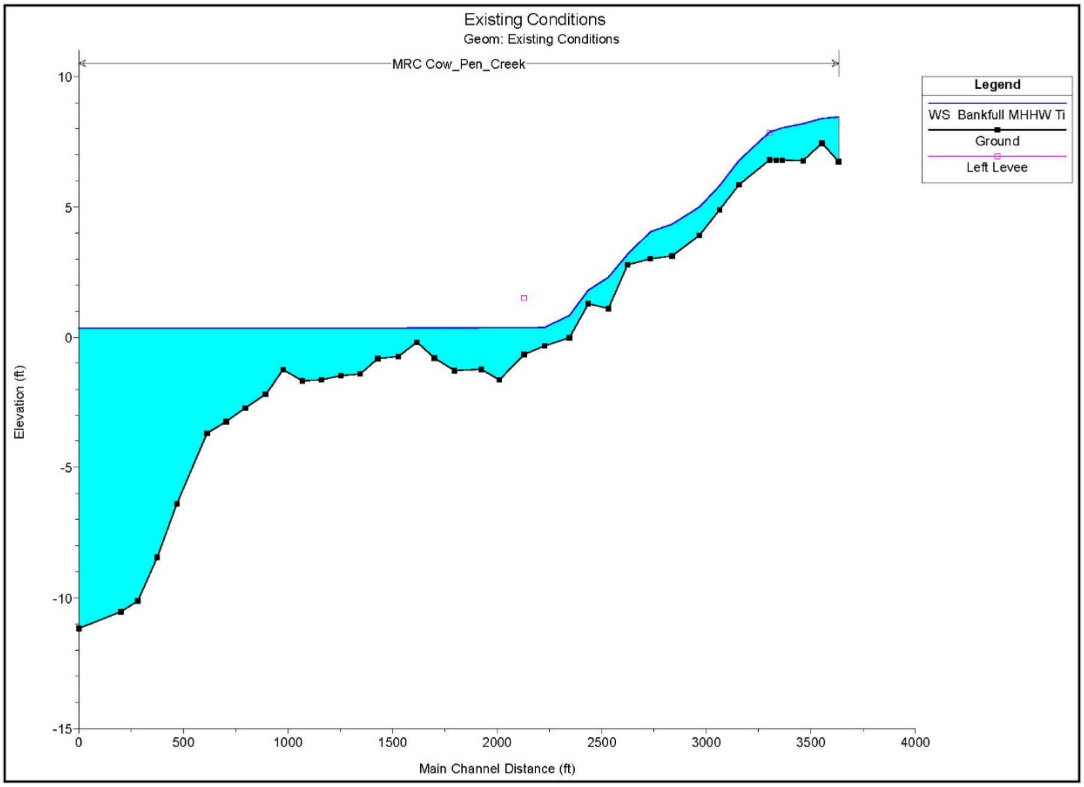


Figure A3-8. Existing Conditions Profile: Bankfull flow – MHHW tide

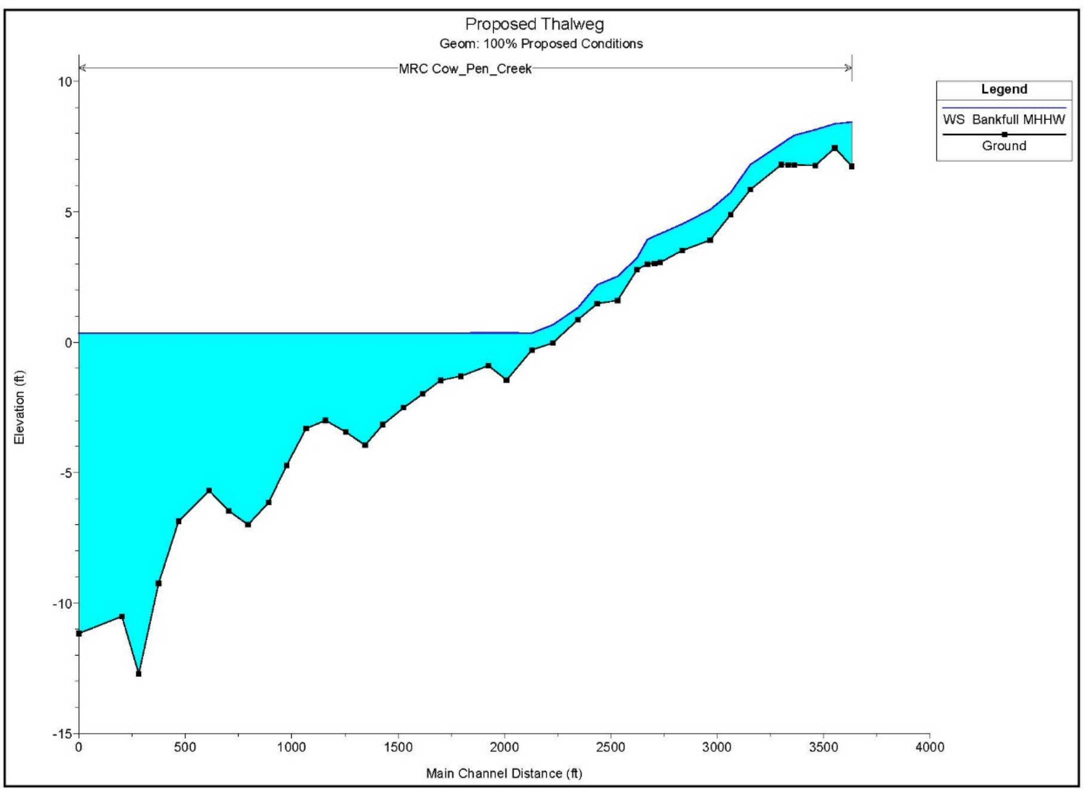


Figure A3-9. Proposed Conditions Profile: Bankfull flow – MHHW tide

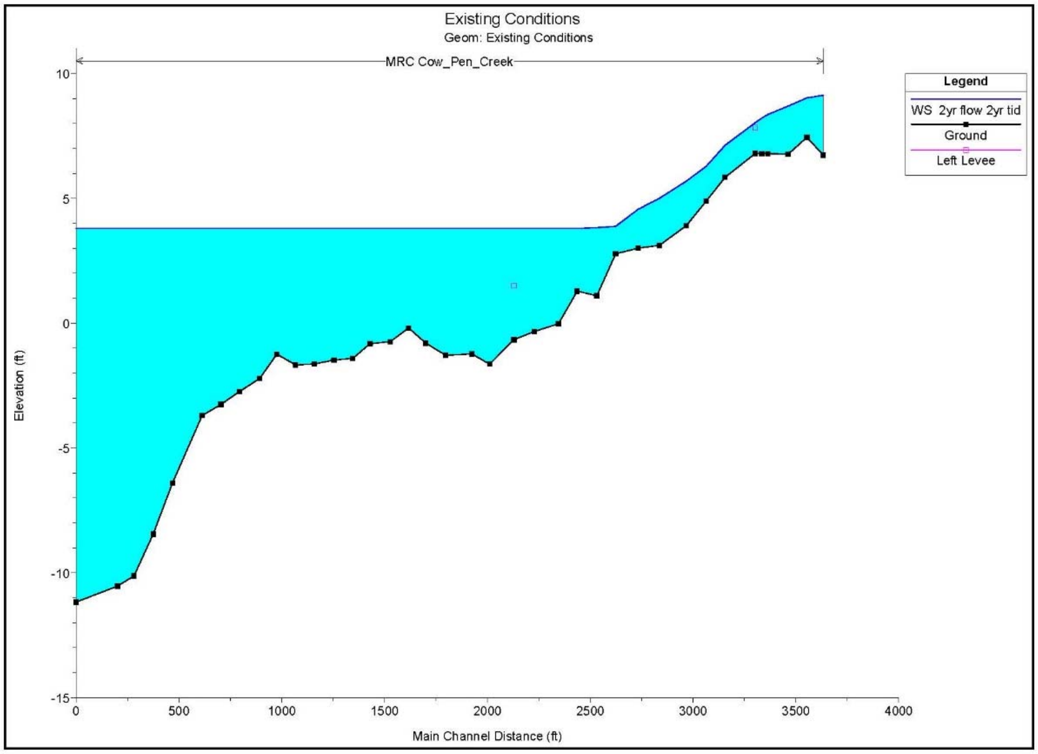


Figure A3-10. Existing Conditions Profile: 2-year flow – 2-year tide

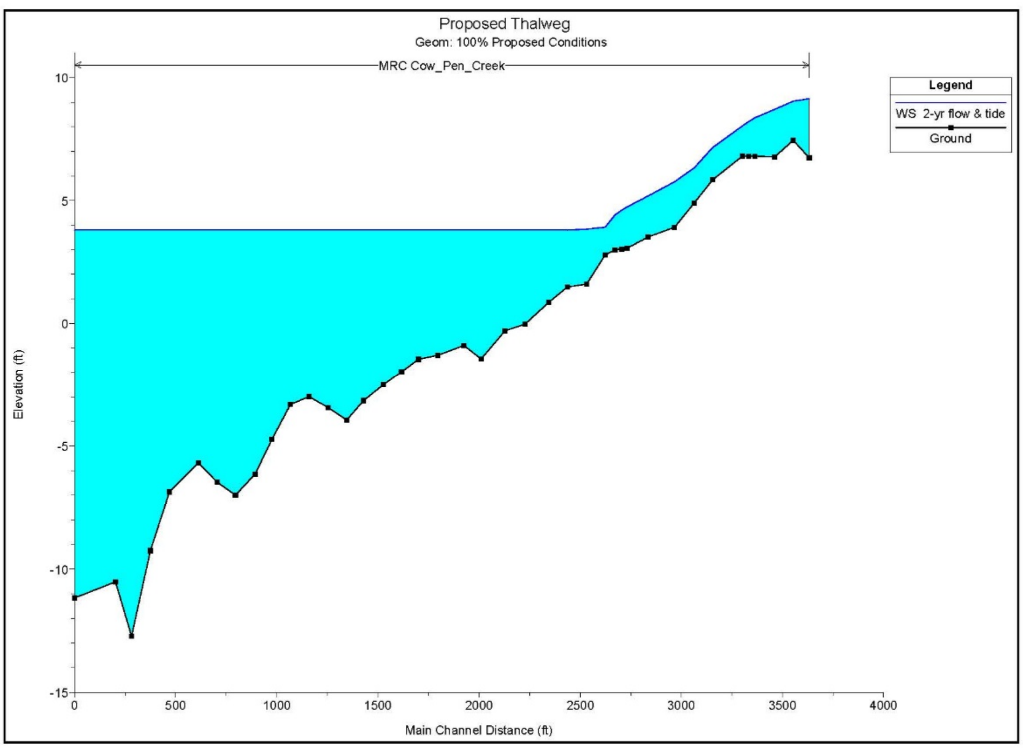


Figure A3-11. Proposed Conditions Profile: 2-year flow – 2-year tide

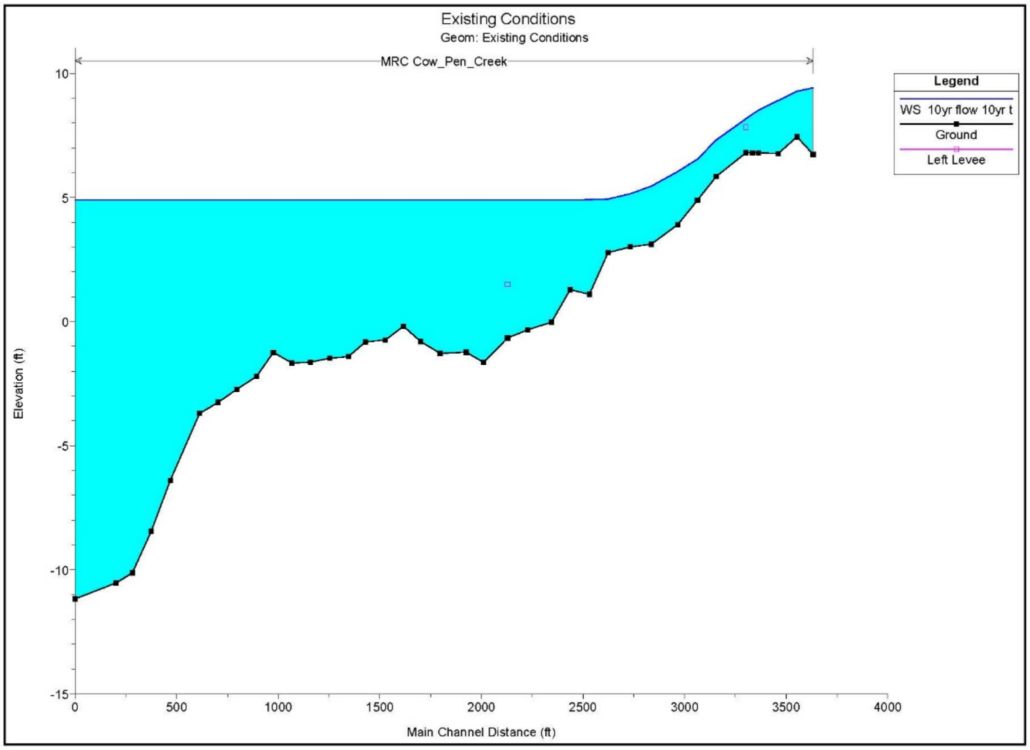


Figure A3-12. Existing Conditions Profile: 10-year flow – 10-year tide

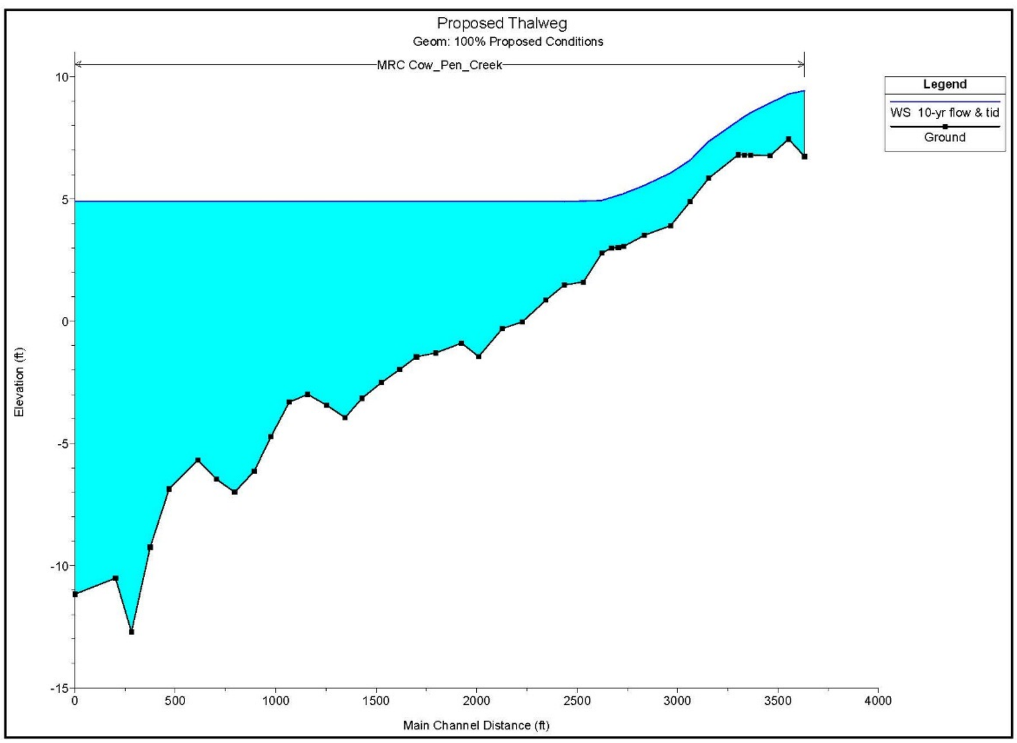


Figure A3-13. Proposed Conditions Profile: 10-year flow – 10-year tide

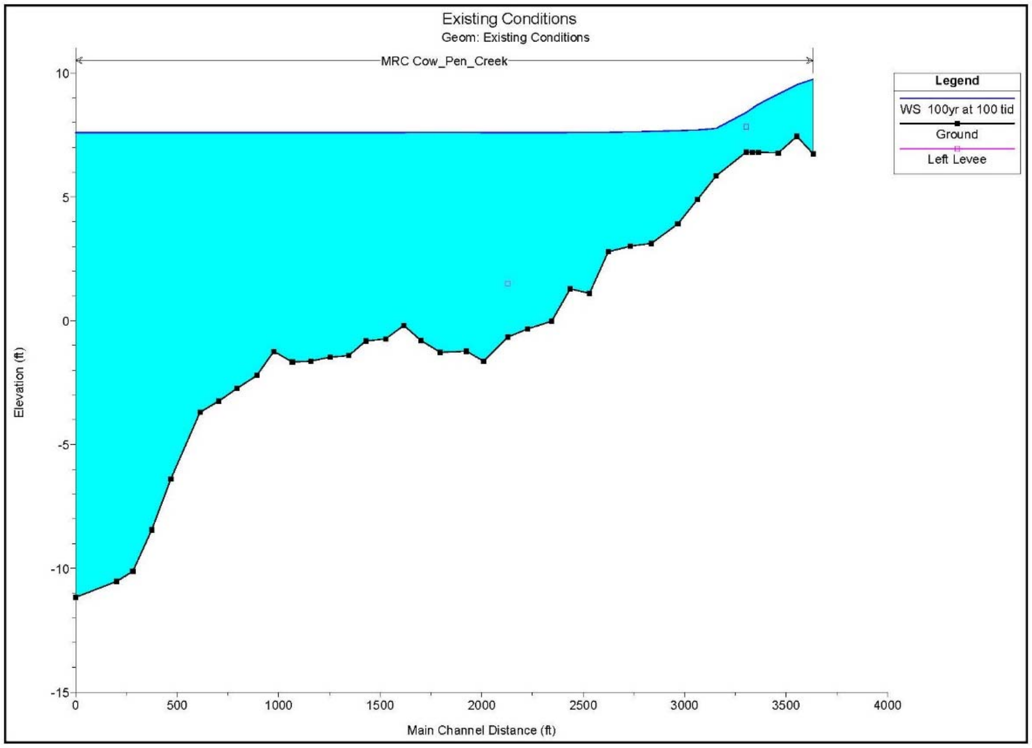


Figure A3-14. Existing Conditions Profile: 100-year flow – 100-year tide

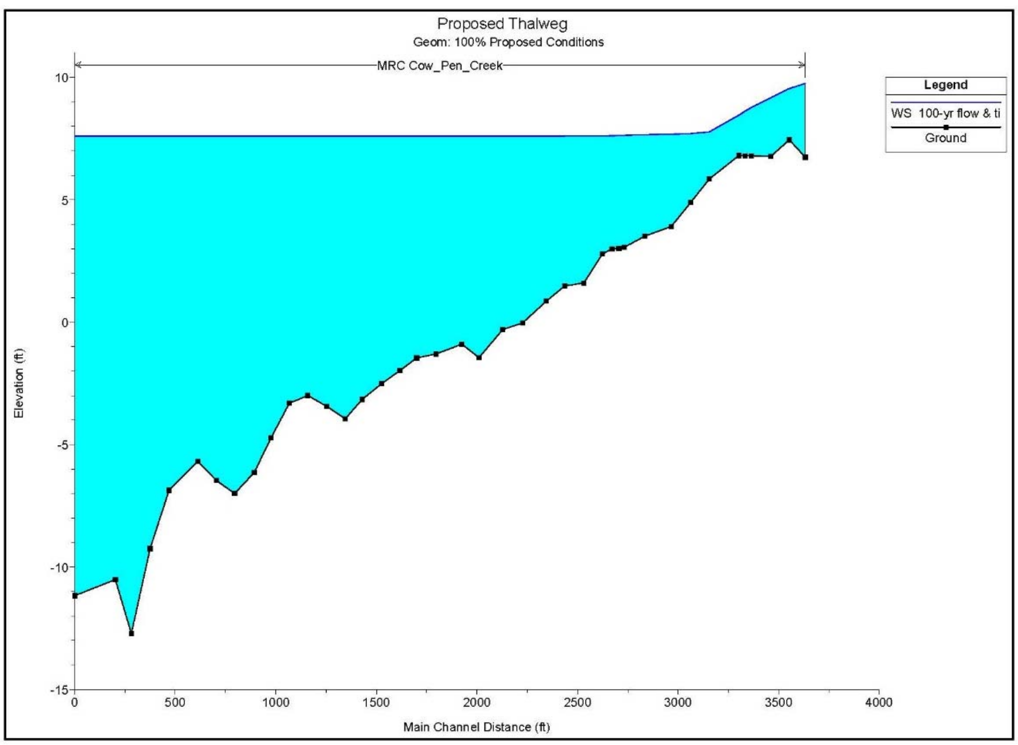


Figure A3-15. Proposed Conditions Profile: 100-year flow – 100-year tide

APPENDIX C—BEST MANAGEMENT PRACTICES ANALYSIS

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APPENDIX C
Best Management Practices Analysis

C.1 INTRODUCTION

This appendix presents the methods used to evaluate, prioritize, and select five best management practices (BMPs) that have the potential to reduce the environmental footprint of the Lockheed Martin Middle River Complex sediment remediation project. This BMP analysis was performed in accordance with the ASTM International (ASTM) Standard Guide E2893-13 – Standard Guide for Greener Cleanups (ASTM, 2013). This appendix provides a discussion of possible sustainability measures that can be used for this project, and the process for which the potential BMPs for this project were selected. This appendix also provides a quantitative evaluation of five BMPs for this project.

Quantitative evaluation (i.e. environmental footprint analysis) of selected BMPs was conducted using the Naval Facilities Engineering Command (NAVFAC) SiteWise™ Version 3 tool for Green and Sustainable Remediation to calculate the environmental footprint of remedial alternatives (NAVFAC, 2013). The method is consistent with United States Environmental Protection Agency's (USEPA's) Green Remediation policy created to enhance the environmental benefits of federal cleanup programs by promoting technologies and practices that are sustainable (USEPA, 2008, USEPA, 2010, USEPA, 2012). USEPA's Green Remediation strategy outlines the principles of green remediation and describes opportunities to reduce the footprint of cleanup activities throughout the life of a project. The SiteWise tool was developed jointly by the United States Navy, the United States Army Corps of Engineers (USACE), and Battelle, and is used to assess the remedial alternatives in terms of a consistent set of environmental metrics.

