EBC Site Remediation and Redevelopment Program:
Remediation of Sites by In-Situ Stabilization
and Ex-Situ Sediment Stabilization
Welcome

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Program Purpose – What You Will Learn

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Remediation via In-Situ Geochemical Stabilization

Lucas Hellerich, PhD, PE, LEP – Woodard & Curran
Greg Booth, PhD – Woodard & Curran
September 11, 2019

Photo provided by Cascade
In-situ Geochemical Stabilization Topics

- What is in-situ geochemical stabilization?
- In situ geochemical immobilization of DNAPL
- Remediating hexavalent chromium (Cr(VI)) using calcium polysulfide (CPS)
- Ferrous sulfide treatment of heavy metals
- Take-aways
What is in-situ geochemical stabilization?

Geochemical stabilization changes speciation, fixates metals, and reduces mass flux.

Mobile species (Cr(VI))

Immobile species (Cr(III))

Before geochemical stabilization

After geochemical stabilization

Higher mass flux

Lower mass flux

Figure 2. Speciation diagram for aqueous chromium

(Rai. et al., 1987)

(ITRC, 2010)
In situ geochemical immobilization of DNAPL

Geochemical stabilization of DNAPL reduces its mobility and results in lower mass flux

Permanganate reacts with an organic compound (R) to yield an oxidized intermediate and manganese dioxide

\[ R + MnO_4 \rightarrow MnO_2 + CO_2 \text{ or } ROx \]

Additives are added to the solution to form mineral “crusts” or “shells” that are similar to birnessite

\[ (Na_{0.3}Ca_{0.1}K_{0.1})(Mn^{4+},Mn^{3+})_2O_4 \cdot 1.5 H_2O \]

ISGS® from Peroxychem

ISGI from Pro vectus
In situ geochemical immobilization of DNAPL

Geochemical stabilization of DNAPL has an estimated lifespan of between 15 to >150 years.

Image from Provectus

Likely NAPL
Reagent coating
Soil Grain
Epoxy (open pore space)
In situ geochemical immobilization of DNAPL
Manganese “crusts” form to stabilize the DNAPL

Permanganate and reacted organics

Before

After

Soil core from a site in Gainesville, Florida treated with ISGS Technology.

Photo from Peroxychem

Photos from Provegetus

ISGS® from Peroxychem

ISGI from Provegetus
Remediation of Cr(VI) using calcium polysulfide

CPS results in the formation of highly reducing sulfur species which reduce some metals and precipitate others

- Strong reductant
- 29% (29 g/ 100 mL)
- Deep red/orange liquid
- Pungent – rotten egg odor
- Chemistry
  - pH 11.5 – 11.8
  - Specific gravity = 1.27 g/mL
  - Water soluble
  - S$^{2-}$, SO$_3^{2-}$, SO$_4^{2-}$, S$_2$O$_3^{2-}$
  - Kinetics = $f$(pH, O$_2$)
- *Iron cycling can extend the effectiveness by years*

$$2\text{CrO}_4^{2-} + 3\text{CaS}_5 + 10\text{H}^+ \leftrightarrow 2\text{Cr(OH)}_3(\text{s}) + 15\text{S}_3(\text{s}) + 3\text{Ca}^{2+} + 2\text{H}_2\text{O}$$

(Rai. et al., 1987)
Remediation of Cr(VI) using calcium polysulfide (CPS) needs to be managed carefully due to its properties.

Photos from Cascade:
- 29% CPS
- Delivery and storage of CPS
Remediation of Cr(VI) using calcium polysulfide (CPS) can be injected via Direct Push™ points or into wells.

