FINAL
FOCUSED FEASIBILITY STUDY

for

Stratford Army Engine Plant
Stratford, Connecticut

Contract No.: W912WJ-15-D-003
Task Order No.: 002

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Prepared for:

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This is to certify that Wood has performed a peer technical review of this deliverable under USACE NAE Contract No. W912WJ-15-D-0005 consistent with Wood's Quality Management Program Procedure-PJM-PRO-002, Technical Review.

QUALITY ASSURANCE STATEMENT

Delivery Order Title: Stratford Army Engine Plant Focused Feasibility Study

Task Order No.: 003

Wood Environment & Infrastructure Solutions, Inc. (Wood) has prepared this Focused Feasibility Study for the Stratford Army Engine Plant located in Stratford, Connecticut. The Program Manager and Project Manager have completed a technical and quality assurance review of this document for technical accuracy and completeness, in accordance with the objectives of the revised Performance Work Statement, dated January 13, 2017 and Wood's (fka Amec Foster Wheeler) Final Proposal, dated March 2, 2017.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

Amec Foster Wheeler	Amec Foster Wheeler Environment & Infrastructure
AOC	Area of Concern
AOI	Area of Interest
ASTM	American Society for Testing and Materials
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BRAC	Base Realignment and Closure
CENAE	United States Army Corps of Engineers New England District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Chain-of-Custody
COPC	Chemical of Potential Concern
CTDEP	Connecticut Department of Environmental Protection (pre-2011)
CT DEEP	Connecticut Department of Energy and Environmental Protection
CT DOT	Connecticut Department of Transportation
CU	Certification Unit
cy	Cubic Yard
ERDC	Engineer Research and Development Center
ERM-Q	Effects Range Median Quotient
FDR	Field Data Record
FOL	Field Operations Leader
FFS	Focused Feasibility Study
FSP	Field Sampling Plan
ft	Feet
HHBRA	Human Health Baseline Risk Assessment
HI	Hazard Index
H_2S	Hydrogen Sulfide
ID	Identification
Kgc2	kg/cm^2, kilograms per square centimeter
MNR	Monitored Natural Recovery
MSL	mean sea level
NCP	National Oil and Hazardous Substances Contingency Plan
NPDES	National Pollutant Discharge Elimination System

OATP	Oil Abatement Treatment Plant
PCB	Polychlorinated Biphenyls
ppm	parts per million
Project	Stratford Army Engine Plant Feasibility Study
Psi	pounds per square inch
QC	Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RDT	rapid drainage test
RI	Remedial Investigation
SAEP	Stratford Army Engine Plant
SD	Sediment
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SSHP	Site-Specific Safety and Health Plan
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
TSF	tons per square foot
VOC	Volatile Organic Compound
USACE	United States Army Corps of Engineers
U.S. Army	United States Department of the Army
USEPA	United States Environmental Protection Agency
µ	micron
Wood	Wood Environment & Infrastructure Solutions, Inc.
WWTP	waste water treatment plant

EXECUTIVE SUMMARY

The United States Army Corps of Engineers (USACE), New England District (CENAE) with the assistance of Wood Environment & Infrastructure Solutions, Inc. (Wood) has prepared this Focused Feasibility Study (FFS) report to document the remedial process and identify a preferred alternative for the Tidal Flats and the Outfall 008 drainage ditch for the Stratford Army Engine Plant (SAEP) (the Site), in Stratford, Connecticut (**Figure 1-1**).

The United States Department of the Army (U.S. Army) is undertaking this FFS as part of its obligations as lead agency for the Site under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12580. The Connecticut Department of Energy and Environmental Protection (CT DEEP) is the state support agency.

The purpose of the FFS is to develop and evaluate remedial alternatives for the Site in accordance with the requirements of CERCLA and generally follows U.S. Environmental Protection Agency (USEPA) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988).

Background

In October 1995, SAEP was placed on the Base Closure and Realignment (BRAC) list, known as BRAC 95. U.S. Army BRAC properties must be investigated to determine the nature and extent of environmental contamination. The Site has undergone various remedial investigations and remedies to date. This FFS focuses on the remedial alternatives for the sediment related to the tidal flats (Area of Concern 52) and the Outfall-008 (OF-008) drainage ditch (Area of Concern 25) portion of the Site. These sediments have been impacted by the following:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc);
- Polychlorinated biphenyls; and
- Polynuclear aromatic hydrocarbons (acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd) pyrene, naphthalene, phenanthrene, and pyrene).

The FFS identifies Applicable or Relevant and Appropriate Requirements (ARARs) for the Site, including location-, chemical-, and action-specific state and federal ARARs and “To be Considered” (TBC) non-promulgated criteria, advisories, guidance, and proposed standards issued by Federal and State governments (USEPA 1989). These ARARs were developed by reviewing federal environment laws and regulations and consulting with CT DEEP to determine which state laws and regulations are ARARs for this cleanup action. A critical consideration resulting from these consultations is the allowable work window for dredging. A seven-month dredging window has been assumed for purposes of the FFS based upon closure periods to protect winter flounder and anadromous fish. The ability to expand this window to twelve months will be key to completing the project in a timelier fashion.

Human Health and Ecological Risk Assessments

Human health and ecological risk assessments were performed for the sediment portion of the Site as part of previous remedial investigations (ACSIM, 2004). The Human Health Baseline Risk Assessment (HHBRA) showed risks associated with exposure to sediments in the Tidal Flats for future recreational users do not exceed the CERCLA 1E-04 total cumulative cancer risk threshold, or the CT DEEP cancer risk limit of 1E-05, applicable when evaluating multiple substances. Risks to recreational and commercial fisherman for consumption of finfish, ribbed mussels, and/or oysters taken from the Tidal Flats exceed the CT DEEP cancer risk limit of 1E-05, applicable when evaluating multiple substances, due to PCB Aroclors 1248, 1254, 1260, and/or arsenic. The estimated hazard index (HI) value for future recreational use (wading) at the Outfall 008 Drainage ditch does not exceed a value of 1 under the assumption that the total chromium detected in ditch sediments is present as trivalent chromium. The Baseline Ecological Risk Assessment (BERA) results indicate no unacceptable risk to macroinvertebrates, forage fish, black duck, or great blue heron in the Tidal Flats; however, there is a potential risk to sandpipers due to chromium in sediment and mercury (assumed to be methyl mercury) in biota. In the Outfall 008 drainage ditch, the BERA indicated a potential risk to macroinvertebrates in sediment due to inorganics and PCB Aroclor 1260, as well as potential risk to sandpipers from chromium to sandpipers, herons, and ducks if they frequently forage at this location (considered unlikely due to poor habitat quality).

Establishing Remedial Goals

Based on the age of the sediment data (1992-1998) associated with the HHBRA and BERA, the CT DEEP requested that, prior to establishment of remedial goals for sediment in the Tidal Flats and Outfall 008 drainage ditch sediments, additional sediment characterization, including toxicity testing, be conducted. Sediment toxicity testing and additional sediment characterization was conducted by the Army in 2014 and 2015. The results of the toxicity testing indicated toxicity to macroinvertebrates from sediment, in contrast to earlier BERA findings, although the toxicity could not be linked to a specific chemical. As an alternative to using toxicity test results alone for development of remediation endpoints, an average Effects Range Median Quotient (ERM-Q) of 0.5 for eight metals (arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc) has been agreed to by CT DEEP to serve as a surrogate for evaluation of toxicity. The pathway to the determination of remedial goals for contaminated sediments in the Tidal Flats and Outfall 008 drainage ditch is documented in Appendix A (see **Appendix A-1** – Final Sediment Remediation Endpoints Report and **Appendix A-2 -** Addendum to Final Sediment Endpoints Report), resulting in the following preliminary remediation goals (PRGs):

- Sample locations with an average ERM-Q value greater than or equal to 0.5 for eight metals (arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc) will be removed; and

- PCB and mercury concentrations after remediation will be not substantially different from those found in reference locations (0.2 mg/kg for total PCBs and 0.4 mg/kg for mercury).

Based on those PRGs, remedial action objectives (RAOs) were established for the site according to the following:

- Tidal Flats, AOC 52: Reduce risk to the environment by reducing sediment toxicity in the top 4 ft of sediment by removing sediment with average ERM-Q values of 0.5 for eight Site-related metals.
- The OF-008 Drainage Ditch AOC 25 - Reduce risk to the environment by reducing sediment toxicity in the top 4 ft of sediment by removing all sediments along the entire length of the OF-008 drainage ditch (inclusive of the "T" section extending to Route 113 to the southwest and Marine Basin to the northeast) to a depth of 4 ft below ground surface.

Upon achieving the RAOs within the Tidal Flats, the remaining total PCBs and mercury concentrations will be not substantially different from background (0.2 and 0.4 mg/kg, respectively), and risks to potential future human and ecological receptors will be substantially reduced. Similarly, upon achieving the RAOs for the Outfall 008 drainage ditch, risks to potential future human and ecological receptors will be substantially reduced.

Based upon these RAOs, approximately 139,341 cubic yards (cy) would require removal within the Tidal Flats, including approximately 8,854 cy of PCB impacted sediments containing greater than or equal to 1.0 ppm PCBs that would be regulated under the Toxic Substances Control Act (TSCA). Those sediments containing between one and less than 50 ppm (8,495 cy), while still regulated under TSCA, may be disposed of in a RCRA Subtitle D landfill. For disposal of >/= 50 ppm PCBs, the PCB regulations authorize disposal of these wastes at TSCA-permitted disposal facilities as well as at RCRA hazardous waste landfills (see 761.61(a)(5)(i)(B)(2)(iii). Approximately 359 cy of PCB impacted sediments contain 50 ppm or more PCBs. The remaining 130,487 cy of sediments containing PCBs at concentrations less than 1.0 ppm are potentially eligible for on-site beneficial reuse. For purposes of the FFS, the volumes and related horizontal and vertical delineation of the remedial footprint have been assumed to be sufficient for remedial implementation based upon the sample density and number of samples previously collected to support remedial footprint decisions presented in the Final Sediment Endpoints Report (Amec Foster Wheeler, 2018a) and Addendum to the Final Sediment Endpoints Report (Amec Foster Wheeler, 2018b). For the OF-008 drainage ditch, a total of approximately 4,900 cy of sediments require remediation, consisting of 1,105 cy of PCB impacted sediments greater than or equal to 1.0 ppm but less than 50 ppm (TSCA-regulated and eligible for RCRA D disposal) and 3,795 cy of non-TSCA sediments (eligible for on-site beneficial reuse).

General Response Actions

General Response Actions (GRAs) and technologies appropriate to meet the RAOs were then identified and screened. Several GRAs (broad categories of technologies) were eliminated from detailed consideration due to the U.S. Army's preference for removal of sediments and elimination of long-term liability. Monitored Natural Recovery, containment, and in-situ treatment were all eliminated as classes of technologies. Removal and other ancillary support technologies were advanced to technology screening.

Technology Identification and Screening

The universe of potentially applicable removal technologies and related processing and support technologies such as dewatering and disposal was identified and screened. All technologies were evaluated against the effectiveness and implementability criteria. A qualitative assessment of relative cost was developed. A conclusion was then drawn regarding each technology each of which was then either eliminated from further consideration or retained for inclusion in the Tidal Flats and/or Outfall 008 drainage ditch alternatives.

A detailed technology screening of dredging technologies was performed and included the evaluation of hydraulic dredging, mechanical dredging, mechanical dredging with hydraulic transport, pneumatic flow tube mixing (combination of mechanical dredging and pneumatic transport with the introduction of processing additives, amphibious dredging (versatile dredging equipment that can work in a variety of water depth and sediment conditions), and conventional removal with a terrestrial long-stick excavator. All options were carried forward into alternatives development. A detailed dredging alternatives evaluation report is included in the Appendices to this report. All mechanical dredging discussed in this FFS refers to dredging equipment that utilizes precision level cut sealed environmental dredging buckets and GPS positioning software to ensure accurate removals with low potential for resuspension and residuals generation.

Other key aspects of the technology screening included the evaluation of dewatering technologies which include: gravity dewatering, stabilization and solidification, belt filter press dewatering, recess chamber filter press, centrifuge, pneumatic flow tube mixing, and several other proprietary dewatering systems (e.g., Hi-G, Genesis).

Disposal technologies evaluated included: confined aquatic disposal (CAD), confined disposal facility (CDF), on-site beneficial reuse, and off-site disposal or reuse.

Treatability Testing

Throughout the technology and alternatives identification and screening process, treatability testing was conducted to evaluate several sediment processing technologies, including dewatering, solidification, and water treatment. Representative samples from several areas of the site were collected to develop a treatability composite sediment sample. Other supporting sample collection and analysis was conducted including modified elutriate, geotechnical evaluations, leaching tests relevant to on- and off-site disposal, waste characterization analysis, and evaluation of residuals from dewatering and solidification treatability testing.

Several dewatering options were evaluated including gravity, belt filter press, recessed chamber, centrifuge, and Geotube dewatering. All dewatering technologies evaluated as part of this FFS were successful at producing a sediment which passed the paint filter test except for gravity dewatering. The belt filter press simulation produced sediment cake with the highest percent solids (53%, passing paint filter) when compared with the other mechanical dewatering technologies (centrifuge and recessed chamber) using a simulated dredge slurry treated with a cationic organic polymer (Solve 137). Additional tests on untreated (no polymer added) slurry yield higher results for the recessed chamber (66%); however, belt press was selected for inclusion the FFS to represent mechanical dewatering technologies. Two additives were evaluated for solidification of sediments generated from the belt press and gravity dewatering: Portland cement and Calciment. Solidification results show excellent strength gain of sediment with Portland cement, and very modest or no strength gain with Calciment. The lowest additive ratio tested for Calciment added to gravity-dewatered sediments did not produce sediments that would pass the paint filter test. Based on the solidification test results, for purposes of the FFS it has been assumed that an addition rate of 6% Portland cement is appropriate for mechanically dredged sediments that are gravity drained. Additional solidification tests performed to simulate pneumatic flow tube mixing (PFTM) also showed excellent strength gain for all percentages tests (6% up to 14%). Therefore, for purposes of this FFS, an addition rate of 6% Portland cement has been selected for addition to sediments processed via PFTM technology to eliminate free moisture and develop strength. No additives are proposed for sediments dewatered via either belt press or Geotube because those methods produced sediments passing the paint filter test (no free liquids)

In addition, leaching tests performed on solidified sediments (for both Portland cement and Calciment additives) show materials pass on-site placement criteria (GWB Synthetic Precipitation Leaching Procedure [SPLP] standards under the CT Remediation Standard Regulations [RSRs]) and off-site disposal (Toxicity Characteristic Leaching Procedure [TCLP] analysis for RCRA toxicity). In addition, untreated sediments also pass both SPLP and TCLP derived criteria for on- and off-site reuse/disposal. These results provide data to support the option to beneficially reuse solidified or non-solidified sediment on the site as potential future fill material.

Initial results of dewatering fluid testing (0.45 micron (µ)) filtered and unfiltered fluids were analyzed) suggested that PCBs and copper may be present in the total and dissolved phases at concentrations exceeding state chronic saltwater criteria. These results suggested that filtration for particulate removal and carbon adsorption may be required to remove PCBs and additional steps for dissolved metals could potentially be required. Subsequent testing was then performed on belt press generated dewatering fluids to determine if a finer filter size and carbon adsorption would further reduce PCBs and copper in water to be discharged. A series of tests were performed on unfiltered and 0.1µ filtered water from the belt press in which a control sample was analyzed and four additional samples with different amounts of activated carbon were added. Results show only copper exceeded CT SB surface water standards in the control samples (0.1µ filtered). There were no exceedances for either PCBs or site metals in any of the other samples.

These results suggest that filtration at the 0.1 µ size is sufficient to remove particulate adsorbed PCBs and that PCBs may not be truly dissolved, given that 0.45 µ filtration shows PCBs present. Furthermore, because PCBs were not detectable above reporting limits in control samples, filtration alone may be sufficient to reduce PCB concentrations to below SB standards. Regarding copper, which was present in control samples at concentrations exceeding SB standards, carbon reduced copper concentrations in dewatering fluids to undetectable levels (below SB standards) using an activated carbon type specially manufactured to remove metallic ions. Therefore, to ensure both PCBs and copper are treated, it is recommended that water treatment include both carbon adsorption and filtration. Additionally, it is recommended that additional discussions with CT DEEP and other appropriate agencies be conducted to establish appropriate discharge criteria for discharge return to the Housatonic River or other indirect discharges to the Stratford Waste Water Treatment Plant (WWTP) if required, accounting for possible dilution. The Engineer Research and Development Center (ERDC) will be conducting dilution modeling to support the analysis and decision for an appropriate dilution factor which may reduce the scope or cost of treatment required.

Alternatives Development and Screening

Eleven alternatives were developed for the Tidal Flats and three alternatives were developed for the OF-008 drainage ditch to provide a wide range of options for the site, with each set including a No Action Alternative. All alternatives were evaluated against the effectiveness, implementability, and cost criteria for screening purposes. For the Tidal Flats, the No Action Alternative (Alternative 1), two alternatives including a sheet pile cofferdam to isolate the dredge area (Alternatives 7 and 8), Amphibious Dredging (Alternative 9), a shoreline CDF alternative for disposal of sediments (Alternative 10), and two CAD cell options (within the Tidal Flats and within the Housatonic River, Alternative 11) were eliminated from further consideration.

The No Action alternative was eliminated due to the requirement to remove sediments. The sheet pile cofferdam options (Alternatives 7 and 8) were eliminated due to the high cost of installing the cofferdam, the extended schedule to design and install the cofferdam, and other technical complexities related to its location adjacent to an existing breakwater and within contaminated areas on the site. Amphibious Dredging (Alternative 9) was dropped from further consideration due to its high potential for generating residuals and resuspended sediments. Alternative 10 (shoreline CDF) was eliminated from further consideration due to its very high cost to install an adequately stable sheet pile wall and the building demolition that would be needed to accommodate space for sediments behind the CDF. Alternative 10 would also not provide any improvement in effectiveness and would be more difficult to implement than other alternatives. Alternative 11 (CAD) was eliminated from further consideration due to the need for sheet pile walls (at tidal flats location), sediment re-handling, the need for an additional geotechnical investigation, and requirement to stockpile excess sediments on land.

Alternatives 2, 3, 4, 5, and 6 were retained for detailed evaluation. These alternatives include various combinations of mechanical and hydraulic dredging; mechanical, hydraulic, and pneumatic transfer of sediments; gravity dewatering, belt filter press dewatering, and Geotube dewatering; solidification; and on-site beneficial reuse or off-site disposal. **Table ES-1** summarizes these options.

For OF-008 three alternatives were developed, including No Action (Alternative 1), Excavation, (Alternative 2) and Mechanical Dredging (Alternative 3). The No Action alternative and Mechanical Dredging were eliminated from further consideration, due to the requirement for removal at the site (No Action) and the lack of effectiveness expected from mechanical dredging in the drainage ditch. Alternative 2, Excavation, was carried forward into the detailed evaluation.

Detailed Evaluation of Alternatives

For purposes of the detailed evaluation, each of the five remedial alternatives for the Tidal Flats was combined with the single alternative for OF-008 to provide complete Site wide alternatives for remediation of the sediments. The following five alternatives (see **Table ES-1** for a summary of the Tidal Flats components) were carried forward into detailed analysis:

- Alternative 2: Hydraulic Dredging and Transport, Filter Press or Geotube Dewater, On-Site Beneficial Reuse or Off-Site Disposal
    - Tidal Flats: Hydraulic dredge to hydraulic off-load and filter press dewater with mechanical backfill for restoration and on-site beneficial reuse or off-site disposal
    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area and on-site beneficial reuse or off-site disposal. Mechanical backfill and restoration.
- Alternative 3: Mechanical Dredging and Transport, Dewater, Solidify, On-Site Beneficial Reuse or Off-Site Disposal
    - Tidal Flats: Precision mechanical dredging to mechanical off-load, dewater and solidify, with mechanical backfill for restoration and on-site beneficial reuse or off-site disposal
    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area and on-site beneficial reuse or off-site disposal. Mechanical backfill and restoration.
- Alternative 4: Mechanical Dredging with Hydraulic Transport, Belt Press or Geotube Dewater, On-Site Beneficial Reuse or Off-Site Disposal
    - Tidal Flats: Precision mechanical dredging to hydraulic offload and filter press dewater with mechanical backfill for restoration and on-site beneficial reuse or off-site disposal.
    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area and on-site beneficial reuse or off-site disposal. Mechanical backfill and restoration.
- Alternative 5: Mechanical Dredging with Pneumatic Flow Tube Mixing Transport and Dewater, On-Site Beneficial Reuse

- ▶ Tidal Flats: Precision mechanical dredging to pneumatic flow tube mixing with mechanical backfill for restoration and on-site beneficial reuse

- ▶ OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area and on-site beneficial reuse. Mechanical backfill and restoration.

▶ Alternative 6: Mechanical Dredging, Off-Site Transport, Process and Disposal

- ▶ Tidal Flats: Precision mechanical dredging to barge off-site for processing (Clean Earth or Tipping Point) with mechanical backfill for restoration and off-site disposal.

- ▶ OF-008: Isolate and dewater area for mechanical excavation and truck transport to on-site sediment processing area and off-site disposal. Mechanical backfill and restoration.

Table ES-1 summarizes the components of each remedial alternative for the Tidal Flats remedial area and the disposal and dewatering options as described above. For costing purposes each of alternatives 2 through 4 include the following:

- An on-site beneficial re-use option for sediments containing less than 1.0 mg/kg PCBs coupled with off-site disposal for all other sediments at appropriate RCRA-D and TSCA facilities; and
- An off-site disposal option (assuming no on-site beneficial reuse) for all sediments at appropriate RCRA-D and TSCA facilities.

Alternative 5 (solidification through the PFTM process) includes only on-site beneficial reuse of sediments containing less than 1.0 mg/kg PCBs and off-site disposal of sediments exceeding PCB concentrations of 1.0 mg/kg. Alternative 6 does not include an on-site beneficial re-use option and only considers off-site disposal of all sediments via barge transport and off-site processing and disposal. Alternatives 2 and 4 also include dewatering options for the use of either a belt filter press or Geotubes, as these technologies were successful at producing dewatered sediment which passed the paint filter test.

Each of the five alternatives were described in detail and then evaluated against seven of the nine CERCLA FS criteria, including Overall Protection of Human Health and the Environment, Compliance with ARARs, Long-term Effectiveness, Short-term Effectiveness, Reduction of Toxicity, Mobility, or Volume through Treatment, Implementability, and Cost and Region I and CT-specific Sustainability criteria. The two remaining criteria, State and Community Acceptance, will be evaluated following public and state review of the Proposed Plan and documented in the Responsiveness Summary within the Decision Document. Cost evaluations include the development of capital costs, operations, maintenance, and monitoring costs (OMM), total costs, and total present worth costs.

Comparative Analysis

A comparative analysis was then conducted to identify the balancing factors to aid in selection of a preferred remedy. Based on this evaluation, all alternatives would meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs, and there are no substantive differences with respect to these criteria among the alternatives. Each of these alternatives would adequately remove sediments to meet RAOs (providing protection to human health and the environment) and the work would be performed in compliance with ARARs.

The remaining criteria are known as the "primary balancing" criteria. The evaluations are summarized as follows:

Long-term Effectiveness. Each of the alternatives would permanently remove sediments from Tidal Flats and OF-008, and place backfill materials to reestablish habitat. There is essentially no difference between alternatives with respect to this criterion. Following remediation, ecological risks would be addressed in the tidal flats and the Outfall 008 drainage ditch, with no sediments remaining within these areas exceeding site PRGs. Any site contaminants remaining would be at concentrations that do not cause exceedance of the ERM-Q of 0.5, and below 0.40 mg/kg Hg and 0.2 mg/kg PCBs (PCBs and Hg are co-located with the other eight targeted inorganics and are therefore not driving the remediation footprint).

However, when comparing options for on-site re-use and off-site disposal, off-site disposal has more permanence because the material would be placed in a secure offsite landfill facility rather than placed on-site. For placement of contaminated sediments on land, the State of CT does not have regulations that are directly applicable; however, through dewatering and processing of the removed sediments, the material will be rendered soil-like and as such, the "polluted soil" regulations[1] are relevant and appropriate to the placement and beneficial re-use of site sediments at the site. The polluted soil regulations require certain conditions to be met prior to placement of contaminated materials (RSRs Section 22a-133k-1(h)) on land – these conditions would be met including placement above the water table and documenting the location of the polluted soil with the Commissioner; however, under CT RSRs it is uncertain if the material would be considered "inaccessible soil" or "environmentally isolated" because the exact location for placement has not yet been determined, and ultimately must be consistent with the future developer's plans. Therefore, the adequacy and reliability of the engineering controls to be used to ensure future isolation of the contaminated materials is uncertain until a full development plan is available.

Furthermore, on-site options that do not include solidification, Alternatives 2 and 4, which rely on mechanical dewatering methods or Geotubes, do not require the addition of additives for placement on site. In this respect, the remediation may not be permanent because future solidification may be required to meet future reuse criteria with respect to strength, which are currently unknown.

[1] The "polluted soil" definition (Remediation Standard Regulations Section 22a-133k-1(a)(50) includes soil that is affected by a release of a substance at concentrations above the analytical detection limit for that substance; however, the definitions of soil and sediment are mutually exclusive, and no analogous definition is provided for sediment.

Reduction of Toxicity, Mobility, and Volume through Treatment. None of the alternatives have treatment as a principle element to permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. However, all alternatives include some form of treatment to process dredged material or treat dewatering fluids. Alternatives that involve hydraulic transport of sediment significantly increase the volume of materials requiring processing/treatment due to the large volume of water entrained to move sediments in a slurry. Alternative 2 is evaluated least favorably, followed by Alternative 4, and then the remaining alternatives. Alternatives that involve the addition of additives to sediments increase the volume of materials, which is viewed negatively under this criterion. This includes any process involving mechanical dredging due to the need for additives (e.g., Portland cement) to reduce free water. However, this volume increase is modest relative to the volume of water entrained in hydraulic transport options. Mechanical dredging options generate a lower volume of dredged materials than hydraulic dredging options due to the high level of precision of the level cut bucket proposed.

Short Term Effectiveness. The main differentiating factor under this criterion is time to achieve RAOs. Alternatives that include mechanical dredging and mechanical transport (Alternatives 3, 5, and 6) have the highest dredging productivity and therefore the shortest overall schedule and are evaluated more highly in this regard. Mechanical dredging with hydraulic transport (Alternative 4) has a slightly longer schedule due to the more complex slurry component required to transport sediment to land. Alternative 2 (Hydraulic dredging) would have the longest overall schedule and therefore is evaluated least favorably.

An additional consideration is release of suspended sediments, which has the potential to impact downstream ecological receptors. All mechanical and hydraulic dredging alternatives will cause release and resuspension to some degree as affected by the necessary operational processes; for example, at the cutter head or bucket, tug and support vessel propwash, anchor management, pipeline back flushing, and impacts with the bed. In most cases these release mechanisms can be managed by selecting appropriately sized and configured equipment, conducting operations in a manner that avoids or minimizes release, and mitigated by installing proper engineering controls. Properly installed and maintained turbidity curtain systems coupled with a properly implemented turbidity monitoring, maintenance, and management program would are one such engineering control that can substantially contain resuspension.

Implementability. Generally, the dredging technologies selected (mechanical and hydraulic) are widely available and proven and evaluated similarly for implementability. Alternatives 2 (hydraulic), 3 (mechanical), and 6 (mechanical/off-site processing and disposal) are all evaluated similarly with respect to implementability for the sediment portions of the alternatives. Alternatives 3 and 5 rely upon innovative technologies (mechanical dredging with hydraulic transport) or technologies that are not widely used (PFTM) and are therefore considered more difficult to implement given the scarcity of contractors able to perform the work. Alternatives that rely on significant water treatment systems (Alternatives 2 and 4) are considered more difficult to implement given the additional complexity of mobilizing and operating large dewatering and water treatment systems. Alternative 5 (PFTM) has the added advantage of very little or no water treatment required for non-TSCA sediments. In addition, the Geotube option is evaluated more favorably over the mechanical dewatering option (belt press) based on its simpler operation. However, both the belt filter press and Geotube options require a larger footprint relative to alternatives that rely on gravity dewatering, complicating site logistics, particularly when considering on-site placement of fill materials.

Cost. Both on-site beneficial reuse and off-site disposal were evaluated. For on-site reuse, Alternative 3, Mechanical Dredging and Alternative 4, Hybrid Dredging (Geotubes) have the lowest estimated costs at $79.4M and $78.4M, respectively. For off-site disposal, Alternative 6 (off-site disposal via barge) had the lowest overall cost ($93.5M). Figure ES-1 presents the total cost for each alternative (with both on-site beneficial reuse and off-site disposal options). Figure ES-1 also includes lines indicating the -30% cost line and +50% cost line for each option. These lines depict graphically the CERCLA-defined cost accuracy range of -30%/+50%. The two lines for on-site re-use options and the two lines for the off-site disposal options illustrate that all remedial alternative costs fall within the CERCLA range of FS accuracy as defined by the alternatives analyzed, indicating that differences in cost among the alternatives are generally not significant given the current stage of project definition.

Preferred Remedy

Based upon the detailed and comparative analyses, the preferred remedy is Alternative 3, Mechanical Dredging for on-site beneficial reuse of sediments. This option has the highest anticipated productivity rates (and therefore shortest overall schedule) and would generate a smaller volume of dredged material than hydraulic dredging based on the precision mechanical dredging bucket proposed. In addition, this option would generate a significantly lower volume of water relative to hydraulic dredging or hydraulic transport options (Alternative 2 and 4). A precision low turbidity level cut environmental clamshell bucket would be used to minimize over-dredge and the generation of resuspended sediments. As with any of the alternatives, resuspended sediments can be adequately controlled through a properly implemented turbidity monitoring, management, and engineering controls program via silt curtain or other appropriate technology and proper selection of equipment by an experienced dredging contractor. The use of a precision low turbidity level cut environmental clamshell bucket results in a reduction of volume of dredged materials relative to hydraulic dredging options based upon its accuracy. In addition, this type of bucket will result in less mixing of underlying clean sediments relative to hydraulic dredging. Mechanical dredging systems are more easily converted to capping barges, which reduces costs. Mechanically dredged and conveyed materials will require cement solidification because gravity drainage alone will not reduce free liquids sufficiently; however, this is a standard element of dredged material processing and not difficult to incorporate. In addition, Alternative 2 and 4 do not include Portland cement, so an additional cost for solidification would be realized to ultimately meet on-site strength requirements for beneficial reuse.

In summary, when on-site beneficial re-use is considered, Alternative 3 would meet the threshold criteria and provides the best performance relative to the balancing criteria. Alternative 3 would provide benefits comparable to or better than all other on-site reuse options while achieving this at a low overall cost using the proven and accurate technologies that achieve results quickest with the lowest overall environmental impacts.

If off-site disposal of all sediments is required, Alternative 6 (Mechanical Dredging and Off-site Disposal via Barge) would achieve the same benefits with respect to dredging activities as Alternative 3 (Mechanical Dredging) but would achieve those results at the lowest cost relative to other options that couple dredging with off-site disposal via truck. In addition, because all tidal flats work would be managed from the water, Alternative 6 would have essentially no on-site footprint, except for a limited area to support the Outfall 008 work including material processing and transport. The limited on-site footprint would provide a significant benefit for the schedule of on-site development by allowing dredging and site development work to continue simultaneously.

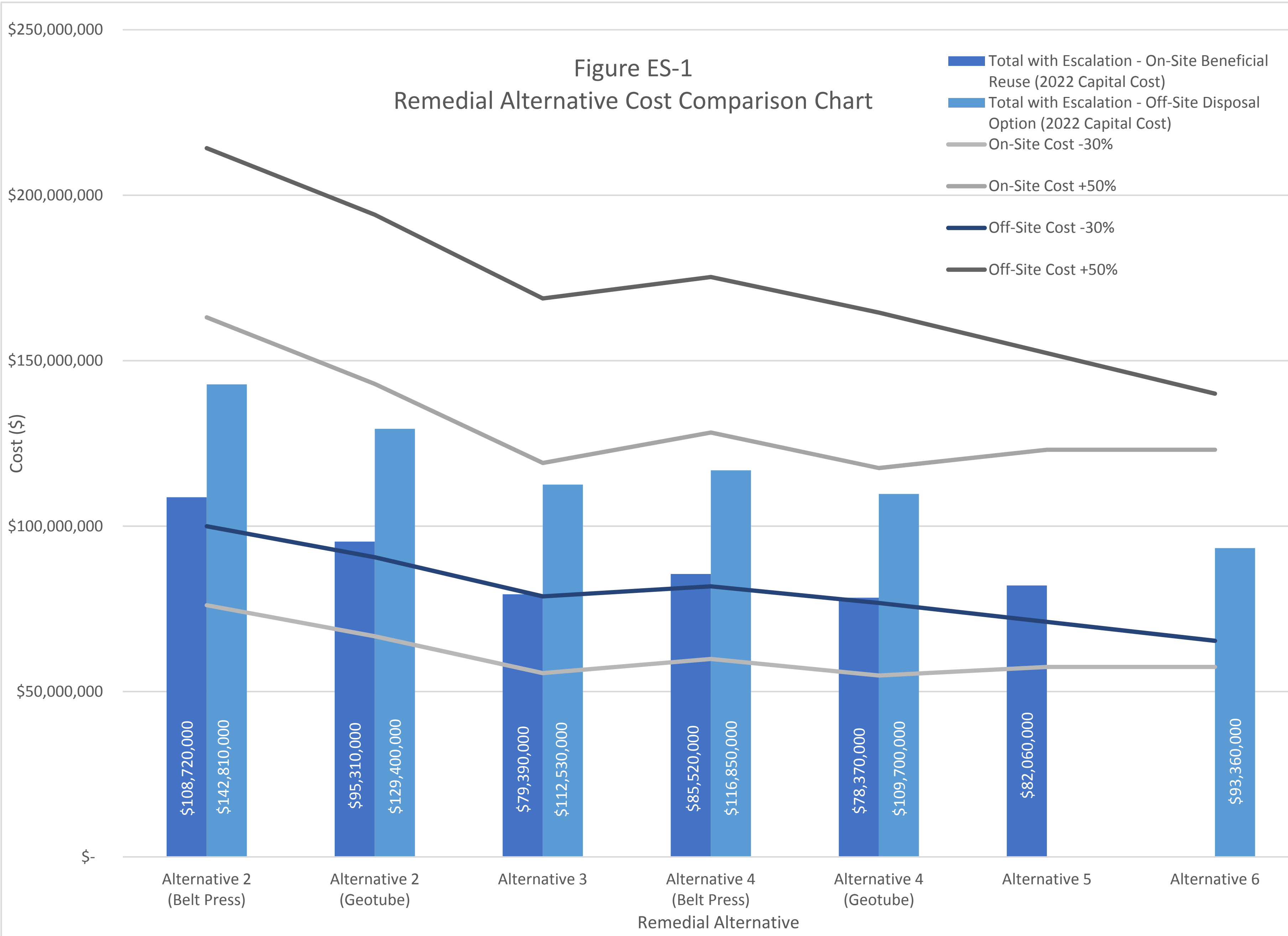
Figure ES-1
Remedial Alternative Cost Comparison Chart
Total with Escalation - On-Site Beneficial Reuse (2022 Capital Cost)
Total with Escalation - Off-Site Disposal Option (2022 Capital Cost)
On-Site Cost -30%
On-Site Cost +50%
Off-Site Cost -30%
Off-Site Cost +50%
Cost ($)
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$-
$108,720,000
$142,810,000
$95,310,000
$129,400,000
$79,390,000
$112,530,000
$85,520,000
$116,850,000
$78,370,000
$109,700,000
$82,060,000
$93,360,000
Alternative 2 (Belt Press)
Alternative 2 (Geotube)
Alternative 3
Alternative 4 (Belt Press)
Alternative 4 (Geotube)
Alternative 5
Alternative 6
Remedial Alternative

Table ES-1
Alternative Summary
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Dredge Method	Transport	Dewater Method	PCB < 1.0 mg/kg	1.0 mg/kg ≤ PCB < 50 mg/kg	50 mg/kg ≤ PCB
Alternative 2 Hydraulic Dredge to Hydraulic Transport with Dewatering: Belt Press or Geotubes	Hydraulic	Hydraulic	Belt Filter Geotube	On-Site Beneficial Reuse or Off-Site Disposal at RCRA D Facility	Off-Site Disposal at RCRD D Facility	Off-Site Disposal at TSCA Permitted Facility
Alternative 3 Mechanical Dredge to Mechanical Transport with Solidification (Portland Cement)	Mechanical	Mechanical	Gravity and Solidification	On-Site Beneficial Reuse or Off-Site Disposal at RCRA D Facility	Off-Site Disposal at RCRD D Facility	Off-Site Disposal at TSCA Permitted Facility
Alternative 4 Mechanical Dredge to Hydraulic Transport with Dewatering: Belt Press or Geotubes	Mechanical	Hydraulic	Belt Filter Geotube	On-Site Beneficial Reuse or Off-Site Disposal at RCRA D Facility	Off-Site Disposal at RCRD D Facility	Off-Site Disposal at TSCA Permitted Facility
Alternative 5 Mechanical Dredge to PFTM Transport and Solidification (Non-TSCA) and Barge Transport (TSCA)	Mechanical	PFTM (on-site) Barge (off-site)	Gravity and PFTM Solidification	On-Site Beneficial Reuse or Off-Site Disposal at RCRA D Facility	Off-Site Disposal at RCRD D Facility	Off-Site Disposal at TSCA Permitted Facility
Alternative 6 Mechanical Dredge to Mechanical Transport for Off-Site Process/Disposal (All)	Mechanical	Barge	Gravity and Off-Site Solidification	On-Site Beneficial Reuse or Off-Site Disposal at RCRA D Facility	Off-Site Disposal at RCRD D Facility	Off-Site Disposal at TSCA Permitted Facility

Notes:
PFTM = Pneumatic Flow Tube Mixing; TSCA = Toxic Substance Control Act

1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE), New England District (CENAE) with the assistance of Wood Environment & Infrastructure Solutions, Inc. (Wood) has prepared this Focused Feasibility Study (FFS) report to document the remedial process and select a remedial alternative for dredging of sediments in the Tidal Flats and the Outfall-008 (OF-008) drainage ditch (the Site) at the Stratford Army Engine Plant (SAEP), in Stratford, Connecticut (**Figure 1-1**).

The United States Department of the Army (U.S. Army) is undertaking this FFS as part of its obligations as lead agency for the Site under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12580. The Connecticut Department of Energy and Environmental Protection (CT DEEP) is the state support agency.

The Tidal Flats and OF-008 define the Site as discussed in this FFS, the remainder of the SAEP is regulated under a Resource Conservation and Recovery Act (RCRA) Stewardship Permit and will be addressed under separate action(s).

1.1 Purpose and Organization of Report

The purpose of the FFS is to develop and evaluate remedial alternatives for the Site in accordance with the requirements of the CERCLA and follows U.S. Environmental Protection Agency (USEPA) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988).

The FFS report is based on the nature and distribution of contaminants, human-health and ecological risk assessments, derivation of the effects range median quotient (ERM-Q) and use of the ERM-Q value of 0.5 to define the proposed areas to be remediated (Amec Foster Wheeler, 2018a). The report consists of the following seven sections:

Section 1.0 introduces the FFS report and its purpose. Section 1.0 briefly describes the FFS process to enhance the reader's understanding when reviewing relevant sections of the report and includes a brief background description of the SAEP including site location and facility history. Previous remedial investigations (RI) are summarized in the Sediment Remediation Endpoints Report (Amec Foster Wheeler, 2018a) which is included as **Appendix A-1**. Section 1.0 also summarizes site characteristics associated with the Tidal Flats and OF-008, the contamination assessment for Area of Concern (AOC)-52 Tidal Flats and AOC-25 OF-008 drainage ditch, and work with the CT DEEP to develop remedial goals based on multiple site-related chemicals in comparison to background concentrations in the Housatonic River sediment. Section 1.0 also presents a site conceptual model that considers the interrelationships of contaminant source areas, site geology, site hydrogeology, contaminant persistence, and contaminant distribution.

Section 2.0 identifies the basis for remediation. This section links the results of the risk assessments to the selection of remedial technologies by identifying remedial response objectives and preliminary remediation goals (PRGs), developing remedial action objectives (RAOs), and listing the resultant general response actions (GRAs). This section initiates the risk-management decision process and presents Applicable or Relevant and Appropriate Requirements (ARARs) for the project including location-, chemical-, and action-specific state and federal ARARs and "To be Considered" (TBC) non-promulgated criteria, advisories, guidance, and proposed standards issued by Federal and State governments (USEPA 1989).

Section 3.0 identifies and screens remedial technologies for the corresponding GRAs.

Section 4.0 describes the assembly of these technologies into remedial alternatives, and screens them against the criteria of implementability, effectiveness, and cost.

Section 5.0 presents the detailed evaluation of the retained remedial alternatives. Detailed descriptions of the components of each alternative and an evaluation of each alternative against the first seven evaluation criteria (Overall Protection of Human Health and Environment, Compliance with ARARs, Long-term Effectiveness, Reduction of Toxicity, Mobility, and Volume through Treatment, Implementability, and Cost) listed in the National Oil and Hazardous Substances Contingency Plan (NCP) (USEPA, 1990) are presented.

Section 6.0 presents the comparative analysis of the retained alternatives with respect to CERCLA guidance highlighting relative advantages and disadvantages of, and differences between, the alternatives with respect to the seven evaluation criteria.

Section 7.0 presents the preferred alternative selected based on the comparative analysis and a four-point ranking system for each of the seven criteria. The tradeoffs between the alternatives and how the scoring was developed are described.

Section 8.0 presents the historic documents and references cited in the text of this FFS.

Figures, Tables, and Appendices are presented following Section 8.

1.2 Background

The former SAEP is located at 550 Main Street in Stratford, Connecticut. This FFS is solely focused on the Tidal Flat area (AOC-52) located between the SAEP and the Housatonic River channel, and the OF-008 drainage ditch (AOC-25) (**Figure 1-2**) which are being remediated under CERCLA and DERP. The remainder of the Site is regulated under RCRA Stewardship permit. Compliance work performed under the Stewardship Permit is a separate, future action.

The property was developed in 1927 for Sikorsky Aircraft where aircraft and engines were manufactured from 1929 to 1948. The plant was expanded during World War II to accommodate mass production of the F4U Corsair fighter plane. During this time the shoreline was extended to provide land area for new buildings. The plant was idle from 1948 until 1951. From 1952 until it closed in 1997, the plant was used to produce reciprocating aircraft engines and turbine engines for both commercial and military applications.

Process wastes generated on-site included waste oils, fuels, solvents, and paints. An on-site chemical waste treatment plant operated to treat waste generated at the facility and released effluent to the Housatonic River under a National Pollutant Discharge Elimination System (NPDES) permit. Waste lagoons on the Site were regulated and evaluated under RCRA in the 1980s. The facility was cited in 1983 for violating the Toxic Substances Control Act (TSCA) regarding reporting of polychlorinated biphenyl (PCB)-containing transformers. The Site was owned by the United States (U.S.) Air Force until 1976, when ownership was transferred to the U.S. Army (USEPA, 2016).

All manufacturing operations at the facility have ceased, and some office space is currently utilized for site security and building maintenance.

1.2.1 Site Description

The SAEP is located on the Stratford Point peninsula in the southeast corner of Fairfield County. The Site is on the border of the Bridgeport and Milford U.S. Geological Survey (USGS) Quadrangles. Latitudinal and longitudinal coordinates of the SAEP are approximately 41° 10’ North and 73° 07’ West. The location of the SAEP is shown on **Figure 1-1**.

SAEP consists of approximately 124 acres, of which about 76 acres are improved land, and the Army has riparian rights (access) to approximately 48 acres of adjacent tidally influenced property bordering the Housatonic River. All tidal lands below the mean high-water line are owned by the State of Connecticut as public trust land. The 76 acres of improved land contain 49 buildings, paved roadway and grounds, and five paved parking lots. The 48 acres of tidally influenced property adjacent to the Housatonic River are known as the “Tidal Flats”. An area map is provided as **Figure 1-2**.

The SAEP has a long industrial history and was used to develop, test, and manufacture aircraft, aircraft engines, and other aerospace products for 68 years. The plant closed in 1997. Access to the Site is restricted by perimeter fencing and security personnel. The SAEP Site is bordered by a paved parking lot and wetlands to the north; the Tidal Flats and Housatonic River to the east; an open field, a drainage channel, and small businesses to the south; and hangar buildings, the Sikorsky Memorial Airport, several small businesses, and Frash Pond to the west. Land near the Site is zoned light industrial, business, commercial, or residential. There are several businesses located west of Main Street across from SAEP, including a small strip mall, service stations, and a restaurant.

Nearby recreational areas include Short Beach Park ½-mile to the southeast, and public wildlife areas, including Nells Island and the Great Meadow Salt Marsh across the Housatonic River from SAEP.

1.2.2 Site History

As part of the 2004 RI Report (ACSIM, 2004), the Site was organized into almost 70 AOCs. These AOCs were then consolidated into groups according to the type and location of each. These AOC groups were identified to include:

- Hazardous Waste Storage Area
- Chemical Waste Treatment System
- Manufacturing, Testing, Research and Development Area
- Stormwater and Wastewater System
- Miscellaneous Areas

From the list above, three primary AOCs are further discussed below and are the primary focus of this FFS.

- Chemical Waste Treatment System (CWTS)
  - AOC 25 (Outfall-008 and Drainage Ditch)
- Stormwater and Wastewater System
  - AOC 24 (Discharge to the Housatonic River at Outall-007)
  - AOC 52 (Outfalls-001 through -006 and the Tidal Flats)

For the purposes of this report, AOCs 24 and 52 are combined to represent the Tidal Flats sediments.

1.2.2.1 AOC 24: Discharge to the Housatonic River at Outfall-007

Treated stormwater from the oil abatement treatment plant (OATP) had discharged through Outfall-007 (OF-007) to the Tidal Flats of the Housatonic River (**Figure 1-3**). The OATP received and treated stormwater and dry weather flow, including the first flush of stormwater, from the six storm pump stations. Industrial wastewater discharged to the OATP included boiler blowdown, cooling water, laboratory wastes, photographic processing wastes, paint-contaminated wastewater, soluble and insoluble cutting oils, spent hydraulic fluid, penetrant dyes, brine, and emulsion cleaning detergents (ESE, 1981; W-C, 1991).

Four chemical releases to the Tidal Flats have been documented. These releases involved:

- In May 1978, a spill of 25 to 30 pounds of chromic acid was discharged into the OATP and into the river via OF-007 (W-C, 1991).
- In August 1978, Connecticut Department of Environment Protection (CTDEP) was advised that a yellow plume of hexavalent chromium was extending approximately 200 yards from OF-007 (CDM FPC, 1992). This release occurred during a period when it is suspected that effluent from the CWTS was routed to the OATP for discharge via OF-007.
- Approximately 75 gallons of oil sludge from the OATP bypassed clogged skimmers and discharged from OF-007 in July 1979 (W-C, 1991).
- In October 1981, approximately 20 gallons of “Zyglo,” a fluorescent metal penetrant dye was spilled into a storm drain and discharged from OF-007 (W-C, 1991).

1.2.2.2 AOC 52: Facility Outfalls-001 through -006 and the Tidal Flats

In 1953, six storm pump stations were built (Buildings B-36, B-37, B-38, B-39 [demolished in 1971], B-40, and B-41) that discharged to the Tidal Flats and Housatonic River via associated outfalls (OF-001 through OF-006) (W-C, 1991) (**Figure 1-3**). Also, the outfalls received surface runoff, which may have contacted wastes potentially spilled on the Site grounds (W-C, 1991).

In 1976, the OATP (Building B-64-2), an associated pump station (Building B-64-1), and OF-007 were constructed to address oil and grease from influent wastewater in the collection system to meet NPDES requirements. Outlet piping was reconfigured for the existing pump houses, such that base flow and the first flush of stormwater would be routed to the OATP for treatment prior to discharge to the river via OF-007. The result was that discharge from OF-001 through OF-006 would occur only during large storm events when excessive runoff was present (W-C, 1991).

Specific amounts or constituents of materials/wastes that may have been discharged from OF-001 through OF-006 in the past is not known; however, any material or waste discharged or spilled into storm drains prior to construction of OATP was potentially released to the Tidal Flats through one of these outfalls. Industrial wastewaters produced at SAEP have included boiler blowdown, cooling water, laboratory wastes, photographic processing wastes, paint-contaminated wastewater, soluble and insoluble cutting oils, spent hydraulic fluid, penetrant dyes, brine, and emulsion cleaning detergents (ESE, 1981; W-C, 1991). These waste streams likely contained waste fuels and solvents in addition to documented compounds. Further information regarding the waste streams potentially handled by the outfalls is provided in the RI Report (ACSIM, 2004).

Historically, waste oils, fuels, solvents, and paints likely have been released to the storm and wastewater lines which lead to OF-001 through OF-006. Solvent, PCBs, and fuel-related contaminants were detected in sediment samples located adjacent to the six facility outfalls associated with the stormwater system. It should be noted, however, that in addition to impacts from SAEP-originating contamination, some sediment samples in the eastern portion of the Tidal Flats adjacent to the Housatonic River channel may be impacted by former historical industrial operations upriver. As an additional note, the current SAEP shoreline is a result of several expansions, most notably in 1943, which utilized both river sediments and fill from off-site.

1.2.2.3 AOC 25: Outfall-008 and Drainage Ditch

This AOC consists of discharge from the former Chemical Waste Treatment Plant to OF-008 and the associated drainage ditch (ACSIM, 2004) (**Figure 1-4**). The Outfall 008 drainage ditch is located at the southern boundary of the site and was used to discharge treated wastewater associated with metal plating into a drainage ditch that flows to the south. The drainage ditch originates at Outfall 008. It is approximately 10 to 12 feet wide and generally less than 2 feet deep. From Outfall 008 the ditch extends south-southeast a distance of 1,100 feet where it intersects a perpendicular ditch. This perpendicular ditch formerly carried runoff from the airport (located to the southwest, across Main Street) to Marine Basin (located 250 feet east of the junction of the Outfall 008 Drainage Ditch and the perpendicular ditch). The Connecticut Department of Transportation (CT DOT) re-routed this ditch in 2014, isolating it from the OF-008 ditch by creating a new ditch that drains runoff from the airport and runs parallel to the OF-008 ditch, connecting directly to the Marine Basin. In addition, a partially collapsed steel culvert which formerly ran underneath dirt road 100 feet upstream of the east-west portion of the OF-008 drainage ditch was removed in 2014. The steel culvert had limited tidal fluctuation impacts in the portion of the ditch between the culvert and Outfall 008 until it was removed. Water in the perpendicular drainage ditch flows to the Marine Basin, which in turn drains to the Housatonic River. There is a non-functioning tide gate at the confluence of the OF-008 ditch and the Marin Basin which currently limits tidal fluctuation impacts in the ditch between the culvert and the Marine Basin.

OF-008 was used to discharge supernatant from the waste treatment plant clarifier to the drainage channel immediately northeast of Building B-18, to Marine Basin and ultimately the Housatonic River. The outfall was constructed in 1979. The facility's 1985 NPDES permit allowed a discharge of 190,000 gallons per day of treated finishing wastewater from the outfall, and in 1991, the renewed NPDES permit allowed the facility to discharge 123,840 gallons per day of metal finishing wastewater from cyanide and chromium plating operations via the outfall.

Records indicate that frequent violations of permit limitations (e.g., elevated pH levels, heavy metals concentrations exceeding permitted levels, and discharges exceeding the allowable maximum daily flow) occurred prior to the mid-1980s. Violations occurred after that time with less frequency (ACSIM, 2004). During a 1984 USEPA inspection, white foam was observed where lime-green colored liquids were being discharged from the CWTS clarifier into the tidal basin (ACSIM, 2004). A review of the monthly Discharge Monitoring Reports for 1990 identified violations of permit limitations for average daily flow and maximum daily concentration limits for nickel, cyanide, and total toxic organics (ACSIM, 2004). Elevated levels of chlorinated volatile organic compounds (VOCs), fuel-related VOCs, and other VOCs were detected during required NPDES Permit sampling (ACSIM, 2004).

As part of the CT DOT Runway Safety Area Project (Re-alignment of CT Route 113, CT DOT Project 15-336), in 2013 parts of the Outfall 008 drainage ditch and a portion of the property adjacent to the ditch were evaluated for the presence of Raymark waste. The investigation determined that Raymark waste was present adjacent to the Outfall 008 drainage ditch, and the extent of Raymark waste is depicted in Figure 1-3 of the Final Sediment Remediation Endpoints Report (Amec Foster Wheeler, 2018a). The Removal Work Plan identifies Raymark wastes at depths up to 8 feet in areas adjacent to the drainage ditch, and states that "RMW (Raymark Waste) extends into the tidal channel." The delineation of Raymark Waste did not extend upstream along the drainage channel to the north, toward Outfall 008, beyond a limited area near the junction of the "T" shape of the channel. The excavation of Raymark Waste was conducted in 2015, slightly altering the portion of the Outfall 008 drainage ditch adjacent to the former Raymark Waste, including removal of a culvert crossing and regrading of the ditch banks. The final report (AECOM 2015) does not indicate additional removals beyond those identified in the Removal Work Plan (URS Corporation AES 2014) and presents a figure depicting the same extent of removal as was identified in the work plan Figure 2. Confirmation sampling was performed only along Route 113 at a location where excavation could not extend to the predetermined limits. These figures both note that the limits of excavation were defined by borings that do not contain Raymark waste (see figure 2 URS Corporation AES 2014). In addition, the design called for the installation of sheetpile along and into the Outfall 008 ditch coincident with the line of samples that did not contain Raymark waste, which was used during the remediation to control water. The use of sheetpile would have prevented the inspection of sidewalls and/or collection of additional confirmation samples within or immediately adjacent to the Outfall 008 ditch.

1.2.3 Summary of Sediment Investigations

There have been numerous investigations of the sediments in the Tidal Flats and Outfall 008 areas prior to 2014, and are summarized as follows:

- Sampling of the Tidal Flats and Outfall 008 drainage ditch sediments was conducted by the U.S. Army in 1992, 1994, and 1999 as part of a RI. These data are presented in the RI Report (ACSIM, 2004).
- The CTDOT also conducted sediment investigations in the Outfall 008 drainage ditch in August 2012.
- Background/reference sediment sampling was conducted in 1994, 1999, 2009, and 2012.
- In April and May 2014, additional sediment sampling and toxicity testing were conducted in the Tidal Flats and Outfall 008 drainage area. A description of investigations and findings is presented in the Final Sediment Endpoints Report (Amec Foster Wheeler, 2018a) (**Appendix A-1**).
- In April 2015, additional sediment sampling was conducted in the Tidal Flats and OF-008 areas, as follows:
    - between the Tidal Flats and the margin of the dredged Housatonic River channel,
    - at depths greater than 2 feet below ground surface (bgs) in the Tidal Flats, and
    - at depths greater than 2 feet bgs in the OF-008 drainage ditch.

  A description of investigations and findings is presented in the Addendum - Final Sediment Endpoints Report (Amec Foster Wheeler, 2018a) (**Appendix A-2**).
- In August 2017, limited pre-design investigations collected contaminated sediments from the Tidal Flats to conduct treatability studies for potential land-side re-use of sediments, as well as to characterize the sediments relevant to dredging, disposal, and treatment evaluations. Treatability testing was conducted in accordance with the Feasibility Study Final Field Sampling Plan (FSP) (Amec Foster Wheeler, 2018b). The treatability testing included:

  - sediment dewatering, flocculation, solidification/stabilization, disposal characteristics, elutriate characteristics, and geotechnical properties; and
  - evaluation of water treatment technologies to reduce PCBs and metals concentrations in water generated from dewatering of sediments to meet likely effluent discharge standards.

  Evaluation of the treatability testing data is presented in **Appendix C**. Figure C-1 shows the locations of treatability sampling collection efforts.

- In October 2017, additional sediment samples were also collected for geotechnical parameter analysis at 10 locations across the Tidal Flats to provide a more comprehensive spatial representation of the material to be removed. Geotechnical samples were collected from depths ranging from 1 to 4 ft bgs and were composited at each location. The grain size analyses associated with the samples are included in **Appendix D** and are summarized in Section 3.0 of **Appendix C** and Table C-6.

- In October 2017, additional sediment coring activities were completed to evaluate: 1) the concentrations of total PCBs greater than or equal to 50 mg/kg in the 0-2 ft bgs interval of the Tidal Flats sediments, and 2) concentrations of PCBs at depths between 4 and 8 ft bgs near the historic wastewater outfalls which discharged to the Tidal Flats west of the Causeway, as presented in the Final FSP (Amec Foster Wheeler, 2018b). The results of these investigations and the impact on sediment removal quantities is presented in the Addendum to Final Sediment Remediation Endpoints Report (Amec Foster Wheeler, 2018c), which is presented as **Appendix A-2**.

The investigations conducted in the Tidal Flats have adequately characterized the contamination in sediments exceeding PRGs and requiring remediation. However, there remains the possibility of residual contamination exceeding background concentrations at depths greater than 4 feet bgs in the Tidal Flats from historic activities at SAEP, as well as former industrial processes along Housatonic River. Future exposure to the potential presence of detectable contamination at depths below 4 feet is not anticipated; however, the Army proposes some limited pre-design sediment characterization in those areas where ERM-Q > 0.5 in the 3-4 foot bgs interval to evaluate those areas to a depth of 6 feet bgs, sampling over the 4-5 ft and 5-6 ft intervals. The proposed characterization program is presented in **Appendix A-3**.

Appendix A-4 contains an evaluation of LiDAR elevation surveys of the Tidal Flats (conducted in 2006, 2012, and 2015) encompassing the timeframe of Hurricane Sandy (October 2012) to assess the potential impacts of a severe storm event on the sediments of the Tidal Flats. The primary conclusions of this evaluation are as follows:

- Between the years 2006 and 2015, the mean elevation of the Tidal Flats surface increased by 0.39 feet.