C.2 SUSTAINABILITY MEASURES

USEPA's Green Remediation strategy outlines the goal of comprehensively evaluating cleanup actions to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities to the maximum extent possible (USEPA, 2010). Green remediation comprises a range of best practices that may be applied throughout the cleanup process. The best management practices of green remediation provide the means to potentially improve waste management; conserve or preserve energy, fuel, water, and other natural resources; reduce greenhouse gas (GHG) emissions; promote sustainable long-term stewardship; and reduce adverse impacts on local communities during and after remediation activities.

Lockheed Martin Corporation (Lockheed Martin) is committed to minimizing the carbon footprint of construction activities anticipated as part of the execution of the remedy. During the design phase, evaluations were conducted to identify opportunities to incorporate sustainability concepts, including those presented in the USEPA's Clean and Green Policy (USEPA, 2010) into all aspects of the remediation. To the extent practicable, the use of renewable energy sources, the use of locally produced/sourced materials and supplies, reduction/elimination of waste, efficient use of resources and energy, and other practices will be incorporated into the remedial design, and will be implemented during remedial construction. The best way to reduce GHG emission is through the use of BMPs.

Carbon dioxide (CO_2) production is generally driven by fuel consumption during on-site and off-site activities. Reducing CO_2 emissions on a large scale is difficult for the Lockheed Martin Middle River Complex (MRC) remedial alternatives because of the activities required for sediment remediation and the limitations of available technology to reduce CO_2 emissions associated with heavy construction equipment. It may be possible to reduce CO_2 emissions by using alternative fuels and adopting sustainable BMPs during the project. A reduction in CO_2 emissions can be achieved by using biodiesel as fuel for the smaller construction equipment (e.g., front-end loaders). If hydraulic dredging, or dewatering slurried sediment is considered, electric booster pumps can be used if an upland booster pump is needed to pump hydraulically dredged material into geotextile dewatering bags. Electric pumps can also be during dewatering Cow Pen Creek in segment. Emissions of particulate matter (PM_{10}) are primarily generated through the operation of construction equipment (i.e., internal combustion in construction equipment) and dust generated by transportation equipment.

Fuel consumption efficiency can also be achieved using the best methods for transport of materials. Using delivery trucks equipped with engines manufactured in 2007 or later, or with engines meeting diesel retrofit technology will reduce the project's carbon footprint. Biodiesel will be evaluated and may be used in delivery trucks and on-site equipment for further carbon footprint reduction. Some of the variables that will be considered during the project for fuel efficiency and sustainability measures are: the distance to the project site, the material sources, production and delivery efficiency, handling considerations, and ways to minimize the area of impact, both at the dredge site and at the stockpiles of dredged sediment.

C.3 BEST MANAGEMENT PRACTICES

The selection of the BMPs for this project is following the multistep guidance set forth by the ASTM – E2893-13 - *Standard Guide for Greener Cleanups* (ASTM, 2013). The following subsections detail this step-wise process, and present the selected BMPs that are applicable to this remediation project.

C.3.1 BMP Selection Process

Guidance describes a process for identifying, evaluating, and incorporating BMPs, and for integrating a quantitative evaluation to reduce the environmental footprint, as defined by the core elements. These core elements (ASTM, 2013) are as follows:

- Minimize total energy use and maximize use of renewable energy – reducing total energy use while also identifying the means to increase the use of renewable energy throughout the project activities
- Minimize air pollutants and greenhouse gas emissions – reducing total air emissions, including emissions of air pollutants and greenhouse gases, throughout the project activities
- Minimize water use and impacts to water resources – minimizing the use of water and impacts to water resources throughout the project activities
- Reduce, reuse, and recycle materials and waste – minimizing the use of virgin materials and generation of waste throughout the project activities, and maximizing the use of recycled materials
- Protect land and ecosystems – reducing impacts to the land and ecosystem services throughout the project activities

The ASTM BMP process is used with the core elements discussed above to identify, prioritize, select, implement, and document the use of BMPs, ultimately reducing the environmental footprint of the project activities.

The guidance states there are five steps to the BMP process, as discussed below:

1. BMP opportunity assessment – This is a screening level assessment in which all BMPs potentially applicable to the project site conditions are identified. All BMPs should be considered without regard to factors that may influence the selection of those BMPs, such as relative benefit, logistics, or cost.

2. BMP prioritization – This step reviews each identified BMP, and prioritizes them based on their relative ability to reduce the environmental footprint of the project activities. All BMPs identified as having a low probability of reducing the environmental footprint will be given a low priority. This low priority rating will facilitate the elimination of these lower-value BMPs in the following step. Prioritization is based on sound engineering and does not require a detailed analysis.

3. BMP selection – In this step, each BMP in the prioritized list is reviewed, and the BMPs retained for implementation are selected. The selection will be based on potential environmental footprint reductions, relative to factors such as implementability, effectiveness, reliability, short-term risk, community concerns, cost, and potential for environmental trade-offs.

4. BMP implementation –BMPs are implemented in this step. If new information or changed circumstances relevant to the BMP or project site cause the selected BMP impractical to implement, it can be decided not to implement that BMP. This step has not yet been completed, as the project is still in the design phase. Implementation of the selected BMPs will not occur until construction starts.

5. BMP documentation – This step involves documenting the BMP steps taken in a table. This table will include the prioritized list of BMPs for the project, and will identify BMPs that have been implemented. This step has not yet been completed, as the project is still in the design phase. Implementation of the BMPs will occur during construction.

C.3.2 BMP Opportunity Assessment

An opportunity assessment was completed to evaluate the types of BMPs used in this remediation project. The assessment for this project was conducted by considering all construction elements related to remediation activities. The primary environmental impacts that may occur are temporary water quality impacts during in-water dredging and erosion and sedimentation during excavation. This project will improve long-term water and sediment quality by removing contaminated sediment. Potential impacts will be minimized by implementing mitigation measures during construction. Refer to Section 3.3 of the design report for detailed potential impacts and mitigation measures of the project. Few mitigation measures are listed below.

- Timing of excavation and dredging: in-water work will need to be restricted to certain times of the year to minimize potential impacts to important fish, wildlife, and habitat resources. All in-water construction will be conducted within the designated time period, also known as a seasonal window.
- Treatment of contaminated sediment contact water: stormwater in contact with contaminated sediment, water pumped from excavation areas, and water that that drains from stockpiles of dredged or excavated material will be treated onsite and discharged to either the local publicly owned treatment works (POTW) or to an approved disposal facility in compliance with applicable permits and water quality standards. Decontamination fluids and stormwater generated from onsite pavement or land disturbing activities will also be collected and treated onsite.
- Erosion and sedimentation controls: temporary and permanent erosion and sedimentation controls will be installed over excavated bank surfaces, down slope and adjacent to all disturbed soil. The controls will include temporary and permanent stabilization mats, fabric filter fences, coir logs, covering of stockpiles and/or similar measures.
- Water quality monitoring: water quality will be monitored during in-water work in accordance with an approved water quality monitoring plan. Care will also be taken to prevent any petroleum products or other materials related to construction equipment from entering the water. The contractor will keep spill response plans and materials while operating onsite.

With these mitigation efforts in mind, the list of possible BMPs provided by ASTM in the E2893-13 Standard guide was narrowed to the BMPs considered applicable for this remediation project (Attachment 1).

C.3.3 BMP Prioritization

Following the opportunity assessment, the list of possible BMPs was prioritized based on the ability of each BMP to reduce the environmental footprint of project activities. The efficiency prioritization was accomplished by classifying the BMPs using three categories: high, medium, and low (Attachment 1). The purpose of this prioritization is to identify BMPs that have the high and medium ability to reduce the project's environmental footprint. The low-efficiency BMPs will not be carried forward into the BMP selection step of this process.

C.3.4 Selected BMPs

The BMPs identified as having a high and medium probability of reducing the environmental footprint were selected as the BMPs potentially to be implemented in this project (Attachment 2). These BMPs can be revised or new BMPs can be added when sediment remediation projects in both Cow Pen Creek and Dark Head Cove are considered together. The BMPs selected for quantitative analysis are listed below and are highlighted by color in Attachment 2 corresponding to the following categories:

1. Fuel efficiency:
    - perform construction sequentially to reduce unnecessary movement of construction equipment
    - limit on-site vehicle speed to reduce particle suspension and increase fuel efficiency
    - select properly sized and powered equipment
    - select fuel efficient equipment
    - use on-site local materials, and nearby sources for backfill material
2. Alternative fuel sources:
    - use low sulphur fuels if possible
    - select lower GHG emitting fuel sources (e.g., biodiesel) for small equipment and trucks
    - use electric power generators instead of diesel-powered generators for use during construction
3. Recycle uncontaminated materials removed (i.e., metals, construction debris, tires, etc.) and use recycled bio-based products:
    - reuse or recycle removed materials to reduce the volume of material placed in landfills
    - reuse removed materials so that the amount of virgin materials used on project is minimized
    - use bio-based products such as biodegradable seed matting, geotextile fabric composed of recycled materials,
4. Wastewater treatment:
    - treat wastewater,
    - use treated wastewater for wash water, irrigation, dust control, or other uses, reduces the consumption of clean water for the project,
    - use regenerated GAC in carbon beds
    - use bag/cartridge filters that can be backwashed to avoid frequent disposal of filters

5. Restore and maintain streambanks to preserve natural conditions, minimize sediment runoff:
    - minimize clearing of tress throughout the project site
    - revegetate areas disturbed by excavation
    - maximize use of native, non-invasive vegetative cover
    - provides a reduction of scour within Cow Pen Creek
    - improves the local ecosystem
    - increases opportunities for recreation for the local community

A quantitative evaluation for these proposed BMPs will be completed to demonstrate that the environmental footprint of this project is being reduced by the selected BMPs. This quantitative evaluation will include measurements of emissions, resource use, and wastes related to the project activities, as estimated using a footprint analysis using the NAVFAC SiteWise tool.

C.4 QUANTITATIVE EVALUATION OF SELECTED BMPS

Quantitative evaluation of selected BMPs will be completed at further stages of design combined with the remediation activities in Dark Head Cove and Cow Pen Creek. Methodology for the analysis is summarized in this section.

C.4.1 Methodology for Environmental Footprint Analysis

Potential environmental footprint of a project action is associated with the emission of GHG such as carbon dioxide (CO_2) and others contributing to climate change; energy use; air emissions of criteria pollutants including nitrogen oxide (NOx), sulfur oxide (SOx), and particulate matter (PM_{10}); water consumption; resource consumption; landfill space; and worker safety. The net carbon emission associated with a defined activity is often referred to as the activity's carbon footprint (USEPA, 2010). The SiteWise tool will be used to quantify the environmental footprint of the remedial actions.