Photo from Cascade
Ferrous sulfide treatment of heavy metals
The reductant amendment geochemically fixates chromium and other metals

FerroBlack®-H reductant
(Redo Solutions, Carmel, IN, USA)

Solid phases
- Iron sulfides 7 – 8%
- Other solids 2 – 4%

Soluble phases
- Sulfides 1 – 2%
- Other diss. salts
- Water

Constituents treated by FerroBlack®-H
- Heavy metals (As, Cr, Cd, Cu, Hg, Ni, Pb, Se)
- CCA wood preserving contaminants
- Gas treatment in coal power plants
- Wet scrubber additives
- Chlorinated solvents

Hexavalent chromium is reduced and precipitated out of solution. Other metals form metal-sulfide complexes.

Mackinawite (Mullet, et al., 2004)

Source: Adapted from Du, et al., 2016
Ferrous sulfide treatment of heavy metals

The reductant amendment is mixed into clean backfill and placed into an excavated source area.

1. System layout
2. FerroBlack®-H mixing with dense graded aggregate
3. Placement of amended DGA
4. Compaction of amended DGA

DGA = dense-graded aggregate
Ferrous sulfide treatment of heavy metals
Case study: shallow groundwater Cr(VI) and total chromium are being remediated

Both source removal and the use of FerroBlack-H amended backfill has successfully cleaned up the majority of the shallow groundwater. Concentration trends continue to be downward.
Key take-away concepts

Geochemical stabilization is designed to reduce toxicity, mobility, and flux of constituents

- DNAPLs are encapsulated within a Mn-based “crust”, resulting in lower mobility and mass flux for a long time period
- Metals are fixated into precipitates through the use of iron and sulfide based reagents
- Stabilization agent longevity is a function of dosing and site hydrogeochemistry
- Monitoring programs need to be designed to assess geochemical changes and changes in flux
- There are additional technologies and products available to perform geochemical stabilization
Pneumatic Flow Tube Mixing Process (PFTM) for Ex-Situ Contaminated Sediments/Dredged Material Stabilization with Beneficial Use Applications

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Pneumatic Flow Tube Mixing Process (PFTM) for Ex-Situ Contaminated Sediments/Dredged Material Stabilization with Beneficial Use Applications

Tipping Point Resources Group, LLC / Jafec USA, Inc
11 September 2019 / Woburn, MA

EBC Site Remediation and Redevelopment Program:
Remediation of Sites by In-Situ Stabilization and Ex-Situ Sediment Stabilization

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Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth
Tipping Point Resources Group
An Environmental Industrial Service Company

Stephen Matic (CEO)
Eric A. Stern (President-Strategic Operations)
Alfred N. Kovalik, PE (President-Managing Director)
Robert Miskewitz, PhD (Chief Science Officer)
Ali Maher, PhD (Senior Technical Consultant)

- Partnership of recognized national/global experts in the dredged material / disruptive contaminated sediment and brownfield management and technology space
- Innovative sediment management and technology development, geotechnical engineering, applied materials science, treatability testing, beneficial use, regulatory affairs and community development
- Facilitate alignment of challenging sediment management projects with upland or subaqueous alternatives that include beneficial use applications

➢ Present Application Focus: Stabilization of Soft Sediments / Pneumatic Flow Tube Mixing.

- JAFEC- USA, the Tokyo Institute of Technology and Rutgers University, New Jersey are affiliate members of Tipping Point
- Collaborate with A/E Consulting Firms, Marine and Dredging Constructors, Waste Management Back-end Disposition Companies
JAFEC USA, Inc. is the US subsidiary of the Japan Foundation Engineering Company, ltd. (JAFEC) and AOMI, the Marine Contractors working in exclusive partnership with Tipping Point in implementing the Pneumatic Flow Tube Mixing (PFTM) technology.

The JAFEC Group's capabilities include all aspects of Ground Improvement including: excavation support, ground anchors, deep foundations, marine construction of quays and seawalls, cut-off walls & seepage barriers, ISS sediment stabilization and liquefaction mitigation.

Among the technical methods used by JAFEC USA in such works are Deep Soil Mixing (DSM), PFTM, Jet Mixing (DJM), Vibro-Stone Columns (SCP), Static Stone Columns (KS-EGG), Large Diameter Casing Rotation, Injection Grouting, Chemical Grouting, Jet Grouting, and Direct Power Compaction (DPC).