- In October 2012, Hurricane Sandy's effects impacted the Connecticut coast, and immediately after the event, a LiDAR elevation survey of the Connecticut coast was conducted.

- The evaluation in **Appendix A-4** provides an estimate of a mean elevation increase across the Tidal Flats of 0.14 feet between 2006 and immediately following Hurricane Sandy in November 2012.
- However, using an estimated sedimentation rate of 0.07 feet/year (calculated from a comparison of the 2012 and 2015 data sets), the theoretical amount of increase between 2006 and 2012 if Hurricane Sandy had not occurred should have been on the order of 0.42 feet, yielding a maximum theoretical amount of sediment elevation decrease from Sandy of 0.28 feet.
- Evaluation of LiDAR data by Wood indicates that between 2006 and 2015, the elevation of the Tidal Flats sediments generally increased, with a mean increase of 0.39 feet over the 9-year period inclusive of Hurricane Sandy. Even with the impacts of Hurricane Sandy, these data support that sedimentation processes are occurring within the Tidal Flats.
- Using a sedimentation rate of 0.07 ft/yr, it is estimated that it would take roughly 14 years for a 1-foot thickness of new sediment to accumulate on the Tidal Flats. However, this does not consider that if the Tidal Flats were excavated and backfilled to 1 foot below existing grade, the non-equilibrium condition generated by leaving the last 1-foot unfilled would likely increase the rate of sedimentation. Increases in sedimentation rates have been documented at other sediment excavation sites where excavations have not been completely backfilled to grade (http://www.nae.usace.army.mil/Portals/74/docs/DAMOS/TechReports/186.pdf).

1.3 Summary of Pathway to Sediment Remediation Goals

In October 1995, SAEP was placed on the Base Closure and Realignment (BRAC) list, known as BRAC 95. U.S. Army BRAC properties must be investigated to determine the nature and extent of environmental contamination. The U.S. Army prepared a RI Report (ACSIM, 2004) for the SAEP to characterize the nature and extent of contamination and evaluate potential risk to human health and the environment attributable to the Site.

As presented in the RI Report, under the legal and regulatory framework of the CERCLA, remedial action and cleanup standards at SAEP will be primarily driven by the CERCLA §120(a)(4) mandate to meet the legally applicable state laws at non-NPL facilities. Under this mandate, two legally applicable state requirements will drive the remedial actions/cleanup standards at the site: (1) the Connecticut Remediation Standard Regulations (RSRs) for soil and groundwater, and (2) the Connecticut Surface Water Standards. Since these criteria are required to be met, regardless of the presence or absence of unacceptable risk, the risk assessment process in this RI Report serves a modified use other than the traditional use of a risk assessment in a RI Report. For those exposure pathways/media covered by the above applicable requirements, the risk assessment will not be decisive of the need for remedial action. Instead, the exceedance of the RSR standards/surface water standards will determine the need for remedial action. For these exposure pathways/media, the human health and ecological risk assessments in the RI Report will be primarily utilized as a basis to develop alternative criteria under the RSRs, when determined to be pertinent and to clearly demonstrate compliance with the CERCLA protectiveness mandate in the administrative record.

The RI Report states that for exposure pathways/media not covered by the above applicable requirements (i.e., sediment and ecological receptors), the risk assessment will be used in the traditional sense to identify media/exposure pathways that require remedial action to meet the CERCLA protectiveness mandate.

The RI Report (ACSIM, 2004) utilized the results of the investigations completed prior to 2002 to develop human health and ecological risk assessments to evaluate risk associated with the sediments of the Tidal Flats and Outfall 008 drainage ditch. The Human-Health Baseline Risk Assessment (HHBRA) considered exposure to sediments for recreational and commercial anglers and shell-fishermen (Harding ESE, 2004). The following bullets summarize the HHBRA findings for potential exposure to sediments and consumption of biota:

- Tidal Flats:
  - Cumulative cancer risks to future recreational visitors (2E-04) and commercial fishermen (2E-04) for consumption of oysters from the Tidal Flats exceed the CERCLA 1E-04 total cumulative cancer risk threshold required to take an action.
  - Risks associated with potential exposures to chemicals of potential concern (COPCs) in sediment under future recreational use conditions (wading or angling) at the Tidal Flats are 1E-05, and do not exceed the CTDEP cancer risk limit of 1E-05, applicable when evaluating multiple substances.
  - Risks associated with hypothetical future commercial fishing for dermal contact and ingestion of sediment from the Tidal Flats are 1E-05, and do not exceed the CTDEP cancer risk limit of 1E-05, applicable when evaluating multiple substances.
  - Risks to recreational fishermen associated with consumption of finfish (1E-04) and ribbed mussels (1E-04) at the Tidal Flats exceed the CTDEP cancer risk limit of 1E-05 (applicable when evaluating multiple substances), and an HI of 1, due to PCB Aroclors 1248, 1254, and 1260.
  - Risks to hypothetical future commercial fishermen associated with consumption of finfish, ribbed mussels, and oysters taken from the Tidal Flats exceed the CTDEP cancer risk limit of 1E-05 (applicable when evaluating multiple substances), due to PCB Aroclors 1254 and 1260, and arsenic.
- Outfall 008:
  - Total receptor risks associated with potential exposures to chemicals of potential concern (COPCs) in sediment under future recreational use conditions (child, adolescent, and adult wading) at the Outfall 008 drainage ditch are 8E-06, and do not exceed the CTDEP cancer risk limit of 1E-05, applicable when evaluating multiple substances.

- The estimated hazard index (HI) value for future recreational use (wading) at the Outfall 008 Drainage ditch does not exceed a value of 1 under the assumption that chromium detected in ditch sediments is present as trivalent chromium (it is likely that the total chromium in the sediments is in the trivalent form because of the anaerobic conditions in this medium).

The Baseline Ecological Risk Assessment (BERA) was conducted to characterize ecological risks at the site in accordance with USEPA performance standards for risk characterization (ACSIM, 2004). The following bullets summarize the BERA findings for potential risks to ecological receptors in the Tidal Flats and Outfall 008 drainage ditch:

- Tidal Flats:
  - The BERA indicates that there is no unacceptable risk to macroinvertebrates in the Tidal Flats.
  - The results of the BERA indicate that there is no significant risk to forage fish inhabiting the Tidal Flats; tissue concentrations are comparable to tissue concentrations from reference locations.
  - At the Tidal Flats, there is no significant risk to the black duck and great blue heron, but a potential risk to sandpipers due to chromium in sediment and mercury (assumed to be methyl mercury) in biota.
- Outfall 008:
  - There is a potential risk to macroinvertebrates in the Outfall 008 drainage ditch due to inorganics (barium, chromium, and copper) and Aroclor-1260 in sediment.
  - At Outfall 008, chromium concentrations in sediment may pose a risk to sandpipers, herons, and ducks if they frequently forage at this location (considered unlikely due to poor habitat quality).

Based on the age of the sediment data (1992-1998) associated with the HHBRA and BERA, the CT DEEP requested that, prior to establishment of remedial goals for sediment in the Tidal Flats and Outfall 008 drainage ditch sediments, additional sediment characterization, including toxicity testing, be conducted.

In April 2014, the U.S. Army issued the Final Work Plan for Determination of Sediment Remediation Endpoints, Tidal Flats and Outfall 008, Stratford Army Engine Plant, Stratford, Connecticut (AMEC, 2014a). This work plan was reviewed and approved by the CT DEEP. The Work Plan proposed sediment toxicity testing to assist in developing the remediation endpoint goals for the sediments in question and laid out the steps for development of the remediation endpoints. The Final Work Plan also presented some of the historical sediment data referenced above. In April and May 2014, additional sediment sampling and toxicity testing were conducted, and in September 2014 the Army issued the Draft Sediment Remediation Endpoints Report for the Tidal Flats and Outfall 008 (AMEC, 2014b). The report presented the results of sediment chemical characterization, toxicity testing results, and proposed sediment remediation endpoints for the Tidal Flats and Outfall 008 areas. The results of the toxicity testing indicated toxicity to macroinvertebrates from sediment, in contrast to earlier BERA findings, although the toxicity could not be linked to a specific chemical. As an alternative to using toxicity test results alone for development of remediation endpoints, the report presented statistical analyses of the data and proposed using an ERM-Q of 1.0 for the metals cadmium, chromium, and copper, as a surrogate for evaluation of toxicity.

On December 2, 2014, the CT DEEP submitted comments on the Draft Sediment Remediation Endpoints Report (AMEC, 2014b). CT DEEP concluded from their review of the report that toxicity is not definitively linked with a specific chemical and recommended setting the remedial goal based on multiple chemicals to more accurately describe the chemical quality associated with the non-toxic samples. CT DEEP's recommendations for determining the sediment remediation endpoint goals were as follows:

- Use an average ERM-Q of 0.5 for the eight metals arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc; an average ERM-Q > 0.5 would require remediation.
- Concentrations of mercury and PCBs should generally not be present in post-remedial conditions.
- Additional site characterization was needed to refine the area of sediment contamination both at depth within the Tidal Flat and Outfall 008 areas, as well as within surficial and deeper sediments between the eastern edge of the intertidal flats and the Housatonic River.

On February 17, 2015, the U.S. Army responded to CT DEEP's comments indicating that they agreed to removal of contaminated sediments with average ERM-Qs > 0.5 from the 0-2 foot bgs interval in both the Tidal Flats and Outfall 008 areas, as well as replacement with CT DEEP-approved backfill.

Following further discussions with CT DEEP, the U.S. Army issued a memorandum to CT DEEP on March 24, 2015 indicating that they were committed to proceeding with the additional sampling in a timely manner to ensure redevelopment of the SAEP site without further delay.

In April 2015, additional sediment sampling was conducted in the Tidal Flats and Outfall 008 areas, as follows:

- between the Tidal Flats and the margin of the dredged Housatonic River channel,
- at depths greater than 2 feet bgs in the Tidal Flats, and
- at depths greater than 2 feet bgs in the Outfall 008 drainage ditch.

In November 2015, Amec Foster Wheeler was placed under contract to analyze the sediment samples collected in April 2015, and to incorporate the analytical results into a revised version of the Sediment Remediation Endpoints Report. The revised Sediment Remediation Endpoints Report was issued to the U.S. Army on July 29, 2016, and to the CT DEEP on March 7, 2017.

On May 17, 2017, the U.S. Army received comments from the CT DEEP on the Sediment Remediation Endpoints Report. These comments, and responses from the U.S. Army, are included as Appendix F of the Final Sediment Remediation Endpoints Report (Amec Foster

Wheeler, 2018a) (**Appendix A-1**). Because of CT DEEP and USEPA comments, the U.S. Army developed a Field Sampling Plan (Amec Foster Wheeler, 2018c) to conduct sediment sampling and analyses in the Tidal Flats to further delineate:

- concentrations of PCBs from 0-2 feet bgs at locations where total PCBs have been detected at concentrations exceeding 50 ppm; and
- concentrations of PCBs and Hg at depths between 4 and 8 feet bgs near the historic wastewater outfalls which discharged to the Tidal Flats west of the Causeway.

The results of these investigations and the impact on sediment removal quantities is presented in the Addendum to Final Sediment Remediation Endpoints Report (Amec Foster Wheeler, 2018b), which is presented as **Appendix A-2**.

2.0 REMEDIAL ACTION OBJECTIVES AND APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section presents ARARs, development of PRGs, RAOs, and development of areas and volumes of media to be remediated for the Tidal Flats (AOC 52) and the OF-008 Drainage Ditch (AOC 25).

2.1 Applicable or Relevant and Appropriate Requirements

The CERCLA, the Superfund Amendments and Reauthorization Act, and the NCP require that on-site Superfund remedial actions attain federal standards, requirements, limitations, or more stringent state standards determined to be legally applicable or relevant and appropriate to the circumstances at a given site. ARARs are federal and state environmental and facility siting requirements and guidelines used to:

- evaluate the appropriate extent of site cleanup;
- define and formulate remedial action alternatives; and
- govern implementation and operation of the selected action.

Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured.

Numerous federal and state laws and their implementing regulations were reviewed to identify ARARs for potential cleanup levels and other action- and location-specific requirements for the site. This section defines ARARs and discusses specific laws and regulations that were considered as potential ARARs as they apply to remedial actions to be applied to this Project. Relevant federal and state guidance documents were also reviewed as potential To Be Considered criteria. **Figure 2-1** presents the USACE ARAR Logic Flowchart that provides the method for determining if a regulation is an ARAR. The NCP defines two ARAR components: (1) applicable requirements; and (2) relevant and appropriate requirements. To properly consider ARARs and to clarify their function in the remedy selection process, these definitions must be considered.

CERCLA considers ***applicable*** requirements to include cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site.

Relevant and appropriate requirements include those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site.

CERCLA considers three types of ARARs:

- ***Location-specific ARARs*** are requirements driven by the geographical or physical position of the site, rather than by the nature of the chemicals of concern or the actions at the site. Location-specific ARARs are typically restrictions or requirements placed on the concentration of hazardous substances or the conduct of activities solely because they occur in a specific location.
- ***Chemical-specific ARARs*** are laws and regulations that identify health- or risk-based numerical values that, when applied to site-specific conditions, result in the establishment of concentration cleanup limits for specific hazardous substances. These limits establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the environment.
- ***Action-specific ARARs*** are requirements that define acceptable performance, design, or other similar controls or restrictions imposed on particular kinds of activities. Action-specific ARARs are usually technology- or activity-based requirements.

In general, chemical- and location-specific ARARs provide a basis for determining the objectives and goals of remedial action for the site, whereas action-specific ARARs provide a basis for determining how the remedial action will be implemented.

Table 2-1 provides a list of the ARARs that have been evaluated and determined to be relevant to the screening and evaluation of remedial alternatives based on site conditions and results of the RI and other investigations. The selected remedial alternative will be implemented in accordance with the substantive requirements of all applicable federal, state, and local regulations and permitting requirements to the extent practicable. The ARARs provide the location-, chemical-, and action-specific requirements relevant to the alternatives identified in the FFS only – ARARs for the actual selected remedy may differ and will need to be evaluated upon remedy selection, design, and implementation.

Several regulations will be followed during the implementation of the selected remedy but are not ARARs. For example, RCRA is not an ARAR as RCRA pertains to the potential off-site disposal and ARARs are on-site requirements only. RCRA requirements, among others, will be followed in the transport and disposal of residual materials off-site. However, as RCRA and several other regulations do not impact the FFS, these regulations are not ARARs and are not included in the FFS; however, are provided in **Table 2-1** for information purposes only.

Similarly, OSHA is not identified as an ARAR; however, all work conducted by USEPA or work completed under Superfund must be OSHA-compliant.

Other requirements that will be followed during the implementation of the remedial action that are not ARARs include the Endangered Species Act and the National Historic Preservation Act;

however, the USACE will coordinate wetland activities with the local jurisdictions to meet substantive requirements.

State and Federal-listed Species. On April 23, 2018, CT DEEP sent a letter to Amec Foster Wheeler regarding the impact of the proposed remediation on State-listed species (Appendix B). The letters signee, Shannon B. Kearney (Wildlife Biologist), stated that based on the review of Natural Diversity Data Base maps and files, the proposed activities are not anticipated to negatively impact State-listed species. This review is based on the current scope of work and is viable for work started before April 23, 2020.

CENAE has coordinated with USFWS and NMFS regarding impacts of the proposed project on federally listed species under Section 7 of the Endangered Species Act of 1973 (16 U.S.C § 1531 et seq.) and that correspondence will be completed during final design.

Time-of-Year Restrictions. There are three potential time-of-year dredge restrictions that are of concern based upon informal consultation discussions with State and Federal resource agencies including:

- winter flounder spawning (February 1st- May 31st);
- anadromous fish migration (March 1st - June 30th);
- oyster spawning (June 1st - October 1st).

If implemented, these dredge restriction periods would occur annually over the life of the project and would allow for a four-month work window (October 1st through January 31st). For purposes of cost and schedule estimation, it has been assumed that the allowable work window will be from July 1st through January 31st assuming the oyster spawning window can be eliminated. Suspended sediment produced during dredging would be contained to the immediate dredge area (tidal flats) in accordance with the approved turbidity monitoring, management, and maintenance program and would not have a substantial impact on oyster resources that are harvested within the main river channel of the Housatonic River. Also, oysters are well adapted to withstand temporary increases in suspended sediments and sedimentation within the main river channel is not likely to exceed levels experienced during natural storm events.

Based on USACE analysis of these environmental resources, remedial dredging should be conducted without any time-of-year restrictions to ensure project impacts do not span multiple seasons. In addition, if completion of the work is compressed into no more than one or two seasons, the disturbed habitat can be recolonized and utilized by local fauna much more quickly than if work must extend into three or more seasons.

2.2 Preliminary Remediation Goals

A summary of the pathway to determination of sediment remedial goals is presented in Section 1.3 of this FFS Report. The PRGs for the Tidal Flats sediments are as follows:

- ► Sample locations with an average ERM-Q value greater than or equal to 0.5 for eight metals will be excavated, and

- PCB and mercury concentrations after remediation will be not substantially different from those found in reference locations.

As presented in the Final Sediment Remediation Endpoints Report, the U.S. Army has agreed with CT DEEP to remediate the entire length of the OF-008 drainage ditch (inclusive of the "T" section extending to Route 113 to the southwest and Marine Basin to the northeast) to a depth of 4 ft bgs.

2.3 Remedial Action Objectives

Remedial action objectives are specific goals for protecting human health and the environment and ecological receptors that also define a framework for remediation sites. The following RAO was identified for the Tidal Flats:

- Reduce risk to the environment by reducing sediment toxicity in the top 4 ft of sediment by removing sediment with average ERM-Q values greater than or equal to 0.5 for eight Site-related metals (arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc);

By achieving this RAO, total PCBs and mercury remaining within the footprint of the removal area will be at concentrations not substantially different than those found in reference locations (0.2 ppm for total PCBs and 0.4 ppm for mercury). As presented in Appendix A-2, the mean and 95% UCL concentrations of total PCBs and mercury remaining following the proposed removal of sediment within the ERM-Q > 0.5 footprint are less than the CT DEEP-proposed background concentrations of 0.2 and 0.4 ppm, respectively.

In addition, cancer risks for future recreational and commercial fishermen and anglers from multiple PCB Aroclors and arsenic in Tidal Flats sediments as identified in the HHRA (ACSIM, 2004) will be reduced and are anticipated to be well below the CT DEEP cancer risk limit of 1E-05, applicable when evaluating multiple substances, in post-removal conditions.

The following RAOs were identified for the OF-008 Drainage Ditch:

- Reduce risk to the environment by reducing sediment toxicity in the top 4 ft of sediment by removing all sediments along the entire length of the OF-008 drainage ditch (inclusive of the "T" section extending to Route 113 to the southwest and Marine Basin to the northeast) to a depth of 4 ft bgs.

Potential risk to sandpipers due to chromium in sediment and mercury (assumed to be methyl mercury) in biota as identified in the BERA (ACSIM, 2004) will be significantly reduced by the proposed removal of sediments in the Tidal Flats and Outfall 008 drainage ditch.

It is important to note that the RAOs incorporate the U.S. Army's overarching objective to eliminate to the extent feasible any long-term liability for contamination remaining on the Site within the Tidal Flats and the Outfall 008 drainage ditch. The U.S. Army has placed emphasis on remedial actions that reduce ecological risk through ***removal** of* sediment rather than those actions that rely upon containment, consolidation, or only in situ treatment of sediments within AOCs 25 and

52. By removing sediments exceeding PRGs and achieving the RAOs, the U.S. Army would eliminate any requirements to perform long-term monitoring and maintenance of the remedy. Consistent with this strategy, remedial approaches that have been screened out at the very first steps of the alternatives development process prior to the detailed evaluation include:

- Monitored Natural Recovery
- Containment; and
- In Situ Treatment.

These RAOs and the U.S. Army's preference for removal were used to guide the screening of suitable technologies, as well as the development and evaluation of remedial action alternatives in Sections 5 and 6 of this FFS in accordance with CERCLA.

2.4 Areas and Volume of Media (Tidal Flats and Outfall 008 Ditch)

2.4.1 Tidal Flats

The proposed remedial footprint for Tidal Flats sediments, and the rationale for its selection, is presented in **Appendix A-2**. Sediments with average ERM-Q values greater than or equal to 0.5 were considered to require remediation. For each depth interval, interpolated areas of sediments with average ERM-Q values greater than or equal to 0.5 were drawn. Total PCB (both Aroclors and Homologs) data from 1992 through 2017 were plotted by depth interval to evaluate total PCB concentrations relative to the average ERM-Q based remedial footprint (**Appendix A-2**). In addition, the interpolated areas of PCB concentrations between 1 and 50 ppm, and > 50 ppm were drawn. Figures of total mercury data from 1992 through 2017 were created by depth interval to evaluate mercury concentrations relative to the average ERM-Q based remedial footprint (**Appendix A-2**).

Figure 2-2 represents the proposed remediation footprint for the Tidal Flats based on the conclusions of **Appendix A-2**. As depicted in the **Figure 2-2**, approximately 47 acres of tidal flats area require remediation ranging from one to four ft of sediment removal. A majority of the area (approximately 38 acres) requires one or two feet of removal, with the remaining ten acres requiring three or foot ft of sediment removal. No remediation is proposed below 4 ft bgs, as there are no average ERM-Q values > 0.5, and no concentrations of PCBs or mercury exceeding CT DEEP-proposed background concentrations of 0.2 and 0.4 ppm, respectively (see **Appendix A-2**).

Figure 2-3 through **Figure 2-6** represent the remediation footprints of PCBs at concentrations greater than 1 and less than 50 ppm, and greater than or equal to 50 ppm within the Tidal Flats. **Figures 2-7** and **Figure 2-8** represent cross-sections of the Tidal Flats where the section lines are shown on **Figure 2-2**. **Table 2-2** presents a summary of the estimated volume of in-place sediments proposed for removal from the Tidal Flats Area, which totals approximately 139,400 cy. For purposes of compliance with TSCA and for categories of on-site beneficial reuse and off-site disposal, the sediments have been categorized according to three ranges of PCB concentrations: less than 1 mg/kg PCBs, greater than or equal to 1 mg/kg but less than 50 mg/kg PCBs, and greater than or equal to 50 mg/kg PCBs. Most of this volume of sediment contains PCBs at concentrations less than 1 mg/kg PCBs (130,500 cy). A relatively small volume contains PCBs between 1 and 50 mg/kg (8,500 cy), and a very small amount contains PCBs greater than or equal to 50 mg/kg (400 cy). Sediments containing greater than or equal to 1.0 ppm PCBs are regulated under TSCA at this facility.

2.4.2 OF-008 Drainage Ditch

As discussed with CT DEEP, the U.S. Army agreed to remediate the entire length of the OF-008 drainage ditch to a depth of 4 ft bgs (Amec Foster Wheeler, 2018a). The proposed remedial footprint for the 0-4 foot depth interval and cross-sections are depicted in **Figure 2-9** through **Figure 2-15**. The proposed PCB remedial footprint for concentrations greater than or equal to 1 and less than 50 ppm is shown on **Figures 2-10** and **2-11**. **Table 2-3** presents a summary of the estimated volume of in-place sediments proposed for removal from OF-008 drainage ditch, which totals approximately 4,900 cy. Approximately 3,800 cy of this volume contains PCBs at concentrations less than 1 mg/kg. The remainder of the volume (1,100 cy) contains PCBs at concentrations less than 50 mg/kg but greater than or equal to 1 mg/kg.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies and screens potential remedial technologies that will be combined into remedial alternatives to address impacted sediment at the Site. Following identification, candidate technologies are screened based on their applicability to site- and contaminant-limiting characteristics. Site-limiting characteristics consider the effects of physical features on the implementability of a technology, such as topography/bathymetry, geology, and available space and resources to implement the technology. Contaminant-limiting characteristics consider the suitability of a technology based on contaminant types, as well as physical and chemical properties of the waste (e.g., grain size, organic carbon content, volatility, solubility, and mobility).

The process to identify and screen technologies includes the following steps:

1. First, GRAs with potential to attain the RAOs established in Section 2 were identified. GRAs are broad categories of remedial actions or strategies that may be appropriate to reduce site risks. Section 3.1 below lists the GRAs identified for the project. To eliminate those GRAs that will not meet the RAOs and avoid the unnecessary step of also identifying and screening technologies that fall under those GRAs, an initial screening step of GRAs only was performed. This screening step is presented in **Table 3-1** and summarized below in Section 3.1. This approach is consistent with the U.S. Army's approach to minimizing long-term liability and maintenance activities at the Site.

2. Next, an extensive list of potential technologies representing each remaining GRA was developed based on experience with similar studies, site media, and contaminant-driven considerations. Remediation technologies are grouped by category in **Table 3-2**, with individual technology process option(s) identified. Demonstrated performance of each technology for site contaminants and conditions is considered during technology identification.

3. Lastly, the resulting list of potential technologies was then screened against the effectiveness, implementability, and criteria. Costs at this stage of the process are generally defined in relative terms only (i.e., high, medium, and low), rather than quantitatively, and are generally not used to screen out technologies; however, costs can be used to differentiate between similar process options to aid in selection of appropriate process options to carry forward into alternatives development. Site- and waste-limiting characteristics are identified under these criteria to ensure that only the most promising technologies are carried forward into alternatives development. Additionally, to refine the development of site-wide remedial alternatives with technologies that have multiple process options, only the most promising process options applicable to each GRA are carried forward. This process ensures that only those technologies and process options applicable to Site contaminants, with consideration of the physical characteristics of the

Tidal Flats and OF-008 drainage ditch are carried forward for combination into remedial alternatives.

3.1 General Response Actions

GRAs are broad categories of remedial actions that may be implemented to attain RAOs by reducing contaminant concentrations in each medium below the PRGs, preventing receptor exposure to the contaminated medium, or monitoring the natural attenuation of contaminants.

Potential GRAs for the Tidal Flats and OF-008 include:

- Institutional Controls
- Monitored Natural Recovery
- Containment
- In situ Treatment
- Removal
- Material Transport
- Material Dewatering and Processing
- Disposal
- Habitat Restoration

Brief descriptions of these GRAs are included in **Table 3-1**.

Monitored natural recovery (MNR), containment, and in-situ treatment were eliminated because these GRAs would not remove targeted sediments and would leave the U.S. Army with long-term obligations such as monitoring and maintenance. The U.S. Army's objective for the sediment remediation is to eliminate future liability for any contamination left in place at the Site, and to transfer that liability to the future property owner for any sediments placed within the uplands portion of the site for beneficial reuse. Institutional controls have been retained only as an ancillary (not primary) component (to the extent necessary) of all remedial alternatives. Habitat restoration has been retained for the OF-008 drainage ditch and the salt marshes of the Tidal Flats, which will require revegetation and restoration. The remainder of the Tidal Flats will require simple backfill to restore the remediation footprint to a depth of 1 foot below the pre-remediation elevation.

The following subsections describe in more detail the rationale for screening out MNR, Containment, and In Situ Treatment.

3.1.1 Monitored Natural Recovery

MNR is one of the three main remedial alternatives for contaminated sediment recognized by US EPA that are typically addressed at sediment sites (removal "dredging" and capping "containment" are the others). MNR relies upon ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. These processes can convert contaminants to less toxic forms (biodegradation), bind contaminants more tightly to sediment (sorption), or bury contaminated sediment beneath clean sediment (sedimentation). For this Site, natural sedimentation is generally the process which constitutes MNR. Long-term monitoring with sediment sampling occurring at a set frequency (i.e., quarterly, semi-annual, and/or annual) is required as part of MNR to document reduction in sediment concentrations through deposition of incoming “cleaner” sediment, and/or dilution to reduce concentrations of impacted sediments.

MNR would not immediately remove or reduce contaminant concentrations and would therefore not meet the U.S. Army’s preference for actions that eliminate long-term monitoring and maintenance at the Site. For these reasons, MNR will not be considered for further evaluation.

3.1.2 Containment

Like MNR, contaminated sediments exceeding PRGs would not be removed; rather, an engineered barrier would be placed over the contaminated sediments to isolate them and prevent migration of contamination. Caps are typically designed with several layers depending on contaminant concentration(s) and type(s), migration of contamination, erosion potential, and ecological considerations such as appropriate substrate. An isolation layer to provide physical separation between contaminated sediment and the bioturbation zone may be a component. Additionally, a chemical treatment layer consisting of an aggregate material, such as sand treated with a chemically active treatment material such as activated carbon or other specialty media, may be a cap component. Above this layer, an erosion protection layer may be required to prevent the loss of upper layers of the chemical isolation or treatment zones. The erosion layer may have more than one material type depending on the gradation compatibilities. Finally, a bioturbation zone is typically required to re-establish habitat for benthic and other organisms.

Typically, some amount of removal of contaminated sediments is required to “fit” the cap without filling the waterway. The depth of removal depends on the design thickness of each of the layers required for the cap.

Containment, as a GRA, has been screened from further consideration because removal of sediments exceeding PRGs to a depth of four feet would not be accomplished. Under this GRA, long-term liability would not be eliminated for the U.S. Army because some amount of sediments exceeding the PRGs would remain on the Site, obligating the U.S. Army to perform long-term monitoring and maintenance of the cap. For these reasons, containment has been eliminated from further consideration.

3.1.3 In Situ Treatment

In-situ treatment relies on the use of amendments dispersed on top of sediment to create a shallow treatment zone. Within this shallow treatment zone, the amendments alter the physical or chemical properties of the sediment, porewater, and/or contaminants to reduce the bioavailability of contaminants to benthic organisms. In situ treatment can be effective to interrupt processes of bioaccumulation to protect higher level organisms. In situ treatment has been well demonstrated for PCBs and some metals; however, it is a relatively recent technology that has not been extensively used. Multiple applications of in situ treatment amendments are likely required over time to ensure effectiveness.

In situ treatment would not include any removal of contaminated sediments, and for reasons similar to those for containment and MNR (i.e., long-term liability and monitoring and maintenance required by the U.S. Army), it has been eliminated from further consideration in this FFS.

3.2 Technology Identification

Remedial technologies and process options were identified for the remaining GRAs based on a review of engineering experience, literature, vendor information, and past performance data. Process options with the potential to attain RAOs are identified in **Table 3-2** which also further identifies the applicability of technologies to the Tidal Flats and OF-008 drainage ditch remediation.

3.3 Screening of Technologies

The purpose of the screening step is to reduce the number of potentially applicable technologies and process options by evaluating factors that may influence effectiveness, implementability, and relative cost. This overall screening is consistent with guidance for performing FSs under CERCLA (USEPA, 1988). **Table 3-2** summarizes the technology screening process.

Technologies and process options judged ineffective, not implementable or too difficult to implement, or too costly were eliminated from further consideration. The technologies retained following screening represent the inventory of technologies considered most suitable for removal, processing, and final disposition of sediment at the Site. Technologies/process options retained in this section may be used either alone or integrated with other technologies to provide site wide remedial alternatives.

The rationales for including or eliminating each technology are described in more detail below.

3.3.1 Removal

Several removal technologies applicable to both the Tidal Flats and the OF-008 drainage ditch were evaluated. These technologies included mechanical dredging[2], hydraulic dredging, amphibious dredges, and traditional excavation, as well as ancillary support technologies such as debris removal, turbidity control, and temporary dams. These technologies are described in additional detail below and in the Dredging Alternatives Evaluation (**Appendix E**). **Appendix E** provides a detailed evaluation of hydraulic dredging, precision mechanical dredging, precision mechanical dredging by hydraulic transport of sediments, amphibious dredging, and long-reach terrestrial excavation (see **Table 7** of **Appendix E** for a comparison). Technical details associated

[2] All mechanical dredging discussed in this FFS refers to dredging equipment that utilizes precision level cut sealed environmental dredging buckets and GPS positioning software to ensure accurate removals with low potential for resuspension and residuals generation.

with each of those removal approaches are presented in detail in **Appendix E**, which form the basis for the screening evaluation presented in this Section.

3.3.1.1 Mechanical Dredging

Mechanical dredging is a presumptive remedial technology for contaminated sediments. Mechanical dredging removes impacted sediments from the area of concern within a waterway by using direct mechanical force to dislodge and contain the material. Heavy equipment (various sizes of excavators and cranes) are mounted onto a barge and used to excavate the area of concern using precise global positioning system (GPS) guided equipment for horizontal and vertical accuracy. The dredge area can also be dewatered, and the sediment removed mechanically in a dry environment using sheet pile, Portadam, muscle walls, or Aqua-Barrier® (see below under "Excavation"). Alternatively, these methods can also be used to keep water levels high in areas subject to fluctuating water levels (e.g., tidally influenced shallow areas) allowing water-based equipment to operate throughout the tidal cycle.

Removed sediments are typically placed on a materials barge where they are temporarily stockpiled to allow water to be collected and treated through a water treatment system. Once the bulk of the water has been collected, treated and discharged within the environmental barriers, the sediments are transported to a land transfer facility for additional processing. Sediments are then further dewatered (if necessary) and then treated with a drying agent (typically Portland cement) to reduce the moisture content of sediments to an allowable limit and improve strength and handling characteristics for off-site transportation and disposal. In some cases, sediments are treated directly within the barge following initial dewatering. The sediments are then conveyed from the processing facility into barges or trucks for off-site disposal or beneficially re-used on-site as fill materials. If mechanically dredging in the dry, access roads within the dredge area would be constructed to allow direct loading of sediments into trucks for hauling to the processing/disposal area.

Due to Site constraints, a sediment processing and off-loading bulkhead will be required, or an off-site shipping yard will need to be used for all waterway access, sediment processing, transportation and disposal. Tide information, bridge clearances, navigation channels, and underwater utility locations are important considerations in mechanical dredging projects and must be identified and considered during the remedial design. Proximity to local shipping yards and coordination with harbor masters is also a consideration during mechanical dredging of materials.

Mechanical dredging has been retained for further consideration for the Tidal Flats.

The OF-008 drainage ditch has limited water access due to the tidal gate and is very narrow in certain portions of the ditch making it difficult to navigate a barge. For these reasons, mechanical dredging has been screened out for OF-008.

3.3.1.2 Debris and Large Material Removal

This step is typically required before hydraulic dredging if significant oversize debris or other objects are present. Removal may also be necessary prior to mechanical dredging depending on potential for interference with bucket operation. Sediment is first sifted with rakes, grapples, or an excavator bucket to remove interfering debris which is then and placed on barges. Debris is then transported to land for further processing and off-site disposal. Removal allows for more efficient dredging operations.

Debris is not believed to be a significant concern within the Tidal Flats based on observations of the site and anecdotal information obtained during discussion with on-site maintenance staff who know site history.

Limited debris removal has been retained for inclusion in the remedial alternatives due to its potential applicability.

3.3.1.3 Hydraulic Dredging

Hydraulic dredging uses mechanical cutting action to dislodge sediment and a pump to create suction at the dredge head to remove and transport sediment in a slurry form. The dredged material is usually pumped through a pipeline to a settling lagoon or tank (typically on land). Environmental dredging using hydraulic dredges typically produces slurries between approximately 5 and 10% solids by weight. A “cutter head” hydraulic dredge is commonly used to apply mechanical force to dislodge the sediments for removal by the dredge pump. In some cases when the sediment is particularly loose, suction alone is sufficient to transport sediments and a cutter head is not necessary. The slurry requires extensive dewatering and additional process prior to on-site beneficial reuse or off-site disposal of the dredged materials. This is often accomplished using settling tanks, mechanical filter presses, Geotubes, and stabilization agents and may require multiple steps. Water generated during dredging and dewatering of the slurry is typically treated and discharged back to the dredge area. Hydraulic dredging typically generates water flow rates 10 to 100 times that of mechanically dredged sediments due to the much lower percent solids slurry.

Debris can be a concern with hydraulic dredging due to its potential to clog the suction head or impede cutting action. Significant debris is not expected at the Tidal Flats.

Hydraulic dredging has been retained for further evaluation for the Tidal Flats.

The OF-008 drainage ditch has limited water access due to the tidal gate and is very narrow in certain portions of the ditch making it difficult to navigate a barge. For these reasons, hydraulic dredging has been screened out for OF-008.

3.3.1.4 Mechanical Excavation

Traditional or specialized low ground pressure excavation equipment can be used to remove nearshore sediments or sediments that can support heavy equipment with or without constructed access roads. Standard excavation would occur “in the dry,” i.e., at low tide or when the water body is in an engineered dewatered condition. Standard reach or long-reach excavation equipment can be used to access sediments. Traditional equipment is particularly applicable for the removal of sediments along the perimeter of the Tidal Flats and for the entire length of the OF-008 drainage ditch.

Traditional excavation has been retained for further evaluation for use along the perimeter of the Tidal Flats (equipment staged along the dike and Causeway) and the OF-008 drainage ditch (equipment staged at the top of bank).

3.3.1.5 Amphibious Dredging

Specialty amphibious dredging equipment can combine elements of mechanical and hydraulic dredging and traditional excavation. The advantage of this equipment is its ability to work longer throughout the tidal cycle on the mud flats. However, because of the potential to generate excessive turbidity and the soft nature of the sediments, amphibious dredging has been screened from further consideration.

3.3.1.6 Temporary Dams

These technologies include both pre-packaged available proprietary systems (e.g., Portadam, Aquabarrier®, and Muscle Wall) and site-specifically engineered systems (sheet pile walls or earthen dams). These structures are installed within waterways to control water, either to keep water levels high (e.g., to allow mechanical dredging in areas subject to tidal fluctuations), or to keep water levels low (e.g., to allow excavation in the dry either in the Tidal Flats or for the OF-008 drainage ditch). Proprietary systems offer the advantage that they are easily deployed and require little engineering; however, these systems are feasible only in limited circumstances – water depth, current, wave action, or tidal fluctuation all impact their applicability.

Alternatively, engineered systems such as sheet pile and earthen berms can be scaled to almost any size and configuration to handle a much wider variety of site conditions including deeper water, currents, tides, and wave action.

Therefore, only sheet pile (Tidal Flats and OF-008) and earthen dams (OF-008) have been retained for further evaluation.

3.3.1.7 Engineering Controls

Additional engineering controls are typically required for dredging projects. Turbidity barriers, wave attenuators, and fish barriers have been identified as relevant to operations at the SAEP. Turbidity barriers include both silt curtains and harder structures such as cofferdams. A full-length silt curtain (Type II or Type III) would be appropriate to contain resuspended sediments and manage water quality impacts. Properly installed and maintained silt curtains can be very effective at reducing water quality impacts.

An installed sheet pile cofferdam would essentially eliminate the possibility of resuspended sediment from leaving the work area through complete physical separation. The sheet pile cofferdam would be installed to completely enclose the work area, beginning in a line parallel to the breakwater, and running just outside of the work zone beyond the Causeway, and then terminating at shore to the east of the Causeway.

Wave attenuators dissipate the energy from wave action entering the work zone, from either vessel induced wake or wind driven waves. These structures allow the dredge plant to operate more efficiently by reducing the wave impacts on the dredge and appurtenant equipment.

These technologies are all retained for further evaluation for the Tidal Flats. Sheet pile cofferdams have been retained to segregate work areas and control water at OF-008.

3.3.2 Material Transport

Several modes of transportation of removed sediment are applicable, including barge transport, pneumatic flow tube mixing (PFTM), hydraulic slurry transport, and truck transport.

3.3.2.1 Barge/Scow

A barge/scow is a flat-bottomed boat with a rectangular hull that is used to decant, store, and transport mechanically dredged sediments. During mechanical sediment removal, a barge/scow is kept near the mechanical dredge barge and dredged sediment is placed in the adjacent barge/scow. Water is then decanted from the sediment within the dredge footprint. Once the barge/scow is full it is transported to the off-loading facility for sediment removal and returned to the dredging area to be reloaded.

In addition, barge transport can be used to transport sediments directly to an off-site sediment processing facility following dredging. This method avoids the need to build significant on-site infrastructure for sediment processing. There are several sediment processing facilities operating within the greater New York/New Jersey area that are within an economically feasible transport distance. Following transport to the off-site sediment processing facility, sediments are off-loaded and further processed as necessary in accordance with facility permits and transported via truck or rail to off-site permitted locations for either disposal in a landfill or beneficial reuse. Clean Earth operates several of these types of processing facilities Kearny, Carteret, and Jersey City, NJ.

Barge transport has been retained for further evaluation for the Tidal Flats. The OF-008 drainage ditch has limited water access due to the tidal gate and is very narrow in certain portions of the ditch making it difficult to navigate a barge. For these reasons, barge transport has been screened out for OF-008.

3.3.2.2 Pneumatic Flow Tube Mixing

In PFTM, dredged sediment is first placed in a hopper barge, and then fed into a transport pipe where the sediment is pushed along in "plugs" by pockets of air pumped into the pipeline. An injection port is used to inject a Portland cement slurry into the moving sediment. The amendment (typically Portland cement) and sediment mix within the transport pipe through the agitation created by the pneumatic pumping. The mixed sediment and cement are then discharged to selected locations for final placement for beneficial reuse on-site.

This material transport method reduces the need for upland processing of sediment and creates a more stable material with significant strength that can be used in various capacities as fill material on site. PFTM also reduces or eliminates the need for water treatment. There is only one known commercially viable vendor for this process on the East Coast, known as Tipping Point Resources Group (TPRG), LLC. TPRG has been permitted to operate a PFTM system in the New Haven area, coupled with the disposal of treated sediments at permitted sites within the state of CT. TPRG would mobilize their equipment to the project Site to set up a similar operation for on-site placement of material.

PFTM is retained for further evaluation for the Tidal Flats. Due to the available landside access of the OF-008 remediation footprint, PFTM has been screened out for OF-008.

3.3.2.3 Hydraulic Material Transport

Hydraulic material transport efficiently moves low solids content slurry from a sediment barge or directly from a hydraulic dredging operation. The sediment is high in water content allowing it to be pumped from the waterside to the landside through a series of pipe and pump networks. Hydraulic material transport can be used with mechanical or hydraulic dredging applications.

Hydraulic transport has been retained for further evaluation for the Tidal Flats. Due to the available landside access of the OF-008 remediation footprint, hydraulic transport has been screened out for OF-008.

3.3.2.4 Truck Transport

Truck transport is potentially viable for several applications at the SAEP. Trucks can be used to haul mechanically dredged sediments off-loaded from a barge to a land-based sediment processing area. Truck transport is also viable for hauling sediments excavated from the shallow perimeter of the Tidal Flats accessed by a standard excavator or for the OF-008 drainage ditch. If dredging is completed in the dry, access roads can be built to allow low pressure equipment to drive onto the sediment and be directly loaded from a mechanical dredge or excavator. This type of material transport can be highly disruptive if building roads in soft sediments; therefore, truck transport within the tidal flats has been eliminated from further consideration.

Truck transport is necessary for the off-site hauling of processed sediment to off-site disposal facilities.

Land based truck transport from the off-loading bulkhead to the dewatering and processing area has been retained for further evaluation in conjunction with mechanically dredged sediments in the Tidal Flats and sediment excavated via standard excavation equipment in OF-008. Truck transport is also retained for sediment hauling to off-site disposal facilities.

3.3.3 Sediment Dewatering and Processing

There are several types of processing and dewatering technologies available to process sediment that is dredged either mechanically or hydraulically. Dewatering technologies include gravity dewatering, mechanical dewatering processes, and filter bag dewatering. Mechanical dewatering processes typically include steps for size separation to remove oversize material from the slurry prior to processing within the mechanical dewatering equipment.

3.3.3.1 Gravity Dewatering

Dredged sediment is placed into a barge or on a dewatering pad for a period of time to allow water to drain out via gravity. Gravity dewatering, therefore, is the least complex of the dewatering technologies and requires the least amount of preparation and pre-processing. Sediments that are mechanically dredged are typically near or slightly above their natural in situ moisture content. Sediment can be gravity dewatered on a barge as a first dewatering step followed by gravity dewatering on land. This method can be particularly effective for coarser materials such as sand, which do not typically require any additional processing following gravity dewatering. Silty material or material high in organic content may not drain sufficiently and may require the addition of amendments such as Portland cement to eliminate free water.

Gravity dewatering has been retained for further evaluation for both Tidal Flats and OF-008 sediments.

3.3.3.2 Mechanical Dewatering

Mechanical dewatering technologies include a wide variety of techniques to dewater sediment that is hydraulically transported at fairly low percent solids (2 to 20% solids). These techniques typically require complex treatment process systems to separate out various larger material sizes (that can be gravity drained) before the remaining fine material is dewatered. Oversize material (debris, rocks, gravel, and sand) must be screened out. This can be accomplished through a variety of methods, including settling basins, bar screens, augers, progressively finer screens, vibrating screens, hydrocyclones, and clarifiers, all designed to generate a slurry containing only fines that can be processed in mechanical dewatering equipment. Several proprietary processes combine these elements into a complete system that produces fine dewatered sediments, oversize material, and clarified or filtered water. Equipment from the mining and shale industries have been adapted for use in sediment dewatering. The water generated by these processes may or may not require further treatment before discharge back to the original water body. The dewatered sediments typically have been dewatered to a moisture content that is low enough to pass the paint filter test, allowing the material to be transported off-site for re-use or disposal or for placement on-site as fill material.

The following subsections describe the more commonly available technologies for mechanical dewatering.

3.3.3.2.1 Belt Press

A belt filter press uses a series of mesh fabrics and rollers to squeeze the sediment slurry, producing a filtrate liquid and a sediment filter cake at high percent solids. A coagulant polymer is often added to the slurry prior to the belt filter press to aid in the dewatering process, allowing the solids to more effectively coalesce and create the filter cake. As the sediment slurry is processed through the belt filter press, the rollers typically decrease in radial size, increasing the pressure on the sediment and increasing its percent solids. The filtrate squeezed from the solids is collected for further treatment and disposal. A solid sediment cake is collected at the end of the belt press and stockpiled for further processing, beneficial reuse on site, or disposal off-site.

Belt press technology has been retained for further evaluation for the Tidal Flat sediment dewatering and eliminated for OF-008. OF-008 sediments are proposed to be excavated in the dry which will result in much higher percent solid material which can be gravity drained and stabilized with Portland cement.

3.3.3.2.2 Recessed Chamber Filter Press

The recessed chamber filter press machine uses a series of plates (typically polypropylene) mounted on a steel frame to squeeze the sediment slurry at high pressure to drive water out of the sediment. The plates have a concave depression and hole in the middle to create a chamber for squeezing the sediment. A filter cloth lining between each of the plates filters the expressed liquid as it is generated. Processing is in batches, with filter cake generated on a certain time cycle. Like other mechanical dewatering technologies, the addition of polymers to the slurry can enhance the dewatering process through coagulation.

Recessed chamber filter press has been retained for further evaluation for the Tidal Flat sediment dewatering and eliminated for OF-008. OF-008 sediments are proposed to be excavated in the dry and gravity dewatered, followed by sediment stabilization with Portland cement.

3.3.3.2.3 Centrifuge

The centrifuge separates solids and water by taking advantage of centrifugal force and differential densities. The sediment/water slurry is spun at high (4,500) revolutions per minute along a horizontal axis, causing the heavier solids to separate from the water in the slurry. The solids and water are drawn off separately. Centrifuges are complex machines with many moving parts operating at high speeds. Like other mechanical dewatering processes, polymers typically enhance the separation of solids and water. A technology that is similar, but more passive with less moving parts, is the hydrocyclone. This technology operates on the same principal of centrifugal force as the centrifuge. Hydrocyclones can be used in conjunction with centrifuges and other mechanical dewatering systems.

Centrifuge technology has been retained for further evaluation for the Tidal Flat sediment dewatering and eliminated for OF-008. OF-008 sediments are proposed to be excavated in the dry and gravity dewatered, followed by sediment stabilization with Portland cement.

3.3.3.2.4 Proprietary Mechanical Dewatering Systems

There are many proprietary complete dewatering systems available commercially. These systems include a combination of the technologies described above to provide a complete solution to dewater sediment. Examples of these processes include Hi-G by Derrick (a series of vibratory screens that rotate elliptically rather than linearly, generated higher forces for screening, and hydrocyclones), the Genesis Rapid Dewatering System (proprietary Aquascreen® and capillary action), and the TCW-3000 Plus by DEL Tank and Filtration Systems (vibrating screens and hydrocyclones).

For purposes of this FFS, the Hi-G screening system was selected for further evaluation as part of the Treatability Study; however, upon coordination with the vendor (Derrick), Derrick could not accept material with PCB concentrations present and declined to perform the treatability study (**Appendix C, Section 7.1**). However, ultimately any of these process options (whole systems) could potentially provide effective dewatering. The selected system for dewatering may depend on the selected dredging contractor’s preferences and equipment availability.

3.3.3.3 Geotubes

Geotube dewatering containers are large diameter fabric tubes that filter low percent solids slurries to create materials with higher percent solids that can in turn be beneficially re-used or disposed of. Prior to being pumped into the Geotubes, the hydraulically conveyed sediment slurry is treated with coagulant polymers to aid in particulate filtration, similar to other slurry dewatering applications. One advantage of Geotubes is that little or no size separation is needed prior to Geotube dewatering; therefore, hydraulically conveyed sediments can generally be pumped directly into Geotubes. Initial filtration of the solids occurs through pressure generated from pumping the slurry into the tubes, followed by secondary filtration driven by the force of gravity over a longer period, which can typically be 30 to 45 days or longer. The filtered water is drained and collected for further treatment, leaving the solids within the Geotubes. When full, the Geotubes can remain on-site for beneficial reuse in the as-delivered location or the dried solids can be hauled off-site for disposal at a landfill or beneficial re-use.

Geotubes have been retained for further evaluation for the Tidal Flat sediment dewatering. OF-008 sediments are proposed to be excavated in the dry and gravity drained, followed by sediment stabilization with Portland cement, making Geotubes not applicable.

3.3.3.4 Solidification and Stabilization

Solidification and stabilization (S/S) include the physical improvement of the sediment for workability, transport, and placement and chemical fixation to reduce the potential for leaching of site contaminants. These two processes typically work in conjunction with each other and can be used with either hydraulic or mechanical dredge operations. Dewatered sediment is transported to the processing area where a certain amount (depending on the type of sediment and objectives of S/S) of additive (typically Portland cement) is mixed into the sediment, completing the dewatering process, solidifying the sediment, and reducing leachability of contaminants. Once solidified, the sediment can be transported by truck off-site, or stockpiled and reused on-site. Depending on the requirements of the off-site facility or on-site beneficial reuse, strength of the sediment may be an important consideration. Additives such as Portland cement and lime are typical to achieve moisture reduction, chemical fixation, and strength improvement.

S/S can be implemented using traditional excavator bucket mixing, pug mill mixing, dual or single axis mixer head application, or PFTM.

S/S has been retained for further evaluation for both the Tidal Flats and OF-008.

3.3.3.5 Wastewater Treatment Technologies

There are a wide variety of technologies available to treat dewatering fluids generated from sediment dewatering. These technologies include settling, pH adjustment, coagulant and flocculent addition, metals precipitation, filtration, carbon adsorption, ion exchange, reverse osmosis, and other specialty media treatment. The required treatment train can be simple, or complex depending on the influent water quality and required discharge standards. At a minimum, settling, filtration, and carbon adsorption are likely to be applicable to the SAEP site based upon the presence of various metals and PCBs.

Wastewater treatment technologies have been retained for further evaluation.

3.3.4 Disposal/Re-Use

3.3.4.1 Confined Disposal Facility

A confined disposal facility (CDF) is an approved upland area typically located along the shoreline for placement of dredged materials. Dredged material is placed directly in the CDF and allowed to dewater by gravity drainage or pumped to Geotubes for dewatering within the CDF. Dewatering fluid may require additional treatment before discharge. Typically, these areas are contained within sheet pile enclosures which become permanent features and may be used as an additional shoreline resource (e.g., for recreational or commercial purposes) upon completion.

Two options have been considered for implementation at the SAEP. One option would include essentially straight walls that would “square off” the curved shoreline of the existing Tidal Flats. This would create significant shoreline encroachment below the high tide line, reducing the Tidal Flats area. This option has been screened out due to numerous regulatory and ecological concerns.

Another configuration would be a shoreline CDF constructed parallel to the shoreline all the way around the Causeway at the high tide line to minimize the impacts to the Tidal Flats. This configuration is more acceptable to regulators and would potentially provide benefits for future development.

The shoreline CDF constructed parallel to the shoreline has been retained for further evaluation for the Tidal Flats. To eliminate future liability and long-term monitoring and maintenance for the U.S. Army, a key component of this technology would be to permanently transfer long-term liability to the future owner of the upland property. The shoreline CDF is also applicable to sediments removed from the OF-008 drainage ditch.

3.3.4.2 Confined Aquatic Disposal Cell

Confined Aquatic Disposal (CAD) cell placement involves the transport of dredged materials to an approved open-water location which has been dredged to create a cell for the contaminated materials. The contaminated sediments are then placed in the CAD cell. The material can be hydraulically pumped to the CAD or placed mechanically from a barge or released from a split hull hopper barge. The material is placed into the CAD cell in this manner until its capacity is reached. Once capacity is reached, the CAD cell is capped. Capping of the CAD cell would be similar in design as capping that has been described above as a containment GRA. Capping is intended to isolate the contaminated dredged materials to prevent environmental impacts.

Two CAD cell locations near the site within the Housatonic River and at the site were evaluated for potential applicability to the project and inclusion in the remedial alternatives.

CAD cell construction has been retained for inclusion in remedial alternatives for both Tidal Flats and OF-008 sediments.

3.3.4.3 On-Site Beneficial Reuse

The entire SAEP site is within a floodplain; therefore, the SAEP requires approximately 7 ft of fill to be placed across the site to make the site developable. For this reason, the on-site beneficial reuse of sediments is a potential option for disposition of dredged material. For the material to be acceptable for on-site use, it must meet physical and chemical requirements. The chemical requirements for land disposal of treated sediment include meeting appropriate groundwater protection standards as measured through the Toxicity Characteristic Leaching Procedure (TCLP) (EPA Method 1311) or Synthetic Precipitation Leaching Procedure [SPLP] test (EPA Method 1312). Treatability results of raw sediment, dewatered sediment, and sediments treated with S/S agents all show the sediment to meet GW B standards (the site is zoned GW B which includes industrial process water and cooling water uses etc., not suitable for human consumption, CT DEEP 2017) as measured via the SPLP test (Appendix B to RSRs, CT DEEP 2013). For the Pollutant Mobility Criteria cited in the CT RSRs (Section 22a-133k-3), the method of measurement is the SPLP or TCLP test methods, which is the method performed on treated and untreated site sediments for purposes of this comparison. **Table C-8** of **Appendix C** (Treatability Testing Evaluation) presents the SPLP results and a comparison to state GWB standards.

Regarding physical characteristics of the processed sediment, it is not currently possible to identify a final or exact on-site disposal area that will meet future unknown redevelopment plans and requirements. The currently available site development plan is highly conceptual at this stage and subject to numerous changes based on market demand and input from various local stakeholders. Therefore, establishing material physical properties that meet the intended future uses is difficult at this stage.

However, based on a review of similar sites that require the solidification of sediments or subsurface soils, generally the unconfined compressive strength (UCS) (ASTM D1633) test is used as a basis for specifications. Typically, material strengths ranging from 40 to 80 pounds per square inch (psi) are required for most development uses. For comparison purposes, concrete has a UCS of 3,000 psi or greater. Generally, soil or treated sediment becomes un-excavatable at 200 psi or greater. Materials below 100 psi in strength are generally workable and can be removed and re-compacted as necessary to support development requirements, like other soil materials used for various development purposes.

In treatability testing performed on Site sediments, UCS results of 5.5, 61, and 90 psi were obtained on gravity-drained sediments for additive ratios of 2%, 4%, and 5% Portland cement, respectively, and 8.8, 108, and 91 psi were obtained on belt pressed dewatered sediments treated with 3%, 6%, and 8% Portland cement, respectively. During initial curing at days 1, 3, and 5, both torvane and pocket penetrometers readings were obtained. For belt press dewatered sediments amended with Portland cement, pocket penetrometer results developed to 0.25 tons per square foot (TSF) (3%) and >4.5 TSF (6% and 8%) after five days. Torvane results show strength development of 2.8 to 5.5 (torvane results are reported in kg/cm^2 [kgc2]).

For gravity drained sediments, pocket penetrometer results yielded 0.5 to >4.5 TSF and torvane results ranged from 2 to 3.5 kgc2. In general, the pocket penetrometer and torvane tests provided verification of the cement curing process in the early days following mixture development.

For the Mintek Calciment results, pocket penetrometer and torvane results were much lower, as expected, and were 0.25 TSF for all belt press dewatered mixtures and 1 to 2.5 kgc2 for the torvane tests. Similarly, for gravity drained sediments, pocket penetrometer results ranged from 0.0 to 0.5 TSF and 0 to 2 kgc2 for torvane (see **Appendix C** subsection 7.3 and Kemron treatability report for more details).

Similarly, sediments solidified using a bench-testing process designed to mimic the PFTM process yielded results ranging from 81 to 170 psi for Portland cement additive ratios ranging from 6% to 14%. In conclusion, the addition of 6% Portland cement is believed to be sufficient for likely on-site beneficial re-use requirements (see **Appendix C** Section 7.3 Solidification, Section 8 Tipping Point Treatability Study, and **Appendix C Attachment C**).

Once the sediment has been processed and meets the required geotechnical parameters for re-use it can be placed as fill as needed on-site. For purposes of this FFS, a generic stockpiling area has been assumed for processed sediment. It is important to note that the above strengths are not necessary to simply create a stockpile of dewatered sediment for future use.

On-site beneficial re-use has been retained for further evaluation for both the Tidal Flats and OF-008.

3.3.4.4 Off-Site Disposal and Beneficial Reuse

Off-site disposal of sediments includes disposal at both RCRA C/TSCA-permitted facilities and RCRA D landfill facilities. All sediments from the Site have been assumed to be non-RCRA (listed or characteristic). There is no site history that would link the use of RCRA listed processes to sediment contamination. Therefore, the sediments are not considered a listed hazardous waste. To determine if the waste could be a characteristic hazardous waste, hazardous waste parameter analyses were completed. TCLP analysis of raw and treated sediment was conducted. Results show that the sediment does not fail the toxicity characteristic ("D" waste codes, see Appendix C, **Table C-9**). Furthermore, other hazardous waste parameters, ignitability, reactivity, and corrosivity all show that the sediment does not exhibit hazardous waste characteristics. Therefore, it is assumed that all sediment can be disposed of in RCRA Subtitle D (solid waste) landfills.