C.4.2 SiteWise Input

Environmental footprint metrics to evaluate each selected BMP are determined (Table C-1). These metrics were entered into SiteWise analyses as input to its corresponding categories for the four selected BMPs. Refer to Attachment 3 for SiteWise input data. Following assumptions were made to differentiate each BMP:

- BMP 1 – Fuel efficiency: It is assumed that a 10% decrease in fuel consumption would be achieved through operational measures

- BMP 2 – Alternative fuel sources: It is assumed that biodiesel would be used instead of diesel and that electric generators would be used to maintain the dewatering pumps for Cow Pen Creek rather than diesel generators

- BMP 3 – Recycling: It is assumed that about 200 tons of concrete, rock, stone debris would be recycled instead of transporting to the landfill

- BMP 4 – Wastewater treatment: It is assumed that about 200,000 gallon of water would be treated on-site and discharged to POTW instead of trucking to an off-site treatment and disposal facility

- BMP 5 – Reduce sediment runoff: An environmental footprint analysis to restore and maintain streambanks to preserve natural conditions and minimize sediment runoff is the only BMP that was not quantified by SiteWise, as it is not appropriate tool to quantify benefits of BMP-5. See below for further discussion of BMP 5.

C.4.3 Inventory of Metrics

The remedy environmental footprint will be calculated in SiteWise by multiplying the impact factors (e.g., emissions per usage rate) with the usage rate (consumption) of fuel during a remedial action.

SiteWise performs all of the calculations based on emission factors obtained from governmental or non-governmental research sources. USEPA Climate Leaders Program (USEPA, 2009) provides a GHG Inventory Guidance used by industry to document emissions of GHGs including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The USEPA *Climate Leaders GHG Inventory Guidance* is a modification of the GHG protocol developed by the World Resources Institute and the World Business Council for Sustainable Development. SiteWise also uses emission factors developed by Argonne National Laboratory's Greenhouse Gases, Regulated

Emissions, and Energy Use in Transportation (GREET) model, USEPA's Mobile 6 model, and USEPA's non-road model. Emission factors for consumables are life cycle-based and obtained from sources that provide life cycle inventories (e.g., the life cycle inventory provided by National Renewable Energy Laboratory).

C.4.4 Methodology to Evaluate BMP 5

BMP 5 will implement bank stabilization and along the excavated area of Cow Pen Creek, by combining erosion control measures and revegetation. A comparison of construction with no BMPs implemented, construction with BMPs implemented, and the site without any construction was completed using Revised Universal Soil Loss Equation, Version 2 (RUSLE2) Soil Erosion Prediction software developed by the United States Department of Agriculture (USDA) - Agricultural Research Service (ARS). By analyzing the soil loss in tons per acre per year, the estimated soil leaving the graded stream banks was quantified.

C.4.5 Results

Environmental footprint analysis of selected BMPs for Cow Pen Creek and Dark Head Cove remediation construction was performed and the results are summarized in Table C-2 and Figures C-1 to C-4. Note that some of the input data have been revised due to design progress towards completion. Comparative analysis of BMPs and discussion of the results remain the same as follows:

- BMP 1 – Fuel efficiency: Reduces total energy use and all of the air pollution emissions. The reduction is the most compared to the other BMPs.
- BMP 2 – Alternative fuel sources: Use of biodiesel and electricity would reduce GHG emissions but total energy use for production of biodiesel is typically higher than diesel. Air pollution emissions would be the same as the baseline analysis.
- BMP 3 – Recycling: It provides minor reduction is all categories due to the low amount of expected debris compared to the non-hazardous waste disposal.
- BMP 4 – Wastewater treatment: It provides minor reduction in GHG emissions. One factor that can be incorporated into SiteWise is the additional fuel consumption due to

transportation of collected dewater to a treatment facility if not treated on-site. The benefit of BMP can be further refined by incorporating other practices during wastewater treatment operations (e.g. using regenerated GAC or backwashing filters).

- BMP 5 – Reduce sediment runoff: Erosion reduction measures will greatly reduce soil loss during remedial construction in Cow Pen Creek by utilizing a combination of stabilization practices. It is estimated about of 98 percent of soil will not leave the Cow Pen Creek site by implementing effective stabilization techniques with erosion control BMPs during excavation.

Table C-1. BMP Evaluation Metrics

		CPC, DHC Design Metrics	BMP 1	BMP 2 Biodiesel/Electric	BMP 3 Recycling	BMP 4 WW Treatment
Input Data	Dredge Volume at Cow Pen Creek by mechanical dredging/excavation(cy) [a/]	26,500	26,500	26,500	26,500	26,500
	Dredge Volume at Dark Head Cove by mechanical dredging (cy) [a/]	20,500	20,500	20,500	20,500	20,500
	Residual management volume at CPC and DHC (cy) [b/]	10,970	10,970	10,970	10,970	10,970
	Activated Carbon Mass (lb) [c/]	426,800	426,800	426,800	426,800	426,800
	Activated Carbon Mass (cy)	800	800	800	800	800
Equipment Hours - Dredging/Excavation [d/]						
Dredging and Excavation	Excavation in Cow Pen Creek (hr)	1,325	1,193	1,325	1,325	1,325
	Mechanical dredging in DHC, mouth of CPC (barge mounted derrick crane) (hr)	684	616	684	684	684
	Total hours of dredging/excavation at CPC and DHC	2,100	1,900	2,100	2,100	2,100
	Total hours of geneator use in CPC	1,325	1,193	1,325	1,325	1,325
Equipment Hours - Transloading [e/]						
Transloading	Excavated material from Cow Pen Creek to transloading/dewatering area (hr)	663	597	663	663	663
	Dredged material from Dark Head Cove to transloading/dewatering area (hr)	342	308	342	342	342
	Total hours of transloading dredged material	1,100	1,000	1,100	1,100	1,100
	Material handling at transloading/dewatering area by front loaders (cy)	47,000	47,000	47,000	47,000	47,000
	Material handling at transloading/dewatering area by front loaders (hr)	2,100	1,900	2,100	2,100	2,100
	Debris handling (tons)	200	200	200	0	200
Equipment Hours - Transportation [f/]						
Transportation	Dredge Material (ton)	61,100	61,100	61,100	61,100	61,100
	Dredge material to landfill - truck trips	3,200	3,200	3,200	3,200	3,200
	Dredge material to landfill - truck miles	800,000	800,000	800,000	800,000	800,000
	Debris to landfill - truck trips	20	20	20	0	20
	Water Treatment Volume for mechanical dredging at CPC and DHC (gal)	196,000	196,000	196,000	196,000	0
	Transport of water treatment facility - truck trips	40	40	40	40	0
	Activated carbon to Site - truck trips	80	80	80	80	80
	Activated carbon to Site - truck hours	800	720	800	800	800
	Residual management material to site - barge (hr)	28	28	28	28	28
Equipment Hours - Backfill, Restoration, In situ Treatment [g/]						
Residual Management Layer, CPC Restoration, Activated Carbon	Residual management handling at quarry to barge by front loaders (cy)	10,970	10,970	10,970	10,970	10,970
	CPC restoration backfill (hr)	300	300	300	300	300
	Residual management placement in CPC, DHC (hr)	220	198	220	220	220
	Activated carbon placement - barge mounted crane (hr)	200	180	200	200	200
	Total hours of residual management layer/activated carbon placement (hours)	720	678	720	720	720

Notes:

[a/] 60% design volume - including overdredge

[b/] 60% design volume - 6 inch placement over dredge + excavated areas including CPC restoration

[c/] 35,000 kg granulated activated carbon per hactare (31,230 lb/ha) (Ghosh, 2011). DHC in situ treatment avg. 5.5 ha (13.7 acre).

[d/] Excavation in CPC (200 cy/day). Mechanical dredging by barge mounted derrick crane (300 cy/day). Both operations 25 gal/hr, 10 hour/day. Use of generators during creek dewatering operations at 5 gal/hr, or 5 kW if electric generator is used.

[e/] Excavated material transport to dewatering pad (40 cy/hr, 25 gal/hr). Dredged material offloading from barge by derrick crane at the transloading area (60 cy/hr, 25 gal/hr).

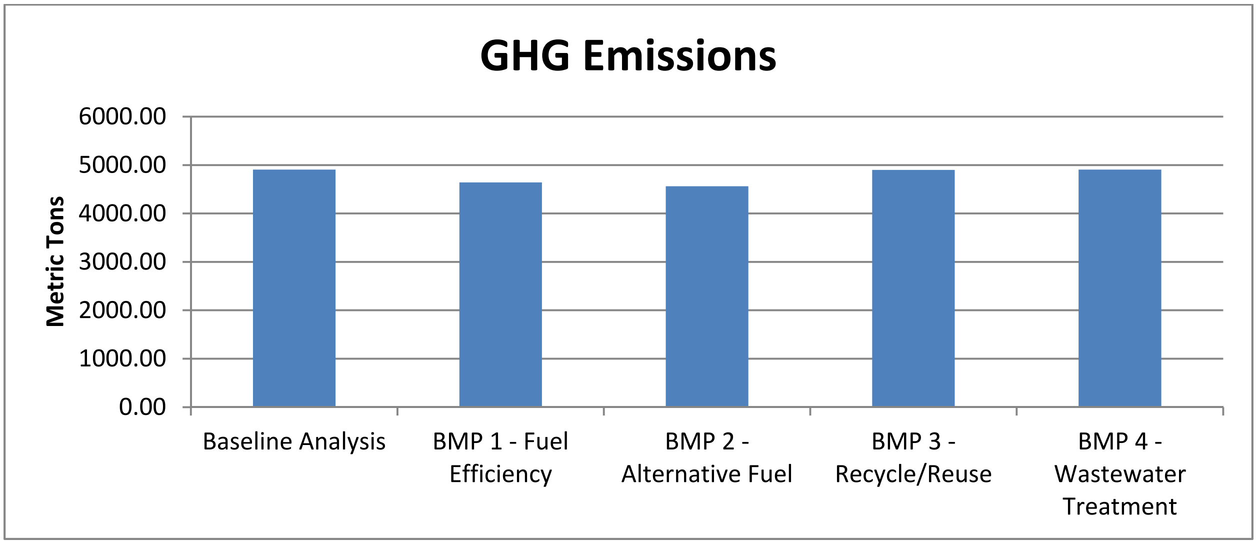
[f/] Assumptions: 1) dredged material will be transported by trucks from the transloading area to Grows North landfill in Morrisville, PA (15 cy/truck, 250 mile/round trip, 0.22 gal/miles) and from landfilll offloading site to the disposal cell (15 cy/truck, 12 miles/round trip, 0.22 gal/miles); 2) Refer to design calcs for estimates of dewatering water volume. Water will be trucked to a treatment facility at baseline analysis at 5,000 gal (20 ton) tankers, 20 miles; 4) Activated carbon will be delivered by trucks (10 cy/truck, 10 hr per trip); 5) RML and backfill material will be delivered by barge (barge capacity: 1,600 cy, speed: 5 miles/hr avg., distance from quarry (A&C aggregate, 301 Earls Road, Middle River, MD 21220): 10 miles, each barge trip: 4 hours, fuel consumption: 85 gal/hr).