With more than 50 years of hands-on experience with technology development, "boots on the ground" construction and professional practice, the JAFEC Group and its US subsidiary, JAFEC USA, Inc. are uniquely qualified to deliver effective and economical Ground Improvement, sediment stabilization, innovative beneficial use applications and geotechnical construction services in the US and globally.
PFTM Ex/in-situ S/S Applications and Placement Options

Why do we care?

- **Environmental**
  - S/S of contaminated soft sediments (no dewatering or H₂O Treatment)
    - Upland beneficial use of unsuitable dredged materials not meeting aquatic placement criteria (open H₂O)
    - Remediation: materials handling transport alternatives – direct pumping upland or sub-aqueous capping /
      - *Superfund (complex footprints and infrastructure)*
      - *MGP / Utility Sites*
  - Brownfields
  - Coastal Restoration
  - Coal Combustion Residues (CCR) / fly ash
  - Sediments loads behind Dams
  - Rapid and efficient utilization of stored CDF materials / lagoons
  - Landfill cover
  - Windfarm Energy Support

- **Structural**
  - Bulkhead backfills (Gowanus Canal, Newtown Creek, New York)
    - Reduction of lateral earth pressures
    - Berm construction for flood control
    - Trench filling
    - Structural Caps – brownfields / or sub-aqueous
    - Structural and non-structural fills
    - Shallow improvement
    - Liquefaction mitigation and improvement of dynamic response
  - Port Expansion
    - New London, CT State Pier,
    - Gothenberg Sweden, Norway, UK

- **Allows Project Flexibility in Design and Construction Options Not Realized**
PFTM Placement Options (continued)

• PFTM system is **barge mounted** and can deploy to any coastal site / Can be operated **land side** and work interior (lagoon or dock)
  • Anchored to a Regional Dredged Material Manufacturing Facility (RDMMF) – New Haven Terminal / New London State Pier (pending)
  • Operating directly adjacent to project site and pump upland for beneficial use / landfill closure, brownfield redevelopment, bulkhead stabilization

• Integrates contaminated sediment placement with fill required at many coastal sites (levees, dikes and impoundments)
  • Raising/elevation for flood protection / pump into Geotubes
  • Capping / landfills (interior or coastal) via pumping

• Stabilized material is designed to meet or exceed geotechnical end-use specific (regulatory) criteria
  • Geotechnical
  • Environmental

❖ Research for alternative amendments and binders

➤ Can be pumped under bridges or challenging urban infrastructure to a trans-loading facility or used internally for Beneficial Use / structure – habitat restoration or coastal protection
Examples of Current State of Practice - Sediment/pozzolan mixing head

In Barge Pneumatic feed system with misting ring
Considerations with In-Barge S/S

- Debris
- Uneven Mixing
- One mix for entire barge
- Often over/under design mix
- Dust and Air Emissions
Bellingham, Washington USA
Squalicum Harbor

EIS Associates,
NY/NJ Harbor

Dredged Material Cement Pug Mill / Geotube Operations (large footprint)

Boskalis – Membrane Dewatering
Lower Passaic River, New Jersey

Pneumatic Flow Tube Mixing Operations (small footprint)

Sediment Dewatering Processes (S/S, Mechanical and Passive)
PFTM History

Pneumatic Flow Tube Mixing (PFTM)

• Developed in Japan in early 2000 for large scale land and water reclamation projects using fine silty clay sediments
• Many successful examples including reclamation works for Tokyo (Haneda-2010) and Central Japan (Chubu-2005) Airport Projects.