However, given the presence of PCBs in the sediment, the Toxic Substances Control Act (TSCA) must be considered for on-site handling and off-site disposal considerations. For off-site sediment disposal, RCRA D landfills do not accept soils containing PCB concentrations equal to or greater than 50 ppm. In addition, the operating permits of many state-permitted landfills and Treatment, Storage and Disposal Facilities (TSDFs), including asphalt batch plants and thermal incinerators may limit PCB concentrations at lower levels. This will limit the number of landfills or facilities permitted to accept the processed sediment and may increase the cost for disposal.

Once the sediment has been sufficiently processed and has been accepted by the off-site disposal facility, it will be loaded into trucks, rail cars, or barges and disposed of off-site.

Sediment meeting beneficial reuse criteria may be reused off-site as landfill daily cover or road base material, urban fill, or for other uses including mine and site reclamation depending on the chemical characterization of the sediment and the permitting requirements of the site. The potential for reuse of the sediments off-site will need to be determined at the time of contractor bidding for the project, as these options can change over time.

Off-site disposal has been retained for further evaluation as an alternative disposal option for both the Tidal Flats and OF-008.

3.3.5 Habitat Restoration

The following restoration options are applicable to various areas of the site and would be implemented following remediation.

3.3.5.1 Bank Treatments/Bioengineering

Banks along rivers and streams require hard and soft structures to ensure they are stable and allow vegetation to re-establish itself. The structures or materials include coir fabrics and logs, native vegetation, rip rap, placement of trees, and other bank features to replicate desired conditions.

3.3.5.2 Riparian Vegetation

Potentially applicable to the OF-008 drainage ditch, replanting of vegetation along the banks of rivers and streams is an essential component of reestablishing a water body's function. This method re-establishes trees, shrubs, forbs, grasses, and sedges as appropriate to recreate the desired ecosystem.

3.3.5.3 Tidal Salt Marsh

A saltmarsh is a coastal ecosystem in the upper coastal intertidal zone between land and open saltwater or brackish water that is regularly flooded by the tides. Tidal salt marsh restoration will be completed for areas of the tidal mudflats and in the OF-008 remediation area (if present) once the sediments are removed. There are several acres of high salt marsh present within the tidal mudflats. These areas are located towards the northern limits of the Tidal Flats inside the breakwater and along the western shoreline of the mudflats adjacent to the hurricane dike. Similar soil material will be replaced and planted with salt marsh grass to reestablish habitat.

3.3.5.4 Tidal Mudflats

Tidal mudflats are coastal wetlands that accumulate mud deposited by tides. Most of the sediment within a mudflat is within the intertidal zone, and thus the flat is submerged and exposed approximately twice daily. The tidal mudflats will be backfilled to elevations that are one foot below the existing mudline using a sandy material to enhance the restoration process. The remaining one foot of material is assumed to be re-deposited by natural processes over time and will allow for the top foot of material to be similar in grain size to existing conditions.

An evaluation of LiDAR survey data collected between 2006 and 2015 (see **Appendix A-4**) for the Tidal Flats area clearly demonstrates that the mean sediment elevation of the flats increased by 0.39 feet over the 9-year period. This sedimentation occurred despite the impacts of Hurricane Sandy in late October 2012, which was estimated to have potentially decreased the mean elevation of the flats by as much as 0.28 feet. Using the LiDAR data for the 2012 (post-"Sandy") and 2015, an estimated sedimentation rate of 0.07 feet/year was calculated; using this rate it is theorized that the remaining one foot of excavation that is not intended to be backfilled will require 14 years to accumulate sediment through natural processes. However, it is important to note that this time estimate is likely a maximum value. The 1-foot removal depth areas which are not planned to be backfilled to existing grade represent non-equilibrium conditions for the mudflats, and as such will result in an accelerated sedimentation rates in those areas. Increases in sedimentation rates have been documented at other sediment excavation sites where excavations have not been completely backfilled to grade (http://www.nae.usace.army.mil/Portals/74/docs/DAMOS/TechReports/186.pdf). Although it is difficult to quantitatively estimate the impact of the non-equilibrium condition on the sedimentation rate, it is possible that the timeframe to naturally backfill the 1-foot interval to existing grade will be less than 14 years and may be on the order of +/-10 years.

Due to the documented net sedimentation occurring on the Tidal Flats, over a time period encompassing storm impacts from Hurricane Sandy, long-term monitoring of the restoration outside of re-vegetated areas is considered unnecessary and will not be conducted.

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, technically feasible technologies retained following screening in Section 3.0 are combined to form remedial action alternatives that may be applicable to the Tidal Flats and the OF-008 drainage ditch at the SAEP.

The alternatives are developed to meet the RAOs presented in Section 2.4, using the GRAs identified in Section 3.1 either singly or in combination. Developed remedial alternatives are then screened with respect to the criteria of effectiveness, implementability, and cost in accordance with the requirements of CERCLA and the NCP. Cost is not formally evaluated in this section. Rather, based on knowledge of relative costs, professional judgment is used to identify the relative cost-effectiveness of each alternative. Detailed cost evaluations are presented in Section 5.0 as part of the detailed evaluation of alternatives passing this section’s screening.

The objective of the alternative screening step is to eliminate impractical alternatives or higher cost alternatives that are not considered cost-effective (i.e., that provide little or no increase in effectiveness or improvement in implementability over their lower-cost counterparts). The effectiveness and implementability criteria used for screening the alternatives are defined below.

Effectiveness. Each alternative is evaluated for its ability to protect human health and the environment, including the extent to which toxicity, mobility, or volume of contaminants is reduced. Both short- and long-term effectiveness are considered. Short-term effectiveness involves the extent to which existing risks to receptors during the construction and implementation period are reduced, identifying and mitigating expected effects to the environment during construction and implementation, the alternative’s ability to meet RAOs, and the relative time frame required to achieve RAOs. Long-term effectiveness, which applies after RAOs have been attained, considers the magnitude of the remaining residual risk due to residual contaminant sources, and the adequacy and reliability of specific technical components and control measures to maintain compliance with RAOs over the life of the remediation.

Implementability. Each alternative is also evaluated in terms of technical and administrative feasibility. In the assessment of short-term technical feasibility, availability of a technology for construction or mobilization and operation, as well as compliance with action-specific ARARs during the remedial action, are considered. Long-term technical feasibility considers the ease of operation and maintenance (O&M), technical reliability, the ease of undertaking additional remedial actions, and the degree of monitoring of technical controls for residuals and untreated wastes. Administrative feasibility for implementing a given technology addresses coordination with other agencies, public acceptance, and the commercial availability of required services and trained specialists or operators.

Table 4-1 highlights each alternative’s advantages and disadvantages with respect to effectiveness, implementability, and relative cost. Based on this table, a decision is made to either retain the alternative for detailed analysis or eliminate it from further consideration.

Consistent with USEPA guidance (USEPA 1988), a No Action Alternative was developed for the Tidal Flats and OF-008; however, these options have not been carried forward to the detailed analysis based on the U.S. Army's preference for complete removal of sediments exceeding PRGs.

4.1 Development of Alternatives

Remedial alternatives are developed in this subsection for the Tidal Flats and OF-008 drainage ditch at the SAEP. A total of eleven alternatives for the Tidal Flats, and three alternatives for the OF-008 drainage ditch have been developed, including the No Action Alternative for each. The alternatives consider the following key elements of the sediment remediation process:

- the required removals (location and depth) and methods for removal;
- available site infrastructure for support and processing;
- affected media and methods for dewatering and other processing of sediment;
- contaminant type and distribution;
- tidal cycles;
- control, treatment, and sampling of discharge water; and
- control of resuspended sediments.

In assembling these alternatives, GRAs and process options chosen to represent the various technology types are combined to form alternatives for the site. Alternatives were developed to provide a range of options consistent with USEPA RI/FS guidance (USEPA, 1988).

In addition, treatability studies have been completed to support the development, screening, and analysis of alternatives. Results of the treatability testing are provided in **Appendix C** and include work conducted by Wood and its laboratory subcontractors, ESI of Hampton NH, Alpha Analytical of Mansfield, MA, Rutgers Weeks Geotechnical Laboratory in Piscataway, NJ, and Kemron Environmental Services in Atlanta, GA. Treatability tests and other laboratory analyses completed to support these evaluations include:

- ► Modified elutriate analysis to support water treatment and discharge evaluations (see **Tables C-3, C-4, and C-5**);
- ► SPLP and TCLP analysis of raw sediments to support evaluation of on- and off-site disposal and the need for sediment stabilization for purposes of chemical fixation (**Table C-8**, SPLP and TCLP results);
- ► Grain size, hydrometer, and organic carbon content to assess the materials dredging and dewatering characteristics (**Tables C-6** and **C-7**);

- Geotechnical parameters including bulk and dry density, specific gravity, Atterberg limits, and moisture content to provide general physical characteristics of the material and support dredge evaluations (**Tables C-6** and **C-7**);
- Strength testing of solidified sediments, including pocket penetrometer, torvane, and unconfined compressive strength (**Appendix C**, Attachment C, Kemron Treatability Study);
- Waste characterization analyses to support ultimate disposition of the material for on-site beneficial reuse or off-site disposal (**Tables C-9, C-10**, and **C-11**); and
- Dewatering, solidification, and water treatment tests to identify appropriate methods for treatment, processing, and disposal/discharge, support cost estimate development, and determine suitability for on-site re-use of dredged materials (**Tables C-12** through **C-18**).

Tables C-1 and **C-2** of Appendix C summarize the sampling performed for treatability testing. **Figure C-1** shows the locations of sampling points for treatability testing and **Section 1.0** of **Appendix C** describes the sampling program.

4.2 Tidal Flats Alternatives

Eleven remedial alternatives (including No Action) are identified in this subsection to address RAOs for the sediment in the Tidal Flats. These alternatives and their key components are the following:

- **Alternative 1: No Action**
- **Alternative 2: Hydraulic Dredging**
  - Hydraulic dredging
  - Turbidity monitoring, management, and engineering controls (silt curtain)
  - Land-based Long-stick excavation of near shore sediments
  - Hydraulic slurry transport
  - Dewatering via belt filter or Geotube
  - S/S to meet on-site re-use requirements
  - Water treatment and discharge back to Housatonic River
  - Mechanically placed backfill
  - Off-site disposal of sediments containing 1.0 mg/kg PCBs or greater

  - On-site beneficial re-use or off-site disposal of sediments with less than 1.0 mg/kg PCBs

- **Alternative 3: Mechanical Dredging**
  - Mechanical dredging
  - Turbidity monitoring, management, and engineering controls (silt curtain) to control turbidity
  - Land-based long-stick excavation of near shore sediments
  - Mechanical off-loading of mechanically dredged sediment and truck transport of sediment to processing area
  - Gravity dewatering
  - S/S of dewatered sediments to meet on-site re-use requirements or off-site disposal acceptance criteria
  - Water treatment and discharge back to Housatonic River
  - Mechanically placed backfill
  - Off-site disposal of sediments containing 1.0 mg/kg PCBs or greater
  - On-site beneficial re-use or off-site disposal of sediments with less than 1.0 mg/kg PCBs

- **Alternative 4: Mechanical Dredging with Hydraulic Transport**
  - Mechanical dredging
  - Turbidity monitoring, management, and engineering controls (silt curtain) to control turbidity
  - Land-based long-stick excavation of near shore sediments
  - Hydraulic slurry transport and truck transport of sediments to processing area
  - Dewatering via belt press
  - S/S to meet on-site re-use requirements
  - Water treatment and discharge back to Housatonic River
  - Mechanically placed backfill

- Off-site disposal of sediments containing 1.0 mg/kg PCBs or greater
- On-site beneficial re-use or off-site disposal of sediments with less than 1.0 mg/kg PCBs

- **Alternative 5: Pneumatic Flow Tube Mixing**
  - Mechanical dredging followed by pneumatic conveyance and PFTM to solidify sediments and direct on-site placement of treated sediments
  - Turbidity monitoring, management, and engineering controls (silt curtain) to control turbidity
  - Land-based long-stick excavation of near shore sediments and truck transport to processing area
  - Gravity dewatering (minimal) of excavated sediments
  - S/S of dewatered sediments
  - Water treatment and discharge back to Housatonic River
  - Mechanically placed backfill
  - Off-site disposal of sediments containing 1.0 mg/kg PCBs or greater
  - On-site beneficial re-use of sediments containing less than 1.0 mg/kg PCBs

- **Alternative 6: Mechanical Dredging and Off-Site Processing**
  - Mechanical dredging
  - Turbidity monitoring, management, and engineering controls (silt curtain) to control turbidity
  - Initial gravity dewatering
  - Water treatment and discharge back to Housatonic River
  - Barge transport of all sediments to off-site processing facility
  - Processing (dewatering and S/S) at an off-site facility (e.g., Clean Earth)
  - Mechanically placed backfill
  - Off-site disposal of all sediments.

- **Alternative 7: Hydraulic Dredge/Cofferdam**

- Same components as Alternative 2 except for the following
- Turbidity monitoring, management, and engineering controls - cofferdam installation in lieu of silt curtain to accomplish:
    - Turbidity control; and
    - Hydraulic control of water level to allow for dredging over entire tidal cycle.

- **Alternative 8: Mechanical Dredge/Cofferdam**
    - Same components as Alternative 3 except for the following
    - Turbidity monitoring, management, and engineering controls - cofferdam installation in lieu of silt curtain to accomplish:
        - Turbidity control; and
        - Hydraulic control of water level to allow for dredging over entire tidal cycle.
- **Alternative 9: Amphibious Dredge**
    - Either mechanical or hydraulic dredge operated on Tidal Flats or on water surface throughout tidal cycle
    - Remaining components as described above for Alternatives 2 and 3 for mechanical or hydraulic methods
- **Alternative 10: Hydraulic Dredge/Shoreline CDF**
    - Hydraulic dredging
    - Turbidity monitoring, management, and engineering controls (silt curtain) to control turbidity
    - Hydraulic slurry transport
    - Installation of shoreline sheet pile with/ toe drains for CDF construction
    - Building demolition to accommodate CDF
    - Dewatering via Geotube behind CDF wall
    - Water treatment and discharge back to Housatonic River
    - Mechanically placed backfill
    - Off-site disposal of sediments containing 1.0 mg/kg PCBs or greater

    - On-site beneficial re-use of sediments containing less than 1.0 mg/kg PCBs as fill within shoreline CDF

- **Alternative 11: CAD Cell**
    - Hydraulic dredging
    - Turbidity monitoring, management, and engineering controls (silt curtain) to control turbidity
    - Hydraulic slurry transport
    - Installation/Excavation of CAD within either tidal flats or within Housatonic channel
    - Sheet pile for tidal flats CAD
    - Dewatering via Geotube on-site
    - Water treatment and discharge back to Housatonic River
    - Mechanically placed backfill including use of clean CAD sediments
    - Off-site disposal of sediments containing 1.0 mg/kg PCBs or greater
    - Placement of sediments containing less than 1.0 mg/kg PCBs within near-site CAD cell

4.3 Outfall-008 Drainage Ditch Alternatives

Three remedial alternatives (including No Action) are identified in this subsection to address RAOs for the sediment in the OF-008 drainage ditch. These alternatives are:

- **Alternative 1: No Action**
- **Alternative 2: Mechanical Excavation**
    - Isolate and dewater area with sheet piles, earthen dams, and/or other temporary dam systems
    - Mechanical excavation “in the dry” with conventional excavation (standard reach and/or long-reach) equipment
    - Truck transport to sediment processing area
    - Gravity dewatering
    - S/S of dewatered sediments to meet on-site re-use requirements or off-site disposal acceptance criteria

    - Water treatment and discharge back to Housatonic River
    - Mechanically placed backfill
    - Site/habitat restoration
    - On-site re-use of non-TSCA sediments
    - Off-site disposal of TSCA-regulated sediments
- **Alternative 3: Mechanical Dredging**
    - Mechanical dredging with precision low turbidity mechanical dredge
    - Mechanical off-loading of mechanically dredged sediment and truck transport of sediment to processing area
    - Gravity dewatering
    - S/S of dewatered sediments to meet on-site re-use requirements or off-site disposal acceptance criteria
    - Water treatment and discharge back to Housatonic River
    - Mechanically placed backfill
    - Site/habitat restoration
    - Off-site disposal of TSCA-regulated sediments
    - On-site re-use or off-site disposal of non-TSCA sediments

4.4 Tidal Flats Alternatives Screening

Table 4-1 summarizes the alternatives against effectiveness, implementability, and cost.

For the Tidal Flats, Alternatives 1, 7, 8, 9, 10, and 11 as outlined in Section 4.2, have been eliminated from further evaluation.

Alternative 1 (No Action) has been eliminated because the Army has determined that a remedial action must be taken to close the Site and continue with future development plans.

Alternatives 2 through 6 have been retained because they all can achieve the RAOs, are implementable, and have comparable costs (moderately high).

Alternatives 7 and 8 have been eliminated because of the complex implementation, extensive engineering, and high cost related to installation of a steel sheet pile cofferdam. Although this option would allow remediation to continue throughout the year because of the completeness of turbidity control, the additional time to design and install the structure is significant and the additional costs ($20M) are not justified. Additionally, the design and installation of the cofferdam is technically complex near the existing breakwater, and sufficient buffer must be maintained so as not to encroach upon or damage that structure. This may necessitate removal occurring in that area prior to cofferdam installation, resulting in the need for turbidity control via silt curtain regardless for a portion of the work. Other significant technical challenges include ensuring complete enclosure around the area to ensure no bypass of tide waters into or out of the Tidal Flats.

Alternative 9 has been eliminated due to the very soft nature of the site sediments and the elevated risk of generating excessive resuspended sediments using amphibious equipment. These risks outweigh the benefit of being able to work throughout tidal cycles.

Alternative 10 (Shoreline CDF) has been eliminated from further consideration due to high cost, technical complexity, and additional time required to complete, with no additional benefits to site cleanup. Installation of this CDF would require extensive building demolition along the shoreline to allow for the placement of dewatered sediments. The wall itself must be installed to a depth of approximately 90 ft due to the low strength sediments present at the site. This option would add approximately one year on to the project schedule for design and construction.

Alternative 11 (CAD cell) has been eliminated from further consideration. The selected locations are considered very difficult and time consuming to implement given the multiple jurisdictions that would be involved and its location within a navigation channel (Housatonic River). A CAD cell located in the Tidal Flats was also evaluated but determined infeasible based on the Site logistics, equipment needs, potential for conflict with future development plans, and the need for sheet pile walls. Other locations are possible; however, this disposal technology is not considered feasible within the timeframes anticipated for implementation of the project (immediate) and would not relieve the U.S. Army of long-term liability and related monitoring and maintenance activities.

4.5 Outfall 008 Alternatives Screening

Table 4-1 summarizes the alternatives against effectiveness, implementability, and cost.

For the OF-008 Alternatives, Alternatives 1 and 3 have been eliminated from further evaluations.

Alternative 1 has been eliminated because no sediments would be removed, and it would not meet the RAOs or the U.S. Army's preference to eliminate long-term liability.

Alternative 2 (isolate, dewater, and excavate), has been retained because the technologies are well established and can be effectively implemented. Water control is a critical element of this alternative; however, the technologies and expertise to implement this work are widely available.

Alternative 3 (Mechanical Dredging) has been eliminated due to the difficulty of accessing the site by water, its narrow footprint, and an inability to effectively haul dredged material to the site for processing. Dredging and restoration with water present is more difficult than doing this work in a dewatered condition, and inherently less accurate or complete. Although costs are expected to be lower relative to excavation in the dry, the lack of effectiveness outweighs the potential cost advantages.

The following FFS sections describe the detailed evaluation and comparative analysis of the retained alternatives developed for remediation of sediment at the Site.

5.0 DETAILED EVALUATION OF ALTERNATIVES

This section presents the detailed analyses of the remedial action alternatives retained in Section 4 for the Tidal Flats and OF-008 at the Site. The detailed analysis is intended to provide decision-makers with information to aid in selection of a remedial alternative that best meets the following CERCLA requirements:

- protects human health and the environment;
- attains ARARs (or provides grounds for invoking a waiver);
- utilizes permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable;
- satisfies the preference for treatment that reduces toxicity, mobility, or volume of hazardous substances as a principal element; and
- is cost-effective.

The detailed analysis is summarized in **Table 5-1** and was performed in accordance with CERCLA Section 121, the NCP (USEPA, 1990), and USEPA RI/FS guidance (USEPA, 1988). The detailed analysis contains the following:

- a detailed description of each candidate remedial alternative, emphasizing the application of various component technologies; and
- an assessment of each alternative with respect to the first seven of the nine evaluation criteria described in the NCP (USEPA, 1990). State and community acceptance are addressed following public review of the Proposed Plan.

The detailed description of technologies or processes used for each alternative includes, where appropriate, preliminary site layouts and a discussion of limitations, assumptions, and uncertainties for each component. The descriptions provide a conceptual design of each alternative and are intended for alternative-comparison and cost-estimation purposes only.

Remedial alternatives are evaluated according to the first seven of nine NCP evaluation criteria. The nine NCP evaluation criteria are defined in the following paragraphs as they pertain to this FFS.

Overall Protection of Human Health and the Environment. Assesses how well an alternative achieves and maintains protection of human health and the environment.

Compliance with ARARs. Assesses how the alternative complies with location-, chemical-, and action-specific ARARs, and whether a waiver is required or justified.

Long-term Effectiveness and Permanence. Evaluates the effectiveness of the alternative in protecting human health and the environment after response objectives have been met. This criterion includes consideration of the magnitude of residual risks and the adequacy and reliability of controls.

Reduction of Toxicity, Mobility, or Volume through Treatment. Evaluates the effectiveness of treatment processes used to reduce toxicity, mobility, and volume of hazardous substances. It also considers the degree to which treatment is irreversible, and the type and quantity of residuals remaining after treatment.

Short-term Effectiveness. Examines the effectiveness of the alternative in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met. It also considers the protection of the community, workers, and the environment during implementation of remedial actions.

Implementability. Assesses the technical and administrative feasibility of an alternative and availability of required goods and services. Technical feasibility considers the ability to construct and operate a technology and its reliability, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of a remedy. Administrative feasibility considers the ability to obtain approvals from other parties or agencies and the extent of required coordination with other parties or agencies.

Cost. Evaluates the capital, and operation and maintenance costs of each alternative. Present worth (PW) costs are calculated to help compare costs among alternatives.

State Acceptance. Considers the state's preferences among or concerns about the alternatives, including comments on ARARs or the proposed use of waivers. This criterion is addressed in the Responsiveness Summary following state input on the Proposed Plan.

Community Acceptance. Considers the community's preferences among or concerns about the alternatives. This criterion is addressed following community input on the Proposed Plan.

The detailed analysis of each alternative includes an estimate of the time necessary for completion of the alternative (i.e., remedial duration) and a cost estimate (**Appendix F**). The time-frame estimates were based on development of productivity estimates for various methods of removal, the available schedule (hours per day, days per week, and months per year), and professional judgment. For purposes of the FFS, a seven-month work window (July 1^{st} through January 31^{st}) was assumed (see Section 2.1 for additional details).

Costs are intended to be within the target accuracy range of minus 30 to plus 50 percent of actual cost (USEPA, 1988). Assumptions used to develop and estimate costs may or may not remain valid during alternative implementation. For example, as part of this FFS, it has been assumed that no building demolition will be included to accommodate on-site activities including placement of fill on-site. This assumption has potential to change as various stakeholders review the FFS and Proposed Plan. In addition, maintenance has not been included and is assumed to be the responsibility of the future property owner. Details related to monitoring and maintenance and related agreements will need to be evaluated and may affect costs. Cost uncertainties, where possible, are discussed in the text.

Each cost estimate includes a present worth analysis to evaluate expenditures that occur over different time periods. The analysis discounts future costs to a present worth and allows the cost of remedial alternatives to be compared on an equal basis. Present worth can be a useful evaluation tool when comparing alternatives that rely differently upon aggressive source control actions vs. long-term monitoring (e.g., MNR). Consistent with USEPA guidance, a discount rate of 2.8% was used to prepare the cost estimates (USEPA, 2000) based upon the most recent Office of Management and Budget Circular A-94 (OMB 2016). In addition, costs occurring in future years were escalated to account for typical anticipated increases in construction costs. A value of 3% per year has been used (RS Means 2017).

Each cost estimate includes the following items, as applicable:

- engineering design at a percentage of direct capital costs (5%);
- project and construction management, including health and safety, legal, and administrative fees, at a percentage of direct capital costs (5% and 6%, respectively);
- a contingency to account for unforeseen project complexities such as adverse weather, the need for additional and unexpected site characterization, and increased construction standby times at a percentage of direct capital costs (20%); and
- Escalation to account for the anticipated yearly increases in construction costs (3%).

Details and assumptions pertaining to the cost estimates are also included in each alternative's cost description.

5.1 Description of Remedial Alternatives

Detailed descriptions of the retained remedial action alternatives are described below. **Table 5-2** summarizes the key quantitative factors and assumptions for each of the remedial action alternatives used in the detailed evaluation. At this stage of evaluating the remedial alternatives, the Tidal Flats and OF-008 AOCs have been combined to create Site wide remedial action alternatives as further described below.

Tables 5-1 and **5-2** both include costs for on-site beneficial reuse and off-site disposal options as appropriate for each alternative. Cost differences between on- and off-site options for Alternatives that have both options are driven by two main factors: 1. For options including hydraulic dredging (Alternative 2), the overdredge volume is larger than for options that include mechanical dredging, which requires the processing and disposal of a larger quantity of sediment; and 2. For options utilizing geotubes or belt press dewatering (Alternative 2 and 4), no Portland cement is included while for options that utilize mechanical dredging the addition of 6% Portland cement adds to the cost (Alternatives 3, 5, and 6).

5.1.1 Alternative 2

5.1.1.1 Tidal Flats

Alternative 2 includes the following remedial elements:

- Mobilization
- Site preparation
- Mechanical debris removal
- Hydraulic dredging and hydraulic pipeline transfer of the Tidal Flats sediments
- Mechanical placement of backfill
- Mechanical dewatering
    - Belt filter press
    - Geotubes
- On-Site beneficial re-use (stockpiling) of sediments containing <1.0 mg/kg PCBs
- Off-site disposal of sediments containing >= 1.0 m/kg PCBs or off-site disposal of all sediments
- Site restoration
- Demobilization

Figure 5-1 provides a conceptual layout of equipment, transport routes, and processing and disposal areas for Alternative 2. **Figure 5-2** provides a conceptual process flow diagram for the main components of Alternative 2.

Mobilization – Alternative 2 will include a combination of land based and water-based mobilization. The location of the Site allows equipment and barges to be mobilized and assembled off-site then towed or pushed to the Site. It also allows for most water-based equipment to be mobilized to the Site by land and assembled on-site. Land based equipment or water-based equipment assembled on-site will be transported to the Site using federal, state, and local roads following all rules and regulations. Exact means and methods will be determined by the selected remedial alternative and contractor. Alternative 2 includes mobilization of a hydraulic dredge, hydraulic pipeline, mechanical dewatering equipment, and a land-based water treatment system.

Site Preparation - Prior to initial mobilization of remedial equipment and construction of the staging area(s), erosion and sedimentation controls such as straw bales, silt fence, and silt socks will be installed on all downgradient slopes and catch basins as required in accordance with applicable Best Management Practices (BMPs). Once erosion and sedimentation controls are in place, the staging area(s) will be constructed. The staging area(s) will include an impervious area and a water collection sump in one or more locations to collect, transfer, and treat waste water generated through dredge material dewatering and rain water. The surface of the staging area(s) will be prepared by placing, grading toward the installed sump(s), and compacting an appropriate sized layer of dense grade aggregate. An impermeable high-density polyethylene liner will be placed over the aggregate followed by a layer of bituminous asphalt. Additional features including, but not limited to sidewalls, bituminous curbing, wheel wash stations, and decontamination areas may be installed as required by the selected remedial action contractor.

For purposes of the FFS, we have identified two potential staging areas to be used depending on the Alternative selected; the smaller parking lot to the north of the site and the larger parking lot to the south of the site. The larger southern parking lot is approximately 10 acres in size while the smaller northern parking lot is approximately 3 acres. Eight acres of the southern parking lot is designated as the on-site stockpile location for all Alternatives (except Alternative 6) because it is adjacent to the OF-008 drainage ditch and is slightly more remote to commercial activities along Main Street. For Alternative 2, the mechanical dewatering equipment, water treatment, and temporary sediment stockpile are assumed to be staged in the small northern area. Access between the two staging areas will be via existing roads within the SAEP property and a temporary roadway crossing at the main site gate along Sniffens Lane.

For purposes of cost estimating and describing the required elements of the work, it has been assumed that in-water resuspension controls such as turbidity curtains will be installed to surround the work area prior to the start of any silt producing activities and will be maintained throughout all silt producing activities including backfilling and restoration. During the design process, a performance specification would be developed to establish the turbidity monitoring requirements, including the following:

- the type of, number of, and locations of real-time multi-depth monitoring equipment,
- action levels (typically one or more progressive triggers based on an increase in turbidity at a downstream monitoring location relative to a background upstream location), including potentially different action levels for environmentally sensitive time periods, and
- required remediation contractor responses for turbidity management and control which may include evaluating the current data, slowing or modifying methods, changing equipment, temporarily stopping work, or other actions.

The details of the performance specification will be developed by the Army and reviewed and approved by appropriate agencies including CT DEEP. The design will also include a review and analysis of site specific conditions which must be factored into contractor selection of the turbidity control systems. The conditions and factors will include but may not be limited to the following:

- weather conditions, including wind driven waves that directly affect the turbidity management system;
- tidal fluctuations, including extreme astronomical or meteorologically driven tidal events;

- flows in the Housatonic River, including storm flows and seasonally high flows; ant
- the remedial contractor means and methods for transit of equipment and materials to and from the site.

Figure 5-1 presents a potential configuration of the proposed resuspension controls. The anticipated orientation of the silt curtain is generally parallel to the river flow and not within deeper sections of the river, and generally perpendicular to tidal flux in and out of the tidal flats. Given this configuration, tidal fluxes will likely govern aspects of the turbidity barrier design. The specific layout of the turbidity barrier will likely vary from what is currently shown depending on the approved final performance specification and approved contractor work plans.

For purposes of the FFS, it has been assumed that resuspension controls will be maintained a minimum of one foot to a maximum of three feet from the sediment surface using attached reefing lines to prevent sweeping of bottom sediments and residual transport out of the work area. Type III permeable curtains (capable of withstanding water currents up to 3 knots or 5 feet per second) will be utilized in a bridal anchor configuration using Danforth or similar types of anchors. The permeable curtains coupled with a bridal anchor configuration will allow for water diffusion through the curtain on both ebb and flood tides while maintaining the curtain securely in position. The silt curtains may also be installed as a double curtain with windows to allow for the passage of more significant currents, if required. The final configuration and specification of turbidity curtain will be completed during the design process and will be required to meet the anticipated current flows of the Housatonic River and ebb and flood tides.

Pre-construction surveys are proposed for all limits of work including the staging areas, site features (utilities, pavement cover, etc.), Tidal Flats, and OF-008. The pre-construction surveys will be a combination of topographic and bathymetric surveys to ensure the full site is characterized properly. It is assumed for this FFS that a limited pre-design investigation would be implemented to more accurately define where the dredge prism changes from one to two ft, two to three ft, and three to four ft removal depths.

Tidal Flats Dredging - This alternative includes hydraulic dredging of 139,575 cy (neat) of Tidal Flats sediments range in thicknesses from 1 to 4 ft over approximately 47 acres. For purposes of this FFS, it has been assumed that an 8-inch swinging ladder cutter suction hydraulic dredge (**Appendix E,** see **Table 7**) would remove sediment by collecting sediment and water at the suction end (intake) of the dredge pump. The dredged material is first loosened and mixed with ambient water using the cutter head and pumped as a fluid (slurry). This slurry, which is anticipated to typically contain approximately 6% solids, but can vary from as low as 2% to as high as 20% depending on material type and dredge cut thickness, will then be pumped through a floating pipeline at a flow rate of approximately 1,250 gallons per minute (gpm) to the sediment processing area(s). Smaller 8-inch hydraulic dredges typically draft less than 2 ft; however, the selected remedial contractor will be required to closely monitor tides and schedule dredging operations to minimize downtime. This type of dredge has a vertical accuracy of 0.4 to 0.7 ft and typically can achieve an average over dredge of approximately 0.4 ft which has been used for purposes of cost estimating. In addition to over dredge, side slope volume has been included for cost estimating purposes as 1% of the neat line volume. The additional volume of over dredge and side slopes is estimated to be approximately 30,811 cy which will be removed as part of the dredging operation, processed, and either disposed of or re-used on-site.

It is anticipated the contractor can maintain approximately 34% working efficiency with the appropriate coordination with tidal cycles and existing bathymetry over the course of a 12-hour day (5 to 6 hours available working time per shift in some areas due to tides). The production of hydraulic dredging is typically defined by the diameter of the dredge pump, the discharge velocity, the in-situ percent solids, the percent solids of the slurry, and the anticipated downtime associated with repositioning of the dredge. Two hydraulic systems as described above will have a combined average production of approximately 25 cy/hour (8-inch dredge, 1,250 gpm, 6% solids, and 34% efficient). This is equivalent to an average production of 304 cy per day for two hydraulic dredge systems assuming a 12-hour operating schedule, after accounting for efficiency. Based on these assumptions, and assuming a 5-day per week work schedule and seven months of allowable work window, three to four seasons of dredging work would be required to complete dredging.

Dredging will generally need to proceed in a manner that allows the segregation of several categories of material and works from higher levels of contamination to lower levels of contamination: PCBs ≥ 50 ppm (for off-site TSCA-permitted disposal), 1 ≤ PCBs < 50 ppm (for off-site RCRA D disposal), and PCBs < 1 ppm for on-site beneficial reuse or off-site non-TSCA/RCRA D disposal or beneficial reuse. Segregation of materials is an additional factor that reduces efficiency further. Dredged materials meeting these criteria will require segregation on Site. Equipment will need to be decontaminated or flushed when moving from TSCA to non-TSCA areas.

For purposes of cost estimating, it has been assumed that all sediments in the Tidal Flats would be removed via hydraulic dredging. However, it is feasible to excavate a portion of sediment from land in addition to hydraulic dredging. A long-stick excavator capable of reaching approximately 75 ft could be used to allow for continued work at low tide for areas of the site which are most exposed at low tide and have the least number of workable hours for water-based equipment. It is estimated that 5,000 to 10,000 cy of material can be accessed from the dike and Causeway areas by a long-stick excavator. This material would need to be placed in off-road trucks and hauled to the staging area for gravity dewatering and solidification. This option has the potential to reduce the overall time required to complete the alternative by 1 to 2 months.

Sediment removal areas have been assumed to be adequately delineated based upon previous sampling efforts and the remediation footprint presented in the Sediment Endpoints Report (Amec Foster Wheeler 2017). Limited additional sampling will be required prior to design to better define the limits where changes in the dredge prism depths occur. Removals will occur based on meeting bathymetric targets as determined by previous sampling activities.

Processing and Dewatering – Two options for dewatering have been retained for the hydraulic dredging option based upon treatability tests for purposes of this FFS. Both Geotube dewatering and belt filter press dewatering have been evaluated as options based upon results of bench-scale treatability testing (**Appendix C,** Kemron report **Section 4.0, Table 2, Section 7, Table 5**); however, additional mechanical dewatering options that may be available to remedial contractors include a variety of proprietary dewatering systems such as Hi-G and Genesis. The belt filter press was selected to represent the mechanical dewatering technologies because in initial tests on polymer treated slurry, belt press outperformed both the recessed chamber press and the centrifuge, based on cake percent solids (53% for belt press, 42% for centrifuge, and 43% for recessed chamber at 100 psi). In subsequent tests performed for the recessed chamber press (baroid) on untreated slurry (no polymer) at pressures of 100 psi and 125 psi, the recessed chamber achieved cake percent solids of 66% at both the 100 and 125 psi pressures and 49% at 125 psi. The actual polymers to be used for purposes of dewatering and water treatment will be determined by the selected remedial contractor and will be dependent on the actual technologies selected and contractor preference. Additional testing by the contractor will likely be required.

Belt Press Dewatering (Option 2A) - It is anticipated that mechanical separation equipment and a series of 2.2-meter belt filter presses will be used for dewatering dredged materials at the Site. The incoming slurry will be dewatered in real time and will match the production of the dredge.

Once the material is in the slurry and transferred to the staging area, it will undergo size separation using mechanical separation equipment followed by mechanical dewatering of the finer particulate sediment. For purposes of this FFS, belt filter press technology has been selected as a mechanical dewatering method to represent several process options that were evaluated in the treatability study (**Appendix C**, Section 7.1.1 and **Appendix C, Attachment C**, Kemron Treatability Report). For purposes of this FFS, it has been assumed that the slurry will be pumped to a series of screens and hydrocyclones that will separate the coarse fraction (sieve size 200+) to “de-sand” the material, leaving behind the finer materials (silt and clay fractions or sieve size 200-) which can then be dewatered by the belt filter press. The coarse material will be stockpiled and allowed to gravity dewater. The fine material slurry at approximately 8% solids that passes the #200 sieve will be conditioned with a polymer and will proceed to a high-pressure, continuous feed belt press capable of obtaining pressures of approximately 200-500 psi (e.g., BP-1900 2.2 M Andritz SMX-7 or similar) and pressed to provide a filter cake averaging 50-60% solids. The current recommendation from treatability testing is for addition of “Solve 137” (an organic cationic polymer) made down to a concentration of 0.5% added at a rate of 2.3 lbs/dry ton of solids to the slurry. Initial treatability study results indicated that a belt filter press resulted in filter cake that passes paint filter testing and achieved 53% solids (**Appendix C, Attachment C,** Kemron Treatability Report). Treatment of water generated from the dewatering process is discussed in greater detail below.

The dewatered fines fraction filter cake should undergo additional testing to verify the concentrations of site contaminants are suitable for on-site beneficial re-use or other respective disposal categories due to the potential for contaminants (particularly PCBs) to adhere to the fine sediment particles. Given that in general, tidal flats sediment is at least 60 to 80% fine material in situ, the concerns over concentration of contaminants in the fines fraction is relatively limited but nonetheless should be monitored for any dewatering technology that relies upon size separation.

Odor Control. During any dredging project, there is potential for odor generation from the various components of dredging and dredge material management processes. Generally, odor from sediments will be caused by anaerobic bacteria decomposing organic matter, ultimately producing hydrogen sulfide (H_2S) which has the following characteristics and sources:

- H_2S is a colorless gas that is heavier than air, poisonous, corrosive, flammable, and explosive.
- H_2S is relatively harmless at low concentrations, however, at higher concentrations the human nose is desensitized to H_2S odor, and consequently a person cannot detect its presence by smell alone. OSHA sets the permissible exposure limit (PEL) for H_2S.
- H_2S can be detected and is a risk at the point of dredging, on dredges, in barges, dredge slurry, processing operations, offloading operations, and within any enclosed spaces such as treatment, storage, and handling facilities;
- Hydraulic transport of slurry can generate significant concerns at the point of discharge due to agitation and accumulation of H_2S within the pipeline, and
- Combined sewer outfalls, deeper dredge cuts, and clay can often be potential higher sources of H2S risk which are generally not expected at SAEP.

The following typical methods can help reduce or eliminate odors generated from dredging, material handling, dewatering, and water treatment:

1. Dredging the sediment will expose the odor causing anaerobic bacteria to oxygen, reducing the potential to produce odor causing substances and air stripping the H_2S. In the absence of implementing other odor control techniques, odor will decrease naturally through this mechanism over time.
2. Increasing pH of sediment, slurry or water will stop off-gassing of H_2S. The addition of Portland Cement or other alkalizing reagents (lime, calciment, caustic soda, etc.) will have an odor reducing effect by increasing the pH.
3. Adding oxidizers such as permanganate, ferric chloride, ferric sulfate, peroxide, or chlorine bleach to sediment, slurry, or water treatment applications as appropriate will reduce the generation of H_2S and/or oxidize sulfide to sulfate. Other concerns related to these chemicals include how would they be added to sediment (or water), what are the costs, will there be other nuisance odors generated, and what are the health and safety concerns.
4. Cover sediment stockpiles with Rusmar foam or similar. This will contain and mask the odors but will not neutralize them. Foam odor control agents are often used on MGP site remediation projects and control of odors from municipal solid waste transfer stations, which have extremely strong objectionable odors and can be easily adapted for use with sediment management.

5. Other methods such as air release systems and venting systems coupled with air treatment for enclosed spaces or targeted air handling systems over operation can be necessary (e.g., “Sprung” structure).

Based upon experience at other sites, the combination of oxidation during dredging and processing, processing with Portland cement or similar, and controlling odors with odor control foam or misters, would generally be sufficient in even the most sensitive projects. The Design and Contractor work plans will address the final methods to be selected for odor control that are specific to the final work methodologies.

Geotube Dewatering (Option 2B) - The dredged slurry will be pumped directly into Geotubes for dewatering. Typically, polymers are added to the slurry to aid in coagulation and flocculation with the Geotubes to enhance filtration. As described in Section 3, Geotubes are large filter fabric bags which can accept a wide variety of dredged materials. Initial dewatering occurs as a result of solids flocculation, settling, and pressure from filling the bags. Following this initial dewatering, the bags are stockpiled on top of one another, allowing gravity to generate pressure and continue to squeeze water from the sediment over longer periods of time. Ideally, the Geotubes should sit for 30 to 45 days or longer, and, if possible, through a winter to allow additional dewatering from the freeze/thaw cycle. Following dewatering, the sediment would either be left on-site or excavated from the Geotubes and transported off-site. Treatability testing following the PGT (pressure-gravity drainage test) protocol showed that a starting slurry (conditioned with 2.3 lbs of Solve 137 polymer per ton of dry solids) containing 6% solids can be dewatered to 49% solids and pass the paint filter test, which is sufficient for off-site disposal (**Appendix C**, Attachment C, Kemron Treatability Report, Section 5.2 and Table 3).

Water Treatment and Discharge - Fluids generated from dewatering processes will be collected and pumped to a water treatment system capable of treating influent to concentrations acceptable for discharge back into the Housatonic River adjacent to the Site. For purposes of this feasibility study, it has been assumed that water treatment will consist of equalization, initial chemical-aided settling, bag filtration, carbon adsorption, and final filtration. The estimated flow rate of the water treatment system has been calculated to be approximately 2,000 gpm. Based on the results of the treatability testing, dissolved metals may not be below state chronic marine standards (CT SB standards); however, because a dilution factor has not yet been determined (ERDC is developing a modeling to support appropriate dilution factors), it has been assumed that filtration to a finer size than 0.45μ may be needed to remove adhered particulates sufficiently to meet these standards without accounting for possible allowable dilution (**Appendix C, Section 7.1.3** and **Tables C-13** and **C-14**). This assumption will need to be reassessed based upon substantive compliance with water quality certification requirements from CT DEEP. In the event of an indirect discharge to the Housatonic River through the Stratford WWTP (located just north of the site), an evaluation of the impacts to the WWTP would need to be completed in addition to the assessment of the impacts of discharge to the Housatonic River.

In addition to comparison to numerical standards for site contaminants and other parameters, whole effluent toxicity (WET) testing will be required after selection of the final dewatering chemistry by the remedial contractor in accordance with narrative standards requiring waters and sediments to be free from toxicity [RCSA 22a-426-4(a)(5)].

For PCBs, treatability results generally showed dissolved PCBs meeting standards (see **Appendix C**, **Tables C-3** through **C-5** for elutriates, and **C-12** for dewatering fluids); however, for the belt press, PCBs exceeded the state standard of 0.03 ug/L in the dissolved sample. Therefore, to ensure that dissolved PCBs or other organic contaminants do not exceed discharge standards, a polishing treatment step including activated carbon has been assumed. Additional water treatment tests have shown that filtration alone at the 0.1μ size is effective at reducing PCBs to acceptable levels. However, for purposes of this FFS, it has been assumed that filtration coupled with activated carbon is necessary to achieve the required standards (not accounting for possible dilution) as PCBs may be preferentially sorbed to sediments and in the dissolved phase. In addition, of note is that in the belt filter press sample, PCBs in the filtered sample exceeded the TSCA treatment criterion of 0.5 μg/L for discharge to a water body, suggesting that treatment may be required regardless of dilution to meet this standard (see **Appendix C Tables C-12, C-13**, and **C-14**).

Treated water meeting discharge standards would be discharged via a discharge line running along the Causeway and discharging into deeper areas of the Housatonic River adjacent to the site. A flow diffuser would be included, if necessary, to meet water quality certification requirements and enhance dilution at the discharge area.

Disposal and Beneficial Re-Use - The final step of dredged material processing is to dispose of or beneficially reuse the sediment on-site. All TSCA-regulated sediment will be dredged, processed, and stockpiled separately. Once dewatered, this sediment will be loaded onto haul trucks and sent off-site for disposal at a RCRA D and TSCA-permitted facilities based upon PCB concentrations. For purposes of this FFS, it has been assumed that the US Ecology Wayne Disposal facility in Michigan can accept the material.

Non-TSCA sediment (containing less than 1.0 mg/kg PCBs and otherwise meeting CT RSR residential soil standards) will be managed in one of two ways pending further negotiations and approvals:

- The first option is to beneficially reuse sediment on-site in the future. Under this scenario, the Army has assumed that an agreement with the developer will be in place which specifies that the developer will use the processed dredged materials as fill on site and that the Army will transfer ownership of the stockpile to the developer following completion of the tidal flats dredging project. Once dewatered, sediment would be placed in a stockpile suitable for long-term storage and future use as fill material. Sediment stockpiled on-site for future use will need to be protected against erosion and migration of contamination. An engineered soil cover will be needed over the stockpile, consisting of either a “spray-on” long-term foam which forms an impermeable cover (like a polyethylene liner) or top soil and seed (“loam and seed”). For purposes of this FFS it has been assumed that the stockpile would be covered with loam and seeded and would require annual inspections for five years to verify that erosion is not occurring. These requirements would be outlined in a stockpile maintenance plan that would be developed and implemented to ensure proper maintenance of the stockpile until the materials are re-used on-site by the developer. Final placement of the stockpile will be identified during design, developed in conjunction with future land owner preferences, and approved by CT DEEP prior to mobilization to address regulatory requirements regarding engineering controls and land use restrictions.

- For purposes of Alternative 2, it has been assumed that no additional processing beyond dewatering to meet the paint filter test would be necessary for sediments stored on site for future re-use. Results of leachability testing show the raw sediment and filter cake from both the belt press and Geotube to meet state groundwater B standards as measured via the SPLP test. This option would provide the most flexibility for future use of the sediments on the site (see **Appendix C** Section 4.0 and **Table C-8**).

- The second option for sediment disposition is off-site disposal. Once the sediment is dewatered and passes the paint filter test, the sediment will be loaded into haul trucks and disposed of off-site at the appropriate landfill based on characterization testing results and landfill acceptance requirements. Based on results of treatability testing, both filter pressing and Geotube dewatering yielded dewatered sediments that pass the paint filter test without the need for additional drying agents such as Portland cement or Calciment. In addition, it has been assumed that additional strength development of the dewatered sediments is not necessary to meet disposal facility requirements. Therefore, the addition of drying and/or strengthening agents has not been included for sediments being disposed of off-site. However, the addition of Calciment or other drying agents may provide a benefit by reducing the possibility of the release of liquids during transport and should be considered during design. Dump trailers used for transport are loaded to approximately 32 tons per truck (approximately 6,000 to 7,000 loads of processed sediment). For purposes of this FFS, it has been assumed that processed sediment meeting RCRA Subtitle D disposal facility requirements would be transported to and disposed of at Waste Management's Turnkey Landfill in Rochester, NH (see **Appendix C** Section 5.0 and **Table C-9** for hazardous waste characteristic results).

Additionally, if the dredged material described above cannot be used on-site as fill material after initial placement on-site and must be removed, it would be loaded into dump trailers trucks and transported as described above to appropriate disposal facilities. This process would be essentially identical to that describe above as the second sediment management option except for the need to re-excavate the material.

Additional options may be available for off-site beneficial re-use of project sediments at the time of project implementation. These options should be considered and investigated during design and by remediation contractors when bidding the project. Within the state of CT, disposal as "polluted soil" under the state's polluted soil standards may be an option for the treated sediments. Under this regulation, soils containing low level detections of organic and inorganic substances may be used as fill at permitted sites within the state (if certain requirements are met, including approval by the Commissioner of CT DEEP). Disposal or re-use of dredged materials in this manner can be a cost-effective solution for disposal.

Backfill and Restoration – Upon completion of sediment dredging and when the dredge area is approved for backfill placement, the northern staging area or another approved staging area on-site will be decontaminated and prepped for backfill delivery and stockpiling. Backfilling of the dredged area in this alternative will occur mechanically. Backfill material will be delivered and stockpiled near the Causeway. A Telebelt or similar will be positioned at the base of the Causeway. The Telebelt will load shallow draft sediment barges which will then be positioned next to the mechanical dredge. The dredge will reverse operations and place backfill material to the designed elevations. The material will be placed in thin lifts over the dredge area to design elevations. For purposes of the FFS, it has been assumed that a sand material will be used as backfill material, similar to, but generally slightly coarser than, the existing material which is predominantly silt. Silt and clay backfill material can be difficult to place due to material loss to the water column which causes excessive turbidity. In addition, finer material can be less stable and susceptible to erosion and/or movement and deposition, particularly in the Tidal Flats. Final backfill elevations have been assumed to be one foot below the pre-existing mudline with no backfill placed in the areas with 1-foot removal areas, which will allow for natural siltation to occur and bring elevations back to pre-existing conditions over time with silty material.

For purposes of this FFS, it has been assumed that backfill restoration would be performed sequentially following dredging of all areas. However, it is likely that the site will be broken into certification units (CU), so that upon completion of one unit (for example, a five-acre area) based on meeting bathymetric and confirmation sampling requirements, backfill could begin in that area. The sequencing and location of the CUs would need to be determined in a logical fashion during design and/or contractor work plan development to account for factors such as dredging lanes, residuals management, cross contamination from migration of resuspended sediments, and other factors unique to the site. The turbidity management program would need to be developed to address these concerns which may include adjustment of monitoring station location and placement of additional engineering controls to minimize cross-contamination. With a separate crew and equipment, it is possible to reduce the project schedule considerably using this method.

Establishing CUs is typically completed during design and document in a Basis of Design Report; therefore, this FFS does not include the development of CUs. Typically, CUs (management units) are formed either by regulatory requirement based on metrics specific to the type of dredging project. For a sediment remediation project like SAEP, CUs would likely be based on operational metrics (i.e., 1 acre or 5 acres), over which say dredging, confirmatory sampling, and capping/backfilling remediation components can efficiently be completed. The sequencing of CUs and procedures to address potential for cross-contamination would need to be addressed in the design and acceptance of contractor work plans. The use of CUs will be critical to compression of the schedule so that simultaneous dredging and backfill can occur according to the approved plan.

The salt marsh areas within the Tidal Flats and OF-008 will be restored to pre-remediation conditions. When restoring a salt marsh, consideration of physical, hydrological, and biological conditions is critical. This is best done by thoroughly understanding the current conditions which allowed the salt marsh to become established. In addition, identifying a reference salt marsh is also critical to provide a point of comparison for the restored salt marsh.

The initial step is to establish the edge of the marsh and restore the elevations, which are based on current and reference marsh elevations. Where existing marsh currently exists in small patches and along the shore within the Tidal Flats and OF-008, the seaward edge of these small marsh ‘islands’ and salt marsh bands would be where the edge of the restored marsh would begin and would continue landward to the rocky shore. This would likely increase the net area of restored salt marsh but would be the most ecologically sound and logical restoration approach. To establish the edge of the marsh, clam and oyster shell filled biodegradable bags (or similar materials) would be staked in place and then a sandy silt material would be backfilled up to the pre-established marsh elevation. Once the back fill has been placed and the elevation has been restored the hydrology should be consistent (i.e., tide cycle flooding and exposure) with existing conditions.

Restoring the salt marsh vegetation with the same species of plants is also critical, as is where the marsh vegetation is replanted, as different salt marsh plant species occur on the salt marsh based on tolerance to several factors including tidal inundation and salinity. For instance, saltmarsh cord grass (*Spartina alternaflora*) typically grows along the edge of the salt marsh and tidal creeks and salt hay (*Spartina pattens*) typically grows in the inner and upper salt marsh. The source of plant material to reestablish the salt marsh can be purchased from commercial sources; however, it should be augmented if possible with plugs taken from adjacent or nearby salt marsh.

The salt marsh restoration as generally described above would require a detailed Restoration Plan that would include a Restoration Monitoring Plan with five years of post-restoration monitoring and a robust invasive species mitigation plan. The details of the Restoration Plan and Restoration Monitoring Plan will be developed during remedial design and will include the following elements at a minimum:

- Material Selection and Testing including physical and chemical acceptance criteria;
- Placement methods including the requirement to place all materials within turbidity management areas;
- Vegetation types and methods for re-establishment, and applicable areas; and
- A five-year monitoring plan to document vegetation restoration success which would include recommendations for additional care as necessary.

Demobilization - Upon approval of the final backfill, the staging area(s) and all impacted areas will be returned to preconstruction conditions. All equipment will be demobilized from the Site, including dewatering equipment, heavy construction equipment, dredges, and barges. All facilities constructed for the purposes of remedial operations will need to be removed from the site and disposed of, including staging areas, dewatering areas, asphalt material, trailers, and any other site facilities.

5.1.1.2 OF-008

Remediation of OF-008 includes mobilization of a long reach mechanical excavator, off-road transport trucks, sheet pile material and related installation equipment such as cranes, and construction of temporary roads. It is anticipated that the staging area used for dredging of the Tidal Flats will be used for staging, dewatering, and processing of sediments excavated from the OF-008 ditch prior to on-site placement and/or off-site disposal.

Site Preparation - Prior to excavation, a temporary access road will be constructed along the west side of the drainage ditch which will allow for access by the long-reach excavator for most of the channel. At the head of the ditch, near the southern parking lot and staging area, the ditch is much wider and a second access road approximately 200 ft long along the east bank will be required to reach all parts of the ditch (see **Figure 5-1**). The temporary access road will be constructed directly over the existing surface and will consist of a geotextile liner followed by placement and compaction of 2 ft of dense-grade aggregate.

The OF-008 work area is approximately 350 feet from the end of the Sikorsky Memorial Airport. Based on a limited analysis, sheetpile installation (crane use), sediment excavation, and transport activities for Outfall 008 will be within the approach zone to the airport, requiring the project will to file with the FAA for an airspace analysis. Special airport lighting, flagging, and equipment restrictions may be implemented based on the final design and construction coordination and construction start and notifications. Filing must be initiated at least 45 days prior to construction

Water Control - To control stormwater entering the ditch from the outfall itself, a temporary pumping station will need to be constructed to divert water to the Marine Basin to the southeast. There are several methods for constructing this pumping station; however, for purposes of this FFS it has been assumed that sheet piling will be installed around the outfall to isolate the flow. Erosion control material consisting of riprap or large stone and a pump would be installed at the outlet. Water would then be pumped and discharged to the Marine Basin. A sampling plan would be implemented for the dewatering activities to ensure the water is free of entrained contaminants prior to discharge to the Marine Basin. A flow diffuser and sediment trap or other BMP would be installed to reduce any erosion at the pump discharge point. This pumping station would need to be operated during the length of the remediation.

Water entering from flood tides will also need to be controlled. Based on observations made during two site visits conducted in February and October 2017, and based on conversations with site maintenance staff, tidal waters enter the OF-008 drainage ditch from both the adjacent airport drainage ditch and through the existing non-functioning gate at the ditch's outlet. Both of these sources of water will need to be controlled. As part of the remediation, the nonfunctioning tidal gate could be replaced or repaired so that it could be shut, sealing out tidal waters during remediation. Following remediation, it could then be returned to a normal open position depending on the desired level of interaction between the estuarine water and the ditch. Other methods to temporarily block tidal flow include installation of sheet piles landward of the tidal gate, or temporarily sealing the gate with inflatable pigs or grout. As-built drawings of the tidal gate are not available; therefore, the exact method will need to be determined during design or bidding. In addition, the method to control water during remediation will be dependent upon the final restoration to be designed for the ditch. Following remediation, the ditch could be fully opened to the estuarine waters, allowing full tidal interchange with the entire ditch.

To control water entering the OF-008 drainage ditch from the airport ditch, an earthen berm or sheet pile wall would need to be installed. Elevations of the crest of the existing berm between the two ditches are in some locations only approximately 2 ft above mean water. High tides routinely exceed 3 ft above mean water and may be as high as 4 ft during extreme tides and even higher during storm events. Therefore, the berm or sheets, need to have a top elevation approximately 6 ft above mean water to ensure adequate freeboard to cover most storms. In addition, final restoration of this area will depend upon the intended hydrologic function of the area (complete saltwater connection or isolated freshwater drainage ditch with functioning tide gate).

Sediment Removal - Once the access road, temporary facilities, and water control structures are constructed, sediment removal can begin. Sediment within the drainage ditch will be excavated in the dry in sections. The exact length of each section will depend on the selected contractor’s approach to the work. For purposes of this FFS, it has been assumed the work will be completed in three cells: two cells of approximately 600 ft each for the main stem of the ditch which runs approximately 1200 ft in a NNW to SSE direction and one cell for the E-W portion of the ditch which is approximately 400 ft long. Temporary sheet pile will be installed across the ditch and water will be pumped and/or diverted out or around the section being excavated. Generally, standing surface water will be pumped around and discharged to the Marine Basin without treatment; however, for water remaining in the bottom of the ditch, and for water which enters the ditch from groundwater seepage, treatment may be required before discharge to reduce turbidity and/or chemical contamination. A dedicated water treatment system for the initial and continued dewatering of OF-008 will be located at the southern staging area.