[g/] Assumptions: 1) CPC stream/floodplain construction, streambed mix (150 cy/day), residual management material placement (300 cy/day); 2) GAC placement rate is 1 ton/hr or 10 ton/day based on field pilot studies (e-mail correspondence with Dr. Ghosh).

cy=cubic yard; MNR=monitored natural recovery; gal=gallon; CPC=Cow Pen Creek; DHC=Dark Head Cove

Table C-2. Environmental Footprint Summary of Baseline Analysis, BMP 1 through BMP 4

Remedial Alternatives	GHG Emissions	Total energy Used	Total NO_x Emissions	Total SO_x Emissions	Total PM_{10} Emissions
	metric ton	MMBTU	metric ton	metric ton	metric ton
Baseline Analysis	4907.37	6.35E+04	3.25E+01	5.59E+00	1.31E+01
BMP 1 - Fuel Efficiency	4641.76	6.07E+04	2.98E+01	5.25E+00	1.29E+01
BMP 2 - Alternative Fuel	4562.83	7.16E+04	3.27E+01	5.71E+00	1.31E+01
BMP 3 - Recycle/Reuse	4899.41	6.34E+04	3.25E+01	5.59E+00	1.31E+01
BMP 4 - Wastewater Treatment	4905.46	6.35E+04	3.25E+01	5.58E+00	1.31E+01



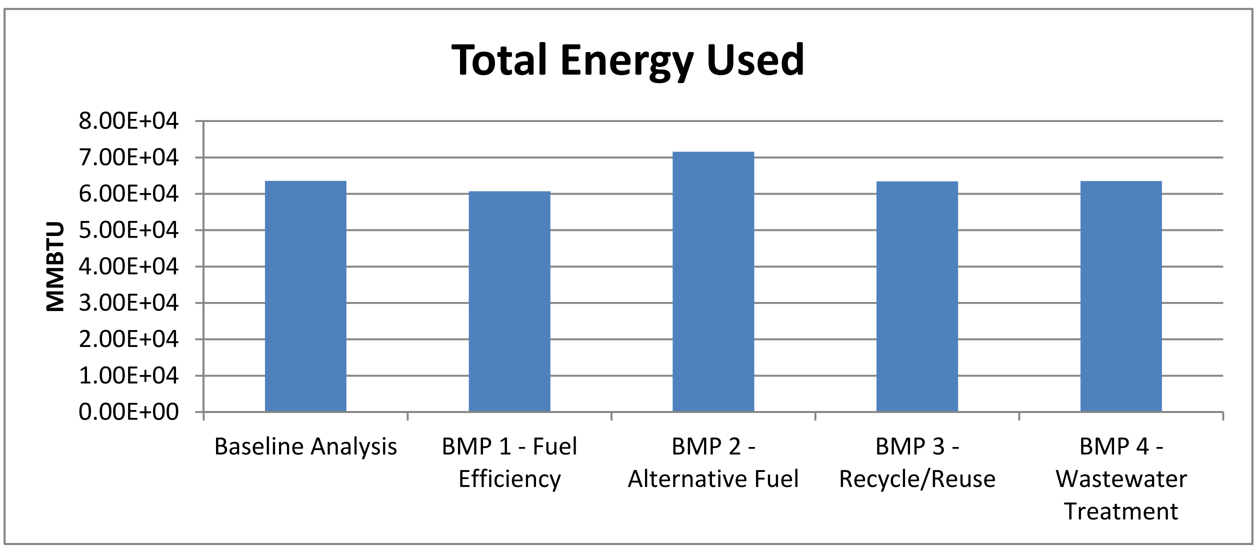
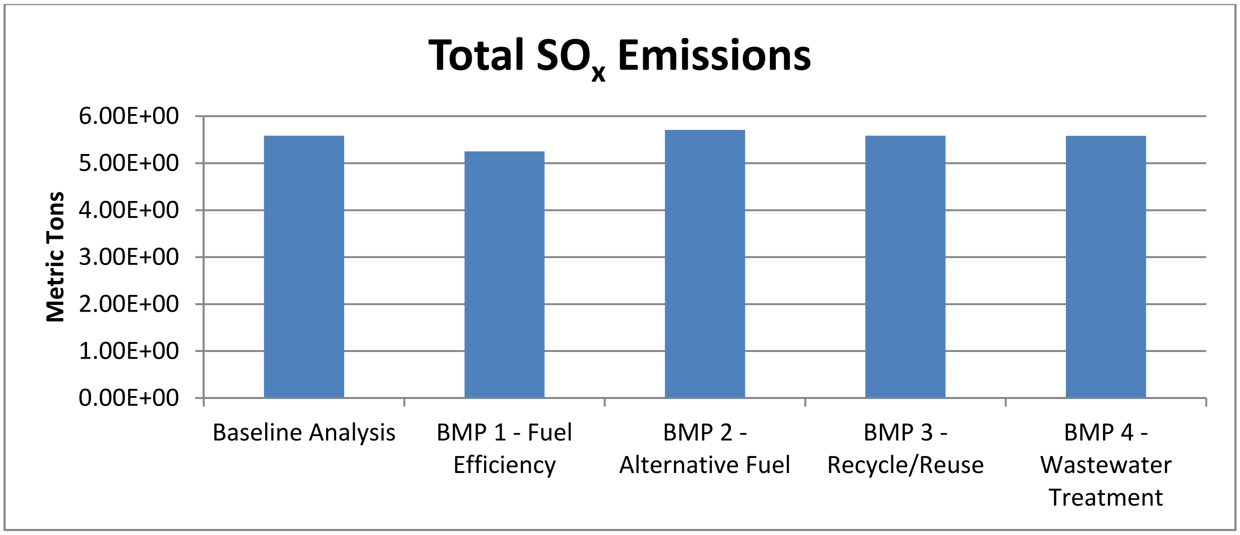
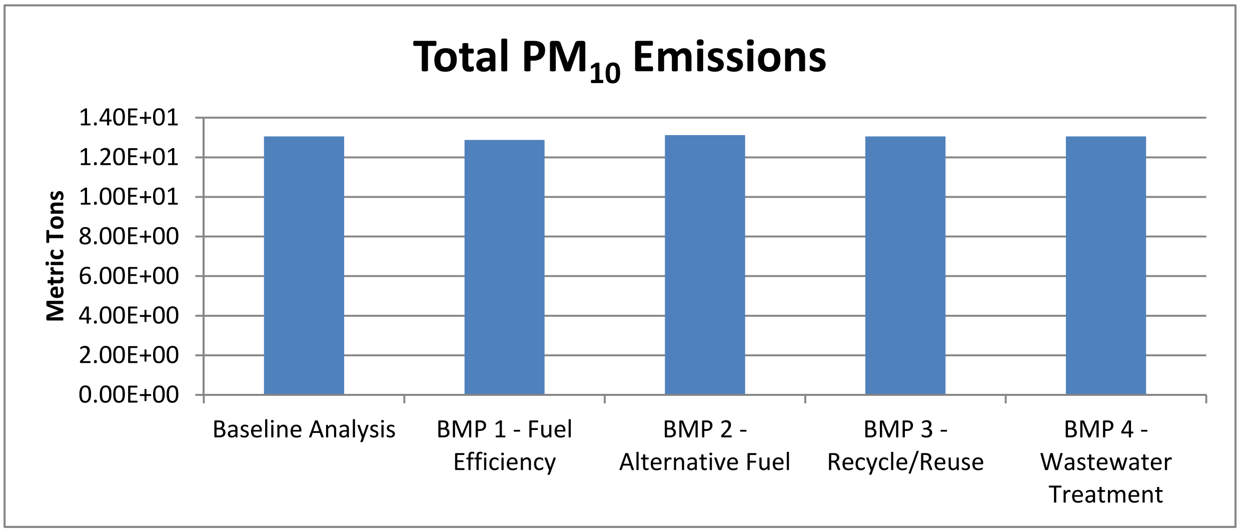


Figure C-1. Greenhouse Gas Emissions and Total Energy Used Comparison of BMP 1 through BMP 4





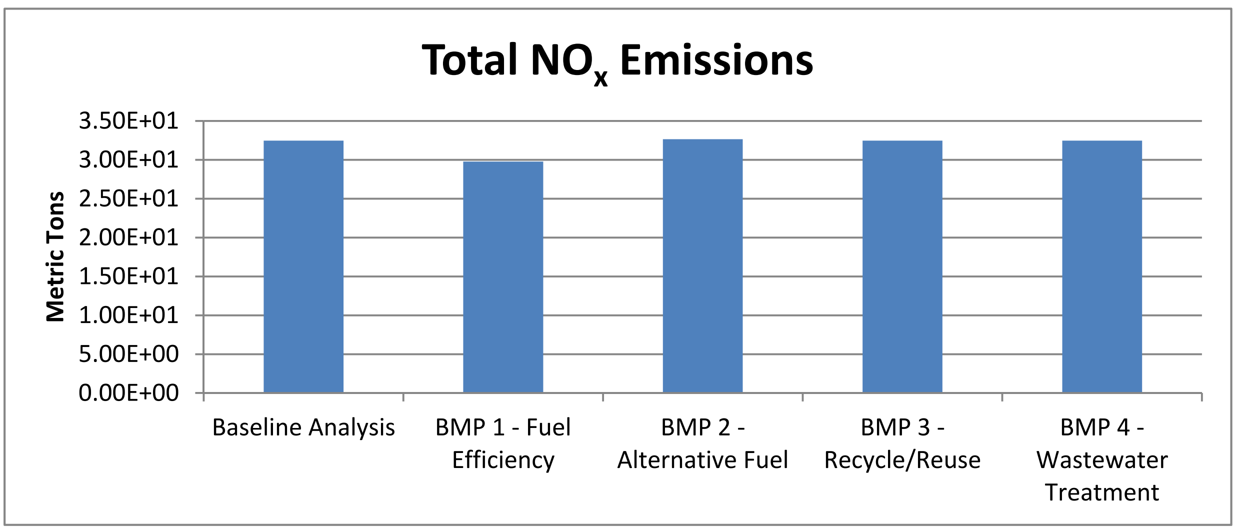


Figure C-2. Air Pollution Emission Comparison of BMP 1 through BMP 4

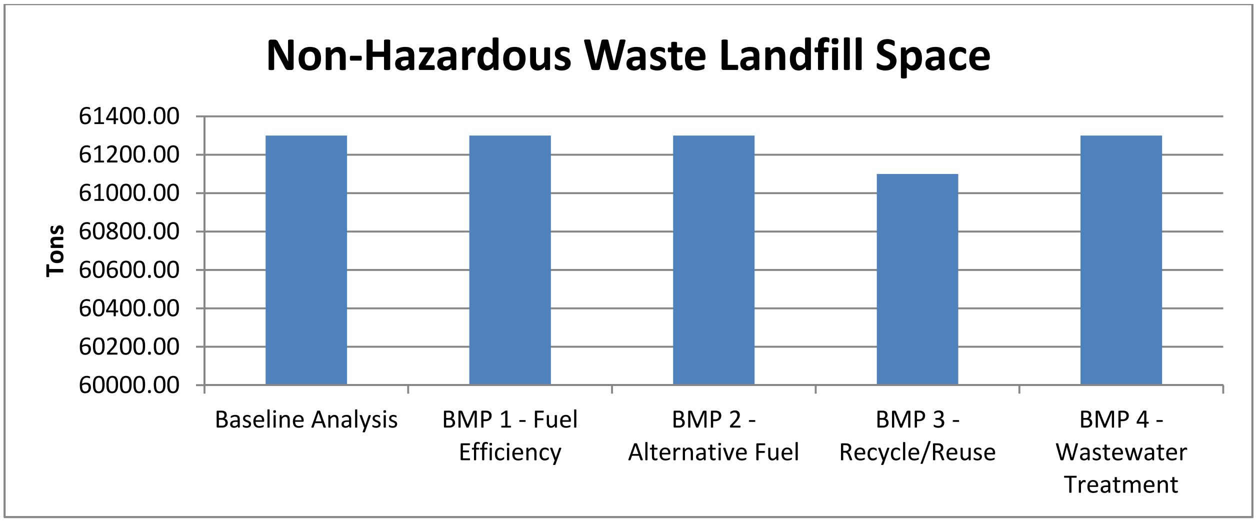


Figure C-3. Non-hazardous Waste Landfill Space Comparison of BMP 1 through BMP 4

Soil Type	Area (ac)		Soil Loss Rate Estimates (tons/ac/year)		
	In-Channel	Total Grading	Clearing	Excavation w/o BMPs	Excavation with BMPs
Project Site					
Aldino (Silt Loam)		1.1	130	88	2.7
Aldino (Silt Loam)	4.9		2.9	1.5	0.065
		Subtotal (tons/yr)	155.8	103.2	3.3