(Kitazume, 2016 CRC Press, ISBN 9781138029842 - CAT# K30201)
Haneda Airport Reclamation 2010

Cement treated soil with pneumatic flow mixing method
Dredged clay + Cement
Approx. 5,400,000 m³
at Central Japan International Airport

Pneumatic Flow Mixing method

Cement treatment

Pressured air  Air  Cement fluid
Mud  Plug flow  Mixture

Pressured mud
PFTM Process Flow
10,000 yd³/day (Japan)

- Deposition spreader (placement)
- PFTM Platform (stabilizing agents /supplier barge)
- Dredge Screen Barge
PFTM Process Flow – 10K yd³/Day (Japan)
Sub-Aqueous Placement
Soft sediment is broken into “plugs” by compressed air.

Plugs reduce pipe surface friction easing flow. During transport, cement and clay are mixed by the turbulent flow within the “plug” 

Kitazume 2002
PFTM Process Flow (Detailed)
Portland Cement Dosing / feedback loop

- Water content (%)
- Flow value (mm)
- Amount of cement (kg/m³)

Graph showing the relationships between time, water content, flow value, and amount of cement.
PFTM Attributes in Urban Sediment Management Environment - Summary

- Mixing and transport in a closed pipe system
- Pumped (up to 1 Km+) as a directed flowable fill
- Barge or land-based operation
- No water or air discharge (no need for geotubes, water treatment or mechanical presses)
- High quality structural flowable fill output that can be directed
  - Based on over 20 years of stabilization work performed in Japan and demonstrated for NJDOT in 2015
- Shortened processing and construction schedules
- Lower Costs
- Smaller land footprint (if any)
Amended dredged material pumped from PFTM

Hardened / cured dredged material as structural fill - one day
SPLP leachate analysis results indicated no detectable mass of any PAHs, Pesticides or PCBs.

Arsenic in the leachate from the raw sediment for the 8% mix were 14.8 and 15.9 µg/L and 3.97, 3.47 and 3.97 µg/L in the stabilized material indicating that 75% of potential leaching arsenic was mitigated by the stabilization procedure.

Chemical analyses indicate that the material was suitable for placement at the site.
Pneumatic Flow Tube Mixer (PFTM2000) – MOBILE SEDIMENT ENGINEERING SYSTEM (MOSES)
Port of Coeymans, New York Hudson River Assembly / Carver Marine (2017)
Vibratory Grizzly Screener with Debris Chutes / Collectors into Roll-offs
State of the Art Debris Screening - Hopper Charging Deck and Two Stage Vibratory Screening
Dual Sediment Slurry Reservoirs with Outlet into Eddy Pump to PFTM
Pneumatic Flow Tube Mixer (PFTM) – 2,000 yd³/day (8hr shift)
PFTM Outlet Cyclone Diffuser
Pier PFTM Layout
3D PFTM Barge Design
Case Study 1: Bridgeport, CT Marina Dredging / Upland Remediation Beneficial Use Integration / Bundle
Case Study 2: Conceptual Layout for PFTM Barge Mounted System and Beneficial Use of Sediment at Stratford, Connecticut Remediation Site US Army Tank Engine Plant
Case Study 3: Port Development and Beneficial Use Strategies

Mechanical Dredging, Transport via Dredging Scow to Pier

Processing with Barge Mounted PFTM MOSES

Beneficial Use Placement Alternatives
Mobile Sediment Engineering System (MOSES) 55x135 spud barge

Hopper Barge with Sediment for Stabilization

Direct Placement Subaqueous

Direct Placement on Land

Place and Stockpile for Future Onsite Use or Transload for Offsite

Beneficial Use
Alternatives for PFTM Amended Sediments
Sustainable Green Development of a Connecticut Brownfield