Once the sheets are installed and the water is diverted, all debris discovered within the OF-008 ditch will be removed and hauled to the staging area for off-site disposal. The horizontal limits of targeted sediment removal are defined by the 0.0 MSL topographic contour, which will need to be verified at the time of remediation. The targeted sediment thickness for removal is four ft; therefore, all sediment with mudline elevations at 0.0 ft MSL or lower will be removed to a depth of four feet below the existing mudline. Sediment will be excavated with a vertical accuracy of approximately 0.25 ft (3 in) and a horizontal accuracy of approximately 0.33 ft (4 in) using a precision long reach excavator with a 2 cy open digging bucket.

Additional removal above 0.0 MSL will be necessary to create stable side slopes (see **Figures 2-12 through 2-15**). Beginning at the -4.0 ft MSL elevation (which is the vertical extent of excavation at the 0.0 ft MSL limit), sediment will be removed with an assumed side slope of 2V:1H upward from the -4.0 MSL point until the slope daylights at the surface on both sides of the ditch. This material will require segregation and characterization like the targeted sediments.

The excavator will be outfitted with a Real Time Kinematic and Differential Global Positioning System (RTK-DGPS) that uses a series of inclinometers and sensors for precise location and monitoring of the bucket. This method of excavation will provide a high degree of accuracy and precision while removing sediments with percent solids concentrations near in situ values. It is anticipated the contractor can maintain 50% working efficiency with appropriate coordination. The production of the excavator is defined by the capacity of the bucket, the average grab of each bucket, the dig-swing-empty-reposition cycle time of the excavator, and the anticipated downtime associated with repositioning equipment. The mechanical system described above will have an average production of approximately 12 cy/hour (2 cy bucket, 60% full, 3-minute cycle time, and 50% efficiency), which is equivalent to 144 cy per 12-hour shift. Therefore, the length of time to complete the excavation portion of the work is estimated at approximately 3 weeks per cell, or a total of 9 weeks of excavation work.

Excavated sediment will be loaded into watertight Moxy MT-31 end dump trucks (or similar) with covered beds (or similar) positioned on the temporary road. The trucks will drive to the staging area(s) where the sediment will be processed. For TSCA-regulated sediments (i.e., concentration of 1.0 ppm PCBs or greater), material will be staged for gravity drainage to allow for the maximum amount of dewatering. Dewatering fluids will be captured and treated along with other waters from the site prior to discharge. Following dewatering of the TSCA-regulated sediment to the extent feasible, 6% Portland cement by weight will be mixed with sediment to eliminate any remaining free water and strengthen the sediment (this approach is intended to meet the substantive requirements of a TSCA risk-based approval from U.S. EPA following 40 CFR 761(c). For non-TSCA sediments, gravity drainage is not necessary, and sediments can be solidified immediately following placement at the staging area with 6% Portland cement. Based on treatability testing completed for Tidal Flats sediments, it was found that gravity drained sediments will not sufficiently dewater to pass the paint filter test in a reasonable amount of time; therefore, amendments have been assumed to be necessary to reduce free liquids for drainage ditch sediments (**Appendix C, Attachment C,** Kemron Treatability Report Section 6 Table 4 for gravity drainage results and Section 8.0, Table 6 for solidification test results and **Appendix C Table C-15** for leaching test results on solidified sediments). However, because the OF-008 drainage ditch sediments likely differ from the Tidal Flats sediments, it may be possible to fully or partially dewater the sediment via gravity drainage to reduce or eliminate additives necessary. Additional treatability testing may be required as part of bidding to determine if gravity drainage will be effective and what the exact percentage of stabilization agent to be mixed is. Once mixed, sediment will be stockpiled and allowed to cure prior to paint filter testing.

Sediment removal areas are assumed to be horizontally and vertically delineated prior to dredging. However, additional delineation is recommended for Outfall 008 during pre-design or pre-construction to more accurately delineate the limits of TSCA- and non-TSCA-regulated material and establish the vertical limits due to the limited number of samples available. An elevation of 0.0 MSL has been assumed for purposes of the FFS for vertical removal limits. Sampling would be needed to verify the vertical limits of PRG exceedances. The proposed remedial alternatives do not include confirmation sampling or residual dredging in the cost or schedule for Outfall 008.

All sediments containing 1.0 ppm or greater of PCBs will be excavated, processed, and stockpiled separately for either off-site RCRA D disposal (sediments greater than or equal to 1 ppm but less than 50 ppm) or TSCA-permitted facility disposal (sediments greater than or equal to 50 ppm). Once processed and dewatered at the staging area, this sediment will be loaded into on-road trucks and sent off-site for disposal at a RCRA D or TSCA approved landfill. For purposes of this FFS, it has been assumed that TSCA materials will be shipped to the US Ecology Wayne Disposal facility in Michigan.

Non-TSCA sediment will be managed in one of two ways (on-site beneficial re-use or off-site disposal) pending further negotiations and approvals as described above for the Tidal Flats sediments.

Water generated from the staging area will be collected and pumped to an on-site water treatment system consisting of settling, filtration, and carbon adsorption. Treated water meeting discharge requirements will be discharged back to the Marine Basin near the tidal gate at the end of the OF-008 drainage ditch.

Once all sediment is excavated in the sheeted area and the area is approved, equipment and trucks will be decontaminated and prepped for backfill. The backfill material will be loaded into transport trucks where it will be driven down the temporary access road alongside the drainage ditch. The excavator will reverse operations and place backfill material to the appropriate elevations. For purposes of this FFS, it has been assumed that the backfill material will include 3 ft of common fill overlain by a 1 ft layer of sandy organic material. Erosion control matting and seeding will be installed along the upper portions of the bank. Depending on requirements for restoration of the bank, and the type of environment (saltwater or freshwater), appropriate plant species and erosion protection will be installed as part of the restoration process.

Once the area has been completely backfilled and approved, the area will be hydrated, and excavation will continue on the next section of the drainage ditch. This process will continue in sequence until all dredge and backfill has been completed.

Upon approval of the final backfill, the staging area(s), temporary access road, and all impacted areas will be returned to preconstruction condition. All water control structures will be removed, and any remaining flooding of remediating areas will occur in a controlled fashion. It is assumed based on preliminary discussions with CT DEEP that the tidal gate between the Outfall 008 drainage ditch and Marine Basin will be removed upon completion of the remediation to allow the full circulation of tidal waters to enter the Outfall 008 drainage ditch (Appendix D). Equipment will be demobilized from the Site.

5.1.2 Alternative 3

5.1.2.1 Tidal Flats

Alternative 3 includes the following remedial elements:

- Mobilization
- Site preparation
- Mechanical debris removal
- Mechanical dredging and mechanical transfer of the Tidal Flats sediments
- Mechanical placement of backfill

- Gravity dewatering
- Solidification
- On-Site beneficial re-use (stockpiling) of sediments containing <1.0 mg/kg PCBs
- Off-site disposal of sediments containing >= 1.0 m/kg PCBs or off-site disposal of all sediments
- Site restoration
- Demobilization

Figure 5-3 provides a conceptual layout of equipment, transport routes, and processing and disposal areas for Alternative 3. **Figure 5-4** provides a conceptual process flow diagram for the main components of Alternative 3.

Mobilization – Mobilization for Alternative 3 will be as discussed above for Alternative 2; however, Alternative 3 also includes a mechanical dredge (rather than a hydraulic dredge), shallow draft barges, transport trucks, floating temporary water treatment system (rather than a land-based water treatment system and dewatering equipment as required for hydraulic dredging), crane barge, construction of temporary roads, and a pugmill. It is anticipated that the staging area located to the south of the site will be prepared and used for gravity dewatering and stabilization of the material prior to on-site placement and/or off-site disposal.

Site Preparation - as discussed in Alternative 2. Prior to dredging and offloading, a temporary access road and drip apron will be constructed on the Causeway. The temporary access road will be constructed directly over the existing surface of the Causeway and will consist of a geotextile liner followed by compacted dense-grade aggregate. The drip apron will be designed to catch and contain any water and dredge material that may fall during transloading from barges to trucks.

A static load analysis (Appendix E) was performed on the Causeway to determine the maximum allowable static load, given the current data and information available. It was determined that if a 2 ft thick and 20 ft wide construction access road was installed on top of the existing Causeway, the maximum allowable static surcharge load with an adjacent 4 ft deep dredge cut would be approximately 500 pounds per square foot, exceeding the typical loading expected from loaded off-road trucks. Additional modifications to the Causeway, such as the use of a geogrid and/or crane mats can further increase the load capacity. For this reason, the Causeway was considered a feasible loading/offload alternative.

An additional analysis should be completed as part of design for sediment removal from the Tidal Flats to analyze dynamic loading and its impacts, including any protective measures that may be needed for the marine mattresses which armor the edges of the Causeway cover system.

Tidal Flats Dredging - This alternative includes mechanical dredging using a precision low turbidity level cut environmental clamshell bucket which limits the amount of “overdredge” necessary to meet bathymetric targets while reducing the amount of excess water entrained in comparison to hydraulic dredging removal methods. Sediment will be dredged with a high degree of accuracy using a barge mounted precision excavator or a barge mounted crane coupled with a 3.5 cy level-cut sealed environmental clam shell bucket. The mechanical dredge(s) will be outfitted with a RTK-DGPS that uses a series inclinometers and rotation sensors for precise location and monitoring of the dredge bucket. This method of dredging will provide a high degree of accuracy and precision for removing sediments while maintaining solids content close to or slightly lower than the in-situ percent solid concentrations.

Typical shallow draft barges will draft 2 to 3 ft. For this reason, the selected remedial contractor will be required to closely monitor tides and schedule dredging operations to minimize downtime. It is anticipated the contractor can maintain 31% working efficiency over a 12-hour work day with the appropriate coordination. The production of a mechanical dredge is generally defined by the capacity of the bucket, the average grab of each bucket, the dig-swing-empty-reposition cycle time of the crane or excavator, and the anticipated downtime associated with repositioning of the dredge barge. Two mechanical systems as described above will have an average production of approximately 39 cy/hour (3.5 cy bucket, 60% full, 2-minute cycle time, and 31% efficiency) or 469 cy per 12-hour shift. This type of dredge has a vertical accuracy of 0.2 to 0.5 ft and typically can achieve an average over dredge of approximately 0.2 ft which has been used for purposes of cost estimating. The additional over dredge and side slope volume is estimated at an additional 16,100 cy above and beyond the neat volume which will be removed during dredging operations, processed, and disposed of or re-used. Based on these assumptions, and assuming a 5-day per week work schedule and seven months of allowable work window, two to three seasons of dredging work would be required to complete dredging.

Sediment removal areas are assumed to be horizontally and vertically delineated prior to dredging except for a relatively minor amount of pre-design sampling to better define the transitions from one depth to the next for purposes of designing the dredge prism and to further delineate several areas at the 4 to 5 ft and 5 to 6 ft depths below mudline that had not been previously characterized.

Confirmation Sampling. The proposed remedial alternatives will include confirmation sampling and re-dredging as necessary to address residuals and achieve PRGs. For cost-estimating purposes in the FFS, a set of assumptions have been developed for analysis purposes; however, a detailed confirmation sampling program outlining the criteria for compliance will need to be developed during the design process. The design will define the type and frequency of samples to be collected, the required statistical evaluations of the data, appropriate comparisons against the PRGs, and decision criteria for the amount/extent of re-dredging in the case of failures.

For purposes of the FFS, it was assumed that following dredging to the initial required limits, confirmation samples would be collected on a roughly 200 ft by 200 ft grid (0.92 acres) in the areas of sediment removal. Samples would be collected from each grid, advancing cores from 0 to 12” below the newly dredged surface to adequately characterize the material. Analytes would include the eight site target metals for ERM-Q calculations, PCBs, and Hg.

Typically, compliance with the PRGs would be measured by grouping the results from a number of grid cells within a compliance unit and performing a statistical analysis of the data followed by comparisons against PRGs. The next step in the process would be to determine what if any additional removals are required to achieve compliance. Depending on the methodology selected, it may be acceptable for a limited number of individual samples to exceed the PRGs while the average over a compliance unit would not exceed the PRG or the appropriate statistical comparisons. The actual number of samples to be collected and grouped together, and the frequency and type of samples (discrete or composite) will be determined during design. In addition, for areas containing PCBs exceeding 1.0 mg/kg, the design process will allow for the development of a separate confirmation sampling program for PCBs, which could include different sampling methods, frequencies, and statistical comparisons.

It has been assumed that additional dredging of one foot would be conducted at 10% of these areas within the target dredge footprint. Following removal of an additional one foot of material, another round of confirmation sampling will be conducted to document remaining concentrations; however, no additional dredging would be performed beyond the additional one foot and in no case would dredging below a depth of 6 ft be conducted. Confirmation sampling followed by residual dredging would ensure the following:

- sediments resuspended during dredging and then redeposited onto the completed dredge surface would be sampled and potentially removed if in quantities sufficient to cause exceedance of PRGs (this is of particular importance when dredging within TSCA-regulated areas to ensure that any potential migration of PCBs is detected and addressed if necessary);
- sediments initially targeted for removal but not removed during the dredging process would be sampled and potentially removed if in quantities large enough to cause PRG exceedances; and
- sediments below target elevations that remain above PRGs that were not identified during site characterization efforts would be sampled and potentially removed.

Processing, Dewatering, and Water Treatment - Dredged buckets of sediment will be loaded into one of three shallow draft barges, with sump basins in the corners of the barges to facilitate dewatering. Barge capacities will range from 100 to 200 cy.

Once a barge is loaded to capacity, the loaded barge will be transported via push boat to the barge offloading area positioned at the end of the Causeway where adequate draft is available during the entire tidal cycle. The barge will be docked against a floating temporary water treatment system to remove surficial freestanding water. Water collected will be treated by pumping through a water treatment system capable of treating influent to levels acceptable for discharge back into the waterbody at the Site. Based on the results of treatability testing, treatment has been assumed to consist of settling, filtration, and carbon adsorption (**Appendix C, Section 7.1.3**). The assumed flow rate of the system is 250 gpm. Once the barge is sufficiently decanted of freestanding water, it will be moved to a floating spudded crane barge. The crane will offload the sediment barge using a clamshell bucket and place the sediment into water tight Moxy MT-31 end dump trucks with covered beds (or similar) positioned on the Causeway. The trucks will drive to the staging area where the sediment will be loaded into a pugmill to mix a precise ratio of Portland cement (PC). A percentage of 6% by weight of PC has been assumed as a stabilization agent to be mixed with sediment (**Appendix C, Section 7.3**). Once mixed, sediment will be stockpiled and allowed to cure to pass the paint filter test. TSCA sediments will be handled as described above for OF-008 and may require additional gravity dewatering on land to allow for dewatering to the maximum extent feasible prior to any solidification to comply with the substantive requirements of a TSCA risk-based approval under 40 CFR Part 761(c) (see Table 2-1).

Disposal - All TSCA sediment will be dredged, processed, and stockpiled separately. Once dewatered, this sediment will be loaded onto haul trucks and sent off-site for disposal at a TSCA-approved landfill. For purposes of this FFS, it has been assumed that the US Ecology Wayne Disposal facility in Michigan can accept the material.

Non-TSCA sediment will be managed in one of two ways pending further negotiations and approvals (see above for Alternative 2 for a description of the two options, which are on-site beneficial reuse as fill material and off-site disposal at a RCRA D landfill).

Water generated from the staging area will be collected and pumped to the floating water treatment system for treatment and discharge back to the Housatonic River near the Site.

Backfill and Site Restoration - Once all sediment is dredged and the area is approved, the staging area(s) will be decontaminated and prepped for backfill delivery and stockpiling. Backfilling of the dredged area will occur mechanically. The backfill material will be loaded into articulated trucks where it will be driven down the Causeway and off-loaded. The crane will load decontaminated sediment barges which will then be positioned next to the mechanical dredge. The dredge will reverse operations and place backfill material to the design elevations using the same precise RTK GPS system used during sediment removal activities.

Upon approval of the final backfill, the staging area(s), temporary access road, and all impacted areas will be returned to preconstruction condition. Equipment will be demobilized from the Site.

5.1.2.2 Outfall-008

The remedial alternative for OF-008 is as described in Alternative 2 for all Alternatives at the Site.

5.1.3 Alternative 4

5.1.3.1 Tidal Flats

Alternative 4 includes the following remedial elements:

- Mobilization
- Site preparation
- Mechanical debris removal

- Mechanical dredging
- Hydraulic pipeline transfer of the Tidal Flats sediments
- Mechanical placement of backfill
- Mechanical dewatering
    - Belt filter press
    - Geotubes
- On-Site beneficial re-use (stockpiling) of sediments containing <1.0 mg/kg PCBs
- Off-site disposal of sediments containing >= 1.0 m/kg PCBs or off-site disposal of all sediments
- Site restoration
- Demobilization

Figure 5-5 provides a conceptual layout of equipment, transport routes, and processing and disposal areas for Alternative 4. **Figure 5-6** provides a conceptual process flow diagram for the main components of Alternative 4.

Mobilization - as discussed in Alternative 2 and 3, and includes mobilization of a mechanical dredge, crane barge, mechanical dewatering equipment, and a land-based water treatment system. It is anticipated that the north staging area will be prepared and used for dewatering of the material prior to on-site placement at the south staging area and/or off-site disposal.

Site Preparation - as discussed in Alternative 2.

Tidal Flat Dredging – This alternative includes mechanical dredging technology as discussed in Alternative 3, with the ability to hydraulically transfer the dredged sediment. Alternative 4 requires a larger dredge barge to accommodate the onboard slurry box and pump. It is anticipated the contractor can maintain 26% working efficiency over a 12-hour work day with the appropriate coordination. Two mechanical systems as described above will have a combined average production of approximately 33 cy/hour (3.5 cubic yard bucket, 60% full, 2- minute cycle time, and 26% efficiency) or 395 cy per 12-hour shift. This type of dredge has a vertical accuracy of 0.2 to 0.5 ft and typically can achieve an average over dredge of approximately 0.2 ft which has been used for purposes of cost estimating. The additional over dredge and side slope volume is estimated at an additional 16,100 cy which will be removed during dredging operations, processed, and disposed of off-site or re-used on-site. Based on these assumptions, and assuming a 5-day per week work schedule and seven months of allowable work window, two to three seasons of dredging work would be required to complete dredging.

Processing and Dewatering - Dredged buckets of sediment will be direct loaded into a slurry box with a screen located on the deck of the dredge barge. Material that passes the debris screen will enter the slurry box and will be slurried via a high efficiency, automated pump, with just enough makeup water to transport the material at the maximum rate practical and steady-state concentrations.

Once the material is in the slurry it is handled the same way as Alternative 2.

For purposes of the FFS, it has been assumed that dewatering fluids would be treated and discharged back to the Housatonic water, and that makeup water for the slurry system will be obtained from water adjacent to the operation. However, it is possible to recirculate fluids generated from the process for use as makeup water for the incoming slurry. Recirculation, therefore, has the potential to reduce the volume of water requiring treatment and the costs associated with water treatment. These factors would need to be analyzed in more detail in design and construction to determine if recirculation is feasible.

Disposal - All TSCA sediment will be dredged, processed, and stockpiled separately. Once dewatered, this sediment will be loaded onto haul trucks and sent off-site for disposal at appropriate RCRA Subtitle D and TSCA-approved landfills based on PCB concentration. For purposes of this FFS, it has been assumed that the US Ecology Wayne Disposal facility in Michigan can accept the material.

Non-TSCA sediment will be managed in one of two ways pending further negotiations and approvals (see above for Alternative 2 for a description of the two options, which are on-site beneficial reuse as fill material and off-site disposal at RCRA Subtitle D landfills).

Backfill and Restoration - Once all sediment is dredged and the area is approved, the staging area(s) will be decontaminated and prepped for backfill delivery and stockpiling. Backfilling of the dredged area with Alternative 4 will occur mechanically. Backfill material will be delivered and stockpiled near the Causeway. A Telebelt or similar will be positioned at the base of the Causeway. The Telebelt will load shallow draft sediment barges which will then be positioned next to the mechanical dredge. The dredge will reverse operations and place backfill material to the designed elevations.

Upon approval of the final backfill, the staging area(s) and all impacted areas will be returned to preconstruction condition. Equipment will be demobilized from the Site.

5.1.3.2 Outfall-008

The remedial alternative for OF-008 is as described in Alternative 2 for all Alternatives at the Site.

5.1.4 Alternative 5

5.1.4.1 Tidal Flats

Alternative 5 includes the following remedial elements:

- Mobilization
- Site Preparation
- Mechanical Debris Removal
- Mechanical Dredging
- Gravity Dewatering
- Pneumatic Transfer and Mixing of Portland Cement of the Tidal Flats Sediments
- Mechanical Placement of Backfill
- Solidification (via PFTM)
- On-Site beneficial re-use (stockpiling) of sediments containing <1.0 mg/kg PCBs
- Off-site disposal of sediments containing >= 1.0 m/kg PCBs
- On-Site Stockpiling
- Site Restoration
- Demobilization

Figure 5-7 provides a conceptual layout of equipment, transport routes, and processing and disposal areas for Alternative 5. **Figure 5-8** provides a conceptual process flow diagram for the main components of Alternative 5.

Mobilization - as discussed in Alternative 2, and also includes mobilization of a mechanical dredge, shallow draft barges, and a pneumatic flow tube mixer.

Site Preparation - as discussed in Alternative 2.

Tidal Flat Dredging – as discussed in Alternative 3.

Processing and Dewatering - Once one of the barge is loaded to capacity, the loaded barge will be transported via push boat to the barge offloading area positioned at the end of the Causeway where adequate draft is available during all tidal ranges. The barge will be docked against a floating temporary water treatment system to remove surficial freestanding water. Water collected will be treated, if necessary, by pumping through a water treatment system capable of treating influent to levels acceptable for discharge back into the waterbody at the Site. In general, dewatering fluids can be incorporated into the Portland cement slurry that is created for mixing in the PFTM process. Once the barge is sufficiently decanted of freestanding water, it will be moved to a floating spudded crane barge. The crane will offload the sediment from the loaded scow and placed into a hopper for initial screening of large debris. Material that passes the debris screen will enter the pneumatic flow tube mixing system where it will be mixed with Portland cement and transported via pipeline. The sediment is conveyed via air pressure, which pushes the sediment in “plugs” with reduced friction in the pipeline. A Portland cement slurry is injected into the pipeline which is then thoroughly mixed in transit due to the turbulence created by the pneumatic pumping process. The end of the pipeline will be positioned to place the mixed sediment where it will be beneficially reused or stockpiled on site. In this regard, Alternative 5 has an advantage over other Alternatives when the final placement location is known because a second handling step would be avoided when the material is placed directly in its final location. The material cures quickly and is placed in lifts of desired thickness. Pneumatic flow tube mixers are capable of processing 2,000 to 3,000 cy per day, well in excess of the anticipated dredging rates in the Tidal Flats. The exact production rate of the pneumatic flow tube mixer will vary with the sediment type and size of mixer.

Treatability tests performed on Site sediments to simulate the PFTM process for solidification have shown that significant strength can be developed at modest Portland cement addition ratios which as little as 6% producing adequately strengthened sediments for on-site beneficial reuse (see **Appendix** C Section 8.0 and **Appendix C** Attachment D, Rutgers Center for Advanced Infrastructure and Transportation Solidification Report). Additionally, leaching tests on the solidified sediments show passing results for both SPLP (for on-site beneficial reuse, comparison against CT pollutant mobility criteria for GB zoned sites) and TCLP (for potential off-site disposal) (see **Appendix C Tables C-17** and **C-18**)

Disposal - This alternative assumes that all non-TSCA material will be beneficially re-used on-site. TSCA-regulated sediment will be dredged as described above, except the material will be transferred from the smaller hopper barges to large 2,000 cy barges. The material will be transported via barge to an off-site TSCA-permitted processing and disposal facility such as Clean Earth or other approved facility.

Backfill and Restoration - Once all sediment is dredged and the area is approved, the staging area(s) will be decontaminated and prepped for backfill delivery and stockpiling. Backfilling of the dredged area with Alternative 5 will occur mechanically. Backfill material will be delivered and stockpiled near the Causeway. A Telebelt or similar will be positioned at the base of the Causeway. The Telebelt will load decontaminated sediment barges with backfill material which will then be positioned next to the mechanical dredge. The dredge will reverse operations and place backfill material to the designed elevations.

Upon approval of the final backfill, the staging area(s) and all impacted areas will be returned to preconstruction condition. Equipment will be demobilized from the Site.

5.1.4.2 Outfall-008

The remedial alternative for OF-008 is as described in Alternative 2 for all Alternatives at the Site.

5.1.5 Alternative 6

5.1.5.1 Tidal Flats

Alternative 6 includes the following remedial elements:

- Mobilization
- Site preparation
- Mechanical debris removal
- Mechanical dredging
- Mechanical transfer of the Tidal Flats sediments and transfer to off-site sediment Processing Facility
- Mechanical placement of backfill
- Off-Site sediment processing including
  - Gravity dewatering
  - Solidification
- Off-Site disposal of sediments
- Site restoration
- Demobilization

Figure 5-9 provides a conceptual layout of equipment, transport routes, and processing and disposal areas for Alternative 6. **Figure 5-10** provides a conceptual process flow diagram for the main components of Alternative 6.

Mobilization - as discussed in Alternative 2, and also includes a mechanical dredge, shallow draft barges, crane barge, and large capacity barges.

Site Preparation - An upland staging area, as required for Alternatives 2, 3, and 4, will not be required for this option because there will be no processing or dewatering of sediment in the upland.

Tidal Flat Dredging – as discussed in Alternative 3.

Processing and Dewatering - Once one of the barges is loaded to capacity, the loaded barge will be transported via push boat to the barge offloading area positioned at the end of the Causeway where adequate draft is available during all tidal ranges. The barge will be docked against a floating temporary water treatment system to remove surficial freestanding water. Water collected will be treated by pumping through a water treatment system capable of treating influent to levels acceptable for discharge back into the waterbody at the Site. Once the barge is sufficiently decanted of freestanding water, it will be moved to a floating spudded crane barge. The crane will offload the sediment from the loaded scow and place into large (typically 2,000 cy) barges. The material will then be transported via barge to an off-site processing and disposal facility. For purposes of this FFS, it has been assumed that the Clean Earth facility in New Jersey can accept the sediment.

Once all sediment is dredged and the area is approved, the staging area(s) will be decontaminated and prepped for backfill delivery and stockpiling. Backfilling of the dredged area under Alternative 6 will occur mechanically. Backfill material will be delivered and stockpiled near the Causeway. A Telebelt or similar will be positioned at the base of the Causeway. The Telebelt will load decontaminated sediment barges which will then be positioned next to the mechanical dredge. The dredge will reverse operations and place backfill material to the designed elevations.

Backfill and Restoration - Upon approval of the final backfill, the staging area(s) and all impacted areas will be returned to preconstruction condition. Equipment will be demobilized from the Site.

Disposal - This alternative assumes that all non-TSCA and TSCA material will be transported via barge to an off-site processing and disposal facility.

5.1.5.2 Outfall-008

The remedial alternative for OF-008 is as described in Alternative 2 for all Alternatives at the Site.

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The comparative analysis compares the candidate remedial alternatives with respect to the evaluation criteria used during the detailed analysis of alternatives. The purposes of the comparative analysis are to identify the advantages and disadvantages of alternatives relative to one another, to highlight differences among alternatives, and to aid in the development of a preferred remedial alternative that will be included in the Proposed Plan for the SAEP. The evaluation criteria are divided into three broad categories during remedy selection: Threshold Criteria, Primary Balancing Criteria, and Sustainability Criteria. Subsection 6.1 presents the approach of the comparative analysis based on the NCP with respect to these three categories; Subsection 6.2 presents the comparison of remedial alternatives.

State and Community Acceptance are the Modifying Criteria and are not factored into the FFS; however, they will be addressed in the Responsiveness Summary which is appended to the Record of Decision following the public review process of the Proposed Plan. State and community acceptance are factored into a final balancing that determines the selected remedy. Formal state regulatory agency comments will not be received until after the agencies have reviewed the FFS report and Proposed Plan.

6.1 Evaluation Criteria

Table 6-1 presents the comparative analysis of the alternatives with respect to the threshold and primary balancing criteria (identified in CERCLA guidance, USEPA 1988 and presented above in Section 5.0) and the Sustainability Criteria (consistent with state and federal guidance). These criteria are further discussed below.

6.1.1 Threshold Criteria

USEPA designated (1) overall protection of human health and the environment, and (2) compliance with ARARs are the two threshold criteria. An alternative must meet both criteria to be eligible for selection as the preferred Site remedy or an ARAR waiver must be obtained.

6.1.2 Primary Balancing Criteria

The five primary balancing criteria are:

- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

The balancing criteria provide a preliminary assessment of the extent to which permanent solutions and treatment can be used practicably and in a cost-effective manner.

An alternative that is protective of human health and the environment, is ARAR-compliant, and affords the best balance among these criteria is identified as the preferred alternative in the Proposed Plan. Evaluation of the balancing criteria emphasizes long-term effectiveness and reduction of toxicity, mobility, or volume through treatment over short-term effectiveness, implementability and cost.

6.1.3 Sustainability Criteria

In accordance with the USEPA Consideration of Greener Cleanup Activities in the Superfund Cleanup Process (2016), the USEPA's Region 1 Clean and Green Policy for Contaminated Sites (2016), and CT DEEPs Guidance for Green Remediation in Connecticut, the applicability of green remediation practices is discussed for each of the remedial alternatives. The state largely references EPA criteria and guidance on its webpage:

https://www.ct.gov/deep/cwp/view.asp?a=2715&q=570838&deepNav_GID=1626

In addition, a presentation titled "Greener Cleanups: Integrating More Sustainable Approaches into Site Remediation in Connecticut," is included on the state's web page and describes EPA's core elements of greener cleanups related to: materials and wastes, energy, air, water, and land and ecosystems. CT DEEP also references BMPs and the ASTM Greener Cleanups Standard.

6.2 Comparative Analysis of the Remedial Alternatives

Comparative analyses of alternatives for the SAEP are presented in the following subsections and summarized in **Table 6-1**. The remedial alternatives that are the focus of the comparative analysis are:

- Alternative 2:
  - Tidal Flats: Hydraulic dredge to hydraulic off-load and belt filter press or Geotube dewatering with mechanically placed backfill and on-site beneficial reuse or off-site disposal.
  - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area, gravity dewatering, solidification, on-site beneficial reuse or off-site disposal, mechanically placed backfill, and restoration.
- Alternative 3:
  - Tidal Flats: Mechanical dredge to mechanical off-load, gravity dewatering, solidification, mechanically placed backfill and on-site beneficial re-use or off-site disposal.

    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area, gravity dewatering, solidification, on-site beneficial reuse or off-site disposal, mechanically placed backfill, and restoration.
- Alternative 4:
    - Tidal Flats: Mechanical dredge to hydraulic offload and belt filter press or Geotube dewatering with mechanically placed backfill and on-site beneficial reuse or off-site disposal.
    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area, gravity dewatering, solidification, on-site beneficial reuse or off-site disposal, mechanically placed backfill, and restoration.
- Alternative 5: Mechanical Dredging/Pneumatic Flow Tube Mixing
    - Tidal Flats: Mechanical dredge to PFTM with mechanically placed backfill and on-site beneficial re-use and off-site disposal of sediments exceeding 1 mg/kg PCBs.
    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area, gravity dewatering, solidification, on-site beneficial reuse or off-site disposal, mechanically placed backfill, and restoration.
- Alternative 6: Mechanical Dredging/Off-Site Processing and Disposal
    - Tidal Flats: Mechanical dredge to barge for off-site processing (Clean Earth or similar facility) with mechanically placed backfill and off-site disposal.
    - OF-008: Isolate and dewater area for mechanical excavation and truck transport to sediment processing area, gravity dewatering, solidification, off-site disposal, mechanically placed backfill, and restoration.

Each of the above alternatives includes off-site disposal of TSCA-regulated sediments containing PCBs at concentrations greater than or equal to 1 ppm, defined in two primary categories:

- RCRA Subtitle D disposal eligible - greater than or equal to 1 ppm but less than 50 ppm; and
- TSCA-permitted disposal facility - greater than or equal to 50 ppm.

6.2.1 Overall Protection of Human Health and the Environment

According to CERCLA, this criterion must be met for a remedial alternative to be chosen as a final site remedy.

Alternatives 2 through 6 would all provide adequate protection of human health and the environment by removing contaminated sediments from the Tidal Flats, dewatering and treating those sediments as necessary to render them dry and non-leaching, and placing those sediments on-site for future beneficial re-use or disposing of those sediments off-site in a secure landfill.

Each of these alternatives would protect the environment by removing sediments exceeding the ERMQ's and Hg and PCB cleanup criteria. Based on the proposed remedial footprint, concentrations of site-related contaminants remaining at depth by remediating sediment exceeding the PRGs will be at concentrations which do not exceed the ERM-Q PRG and will not be substantially different from background (Hg and PCBs). Short-term impacts to aquatic species would be mitigated through proper installation and maintenance of silt curtains.

Although no human health risks were identified as drivers of remediation, all alternatives would also be protective of human health by removing sediments that exceed the ecologically-based PRGs, which are essentially more restrictive than human health criteria. By removing site contaminant concentrations to levels below ERM-Qs and to background concentrations, human health and ecological risks would be further reduced and the Tidal Flats and Outfall 008 drainage ditch will be returned to a condition for unrestricted use. By meeting these standards no long-term monitoring and maintenance will be required.

6.2.2 Compliance with ARARs

CERCLA requires that the selected alternatives also meet a second threshold criterion of compliance with ARARs or obtain a waiver if the criterion cannot be met. This criterion, according to CERCLA, must be met for a remedial alternative to be chosen as a final site remedy. Table 2-1 presents the location-, chemical-, and action specific ARARs that have been identified for the Site.

Alternatives 2 through 6 will all meet chemical-, location- and action-specific ARARs.

All in-water work will comply with aquatic species work windows as required by CT DEEP, USFW, and NMFS. Currently, the allowable work window is from July 1st to January 31st; and all the alternatives would comply with this work window; however, USACE is actively working with the agencies and stakeholders to determine if it is feasible to extend this work window further. Appropriate mitigation measures will be implemented as required if the work window is extended beyond this period. All work will comply with substantive requirements of permits or certifications typically required for this work and in accordance with requirements negotiated with the agencies.

All alternatives would meet WQC requirements for discharge of treated water back to the Housatonic River using appropriate water treatment technologies. Although all alternatives would meet these criteria, there are significant differences in the volumes of flow that would likely be treated and therefore, the likely allowable dilution which affects discharge standards.

Any sediment placed on land at the site for beneficial reuse would comply with the CT DEEP regulations RCSA 22a-133k-2(h) "Use of Polluted Soil and Reuse of Treated Soil." Following completion of the Tidal Flats dredging, the Army would transfer ownership of stockpiles of processed dredged materials to the developer who would then be responsible for maintenance. Stockpiles of sediment would be covered or planted with grass to control erosion, with erosion control measures placed downgradient of the stockpiles to ensure there is no migration of sediments back to the Tidal Flats and OF-008. Sediment placed on-site would meet the CT GWB standards as measured by the SPLP test (treatability tests have shown that raw sediment meets these standards – see Section 4.0 of **Appendix C** and **Table C-8**) and sediments treated with Portland cement and Calciment by Mintek also meet these standards (see Sections 7.3 and 8.0 of **Appendix C and Tables C-15, C-16, C-17, and C-18**) and would not be placed below the water table. In addition, a stockpile maintenance plan would be developed and implemented to ensure proper maintenance of the stockpile until the materials are reused on-site.

All alternatives will comply with the substantive requirements of TSCA, including segregation of materials, decontamination of equipment, and off-site disposal at appropriately permitted facilities including RCRA Subtitle D facilities (for sediments with PCB concentrations between one and 50 ppm) and TSCA-permitted facilities (for sediments containing PCBs at concentrations greater than or equal to 50 ppm). In addition, sediments will be dewatered to the maximum extent feasible prior to any solidification, and all alternatives would comply with the substantive requirements of obtaining a risk-based approval for solidification under 40 CFR Part 761(c).

Sediment disposed of off-site would be processed to meet the receiving facilities' acceptance criteria.

Restoration of the Tidal Flats and OF-008 will be completed using a backfill material that is consistent with existing soils. The flood storage capacity of each of these bodies of water would be maintained or increased, which no encroachment below the high tide line.

6.2.3 Long-term Effectiveness and Permanence

Each of the alternatives would permanently remove sediments from Tidal Flats and OF-008, and place backfill materials to reestablish habitat. There is essentially no difference between alternatives with respect to this criterion. Following remediation, ecological risks would be addressed in the tidal flats and the Outfall 008 drainage ditch, with no sediments remaining within these areas exceeding site PRGs. Any site contaminants remaining would be at concentrations that do not cause exceedance of the ERM-Q of 0.5, and below 0.40 mg/kg Hg and 0.20 mg/kg PCBs (PCBs are co-located with metals and are therefore not driving the remediation footprint).

However, when comparing options for on-site re-use and off-site disposal, off-site disposal has more permanence because the material would be placed in a secure off-site landfill facility rather than placed on-site The State of CT requires certain conditions to be met prior to placement of contaminated materials on land – these conditions (as defined for "polluted soils" under the CT RSRS, Section 22a-133k-1(a) and (h)) would be met including placement above the water table; however, under CT RSRs it is uncertain if the material would be considered "inaccessible soil" or "environmentally isolated" because the exact location for placement has not yet been determined and ultimately must be consistent with the future developer's plans. Therefore, the adequacy and reliability of the engineering controls to be used to ensure future isolation of the contaminated materials is uncertain until a full development plan is available.

Furthermore, on-site options that do not include solidification, Alternatives 2 and 4, which rely on mechanical dewatering methods or Geotubes, do not require the addition of additives for placement on site. In this respect, the remediation may not be permanent because future solidification may be required to meet future reuse criteria with respect to strength, which are currently unknown.

6.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment.

This criterion evaluates whether the alternatives meet the statutory preference for treatment under CERCLA. The criterion evaluates the reduction of toxicity, mobility, or volume of contaminants, and the type and quantity of treatment residuals.

None of the alternatives have as a principle element treatment or destruction of site contaminants. Alternatives 2 through 6 all reduce contaminant toxicity, mobility, and volume through sediment removal, processing, and placement on land. Alternative 2 and Alternative 4 both include the hydraulic transport of a sediment slurry and therefore have a higher volume of water treatment required in comparison to Alternative 3, mechanical transport, Alternative 5, PFTM transport and Alternative 6, off-site transport.

All dewatering fluids will be treated to remove metals and PCBs down to acceptable concentrations for discharge, with the contaminants concentrated in filtered solids and activated carbon, which require separate off-site disposal or regeneration.

All alternatives that include mechanical dredging with barge movements, have a slightly higher potential when compared to hydraulic transport options to temporarily resuspend sediments due to the movements of tug boats and barges. These resuspended sediments can be controlled using silt curtains and a properly implemented turbidity monitoring, management, and control program.

Alternatives that include solidification (Alternatives 3, 5, and 6) have the potential to increase the volume of material due to bulking which can occur. Typically, this bulking is a modest increase (5 to 10%) given the anticipated percentages of additives.

6.2.5 Short-term Effectiveness

CERCLA requires that potential adverse short-term effects to workers, the surrounding community and the environment be considered during implementation of a remedial action.

All the alternatives include removal as a component, therefore the RAOs will be met upon completion of the work. The time to achieve RAOs includes the time for mobilization, dredging, backfill, and site restoration. These factors vary between the alternatives and the most significant factor for the time to achieve RAOs is whether sediments are dredged mechanically or hydraulically. Generally, mechanical dredging options have a shorter timeframe because of the higher anticipated productivities.

The baseline schedule assumptions for the project schedule include a seven-month allowable work window and five twelve-hour days per week.

For options that include mechanical dredging, the time is shortest and is essentially the same or similar for all alternatives. For alternatives 3, 4, 5, and 6, the time required to complete the project is estimated at 3 to 4 seasons (assuming a seven-month work window and five twelve-hour days per week). In terms of months of dredging (not including backfilling), these alternatives are estimated to require approximately 15 months (slightly over two full seasons) to complete. However, with respect to schedule, Alternative 6 would have the shortest overall schedule for work on the site because it would require the least amount of on-site infrastructure, because it does not require sediments to be placed on the site. Following Alternative 6, Alternative 5 (PFTM) would have the next longest schedule, followed by Alternative 3, Mechanical Dredging.

Alternative 4, Mechanical Dredging with Hydraulic Transport, while similar to other mechanical dredging options, would have the next longest schedule, which is also estimated to require three to four dredge seasons, and approximately 18 months of dredging.

Alternative 2, Hydraulic Dredging would have the longest schedule, with an estimated total project time of five to six seasons. Dredging work requires approximately 26 months to complete. This extended period of time is driven by the lower anticipated productivity of a hydraulic dredge in this environment.

Given the baseline schedule of 7 months of working time per year, multiple mobilizations and demobilization (mob/demob) will need to occur. Except for at the very beginning of the project and final demobilization, these mob/demobs do not add to the overall project schedule because they can be conducted during the off-season. For each alternative it is assumed that mobilization and demobilization each add approximately three months to the beginning and end of the project.

Table 6-2 provides a work schedule sensitivity analysis which analyzes the effect on overall schedule when the baseline assumptions are varied. Three key assumptions were changed: 12-hours working day to a 24-hour working day; five days per week was varied to six and seven days; and the annual work window was expanded from seven months to twelve months. The simple change in the baseline assumptions of going to 24 hours per day results in the schedule decreasing to 2 to 3 seasons from the baseline condition of 3 to 5 seasons.

By changing the daily work schedule to 24 hours per day, the overall project schedule decreases from three to five seasons down to 2 to 3 seasons for five days per week to as little as one to two seasons for 7 days per week operation.

Finally, if 12 months per year operation is implemented, the project schedule improves to 2 to 3 seasons for five-day and one to two seasons for seven-day operation. If the schedule is improved to 24-hour operation, the timeframes decrease to one to two seasons (five days per week) to as little as approximately one season, or even slightly less. All these scenarios assume two dredges operating simultaneously. For any option that considers twelve months per year operation, six months of mob/demob time must be added to the schedule (i.e., a twelve-month dredging during becomes an 18-month project duration).

To support the option to operate twelve months per year, the option to install a cofferdam was further evaluated. Design and construction of a large cofferdam is a time-consuming, technically challenging, and expensive task. In this case, the cofferdam would likely be a semi-permanent structure approximately ½ mile long, beginning just inboard or outboard of the rock breakwater and extending parallel to the river, then continuing southeast beyond the tip of the Causeway, then turning towards shore to enclose the entire remedial footprint of the Tidal Flats. Additional geotechnical data would need to be collected along its proposed alignment to ensure constructability. The structure itself would likely need to be a double sheet pile infilled wall embedded approximately 90 ft into sediment (based on current information regarding subsurface conditions) to be able to withstand tidal elevation differences, wave action, and other concerns, such as ice and flooding. Near the existing breakwater, construction would need to be done with adequate offsets to ensure no damage to the structure. Other considerations such as concerns regarding potential flooding and how to maintain water levels must be evaluated thoroughly. The movement into and out of site by dredging equipment, maintenance and other vessels, would all be significantly impacted by the presence of a cofferdam.

Construction of a coffer dam may produce a great deal of suspended sediment during its installation, likely more than those suspended sediments anticipated from dredging. Consultations with NMFS, USFWS and CT DEEP would be required and their opinion of the use of a coffer dam and its environmental impacts is unknown. There would still be impacts to potential winter flounder habitat within the Tidal Flats. There would still be a degree of sedimentation during construction that would have an impact on shellfish spawning and general mortality due to burial, as well as impacts to migrating anadromous fish depending on the time of year.

The design and construction of a cofferdam would likely add a year to the project schedule and would have to be removed at the end of the project adding yet more time to the project schedule. The additional cost of installing a cofferdam is likely $20M.

Traditional methods of turbidity control using silt curtains or similar technology can achieve a similar, if not better, level of overall performance with respect to turbidity control (especially when considering the construction of the cofferdam itself).

Given the ability to mitigate the effects of sediment resuspension for dredging, the time required to design and construct the cofferdam, and the cost, use of a cofferdam is not considered a cost-effective option for the site.

An additional consideration is release of suspended sediments, which has the potential to impact downstream ecological receptors. All mechanical and hydraulic dredging alternatives will cause release and resuspension to some degree as affected by the necessary operational processes; for example, at the cutter head or bucket, tug and support vessel propwash, anchor management, pipeline back flushing, and impacts with the bed. In most cases these release mechanisms can be managed by selecting appropriately sized and configured equipment, conducting operations in a manner that avoids or minimizes release, and mitigated by installing proper engineering controls. Properly installed and maintained turbidity curtain systems as part of a properly implemented turbidity monitoring, management, and maintenance program is one such engineering control that can substantially contain resuspension and manage any turbidity migration.

There are other differences between the alternatives that can be highlighted. Alternatives that require stockpiling and dewatering of the sediment on-site will generate nuisance odors, visual disturbance, and excess noise due to the processing equipment. Only Alternative 6 (off-site processing), which relies on off-site processing with hauling by barge would have no or little on-site stockpiling of sediment and would therefore impact the local community less. Alternative 5, through the PFTM process, would also impact the local community less than Alternatives 2 through 4 because sediment is treated with Portland cement before it is placed on land. When the sediment is placed, it requires little or no handling, reducing noise, visual disturbance and odors (because it has been pre-treated).

Finally, any alternative that involves hydraulic dredging or hydraulic transport (Alternatives 2 and 4) will generate many times more water than mechanical dredging (Alternatives 3, 5, and 6) which increase the footprint of the site and the general amount of activity on the site.

Alternatives 2 through 5 involving complete off-site disposal of sediments via truck as an option will generate on the order of 6,000 truck trips to transport sediments off-site.

Impacts to workers are considered essentially equal among the alternatives, and include work with heavy equipment, other mechanical equipment, work on water, and potential chemical exposure to PCBs and metals. These risks can be mitigated by following OSHA requirements and an approved safety plan.

6.2.6 Implementability

This criterion evaluates each alternative’s ease of construction and operation, and availability of services, equipment, and materials to construct and operate the alternative. Also evaluated is the ease of undertaking additional remedial actions and administrative feasibility.

Alternatives 2, 3, and 4 all rely upon technologies that are well-established, readily available, and easily mobilized at the site. Alternative 5 relies upon the PFTM technology, which, while well-established and available in Asia, has not been widely available in the United States. Only one vendor of this technology is known to exist in the United States and it is actively pursuing permits to operate within CT. The equipment would likely have to be customized for this project.

Alternative 6 relies upon the ability to transport sediments to an off-site processing facility. Currently there are several facilities within the greater New York City area that could receive sediments. These facilities, while relatively new, are up and running and have indicated they can accept Site sediments for processing and off-site disposal. Barge transport can be cost-effective and can open up rail transport options which can then allow for cost-effective disposal at potentially more off-site facilities.

The dewatering and water treatment technologies are all well established and available and can relatively easily be mobilized and operated at the site. However, systems that are more complex (i.e., mechanical dewatering methods or Geotubes, Alternatives 2 and 4), will require more maintenance and have more risk of unreliable operations than a simple gravity dewatering operation. Geotubes require additional space for layout, may require additional time for dewatering, can experience biological fouling or clogging and mechanical equipment is subject to breakdown.

Similarly, these options (Alternatives 2 and 4) require larger and more complicated water treatment systems that have more risk of failures than the smaller systems required to handle water from gravity drainage (Alternatives 3 and 5). It is possible to reduce the volume of water generated under Alternative 4 further by recirculating dewatering fluids back into the slurry box. Alternatives 2 and 4 require mechanical dewatering systems (traditional belt press, recessed chamber, or centrifuge), Geotube bag filtration, or other systems (proprietary systems that use a combination of technologies, examples include Hi-G by Derrick and Genesis). These proprietary systems were not evaluated as part of the FFS; however, they may be viable depending on the selected contractor's familiarity with and access to this specialty equipment. The Derrick Hi-G system (a hydrocyclone and screening system that utilizes a unique elliptical screen motion to accelerate dewatering of fines) had been selected as a representative technology for evaluation in treatability studies; however, this work could not be completed based on Derrick's inability to test PCB-contaminated sediments. Although the primary dewatering methods evaluated in this FFS are the belt filter press and Geotube dewatering systems, proprietary systems should not be eliminated from potential consideration in remedial contractor bids due to their potential to effectively dewater sediments.

Placement of sediments on-site as beneficial re-use material would be most difficult to implement relative to the other options given the coordination and approvals required, followed by off-site disposal via truck, with off-site processing by barge being easiest to implement.

If material stored on site in a stockpile requires future excavation and disposal off-site, it is relatively easy to implement this remedial action. However, if the material is incorporated as site fill material beneath structures, roadways, etc. as part of development, it would be very difficult to remove and take to an off-site location.

6.2.7 Cost

Table 6-3 presents a summary of the costs for each alternative. Costs are presented as total capital costs and total present-worth for each remedial alternative based on the estimated clean-up time (USEPA, 2000). The only operations, monitoring, and maintenance costs assumed for the alternatives are related to the inspections of the sediment stockpile on-site prior to beneficial re-use on the site. Except for Alternative 6, each alternative has a cost associated with on-site beneficial reuse of sediments and off-site disposal of sediments. The on-site beneficial reuse of sediments also includes cost for development of a 5-year stockpile maintenance plan and cost associated with maintaining the stockpile until the materials are reused on-site. Alternative 6 only has an off-site disposal cost. The cost baseline is based upon on-site beneficial re-use of sediments. The cost to dispose of sediments off-site was also analyzed and is presented as a separate set of cost estimates to provide a sensitivity analysis with respect to the ultimate disposition of site sediments.

On-Site Beneficial Reuse of Sediments. Costs for the alternatives range from $78.4M to $108.7M for on-site beneficial reuse. The least cost alternatives are Alternatives 3 ($79.4M) and 4 (Geotube, $78.4M), followed closely by Alternative 5 ($82.1M), and Alternative 4 (belt filter press, $85.5M). These alternatives are very similar in cost, ranging from $79.4 M to $85.5 M. Given the approximate nature of these cost estimates, there is virtually no difference in cost between Alternatives 3, 4 (belt filter press and Geotube), and 5.

Alternative 2 belt filter press ($108.7 M) and Geotube ($95.3 M) are the most expensive options due to the duration of dredging and equipment costs.

Alternative 6 is not included in the cost analysis for on-site beneficial reuse of sediments because it relies entirely upon off-site disposal of sediments.

It is important to note these alternatives fall within the cost accuracy range of -30% to +50%. Applying this range to the lowest cost alternative (Alternative 5) yields an accuracy range of $54.9 M to $117.6 M. All other alternative costs fall within this range, suggesting that all alternatives can be considered cost-effective and that the differences between the alternatives are relatively minor. Figure 6-1 presents the total cost for each alternative (with both on-site beneficial reuse and off-site disposal options) with their respective ranges of -30%/+50% accuracy to illustrate that all remedial alternative costs fall within the CERCLA range of FS accuracy.

Off-Site Disposal of Sediments. For Alternatives 2 through 4, off-site disposal generally adds approximately $30 to $35 M relative to the base cost for on-site beneficial reuse. The differences among the alternatives for these additional costs are primarily related to differences in the amount of material dredged (more over-dredge for hydraulic as compared with mechanical dredging) and the need for additives to eliminate free liquids (6% Portland cement added to mechanically dredged sediments and no additives for either Geotube or belt filter press dewatered sediments). These additional costs bring the total costs of the alternatives for off-site disposal up to a range of $109.7 M to $142.8 M. Alternative 6, which relies entirely upon transporting sediments via barge to an off-site processing facility has total estimated costs of $93.5 M. Alternative 6 is therefore considered the least cost alternative for off-site disposal. A significant factor in this reduction in costs is related to the lack of need for on-site infrastructure related to off-loading, processing, placing, and hauling material. Another factor is the efficiency of barge transport relative to trucking. The next lowest cost alternative is Alternative 5 (Geotube $109.7 M) followed by Alternative 3 ($112.5 M).

It is important to note that costs of these alternatives (except for Alternative 2, belt filter press) fall within the FFS accuracy range of -30%/+50% for the lowest off-site disposal alternative. For example, the -30%/+50% FFS cost accuracy yields a range of $65.4 M to $140.2 M for Alternative 6 (lowest off-site disposal alternative). All other alternative costs (except for Alternative 2) fall within this range, suggesting that most alternatives can be considered cost-effective and that the differences between the alternatives are relatively minor (see Figure 6-1). .

7.0 PREFERRED REMEDY

Based on the rankings presented in **Table 7-1** and the detailed and comparative analyses, the preferred remedy for the Tidal Flats is Alternative 3, Mechanical Dredging, when coupled with on-site beneficial re-use of sediments. This option has the highest ranking at a score of 25 points, with an accuracy range 24 to 26 points, while other options ranged from 14 to 24 points, with accuracy ranges of 13 to 15 points and 23 to 25 points, respectively[3]. While the score of this alternative falls within the accuracy range for Alternative 4, Geotubes, which has a score of 24 points and an accuracy range of 23 to 25 points, there are several advantages including its relative simplicity which make it the preferred remedy. It is protective of human health and the environment, complies with ARARs, is cost-effective, and provides the best tradeoffs with respect to the balancing criteria (as compared with other alternatives) including the best combination of time to achieve the RAOs, certainty of success, and reliability.

The main factors that differentiate Alternative 3 from other Alternatives include: shortest overall schedule/highest productivity, lower amount of water incorporated with dredged materials, lower volume of sediments excavated, easily implemented and less technically complex due to the lack of need for very large-scale dewatering and water treatment equipment, and lowest overall cost.

The preferred remedy for the Tidal Flats would be coupled with the preferred remedy for Outfall 008, which is mechanical excavation in the dry coupled with on-site beneficial reuse. Only one Alternative was retained and analyzed for Outfall 008 and therefore rankings were not developed for this AOC.

7.1 Preferred Remedy Advantages

Alternative 3 would utilize the latest technology in environmental dredging by including a precision low turbidity level cut, environmental clamshell bucket. This equipment minimizes overdredge, reducing the amount of dredged materials generated, minimizes the generation of resuspended sediment relative to other mechanical dredging technologies and mixing of underlying clean sediments, and entrains a much lower amount of water (orders of magnitude) with dredged materials relative to hydraulic dredging, particularly when operated by experienced, qualified contractors.

In addition, Alternative 3 has the highest anticipated productivity rate which would result in the overall shortest schedule as compared with other alternatives. Alternative 3 provides these benefits at a cost that is nearly lowest among all the alternatives evaluated (only Alternative 4,

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[3] The development of scores for alternatives is by its nature highly subjective; however, it provides a useful framework for categorizing and organizing the performance of various alternatives with respect to the evaluation criteria. Using the 0 to 4-point scale for each criterion, total scores within one point of each other can be considered essentially the same sue to the subjective nature of this evaluation. The score itself is not the final decision factor in selecting a remedy. Rather, it helps to identify the major advantages and disadvantages among the alternatives to be discussed as part of the preferred remedy.

Mechanical Dredging with Hydraulic Transport of sediments and Geotubes is slightly lower by $1M) while completing the work in less time and performing the work more accurately.

The technologies for Alternative 3 are readily available and are easily implemented. Alternative 3 would generate a significantly lower volume of water relative to hydraulic dredging and hydraulic transport options. Operation of this alternative will be less complex than other alternatives and its on-site footprint will be less than hydraulic transport options because of the lack of a large, complex dewatering and water treatment system.

Generation of turbidity can be minimized through proper operation of the equipment and selection of an experienced dredging contractor and can be adequately controlled via silt curtain technology as part of a turbidity monitoring, management, and maintenance program. Dredged materials will require Portland cement solidification because gravity drainage alone will not reduce free liquids sufficiently; however, this is a standard element of dredged material processing and not difficult to incorporate.

Finally, under Alternative 3, sediment that is beneficially reused on-site requires solidification which provides the added benefit of increased strength (which is likely required for future development purposes) and its capacity to entrain and isolate contamination. Alternative 3 includes solidification with Portland cement at 6% and will generate a material that would achieve typical UCS required for on-site use, while other options (Alternative 2 and 4) do not include strengthening additives. These factors additionally make Alternative 3 most preferable.

For off-site disposal, Alternative 6 (Mechanical Dredging with Off-site Disposal via Barge) is the preferred remedy because of its cost-effectiveness. This alternative achieves many of the same benefits as Alternative 3 (on-site beneficial reuse). In addition, when Alternative 6 is compared to alternatives that utilize hydraulic dredging or hydraulic transport followed by mechanical dewatering technologies, the additional costs for dewatering and added complexity are not justified. These dewatering technologies have the potential to reduce the amount of dewatered material disposed of off-site by achieving higher percent solids as compared with gravity drainage (Alternatives 3 and 6). Finally, Alternative 6 would have a minimal on-site footprint, with the lowest short-term impacts to the Site and local community because it is primarily a water-based operation.

7.2 Criteria-Specific Rankings

This subsection describes the differences among the alternatives that were used to develop the scores for each alternative as presented on Table 7.1.

7.2.1 Overall Protection of Human Health and the Environment, Compliance with ARARs, and Long-term Effectiveness

All Alternatives were scored the same with respect to the first three of the seven criteria: Protection of Human Health and the Environment, Compliance with ARARs, and Long-term Effectiveness.

All alternatives were rated high because they all adequately protect human health and the environment, comply with ARARs, and remove all impacted sediments from the Site. As a result, each alternative was scored "high" and scored four points each in each of these categories.

7.2.2 Reduction of Toxicity, Mobility or Volume through Treatment

Mechanically dredged sediments (Alternative 3, 5, and 6) scored highest under this criterion and each received a rating of "moderate to high," or three points. These alternatives all have the advantage of the ability to dredge less materials than hydraulic dredging based upon the accuracy of the equipment. For purposes of this FFS, the overdredge quantity of 0.2 ft results in an additional volume of approximately 16,100 cy for Alternative 3, 4, 5, and 6, while an assumed overdredge of 0.4 ft results in an additional volume of 30,800 cy (Alternative 2) over the neat volume of approximately 140,000 cy. These differences are reflected in the scores.