Estimates Using Revised Universal Soil Loss Equation

		Construction Period (mo)	Soil Loss (tons) without BMPs	Soil Loss (tons) with BMPs
Site (6.0 acres)	Clearing	1	13.0	0.3
	Excavation	2.5	21.5	5.8
	Total	3.5	**34.5**	**6.1**

Soil Loss Rate Estimates (tons/ac/year)

	Clearing	**Excavation w/o BMPs**	**Excavation with BMPs**
Area (ac)	130	88.0	2.7
Duration (mo)	0.25	0.75	1.00
Soil Loss (ton)	2.9	6.0	0.2
Total (ton)	**8.9**		**0.2**

Assumptions:

- In-Channel will be limited to in channel (5 ft MLLW to -5 MLLW, 8+00 to 31+00) = slope of 0.43%
- Grading will be limited to proposed side slopes only, at 100% slope for 10ft
- The No Project soil loss assumes a vegetation barrier, fair condition' management scenario

Notes:

1. Soil losses (tons/acre/year) are estimated using RUSLE2 software.
   - The soil characteristics were estimated using RUSLE2 soil profiles corresponding to the mapped NRCS soil units.
   - Estimates of actual soil losses use the RUSLE2 soil loss times the duration and the affected area.

RUSLE2 Assumptions as follows:

- Clearing soil losses assume the following inputs: Management - rough bare/ freshly disturbed; Contouring - not contoured; Strips and Barriers - None; Diversion/terracing - None
- Construction soil losses assume the following inputs: Management - smooth bare cut; Contouring - not contoured; Strips and Barriers - None; Diversion/terracing - None
- Construction with BMP soil losses assume the following inputs: Management - Permanent seeding, wood fiber; Contouring - perfect contouring; Strips and Barriers - silt fence will full retardence; Diversion/terracing - None
- No Project soil losses assume the following inputs: Management - vegetation barrier, fair condition; Contouring - not contoured; Strips and Barriers - None; Diversion/terracing - None

Figure C-4. Soil Loss Predictions

C.5 REFERENCES

1) ASTM International (ASTM), 2013. Standard Guide for Greener Cleanup. June.

2) United States Department of Agriculture (USDA) - Agricultural Research Service (ARS), 2008. Revised Universal Soil Loss Equation, Version 2 (RUSLE2) Soil Erosion Prediction software. Available at http://fargo.nserl.purdue.edu/ rusle2_dataweb /RUSLE2_Index.htm

3) United States Environmental Protection Agency (USEPA), 2008. Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites. April.

4) United States Environmental Protection Agency (USEPA), 2009. Climate Leaders Program Direct Emissions from Stationary Combustion Sources. Available at: www.epa.gov/climateleaders.

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6) United States Environmental Protection Agency (USEPA), 2012. Green Remediation Best Management Practices: Overview of EPA's Methodology to Address the Environmental Footprint of Site Cleanup. March 2012.

7) Naval Facilities Engineering Command (NAVFAC), 2013. SiteWise Version 3 User Guide. Battelle Memorial Institute, Columbus, Ohio. June.

ATTACHMENT 1

Greener Cleanup BMPs Specified by ASTM E2893-13 and Potentially Applicable to Middle River Complex Sediment Remedy

Attachment 1. Greener Cleanup BMPs Specified by ASTM E2893-13 and Potentially Applicable to MRC Sediment Remedy									
		Core Elements Addressed (at Site Level)					BMP Prioritization - Ability to Reduce Environmental		
Category	BMP Description	Energy	Air	Water	Materials and Waste	Land and Ecosystems	High	Medium	Low
Buildings	Reuse existing structures for treatment system, storage, sample management, etc.	X	X		X	X			X
Materials	Use recycled content (for example, steel made from recycled metals, concrete and/or asphalt from recycled crushed concrete and/or asphalt, respectively, plastic made from recycled plastic, tarps made with recycled or bio-based contents instead of virgin petroleum-based contents)				X			X	
Materials	Use bio-based products (for example, erosion control fabrics containing agricultural byproducts)				X		X		
Materials	Use on-site/local materials, when possible (for example, wood waste for compost, rocks for drainage control)	X	X		X		X		
Materials	Use regenerated GAC for use in carbon beds				X		X		
Materials	Salvage uncontaminated objects/infrastructure with potential recycle, resale, donation, or reuse				X			X	
Materials	For constructed wetlands, select materials that are compatible with local and regional ecosystems and require minimal water and amendments			X	X	X		X	
Materials	Choose geotextile fabric or drainage tubing composed of 100% recycled materials, rather than virgin materials, for lining, erosion control, and drainage				X			X	
Materials	Use local plant stock to minimize transportation and increase acclimation survivability	X	X		X	X	X		
Materials	Use biodegradable seed matting constructed of recycled materials (for example, paper, saw dust, hay)				X	X		X	
Materials	Prepare, store, and distribute documents electronically using an environmental information management system				X			X	
Materials	Recycle as much non-usable/spent equipment/materials as possible following completion of project				X			X	
Power and Fuel	When possible, operate remediation system during off-peak hours of electrical demand without compromising cleanup progress	X							X
Power and Fuel	Use gravity flow where feasible to reduce the number of pumps for water transfer	X			X		X		
Power and Fuel	Purchase renewable energy via local utility and Green Energy Programs for renewable energy credits/certificates (RECs or Green Tags) to power cleanup activities	X	X					X	
Power and Fuel	Employ auxiliary power units to power cab heating and air conditioning when a machine is not operating (such as smartway generator or plug in outlet)	X	X						X
Power and Fuel	Use biodiesel produced from waste for cellulose-based products, preferring local sources wherever readily available to reduce transportation impacts				X		X		
Project Planning and Team Management	Perform construction sequentially to reduce unnecessary movement of construction equipment	X	X	X	X	X	X		
Project Planning and Team Management	Use local staff (including subcontractors) when possible to minimize resource consumption	X	X		X			X	
Project Planning and Team Management	Buy carbon offset credits (for example, for airline flights) when in-person meetings are required		X						X
Project Planning and Team Management	Establish green requirements (for example, SMPs and BMPs) as evaluation criteria in the selection of contractors and include language in RFPs, RFQs, subcontracts, contracts, etc.	X	X	X	X	X	X		
Project Planning and Team Management	Plant at optimum time of season (for example, late winter/early spring) to minimize irrigation requirements and increase acclimation survivability	X		X	X	X		X	

Attachment 1. Greener Cleanup BMPs Specified by ASTM E2893-13 and Potentially Applicable to MRC Sediment Remedy									
		Core Elements Addressed (at Site Level)					BMP Prioritization - Ability to Reduce Environmental		
Category	BMP Description	Energy	Air	Water	Materials and Waste	Land and Ecosystems	High	Medium	Low
Project Planning and Team Management	Develop a contingency plan that maximizes the replanting needs while minimizing re-mobilization	X			X	X			X
Residual Solid and Liquid Waste	Minimize off-site disposal of solid waste by improving solids dewatering with a filter press or other technologies	X	X		X			X	
Residual Solid and Liquid Waste	Reuse or recycle recovered product (such as resale of captured petroleum products) and materials (for example, cardboard, plastics, asphalt, concrete, etc.)				X			X	
Residual Solid and Liquid Waste	Use filters (for example, bag/cartridge filters) that can be backwashed to avoid frequent disposal of filters				X				X
Residual Solid and Liquid Waste	Use geotextile bags or nets to contain excavated sediment, facilitate sediment drying, and increase ease of sediment placement or transport, when appropriate			X		X		X	
Residual Solid and Liquid Waste	Provide on-site collection and storage area for compostable materials for use on-site for by the local community				X	X		X	
Site Preparation / Land Restoration	Vegetate excavated areas and/or areas disrupted by equipment or vehicles as quickly as possible using native vegetation, if possible, and restore as close as possible to original conditions			X		X		X	
Site Preparation / Land Restoration	Minimize use of pesticides through the use of green alternatives (for example, non-chemical solarizing technique) and an integrated pesticide management plan				X	X			X
Site Preparation / Land Restoration	Minimize clearing of trees throughout the project site	X		X	X	X		X	
Site Preparation / Land Restoration	Maximize use of native, non-invasive and/or drought resistant vegetative cover across the site during restoration using a suitable mix of shrubs, grasses, and forbs to preserve the biodiversity and related ecosystem services			X		X	X		
Site Preparation / Land Restoration	Minimize soil compaction and land disturbance during site activities by restricting traffic to confined corridors and protecting ground surfaces with biodegradable covers, where applicable			X		X	X		
Site Preparation / Land Restoration	Reclaim and stockpile uncontaminated soil for use as fill or other purposes such as frost prevention and erosion control layers				X	X			X
Site Preparation / Land Restoration	Salvage uncontaminated and pest- or disease-free organic debris, including downed tree during site clearing, for use as fill, mulch, compost, or habitat creation				X	X	X		
Site Preparation / Land Restoration	Cover filled excavations with biodegradable fabric to control erosion and serve as a substrate for ecosystems			X		X		X	
Site Preparation / Land Restoration	Restore and maintain surface water banks in ways that mirror natural conditions			X		X		X	
Site Preparation / Land Restoration	Use on-site or nearby sources of backfill material for excavated areas, if shown to be free of contaminants	X	X		X			X	
Site Preparation / Land Restoration	Design systems to allow natural volunteer growth/spreading to fill in entire target area over time (minimize initial planting, fill in over time), if time permits			X	X	X		X	
Surface / Storm Water	Install and maintain silt fences and basins to capture sediment runoff along sloped areas			X		X		X	
Surface / Storm Water	Use captured rainwater for tasks such as wash water, irrigation, dust control, constructed wetlands, or other uses			X		X		X	
Vehicles and Equipment	Select properly sized and powered equipment for construction activities	X	X		X	X	X		