Triangle Wire Redevelopment Plan
Griswold, Connecticut
Mixing and transport in a closed pipe system
  • Transport with air allows pumping amended sediments with up to 3000 feet from processing site (simplifies supporting and staging areas needed)
No water or air discharge (no need for geotubes, water treatment or mechanical presses)
  – No dewatering area; reduces the footprint needed
  – No waste water treatment plant needed
• Sustainable approach to remediation sediment management (less water and energy consumption, beneficial use applicability)
• Barge or land mounted equipment (flexible) with a high processing to operating footprint
  – PFTM 500 / 60 CY/hr
  – PFTM 2000 / 250 CY/hr
Structural flowable fill output that can be directed
• Based on over 20 years of stabilization work performed in Japan and demonstrated for NJDOT in 2015
Shortened schedule
Lower Costs
• Smaller land footprint (if any) – barge mounted (fixed) or modular barges, land skid system
• Material is ready for trucking and/or or being barged at the end of the process to a trans-loading facility
• Material can be used for many different types of beneficial use right away
• Material is stabilized and can be designed to meet or exceed client / regulatory specific criteria (treatability testing)
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Upland Beneficial Use of Sediments and Soils Driving Sustainable Economic Growth
In-Situ Soil Stabilization, MGP Project case study – First ISS Project Permitted in CT

Larry Hogan
Associate Vice President
AECOM

Bryan MacDonald
Project Remediation Engineer
AECOM

Environmental Business Council of New England
Energy  Environment  Economy
Former Waterbury North MGP

Interim Remedial Action

Eversource Energy – Site Owner
AECOM – Engineer, LEP of Record

September 11, 2019
Agenda

– Site History
– Project Background
– Remedial Planning
– Remedial Action
– Post Remediation
Introduction

Site History

Former manufactured gas plant located in Waterbury, CT

Operations ceased in 1928

MGP structures demolished in 1964

Several rounds of investigation completed
– VRP, December 2015
– Phase III, March 2017
– BERA, March 2017

CT DOT Site Work commenced in May 2018
Investigation Locations

Figure 3.1 Supplemental Investigation Sampling Locations
Former Waterbury North WWTP
Eversource approached AECOM in late 2016 with plan to perform interim remedial action at site

Waterbury selected due to CT DOT Mixmaster project scheduled to begin in spring 2018

AECOM revised project scope to focused interim remedial action and commenced planning activities.

Project Team
- Engineering: Craig MacPhee, Bryan MacDonald, Randy Twiss
- LEP: Larry Hogan, Matt Rood
- PDI/Treatability Study: Gabe Knight, Stef Shea, Bryan MacDonald
- Oversight: John Crespo, Bryan MacDonald, Stef Shea
- Monitoring and Data: Stef Shea, Liz Doerfler

Remedial approach was excavation and off-site disposal. Retain ISS as an alternative to deal with highly impacted materials
Project Background - Planned CT DOT Work Area
Remedial Planning

– Pre-design Investigation (PDI): March/April 2017
– Discussions with regulators: June 2017
– Treatability Study: August 2017
– Interim Remedial Action Plan: October 2017
– Permitting: September 2017 – February 2018
– Bid Preparation and Bidding: December 2017 – January 2018
Proposed Remediation Areas
PDI - Holder Details

Holder 1 Cross-Section

- B6: 230 ug/kg
- B6: 2,480 ug/kg
- B8: 3,433,000 ug/kg
- B5: 340 ug/kg
- B7: 7,165,000 ug/kg
- B7: 8,771,000 ug/kg
- B7: 8,380,000 ug/kg
- B7: 8,295,000 ug/kg
- B5: 323,900 ug/kg

Composite Result:
- Sulfur: 1,100 mg/kg
- TCLP Benzene: 70,020 mg/kg
- Total SVOCs: 676 mg/kg

- Depth (feet below grade):
  - 2: 156
  - 4: 45.7
  - 6:
  - 8:
  - 10:
  - 12:
  - 14:
  - 16:
  - 18:
  - 20:
  - 22:
  - 24:

- 181,300 ug/kg

Legend:
- Weathered and Fractured Concrete
- Urban Fill
- Transition from Fill to Native
- Native Sand and Gravel

Eversource AECOM
**PDI - Holder Details**

**Holder 2 Cross-Section**

- **Depth (feet below grade):**
  - 2
  - 4
  - 6
  - 8
  - 10
  - 12
  - 14
  - 16
  - 18
  - 20
  - 22
  - 24