Hydraulically conveyed sediments (Alternatives 2 and 4) treated via Geotubes also scored "moderate to high" and received three points each. This score reflects the fact that while Alternatives 3, 5, and 6 generated the lowest amount of water to be treated, the addition of Portland cement was found to be necessary, which generally slightly increases the volume of materials. Alternative 3, 4, 5, and 6 also have the added advantage of less mixing of underlying clean sediments as compared with Alternative 2 (see **Appendix E**, Dredging Alternative Evaluation, **Table 7**, "Point of Dredging").

For Alternatives relying upon belt press or Geotube technology, Portland cement addition was not found to be necessary to eliminate free liquids. However, these same alternatives were deducted a point each due to the results of the treatability testing which showed that the pressate from the belt press contained dissolved PCBs above state surface water SB standards (see **Table C-12** of **Appendix C**) in both unfiltered and filtered samples whereas Geotube filtrate did not contain PCBs. Furthermore, hydraulically dredged sediments (Alternative 2) were deducted an additional point due to the extra volume that would be removed due to the lower dredging accuracy of this equipment relative to a precision mechanical bucket. Therefore, Alternative 2 was assigned "low to moderate" (one point) and "moderate" (two points) for belt press and Geotube dewatering, respectively.

7.2.3 Short-term Effectiveness

The scoring for short-term effectiveness was heavily influenced by the anticipated schedule (time to achieve RAOs). Alternatives relying upon mechanical dredging all scored "moderate to high" or three points each based upon the estimated time frame of three to four seasons to complete the work. None of the on-site beneficial re-use options scored a "high" rating (four points) due to this long-time frame and the amount of on-site infrastructure needed to complete the work (related to short-term impacts to workers and the local community). Alternative 6 scored "high" because of its lack of on-site infrastructure, minimizing local impacts and the time required to mobilize and demobilize from the site.

Alternative 2, Hydraulic Dredging, was rated lowest, due to its anticipated longer time resulting from lower productivities (four to five seasons vs. three to four seasons for mechanically dredged materials). Furthermore, alternatives (Alternatives 2 and 4) that rely upon belt press technology were scored lower than their Geotube counterparts due to increased short-term impacts to the site and workers related to the larger footprint required for dewatering and potentially water treatment (truck traffic, increased noise, and worker safety issues). Alternatives 2 and 4 were scored “low” (zero points) and “moderate” (two points), respectively, for the belt press option, and “low to moderate” (one point) and “moderate to high” (three points), respectively, for the Geotube option to account for these factors.

Alternatives 3, 5 and 6 all scored similarly for short-term effectiveness since they all incorporated mechanical dredging as the sediment removal method. However, Alternative 6 ranked the highest in short term effectiveness due to barging sediment off-site.

7.2.4 Implementability

Alternative 3 was rated “moderate to high” (three points), higher than any other on-site options due to the relatively lower level of complexity, in total, of this alternative as compared with other options. Alternatives 2 and 4 (Geotube) were both rated “moderate” (two points) to reflect increased complexity of the alternative related to dredging technology, dewatering, and water treatment relative to Alternative 3. Alternatives 2 and 4 (belt press) were rated lower than their Geotube counterparts due to the increased complexity of operation related to belt press technology. Another subtle factor which is considered when comparing Alternatives 2 and 4 is the balance between established technologies of hydraulic dredging and mechanical dredging and the innovative nature of the mechanical dredging/hydraulic transport approach, which balances the scores for these two options (both receiving the same scores of “low to moderate” and “moderate” for belt press and Geotube technology, respectively).

Alternative 5 is scored “moderate” (two points) to reflect two balancing factors relative to other alternatives. The technology is relatively unproven within the United States which results in a lack of availability of this technology (only one contractor is known to exist on the East coast); however, the alternative does not rely on extensive dewatering and water treatment technologies.

When off-site disposal is considered, Alternative 6 is considered the most easily implemented due to its limited need for on-site infrastructure.

7.2.5 Cost

Alternatives 3 and 4 (Geotube) both scored “high” (four points) based on their very similar lowest total capital costs ($79.4 vs. $78.4M, respectively). These alternatives achieve these costs through high productivity and lower volume (Alternatives 3 and 4), low volume of water for treatment (Alternative 3) and ease of operation (Alternative 4, geotubes). However, it is important to note that while Alternative 3 includes the addition of 6% Portland cement, Alternative 4 does not, which, if required to meet on-site strength requirements, could add several million dollars to the overall cost. The next lowest cost alternatives, Alternatives 5 ($82.1M, including 6% Portland cement) and 4 (belt press, $85.5M, no Portland cement) were scored “moderate” (two points) followed by Alternative 2 ($95.3M, geotubes, no Portland cement) “low to moderate” (one point) and Alternative 2 ($108.7M, belt press, no Portland cement) “low” (zero points).

Among the off-site disposal options. Alternative 6 scored highest based on its lowest overall cost of $93.5M.

7.3 Conclusion

The preferred remedy for the SAEP tidal flats and Outfall 008 dredging is Alternative 3, Mechanical Dredging coupled with on-site beneficial reuse. Alternative 3 would provide protection to human health and the environment, would comply with ARARs, and provides the best mix of tradeoffs among the balancing criteria. Alternative 3 would minimize environmental impacts by utilizing precision mechanical dredging technology which reduces resuspension and residuals. Alternative achieves these benefits by minimizing the volume of sediments removed through the most accurate dredging technology available and by minimizing the amount of water entrained with sediments. Alternative 3 also would minimize impacts by completing the work in the shortest overall schedule, which is estimated to be three to four seasons for a seven-month working window and two years if the work schedule can be expanded to seven days per week and 24 hours per day. If twelve months per year working time are permitted, then the schedule could shorten even further to approximately eighteen months. Finally, Alternative 3, when coupled with on-site beneficial reuse, would generate sediments processed with Portland cement that can readily be reused at the site for most redevelopment purposes.

Should off-site disposal of all sediments be required, Alternative 6, Mechanical Dredging followed by off-site disposal via barge transport is the preferred remedy.

8.0 REFERENCES

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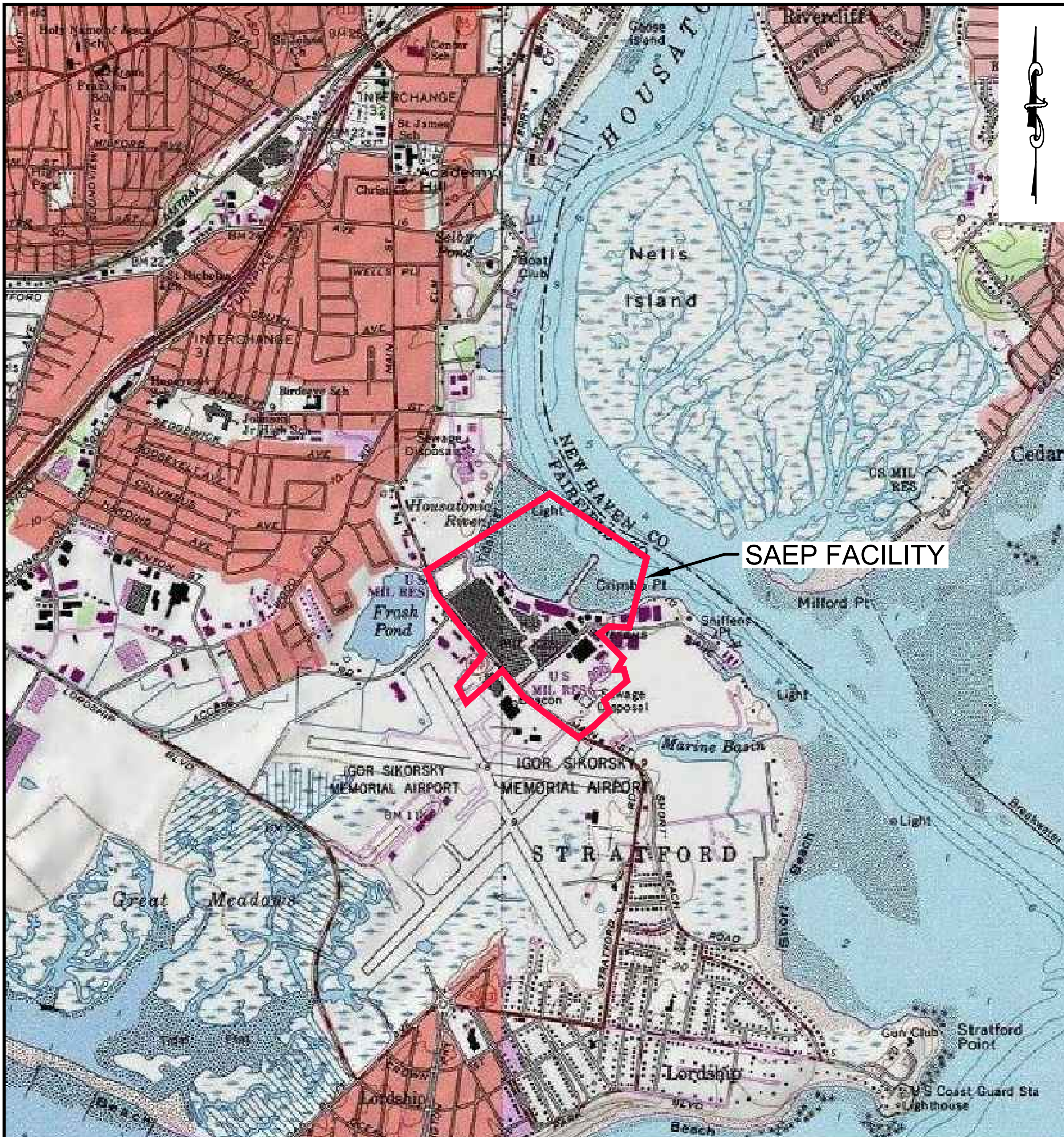
FIGURES



SOURCE:
www.ARCGIS.com – USA TOPO MAPS,
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AND ESRI IS THE OWNER OF RIGHTS THEREIN.

0' 1000' 2000' 3000'
1" = 2000'

CLIENT	US ARMY CORPS OF ENGINEERS NEW ENGLAND DISTRICT, CONCORD, MA
PROJECT	STRATFORD ARMY ENGINE PLANT SEDIMENT DREDGING, STRATFORD, CT
TITLE	SITE LOCATION MAP

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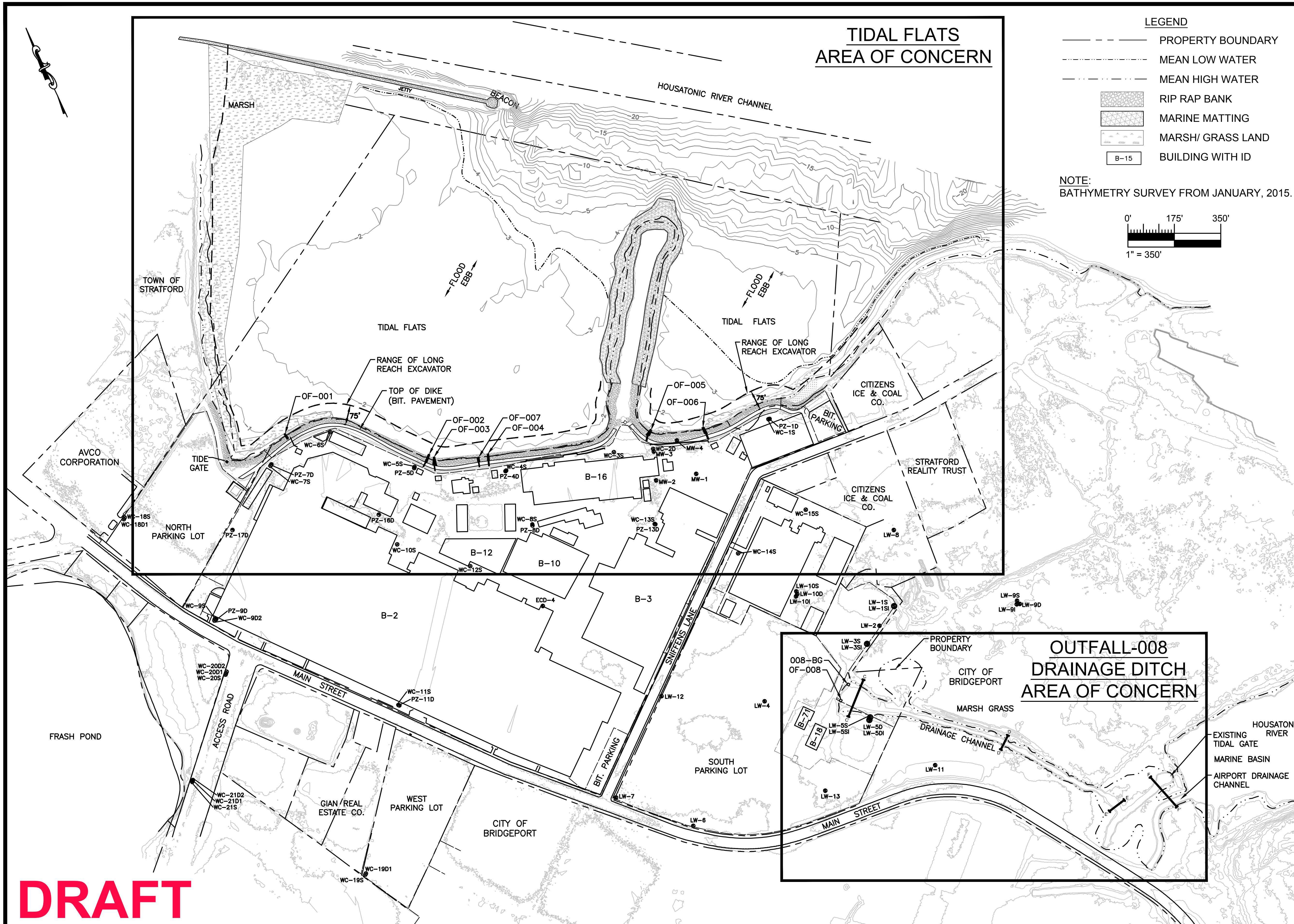
DWN BY: BEG	SCALE: AS SHOWN	DATE: FEB 2018
CHK'D BY: DAA	PROJECT NO: 3616176064	FIGURE No. 1-1

U:\– CAD Projects\USACE – SAEP\7.0 CAD\7.1 Design – Permitting\Sheets\Feasibility Study\FIG 1–1 – LOCUS.dwg – Layout1 – Mar. 12, 2018 4:14pm – benjamin.girardet



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SCALE: AS SHOWN	DATE: FEB 2018
DATUM: NAD83	PROJECTION: CT STATE PLANE
PROJECT NUMBER: 3616176064	

TITLE:

AREA MAP

FIGURE NUMBER:

1-2

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 1-2 - Area Map.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 4:58pm

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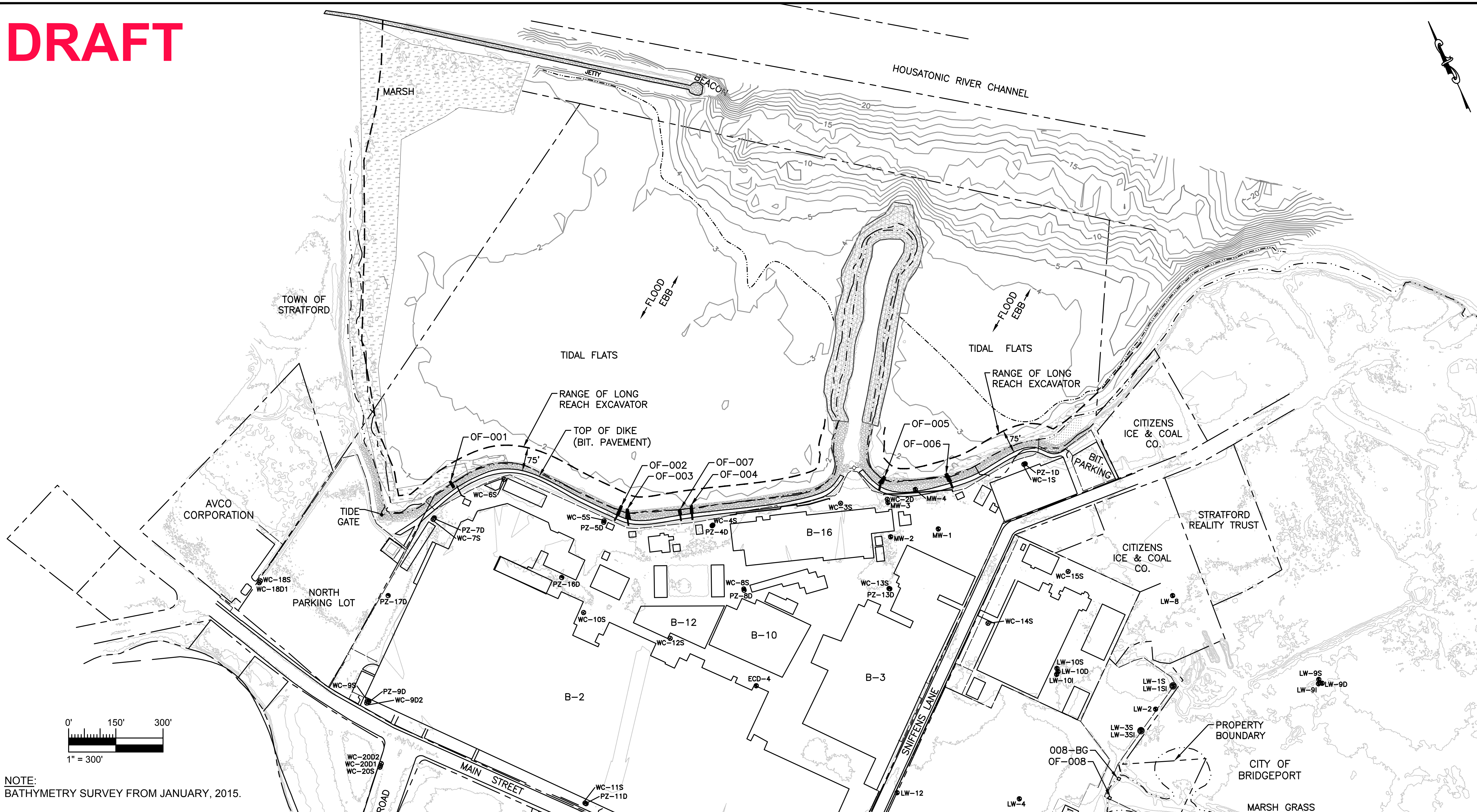

NOTE:
BATHYMETRY SURVEY FROM JANUARY, 2015.

LEGEND
- MARINE MATTING
- MARSH/ GRASS LAND
- B-15 BUILDING WITH ID
- PROPERTY BOUNDARY
- MEAN LOW WATER
- MEAN HIGH WATER

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DATUM: NAD 83
PROJECTION: CT STATE PLANE
SCALE: AS SHOWN

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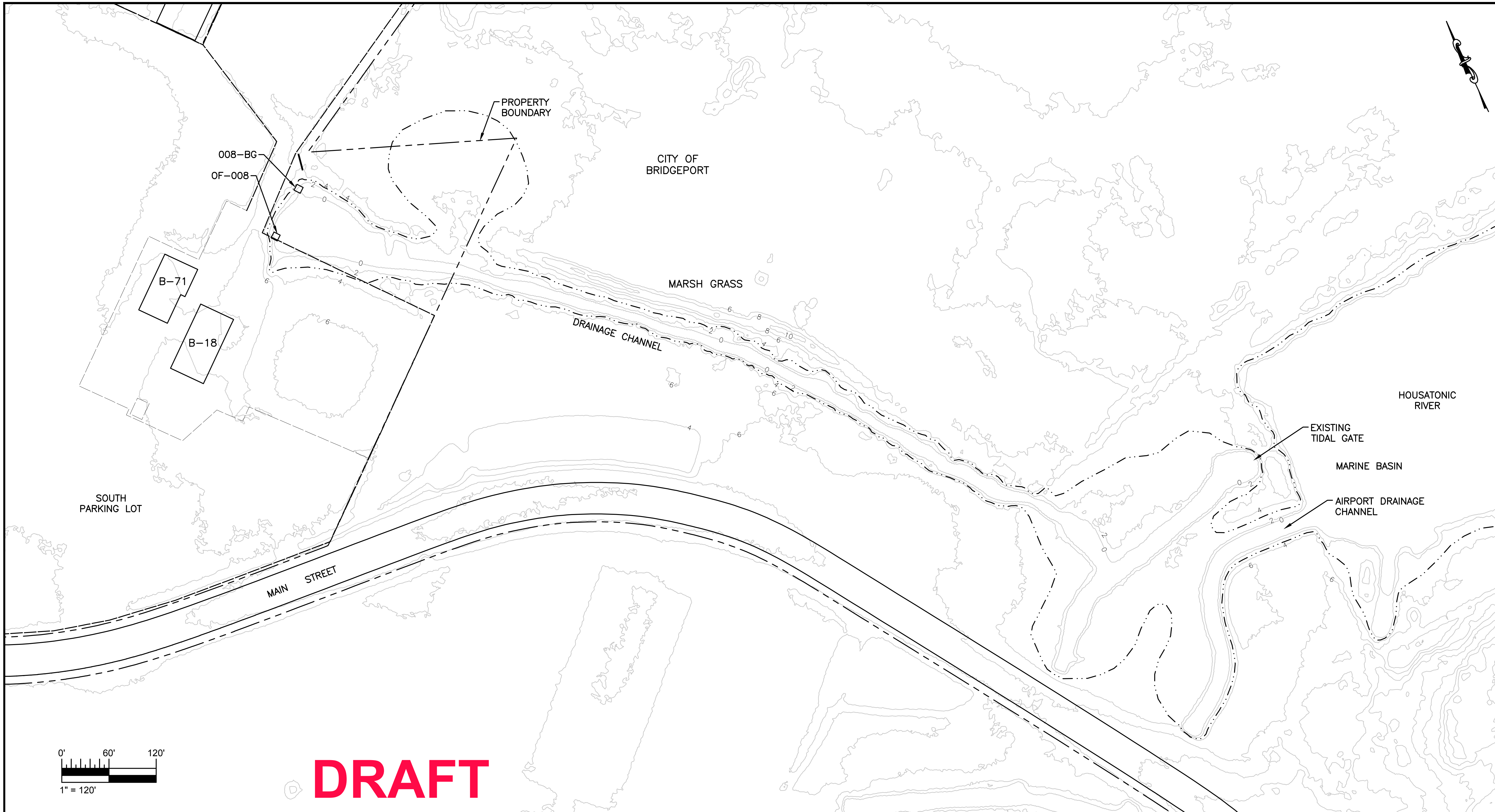
TITLE: TIDAL FLATS EXISTING CONDITIONS PLAN

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 1-3

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 1-3 - EC Plan.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 4:59pm



LEGEND

- BUILDING
- MEAN HIGH TIDE
- PROPERTY BOUNDARY

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CHECKED BY:	DAA
DATUM:	NAD 83
PROJECTION:	CT STATE PLANE
SCALE:	AS SHOWN
TITLE	DRAINAGE DITCH EXISTING CONDITIONS PLAN
DATE:	FEB 2018
PROJECT NO:	3616176064
FIGURE No.	1-4

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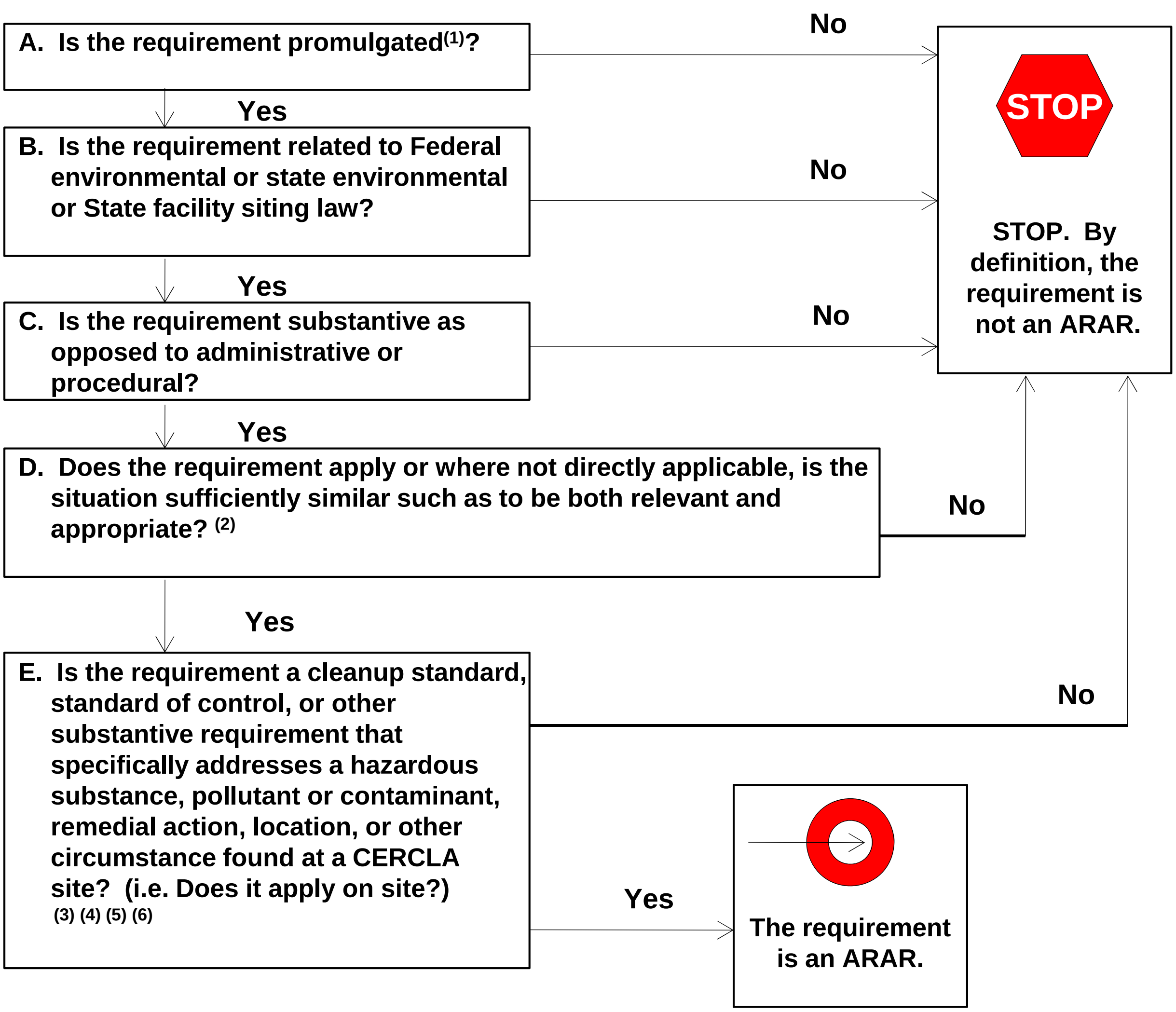
FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 1-4 - DC EC Plan.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 5:00pm

ARAR Logic Flowchart

For Determining if a Requirement is an ARAR



(1) Promulgated means the requirement is of general applicability and legally enforceable. In general, regulations have gone through the formal administrative procedures to make them legally enforceable. Guidance documents are not promulgated.

(2) See NCP criteria for relevant and appropriate discussed below or in 40 CFR 300.400(g)(2).

(3) MMRP sites are treated as CERCLA sites, by policy, regardless of whether or not a hazardous substance, pollutant, or contaminant has been released (ER-2003-1).

(4) “Hazardous substances” are defined in CERCLA 101(14) and 40 CFR 300.5 and listed by chemical name in 40 CFR 302.4.

(5) “Pollutant or contaminant” is defined in CERCLA 101(33) and 40 CFR 300.5 and response authority is limited to pollutants and contaminants that “may present an imminent and substantial danger to public health or welfare of the United States.”

(6) ARARs are identified for actions which occur onsite. Off-site activities must comply with all applicable requirements, but are not subject to designation of ARARs.

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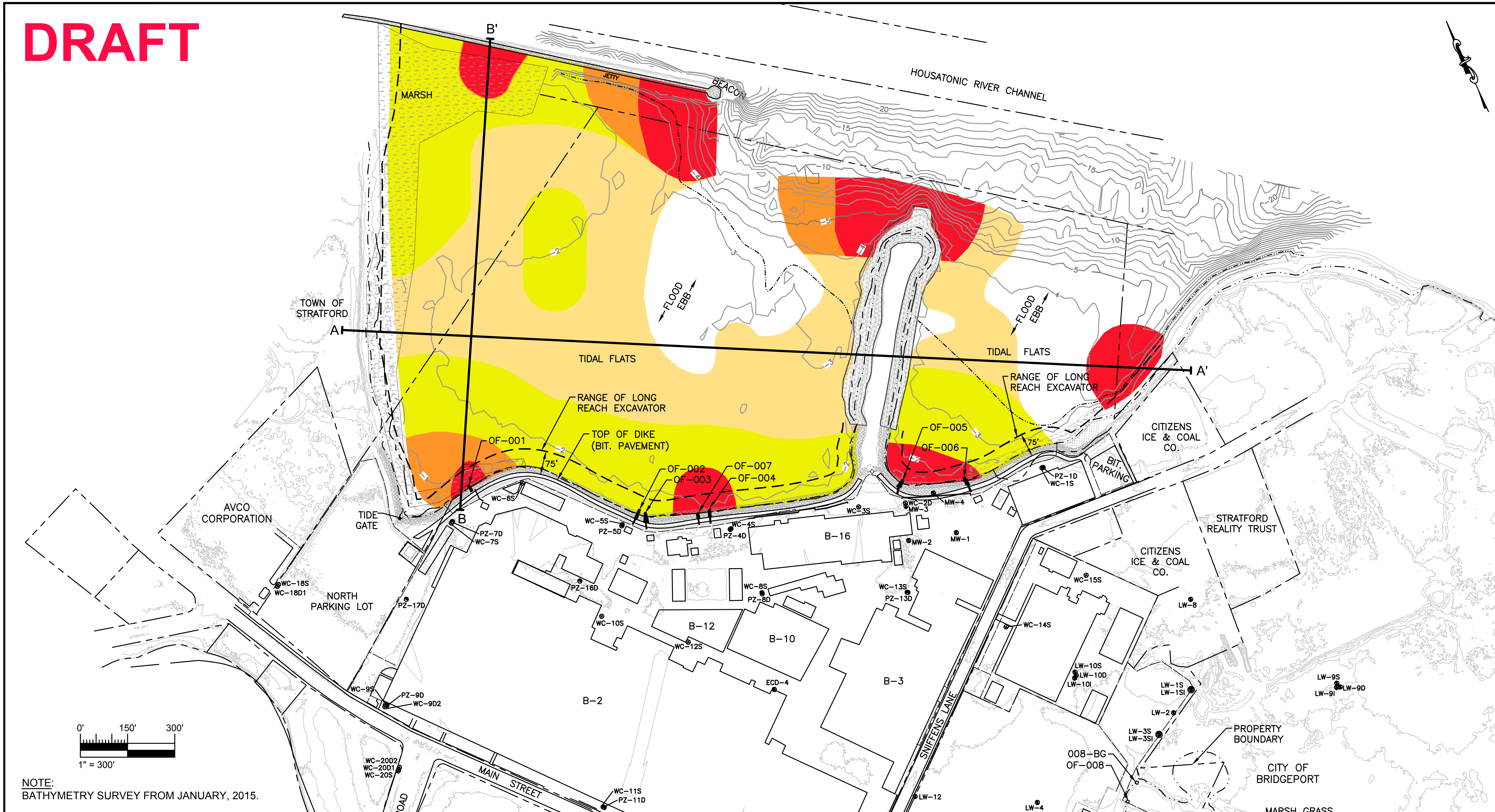
Figure 2-1: ARAR Logic Flowchart

Stratford Army Engine Plant Feasibility Study

Stratford, Connecticut

February 2018



NOTE: BATHYMETRY SURVEY FROM JANUARY, 2015.

LEGEND

- 0-4' DREDGE AREA
- 0-3' DREDGE AREA
- 0-2' DREDGE AREA
- 0-1' DREDGE AREA
- A ——— A' CROSS SECTION LOCATION

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PROJECTION:	CT STATE PLANE
SCALE:	AS SHOWN

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TITLE: TIDAL FLATS PROPOSED REMEDIATION AREAS

DATE:	FEB 2018
PROJECT NO:	3616176064
FIGURE No.	2-2

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-2 - Proposed Removal Areas.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 5:00pm

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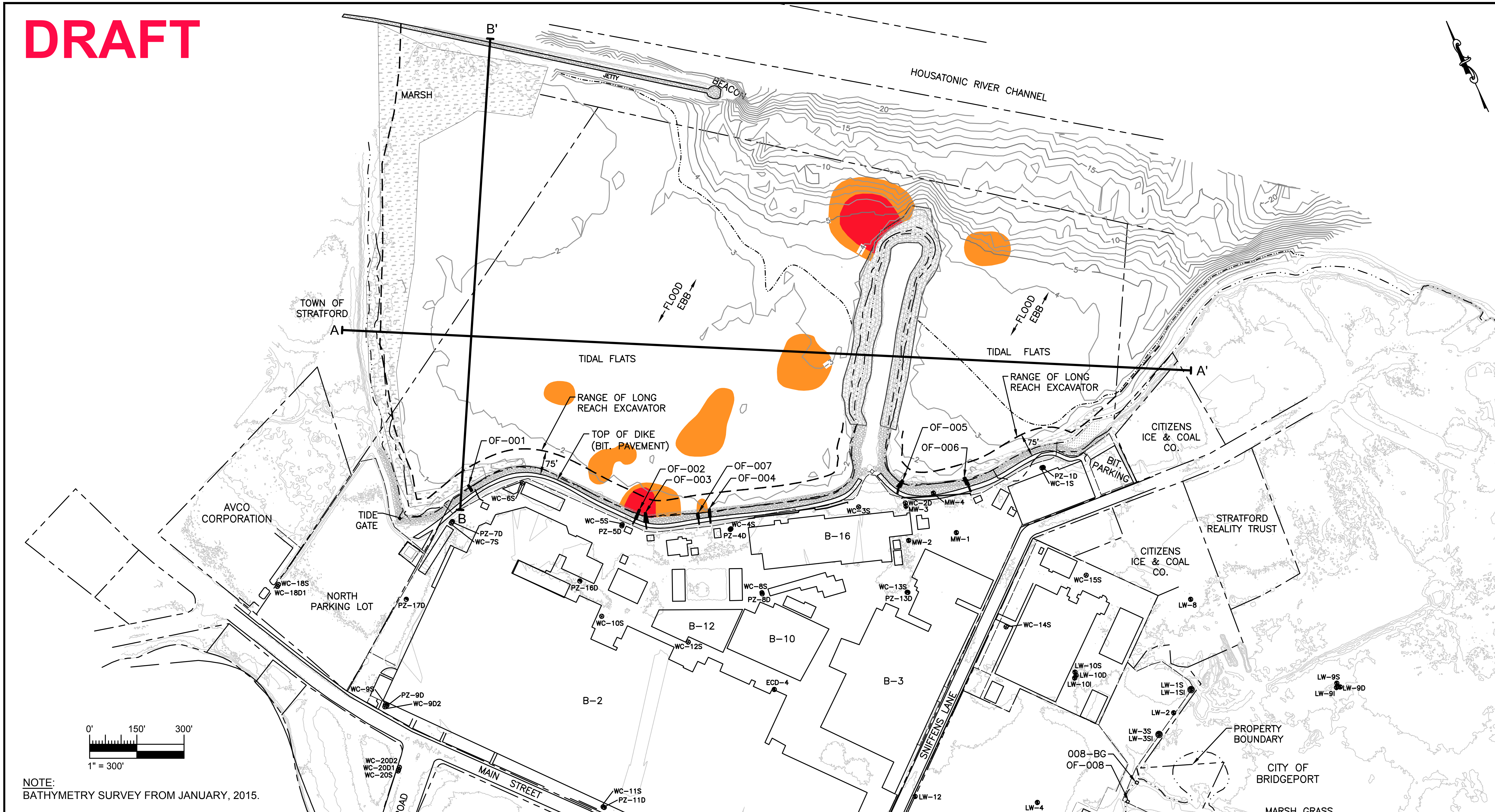

NOTE: BATHYMETRY SURVEY FROM JANUARY, 2015.

LEGEND

- PCBs ≥1 AND <50 PPM
- PCBs ≥50 PPM

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PROJECTION:	CT STATE PLANE
SCALE:	AS SHOWN

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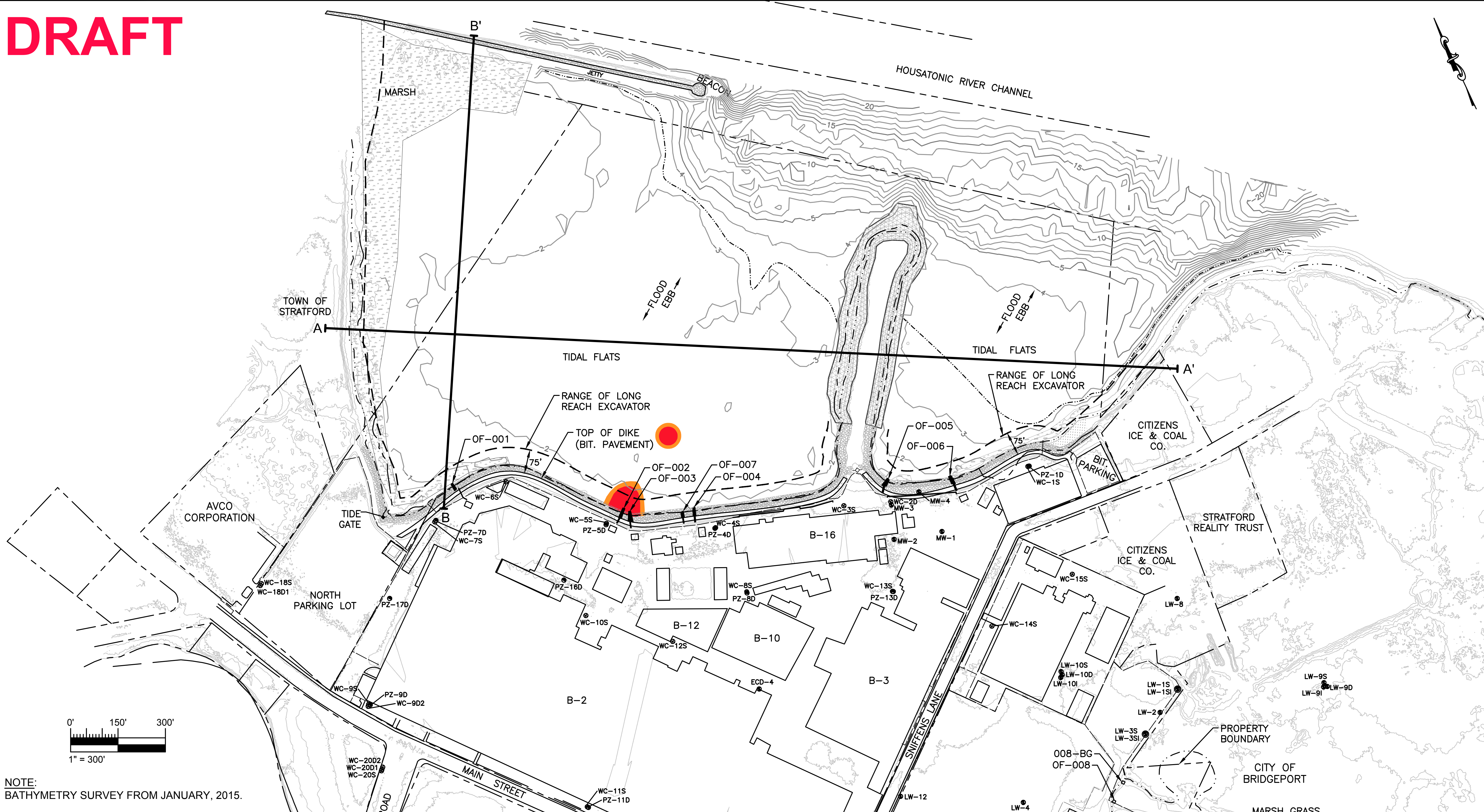
TITLE: TIDAL FLATS - AREAS WITH PCBs
FROM 0 TO -1 FT DEPTH

DATE:	FEB 2018
PROJECT NO:	3616176064
FIGURE No.	2-3

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-3 thru 2-5 - PCB areas.dwg BY: benjamin.girardet DATE: 16 Mar 2018 - 1:34pm

DRAFT



NOTE: BATHYMETRY SURVEY FROM JANUARY, 2015.

LEGEND

PCBs ≥1 AND <50 PPM

PCBs ≥50 PPM

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PROJECTION: CT STATE PLANE
SCALE: AS SHOWN

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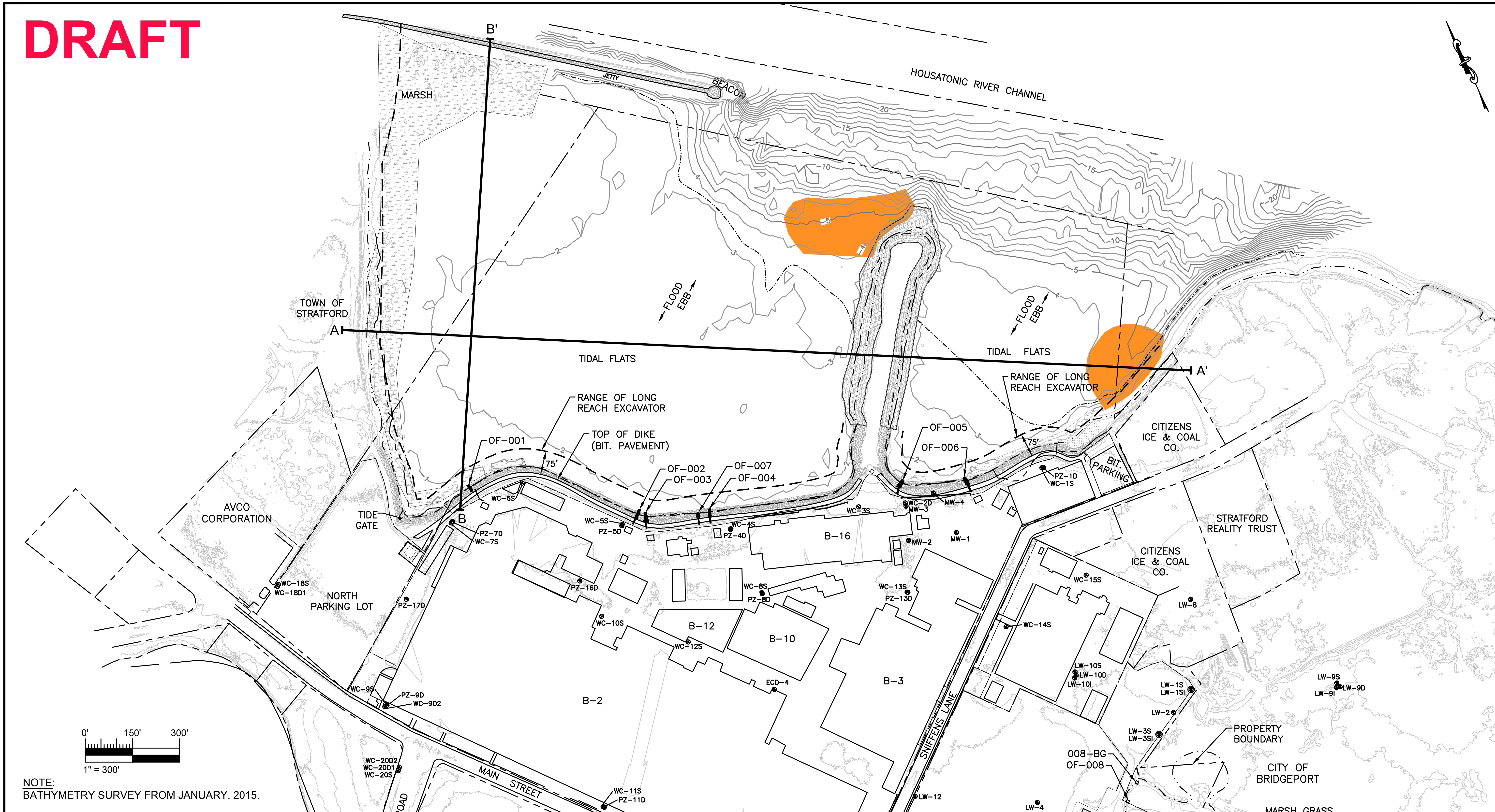
TITLE: TIDAL FLATS - AREAS WITH PCBs FROM -1 TO -2 FT DEPTH

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 2-4

DRAFT



NOTE:
BATHYMETRY SURVEY FROM JANUARY, 2015.

LEGEND

PCBs ≥1 AND <50 PPM

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CHECKED BY: DAA

DATUM: NAD 83

PROJECTION: CT STATE PLANE

SCALE: AS SHOWN

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TITLE: TIDAL FLATS - AREAS WITH PCBs FROM -2 TO -3 FT DEPTH

DATE: FEB 2018

PROJECT NO: 3616176064

FIGURE No. 2-5

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-3 thru 2-5 - PCB areas.dwg BY: benjamin.girardet DATE: 16 Mar 2018 - 1:31pm

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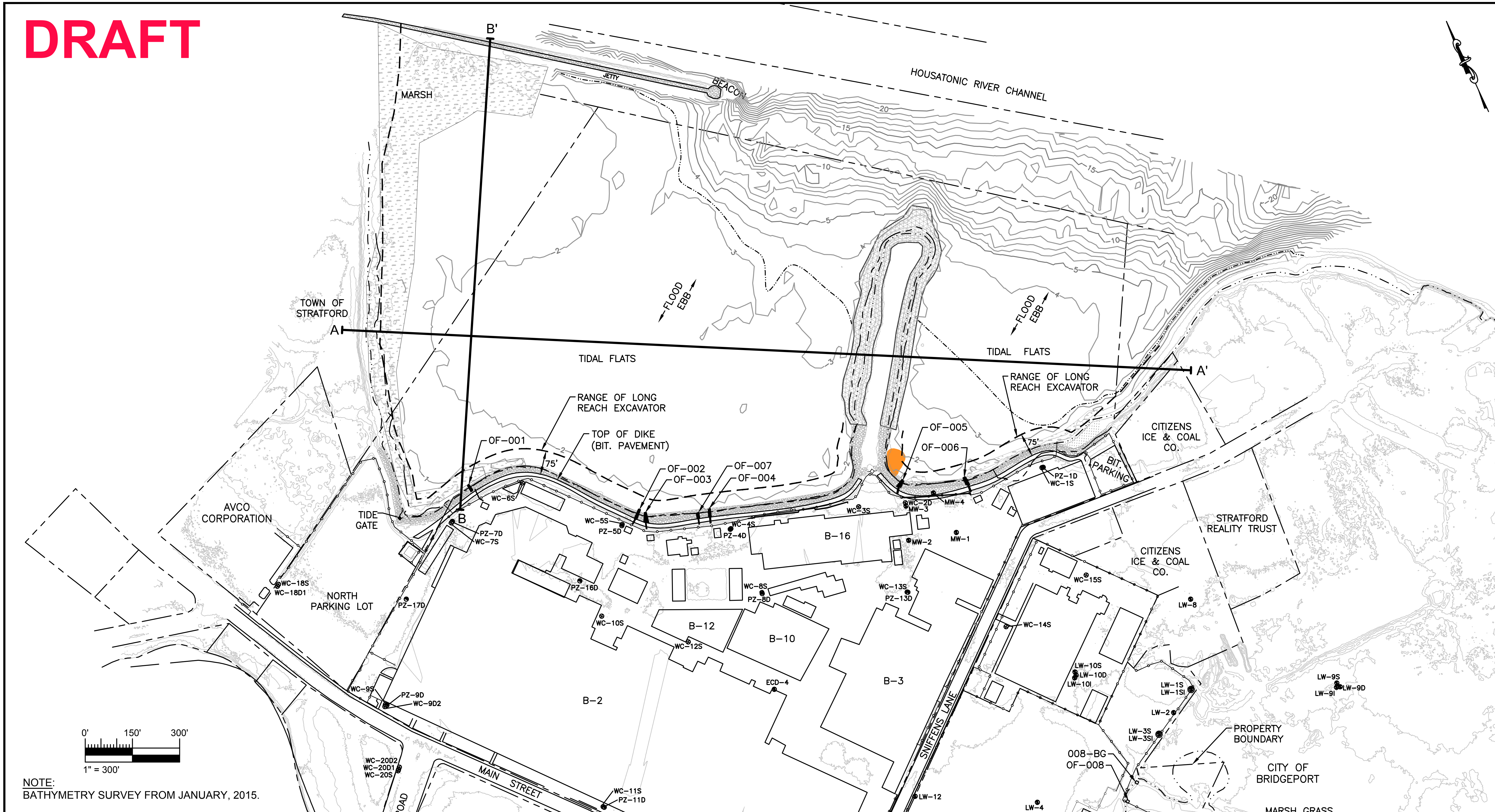

NOTE:
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LEGEND

PCBs ≥1 AND <50 PPM

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PROJECTION:	CT STATE PLANE
SCALE:	AS SHOWN

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TITLE: TIDAL FLATS - AREAS WITH PCBs
FROM -3 TO -4 FT DEPTH

DATE:	FEB 2018
PROJECT NO:	3616176064
FIGURE No.	2-6

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-3 thru 2-6 - PCB areas.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:17am

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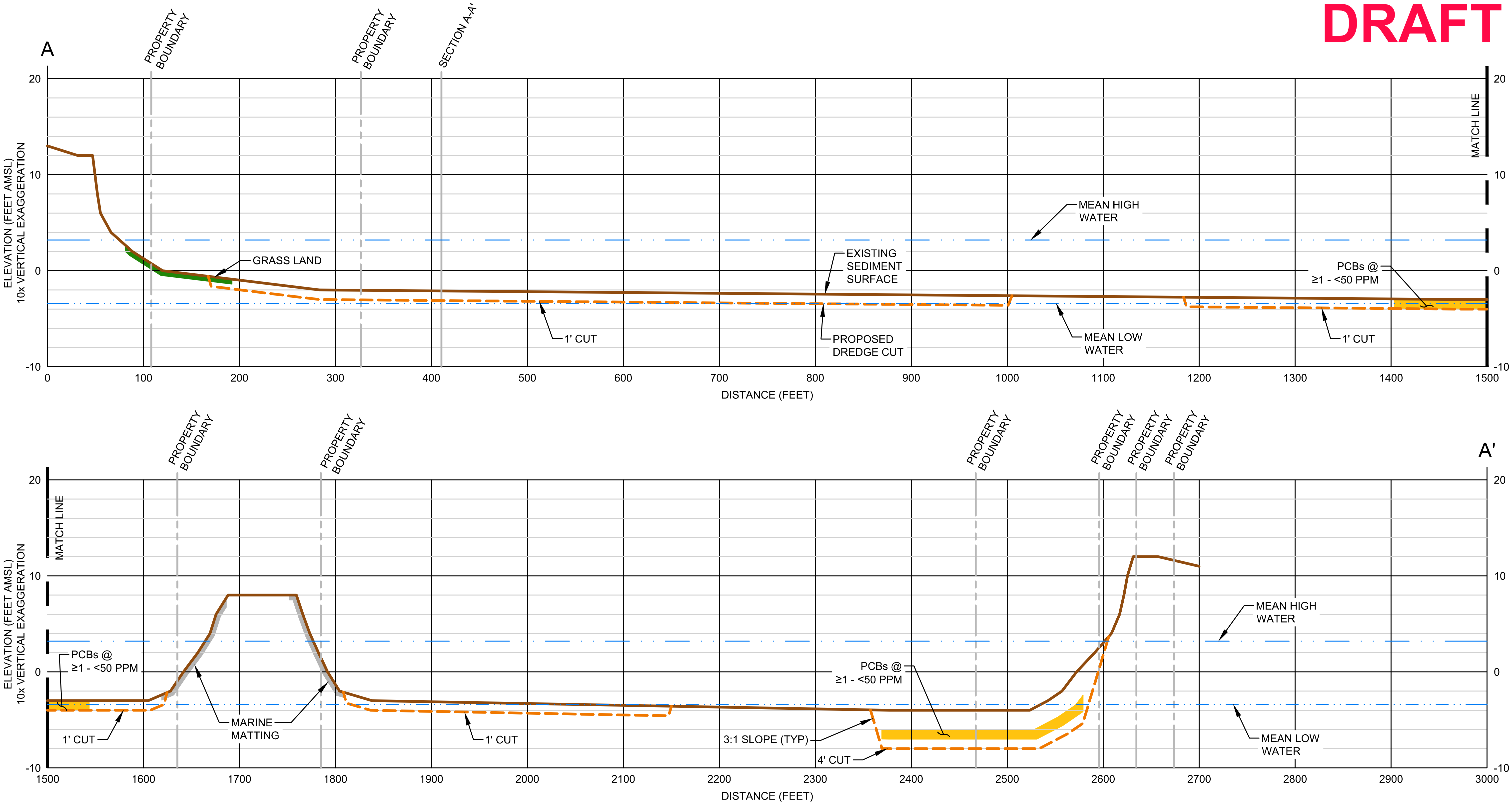

HORIZONTAL SCALE: 1" = 100'

0 100' 200'

0 10' 20'

VERTICAL SCALE: 1" = 10'

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STRATFORD, CONNECTICUT

DRAWN BY: BEG
CHECKED BY: DAA
DATUM: NONE
PROJECTION: NONE
SCALE: AS SHOWN

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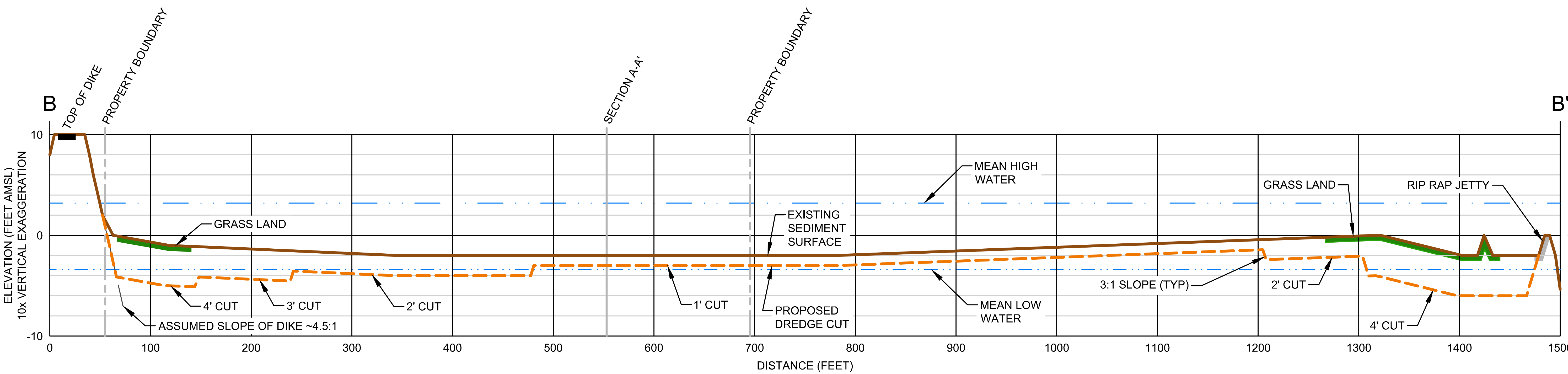
TITLE: TIDAL FLATS - CROSS SECTION A-A'

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 2-7

FILE: U:_ CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-7 and 2-8 - Tidal Flats X-SECs.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:12am



DRAFT

HORIZONTAL SCALE: 1" = 100'

0 100' 200'

0 10' 20'

VERTICAL SCALE: 1" = 10'

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STRATFORD, CONNECTICUT

DRAWN BY: BEG
CHECKED BY: DAA
DATUM: NONE
PROJECTION: NONE
SCALE: AS SHOWN

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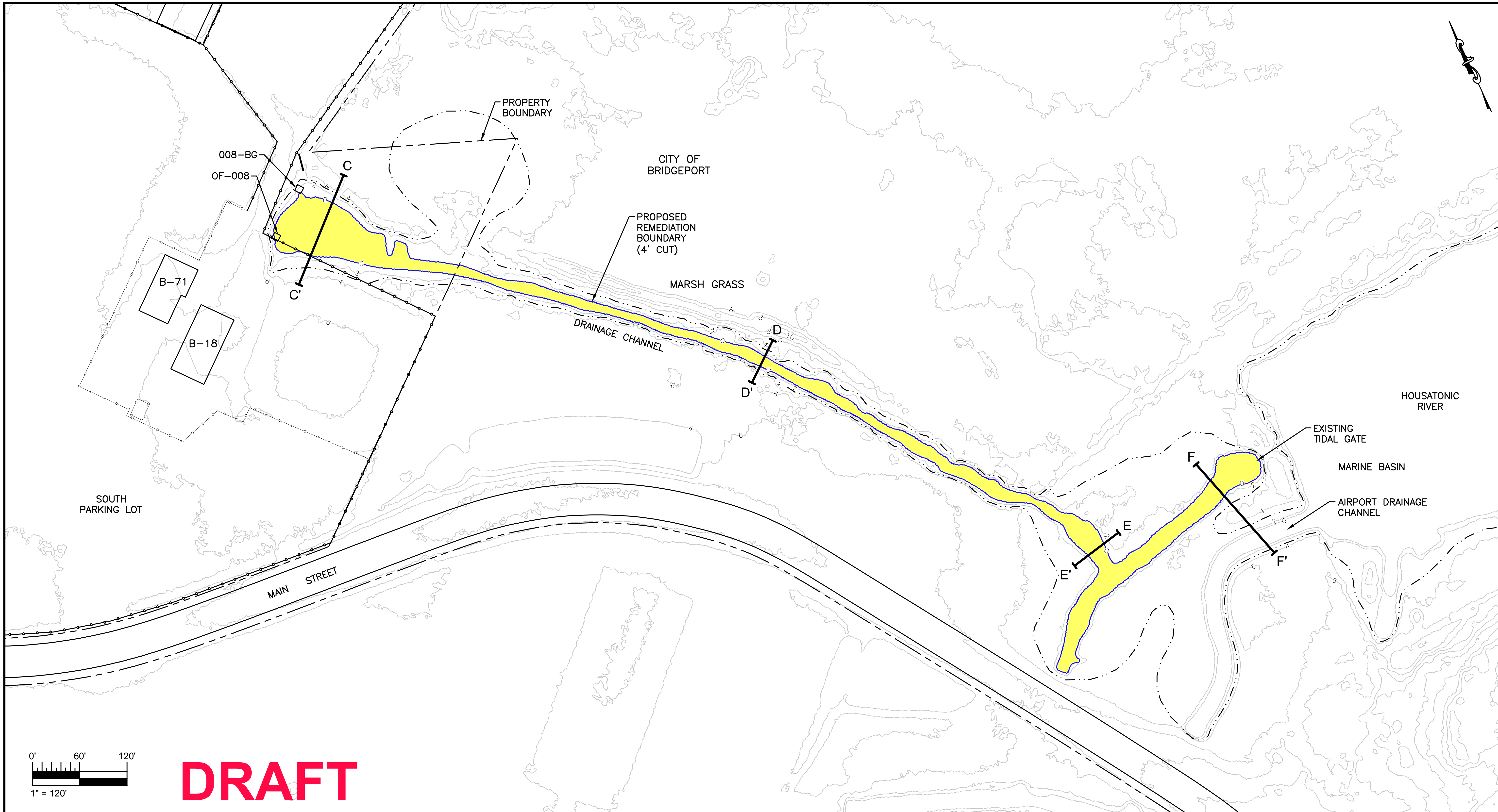
TITLE
TIDAL FLATS - CROSS SECTION B-B'