Attachment 1. Greener Cleanup BMPs Specified by ASTM E2893-13 and Potentially Applicable to MRC Sediment Remedy									
		Core Elements Addressed (at Site Level)					BMP Prioritization - Ability to Reduce Environmental		
Category	BMP Description	Energy	Air	Water	Materials and Waste	Land and Ecosystems	High	Medium	Low
Vehicles and Equipment	Use biodegradable hydraulic fluids on hydraulic equipment				X		X		
Vehicles and Equipment	Implement an idle reduction plan	X	X			X	X		
Vehicles and Equipment	Limit on-site vehicle speed to reduce particle suspension and increase fuel efficiency	X	X		X	X	X		
Vehicles and Equipment	Minimize diesel emissions through the use of retrofitted engines, ultra low or low sulfur diesel or alternative fuels, or filter/treatment devices to achieve BACT[1] or MACT[2]		X				X		
Vehicles and Equipment	Soundproof all above-ground equipment housing to prevent noise disturbance to surrounding environment					X		X	
Vehicles and Equipment	Implement a telemetry system to reduce frequency of site visits	X	X						X
Vehicles and Equipment	Replace conventional vehicles with electric, hybrid, ethanol, or compressed natural gas vehicles	X	X				X		
Wastewater	Use dewatering processes that maximize water reuse			X	X			X	
Wastewater	Use uncontaminated wastewater or treated water for tasks such as wash water, irrigation, dust control, constructed wetlands, or other uses			X	X			X	
Wastewater	Employ closed-loop gray water washing system for decontamination of trucks			X	X			X	

1/ best achievable control technology (BACT) is a pollution control standard mandated by the United States Environmental Protection Agency (USEPA)

2/ maximum achievable control technology (MACT) is a pollution control standard mandated by the United States Environmental Protection Agency (USEPA)

ATTACHMENT 2

BMPs Selected for Implementation for Middle River Complex Sediment Remedy

Attachment 2. BMPs Selected for Implementation for MRC Sediment Remedy							
			Core Elements Addressed (at Site Level)				
Category	BMP Description (as presented in ASTM E2893-13 Guidance)	Applicability to MRC Sediment Remediation Project	Energy	Air	Water	Materials and Waste	Land and Ecosystems
Materials	Use recycled content (for example, steel made from recycled metals, concrete and/or asphalt from recycled crushed concrete and/or asphalt, respectively, plastic made from recycled plastic, tarps made with recycled or bio-based contents instead of virgin petroleum-based contents)	Recycled asphalt for dewatering pad, crushed concrete to slope dewatering pad , recycled tarps for stockpile materials				X	
Materials	Use bio-based products (for example, erosion control fabrics containing agricultural byproducts)	Temporary erosion control blankets for excavated slopes				X	
Materials	Use on-site/local materials, when possible (for example, wood waste for compost, rocks for drainage control)	Rocks removed during excavation used for bank stabilization/habitat creation, removed trees used as compost	X	X		X	
Materials	Use regenerated GAC for use in carbon beds	Wastewater treatment system to treat dredged water and stormwater runoff during dewatering operations				X	
Materials	Salvage uncontaminated objects/infrastructure with potential recycle, resale, donation, or reuse	Applicable to debris in Cow Pen Creek, rocks reused in bank stabilization/habitat creation, trees reused for compost, all steel to be sold/donated				X	
Materials	Choose geotextile fabric or drainage tubing composed of 100% recycled materials, rather than virgin materials, for lining, erosion control, and drainage	Recycled geotextile fabrics used for bank stabilization, temporary and permanent erosion control. Recycled tubing may be used for temporary drainage				X	
Materials	Use local plant stock to minimize transportation and increase acclimation survivability	Applicable for revegetation Cow Pen Creek	X	X		X	X
Materials	Use biodegradable seed matting constructed of recycled materials (for example, paper, saw dust, hay)	Use for temporary erosion control on excavated slopes				X	X
Materials	Prepare, store, and distribute documents electronically using an environmental information management system	Lockheed Martin's administrative protocol to manage the CPC remediation project				X	
Materials	Recycle as much non-usable/spent equipment/materials as possible following completion of project	Applicable to debris in Cow Pen Creek, as well as any uncontaminated construction material left post-construction				X	
Power and Fuel	Use gravity flow where feasible to reduce the number of pumps for water transfer	Temporary diversion of Cow Pen Creek, stormwater runoff collection during construction	X			X	
Power and Fuel	Purchase renewable energy via local utility and Green Energy Programs for renewable energy credits/certificates (RECs or Green Tags) to power cleanup activities	Contractor to research and identify opportunities	X	X			
Power and Fuel	Use biodiesel produced from waste for cellulose-based products, preferring local sources wherever readily available to reduce transportation impacts	For all construction equipment on project, when applicable				X	
Project Planning and Team Management	Perform construction sequentially to reduce unnecessary movement of construction equipment	During construction planning phase, streamline construction phasing to accomplish	X	X	X	X	X
Project Planning and Team Management	Use local staff (including subcontractors) when possible to minimize resource consumption	Utilize local labor during construction	X	X		X	
Project Planning and Team Management	Establish green requirements (for example, SMPs and BMPs) as evaluation criteria in the selection of contractors and include language in RFPs, RFQs, subcontracts, contracts, etc.	Lockheed Martin's administrative protocol to manage the CPC remediation project	X	X	X	X	X
Project Planning and Team Management	Plant at optimum time of season (for example, late winter/early spring) to minimize irrigation requirements and increase acclimation survivability	Design vegetation plan by consulting local agencies, local botanists to restore existing habitat values	X		X	X	X
Residual Solid and Liquid Waste	Minimize off-site disposal of solid waste by improving solids dewatering with a filter press or other technologies	Dewatering sediment by mixing with sediment amendment. Explore use of active dewatering system at later stages of design.	X	X		X	
Residual Solid and Liquid Waste	Reuse or recycle recovered product (such as resale of captured petroleum products) and materials (for example, cardboard, plastics, asphalt, concrete, etc.)	Applicable to debris in Cow Pen Creek, possible reuse and recycling of materials				X	
Residual Solid and Liquid Waste	Use filters (for example, bag/cartridge filters) that can be backwashed to avoid frequent disposal of filters	Applicable to wastewater treatment system to treat the dredged water					
Residual Solid and Liquid Waste	Use geotextile bags or nets to contain excavated sediment, facilitate sediment drying, and increase ease of sediment placement or transport, when appropriate	Dewatering sediment by mixing with sediment amendment. Explore use of active dewatering system at later stages of design.			X		X
Site Preparation / Land Restoration	Revegetate excavated areas and/or areas disrupted by equipment or vehicles as quickly as possible using native vegetation, if possible, and restore as close as possible to original conditions	Design vegetation plan by consulting local agencies, local botanists to restore existing habitat values			X		X
Site Preparation / Land Restoration	Minimize clearing of trees throughout the project site	Applicable to Cow Pen Creek, develop clearing limits to minimize impact to habitat	X		X	X	X

Attachment 2. BMPs Selected for Implementation for MRC Sediment Remedy

Category	BMP Description (as presented in ASTM E2893-13 Guidance)	Applicability to MRC Sediment Remediation Project	Core Elements Addressed (at Site Level)				
			Energy	Air	Water	Materials and Waste	Land and Ecosystems
Site Preparation / Land Restoration	Maximize use of native, non-invasive and/or drought resistant vegetative cover across the site during restoration using a suitable mix of shrubs, grasses, and forbs to preserve the biodiversity and related ecosystem services	Design vegetation plan by consulting local agencies, local botanists to restore existing habitat values			X		X
Site Preparation / Land Restoration	Minimize soil compaction and land disturbance during site activities by restricting traffic to confined corridors and protecting ground surfaces with biodegradable covers, where applicable	Develop access plan to minimize disturbance			X		X
Site Preparation / Land Restoration	Reclaim and stockpile uncontaminated soil for use as fill or other purposes such as frost prevention and erosion control layers	Uncontaminated soil excavated from water collection sump on dewatering pad can be used for floodplain and habitat creation				X	X
Site Preparation / Land Restoration	Salvage uncontaminated and pest- or disease-free organic debris, including downed tree during site clearing, for use as fill, mulch, compost, or habitat creation	Applicable to trees being clearing during excavation/dredging operations				X	X
Site Preparation / Land Restoration	Cover filled excavations with biodegradable fabric to control erosion and serve as a substrate for ecosystems	For use on stockpiled materials and may be incorporated into habitat creation design			X		X
Site Preparation / Land Restoration	Restore and maintain surface water banks in ways that mirror natural conditions	Applicable to Cow Pen Creek, restore streambank to minimize scour, improve local ecosystem, and provide increased opportunity for recreation for local community			X		X
Site Preparation / Land Restoration	Use on-site or nearby sources of backfill material for excavated areas, if shown to be free of contaminants	For floodplain and habitat creation in Cow Pen Creek	X	X		X	
Site Preparation / Land Restoration	Design systems to allow natural volunteer growth/spreading to fill in entire target area over time (minimize initial planting, fill in over time), if time permits	Design vegetation plan by consulting local agencies, local botanists to restore existing habitat values			X	X	X
Surface / Storm Water	Install and maintain silt fences and basins to capture sediment runoff along sloped areas	For excavated and dredged slopes in Cow Pen Creek			X		X
Surface / Storm Water	Use captured rainwater for tasks such as wash water, irrigation, dust control, constructed wetlands, or other uses	Will incorporate into design if MRC facility has this BMP in-place.			X		X
Vehicles and Equipment	Select properly sized and powered equipment for construction activities	During construction planning phase, select equipment to minimize impact on ecosystem	X	X		X	X
Vehicles and Equipment	Use biodegradable hydraulic fluids on hydraulic equipment	Contractor to research and identify opportunities				X	
Vehicles and Equipment	Implement and idle reduction plan	During construction planning phase, implement plan to minimize impact on ecosystem	X	X			X
Vehicles and Equipment	Limit on-site vehicle speed to reduce particle suspension and increase fuel efficiency	During construction planning phase, set limits to minimize impact on ecosystem	X	X		X	X
Vehicles and Equipment	Minimize diesel emissions through the use of retrofitted engines, ultra low or low sulfur diesel or alternative fuels, or filter/treatment devices to achieve BACT[1] or MACT[2]	Contractor to research and identify opportunities		X			
Vehicles and Equipment	Replace conventional vehicles with electric, hybrid, ethanol, or compressed natural gas vehicles	During construction planning phase, select equipment to minimize impact on ecosystem	X	X			
Wastewater	Use dewatering processes that maximize water reuse	Implementation of mechanical dredge will minimize the wastewater generation			X	X	
Wastewater	Use uncontaminated wastewater or treated water for tasks such as wash water, irrigation, dust control, constructed wetlands, or other uses	N/A. Treated water will be released to POTW or trucked to another permitted offiste facility			X	X	
Wastewater	Employ closed-loop gray water washing system for decontamination of trucks	N/A. Treated water will be released to POTW or trucked to another permitted offiste facility			X	X	

[1]/ best achievable control technology (BACT) is a pollution control standard mandated by the United States Environmental Protection Agency (USEPA)

[2]/ maximum achievable control technology (MACT) is a pollution control standard mandated by the United States Environmental Protection Agency (USEPA)

BMPs selected for quantitative footprint analysis:

- BMP 1. Fuel efficiency, BMP 2. Alternative fuel sources
- BMP 3. Recycle uncontaminated materials, use recycled products
- BMP 4. Wastewater treatment
- BMP 5. Restore streambanks, minimize sediment runoff