- **Boring Details:**
  - B4: 2,816 ug/kg
  - B3: 28,350 ug/kg
  - B2: 4,518,000 ug/kg
  - B1: 5,869,000 ug/kg
  - B3: 5,213,000 ug/kg
  - B3: 7,334,200 ug/kg
  - B1: 3,493,000 ug/kg
  - B1: 493,800 ug/kg

- **Composite Results:**
  - Sulfur
  - TCLP Benzene
  - Total SVOCs
  - 1,320 mg/kg
  - < 25 ug/kg
  - 44,500 ug/kg
  - 762 mg/kg
  - < 100 ug/kg
  - 1,355,400 ug/kg
  - 795 mg/kg
  - 270 ug/L
  - 2,261,000 ug/kg
  - 4,160 mg/kg
  - 3,300 ug/L
  - 7,579,000 ug/kg
  - 10,000 mg/kg
  - 11,000 ug/L
  - 8,330,000 ug/kg
  - 1,220 mg/kg
  - 3,000 ug/L
  - 3,030,000 ug/kg
  - 624 mg/kg
  - 1,700 ug/L
  - 2,330,000 ug/kg

- **Total VOC Concentrations from listed boring:**
  - Weathered and Fractured Concrete
  - Urban Fill
  - Transition from Fill to Native
  - Native Sand and Gravel

- **246 ug/kg**
Eversource and AECOM project team met with CT DEEP in June 2017 to discuss remedial approach

CT DEEP amenable to approach and use of ISS – needed permitting mechanism
- ISS not performed (permitted) in Connecticut previously so no precedent for authorization
- CT DEEP decided that a Temporary Authorization was the best way to approve this technology

Regulatory concerns
- Groundwater monitoring
- Impediments to future site-wide remediation
- NAPL removal
On-site bench-scale testing performed to evaluate applicability of ISS

Performance criteria (cured ISS mix) from ITRC guidance:
- Permeability: $< 1 \times 10^{-6}$ cm/sec
- Unconfined compressive strength: 50 – 200 psi
  - $> 200$ psi becomes difficult to excavate

<table>
<thead>
<tr>
<th>Mix ratio</th>
<th>Mix Type</th>
<th>Holder #2</th>
<th>Holder #1</th>
<th>Oil Tank A</th>
<th>Composite Holder #1/#2</th>
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</thead>
<tbody>
<tr>
<td>8% PC and 12% GBFS</td>
<td>Rich Mix</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6% PC and 8% GBFS</td>
<td>Average Mix</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8% PC</td>
<td>Portland Cement Only</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6% PC</td>
<td>Portland Cement Only</td>
<td></td>
<td></td>
<td>X*</td>
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<tr>
<td>10% PC</td>
<td>Portland Cement Only</td>
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<td></td>
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<td>– Lean Mix</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>– Rich Mix</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
## Treatability Study - Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mix Type</th>
<th>Mix Ratio</th>
<th>Water-to-Reagent Ratio</th>
<th>Penetrometer (ton/sq ft)</th>
<th>7-day UCS (psi)</th>
<th>14-day UCS (psi)</th>
<th>28-day UCS (psi)</th>
<th>28-day Permeability (cm/s)</th>
<th>Notes</th>
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<tr>
<td>Holder #2</td>
<td>Rich Mix</td>
<td>8% PC and 12% Slag</td>
<td>1:1</td>
<td>&gt;4.5</td>
<td>220</td>
<td>500</td>
<td>X</td>
<td>4.5 x 10^-8</td>
<td>Very soupy</td>
</tr>
<tr>
<td></td>
<td>Average Mix</td>
<td>6% PC and 8% Slag</td>
<td>0.75:1</td>
<td>&gt;4.5</td>
<td>445</td>
<td>670</td>
<td>X</td>
<td>6.4 x 10^-8</td>
<td>Good mix</td>
</tr>
<tr>
<td></td>
<td>Portland Only</td>
<td>8% PC</td>
<td>0.75:1</td>
<td>&gt;4.5</td>
<td>190</td>
<td>260</td>
<td>X</td>
<td>1.6 x 10^-7</td>
<td>Good mix</td>
</tr>
<tr>
<td>Holder #1</td>
<td>Average Mix</td>
<td>6% PC and 8% Slag</td>
<td>0.75:1</td>
<td>0.25</td>
<td>20</td>
<td>140</td>
<td>185</td>
<td>1.4 x 10^-7</td>
<td>Good mix</td>
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<tr>
<td>Oil Tank A</td>
<td>Average Mix</td>
<td>6% PC and 8% Slag</td>
<td>0.75:1</td>
<td>0.25</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>6.4 x 10^-6</td>
<td>Soil very dry - mix not setting well</td>
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<tr>
<td></td>
<td>Portland Only</td>
<td>8% PC</td>
<td>1:1</td>
<td>1.0</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>5.1 x 10^-6</td>
<td>Mix is pretty dry</td>
</tr>
<tr>
<td></td>
<td>Rich Portland Only</td>
<td>10% PC</td>
<td>1:1</td>
<td>-</td>
<td>NA</td>
<td>NA*</td>
<td>45</td>
<td>4.6 x 10^-7</td>
<td>Good mix</td>
</tr>
<tr>
<td>Composite Holder #1/#2</td>
<td>Lean Portland Only</td>
<td>6% PC</td>
<td>1.25:1</td>
<td>-</td>
<td>65</td>
<td>75</td>
<td>70</td>
<td>1.3 x 10^-6</td>
<td>Good mix</td>
</tr>
</tbody>
</table>