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 2-8

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-7 and 2-8 - Tidal Flats X-SECs.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:12am



LEGEND

(yellow)	0-4 FOOT REMEDIATION AREA
— — —	PROPERTY BOUNDARY
—·—·—	MEAN HIGH WATER

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STRATFORD, CONNECTICUT

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CHECKED BY: DAA

DATUM: NAD 83

PROJECTION: CT STATE PLANE

SCALE: AS SHOWN

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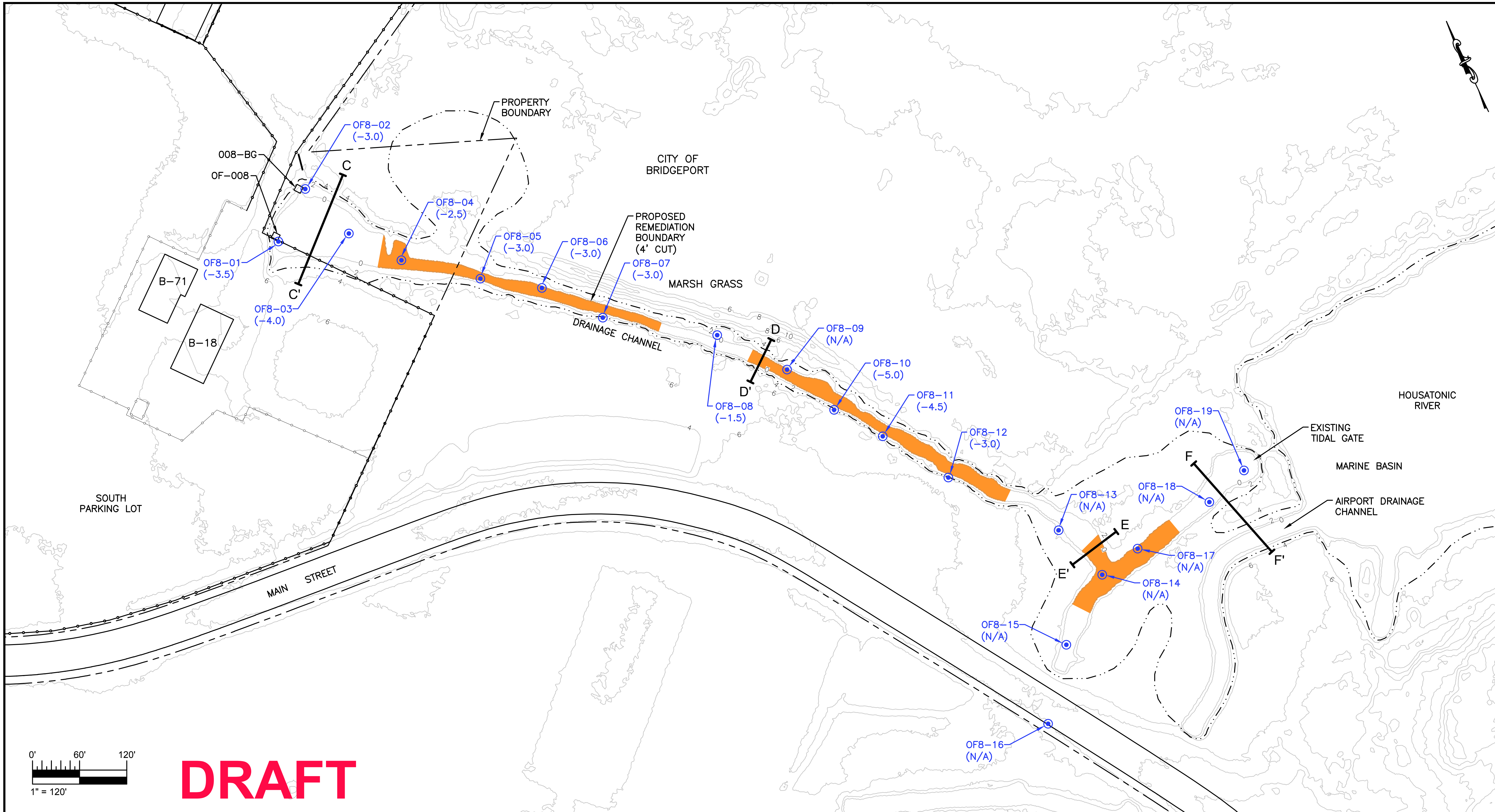
TITLE: OF-008 DRAINAGE DITCH
PROPOSED REMEDIATION AREA

DATE: FEB 2018

PROJECT NO: 3616176064

FIGURE No. 2-9

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-9 - DC Proposed Removal Area.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:18am



LEGEND

OF8–06 (–3.0)	SEDIMENT SAMPLE TAKEN 4/2014 (DEPTH OF WATER)
(orange fill)	PCBs ≥1 - <10 PPM
(dashed line)	PROPERTY BOUNDARY
(dash-dot line)	MEAN HIGH WATER

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STRATFORD, CONNECTICUT

DRAWN BY: BEG
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PROJECTION: CT STATE PLANE
SCALE: AS SHOWN

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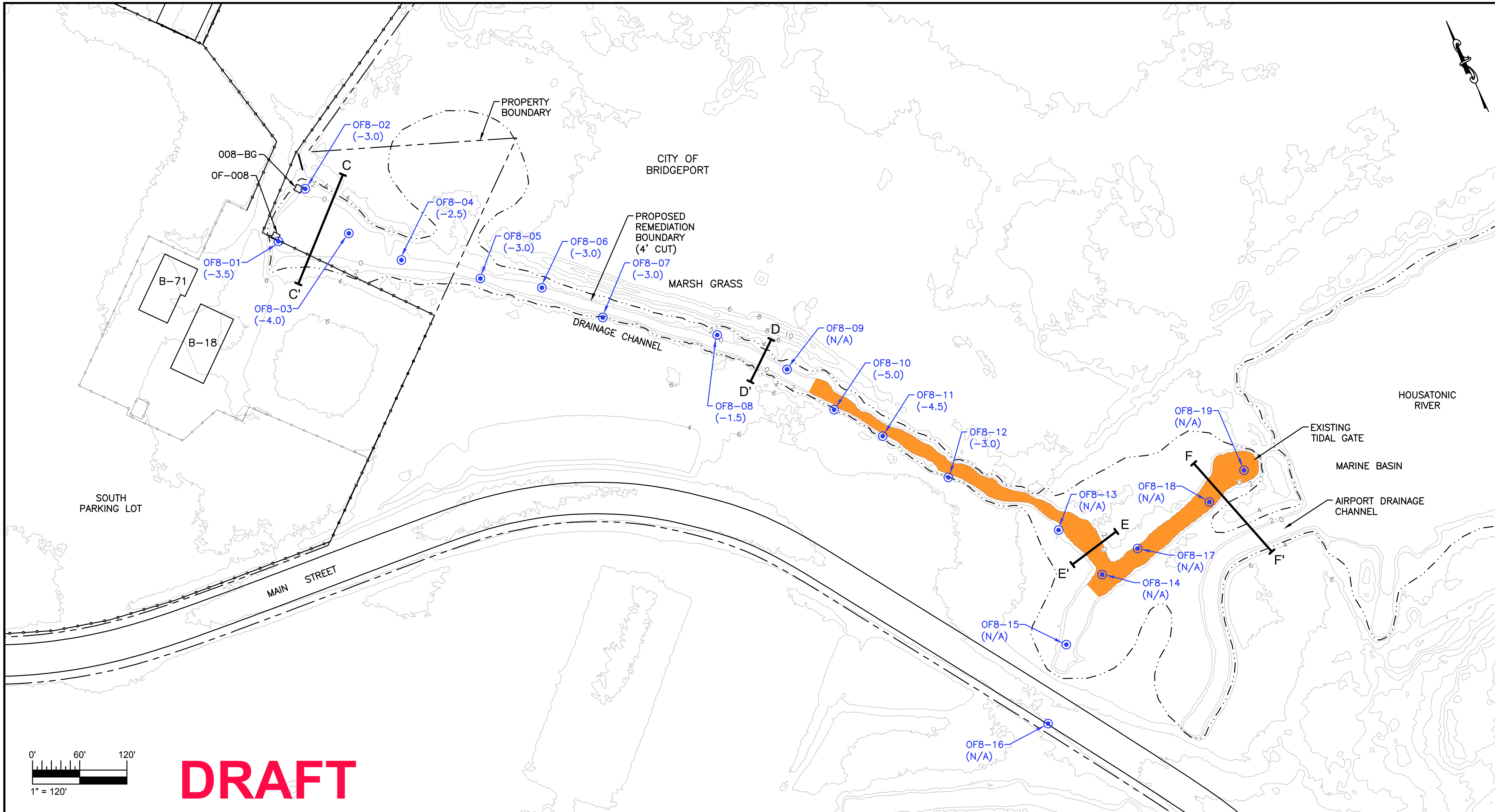
TITLE: OF-008 DRAINAGE DITCH - AREAS WITH PCBs FROM -2 TO -3 FT DEPTH

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 2-10

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-10 and 2-11 - OC PCB Areas.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:20am



LEGEND

OF8-06 (-3.0) ◉	SEDIMENT SAMPLE TAKEN 4/2014 (DEPTH OF WATER)
(orange fill)	PCBs ≥1 - <10 PPM
— — —	PROPERTY BOUNDARY
-··-··-	MEAN HIGH WATER

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PROJECT: STRATFORD ARMY ENGINE PLANT SEDIMENT DREDGING STRATFORD, CONNECTICUT

DRAWN BY: BEG

CHECKED BY: DAA

DATUM: NAD 83

PROJECTION: CT STATE PLANE

SCALE: AS SHOWN

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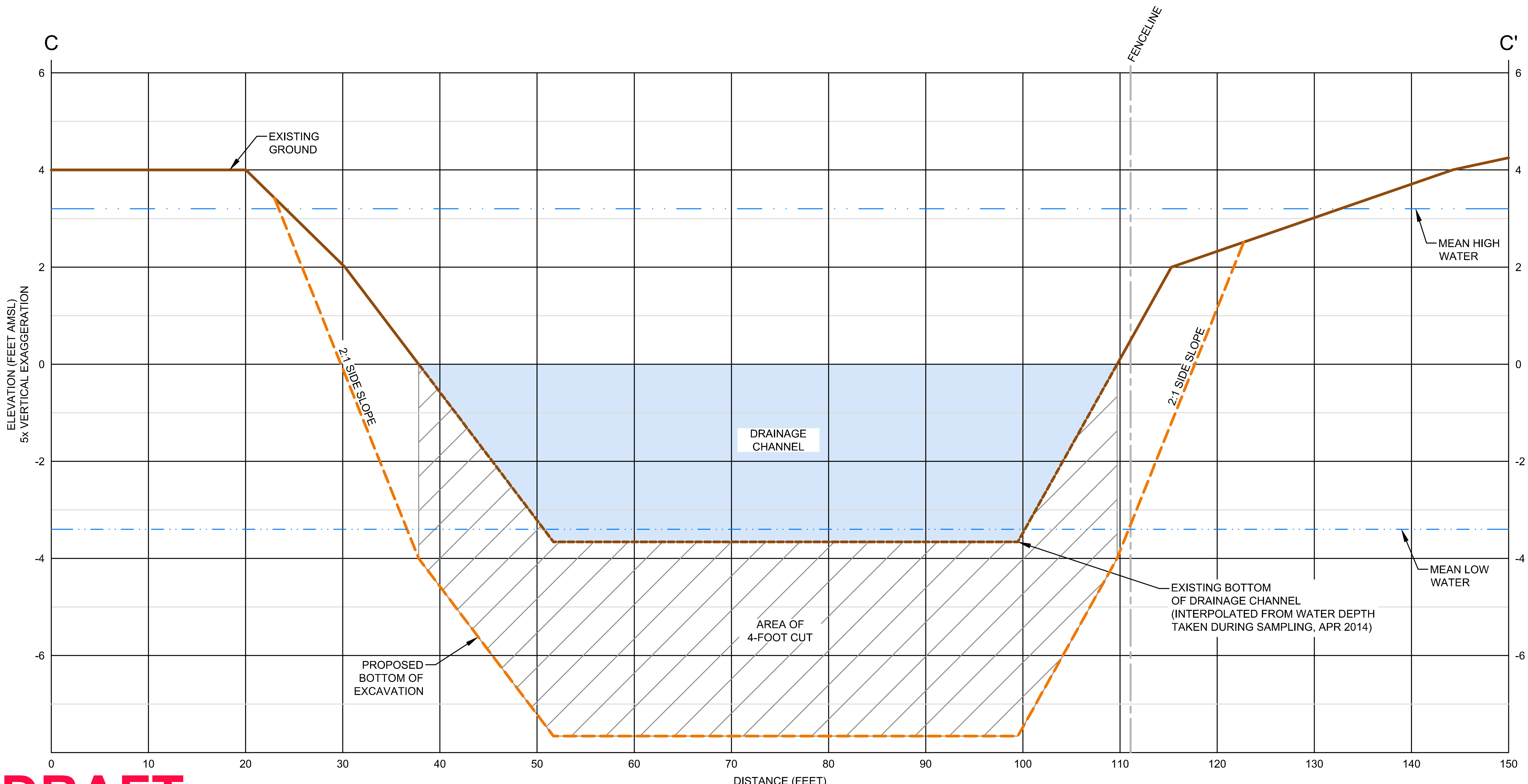
TITLE: OF-008 DRAINAGE DITCH - AREAS WITH PCBs FROM -3 TO -4 FT DEPTH

DATE: FEB 2018

PROJECT NO: 3616176064

FIGURE No. 2-11

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-10 and 2-11 - DC PCB Areas.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:20am



DRAFT

HORIZONTAL SCALE: 1" = 10'

0 10' 20'

0 2' 4'

VERTICAL SCALE: 1" = 2'

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CHECKED BY: DAA
DATUM: NONE
PROJECTION: NONE
SCALE: AS SHOWN

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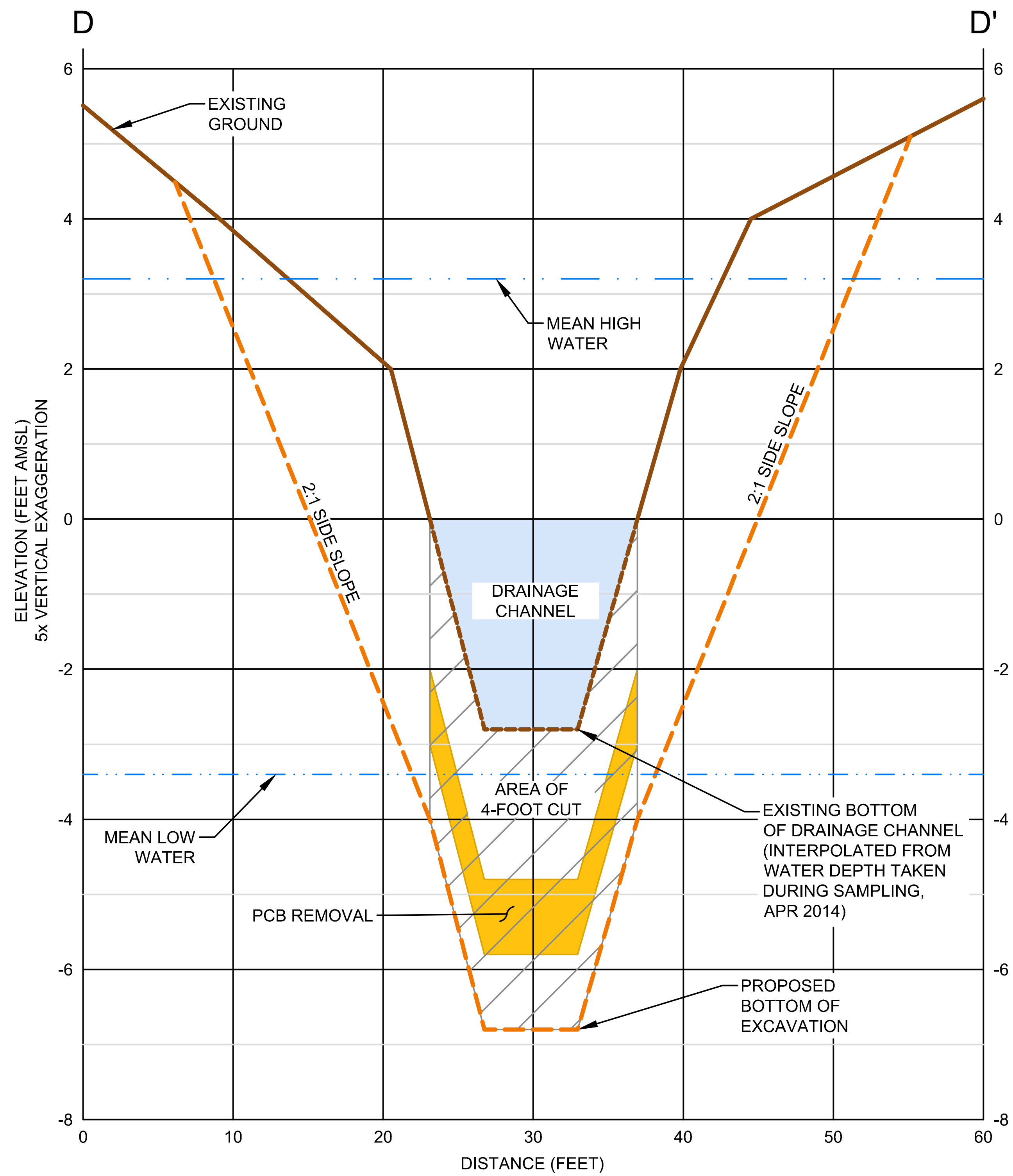
TITLE: OF-008 DRAINAGE DITCH - CROSS SECTION C-C'

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 2-12

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-12 thru 2-15 - DC X-SECs.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:22am



DRAFT

NOTE:
PCB DELINEATION TO BE COMPLETED PRIOR TO FINAL DESIGN

HORIZONTAL SCALE: 1" = 10'

0 10' 20'

0 2' 4'

VERTICAL SCALE: 1" = 2'

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CHECKED BY:	DAA
DATUM:	NONE
PROJECTION:	NONE
SCALE:	AS SHOWN

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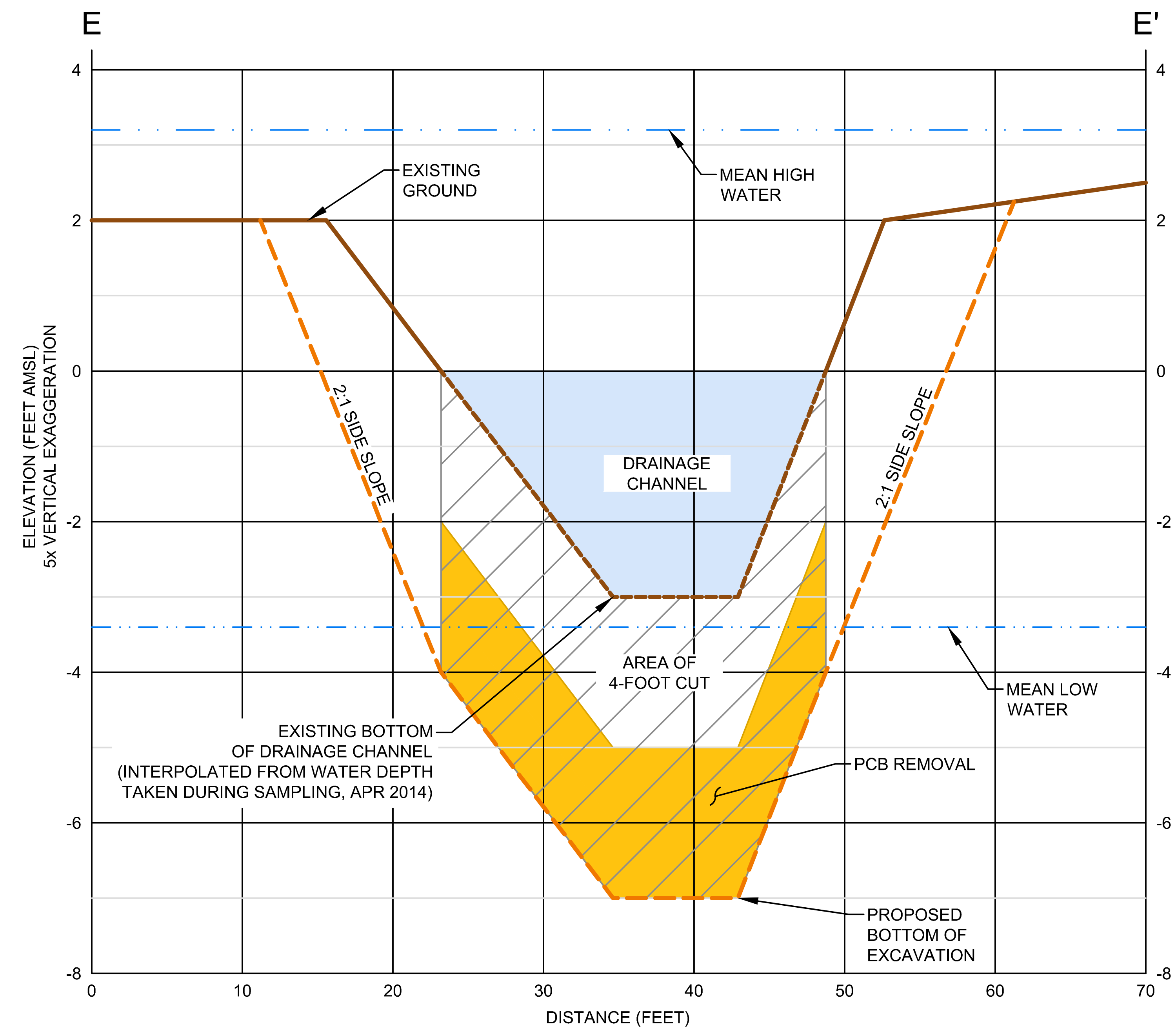
TITLE: OF-008 DRAINAGE DITCH - CROSS SECTION D-D'

DATE:	FEB 2018
PROJECT NO:	3616176064
FIGURE No.	2-13

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-12 thru 2-15 - DC X-SECs.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:22am



DRAFT

NOTE:
PCB DELINEATION TO BE COMPLETED PRIOR TO FINAL DESIGN

HORIZONTAL SCALE: 1" = 10'

0 10' 20'

0 2' 4'

VERTICAL SCALE: 1" = 2'

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CHECKED BY: DAA

DATUM: NONE

PROJECTION: NONE

SCALE: AS SHOWN

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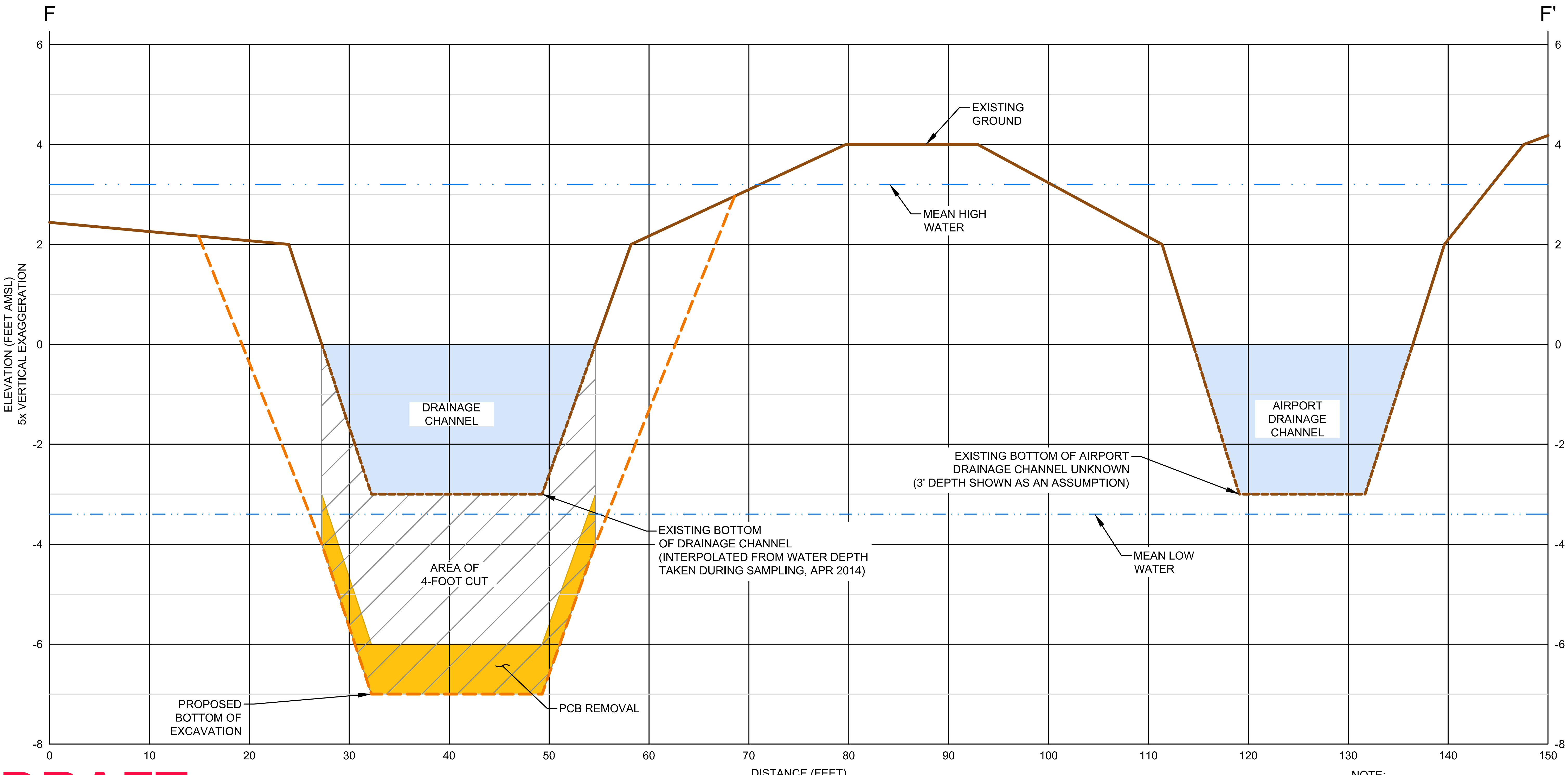
TITLE: OF-008 DRAINAGE DITCH - CROSS SECTION E-E'

DATE: FEB 2018

PROJECT NO: 3616176064

FIGURE No. 2-14

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-12 thru 2-15 - DC X-SECs.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:23am



DRAFT

NOTE:
PCB DELINEATION TO BE COMPLETED PRIOR TO FINAL DESIGN

HORIZONTAL SCALE: 1" = 10'
0 10' 20'
0 2' 4'
VERTICAL SCALE: 1" = 2'

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STRATFORD, CONNECTICUT

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CHECKED BY: DAA
DATUM: NONE
PROJECTION: NONE
SCALE: AS SHOWN

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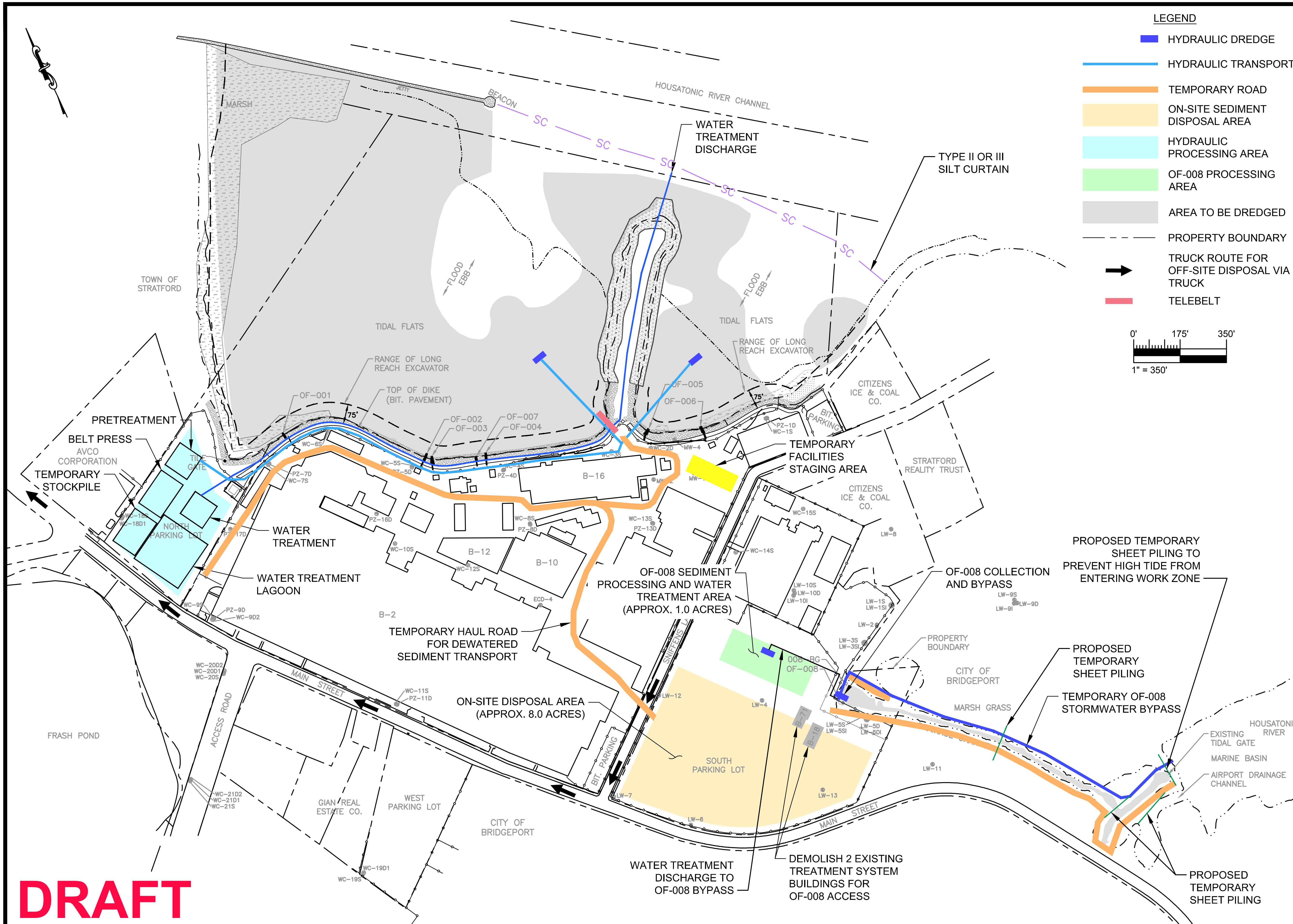
TITLE: OF-008 DRAINAGE DITCH - CROSS SECTION F-F'

DATE: FEB 2018
PROJECT NO: 3616176064
FIGURE No. 2-15

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 2-12 thru 2-15 - DC X-SECs.dwg BY: benjamin.girardet DATE: 21 Mar 2018 - 11:23am



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PROJECT:

STRATFORD ARMY ENGINE PLANT
SEDIMENT DREDGING
STRATFORD, CT

DRAWN BY: BEG	CHECKED BY: DAA
SCALE: AS SHOWN	DATE: FEB 2018
DATUM: NAD83	PROJECTION: CT STATE PLANE
PROJECT NUMBER: 3616176064	

TITLE:

HYDRAULIC DREDGE ALTERNATIVE 2

FIGURE NUMBER:

5-1

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 5-1 thru 5-9_odd NOs_Staging Areas Map.dwg BY: benjamin.girardet DATE: 20 Mar 2018 - 10:00am

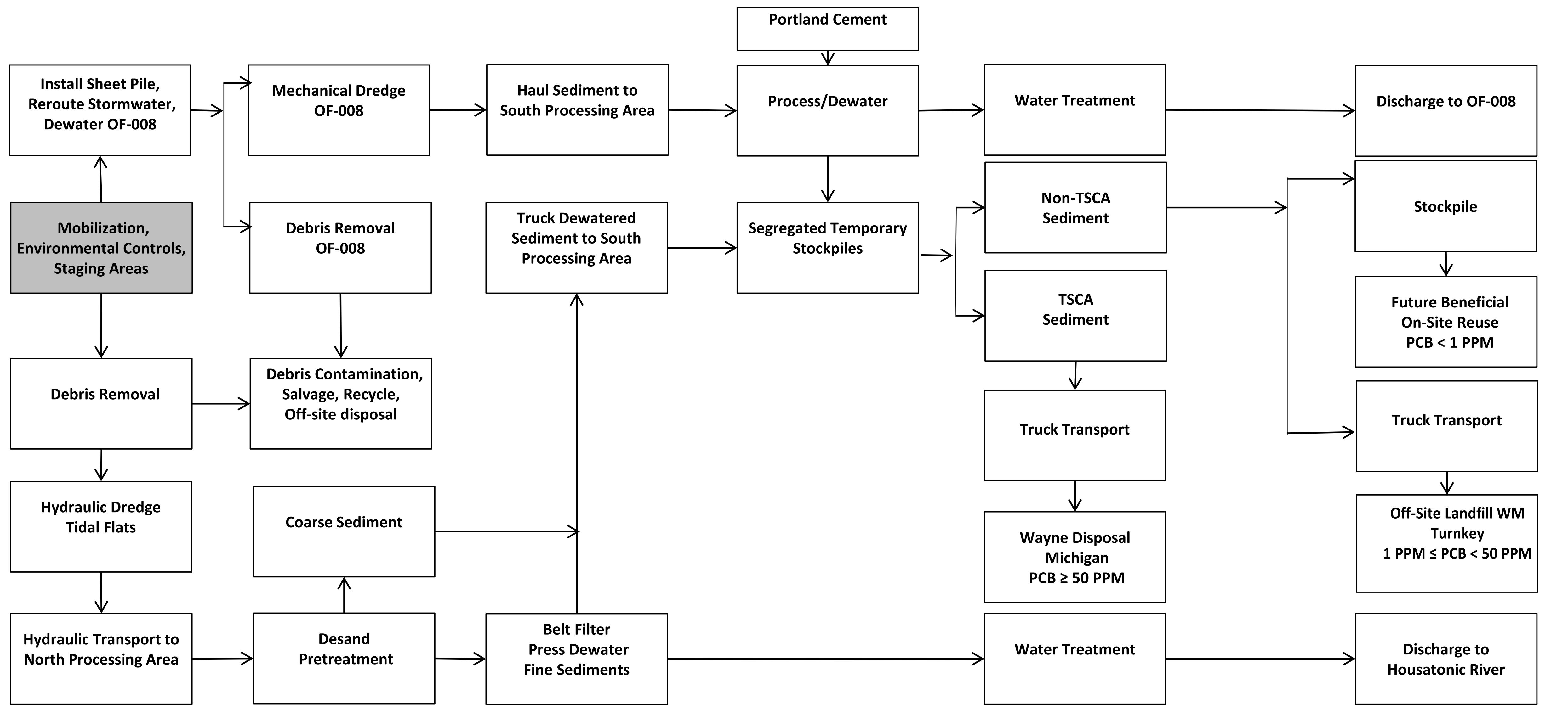
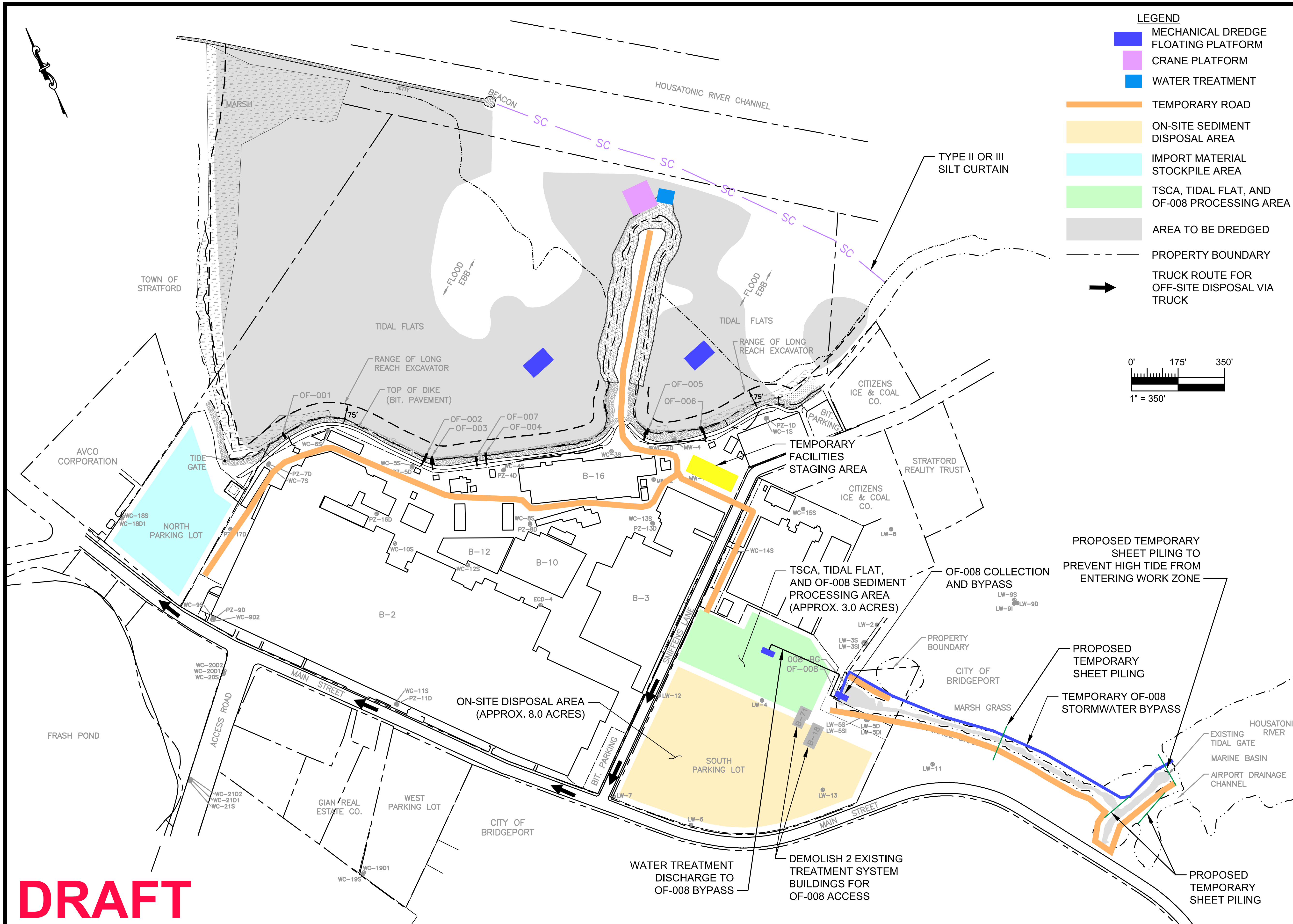


Figure 5-2: General Process Diagram for Remedial Alternative 2
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut
February 2018



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STRATFORD, CT

DRAWN BY: BEG	CHECKED BY: DAA
SCALE: AS SHOWN	DATE: FEB 2018
DATUM: NAD83	PROJECTION: CT STATE PLANE
PROJECT NUMBER: 3616176064	

TITLE:

MECHANICAL DREDGE ALTERNATIVE 3

FIGURE NUMBER:

5-3

FILE: U:\~ CAD Projects\USACE – SAEP\7.0 CAD\7.1 Design – Permitting\Sheets\Feasibility Study\FIG 5-1 thru 5-9_add NOs_Staging Areas Map.dwg BY: benjamin.girardet DATE: 12 Mar 2018 – 5:41pm

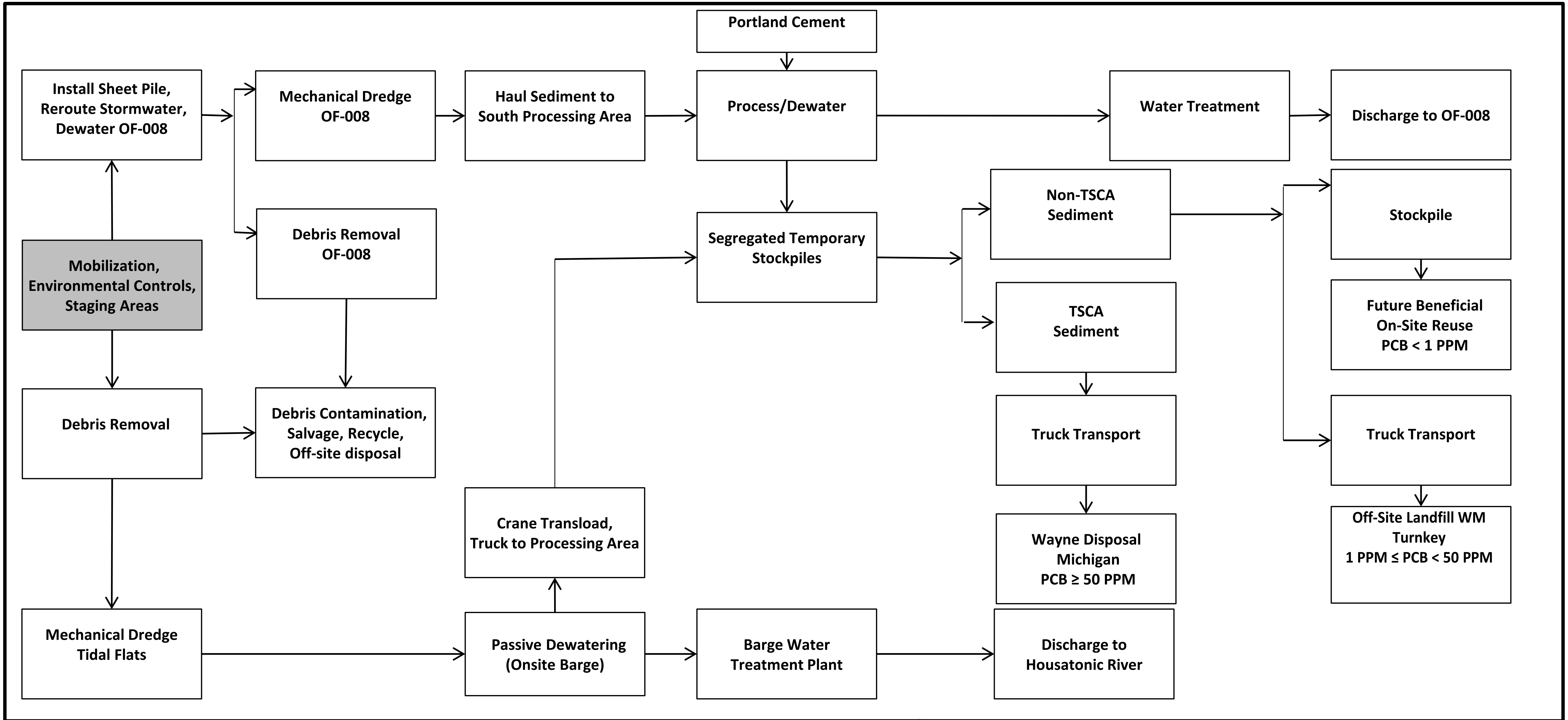
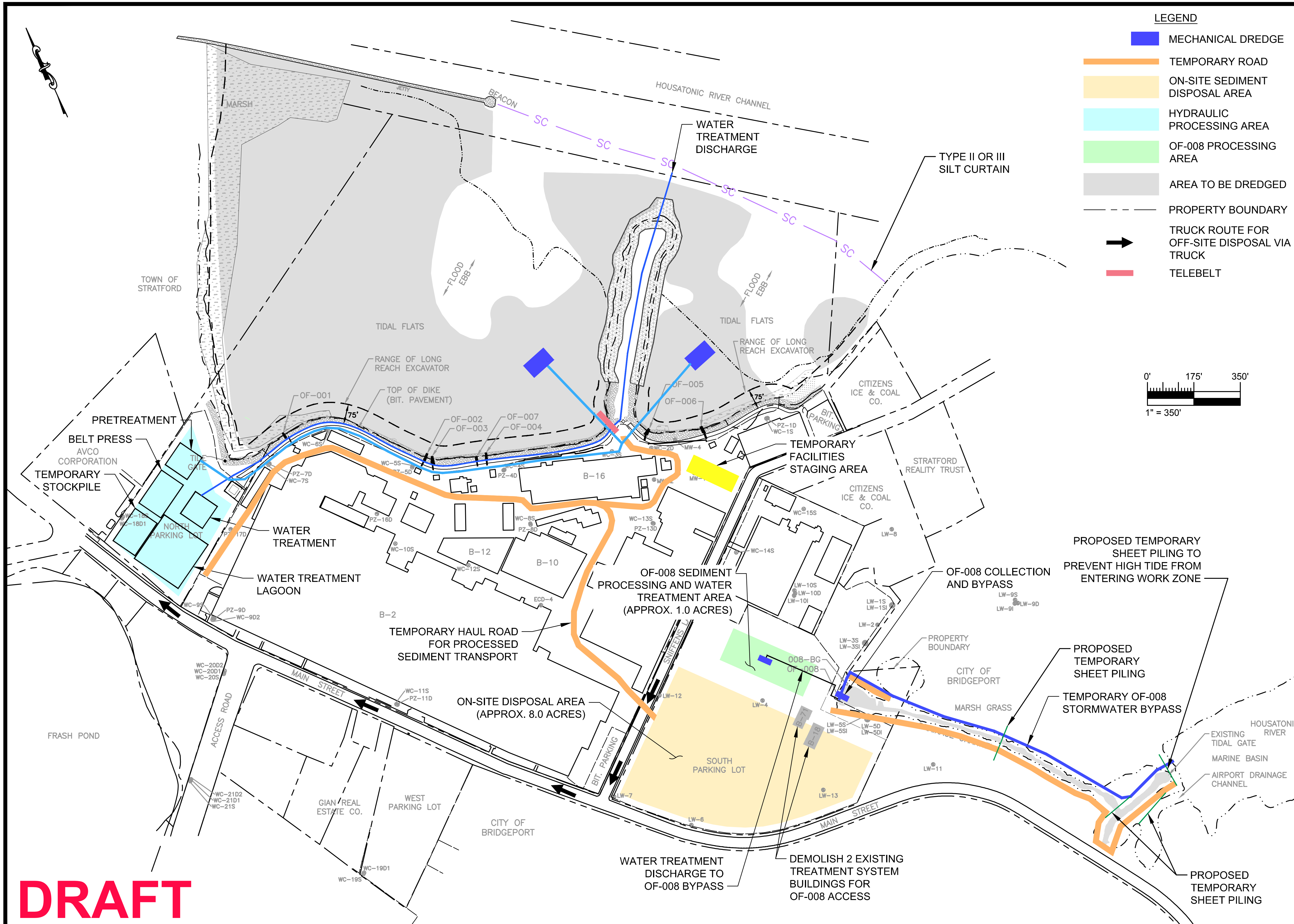


Figure 5-4: General Process Diagram for Remedial Alternative 3

Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut
February 2018



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STRATFORD, CT

DRAWN BY: BEG	CHECKED BY: DAA
SCALE: AS SHOWN	DATE: FEB 2018
DATUM: NAD83	PROJECTION: CT STATE PLANE
PROJECT NUMBER: 3616176064	

TITLE:

MECHANICAL DREDGING WITH HYDRAULIC TRANSPORT DREDGE ALTERNATIVE 4

FIGURE NUMBER:

5-5

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 5-1 thru 5-9_odd NOs_Staging Areas Map.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 5:45pm

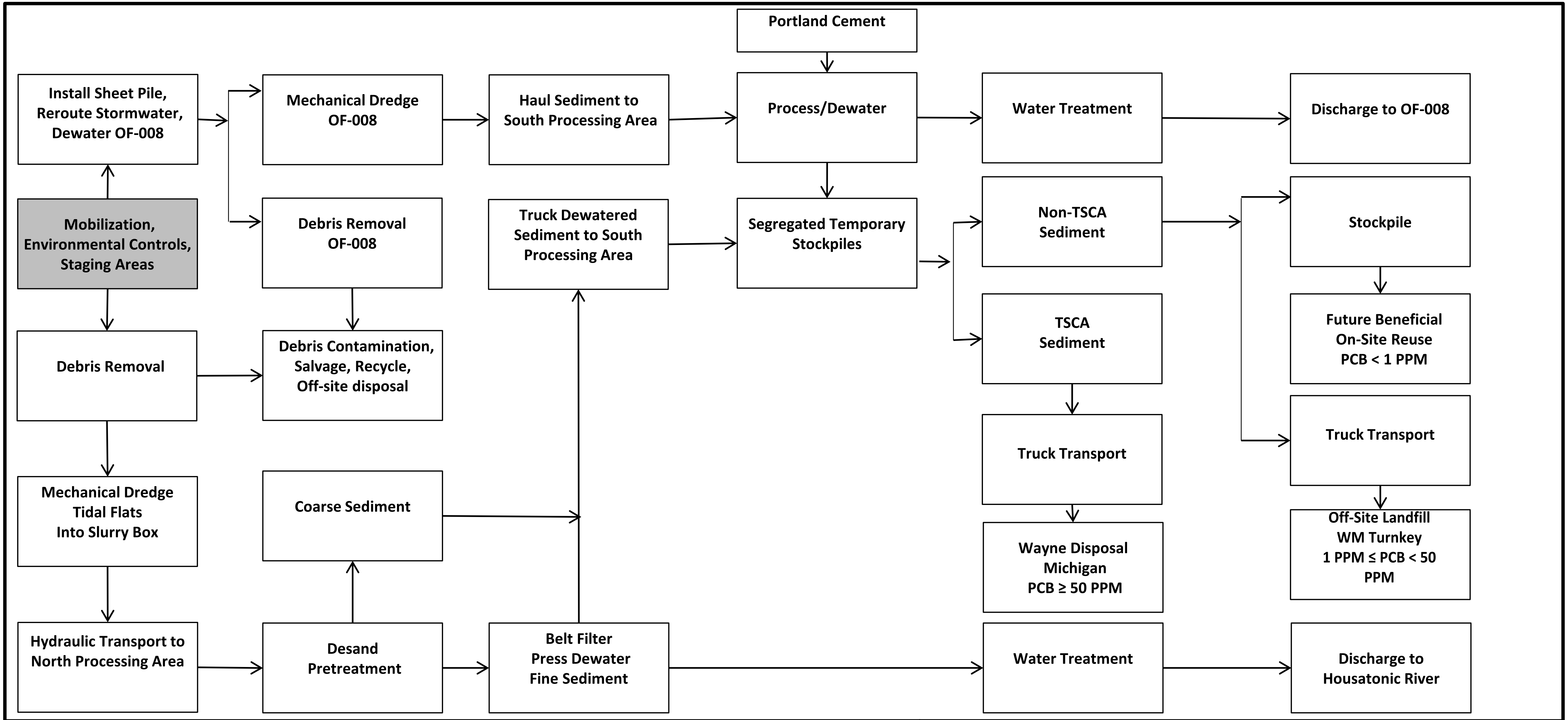
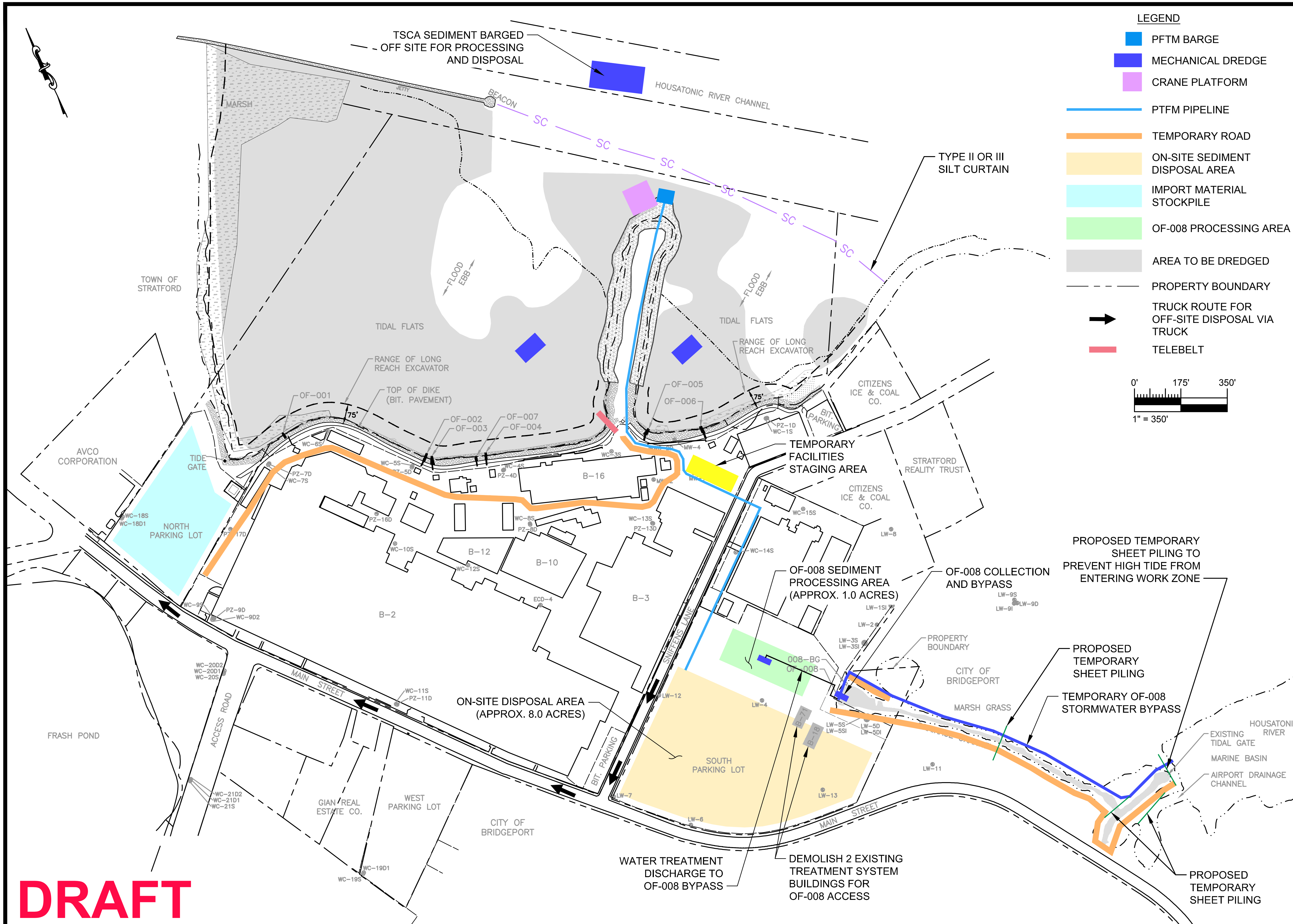


Figure 5-6: General Process Diagram for Remedial Alternative 4

Stratford Army Engine Plant Feasibility Study

Stratford, Connecticut

February 2018



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STRATFORD, CT

DRAWN BY: BEG	CHECKED BY: DAA
SCALE: AS SHOWN	DATE: FEB 2018
DATUM: NAD83	PROJECTION: CT STATE PLANE
PROJECT NUMBER: 3616176064	

TITLE:

MECHANICAL DREDGE
PFTM
ALTERNATIVE 5

FIGURE NUMBER:

5-7

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 5-1 thru 5-9_add NOs_Staging Areas Map.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 5:45pm