ATTACHMENT 3

SiteWise Input

BASELINE ANALYSIS =

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Excavator	Loader/Backhoe	Loader/Backhoe	Loader/Backhoe	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	26,500	10,970	800	4,370		
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT DREDGING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose dredge equipment type from drop down menu	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Choose dredge fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be dredged (yd3)	20,500					
Choose dredge equipment size	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1
Suggested dredge equipment size	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1
Input number of dredge tenders (default already present, user override possible)	1	1	1	1	1	1
Choose dredge tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	684	0	0	0	0	0
Input number of scow tenders (default already present, user override possible)	2	2	2	2	2	2
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possi	684	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override pc	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT MANAGEMENT (STAGING AND DRYING)	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Loader/Backhoe	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	47,000					
Is volume input that of saturated sediment?	Yes	Yes	Yes	Yes	Yes	Yes
Will the sediment be dry when this work is performed?	No	No	No	No	No	No
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT CAPPING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose capping method from drop down menu	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release
Choose capping equipment fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of capping material to be placed (yd3)	6,600	800				
Choose capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Suggested capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Input number of dredge tenders (hr) (default already present, user override possible)	1	1	1	1	1	1
Choose tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	220	200	0	0	0	0
Input number of scow tenders (default already present, user override possible)	0	0	0	0	0	0
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	0	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	1325					

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)	25	25	25	85		
Input operating hours (hr)	1100	2100	800	28		

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)	15.0	20.0		10.0		
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input total number of trips	3220.0	40.0		20.0		
Input number of miles per trip	250.0	20.0		250.0		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)	61100.0			200.0		
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	MD	MD	MD	MD	MD	MD

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)	196000					

BMP 1 – FUEL EFFICIENCY =

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Excavator	Loader/Backhoe	Loader/Backhoe	Loader/Backhoe	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	26,500	10,970	800	4,370		
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT DREDGING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose dredge equipment type from drop down menu	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Choose dredge fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be dredged (yd3)	20,500					
Choose dredge equipment size	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1
Suggested dredge equipment size	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1
Input number of dredge tenders (default already present, user override possible)	1	1	1	1	1	1
Choose dredge tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	616	0	0	0	0	0
Input number of scow tenders (default already present, user override possible)	2	2	2	2	2	2
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possi	616	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT MANAGEMENT (STAGING AND DRYING)	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Loader/Backhoe	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	47,000					
Is volume input that of saturated sediment?	Yes	Yes	Yes	Yes	Yes	Yes
Will the sediment be dry when this work is performed?	No	No	No	No	No	No
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT CAPPING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose capping method from drop down menu	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release
Choose capping equipment fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of capping material to be placed (yd3)	6,600	800				
Choose capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Suggested capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Input number of dredge tenders (hr) (default already present, user override possible)	1	1	1	1	1	1
Choose tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	198	180	0	0	0	0
Input number of scow tenders (default already present, user override possible)	0	0	0	0	0	0
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possi	0	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)	25	25	25	85		
Input operating hours (hr)	1000	1900	720	28		

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)	15.0	20.0		10.0		
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input total number of trips	3220.0	40.0		20.0		
Input number of miles per trip	250.0	20.0		250.0		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)	61100.0			200.0		
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	MD	MD	MD	MD	MD	MD

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)	196000					

BMP 2 – ALTERNATIVE FUEL =

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Excavator	Loader/Backhoe	Loader/Backhoe	Loader/Backhoe	Dozer	Dozer
Choose fuel type from drop down menu	Biodiesel 20	Biodiesel 20	Biodiesel 20	Biodiesel 20	Diesel	Diesel
Input volume of material to be removed (yd3)	26,500	10,970	800	4,370		
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT DREDGING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose dredge equipment type from drop down menu	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Choose dredge fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be dredged (yd3)	20,500					
Choose dredge equipment size	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1
Suggested dredge equipment size	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1
Input number of dredge tenders (default already present, user override possible)	1	1	1	1	1	1
Choose dredge tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override poss	684	0	0	0	0	0
Input number of scow tenders (default already present, user override possible)	2	2	2	2	2	2
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	684	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT MANAGEMENT (STAGING AND DRYING)	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Loader/Backhoe	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane
Choose fuel type from drop down menu	Biodiesel 20	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	47,000					
Is volume input that of saturated sediment?	Yes	Yes	Yes	Yes	Yes	Yes
Will the sediment be dry when this work is performed?	No	No	No	No	No	No
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT CAPPING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose capping method from drop down menu	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release
Choose capping equipment fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of capping material to be placed (yd3)	6,600	800				
Choose capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Suggested capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Input number of dredge tenders (hr) (default already present, user override possible)	1	1	1	1	1	1
Choose tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override poss	220	200	0	0	0	0
Input number of scow tenders (default already present, user override possible)	0	0	0	0	0	0
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	0	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

Method 2 - ELECTRICAL USAGE IS KNOWN						
Input equipment electrical usage, if known (kWh)	6625	0	0	0	0	0
Region						
Electricity Region	MD	MD	MD	MD	MD	MD

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	0					

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Biodiesel 20	Biodiesel 20	Biodiesel 20	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)	25	25	25	85		
Input operating hours (hr)	1100	2100	800	28		

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)	15.0	20.0		10.0		
Choose fuel used from drop down menu	Biodiesel 20	Biodiesel 20	Gasoline	Biodiesel 20	Gasoline	Gasoline
Input total number of trips	3220.0	40.0		20.0		
Input number of miles per trip	250.0	20.0		250.0		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)	61100.0			200.0		
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	MD	MD	MD	MD	MD	MD

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)	196000					

BMP 3 – RECYCLE/REUSE =

EQUIPMENT USE

EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Excavator	Loader/Backhoe	Loader/Backhoe	Loader/Backhoe	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	26,500	10,970	800	4,370		
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT DREDGING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose dredge equipment type from drop down menu	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Choose dredge fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be dredged (yd3)	20,500					
Choose dredge equipment size	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1
Suggested dredge equipment size	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1
Input number of dredge tenders (default already present, user override possible)	1	1	1	1	1	1
Choose dredge tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	684	0	0	0	0	0
Input number of scow tenders (default already present, user override possible)	2	2	2	2	2	2
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	684	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT MANAGEMENT (STAGING AND DRYING)	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Loader/Backhoe	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	47,000					
Is volume input that of saturated sediment?	Yes	Yes	Yes	Yes	Yes	Yes
Will the sediment be dry when this work is performed?	No	No	No	No	No	No
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT CAPPING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose capping method from drop down menu	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release
Choose capping equipment fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of capping material to be placed (yd3)	6,600	800				
Choose capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Suggested capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Input number of dredge tenders (hr) (default already present, user override possible)	1	1	1	1	1	1
Choose tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	220	200	0	0	0	0
Input number of scow tenders (default already present, user override possible)	0	0	0	0	0	0
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	0	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	1325					

RESIDUAL HANDLING						
RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)	15.0	20.0		0.0		
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input total number of trips	3220.0	40.0		0.0		
Input number of miles per trip	250.0	20.0		0.0		
LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)	61100.0			200.0		
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	MD	MD	MD	MD	MD	MD

RESOURCE CONSUMPTION						
WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)	196000					

BMP 4 – WASTEWATER TREATMENT =

EQUIPMENT USE						
EARTHWORK	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Excavator	Loader/Backhoe	Loader/Backhoe	Loader/Backhoe	Dozer	Dozer
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	26,500	10,970	800	4,370		
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT DREDGING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose dredge equipment type from drop down menu	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Choose dredge fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be dredged (yd3)	20,500					
Choose dredge equipment size	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1	awler Crane, 25 ton, 1
Suggested dredge equipment size	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1	wler Crane, 25 ton, 1
Input number of dredge tenders (default already present, user override possible)	1	1	1	1	1	1
Choose dredge tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	684	0	0	0	0	0
Input number of scow tenders (default already present, user override possible)	2	2	2	2	2	2
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	684	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT MANAGEMENT (STAGING AND DRYING)	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose earthwork equipment type from drop down menu	Loader/Backhoe	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane	Crawler Crane
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be removed (yd3)	47,000					
Is volume input that of saturated sediment?	Yes	Yes	Yes	Yes	Yes	Yes
Will the sediment be dry when this work is performed?	No	No	No	No	No	No
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

SEDIMENT CAPPING	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
Choose capping method from drop down menu	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release	Surface Release
Choose capping equipment fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of capping material to be placed (yd3)	6,600	800				
Choose capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Suggested capping equipment size/type	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge	Hopper Barge
Input number of dredge tenders (hr) (default already present, user override possible)	1	1	1	1	1	1
Choose tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override pos	220	200	0	0	0	0
Input number of scow tenders (default already present, user override possible)	0	0	0	0	0	0
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possil	0	0	0	0	0	0
Choose size of research vessel from drop down menu	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large	esearch Vessel (large
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override po	0	0	0	0	0	0
Will DIESEL-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No

GENERATORS	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
Choose fuel type from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Choose horsepower range from drop down menu	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Input operating hours (hr)	1325					

INTERNAL COMBUSTION ENGINES	Engine 1	Engine 2	Engine 3	Engine 4	Engine 5	Engine 6
Choose fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input fuel consumption rate (gal/hr or scf/hr)	25	25	25	85		
Input operating hours (hr)	1100	2100	800	28		

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING	Soil Residue	Residual Water	Material Residue	Other Residuals	Other Residuals	Other Residuals
Will DIESEL-run vehicles be retrofitted with a particulate reduction technology?	No	No	No	No	No	No
Input weight of the waste transported to landfill or recycling per trip (tons)	15.0	0.0		10.0		
Choose fuel used from drop down menu	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Input total number of trips	3220.0	0.0		20.0		
Input number of miles per trip	250.0	0.0		250.0		

LANDFILL OPERATIONS	Operation 1	Operation 2	Operation 3	Operation 4	Operation 5	Operation 6
Choose landfill type for waste disposal	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous	Non-Hazardous
Input amount of waste disposed in landfill (tons)	61100.0			200.0		
Input landfill methane emissions (metric tons CH4)						
Region						
Electricity Region	MD	MD	MD	MD	MD	MD

RESOURCE CONSUMPTION

WATER CONSUMPTION	Treatment System 1	Treatment System 2	Treatment System 3	Treatment System 4	Treatment System 5	Treatment System 6
Input total water consumed from potable water treatment facility (gal)						
Input total water disposed to wastewater treatment facility (gal)	0					

APPENDIX D—DESIGN CALCULATIONS

DESIGN CALCULATIONS

Calculation 8585-01	Tidal Datums
Calculation 8585-02	Design Wave Height and Period
Calculation 8585-03	Removal Volume Estimates
Calculation 8585-04	Dewatering Pad Design Considerations
Calculation 8585-05	Silt Curtain
Calculation 8585-06	Cow Pen Creek Restoration
Calculation 8585-07	Slope Stability Analysis
Calculation 8585-08-1	Armor Riprap Stability
Calculation 8585-08-2	Articulating Concrete Blocks
Calculation 8585-09	*In Situ* Treatment and MNR Evaluations