NA: not analyzed due to insufficient soil volume
NA*: not analyzed because sample not able to withstand removal from mold
X: not analyzed because upper limit for UCS already exceeded
Results showed that 6% addition by weight of Portland cement would achieve performance goals for treatment of soil in Holders 1 and 2.

- 8% Portland cement was the final dosing rate for the project to ensure that remedial goals were met.

- Results were incorporated into the Interim Remedial Action Plan and TA submittal for the remediation.
Interim Remedial Action Plan

– Excavate upper material
  • Amend soil if necessary
  • Off-site disposal - thermal desorption and/or landfill

– Assess deeper material
  • Presence of debris
  • Characterize soil/tar
  • Assess water conditions in holder (perched vs. water table)

– Evaluate: continue excavation or implement ISS based on field conditions

– Interim Remedial Action Plan submitted to CT DEEP in October 2017
Permitting

- Temporary Authorization for Discharge to Groundwater
  - Applicable for mixing of remedial amendment (Portland cement) below the water table
  - Groundwater monitoring to confirm protection of downgradient receptor and site COCs not mobilized
  - Extensive monitoring program
    - AECOM proposed vs. DEEP required

- General Permit for Remediation Wastewater Discharge to Sanitary Sewer
  - No on-site discharge points
  - Trucking to POTW
  - Permit requirements changed after submitted – required CTDEEP coordination

- NDDB Review
  - Applicable to TA and GP – remediation proposed during peregrine falcon nesting season. Needed to address with ornithologist review and protection plan
Bid Preparation and Bidding

AECOM
- Detailed design, treatability testing, selection of performance criteria
- Specifications and drawings
- Bid forms
- Perimeter Air Monitoring Plan

Eversource
- Procurement
  - LAND Remediation (NY)
  - Previous work with Eversource in MA (ISS and tar stabilization in CT River-Holyoke)
Scope Changes and Considerations

– LAND determined that increasing ISS volume would be more cost effective
  • TA modification
  • ISS 4’ to design depth or 16’

– Bidding process underway prior to TA approval
  • Key requirement of TA approval (and RSRs) was removal of NAPL PRIOR to implementation of ISS – point of contention between Engineer and Contractor
Remedial Action

– AECOM, Eversource and Land Kickoff meeting February 27, 2018
  • Key issues: NAPL removal, safety, test pits, ISS dosing rate

– Roles clearly defined, Health and Safety programs reviewed and were compatible.