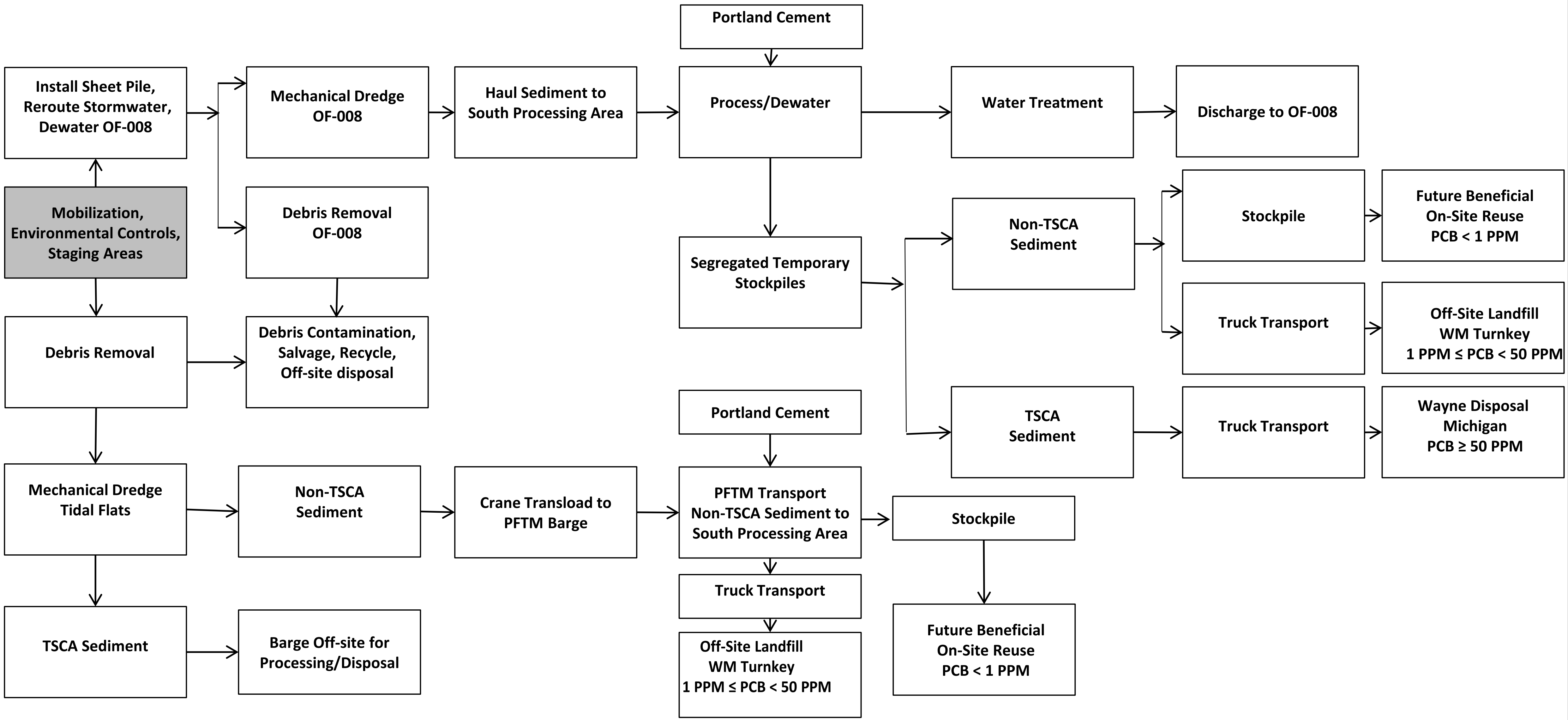

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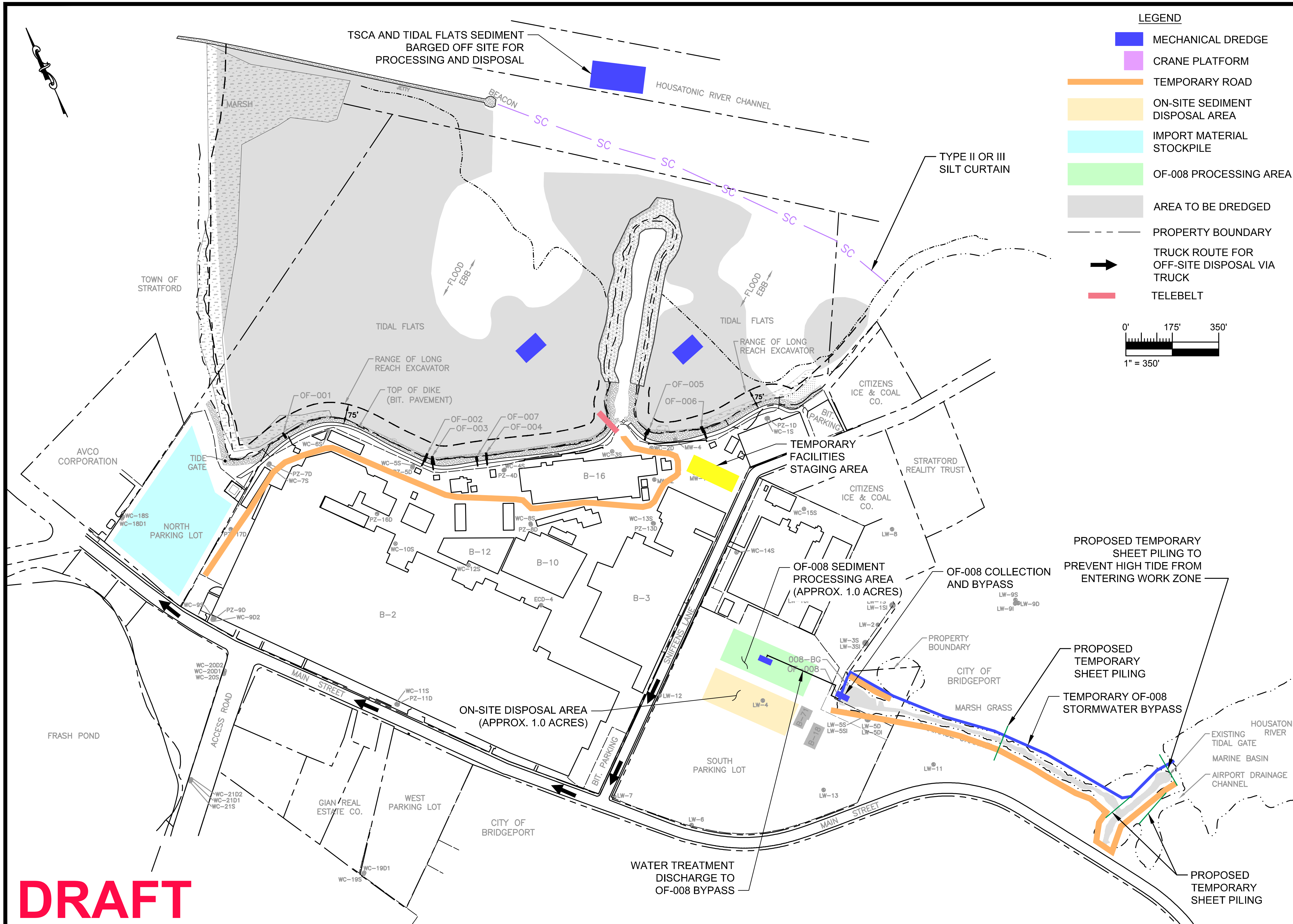
Figure 5-8: General Process Diagram for Remedial Alternative 5

Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut
February 2018



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PROJECT:

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STRATFORD, CT

DRAWN BY: BEG	CHECKED BY: DAA
SCALE: AS SHOWN	DATE: FEB 2018
DATUM: NAD83	PROJECTION: CT STATE PLANE
PROJECT NUMBER: 3616176064	

TITLE:

MECHANICAL DREDGE
OFF-SITE DISPOSAL
ALTERNATIVE 6

FIGURE NUMBER:

5-9

FILE: U:\- CAD Projects\USACE - SAEP\7.0 CAD\7.1 Design - Permitting\Sheets\Feasibility Study\FIG 5-1 thru 5-9_odd NOs_Staging Areas Map.dwg BY: benjamin.girardet DATE: 12 Mar 2018 - 5:46pm

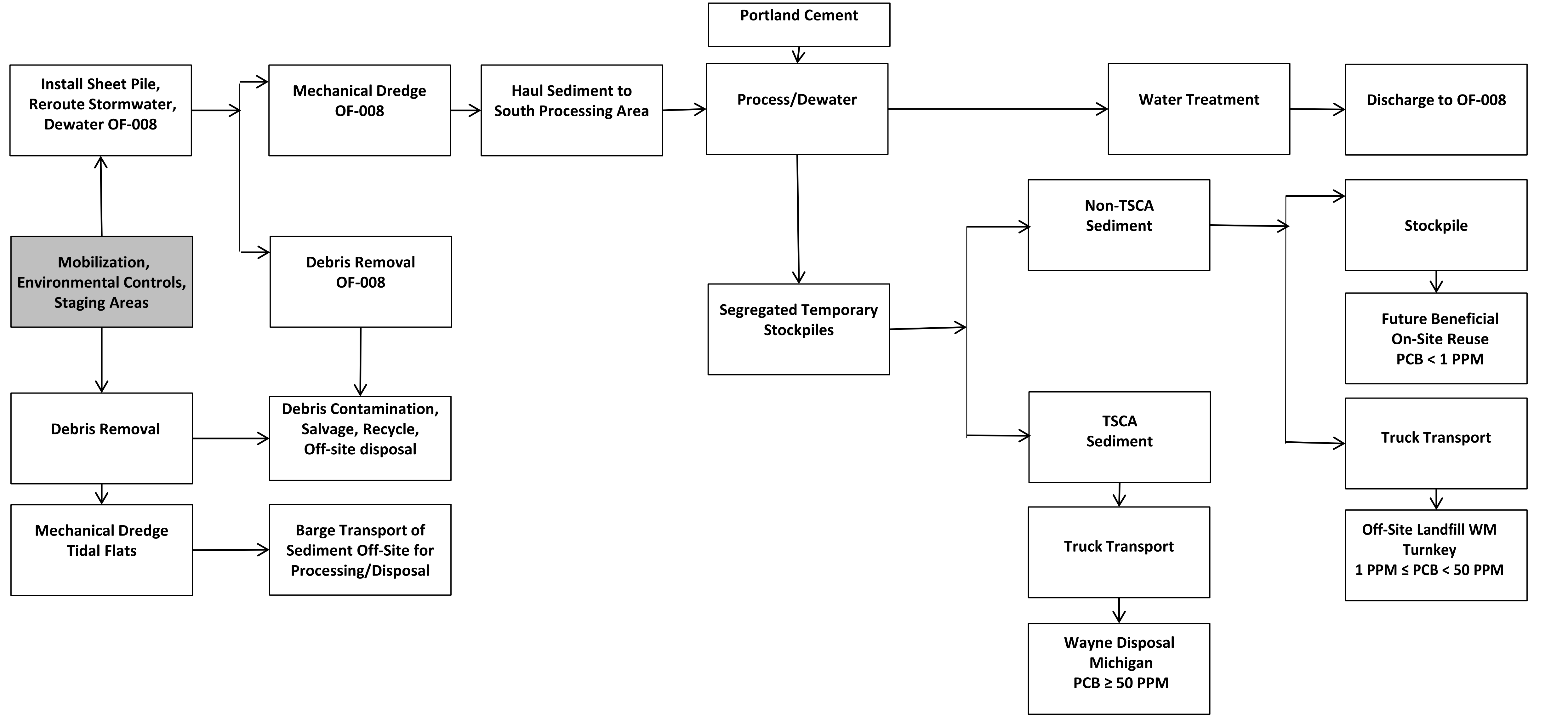

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Figure 5-10: General Process Diagram for Remedial Alternative 6
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut
February 2018

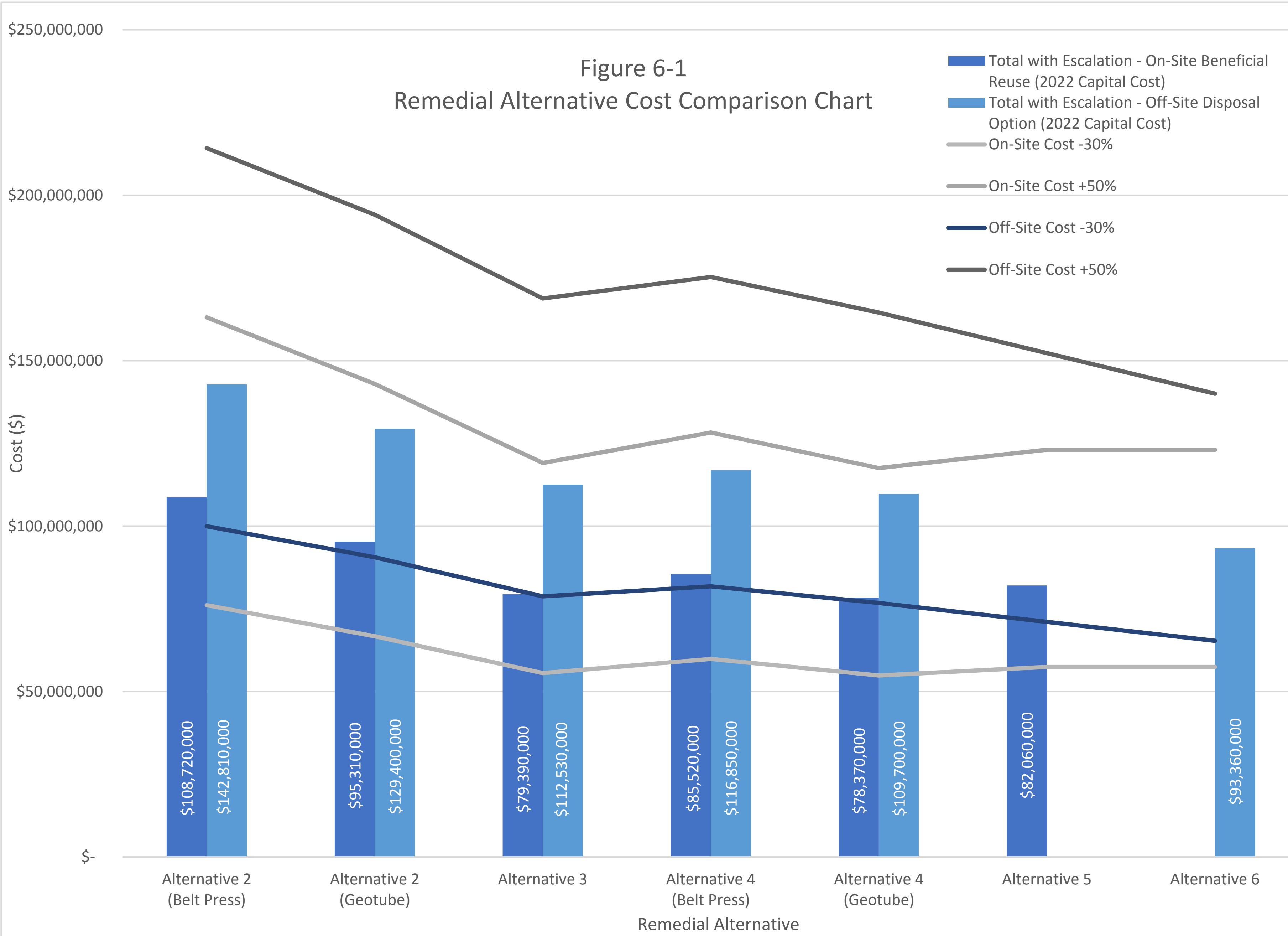
Figure 6-1
Remedial Alternative Cost Comparison Chart
Total with Escalation - On-Site Beneficial Reuse (2022 Capital Cost)
Total with Escalation - Off-Site Disposal Option (2022 Capital Cost)
On-Site Cost -30%
On-Site Cost +50%
Off-Site Cost -30%
Off-Site Cost +50%
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$-
Cost ($)
$108,720,000
$142,810,000
$95,310,000
$129,400,000
$79,390,000
$112,530,000
$85,520,000
$116,850,000
$78,370,000
$109,700,000
$82,060,000
$93,360,000
Alternative 2 (Belt Press)
Alternative 2 (Geotube)
Alternative 3
Alternative 4 (Belt Press)
Alternative 4 (Geotube)
Alternative 5
Alternative 6
Remedial Alternative

TABLES

Table 2-1
Applicable or Relevant and Appropriate Requirements
Stratford Army Engine Plant
Stratford, Connecticut

Regulatory Authority	Chemical, Action, or Location Specific	Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement	Applicable To Alternative
Federal	Action	The Resource Conservation and Recovery Act (RCRA) Subtitle C (Hazardous Waste), Section 268, Land Disposal Restriction	Relevant and Appropriate	The Resource Conservation and Recovery Act (RCRA) (42 U.S.C. §6901 et seq.) was established in 1976 to control non-hazardous and hazardous wastes, including the generation, transportation, treatment, storage and disposal of hazardous wastes. . The 1984 amendments to RCRA granted the U. S. Environmental Protection Agency (USEPA) expanded authority to require corrective action at permitted and non-permitted treatment, storage, and disposal facilities. Section 268 identifies hazardous wastes or other designated wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may continue to be land disposed	RCRA Subtitle C (hazardous waste) will apply to the generation, transportation, treatment, storage, and disposal of any hazardous wastes that are generated during the course of remedial activities. This includes managing hazardous wastes or other wastes that exhibit the toxicity characteristic for metals or contain PCBs on-site as well as off-site at treatment, storage, or disposal facilities. RCRA hazardous wastes include both listed (specific lists of wastes from non-specific sources, specific sources, and discarded commercial chemical products) and characteristic (toxic, ignitable, corrosive, or reactive, as determined through testing). Dredged material will need to be properly categorized according to RCRA requirements.	No hazardous wastes are anticipated. Applicable only to off-site disposal activities.
Federal	Action	RCRA Subtitle D (Non-Hazardous Waste), Sections 239: State Permit Program Determination of Adequacy and Section 258: Criteria for Municipal Solid Waste Landfills		RCRA Subtitle D specifies the requirements that state permit programs must meet to be determined adequate by the EPA under section 4005(c)(1)(C) of RCRA and the procedures EPA will follow in determining the adequacy of state permit programs to regulate and non-hazardous waste disposal facilities, including Municipal Solid Waste Landfills	RCRA Subtitle D applies to the regulation of the disposal of all non-hazardous solid waste generated from remediation activities, including the applicability of state agencies regulating and enforcing RCRA requirements. Waste materials (other than materials to be beneficially reused) will need to be disposed of at facilities properly permitted by the State under RCRA.	Applicable to off-site disposal activities

Regulatory Authority	Chemical, Action, or Location Specific	Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement	Applicable To Alternative
Federal	Action	The Clean Water Act (CWA) 33 U.S.C. §1251 et seq. (1972) CWA Section 404 Permit Program	Applicable	The Clean Water Act (CWA) (33 U.S.C. §1251 et seq.1972), establishes the regulatory structures controlling discharge of pollutants and regulation of water quality in surface waters of the U.S. Permitting actions under different sections of the CWA are implemented by different agencies and will be potentially applicable to the various remediation alternatives considered, and ultimately implemented, for the Housatonic River a designated navigable water of the U.S. The basic premise of the program is that no discharge of dredged or fill material may be permitted if: (1) a practicable alternative exists that is less damaging to the aquatic environment or (2) the nation's waters would be significantly degraded. Permits are required to demonstrate that impacts have been avoided to the maximum extent practicable:	Section 404 of the CWA establishes the permit program whereby USACE regulates the discharge of dredged or fill material into waters of the U.S. (including wetlands and other aquatic areas). USACE conducts a "public interest review" of proposed actions to evaluate the benefits of a proposed activity against its potential detrimental impacts. USACE must determine that an applicant has taken all appropriate and practicable steps, including evaluating alternatives, to avoid and minimize adverse impacts to waters of the United States, and that unavoidable impacts are appropriately mitigated, including compensatory mitigation where deemed necessary. The USACE New England District has issued a General Permit for the State of CT authorizing categories of activities in both inland and tidal waters which meet the conditions of the General Permit as either Category 1 (self-verification notification required) or Category 2 (application to and written approval from USACE required). Activities that do not meet the conditions of the General Permit Category 1 or 2 require an Individual Permit, including public notice and a public comment period. The USACE General Permit serves as authorization under Section 404 of the CWA, as well as authorization for regulated activities under Section 10 of the Rivers and Harbors Act of 1899 and Section 103 of the Marine Protection, Research and Sanctuaries Act (MPRSA). In addition, USACE requires and evaluates compliance with several other federal laws, including as applicable (but not necessarily limited to) Sections 401 and 402 of the CWA, Section 307(c) of the Coastal Zone Management Act, the National Historic Preservation Act, the Endangered Species Act, the Fish and Wildlife Act, the Marine Mammal Protection Act, the Magnuson-Stevens Act and the Wild and Scenic Rivers Act, as well as applicable Executive Orders. Remediation activities requiring either dredge or fill activities in the Housatonic River will require authorization from USACE under Section 404 of the CWA. The level of permit required will depend on the regulated remedial alternative selected. Substantive requirements cover dewatering, barge transportation, disposal of dredged sediment, and discharge of treated waters back to the Housatonic.	All alternatives will meet the definition of discharging dredged or fill material into waters of the U.S.

Regulatory Authority	Chemical, Action, or Location Specific	Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement	Applicable To Alternative
Federal	Action	The Clean Water Act (CWA) 33 U.S.C. §1251 et seq. (1972) CWA Section 401 Certification		Section 401 of the CWA requires that any activity requiring a federal license or permit, which may result in any discharge into waters of the U.S., receive certification from the state in which it is to be located that such discharge will comply with applicable water quality standards. This certification is known as a Water Quality Certificate (WQC), and is issued by the appropriate state authority.	Under Section 401, a federal agency cannot issue a permit or license for an activity that may result in a discharge to waters of the U.S. until the state (or tribe) where the discharge would originate has granted or waived Section 401 certification. Granting certification, with or without conditions, allows the federal permit or license to be issued consistent with any conditions of the certification. States (and Tribes) make their decisions to deny, certify, or condition permits or licenses based in part on the proposed project's compliance with EPA-approved water quality standards and whether the activity leading to the discharge will comply with any applicable effluent limitations guidelines, new source performance standards, toxic pollutant restrictions, and other appropriate requirements of state or tribal law.	All alternatives will require Water Quality Certification substantive compliance
Federal	Action	The Clean Water Act (CWA) 33 U.S.C. §1251 et seq. (1972) CWA Section 402 National Pollutant Discharge Elimination System Program		Section 402 of the CWA establishes the National Pollutant Discharge Elimination System (NPDES) Program, which requires a permit for discharge of any pollutant to waters of the U.S. Discharges requiring permits include industrial, municipal, agricultural, stormwater, and commercial vessel wastewaters. The state of CT has permitting authority under the NPDES Program and issues general and individual permits through CTDEEP.	Under Section 402, stormwater discharge activities require compliance with state and federal NPDES regulations. A permit will be required from CT DEEP for applicable discharges. All substantive requirements will be met.	All alternatives have the potential to release stormwater into local surface waters and will comply with substance requirements
State	Location	Connecticut Coastal Management Act (CCMA) (P.A. 78-15, 1979, as amended) Section 22a – 94 through 100 and Section 22a - 361	Applicable	Coastal management in Connecticut is administered by the Department of Energy and Environmental Protection (DEEP) and is approved by NOAA (National Oceanic and Atmospheric Administration) under the federal Coastal Zone Management Act. Under the statutory umbrella of the Connecticut Coastal Management Act (CCMA), enacted in 1980, DEEP regulates work in tidal, coastal and navigable waters and tidal wetlands.	Section 22a 94 through 100 regulates coastal area remediation activities that will need to undergo federal consistency review relative to the CT program. The standards and criteria of various enumerated state environmental permitting and licensing laws and regulations ("core laws") serve as the enforceable policies of the CT Coastal Program. Thus, approval of state permits required to be obtained by a core law require the State's consistency concurrence. Sec. 22a-36 covers permits for dredging, structures, placement of fill, obstruction or encroachment, or mooring area or facility. Activities require the submittal of an application to DEEP for applicable work. Applicants must agree to carry out any conditions necessary to the implementation of such certificate or permit.	All

Table 2-1
Applicable or Relevant and Appropriate Requirements
Stratford Army Engine Plant
Stratford, Connecticut

Regulatory Authority	Chemical, Action, or Location Specific	Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement	Applicable To Alternative
State	Chemical	Remediation Standard Regulations RCSA §22a--133k-2 (c) (all); especially Polluted Soil definitions and requirement; Appendix B Pollutant Mobility criteria	Relevant and Appropriate	These regulations were adopted on January 30, 1996 and amended on June 27, 2013, under the statutory authority provided by CGS §22a-133k. They provide specific numeric cleanup criteria for a wide variety of contaminants in soil, ground water, surface water and soil vapor. Copies of the regulation are available from http://eregulations.ct.gov/eRegsPortal/Browse/RCSA/%7BEAD3787B-7651-4803-8239-CCD2B569E8A0%7D DEEP web page with associated information is http://www.ct.gov/deep/cwp/view.asp?a=2715&q=325012&deepNav_GID=1626	Sediments placed on land at the site will meet CT RSRs for leaching to groundwater. Placement of sediment on land will follow the requirements for placing "polluted soil" on land, including meeting SPLP standards, required separation from the groundwater table, and engineering controls.	Relevant to any alternative where processed sediments are placed on land at the site.
State	Action	Connecticut Water Quality Standards CGS §22a-426 RCSA §22a-426-4 (Surface Waters), 22a-426-8 (Antidegradation Standards) and 22-426-9 (Environmental Criteria)	Potentially Applicable	Connecticut's Water Quality Standards Regulations were initially adopted effective October 10, 2013 (last updated 11/21/2015), superseding earlier WQS adopted under the statute but not in the same regulatory form. They establish specific numeric criteria, designated uses, and antidegradation policies for groundwater and surface water. Statute available at https://www.cga.ct.gov/current/pub/chap_446k.htm#sec_22a-426. A summary of the WQS is available from DEEP's website at http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325618&deepNav_GID=1654.	Discharges to Housatonic River will meet the substantive requirements for surface water discharges, antidegradation standards, and environmental criteria.	All alternatives impact surface waters through dredging, filling, and discharging.
State	Action	Hazardous Waste Management: Generator Standards RCSA §22a-449(c)102	Potentially applicable	This section establishes standards for various classes of generators. The standards of 40 CFR §262 are incorporated by reference. Storage requirements given at 40 CFR §265.15 are also included. Current regulations are available at http://eregulations.ct.gov/eRegsPortal/Browse/RCSA?id=Title%2022a|22a-449%28c%29|22a-449c-102|22a-449c-102	Waste stored at the site will be stored in accordance with these requirements.	Potentially all alternatives.
State	Action	Hazardous Waste Management: Land Disposal Restrictions RCSA §22a-449(c)108(a)(2)(V)	Potentially applicable	This section incorporates by reference the Federal Land Disposal Restrictions given at 40 CFR §268. See http://eregulations.ct.gov/eRegsPortal/Browse/RCSA?id=Title%2022a|22a-449%28c%29|22a-449c-108|22a-449c-108	If applicable, land disposal restrictions will be followed.	Potentially all alternatives.

Regulatory Authority	Chemical, Action, or Location Specific	Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement	Applicable To Alternative
State	Action	Disposition of PCBs CGS §§22a-463 through 469. Disposition of PCB regulated by §22a-467	Potentially applicable – depending on alternatives analyzed.	This section requires that PCBs be disposed under a permit issued by the Commissioner. PCBs may also be disposed of under a written approval of the Commissioner in a manner which results in the destruction of the PCB or in a manner not inconsistent with the Requirements of the Toxic Substances Control Act (TSCA), listed at 40CFR §761. This section of the Statutes is available at https://www.cga.ct.gov/current/pub/chap_446k.htm#sec_22a-463	PCBs will be disposed of in accordance with state and federal regulations (TSCA). PCBs between 1 and 50 mg/kg and PCBs > 50 mg/kg will be segregated for proper disposal apart from sediments containing <1 mg/kg PCBs	All removal alternatives.
State	Chemical	Air Pollution Control Control of Organic Compound Emissions RCSA §22a-174-20	Potentially relevant and appropriate.	This section regulates volatile organic compounds. Subsection (f) sets limits for emission of organic solvents. See http://eregulations.ct.gov/eRegsPortal/Browse/RCSA?id=Title%2022a|22a-174|22a-174-20|22a-174-20	Although not anticipated, any emissions of organic solvents exceeding thresholds will be properly controlled and/or treated. Will need to be evaluated at design and implementation stage depending on exact processes to be used.	Potentially all.
State	Action	Regulation of Dredging and Erection of Structures and Placement of Fill in Tidal, Coastal, or Navigable Waters CGS §§22a-361	Potential ARAR – depending on alternatives analyzed.	These statutes regulate dredging, the erection of structures and placement of fill in tidal, coastal or navigable waters waterward of the high tide line. Section 361 Restricts dredging, erecting any structure, placing any fill, obstructing or encroaching or carrying out any work incidental to these activities, in the tidal, coastal or navigable waters of the state waterward of the coastal jurisdiction line until such person, firm or corporation has submitted an application and has secured from DEEP a certificate or permit for such work and has agreed to carry out any conditions necessary to the implementation of such certificate or permit.	Dredging and capping work will following substantive requirements.	All
State	Action	Tidal Wetlands Statutes CGS §§22a-32	Potential ARAR	These statutes regulate activities within tidal wetlands. Sec. 22a-32. Regulates work in tidal wetlands and states that "No regulated activity shall be conducted upon any wetland without a permit. Any person proposing to conduct or cause to be conducted a regulated activity upon any wetland shall file an application for a permit with the commissioner, in such form and with such information as the commissioner may prescribe".	Substantive requirements will be met.	All

Regulatory Authority	Chemical, Action, or Location Specific	Requirement	Status	Requirement Synopsis	Action To Be Taken To Attain Requirement	Applicable To Alternative
State	Location	Standards for flow of water in rivers or streams RCSA §§ 26-141b-4	To be considered	These statutes provide for establishment of standards for flow of water in rivers or streams and regulations to implement these standards. Section 26-141(b)-4 establishes streamflow standards and regulations for various classes of rivers and stream segments. See the statutes at: Stream Flow Standards and Regulations are at https://eregulations.ct.gov/eRegsPortal/Browse/RCSA/%7B95FC4BE3-B209-4B6B-B103-E54948C7AC1C%7D General information can be found at http://www.ct.gov/deep/cwp/view.asp?a=2719&q=434018&deepNav_GID=1654	Substantive requirements will be met.	All
State	Action	Air Pollution Control Control of Odors RCSA §22a-174-23	Relevant and Appropriate	No person shall cause or permit the emission of any substance or combination of substances which creates or contributes to an odor, in the ambient air, that constitutes a nuisance. Air Pollution Control, Control of Odors can be found at: http://www.ct.gov/deep/lib/deep/air/regulations/mainregs/sec23.pdf	If applicable, odor control will be implemented.	Relevant to any alternative where sediments are processed and/or placed on land at the site.
Federal	Chemical	Toxic Substances Control Act (TSCA) PCB Remediation Wastes 40 CFR 761.61, 761.79	To be considered	Identifies storage, disposal, and decontamination requirements for various PCB waste types and specifies requirements for PCB remediation waste. PCB remediation waste is defined as waste containing PCBs as a result of a spill, release, or other unauthorized disposal at the following concentrations: • Materials disposed of prior to April 18, 1978, that are currently at concentrations > 50 ppm PCB, regardless of the concentrations of the original spill; • Materials currently at any volume or concentration where the original source was >500 ppm PCB beginning on April 18, 1978, or > 50 ppm PCB beginning on July 2, 1979; and • Materials currently at any concentration if the PCBs are from a source not authorized for use. Dredged materials are specifically regulated.	Dredged materials will be managed as PCB remediation wastes based on the concentrations at which the PCBs are found, as opposed to their original concentration. Requires coordination with USEPA TSCA Regional coordination per guidance to determine applicability and path forward.	All

Notes/Abbreviations:

ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
RSR = Remediation Standard Regulations
TSCA = Toxic Substances Control Act
PCBs = Polychlorinated Biphenyls

Prepared by: TD 1/28/18
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Table 2-2
Tidal Flat Remediation Area and Neat Volume Summary [1]
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Removal Depth (ft)	Non-TSCA Removal Area (ft^2) (Beneficial On-Site Reuse)	Non-TSCA Removal Volume (cy) (Beneficial On-Site Reuse)	TSCA Removal Area (ft^2) 1 ppm ≤ PCB < 50 ppm (RCRA D Disposal)	TSCA Removal Volume (cy) 1 ppm ≤ PCB < 50 ppm (RCRA D Disposal)	TSCA Removal Area (ft^2) 50 ppm ≤ PCB (TSCA Disposal)	TSCA Removal Volume (cy) 50 ppm ≤ PCB (TSCA Disposal)
0-1	1,852,623	68,616	106,704	3,952	6,561	243
1-2	1,131,691	41,914	8,416	312	3,141	116
2-3	277,615	10,282	110,726	4,101	0	0
3-4	267,404	9,904	3,499	130	0	0
Total	**-**	**130,487**	**-**	**8,495**	**-**	**359**

[1] Area and Volumes provided are in-place calculations and do not account for over dredge, side slopes, bulking or other factors that may increase the area or volume to be remediated.

Table 2-3
OF-008 Remediation Area and Neat Volume Summary [1]
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Removal Depth (ft)	Non-TSCA Removal Area (ft^2) (Beneficial On-Site Reuse)	Non-TSCA Removal Volume (cy) (Beneficial On-Site Reuse)	TSCA Removal Area (ft^2) 1 ppm ≤ PCB < 50 ppm (RCRA D Disposal)	TSCA Removal Volume (cy) 1 ppm ≤ PCB < 50 ppm (RCRA D Disposal)
0-1	33,024	1,225	0	0
1-2	33,024	1,225	0	0
2-3	17,741	660	15,283	565
3-4	18,468	685	14,556	540
Total	**-**	**3,795**	**-**	**1,105**

[1] Area and Volumes provided are in-place calculations and do not account for over dredge, side slopes, bulking or other factors that may increase the area or volume to be remediated.

Table 3-1
General Response Action Screening
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

General Response Action	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
					Tidal Flats	OF-008 Drainage Ditch	
INSTITUTIONAL CONTROLS	Physical or administrative restrictions designed to prevent exposure to impacted sediment	**Limited Effectiveness**. Can be a useful tool to educate the public about the Site, however with future development requirements, future access restrictions, easements, covenants and regulatory restrictions cannot be enforced. Not effective for reducing ecological risks.	**Variable Difficulty.** It can be easy to implement educational programs however it would be difficult to enforce land use restrictions with future development needs.	Low	No	No	Sediment removal is required, therefore, screened out except as a necessary ancillary component of remedial alternatives.
MONITORED NATURAL RECOVERY	Allowing ongoing, naturally-occurring processes (reduction through deposition of incoming "cleaner" sediment, and/or dilution) to reduce constituent concentrations in sediment. Includes long-term monitoring to document decline in constituent concentrations.	**Effective.** Likely would be effective in the long term. Not effective in the short term. Time for Site to meet remedial goals unknown but estimated to be on the order of 20 to 80 years.	**Low Difficulty.**	Low	No	No	Will not meet RAOs in a reasonable time frame. Long term monitoring required to document recovery.
CONTAINMENT	Containment is accomplished by placing clean material over sediment within the areas of concern. Placement thicknesses vary and materials can range from silty sand to gravel. The containment cap may include multiple layers of various materials including armoring materials such as rip rap, a chemical isolation layer, and a chemical treatment layer to treat dissolved and/or migrating site contaminants. Cap materials would be selected to prevent erosion of underlying contaminated sediment and include a habitat, or bioactive, zone as well as armoring to keep cap materials in place. Delivery methods could include mechanical or hydraulic methods.	**Effective.** A cap would provide immediate isolation of contaminated sediment and prevent resuspension of contaminated bottom sediment. Treatability and engineering studies would be required during design phase to determine optimum cap material(s) and thicknesses. Cap thickness would need to be constructed in a manner to allow for boat traffic with possible access restrictions. Bench- or pilot-scale studies may be required to determine the effectiveness of different capping materials, cap placement, and construction. Flux of dissolved phase constituents to the tidal flats is not a concern at this Site.	**Moderate Difficulty.** Requires specialized equipment to place cap material. Could require several "lifts" or application of one layer at a time. May require construction of staging areas and access roads. Water level that varies may make application more difficult, depending on application method and variation in water levels. Containment without dredging will raise bottom bathymetry. Capping design can be complicated.	Moderate	No	No	Containment as a remedy that leaves behind contamination has been eliminated from further consideration. Straight backfill of removal areas will be a necessary component for inclusion in removal alternatives.

General Response Action	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
					Tidal Flats	OF-008 Drainage Ditch	
IN-SITU TREATMENT	Placement of a substrate, such as activated carbon or other specialized media, to reduce bioavailability of site contaminants.	**Variable Effectiveness.** Reduces exposure/bioavailability of contaminants to benthic organisms. Has been demonstrated for PCBs and some metals; however, effectiveness is not known for all contaminants. Amended sediment may not be good substrate for benthic organisms. Bench and pilot studies may be needed to appropriately design a remedy.	**Moderate Difficulty.** Easily implemented within the tidal flats and drainage ditch; however, repeated applications may be needed over a long period of time.	Moderate	No	No	Site contaminants would not be removed. Effectiveness at reducing bioavailabiity is uncertain for all contaminants. Doesn't address risk to benthic organisms.
REMOVAL	Physical removal of contaminated material including hydraulic and mechanical dredges, traditional excavator, cranes, and amphibious/multipurpose dredges. Typical controls may be required for all removal technologies to reduce impacts on water quality, marine plants, and species. Controls may include various types of resuspension controls and fish exclusion barriers.	**Effective.** Using appropriate technology, can effectively reduce the volume of contaminated sediment with precise GPS assisted removal.	**Moderate- High Difficulty.** Typically requires construction of supporting infrastructure such as access roads, staging areas, piping, and offloading facilities for dredged sediment. Requires engineering controls to reduce impacts of suspended sediments. Sediment dewatering and water treatment are typically required. Disposal or re-use of sediment is an important consideration.	Moderate-High	Yes	Yes	Proven technology for sediment removal
MATERIAL TRANSPORT	Required to move the removed sediment from the water to land for processing and disposal or reuse. Material is loaded to a barge or scow by mechanical methods, conveyed through a pipeline hydraulically or pneumatically, and/or directly placed in trucks for transport. The barge or scow is maneuvered using tug and/or push boats to the transloading area. Requires landside bulkhead, pier or wharf for barge docking and off-loading.	**Effective.** Very effective in areas with space and adequate draft. Methods are proven and well-established.	**Moderate Difficulty.** Can be implemented with various removal technologies to transfer removed sediments. Barge/scow limited by water depth and landside access. Multiple logistical concerns based on-site access and productivities	Moderate-High	Yes	Yes	Universal transportation methods for sediment removal projects.

Table 3-1
General Response Action Screening
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

General Response Action	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
					Tidal Flats	OF-008 Drainage Ditch	
MATERIAL DEWATERING AND PROCESSING	Multiple process options are available to dewater sediment, treat wastewater, and process sediment. Water treatment options include pH adjustment, flocculants, settling, clarification, carbon adsorption. Dewatering options include gravity dewatering, Geotubes, belt press, plate and frame press and others.	**Effective.** These technologies are proven and widely available to process sediment and wastewater prior to discharge. Bench-scale studies are typically required to determine which process options best meet project objectives including discharge criteria and disposal objectives.	**Variable Difficulty**. Will depend on the dredge method selected. Size of treatment systems dictated by volume of water, throughput, and complexity of needed processing systems. Various options for solidification are available. Permit discharge requirements will determine the treatment processes necessary prior to discharge. Water treatment systems can be land-based or barge-based. Discharge may be to local POTW or back to site surface waters. Stabilization technologies are generally easily implemented.	Low-High	Yes	Yes	Required for any option that includes sediment removal
DISPOSAL, RE-USE, AND PLACEMENT	Disposal of excavated material at a permitted landfill or appropriate re-use on-or off-site following implementation of removal options identified above. Removed material that meets beneficial reuse limitations (both chemical and physical) can be transported to pre-approved locations for re-use rather than disposal or placed and managed on-site as fill material to be used in future development. Examples of off-site beneficial reuse include landfill daily cover or roadway base, mine reclamation, or other impaired site fill. Off-site disposal includes both TSCA and non-TSCA landfills based upon PCB concentrations in sediments. Also includes placement of sediments within a confined disposal facility (CDF) or confined aquatic disposal (CAD) cell.	**Effective.** An effective use of treated sediment. Sediments re-used on-site would need to meet SPLP standards. Landfill technology is effective at eliminating exposure to contaminated sediment and controlling any leachate generated. CAD and CDF technologies can be very effective when properly designed and implemented.	**Low-High Difficulty.** Would likely require physical conditioning in the form of dewatering and drying and addition of amendments such as lime or Portland cement to meet physical acceptance criteria either on-site or off-site. Off-site disposal requires extensive waste characterization sampling. CDF Implementability can be difficult due to encroachment into waterways. CAD cells can be difficult to implement due to public perception, extension coordination among agencies, and identifying a suitable location.	Low-moderate	Yes	Yes	Necessary options for disposition of removed sediment.

General Response Action	Description	Effectiveness	Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
					Tidal Flats	OF-008 Drainage Ditch	
HABITAT RESTORATION	Activities completed to mitigate short-term impacts of remedial actions to local habitat. Re-establish stable cross section following remediation. Reestablish trees, shrubs, forbes, grasses and sedges depending on the ecological zone and restoration objectives. May include invasive species management.	**Moderately Effective.** Habitat restoration is a proven, documented practice; however, monitoring and maintenance is required to ensure success. Must be designed and installed by qualified, experienced personnel.	**Moderate Difficulty.** Can require significant coordination and planning with agencies.	Moderate	No	Yes	Necessary for the OF-008 drainage ditch.

Table 3-2
Initial Technology Screening
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
						Tidal Flats	OF-008 Drainage Ditch	
REMOVAL Physical excavation and disposal on- or off-site of contaminated material. Typical controls may be required for all removal technologies to reduce impacts on water quality, marine plants, and species. Controls may include various types of resuspension controls and fish exclusion barriers.	**Mechanical Dredging**	Stationary dredgers that mechanically remove sediment from areas of concern. Equipment available with a variety of different dredging heads. Removed material is placed onto the back of the barge or an adjacent barge.	**Variable Effectiveness.** Effectively reduces the volume of contaminated sediment with precise GPS assisted removal. Overall effectiveness will be determined by contaminant delineation and removal.	**Moderate-High Difficulty.** May require construction of access roads, staging areas, and offloading facilities for dredged sediment. Requires engineering controls to prevent resuspension. Requires engineering controls to reduce impacts of suspended sediments as well as water treatment or disposal of dredge water.	High	Yes	No	Good technology for most sediment types and Sites with sediments that may generate sheen when agitated. Generally a slower removal method than hydraulic.
	Debris and Large Material Removal	Prior to dredging, sediments are sifted to remove debris and large objects from the dredge prism. This step allows material to be hydraulically dredged and turned into a slurry for hydraulic pumping through a pipeline of designed length to landside processing areas	**Limited Effectiveness.** Allows for areas with debris or other factors limiting hydraulic dredging to be hydraulically processed.	**Moderate-High Difficulty.** Requires additional equipment to be staged and assembled to allow for material screening. Operation would likely be in place and used in combination with hydraulic dredging or mechanical dredging with hydraulic transfer.	Moderate	Yes	No	May require pilot tests to determine site-specific and setting-specific effectiveness. Applicable to Tidal Flats; however, debris is not a major concern.
	Hydraulic Dredging	Stationary dredger that hydraulically remove sediment from areas of concern by means of loosening and disintegrating the bottom material into particle sizes compatible with a high velocity suction intake. The removed sediment is transported as a slurry through a pile line of designed length to the deposit area. The deposit area may be a barge, Geotube, or a confined disposal facility	**Variable Effectiveness.** Effectively reduces the volume of contaminated sediment. Overall effectives will be determined by contaminant delineation and removal.	**Moderate-High Difficulty.** May require construction of access roads, staging areas, pipelines, and offloading facilities for dredged sediment. Requires engineering controls to reduce impacts of suspended sediments as well as water treatment or disposal of dredge water.	High	Yes	No	Hydraulic dredging may be difficult in sensitive environments at Sites with sediments that may generate sheen when agitated. Good for fine loose sediments with a high water content. Difficult technology to be used in areas with debris and hard sediments or clays. Generally a faster removal technology than mechanical but requires a larger processing area for dewatering.
	Mechanical Excavation in the Dry	Traditional excavation of sediment “in the dry,” relying on other technologies (or at low tide only) to allow this technique. Standard reach or long-reach excavation equipment can be staged along shoreline, or placed within dewatered area with or without access roads to remove sediments for placement into trucks for hauling to the site.	**Variable.** Allows more controlled removal with increased visibility of sediment and operations at opposite ends of the tidal cycle. Reduces water treatment and sediment processing required. Softness of sediment makes placing standard equipment on Tidal Flats ineffective.	**Moderate-High Difficulty.** Excavation equipment is well-established and available. Must be carefully coordinated with tidal cycles, dewatering efforts. Logistics can be challenging; therefore, experienced contractors are needed to implement in areas requiring significant water control challenges. More difficult in deep water, tidal, high current conditions, or soft sediment situations.	Moderate-High	Yes (perimeter only)	Yes	Tidal Flats have vast open area and sediments are soft, making excavation in this manner impractical. Applicable to perimeter of Tidal Flats with long-reach excavator OF-008 easier to isolate and dewater at the mouth of the drainage ditch and at OF-008. Standard excavation is feasible.

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
						Tidal Flats	OF-008 Drainage Ditch	
	Amphibious Dredge	Dredging equipment designed to handle a wide variety of site conditions. Units can include both mechanical excavation and hydraulic excavation tooling, and can operate as floating plant or on sediment surface. "Swamp buggy" equipment is traditional excavation equipment with very large tracks with very low ground pressures and can even float. Amphibex manufactures dredges that can operate in hydraulic or mechanical mode.	**Variable Effectiveness.** Ideal for tidal cycle fluctuation work. Works in a variety of environments. May cause excessive turbidity generated due to disturbance of sediment surface by equipment operation.	**High Difficulty.** Potential concerns with Jones Act compliance (Amphibex); however, equipment with U.S. constructed hulls can be provided but may have long lead time. Marsh buggy equipment generally available.	High	Yes	No	Potential applicability to Tidal Fats given its ability to work around the tidal cycle.
	Temporary Dams	Temporary dam technologies to support mechanical dredging or traditional excavation "in the dry" include: **Aqua-Barrier:** Portable, water-inflated temporary dam designed for dewatering the dammed area to support dry excavation within waterways. **Porta dam:** Constructed of steel supports and poly-tarping Porta dam creates a temporary diversion for water to support dry excavation within waterways. **Sheet Piling:** Steel or plastic sheet piling is used to create a physical barrier around the desired construction area designed to limit waters from entering and/or for dewatering the dammed area to support dry excavation within waterways. **Muscle Wall:** Light weight barriers constructed of low density polyethylene are used to support containment. **Earthen Berms:** Barriers constructed of impermeable or semi-impermeable soil materials to create an embankment allowing control of water levels.	**Variable Effectiveness.** Allows for excavation "in the dry" improving the ability to more accurately remove sediments with less over dredge. Can increase work hours available. Reduces water treatment and sediment processing requirements. These systems, with the exception of sheet piling may have limited effectiveness given water depths at high tides.	**Moderate-High Difficulty.** Can be implemented in combination with excavation and removal technologies to isolate saturated soils. More difficult in deep water, tidal or high current conditions. Challenging to implement adjacent to existing breakwater.	Moderate-High	Yes (only sheet pile)	Yes	Tidal Flats have vast open area and difficult to fully dewater and isolate from the river. Sheet pile only retained for Tidal Flats Various technologies have applicability for OF-008, for cut off of mouth of the drainage ditch, excavation cell isolation, inlet control, and adjacent runway ditch control.

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
						Tidal Flats	OF-008 Drainage Ditch	
	Other Engineering Controls (Turbidity Control/ Fish Barriers)	Barriers (silt curtains and sheet pile cofferdams) to prevent or reduce the migration of re-suspended sediment that can cause exceedance of turbidity monitoring requirements. Fish barriers prevent species of concern from entering work area.	**Variable Effectiveness.** Turbidity barriers must be selected and installed carefully to be fully effective given waterway and sediment characteristics (water depth, current, tidal cycle, sediment fines). A sheet pile cofferdam would eliminate migration of resuspended sediments. Proper design would ensure complete enclosure of area. Sheet pile cofferdam would allow for the possibility of 24/7, 365 days per year operation. Fish barriers are effective if properly sized, engineered for strength, and anchored.	**Variable Difficulty.** Silt curtains are easily installed and maintained (requires knowledgeable contractors) and require straightforward design. A sheet pile cofferdam requires significant engineering, coordination with agencies, and requires specialty marine contractors to install. May add significant time to schedule before dredging can begin. Significant challenges installing near existing breakwater. Relatively easily to install fish barriers, but must be maintained. Fish within Outfall 008 drainage ditch may need to be "relocated" prior to dewatering.	Low-Very High	Yes	No	Both turbidity barrier methods and fish barriers are applicable to Tidal Flats work. Not applicable to Outfall 008 if work done "in the dry."
MATERIAL TRANSPORT Required to move the removed sediment from the water to land for processing and disposal.	**Barge/Scow**	Material is loaded to a barge or scow by hydraulic or mechanical methods. The barge or scow is maneuvered using tug and/or push boats to the deposit area. Requires landside bulkhead, pier or wharf for barge docking and off-loading.	**Effective.** Very effective in areas with space and adequate draft. Coupled with tug/push boats, has potential to generate resuspended sediments due to propulsion and draft.	**Moderate Difficulty.** Can be implemented with various removal technologies to transfer removed sediments. Barge/scow limited by water depth and landside access.	Moderate-High	Yes	No	Universal transportation method for mechanical dredge projects. Geotubes may be placed inside barges/scows in combination with a barge based water treatment system for hydraulic dredging.
	Pneumatic Flow Tube Mixing (PFTM)	Dredged materials are placed into a hopper barge, then run through a metered pugmill which feeds material into a pipeline which is then conveyed in "slugs" via pneumatic pumping. Stabilization agents (e.g. Portland Cement) are mixed in-line to create a material which, when discharged, can be beneficially reused as a soil-like product.	**Effective.** Effective with evenly graded sediments and adequate upland space for discharge/disposal.	**Moderate-High Difficulty.** Pipelines can be assembled at various lengths and can be floated on the surface of the water or be run over land to the deposit area. Requires specialized pump equipment and maintenance.	High	Yes	No	PTFM can be very effective at moving dredged sediment and eliminating the need for dewatering and processing.

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
						Tidal Flats	OF-008 Drainage Ditch	
	Hydraulic	Material is transported as a slurry from the dredge area through a pipe line of designed length to the deposit area. Requires slurry to have low percent solids for pumping.	**Effective.** Very effective at moving slurries of sediment less than ½ inch in diameter and free of debris.	**Moderate-High Difficulty.** Pipelines can be assembled at various lengths and can be floated on the surface of the water or be run over land to the deposit area. Will require additional material processing if dredging mechanically to make the dredged material into a slurry. May require extensive water treatment.	High	Yes	No	Universal transportation method for hydraulic dredge projects. Can be coupled with mechanical dredging by placement of dredged sediments in a slurry box, and transforming into a slurry and conveyed to land.
	Trucks	Material is mechanically loaded to trucks and driven to deposit area. Requires sediment to have relatively low water content.	**Variable Effectiveness.** Effective in areas close to land not requiring trucks to enter public roadways unless the material is free of liquids.	**Variable Difficulty.** Limited capacity per truck requiring multiple trucks. Not suitable for hydraulic removal methods. Most areas of the site are not adjacent to land eliminating this technology. In areas where trucks can be accessed by mechanical equipment, this technology may be acceptable.	Moderate-High	Yes	Yes	Potentially useful if performing mechanical excavation in the dry using excavation support and in intertidal areas with longer periods of exposure if mechanically removing in the dry during tidal cycles.
MATERIAL DEWATERING AND PROCESSING	**Gravity Dewatering**	Dewatering method where sediment is transported to land and placed in a sediment dewatering area to allow water to be removed through evaporation, and gravity draining with collection and treatment.	**Limited Effectiveness.** Highly effective and relatively quick for coarse grained material. Fine or well graded materials may retain water for longer periods of time reducing effectiveness and requiring additional space for large operations.	**Easy-Moderate Difficulty.** Requires staging areas and space. Dewatering time will vary depending on material properties.	Low	Yes	Yes	Simple to implement. May require additional tests to determine site-specific and setting-specific effectiveness.
	Material Screening and Size Separation	Slurried sediment is passed through a series of screens, augers, etc. to separate coarse material and debris from the fine material to allow for mechanical dewatering of the dredge slurry.	**Limited Effectiveness.** Pilot-testing is likely required. Allows for slurry to be mechanically dewatered.	**Moderate-High Difficulty.** Requires additional equipment to be staged and assembled to allow for material screening prior to mechanical dewatering. Equipment can become bridged or jammed and requires maintenance. Operation would be used in combination with hydraulic transfer.	Moderate	Yes	No	May require pilot tests to determine site-specific and setting-specific effectiveness.

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
						Tidal Flats	OF-008 Drainage Ditch	
	Belt Press	Continuous dewatering devices that rely on confining (squeezing) the sediment in between two polymer mesh tensioned belts, allowing the pressate to seep through the fabric. The belt press can produce dewatered materials at 35-55% solids at 125 psi operating pressure with properly conditioned incoming slurry.	**Effective.** Requires material to be hydraulically dredged or hydraulically transferred. Requires desanding and processing of dredged slurry prior to dewatering.	**Moderate Difficulty.** Can be implemented with various removal technologies. May require extensive water treatment. May require use of polymers to enhance filtration.	Moderate-High	Yes	No	Can be used with for all dredging technologies, however, additional processing is required to hydraulically slurry mechanically dredged sediment. Can required a large space for laydown and be a slow process.
	Recessed Chamber Filter Press	Dewatering devices that rely on confining the slurry within a series of steel or rigid composite plates with the filter media stretched across the plate frame. The sediment particulate coats the media and the filtrate passes into the plate and is drained through channels in the press. As a result of the rigid frame, the press can operate at higher pressures (up to 225 psi), which produces dewatered sediments in excess of 60% solids.	**Effective.** Requires material to be hydraulically dredged or hydraulically transferred. Requires desanding and processing of dredged slurry prior to dewatering.	**Moderate Difficulty.** Can be implemented with various removal technologies. May require extensive water treatment. May require use of polymers to enhance filtration.	Moderate-High	Yes	Yes	Can be used with for all dredging technologies, however, additional processing is required to hydraulically slurry mechanically dredged sediment. Can required a large space for laydown and be a slow process.
	Centrifuge	Slurry is spun at high rpms to separate solids from water	**Effective.** Uses centrifugal forces to separate particles from water.	**Moderate-High Difficulty.** Complex machines that can be difficult to operate. May require use of polymers to enhance separation.	High	Yes	No	Included for evaluation in treatability studies
	Proprietary Mechanical Dewatering Systems	Commercially available complete dewatering systems for sediment, including Genesis Rapid Dewatering System, Hi-G screening, and TCW 3000 Plus.	**Effective.** Used in other industries and adapted to sediments dewatering. Combines various technologies into complete system.	**Moderate-High Difficulty.** Dewatering is complex and use of these proprietary systems depends on contractor familiarity. May require use of polymers to enhance filtration.	High	Yes	No	Retained Hi-G screening as representative technology only.
	Geotubes	Continuous dewatering device that relies on pumping of the dredged slurry into large tubes (up to 200 feet long, up to 60 feet in circumference) of woven geotextile fabric. The fabric retains the sediment particles allowing the filtrate to pass and the sediment is concentrated within the tube to a solids level of ~25-50% based on the sediment using the pressure of the slurry pump (generally 60 psi or less).	**Effective.** Sediment is retained and dewatered at the same time. Requires material to be hydraulically dredged or hydraulically transferred. Does not require size separation – can handle sand and larger sized particles.	**Moderate Difficulty.** Can be implemented with various removal technologies. May require extensive water treatment. Can require large areas to stage tubes for long periods of time (45 days or more). May require use of polymers to enhance filtration.	Moderate-High	Yes	No	Can be used with for all dredging technologies, however, additional processing is required to hydraulically slurry mechanically dredged sediment. Useful as erosion protection barriers and to build land in used in combination with a CDF. To be evaluated in treatability studies.
	Solidification and Stabilization	Mixing of reagents with dredged material to reduce water content,	**Effective.**	**Moderate Difficulty.**	Moderate-High	Yes	Yes	May require pilot tests to determine the most

Table 3-2
Initial Technology Screening
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation: Tidal Flats	Retained for Further Evaluation: OF-008 Drainage Ditch	Screening Rationale and Comment
		increase strength, fix contaminants, and solidify sediment. Reagents may include Portland cement, lime, Calciment, etc. Requires landside area for sediment processing or barge mounted equipment to for processing on the water.	Sediment treatability studies would be required to determine site-specific and setting-specific effectiveness of the various reagents available.	Once material is dredged it is then treated ex-situ in preparation for disposal or re-use on-site. Requires landside access for barge docking and processing.				effective reagents, and specialized equipment for the solidification/ stabilization process. To be evaluated in treatability studies.
	Wastewater Treatment Technologies	**Multiple Process Options** Multiple process options are available for treatment of wastewater from ex situ operations. Options include pH adjustment, flocculants, settling, clarification, carbon adsorption, ion exchange, reverse osmosis, and specialty media treatment.	**Effective.** Multiple process options that are proven technologies are available to treat waste water prior to discharge. Bench-scale and/or pilot-scale studies would be required to determine which process options would be required to meet permitted discharge criteria.	**Variable Difficulty**. Permit discharge requirements will determine the treatment processes necessary prior to discharge. Systems can be land-based of barge-based and may be discharged to sewers or back to the remediation area waters.	Low-High	Yes	Yes	Required for any de-watering process. Bench-scale and/or pilot-scale studies would be required to determine site-specific and setting-specific effectiveness. To be evaluated in treatability studies.
DISPOSAL/RE-USE Disposal of excavated material at a permitted landfill or appropriate re-use on-or off-site following implementation of removal options identified above.	**Confined Disposal Facility (CDF)**	Upland areas and near shore areas that are diked to contain dredged material and allow clear water to return to the waterbody.	**Effective.** CDFs are a proven technology to contain sediment.	**Moderate-High Difficulty.** Requires available area for disposal. Areas will eventually create a land mass that will require a cap or institutional controls to prevent entry. Approval/permitting may be difficult.	Moderate-High	Yes	Yes	Can be used with for all dredging technologies. Material can be hydraulically slurried or mechanically placed. Eliminates the need for dewatering. Design, siting, and regulatory approvals would be required to determine site-specific and setting-specific viability. Agencies have indicated initial interest in shoreline CDF. Placement along shoreline to be evaluated further.
	Confined Aquatic Disposal (CAD) Cell	Construct an approved CAD cell. An approved underwater area is excavated to allow the placement of contaminated sediment within the area. Once full, the CAD cell is capped with material to prevent diffusion of contaminants.	**Effective.** Aquatic disposal cells are a proven technology to contain contaminated sediment.	**High Difficulty.** Requires available area for disposal and rigorous design and construction to place and contain buried sediment. Approval/permitting may be difficult and require long-lead time with coordination with multiple agencies and jurisdictions.	High	Yes	No	Can be used for mechanical dredging and potentially hydraulic dredging with additional processing prior to placement. Design, siting, and regulatory approvals would be required to determine site-specific and setting-specific viability. Not viable.
	Beneficial Reuse	Removed material that meets off or on-site beneficial reuse limitations (both chemical and physical) can be	**Effective.** An effective use of treated sediment.	**Low Difficulty.** Would likely require physical conditioning in the form of dewatering	Low-Moderate	Yes	Yes	Will require additional testing and precharacterization.

General Response Action and Description	Remedial Technology	Process Option and Description	Effectiveness	Difficulty and Implementability	Cost	Retained for Further Evaluation		Screening Rationale and Comment
						Tidal Flats	OF-008 Drainage Ditch	
		transported to pre-approved locations for re-use rather than disposal or placed and managed on-site as future fill material to be used in future development. Examples include landfill cover, roadway base, and on-site fill.		and drying and addition of amendments such as lime or Portland cement to meet physical acceptance criteria. Presence of significant organic matter (i.e., wood waste), which is not expected, may not be acceptable.				
	Off-Site Disposal	Dredged material would be dewatered and transported off-site to an approved landfill. Material assumed to be appropriate for disposal as RCRA subtitle D.	**Effective.** A permitted landfill is a technology proven to contain waste. Conditioning of sediments (e.g., dewatering, drying, and amendments such as Portland cement or lime) to meet landfill's physical acceptance criteria would likely be required.	**Low Difficulty.** Landfilling dredged material is a common practice. Waste characterization sampling would be required prior to disposal. Would require access roads for trucks, but these would likely already be in place from removal activities.	High	Yes	Yes	Will require additional testing and precharacterization.
HABITAT RESTORATION Activities completed to mitigate short-term impacts of remedial actions to local habitat and reestablish physical and biological functions of the waterways.	**Bank Treatments/ Bioengineering**	Bank Treatments/Bioengineering use coir fabrics, coir logs, and native vegetation to reduce erosion, improve water quality and improve habitat. Intended to maintain stable channel.	**Effective.** This is a proven, documented restoration strategy.	**Low-Moderate Difficulty.** Could be as simple as planting vegetation, or as complicated as re-grading banks and constructing engineered banks including coir fabric and logs.	Low	No	Yes	May be applicable depending on final restoration plan.
	Riparian Vegetation	Establish buffer of trees, shrubs, forbes, grasses and sedges depending on the ecological zone. May include invasive species management.	**Effective.** This is a proven, documented restoration strategy implemented by qualified, experienced personnel.	**Low Difficulty.** Planting appropriate vegetation to maintain or repair the riparian zone as part of remediation. Requires maintenance.	Low	No	Yes	May be applicable depending on final restoration plan.
	Tidal Salt Marsh	Re-plant tidal salt marsh grasses. May include invasive species management.	**Effective.** This is a proven, documented restoration strategy if implemented by qualified, experienced personnel.	**Low-Moderate Difficulty.** Planting appropriate vegetation to maintain or repair the tidal salt marsh as part of remediation. Requires maintenance.	Low	Yes	Yes	May be applicable depending on final restoration plan.
	Tidal Mudflats/Backfilling	Replaced removed material with properly sized material depending on the ecological zone and the physical forces.	**Effective.** This is a proven, documented restoration strategy.	**Low Difficulty.** Installing properly sized material in the tidal mudflat zone as part of remediation easily implemented.	Low	Yes	Yes	Applicable to all Tidal Flats area and the Outfall 008 drainage ditch.

Table 4-1
Screening of Remedial Action Alternatives
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Tidal Flats Alternatives				
Remedial Alternative	**Effectiveness**	**Implementability**	**Cost[1,3]**	**Retained/Ranking[2]**
Alternative 1 (No Action) • No Further Action	Low (1) • Will not achieve remedial goals for the site, risks will remain on-site	High (3) • Low technical complexity due to ongoing monitoring plan	Low (3) • continued maintenance and monitoring plan	Not Retained (7) • Remediation required
Alternative 2 (Hydraulic Dredge) • Hydraulic dredge to hydraulic off-load; • Turbidity barrier to control migration of resuspended sediments; • Land-based Long-stick excavation of near shore sediments • Filter press or Geotube dewatering[4]; • Mechanically placed backfill; • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Water treatment and discharge to Housatonic River	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Turbidity curtains will minimize migration of residuals • Five to six seasons required to complete due to aquatic species restrictions • Operate 7 months of year in accordance with fish windows	Low-Moderate (1.5) • High technical complexity due to large footprint for sediment dredging and capping, tide fluctuations, and existing bathymetry • Moderate operation, maintenance, and monitoring (OM&M) to ensure stability of cap • Relative low need for temporary infrastructure (i.e., roadways, docking, etc.) • Readily available services, materials, equipment and specialists locally • On-Site area available for processing and treatment facilities, large footprint needed for water treatment equipment • Greater amount of water generated requiring treatment • Will meet substantive requirements of multiple permits needed for implementation	Moderate-High (1.5) • Low relative costs	Retained (6) • Standard industry accepted dredging technologies • Readily available technology • Low impact dredging with few roads/infrastructure needs • Low relative costs with high production rates
Alternative 3 (Mechanical Dredge) • Mechanical dredge to mechanical off-load, • Turbidity barrier to control migration of resuspended sediments; • Gravity drainage followed by solidification; • Mechanically placed backfill • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Land-based Long-stick excavation of near shore sediments; • Water treatment and discharge back to Housatonic River	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Turbidity curtains will minimize migration of residuals • Three to four seasons required to complete due to aquatic species restrictions with 7 months of year as operating window	Moderate (2) • High technical complexity due to large footprint for sediment dredging and capping, tide fluctuations, and existing bathymetry • Moderate operation, maintenance, and OM&M to ensure stability of cap • Greater need for temporary infrastructure for crane platform, dock, trucking, staging. • Readily available services, materials, equipment and specialists locally • On-Site area available for processing and treatment facilities • Will meet substantive requirements of multiple permits needed for implementation	Moderate-High (1.5) • Moderately high relative costs	Retained (6.5) • Standard industry accepted dredging technologies • Readily available technology • Low impact dredging with few roads/infrastructure needs • Low relative costs with high production rates

Table 4-1
Screening of Remedial Action Alternatives
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Tidal Flats Alternatives				
Remedial Alternative	**Effectiveness**	**Implementability**	**Cost[1,3]**	**Retained/Ranking[2]**
Alternative 4 **(Mechanical Dredge/Hydraulic Transport)** • Mechanical dredge • Hydraulic offload • Turbidity barrier to control migration of resuspended sediments • Filter press or Geotube dewatering[4] • Mechanically placed backfill • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Land-based Long-stick excavation of near shore sediments • Water treatment and discharge back to Housatonic River	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Turbidity curtains will minimize migration of residuals • Three to four seasons required to complete due to aquatic species restrictions with 7 months of year as operating window	Low-Moderate (1.5) • High technical complexity due to large footprint for sediment dredging and capping, tide fluctuations, and existing bathymetry • Moderate operation, maintenance, and OM&M to ensure stability of cap • Relative low need for temporary infrastructure (i.e., roadways, docking, etc.) • Readily available services, materials, equipment and specialists locally • On-Site area available for processing and treatment facilities • Will meet requirements of multiple permits needed for implementation	Moderate-High (1.5) • Moderate to low relative cost	Retained (6) • Standard industry accepted dredging technologies • Readily available technology • Low impact dredging with few roads/infrastructure needs • Low relative costs with high production rates
Alternative 5 (PFTM) • Mechanical dredge • Land-based Long-stick excavation of near shore sediments • Pneumatic flow tube mixing • Turbidity barrier to control migration of resuspended sediments • Mechanically placed backfill • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Water treatment and discharge back to Housatonic River	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Turbidity curtains will minimize migration of residuals • Three to four seasons required to complete due to aquatic species restrictions with 7 months of year as operating window	Relatively Unknown (1) • PFTM is a relatively new technology with limited case studies demonstrating success for this type of application. There are greater operating concerns with a proprietary system. • Has been used extensively in Japan for large construction projects • Relatively little infrastructure needed on-site	Moderate-High (1.5) • Low relative costs, limited water treatment is needed, and offloading is largely eliminated	Retained (5.5) • Newer technology with limited options for service and technical support
Alternative 6 (Off-Site Processing) • Mechanical dredge • Land-based Long-stick excavation of near shore sediments • Turbidity barrier to control migration of resuspended sediments	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping	High (3) • Implementation is relatively easy due to little infrastructure requirements. There are no roads, docks, or staging areas required. • Relies on off-site facilities to be fully permitted to process sediment	High (1) • There is a significant cost associated with off-site processing and disposal when on-site processing and beneficial re-use options are available.	Retained (7) • Standard industry accepted dredging technologies • Readily available technology • Low impact dredging with few roads/infrastructure needs

Tidal Flats Alternatives				
Remedial Alternative	**Effectiveness**	**Implementability**	**Cost[1,3]**	**Retained/Ranking[2]**
• Barge offsite for processing (clean earth or tipping point) • Mechanically placed backfill • Off-site disposal of all sediments (TSCA and non-TSCA materials) • Water treatment and discharge back to Housatonic River	• Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Turbidity curtains will minimize migration of residuals • Three to four seasons required to complete due to aquatic species restrictions with 7 months of year as operating window			• Significant cost implications with readily available on-site processing and beneficial re-use options.
Alternative 7(Hydraulic Dredge/Cofferdam) • Hydraulic dredge • Hydraulic off-load • Dewater using either filter press or Geotube[4] • Cofferdam as turbidity barrier to control migration of resuspended sediments • Mechanically placed backfill • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Cofferdam installation to allow for hydraulic control of the area over all tide cycles to allow for dredging with draft; Allows for dredging 365 days per year. • Water treatment and discharge back to Housatonic River	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Cofferdam can be effective but conditions are unknown and a significant design effort would be required to ensure a water tight seal. • Cofferdam will act as turbidity curtain and allow for 12 month operation. • One to two seasons required to complete work • Additional time required to design and install cofferdam prior to dredging	Low (1) • Difficult to implement due to large cofferdam installation, monitoring and maintenance • Dredging implementability would be enhanced to be able to dredge with constant draft without tide influence	High (1) • High cost of the cofferdam installation and monitoring would outweigh the cost savings in production	Not Retained (5) • Standard industry accepted dredging technologies • High installation costs for cofferdam • High monitoring and maintenance for cofferdam
Alternative 8 (Mechanical Dredge/Cofferdam) • Mechanical dredge • Mechanical off-load • Process and dewater using Portland cement • Mechanically placed backfill • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Land-based Long-stick excavation of near shore sediments	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Cofferdam can be effective but conditions are unknown and a significant design effort would be required to ensure a water tight seal.	Low (1) • Difficult to implement due to large cofferdam installation, monitoring and maintenance • Dredging implementability would be enhanced to be able to dredge in the dry without tide influence	High (1) • High cost of the cofferdam installation and monitoring would outweigh the cost savings in production	Not Retained (5) • Standard industry accepted dredging technologies • High installation costs for cofferdam • High monitoring and maintenance for cofferdam

Table 4-1
Screening of Remedial Action Alternatives
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Tidal Flats Alternatives				
Remedial Alternative	**Effectiveness**	**Implementability**	**Cost[1,3]**	**Retained/Ranking[2]**
• Cofferdam as turbidity barrier to control migration of resuspended sediments • Cofferdam installation to allow for hydraulic control of the area over all tide cycles to allow for dredging in the dry; Allows for dredging 365 days per year. • Water treatment and discharge back to Housatonic River	• Cofferdam will act as turbidity curtain and allow for 12 month operation. • One to two seasons required to complete work • Additional time required to design and install cofferdam prior to dredging			
Alternative 9 (Amphibious Dredge) • Amphibious mechanical dredge • Hydraulic off-load • Turbidity barrier to control migration of resuspended sediments • Dewater using filter press or Geotube[4] • Mechanically placed backfill • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Water treatment and discharge back to Housatonic River	Moderate (2) • May achieve remedial goal but more difficult than other alternatives • Soft nature of sediments at the site pose risk of mixing and residuals • Operate 7 months of year in accordance with fish windows • Three to four seasons required to complete due to aquatic species restrictions with 7 months of year as operating window	Low (1) • Difficult to traverse mud flats without causing significant mixing of underlying sediments with impacted sediments.	Low (3) • Relatively low implementation costs	Not Retained (6) • Effectiveness of dredging and segregation of materials is too difficult to maintain with soft sediments
Alternative 10 (Hydraulic/Shoreline CDF) • Hydraulic dredge to hydraulic off-load; • Turbidity barrier to control migration of resuspended sediments; • Building Demolition behind dike • Sheet pile shoreline CDF construction • Geotube dewatering; • Mechanically placed backfill; • On-site beneficial reuse of dewatered material behind constructed shoreline CDF; • Water treatment and discharge back to Housatonic River	Moderate (2) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Turbidity curtains will minimize migration of residuals • Five to six seasons required to complete due to aquatic species restrictions with 7 months of year as operating window • Additional time required to design and install shoreline CDF prior to dredging and filling	Low-Moderate (1.5) • High technical complexity due to large footprint for sediment dredging and capping, tide fluctuations, and existing bathymetry • Relative low need for temporary infrastructure for dredging (i.e., roadways, docking, etc.); however, significant infrastructure needs and time required to install shoreline CDF. • Readily available services, materials, equipment and specialists locally • On-Site area available for processing, and treatment facilities, large footprint needed for water treatment equipment • Greater amount of water generated requiring treatment • Will meet substantive requirements of multiple permits needed for implementation	High (1) • Sheet pile shoreline CDF installation costs are very high due to depth required to create stable wall • Significant building demo required to accommodate sufficient space behind CDF	Not Retained (4.5) • Standard industry accepted dredging technologies • Readily available technology • Significant additional schedule and cost impacts for CDF design and construction

Table 4-1
Screening of Remedial Action Alternatives
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Tidal Flats Alternatives				
Remedial Alternative	**Effectiveness**	**Implementability**	**Cost[1,3]**	**Retained/Ranking[2]**
Alternative 11 (Hydraulic/Tidal Flats CAD) • Hydraulic dredge to hydraulic off-load; • Turbidity barrier to control migration of resuspended sediments; • Sheet pile to support sides of CAD cell in tidal flats (not needed if in Housatonic) • Geotube dewatering; • Mechanically placed backfill; • Water treatment and discharge to Housatonic River	Moderate (2) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be disposed of in CAD cell • Turbidity curtains will minimize migration of residuals • Five to six seasons required to complete due to aquatic species restrictions with 7 months of year as operating window • Additional time required to design and build CAD prior to dredging and filling	Low-Moderate (1.5) • High technical complexity due to large footprint for sediment dredging and capping, tide fluctuations, and existing bathymetry • Need for temporary infrastructure for dredging (i.e., roadways, docking, etc.); however, significant infrastructure needs and time required to build CAD including geotechnical investigation • Sediment rehandling is necessary • Readily available services, materials, equipment and specialists locally • On-Site area available for processing, and treatment facilities, large footprint needed for water treatment equipment and placement of excess sediments • Will meet substantive requirements of multiple permits needed for implementation • Clean material excavated for CAD cell used as backfill in tidal flats	High (1) • Sheet pile installation costs are very high due to depth required to create CAD cell wall	Not Retained (4.5) • Standard industry accepted dredging technologies • Readily available technology • Significant additional schedule and cost impacts for CAD design and construction • Disruptive of navigation channel

Table 4-1
Screening of Remedial Action Alternatives
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Stratford, Connecticut

Outfall 008 Drainage Ditch Alternatives				
Remedial Alternative	**Effectiveness**	**Implementability**	**Cost[1,3]**	**Retained/Ranking[2]**
Alternative 1 (No Action) No Further Action	Low (1) • Will not achieve remedial goals for the site, risks will remain on-site	High (3) • Low technical complexity due to ongoing monitoring plan	Low (3) • continued maintenance and monitoring plan	Not Retained (7) Remediation required
Alternative 2 (Mechanical Excavation) • Isolate and dewater area for mechanical excavation using land based excavator • Truck transport to processing area • Process and dewater with Portland cement • Import clean material for mechanically placed backfill and restoration • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Water treatment and discharge back to Housatonic River	High (3) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Isolation and dewatering of the drainage ditch will contain sediments and minimize turbidity migration • Restoration more effective under dewatered scenario	Moderate (2) • Moderate technical complexity due tide fluctuations, interconnection with adjacent ditch, and existing bathymetry • Greater need for temporary infrastructure for roadways and processing of sediments • Readily available services, materials, equipment and specialists locally • On-Site area available for processing, treatment, and handling facilities • Will meet substantive requirements of multiple permits needed for implementation	Moderate-High (1.5) • Moderate relative cost, significant costs to control water	Retained (6.5) • Standard industry accepted dredging technologies • Readily available technology • Low impact dredging with few roads/infrastructure needs • Low relative costs with high production rates
Alternative 3 (Mechanical Dredging) • Mechanical dredge to mechanical off-load, • Turbidity barrier to control migration of resuspended sediments; • Gravity drainage followed by solidification; • Mechanically placed backfill; • On-site beneficial reuse of non-TSCA sediments (<1 ppm PCBs) and off-site disposal of TSCA sediments (1 ppm ≤ PCBs < 50 ppm and ≥ 50 ppm) or off-site disposal of all sediments; • Land-based Long-stick excavation of near shore sediments; • Water treatment and discharge back to Housatonic River	Low-Moderate(1.5) • Will achieve the remedial goals with impacts removed by dredging and isolated by capping • Significant quantity of impacted sediment which poses a risk to be reused on-site or disposed of off-site • Possible release of resuspended sediments into adjacent airport ditch and marine basin - turbidity curtains needed minimize migration of residuals • Several seasons required to complete due to aquatic species restrictions • Restoration difficult/less effective for high water conditions	Low (1) • High technical complexity due to narrow footprint of the drainage channel for sediment dredging and capping, tide fluctuations, and existing bathymetry • Greater need for temporary infrastructure for crane platform, dock, trucking, staging. • Readily available services, materials, equipment and specialists locally • On-Site area available for processing and treatment facilities • Will meet substantive requirements of multiple permits needed for implementation	Moderate (2) • Low relative costs, little to no costs related to control of water	Not Retained (4.5) • Not an effective solution for the size of the drainage ditch to be dredged. • Tidal fluctuations and site logistics would hinder production rates making it an impractical alternative

Notes:
[1] Costs are assessed in a relative sense. Quantitative costs are developed for the retained alternatives in Section 5 and will be equivalent to "engineer's estimates" within minus 30% and plus 50% of actual quantities consistent with USEPA feasibility study guidance.
[2] Ranking evaluations based on High (3), Moderate (2) and Low (1).
[3] Ranking for Cost are reversed to reflect accurate ranking (i.e., high cost was given a low ranking).
[4] Other dewatering systems may be viable, equally effective, and have lower costs; however, it is beyond the scope of this FFS to evaluate all systems available.

Table 5-1
Criteria Evaluation
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Performance	Reduction of Toxicity, Mobility, or Volume through Treatment	Short Term Effectiveness and Schedule	Implementability	Total Capital Cost[1,4]	
							On-Site Beneficial Reuse[2]	Off-Site Disposal[3]
Alternative 2 Tidal Flats: Hydraulic Dredge, Belt Press or Geotube dewatering, Hydraulic Transport Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering Truck Transport Figure 5-1 Figure 5-2	• Would provide Overall Protection of Human Health and the Environment by removing affected sediments from the tidal flats and drainage ditch. Disposing TSCA sediments off-site in a RCRA D or TSCA landfill and either beneficially reusing Non-TSCA sediment on-site or disposing off-site. • Will achieve remedial objectives, restore natural resources, and allow for reuse of property	• Will fully comply with ARARs, including those for aquatic species protection, water quality, and on-site reuse of materials. • Will fully comply with TSCA by segregating TSCA and non-TSCA materials, dewatering TSCA sediments to the maximum feasible, and meeting substantive requirement of a risk-based approval for solidification of sediments that do not pass the paint filter test under 40 CFR 761.61(c)	• High certainty of success with impacts removed by dredging and locally isolated by capping • High long-term effectiveness by removing the impacts by dredging • Habitat will be improved through restoration activities over the long term • Recreational use of the Tidal Flats will be restored for future • Minimal long-term risk to public/environment with on-site reuse or off-site disposal	• No reduction through treatment as a principle element • Will remove contaminant mass • Impacted sediment which poses a risk to be processed and reused on-site or disposed of off-site • Higher volume of water treatment required for hydraulic dredge/transport than mechanical dredging • Higher volume of sediment due to precision of hydraulic dredge equipment (0.4 ft over dredge) • Minimal potential for resuspension of sediments	• Larger treatment footprint for processing/dewatering • Potential odor issues with processing and stockpiling • Moderate import of materials for processing • 5-6 season construction duration • Moderate short-term risk to construction workers during implementation associated with use of heavy equipment and dredging of impacted sediment • Minimal short-term risk to public/environment during dredging, and transport • Silt curtains will protect downstream water resources	• Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • More processing and water treatment required due to hydraulic slurry transport • High complexity of water treatment system with larger volume of water to be treated • Previously developed landside access used for processing, disposal • High availability of services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities	Belt Press $108.7 M Geotube $95.3 M	Belt Press $142.8 M Geotube $129.4 M
Alternative 3 Tidal Flats: Mechanical Dredge, Gravity Dewatering, Mechanical Transport Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering Truck Transport Figure 5-3 Figure 5-4	• Would provide Overall Protection of Human Health and the Environment by removing affected sediments from the tidal flats and drainage ditch. Disposing TSCA sediments off-site in a RCRA D or TSCA landfill and either beneficially reusing Non-TSCA sediment on-site or disposing off-site. • Will achieve remedial objectives, restore natural resources, and allow for reuse of property	• Will fully comply with ARARs, including those for aquatic species protection, water quality, and on-site reuse of materials. • Will fully comply with TSCA by segregating TSCA and non-TSCA materials, dewatering TSCA sediments to the maximum feasible, and meeting substantive requirements of a risk-based approval for solidification of sediments that do not pass the paint filter test under 40 CFR 761.61(c)	• High certainty of success with impacts removed by dredging and locally isolated by capping • High long-term effectiveness by removing the impacts by dredging • Habitat will be improved through restoration activities over the long term • Recreational use of the Tidal Flats will be restored for future • Minimal long-term risk to public/environment with on-site reuse or off-site disposal	• No reduction through treatment as a principle element • Will remove contaminant mass • Impacted sediment which poses a risk to be processed and re-used on-site or disposed of off-site • Lower volume of water treatment required for mechanical dredge/transport • Lower volume of sediment due to precision of mechanical dredge equipment (0.2 ft over dredge) • Potential for resuspension of	• Smaller treatment footprint for processing/dewatering • Potential odor issues with processing and stockpiling • Higher import of materials for processing • 3-4 season construction duration • Moderate short-term risk to construction workers during implementation associated with use of heavy equipment and dredging of impacted sediment • Moderate short-term risk to public/environment during dredging, transport and reuse or disposal	• Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • Minimal water treatment required due to gravity drainage system • Minimal complexity of water treatment with gravity drainage • Previously developed landside access used for processing, disposal • High availability of necessary services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities	$79.4 M	$112.5 M

Table 5-1
Criteria Evaluation
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Performance	Reduction of Toxicity, Mobility, or Volume through Treatment	Short Term Effectiveness and Schedule	Implementability	Total Capital Cost[1,4] On-Site Beneficial Reuse[2]	Total Capital Cost[1,4] Off-Site Disposal[3]
				sediments from operation of tug/push boats	• Silt curtains will protect downstream water resources			
Alternative 4 Tidal Flats: Mechanical Dredge, Hydraulic Transport, Belt Press or Geotube Dewatering Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering, Truck Transport Figure 5-5 Figure 5-6	• Would provide Overall Protection of Human Health and the Environment by removing affected sediments from the tidal flats and drainage ditch. Disposing TSCA sediments off-site in a RCRA D or TSCA landfill and either beneficially reusing Non-TSCA sediment on-site or disposing off-site. • Will achieve remedial objectives, restore natural resources, and allow for reuse of property	• Will fully comply with ARARs, including those for aquatic species protection, water quality, and on-site reuse of materials. • Will fully comply with TSCA by segregating TSCA and non-TSCA materials, dewatering TSCA sediments to the maximum feasible, and meeting substantive requirements of a risk-based approval for solidification of sediments that do not pass the paint filter test under 40 CFR 761.61(c)	• High certainty of success with impacts removed by dredging and locally isolated by capping • High long-term effectiveness by removing the impacts by dredging • Habitat will be improved through restoration activities over the long term • Recreational use of the Tidal Flats will be restored for future • Minimal long-term risk to public/environment with on-site reuse or off-site disposal	• No reduction through treatment as a principle element • Will remove contaminant mass • Impacted sediment which poses a risk to be processed and reused on-site or disposed of off-site • Moderate volume of water treatment required for mechanical dredge/hydraulic transport • Lower volume of sediment due to precision of mechanical dredge equipment (0.2 ft over dredge) • Minimal potential for resuspension of sediments	• Larger treatment footprint for processing/dewatering • Potential odor issues with processing and stockpiling • Moderate import of materials for processing • 3-4 season construction duration • Moderate short-term risk to construction workers during implementation associated with use of heavy equipment and dredging of impacted sediment • Moderate short-term risk to public/environment during dredging, transport and reuse or disposal • Silt curtains will protect downstream water resources	• Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • More processing and water treatment required due to hydraulic slurry transport • High complexity of water treatment system with moderate volume of water to be treated • Previously developed landside access used for processing, disposal • High availability of services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities	Belt Press $85.5 M Geotube $78.4 M	Belt Press $116.9 M Geotube $109.7 M
Alternative 5 Tidal Flats: Mechanical Dredge, no dewatering (non-TSCA), Pneumatic Transport Gravity Dewatering; barge transport for TSCA sediments Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering, Truck Transport Figure 5-7	• Would provide Overall Protection of Human Health and the Environment by removing affected sediments from the tidal flats and drainage ditch. Disposing TSCA sediments off-site in a RCRA D or TSCA landfill and either beneficially reusing Non-TSCA sediment on-site or disposing off-site. • Will achieve remedial objectives, restore natural	• Will fully comply with ARARs, including those for aquatic species protection, water quality, and on-site reuse of materials. • Will fully comply with TSCA by segregating TSCA and non-TSCA materials, dewatering TSCA sediments to the maximum feasible, and meeting substantive requirements of a risk-based approval for solidification of sediments that do not pass the paint filter test under 40 CFR 761.61(c)	• High certainty of success with impacts removed by dredging and locally isolated by capping • High long term effectiveness by removing the impacts by dredging • Habitat will be improved through restoration activities over the long term • Recreational use of the Tidal Flats will be restored for future • Minimal long-term risk to public/environment with	• No reduction through treatment as a principle element • Will remove contaminant mass • Will achieve the remedial objective with impacts removed by dredging • Impacted sediment which poses a risk to be processed and reused on-site or disposed of off-site • Minimal volume of water treatment required for mechanical dredge and PFTM	• Small treatment footprint as little processing/dewatering required • Less potential odor issues with little processing required • Import materials for processing • 3-4 season construction duration • Moderate short-term risk to construction workers during implementation associated with use of heavy equipment and dredging of impacted sediment	• Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • Little water treatment required due to PFTM transport. Little sediment handling. • Previously developed landside access used for processing, disposal • Limited availability of necessary services, materials, equipment and specialists locally for PFTM	$82.1 M	NA

Table 5-1
Criteria Evaluation
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Performance	Reduction of Toxicity, Mobility, or Volume through Treatment	Short Term Effectiveness and Schedule	Implementability	Total Capital Cost[1,4]	
							On-Site Beneficial Reuse[2]	Off-Site Disposal[3]
Figure 5-8	resources, and allow for reuse of property		on-site reuse or off-site disposal	• Lower volume of sediment due to precision of mechanical dredge equipment (0.2 ft over dredge) • Potential for resuspension of sediments from operation of tug/push boats	• Minimal short-term risk to public/environment during dredging, transport and reuse or disposal • Silt curtains will protect downstream water resources	• Moderate availability of off-site disposal facilities		
Alternative 6 Tidal Flats: Mechanical Dredge, Gravity Dewatering, Barge Transport Off-Site Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering, Truck Transport Figure 5-9 Figure 5-10	• Would provide Overall Protection of Human Health and the Environment by removing affected sediments from the tidal flats and drainage ditch. Disposing TSCA sediments off-site in a RCRA D or TSCA landfill and either beneficially reusing Non-TSCA sediment on-site or disposing off-site. • Will achieve remedial objectives, restore natural resources, and allow for re-use of property	• Will fully comply with ARARs, including those for aquatic species protection, water quality, and on-site reuse of materials. • Will fully comply with TSCA by segregating TSCA and non-TSCA materials, dewatering TSCA sediments to the maximum feasible, and meeting substantive requirements of a risk-based approval for solidification of sediments that do not pass the paint filter test under 40 CFR 761.61(c)	• High certainty of success with impacts removed by dredging and locally isolated by capping • High long-term effectiveness by removing the impacts by dredging • Habitat will be improved through restoration activities over the long term • Recreational use of the Tidal flats will be restored for Future • Minimal long-term risk to public/environment with on-site reuse or off-site disposal	• No reduction through treatment as a principle element • Will remove contaminant mass • Will achieve the remedial objective with impacts removed by dredging • Impacted sediment which poses a risk to be processed and reused on-site or disposed of off-site • Minimal volume of water treatment required for mechanical dredge and off-site process and disposal • Lower volume of sediment due to precision of mechanical dredge equipment (0.2 ft over dredge) • Potential for resuspension of sediments from operation of tug/push boats	• Little treatment footprint for OF-008 only • Limited potential odor issues, only OF-008 processing and stockpiling • Little import materials for processing • 3-4 season construction duration • Moderate short-term risk to construction workers during implementation associated with use of heavy equipment and dredging of impacted sediment • Minimal short-term risk to public/environment during dredging, transport and reuse or disposal • Silt curtains will protect downstream water resources	• Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • Minimal water treatment required due to gravity drainage system • Minimal complexity of water treatment with gravity drainage for OF-008 • Previously developed landside access used for OF-008 processing, disposal • High availability of necessary services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities	NA	$93.5 M

Notes:
1. Costs are engineer's estimates and are anticipated to be within minus 30% and plus 50% of actual quantities consistent with USEPA feasibility study guidance.
2. "On-Site beneficial reuse" cost includes off-site disposal costs for TSCA material (>= 50 mg/kg PCBs) and RCRA-D material (>=1 and < 50 mg/kg PCBs) and on-site processing and placement of sediments containing <1.0 mg/kg PCBs and otherwise meeting CT residential soil criteria.
3. See Table 6-3 and Appendix E for additional cost information. Off-site disposal assumes all materials will be disposed of off-site.

4. Cost differences between on- and off-site options for Alternatives that have both options are driven by two main factors: 1. For options including hydraulic dredging (Alternative 2), the overdredge is larger than for options that include mechanical dredging, which requires the processing and disposal of a larger quantity of sediment; and 2. For options utilizing geotubes or belt press dewatering (Alternative 2 and 4), no Portland cement is included while for options that utilize mechanical dredging the addition of 6% Portland cement adds to the cost (Alternatives 3, 5, and 6).

Table 5-2
Key Quantitative Factors for Alternatives Evaluation
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Sediment Volume (CY)	Stabilization	Backfill Volume	Water Treatment (Gallons)	Productivity	Schedule[2]	Total Cost[1,6]	
							On-Site Beneficial Reuse[3]	Off-Site Disposal[4]
Alternative 2 Tidal Flats: Hydraulic Dredge, Hydraulic Transport, Belt Press or Geotube Dewatering Outfall-008: Isolate and Dewater, Mechanical Excavation, Truck Transport, Gravity Dewatering Figures 5-1, 5-2	Tidal Flats • 139,471 (Neat Volume) • 170,281 (Total Volume with Overdredge and Side Slopes) Outfall-008 • 4,900 (Neat Volume) • 6,125 (Total Volume with Overdredge and Side Slopes)	Tidal Flats • None Outfall-008 • Required • 6% Addition	Tidal Flats • 97,470 (Neat Volume) • 127,240 (Total Volume with Overplacement and Material Loss) Outfall-008 • 4,892 (Neat Volume) • 5,779 (Total Volume with Overplacement and Material Loss)	Tidal Flats • 303,716,691 Outfall-008 • 6,860,000	Tidal Flats • 304 cy/day (Dredge) • 625 cy/day (Backfill) Outfall-008 • 144 cy/day (Dredge) • 192 cy/day (Backfill)	Tidal Flats • 743 working days • 34 months • 4-5 Seasons Outfall-008 • 64 days • 4 months • Occurs during tidal flat remediation	$108.7 M (belt press) $95.3 M (Geotube)	$142.8 M (belt press) $129.4 M (Geotube)
Alternative 3 Tidal Flats: Mechanical Dredge, Gravity Dewatering, Mechanical Transport Outfall-008: Isolate and Dewater, Mechanical Excavation, Truck Transport, Gravity Dewatering Figures 5-3, 5-4	Tidal Flats • 139,471 (Neat Volume) • 155,573 (Total Volume with Overdredge and Side Slopes) Outfall-008 • 4,900 (Neat Volume) • 6,125 (Total Volume with Overdredge and Side Slopes)	Tidal Flats • Required • 6% Addition Outfall-008 • Required • 6% Addition	Tidal Flats • 82,763 (Neat Volume) • 111,062 (Total Volume with Overplacement and Material Loss) Outfall-008 • 4,892 (Neat Volume) • 5,779 (Total Volume with Overplacement and Material Loss)	Tidal Flats • 19,676,260 Outfall-008 • 6,860,000	Tidal Flats • 496 cy/day (Dredge) • 625 cy/day (Backfill) Outfall-008 • 144 cy/day (Dredge) • 192 cy/day (Backfill)	Tidal Flats • 502 working days • 23 months • 3 to 4 Seasons Outfall-008 • 64 days • 4 months • Occurs during tidal flat remediation	$79.4 M	$112.5 M
Alternative 4 Tidal Flats: Mechanical Dredge, Hydraulic Transport, Belt Press or Geotube Dewatering Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering Truck Transport Figures 5-5, 5-6	Tidal Flats • 139,471 (Neat Volume) • 155,573 (Total Volume with Overdredge and Side Slopes) Outfall-008 • 4,900 (Neat Volume) • 6,125 (Total Volume with Overdredge and Side Slopes)	Tidal Flats • None Outfall-008 • Required • 6% Addition	Tidal Flats • 82,763 (Neat Volume) • 111,062 (Total Volume with Overplacement and Material Loss) Outfall-008 • 4,892 (Neat Volume) • 5,779 (Total Volume with Overplacement and Material Loss)	Tidal Flats • 71,246,428 Outfall-008 • 6,860,000	Tidal Flats • 393 cy/day (Dredge) • 625 cy/day (Backfill) Outfall-008 • 144 cy/day (Dredge) • 192 cy/day (Backfill)	Tidal Flats • 562 working days • 26 months • 3-4 Seasons Outfall-008 • 64 days • 4 months • Occurs during tidal flat remediation	$85.5 M (belt press) $78.4 M (Geotube)	$116.9 M (belt press) $109.7 M (Geotube)

Table 5-2
Key Quantitative Factors for Alternatives Evaluation
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Sediment Volume (CY)	Stabilization	Backfill Volume	Water Treatment (Gallons)	Productivity	Schedule[2]	Total Cost[1,6]	
							On-Site Beneficial Reuse[3]	Off-Site Disposal[4]
Alternative 5 Tidal Flats: Mechanical Dredge, Pneumatic Transport, (no dewatering non-TSCA sediments), Gravity Dewatering of TSCA sediments and off-site disposal via barge transport Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering, Truck Transport Figures 5-7, 5-8	Tidal Flats • 139,471 (Neat Volume) • 155,573 (Total Volume with Overdredge and Side Slopes) Outfall-008 • 4,900 (Neat Volume) • 6,125 (Total Volume with Overdredge and Side Slopes)	Tidal Flats • Required • 6% Addition Outfall-008 • Required • 6% Addition	Tidal Flats • 82,763 (Neat Volume) • 111,062 (Total Volume with Overplacement and Material Loss) Outfall-008 • 4,892 (Neat Volume) • 5,779 (Total Volume with Overplacement and Material Loss)	Tidal Flats • 19,676,260 Outfall-008 • 6,860,000	Tidal Flats • 496 cy/day (Dredge) • 625 cy/day (Backfill) Outfall-008 • 144 cy/day (Dredge) • 192 cy/day (Backfill)	Tidal Flats • 502 working days • 23 months • 3-4 Seasons Outfall-008 • 64 days • 4 months • Occurs during tidal flat remediation	$82.1 M	NA
Alternative 6 Tidal Flats: Mechanical Dredge, Gravity Dewatering, Barge Transport Off-Site Outfall-008: Isolate and Dewater, Mechanical Excavation, Gravity Dewatering, Truck Transport Figures 5-9, 5-10	Tidal Flats • 139,471 (Neat Volume) • 155,573 (Total Volume with Overdredge and Side Slopes) Outfall-008 • 4,900 (Neat Volume) • 6,125 (Total Volume with Overdredge and Side Slopes)	Tidal Flats • None Outfall-008 • Required • 6% Addition	Tidal Flats • 82,763 (Neat Volume) • 111,062 (Total Volume with Overplacement and Material Loss) Outfall-008 • 4,892 (Neat Volume) • 5,779 (Total Volume with Overplacement and Material Loss)	Tidal Flats • 19,676,260 Outfall-008 • 6,860,000	Tidal Flats • 496 cy/day (Dredge) • 625 cy/day (Backfill) Outfall-008 • 144 cy/day (Dredge) • 192 cy/day (Backfill)	Tidal Flats • 502 working days • 23 months • 3-4 Seasons Outfall-008 • 64 days • 4 months • Occurs during tidal flat remediation	NA	$93.5 M

Notes:
1. Costs are engineer's estimates and are anticipated to be within minus 30% and plus 50% of actual quantities consistent with USEPA feasibility study guidance.
2. Season assumes a work window is July 1 through January 31. See Table 6-2 for a Detailed Schedule Comparison.
3. On-Site beneficial reuse cost includes off-site disposal costs for TSCA material.
4. See Table 6-3 and Appendix E for additional cost information.
5. NA – Not Applicable
6. Cost differences between on- and off-site options for Alternatives that have both options are driven by two main factors: 1. For options including hydraulic dredging (Alternative 2), the overdredge is larger than for options that include mechanical dredging, which requires the processing and disposal of a larger quantity of sediment; and 2. For options utilizing geotubes or belt press dewatering (Alternative 2 and 4), no Portland cement is included while for options that utilize mechanical dredging the addition of 6% Portland cement adds to the cost (Alternatives 3, 5, and 6).

Table 6-1
Comparative Analysis
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Threshold Criteria	Primary Balancing Criteria[1, 2]	Sustainability Criteria
Alternative 2: Site Preparation: Environmental controls, 2 staging areas (processing and dewatering for hydraulic dredge and another for OF-008 processing and dewatering), temporary access roads and offices. Tidal Flats: Hydraulic dredge to hydraulic off-load with belt filter press or Geotube dewatering. Water treatment system with water discharge to Housatonic River. Beneficial on-site reuse of non-TSCA sediment. On-site processing off-site disposal of TSCA sediments. Mechanical backfill and restoration. OF-008: Isolate and dewater area for mechanical dredge and truck transport to sediment processing area. On-site beneficial reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. Mechanical backfill and restoration.	• Protective of human health and the environment by removing impacted sediment, treating the sediment and water discharge and restoring the Tidal Flats with in-kind backfill • Recreational use of the Tidal Flats will be restored for future use • Meets all ARARs for the site	• High certainty of success and long-term effectiveness with impacts removed by dredging • Removal of sediment is effective in the short- and long-term with no long-term risk of recontamination • Will remove contaminant mass, restore natural resources and allow for re-use of property • Longest time among alternatives to achieve RAOs • Will re-establish habitat • Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • More processing and water treatment required due to hydraulic slurry transport • High complexity of water treatment system with larger volume of water to be treated • High on-site beneficial reuse cost range between $108.7 M (belt press) and $95.3 M (Geotube) • High off-site disposal cost range between $142.8 M (belt press) and $129.4 M (Geotube) • Practical and cost effective alternative for the large sediment removal areas. • Potential odor issues with processing and stockpiling	• Less sustainable alternative with a larger volume of water generated for treatment, larger area for processing and dewatering • Belt press has a high energy and maintenance cost • Geotubes have less maintenance and little to no energy costs • Trucking required from the temporary stockpile area to the larger on-site beneficial reuse area • Less trucking required than if sediment was sent for off-site disposal. No trucking required from barge to processing with hydraulic slurry transport • Impacted sediment which poses a risk to be processed and beneficially reused on-site or disposed of off-site
Alternative 3: Site Preparation: Environmental controls, 1 staging area (processing and dewatering area for both Tidal Flats and OF-008), temporary access roads and offices. Tidal Flats: Mechanical dredge to mechanical off-load and stabilize dewater with mechanical backfill and beneficial on-site reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. OF-008: Isolate and dewater area for mechanical dredge and truck transport to sediment processing area and beneficial on-site reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. Mechanical backfill and restoration.	• Protective of human health and the environment by removing impacted sediment, treating the sediment and water discharge and restoring the Tidal Flats with in-kind backfill • Recreational use of the Tidal Flats will be restored for future use • Meets all ARARs for the site	• High certainty of success and long-term effectiveness with impacts removed by dredging • Removal of sediment is effective in the short and long-term with no long-term risk of recontamination • Will re-establish habitat • Will remove contaminant mass, achieve remedial objectives, restore natural resources and allow for re-use of property in timely manner • Requires crane barge for sediment off-load • Haul trucks for transport from barge to processing area • Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • Previously developed landside access will be allowed for processing, disposal • Moderate operation, maintenance, and monitoring (OM&M) • Moderate complexing of water treatment with gravity drainage • Moderate availability of necessary services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities • Smaller treatment footprint for processing/dewatering • Potential odor issues with processing and stockpiling • Low on-site beneficial reuse cost of $79.4 M • Moderate off-site disposal cost of $112.5 M • Practical and cost effective alternative for the large sediment removal areas	• More sustainable alternative with a smaller volume of water generated for treatment • Uses Portland cement, which has high energy consumption during production and transport • Less sustainable with larger equipment required to process the sediment on-site • Trucking required from the temporary stockpile area to the larger beneficial on-site reuse area • Less on-site trucking required if sediment was sent for off-site disposal • Mechanical dredging with mechanical transport is a CT DEEP accepted sediment removal technology, however hydraulic dredging is their preferred technology • Dredging and restoration will immediately improve aesthetics of site • Access to embayment limited for shorter duration of dredging and restoration

Table 6-1
Comparative Analysis
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Threshold Criteria	Primary Balancing Criteria[1, 2]	Sustainability Criteria
Alternative 4: Site Preparation: Environmental controls, staging, processing and dewatering areas, temporary access roads and offices. Tidal Flats: Mechanical dredge to hydraulic off-load, belt filter press or Geotube dewater. Water treatment system with water discharge to Housatonic River. Mechanically placed backfill and beneficial on-site reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. OF-008: Isolate and dewater area for mechanical dredge and truck transport to sediment processing area and beneficial on-site reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. Mechanical backfill and restoration.	• Protective of human health and the environment by removing impacted sediment, treating the sediment and water discharge and restoring the Tidal Flats with in-kind backfill • Recreational use of the Tidal Flats will be restored for future use • Meets all ARARs for the site	• Removal of sediment is effective in the short and long-term with no long-term risk of recontamination • High certainty of success and long-term effectiveness with impacts removed by dredging which will restore natural resources and allow for re-use of property in timely manner • Will re-establish habitat • Highly likely to remove mass, achieve remedial objectives • Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • More processing and water treatment required due to hydraulic slurry transport • High complexity of water treatment system with larger volume of water to be treated • Previously developed landside access will be allowed for processing, beneficial on-site reuse; little disturbance of previously undisturbed areas • Moderate availability of necessary services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities if required • Potential odor issues with processing and stockpiling • Moderate to low on-site beneficial reuse cost range between $85.5 M (belt press) and $78.4 M (Geotube) • Moderate off-site disposal cost range between $116.9 M (belt press) and $109.7 M (Geotube)	• Less sustainable alternative with a larger volume of water generated for treatment, larger area for processing and dewatering • Belt press has a high energy and maintenance cost • Geotubes have less maintenance and little to no energy costs • Trucking required from the temporary stockpile area to the larger beneficial on-site reuse area • Less trucking required than if sediment was sent for off-site disposal. No trucking required from barge to processing with hydraulic slurry transport • Impacted sediment which poses a risk to be processed and beneficially reused on-site or disposed of off-site
Alternative 5: Site Preparation: Environmental controls, 1 staging area (processing and dewatering area for OF-008), temporary access roads and offices. Tidal Flats: Mechanical dredge to pneumatic flow tube mixing (PFTM) and beneficial on-site reuse of non-TSCA sediment. Off-site processing and disposal of TSCA sediment. Mechanical backfill and restoration. OF-008: Isolate and dewater area for mechanical dredge and truck transport to sediment processing area and beneficial on-site reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. Mechanical backfill and restoration.	• Protective of human health and the environment by removing impacted sediment, treating the sediment and water discharge and restoring the Tidal Flats with in-kind backfill • Recreational use of the Tidal Flats will be restored for future use • Meets all ARARs for the site	• Removal of sediment is effective in the short and long-term with no long-term risk of recontamination • High certainty of success and long-term effectiveness with impacts removed by dredging which will restore natural resources and allow for re-use of property in timely manner • Will re-establish habitat • Will remove contaminant mass, achieve remedial objectives • Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • Minimal volume of water treatment required for mechanical dredge and pneumatic transport, minimal sediment handling • Small treatment footprint as little processing/dewatering required • Less potential odor issues with little processing required • Lower volume of import materials for processing • Higher technical complexity for PFTM as it is a specialized sediment transport mechanism • Previously developed landside access will be allowed for processing, disposal • Moderate availability of necessary services, materials, equipment and specialists locally • Moderate on-site beneficial reuse cost of $82.1 M • Little potential odor issues with PFTM, direct stockpiling of processed sediment, and limited water treatment	• Most sustainable alternative with smallest volume of water generated for treatment, small area for OF-008 processing and dewatering • Uses Portland cement, which has high energy consumption during production and transport • PFTM has a high energy and maintenance cost associated with pumping, potential clogging • Less trucking required than if sediment was sent for off-site disposal. No trucking required from barge to processing with PFTM transport • Impacted sediment which poses a risk to be processed and beneficially reused on-site • Mechanical dredging with PFTM transport is a CT DEEP accepted sediment removal technology, however hydraulic dredging is their preferred technology

Table 6-1
Comparative Analysis
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Threshold Criteria	Primary Balancing Criteria[1, 2]	Sustainability Criteria
Alternative 6: Site Preparation: Environmental controls, 1 staging area (processing and dewatering area for OF-008), temporary access roads and offices. Tidal Flats: Mechanical dredge to off-site processing and disposal. Mechanical backfill and restoration. OF-008: Isolate and dewater area for mechanical dredge and truck transport to sediment processing area and beneficial on-site reuse for non-TSCA sediment. On-site processing and off-site disposal for TSCA sediment. Mechanical backfill and restoration.	• Protective of human health and the environment by removing impacted sediment, treating the sediment and water discharge and restoring the Tidal Flats with in-kind backfill • Recreational use of the Tidal Flats will be restored for future use • Meets all ARARs for the site	• Removal of sediment is effective in the short and long-term with no long-term risk of recontamination • High certainty of success and long-term effectiveness with impacts removed by dredging which will restore natural resources and allow for beneficial reuse of property in timely manner • Will re-establish habitat • Will remove contaminant mass, achieve remedial objectives • Moderate technical complexity due to large footprint for sediment dredging and restoration, tide fluctuations, and existing bathymetry • Minimal volume of water treatment required for mechanical dredge and off-site processing and disposal, minimal sediment handling • Small treatment footprint as little processing/dewatering required for OF-008 • Less potential odor issues with little processing required • Minimal volume of import materials for OF-008 processing • Low technical complexity for mechanical dredging and OF-008 processing • Previously developed landside access will be allowed for processing and disposal, no new land disturbance • High availability of necessary services, materials, equipment and specialists locally • Moderate availability of off-site disposal facilities • Lowest off-site disposal cost of $93.5 M • Little potential odor issues with off-site transport, minimal OF-008 odor during process/dewatering	• Most locally sustainable alternative with little on-site volume of water generated for treatment, small area for OF-008 processing and dewatering • Uses Portland cement, which has high energy consumption during production and transport • Minimal energy and maintenance cost associated with mechanical dredging, OF-008 processing/dewatering • Less trucking required than if sediment was sent for off-site disposal. • Barging is an energy efficient transport mode, and opens up possibility of rail transport to off-site disposal facilities, which is also energy efficient. • Mechanical dredging with off-site transport is a CT DEEP accepted sediment removal technology however hydraulic dredging is their preferred technology • Shortest project duration with minimal processing/dewatering on-site.

Notes:
1. Costs are engineer's estimates and are anticipated to be within minus 30% and plus 50% of actual quantities consistent with USEPA feasibility study guidance.
2. Costs provided are Total Capital Costs. See Table 6-3 and Appendix E for more information.

cy – cubic yard
ft - feet

Table 6-2
Alternative Schedule Summary
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative	Remediation Duration (Years) July – January Work Window						Remediation Duration (Years) No Work Window					
	12 Hour Schedule			24 Hour Schedule			12 Hour Schedule			24 Hour Schedule		
	5 Working Days/Week	6 Working Days/Week	7 Working Days/Week	5 Working Days/Week	6 Working Days/Week	7 Working Days/Week	5 Working Days/Week	6 Working Days/Week	7 Working Days/Week	5 Working Days/Week	6 Working Days/Week	7 Working Days/Week
2	4.8	4.1	3.5	2.4	2.0	1.8	2.8	2.4	2.1	1.4	1.2	1.0
3	3.3	2.8	2.4	1.6	1.4	1.2	1.9	1.6	1.4	1.0	0.8	0.7
4	3.7	3.1	2.7	1.8	1.5	1.3	2.1	1.8	1.6	1.1	0.9	0.8
5	3.3	2.8	2.4	1.6	1.4	1.2	1.9	1.6	1.4	1.0	0.8	0.7
6	3.3	2.8	2.4	1.6	1.4	1.2	1.9	1.6	1.4	1.0	0.8	0.7

Table 6-3
Alternative Cost Summary[1]
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

	Cost Category	Alternative 2 (Belt Press)	Alternative 2 (Geotube)	Alternative 3	Alternative 4 (Belt Press)	Alternative 4 (Geotube)	Alternative 5	Alternative 6
On-Site Beneficial Reuse Tidal Flats	Mobilization, Temporary Construction, Surveys, Environmental Protection & Monitoring	$ 12,230,000	$ 10,130,000	$ 7,350,000	$ 8,900,000	$ 7,710,000	$ 6,210,000	$ 5,310,000
	Dredging, Offloading, Processing & Water Treatment	$ 27,780,000	$ 23,420,000	$ 18,430,000	$ 21,460,000	$ 19,260,000	$ 22,970,000	$ 9,940,000
	Backfill Material & Backfill Placement	$ 12,940,000	$ 12,940,000	$ 12,260,000	$ 11,520,000	$ 11,520,000	$ 11,520,000	$ 11,520,000
	Beneficial On-Site Reuse and/or Off-Site Disposal	$ 3,140,000	$ 3,140,000	$ 2,900,000	$ 2,740,000	$ 2,740,000	$ 2,930,000	$ 32,730,000
	Site Restoration & Demobilization	$ 8,140,000	$ 6,050,000	$ 4,580,000	$ 4,820,000	$ 3,640,000	$ 3,610,000	$ 3,600,000
	Tidal Flat Sub-Total	**$ 64,230,000**	**$ 55,680,000**	**$ 45,520,000**	**$ 49,440,000**	**$ 44,870,000**	**$ 47,240,000**	**$ 63,100,000**
On-Site Beneficial Reuse OF-008 Drainage Ditch	Mobilization, Temporary Construction, Surveys, Environmental Protection & Monitoring	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000	$ 250,000
	Sheet Pile Installation for Water Diversion	$ 1,980,000	$ 1,980,000	$ 1,980,000	$ 1,980,000	$ 1,980,000	$ 1,980,000	$ 1,980,000
	Debris Removal, Excavation, Processing & Water Treatment	$ 1,220,000	$ 1,220,000	$ 1,220,000	$ 1,220,000	$ 1,220,000	$ 1,220,000	$ 1,220,000
	Backfill Material & Backfill Placement	$ 570,000	$ 570,000	$ 570,000	$ 570,000	$ 570,000	$ 570,000	$ 570,000
	Beneficial On-Site Reuse and/or Off-Site Disposal	$ 630,000	$ 630,000	$ 630,000	$ 630,000	$ 630,000	$ 630,000	$ 630,000
	Site Restoration & Demobilization	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000
	OutFall-008 Subtotal	**$ 5,010,000**	**$ 5,010,000**	**$ 5,010,000**	**$ 5,010,000**	**$ 5,010,000**	**$ 5,010,000**	**$ 5,010,000**
	Construction Subtotal	**$ 69,240,000**	**$ 60,690,000**	**$ 50,530,000**	**$ 54,450,000**	**$ 49,880,000**	**$ 52,250,000**	**$ 68,110,000**
	Construction Subtotal with 20% Contingency	$ 83,100,000	$ 72,830,000	$ 60,630,000	$ 65,330,000	$ 59,850,000	$ 62,680,000	$ 75,630,000
	Pre-Design Investigation	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
	Project/Construction Management (11%) and Design (5%)	$ 13,300,000	$ 11,650,000	$ 9,700,000	$ 10,450,000	$ 9,580,000	$ 10,030,000	$ 7,220,000
	Total Design, Management & Construction with Contingency	**$ 96,600,000**	**$ 84,680,000**	**$ 70,540,000**	**$ 75,980,000**	**$ 69,630,000**	**$ 72,910,000**	**$ 83,050,000**
	Annual Inspection (Years 1-5)	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	NA
	Total Cost with Escalation[2] On-Site Beneficial Reuse (Cost in Year 2022)	**$ 108,720,000**	**$ 95,310,000**	**$ 79,390,000**	**$ 85,520,000**	**$ 78,370,000**	**$ 82,060,000**	**NA**
	Total Cost with Escalation[2] Off-Site Disposal Option (Cost in Year 2022)	**$ 142,810,000**	**$ 129,400,000**	**$ 112,530,000**	**$ 116,850,000**	**$ 109,700,000**	**NA**	**$ 93,480,000**

Notes: 1. See Appendix E for additional cost information. 2. Escalation calculated using a 3% per year annual construction inflation with assumed midpoint of construction in the year 2022

Table 7-1
Alternative Ranking
Stratford Army Engine Plant Feasibility Study
Stratford, Connecticut

Alternative [1]	Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Performance	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost[2,3]		Total Ranking	
							On-Site Beneficial Reuse	Off-Site Disposal	On-Site Beneficial Reuse	Off-Site Disposal
Alternative 2 Hydraulic Dredge to Hydraulic Transport with Belt Filter Dewatering	●	●	●	◑	○ 4-5 Seasons	◔	○ $108.7 M	○ $142.8 M	15	15
Hydraulic Dredge to Hydraulic Transport with Geotube Dewatering	●	●	●	◕	◔ 4-5 Seasons	◑	◔ $95.3 M	○ $129.4 M	19	18
Alternative 3 Mechanical Dredge to Mechanical Transport	●	●	●	◕	◕ 3-4 Seasons	◕	● $79.4 M	◑ $112.5 M	25	23
Alternative 4 Mechanical Dredge to Hydraulic Transport with Belt Filter Dewatering	●	●	●	◑	◑ 3-4 Seasons	◔	◑ $85.5 M	◔ $116.9 M	19	20
Mechanical Dredge to Hydraulic Transport with Geotube Dewatering	●	●	●	◕	◕ 3-4 Seasons	◑	● $78.4 M	◕ $109.7 M	24	23
Alternative 5 Mechanical Dredge to PFTM Transport On-Site Beneficial Reuse	●	●	●	◕	● 3-4 Seasons	◔	◑ $82.1 M	NA	21	NA
Alternative 6 Mechanical Dredge to Mechanical Transport for Off-Site Process/Disposal	●	●	●	◕	◕ 3-4 Seasons	●	NA	● $93.5 M	NA	27

Notes:
1. Ranking is for the Alternatives which incorporate both the Tidal Flat and OF-008 Remediation Area
2. Costs are engineer's estimates and are anticipated to be within minus 30% and plus 50% of actual quantities consistent with USEPA feasibility study guidance. High Cost = Low Rank, Lower Costs = High Rank
3. Costs presented are total escalated capital costs to year 2022. See Table 6-3 and Appendix E for additional information.
4. The development of scores for alternatives is by its nature highly subjective; however, it provides a useful framework for categorizing and organizing the performance of various alternatives with respect to the evaluation criteria. Using the 0 to 4 point scale for each criterion, total scores within one point of each other can be considered essentially the same due to the subjective nature of this evaluation. The score itself is not the final decision factor in selecting a remedy. Rather, it helps to identify the major advantages and disadvantages among the alternatives to be discussed as part of the preferred remedy.

○ Low (0 points) ◔ Low to Moderate (1 point) ◑ Moderate (2 points) ◕ Moderate to High (3 points) ● High (4 points)