– Lines of communication clearly established with AECOM as project engineer acting on behalf of Eversource.

– Early establishment of roles leads to smooth and safe project execution.

– Remediation began March 5 and all work complete and contractor off-site by May 18 (CT DEEP deadline)
Remediation Plan

NOTES:
1. ESTIMATED PRE-CUT THICKNESS 5 FEET
2. ESTIMATED ISS THICKNESS FOR NO. 1 GAS HOLDER 11 FEET
3. ESTIMATED ISS THICKNESS FOR NO. 2 GAS HOLDER 12 FEET
4. COMPLETE EXCAVATION OF OIL TANKS "A" & "B"

B CELL 4 TYP
MAX REACH 22.3'
AREA: 389 FT²
PRE-CUT: 72 CY
ISS: 148 CY

D CELL 4 TYP
20' x 20'
AREA: 400 FT²
PRE-CUT: 74 CY
ISS: 196 CY

C CELL 4 TYP
19' OC
MAX REACH 22'
AREA: 556 FT²
PRE-CUT: 124 CY
ISS: 273 CY

A CELL 8 TYP
22.3' OC
MAX REACH 25.4'
AREA: 585 FT²
PRE-CUT: 125 CY
ISS: 222 CY

OIL TANK "A"
27.8' DIAMETER
AREA: 607 FT²
EXCAV VOL: 443 CY

OIL TANK "B"
41' DIAMETER
AREA: 1,320 FT²
EXCAV VOL: 406 CY
Site Preparation
Site Preparation
Implementation
Implementation – Test Pits
Grout Plant
Dewatering
ISS Mixing

Mixing Head

Skeleton Bucket
ISS Sampling

In-site Sampling Tool

Bucket Sample - AECOM

Sample from C-4
ISS Performed on 4/23/18. Mixture was well homogenized. Rocks settled to bottom during curing. Slight odor observed.
ISS Completed Cell
Unconfined Compressive Strength (UCS) Testing Results - Holder No. 1

UCS Performance objective = 50 - 200 psi achieved at 7 days for each cell

Cell IDs: C-1, C-3, C-2, C-4, D-1

Strengths at 7-day, 14-day, and 28-day intervals are shown for each cell.
ISS Performance Testing Results

Unconfined Compressive Strength (UCS) Testing Results - Holder No. 2

Unconfined Compressive Strength (psi)

UCS Performance objective = 50 - 200 psi achieved at 7 days for each cell

- Holder No. 2

- 7-day
- 14-day
- 28-day


Cell ID

Performance objective = 50 - 200 psi achieved at 7 days for each cell
ISS Completion

Finish and Restore

- ISS completed from design depth to 4’ below grade
- Complies with DEC
- Clean fill placed and compacted over ISS mass
- Off-site and demob on May 18
Post - Remediation

- Ongoing TA groundwater monitoring required – 1 year minimum
- Remedial Action Report due 120-days from final discharge
- CT DOT construction support – 5 year project
- Prepare for site-wide remediation
  - Remaining holders and tail race
Lessons Learned

– Initial ISS performance results favorable for UCS and permeability
– Test pits to evaluate materials in ISS footprint
– Reduction in off-site disposal saved approx. $800,000
– Applicable to more MGPs in CT – Eversource has ~15 sites
– Green / sustainable remediation
  • Less waste traveling for disposal (thermal desorption)
Thank You!
Moderated Discussion

Moderator: David Austin, AECOM

Panelists:
• Lucas Hellerich, Woodard & Curran
• Larry Hogan, AECOM
• Bryan MacDonald, AECOM
• Robert Miskewitz, Tipping Point Resources
• Eric A. Stern, Tipping Point Resources
EBC Site Remediation and Redevelopment Program:
Remediation of Sites by In-Situ Stabilization
and Ex-Situ Sediment Stabilization